LANDIS-II

Climate Library v1

User Guide

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# Introduction

This document describes the climate library for the LANDIS-II model. For information about the LANDIS-II model and its core concepts including succession, see the *LANDIS‑II Conceptual Model Description.*

The role of the climate library is to create a central repository of climate data so that all the model extensions will ‘feed’ off of the same stream of climate.

The library can directly utilize daily or monthly climate data available from PRISM (baseline or historic climate data) and the USGS Geo Data Portal (climate change data). The output data will be aggregated to the ecoregion level, the fundamental climate unit of LANDIS-II and then delivered to LANDIS-II as either monthly or daily for the requested time period in a common format (comma delimited with a header). These data will be read into a new climate library (a sharable body of code) that will perform all necessary pre-processing for all climate-dependent LANDIS-II extensions.

Each extension requires slightly different climate data inputs; the succession extension will serve as the nominal controller of the climate library (activating it with necessary input file(s)). Such deep integration across ecological processes (extensions) allows LANDIS-II to respond to climate in a coordinated fashion at each model time step and allows climate variability to produce realistic emergent properties of species composition, disturbance regimes, and ecosystem dynamics (e.g., carbon cycling). This integration will also facilitate rapid deployment and will minimize the pre-processing overhead typical of many landscape models.

## Interface between Succession and Climate Library

The Climate Library was designed to be used with any succession extension. The information below uses the Century Succession extension as an illustrative example. Century Succession is also the only succession extension for which the Climate Library has been integrated as of March 2014.

***Note: The Climate Library must be initiated from within a succession extension. The Climate Library will not work with other extension, e.g., MultiRegimeFire, if the succession extension operating does not initialize the Climate Library, as below.***

With the Climate Library, the user specifies an intermediate text file that then refers to all the climate data. It is similar to the scenario file in that it is the master climate file that specifies which options and which files to use. In the example below, the keyword ClimateConfigFile refers to a file called “climate-generator-CC.txt”. The file “climate-generator-CC.txt” is the climate configuration file for the climate library.



## Acknowledgments

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# Climate Library Configuration File

The text in the climate configuration file must comply with the general format requirements described in section 3.1 *Text Input Files* in the *LANDIS‑II Model User Guide*.

## LandisData

This parameter’s value must be "Climate Config".

## ClimateTimeSeries (Future climate data)

This data is used to specify the options for ‘future’ data, i.e. the climate used during the simulation years of the model (from time=0 until the end of the simulation). It does not refer to the spin-up data (see section 2.5).

There are seven valid values for the ClimateTimeSeries input parameter: Monthly\_AverageAllYears, Monthly\_AverageWithVariation, Monthly\_RandomYear, Monthly\_SequencedYears, Daily\_RandomYear, Daily\_AverageAllYears, and Daily\_SequencedYears. Each one is described below.

### Monthly\_AverageAllYears

If the ‘Monthly\_AverageAllYears’ option is used, the user will need to supply monthly data in the input file. The climate library will calculate mean monthly temperature and total monthly precipitation **across all years included in the input file.** Then it will use those calculated temperature and precipitation values for each month in each year of the simulation; **this means that the climate will be the same for each year of the simulation.**

### Monthly\_AverageWithVariation

If the ‘Monthly\_AverageWithVariation’ option is used, the user will need to supply monthly data in the input file. The climate library will calculate mean and standard deviation of monthly temperature and total and standard deviation monthly precipitation **across all years included in the input file..**  Climate for an individual month of a simulation will be calculated by applying a random percentage (0-100) of 1 standard deviation above or below the mean temperature and total precipitation for that month. Though the mean temperature and total precipitation of each individual month across years will not change, by applying random percentages of SD above/below the mean temperature and total precipitation, interannual variability will be introduced.

### Monthly\_RandomYear

If the ‘Monthly\_RandomYear’ option is used, the user will need to supply monthly data in the input file. For each year of the simulation, the climate library will randomly select a years’ worth of climate data at a monthly time step. For example, if the user supplies data for years 2014-2015, the climate library might choose the climate in year 2015 for year 1 of the simulation and year 2014 as year 2 of the simulation. The climate library will not give any preference for chronological order.

### Monthly\_SequencedYears

If the ‘Monthly\_SequencedYears’ option is used, the user will need to supply monthly data in the input file. **The years in the input file will correspond exactly with the data used by LANDIS during the simulation.**  For example, if the user supplies climate data for years 2010 to 2015, then the model will run using 2010 as time= 1 in the simulation. Simulation years 2-6 will correspond to years 2011 to 2015 in the input data. If the duration of the simulation exceeds the number of years supplied, the last year of input data will be repeatedly used as climate data until the simulation is complete.

### Daily\_RandomYear

If the ‘Daily\_RandomYear’ option is used, the user will need to supply daily data in the input file. The climate library will take all the daily data and calculate an average of temperature (sum for precipitation) for **each month and year.** For each year of the simulation, the climate library will randomly select a years’ worth of climate data at a monthly time step (see Monthly\_RandomYear for more details).

### Daily\_AverageAllYears

If the ‘Daily\_AverageAllYears’ option is used, the user will need to supply daily data in the input file. For extensions requiring daily data (e.g. Dynamic Fire), the climate library will take all the daily data for all the years of the input data and calculate an average of temperature (sum for precipitation) **across all years for each day of the simulation.** Then it will use that **average** (or sum) for each day for each year of the simulation; **this means that the climate will be the same for each year of the simulation.**

For extensions requiring monthly data (e.g. Century), the climate library will take all the daily data for all the years of the input data and calculate an average of temperature (sum for precipitation) **across all years for each month of the simulation.** Then it will use that **average** (or sum) for each month for each year of the simulation; **this means that the climate will be the same for each year of the simulation.**

### Daily\_SequencedYears

If the ‘Daily\_SequencedYears’ option is used, the user will need to supply daily data in the input file. The years in the input file will correspond exactly with the data used by LANDIS during the simulation (see Monthly\_SequencedYears for more details).

For extensions requiring daily data (e.g. Dynamic Fire), no additional processing is necessary**.** For extensions requiring monthly data (e.g. Century), the climate library will calculate an average of temperature (sum for precipitation) **for each month and year of the simulation.**

## ClimateFile

This parameter references the file that contains all the climate data (Tmin, Tmax and Precipitation). Details about how to configure the ClimateFile are described in Chapter 3.

## ClimateFileFormat

This parameter specifies the type of format for the ClimateFileFormat. There are currently six options (ipcc3\_daily, ipcc3\_monthly, ipcc5\_daily, ipcc\_monthly, prism\_monthly, Mauer\_daily) described below.

### ipcc3\_daily

If the ‘ipcc3\_daily’ option is used, the climate will need to be supplied in a daily format using the units from the 3rd Assessment of the IPCC.

### ipcc3\_monthly

If the ‘ipcc3\_monthly’ option is used, the climate will need to be supplied in a monthly format using the units from the 3rd Assessment of the IPCC.

### ipcc5\_daily

If the ‘ipcc5\_daily’ option is used, the climate will need to be supplied in a daily format using the units from the 5th Assessment of the IPCC.

### ipcc5\_monthly

If the ‘ipcc5\_monthly’ option is used, the climate will need to be supplied in a monthly format using the units from the 5th Assessment of the IPCC.

### prism\_monthly

If the ‘prism\_monthly’ option is used, the input file will correspond to the PRISM dataset of the USGS data portal, downloaded at a monthly time step.

### Mauer\_daily

If the ‘Mauer\_daily’ option is used, the input file will correspond to the gridded observed Mauer dataset of the USGS data portal which is downloaded at a daily time step.

## SpinUpClimateTimeSeries

This data is used to specify the options for ‘spin-up’ data, i.e. the climate used during the spin-up phase of the model.

There are seven valid values for the SpinUpClimateTimeSeries input parameter: Monthly\_AverageAllYears, Monthly\_AverageWithVariation, Monthly\_RandomYear, Monthly\_SequencedYears, Daily\_RandomYear, Dialy\_AverageAllYears, and Daily\_SequencedYears. Each one is described above in section 2.2.

## SpinUpClimateTimeFile

This parameter references the file that contains all the climate data (Tmin, Tmax and Precipitation) for the spin-up phase of the model. Details about how to configure the ClimateFile are described in Chapter 3.

## SpinUpClimateFileFormat

This parameter specifies the type of format for the SpinupClimateFile. There are currently six options (ipcc3\_daily, ipcc3\_monthly, ipcc5\_daily, ipcc\_monthly, prism\_monthly, Mauer\_daily) described above in section 2.4.

# Climate Input Files

The map of the climate regions (Note: climate regions NOT ecoregions) need to be converted to a shp file and zipped prior to downloading data.

For each climate scenario, I compiled maximum/minimum temperature, and precipitation from the downscaled Geo Data Portal for the 100 years of climate change data available.

Specifically, I used the USGS data portal (<http://cida.usgs.gov/gdp/>) and clicked on Areal Statistics, and then selected a dataset (see example below).

Then I clicked on Process Data with the Geo Data Portal. Then I hit Upload Shapefile and uploaded the zipped climate region shp files, selected GRIDCODE as the available attribute, and Area Grid Statistics (weighted) as the algorithm. For the next menu, I left everything as the defaults, but select the Mean, Variance and SD as the statistics of interest. I selected the min temperature, max temperature and precipitation and the data range from 2000 to 2099. Hit Submit for Processing and they email you when the file is ready.

I repeated these steps to download MONTHLY PRISM data for each climate region and selecting years 1895 to 2012. These data are ACTUAL (historic) data and therefore will be used during the spin-up phase of the model and for the baseline scenario, where we assume that the climate will not change over time (i.e. no climate change).

**Making the Climate Input File for Century**

The climate data from the USGS data portal (see section called **Downloading climate change and PRISM data)** is downloaded for each CLIMATE region (n=5), but not ecoregion (n=25). Since LANDIS needs to have a climate for **each ecoregion**, I had to copy each climate column five times (5\*5=25 ecoregions) for each of the parameters (e.g. max temp).

The columns for each ecoregion need to be numbered starting at zero (if there are no inactive ecoregions) or 1 if the first ecoregion is inactive. Alternatively, the user can use the ecoregion names as they appear in the ecoregion.txt file. The climate library will only run if you have an inactive ecoregion that’s first in the ecoregion.txt file.

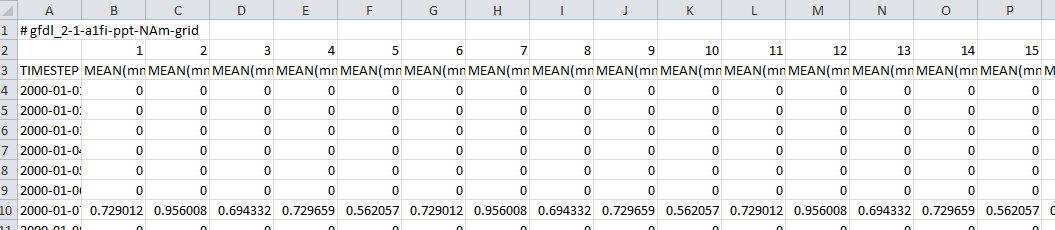
Also the headings have to be identical to those below:

# gfdl\_2-1-a1fi-ppt-NAm-grid

# gfdl\_2-1-a1fi-maxtemp-NAm-grid

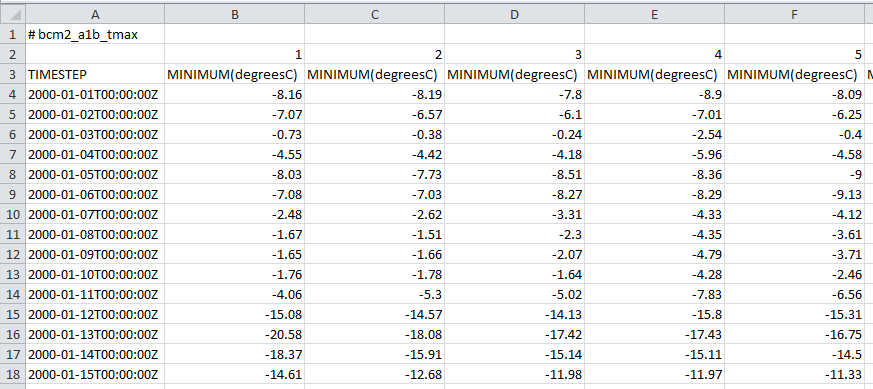
# gfdl\_2-1-a1fi-mintemp-NAm-grid

See clip below as an example of the input data:



The USGS-GDP serves downscaled (12 km resolution) data **projected** from multiple global circulation models and multiple emissions scenarios. The user can upload a shape file to their web site that enables their web server to parse the landscape byecoregion. The data is then downloaded by the user as **daily** means, variances and standard errors for minimum temperature, maximum temperature and mean precipitation for each climate region for the requested time period in a common format (comma delimited with a header, Figure 3). At this time, the variances and standard errors from the USGS data portal are not utilized by the climate library. These represent variation in the climate between grid cells; this is a small source of variation so we are currently omitting this variation.

The user would need to parse the data by GCM and emissions scenario so that each input file contains one climate change scenario (eg. Bcm2\_a1b).



If there are multiple soil regions within each climate region, the user will need to copy the climate regions so that each ecoregion has a climate. For example, in the CNF+ landscape, we have five climatic regions (i.e. five polygons) so we download data from the USGS data portal for the five regions. Then we copy the data from each climate region for each of the soil regions for a total of 25 ecoregions (5 climate regions \* 5 soil regions = 25 ecoregions).

The user will need to adjust the headers, with the **climate regions starting at 1** if the first ecoregion is inactive in the ecoregion.txt file (e.g. Figure 7). If there are no inactive ecoregions, the user will need to start numbering the **climate regions at zero**. The user will also need to have the correct key words (words are not case sensitive) to identify the data (i.e. if it’s max or minimum temperature). The relative humidity and wind speed data are optional when you run LANDIS, Century Extension. They are only needed if you run the fire extension.

Table 1. Key words needed in climate input file

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Maximum temperature | Minimum temperature | Precipitation | Relative humidity | Wind speed |
| # Tmax | # Tmin | # Prcp | #rh | #windspeed |
| # maxtemp | # mintemp | # ppt | #RH | #windSpeed |

These data will then be read into the new climate library which will store the data by ecoregion. This library will then provide all the necessary climate data for the other extensions, keeping in mind that the some extensions require monthly climate data (e.g. Century succession, drought extension, insect leaf biomass extension), while others require daily climate data (e.g. the Dynamic Fire extension). The fire extension will use the daily data from the climate library (see task 7) to make all the calculations needed to simulate fire.

For the Century succession extension, the climate library will convert daily data to monthly data for the following parameters: maximum temperature, minimum temperature, and precipitation. To convert from daily to monthly data, the climate library will treat temperatures differently than precipitation, since the temperatures reflect monthly averages and the precipitation is a monthly sum (cumulative). Also, the original precipitation data from the USGS data portal is reported in mm/day, but LANDIS uses cm/day or cm per month. So the precipitation values need to be divided by 10. For min and max temperature, it will simply take the average and standard deviaton data for each month. For precipitation, the climate library will sum all the daily precipitation and calculate the standard deviation for that month.

When the user runs Century, the climate library will produce a file that shows all the summarized data in the “old” format (see Figure 3).

When the user runs LANDIS, the model produces a century-succession-monthly-log.csv file which summarizes the temperature and precipitaiton data for the model run. When the model is run, it selects the temperature or precipitation for that month, but then randomly selects the actual value by sampling within the distribution of values which is determined by the standard deviation for that month.

# Example Inputs

## Main Climate Configuration (“Climate Config”) File

ClimateTimeSeries Daily\_AverageAllYears

ClimateFile Daily\_Mauer\_Baseline\_SC.csv

ClimateFileFormat ipcc5\_daily

SpinUpClimateTimeSeries Monthly\_AverageWithVariation <<MonthlyRandom>

SpinUpClimateFile PRISM\_data\_AFRI\_4.18.13\_SC.csv

SpinUpClimateFileFormat prism\_monthly