CAM-chem Status

Louisa Emmons
Simone Tilmes
CESM 1.2 with Chemistry

• CAM4 and CAM5, described in:

  Tilmes, S., et al., Description and evaluation of tropospheric chemistry and aerosols in the Community Earth System Model (CESM1.2), Geosci. Model Dev. Discuss., 7, 8875-8940, doi:10.5194/gmdd-7-8875-2014, 2014.

• Recent additions (not available in public version yet):
  – Neu wet dep in CAM5
  – MAM4
  – Improved dry deposition in CLM4.0 & CLM4.5 (Val Martin et al., GRL, 2014)
  – Updated volcanic heating (in CCMI ver.)
  – Removed aerosol double counting in troposphere/stratosphere (in CCMI ver.)
  – New polar chemistry (Kinnison et al., in prep., Solomon et al., in prep.) (in CCMI ver.)
  – MEGAN corrections in CLM4.5 (get CO2 from atm, not namelist; correct LAI average for last 10 days)
  – Updated SO2 Henry’s Law coefficient (had been set to H2O2)

→ See bug reports
MEGAN emissions flux for species $i$: $F_i = \gamma_i \sum \varepsilon_{i,j} \chi_j$

$\gamma_i = C_{CE} \text{LAI} \gamma_{P,i} \gamma_{T,i} \gamma_{A,i} \gamma_{SM} \gamma_{C,i}$
$\varepsilon_{i,j} = \text{emission factor at standard conditions (species } i, \text{ PFT } j)$
$\chi_j = \text{area of grid box for PFT } j$

$C_{CE}$: canopy environment
LAI: Leaf area index
$\gamma_P = (1-LDF) + LDF \gamma_{P,LDF}$ -- Light dependent factor; depends on PAR in sun and shade, and current and 10-day average
$\gamma_T$ -- Temperature dependence, also includes light dependence, and difference from past 10-day average
$\gamma_A$ -- Leaf age factor (difference from past 10-day average LAI)
{CLM4.0 used difference from last time step}
$\gamma_{SM}$ -- Soil moisture (=1)
$\gamma_C$ -- CO$_2$ inhibition (isoprene only)
{CLM4.0 used namelist CO2 value, not actual CAM atmosphere value}
CLM/Chemistry Coupling

Impact of different land model versions on MEGAN VOC emissions and dry dep.

**Model Versions:** 1.9x2.5, FV, F2000, CO₂ coupling added, **10years**
- CAM5-chem, CLM4.0, prescribed LAI climatology
- CAM5-chem, CLM4.0, including CN coupling -> LAI is calculated online
- CAM5-chem, CLM4.0, including CN coupling, 10-day avg previous LAI used for VOC emission calculation (previous version uses 1-timestep for previous LAI)

**F2000 10years, and FSD, 1year**
- CAM5-chem, CLM4.5, prescribed LAI climatology
- CAM5-chem, CLM4.5, including CN/BGC coupling -> LAI is calculated online
- CAM5-chem, CLM4.5, including CN coupling, 10-day avg previous LAI used for VOC emission calculation

Coupling between LAI, VOC emissions and dry deposition:

1. **LAI important for MEGAN VOC emission calculation**
   - CO₂ coupling added for CO2 inhibition of isoprene emission calculation
   - VOC depends on previous LAI: emission activity factor (gamma) [unitless] includes dependence on PPFT, temperature, LAI, leaf age and soil moisture.
   - **LAI important for leaf cuticular resistance (R_{lu}) and stomatal resistance (R_{st})** and therefore deposition velocities -> changes chemistry (surface ozone)
Leaf Area Index (LAI) in different versions

Most difference in Shaded LAI
Biogenic Isoprene Emissions

- SD-CAM5-CLM45
  - avg=0.033
  - 459 Tg/yr

- CAM5-CLM45
  - avg=0.027
  - 427 Tg/yr

- SD-CAM5-CLM45-BGC
  - avg=0.026
  - 383 Tg/yr

- CAM5-CLM45-BGC
  - avg=0.024
  - 379 Tg/yr

- CAM5-CLM45-CO2_CN
  - avg=0.025
  - 373 Tg/yr

- CAM5-CLM45-10d
  - avg=0.023
  - 370 Tg/yr
<table>
<thead>
<tr>
<th></th>
<th>F2000 Satellite LAI</th>
<th>F2000 BGC</th>
<th>F2000 BGC 10d Leaf Age</th>
<th>SD Sat. LAI</th>
<th>SD BGC</th>
<th>SD BGC 10d Leaf Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoprene</td>
<td>426.872</td>
<td>379.181</td>
<td>370.162</td>
<td>459.313</td>
<td>383.464</td>
<td>373.035</td>
</tr>
<tr>
<td>Monoterpene</td>
<td>131.451</td>
<td>130.501</td>
<td>133.021</td>
<td>136.741</td>
<td>136.219</td>
<td>138.526</td>
</tr>
<tr>
<td>Methanol</td>
<td>88.287</td>
<td>111.817</td>
<td>128.273</td>
<td>97.575</td>
<td>109.507</td>
<td>125.490</td>
</tr>
<tr>
<td>Acetone</td>
<td>41.668</td>
<td>47.526</td>
<td>47.575</td>
<td>43.762</td>
<td>48.036</td>
<td>48.007</td>
</tr>
</tbody>
</table>

F2000: 7-yr average  
SD: GEOS-5 for 2000

Some differences between:  
• free-running and specified dynamics  
• satellite LAI and CLM-BGC calculated

But all totals within expected range
Changes in $O_3$ Deposition Velocities

Small differences between CLM 4.0 and 4.5
# CESM1 CAM4-chem simulations for CCMI

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Status (not planned; about to start; running; finished data linked/ uploaded to BADC)</th>
<th>Priority (High, Medium, or Low)</th>
<th>How many ensemble members?</th>
</tr>
</thead>
<tbody>
<tr>
<td>REF-C1</td>
<td>finished</td>
<td>high</td>
<td>3 members</td>
</tr>
<tr>
<td>REF-C1SD</td>
<td>finished</td>
<td>high</td>
<td>1 member</td>
</tr>
<tr>
<td>REF-C2 (RCP 6.0)</td>
<td>finished</td>
<td>high</td>
<td>3 members</td>
</tr>
<tr>
<td>SEN-C1-Emis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN-C1SD-Emis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN-C1-fEmis</td>
<td>about to start</td>
<td>medium</td>
<td>1 member</td>
</tr>
<tr>
<td>SEN-C1SD-fEmis</td>
<td>running</td>
<td>high</td>
<td>3 slightly diff. versions</td>
</tr>
<tr>
<td>SEN-C1-SSI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN-C2-RCP2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN-C2- RCP4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN-C2- RCP8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEN-C2-fODS</td>
<td>about to start</td>
<td>medium</td>
<td>1 member</td>
</tr>
<tr>
<td>SEN-C2-fODS2000</td>
<td>about to start</td>
<td>medium</td>
<td>1 member</td>
</tr>
<tr>
<td>SEN-C2-fGHG</td>
<td>about to start</td>
<td>medium</td>
<td>1 member</td>
</tr>
<tr>
<td>SEN-C2-fEmis</td>
<td>about to start</td>
<td>medium</td>
<td>1 member</td>
</tr>
<tr>
<td>SEN-C2-GeoMIP (1x)</td>
<td>running</td>
<td>high</td>
<td>3 members</td>
</tr>
<tr>
<td>SEN-C2-SolarTrend</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HTAP2 Simulations
Louisa Emmons, Steve Arnold, Tim Butler

• Using CCMI configuration of CAM-chem
• Emissions provided by HTAP2, 2008 & 2010
• Regional source perturbation experiments
UK CESM “Meeting”

Paul Young – Lancaster
Ryan Neely – Leeds
Maria Val Martin – Sheffield
Steve Arnold - Leeds

Setting up common model version for all on the UK machine (1.1.1 and 1.2.2)

A core theme that they may target is vegetation-composition-climate
• If you are on ReadyTalk you need to call in to hear us!!!!