
WACCM CCMI Simulations: Status and Analysis

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Outline

- CCMI updates (over CMIP5)
- Status of CCMI Simulations
 - Definition
 - Completed
- Analysis
 - Total column ozone (TOZ) and local ozone.
 - Mean age-of-air
- Summarize / next step

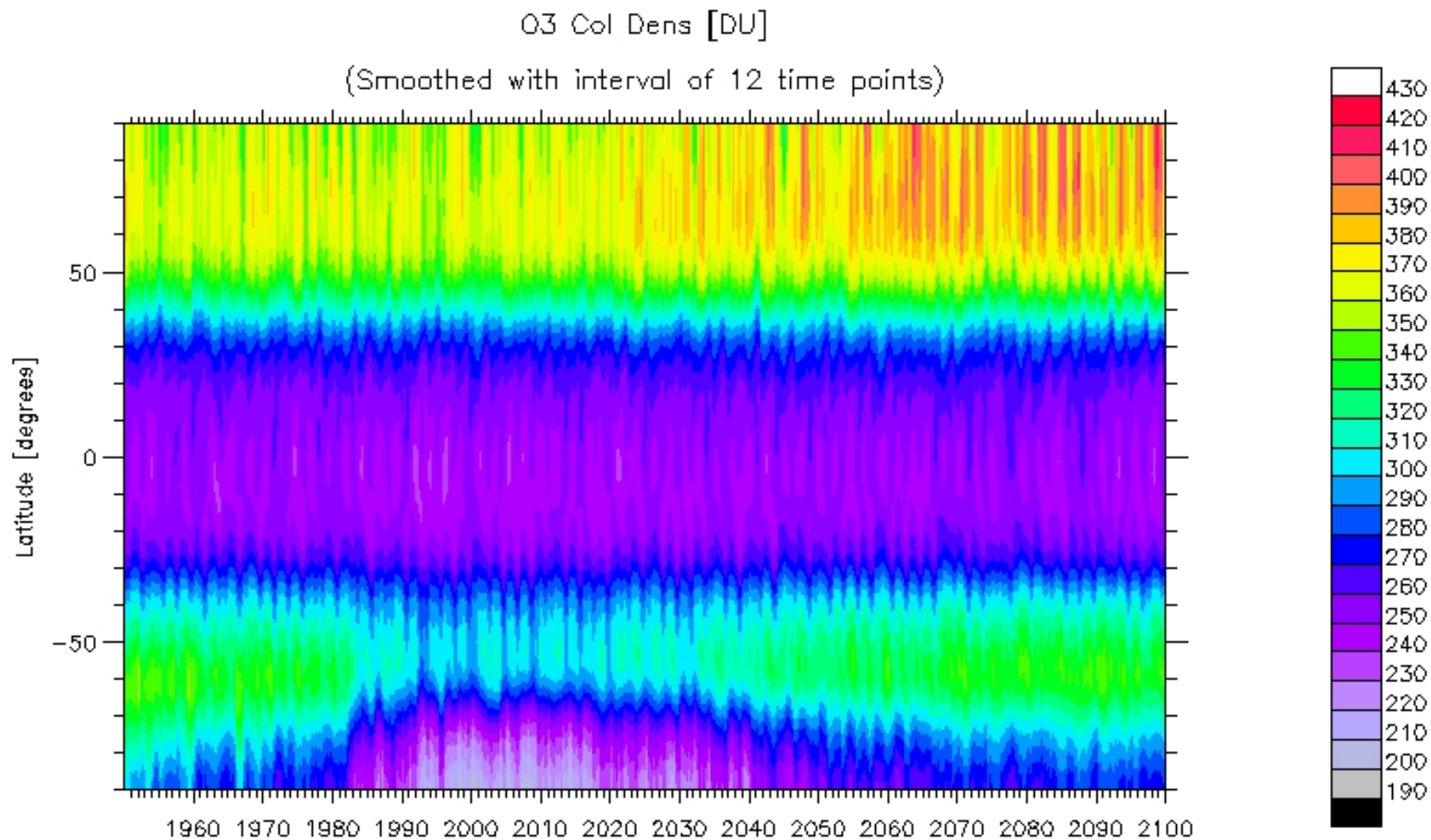
CCMI Updates Since CMIP5

- 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).
- Additional tropospheric chemistry (Total of 164 Species and 450 reactions).
- Also creating a VSL mechanism for CCMI (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).
- New Sulfate Surface Area Density (SAD) Time series (1960-2010).
- Improved representation of volcanic heating (R. Neely and A. Conley).
- Satellite output for SD simulations.
- Rate output now available (tagged to individual or sum of reactions).

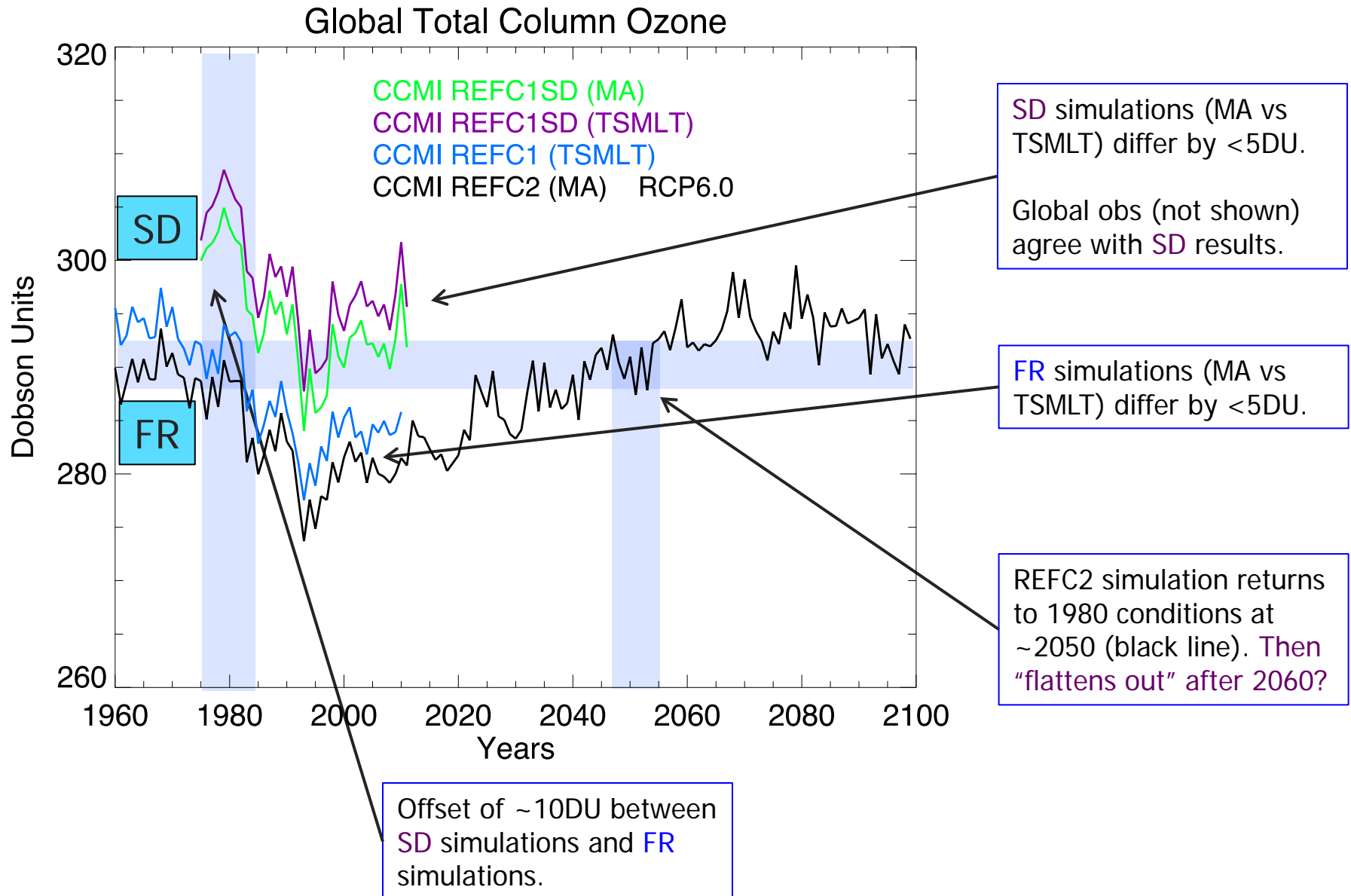
CCMI Scenarios

- REFC1 (3-realizations) *** 1950-2010
 - Data Ocean
 - QBO (nudged)
 - TSMLT Mechanism (164 species, 459rxns)
 - SV, Volcanic Heating and SAD for Chem.
- REFC1SD (2-simulations) *** 1975-2012
 - MERRA (50-hr nudging)
 - QBO (internal to MERRA)
 - TSMLT & MA (85 species; 287rxns) Mechanisms
 - SV, Volcanic SAD for Chem.
- REFC2 (3-realizations) *** 1950-2100 *** RCP6.0
 - Interactive ocean
 - QBO (nudged)
 - MA Mechanism (14-tracers)
 - SV, Volcanic Heating and SAD for Chem.

Total Column Ozone (REFC2; RCP6.0)

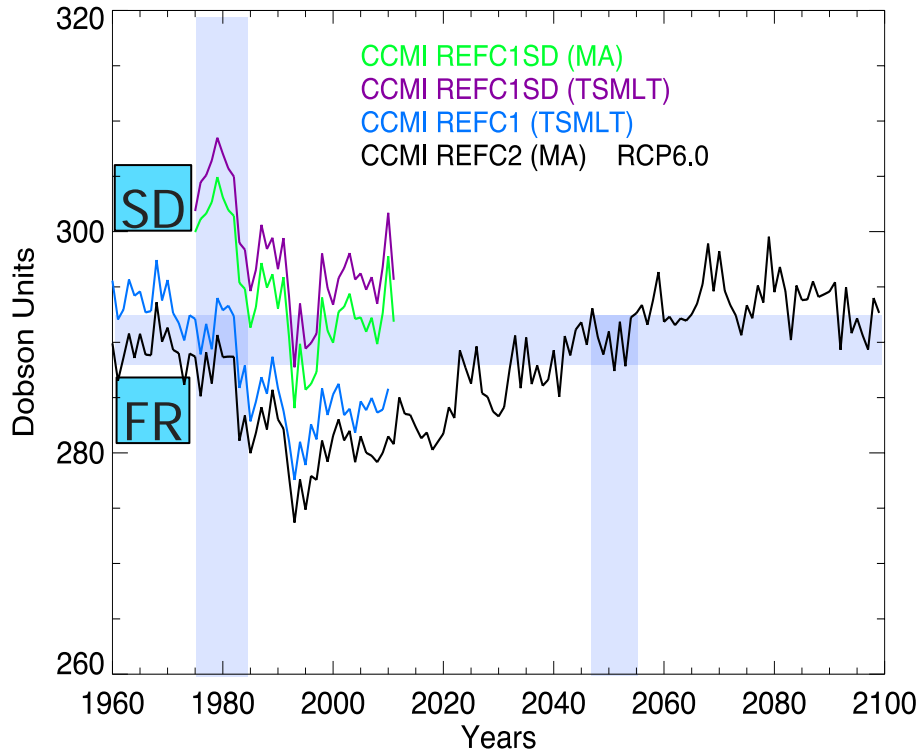


Comparison of CCMI Simulations: Global Annual TOZ



Comparison to CMIP5 simulations: GI Annual TOZ

Global Total Column Ozone



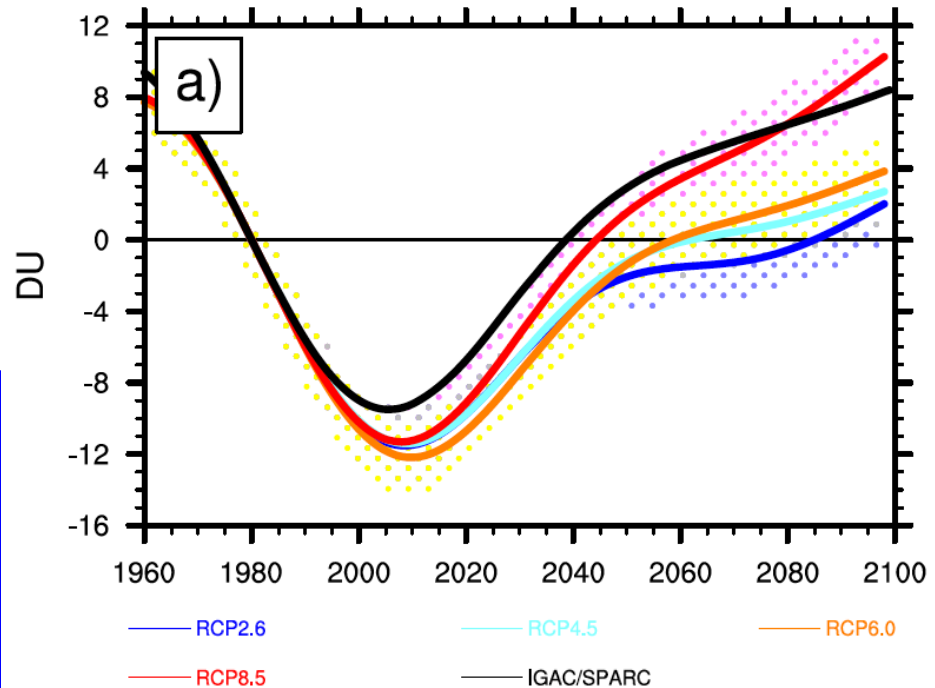
RCP 6.0 in CCMI WACCM (above).

- FR WACCM TOZ change from 1960-2010 was ~15DU.
- FR WACCM RCP6.0 returned to 1980 around 2050.

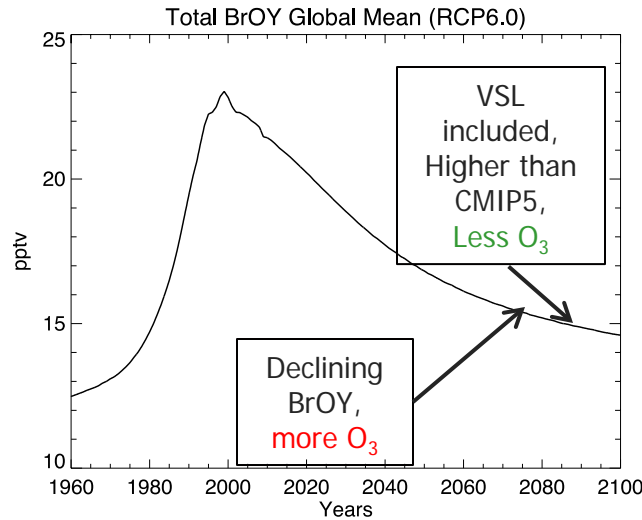
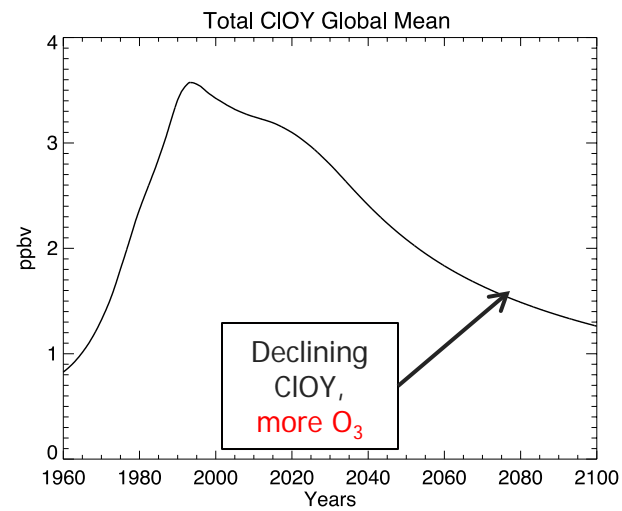
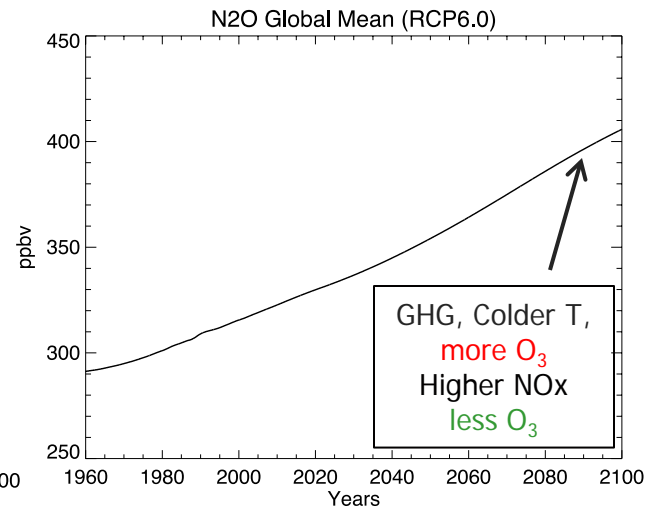
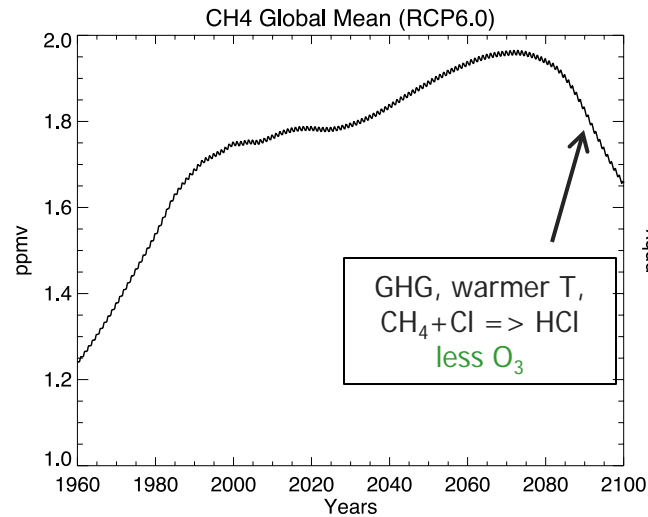
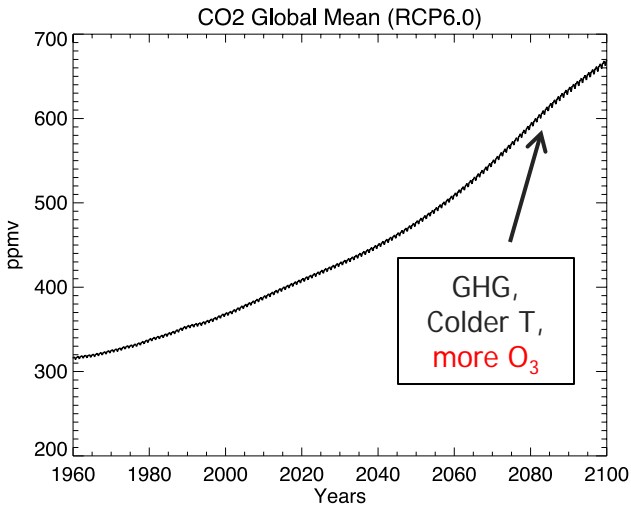
RCPs in Eyring et al., JGR, 2013 (below).

- Total obs change from 1960-2010 was ~16DU.
- RCP6.0 (models) returned to 1980 around 2060.

Stratospheric Ozone Column ANN 90N-90S



GHG (RCP6.0), Chlorine, & Bromine LBC

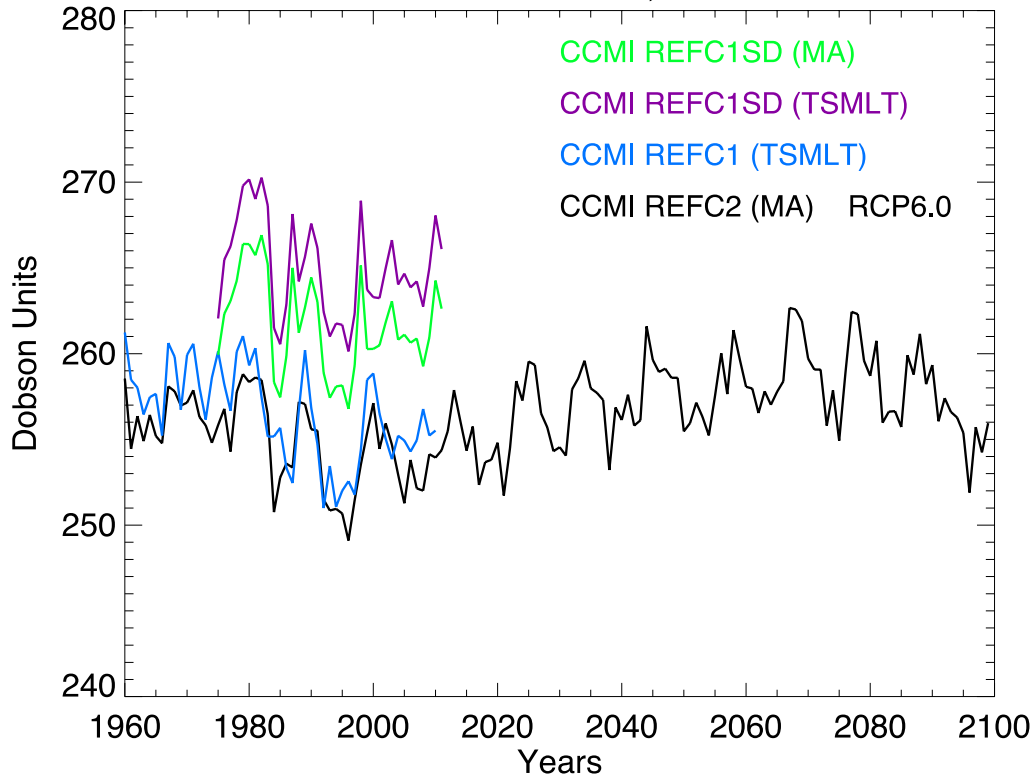


It will be interesting to compare the CCM1 WACCM to the CMIP5 WACCM.

NOTE: The CMIP5 WACCM didn't run RCP6.0 and didn't have the extra VSL halogens.

Comparison of CCM1 Simulations: Annual 25S-25N

Total Column Ozone, 25S-25N



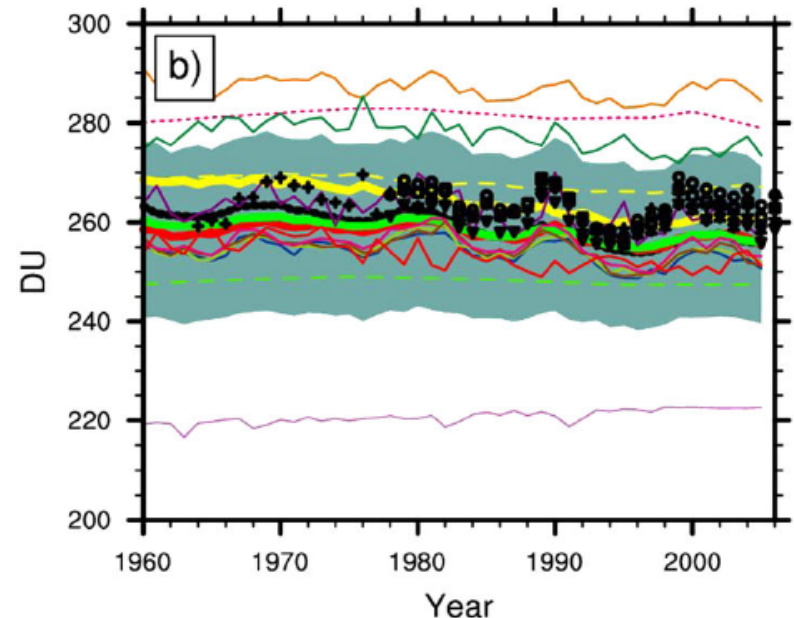
CCM1 WACCM (above).

- **FR WACCM** has a small trend in total TOZ. The absolute magnitude is underestimate (~10DU)
- **SD-WACCM** agrees with observations in the tropics.

CMIP5 models and observations in Eyring et al., JGR, 2013 (below).

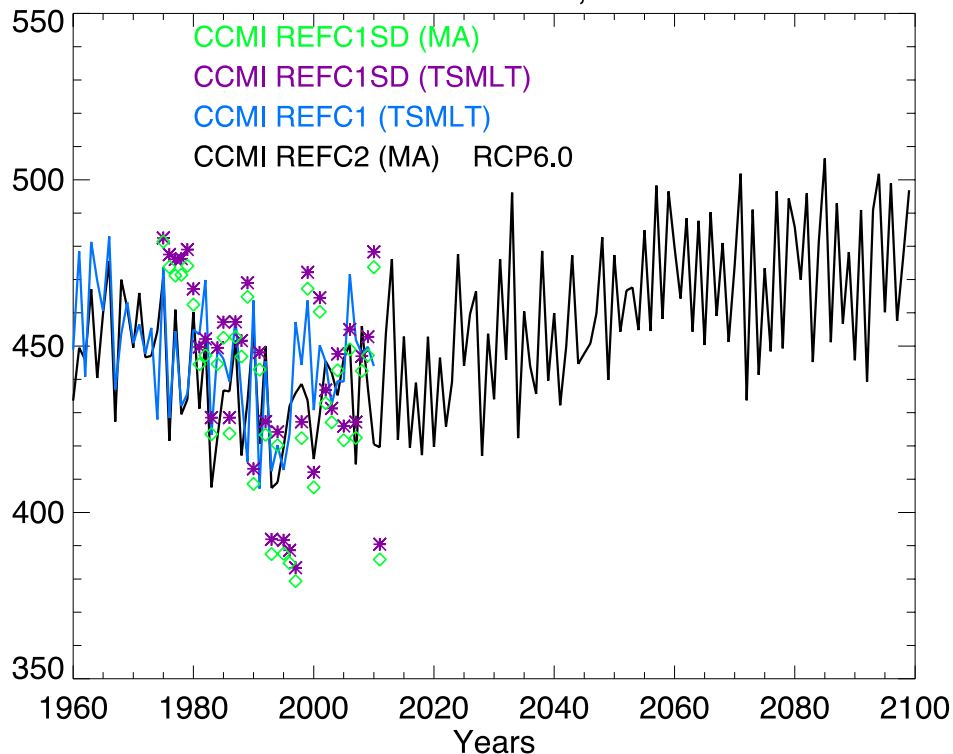
- No trend in total obs TOZ.
- Absolute Magnitude 265-270 DU.
- **Thin red line** is CESM (WACCM), Marsh et al., 2013.

Total Ozone Column ANN 25N-25S



Comparison of CCM1 Simulations: March 60N-90N

Total Column Ozone, 60N-90N



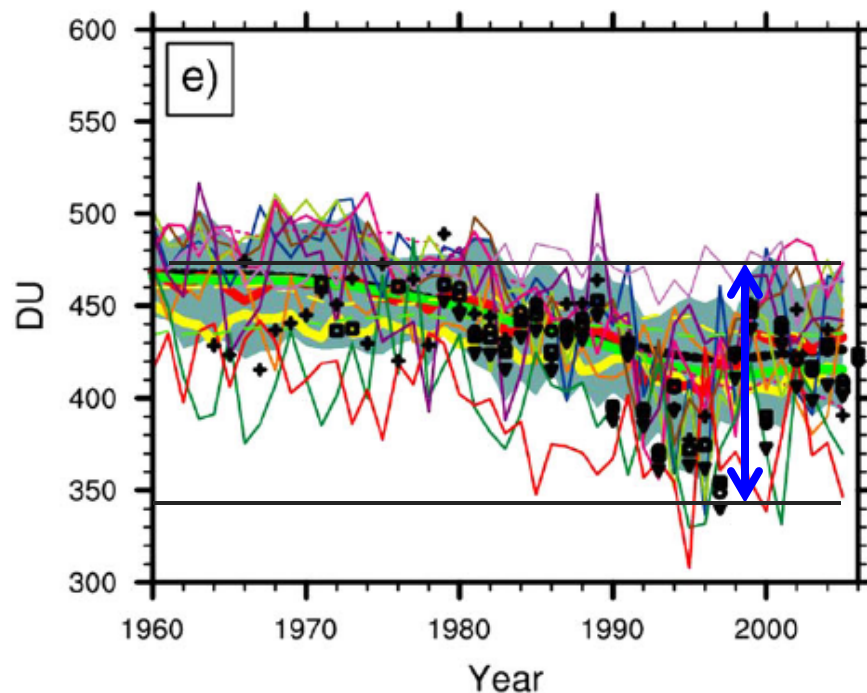
CCMI WACCM (above).

- **FR WACCM** total change from 1960-2010 was ~60DU (min/max).
- **SD-WACCM** doesn't get the observed minimum. MERRA T-bias of ~2K was noted in Brakebusch et al., 2013. More work is need here.

CMIP5 models and observations in Eyring et al., JGR, 2013 (below).

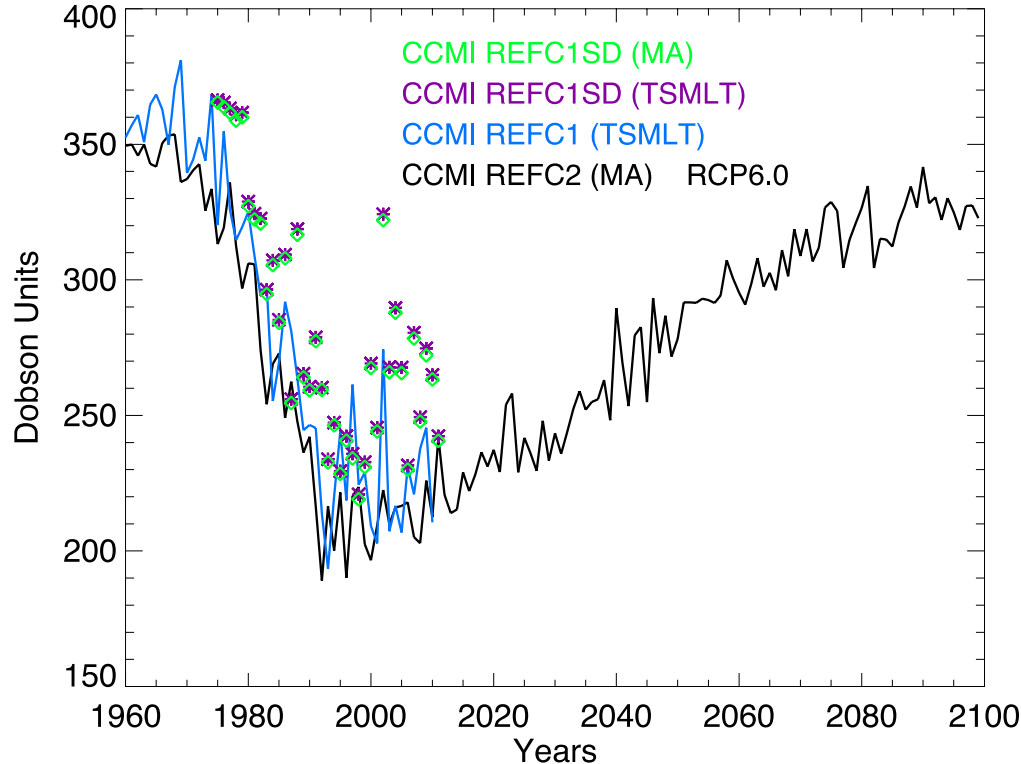
- Total obs change from 1960-2010 was ~125DU (min/max).
- **Thin red line** is CESM (WACCM), Marsh et al., 2013.

Total Ozone Column MAR 90N-60N



Comparison of CCM Simulations: Oct 90S-60S

Total Column Ozone, 90S-60S



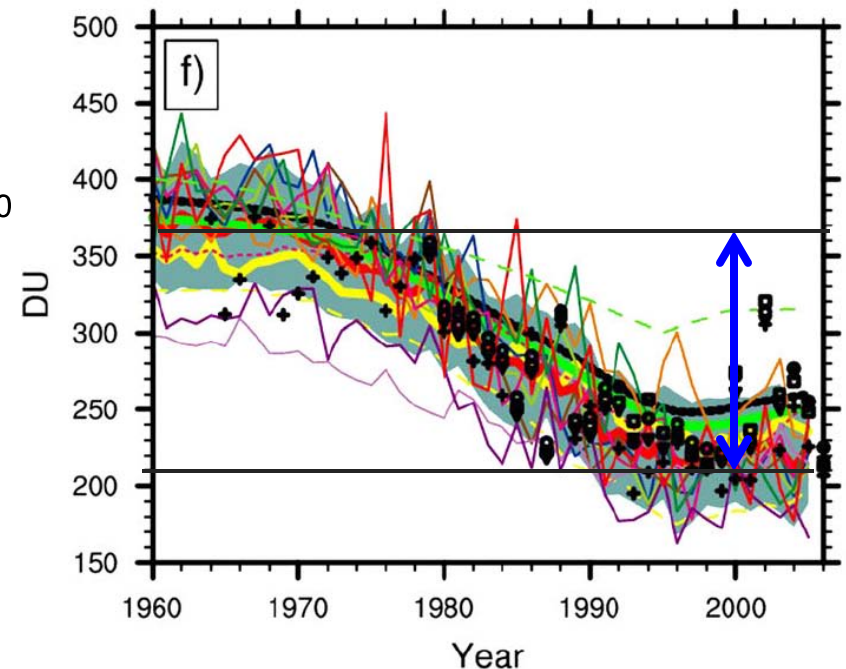
CCMI WACCM (above).

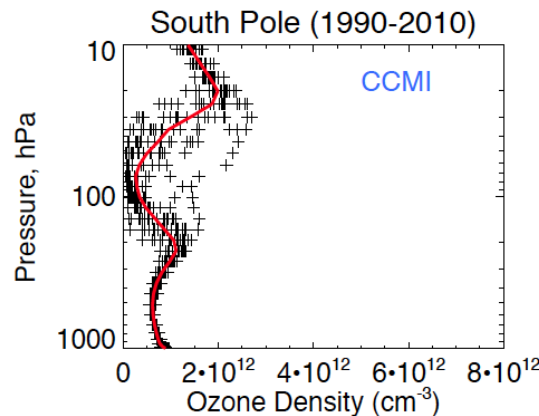
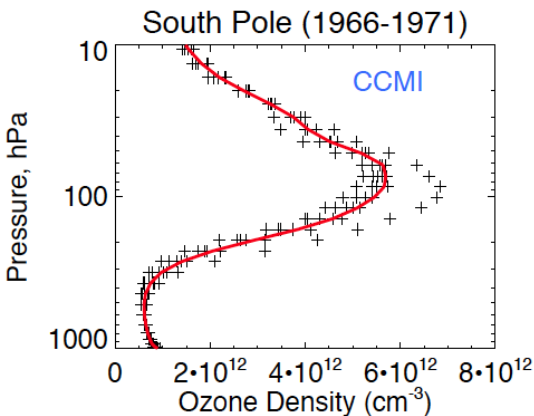
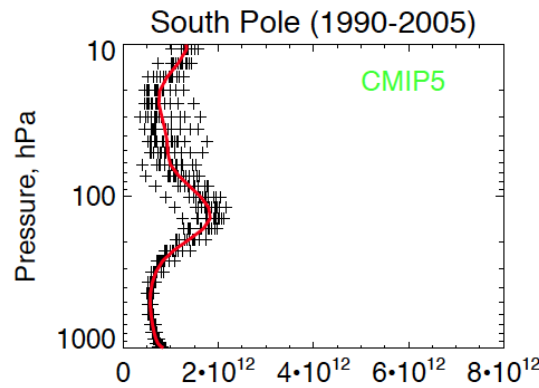
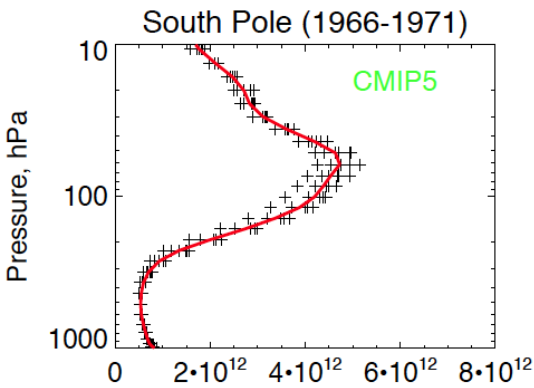
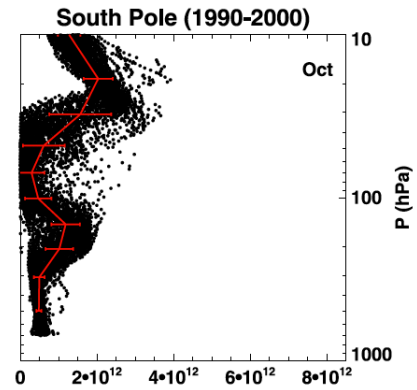
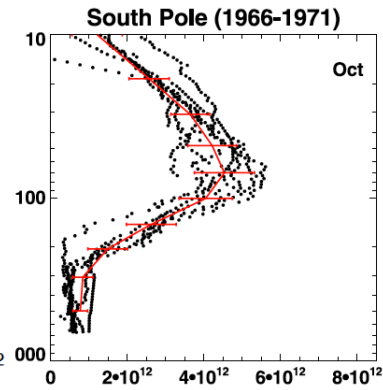
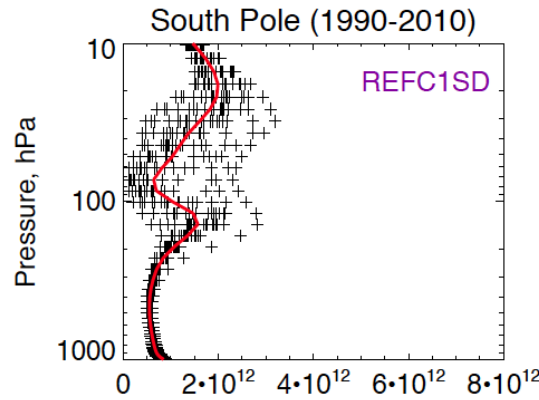
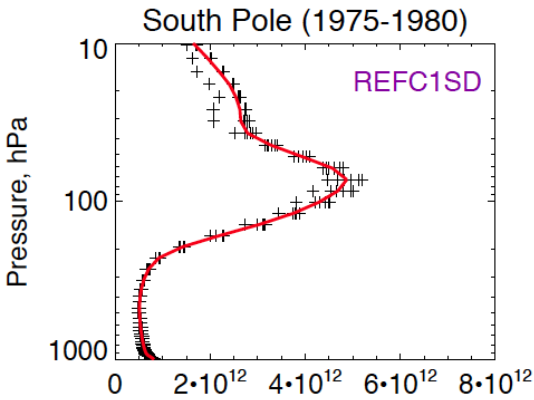
- **FR WACCM** total change from 1960-2010 was ~150DU. Good agreement with obs (see Garcia talk for more details).
- Note: Small difference is **SD** simulations between MA and TSMLT mechanisms.

CMIP5 models and observations in Eyring et al., JGR, 2013 (below).

- Total obs change from 1960-2010 was ~160DU.
- **Thin red line** is CESM (WACCM), Marsh et al., 2013.

Total Ozone Column OCT 60S-90S

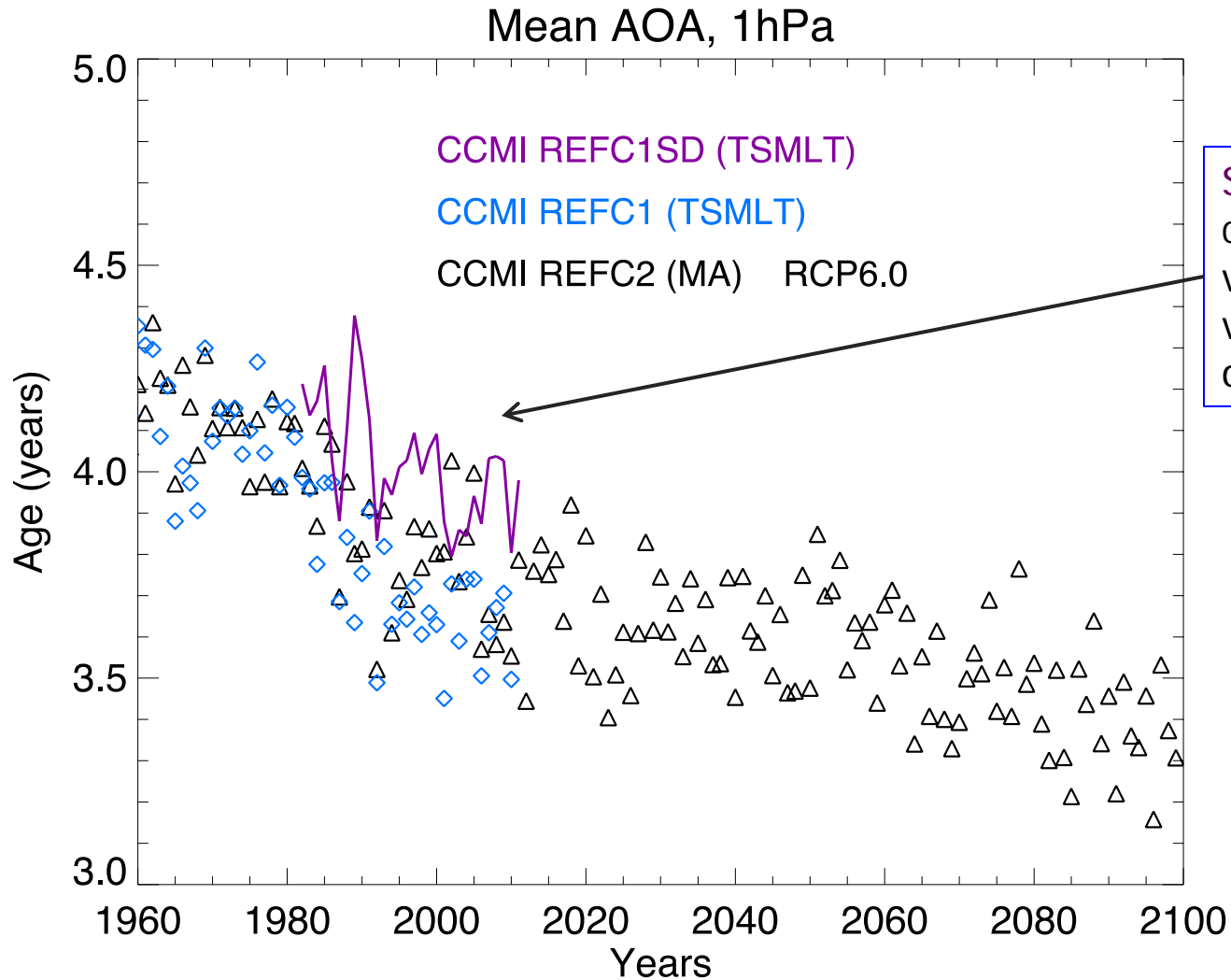




Comments:

- The model results are taken from monthly mean output. For REFC1SD, one should look at daily output for each Ozonesonde.
- The minimum in O₃ density at ~70-80 hPa and the peak at ~20hpa is represented by both CCMI REFC1SD and REFC2. The vertical structure for CMIP5 is different in these regions.
- The maximum O₃ density at ~200hPa is represented by all three model versions.
- Overall, the CCMI simulation does a nice job of representing the O₃ density profile at South Pole Station.

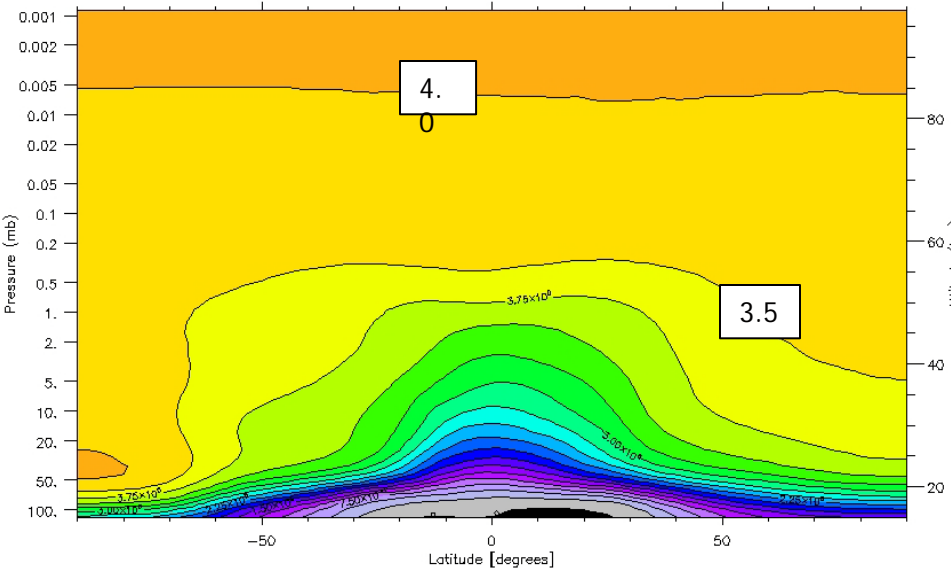
Annual Average Mean AOA: 25S-25N



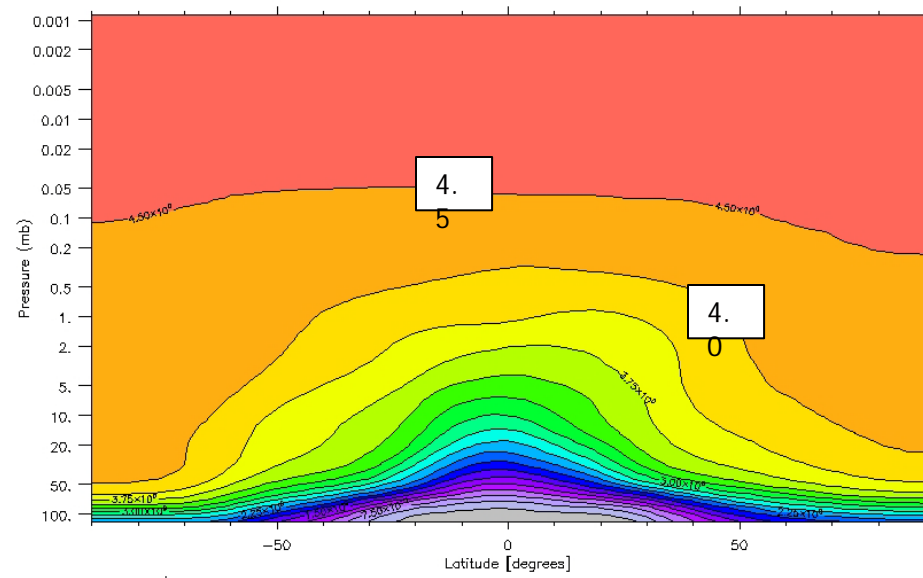
SD has a similar trend compared to FR versions; absolute values are ~0.5 years older in SD.

Change in Annual Mean AOA (20 Year Climatology)

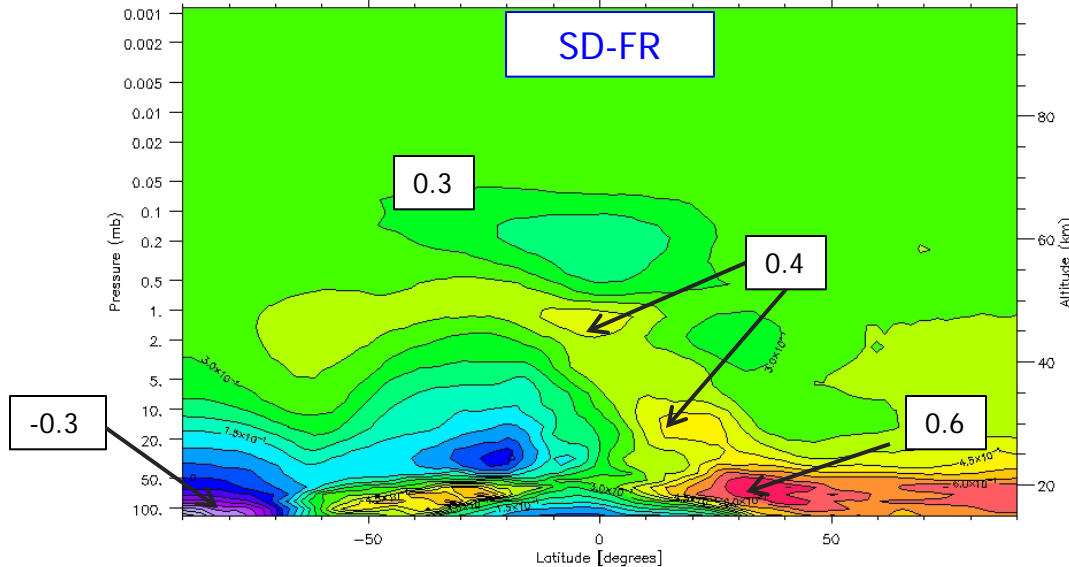
REFC1.002



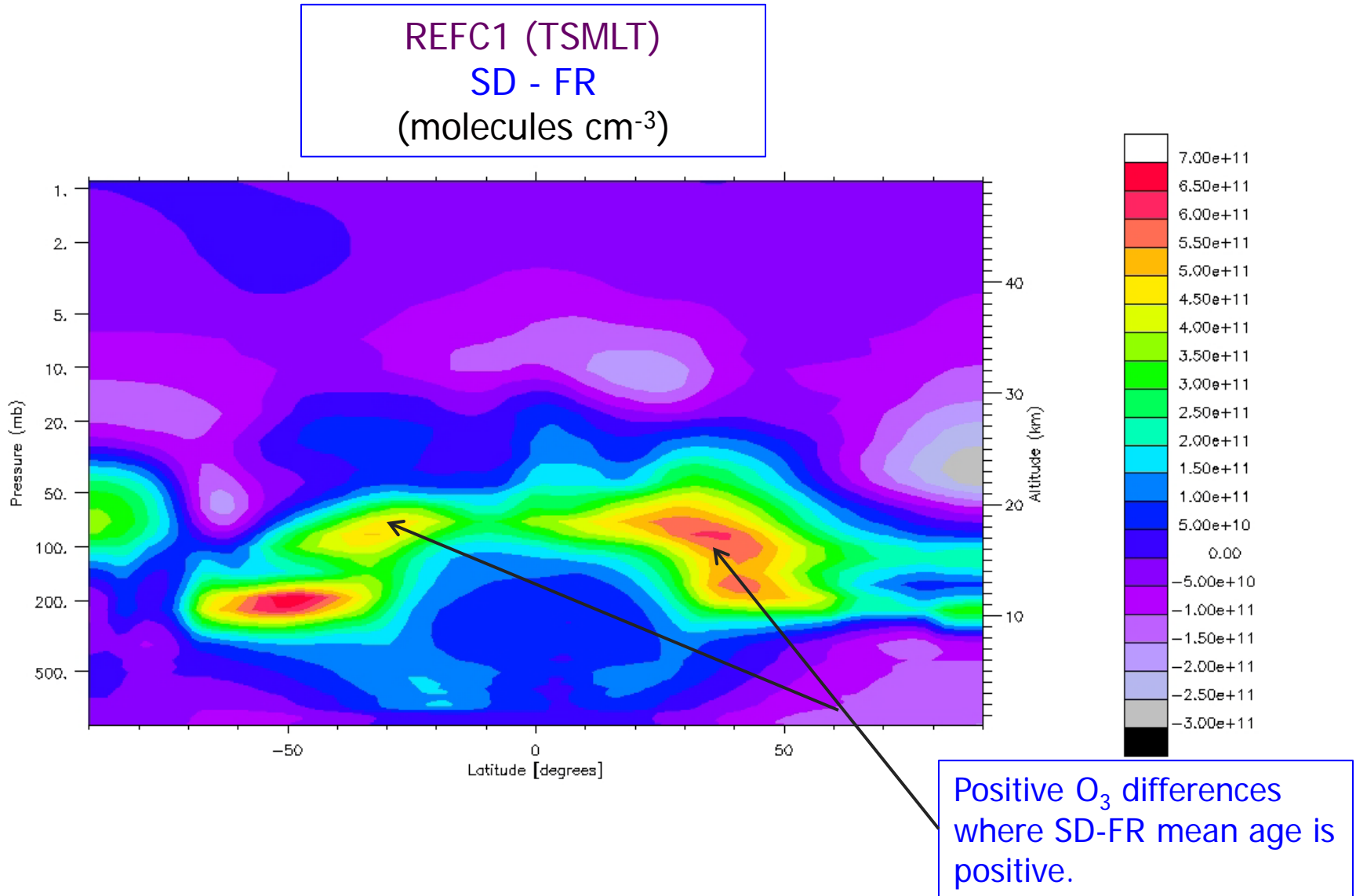
REFC1SD.002



SD-FR



Change in Annual Mean Ozone (20 Year Climatology)



Conclusion

- Completed 3 realizations of both CCM1 REFC1 and REFC2 simulations.
- Completed 2 SD-WACCM / MERRA simulations with two different chemical mechanisms (TSMLT, MA).
 - Paper will be written on these sims.
- Preliminary examination of TOZ, Mean AOA, and Local Ozone.
 - SD simulations grade out the highest;
 - FR simulations have improved over CMIP5 in the polar regions (Garcia pres.). Has a global low bias in TOZ. Mean AOA is ~ 0.5 year younger than SD.

Future Work

- Additional Simulations:
 - REFC2 MA, RCP8.5? (3-realizations)
 - REFC2 MA, CMIP5 WACCM RCP6.0 (1-realization).
 - REFC1 MA, (3-realizations)
 - Have completed the REFC1 TSMLT sims.
- CMI meeting: May 2014.
- Eventual release to community.

Thank you for your attention!

