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

P.S. Smitha, B. Narasimhan, K.P. Sudheer
Indian Institute of Technology, Madras
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: 5423 km²
  - Mean annual precipitation: 750 mm
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.

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

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

\[ \overline{\Delta P} \pm \delta_{\Delta P} \]

- Where \( \overline{\Delta P} \) is 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
Box plot showing the variability in mean rainfall for RCP 4.5 and 8.5.
Box plot showing the variability in mean temperature for RCP 4.5 and 8.5.
Box plot showing the variability in PET
Projected change in mean monthly precipitation

RCP 4.5 Early Century

RCP 4.5 Mid Century

RCP 8.5 Early Century

RCP 8.5 Mid Century
Projected changes in mean monthly temperature
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
Table 2: Relative change in Annual Water Yield (in %)

<table>
<thead>
<tr>
<th>Model</th>
<th>Rcp4.5 early</th>
<th>Rcp4.5 mid</th>
<th>Rcp8.5 early</th>
<th>Rcp8.5 mid</th>
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</table>
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 😊