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Final Report

Title of Research Task:

Simulation of Tropical Biomass Burning

Grant number

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The work proposed was carried out as planned. It might be noted that we underwent a personnel change during this time period when Dr. Zitian Guo took over the duties carried out previously by Dr. Long Li. Fortunately, this changeover was carried out smoothly. The work described in this final report formed the basis for a follow-on research grant from NASA Ames Research Center.

The research objectives that were achieved during the course of our studies include the following:

Over the last few years, a model has been developed in the Atmospheric Chemistry and Dynamics Branch at Ames Research Center in collaboration with the Physics Department at San Jose State University. It is referred to as the Global/Regional Atmospheric Chemistry Event Simulator (GRACES). Currently, the GRACES model system combines an atmospheric chemistry and transport model [Chatfield et al., 1996, Toon et al., 1988, Smolarkiewicz, 1984], and a regional mesoscale meteorological model, MM5 [Grell et al., 1995]. Therefore this system is suitable for simulating the conditions observed by the tropical observation missions, such as PEM-Tropics (the Pacific Exploratory Mission in the Tropics, SONEX (Study of Ozone and Nitrogen oxides Experiment), and other periods.

Specifically, the research carried out included the evaluation of the behavior of several components of the MM5 (Meteorological Model 5, version 2) and the GRACES combined modeling system. We initiated research on (a) the ability of the MM5 model to assimilate downward vertical velocities at least as high as the analyses (b) the ability of the Graces model to incorporate the vertical velocities from MM5, and (c) other factors related to transport patterns required to transport CO in the observed manner.

We carried out improved calculations of the transport of tracers for both NASA airborne missions, SONEX and PEM-Tropics.

We also made improved source-strength estimates for isoprene, dust, and similar emissions from the Earth's surface. This required the use of newly available databases on the Earth's surface and vegetation.

We completed atmospheric chemistry simulations of radicals and nitrogen oxide species, following work accomplished by Professor Folkins. We were fortunate to have Professor Folkins spend two periods of time (of several weeks each) working with us on this project.

We have improved the handling of cumulonimbus convection by modifying the existing Georg Grell [1993] Scheme. A newly developed deep convection scheme by Zhang and MacFarlane [1994] has been recognized among the community, and has shown promising improvements of simulating precipitation in the newly released NCAR/CCM3 [Kiehl, 1996, personal communication], which has the relatively coarse 100 km grid scale as our GRACES model.

Previous studies [e.g., Chatfield and Delany 1990, Chatfield et al., 1996] have shown that the convective boundary layers can be as high as a few kilometers during the TRACE-A experiment periods, and could play an important role on transport of the biomass burning plumes into the mid-troposphere. It is also demonstrated that the timing of the deep convective mixing within the boundary layers and the convective cloud is crucial for promoted escape to the free troposphere.

We have identified in clear detail the role of the African Intertropical Front. We will use MM5's nesting capability to refine model resolution in crucial areas, such as where low level convergence of the inflows is strong, as well as where cloud activities is the strongest. This will enhance our understanding of the impacts of various meteorological processes on affecting venting of "Great African Plumes".

In order to provide better weather presentation, we began using MRF planetary boundary layer (PBL) and CCM2 radiative schemes. The hourly averaged, instead of immediate cloud information including cloud base and top, cloud mass flux, cloud down draft heights and down draft strength are now saved for GRACES model. The precipitation efficiency was increased up to 0.9 and cloud down draft is decreased by 10 and correspondence with other MM5 development scientists. We applied MM5 with these modification to NASA's PEMT-A and SONEX project. verification of wind fields and radiative cooling shows the MM5 has better performance.

We also modified the MM5 trajectory program to allow it work much better for a parcel crossing the west/east boundaries. We have used MM5 in the Mercator projection with a global wrap. Behavior at the seam is somewhat different, and we have addressed second-order effects on the models accuracy there.

We applied GRACES model to PEMT-A and SONEX projects. In the former, we aided in the modification of periodic boundary conditions. In the latter, we began work evaluating approaches to lightning parameterization. The analyses of boundary values showed excessive emissions accumulating on the SONEX boundaries. Following this finding, better results were obtained by corrections to the boundary conditions and integration technique.

Bad inputs provided to MM5 often resulted in crashes of the GRACES's model. A program has been generated to check all the input meteorological variables from MM5 in order to run GRACES more smoothly.

The project involved using various programs and languages such as VIS5D, GRADS and IDL. A moderate amount of work was required to show model results well on a Lambert map projection with the GRADS program. This helped us in understanding our model's behavior.

A simple model has been generated to calculate NO_x due to the lightning from MM5 hourly data. In this model, the scheme based on height of cloud top or based on cloud mass flux is used.

References

- Grell, G. A., 1993: "Prognostic evaluation of assumptions used by cumulus parameterizations." *Mon. Weather Rev.*, 121, 764-787, 1993.
- Grell, G.A., J. Dudhia, and D.R. Stauffer: "A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model Version (MM5)", NCAR Tech Note, NCAR/TN-398+STR, Nat'l Center for Atmos. Res. Boulder, Colo. (1995).
- Smolarkiewicz, P.K., 1984: "A fully multidimensional positive advection scheme with small implicit diffusion", *J. Comp. Phys.*, 54, 325-362.
- Toon, O. B., R. P. Turco, D. Westphal, R. Malone, and M. S. Liu, 1988: "A multi-dimensional model for aerosols: Description of computational analogs", *J. Atmos. Sci.*, 45, 2123-2143.
- Chatfield, R. B., and A. C. Delany, 1990: "Convection links biomass burning to increased tropical ozone: However, models will tends to overpredict O₃", *J. Geophys. Res.*, 95, 18,473-18488.
- Chatfield, R.B., J. A. Vastano, H. B. Singh, and G. Sachse, 1996: "A general model of how fire emissions and chemistry produce African/oceanic plumes (O₃, CO, PAN, Smoke) seen in TRACE-A", *J. Geophys. Res.* in press.
- Zhang, G. J., and N. A. McFarlane, 1994: "Sensitivity of climate simulations to the parameterization of cumulus convection in the Canadian Climate Centre General circulation model", *Atmos. Ocean*, 33, 407-423,

Publications and Presentations

A number of presentations at scientific conferences and at seminars have helped to make our work known to the scientific community.

"Meteorology of the Southern Global Plume: African and South American Fires Pollute the South Pacific" Z. Guo and R.B. Chatfield. *Atmospheric Sciences and Applications to Air Quality 6th International conference*. Nov. 3-5, 1998 Beijing, CHINA.

"Mechanism of the Southern Global Plume: How tropical burning plumes affect the remote Pacific, R.B. Mechanism of the Southern Global Plume: How tropical burning plumes affect the remote Pacific," Z. Guo, G.W. Sachse, N. Blake, and E. Browell, submitted to *J. Geophysical Res.*, 1998.