Observing and data assimilation strategies to improve short-term low-level wind forecast for sustainable energy applications

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Over the last years, climate monitoring and operational weather forecasts have become an important topic for the renewable energy sector. One of the main goals of the renewable energy management is to find a right balance between different energy sources considering their energy costs, power production capacity, and carbon emissions. This requires a reliable prediction of power generation from renewable sources. In Germany a large part of renewable energy generation is attributed to wind. Therefore, an accurate forecast of low-level wind is crucial for the power output prediction. Currently, short-term low-level wind forecasts have considerable uncertainties. One of the ways to improve the low-level wind forecast is an assimilation of new observations into numerical weather prediction models. Ground-based remote-sensing instruments are a potential source of valuable information for the data assimilation. These instruments have a high temporal and spatial resolution, in particular in the atmospheric boundary layer. During the last decades, the number of ground-based remote-sensing sites have been continuously growing. However, the coverage of ground-based remote-sensing observations is still not optimal for short-term low-level wind forecasts. Before an investment in an expanded network of ground-based instruments, it is essential to understand what kind of instruments is better to install, what impact from instruments to expect, and what spatial density of the instruments should be.

A valuable information for data assimilation for improvements of low-level wind forecasts can be obtained from Doppler lidars. This study focuses on an estimation of the potential impact of a network of Doppler lidars for short-term wind forecasts at the hub-height of wind turbines. The impact is analyzed using the ensemble sensitivity analysis (ESA) [1, 3]. In this study we analyze the impact of Doppler lidars with respect to surface observations operationally assimilated by national weather services. We show the sensitivity of the obtained results to different factors such as the number of Doppler lidars in the network and their location, the number of altitude layers observed by Doppler lidars, and the forecast lead time. We also demonstrate how results of ESA change for different localization length scales, regularization coefficients, and observation errors. For our analysis, we use 1000-member ensemble simulations over Germany with the main focus on the urban and highly populated Rhein-Ruhr area and its surroundings [2]. The simulations are based on full-physics non-hydrostatic regional model SCALE-RM and covers a two-week time period in May/June 2016.

This work has been conducted in the framework of the Hans-Ertel-Centre for Weather Research funded by the German Federal Ministry for Transportation and Digital Infrastructure (grant number BMVI/DWD 4818DWDP5A). This online publication is based upon work within the COST Action CA18235 supported by COST (European Cooperation in Science and Technology), funding agency for research and innovation networks, weblink: www.cost.eu. We acknowledge RIKEN for providing the SCALE-RM model data.

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