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IMPACT ASSESSMENT OF ROTOR MISALIGNMENTS AND BLADE ANGLE IMBALANCES ON WIND TURBINE PERFORMANCE THROUGH NUMERICAL SIMULATIONS

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Abstract. Wind energy represents one of Uruguay's primary sources of electricity generation, with a penetration of over 30%. Most wind farms have been in operation for over five years, which entails significant challenges in terms of operation and maintenance. Regarding operational problems in wind turbines, there is a relevant number of published works associated with detecting rotor disorientations with respect to the incident wind and the pitch angles of the wind turbine blades. However, few references have been identified where the impact on the production of a wind turbine operating under different imbalance conditions, particularly blade angle, is quantified. It should be noted that rotor misalignment has been studied as a strategy to maximize the overall production of wind farms, so further analysis of its impact will also contribute in that sense. The present work evaluates the impact on the production of a wind turbine operating under conditions of misalignment with respect to the incident wind or of one of its blades with respect to the desired blade angle, under various incident wind and operating conditions, through high-fidelity computational fluid dynamics (CFD) simulations. For this purpose, the caffa3d code is used, employing the Large Eddy Simulation-Actuator Line Model (LES-ALM) strategy. caffa3d uses the finite volume method on a mesh of unstructured blocks, each with a structured mesh. The scale-dependent dynamic subgrid model is used, while Crank-Nicolson is used as the temporal scheme. Different wind speed and turbulence intensity profiles are considered as wind conditions. These conditions are obtained through precursor simulations in a domain of equal dimension but with periodic boundary conditions and without the presence of wind turbines. Regarding the operating conditions, different wind turbine configurations are analyzed, particularly subject to free wind flows and under the presence of wakes.