Chemistry Updates for CCMI

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11 February 2013

WACCM Working Group Meeting

NCAR

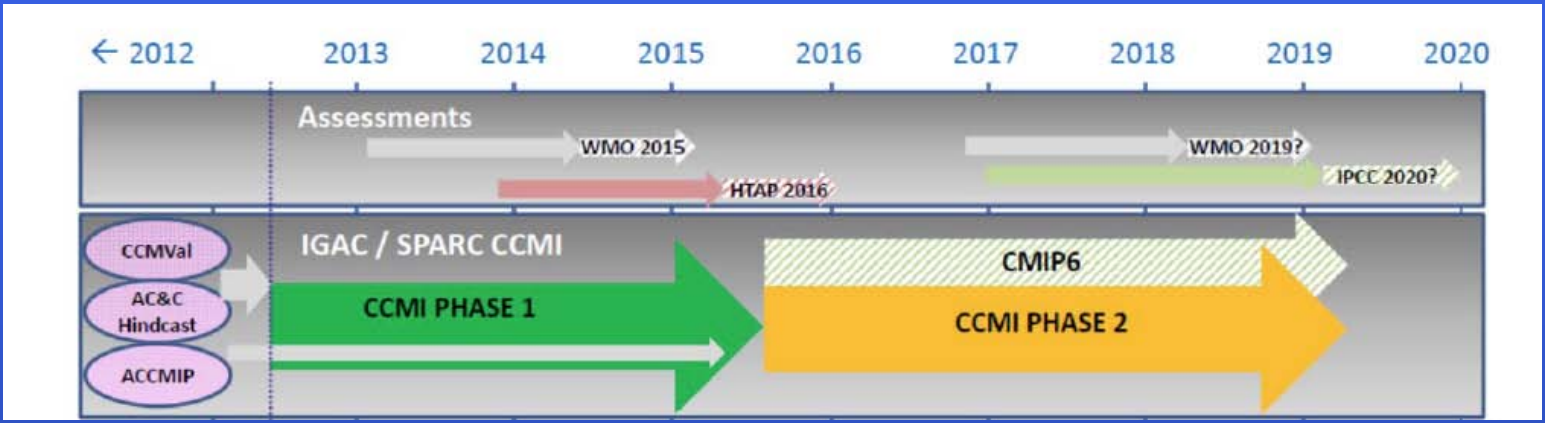
Why Do Another Assessment?

- NESL / ACD community contribution.
- Increases national and international collaborations.
- Fosters model improvements (preparing for simulations).
- Creates new model diagnostics and model improvements after simulations are complete!
- Promotes scientific research.

Recommendations from CCMVal2

- Inclusion of a more comprehensive representation of troposphere-stratospheric chemical processes. DONE
- Inclusion of VSL Organic Bromine species. DONE
- Inclusion of a couple ocean. DONE
- Inclusion of internally derived QBO. Maybe
- Correct the persistent late-spring breakdown of the Antarctic Vortex. NO
- Improve the representation of volcanic heating. NO

Chemistry Climate Model Initiative (CCMI)



- First meeting was in May 2012 (Davos Switzerland).
- Next meeting will be hosted by NCAR in May 2013.
- The initial phase of CCMI will be to support the WMO 2015 O_3 Assessment.
- Model simulation will start by 1 March 2013.
- Model simulation will include “nudged” approaches for CCMI.

Planned Simulations

Table 1. Summary of proposed IGAC/SPARC CCMI reference simulations.

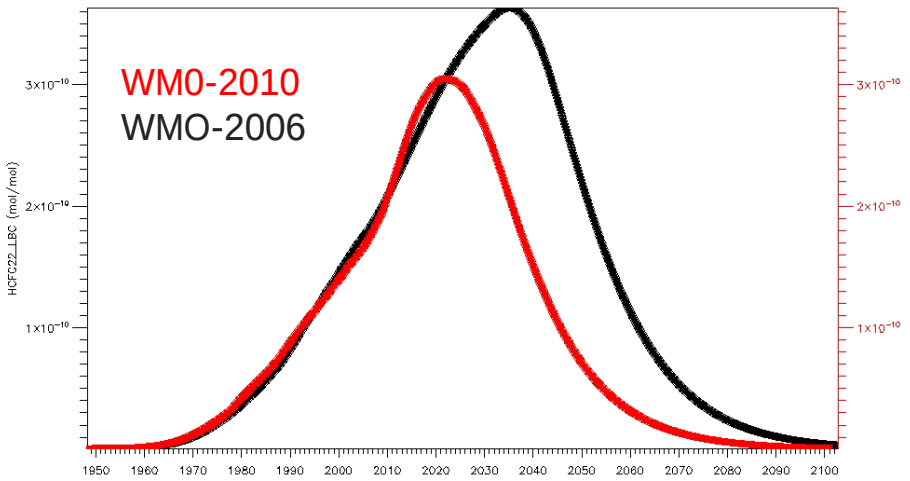
Name of Reference Simulation	Period	Greenhouse Gases	ODSs	SSTs/SICs	Background & Volcanic Aerosol	Solar Variability	VSLS	QBO	Ozone and Aerosol Precursors
REF-C1	**Transient simulation 1960-2010** Appropriate spin up prior to 1960	**OBS** GHG used for CMIP5 simulations, updated until 2010.	**OBS** (WMO, 2011)	**OBS** HadISST1	**OBS** Surface Area Density data (SAD)	**OBS** Spectrally resolved irradiance data, Proton ionization, Ap	**YES**	**OBS or internally generated**	**OBS** Based on Lamarque et al. (2010), but annual emissions
REF-C1SD (nudged for CCMs, or CTMs)	**Transient simulation 1980-2010**	**OBS** Same as **REF-C1**	**OBS** Same as **REF-C1**	**OBS** Consistent with met. reanalysis	**OBS** Same as **REF-C1**	**OBS** Same as **REF-C1**	Same as **REF-C1**	Same as **REF-C1**	**OBS** Same as **REF-C1**
REF-C2	**Transient simulation 1960-2100** 10-year spin up prior to 1960	**OBS to 2005 then RCP 6.0 (Masui et al., 2011)**	**OBS + A1 scenario from WMO (2011)**	**Modeled SSTs**	**OBS** Background SAD	**YES** Spectrally resolved irradiance data, Proton ionization, Ap	**YES**	**YES**	**Same as REF-C1 until 2000 + RCP 6.0 scenario in the future**

Chemistry Updates

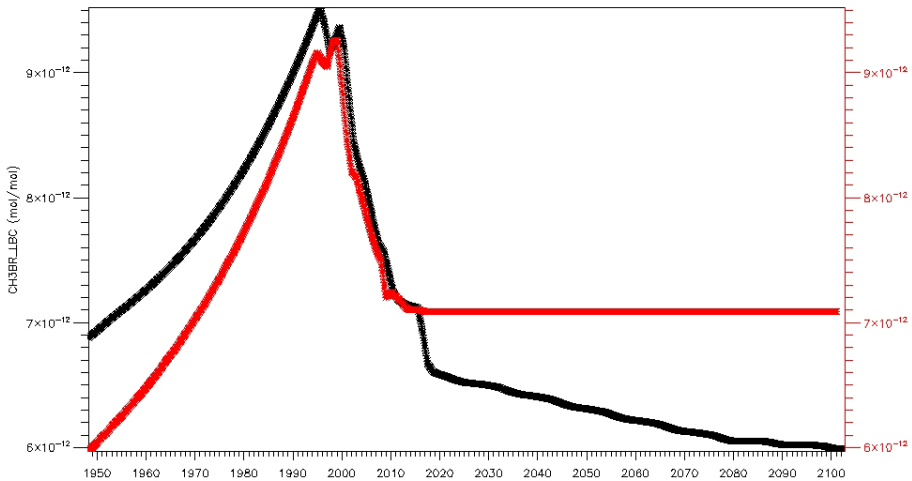
- Organic Halogens
- Tropospheric Chemistry Additions
- Updated Heterogeneous Module
- New Surface Area Density Time series
- Rate and Satellite / Aircraft Output.

Organic Halogens Updated to WM0-2010

HCFC -22



CH3Br

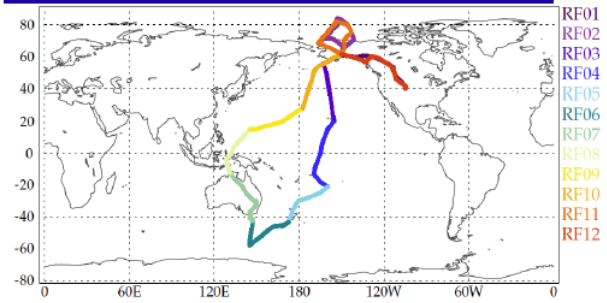


- **WMO-2010, Chapter 5**
  - SD-WACCM / MERRA
- **No Surrogates**
  - 18 species total
  - 8 new species
- **Long-lived (> 50 years)**
  - CFC-11, CFC-12, CFC-113, CFC-114, CFC-115, CCl_4, halon-1301
- **Medium (10-50 year)**
  - halon-1211, halon-1202, halon-2402, HCFC-22, HCFC-142b
- **Short (1-10 years)**
  - CH_3Cl, CH_3Br, CH_3CCl_3, HCFC-141b
- **Very Short Lived (<6months)**
  - $CHBr_3$, CH_2Br_2

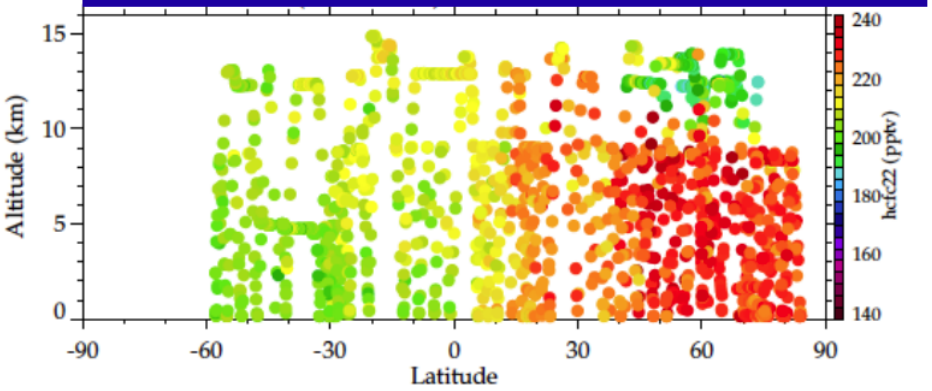
SPaRC Lifetime Assessment

Organic Halogens Latitudinal Gradient

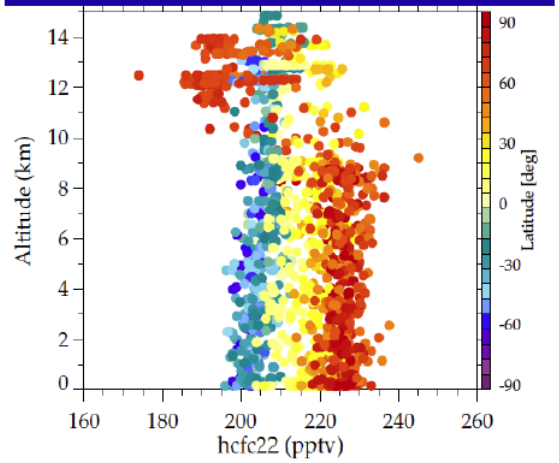
1. HIPPO-4 Flight Tracks (6/14-7/11, 2011)



2. HIPPO-4 HCFC22



3. HIPPO-4 HCFC22 profiles (color: latitude)



4. WACCM4 HCFC22 (interpolated to HIPPO-4)

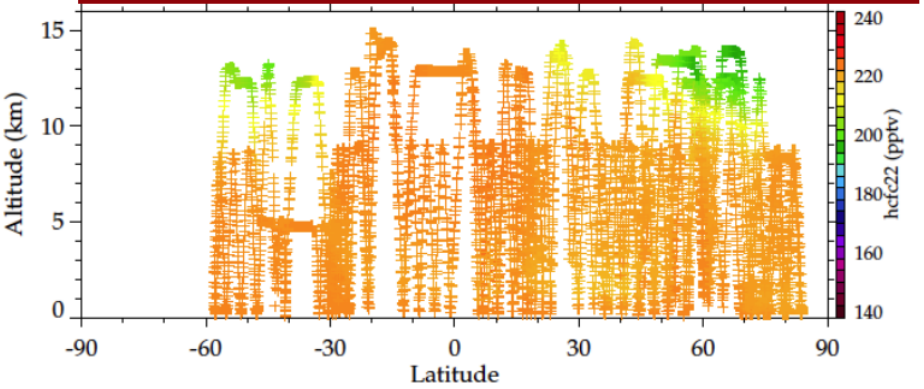
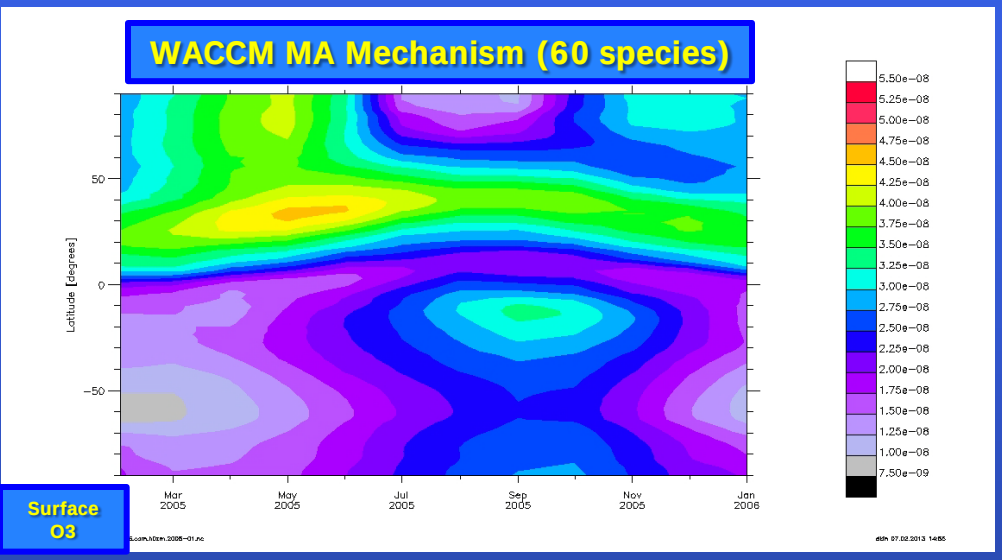
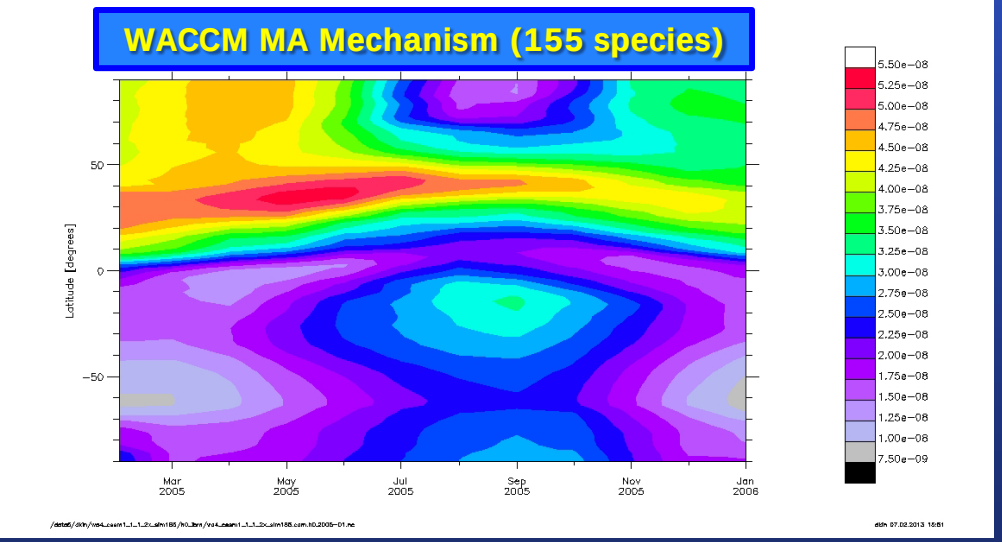


Figure Courtesy of M. Park

Inclusion of Tropospheric Chemistry (155 Species; 434 Rxns)





Acknowledge: G. Brasseur, J. F. Lamarque, L. Emmons, J. Orlando, C. Granier, et al.,

Standard Tropospheric Species

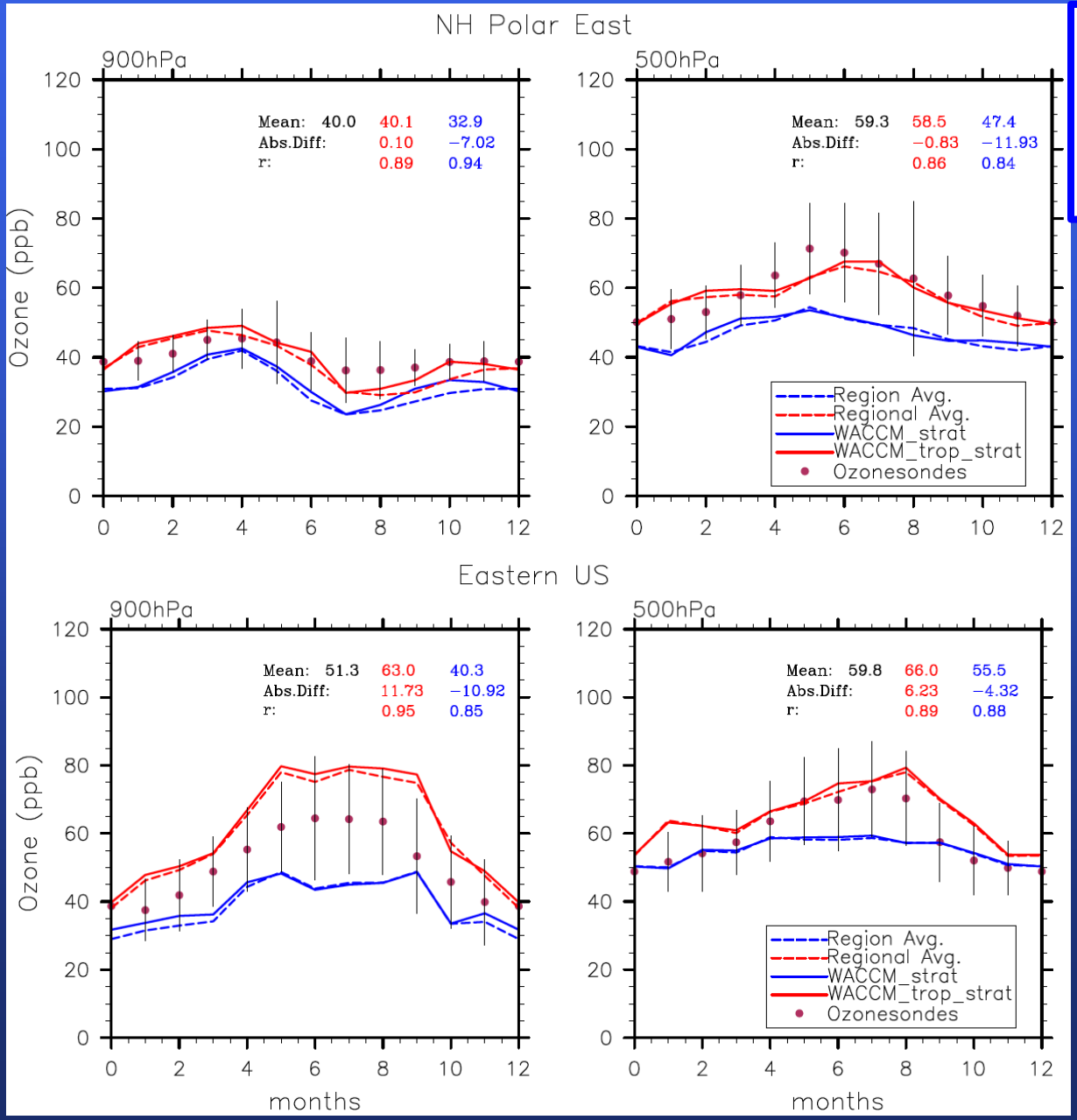
- CH_4, CO, CH_2O, CH_3COOH, CH_3O_2

Additional Tropospheric Species (srf emis)

- **C1:** CH_3OH, HCOOH, $HOCH_2OO$
- **C2:** C_2H_2, C_2H_6, C_2H_4, C_2H5O_2, C_2H_5OH, C_2H_5OOH, CH_3CO_3, CH3COOOH, EO2, EO, EOOH, GLYALD, GLYOXAL, PAN
- **C3:** C_3H_6, C_3H_8, $C_3H_7O_2$, C_3H_7OOH, CH_3COCH_3, CH_3COCHO, PO2, POOH, CH_3CHO, RO2, ROOH, HYAC, ONIT
- **C4:** BIGENE, ENEO2, MEK, MEKO2, MEKOOH, MVK, MACR, MACRO2, MACROOH, MCO3, MPAN,
- **C5:** ISOP, ISOPO2, ISOPNO3, ISOPOOH, BIGALK, BIGALD, HYDRALD, ALKO2, ALKOOH, ONITR, XO2, XOOH
- **C7:** TOLUENE, CRESOL, TOLO2, TOLOOH, XOH, TERPO2, TERPOOH
- **C10:** C10H16
- **Other:** HCN, CH3CN
- **Aerosol:** NH_3, OC1, OC2, CB1, CB2, DMS, SO_2.

- **Emissions (CO, NO, NMHCs):**
  - IPCC ACCMIP / CCMI (1950-2100).
  - Emmons (1992-2010)
- **Bulk Aerosol Model (BAMS)**
  - Sulfate, Black Carbon, Organic Carbon, and Ammonium Nitrate, SOA, SSLT(4), DST(4)
- **Neu Wet deposition**

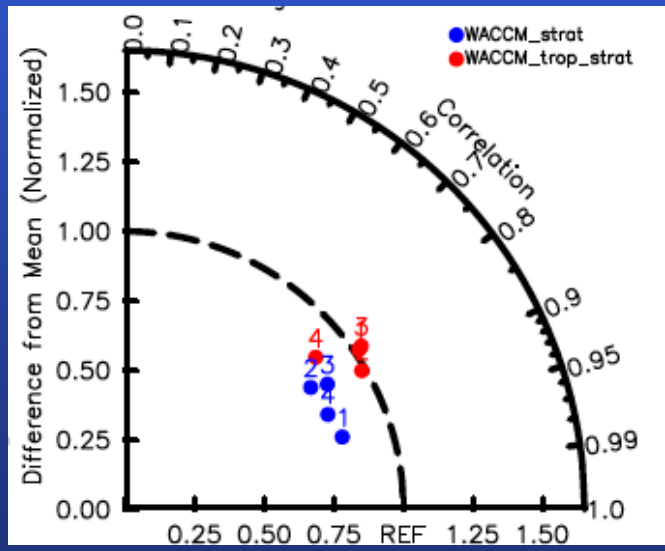
Comparison to Ozone Sondes



Ozonesondes

Strat/trop (155 species)

Strat. (60 species)



1: NH W Pol
2: NH E Pol
3: Canada
4: SH Polar

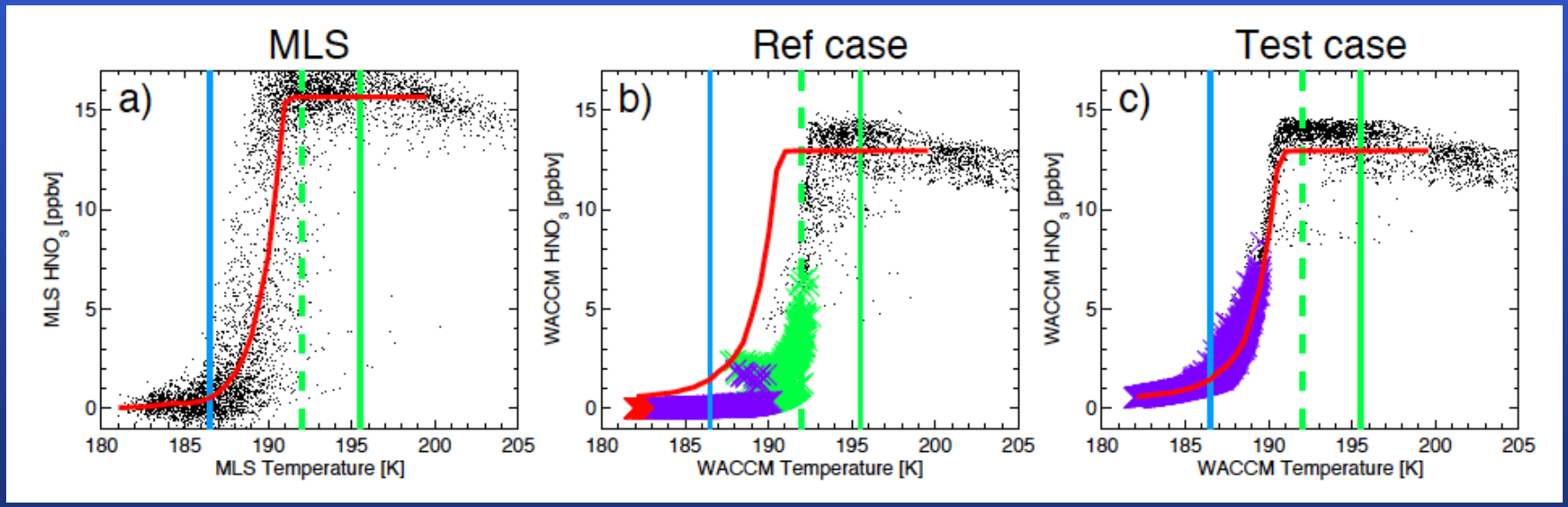
Courtesy of Simone Tilmes.

New Heterogeneous Module

Wegner, T, D. E. Kinnison, R. R. Garcia, S. Madronich, S. Solomon, and M. von Hobe, On the depletion of HCl in the Antarctic polar vortex, in review, *J. Geophys. Res.*, 2013.

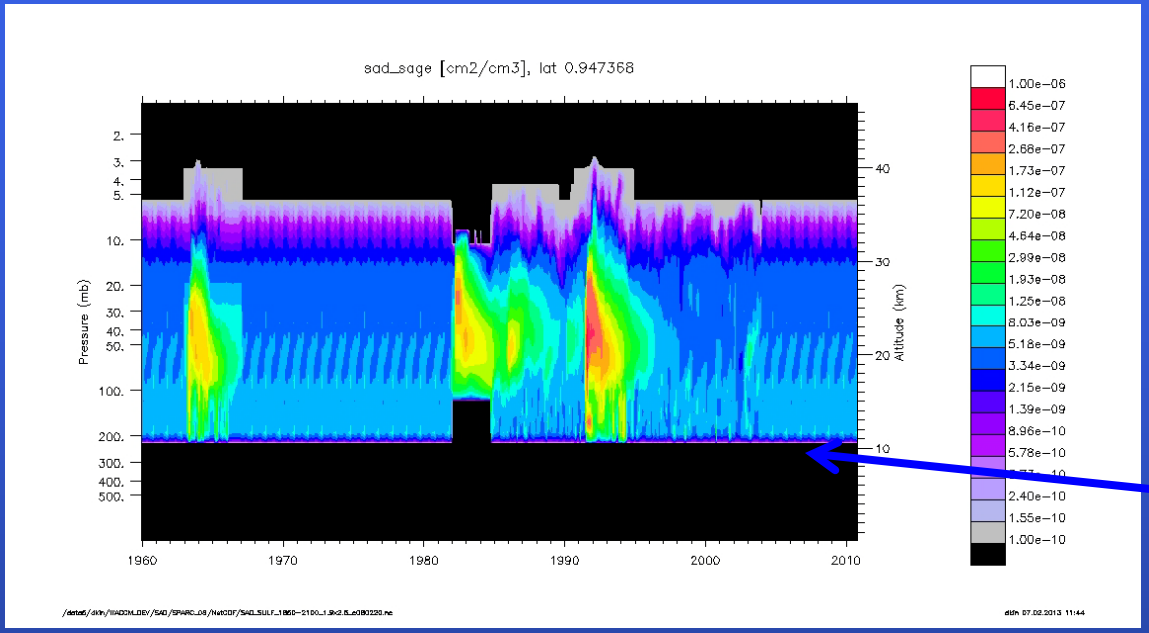
Wegner, T, D. E. Kinnison, R. R. Garcia, S. Madronich, and S. Solomon, Polar Stratospheric Clouds in SD-WACCM4, in review, *J. Geophys. Res.*, 2013.

Brakebusch, M., C. E. Randel, D. Kinnison, S. Tilmes, M. Santee, and G. Manney, Evaluation of Whole Atmosphere Community Climate Model simulations of ozone during Arctic winter 2004-2005, *in press*, *J. Geophys. Res.*, 2012.



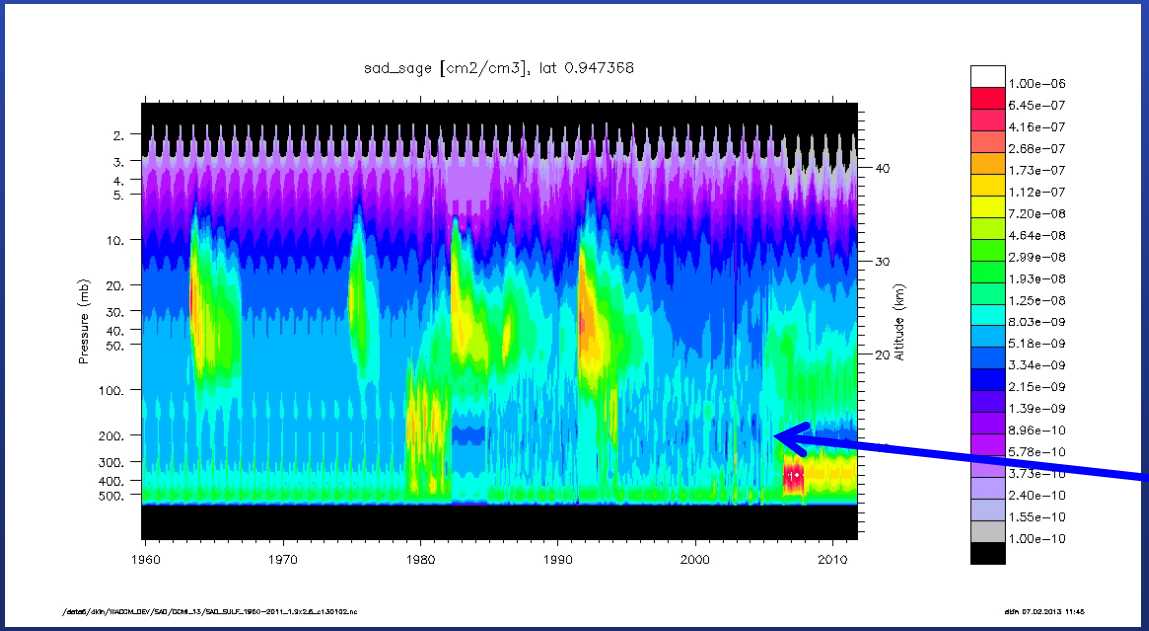
Also improved the representation of dehydration.
Set a rhminh for the stratosphere (dehydration starts at 100% saturation of H_2O over ICE.

New Sulfate Surface Area Density Time Series



CCMVal-2 SAD

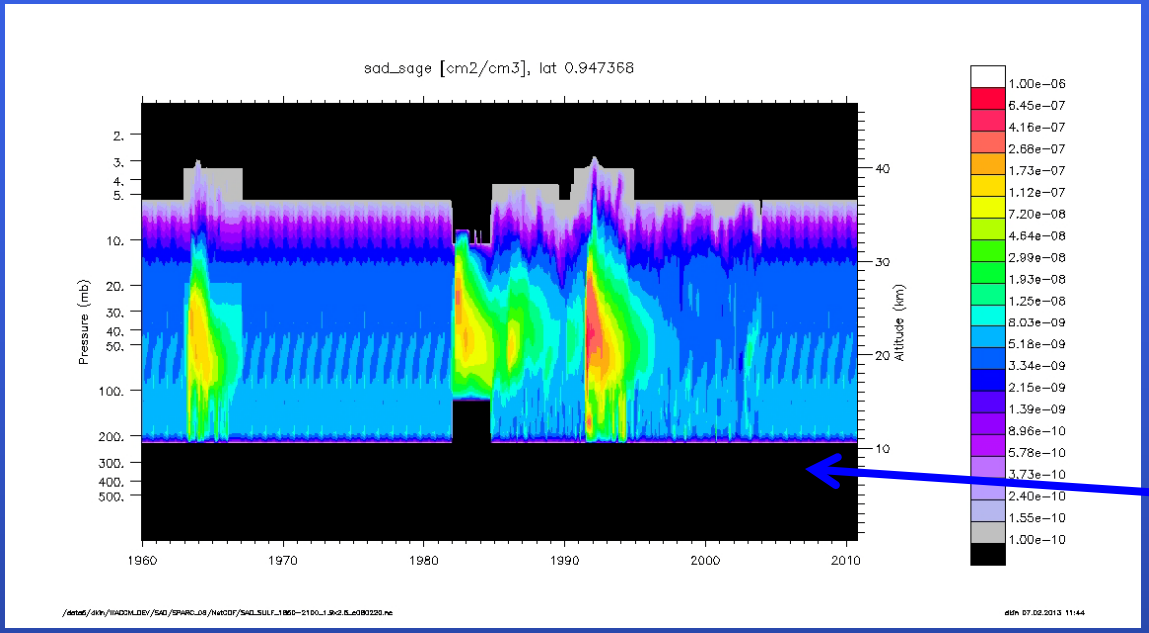
SAD zero for P >200 hPa



CCMI SAD

Note the volcanic influence below the tropopause.

New Sulfate Surface Area Density Time Series



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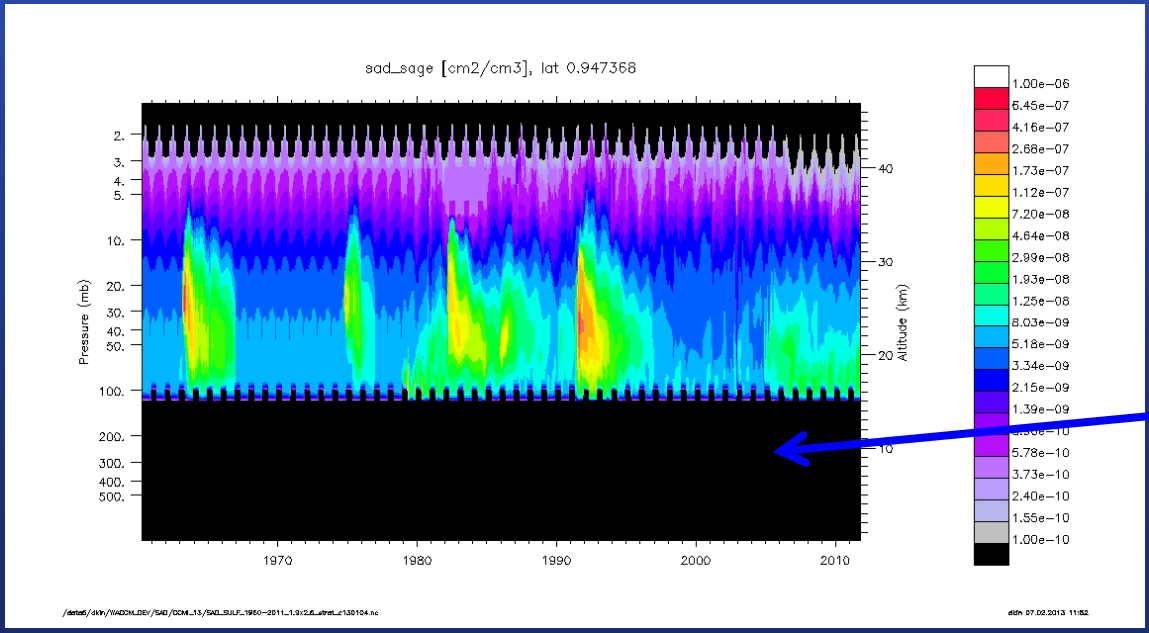


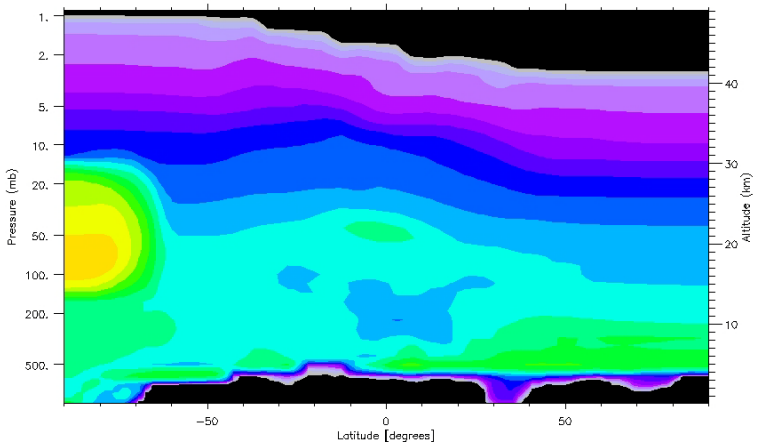
CCMI SAD

Zero SAD below Tropopause.

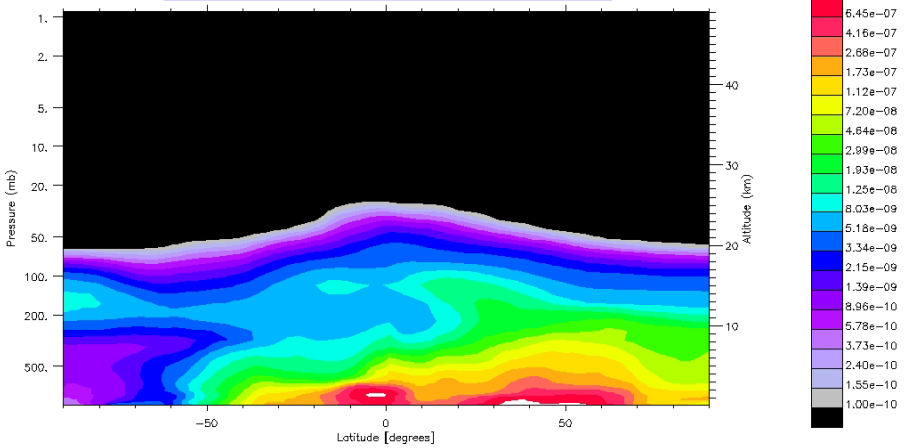
Ryan Neeley is currently examining impact of SAD time series.

Stratospheric and Tropospheric SAD (BAMS) - July

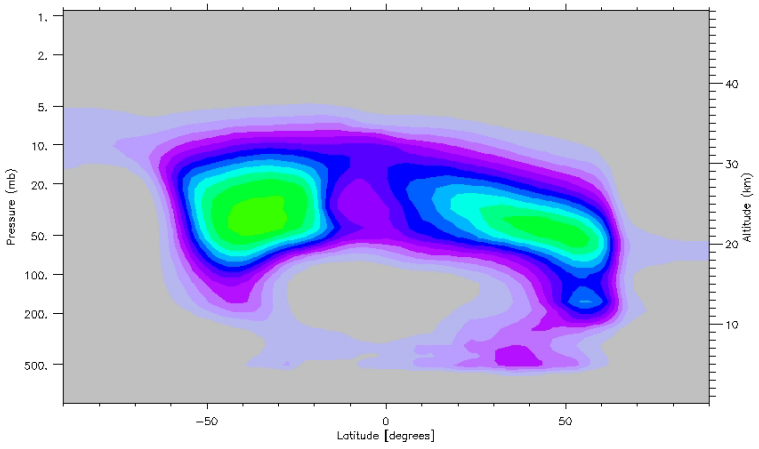
Stratospheric SAD



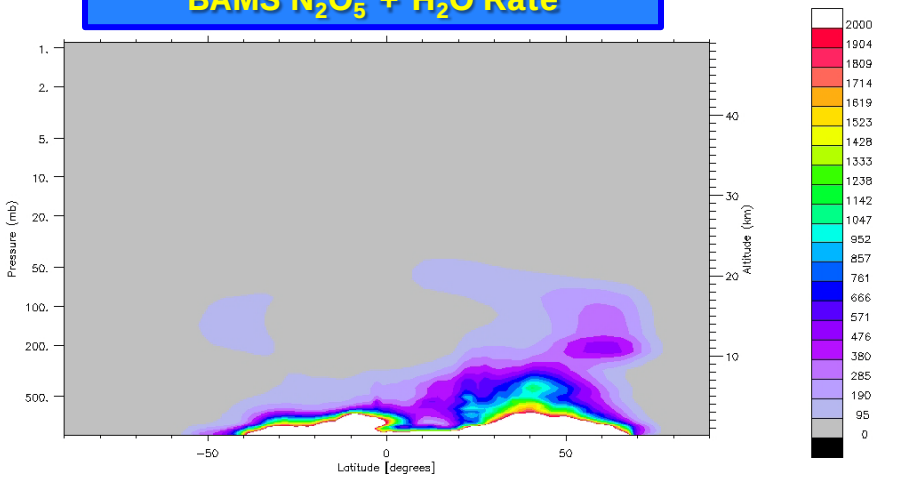
BAMS SAD



Stratosphere N_2O_5 + H_2O Rate

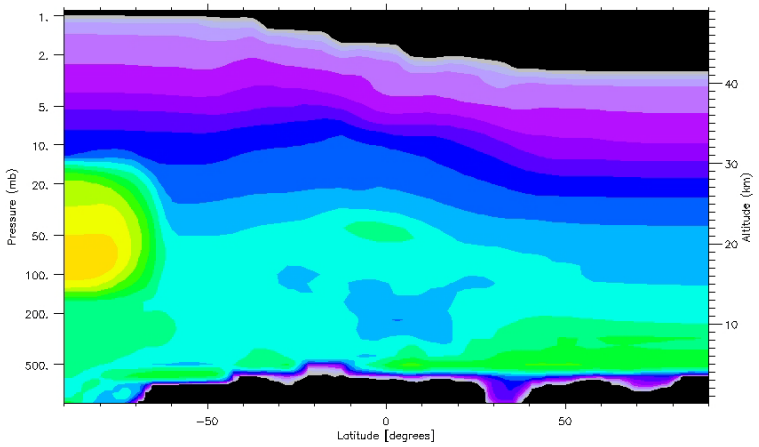


BAMS N_2O_5 + H_2O Rate

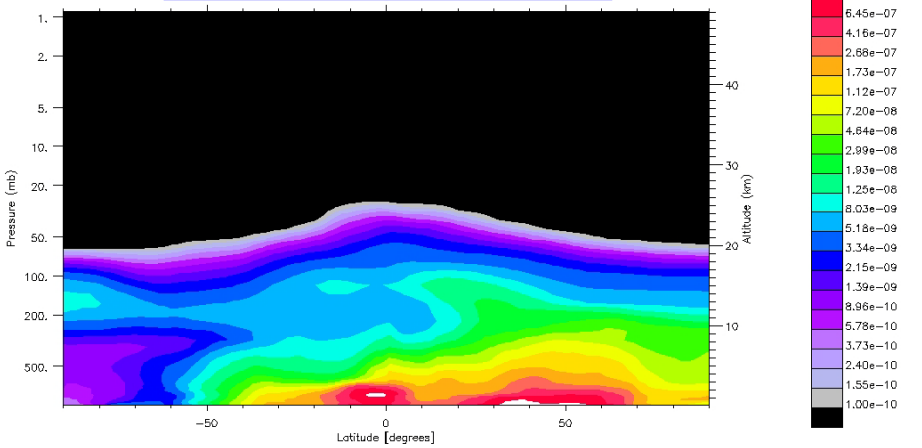


Stratospheric and Tropospheric SAD (BAMS) - July

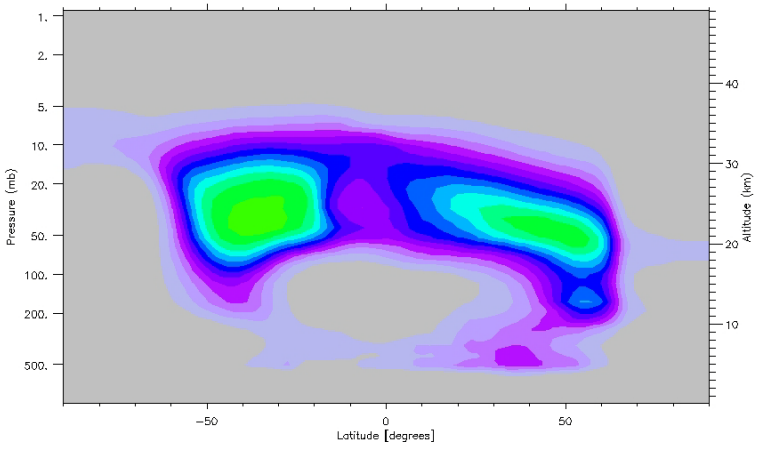
Stratospheric SAD



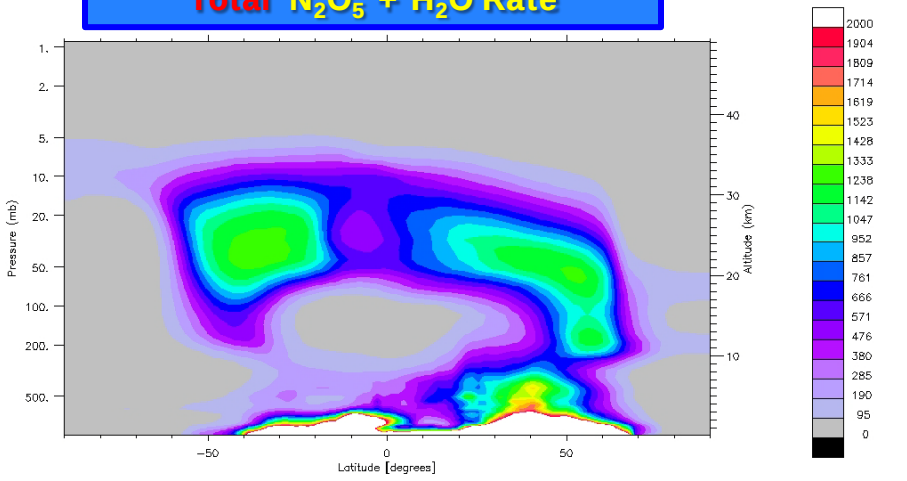
BAMS SAD



Stratosphere N_2O_5 + H_2O Rate

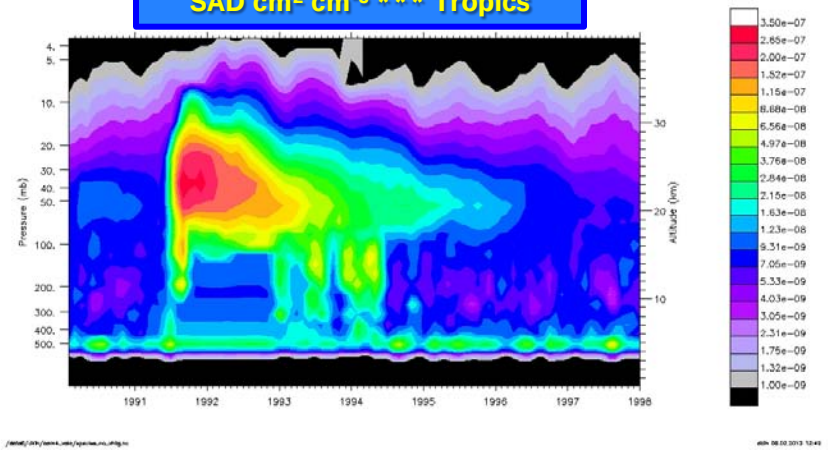


Total N_2O_5 + H_2O Rate

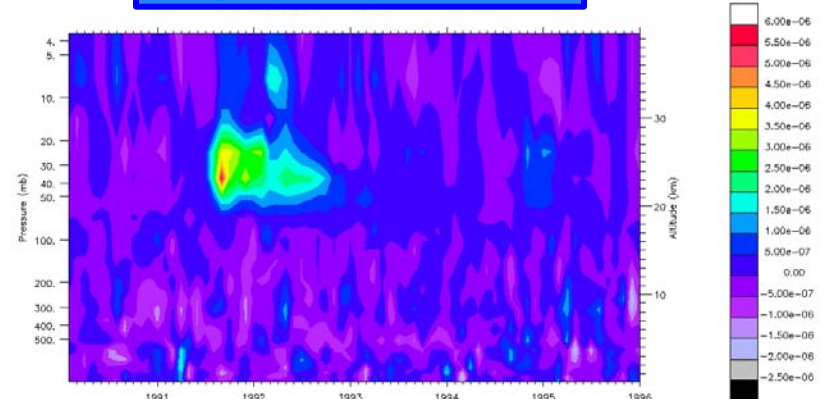


Volcanic Heating

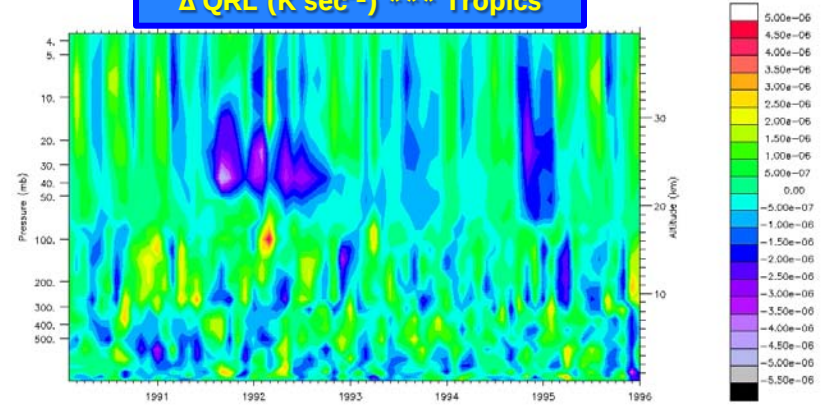
SAD cm^2 cm^{-3} * Tropics**



Δ QRS (K sec^{-1}) * Tropics**



Δ QRL (K sec^{-1}) * Tropics**



Procedure to derive heating rates:

1) Derive Volume Density (cm^{-3} aer / cm^3 air)
   - Function (SAD, size distribution, # particles)

1) Density of H_2SO_4 Aerosol (g aer / cm^3 aer
   - Liquid binary model (Tabazedeh, 1997)

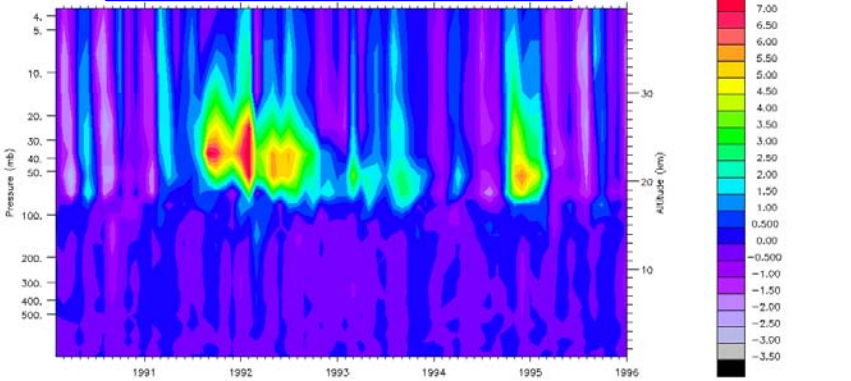
1) Weight fraction (g H_2SO_4 / g Aer)
   - Tabazedeh et al., 1997.

Chemistry: g H_2SO_4 cm^{-3} air

Radiation wants: H_2SO_4 in kg m^{-2}

CAMRT Derives Heating
   - Optics: 75% wt; 0.5 micron

Δ T (K) * Tropics**



Satellite Output for SD Simulation.

Don't have =>

Don't have =>

	O_3	H_2O	CH_4	N_2O	CCl_3F	CCl_2F_2	CO	HF	SF_6	NO	NO_2	NO_x	HNO_3	HNO_4	N_2O_5	$ClONO_2$	NO_y	HCl	ClO	HOCl	BrO	OH	HO_2	CH_2O	CH_3CN	aerosol
ACE-FTS	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						x		
Aura-MLS	x	x		x			x						x					x	x	x		x	x			
GOMOS	x										x															x
HALOE	x	x	x					x		x	x	x						x								
HIRDLS	x				x	x					x		x													
LIMS	x	x									x		x													
MAESTRO	x																									
MIPAS	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x				x		
OSIRIS	x										x	x d					x m				x					x
POAM II	x										x															x
POAM III	x	x									x															x
SAGE I	x																									
SAGE II	x	x									x															x
SAGE III	x	x									x															x
SCIAMACHY	x	x									x	x d									x					x
SMILES	x												x					x	x	x	x		x		x	
Odin/SMR	x	x		x			x			x			x				x m		x				x			
TES	x t						x t																			
UARS-MLS	x	x											x						x							

In additions:

- BUV, SBUV Nimbus 7,9,11,14,16,17,18,19
- CONCORDIASI PSC (6-balloon campaign)
- SOFIE
- SABER
- PEX 2005, 2010
- RECONCILE 2010
- SME

Acknowledge: Matthias Brakebusch (CU) for assembling coordinate file.

Aircraft Output

TBD!


Thank you for your attention!