Status of SD-WACCM

Doug Kinnison

F. Vitt, P. Hess, P. Rasch,
D. Marsh, R. Garcia, J-F Lamarque, L. Emmons, S. Tilmes, V. Yudin, and J. Orlando

16 February 2011
WACCM Working Group Meeting

SD-WACCM

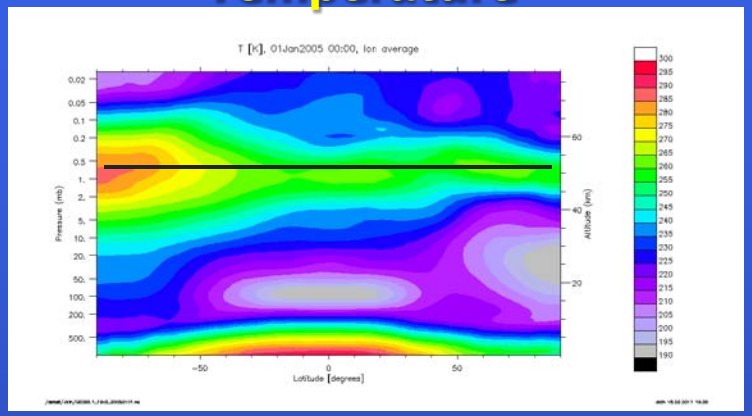
- **Specified Dynamics (SD) version of WACCM.**
  - meteorological fields are from the NASA GMAO [GEOS5.1].
  - Resolution: 0.5°x0.66°, 72L (80km) ➔ 1.9°x2.5°
    - Vertical: 88L (140km)
    - Typically the cross over point from SD to fully interactive dynamics is near 50km.
- **Nudge the model at every dynamics timestep, e.g.**
  - $U_{SD} = U_{WA}*(1-g) + U_{GEOS}*g$
  - Nudge T, U, V, PS
- **Simulation period: 1 Jan 2004 through 1 October 2010**
  - Results available – contact me if your interested...
- **Future: plan to run SD-WACCM (1979-2010) using MERRA meteorological fields.**

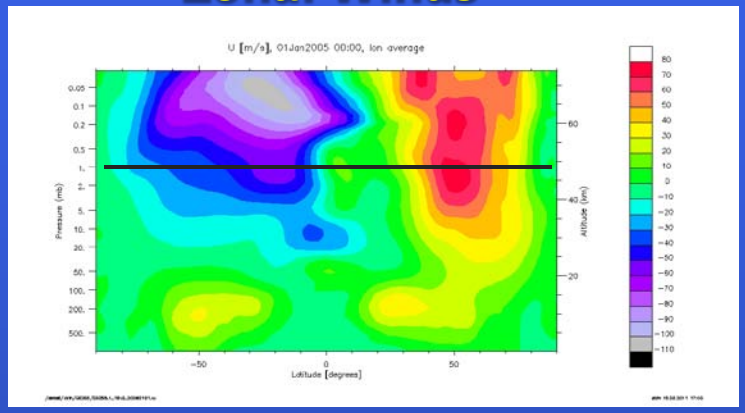
Nudging Sensitivity

Temperature

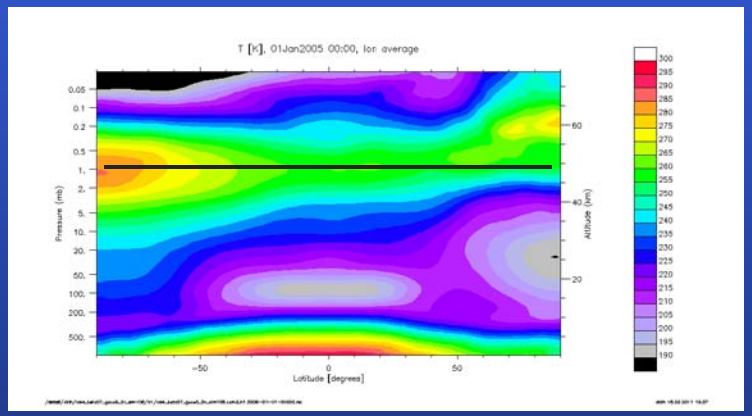
Zonal Winds

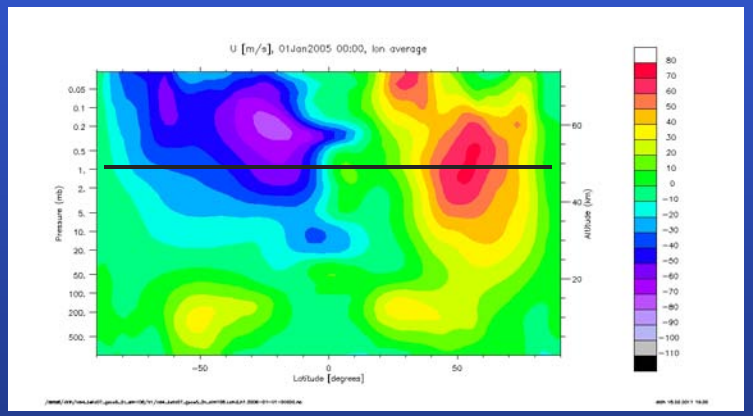
GEOS5



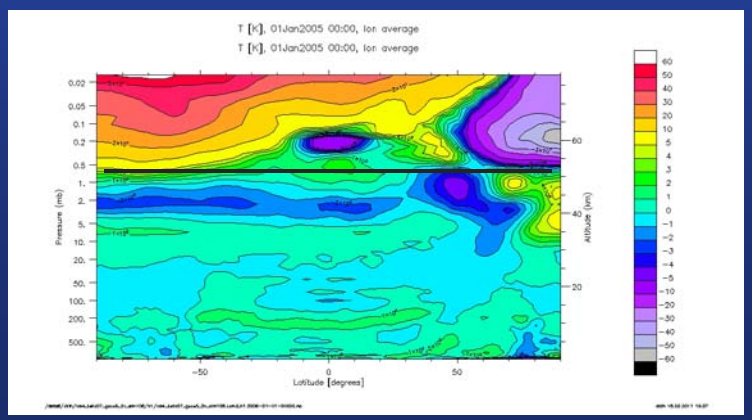


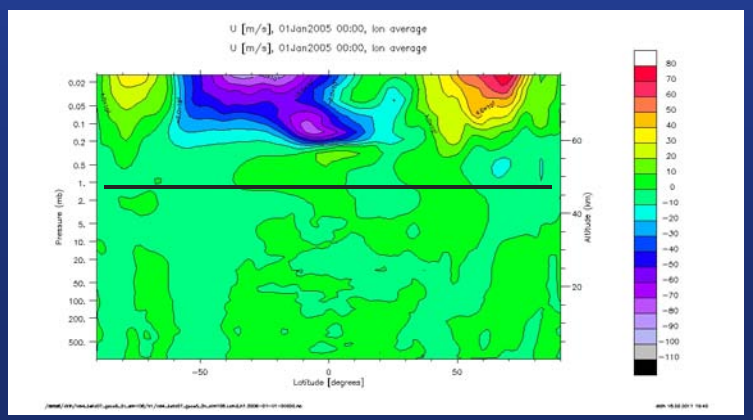
1%





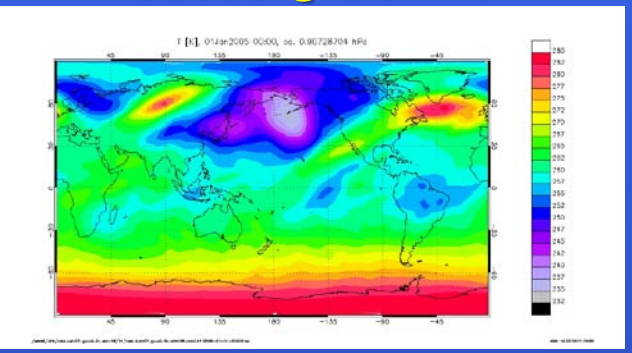
G5-WA



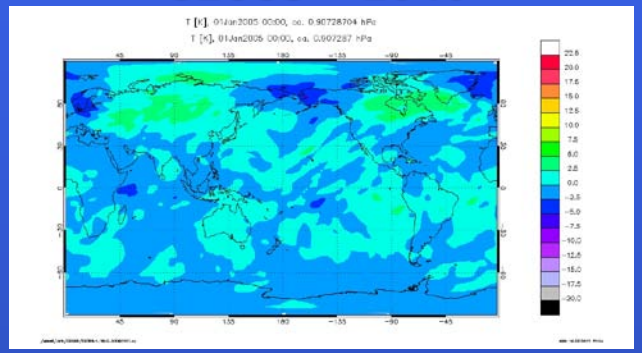


Nudging Sensitivity: 1% vs 10%

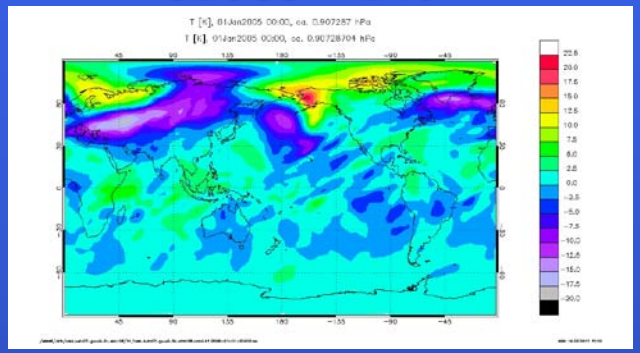
GEOS5 @ 0.9 hPa



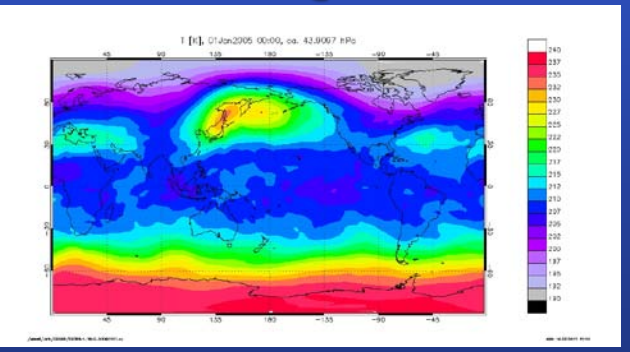
GEOS5 – 10%



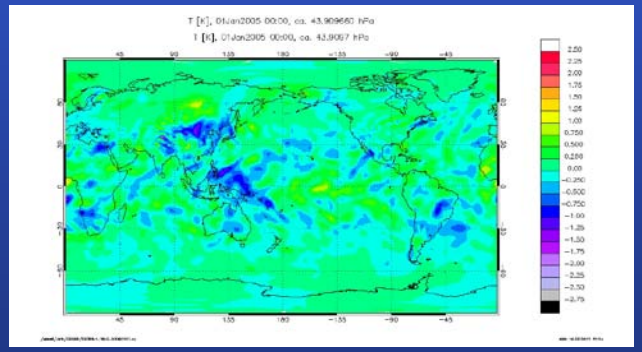
GEOS5 – 1%



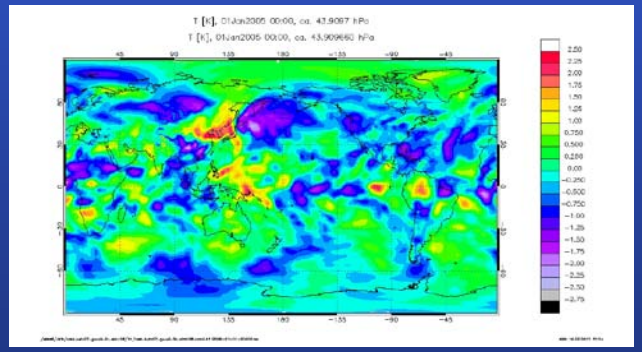
GEOS5 @ 43 hPa



GEOS5 – 10%



GEOS5 – 1%



SD-WACCM Chemical Mechanism

- **Standard Middle Atmosphere Mechanism (CCMVal-2):**
  - 57 species
  - Ox, NOx, HOx, ClOx, BrOx species.
  - Heterogeneous reactions on Sulfate, NAT, and Water ice aerosols
  - Ion chemistry
  - CH4 and its oxidation products...
  - 230 photochemical reactions...
- **Troposphere => Lower Thermosphere (not publically released)**
  - 122 species
  - Includes the MZ4 troposphere mechanism (Emmons et al. 2010.)
  - 380 photochemical reactions

Science Studies

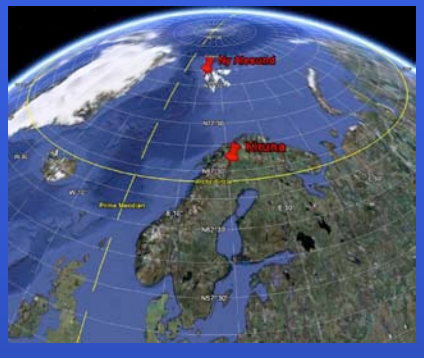
- Mesospheric CO [Hoffman et al…]
- Mesospheric Ozone [Marsh et al…]
- HIRDLS Evaluation [Gille et al.,]
- Stratospheric Ozone Loss [Brakebusch, et al…]
- UTLS Studies [Pan, Bowman et al…]
- Monsoon and Tropical [Park, Randel, et all…]

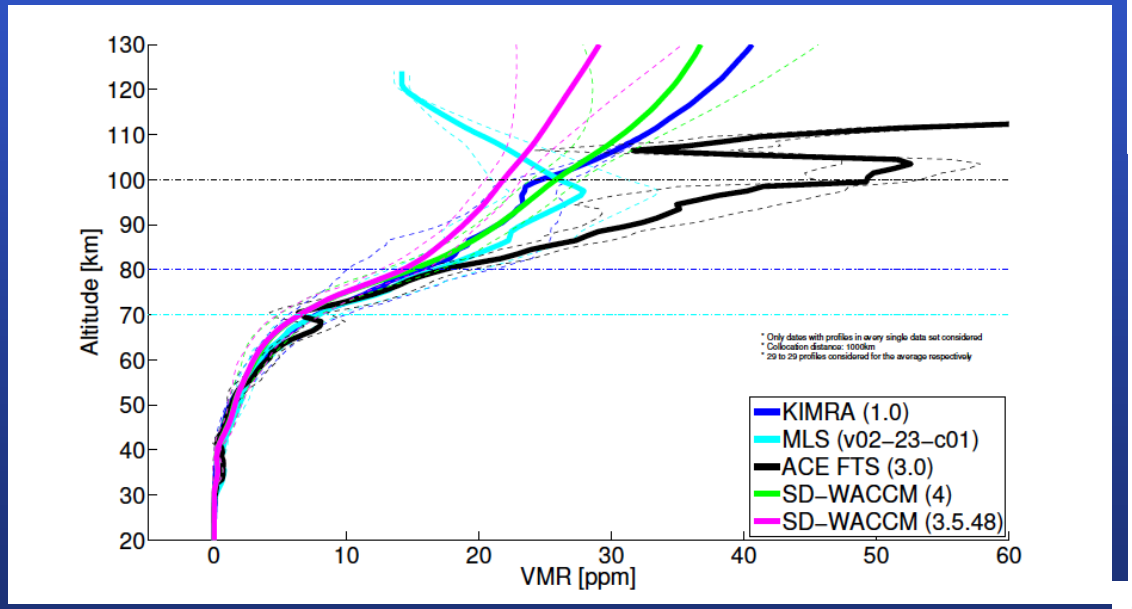
- NASA Arctas Campaign [Salawitch et al., GRL, 2010]
- SMILES Evaluation [Masato Shiotani et al…]
- Transport studies [Peterson, Brasseur et al…]
- Isotopologues, CH_3D, $^{13}CH_4$ [Bernath et al…]

Mesospheric CO – Hoffman et al.

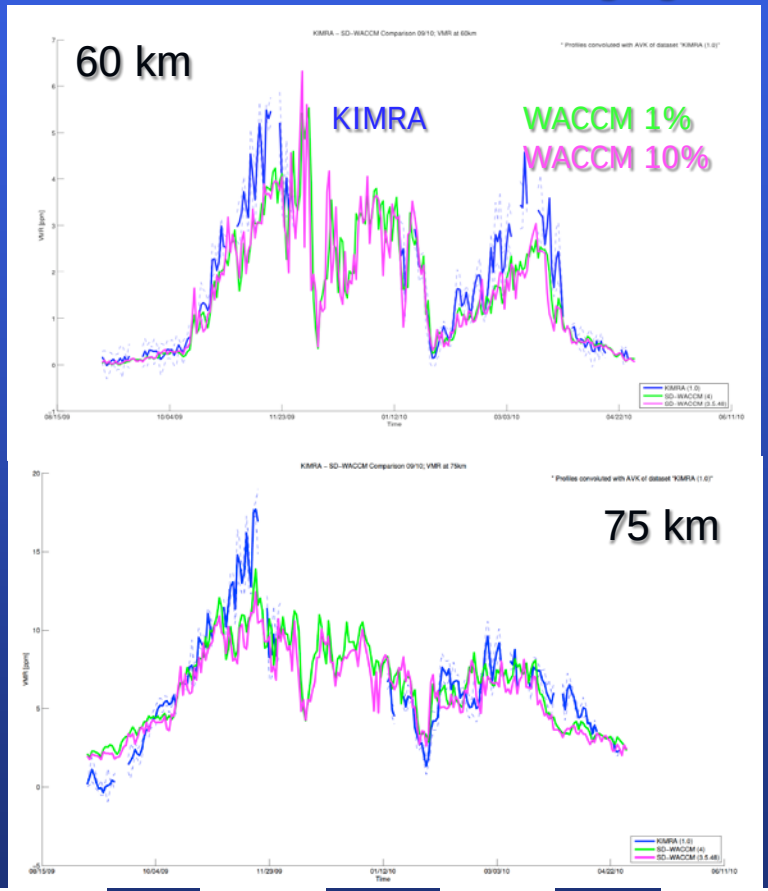
Instrument Description

- Kiruna Microwave Radiometer (KIMRA) – 68N
- Measurement of CO transition at 230 GHz
- Optimal Estimation – WACCM apriori
- Sensitivity between 40-80km





CO time series *** 1% Nudging



8/15/09 | 11/23/09 | 4/22/10 | 6/11/10

Additional CO Production:

UBC: Fixed

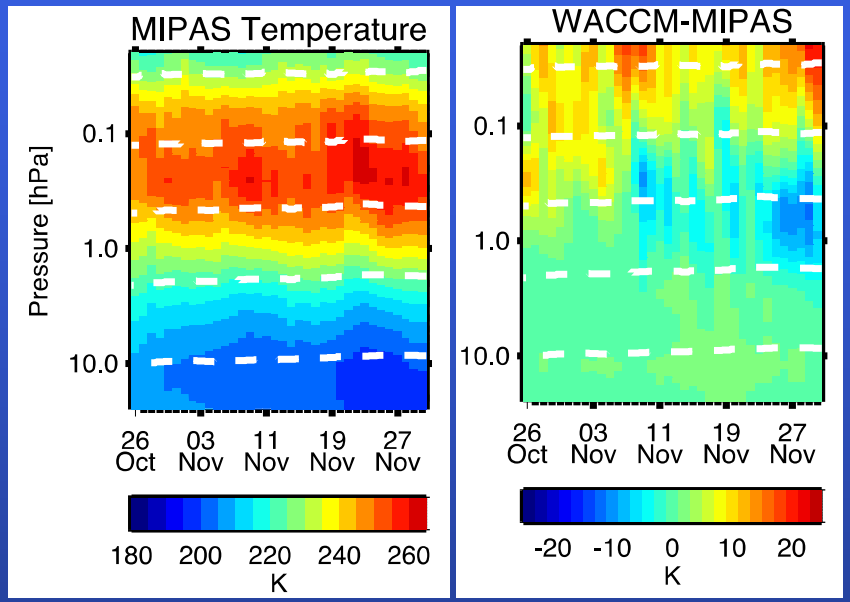
JCO_2 + hv (euv) -> CO + O

$CO_2 + O^+ \rightarrow CO + O2^+$

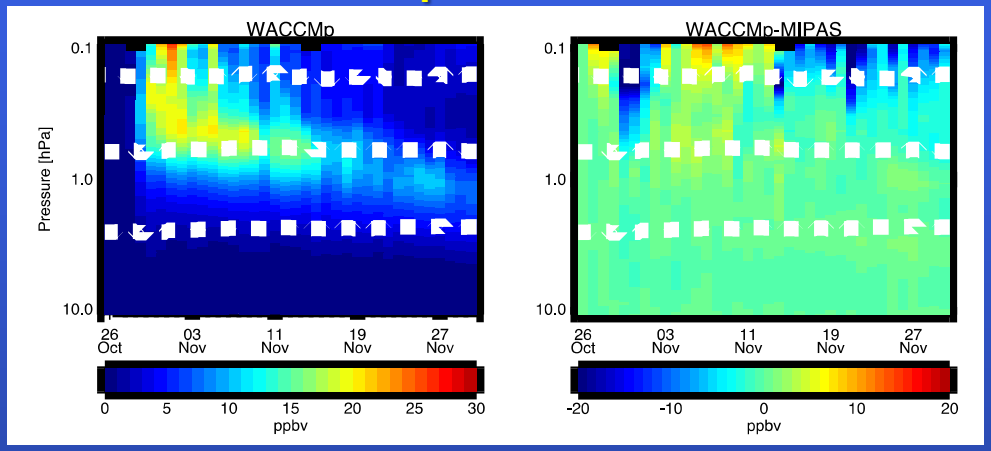
HEPPA1 intercomparison – 'Halloween Storm' 2003 SPE

Marsh et al…

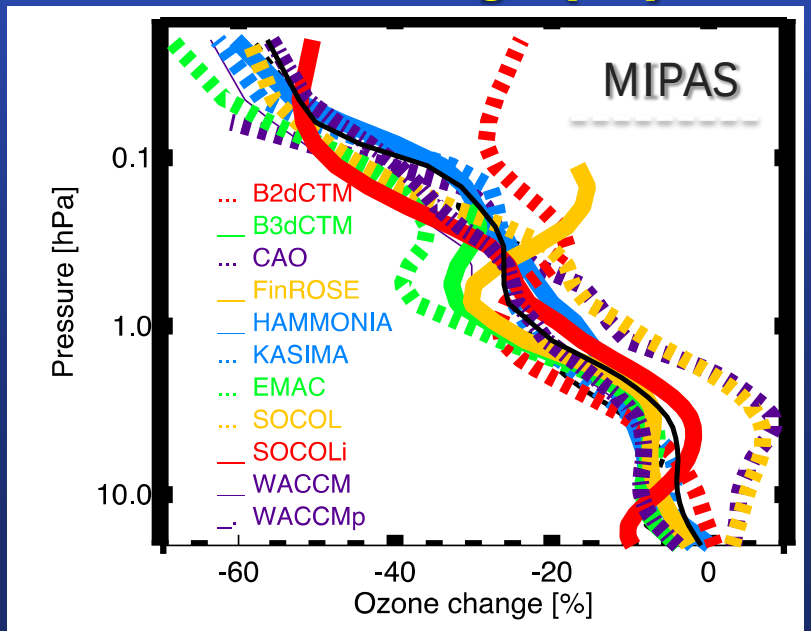
Temperature



NO_Y increase



Ozone change (%)



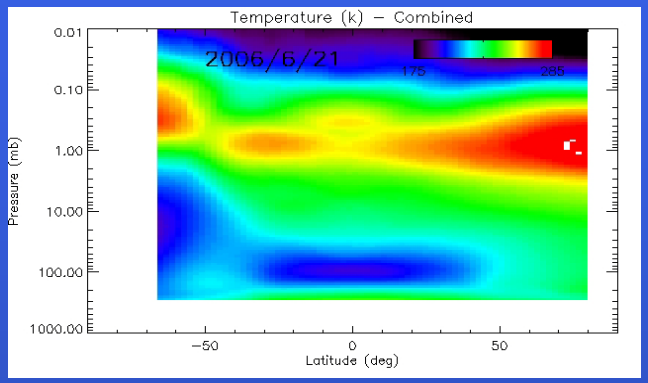
- SD-WACCM nudged to MERRA up to 1hPa
- SPE ionization increases NOy, leads to large ozone decreases
- Study submitted to ACPD!

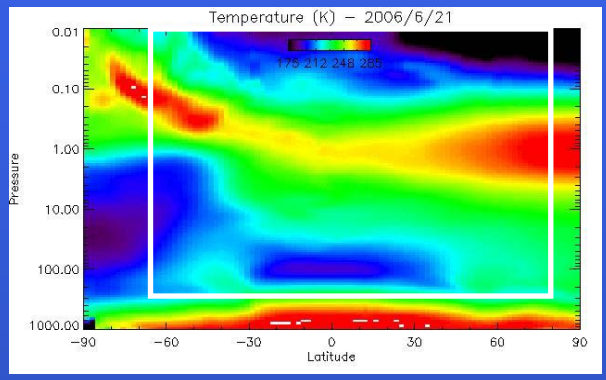
HIRDLS Evaluation

High Resolution Dynamics Limb Sounder

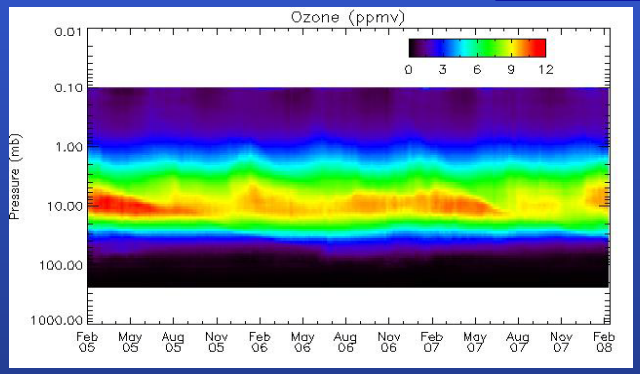
- 21-channel IR filter radiometer
- Obs: Jan 2005 – March 2008

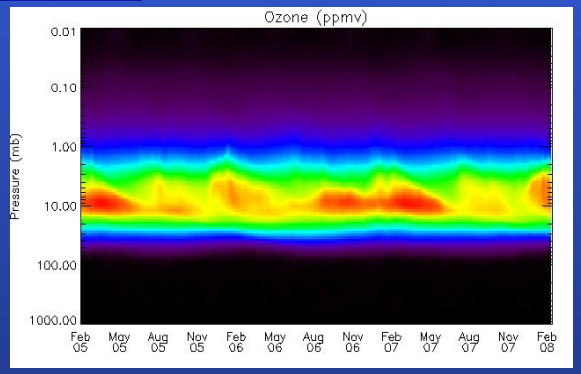
HIRDLS **Temperature** WACCM - GEOS5

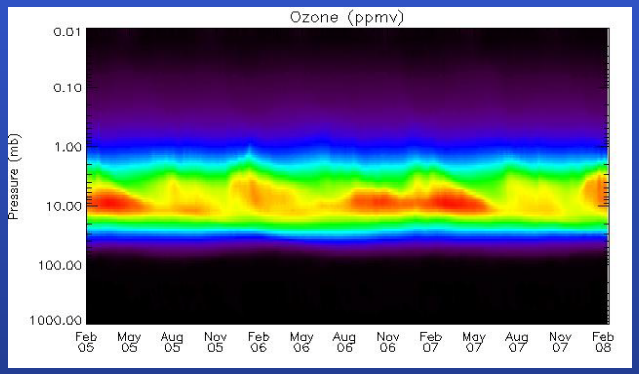




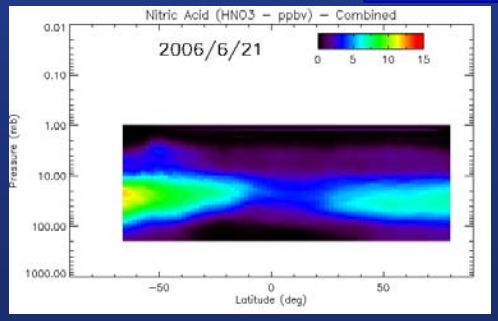
HIRDLS **Ozone** WACCM - GEOS5 Aura-MLS

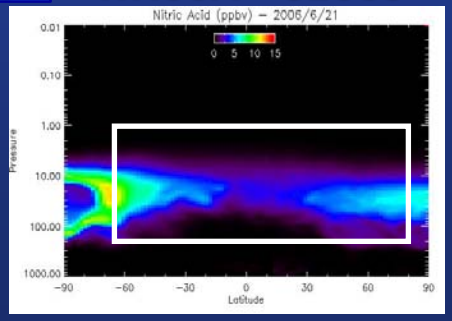




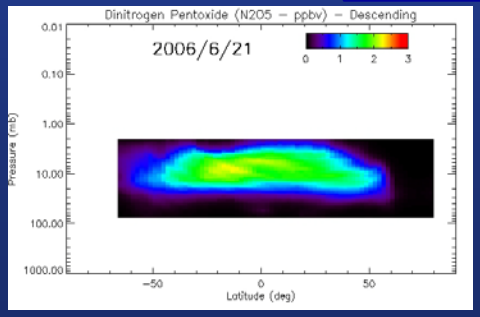


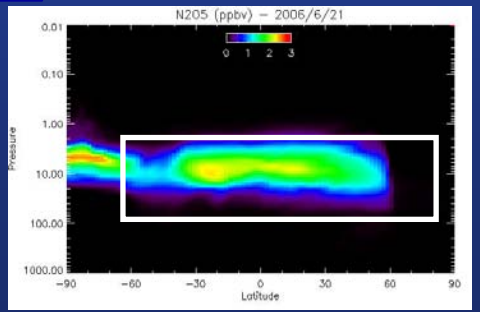
HIRDLS **HNO3** WACCM - GEOS5





HIRDLS **N2O5** WACCM - GEOS5



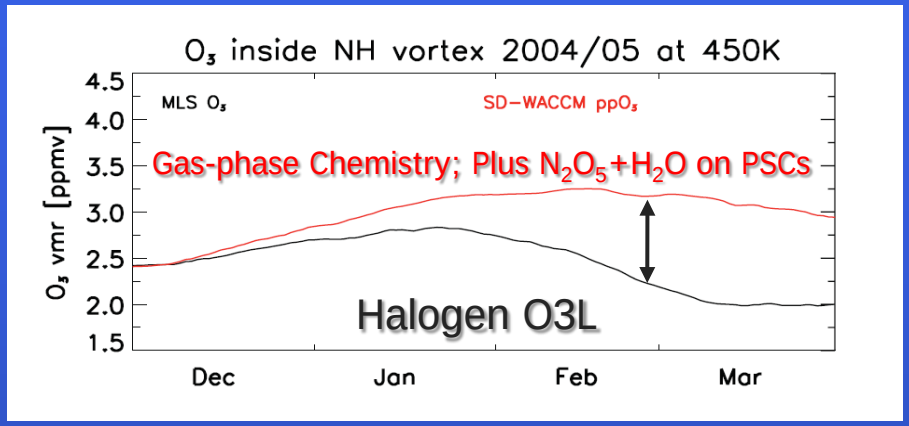


Figures Courtesy of Maria Rivas

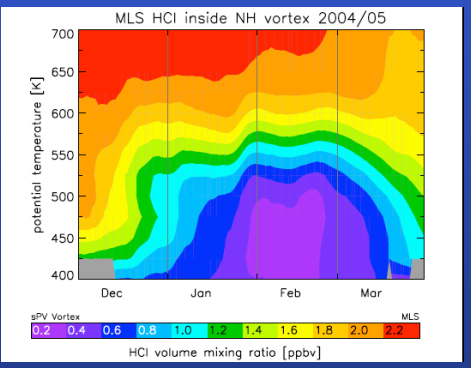
Stratospheric Ozone Loss

Used SD-WACCM with MLS observations to derive the chemical ozone loss (halogen loss).

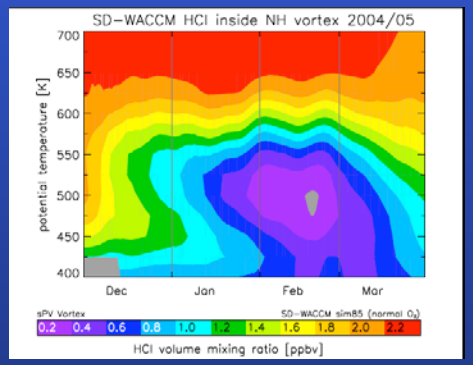
- Use the Pseudo-passive Ozone (ppO_3) approach [Singleton et al., 2007].
- Good evaluation of the heterogeneous chemistry!



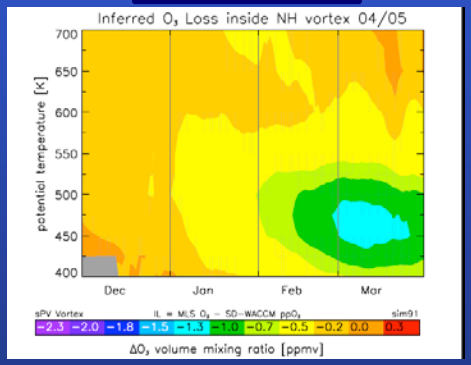
MLS HCl



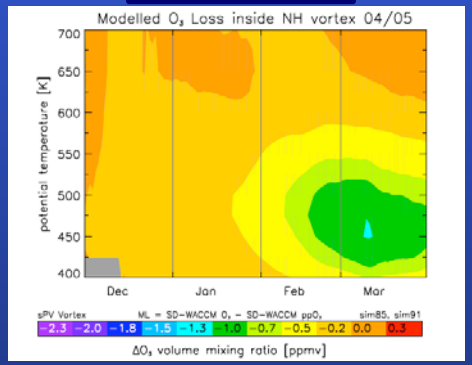
Model HCl



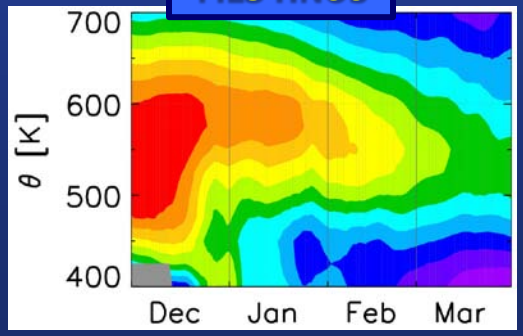
MLS O3L



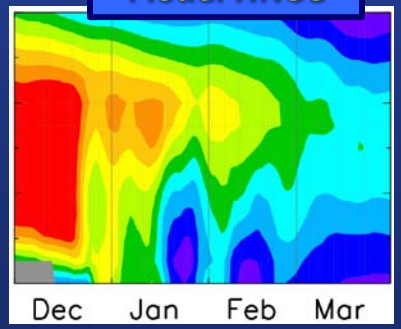
Model O3L



MLS HNO3



Model HNO3



Figures Courtesy of Matthias Brakebusch

Monsoon and Tropical Comparisons

Asian Monsoon Transport of Pollution to the Stratosphere

William J. Randel,[1]* Mijeong Park,[1] Louisa Emmons,[1] Doug Kinnison,[1] Peter Bernath,[2,3] Kaley A. Walker,[4,3] Chris Boone,[3] Hugh Pumphrey[5]

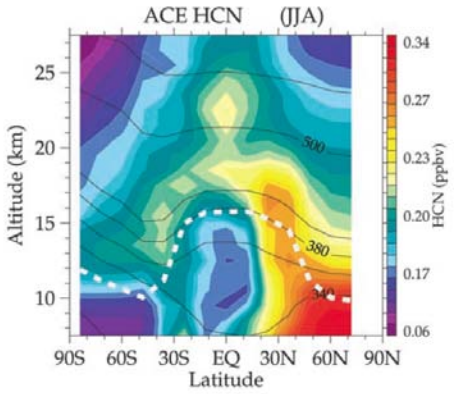
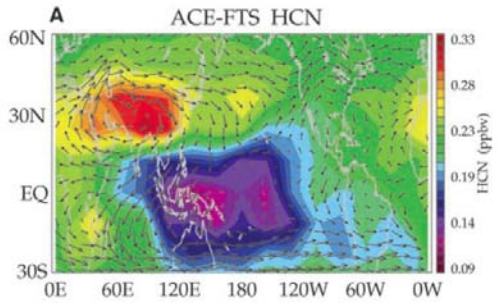


Fig. 2. Time and zonal average mixing ratio (ppbv) of HCN during boreal summer (June to August) derived from ACE-FTS satellite measurements. The white dashed line denotes the tropopause, and black lines denote isentropic levels.



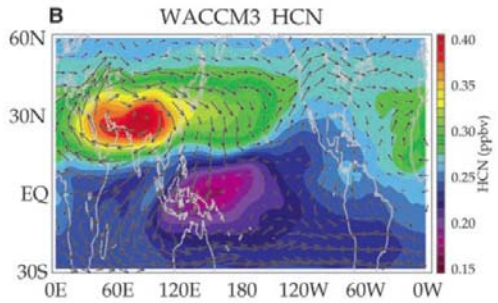


Fig. 1. Time average mixing ratio [parts per billion by volume (ppbv)] of HCN near 13.5 km during boreal summer (June to August) derived from (**A**) ACE-FTS observations and (**B**) WACCM chemical transport model calculations. Arrows in both panels denote winds at this level derived from meteorological analysis, showing that the HCN maximum is linked with the upper tropospheric Asian monsoon anticyclone.

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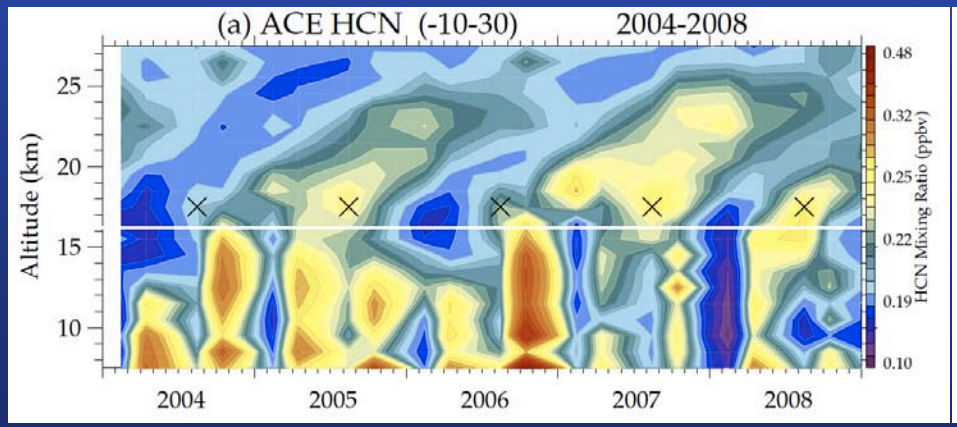
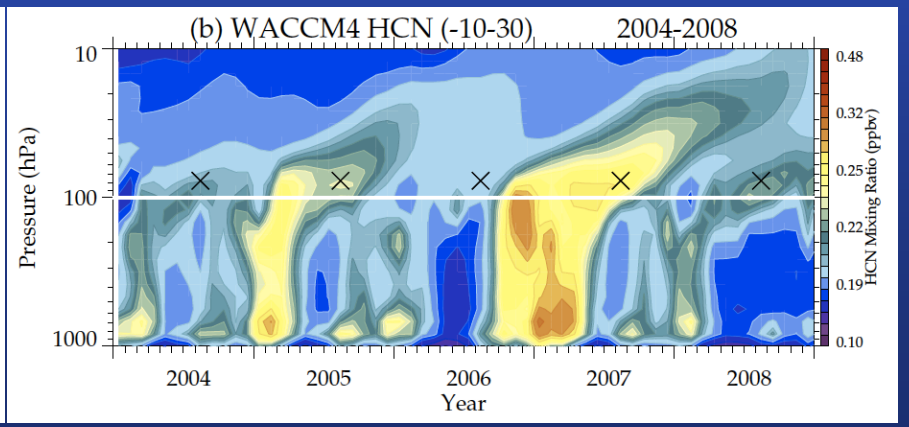
HCN (10S-30N)

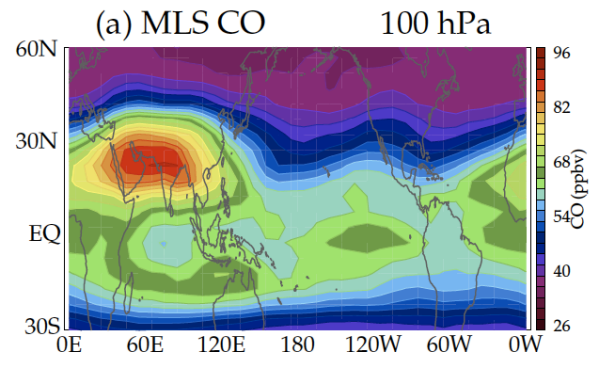


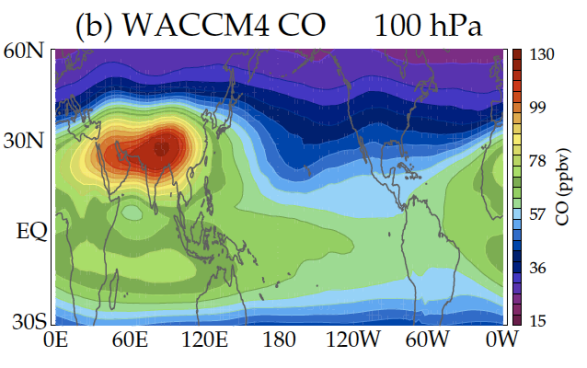


Figures Courtesy of Mijeong Park and William Randel

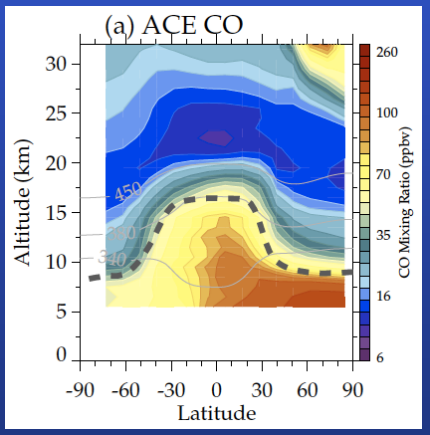
Monsoon and Tropical Comparisons

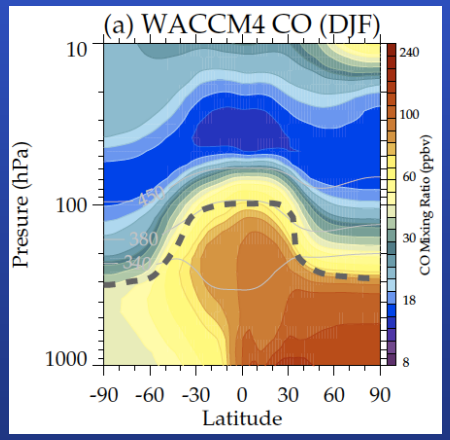
CO Climatology at 100 hPa (Jun-Aug)



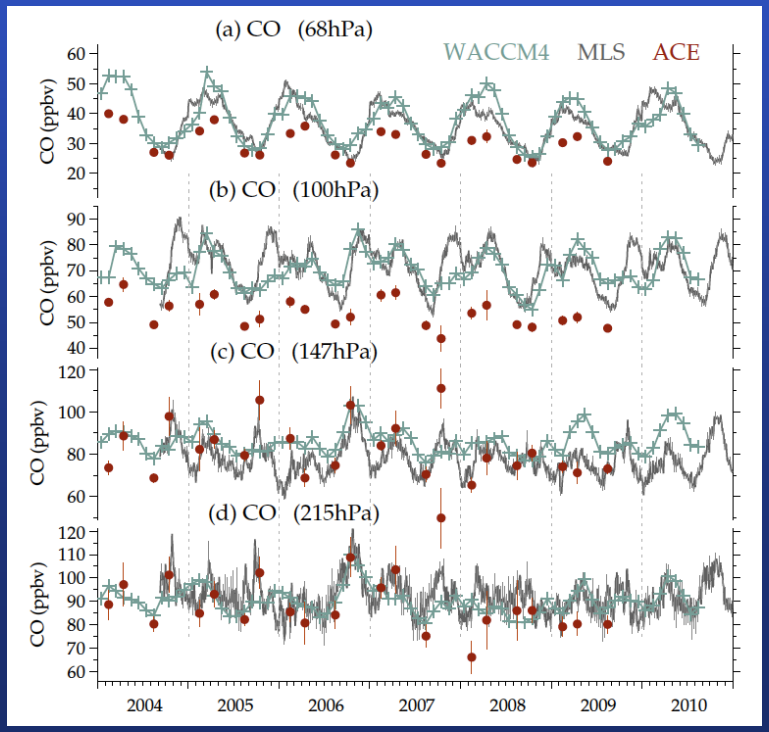


CO Climatology - Dec-Feb





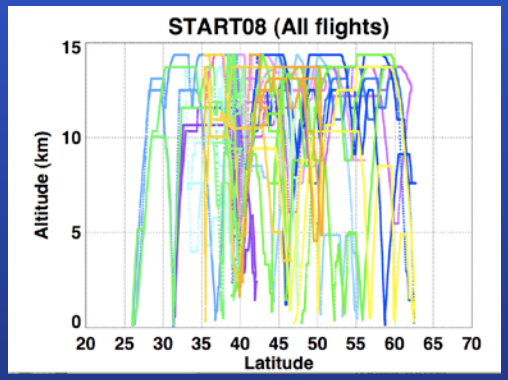
CO time series (MLS, ACE and WACCM4)

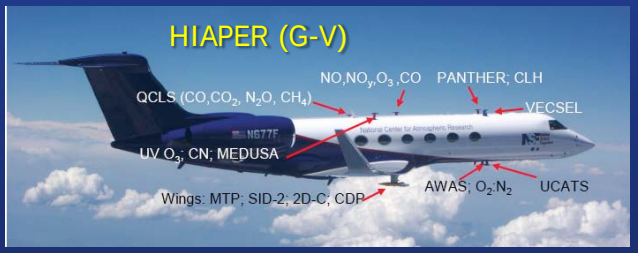


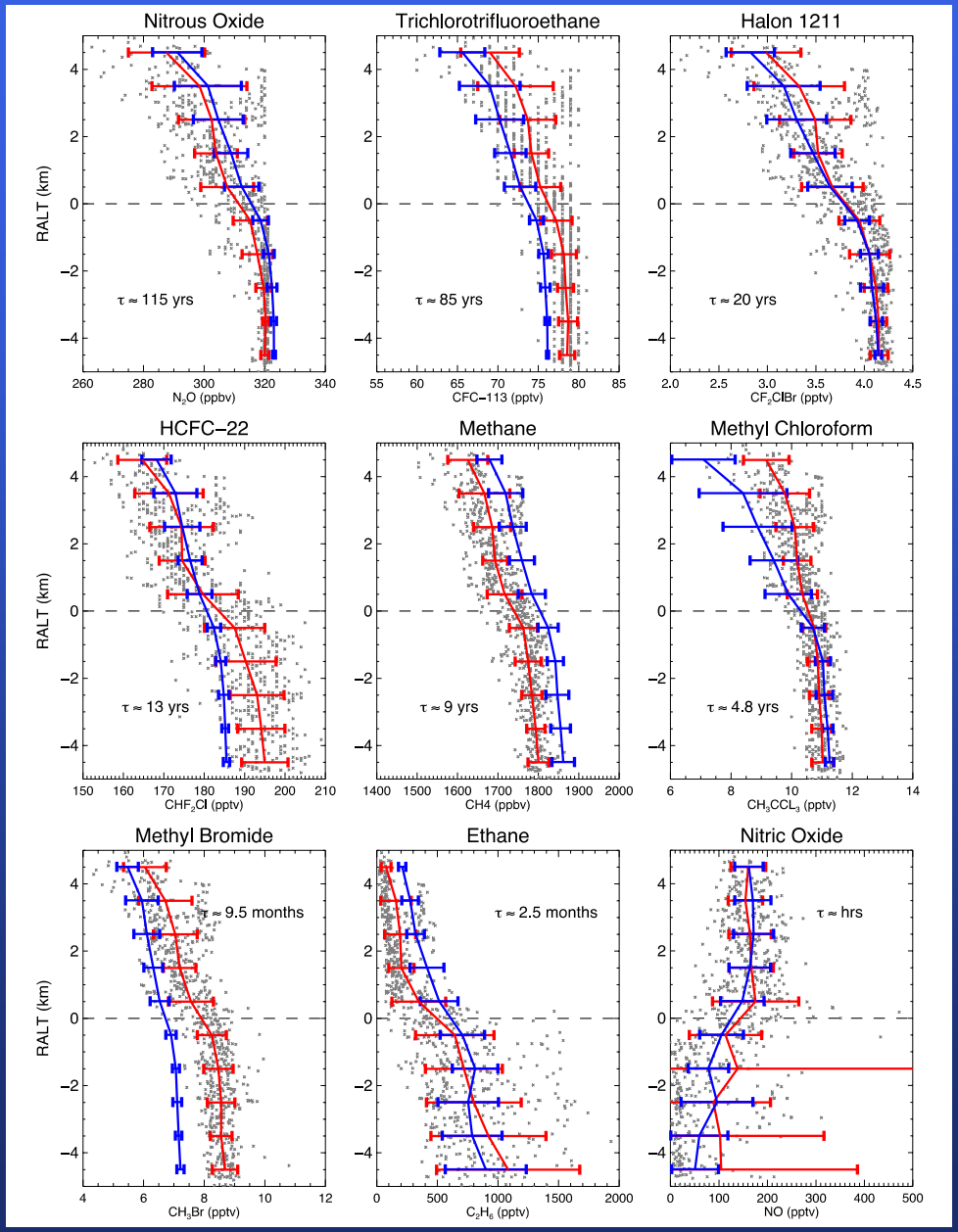
Figures Courtesy of Mijeong Park

START08 - UTLS Studies

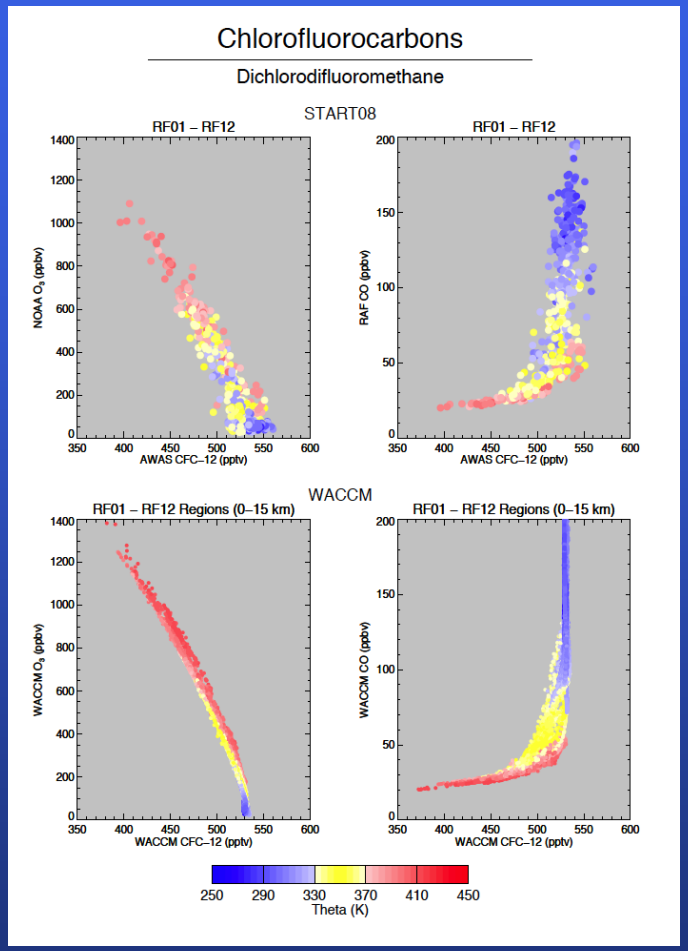
START08/PreHIPPO
April-June 2008

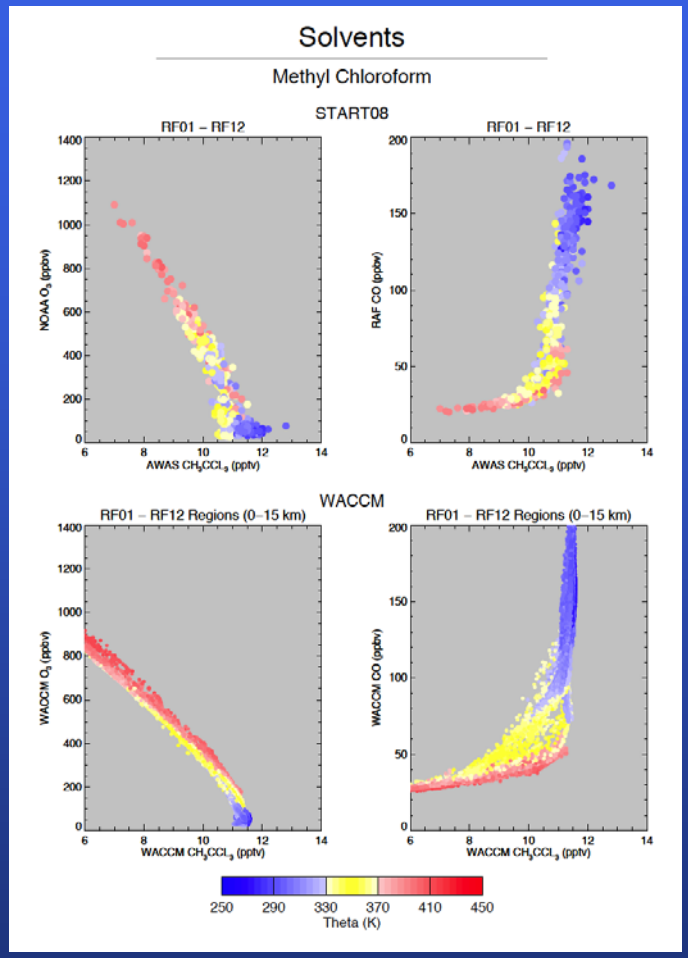






START08 - UTLS Studies





Next Step

- Kinnison *et al.*, Description and evaluation of the Whole Atmosphere Community Climate Model (WACCM): Chemistry Update, Geosci. Model Dev., 2011.

- SD-WACCM / Merra period 1979 – 2011; > 120 species mechanism.