Boulder Fluid Dynamics Seminar Series

Tuesday, August 20, 2013, 3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado at Boulder

Adjoint sensitivity analysis in an online weather forecast model: Developing the Adjoint of Black Carbon in WRFPLUS

Jonathan Guerrette, *University of Colorado at Boulder*

Black carbon is a primary absorbing aerosol with an impact on climate that is potentially large, and still highly uncertain. Sparse in situ aerosol measurements and complex interactions between dynamics, microphysics, and radiation motivate development of models to predict climate impacts of black carbon sources, such as anthropogenic emissions and biomass burning. Regional modeling is a valuable means of determining the relative influences of emissions, wet and dry removal, and subgrid-scale vertical transport on aerosol distribution. In order to isolate the impact of each of these mechanisms, traditional sensitivity studies employ multiple forward model runs. In contrast, adjoint sensitivities of a scalar model response metric with respect to all parameters, such as spatially and temporally resolved emission rates and initial conditions, can be found with a single forward and reverse model run. Previous CTM adjoint sensitivity studies of black carbon use reanalysis meteorology, and thus decouple important feedbacks. Here we introduce recent developments in the inclusion of black carbon into the WRFPLUS adjoint and tangent linear models. Utilizing WRF online dynamics will enable sensitivity studies of regional weather phenomena to the presence of absorbing aerosol. This talk will present new adjoint sensitivity analysis of the relationship between the vertical distribution of black carbon and hourly anthropogenic and biomass burning emission inventories. These efforts lay the groundwork for the online 4D-Var assimilation of black carbon aerosol, and, eventually, a full suite of chemically speciated observations with the adjoint of WRF-Chem.

Influences of wind farms on regional and global climates

Julie K. Lundquist, *University of Colorado at Boulder and NREL/NWTC*

Large wind farms are expected to influence local and regional atmospheric circulations. As wind energy deployment grows, the potential for interactions between wind farms and for downwind impacts of wind farms must be addressed. An open-source representation of wind farms within the mesoscale numerical weather prediction model, WRF, has been implemented and distributed by a university-NREL-NCAR-NOAA team. This parameterization can be a useful tool to assess downwind impacts of wind farms. In addition to representing the increase of surface roughness due to the wind farm, the parameterization incorporates an increase of turbulent kinetic energy generated within turbine wakes.

This presentation will explain the physics incorporated in the WRF Wind Farm Parameterization (WRF-WFP). Simulations allow us to quantify the impact of a wind farm on an atmospheric boundary layer through a daily cycle. The presence of a wind farm covering 10x10km has a significant impact on the local atmospheric flow and on regions up to 60 km downwind at night. At night, near-surface warming ~ 0.5 K is observed. Other impacts on wind profiles, turbulent kinetic energy, surface heat fluxes, and boundary-layer height will be presented.

Assessments of impacts of wind farms on global climate typically represent wind farms with a simpler approach, an increase in aerodynamic roughness length. Studies employing this simpler method have found near-surface temperature changes of 1-2K over wind farms. We directly compare the two approaches, and find nearly the opposite wake structure between the two methods. Sensible heat fluxes are exaggerated in the simpler approach, leading to much greater changes in temperatures. We conclude that the increased surface roughness approach is not an appropriate option for representing wind farms or exploring their impacts.

Potential field campaign designs for validating the WRF-WFP will be discussed.