Observed and modeled near-wake flow behind a solitary tree

This study reports simultaneous measurements of wind at single point positions up- and downstream of a tree and a numerical experiment with the aim of quantifying the interaction of a solitary tree and the wind field. Relative to the inflow velocity, the velocity deficit in the wake of the tree showed strong seasonal dependence, with wake velocities changing between 70% and 10% of the upstream value from no-leaf winter conditions to full-leaf summer conditions. Whereas for the winter tree the turbulence intensity in the wake is everywhere reduced relative to the upwind flow, for the summer tree the turbulent intensity is markedly reduced in the inner wake, but increased in the outer wake.

For the numerical experiment, the combination of (i) a high-detail tree model, based on terrestrial lidar scanning, and (ii) observations of the total bending moment on the tree, taken from strain gauges mounted on the stem, provided the tree parameterization. By this approach, the drag coefficient is not calibrated to fit the observed wind speed in the wake, but the total observed bending moment. Mean wind speed observations in the wake of both the winter and summer tree were well reproduced by the model with mean absolute errors lower than or equal to 5% throughout the wake transect. Also the turbulence intensity in the wake were well reproduced for the summer tree, whereas it was overestimated for the winter tree. Effects of changing tree model and grid resolution are demonstrated and discussed. Based on the presented findings, we recommend to estimate the total bending moment (or drag force) on modelled trees to ensure transferability of results between different numerical setups.

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The presence of solitary trees in a flat terrain introduce heterogeneities, which modify the characteristics of the wind. Trees act like obstacles that extract energy from the mean flow and increase the turbulence of the wind. This has an impact on the momentum flux and thus is of particular interest in climate related studies. Furthermore, the wind-trees interaction is a topic of study also in applied research areas, like wind energy, where the estimation of wind resources and associated turbulence levels is necessary to describe accurately the wind conditions over an area. In the case of rough landscapes typical uncertainties in the estimation of the terrain roughness can result to 10% uncertainty in the annual energy production estimate [1]. In order to contribute to the understanding of the aforementioned topics a project called Single Tree was initiated in the Wind Energy Department of the Technical University of Denmark (DTU), with the objective to characterize the flow around a solitary tree. For the needs of this study a European Oak tree (Quercus robur), located on the shore of the Roskilde fjord in Denmark, was selected. Such a tree is commonly found in forests or solitarily in urban and rural environments in temperate regions. Using a commercial terrestrial laser scanner, the dimensions and the detailed geometry of the tree were measured (see Figure 1 and Figure 2, left) and two meteorological masts equipped with multiple in-situ sonic anemometers were used to provide reference measurements of the wind conditions. A phenomenon that describes the wind-trees interaction is the wake of a tree, since it is the result of the momentum extracted from the wind due to the presence of the tree, which acts as a porous obstacle with a complex geometry. This complex geometry creates challenges in the numerical prediction of wind-trees interactions and thus the generation of high quality experimental flow data is paramount. Such an investigation is feasible using three short-range WindScanners, which are mobile remote sensing instruments developed in the Wind Energy Department of DTU [2].
Evaluating Humidity and Sea Salt Disturbances on CO2 Flux Measurements

Global oceans are an important sink of atmospheric carbon dioxide (CO2). Therefore, understanding the air–sea flux of CO2 is a vital part in describing the global carbon balance. Eddy covariance (EC) measurements are often used to study CO2 fluxes from both land and ocean. Values of CO2 are usually measured with infrared absorption sensors, which at the same time measure water vapor. Studies have shown that the presence of water vapor fluctuations in the sampling air potentially results in erroneous CO2 flux measurements resulting from the cross sensitivity of the sensor. Here measured CO2 fluxes from both enclosed-path Li-Cor 7200 sensors and open-path Li-Cor 7500 instruments from an inland measurement site are compared with a marine site. Also, new quality control criteria based on a relative signal strength indicator (RSSI) are introduced. The sampling gas in one of the Li-Cor 7200 instruments was dried by means of a multitube diffusion dryer so that the water vapor fluxes were close to zero. With this setup the effect that cross sensitivity of the CO2 signal to water vapor can have on the CO2 fluxes was investigated. The dryer had no significant effect on the CO2 fluxes. The study tested the hypothesis that the cross-sensitivity effect is caused by hygroscopic particles such as sea salt by spraying a saline solution on the windows of the Li-Cor 7200 instruments during the inland field test. The results confirm earlier findings that sea salt contamination can affect CO2 fluxes significantly and that drying the sampling air for the gas analyzer is an effective method for reducing this signal contamination.
From lidar scans to roughness maps for wind resource modelling in forested areas

Applying erroneous roughness lengths can have a large impact on the estimated performance of wind turbines, particularly in forested areas. In this study, a new method called the objective roughness approach (ORA), which converts tree height maps created using airborne lidar scans to roughness maps suitable for wind modelling, is evaluated via cross predictions among different anemometers at a complex forested site with seven tall meteorological masts using the Wind Atlas Analysis and Application Program (WAsP). The cross predictions were made using ORA maps created at four spatial resolutions and from four freely available roughness maps based on land use classifications. The validation showed that the use of ORA maps resulted in a closer agreement with observational data for all investigated resolutions compared to the land use maps. Further, when using the ORA maps, the risk of making large errors (>25%) in predicted power density was reduced by 40–50% compared to satellite-based products with the same resolution. The results could be further improved for high-resolution ORA maps by adding the displacement height. The improvements when using the ORA maps were both due to a higher roughness length and due to the higher resolution.

General information

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Organisations: Department of Wind Energy, Resource Assessment Modelling, Meteorology & Remote Sensing, Aarhus University, Uppsala University
Contributors: Floors, R. R., Enevoldsen, P., Davis, N., Arnqvist, J., Dellwik, E.
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New European Wind Atlas: The Østerild balconies experiment

One of the main objectives of the New European Wind Atlas (NEWA) project is to carry out large scale field experiments at a high spatial and temporal resolution, and provide a significant upgrade to the experimental databases currently available. The Østerild balconies experiment aimed at collecting measurements over a relatively flat and semi-forested terrain to quantify the effect of various terrain features on the mean wind field. The experiment was performed at the Østerild test station for large wind turbines in Northern Denmark, from April to August 2016. The two 250 m meteorological towers available at the test site were equipped with balconies, first at 50 m above local ground level, later raised to 200 m. Scanning lidars were placed on each of the balconies, performing horizontal scans over 90° arcs with an east or west orientation depending on the incoming wind direction. The purpose of this study is to describe i) the new filtering method applied to the data, ii) the wind field reconstruction and the iii) utilisation of the derived wind fields to examine the imprint of surface heterogeneity on the mean wind flow. Cloud point data from aerial lidar scans were used to accurately derive the terrain and tree height. The mean wind flow patterns appeared to be heavily influenced by the terrain characteristics at the height of 50 m above ground level.

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Contributors: Karagali, I., Mann, J., Dellwik, E., Vasiljević, N.
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Optimal yaw strategy for optimized power and load in various wake situations: Paper

The interaction between nearby wind turbines in a wind farm modifies the power and loads compared to their stand-alone values. The increased turbulence intensity and the modified turbulence structure at the downstream turbines creates higher fatigue loading, which can be mitigated by wind farm and/or wind turbine control. To alleviate loads and maximize power possible strategies such as wake steering, where the turbine is yawed to redirect the wake such that it does not impinge the downstream turbine, have been studied. The work presented here focuses on situations where the wake is nevertheless affecting the downstream turbine, and more specifically how high loads can be avoided by yawing the wake-affected turbine. The analysis is conducted on a 2.3 MW machine, and the flow field is simulated using the Dynamic Wake Meandering model. The study investigates the impact on power and loads for different longitudinal interspacing and turbulence intensities. Optimal yaw strategies are defined for above rated regions where no power loss occurs. The potential load alleviation for different load sensors are studied, but the presentation is focussed on the blade root flapwise fatigue loading. For full wake at 3D interspacing and turbulence intensity of 5 %, around 35 % of load reduction on the 1 Hz Damage Equivalent Loads can be achieved at high wind speeds. Smaller reductions are achieved for higher atmospheric turbulence; the analogue case with 15 % turbulence intensity shows 17 % potential alleviation. The alleviation on the wind turbine lifetime is also calculated and compared for different turbulence intensities and mean wind speeds. Small reductions are achieved for sites with low mean wind speed and high turbulence intensity, but high reductions, of around 19 %, are accomplished in low turbulence intensity with high mean wind speed.

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Sentinel-1 SAR for wind energy roughness maps over land

For the wind energy application, updated information on aerodynamic surface roughness is important for an accurate prediction of the land surface effect on the atmosphere. Tall wind turbines are commonly sited in forested areas, and since the forest both increase turbulence levels and decrease the wind resource, the parametrization of forest roughness in wind
models is of high relevance. Here, we investigate whether the Sentinel-1 SAR images can be used to identify high-roughness forested areas. The backscatter properties of the SAR images are compared to digital surface models and vegetation density maps derived from near-concurrent aerial lidar scans (ALS). These ALS products have previously shown good results in wind models for the wind energy application, but the scans are costly to perform and therefore typically only represent a snapshot in time, whereas the Sentinel mission SAR images provide frequent updated information. We investigate how the SAR images vary with season over both deciduous and needle-leaf forests and in addition test whether nearby meteorological observations can explain image to image differences in the backscatter level. In order to understand the backscatter level, new products from the ALS point cloud are derived and compared with the SAR images. This part of the work is focused on whether we also can quantify the roughness based on the SAR backscatter. Since SAR images are affected by speckle noise, they are averaged over monthly and bimonthly intervals after careful inspection of each image. The work is focused on the Østerild test site for large wind turbines in Northern Denmark, where extensive wind experiments have been performed.

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Organisations: Meteorology & Remote Sensing, Department of Wind Energy, Microwaves and Remote Sensing, National Space Institute
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Web of Science (2013): Indexed yes
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Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
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Research output: Research - peer-review » Conference abstract in journal – Annual report year: 2018

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’.

General information
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Flux footprints for a tall tower in a land–water mosaic area: A case study of the area around the Risø tower
The understanding of scalar fluxes observed in the lower atmosphere is a challenging task, when the underlying surface is non-uniform. In this paper, we apply a micro-scale flow model with a two-equation closure scheme to analyse the influence of the surface heterogeneity on a flux measurement in the area surrounding the 122-m tower at Risø (Denmark), which is a mosaic of water, agricultural areas and forests. These heterogeneities are clearly reflected in the tower-based observations of the turbulence statistics from a profile of six sonic anemometers and are also reproduced by the flow model. Using the two-dimensional mode of the model, in combination with the footprint estimator, we calculate the scalar flux footprints for the 122 m eddy-covariance location and compare these results to analytical footprint estimators, which are only valid for homogeneous terrain, but are commonly applied also for heterogeneous terrain. Whereas the results by the analytical footprint estimator indicate smooth source areas regardless of the surface heterogeneities, the footprint estimator based on the micro-scale model indicates source hotspots, which have a stronger weight in the footprint. The hotspots coincide with areas, where the mean vertical velocity is positive. The positive mean vertical velocity is, in turn, related to topography and forest edge effects on the flow. Relative to the surface roughness estimated from a sonic anemometer, a higher value of the surface roughness was needed for the analytical footprint estimator in order to coarsely match the flow model-based footprint result. Although neither footprint model can be directly verified, the difference in the results underlines that the analytical model should be used with caution in heterogeneous areas. We also estimate the effect of the surface flux source-strength on the observed CO2 flux. This step demonstrates a novel way of evaluating the CO2 exchange with the surface, which is useful for constraining models of the surface source or sink.

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Web of Science (2017): Impact factor 4.039
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Scopus rating (2016): CiteScore 4.62 SJR 2.047 SNIP 1.916
Web of Science (2016): Impact factor 3.887
Web of Science (2016): Indexed yes
Inflow conditions and wake effects for wind turbines in forested terrain

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Wind turbine loads & control, Technical University of Denmark, Uppsala University
Contributors: Dellwik, E., Papetta, A., Arnqvist, J., Nielsen, M., Larsen, T. J.
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Inflow conditions and wake effects for wind turbines in forested terrain

Lidars Lifted: The Østerild Balconies Experiment

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing
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Research output: Research » Sound/Visual production (digital) – Annual report year: 2017

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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Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2017

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 highresolution 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 leafs 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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Aerial LIDAR scans for validation of CFD models in complex forested terrain

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Resource Assessment Modelling, Aerodynamic design, Uppsala University, Siemens A/S
Contributors: Dellwik, E., Arnqvist, J., Cavar, D., Enevoldsen, P., van der Laan, P.
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Event: Abstract from WindEurope Summit, Hamburg, Germany.
Electronic versions:
How Forest Inhomogeneities Affect the Edge Flow

Most of our knowledge on forest-edge flows comes from numerical and wind-tunnel experiments where canopies are horizontally homogeneous. To investigate the impact of tree-scale heterogeneities (>1 m) on the edge-flow dynamics, the flow in an inhomogeneous forest edge on Falster island in Denmark is investigated using large-eddy simulation. The three-dimensional forest structure is prescribed in the model using high resolution helicopter-based lidar scans. After evaluating the simulation against wind measurements upwind and downwind of the forest leading edge, the flow dynamics are compared between the scanned forest and an equivalent homogeneous forest. The simulations reveal that forest inhomogeneities facilitate flow penetration into the canopy from the edge, inducing important dispersive fluxes in the edge region as a consequence of the flow spatial variability. Further downstream from the edge, the forest inhomogeneities accentuate the canopy-top turbulence and the skewness of the wind-velocity components while the momentum flux remains unchanged. This leads to a lower efficiency in the turbulent transport of momentum within the canopy. Dispersive fluxes are only significant in the upper canopy. Above the canopy, the mean flow is less affected by the forest inhomogeneities. The inhomogeneities induce an increase in the mean wind speed that was found to be equivalent to a decrease in the aerodynamic height of the canopy. Overall, these results highlight the importance of forest inhomogeneities when looking at canopy–atmosphere exchanges in forest-edge regions.
Lidar-based maps for flow modeling in complex forested terrain

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Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Aerodynamic design
Contributors: Dellwik, E., van der Laan, P.
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Peer-reviewed: Yes
A LiDAR method of canopy structure retrieval for wind modeling of heterogeneous forests

The difficulty of obtaining accurate information about the canopy structure is a current limitation towards higher accuracy in numerical predictions of the wind field in forested terrain. The canopy structure in computational fluid dynamics is specified through the frontal area density and this information is required for each grid point in the three-dimensional computational domain. By using raw data from aerial LiDAR scans together with the Beer-Lambert law, we propose and test a method to calculate and grid highly variable and realistic frontal area density input. An extensive comparison with ground-based measurements of the vertically summed frontal area density (or plant area index) and tree height was used to optimize the method, both in terms of plant area index magnitude and spatial variability. The resolution of the scans was in general low (}
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.62 SJR 2.047 SNIP 1.916
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.63 SJR 2.162 SNIP 1.992
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.31 SJR 2.056 SNIP 1.906
Web of Science (2014): Impact factor 3.762
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.07 SJR 1.827 SNIP 2.061
Web of Science (2013): Impact factor 3.894
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.71 SJR 1.899 SNIP 2.065
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Scopus rating (2011): CiteScore 3.56 SJR 1.783 SNIP 1.69
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Web of Science (2010): Indexed yes
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Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.796 SNIP 1.631
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Scopus rating (2003): SJR 1.529 SNIP 1.636
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Web of Science (2002): Indexed yes
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Scopus rating (1999): SJR 1.148 SNIP 1.445

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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.

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 usually associated with the vertical component of the wind and are important to characterize.
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.
Reynolds-averaged Navier-Stokes and Large-Eddy Simulation Over and Inside Inhomogeneous Forests

Numerical modeling is a useful tool for estimating the local wind resource in relation to wind turbine siting. At onshore sites, the wind climate is often influenced by nearby forests and they cause an increase in wind shear and turbulence intensity, which may compromise the performance of wind turbines. The wind flow over forests therefore needs to be predicted with a high degree of accuracy. Forests are however inhomogeneous in nature causing complex flow dynamics difficult to capture in numerical models. An accurate description of the canopy structure is necessary to properly evaluate the performance of wind models in such environment.

A systematic method to acquire gridded input of canopy structure from aircraft based LiDAR scans of heterogeneous forests is defined. An extensive validation against ground-based measurements of the vertically summed frontal area density (or plant area index) and tree height is performed. The method is optimized both in terms of plant area index magnitude and spatial variability. A forest grid is generated from the LiDAR method using airplane scans of a 5×5 km² forested site in Sweden. The grid serves as the basis for Reynolds-averaged Navier-Stokes (RANS) simulations. Wind observations from an instrumented mast are used for validation where a good correlation is found for the mean wind speed of two contrasting wind directions with different influences from the upstream forest.

The effects of successive simplifications of the forest representation show an important influence of the smaller heterogeneities on the flow when the site is complex. A second helicopter-based LiDAR scan of high resolution is used to create a highly detailed forest grid at the site of a previous forest edge experiment on the island of Falster in Denmark. This input is used in a large-eddy simulation (LES) study using the Advanced Regional Prediction System. The results show important spatial variability in the flow field, in close correlation with the canopy structure. Both the RANS and the LES studies demonstrate that a detailed representation of the flow over and inside inhomogeneous forests can be acquired using the LiDAR based forest parameterization. This opens up for a new way of developing and evaluating wind models adapted to complex forested terrains.

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.
Wind Statistics from a Forested Landscape

An analysis and interpretation of measurements from a 138-m tall tower located in a forested landscape is presented. Measurement errors and statistical uncertainties are carefully evaluated to ensure high data quality. A 40° wide wind-direction sector is selected as the most representative for large-scale forest conditions, and from that sector first-, second- and third-order statistics, as well as analyses regarding the characteristic length scale, the flux-profile relationship and surface roughness are presented for a wide range of stability conditions. The results are discussed with focus on the validity of different scaling regimes. Significant wind veer, decay of momentum fluxes and reduction in shear length scales with height are observed for all stability classes, indicating the influence of the limited depth of the boundary layer on the measured profiles. Dimensionless gradients are shown to follow theoretical curves up to 100 m in stable conditions despite surface-layer approximations being invalid. This is attributed to a balance of momentum decay and reduced shear length scale growth with height. The wind profile shows a strong stability dependence of the aerodynamic roughness length, with a 50% decrease from neutral to stable conditions.
Canopy structure effects on the wind at a complex forested site

We investigated the effect of the canopy description in a Reynolds-averaged Navier-Stokes method based on key flow results from a complex forested site. The canopy structure in RANS is represented through the frontal area of canopy elements per unit volume, a variable required as input in canopy models. Previously difficult to estimate, this variable can now be easily recovered using aerial LiDAR scans. In this study, three approaches were tested which were all based on a novel method to extract the forest properties from the scans. A first approach used the fully spatial varying frontal area density. In a second approach, the vertical frontal area density variations were ignored, but the horizontally varying forest heights were kept represented. The third approach ignored any variations: the frontal area density was defined as a constant up to a fixed tree height over the whole domain. The results showed significant differences among the cases. The large-scale horizontal heterogeneities produced the largest effect on the variability of wind fields. Close to the surface, specifying more details about the canopy resulted in an increase of x – y area-averaged fields of velocity and turbulent kinetic energy.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Aeroelastic Design
Contributors: Boudreault, L., Bechmann, A., Sørensen, N. N., Sogachev, A., Dellwik, E.
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Journal: Journal of Physics: Conference Series (Online)
Volume: 524
Issue number: 1
Article number: 012112
ISSN (Print): 1742-6596
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
A method is presented for development of satellite green vegetation fraction (GVF) time series for use in the Weather Research and Forecasting (WRF) model. The GVF data is in the WRF model used to describe the temporal evolution of many land surface parameters, in addition to the evolution of vegetation. Several high-resolution GVF products, derived from high-quality satellite retrievals from Moderate Resolution Imaging Spectroradiometer images, were produced and their performance was evaluated in long-term WRF simulations. The atmospheric conditions during the 2006 heat wave year over Europe were simulated since significant interannual variability in vegetation seasonality was found. Such
interannual variability is expected to increase in the coming decades due to climatic changes. The simulation using a quadratic normalized difference vegetation index to GVF relationship resulted in consistent improvements of modeled temperatures. The model mean temperature cold bias was reduced by 10 % for the whole domain and by 20–45 % in areas affected by the heat wave. The study shows that WRF simulations during heat waves and droughts, when vegetation conditions deviate from the climatology, require concurrent land surface properties in order to produce accurate results.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, National Center for Atmospheric Research, Roskilde University
Contributors: Nielsen, J. R., Dellwik, E., Hahmann, A. N., Barlage, M. J., Boegh, E.
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Journal: Theoretical and Applied Climatology
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ISSN (Print): 0177-798X
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BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.07 SJR 0.867 SNIP 0.999
Web of Science (2017): Impact factor 2.321
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.09 SJR 1.054 SNIP 1.12
Web of Science (2016): Impact factor 2.64
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.82 SJR 1.062 SNIP 1.03
Web of Science (2015): Impact factor 2.433
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.92 SJR 0.964 SNIP 1.067
Web of Science (2014): Impact factor 2.015
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.96 SJR 1.032 SNIP 1.208
Web of Science (2013): Impact factor 1.742
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.94 SJR 1.232 SNIP 1.243
Web of Science (2012): Impact factor 1.759
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.94 SJR 1.209 SNIP 1.269
Web of Science (2011): Impact factor 1.942
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.157 SNIP 1.294
Web of Science (2010): Impact factor 1.684
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.075 SNIP 1.478
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 level show that the minimum wind speed occurred just upwind of the edge. At the 1.25hc level, at the forest mast, the
momentum flux 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.

**General information**
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Organisations: Department of Wind Energy, Meteorology
Contributors: Dellwik, E., Bingöl, F., Mann, J.
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Peer-reviewed: Yes

**Publication information**
Journal: Quarterly Journal of the Royal Meteorological Society
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ISSN (Print): 0035-9009
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.1 SJR 2.258 SNIP 1.306
Web of Science (2017): Impact factor 2.978
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.33 SJR 2.538 SNIP 1.446
Web of Science (2016): Impact factor 3.444
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.1 SJR 2.502 SNIP 1.416
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 5 SJR 5.248 SNIP 2.38
Web of Science (2014): Impact factor 3.252
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.17 SJR 4.325 SNIP 2.027
Web of Science (2013): Impact factor 5.131
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.99 SJR 3.589 SNIP 1.569
Web of Science (2012): Impact factor 3.327
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.86 SJR 2.687 SNIP 1.328
Web of Science (2011): Impact factor 2.907
Meso-scale modeling of a forested landscape

Meso-scale models are increasingly used for estimating wind resources for wind turbine siting. In this study, we investigate how the Weather Research and Forecasting (WRF) model performs using standard model settings in two different planetary boundary layer schemes for a forested landscape and how this performance is changed when enhancing the roughness by a factor four in one of the schemes. The model simulations were evaluated using data from a 138 m tall mast in southeastern Sweden, where an experiment with six sonic anemometers and standard meteorological instrumentation was performed 2010-2012. The land cover around the mast is dominated by forest and for the most common wind direction, the forest extends more than 200 km from the mast. The two low-roughness simulations showed differences both in terms of estimated wind resource and wind shear. The simulation with enhanced roughness results in an improved correlation with measured data for near-neutral situations in the observed height range, whereas the correlation is deteriorated relative to the standard setup for stable atmospheric stratifications for heights above approximately 80 m. The inclusion of the displacement height in the post-processing of the results is also discussed.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Uppsala University, WeatherTech Scandinavia AB
Contributors: Dellwik, E., Arnqvist, J., Bergström, H., Mohr, M., Söderberg, S., Hahmann, A. N.
Number of pages: 6
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 524
Issue number: 1
Article number: 012121
On the determination of stability conditions over forested areas from velocity measurements

Two proxies able to determine the sign of the atmospheric stability in the absence of temperature measurements were investigated using data from four forested sites in Sweden. The results indicate that the simple proxy based on the time of the day when the measurement was taken was sufficient to identify approximately 75% of the stable occurrences.
However, also during daytime, stable stratification was not infrequent. A criterion based on a combination of the local turbulence intensity and shear exponent was therefore also investigated, and the combination of the two criteria was able to estimate approximately 90% of the overall stable data. When selecting data with mean wind speeds over 5 m/s at 80 m height, the presented data sets include mostly data where temperature effects are small (near-neutral), followed by stable data. Only few occurrences of unstable conditions were anyway observed. The investigated data sets show large variation of shear and turbulence intensity with increasing stability, indicating the need for proxies that also can be used to characterize the degree of atmospheric stability.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, DNV GL USA, KTH - Royal Institute of Technology
Contributors: Medici, D., Segalini, A., Dellwik, E.
Number of pages: 9
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Host publication information
Title of host publication: Proceedings of EWEA 2014
Publisher: European Wind Energy Association (EWEA)
Keywords: Atmospheric stability, Obukhov length, Richardson number

Electronic versions:
On_the_determination.pdf

Research output: Research - peer-review › Article in proceedings – Annual report year: 2015

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
State: Published
Organisations: Department of Wind Energy, Meteorology, Test and Measurements
Contributors: Dellwik, E., Sathe, A., Mann, J.
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Publication information
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BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.35 SJR 0.252 SNIP 0.374
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.32 SJR 0.264 SNIP 0.352
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.25 SJR 0.245 SNIP 0.293
ISI indexed (2013): ISI indexed no
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.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology
Contributors: Mann, J., Dellwik, E.
Number of pages: 9
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Volume: 524
Article number: 012103
ISSN (Print): 1742-6596
Ratings:
A data-driven analysis of energy balance closure across FLUXNET research sites: The role of landscape scale heterogeneity

The energy balance at most surface-atmosphere flux research sites remains unclosed. The mechanisms underlying the discrepancy between measured energy inputs and outputs across the global FLUXNET tower network are still under debate. Recent reviews have identified exchange processes and turbulent motions at large spatial and temporal scales in heterogeneous landscapes as the primary cause of the lack of energy balance closure at some intensively-researched...
sites, while unmeasured storage terms cannot be ruled out as a dominant contributor to the lack of energy balance closure at many other sites. We analyzed energy balance closure across 173 ecosystems in the FLUXNET database and explored the relationship between energy balance closure and landscape heterogeneity using MODIS products and GLOBEstat elevation data. Energy balance closure per research site (CEB,s) averaged 0.84±0.20, with best average closures in evergreen broadleaf forests and savannas (0.91–0.94) and worst average closures in crops, deciduous broadleaf forests, mixed forests and wetlands (0.70–0.78). Half-hourly or hourly energy balance closure on a percent basis increased with friction velocity (u*) and was highest on average under near-neutral atmospheric conditions. CEB,s was significantly related to mean precipitation, gross primary productivity and landscape-level enhanced vegetation index (EVI) from MODIS, and the variability in elevation, MODIS plant functional type, and MODIS EVI. A linear model including landscape-level variability in both EVI and elevation, mean precipitation, and an interaction term between EVI variability and precipitation had the lowest Akaike's information criterion value. CEB,s in landscapes with uniform plant functional type approached 0.9 and CEB,s in landscapes with uniform EVI approached 1. These results suggest that landscape-level heterogeneity in vegetation and topography cannot be ignored as a contributor to incomplete energy balance closure at the flux network level, although net radiation measurements, biological energy assimilation, unmeasured storage terms, and the importance of good practice including site selection when making flux measurements should not be discounted. Our results suggest that future research should focus on the quantitative mechanistic relationships between energy balance closure and landscape-scale heterogeneity, and the consequences of mesoscale circulations for surface-atmosphere exchange measurements.

**General information**

State: Published
Organisations: Department of Chemical and Biochemical Engineering, Ecosystems Programme, Department of Wind Energy, Meteorology, Montana State University, Karlsruhe Institute of Technology, University of Bayreuth, McMaster University, Fondazione Edmund Mach, Roskilde University, Lund University, Finnish Meteorological Institute, Dresden University of Technology, European Commission - Joint Research Center, Consiglio Nazionale delle Ricerche, Commonwealth Scientific and Industrial Research Organisation, University College Cork, University of Göttingen, Universite Laval, Queen's University Kingston, Swiss Federal Institute of Technology, Free University of Bozen-Bolzano, Tuscia University, Max Planck Institute, University College Dublin, Estación Experimental de Zonas Áridas, University of Sassari, Russian Academy of Sciences


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Peer-reviewed: Yes

**Publication Information**

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Ratings:
- BFI (2019): BFI-level 2
- Web of Science (2019): Indexed yes
- BFI (2018): BFI-level 2
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 4.67 SJR 1.818 SNIP 1.794
- Web of Science (2017): Impact factor 4.039
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 4.62 SJR 2.047 SNIP 1.916
- Web of Science (2016): Impact factor 3.887
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 4.63 SJR 2.162 SNIP 1.992
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 4.31 SJR 2.056 SNIP 1.906
- Web of Science (2014): Impact factor 3.762
A single laser all fibre based optical sensor and switching system and method for measuring velocity in atmospheric air flow

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.

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Organisations: Department of Wind Energy, Meteorology, Test and Measurements
Contributors: Dellwik, E., Mann, J., Kristensen, L., Mikkelsen, T.
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Date: 27/06/2013
Original language: English
Electronic versions:
WO2013092746A1.pdf

Bibliographical note
DTU reference no: 92641
Research output: Research › Patent – Annual report year: 2013

Evapotranspiration and heat fluxes over a small forest - a study using modelling and measurements
Some forests in Europe are too small to fulfil the strict fetch requirements associated with idealized flux observations. As a consequence of limited fetch, the flux measured above the canopy will often deviate from the source strength underlying the measurements. Because such flux measurements are very often used for calibration of forest parameters or model constants, further use of these parameters without a proper interpretation in mesoscale or global circulation models can result in serious bias of estimates of modelled evapotranspiration or heat fluxes from the given area. In the present work, we apply the atmospheric boundary layer (ABL) model SCADIS with enhanced turbulence closure including buoyancy for investigation of the spatial distribution of latent and sensible heat vertical fluxes over patchy forested terrain in Denmark during selected days in the summer period. The approach used can be utilized in interpretation of already existing experimental data and in the planning of future experiments.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Roskilde University
Contributors: Sogachev, A., Dellwik, E., Boegh, E.
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Publication date: 2013

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Publisher: IAHS Press
ISBN (Print): 978-1-907161-37-7
(IAHS Publications Series (Red Books); No. 359).
Keywords: Latent flux, Heat flux, Atmospheric boundary layer, Modelling, Heterogeneous surface
Source: dtu
Source-ID: n:oai:DTIC-ART:bl/409238772::36305
Research output: Research - peer-review › Article in proceedings – Annual report year: 2013

Updated vegetation information in high resolution WRF simulations
Climate studies show that the frequency of heat wave events and above-average high temperatures during the summer months over Europe will increase in the coming decades. Such climatic changes and long-term meteorological conditions will impact the seasonal development of vegetation and ultimately modify the energy distribution at the land surface. In weather and climate models it is important to represent the vegetation variability accurately to obtain reliable results. The weather research and forecasting (WRF) model uses green vegetation fraction (GVF) time series to represent vegetation seasonality. The GVF of each grid cell is additionally used to scale other parameters such as LAI, roughness, emissivity and albedo within predefined intervals. However, the default GYP used by WRF does not reflect recent climatic changes
or change in management practices since it was derived more than 20 years ago. In this study, a new high resolution GYP product based on MODIS images is applied in a high resolution WRF simulation over Denmark during the 2006 heat wave year. It is found that the GYP is very different in a heat wave year compared to the default GVF. The simulation is compared to a control run using the default GVF data and their performances are quantified against gridded data. The verification includes 2-m temperature and precipitation. The results show that although the simulation using the new GYP product performs well, it does not significantly improve performance compared to the default GYP, despite significant differences in vegetation fractions.

General information
State: Published
Organisations: Meteorology, Department of Wind Energy, Roskilde University
Contributors: Nielsen, J. R., Dellwik, E., Hahmann, A. N., Boegh, E.
Number of pages: 6
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Publication date: 2013

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Publisher: IAHS Press
(IAHS Publications Series (Red Books); No. 359).
Keywords: GEOSCIENCES, METEOROLOGY, WATER, CLIMATE-CHANGE, VARIABILITY, EUROPE, green vegetation fraction, WRF, heat wave

Abstract
Source: FindIt
Source-ID: 259337222
Research output: Research - peer-review › Article in proceedings – Annual report year: 2013

Wind Climate Estimating using WRF model Output: Model Sensitivities

General information
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Organisations: Department of Wind Energy, Meteorology
Publication date: 2013

Event information
Event: European Wind Energy Conference & Exhibition 2013
Location: Vienna, Austria

Research output: Research › Sound/Visual production (digital) – Annual report year: 2013

Wind power in forests: Winds and effects on loads
I projektet V-312, Vindkraft i skog, har forskare och en doktorand vid Uppsala universitet, WeatherTech Scandinavia, Kungliga tekniska högskolan (KTH), DTU Wind Energy i Danmark och Teknikgruppen samarbetat. I projektet har det gjorts mätningar med hög vertikal upplösning av turbulensen i atmosfären, även ned mellan träden, syftande till att möjliggöra en bättre teoretisk beskrivning av de observerade egenskaperna. Dessutom har flera mesoskaliga modeller använts för att modellera vindarna ovanför skogen. Mätningarna i atmosfären har kompletterats med vindtunnelmätningar där bottnen i vindtunneln har bestyckats med små cylindriska träpinnar vilka skulle simulera effekterna av trä och ge upphov till en käns friktionskraft som påverkar strömningen. De kombinerade nya kunskaperna om vind och turbulens i gränsskiktet över en skog har använts för att driva en datormodell som beskriver dynamiken hos vindturbinerna. Detta har sedan använts för att simulera lasterna på turbinerna som uppstår i det turbulenta vindfältet.

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State: Published
Organisations: Meteorology, Department of Wind Energy, Uppsala University
Number of pages: 182
Publication date: 2013
Flow characteristics at a forested site with wind turbines

General information
State: Published
Organisations: Department of Wind Energy, Meteorology
Contributors: Dellwik, E.
Number of pages: 1
Publication date: 2012
Peer-reviewed: Yes
Event: Abstract from 12th EMS Annual Meeting and 9th European Conference on Applied Climatology (ECAC), Łódź, Poland.
Electronic versions:
Flow_characteristics.pdf
Research output: Research – peer-review › Conference abstract for conference – Annual report year: 2013

Flow distortion at a dense forest edge

General information
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Organisations: Department of Wind Energy, Meteorology
Contributors: Dellwik, E.
Number of pages: 1
Publication date: 2012
Peer-reviewed: Yes
Event: Abstract from 12th EMS Annual Meeting and 9th European Conference on Applied Climatology (ECAC), Łódź, Poland.
Electronic versions:
Flow_distortion.pdf
Research output: Research – peer-review › Conference abstract for conference – Annual report year: 2013

Impacts of updated green vegetation fraction data on WRF simulations of the 2006 European heat wave

General information
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Organisations: Department of Wind Energy, Meteorology
Contributors: Nielscn, J. R., Dellwik, E., Hahmann, A. N., Barlage, M., Boegh, E.
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Peer-reviewed: Yes
Electronic versions:
Impacts_of_updated_green.pdf
Research output: Research – peer-review › Conference abstract for conference – Annual report year: 2013

Input parameters for CFD flow modelling of forested terrain

General information
State: Published
Organisations: Meteorology, Department of Wind Energy, Technical University of Denmark
Contributors: Boudreau1, L., Dellwik, E., Sogachev, A., Bøgh, E.
Number of pages: 1
Publication date: 2012
Input parameters for CFD flow modelling of forested terrain

Micro-scale modelling of energy fluxes over a small Fluxnet forest site in Denmark

Most forests, especially in Europe, are too small to fulfil strict fetch requirements associated with idealized flux observations in undisturbed, homogeneous flow. As a consequence of limited fetch, the flux measured above the canopy will often deviate from the source strength underlying the measurements. Since representative measurements focused on heterogeneous effects are scarce because of demanding experimental arrangements the numerical modelling are often recruited for analysis of these deviations. During the last years the atmospheric boundary layer (ABL) model SCADIS (scalar distribution model; Sogachev et al., 2002, Tellus 54B, 784-819) has been successfully applied especially in the region adjacent to a forest edge in order to improve flux data interpretation. Most of the analyses were done for the neutral case and in two-dimensional mode. When analyzing the effect of a forest edge on both flow and passive scalar properties, numerical studies showed that sources located on a soil surface are major contributors to wave-like flux behavior downwind of the leading edge, and that it is important to distinguish the effects of ground sources from those of the foliage. In the present work, we apply the SCADIS model with enhanced turbulence closure including buoyancy for investigation of the daily course of energy fluxes over patchy forested terrain in Denmark, where the model is used in three-dimensional mode. The modelling results (with 50 m horizontal resolution) are in good qualitative agreement with high-resolution (60 m and 120 m) remote-sensing data of the effective surface temperature of the area near the site in focus: the forested areas are colder in daytime and warmer in night time than surrounding open areas. In contrast to the remote sensing approach, SCADIS provides the information about spatial distribution of latent and sensible heat vertical fluxes in the whole ABL. Topography and forest edge effects result in vertical turbulent fluxes that deviate significantly from the original sources producing apparent local energy imbalance, when advection is not considered. A closer look at the result shows that though the measuring mast is located in the middle of a forest patch by size about 1x2 km², it is not free from uncertainties regarding energy balance closure and that caution is needed when interpreting measured flux data. The approach used in this work can be utilized in interpretation of already existed experimental data and in the planning of future experiments.
Numerical modeling of the airflow around a forest edge using LiDAR-derived forest heights

A 3D methodology to quantify the effect of forests on the mean wind flow field is presented. The methodology is based on the treatment of forest raw data of light detection and ranging (LiDAR) scans, and a computational fluid dynamics (CFD) method based on a Reynolds-averaged Navier-Stokes (RaNs) approach using the k−ε turbulence model with a corresponding canopy model. The example site investigated is a forest edge located on the Falster island in Denmark, where a measurement campaign was conducted. The LiDAR scans are used in order to obtain the forest heights, which served as input to the numerical CFD model. A sensitivity analysis with regards to the resolution of the structured forest height grid obtained from the implemented digital elevation model (DEM) was carried out. CFD calculations were conducted with the forest height grid taken as input and the complete methodology results are finally briefly compared to the wind measurements of the site with regards to the calculated wind field prediction accuracy.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology, Aeroelastic Design
Contributors: Boudreault, L., Dellwik, E., Bechmann, A., Sørensen, N. N., Sogachev, A.
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Publication date: 2012
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Event: Paper presented at 8th PhD Seminar on Wind Energy in Europe, Zurich, Switzerland.
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Electronic versions:
ETHseminar_paper.pdf
Source: dtu
Source-ID: u::6769
Research output: Research › Paper – Annual report year: 2013

Thermal optimality of net ecosystem exchange of carbon dioxide and underlying mechanisms

It is well established that individual organisms can acclimate and adapt to temperature to optimize their functioning. However, thermal optimization of ecosystems, as an assemblage of organisms, has not been examined at broad spatial and temporal scales. Here, we compiled data from 169 globally distributed sites of eddy covariance and quantified the temperature response functions of net ecosystem exchange (NEE), an ecosystem-level property, to determine whether NEE shows thermal optimality and to explore the underlying mechanisms. We found that the temperature response of NEE followed a peak curve, with the optimum temperature (corresponding to the maximum magnitude of NEE) being positively correlated with annual mean temperature over years and across sites. Shifts of the optimum temperature of NEE were mostly a result of temperature acclimation of gross primary productivity (upward shift of optimum temperature) rather than changes in the temperature sensitivity of ecosystem respiration. Ecosystem-level thermal optimality is a newly revealed ecosystem property, presumably reflecting associated evolutionary adaptation of organisms within ecosystems, and has the potential to significantly regulate ecosystem–climate change feedbacks. The thermal optimality of NEE has implications for understanding fundamental properties of ecosystems in changing environments and benchmarking global models.

General information
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Organisations: Department of Wind Energy, Meteorology, Department of Chemical and Biochemical Engineering, Ecosystems Programme, University of Oklahoma, National Ecological Observatory Network Inc., Oregon State University, Agroscope, McMaster University, Lund University, Université de Liege, Climate Research Division, Monash University, University of British Columbia, Vrije Universiteit Amsterdam, Oak Ridge National Laboratory, University of South Dakota, Centre for Ecology and Hydrology, Hokkaido University, United States Department of Agriculture, Trinity College Dublin, University College Cork, Northern Arizona University, Thunen-Institut, Trent University, National Center for Atmospheric Research, Chinese Academy of Sciences, University of New Mexico, INRA Institut National de La Recherche Agronomique, Aarhus University, Czech Academy of Sciences, University of Florida, Italian National Research Council, European Commission - Joint Research Center, Alterra, Dresden University of Technology, Swiss Federal Institute of Technology, University of Toledo, University of Wisconsin-Madison, Fondazione Edmund Mach, University of Antwerp, University of California at Berkeley, Harvard University, North Carolina State University, University of Innsbruck, Fudan University, San Diego State University, Poznan University Of Life Sciences, University of California at Davis, CNRS, Consiglio Nazionale delle Ricerche, Montana State University, Russian Academy of Sciences, Southwest Watershed Research Center, Agenzia Regionale per la Prevenzione e l'Ambiente dell'Emilia Romagna, Beijing Normal University, Pennsylvania State University, University of Helsinki, University of Sassari
Updated green vegetation fraction data for use in WRF

General information
State: Published
Organisations: Department of Wind Energy, Meteorology
Contributors: Dellwik, E.
Number of pages: 1
Publication date: 2012
Peer-reviewed: Yes
Event: Abstract from 12th EMS Annual Meeting and 9th European Conference on Applied Climatology (ECAC), Łódź, Poland.
Electronic versions:
Updated_green_vegetation.pdf

Bibliographical note
EMS conference, Lodz Poland 2012
Source: dtu
Source-ID: u::7381
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2013

Methanol and other VOC fluxes from a Danish beech forest during late springtime

In-canopy mixing ratio gradients and above-canopy fluxes of several volatile organic compounds (VOCs) were measured using a commercial proton transfer reaction mass spectrometer (PTR-MS) in a European beech (Fagus sylvatica) forest in Denmark. Fluxes of methanol were bidirectional: Emission occurred during both day and night with highest fluxes (0.2 mg C m⁻² h⁻¹) during a warm period; deposition occurred dominantly at daytime. Confirming previous branch-level measurements on beech, the forest's monoterpene emissions (0–0.5 mg C m⁻² h⁻¹), and in-canopy mixing ratios showed a diurnal cycle consistent with light-dependent emissions; a result contrasting temperature-only driven emissions of most conifer species. Also emitted was acetone, but only at ambient temperatures exceeding 20°C. Slow deposition dominated at lower temperatures. Our in-canopy gradient measurements contrast with earlier results from tropical and pine forest ecosystems in that they did not show this beech ecosystem to be a strong sink for oxygenated VOCs (OVOCs). Instead, their gradients were flat and only small deposition velocities ( 

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Biosystems Division. Management, Biosystems Division
Micro- and meso-scale effects of forested terrain

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.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Mann, J., Sogachev, A., Hahmann, A. N.
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Publisher: European Wind Energy Association (EWEA)
Keywords: Aeroelastic design methods

Surface energy balance measurements in wind energy experiments

General information
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Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Mann, J.
Publication date: 2011
Peer-reviewed: No
Event: Poster session presented at EERA Workshop on Wind Conditions, Porto, Portugal.
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http://indico.conferences.dtu.dk/contributionDisplay.py?contribId=19&sessionId=5&confId=70
Source: orbit
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Research output: Research › Poster – Annual report year: 2011
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
Contributors: Sogachev, A., Mann, J., Dellwik, E., Ejësing Jørgensen, H.
Publication date: 2010
Peer-reviewed: Yes

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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
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Keywords: Wind power meteorology, Wind Energy
Electronic versions:
Sogachev_cfd.pdf
Source: orbit
Source-ID: 270661
Research output: Research - peer-review > Conference article – Annual report year: 2010

Climate control of terrestrial carbon exchange across biomes and continents
Understanding the relationships between climate and carbon exchange by terrestrial ecosystems is critical to predict future levels of atmospheric carbon dioxide because of the potential accelerating effects of positive climate–carbon cycle feedbacks. However, directly observed relationships between climate and terrestrial CO₂ exchange with the atmosphere across biomes and continents are lacking. Here we present data describing the relationships between net ecosystem exchange of carbon (NEE) and climate factors as measured using the eddy covariance method at 125 unique sites in various ecosystems over six continents with a total of 559 site-years. We find that NEE observed at eddy covariance sites is (1) a strong function of mean annual temperature at mid- and high-latitudes, (2) a strong function of dryness at mid- and low-latitudes, and (3) a function of both temperature and dryness around the mid-latitudinal belt (45°N). The sensitivity of NEE to mean annual temperature breaks down at ~ 16 °C (a threshold value of mean annual temperature), above which no further increase of CO₂ uptake with temperature was observed and dryness influence overrules temperature influence.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Ecosystems, Biosystems Division, Biosystems Division, Management, City College of New York, Oak Ridge National Laboratory, Lund University, Polytechnic Institute of Leiria, Agroscope, McMaster University, National Institute of Amazonian Research, Finnish Meteorological Institute, Eötvös Loránd University, Climate Research Division, INRA Institut National de La Recherche Agronomique, Monash University, Dresden University of Technology, University of Minnesota, Royal Netherlands Meteorological Institute, Forest Research, Swiss Federal Institute of Technology, National Center for Atmospheric Research, National Institute for Agronomic Research, University of Toronto, University of Toledo, Centre National de la Recherche Scientifique, University of Edinburgh, Trent University, The Ohio State University, University of Maine, Universite Paris-Sud, University of Wisconsin-Madison, Indiana University-Purdue, Worcester State University, Alterra, University of California at Davis, University of Basel, University of Lethbridge, University of Bayreuth, United States Department of Agriculture, Fondazione Edmund Mach, University of California at Berkeley, University of California at Irvine, Fudan University, University of Innsbruck, Chinese Academy of Sciences, Hungarian Meteorological Service, Centre for Ecology and Hydrology, Vrije Universiteit Amsterdam, Charles Darwin University, Universidade Técnica de Lisboa, University College Cork, Thunen-Institut, CSIRO Marine and Atmospheric Research, Jackson State University, Consiglio Nazionale delle Ricerche, Institute of Systems Biology and Ecology, Universite Laval, University of Florida, Argonne National Laboratory, Italian National Research Council, Queen's University Kingston, Max Planck Institute, Università degli Studi di Milano, University of Colorado Boulder, Alterra Green World Research, Zambia Meteorological Department, Harvard University, Szent Istvan University, North Carolina State University, San Diego State University, University of Missouri, University of Aveiro, Instituto Superior Técnico, National Institute of Space Research, McGill University, Utah State University, National Institute for Environmental Studies, Parque Tecnologico, Agricultural Research Council, Forschungs Zentrum Karlsruhe GmbH, European Commission - Joint Research Center, University of Alabama,
Contrasting response of European forest and grassland energy exchange to heatwaves

Recent European heatwaves have raised interest in the impact of land cover conditions on temperature extremes. At present, it is believed that such extremes are enhanced by stronger surface heating of the atmosphere, when soil moisture content is below average. However, the impact of land cover on the exchange of water and energy and the interaction of this exchange with the soil water balance during heatwaves is largely unknown. Here we analyse observations from an extensive network of flux towers in Europe that reveal a difference between the temporal responses of forest and grassland ecosystems during heatwaves. We find that initially, surface heating is twice as high over forest than over grassland. Over grass, heating is suppressed by increased evaporation in response to increased solar radiation and temperature. Ultimately, however, this process accelerates soil moisture depletion and induces a critical shift in the regional climate system that leads to increased heating. We propose that this mechanism may explain the extreme temperatures in August 2003. We conclude that the conservative water use of forest contributes to increased temperatures in the short term, but mitigates the impact of the most extreme heat and/or long-lasting events.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Swiss Federal Institute of Technology, MeteoSwiss, Max Planck Institute, Alterra, Laboratoire des Sciences de Climat et de l’Environnement, KNMI, Agroscope, Dresden University of Technology, Fondazione Edmund Mach, University of Antwerp, National Institute for Agronomic Research, Free University of Bozen-Bolzano, University of Innsbruck, University of Liege
Pages: 722-727
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Peer-reviewed: Yes

Publication information
Journal: Nature Geoscience
Volume: 30
Issue number: 10
Effective roughness in meso-scale modeling

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Nielsen, J., Dellwik, E., Hahmann, A. N., Sogachev, A., Hasager, C. B.
Publication date: 2010
Flow tilt angle measurements from the ground

General information
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Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Test and Measurements, Centre for Renewable Energy Sources
Contributors: Mann, J., Dellwik, E., Bingöl, F., Courtney, M., Foussekis, D.
Publication date: 2010

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Publisher: ISARS
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O_RET04_Mann.pdf
URLs:
http://www.isars2010.uvsq.fr/
Source: orbit
Source-ID: 265521
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Flow tilt angle measurements using lidar anemometry

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Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Mann, J.
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Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Keywords: Wind power meteorology, Wind Energy
Source: orbit
Source-ID: 270600
Research output: Research - peer-review › Conference article – Annual report year: 2010
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.

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State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Ecosystems, Biosystems Division
Contributors: Dellwik, E., Mann, J., Larsen, K. S.
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Publication information
Journal: Biogeosciences
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ISSN (Print): 1726-4170
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.96 SJR 2.072 SNIP 1.235
Web of Science (2017): Impact factor 3.441
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.25 SJR 2.397 SNIP 1.315
Web of Science (2016): Impact factor 3.851
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.04 SJR 2.444 SNIP 1.326
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.
Implementing earth observation and advanced satellite based atmospheric sounders for water resource and climate modelling

This paper discusses preliminary remote sensing (MODIS) based hydrological modelling results for the Danish island Sjælland (7330 km²) in relation to project objectives and methodologies of a new research project “Implementing Earth observation and advanced satellite based atmospheric sounders for effective land surface representation in water resource modeling” (2009-2012). The purpose of the new research project is to develop remote sensing based model tools capable of quantifying the relative effects of site-specific land use change and climate variability at different spatial scales. For this purpose, a) internal catchment processes will be studied using a Distributed Temperature Sensing (DTS) system, b) Earth observations will be used to upscale from field to regional scales, and c) at the largest scale, satellite based atmospheric sounders and meso-scale climate modelling will be used to study and verify the modelling of land surface hydrology processes.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Urban Water Engineering, Department of Environmental Engineering, Roskilde University
Contributors: Boegh, E., Dellwik, E., Hahmann, A. N., Hasager, C. B., Nielsen, J. R., Rosbjerg, D.
Publication date: 2010
Peer-reviewed: No
Event: Poster session presented at Earth observation and water cycle science, Frascati (IT), 18-20 Nov., .
Keywords: Wind energy, Wind power meteorology
Electronic versions:
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Source: orbit
Source-ID: 263658
Research output: Research - peer-review → Journal article – Annual report year: 2010
Trends in CO2 exchange over a deciduous forest based on continuous eddy covariance measurements over 14 years

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Biosystems Division, Wind Energy Division
Contributors: Pilegaard, K., Ibrom, A., Dellwik, E.
Pages: EGU2010-9169
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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
Electronic versions:
EGU2010_9169.pdf
Research output: Research - peer-review › Conference abstract in journal – Annual report year: 2010

Carbon dioxide exchanges between the land surface and the atmosphere for natural and managed ecosystems in Denmark

General information
State: Published
Organisations: Biosystems Division. Management, Biosystems Division, Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division, University of Copenhagen
Contributors: Søgaard, H., Pilegaard, K., Dellwik, E., Herbst, M., Friborg, T.
Pages: 042030
Publication date: 2009

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Title of host publication: Climate change: Global risks, challenges and decisions
Publisher: IOP Publishing
(IOP Conference Series: Earth and Environmental Science; No. 6).
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
DOIs:
10.1088/1755-1307/6/4/042030
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Source-ID: 256570
Research output: Research › Conference abstract in proceedings – Annual report year: 2009

Comparison of net CO2 fluxes measured with open- and closed-path infrared gas analyzers in an urban complex environment

Simultaneous eddy covariance (EC) measurements of CO2 fluxes made with open-path and closed-path analyzers were done in urban area of Helsinki, Finland, in July 2007–June 2008. Our purpose was to study the differences between the two analyzers, the necessary correction procedures and their suitability to accurately measure CO2 exchange in such non-ideal landscape. In addition, this study examined the effect of open-path sensor heating on measured fluxes in urban terrain, and these results were compared with similar measurements made above a temperate beech forest in Denmark. The correlation between the two fluxes was good (R2 = 0.93) at the urban site, but during the measurement period the open-path net surface exchange (NSE) was 17% smaller than the closed-path NSE, indicating apparent additional uptake of CO2 by open-path measurements. At both sites, sensor heating corrections evidently improved the performance of the open-path analyzer by reducing discrepancies in NSE at the urban site to 2% and decreasing the difference in NSE from 67% to 7% at the forest site. Overall, the site-specific approach gave the best results at both sites and, if possible, it should be preferred in the sensor heating correction.
Effects of climate change on carbon sequestration in a Danish Beech forest

General information
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Organisations: Biosystems Division. Management, Biosystems Division, Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division, Ecosystems
Contributors: Pilegaard, K., Dellwik, E., Ibrom, A.
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Publisher: IOP Publishing
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Source-ID: 256571
Research output: Research › Conference abstract in proceedings – Annual report year: 2009

Implementing Earth Observation and Satellite Based Atmospheric Sounders for Water Resource and Climate Modeling

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Residual Resource Engineering, Department of Environmental Engineering, Roskilde University
Contributors: Boegh, E., Dellwik, E., Hahmann, A. N., Hasager, C. B., Rosbjerg, D.
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Publication date: 2009

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Publisher: ESA-ESRIN
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Research output: Research › Conference abstract in proceedings – Annual report year: 2009

Remote sensing based evapotranspiration and runoff modeling of agricultural, forest and urban flux sites in Denmark: From field to macro-scale
Evapotranspiration (E) and runoff (RT) was modeled for the island of Sjælland (≈7330 km2) in Denmark at multiple spatial scales encompassing agricultural, forest and urban land surfaces. National data were used to represent spatial variations in climate, soil properties and lower boundary conditions, and the EOS/MODIS Normalized Difference Vegetation Index (NDVI) was used to map (a) the temporal development in leaf area index for agricultural fields, (b) a dynamic “canopy”
coefficient (Kc) of forests being scaled between its minimum and maximum values for use in the FAO Penman–Monteith equation, and (c) the impervious land cover fraction of urban regions. At field level, the use of local-scale model parameters, NDVI time series and site-specific methodologies to simulate E of the 3 major land surface types (agricultural land, forests and urban regions) explained 67–79% of the observed variability in eddy covariance latent heat fluxes. The “effective” spatial resolution needed to adopt local-scale model parameters for spatial-deterministic hydrological modeling was assessed using a high-spatial resolution (30 m) variogram analysis of the NDVI. The use of the NDVI variogram to evaluate land surface heterogeneity is based on the assumption that sub-class soil heterogeneity can be indirectly represented by the observed spatial variations in NDVI due to its close affiliation with vegetation growth, soil water uptake and evapotranspiration. Multiple spatial resolution water balance simulations were compared to validate the identified effective spatial resolution (500 m) model representation of land cover, NDVI and drainage pattern. Simulated RT of 30 catchments were compared with the fast-flow component of stream discharge data (Q − Qb) which is insensitive to groundwater abstraction and most sensitive to the spatial land surface representation. A good agreement was observed in the timing and size of peak flows in catchment dominated by agricultural, forest and urban land uses in periods when E has important control on the water balance and soil water percolation to groundwater is negligible (Days 125–300). The presence/absence of pipe drains, urban surface runoff and forest parameterization cause very large differences in the water balance of agricultural, forest and urban regions. The results show that the use of local-scale standard model parameters and NDVI time series representing agricultural, forest and urban land surfaces in physically based hydrological modeling makes it possible to reproduce much of the observed variability (48–73%) in stream flow (Q − Qb) when data and modeling is applied at an effective spatial resolution capable of representing land surface heterogeneity. In order to further improve the results, (1) advanced spatial parameterization methods are needed to improve the modeling of bare soil E of agricultural fields, (2) the impact of local conditions, such as tree age and nutrient levels, should be used to parameterize the maximum Kc used for forest E modeling, (3) high accuracy remote sensing based estimation of vegetation parameters is particularly important during sparsely vegetated conditions, and (4) the use of component stream flow data to evaluate the physical consistency of spatial-deterministic models appears to be feasible and should be further explored.

**General information**

State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Ecosystems, Biosystems Division, Biosystems Division. Management, Roskilde University, DHI Water - Environment - Health, University of Copenhagen
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Peer-reviewed: Yes

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Journal: Journal of Hydrology
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BFI (2017): BFI-level 2
Web of Science (2017): Impact factor 3.727
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.89 SJR 1.813 SNIP 1.772
Web of Science (2016): Impact factor 3.483
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.54 SJR 1.686 SNIP 1.761
Web of Science (2015): Impact factor 3.043
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.45 SJR 1.667 SNIP 1.993
Web of Science (2014): Impact factor 3.053
Wind and turbulence at a forest edge

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Bingöl, F., Mann, J., Sogachev, A.
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.

Biophysical controls on CO2 fluxes of three Northern forests based on long-term eddy covariance data

Six to nine years of net ecosystem carbon exchange (NEE) data from forests in Hyytiala in Finland, Soro in Denmark and Norunda in Sweden were used to evaluate the interannual variation in the carbon balance. For half-monthly periods, average NEE was calculated for the night-time data. For the daytime data parameters were extracted for the relationship to photosynthetic active radiation (PAR). The standard deviation of the parameters was highest for Norunda where it typically was around 25% of the mean, while it was ca. 15% for Hyytiala and Soro. Temperature was the main controller of respiration and photosynthetic capacity in autumn, winter and spring but explained very little of the interannual variation in summer. A strong correlation between respiration and photosynthesis was also revealed. The start, end and length of the growing season were estimated by four different criteria. The start date could explain some of the variation in yearly total NEE and gross primary productivity (GPP) in Hyytiala and Soro, but the average maximum photosynthetic capacity in summer explained more of the variation in annual GPP for all sites than start, end or length of the growing season.
Effects of water vapour pressure deficit on bulk canopy conductance in a beech forest

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Biosystems Division, Wind Energy Division, University of Copenhagen
Contributors: Lundberg, A. E., Ibrom, A., Dellwik, E., Pilegaard, K., Beier, C.
Pages: EGU2008-A-08553
Publication date: 2008
Peer-reviewed: No

Publication information
Journal: Geophysical Research Abstracts
Volume: 10
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
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Electronic versions:
- EGU2008_A_08553_1.pdf
Source: orbit
Source-ID: 251442
Research output: Research › Conference abstract in journal – Annual report year: 2008

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
Contributors: Sogachev, A., Dellwik, E., Mann, J., Vesala, T.
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
Source: orbit
Source-ID: 231721
Research output: Research › Conference abstract in proceedings – Annual report year: 2008
Laser measurements of flow over a forest
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.

Leaf area index is the principal scaling parameter for both gross photosynthesis and ecosystem respiration of Northern deciduous and coniferous forests

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Sogachev, A., Dellwik, E.
Publication date: 2008
Peer-reviewed: No
Source: orbit
Source-ID: 232457
Research output: Research › Paper – Annual report year: 2008
Quality control of CarboEurope flux data - Part 1: Coupling footprint analyses with flux data quality assessment to evaluate sites in forest ecosystems

We applied a site evaluation approach combining Lagrangian Stochastic footprint modeling with a quality assessment approach for eddy-covariance data to 25 forested sites of the CarboEurope-IP network. The analysis addresses the spatial representativeness of the flux measurements, instrumental effects on data quality, spatial patterns in the data quality, and the performance of the coordinate rotation method. Our findings demonstrate that application of a footprint filter could strengthen the CarboEurope-IP flux database, since only one third of the sites is situated in truly homogeneous terrain. Almost half of the sites experience a significant reduction in eddy-covariance data quality under certain conditions, though these effects are mostly constricted to a small portion of the dataset. Reductions in data quality of the sensible heat flux are mostly induced by characteristics of the surrounding terrain, while the latent heat flux is subject to instrumentation-related problems. The Planar-Fit coordinate rotation proved to be a reliable tool for the majority of the sites using only a single set of rotation angles. Overall, we found a high average data quality for the CarboEurope-IP network, with good representativeness of the measurement data for the specified target land cover types.

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Biosystems Division. Management, Biosystems Division
Pages: 433-450
Publication date: 2008
Peer-reviewed: Yes
The evolution and achievements of SCADIS

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy, Biosystems Division. Management, Biosystems Division
Turbulence spectra, shear stress and turbulent kinetic energy budgets above two beech forest sites in Denmark

**General information**
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Mammarella, I., Dellwik, E., Jensen, N. O.
Pages: 179-187
Publication date: 2008
Peer-reviewed: Yes

**Publication information**
Journal: Tellus B: Chemical and Physical Meteorology
Volume: 60
ISSN (Print): 0280-6509
Ratings:
- BFI (2019): BFI-level 1
- Web of Science (2019): Indexed yes
- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 2.03 SJR 1.203 SNIP 0.654
- Web of Science (2017): Impact factor 2.013
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 2.66 SJR 1.553 SNIP 1.02
- Web of Science (2016): Impact factor 2.854
- BFI (2015): BFI-level 1
- Scopus rating (2015): CiteScore 2.85 SJR 1.678 SNIP 1.045
- Web of Science (2015): Impact factor 2.402
- BFI (2014): BFI-level 1
- Scopus rating (2014): CiteScore 2.75 SJR 1.81 SNIP 1.061
- Web of Science (2014): Impact factor 2.147
- BFI (2013): BFI-level 1
- Scopus rating (2013): CiteScore 3.75 SJR 2.342 SNIP 1.377
- Web of Science (2013): Impact factor 3.76
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): CiteScore 3.17 SJR 2.727 SNIP 1.149
- Web of Science (2012): Impact factor 3.197
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): CiteScore 3.79 SJR 2.521 SNIP 1.352
- Web of Science (2011): Impact factor 4.382
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 2.513 SNIP 1.181
- BFI (2009): BFI-level 1
Wind profile measurements over a forest with lidar

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Rathmann, O., Mann, J., Dellwik, E., Bingöl, F.
Publication date: 2008
Peer-reviewed: No
Electronic versions:
2008_63.pdf
URLs:
http://www.risoe.dk/rispubl/art/2008_63.pdf
Source: orbit
Source-ID: 222980
Research output: Research › Conference abstract for conference – Annual report year: 2008

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
Contributors: Mann, J., Bingöl, F., Dellwik, E., Rathmann, O.
Pages: 688-690
Publication date: 2007

Host publication information
Title of host publication: Advances in turbulence 9. Proceedings
Volume: 117
Place of publication: Berlin
Publisher: Springer
Editors: Palma, J., Lopes, A.
ISBN (Print): 35-40-72603-6
(Springer Proceedings in Physics, 117).
Source: orbit
Source-ID: 216121
Research output: Research › Article in proceedings – Annual report year: 2007
Lidar measurements of the spatial variability of the wind over a forest

General information
State: Published
Organisations: Meteorology, Wind Energy Division, Risø National Laboratory for Sustainable Energy
Contributors: Gryning, S., Christiansen, M. B., Serensen, L. L., Dellwik, E.
Number of pages: 86
Publication date: 2007

Host publication information
Title of host publication: [Programme and Abstracts]
Place of publication: Poznan
Publisher: Organizing Committee
Source: orbit
Source-ID: 215986
Research output: Research › Conference abstract 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
Contributors: Mann, J., Bingöl, F., Mikkelsen, T., Antoniou, I., Courtney, M. S., Larsen, G. C., Dellwik, E., Trujillo, J., Ejising Jørgensen, H.
Publication date: 2007
Peer-reviewed: No
URLs:
Source: orbit
Source-ID: 215518
Research output: Research › Conference abstract for conference – Annual report year: 2007

On the use of the Webb-Pearman-Leuning theory for closed-path eddy correlation measurements
We consider an imperfection of real closed-path eddy correlation systems—the decoupling of the water vapour and CO2 concentrations— with respect to the application of the Webb-Pearman-Leuning (WPL) theory. It is described why and how the current application of the WPL theory needs to be adapted to the processes in closed-path sensors. We show the quantitative effects of applying the WPL theory in different ways using CO2 flux measurements taken above the Danish Beech forest CarboEurope site near Soro, Zealand.

Using the WPL theory in closed-path sensors without taking amplitude damping and decoupling into account, over-corrected the annual flux by 21%, or 31 g m(-2) yr(-1). To which the decoupling effect contributed with 7%. We suggest either converting the raw data point-by-point to mixing ratios or using the uncorrected covariances of water vapour mole fractions with the vertical wind velocity that were calculated with the same time lag as for the scalar concentration when correcting the dilution effect. We showed that the two approaches yielded equivalent flux results. Correct ways of applying spectral corrections to CO2 fluxes calculated in either way are also shown. The findings reported here do not apply to open-path sensors.

General information
State: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division, Biosystems Division. Management
Contributors: Ibrom, A., Dellwik, E., Larsen, S. E., Pilegaard, K.
Pages: 937-946
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Tellus B: Chemical and Physical Meteorology
Volume: 59
Issue number: 5
ISSN (Print): 0280-6509
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<td>CiteScore 3.79 SJR 2.521 SNIP 1.352</td>
<td>Impact factor 4.382</td>
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Original language: English

DOI: 10.1111/j.1600-0889.2007.00311.x
Scaling of carbon fluxes in canopies: Simulation of gross canopy photosynthesis in a beech forest canopy

General information
State: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Meteorology, Wind Energy Division, Biosystems Division. Management
Contributors: Ibrom, A., Mikkelsen, T., Dellwik, E., Pilegaard, K.
Publication date: 2007
Peer-reviewed: No
Source: orbit
Source-ID: 215802
Research output: Research - peer-review › Journal article – Annual report year: 2007

Strong low-pass filtering effects on water vapour flux measurements with closed-path eddy correlation systems
Turbulent water vapour fluxes measured with closed-path eddy correlation (EC) systems are unintentionally low-pass filtered by the system in a manner that varies with environmental conditions. Why and how is described here. So is the practical method that systematically corrects long-term flux datasets for this substantial measurement error. In contrast to earlier studies, a large number of spectra and raw data have been used in the analysis to define the low-pass filtering characteristic of the EC system. This revealed that the cut-off frequency of the closed-path EC system for water vapour concentration measurements decreases exponentially with increasing relative humidity. After correction for this unintended filtering, the fluxes are consistent with CO2 and H2O fluxes that were measured with an open-path sensor at the same time. The correction of water vapour flux measurements over a Beech forest in Soro, Zealand, Denmark, amounted on average to 42% of the measured flux, while it was only 4% for the CO2 flux, which was measured with the same EC system. We recommend using the described method to correct water vapour fluxes measured in any closed-path EC system for unintended low-pass filtering effects. Other than for CO2 is the magnitude of the correction for water vapour flux measurements unsatisfactorily high, i.e. the EC system needs to be technically improved. Our results suggest that such high correction can be avoided by keeping relative humidity in the entire gas transport system of the EC system lower than 30%, e.g. by heating intake filters and tubes. (c) 2007 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Cell Biology, Meteorology, Wind Energy Division, Biosystems Division. Management
Contributors: Ibrom, A., Dellwik, E., Flyvbjerg, H. K., Jensen, N. O., Pilegaard, K.
Pages: 140-156
Publication date: 2007
Peer-reviewed: Yes
Publication information
Journal: AGRICULTURAL AND FOREST METEOROLOGY
Volume: 147
Issue number: 3-4
ISSN (Print): 0168-1923
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.67 SJR 1.818 SNIP 1.794
Web of Science (2017): Impact factor 4.039
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.62 SJR 2.047 SNIP 1.916
Web of Science (2016): Impact factor 3.887
Web of Science (2016): Indexed yes
Aggregating fluxes and surface characteristics of heterogeneous surfaces
Aggregating fluxes and surface characteristics of heterogeneous surfaces (invited lecture)

Flux divergence due to spatial variability

Long-term (1-20 years) prediction of wind resources (WAsP)
Low-pass filtering of the latent heat flux

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ibrom, A., Dellwik, E., Jensen, N., Flyvbjerg, H., Pilegaard, K.
Pages: 207-210
Publication date: 2006

Host publication information
Title of host publication: Proceedings of BACCI, NECC and FCoE activities 2005. Book A
Place of publication: Helsinki
Publisher: Finnish Association for Aerosol Research
Editors: Kulmala, M., Lindroth, A., Ruuskanen, T.
Source-ID: 309283
Research output: Research - peer-review › Book chapter – Annual report year: 2006

The calculation of fluxes - impact study of new recommendations

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Ibrom, A., Pilegaard, K., Jensen, N.
Pages: 95-100
Publication date: 2006

Host publication information
Title of host publication: Proceedings of BACCI, NECC and FCoE activities 2005. Book A
Place of publication: Helsinki
Publisher: Finnish Association for Aerosol Research
Editors: Kulmala, M., Lindroth, A., Ruuskanen, T.
Source-ID: 309281
Research output: Research - peer-review › Book chapter – 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
Contributors: Dellwik, E., Mann, J., Rosenhagen, G.
Number of pages: 27
Publication date: 2006

Publication information
ISBN (Print): 87-550-3452-7
Original language: English
Source-ID: 309074
Research output: Research › Report – Annual report year: 2006

Electronic versions:
ris_r_1521.pdf
Source-ID: 309074

WAsP engineering in the forest

General information
State: Published
Flux-profile relationships over a fetch limited beech forest

The influence of an internal boundary layer and a roughness sublayer on flux-profile relationships for momentum and sensible heat have been investigated for a closed beech forest canopy with limited fetch conditions. The influence was quantified by derivation of local scaling functions for sensible heat flux and momentum ($\phi(h)$ and $\phi(m)$) and analysed as a function of atmospheric stability and fetch. For heat, the influences of the roughness sublayer and the internal boundary layer were in agreement with previous studies. For momentum, the strong vertical gradient of the flow just above the canopy top for some wind sectors led to an increase in $\phi(m)$, a feature that has not previously been observed. For a fetch of 500 m over the beech forest during neutral atmospheric conditions, there is no height range at the site where profiles can be expected to be logarithmic with respect to the local surface. The different influence of the roughness sublayer on $\phi(h)$ and $\phi(m)$ is reflected in the aerodynamic resistance for the site. The aerodynamic resistance for sensible heat is considerably smaller than the corresponding value for momentum.
Fordampning fra landbrug og skov

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ladekarl, U., Beier, C., Dellwik, E.
Pages: 44-47
Publication date: 2005
Peer-reviewed: Unknown

Publication information
Journal: Vand & Jord
Volume: 12
Issue number: 2
ISSN (Print): 0908-7761
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English
Source: orbit
Source-ID: 308171
Research output: Communication – Journal article – Annual report year: 2005

Low pass filter correction to turbulence data using a digital recursive filter

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ibrom, A., Dellwik, E., Jensen, N., Pilegaard, K.
Number of pages: 31
Publication date: 2005

Host publication information
Title of host publication: ACCENT-BIAFLUX workshop 2005. Trace gas and aerosol flux measurement techniques.
Abstract book
Volume: Risø-R-1508(EN)
Editors: Werner, A., Sørensen, L.
ISBN (Print): 87-550-3421-7
URLs:
http://www.risoe.dtu.dk/rispubl/VEA/veapdf/ris-r-1508.pdf
Source: orbit
Source-ID: 307941
Research output: Research › Conference abstract in proceedings – Annual report year: 2005
NECC and BACCI flux measurement sites in Denmark

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Jensen, N., Sørensen, L., Pilegaard, K., Barthelmie, R., Christensen, L., Dellwik, E., Lund, S., Pryor, S.
Publication date: 2005
Peer-reviewed: No
Event: Abstract from 2nd Advisory Board Meeting and NCoE, Lund, Sweden.
Source: orbit
Source-ID: 307795
Research output: Research › Conference abstract for conference – Annual report year: 2005

Offshore wind resource estimation from satellite SAR wind field maps

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 403-419
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Wind Energy
Volume: 8
ISSN (Print): 1095-4244
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Impact factor 2.938
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Impact factor 2.725
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.06 SJR 1.201 SNIP 2.165
Web of Science (2015): Impact factor 2.891
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.42 SJR 1.209 SNIP 3.688
Web of Science (2014): Impact factor 3.069
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.75 SJR 1.235 SNIP 2.486
Web of Science (2013): Impact factor 2.556
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.36 SJR 1.062 SNIP 2.297
Web of Science (2012): Impact factor 1.436
Upscaling the water balance using multiple spatial resolution Earth observations and GIS based agro/eco-hydrological modeling

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2005

Host publication information
Title of host publication: Proceedings (CD-ROM)
Place of publication: St. Petersburg
Publisher: Nansen International Environmental and Remote Sensing Centre
Source: orbit
Source-ID: 308156
Research output: Research - peer-review › Journal article – Annual report year: 2005

WAsP in the forest
This article compares mean wind estimates from a WAsP analysis for three forest sites and one site near a forest with measurements taken at the sites. By standard WAsP settings for forest, the mean wind speed at the sites was overestimated. Agreement between the estimates and the measurements improved significantly if displacement height
and roughness length as calculated from the forest mast data were used or if a simple model estimate of roughness length and displacement height based on stand density (frontal area index) was used. The two estimates of displacement height and roughness length (mast data and simple model) did not agree well with each other. One reason for this may be that all evaluated sites are windy and that both d and z₀ depend on the wind speed. All analysed forest sites are dense, in which case the influence from the roughness sublayer is limited and the effect on mean wind speeds from this layer could not be evaluated. Copyright © 2005 John Wiley & Sons, Ltd.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Landberg, L., Jensen, N. O.
Pages: 211-218
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Wind Energy
Volume: 9
ISSN (Print): 1095-4244
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.18 SJR 1.051 SNIP 1.834
Web of Science (2017): Impact factor 2.938
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.37 SJR 1.079 SNIP 2.316
Web of Science (2016): Impact factor 2.725
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.06 SJR 1.201 SNIP 2.165
Web of Science (2015): Impact factor 2.891
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.42 SJR 1.209 SNIP 3.688
Web of Science (2014): Impact factor 3.069
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.75 SJR 1.235 SNIP 2.486
Web of Science (2013): Impact factor 2.556
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.36 SJR 1.062 SNIP 2.297
Web of Science (2012): Impact factor 1.436
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.49 SJR 0.892 SNIP 2.582
Web of Science (2011): Impact factor 1.768
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.364 SNIP 2.026
A meteorologist's view on SVAT modelling

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E.
Publication date: 2004
Peer-reviewed: No
Event: Abstract from Dresdner Wasserseminar, Dresden (DE), 22 Jun, .
Source: orbit
Source-ID: 307102
Research output: Research › Conference abstract for conference – Annual report year: 2004

Comparison of turbulence structure above and within a fetch-limited forest canopy

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Jensen, N., Pilegaard, K.
Publication date: 2004
Peer-reviewed: No
Event: Abstract from NATO Advanced Study Institute: Flow and transport processes in complex obstructed geometries, Kiev (UA), 4-15 May, .
Source: orbit
Source-ID: 307101
Research output: Research › Conference abstract for conference – Annual report year: 2004

Flux divergences of gaseous and particulate nitrogen due to chemistry and horizontal heterogeneity

General information
State: Published
Implementation of the optimal stomatal control formulation into a single layer model

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Mikkelsen, T. N.
Publication date: 2004
Peer-reviewed: No
Event: Abstract from International conference on modeling forest production, Vienna (AT), 19-22 Apr, .
Source: orbit
Source-ID: 307100
Research output: Research › Conference abstract for conference – Annual report year: 2004

MODIS data for modelling the water balance at Zealand, Denmark

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2004
Peer-reviewed: No

**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: 306778
Research output: Research › Journal article – Annual report year: 2004

Validation of ERS-2 SAR offshore wind-speed maps in the North Sea

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hasager, C., Dellwik, E., Nielsen, M., Furevik, B.
Pages: 3817-3841
Publication date: 2004
Peer-reviewed: Yes

**Publication information**
Effective roughness calculated from satellite-derived land cover maps and hedge-information used in a weather forecasting model

In numerical weather prediction, climate and hydrological modelling, the grid cell size is typically larger than the horizontal length scales of variations in aerodynamic roughness, surface temperature and surface humidity. These local land cover variations give rise to sub-grid scale surface flux differences. Especially the roughness variations can give a significantly different value between the equilibrium roughness in each of the patches as compared to the aggregated roughness value, the so-called effective roughness, for the grid cell. The effective roughness is a quantity that secures the physics to be well-described in any large-scale model. A method of aggregating the roughness step changes in arbitrary real terrain has been applied in flat terrain (Denmark) where sub-grid scale vegetation-driven roughness variations are a dominant characteristic of the landscape. The aggregation model is a physical two-dimensional atmospheric flow model in the horizontal domain based on a linearized version of the Navier Stoke equation. The equations are solved by the Fast Fourier Transformation technique, hence the code is very fast. The new effective roughness maps have been used in the High Resolution Limited Area Model (HIRLAM) weather forecasting model and the weather prediction results are compared for a number of cases to synoptic and other observations with improved agreement above the predictions based on current standard input. Typical seasonal springtime bias on forecasted winds over land of +0.5 m s\(^{-1}\) and -0.2 m s\(^{-1}\) in coastal areas is reduced by use of the effective roughness maps.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hasager, C., Nielsen, N., Jensen, N., Bøgh, E., Christensen, J., Dellwik, E., Søgaard, G.
Offshore wind resource assessment based on satellite wind field maps

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hasager, C., Rathmann, O., Nielsen, M., Barthelmie, R., Pryor, S., Dellwik, E., Furevik, B.
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)
Source: orbit
Source-ID: 305928
Research output: Research › Article in proceedings – Annual report year: 2003

Surface layer characteristics and SVAT modelling of a fetch-limited forest

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Dellwik, E.
Number of pages: 140
Publication date: 2003

Publication information
Place of publication: Roskilde
Publisher: Riso National Laboratory
ISBN (Print): 87-550-3259-1
Original language: English
(Denmark. Forskningscenter Risoe. Risoe-R; No. 1429(EN)).
Keywords: Risø-R-1429, Risø-R-1429(EN)
Electronic versions:
ris-r-1429.pdf
Source: orbit
Source-ID: 43477
The parametrization of atmospheric resistances for fluxes between forests and atmosphere could be rather simple.

**General information**
- **State:** Published
- **Organisations:** Risø National Laboratory for Sustainable Energy
- **Contributors:** Dellwik, E., Jensen, N.
- **Number of pages:** 11
- **Publication date:** 2003

**Host publication information**
- **Title of host publication:** BACCI
- **Place of publication:** Roskilde
- **Publisher:** Risø National Laboratory
- **URLs:**
- **Source:** orbit
- **Source-ID:** 306068

**Assimilation of remote sensing data in the weather forecasting model**

**General information**
- **Organisations:** Risø National Laboratory for Sustainable Energy
- **Contributors:** Hasager, C., Nielsen, N., Søgaard, H., Bøgh, E., Christensen, J., Jensen, N., Rasmussen, M., Astrup, P., Dellwik, E.
- **Publication date:** 2002
- **Peer-reviewed:** No
- **Event:** Abstract from Seminar Day: Remote Sensing Applied in Hydrology and Agrometeorology, Copenhagen, Denmark.
- **Source:** orbit
- **Source-ID:** 304649

**Satellite synthetic aperture radar (ERS-2 SAR) validation study for offshore wind speed mapping**

**General information**
- **Organisations:** Risø National Laboratory for Sustainable Energy
- **Contributors:** Hasager, C., Furevik, B., Dellwik, E., Nielsen, M.
- **Publication date:** 2002
- **Peer-reviewed:** No
- **Event:** Abstract from North Forum for Photogrammetry and Remote Sensing, Copenhagen (DK), 2-4 Oct.
- **Source:** orbit
- **Source-ID:** 304585

**Status of the Danish CarboEuroFlux contribution**

**General information**
- **Organisations:** Risø National Laboratory for Sustainable Energy
- **Contributors:** Pilegaard, K., Jensen, N., Dellwik, E.
- **Publication date:** 2002
- **Peer-reviewed:** No
- **Event:** Abstract from 2nd CarboEurope Meeting, Budapest, Hungary.
- **Source:** orbit
- **Source-ID:** 303818
Evaluation of the aerodynamic and viscous sub-layer resistances for a beech forest with limited fetch

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Jensen, N.
Publication date: 2001
Peer-reviewed: No
Event: Abstract from 26th EGS General Assembly, Nice, France.
Source: orbit
Source-ID: 302306
Research output: Research › Conference abstract for conference – Annual report year: 2001

Evapotranspiration in Soil-Vegetation-Atmosphere-Transfer (SVAT) models

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E.
Publication date: 2001
Peer-reviewed: No
Event: Abstract from Forelæsning på Danmarks Tekniske Universitet, Lyngby (DK), 23 Feb
Source: orbit
Source-ID: 302411
Research output: Research › Conference abstract for conference – Annual report year: 2001

Six years of continuous CO₂ eddy-flux measurements over a Danish beech forest

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Pilegaard, K., Jensen, N.
Publication date: 2001
Peer-reviewed: No
Event: Abstract from Workshop on phenology and CO₂ and H₂O fluxes, Hyytiälä (FI), 3-5 Sep
Source: orbit
Source-ID: 303369
Research output: Research › Conference abstract for conference – Annual report year: 2001

Derivation of viscous sublayer and canopy resistance for a beech forest from long-term flux measurements

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Jensen, N.
Publication date: 2000
Peer-reviewed: No

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
Internal equilibrium layer growth over forest

Friction velocity data from different heights above a forest are used to evaluate the influence from the surrounding landscape on forest micro-meteorological measurements under near-neutral conditions. Data are used from one field site and two forest sites. The field site data are used to estimate the magnitude of the scatter. Different theoretical friction velocity profiles for the Internal Boundary Layer (IBL) are tested against the forest data. The results yield information on the Internal Equilibrium Layer (IEL) growth and an equation for the IEL height for neutral conditions is derived. For stable conditions the results indicate that very long fetches are required in order to measure parameters in equilibrium with the actual surface.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Jensen, N.
Pages: 173-184
Publication date: 2000
Peer-reviewed: No

Publication information
Journal: Theoretical and Applied Climatology
Volume: 66
Issue number: 3-4
ISSN (Print): 0177-798X
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.07 SJR 0.867 SNIP 0.999
Web of Science (2017): Impact factor 2.321
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.09 SJR 1.054 SNIP 1.12
Web of Science (2016): Impact factor 2.64
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.82 SJR 1.062 SNIP 1.03
Web of Science (2015): Impact factor 2.433
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.92 SJR 0.964 SNIP 1.067
Web of Science (2014): Impact factor 2.015
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.96 SJR 1.032 SNIP 1.208
Web of Science (2013): Impact factor 1.742
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.94 SJR 1.232 SNIP 1.243
Web of Science (2012): Impact factor 1.759
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.94 SJR 1.209 SNIP 1.269
Footprint considerations for flux measurements over forest

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Hummelshøj, P., Hasager, C., Jensen, N., Pilegaard, K.
Pages: 439
Publication date: 1999
Peer-reviewed: Yes

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: 300420
Research output: Research - peer-review › Journal article – Annual report year: 1999
Internal equilibrium layer growth over a forest under neutral conditions

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Dellwik, E., Jensen, N., Hasager, C.
Publication date: 1999
Peer-reviewed: No
Event: Abstract from 1st Danish Society for Atmospheric Research Conference, Copenhagen, Denmark.
Source: orbit
Source-ID: 299834
Research output: Research › Conference abstract for conference – Annual report year: 1999

Projects:

TrueWind: TrueWind
The project objective is to increase the accuracy in wind measurements of cup anemometry using state-of-the-art remote-sensing technology in wind tunnel and free field environments. TrueWind will contribute to three significant commercial exploitations and a technological achievement:

- Very short range wind lidar (lidic) calibration capability installed in the wind tunnels of Svend Ole Hansen ApS, and studies on tunnel boundary and turbulence influence on calibration holds potential for a substantial reduction in measurement uncertainty resulting in an increased global calibration market share, partly in Danish wind tunnels, partly in US based wind tunnels.
- Improvement of WindSensor ApS cup anemometers, will ensure world's best classification for wind resource assessment and power performance verification and will result in increased global market share.
- Commercialisation of lidic wind measurement equipment for wind tunnel applications by Dantec Dynamics A/S, will supplement a world leading LDA portfolio for wind tunnel measurement equipment and maintain global leadership in accurate wind tunnel measurement equipment.

An open field calibration facility at DTU Risø campus, based on a short range wind scanner with 3 lidic’s, will be developed to verify and improve a cup anemometer model used in the IEC61400-12-1 standard classification, and demonstration of the free field calibration facility capabilities will maintain technological leadership in DTU lidar technology.

Wagner, R., Project Manager, Meteorology & Remote Sensing, Department of Wind Energy
Courtney, M., Project Participant, Test and Measurements, Department of Wind Energy
Pedersen, T. F., Project Participant, Department of Wind Energy
Rolighed Thorsen, G., Project Participant, Test and Measurements, Department of Wind Energy
Pedersen, A. T., Project Participant, Test and Measurements, Department of Wind Energy
Dellwik, E., Project Participant, Meteorology & Remote Sensing, Department of Wind Energy
Mikkelsen, T. K., Project Participant, Meteorology & Remote Sensing, Department of Wind Energy
Sjöholm, M., Project Participant, Meteorology & Remote Sensing, Department of Wind Energy

01/01/2016 → 31/10/2019
Keywords: cup anemometer, lidar, LDA, wind tunnel
Nature of activity type: Research
Project: Research

NEWA: New European Wind Atlas
A New European Wind Atlas will be developed to be used as a standard for site assessment. The new Atlas, based on improved modelling competencies on atmospheric flow, together with the guidelines and best practices for the use of data, should become a key tool not only for manufacturers and developers, but also for public authorities and decision-makers, by reducing overall uncertainties in determining wind conditions.

Karagali, I., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Hasager, C. B., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Badger, M., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Vasiljevic, N., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Dellwik, E., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Menke, R., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Hahmann, A. N., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Badger, J., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Cavar, D., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Olsen, B. T., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Volker, P., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Davis, N., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Mann, J., Project Manager, Department of Wind Energy, Meteorology & Remote Sensing
De Azevedo Santos, P. A., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Peña, A., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
InnoWind: Innovation for Global Wind Energy Exploitation on Land using Satellites
Funded by Innovation Fund Denmark
Badger, M., Project Manager, Department of Wind Energy, Meteorology & Remote Sensing
Karagali, I., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Dellwik, E., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Bechmann, A., Project Participant, Department of Wind Energy, Resource Assessment Modelling
Hahmann, A. N., Project Participant, Department of Wind Energy, Resource Assessment Modelling

NESA: New Satellite Products for Wind Energy
Karagali, I., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Maule, P., Project Participant, Department of Wind Energy, Integration & Planning
Hasager, C. B., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing
Dellwik, E., Project Participant, Department of Wind Energy, Meteorology & Remote Sensing

An experimental assessment of how trees affect the wind field
Angelou, N., PhD Student, Department of Wind Energy
Dellwik, E., Main Supervisor, Department of Wind Energy
Mann, J., Supervisor, Department of Wind Energy
Forskningsrådsfinansiering

VIROS: VInd i ROSkilde
Vind i ROSkilde (VIROS) projektet vil undersøge om man kan benytte en vindkraftstrategi, som er baseret på mellemstørrelses møller under 100 m totalhøjde og som dermed kan opstilles i mange flere områder end 125-150 m høje møller tidligere undersøgt for Roskilde kommune. Samtidig undersøges det, om vindmøllerne via placering og udfordning kan bruges som en "grøn" kunst installation på lige fod med forbrændingsanlægget for derved at signalere Roskildes grønne aftryk og udvikling. VIROS kommer med tre forslag til, hvorledes lokale vindkraft kan bidrage til energiforsyningen og dermed til reduktionen af CO2-udledningen i Roskilde kommune. 1) Mellemstore møller nær infrastruktur, hvor eksempelvis 10 møller placeres langs kommunens infrastruktur i form af motorvej, jernbane eller industri, 2) Erstatning af gamle møller med mellemstore møller (repowering) og 3) Mellemstore møller placeret i landzoner. Disse forslag er i overensstemmelse med Roskilde komunes strategiske energiplan for 2015-2020 med overvejelser for vindkraft med bortsmelting af forbrændingsanlæg. For at øge medejerskabet af møllerne vil der blive arrangeret en informationsmøde i samarbejde med Roskilde Festival og Musicon, hvor interesserede partnere i kommunen vil blive inviteret. Projektet vil til sidst evaluere om en vindkraftstrategi baseret på møller af mellemstørrelse er en mulighed for Roskilde og skitsere hvordan den i givet fald kan implementeres

Award relations:

Documents:
Inflow Characterization based on Remote Sensing using Pitot Tubes

Pedersen, M. M., PhD Student, Department of Wind Energy
Larsen, T. J., Main Supervisor, Department of Wind Energy
Aagaard Madsen, H., Supervisor, Department of Wind Energy
Schmidt Paulesen, U., Supervisor, Department of Wind Energy
Dellwik, E., Examiner, Department of Wind Energy
Kragh, K. A., Examiner, Department of Wind Energy
Riziotis, V. A., Examiner

Institut stipendie (DTU)
01/02/2015 → 08/06/2018
Award relations: Inflow Characterization based on Remote Sensing using Pitot Tubes
Project: PhD

Udvikling af SVAT-model

Dellwik, E., PhD Student, Department of Wind Energy
Sonnenborg, T. O., Main Supervisor, Department of Environmental Engineering
Jensen, N. O., Supervisor, Risø National Laboratory for Sustainable Energy
Jensen, K. H., Supervisor, Department of Hydrodynamics and Water Resources
Rosbjerg, D., Examiner, Department of Environmental Engineering
Barnhofer, C., Examiner
Schelde, K., Examiner, Department of Hydrodynamics and Water Resources
Jensen, N., Supervisor

Forskerakademiet Samfinansier
01/06/1999 → 12/02/2004
Award relations: Udvikling af SVAT-model
Project: PhD

Flow over complex forested terrain

Boudreault, L., PhD Student, Department of Wind Energy
Dellwik, E., Main Supervisor, Department of Wind Energy
Bechmann, A., Supervisor, Department of Wind Energy
Mann, J., Examiner, Department of Wind Energy
Edward Garrett, P., Examiner
Neil Ross, A., Examiner

Offentlig finansiering
15/10/2011 → 24/08/2015
Award relations: Flow over complex forested terrain
Project: PhD

Meso-scale modelling with focus on the water vapour profile

Nielsen, J. R., PhD Student, Department of Wind Energy
Dellwik, E., Main Supervisor, Department of Wind Energy
Boegh, E., Supervisor
Hahmann, A. N., Supervisor, Department of Wind Energy
Badger, J., Examiner, Department of Wind Energy
Nielsen, N. W., Examiner
Verhoef, A., Examiner
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.

Rodrigo, P. J., Project Manager, Department of Photonics Engineering, Optical Sensor Technology
Pedersens, C., Project Participant, Department of Photonics Engineering, Optical Sensor Technology
Dellwik, E., Project Participant, Meteorology, Department of Wind Energy
Mann, J., Project Participant, Meteorology, Department of Wind Energy
Sjöholm, M., Project Participant, Department of Wind Energy, Test and Measurements

Project ID: 70720
Energiteknologisk udviklings- & demonstreringsprogram, Energistyrelsen: DKK7,391,990.00
01/03/2012 → 28/02/2014
Collaborators: Windar Photonics A/S
Award relations: Low-cost semiconductor laser wind sensors
Project: Research
Modeling of soil-vegetation-atmosphere transfer processes
The aim of the project is to develop a micro-scale SVAT (Soil Vegetation Atmospheric Transfer) model using data from the Danish EUROFLUX site Søreb Lille Bøgeskov. Presently the data covers four growing seasons of measurements in a closed beech canopy. To understand how carbon dioxide and water vapour fluxes depend on other environmental variables is an important question when modelling the global climate. Micro-scale models provide useful information for larger scale models. Important steps in this project are to understand which parameters are most important to the canopy conductance and then to use the result to simplify an existing SVAT model.

Jensen, K. H., Project Manager, Department of Hydrodynamics and Water Resources
Dellwik, E., Project Participant, Department of Hydrodynamics and Water Resources

Ukendt: DKK1,200,000.00
01/06/1999 → 31/05/2002
Award relations: Modeling of soil-vegetation-atmosphere transfer processes
Project: Research

Activities:

Wind, temperature and water vapor fields over the oasis – desert ecosystem: measurements and numerical simulations
Period: 4 Sep 2018
Andrey Sogachev (Other)
Ebba Dellwik (Other)

Resource Assessment Modelling
Department of Wind Energy
Meteorology & Remote Sensing

Degree of recognition: International
Documents:
EMS2018-666

Related event
European Meteorological Society Annual meeting
03/09/2018 → 07/09/2018
Budapest, Hungary
Activity: Talks and presentations › Conference presentations

The Østerild balconies experiment
Period: 20 Jun 2018
Ioanna Karagali (Speaker)
Ebba Dellwik (Other)
Jakob Mann (Other)
Nikola Vasiljevic (Other)

Meteorology & Remote Sensing
Department of Wind Energy

Description
poster presentation
Degree of recognition: International
Documents:
TORQUE_Balcony

Related event
The Science of Making Torque from Wind 2018
20/06/2018 → 22/06/2018
Milan, Italy
Activity: Talks and presentations › Conference presentations
Sentinel-1 SAR for wind energy roughness maps over land
Period: 8 Apr 2018 → 13 Apr 2018
Merete Badger (Speaker)
Ebba Dellwik (Other)
Elin Svensson (Other)
Henning Skriver (Other)
Ioanna Karagali (Other)
Meteorology & Remote Sensing
Department of Wind Energy
Microwaves and Remote Sensing
National Space Institute

Description
Oral presentation
Degree of recognition: International

Related event
EGU General Assembly: 2018
08/04/2018 → 13/04/2018
Vienna, Austria
Activity: Talks and presentations › Conference presentations

The Østerild Balconies Experiment
Period: 12 Dec 2017
Ioanna Karagali (Guest lecturer)
Jakob Mann (Guest lecturer)
Ebba Dellwik (Guest lecturer)
Guillaume Lea (Guest lecturer)
Elliot Simon (Guest lecturer)
Nikola Vasiljevic (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Test and Measurements
Degree of recognition: International

Related event
2017 AGU Fall Meeting
11/12/2017 → 15/12/2017
New Orleans, United States
Activity: Talks and presentations › Conference presentations

Land surface parametrizations for CFD models and WAsP in complex forested terrain
Period: 26 Sep 2017
Ebba Dellwik (Invited speaker)
Department of Wind Energy
Meteorology & Remote Sensing

Related event
Expert meeting at OX2, Stockholm
26/09/2017 → 26/09/2017
Stockholm, Sweden
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations
WAsP-ForestGALES: a merged tool for improved forest wind damage prediction
Period: 19 Jul 2017
Ebba Dellwik (Guest lecturer)
Ducan Heathfield (Guest lecturer)
Barry Gardiner (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Conference presentation, talk
Degree of recognition: International
Documents:
WAsP-ForestGALES_final

Related event
IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

Initial results from the Single Tree Experiment
Period: 17 Jul 2017
Ebba Dellwik (Guest lecturer)
Jakob Mann (Guest lecturer)
Nikolas Angelou (Guest lecturer)
Andrey Sogachev (Guest lecturer)
Niels Troldborg (Guest lecturer)
Barry Gardiner (Guest lecturer)
Timothy Newson (Guest lecturer)
Horia Hangan (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Aerodynamic design

Description
Conference presentation, talk
Degree of recognition: International
Documents:
Initial results from the single tree experiment_nofilms

Related event
IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

Initial results from the Single-Tree Experiment
Period: 17 Jul 2017
Ebba Dellwik (Speaker)
Jakob Mann (Other)
Nikolas Angelou (Other)
Andrey Sogachev (Other)
Niels Troldborg (Other)
Barry Gardiner (Other)
Timothy Newson (Other)
Horia Hangan (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Aerodynamic design

Description
Conference presentation, Talk
Degree of recognition: International

Related event
IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

Long-term measurements of the dynamic wind loads on an open-grown oak tree
Period: 17 Jul 2017
Nikolas Angelou (Guest lecturer)
Jakob Mann (Guest lecturer)
Ebba Dellwik (Guest lecturer)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Conference presentation, talk
Degree of recognition: International

Related event
IUFRO Wind and trees conference 2017
17/07/2017 → 20/07/2017
Boulder, United States
Activity: Talks and presentations › Conference presentations

The Østerild Balconies Experiment
Period: 28 Jun 2017
Ioanna Karagali (Speaker)
Ebba Dellwik (Other)
Guillaume Lea (Other)
Elliot Simon (Other)
Nikola Vasiljevic (Other)
Jakob Mann (Other)
Department of Wind Energy
Meteorology & Remote Sensing

Description
Mini Symposia “Exp. Investigations of Wind Resourced and Siting Parameters”

Related event
Wind Energy Science Conference 2017
26/06/2017 → 29/06/2017
Inflow conditions and wake effects for wind turbines in forested terrain

Period: 27 Jun 2017

Ebba Dellwik (Invited speaker)
Alkistis Papetta (Other)
Johan Arnqvist (Other)
Morten Nielsen (Other)
Torben J. Larsen (Other)

Department of Wind Energy
Meteorology & Remote Sensing
Resource Assessment Modelling
Wind turbine loads & control

Documents:
abstract - WESC2017-final

Related event
27/06/2017 → 27/06/2017
Copenhagen, Denmark

Load conditions for wind turbines based on tall-lower observations at forested sites

Period: 20 Jan 2017 → 30 Jun 2017

Ebba Dellwik (Main supervisor)

Department of Wind Energy
Meteorology & Remote Sensing

Description
Supervision of MSc student

Approaches to characterize forest structures for wind resource assessment using airborne laser scan data

Period: 1 Nov 2016 → 30 Jun 2017

Ebba Dellwik (Main supervisor)

Department of Wind Energy
Meteorology & Remote Sensing

Description
Erasmus+ student
Degree of recognition: International

The single tree experiment: 16th EMS Annual Meeting & 11th European Conference on Applied Climatology (ECAC)

Period: 16 Sep 2016

Ebba Dellwik (Lecturer)

Department of Wind Energy
Meteorology & Remote Sensing
Flow distortion at a dense forest edge
Period: 3 Dec 2012
Ebba Dellwik (Speaker)
Department of Wind Energy
Meteorology

Related event

2012 AGU Fall Meeting
03/12/2012 → 07/12/2012
San Francisco, United States
Activity: Talks and presentations › Conference presentations