CCMVal 2007 Workshop

University of Leeds, UK; June 26-28, 2007

Workshop website: **http://www.see.leeds.ac.uk/ccmval2007**

Agenda and Abstracts

Background and scope:

The 2007 Chemistry-Climate Modeling workshop will focus on process-oriented validation and comparison of coupled chemistry-climate models (CCMs) and progress in Chemistry Climate Modeling in the stratosphere. This workshop is part of a SPARC activity for CCM Validation (CCMVal) (http://www.pa.op.dlr.de/CCMVal/). Further details on the CCMVal project, including a summary of the 2003 and 2005 meetings are available on the web site. This activity is aimed at bringing together the expertise of the measurement and process-studies communities to bear on improving our confidence in future predictions of CCMs. We have encouraged the participation of global modellers as well as observationalists.

Workshop goals:

The goals of the workshop are to: (i) discuss new measurements and methods for evaluating CCMs, (ii) discuss progress in the evaluation of current CCMs, (iii) coordinate the planned SPARC Report on evaluation of CCMs, and (iv) discuss and suggest a strategy for CCM simulations for the next round of WMO Ozone and IPCC Climate Assessments.

The workshop is being held under the auspices of the CCM Validation Activity for WCRP's (World Climate Research Programme) SPARC (Stratospheric Processes and their Role in Climate) activity and the School of Earth and Environment at the University of Leeds.

Agenda

The talks will take place in the School of Chemistry Lecture Theatre A at the University of Leeds.

Monday, 25 June 2007

17:00 onwards	***Registration, and poster set-up***
18:00 – 20:00	***Icebreaker***

Tuesday, 26 June 2007

08:00 - 09:00	***Registration and poster set-up***	
Introduction		
Chair:	**David Fahey**	
09:00 - 09:10	**Welcome and Logistics**	**Dwayne Heard, M. Chipperfield & P. Forster**
09:10 - 09:20	**The Role of CCMVal within SPARC &WCRP**	**Ted Shepherd**
09:20 - 09:35	**CCMVal Status and Workshop Goals**	**Veronika Eyring**
Introduction to Breakout Groups		
09:35 – 09:50	**Group I: New CCMVal Reference Simulations**	**Paul Newman**
09:50 - 10:05	**Group II: CCMVal Tools and Data**	**Andrew Gettelman**
10:05 - 10:20	**Group III: Standard for CCMVal Performance**	**Steven Pawson**
10:20 - 10:35	**Group IV: CCMVal SPARC Report**	**Darryn Waugh**
10:35 - 11:00	*Coffee*	
11:00 - 11:20	**Outstanding Science Questions WMO 2006**	**Bill Randel**
State and future of CCMs		
Chair:	**Ted Shepherd**	
Rapporteur:	**Hideharu Akiyoshi**	

What sort of model configuration the CCM groups plan to use for the next round of assessments, e.g. coupled to ocean, with tropospheric chemistry, changes in model configuration compared to WMO 2006, what time period, how much capacity for different scenarios, etc. ?

Groups will be asked to send in 2-3 slides in advance, to be assembled into a single presentation along with a set of questions. Preferably and if they have a representative there, then someone from the group should stand up and present that group's slides.

11:20 - 12:45 **State and future of CCMs** (approx. 15 CCM groups)

12:45 - 14:00 *Lunch*

Research in Coupled Chemistry Climate Modeling (Transport & UTLS)

Chair: **Ulrike Langematz**
Rapporteur: **Andrew Gettelman**

14:00 – 14:15	**Persistence and photochemical decay of springtime total ozone anomalies in CCMs (B1)**	**Susann Tegtmeier**
14:15 – 14:30	**Relationships among age-of-air, chlorofluorcarbon loss and mixing ratio boundary conditions in assessment simulations (B3)**	**Anne Douglass**
14:30 – 14:45	**O3-N2O correlations: Revisiting a diagnostic of transport and chemistry in the stratosphere (B2)**	**Michaela Hegglin**
14:45 – 15:00	**A new method to deduce stratospheric transport times from observations and models (B5)**	**Peter Hoor**
15:00 – 15:15	**Diagnostics for seasonally varying and seasonally invariant transport in the lowermost stratosphere (C8)**	**Susan Strahan**
15:15 – 15:30	**Tropical Tropopause Layer Structure in CCMs (C10)**	**Andrew Gettelman**
15:30 – 15:45	**An approach to validate the transport of water vapour through the tropical tropopause in CCMs (C11)**	**Stefanie Kremser**
15:45 – 16:00	**Variability and trends in global tropopause Parameters (C13)**	**Thomas Birner**

16:00 - 16:20 *Tea*

16:20 – 18:20 **Poster session**

18:20 – 19:00 **Side Meeting with Lead Authors of the SPARC CCMVal Report**

Wednesday, 27 June 2007

Breakout Sessions I-III in parallel

Chairs & Rapporteurs:

Group I: New CCMVal Reference Simulations	**Paul Newman & Martyn Chipperfield**
Group II: CCMVal Tools and Data	**Andrew Gettelman & Neal Butchart**
Group III: Standard for CCMVal Performance	**Steven Pawson & David Fahey**

09:00 - 10:30 **Breakout Groups I-III**

09:00 - 09.15 **Talk in Breakout Group II:** **Martin Juckes**
The role of BADC in CCMVal: possibilities and limitations (I1)

10:30 - 11:00 *Coffee*

11:00 - 12:00 **Plenary Discussion on Breakout Groups I-III**

12:00 - 13:15 *Lunch*

Research in Coupled Chemistry Climate Modeling (Stratospheric Chemistry & Long-term Changes)

13:15 - 14:30 **Poster session**

Chair: **Markus Rex**
Rapporteur: **Martyn Chipperfield**

14:30 – 14:45 **Simple measures of ozone depletion in the polar stratosphere (E1)** **Rolf Müller**

14:45 – 15:00 **The impact of mixing across the polar vortex edge on ozone loss estimates: Implication for the validation of CCMs (E8)** **Jens-Uwe Grooss**

15:00 – 15:15 **Evaluation of Chemical Polar Ozone Loss in the Lower Stratosphere within CCM Models (E9)** **Simone Tilmes**

15:15 – 15:30 **Inorganic Chlorine and Ozone Recovery in CCMs (G2)** **Darryn Waugh**

15:30 - 16:00 *Tea*

16:00 – 16:15 **Quantifying key sensitivities within CCMs as a means of CCM validation (G7)** **Greg Bodeker**

16:15 – 16:30	**Diagnostic tests of polar ozone recovery**	**(G10)**	**Paul Newman**
16:30 – 16:45	**Volcano-induced Climate Impacts and ENSO Interaction**	**(H1)**	**Georgiy Stenchikov**

Breakout Session IV

Chairs & Rapporteurs Breakout Group IV: Veronika Eyring, Ted Shepherd & Darryn Waugh

16:45 – 18:30 **Breakout Session IV: CCMVal SPARC Report (0.5 hours in plenary, to discuss the overall structure and timetable, followed by 1.0 hour in chapter groups)**

Thursday, 28 June 2007

Research in Coupled Chemistry Climate Modeling (Dynamics & Natural Variability)

Chair: John Scinocca
Rapporteur: Hideharu Akiyoshi

09:00 – 09:15	**Evaluation of the response of the stratosphere to ENSO events in CCMs**	**(A2)**	**Chiara Cagnazzo**
09:15 – 09:30	**Winter Climate Response to ENSO in three chemical-climate models**	**(F3)**	**Andreas Fischer**
09:30 – 09:45	**The Role of the QBO in Simulating the Solar Signal in the Atmosphere**	**(F2)**	**Katja Matthes**
09:45 – 10:00	**Coupled chemistry climate model simulations of the solar cycle in ozone and temperature**	**(F1)**	**John Austin**
10:00 – 10:15	**The CMAM transient simulations for CCMVal: Analysis of long-term changes in ozone**	**(G11)**	**David Plummer**

10:15 - 10:45 *Coffee*

Breakout Sessions IV (Continued)

Chairs & Rapporteurs Breakout Group IV: Veronika Eyring, Ted Shepherd & Darryn Waugh

10:45 – 12:45	**Breakout Session IV: CCMVal SPARC Report (1 hour in chapter groups, followed by ¾ hour in plenary)**	
12:45 - 14:00	*Lunch*	

Research in Coupled Chemistry Climate Modeling (Continued)

Chair:	**Doug Kinnison**	
Rapporteur:	**Markus Rex**	
14:00 – 14:15	**Sulfur injections into the stratosphere to alter the atmospheric chemical and dynamical state (E3)**	**Thomas Peter**
14:15 – 14:30	**The Potential Impact of Aerosols in the Upper Troposphere on Ice Clouds (C3)**	**Joyce Penner**
14:30 – 14:45	**A long-term climatology of transport processes in the TTL during NH winter (C2)**	**Kirstin Krueger**
14:45 – 15:00	**Ozone Radiative Feedback on the Quasi-Biennial Oscillation (A5)**	**Kiyotaka Shibata**
15:00 – 15:15	**The SPARC Dynamics and Variability Project and Connections to CCMVal (A9)**	**Paul Kushner**
15:15 - 15:45	*Tea*	

Final Session

Chairs:	**Chairs of Breakout Groups I-IV**
Rapporteurs:	**CCMVal Steering Committee**
15:45 - 17:00	**Refinement and approval in plenary for Breakout Groups I to IV**
Chairs:	**Veronika Eyring & Neil Harris**
Rapporteurs:	**CCMVal Steering Committee**
17:00 - 18:00	**Final Plenary Discussion**
19:30	*Conference banquet in Weetwood Hall* http://www.weetwood.co.uk/weetwood.html

Friday, 29 June 2007

09:00 - 12:30 **CCMVal Steering Committee Meeting**

Proposed Breakout Groups:

Breakout Group I: New CCMVal Reference and Sensitivity Simulations in Support of Upcoming Ozone and Climate Assessments

- Needs of assessments, timeframe
- Possible scenarios
- Forcing data sets

Breakout Group II: CCMVal Diagnostic Tools, Data Archiving and Data Formats

- Formats for next set of runs
- Development of a standard CCMVal diagnostic package from tables: who will use it, who will help develop it?

Breakout Group III: Define a Strategy for Developing Standards for CCMVal Performance

- Consider defining a threshold level of performance or weighting for those models that are used to make the next assessment predictions.

Breakout Group IV: SPARC CCMVal Report on CCM Evaluation

- Purpose and structure of the report, time schedule, main science questions etc.

Discuss specific diagnostics, validation and analysis activities in each chapter

List of Posters

1. A1 (Erbertseder)
2. A3 (George)
3. A4 (Butchart)
4. A6 (Hegglin)
5. A7 (Charlton)
6. B4 (Bruehl)
7. C1 (Kunze)
8. C4 (Khosrawi)
9. C5 (Teyssedre)
10. C6 (Saint-Martin)
11. C7 (Pitari)
12. C9 (Tilmes)
13. C12 (Olivie)
14. C14 (Son)
15. D1 (Forster)
16. D2 (Forster)
17. D3 (Tourpali)
18. E2 (Stenke)
19. E5 (Ruhnke)
20. E6 (Liang)
21. E7 (Rex)
22. E10 (Tian)
23. F4 (Akiyoshi)
24. F5 (Mieruch)
25. G1 (Eyring)
26. G3 (Austin)
27. G4 (Oman)
28. G5 (Jonsson)
29. G6 (Rozanov)
30. G8 (Cordero)
31. G9 (Jegou)
32. G12 (Akiyoshi)
33. G13 (Stolarski)
34. G14 (Kenzelmann)
35. G15 (Nielsen)
36. H2 (Krueger)
37. H3 (Damoah)
38. H4 (Tian)

Abstracts

66 abstracts divided into 9 Categories:

A. Dynamics	(9 abstracts)
B. Stratospheric Transport	(5 abstracts)
C. Upper Troposphere / Lower Stratosphere	(14 abstracts)
D. Radiation	(3 abstracts)
E. Stratospheric Chemistry and Microphysics	(10 abstracts)
F. Natural Variability	(5 abstracts)
G Long Term Changes in the Stratosphere	(15 abstracts)
H Effect of Stratosphere on Troposphere	(4 abstracts)
I Database	(1 abstract)

A. Dynamics

Abstract A1 (Poster)

Hemispheric ozone variability indices derived from satellite observations and comparison to CCMs

Thilo Erbertseder, Veronika Eyring, Michael Bittner, Martin Dameris, and CCMVal team

Total column ozone is used to trace the dynamics of the lower and middle stratosphere which is governed by planetary waves. In order to analyse the planetary wave activity a Harmonic Analysis is applied to global multi-year total ozone observations from the Total Ozone Monitoring Spectrometer (TOMS).

As diagnostic variables we introduce the hemispheric ozone variability indices one and two. They are defined as the hemispheric means of the amplitudes of the zonal waves number one and two, respectively, as traced by the total ozone field.

The application of these indices as a simple diagnostic for the evaluation of coupled chemistry-climate models (CCMs) is demonstrated by comparing results of the CCM ECHAM4.L39DLR/CHEM (hereafter: E39/C) against satellite observations. It is quantified to what extent a multiyear model simulation of E39/C representing 2000 climate conditions is able to reproduce the zonal and hemispheric planetary wave activity derived from TOMS data.

We are planning to apply this analysis to multi-year total ozone data from transient CCM simulations. It will be quantified to what extent the CCMs are able to reproduce the zonal and hemispheric planetary wave activity.

Abstract A2 (Oral)

Evaluation of the response of the stratosphere to ENSO events in CCMs

Chiara Cagnazzo, E. Manzini, H. Akiyoshi, J. Austin, S. Bekki, C. Bruhl, N. Butchart, M. Chipperfield, M. Dameris, M. Deushi, A. Douglass, V. Eyring, F. Jegou, R. Garcia, A. Gettelman, M.A. Giorgetta, V. Grewe, D. Hauglustaine, D. Kinnison, E. Mancini, D. Marsh, T. Nagashima, P. Newman, S. Pawson, G. Pitari, D. Plummer, E. Rozanov, M. Schraner, J. Scinocca, K. Shibata, R. Stolarski, H. Struthers, M. Takahashi and W. Tian

The effect of ENSO events on the northern winter polar stratospheric circulation is addressed through the analysis of simulations with observed SSTs recently performed with 13 Chemistry Climate Models. Composites of temperature, zonal winds, geopotential height and total ozone fields from time series of an ENSO index for cold, neutral and warm SST conditions have been constructed.

Given that the internal variability is high and the external forcing included in the simulations, results from investigations indicate that the stratospheric polar warming possibly associated with ENSO is quite different across the models in terms of altitude, month and amplitude of occurrence. In order to identify the coherence in the responses across the models and to understand the causes of the range of stratospheric responses in terms of simulation designs and model biases, the response of the model to ENSO in the tropical and extratropical troposphere is also analysed.

Abstract A3 (Poster)

Modelling the effects of a realistic QBO on Antarctic ozone variability

Steve George and Adrian McDonald

The size and intensity of the Antarctic ozone hole is known to be influenced by a number of natural and anthropogenic factors. This is due to the heterogeneous chemistry of ozone destruction being extremely sensitive to changes in stratospheric temperature within the polar vortex. Defining temperature anomaly mechanisms is crucial if one wishes to understand the austral springtime formation, and interannual variability, of the ozone hole.

Recent work using a chemistry-climate model (SOCOL) has investigated chemical and dynamical variations associated with both the solar cycle and the solar rotation period. It is hypothesised that the model simulation of Antarctic ozone would be significantly improved by the inclusion of an important mode of atmospheric variability known as the Quasi-Biennial Oscillation (QBO).

The QBO dominates the variability of the equatorial stratosphere and is characterised by downward propagating easterly and westerly wind regimes, with a variable period averaging 28 months. Although essentially equatorial in nature, several studies have shown evidence of a relationship between QBO phase and Antarctic ozone loss. The mechanism is as yet not completely understood, but a likely candidate is that induced changes in zonal winds and potential vorticity increases the effectiveness of wave energy propagation to high latitudes in the easterly phase while reducing it in the westerly phase. In turn, temperatures in the Southern Hemisphere stratosphere are respectively increased/reduced with associated impacts on the nonlinear heterogeneous ozone chemistry.

Present-generation model resolution limits the explicit representation of small-scale wave sources that help drive the QBO e.g. deep convection, boundary-layer turbulence. Instead, this non-orographic gravity wave drag (NOGWD) can be parameterised by defining an energy launch spectrum in the troposphere or lower stratosphere. This presentation discusses a new SOCOL NOGWD scheme of a type initially described by Warner and McIntyre which has since been used successfully in the Canadian Middle Atmosphere Model. Comparison will be made with the original, non-QBO resolving, SOCOL model.

Abstract A4 (Poster)

Stratospheric Climate and Circulation Changes

Neal Butchart, Veronika Eyring, Darryn Waugh, Eugene Cordero and CCMVal Team

The CCM simulations are used to study stratospheric climate and circulation changes. In contrast to previous comparisons of stratospheric climate predictions, the CCM simulations used here are all transient simulations and have almost identical experimental set-up and forcings. The analyses updates or extends the few other published intercomparisons of stratospheric predictions, including the heat flux - temperature relationship as assessed in Austin et al. (2003), temperature changes discussed in Eyring et al. (2006) and the changes in tropical upwelling considered by Butchart et al. (2006). We present those aspects of stratospheric climate and circulation change which are robust, i.e. model independent. A more detailed analysis of temperature changes than in Eyring et al. (2006) considers the seasonal and spatial distribution of the trends and separate secular trends from low frequency variability. The relative importance of the diabatic and adiabatic contributions to the temperature changes is assessed. A key question that is addressed is how the Arctic polar vortex changes in the REF2/SCN2 simulations. Other key questions are: what are the predicted changes in the Brewer-Dobson circulation and to what extent are these changes related to age of air changes in the different models. Also how do changes in tropical upwelling relate to changes in polar downwelling.

Abstract A5 (Oral)

Ozone Radiative Feedback on the Quasi-Biennial Oscillation

Kiyotaka Shibata and Makoto Deushi

Simulations of the recent past stratosphere and mesosphere were made with a chemistry-climate model (CCM) of Meteorological Research Institute (MRI). Three runs with different transport schemes for chemical species were performed for 25 years from 1980 to 2004. The three transport schemes are formally hybrid semi-Lagrangian type, which is of flux form in the vertical and, at once, of ordinary type in the horizontal, while they use different interpolation and/or approximation in calculating in-cell profiles from cell-average values, resulting in different properties in diffusiveness. The prototype scheme Cubic3 uses a Lagrangian cubic interpolation of neighbouring abundances in the horizontal and also uses it for overhead column abundances in the vertical. To the Cubic3 scheme, two improvements are successively incorporated: one is the piecewise rational-function method (PRM) in the vertical, and the other is a quintic Lagrangian interpolation in the horizontal, resulting in PRM3 vertically PRM and horizontally cubic and PRM5 vertically PRM and horizontally quintic schemes.

The dynamics module of MRI-CCM is a spectral global model of T42 truncation with 68 layers extending from the surface to 0.01 hPa (about 80 km), wherein the vertical spacing is 500m in the stratosphere between 100 hPa and 10 hPa. Hines gravity wave (GW) drag is incorporated with an enhanced GW source in the tropics to spontaneously reproduce the QBO in zonal wind. The chemistry-transport module treats 36 long-lived species including 7 families, and 15 short-lived species with 80 gas phase reactions, 35 photochemical reactions and 9 heterogeneous reactions.

MRI-CCM is integrated with observed forcings of SSTs, sea ice, volcanic aerosols, 11-year solar cycle, greenhouse gases, and halogens, the latter two of which are specified at the surface. It is found that PRM3 and PRM5 schemes substantially reduce the systematic positive bias in ozone, particularly in the tropical lower stratosphere and upper troposphere and that PRM5 reproduces most realistic ozone and other chemical species distributions with PRM3 being the next. For example, the ozone decrease amounts to about 40 at 100hPa in PRM5 run. Along with these ozone reductions, the QBO period is also changed: it is about 27 months in Cubic3 run, while it is about 23 and 20 months for PRM3 and PRM5 runs. This shortening of the QBO period with the decrease in ozone abundance is compatible with authors previous simulations, in which switching on/off of ozone radiative feedback prolongs/shortens the QBO period by about 80 35 . In a less ozone background condition in the lower stratosphere the ozone QBO amplitude also becomes smaller, so that the ozone radiative feedback weakens, leading to a shorter QBO period.

Abstract A6 (Poster)

Validation of the global extratropical UTLS region in CCMs using ACE satellite data

Michaela I. Hegglin, G. Manney, T.G. Shepherd, K.A. Walker, P. Bernath, C. Boone, P. Hoor, and C. Schiller

The upper troposphere/lower stratosphere (UTLS) plays a key role in chemistry-climate coupling due to the strong radiative impact of trace gases such as O_3 and H_2O in this region. Within the ongoing CCMVal activities, a particular effort is hence directed towards the validation of the chemical and dynamical processes determining tracer distributions in the UTLS in CCMs. While many diagnostics have already been proposed, most existing knowledge of the spatio-temporal structure of chemical composition in the UTLS, and its relation to dynamical features such as the tropopause, stems from aircraft and balloon platforms. On the other hand, these measurements are necessarily restricted in space and time. Satellite measurements from the Canadian Atmospheric Chemistry Experiment (ACE) offer unprecedented accuracy and vertical resolution, allowing a new global perspective on trace gas distributions in the UTLS and hence providing a potentially useful data set for the CCMVal community. We examine tracer-tracer correlations and vertical profiles of O_3, CO, and H_2O relative to the local tropopause height and show by comparison with previous aircraft measurements in the Northern Hemisphere the high potential of the ACE measurements in resolving the vertical structure of UTLS tracer distributions. We then compare the results to the Canadian Middle Atmosphere Model (CMAM) and have a first glance at the tracer evolution in a changing climate.

Abstract A7 (Poster)

Changes to Sudden Stratospheric Warmings in Future Climates

Andrew Charlton, Lorenzo Polvani, John Austin and Feng Li

The dynamical coupling between the Stratosphere and Troposphere are strongest during extreme events in the Stratosphere known as Stratospheric Sudden Warmings (SSWs). Our recent work has focussed on establishing a new climatology of these events and developing, dynamically realistic benchmarks for their simulation in GCMs. Here we use these new tools together with a state-of-the-art coupled chemistry climate model to investigate if either the frequency or character of SSWs is predicted to change over the coming century. Our motivation is simple, to understand what role the stratosphere might play in future tropospheric climate we must first understand and quantify the future stratospheric climate. We investigate two sets of three ensemble member integrations, the first forced with observed SSTs and climate forcings between 1960 and 2000 and the second forced with SSTs from a coupled model run forced with trace gas concentrations based on the SRES A1B scenario of the IPCC and equivalent climate forcings. As far as we are aware this is the longest set of integrations used for a study of this kind. We find an upward trend in SSW frequency of 1 SSW per decade which is statistically significant at the 90% confidence level and is consistent over the two sets of model integrations. Comparison of SSW climatology between the late 20th and 21st centuries in our model shows that the increase is largest toward the end of the winter season. Comparison of the dynamical properties of SSWs in the 20th and 21st centuries shows that the character of SSWs is not altered by the increase in SSW frequency. This result has important consequences for prediction of the impact of future stratospheric climate on the troposphere and also on future concentrations of Ozone in the Northern Hemisphere stratosphere.

Abstract A8 (Withdrawn)

TropChem and CCMval

Jean-Francois Lamarque and Mark Lawrence

I will discuss the role of TropChem, a new IGAC/SPARC activity that focuses on tropospheric chemistry, and its interaction with existing programs such as CCMVal and AEROCOM. In particular, I will describe what TropChem can bring to the CCMVal community in terms of defining model simulations, creating new analysis tools and organizing new science questions.

Abstract A9 (Oral)

The SPARC Dynamics and Variability Project and Connections to CCMVal

Paul Kushner et al

Several lines of evidence suggest that the stratospheric state exerts a significant influence on the tropospheric circulation. As global climate models, which typically represent the stratosphere poorly, become increasingly comprehensive, important questions arise: How does a poor representation of the stratosphere degrade the simulation of tropospheric circulation in climate models? Furthermore, how does stratospheric representation affect the simulated circulation response to climate change? To address these questions the WCRP SPARC group recently initiated the SPARC Dynamics and Variability Project, which will set up a model intercomparison to explore the dynamical coupling between the stratosphere and the troposphere. The project aims to compare in detail the climate, climate variability, and climate-change response of standard "low-top" climate models and stratosphere-resolving "hi-top" climate models. The means to effectively coordinate this project with the ongoing SPARC CCMVal and CLIVAR C20C projects will be discussed.

B. Stratospheric Transport

Abstract B1 (Oral)

Persistence and photochemical decay of springtime total ozone anomalies in CCMs

Susan Tegtmeier and Theodore Shepherd

The persistence and decay of springtime total ozone anomalies over the entire extratropical midlatitudes plus polar regions is analysed using results from the Canadian Middle Atmosphere Model (CMAM). As in the observations, interannual anomalies established through winter and spring persist with very high correlation coefficients above 0.8 through summer until early autumn, while decaying in amplitude as a result of photochemical relaxation in the quiescent summertime stratosphere. We will show that ozone anomaly persistence and decay does not depend on how the springtime anomalies are created or on their magnitude, but reflects the transport and photochemical decay in CMAM. The extent to which ozone anomaly persistence and decay explains the seasonality of ozone trends in CMAM simulations, in both hemispheres, is assessed.

Following the same approach total ozone timeseries from further CCMs will be used to analyse the persistence and decay of springtime total ozone anomalies. The model results will be compared to the observations to assess the summertime transport and photochemical decay in the models, and the extent to which the summertime long-term ozone trends reflect the winter/spring trends.

Abstract B2 (Oral)

O_3-N_2O correlations: Revisiting a diagnostic of transport and chemistry in the stratosphere

Michaela I. Hegglin and Theodore G. Shepherd

We revisit a widely used diagnostic of transport and chemistry in the stratosphere, the O_3-N_2O correlation, with newly obtained data from the Atmospheric Chemistry Experiment (ACE) satellite instrument. ACE provides the first comprehensive data set for the investigation of inter-hemispheric, inter-seasonal, and height-resolved differences of the O_3-N_2O structure. Our knowledge of stratospheric O_3-N_2O correlations is thereby extended and their potential for model-measurement comparison assessed. By sub-sampling fields from the Canadian Middle Atmosphere Model (CMAM) and comparison to the full CMAM fields, we show that the representativeness of the ACE data is somewhat restricted and therefore may lead to biases in the interpretation of the O_3-N_2O structure. Similar issues could arise in any model-measurement comparison and hence we suggest testing the robustness of diagnostics used within CCMVal to sampling biases. However, in our case the solution was provided by the use of area- and measurement-weighted joint probability density functions (PDFs), which can drastically improve the evaluation, especially in the middle stratosphere where the correlations are not compact and therefore mainly reflect data sampling. It is shown that PDFs provide a detailed picture of key aspects of transport and mixing such as the tropical pipe, surf zone and polar vortex, but also trace polar ozone loss.

Abstract B3 (Oral)

Relationships among age-of-air, chlorofluorcarbon loss and mixing ratio boundary conditions in assessment simulations

Anne Douglass, Richard Stolarski, Susan Strahan, Charles Jackman, and Paul Newman

Comparison of the distribution for stratospheric age-of-air derived from observations with that produced by simulations is a common performance metric for atmospheric models used to predict the future response of ozone to changes in atmospheric composition. The realism of simulated distributions of constituents such as chlorofluorocarbons CFCs and the inorganic chlorine species such as HCl that are produced through destruction of CFCs is also an important aspect of evaluation.

We explore the relationships among the age-of-air, the CFC loss distributions, and the fractional release, i.e. the fraction of a CFC that has been destroyed relative to the amount initially present in an air parcel. We examine simulations using several models, including our coupled chemistry-climate model the GEOS-CGCM, an off-line Chemistry and Transport Model (CTM) developed through NASAs Global Modeling Initiative GMI, and a two-dimensional CTM. There are two implementations of both the GMI CTM and the 2DCTM, one of which produces a realistic distribution for the age-of-air and a second with young air.

The evolution of chlorine species in these simulations is greatly constrained by the imposition of mixing ratio boundary conditions. The boundary conditions disconnect the simulated chlorine evolution from the modeled loss even though this loss is greater for the simulations with young age distributions compared to simulations with realistic age distributions. This analysis suggests that future assessments should use flux boundary conditions rather than mixing ratio boundary conditions for the following reasons. First, comparisons with atmospheric observations such as the HALOE HCl time series provide additional information about the fidelity of a simulation using flux boundary conditions because the model burden and its time dependence are not constrained. Second, the specified mixing ratios constrain recovery scenarios. If the overturning circulation is speeding up, a common feature of chemistry-climate models, the CFC lifetimes decreases with time. This feedback that is missing from simulations using mixing ratio boundary conditions.

Abstract B4 (Poster)

Comparison of the chemistry-climate model ECHAM5/MESSy with nudged tropospheric meteorology with 9 years of satellite data

Christoph Bruehl, Benedikt Steil, Patrick Joeckel, Gabriele Stiller, and Bernd Funke

For a direct comparison with observations the new CCM ECHAM5/MESSy was run with a horizontal resolution of T42 and 90 layers from the surface to the mesopause with vorticity, divergence, temperature and surface pressure nudged to ECMWF analysis data in the troposphere 700 - 200 hPa for the period 1996 to 2006. The model has an internal QBO close to the observations. The simulation data were interpolated in space and time to the coordinates of the observations of HALOE on UARS and MIPAS on ENVISAT. We show timeseries and statistics correlations and probability density functions of long-lived tracers like water vapour, ozone, methane, HCl, N_2O and NOy in the stratosphere for different latitudes and altitudes. We demonstrate that the CCM reproduces the main features of the observations.

Abstract B5 (Oral)

A new method to deduce stratospheric transport times from observations and models

Peter Hoor, Jos Lelieveld, Hubertus Bromberger, Harald Boenisch, Andreas Engel, Horst Fischer, Patrick Joeckel, Benedikt Steil, and Susan Strahan

We present a new method to determine transport times in the stratosphere which is based on observations of N_2O and CO_2. So far CO_2 has been used to calculate mean ages of air in the stratosphere, whereas shorter lived trace gases like CO are used to investigate cross tropopause transport and mixing on short time-scales close to the tropopause.

The new approach is applicable from the extratropical tropopause deep into the overworld. It allows in particular to quantify the mean transport time of the younger peak in bimodal age spectra from in-situ observations. In addition, the boundary of the subtropical barrier can be clearly defined. We use stratospheric observations from the ER-2 and satellite platforms to establish the method. The approach is applied and tested with ECHAM5/MESSy model results, indicating that quasi-horizontal mixing in the model above the tropical tropopause is too strong compared to observations, but nevertheless upward velocities in the tropical pipe and its boundaries are captured well.

C. Upper Troposphere / Lower Stratosphere

Abstract C1 (Poster)

Comparison of SCOUT-O3 Darwin campaign measurements with results from a global chemistry-climate model along flight tracks

Markus Kunze, Christoph Bruehl, Francesco dAmato, Martin Dameris, Peter Hoor, Patrick Joeckel Christian Kurz, Ulrike Langematz, Mark Lawrence, Fabrizio Ravegnani, Cornelius Schiller, Hans Schlager, Nikolay Sitnikov, Alexey Ulanovsky, Silvia Viciani, and Michael Volk

We use measurements taken on-board the Geophysica aircraft during the SCOUT-O3 Darwin campaign in November/ December 2005 for further evaluation of the new Chemistry Climate model (CCM) ECHAM5/MESSy. The CCM was run with a horizontal resolution of T42 and 90 layers from the surface to the mesopause with vorticity, divergence, temperature and surface pressure nudged to ECMWF analysis data in the troposphere 700 - 200 hPa for the period 1996 to 2005. We focus on the tropical tropopause layer where the vertical resolution of the model is about 600m.

To compare the results of this CCM run with the measurements taken during the Darwin campaign, the CCM results were interpolated to the tracks of the Geophysica flights.

Emphasis of the analysis is on water vapour measured with the instruments FISH and FLASH, ozone (FOZAN), methane (ALTO), carbon monoxide (CO_TDL), CFC-12, CFC-11, Halon 1211 (HAGAR), nitric oxide and total reactive nitrogen (SIOUX). Despite the large differences in temporal and spatial resolution between the campaign measurements and the model data, the overall agreement is quite good.

Abstract C2 (Oral)

A long-term climatology of transport processes in the TTL during NH winter

Kirstin Krueger, Susann Tegtmeier, Franz Immler and Markus Rex

Recent investigations of transport processes in the tropical tropopause region have shown that the interaction between vertical and horizontal transport plays an important role in dehydrating air while entering the stratosphere. Uncertainties in the formulation of vertical transport typically limit our understanding of the dynamical processes in the tropical tropopause layer (TTL).

In this paper we present results of multi-year calculations covering the ERA40 and operational ECMWF analyses period. For this purpose we have developed a different approach to better constrain the vertical velocities in trajectory models of this region of the atmosphere: a reverse domain filling trajectory model driven by diabatic heating rates from the ECMWF's radiative transfer model.

We focus on the northern hemispheric winter months which show the lowest temperatures during the seasonal cycle and hence the lowest stratospheric water vapour mixing ratios. The analysis will focus on Lagrangian cold point temperature (LCPT), diabatic ascent and residence time within the TTL region, which have a strong impact on reliable studies of transport processes of e.g. very short live substances travelling from the surface to the stratosphere. The differences which arise from this new approach will be discussed in context with previous studies that relied on the noisy assimilated vertical wind fields. NH winter also shows a strong interannual variability in the LCPT, which will be investigated in more detail taking care of the most prominent dynamical mechanism such as the influence of ENSO, QBO, solar cycle and volcanoes in driving this variability.

Abstract C3 (Oral)

The Potential Impact of Aerosols in the Upper Troposphere on Ice Clouds

Joyce Penner, Xiaohong Liu, and Minghuai Wang

Cirrus clouds have a net warming effect on the atmosphere and cover about 30% of the Earth's area. Aerosol particles initiate ice formation in the upper troposphere through modes of action that include homogeneous freezing of solution droplets, heterogeneous nucleation on solid particles immersed in a solution, and deposition nucleation of vapor onto solid particles. Here, we examine the change in ice number concentration from anthropogenic soot originating from surface sources of fossil fuel and biomass burning and from aircraft that deposit their aerosols directly in the upper troposphere using a the coupled IMPACT aerosol with the NCAR CAM3 climate model. The introduction of ice nucleation in the upper troposphere in CAM improves the representation of ice in comparison to the AURA satellite. The cloud forcing introduced by surface soot, anthropogenic sulfate aerosols and aircraft is evaluated.

Abstract C4 (Poster)

The seasonal cycle of averages of nitrous oxide and ozone in the Northern and Southern Hemisphere polar, midlatitude, and tropical regions derived from ILAS/ILAS-II and Odin/SMR observations

Farahnaz Khosrawi, Rolf Mueller, Mike H. Proffitt, Jo Urban, Donal Murtagh, and Hideaki Nakajima

Northern and southern hemispheric monthly averages of ozone (O_3) and nitrous oxide (N_2O) have been suggested as a tool for validating atmospheric photochemical models. An adequate data set for such a validation study can be derived from measurements made by satellites which in general have a high spatial and temporal resolution. Here, we use measurements made by the Improved Limb Atmospheric Spectrometers (ILAS and ILAS-II) which use the solar occultation technique and by the Odin-Sub Millimetre Radiometer (Odin/SMR) which passively observes the thermal emissions from the Earth's limb. Using correlations of N_2O and O_3, the data are organized monthly in both hemispheres by partitioning these data into equal bins of altitude or potential temperature. The resulting families of curves help to differentiate between O_3 changes due to photochemistry from those due to transport. From ILAS/ILAS-II and Odin/SMR observations 1-year climatologies of monthly averaged O_3 and N_2O were derived for the altitude range between 60 to 90 and -60 to -90, respectively. A comparison between both climatologies shows a good agreement and verifies that limited sampling from satellite occultation experiments does not constitute a problem for deriving such a climatology. Since Odin/SMR provides measurements for the entire hemisphere, a 1-year climatology is reported here for the entire Northern and Southern Hemisphere from these measurements. Further, the 1-year climatologies derived from Odin/SMR is separated into climatologies for the low latitudes, midlatitudes, and high latitudes. The 1-year climatologies from Odin/SMR and ILAS/ILAS-II as well as the climatologies for the specific latitude regions from Odin/SMR provide a potentially important tool for the validation of atmospheric photochemical models.

Abstract C5 (Poster)

The climatic version of the MOCAGE tropospheric-stratospheric Chemistry and Transport Model: description, evaluation and sensitivity to surface processes

Hubert Teyssedre, Martine Michou, Hannah Clark, Fernand Karcher, Dirk Olivi, Vincent-Henri Peuch, David Saint-Martin, Daniel Cariolle, Phillippe Ricaud, and Francoise Chroux

We present the climate configuration of the Météo-France Chemistry and Transport Model, MOCAGE-Climat that, among few models, simulates the global distribution of ozone and its precursors (82 chemical species) both in the troposphere and the stratosphere, up to the mid-mesosphere (70 km). Surface process emissions, dry deposition, convection, and scavenging are explicitly described in the model that has been driven by the ECMWF operational analyses of the period 2000-2005, on T21 and T42 horizontal grids and 60 hybrid vertical levels, with and without a procedure that reduces calculations in the boundary layer, and with on-line or climatological deposition velocities. Model outputs have been compared thoroughly to observations, both from satellites (TOMS, UARS, SCIAMACHY, ODIN, MOPITT) and in-situ measurements (ozone sondes, MOZAIC and aircraft campaigns) at climatological timescales.

In the stratosphere, putting apart shortcomings linked to a too fast Brewer-Dobson circulation such as too large accumulations of ozone in the lower to mid-stratosphere, long-lived species conform reasonably to observations. However, conversions between radical and reservoir forms of chlorine and nitrogen are not fully resolved in the stratosphere and consequently the ozone hole is not deep enough. Ozone in the UTLS region does not show any systematic bias, while in the troposphere better agreement with ozone sonde measurements is obtained at mid and high latitudes and differences with observations are the lowest in summer.

Simulations with the simplification of the boundary layer lead to model outputs further away from observations up to the mid-troposphere. NOx in the lowest troposphere are in general overestimated, especially in the winter months over the northern hemisphere. This might result from a positive bias in OH. Dry deposition fluxes of O_3 and nitrogen species are within the range of values reported by recent inter-comparison model exercises. The use of climatological deposition velocities versus on-line ones impacted the most HNO_3 and NO_2 in the troposphere.

The next step will be to drive and validate MOCAGE-Climat over longer periods with the climatological fields of the ARPEGE-Climat atmospheric General Circulation Model.

Abstract C6 (Poster)

Sensitivity of atmospheric chemistry to the water vapour modelling in the UTLS region

David Saint-Martin, Daniel Cariolle, Hubert Teyssedre, Martine Michou, and Dirk Olivi

In the atmosphere, water vapour controls both weather and climate and plays a central role in the stratospheric radiative balance and in stratospheric chemistry, influencing the heterogeneous chemical reactions that destroy stratospheric ozone. The existence of significant cross-tropopause gradients in both ozone and water vapour requires a detailed modelling of the mechanisms which involve water vapour in the upper troposphere and lower stratosphere region UTLS.

We investigate the impact on chemical distributions in UTLS of both various definition of the tropopause standard definition, dynamic definition with potential vorticity isosurfaces, chemical definition with ozone concentrations and various parameterisations used in troposphere ice supersaturation scheme and in stratosphere oxidation of methane, polar stratospheric cloud formation.

We present results from a multi-year model simulation, using the global chemical transport model, MOCAGE, forced by the general circulation model, ARPEGE-Climat, which provides temperature, wind and tropospheric moisture fields.

Abstract C7 (Poster)

Recent Updates of the ULAQ-CCM: inclusion of the equatorial QBO and parameterization of UT/LS ice clouds

Giovanni Pitari, Eva Mancini, and Daniela Iachetti

The ULAQ-CCM University of L'Aquila climate-chemistry coupled model is a low resolution model, including an on-line microphysics code for aerosol formation and growth. In order to improve the ULAQ-GCM ability to simulate the interannual variability of the stratospheric circulation, a forcing term for the quasi-biennial oscillation of the equatorial winds (QBO) has been included in the vorticity equation. The forcing term is calculated using the observed time-dependent equatorial tropical winds 1960-2004, with a relaxation time of 7 days. A comparison between observations and results is shown.

The second major improvement of the CCM has to do with the parameterisation for homogeneous freezing of cirrus ice particles: the effects of aerosol size distribution changes are now taken into account. The ice particles impact on the radiation budget is calculated using a multi-layer δ-Eddington approximation for the solar flux and scaling pre-calculated longwave fluxes with appropriate 963T4 values for the IR part. Non-spherical ice particle are taken into account in the effective radius calculation. The atmospheric sensitivity to cirrus ice particles has been studied by means of subsonic aircraft emissions: increasing water vapour and aerosols in the UT/LS, with respect to a no-aircraft atmosphere, has the effect to perturb the ice particle population and size distribution. Changes in cirrus cloud optical thickness have been calculated, as well as solar and infrared radiative forcing terms

Abstract C8 (Oral)

Diagnostics for seasonally varying and seasonally invariant transport in the lowermost stratosphere

Susan Strahan and Peter Hoor

The composition of the extratropical lowermost stratosphere (LMS) is affected by seasonal variations in the strength of the downward branch of the Brewer-Dobson circulation. In the summer, composition changes due to increased meridional transport from low latitudes this can be seen in long-lived tracers between 340K-380K. In contrast to the upper LMS, tracer behavior closer to the dynamical tropopause (300K-340K) suggests that mixing between the troposphere and stratosphere occurs in all seasons, resulting in a mixed layer with little seasonal variation in thickness.

We present transport diagnostics for these two regions of the lowermost stratosphere which are based on analyses of N_2O, CO, and CO_2 aircraft data from the SPURT campaigns and AURA MLS CO measurements. In the upper LMS, the degree to which a models composition is seasonally influenced by tropical upper tropospheric air can be assessed by comparison with seasonal changes seen in SPURT N_2O observations. In the lower LMS, the results of Hoor et al (2004), which showed that an extratropical tropopause mixed layer 30K thick exists year-round, can be used to gauge whether model processes realistically couple the troposphere and stratosphere to create the mixed layer. AURA MLS, which has global coverage and a much larger CO data set than SPURT, also supports the existence of the mixed layer. MLS CO data provide new details on mixing as a function of height in the lowermost stratosphere. Evidence of the mixed layer is also provided by SPURT CO_2 seasonal cycles above and below the tropopause.

Abstract C9 (Poster)

Evaluation of NCAR MOZART-3 and WACCM models in the UTLS region using tracers with different lifetimes

Simone Tilmes, Laura Pan, Douglas Kinnison, Sue Schauffler, and Rolando Garcia

The representation of chemical transport processes that couples the upper troposphere (UT) and lower stratosphere (LS) in CCMs is a key component for the models to simulate future climate scenarios. Different methods have been proposed to diagnose the model transport issues in this region. Here, we present an extension to the diagnostics described in Pan et al., (2006), using tracers with a wide range of lifetimes. Trace gas profiles in relative altitude and tracer-tracer relationships are used to examine the performance of NCAR MOZART-3 and WACCM-3 models. In situ chemical tracers, including those from the Whole Air Sampler, measured onboard NASA research aircraft during several campaigns are used to compare with the model results. Model and observational data are compared for tropics high tropopause, extra-tropics lower tropopause and the subtropical region, where a double tropopause often exists. The results show that, in general, the slopes of tracers in relative altitudes are in good agreement between models and observations. Tracer-tracer correlations indicate a general agreement for long-lived tracers, but differences exist for shorter-lived tracer between models and observations. Implications of these results to the modeled age spectrum in the UTLS region and the related transport pathways will be discussed.

Abstract C10 (Oral)

Tropical Tropopause Layer Structure in CCMs

Andrew Gettelman and Thomas Birner

The structure and variability of the Tropical Tropopause Layer (TTL) are analyzed in multiple global coupled chemistry climate models (CCMs), and compared to observations from ozone/radiosondes and GPS occultations. Detailed diagnostics are performed using four-dimensional fields on model levels from two specific CCMs – the Whole-Atmosphere Community Climate Model (WACCM) and the Canadian Middle Atmosphere Model (CMAM). The analysis is expanded to the CCMVal set of models. Relationships between water vapor, clouds, ozone and the thermal structure of the TTL are examined.

The results indicate that the thermal structure of the TTL is well reproduced by the CCMs. Variability of the TTL is also reproduced by global models at the scales they can resolve. The models broadly reproduce observed relationships between clouds and the thermal structure, and clouds and the trace gas structure ozone and water vapor. Model deficiencies regarding clouds and small scale structure are discussed. The results and diagnostics in the simulations allow us to make conclusions regarding the role of transport, radiation and convection in regulating the variability and mean structure of the TTL.

Abstract C11 (Oral)

An approach to validate the transport of water vapour through the tropical tropopause in chemistry climate models

Stefanie Kremser, Markus Rex, Ingo Wohltmann, Ulrike Langematz, and Martin Dameris

The interaction of horizontal and vertical transport in the tropical tropopause layer (TTL) determines the distribution of points where individual air masses encounter their minimum temperature while they slowly ascend from the TTL into the stratosphere. The geographical distribution of these dehydration points and the local conditions there determine the overall flux of water vapour from the TTL into the stratosphere. The representation of both, the geographical distribution of the dehydration points and the local conditions there, is a measure how realistic the water vapour transport into the stratosphere is represented in coupled chemistry climate models (CCMs). A correct representation of these points in a model is crucial for a correct representation of potential long-term changes of water vapour transport into the stratosphere due to changes in greenhouse gas concentrations. We have developed a lagrangian framework to assess the dehydration patterns in CCMs and will present results from two different CCMs.

Abstract C12 (Poster)

On the coupling of the MOCAGE-Climat CTM and the ARPEGE-Climat GCM

Dirk Olivie, Hubert Teyssedre, Martine Michou, David Saint-Martin, and Daniel Cariolle

We present the coupling of the General Circulation Model ARPEGE-Climat with the Chemical Transport Model MOCAGE-Climat. This coupling might allow progress in understanding the two-way interactions between reactive gases and the climate system.

The Arpege-Climat GCM from Centre National de Recherches Météorologiques is a state-of-the-art GCM and has been used in different climate studies. At the moment it currently contains only a simple representation of atmospheric ozone chemistry.

MOCAGE-Climat is the climate version of the Météo-France multi-scale Chemical Transport Model MOCAGE (see. Michou et al., this workshop) which covers a wide range of scientific applications, and includes both tropospheric and stratospheric chemistry. Driven by operational analyses from ECMWF, it has been compared extensively with observations for the period 2000-2005.

In a first step towards the coupling of the GCM ARPEGE-Climat and the CTM MOCAGE-Climat, the sensitivity of MOCAGE-Climat to the specification of the meteorological parameters is investigated in an off-line mode applying the meteorological forcing from the ARPEGE-Climat.

In a second step, we will report here on the first results from the coupling between the GCM ARPEGE-Climat with the CTM MOCAGE-Climat. The coupling currently consists, apart from meteorological fields from ARPEGE-Climat towards MOCAGE-Climat, in the transfer of ozone fields of MOCAGE-Climat towards ARPEGE-Climat.

In the future, we intend to exchange distributions of other radiatively active gases from MOCAGE-Climat to ARPEGE-Climat. This new system should allow the study of a significant number of interactions and feedbacks from chemistry on the climate which are essential for climate scenario studies.

Abstract C13 (Oral)

Variability and trends in global tropopause parameters

Thomas Birner

The tropopause region is sensitive to both tropospheric and stratospheric climate change. This makes the tropopause region an ideal place to test and validate global chemistry climate models. Here, variability and trends in global tropopause parameters are analyzed as obtained from the Canadian Middle Atmosphere Model (CMAM) for the period 1960-2100 and ERA40 1958-2001. For the current climate results are compared to observations from radiosondes and GPS occultations. CMAM reproduces the key features of observed tropopause structure and variability well including a negative trend in tropopause pressure. Tropopause temperature shows a negative trend in the polar regions and a small positive trend in the tropics. Interestingly, the stratification around the tropopause shows trends as well such as to lead to decreased tropopause sharpness in future climate. Polar and tropical tropopause are coupled through the Brewer-Dobson circulation such that an anomalously high tropical tropopause is associated with an anomalously low polar tropopause. It is shown that this represents a dominant part of the year-to-year variability in tropopause parameters. Furthermore, an intensified Brewer-Dobson circulation in future climate amplifies the tropopause trend in the tropics but attenuates it in the polar regions.

Abstract C14 (Poster)

The tropopause in the 21st century

Seok-Woo Son, Darryn Waugh and Lorenzo Polvani

The tropopause in the 21st century is examined with CCMs. Despite the fast recovery of stratospheric ozone, global tropopause pressure height is found to decrease rise almost linearly in the future climate. This trend is primarily associated with the continuous decrease in ozone at the tropical lower stratosphere. It suggests that the positive correlation between the tropopause pressure and total column ozone in the literature might be misleading. The possible impact of a stronger Brewer-Dobson circulation in the future climate on the tropopause pressure is also discussed.

D. Radiation

Abstract D1 (Poster)

CCMVal Radiation comparison test designs

Piers Forster

This will illustrate the webpage where modelling groups can register and download test profiles to participate in the offline comparison of radiative transfer codes. This will concentrate on simulations of the stratospheric temperature response. The aim is to have representation from ALL the CCMval models and several line-by line models.

Abstract D2 (Poster)

Attribution studies with CCMval model temperature change in the stratosphere

Piers Forster and John Austin

Temperatures changes in the stratosphere of the CCMval models are due to a variety of effects. This work uses offline radiative transfer calculations and fixed dynamical heating models to try to establish cause and effect for the models own temperature response.

Abstract D3 (Poster)

Clear sky UV simulations in the 21st century based on CCM predictions

K. Tourpali, A.F. Bais, A. Kazantzidis, N. Butchart, C. Brühl, M P. Chipperfield, M. Dameris, V. Eyring, M.A. Giorgetta, U. Langematz, E. Mancini, E. Manzini, G. Pitari, E. Rozanov

Future solar UV radiation levels will depend on the evolution of various factors, known to influence the propagation of UV radiation in the atmosphere. Some of these factors, such as ozone, clouds and surface reflectivity are included in coupled Climate Chemistry Model (CCM) output, whereas the prediction of future aerosol levels and their optical characteristics, important for UV radiation, is presently not feasible. Under clear skies, the most important factor for UV-B radiation is stratospheric ozone, followed by tropospheric ozone and aerosols.

In this preliminary study we have used monthly mean total ozone (TOZ) as provided by CCMs taking part in SCOUT-O3 Activity 1. TOZ data are an outcome of simulations run under the REF2 and SCN2 scenarios, consistent with the reference simulations proposed by CCMVal. TOZ is then used as input to a radiative transfer model (LibRadTran) for the simulation of the corresponding future UV irradiance levels, presented here as time series of monthly erythemal irradiance received at the surface during local noon, with a time span following the CCM output.

E. Stratospheric Chemistry and Microphysics

Abstract E1 (Oral)

Simple measures of ozone depletion in the polar stratosphere

Rolf Mueller, Jens-Uwe Grooss, Carsten Lemmen, Daniel Heinze, Martin Dameris, Greg Bodeker

Simple measures of polar chemical ozone loss are frequently used that are solely based on measurements of total colum ozone. One of the common measures is monthly mean column ozone poleward of a latitude of 63^{o} in spring. For the Arctic, a latitude of 63^{o} is a reasonable boundary for polar air, for the Antarctic the monthly means but not their year-to-year variability are sensitive to the exact choice of 63^{o}. Close relations of such simple measures cannot be obtained with meteorological quantities that describe the potential for polar heterogeneous chlorine activation and thus ozone loss. Another popular measure, the minimum of daily total ozone poleward of a particular latitude, is particularly problematic insofar as it relies on one singe measurement or model grid point for Arctic conditions; this minimum value occurs often in air outside of the polar vortex. This concept should no longer be used when comparing polar ozone loss in observations and models. A possible alternative is to consider the minimum of daily average total ozone poleward of a particular equivalent latitude or in the vortex in spring. This definition both avoids relying on one single data point and reduces the impact of year-to-year variability in the Arctic vortex breakup on ozone loss measures. If possible, it is always preferable to employ more sophisticated measures of chemical polar ozone loss that bring in additional information to disentangle the impact of transport and chemistry on ozone.

Abstract E2 (Poster)

Further Developments of the CCM E39C - Documentation of Significant Model Improvements

Andrea Stenke, Martin Dameris, and Volker Grewe

An ensemble of long-term transient simulations 1960-2020 with the coupled climate-chemistry model (CCM) E39C have been analysed (Dameris et al., 2005, 2006) and evaluated in a number of extra scientific investigations (e.g. Erbertseder et al., 2006; Eyring et al., 2006; Steinbrecht et al., 2006). On the one hand it has been demonstrated that E39C is able to reproduce important features of stratospheric dynamics and chemistry, but on the other hand significant deficiencies have been identified which must be eliminated to provide a more reliable prediction of the evolution of stratospheric dynamics and chemistry.

In an updated version of E39C, i.e. E39C-A, a variety of model developments have been implemented: The most important advancement concerns the change of the advection scheme from a semi-Lagrangian approach by Rasch and Williamson (1994) to the full Lagrangian transport scheme ATTILA (Reithmeier and Sausen, 2002). Since ATTILA is a numerically non-diffusive scheme, it is able to maintain steeper and therefore more realistic gradients than the semi-Lagrangian scheme. Furthermore, a parameterisation to consider bromine chemistry (pers. comm. M. Rex, 2006) has been introduced into the model and improved net heating rates has been used to describe impact of large volcanic eruptions as realistic as possible (Stenchikov et al., 2006).

Results of a new transient model simulation 1960-2004 with the updated model version E39C-A are presented and specific improvements are discussed in detail: The Lagrangian transport scheme leads to a significant improvement of the simulated water vapour distribution which in turn results in a significant reduction of cold bias in the extratropical lowermost stratosphere and a much better representation of stratospheric wind variations. Furthermore, simulated tracer distributions in the stratosphere are improved. For example, the vertical distribution of stratospheric chlorine is now in agreement with analyses derived from observations and other CCMs which leads to a better assessment of ozone destruction. Finally, the simulated response of stratospheric temperatures and water vapour concentrations on large volcanic eruptions agrees well with observations.

Abstract E3 (Oral)

Sulfur injections into the stratosphere to alter the atmospheric chemical and dynamical state

Thomas Peter, Patricia Kenzelmann, Peter Spichtinger, Stephan Fueglistaler, Martin Schraner, and Eugene Rozanov

In the past large eruptions of tropical volcanoes led to a net cooling of surface temperatures. The cooling is due to enhanced stratospheric sulfur aerosols, which shield a part of the short-wave radiation coming from the sun. Could this effect help to find a way to reduce the effects of global warming? Recently Crutzen suggested investigating the possibility of performing a geoengineering project in which yearly 1-2 Tg of sulfur are injected into the stratosphere, which is 10-20% of the stratospheric sulfur loading caused by the Mt. Pinatubo eruption, in order to compensate anthropogenic global warming.

Such a project differs in some crucial features from a natural experiment like the eruption of Mt. Pinatubo. In the geoengineering project there would be a constant source of sulfur to the stratosphere, in contrast to the transient volcanic eruptions. Consequently the geoengineering project would lead to a new equilibrium state of the climate system. The dynamical and chemical state of the troposphere and the stratosphere would change remarkably.

Steady state runs with the chemistry climate model SOCOL suggest a significant impact on stratospheric chemistry and dynamics. The lower stratosphere would warm considerably and the polar vortex would intensify. This results in a feedback to the troposphere, where during wintertime in some regions a considerable warming takes place. We will also discuss the problem of polar winter warming under conditions of enhanced stratospheric aerosol loading, and from there attempt an overall evaluation of the effects of the geoengineering proposal on stratosphere and troposphere.

Abstract E4 (Withdrawn)

An Evaluation of Chemical Loss of Extra-Polar Ozone within CCMs: Overview

Ross Salawitch

Chemical loss of ozone outside of the polar regions is controlled by a series of catalytic reactions involving HOx, NOx, ClOx, and BrOx radicals. The total rate of ozone loss and relative contribution from each family to total loss are sensitive to a variety of factors, including altitude, latitude, temperature, and aerosol loading. I shall examine the representation of chemical loss within CCMs by comparing a variety of comparing a variety of factors from the models to data: the representation of long-lived radial precursors e.g., NOy vs N_2O, Cly vs CFC-11, Bry vs CH_3Br the partitioning within radical families e.g., NOx/NOy, ClOx/Cly, BrOx/Bry the abundance of HOx total and partial column BrO and, the fractional contribution to total ozone loss from the various chemical families. Recent satellite and balloon data will be featured throughout. Strengths and weaknesses of the comparisons will be noted, as appropriate. I shall conclude by suggesting future improvements both in output model diagnostics and CCM capability.

Abstract E5 (Poster)

First ECHAM5-MESSy1 simulation results peformed with a new PSC parameterisation and comparison with MIPAS-ENVISAT data

Roland Ruhnke, Ole Kirner, Michael Hoepfner, and Gabi Stiller

Polar stratospheric clouds (PSCs) such as STS, NAT, and ice play a major role in polar ozone depletion: directly via the activation of chlorine reservoirs at the surface of the PSCs and indirectly via denitrification delaying the deactivation of active chlorine in polar spring.

Despite this importance of PSCs the representation of PSC microphysics is rather poor in current CCMs. Here we present the first results of a multi-year simulation of ECHAM5-MESSy1 from November 2002 through spring 2005 performed with a new PSC parameterisation for the CCM ECHAM5-MESSy1 based on the efficient growth and sedimentation algorithm of van den Broek et al. (2004). The results will be compared to ECHAM5-MESSy1 simulation results obtained by using the standard thermodynamical PSC scheme. In addition, the ECHAM5-MEssy1 results with the new PSC scheme will be analysed with respect to the occurrence and composition distinguished between NAT, ice and STS of PSC fields and compared to PSC measurements of the MIPAS-ENVISAT experiment Hoepfner et al., (2006).

Abstract E6 (Poster)

Examining tropospheric seasonal cycle of chlorofluorobarbons using GEOSCCM with emission-based boundary conditions

Qing Liang, Richard Stolarski, Anne Douglass, Paul Newman, Eric Nielsen, and Steven Pawson

To more accurately predict the impact of climate change on atmospheric circulation and lifetimes of long-lived ozone depleting substances, and therefore future ozone recovery, it is desirable to switch from the current commonly adopted mixing ratio-based forcings to emission-based forcings in general circulation models GCMs. As a first step of this model transition, we have conducted a 45-year 1960-2005 emission-based simulation of CFC-11, CFC-12, and CFC-113 using the GEOS CCM. CFCs are released at the surface based on the WMO/UNEP A-1 scenario emissions with a regional distribution, and destroyed in the stratosphere through photolysis and reaction with O^1D. We evaluate CFC emissions and the model simulation by comparing the model results with surface CFC observations at AGAGE sites. The simulation agrees with the observed mixing ratios of CFC-11 and CFC-12, reflecting a good estimate of emissions as well as atmospheric lifetimes. The simulated CFC-113 mixing ratios show a high bias, implying an overestimate in emissions and/or an overestimate of loss rate. Surface CFCs at many AGAGE sites show seasonal cycles with varying amplitudes and seasonal maxima/minima. We repeat the simulation for 1995-2005 with two additional suites of tagged CFC tracers three tropospheric tracers to track recently emitted CFCs, and three stratospheric tracers to track CFCs that have been at some time in the stratosphere. Using the tagged tracers, we will analyze the seasonal cycle of CFCs at several AGAGE stations and quantify the contribution of stratosphere-to-troposphere transport and tropospheric transport for seasonal variations of CFCs in the troposphere.

Abstract E7 (Poster)

Is the major fraction of polar stratospheric ozone loss due to an unknown mechanism?

Markus Rex, Robyn Schofield, Timothy Canty, and Ross J. Salawitch

Uncertainties in the photolysis cross sections of ClOOCl have long been a limiting factor in our theoretical understanding of the rate of polar stratospheric ozone losses. Previous work suggested that values slightly larger than current recommendations, which are based on laboratory measurements, result in improved agreement between model calculations of polar stratospheric ozone loss rates and observations while at the same time also leading to improved agreement between observations of the diurnal variation of ClO and model calculations of this species. But new laboratory work on the cross sections of ClOOCl suggest that its photolysis under polar stratospheric winter/spring conditions is nearly an order of magnitude slower than what would be required to explain the observations of ozone loss and ClO in the atmosphere and a factor of six slower than a value based on the current recommendations. We show the impact of these new results on our understanding of polar ozone chemistry.

For typical Arctic conditions calculated ratios of ClO/ClOx decrease by about a factor of two. The ozone loss rate by the ClO-dimer cycle, so far believed to be the most efficient ozone loss cycle, drops by about a factor of four and the loss rate by the coupled ClO-BrO cycle by nearly a factor of two. Overall ozone loss rates calculated based on the known ozone loss mechanisms drop by a factor of two to three and become much smaller than observations. Also the calculated levels of ClO become much smaller than those observed in the stratosphere. These results suggest that a major fraction of the observed ozone loss in the polar stratosphere is due to a currently unknown mechanism - a major challenge of our fundamental understanding of the polar stratospheric ozone loss process.

We will discuss potential new chemistry that would lead to improved agreement between calculations of ozone loss and ClO diurnal variations with in-situ observations in the stratosphere.

Abstract E8 (Oral)

The impact of mixing across the polar vortex edge on ozone loss estimates: Implication for the validation of CCMs

Jens-Uwe Grooss, R. Muller, P. Konopka, H.-M. Steinhorst, A. Engel, T Mbius, C.M Volk, and T. von Clarmann

Published estimates of accumulated Arctic polar ozone loss show a compact linear relation with the temperature-based proxy V_{PSC}. It has been suggested to use this relation for the validation of CCMs. The underlying methods e.g. Vortex average method/Match however do not take into account the mixing across the vortex edge.

We show for the winter 2002/03 that significant mixing across the vortex edge did occur and that it can be modeled accurately by the Chemical Lagrangian Model of the Stratosphere. Observations of inert tracers in-situ from HAGAR on the Geophysica aircraft and also remote from MIPAS IMK on ENVISAT can be reproduced well. CLaMS is even able to reproduce a small vortex remnant that was isolated until June 2003 and was observed in-situ by a balloon-borne whole air sampler.

From this simulation, the impact of mixing across the vortex edge on ozone loss estimates is evaluated. The impact may be two-fold:

1 The time integration of the vortex average ozone loss must be corrected for the export of ozone-depleted air into mid latitudes. For the winter 2002/03, the accumulated ozone loss without this correction is 39% larger than the simulated vortex average column ozone loss.

2 A continuous import of air masses with lower ozone mixing ratios can mimic enlarged ozone loss rates for the Vortex Average estimate, but also for the Match approach even though it aims to avoid air masses which are influenced by mixing. Both effects yield an over-estimation of ozone loss in the Match and vortex-average methods.

For better validation of the ozone loss and transport in CCMs we suggest comparing the simulated V_{PSC}/O_3 relation with caution, and also (a) to compare with observations of ozone mixing ratio and other inert tracers like CH_4 or N_2O in equivalent latitude and potential temperature coordinates e.g. Grooss and Russell, 2005 and (b) to compare ozone column with meaningful averages in equivalent latitude coordinates (cf. contribution of Muller et al).

Abstract E9 (Oral)

Evaluation of Chemical Polar Ozone Loss in the Lower Stratosphere within CCM Models

Simone Tilmes, Rolando R. Garcia, Douglas E. Kinnison, Rolf Mueller, Ross Salawitch, Markus Rex, Daniel R. Marsh, and Fabrizio Sassi

The simulation of the evolution of ozone in polar regions in different CCMs still indicates significant differences. Especially, discrepancies exist for the simulations of Arctic conditions among different models Austin et al, (2003). To understand discrepancies between models and observations, and among models themselves, we need diagnostics to clearly indicate the source of the shortcomings in the models, and to describe separately the impact of chemical and meteorological processes on ozone loss. A nearly linear relationship between chemical ozone loss and the volume of air exposed to PSC temperatures during the course of winter (V_{PSC}) was derived based on analysis of ozone sonde data using the vortex averaged descent method (Rex et al., 2004) and satellite data using the tracer-tracer method (Tilmes et al., 2004). This relationship was proposed as a diagnostic to indicate whether models are able to couple realistically temperature and chemical ozone destruction. However, this diagnostic alone does not indicate the reason for shortcomings in the model and a detailed analysis of different factors controlling chemical ozone loss is necessary. New diagnostics will be introduced that specifically analyze the meteorological conditions, vortex temperature, vortex volume, volume of potential chlorine activation, and the lifetime of the vortex, described by the potential for activated chlorine (PACl).

Here, we will discuss differences of these diagnostics, and the derived relationship between chemical ozone loss and PACl, between all CCMs that have submitted the requisite model output to the data archive and observations. Using NCAR's Whole Atmosphere Community Climate Model (WACCM), we will show that the described diagnostics and the strength and sharpness of the polar vortex edge in the model are important factors that influence heterogeneous processes in the polar vortex. We will discuss the importance of horizontal resolution for polar processes in the model.

Abstract E10 (Poster)

Evaluation of NOy Chemistry in CCMVAL Models

Wenshou Tian and Martyn Chipperfield

We have used output from CCMVal models to test their representation of stratospheric NOy chemistry. We will show comparisons with satellite climatologies and tracer-tracer correlations. Large differences exist between the models.

F. Natural Variability

Abstract F1 (Oral)

Coupled chemistry climate model simulations of the solar cycle in ozone and temperature

John Austin, Eugene Rozanov, Klairie Tourpali, et al.

The results from new simulations of coupled chemistry climate models are examined for the presence of the 11-year solar cycle in ozone and temperature. In contrast to most previously published simulations, the new simulations are in better agreement with satellite observations of the vertical profile of the ozone response, particularly in low latitudes where the observational signal can be more firmly established. It is found that this improved agreement occurs by incorporating variability only in the solar fluxes in the models and that the upper atmospheric effects of energetic particles are not important for the low latitude ozone signal. The results also suggest that the presence of the quasi biennial oscillation is not necessary to simulate the observed low latitude minimum in lower stratospheric ozone response. Comparisons are also made between model simulations and total column ozone. As in previous studies, the model simulations agree well with observations. However, a substantial difference exists between the observed signal for the period 1960-1980 and for the period 1980-2000. This is reproduced by those models which cover the full temporal range, and it is shown that the difference between the solar cycles in the simulations is due almost entirely to ozone changes below 50 hPa. Possible reasons for the tropical ozone minimum, and for the difference in ozone response for different solar cycles are discussed in addition to the impacts of the solar response on the troposphere.

Abstract F2 (Oral)

The Role of the QBO in Simulating the Solar Signal in the Atmosphere

Katja Matthes, Rolando Garcia, Dan Marsh, and Anne Smith

The 11-year solar cycle has an impact on the chemical, thermal, and dynamical structure of the atmosphere. Observational and modeling studies have shown that direct radiative changes in the upper stratosphere can lead to indirect dynamical changes throughout the atmosphere. However, the understanding of the interaction with the equatorial stratospheric Quasi-Biennial Oscillation is still a challenging topic. Discrepancy exists in separating the solar and QBO signals in observations partly due to the short length of existing data sets. Therefore modeling studies are useful to enhance the understanding of the underlying physical mechanisms.

To understand the response of the middle atmosphere to the 11-year solar cycle and its possible transfer to the troposphere a comprehensive set of experiments made with a state-of-the-art chemistry climate model that incorporates the whole atmosphere up to the thermosphere will be investigated. Especially the role of an externally prescribed stratospheric QBO in influencing the 11-year solar cycle signal in NCAR's Whole Atmosphere Community Climate Model WACCM3 will be discussed.

The set of experiments with WACCM3 consists of different perpetual condition experiments solar cycle only or solar cycle and QBO as well as long-term 110-year sensitivity experiments, in which only a realistic time varying solar cycle, only a synthetic, time varying QBO or both the solar cycle and the QBO, were included. In all simulations the sea surface temperatures had a repeating climatological seasonal cycle and the greenhouse gases were set constant to 1995 conditions.

Abstract F3 (Oral)

Winter Climate Response to ENSO in three chemical-climate models

Andreas Fischer, Drew Shindell, Michel Bourqui, Barbara Winter, Eugene Rozanov, and Stefan Bronnimann

El Nino / Southern Oscillation (ENSO) plays an important role in interannual climate variability. Yet the impacts of ENSO on chemical climate variability in the northern stratosphere are not completely understood to date. Knowledge about the performance of chemistry-climate models CCMs in reproducing past ENSO events is therefore highly relevant both as a test for current climate models as well as to improve our current understanding of the mechanisms linking ENSO with the northern stratosphere.

Here we present a model-intercomparison of three CCMs SOCOL, IGCM-FASTOC, GISS that simulated the El Nino event of 1940/41 and the La Nina event 1975/76. SOCOL is a middle atmosphere version of ECHAM4 MPI, Hamburg, which is coupled to the chemistry-transport model MEZON PMOD/WRC, Davos. The IGCM-FASTOC is composed of the Intermediate General Circulation Model of the University of Reading, coupled to the Fast STratospheric Ozone Chemistry scheme, an efficient input-output model composed of pre-computed nonlinear functions. The chemistry-climate model of GISS consists of the stratospheric GCM version with ozone photochemistry and parameterized ozone-related heterogeneous chemistry. The simulations were done in ensemble-mode 20 members prescribing sea surface temperature, sea ice distribution, volcanic aerosols, solar variability, greenhouse gases and ozone depleting substances.

The model-intercomparison will entail a detailed analysis of the model-response to the winter difference of El Nino (1941) and La Nina (1976) in the Northern Hemisphere stratosphere. We will analyse ozone, temperature, geopotential height, and zonal wind as well as Eliassen-Palm (EP) flux and compare model results with observational databases.

Abstract F4 (Poster)

Delay of the Antarctic polar vortex breakup time in the year 1980-1999 due to ozone depletion simulated by the CCSR/NIES CCM with the CCMVal-REF1 and -REF2 scenarios

Hideharu Akiyoshi, Libo Zhou, Kei Sakamoto, Motoyoshi Yoshiki, Tatsuya Nagashima, Masaaki Takahashi, Jun-ichi Kurokawa, Masayuki Takigawi, and Takashi Imamura

The delay of the Antarctic polar breakup time in the year 1980-1999 is examined using the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA40 data and the output of Chemistry-Climate Model (CCM) calculations. The CCM used in this study is the Center for Climate System Research/National Institute for Environmental Studies (CCSR/NIES) CCM. The CCM calculations follow the REF1 and REF2 scenarios for Chemistry-Climate Model Validation Activity CCMVal.

The CCM simulates the ozone hole development from 1982 to 2000 observed by Total Ozone Mapping Spectrometer (TOMS), although the year-to-year variation is different from the observation because of the internal variability of CCM and the ozone mass deficit is smaller than the observation. The ERA40 data shows a delay trend of the breakup time of the Antarctic polar vortex in the period 1980-1999. The delay is simulated by the two ensembles of the CCM calculations, in which long-term variations of the solar 11-year cycle, the quasi-biennial oscillation (QBO), and the volcanic eruptions El Chichon and Pinatubo are included following the REF1 scenario of CCMVal. A CCM calculation without these long-term variations the REF2 scenario of CCMVal shows a larger delay trend of the breakup time than that of the REF1 simulation. The wave flux from the troposphere to the stratosphere and its deposition in the lower stratosphere are also examined. The vertical component of the Eliassen-Palm (EP) Flux at 100 hPa and the EP flux divergence at 50-150 hPa calculated from ERA40 data shows an acceleration trend for earlier polar vortex breakup time in the period 1980-1996, and those calculated from the three CCM calculations show almost no trends. All these results suggest that the delay of the breakup time of the Antarctic polar vortex in the period 1980-1999 is largely caused by the ozone loss in the Antarctic lower stratosphere.

Abstract F5 (Poster)

Total column water vapour trends from GOME and SCIAMACHY satellite measurements - A new data set for the evaluation of chemistry-climate model simulations

Sebastian Mieruch, Stefan Noel, Heinrich Bovensmann, and John Burrows

Satellite observations provide us today with high quality and high resolution global data and are well suited for monitoring of environmental parameters as well as for comparison with model calculations.

Global water vapour total column amounts have been retrieved from spectral data provided by the Global Ozone Monitoring Experiment (GOME) flying on ERS-2 which was launched in April 1995 and the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) onboard ENVISAT launched in March 2002.

For this purpose the Air Mass Corrected Differential Optical Absorption Spectroscopy (AMC-DOAS) approach is used. The combination of the data from both instruments, which requires special treatment at the interchange, provides us with a long-term global data set spanning already now more than 11 years with the possibility of extension up to 2020 by GOME-2 on Metop. Thus this data set is well suited for a trend analysis.

Using linear and non-linear methods from time series analysis as well as standard statistics the trends of water vapour contents and their errors are calculated. Several factors affecting the trend such as the length of the time series, the magnitude of the variability of the noise and the autocorrelation of the noise are investigated. Special emphasis lies on the calculation of the statistical significance of the observed trends which reveal local significant changes, decrease as well as increase, of water vapour concentrations distributed over the whole globe.

The data set is suitable to test the ability of coupled chemistry-climate models, CCMs, to reproduce total column water vapour trends in the past. We plan to compare the trend analysis to results of the CCMVal simulations.

G. Long-Term Changes in the Stratosphere

Abstract G1 (Poster)

Coupled Chemistry-Climate Model Assessment and Projections of Stratospheric Ozone in the 21st century

Veronika Eyring, Darryn W. Waugh, Greg E. Bodeker, Neal Butchart, Eugene Cordero and CCMVal Team

Simulations of the recent past from thirteen coupled chemistry-climate models CCMs participating in the CCM Validation Activity for SPARC CCMVal are evaluated to provide guidance for the interpretation of ozone projections made by the same CCMs. Several different diagnostics are used to evaluate temperature, trace species and ozone in the models. The core period of the evaluation is from 1980 to 1999 but long-term trends are compared for an extended period 1960-2004. Most CCMs show reasonable agreement with observed total ozone trends and variability on a global scale, but a greater spread in the ozone trends in polar regions in spring. Global long-term stratospheric temperature trends are in reasonable agreement with satellite and radiosonde observations. The simulated ozone evolution in the 21st century in the CCMs is mainly determined by decreases in halogen concentrations and continued cooling of the global stratosphere due to increases in greenhouse gases. Differences in stratospheric inorganic chlorine (Cly) among the models are key to diagnosing the inter-model differences in simulated ozone hole recovery.

Abstract G2 (Oral)

Inorganic Chlorine and Ozone Recovery in CCMs

Darryn Waugh, Veronika Eyring, and CCMVal Team

Changes in stratospheric chlorine play a major role in long-term changes of ozone, and it is important that coupled chemistry-climate models CCMs correctly model the time evolution of stratospheric chlorine. We examine here the evolution of stratospheric inorganic chlorine (Cly) and ozone (O_3) in the CCMs participating in the CCM Validation Activity. It is found that there are substantial quantitative differences between the simulations of Cly, with corresponding differences in the simulated ozone. In the polar lower stratosphere the peak Cly varies from less than 2 ppb to over 3.5 ppb, and the date at which the Cly returns to 1980 values varies from before 2030 to after 2050. There is a corresponding large range in the timing of recovery of Antarctic ozone back to 1980 values, and models with an earlier Cly recovery generally have an earlier ozone recovery. This agreement indicates that the differences in Cly between models are key to diagnosing the inter-model differences in simulated ozone recovery.

Abstract G3 (Poster)

Coupled chemistry climate model simulations of stratospheric temperature

John Austin, Piers Forster, John Wilson, et al

Temperature results from the CCMval simulations for the past are analysed using multi-linear regression including a trend, solar cycle and volcanic aerosol terms. The climatology of the models for recent years is in good agreement with observations for the troposphere and gradually diverge from each other in the stratosphere. Overall, the models agree better with observations than previous assessments. As a function of latitude and pressure, the model trends vary substantially from model to model, although all models show consistent features of overall cooling peaking near 1 hPa, and statistically significant cooling trends from generally the lower stratosphere upwards in the low and middle latitudes. Several models also indicate statistically significant cooling in the lower stratosphere over the polar regions. Many models also show statistically significant warming in the troposphere. The temporal variation in the global average temperature in the lower stratosphere is also compared with radiosonde observations, indicating clear warming signals during the volcanic eruptions, superimposed on an overall cooling. The model response to the volcanoes varies by about a factor of 2 with several models substantially overpredicting the observed response during the 1980s and 1990s. Comparison of the globally averaged temperature simulated by the models is generally in agreement with satellite data over much of their range, except near 5 hPa and 0.5 hPa. Model trend comparisons are also shown for the polar spring.

Abstract G4 (Poster)

Understanding the Changes of Stratospheric Water Vapor in GEOSCCM Simulations

Luke Oman, Darryn Waugh, Richard S. Stolarski, Steven Pawson, Anne R. Douglass, Paul Newman, and Eric J. Nielsen

Stratospheric water vapor is a very important part of the chemistry of the upper atmosphere. Therefore, any changes in the long term trend in the amount of water vapor could be significant. In this context, we examine the period of 1950-2100 in simulations using the GEOS coupled chemistry/climate model CCM to understand the forcings responsible for interseasonal to decadal scale variability in stratospheric water vapor. This will allow us to understand the relative impacts of changes in tropical sea surface temperatures, ozone, and meridional heat flux in determining the temperature response over tropical tropopause layer. It will be shown that this model does an excellent job reproducing the current mean state of stratospheric water vapor as compared to observations.

We will show that in GEOSCCM changes in tropical temperatures at 85 hPa, which is the cold point tropopause, can quantitatively explain most of the interannual variations in stratospheric entry water vapor. In contrast, the trend in 100 hPa tropical temperature is much larger, showing that examining 100 hPa temperatures might not be appropriate for analysis of changes in stratospheric water vapor. Over the 150 year simulation the cold point temperatures, and hence stratospheric entry water vapor, are very stable, and most of the trend in extra-tropical stratospheric water vapor is due to changes in methane.

Abstract G5 (Poster)

Transient simulations of climate changes in the upper stratosphere and mesosphere

Andreas I. Jonsson and Victor I. Fomichev

The Canadian Middle Atmosphere Model (CMAM) is a coupled chemistry-climate model (CCM) which extends from the surface up to about 95 km. It includes realistic implementations of the major physical and chemical processes necessary to represent the complexity of interactions throughout the model domain. An ensemble of three model simulations for the period 1960 to 2100 has been performed to investigate the atmospheric response to transient forcings in sea surface temperatures, CFCs and greenhouse gases, including CO_2, CH_4 and N_2O. This paper focuses on model results in the upper stratosphere and mesosphere. In particular, we analyze simulated trends in temperature, ozone and water vapor, and compare with available long-term observations.

While enhanced CO_2 acts to cool the middle atmosphere, temperature trends are modulated by long-term changes in ozone concentrations: CFC-induced ozone depletion in the past has lead to enhanced cooling whereas ozone recovery in the future will reduce the CO_2 effect. Also, due to the temperature dependency of gas-phase ozone chemistry the colder temperatures in the future will lead to a super recovery of ozone. Water vapor increases, mainly induced by increasing CH_4, can cool the atmosphere either directly through enhanced long-wave cooling or indirectly through reduced ozone concentrations resulting from enhanced HOx catalytic cycling. For an improved understanding of the relevance of the different processes we analyze changes in shortwave and longwave heating rates.

Abstract G6 (Poster)

Validation of the new version of the CCM SOCOL against satellite data.

Eugene Rozanov, Martin Schraner, Andreas Fischer, Vladimir Zubov, Patricia Kenzelman, Tatiana Egorova, Werner Schmutz, and Thomas Peter

The comparison of the CCM SOCOL results with observations and other models revealed some weaknesses of the model. A number of modifications of the transport and chemical part of the model were implemented to overcome the discovered problems. We have applied the family transport approach in the transport part of the code to prevent excessive destruction of the active chlorine in the high-latitudes lower stratosphere during winter season. The mass-fixer scheme for the ozone was modified to avoid artificial ozone loss during the early winter over the southern high-latitudes. We have also updated the chemical solver, description of the heterogeneous chemistry and the properties of the stratospheric sulfate aerosol. To fix the overall overestimation of the stratospheric water vapor we have parameterized the removal of the water vapor in the lower tropical stratosphere caused by freezing and sedimentation of the ice particles. We have carried out 29-year long model run covering 1976-2004 and compared the results of the new SOCOL version with available observations. The results of the comparison showed substantial improvement of the model performance especially over the polar areas. These results will be presented in details together with brief overview of further model development.

Abstract G7 (Oral)

Quantifying key sensitivities within CCMs as a means of CCM validation

Greg Bodeker, Petra Huck, Hamish Struthers, Irene Cionni, Dan Smale, Birgit Hassler, Tatiana Egorova, Eugene Rozanov, and Adrian McDonald

The climate sensitivity parameter, the change in global mean surface temperature corresponding to a given change in radiative forcing, is a useful diagnostic quantity for comparing global climate models with each other and with observations. In an analogous manner, in this study two semi-empirical equations were developed which relate the conversion of inactive Equivalent Effective Antarctic Stratospheric Chlorine (EEASC) to activated EEASC, and then the rate of ozone destruction to activated EEASC. The coefficients from these equations capture key sensitivities in the real atmosphere which can also be easily computed in CCMs. We propose that comparisons of these sensitivities may provide new insights into potential sources of differences in CCM projections of Antarctic ozone depletion.

The first semi-empirical model, regressed against MLS observations of ClO, was used to calculate the total mass of activated EEASC through a given Antarctic season when provided with stratospheric temperature fields and a definition of the vortex edge. The equation is a first order differential equation that results in two coefficients and relates the tendency time rate of change of activated EEASC to:

1 unactivated EEASC multiplied by PSC area multiplied by sunlight hours, and

2 a decay in activated EEASC to account for conversion back to reservoir species.

The second semi-empirical model, regressed against 20 years of Antarctic ozone mass deficit OMD observations, results in four coefficients and relates the time rate of change in Antarctic OMD to:

1 the mass of activated EEASC as derived from the first equation including a non-linear dependence,

2 strictly seasonally dependent increases in ozone within the vortex, and

3 to mid-latitude planetary wave activity to account for year-to-year differences in diabatic descent and/or dynamical resupply of ozone.

The OMD is a robust measure of the severity of Antarctic ozone depletion and these two semi-empirical models are able to explain much of the intra- and inter-annual variability observed in daily OMD time series. The paper presents a derivation of the 6 coefficients, shows how they quantify key sensitivities in reality, and discusses how they may be used for process oriented validation of CCMs.

Abstract G8 (Poster)

A comparison of temperature trends from CCMs and AOGCMs

Eugene Cordero and Veronika Eyring

Simulations of 20th and 21st century temperatures from coupled chemistry-climate models (CCMs) used for the 2006 WMO/UNEP Ozone Assessment and atmosphere ocean general circulation models (AOGCMs) used for the Intergovernmental Panel on Climate Change Fourth Assessment Report are compared to understand the role of interactive chemistry on temperature variability and trends. Climatological mean temperatures from the two model datasets are compared with observations to investigate annual and seasonal biases. Trend calculations between 1960-2000 are then examined to determine if CCMs are better constrained to observations in the stratosphere and upper troposphere than the AOGCMs. Trends in the 21st century are also investigated, and the relationship between these results and the simulated ozone and water vapor evolution will be discussed.

Abstract G9 (Poster)

Validation of the LMDZ-INCA climate chemistry model

Fabrice Jegou, Didier Hauglustaine, Francois Lott, Jean-Pierre Pomereau, Franck Lefevre, and Slimane Bekki

LMDZ-INCA is a coupled Climate-Chemistry Model developed to study the interactions between dynamical, physical and chemical processes in the troposphere and stratosphere and in particular the upper troposphere and lower stratosphere. The model uses 50 vertical levels from the surface to 76 km and a horizontal resolution of 2.5^{o} in latitude and 3.75^{o} in longitude. 63 chemical species are treated with this model.

Our first reference simulation was to reproduce the 1980-2006 period REF2 CCM-Val simulation. This simulation is designed to reproduce the well-observed period of the last 25 years during which ozone depletion is well recorded, and allows for 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, volcanic eruptions, and sea surface temperatures SSTs. SSTs in this run are based on observations.

In this study, we evaluate LMDZ-INCA by making comparisons with satellites and ground-based measurements. We use the UARS observations provided by the CLAES 1991-1993, HALOE, and MLS 1991-2005 instruments. To complete the 2000s period, we use the Odin SMR and OSIRIS 2001-2006 measurements. We also compare the LMDZ-INCA ozone field with the TOMS observations. The NDACC network observations give us the opportunity to make comparisons up to the stratosphere through lidar and micro-wave profiles. Finally we use the HIBISCUS campaign to improve our understanding of the H_2O stratospheric concentration.

The reference simulation is performed within the European project SCOUT O3 Activity 1 Ozone, climate and UV predictions. This reference simulation is also carried out in the framework of the ongoing CCMval activity established within the SPARC project.

Abstract G10 (Oral)

Diagnostic tests of polar ozone recovery

Paul Newman, E.R. Nash, A.R. Douglass, J.E. Nielsen, S. Pawson, and R.S. Stolarski

Correctly reproducing polar ozone losses in CCMs is technically challenging. First, the zeroth order dynamical processes must be correctly reproduced. This includes both temperature cold enough to form PSCs and a polar vortex that isolates the polar latitudes from mid-latitude influence. Second, the first order mean poleward and downward Brewer-Dobson circulation must be reproduced. Third, direct heterogeneous reactions and catalytic cycles must be correctly represented. Finally, the degradations of fully halogenated chlorofluorocarbons must be correctly simulated. In this work we show estimates of dynamical and chemical parameters from the GSFC GEOS-CCM that provide tests of the dynamics, transport, and chemistry for correctly simulating polar ozone loss. We will also show the recovery predictions of the GSFC-CCM.

Abstract G11 (Oral)

The CMAM transient simulations for CCMVal: Analysis of long-term changes in ozone

David Plummer, Stephen Beagley, Krill Semeniuk, John Scinocca, Jack McConnell, and Ted Shepherd

The Canadian Middle Atmosphere Model (CMAM) has been used to produce a three-member ensemble of transient simulations charting the evolution of the stratosphere from 1950 to 2100. To first-order, changes in total column ozone from the recent past out to the end of the 21st century displays the effects of changing chlorine loading, cooling of the upper stratosphere and dynamical changes associated with changes in wave-forcing from the troposphere. As chlorine loadings decrease CMAM projects a super-recovery in mid-latitude ozone columns, with a stronger recovery in the Northern Hemisphere, while tropical ozone is projected to remain below pre-1975 levels. The chemical and dynamical effects controlling these changes are analysed and will be discussed.

Abstract G12 (Poster)

A future prediction of the ozone layer using the CCSR/NIES Chemistry-Climate Model in the CCMVal-REF2 scenario

Hideharu Akiyoshi, Kei Sakamoto, Tatsuya Nagashima, Masaaki Takahashi, and Takashi Imamura

Global ozone variation in the REF2 scenario of CCMVal was calculated by the Center for Climate System Research, University of Tokyo / National Institute for Environmental Studies (CCSR/NIES) chemistry-climate model (CCM) in the years 1980-2100 using the Ab scenario (WMO 2003, Table 4B-2) for the halogen concentration and the IPCC A1B scenario (IPCC, 2000) for the greenhouse gas concentration. Table 1-16 in WMO 2003 is used for the halogen concentration after 2050. The sea-surface temperatures for the past and future are prescribed by the outputs of an atmosphere-ocean coupled general circulation model (CGCM) calculation for climate change, which uses the same greenhouse gas scenario. The CGCM was developed by CCSR, NIES, and the Frontier Research Center for Global Change of the Japan Agency for Marine-Earth Science and Technology (FRCGC).

The results of the REF2 run suggest that the ozone hole will disappear around 2050-2065. A sensitivity run was performed, in which the concentration of the global warming gases was fixed to the values at 1975 and the sea surface temperature was fixed to the 1970s mean. Although this calculation was stopped at the year 2063 by a computer renewal of NIES in March, the results suggest that the global warming effect accelerates the disappearance of the ozone hole by 10-20 years owing to ozone production in the colder stratosphere of the future atmosphere. However, in order to make the conclusion we have to carefully consider the low bias of stratospheric water vapor amount in the current version of the CCSR/NIES CCM. A tropopause height elevation in the future atmosphere of the REF2 scenario is obtained and its effects on the ozone profile are analyzed and discussed. A small ozone hole in a given year in high planetary wave activity with high equivalent effective stratospheric chlorine EESC concentration in the REF2 run is also analyzed, discussed, and compared with the observed 2002 ozone hole.

Abstract G13 (Poster)

Some results of time-dependent and time-slice simulations of stratospheric chemistry, dynamics, and temperature from the GEOS CCM

Richard Stolarski, Steven Pawson, Anne Douglass, Paul Newman, Randy Kawa, Qiung Liang, Eric Nielsen, Darryn Waugh, and Luke Oman

This paper will examine the co-evolution of ozone and temperature, particularly in the upper stratosphere, in the simulations of the GEOS CCM. We demonstrate that, in our simulations, nearly 2/3 of the temperature change in the northern mid-latitude upper and lower stratosphere were response to the changes in ozone over that time period. The temperature changes in both regions are expected to be significantly smaller over the next two decades as the ozone term changes sign with the projected beginning of ozone recovery. These temperature responses to ozone change go in the same direction as the ozone change, i.e. ozone decrease implies temperature decrease. As CFCs are removed from the atmosphere, the temperature change due to increasing greenhouse gases begins to dominate and the ozone response goes in the opposite direction as the temperature change, i.e. temperature decrease implies ozone increase due to temperature dependent ozone loss rates. The result is a super-recovery of ozone over much of the upper stratosphere. We will compare both ozone and temperature changes from our past simulations with the data record and will discuss the implication of these comparisons for the uncertainty in projection into the future using CCMs.

Abstract G14 (Poster)

The impact of increasing methane concentration on stratospheric chemistry and dynamics

Patricia Kenzelmann, Stephan Fueglistaler, Martin Schraner, Eugene Rozanov, and Thomas Peter

Methane is, after carbon dioxide, the strongest anthropogenic emitted greenhouse gas, which results in warming the troposphere and cooling the stratosphere. Its atmospheric concentrations roughly doubled in the last 100 years. Besides the direct effect of methane as greenhouse gas, tropospheric methane emissions influence the stratosphere chemically radiatively, and thus dynamically.

Increasing methane concentrations lead to higher water vapour concentrations in the stratosphere. It is expected that this results in enhanced ozone destruction by HOx-catalysed destruction cycles. The distribution of chemical species in the stratosphere is crucial for stratospheric temperatures, and the resulting perturbation of stratospheric dynamics can propagate downwards into the troposphere.

By means of the chemistry climate model SOCOL we performed sensitivity tests to investigate the impact of methane increase on processes in the stratosphere and troposphere. Steady state runs for pre-industrial 0.7 ppmV, present 1.7 ppmV and possible future methane concentration 2.7 ppmV suggest the following:

While the water vapour content increases roughly linearly with increasing methane, the perturbation in ozone differs in latitude and altitude. Increasing methane concentrations reduce polar ozone destruction, because active chlorine is reduced by reaction with methane. Conversely, ozone decreases in the upper stratosphere and mesosphere, because of enhanced HOx chemistry. We will further discuss the asymmetric behaviour of the southern and northern hemisphere with respect to changes in dynamics and chemistry related to methane concentrations.

Abstract G15 (Poster)

Stratospheric chemistry/climate simulations with the GEOS CCM

Eric Nielsen and Steven Pawson

This work discusses the Goddard Earth Observing System Chemistry Climate Models (GEOS CCMs.) The first version is based on the GEOS-4 General Circulation Model GCM coupled to a comprehensive stratospheric chemistry component. A number of multi-decadal simulations spanning the period 1950-2100 are complete, and the results are being used to study problems associated with ozone and climate in the current and future stratosphere. Some of the results will be presented, while others are included in the CCMVal model inter-comparison evaluations. A second version of GEOS CCM is recently complete, and it utilizes the chemistry component of the first version integrated into the next generation GEOS-5 GCM. A few sensitivity experiments have been run, and the impacts of gravity wave drag on polar stratosphere dynamics and ozone are discussed. Development is now focused upon integrating a combined troposphere-stratosphere chemistry module into GEOS-5. Our strategy for future simulations will be illustrated. Some early results may be shown.

H. Effect of Stratosphere on Troposphere

Abstract H1 (Oral)

Volcano-induced Climate Impacts and ENSO Interaction

Georgiy Stenchikov and Thomas Delworth

Strong explosive volcanic eruptions can produce global stratospheric aerosol clouds affecting the Earth's radiative balance. The climate responses to such volcanic eruptions form as a result of the interaction of associated thermal and dynamic perturbations of the major modes of climate variability, e.g., Arctic Oscillation (AO) and El Nino-Southern Oscillation (ENSO). The paleo-proxy data (Adams et al., 2003) even suggest that strong tropical eruptions could increase the likelihood of El Nino. It was also observed that the strong low-latitude eruptions affect the mid-to-high-latitude circulation forcing an anomalously positive phase of AO but the AO responses to volcanic forcing might depend on the ENSO phase (Stenchikov et al., 2006).

The strongest explosive eruptions of the second half of 20th century Agung, El Chichon, and Pinatubo occurred in El Nino years and had a significant effect on the climate (Delworth et al., 2005; Ramaswamy et al., 2006). The El Nino that occurred in the same year as the El Chichon eruption 1982 was especially strong and significantly affected the climate response. To better quantify an ENSO-Volcano-AO interaction in this study we employed a coupled climate model (GFDL CM2.1) and specifically designed the numerical experiments to study how volcanic eruptions could perturb AO and ENSO and how the ENSO phase could affect the AO sensitivity and global climate response. As a test eruption we have chosen the strongest and best observed eruption in 20th century -- that of Mt. Pinatubo June, 1991. To synchronize volcanic eruptions and the specific ENSO phase we have chosen initial conditions from those years of the 300-year control run that exhibited, respectively, El Nino, La Nina, or neutral ENSO phase and conducted ten 20-year ensemble runs with El Nino and La Nina initial conditions, and 30 five-year runs for neutral initial conditions.

We found that in CM2.1 simulations volcanic forcing cannot affect the phase of ENSO. However, the surface air temperature anomaly depends significantly on ENSO. The maximum cooling for El Nino cases tends to shift to the second year after the eruption. In La Nina cases maximum cooling appears in the year when the eruption occurred. However, the temperature responses appear to be very similar in both El Nino and La Nina cases when the SST effect was removed, suggesting a linear superposition of global responses to volcanic forcing and SST. Because of high climate variability in the coupled model we could not obtain a definite conclusion about differences of the AO sensitivity to volcanic forcing for El Nino and La Nina initial conditions.

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Abstract H2 (Poster)

The influence of major volcanic eruptions on the atmosphere as represented in different ECHAM model versions

Kirstin Krüger, Janine Flöter, Ralf Hand, Claudia Timmreck, Irene Fischer-Bruns, Marco Giorgetta, Benedikt Steil, Christoph Brühl and Erich Roeckner

Since the volcanic eruption of Mt. Pinatubo in 1991, no other major volcanic eruption has taken place in the past 16 years. In this paper the effects of major volcanic eruptions will be analysed in more detail using two different versions of the state of the art general circulation model ECHAM.

One version is the coupled atmosphere ocean model ECHAM5-OM1 with a top layer of the model lid at 10 hPa (~30 km altitude). This model was run in an IPCC type of experiment from 1860 to 1999 including the major volcanic eruptions. To derive a statistical analysis three ensemble runs have been carried out. The other model version is the Middle Atmosphere ECHAM4 coupled with the interactive chemistry tool CHEM (MAECHAM4-CHEM) with a model top at 0.01 hPa (~80km altitude). This set up was once run from 1960 to 1999 and secondly from 1980 to 1999.

Both models have their advantages and disadvantages. The first model takes care of atmospheric feedbacks with an interactive ocean, taking care of the longer term memory of the ocean for climate change scenarios but without a realistic representation of the Brewer-Dobson Circulation (BDC). The latter model is coupled to an interactive stratospheric chemistry tool taking chemical feedbacks of e.g. volcanic aerosols into account and the full branch of the BDC.

The influence of major volcanic eruptions (Mt. Agung 1963, El Chichon 1982 and Mt. Pinatubo 1991) on the atmosphere will be analysed in both model setups analysing global temperature anomalies, changes of the residual circulation and the Arctic oscillation patterns in detail. Agreements and deficiencies between the two different model setups will be used to derive a better understanding of the underlying important atmospheric processes.

Abstract H3 (Poster)

Troposphere/Stratosphere coupling and its effect on Tropospheric Ozone.

Richard Damoah, David Stevenson, Wenshou Tian and Martyn Chipperfield

Two detailed chemistry schemes, one tropospheric and one stratospheric, have been coupled within the Met Office Unified Model HadAM3. Both schemes have been used independently within the UM for many studies and using them simultaneously provides a computationally efficient full stratosphere-troposphere model. The tropospheric scheme is from the STOCHEM model chemistry calculated up to 50 hPa, which integrates 70 species including detailed non-methane hydrocarbon chemistry. Many of the natural sources e.g. lightning NOx, biogenic isoprene are derived interactively from the climate model. In the stratosphere, we use the scheme from the SLIMCAT CTM chemistry calculated above 145 hPa which contains a description of Ox, NOy, HOx, Cly, Bry, source gases and CH_4 oxidation as well as heterogeneous chemistry on sulfate aerosols and polar stratospheric clouds. Both schemes operate independently but common fields e.g. O_3, CH_4, CO, HNO_3, NOx and N_2O_5 are exchanged between the schemes. Model fields O_3, CH_4, CO, HNO_3, NOx and N_2O_5 are merged in the overlap region of the UT/LS 145 hPa-75 hPa every 3 hours.

We have compared the coupled output with observations and model results from an uncoupled version. The coupling led to an increase in modelled tropospheric O_3 concentrations of up to 100 in the lower/middle troposphere, but much larger increases occur in the southern hemisphere and the upper troposphere. Compared with observations the coupled model shows an improvement over the uncoupled version where STOCHEM used a fixed stratosphere, which tends to underestimate tropospheric O_3. The impact of coupling is least in the tropics where changes are less than 10%. Tropospheric ozone budgets were also affected by coupling as follows: stratospheric input rose sharply by 120% chemical production fell by 10% chemical loss almost unchanged and dry deposition rose by 10%. Both the ozone burden and the ozone lifetime were approximately unchanged at 285 Tg and 19 days, respectively.

Abstract H4 (Poster)

Troposphere/Stratosphere coupling and its effect on Tropospheric Ozone.

Wenshou Tian, Richard Damoah, David Stevenson and Martyn Chipperfield

Two detailed chemistry schemes, one tropospheric and one stratospheric, have been coupled within the Met Office Unified Model HadAM3 (see poster by Damoah et al). Here we use results from 2 runs of the model to investigate the impact of stratospheric ozone recovery on tropospheric chemistry.

I. Data

Abstract I1 (Oral)

The role of BADC in CCMVal: Possibilities and limitations

Martin Juckes

The British Atmospheric Data Centre exists to collect, archive, curate and distribute atmospheric data in support of UK atmospheric science research activities. The role of accurate and easily accessible information about the data has become clear in recent years, as users increasingly turn towards data products which they can access easily and transparently. The BADC supports this trend by participating in international debates about data formats and data description conventions, by developing supporting software, both at the data management and at the scientific level. Recent projects relevant to CCMVal include the support for HIGEM, in which BADC work led to early identification of problems in the model output, and the IPCC Data Distribution Centre, for which BADC is implementing a new web service based data visualisation tool. In ongoing development work the capabilities of the visualisation tool will be expanded to include simple analysis options, such as differencing and ensemble averaging of experiments. The level of support which BADC can give to any given project is ultimately determined by the success or failure of attempts to fund that support. The quality of the products made available through the BADC web services depends in turn, not only on the level of support provided by BADC, but also on the quality of the data, and the information about it, provided to the BADC.