Complex terrain experiments in the New European Wind Atlas
The New European Wind Atlas project will create a freely accessible wind atlas covering Europe and Turkey, develop the model chain to create the atlas and perform a series of experiments on flow in many different kinds of complex terrain to validate the models. This paper describes the experiments of which some are nearly completed while others are in the planning stage. All experiments focus on the flow properties that are relevant for wind turbines, so the main focus is the mean flow and the turbulence at heights between 40 and 300 m. Also extreme winds, wind shear and veer, and diurnal and seasonal variations of the wind are of interest. Common to all the experiments is the use of Doppler lidar systems to supplement and in some cases replace completely meteorological towers. Many of the lidars will be equipped with scan heads that will allow for arbitrary scan patterns by several synchronized systems. Two pilot experiments, one in Portugal and one in Germany, show the value of using multiple synchronized, scanning lidar, both in terms of the accuracy of the measurements and the atmospheric physical processes that can be studied. The experimental data will be used for validation of atmospheric flow models and will by the end of the project be freely available. This article is part of the themed issue ‘Wind energy in complex terrains’.

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ISSN (Print): 1364-503X
Ratings:
Detecting wind turbine wakes with nacelle lidars: Paper

Because the horizontal homogeneity assumption is violated in wakes flows, lidars face difficulties when reconstructing wind fields. Further, small-scale turbulence which is prevalent in wake flows causes Doppler spectrum widths to be broader than in the free stream. In this study the Doppler peak variance is used as a detection parameter for wakes. A one month long measurement campaign, where a continuous-wave lidar on a turbine has been exposed to multiple wake situations, is used to test the detection capabilities. The results show that it is possible to identify situation where a downstream turbine is in wake by comparing the peak widths. The used lidar is inexpensive and brings instalments on every turbine within economical reach. Thus, the information gathered by the lidars can be used for improved control at wind farm level.
Effects of normal and extreme turbulence spectral parameters on wind turbine loads

Loads simulations as performed to obtain design loads on wind turbines, requires wind turbulence as an input, characterized by parameters associated with the turbulence length scale, dissipation and anisotropy. The effect of variation in these turbulence spectral parameters on the magnitude of design loads is investigated with a focus on the commonly used Mann turbulence model. Quantification of the Mann model parameters is made through wind measurements acquired from the Høvsøre site. The parameters of the Mann model fitted to site specific observations can differ significantly from the recommended values in the IEC 61400-1 Ed.3 that is used for wind turbine design. The present paper investigates the impact of Mann turbulence model parameter variations on the design loads envelope for 5 MW and 10 MW reference wind turbines. Specific focus is made on the blade root loads, tower top moments and tower base loads under normal turbulence and extreme turbulence, whereby the change in operating extreme and fatigue design loads obtained through turbulence model parameter variations is compared with corresponding variations obtained from random seeds of turbulence. The investigations quantify the effects of turbulent length scale and anisotropy on the major wind turbine component extreme and fatigue loads.

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Authors: Dimitrov, N. K. (Intern), Natarajan, A. (Intern), Mann, J. (Intern)
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.845 SNIP 2.118 CiteScore 4.51
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
For wind turbines in complex terrain, the devil is in the detail
The cost of energy produced by onshore wind turbines is among the lowest available; however, onshore wind turbines are often positioned in a complex terrain, where the wind resources and wind conditions are quite uncertain due to the surrounding topography and/or vegetation. In this study, we use a scale model in a three-dimensional wind-testing chamber to show how minor changes in the terrain can result in significant differences in the flow at turbine height. These differences affect not only the power performance but also the life-time and maintenance costs of wind turbines, and hence, the economy and feasibility of wind turbine projects. We find that the mean wind, wind shear and turbulence level are extremely sensitive to the exact details of the terrain: a small modification of the edge of our scale model, results in a reduction of the estimated annual energy production by at least 50% and an increase in the turbulence level by a factor of five in the worst-case scenario with the most unfavorable wind direction. Wind farm developers should be aware that near escarpments destructive flows can occur and their extent is uncertain thus warranting on-site field measurements.
Lidars Lifted: The Østerild Balconies Experiment

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Simon, E. (Intern), Courtney, M. (Intern), Vasiljevic, N. (Intern), Lea, G. (Intern), Dellwik, E. (Intern), Karagali, I. (Intern), Mann, J. (Intern)
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Scopus rating (2016): CiteScore 4.74 SJR 2.628 SNIP 1.575
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.726 SNIP 1.557 CiteScore 4.51
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.153 SNIP 1.435 CiteScore 3.91
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.284 SNIP 1.676 CiteScore 4.06
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.1 SNIP 1.583 CiteScore 3.65
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.907 SNIP 1.511 CiteScore 3.51
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.717 SNIP 1.288
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.816 SNIP 1.266
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.725 SNIP 1.269
Web of Science (2008): Indexed yes
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Wind power plants, Energy resources, Geophysical techniques and equipment, terrain mapping, wind power, wind turbines, onshore wind turbines, energy cost, wind resources, wind conditions, scale model, three-dimensional wind-testing chamber, life-time costs, maintenance costs, mean wind, wind shear, turbulence level, estimated annual energy production reduction, on-site field measurements

Original language: English
Measurements of surface-layer turbulence in a wide Norwegian fjord using synchronized long-range Doppler wind lidars

Three synchronized pulsed Doppler wind lidars were deployed from May 2016 to June 2016 on the shores of a wide Norwegian fjord called Bjørnafjord to study the wind characteristics at the proposed location of a planned bridge. The purpose was to investigate the potential of using lidars to gather information on turbulence characteristics in the middle of a wide fjord. The study includes the analysis of the single-point and two-point statistics of wind turbulence, which are of major interest to estimate dynamic wind loads on structures. The horizontal wind components were measured by the intersecting scanning beams, along a line located 25m above the sea surface, at scanning distances up to 4.6km. For a mean wind velocity above 8m·s⁻¹, the recorded turbulence intensity was below 0.06 on average. Even though the along-beam spatial averaging leads to an underestimated turbulence intensity, such a value indicates a roughness length much lower than provided in the European standard EN 1991-1-4:2005. The normalized spectrum of the along-wind component was compared to the one provided by the Norwegian Petroleum Industry Standard and the Norwegian Handbook for bridge design N400. A good overall agreement was observed for wave-numbers below 0.02m⁻¹. The along-beam spatial averaging in the adopted set-up prevented a more detailed comparison at larger wave-numbers, which challenges the study of wind turbulence at scanning distances of several kilometres. The results presented illustrate the need to complement lidar data with point-measurement to reduce the uncertainties linked to the atmospheric stability and the spatial averaging of the lidar probe volume. The measured lateral coherence was associated with a decay coefficient larger than expected for the along-wind component, with a value around 21 for a mean wind velocity bounded between 10m·s⁻¹ and 14m·s⁻¹, which may be related to a stable atmospheric stratification.
Modeling and Validation across Scales: Parametrizing the effect of the forested landscape

When validating the performance of a flow model in forested areas, it is important that the model accurately represents the forest effects. This presentation concerns the use of remote-sensing technology for describing forest effects, and more specifically, how positioning lidar data can be transferred into a parametrization of forests in wind models. The presentation covers three scales: the single tree, the forest edges and clearings, and the large-scale forested landscape in which the forest effects are parameterized with a roughness length. Flow modeling results and validation against observations are presented along with the different forest presentations for each of the cases. In a new research project called InnoWind, the use of satellite-based alternatives to airborne lidar campaigns are investigated, and examples of satellite products in wind power modeling are discussed.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling , Aerodynamic design
Authors: Dellwik, E. (Intern), Badger, M. (Intern), Angelou, N. (Intern), Mann, J. (Intern), Karagali, I. (Intern), Hahmann, A. N. (Intern), Cavar, D. (Intern), van der Laan, P. (Intern)
Publication date: 2017
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Main Research Area: Technical/natural sciences
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AbstractTemplate_Boulder2017_final.pdf
Source: PublicationPreSubmission
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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Modeling Atmospheric Turbulence via Rapid Distortion Theory: Spectral Tensor of Velocity and Buoyancy

A spectral tensor model is presented for turbulent fluctuations of wind velocity components and temperature, assuming uniform vertical gradients in mean temperature and mean wind speed. The model is built upon rapid distortion theory (RDT) following studies by Mann and by Hanazaki and Hunt, using the eddy lifetime parameterization of Mann to make the model stationary. The buoyant spectral tensor model is driven via five parameters: the viscous dissipation rate epsilon, length scale of energy-containing eddies L, a turbulence anisotropy parameter Gamma, gradient Richardson number (Ri) representing the local atmospheric stability, and the rate of destruction of temperature variance eta(theta). Model output includes velocity and temperature spectra and associated cospectra, including those of longitudinal and vertical temperature fluxes. The model also produces two-point statistics, such as coherences and phases of velocity components and temperature. The statistics of uniformly sheared and stratified turbulence from the model are compared with atmospheric observations taken from the Horizontal Array Turbulence Study (HATS) field program, and model results fit observed one-dimensional spectra quite well. For highly unstable stratification, however, the model has deficiencies at low wavenumbers that limit its prediction of longitudinal velocity component spectra at scales on the order of 0.6 km. The model predicts coherences well for horizontal separations but overestimates vertical coherence with increasing separation. Finally, it is shown that the RDT output can deviate from Monin-Obukhov similarity theory.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling , Wind turbine loads & control, University of Agder
Authors: Chougule, A. S. (Ekstern), Mann, J. (Intern), Kelly, M. C. (Intern), Larsen, G. C. (Intern)
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Pages: 949-974
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Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of the Atmospheric Sciences
Volume: 74
Issue number: 4
On the spatial and temporal resolution of land cover products for applied use in wind resource mapping

The suitability of Copernicus Global Land Service products for wind assessment is investigated using two approaches. In the first approach the CORINE land cover database and the pan-European high-resolution products were considered as input to atmospheric flow models. The CORINE data were used as input for modelling the wind conditions over a Danish near-coastal region. The flow model results were compared to alternative use of USGS land cover. Significant variations in
the wind speed were found between the two atmospheric flow model results. Furthermore the wind speed from the flow model was compared to meteorological observations taken in a tall mast and from ground based remote-sensing wind profiling lidars. It is shown that simulations using CORINE provide better wind flow results close to the surface as compared to those using USGS on the investigated site. The next step towards improvement of flow model inputs is to investigate in further detail applied use of satellite maps in forested areas. 75% of new land-based wind farms are planned in or near forests in Europe. In forested areas the near surface atmospheric flow is more challenging to calculate than in regions with low vegetation because the tall vegetation to a high degree influences the atmospheric flow. Also in many forests the variation in forest plant structure is high. The forest structure depends on the tree height, the tree density, the existence of clearings, the types of leaves and branches and their structure. So the method of assigning one typical roughness length for land cover type 'forest' is at many sites not sufficient. This method assumes that all land cover classes can be represented with one value each. In our second approach, we look at a forested area in Northern Denmark, where an aerial lidar data observing terrain height, tree height and derived plant parameters provided a novel input for atmospheric flow modelling in forested areas. The flow model results were compared to horizontally scanning wind lidar observations and the results are very promising. Since, aerial lidar data are not available everywhere, we discuss the possibility of using similar Copernicus Global Land Service products as input to the flow model.

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State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Hasager, C. B. (Intern), Badger, M. (Intern), Delliwk, E. (Intern), Floors, R. R. (Intern), Hahmann, A. N. (Intern), Mann, J. (Intern)
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Main Research Area: Technical/natural sciences
Electronic versions:
WorldCover2017_poster_Hasager_et_al.pdf
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Perdigão 2015: Methodology for atmospheric multi-Doppler lidar experiments
The long-range and short-range WindScanner systems (LRWS and SRWS), multi-Doppler lidar instruments, when combined together can map the turbulent flow around a wind turbine and at the same time measure mean flow conditions over an entire region such as a wind farm. As the WindScanner technology is novel, performing field campaigns with the WindScanner systems requires a methodology that will maximize the benefits of conducting WindScanner-based experiments. Such a methodology, made up of 10 steps, is presented and discussed through its application in a pilot experiment that took place in a complex and forested site in Portugal, where for the first time the two WindScanner systems operated simultaneously. Overall, this resulted in a detailed site selection criteria, a well-thought-out experiment layout, novel flow mapping methods and high-quality flow observations, all of which are presented in this paper.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Porto
Authors: Vasiljevia, N. (Intern), Palma, J. M. (Ekstern), Angelou, N. (Intern), Matos, J. C. (Ekstern), Menke, R. (Intern), Lea, G. (Intern), Mann, J. (Intern), Courtney, M. (Intern), Ribeiro, L. F. (Ekstern), Gomes, V. M. (Ekstern)
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Volume: 10
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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.59 SJR 1.956 SNIP 1.612
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.019 SNIP 1.433 CiteScore 3.37
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.116 SNIP 1.561 CiteScore 3.22
Turbulence characterization from a forward-looking nacelle lidar

We present two methods to characterize turbulence in the turbine inflow using radial velocity measurements from nacelle-mounted lidars. The first uses a model of the three-dimensional spectral velocity tensor combined with a model of the spatial radial velocity averaging of the lidars, and the second uses the ensemble-averaged Doppler radial velocity spectrum. With the former, filtered turbulence estimates can be predicted, whereas the latter model-free method allows us to estimate unfiltered turbulence measures. Two types of forward-looking nacelle lidars are investigated: a pulsed system that uses a five-beam configuration and a continuous-wave system that scans conically. For both types of lidars, we show how the radial velocity spectra of the lidar beams are influenced by turbulence characteristics, and how to extract the velocity-tensor parameters that are useful to predict the loads on a turbine. We also show how the velocity-component variances and co-variances can be estimated from the radial-velocity unfiltered variances of the lidar beams. We demonstrate the methods using measurements from an experiment conducted at the Nørrekaer Enge wind farm in northern Denmark, where both types of lidars were installed on the nacelle of a wind turbine. Comparison of the lidar-based along-wind unfiltered variances with those from a cup anemometer installed on a meteorological mast close to the turbine shows a bias of just 2%. The ratios of the unfiltered and filtered radial velocity variances of the lidar beams to the cup-anemometer variances are well predicted by the spectral model. However, other lidar-derived estimates of velocity-component variances and co-variances do not agree with those from a sonic anemometer on the mast, which we mostly attribute to the small cone angle of the lidar. The velocity-tensor parameters derived from sonic-anemometer velocity spectra and those derived from lidar radial velocity spectra agree well under both near-neutral atmospheric stability and high wind-speed conditions, with differences increasing with decreasing wind speed and increasing stability. We also partly attribute these differences to the lidar beam configuration.

General information

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
Authors: Peña, A. (Intern), Mann, J. (Intern), Dimitrov, N. K. (Intern)
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10.5194/wes-2-133-2017
A Micropulse eye-safe all-fiber molecular backscatter coherent temperature lidar

In this paper, we analyze the performance of an all-fiber, micropulse, 1.5 μm coherent lidar for remote sensing of atmospheric temperature. The proposed system benefits from the recent advances in optics/electronics technology, especially an all-fiber image-reject homodyne receiver, where a high resolution spectrum in the baseband can be acquired. Due to the presence of a structured spectra resulting from the spontaneous Rayleigh-Brillouine scattering, associated with the relevant operating regimes, an accurate estimation of the temperature can be carried out. One of the main advantages of this system is the removal of the contaminating Mie backscatter signal by electronic filters at the baseband (before signal conditioning and amplification). The paper presents the basic concepts as well as a Monte-Carlo system simulation as the proof of concept.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Colorado, National Center for Atmospheric Research
Authors: Abari, C. F. (Ekstern), Chu, X. (Ekstern), Mann, J. (Intern), Spuler, S. (Ekstern)
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Web of Science (2015): Indexed yes
Scopus rating (2014): SNIP 0.141 SJR 0.165
Scopus rating (2013): SNIP 0.101 SJR 0.15
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SNIP 0.139 SJR 0.171
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SNIP 0.193 SJR 0.151
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SNIP 0.347 SJR 0.319
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An Inter-Comparison Study of Multi- and DBS Lidar Measurements in Complex Terrain

Wind measurements using classical profiling lidars suffer from systematic measurement errors in complex terrain. Moreover, their ability to measure turbulence quantities is unsatisfactory for wind-energy applications. This paper presents results from a measurement campaign during which multiple WindScanners were focused on one point next to a reference mast in complex terrain. This multi-lidar (ML) technique is also compared to a profiling lidar using the Doppler beam swinging (DBS) method. First- and second-order statistics of the radial wind velocities from the individual instruments and the horizontal wind components of several ML combinations are analysed in comparison to sonic anemometry and DBS measurements. The results for the wind speed show significantly reduced scatter and directional error for the ML method.
in comparison to the DBS lidar. The analysis of the second-order statistics also reveals a significantly better correlation for the ML technique than for the DBS lidar, when compared to the sonic. However, the probe volume averaging of the lidars leads to an attenuation of the turbulence at high wave numbers. Also the configuration (i.e., angles) of the WindScanners in the ML method seems to be more important for turbulence measurements. In summary, the results clearly show the advantages of the ML technique in complex terrain and indicate that it has the potential to achieve significantly higher accuracy in measuring turbulence quantities for wind-energy applications than classical profiling lidars.

General information
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Authors: Pauscher, L. (Ekstern), Vasiljevic, N. (Intern), Callies, D. (Ekstern), Lea, G. (Intern), Mann, J. (Intern), Klaas, T. (Ekstern), Hieronimus, J. (Ekstern), Gottschall, J. (Ekstern), Schwesig, A. (Ekstern), Kühn, M. (Ekstern), Courtney, M. (Intern)
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Scopus rating (2015): SJR 1.339 SNIP 1.691 CiteScore 3.76
Web of Science (2015): Indexed yes
Scopus rating (2014): SJR 1.28 SNIP 1.886 CiteScore 3.23
Web of Science (2014): Indexed yes
Scopus rating (2013): SJR 1.167 SNIP 1.981 CiteScore 3.01
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): SJR 0.999 SNIP 1.645 CiteScore 2.36
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.498 SNIP 1.268 CiteScore 1.3
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.315 SNIP 0.531
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Multi-lidar, WindScanner, Complex terrain, Turbulence, Wind energy
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Erratum
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Source-ID: 2345652645
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Application of short-range dual-Doppler lidars to evaluate the coherence of turbulence
Two synchronized continuous wave scanning lidars are used to study the coherence of the along-wind and across-wind velocity components. The goal is to evaluate the potential of the lidar technology for application in wind engineering. The wind lidars were installed on the Lysefjord Bridge during four days in May 2014 to monitor the wind field in the horizontal plane upstream of the bridge deck. Wind records obtained by five sonic anemometers mounted on the West side of the bridge are used as reference data. Single- and two-point statistics of wind turbulence are studied, with special emphasis on the root-coherence and the co-coherence of turbulence. A four-parameter decaying exponential function has been fitted to the measured co-coherence, and a good agreement is observed between data obtained by the sonic anemometers and the lidars. The root-coherence of turbulence is compared to theoretical models. The analytical predictions agree rather well with the measured coherence for the along-wind component. For increasing wavenumbers,
larger discrepancies are, however, noticeable between the measured coherence and the theoretical predictions. The WindScanners are observed to slightly overestimate the integral length scales, which could not be explained by the laser beam averaging effect alone. On the other hand, the spatial averaging effect does not seem to have any significant effect on the coherence.

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Test and Measurements, University of Stavanger, Reykjavik University, Christian Michelsen Research AS
Authors: Cheynet, E. (Ekstern), Jakobsen, J. B. (Ekstern), Snæbjörnsson, J. (Ekstern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Mann, J. (Intern), Hansen, P. (Intern), Angelou, N. (Intern), Svardal, B. (Ekstern)
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BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.994 SNIP 1.324 CiteScore 2.18
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.193 SNIP 1.592 CiteScore 2.04
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.235 SNIP 1.721 CiteScore 2.21
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.425 SNIP 1.927 CiteScore 2.41
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.114 SNIP 1.82 CiteScore 1.96
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.167 SNIP 1.938 CiteScore 1.93
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.016 SNIP 1.635
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.531 SNIP 1.881
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.658 SNIP 1.903
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.258 SNIP 1.511
Scopus rating (2006): SJR 1.311 SNIP 1.443
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.334 SNIP 1.398
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.765 SNIP 1.365
Web of Science (2004): Indexed yes
Characterization of wind velocities in the upstream induction zone of a wind turbine using scanning continuous-wave lidars

As a wind turbine generates power, induced velocities, lower than the freestream velocity, will be present upstream of the turbine due to perturbation of the flow by the rotor. In this study, the upstream induction zone of a 225kW horizontal axis Vestas V27 wind turbine located at the Danish Technical University’s Rise campus is investigated using a scanning Light Detection and Ranging (lidar) system. Three short-range continuous-wave “WindScanner” lidars are positioned in the field around the V27 turbine allowing detection of all three components of the wind velocity vectors within the induction zone. The time-averaged mean wind speeds at different locations in the upstream induction zone are measured by scanning a horizontal plane at hub height and a vertical plane centered at the middle of the rotor extending roughly 1.5 rotor diameters (D) upstream of the rotor. Turbulence statistics in the induction zone are studied by more rapidly scanning along individual lines perpendicular to the rotor at different radial distances from the hub. The mean velocity measurements reveal that the longitudinal velocity reductions become greater closer to the rotor plane and closer to the center of the rotor. Velocity deficits of 1%–3% of the freestream value were observed 1 D upstream of the rotor, increasing at the rotor plane to 7.4% near the edge of the rotor and 18% near the center of the rotor while the turbine was operating with a high estimated mechanical coefficient of power (CP) of 0.56 yielding an estimated axial induction factor of 0.25. The velocity reductions relative to the freestream velocity become smaller when the turbine’s coefficient of power decreases; for a low CP of 0.16 resulting in an estimated induction factor of 0.04, the velocity deficits are 1% of the freestream value 1 D upstream of the rotor and only 6% at the rotor plane near the center of the rotor. Additionally, the mean radial wind speeds were found to increase close to the edge of the rotor disk indicating an expansion of the incoming flow around the rotor. Radial velocity magnitudes at the edge of the rotor disk of approximately 9% and 3% of the freestream longitudinal wind speed were measured for the abovementioned high and low CP values, respectively. Turbulence statistics, calculated using 2.5-min time series, suggest that the standard deviation of the longitudinal wind component decreases close to the rotor, while the standard deviation of the radial wind component appears to increase. When the turbine was operating with a high CP of 0.54 resulting in an estimated induction factor of 0.22, standard deviation decreases of up to 22% of the estimated freestream value and increases of up to 22% were observed for the longitudinal and radial components, respectively, near the center of the rotor.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, University of Colorado at Boulder
Authors: Simley, E. (Ekstern), Angelou, N. (Intern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Mann, J. (Intern), Pao, L. Y. (Ekstern)
Number of pages: 26
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Main Research Area: Technical/natural sciences

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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
The wind flow over a double-ridge site has been numerically simulated with a nested model-chain coupling, down to horizontal resolutions of 40 m. The results were compared with field measurements attained using a triple-lidar instrument, the long-range WindScanner system, which allowed measurements up to 500 m height and the mapping of the wind speed onto a two-dimensional transect crossing the valley. The site, known as Serra do Perdigão, is located in central Portugal and consists of two parallel ridges 1.4 km apart with height differences of 200 m in between, being characterized by rough terrain and forested areas. The analysis was restricted to June 10th 2015, for which measurements and simulations both predicted gravity wave activity, the later showing formation of rotors in the lee of both ridges and some events of wave breaking above the ridge top.
Demonstration of a Basis for Tall Wind Turbine Design, EUDP Project Final Report

Wind turbine design using calibrated wind models have been proposed to be used in conjunction with load cases which lead to reduced uncertainties in the design of wind turbines with hub heights above 60m. These recommended wind profiles have been made for shear, wind directional change and turbulence. The wind turbulence models used in the loads simulations have been calibrated so that their model parameters reflect the atmospheric stability conditions and the quantile of turbulence intensity considered. Consequently large multi megawatt turbines being designed today can benefit from these more advanced wind inflow models. A revision of the IEC 61400-1 standard is being developed and has incorporated some of the recommendations made from this project. This project demonstrated the impact of wind models by simulating wind turbine loads based on high frequency wind measurements taken between 100m and 200m altitude performed at Høvsøre in Denmark. The project also demonstrated the impact of the new wind models on load cases and the certification envelope of turbines. Further the project provided a detailed assessment of safety factors for IEC 61400-1 load cases using reliability-based procedures incorporating the new models and this has been made as an Annex to the new standard that is due to be issued.

General information

State: Published
Authors: Natarajan, A. (Intern), Dimitrov, N. K. (Intern), Madsen, P. H. (Intern), Berg, J. (Intern), Kelly, M. C. (Intern), Larsen, G. C. (Intern), Mann, J. (Intern), Verelst, D. R. (Intern), Dalsgaard Sørensen, J. (Ekstern), Toft, H. (Ekstern),
Flow over complex terrain. The secrets of Bolund

Since the Bolund field campaign in 2007, the Bolund peninsula in the Roskilde Fjord in Denmark is a well-known reference case for numerical and physical modelling for wind modelling and wind turbine siting. Its well-described characteristics and boundary conditions makes it ideal for the analysis and the understanding of flow over complex terrain. The work presented in this thesis contains two diverse approaches to help understand the flow behavior over a complex terrain site, in this case the Bolund peninsula. The first approach investigates the wake and recirculation zone downstream of the Bolund escarpment with the help of a continuous-wave Doppler lidar (light detection and ranging). The instrument measures the line-of-sight windspeed 390 times per second in highly resolved 7-m tall profiles by rapidly changing the focus distance and beam direction. The profiles reveal a detailed and rapidly changing structure of the recirculation zone induced by the Bolund escarpment. This wake grows with distance from the escarpment, with the wake height depending strongly on the wind direction, such that the minimum height appears when the flow is perpendicular to the escarpment.

Although the presented full-scale experiments around the Bolund escarpment has been performed with great success, experiments in controlled environments such as wind tunnels provide the opportunity to study problems systematically in greater detail. Such a controlled experiment was realized at the WindEEE Dome, a windtunnel facility of the Western University, London, Ontario, Canada and presents the second approach of this thesis. This large-scale wind laboratory investigation of the flow field over a large-scale model of the Bolund peninsula shows that the mean wind, wind shear and turbulence level are extremely sensitive to the exact details of the terrain. A modification of the escarpment of the Bolund model to give a sharper edge has dramatic consequences for a wind turbine positioned close to the edge. Additionally the windtunnel investigations show only a modest Reynolds number dependence of the flow, while it is more sensitive to the details of the inflow wind profile.
Gaussian vs non-Gaussian turbulence: impact on wind turbine loads

From large-eddy simulations of atmospheric turbulence, a representation of Gaussian turbulence is constructed by randomizing the phases of the individual modes of variability. Time series of Gaussian turbulence are constructed and compared with its non-Gaussian counterpart. Time series from the two types of turbulence are then used as input to wind turbine load simulations under normal operations with the HAWC2 software package. A slight increase in the extreme loads of the tower base fore-aft moment is observed for high wind speeds when using non-Gaussian turbulence but is insignificant when taking into account the safety factor for extreme moments. Other extreme load moments as well as the fatigue loads are not affected because of the use of non-Gaussian turbulent inflow. It is suggested that the turbine thus acts like a low-pass filter that averages out the non-Gaussian behaviour, which is mainly associated with the fastest and smallest scales. Copyright © 2016 John Wiley & Sons, Ltd.
In this paper, wake interaction resulting from two stall regulated turbines aligned with the incoming wind is studied experimentally and numerically. The experimental work is based on a full-scale remote sensing campaign involving three nacelle mounted scanning lidars. A thorough analysis and interpretation of the measurements is performed to overcome either the lack of or the poor calibration of relevant turbine operational sensors, as well as other uncertainties inherent in resolving wakes from full-scale experiments. The numerical work is based on the in-house EllipSys3D computational fluid dynamics flow solver, using large eddy simulation and fully turbulent inflow. The rotors are modelled using the actuator disc technique. A mutual validation of the computational fluid dynamics model with the measurements is conducted for a selected dataset, where wake interaction occurs. This validation is based on a comparison between wake deficit, wake generated turbulence, turbine power production and thrust force. An excellent agreement between measurement and simulation is seen in both the fixed and the meandering frame of reference. Copyright © 2015 John Wiley & Sons, Ltd.
Lidar configurations for wind turbine control

Lidar sensors have proved to be very beneficial in the wind energy industry. They can be used for yaw correction, feed-forward pitch control and load verification. However, the current lidars are expensive. One way to reduce the price is to use lidars with few measurement points. Finding the best configuration of an inexpensive lidar in terms of number of measurement points, the measurement distance and the opening angle is the subject of this study. In order to solve the problem, a lidar model is developed and used to measure wind speed in a turbulence box. The effective wind speed measured by the lidar is compared against the effective wind speed on a wind turbine rotor both theoretically and through
simulations. The study provides some results to choose the best configuration of the lidar with few measurement points.

**General information**

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Organisations: Department of Wind Energy, Wind turbine loads & control, Meteorology & Remote Sensing
Authors: Mirzaei, M. (Intern), Mann, J. (Intern)
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  - Web of Science (2016): Indexed yes
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    - Web of Science (2015): Indexed yes
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  - Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
    - Web of Science (2014): Indexed yes
  - BFI (2013): BFI-level 1
  - Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
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    - Web of Science (2013): Indexed yes
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  - BFI (2011): BFI-level 1
  - Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
    - ISI indexed (2011): ISI indexed no
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  - Scopus rating (2010): SJR 0.288 SNIP 0.344
    - Web of Science (2010): Indexed yes
  - BFI (2009): BFI-level 1
  - Scopus rating (2009): SJR 0.253 SNIP 0.321
  - BFI (2008): BFI-level 1
  - Scopus rating (2008): SJR 0.265 SNIP 0.294
    - Web of Science (2008): Indexed yes
  - Scopus rating (2007): SJR 0.257 SNIP 0.39
    - Web of Science (2007): Indexed yes
  - Scopus rating (2006): SJR 0.267 SNIP 0.284
    - Web of Science (2006): Indexed yes
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  - DOIs:
    - 10.1088/1742-6596/753/3/032019

**Bibliographical note**
Long-Range WindScanner System

The technical aspects of a multi-Doppler LiDAR instrument, the long-range WindScanner system, are presented accompanied by an overview of the results from several field campaigns. The long-range WindScanner system consists of three spatially-separated, scanning coherent Doppler LiDARs and a remote master computer that coordinates them. The LiDARs were carefully engineered to perform user-defined and time-controlled scanning trajectories. Their wireless coordination via the master computer allows achieving and maintaining the LiDARs' synchronization within ten milliseconds. The long-range WindScanner system measures the wind field by emitting and directing three laser beams to intersect, and then scanning the beam intersection over a region of interest. The long-range WindScanner system was developed to tackle the need for high-quality observations of wind fields on scales of modern wind turbine and wind farms. It has been in operation since 2013.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Leosphere
Authors: Vasiljevic, N. (Intern), Lea, G. (Intern), Courtney, M. (Intern), Cariou, J. (Ekstern), Mann, J. (Intern), Mikkelsen, T. K. (Intern)
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Scopus rating (2015): SJR 1.339 SNIP 1.691 CiteScore 3.76
Web of Science (2015): Indexed yes
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 0.999 SNIP 1.645 CiteScore 2.36
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.498 SNIP 1.268 CiteScore 1.3
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.315 SNIP 0.531
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Source: FindIt
Source-ID: 2348554448
Publication: Research - peer-review › Journal article – Annual report year: 2017

Long-term research challenges in wind energy – a research agenda by the European Academy of Wind Energy

The European Academy of Wind Energy (eawe), representing universities and institutes with a significant wind energy programme in 14 countries, has discussed the long-term research challenges in wind energy. In contrast to research agendas addressing short- to medium-term research activities, this eawe document takes a longer-term perspective, addressing the scientific knowledge base that is required to develop wind energy beyond the applications of today and
tomorrow. In other words, this long-term research agenda is driven by problems and curiosity, addressing basic research and fundamental knowledge in 11 research areas, ranging from physics and design to environmental and societal aspects. Because of the very nature of this initiative, this document does not intend to be permanent or complete. It shows the vision of the experts of the eawe, but other views may be possible. We sincerely hope that it will spur an even more intensive discussion worldwide within the wind energy community.

**General information**

State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Fluid Mechanics, Wind Turbine Structures and Component Design, Integration & Planning, Department of Management Engineering, Energy Economics and Regulation, Delft University of Technology, National Renewable Energy Laboratory, Durham University, University of Stuttgart, Wageningen IMARES, Carl Von Ossietzky University Oldenburg, Politecnico di Milano, Carl von Ossietzky Universität Oldenburg, Knowledge Centre Wind turbine Materials and Constructions, Centre for Renewable Energy Sources, Aalborg University, Norwegian University of Science and Technology, Royal Belgian Institute of Natural Sciences
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Links:
http://www.wind-energ-sci.net/1/1/2016/

**Bibliographical note**

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**On the Space-Time Structure of Sheared Turbulence**

We develop a model that predicts all two-point correlations in high Reynolds number turbulent flow, in both space and time. This is accomplished by combining the design philosophies behind two existing models, the Mann spectral velocity tensor, in which isotropic turbulence is distorted according to rapid distortion theory, and Kristensen's longitudinal coherence model, in which eddies are simultaneously advected by larger eddies as well as decaying. The model is compared with data from both observations and large-eddy simulations and is found to predict spatial correlations comparable to the Mann spectral tensor and temporal coherence better than any known model. Within the developed framework, Lagrangian two-point correlations in space and time are also predicted, and the predictions are compared with measurements of isotropic turbulence. The required input to the models, which are formulated as spectral velocity tensors, can be estimated from measured spectra or be derived from the rate of dissipation of turbulent kinetic energy, the friction velocity and the mean shear of the flow. The developed models can, for example, be used in wind-turbine engineering, in applications such as lidar-assisted feed forward control and wind-turbine wake modelling.

**General information**

State: Published
Authors: de Mare, M. T. (Ekstern), Mann, J. (Intern)
Pages: 453–474
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Boundary-layer Meteorology
Satellite data used in the New European Wind Atlas

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
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Publication date: 2016

The fence experiment - a first evaluation of shelter models
We present a preliminary evaluation of shelter models of different degrees of complexity using full-scale lidar measurements of the shelter on a vertical plane behind and orthogonal to a fence. Model results accounting for the distribution of the relative wind direction within the observed direction interval are in better agreement with the observations than those that correspond to the simulation at the center of the direction interval, particularly in the far-wake region, for six vertical levels up to two fence heights. Generally, the CFD results are in better agreement with the observations than those from two engineering-like obstacle models but the latter two follow well the behavior of the observations in the far-wake region.

General information
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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling
Authors: Peña, A. (Intern), Bechmann, A. (Intern), Conti, D. (Intern), Angelou, N. (Intern), Mann, J. (Intern)
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Web of Science (2016): Indexed yes
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
We present a homogeneous spectral tensor model for wind velocity and temperature fluctuations, driven by mean vertical shear and mean temperature gradient. Results from the model, including one-dimensional velocity and temperature spectra and the associated co-spectra, are shown in this paper. The model also reproduces two-point statistics, such as coherence and phases, via cross-spectra between two points separated in space. Model results are compared with observations from the Horizontal Array Turbulence Study (HATS) field program (Horst et al. 2004). The spectral velocity tensor in the model is described via five parameters: the dissipation rate ($\varepsilon$), length scale of energy-containing eddies ($L$), a turbulence anisotropy parameter ($\Gamma$), gradient Richardson number ($Ri$) representing the atmospheric stability and the rate of destruction of temperature variance ($\eta_\theta$).
Variations of the Wake Height over the Bolund Escarpment Measured by a Scanning Lidar

The wake zone behind the escarpment of the Bolund peninsula in the Roskilde Fjord, Denmark, has been investigated with the help of a continuous-wave Doppler lidar. The instrument measures the line-of-sight wind speed 390 times per second in highly resolved 7-m tall profiles by rapidly changing the focus distance and beam direction. The profiles reveal the detailed and rapidly changing structure of the wake induced by the Bolund escarpment. The wake grows with distance from the escarpment, with the wake height depending strongly on the wind direction, such that the minimum height appears when the flow is perpendicular to the escarpment. The wake increases by 10–70 % when the wind direction deviates ±15◦ from perpendicular depending on the distance to the edge and to a lesser degree on the method by which the wake height is determined. This finding is supported by a comparison with in situ measurements acquired on the Bolund peninsula.
Wake dynamics in offshore wind farms

Wind turbines within offshore wind farms spend considerable time operating in the wake of neighboring wind turbines. An important contribution to the loads on a wake-affected wind turbine is the slow movement of the wake from the upstream wind turbine across the rotor of the wake-affected wind turbine. A new approach to this so called wake meandering is proposed. Beside the advantage of higher physical realism, the new approach also offers practical advantages compared to the current state-of-the-art method.

An input to the new meandering approach is the time evolution of the so called spectral velocity tensor. An improved such spectral tensor is therefore developed, which, for neutral atmospheric stratification, predicts spatial correlations comparably to the Mann spectral tensor and temporal coherence significantly better than previously existing models, including the Mann model, which is incapable of predicting any temporal correlations beyond those that follows from the application of Taylor’s frozen turbulence hypothesis. As part of the framework a spectral tensor for Lagrangian correlations in space and time is also developed and validated versus measurements of isotropic turbulence. Combined, the models reproduce the cross-over point between Eulerian and Lagrangian temporal covariances. The applications of the Lagrangian spectral tensor, e.g. in the fields of dispersion and mixing, deserve further investigation.

The values of the input parameters of the spectral tensor are shown to be uniquely determined by the friction velocity, the shear and the dissipation of turbulent kinetic energy, all of them physical properties of the flow. If local equilibrium between the turbulent kinetic energy produced by shear and the turbulent kinetic energy dissipated as heat is assumed, then, for neutral atmospheric stratification, the friction velocity and the mixing length determine the spectral tensor. The developed spectral tensor also depends on a dimensionless quantity, which would be beneficial to determine with higher accuracy. An experiment with this objective, studying the ratio between different components of the cross-spectra at known shear, is proposed. Future work could also include investigating if a Rapid Distortion formulation that also includes a term for buoyancy effects is needed in order to make accurate predictions for non-neutral atmospheric stratification.
Polarization Diversity Image-Reject Homodyne Receiver for Directional Radial Velocity Measurements in Light Detection and Ranging (LIDAR) Instruments

The present invention relates to an improved method and a LIDAR system comprising an emitter for emission of a coherent electromagnetic EM signal and a transmitting optical arrangement configured to transmit the electromagnetic signal towards a measurement area. By the method and system, detection of both the polarized and depolarized backscattered EM signal is obtained, whereby an improved signal-to-noise ratio is obtained.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology
Authors: Foroughi Abari, F. (Intern), Mikkelsen, T. K. (Intern), Mann, J. (Intern), Pedersen, A. T. (Intern), Peucheret, C. (Ekstern), Sjöholm, M. (Intern)
Publication date: 2 Apr 2015

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Authors: Mann, J. (Intern)
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Publisher: DTU Wind Energy
Main Research Area: Technical/natural sciences
Links:
https://www.youtube.com/watch?v=YLK5MVuwXzY
Publication: Communication › Sound/Visual production (digital) – Annual report year: 2015

An evaluation of the WindEye wind lidar
Prevision of the wind field by remote sensing wind lidars has the potential to improve the performance of wind turbines. The functionality of a WindEye lidar developed by Windar Photonics A/S (Denmark) for the wind energy market was tested in a two months long field experiment. The WindEye sensor measures the wind speed along two beams to determine the wind direction of the incoming wind field. The field experiment utilized two sonic anemometers located in the two centers of the measurement volumes of the WindEye as reference instruments. It was found that the WindEye measured the wind direction with a high accuracy during the whole campaign.

General information
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Organisations: Department of Wind Energy, Meteorology, Test and Measurements
Authors: Dellwik, E. (Intern), Sjöholm, M. (Intern), Mann, J. (Intern)
Number of pages: 13
An improved k-ε model applied to a wind turbine wake in atmospheric turbulence

An improved k-ε turbulence model is developed and applied to a single wind turbine wake in a neutral atmospheric boundary layer using a Reynolds averaged Navier–Stokes solver. The proposed model includes a flow-dependent Cμ that is sensitive to high velocity gradients, e.g., at the edge of a wind turbine wake. The modified k-ε model is compared with the original k-ε eddy viscosity model, Large-Eddy Simulations and field measurements using eight test cases. The comparison shows that the velocity wake deficits, predicted by the proposed model are much closer to the ones calculated by the Large-Eddy Simulation and those observed in the measurements, than predicted by the original k-ε model.

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General information

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Organisations: Department of Wind Energy, Aeroelastic Design, Meteorology, Energy Research Centre of the Netherlands
Authors: Laan, van der, P. M. (Intern), Sørensen, N. N. (Intern), Réthoré, P. (Intern), Mann, J. (Intern), Kelly, M. C. (Intern), Troldborg, N. (Intern), Schepers, J. G. (Ekstern), Machefaux, E. (Intern)
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Main Research Area: Technical/natural sciences
Application of lidars for assessment of wind conditions on a bridge site

Wind measurement techniques based on remote optical sensing, extensively applied in wind energy, have been exploited in civil engineering only in a limited number of studies. The present paper introduces a novel application of wind lidars in bridge engineering, and presents the findings from the pilot measurement campaign on the Lysefjord Bridge in the South-West Norway. A single long-range pulsed WindScanner lidar and two short-range continuous-wave WindScanner lidars were deployed, in addition to five sonic anemometers installed on the bridge itself, the latter for long-term wind characterization. The paper presents a promising comparison of the measurements obtained by the three different sets of instruments, and discusses their complementary value.

General information
State: Published
Organisations: Department of Wind Energy, Test and Measurements, Meteorology, University of Stavanger, Christian Michelsen Research, University of Bergen
Authors: Jakobsen, J. B. (Ekstern), Cheynet, E. (Ekstern), Snæbjörnsson, J. (Ekstern), Mikkelsen, T. K. (Intern), Sjöholm, M. (Intern), Angelou, N. (Intern), Hansen, P. (Intern), Mann, J. (Intern), Svardal, B. (Ekstern), Kumer, V. (Ekstern), Reuder, J. (Ekstern)
Number of pages: 10
Publication date: 2015

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Electronic versions:
Applications of Telecommunication Transceiver Architectures in All-Fiber Coherent Detection Lidars

Coherent detection lidars have evolved over time and gradually become the de facto instruments for high resolution measurement of atmospheric boundary layer winds. The earlier versions of these lidars were bulky, expensive, and suffered from vulnerability to environmental effects such as temperature and vibrations. However, with the advent of fiber-optic communications a new class of stable, cost-effective, and low-maintenance optical components became available to the lidar community. Coherent detection lidars share many similarities with the high-speed fiber-optic communications. As a result, the new fiber-optic technology was quickly adopted in these lidars. Although coherent detection lidars, especially all-fiber coherent detection lidars, have benefited from the technology available in coherent fiber-optic communications, a considerable gap (in both research and technology) seems to exist between the two. In this thesis, I have presented some of the advances in fiber-optic transceivers, originally developed for high-speed data transmission, and shown how they can be integrated in micropulse and continuous-wave all-fiber coherent detection lidars. The presented technologies not only enable the possibility for performance improvements in existing lidars but also pave the way for the application of coherent detection lidars in areas where their presence was neither plausible nor easy to realize. This thesis, composed of an introduction and four scientific paper and one manuscript, specifically presents the adoption of some of the contemporary fiber-optic communications transceiver architectures in coherent detection lidars. In paper I a new short-range all-fiber coherent Doppler lidar employing an image-reject homodyne receiver is described and demonstrated. In Paper II two different approaches to signal processing, necessary for the estimation of mean velocity from the spectra, are discussed and the associated advantages and disadvantages such as the signal to noise ratio and signal processing overhead are discussed. The performance of the system proposed paper I is put to test in a real measurement campaign the results of which are discussed in Paper III. In Paper IV a patent-pending long-range polarization-diversity coherent Doppler lidar is presented. The system benefits from an improved transmit power (thanks to the availability of two erbium-doped fiber amplifiers separated in polarization) while having the ability to detect the depolarized backscatter signals. The ability to detect the degree of depolarization enables the characterization of aerosol types associated with each measurement range. Eventually, it is shown in Paper V that by adopting the image-reject homodyne receiver in an all-fiber coherent detection lidar, the spectrum of the Rayleigh or the spontaneous Rayleigh-Brillouin scattering (depending on the operating conditions) can be resolved. The system benefits from an eye-safe 1.5μm laser and can provide simultaneous measurements of temperature, pressure, and wind. The focus of the paper in Paper V is the temperature measurement capability of the system, provided as the proof of concept through numerical simulations.

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A six-beam method to measure turbulence statistics using ground-based wind lidars

A so-called six-beam method is proposed to measure atmospheric turbulence using a ground-based wind lidar. This method requires measurement of the radial velocity variances at five equally spaced azimuth angles on the base of a scanning cone and one measurement at the centre of the scanning circle, i.e using a vertical beam at the same height. The scanning configuration is optimized to minimize the sum of the random errors in the measurement of the second-order moments of the components (u,v,w) of the wind field. We present this method as an alternative to the so-called velocity azimuth display (VAD) method that is routinely used in commercial wind lidars, and which usually results in significant averaging effects of measured turbulence. In the VAD method, the high frequency radial velocity measurements are used instead of their variances. The measurements are performed using a pulsed lidar (WindScanner), and the derived turbulence statistics (using both methods) such as the u and v variances are compared with those obtained from a reference cup anemometer and a wind vane at 89m height under different atmospheric stabilities. The measurements show that in comparison to the reference cup anemometer, depending on the atmospheric stability and the wind field component, the six-beam method measures between 85 and 101% of the reference turbulence, whereas the VAD method measures between 66 and 87% of the reference turbulence.
Assessment of wind conditions at a fjord inlet by complementary use of sonic anemometers and lidars

Wind velocity measurement devices based on the remote optical sensing, lidars, are extensively applied in wind energy research and wind farm operation. The present paper demonstrates the relevance and potential of lidar measurements for other wind-sensitive structures such as long-span bridges. In a pilot study in Lysefjord, Norway, a pulsed long-range lidar and two short-range WindScanners were installed at the bridge site, together with a long-term monitoring system based on sonic anemometers. The deployment of the two types of lidars is described in more details and the complementary value of the data from all three types of the instruments is illustrated. The emphasis is on the lidars’ potential to map the wind conditions along the whole span of a bridge in a complex terrain, as opposed to "point" measurements achievable by sonic anemometers. The challenging balance between the spatial and temporal resolution of the data is discussed.

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Experimental Vision Studies of Flow and Structural Effects on Wind Turbines

In the present thesis, two modern vision technologies are developed and used to study wind turbines:
1. Stereo vision to study vibrations and dynamics of the Vertical Axes Wind Turbine (VAWT) via operational modal analysis (OMA)
2. Background-oriented Schlieren (BOS) method to study the tip vortices that are shed from a Horizontal Axis Wind Turbine (HAWT) blades

The thesis starts with an introduction to the stereo vision and OMA and is followed by two practical implementations of the basics derived in the introduction. In the first experiment, we developed the image processing tools to extract the displacement time series from stereo images taken from a VAWT blade subjected to the random vibrations. For analysing the time series, we devised an averaged approach of the covariance-driven stochastic subspace identification (COV-SSI) method. The method enables us to involve short measurement sets in OMA. Therefore, the first four natural frequencies are identified and agreed fairly with classical modal analysis (EMA) and finite element simulation (FEM). The second experiment is conducted on a VAWT rotor in the wind tunnel in a more controlled and designed condition, and the displacement time series are obtained using a more elaborated image processing algorithm. In OMA part, we developed the data-driven stochastic subspace identification (DDSSI) and frequency domain
decomposition (FDD) codes for studying the dynamic behaviour of the turbine. The structural modes of the VAWT obtained with OMA are validated with the simulation and EMA, and then, the differences are explained with the aerodynamic effect and boundary conditions. The other frequencies obtained by OMA are interpreted via vortex shedding phenomena and guy wire effects. In the fifth chapter, the uncertainty of the displacements obtained in the two experiments mentioned above, is evaluated using the law of error propagation and several solutions are presented to decrease the uncertainty in the stereo vision experiments. In the last chapter of the thesis, the BOS method has been used to study the tip vortices behind a Nordtank horizontal axis wind turbine based on the density gradient in the vortex. The BOS method does not need complicated equipment such as special cameras or seeded flow, which makes it a convenient method to study large scale flows. However, the challenging part in the current case is the small refractive index change due to the small Mach number in the flow behind the HAWT. This issue has been addressed in the last chapter by designing a proper experimental setup according to the preliminary estimation of the tip vortex. The changes due to the vortex are modelled, and the tip vortex properties such as vortex size, density distribution and the maximum pressure drop in the vortex core are successfully estimated by comparison between the model and the experimental observations.

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How reliable is the Peak-over-threshold extreme wind assessment method?: On the Peak-Over-Threshold (POT) Extreme Wind estimation as applied at DTU Wind Energy - Recently implemented in WAsP Engineering

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Multiple Turbine Wakes
The central goal of the present research was to study single and multiple interacting wind turbine wakes using both full-scale lidar experiments and high fidelity CFD numerical approaches. Firstly, single wake dynamics have been studied experimentally using full-scale (nacelle based) pulsed lidar measurements conducted on a stall regulated 500 kW turbine
at the DTU Wind Energy, Risø campus test site. As part of the experimental analysis, basic Dynamic Wake Meandering modeling assumptions were validated. A wake center tracking algorithm was used to estimate the measured wake advection velocity and to obtain an estimate of the wake expansion in a fixed frame of reference. A comparison of selected datasets from the campaign showed good far wake agreements of mean wake expansion with Actuator Line CFD computations and simpler engineering models. An empirical relationship, relating maximum wake induction and wake advection velocity, is derived and linked to the characteristics of a spherical vortex structure. Additionally, a new empirical model for single wake expansion is proposed based on an initial wake expansion in the pressure driven flow regime and a spatial gradient computed from the large scale lateral velocities, and thus inspired by the basic assumption behind the Dynamic Wake Meandering model. Secondly, the impact of the atmospheric stability on wind turbine wake deficit is studied experimentally and numerically. The measurements collected from the previous pulsed lidar campaign was reused as part of the experimental analysis. An inflow wind sector of 30° is selected based on both a wind resource and a lidar data assessment. Wake measurements are averaged within a mean wind speed bin of 1 m/s and classified according to atmospheric stability using 3 different approaches: the Obukhov length, the Bulk-Richardson and the Froude number approach. Three test cases are subsequently defined covering various atmospheric conditions. Simulations based on the EllipSys3D ABL flow solver are carried out using Large Eddy Simulation and Actuator disc rotor modeling. The turbulence properties of the incoming wind are adapted to the thermal stratification using a newly developed spectral tensor, which includes buoyancy effects. Discrepancies are discussed as basis for future model development and improvement. Moreover, the impact of atmospheric stability and terrain on large/small scale wake flow characteristics was investigated. Later, wake interaction resulting from two stall regulated turbines aligned with the incoming wind were studied experimentally and numerically. The experimental work was based on a new dedicated full-scale measurement campaign involving 3 nacelle mounted Continuous Wave scanning lidars. A thorough analysis and interpretation of the measurements was performed to overcome either the lack or the poor calibration of relevant turbine operational sensors, as well as other uncertainties inherent to wake resolving from full-scale experiments. The numerical work was based on the in-house EllipSys3D CFD flow solver, using Large Eddy Simulation and fully turbulent inflow, where the rotors are modeled using the Actuator Disc technique. A mutual validation of the CFD model with the measurements is proposed for a selected dataset where wake interactions occur. An excellent agreement between measurement and simulation is seen in both the fixed and the meandering frame of reference. A benchmark of several wake accumulation models is performed as a basis for the subsequent development of an engineering model for wake interaction. Finally, the validated numerical CFD model is used as part of a parametric study where wake interaction is studied in a generic way, under several turbine spacings, mean wind speeds and turbulence intensities and in the fixed and the moving frame of reference of the wake. The analysis revealed that the industry widely used quadratic summation of single wake deficits for modeling the resulting double wake deficit is only relevant at high turbine thrust coefficients. For high wind speed and low thrust coefficient, linear summation should be primarily used. The first iteration of a new engineering model capable of modeling the overlapped wake deficit is formulated and its performance is tested again double, triple and quadruple wake deficits. Good performance in the prediction of both the maximum merged wake deficit and wake width is observed.

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Performance evaluation of an all-fiber image-reject homodyne coherent Doppler wind lidar
The main purpose of this study is to evaluate the near-zero wind velocity measurement performance of two separate 1.5 µm all-fiber coherent Doppler lidars (CDLs). The performance characterization is carried out through the presentation of the results from two separate atmospheric field campaigns. In one campaign, a recently developed continuous wave (CW) CDL benefiting from an image-reject front-end was deployed. The other campaign utilized a different CW CDL, benefiting from a heterodyne receiver with intermediate-frequency (IF) sampling. In both field campaigns the results are compared against a sonic anemometer, as the reference instrument. The measurements clearly show that the image-reject architecture results in more accurate measurements of radial wind velocities close to zero. Close-to-zero velocities are
Performance evaluation of an all-fiber image-reject homodyne coherent Doppler wind lidar

The main purpose of this study is to evaluate the near-zero wind velocity measurement performance of two separate 1.5 μm all-fiber coherent Doppler lidars (CDL). The performance characterization is performed through the presentation of the results from two separate atmospheric field campaigns. In one campaign, a recently developed continuous wave (CW) CDL benefiting from an image-reject front-end was deployed. The other campaign utilized a different CW CDL, benefiting from a heterodyne receiver with intermediate frequency (IF) sampling. In both field campaigns the results are compared against a sonic anemometer as the reference instrument. The measurements clearly show that the image-reject architecture results in more accurate measurements of radial wind velocities close to zero. Close-to-zero velocities are usually associated with the vertical component of the wind and are important to characterize.
Remote Sensing for Wind Energy

The Remote Sensing in Wind Energy report provides a description of several topics and it is our hope that students and others interested will learn from it. The idea behind it began in year 2008 at DTU Wind Energy (formerly Risø) during the first PhD Summer School: Remote Sensing in Wind Energy. Thus it is closely linked to the PhD Summer Schools where state-of-the-art is presented during the lecture sessions. The advantage of the report is to supplement with in-depth, article style information. Thus we strive to provide link from the lectures, field demonstrations, and hands-on exercises to theory. The report will allow alumni to trace back details after the course and benefit from the collection of information. This is the fourth edition of the report and we warmly acknowledge all the contributing authors for their work in the writing of the chapters, and we also acknowledge all our colleagues in the Meteorology and Test and Measurements Sections from DTU Wind Energy in the PhD Summer Schools. We hope to continue adding more topics in future editions and to update and improve as necessary, to provide a truly state-of-the-art ‘guideline’ available for people involved in Remote Sensing in Wind Energy.

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Spectral tensor parameters for wind turbine load modeling from forested and agricultural landscapes

A velocity spectral tensor model was evaluated from the single-point measurements of wind speed. The model contains three parameters representing the dissipation rate of specific turbulent kinetic energy, a turbulence length scale and the turbulence anisotropy. Sonic anemometer measurements taken over a forested and an agricultural landscape were used to calculate the model parameters for neutral, slightly stable and slightly unstable atmospheric conditions for a selected wind speed interval. The dissipation rate above the forest was nine times that at the agricultural site. No significant differences were observed in the turbulence length scales between the forested and agricultural areas. Only a small difference was observed in the turbulence anisotropy at the two sites, except near the surface, where the forest turbulence was more isotropic. The turbulence anisotropy remained more or less constant with height at the forest site, whereas the turbulence became more isotropic with height for the agricultural site. Using the three parameters as inputs, we quantified...
the performance of the model in coherence predictions for vertical separations. The model coherence of all the three velocity components was overestimated for the analyzed stability classes at both sites. As expected from the model approximations, the model performed better at both sites for neutral stability than slightly stable and unstable conditions. The model prediction of coherence of the along-wind and vertical components was better than that of the cross-wind component. No significant difference was found between the performance of the model at the forested and the agricultural areas. © 2014 The Authors. Wind Energy published by John Wiley & Sons, Ltd.

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Authors: Chougule, A. S. (Intern), Mann, J. (Intern), Segalini, A. (Ekstern), Dellwik, E. (Intern)
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The k-ε-fP model applied to wind farms

The recently developed k-ε-fP eddy-viscosity model is applied to one on-shore and two off-shore wind farms. The results are compared with power measurements and results of the standard k-ε eddy-viscosity model. In addition, the wind direction uncertainty of the measurements is used to correct the model results with a Gaussian filter. The standard k-ε eddy-viscosity model underpredicts the power deficit of the first downstream wind turbines, whereas the k-ε-fP eddy-viscosity model shows a good agreement with the measurements. However, the difference in the power deficit predicted by the turbulence models becomes smaller for wind turbines that are located further downstream. Moreover, the difference between the capability of the turbulence models to estimate the wind farm efficiency reduces with increasing wind farm size and wind turbine spacing. Copyright © 2014 John Wiley & Sons, Ltd.

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The k-ε-fP model applied to double wind turbine wakes using different actuator disk force methods

The newly developed k-ε-fP eddy viscosity model is applied to double wind turbine wake configurations in a neutral atmospheric boundary layer, using a Reynolds-Averaged Navier–Stokes solver. The wind turbines are represented by actuator disks. A proposed variable actuator disk force method is employed to estimate the power production of the interacting wind turbines, and the results are compared with two existing methods: a method based on tabulated airfoil data and a method based on the axial induction from 1D momentum theory. The proposed method calculates the correct power, while the other two methods overpredict it. The results of the k-ε-fP eddy viscosity model are also compared with the original k-ε eddy viscosity model and large-eddy simulations. Compared to the large-eddy simulations-predicted velocity and power deficits, the k-ε-fP is superior to the original k-ε model. Copyright © 2014 John Wiley & Sons, Ltd.

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Uncertainties of the 50-year wind from short time series using generalized extreme value distribution and generalized Pareto distribution

This study examines the various sources to the uncertainties in the application of two widely used extreme value distribution functions, the generalized extreme value distribution (GEVD) and the generalized Pareto distribution (GPD). The study is done through the analysis of measurements from several Danish sites, where the extreme winds are caused by the Atlantic lows. The simple extreme wind mechanism here helps us to focus on the issues mostly related to the use of limited wind measurements. Warnings are flagged and possible solutions are discussed. Thus, this paper can be used as a guideline for applying GEVD and GPD to wind time series of limited length. The data analysis shows that, with reasonable choice of relevant parameters, GEVD and GPD give consistent estimates of the return winds. For GEVD, the base period should be chosen in accordance with the occurrence of the extreme wind events of the same mechanism. For GPD, the choices of the threshold, the definition of independent samples and the shape factor are interrelated. It is demonstrated that the lack of climatological representativity is a major source of uncertainty to the use of both GEVD and GPD; the information of climatological variability is suggested to be extracted from global or mesoscale models. © 2013 The Authors. Wind Energy published by John Wiley & Sons, Ltd.
Variations of the wake height over the Bolund escarpment

The here presented results are part of a paper that is submitted and accepted with minor revisions by the Boundary-Layer Meteorology journal. The wake zone behind the escarpment of the Bolund peninsula in the Roskilde Fjord, Denmark, has been investigated with the help of a continuouswave Doppler lidar. The instrument measures the line-of-sight wind speed 390 times per second in highly resolved 7-m tall profiles by rapidly changing the focus distance and beam direction. The profiles reveal the detailed and rapidly changing structure of the wake induced by the Bolund escarpment. The wake grows with distance from the escarpment, with the wake height depending strongly on the wind direction, such that the minimum height appears when the flow is perpendicular to the escarpment. The wake increases by 10% to 70% when the wind direction deviates ± 15 from perpendicular depending on the distance to the edge and to a lesser degree on the method by which the wake height is determined.

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An all-fiber image-reject homodyne coherent Doppler wind lidar
In this paper, we present an alternative approach to the down-conversion (translation) of the received optical signals collected by the antenna of an all-fiber coherent Doppler lidar (CDL). The proposed method, widely known as image-reject, quadrature detection, or in-phase/quadrature-phase detection, utilizes the advances in fiber optic communications such that the received signal can be optically down-converted into baseband where not only the radial velocity but also the direction of the movement can be inferred. In addition, we show that by performing a cross-spectral analysis, enabled by the presence of two independent signal observations with uncorrelated noise, various noise sources can be suppressed and a more simplified velocity estimation algorithm can be employed in the spectral domain. Other benefits of this architecture include, but are not limited to, a more reliable measurement of radial velocities close to zero and an improved bandwidth. The claims are verified through laboratory implementation of a continuous wave CDL, where measurements both on a hard and diffuse target have been performed and analyzed. © 2014 Optical Society of America
A six-beam method to measure turbulence statistics using ground-based wind lidars

A so-called six-beam method is proposed to measure atmospheric turbulence using a ground-based wind lidar. This method requires measurement of the radial velocity variances at five equally spaced azimuth angles on the base of a scanning cone and one measurement at the center of the scanning circle, i.e. using a vertical beam at the same height. The scanning configuration is optimized to minimize the sum of the random errors in the measurement of the second-order moments of the components (u,v,w) of the wind field. We present this method as an alternative to the so-called velocity azimuth display (VAD) method that is routinely used in commercial wind lidars, and which usually results in significant averaging effects of measured turbulence. In the VAD method, the high frequency radial velocity measurements are used instead of their variances. The measurements are performed using a pulsed lidar (WindScanner), and the derived turbulence statistics (using both methods) such as the u and v variances are compared with those obtained from a reference cup anemometer and a wind vane at 89m height under different atmospheric stabilities. The measurements show that in comparison to the reference cup anemometer, depending on the atmospheric stability and the wind field component, the six-beam method measures between 85–101% of the reference turbulence, whereas the VAD method measures between 66–87% of the reference turbulence.
A time-space synchronization of coherent Doppler scanning lidars for 3D measurements of wind fields

This thesis consists of the results of a Ph.D. study that was focused on the development of the system of three time-space synchronized pulsed coherent Doppler scanning lidars, which are coordinated by a remote ‘master computer’. This system has the unique capability to measure a complete three-dimensional flow field by emitting the laser beams from the three spatially separated lidars, directing them to intersect, and moving the beam intersection over an area of interest. Each individual lidar was engineered to be powered by two real servo motors, and one virtual stepper motor. The stepper motor initiates the laser pulse emission and acquisition of the backscattered light, while the two servo motors conduct the scanner head rotation that provides means to direct the laser pulses into the atmosphere. By controlling the rotation of the three motors from the motion controller the strict synchronization and time control of the emission, steering and acquisition were achieved, resulting that the complete lidar measurement process is controlled from the single hardware component. The system was formed using a novel approach, in which the master computer simultaneously coordinates the remote lidars through a UDP/IP and TCP/IP network by exchange of network packets. Since the size of the packets is roughly 1 kB, this approach allows an uninterrupted and fast coordination of the lidars, even in the case of mobile networks such as GSM. With this approach a maximum lag of 10 ms was observed in terms of the scanner heads’ rotation and the measurements among the lidars in the system. The laser beam pointing accuracy of each lidar was estimated to ±0.5° for the laser beam direction, and roughly ±5 m for the sensing distance. A set of procedures were proposed that can improve the pointing accuracy by a factor of 20. Subsequently, two experiments were carried out in which the developed multiple lidars system was used to synchronously measure wind velocity fields in multiple points in the atmosphere.
In each measurement set, one reference point is subjected to an impulse force, and acceleration responses are recorded at three different points. This process continues until the data set contains all the points with their degrees of freedom. Finally the frequency response function (FRF) is obtained for all points, and the natural frequencies and the mode shapes are estimated by peak picking method.

Operational Modal Analysis (OMA) is the second approach used in this project in parallel with stereo vision technique. In this method, only the output is required to be measured; actually the input is random and unknown. In this experiment markers are put on the blade centroid projection line (the same place as the accelerometer positions). The 3-D point deflections are monitored in time using stereo vision. Integration is not required for transforming acceleration to deflection in mode shapes identification because we will get deflection directly in this method. Two identical cameras take pictures of the blade and markers while it is excited by random and wind forces. The cameras are programmed in LabView to take pictures at the same time with 180 fps and store them on a high speed hard disk. The output deflection will be investigated in frequency domain by peak picking method, and then AR (Autoregressive) model is applied to describe the structure in time domain. Results of OMA and EMA show good agreement.
Efficient Turbulence Modeling for CFD Wake Simulations

Wind turbine wakes can cause 10-20% annual energy losses in wind farms, and wake turbulence can decrease the lifetime of wind turbine blades. One way of estimating these effects is the use of computational fluid dynamics (CFD) to simulate wind turbines wakes in the atmospheric boundary layer. Since this flow is in the high Reynolds number regime, it is mainly dictated by turbulence. As a result, the turbulence modeling in CFD dominates the wake characteristics, especially in Reynolds-averaged Navier-Stokes (RANS). The present work is dedicated to study and develop RANS-based turbulence models, that can accurately and efficiently simulate wind turbine wakes. The linear $k-\varepsilon$ eddy viscosity model (EVM) is a popular turbulence model in RANS; however, it underpredicts the velocity wake deficit and cannot predict the anisotropic Reynolds-stresses in the wake. In the current work, nonlinear eddy viscosity models (NLEVM) are applied to wind turbine wakes. NLEVMs can model anisotropic turbulence through a nonlinear stress-strain relation, and they can improve the velocity deficit by the use of a variable eddy viscosity coefficient, that delays the wake recovery. Unfortunately, all tested NLEVMs show numerically unstable behavior for fine grids, which inhibits a grid dependency study for numerical verification. Therefore, a simpler EVM is proposed, labeled as the $k-\varepsilon$ - $fp$ EVM, that has a linear stress-strain relation, but still has a variable eddy viscosity coefficient. The $k-\varepsilon$ - $fp$ EVM is numerically verified with a grid dependency study. With respect to the standard $k-\varepsilon$ EVM, the $k-\varepsilon$ - $fp$ EVM compares better with measurements of the velocity deficit, especially in the near wake, which translates to improved power deficits of the first wind turbines in a row.

When the CFD methodology is applied to a large wind farm, the simulated results cannot be compared directly with wind farm measurements that have a high uncertainty in the measured reference wind direction. When this uncertainty is used to post-process the CFD results, a fairer comparison with measurements is achieved.

Field test of an all-semiconductor laser-based coherent continuous-wave Doppler lidar for wind energy applications

The wind energy industry is gaining interest in prevision of the rotor inflow for turbine control. The potential benefits are increased power production due to better alignment of the rotor to the mean wind direction as well as prolonged lifetime of the turbine due to load reductions. Several lidar-based instruments for wind turbine mounting are now commercially available. However, they suffer from high price and bulkiness. Therefore, the Technical University of Denmark has, in collaboration with the Danish company Windar Photonics A/S, developed a compact and low-cost lidar called WindEye based on a mass-produced all-semiconductor laser. The instrument is a coherent continuous-wave lidar with two fixed-focus telescopes for launching laser beams in two different directions. The alternation between the telescopes is achieved by a novel switching technique without any moving parts. Here, we report results from comparison campaigns with ultrasonic anemometer (METEK USA-1, Germany) measurements at a distance of about 80 meters from the lidar instrument. The influence of the finite spatial sampling volume at this range on the measured wind spectra is demonstrated. The sampling volume in the latest version of the instrument has been narrowed due to an improved telescope design and the signal quality has improved. Good reliability is essential for the anticipated applications for wind turbines. Thus, the lidar has been tested over extended periods in various meteorological conditions and the influence on the lidar signal strength from external atmospheric parameters such as relative humidity and concentrations of atmospheric particles is discussed. This novel lidar instrument design seems to offer a promising low-cost alternative for prevision remote sensing of wind turbine inflow.
Flow distortion at a dense forest edge

The flow near tall forest edges is complex, yet poorly described. A field experiment using two meteorological masts equipped with sonic anemometers and a horizontally staring lidar was performed upwind and downwind of the interface between an open flat farmland and a tall (hc = 24 m) beech forest. Data obtained during near-neutral conditions are presented for the wind direction towards the forest. Results from a high leaf area index period are compared with those from a low leaf area index period. For both periods, the wind speed increased above the forest and decreased within the forest, relative to the measurements upwind of the edge. The lidar data taken at several positions between the masts at 1.25hc show that the minimum wind speed occurred just upwind of the edge. At the 1.25hc level, at the forest mast, the momentum flux \( \overline{\textbf{uw}} \) increased strongly over the forest and positive values were recorded during the high leaf area index period. A spectral analysis revealed that approximately half of this change was caused by low-frequency, positively correlated eddies along the streamline. The remaining increase can qualitatively be explained with the concept of eddy-blocking by the canopy top, which could also explain the observed increase in lateral variance and the decrease in the vertical variance. Despite the short distance to the edge of approximately 1.5hc, the beginning of a new internal boundary layer was visible at 1.04hc as a decrease in the vertical momentum flux. At this level, as well as within the forest, the results depended on the wind speed. The presented findings enhance the understanding of the forest edge flow and are useful for model verification and development.
Laser scanning of a recirculation zone on the Bolund escarpment

Rapid variations in the height of the recirculation zone are measured with a scanning wind lidar over a small escarpment on the Bolund Peninsula. The lidar is essentially a continuous-wave laser Doppler anemometer with the capability of rapidly changing the focus distance and the beam direction. The instrument measures the line-of-sight velocity 390 times per second and scans ten wind profiles from the ground up to seven meters per second. We observe a sharp interface between slow and fast moving fluid after the escarpment, and the interface is moving rapidly up and down. This implies that the position of the maximum velocity standard deviation is elevated a few meters above the surface. Close to the ground the mean wind is reversed relative to the general flow. The results are used to test computational fluid dynamics models for flow over terrain, and has relevance for wind energy. The preliminary comparison shows that the models are incapable of reproducing the reversed flow close to the surface, but more works needs to be done.
Preface

The 186 papers in this volume constitute the proceedings of the fifth Science of Making Torque from Wind conference, which is organized by the European Academy of Wind Energy (EAWE, www.eawe.eu). The conference, also called Torque 2014, is held at the Technical University of Denmark (DTU) 17–20 June 2014. The EAWE conference series started in 2004 in Delft, the Netherlands. In 2007 it was held in Copenhagen, in 2010 in Heraklion, Greece, and then in 2012 in Oldenburg, Germany.

General information
Sudden distortion of turbulence at a forest edge
Dellwik et al. (2013) presented data from a forest edge experiment based on two meteorological towers instrumented with sonic anemometers. The experiment was performed at a dense edge of the Tromnæs Forest, which is a 24 m tall mature beech stand on the island Falster, Denmark. The topography at the site is flat. The towers were placed approximately 1.5 canopy heights upwind and downwind of the edge, respectively, and were two canopy heights tall. For near-neutral, near-perpendicular flow towards the edge, one finding concerned that although the wind speed gradients were similar before and after the edge, the momentum flux was strongly reduced above the canopy. This is contrary to the results by standard Reynolds' averaged Navier-Stokes models that predict an overshoot of the momentum flux. Further, a reduction of the vertical variance of the flow was largely compensated by an increase in the lateral variance, whereas the streamwise variance remained approximately constant. This result is in contrast to the predictions by homogeneous rapid distortion theory. We apply and develop an alternative framework based on inhomogeneous rapid distortion theory, also called blocking, in combination with the turbulence model by Mann (1994), and investigate whether this model can predict the observed changes of the flow. The presented results are relevant for understanding the rapid changes of turbulence in the heterogeneous landscape.
The new European wind atlas
Today a number of well-established models and methodologies exist for estimating resources and design parameters, and in many cases they work well. This is true if good local data are available for calibrating the models or for verification. But the wind energy community is still hampered by many projects having large negative discrepancies between calculated and actual experienced resources and design conditions. However, when such significant discrepancies are found, no well established methods exist to correct the situation. Discrepancies can be introduced at any point in the modeling chain, from insufficient input data to deficient physics and resolution in any of the models, model linking issues, insufficient resolution or errors in surface topographical data such as terrain heights, land cover data etc. Therefore it has been decided on a European Union level to launch a project “The New European Wind Atlas” aiming at reducing overall uncertainties in determining wind conditions; standing on three legs: A data bank from a series of intensive measuring campaigns; a thorough examination and redesign of the model chain from global, mesoscale to microscale models and creation of the wind atlas database. Although the project participants will come from the 27 member states it is envisioned that the project will be opened for global participation through test benches for model development and sharing of data – climatologically as well as experimental. Experiences from national wind atlases will be utilized, such as the Indian, the South African, the Finnish, the German, the Canadian atlases and others.

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Theoretical and experimental signal-to-noise ratio assessment in new direction sensing continuous-wave Doppler lidar
A new direction sensing continuous-wave Doppler lidar based on an image-reject homodyne receiver has recently been demonstrated at DTU Wind Energy, Technical University of Denmark. In this contribution we analyse the signal-to-noise ratio resulting from two different data processing methods both leading to the direction sensing capability. It is found that using the auto spectrum of the complex signal to determine the wind speed leads to a signal-to-noise ratio equivalent to that of a standard self-heterodyne receiver. Using the imaginary part of the cross spectrum to estimate the Doppler shift has the benefit of a zero-mean background spectrum, but comes at the expense of a decrease in the signal-to-noise ratio by a factor of $\sqrt{2}$. 
Validation of the Mann spectral tensor for offshore wind conditions at different atmospheric stabilities

Simulated wind fields are very useful when predicting loads on structures subjected to turbulent winds, wind turbines being a prime example. Knowledge of statistical properties such as the spatial and temporal correlations of real turbulent wind fields increases the realism of the simulated simulated wind fields. The statistical properties of real turbulent wind fields have been shown to depend on quantities such as the surface roughness, the mean wind speed, measurement height and atmospheric stability. The Mann spectral tensor attempts to predict all spatial correlations of shear generated turbulence given only three input parameters. The most suitable such input values have been investigated for different onshore surface roughnesses, but so far not for typical offshore conditions. The meteorological mast at the Rødsand II offshore wind farm has among other instruments sonic anemometers mounted at 15, 40 and 57 meters above sea level. Wind speed spectra at the three heights are calculated and binned with respect to both wind speed and atmospheric stability. The three parameters of the Mann spectral tensor are determined to ensure best fit to the spectra of each of the bins and are presented as a function of mean wind speed, measurement height and atmospheric stability. The behaviour of the presented parameters values are largely consistent with the previous onshore results. The parameter values are also compared to potentially related quantities and a constant quantity is derived. Given optimal parameters the spectral tensor is found to reproduce the surface layer generated turbulence well, also for different atmospheric stabilities, however in the wind speed spectra a contribution from the very large scale quasi-geostrophic turbulence is also observed, a contribution the spectral tensor does not attempt to model.
Vertical cross-spectral phases in atmospheric flow

The cross-spectral phases between velocity components at two heights are analyzed from observations at the Høvsøre test site under diabatic conditions. These phases represent the degree to which turbulence sensed at one height leads (or lags) in time the turbulence sensed at the other height. The phase angle of the cross-wind component is observed to be significantly greater than the phase for the along-wind component, which in turn is greater than the phase for the vertical component. The cross-wind and along-wind phases increase with stream-wise wavenumber and vertical separation distance, but there is no significant change in the phase angle of vertical velocity. The phase angles for all atmospheric stabilities show similar order in phasing. The phase angles from the Høvsøre observations under neutral condition are compared with a rapid distortion theory model which show similar order in phase shift.

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Are local wind power resources well estimated?

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A review of turbulence measurements using ground-based wind lidars

A review of turbulence measurements using ground-based wind lidars is carried out. Works performed in the last 30 yr, i.e., from 1972–2012 are analyzed. More than 80% of the work has been carried out in the last 15 yr, i.e., from 1997–2012. New algorithms to process the raw lidar data were pioneered in the first 15 yr, i.e., from 1972–1997, when standard techniques could not be used to measure turbulence. Obtaining unfiltered turbulence statistics from the large probe volume of the lidars has been and still remains the most challenging aspect. Until now, most of the processing algorithms that have been developed have shown that by combining an isotropic turbulence model with raw lidar measurements, we can obtain unfiltered statistics. We believe that an anisotropic turbulence model will provide a more realistic measure of turbulence statistics. Future development in algorithms will depend on whether the unfiltered statistics can be obtained without the aid of any turbulence model. With the tremendous growth of the wind energy sector, we expect that lidars will be used for turbulence measurements much more than ever before.

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A single laser all fibre based optical sensor and switching system and method for measuring velocity in atmospheric airflow

A system for measuring a velocity of tracer particle motion in a fluid comprising at least one laser emitter configured to emit a continuous wave laser beam and a plurality of optical devices being configured to alternately receive a laser beam, focusing the laser beam onto a same probe volume comprising tracer particles, and receiving backscattered light from the tracer particles. The optical devices have a common optical input/output port for transmitting the received continuous-wave laser beam and for receiving the backscattered radiation. The optical devices are provided to have mutual pointing angles so that each of the plurality of optical devices points at the probe volume under a different angle. A processor is configured to receive a part of the transmitted laser beam and the received backscattered radiation beam to calculate a Doppler shift, and thereby determine a plurality of velocity components of the tracer particles using coherent detection.
Environmental impact of wind energy: Synthesis and Review

One purpose of wind turbines is to provide pollution-free electric power at a reasonable price in an environmentally sound way. In this focus issue the latest research on the environmental impact of wind farms is presented. Offshore wind farms affect the marine fauna in both positive and negative ways. For example, some farms are safe havens for porpoises while other farms show fewer harbor porpoises even after ten years. Atmospheric computer experiments are carried out to investigate the possible impact and resource of future massive installations of wind turbines. The following questions are treated. What is the global capacity for energy production by the wind? Will the added turbulence and reduced wind speeds generated by massive wind farms cool or heat the surface? Can wind farms affect precipitation? It is also shown through life-cycle analysis how wind energy can reduce the atmospheric emission of eight air pollutants. Finally, noise generation and its impact on humans are studied.
Influence of atmospheric stability on wind turbine loads

Simulations of wind turbine loads for the NREL 5 MW reference wind turbine under diabatic conditions are performed. The diabatic conditions are incorporated in the input wind field in the form of wind profile and turbulence. The simulations are carried out for mean wind speeds between 3 and 16 m s\(^{-1}\) at the turbine hub height. The loads are quantified as the cumulative sum of the damage equivalent load for different wind speeds that are weighted according to the wind speed and stability distribution. Four sites with a different wind speed and stability distribution are used for comparison. The turbulence and wind profile from only one site is used in the load calculations, which are then weighted according to wind speed and stability distributions at different sites. It is observed that atmospheric stability influences the tower and rotor loads. The difference in the calculated tower loads using diabatic wind conditions and those obtained assuming neutral conditions only is up to 17%, whereas the difference for the rotor loads is up to 13%. The blade loads are hardly influenced by atmospheric stability, where the difference between the calculated loads using diabatic and neutral input wind conditions is up to 3% only. The wind profiles and turbulence under diabatic conditions have contrasting influences on the loads; for example, under stable conditions, loads induced by the wind profile are larger because of increased wind shear, whereas those induced by turbulence are lower because of less turbulent energy. The tower base loads are mainly influenced by diabatic turbulence, whereas the rotor loads are influenced by diabatic wind profiles. The blade loads are influenced by both, diabatic wind profile and turbulence, that leads to nullifying the contrasting influences on the loads. The importance of using a detailed boundary-layer wind profile model is also demonstrated. The difference in the calculated blade and rotor loads is up to 6% and 8%, respectively, when only the surface-layer wind profile model is used in comparison with those obtained using a boundary-layer wind profile model. Finally, a comparison of the calculated loads obtained using site-specific and International Electrotechnical Commission (IEC) wind conditions is carried out. It is observed that the IEC loads are up to 96% larger than those obtained using site-specific wind conditions. Copyright © 2012 John Wiley & Sons, Ltd.
Influence of atmospheric stability on the spatial structure of turbulence

This thesis consists of three chapters. In the first chapter, the cross-spectral phases between velocity components at two heights are analyzed from observations at the Høvsøre test site under diabatic conditions. These phases represent the degree to which turbulence sensed at one height leads (or lags) in time the turbulence sensed at the other height. The phase angle of the cross-wind component is observed to be significantly greater than the phase for the along-wind component, which in turn is greater than the phase for the vertical component. The cross-wind and along-wind phases increase with stream-wise wavenumber and vertical separation distance, but there is no significant change in the phase angle of vertical velocity. The phase angles for all atmospheric stabilities show similar order in phasing. The phase angles
from the Høvsøre observations under neutral conditions are compared with a rapid distortion theory model, which shows
similar order in phase shift.
In the second chapter, a velocity spectral tensor model was evaluated using single point measurements of wind speed. The model contains three parameters, representing the dissipation rate of specific turbulent kinetic energy, a turbulence length scale and the turbulence anisotropy, respectively. Sonic anemometer measurements taken over a forested and an agricultural landscape were used to calculate the model parameters for neutral, slightly stable and slightly unstable atmospheric conditions over a selected wind speed interval. The dissipation rate above the forest was 9 times that at the agricultural site. No significant differences were observed in the turbulence length scales between the forested and agricultural areas. A small difference was observed in the turbulence anisotropy at the two sites, except near the surface, where the forest turbulence was more isotropic. The turbulence anisotropy remained more or less constant with height at the forest site, whereas the turbulence became more isotropic with height for the agricultural site. Using the three parameters as inputs, we quantified the performance of the model in coherence predictions for vertical separations. The model coherences of all the three velocity components were overestimated for the analyzed stability classes at both the sites. The model performed better at both sites for neutral stability than slightly stable and unstable conditions. The model predictions of coherence of the along-wind and vertical components were better than that of the cross-wind component.
No significant difference was found between the performance of the model at the forested and the agricultural areas. The last chapter summarizes the present state of the theory, in which an attempt is made to investigate the spectral tensor model of both wind velocity and temperature fluctuations, which treats the effects of mean uniform vertical shear and mean uniform temperature gradient. The model is based on rapid distortion theory, which gives the linearized Navier-Stokes equations in Fourier space. We incorporate the general concept of an eddy life time in order to make the model stationary. The parameterized eddy life time from Mann (1994) is used. In addition to the three parameters from the spectral tensor model of Mann (1994), the model contains two extra parameters as a result of introducing a mean uniform temperature gradient. These parameters are: a stability parameter in the form of the Richardson number, and a measure of the rate of destruction of temperature variance. The model seems to work better for stable than unstable conditions. The model is able to predict well the length scales (corresponding to the peaks of (co-) spectra) of the temperature spectrum and temperature-velocity co-spectra. In the inertial subrange, the model shows that the velocity-temperature co-spectra are proportional to the \(-7/3\) power of streamwise wavenumber, which is consistent with the measurements. The model is able to predict the temperature-coherence, moreso in the stable case than in the unstable case. We compare the model predictions against those of Mann (1994) in the coherence estimations, where the new model seems to give slightly improved results.

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Lidar-Observed Stress Vectors and Veer in the Atmospheric Boundary Layer
This study demonstrates that a pulsed wind lidar is a reliable instrument for measuring angles between horizontal vectors of significance in the atmospheric boundary layer. Three different angles are considered: the wind turning, the angle between the stress vector and the mean wind direction, and the angle between the stress vector and the vertical gradient of the mean velocity vector. The latter is assumed to be zero by the often applied turbulent-viscosity hypothesis, so that the stress vector can be described through the vertical gradient of velocity. In the atmospheric surface layer, where the Coriolis force is negligible, this is supposedly a good approximation. High-resolution large-eddy simulation data show that this is indeed the case even beyond the surface layer. In contrast, through analysis of WindCube lidar measurements supported by sonic measurements, the study shows that it is only valid very close to the surface. The deviation may be significant even at 100 m. This behavior is attributed to mesoscale effects. © 2013 American Meteorological Society.

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Model of the Correlation between Lidar Systems and Wind Turbines for Lidar-Assisted Control

Investigations of lidar-assisted control to optimize the energy yield and to reduce loads of wind turbines have increased significantly in recent years. For this kind of control, it is crucial to know the correlation between the rotor effective wind speed and the wind preview provided by a nacelle- or spinner-based lidar system. If on the one hand, the assumed correlation is overestimated, then the uncorrelated frequencies of the preview will cause unnecessary control action, inducing undesired loads. On the other hand, the benefits of the lidar-assisted controller will not be fully exhausted, if correlated frequencies are filtered out. To avoid these miscalculations, this work presents a method to model the correlation between lidar systems and wind turbines using Kaimal wind spectra. The derived model accounts for different measurement configurations and spatial averaging of the lidar system, different rotor sizes, and wind evolution. The method is compared to real measurement data with promising results. In addition, examples depict how this model can be used to design an optimal controller and how the configuration of a lidar system is optimized for a given turbine to improve the correlation.

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Nonlinear Eddy Viscosity Models applied to Wind Turbine Wakes
The linear $k-\varepsilon$ eddy viscosity model and modified versions of two existing nonlinear eddy viscosity models are applied to single wind turbine wake simulations using a Reynolds Averaged Navier-Stokes code. Results are compared with field wake measurements. The nonlinear models give better results compared to the linear model, however, high turbulence levels can produce numerical instabilities.

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Notes for DTU course 46100: Introduction to micro meteorology for wind energy

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Remote Sensing for Wind Energy

The Remote Sensing in Wind Energy report provides a description of several topics and it is our hope that students and others interested will learn from it. The idea behind it began in year 2008 at DTU Wind Energy (formerly Risø) during the first PhD Summer School: Remote Sensing in Wind Energy. Thus it is closely linked to the PhD Summer Schools where state-of-the-art is presented during the lecture sessions. The advantage of the report is to supplement with in-depth, article style information. Thus we strive to provide link from the lectures, field demonstrations, and hands-on exercises to theory. The report will allow alumni to trace back details after the course and benefit from the collection of information. This is the third edition of the report (first externally available), after very successful and demanded first two, and we warmly acknowledge all the contributing authors for their work in the writing of the chapters, and we also acknowledge all our colleagues in the Meteorology and Test and Measurements Sections from DTU Wind Energy in the PhD Summer Schools. We hope to continue adding more topics in future editions and to update and improve as necessary, to provide a truly state-of-the-art 'guideline' available for people involved in Remote Sensing in Wind Energy.

Retrieving wind statistics from average spectrum of continuous-wave lidar

The aim of this study is to experimentally demonstrate that the time-average Doppler spectrum of a continuous-wave (cw) lidar is proportional to the probability density function of the line-of-sight velocities. This would open the possibility of using cw lidars for the determination of the second-order atmospheric turbulence statistics. An atmospheric field campaign and a wind tunnel experiment are carried out to show that the use of an average Doppler spectrum instead of a time series of velocities determined from individual Doppler spectra significantly reduces the differences with the standard deviation measured using ordinary anemometers, such as ultra-sonic anemometers or hotwires. The proposed method essentially removes the spatial averaging effect intrinsic to the cw lidar systems.
The impact of atmospheric stability on wake losses

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The long-range WindScanner system – how to synchronously intersect multiple laser beams

General information
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Alignment of stress, mean wind, and vertical gradient of the velocity vector
In many applications in the atmospheric surface layer the turbulent-viscosity hypothesis is applied, i.e. the stress vector can be described through the vertical gradient of velocity. In the atmospheric surface layer, where the Coriolis force and baroclinic effects are considered negligible, this is supposedly a good approximation. High resolution large-eddy simulation (LES) data show that it is indeed the case. Through analysis of WindCube lidar measurements accompanied by sonic measurements we show that this is, on the other hand, rarely the case in the real atmosphere. This might indicate that large scale mechanisms play an important role in the misalignment observed in the atmosphere. Baroclinicity is one candidate of such, instationarity another. In this contribution we will present ongoing work: data from both a WindCube lidar, sonic anemometers and LES and discuss the results in the context of atmospheric boundary layer modeling. The measurements are from the Danish wind turbine test sites at Høvsøre. With the WindCube lidar we are able to reach heights of 250 meters and hence capture the entire atmospheric surface layer both in terms of wind speed and the direction of the mean stress vector.

Atmospheric stability and its influence on wind turbine loads
Simulations of wind turbine loads for the NREL 5 MW reference wind turbine under diabatic wind conditions are performed for mean wind speeds between 3 \( \leq \) 16 m/s at the turbine hub height. The loads are quantified as the cumulative sum of the damage equivalent load for different wind speeds that are weighted according to the wind speed and stability distribution. It is observed that atmospheric stability influences the tower and rotor loads. The difference in the calculated tower loads using diabatic wind conditions and those obtaining assuming neutral conditions only is approximately 16\%, whereas the difference for the rotor loads is up to 11\%. The blade loads are hardly influenced by atmospheric stability, where the difference between the calculated loads using diabatic and neutral input wind conditions is less than 1\%. The wind profiles and turbulence under diabatic conditions have contrasting influences on the loads, e.g. under stable conditions, loads induced by the wind profile are larger due to increased wind shear, whereas those induced by turbulence are lower due to less turbulent energy. The tower base loads are mainly influenced by diabatic turbulence, whereas the rotor loads are influenced by diabatic wind proles. The blade loads are influenced by both, diabatic wind profile and turbulence, that leads to nullifying the contrasting influences on the loads. The importance of using a detailed boundary-layer wind profile model is also demonstrated. The difference in the calculated blade and rotor loads is up to 6\% and 8\% respectively, when only the surface-layer wind profile model is used in comparison to those obtained using a boundary-layer wind profile model. Finally, a comparison of the calculated loads obtained using site-specific and IEC wind conditions is carried out. It is observed that the IEC loads are up to 75\% larger than those obtained using site-specific wind conditions.
Challenges in noise removal from Doppler spectra acquired by a continuous-wave lidar
This paper is focused on the required post processing of Doppler spectra, acquired from a continuous-wave coherent lidar at high sampling rates (400 Hz) and under rapid scanning of the laser beam. In particular, the necessary steps followed for extracting the wind speed from such Doppler spectra are presented. A method for determining the background noise spectrum without interrupting the transmission of the laser beam is described. Moreover, the dependency between the determination of the threshold of a Doppler spectrum with low signal-to-noise ratios and the characteristics of the wind flow are investigated and a systematic approach for removing the noise is outlined. The suggested post processing procedures are applied to two sample time series acquired by a short-range WindScanner during one second each.

Direct measurement of the spectral transfer function of a laser based anemometer
The effect of a continuous-wave (cw) laser based anemometer's probe volume on the measurement of wind turbulence is studied in this paper. Wind speed time series acquired by both a remote sensing cw laser anemometer, whose line-of-sight was aligned with the wind direction, and by a reference sensor (sonic anemometer) located in the same direction, were used. The spectral transfer function, which describes the attenuation of the power spectral density of the wind speed turbulence, was calculated and found to be in good agreement with the theoretical exponential function, which is based on the properties of the probe volume of a focused Gaussian laser beam. Parameters such as fluctuations of the wind direction, as well as the overestimation of the laser Doppler spectrum threshold, were found to affect the calculation of the spectral transfer function by introducing high frequency noise.

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Experimental and Numerical study of Wake to Wake Interaction in Wind Farms

In this paper, wake interaction between two wind turbines is analyzed using experimental and numerical approaches. Full-scale wake measurements are conducted at Tjæreborg wind farm and are obtained using a continuous wave lidar mounted on the back of the nacelle of a 2MW NM80 turbine. Numerical analyses are conducted for two double wake cases characterized by different turbine spacing, using the in-house EllipSys3D flow solver. Large Eddy Simulation and Actuator Line technique are used for modeling the rotor and the flow field. 10-minute average streamwise velocity and turbulence level are compared, and good agreement is seen between the measurements and the computations despite of a lateral offset and other discrepancies due to uncertainties on the measured inflow conditions and lidar mounting alignment.
First measurements by the DTU wind energy short range windscanner

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Laser scanning of a recirculation zone on the Bolund escarpment

Rapid variations in the height of the recirculation zone are measured with a scanning wind lidar over a small escarpment on the Bolund Peninsula. The lidar is essentially a continuous-wave laser Doppler anemometer with the capability of rapidly changing the focus distance and the beam direction. The instrument measures the line-of-sight velocity 390 times per second and scans ten wind profiles from the ground up to seven meters per second. The results will be used to test computational fluid dynamics models for flow over terrain, and has relevance for wind energy. The development of multiple lidar scanning systems is done primarily for that purpose.

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Lidar Turbulence Measurements for Wind Energy

Modeling of the systematic errors in the second-order moments of wind speeds measured by continuous-wave (ZephIR) and pulsed (WindCube) lidars is presented. These lidars use the velocity azimuth display technique to measure the velocity vector. The model is developed for the line-of-sight averaging and the full extent of conical scanning. The predictions are compared with the measurements from the ZephIR, WindCube and sonic anemometers at a flat terrain test site, under different atmospheric stability conditions. It is observed that the systematic errors are up to 90% for the vertical velocity variance, whereas they are up to 70% for the horizontal velocity variances. The systematic errors also vary with atmospheric stability, being lowest for the very unstable conditions. It is concluded that with the current measurement configuration, these lidars cannot be used to measure turbulence precisely.

Measurement of turbulence spectra using scanning pulsed wind lidars

Turbulent velocity spectra, as measured by a scanning pulsed wind lidar (WindCube), are analyzed. The relationship between ordinary velocity spectra and lidar derived spectra is mathematically very complex, and deployment of the three-dimensional spectral velocity tensor is necessary. The resulting scanning lidar spectra depend on beam angles, line-of-sight averaging, sampling rate, and the full three-dimensional structure of the turbulence being measured, in a convoluted way. The model captures the attenuation and redistribution of the spectral energy at high and low wave numbers very well. The model and measured spectra are in good agreement at two analyzed heights for the u and w components of the velocity field. An interference phenomenon is observed, both in the model and the measurements, when the diameter of the scanning circle divided by the mean wind speed is a multiple of the time between the beam measurements. For the v spectrum, the model and the measurements agree well at both heights, except at very low wave numbers, k1 <0.005 m⁻¹. In this region, where the spectral tensor model has not been verified, the model overestimates the spectral energy measured by the lidar. The theoretical understanding of the shape of turbulent velocity spectra measured by scanning pulsed wind lidar is given a firm foundation.
Wind power meteorology
Model of the Correlation between Lidar Systems and Wind Turbines for Lidar Assisted Control

Investigations for lidar assisted control to optimize the energy yield and to reduce loads of wind turbines increased significantly in recent years. For this kind of control it is crucial to know the correlation between the rotor effective wind speed and the wind preview provided by a nacelle or spinner based lidar system. If on the one side the assumed correlation is overestimated, the uncorrelated frequencies of the preview will cause unnecessary control action, inducing undesired loads. On the other side the benefits of the lidar assisted controller will not be fully exhausted, if correlated frequencies are filtered out. To avoid these uncertainties, this work presents a method to model the correlation between lidar systems and wind turbines using Kaimal wind spectra. The derived model accounts for different measurement configurations and for different turbine sizes. The method is evaluated in two steps: At first the model is compared to the results from a lidar simulator to prove that the model is able to reproduce the effect of volume measurement, limited measurement points and scanning time. In a second step the model is augmented by a model for the decay due to wind evolution and compared to real measurement data with promising results. In addition an example is given, how this model can be used to design an optimal controller for a lidar system with fixed parameters and a given turbine and how the pattern of a scanning lidar system is optimized for a given turbine to improve the correlation.

On the structure of acceleration in turbulence

Acceleration and spatial velocity gradients are obtained simultaneously in an isotropic turbulent flow via three dimensional particle tracking velocimetry. We observe two distinct populations of intense acceleration events: one in flow regions of strong strain and another in regions of strong vorticity. Geometrical alignments with respect to vorticity vector and to the strain eigenvectors, curvature of Lagrangian trajectories and of streamlines for total acceleration, and for its convective part, , are studied in detail. We discriminate the alignment features of total and convective acceleration statistics, which are genuine features of turbulent nature from those of kinematic nature. We find pronounced alignment of acceleration with vorticity. Similarly, and especially are predominantly aligned at 45°with the most stretching and compressing eigenvectors of the rate of the strain tensor, , and , respectively. Via autocorrelation functions of acceleration, conditioned on preferential directions, the vorticity vector field is found to play an important role as an ordering reference axis for acceleration orientation. Associating a velocity–acceleration structure function with an energy flux gives a clear indication that a strong energy flux occurs via compression in strain dominated events and via stretching in vorticity dominated events.
Recipes for correcting the impact of effective mesoscale resolution on the estimation of extreme winds

Extreme winds derived from simulations using mesoscale models are underestimated due to the effective spatial and temporal resolutions. This is reflected in the spectral domain as an energy deficit in the mesoscale range. The energy deficit implies smaller spectral moments and thus underestimation in the extreme winds. We have developed two approaches for correcting the smoothing effect resulting from the mesoscale model resolution on the extreme wind estimation by taking into account the difference between the modeled and measured spectra in the high frequency range. Both approaches give estimates of the smoothing effect in good agreement with measurements from several sites in Denmark and Germany.

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Turbulence measurements using six lidar beams

The use of wind lidars for measuring wind has increased significantly for wind energy purposes. The mean wind speed measurement using the velocity azimuth display (VAD) technique can now be carried out as reliably as the traditional instruments like the cup and sonic anemometers. Using the VAD technique the turbulence measurements are far from being reliable. Two mechanisms contribute to systematic errors in the measurement of turbulence. One is the averaging of small scales of turbulence due to the volume within which lidars measure wind speed. The other is the contamination by the cross components of the Reynolds stress tensor, which arises because, in a VAD scan the lidar beams are combined to obtain different components of the wind field. In this work we demonstrate theoretically, how the contamination by the cross components can be avoided by using the measured variances of the line-of-sight velocities of six lidar beams. Under certain assumptions the volume averaging can then be avoided using the ensemble averaged line-ofsight Doppler velocity spectra. In this way, we can then in principle measure the true turbulence using six lidar beams.

Vertical cross-spectral phases in neutral atmospheric flow

The cross-spectral phases between velocity components at two heights are analyzed from observations at the Hovsøre test site and from the field experiments under the Cooperative Atmosphere-Surface Exchange Study in 1999. These phases represent the degree to which turbulence sensed at one height leads (or lags) in time the turbulence sensed at the other height. The phase angle of the cross-wind component is observed to be significantly greater than the phase for the along-wind component, which in turn is greater than the phase for the vertical component. The cross-wind and along-wind phases increase with stream-wise wavenumber and vertical separation distance, but there is no significant change in the phase angle of vertical velocity, which remains close to zero. The phases are also calculated using a rapid distortion theory model and large-eddy simulation. The results from the models show similar order in phasing, but the slopes of the phase curves are slightly different from the observations, especially for low wavenumbers.
Advancements in Wind Energy Metrology – UPWIND 1A2.3
An overview of wind related metrology research made at Risø DTU over the period of the UPWIND project is given. A main part of the overview is devoted to development of the Lidar technology with several sub-chapters considering different topics of the research. Technical problems are not rare for this new technology, and testing against a traditional met mast have shown to be efficient for gaining confidence with the ground based Lidar technology and for trust in accuracy of measurements. In principle, Lidar measurements could be traceable through the fundamental measurement principles, but at this stage of development it is not found feasible. Instead, traceability is secured through comparison with met masts that are traceable through wind tunnel calibrations of cup anemometers. The ground based Lidar measurement principle works almost acceptable in flat terrain. In complex terrain and close to woods the measurement volume is disturbed because the flow is no longer horizontally homogeneous. These conditions require special attention and correction methods. Due to the large measurement volume, ground based Lidars perform a spatial averaging which has the effect of a low pass filter on turbulence measurements. Theory and measurements seem to be in good agreement. Lidar measurements from a rotating spinner have been performed. The analysis show good perspectives for scanning the incoming wind, which may lead to better controlled wind turbines. Lidars have also been used to scan the wake of wind turbines. These measurements document the meandering wake pattern. The second part of the overview considers power performance measurements. A new investigation on the influence of wind shear points to a revision of the definition of a power curve. A new measurement method has been developed which has a good chance of being implemented in the present revision of the IEC performance standard. Also, a turbulence normalization method has been tested but not found efficient enough for inclusion in the IEC standard. In relation to the coming IEC standard on performance verification with the use of nacelle anemometry, IEC61400- 12-2-CD, nacelle anemometry has been studied, both with experiments and in theory. An alternative to nacelle anemometry has been developed, the so-called spinner anemometer. This type of sensor measures yaw-error with high absolute accuracy, and avoids the draw-backs of nacelle anemometry because the spinner anemometer is positioned in front of the rotor. Advances in classic mast measurement technologies have also been made. A mast flow distortion correction method has been developed to improve classical state of the art mast measurements. Finally, an optical method for measurements of turbine vibrations is considered.

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A windscanner simulator

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Authors: Vasiljevic, N. (Intern), Courtney, M. (Intern), Wagner, R. (Intern), Mann, J. (Intern), Mikkelsen, T. (Intern)
Can wind lidars measure turbulence?

Modeling of the systematic errors in the second-order moments of wind speeds measured by continuous-wave (ZephIR) and pulsed (WindCube) lidars is presented. These lidars use the conical scanning technique to measure the velocity field. The model captures the effect of volume illumination and conical scanning. The predictions are compared with the measurements from the ZephIR, WindCube, and sonic anemometers at a flat terrain test site under different atmospheric stability conditions. The sonic measurements are used at several heights on a meteorological mast in combination with lidars that are placed on the ground. Results show that the systematic errors are up to 90% for the vertical velocity variance, whereas they are up to 70% for the horizontal velocity variance. For the ZephIR, the systematic errors increase with height, whereas for the WindCube, they decrease with height. The systematic errors also vary with atmospheric stability and are low for unstable conditions. In general, for both lidars, the model agrees well with the measurements at all heights and under different atmospheric stability conditions. For the ZephIR, the model results are improved when an additional low-pass filter for the 3-s scan is also modeled. It is concluded that with the current measurement configuration, these lidars cannot be used to measure turbulence precisely.
Conclusions of the Bolund Experiment and Blind Comparison

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How good are remote sensors at measuring extreme winds?

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Laser Doppler scanners for measuring flow over terrain

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**Light detection and ranging measurements of wake dynamics. Part II: two-dimensional scanning**

A nacelle-mounted lidar system pointing downstream has been used to measure wind turbine wake dynamics. The new measurement and data analysis techniques allow estimation of quasi-instantaneous wind fields in planes perpendicular to the rotor axis. A newly developed wake tracking procedure delivers the instantaneous transversal wake position which is quantitatively compared with the prediction of the Dynamic Wake Meandering model. The results, shown for two 10-min time series, suggest that the conjecture of the wake behaving as a passive tracer is a fair approximation; this corroborates and expands the results of one-dimensional measurements already presented in the first part of this paper. Consequently, it is now possible to separate the deterministic and turbulent parts of the wake wind field, thus enabling capturing the wake in the meandering frame of reference. The results correspond, qualitatively and to some extent quantitatively, to the expectations from CFD simulations which are compared in the paper. Copyright © 2010 John Wiley & Sons, Ltd.
The height and rotor diameter of modern wind turbines are so extensive, that the wind conditions they encounter often are well above the surface layer, where traditionally it is assumed that wind direction and turbulent fluxes are constant with respect to height, if the surface is homogenous. Deviations from the requirement of homogeneity are often the focus of micro-scale studies in forested areas. Yet, to explain the wind climate in the relevant height range for turbines, it is necessary to also account for the length scales that are important parameters for the meso-scale flow. These length scales are the height of the planetary boundary layer and the Monin-Obukhov length, which both are related to the energy balance of the surface. Examples of important micro- and meso-scale effects of forested terrain are shown using data and model results from recent and ongoing experiments. For micro-scale modeling, the issue of model resolution is discussed.
Recent Achievements with Ground-Based Remote Sensing for PBL Research

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Recipe for correcting the effect of mesoscale resolution on the estimation of extreme winds

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Rotating prism scanning device and method for scanning

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Surface energy balance measurements in wind energy experiments

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Publication: Research › Poster – Annual report year: 2011

The Bolund Experiment, Part I: Flow Over a Steep, Three-Dimensional Hill
We present an analysis of data from a measurement campaign performed at the Bolund peninsula in Denmark in the winter of 2007–2008. Bolund is a small isolated hill exhibiting a significantly steep escarpment in the main wind direction. The physical shape of Bolund represents, in a scaled-down form, a typical wind turbine site in complex terrain. Because of its small size the effect of atmospheric stratification can be neglected, which makes the Bolund experiment ideal for the validation of neutral flow models and hence model scenarios most relevant to wind energy. We have carefully investigated the upstream conditions. With a 7-km fetch over water, the incoming flow is characterized as flow over flat terrain with a local roughness height based on the surface momentum flux. The nearly perfect upstream conditions are important in forming a meaningful quantitative description of the flow over the Bolund hill. Depending on the wind direction, we find a maximum speed-up of 30% at the hill top accompanied by a maximum 300% enhancement of turbulence intensity. A closer inspection reveals transient behaviour with recirculation zones. From the wind energy context, this implies that the best site for erecting a turbine based on resource constraints unfortunately also imposes a penalty of high dynamic loads. On the lee side of Bolund, recirculation occurs with the turbulence intensity remaining significantly enhanced even at one hill length downstream. Its transient behaviour and many recirculation zones place Bolund in a category in which the linear flow theory is not applicable.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Aeroelastic Design
Authors: Berg, J. (Intern), Mann, J. (Intern), Bechmann, A. (Intern), Courtney, M. (Intern), Ejising Jørgensen, H. (Intern)
Pages: 219-243
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Boundary-Layer Meteorology
Volume: 141
Issue number: 2
ISSN (Print): 0006-8314
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
The Bolund Experiment. Part II: Blind Comparison of Microscale Flow Models

Bolund measurements were used for a blind comparison of microscale flow models. Fifty-seven models ranging from numerical to physical were used, including large-eddy simulation (LES) models, Reynolds-averaged Navier–Stokes (RANS) models, and linearized models, in addition to wind-tunnel and water-channel experiments. Many assumptions of linearized models were violated when simulating the flow around Bolund. As expected, these models showed large errors. Expectations were higher for LES models. However, of the submitted LES results, all had difficulties in applying the specified boundary conditions and all had large speed-up errors. In contrast, the physical models both managed to apply undisturbed 'free wind' boundary conditions and achieve good speed-up results. The most successful models were RANS with two-equation closures. These models gave the lowest errors with respect to speed-up and turbulent kinetic energy (TKE) prediction.
TOPFARM - next generation design tool for optimisation of wind farm topology and operation

The present report is the publishable final activity report for the EU project TOPFARM. The project has been running from 1st December 2007 to 30th November 2010, and has successfully addressed optimization of wind farm topology and control strategy based on aero-elastic modeling of loads as well as of power production as seen in an economical perspective. Crucial factors in this regard are the overall wind climate at the wind farm site, the position of the individual wind turbines, the wind turbine characteristics, the internal wind farm wind climate, the wind turbine control/operation strategy for wind turbines interacting through wakes, various cost models, the optimization strategy and a priori defined constraints imposed on the wind farm topology. In TOPFARM, the object function used in the optimization platform is formulated in economical terms, thus ensuring the optimal balance between capital costs, operation and maintenance costs, cost of fatigue lifetime consumption and power production output throughout the design lifetime of the wind farm. The report describes the project consortium and the project activities, which has been organized in 9 Work Packages. A summary description of the results is given, and reference is made to a large number of publications resulting from the project.

General information

State: Published
Number of pages: 95
Publication date: 2011

Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
Turbulence and wind turbines
The nature of turbulent flow towards, near and behind a wind turbine, the effect of turbulence on the electricity production and the mechanical loading of individual and clustered wind turbines, and some future issues are discussed.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Energy Research Centre of the Netherlands, Carl Von Ossietzky University Oldenburg
Authors: Brand, A. J. (Ekstern), Peinke, J. (Ekstern), Mann, J. (Intern)
Pages: 072005
Publication date: 2011
Conference: 13th European Turbulence Conference, Warsaw (PL), 12–15 Sep, 01/01/2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series
Volume: 318
Issue number: 7
ISSN (Print): 1742-6596
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.344
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.253 SNIP 0.321
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.265 SNIP 0.294
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.257 SNIP 0.39
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.267 SNIP 0.284
Web of Science (2006): Indexed yes
Original language: English
DOIs:
10.1088/1742-6596/318/7/072005
Source: orbit
Source-ID: 315956
Publication: Research - peer-review › Conference article – Annual report year: 2011

**Wind Conditions for Wind Farm Hanstholm**
The net annual energy production (AEP) of the Hanstholm Wind Farm is 158 GWh per year for the Siemens SWT-3.6-120 turbine and 140 GWh for the Vestas V112-3.0 turbine. These values have an uncertainty (standard deviation) of 6%. This result is mainly based on the data for Risø DTU’s test station at Høvsøre where wind speeds are measured at approximately the same height as the turbines at Hanstholm and where the terrain is similar. On top of that meso-scale modeling has been used to extrapolate the climatology from Høvsøre to Hanstholm increasing the AEP by almost 6% compared to just using the Høvsøre climatology directly. This method of extrapolation is rather new, but several older investigations indicate that the wind resource at Hanstholm is slightly higher than at Høvsøre. The work is carried out for Grontmij-Carl Bro according to a contract dated January 18th 2011.

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Department of Wind Energy, Meteorology
Authors: Pena Diaz, A. (Intern), Hahmann, A. N. (Intern), Mann, J. (Intern), Mortensen, N. G. (Intern)
Publication date: 2011

**Publication information**
Publisher: Risø National Laboratory for Sustainable Energy, Technical University of Denmark
Original language: English
Series: Risø-I
Number: 3144(EN)
Main Research Area: Technical/natural sciences

**Bibliographical note**
This is an internal report. For a copy please contact the authors of the report.
Publication: Research › Report – Annual report year: 2011

**Complex Terrain and Wind Lidars**
This thesis includes the results of a PhD study about complex terrain and wind lidars. The study mostly focuses on hilly and forested areas. Lidars have been used in combination with cups, sonics and vanes, to reach the desired vertical measurement heights. Several experiments are performed in complex terrain sites and the measurements are compared with two different flow models; a linearised flow model LINCOM and specialised forest model SCADIS. In respect to the lidar performance in complex terrain, the results showed that horizontal wind speed errors measured by a conically scanning lidar can be of the order of 3-4% in moderately-complex terrain and up to 10% in complex terrain. The findings were based on experiments involving collocated lidars and meteorological masts, together with flow calculations over the same terrains. The lidar performance was also simulated with the commercial software WAsP Engineering 2.0 and was well predicted except for some sectors where the terrain is particularly steep. Subsequently, two experiments were performed in forested areas; where the measurements are recorded at a location deep-in forest and at the forest edge. Both sites were modelled with flow models and the comparison of the measurement data with the flow model outputs showed that the mean wind speed calculated by LINCOM model was only reliable between 1 and 2 tree height (h) above canopy. The SCADIS model reported better correlation with the measurements in forest up to ~6h. At the forest edge, LINCOM model was used by allocating a slope half-in half out of the forest based on the suggestions of previous studies. The optimum slope angle was reported as 17°. Thus, a suggestion was made to use WAsP Engineering 2.0 for forest edge modelling with known limitations and the applied method. The SCADIS model worked better than the LINCOM model at the forest edge but the model reported closer results to the measurements at upwind than the downwind and this should be noted as a limitation of the model. As the general conclusion of the study, it was stated that the lidars can be used in complex terrain with the known limitations and the support of flow models.
**A first attempt to characterize the structure of wake turbulence using a combined experimental and numerical approach**

**Blind Comparison Simulation Cases**

**Host publication information**

Title of host publication: Presentations
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
ISBN (Print): 978-87-550-3841-7

Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1745(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Conference: The Bolund Experiment: Workshop, Risø (DK), 3-4 Dec., 01/01/2010
Wind energy, Aeroelastic design methods, Risø-R-1745, Risø-R-1745(EN)
Electronic versions:
CFD Modelling of nocturnal low-level jet effects on wind energy related variables

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Sogachev, A. (Intern), Mann, J. (Intern), Dellwik, E. (Intern), Ejsing Jørgensen, H. (Intern)
Publication date: 2010
Conference: European Geosciences Union General Assembly 2010, Vienna, Austria, 02/05/2010 - 02/05/2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Issue number: EGU2010-2083
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Ratings:
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ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Wind power meteorology, Wind Energy
Electronic versions:
Sogachev_cfd.pdf
Source: orbit
Source-ID: 270661
Publication: Research - peer-review › Conference article – Annual report year: 2010

Comparison between wind tunnel and field experiments on wind turbine wake meandering

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Aubrun, S. (Ekstern), Tchouaké, T. (Ekstern), Espana, G. (Ekstern), Larsen, G. C. (Intern), Mann, J. (Intern), Bingöl, F. (Intern)
Publication date: 2010
Event: Paper presented at iTi conference on turbulence, Bertinoro, .
Main Research Area: Technical/natural sciences
Aeroelastic design methods, Wind Energy
Source: orbit
Source-ID: 267211
Publication: Research › Paper – Annual report year: 2010

Doppler lidar mounted on a wind turbine nacelle – UPWIND deliverable D6.7.1
A ZephIR prototype wind lidar manufactured by QinetiQ was mounted on the nacelle of a Vestas V27 wind turbine and measurements of the incoming wind flow towards the rotor of the wind turbine were acquired for approximately 3 months (April - June 2009). The objective of this experiment was the investigation of the turbulence attenuation induced in the lidar measurements. In this report are presented results from data analysis over a 21-hour period (2009-05-05 12:00 – 2009-05-06 09:00). During this period the wind turbine was not operating and the line-of-sight of the lidar was aligned with the wind direction. The analysis included a correlation study between the ZephIR lidar and a METEK sonic anemometer. The correlation analysis was performed using both 10 minutes and 10 Hz wind speed values. The spectral transfer function which describes the turbulence attenuation, which is induced in the lidar measurements, was estimated by means of spectral analysis. An attempt to increase the resolution of the wind speed measurements of a cw lidar was performed, through the deconvolution of the lidar signal. A theoretical model of such a procedure is presented in this report. A
simulation has validated the capability of the algorithm to deconvolve and consequently increase the resolution of the lidar system. However the proposed method was not efficient when applied to real lidar wind speed measurements, probably due to the effect, that the wind direction fluctuations along the lidar’s line-of-sight have, on the lidar measurements.

**General information**

State: Published
Organisations: Test and Measurements, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Angelou, N. (Intern), Mann, J. (Intern), Courtney, M. (Intern), Sjöholm, M. (Intern)
Number of pages: 46
Publication date: 2010

**Publication information**

Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
ISBN (Print): 978-87-550-3868-4
Original language: English

Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1757(EN)
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Main Research Area: Technical/natural sciences
Remote measurement and measurement technique, Wind Energy, Risø-R-1757, Risø-R-1757(EN)
Electronic versions:
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Source: orbit
Source-ID: 271829
Publication: Research › Report – Annual report year: 2010

**Flow tilt angle measurements from the ground**

**General information**

State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements, Centre for Renewable Energy Sources
Authors: Mann, J. (Intern), Dellwik, E. (Intern), Bingöl, F. (Intern), Courtney, M. (Intern), Foussekis, D. (Ekstern)
Publication date: 2010

**Host publication information**

Title of host publication: Detailed Program
Publisher: ISARS
Main Research Area: Technical/natural sciences
Wind energy, Wind power meteorology
Electronic versions:
O_RET04_Mann.pdf
Links:
http://www.isars2010.uvsq.fr/
Source: orbit
Source-ID: 265521
Publication: Research › Article in proceedings – Annual report year: 2010

**Flow tilt angle measurements using lidar anemometry**

**General information**

State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Dellwik, E. (Intern), Mann, J. (Intern)
Publication date: 2010
Conference: European Geosciences Union General Assembly 2010, Vienna, Austria, 02/05/2010 - 02/05/2010
Main Research Area: Technical/natural sciences

**Publication information**
Flow tilt angles near forest edges - Part 1: Sonic anemometry

An analysis of flow tilt angles from a fetch-limited beech forest site with clearings is presented in the context of vertical advection of carbon dioxide. Flow angles and vertical velocities from two sonic anemometers by different manufacturers were analyzed. Instead of using rotations, where zero-flow angles were assumed for neutral flow, the data was interpreted in relation to upstream and downstream forest edges. Uncertainties caused by flow distortion, vertical misalignment and limited sampling time (statistical uncertainty) were evaluated and found to be highly significant. Since the attack angle distribution of the wind on the sonic anemometer is a function of atmospheric stratification, an instrumental error caused by imperfect flow distortion correction is also a function of the atmospheric stratification. In addition, it is discussed that the sonic anemometers have temperature dependent off-sets. These features of the investigated sonic anemometers make them unsuitable for measuring vertical velocities over highly turbulent forested terrain. By comparing the sonic anemometer results to that of a conically scanning Doppler lidar (Dellwik et al., 2010b), sonic anemometer accuracy for measuring mean flow tilt angles was estimated to between 2° and 3°. Use of planar fit algorithms, where the mean vertical velocity is calculated as the difference between the neutral and non-neutral flow, does not solve this problem of low accuracy and is not recommended. Because of the large uncertainties caused by flow distortion and vertical alignment, it was only possible to a limited extent to relate sonic anemometer flow tilt angles to upwind forest edges, but the results by the lidar indicated that an internal boundary layer affect flow tilt angles at 21m above the forest. This is in accordance with earlier studies at the site. Since the mean flow tilt angles do not follow the terrain, an estimate of the vertical advection term for near-neutral conditions was calculated using profile measurements of carbon dioxide. The estimated advection term is large, but it is not recommended to include it in the surface carbon balance, unless all terms in the carbon dioxide conservation equation can be precisely estimated.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Ecosystems, Biosystems Division
Authors: Dellwik, E. (Intern), Mann, J. (Intern), Larsen, K. S. (Intern)
Pages: 1745-1757
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Biogeosciences
Volume: 7
Issue number: 5
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.25 SJR 2.328 SNIP 1.305
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Flow tilt angles near forest edges - Part 2: Lidar anemometry

A novel way of estimating near-surface mean flow tilt angles from ground based Doppler lidar measurements is presented. The results are compared with traditional mast based in-situ sonic anemometry. The tilt angle assessed with the lidar is based on 10 or 30 min mean values of the velocity field from a conically scanning lidar. In this mode of measurement, the lidar beam is rotated in a circle by a prism with a fixed angle to the vertical at varying focus distances. By fitting a trigonometric function to the scans, the mean vertical velocity can be estimated. Lidar measurements from (1) a fetch-limited beech forest site taken at 48–175 m a.g.l. (above ground level), (2) a reference site in flat agricultural terrain and (3) a second reference site in complex terrain are presented. The method to derive flow tilt angles and mean vertical velocities from lidar has several advantages compared to sonic anemometry; there is no flow distortion caused by the instrument itself, there are no temperature effects and the instrument misalignment can be corrected for by assuming zero tilt angle at high altitudes. Contrary to mast-based instruments, the lidar measures the wind field with the exact same alignment error at a multitude of heights. Disadvantages with estimating vertical velocities from a lidar compared to mast-based measurements are potentially slightly increased levels of statistical errors due to limited sampling time, because the sampling is disjunct, and a requirement for homogeneous flow. The estimated mean vertical velocity is biased if the flow...
over the scanned circle is not homogeneous. It is demonstrated that the error on the mean vertical velocity due to flow inhomogeneity can be approximated by a function of the angle of the lidar beam to the vertical and the vertical gradient of the mean vertical velocity, whereas the error due to flow inhomogeneity on the horizontal mean wind speed is independent of the lidar beam angle. For the presented measurements over forest, it is evaluated that the systematic error due to the inhomogeneity of the flow is less than 0.2°. The results of the vertical conical scans were promising, and yielded positive flow angles for a sector where the forest is fetch-limited. However, more data and analysis are needed for a complete evaluation of the lidar technique.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Dellwik, E. (Intern), Mann, J. (Intern), Bingöl, F. (Intern)
Pages: 1759-1768
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Biogeosciences
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.25 SJR 2.328 SNIP 1.305
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.453 SNIP 1.324 CiteScore 4.04
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 2.194 SNIP 1.363 CiteScore 4.03
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 2.468 SNIP 1.425 CiteScore 4.21
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.366 SNIP 1.312 CiteScore 3.92
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.524 SNIP 1.178 CiteScore 3.86
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.36 SNIP 1.108
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.951 SNIP 1.197
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.848 SNIP 1.234
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.465 SNIP 1.113
Scopus rating (2006): SJR 0.997 SNIP 0.688
Web of Science (2006): Indexed yes
Full scale measurements of wind turbine wake turbulence

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Fluid Mechanics, Department of Mechanical Engineering, Meteorology, Test and Measurements
Authors: Larsen, G. C. (Intern), Hansen, K. S. (Intern), Mann, J. (Intern), Enevoldsen, K. (Intern), Bingöl, F. (Intern)
Pages: 391-405
Publication date: 2010

Host publication information
Title of host publication: Torque 2010 : The science of making torque from wind
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Conference: Torque 2010, Heraklion (GR), 28-30 June, 01/01/2010
Wind energy, Aeroelastic design methods
Source: orbit
Source-ID: 265091
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Length Scales of the Neutral Wind Profile over Homogeneous Terrain
The wind speed profile for the neutral boundary layer is derived for a number of mixing-length parameterizations, which account for the height of the boundary layer. The wind speed profiles show good agreement with the reanalysis of the Leipzig wind profile (950 m high) and with combined cup–sonic anemometer and lidar measurements (300 m high) performed over flat and homogeneous terrain at Høvsøre, Denmark. In the surface layer, the mixing-length parameterizations agree well with the traditional surface-layer theory, but the wind speed profile is underestimated when the surface-layer scaling is extended to the entire boundary layer, demonstrating the importance of the boundary layer height as a scaling parameter. The turbulence measurements, performed up to 160-m height only at the Høvsøre site, provide the opportunity to derive the spectral-length scales from two spectral models. Good agreement is found between the behaviors of the mixing- and spectral-length scales.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Pena Diaz, A. (Intern), Gryning, S. (Intern), Mann, J. (Intern), Hasager, C. B. (Intern)
Pages: 792-806
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Meteorology and Climatology
Volume: 49
Issue number: 4
ISSN (Print): 1558-8424
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Lidar measurements of wind turbine wake turbulence

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2010
Main Research Area: Technical/natural sciences
Wind energy, Wind power meteorology
Links:
Lidar Scanning of Momentum Flux in and above the Atmospheric Surface Layer

Methods to measure the vertical flux of horizontal momentum using both continuous wave and pulsed Doppler lidar profilers are evaluated. The lidar measurements are compared to momentum flux observations performed with sonic anemometers over flat terrain at Høvsøre, Denmark, and profile-derived vertical momentum flux observations at the Horns Rev wind farm in the North Sea. Generally, the momentum fluxes are reduced because of the finite measuring volume of the instruments, and the filtering is crudely accounted for theoretically. The essential parameter for the estimation of the reduction is the ratio of the turbulence scale to the size of the measuring volume. For the continuous wave lidar the reduction can largely be compensated by averaging Doppler spectra instead of radial velocities.
Light detection and ranging measurements of wake dynamics Part I: One-dimensional Scanning

The vast majority of wind turbines are today erected in wind farms. As a consequence, wake-generated loads are becoming more and more important. In this first of two parts, we present a new experimental technique to measure the instantaneous wake deficit directly, thus allowing for quantification of the wake meandering, as well as the instantaneous wake expansion expressed in a meandering frame of reference. The experiment was conducted primarily to test the simple hypothesis that the wake deficit is advected passively by the larger-than-rotor-size eddies in the atmospheric flow, and that the wake at the same time widens gradually, primarily because of mixing caused by small-scale atmospheric eddies. In this first paper, we focus on our new measurement technique, and test if the wake meandering follows the wind direction fluctuations, i.e. if it is advected passively in the lateral direction. The experimental results are used as a preliminary verification of a wake meandering model that essentially considers the wake as a passive tracer. Copyright © 2009 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Aeroelastic Design
Authors: Bingöl, F. (Intern), Mann, J. (Intern), Larsen, G. C. (Intern)
Pages: 51-61
Publication date: 2010
Main Research Area: Technical/natural sciences

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Issue number: 1
ISSN (Print): 1095-4244
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
On the length-scale of the wind profile

We present the results of an analysis of simultaneous sonic anemometer observations of wind speed and velocity spectra over flat and homogeneous terrain from 10 up to 160 m height performed at the National Test Station for Wind Turbines at Høvsøre, Denmark. The mixing length, l, derived from the wind speed profile, is found to be linearly proportional to the length-scale of turbulence, derived either from the peak of the vertical velocity spectrum, (λm)w, or from a three-dimensional turbulence spectral model, for a range of atmospheric stability conditions, friction Rossby numbers, and within the range of observational heights ((λm)w ∼ 7l). Under very unstable conditions and above 100 m, the local wind shear is low, and the relation between both length-scales is slightly nonlinear. Mixing-length and wind profile models, which depend on both atmospheric stability and friction Rossby number, generally show better agreement to the observations of the length-scale and wind speed profile than the models from surface-layer theory, which show good agreement with the observations for the first 80 m only. The results from this analysis demonstrate a close connection between these two types of length-scales. Copyright © 2010 Royal Meteorological Society

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Pena Diaz, A. (Intern), Gryning, S. (Intern), Mann, J. (Intern)
Pages: 2119-2131
Publication date: 2010
Main Research Area: Technical/natural sciences
Sammenfatning af EFP07 – Metoder til kortlægning af vindforhold i komplekst terræn

This report describes the work done in the project “EFP07 - Metoder til kortlægning af vindforhold i komplekst terræn” granted by the Danish Energy Agency. References to reports published during the project are given. The main purpose of the project has been to investigate micro-scale wind conditions in complex terrain using “remote-sensing” techniques and CFD computations and validate these using measurements. The work done in the project can be divided into three parts:

1. “The Bolund Experiment” is a measuring campaign performed on a small hill located near Risø DTU. The experiment provides data for validating CFD models.
2. “The blind comparison” is a comparison of more than 50 different micro-scale models and the Bolund measurements.
3. “The Benakanahalli Experiment” is a large-scale measuring campaign that provides a complex validation case for micro-scale models.

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements
Authors: Bechmann, A. (Intern), Berg, J. (Intern), Courtney, M. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern), Sørensen, N. N. (Intern)
Number of pages: 8
Publication date: 2010

Publication information
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
ISBN (Print): 978-87-550-3842-4
Original language: Danish

Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1746(DA)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Aeroelastic design methods, Wind Energy, Risø-R-1746, Risø-R-1746(DA)
Electronic versions:
ris-r-1746.pdf
Source: orbit
Source-ID: 266412
Publication: Research › Report – Annual report year: 2010

Spectral analysis of wind turbulence measured by a Doppler Lidar for velocity fine structure and coherence studies

General information
State: Published
Organisations: Test and Measurements, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, IT Service Department
Authors: Sjöholm, M. (Intern), Mikkelsen, T. (Intern), Kristensen, L. (Intern), Mann, J. (Intern), Kirkegaard, P. (Intern)
Publication date: 2010

Host publication information
Title of host publication: Detailed Program (online)
Publisher: ISARS
Main Research Area: Technical/natural sciences
Remote measurement and measurement technique, Wind Energy
Electronic versions:
Sjoholm_spectral analysis.pdf
Links:
http://www.isars2010.uvsq.fr/
Source: orbit
Source-ID: 269344
Publication: Research › Article in proceedings – Annual report year: 2010

Spectral Coherence Along a Lidar-Anemometer Beam
The theory of measuring the spectral coherence by means of a lidar anemometer has been outlined. It is based on the assumption that the turbulent velocity field can be considered statistically locally isotropic and on the validity of Taylor's hypothesis. This implies that the longitudinal coherence cannot be predicted realistically. Special emphasis has been placed on the effect of line average along the beam. One section has been devoted to the effect of spectral aliasing, which
may cause severe problems in the interpretation of measured data. This work is considered the theoretical background for the understanding of the coherences calculated on basis of real data.

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, IT Service Department, Meteorology, Wind Energy Division, Test and Measurements
Authors: Kristensen, L. (Intern), Kirkegaard, P. (Intern), Mann, J. (Intern), Mikkelsen, T. (Intern), Nielsen, M. (Intern), Sjöholm, M. (Intern)
Number of pages: 21
Publication date: 2010

**Publication information**
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
Original language: English

Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1744(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Wind power meteorology, Wind Energy, Risø-R-1744, Risø-R-1744(EN)
Electronic versions:
ris-r-1744.pdf
Source: orbit
Source-ID: 268379
Publication: Research › Report – Annual report year: 2010

**Systematic error in the estimation of the second order moments of wind speeds by lidars**

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements, Delft University of Technology
Authors: Sathe, A. (Ekstern), Mann, J. (Intern), Gottschall, J. (Intern), Courtney, M. (Intern)
Publication date: 2010

**Host publication information**
Title of host publication: Detailed Program (online)
Publisher: ISARS
Main Research Area: Technical/natural sciences
Remote measurement and measurement technique, Wind Energy
Electronic versions:
Systematic error_Mann.pdf
Links:
http://www.isars2010.uvsq.fr/
Source: orbit
Source-ID: 269342
Publication: Research › Article in proceedings – Annual report year: 2010

**Testing of Frozen Turbulence Hypothesis for Wind Turbine Applications with a Scanning LIDAR System**

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, University of Stuttgart, Politecnico di Milano
Authors: Schlipf, D. (Ekstern), Trabucchi, D. (Ekstern), Bischoff, O. (Ekstern), Hofssäss, M. (Ekstern), Mann, J. (Intern), Mikkelsen, T. (Intern), Rettenmeier, A. (Ekstern), Trujillo, J. (Ekstern), Kühn, M. (Ekstern)
Publication date: 2010

**Host publication information**
Title of host publication: Detailed Program
Testing of Frozen Turbulence Hypothesis for Wind Turbine Applications with a Staring Lidar

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, University of Stuttgart, Politecnico di Milano
Authors: Trujillo, J. J. (Ekstern), Trabucchi, D. (Ekstern), Bischoff, O. (Ekstern), Hofssäss, M. (Ekstern), Mann, J. (Intern), Mikkelsen, T. (Intern), Rettenmeier, A. (Ekstern), Schlipf, D. (Ekstern), Kühn, M. (Ekstern)
Publication date: 2010
Conference: European Geosciences Union General Assembly 2010, Vienna, Austria, 02/05/2010 - 02/05/2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Issue number: EGU2010-5410
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Wind power meteorology, Wind Energy
Electronic versions:
Testing of Frozen.pdf
Source: orbit
Source-ID: 270669
Publication: Research - peer-review › Conference article – Annual report year: 2010

The Bolund Experiment

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements
Authors: Bechmann, A. (Intern), Berg, J. (Intern), Courtney, M. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern), Sørensen, N. N. (Intern)
Number of pages: 162
Pages: 33-71
Publication date: 2010

Host publication information
Title of host publication: Presentations
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
Undersøgelse af vindforhold ved det kommende testcenter ved Østerild

A new test station for large wind turbines is planned for a currently forested area in Thy, Denmark. This report documents the numerical modeling and measurements that have been conducted in order to determine how much of the existing forest should be cleared. It is seen that with the current vegetation cover, the wind shear and turbulence intensity in the lower 100m are quite severe. Tree clearances out to several distances are investigated. It is found that a distance from the wind turbines to the forest edge of 1,5km is probably sufficient to give acceptable flow conditions for the proposed test station.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements
Authors: Mann, J. (Intern), Courtney, M. (Intern), Hummelshøj, P. (Intern), Hjuler Jensen, P. (Intern)
Number of pages: 32
Wind climate from the regional climate model REMO

Selected outputs from simulations with the regional climate model REMO from the Max Planck Institute, Hamburg, Germany were studied in connection with wind energy resource assessment. It was found that the mean wind characteristics based on observations from six mid-latitude stations are well described by the standard winds derived from the REMO pressure data. The mean wind parameters include the directional wind distribution, directional and omni-directional mean values and Weibull fitting parameters, spectral analysis and interannual variability of the standard winds. It was also found that, on average, the wind characteristics from REMO are in better agreement with observations than those derived from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) re-analysis pressure data. The spatial correlation of REMO surface winds in Europe is consistent with that of the NCEP/NCAR surface winds, as well as published observations over Europe at synoptic scales. Therefore, REMO outputs are well suited for wind energy assessment application in Northern Europe. Copyright © 2009 John Wiley & Sons, Ltd.
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.826 SNIP 1.559
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.053 SNIP 1.453
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.637 SNIP 1.689
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.287 SNIP 0.9
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.528 SNIP 0.846
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Web of Science (2001): Indexed yes
Web of Science (2000): Indexed yes
Original language: English
Wind energy, Wind power meteorology
DOIs:
10.1002/we.337
Source: orbit
Source-ID: 253620
Publication: Research - peer-review › Journal article – Annual report year: 2010

Wind Turbines: Unsteady Aerodynamics and Inflow Noise
the highest emphasis in semi-empirical models. However it is an open question whether inflow noise has a high emphasis. This illustrates the need to investigate and improve the semi-empirical model for noise due to atmospheric turbulence. Three different aerodynamical models are investigated in order to estimate the lift fluctuations due to unsteady aerodynamics (Sears, W. R.: 1941, Some aspects of non-stationary airfoil theory and its practical application; Goldstein, M. E. and Atassi, H. M.: 1976, A complete second-order theory for the unsteady flow about an airfoil due to a periodic gust; and Graham, J. M. R.: 1970, Lifting surface theory for the problem of an arbitrarily yawed sinusoidal gust incident on a thin airfoil in incompressible flow). Two of these models are investigated to find the unsteady lift distribution or pressure difference as function of chordwise position on the aerofoil (Sears, W. R.: 1941; and Graham, J. M. R.: 1970). An acoustic model is investigated using a model for the lift distribution as input (Amiet, R. K.: 1975, Acoustic radiation from an airfoil in a turbulent stream). The two models for lift distribution are used in the acoustic model. One of the models for lift distribution is for completely anisotropic turbulence and the other for perfectly isotropic turbulence, and so is also the corresponding models for the lift fluctuations derived from the models for lift distribution. The models for lift distribution and lift are compared with pressure data which are obtained by microphones placed flush with the surface of an aerofoil. The pressure data are from two experiments in a wind tunnel, one experiment with a NACA0015 profile and a second with a NACA63415 profile. The turbulence is measured by a triple wired hotwire instrument in the experiment with a NACA0015 profile. Comparison of the aerodynamical models with data shows that the models capture the general characteristics of the measurements, but the data are hampered by background noise from the fan propellers in the wind tunnel. The measurements are in between the completely anisotropic turbulent model and the perfectly isotropic turbulent model. This indicates that the models capture the aerodynamics well. Thus the measurements suggest that the noise due to atmospheric turbulence can be described and modeled by the two models for lift distribution. It was not possible to test the acoustical model by the measurements presented in this work.
Applying flow models of different complexity for estimation of turbine wakes

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Aerodynamic Design, Fluid Mechanics, Department of Mechanical Engineering
Authors: Broe, B. R. (Intern), Mann, J. (Intern), Aagaard Madsen, H. (Intern), Sørensen, J. N. (Intern)
Number of pages: 138
Publication date: Dec 2009

Publication information
Place of publication: Roskilde
Publisher: Risø National Laboratory for Sustainable Energy
ISBN (Print): 978-87-550-3727-4
Original language: English
Series: Risø-PhD
Number: 47(EN)
Main Research Area: Technical/natural sciences
Wind energy, Wind power meteorology, Risø-PhD-47(EN), Risø-PhD-47, Risø-PhD-0047
Electronic versions:
ris-phd-47.pdf
Source: orbit
Source-ID: 256324
Publication: Research › Ph.D. thesis – Annual report year: 2010

Comparison of 3D turbulence measurements using three staring wind lidars and a sonic anemometer

The goals are to compare lidar volume averaged wind measurement with point measurement reference sensors and to demonstrate the feasibility of performing 3D turbulence measurements with lidars. For that purpose three pulsed lidars were used in staring mode, placed so that their beams crossed close to a 3D sonic anemometer mounted at 78 m above the ground. The results show generally very good correlation between the lidar and the sonic times series, except that the variance of the velocity measured by the lidar is attenuated due to spatial filtering. The amount of attenuation can however be predicted theoretically by use of a spectral tensor model of the atmospheric surface-layer turbulence

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements, Leosphere
Authors: Mann, J. (Intern), Cariou, J. (Ekstern), Courtney, M. (Intern), Parmentier, R. (Ekstern), Mikkelsen, T. (Intern), Wagner, R. (Intern), Lindelöw, P. J. P. (Intern), Sjöholm, M. (Intern), Enevoldsen, K. (Intern)
Pages: 135-140
Publication date: 2009
Main Research Area: Technical/natural sciences
Conically scanning lidar error in complex terrain

Conically scanning lidars assume the flow to be homogeneous in order to deduce the horizontal wind speed. However, in mountainous or complex terrain this assumption is not valid implying a risk that the lidar will derive an erroneous wind speed. The magnitude of this error is measured by collocating a meteorological mast and a lidar at two Greek sites, one
hilly and one mountainous. The maximum error for the sites investigated is of the order of 10%. In order to predict the error for various wind directions the flows at both sites are simulated with the linearized flow model, WAsP Engineering 2.0. The measurement data are compared with the model predictions with good results for the hilly site, but with less success at the mountainous site. This is a deficiency of the flow model, but the methods presented in this paper can be used with any flow model.

**General information**

State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Centre for Renewable Energy Sources
Authors: Bingöl, F. (Intern), Mann, J. (Intern), Foussekis, D. (Ekstern)
Pages: 189-195
Publication date: 2009
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Meteorologische Zeitschrift
Volume: 18
Issue number: 2
ISSN (Print): 0941-2948
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BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.923 SNIP 1.803 CiteScore 2.59
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.853 SNIP 1.279 CiteScore 1.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.997 SNIP 0.853 CiteScore 1.35
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.776 SNIP 0.746 CiteScore 1.37
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.975 SNIP 0.908 CiteScore 1.22
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.536 SNIP 0.948 CiteScore 1.81
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.91 SNIP 0.744
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.894 SNIP 0.814
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.979 SNIP 0.878
Scopus rating (2007): SJR 1.112 SNIP 0.674
Scopus rating (2006): SJR 0.928 SNIP 0.813
Scopus rating (2005): SJR 0.765 SNIP 0.714
Scopus rating (2004): SJR 0.841 SNIP 0.931
Scopus rating (2003): SJR 0.631 SNIP 0.641
Scopus rating (2002): SJR 0.482 SNIP 0.559
Scopus rating (2001): SJR 0.565 SNIP 0.577
Scopus rating (2000): SJR 0.425 SNIP 0.439
Do wind farms influence large scale turbulence?

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, DONG Energy A/S
Authors: Larsen, G. C. (Intern), Mann, J. (Intern), Ighil, T. A. (Intern), Mouritzen, A. (Ekstern)
Number of pages: 95
Pages: 38-40
Publication date: 2009

Host publication information
Title of host publication: Extended Abstracts
Publisher: Universidad Politecnica de Madrid
Editors: Crespo, A., Larsen, G. C., Migoya, E.
ISBN (Print): 978-84-7484-220-3
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 508 on Wind Turbine Wakes, Madrid, Spain, 20/10/2009 - 20/10/2009

Experimental investigation of Lagrangian structure functions in turbulence
Lagrangian properties obtained from a particle tracking velocimetry experiment in a turbulent flow at intermediate Reynolds number are presented. Accurate sampling of particle trajectories is essential in order to obtain the Lagrangian structure functions and to measure intermittency at small temporal scales. The finiteness of the measurement volume can bias the results significantly. We present a robust way to overcome this obstacle. Despite no fully developed inertial range, we observe strong intermittency at the scale of dissipation. The multifractal model is only partially able to reproduce the results.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Swiss Federal Institute of Technology
Authors: Berg, J. (Intern), Ott, S. (Intern), Mann, J. (Intern), Luthi, B. (Ekstern)
Pages: 026316
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Volume: 80
Issue number: 2
ISSN (Print): 1539-3755
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.95 SJR 0.993 SNIP 0.896
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.047 SNIP 0.978 CiteScore 1.89
Extreme Winds from the NCEP/NCAR Reanalysis Data

In this study, we test a method to estimate the extreme winds by using the NCEP/NCAR reanalysis data. From the reanalysis pressure or geopotential height records, the geostrophic wind is first calculated, and then extrapolated to 10 m height over a homogeneous surface with roughness length of 0.05 m, i.e. the so-called standard wind. The software Wind Analysis and Application Program will then use this standard wind in a flow model, with the roughness, orography and obstacles around the turbine site to obtain the site-specific wind. The annual maximum method is used to calculate the 50 year wind. We examined extreme winds in different places where the strongest wind events are weather phenomena of different scales, including the mid-latitude lows in Denmark, channelling winds in the Gulf of Suez, typhoons in the western North Pacific, cyclones in the Caribbean Sea, local strong winds: the Mistral in the Gulf of Lions and the Bora in the north Adriatic Sea. It was found that the method introduced here can be applied to places where the extreme wind events are synoptic weather phenomena like in north-western Europe, but a more complicated downscaling, e.g. based on a mesoscale model, is needed for places where the extreme wind events are of mesoscale origin. Copyright © 2009 John Wiley & Sons, Ltd.
LiDAR measurements of full scale wind turbine wake characteristics

Full scale wind speed measurements, recorded inside the wake of an operating 2MW/80m wind turbine, has been performed during the spring 2009, as part of the EU-TOPFARM project. Longitudinal wind speeds in wake cross sections are measured with a LiDAR system mounted in the rear of the nacelle. The experimental setup, the amount of data, preliminary analysis and limitations of using LiDAR measurements to identify the wake dynamics will be presented. Resolving the wake in the meandering frame of reference further allows for identification of the wake characteristics both in terms of wake deficit and wake turbulence.

General information
State: Published
Organisations: Fluid Mechanics, Department of Mechanical Engineering, Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements
Authors: Hansen, K. S. (Intern), Larsen, G. C. (Intern), Mann, J. (Intern), Enevoldsen, K. (Intern)
Number of pages: 95
Pages: 55-56
Publication date: 2009

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Publisher: Sección de Publicaciones de la Escuela Técnica Superior de Ingenieros Industriales. Universidad Politecnica de Madrid.
ISBN (Print): 978-84-7484-220-3
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 508 on Wind Turbine Wakes, Madrid, Spain, 20/10/2009 - 20/10/2009
wind turbine, Wind energy, wakes, Aeroelastic Design, wind farm
Source: orbit
Source-ID: 251698
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009
LIDAR Measurements of Full-scale Wind Turbine Wake Characteristics

General information
State: Published
Organisations: Fluid Mechanics, Department of Mechanical Engineering, Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements
Authors: Hansen, K. S. (Intern), Larsen, G. C. (Intern), Mann, J. (Intern), Enevoldsen, K. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences
Wind energy, Aeroelastic Design
Source: orbit
Source-ID: 246700
Publication: Research › Paper – Annual report year: 2009

Lidar performance in complex terrain modelled by WAsP engineering

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Centre for Renewable Energy Sources
Authors: Bingöl, F. (Intern), Mann, J. (Intern), Foussekis, D. (Ekstern)
Publication date: 2009

Host publication information
Title of host publication: EWEC 2009 Proceedings online
Publisher: EWEC
Main Research Area: Technical/natural sciences
Conference: 2009 European Wind Energy Conference and Exhibition, Marseille, France, 16/03/2009 - 16/03/2009
Wind energy, Meteorology
Electronic versions:
2009_41.pdf
Source: orbit
Source-ID: 241192
Publication: Research › Article in proceedings – Annual report year: 2009

Lidar Scanning of Momentum Flux in the Marine Boundary Layer
Momentum flux measurements are important for describing the wind profile in the atmospheric boundary layer, modeling the atmospheric flow over water, the accounting of exchange processes between air and sea, etc. It is also directly related to the friction velocity, which is a velocity scale required for wind engineering. Estimations of friction velocity over the sea can be performed by combining wind speed measurements, a sea roughness length formulation and the surface-layer wind profile, i.e. a bulk-derived method. This method was tested in Peña et al. (2008) by comparison with direct turbulence measurements from a sonic anemometer, showing high agreement. In this study, a conical scanning lidar is used to derive the momentum flux, which compares well to the estimations from the bulk-derived method, but it also shows a filtering effect due to the large spatial-averaging volume of the lidar. The spectral model by Mann (1994) is then used to numerically estimate the filtering effect of the lidar and the predictions have a good agreement with the observations for near-neutral conditions over the North Sea at the Horns Rev wind farm.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements
Authors: Pena Diaz, A. (Intern), Mann, J. (Intern), Courtney, M. (Intern), Bingöl, F. (Intern), Wagner, R. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences
Wind energy, Meteorology
Electronic versions:
Pena_offshore_poster.pdf
Source: orbit
Source-ID: 251388
Publication: Research › Poster – Annual report year: 2009
Spatial averaging-effects on turbulence measured by a continuous-wave coherent lidar

The influence of spatial volume averaging of a focused continuous-wave coherent Doppler lidar on observed wind turbulence in the atmospheric surface layer is described and analysed. For the first time, comparisons of lidar-measured turbulent spectra with spectra simultaneously obtained from a mast-mounted sonic anemometer at 78 meters height over homogeneous terrain at the test station for large wind turbines at Høvsøre in Western Jutland, Denmark are presented for various backscattering and cloud conditions. Good agreement is found between lidar-measured spectra and spectra predicted by applying a theoretical lidar sampling filter to the three-dimensional turbulence structure.

General information
State: Published
Organisations: Test and Measurements, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Sjöholm, M. (Intern), Mikkelsen, T. (Intern), Mann, J. (Intern), Enevoldsen, K. (Intern), Courtney, M. (Intern)
Pages: 281-287
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
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Issue number: 3
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.923 SNIP 1.803 CiteScore 2.59
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.853 SNIP 1.279 CiteScore 1.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.997 SNIP 0.853 CiteScore 1.35
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.776 SNIP 0.746 CiteScore 1.37
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.975 SNIP 0.908 CiteScore 1.22
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.536 SNIP 0.948 CiteScore 1.81
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.91 SNIP 0.744
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.894 SNIP 0.814
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.979 SNIP 0.878
Scopus rating (2007): SJR 1.112 SNIP 0.674
Scopus rating (2006): SJR 0.928 SNIP 0.813
Scopus rating (2005): SJR 0.765 SNIP 0.714
Scopus rating (2004): SJR 0.841 SNIP 0.931
Scopus rating (2003): SJR 0.631 SNIP 0.641
Scopus rating (2002): SJR 0.482 SNIP 0.559
Scopus rating (2001): SJR 0.565 SNIP 0.577
Scopus rating (2000): SJR 0.425 SNIP 0.439
Scopus rating (1999): SJR 0.742 SNIP 0.536
Original language: English
Wind energy, Test and measurements
DOIs:
10.1127/0941-2948/2009/0379
Source: orbit
Source-ID: 248492
Publication: Research - peer-review › Journal article – Annual report year: 2009

Special issue ISARS 14-International Symposium for the Advancement of Boundary Layer Remote Sensing

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Forschungs Zentrum Karlsruhe GmbH
Authors: Mann, J. (Intern), Emeis, S. (Ekstern)
Pages: 123-124
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Meteorologische Zeitschrift
Volume: 18
Issue number: 2
ISSN (Print): 0941-2948
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.923 SNIP 1.803 CiteScore 2.59
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.853 SNIP 1.279 CiteScore 1.71
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.997 SNIP 0.853 CiteScore 1.35
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.776 SNIP 0.746 CiteScore 1.37
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.975 SNIP 0.908 CiteScore 1.22
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.536 SNIP 0.948 CiteScore 1.81
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.91 SNIP 0.744
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.894 SNIP 0.814
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.979 SNIP 0.878
Scopus rating (2007): SJR 1.112 SNIP 0.674
Scopus rating (2006): SJR 0.928 SNIP 0.813
The Bolund experiment: Overview and background

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements, VESTAS Asia Pacific A/S
Authors: Bechmann, A. (Intern), Berg, J. (Intern), Christiansen, L. C. (Ekstern), Courtney, M. (Intern), Johansen, J. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern), Mogensen, S. H. (Ekstern), Sørensen, N. N. (Intern)
Number of pages: 1
Publication date: 2009

Host publication information
Title of host publication: EWEC 2009 Proceedings online
Publisher: EWEC
Main Research Area: Technical/natural sciences
Conference: 2009 European Wind Energy Conference and Exhibition, Marseille, France, 16/03/2009 - 16/03/2009
Wind energy, Meteorology
Electronic versions:
2009_37.pdf
Source: orbit
Source-ID: 241207
Publication: Research › Conference abstract in proceedings – Annual report year: 2009

The Bolund Experiment: Blind Comparison of Models for Wind in Complex Terrain

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design, Test and Measurements, Meteorology
Authors: Bechmann, A. (Intern), Berg, J. (Ekstern), Courtney, M. (Intern), Jørgensen, H. (Ekstern), Mann, J. (Intern), Sørensen, N. N. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences
Wind energy, Aeroelastic Design
Source: orbit
Source-ID: 255520
Publication: Research › Conference abstract for conference – Annual report year: 2009

The Bolund Experiment: Overview and Background
The Bolund experiment is a measuring campaign performed in 2007 and 2008. The aim of the experiment is to measure the flow field around the Bolund hill in order to provide a dataset for validating numerical flow models. The present report gives an overview of the whole experiment including a description of the orography, the instrumentation used and of the data processing. The Actual measurements are available from a database also described.

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements
Authors: Bechmann, A. (Intern), Berg, J. (Intern), Courtney, M. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern), Sørensen, N. N. (Intern)
Number of pages: 50
Publication date: 2009

The dependence of wake losses on atmospheric stability characteristics

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, DONG Energy A/S
Authors: Larsen, G. C. (Intern), Larsen, T. J. (Intern), Aagaard Madsen, H. (Intern), Mann, J. (Intern), Pena Diaz, A. (Intern), Barthelmie, R. J. (Intern), Jensen, L. (Ekstern)
Number of pages: 95
Pages: 35-37
Publication date: 2009

Host publication information
Title of host publication: Extended Abstracts
Publisher: Universidad Politecnica de Madrid
Editors: Crespo, A., Larsen, G. C., Migoya, E.
ISBN (Print): 978-84-7484-220-3
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 508 on Wind Turbine Wakes, Madrid, Spain, 20/10/2009 - 20/10/2009
Wind energy, Meteorology
Source: orbit
Source-ID: 251691
Publication: Research › Conference abstract in proceedings – Annual report year: 2009

TOPFARM. Background, vision - and challenges

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Larsen, G. C. (Intern), Aagaard Madsen, H. (Intern), Larsen, T. J. (Intern), Mann, J. (Intern), Bingöl, F. (Intern)
Publication date: 2009

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Wind energy, Aeroelastic Design
Electronic versions:
2009_77.pdf
Wind and turbulence at a forest edge

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Dellwik, E. (Intern), Bingöl, F. (Intern), Mann, J. (Intern), Sogachev, A. (Intern)
Publication date: 2009

Host publication information
Title of host publication: EWEC 2009 Proceedings online
Publisher: EWEC
Main Research Area: Technical/natural sciences
Conference: 2009 European Wind Energy Conference and Exhibition, Marseille, France, 16/03/2009 - 16/03/2009
Wind energy, Meteorology
Electronic versions:
2009_49.pdf
Source: orbit
Source-ID: 241201
Publication: Research › Conference abstract in proceedings – Annual report year: 2009

Wind energy availability above gaps in a forest
There is a lack of data on availability of wind energy above a forest disturbed by clear-cuts, where a wind energy developer may find an opportunity to install a wind farm. Computational fluid dynamics (CFD) models can provide spatial patterns of wind and turbulence, and help to develop optimal installation strategies. The canopy-planetary boundary-layer model SCADIS is used to investigate the effect of forest gap size (within the diameter range of 3 - 75 tree heights, h) on wind energy related variables. A wind turbine was assumed with following features: the hub height and rotor diameter of 3.5h and 3h, respectively; this provides the clearance between the rotor and ground of 2h which is similar to the value obtained by the rule of thumb. Spatial variations of wind energy production, the average wind speed shear and cumulative TKE inside the layer of 2h - 5h above the ground around the gaps were estimated from modelled data. The results show that the effect of the forest gaps with diameters smaller than 55h on wind energy captured by the assumed wind turbine and located in the centre of round low-roughness gap is practically insignificant. The high level of spatial variation of considered characteristics within the clear-cut indicates that a joint influence of wind turbine properties and turbine's location within the gap can result in both win and loss of the wind energy capture. Therefore, for any particular land-use situation and wind turbine properties this combined effect should be considered carefully before a placement of turbine.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Georg-August University Göttingen
Authors: Sogachev, A. (Intern), Mann, J. (Intern), Dellwik, E. (Intern), Bingöl, F. (Intern), Rathmann, O. (Intern), Ejsing Jørgensen, H. (Intern), Panferov, O. (Ekstern)
Pages: 4198-4206
Publication date: 2009

Host publication information
Title of host publication: EWEC 2009 Proceedings
Volume: 6
Publisher: EWEC
ISBN (Print): 9781615677467
Main Research Area: Technical/natural sciences
Conference: 2009 European Wind Energy Conference and Exhibition, Marseille, France, 16/03/2009 - 16/03/2009
Wind energy, Meteorology
Electronic versions:
2009_20.pdf
Source: orbit
Source-ID: 241175
Publication: Research › peer-review › Article in proceedings – Annual report year: 2009
Applying canopy flow model for estimation of wind turbine wake

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Wind Turbines
Authors: Sogachev, A. (Intern), Ejings Jørgensen, H. (Intern), Mann, J. (Intern), Frandsen, S. T. (Intern), Ott, S. (Intern)
Pages: A21E-0228
Publication date: 2008

Host publication information
Title of host publication: Eos Transactions AGU
Volume: 89, no. 53 Fall Meeting Supplement
Publisher: American Geophysical Union
Main Research Area: Technical/natural sciences
Conference: American Geophysical Union Fall meeting 2008, San Francisco, United States, 15/12/2008 - 15/12/2008
Source: orbit
Source-ID: 231723
Publication: Research › Conference abstract in proceedings – Annual report year: 2008

Comparison of 3D turbulence measurements using three staring wind lidars and a sonic anemometer

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements
Authors: Mann, J. (Intern), Cariou, J. (Ekstern), Courtney, M. (Intern), Parmentier, R. (Ekstern), Mikkelsen, T. (Intern), Wagner, R. (Intern), Lindelöw, P. J. P. (Intern), Sjöholm, M. (Intern), Enevoldsen, K. (Intern)
Number of pages: 15
Publication date: 2008

Publication information
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
ISBN (Print): 87-55-03705-4
Original language: English
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1660(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Risø-R-1660, Risø-R-1660(EN)
Electronic versions: ris-r-1660.pdf
Source: orbit
Source-ID: 234841
Publication: Research › Report – Annual report year: 2008

Comparison of 3D turbulence measurements using three staring wind lidars and a sonic anemometer
Three pulsed lidars were used in staring, non-scanning mode, placed so that their beams crossed close to a 3D sonic anemometer. The goal is to compare lidar volume averaged wind measurement with point measurement reference sensors and to demonstrate the feasibility of performing 3D turbulence measurements with lidars. The results show a very good correlation between the lidar and the sonic times series. The variance of the velocity measured by the Mar is attenuated due to spatial filtering, and the amount of attenuation can be predicted theoretically.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements
Authors: Mann, J. (Intern), Cariou, J. (Ekstern), Courtney, M. (Intern), Parmentier, R. (Ekstern), Mikkelsen, T. (Intern), Wagner, R. (Intern), Lindelöw, P. J. P. (Intern), Sjöholm, M. (Intern), Enevoldsen, K. (Intern)
Pages: U96-U101
Publication date: 2008
Conference: 14th International symposium for the advancement of boundary layer remote sensing, Risø, Denmark, 23/06/2008 - 23/06/2008
Main Research Area: Technical/natural sciences
Evaluation of different turbulence models with respect to coherences, spectras and lengthscales

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Wind Turbines, Test and Measurements
Authors: Ejsing Jørgensen, H. (Intern), Frandsen, S. T. (Intern), Mann, J. (Intern), Wagner, R. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences
Electronic versions:
2008_60.pdf
Links:
http://www.risoe.dk/rispubl/art/2008_60.pdf
Source: orbit
Source-ID: 222946
Publication: Research - peer-review › Conference article – Annual report year: 2008

Fast wake measurements with LiDAR at Risø test field
The vast majority of wind turbines are today erected in wind farms. As a consequence, wake generated loads are becoming more and more important. We present a new and successful experimental technique, based on remote sensing, to measure instantaneously the flow in the wake of wind turbines. Downstream wind speed can be quantified spatially in one and two dimensions. Data analysis allows us to identify the wake transversal position, thus enabling us to quantify the wake meandering as well as the instantaneous wake expansion expressed in a meandering frame of reference. The experimental results are subsequently used in a preliminary verification of the basic conjecture of a wake meandering model that essentially considers the wake as a passive tracer.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Aeroelastic Design
Authors: Bingöl, F. (Intern), Trujillo, J. (Ekstern), Mann, J. (Intern), Larsen, G. C. (Intern)
Pages: 012022-012030
Publication date: 2008
Conference: 14th International symposium for the advancement of boundary layer remote sensing, Risø, Denmark, 23/06/2008 - 23/06/2008
Main Research Area: Technical/natural sciences

Publication information
Journal: IOP Conference Series: Earth and Environmental Science
Volume: 1
Fetch requirements for CO2 fluxes measured behind a forest edge: A modelling study

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Sogachev, A. (Intern), Dellwik, E. (Intern), Mann, J. (Intern), Vesala, T. (Ekstern)
Pages: 20-21
Publication date: 2008

Host publication information
Title of host publication: Proceedings
Place of publication: Reykjavik
Publisher: NECC and BACCI Nordic Centres of Excellence
Main Research Area: Technical/natural sciences
Conference: NECC and BACCI Conference on Greenhouse Gases and Aerosols, Reykjavik, Iceland, 16/06/2008 - 16/06/2008
Source: orbit
Source-ID: 231721
Publication: Research › Conference abstract in proceedings – Annual report year: 2008

Investigation of the measurement of the wind speed standard deviation using a lidar

General information
State: Published
Organisations: Test and Measurements, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Wagner, R. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern), Courtney, M. (Intern), Antoniou, I. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences

Links:
Source: orbit
Source-ID: 223046
Publication: Research › Conference abstract for conference – Annual report year: 2008

Lagrangian multi-particle statistics

General information
It is estimated that 20-30% of the total European wind energy growth takes place in areas where the wind flow is affected by forests. The description of the wind conditions near and above forests poses a challenge, since assumptions of classical boundary-layer theory are violated. Turbines are designed for maximal turbulence intensity and wind profile gradient. In forested areas, these limits are often violated possibly leading to reduced turbine life-time. In this paper we investigate the mean wind profile and turbulence statistics above an 85 years old dense beech forest by use of a laser Doppler anemometer and compare the profiles with a CFD model specifically made for the modelling of flow over vegetation canopies.
LiDAR error estimation with WAsP engineering

The LiDAR measurements, vertical wind profile in any height between 10 to 150m, are based on assumption that the measured wind is a product of a homogenous wind. In reality there are many factors affecting the wind on each measurement point which the terrain plays the main role. To model LiDAR measurements and predict possible error in different wind directions for a certain terrain we have analyzed two experiment data sets from Greece. In both sites LiDAR and met. mast data have been collected and the same conditions are simulated with Riso/DTU software, WAsP Engineering 2.0. Finally measurement data is compared with the model results. The model results are acceptable and very close for one site while the more complex one is returning higher errors at higher positions and in some wind directions.

LIDAR measurement and modelling of wind turbine far-wake dynamics

The LiDAR measurements, vertical wind profile in any height between 10 to 150m, are based on assumption that the measured wind is a product of a homogenous wind. In reality there are many factors affecting the wind on each measurement point which the terrain plays the main role. To model LiDAR measurements and predict possible error in different wind directions for a certain terrain we have analyzed two experiment data sets from Greece. In both sites LiDAR and met. mast data have been collected and the same conditions are simulated with Riso/DTU software, WAsP Engineering 2.0. Finally measurement data is compared with the model results. The model results are acceptable and very close for one site while the more complex one is returning higher errors at higher positions and in some wind directions.
The Dynamic Wake Meandering (DWM) model and its future perspectives

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Rise National Laboratory for Sustainable Energy, Meteorology
Authors: Larsen, G. C. (Intern), Madsen Aagaard, H. (Intern), Larsen, T. J. (Intern), Mann, J. (Intern), Bingöl, F. (Intern), Trujillo, J. (Intern)
Publication date: 2008
Event: Paper presented at VindKraftNet seminar on wakes, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 223922
Publication: Research › Paper – Annual report year: 2008

Time series analysis of continuous-wave coherent Doppler Lidar wind measurements
The influence of spatial volume averaging of a focused 1.55 μm continuous-wave coherent Doppler Lidar on observed wind turbulence measured in the atmospheric surface layer over homogeneous terrain is described and analysed.
Comparison of Lidar-measured turbulent spectra with spectra simultaneously obtained from a mast-mounted sonic anemometer at 78 meters height at the test station for large wind turbines at Hovsøre in Western Jutland, Denmark is presented for the first time.

General information
State: Published
Organisations: Test and Measurements, Wind Energy Division, Rise National Laboratory for Sustainable Energy, Meteorology
Authors: Sjöholm, M. (Intern), Mikkelsen, T. (Intern), Mann, J. (Intern), Enevoldsen, K. (Intern), Courtney, M. (Intern)
Pages: U411-U416
Publication date: 2008
Conference: 14th International symposium for the advancement of boundary layer remote sensing, Rise, Denmark, 23/06/2008 - 23/06/2008
Main Research Area: Technical/natural sciences
Publication information
Journal: IOP Conference Series: Earth and Environmental Science
Volume: 1
ISSN (Print): 1755-1307
Ratings:
Scopus rating (2016): CiteScore 0.38 SJR 0.186 SNIP 0.567
Scopus rating (2015): SJR 0.253 SNIP 0.358 CiteScore 0.22
Scopus rating (2014): SJR 0.168 SNIP 0.391 CiteScore 0.19
Scopus rating (2013): SJR 0.173 SNIP 0.13 CiteScore 0.06
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.338 SNIP 0.141 CiteScore 0.29
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.116 SNIP 0 CiteScore 0
ISI indexed (2011): ISI indexed no
Web of Science (2008): Indexed yes
Universal intermittent properties of particle trajectories in highly turbulent flows

We present a collection of eight data sets from state-of-the-art experiments and numerical simulations on turbulent velocity statistics along particle trajectories obtained in different flows with Reynolds numbers in the range \( R = \lambda \) is an element of \([120740]\). Lagrangian structure functions from all data sets are found to collapse onto each other on a wide range of time lags, pointing towards the existence of a universal behavior, within present statistical convergence, and calling for a unified theoretical description. Parisi-Frisch multifractal theory, suitably extended to the dissipative scales and to the Lagrangian domain, is found to capture the intermittency of velocity statistics over the whole three decades of temporal scales investigated here.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Ecole Normale Superieure de Lyon, University of Roma ‘Tor Vergata’, Max Planck Institute, University of Twente, La Sapienza - Università di Roma, University of Chicago, Ruhr-University Bochum, National Research Council of Italy, ETH Zurich, Centre National de la Recherche Scientifique, Haverford College, Sibley School of Mechanical and Aerospace Engineering, INFN, Georgia Institute of Technology
Pages: 254504
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Physical Review Letters
Volume: 100
Issue number: 25
ISSN (Print): 0031-9007
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.33 SJR 3.56 SNIP 2.133
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 3.823 SNIP 2.205 CiteScore 5.76
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 5.027 SNIP 2.646 CiteScore 6.62
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 5.674 SNIP 2.796 CiteScore 7.46
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 6.243 SNIP 2.845 CiteScore 7.19
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 6.252 SNIP 2.886 CiteScore 7.02
**Wind climate and extreme winds from the regional climate model REMO**

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Larsén, X. G. (Intern), Mann, J. (Intern), Göttel, H. (Ekstern), Jacob, D. (Ekstern)
Pages: 58-62
Publication date: 2008

**Host publication information**
Title of host publication: Scientific proceedings
Place of publication: Brussels
Publisher: European Wind Energy Conference and Exhibition
Main Research Area: Technical/natural sciences
Conference: 2008 European Wind Energy Conference and Exhibition, Brussels, Belgium, 31/03/2008 - 31/03/2008
Source: orbit
Wind profile measurements over a forest with lidar

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Rathmann, O. (Intern), Mann, J. (Intern), Dellwik, E. (Intern), Bingöl, F. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences
Electronic versions:
2008_63.pdf
Links:
http://www.risoe.dk/rispubl/art/2008_63.pdf
Source: orbit
Source-ID: 222980
Publication: Research › Conference abstract for conference – Annual report year: 2008

Windscanner: 3-D wind and turbulence measurements from three steerable doppler lidars
At RISO DTU we has started to build a new-designed laser-based lidar scanning facility for detailed remote measurements of the wind fields engulfing the huge wind turbines of today. Our aim is to measure in real-time 3D wind vector data at several hundred points every second: 1) upstream of the turbine, 2) near the turbine, and 3) in the wakes of the turbine rotors. Our first proto-type Windscanner is now being built from three commercially available Continuous Wave (CW) wind lidars modified with fast adjustable focus length and equipped with 2-D prism-based scan heads, in conjunction with a commercially available pulsed wind lidar for extended vertical profiling range. Design, construction and initial testing of the new 3-D wind lidar scanning facility are described and the functionality of the Windscanner and its potential as a new research facility within the wind energy community is discussed.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements
Authors: Mikkelsen, T. (Intern), Mann, J. (Intern), Courtney, M. (Intern), Sjöholm, M. (Intern)
Pages: U148-U156
Publication date: 2008
Conference: 14th International symposium for the advancement of boundary layer remote sensing, Risø, Denmark, 23/06/2008 - 23/06/2008
Main Research Area: Technical/natural sciences
Publication information
Journal: IOP Conference Series: Earth and Environmental Science
Volume: 1
ISSN (Print): 1755-1307
Ratings:
Scopus rating (2016): CiteScore 0.38 SJR 0.186 SNIP 0.567
Scopus rating (2015): SJR 0.253 SNIP 0.358 CiteScore 0.22
Scopus rating (2014): SJR 0.168 SNIP 0.391 CiteScore 0.19
Scopus rating (2013): SJR 0.173 SNIP 0.13 CiteScore 0.06
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.338 SNIP 0.141 CiteScore 0.29
ISI indexed (2012): ISI indexed no
Scopus rating (2011): SJR 0.116 SNIP 0 CiteScore 0
ISI indexed (2011): ISI indexed no
Web of Science (2008): Indexed yes
Original language: English
DOIs:
10.1088/1755-1307/1/1/012018
Source: orbit
Source-ID: 222945
Publication: Research › Conference article – Annual report year: 2008
Wind scanner: A full-scale laser facility for wind and turbulence measurements around large wind turbines

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements
Authors: Mikkelsen, T. (Intern), Courtney, M. (Intern), Antoniou, I. (Intern), Mann, J. (Intern)
Publication date: 2008

**Host publication information**
Title of host publication: Conference proceedings (online)
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Conference: 2008 European Wind Energy Conference and Exhibition, Brussels, Belgium, 31/03/2008 - 31/03/2008
Source: orbit
Source-ID: 232712
Publication: Research › Article in proceedings – Annual report year: 2008

Large-eddy simulation of atmospheric flow over complex terrain

The present report describes the development and validation of a turbulence model designed for atmospheric flows based on the concept of Large-Eddy Simulation (LES). The background for the work is the high Reynolds number k - $\epsilon$ model, which has been implemented on a finite-volume code of the incompressible Reynolds-averaged Navier-Stokes equations (RANS). The k - $\epsilon$ model is traditionally used for RANS computations, but is here developed to also enable LES. LES is able to provide detailed descriptions of a wide range of engineering flows at low Reynolds numbers. For atmospheric flows, however, the high Reynolds numbers and the rough surface of the earth provide difficulties normally not compatible with LES. Since these issues are most severe near the surface they are addressed by handling the near surface region with RANS and only use LES above this region. Using this method, the developed turbulence model is able to handle both engineering and atmospheric flows and can be run in both RANS or LES mode. For LES simulations a time-dependent wind field that accurately represents the turbulent structures of a wind environment must be prescribed at the computational inlet. A method is implemented where the turbulent wind field from a separate LES simulation can be used as inflow. To avoid numerical dissipation of turbulence special care is paid to the numerical method, e.g. the turbulence model is calibrated with the specific numerical scheme used. This is done by simulating decaying isotropic and homogeneous turbulence. Three atmospheric test cases are investigated in order to validate the behavior of the presented turbulence model. Simulation of the neutral atmospheric boundary layer, illustrates the turbulence model ability to generate and maintain the turbulent structures responsible for boundary layer transport processes. Velocity and turbulence profiles are in good agreement with measurements. Simulation of the flow over the Askervein hill is also performed. Speed-up and turbulence intensities show good agreement with measurements, except 400m downstream of the hill summit where speed-up is underestimated. Flow over a cube in a thick turbulent boundary layer is the final test case. The turbulence model ability to capture the physics of the large separated region downstream of the cube is demonstrated. The turbulence model is, however, shown to have trouble with very large values of roughness.

**General information**
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Bechmann, A. (Intern), Mann, J. (Intern), Johansen, J. (Intern), Sørensen, N. N. (Intern), Sørensen, J. N. (Intern)
Number of pages: 105
Publication date: Aug 2007

**Publication information**
Original language: English
Series: Risø-PhD
Number: 28(EN)
Main Research Area: Technical/natural sciences
Risø-PhD-28(EN)
Electronic versions:
Andreas.pdf

**Bibliographical note**
Risø-PhD-28(EN)
Source: orbit
Source-ID: 215501
Publication: Research › Ph.D. thesis – Annual report year: 2007
Computational methods in wind power meteorology

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division, Aeroelastic Design
Authors: Jørgensen, B. H. (Intern), Ott, S. (Intern), Sørensen, N. N. (Intern), Mann, J. (Intern), Badger, J. (Intern)
Number of pages: 28
Publication date: 2007

Publication information
Publisher: Risø National Laboratory
Original language: English
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1560(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Risø-R-1560, Risø-R-1560(EN)
Electronic versions:
ris_r_1560.pdf

Bibliographical note
Risø-R-1560(EN)
Source: orbit
Source-ID: 216426
Publication: Research › Report – Annual report year: 2007

Conversion of contours to cartesian grids

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Broe, B. R. (Intern)
Number of pages: 16
Publication date: 2007

Publication information
Publisher: Risø National Laboratory
ISBN (Print): 87-550-3527-2
Original language: English
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1564(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Risø-R-1564, Risø-R-1564(EN)
Electronic versions:
ris_r_1564.pdf
Source: orbit
Source-ID: 216425
Publication: Research › Report – Annual report year: 2007

Dynamic wake meandering modelling

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Larsen, G. C. (Intern), Madsen Aagaard, H. (Intern), Bingöl, F. (Intern), Mann, J. (Intern), Ott, S. (Intern), Sørensen, J. (Ekster), Okulov, V. (Ekster), Trolldborg, N. (Ekster), Nielsen, N. M. (Intern), Thomsen, K. (Intern), Larsen, T. J. (Intern), Mikkelsen, R. (Ekster)
Number of pages: 84
Lagrangian multi-particle statistics

Combined measurements of the Lagrangian evolution of particle constellations and the coarse-grained velocity derivative tensor. $\partial(u)/\partial x(i)$ are presented. The data are obtained from three-dimensional particle tracking measurements in a quasi-isotropic turbulent flow at an intermediate Reynolds number. Particle constellations are followed for as long as one integral time and for several Batchelor times. We suggest a method to obtain $\partial(u)/\partial x(i)$ from velocity measurements at discrete points. Based on an analytical result and on a sensitivity analysis, both presented here, we estimate the accuracy for filtered strain, $(s)$ over tilde, and enstrophy, $(\omega)$ over tilde, at around 30%. The accuracy improves with higher tracer seeding density and with smaller filter scale $\Delta$. We obtain good scaling with $t^* = \sqrt{\Delta(2\Omega(2))}$ for filtered strain and vorticity and present filtered R-Q invariant maps with the typical 'tear drop' shape that is known from velocity gradients at viscous scales. Lagrangian results are given for the growth of particle pairs, triangles and tetrahedra. Their principal axes are preferentially oriented with the eigenframe of coarse-grained strain, just like constellations with infinitesimal separations are known to do. The compensated separation rate is found to be close to its viscous counterpart as $1/2 \cdot t^*/\sqrt{\Delta} \approx 0.12$. It appears that the contribution from the coarse-grained strain field, $r(i)(j)(s)$ over tilde $(i)$ filtered at scale $\Delta = r$, is responsible for roughly 2/3 of the separation rate, while 1/3 stems from scales $\Delta < r$. 

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division
Authors: Lüthi, B. (Intern), Berg, J. (Intern), Ott, S. (Intern), Mann, J. (Intern)
Pages: 1-17
Publication date: 2007
Main Research Area: Technical/natural sciences
Laser based measurements of profiles of wind and momentum flux over a canopy

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Bingöl, F. (Intern), Dellwik, E. (Intern), Rathmann, O. (Intern)
Pages: 688-690
Publication date: 2007
Laser measurements of wake dynamics

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology, Aeroelastic Design
Authors: Bingöl, F. (Intern), Mann, J. (Intern), Larsen, G. C. (Intern)
Pages: 103-106
Publication date: 2007

Host publication information
Title of host publication: Scientific proceedings
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 216390
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Lidars in wind energy

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements, Aeroelastic Design
Publication date: 2007
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 215518
Publication: Research › Conference abstract for conference – Annual report year: 2007

Modelling of wind turbine cut outs in a power system region

General information
State: Published
Organisations: Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology
Authors: Sørensen, P. E. (Intern), Larsén, X. G. (Intern), Mann, J. (Intern), Cutululis, N. A. (Intern)
Number of pages: 4
Publication date: 2007

Host publication information
Title of host publication: Proceedings : Nordic wind power conference (NWPC 2007)
Over-prediction of energy back-scatter due to misaligned eigen-frame of SGS tensor

Self similar two particle separation model
Self-similar two-particle separation model

We present a new stochastic model for relative two-particle separation in turbulence. Inspired by material line stretching, we suggest that a similar process also occurs beyond the viscous range, with time scaling according to the longitudinal second-order structure function $S_2(r)$, e.g., in the inertial range as $\varepsilon^{-1/3}r^{2/3}$. Particle separation is modeled as a Gaussian process without invoking information of Eulerian acceleration statistics or of precise shapes of Eulerian velocity distribution functions. The time scale is a function of $S_2(r)$ and thus of the Lagrangian evolving separation. The model predictions agree with numerical and experimental results for various initial particle separations. We present model results for fixed time and fixed scale statistics. We find that for the Richardson-Obukhov law, i.e., $\varepsilon^{-1/3}r^{2/3}$, to hold and to also be observed in experiments, high Reynolds numbers are necessary, i.e., $Re_{\lambda}>[O](1000)$, and the integral scale needs to be large compared to initial separation, i.e., $[L][r_0]>30$ and $d/[L]>3$ need to be fulfilled, where $d$ is the size of the field of view. Removing the constraint of finite inertial range, the model is used to explore separation dynamics in the asymptotic regime. As $Re_{\lambda}-->[\infty]$, the distance neighbor function takes on a constant shape, almost as predicted by the Richardson diffusion equation. For the Richardson constant we obtain that $g-->0.95$ as $Re_{\lambda}-->[\infty]$. This asymptotic limit is reached at $Re_{\lambda}>1000$. For the Richardson constant $g$, the model predicts a ratio of $gb/gf[approximate]1.9$ between backwards and forwards dispersion. ©2007 American Institute of Physics
The correlation between velocity and acceleration in turbulence

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Berg, J. (Intern), Lüthi, B. (Ekstern)
Pages: 95-98
Publication date: 2007

Host publication information
Title of host publication: Progress in turbulence 2 : Proceedings
Place of publication: Berlin
Publisher: Springer
Editors: Oberfack, M., Khujadze, G., Günther, S., Weller, T., Frewer, M., Peinke, J., Barth, S.
ISBN (Print): 978-3-540-32602-1

Series: Springer Proceedings in Physics, 109
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 216126
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007
Turbulent pair dispersion: A PTV experiment

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Berg, J. (Intern), Lüthi, B. (Ekstern), Mann, J. (Intern), Ott, S. (Intern)
Pages: 213-216
Publication date: 2007

Host publication information
Title of host publication: Progress in turbulence 2 : Proceedings
Place of publication: Berlin
Publisher: Springer
Editors: Oberlack, M., Khujadze, G., Günther, S., Weller, T., Frewer, M., Peinke, J., Barth, S.
ISBN (Print): 978-3-540-32602-1
Series: Springer Proceedings in Physics, 109
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 216125
Publication: Research - peer-review › Article in proceedings – Annual report year: 2007

Wake meandering - an analysis of instantaneous 2D laser measurements

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Aeroelastic Design
Authors: Bingöl, F. (Intern), Larsen, G. C. (Intern), Mann, J. (Intern)
Pages: 8
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 75
ISSN (Print): 1742-6596
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.383
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.24 SNIP 0.373 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.253 SNIP 0.344 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.231 SNIP 0.272 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.28 SNIP 0.354 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.292 SNIP 0.352 CiteScore 0.43
Wind profiles and forests

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2007
Event: Paper presented at Strategisk energiforskning. Igangværende forskningsprojekter under Det Strategiske Forskningsråd (DSF), Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 216151
Publication: Research - peer-review › Conference article – Annual report year: 2007

Aeroelastic response in extreme wind cases

General information
State: Published
Organisations: Aeroelastic Design, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Larsen, G. C. (Intern), Hansen, K. S. (Intern), Larsen, T. J. (Intern), Mann, J. (Intern)
Pages: 69-87
Publication date: 2006

Host publication information
Title of host publication: Research in aeroelasticity EFP-2005
Volume: Rise-R-1559(EN)
Editor: Bak, C.
ISBN (Print): 87-550-3521-3
Main Research Area: Technical/natural sciences
Links:
http://www.risoe.dtu.dk/rispubl/VEA/veapdf/ris-r-1559.pdf
Source: orbit
Source-ID: 309591
Publication: Research › Book chapter – Annual report year: 2006

Backwards and forwards relative dispersion in turbulent flow: An experimental investigation
From particle tracking velocimetry we present an experimental measure of the ratio between backwards and forwards relative dispersion in an intermediate Reynolds number turbulent flow. Lack of time-reversal symmetry implies that their ratio may be different from 1. From a stochastic model, this has recently been studied by Sawford [Phys. Fluids 17, 095109 (2005)] giving ratios between 5 and 20. We find a value of approximately 2 and discuss it in the context of the characteristics of the rate of strain tensor $s_{ij}$. An analysis of a direct numerical simulation by Biferale [Phys. Rev. Lett. 93,
064502 (2004) and Phys. Fluids 17, 021701 (2004)] gives the same result.

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division
Authors: Berg, J. (Intern), Lüthi, B. (Intern), Mann, J. (Intern), Ott, S. (Intern)
Number of pages: 7
Pages: 016304
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**
Volume: 74
Issue number: 1
ISSN (Print): 1539-3755
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.95 SJR 0.993 SNIP 0.896
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.047 SNIP 0.978 CiteScore 1.89
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.22 SNIP 1.123 CiteScore 2.05
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.311 SNIP 1.239 CiteScore 2.28
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.42 SNIP 1.226 CiteScore 2.28
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.485 SNIP 1.225 CiteScore 2.28
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.69 SNIP 1.215
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.694 SNIP 1.259
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.96 SNIP 1.314
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.926 SNIP 1.332
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.787 SNIP 1.324
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.71 SNIP 1.302
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.672 SNIP 1.214
Coarse-grained strain dynamics and backwards/forwards dispersion

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Berg, J. (Intern), Lüthi, B. (Ekstern), Ott, S. (Intern), Mann, J. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Arxiv.com
Original language: English
Links:
http://arxiv.org/abs/physics/0610150v1
Source: orbit
Source-ID: 216118
Publication: Research › Journal article – Annual report year: 2007

Ekstremvinde og kompleks terræn

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 309874
Publication: Research › Conference abstract for conference – Annual report year: 2006

Extreme winds and the connection to reanalysis data (paper and poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Larsén, X. (Intern), Mann, J. (Intern), Ejsing Jørgensen, H. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Fast laser doppler wake measurements

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Bingöl, F. (Intern), Ejsing Jørgensen, H. (Intern), Mikkelsen, T. (Intern), Larsen, G. C. (Intern), Coffey, A. (Ekstern), Harris, M. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 309220
Publication: Research › Conference abstract in proceedings – Annual report year: 2006

Laboratory studies of predator-prey encounters in turbulent environments: Effects of changes in orientation and field of view

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Pecseli, H. (Ekstern), Trulsen, J. (Ekstern)
Pages: 509-522
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Plankton Research
Volume: 28
ISSN (Print): 0142-7873
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.92 SJR 1.098 SNIP 0.848
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.025 SNIP 0.796 CiteScore 1.77
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.095 SNIP 1.255 CiteScore 2.24
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.289 SNIP 1.109 CiteScore 2.39
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Large-eddy simulation of neutral atmospheric boundary layer

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Authors: Hansen, A. (Ekstern), Mann, J. (Intern), Johansen, J. (Intern), Sørensen, N. N. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 8
Issue number: Abstr. EGU06-A-02672
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
Larger scales of wind speeds

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Sørensen, P. E. (Intern), Mann, J. (Intern), Schmidt Paulsen, U. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Geophysical Research Abstracts
Volume: 8
Series: Geophysical Research Abstracts
ISSN: 1607-7962
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 309132
Publication: Research › Conference abstract in proceedings – Annual report year: 2006

Laser Doppler scanning of a wind turbine wake

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Bingöl, F. (Intern), Larsen, G. C. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 8
Issue number: Abstr. EGU06-A-06888
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 309133
Publication: Research › Journal article – Annual report year: 2006
Mean wind and turbulence in the atmospheric boundary layer above the surface layer

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Larsen, S. E. (Intern), Gryning, S. (Intern), Jensen, N. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern)
Pages: 21-25
Publication date: 2006

**Host publication information**
Title of host publication: Wind energy. Proceedings of the Euromech colloquium
Place of publication: Berlin
Publisher: Springer
Editors: Peinke, J., Schaumann, P., Barth, S.
ISBN (Print): 3-540-33865-9
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 464b Wind Energy, Oldenburg, Germany, 04/10/2005 - 04/10/2005
Source: orbit
Source-ID: 309839
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Mean wind and turbulence profiles at greater heights

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Ejsing Jørgensen, H. (Intern), Gryning, S. (Intern), Larsen, S. E. (Intern), Mikkelsen, T. (Intern), Mann, J. (Intern), Astrup, P. (Intern)
Publication date: 2006

**Host publication information**
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 309201
Publication: Research › Article in proceedings – Annual report year: 2006

Scaling of measured velocity spectra from the 168 meter tall met-tower at Høvsøre, Denmark: Evidence of combined inertial $K^{-5/3}$ and production $K^{-1}$ subranges in the near-neutral atmospheric surface layer

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ejsing Jørgensen, H. (Intern), Astrup, P. (Intern), Mann, J. (Intern), Mikkelsen, T. (Intern)
Publication date: 2006

**Host publication information**
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 309213
Publication: Research › Conference abstract in proceedings – Annual report year: 2006
Simulation of turbulence, gusts and wakes for load calculations

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Pages: 87-92
Publication date: 2006

Host publication information
Title of host publication: Wind energy. Proceedings of the Euromech colloquium
Place of publication: Berlin
Publisher: Springer
Editors: Peinke, J., Schaumann, P., Barth, S.
ISBN (Print): 3-540-33865-9
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 464b Wind Energy, Oldenburg, Germany, 04/10/2005 - 04/10/2005
Source: orbit
Source-ID: 309840
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Surface-layer wind and turbulence profiling from LiDAR: Theory and measurements

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Danielian, R. (Ekstern), Ejsing Jørgensen, H. (Intern), Mikkelsen, T. (Intern), Mann, J. (Intern), Harris, M. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 309229
Publication: Research › Article in proceedings – Annual report year: 2006

The effects of disjunct sampling and averaging time on maximum mean wind speeds
Conventionally, the 50-year wind is calculated on basis of the annual maxima of consecutive 10-min averages. Very often, however, the averages are saved with a temporal spacing of several hours. We call it disjunct sampling. It may also happen that the wind speeds are averaged over a longer time period before being saved. In either case, the extreme wind will be underestimated. This paper investigates the effects of the disjunct sampling interval and the averaging time on the attenuation of the extreme wind estimation by means of a simple theoretical approach as well as measurements. The measurements include climates dominated by extratropical lows, as well as more complicated, wind climate types. For both, the investigations are done for omni-directional and sector-wise situations. The theory assumes the time series is a Gaussian Markov chain and it performs adequately for sites in the extratropical regions. The sector-wise situation is more complicated. The attenuation of the extreme mean winds for a sector shows a dependency on the frequency of occurrence from that sector.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Larsén, X. G. (Intern), Mann, J. (Intern)
Pages: 581-602
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Wind Engineering & Industrial Aerodynamics
Volume: 94
Towards more realistic extreme load predictions (paper and poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Aeroelastic Design
Authors: Mann, J. (Intern), Larsen, G. C. (Intern), Larsen, T. J. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings (online)
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 309214
Publication: Research › Article in proceedings – Annual report year: 2006

Traffic restrictions due to wind on the Fehmarn Belt bridge

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Dellwik, E. (Intern), Mann, J. (Intern), Rosenhagen, G. (Ekstern)
Number of pages: 27
Publication date: 2006

Publication information
ISBN (Print): 87-550-3452-7
Original language: English
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1521(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Risø-R-1521, Risø-R-1521(EN)
Electronic versions:
ris_r_1521.pdf
Source: orbit
Source-ID: 309074
Publication: Research › Report – Annual report year: 2006

Wakes in large wind farms

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Barthelmie, R. (Intern), Frandsen, S. (Ekstern), Mechali, M. (Ekstern), Jensen, L. (Ekstern), Sørensen, P. (Ekstern), Rethore, P. (Ekstern), Mann, J. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 8
Issue number: Abstr. EGU06-A-01401
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
WAsP engineering in the forest

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Dellwik, E. (Intern), Mann, J. (Intern)
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 8
Issue number: Abstr. EGU06-A-05658
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 309137
Publication: Research › Journal article – Annual report year: 2006

Wind farm power fluctuations

General information
State: Published
Organisations: Wind Energy Systems, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Meteorology, Test and Measurements
Authors: Sørensen, P. E. (Intern), Mann, J. (Intern), Schmidt Paulsen, U. (Intern), Vesth, A. (Intern)
Number of pages: 338
Pages: 139-145
Publication date: 2006

Host publication information
Title of host publication: Wind energy. Proceedings of the Euromech colloquium
Place of publication: New York, NY (US)
Publisher: Springer Verlag
Editors: Peinke, J., Schaumann, P., Barth, S.
ISBN (Print): 978-3-540-33865-9
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 464b Wind Energy, Oldenburg, Germany, 04/10/2005 - 04/10/2005
Source: orbit
Source-ID: 236905
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
Wind lidar evaluation at the Danish wind test site in Høvsøre

Initial assessments of a wind lidar have shown the technology to have significant potential for wind field measurements in the wind energy industry. A more extended evaluation is now reported using a scanning lidar next to a meteorological mast with calibrated anemometers at the Risø wind test site in Høvsøre on the windy northwest coast of Denmark. Results are presented of wind speed comparisons at heights up to 100 m above ground level showing excellent correlation between the lidar and the cup anemometers. Copyright © 2006 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Smith, D. (Ekstern), Harris, M. (Ekstern), Coffey, A. (Ekstern), Mikkelsen, T. (Intern), Ejisng Jørgensen, H. (Intern), Mann, J. (Intern), Danielian, G. (Ekstern)
Pages: 87-93
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy
Volume: 9
Issue number: 1-2
ISSN (Print): 1095-4244
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.104 SNIP 2.306
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.196 SNIP 2.086 CiteScore 3.06
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.272 SNIP 3.75 CiteScore 3.42
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.275 SNIP 2.464 CiteScore 2.75
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.126 SNIP 2.39 CiteScore 2.36
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.024 SNIP 2.718 CiteScore 2.49
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.487 SNIP 2.013
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.124 SNIP 1.448
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.826 SNIP 1.559
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.053 SNIP 1.453
Advances in particle tracking in turbulent flows

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Lüthi, B. (Intern), Ott, S. (Intern), Berg, J. (Intern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308048
Publication: Research › Conference abstract for conference – Annual report year: 2005

An experimental test of Corrsin's conjecture and some related ideas

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Ott, S. (Intern), Mann, J. (Intern)
Pages: Art. no. 142, 24 p.
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: New Journal of Physics
Volume: 7
ISSN (Print): 1367-2630
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.97 SJR 1.788 SNIP 1.031
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.938 SNIP 1.047 CiteScore 2.8
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.806 SNIP 1.307 CiteScore 2.89
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
A tool for calculation of site specific wind conditions

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Ejsing Jørgensen, H. (Intern), Nielsen, M. (Intern), Jørgensen, E. (Intern), Mann, J. (Intern), Frandsen, S. (Ekstern), Landberg, L. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Wind energy: Connecting customers to clean power today. Proceedings (CD-ROM)
Place of publication: Washington, DC
Publisher: American Wind Energy Association (AWEA)
Main Research Area: Technical/natural sciences
Conference: Windpower 2005 conference and exhibition, Denver, CO (US), 15-18 May, 01/01/2005
Computational wind power meteorology in complex terrain compared to measurements (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Authors: Jørgensen, B. (Intern), Hansen, A. (Intern), Myllerup, L. (Intern), Sørensen, N. N. (Intern), Mann, J. (Intern), Ott, S. (Intern), Badger, J. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 307866
Publication: Research › Article in proceedings – Annual report year: 2005

DSF, ekstemvinde

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308302
Publication: Research › Conference abstract for conference – Annual report year: 2005

Experimental studies of occupation and transit times in turbulent flows

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Berg, J. (Intern), Mann, J. (Intern), Ott, S. (Intern), Pécseli, H. (Ekstern), Trulsen, J. (Ekstern)
Number of pages: 12
Pages: 035111
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Physics of Fluids
Volume: 17
Issue number: 3
ISSN (Print): 1070-6631
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.16 SJR 1.29 SNIP 1.291
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.366 SNIP 1.278
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.354 SNIP 1.348
Hybrid RANS/LES of neutral atmospheric boundary layer: Simple terrain

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Authors: Hansen, A. (Ekstern), Mann, J. (Intern), Johansen, J. (Intern), Sørensen, N. N. (Intern)
Publication date: 2005
Event: Abstract from ITI Conference in Turbulence, Bad Zwischenahn, Germany.
Main Research Area: Technical/natural sciences
Potential climate change impact on wind energy resources in northern Europe

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Pryor, S. (Ekstern), Barthelmie, R. (Intern), Kjellström, E. (Ekstern), Mann, J. (Intern)
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 7
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 307988
Publication: Research › Journal article – Annual report year: 2005

Predator-prey encounters in turbulent waters

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Pécseli, H. (Ekstern), Mann, J. (Intern), Ott, S. (Intern), Trulsen, J. (Ekstern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308051
Publication: Research › Conference abstract for conference – Annual report year: 2005

Profiles of mean wind and turbulence in the atmospheric boundary layer above the surface layer

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Larsen, S. E. (Intern), Gryning, S. (Intern), Jensen, N. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern)
Number of pages: 15
Publication date: 2005

Host publication information
Title of host publication: [Program and abstracts]
Place of publication: Oldenburg
Publisher: ForWind - Center for Wind Energy Research
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 464b Wind Energy, Oldenburg, Germany, 04/10/2005 - 04/10/2005
Source: orbit
Source-ID: 308783
Publication: Research › Conference abstract in proceedings – Annual report year: 2005
Simulation of turbulence, gusts and wakes for load calculations (invited talk)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Number of pages: 26
Publication date: 2005

Host publication information
Title of host publication: [Program and abstracts]
Place of publication: Oldenburg
Publisher: ForWind - Center for Wind Energy Research
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 464b Wind Energy, Oldenburg, Germany, 04/10/2005 - 04/10/2005
Source: orbit
Source-ID: 308784
Publication: Research › Conference abstract in proceedings – Annual report year: 2005

The meteorology of the very large wind turbines

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Astrup, P. (Intern), Jensen, N. (Intern), Landberg, L. (Intern), Ejsing Jørgensen, H. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Proceedings CD-ROM
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 307858
Publication: Research › Article in proceedings – Annual report year: 2005

Turbulent particle flux to a perfectly absorbing surface
The feasibility of an experimental method for investigations of the particle flux to an absorbing surface in turbulent flows is demonstrated in a Lagrangian as well as an Eulerian representation. A laboratory experiment is carried out, where an approximately homogeneous and isotropic turbulent flow is generated by two moving grids. The simultaneous trajectories of many small approximately neutrally buoyant polystyrene particles are followed in time. In a Lagrangian analysis, we select one of these as the centre of a ‘sphere of interception’, and obtain estimates for the time variation of the statistical average of the inward particle flux through the surface of this moving sphere. The variation of the flux with the radius in the sphere of interception, as well as the variation with basic flow parameters is described well by a simple model, in particular for radii smaller than a characteristic length scale for the turbulence. The Eulerian counterpart of the problem is analysed as well, and the two results compared. Applications of the problem to, for instance, the question of the feeding rate of micro-organisms in turbulent marine environments are pointed out.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Pecseli, H. (Ekstern), Trulsen, J. (Ekstern)
Pages: 1-21
Publication date: 2005
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Fluid Mechanics
Volume: 534
ISSN (Print): 0022-1120
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
Wakes within and downwind of large offshore wind farms

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Barthelmie, R. (Intern), Frandsen, S. (Ekstern), Pryor, S. (Ekstern), Mann, J. (Intern)
Publication date: 2005

Host publication information
Title of host publication: Geophys. Res. Abstr. (CD-ROM)
Volume: 7
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 307989
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2005

Wind farm power fluctuations

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Sørensen, P. (Ekstern), Mann, J. (Intern), Paulsen, U. (Ekstern), Vesth, A. (Intern)
Number of pages: 29
Publication date: 2005

Host publication information
Title of host publication: [Program and abstracts]
Place of publication: Oldenburg
Publisher: ForWind - Center for Wind Energy Research
Main Research Area: Technical/natural sciences
Conference: EUROMECH Colloquium 464b Wind Energy, Oldenburg, Germany, 04/10/2005 - 04/10/2005
Source: orbit
Source-ID: 308786
Publication: Research › Conference abstract in proceedings – Annual report year: 2005

Analytical modelling of large wind farm clusters

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division, Meteorology, Wind Turbines
Authors: Barthelmie, R. J. (Intern), Frandsen, S. T. (Intern), Pryor, S. (Ekstern), Larsen, S. E. (Intern), Mann, J. (Intern)
Publication date: 2004
Event: Abstract from European Geophysical Union meeting, Nice (FR), Apr, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 307465
Publication: Research › Conference abstract for conference – Annual report year: 2004

Biases in the estimation of extreme winds

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Larsén, X. (Intern), Kristensen, L. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 6
ISSN (Print): 1607-7962
Ratings:
Can satellite sampling of offshore wind speeds realistically represent wind speed distributions. Part 2. Quantifying uncertainties associated with sampling strategy and distribution fitting methods

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Pryor, S. (Ekstern), Nielsen, M. (Intern), Barthelmie, R. (Intern), Mann, J. (Intern)
Pages: 739-750
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Volume: 43
ISSN (Print): 0894-8763
Ratings:
BFI (2008): BFI-level 1
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Web of Science (2001): Indexed yes
Web of Science (2000): Indexed yes
Original language: English
DOIs: 10.1175/2096.1
Source: orbit
Source-ID: 306916
Publication: Research - peer-review › Journal article – Annual report year: 2004

Computational wind power meteorology in complex terrain compared to measurements (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Authors: Jørgensen, B. (Intern), Hansen, A. (Intern), Myllerup, L. (Intern), Sørensen, N. N. (Intern), Mann, J. (Intern), Ott, S. (Intern), Badger, J. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 307419
Publication: Research › Poster – Annual report year: 2004

Evaluation of a new optical fibre-based monostatic continuous wave Doppler wind lidar for atmospheric boundary layer applications

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Experimental investigation of doubling times of turbulent separation

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Berg, J. (Intern), Pecseli, H. (Ekstern), Trulsen, J. (Ekstern)
Publication date: 2004
Event: Abstract from Fluid mechanical stirring and mixing EU network meeting, Paris (FR), 13-14 Nov, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 306690
Publication: Research › Conference abstract for conference – Annual report year: 2004

Lagrangian experiments

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2004
Event: Abstract from ERCOFTAC SIG 36 meeting on multipoint turbulence structure and modelling, Lyon (FR), 25 Apr, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 306691
Publication: Research › Conference abstract for conference – Annual report year: 2004

Predator-prey encounters in turbulent waters

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Pecseli, H. (Ekstern), Mann, J. (Intern), Ott, S. (Intern), Trulsen, J. (Ekstern)
Publication date: 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 306692
Publication: Research › Conference abstract for conference – Annual report year: 2004
Simulation of extreme gusts

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Nielsen, M. (Intern), Larsen, G. C. (Intern), Mann, J. (Intern), Ott, S. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 6
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 306782
Publication: Research › Journal article – Annual report year: 2004

Site wind field determination using a cw Doppler lidar - comparison with cup anemometers at Risø

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ejsing Jørgensen, H. (Intern), Mikkelsen, T. (Intern), Mann, J. (Intern), Bryce, D. (Ekstern), Coffey, A. (Ekstern), Harris, M. (Ekstern), Smith, D. (Ekstern)
Pages: 261-266
Publication date: 2004

Host publication information
Title of host publication: Proceedings
Place of publication: Delft
Publisher: Delft University of Technology
ISBN (Print): 90-76468-10-9
Main Research Area: Technical/natural sciences
Conference: Special topic conference: The science of making torque from wind, Delft (NL), 19-21 Apr, 01/01/2004
Source: orbit
Source-ID: 306793
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

WindEng - Research activity in an European training network

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division
Pages: 325-337
Publication date: 2004
Main Research Area: Technical/natural sciences
Wind lidar evaluation at the Danish wind test site in Høvsøre

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Smith, D. (Ekstern), Harris, M. (Ekstern), Coffey, A. (Ekstern), Mikkelsen, T. (Intern), Ejsing Jørgensen, H. (Intern), Mann, J. (Intern), Danielian, R. (Ekstern)
Pages: 44-46
An experimental test of Corrsin’s independence hypothesis and related assumptions

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Pages: 31-32
Publication date: 2003

Host publication information
Title of host publication: BACCI
Place of publication: Roskilde
Publisher: Risø National Laboratory
Main Research Area: Technical/natural sciences
Conference: Workshop on surface flux, micrometeorology and chemistry, Risø (DK), 11-12 Nov, 01/01/2003
Source: orbit
Source-ID: 306071
Publication: Research › Conference abstract in proceedings – Annual report year: 2003

Computational methods in wind power meteorology (poster)

General information
State: Published
Organisations: Wind Energy Division, Risø National Laboratory for Sustainable Energy
Authors: Sørensen, N. N. (Intern), Mann, J. (Intern), Jørgensen, B. (Intern)
Publication date: 2003
Event: Poster session presented at DCSC seminar, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 306399
Publication: Research › Poster – Annual report year: 2003

Conditional simulation or Turning your gaussian wind field simulator into a gust machine

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ott, S. (Intern), Larsen, G. C. (Intern), Nielsen, M. (Intern), Mann, J. (Intern)
Pages: 47-51
Publication date: 2003

Host publication information
Title of host publication: IEA joint action
Place of publication: Stockholm
Publisher: FOI
Editor: Thor, S.
Series: FOI-S-0822
Main Research Area: Technical/natural sciences
Source: orbit
Errors introduced by satellite sampling of offshore wind speeds

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Pryor, S. (Ekstern), Barthelmie, R. (Intern), Mann, J. (Intern), Nielsen, M. (Intern)
Publication date: 2003

Host publication information
Title of host publication: Proceedings CD-ROM. CD 2
Place of publication: Brussels
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Workshop: 2003 European Wind Energy Conference and Exhibition, Madrid, Spain, 16/06/2003 - 16/06/2003
Source: orbit
Source-ID: 306173
Publication: Research › Article in proceedings – Annual report year: 2003

Experimental studies of occupation times in turbulent flows
The motion of passively convected particles in turbulent flows is studied experimentally in approximately homogeneous and isotropic turbulent flows, generated in water by two moving grids. The simultaneous trajectories of many small passively convected, neutrally buoyant, polystyrene particles are followed in time by a particle tracking technique. We estimate the probability distribution of the occupation times of such particles in spherical volumes with a given radius. A self-consistently moving particle defines the center of the reference sphere, with the occupation time being defined as the difference between entrance and exit times of surrounding particles convected through the sphere by the turbulent motions. Simple, and seemingly universal, scaling laws are obtained for the probability density of the occupation times in terms of the basic properties for the turbulent flow and the geometry. In the present formulation, the results of the analysis are relevant for understanding details in the feeding rate of micro-organisms in turbulent waters, for instance.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Pécseli, H. (Ekstern), Trulsen, J. (Ekstern)
Number of pages: 4
Pages: 056307
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Volume: 67
Issue number: 5
ISSN (Print): 1539-3755
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.95 SJR 0.993 SNIP 0.896
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.047 SNIP 0.978 CiteScore 1.89
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.22 SNIP 1.123 CiteScore 2.05
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.311 SNIP 1.239 CiteScore 2.28
ISI indexed (2013): ISI indexed yes
Quantifying errors associated with satellite sampling of offshore wind speeds

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Pryor, S. (Ekstern), Barthelmie, R. (Intern), Mann, J. (Intern), Nielsen, M. (Intern)
Pages: 143-157
Publication date: 2003

Host publication information
Title of host publication: Offshore wind energy in Mediterranean and other European seas. Resources, technology, applications
Place of publication: Naples
Publisher: Univ. of Naples
Main Research Area: Technical/natural sciences
Wind Simulation for Extreme and Fatigue Loads

Measurements of atmospheric turbulence have been studied and found to deviate from a Gaussian process, in particular regarding the velocity increments over small time steps, where the tails of the pdf are exponential rather than Gaussian. Principles for extreme event counting and the occurrence of cascading events are presented. Empirical extreme statistics agree with Rice’s exceedence theory, when it is assumed that the velocity and its time derivative are independent. Prediction based on the assumption that the velocity is a Gaussian process underpredicts the rate of occurrence of extreme events by many orders of magnitude, mainly because the measured pdf is non-Gaussian. Methods for simulation of turbulent signals have been developed and their computational efficiency are considered. The methods are applicable for multiple processes with individual spectra and probability distributions. Non-Gaussian processes are simulated by the correlation-distortion method. Non-stationary processes are obtained by Bezier interpolation between a set of stationary simulations with identical random seeds. Simulation of systems with some signals available is enabled by conditional statistics. A versatile method for simulation of extreme events has been developed. This will generate gusts, velocity jumps, extreme velocity shears, and sudden changes of wind direction. Gusts may be prescribed with a specified ensemble average shape, and it is possible to detect the critical gust shape for a given construction. The problem is formulated as the variational problem of finding the most probable adjustment of a standard simulation of a stationary
Gaussian process subject to relevant event conditions, which are formulated as linear combination of points in the realization. The method is generalized for multiple correlated series, multiple simultaneous conditions, and 3D fields of all velocity components. Generalization are presented for a single non-Gaussian process subject to relatively simple conditions, i.e. gusts and velocity jumps. Further generalizations for simulation of multiple correlated non-Gaussian processes are suggested.

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Department of Wind Energy, Fluid Mechanics, Department of Mechanical Engineering
Authors: Nielsen, M. (Intern), Larsen, G. C. (Intern), Mann, J. (Intern), Ott, S. (Intern), Hansen, K. S. (Intern), Pedersen, B. (Ekstern)
Number of pages: 104
Publication date: 2003

**Publication information**
ISBN (Print): 87-550-3281-8
Original language: English

Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1437(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences

Electronic versions:
ris_r_1437.pdf

**Bibliographical note**
(Internet)
Source: orbit
Source-ID: 25742
Publication: Research › Report – Annual report year: 2003

An experimental test of Corrsin's independence hypothesis and related assumptions (poster)

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Publication date: 2002
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Geophysical Research Abstracts
Volume: 4
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Links:
http://www.cosisin.net/abstracts/EGS02/06070/EGS02-A-06070.pdf
Source: orbit
Source-ID: 304006
Publication: Research › Journal article – Annual report year: 2002
Estimering af vindressourcer, herunder WAsP and WAsP engineering

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Landberg, L. (Intern), Mann, J. (Intern)
Publication date: 2002
Event: Abstract from 23rd Nordic Meteorologists’ meeting, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 303951
Publication: Research › Conference abstract for conference – Annual report year: 2002

Eulerian and Lagrangian statistics from particle tracking data

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Publication date: 2002
Event: Abstract from Workshop on turbulence and anomalous transport in plasmas and fluids, Roskilde, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 303997
Publication: Research › Conference abstract for conference – Annual report year: 2002

Predator-prey encounters in turbulent waters
With reference to studies of predator-prey encounters in turbulent waters, we demonstrate the feasibility of an experimental method for investigations of particle fluxes to an absorbing surface in turbulent flows. A laboratory experiment is carried out, where an approximately homogeneous and isotropic turbulent flow is generated by two moving grids. The simultaneous trajectories of many small neutrally buoyant polystyrene particles are followed in time. Selecting one of these to represent a predator, while the others are considered as prey, we obtain estimates for the time variation of the statistical average of the prey flux into a suitably defined “sphere of interception.” The variation of this flux with the radius in the sphere of interception, as well as the variation with basic flow parameters is well described by a simple model, in particular for radii smaller than a characteristic length scale for the turbulence. Also the Eulerian counterpart of the problem has been analyzed, and the particle fluxes from the two studies compared.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Pécseli, H. (Ekstern), Trulsen, J. (Ekstern)
Number of pages: 4
Pages: 026304
Publication date: 2002
Main Research Area: Technical/natural sciences

Publication information
Volume: 65
Issue number: 2
ISSN (Print): 1063-651X
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.95 SJR 0.993 SNIP 0.896
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.047 SNIP 0.978 CiteScore 1.89
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.22 SNIP 1.123 CiteScore 2.05
Sampling statistics of atmospheric observations

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Kristensen, L. (Intern), Kirkegaard, P. (Intern), Mann, J. (Intern)
Pages: 301-313
Publication date: 2002
Main Research Area: Technical/natural sciences
50 year return wind around Denmark from global reanalysis data (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Frank, H. (Intern), Mann, J. (Intern)
Pages: 765-768
Publication date: 2001

Host publication information
Title of host publication: Wind energy for the new millennium. Proceedings
Place of publication: München
Publisher: WIP Renewable Energies
Editors: Helm, P., Zervos, A.
Main Research Area: Technical/natural sciences
Conference: 2001 European Wind Energy Conference and Exhibition (EWEC '01), Copenhagen, Denmark, 02/07/2001 - 02/07/2001
Source: orbit
Source-ID: 303191
Publication: Research › Article in proceedings – Annual report year: 2001

A turbulent diffusion experiment

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Number of pages: 50
Publication date: 2001

Host publication information
Title of host publication: Wind Energy Department: Scientific and technical progress 1999-2000
Volume: Risø-R-1239(EN)
Editors: Skrumsager, B., Larsen, G.
ISBN (Print): 87-550-2818-7
Main Research Area: Technical/natural sciences
Links:
http://www.risoe.dtu.dk/rispubl/VEA/veapdf/ris-r-1239.pdf
Source: orbit
Source-ID: 303259
Publication: Research › Book chapter – Annual report year: 2001

Ekstreme havvinde

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2001
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 302312
Publication: Research › Conference abstract for conference – Annual report year: 2001

Extreme gusts over coastal waters
Oplæg til undersøgelse af ekstraordinære lasttilfælde til havs

Resource assessment: Wind resource estimation, short-term prediction, design wind conditions

WAsP engineering
WAsP engineering

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Number of pages: 26
Publication date: 2001

Host publication information
Title of host publication: Wind Energy Department: Scientific and technical progress 1999-2000
Volume: Risø-R-1239(EN)
Editors: Skrumsager, B., Larsen, G.
ISBN (Print): 87-550-2818-7
Main Research Area: Technical/natural sciences

Links:
http://www.risoe.dtu.dk/rispubl/VEA/veapdf/ris-r-1239.pdf
Source: orbit
Source-ID: 303235
Publication: Research - peer-review › Book chapter – Annual report year: 2001

WAsP Engineering 2000

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Main Research Area: Technical/natural sciences

Source: orbit
Source-ID: 303230
Publication: Research › Conference abstract for conference – Annual report year: 2001

WAsP engineering (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Enevoldsen, K. (Intern), Astrup, P. (Intern), Madsen, P. H. (Intern), Heathfield, D. (Ekstern)
Event: Poster session presented at 2001 European Wind Energy Conference and Exhibition (EWEC '01), Copenhagen, Denmark.
Main Research Area: Technical/natural sciences

Source: orbit
Source-ID: 303052
Publication: Research › Poster – Annual report year: 2001

WAsP engineering. User manual

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Number of pages: 38
Publication date: 2001

Publication information
Original language: English
Main Research Area: Technical/natural sciences

Source: orbit
Source-ID: 302980
Publication: Research - peer-review › Report – Annual report year: 2001
An experiment on relative dispersion in turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Publication date: 2000
Event: Abstract from Meeting at Cornell University, New York, NY (US), 29 Aug, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 301339
Publication: Research › Conference abstract for conference – Annual report year: 2000

En orkan, dens fysik og dens ekstreme vinde

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Aakjær, P. (Ekstern), Mann, J. (Intern)
Publication date: 2000
Event: Abstract from Medlemsmøde i DaMS, København (DK), 20 Sep, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 301126
Publication: Research › Conference abstract for conference – Annual report year: 2000

Én storm gør ingen norm

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Hansen, S. (Ekstern)
Pages: 28-34
Negative shear gusts in complex terrain

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2000
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 301338
Publication: Research › Conference abstract for conference – Annual report year: 2000

Particle tracking in three dimensions

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ott, S. (Intern), Mann, J. (Intern)
Publication date: 2000
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 301535
Publication: Research › Conference abstract for conference – Annual report year: 2000

Particle tracking, Kolmogorov's 4/5 law and relative dispersion in turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 2000
Event: Abstract from Colloquium, Optics and Fluid Dynamics Department, Risø (DK), 18 Mar.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 300787
Publication: Research › Conference abstract for conference – Annual report year: 2000

Quantification of anisotropy in an oscillating grid flow

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Pages: 877-880
Publication date: 2000

Host publication information
Title of host publication: Advances in turbulence 8. Proceedings
Relative turbulent diffusion

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ott, S. (Intern), Mann, J. (Intern)
Publication date: 2000
Event: Abstract from Meeting at Roskilde University Center, Roskilde (DK), 24 Feb, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 301533
Publication: Research › Article in proceedings – Annual report year: 2000

Scaling of turbulent spectra in the atmospheric surface layer under stable conditions

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ejsing Jørgensen, H. (Intern), Larsen, S. E. (Intern), Mann, J. (Intern)
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Geophysical Research Abstracts
Volume: 2
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 301012
Publication: Research › Conference abstract for conference – Annual report year: 2000

The spectral velocity tensor in moderately complex terrain

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Pages: 153-169
Publication date: 2000
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Wind Engineering & Industrial Aerodynamics
Volume: 88
Velocity-acceleration structure function and Kolmogorov's 4/5 law

General information
State: Published
3D particle tracking - measurements on turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Andersen, J. (Ekstern), Ott, S. (Intern), Mann, J. (Intern)
Publication date: 1999

Host publication information
Title of host publication: Programme. Abstracts. List of participants
Place of publication: København
Publisher: HCØ Tryk
ISBN (Print): 87-7834-335-6
Main Research Area: Technical/natural sciences
Conference: 1999 Annual meeting of the Danish Physical Society, Nyborg, Denmark, 03/06/1999 - 03/06/1999
Source: orbit
Source-ID: 300272
Publication: Research › Conference abstract in proceedings – Annual report year: 1999

Danish extreme wind atlas: Background and methods for a WAsP engineering option

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Rathmann, O. (Intern), Kristensen, L. (Intern), Mann, J. (Intern), Hansen, S. (Ekstern)
Pages: 1058-1061
Publication date: 1999

Host publication information
Title of host publication: Wind energy for the next millennium. Proceedings
Place of publication: London
Publisher: James and James Science Publishers
Editors: Petersen, E., Hjuler Jensen, P., Rave, K., Helm, P., Ehmann, H.
ISBN (Print): 1-902916-00-X
Main Research Area: Technical/natural sciences
Conference: 1999 European Wind Energy Conference and Exhibition, Nice, France, 01/03/1999 - 01/03/1999
Source: orbit
Source-ID: 299890
Publication: Research › Article in proceedings – Annual report year: 1999

Engineering spectra over water

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Pages: 437-461
Publication date: 1999

Host publication information
Title of host publication: Air-sea exchange: Physics, chemistry and dynamics
Place of publication: Dordrecht
Publisher: Kluwer Academic Publishers
Editor: Geernaert, G.
Main Research Area: Technical/natural sciences
Experimental study of relative, turbulent diffusion

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Andersen, J. (Ekstern)
Number of pages: 75
Publication date: 1999

Publication information
ISBN (Print): 87-550-2370-3
Original language: English
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1036(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Risø-R-1036, Risø-R-1036(EN)
Electronic versions:
ris_r_1036.pdf
Source: orbit
Source-ID: 300036
Publication: Research › Report – Annual report year: 1999

Measurements of structure functions and relative dispersion in turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern)
Publication date: 1999
Event: Abstract from Seminar at Danish Center for Applied Mathematics and Mechanics (DCAMM), Lyngby (DK), 17 Feb,
.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 299874
Publication: Research › Conference abstract for conference – Annual report year: 1999

Modelling of the spectral velocity tensor in complex terrain

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Pages: 257-264
Publication date: 1999

Host publication information
Title of host publication: Wind engineering into the 21. century. Vol. 1
Place of publication: Rotterdam
Publisher: Balkema Publishers, A.A. / Taylor & Francis The Netherlands
Editors: Larsen, A., Larose, G., Livesey, F.
ISBN (Print): 90-5809-059-0
Main Research Area: Technical/natural sciences
Conference: 10th International Conference on Wind Engineering, Copenhagen, Denmark, 21/06/1999 - 21/06/1999
Source: orbit
Source-ID: 300053
Publication: Research › Article in proceedings – Annual report year: 1999
Particle tracking, Kolmogorov's 4/5-law and relative dispersion in turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ott, S. (Intern), Mann, J. (Intern), Andersen, J. (Ekstern)
Publication date: 1999
Event: Abstract from Meeting on chaos and turbulence studies, Niels Bohr Institute, Copenhagen (DK), 21 Apr, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 300017
Publication: Research › Conference abstract for conference – Annual report year: 1999

Scaling of turbulent spectra in the atmospheric surface layer under strong diabatic conditions

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Ejsing Jørgensen, H. (Intern), Larsen, S. E. (Intern), Mann, J. (Intern), Mikkelsen, T. (Intern), Cuxart, J. (Ekstern)
Pages: 436
Publication date: 1999
Main Research Area: Technical/natural sciences
Publication information
Journal: Geophysical Research Abstracts
Volume: 1
ISSN (Print): 1607-7962
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 300424
Publication: Research › Journal article – Annual report year: 1999

The effects of atmospheric turbulence on the cross correlation between wind and travel time fluctuations

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Norris, D. (Ekstern), Kristensen, L. (Intern), Mann, J. (Intern), Thomson, D. (Ekstern), Swanson, D. (Ekstern)
Pages: 2804
Publication date: 1999
Main Research Area: Technical/natural sciences
Publication information
Volume: 103
Issue number: 5 Pt. 2
ISSN (Print): 0001-4966
Ratings:
BFI (2018): BFI-level 2
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.83 SJR 0.749 SNIP 1.27
Turbulence in complex terrain

General information
State: Published
Gust loading on streamlined bridge decks
The current analytical description of the buffeting action of wind on long-span bridges is based on the strip assumption. However, recent experiments on closed-box girder bridge decks have shown that this assumption is not valid and is the source of an important part of the error margin of the analytical prediction methods. In this paper, an analytical model that departs from the strip assumption is used to describe the gust loading on a thin airfoil. A parallel is drawn between the analytical model and direct measurements of gust loading on motionless closed-box girder bridge decks. Empirical models of aerodynamic admittance and span-wise coherence of the aerodynamic forces are proposed for a family of deck cross-sections. (C) 1998 Academic Press.
Measurements of structure functions and relative dispersion in turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Ott, S. (Intern), Andersen, J. (Ekstern)
Publication date: 1998
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 297686
Publication: Research › Conference abstract for conference – Annual report year: 1998

Stochastic wind loads on structures. Lecture notes

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Number of pages: 20
Publication date: 1998
Uncertainties of extreme winds, spectra, and coherences

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Kristensen, L. (Intern), Jensen, N. (Intern)
Pages: 49-56
Publication date: 1998

Host publication information
Title of host publication: Bridge aerodynamics
Place of publication: Rotterdam
Publisher: Balkema Publishers, A.A. / Taylor & Francis The Netherlands
Editors: Larsen, A.; Esdahl, S.
ISBN (Print): 90-5410-961-0
Main Research Area: Technical/natural sciences
Conference: International Symposium on Advances in Bridge Aerodynamics, Copenhagen, Denmark, 10/05/1998 - 10/05/1998
Source: orbit
Source-ID: 298771
Publication: Research › Article in proceedings – Annual report year: 1998

Wind field simulation

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Pages: 269-282
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Probabilistic Engineering Mechanics
Volume: 13
ISSN (Print): 0266-8920
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.834 SNIP 1.632 CiteScore 1.9
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.313 SNIP 1.967 CiteScore 2.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.65 SNIP 1.958 CiteScore 2.08
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 1.543 SNIP 2.054 CiteScore 2.6
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.318 SNIP 1.998 CiteScore 1.62
ISI indexed (2012): ISI indexed yes
How close is close enough when measuring scalar fluxes with displaced sensors?

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Kristensen, L. (Intern), Mann, J. (Intern), Oncley, S. (Ekstern), Wyngaard, J. (Ekstern)
Pages: 814-821
Publication date: 1997
Main Research Area: Technical/natural sciences

Publication Information
Journal: Journal of Atmospheric and Oceanic Technology
Volume: 14
ISSN (Print): 0739-0572
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.521 SNIP 1.425 CiteScore 2.37
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.522 SNIP 1.406 CiteScore 2.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.299 SNIP 1.272 CiteScore 1.85
Regional-scale surface flux observations across the boreal forest during BOREAS

A major role of the National Center for Atmospheric Research (NCAR) Electra aircraft during the Boreal Ecosystem-Atmosphere Study (BOREAS) was to measure fluxes of momentum, sensible and latent heat, carbon dioxide, and ozone on a transect that crossed the entire boreal forest biome. The observations spanned the growing season (late May to mid-September 1994) and extended the fluxes obtained in two intensive study areas to larger spatial scales to help provide a data set that is useful for comparison with and validation of large-scale models and satellite retrievals. We found the deciduous forests to be more photosynthetically active than nearby coniferous forests. Coniferous forest fluxes across the transect from the BOREAS southern to northern study areas show no apparent spatial trend, though smaller-scale variability is large. The fluxes make a smooth transition from the BOREAS northern study area to the subarctic tundra. Typical midsummer, midday, large-scale net ecosystem exchanges of carbon dioxide were about -10 µmol m⁻² s⁻¹ for primarily deciduous forests, about -6 µmol m⁻² s⁻¹ for the primarily coniferous regions between and including the two BOREAS study areas, and about -2 µmol m⁻² s⁻¹ for the subarctic tundra. The first two values are similar to those observed by flux towers in the region. Throughout the boreal forest the fluxes are influenced by the presence of lakes. Lake fraction is found to be a dominant source of variability in the fluxes observed along the transect. Lakes are also found to be large sinks of available radiant energy. Regional ground storage of heat is estimated to be about 30% of the net radiation over the forest, and 40% over the subarctic tundra, largely due to the presence of lakes.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Oncley, S. (Ekstern), Lenschow, D. (Ekstern), Campos, T. (Ekstern), Davis, K. (Ekstern), Mann, J. (Intern)
Role of entrainment in surface-atmosphere interactions over the boreal forest

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Davis, K. (Ekstern), Lenschow, D. (Ekstern), Oncley, S. (Ekstern), Kiemle, C. (Ekstern), Ehret, G. (Ekstern), Giez, A. (Ekstern), Mann, J. (Intern)
Pages: 29219-29230
Publication date: 1997
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Geophysical Research: Atmospheres
Volume: 102
ISSN (Print): 2169-897X
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.36 SJR 1.996 SNIP 1.313
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.288 SNIP 1.362 CiteScore 3.39
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.324 SNIP 1.349 CiteScore 3.27
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.357 SNIP 1.44 CiteScore 3.38
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.365 SNIP 1.35 CiteScore 2.93
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.239 SNIP 1.301 CiteScore 3.03
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.449 SNIP 1.324
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.347 SNIP 1.359
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.101 SNIP 1.296
Validation of NCAR 10.6-μm CO₂ doppler lidar velocity measurements and comparison with a 915-MHz profiler

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mayor, S. (Ekstern), Lenschow, D. (Ekstern), Schwiesow, R. (Ekstern), Mann, J. (Intern), Frush, C. (Ekstern), Simon, M. (Ekstern)
Pages: 1110-1126
Publication date: 1997
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Atmospheric and Oceanic Technology
Volume: 14
ISSN (Print): 0739-0572
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.521 SNIP 1.425 CiteScore 2.37
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.522 SNIP 1.406 CiteScore 2.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.299 SNIP 1.272 CiteScore 1.85
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.598 SNIP 1.386 CiteScore 2.13
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.075 SNIP 1.62 CiteScore 2.13
ISI indexed (2012): ISI indexed yes
Development of a microscale model for the averaging of surface fluxes in inhomogeneous terrain

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Jensen, N. (Intern), Hasager, C. (Intern), Frank, H. (Intern), Mann, J. (Intern), Mahrt, L. (Ekstern)
Publication date: 1996

Host publication information
Title of host publication: Heat, moisture and mass exchange processes on a regional scale in a non homogeneous terrain. Final report. Environment programme
Place of publication: Karlsruhe
Publisher: Universität Karlsruhe. Institut für Meterologie und Klimaforschung
Editor: Fiedler, F.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 294456
Publication: Research - peer-review › Book chapter – Annual report year: 1996

Lake-induced modification of the boundary layer over the Boreal Forest

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Lenschow, D. (Ekstern), Qing Wang (Ekstern), Oncley, S. (Ekstern), Davis, K. (Ekstern), Mann, J. (Intern)
Publication date: 1996
Event: Abstract from 76th Annual Meeting of the American Meteorological Society. 22nd Conference on Agricultural and Forest Meteorology, Atlanta, GA, United States.
Main Research Area: Technical/natural sciences
Source: orbit
Regional-scale surface flux observations across the Boreal Forest during BOREAS

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Oncley, S. (Ekstern), Lenschow, D. (Ekstern), Davis, K. (Ekstern), Campos, T. (Ekstern), Mann, J. (Intern)
Publication date: 1996
Event: Abstract from 76th Annual Meeting of the American Meteorological Society. 22nd Conference on Agricultural and Forest Meteorology, Atlanta, GA, United States.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 295763
Publication: Research › Conference abstract for conference – Annual report year: 1996

Airborne observations of the boundary layer top and associated gravity waves and boundary layer structure

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 1995
Event: Abstract from NCAR, Boulder, CO (US), 16 Mar, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 292935
Publication: Research › Conference abstract for conference – Annual report year: 1995

Airborne observations of the boundary layer top, and associated gravity waves and boundary layer structure

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Davis, K. (Ekstern), Lenschow, D. (Ekstern), Oncley, S. (Ekstern), Kiemle, C. (Ekstern), Ehret, G. (Ekstern), Giez, A. (Ekstern), Schreiber, H. (Ekstern)
Pages: 113-116
Publication date: 1995
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 294199
Publication: Research › Article in proceedings – Annual report year: 1995

Airborne observations of the boundary layer top, and associated gravity waves and boundary layer structure

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Davis, K. (Ekstern), Lenschow, D. (Ekstern), Oncley, S. (Ekstern), Kiemle, C. (Ekstern), Ehret, G. (Ekstern), Giez, A. (Ekstern), Schreiber, H. (Ekstern)
Publication date: 1995
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 294127
Publication: Research › Article in proceedings – Annual report year: 1995

Airborne observations of the boundary layer top, and associated gravity waves and boundary layer structure

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Davis, K. (Ekstern), Lenschow, D. (Ekstern), Oncley, S. (Ekstern), Kiemle, C. (Ekstern), Ehret, G. (Ekstern), Giez, A. (Ekstern), Schreiber, H. (Ekstern)
Publication date: 1995
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 295169
Publication: Research › Conference abstract for conference – Annual report year: 1995
Analysis of doppler lidar measurements in the boundary layer

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Schwiesow, R. (Ekstern), Mayor, S. (Ekstern), Mann, J. (Intern), Frush, C. (Ekstern)
Pages: 129-134
Publication date: 1995

Host publication information
Title of host publication: Ninth symposium on meteorological observations and instrumentation. Preprints
Place of publication: Boston, MA
Publisher: American Meteorological Society
Main Research Area: Technical/natural sciences
Conference: 9th Symposium on Meteorological Observations and Instrumentation, Charlotte, NC, United States, 27/03/1995 - 27/03/1995
Source: orbit
Source-ID: 294128
Publication: Research › Article in proceedings – Annual report year: 1995

Analysis of doppler lidar measurements in the boundary layer

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Schwiesow, R. (Ekstern), Mayor, S. (Ekstern), Mann, J. (Intern), Frush, C. (Ekstern)
Publication date: 1995

Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 294171
Publication: Research › Conference abstract for conference – Annual report year: 1995

An objective method for flux aggregation over inhomogeneous surfaces

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Jensen, N. (Intern), Mann, J. (Intern)
Publication date: 1995

Host publication information
Place of publication: Boulder, CO
Publisher: IUGG
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 293893
Publication: Research › Conference abstract in proceedings – Annual report year: 1995

An objective method for surface-flux aggregation or upscaling

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Jensen, N. (Intern), Mann, J. (Intern)
Pages: C351
Publication date: 1995
Main Research Area: Technical/natural sciences
Comments on 'A definitive approach to turbulence statistical studies in planetary boundary layers'

General information
Influence of transversal turbulence on lifetime predictions for a HAWT

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Mathematical models of the wind

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 1995
Event: Abstract from University of Florence, Florence (IT), 8 May, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 292955
Publication: Research › Conference abstract for conference – Annual report year: 1995

The spatial structure of neutral surface-layer turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Publication date: 1995
Event: Abstract from Pennsylvania State University, State College, PA (US), 21 Mar, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 292956
Publication: Research › Conference abstract for conference – Annual report year: 1995

Errors in airborne flux measurements

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Lenschow, D. (Ekstern)
Pages: 14519-14526
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Geophysical Research
Volume: 99
Issue number: D7
ISSN (Print): 0148-0227
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.36 SJR 1.996 SNIP 1.313
Web of Science (2016): Indexed yes
Fourier simulation of a non-isotropic wind field model

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Krenk, S. (Ekstern)

Original language: English
Source: orbit
Source-ID: 292266
Publication: Research - peer-review › Journal article – Annual report year: 1994
How long is long enough when measuring fluxes and other turbulence statistics?

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Lenschow, D. (Ekstern), Mann, J. (Intern), Kristensen, L. (Intern)
Pages: 661-673
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Atmospheric and Oceanic Technology
Volume: 11
ISSN (Print): 0739-0572
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.521 SNIP 1.425 CiteScore 2.37
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.522 SNIP 1.406 CiteScore 2.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.299 SNIP 1.272 CiteScore 1.85
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.598 SNIP 1.386 CiteScore 2.13
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 2.075 SNIP 1.62 CiteScore 2.13
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.921 SNIP 1.419 CiteScore 2.2
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.715 SNIP 1.246
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.595 SNIP 1.3
BFI (2008): BFI-level 1
Influence of transversal turbulence on lifetime predictions for a HAWT

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Thirstrup Petersen, J. (Ekstern), Kretz, A. (Ekstern), Mann, J. (Intern)
Publication date: 1994
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 292572
Publication: Research - peer-review › Journal article – Annual report year: 1994

The spatial structure of neutral atmospheric surface-layer turbulence

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Pages: 141-168
Publication date: 1994
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Fluid Mechanics
Volume: 273
ISSN (Print): 0022-1120
Ratings:
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.82 SJR 1.671 SNIP 1.636
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.912 SNIP 1.676 CiteScore 2.57
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.865 SNIP 1.808 CiteScore 2.66
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Aspects of the natural wind of relevance to large bridges

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Jensen, N. (Intern), Mann, J. (Intern), Kristensen, L. (Intern)
Pages: 25-32
Publication date: 1992

Host publication information
Title of host publication: Aerodynamics of large bridges
Place of publication: Rotterdam
Publisher: Balkema Publishers, A.A. / Taylor & Francis The Netherlands
Editor: Larsen, A.
Measurements of wind spectra on the Roque de los Muchachos

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern)
Number of pages: 12
Publication date: 1991

Publication information
Place of publication: Oslo
Publisher: Large Earth-based Solar Telescope. Institute of Theoretical Astrophysics. University of Oslo
Original language: English
Series: LEST-TR-48
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 289249
Publication: Research - peer-review › Report – Annual report year: 1991

The Great Belt coherence experiment. A study of atmospheric turbulence over water

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Mann, J. (Intern), Kristensen, L. (Ekstern), Courtney, M. (Intern)
Number of pages: 51
Publication date: 1991

Publication information
ISBN (Print): 87-550-1747-9
Original language: English
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 596(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Risoe-R-596, Risoe-R-596(EN)
Source: orbit
Source-ID: 289281
Publication: Research › Report – Annual report year: 1991

Projects:

Large scale atmospheric structures in space-time over flat terrain

Department of Wind Energy
Period: 15/11/2017 → 14/11/2020
Number of participants: 4
Phd Student:
Alcayaga Romàn, Leonardo Andrès (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Mann, Jakob (Intern)
Main Supervisor:
**An experimental assessment of how trees affect the wind field**

Department of Wind Energy  
Period: 01/04/2017 → 31/03/2020  
Number of participants: 3  
PhD Student:  
Angelou, Nikolas (Intern)  
Supervisor:  
Mann, Jakob (Intern)  
Main Supervisor:  
Dellwik, Ebba (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Institut stipendie (DTU)  
Project: PhD

**Reducing uncertainty of near-shore wind resource estimates using onshore lidars**

RUNE aims at reducing the uncertainty of near-shore wind resource estimates by using onshore scanning lidar technology combined with ocean and satellite information

Department of Wind Energy  
Meteorology  
Test and Measurements  
DONG Energy A/S  
DHI Denmark  
Fraunhofer Institute for Wind Energy and Energy System Technology  
Period: 01/02/2015 → 31/03/2016  
Number of participants: 13  
Acronym: RUNE  
Project ID: 12263  
Project participant:  
Courtney, Michael (Intern)  
Vasiljevic, Nikola (Intern)  
Lea, Guillaume (Intern)  
Hasager, Charlotte Bay (Intern)  
Hummelsøj, Poul (Intern)  
Floors, Rogier Ralph (Intern)  
Ejsing Jørgensen, Hans (Intern)  
Hahmann, Andrea N. (Intern)  
Mann, Jakob (Intern)  
Badger, Merete (Intern)  
Hansen, Kristoffer schrøder (Intern)  
Karagali, Ioanna (Intern)  
Project Coordinator:  
Peña, Alfredo (Intern)

**Financing sources**  
Source: Public research council  
Name of research programme: ForskEL  
Web address: https://www.forskel.dk/Pages/default.aspx
Probabilistic wind characterization and wind turbine design

Department of Wind Energy
Period: 01/04/2014 → 30/05/2018
Number of participants: 4
Phd Student:
Hannesdóttir, Ásta (Intern)
Supervisor:
Natarajan, Anand (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Kelly, Mark C. (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

PhD scholarship in Turbulent Atmospheric Flow with Relevance for Wind Energy

Department of Wind Energy
Period: 01/03/2013 → 29/09/2016
Number of participants: 6
Phd Student:
Lange, Julia (Intern)
Supervisor:
Berg, Jacob (Ekstern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Larsen, Gunner Chr. (Intern)
Aubrun, Sandrine (Ekstern)
Porté-Agel, Fernando (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet

Relations
Publications:
Flow over complex terrain. The secrets of Bolund
Project: PhD

National Wind Tunnel
To design and establish a national Wind tunnel, which is a national research infrastructure able mainly to test 2D airfoils up to Re=7 mio aerodynamically and aero-acoustically and in alater phase be able to measure model rotors and wakes.

Department of Wind Energy
Aeroelastic Design
Fluid Mechanics
Meteorology
Period: 15/08/2012 → 31/12/2016
Number of participants: 6
Acronym: 44525-4610
Project participant:
Fischer, Andreas (Intern)
Gaunaa, Mac (Intern)
Mikkelsen, Robert Flemming (Intern)
Mann, Jakob (Intern)
Barlas, Athanasios (Intern)
Project Manager, academic:
Bak, Christian (Intern)

Project Experimental Stereo Vision Studies of Flow and Structural Effects on Wind Turbines
Department of Wind Energy
Period: 01/03/2012 → 30/11/2015
Number of participants: 7
PhD Student:
Najafi, Nadia (Intern)
Supervisor:
Sjöholm, Mikael (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Schmidt Paulsen, Uwe (Intern)
Examiner:
Georgakis, Christos T. (Intern)
Griffith, D. Todd (Ekstern)
Tcherniak, Dmitri (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut/centerfinansieret

Relations
Publications:
Experimental Vision Studies of Flow and Structural Effects on Wind Turbines
Project: PhD

Low-cost semiconductor laser wind sensors
Our objective is to develop, demonstrate and validate prototype laser wind sensors that measure wind speed and direction based on low-cost, compact semiconductor lasers and new optical methods we have recently devised and patented. These wind sensor prototypes will represent the next-generation of compact, rugged and inexpensive laser-based wind sensors for wind energy research and turbine industry.

Department of Photonics Engineering
Optical Sensor Technology
Meteorology
Department of Wind Energy
Test and Measurements
Windar Photonics A/S and Opdi Technologies A/S
Period: 01/03/2012 → 28/02/2014
Number of participants: 5
Project ID: 70720
Project participant:
Development of Efficient Turbulence Models for CFD Wake Simulations

Department of Wind Energy
Period: 15/12/2011 → 24/04/2015
Number of participants: 8
Phd Student:
van der Laan, Paul (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Réthoré, Pierre-Elouan (Intern)
Mann, Jakob (Intern)
Main Supervisor:
Sørensen, Niels N. (Intern)
Examiner:
Mikkelsen, Robert Flemming (Intern)
Madsen, Jens Ingemann (Ekstern)
Masson, Christian (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Two-dimensional rotor plane wind data retrieval - HTF Wind Lidar

Department of Wind Energy
Period: 15/12/2011 → 24/09/2015
Number of participants: 6
Phd Student:
Foroughi Abari, Farzad (Intern)
Supervisor:
Sjöholm, Mikael (Intern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Courtney, Michael (Intern)
Cariou, Jean-Pierre (Ekstern)
Water, Willem van de (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Multiple Turbine Wakes
Flow over complex forested terrain

Department of Wind Energy
Period: 15/10/2011 → 24/08/2015
Number of participants: 6
Phd Student:
Boudreault, Louis-Etienne (Intern)
Supervisor:
Bechmann, Andreas (Intern)
Main Supervisor:
Dellwik, Ebba (Intern)
Examiner:
Mann, Jakob (Intern)
Edward Garrett, Patton (Ekstern)
Neil Ross, Andrew (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Offentlig finansiering
Project: PhD

The impact of non-neutral atmosphere on offshore wind turbines

Department of Wind Energy
Period: 15/03/2011 → 24/09/2015
Number of participants: 7
Phd Student:
de Mare, Martin Tobias (Intern)
Supervisor:
Larsen, Gunner Chr. (Intern)
Veldkamp, Dick (Ekstern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Berg, Jacob (Intern)
Bossanyi, Ervin Ashoka (Ekstern)
George, William K (Intern)

Financing sources
Source: Internal funding (public)
Flow measurements in complex terrain using a 3D LIDAR Windscanner

Department of Wind Energy
Period: 01/06/2010 → 30/09/2014
Number of participants: 6
Phd Student:
Vasiljevic, Nikola (Intern)
Supervisor:
Mann, Jakob (Intern)
Main Supervisor:
Courtney, Michael (Intern)
Examiner:
Ejsing Jørgensen, Hans (Intern)
Margulis, Michael S. (Ekstern)
Rankers, Adrian M. (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Marie Curie (EU-stipendium)
Project: PhD

Simulation and prediction of wakes and wake interaction in wind farms

Department of Wind Energy
Period: 01/06/2010 → 27/01/2014
Number of participants: 7
Phd Student:
Andersen, Søren Juhl (Intern)
Supervisor:
Mikkelsen, Robert Flemming (Intern)
Shen, Wen Zhong (Intern)
Main Supervisor:
Sørensen, Jens Nørkær (Intern)
Examiner:
Mann, Jakob (Intern)
Ivanell, Stefan S. A. (Ekstern)
Meyers, Johan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

Atmospheric turbulence and wind energy

Department of Wind Energy
Period: 15/04/2010 → 20/09/2013
Number of participants: 5
Phd Student:
Chougule, Abhijit S. (Intern)
Supervisor:
Kelly, Mark C. (Intern)
Main Supervisor:
Mann, Jakob (Intern)
Examiner:
Sørensen, Jens Nørkær (Intern)
Cheng, Po Wen (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD

Noise from Wind Turbines due to Inflow Turbulence
Department of Mechanical Engineering
Period: 01/12/2004 → 27/01/2010
Number of participants: 6
Phd Student:
Broe, Brian Riget (Intern)
Supervisor:
Mann, Jakob (Intern)
Main Supervisor:
Sørensen, Jens Nørkær (Intern)
Examiner:
Jacobsen, Finn (Intern)
Graham, J. Michael R. (Ekstern)
Keith, Graeme (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Risø (Løn)
Project: PhD

Large-Eddy Simulation of atmospheric flow over complex terrain
Department of Mechanical Engineering
Period: 01/10/2003 → 15/08/2007
Number of participants: 8
Phd Student:
Bechmann, Andreas (Intern)
Supervisor:
Johansen, Jeppe (Intern)
Mann, Jakob (Intern)
Sørensen, Niels N. (Intern)
Main Supervisor:
Sørensen, Jens Nørkær (Intern)
Examiner:
Bingham, Harry B. (Intern)
Fuchs, Laszlo (Ekstern)
Gryning, Sven-Erik (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Risø (Løn)
Project: PhD

Activities:

The Østerild Balconies Experiment
Period: 28 Jun 2017
Ioanna Karagali (Speaker)
Ebba Dellwik (Other)
Guillaume Lea (Other)
Elliot Simon (Other)
Nikola Vasiljevic (Other)
Mapping offshore winds in the New European Wind Atlas (NEWA)
Period: 7 Jun 2017
Ioanna Karagali (Invited speaker)
Charlotte Bay Hasager (Other)
Merete Badger (Other)
Andrea N. Hahmann (Other)
Patrick Volker (Other)
Alfredo Peña (Guest lecturer)
Julia Gottschall (Other)
Eleonora Catalano (Other)
Jakob Mann (Other)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling

Related event
Offshore Wind Energy 2017
06/06/2017 → 08/06/2017
London, United Kingdom
Activity: Talks and presentations › Conference presentations

DESCOTOLO
Period: 1 Aug 2016 → 22 Dec 2016
Ioanna Karagali (Consultant)
Rogier Ralph Floors (Consultant)
Andrea Vignaroli (Consultant)
Jakob Mann (Consultant)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Test and Measurements

Description
Design Conditions for Tower Loads

Related external organisation
Vestas Wind Systems (DK)
Activity: Public and private sector consultancy › Consultancy
Experimental investigations of flow over terrain for wind energy

Period: 21 Oct 2015

Jakob Mann (Invited speaker)

Department of Wind Energy
Meteorology

Related event

2nd International Conference on Future Technologies in Wind Energy
19/10/2015 → 21/10/2015
London, ON, Canada
Activity: Talks and presentations › Conference presentations