Resolvent Analysis of the Atmospheric Boundary Layer

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ABSTRACT

The identification and characterization of large-scale coherent structures of turbulent flows is a problem that demands extensive field measurements or sophisticated numerical simulations, especially when it is referred to highly turbulent and variable flows like the atmospheric boundary layer (ABL). In this study, we explore the efficacy of Resolvent Analysis as a cost-effective way to model ABL coherent structures, based only on the mean flow field of the ABL. The Resolvent analysis uses the singular value decomposition of the linearized Navier-Stokes operator, treating nonlinear terms as external forcing. This decomposition generates response modes directly correlated with the most energetic coherent structures of the flow [1]. To validate this approach, we compare its outcomes with modes obtained through Spectral Proper Orthogonal Decomposition [2] applied to detailed numerical data from Large-Eddy Simulation (LES) of a rotating half-channel flow [3] as a first approximation of the ABL. Errors associated with the subgrid-scale and wall models of the LES are first discussed, as well as the impact of the Coriolis force in the resolvent modes. This study serves as a first step to the more complete ABL representation using resolvent analysis, which will include the buoyancy force and the presence of surface elements such as vegetation and topography.

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