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On the way to realistic large eddy simulations – A comparison of virtual measurements with CHEESEHEAD19 field measurements

Luise Wanner[1], Sreenath Paleri[2], Johannes Speidel[1], Ankur Desai[2], Matthias Sühring[3], Hannes Vogelmann[1], Timothy Wagner[4], Steven Oncley[5], William Brown[5], and Matthias Mauder[1,6]
[1]Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research - Atmospheric Environmental Research, Garmisch-Partenkirchen, Germany
[2]University of Wisconsin Madison, Department of Atmospheric and Oceanic Sciences, Madison, WI, United States
[3]Leibniz University Hannover, Institute of Meteorology and Climatology, Hannover, Germany
[4]University of Wisconsin Madison, Space Science and Engineering Center, Madison, WI, United States
[5]National Center for Atmospheric Research, Earth Observing Laboratory, Boulder, CO, United States
[6]Karlsruhe Institute of Technology, Institute of Geography and Geoecology, Karlsruhe, Germany

Large-eddy simulations are useful tools to study transport processes by mesoscale structures in the atmospheric boundary layer, since in contrast to single-tower eddy covariance measurements, they provide not only temporally but also spatially highly resolved information. Therefore, they are well suited to study the energy balance closure problem, for which the mesoscale transport of latent and sensible heat, triggered by heterogeneous ecosystems, is suspected to be a major cause. However, this requires simulations that are as realistic as possible and thus allow a comparison of real measurements in the field and virtual measurements in the simulation.
During the Chequamegon Heterogeneous Ecosystem Energy-balance Study Enabled by a High-density Extensive Array of Detectors (CHEESEHEAD) experiment in the summer of 2019, a heterogeneous 10x10 square km domain was intensively sampled across scales. This data offers a unique possibility to set up large-eddy simulations with realistic surface heterogeneity. We use PALM to simulate two days and an area of 40 by 40 square kilometers incorporating the CHEESEHEAD site. The large scale atmospheric forcings to inform the boundary conditions are determined from the NCEP HRRR product. As the lower boundary condition, we use a soil and land-surface model coupled with a plant-canopy model, which we adapt to the CHEESEHEAD area based on ground-based and airborne measurements of plant physiological data.
In this study, we investigate how well the simulations match with real measurements by comparing simulated profiles and virtual tower measurements with field measurements from radiosonde ascents, lidar measurements of three-dimensional wind and water vapor, eddy-covariance measurements from the 400 meter tower in the center of the study domain, as well as from typical eddy-covariance stations distributed through the study area. This way, we investigate how realistic the simulations actually are and to what extent the knowledge gained from them concerning the energy balance closure problem can be transferred to field measurements.