Status of the SPARC CCMVal Report on the Evaluation of Chemistry Climate Models

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NCAR

WACCM

Outline

- **What is CCMVal?**
  - General overview
  - Scenarios
- **SPARC CCMVal Report: Evaluation of CCMs**
  - Structure
  - Grading of CCMs
  - Evaluation of WACCM3 [Chemistry; TTL]
  - Report Timelines
- **WMO 2010 Assessment**
  - Structure
  - New simulations?

WACCM

What is CCMVal?

- **CCMVal = Chemistry-Climate Model Validation Activities.** [First Meeting was in Nov. 2003]

- **Organized under the auspices of Stratospheric Processes And their Role in Climate (SPARC).**

- **Process-oriented evaluation of CCMs**
  - Eyring et al., A strategy for process-orientated evaluation of coupled chemistry-climate models, BAMS, 2005.

- **CCMVal activities have contributed directly to the evaluation of CCMs during the preparation of the 2007 UNEP/WMO Scientific Assessments of Ozone Depletion.**

  - **Eyring *et al.*, (> 20 co-authors), Multi-model projections of ozone recovery in the 21st century, *J. Geophys. Res.*, 112, D16303, doi:10.1029/2006JD008332, 2007.**

WACCM3 Simulation for CCMVal and Beyond

Scenario	Period	Real	Res.	Base Sim.	Comments
REF-B0	2000	1	CSL	No QBO; Avg SSTs	Internal variability
REF-B1	1960-2006	4	CSL	Obs SSTs, QBO, Volc SAD, TG, SV	Historical Simulation
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SCN-B1	1960-2006	1	ACD	REF-B1	+ Enhanced Bromine
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IPCC	1850-2050	2	CSL	REF-B1/2 like	Fully Coupled

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2010 SPARC CCMVal Report

- Report Outline:
  - Ch 1: Synthesis Chapter [Waugh, Shepherd, Eyring]
  - Ch 2: CCMs Description and Scns [Giorgetta, Shibata]
  - Ch 3: Radiation [Fomichev and Forster]
  - Ch 4: Dynamics [Butchart and Charlton]
  - Ch 5: Transport [Neu, Strahan]
  - Ch 6: Chemistry [Chipperfield and Kinnison]
  - Ch 7: UTLS [Gettelman and Hegglin]
  - Ch 8: Natural Variability [Manzini and Matthes]
  - Ch 9: Long-term Proj. of Strat. O_3 [Austin and Scinocca]
  - Ch 10: Effect of the Strat. on Climate [Baldwin and Gillett]
- The report will be based on the diagnostic metrics developed within SPARC CCMVal and will be completed in time to provide useful information fo the 2010 WMO/UNEP assessment.

Chemistry

Process	Diagnostic	Variables	Observations	Simulation	Lead
Photolysis rates	MMII - off-line model	Photolysis rates	Benchmark Reference model (Prather)	Tests 1, 2, and 3 (see Photocomp instructions)	Michael Prather and Huisheng Bian
Photochemical mechanisms and short timescale chemical processes	Offline box model comparisons of fast chemistry (of order one day or less)	Full chemical constituents (O_3 loss due to O_x, HO_x, NO_x, ClO_x, BrO_x)	Benchmark Photostationary State Model (Salawitch) – validated by aircraft campaigns.	REFB1 [1993 high SAD] and [2003 low SAD]	Ross Salawitch Tim Canty
Long timescale chemical processes	Comparison of abundance of reservoirs and radical precursors	Instantaneous output of all chemical constituents and temperature (one per month)	Satellite [e.g., MIPAS, Aura MLS, others…], Ground based [NDACC]	REFB1 (2000-2006].	Martyn Chipperfield, Wenshou Tian, Slimane Bekki and Chritoph Bruehl
	Tracer-tracer relations	O_3, NO_y, CH_4, H_2O, N_2O	Satellite [e.g., HALOE], Aircraft [e.g., ER2, WB57]	REFB1 [1995-2006]	Martyn Chipperfield and Sandip Dhomse
Polar processes in winter / spring	Partitioning of species within the families	Species from families (ClO_x, NO_x, HO_x, BrO_x, Cl_y, NO_y, Br_y) temperature, PV from wind fields	Benchmark Photostationary State Model (Salawitch) – validated by aircraft campaigns.	REFB1	Ross Salawitch and Tim Canty
	Denitrification / dehydration	NO_y, HNO_3, N_2O, CH_4, etc.; H_2O; obs and model results transformed to EqLat - theta	Satellite [e.g., Aura MLS]	REFB1 [2000-2006]	Lucien Froidevaux, Michelle Santee, Doug Kinnison
	Chemical Ozone Loss versus PSC activity	O_3, passive O_3 tracer, O_3 prod./loss rate, PV from wind fields, temperature	Satellite [e.g., HALOE, ILAS, ILAS-II], Aircraft [e.g., Geophysika]	REFB1 [2000-2006]. REFB2 - ozone recovery	Simone Tilmes and Rolf Muller
Stratospheric Aerosols	Spatial and temporal variation of sulfate aerosols and PSCs.	Surface area density of different particle types.	Model / model comparison. Limited observations exist for this evaluation.	REFB1 [1995-2006]	Cora Randall, Lynn Harvey, and Doug Kinnison
	Temperature response in the lower stratosphere; Chlorine and nitrogen partitioning	All species from chlorine and nitrogen families, temperature	Benchmark Photostationary State Model (Salawitch) – validated by aircraft campaigns.	REFB1 [1993 high SAD] and [2003 low SAD]	Ross Salawitch and Tim Canty

Example Metric Table

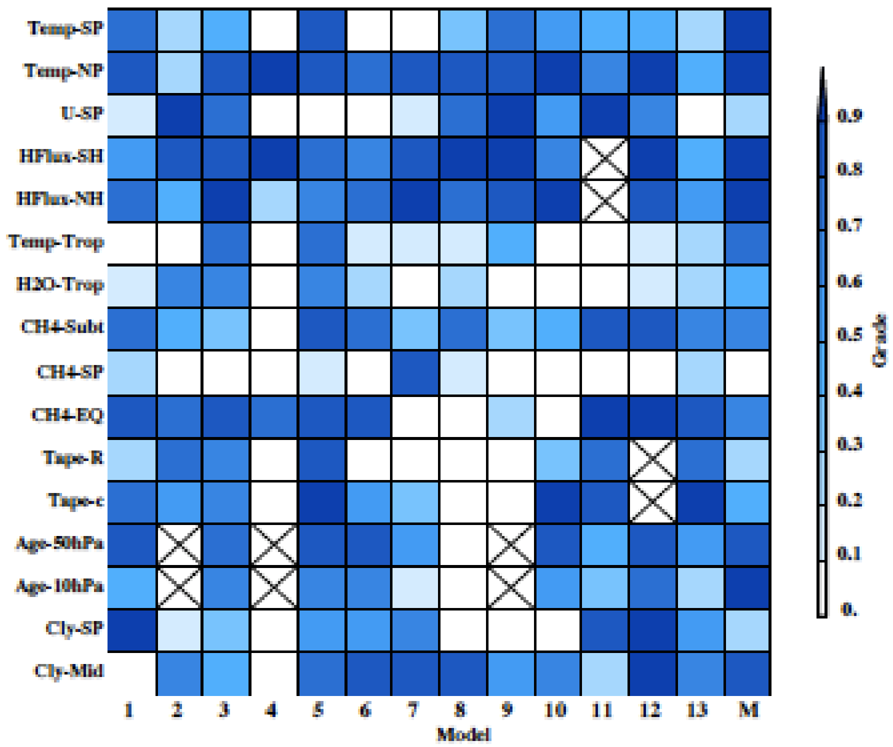


Fig. 2. Matrix displaying the grades (see color bar) for application of each diagnostic test to each CCM. Each row shows a different test, and each column a CCM. The right most column is the "mean model". A cross indicates that this test could not be applied, because the required output was not available from that model. See Table 1 for model names.

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

Photochemical Steady State Approach

PSS Model Comparisons: Overview

- Constrain photochemical steady state (PSS) model, which has been used for extensive comparisons to atmospheric observations, with profiles of:

  p, T, sulfate SA, O_3, H_2O, CH_4, CO, NO_y, Cl_y, Br_y

  defined from zonal, monthly mean (ZMM) values from each CCM model
- Focus on periods of time when atmospheric observations are available
- Examine:

  a) profiles of tracers

  b) tracer – tracer relations

  c) radicals

  For radicals, the comparison is between 24 hour average output of the PSS model versus the ZMM of the CCM model

  If the chemistry is properly represented in both models, this comparison should look reasonably good (but will not be perfect!)

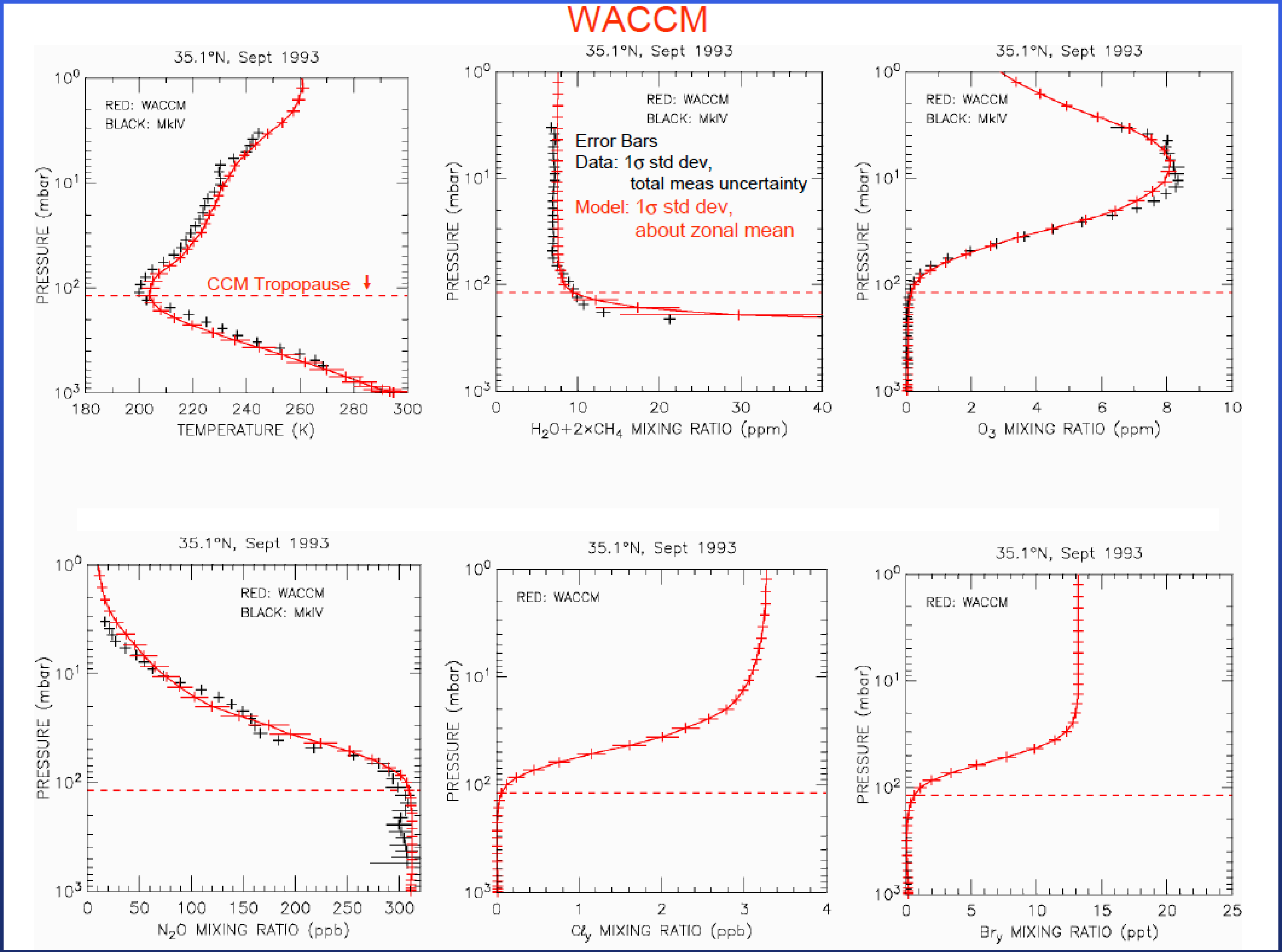
  Powerful method to diagnose representation of fast chemistry in models
- Initial focus on 35°N, Sept 1993:

  a) time of high aerosol loading

  b) atmosphere sampled by a high altitude balloon flight that has resulted in mane papers documenting atmospheric composition

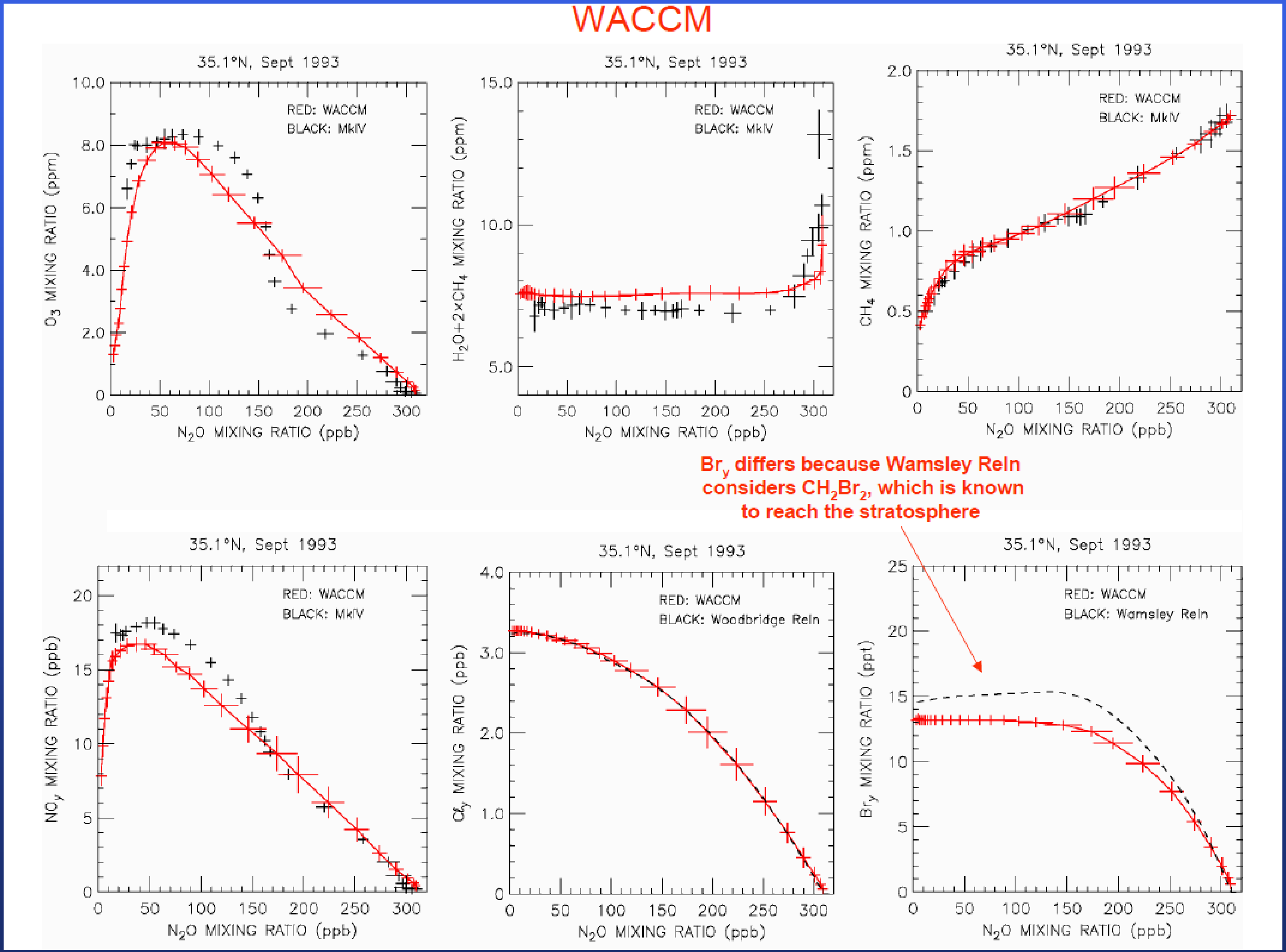
Salawitch, Johnson, Canty, et al.

Evaluation of T, O_3, N_2O, Cly, Bry Profiles



Salawitch, Johnson, Canty, et al.

Tracer / Tracer Correlations



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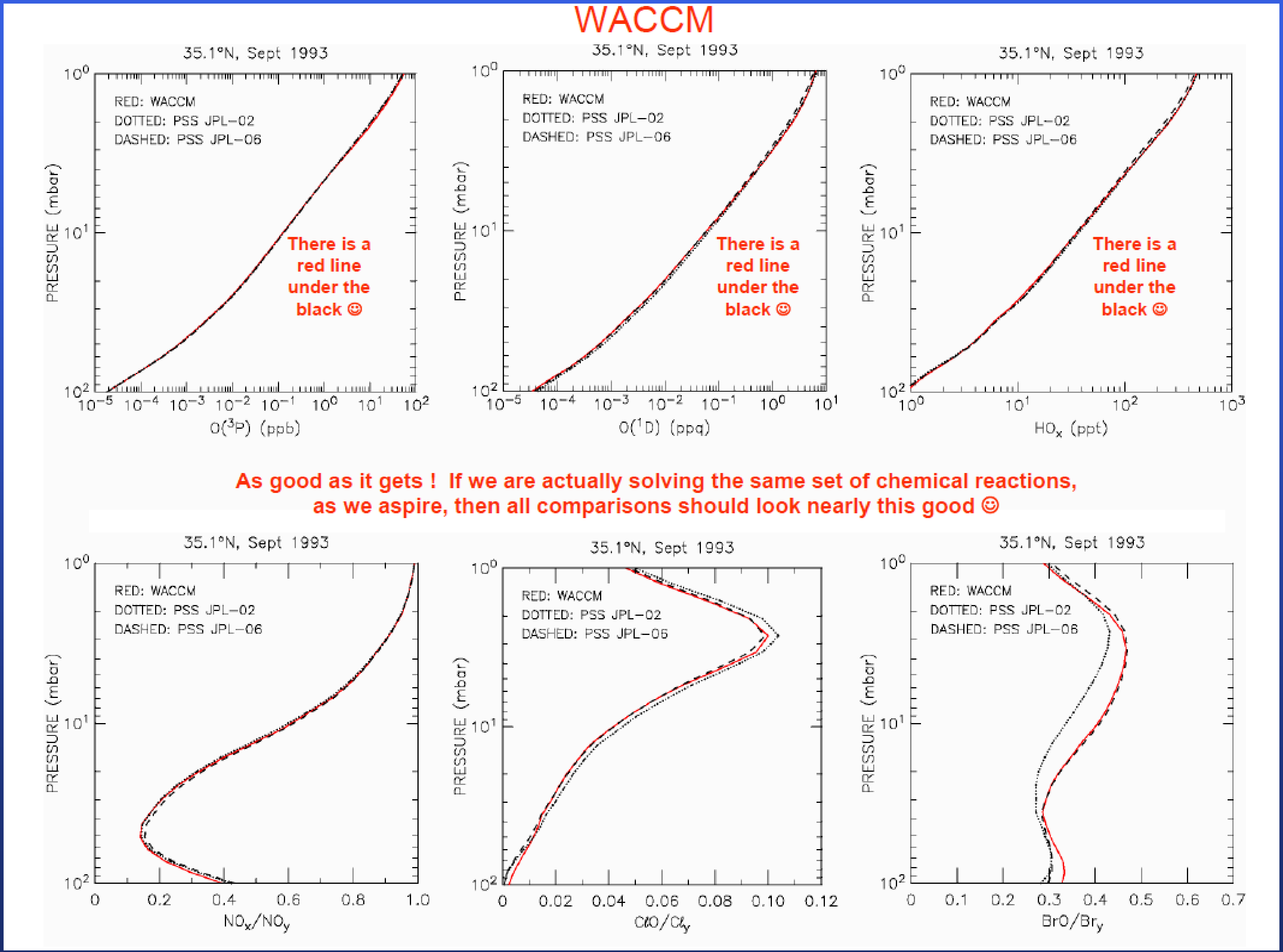
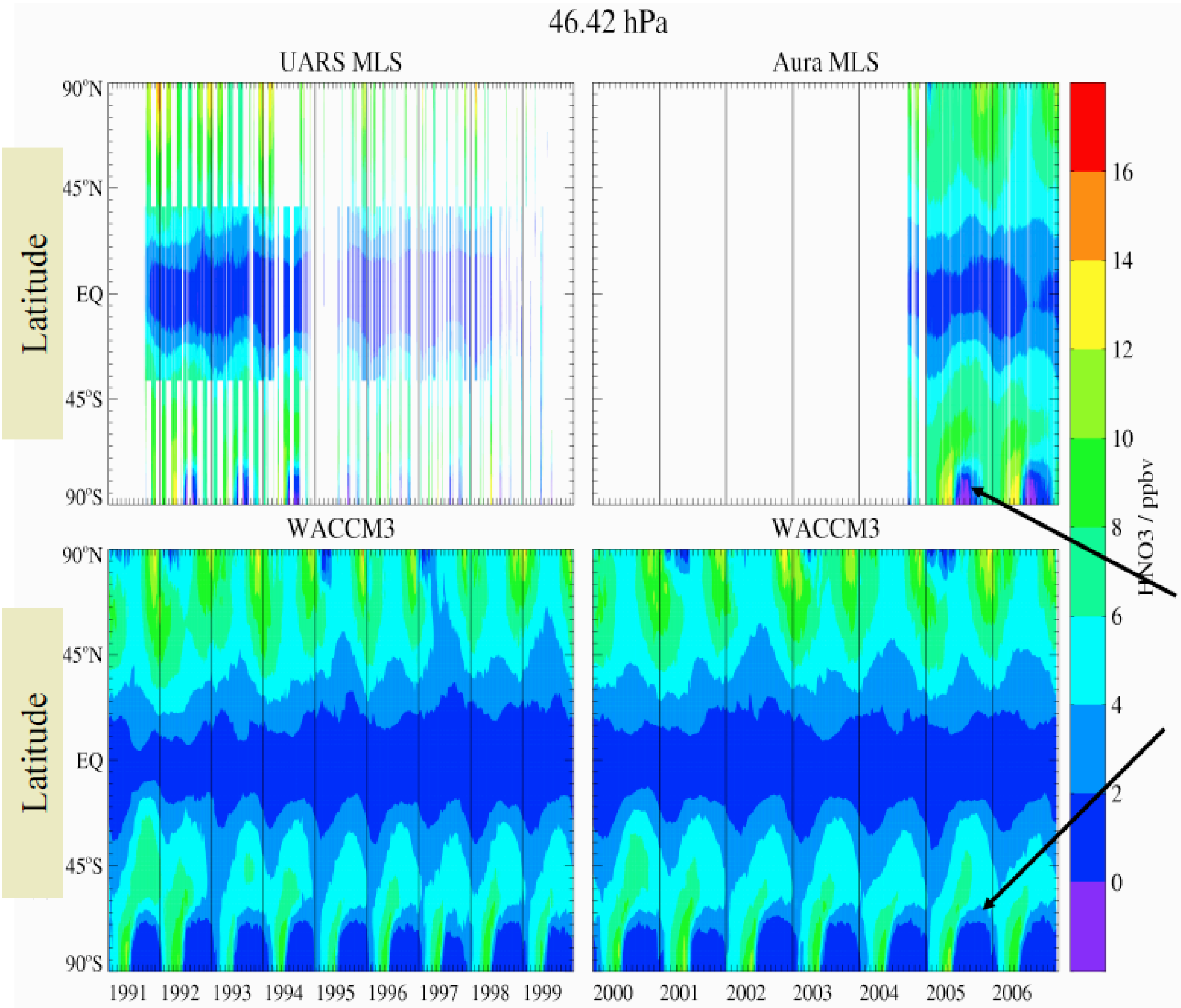
Evaluation of Radicals and Partitioning



Salawitch, Johnson, Canty, et al.

Polar processing issues: data versus WACCM3 model



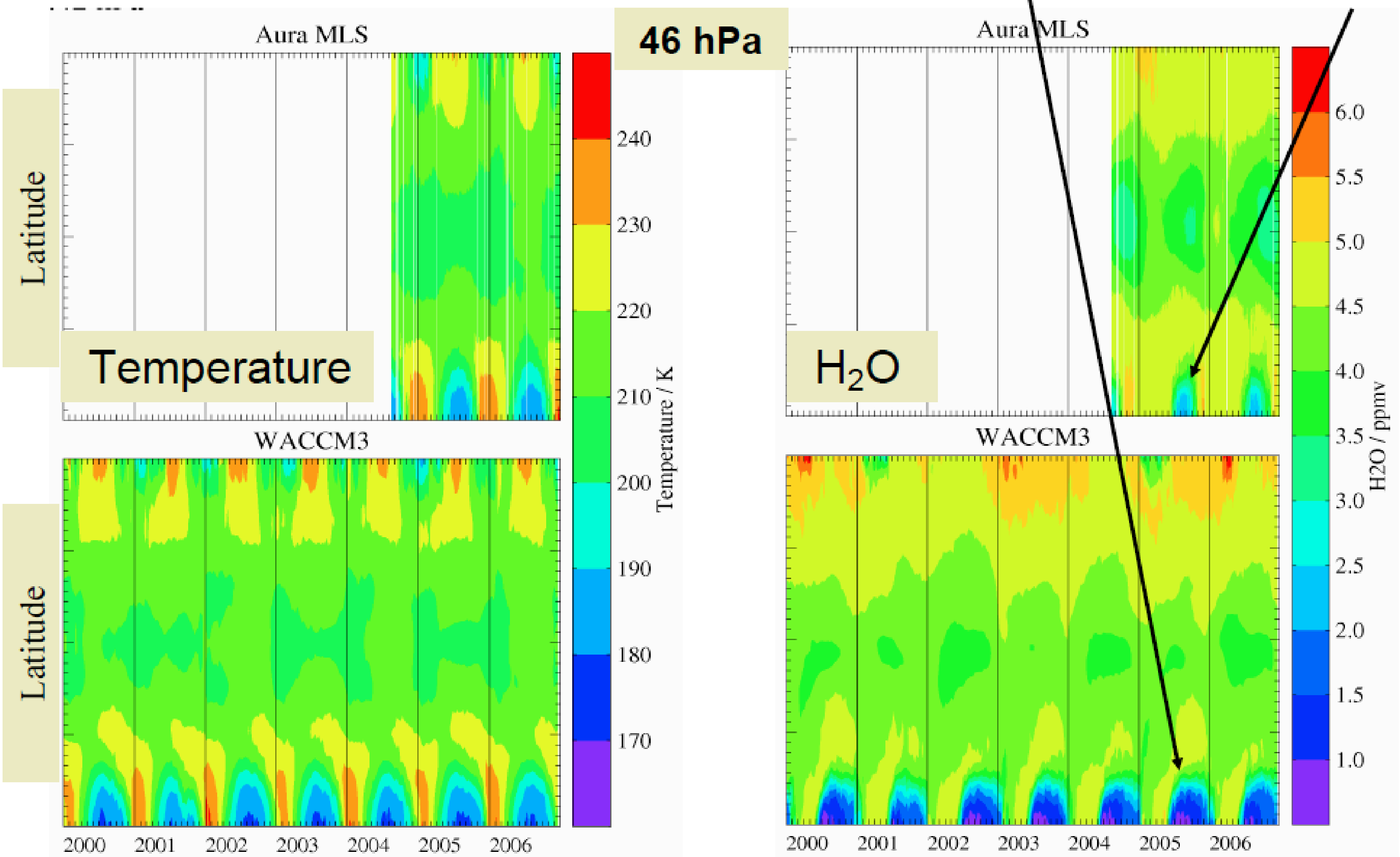
The seasonal time period for low HNO_3 (and also presumably for denitrification) at high SH lats. is shorter in MLS observations than in the model.

The latitudinal extent differs as well.

Polar processing issues: data versus WACCM3 model

- Heterogeneous polar chemistry "follows" the temperature behavior.

Broader periods of low T & H_2O are seen in the model than in the data.



H_2O (ppmv) *** NCL Diagnostic tool

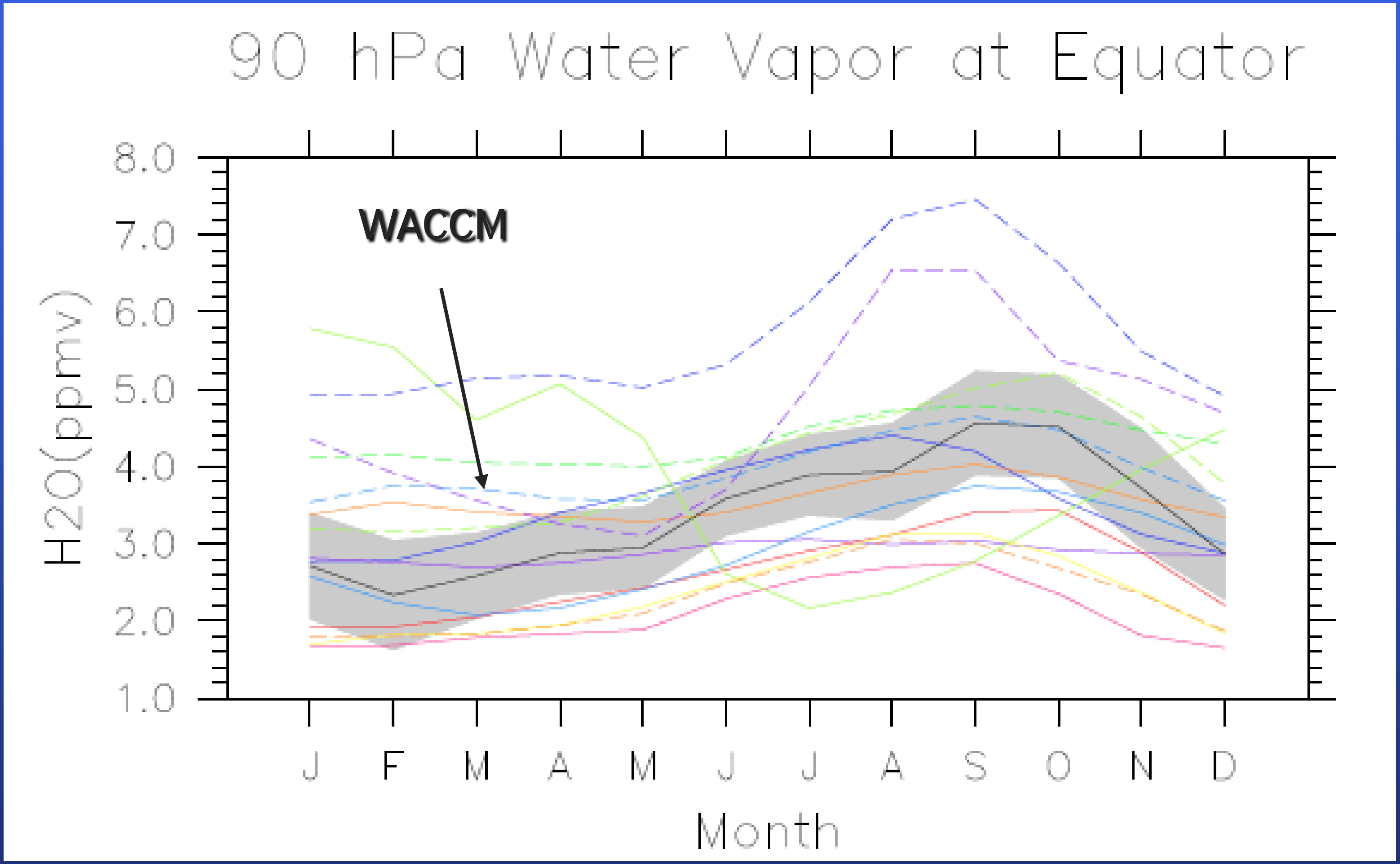
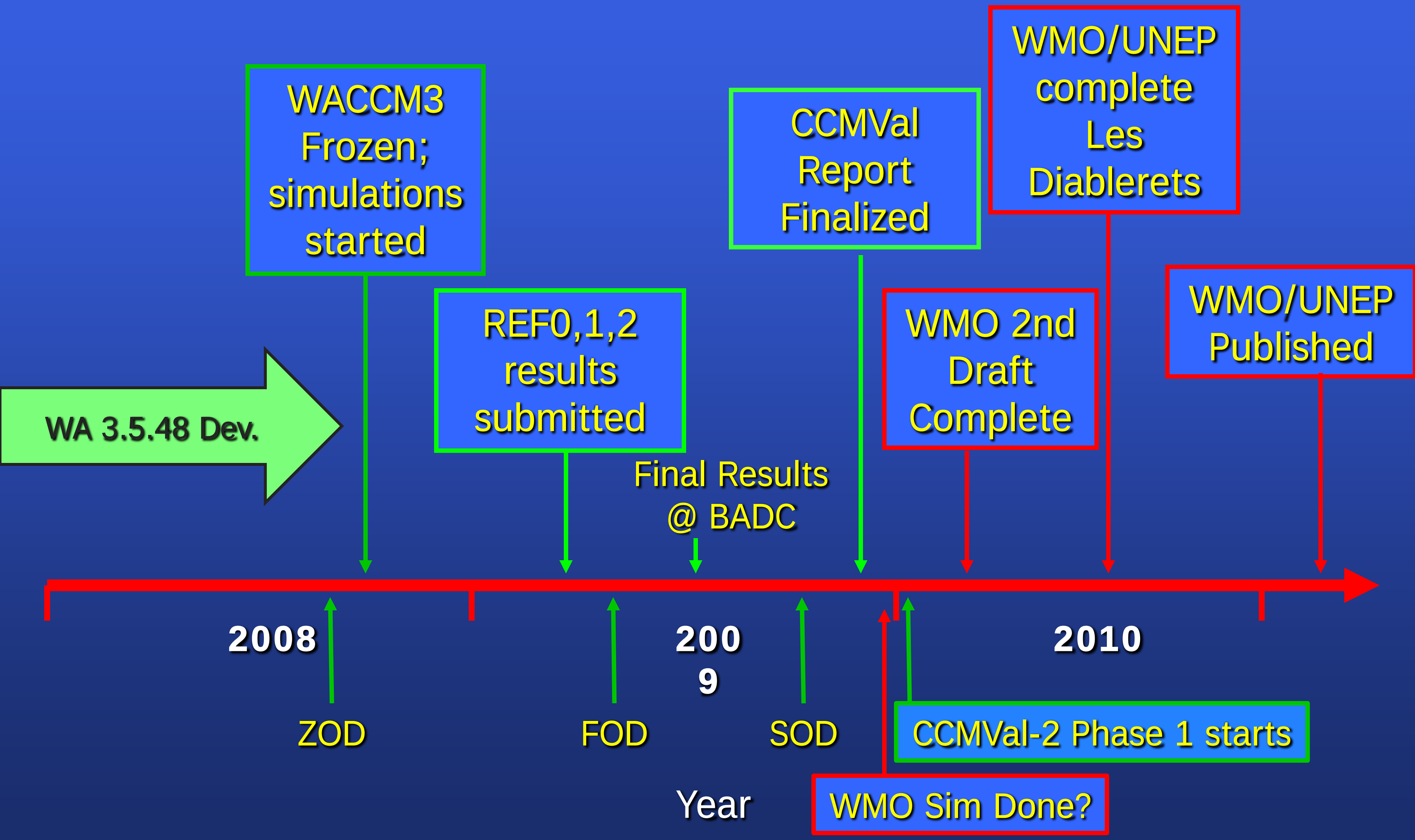


Figure Courtesy of A. Gettelman

CCMVal and WMO Timelines



WMO 2010

Chapter 1: Ozone-Depleting Substances (ODSs) and Related Chemicals
Steve Montzka (NOAA, USA); Stefan Reimann (EMPA, Switzerland)

Chapter 2: Stratospheric Ozone and Surface Ultraviolet Radiation
Anne Douglass (NASA, USA); Vitali Fioletov (EC, Canada)

Chapter 3: The Future of the Ozone Layer and Its Impact on Surface UV:The Influence of ODSs, Climate, and Other Factors
Slimane Bekki (CNRS, France); Greg Bodeker (NIWA, New Zealand)

Chapter 4: Impact of Stratospheric Changes on Climate
Piers Forster (Univ. Leeds, UK); Dave Thompson (Colorado State University, USA)

Chapter 5: Information and Options for Policymakers
John Daniel (NOAA, USA); Guus Velders (Netherlands Environmental Assessment Agency, Netherlands)

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The End!