Downscaling User Guide - R

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1 Overview

This document is a guide to perform downscaling in R having coarse projections and observational data pre-processed and saved in certain formats.

Section 3 will explain performing standard downscaling, which is a cost-effective method for statistical downscaling. Section 4 will outline a novel procedure for downscaling with Basis Graphical Lasso (BGL), which yields enhanced accuracy and uncertainty estimates in the downscaled projections. Although this method may not be as swift as the standard approach, it's designed to be computationally feasible for large datasets.

2 Preprocessing data

You will need to have the coarse and observational data saved in .csv files in following formats. An example code to process netcdf files and create .csv files can be found in the file named "Prepossess.R"

- If N is the number of fine pixel locations in the region and T_o is the total time points in the current observational period, save observational data matrix in a .csv file named "Obs_data.csv" of the form of $N \times (T_o + 2)$ matrix. First two additional columns will provide lon/lat information.

- If M is the number of coarse grid cells in the region, $T(> T_o)$ is the total number of time points in the current and the future downscaling periods, have the model data saved in a file named Model_data of the form of $M \times (T + 2)$ matrix. First two additional columns will provide lon/lat information. Name the fist two columns "lon", "lat" and the subsequent columns with respective years. Naming the columns is crucial here as it enables the code to identify the model projections relevant to the training period.

3 Standard downscaling

This downscaling process primarily involves interpolation and bias correction. While this approach is cost effective, for downscaled projections accompanied

by uncertainty estimates with enhanced precision, consider utilizing BGL downscaling as detailed in Section 4.

3.1 Running codes

- Download and install R from `https://cran.r-project.org` (if you don't have R in your local server).

- Download and save all the files provided into your working directory.

- To run the codes, first run the R function and then type the command **Downscaling(arg1,arg2,arg3)** in R console.
R script takes following arguments. Specify all the arguments within air quotes.

    - arg1: This is the path to your working directory.
    - arg2: Frequency of your data. For example if its is monthly data, frequency is 12. If it is daily data, frequency is 365.
    - arg3: This argument is to choose between standard downscaling and BGL downscaling. As you perform standard downscaling, type "off".

- Provided sample observational data "Obs_data.csv" file includes example monthly observational temperature data set for 204 months at 4904 fine-scale locations. Climate model data file "Model_data.csv" includes coarse projections for the current 204 months plus additional 24 future months for downscaling.

3.2 Output files

You will have below files as outputs.

- "Stand_Downscaled.csv": This files includes fine projections from standard downscaling. First two columns are lon/lat information and the subsequent columns are downscaled projections having respective year as column heading.

4 BGL downscaling

BGL downscaling involves fitting a multivariate spatial statistical model that utilizes Basis Graphical Lasso for enhanced computing. The code will first perform standard downscaling in Section 3 and model it bivariately with observational data at finer resolution.

4.1 Running codes

- Download and install R from `https://cran.r-project.org` (if you don't have R in your local server).

- Download and save all the files provided into your working directory.

- To run the codes, first run the R function and then type the command **Downscaling(arg1,arg2,arg3)** in the R console.
R script takes following arguments. Specify all the arguments within air quotes.

    - arg1: This is the path to your working directory.
    - arg2: Frequency of your data. For example if its is monthly data, frequency is 12. If it is daily data, frequency is 365.
    - arg3: Type "on" for BGL downscaling.

- Provided sample observational data "Obs_data.csv" file includes example monthly observational temperature data set for 204 months at 4904 fine-scale locations. Climate model data file "Model_data.csv" includes coarse projections for the current 204 months plus additional 24 future months for downscaling.

4.2 Output files

You will have below files as outputs.

- "Stand_Downscaled.csv": This file contains fine projections resulting from standard downscaling, serving as a byproduct of our use of standard downscaling in the BGL downscaling process. First two columns are lon/lat information and the subsequent columns are downscaled projections having respective year as column heading.

- "BGL_Downscaled.csv": This files includes downscaled projections from BGL downscaling. First two columns are lon/lat information and the subsequent columns are downscaled projections having respective year as column heading.

- "BGL_Downscaled.UQ.csv": This files includes standard erros for the projections from BGL downscaling. First two columns are lon/lat information and the subsequent columns are downscaled projections having respective year as column heading.