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Parametrizing wind farms in mesoscale models: review of existing approaches, applications and future advancements

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With the expansion of wind energy on- and offshore, large-scale wind farm flow effects in a temporal and spatially heterogeneous atmosphere become increasingly relevant. Mesoscale models equipped with a Wind Farm Parametrization (WFP) can be used to study these effects. In the past, different WFPs have been developed and were applied with different aims. The aim of this study is to provide a better overview on existing WFPs, their development stage and application areas.

Through a systematic literature review based approach, 617 potentially relevant publications were identified, out of which 59 were reviewed in detail. From these studies, 10 different explicit WFPs have been identified along with three main application areas: (1) the characterizations of wind farm flow effects, (2) the environmental impact of wind farms and (3) the implication for wind energy planning.

In this presentation, we will review differences between the identified WFPs including their description of the turbine-induced forces and turbulent kinetic energy production as well as their treatment of sub-grid scale effects. In addition, we will summarize the literature findings on existing validation of the WFPs and on the sensitivity of the WFPs to the mesoscale model set-up. Reviewing the results for the different application areas indicated that wind farm wakes can last for several 10s of kilometers downstream depending on stability, surface roughness and terrain. Therefore, neighbouring wind farms need to be taken into account for regional planning of wind energy. Yet, their environmental impact, in terms of other reviewed parameters than wind, is mostly confined to areas close to the farm.

Based on these findings, we suggest that future work should include, among other things, benchmark-type validation studies with long-term measurements for different WFPs, further developments of WFPs and mesoscale model physics and more interactions between the mesoscale and microscale community.