THESIS CLM5 Land Use Data Tool

This tool is used to generate the transient land use and land cover change data used in transient CLM5 simulations with CESM2. The tool has been built to read historical or future scenarios of land use and land cover change data in the annual time series format compiled for the CMIP6 Land Use and Scenario Model Intercomparison Projects (LUMIP and ScenarioMIP), *(Lawrence, Hurtt et al. 2016),* shown in *figure 1*. The tool can be used over a range of spatial extents from global down to a predefined region, and over a range of grid resolutions as defined in the region files. The tool takes time series data following the Global Land Model (GLM) 12 land units that represent dynamics of agriculture and forests. The land units include:

- Primary Forest - Primary Non Forest
- Secondary Forest - Secondary Non Forest
- Crop C3 Annual - Crop C3 Perennial
- Crop C3 Nitrogen Fixing - Crop C4 Annual
- Crop C4 Perennial - Grazing Pasture
- Grazing Rangeland - Urban

The land use data also provides management information for crops and forests through transient nitrogen fertilizer and irrigation fraction, and through wood harvest in terms of carbon biomass removal.

New Resolution
0.25° grid-cell fraction

New History
Hyde 3.2, FAO based
Landsat F/NF
Multiple crop types (5)
Multiple pasture types (2)
Updated Forest Cover/Biomass
Updated Wood harvest
Updated Shifting Cultivation
Extended time domain (850-2015)

New Management Layers
Agriculture
Fraction of cropland irrigated
Fraction of cropland flooded
Fraction of cropland fertilized (industrial)
Industrial Fertilizer application rates
Fraction of cropland for biofuels
Crop rotations
Wood Harvest
Fraction used for industrial products
Fraction used for commercial biofuels
Fraction used for fuelwood

New Future Scenarios
Six futures, SSP-based
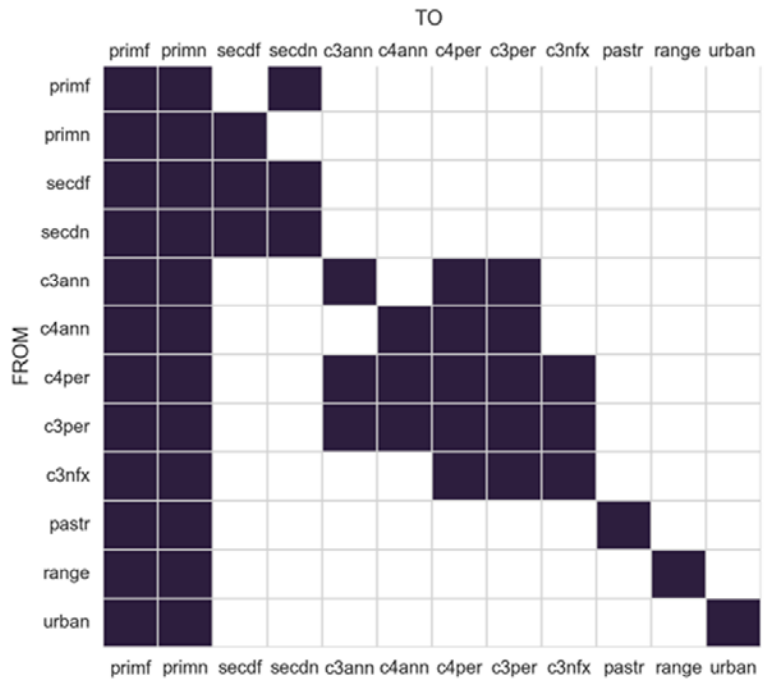

New Transition Matrix

Figure 1. CMIP6 LUMIP Land Use Harmonization (LUH2) overview.

The CLM5 land use data tool generates annual raw CLM5 land use and land cover data from the GLM land unit states and transitions files combined with CLM5 PFT and CFT specific descriptions of current day forest, pasture, crop and other land units. The current day descriptions are taken from 1km resolution MODIS, MIRCA 2000, ICESAT, AVHRR, SRTM, and CRU data products combined with the GLM year 2005 distributions of those land units. Where land units are not represented in the current day the CLM5 descriptions have been spatially extrapolated from their nearest grid cells using a distance weighted algorithm.

The tool takes a single namelist file as a command line option that specifies the location and names of all input and output data. It is recommended that the namelist file is kept in the output directory to record all of the input data used for generating the data in that directory.

The namelist file specifies the region and grid cell resolution in the file specified by regionfilename. The region file specifies the lower left and upper right coordinates of the domain as well as the grid cell resolution in decimal degrees. The namelist file also specifies the years to be processed along with the output location of the annual time series files and the series name used to generate each individual file.

The input data files used by the tool are divided into the GLM time series files:

refstatesdb :	reference state file usually the historical for the year 2005
luhstatesdb :	scenario state file (historical or future)
luhmanagedb:	scenario management file (n fertilizer and irrigation)
luhtransitions:	scenario transitions and wood harvest.

And the CLM PFT and CFT description files:

clmcurrentsurfdb:	climatology description of PFTs and CFTs for the reference year
clmLUHforestdb:	description of PFTs in the forest land units
clmLUHpasturedb:	description of PFTs in the pasture land units
clmLUHotherdb:	description of PFTs in the non-forest and rangeland land units
clmLUHc3anndb:	description of CFTs in C3 annual crop land units
clmLUHc4anndb:	description of CFTs in C4 annual crop land units
clmLUHc3perdb:	description of CFTs in C3 perennial crop land units
clmLUHc4perdb:	description of CFTs in C4 perennial crop land units
clmLUHc3nfxdb:	description of CFTs in C3 nitrogen fixing crop land units

Additionally there are lookup tables defined to map from the GLM time series land units to the CLM5 PFTs and CFTs. The tool also has options to latitude flip the GLM time series files to make them consistent with the CLM description files and the CLM5 land use output data. For regional domains where CLM5 mapping files do not prescribe an ocean mask, grid cells that fall within the ocean area can be filled with lakes.

To use the land use time series data generated by the tool with CLM5 the data must be processed by mksurfdata_map tool located in the tools directory of the CESM2 model. The mksurfdata_map tool uses two name list files to generate the surface data file and the land use time series file.

Reference

Lawrence, D. M., G. C. Hurtt, A. Arneth, V. Brovkin, K. V. Calvin, A. D. Jones, C. D. Jones, P. J. Lawrence, N. de Noblet-Ducoudre, J. Pongratz, S. I. Seneviratne and E. Shevliakova (2016). "The Land Use Model Intercomparison Project (LUMIP): Rationale and experimental design." Geoscientific Model Development **9**: doi:10.5194/gmd-9-2973-2016.