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Sensitivity analysis of the 2D VAR retrieval method in the application to the wind turbine wakes

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Scanning lidars measure a wind field over a large area with a higher resolution than numerous anemometer installations would allow. The drawback is that a scanning lidar measures only the radial velocity – the projection of the actual velocity to the lidar's line of sight. Reconstructing the original wind field requires a retrieval procedure. Most of the retrieval algorithms were developed for homogeneous wind fields. While those algorithms estimate the free flow well, they do not preserve non-homogeneous structures such as wind turbine wakes.

A recently developed 2D-VAR algorithm [1] utilizes the property of conventional retrieval methods to estimate the homogeneous flow and uses it as an input to the cost-optimization function. The cost-optimization retrieves the wake structures more accurately. While the solution for a homogeneous flow is stable, the result of the cost optimization is affected by the initial guess field, e.g., a uniform wind field based on the FINO1 or SCADA time series.

We perform a sensitivity analysis of the 2D VAR retrieval algorithm for lidar scans of the Alpha Ventus wind farm taken from the FINO1 platform during the OBLEX-F1 campaign. Partially covering September 2016, the dataset provides a range of wind speeds and directions to test the algorithm's performance under various conditions. The algorithm's sensitivity is evaluated for different initial guess fields.

The retrieval algorithm is evaluated based on the agreement with the reference data: FINO1 cup anemometer or SCADA time series. The retrieval accuracy is described by comparing the radial velocity calculated from the retrieved field to the original lidar scan. The results show that the retrieved field near the wind turbine tends to agree with the SCADA series better than with the FINO1 series. The agreement to the SCADA data is the best when the initial guess is based on the corresponding turbine series. The radial velocity residuals are slightly biased and are primarily localized in the near wake. Whether it is a positive or negative bias depends on the intensity of the wakes.

[1] Cherukuru, N. W., Calhoun, R., Krishnamurthy, R., Benny, S., Reuder, J. and Flügge, M.: 2D VAR single Doppler lidar vector retrieval and its application in offshore wind energy, Energy Procedia, 137, 497–504, doi:10.1016/j.egypro.2017.10.378, 2017.