Investigation of uncertainty in the IPCC AR5 precipitation and temperature projections over Iran under RCP scenarios

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PARIS2015 UN CLIMATE CHANGE CONFERENCE COP21·CMP11

UPMC PARIS UNIVERSITAS

Abstract

Upon release of new scenarios based on Radiative Forcing which are known as Representative Concentration Pathway scenarios (RCP scenarios), by Intergovernmental panel on climate change (IPCC) in fifth assessment report (AR5), a new set of 42 global climate models (GCMs) have been proposed for future climate projections. Apart from increased number of available models, three main sources of uncertainty including: measurement error, variability, and model structure, have been explained and studied in AR5. The main aim of this study is to investigate the uncertainty of output of 37 Coupled Model Intercomparison Project Phase 5 (CMIP5) for precipitation and temperature data in Iran. Required data consist of two main groups: simulated historical data and observations. The observed data of rainfall and temperature were retrieved from three sources. Two databases namely; Climatic Research Unit (CRU), NCEP/NCAR Reanalysis Project, and selected synoptic stations over Iran. Comparisons were made between the data reported in the climatic databases and those observed in synoptic stations using Root Mean Square Error (RMSE) and Mean Bias Error (MBE) indices. The Monte Carlo simulation approach was used for uncertainty analysis of the simulated values of monthly precipitation and temperature and reported observations of study stations. The results showed that there exists a close agreement between NCEP/NCAR Reanalysis Project data and observed ones, hence it was chosen as an alternate to observations for choosing the best models among the 37 selected GCMs. The latter section of study revealed that among the selected models, MPI-ESM-MR, MPI-ESM-LR, and NorESM1-M have the best performance in generating the rainfall and temperature data for baseline period of 1960-2000. Further studies using different sets of GCMs is recommended for more scrutiny.

Keywords: RCP Scenarios, CMIP5, Uncertainty, Monte Carlo analysis, Iran

Introduction

As the soft computing skills increased in recent decades, more number of climate models have been developed for weather and climate predictions which have significantly improved the quality and quantity of projections. This notable increase in number of climate models has enabled the scientists to estimate a wide range of main climate variables such as precipitation and temperature in fine temporal an spatial resolution. Although the uncertainty in model outputs remains a main challenge.

Kanz (2002) has reviewed the sources of error including: measurement error, variability, model structure, and scaling/aggregation; Besides, he described the approaches used for uncertainty analysis i.e. sensitivity, scenario, and Monte Carlo simulation analysis. Sansom et al. (2012) used "weighted mean" scheme instead of "one model, one vote" method for producing an ensemble of climate models for projection of North Atlantic storms. Their results showed that this approach would decrease uncertainty comparing to "one model, one vote" method. Ashofteh and Massah (2012), and Kamal and Massah, (2012) precisely studied the importance of uncertainty analysis for climate estimation in Gharanghu and Gharesu basins in Iran.

Based on the IPCC guidance note on consistent treatment of uncertainties, the AR5 has relied on two metrics for communicating the degree of certainty in key findings: 1-confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence and the degree of agreement. Confidence is expressed qualitatively.; 2- Quantified measures of uncertainty in a finding expressed probabilistically(Mastrandrea, et al., 2010).

The aim of the current study is to investigate of uncertainty in the IPCC AR5 precipitation and temperature projections over Iran under RCP scenarios using outputs of selected set of Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models found to be suitable in climatic condition of Iran.

Materials and Methods

The study was performed using climatic data of 37 stations of Iran. The country is located in the southwestern region of Asia with an area of approximately 1,648,000 km2. It stretches through 25–40°N and 44–64°E and has a complex, four-season climate. Figure 1 shows the position of synoptic stations used in the study.

The materials of this study is divided into two main parts; First part includes three subgroups: i. Monthly Climatic Research Unit (CRU) Time-Series (TS3.10); ii. NCEP/NCAR Reanalysis data; and iii. observed data from 37 selected synoptic stations of Iran for baseline period 1960-2000. The observed historical data were compared with those retrieved from CRU and NCEP/NCAR databases for the same period.

The second group of the data was comprised of 37 CMIP5 Global Climate Model (GCM) projections. Table 1 shows the list of CMIP5 models included in the study.

Fig 1. Geographical distribution of study stations

NCEP/NCAR and CRU outputs were compared with station observation, using T-test which indicated the suitability of NCEP/NCAR data for application over Iran. Finding this, the outputs of 37 global climate models (GCMs) were evaluated using Root Mean Square Error (RMSE) and Mean Bias Error statistics, as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(O_i - E_i)^2}{N}} \qquad MBE = \frac{\sum_{i=1}^{N} O_i - E_i}{N}$$

Where, Oi and Ei are observed and estimated values at time i.

Table 1. List of CMIP5 models included in the study

BCC-CSM1.1	INM-CM4	HadGEM2-CC	GISS-E2-R	GFDL-ESM2G
BCC-CSM1.1(m)	IPSL-CM5A-LR	HadGEM2-ES	GISS-E2-R-CC	GFDL-ESM2M
CanCM4	IPSL-CM5A-MR	MPI-ESM-LR	CCSM4	CESM1(BGC)
CanESM2	IPSL-CM5B-LR	MPI-ESM-MR	NorESM1-M	CESM1(CAM5)
CNRM-CM5	MIROC5	MRI-CGCM3	NorESM1-ME	CESM1(WACCM)
CSIRO-Mk3.6.0	MIROC-ESM	MRI-ESM1	HadGEM2-AO	
CSIRO-Mk3L-1-2	MIROC-ESM-CHEM	GISS-E2-H	GFDL-CM2.1	
EC-EARTH	HadCM3	GISS-E2-H-CC	GFDL-CM3	

Results and Discussion

MATLAB (ver. R2013a) was used to work out the input data and statistical indices calculations using NetCDF files of Global Climate Models. In addition, an ensemble of all models and its RMSE and MBE values were calculated. According to the results of this study, for precipitation variable, MPI-ESM-LR model turned out to be the best model with lowest RMSE. BCC-CSM1.1(m) and MPI-ESM-MR were ranked as second and third suitable models, respectively. Similarly, for temperature, MPI-ESM-MR, CESM1(BGC) and CCSM4 found to be the best options.

The results also indicated the close agreement in trend of RMSE and MBE among the models. Figures 2 and 3 show the RMSE and MBE of each model for temperature and precipitation historical estimates.

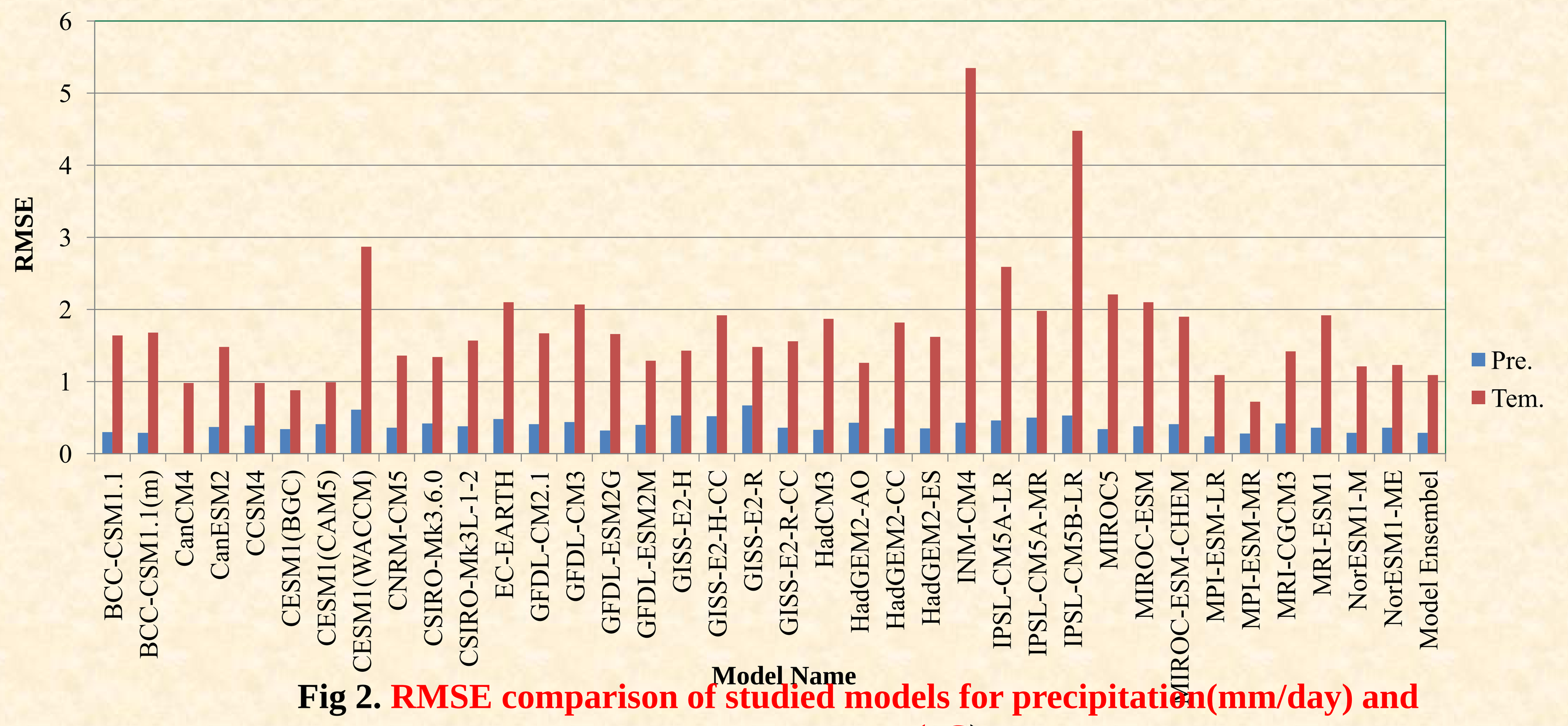

Fig 2. RMSE comparison of studied models for precipitation(mm/day) and temperature(oC).

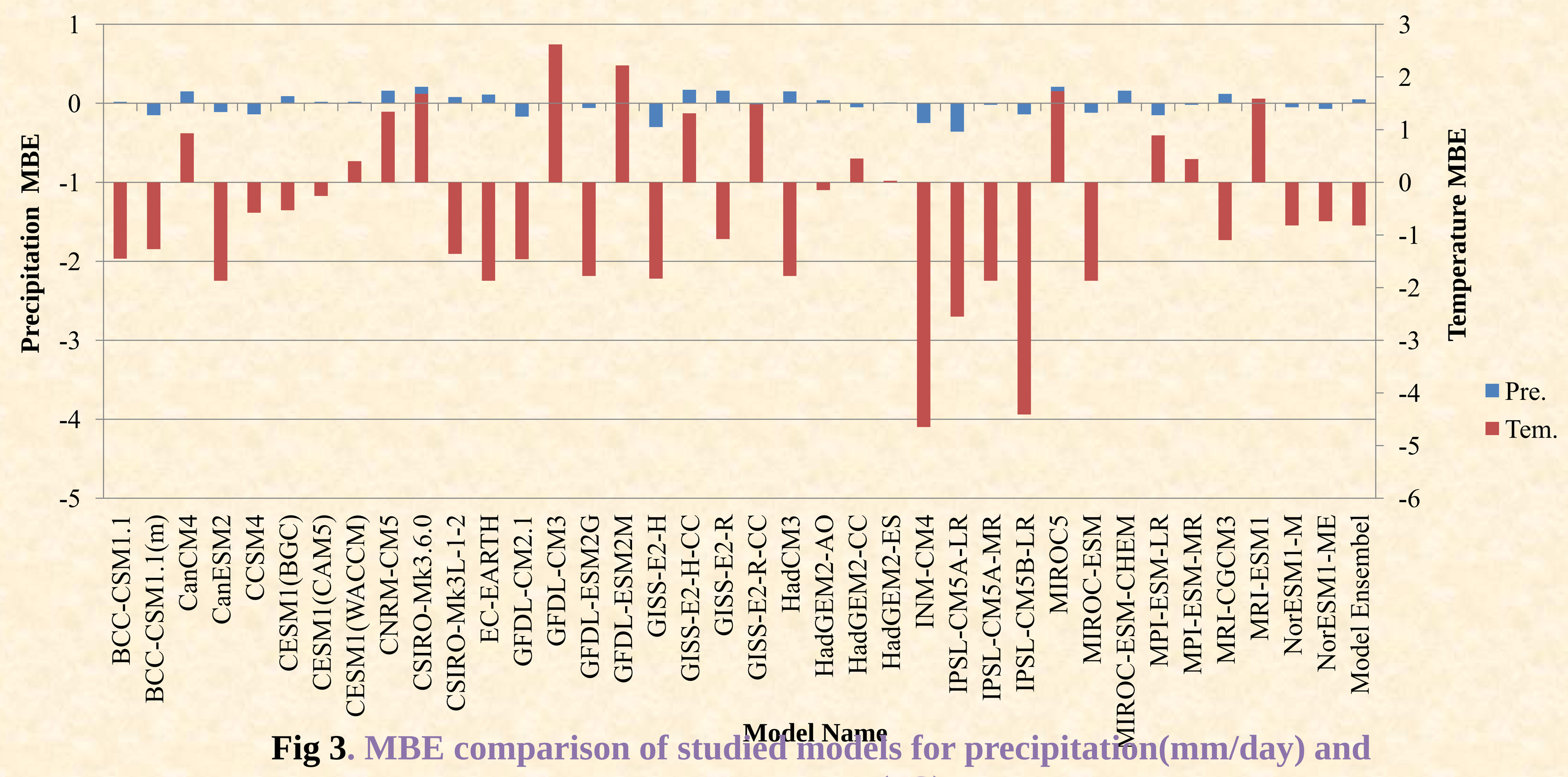

Fig 3. MBE comparison of studied models for precipitation(mm/day) and temperature(oC).

References

1.Ashofteh, P. S., Massah, A. R. (2012). Investigation of AOGCM Model Uncertainty and Emission Scenarios of Greenhouse GasesImpact on the Basin Runoff under Climate Change, Case study Gharanghu Basin, East Azerbaijan. Iran.Water Resources Research. Volume 8, No. 2, pp. 36-47.

2.Kamal, A. R., Massah, A. R. (2012).The uncertainty assessment of AOGCM & Hydrological models for estimating Gharesu basin temperature, precipitation, and runoff under climate change impact. Iranian Water Research Journal. No. 9, pp, 39-50.

3.Katz, R. W. (2002). Techniques for estimating uncertainty in climate change scenarios and impact studies. Climate Research, 20(2), 167-185.

4.Sansom, P. G., Stephenson, D. B., Ferro, C. A., Zappa, G., &Shaffrey, L. (2013). Simple uncertainty frameworks for selecting weighting schemes and interpreting multimodel ensemble climate change experiments. Journal of Climate, 26(12), 4017-4037.

5. Mastrandrea, M. D., et al. (2010). Guidance note for lead authors of the IPCC fifth assessment report on consistent treatment of uncertainty. IPCC Cross-Working Group Meeting on Consistent Treatment of Uncertainties, Jasper Ridge, CA, USA, 6-7 July 2010.