Global warming and Mean Indian summer monsoon

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The rising level in concentration of green house gases(GHGs) in the atmosphere have led to enhanced radiative heating of the earth. Global warming is evident from increase in temperature, sea level rise etc(IPCC,1990,IPCC WG1 TAR,2001). The extreme events of climate system such as floods and droughts is projected(IPCC WG1 TAR, 2001). The impact of climate change on monsoon and its variability is a major issue for Indian subcontinent where agriculture and economic growth is strongly linked to behavior of monsoon. Current versions of Atmosphere-Ocean General Circulation Models(AOGCM) provide reliable simulations of the large scale features of the present day climate but there are uncertainties on regional scale. The present study emphasis the possible impact of climate change on the daily mean summer precipitation focusing on Indian region simulated by ten AOGCMs.

Daily precipitation simulated by ten AOGCMs that participated in IPCC for fourth assessment report is used in the present study. The model output from variety of experiments carried out by different modeling groups throughout the world is archived by PCMDI and made available on request to international research community on pcmdi.llnl.gov/ipcc/about_ipcc.php website. Two experiments namely 1pctto2x (1% per year CO_2 increase to doubling) and 1pctto4x (1% per year CO_2 increase to quadrupling) have been used to study the influence of climate change relative to control experiment. The period 1981-2000 from 'climate of the 20th century project(20C3M)' is used as control. In 1pctto2x experiment, CO_2 is increased by 1% per year for 70 years (time of doubling) and with doubled CO_2 additional 150 years run is carried. In 1pctto4x, CO_2 is increased at the rate of 1% per year for 140 years (time of quadrupling) and then an additional 150 years is made with quadrupled CO_2.The details of various model data available for twenty years in 1pctto2x and 1pctto4x experiments that is used in present study is provided in Table-1.

Mean daily precipitation from control simulations are validated with rainfall observations (averaged for 1981-2000) over Indian land prepared by Indian Institute of Tropical Meteorology(IITM) , Pune, India (personal communication, Revadekar) using data of 200 well distributed stations published by India Meteorological Department (IMD) in Indian Daily Weather Report (IDWR). The daily rainfall grid point data on 0.5^0x$0.5^{0,}$ was prepared from station data using inverse distance method. Daily mean precipitation from 16May-15October in 1pctto2x,1pctto4x and 20C3M experiments of ten AOGCMS and IITM observations averaged over central Indian region from 73^0E-82^0E; 18^0N-28^0N are shown in figure 1(a-j). Observed Mean daily cycle shows normal distribution reaching peak at the end of July. Comparison of control simulations with observation shows that, models underestimate precipitation although the magnitude of underestimation varies from model to model. Among all the models, MIROC3_2_MEDRES best reproduces daily cycle. MRI_CGCM2_3_2a also compares well with observation and only few deficiencies such as late onset and underestimation are found. Few models such as CCCMA_CGCM3_1, ECHAM5/MPI-OM and both versions of GFDL models have double peak during the season. INMCM3.0 and ECHO_G models have peak much latter than observed. The response of mean daily precipitation over central Indian region to increased CO2 is evaluated by comparing 1pctto2x and 1pctto4x with control simulation. Inter model differences are observed in response to climate change such as couple of models shows more increase in precipitation during later part of the season from mid-August and less increase (ECHO_G and GFDL_CM2.1) or even decrease (ECHAM55/MPI-OM,MIROC3_2_3_MEDRES) till mid-August. Marked increase in mean precipitation throughout the season consistently in both climate change scenarios is observed only in MRI_CGCM2_3_2a model. The increase in 1pctto2x simulation is of slightly lower magnitude than 1pctto4x. In MIROC_2_3_MEDRES, increase is only during peak. GFDL_CM2.0 model does not show any change in both climate change experiments.

References:

IPCC,1992: The supplementary Report to the IPCC,1990,Scientific assessment, WMO-UNEP, Cambridge University press, Cambridge,200pp.

IPCC, 2001: Climate change 2001;The scientific basis. Contributions of working group I to third assessment report of IPCC(J.T. Houghton et al) Cambridge University press, Cambridge, UK and New York,NY,USA,881 pp

Table 1 : Details of model integration period considered for analysis

Sr. No.	*Model*	*1pctto2x*		*1pctto4x*	
		First 20-years	Last 20-years	First 20-years	Last 20-years
1	GFDL_CM2.0	---	2061-2080	---	2131-2150
2	GFDL_CM2.1	---	2061-2080	---	2131-2150
3	MRI_CGCM2_3_2A	2001-2020	---	2071-2090	---
4	MIROC3_2_MEDRES	---	2051-2070	---	2121-2140
5	CCCMA_CGCM3_1	---	2050-2069	---	2120-2139
6	ECHAM5/MPI-OM	---	2061-2080	---	2131-2150
7	GISS_e_r	2101-2120	---	2171-2190	---
8	IPSL_CM4	---	2061-2080	---	---
9	INMCM3.0	---	2071-2090	---	2141-2160
10	ECHO_G	2051-2070	2261-2280	2121-2140	2261-2280

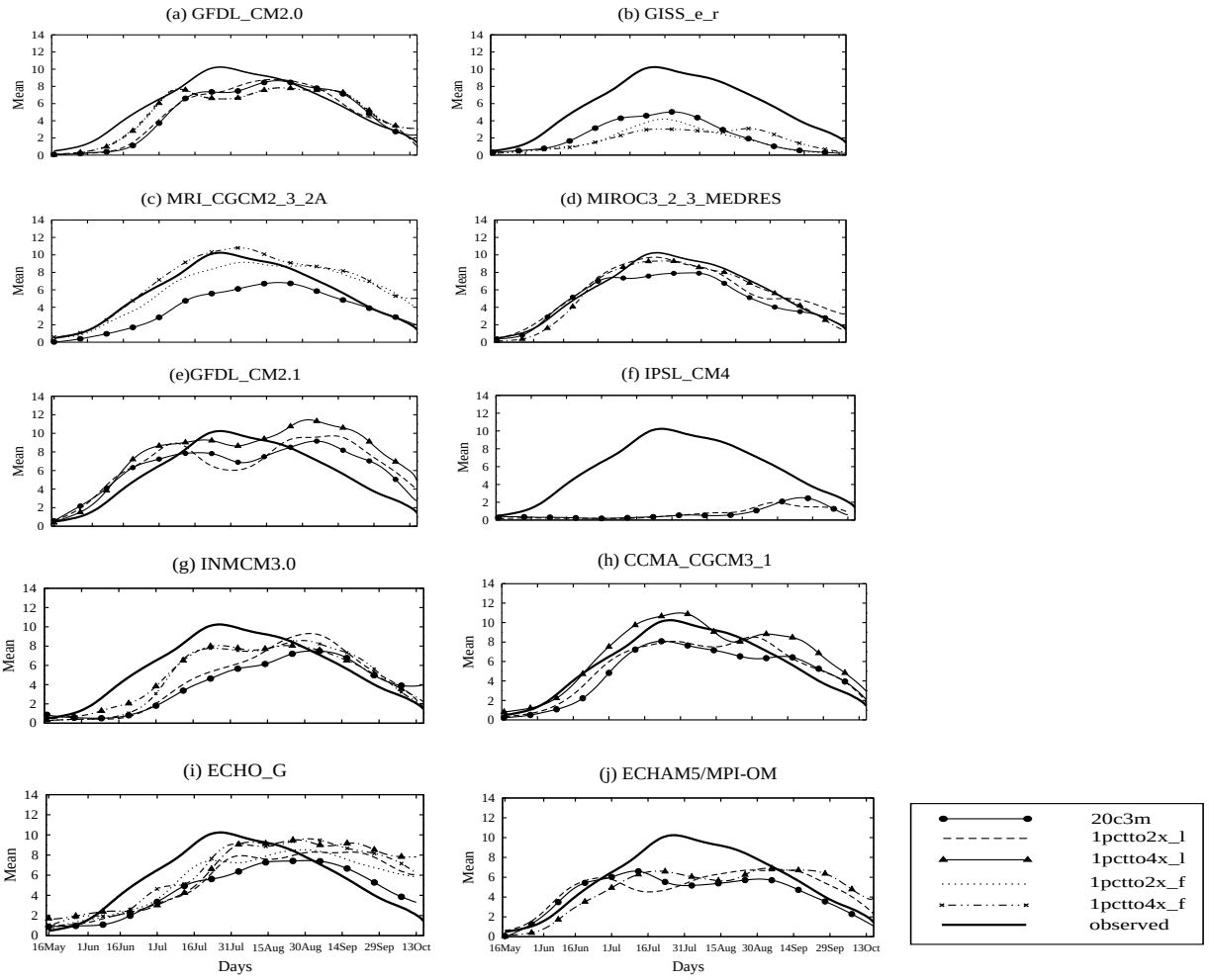

Figure 1: Daily precipitation climatology