WACCM CCMI Simulations: Status and Analysis


(NCAR)

13 February 2014,
WACCM Working Group Meeting,
Boulder Colorado
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, COF$_2$, COFCl).
- Additional tropospheric chemistry (Total of 164 Species and 450 reactions).
- Also creating a VSL mechanism for CCMI (Saiz-Lopez et al. 2012).
- 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.
Comparison of CCMI Simulations: Global Annual TOZ

Global Total Column Ozone

- SD simulations (MA vs TSMLT) differ by <5DU.
- Global obs (not shown) agree with SD results.
- FR simulations (MA vs TSMLT) differ by <5DU.
- REFC2 simulation returns to 1980 conditions at ~2050 (black line). Then “flattens out” after 2060?
- Offset of ~10DU between SD simulations and FR simulations.
Comparison to CMIP5 simulations: GI Annual TOZ

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

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

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

NOTE: The CMIP5 WACCM didn’t run RCP6.0 and didn’t have the extra VSL halogens.
Comparison of CCMI Simulations: Annual 25S-25N

CCMI 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.
Comparison of CCMI Simulations: March 60N-90N

Total Column Ozone, 60N-90N

CCMI REFC1SD (MA)  
CCMI REFC1SD (TSMLT)  
CCMI REFC1 (TSMLT)  
CCMI REFC2 (MA)  
RCP6.0

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.

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 needed here.
Comparison of CCMI Simulations: Oct 90S-60S

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

0.3

0.4

0.6

-0.3

4.0

4.5

3.5

0.001

0.001

0.005

0.005

0.01

0.01

0.05

0.05
Positive $O_3$ differences where SD-FR mean age is positive.
Conclusion

- Completed **3 realizations** of both **CCMI 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.
• CCMI meeting: May 2014.
• Eventual release to community.
Thank you for your attention!

Photo taken from GV by Pavel Romashkin (near Guam)