Overview of planned coupled chemistry-climate simulations to support upcoming ozone and climate assessments

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On behalf of the CCM Validation Activity for SPARC (CCMVal)

1. Introduction

SPARC has established a new validation activity, CCMVal, for coupled chemistry-climate models (CCMs). The activity is based on the framework developed at the SPARC workshop on process-oriented CCM validation held in Grainau, Germany in November 2003 (Eyring et al., 2004, 2005) and draws upon the experiences within the SPARC GCM-Reality Inter-comparison Project (GRIPS) (Pawson et al., 2000; GRIPS report in this issue). As more climate models include chemical components, the time has arrived for formal comparisons of these coupled chemistry-climate models. Within SPARC, this new activity will be one of the supporting “pillars” of the integrated themes.

The goal of the new activity is to improve understanding of CCMs and their underlying GCMs (General Circulation Models) through process-oriented validation. One outcome of this effort is expected to be improvements in how well CCMs represent physical, chemical, and dynamical processes. In addition, this effort will focus on understanding the ability of CCMs to reproduce past trends and variability and providing predictions from ensembles of long model runs. Achieving these goals will involve comparing CCM constituent distributions with (robust) relationships between constituent variables as found in observations. This effort is both a model-model and model-data comparison exercise. At the Grainau workshop, a set of key diagnostics was defined for evaluating CCM performance with respect to radiation, dynamics, transport, and stratospheric chemistry and microphysics (http://www.pa.op.dlr.de/CCMVal/). This approach allows modelers to decide (based on their own priorities and resources) which diagnostics to examine in any particular area. The CCMVal activity will help coordinate and organize CCM model efforts around the world. In this way, the CCM community can provide the maximum amount of useful scientific information for WMO/UNEP and IPCC assessments.

As a first step, the CCM community has defined two reference simulations and a set of model forcings to support the upcoming WMO/UNEP Scientific Assessment of Ozone Depletion. The forcings are defined by natural and anthropogenic emissions based on existing scenarios, on atmospheric observations, and on the Kyoto and Montreal Protocols and Amendments. In the following sections, we describe current models and proposed model simulations, and discuss several special issues related to the use of CCMs.

2. Participating models

During the last few years, a number of new CCMs have been developed, which significantly deepens the pool of available models. In comparison with the models used in support of the last WMO/UNEP
ozone assessment (Austin et al., 2003; WMO, 2003), current CCMs generally have improved representations of physical processes, and modeling groups have greater computational resources. Table 1 gives an overview of current coupled-chemistry climate models around the world.

Table 1. Main features of current coupled chemistry-climate models (CCMs). CCMs are listed alphabetically. The horizontal resolution is given in either degrees latitude x longitude (grid point models), or as T21, T30, etc., which are the resolutions in spectral models corresponding to triangular truncation of the spectral domain with 21, 30, etc., wave numbers, respectively. All CCMs have a comprehensive range of chemical reactions except the UMUCAM model, which has parameterized ozone chemistry. The coupling between chemistry and dynamics is represented in all models, but to different degrees. All models include orographic gravity wave drag schemes (O-GWD); most models additionally include non-orographic gravity wave drag schemes (NonO-GWD).

<table>
<thead>
<tr>
<th>Model</th>
<th>Horizontal Resolution</th>
<th>No. Vertical Levels/ Upper Boundary</th>
<th>Group and location</th>
<th>Model Reference</th>
<th>Contacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMTRAC</td>
<td>2 °x 2.5°</td>
<td>48 / 0.0017 hPa</td>
<td>GFDL, USA</td>
<td>Anderson et al. (2004); Austin (2002)</td>
<td>J. Austin</td>
</tr>
<tr>
<td>CCSR/ NIES</td>
<td>T21</td>
<td>30 / 0.06 hPa</td>
<td>NIES, Tokyo, Japan</td>
<td>Nagashima et al. (2002); Takigawa et al. (1999)</td>
<td>H. Akiyoshi, T. Nagashima, M. Takahashi</td>
</tr>
<tr>
<td>CMAM</td>
<td>T32 or T47</td>
<td>65 / 0.0006 hPa</td>
<td>MSC, University of Toronto and York University, Canada</td>
<td>Beagley et al. (1997); de Grandpré et al. (2000)</td>
<td>T.G. Shepherd</td>
</tr>
<tr>
<td>E39/C</td>
<td>T30</td>
<td>39 / 10 hPa</td>
<td>DLR Oberpfaffenhofen, Germany</td>
<td>Dameris et al. (2005)</td>
<td>M. Dameris, V. Eyring, V. Grewe, M. Ponater</td>
</tr>
<tr>
<td>ECHAM5/MESSy</td>
<td>T42</td>
<td>90 / 0.01 hPa</td>
<td>MPI Mainz, MPI Hamburg, DLR Oberpfaffenhofen, Germany</td>
<td>Jöckel et al. (2004); Roeckner et al. (2003); Sander et al. (2004)</td>
<td>C. Brühl, M. Giorgetta, P. Jöckel, E. Manzini, B. Steil</td>
</tr>
<tr>
<td>FUB-CMAM-CHEM</td>
<td>T21</td>
<td>34 / 0.0068 hPa</td>
<td>FU Berlin, MPI Mainz, Germany</td>
<td>Langematz, et al. (2005)</td>
<td>U. Langematz</td>
</tr>
<tr>
<td>GCCM</td>
<td>T42</td>
<td>18 / 2.5 hPa</td>
<td>Univ. of Oslo, Norway; SUNY Albany, USA</td>
<td>Wong et al. (2004)</td>
<td>M. Gauss, I. Isaksen</td>
</tr>
<tr>
<td>GEOS CCM</td>
<td>2° x 2.5°</td>
<td>55 / 80km</td>
<td>NASA/GSFC, USA</td>
<td>In preparation</td>
<td>A. Douglass, P.A. Newman, S. Pawson, R. Stolarski</td>
</tr>
<tr>
<td>GISS</td>
<td>4° x 5°</td>
<td>23 / 0.002 hPa</td>
<td>NASA GISS, New York, USA</td>
<td>Schmidt et al. (2005a)</td>
<td>D. Rind, D. Shindell</td>
</tr>
<tr>
<td>HAMMONIA</td>
<td>T31</td>
<td>67 / 2 x 10⁻⁷ hPa</td>
<td>MPI Hamburg, Germany</td>
<td>Schmidt et al. (2005b)</td>
<td>G. Brasseur, M. Giorgetta, H. Schmidt,</td>
</tr>
<tr>
<td>LMDREPRO</td>
<td>2.5° x 3.75°</td>
<td>50 / 0.07 hPa</td>
<td>IPSL, France</td>
<td>In preparation</td>
<td>S. Bekki, D. Hauglustaine, L. Jourdain</td>
</tr>
</tbody>
</table>
### 3. Multi-model simulations to support the upcoming WMO/UNEP assessment

CCMs represent both natural dynamical variability and the dynamical response to forcings such as sea surface temperatures (SSTs). As a result, a meaningful comparison of different CCM results requires a proper analysis of statistical significance and a careful representation of natural and anthropogenic forcings. To address these issues, a set of questions on possible model simulations and forcings for the community to decide has been set up. The draft was opened for discussion within the CCM community (see Table 1) and with several other experts.

The proposed scenarios were developed to address the following key question outlined by the WMO/UNEP Steering Committee to be of significance to the upcoming assessment: (1) How well do we understand the observed changes in stratospheric ozone (polar and extra-polar) over the past few decades during which stratospheric climate and constituents (including halogens, nitrogen oxides, water, and methane) were changing? (2) What does our best understanding of the climate and halogens, as well as the changing stratospheric composition, portend for the future? (3) Given this understanding, what options do we have for influencing the future state of the stratospheric ozone layer?

In order to address questions (1) and (2), two reference simulations (REF) have been proposed.

### 3.1. REPRODUCE THE PAST: Reference simulation 1 (REF1), Core time period 1980 to 2004

REF 1 is designed to reproduce the well-observed period of the last 25 years during which ozone depletion is well recorded, and allows a more detailed investigation of the role of natural variability and other atmospheric changes important for ozone balance and trends. This transient simulation includes all anthropogenic and natural forcings based on changes in trace gases, solar variability, volcanic
eruptions, quasi-biennial oscillation (QBO), and sea surface temperatures (SSTs). SSTs in this run are based on observations. Depending on computer resources some model groups might be able to start earlier. We highly recommend reporting results for REF1 between 1960 and 2004 to examine model variability. Forcings for the simulation and a detailed description can be downloaded from the CCMVal website (http://www.pa.op.dlr.de/CCMVal/Forcings/CCMVal_Forcings.html). They are defined for the time period 1950 to 2004.

SSTs in REF1 are prescribed as monthly means following the global sea ice and sea surface temperature (HadISST1) data set provided by the UK Met Office Hadley Centre (Rayner et al., 2003). This data set is based on blended satellite and in situ observations.

Both chemical and direct radiative effects of enhanced stratospheric aerosol abundance from large volcanic eruptions are considered in REF1. The three major volcanic eruptions (Agung, 1963; El Chichon, 1982; Pinatubo, 1991) are taken into account, i.e., additional heating rates and sulfate aerosol densities are prescribed on the basis of model estimates and measurements, respectively. A climatology of sulfate surface area density (SAD) based on monthly zonal means derived from various satellite data sets between 1979 and 1999 has been provided by David Considine (NASA Langley Research Center, USA). Details on how to represent the sulfate SAD before 1979 are described on the CCMVal web site.

The QBO is generally described by zonal wind profiles measured at the equator. While the QBO is an internal mode of atmospheric variability and not a “forcing” in the usual sense, at the present time most models do not exhibit a QBO. This leads to an underestimation of ozone variability, and compromises the comparison with observations. While some of the models internally generate a QBO, for the others it has been agreed to assimilate observed tropical winds. Assimilation of the zonal wind in the QBO domain can add the QBO to the system, thus providing for example its effects on transport and chemistry. Radiosonde data from Canton Island (1953-1967), Gan/Maledives (1967-1975) and Singapore (1976-2000) have been used to develop a time series of measured monthly mean winds at the equator (Naujokat, 1986; Labitzke et al., 2002). This data set covers the lower stratosphere up to 10 hPa. Based on rocket wind measurements near 8 degree latitude, the QBO data set has been vertically extended to 3 hPa. The software package to assimilate the QBO by a linear relaxation method (also known as “nudging”) as well as the wind data sets have been provided by Marco Giorgetta (MPI Hamburg, Germany).

The influence of the 11-year solar cycle on photolysis rates is parameterized according to the intensity of the 10.7 cm radiation of the sun (which is a proxy to the phase of the given solar cycle). The spectral distribution of changes in the observed extra-terrestrial flux is based on investigations presented by Lean et al. (1997) (see http://www.drao.nrc.ca/icarus/www/sol_home.shtml for details).

3.2. MAKING PREDICTIONS: Reference simulation 2 (REF2), Core time period 1980 to 2025

REF 2 is an internally consistent simulation from the past into the future. The proposed transient simulation uses the IPCC SRES scenario A1B(medium) (IPCC, 2000). REF 2 only includes anthropogenic forcings; natural forcings such as solar variability are not considered, and the QBO is not externally forced (neither in the past, nor in the future). Sulfate surface area density is consistent with REF1 through 1999. Sulfate surface area densities beyond 1999 will be fixed at 1999 conditions (volcanically clean conditions). Changes in halogens will be prescribed following the Ab scenario (WMO, 2003; Table 4B-2). SSTs in this run are based on coupled atmosphere-ocean model-derived SSTs. Depending on computer resources some model groups might be able to run longer and/or start
earlier. We recommend reporting results for REF2 until 2050. The forcings on the website are defined through 2100.

Fully coupled atmosphere-ocean CCMs that extend to the middle atmosphere and include coupled chemistry, will use their internally calculated SSTs. CCMs driven by SSTs and sea ice distributions from the underlying IPCC coupled-ocean model simulation could use the model consistent SSTs. One constraint is to make the SST dataset consistent with the SRES greenhouse gas (GHG) scenario A1B(medium). All other CCM groups will run with the same SSTs, provided by a single IPCC coupled-ocean model simulation. These simulations have good spatial resolution, so the data-sets should be suitable for all the CCMs participating in the WMO/UNEP assessment.

3.3. Sensitivity simulations

Scenarios for sensitivity experiments to address question (3) will be defined later. Possible sensitivity experiments could be:

SCN 1 (REF 1 with enhanced Br$_2$): An additional simulation is being developed to represent the known lower stratospheric deficit in modeled inorganic bromine abundance. This simulation will be identical to REF 1, with the exception of including source gases abundances that will increase the stratospheric burden of Br$_2$. Details of this simulation will be made available shortly.

SCN 2 (REF 2 with natural forcings): A sensitivity simulation has been defined similar to REF1, with the inclusion of solar variability, volcanic activity, and the QBO in the past. Future forcings include a repeating solar cycle and QBO, under volcanically clean aerosol conditions. SSTs are based on REF2. Greenhouse gases and halogens will be the same as in REF2.

A summary of the proposed CCMVal reference and sensitivity simulations is given in Table 2.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Period</th>
<th>Trace Gases</th>
<th>Halogens</th>
<th>SSTs</th>
<th>Background &amp; Volcanic Aerosol</th>
<th>Solar Variability</th>
<th>QBO</th>
<th>Enhanced Br$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>REF1</td>
<td>1980-2004</td>
<td>OBS GHG used for WMO/UNEP 2002 runs. Extended until 2004</td>
<td>OBS used for WMO/UNEP 2002 runs.</td>
<td>OBS HadISST1</td>
<td>OBS Surface Area Density data (SAD)</td>
<td>OBS MAVER data set, observed flux</td>
<td>OBS or internally generated</td>
<td>-</td>
</tr>
<tr>
<td>REF2</td>
<td>1980-2025</td>
<td>OBS + A1B(medium)</td>
<td>OBS + Ab scenario from WMO/UNEP 2002</td>
<td>Modeled SSTs</td>
<td>OBS / SAD from 1999</td>
<td>-</td>
<td>Only internally generated</td>
<td>-</td>
</tr>
<tr>
<td>SCN1</td>
<td>1980-2004</td>
<td>OBS</td>
<td>OBS used for WMO/UNEP 2002 runs</td>
<td>OBS</td>
<td>OBS</td>
<td>OBS or internally generated</td>
<td>Included Based on Salawitch et al. (2005)</td>
<td>-</td>
</tr>
<tr>
<td>SCN2</td>
<td>1980-</td>
<td>OBS +</td>
<td>OBS + Ab</td>
<td>Modeled</td>
<td>OBS / SAD</td>
<td>OBS</td>
<td>OBS</td>
<td>-</td>
</tr>
</tbody>
</table>
A web site containing descriptions of the model simulations, as well as relevant forcings (past and present), can be found at http://www.pa.op.dlr.de/CCMVal/Forcings/CCMVal_Forcings.html. The forcings for the specified simulations can be downloaded from this website.

4. Discussion

In the effort to select the simulations in Table 2, several issues arose that required a special action or decision. A brief perspective on these issues is presented in this section.

4.1 Greenhouse Gases and Halogens

4.1.1 Historical and Future Trends

It has been agreed that the simulations to represent the past (REF1) should not stop in the year 2000, but should be extended until 2004. Between the years 2000 and 2004 new measurements of trace gases from the SCIAMACHY, MIPAS, AURA, ACE and ODIN satellite instruments became available. In addition, new data from existing satellite instruments, such as TOMS, GOME, and HALOE, are also available for CCM inter-comparisons. In response, Stephen Montzka (NOAA Climate Monitoring and Diagnostics Laboratory, USA) has offered to update the datasets of halogen and other greenhouse gas observations to 2004. Datasets of sea surface temperatures up to 2004 are available on the Hadley Centre’s web site (see http://www.hadobs.org/).

For the prediction simulation (REF 2) the community agreed to run with the GHG scenario SRES A1B(medium) with the halogen scenario Ab from WMO (2003). However, Paul Fraser (CSIRO, Australia) mentioned that the SRES reference scenario A1B is very unlikely to be realistic for CH₄ over the next 20 years. A1B requires CH₄ to increase from 1760 ppb in 2000 to 2026 ppb in 2020, i.e., with a growth rate of 13-14 ppb per year. This growth rate has not been observed since the late 1970s. In contrast, the growth rate in the Southern and Northern Hemispheres for the past five years has been less than 1 ppb per year, with the current globally averaged concentration at 1750 ppb (2004).

In the proposed simulation REF2, the CCMs are driven by SSTs and sea ice distributions from coupled ocean-atmosphere model simulations using IPCC SRES GHG scenarios. To be consistent with the IPCC simulations, the GHG scenarios must be the same as in the coupled ocean-atmosphere model simulations. Therefore, it has been decided that CH₄ emissions during this phase of the assessment process will not be changed from the IPCC SRES GHG scenarios for REF2.

4.1.2 Inorganic Bromine Deficit

Model representations of inorganic bromine radicals in the lower stratosphere and comparisons with observations have recently been documented (see WMO, 2003, chapters 1 and 2; Salawitch et al., 2005 and references within). Results from these comparisons strongly suggest that models greatly underestimate the total inorganic bromine (Brᵥ) in this region (up to 6 pptv). Furthermore, it is clear that using time-dependent boundary conditions as prescribed in the Ab scenario (WMO 2003) will not correct the modeled Brᵥ distribution. It is believed that this discrepancy occurs because very short-
lived (VSL) bromine-containing source gases are not included in the models. Incorporating these species into CCMs will require understanding of the magnitude and geographic distribution of the sources of these VSL gases and their loss processes in the atmosphere. Based on input from Ross Salawitch (Jet Propulsion Laboratory, USA), Martyn Chipperfield (University of Leeds, UK), and Stephen Montzka, and considering the time constraints of including VSL species and related processes into CCMs, it was decided that no attempt should be made to address the Br\(_y\) deficit in the reference simulations (REF1 and REF2). This means that the reference CCM experiments will necessarily underestimate stratospheric Br\(_y\) by about 25%. This will impact their ability to reproduce e.g. polar ozone loss quantitatively and predict the future ozone changes; this caveat needs to be remembered when analyzing the results. However, a sensitivity simulation is being developed to examine this issue (SCN1). Quantification of the effect of enhanced Br\(_y\) on ozone trends for the WMO/UNEP 2006 ozone assessment will most likely done with 2D and 3D chemical-transport models.

### 4.2 QBO and Solar Variability

Solar activity as well as the QBO have a strong influence on ozone variability. Some CCMs with high horizontal and vertical resolutions are able to internally generate a QBO. However, the majority of CCMs do not generate a QBO. Consequently these models simulate permanent tropical easterlies instead of a QBO. As the QBO is important for wave propagation and interaction with high latitudes, the latter CCMs therefore have a known deficit which would affect both the means and variabilities of trace gas distributions. Therefore, part of the community felt that QBO and solar variability should also be included in future years in the reference simulations to the year 2025 and, therefore, suggested using SCN2 as the reference simulation instead of REF2.

However, others have reservations about including a QBO and solar cycle in the future, since these are not anthropogenic forcings and, hence, cannot be predicted. In the case of the QBO, which is an internal mode of atmospheric variability and not a “forcing” at all, the amplitude and phase of the QBO will have no connection to the prognostic model variables or the SSTs and, of course, will not respond to climate changes.

The obvious way to address the opposing views is to encourage groups to run both simulations, REF2 and SCN2. However, due to limited time and computer resources it is not very likely that all, or even most, groups can afford to run both the REF2 and SCN2 simulations. Therefore, a decision was made to make REF1 and REF2 the highest priority and encourage groups to run SCN2 in addition if resources allow.

### 4.3 Sea Surface Temperatures

One of the most critical issues in the discussion was the design of the future simulation REF2. The problem is how to extend SST observations into the future without introducing a discontinuity at the present-to-future transition.

One possibility would be to add time-evolving anomalies to the observed SSTs that are specified for REF1. However, the community sees at least two problems with this approach. First, the patterns and temporal variability are changed, depending on the shortcomings of the coupled system. Second, the ice distribution in the SST observational dataset is not the same as in the model. This is especially problematic in regions where the ice cover disagrees significantly between model and observations.
We can avoid these problems if the one-simulation-for-all design is abandoned in favor of a design including two separate simulations. The first would be for the observed period (REF1), for which we can assess the degree to which observed stratospheric dynamics and chemistry are reproduced. The second would be an internally consistent simulation from the past to the future (REF2). With this approach, fully coupled atmosphere-ocean CCMs with the atmosphere extending to the middle atmosphere and with coupled chemistry, will use their internally calculated SSTs in REF2, whereas all other CCMs will use modeled SSTs from a coupled atmosphere-ocean simulation for the full time period (1980 to 2025 or longer). One constraint is to make the external SST dataset consistent with the GHG scenario A1B.

There has also been a debate on whether or not the model simulations should use the same set of SSTs for future years in REF2. Obviously, if different SSTs are used, the forced low frequency variability could be quite different between the simulations. One of the biggest uncertainties is the predictability of the decadal timescale and the separation of internal from externally forced variability in the models. However, the focus of the future simulation is not a model-model inter-comparison. Rather we would like to provide the best available prediction of the future. REF2 is a simulation that focuses on consistency and that follows the IPCC simulations. Essentially we are asking that modeling groups make their best prediction. Therefore, it is not necessary to have consistent SSTs. In fact, by applying different SSTs the change in climate and its variability are effectively included in the simulation. (To use a common set of SSTs would certainly underestimate the uncertainty in future climate predictions, and any error in these SST predictions would lead to a bias in the model predictions.)

Finally, an agreement was reached that at least a subset of groups will run with the same SST forcings, whereas others will use internally calculated SSTs or model-consistent SSTs. This will allow us to address both views.

5. Summary and Outlook

CCM Modeling groups are encouraged to run the proposed reference simulations with the same forcings. In order to facilitate the set-up of the reference simulations, CCMVal has established a website where the forcings for the simulations can be downloaded (http://www.pa.op.dlr.de/CCMVal/Forcings/CCMVal_Forcings.html). This web site was developed to serve the needs of the CCM community, and encourage consistency of anthropogenic and natural forcings in future model/model and model/observation inter-comparisons. Any updates as well as detailed explanation and further discussion will be placed on this website.

We encourage the groups to run both simulations, REF1 and REF2. If a model only provides REF2 it will be more difficult to assess the model’s ability to simulate realistic trends and variability. Changes on the decadal timescale are not necessarily part of the secular trend. It is quite probable that some of the changes are due to low frequency variability that is likely to be unpredictable if the source is internal. It is then possible that some of the differences between the deterministic model predictions will be attributed to unpredictability and not to differences in the fundamental forcings and responses of the models. For these reasons, we encourage groups to run ensembles. Depending on computer resources, a sub-set of groups might also be able to carry out sensitivity simulations. Especially if the prediction simulation only covers the short-term prediction (e.g. until 2025), it would be very useful to see how the prediction changes if a solar cycle and the QBO are included. If you are interested in this topic, please run the sensitivity simulation SCN2.
In agreement with the experts in this field, it has been decided that the enhanced stratospheric bromine scenario should not be included in the reference simulation (REF1 and REF2). Enhancing the inorganic bromine reservoir increases BrO, a reaction partner for anthropogenically derived ClO, above that found in the standard simulation in the first few km of the stratosphere. The sensitivity of ozone to enhanced bromine in the lowermost stratosphere will likely depend on details of the model simulation of ClO just above the tropopause. Due to the inherent three dimensional nature of accurately simulating ClO and BrO near the tropopause, it is hoped that one or more of the CCMs will carry out simulation SCN1. It is also expected that 2D and 3D chemical transport model (CTM) simulations will be relied upon to further assess the sensitivity of ozone trends to bromine in the lowermost stratosphere for the next UNEP/WMO ozone assessment.

CCMVal will provide a list of model recommendations that will be placed on the website. We encourage groups to check the CCMVal forcing website for recommendations concerning the model set-up and the variables that should be stored in order to allow sophisticated inter-comparisons of chemistry, transport, dynamics and radiation within the CCM.

A detailed inter-comparison of CCM results and observations has successfully started. Model results from 10 European model groups that are participating in the European Integrated Project SCOUT-O3 and one model group from outside Europe (CCSR/NIES) have been obtained. The first phase of the inter-comparison will be based on existing runs. With the exception of total column ozone, only transient model simulations for the time period 1980 to 1999 will be compared (no time slice experiments). We would like to encourage other model groups to join in the inter-comparison and to send data from existing runs. As soon as the results of the CCMVal simulations with equal forcings become available the inter-comparisons and analyses will be repeated. It will be interesting to see how the results and interpretation change when runs with equal forcings are compared. CCMVal is still looking for volunteers from around the world to assist with the inter-comparison. If you are interested in a certain diagnostic or scientific topics, please contact us.

A second CCMVal workshop will be held from October 17 to 19, 2005 at the National Center for Atmospheric Research in Boulder, Colorado (http://www.pa.op.dlr.de/workshops/CCMVal2005/). The 2005 Chemistry-Climate Modeling Workshop will focus on progress in chemistry-climate modeling and process-oriented validation of CCMs. The aims of the workshop are to identify near-term and long-term goals within the validation architecture and to coordinate activities among the participating modeling groups. In addition we will discuss how CCM results can support the WMO/UNEP Scientific Assessment of Ozone Depletion 2006 and other upcoming assessment reports. We encourage the participation of global modelers as well as scientists who make atmospheric observations that are relevant for model evaluation.

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