# Modeling atmospheric turbulence: Large-eddy simulation of the atmospheric boundary layer

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**Abstract**.

Turbulence, convection, and clouds are at the core of key climate prediction problems. For example, to reduce uncertainties in climate projections, it is critical to improve predictions of cloud–climate feedbacks (how clouds respond to, and influence, climate change), which are controlled by interactions between turbulence, water phase transitions, and radiation. Large-eddy simulation (LES) is an invaluable technique in the study and prediction of atmospheric turbulence because it can capture the detailed flow structure, including clouds. In spite of the widespread use of LES, predictions of atmospheric flows lack the required fidelity. The development of a novel state of the art LES framework suitable for the simulation of atmospheric flows is discussed. The main components of the LES framework are a high-order fully conservative finite difference discretization and the buoyancy-adjusted stretched-vortex subgrid-scale (SGS) model. The development of a stability correction for the stretched-vortex SGS model is presented. The stability correction accounts of the increasing anisotropy of turbulence motions as stratification increases in a way that is consistent with the physics of stratified turbulence. Moreover, the SGS model employs no flow adjustable parameters. A series of LES runs of diverse meteorological conditions is carried out using identical LES setup (e.g., advection scheme and SGS-model parameters) in order to validate the extension of the model to stratified flows and assess its performance. The new LES framework accurately predicts a diverse set of atmospheric conditions. In all cases the flow statistics exhibit good grid resolution independence, even for resolutions that are typically considered coarse. A specific application of the LES model to stratocumulus cloud physics is discussed.