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Low-order modelling of wake meandering behind turbines[1]

VIKRANT GUPTA, MINPING WAN, Southern University of Science and Technology, Shenzhen — Far-wake regions behind tidal or wind turbines usually have low-frequency oscillations, referred as wake meandering, that cause an increase in turbulence level and thus adversely affect the performance of the downstream turbines in an energy farm. We propose a Ginzburg–Landau equation based low-order model for the far-wake region. The model reproduces the main qualitative features of wake meandering: (i) its origin via amplification of upstream structures, (ii) dependence of oscillation frequency on the upstream disturbance amplitude (higher amplitudes lead to lower frequencies), and (iii) shift towards lower frequencies as the wake flow evolves in the streamwise direction. Additionally, the model also predicts the increase in the meandering amplitude and an advancement in its onset with increasing thrust coefficient. To our knowledge, this is the first low-order dynamical system in the literature that models wake meandering. The model coefficients are obtained from the mean flow local stability results that we show correctly account for the changing operating conditions and thus pave way for the prediction of wake meandering features. Its low-order makes it suitable to use inside an energy farm design model, where it can help to mitigate the adverse effects of wake meandering.

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