Modeling aerosol climate effects

Wei-Chyung Wang, Guo-Xing Chen, Chu-Chun Huang, and Yang-Yang Song
Atmospheric Sciences Research Center, University at Albany, State University of New York
Collaborators: Institute of Atmospheric Physics/Chinese Academy of Sciences; Dept. of Atmospheric Sciences/National Taiwan University

Modeling Approach:

IAP (H. Liao)
- *Aerosol measurements* (Mass & size)

NTU (J.-P. Chen)
- *Cloud schemes* (Warm/mixed–phase/ice)
- *Aerosol schemes* (Size, mixing state)

IAP (Q. Bao)
- *Global model* (Season-decade time scales climate effects)

SUNYA
- *WRF model* (Macro- & micro cloud-radiation-meteorology)

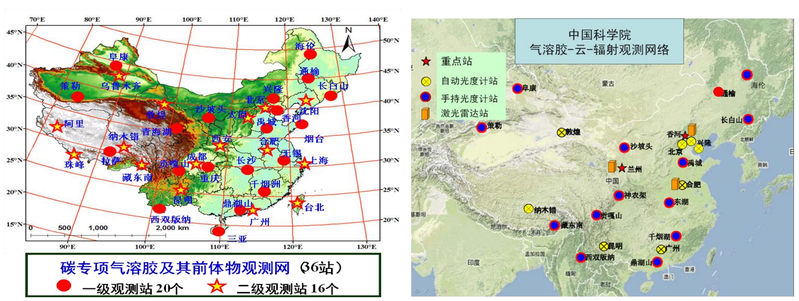
❑ IAP global model

The NTU cloud scheme (Cheng et al., 2010) has been implemented with multi-component aerosols (sulfates, dust, black carbon, sea salt, and organic aerosols) included. Studies on the aerosol effects on the direct radiative forcing (DRF) using the IAP model simulated meteorology were documented in Li et al. (2012, 2014). The results indicate that larger DRF values over East Asia can be partly attributed to relatively higher atmospheric moisture, which enhances the aerosol hygroscopic effect, then increases aerosol optical depth and DRF at clear-sky TOA and surface and even influences their long-term changes. A model simulation including both the DRF and cloud adjustments for the present climate is currently being evaluated and used to contrast the simulation without aerosols.

❑ Model-intercomparisons of *aerosol effects on clouds*

The 10th East Asia Climate and Environment (EACE) Workshop, **"Aerosol climate effects over East Asia",** coordinated by W.-C. Wang & J.-P. Chen, and organized by H. Liao, was held April 17-18, 2014 in Beijing, covering the measurements, observational analyses, and modeling studies. H. Liao (CAS project PI) gave a presentation on, "***Ongoing nationwide measurements of concentrations and optical properties of aerosols by Chinese Academy of Sciences***":

- To establish a 3-years aerosol measurements: 36-sites size-resolved & 28-sites optical properties;



- To study historical (1980-2010) changes of aerosols in China using satellite measurements;
- To reconstruct the deposition of carbonaceous aerosols in lake sediments and ice-core records over 1850-2000;

A model-intercomparisons of "the effects of aerosols on clouds" based on measurements in China was proposed, and is currently being planned.

❑ SUNYA WRF model: Effects of anthropogenic aerosols on marine stratocumulus over SE Pacific

Southeast Pacific is covered by a large, persistent stratocumulus deck, which may be affected by transported anthropogenic aerosols produced by industry developments in South America. A study of the ***aerosol effects on cloud macro- & micro-physical parameters and radiation*** was conducted, using the WRF model (with NTU cloud scheme; Cheng et al., 2010) together with the data from the October-November 2008 VOCALS [VAMOS (Variability of the American Monsoon System) Ocean-Cloud-Atmosphere-Land Study] Campaign. Background aerosols are assumed to be ammonium sulfates, with initial size distribution fitted to the VOCALS observed spectra. Aerosols will be regenerated when cloud drops completely evaporate.

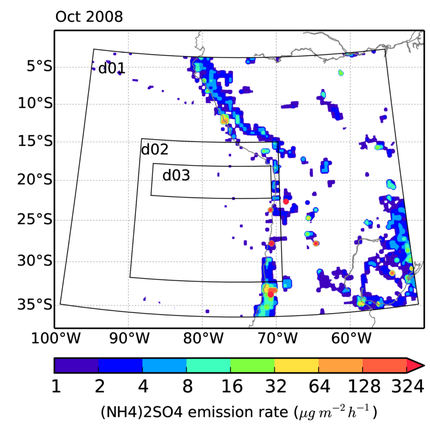


Fig. 1. Model domain with 27 km, 9 km, 3 km resolutions

Simulation results from d03 will be used to compare with observations from the VOCALS 20 °S survey. Colored shadings indicate the sulfate emission rate based on GEIA (Global Emission InitiAtive). Most emission occurs on the continent.

The aerosol effects on clouds are studied by comparing two simulations for the period October 20-29, 2008:

- Control case : Background plus anthropogenic sulfates;
- Clean case: Background sulfates.

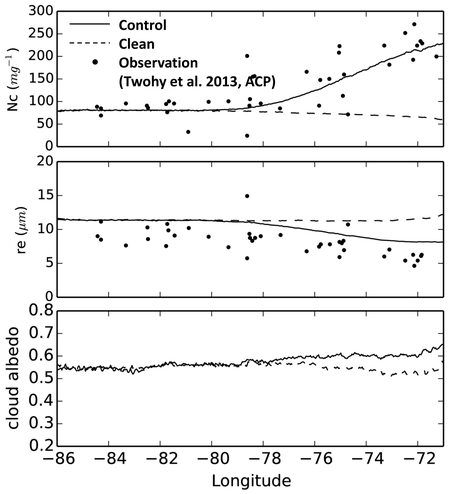


Fig. 2. d03 zonal mean cloud droplet number concentration (Nc), cloud droplet effective radius (r_e) and cloud albedo.

- **Observations versus Control case** (from East to West): both show decreased Nc and r_e which are consistent with decreased aerosol concentration.
- **Control versus Clean cases**: More aerosols lead to more but smaller cloud droplets, and enhanced cloud albedo with larger effects near the coast.
- Aerosol effects on cloud cover and liquid water path are found to be small, so are aerosols effects on longwave radiation at the surface and meteorology (not shown).

Cheng, C.-T., W.-C. Wang, and J.-P. Chen, 2010: Simulation of the effects of increasing cloud condensation nuclei on mixed-phase clouds and precipitation of a front system. Doi:10.1016/***J. AtmosRes***.2010.02.00.

Li, J.-D., Z. Sun, Y.-M. Liu, J.-N. Li, W.-C. Wang, and G.-X. Wu, 2012: A study on sulfate optical properties and direct radiative forcing using LASG-IAP general circulation model. ***Adv. Atmos. Sci***., **29**, 1185-1199.

Li, J.-D., W.-C. Wang, Z. Sun, G.-X. Wu, H. Liao, and Y.-M. Liu, 2014: Decadal variation of East Asian radiative forcing due to anthropogenic aerosols during 1850–2100 and the role of atmospheric moisture. ***Clim. Res***. (accepted)