**How to use MEGAN in CESM1.1.1**
**6 March 2013**

MEGAN-v2.1 has been incorporated into CLM4.0, as described in *Guenther et al.* [GMD, 2012]. When MEGAN is turned on, CLM will calculate biogenic emissions for 150 compounds. These compounds are mapped to the chemical species in CAM-chem through a namelist. The resulting biogenic emissions depend strongly on the driving parameters (LAI, temperature, solar radiation). Listed below are the recommendations for various CESM settings and namelist variables for different model scenarios.

The following compsets include MEGAN emissions as a default in CESM1.2.1: F2000_MOZSOA, F2000_STRATSOA.

**To turn on MEGAN in CESM without chemistry, else the settings are specified in the namelist.**
In **env_run.xml**:
```
<entry id="CLM_BLDNML_OPTS"   value="-megan"  />
```

**MEGAN emission factors file:**
The current file is specified in **drv_flds_in** or **user_nl_cam,** within **megan_emis_nl**:

```
megan_factors_file = '/glade/p/cesm/cseg/inputdata/atm/cam/chem/
trop_mozart/emis/megan21_emis_factors_c20130304.nc'
```

This file contains the emission factors at standard temperature and pressure for each compound for each plant functional type, as well as the other model parameters. The compound names are given in the variable "Comp_Name".

CLM/MEGAN-v2.1 includes an option for using a map of emission factors for isoprene. The map in the current release is out of date and SHOULD NOT BE USED.
Under **megan_emis_nl**, in **drv_flds_on or user_nl_cam:**
**`megan_mapped_emisfctrs = .false.`**

**Emissions files**
Be sure that the emissions files you are using for CAM-chem do not contain biogenic emissions for the species you will be calculating with MEGAN, as they will be read and added to those computed by MEGAN, resulting in double the emissions.

**Vegetation (LAI)**
There are several choices for CLM_CONFIG_OPTs in **env_build.xml**:
If you want to use satellite LAI:
```
<entry id="CLM_CONFIG_OPTS"   value="-bgc none"  />
```

If you want to use the CN (carbon-nitrogen) model:
```
<entry id="CLM_CONFIG_OPTS"   value="-bgc cn"  />
```

It is also possible to run the dynamic vegetation model with CLM:

```
<entry id="CLM_CONFIG_OPTS"   value="-bgc cndv"  />
```

The CN and CNDY options are generally used for long-term climate simulations.
If you run CLM with bgc-cn or bgc-cndv, the model often needs to be run for a long period to spin-up to stable conditions.

**Offline CLM**
To run offline CLM/MEGAN, there are a few different options. One could select the compsets starting with "I" or create your own compset if you are familiar with that. The default atmospheric forcing data for the offline CLM in the "I" compsets is Qian-met.
The time period for the driving meteorology that the CLM will use can be set using the min and max years of interest. For example, to run for year 2000 only:
&clm_inparm
datm_cycle_beg_year = 2000
datm_cycle_end_year = 2000
/
Set `CLM_CONFIG_OPTS` for LAI maps or dynamic vegetation, according to your scientific question (see above).

You may also wish to use this model configuration to calculate biogenic emissions resulting from a theoretical or predicted land cover change scenario. In this case, you need to specify a new land surface (fsurdat) file corresponding to your desired modified PFT distribution, and also set no initial condition (ic) file for the CLM:

fsurdat = '/glade/scratch/sra/new_pft_scenario.nc'
finidat = ''

This is because the CLM will not run if the PFT distributions in the land cover data and ic data are significantly different. In this case, the CLM will need to be spun up over a period of around 40 years in order for the water cycle and BVOC emissions to stabilize. We have tested this using the present-day satellite LAI surface data, and find only a 0.4% difference between the isoprene emission total after 1 year with initial conditions and the emission total after 40 years with no initial conditions.

The "interpinic" tool can be used to create a CLM ic file from the final year of your long simulation that can be used as initial conditions to re-run the given scenario.

**CAM-chem**
LAI: When running CAM-chem with specified dynamics, one is likely trying to reproduce the present-day atmosphere as accurately as possible, therefore, using satellite observations of LAI is preferred. This is set in **env_build.xml**:
```
<entry id="CLM_CONFIG_OPTS"   value="-bgc none"  />
```

MEGAN namelist: To match CLM compounds to the species in the chemical mechanism of CAM-chem, use 'megan_specifier' within megan_emis_nl. An example for trop_mozart (MOZART-4) chemistry is given here.

In **drv_flds_in** or **user_nl_cam**:

```
&megan_emis_nl
 megan_factors_file = '/glade/p/cesm/cseg/inputdata/atm/cam/chem/
trop_mozart/emis/megan21_emis_factors_c20130304.nc'
 megan_specifier = 'ISOP = isoprene',
                   'C10H16 = myrcene + sabinene + limonene + carene_3 +
ocimene_t_b + pinene_b + pinene_a + 2met_styrene + cymene_p + cymene_o
+ phellandrene_a + thujene_a + terpinene_a + terpinene_g + terpinolene
+ phellandrene_b + camphene + bornene + fenchene_a + ocimene_al +
ocimene_c_b',
                   'CH3OH = methanol',
                   'C2H5OH = ethanol',
                   'CH2O = formaldehyde',
                   'CH3CHO = acetaldehyde',
                   'CH3COOH = acetic_acid',
                   'CH3COCH3 = acetone',
                   'HCOOH = formic_acid',
                   'HCN = hydrogen_cyanide',
                   'CO = carbon_monoxide',
                   'C2H6 = ethane',
                   'C2H4 = ethene',
                   'C3H8 = propane',
                   'C3H6 = propene',
                   'BIGALK = pentane + hexane + heptane + tricyclene',
                   'BIGENE = butene',
                   'MEK = butanone_2',
                   'TOLUENE = toluene'
megan_mapped_emisfctrs   = .false.
/
```

**History output**

In CLM history files, all MEGAN-calculated compounds that are included in the megan_specifier are automatically saved to the monthly output, with variable names "MEG_{compound}".

In CESM1.1, these values have been scaled to account for the land partial land fraction of the gridboxes along coastlines. In CESM1.2, these values will need to be multiplied by the landfrac value to get the true emissions.

To save the MEGAN emissions in the CAM history files, include the desired MEG_{species} variables in the fincl* fields of user_nml_cam. The SF{species} variables are the total emissions fluxes for each species, so will include all sources if an emissions file was also read for other sources (such as bb).

**Emissions Totals**

For various configurations, here are the global emissions totals that can be expected.

| **Model configuration** | | | | **Emissions totals** | | | |
|---|---|---|---|---|---|---|---|
| CAM/CLM | Meteorology (CAM/GEOS5) | BGC, LAI (cn/off) | Year | Isoprene (Tg/yr) | C10H16 (Tg/yr) | Methanol (Tg/yr) | Acetone (Tg/yr) |
| CAM4 | GEOS5 | Off | 2006 | 474.8 | 113.7 | 84.5 | 60.0 |
| CAM | CAM | Off | | 539.3 | 152.0 | 100.7 | 43 |
| Offline CLM | | | | | | | |
| CAM4 | trop | Off | 2000 | 489.6 | 142.1 | 102.6 | 67.7 |
| CAM4 | trop/strat | Off | 2000 | 483.9 | 140.9 | 101.4 | 67.2 |