This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

Do Human Activities Influence Reservoir based Hydrological Droughts?

Deep Shah[1], Gang Zhao[1,2], Yao Li[1], Huilin Gao[1]

1. Department of Civil Engineering, Texas A & M University, College Station, Texas, 77843
2. Department of Global Ecology, Carnegie Institution for Science, Stanford, California, 94305

May 27, 2022

Introduction

- Hydrological drought generally has been focused on **streamflow, but *reservoir based droughts* remain unexplored.**
- Reservoir **evaporation losses and their functionality** could significantly affect the reservoir-based hydrological droughts.
- Despite this, the **understanding of reservoir based droughts (RBD)**, and **human contribution** to them are still unrecognized.

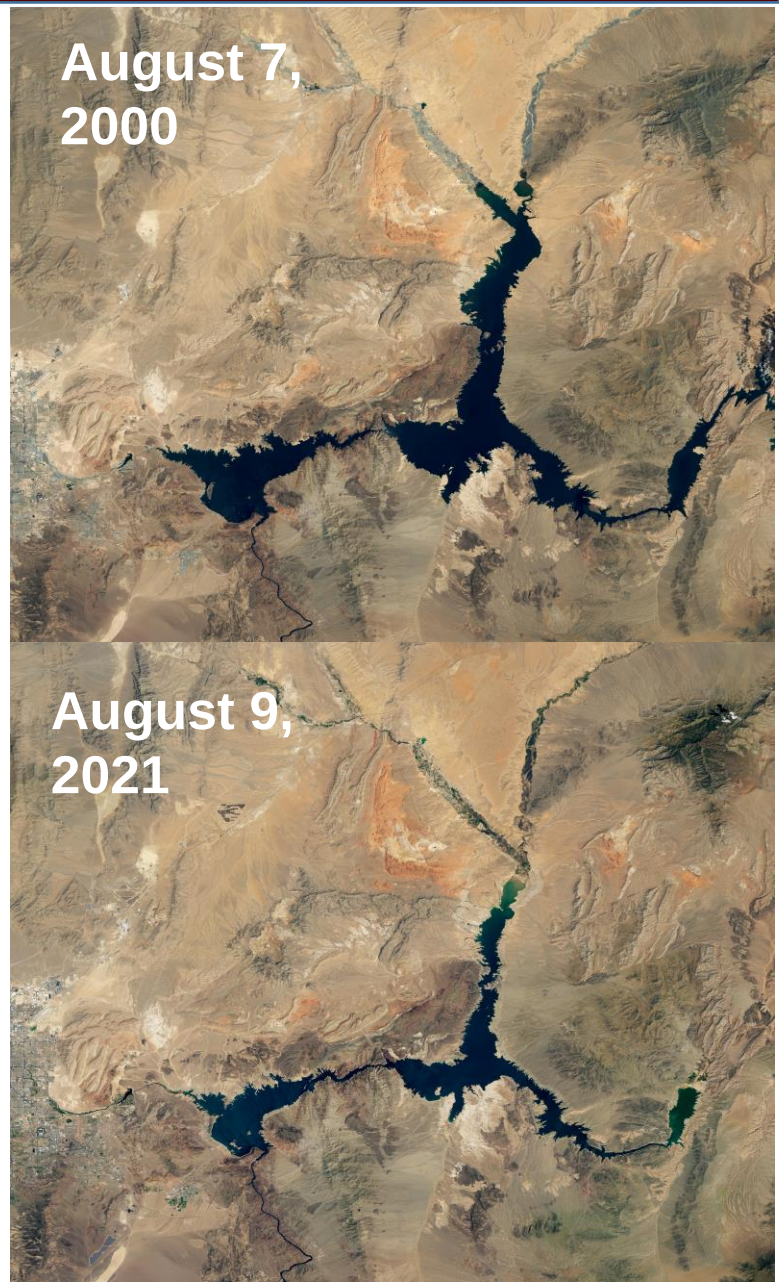
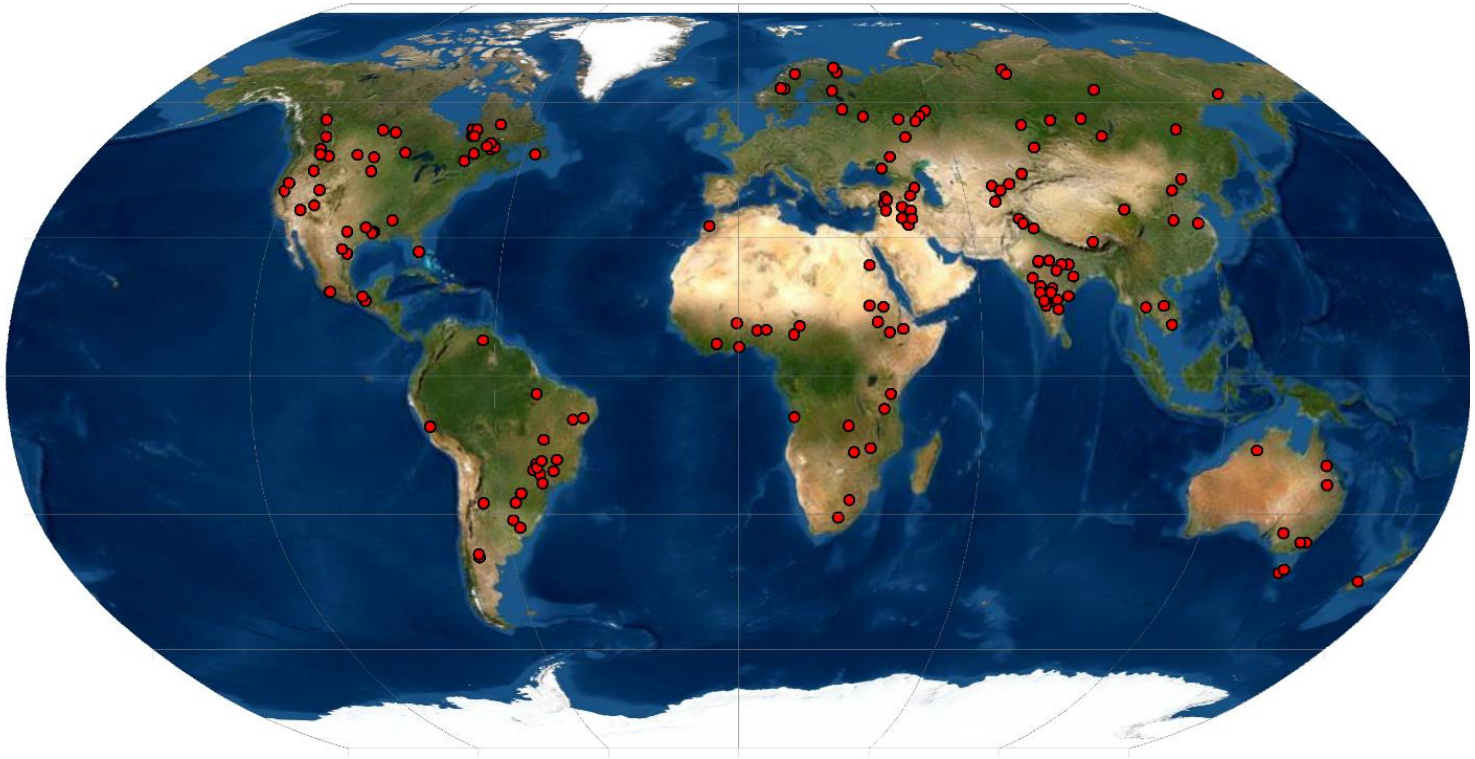


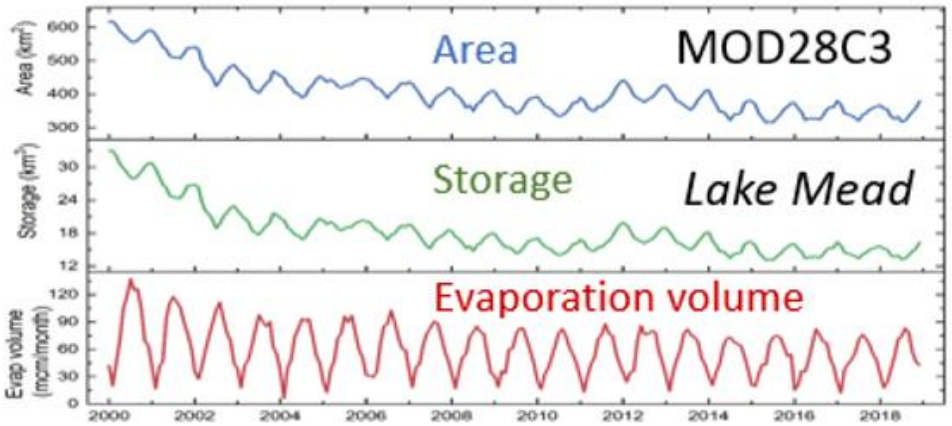
Photo credits: NASA

Objectives

- To **develop Integrated Reservoir Drought Index (IRDI)** based on **reservoir storage** and **evaporation losses**, which can effectively capture reservoir based hydrological drought globally.
- To **reconstruct reservoir based hydrological droughts** in observed climate (2000-2018) using IRDI.
- To **evaluate the role of anthropogenic activities** such as water management activities on global reservoir based droughts

NASA's Global Water Reservoir Product





- **Developed at 8-Day and Monthly temporal resolutions**
- **Covers 164 global reservoirs (Area > 25 km^2)**
- **Total capacity of 2904 km^3, 43.65% of the global capacity.**

References: Li et al., 2021; Zhao et al., 2021; Zhao et al., 2020

More information at : https://modis-land.gsfc.nasa.gov/modgwr.html (**PI: Huilin Gao, Texas A&M University**)

Methodology

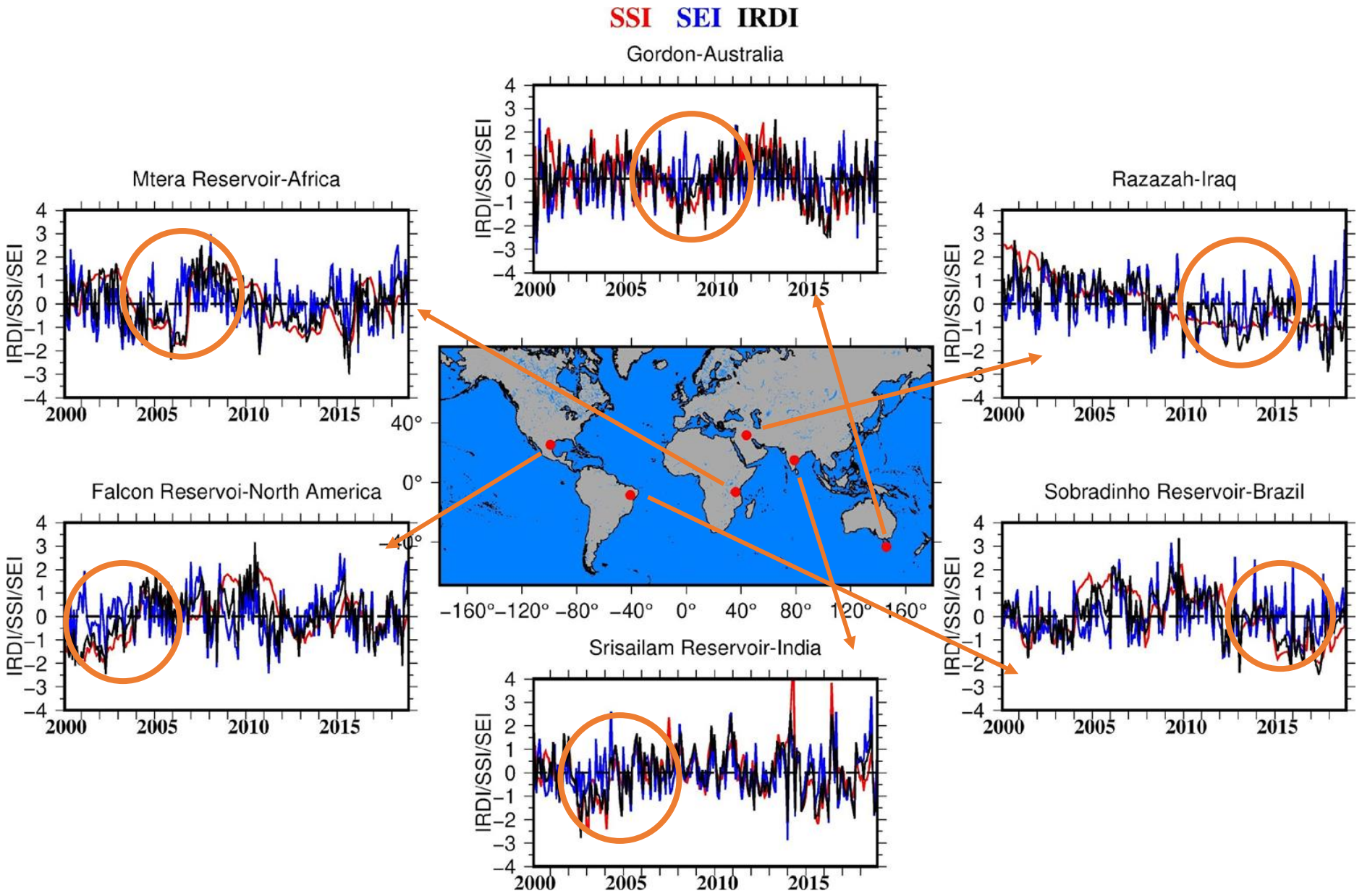
Construction of Standardized Storage Anomalies (SSI) and Standardized Evaporation Anomalies (SEI)

Construction of IRDI using Frank Archimedean copula

Reconstruction of drought characteristics using IRDI

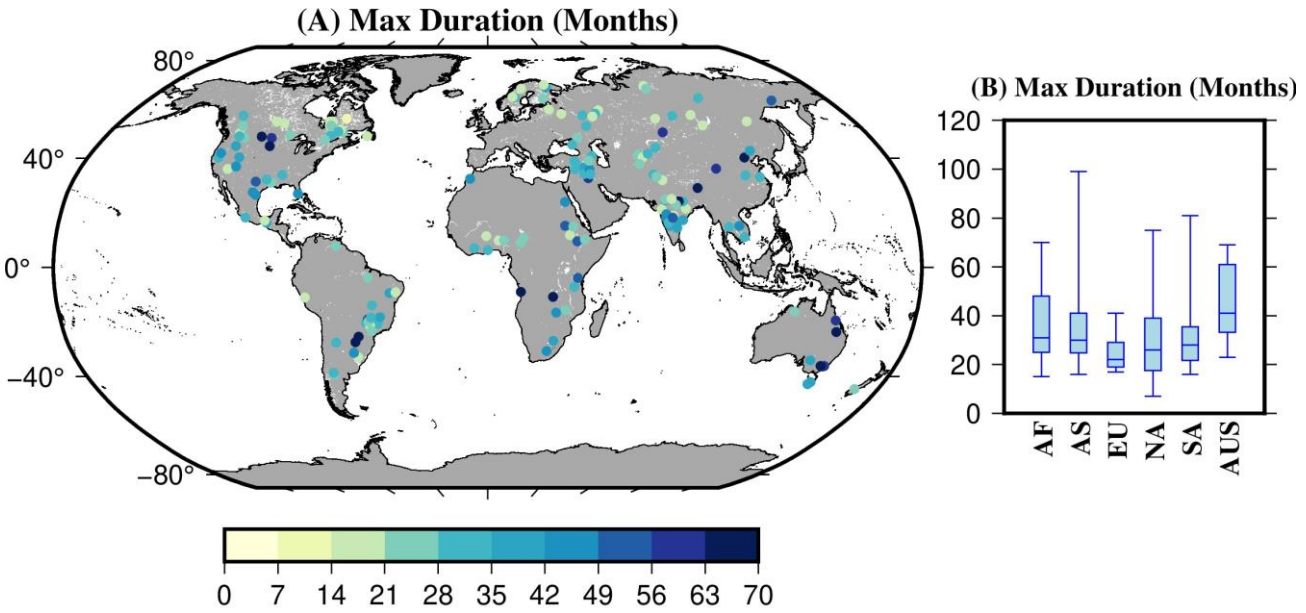
Identifying the role of human activities on reservoir-based droughts

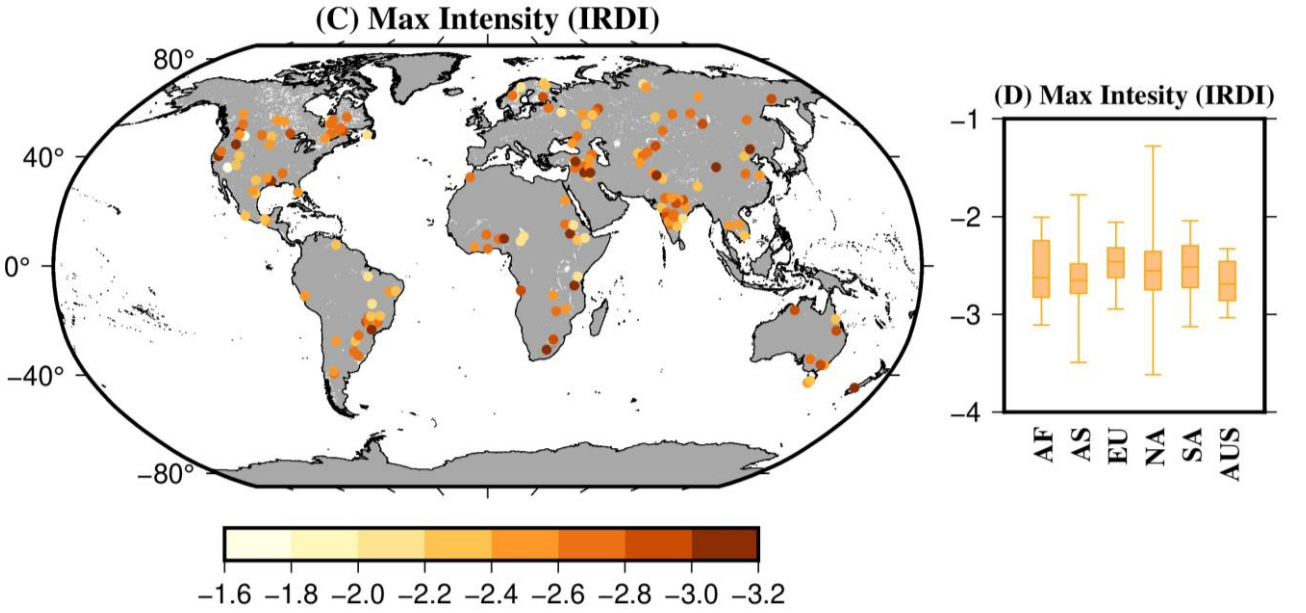
Results : Importance of IRDI



- The circles highlight droughts according to one indicator getting missed by the other indicator, highlighting the need for the integrated approach.
- IRDI successfully captures the droughts based on both storage and evaporation losses

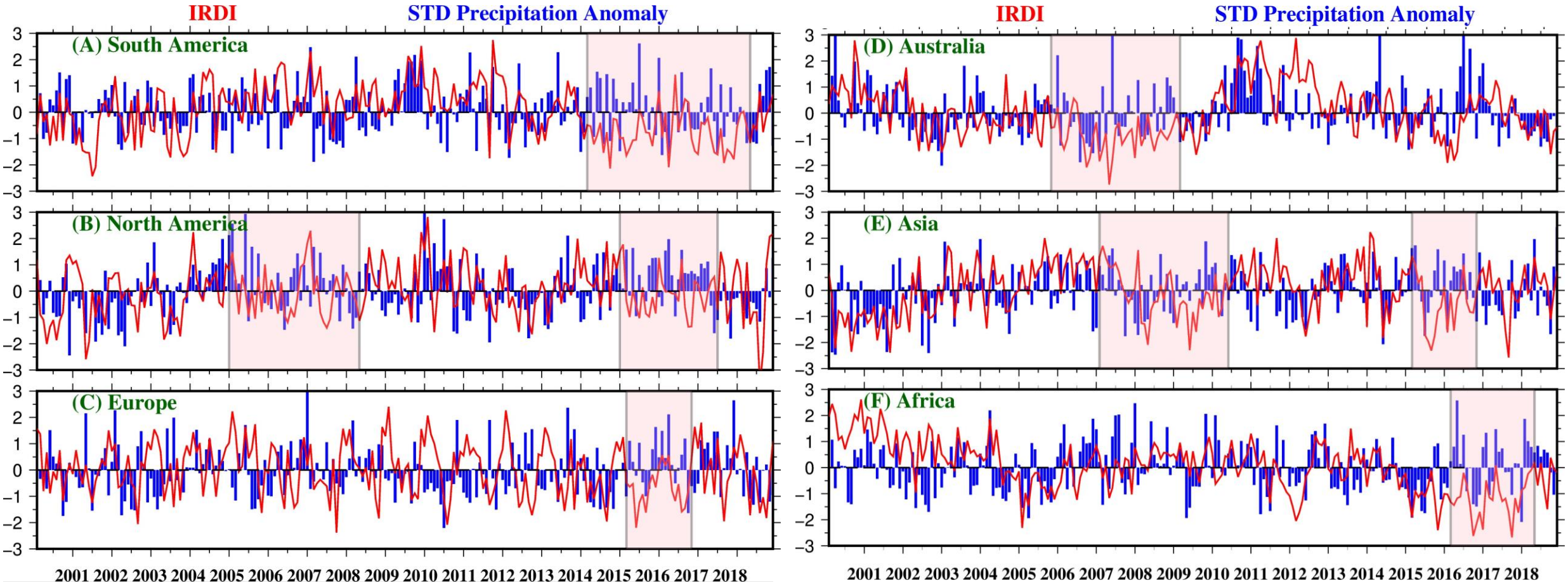
Results : Reconstruction of Droughts





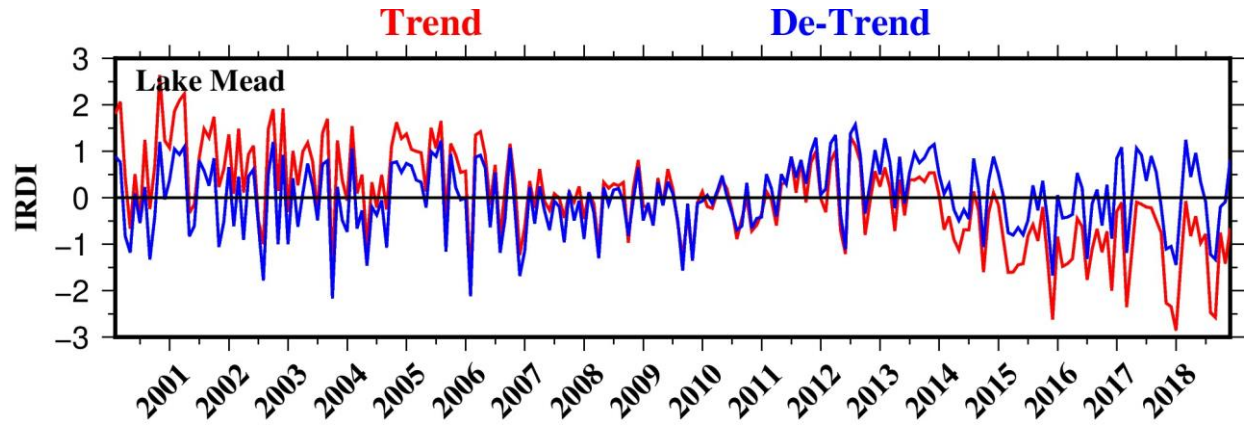
- The Northern part of North America(NA), Australia(AUS), Southern part of South America (SA), Eastern Asia (AS) and South Africa (AF) show more prolonged droughts
- However, Europe (EU), South America, and Africa show relatively more intense reservoir based droughts

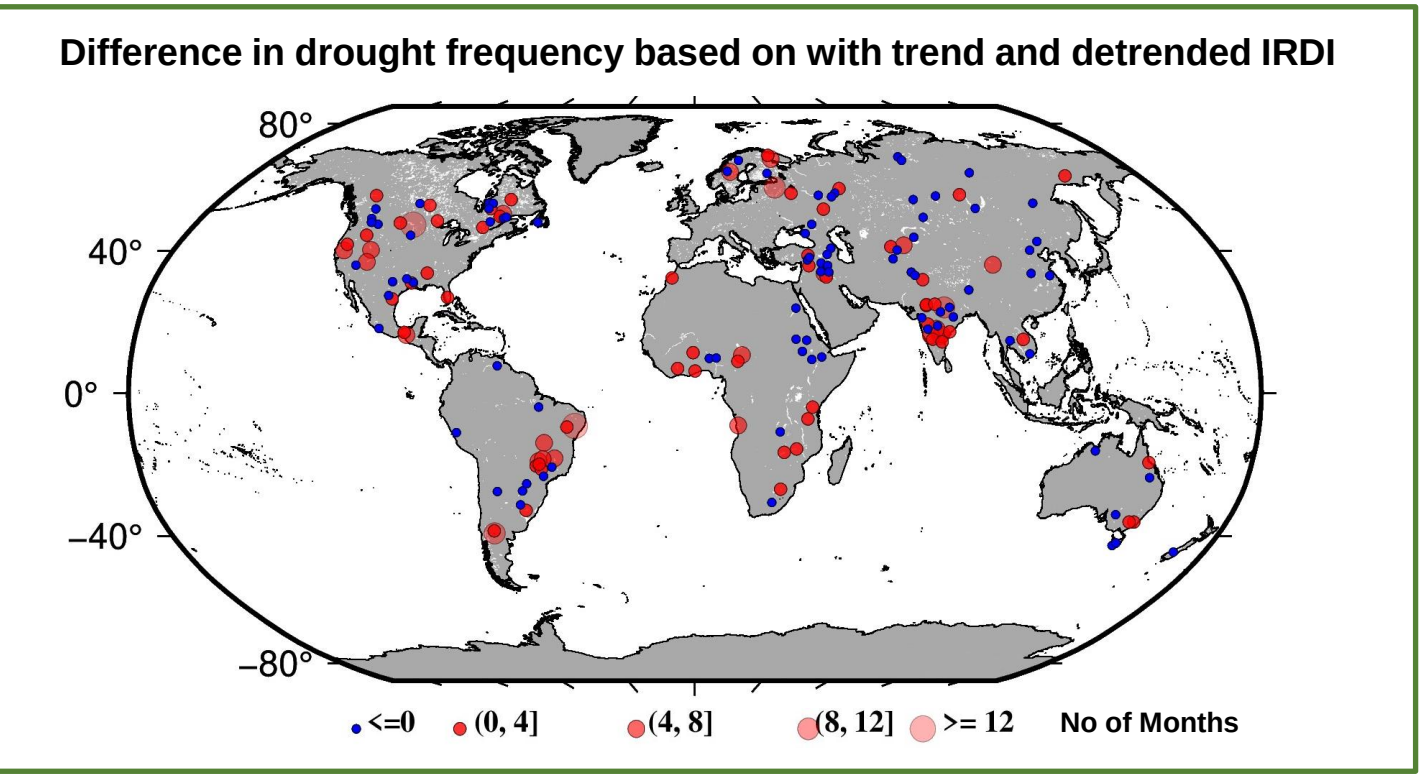
Results :Comparison of IRDI and Precipitation



- The pink boxes show the instances where the reservoir based droughts did not recover despite having high precipitation.

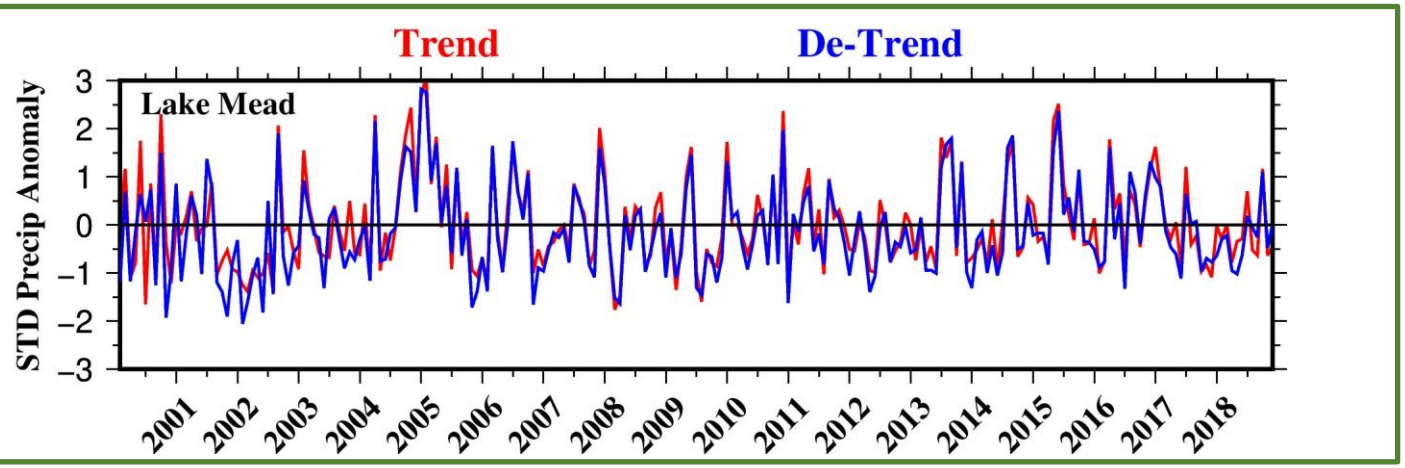
Results : Impacts of Human Influence on Droughts



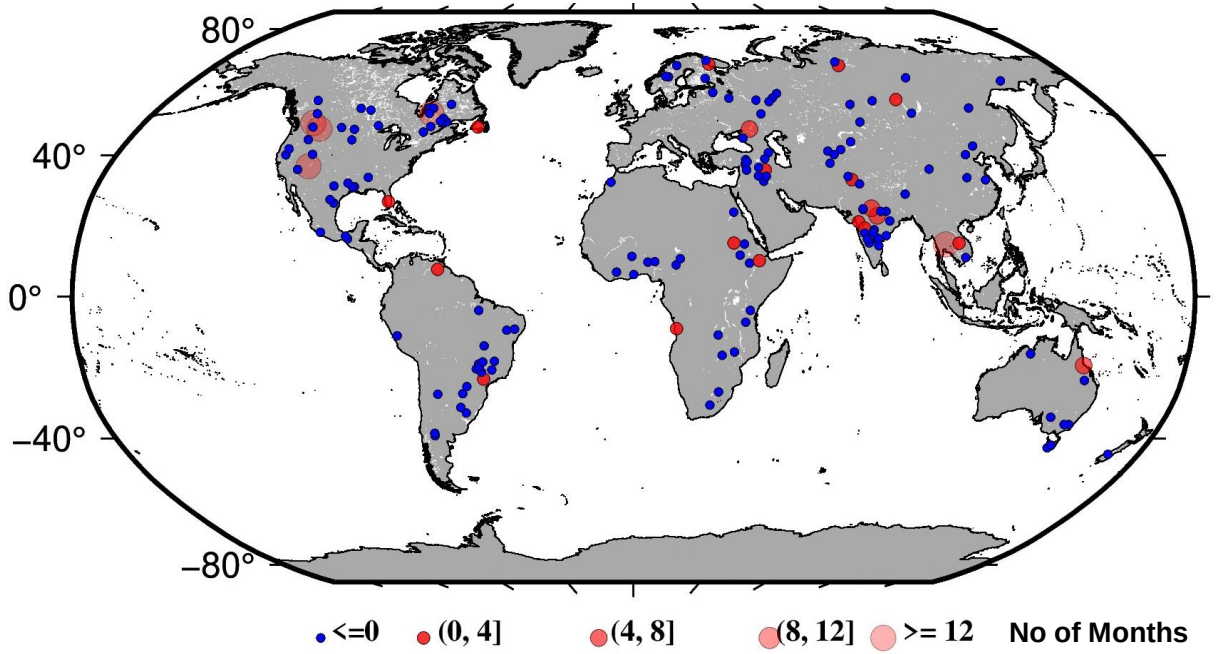


- To identify the role of human influence, we detrended the IRDI using Ensemble Empirical Mode Decomposition (EEMD) method.
- Then, we estimate the difference in moderate to exceptional drought frequency (IRDI <= 1 Standard Deviation (1SD)) in both Trend and detrend scenarios as below.
- Change = [Number of Months having IRDI value <1SD (Trend)]
  - [Number of Months having IRDI values <1SD (De-Trend)]

Results : Impacts of Human Influence on Droughts



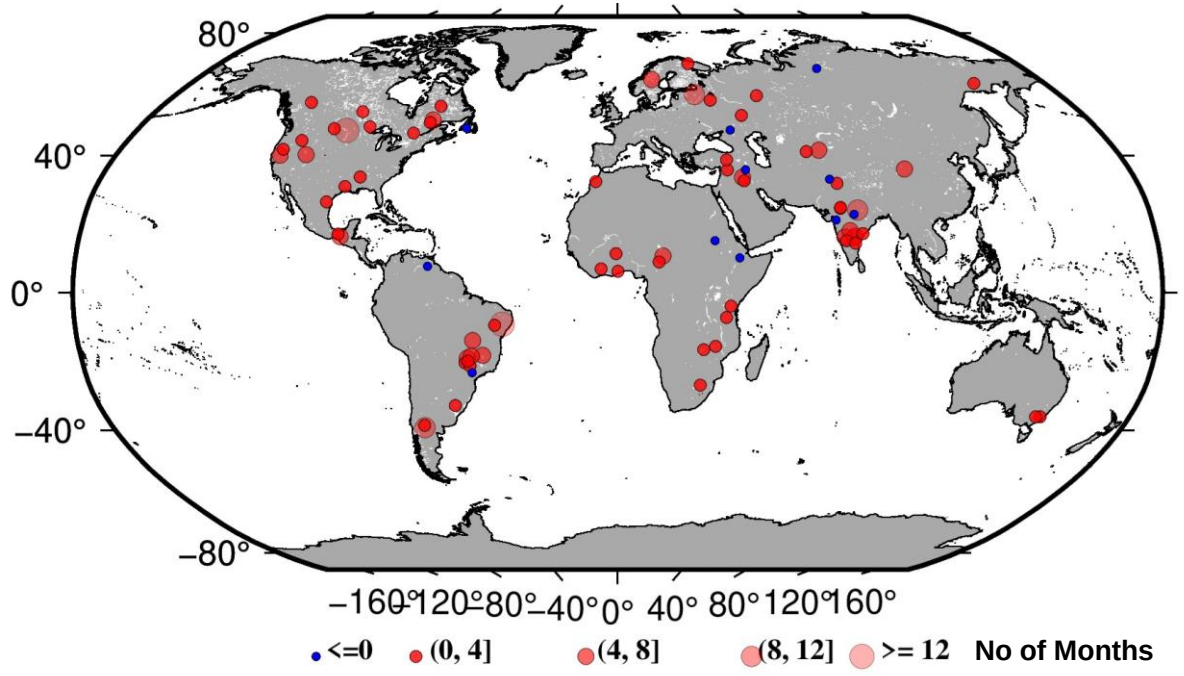
Difference in Trend and detrend drought frequency based on Precip

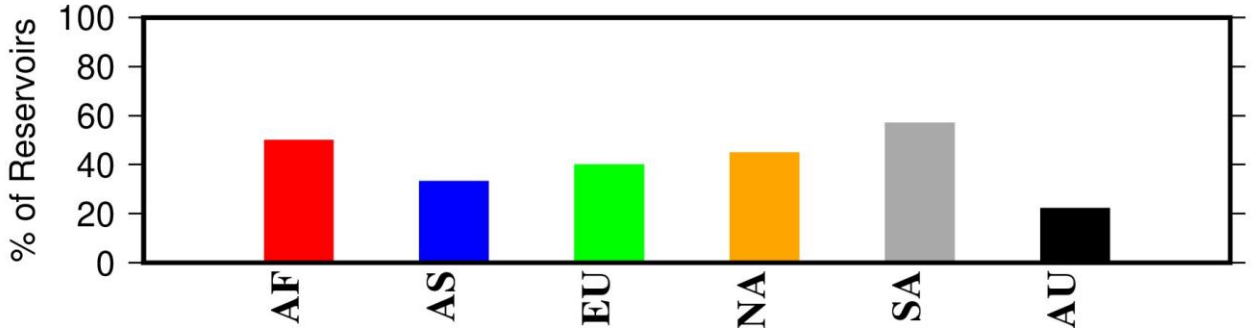


- Similarly, we perform the analysis using standardized precipitation anomalies.
- We estimate the difference in moderate to exceptional drought frequency (STD Precip <=1SD) in both Trend and detrend scenarios as below.
- Change = [Number of Months having STD Precip anomaly values <1SD(Trend)] - [Number of Months having STD Precip anomaly values <1SD (De-Trend)]

Results : Impacts of Human Influence on Droughts

Reservoirs with the human influence





- We hypothesize that trend in IRDI is either due to the human influence or due to the trend in precipitation.
- Lastly, we compared the difference in drought frequencies based on both IRDI and precipitation and identify the reservoirs with the contrasting patterns.
- The figure shows the reservoirs having droughts due to the human influence or inefficient water management activities.

Conclusions

1. **IRDI successfully captures** the drought variabilities exhibited by standardized storage and evaporation anomalies. An integrated approach helps identify the overall drought characteristics on a better scale.
2. Overall, **Asia and Australia experience relatively longer** RBD than the other countries/continents. However, **Europe and South America show more intense droughts**. North America shows droughts with high mean intensity.
3. Human influence (water management activities) alter reservoir-based droughts in each continent with **Africa and South America having the most percentage of reservoirs affected** (This can change based on the number of reservoirs considered in each continent).

Contacts: deep.shah@tamu.edu ; hgao@tamu.edu

References

- Zhao, G., X. Cai, and H. Gao, Estimating lake temperature profile and evaporation losses by leveraging MODIS LST data, Remote Sensing of Environment (2020), https://doi.org/10.1016/j.rse.2020.112104, 2020.
- Zhao, G., Li, Y., Zhang, S., Shah, D., & Gao, H. (2021). Collection 6.1 MODIS Reservoir Product Algorithm Theoretical Basis Document (ATBD) Version 1.0. NASA GSFC.
- Li, Y., Zhao, G., Shah, D., Zhao, M., Sarkar, S., Devadiga, S., Zhao, B., Zhang, S., and Gao, H. (2021). NASA's MODIS/VIIRS Global Water Reservoir Product suite from moderate resolution remote sensing data. Remote Sensing, 13(4), 565; https://doi.org/10.3390/rs13040565.

Acknowledgement

- This research was funded by NASA Science of Terra, Aqua, and Suomi NPP (80NSSC18K0939)
- The authors also would like to thank Drs. Maosheng Zhao, Sudipta Sarkar, Sadashiva Devadiga and many others from the LDOPE/NASA LandSIPS team for their help with the product.

Thank you