GMI Status Report Part II:
Work in Progress, May-October, 2005

Contents

I. Combo (combined strat-trop chemistry) model

Model Development and Simulations

The Combo model is running with 5 years of FVGCM met data reprocessed to 42 levels (lid at 0.015 hPa), both 4x5 (completed) and 2x2.5 horizontal resolutions. David Considine has evaluated ozone in the UT/LS in the 4x5 version, comparing it to the tropospheric model and to SAGE II and ozonesonde climatologies (see David's presentation from the June 2005 Science Team meeting on the GMI website). The model shows less variability than the climatologies. By comparing to an experiment without convection, he found convection significantly affects ozone in the tropical UT but has little effect in the extratropics.

Bryan Duncan has made several additions to the combo to bring its troposphere up to par with the GMI (V2) tropospheric model. This includes the effect of clouds, tropospheric aerosols, and UV albedo (surface-varying, rather than fixed at 0.3) on photolysis rates (using Fast-JX). The stratospheric chemistry is updated to JPL2002. Inactive species have been removed from the mechanism, as in the GEOS-CHEM mechanism. Output is written for 110 chemically active species (117 total, including N_2, O_2, dehyd, etc). Bryan also modified KMG (the mechanism-generating code) so that it is no longer 'hard-wired' to a fixed species numbering. This increased flexibility makes it easier to test different versions of a chemical mechanism.

Evaluation at 2x2.5 resolution

The 2x2.5 version combo integration is continuing; one year has been completed. Using 124 processors on halem, the 2x2.5 combo model integrates at a rate of 5 weeks per day. Some preliminary evaluation shows that the globally averaged total column O_3 is lower than in the stratospheric hindcasts (7 DU). The Hindcasts were already ~30 DU too low compared to TOMS because they had no tropospheric ozone, but the combo has a reasonable tropospheric column (see 'Early Science Results'). Compared to the Hindcast, the Combo has lower partial columns in the extratropical lower and middle stratosphere, and only 9 ppm O_3 at the peak (rather than 10 ppm). Combo NO_x is ~1.5 ppb higher at the ozone peak. These differences arise from differences between the stratospheric look-

up table, used in the Hindcast, and Fast JX cross sections, used in the Combo. In the UT/LS, David has found that ozone profiles had a worse comparison to the climatologies than the 4x5 combo did. Both David and Bryan have found too much ozone in the NH extratropical upper troposphere, suggesting the problem comes from the stratosphere. Evaluation of this integration is continuing.

We are making runs with the stratospheric and tropospheric mechanisms using the 5-year fvgcm met fields to examine differences in the composition in the UT/LS. Mark Olsen has calculated the 380K mass flux in the 5 years and found little interannual variability.

Low cloud OD has been identified in the tropics in the fvgcm. However, using the Global Precipitation Climatology Project (GPCP) database, Bryan has compared PDF's of precipitation rates in the tropics and extratropics and has found that the fvgcm is in quite good agreement with observations.

Early Science Results

Bryan is working with Jerry Ziemke and Sushil Chandra (GSFC) on comparing combo model tropospheric column ozone with satellite observations. The model tropospheric column agree quite well with OMI and MLS measurements in the tropics and southern hemisphere, but are biased slightly high (5-10 DU) in the north. They expect to have a paper submitted to JGR in a month ("Tropospheric ozone determined from Aura OMI and MLS: Evaluation of measurements and comparison with a chemical tracer model" J. Ziemke, S. Chandra, B. Duncan, L. Froidevaux, and P.K. Bhartia).

II. New Modules & Met Fields

Forecast vs Assimilated Met Fields. We have run combo experiments with 'pieced' forecasts and assimilated met fields for Jan-Apr 2001. Bryan has demonstrated a number of improved transport characteristics in the pieced forecasts. Even with only 4 months, we can see that the stratospheric residual circulation in the forecasts has been slowed down compared to the assimilation (a good thing!). Because of these encouraging early results, we are acquiring a full year of forecast for further testing, optimization of forecast 'piecing', and comparison with Aura data. This new met data set will cover ~June 2004 to present. Bryan will present results from this investigation at the Fall 2005 AGU meeting.

GEOS-4-DAS Meteorological Fields. We are processing GEOS-4 assimilated met fields for Jan 15, 2004 to the present. Steve Steenrod is overseeing this laborious, multi-step process which requires considerable quality control. These met fields will be used in the Combo model, allowing comparisons with Aura data. We expect to have 22 months of assimilated met fields by the end of this month.

Michigan microphysical module. Xiaohong Liu and Bhat have worked together to implement the Michigan microphysical module into the Version 2 GMI model. Two year

simulations of DAO, FVGCM, and GISS met fields were run. Xiaohong has evaluated the simulation with DAO met fields and is satisfied with the implementation.

Langley Chemical Mechanism. David Considine has implemented this combined strat-trop mechanism and has a 2-year test simulation using CCM3 met fields. This mechanism has fewer species than the 'standard' combo mechanism and runs ~50% faster. He finds good agreement with the standard mechanism and with surface observations of CO and O3. He is currently working on modifications to handle isoprene chemistry and on the implementation of the Langley solver.

New lightning parameterization. Dale Allen, Ken Pickering, and Bhat have completed the implementation of a revised lightning parameterization for the tropospheric model. The NO_x produced by lightning in new simulations with DAO, fvgcm, and GISS met fields are being evaluated against the previous parameterization and against simulations with no lightning NOx. Model evaluation also includes comparisons with O_3 sondes.

"Doubling to convergence" Experiments. Tom Kucsera is using the utility 'ncregrid' to double vertical and then the horizontal resolution of GISS met fields. This project complements experiments done by Michael Prather with the UCI CTM, where they showed that their advection scheme produces results (for a 10-yr CO2 simulation) that converge as the met field resolution increases. The first doubling experiment (vertical) was successful and the 'full doubling' experiment will be done soon. We will be looking for 1) convergence with increasing resolution in the GMI Lin & Rood advection scheme, and 2) covergence of the GMI results with those obtained by the UCI CTM (second order moments scheme).

Coupling the aerosol and chemistry calculations. Jose Rodriguez, Dan Bergmann, Xiaohong Liu, and Hamid Oloso (core team) are working on coupling the aerosol and gas phase tropospheric chemical mechanisms. Bryan has added sulfur reactions to the chemical mechanism.

AEROCOM-B Emissions. Xiaohong Liu and Joyce Penner delivered the AEROCOM-B emission scenarios. Tom Kucsera regridded them for use in the GMI aerosol model. We are considering whether to run and submit these results to AEROCOM.

III. Ongoing work/miscellaneous

Thanos Nenes and Nickolas Meskhidze (GA Tech), with help from Jules Kouatchou, have successfully ported the GMI aerosol model to their Linux cluster. They have implemented three different parameterizations for CCM activation. They plan to run the AEROCOM-B scenarios and present results from an indirect radiative forcing calculation at the Fall 2005 AGU meeting.

Jules Kouatchou and Tom Clune have been working to isolate and 'refactor' the GMI chemical mechanisms, a step toward ESMF-compliance. Testing of this refactored

mechanism is nearly complete. This will facilitate the delivery of our combo mechanism to the next version of the GMAO general circulation model (GEOS-5).

Hamid Oloso has implemented updates to Fast JX and Jules Kouatchou is making it MPI compatible.

Restart files have been changed to double precision so that we can rerun experiments and get the same results.

Bhat has worked on developing and applying code to process slant columns of MOPITT CO and GOME NO_2.

In moving to 2x2.5 resolution in many of our experiments, we have found it necessary to decrease the grand timestep to 30 min (from 1 hr). A 1 hr timestep causes oscillations in species that have a strong dependence on solar zenith angle (i.e., ones that change rapidly at sunrise or sunset). This effect is very noticeable in NO, causing ripples with an amplitude of ~10% of the NO mixing ratio. ClO_x species are affected to a smaller extent. This effect is visible in the hindcast (stratospheric) simulations and in the combo model run at 2x2.5. The problem is greatly reduced though, not eliminated, by a 30 min timestep.

IV. GMI or GMI-related manuscripts

Xiaohong Liu, Joyce E. Penner, Bigyani Das, et al., Uncertainties in global aerosol simulations: Assessment using three meteorological datasets, *J. Geophys. Res., submitted*, August, 2005.

D. B. Considine, D.J. Bergmann, and H. Liu, Sensitivity of Global Modeling Initiative chemistry and transport model simulations of radon-222 and lead-210 to input meteorological data, Atmos. Chem. Phys. Discuss., 5, 5325-5372, 2005.

S.E. Strahan and B.C. Polansky, Implementation issues in chemistry and transport models, Atmos. Chem. Phys. Discuss., 5, 10,217-10,258, 2005.

D.S. Stevenson, F.J. Dentener, M.G. Schultz, and a cast of thousands, Multi-model ensemble simulations of present-day and near-future tropospheric ozone, *J. Geophys. Res., accepted,* 2005.