Numerical Studies of Aerosol Effects During the ISDAC Field Campaign

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Comparing Polluted vs. Clean Cases Using WRF/Chem Model (Two Case Studies During ISDAC)

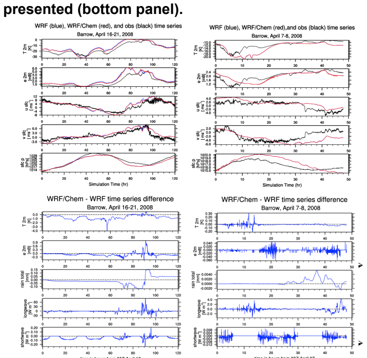
GOAL

- Attempt to quantify aerosol effects on the surface energy budget during clean and polluted instances.

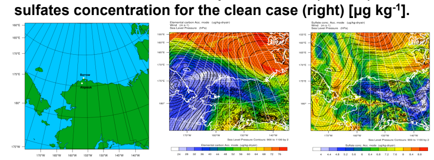
METHOD

- Compare differences in WRF/Chem from a baseline WRF simulation for a polluted case on 11-16 April, 2008 and a clean case on 7-8 April, 2008 during ISDAC.
- The polluted case is initialized with a uniform profile of black carbon, while the clean case is initialized with a sulfate profile based upon northern hemispheric, mid-latitude, clean environment conditions (setting in WRF/Chem).
- Both the polluted and clean cases are compared to the baseline WRF results and ISDAC observational data to assess the impact of the aerosols.

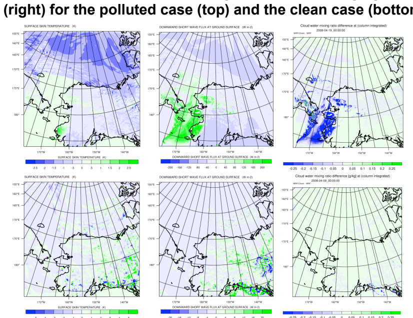
Time series comparisons from the baseline WRF/Chem & WRF simulations, and ARM field observations for 2m temperature, water vapor pressure, u & v horizontal wind components, and surface pressure for the polluted case (left) and clean case (right). WRF/Chem–WRF time series difference for surface parameters are also presented (bottom panel).



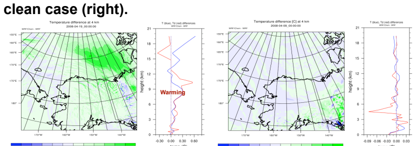
WRF/Chem simulation domain (left), column integrated black carbon concentration for the polluted case (middle), and sulfates concentration for the clean case (right) [μg kg^{-1}].



WRF/Chem-WRF surface skin temperature difference [°K] (left), downward shortwave radiation difference [W m^{-2}] (middle), and cloud water mixing ratio difference [g kg^{-1}] (right) for the polluted case (top) and the clean case (bottom).



WRF/Chem-WRF temperature difference [°K] at 4km altitude, and temperature [°C] & dew point temperature [°C] differences at Barrow site for the polluted case (left) and the clean case (right).



RESULTS

The clean case did not affect the surface energy balance or the microphysics to the degree of the polluted case.

We will further examine the effects of different aerosol concentrations and size distributions.

Solution Adaptive Modeling Technique (For studying aerosol-cloud-radiation interaction)

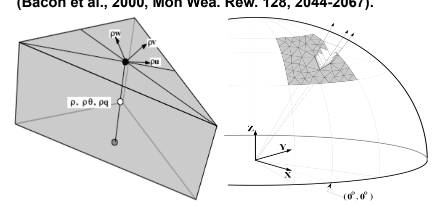
GOAL

- To improve aerosol-cloud-radiation interaction.

PROBLEM

- One method to improve the prediction of Numerical Weather Prediction (NWP) model is to enhance to spatial grid resolution.
- However, introducing fine spatial resolution throughout a simulation domain is not always practical since the size of the modeling domain and the interactions between the various atmospheric processes places restrictions on the grid resolution that can be achieved using current computers.
- These limitations prohibit the use of uniform high spatial resolution that is appropriate to resolve the small scales of interest (e.g., clouds).

OMEGA model grid and rotating Cartesian coordinate system (Bacon et al., 2000, Mon Wea. Rew. 128, 2044-2067).



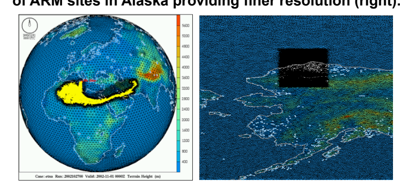
FUTURE WORK

- Solution adaptive modeling technique will be used to adapt the model grid dynamically to evolving aerosol distribution and/or clouds to improve aerosol-cloud-radiation interaction.

METHOD

- The alternative is then to develop methodologies capable of providing local refinement in certain key regions.
- The approach of Solution Adaptive (i.e., dynamic grid adaptation) modeling technique provides this capability.

For example, OMEGA model uses triangular prism grid that can be adapted to evolving weather features (e.g., clouds). OMEGA simulated 10-day forecast of Mount Etna volcanic eruption showing that the grid is adapting dynamically during the run to the evolving volcanic ash with grid resolution ranging from 100 km down to 1 km (left) and OMEGA grid statically adapting to the location of ARM sites in Alaska providing finer resolution (right).



The various grid operations performed on the grid in the process of adaptation: vertex addition & edge reconnection (top figures), vertex deletion (middle figures), and edge bifurcation (shaded cells) & vertex relaxation (blue edges) (bottom figures).