

Hemispheric pollution to regional air quality: An issue of resolution

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Scientific advances to be accomplished within this project

- 1) Improved understanding of feedbacks between climate change and air pollution: effects of changing temperatures/precipitation/water vapor on chemistry, effects of changing emissions (biogenic NO_x and VOC, lightning NO_x, biomass burning, anthropogenic emissions), effects of changing meteorology (synoptic and hemispheric scales, stratosphere-troposphere exchange).
- 2) Improved understanding of feedbacks between climate change and export of pollution to the global atmosphere: will a warmer climate lead to more efficient export of pollution? How will it affect the long-range transport of pollution?
- 3) Improved understanding of the horizontal resolution needed to accurately predict the influences of future climate change on regional air quality and vice versa, through the use of the Weather Research and Forecasting (WRF) model in conjunction with CAM.
- 4) Exploration of the possibility of downscaling global simulations for analysis of regional air quality.

Necessary model capability

To perform these studies, a version of CAM with full tropospheric chemistry, including aerosols, and coupling to the Land Model (CLM) will be required. In order to represent the air pollution chemistry, a representation of higher hydrocarbons is needed, including online calculation of biogenic VOC and soil NO emissions. Size-resolved aerosols are needed.

To achieve the horizontal resolution needed to study urban and regional scales, WRF-Chem will be used in parallel to CAM. The same (or at least comparable) chemical and aerosol used in CAM will be needed in WRF. As an initial step, a one-way coupling of CAM providing boundary conditions (every 3-6 hours) to WRF will be used. As a later goal, the two-way coupling of CAM and WRF will be explored.

Current status of models/ model development. Key scientific personnel needed. Who will do it? Do we have internal/external funds?

CAM with full tropospheric chemistry, with coupling to CLM, is completed. An improved aerosol scheme is being developed by the **Aerosol Effects on Clouds, Energy & Hydrologic Cycle** project of this working group, led by S. Ghan. Some chemistry and aerosols are in WRF [G. Grell, NOAA; X.X. Tie, NCAR].

The coupling of WRF and CAM is needed.

It has not been determined who will perform and evaluate the simulations.

No internal or external funds have been identified.

What types of CCSM simulations are needed? What are the benchmarks and validation?

1) Present-day simulations of CAM and WRF, with full tropospheric chemistry and aerosols, for evaluation.

Comparison will be made to a variety of observations, such as: for US, surface ozone (AIRS and CASNET networks) and aerosols (IMPROVE and CASNET); aircraft profiles for ozone and other species; ozonesondes; satellite observations: CO (MOPITT), NO₂ (GOME, SCIAMACHY), O₃ (GOME), AOD (MODIS).

2) Simulations of current climate and future climate (2050? 2100?), running several years for each scenario to assess variability of feedbacks.

3) Comparison and evaluation of WRF results with different convective, radiative, and boundary layer parameterizations.

4) Comparison of WRF results using different domain sizes. E.g., where should boundaries be set for calculating U.S. air quality? What about for smaller regions within the U.S.?

5) Sensitivity studies of the impact of different resolutions on the solutions.

A series of simulations with CAM at different resolutions (from 0.5° x 0.625° to 4°x5°) is currently being run by Peter Hess and Louisa Emmons. Tracers with different lifetimes are emitted from the eastern US, Mexico City, China, and Indonesia. Comparisons will be made between simulations with online and offline winds, and the impact of resolution on the transport patterns will be analyzed.

6) Analysis of the effects of downscaling CAM meteorology to WRF resolution. When WRF is run with CAM initial and boundary conditions, how do the WRF results differ from the results obtained by CAM? What features can WRF resolve that CAM cannot? How much more useful information can be obtained by WRF compared to CAM?

Time frame

None set at this time.

Computing resources needed

CAM with chemistry requires 200 GAUs per simulation year. The improved aerosol scheme will add significant cost. Cost of running WRF is unknown.