Prediction of groundwater storage variability in India

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INTRODUCTION

- India is the largest user of groundwater in the world. It uses an estimated 230 cubic-kilometers of groundwater per year - over a quarter of the global total.
- More than 60% of irrigated agriculture and 85% of drinking water supplies are dependent on groundwater.
- Meteorological droughts and precipitation characteristics affect groundwater storage in India. Despite the importance of groundwater for water and agriculture, efforts to provide prediction of groundwater storage remains limited.
- The objective of this study is to analyze how precipitation and temperature affect groundwater storage in India.

DATA

DATA	SOURCE AND DESCRIPTION
Groundwater level data	Seasonal GW depth data (Jan, May, Aug, Nov) from 1996 - 2016; Maintained by CGWB
Precipitation	Gridded data at a spatial resolution of 2.5°; Daily data aggregated to monthly scale; Maintained by IMD (1951-2016)
Temperature	Gridded data at a spatial resolution of 2.5°; Monthly mean of daily temperature for analysis; Maintained by IMD (1951-2016).

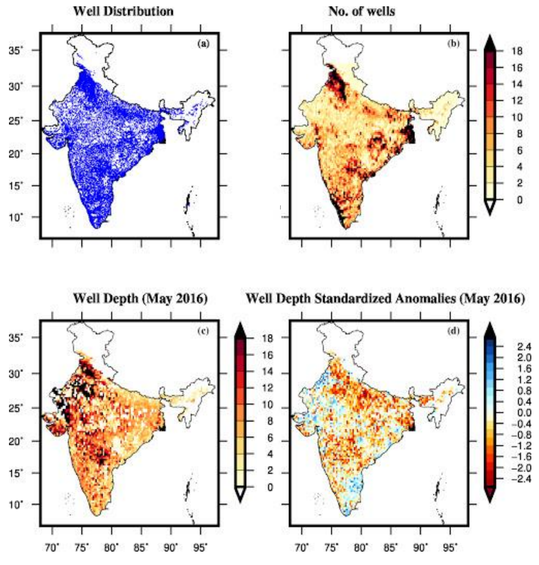

Figure 1:

(a) Distribution of available wells in India.

(b) Number of wells in each 25 km x 25 km grid.

(c) Depth of groundwater averaged over each grid for the month of May 2016.

(d) Standardized anomalies of the depth of groundwater for the month of May 2016.

METHODS

Standardized Precipitation Index (SPI)

- Fitting the gamma distribution to the long-term monthly precipitation record (1951 - 2016) gives the cumulative probability distribution for a accumulation period of 12 months.
- Transforming the cumulative probability distribution to a standard normal distribution gives the SPI for the same accumulation period.

Standardized Precipitation-Evapotranspiration Index (SPEI)

- Hargreaves method calculates the potentio-evapotranspiration (PET) using daily temperature data.
- Subtracting PET from the long term monthly precipitation and fitting the result to a log-logistic function gives the SPEI for a accumulation period of 12 months.

Standardized Groundwater Index (SGI):

- Fitting gamma distribution to the gridded standardized anomalies of groundwater (0.25°) gives its cumulative probability distribution.
- Transforming the cumulative probability distribution to a standard normal distribution gives the SGI for the same accumulation period.

RESULTS

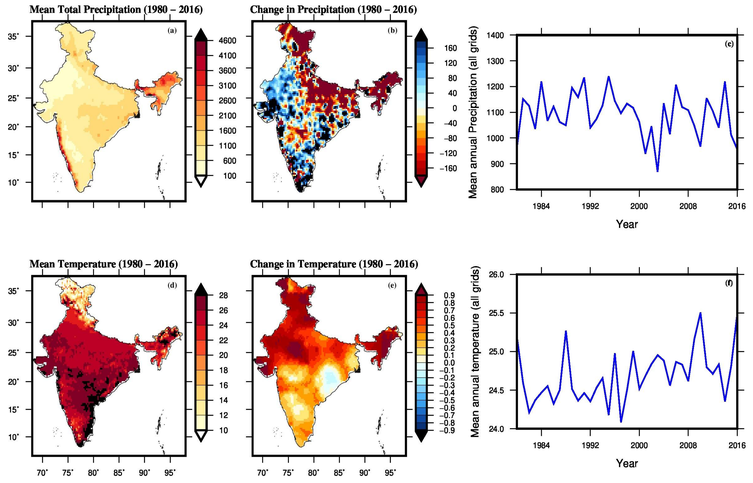

Figure 2: **(a)** Mean total precipitation (in mm) from 1980 to 2016; **(b)** Change in precipitation (in mm) from 1980 to 2016; **(c)** Mean annual precipitation calculated by averaging the precipitation values of all the grids; **(d)** Mean annual temperature; **(e)** Change in temperature; **(f)** Mean annual precipitation calculated by averaging the precipitation values of all the grids.

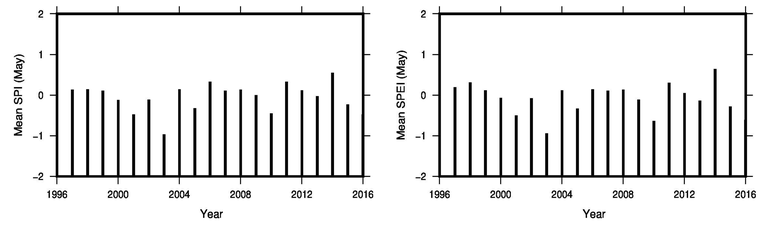

Figure 3: The mean SPI and SPEI of all the grids at the end of May for each year (1980 - 2016)

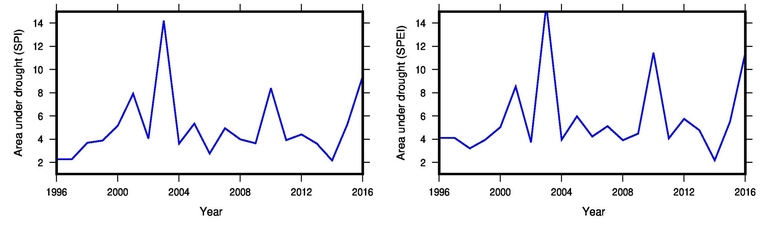

Figure 4: The plot represents the area of the **grids having SPI/SPEI ≦ -1**. This gives us the idea of the major drought years between 1996 and 2016. These are the years of 2003, 2010, 2013, 2016.

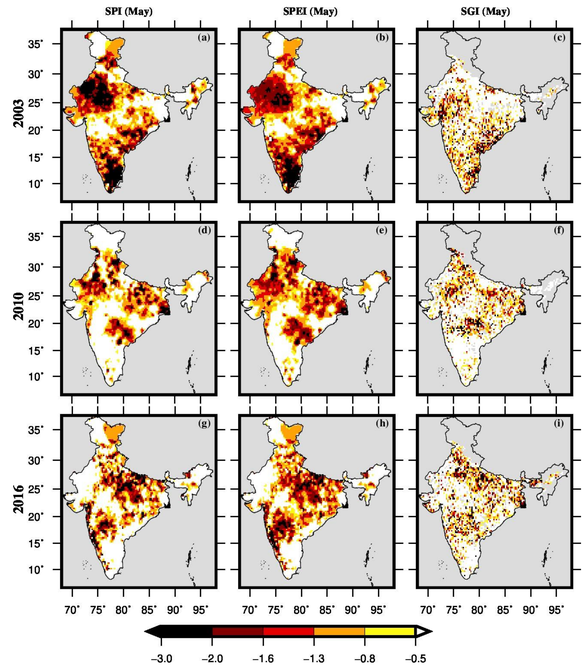

Figure 4: The maps show the SPI, SPEI and SGI for major drought years for the month of May. These plots clearly picture the strong correlation between the 12 month SPI/SPEI with the SGI value.

CONCLUSIONS

- In India, the groundwater storage at a particular month is best correlated with the accumulated **precipitation of last 12 months**.
- The major groundwater droughts years between 1996 - 2016 are **2003, 2010, 2013, 2016**.
- We find a strong relationship between **12-month SPI** and **SPEI** against **standardized groundwater drought index (SGI)** for most of the regions.
- The SPI and SPEI shows similar spatial distribution across the country. This indicates that **temperature has little effect in groundwater storage variability in India**.
- **4 months SPI** at the end of September can be used to **predict the groundwater storage anomaly for the dry season** (October - May).

REFERENCES

- Bloomfield, J. P., and B. P. Marchant. 2013. **Analysis of Groundwater Drought Building on the Standardised Precipitation Index Approach**." *Hydrology and Earth System Sciences.*
- Asoka, Akarsh, et al. 2017. **Relative contribution of monsoon precipitation and pumping to changes in groundwater storage in India.** *Nature Geoscience.*

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