

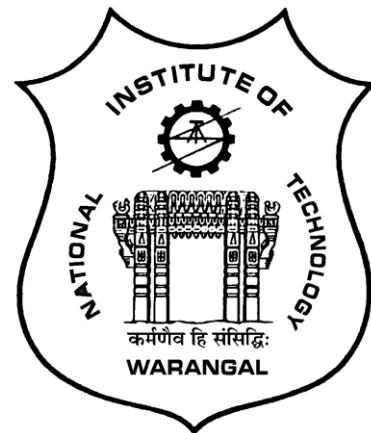
# Impact of Climate Change on Water Resources of USDA- ARS Experimental Watershed

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PORTO DE GALINHAS, PERNAMBUCO, BRAZIL  
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# INTRODUCTION

- **Water resources:**
  - Limited availability and significant spatial and temporal variation
  - Climate change enhance the problem
- **Climate change impacts management**
  - Study the hydrologic regime of the region under climate change scenarios
  - Plan the various adaptation methods under changed conditions.
  - Scientific unit: Basin/Catchment/Watershed

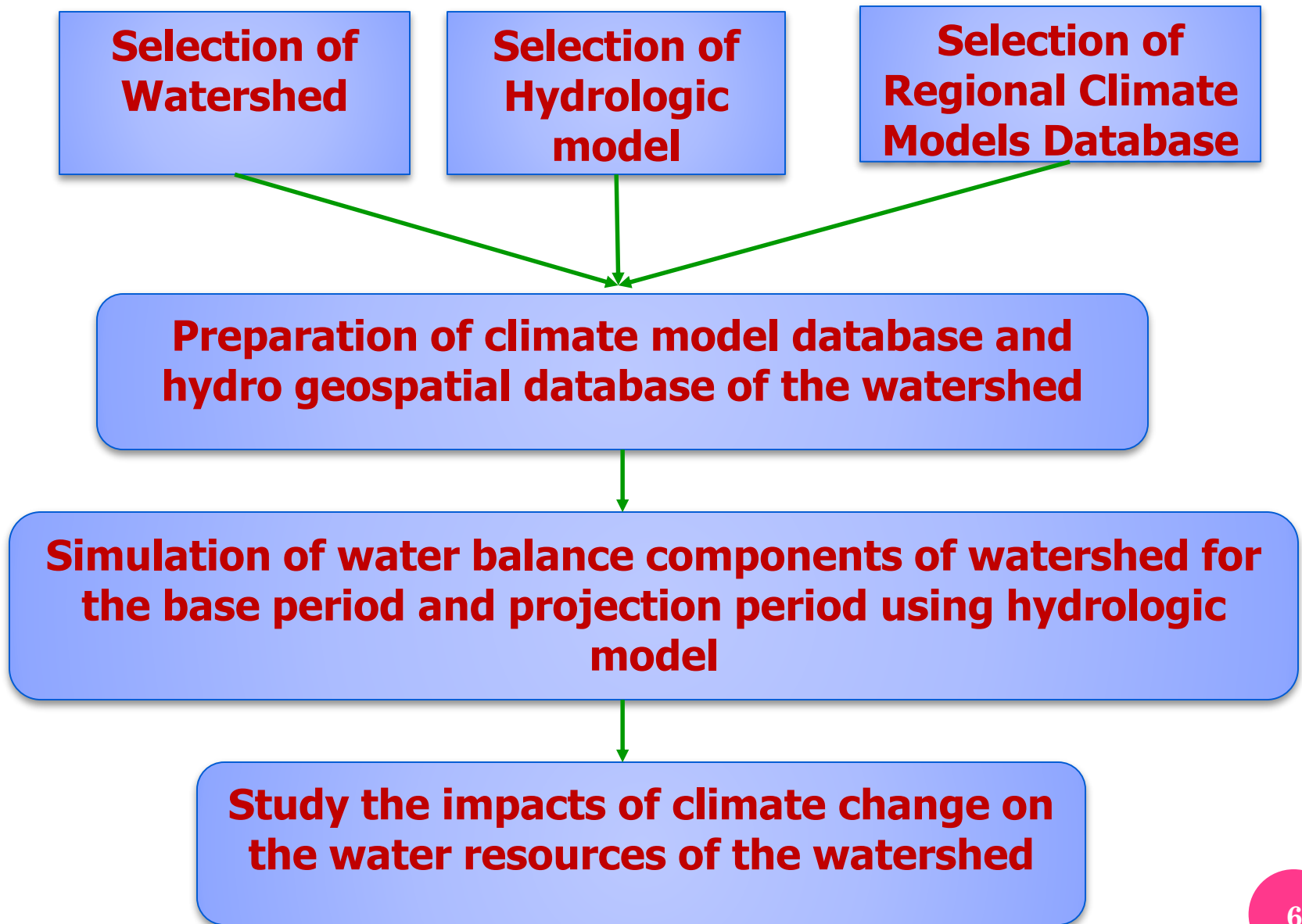
- **Climate change impact study needs:**
  - Robust hydrological models
  - High resolution climate model database for the present and projection periods
- **Hydrologic model**
  - SWAT (Soil and Water Assessment Tool) model
  - Robust interdisciplinary watershed modeling tool
  - Widely used in climate change impact studies

# CLIMATE MODELS DATABASE

- Coupled Model Intercomparison Project Phase 5 (CMIP5)
  - Disseminates simulated climate database of the different parts of the world  
(<http://cmip-pcmdi.llnl.gov/cmip5/>)
- North American Regional Climate Change Assessment Program (NARCCAP)
  - Provides the high resolution climate model database for conterminous USA  
([www.narccap.ucar.edu](http://www.narccap.ucar.edu))

# OBJECTIVES

- Retrieval, bias correction and preparation of regional climate model data in SWAT model format - R programming environment
- Simulation of the hydrological processes of the watershed - SWAT model
- Study the impact of climate change on the water resources of watershed - SWAT model simulations



## Methodology Flowchart

# STUDY AREA

## ○ Walnut Gulch Watershed

- Experimental watershed located Tucson, Arizona, USA
- United States Department of Agriculture-Agricultural Research Service (USDA-ARS)
- Well maintained long term hydro-meteorological database
- Sandy gravely loamy soils with major vegetation of grass and shrub species
- Watershed falls in semi-arid climate zone
- Drainage area:150 square kilometers



**Location Map of the Walnut  
Gulch Watershed**



# DATABASE PREPARATION

- Hydro-geospatial database: Downloaded from the online data access facility of USDA-ARS

(<http://www.tucson.ars.ag.gov/dap/>)

- Digital Elevation Model (DEM),
- Land Use/Land Cover (LU/LC)
- Soil, observed rainfall and temperature

- Daily climate model data: Downloaded from NARCCAP web database

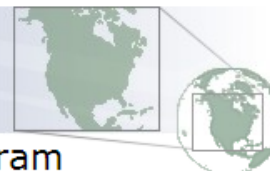
(<http://www.narccap.ucar.edu/>)

- Historic and future periods climate data are available for the conterminous USA

# NARCCAP CLIMATE DATABASE

- **Generated from running a set of regional climate models (RCMs) driven by a set of atmosphere-ocean general circulation models (AOGCMs)**
- **The RCM-GCM combinations used in the present study**
  1. CRCM (RCM)-CCSM (GCM DRIVER)
    - CRCM- Canadian Regional Climate Model (RCM)
    - CCSM- Community Climate System Model
  2. RCM3-GFDL
    - RCM3- Regional Climate Model version 3
    - GFDL- Geophysical Fluid Dynamics Laboratory  
GCM

# NARCCAP



## North American Regional Climate Change Assessment Program

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### PROGRAM

- ♦ [About NARCCAP](#)
- ♦ [About Data](#)
- ♦ [Contact Us](#)

### RESOURCES

- ♦ [For PIs](#)
- ♦ [For Users](#)
  - [Register for Access](#)
  - [User Directory](#)
  - [Contributions](#)
  - [Acknowledgements](#)

### RESULTS

- ♦ [Output Data Catalog](#)
- ♦ [General Results](#)
  - [NCEP-Driven RCM Runs](#)
- ♦ [Climate Change Results](#)
  - [CRCM+CCSM](#)
  - [CRCM+CGCM3](#)
  - [ECP2+GFDL](#)
  - [HRM3+GFDL](#)
  - [HRM3+HadCM3](#)
  - [MM5I+CCSM](#)
  - [MM5I+HadCM3](#) **NEW!**
  - [RCM3+CGCM3](#)
  - [RCM3+GFDL](#)
  - [WRFG+CCSM](#)
  - [WRFG+CGCM3](#)

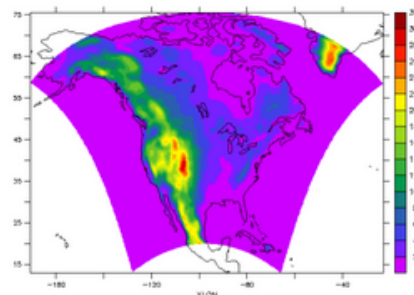
### SPONSORS

## Welcome to NARCCAP!

### About NARCCAP

NARCCAP is an international program that serves the high resolution climate scenario needs of the United States, Canada, and northern Mexico, using regional climate model, coupled global climate model, and time-slice experiments.

[More about NARCCAP.](#)



### Users

NARCCAP users include those interested in regional analysis, impacts studies, and further downscaling. [User resources.](#)

### Data

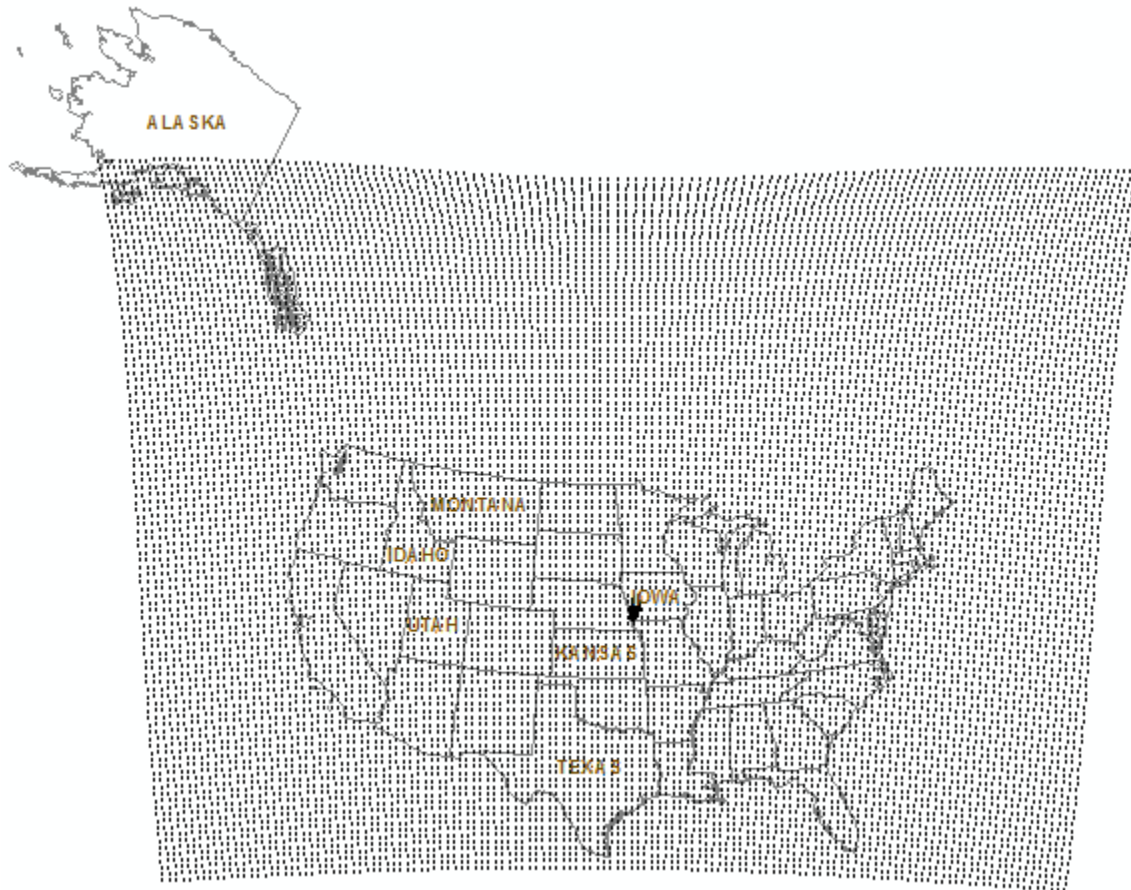
NARCCAP data is stored in CF-compliant NetCDF format and distributed through the Earth System Grid. [Data access and documentation.](#)

### News

**Timeslice Climate Change Plots** — Plots for the GFDL-timeslice have been updated, and plots for the CCSM-timeslice have been added. Both experiments now have three RCMs for comparison: [Timeslice Results.](#)

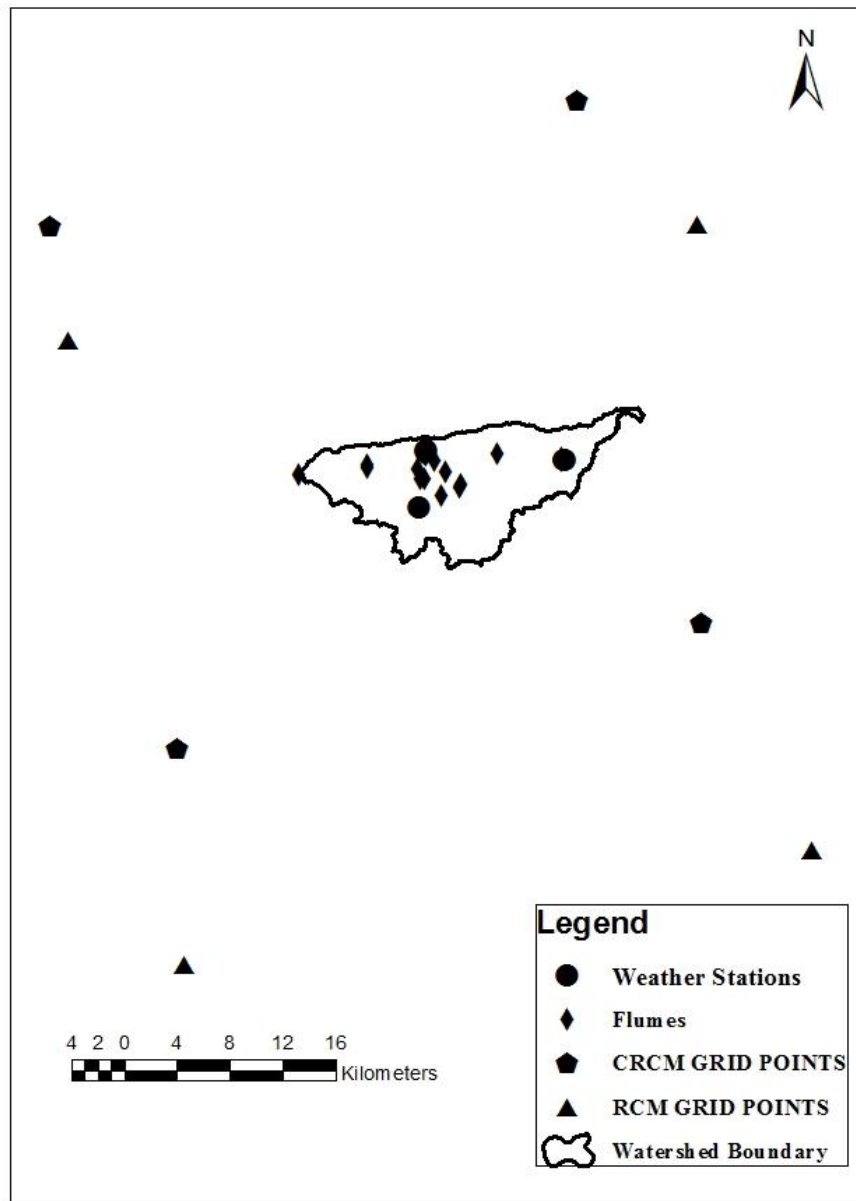
**New Data as of October 2012** — Recently-published data includes 3-D variables from both HRM3-grdl runs; a number of missing 2-D variables from the MM5I-ccsm runs, as well as 3-D data from the MM5I-ccsm current run; and multiple variables (2-D and 3-D) from both runs of the CAM3 timeslice experiment.





**NARCCAP Grid for Conterminous USA**





**Locations of regional climate grid points, weather stations and gauge stations of the watershed**

# STATISTICS AND CORRECTIONS

- Calculation of statistics for the historic and future period
  - Mean monthly parameters
  - Monthly and annual parameter variations
  - R codes
- NARCCAP data
  - Historic period - 1971-2000
  - Future Period - 2041- 2070



# CORRECTIONS TO CLIMATE DATA

## ○ Bias correction

(Teutschbein and Seibert, 2012)

$$BC = MMCV_{obs} \% \text{ or } - MMCV_{his} \quad (1)$$

$$CCV_{his} = CV_{his} \times \text{ or } + BC \quad (2)$$

$$CCV_{fu} = CV_{fu} \times \text{ or } + BC \quad (3)$$

*BC* - Bias Correction,

*MMCV<sub>obs</sub>* - Mean monthly climate variable for observed data

*MMCV<sub>his</sub>* - Mean monthly climate variable for historic data

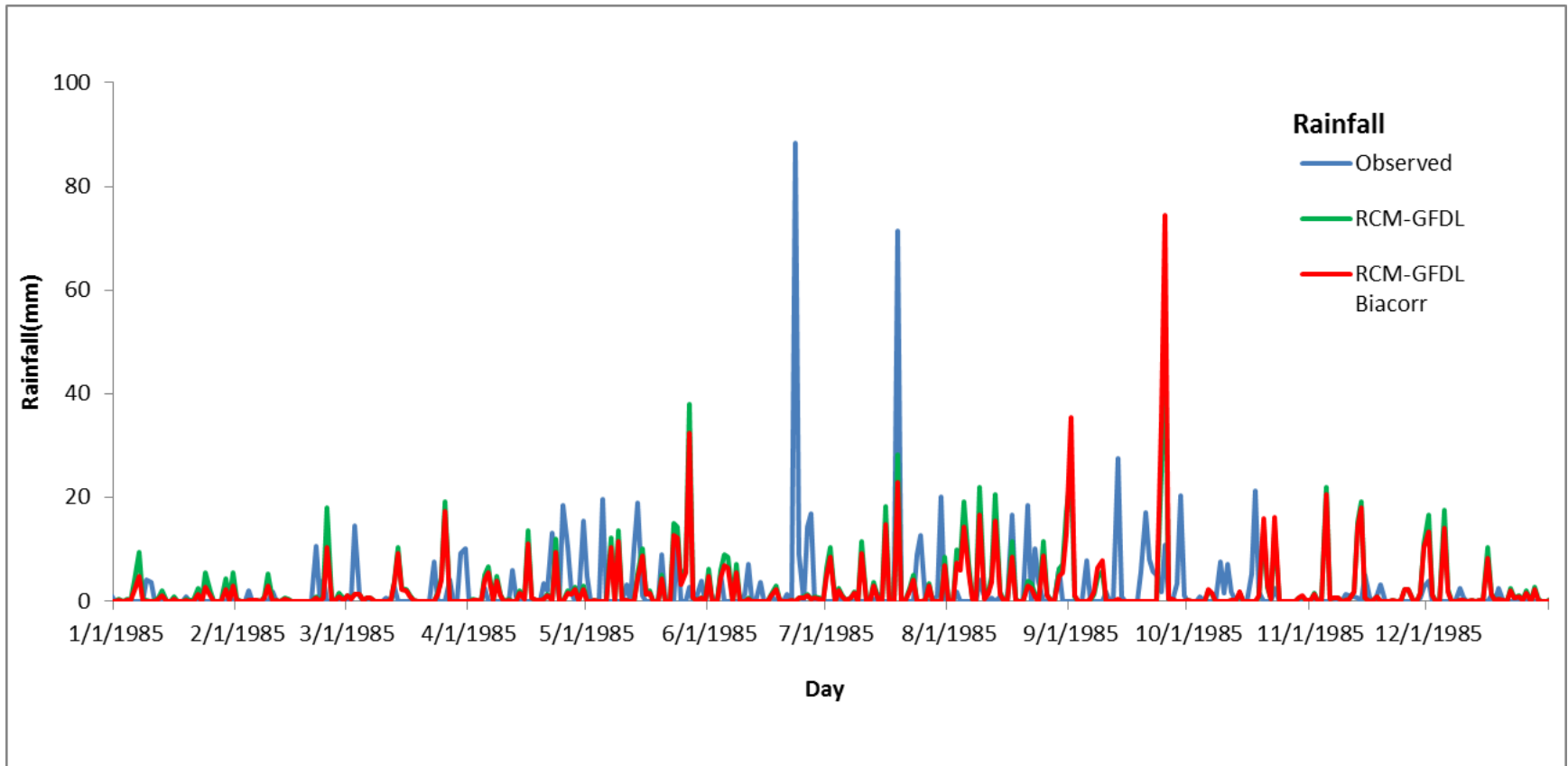
*CCV<sub>his</sub>* - Corrected Climate Variable for historic data

*CV<sub>his</sub>* - Climate Variable for historic data.

*CCV<sub>fu</sub>* - Corrected Climate Variable for future projection data

*Cv<sub>fu</sub>* - Climate Variable for future projection data



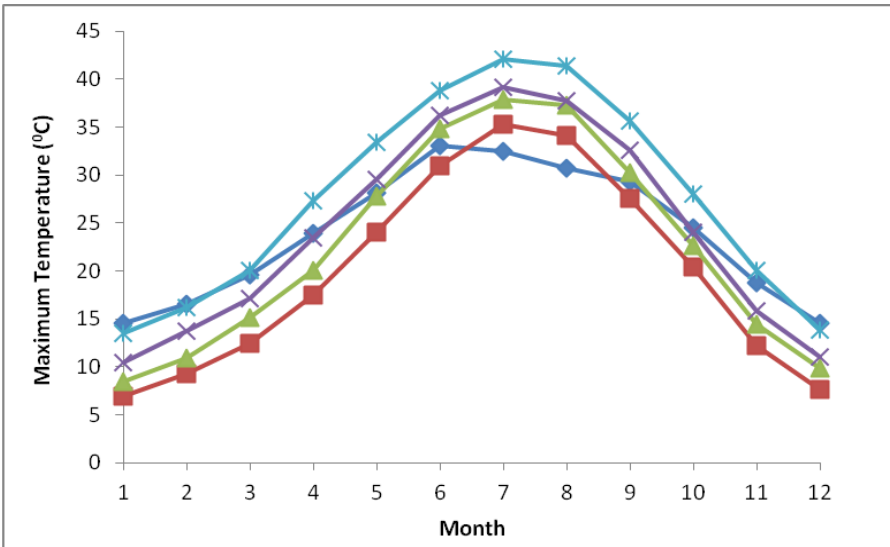


**Daily rainfall variations for the historic period from simulations of RCM-GFDL**

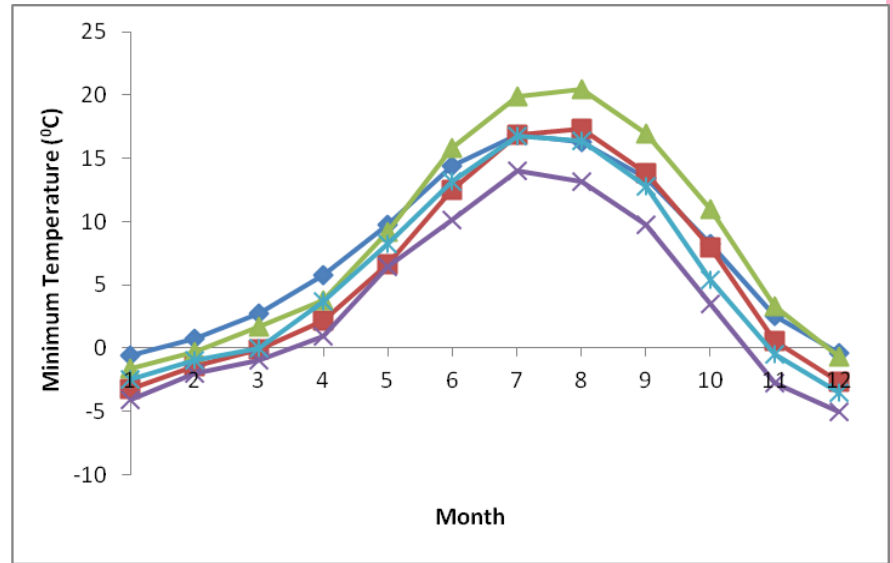




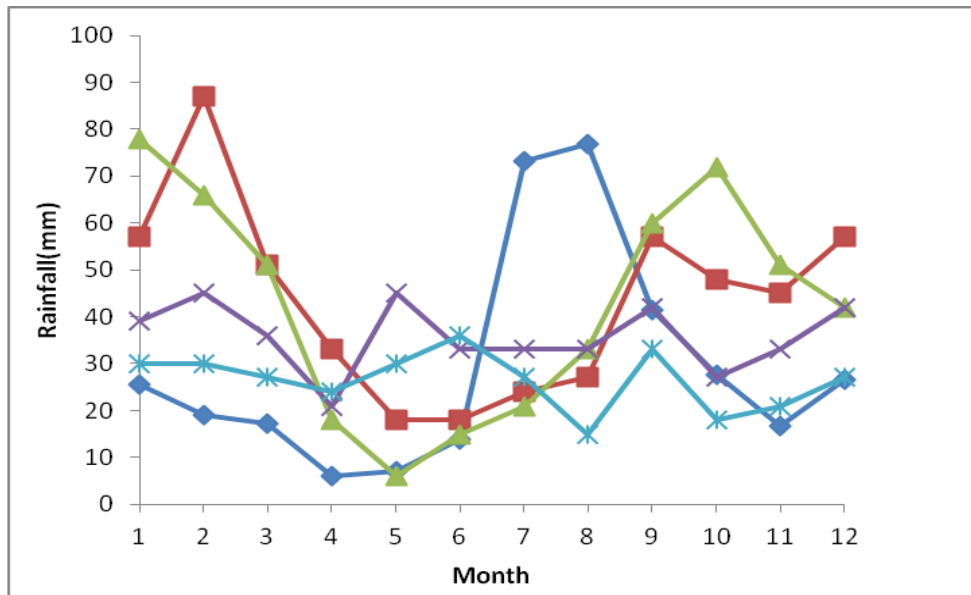
# RESULTS AND DISCUSSIONS



**Maximum Temperature**



**Minimum Temperature**



**Rainfall**

- ◆— Observed
- RCM-GFDL-Historic (1971-98)
- ▲— RCM-GFDL-Future(2041-69)
- ×— CRCM-CCSM-Historic (1971-98)
- \*— CRCM-CCSM-Future(2041-69)

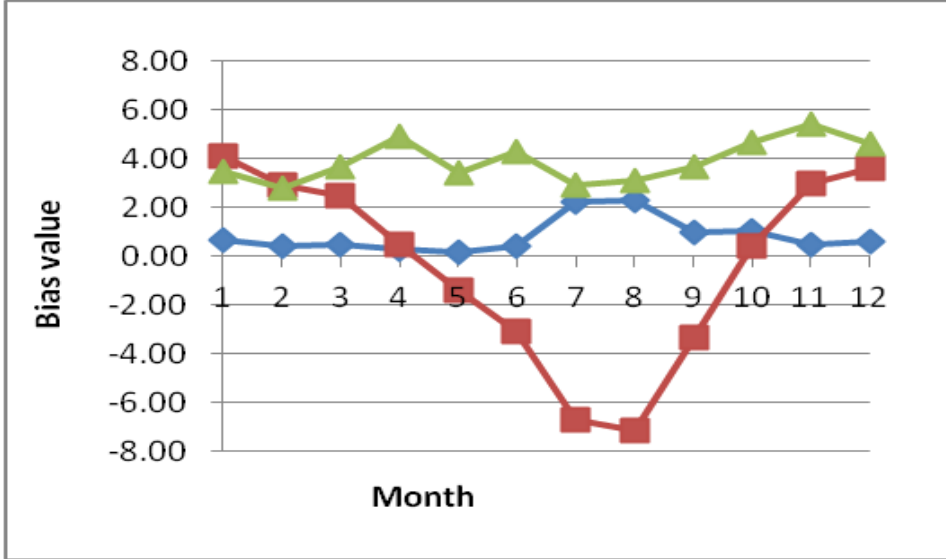
**Mean Monthly Variations in Climate Parameters**

## ○ Mean monthly maximum temperature and minimum temperature

- Increased in future projection period in the months of June, July and August
- Decreased in future projection period in the months of January, February and December

## ○ Rainfall trends in the future projections

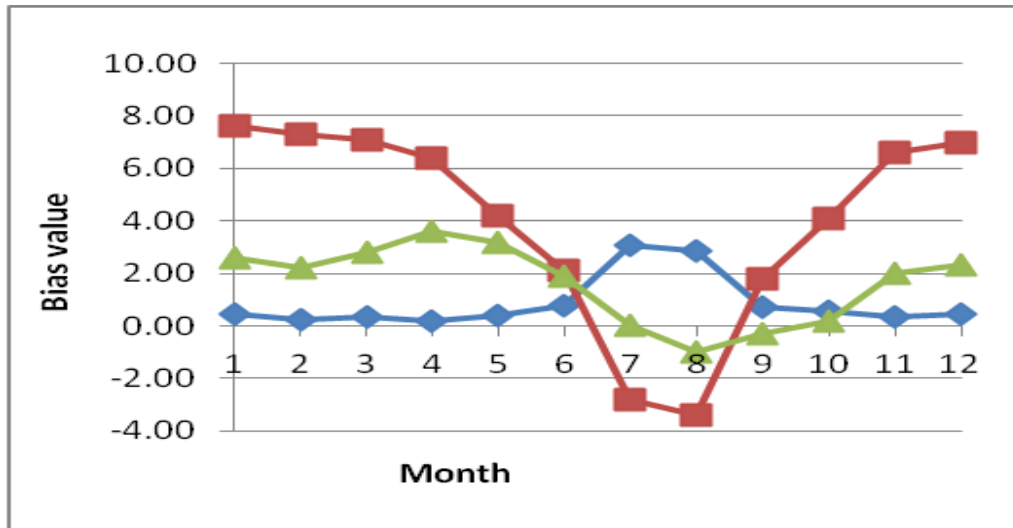
- Higher in January, February, November and December months
- Lower in July and August Months



**CRCM-CCSM**

Mean Monthly Biases

- ◆ Rainfall
- Maximum Temperature
- ▲ Minimum Temperature



**RCM-GFDL**

**Mean Monthly Biases in Climate Parameters**

- Significant biases between observed and climate model datasets

## Bias Values

- Maximum temperature

- RCM-GFDL : Varies from 2.1 °C to 7.6 °C
- CRCM-CCSM: Varies from 0.4 °C to 7.1 °C

- Min temperature

- RCM-GFDL: Varies from 0 °C to 3.6 °C
- CRCM-CCSM: Varies from 2.9 °C to 4.7 °C

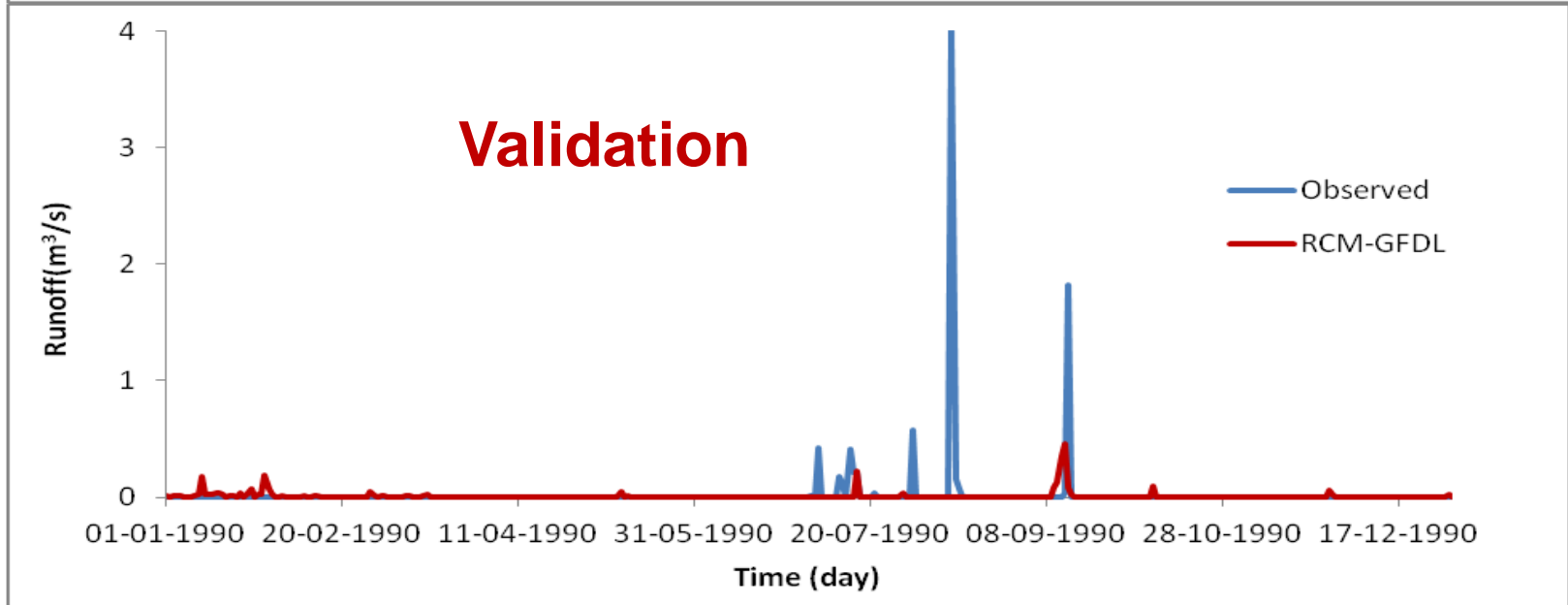
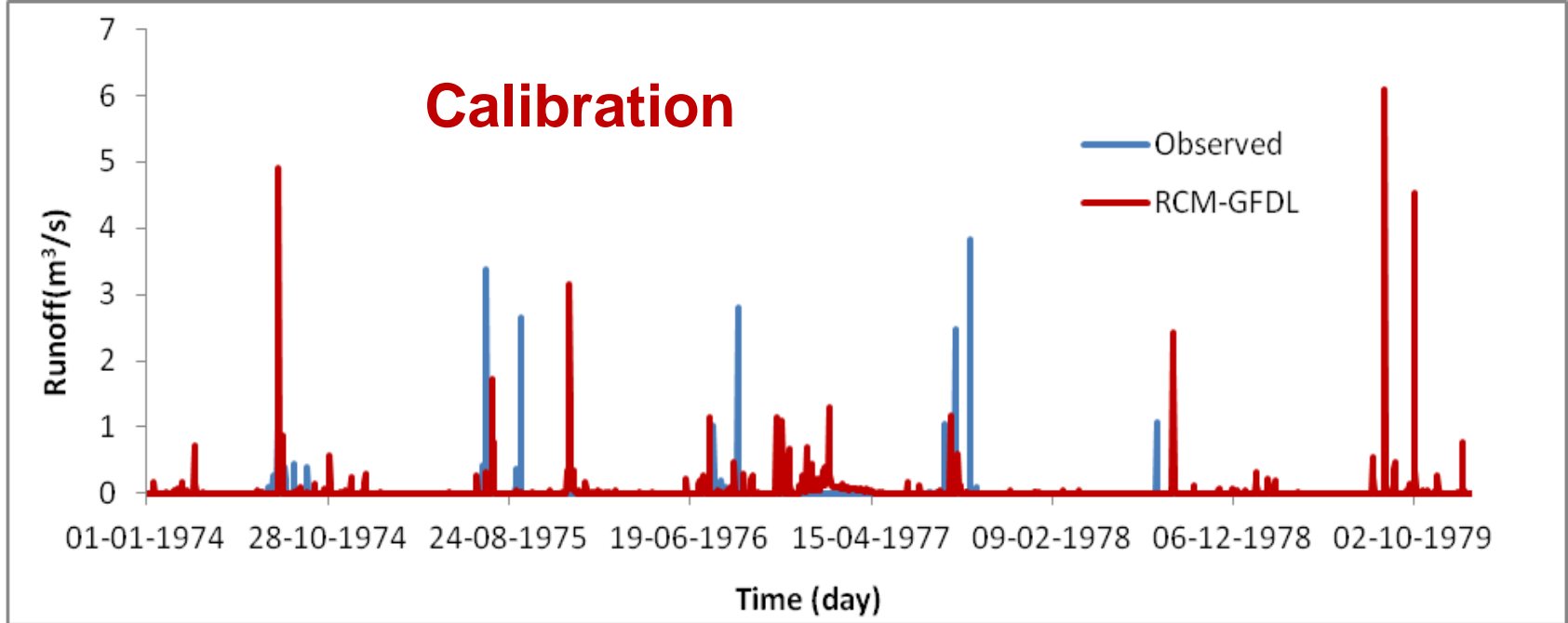
- Rainfall

- RCM-GFDL: 0.18 to 3.05
- CRCM-CCSM: 0.16 to 2.33

# SWAT MODEL SIMULATIONS

- The bias corrected data
  - 1971-1998 - Base period
  - 2041-2069 - Future projection period
- Model calibration - 1971-1980
  - Validation - 1981 to 1998
- The calibration process in this watershed is very difficult
  - Runoff occurs from convective storms
  - Most of the overland flow is absorbed by the porous soils which results in less runoff at the outlet

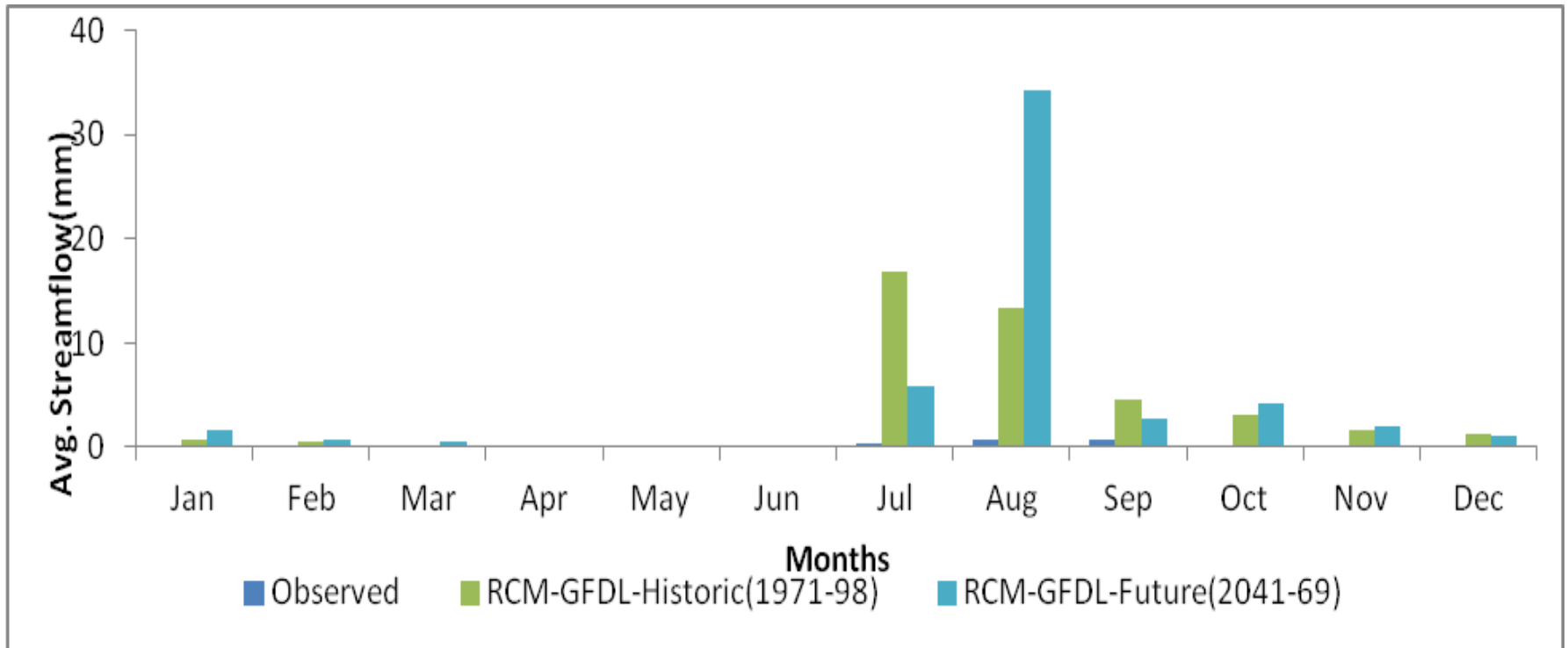
- Calibrated parameters for observed rainfall and runoff have been given to simulate hydrologic processes from the climate model data for historic and future projection periods
- Simulation results of CRCM-CCSM climate data shows unusually high simulated stream flows for the historic and future projection period
  - This simulation results are not considered for further analysis



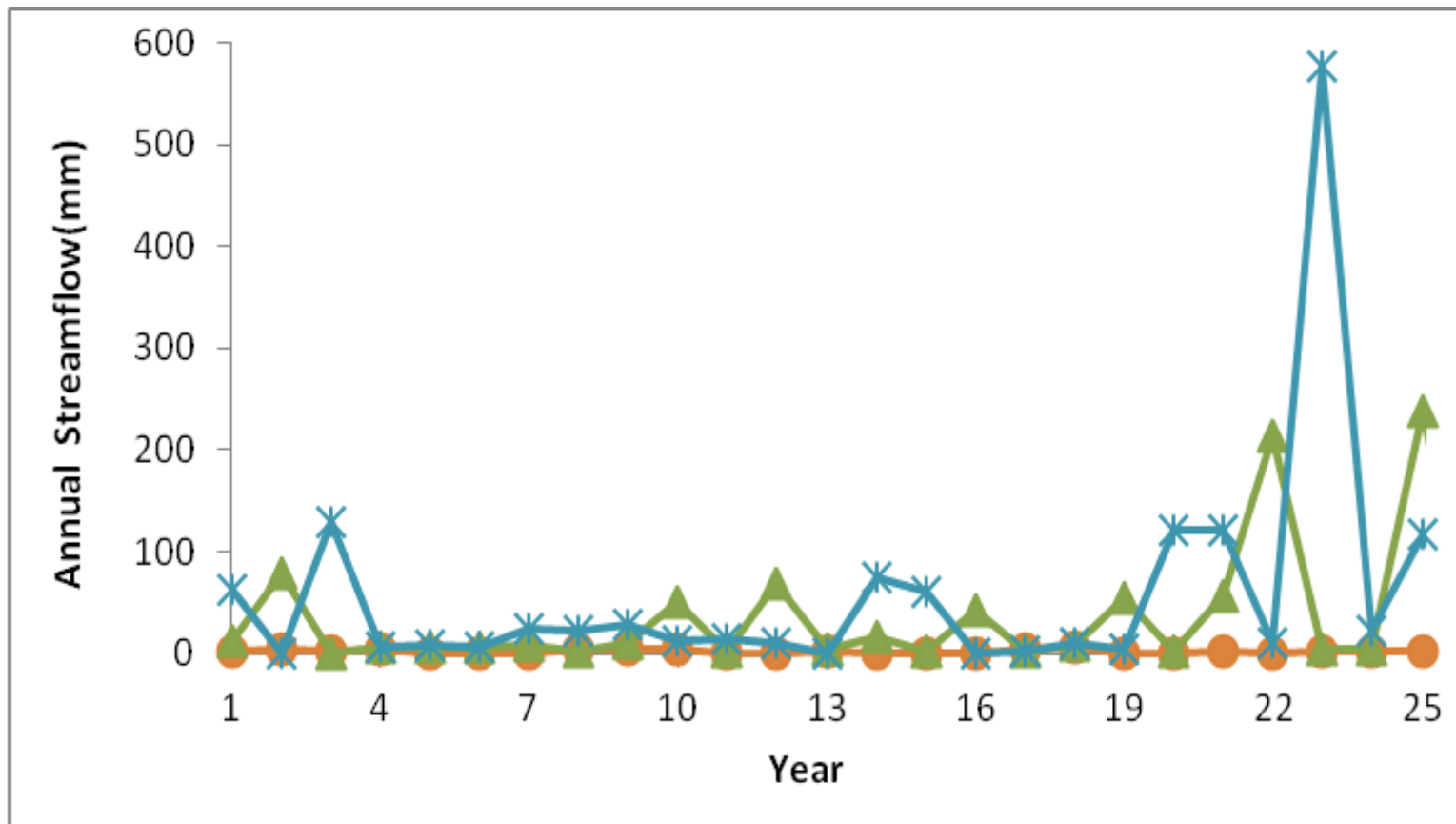
**Simulated hydrographs with observed and RCM-GFDL Historic climate model data**



- From the daily simulated hydrographs
  - Climate model data is able to capture the runoff events
  - In some days, even though there is no observed rainfall, model is simulated runoff with climate model data
  - This may be due to climate model data has rainfall during those days
  - In some days unusually high peak flows are observed with climate model data

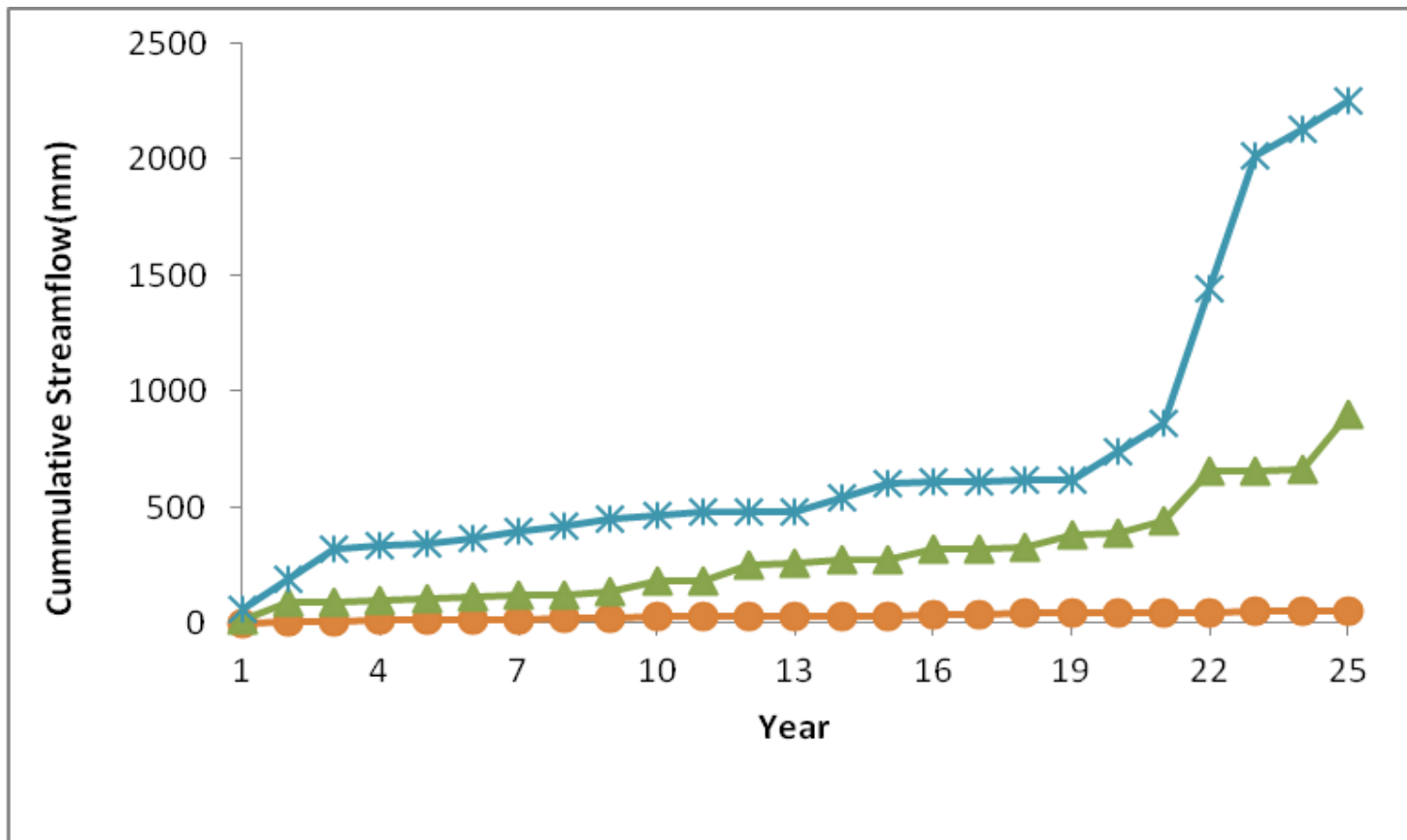


## Mean monthly stream flows of the watershed



—●— Observed     
 —▲— RCM-GFDL-Historic (1971-1998)     
 —\*— RCM-GFDL-Future(2041-2069)

## Annual stream flows for the historic and future projection period



● Observed     
 ▲ RCM-GFDL-Historic (1971-1998)     
 ✱ RCM-GFDL-Future(2041-2069)

Cumulative stream flows for the historic and future projection period

- Mean monthly stream flows
  - There is increase in stream flows in this watershed in July, August and September months.
- Annual and cumulative stream flows for the historic and future projection period
  - There is increase in stream flows by the end of the future projection period in the watershed.
  - These results have to be further studied with ensemble of climate models to check the validity of the results

# SUMMARY AND CONCLUSIONS

- Presented the impact of climate change on the water resources of the experimental watershed with climate model database
- Significant biases between observed and climate model datasets
- Higher rainfall trends are observed in the future projections in some months and lower future rainfall in some months
- Increase in stream flows in this watershed in July, August and September months

- These results have to be further studied with ensemble of climate models to check the validity of the results.
- Methodology presented in the study can be extended to any type of watershed
- Climate impact study for big river basin of USA is under progress

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- Dr. Seth McGinnis and other scientists of North American Regional Climate Change Assessment Program (NARCCAP)
- Mr. Jeffry J. Stone, Hydrologist, USDA-ARS Southwest Watershed Research Center

A serene pond scene with several ducks and a swan swimming. The water is calm, reflecting the sky and the surrounding greenery. The ducks are of various breeds, including a brown duck, a black duck, and a white swan. The scene is framed by hanging branches and leaves, creating a peaceful and natural atmosphere.

THANK U