

WACCM: State of the Model

Whole Atmosphere Working Group

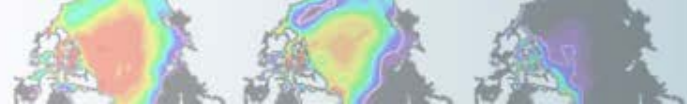
Michael Mills, liaison

Andrew Gettelman, internal co-chair

Lorenzo Polvani, external co-chair

CESM Workshop, June 2014

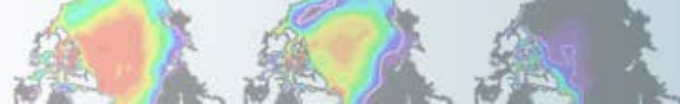




Scientifically validated configurations

- For publishable science with CESM1(WACCM)
- Code base: CESM1.0.x (1.0.6 released 4/2014)
- Horizontal resolution: 1.9°x2.5° atmosphere with 1° full ocean (1.9x2.5_gx1v6)
- Compsets:
 - CMIP5:
 - B_1850_WACCM_CN
 - B_1850-2005_WACCM_CN
 - B_1955-2005_WACCM_CN
 - B_RCP2.6_WACCM_CN
 - B_RCP4.5_WACCM_CN
 - B_RCP8.5_WACCM_CN
 - B_1850_WACCM_SC_CN
 - B_1955-2005_WACCM_SC_CN
 - B_RCP2.6_WACCM_SC_CN
 - B_RCP4.5_WACCM_SC_CN
 - B_RCP8.5_WACCM_SC_CN
(see Ryan Neely's talk)
- All other configurations are for development, and require user validation (including CESM1.2.2).

New Specified Chemistry



Current Status

- New SC compsets in CESM 1.0.6 and 1.2.2 releases
- WACCM Simulations
 - CMIP5, CCMI Runs, Last Millennium Ensemble (850—2005)
 - WACCM Large ensemble simulations under discussion (see end of session)
- WACCM-SE high resolution (0.25 deg)
- WACCM development timeline

CESM1.0.6 and 1.2.2

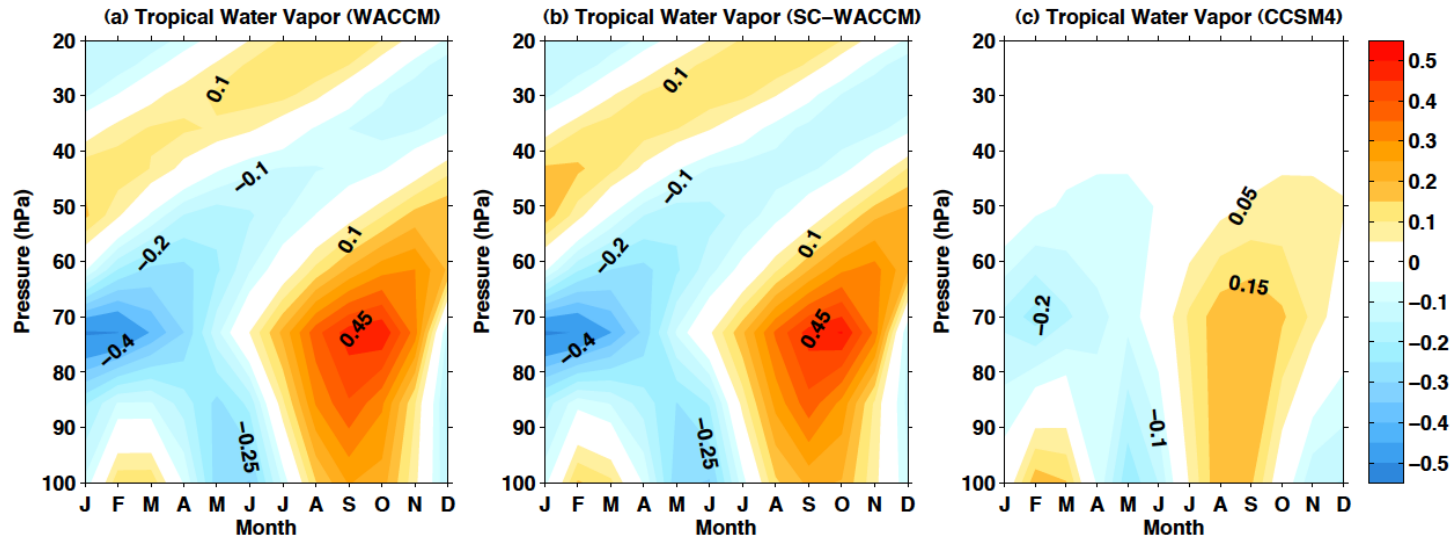
- WACCM Specified Chemistry (WACCM-SC)
 - Specifies Ozone (among other species)
 - 2x as fast as WACCM if you want to do stratospheric dynamics: with nearly identical results (see next slide)

Model	# cores	simulated years/day	core-hrs/simulated year
WACCM	352	7.5	1130
SC-WACCM	352	14.8	573
CCSM4 1°	352	19.6	432
CCSM4 2°	416	42.0	237

- Bug Fixes
- Last support for CESM1.0 series (we think): all functionality and similar solutions available in CESM1.2.2 (for WACCM4)

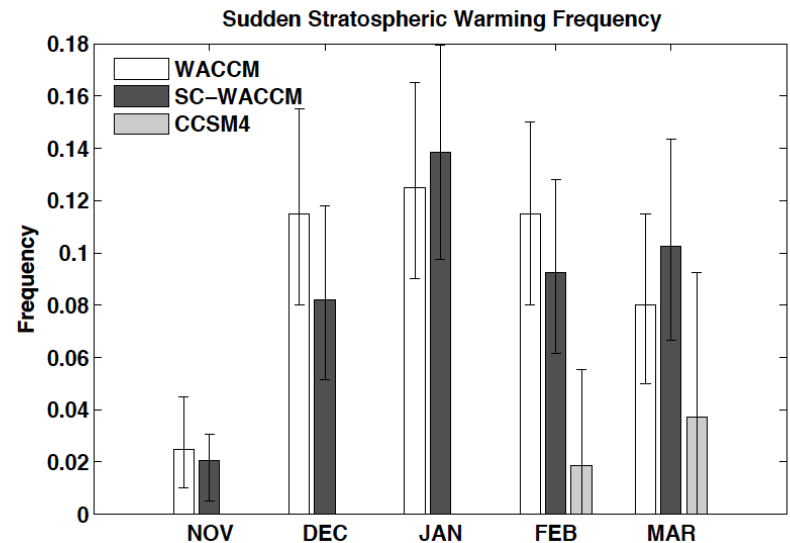
WACCM4-SC

Preview: See Neely Talk (also details about WACCM-SC O3)



Above: Tropical H₂O Tape Recorder looks like WACCM (good), not CCSM4 (bad)

Right: WACCM4-SC also gets SSWs



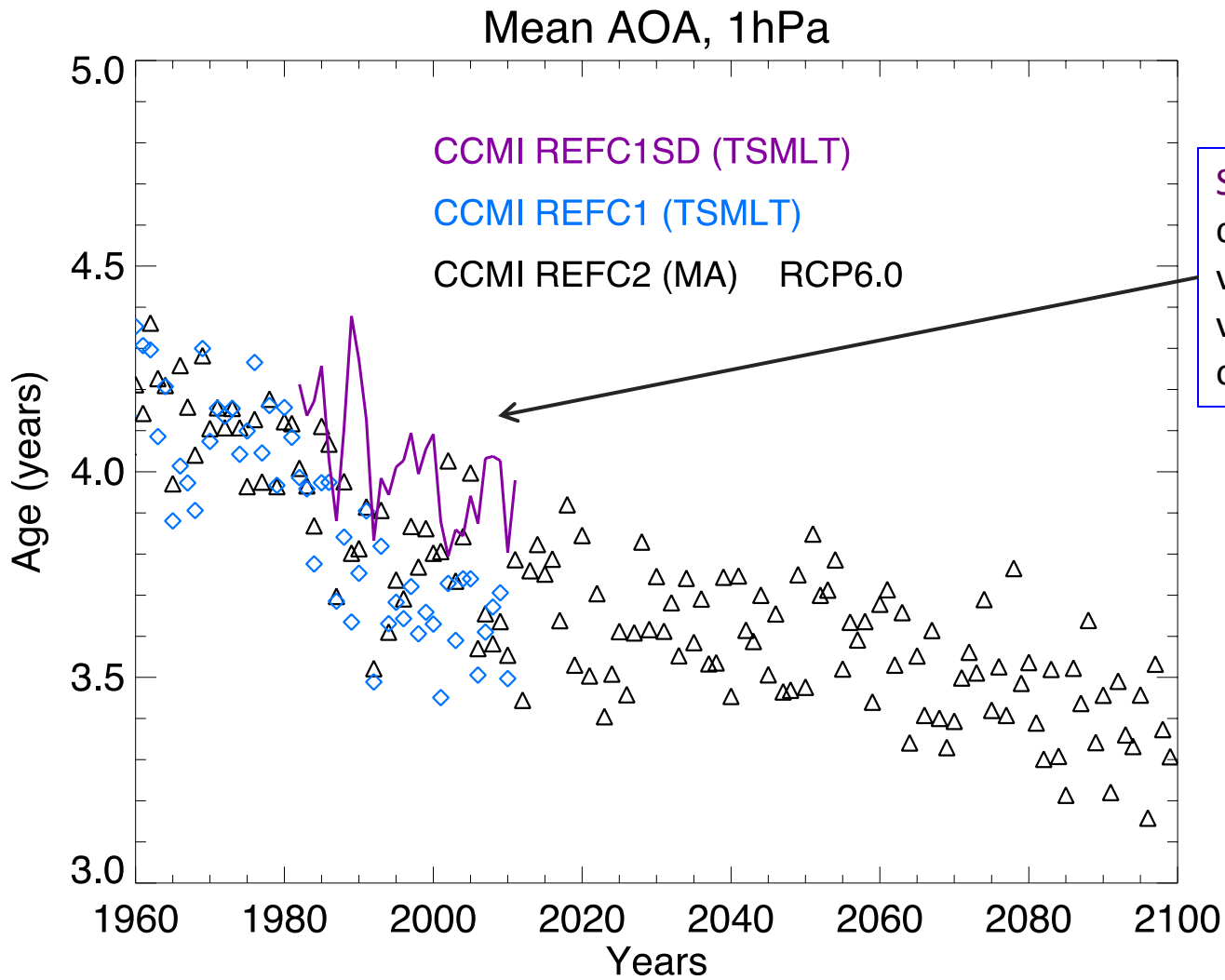
CESM1(WACCM) CCM1 Updates Since CMIP5

- Chemistry updates
 - Updated chemical rate constants to JPL-2010.
 - Additional organic halogens (no surrogates) were included – 18 total.
 - Include representation of very short lived (VSL) organic bromine.
 - Included representation of Fluorine chemistry (F, HF, COF₂, COFCl).
 - Added tropospheric chemistry (Total: 164 Species and 450 reactions).
 - Also created a VSL mechanism for CCM1 (Saiz-Lopez et al. 2012).
 - Updated Heterogeneous Chemistry Module (*Wegner et al.*, 2013).
 - Update Wet (Neu) / Dry (land model) Deposition.
 - New recommendation on future organic halogen evolution (WMO 2010).
- Prescribed stratospheric sulfate
 - New Sulfate Surface Area Density (SAD) time series (1960-2010).
 - Improved representation of volcanic heating (R. Neely and A. Conley).
- Output
 - Satellite output for SD simulations.
 - Rate output now available (tagged to individual or sum of reactions).
- Physics: Addition of Inertia Gravity Waves (IGWs) – See R. Garcia's presentation.

CESM1(WACCM) CCM1 Scenarios and Simulations

- REFC1: 1950-2010 historical (completed 3 realizations)
 - Data Ocean
 - QBO (nudged)
 - Troposphere-Stratosphere-Mesosphere-Lower-Thermosphere (**TSMLT**) Mechanism (164 species, 459rxns)
 - Solar variability, Volcanic Heating and SAD for Chem.
- REFC1SD: 1975-2012 historical (completed 2 simulations)
 - MERRA (50-hr nudging), data ocean
 - QBO (internal to MERRA)
 - 1 sim with **TSMLT** Mechanism
 - 1 sim with Middle Atmosphere (**MA**, 85 species; 287rxns)
 - Solar variability, Volcanic SAD for Chem.
- REFC2: 1950-2100, RCP6.0 (completed 3 realizations)
 - Interactive ocean
 - QBO (nudged)
 - **MA** Mechanism (14-tracers)
 - Solar variability, Volcanic Heating and SAD for Chem.
- SENS2: 2000-2100, RCP8.5 (completed 1 realization)
 - Same setup as REFC2, different RCP.
- Results to be released publicly after description papers are submitted (Garcia et al., 2014; Kinnison et al., 2014)

Annual Average Mean AOA: 25S-25N



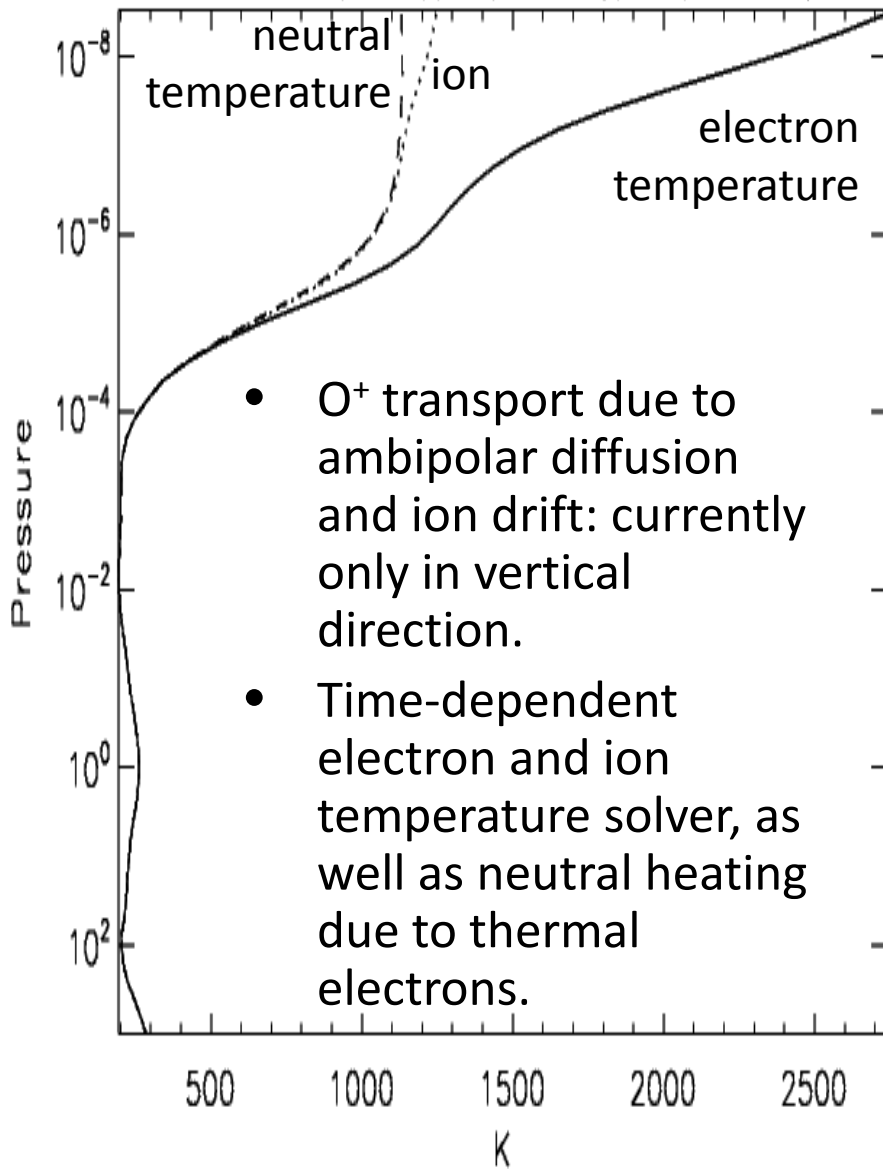
SD has a similar trend compared to FR versions; absolute values are ~0.5 years older in SD.

New Developments

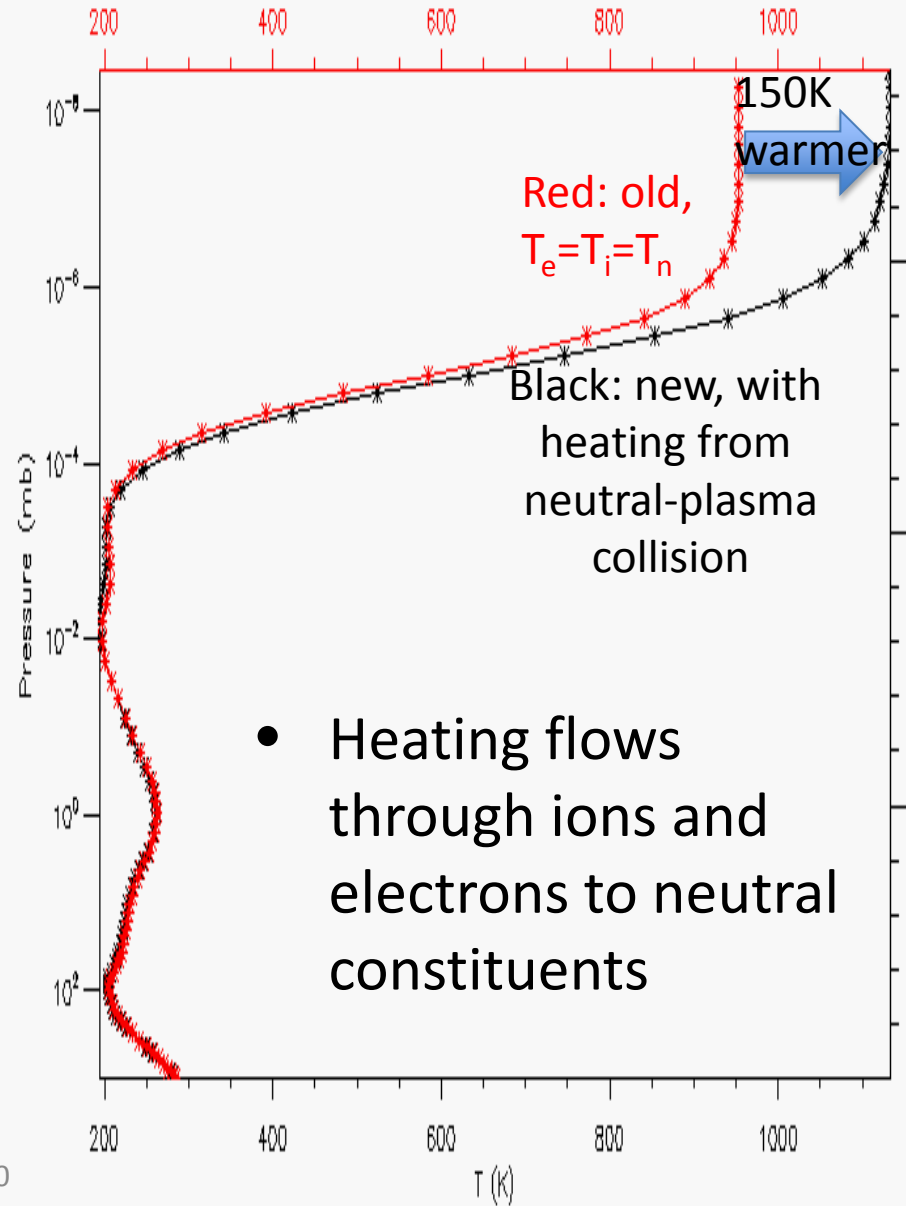
- QBO: new adjustments to GW and levels
- SE-WACCM5: High Resolution (0.25d)
- WACCM-X
 - Ionosphere Energetics and Transport
- Stratospheric Sulfur
 - New prescribed volcanic aerosol file
 - Prognostic MAM volcanic sulfur
 - GEOMIP simulations

WACCM-X Ionosphere Modules

Global Ave. Te(solid)/Ti(dotted)/Tn(dashed), Jan



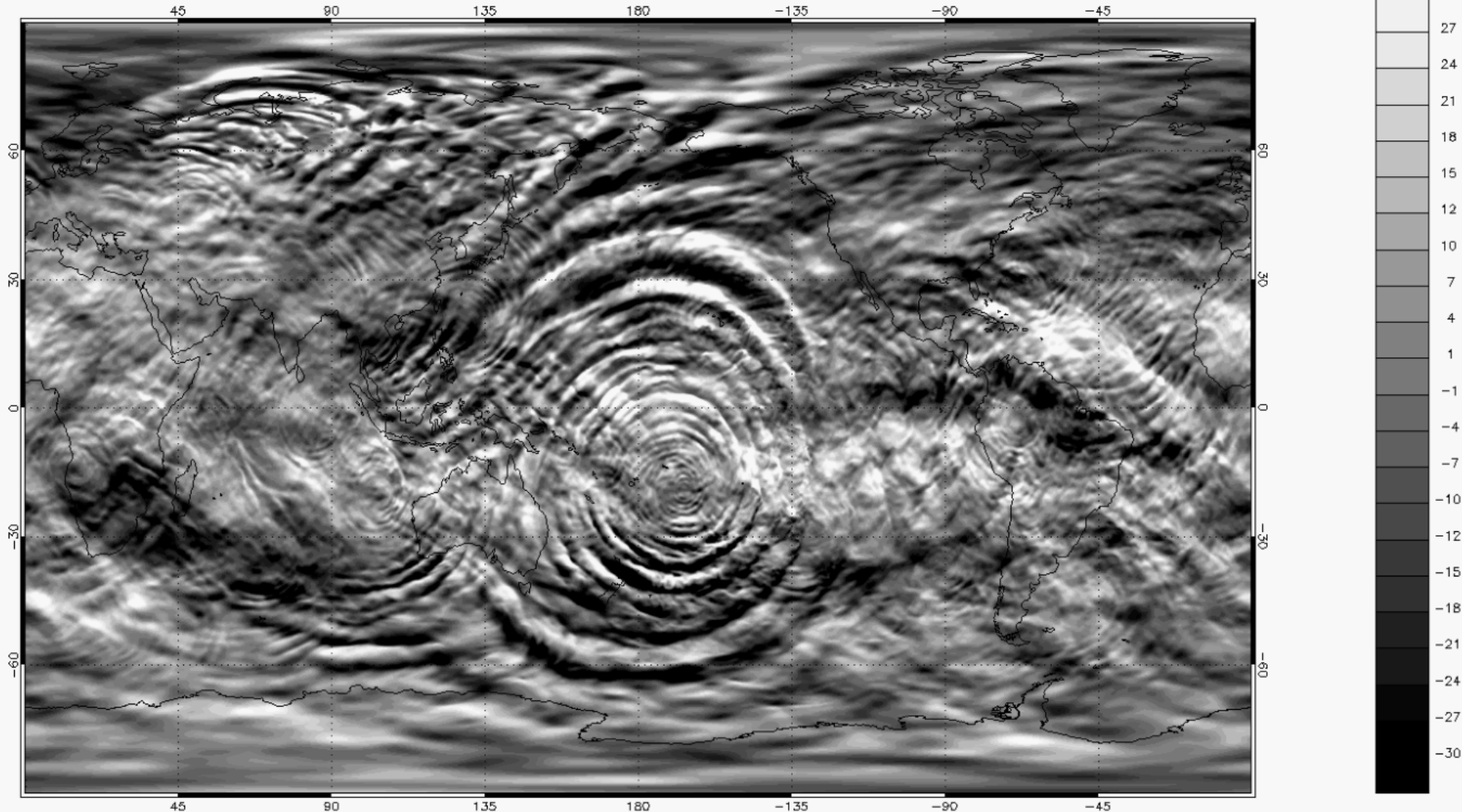
T [K], 14Jan2000 00:00, global average



WACCM5-High Res (25km) Meridional Wind at ~110km:

Space Weather Driven by Terrestrial Weather

V [m/s], 05Feb 1 00:00

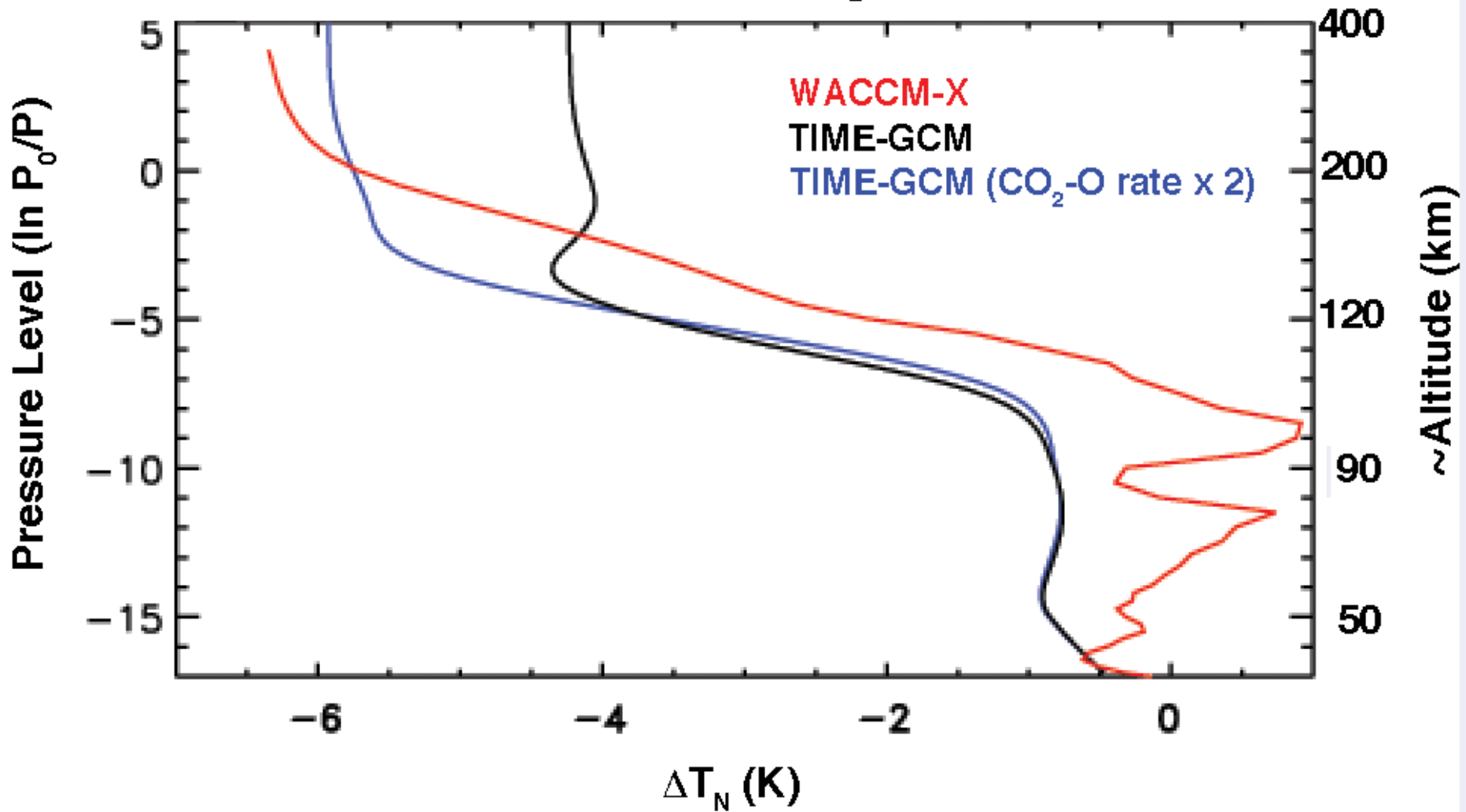


SE-WACCM at ne120: upper atmospheric wave structures are driven by the troposphere. Ripples are gravity waves (e.g. tropical waves), also frontal generated waves.

See Hanli Liu's presentation

WACCM-X: CO₂ Trends

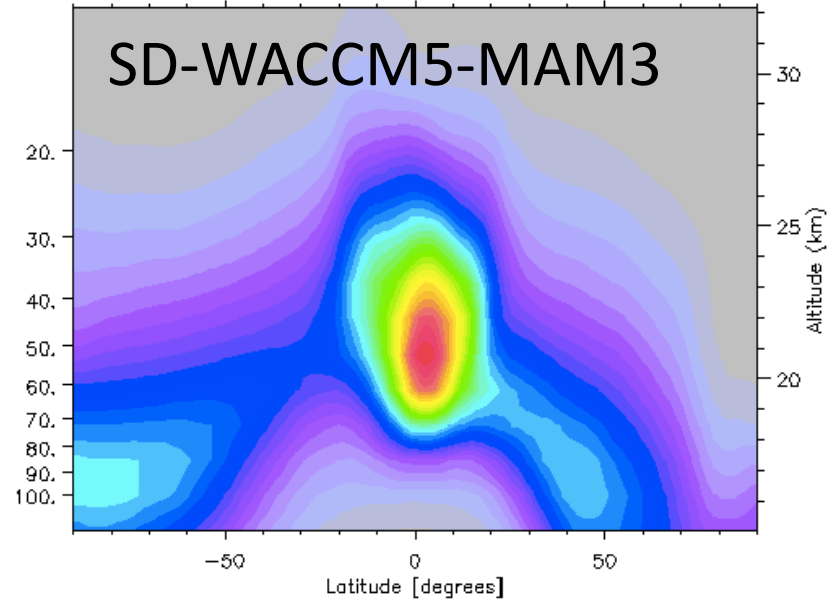
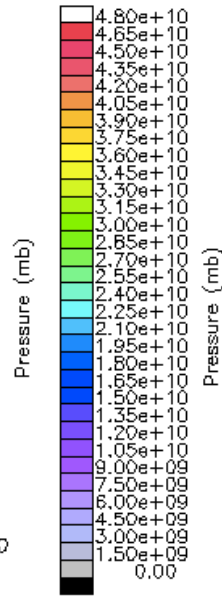
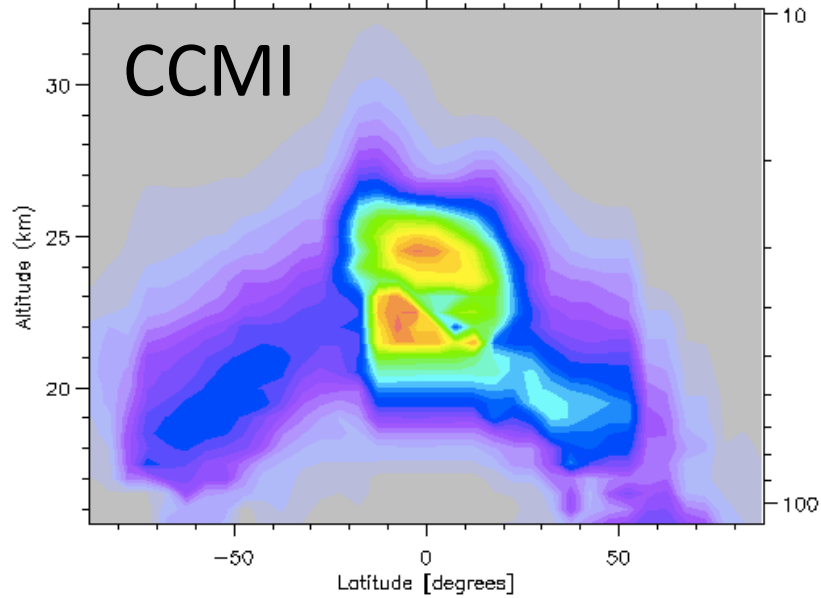
Temperature Change due to CO₂ Increase (2008-1996)



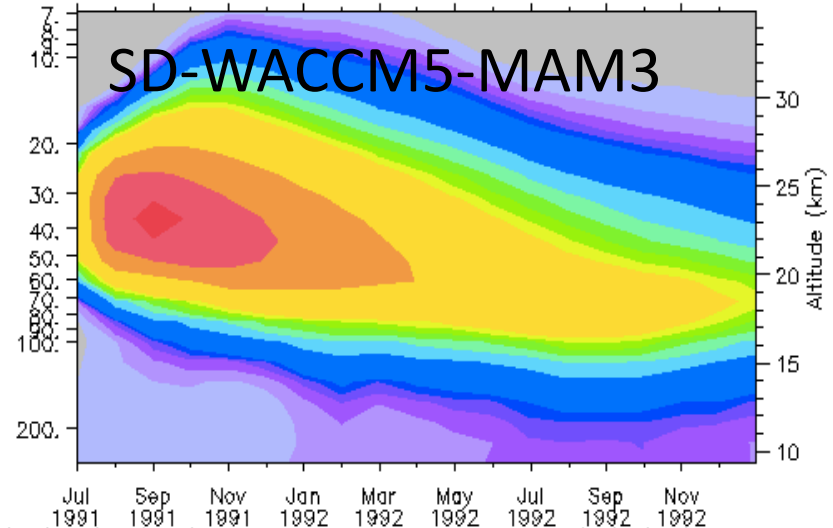
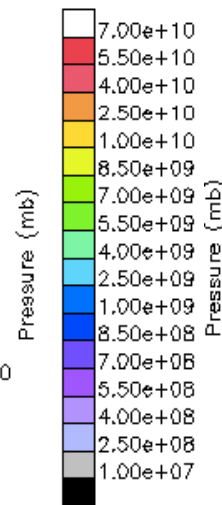
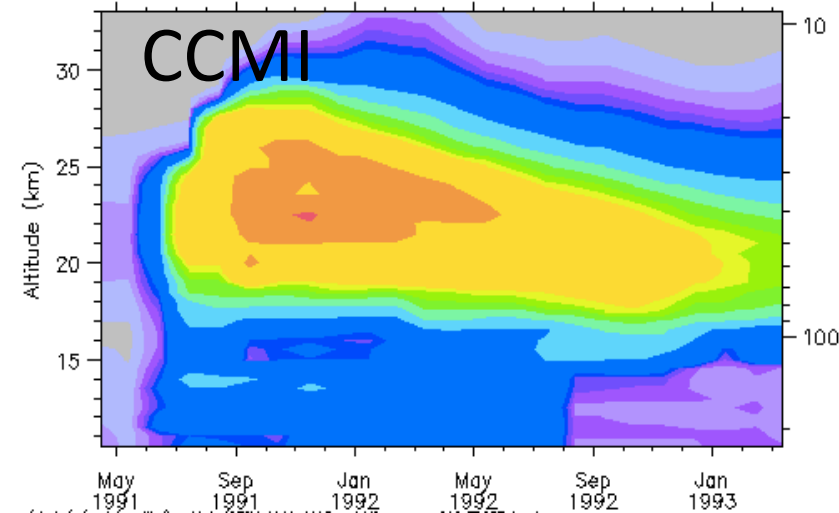
Prognostic stratospheric aerosols

January 1992

See second Mills presentation



Tropical average



WACCM Graphical Timeline

