PO151

OWA GloBE: The management, processing and evaluation of a large dataset for the identification and quantification of Global Blockage Effects

Nassir Cassamo¹, Marco Turrini¹, Jan Willem Wagenaar¹, Mike Wilmer¹, Christopher Rodaway², Kester Gunn², Sam Williams², Neil Adams³, Elliot Simon⁴, Michael Courtney⁴, Gunhild Thorsen⁴, Pedro Santos⁵,

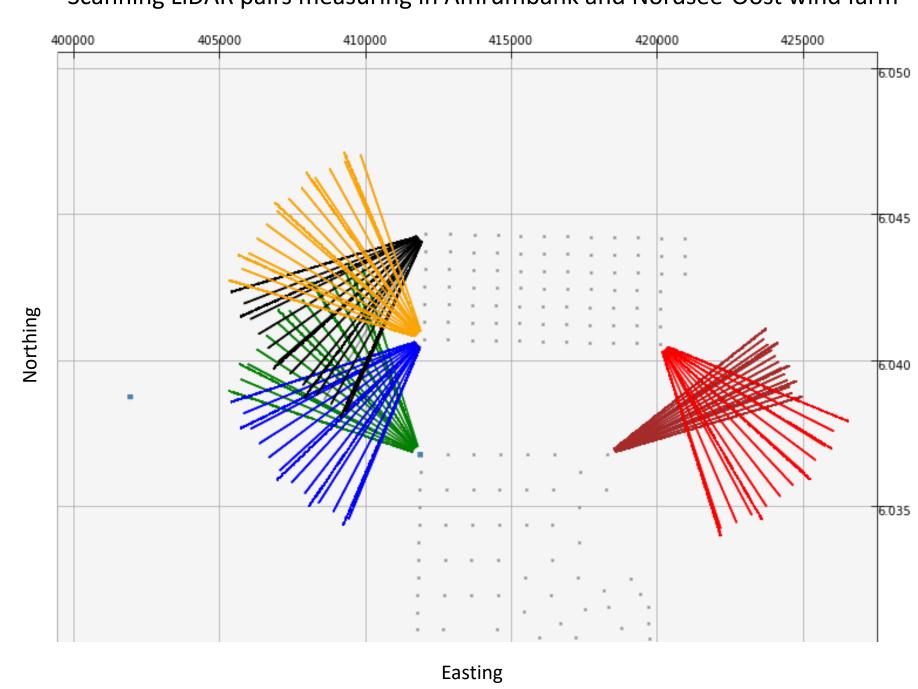


Martin Dörenkämper⁵, Erik Patschke⁵ and Julia Gottschall⁵

¹TNO, ²RWE, ³The Carbon Trust, ⁴DTU, ⁵Fraunhofer IWES

Abstract

project represents one of the most extensive offshore GLOBE measurement campaigns ever conducted in the wind energy industry, aiming to reduce the commercial uncertainty around the modelling of Global Blockage Effects (GBE), launched under the Carbon Trust's Offshore Wind Accelerator and led by RWE. The campaign took place at the Heligoland wind farm cluster in the German Bight. The campaign made use of 6 WindCube 400s devices measuring in a step-stare pattern up to 7km with drone calibration (picture is below. In blue and green, LiDAR 1 and 2, in black and yellow, LiDAR 5 and 6, in red and brown, LiDAR 4 and 7), a refurbished met mast equipped with profiling and high frequency measurement devices (cup and sonic anemometers), amongst others. The raw product of the campaign comprises terabytes of data from various different sources, and its analysis required the usage of data engineering, data science and statistics techniques. The work here presented culminates in an analysis of the magnitude of GBE depending on different atmospheric conditions and presents the various creative technical solutions found to address the challenge of processing a highly complex data set and relevant to any organisation wishing to engage in such an effort. Scanning LiDAR pairs measuring in Amrumbank and Nordsee-Oost wind farm



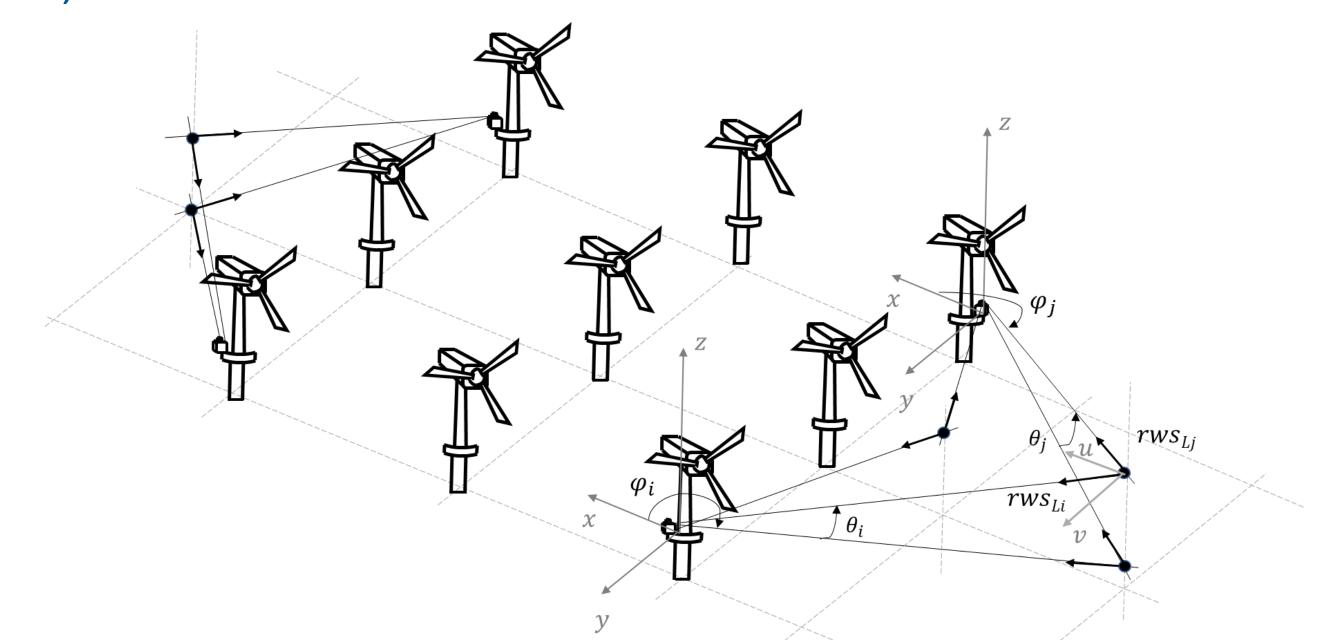
Objectives

The main objective is to evaluate the magnitude of GBE depending on existing atmospheric phenomena and the underlying uncertainty. For that, three steps are devised related to (1) data engineering, ensuring data is properly stored and easily accessible in a database (2) data analysis, ensuring a proper methodology for the quantification of GBE exists and (3) data visualization, ensuring that the final results can be properly inspected to retrieve meaningful conclusions.

Methodology: from raw data to wind speed ratios

The first step encompasses managing the high volumes of information retrieved from the measurement campaign (~ million netcdf files). A dedicated solution was developed in order to ensure that the data analysis could be performed in a fast and reliable manner. To ensure this, all the data was stored in tables in a postgresql database, launched in a docker container. The database was hosted on a SSG-5018D8-AR12L storage server with 64GB of RAM and conventional server grade hard disks (not SSD). The data was stored on a ZFS mirrored pool with a dataset tuned for databases, most importantly using Iz4 compression for storage. The maximum expected storage size was estimated at 10TB, so a 16TB storage pool was used. Despite the use of traditional hard disks, the system has been perceived as very performant. The LZ4 compression reached a compression rate of 2.5 and total physical storage came down to 4.7TB.

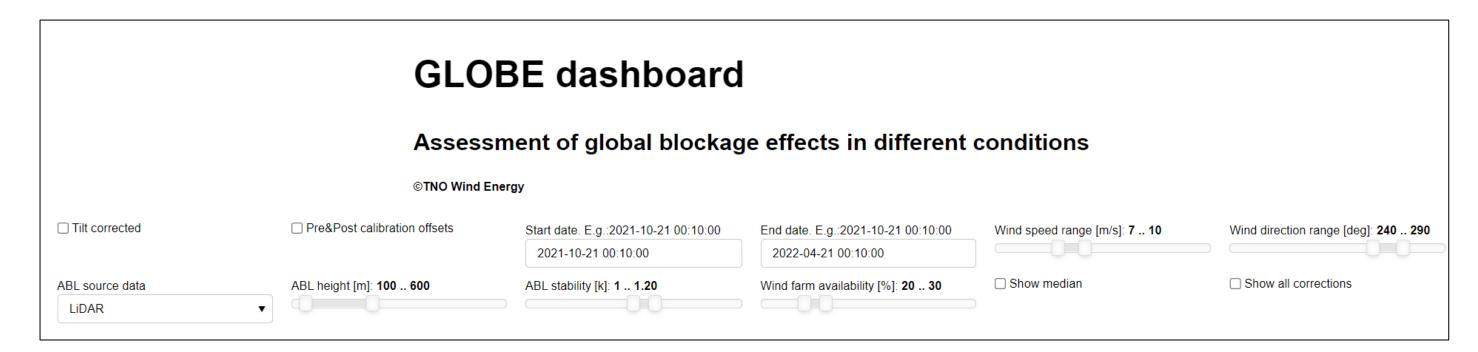
The second step relates to the data analysis. A methodology to assess GBE was developed according to the following steps: import data directly form the database, filter radial wind speed measurements for the locations where LiDAR beams meet and for signal quality, aggregate measurement points for each location over a ten minute interval, merge data from LiDAR system pairs, reconstruct the horizontal wind speed and evaluate the ratio with relation to the horizontal wind speed at the points closest to the farm. The latter, the Wind Speed Ratio (WSR), evaluated at each point where the LiDAR beams meet, constitutes the Key Performance Indicator for the assessment of GBE. A simplified schematic is provided on the right column, showcasing the reference system used and LiDAR beams meeting.



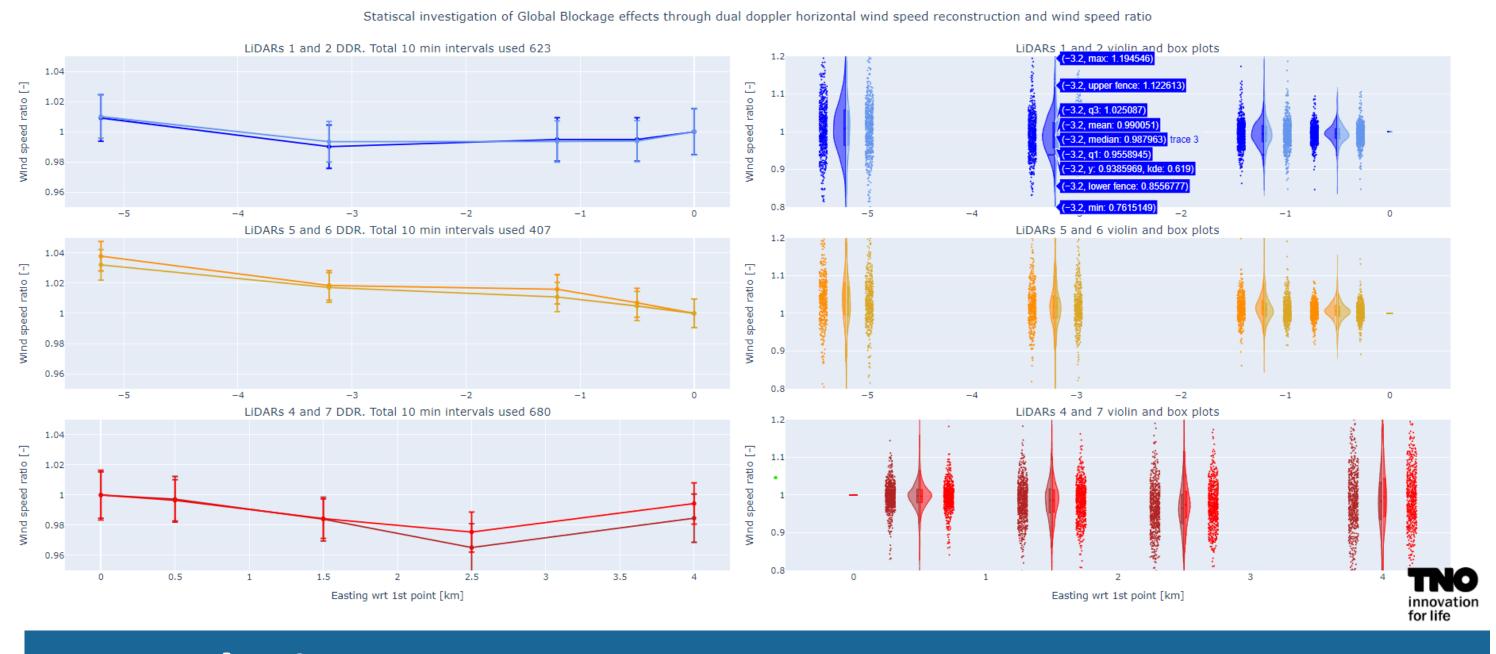
Furthermore, different types of corrections are applied to the data in order to account for (1) offsets in the radial wind speed measurements from pre and post campaign calibration exercises, (2) the tilting of the turbine, (3) offsets in the LiDAR and inclinometer sensors estimated by usage of a drone and (4) effects from other wind farm clusters (wakes).

Results: evaluating wind speed ratios

The final results are shown in an interactive dashboard so the user can evaluate the mean or median value of the WSR at each location upstream of the LiDAR pair. The main objective is to evaluate how the magnitude of GBE changes according to the external conditions, more specifically, wind speed and wind direction, Atmospheric Boundary Layer height and stability and wind farm availability. Various widgets are included in the dashboard, so that the user can assess the sensitivity of the results to both external conditions and corrections applied to the data. A figure of the available filtering criteria is shown below. The dashboard is coded resorting to the python *panel* library.



The final results are shown in a dedicated format. On the left, the mean or median statistics of the WSR at each relevant locations are shown. On the right side, the distribution of the underlying WSRs is show. The underlying distribution is represented in violin plots, where the distribution of the WSR for the filtered conditions can be evaluated in great detail. In each row the results for a different pair are represented. Pair 12 is represented in the top row, followed by pairs 56 and 47. The below figure illustrated the final results.

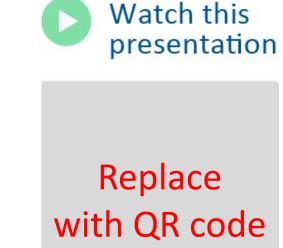


Conclusions

The data retrieved in the GLOBE campaign culminates in a comprehensive data analysis process. This can only be successfully achieved with proper data management techniques that ensure a fast, reliable and automated analysis. Furthermore, the evaluation of GBE requires proper visualization tools so that results can be easily navigated, understood and a consensus on GBE built.

Acknowledgments

The AFFABLE project is co-financed by TKI-Energy from the 'Toeslag voor Topconsortia voor Kennis en Innovatie (TKI's)' of the Ministry of Economic Affairs and Climate. Fraunhofer IWES supported some of this work by providing access to data and infrastructure within the "Testfeld BHV" project funded by the German Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag (FKZ 0324148).





Download the poster



