

Working with climate data and niche modeling

I. Creation of bioclimatic variables

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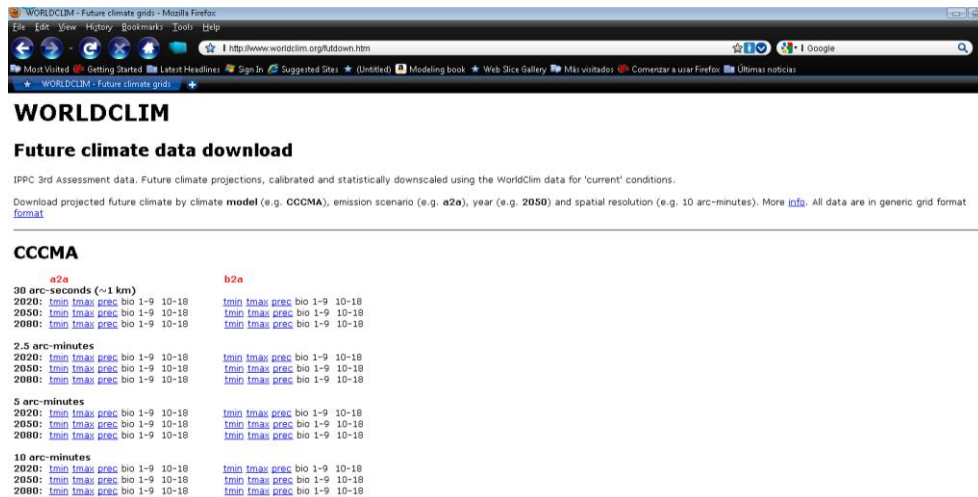
With the recent and rapid spread of ecological niche modeling (ENM) and geographic information systems (GIS), the need for a detailed dataset of environmental characterization has increased substantially. The creation of the WorldClim dataset (Hijmans *et al.*, 2005, available at <http://www.worldclim.org>) is a considerable advance in terms of global environmental characterization as it provides high resolution (i.e. nearly 1 km) climatic surfaces derived from historical records from a number of weather stations across the globe. With this dataset, several analyses by means of GIS can be performed. WorldClim provides high resolution monthly maximum (tmax), minimum (tmin), and mean temperatures (tmean), and monthly precipitation (prec); and from those, a set of 19 bioclimatic variables can be derived (Busby, 1991).

The maximum entropy algorithm (Maxent, Phillips *et al.*, 2006) for species distributions modeling is one of the most accurate and globally used ecological niche models. Many modelers currently use the set of bioclimatic variables available at the WorldClim website when modeling a certain species geographic distribution using Maxent. This is a relatively easy task when the user works with current conditions (interpolations historical observed data, representative of 1950-2000 climates) since the bioclimatic variables needed for the analysis can be directly downloaded from the WorldClim website. However, often when working with future conditions (i.e. climate change), these 19 bioclimatic layers must be derived from the three basic climatic variables (i.e. tmin, tmax, prec) no matter the future climate pattern (i.e. global climate model [GCM]) that will be used in the analysis. In this document, we present a simple tutorial to generate the necessary environmental datasets (i.e. 19 bioclimatic variables) to be used as inputs for the Maxent software (any version), without using any complicated Arc-Info script (i.e. AML).

In order to complete the tutorial, however, you will need to first:

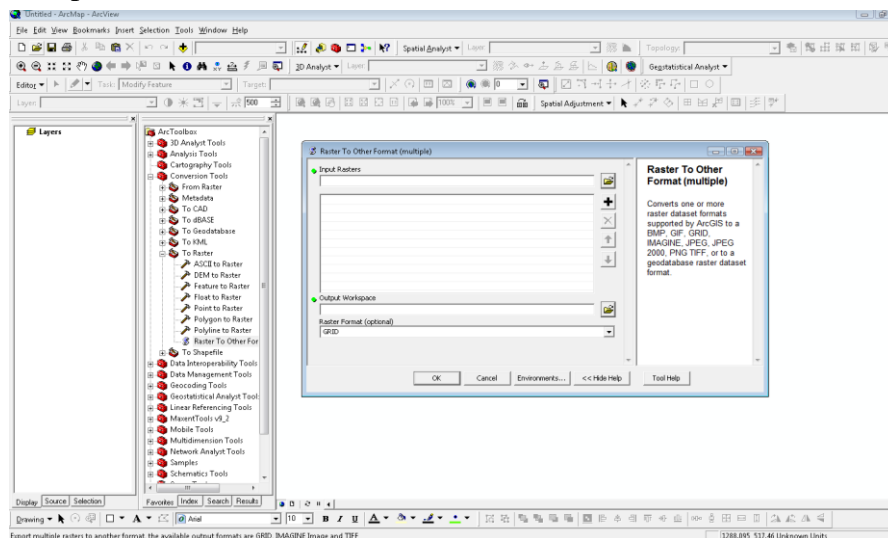
- a. Download and install the latest version of DIVA-GIS [7.1.7] (freely available at <http://www.diva-gis.org>)
- b. Have a stable internet connection
- c. Check if you have the ESRI software ArcGIS (with an ArcInfo licence). Version 9.0 or superior.

1. **Download** the tmin, tmax and prec variables from the climate model (e.g. CCCMA), emission scenario (e.g. a2a), year (e.g. 2050) and spatial resolution (e.g. 10 arc-minutes) of interest (<http://www.worldclim.org/futdown.htm>)

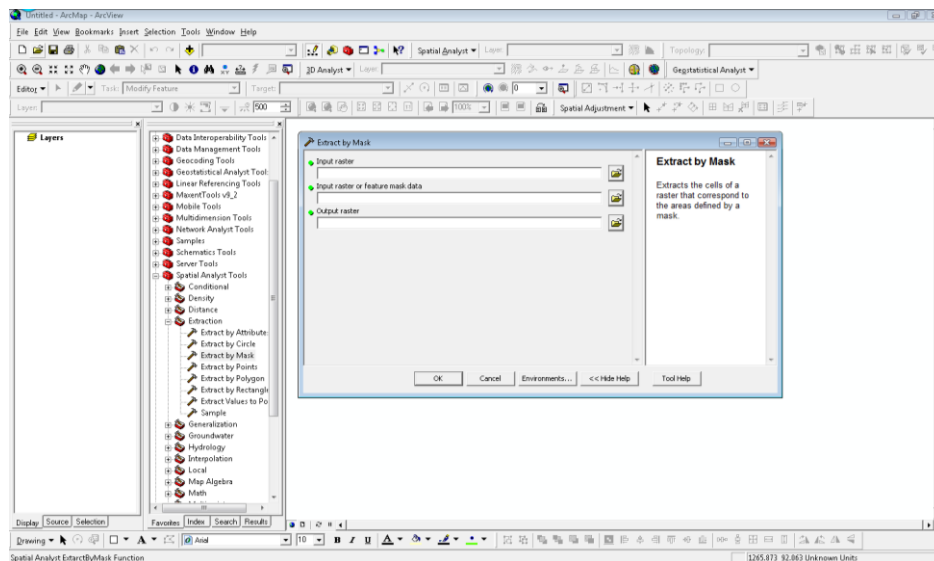


2. **Convert** the .BIL files to ESRI GRID

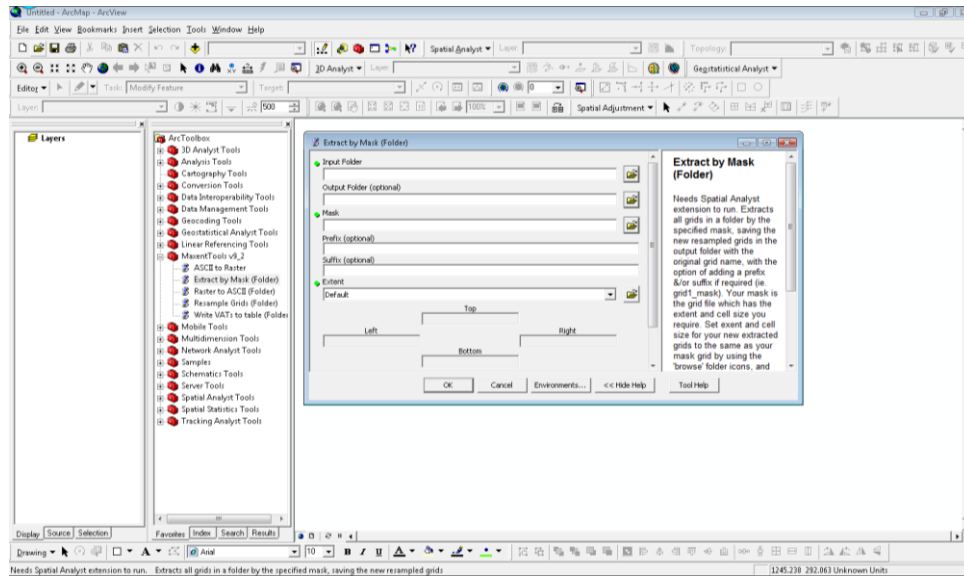
- a. For this step you must use ArcMap
- b. Open ArcMap → Toolbox → Conversion tools → To raster → Raster to other format
- c. Input rasters: Browse for the uncompressed .BIL file you downloaded in (1). You need to add all the grids one by one.
- d. Output workspace: select a folder (preferably different from the input folder) in which you will store your grids.
- e. Output format: select “GRID”



3. Once you have your files in ESRI Grid format, select and **cut** the area of interest for each of the monthly layers. This is an **optional** step and you could avoid it if you are using a single tile (i.e. you downloaded a single tile from the WorldClim website), or if you are working with a spatial resolution other than 30 arc-seconds.
 - a. Using ArcMap normal features
 - i. Toolbox → Spatial Analyst Tools → Extraction
 - ii. Select the appropriate function:
 1. The “extract by mask” option could be useful if you already have a delimited area (a shapefile or a grid)
 2. If not, you can download country boundaries in shapefile (*.shp) format from the DIVA-GIS website (look for the “data” link).
 3. If you want to work with a rectangular area rather than with a particular shape, you can use the “extract by rectangle” option, in which you will be asked to provide the top, bottom, left and right sides of a box within which the data will be conserved.
 4. You can explore yourself other methods to cut your surface such as “extract by circle”, or “extract by polygon”



- b. Using the Arcview9.2ToolsforMaxent script (freely available at <http://groups.google.com/group/Maxent/files?&sort=name>). You may first read the tool tutorial in order to install it on the ArcGIS environment.
 - i. Toolbox → MaxentTools v9_2 → Extract by mask (folder)



4. **Export** the selected area layers to an ASCII format (.ASC)

a. Using ArcMap

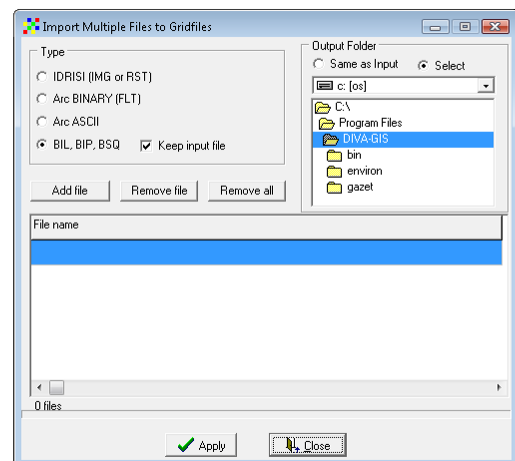
- i. Toolbox → Conversion tools → From raster → Raster to ASCII
- ii. Browse for the input raster
- iii. Select both a name and output folder for the output file. Please be aware of selecting the correct type “File (.ASC)”

b. Using the Arcview9.2ToolsforMaxent script

- i. Toolbox → MaxentTools v9_2 → Raster to ASCII (Folder)

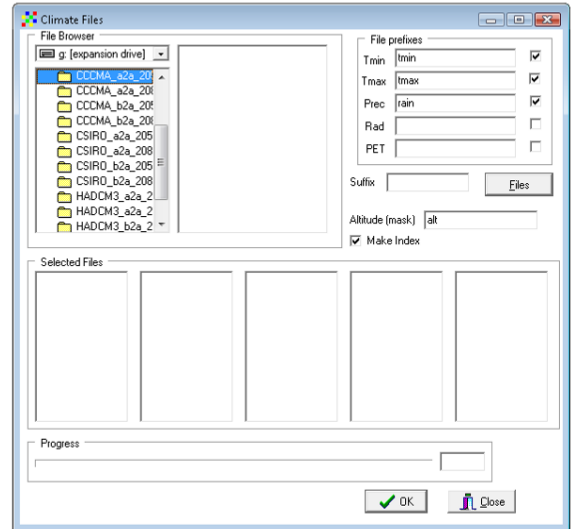
5. Open DIVA-GIS and **Import** each of the .ASC file into a .GRD format

- a. Data → import to Grid file → multiple files
- b. On “type”, select “Arc ASCII”
- c. Click on “add file”, browse the path where you saved your ASCII files and then add all of them
- d. In “output folder” you may browse for a folder in which you want to save your new .GRD files. Otherwise, select “same as input” and the program will save the files inside the folder from which you loaded the input ASCII files.



6. This process will produce a .CLM file to be used as input for DIVA-GIS in order to generate the bioclimatic variables. You must first **copy** one of the converted .GRD file (with its complementary .GRI file) in the same folder and rename them as “alt” (conserve the extensions of the files). With this method the altitude dataset will have no sense in terms of data, but will be useful for further steps as the altitude dataset is not necessary to produce any of the bioclimatic variables. This is a trick to avoid you from downloading altitude data you won't really need.

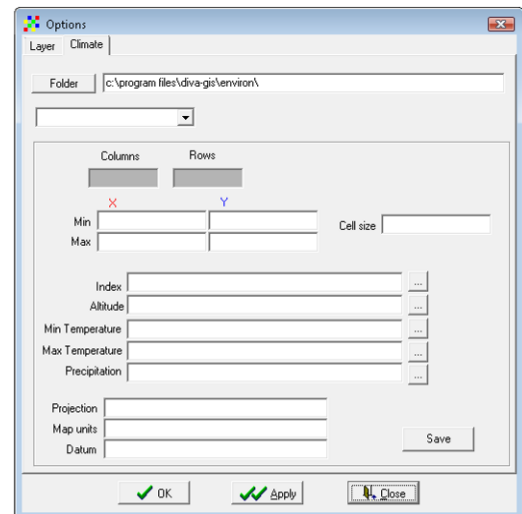
- a. Data → Climate → Make CLM Files
- b. Browse to the folder where all the .GRD files are located. You will see the .GRD files when you reach the right folder in the box just in the left of the “file browser”. 36 monthly files plus the altitude file should be listed in this box.
- c. In “File prefixes” add a “_” after “tmin” and “tmax”, and change the word “rain” by “prec_”
- d. Leave the “suffix” and other boxes blank
- e. Click on “Files”
- f. You should now see a 12-file set in each “selected files” box. The two left boxes should appear in blank
- g. Click “OK”



When performing this step, please ensure your DIVA-GIS **version** is ≥ 5.4 .

7. Load the CLM File in DIVA-GIS

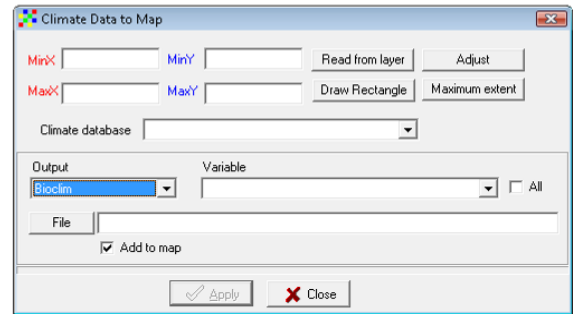
- a. Tools → Options
- b. Click on “Folder” and browse the folder containing the CLM files
- c. Click on “Apply” and verify that all the boxes are now filled with some names, metadata, or names of the files
- d. Click on “OK”
- e. Close the window



8. Create the bioclimatic variables

- a. Data → Climate → Map

- b. Select “Bioclim” from the “Output” several choices
- c. Check the “all” variables box,
- d. Check the “Add to map” box to visualize each of the 19 derived bioclimatic variables
- e. Click on “File”, browse for an output folder, and put any name you may want
- f. Click on “Apply”



9. Export the 19 variables (BIO1 to BIO19) to an ASCII format (.ASC)
 - a. Data → Export Gridfile → Multiple files
 - b. Select “ESRI ASCII” on “File type”
 - c. Click on “add file” and browse for your bioclimatic files in .GRD format
 - d. Choose an output folder if desired. Otherwise, select “Same as input”

10. Load the ASCII files (.ASC) of interest into the Maxent interface

References

- Busby, J. R. (1991) A bioclimatic analysis and prediction system. *In: Nature Conservation: cost effective biological surveys and data analysis*, eds, Margules, CR; Austin, MP. CSIRO Australia pp. 64-68.
- Hijmans R.J., Cameron S.E., Parra J.L., Jones P.G., and Jarvis, A. (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965-1978.
- Phillips S.J., Anderson R.P., and Schapire R.E. 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling* 190: 231-259.

Note from the authors

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