Updates on available compsets and their performance

*Simone Tilmes, Francis Vitt, Jean-Francois Lamarque, CAMChem and WACCM team*
<table>
<thead>
<tr>
<th>Compsets: CESM1.1.1 1.9x2.5</th>
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<th>Components / Meteorology</th>
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<td>B_2000_TROP_MOZART (BMOZ)</td>
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<td>trop_mozart + soa chemistry</td>
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<tr>
<td>B_2000_MOZSOA_CN</td>
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<tr>
<td>F_SD_CAMCHEM_CN</td>
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Functional Release: compsets runs out of the box, but is not scientifically wetted
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All these compsets have not changed and are still available
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Also available as B compsets but not tested

### Goal:
**Scientifically Supported Compsets:**
Evaluation of chemistry and aerosol performance
Updated features in CESM1.2

- Coupling of tropospheric and stratospheric chemistry with the CAM5 modal aerosol mode 3 and 7
  - bug fix of SAD_TROP calculation
- Expansion of the representation of secondary-organic aerosols
  Implementation of MEGAN 2.0 in CLM, including a flexible framework for assigning MEGAN 2.0 emissions to species represented in the chemistry.
  - CLM bug fix of surface pressure in drydep, MEGAN fix of initial values and units
- Other updates
  - Updated chemistry: JPL2010 only SOA and CAM5 compsets
  - Remove organic halogen surrogates (better description of organic species)
  - Updated heterogeneous polar chemistry (stratosphere only)
  - Include better representation of very short-lived (VSL) organic bromine (CHBr₃, CH₂Br₂)
  - New SAD dataset
Performance of F2000 model simulations

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<td>CO_BURDEN (Tg)</td>
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<td>341.919</td>
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<td>276.543</td>
<td>294.887</td>
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<td></td>
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<td>1522.102</td>
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<td>CO_LIFETIME (yr)</td>
<td>0.171</td>
<td>0.233</td>
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<td>O3_BURDEN (Tg)</td>
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<td>O3_LIFETIME (yr)</td>
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<td>0.443</td>
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<tr>
<td>O3_NET_CHEM_CHANGE (Tg/yr)</td>
<td>253.273</td>
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<td>305.186</td>
<td>309.427</td>
<td>317</td>
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<tr>
<td>O3_TDEP (Tg/yr)</td>
<td>692.556</td>
<td></td>
<td>688.865</td>
<td>721.533</td>
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<tr>
<td>O3_LIFETIME (yr)</td>
<td>0.443</td>
<td></td>
<td>0.443</td>
<td>0.429</td>
<td></td>
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<tr>
<td>O3_NET_CHEM_CHANGE (Tg)</td>
<td>253.273</td>
<td></td>
<td>253.773</td>
<td>288.698</td>
<td></td>
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<tr>
<td>O3_STE (Tg/yr)</td>
<td>439.283</td>
<td></td>
<td>435.092</td>
<td>432.835</td>
<td></td>
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<tr>
<td>ISOP_EMIS TgN/yr</td>
<td>537.408</td>
<td>537.408</td>
<td>537.408</td>
<td>485.535</td>
<td>488.293</td>
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<tr>
<td>Monoterpene_EMIS TgN/yr</td>
<td>81.795</td>
<td>81.795</td>
<td>81.795</td>
<td>141.223</td>
<td>141.894</td>
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<tr>
<td>Methanol_EMIS TgN/yr</td>
<td>236.88</td>
<td>236.88</td>
<td>236.88</td>
<td>101.722</td>
<td>102.502</td>
</tr>
<tr>
<td>Aceton_EMIS TgN/yr</td>
<td>26.956</td>
<td>26.956</td>
<td>26.956</td>
<td>67.321</td>
<td>67.522</td>
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<tr>
<td>LNO_PROD (TgN/yr)</td>
<td>3.933</td>
<td>4.105</td>
<td>4.108</td>
<td>4.263</td>
<td>4.034</td>
</tr>
<tr>
<td>Total optical depth</td>
<td>0.089</td>
<td>0.088</td>
<td>0.087</td>
<td>0.101</td>
<td>0.098</td>
</tr>
<tr>
<td>DUST optical depth</td>
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<td>0.019</td>
<td>0.019</td>
<td>0.032</td>
<td>0.032</td>
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<tr>
<td>CLDHGH</td>
<td>38.503</td>
<td>38.408</td>
<td>38.668</td>
<td>31.577</td>
<td>31.48</td>
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<tr>
<td>CLDLOW</td>
<td>44.313</td>
<td>44.135</td>
<td>44.308</td>
<td>34.814</td>
<td>34.774</td>
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<tr>
<td>CLDMED</td>
<td>27.341</td>
<td>27.339</td>
<td>27.401</td>
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<td>18.951</td>
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<tr>
<td>CLDTOT</td>
<td>64.759</td>
<td>64.543</td>
<td>64.849</td>
<td>54.088</td>
<td>53.956</td>
</tr>
</tbody>
</table>
CAM5Chem vs. CAM4Chem (strat/trop mechanism)

CH4 Lifetime:
CAM5 9.6, CAM4 8.4

Colder temperatures, clouds, and transport differences:
More ozone and NOy in the LMS, troposphere
-> change in photolysis rates
CAM5Chem vs. CAM4Chem (strat/trop mechanism)

Temperature

CH4 Lifetime:
CAM5 9.6, CAM4 8.4

NOy

Colder temperatures, clouds, and transport differences:
More ozone and NOy in the LMS, troposphere
\(<\) change in photolysis rates

O3

HNO3

More SAD: at night more N2O2
converted to HNO3
\(<\) less PAN formation

PAN
CAM5Chem vs. CAM4Chem (strat/trop mechanism)

Both differences in meteorology and SAD influence tropospheric chemistry and therefore the lifetime of methane.
Comparison to Ozoneonde Observations

Difference between the models in comparison to observations is small. Too much ozone in 50hPa in CAM5Chem due to too cold temperatures.
CAM5Chem vs. CAM4Chem (strat/trop mechanism)

Comparison to Ozone sonde Observations

Difference between the models in comparison to observations is small. Too much ozone in 50hPa in CAM5Chem due to too cold temperatures.
Comparison to Aircraft Observations

(1999 and 2004)

East Coast

(2000 and 2006)

Texas

Variability of aircraft observations larger than differences between the two model version. Shortcomings in both model version in hydrocarbons.
Prescr. Stratosphere vs. calculated Stratosphere

CH4 Lifetime:
trop: 9.6, trop-strat: 8.4

Less HNO$_3$ in the stratosphere, with reduction in the LMS and high latitudes. More NOy in the Tropics.

Increased CO consistent with reduced OH.
Need for updated prescribed stratospheric values.
Evaluation of Organic Aerosols

Tsigaridis et al., to be submitted: An AeroCom intercomparison exercise on organic aerosol global modeling (to ACP, 70+ authors, 40+ affiliations)
- Uses ground based, filters, period anywhere between 1980 and 2007
- CAM4Chem, SOA advanced chemistry

Work is in progress to further improve SOA in CAMChem
# Updated CCMI compsets based on CESM1.1.1

<table>
<thead>
<tr>
<th>CCMI Compsets: CESM1.1.1 (1.9x2.5)</th>
<th>Model (phys)/radiation</th>
<th>Chemistry (JPL 2010)</th>
<th>Components / Meteorology</th>
</tr>
</thead>
<tbody>
<tr>
<td>REFC1: F_1950-2010_CCMI_REFC1_TROP_STRAT (BCCMITSREFC1)FCCMITSREFC1</td>
<td>CAM4, active BAM</td>
<td>trop/strat mozart + soa chemistry</td>
<td>Prescr. ocn/ice, MEGAN</td>
</tr>
<tr>
<td>REFC1 SD: F_SD_1975-2010_CCMI_REFC1_TROP_STRAT (FSDCCMITSREFC1)</td>
<td></td>
<td></td>
<td>MERRA driven, 10% nudging, MEGAN</td>
</tr>
<tr>
<td>REFC2: B_1950-2100_CCMI_REFC2_TROP_STRAT (BCCMITSREFC2)</td>
<td>CAM4, active ocn/ice</td>
<td></td>
<td>active ocn/ice, MEGAN</td>
</tr>
</tbody>
</table>
Updated features in CESM CESM1.1, CAM4, 1.9x2.5

In addition to release changes:

• Rate approach added to pre-processor
• New volcanic heating calculation (R. Neely and A. Conley)
• Updated SAD_TROP and SAD in the stratosphere
• Inclusion of QBO and TMS
• Inclusion of solar proton events (in progress)
• In progress: updated gravity wave forcing to fix stratospheric temperatures (cold pole)
• Plans to run SD-CAMChem in 0.5x0.63
• Plants to tests nudging/overwriting
Performance of CCMI model simulations

Western Europe

500hPa

DJF

Ozone (ppbv)

WACCM
CAMChem
SD WACCM

Ozonesondes

500hPa

MAM

500hPa

JJA

SON


Ozone (ppbv)
Outlook and Discussion on Chemistry Compsets

Changes to existing compsets (sandbox, and next release):
- Update of compsets with prescribed stratosphere
- SO$_2$ emissions in CAM4
- Dry deposition code fix (Maria ValMartin and Steve Arnold)
- Adding the CCMI functionality

Update all SD transient compsets using new chemistry mechanism:
- Need new emissions for SD transient CAM5 aerosols (so far only available from CMIP5, and for POLMIP)
- Test new aerosol wet deposition and convection changes
- Setup and test CAM4 Carbon/Nitrogen cycle with MEGAN 2.0 (B-cases)

Update superfast chemistry compsets?
Outlook and Discussion on Chemistry Compsets

New Compsets (setup and evaluate performance) ?

- MAM4?
- Spectral Element core?
- CAM5 SD chemistry compsets?
- NOx tagged mechanism?
- SD compsets with 0.5x0.63 or higher resolution B1850?
- Transient B-cases for CAM5 (CAM4 at this point from 1960)?
- F2000 with different resolutions?
- 60L chemistry compsets?
- Priorities?
Chemistry/Aerosol Diagnostic Package

Aerosol metrics

- Aerosol optical depth (satellite, AERONET)
- Aerosol absorption optical depth (AERONET)
- Surface concentrations of SO$_2$, sulfate, black carbon, organic carbon, sea salt, mineral dust at sites (IMPROVE, EMEP, U. Miami, Mahowald)
- Surface deposition measurements (Mahowald)
- Ice core records of black carbon deposition
- Aerosol size distribution (Heinzenberg)
- CN vertical profiles (Minikin)
- Vertical profiles of CCN concentration at 0.1% supersaturation (Ghan et al. 2001)
- Aircraft measurements of vertical profiles of black carbon (ARCTAS, ARCPAC, CARB, HIPPO)
Chemistry/Aerosol Diagnostic Package

**Tropospheric Chemistry**
- Tables: Budgets, lifetime, biogenic emissions
- Ozone climatology comparison (Tilmes et al., 2012)
- Surface $O_3$ (Lamarque et al., 2012)
- Nitrate, Sulfate and Ammonium Deposition (Lamarque, et al., 2013)
- Aircraft: Emmons climatology of key species
- Aircraft: HIPPO CO, $O_3$, PAN
- OH climatology
- SOA diagnostics?

**Stratospheric Chemistry**
- Total Ozone Column, comparison to Halley (Kinnison)
- Stratospheric Chemistry comparison with ACE data?
- Temperature comparison with MERRA?
Chemistry/Aerosol Diagnostic Package

Timeline

• Produce/update diagnostics by September 1st
• Merge to AMWG, October 1st
• Testing done by November 1st
• Merge with Swift
• Release by the end of the year