Community Land Model: Update on Progress, Plans, and Results from CCSM4 Simulations

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with input from lots of LMWGers

NCAR is sponsored by the National Science Foundation
Considering a “Cornice Parameterization” for CLM
The CCSM4 land simulation, 1850-2005: Assessment of surface climate and new capabilities (submitted)
  – Lawrence D et al.

The biophysical and biogeochemical impacts of landcover and land use change over 20th and 21st centuries
  – Lawrence P et al.

Contrasts between urban and rural climate in CCSM4 CMIP5 climate change scenarios (submitted)
  – Oleson

Permafrost in CCSM4
  – Lawrence D et al.
- Mean and variability of the carbon cycle in CESM1
  - Lindsay et al.
- The transient carbon cycle response in CESM1
  - Lindsay et al.
- An assessment of terrestrial carbon and nitrogen cycling in CESM1
  - Thornton et al.
- Dynamic Vegetation in CESM1
  - Castillo et al.
- Land-atmosphere interactions across several generations of CAM/CLM
  - Lawrence D et al.
- Crops in CESM1
  - Levis et al.
CCSM4 data

- 1850 control and 20th century and RCPs ensembles
  - All simulations: CLM is fully active with CN on and transient land cover change, aerosol and nitrogen deposition
  - Data posted on Earth System Grid (ESG) on or about May 1, 2011
Note that although CESM1.0 supersedes CCSM4.0, users can run equivalent CCSM4.0 experiments from the CESM1.0 code base. Also note that the CCSM4.0 experiments below are equivalent to running CESM1.0 (CAM4).

Note that all current CESM release codebases (e.g. cesm1_0, cesm1_0_1 or cesm1_0_2) can also reproduce the climates shown below.

If you still have questions after reviewing the details of the model runs below, it is recommended that you contact the relevant CESM Working Group Liaison.

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**$T_{air}$: RMSE and Annual Mean Bias (CCSM4 vs CCSM3)**

**Reduced RMSE at high lats and in tropics**
**Mixed results for bias, E. Europe warm bias related to no aerosol indirect?**
Land temperature anomalies from 1961-1990

Graph showing temperature anomalies over time with trends from different models compared to observations.
Total Land Water Storage (CCSM vs GRACE)

Mean Seasonal Cycle

Mean Annual TWS

Amazon

Mississippi

Ob

S [mm]

Jan Apr July Oct

1850 1900 1950 2000

S [mm]

Jan Apr July Oct

1850 1900 1950 2000

S [mm]

Jan Apr July Oct

1850 1900 1950 2000

S [mm]

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1850 1900 1950 2000

GRACE

CCSM4

CCSM3
Black carbon snow forcing in CCSM4

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<th>Species</th>
<th>Pre-Industrial (1850-1869) (W m(^{-2}))</th>
<th>Present (1986-2005) (W m(^{-2}))</th>
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<tr>
<td>Black carbon</td>
<td>0.023</td>
<td>0.037</td>
</tr>
<tr>
<td>Mineral dust</td>
<td>0.046</td>
<td>0.036</td>
</tr>
<tr>
<td>Combined effect</td>
<td>0.075</td>
<td>0.083</td>
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Snow albedo feedback

- Net
- Snow Cover
- Metamorphosis

Feedback (%/K)

OBS
CCSM3
CCSM4
LAI and LAI change (2080-2099 minus 1980-1999) in CCSM4

CCSM4: $LAI_{\text{MAX}}$

CCSM3: $LAI_{\text{MAX}}$

CCSM4: $\Delta LAI_{\text{MAX}}$

CCSM3: $\Delta LAI_{\text{MAX}}$
Permafrost extent and active layer thickness

![CCSM3 and CCSM4 Maps]

IPA Observed Extent

![IPA Observed Extent Map]

![Temperature and Snow Depth Graphs]
Despite increase in LAI variability (by definition) lower variability in LH and $T_{air}$ due to wetter model

Planning supplementary 1850 control and 20th century simulation with prescribed MODIS LAI
CESM1 update: to be released on May 15, 2011

- **CAM5.1**
  - Bug fixes, model version used for CESM1 (CAM5) simulations for CMIP5

- **CLM4**
  - Crops (spring wheat, corn, soybean)
  - Irrigation
  - Support for Flux Tower Site simulations (PTCLIM)
  - PFT physiology and RTM directional file converted to netCDF
  - Parallel I/O

- **GLC (Greenland ice sheet) Compsets**

- **POP, CICE ???**
CLM4.x (potential release with CESM update June, 2012)
- Crops and irrigation
  - Connect crops and irrigation
  - Fertilization and other updates, expand crop PFTs
- Revised cold region hydrology
  - Impedance factor, perched water table
  - Surface water store (prognostic wetlands)
  - New snow cover fraction param; separate surface energy calc for snow covered, surface water, and bare ground surfaces
  - 2-way grid cell – RTM interactions (flooding)
- Canopy physiology
  - Update GPP (Bonan et al. 2011); multilayer canopy radiation and photosynthesis, leaf optimization
CLM4.x (potential release with CESM update June, 2012)

- Improved fire algorithm including human triggers and suppression
  - Kloster et al., *Biogeosciences*, 2010
- Methane emissions model
  - Based on Riley et al. 2011; with options from Meng et al. 2011 (?)
- Revised lake model
  - New lake physics and lake area dataset
- Dynamic landunits
  - Land unit transitions: e.g., glacier to vegetated, vegetated to crop, vegetated to urban, etc.
– Software engineering

• High resolution: new input datasets (?); update tools mksrfdat, interpinc
• Simplified soil C and N pools coding structure
• Move CN (and other) model parameters to input file
• Model output: by default PFT/column – level output
• Unstructured grid
CLM and Unstructured Grids

• Capability introduced to run with non lat/lon or logically rectangular grids
  – Leverage new ESMF parallel offline regridding capability for this work
  – *New* surface dataset generation tool for non lat/lon grids (faster)
  – *New* CLM code support to deal with non lat/lon surface datasets and generate appropriate history files
  – *New* offline post-processing utility to map non lat/lon history files to 2d for visualization

• New ways to run CLM
  – Regionally refined grids (e.g. over USA)
  – CAM/HOMME cubed sphere grid with and without regional refinement
  – “Collection” of tower sites in parallel
  – Catchment grid
Other CLM development activities

- Soil carbon and nitrogen biogeochemistry
- Ecosystem demography, temporal response to disturbance
- Sub-surface hydrological processes
- Sub-grid soil moisture and snow heterogeneity
- 3-D canopy radiation
- Integrated Assessment Modeling
- Water (and carbon?) Isotopes
- N$_2$O emissions
- Phenology
- Phosphorous
- Data assimilation
- Riverine transport of nutrients and sediments
Lectures on simulating the climate system
Practical sessions on running CESM, modifying components, and analyzing data
Targeted at graduate student level
  - Max 80 students with financial support for up to 40 students
  - Acceptance criteria:
    - Preference given to early career graduate students, though we will aim for a mix of graduate students, postdocs, and early career research scientists and faculty
    - Project descriptions and their fit with broader CESM goals and activities
    - Balance attendees across institutions
How to Apply:
  - Application website online at www.cesm.ucar.edu in early January, 2011
  - Application deadline: March 25, 2011
  - Accepted students informed by late April
  - Questions should be directed to Dave Lawrence (dlawren@ucar.edu)
Session C10: Land, Water and Climate
(conveners: D. Lawrence, P. Kabat)
Abstract deadline April 30, 2011