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Investigations of boundary layer structure, cloud characteristics and vertical mixing of aerosols at Barbados with large eddy simulations

Michael Jähn (1), Domingo Muñoz-Esparza (2), Fernando Chouza (3), Oliver Reitebuch (3), Oswald Knoth (1), Moritz Haarig (1), Albert Ansmann (1), and Ina Tegen (1)

(1) Leibniz Institute for Tropospheric Research, Leipzig, Germany, (2) Research Applications Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA, (3) Deutsches Zentrum f. Luft- und Raumfahrt, Institute of Atmospheric Physics, Oberpfaffenhofen-Wessling, Germany

Large eddy simulations (LESs) with ASAM (All Scale Atmospheric Model) are performed for the area of the Caribbean island Barbados to investigate island effects on boundary layer modification, cloud generation and vertical mixing of aerosols. In order to generate inflow turbulence consistent with the upstream marine boundary layer forcing, we use the cell perturbation method based on finite amplitude potential temperature perturbations. This method is now also validated for moist boundary layer simulations with open lateral boundary conditions.

Observational data obtained from the SALTRACE (Saharan Aerosol Long-range Transport and Aerosol-Cloud-Interaction Experiment) field campaign is used for both model initialization and comparisons. Several sensitivity tests are carried out to demonstrate the problems related to “gray zone modeling” or when the turbulent marine boundary layer flow is replaced by laminar winds. Additional simulation cases deal with modified surface characteristics and their impacts on the simulation results.

Saharan dust layers that reach Barbados via long-range transport over the North Atlantic are included as passive tracers in the model. Effects of layer thinning, subsidence and turbulent downward transport near the layer bottom at z $\approx$ 1800 m become apparent. The exact position of these layers and strength of downward mixing is found to be mainly controlled atmospheric stability (especially inversion strength) and wind shear. Comparisons of LES model output with lidar data show similarities in the downwind vertical wind structure and accurately reproduces the development of the daytime convective boundary layer measured by the Raman lidar.