

3D wake measurements from a scanning wind lidar in combination with a fast wind field reconstruction model

Mikkelsen, Torben Krogh; Herges, T. G.; Astrup, Poul; Sjöholm, Mikael; Naughton, B. T.

Published in:
WESC2017 – Wind Energy Science Conference, Book of abstract

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Mikkelsen, T. K., Herges, T. G., Astrup, P., Sjöholm, M., & Naughton, B. T. (2017). 3D wake measurements from a scanning wind lidar in combination with a fast wind field reconstruction model. In WESC2017 – Wind Energy Science Conference, Book of abstract [264]

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Keywords identification: Wake measurements, SpinnerLidar, 3D wind field reconstruction

3D wake measurements from a scanning wind lidar in combination with a fast wind field reconstruction model

T. Mikkelsen^a, T. G. Herges^b, P. Astrup^a, M. Sjöholm^a, B. T. Naughton^b

High-resolution lidar wake measurements are part of an ongoing field campaign being conducted at the Scaled Wind Farm Technology (SWiFT) facility¹ by Sandia National Laboratories and the National Renewable Energy Laboratory using a customized scanning “DTU SpinnerLidar”² from the Technical University of Denmark. The purpose of the SpinnerLidar measurements at SWiFT is to measure the response of a V27 turbine wake to varying inflow conditions and turbine operating states.

Although our fast scanning SpinnerLidar is able to measure the line-of-sight projected wind speed at up to 400 points per second, a single lidar is in principle never able to measure all three wind components (u , v , w) in the scan plane at the same time. This limitation is often referred to as the “lidar cyclops syndrome”. However, by processing the scanned line-of-sight wind speed data via a fast linearized Navier-Stokes CFD code “*Lincom Cyclop-buster model*,”³ the corresponding 3D wind vector field (u , v , w) can be reconstructed under constraints for conservation of mass and momentum. The resulting model calculated line-of-sight projections of the 3D wind velocity vectors will become consistent with the line-of-sight wind speed measurements from the SpinnerLidar.

In this way, SpinnerLidar measured line-of-sight wake data from the SWiFT site at a range of downwind distances were used to calculate the three wind components $u(x, y)$, $v(x, y)$ and $w(x, y)$ in the turbine wake in a number of downwind crosswind scan planes. Fig.1 shows: a) the experimental setup, b) the line-of-sight measured wind field in a crosswind plane 66.2 m downwind, and 3) the corresponding Lincom model reconstructed axial wind component $u(x, y)$.

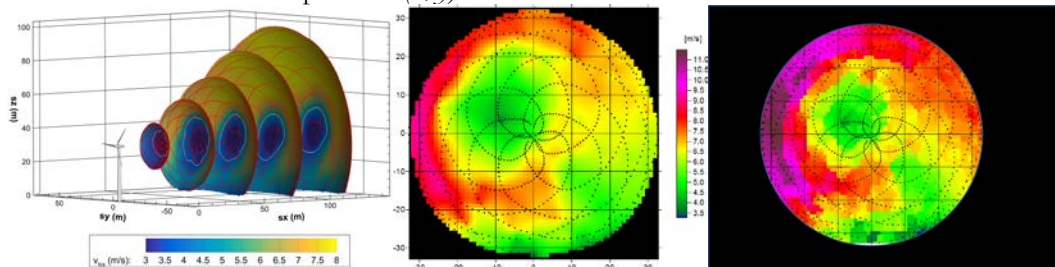


Fig.1. [Left]: SpinnerLidar scanning pattern in the wake of the V27 test turbine at the SWiFT site, overlaid on interpolated line-of-sight speed measurements; [Middle]: Line-of-sight wind speeds measured by the SpinnerLidar on Dec 2016 20:31:00 to 20:31:02 at 66.2 m downwind distance, interpolated on a 1*1 m grid facing the turbine, i.e. the turbine is behind the frame. [Right]: The corresponding Lincom Cyclop-buster wind field reconstructed axial wind field $u(x, y)$.

The multiple line-of-sight speed measurements from the SpinnerLidar can be retrofitted to yield all three wind components on a standard PC in less than one second. The described wind field reconstruction methodology can thus be used in real-time for determination of the axial wind component flow, in the wake or in the inflow, from a single scanning lidar mounted on the turbine. The described methodology could potentially also be of benefit for providing upwind 3D wind data in real-time for advanced feed-forward turbine control.

^a Technical University of Denmark, Department of Wind Energy, DTU Risø Campus, Frederiksborgvej 399, Roskilde, Denmark.

^b Sandia National Laboratories, Albuquerque, NM, 87185, USA.

1. Herges, T. G., Maniaci, D. C., Naughton, B. T. & Mikkelsen, T. High resolution wind turbine wake measurements with a scanning lidar. In Proceedings of EWEA Wake Conference May 30 - June 1 2017 (ed. EWEA).

2. Sjöholm, M. *et al.* Full two-dimensional rotor plane inflow measurements by a spinner-integrated wind lidar. in EWEA 2013 PO.ID 250 (2013).t

3. Mikkelsen, T.; Astrup P.; van Dooren, M. F. The Lidar Cyclops Syndrome Bypassed: 3D Wind Field Measurements from a Turbine mounted Lidar in combination with a fast CFD solver. In: ISARS 2016: 18. international symposium for the advancement of boundary layer remote sensing, Varna, June 2016.