

# Spatiotemporal assessment of terrestrial water storage over Indian sub-continent

Shivam Rawat<sup>1</sup>, Abinesh Ganapathy<sup>1</sup>, Ravi Guntu<sup>1</sup>, and Ankit Agarwal<sup>1</sup>

<sup>1</sup>Indian Institute of Technology Roorkee

November 23, 2022

## Abstract

Drought is a natural disaster that mainly affects water resources, agriculture, and a country's social and economic development due to its long-term and frequent occurrence. Therefore, it is important to characterize and monitor drought and its propagation to minimize the impact. Precipitation and Terrestrial water storage are popular hydrological components used frequently to understand the drought process. However, spatiotemporal assessment of drought propagation over India based on terrestrial water storage is unexplored. In this study, the terrestrial water storage anomalies (TWSA) obtained from a Gravity Recovery and Climate Experiment (GRACE) and Combined Climatological Deviation Index (CCDI) are used to characterize the drought at different spatial scales. The changing pattern of TWSA and CCDI is investigated using the non-parametric Mann-Kendall test and its slope is estimated using the Theil-Sen slope estimator. TWSA trends unravel that the Ganga and Indus River Basin have significant negative trends throughout the year. However, the trends are oscillating for Peninsular basins. The major river basins Ganga, Indus, Brahmaputra shows decreasing trends for all seasons; however, Cauvery, Mahanadi, Krishna, and the Godavari show decreasing trends for winter and Post-monsoon season and increasing trends for pre-monsoon and monsoon season. It shows that Ganga, Indus, and Brahmaputra river basins are more prone to drought in the near future.

## Hosted file

drought event dsi.docx available at <https://authorea.com/users/543122/articles/601165-spatiotemporal-assessment-of-terrestrial-water-storage-over-indian-sub-continent>

# Spatiotemporal assessment of terrestrial water storage over Indian sub-continent

Shivam Rawat, Abinesh Ganapathy, Ravi Kumar Guntu, and Ankit Agarwal

Department of Hydrology, Indian Institute of Technology Roorkee, 247667, India,



## Introduction

- ❖ Drought is a natural disaster that mainly affects water resources, agriculture, and social and economic development due to its long-term and frequent occurrence
- ❖ According to Indian Meteorological Department (IMD), meteorological drought occurs if rainfall deficiency is greater than 26%
- ❖ Direct observation of Terrestrial water storage (TWS) from GRACE or its deviation from climatologic mean can be used as a metric for drought characterization
- ❖ Combined Climatologic Deviation Index (CCDI) and GRACE-based Drought severity index (GRACE-DSI) are effective for drought characterization

## Study area & Data used

- ❖ 90 sub-basins within the 25 river basins lying inside the Indian boundary for this study
  - ❖ Gridded Precipitation data and GRACE-TWSA data.
  - ❖ Time period – 2002-2017
- Fig. Study area map including 90 Indian sub-basins



## Methodology

- ❖ Computation of CCDI and GRACE-DSI indices
- ❖ Trends analysis

$$GRACE - DSI_{i,j} = \frac{TWSA_{i,j} - \overline{TWSA}_j}{TWSA_{i,j}} \quad (1)$$

$$PA_{i,j} = P_{i,j} - P_{\mu} \quad (2)$$

$$PAR_{i,j} = PA_{i,j} - \overline{PA}_j \quad (3)$$

$$TWSAR_{i,j} = TWSA_{i,j} - \overline{TWSA}_j \quad (4)$$

$$CD_{i,j} = TWSAR_{i,j} + PAR_{i,j} \quad (5)$$

$$CCDI_{i,j} = \frac{CD_{i,j} - \overline{CD}_j}{CD_{i,j}} \quad (6)$$

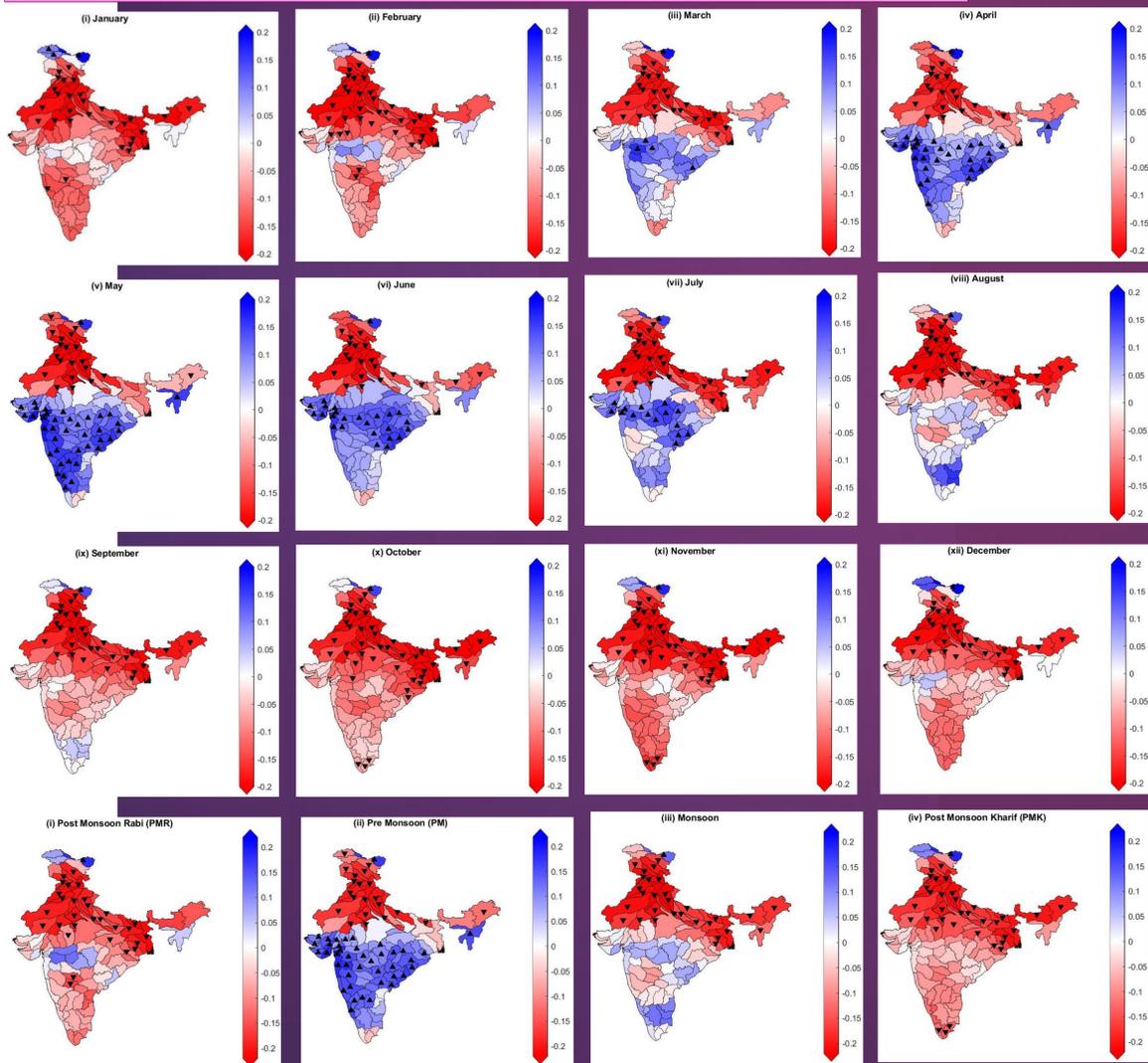
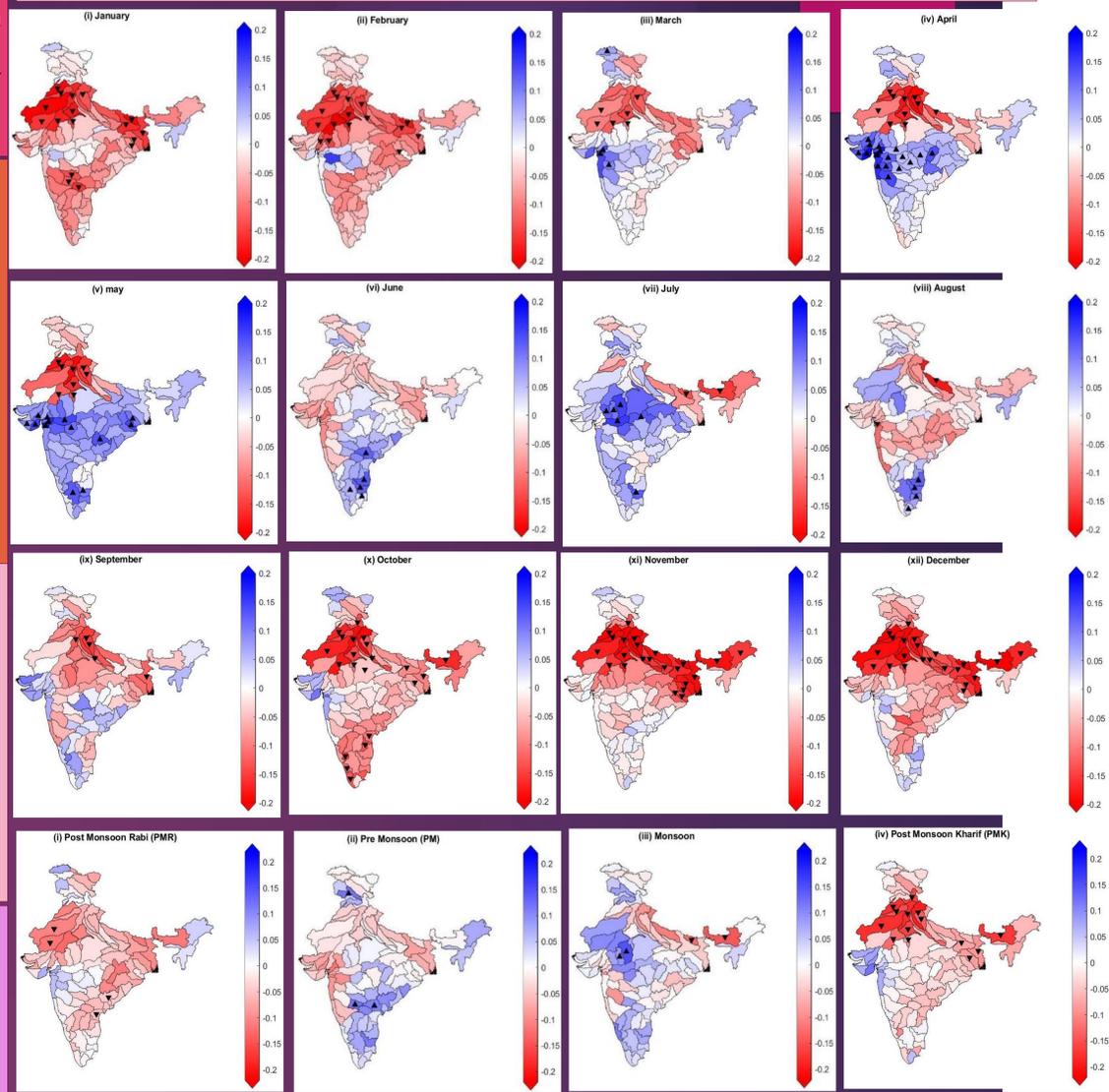
## Results & Discussion

- ❖ Monthly & Seasonal GRACE-DSI trends

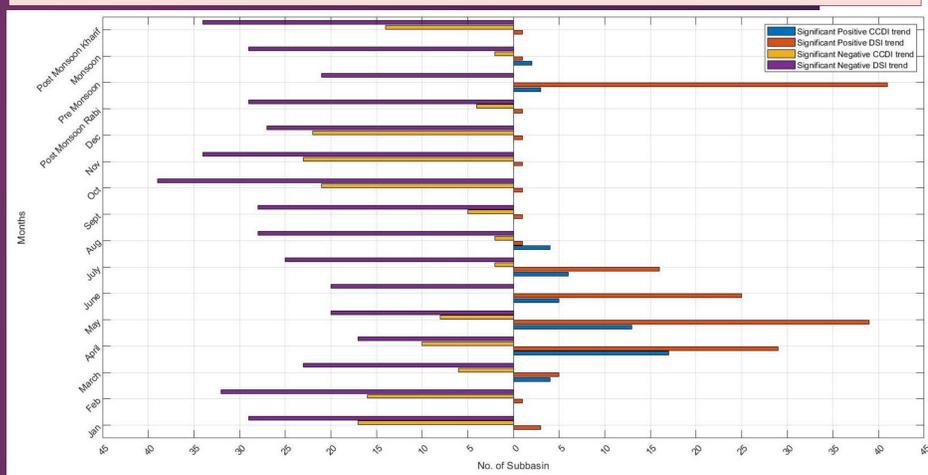
Monthly & Seasonal trend analysis of GRACE-DSI shows that sub-basins of Ganga and Indus have continuous negative trends throughout the months while other sub-basin shows changing trends

## Monthly & Seasonal CCDI trends

CCDI monthly trends for most sub-basins are showing changing trends. Sub-basin which shows significant negative trends for both CCDI and GRACE-DSI conclude that sub-basin getting low or no rainfall due to which TWS continuously depleting



- ❖ We plot month vs no. of sub-basin showing significant negative or positive trends for GRACE-DSI and CCDI. In Appendix Fig.1, most of the sub-basin shows significant negative trends for both GRACE-DSI and CCDI. The number of sub-basins showing significant negative trends for GRACE-DSI is more than that for CCDI



## Conclusions

- ❖ GRACE-DSI shows significant negative trends over most of the Indian sub-basins relative to CCDI, indicating that most of the drought events are due to depletion of TWS
- ❖ 23 nos. of sub-basins show CCDI significant negative trends for November month and 14 no. of sub-basins show for Post monsoon Kharif season
- ❖ 39 nos. of sub-basins show GRACE-DSI significant negative trends for October month and 34 no. of sub-basins show for Post monsoon Kharif season

## References

- Cao, Y., Nan, Z., Cheng, G., 2015. GRACE gravity satellite observations of terrestrial water storage changes for drought characterization in the arid land of northwestern China. *Remote Sens.* 7, 1021–1047. <https://doi.org/10.3390/rs70101021>
- Mann, H.B., 1945. Non-Parametric Test Against Trend. *Econometrica* 13, 245–259.
- Sinha, D., Syed, T.H., Famiglietti, J.S., Reager, J.T., Thomas, R.C., 2017. Characterizing drought in India using GRACE observations of terrestrial water storage deficit. *J. Hydrometeorol.* 18, 381–396. <https://doi.org/10.1175/JHM-D-16-0047.1>
- Theil H (1950) A rank-Invariant method of linear and polynomial regression analysis.
- Zhao, M., A. G., Velicogna, I., Kimball, J.S., 2017. A Global Gridded Dataset of GRACE Drought Severity Index for 2002–14: Comparison with PDSI and SPEI and a Case Study of the Australia Millennium Drought. *J. Hydrometeorol.* 18, 2117–2129. <https://doi.org/10.1175/JHM-D-16-0182.1>

Contact: Shivam Rawat ([s\\_rawat@hy.iitr.ac.in](mailto:s_rawat@hy.iitr.ac.in)), Abinesh Ganapathy ([abinesh\\_g@hy.iitr.ac.in](mailto:abinesh_g@hy.iitr.ac.in)), Ravi Kumar Guntu ([guntu\\_r@hy.iitr.ac.in](mailto:guntu_r@hy.iitr.ac.in)), Ankit Agarwal ([ankit.agarwal@hy.iitr.ac.in](mailto:ankit.agarwal@hy.iitr.ac.in))