RECAST
Status January 2019

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PROJECT GOALS

RECAST is a research project led by DTU Wind Energy in collaboration with RES, EMD International and Vestas. The project started in February 2018 and has a duration of 2 years and 9 months. The aim is to provide a new approach for pre-construction resource and site assessment. Instead of measuring the wind at one position with a met mast, we will measure the wind at several (e.g. 10 to 15) positions using a WindScanner system. Multiple point measurements reduce the uncertainty of the spatial extrapolation of the wind climate from the measurement position to considered turbine positions and the AEP uncertainty overall.

A WindScanner system combines two scanning lidars in such a way that they are capable of steering their beams synchronously in space and time. Thus, the system provides a 2D instantaneous wind speed vector at every position.

To make WindScanner campaigns cost effective, the measurement duration should be less than 12 months, but shortening the measurement duration will increase the uncertainty of the estimated wind climate. However, this can be minimised by optimising the measurement duration and time of the year (e.g. season) based on mesoscale model data (e.g. WRF) to capture the range of wind speeds, directions and turbulence conditions of the site.

RECAST aims at providing a cost-effective way to use breakthrough technology to reduce the uncertainty of AEP estimates.

Planned deliverables:

1. Software estimating the wind climate derived from short time measurements (i.e. shorter than 12 months) and uncertainty (WP1.1);
2. WAsP module to estimate speed ups and wind speed uncertainties using multiple point measurements;
3. User friendly WindScanner software specific to WRA application:
4. Digital Campaign Planning Tool to optimize the measurement positions and WindScanner locations with respect to them (i.e., WindScanner layout).
5. Uncertainty vs cost calculation tool to help choosing the most suitable measurement strategy;
6. Evaluation of usability of short term and WindScanner measurement for site suitability purposes (vertical shear and turbulence intensity);
7. Demonstration campaign with a WindScanner system on a site to be assessed for wind resource.

1. Reducing the assessment time

The representativeness of the seasonal variability of a time series that is shorter than 12 months depend on the season or period of year during which the measurements take place. Mesoscale reanalysis data can be used to predict the best period and duration of the measurements; i.e. for which period of the year the error due to the lack of information about seasonal variations will be lowest. WRF data from 4 different sites have been used to show the "error" in wind distribution from 30days, 90 days and 180 days compared to 365 days. The mesoscale data bias has been evaluated by comparison to in situ measurements in many different places.

Next steps:

- Characterize the mesoscale data bias and develop a correction procedure;
- Estimate the uncertainty of the correction and the uncertainty of the long term corrected wind climate.
- Software release planned after summer 2019 (tbc).

2. WRA using multiple measurement points

The method described in (Clerc – 2012) has been used as staring point to estimate the uncertainty in AEP estimate. The speed up uncertainty is derived from empirical functions of the speed up and the distance to the mast. The method was implemented to WAsP and need further testing (with different sites). The method was also implemented to a CFD model and tested for two sites with various number of measurement positions.

Next steps:

- Adapt the empirical functions to the different models;
- Apply using multiple measurement points;
- Compare WAsP and CFD model for a specific site;
- PyWAsP release expected around September 2019.

3. Campaign Planning Tool

The number of measurement positions and their locations results from a trade-off between the spatial extrapolation uncertainty (that should be minimised) and the limitations imposed by the WindScanner technology and site. Our Campaign Planning Tool (CPT) provides the optimal positioning of the lidars accounting for the expected measurement range, measurement uncertainty, and potential blockage of the lidar beams due the terrain, vegetation and near-by obstacles. In the search for the optimal lidar placement, the tool highlights best locations for lidars, which enables accurate retrieval of the two components of the horizontal wind speed vector. An alpha version of the Campaign Planning Tool has been implemented and tested for three different sites. This highlighted the relevance of the lidar maximum range relative to the wind farm size in term of space.

Next steps:

- Interface CPT with WindScanner software
- Try to use WRF information about the aerosol distribution in order to evaluate the expected maximum measurement range for a given site and a given season;
- Include eye safety requirements.
- Include optimization routines which will automatically suggest several potential campaign layouts and measurement strategies
- Develop the front-end for CPT (i.e., graphical user interface)

4. User friendly WindScanner

Currently the long range WindScanner is a research tool that requires to be operated, monitored and data analyzed by an expert. In RECAST, DTU is developing a software version focusing on WRA application.

The overall architecture has been designed:

- The input will be the measurement points coordinates and the trajectory to go through them (output form the CPT).
- The quality control module will flag the data with low CNR in real time.
- The wind reconstruction module will calculate the horizontal speed and direction in real time.
- The Display Data module will display the reconstructed wind speed and direction in real time – for easy monitoring.

Next steps:

- Programming of “automated interpretation” of measurement point coordinates and trajectory into beam orientation and range gate selection;
- Proof-of-concept test at Risø campus in March 2019;
- Programming of wind reconstruction module.

5. Site suitability

The approach proposed in the RECAST project is only relevant if the short term WindScanner measurements are also sufficient for site suitability purposes. We are focusing on vertical shear and turbulence intensity estimates.

Challenge 1: uncertainty of WindScanner turbulence measurement.

A WindScanner measures over a volume, and underestimate the turbulence intensity (for near horizontal beams). Data from a previous measurement campaign ((Vasiljevic – 2015; Simon -2016)) – where two synchronized lidars were staring at a sonic anemometer (in flat terrain) – were analyzed. The WindScanner error was shown to depend on the wind direction relative to the wind and on the turbulence length scale.

Next steps:

- Analyse TI measurement from WindScanner over a ridge (data from two NEWA campaigns);
- Validate error estimation using Mann model spectral tensor;
- Analyse TI measurement from 4 staring WindScanners compared to a sonic.

Challenge 2: long term correction of TI and shear short term measurements

Similar to the wind speed, short term measurements of TI and shear need to be corrected for the seasonal variations. The method from Casella (Casella - 2015) has been applied to TI and shear at 2 different sites.

Next steps:

- Apply to more sites with different terrain site characteristics and ABL thermal stratification;
- Implement full uncertainty chain using Vestas model for loads and site suitability and apply to 2 sites.

6. Business model

At the end of the project, all the developments should be accessible by any interested user while the operation of the WindScanner for WRA purposes should not require specialists. We are therfreo also investigating the best business strategy for the final project outcomes.

- Multi point measurements will be implemented in PyWAsP and available to WAsP users.
- The medium- and long-term corrections will be implemented in WindPro by EMD.
- The WindScanner WRA specific software will be distributed by DTU.
- The CPT distribution is unclear at the moment.
- Several wind measurement providers have been contacted in order to evaluate interet in providing such a service as WindScanner measurements for WRA assessment. One have shown strong interest, two other moderate interest.

7. Dissemination

- WindScanner TI measurement error at Høvøsre (from DDvsSS) - report by Alfredo Peña et al – February 2019
- WindScanner Campaign Planning Tool – Concept and tests – paper by Nikola Vasiljevic et al – March 2019
- Wind Energy Science Conference, 17-20 June 2019, Cork, Ireland:
    - AEP estimate and uncertainty using multipoint measurements (proof of RECAST concept) – presentation – Andreas Bechmann;
    - WindScanner Campaign Planning Tool – presentation – Nikola Vasiljevic;
    - Uncertainty of turbulence measurements form WindScanner System – presentation – Alfredo Peña.
- Abstract submitted to WindEurope WRA workshop, 27-28 June 2019, Brussels
    - Overview of project – concept and status – Rozenn Wagner.

References

(Casella – 2015) Casella, Livio. “Performance Analysis of the First Method for Long-Term Turbulence Intensity Estimation at Potential Wind Energy Sites.” Renewable Energy 74 (2015): 106–115. Web.

(Clerc - 2012) Clerc, Alex et al. “A Systematic Method for Quantifying Wind Flow Modelling Uncertainty in Wind Resource Assessment.” Journal of Wind Engineering and Industrial Aerodynamics 111 (2012): 85–94. Web.

(Simon – 2016) Simon, E., & Courtney, M. (2016). A Comparison of sector-scan and dual Doppler wind measurements at Høvsøre Test Station – one lidar or two? DTU Wind Energy. DTU Wind Energy E, Vol. 0112

(Vasiljevic – 2015) Nikola Vasiljević, Michael Courtney, Alfredo Peña, Guillaume Lea and Andrea Vignaroli Measuring offshore winds from onshore – one lidar or two? EWEA Offshore 2015, Copenhagen

Access to data: https://data.dtu.dk/articles/A_data_set_for_comparison_of_sector-scan_and_dual-Doppler_retrievals_of_horizontal_wind_speed_and_wind_direction_made_using_multiple_scanning_lidars/7378190