Chemistry-Climate Model Validation Activity for SPARC (CCMVal)

- Status and Overview -

DARRYN WAUGH (JHU) AND VERONIKA EYRING (DLR)

Joint TF HTAP/ NAS / AC&C workshop

Washington DC, 9-13 June 2008

Institut für Physik der Atmosphäre

Department of Earth and Planetary Sciences

HISTORY

- 1st CCMVal workshop (Grainau, Germany, 2003):

  Core processes and a set of **standard diagnostics** defined.

- 2nd workshop (NCAR, USA, 2005):

  The set of **standard diagnostics** was further refined.

  Common reference simulations and **data requests** agreed

- CCMVal-1 Simulations

  Results used in support of **2006 WMO/UNEP Ozone Assessment and IPCC AR4.**

- 3rd workshop (Leeds, 2007)

  Planning of **CCMVal-2** and **SPARC CCMVal Report.**

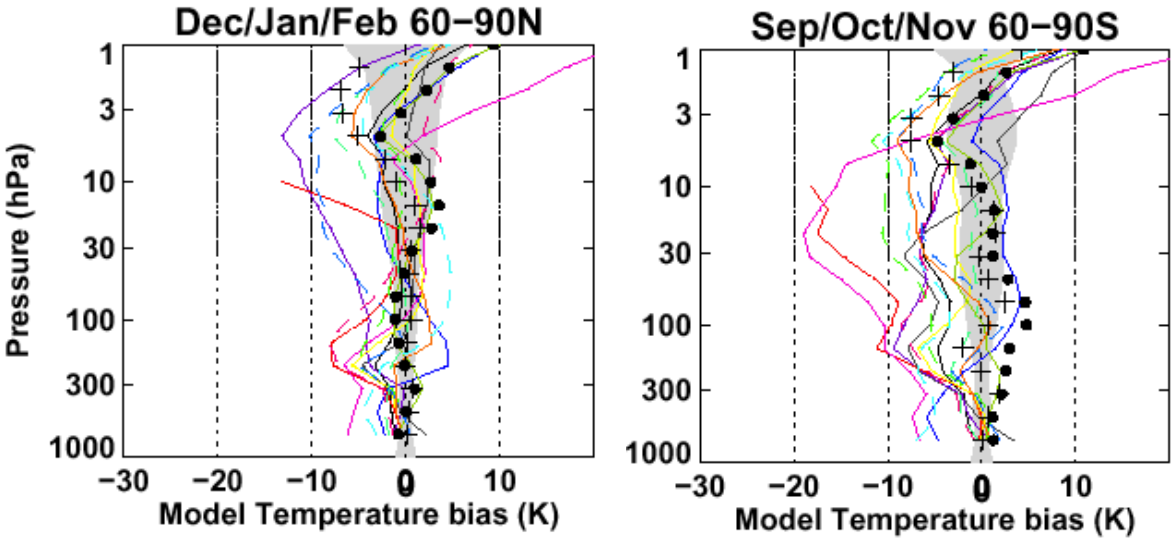
- 4th workshop planned for Toronto 2009.

CCMVAL-1

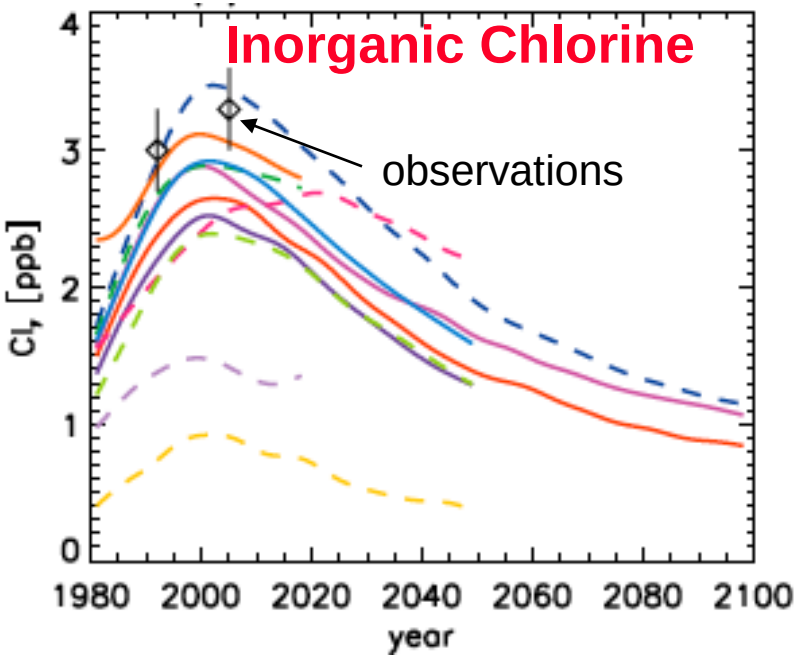
- 13 CCMs participated in the first round of CCMVal (CCMVal-1)
- Output collected in the central CCMVal database at the **British Atmospheric Data Centre (BADC)**
- Evaluation diagnostics obtained from various observational datasets
- Results have been used to support the **2006 WMO/UNEP Scientific Assessment of Ozone Depletion** and **IPCC AR4**
- Currently 35 **CCMVal Collaborators** working with CCMVal output
  - Open archive; If you are interested working with the CCMVal data, see **Guidelines for CCMVal Collaborators** at **http://www.pa.op.dlr.de/CCMVal/**
- Several CCMVal-1 papers published, submitted or in preparation
- Demonstrated the advantage of a multi-model evaluation strategy

CCMVal-1: Model Assessment

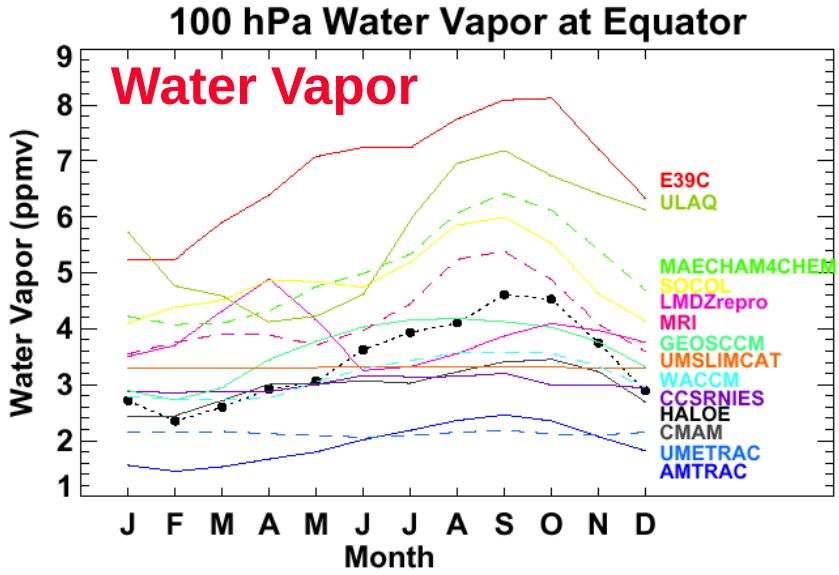
Temperature Bias



Inorganic Chlorine

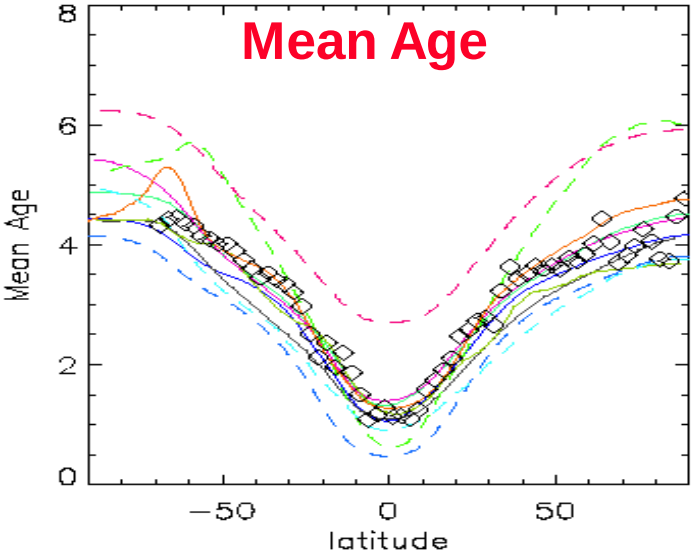


Water Vapor

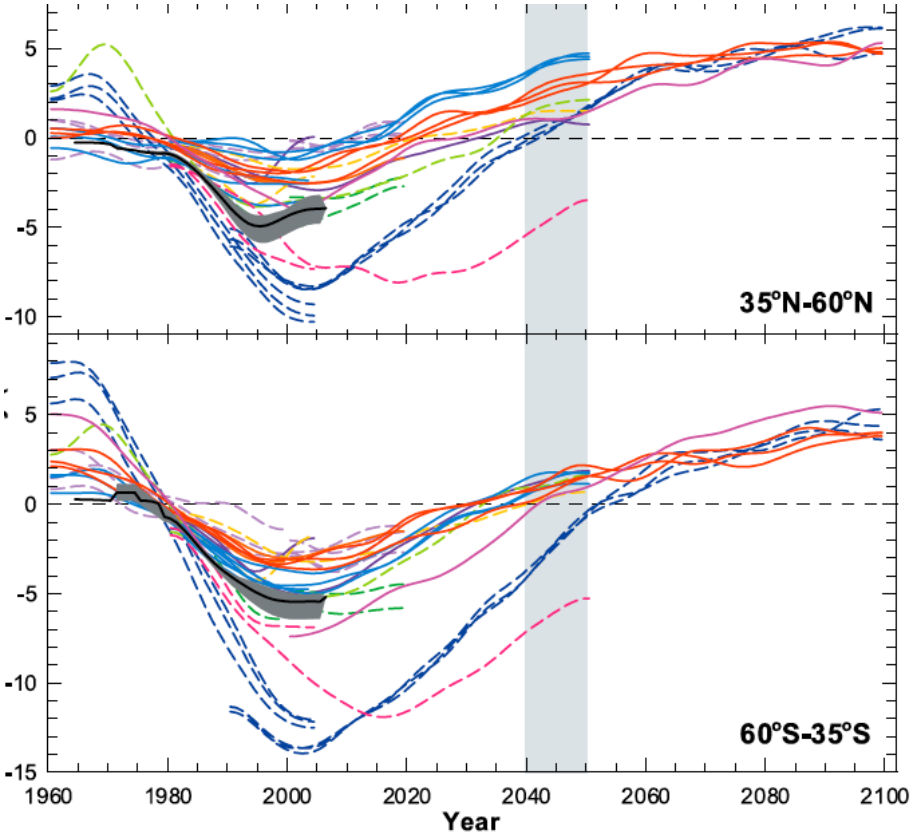


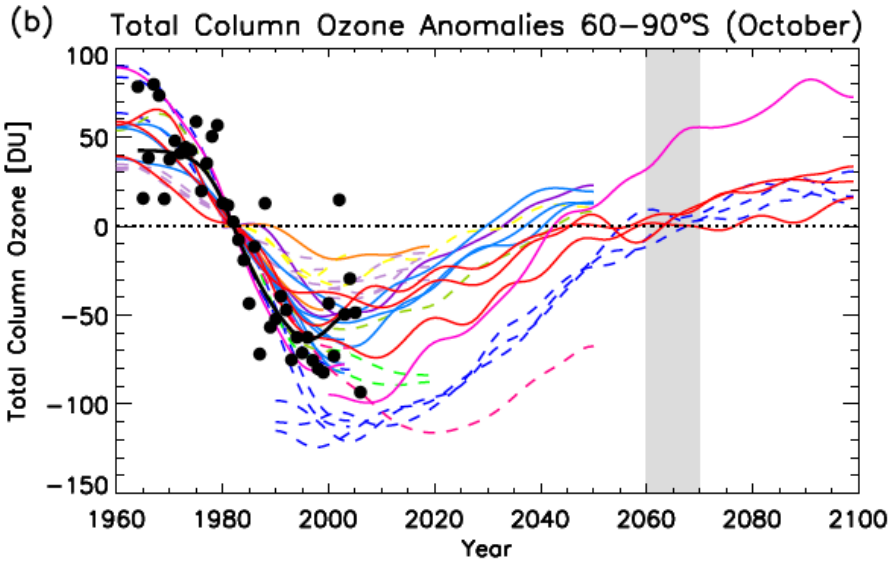
Eyring et al, JGR, 2006

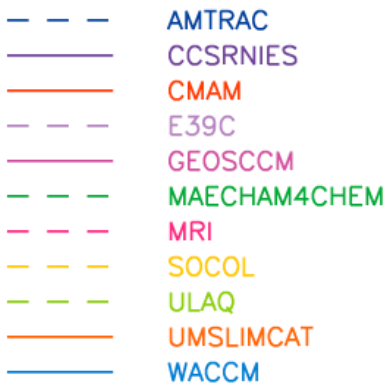
Mean Age



CCMVal-1: Ozone Projections



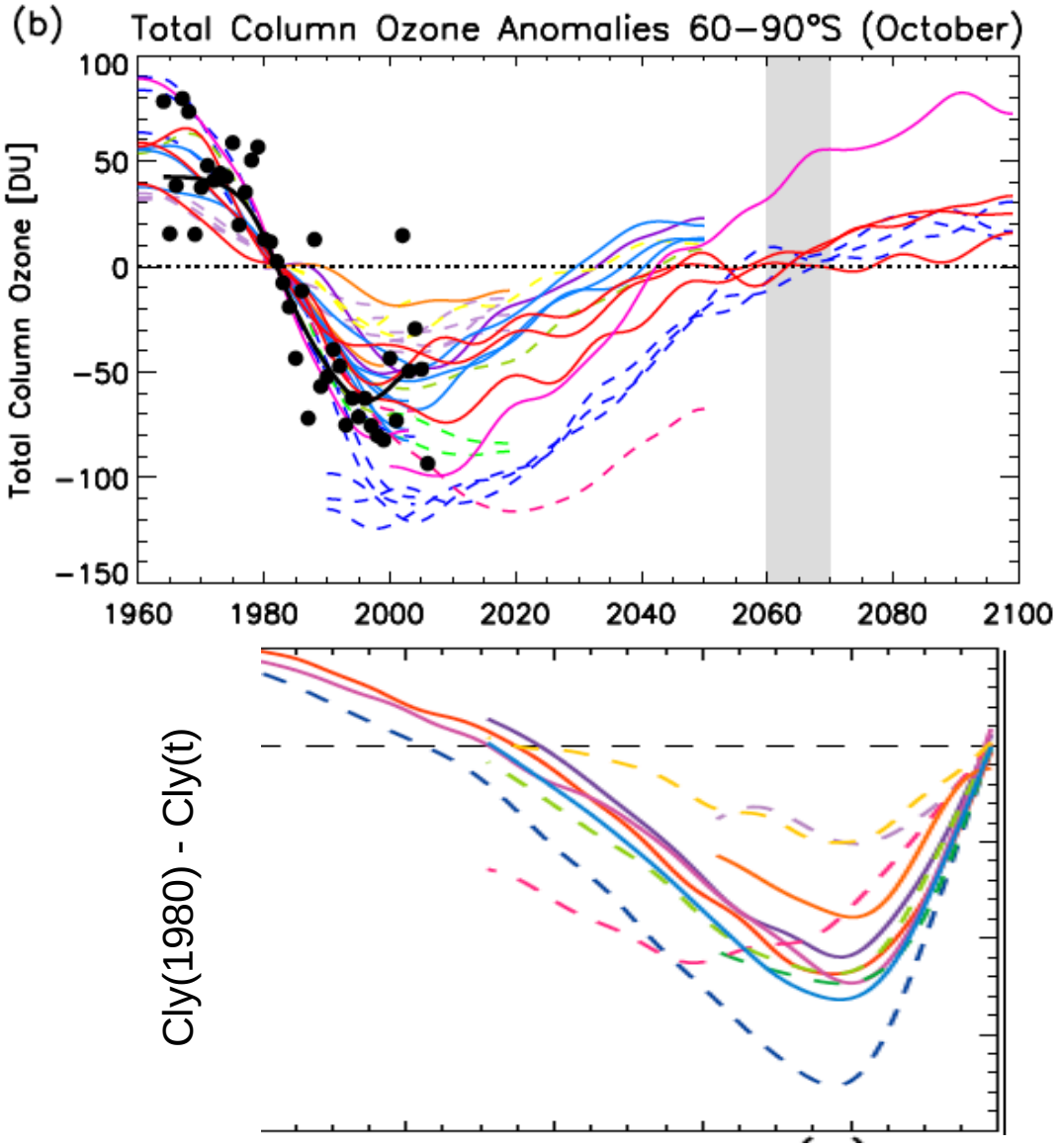




Large spread in simulated column ozone, both for mid-latitudes and polar regions.

Eyring et al, JGR, 2007

CCMVal-1: Ozone and Cly



Eyring et al, JGR, 2007

Good correspondence between evolution of Cly and O_3 (variations in the simulated Cly explain a lot of the variations in O_3).

AMTRAC
CCSRNIES
CMAM
E39C
GEOSCCM
MAECHAM4CHEM
MRI
SOCOL
ULAQ
UMSLIMCAT
WACCM

CCMVal-2

- Next round of CCMVal (CCMVal-2)
- Around 20 CCMs participating. Include varying degrees of **tropospheric chemistry.** Some may include dynamics **oceans**.
- Standardized data format, again archived at **British Atmospheric Data Centre (BADC)**
- Evaluation of models will be done in SPARC CCM Report.
- Results will be available for the **2010 WMO/UNEP Scientific Assessment of Ozone Depletion** and **IPCC AR5**

CCM groups expected to participate in CCMVal-2

	Model	Group and location	Horiz. resolution	Vertical Layers / Upper Boundary
1	**AMTRAC**	GFDL, USA	2 x 2.5	48 L / 0.002 hPa
2	**CHASER**	CCSR, NIES, FRCGC, Nagoya University , Japan	T42 or T63	40 L / 0.01 hPa
3	**CMAM**	Univ. of Toronto, York Univ., CCCma, Canada	T47 or T63	71 L / 0.0006 hPa
4	**E39C-ATTILA**	DLR Oberpfaffenhofen, Germany	T30	39 L / 10 hPa
5	**ECHAM5MESSy**	MPI-M, Germany	T42	90 L / 0.01 hPa
6	**ECHAM5MESSy(DLR)**	DLR Oberpfaffenhofen, Germany	T42	41 L / 5 hPa
7	**ECHAM5MESSy-O**	FUB Berlin, Germany	T42	39 L / 0.01 hPa
8	**GEOSCCM**	NASA/GSFC, USA	2 x 2.5	72 L / 0.01hPa
9	**HAMMONIA**	MPI-M, Germany	T31	119 L / 1.7e-7
10	**LMDz-INCA**	LSCE/CNRS, France	3.75 x 2.5	50 L / 0.07
11	**LMDzrepro**	IPSL, France	2.5 x 3.75	50 L / 0.07 hPa
12	**MOCAGE-Climat**	Météo-France/CNRM	T42	60 L / 0.07 hPa
13	**MRI**	MRI, Tsukuba, Japan	T42 or T63	68 L / 0.01 hPa
14	**Oslo-WACCM**	Univ. of Oslo, Norway	2.5 x 2.5	66 L / ~5 x 10^{-6}
15	**SOCOL**	PMOD/WRC and ETHZ, Switzerland	T30	39 L / 0.1 hPa
16	**UKCA**	Univ. of Cambridge, MetOffice, UK	3.75 x 2.5	60 L / 84 km
17	**ULAQ**	University of L'Aquila, Italy	10 x 22.5	26 L / 0.04 hPa
18	**UMETRAC**	UK Met Office, UK; NIWA Lauder (NZ)	2.5 x 3.75	64 L / 0.01 hPa
19	**UMSLIMCAT**	University of Leeds, UK	2.5 x 3.75	64 L / 0.01 hPa
20	**WACCM**	NCAR, USA	1.9 x 2.5	66 L / ~5 x 10^{-6} hPa

CCMVAL-2 REFERENCE SIMULATIONS

	Period	Greenhouse Gases	ODSs	SSTs/SICs	Aerosol	Solar Variability	QBO	Ozone and Aerosol Precursors
REF-B0	**Time slice 2000** 20 yrs	**OBS** Fixed at 2000 concentrations (from IPCC, 2001), repeating each year	**OBS** Fixed at 2000 concentrations (from Table 8-5 WMO, 2007), repeating each year	**OBS** 1995-2004 average derived from HadISST1, repeating each year	**OBS** Background SAD from 2000	**OBS** Averaged solar irradiance over 1 solar cycle	**Only internally generated**	**OBS** RETRO 1998-2000 mean
REF-B1	**Transient simulation 1960-2006**	**OBS**	**OBS**	**OBS** HadISST1	**OBS**	**OBS**	**OBS or internally generated**	**OBS** Extended RETRO data set
REF-B2	**Transient simulation 1960-2100**	**A1B(medium)** (from IPCC, 2000)	**OBS + adjusted A1 scenario** [WMO 2007, Table 8-5]	**Modeled SSTs**	**OBS** Background SAD from 2000	**NO**	**Only internally generated**	**Same as REF-B1 until 2000 + adjusted scenario through 2100**

+ Several Sensitivity and Control Simulations

CCMVal-2 Sensitivity and Control Simulations

Scenario	Period	GHGs	ODSs*	SSTs/SICs	Background & Volcanic Aerosol	Solar Variability	QBO	Ozone and Aerosol Precursors
CTL-B0 1960	**Time slice 1960** Spin up then provide a minimum of 20 years of output.	**OBS** Fixed at 1960 concentrations (from IPCC, 2001), repeating each year	**OBS** Fixed at 1960 concentrations (from Table 8-5 WMO, 2007), repeating each year	**OBS** 1955-1964 average derived from HadISST1, repeating each year	**OBS** Background SAD from 1979	**OBS** Averaged solar irradiance over 1 solar cycle	**Only internally generated**	**OBS** RETRO 1958-1962 mean
SCN-B2a SRESA2 (or new IPCC RCPs)	**1960-2100**	**OBS + new IPCC GHG RCP**	Same as in REF-B2	**SSTs/SICs distribution consistent with SRES A2 GHG scenario**	Same as in REF-B2	Same as in REF-B2	Same as in REF-B2	**Same as REF-B1 until 2000 + new IPCC GHG RCP**
SCN-B2b Fixed Halogens	**1960-2100**	Same as in REF-B2	**Fixed halogen scenario**	Same as in REF2	Same as in REF-B2	Same as in REF-B2	Same as in REF-B2	Same as in REF-B2
SCN-B2c NCC	**1960-2100**	**Fixed GHG**	Same as in REF-B2	1955-1964 average of values used in REF-B2, repeating each year	Same as in REF-B2	Same as in REF-B2	Same as in REF-B2	Same as in REF-B2
SCN-B2d Natforcing QBO	**1960-2100**	Same as in REF-B2	Same as in REF-B2	Same as in REF-B2	**OBS in the past and background aerosol in the future**	**OBS repeating in future**	**OBS / repeating in future or internally generated**	Same as in REF-B2

Standardized Input and Data Archive

- **Output will be collected in 'Climate and Forecast (CF)' compliant netCDF format**
- **Output file name specified**
  - **CCMVal2_${CCMVal-model-experiment}_${MODELNAME}_${ID-ENSEMBLE}_'${Output field number}_${output variable name}**
  - e.g., **CCMVal2_REF-B1_CMAM_1_T3M_ta** for monthly-mean 3-d temperature data or **CCMVal2_REF-B1_CMAM_1_T2Mz_ta** for monthly-mean zonal mean 2-d temperature data
- **Global Attributes for netCDF files have been defined**
- **Example Headers and a Reformatting Tool are available on the CCMVal website** http://www.pa.op.dlr.de/CCMVal/DataRequests/CCMVal-2_ExampleHeaders.html
  - The purpose of this reformatting tool is to convert an arbitrary netCDF file to a CF1.1 netCDF file, using the name convention of the CCMVal Data Request.
- Management (Cataloging, Checking consistency formats etc)
- **Metadata for model documentation to be collected at BADC**
- **CCMVal diagnostic tool and code repository for more complex diagnostics will be developed and will be made publicly available**

CCMVal-2 DATA REQUEST (NEW CF NAMES DEFINED FOR MORE THAN 150 VARIABLES)

	CF standard name (all accepted)	**Long_name** (given in addition for some variables or where a CF name doesn't exist)	**Output variable name***	**Units**	**Output Fields**	**Notes** Numbers in [] refer to chapters of the SPARC CCMVal report
1	air_temperature		ta	K	**T3M, T2Mz, T3I, T2Iz**	[6,7]
2	air_temperature		ta10	K	**T2Is**	[6,7] temperature on the 10 hPa surface
3	air_temperature		ta100	K	**T2Is**	[6,7] temperature on the 100 hPa surface
4	air_pressure		plev	Pa	**T2Mz, T3I**	[6,7]
5	ertel_potential_vorticity		vorpot	K m^2 kg^{-1} s^{-1}	**T3I**	[6,7]
6	age_of_stratospheric_air	mean_age_of_ stratospheric_ air	mean_age	years	**T3M, T2Mz, T3I**	The mean age of air is defined as the mean time that a stratospheric air mass has been out of contact with the well-mixed troposphere.
..	...		...	...	...	...
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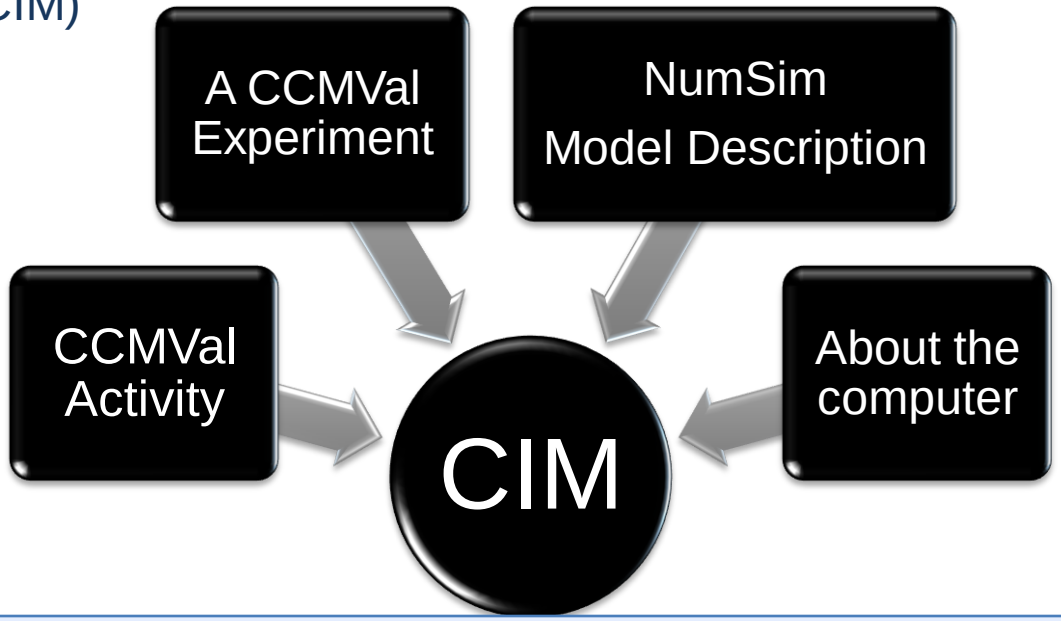
Connecting Metadata

- CCMVal is the prototype dataset for the development of METAFOR services at the BADC
- "One-Stop-Shop" access to simulation holdings informed by the METAFOR Common Information Model (CIM)



Linking information about simulations in a structured way.
Aiding their discovery and maintaining their provenance.

- CCMVal will benefit from improvements in our ability to capture key aspects of model descriptions in the CIM.
- METAFOR will benefit from the lessons we learn when applying these concepts to CCMVal.

NEW CCMVAL DATA POLICY

- http://www.pa.op.dlr.de/CCMVal/CCMValDataPolicy_Feb2008.pdf

  - **PHASE 1:** From the date of submission of model output to BADC there will be a **1.5-year restricted use policy** for all new runs. This allows use of model output by 'CCMVal Collaborators' but includes the **obligation to offer co-authorship for model PIs** during this time. **CCMVal collaborators are expected to provide an abstract** of the planned research for the CCMVal website at the beginning of their studies. **CCMVal and BADC should be explicitly acknowledged** in papers and the models need to be properly referenced.

  - **PHASE 2: after 1.5 years from submission to BADC** the model data will **still be password restricted at BADC** but **the obligation to offer co-authorship for model PIs is removed**. CCMVal collaborators are expected to send **draft presentations or papers to model PIs and CCMVal coordinators** 2 weeks before submission for notification and for the possibility to comment within this 2-week period. **Collaborators still need to provide an abstract** of the planned research for the CCMVal website at the beginning of their studies. **Model groups, CCMVal and BADC** should be explicitly acknowledged in papers and the **models need to be properly referenced.**

SPARC CCMVal Report

The "**SPARC CCMVal Report on Evaluation of Chemistry Climate Models**" aims to provide a comprehensive, up-to-date assessment of

1. The ability of CCMs to represent the stratospheric ozone layer, stratospheric climate and variability, and
2. The coupled ozone-climate response to natural and anthropogenic forcing.

The report will be completed in time (late 2009) to provide useful and timely information for the 2010 WMO/UNEP Ozone Assessment and IPCC AR5. It will:

- Allow a better overall evaluation of the models
- Couple assessments of models with analysis of the science
- Improve input of CCM community to the assessments
- The Report will assign quantitative scores (grades) to the different data-based diagnostic tests.

SPARC CCMVAL REPORT OUTLINE

- Synthesis Chapter and Introduction *{Eyring, Shepherd, Waugh}*
- Chemistry Climate Models and Scenarios *{Giorgetta, Shibata}*
- *Part A: Process evaluation*
  - Radiation *{Fomichev, Forster}*
  - Dynamics *{Butchart, Charlton}*
  - Transport *{Neu, Strahan}*
  - Chemistry and microphysics *{Chipperfield, Kinnison}*
  - UTLS *{Gettelman, Hegglin}*
- *Part B: Chemistry-Climate Coupling*
  - Natural Variability *{Manzini, Matthes}*
  - Long-term Projection of Stratospheric Ozone *{Austin, Scinocca}*
  - Effect of the Stratosphere on Climate. *{Baldwin, Gillett}*

Quantitative Performance Metrics ("Grading")

The SPARC report chapters will assign "grades" to model-data comparisons.

Several potential benefits:

- It will allow easy visualization of the model's performance for multiple aspects of the simulations.
- In the case of a systematic bias for all models, it will allow identification of missing or falsely modeled processes.
- It will enable a quantitative assessment of model improvements, for different versions of individual CCMs, and for different generations of community-wide collection of models used in international assessments (e.g. CCMVal-1 vrs CCMVal-2).
- It will make it possible to assign relative weights to the prediction by the different models and to form a best estimate plus variance that takes into account the differing abilities of models to reproduce key processes.

Initial grading study

Waugh and Eyring (ACPD, 2008) examined the application of grading metrics to CCMs.

Considered the same 13 CCMs, same process-oriented diagnostics, and same data as used in *Eyring et al.* (2006).

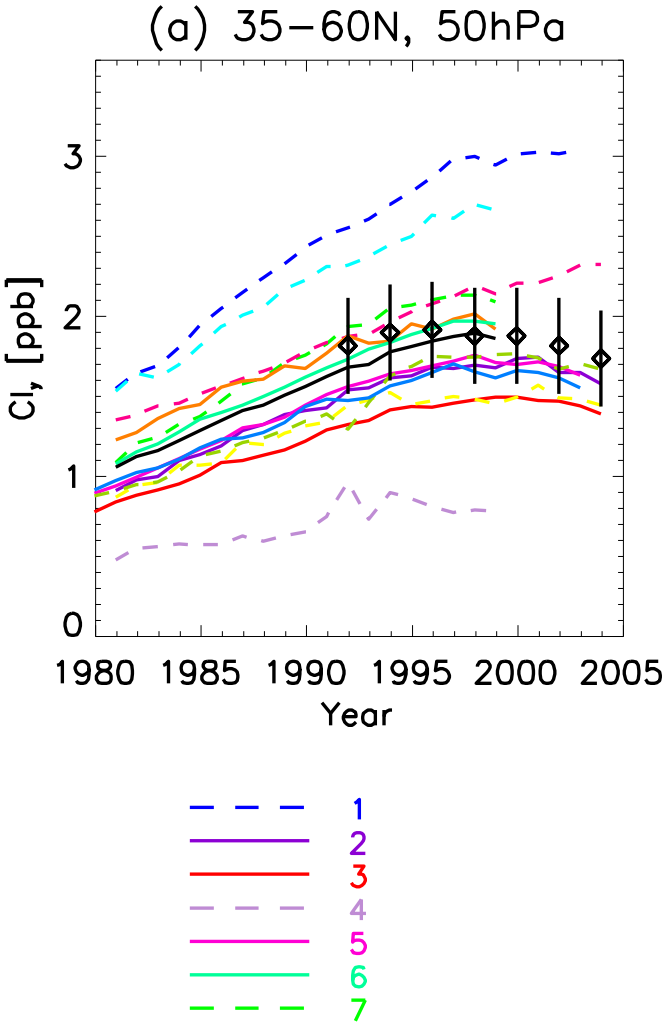
Use the same metric for all diagnostic tests.

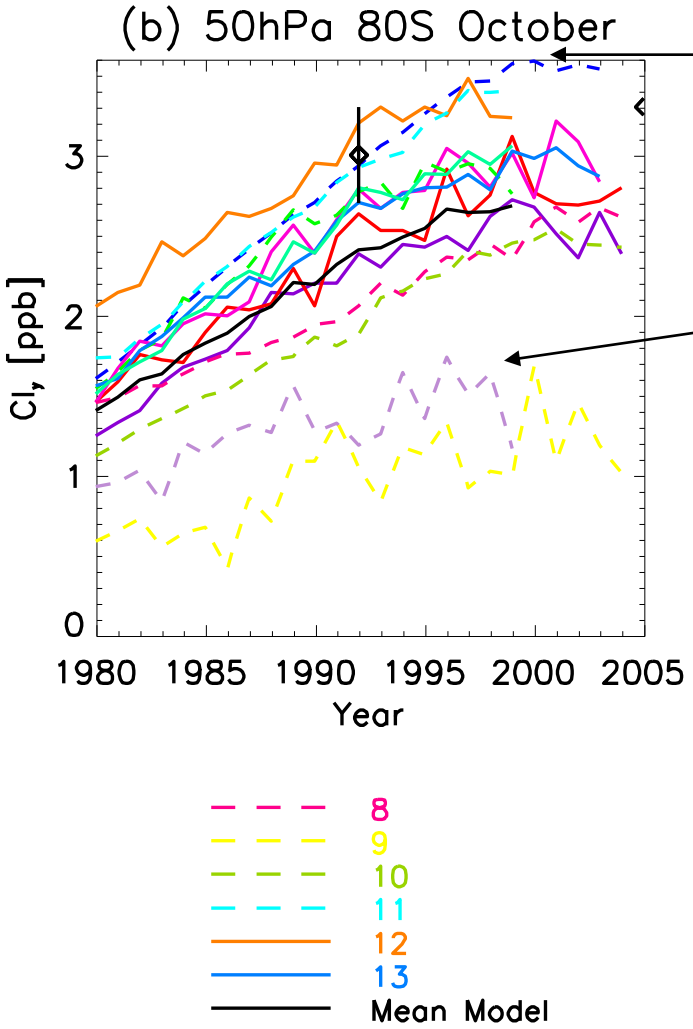
$$g = 1 - \frac{1}{n_g} \frac{|\mu_{\text{model}} - \mu_{\text{obs}}|}{\sigma_{\text{obs}}}$$

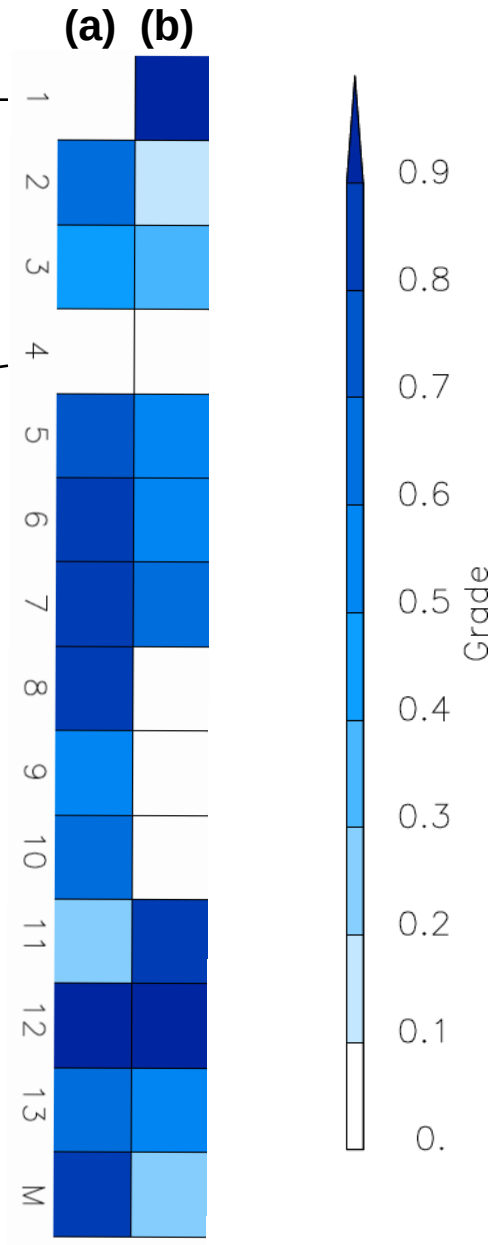
If scale factor $\mathbf{n_g=3}$, then g=0 if the model mean is 3σ from the observed mean.

Quantitatively showed what *Eyring et al.* (2006) had said in words.

Example: Inorganic Chlorine Cly

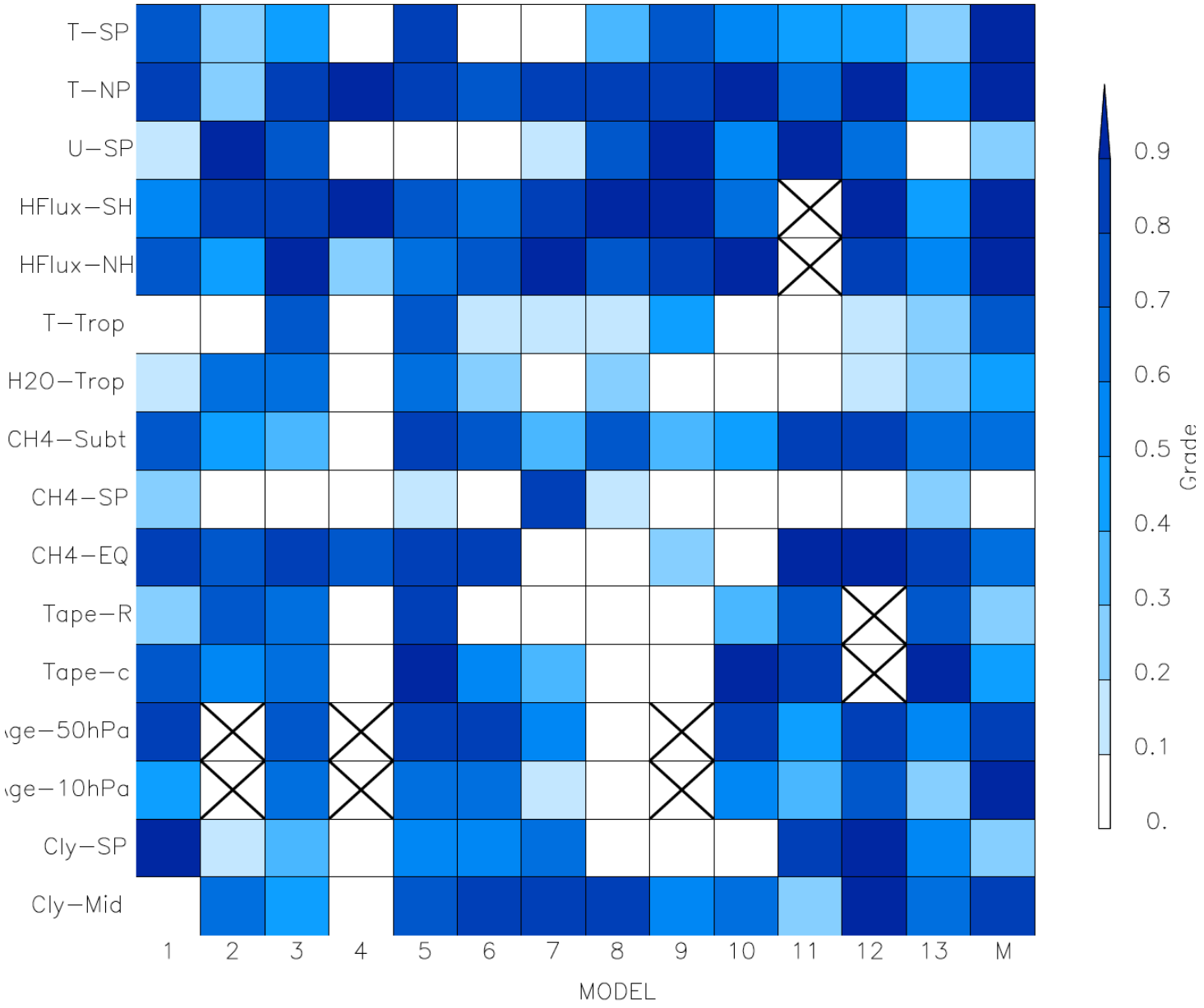






Waugh and Eyring, ACPD, 2008

Grading Matrix



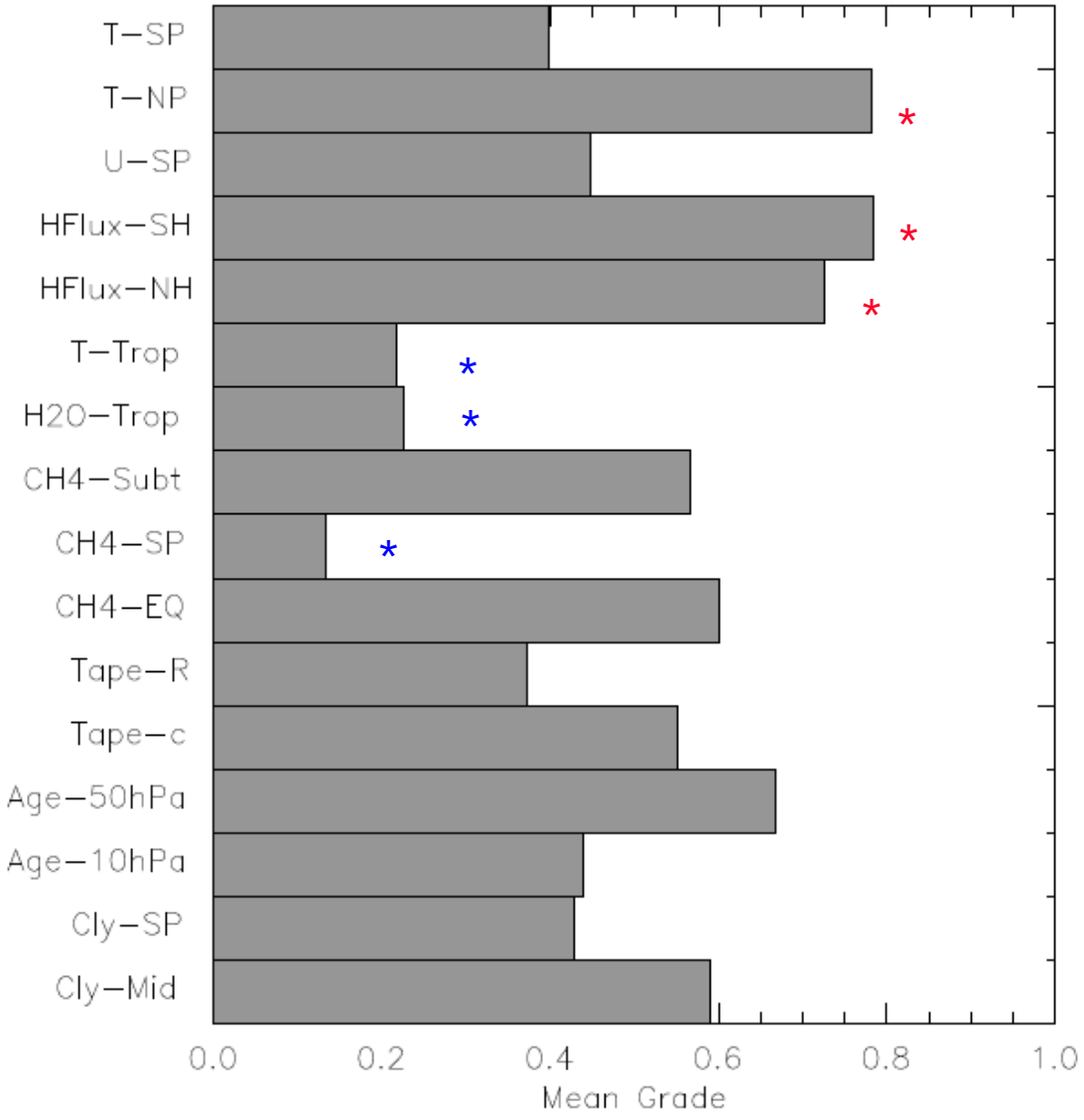
Wide range of grades

- can occur for different diagnostics applied to same model (6,7,12)
- for the same diagnostic but different models (most rows)

No model scores high / low on all tests.

Waugh and Eyring, ACPD, 2008

Grading: Variations between diagnostic tests

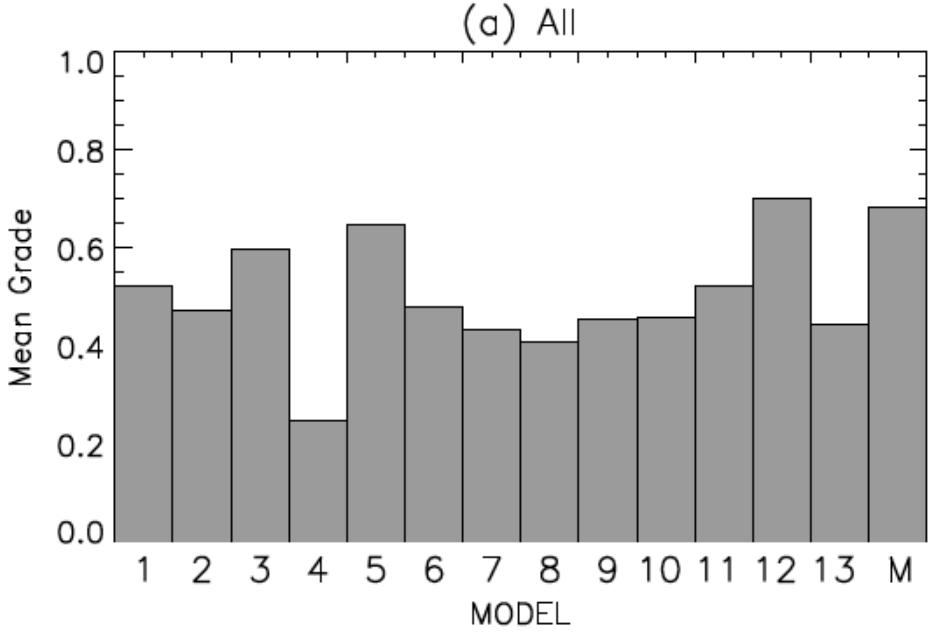


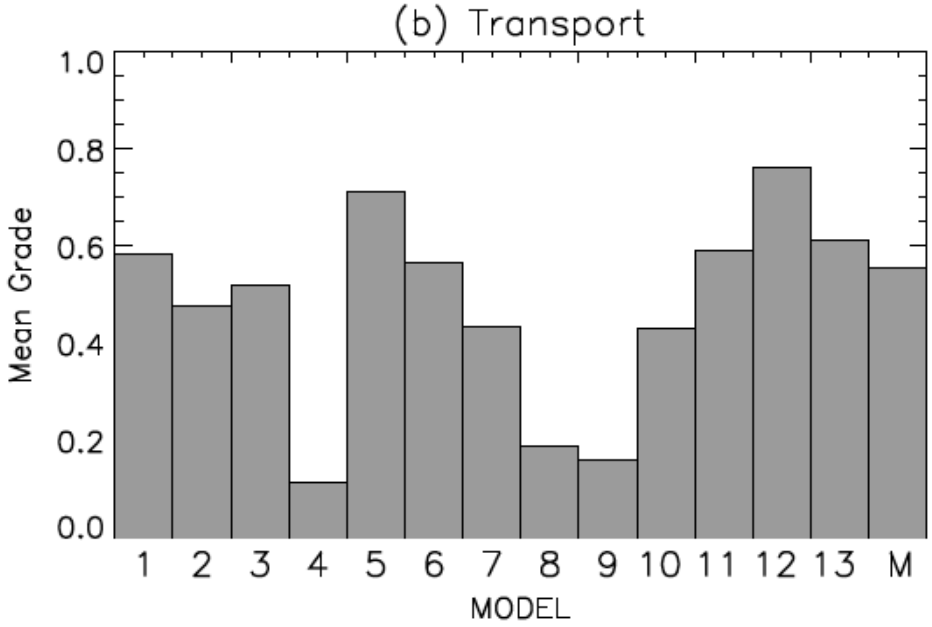
* Generally high grades for temperature in NH polar region and heat fluxes at 100 hPa

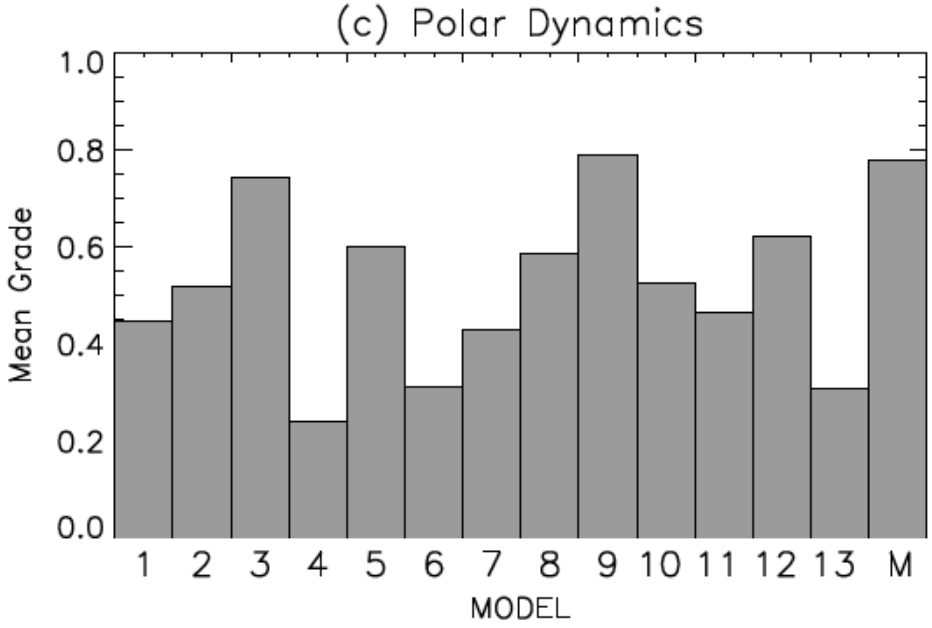
* Relatively poorly grades for temperature and H_2O at tropical tropopause and south polar CH_4

Waugh and Eyring, ACPD, 2008

Mean Grades for models



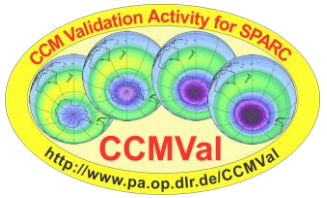




Differences can be seen in the performance of the models, especially for transport diagnostics.

Waugh and Eyring, ACPD, 2008

CCMVal workshop 2009



University of Toronto, Toronto, Canada

1-5 June 2009

Local Organization: Ted Shepherd (University of Toronto)

Conveners: Veronika Eyring (DLR, Germany)
Ted Shepherd (Univ. of Toronto, Canada)
Darryn Waugh (JHU, USA)

Background and scope:

The 2009 Chemistry-Climate Modeling workshop will focus on discussions on the SPARC CCMVal Report and related science

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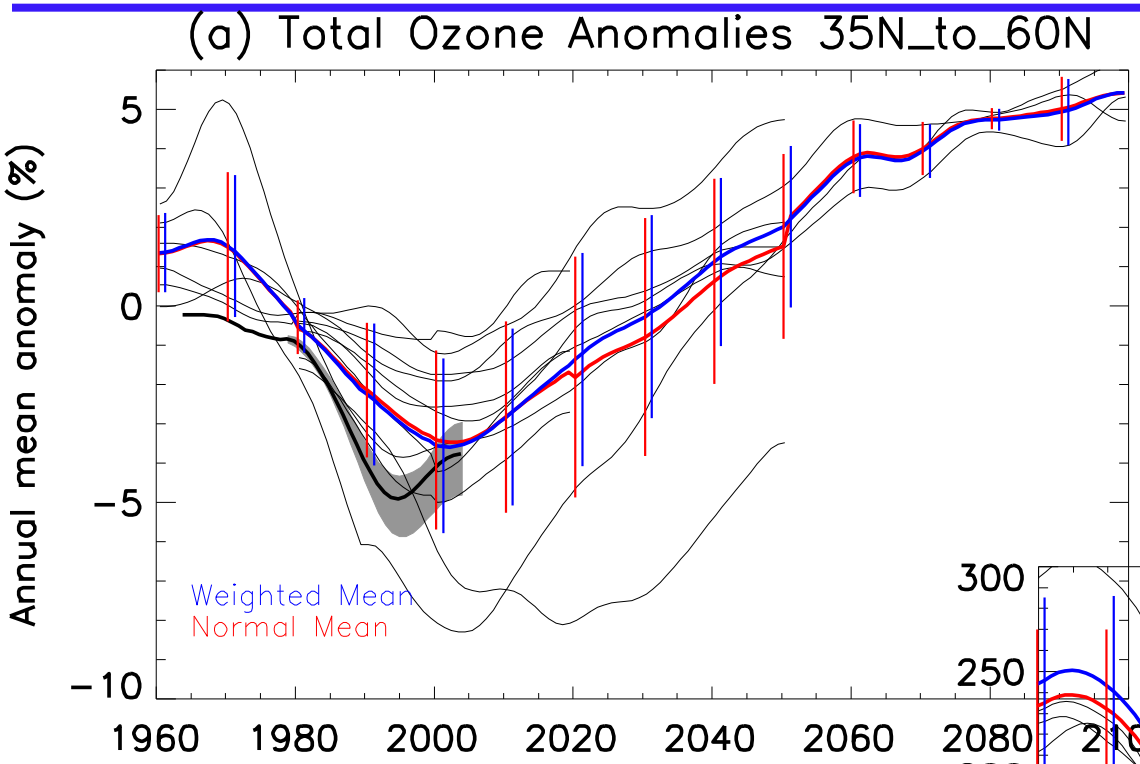
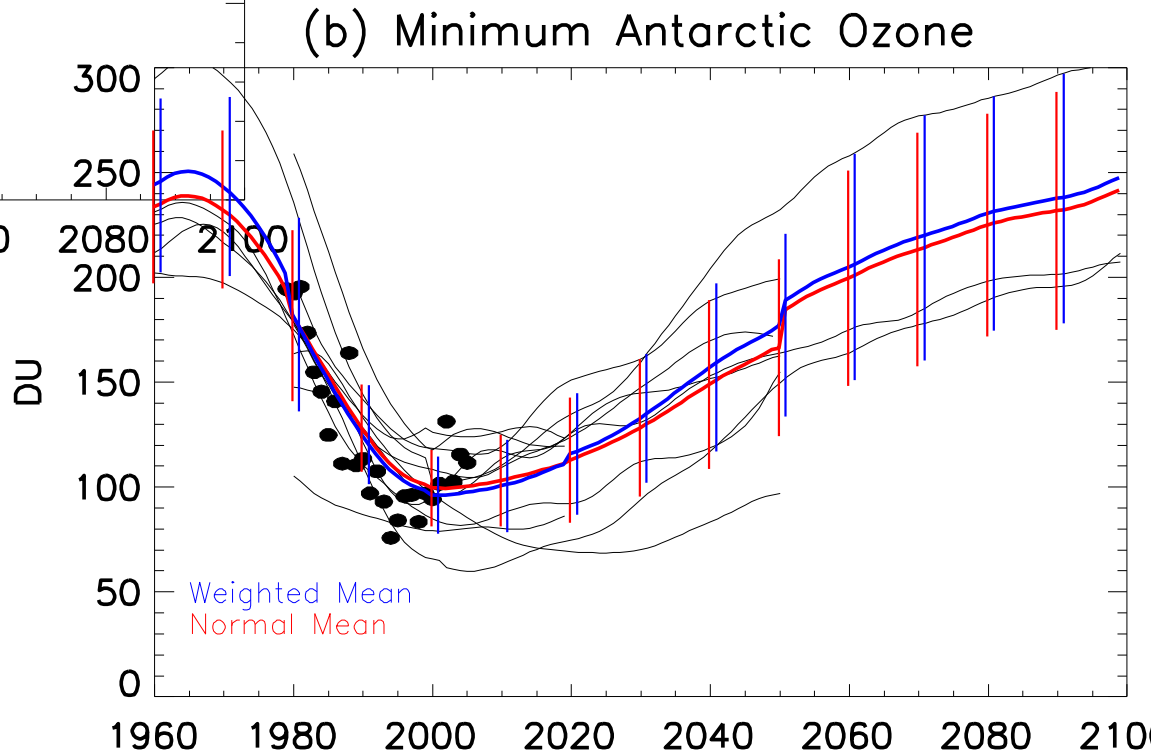
Weighted versus unweighted multi-model mean total ozone time series



Weighted with transport diagnostics only



Waugh and Eyring, ACPD, 2008