Effects of Black Carbon Concentration on the Surface Energy Budget

A Polluted Case study for the ISDAC field campaign, 16-21 April, 2008

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PROBLEM:

✓ **Under polluted conditions, examining effects of black carbon concentration on the energy budgets of the surface and atmosphere.**

METHOD:

✓ **Compare simulations from a baseline WRF run without black carbon concentration with a WRF/Chem run representing direct and semi-direct effects.**

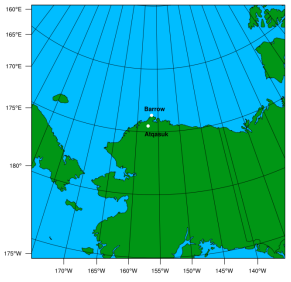
✓ **WRF/Chem is initialized with uniform black carbon emission into the flow field of WRF as representative of polluted atmosphere.**

✓ **Compare the WRF/Chem and WRF model results and differences with observational data from ISDAC.**

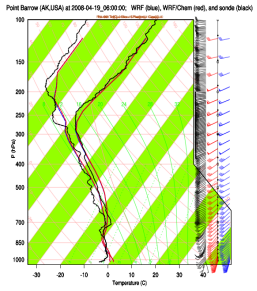
GOAL:

✓ **Investigate the surface energy budget response to black carbon concentration effects with the use of a numerical model containing aerosol modules.**

✓ **The Weather, Research, and Forecasting (WRF) model coupled with Chemistry (WRF/Chem) is used for simulations.**

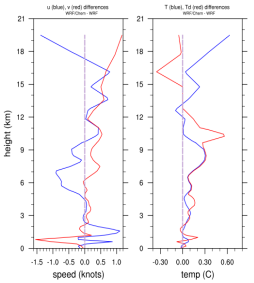


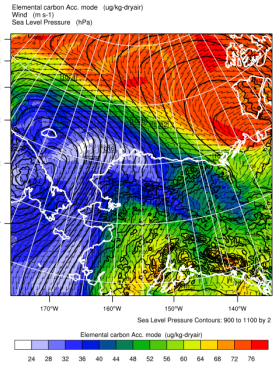
5km uniform horizontal grid resolution is used for the WRF model simulation domain (shown above). The models were run 00Z 16-21 August, 2008, and results are shown for 00Z 19 August, 2008.



Top: Sounding profile comparisons between WRF/Chem and WRF results, and ARM observations at Barrow, AK.

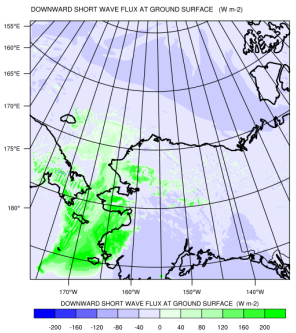
Bottom: u, v [m s^{-1}] horizontal wind components, and temperature [°C] and dew point temperature [°C] differences (i.e., WRF/Chem – WRF).

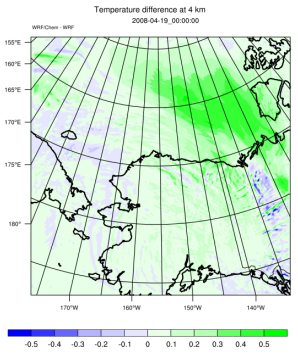




Top: Column integrated black carbon concentration [μg kg^{-1}] .

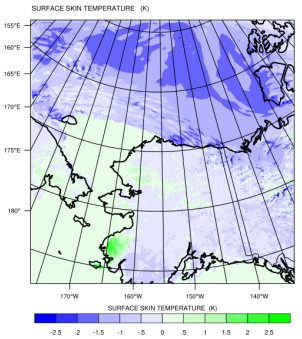
Bottom: WRF/Chem - WRF downward shortwave radiation difference [W m^{-2}] at the surface.

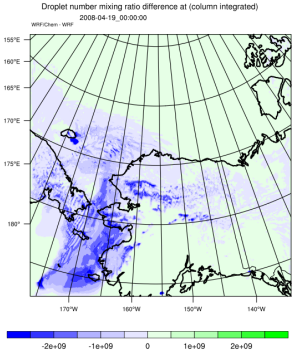




Top: WRF/Chem - WRF temperature difference [°K] at 4km altitude .

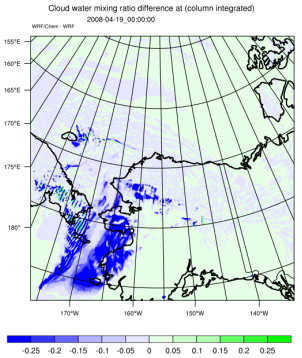
Bottom: WRF/Chem - WRF surface skin temperature difference [°K] .

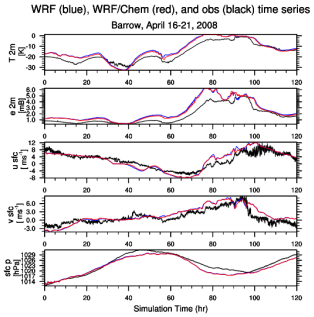




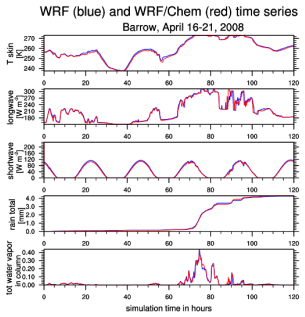
Top: WRF/Chem - WRF droplet number mixing ratio difference [kg^{-1}] .

Bottom: WRF/Chem – W RF cloud water mixing ratio difference [g kg^{-1}] .

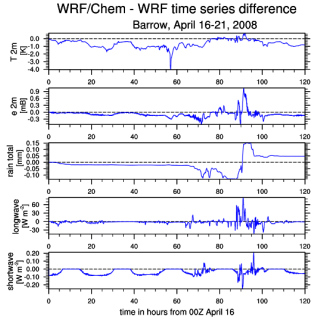




Time series comparisons during ISDAC from the baseline WRF & WRF/Chem simulations, and ARM field observations for 2m temperature, water vapor pressure, u and v horizontal wind components, and surface pressure



Time series comparisons during ISDAC from the baseline WRF & WRF/Chem simulations for the skin temperature, surface downward longwave and shortwave radiation, total rainfall, and column integrated water vapor



WRF/Chem-WRF time series difference for surface parameters; temperature at 2m above the surface , vapor pressure, total rainfall, downwards longwave, and shortwave radiation on the ground surface.

RESULTS and FUTURE WORK:

✓ **Black carbon aerosols absorb solar radiation, thereby warming and drying the atmosphere and negatively affecting cloud formation (semi-direct effect).**

✓ **Less solar radiation reaches the ground surface (direct effect), which experiences a cooling effect except in the cloudy areas where a decrease in cloud droplet mass and number concentration leads to an increase in shortwave radiation and surface warming.**

✓ **We plan to examine impacts of other aerosols (sulfates, etc), and multiple aerosol concentrations along with different modal distributions. More realistic aerosol profiles will also be used, and surface effects of radiation forcing will be analyzed.**