



Atmospheric Modeling at Large Eddy Simulation (LES) Scales: Opportunities and Challenges

Wednesday-Thursday, September 4-5, 2013
at Argonne National Laboratory, IL

Numerical models of atmospheric flows represent the effects of turbulence by using parameterizations to address the problem of closure in the fluid dynamics equations. These parameterizations are scale-dependent at various levels of sophistication. For Regional Climate Models (RCMs), this scale is very large - well beyond the convective scales of CFD-LES models. As a result, even at the finest resolved scales in the RCM-LES models, there exist certain physical processes, and effects of surface features must be parameterized.

Our understanding of RCMs and the physics they purport to simulate suggests that the current parameterization schemes, while effective at the length scales at which RCM normally operate (i.e. at tile resolutions of about 4 Km), are too simplistic in describing the effects of the subgrid processes when one pushes these RCMs to simulate phenomena for which they were not designed for in the first place, namely, the simulation of wind farms consisting of a wide array of wind turbines, and the simulation of cloud formation at hitherto unprecedented levels of resolution. Further, our knowledge about the physical processes and their feedback mechanism at these scales limits our attempts to improve these parameterizations.

It would appear, therefore, that there is considerable room to improve the existing subgrid RCM-LES models, and also develop newer sub-grid models for extending the resolutions at which we expect to employ RCM-LES models, by better understanding the underlying physical processes by way of high resolution observations and numerical simulations. With the increasing power of supercomputing (e.g. the installation of the IBM Blue Gene/Q, Mira, at Argonne National Laboratory), and the steady march towards exascale computing, we are poised to see an overlap between CFD-LES simulations, where one can consider larger computational domains while still effectively capturing the subgrid physics at the convective scales, and RCM-LES models, such as WRF-LES, where one can consider an increase in the resolution of the surface tiles and account for additional physical processes. This opens up a range of possibilities, such as, utilizing CFD-LES codes to develop newer parameterizations for very small-scale (i.e. well below the RCM-LES scale) processes, downscaling/super-parameterizations, and dynamically coupling CFD-LES and RCM-LES codes.

We thus see this is as a good opportunity to bring together CFD code developers, turbulence and RCM modelers, and atmospheric scientists to participate in a workshop on the theme of "Atmospheric Modeling at LES Scales" motivated by two key science interest areas:

1. The interaction of flows with complex objects such as wind turbines: can CFD-LES models be used to construct a parameterization scheme for RCM-LES scale flows?
2. How can we use CFD to improve sub-LES scale processes in cloud entrainment, detrainment thermodynamics and microphysics? Can CFD be another scale used to improve the representation of clouds in large-scale models?

We will be inviting a number of domain experts in CFD and LES modeling to Argonne as well as stakeholders (Atmospheric, Wind Energy and Climate Science) and observationalists at these scales to discuss the best framework for two-way coupling processes at RCM-LES scales and CFD-LES scales, and the science questions pertinent to DOE (EERE, BER, ASCR) that can be addressed using this approach. And, essential to applied research, what existing or future datasets can be used to constrain, direct, and validate our modeling efforts.

Workshop Chairs:

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