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Data-driven reduced order model for prediction of wind turbine wake dynamics MITHU DEBNATH, CHRISTIAN SANTONI, MARIO A. ROTEA, STEFANO LEONARDI, GIACOMO VALERIO IUNGO, UT Dallas — Wind turbine wakes are highly turbulent flows for which coherent vorticity structures lead to complex dynamics and instabilities. In this study, high-fidelity large eddy simulations (LES) data of a utility-scale wind turbine is analyzed through proper orthogonal decomposition (POD) and dynamic mode decomposition (DMD) in order to detect the main dynamic contributions to the temporal and spatial evolution of a wind turbine wake. Eigenmodes obtained from modal decomposition are clustered as a function of their physical origin, energy, spectral contribution and growth rate. A subset of the eigenmodes is then selected accordingly to a customized objective function in order to represent an optimal blend of the different dynamic contributions. The selected eigenmodes are embedded in a time-marching algorithm enabling the prediction of the wake velocity field and loads on downstream turbines. This reduced order model is characterized by a relatively low rank compared to the dimension of the physical space of the original LES data, thus by a low computational cost. The reduced order model is then embedded within a Kalman filter in order to perform data assimilation of new available observations in order to maximize agreement between the forecast and observations.

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