IOWA STATE UNIVERSITY
Department of Geological and Atmospheric Sciences

International Conference on Regional Climate ICTP-CORDEX 2023
9/25/2023-9/29/2023

Olivia F. McCauley, William J. Gutowski, Jr., Philip W. Gassman[1], Ian N. Williams

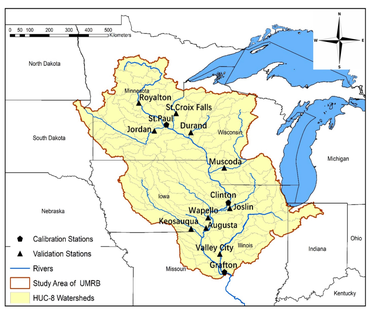
[1]Iowa State University Center for Agricultural and Rural Development

Projected Changes in Extreme River-Flow in the Upper Mississippi River Basin

Introduction

- Earth's climate system is made up of numerous complex and intricate physical processes involving the transfer of energy and matter.
- Preparing for and projecting the wide range of climate change impacts such as flooding, drought, severe heat and cold events, etc, is crucial to preserve human life and property.
- In one study, severe flooding in the Midwestern US and Upper Mississippi was identified as a great future-risk concern (Reed et al. 2020).
- Yet also, Iowa suffered a significant drought in 2020 that led to $308.2 million in crop damages (Eller, 2020).

Domain

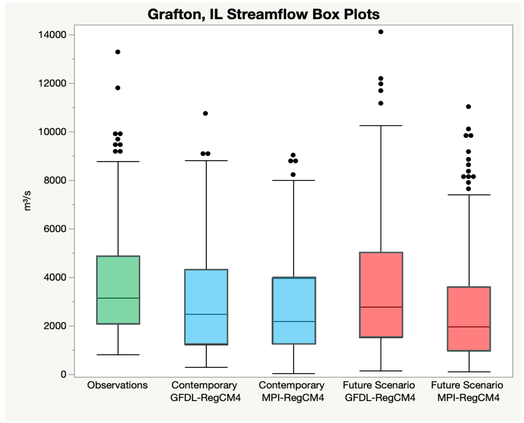


- Average annual precipitation from 1983-2005 is <600 mm in northern region and >1000 mm in southern region (Chen et al. 2020)
- Land use (Chen et al. 2020):
  - 44.7% Cropland
  - 20.1% Forest
  - 16.2% Grassland
  - 9.9% Wetlands
  - 9.1% Urban/Developed Areas
- Grafton, IL gauge site drains an area of 447,802 km^2
- Comprised of 119 HUC-8 watersheds

Data & Methods

- Observations:
  - USGS Station 05587450 (Grafton, IL)
  - PRISM: Gridded observations (4-km then aggregated to 25-km grid)
- Hydrology Model: SWAT Model (Arnold et al 1998):
  - Spatially Semi distributed
  - Time continuous
- Driving Climate-Model Simulations:
  - RegCM4 (RCM) (25-km grid spacing)
  - Boundary conditions: CMIP5 GFDL & MPI GCMs
  - Contemporary [1981-2010] & RCP 8.5 Scenario [2041-2070]
- Data Analysis Methods:
  - Constructed box plots, calculated means, percent differences, and 95% confidence level p-values for streamflow, precip, ET, PET, and water-yield

Results

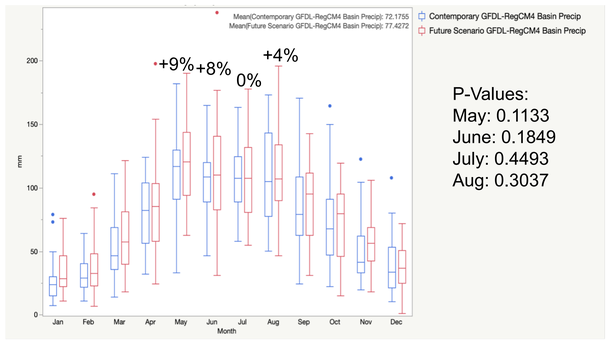


Grafton, IL, Percentile Exceedance Count

Percentiles based on USGS observations

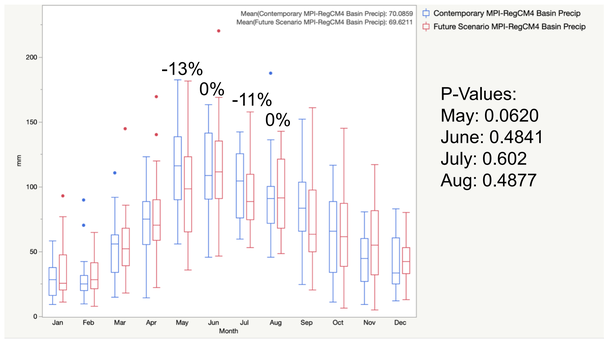
Model/Climatological Period	90th Percentile	95th Percentile	98th Percentile
GFDL-RegCM4 Contemporary	26	9	5
MPI-RegCM4 Contemporary	26	11	2
GFDL-RegCM4 Future Scenario	53	33	17
MPI-RegCM4 Future Scenario	22	12	6

Contemporary and Future-Scenario GFDL-RegCM4 Monthly Precip. (mm)



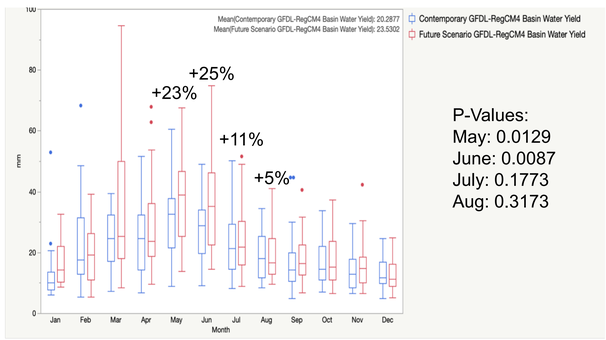
P-Values:
May: 0.1133
June: 0.1849
July: 0.4493
Aug: 0.3037

Contemporary and Future-Scenario MPI-RegCM4 Monthly Precip. (mm)



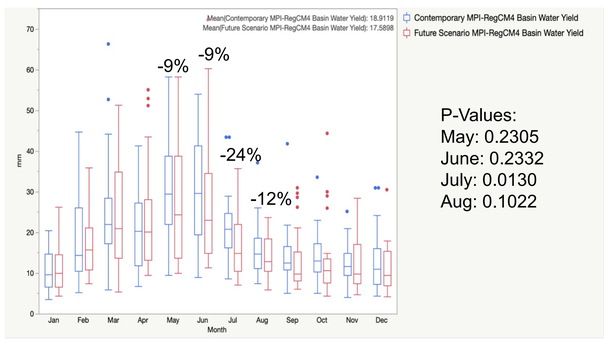
P-Values:
May: 0.0620
June: 0.4841
July: 0.602
Aug: 0.4877

Contemporary and Future-Scenario GFDL-RegCM4 Monthly Water-Yield (mm)



P-Values:
May: 0.0129
June: 0.0087
July: 0.1773
Aug: 0.3173

Contemporary and Future-Scenario MPI-RegCM4 Monthly Water-Yield (mm)



P-Values:
May: 0.2305
June: 0.2332
July: 0.0130
Aug: 0.1022

Conclusions

- GFDL-RegCM4 projects large **increases** in extreme river-flows at Grafton, IL.
- Both models project similar extreme **low flows** as in the contemporary period.
- GFDL-RegCM4 projects **higher** precipitation overall and in the high-water season.
- MPI-RegCM4 projects **lower** overall and high-water season precipitation.
- Both models project a **warmer** climate, but MPI-RegCM4 projects a **dryer** climate.
- GFDL-RegCM4 projects **higher** water yield/Net **gain** in water
- MPI-RegCM4 projects **lower** water yield/Net **loss** in water.

References

Reed T, Mason LR, Ekenga CC. Adapting to Climate Change in the Upper Mississippi River Basin: Exploring Stakeholder Perspectives on River System Management and Flood Risk Reduction. *Environmental Health Insights.*, January 2020.

Eller, Donnelle. “Iowa Farmers Absorbed $243 Million in Losses from Last Year’s Devastating Drought, Derecho, New Tally Says.” *The Des Moines Register*, Des Moines Register, 27 July 2021

Chen, Manyu et al. “Analysis of alternative climate datasets and evapotranspiration methods for the Upper Mississippi River Basin using SWAT within HAWQS.” *Science of the Total Environment,* vol. 720 (2020): 137562.

Arnold, J. G., R. Srinivasan, R. S. Muttiah, and J. R. Williams. 1998. Large-area hydrologic modeling and assessment: Part I. Model development. *J. American Water Resour. Assoc.,* 34(1): 73-89.

Acknowledgements: This work supported by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research program under Award Number DE-SC0016605 and Simulations Provided by NA-CORDEX