E3SM, ELM & OLMT User Documentation

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Revision Notes

- [10/25/2023] Initial Draft
- [02/03/2024] Added Examples after Testing

1. Setting Up Docker and Environments

Docker is an open-source project that allows programmers to deploy their applications in a sandbox (called containers) to run on the host operating system (Linux). Docker allows programmers to package an application with all its dependencies (code, data, etc.) into a standardized unit that other users can work with despite running different types of operating systems. This manual is based in docker, since setting up environments for E3SM for individual computer requires extensive work.

1a. Install Docker from Web.

Visit docker website: https://www.docker.com/ and install docker. After installing, revise some settings following the instructions below.

- Open Docker Desktop.
- Skip the Docker tutorial.
- Go to Settings by opening the gear symbol in the upper right corner of the Docker app.
- Select the "Resources" tab on the left-hand menu,
- Select "Filesharing" tab on the left-hand menu under "Advanced".
- Select the "+" symbol and add your computer's main drive here so Docker can access and write to your computer.
    - Windows users: this will probably look like "C:\Users\username" where "username" is your local username on the computer.
    - Mac users: this will probably look like "/Users/username" where "username" is your local username on the computer.
- All users: If you don't want to share your whole drive, you can also add only specific folders, e.g., "/Users/username/scratch".
- Hit the button "Apply and restart" in the bottom right corner of the window.

1b. Create Volume to Hold Data.

We will create two volumes in docker, namely elmdata and elmoutput, which contains input and output data for the E3SM. The command is given below. Hereafter, the command in blue represents the command to be executed in local terminal, not docker. Commands for docker terminal will be marked as red.

```
> docker volume create elmdata
> docker volume create elmoutput
```

Next, we will pull the image from the FASSt simulation repository.

```
> docker pull fasstsimulation/elm-builds:elm_v2-for-ngee-serial_multiarch
```

By doing this, the initial elmdata volume will contain default E3SM models.

1c. Clone E3SM & OLMT to Local Machine.

To enable more efficient model development and testing we will set up a directory on the host machine to interface with git and clone the repositories. Here we will define the host directory in the local machine as <ELM> in desktop.

```
> cd /Users/jangholee/desktop
> mkdir ELM
> cd ELM
```

On this ELM directory, we will install specific builds of E3SM using github. First, we need to get the ssh credential key from git (user-specific):

https://docs.github.com/en/authentication/connecting-to-github-with-ssh/generating-a-new-ssh-key-and-adding-it-to-the-ssh-agent

After getting the credential key, place it in the .ssh in home directoty (access in finder using cmd+shift+.: to show hidden files). Rename the keys to [id_rsa.pub] and [id_rsa].

We will install two specific versions of E3SM: [Maintenance branch 2.1] and [Fengming's branch for high resolution simulations using DAYMET]

```
> cd ELM
> ssh-keyscan github.com >> ~/.ssh/known_hosts
> git clone -b maint-2.1 --recursive git@github.com:E3SM-Project/E3SM.git
> git clone -b fmyuan/lnd/ELM-highres --recursive git@github.com:E3SM-
Project/E3SM.git
```

Now we install OLMT, which is a wrapper to run E3SM.

```
> cd ELM
> git clone https://github.com/dmricciuto/OLMT.git
```

Now the ELM directory should contain three folders: E3SM (maintenance branch 2.1), E3SM-hires (high resolution simulation), OLMT. If the names are different, rename it.

1d. Running Docker in Terminal & Setting up Environments.

We can now run docker from the local terminal window with the following command.

```
> docker run -t -i --hostname=docker --user modeluser -v elmdata:/inputdata
-v elmoutput:/output -v /Users/jangholee/desktop/ELM:/code
fasstsimulation/elm-builds:elm_v2-for-ngee-serial_multiarch /bin/bash
```

This will open docker terminal. In this docker terminal, [elmdata] (in docker volume) will refer to as [/inputdata], [elmoutput] (in docker volume) will be [/output] and [ELM] directory (in local desktop) will refer to as [/code].

We need to create folders for run and case directories. Note that commands in docker terminal is marked in red.

```
> cd /output
> mkdir cime_run_dirs
> mkdir cime_case_dirs
```

We will then need to download the input data onto the inputdata volume (which is elmdata in docker UI). For the example dataset:

```
> cd /inputdata
> wget
https://web.lcrc.anl.gov/public/e3sm/ac.ricciuto/scripts/download_inputdata_
docker.sh
> chmod u+x download_inputdata_docker.sh
> ./download_inputdata_docker.sh
```

For the Daymet input data for Chicago region (38GB):

```
> cd /inputdata/atm/datm7/GSWP3_daymet
>wget
https://web.lcrc.anl.gov/public/e3sm/inputdata/atm/datm7/GSWP3_daymet/TILES_
CHICAGO.tar
> tar -xvf TILES_CHICAGO.tar
> rm TILES_CHICAGO.tar
```

2. Workflow of E3SM

2a. Land Part of E3SM.

Land part input data are in three files: 1) domain.nc, 2) surfdata.nc, 3) surfdata.pftdyn.nc, and 4) clmdata.nc. Below are the variables containing each netCDF files. Description of variables is attached in appendix 1. Domain.nc shows the geolocation of target point. Surfdata shows the surface property of that point, and surfdata.pftdym describes the time-evolving dynamics of the surfdata. Clmdata.nc consists general constants and variables.

Below is the table describing pft (plant functional types).

PFT Index	Type
0	not vegetated
1	needleleaf_evergreen_temperature_tree
2	needleleaf_evergreen_boreal_tree
3	needleleaf_deciduous_boreal_tree
4	broadleaf_evergreen_tropical_tree
5	broadleaf_evergreen_temperate_tree
6	broadleaf_deciduous_tropical_tree
7	broadleaf_deciduous_temperate_tree
8	broadleaf_deciduous_boreal_tree
9	broadleaf_evergreen_shrub
10	broadleaf_deciduous_temperate_shrub
11	broadleaf_deciduous_boreal_shrub
12	c3_arctic_grass
13	c3_non-arctic_grass
14	c4_grass
15	c3_crop
16	c3_irrigated

2b. Stabilizing Part of E3SM.

To stabilize the climate and vegetation (e.g., carbon budget, nitrogen, etc.) E3SM undergoes the “spin-up” phase before doing transient-year (climate forcing) simulations. This consists of two phase – AD-spin up (default 200 years) and regular-spin up (default 250 years).

2c. Transient Forcing of E3SM.

For the climate forcing, Daymet variables are generally used for Chicago region. Required variables are: 1) FLDS (atmospheric longwave radiation), 2) FSDS (atmospheric shortwave radiation), 3) PRECTmms (precipitation) 4) PSRF (surface pressure), 5) QBOT (atmospheric specific humidity), 6) TBOT (atmospheric air temperature, 2-m), and 7) WIND (wind speed).

2d. Outputs

E3SM will result full model output. The list of variables for the output netCDF files are listed in appendix 2.

3. E3SM Usage with Examples

3a. Single-Grid Cell Simulation at Missouri Ozark site

All codes for running E3SM is embedded in OLMT directory. First, get into OLMT directory within docker terminal.

```
> cd /code/OLMT
```

Now run the MOz experiment

```
> python site_fullrun.py --site US-MOz --tstep 1 --cpl_bypass --model_root
/code/E3SM-hires --runroot /output/cime_run_dirs/ --caseroot
/output/cime_case_dirs/ --ccsm_input /inputdata/ --nyears_ad_spinup 50 --
nyears_final_spinup 50 --caseidprefix dockertest --machine docker --nopftdyn
```

Description of each argument are given as follows.

caseidprefix	Identifier used to name the case
cpl_bypass	Use coupler bypass enabled version of ELM (avoids using DATM)
daymet4	Use Daymet reanalysis (uses gswp3 for temporal downscaling)
domainfile	Domain file defining region to use
gswp3	Use GSWP3 reanalysis meteorological forcing data
hist_nhtfrq_trans	Output timestep (-1 * number of hours, e.g. -24 for daily, -1 for hourly)
hist_mfilt_trans	Number of output timesteps in history file for transient simulation (e.g. 365 would give you annual files if hist_nhtfrq_trans = -24; 8760 would give you annual files if hist_nhtfrq_trans = -1)
machine	Machine to run on
metdir	Directory containing meteorological forcing (if non-default)
mpilib	Mpi library to use
nopftdyn	Don't use dynamic PFT (plant functional type) information
np	Number of processors for this job
nyears_ad_spinup	Length of accelerated decomposition spinup phase
nyears_final_spinup	Length of final spinup phase
postproc_file	<filename> Postprocessing file (see examples/postproc_file_example)
surffile	Surface data file to use (contains PFT, soil info, etc.)
tstep	Model timestep in hours
walltime	Walltime in hours to assign to this job

The output will be stored in:

```
> /output/cime_run_dirs/<caseid_prefix>_<site>_<compset>/run
```

We can access this while the model is running by opening up a new container (see docker run command above), or by going to the Docker Desktop GUI, clicking on “Volumes”, “elmoutput”, click on “Data” near the top (rather than “In Use”) and navigating the the correct directory. You can download individual files or .zip archives of whole directories to the host machine by clicking on the three vertical dots on the right side and then clicking “Save as”.

To check if the model is running properly, we can plot the first few years.

```
> pip3 install matplotlib
> python plotcase.py --runname dockertest_US-MOz_ICB20TRCNPRDCTCBC --ystart 1850 --yend 1852 --avpd 1 --vars TLAI,FPSN --csmdir /output/cime_run_dirs/ --outputdir ./plots --png
```

By default, the plots will go into the /output/cime_run_dirs/<case>/plots directory. Here we specify --outputdir so that the plots and output go into OLMT/plots/<case>. Because this folder is on the host machine, you will not have to move files off the container to view them. A netcdf file is also included containing the model outputs used to make the plots.

When there is an error check this: cime_config/machines/cmake_macros/gnu.cmake -> change medium to small (two replacements)

3b. Single-Grid Cell Ensemble Simulation

This is using the same site and setup as the Example 1, but 3 additional options are added to enable ensemble simulations. The following produces 10 ensemble members (size specified by –mc_ensemble) using 6 processors and the parameters specified in the file OLMT/examples/parm_list_example. Parameter samples are randomly selected from the ranges defined in the parm_list file.

```
> cd /code/OLMT
> python site_fullrun.py --site US-MOz --tstep 1 --cpl_bypass --model_root
/code/E3SM-hires --runroot /output/cime_run_dirs/ --caseroot
/output/cime_case_dirs/ --ccsm_input /inputdata/ --nyears_ad_spinupz50 --
nyears_final_spinup 50 --caseidprefix dockertest2 --machine docker --
nopftdyn --mc_ensemble 10 --ng 6 --parm_list examples/parm_list_example
```

Note that ng must be less than or equal to the size of the ensemble + 1.

If you want to provide your own parameter samples file with specific values you want to use, you can replace —-mc_ensemble 10 with the following:

```
—-ensemble_file <filename>
```

You must have one column in the file for each parameter (row) in the parm_list file. Output will be created in 10 different run directories, one for each ensemble member. The output will write into :

```
> /output/cime_run_dirs/<caseid_prefix>_<site>_<compset>/UQ/gxxxxx
```

Where “xxxxx” is a number 00001 - 00010, one for each ensemble member. You can also specify a “--postproc_file” option to automatically post process specific outputs of interest for given time periods (see options below and in OLMT/examples/postproc_file_example for an example file).

3c. Adding a new site of Chicago region using DayMet inputs and grid

First, we need to create a new site group in the following directory:

```
/inputdata/lnd/clm2/PTCLM
```

We will create 3 files:

```
Chicago_sitedata.txt
Chicago_pftdata.txt
Chicago_soildata.txt
```

To move files,

```
docker cp
/Volumes/Research2/surfaceToAir/python/01_pftSensitivitySelect/ChicagoPftSen
_pftdata.txt ef80f2f47162:/inputdata/lnd/clm2/PTCLM
```

You can follow the example of the files in AmeriFlux site group. In the Chicago_sitedata.txt file, you will create a 6-character code (e.g. CH-001), and add the lat, lon, elevation, start year, and end year Information. For DAYMET forced runs the start year and end year will be 1980 and 2014. For align year, enter 1851 (this is not used).

For the Chicago_pftdata file you can enter percentage information for up to 5 PFTs. The numbers must add up to 100% (see AmeriFlux_pftdata.txt for an example; BR-Sa1 uses 100% of PFT4, while US-Bo1 has 50% of PFT 13 and 50% of PFT 14). For the Chicago_soildata.txt, again follow the example of AmeriFlux_soildata.txt. Note only the % sand and % clay columns are actually used. The sand and clay percentages don't have to add to 100% (the remaining portion is loam), but they should not exceed 100%.

Note the following command assumes you have already extracted the single gridcell of interest from the surface data and domain files and renamed them (surfdata_CH-001.nc and domain_CH-001.nc).

```
> python site_fullrun.py --site CH-001 --sitegroup Chicago --tstep 1 --
cpl_bypass --model_root /code/E3SM-hires --runroot /output/cime_run_dirs/ --
caseroot /output/cime_case_dirs/ --ccsm_input /inputdata/ --caseidprefix
dockertest --machine docker --nopftdyn --daymet4 --metdir
/inputdata/atm/datm7/GSWP3_daymet/TILES_CHICAGO/cpl_bypass_full --
nopointdata --surffile
```

```
/inputdata/atm/datm7/GSWP3_daymet/TILES_CHICAGO/cpl_bypass_full/surfdata_CH-
001.nc --domainfile
/inputdata/atm/datm7/GSWP3_daymet/TILES_CHICAGO/cpl_bypass_full/domain_CH-
001.nc --surfdata_grid --hist_nhtfrq_trans -1 --hist_mfilt_trans 24
```

You may create an ensemble simulation similar to example 2 by adding the 3 options at the end (--mc_ensemble, –ng and –parm_list)

Appendix 1. Naming and explanation of input variables

- domain.nc

Name	Long Name	Dimensions
area	Area of grid cell in radians squared	xc, yc
frac	Fraction of grid cell that is active	xc, yc
mask	Land domain mask 0: Ocean 1: Land	xc, yc
xc	Longitude of grid cell center in degrees east	xc
xv	Longitude of grid cell vertices in degrees east	xv
yc	Latitude of grid cell center in degrees north	yc
yv	Latitude of grid cell vertices in degrees north	yv

- surfdata.nc & surfdata.pftdyn.nc (dynamic change of each pft in time)

Name	Long Name	Dimensions
mxsoil_color	maximum numbers of soil colors	
mxsoil_order	maximum numbers of soil order	
SOIL_COLOR	soil color	lsmlat / lsmlon
SOIL_ORDER	soil order	lsmlat / lsmlon
PCT_SAND	percent sand	nlevsoi / lsmlat / lsmlon
PCT_CLAY	percent clay	nlevsoi / lsmlat / lsmlon
ORGANIC	organic matter density at soil levels	nlevsoi / lsmlat / lsmlon
FMAX	maximum fractional saturated area	lsmlat / lsmlon
LANDFRAC_PFT	land fraction from pft dataset	lsmlat / lsmlon
PFTDATA_MASK	land mask from pft dataset, indicative of real/fake points	lsmlat / lsmlon
PCT_NATVEG	total percent natural vegetation landunit	lsmlat / lsmlon
PCT_CROP	total percent crop landunit	lsmlat / lsmlon
PCT_NAT_PFT	percent plant functional type on the natural veg landunit (% of landunit)	natpft / lsmlat / lsmlon
MONTHLY_LAI	monthly leaf area index	time / lsmpft / lsmlat / lsmlon
MONTHLY_SAI	monthly stem area index	time / lsmpft / lsmlat / lsmlon

MONTHLY_HEIGHT_TOP	monthly height top	time / lsmpft / lsmlat / lsmlon
MONTHLY_HEIGHT_BOT	monthly height bottom	time / lsmpft / lsmlat / lsmlon
AREA	area	lsmlat / lsmlon
LONGXY	longitude	lsmlat / lsmlon
LATIXY	latitude	lsmlat / lsmlon
EF1_BTR	EF btr (isoprene)	lsmlat / lsmlon
EF1_FET	EF fet (isoprene)	lsmlat / lsmlon
EF1_FDT	EF fdt (isoprene)	lsmlat / lsmlon
EF1_SHR	EF shr (isoprene)	lsmlat / lsmlon
EF1_GRS	EF grs (isoprene)	lsmlat / lsmlon
EF1_CRP	EF crp (isoprene)	lsmlat / lsmlon
CANYON_HWR	canyon height to width ratio	numurbl / lsmlat / lsmlon
EM_IMPROAD	emissivity of impervious road	numurbl / lsmlat / lsmlon
EM_PERROAD	emissivity of pervious road	numurbl / lsmlat / lsmlon
EM_ROOF	emissivity of roof	numurbl / lsmlat / lsmlon
EM_WALL	emissivity of wall	numurbl / lsmlat / lsmlon
HT_ROOF	height of roof	numurbl / lsmlat / lsmlon
THICK_ROOF	thickness of roof	numurbl / lsmlat / lsmlon
THICK_WALL	thickness of wall	numurbl / lsmlat / lsmlon
T_BUILDING_MAX	maximum interior building temperature	numurbl / lsmlat / lsmlon
T_BUILDING_MIN	minimum interior building temperature	numurbl / lsmlat / lsmlon
WIND_HGT_CANYON	height of wind in canyon	numurbl / lsmlat / lsmlon
WTLUNIT_ROOF	fraction of roof	numurbl / lsmlat / lsmlon
WTROAD_PERV	fraction of pervious road	numurbl / lsmlat / lsmlon

ALB_IMPROAD_DIR	direct albedo of impervious road	numrad / numurbl / lsmlat / lsmlon
ALB_IMPROAD_DIF	diffuse albedo of impervious road	numrad / numurbl / lsmlat / lsmlon
ALB_PERROAD_DIR	direct albedo of pervious road	numrad / numurbl / lsmlat / lsmlon
ALB_PERROAD_DIF	diffuse albedo of pervious road	numrad / numurbl / lsmlat / lsmlon
ALB_ROOF_DIR	direct albedo of roof	numrad / numurbl / lsmlat / lsmlon
ALB_ROOF_DIF	diffuse albedo of roof	numrad / numurbl / lsmlat / lsmlon
ALB_WALL_DIR	direct albedo of wall	numrad / numurbl / lsmlat / lsmlon
ALB_WALL_DIF	diffuse albedo of wall	numrad / numurbl / lsmlat / lsmlon
TK_ROOF	thermal conductivity of roof	nlevurb / numurbl / lsmlat / lsmlon
TK_WALL	thermal conductivity of wall	nlevurb / numurbl / lsmlat / lsmlon
TK_IMPROAD	thermal conductivity of impervious road	nlevurb / numurbl / lsmlat / lsmlon
CV_ROOF	volumetric heat capacity of roof	nlevurb / numurbl / lsmlat / lsmlon
CV_WALL	volumetric heat capacity of wall	nlevurb / numurbl / lsmlat / lsmlon
CV_IMPROAD	volumetric heat capacity of impervious road	nlevurb / numurbl / lsmlat / lsmlon
NLEV_IMPROAD	number of impervious road layers	numurbl / lsmlat / lsmlon
peatf	peatland fraction	lsmlat / lsmlon
abm	agricultural fire peak month	lsmlat / lsmlon
gdp	gdp	lsmlat / lsmlon
SLOPE	mean topographic slope	lsmlat / lsmlon
STD_ELEV	standard deviation of elevation	lsmlat / lsmlon
binfl	VIC b parameter for the Variable Infiltration Capacity Curve	lsmlat / lsmlon
Ws	VIC Ws parameter for the ARNO Curve	lsmlat / lsmlon
Dsmax	VIC Dsmax parameter for the ARNO curve	lsmlat / lsmlon

Ds	VIC Ds parameter for the ARNO curve	lsmlat / lsmlon
LAKEDEPTH	lake depth	lsmlat / lsmlon
F0	maximum gridcell fractional inundated area	lsmlat / lsmlon
P3	coefficient for qflx_surf_lag for finundated	lsmlat / lsmlon
ZWT0	decay factor for finundated	lsmlat / lsmlon
PCT_WETLAND	percent wetland	lsmlat / lsmlon
PCT_LAKE	percent lake	lsmlat / lsmlon
PCT_GLACIER	percent glacier	lsmlat / lsmlon
GLC_MEC	Glacier elevation class	nglcecp1
PCT_GLC_MEC	percent glacier for each glacier elevation class (% of landunit)	nglcec / lsmlat / lsmlon
PCT_GLC_MEC_GIC	percent smaller glaciers and ice caps for each glacier elevation class (% of landunit)	nglcec / lsmlat / lsmlon
PCT_GLC_MEC_ICESHEET	percent ice sheet for each glacier elevation class (% of landunit)	nglcec / lsmlat / lsmlon
PCT_GLC_GIC	percent ice caps/glaciers (% of landunit)	lsmlat / lsmlon
PCT_GLC_ICESHEET	percent ice sheet (% of landunit)	lsmlat / lsmlon
TOPO_GLC_MEC	mean elevation on glacier elevation classes	nglcec / lsmlat / lsmlon
TOPO	mean elevation on land	lsmlat / lsmlon
PCT_URBAN	percent urban for each density type	numurbl / lsmlat / lsmlon
URBAN_REGION_ID	urban region ID	lsmlat / lsmlon
APATITE_P	Apatite Phosphorus	lsmlat / lsmlon
LABILE_P	Labile Inorganic Phosphorus	lsmlat / lsmlon
OCCLUDED_P	Occluded Phosphorus	lsmlat / lsmlon
SECONDARY_P	Secondary Mineral Phosphorus	lsmlat / lsmlon

- clmdata.nc

Name	Unit	Description	Min	Max
aereoxid	unitless	Fraction of methane flux entering aerenchyma rhizosphere that will be oxidized rather than emitted	0	0
aleaff	unitless	Leaf Allocation coefficient parameter used in CNAllocationn	0	0

allconsl	unitless	Leaf Allocation coefficient parameter power used in CNAllocation	0	5
allconss	unitless	Stem Allocation coefficient parameter power used in CNAllocation	0	5
arootf	unitless	Root Allocation coefficient parameter used in CNAllocation	0	0.2
arooti	unitless	Root Allocation coefficient parameter used in CNAllocation	0	0.5
astemf	unitless	Stem Allocation coefficient parameter used in CNAllocation	0	0.3
atmch4	mol/mol	Atmospheric CH4 mixing ratio to prescribe if not provided by the atmospheric model	1.70E-06	1.70E-06
baset	C	Base Temperature, parameter used in accFlds	0	10
bbbopt		Ball-Berry intercept	10000	40000
bdnr	1/day	bulk denitrification rate	0.5	0.5
bfact	unitless	Exponential factor used in CNAllocation for fraction allocated to leaf	0	0.1
br_mr	gC/gN/s	Base rate for maintenance respiration	2.53E-06	2.53E-06
br_xr	gC/gN/s	Base rate for respiration from carbon storage pool	1.00E-08	1.00E-08
c3psn	flag	Photosynthetic pathway	0	1
capthick	mm	Minimum thickness before assuming h2osfc is impermeable	100	100
cc_dstem	0 to 1	Combustion completeness factor for dead stem	0	0.8
cc_leaf	0 to 1	Combustion completeness factor for leaf	0	0.8
cc_lstem	0 to 1	Combustion completeness factor for live stem	0	0.8
cc_other	0 to 1	Combustion completeness factor for other plant	0	0.8
cn_s1	unitless	Carbon to nitrogen ratio (C:N) for SOM pool 1 (CTC)	12	12
cn_s1_bgc	gC/gN	C:N for SOM 1 (Century)	8	8
cn_s2	gC/gN	C:N for SOM pool 2 (CTC)	12	12
cn_s2_bgc	gC/gN	C:N for SOM pool 2 (Century)	11	11
cn_s3	gC/gN	C:N for SOM pool 3 (CTC)	10	10
cn_s3_bgc	gC/gN	C:N for SOM pool 3 (Century)	11	11
cn_s4	gC/gN	C:N for SOM pool 4 (CTC)	10	10
cnscalefactor	unitless	Scale factor on CN decomposition for assigning methane flux	1	1
compet_decomp_nh4	unitless	Relative competitiveness of immobilizers for NH4	1	1

compet_decomp_no3	unitless	Relative competitiveness of immobilizers for NO3	1	1
compet_denit	unitless	Relative competitiveness of denitrifiers for NO3	1	1
compet_nit	unitless	Relative competitiveness of nitrifiers for NH4	1	1
compet_plant_nh4	unitless	Relative compettiveness of plants for NH4	1	1
compet_plant_no3	unitless	Relative compettiveness of plants for NO3	1	1
convfact		conversion factor from gC/m2 to bu/acre	149	999
crit_dayl	seconds	Critical day length for senescence	39300	39300
crit_dayl_stress	seconds	Critical day length for senescence	36000	36000
crit_offset_fdd	days	Critical number of freezing days to initiate offset	15	15
crit_offset_swi	days	Critical number of water stress days to initiate offset	15	15
crit_onset_fdd	days	Critical number of freezing days to set gdd counter	15	15
crit_onset_gdd	seconds	Critical day length for senescence	500	500
crit_onset_swi	days	Critical number of days > soilpsi_on for onset	15	15
croot_stem	gC/gC	Allocation parameter: new coarse root C per new stem C	0	0.3
crop	logical flag	Binary crop PFT flag:	0	1
cryoturb_diffusion_k	m^2/sec	The cryoturbation diffusive constant for vertical mixing of SOM	1.59E-11	1.59E-11
cumprec_onset	seconds	Critical day length for senescence	20	20
cwd_fcel	unitless	Cellulose fraction for CWD	0.76	0.76
cwd_flig	unitless	Lignin fraction of coarse woody debris	0.24	0.24
dayscrecover	unitless	days to recover negative cpool	30	30
deadwdcn	gC/gN	Dead wood (xylem and heartwood) C:N	0	500
deadwdcn_obs	gC/gN	dead wood CN ratio	0	2400
deadwdcp	gC/gP	dead wood C:P	1	3000
deadwdcp_obs	gC/gP	dead wood CP ratio	0	63164.14
declfact	unitless	Decline factor for gddmaturity used in CNAllocation	0	1.05
decomp_depth_efolding	m	e-folding depth for reduction in decomposition. Sset to large number for depth-independance	0.33	0.33
decompmicc_patch_vr		pft specific soil microbial decomposer density	0	1311.88736

depth_runoff_Nloss	m	Depth over which runoff mixes with soil water for N loss to runoff	0.05	0.05
displar	unitless	Ratio of displacement height to canopy top height	0	0.68
dleaf	m	Characteristic leaf dimension	0	0.04
dnp	unitless	Denitrification proportion	0.01	0.01
dsladlai	m^2/gC	Through canopy, projected area basis: dSLA/dLAI	0	0.002
ef_time	years	e-folding time constant	1	1
evergreen	logical flag	Binary flag for evergreen leaf habit	0	1
f_ch4	unitless	Ratio of CH4 production to total C mineralization	0.2	0.2
f_sat	unitless	Volumetric soil water defining top of water table or where production is allowed	0.95	0.95
fcur	fraction	Allocation parameter: fraction of allocation that goes to currently displayed growth, remainder to storage	0	1
fcurdv	fraction	Alternate fcur for use with CNDV	0	1
fd_pft	hr	Fire duration	0	24
fertnitro	kg N/m2	Max fertilizer to be applied in total	0	0.015
ffrootcn	gC/gN	Fine root C:N during organ fill	0	999
fleafcn	gC/gN	Leaf C:N during organ fill	65	999
fleafi	unitless	Leaf Allocation coefficient parameter fraction used in CNAllocation	0	0.85
flivewd	fraction	Allocation parameter: fraction of new wood that is live (phloem and ray parenchyma)	0	1
flnr	fraction	Fraction of leaf N in Rubisco enzyme	0	0.4102
fm_droot	0 to 1	Fire-related mortality factor for dead roots	0	0.2
fm_dstem	0 to 1	Fire-related mortality factor for dead stem	0	0.8
fm_leaf	0 to 1	Fire-related mortality factor for leaf	0	0.8
fm_lroot	0 to 1	Fire-related mortality factor for live roots	0	0.2
fm_lstem	0 to 1	Fire-related mortality factor for live stem	0	0.8
fm_other	0 to 1	Fire-related mortality factor for other plant	0	0.8
fm_root	0 to 1	Fire-related mortality factor for fine roots	0	0.2
fnitr	unitless	Foliage nitrogen limitation factor	0	1
fnr	unitless	Fraction of Rubisco that is N	7.16	7.16
fr_fcel	fraction	Fine root litter cellulose fraction	0	0.5
fr_flab	fraction	Fine root litter labile fraction	0	0.25
fr_flig	fraction	Fine root litter lignin fraction	0	0.25

froot_leaf	gC/gC	Allocation parameter: new fine root C per new leaf C	0	2
froot_long	years	Leaf longevity	0	3.5
frootcn	gC/gN	Fine root C:N	1	42
frootcn_obs	gC/gN	fine root CN ratio	34.8	87.1
frootcp	gC/gP	fine root C:P	1	1000
frootcp_obs	gC/gP	fine root CP ratio	323	1006.05556
froz_q10	unitless	Separate q10 for frozen soil respiration rates	1.5	1.5
fsr_pft	m/s	Fire spread rate	0	0.55
fstemcn	gC/gN	Stem C:N during organ fill	100	999
fstor2tran	unitless	Fraction of storage to move to transfer for each onset	0.5	0.5
fyield	unitless	fraction of grain that is actually harvested	0.85	999
gddfunc_p1	unitless	Parameter 1 to calculate GDD threshold as fn of annual T	4.8	4.8
gddfunc_p2	unitless	Parameter 2 to calculate GDD threshold as fn of annual T	0.13	0.13
gddmin	unitless	Minimim growing degree days used in CNPhenology	0	50
graincn	gC/gN	Grain C:N	0	50
graincp	gC/gP	grain C:P	1	1000
grnfill	unitless	Grain fill parameter used in CNPhenology	0	0.7
grperc	unitless	Growth respiration factor	0.25	0.3
grpnow	unitless	Growth respiration factor	1	1
highlatfact	unitless	Multiple of qflxlagd for high latitudes	2	2
hybgdd	unitless	Growing Degree Days for maturity used in CNPhenology	0	1900
i_vc		intercept of vcmax~leafcn relationship	0	0
irrigated	logical flag	Binary Irrigated PFT flag	0	1
jmaxha		Jmax activation energy	50000	50000
jmaxhd		Jmax deactivation energy	200000	200000
k_frag	1/day	Fragmentation rate for CWD	0.0010005	0.0010005
k_l1	1/day	Decomposition rate for litter 1	1.2039728	1.2039728
k_l2	1/day	Decomposition rate for litter 2	0.07257069	0.07257069
k_l3	1/day	Decomposition rate for litter 3	0.01409892	0.01409892

k_m	mol/m3-w	Michaelis-Menten oxidation rate constant for CH4 concentration	0.005	0.005
k_m_o2	mol/m3-w	Michaelis-Menten oxidation rate constant for O2 concentration	0.02	0.02
k_m_unsat	mol/m3-w	Michaelis-Menten oxidation rate constant for CH4 concentration	0.0005	0.0005
k_mort	unitless	Coefficient of growth efficiency in mortality equation	0.3	0.3
k_nitr_max	1/sec	Maximum nitrification rate constant	1.16E-06	1.16E-06
k_s1	1/day	Decomposition rate for SOM 1	0.07257069	0.07257069
k_s2	1/day	Decomposition rate for SOM 2	0.01409892	0.01409892
k_s3	1/day	Decomposition rate for SOM 3	0.00140098	0.00140098
k_s4	1/day	Decomposition rate for SOM 4	0.00010001	0.00010001
KM_DECOMP_NH4		affinity of NH4 microbial immobilization	0.18	0.18
KM_DECOMP_NO3		affinity of NO3 microbial immobilization	0.41	0.41
KM_DECOMP_P		affinity of POx microbial immobilization	0.2	0.2
KM_DEN		affinity of NO3 denitrification	0.11	0.11
KM_MINSURF_P_vr		affinity of P adsorption of soil mineral surface	0.41664133	175.548489
KM_NFIX		affinity parameter for N2 fixation	50	50
KM_NIT		affinity of NH4 nitrification	0.76	0.76
KM_PLANT_NH4		plant NH4 maximum uptake affinity	0.14	2.946
KM_PLANT_NO3		plant NO3 maximum uptake affinity	0.27	2.07
KM_PLANT_P		plant POx maximum uptake affinity	0.035	0.6464
KM_PTASE		affinity parameter for phosphatase activity	150	150
koha		Ko activation energy	36380	36380
laimx	unitless	Maximum Leaf Area Index used in CNVegStructUpdate	0	7
lake_decomp_fact	1/s	Base decomposition rate (1/s) at 25oC in lake	9.00E-11	9.00E-11
lamda_ptase		critical value for phosphatase activity	15	15
leaf_long	years	Leaf longevity	0	3.5
leafcn	gC/gN	Leaf C:N	1	40

leafcn_obs		leaf CN ratio	14	47
leafcp	gC/gP	leaf C:P	1	600
leafcp_obs		leaf CP ratio	162	860
lf_fcel	fraction	Leaf litter cellulose fraction	0	0.5
lf_flab	fraction	Leaf litter labile fraction	0	0.25
lf_flig	fraction	Leaf litter lignin fraction	0	0.25
lfemerg	unitless	Leaf emergence parameter used in CNPhenology	0	0.05
lflitcn	gC/gN	Leaf litter C:N	1	80
lflitcp	gC/gP	leaf litter C:P	1	1200
livewdcn	gC/gN	Live wood (phloem and ray parenchyma) C:N	0	50
livewdcn_obs	gC/gN	live wood CN ratio	0	607
livewdcp	gC/gP	live wood C:P	1	3000
livewdcp_obs	gC/gP	live wood CP ratio	0	6616.3
lmrha		Leaf maintenance respiration activation energy	46390	46390
lmrhd		Leaf maintenance respiration deactivation energy	150650	150650
lmrse		Leaf maintenance respiration entropy	490	490
lwtop_ann	unitless	Live wood turnover proportion	0.7	0.7
max_altdepth_cryoturbation	m	Maximum active layer thickness for cryoturbation to occur	2	2
max_altmultiplier_cryoturb	unitless	Ratio of the maximum extent of cryoturbation to the active layer thickness	3	3
max_NH_planting_date	YYYYMMDD	Maximum planting date for the Northern Hemipsphere	0	1130
max_SH_planting_date	YYYYMMDD	Maximum planting date for the Southern Hemipsphere	0	1215
mbbopt		Ball-Berry slope term	4	9
me_herb	unitless	Moisture of extinction for herbaceous PFTs (proportion)	0.2	0.2
me_woody	unitless	Moisture of extinction for woody PFTs (proportion)	0.3	0.3
min_NH_planting_date	YYYYMMDD	Minimum planting date for the Northern Hemipsphere	0	901
min_planting_temp	K	Average 5 day daily minimum temperature needed for planting	272.15	1000
min_SH_planting_date	YYYYMMDD	Minimum planting date for the Southern Hemipsphere	0	1101
minfuel	gC/m2	Dead fuel threshold to carry a fire	100	100
mino2lim	unitless	Minimum anaerobic decomposition rate as a fraction of potential aerobic rate	0.2	0.2

minpsi_hr	MPa	Minimum soil water potential for heterotrophic resp	-10	-10
mxmat	days	Maximum number of days to maturity parameter in CNPhenology	0	265
mxtmp	C	Max Temperature, parameter used in accFlds	0	30
ndays_off	days	Number of days to complete leaf offset	15	15
ndays_on	days	Number of days to complete leaf onset	30	30
nongrassporosratio	unitless	Ratio of root porosity in non-grass to grass, used for aerenchyma transport	0.33	0.33
np_s1_new	none	NP ratio for soil 1	30	30
np_s2_new	none	NP ratio for soil 2	30	30
np_s3_new	none	NP ratio for soil 3	50	50
np_s4_new	none	NP ratio for soil 4	50	50
nstor		Parameter controlling size of non-structural nitrogen pool	3	3
organic_max	kg/m3	Organic matter content where soil is assumed to act like peat for diffusion	130	130
oxinhib	m^3/mol	Inhibition of methane production by oxygen	400	400
pconv	fraction	Deadstem proportions to send to conversion flux	0	1
pftname	unitless	Description of plant type	NA	NA
pftnum	unitless	Plant Functional Type number	0	24
pftpar20	m2	Tree maximum crown area	0	9999.9
pftpar28	degrees_Celsius	Minimum coldest monthly mean temperature	-1000	9999.9
pftpar29	degrees_Celsius	Maximum coldest monthly mean temperature	-17	1000
pftpar30	degree_C_days	Minimum growing degree days (>= 5 degree Celsius)	0	1200
pftpar31	degrees_Celsius	Upper limit of temperature of the warmest month (twmax)	23	1000
pHmax	unitless	Maximum pH for methane production	9	9
pHmin	unitless	Minimum pH for methane production	2.2	2.2
planting_temp	K	Average 10 day temperature needed for planting	280.15	1000
porosmin	unitless	Minimum aerenchyma porosity	0.05	0.05
pprod10	fraction	Deadstem proportions to send to 10 year product pool	0	0.4
pprod100	fraction	Deadstem proportions to send to 100 year product pool	0	0.1

pprodharv10	fraction	Deadstem proportions to send to 10 year harvest pool	0	1
presharv	unitless	porportion of residue harvested with grain	0	0.3
q10_ch4oxid	unitless	Q10 oxidation constant	1.9	1.9
q10_hr	unitless	Q10 for heterotrophic respiration	1.5	1.5
q10_mr	unitless	Q10 for maintenance respiration	1.5	1.5
q10ch4	unitless	Q10 for methane production	1.33	1.33
q10ch4base	K	Temperature at which the effective f_ch4 actually equals the constant f_ch4	295	295
q10lakebase		Base temperature for lake CH4 production	298	298
qflxlagd	days	Days to lag time-lagged surface runoff (qflx_surf_lag) in the tropics	30	30
r_mort	1/year	Mortality rate	0.02	0.02
rc_npool	unitless	resistance for uptake from plant n pool	10	10
redoxlag	days	Number of days to lag in the calculation of finundated_lag	30	30
redoxlag_vertical	days	Time lag (days) to inhibit production for newly unsaturated layers	0	0
rf_cwdl2_bgc	unitless	respiration fraction from CWD to litter 2	0	0
rf_cwdl3_bgc	unitless	respiration fraction from CWD to litter 3	0	0
rf_l1s1	unitless	Respiration fraction for litter 1 -> SOM 1	0.39	0.39
rf_l1s1_bgc	unitless	Respiration fraction for litter 1 -> SOM 1	0.55	0.55
rf_l2s1_bgc	unitless	respiration fraction litter 2 to SOM 1	0.5	0.5
rf_l2s2	unitless	Respiration fraction for litter 2 -> SOM 2	0.55	0.55
rf_l3s2_bgc	unitless	respiration fraction from litter 3 to SOM 2	0.5	0.5
rf_l3s3	unitless	Respiration fraction for litter 3 -> SOM 3	0.29	0.29
rf_s1s2	unitless	Respiration fraction for SOM 1 -> SOM 2	0.28	0.28
rf_s2s1_bgc	unitless	respiration fraction SOM 2 to SOM 1	0.55	0.55
rf_s2s3	unitless	Respiration fraction for SOM 2 -> SOM 3	0.46	0.46
rf_s2s3_bgc	unitless	Respiration fraction for SOM 2 -> SOM 3	0.55	0.55
rf_s3s1_bgc	unitless	respiration fraction SOM 3 to SOM 1	0.55	0.55
rf_s3s4	unitless	Respiration fraction for SOM 3 -> SOM 4	0.55	0.55
rholnir	fraction	Leaf reflectance: near-IR	0	0.45
rholvis	fraction	Leaf reflectance: visible	0	0.11
rhosnir	fraction	Stem reflectance: near-IR	0	0.53
rhosvis	fraction	Stem reflectance: visible	0	0.31
rij_kro_a	unitless	Best-fit parameter of simple-structure model (Arah and Vinten 1995)	1.50E-10	1.50E-10
rij_kro_alpha	unitless	Simple-structure model parameter (Arah and Vinten 1995)	1.26	1.26

rij_kro_beta	unitless	Simple-structure model parameter (Arah and Vinten 1995)	0.6	0.6
rij_kro_delta	unitless	Simple-structure model parameter (Arah and Vinten 1995)	0.85	0.85
rij_kro_gamma	unitless	Simple-structure model parameter (Arah and Vinten 1995)	0.6	0.6
rob	unitless	Ratio of root length to vertical depth (root obliquity)	3	3
root_dmx	m	maximum rooting depth of crops	0.9	999
roota_par	1/m	CLM rooting distribution parameter	0	11
rootb_par	1/m	CLM rooting distribution parameter	0	3
rootlitfrac	unitless	Fraction of soil organic matter associated with roots	0.5	0.5
rootprof_beta	unitless	Rooting beta parameter, for C and N vertical discretization	0	0.976
rsub_top_globalmax	gC/gN/s	Base rate for maintenance respiration	0.022	0.022
s_vc		slope of vcmax~leafcn relationship	0	62.75
satpow	unitless	Exponent on watsat for saturated soil solute diffusion	2	2
scale_factor_aere	unitless	Scale factor on the aerenchyma area for sensitivity tests	1	1
scale_factor_gasdiff	unitless	Scale factor for gas diffusion	1	1
scale_factor_liqdiff	unitless	Scale factor for solute diffusion in liquid (water)	1	1
season_decid	logical flag	Binary flag for seasonal-deciduous leaf habit	0	1
sf_minn	unitless	Soluble fraction of mineral N	0.1	0.1
sf_no3	unitless	Soluble fraction of NO3	1	1
shape_fluxprof_param1	unitless	Shape parameter of advection/diffusion profile	1.00E+10	1.00E+10
slatop	m^2/gC	Specific Leaf Area (SLA) at top of canopy, projected area basis	0	0.07
smp_crit	mm	Critical soil moisture potential to reduce oxidation (mm) due to dessication of methanotrophs above the water table	-240000	-240000
smpsc	mm	Soil water potential at full stomatal closure	-428000	0
smpso	mm	Soil water potential at full stomatal opening	-83000	0
soilpsi_off	MPa	Critical soil water potential for leaf offset	-2	-2
soilpsi_on	MPa	Critical soil water potential for leaf onset	-2	-2

som_diffus	m^2/sec	Vertical soil organic matter diffusion coefficient for flat adv/diff profile	3.17E-12	3.17E-12
stem_leaf	gC/gC	Allocation parameter: new stem C per new leaf C (-1 means use dynamic stem allocation)	-1.3	0.2
stress_decid	logical flag	Binary flag for stress-deciduous leaf habit	0	1
surface_tension_water	J/m^2	Surface tension of water (Arah and Vinten 1995)	0.073	0.073
tau_cwd	1/year	Corrected fragmentation rate constant CWD	3.33333333	3.33333333
tau_l1	year	Turnover time of litter 1	0.05405405	0.05405405
tau_l2_l3	year	Turnover time of litter 2 and litter 3	0.20408163	0.20408163
tau_s1	year	Turnover time of soil organic matter (SOM) 1	0.1369863	0.1369863
tau_s2	year	Turnover time of soil organic matter (SOM) 2	5	5
tau_s3	year	Turnover time of soil organic matter (SOM) 3	222.222222	222.222222
taulnir	fraction	Leaf transmittance: near-IR	0	0.34
taulvis	fraction	Leaf transmittance: visible	0	0.05
tausnir	fraction	Stem transmittance: near-IR	0	0.25
tausvis	fraction	Stem transmittance: visible	0	0.12
theta_cj			0.8	0.98
unsat_aere_ratio	unitless	Ratio to multiply upland vegetation aerenchyma porosity by compared to inundated systems	0.16666667	0.16666667
vcmaxha		Vcmax activation energy	72000	72000
vcmaxhd		Vcmax deactivation energy	200000	200000
vgc_max	unitless	Ratio of saturation pressure triggering ebullition	0.15	0.15
vmax_ch4_oxid	mol/m3-w/s	Oxidation rate constant	1.25E-05	1.25E-05
VMAX_MINSURF_P_vr		maximum P adsorption capacit of soil mineral surface	1.33325225	326.340139
VMAX_NFIX		maximum N2 fixation rate	1.58E-09	1.58E-09
vmax_oxid_unsat	mol/m3-w/s	Oxidation rate constant	1.25E-06	1.25E-06
VMAX_PLANT_NH4		plant NH4 maximum uptake affinity	1.38E-08	2.47E-07

VMAX_PLANT_NO3		plant NO3 maximum uptake affinity	3.21E-09	1.85E-07
VMAX_PLANT_P		plant POx maximum uptake affinity	8.90E-09	1.39E-07
VMAX_PTASE_vr		maximum phosphatase activity	0	7.13E-09
wcf	unitless	Wood combustion fraction	0.4	0.4
woody	logical flag	Binary woody lifeform flag	0	1
xl	unitless	Leaf/stem orientation index	-0.5	0.65
z0mr	unitless	Ratio of momentum roughness length to canopy top height	0	0.12
ztopmx	m	Canopy top coefficient used in CNVegStructUpdate	0	2.5

Appendix B. Description of output variables

Output	Description	Units
ACTUAL_IMMOB	actual N immobilization	gN/m^2/s
ACTUAL_IMMOB_P	actual P immobilization	gP/m^2/s
ADSORBTION_P	adsorb P flux	gP/m^2/s
AGNPP	aboveground NPP	gC/m^2/s
AGWDNPP	aboveground wood NPP	gC/m^2/s
ALT	current active layer thickness	m
ALTMAX	maximum annual active layer thickness	m
ALTMAX_LASTYEAR	maximum prior year active layer thickness	m
AR	autotrophic respiration (MR + GR)	gC/m^2/s
AVAILC	C flux available for allocation	gC/m^2/s
AVAIL_RETRANSP	P flux available from retranslocation pool	gP/m^2/s
BAF_CROP	fractional area burned for crop	proportion/sec
BAF_PEATF	fractional area burned in peatland	proportion/sec
BCDEP	total BC deposition (dry+wet) from atmosphere	kg/m^2/s
BGNPP	belowground NPP	gC/m^2/s
BIOCHEM_PMIN	biochemical rate of P mineralization	gP/m^2/s
BIOCHEM_PMIN_TO_PLANT	plant uptake of biochemical P mineralization	gP/m^2/s
BTRAN	transpiration beta factor	1
BUILDHEAT	heat flux from urban building interior to walls and roof	W/m^2
CH4PROD	Gridcell total production of CH4	gC/m2/s
CH4_SURF_AERE_SAT	aerenchyma surface CH4 flux for inundated area; (+ to atm)	mol/m2/s
CH4_SURF_AERE_UNSAT	aerenchyma surface CH4 flux for non-inundated area; (+ to atm)	mol/m2/s
CH4_SURF_DIFF_SAT	diffusive surface CH4 flux for inundated / lake area; (+ to atm)	mol/m2/s
CH4_SURF_DIFF_UNSAT	diffusive surface CH4 flux for non-inundated area; (+ to atm)	mol/m2/s
CH4_SURF_EBUL_SAT	ebullition surface CH4 flux for inundated / lake area; (+ to atm)	mol/m2/s
CH4_SURF_EBUL_UNSAT	ebullition surface CH4 flux for non-inundated area; (+ to atm)	mol/m2/s
CMASS_BALANCE_ERROR	Gridcell carbon mass balance error	gC/m^2
COL_PTRUNC	column-level sink for P truncation	gP/m^2
CONC_CH4_SAT	CH4 soil Concentration for inundated / lake area	mol/m3

CONC_CH4_UNSAT	CH4 soil Concentration for non-inundated area	mol/m3
CONC_O2_SAT	O2 soil Concentration for inundated / lake area	mol/m3
CONC_O2_UNSAT	O2 soil Concentration for non-inundated area	mol/m3
CPOOL	temporary photosynthate C pool	gC/m^2
CWDC	CWD C	gC/m^2
CWDC_HR	coarse woody debris C heterotrophic respiration	gC/m^2/s
CWDC_LOSS	coarse woody debris C loss	gC/m^2/s
CWDC_TO_LITR2C	decomp. of coarse woody debris C to litter 2 C	gC/m^2/s
CWDC_TO_LITR3C	decomp. of coarse woody debris C to litter 3 C	gC/m^2/s
CWDC_vr	CWD C (vertically resolved)	gC/m^3
CWDN	CWD N	gN/m^2
CWDN_TO_LITR2N	decomp. of coarse woody debris N to litter 2 N	gN/m^2
CWDN_TO_LITR3N	decomp. of coarse woody debris N to litter 3 N	gN/m^2
CWDN_vr	CWD N (vertically resolved)	gN/m^3
CWDP	CWD P	gP/m^2
CWDP_TO_LITR2P	decomp. of coarse woody debris P to litter 2 N	gP/m^2
CWDP_TO_LITR3P	decomp. of coarse woody debris P to litter 3 N	gP/m^2
CWDP_vr	CWD P (vertically resolved)	gP/m^3
DEADCROOTC	dead coarse root C	gC/m^2
DEADCROOTN	dead coarse root N	gN/m^2
DEADCROOTP	dead coarse root P	gP/m^2
DEADSTEMC	dead stem C	gC/m^2
DEADSTEMN	dead stem N	gN/m^2
DEADSTEMP	dead stem P	gP/m^2
DEFICIT	runoff supply deficit	mm/s
DENIT	total rate of denitrification	gN/m^2/s
DESORPTION_P	desorp P flux	gP/m^2/s
DISPVEGC	displayed veg carbon, excluding storage and cpool	gC/m^2
DISPVEGN	displayed vegetation nitrogen	gN/m^2
DISPVEGP	displayed vegetation phosphorus	gP/m^2
DSTDEP	total dust deposition (dry+wet) from atmosphere	kg/m^2/s
DSTFLXT	total surface dust emission	kg/m2/s

DWB	net change in total water mass	mm/s
DWT_CONV_CFLUX_DRIBBLED	conversion C flux (immediate loss to atm), dribbled throughout the year	gC/m^2/s
DWT_CONV_CFLUX_GRC	conversion C flux (immediate loss to atm) (0 at all times except first timestep of year)	gC/m^2/s
DWT_CONV_NFLUX_GRC	conversion C flux (immediate loss to atm) (0 at all times except first timestep of year)	gN/m^2/s
DWT_CONV_PFLUX_GRC	conversion C flux (immediate loss to atm) (0 at all times except first timestep of year)	gP/m^2/s
DWT_SLASH_CFLUX	slash C flux to litter and CWD due to land use	gC/m^2/s
DWT_SLASH_NFLUX	slash N flux to litter and CWD due to land use	gN/m^2/s
DWT_SLASH_PFLUX	slash P flux to litter and CWD due to land use	gP/m^2/s
EFLX_DYNBAL	dynamic land cover change conversion energy flux	W/m^2
EFLX_GRND_LAKE	net heat flux into lake/snow surface, excluding light transmission	W/m^2
EFLX_LH_TOT	total latent heat flux [+ to atm]	W/m^2
EFLX_LH_TOT_R	Rural total evaporation	W/m^2
EFLX_LH_TOT_U	Urban total evaporation	W/m^2
ELAI	exposed one-sided leaf area index	m^2/m^2
ER	total ecosystem respiration, autotrophic + heterotrophic	gC/m^2/s
ERRH2O	total water conservation error	mm
ERRH2OSNO	imbalance in snow depth (liquid water)	mm
ERRSEB	surface energy conservation error	W/m^2
ERRSOI	soil/lake energy conservation error	W/m^2
ERRSOL	solar radiation conservation error	W/m^2
ESAI	exposed one-sided stem area index	m^2/m^2
FAREA_BURNED	timestep fractional area burned	proportion
FCEV	canopy evaporation	W/m^2
FCH4	Gridcell surface CH4 flux to atmosphere (+ to atm)	kgC/m2/s
FCH4TOCO2	Gridcell oxidation of CH4 to CO2	gC/m2/s
FCH4_DFSAT	CH4 additional flux due to changing fsat, vegetated landunits only	kgC/m2/s
FCOV	fractional impermeable area	unitless
FCTR	canopy transpiration	W/m^2
FGEV	ground evaporation	W/m^2
FGR	heat flux into soil/snow including snow melt and lake / snow light transmission	W/m^2
FGR12	heat flux between soil layers 1 and 2	W/m^2

FGR_R	Rural heat flux into soil/snow including snow melt and snow light transmission	W/m^2
FGR_U	Urban heat flux into soil/snow including snow melt	W/m^2
FH2OSFC	fraction of ground covered by surface water	1
FINUNDATED	fractional inundated area of vegetated columns	1
FINUNDATED_LAG	time-lagged inundated fraction of vegetated columns	1
FIRA	net infrared (longwave) radiation	W/m^2
FIRA_R	Rural net infrared (longwave) radiation	W/m^2
FIRA_U	Urban net infrared (longwave) radiation	W/m^2
FIRE	emitted infrared (longwave) radiation	W/m^2
FIRE_R	Rural emitted infrared (longwave) radiation	W/m^2
FIRE_U	Urban emitted infrared (longwave) radiation	W/m^2
FLDS	atmospheric longwave radiation	W/m^2
FPG	fraction of potential gpp due to N limitation	proportion
FPG_P	fraction of potential gpp due to P limitation	proportion
FPI	fraction of potential immobilization of nitrogen	proportion
FPI_P	fraction of potential immobilization of phosphorus	proportion
FPI_P_vr	fraction of potential immobilization of phosphorus	proportion
FPI_vr	fraction of potential immobilization of nitrogen	proportion
FPSN	photosynthesis	umol/m2s
FPSN_WC	Rubisco-limited photosynthesis	umol/m2s
FPSN_WJ	RuBP-limited photosynthesis	umol/m2s
FPSN_WP	Product-limited photosynthesis	umol/m2s
FROOTC	fine root C	gC/m^2
FROOTC_ALLOC	fine root C allocation	gC/m^2/s
FROOTC_LOSS	fine root C loss	gC/m^2/s
FROOTN	fine root N	gN/m^2
FROOTP	fine root P	gP/m^2
FROST_TABLE	frost table depth (vegetated landunits only)	m
FSA	absorbed solar radiation	W/m^2
FSAT	fractional area with water table at surface	unitless
FSA_R	Rural absorbed solar radiation	W/m^2
FSA_U	Urban absorbed solar radiation	W/m^2
FSDS	atmospheric incident solar radiation	W/m^2
FSDSND	direct nir incident solar radiation	W/m^2

FSDSNDLN	direct nir incident solar radiation at local noon	W/m^2
FSDSNI	diffuse nir incident solar radiation	W/m^2
FSDSVD	direct vis incident solar radiation	W/m^2
FSDSVDLN	direct vis incident solar radiation at local noon	W/m^2
FSDSVI	diffuse vis incident solar radiation	W/m^2
FSDSVILN	diffuse vis incident solar radiation at local noon	W/m^2
FSH	sensible heat	W/m^2
FSH_G	sensible heat from ground	W/m^2
FSH_NODYNLNDUSE	sensible heat not including correction for land use change	W/m^2
FSH_R	Rural sensible heat	W/m^2
FSH_U	Urban sensible heat	W/m^2
FSH_V	sensible heat from veg	W/m^2
FSM	snow melt heat flux	W/m^2
FSM_R	Rural snow melt heat flux	W/m^2
FSM_U	Urban snow melt heat flux	W/m^2
FSNO	fraction of ground covered by snow	1
FSNO_EFF	effective fraction of ground covered by snow	1
FSR	reflected solar radiation	W/m^2
FSRND	direct nir reflected solar radiation	W/m^2
FSRNDLN	direct nir reflected solar radiation at local noon	W/m^2
FSRNI	diffuse nir reflected solar radiation	W/m^2
FSRVD	direct vis reflected solar radiation	W/m^2
FSRVDLN	direct vis reflected solar radiation at local noon	W/m^2
FSRVI	diffuse vis reflected solar radiation	W/m^2
F_CO2_SOIL	total soil-atm. CO2 exchange	gC/m^2/s
F_CO2_SOIL_vr	total vertically resolved soil-atm. CO2 exchange	gC/m^3/s
F_DENIT	denitrification flux	gN/m^2/s
F_DENIT_vr	denitrification flux	gN/m^3/s
F_N2O_DENIT	denitrification N2O flux	gN/m^2/s
F_N2O_NIT	nitrification N2O flux	gN/m^2/s
F_NIT	nitrification flux	gN/m^2/s
F_NIT_vr	nitrification flux	gN/m^3/s
GC_HEAT1	initial gridcell total heat content	J/m^2
GC_ICE1	initial gridcell total ice content	mm
GC_LIQ1	initial gridcell total liq content	mm

GPP	gross primary production	gC/m^2/s
GR	total growth respiration	gC/m^2/s
GROSS_NMIN	gross rate of N mineralization	gN/m^2/s
GROSS_PMIN	gross rate of P mineralization	gP/m^2/s
H2OCAN	intercepted water	mm
H2OSFC	surface water depth	mm
H2OSNO	snow depth (liquid water)	mm
H2OSNO_TOP	mass of snow in top snow layer	kg/m2
H2OSOI	volumetric soil water (vegetated landunits only)	mm3/mm3
H2O_MOSS_WC	Relative water content of Moss	proportion
HC	heat content of soil/snow/lake	MJ/m2
HCSOI	soil heat content	MJ/m2
HEAT_FROM_AC	sensible heat flux put into canyon due to heat removed from air conditioning	W/m^2
HR	total heterotrophic respiration	gC/m^2/s
HR_vr	total vertically resolved heterotrophic respiration	gC/m^3/s
HTOP	canopy top	m
INT_SNOW	accumulated swe (vegetated landunits only)	mm
LABILEP	soil Labile P	gP/m^2
LABILEP_TO_SECONDP	LABILE P TO SECONDARY MINERAL P	gP/m^2/s
LABILEP_vr	soil labile P (vert. res.)	gp/m^3
LAISHA	shaded projected leaf area index	1
LAISUN	sunlit projected leaf area index	1
LAKEICEFRAC	lake layer ice mass fraction	unitless
LAKEICETHICK	thickness of lake ice (including physical expansion on freezing)	m
LAND_UPTAKE	NEE minus LAND_USE_FLUX, negative for update	gC/m^2/s
LAND_USE_FLUX	total C emitted from land cover conversion and wood product pools	gC/m^2/s
LEAFC	leaf C	gC/m^2
LEAFC_ALLOC	leaf C allocation	gC/m^2/s
LEAFC_LOSS	leaf C loss	gC/m^2/s
LEAFC_TO_LITTER	leaf C litterfall	gC/m^2/s
LEAFN	leaf N	gN/m^2
LEAFP	leaf P	gP/m^2
LEAF_MR	leaf maintenance respiration	gC/m^2/s

LFC2	conversion area fraction of BET and BDT that burned	per sec
LITFALL	litterfall (leaves and fine roots)	gC/m^2/s
LITHR	litter heterotrophic respiration	gC/m^2/s
LITR1C	LITR1 C	gC/m^2
LITR1C_TO_SOIL1C	decomp. of litter 1 C to soil 1 C	gC/m^2/s
LITR1C_vr	LITR1 C (vertically resolved)	gC/m^3
LITR1N	LITR1 N	gN/m^2
LITR1N_TNDNCY_VERT_TRANS	litter 1 N tendency due to vertical transport	gN/m^3/s
LITR1N_TO_SOIL1N	decomp. of litter 1 N to soil 1 N	gN/m^2
LITR1N_vr	LITR1 N (vertically resolved)	gN/m^3
LITR1P	LITR1 P	gP/m^2
LITR1P_TNDNCY_VERT_TRANS	litter 1 P tendency due to vertical transport	gP/m^3/s
LITR1P_TO_SOIL1P	decomp. of litter 1 P to soil 1 N	gP/m^2
LITR1P_vr	LITR1 P (vertically resolved)	gP/m^3
LITR1_HR	Het. Resp. from litter 1	gC/m^2/s
LITR2C	LITR2 C	gC/m^2
LITR2C_TO_SOIL2C	decomp. of litter 2 C to soil 2 C	gC/m^2/s
LITR2C_vr	LITR2 C (vertically resolved)	gC/m^3
LITR2N	LITR2 N	gN/m^2
LITR2N_TNDNCY_VERT_TRANS	litter 2 N tendency due to vertical transport	gN/m^3/s
LITR2N_TO_SOIL2N	decomp. of litter 2 N to soil 2 N	gN/m^2
LITR2N_vr	LITR2 N (vertically resolved)	gN/m^3
LITR2P	LITR2 P	gP/m^2
LITR2P_TNDNCY_VERT_TRANS	litter 2 P tendency due to vertical transport	gP/m^3/s
LITR2P_TO_SOIL2P	decomp. of litter 2 P to soil 2 N	gP/m^2
LITR2P_vr	LITR2 P (vertically resolved)	gP/m^3
LITR2_HR	Het. Resp. from litter 2	gC/m^2/s
LITR3C	LITR3 C	gC/m^2
LITR3C_TO_SOIL3C	decomp. of litter 3 C to soil 3 C	gC/m^2/s
LITR3C_vr	LITR3 C (vertically resolved)	gC/m^3
LITR3N	LITR3 N	gN/m^2
LITR3N_TNDNCY_VERT_TRANS	litter 3 N tendency due to vertical transport	gN/m^3/s
LITR3N_TO_SOIL3N	decomp. of litter 3 N to soil 3 N	gN/m^2
LITR3N_vr	LITR3 N (vertically resolved)	gN/m^3

LITR3P	LITR3 P	gP/m^2
LITR3P_TNDNCY_VERT_TRANS	litter 3 P tendency due to vertical transport	gP/m^3/s
LITR3P_TO_SOIL3P	decomp. of litter 3 P to soil 3 N	gP/m^2
LITR3P_vr	LITR3 P (vertically resolved)	gP/m^3
LITR3_HR	Het. Resp. from litter 3	gC/m^2/s
LITTERC	litter C	gC/m^2
LITTERC_HR	litter C heterotrophic respiration	gC/m^2/s
LITTERC_LOSS	litter C loss	gC/m^2/s
LIVECROOTC	live coarse root C	gC/m^2
LIVECROOTN	live coarse root N	gN/m^2
LIVECROOTP	live coarse root P	gP/m^2
LIVESTEMC	live stem C	gC/m^2
LIVESTEMN	live stem N	gN/m^2
LIVESTEMP	live stem P	gP/m^2
MR	maintenance respiration	gC/m^2/s
M_LITR1C_TO_LEACHING	litter 1 C leaching loss	gC/m^2/s
M_LITR2C_TO_LEACHING	litter 2 C leaching loss	gC/m^2/s
M_LITR3C_TO_LEACHING	litter 3 C leaching loss	gC/m^2/s
M_SOIL1C_TO_LEACHING	soil 1 C leaching loss	gC/m^2/s
M_SOIL2C_TO_LEACHING	soil 2 C leaching loss	gC/m^2/s
M_SOIL3C_TO_LEACHING	soil 3 C leaching loss	gC/m^2/s
M_SOIL4C_TO_LEACHING	soil 4 C leaching loss	gC/m^2/s
NBP	net biome production, includes fire, landuse, and harvest flux, positive for sink	gC/m^2/s
NDEPLOY	total N deployed in new growth	gN/m^2/s
NDEP_TO_SMINN	atmospheric N deposition to soil mineral N	gN/m^2/s
NEE	net ecosystem exchange of carbon, includes fire, landuse, harvest, and hrv_xsmrpool flux, positive for source	gC/m^2/s
NEM	Gridcell net adjustment to NEE passed to atm. for methane production	gC/m2/s
NEP	net ecosystem production, excludes fire, landuse, and harvest flux, positive for sink	gC/m^2/s
NET_NMIN	net rate of N mineralization	gN/m^2/s
NET_PMIN	net rate of P mineralization	gP/m^2/s
NFIRE	fire counts valid only in Reg.C	counts/km2/sec
NFIX_TO_SMINN	symbiotic/asymbiotic N fixation to soil mineral N	gN/m^2/s
NPP	net primary production	gC/m^2/s

OCCLP	soil occluded P	gP/m^2
OCCLP_vr	soil occluded P (vert. res.)	gp/m^3
OCDEP	total OC deposition (dry+wet) from atmosphere	kg/m^2/s
O_SCALAR	fraction by which decomposition is reduced due to anoxia	1
PARVEGLN	absorbed par by vegetation at local noon	W/m^2
PBOT	atmospheric pressure	Pa
PCH4	atmospheric partial pressure of CH4	Pa
PCO2	atmospheric partial pressure of CO2	Pa
PCT_LANDUNIT	% of each landunit on topounit	%
PCT_NAT_PFT	% of each PFT on the natural vegetation (i.e., soil) landunit	%
PDEPLOY	total P deployed in new growth	gP/m^2/s
PDEP_TO_SMINP	atmospheric P deposition to soil mineral P	gP/m^2/s
PFT_FIRE_CLOSS	total patch-level fire C loss for non-peat fires outside land-type converted region	gC/m^2/s
PFT_FIRE_NLOSS	total pft-level fire N loss	gN/m^2/s
PLANT_CALLOC	total allocated C flux	gC/m^2/s
PLANT_NDEMAND	N flux required to support initial GPP	gN/m^2/s
PLANT_NDEMAND_COL	N flux required to support initial GPP	gN/m^2/s
PLANT_PALLOC	total allocated P flux	gP/m^2/s
PLANT_PDEMAND	P flux required to support initial GPP	gP/m^2/s
PLANT_PDEMAND_COL	P flux required to support initial GPP	gN/m^2/s
POTENTIAL_IMMOB	potential N immobilization	gN/m^2/s
POTENTIAL_IMMOB_P	potential P immobilization	gP/m^2/s
POT_F_DENIT	potential denitrification flux	gN/m^2/s
POT_F_NIT	potential nitrification flux	gN/m^2/s
PRIMP	soil primary P	gP/m^2
PRIMP_TO_LABILEP	PRIMARY MINERAL P TO LABILE P	gP/m^2/s
PRIMP_vr	soil primary P (vert. res.)	gp/m^3
PROD1P_LOSS	loss from 1-yr crop product pool	gP/m^2/s
PSNSHA	shaded leaf photosynthesis	umolCO2/m^2/s
PSNSHADE_TO_CPOOL	C fixation from shaded canopy	gC/m^2/s
PSNSUN	sunlit leaf photosynthesis	umolCO2/m^2/s
PSNSUN_TO_CPOOL	C fixation from sunlit canopy	gC/m^2/s
Q2M	2m specific humidity	kg/kg
QBOT	atmospheric specific humidity	kg/kg
QCHARGE	aquifer recharge rate (vegetated landunits only)	mm/s

QDRAI	sub-surface drainage	mm/s
QDRAI_PERCH	perched wt drainage	mm/s
QDRAI_XS	saturation excess drainage	mm/s
QDRIP	throughfall	mm/s
QFLOOD	runoff from river flooding	mm/s
QFLX_ADV	Vertical flow across soil layers	mm/s
QFLX_ICE_DYNBAL	ice dynamic land cover change conversion runoff flux	mm/s
QFLX_LIQ_DYNBAL	liq dynamic land cover change conversion runoff flux	mm/s
QH2OSFC	surface water runoff	mm/s
QINFL	infiltration	mm/s
QINTR	interception	mm/s
QIRRIG_GRND	Groundwater irrigation	mm/s
QIRRIG_ORIG	Original total irrigation water demand (surface + ground)	mm/s
QIRRIG_REAL	actual water added through irrigation (surface + ground)	mm/s
QIRRIG_SURF	Surface water irrigation	mm/s
QIRRIG_WM	Surface water irrigation demand sent to MOSART/WM	mm/s
QOVER	surface runoff	mm/s
QOVER_LAG	time-lagged surface runoff for soil columns	mm/s
QRGWL	surface runoff at glaciers (liquid only), wetlands, lakes	mm/s
QRUNOFF	total liquid runoff (does not include QSNWCPICE)	mm/s
QRUNOFF_NODYNLNDUSE	total liquid runoff (does not include QSNWCPICE) not including correction for land use change	mm/s
QRUNOFF_R	Rural total runoff	mm/s
QRUNOFF_U	Urban total runoff	mm/s
QSNOMELT	snow melt	mm/s
QSNWCPICE	excess snowfall due to snow capping	mm/s
QSNWCPICE_NODYNLNDUSE	excess snowfall due to snow capping not including correction for land use change	mm H2O/s
QSOIL	Ground evaporation (soil/snow evaporation + soil/snow sublimation - dew)	mm/s
QVEGE	canopy evaporation	mm/s
QVEGT	canopy transpiration	mm/s
RAIN	atmospheric rain	mm/s

RETRANSN	plant pool of retranslocated N	gN/m^2
RETRANSN_TO_NPOOL	deployment of retranslocated N	gN/m^2/s
RETRANSP	plant pool of retranslocated P	gP/m^2
RETRANSP_TO_PPOOL	deployment of retranslocated P	gP/m^2/s
RH2M	2m relative humidity	%
RH2M_R	Rural 2m specific humidity	%
RH2M_U	Urban 2m relative humidity	%
RR	root respiration (fine root MR + total root GR)	gC/m^2/s
SABG	solar rad absorbed by ground	W/m^2
SABG_PEN	Rural solar rad penetrating top soil or snow layer	watt/m^2
SABV	solar rad absorbed by veg	W/m^2
SCALARAVG_vr	average of decomposition scalar	fraction
SECONDP	soil secondary P	gP/m^2
SECONDP_TO_LABILEP	SECONDARY MINERAL P TO LABILE P	gP/m^2/s
SECONDP_TO_OCCLP	SECONDARY MINERAL P TO OCCLUDED P	gP/m^2/s
SECONDP_vr	soil secondary P (vert. res.)	gp/m^3
SEEDC_GRC	pool for seeding new PFTs via dynamic landcover	gC/m^2
SMINN	soil mineral N	gN/m^2
SMINN_TO_NPOOL	deployment of soil mineral N uptake	gN/m^2/s
SMINN_TO_PLANT	plant uptake of soil mineral N	gN/m^2/s
SMINN_TO_SOIL1N_L1	mineral N flux for decomp. of LITR1to SOIL1	gN/m^2
SMINN_TO_SOIL2N_L2	mineral N flux for decomp. of LITR2to SOIL2	gN/m^2
SMINN_TO_SOIL2N_S1	mineral N flux for decomp. of SOIL1to SOIL2	gN/m^2
SMINN_TO_SOIL3N_L3	mineral N flux for decomp. of LITR3to SOIL3	gN/m^2
SMINN_TO_SOIL3N_S2	mineral N flux for decomp. of SOIL2to SOIL3	gN/m^2
SMINN_TO_SOIL4N_S3	mineral N flux for decomp. of SOIL3to SOIL4	gN/m^2
SMINP	soil mineral P	gP/m^2
SMINP_LEACHED	soil mineral P pool loss to leaching	gP/m^2/s
SMINP_TO_PLANT	plant uptake of soil mineral P	gP/m^2/s
SMINP_TO_PPOOL	deployment of soil mineral P uptake	gP/m^2/s
SMINP_TO_SOIL1P_L1	mineral P flux for decomp. of LITR1to SOIL1	gP/m^2
SMINP_TO_SOIL2P_L2	mineral P flux for decomp. of LITR2to SOIL2	gP/m^2
SMINP_TO_SOIL2P_S1	mineral P flux for decomp. of SOIL1to SOIL2	gP/m^2
SMINP_TO_SOIL3P_L3	mineral P flux for decomp. of LITR3to SOIL3	gP/m^2
SMINP_TO_SOIL3P_S2	mineral P flux for decomp. of SOIL2to SOIL3	gP/m^2
SMINP_TO_SOIL4P_S3	mineral P flux for decomp. of SOIL3to SOIL4	gP/m^2
SMINP_vr	soil mineral P (vert. res.)	gp/m^3

SMIN_NH4	soil mineral NH4	gN/m^2
SMIN_NH4_vr	soil mineral NH4 (vert. res.)	gN/m^3
SMIN_NO3	soil mineral NO3	gN/m^2
SMIN_NO3_LEACHED	soil NO3 pool loss to leaching	gN/m^2/s
SMIN_NO3_RUNOFF	soil NO3 pool loss to runoff	gN/m^2/s
SMIN_NO3_vr	soil mineral NO3 (vert. res.)	gN/m^3
SNOBCMCL	mass of BC in snow column	kg/m2
SNOBCMSL	mass of BC in top snow layer	kg/m2
SNODSTMCL	mass of dust in snow column	kg/m2
SNODSTMSL	mass of dust in top snow layer	kg/m2
SNOINTABS	Percent of incoming solar absorbed by lower snow layers	%
SNOOCMCL	mass of OC in snow column	kg/m2
SNOOCMSL	mass of OC in top snow layer	kg/m2
SNOW	atmospheric snow	mm/s
SNOWDP	gridcell mean snow height	m
SNOWICE	snow ice	kg/m2
SNOWLIQ	snow liquid water	kg/m2
SNOW_DEPTH	snow height of snow covered area	m
SNOW_SINKS	snow sinks (liquid water)	mm/s
SNOW_SOURCES	snow sources (liquid water)	mm/s
SOIL1C	SOIL1 C	gC/m^2
SOIL1C_TO_SOIL2C	decomp. of soil 1 C to soil 2 C	gC/m^2/s
SOIL1C_vr	SOIL1 C (vertically resolved)	gC/m^3
SOIL1N	SOIL1 N	gN/m^2
SOIL1N_TNDNCY_VERT_TRANS	soil 1 N tendency due to vertical transport	gN/m^3/s
SOIL1N_TO_SOIL2N	decomp. of soil 1 N to soil 2 N	gN/m^2
SOIL1N_vr	SOIL1 N (vertically resolved)	gN/m^3
SOIL1P	SOIL1 P	gP/m^2
SOIL1P_TNDNCY_VERT_TRANS	soil 1 P tendency due to vertical transport	gP/m^3/s
SOIL1P_TO_SOIL2P	decomp. of soil 1 P to soil 2 N	gP/m^2
SOIL1P_vr	SOIL1 P (vertically resolved)	gP/m^3
SOIL1_HR	Het. Resp. from soil 1	gC/m^2/s
SOIL2C	SOIL2 C	gC/m^2
SOIL2C_TO_SOIL3C	decomp. of soil 2 C to soil 3 C	gC/m^2/s
SOIL2C_vr	SOIL2 C (vertically resolved)	gC/m^3
SOIL2N	SOIL2 N	gN/m^2

SOIL2N_TNDNCY_VERT_TRANS	soil 2 N tendency due to vertical transport	gN/m^3/s
SOIL2N_TO_SOIL3N	decomp. of soil 2 N to soil 3 N	gN/m^2
SOIL2N_vr	SOIL2 N (vertically resolved)	gN/m^3
SOIL2P	SOIL2 P	gP/m^2
SOIL2P_TNDNCY_VERT_TRANS	soil 2 P tendency due to vertical transport	gP/m^3/s
SOIL2P_TO_SOIL3P	decomp. of soil 2 P to soil 3 N	gP/m^2
SOIL2P_vr	SOIL2 P (vertically resolved)	gP/m^3
SOIL2_HR	Het. Resp. from soil 2	gC/m^2/s
SOIL3C	SOIL3 C	gC/m^2
SOIL3C_TO_SOIL4C	decomp. of soil 3 C to soil 4 C	gC/m^2/s
SOIL3C_vr	SOIL3 C (vertically resolved)	gC/m^3
SOIL3N	SOIL3 N	gN/m^2
SOIL3N_TNDNCY_VERT_TRANS	soil 3 N tendency due to vertical transport	gN/m^3/s
SOIL3N_TO_SOIL4N	decomp. of soil 3 N to soil 4 N	gN/m^2
SOIL3N_vr	SOIL3 N (vertically resolved)	gN/m^3
SOIL3P	SOIL3 P	gP/m^2
SOIL3P_TNDNCY_VERT_TRANS	soil 3 P tendency due to vertical transport	gP/m^3/s
SOIL3P_TO_SOIL4P	decomp. of soil 3 P to soil 4 N	gP/m^2
SOIL3P_vr	SOIL3 P (vertically resolved)	gP/m^3
SOIL3_HR	Het. Resp. from soil 3	gC/m^2/s
SOIL4C	SOIL4 C	gC/m^2
SOIL4C_vr	SOIL4 C (vertically resolved)	gC/m^3
SOIL4N	SOIL4 N	gN/m^2
SOIL4N_TNDNCY_VERT_TRANS	soil 4 N tendency due to vertical transport	gN/m^3/s
SOIL4N_TO_SMINN	mineral N flux for decomp. of SOIL4	gN/m^2
SOIL4N_vr	SOIL4 N (vertically resolved)	gN/m^3
SOIL4P	SOIL4 P	gP/m^2
SOIL4P_TNDNCY_VERT_TRANS	soil 4 P tendency due to vertical transport	gP/m^3/s
SOIL4P_TO_SMINP	mineral P flux for decomp. of SOIL4	gP/m^2
SOIL4P_vr	SOIL4 P (vertically resolved)	gP/m^3
SOIL4_HR	Het. Resp. from soil 4	gC/m^2/s
SOILC	soil C	gC/m^2
SOILC_HR	soil C heterotrophic respiration	gC/m^2/s
SOILC_LOSS	soil C loss	gC/m^2/s

SOILICE	soil ice (vegetated landunits only)	kg/m2
SOILICE_ICE	soil ice (ice landunits only)	kg/m2
SOILLIQ	soil liquid water (vegetated landunits only)	kg/m2
SOILLIQ_ICE	soil liquid water (ice landunits only)	kg/m2
SOILPSI	soil water potential in each soil layer	MPa
SOILWATER_10CM	soil liquid water + ice in top 10cm of soil (veg landunits only)	kg/m2
SOLUTIONP	soil solution P	gP/m^2
SOLUTIONP_vr	soil solution P (vert. res.)	gp/m^3
SOMHR	soil organic matter heterotrophic respiration	gC/m^2/s
SOM_C_LEACHED	total flux of C from SOM pools due to leaching	gC/m^2/s
SR	total soil respiration (HR + root resp)	gC/m^2/s
STORVEGC	stored vegetation carbon, excluding cpool	gC/m^2
STORVEGN	stored vegetation nitrogen	gN/m^2
STORVEGP	stored vegetation phosphorus	gP/m^2
SUPPLEMENT_TO_SMINN	supplemental N supply	gN/m^2/s
SUPPLEMENT_TO_SMINP	supplemental P supply	gP/m^2/s
SUPPLY	runoff supply for land use	mm/s
SoilAlpha	factor limiting ground evap	1
SoilAlpha_U	urban factor limiting ground evap	1
TAUX	zonal surface stress	kg/m/s^2
TAUY	meridional surface stress	kg/m/s^2
TBOT	atmospheric air temperature	K
TBUILD	internal urban building temperature	K
TCS_MONTH_BEGIN	total carbon storage at the beginning of a month	mm
TCS_MONTH_END	total carbon storage at the end of a month	mm
TG	ground temperature	K
TG_R	Rural ground temperature	K
TG_U	Urban ground temperature	K
TH2OSFC	surface water temperature	K
THBOT	atmospheric air potential temperature	K
TKE1	top lake level eddy thermal conductivity	W/(mK)
TLAI	total projected leaf area index	1
TLAKE	lake temperature	K
TOTCOLC	total column carbon, incl veg and cpool but excl product pools	gC/m^2
TOTCOLCH4	total belowground CH4, (0 for non-lake special landunits)	gC/m2
TOTCOLN	total column-level N but excl product pools	gN/m^2

TOTCOLP	total column-level P but excl product pools	gP/m^2
TOTECOSYSC	total ecosystem carbon, incl veg but excl cpool but excl product pools	gC/m^2
TOTECOSYSN	total ecosystem N but excl product pools	gN/m^2
TOTECOSYSP	total ecosystem P but excl product pools	gP/m^2
TOTLITC	total litter carbon	gC/m^2
TOTLITC_1m	total litter carbon to 1 meter depth	gC/m^2
TOTLITN	total litter N	gN/m^2
TOTLITP	total litter P	gP/m^2
TOTLITP_1m	total litter P to 1 meter	gP/m^2
TOTPFTC	total patch-level carbon, including cpool	gC/m^2
TOTPFTN	total PFT-level nitrogen	gN/m^2
TOTPFTP	total PFT-level phosphorus	gP/m^2
TOTSOMC	total soil organic matter carbon	gC/m^2
TOTSOMC_1m	total soil organic matter carbon to 1 meter depth	gC/m^2
TOTSOMN	total soil organic matter N	gN/m^2
TOTSOMP	total soil organic matter P	gP/m^2
TOTSOMP_1m	total soil organic matter P to 1 meter	gP/m^2
TOTVEGC	total vegetation carbon, excluding cpool	gC/m^2
TOTVEGC_ABG	total aboveground vegetation carbon, excluding cpool	gC/m^2
TOTVEGN	total vegetation nitrogen	gN/m^2
TOTVEGP	total vegetation phosphorus	gP/m^2
TREFMNAV	daily minimum of average 2-m temperature	K
TREFMNAV_R	Rural daily minimum of average 2-m temperature	K
TREFMNAV_U	Urban daily minimum of average 2-m temperature	K
TREFMXAV	daily maximum of average 2-m temperature	K
TREFMXAV_R	Rural daily maximum of average 2-m temperature	K
TREFMXAV_U	Urban daily maximum of average 2-m temperature	K
TSA	2m air temperature	K
TSAI	total projected stem area index	1
TSA_R	Rural 2m air temperature	K
TSA_U	Urban 2m air temperature	K
TSOI	soil temperature (vegetated landunits only)	K
TSOI_10CM	soil temperature in top 10cm of soil	K

TSOI_ICE	soil temperature (ice landunits only)	K
TV	vegetation temperature	K
TWS	total water storage	mm
TWS_MONTH_BEGIN	total water storage at the beginning of a month	mm
TWS_MONTH_END	total water storage at the end of a month	mm
T_SCALAR	temperature inhibition of decomposition	1
U10	10-m wind	m/s
URBAN_AC	urban air conditioning flux	W/m^2
URBAN_HEAT	urban heating flux	W/m^2
VCMAX25TOP	vcmax at top canopy at 25oC	umolCO2/m^2/s
VOLR	river channel total water storage	m3
VOLRMCH	river channel main channel water storage	m3
WA	water in the unconfined aquifer (vegetated landunits only)	mm
WASTEHEAT	sensible heat flux from heating/cooling sources of urban waste heat	W/m^2
WF	soil water as frac. of whc for top 0.05 m	proportion
WIND	atmospheric wind velocity magnitude	m/s
WOODC	wood C	gC/m^2
WOODC_ALLOC	wood C eallocation	gC/m^2/s
WOODC_LOSS	wood C loss	gC/m^2/s
WOOD_HARVESTC	wood harvest carbon (to product pools)	gC/m^2/s
WOOD_HARVESTN	wood harvest N (to product pools)	gN/m^2/s
WTGQ	surface tracer conductance	m/s
W_SCALAR	Moisture (dryness) inhibition of decomposition	1
XR	total excess respiration	gC/m^2/s
XSMRPOOL	temporary photosynthate C pool	gC/m^2
ZBOT	atmospheric reference height	m
ZWT	water table depth (vegetated landunits only)	m
ZWT_CH4_UNSAT	depth of water table for methane production used in non-inundated area	m
ZWT_PERCH	perched water table depth (vegetated landunits only)	m
cn_scalar	N limitation factor	
cp_scalar	P limitation factor	
leaf_npimbalance	leaf np imbalance partial C partial P/partial C partial N	gN/gP
nlim_m	runmean N limitation factor	
o2_decomp_depth_unsat	o2_decomp_depth_unsat	mol/m3/2

plim_m	runmean P limitation factor	
water_scalar	water limitation factor for plant dynamic allocation	
wlim_m	runmean water limitation factor for plant dynamic allocation	