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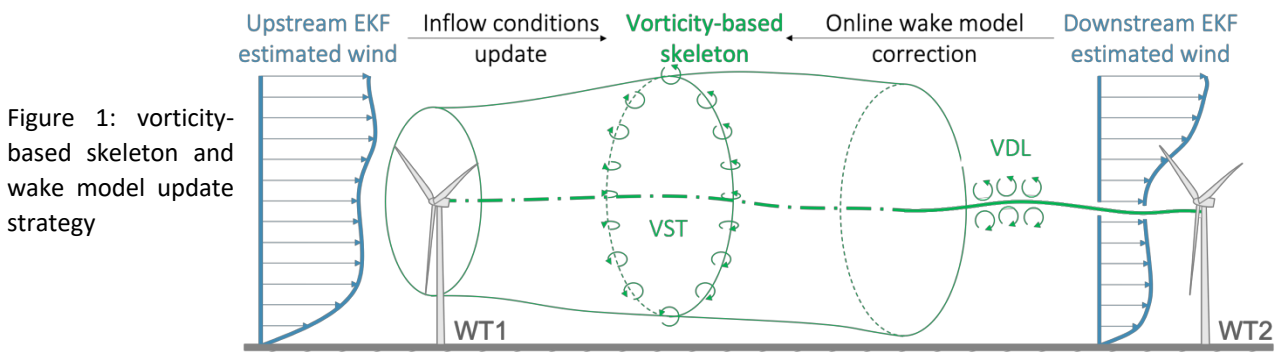
Characterisation and Online Update of a Vorticity-Based Wind Skeleton Wake Model

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Wind turbine wake physics is by nature unsteady and highly sensitive to the local wind characteristics. While modern Computational Fluid Dynamic methods (eg: Large Eddy Simulation) allow to accurately capture the flow at the wind farm scale, they still come at a prohibitive computational cost preventing their use for online control or Machine Learning schemes. This work pursues the recent efforts undertaken by Marichal et al.¹ to develop a computationally affordable yet accurate unsteady Wake Model.

Marichal et al.³ introduced and successfully tested a vorticity-based skeleton Wake Model (WM). This vorticity-based skeleton essentially consists of a regularized Vortex Sheet Tube (VST) in the near wake which then transitions into a Vortex Dipole Line (VDL) in the far wake. The rotor operation itself is modelled using the Blade Element theory.

The present study further assesses the performances of the WM: it extends the validation procedure to various wind turbine settings (ie: different Tip Speed Ratios) and inflow conditions. The data recovered from the wake model is compared to that extracted from high fidelity numerical simulations performed on the NREL 5MW wind turbine² using an Immersed Lifting Line-enabled Vortex Particle-Mesh (VPM) flow solver.



Online model update strategies are then discussed. Indeed, the existing WM still requires the knowledge of the upstream wind conditions in order to provide an accurate downstream wind field estimate. Following Bottasso et al.³, an Extended Kalman Filter (EKF) estimating the Rotor-Effective Wind Speed by a Blade-Load-based Estimator is implemented. This EKF allows to estimate the wind profile upstream the wind turbine and eventually to feed it to the vorticity-based skeleton wake model as an input parameter.

We finally plan to extend the tools developed to a two-turbines system. The downstream wind profile provided by the Kalman estimator will be compared to that given by the wake model computed by the upstream turbine. Data assimilation techniques will then be used to correct the wake model online.

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