Statistical Downscaling for Hydro-climatic projections with CMIP5 simulations to assess Impact of Climate Change

Basic Description:

This project is aimed at performing statistical downscaling of rainfall for monsoon period for Indian rainfall. The statistical downscaling is a data driven approach that exploits the relationship between large scale climate variables and local scale desired variables. The project composed of four sectors with different institutions working on each of them separately. IIT Bombay has worked on Kernel Regression Based Statistical Downscaling and IIT Kanpur and IIT Guwahati have collaboratively worked on ANN based Statistical Downscaling. IIT Gandhinagar and IISc Bangalore worked on Bias Correction Spatial Disaggregation and Uncertainty Modeling respectively. This work was funded by Indian National Committee on Climate Change (INCCC) and Ministry of Water Resources, Government of India

Goal and Objectives:

1. To prepare statistically downscaled precipitation product for Indian rainfall with Kernel Regression Based Statistical Downscaling and ANN based statistical downscaling.
2. In addition, perform Bias Correction Spatial Disaggregation and Uncertainty Modeling.
3. To prepare an online portal to allow free access to this product.

Methodology and data used:

Data used:

The data was obtained for the important climatic variables from five GCMs (CMIP5) for the emission scenarios (SRESs) prescribed by the Intergovernmental Panel on Climate Change (IPCC). The following Global Circulation Models (GCMs) were selected for the current analysis:

1. CCCMA CanESM2;
2. CNRM CM5;
3. MPI ESM MR;
4. MPI ESM LR and;
5. BNU ESM

From each GCM, following predictors were taken for rainfall projection:

1. Near-surface Air Temperature (TAS);
2. Air Temperature at 850hpa pressure level (T850);
3. Air Temperature at 500hpa pressure level (T500);
4. Eastward Near-surface Wind Velocity (UAS);
5. Eastward Wind Velocity at 850hpa pressure level (U850);
6. Northward Near-surface Wind Velocity (VAS);
7. Northward Wind Velocity at 850hpa pressure level (V850);
8. Specific Humidity at 850hpa pressure level (Q850);
9. Sea level Air Pressure (PSL); and
10. Geo-potential Height at 500hpa pressure level

More details about the original CMIP5 dataset can be found at http://cmip-pcmdi.llnl.gov/cmip5/.

Selection of GCMs is important for a specific application. The above mentioned GCMs and predictors were selected for the rainfall projection because of the following reasons:

1. All the GCMs listed above provide data for the desired analysis period that is a historical period (19512005) and a future period (2006-2100 for RCP4.5 and RCP8.5 climate scenarios)

2. All the GCMs listed above can simulate all the predictors listed above
3. The predictors listed above have good correlation with the predictand (i.e. rainfall)

Methods Used

Kernel Regression:

The statistical downscaling model develops a statistical relationship between large-scale climate variables from reanalysis data (NCEP/NCAR) and fine-resolution observed rainfall (IMD) using classification and regression tree (CART) and kernel regression techniques. This relationship is then applied to bias-corrected coarse-resolution GCM outputs to project rainfall in India. The biases in the GCM outputs were corrected using quantile-based mapping techniques and Figure 1 An example of Bias correction applied on Humidity. (Salvi. et al. 2013) shows an example of it applied on humidity. The statistical downscaling model (Figure 2 Flow chart illustrating methodology for Kernel Regression based statistical downscaling. (Salvi et al, 2013), Salvi et al., 2013) was applied independently for different meteorologically homogeneous zones namely (a) Central, (b) Jammu and Kashmir, (c) North, (d) Northeast hills, (e) Western, (f) South, and (g) Northeast. Rainfall for each zone was projected for different seasons namely (a) DJF, (b) MAM, (c) JJAS, and (d) ON. Please refer the following papers for a detailed description of the development of statistical downscaling model for the multisite rainfall projection in India.

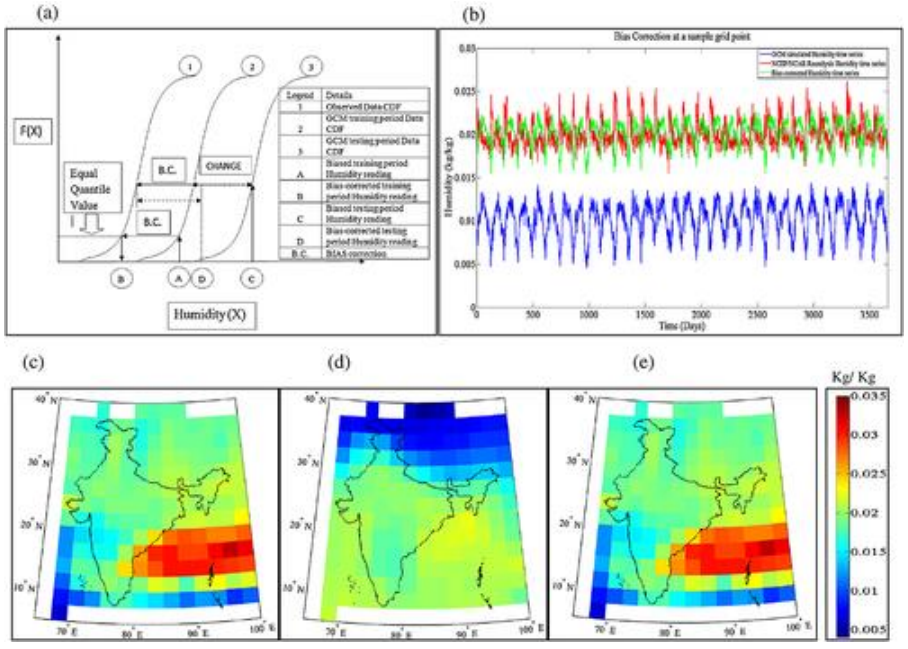

Figure 1 An example of Bias correction applied on Humidity. (Salvi. et al. 2013)

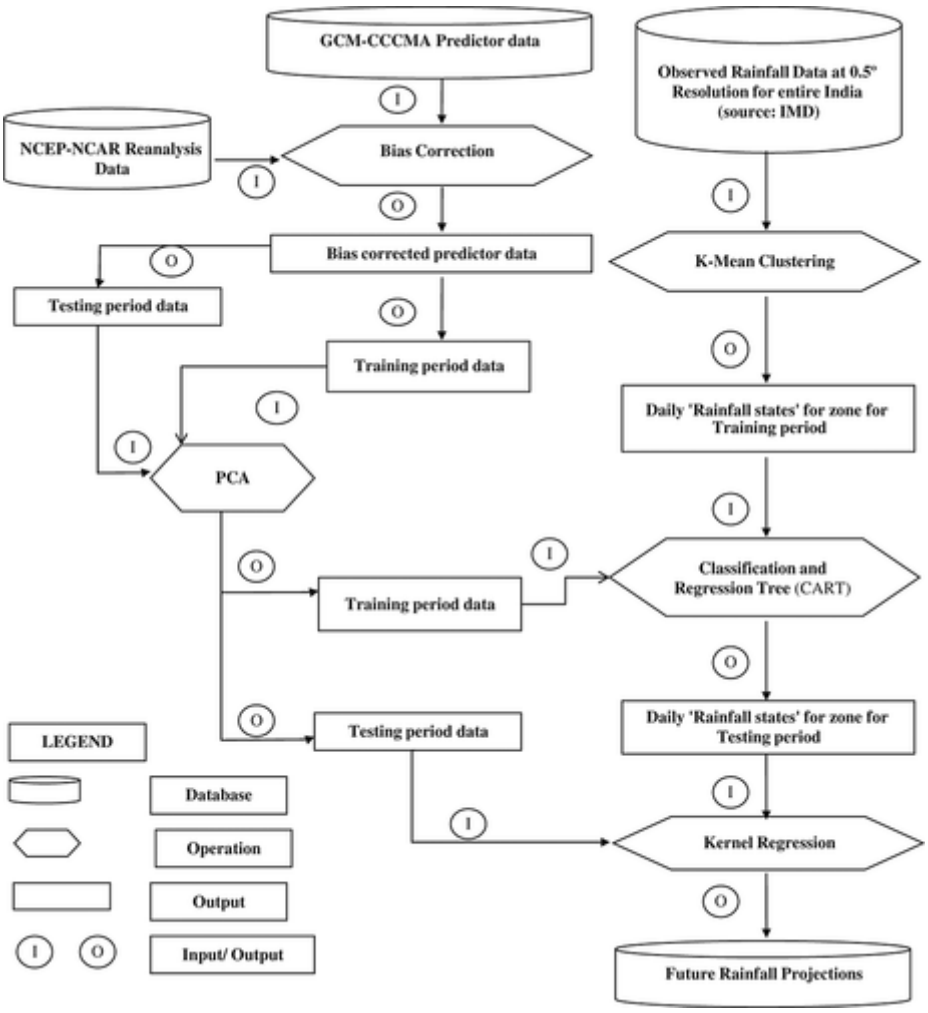

Figure 2 Flow chart illustrating methodology for Kernel Regression based statistical downscaling. (Salvi et al, 2013)

Generalized Regression Artificial Neural Network GRNN

GRNN is a probabilistic-based ANN Model for performing regression. Output is estimated using weighted average of the output of training dataset, where the weight is calculated using the Euclidean distance between the training data and test data. If the distance is large then the weight will be very less and if the distance is small it will put more weight to the output. In Generalized Regression Artificial Neural Network choosing architecture becomes important.

Outputs and Results

The results from the statistical downscaling model were compared with the observed dataset provided by Indian Meteorological Department. Here we provide comparison of statistically downscaled rainfall using Kernel Regression from CCCMA CanESM2 with IMD observed rainfall. Figure 3 Observed (IMD) Mean Rainfall (1976-2005) provides mean IMD rainfall averaged from 1976-2005 and Figure 4 Projected Mean Rainfall using GCM Predictors (1976-2005)provides projected rainfall using Kernel Regression. Figure 5 Errors in mean rainfall (IMD - Projected) Provides Difference between the two.

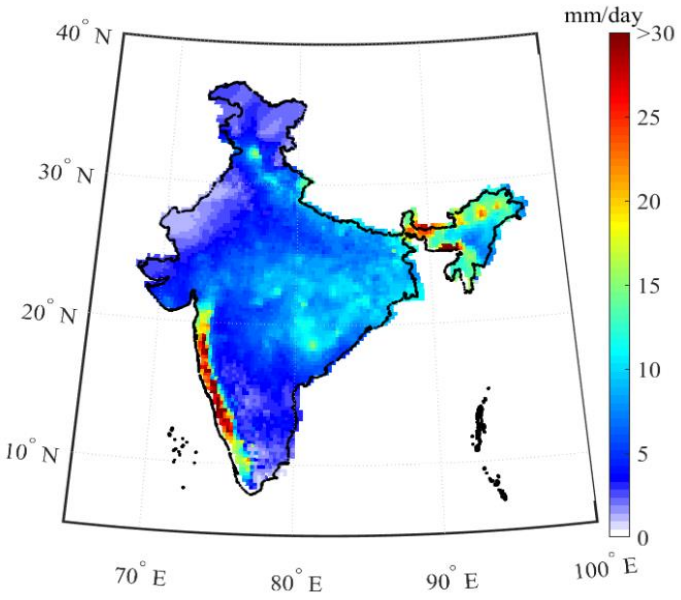

Figure 3 Observed (IMD) Mean Rainfall (1976-2005)

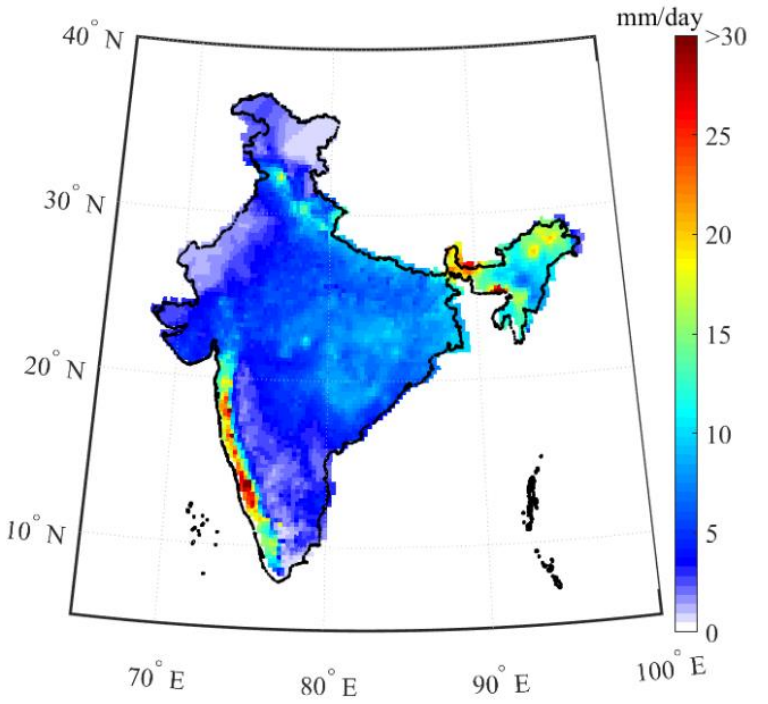

Figure 4 Projected Mean Rainfall using GCM Predictors (1976-2005)

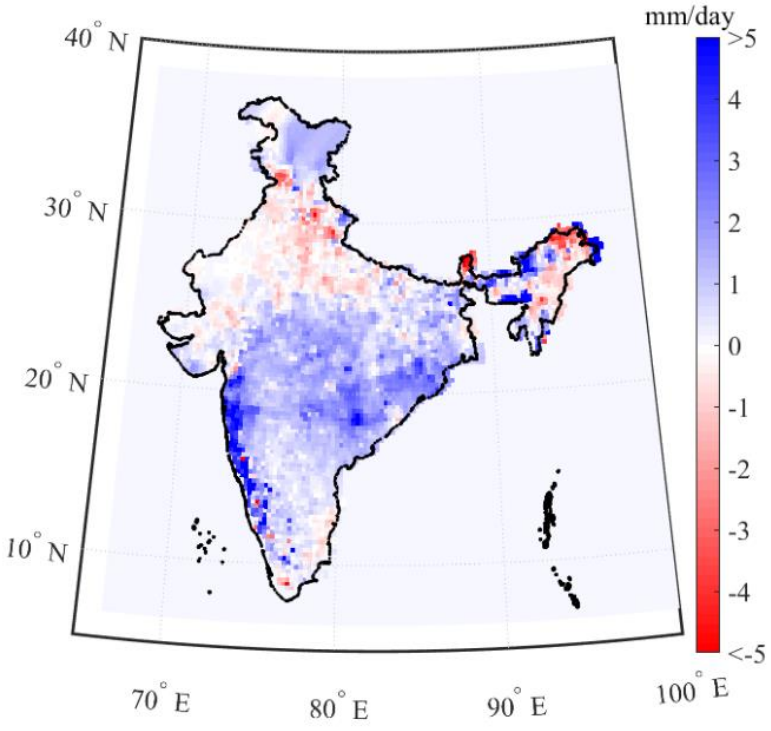

Figure 5 Errors in mean rainfall (IMD - Projected)

Online Portal details:

The data from this project can be access through online portal. The online portal can be accessed from http://www.regclimindia.in .The data can be freely accessed and used for research purposes with some terms and conditions specified at the portal itself.

The website allows you to choose a particular method, GCM and variable to download. Choose model name under "Model and Data" tab on the website to select method and then model (**Error! Reference source not found.**). This opens up the list of variables (**Error! Reference source not found.**) available for download. Click on desired variable and choose a Historical or Future Scenarios. Source lists will also be available on the website for downloading multiple files.

List of variables available:

1. Downscaled Precipitation
2. Near-surface Air Temperature (TAS);
3. Air Temperature at 850hpa pressure level (T850);
4. Air Temperature at 500hpa pressure level (T500);
5. Eastward Near-surface Wind Velocity (UAS);
6. Eastward Wind Velocity at 850hpa pressure level (U850);
7. Northward Near-surface Wind Velocity (VAS);
8. Northward Wind Velocity at 850hpa pressure level (V850);
9. Specific Humidity at 850hpa pressure level (Q850);
10. Sea level Air Pressure (PSL); and
11. Geo-potential Height at 500hpa pressure level
12. Maximum Near-surface Air Temperature (Tmax)
13. Minimum Near-surface Air Temperature (Tmin)

Variables 2 to 11 are bias-corrected with respect to Ncep/Ncar data and are used as predictors for statistical downscaling. Variables 12 and 13 are bias-corrected with respect to IMD dataset.

References

Kannan, S., and S. Ghosh (2011), Prediction of daily rainfall state in a river basin using statistical downscaling from GCM output, Stochastic Environ. Res. Risk Assess. doi: 10.1007/s0047-010-0415-y.

Kannan, S., and S. Ghosh (2013), A nonparametric Kernel regression model for downscaling multisite daily precipitation in the Mahanadi basin, Water Resour. Res., 49, doi: 10.1002/wrcr.20118.

Salvi, K., S. Kannan, and S. Ghosh (2013), High-resolution multisite daily rainfall projections in India with statistical downscaling for climate change impact assessment, J. Geophys. Res. Atmos., 118, 3557-3578, doi: 10.1002/jgrd.50280