MULTI MODEL ENSEMBLE FOR ASSESSING THE IMPACT OF CLIMATE CHANGE ON THE HYDROLOGY OF A SOUTH INDIAN RIVER BASIN

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2017 International SWAT Conference in Warsaw, Poland

June 28-30, 2017

Introduction

- Climate models have uncertainties and biases due to
  - imperfect model representation of climate processes,
  - imperfect knowledge of current climate conditions,
  - difficulty in representing inter annual and decadal variability
  - uncertainty in future levels of anthropogenic emissions and natural forcings

Introduction

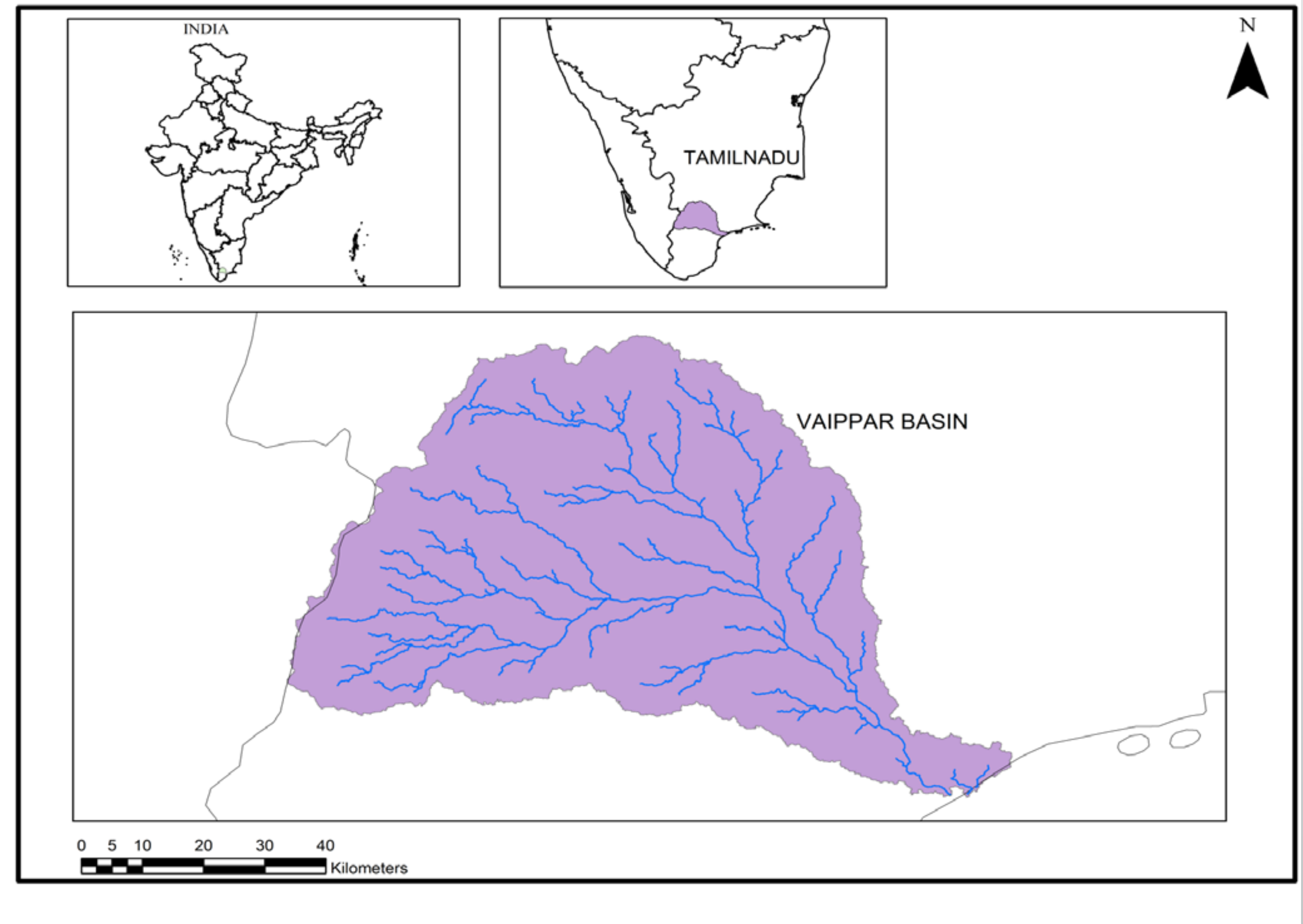
- Multi-model ensembles (MME) are considered superior to single models (IPCC 2001, Duan and Phillips 2010, Miao et al 2013).
- Multi model ensembles consist of a group of comparable climate model simulations
  - widely utilized to provide useful insights into uncertainty
  - estimates of climate model projections are represented as a bound on the range of uncertainty

Objective

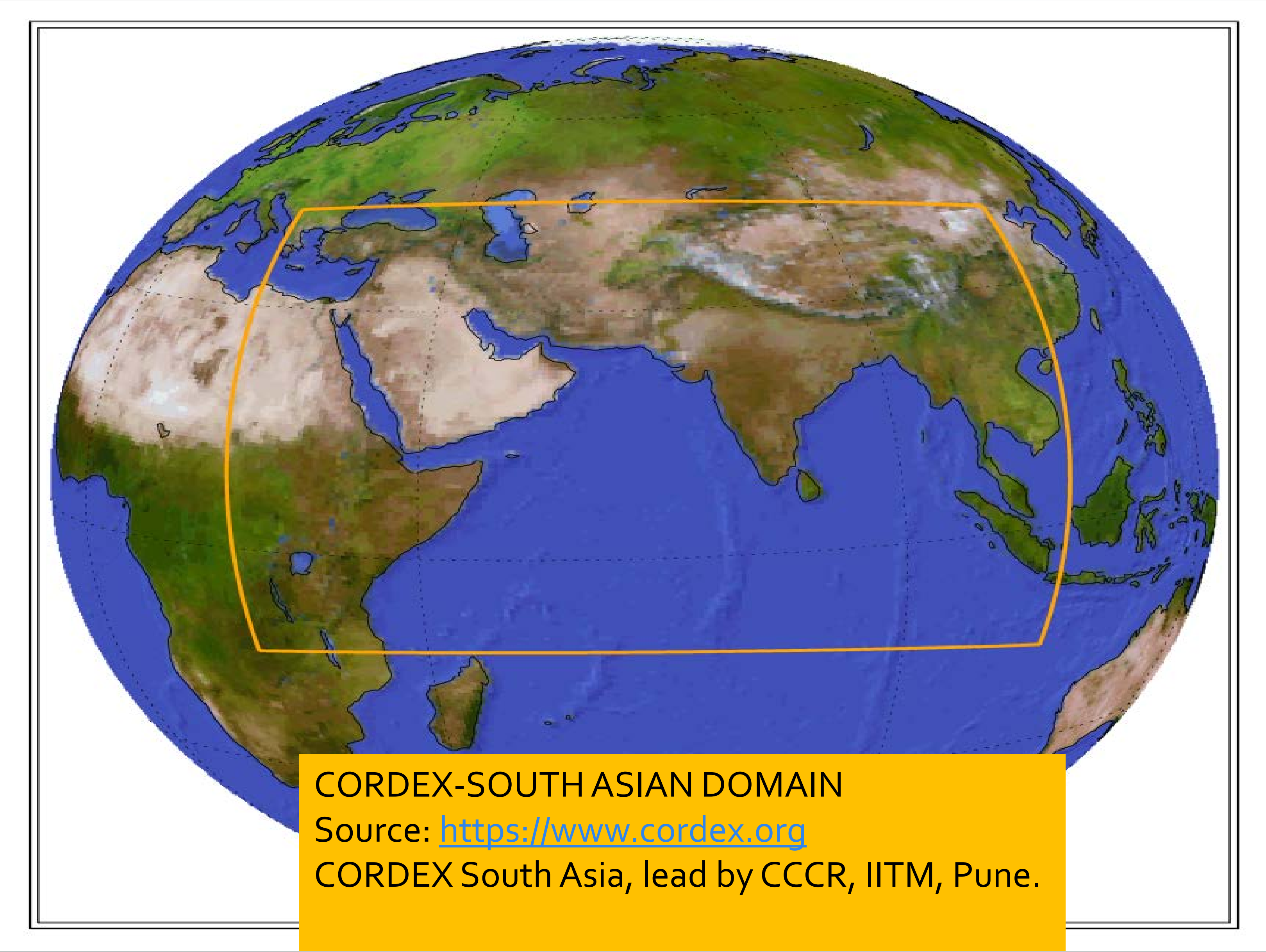
- Assess the implications of climate change on the hydrology and water resources of Vaippar Basin, Tamil Nadu, India.
  - using a multi model ensemble approach in which downscaled and bias corrected output from 6 General Circulation Models (GCMs) using SWAT model.

Study area

- Vaippar basin, Tamil Nadu
  - Catchment area- 5423km^2
  - Mean annual precipitation
    - 750mm



Data used



CORDEX-SOUTH ASIAN DOMAIN
Source: https://www.cordex.org
CORDEX South Asia, lead by CCCR, IITM, Pune.

Data used

- **ACCESS1.0, CNRM-CM5.0, CCSM4, GFDL-CM3.0, MPI-ESM-LR, Nor-ESM-M**
  - Dynamically downscaled using Conformal-Cubic Atmospheric Model (CCAM)
- Bias corrected daily precipitation, minimum and maximum temperature (Q-Q adjustments)
  - Using Observed rainfall and temperature data from IMD (1901-2014)
- Selected emission scenarios - RCP 4.5 and 8.5
  - 1970-2005(historic)
  - 2006-2040(early century)
  - 2041-2070 (mid century)

Methodology

- A simple approach developed by Giorgi and Mearns (2002) for climate change estimates and associated uncertainty range has been adopted
- Uncertainty is measured by root-mean-square difference (RMSD) for precipitation

$$\delta_{\Delta P} = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\Delta P_i - \overline{\Delta P}\right)^2\right]^{1/2}$$

- Multi Model Ensemble (MME) average uncertainty interval for precipitation

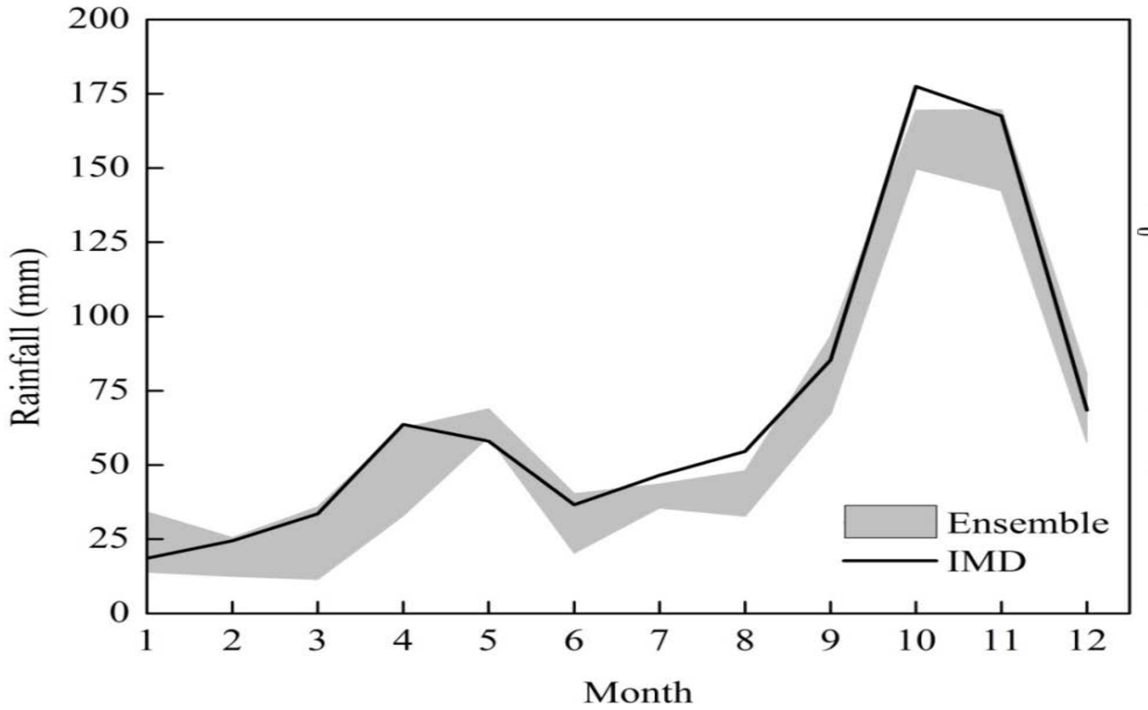
$$\overline{\Delta P} \pm \delta_{\Delta P}$$

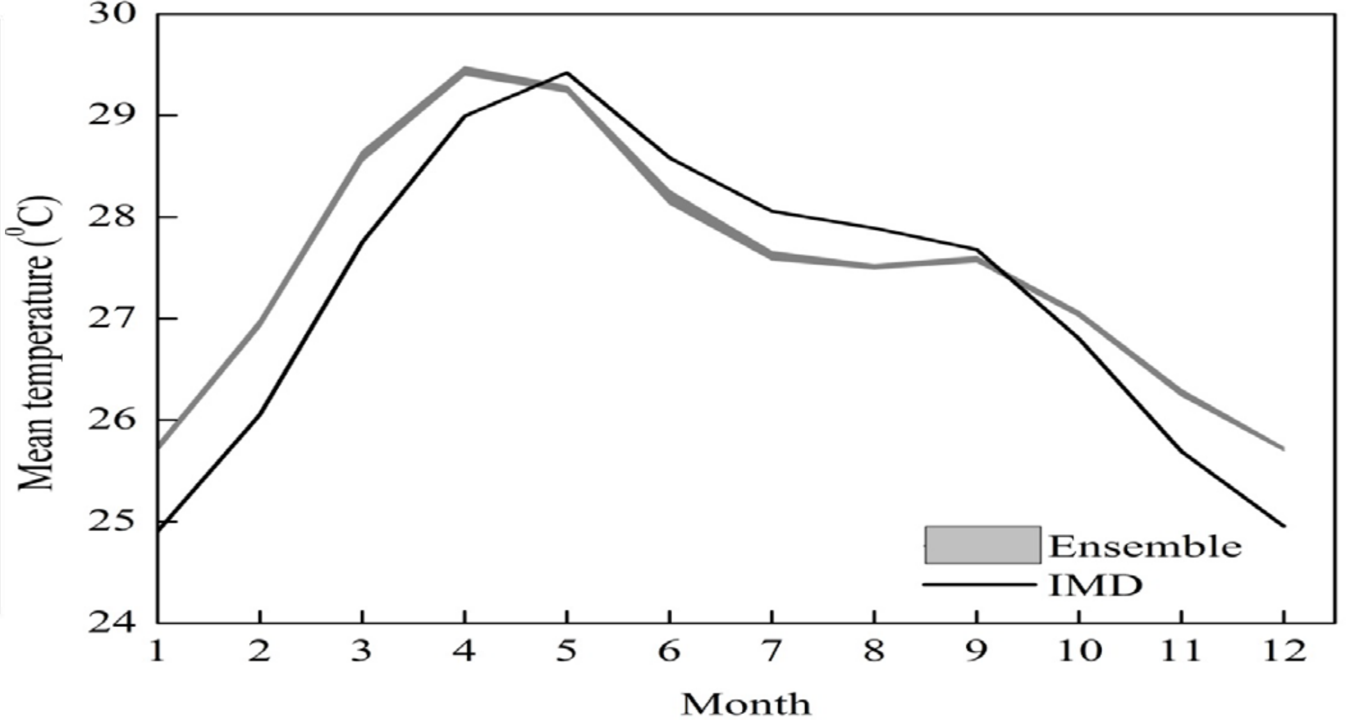
- Where $\overline{\Delta P}$ MME average relative change in the precipitation

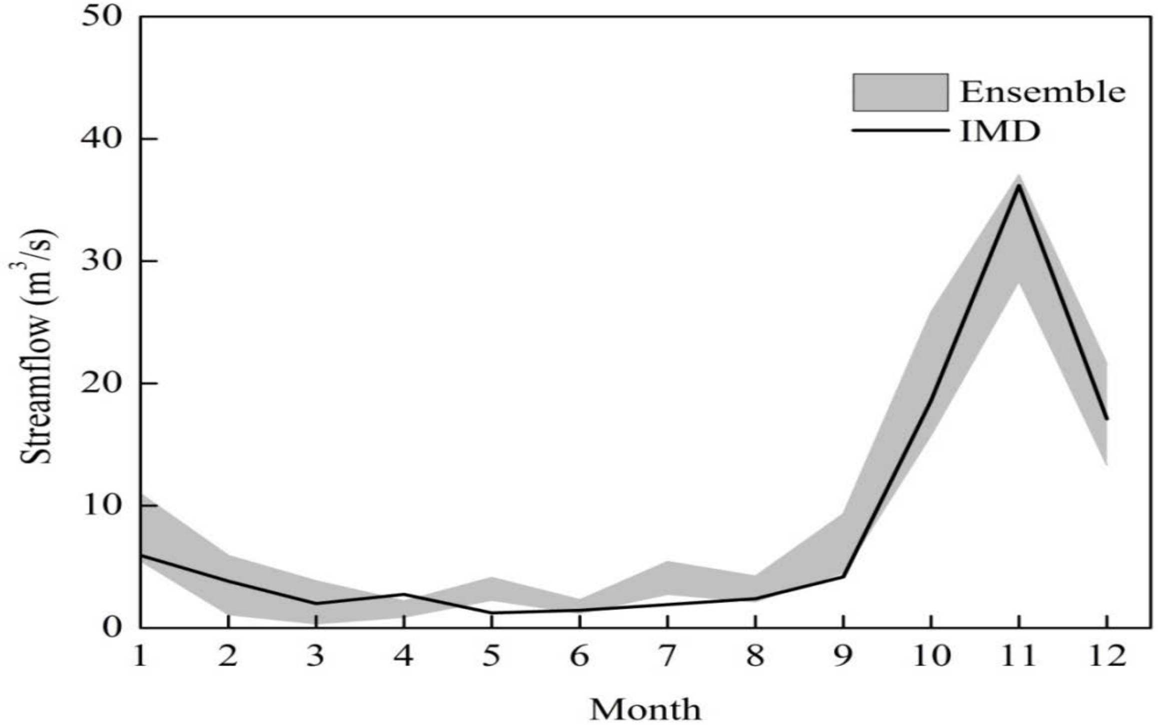
N– total number of models , i= a particular model chosen

Methodology

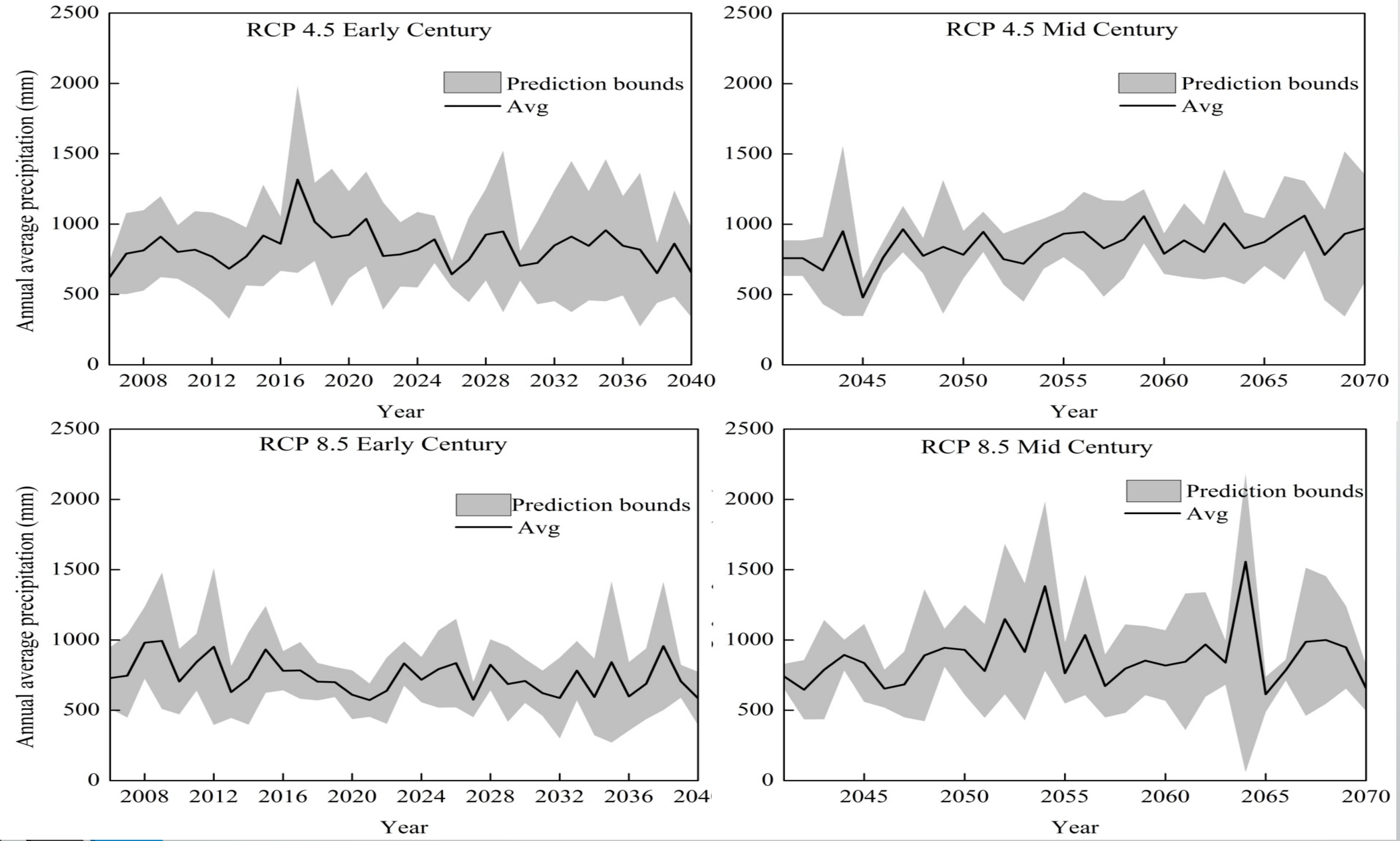
- Uncertainty assessment for both temperature and precipitation were done
  - Annual and Monthly
- Calibrated SWAT model was further used to quantify the associated uncertainty in
  - mean monthly runoff
  - Annual and monthly flow duration curves (FDC)
  - Annual maximum series (AMS)
  - Annual water yield



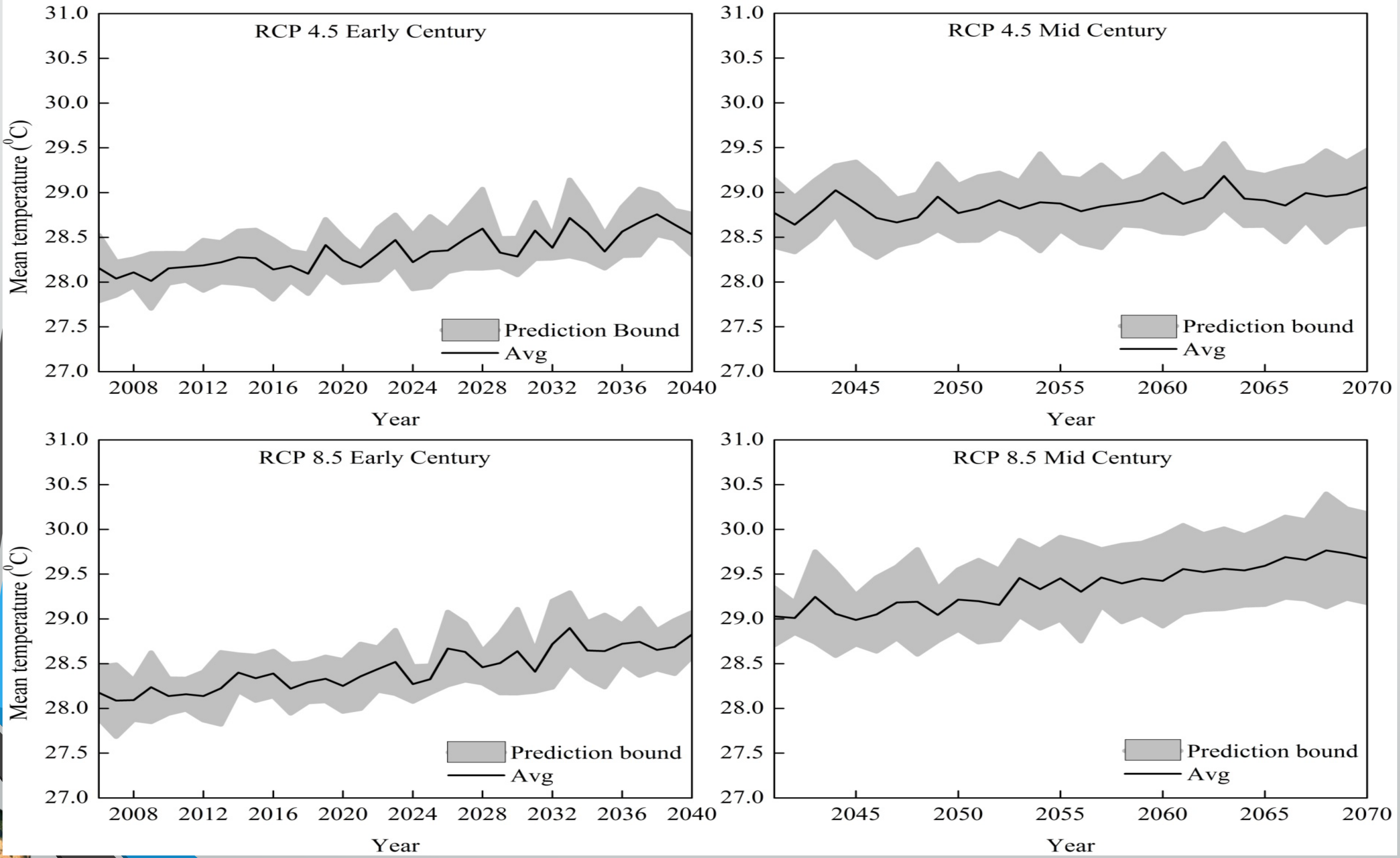




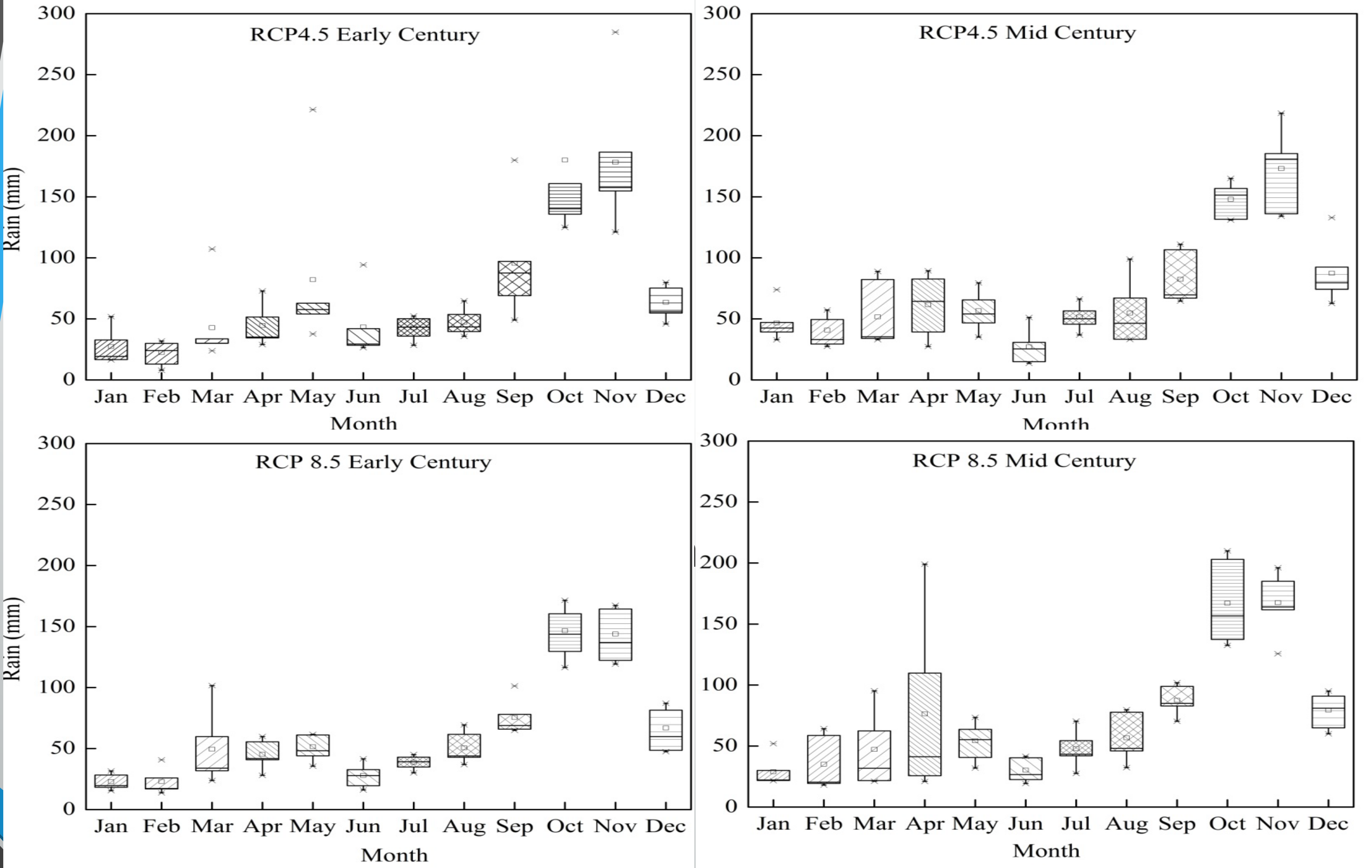
MME simulations of average monthly precipitation, temperature and streamflow along with IMD data for current climate



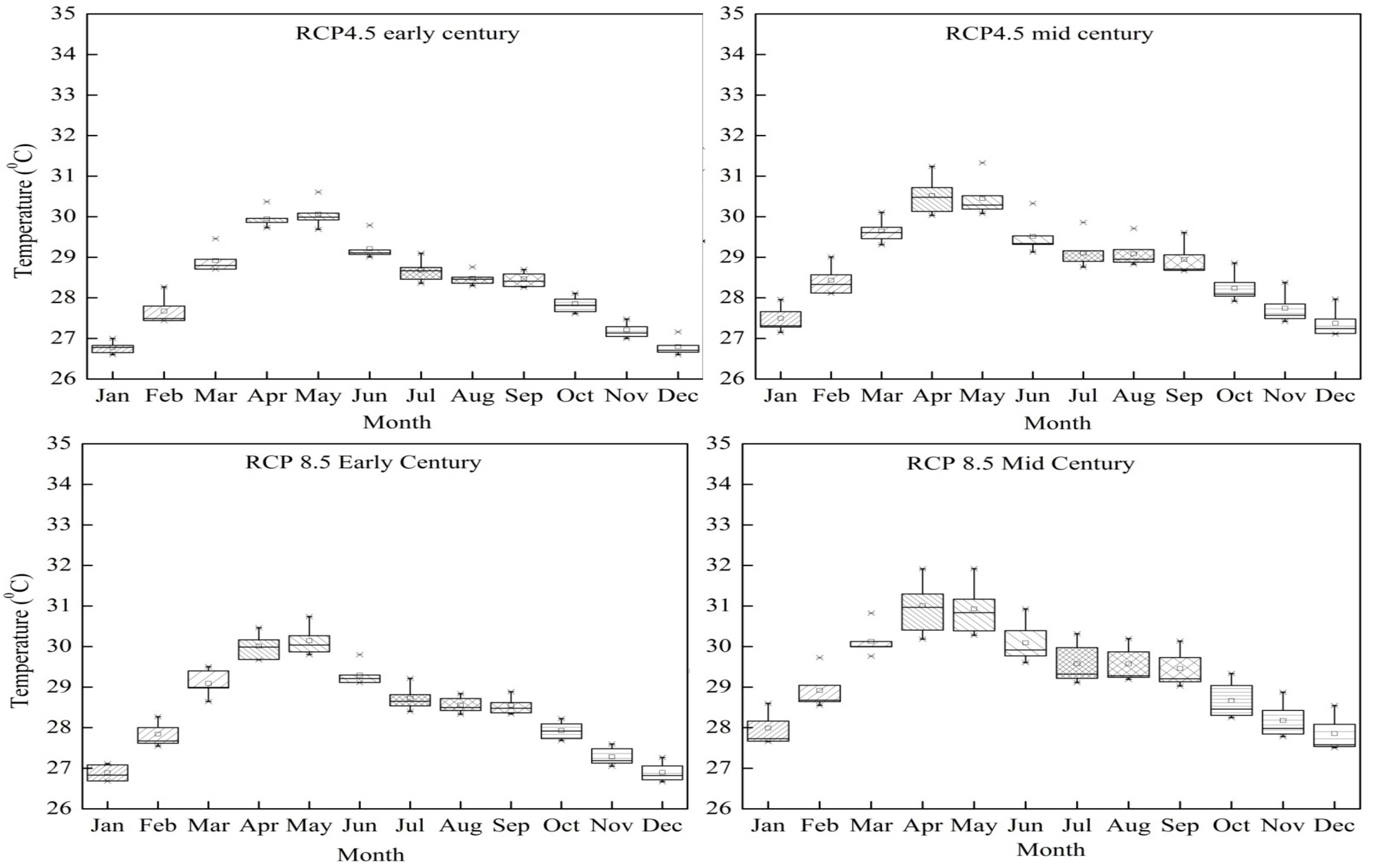
Projected average Rainfall over the Vaippar basin

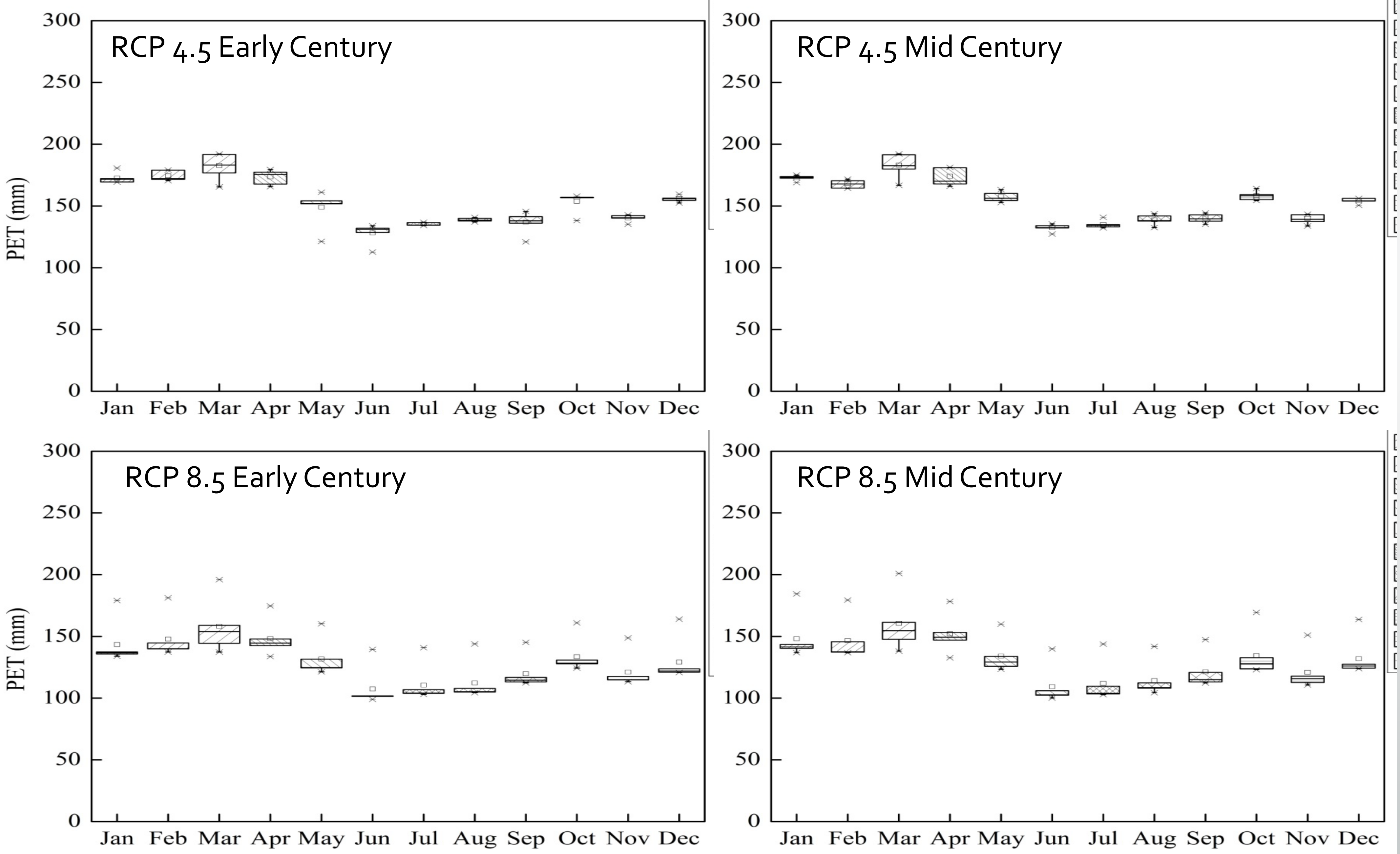


Projected average temperature over the Vaippar basin

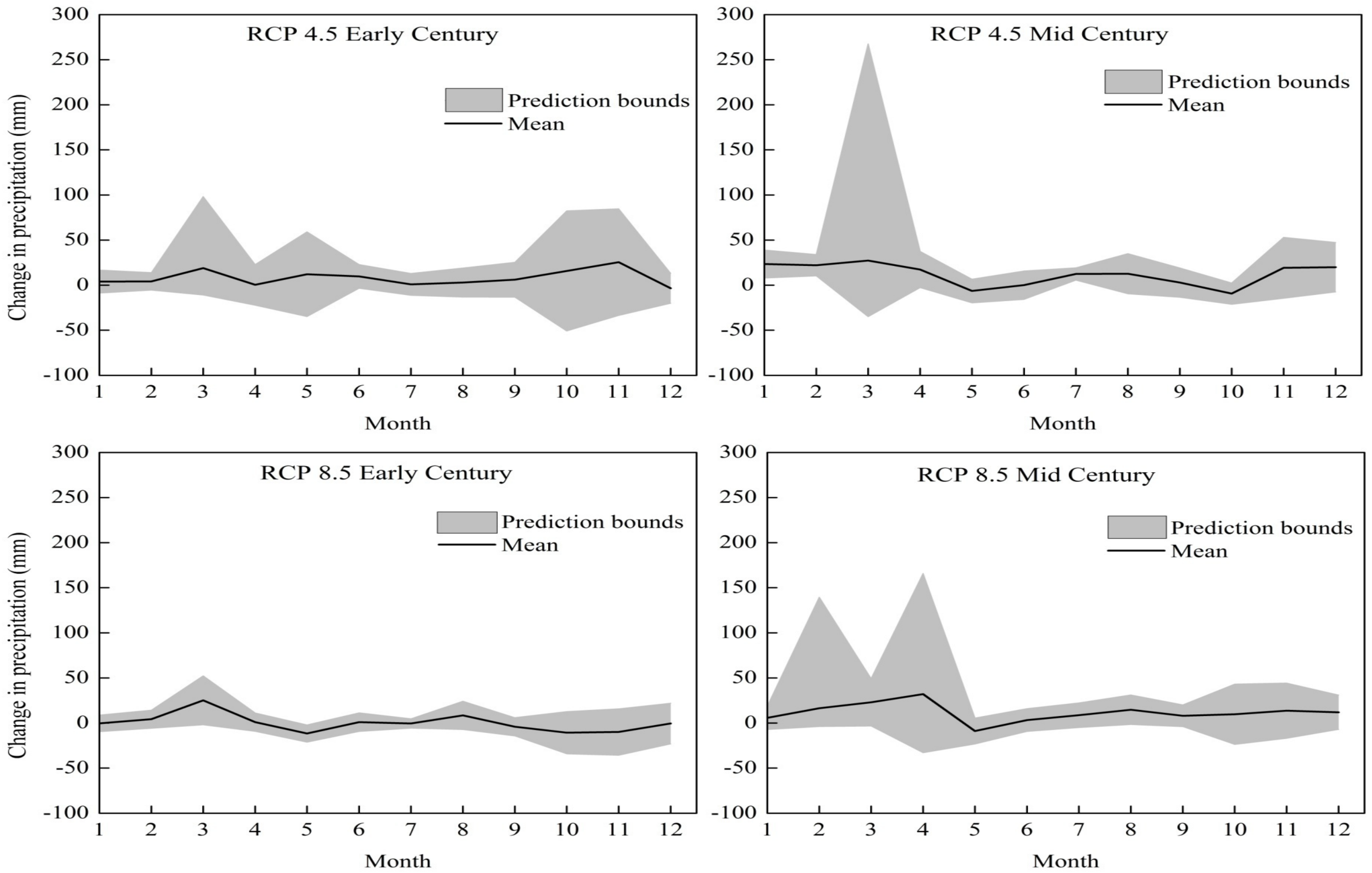


RCP4.5 Early Century
RCP4.5 Mid Century
RCP 8.5 Early Century
RCP 8.5 Mid Century
Rain (mm)
Month
0
50
100
150
200
250
300
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

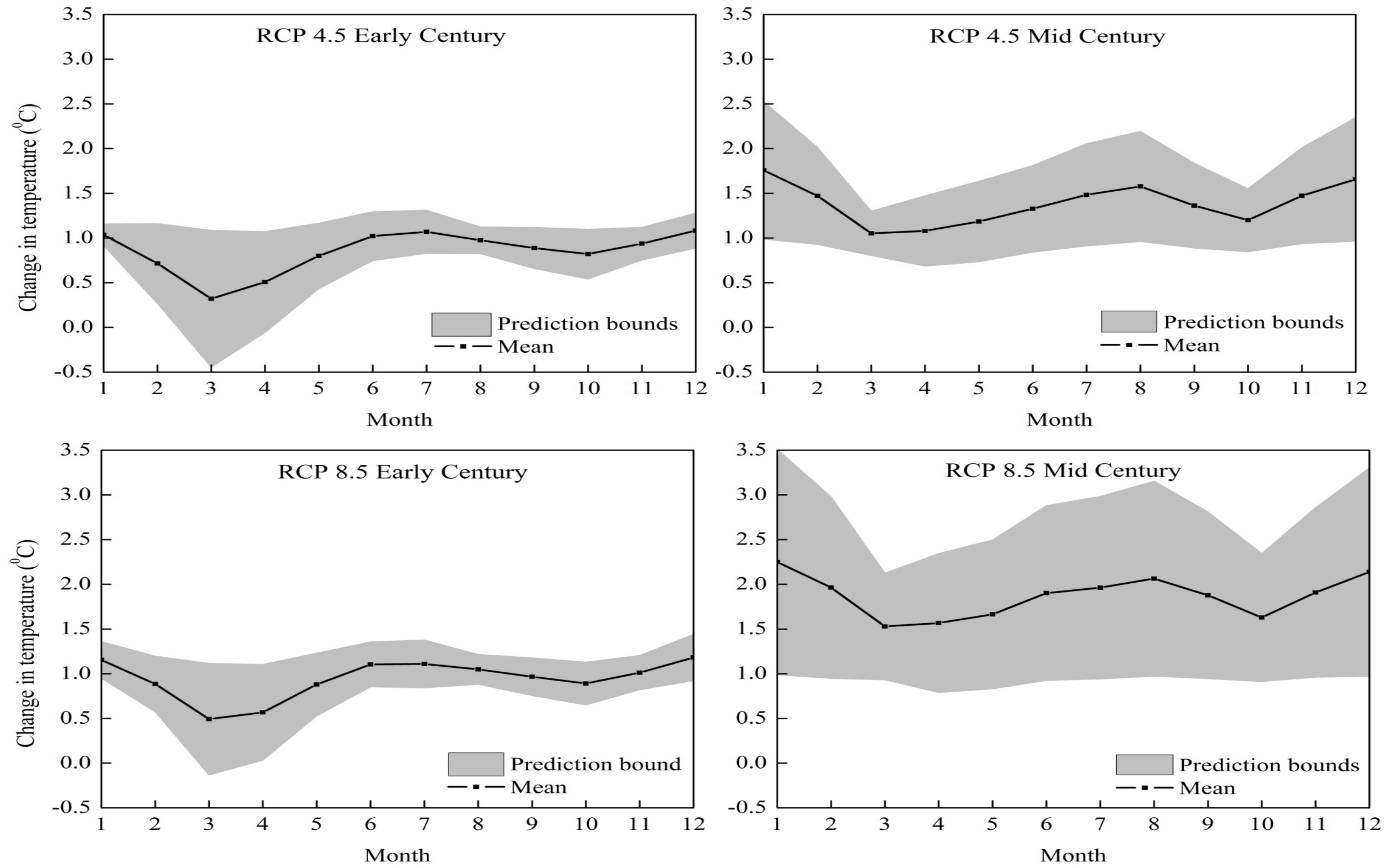

RCP4.5 early century
RCP4.5 mid century
RCP 8.5 Early Century
RCP 8.5 Mid Century
Temperature (⁰C)
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
26 27 28 29 30 31 32 33 34 35

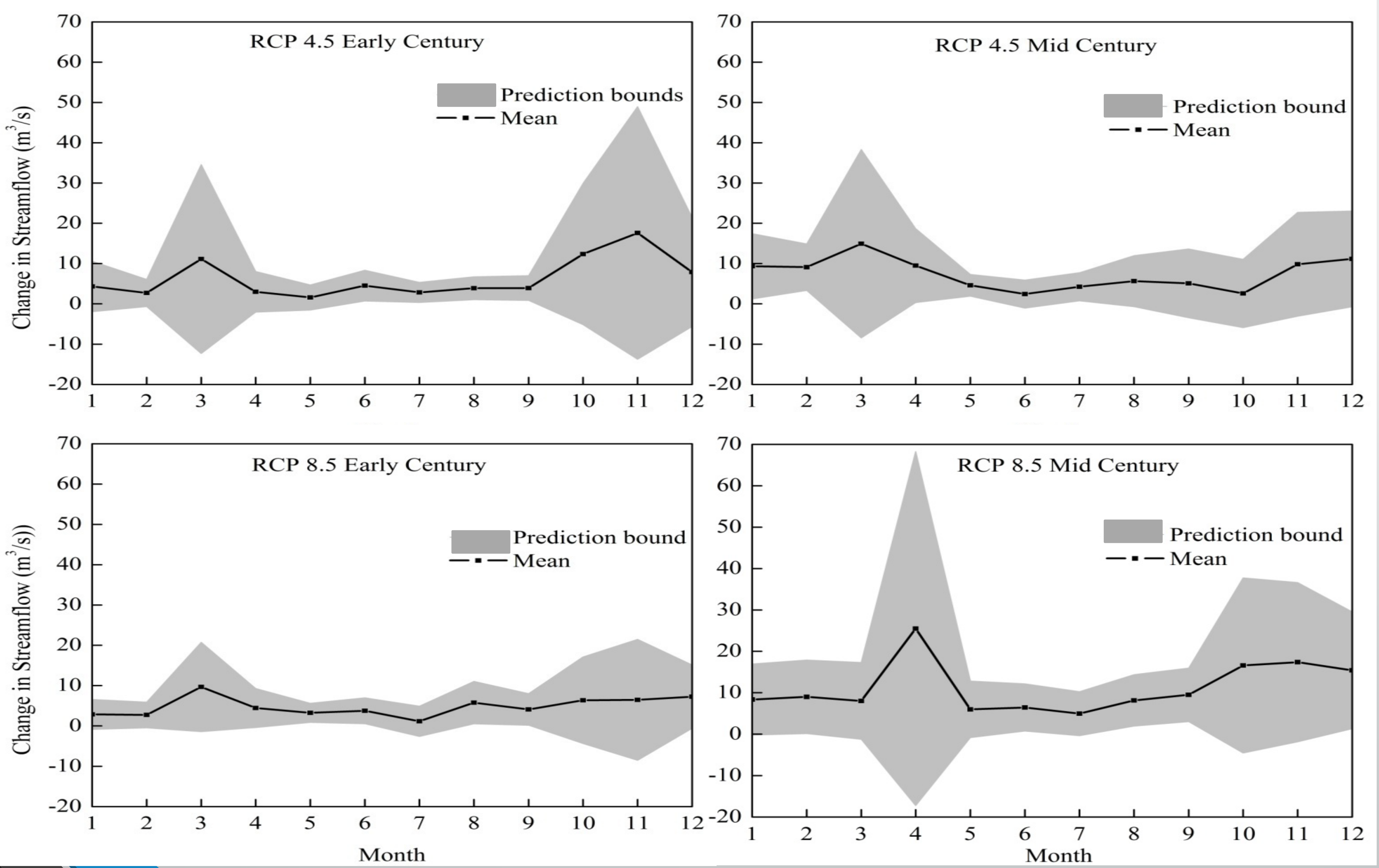


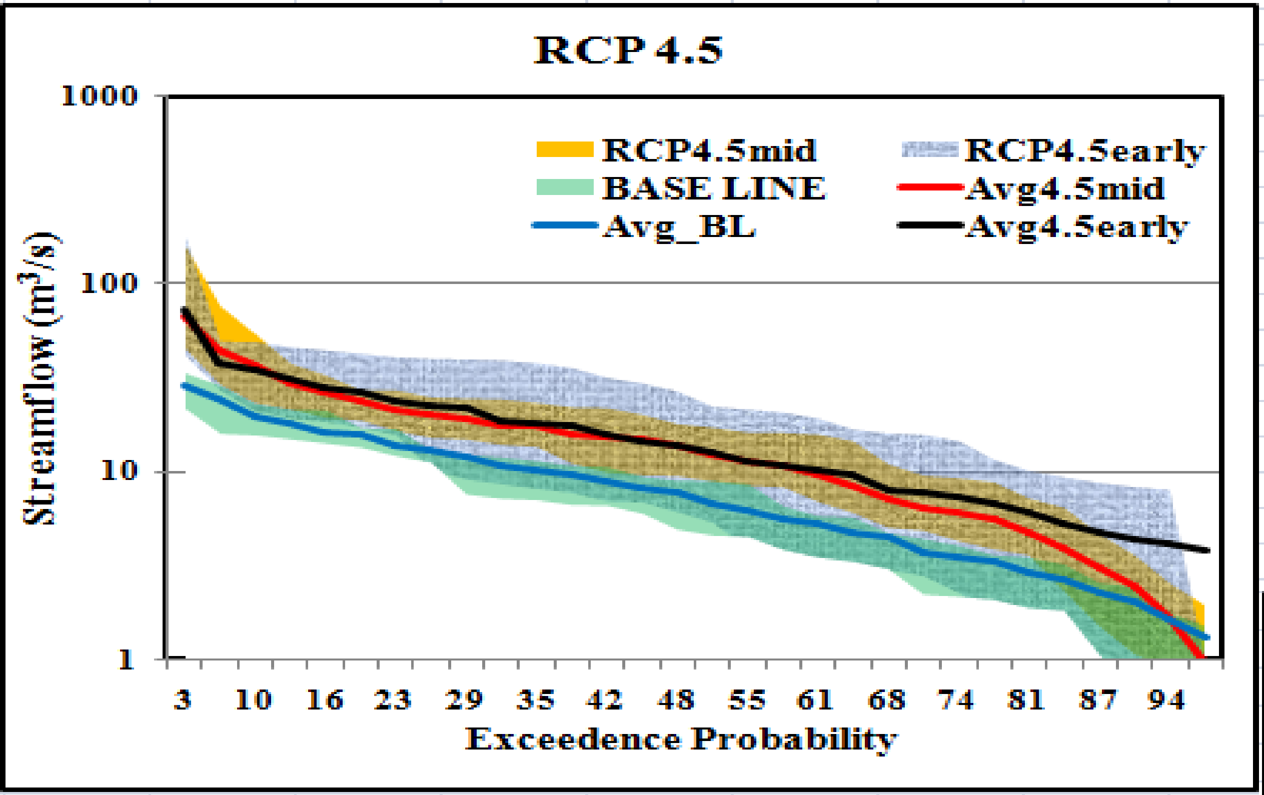
Box plot showing the variability in PET


RCP 4.5 Early Century
RCP 4.5 Mid Century
RCP 8.5 Early Century
RCP 8.5 Mid Century
Prediction bounds
Mean
Change in precipitation (mm)
Month
300
250
200
150
100
50
0
-50
-100
1
2
3
4
5
6
7
8
9
10
11
12

Projected changes in mean monthly temperature

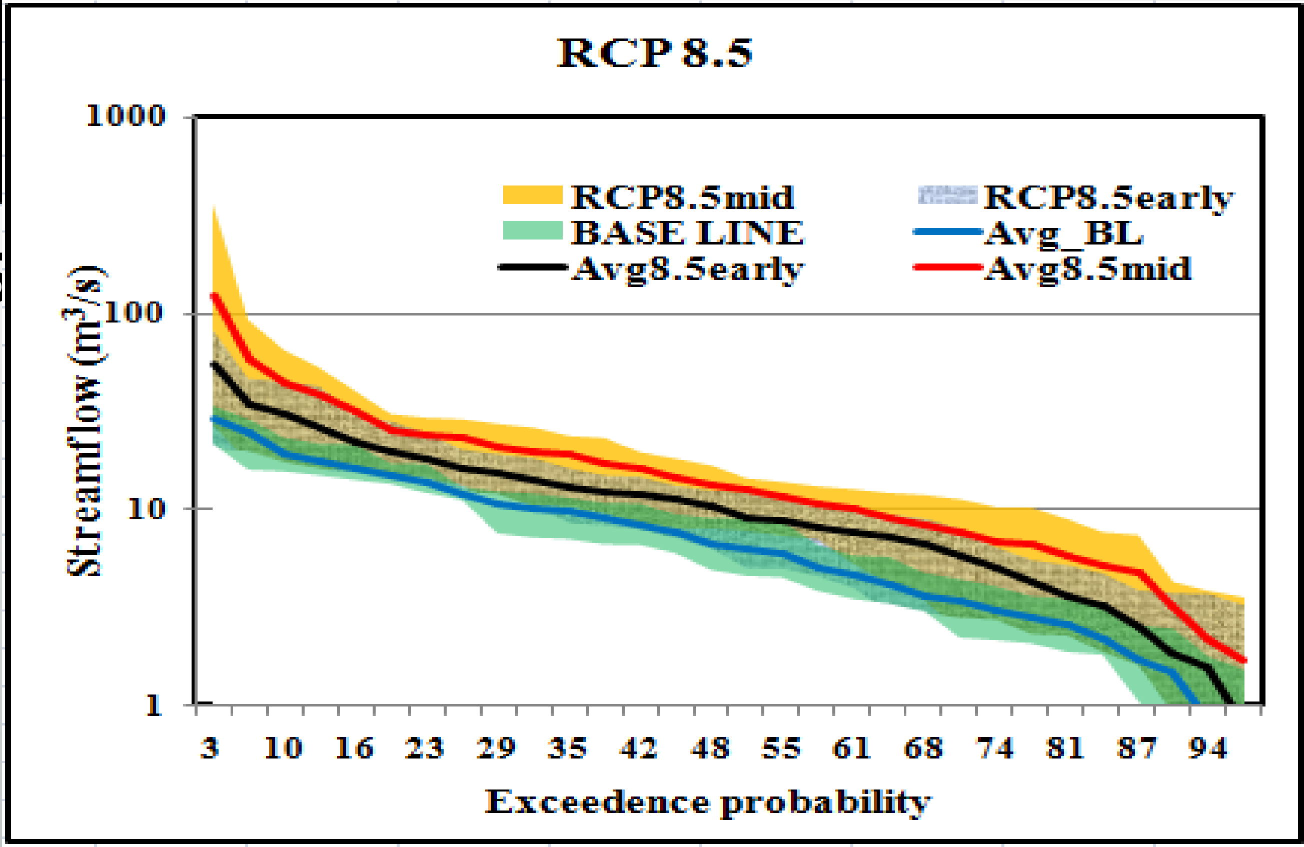



RCP 4.5 Early Century
Prediction bounds
Mean
RCP 4.5 Mid Century
Prediction bound
Mean
RCP 8.5 Early Century
Prediction bound
Mean
RCP 8.5 Mid Century
Prediction bound
Mean
Change in Streamflow (m^3/s)
Change in Streamflow (m^3/s))
Month
Month

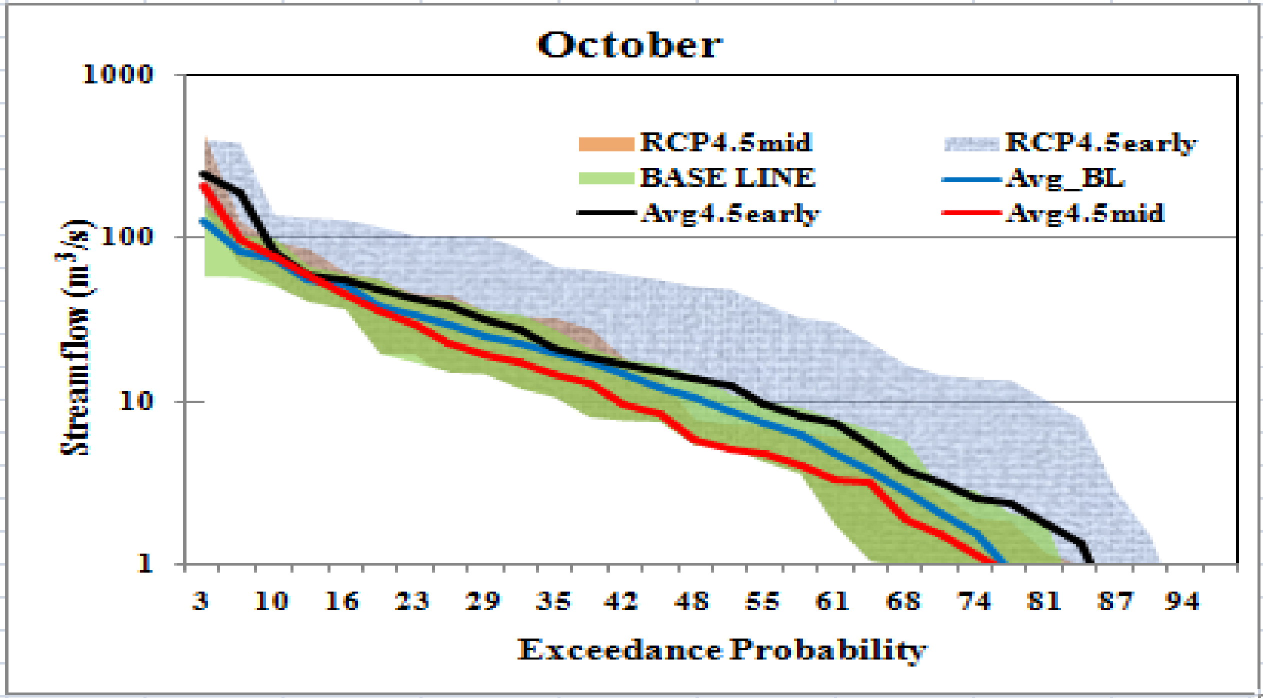


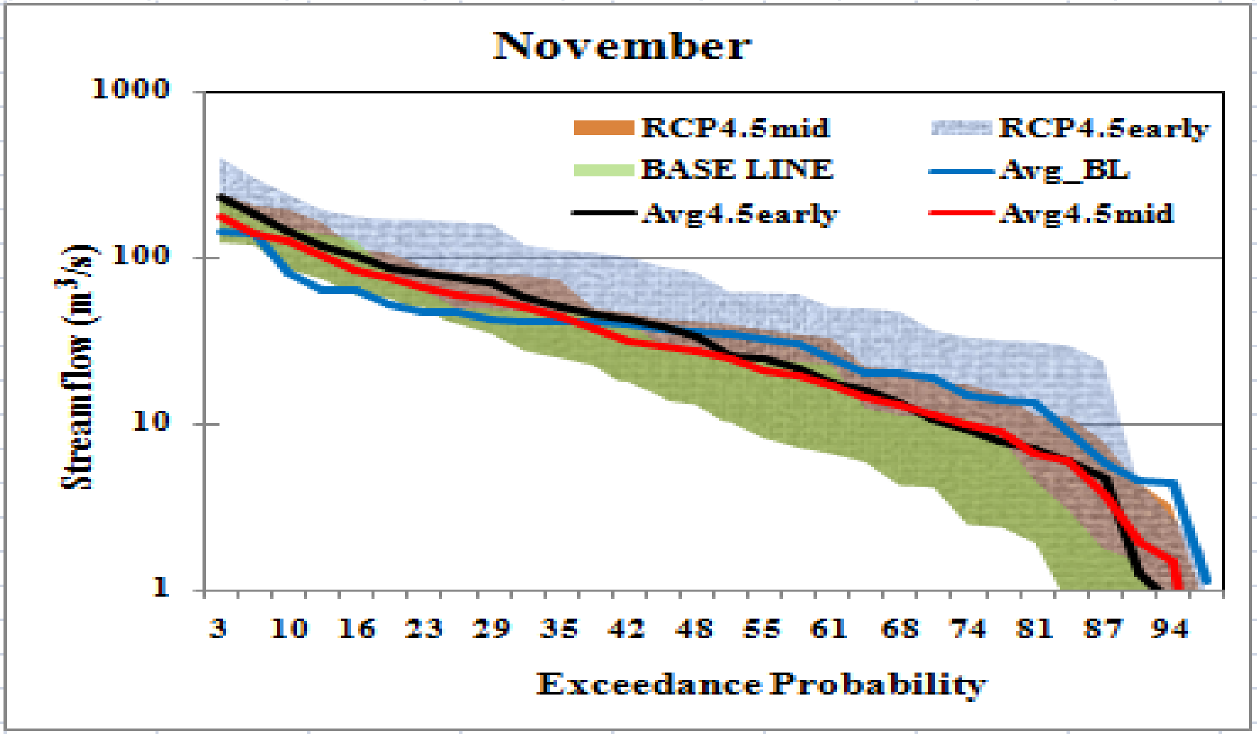
Annual flow duration curve for RCP 4.5

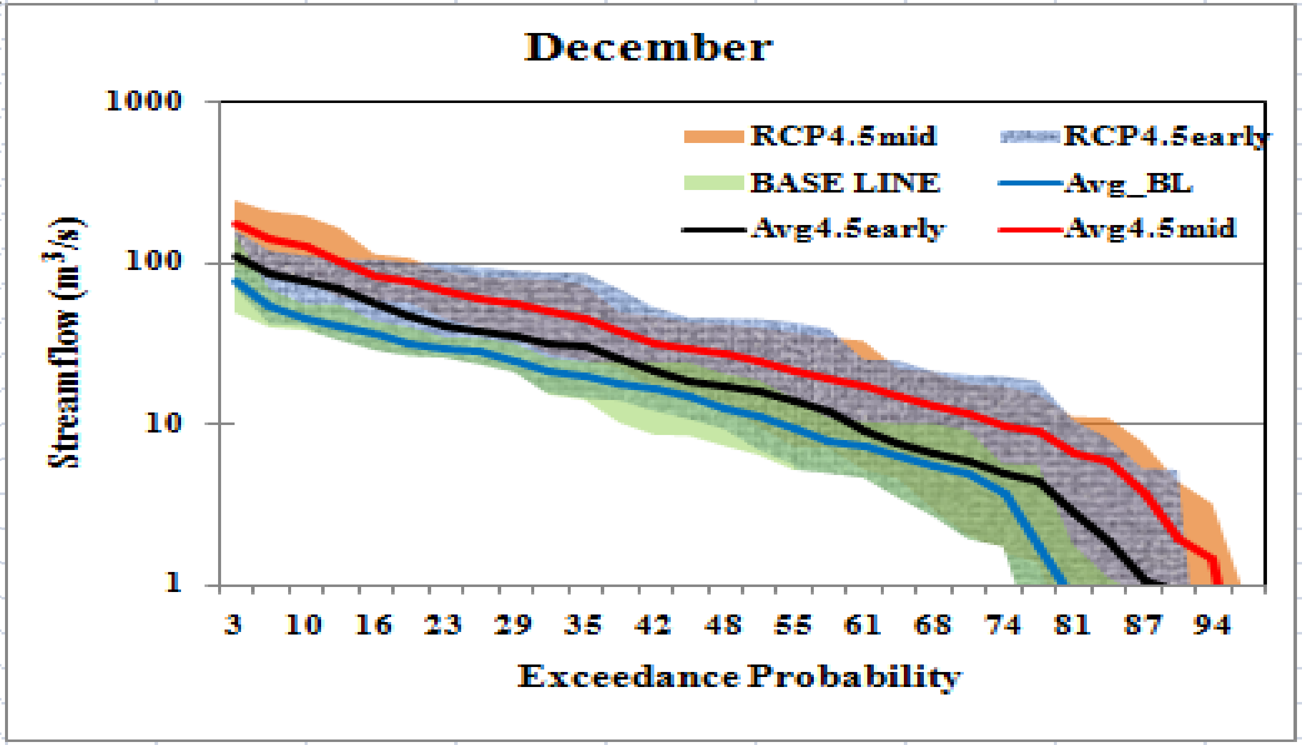
Annual flow duration curve for RCP 8.5



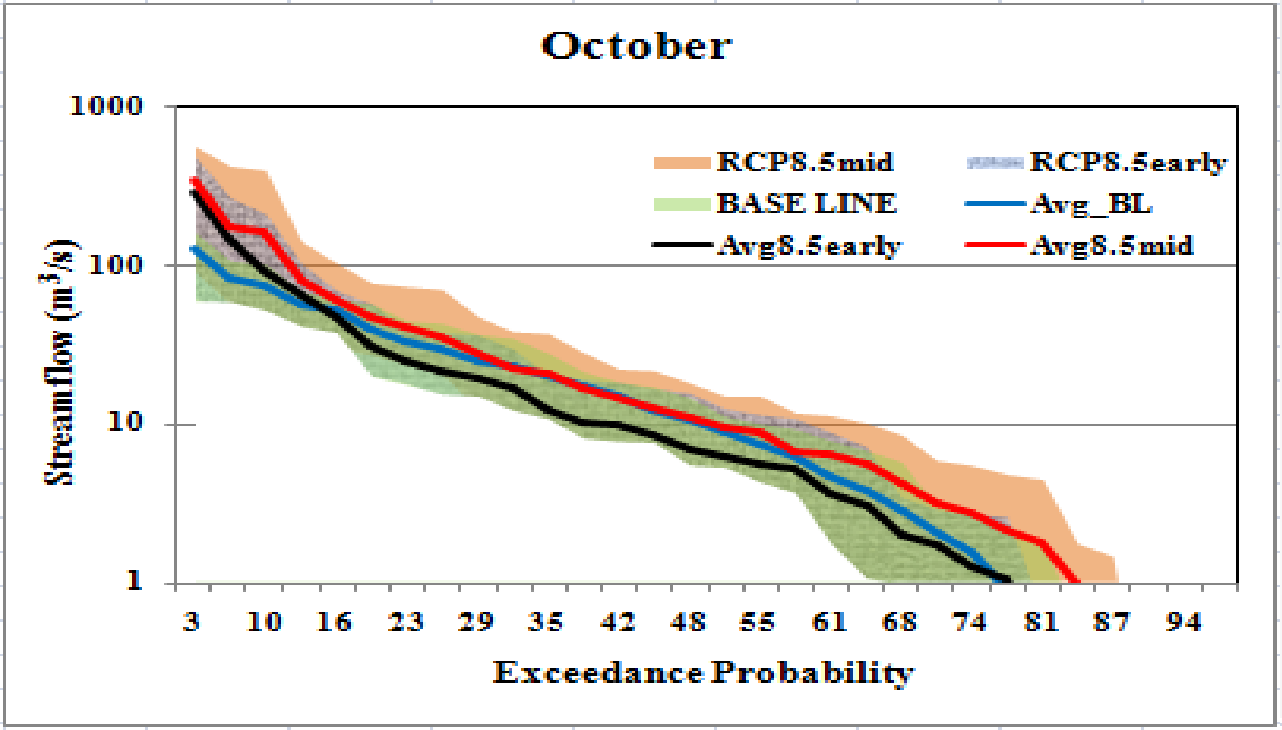
Flow duration curves of October –December (major rainy season) for RCP 4.5

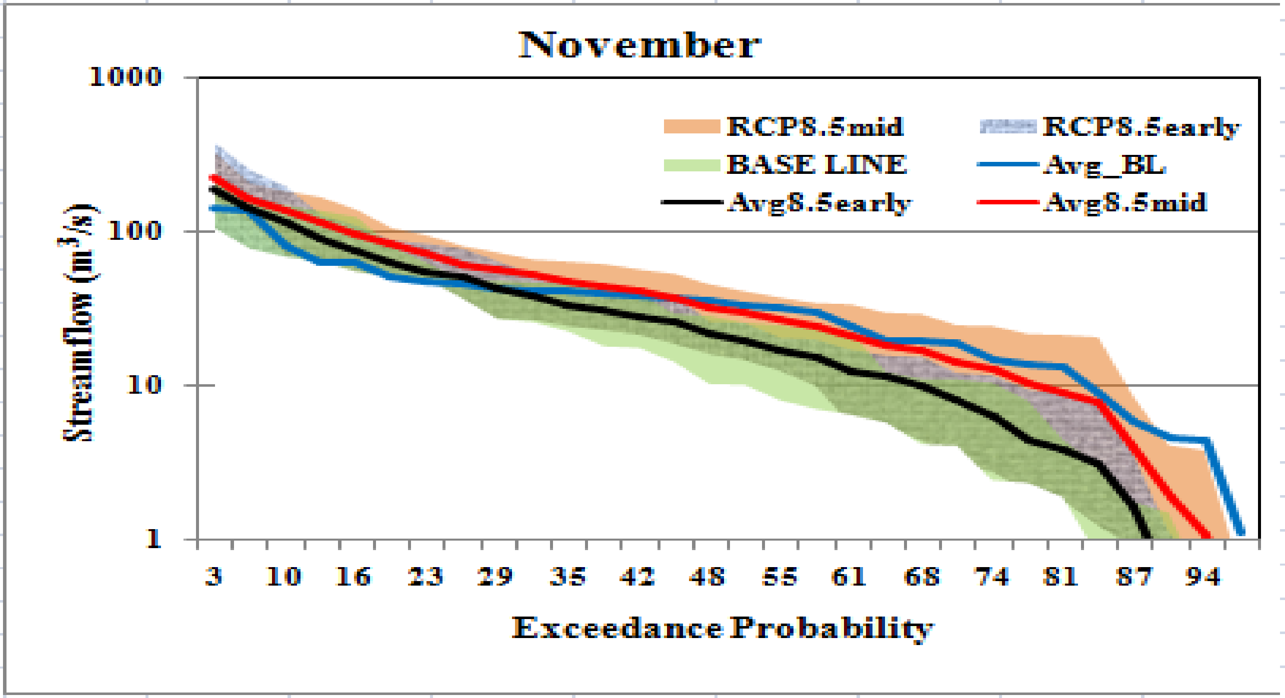


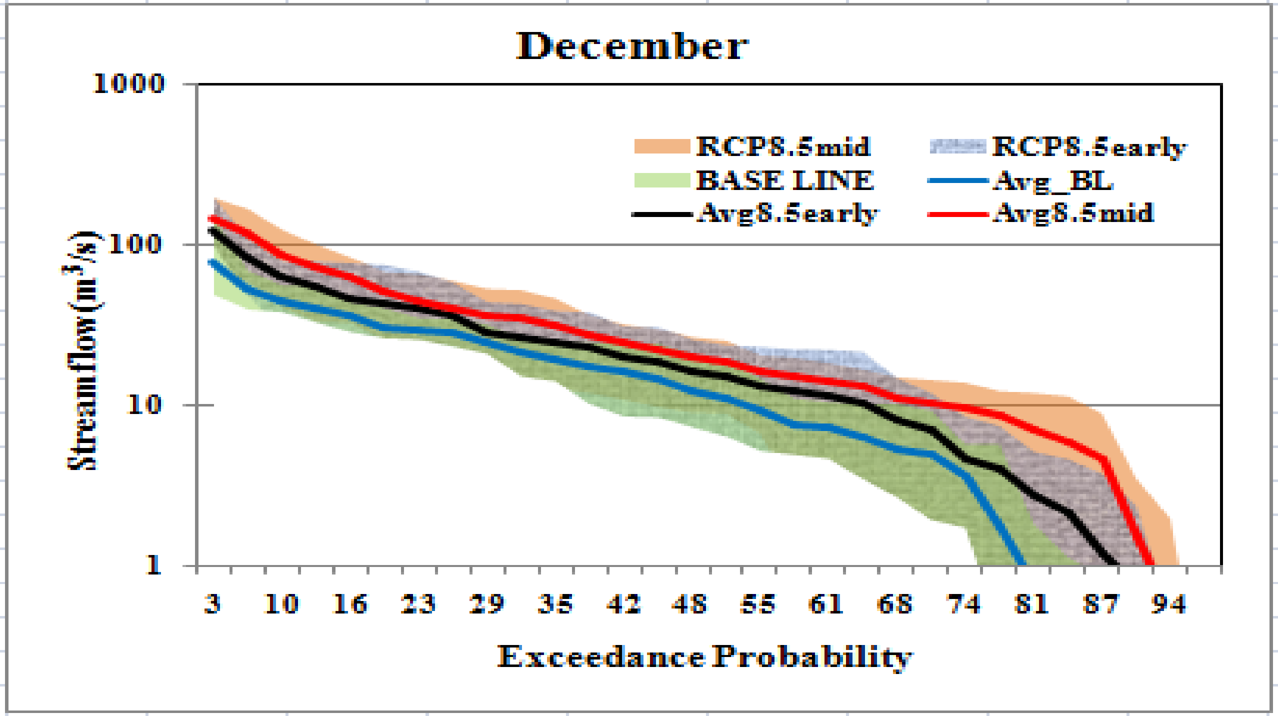


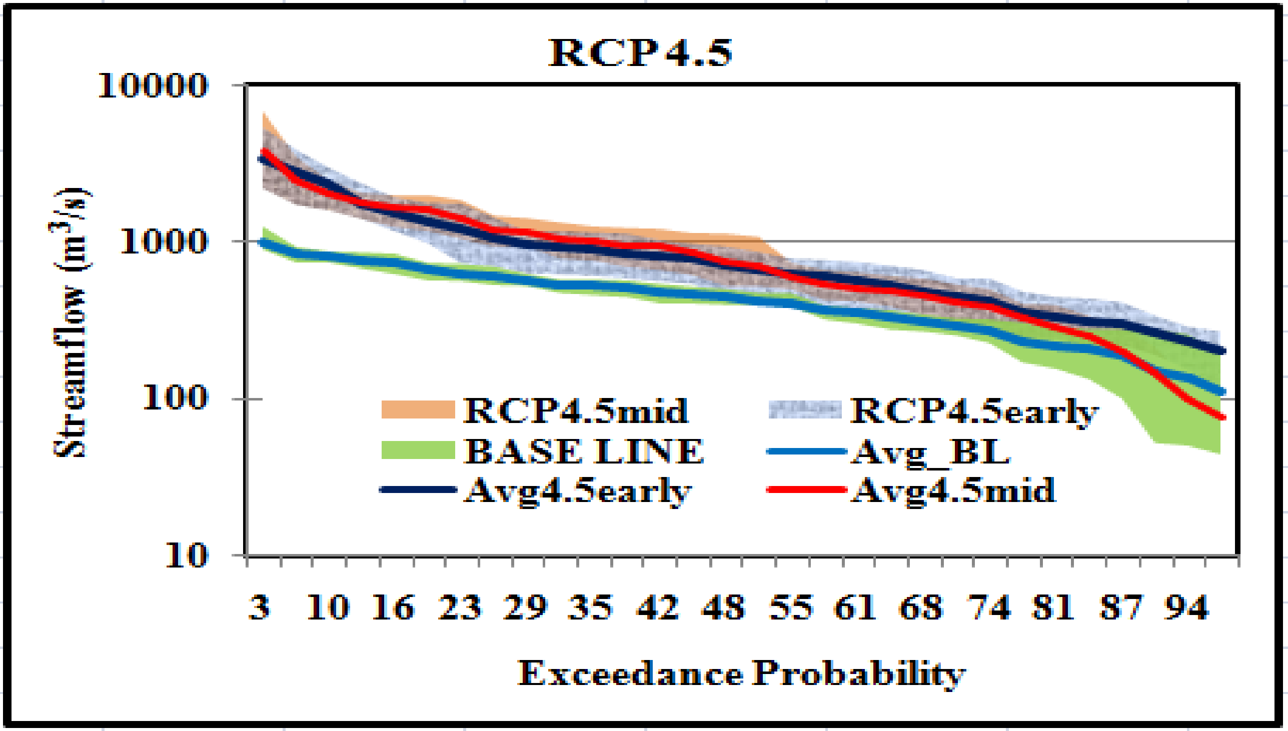


Flow duration curves of October –December (major rainy season) for RCP 8.5









Annual Maximum series for RCP 4.5

Annual Maximum series for RCP 8.5

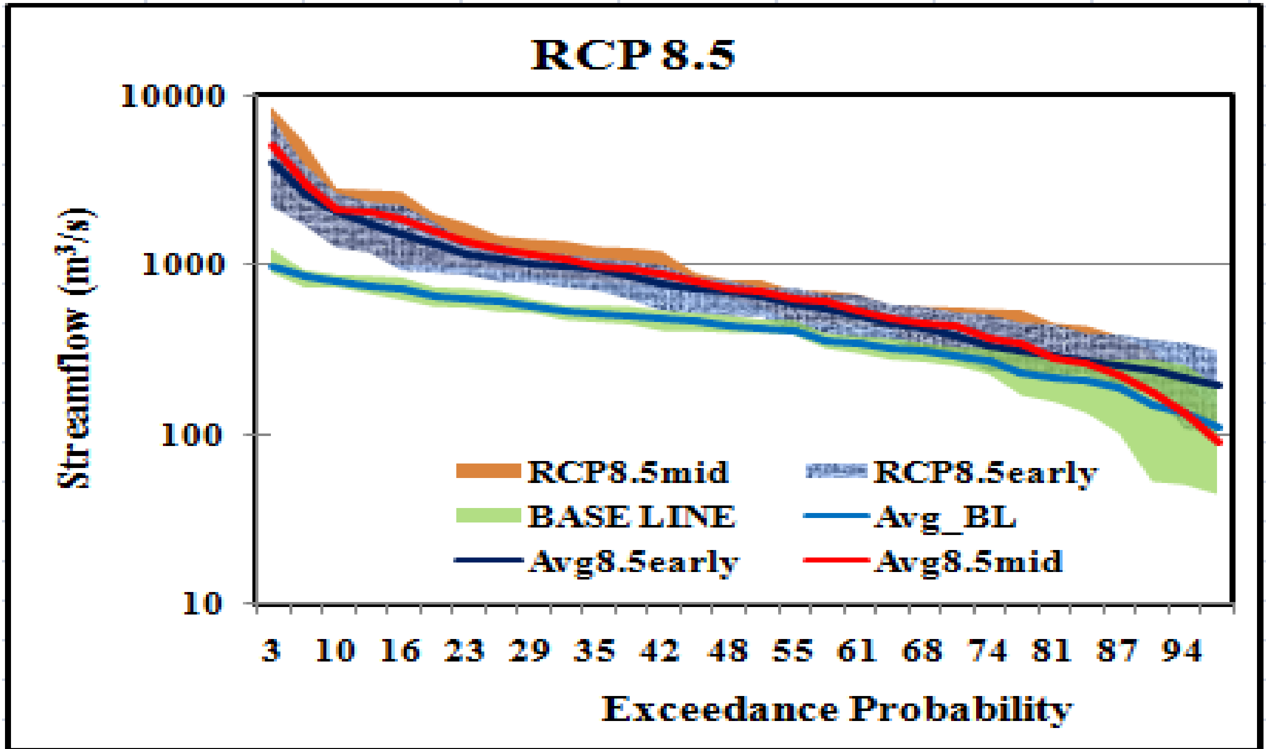


Table2: Relative change in Annual Water Yield(in %)

Model	Rcp4.5early	Rcp4.5mid	Rcp8.5early	Rcp8.5mid
ACCESS1.0	**65.23**	**72.07**	31.97	99.54
CCSM4	49.35	49.38	49.96	98.30
CNRM-CM5.0	**-23.62**	61.59	**-26.54**	**14.43**
GFDL-CM3.0	29.37	56.09	27.77	67.99
MPI-ESM-LR	-3.29	**9.12**	47.99	76.32
NorESM-M	34.57	63.00	**54.16**	**109.14**

CONCLUSION

- Substantial variability in precipitation among various climate models
- From flow duration curves it can be concluded that increased flow can be expected in the future period both for RCP 4.5 and 8.5 scenarios.
- RCP 4.5
  - Annual water yield varies from -23% to 65% for near-term (2006-40)
  - Annual water yield increases from 9% to 72% for mid-term (2041-70)
- RCP 8.5
  - Annual water yield varies from -26% to 54% for near-term (2006-40)
  - Annual water yield increases from 14% to 109% for mid-term (2041-70)
- Uncertainty interval that incorporates all possible uncertainties brought about by multi model ensembles, can provide useful insights to stakeholders for assessing various options in the decision-making process

Thank You ☺