Proposal Title: Global Distribution of Tropospheric Aerosols: A 3-D Model Analysis of Satellite Data
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Summary Report (September 1, 1998 – August 31, 2002)

A. Summary

We have reached all the objectives that we proposed for the GACP project. There objectives are:

(1) Interpreting satellite aerosol measurements. Our first objective is to use a global aerosol model to interpret the total column aerosol quantities retrieved from satellite observations (e.g., aerosol optical depth or index). This model should be validated against many field measurements such that the model can be used with reasonable confidence when analyzing the satellite data. Model results can also in turn help reduce uncertainties in satellite retrieval.
(2) Defining global distributions of major aerosol types. Each aerosol type has its own optical property and radiative effects. It is clear that knowledge of only total aerosol optical depth is not sufficient for estimating the aerosol forcing on climate, especially for projecting future climate change due to the change of aerosol sources. Instead, distributions and properties need to be determined for each major aerosol types individually so that the total aerosol optical properties reflect the variations of aerosol composition.
(3) Assessing the contribution of human activities to global aerosol loading. With the exception of sea salt, all the major types of aerosol have very strong anthropogenic sources. Those sources are likely to grow through the next century. However, because anthropogenic sources are concentrated in the continental surface, anthropogenic aerosols could be sufficiently removed within the boundary layer by dry or wet depositions. Hence, the impact of human activities on aerosol loading, in both boundary layer and free troposphere, needs to be investigated and quantified in order to assess the climate change caused by the increase of anthropogenic sources.

Our accomplishments include:

- We have now the capability of simulating all major types of tropospheric aerosols, including sulfate (and precursors), dust, organic carbon, black carbon, and sea-salt, in the Georgia Tech/Goddard Global Ozone Chemistry Aerosol Radiation and Transport (GOCART) model, with emissions from industrial, biomass burning, volcanoes, desert, ocean, and biosphere.

- We have compared the model results with satellite data of TOMS and AVHRR, and the ground-based sun-photometer network AERONET and used the model to analyze these data.

- We have calculated the radiative forcing by anthropogenic aerosols using the IPCC projected emission scenarios for year 2000, 2030, and 2100.

- With additional support from GACP, we have been actively involved in the international program ACE-Asia field experiment, which was conducted in spring 2001 over western Pacific. During the intensive operation period, we were stationed in the operation center in Japan, providing daily 3-day aerosol forecasts for flight planning. Our products include total and individual type of aerosol optical thickness, aerosol species concentrations, and vertical profiles. We made our products available from our website (*http://code916.gsfc.nasa.gov/Mission/ACEASIA/forecast/Index.html*) as well as from the Joint Office of Science Support (JOSS, which handled the mission support and logistics during ACE-Asia) field catalog site. Our forecast paper has been submitted to the ACE-Asia special issue (preprint at *http://code916.gsfc.nasa.gov/People/Chin/ACEA1.pdf*). We are now actively working on analyzing ACE-Asia data.

- A summary of our GACP investigation has been published in the GACP special issue of the Journal of Atmospheric Sciences *(http://code916.gsfc.nasa.gov/People/Chin/jas.all.pdf)*. I have to say that this is my favorite project. It has built a solid foundation for us to move forward on investigations of aerosol-climate-chemistry interactions.

- Our results have been widely and frequently used by other scientists, for example, to impose initial conditions for regional models, provide dust source functions for other global models, supply aerosol fields for chemistry and climate models, help data group interpret their measurements, select monitoring sites for ground observation network, and assist satellite retrievals. Model calculated multiple-year optical thickness for individual and total aerosols are at *http://code916.gsfc.nasa.gov/People/Chin/aot.html*.

- We are continuing working on model improvement and analyzing satellite data. We are going to work with the new MODIS satellite data on aerosol optical thickness and size information. A MODIS and GOCART comparison movie can be found at *http://earthobservatory.nasa.gov/Newsroom/Aerosols*.

B. Publications of results of this project:

Chin, M., et al., Tropospheric aerosol optical thickness from the GOCART model and comparisons with satellite and sunphotometer measurements, *J. Atmos. Sci., 59,*, 461-483, 2002.

Chin, M., Ginoux, P., and Lucchesi, R., A global model forecast for the ACE-Asia field experiment, submitted to *J. Geophys. Res.*, 2002.

Penner, J., Zhang, S. Y., Chin, M., et al., A comparison of model- and satellite-derived aerosol optical depth and reflectivity, *J. Atmos. Sci., 59*, 441-460, 2002.

Martin, R.V., Jacob, D.J. Yantosca, R.M. Chin, M. and Ginoux, P., Global and Regional Decreases in Tropospheric Oxidants from Photochemical Effects of Aerosols, *J. Geophys. Res.*, 10.1029/ 2002JD002622, 2002.

Yu, H., Dickerson, R. E., Chin, M., Kaufman, Y. J., Holben, B. N., Geogdzhayev, I. V., and Mishchenko, M. I., Annual cycle of global distribution of aerosol optical depth from integration of MODIS retrievals and GOCART model simulations, *J. Geophys. Res.*, in press, 2002.

Park, R., Jacob, D., Chin. M., and Martin, R. V., Sources of carbonaceous aerosols over the United States and implications for natural visibility, submitted to *J. Geophys. Res.*, 2002.

Duncan, B., Bey, I., Chin, M., Mickley, L. J., Fairlie, D., Peirce, R. B., Martin, R. V., and Matsueda, H., Indonesian wildfires of 1997: Impact on tropospheric chemistry, submitted to *J. Geophys. Res.*, 2002.

Ginoux, P., Prospero, J., Torres, O., and Chin, M., Long-term simulation of dust distribution with the GOCART model: Correlation with the North Atlantic Oscillation, submitted to *Environ. Modeling and Software*, 2002.

Chin, M., Ginoux, P., Holben, B., Chou, M.-D., Kinne, S., and Weaver, C., "The GOCART model study of aerosol composition and radiative forcing," in the *Special Volume for A Millennium Symposium on Atmospheric Chemistry, 81st AMS Annual Meeting,* Am. Meteor. Soc., 2001.

Ginoux, P., Chin, M., Tegen, I., Prospero, J., Holben, B., Dubovik, O., and Lin, S.-J., "Sources and global distributions of dust aerosols simulated with the GOCART model," *J. Geophys. Res., 106,* 20,255-20,273, 2001.