Standardized Variability Index (SVI): A multiscale index to assess the variability of precipitation

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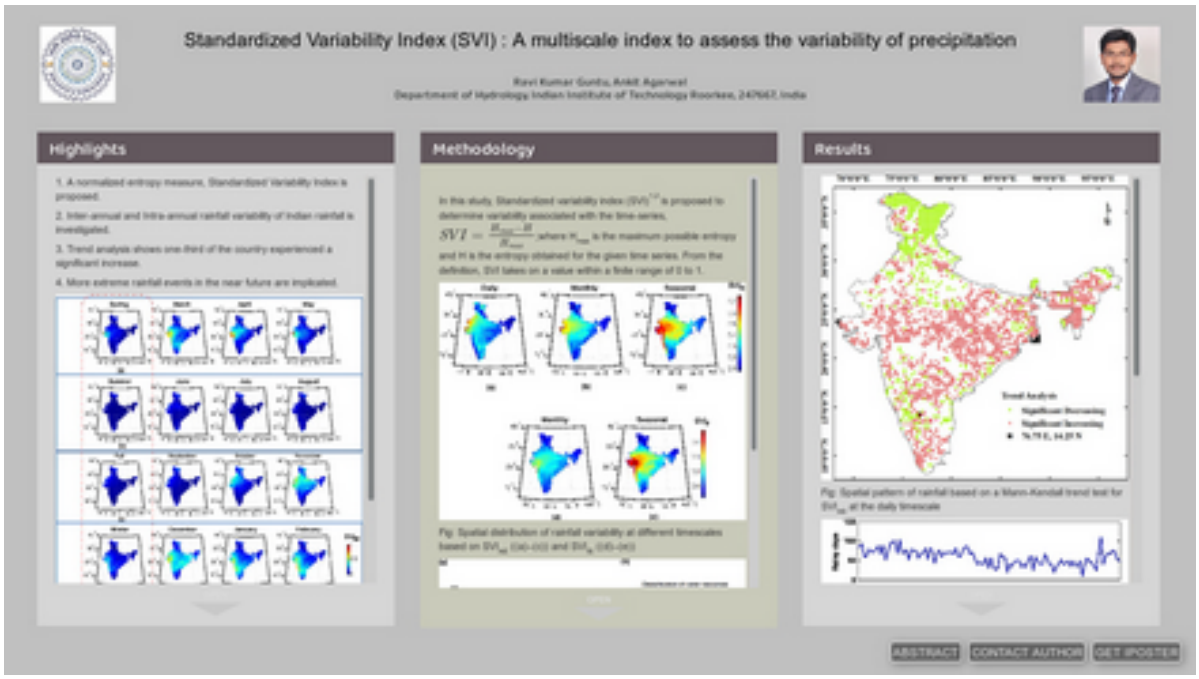
Abstract

Quantifying the spatiotemporal variability of precipitation is the principal component for the assessment of the impact of climate change on the hydrological cycle. A better understanding of the quantification of variability and its trend is vital for water resources planning and management. Therefore, a multitude of studies has been dedicated to quantify the precipitation variability over the years. Despite their importance for modeling precipitation variability, the studies mainly focused on the amount of precipitation and its spatial patterns. The studies investigating the spatial and temporal variability of precipitation across the Indian subcontinent, in general, and at multiscale, in particular, are limited. In this study, we introduce a novel measure, Standardized Variability Index (SVI), based on information entropy to investigate the spatiotemporal variability of precipitation. The proposed measure is independent of the temporal scale, the length of the data and can compare the precipitation variability at multiple timescales. Distinct spatial patterns were observed for information entropies at the monthly and seasonal scale. Stations with statistically significant trends were observed and vary from monthly to seasonal scale. There is an increase in the variability of precipitation amount across Central India. Trend analysis revealed there is changing behaviour in the precipitation amount as well as rainy days, showing an increase in the probability of occurrence of extreme events in the near future. In addition, coupling the mean annual rainfall with SVI enables a relative assessment of the water resources availability.

Standardized Variability Index (SVI) : A multiscale index to assess the variability of precipitation



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HIGHLIGHTS

1. A normalized entropy measure, Standardized Variability Index is proposed.

2. Inter-annual and Intra-annual rainfall variability of Indian rainfall is investigated.

3. Trend analysis shows one-third of the country experienced a significant increase.

4. More extreme rainfall events in the near future are implicated.

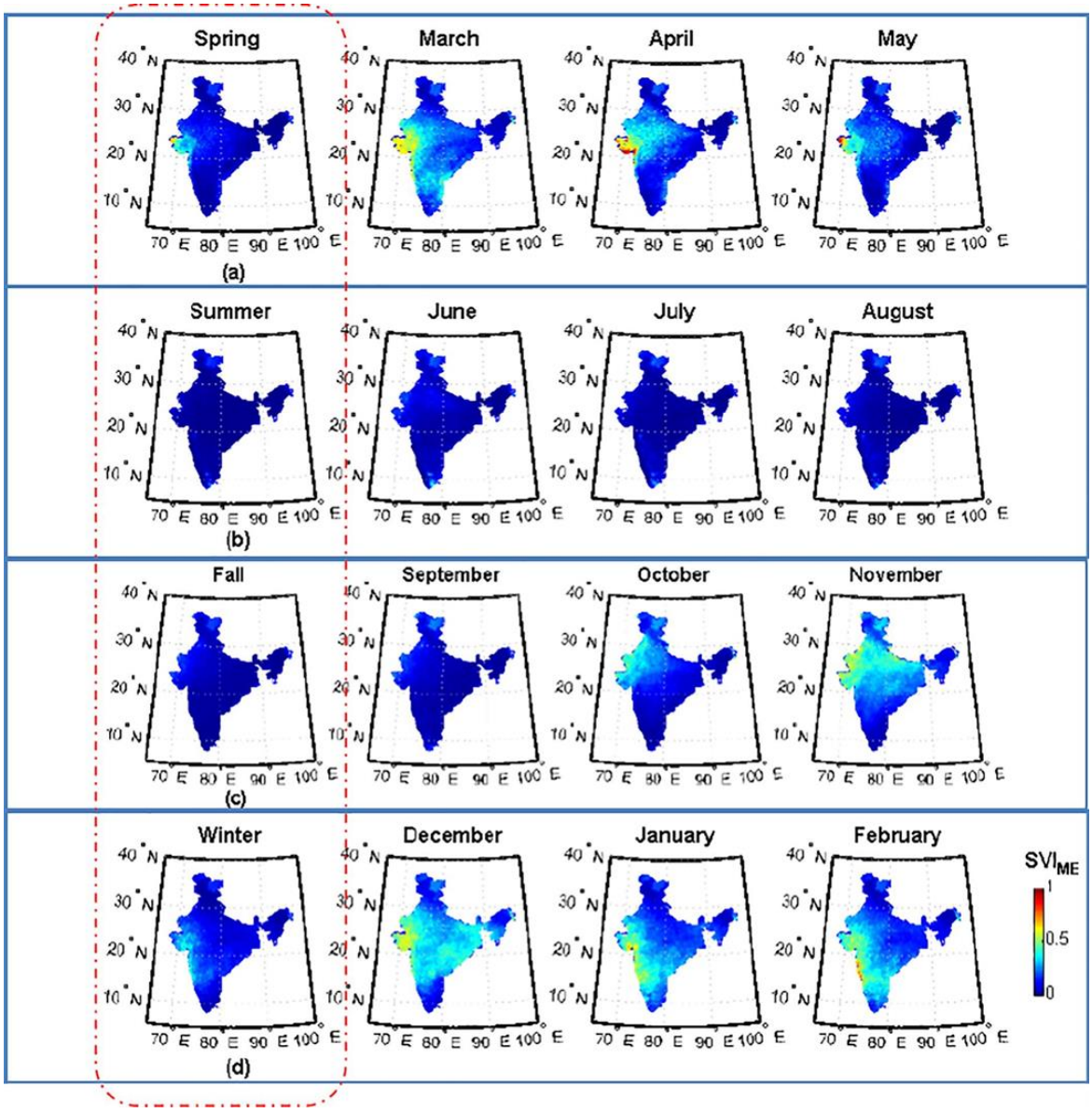

Fig: Spatial distribution of rainfall variability for different seasons over the period 1901–2013 based on SVI_{ME}: (a) Spring and its constituent months; (b) Summer and its constituent months; (c) Fall and its constituent months; and (d) Winter and its constituent months

METHODOLOGY

In this study, Standardized variability index (SVI)[1,2] is proposed to determine variability associated with the time-series, $SVI = \frac{H_{max}-H}{H_{max}}$;where H_{max} is the maximum possible entropy and H is the entropy obtained for the given time series. From the definition, SVI takes on a value within a finite range of 0 to 1.

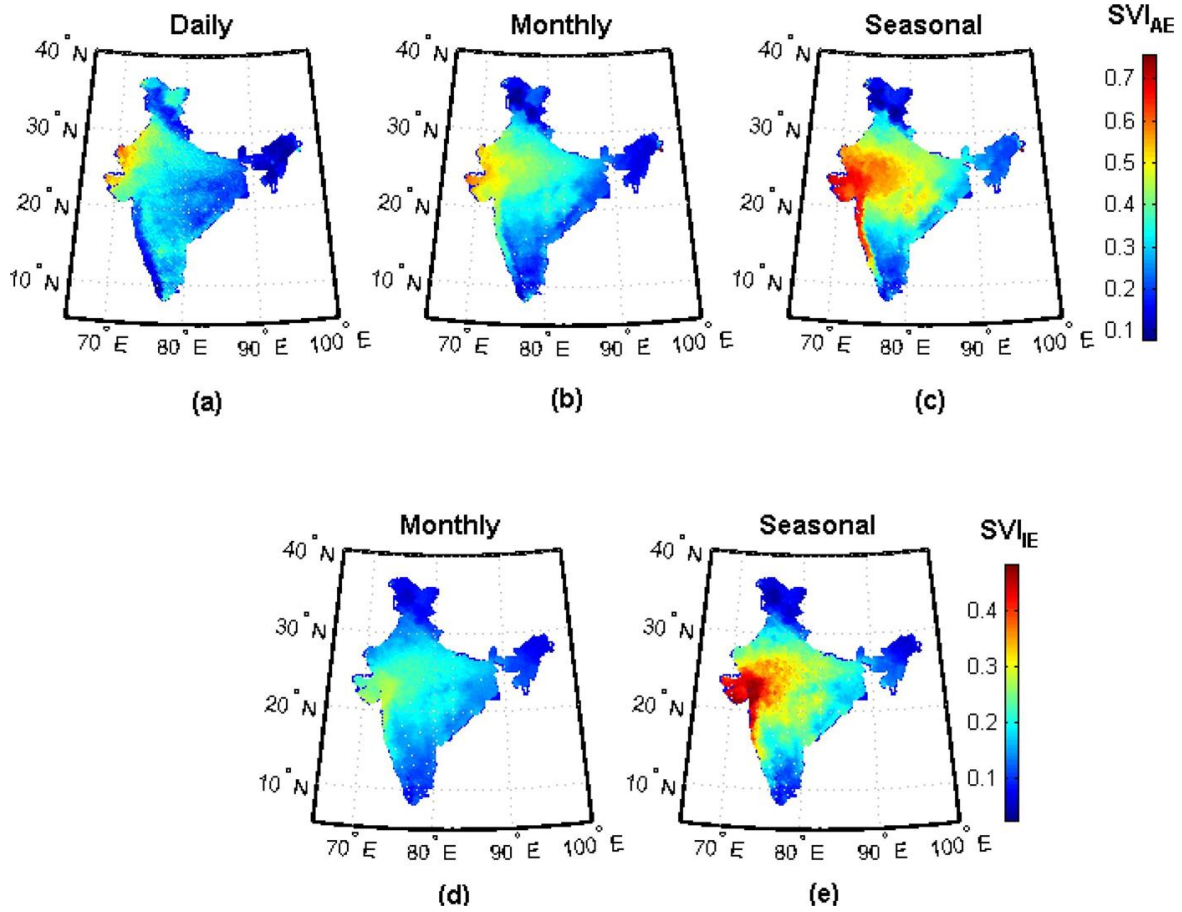

Fig: Spatial distribution of rainfall variability at different timescales based on SVI_{AE} ((a)–(c)) and SVI_{IE} ((d)–(e))

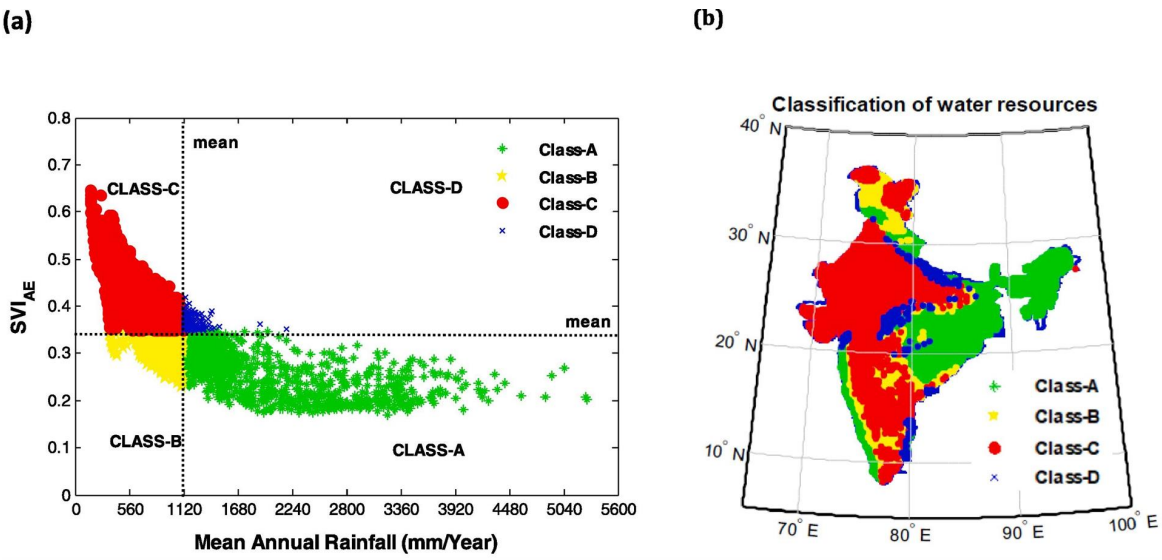

Fig: (a) Plot between mean annual rainfall and its variability (daily SVI_{AE}) for all the 4443 grid locations across the country; and (b) Geographical locations of the grid locations falling under different classes

RESULTS

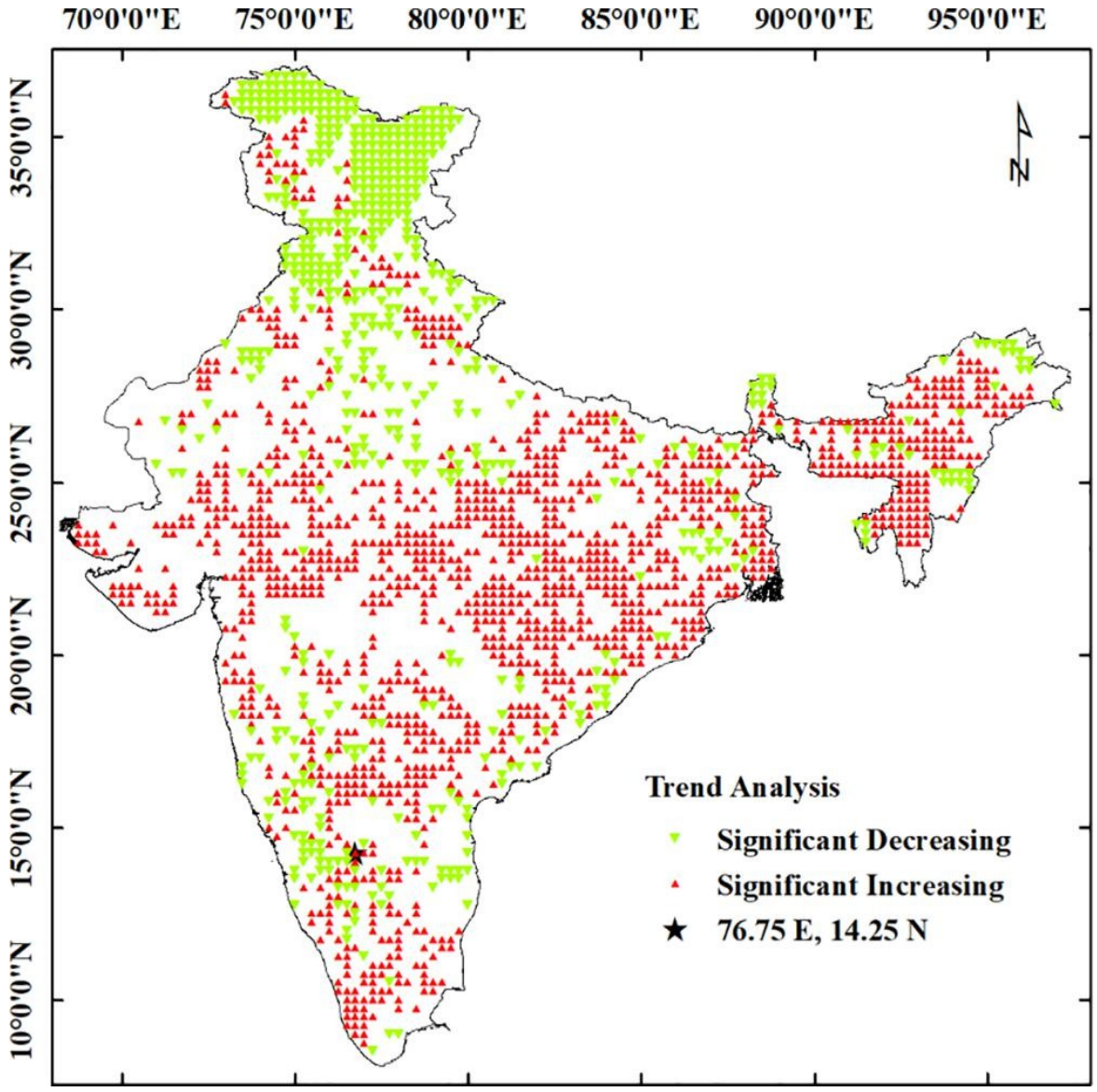

Fig: Spatial pattern of rainfall based on a Mann-Kendall trend test for SVI_{AE} at the daily timescale

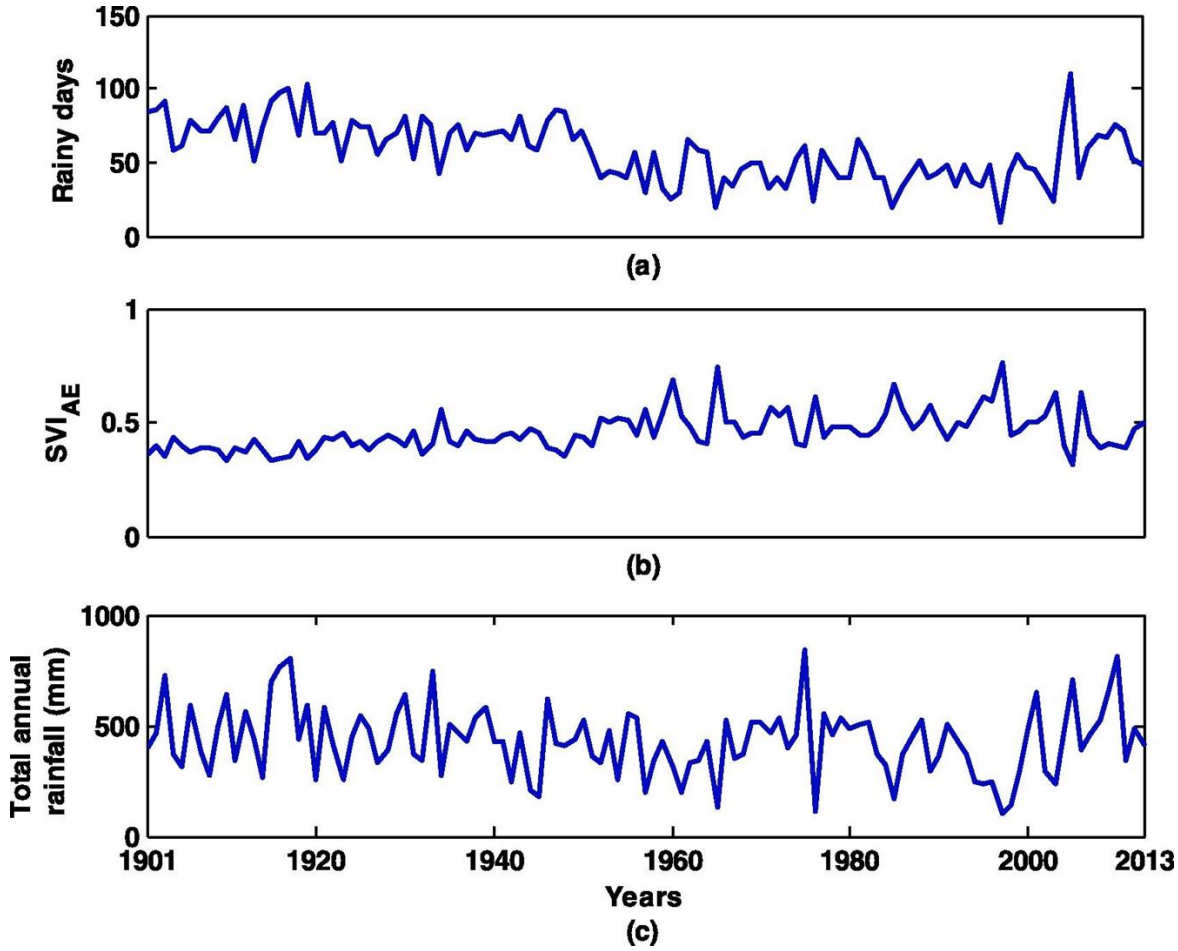

Fig: Temporal pattern of (a) rainy days, (b) its variability, and (c) total rainfall amount over the period 1901–2013 for a randomly selected station (76.75° E, 14.25° N)

[1]*Guntu, R. K., Rathinasamy, M., Agarwal, A., & Sivakumar, B. (2020). Spatiotemporal variability of Indian rainfall using multiscale entropy. Journal of Hydrology, 124916. https://doi.org/10.1016/j.jhydrol.2020.124916 (https://doi.org/10.1016/j.jhydrol.2020.124916)*

[2]*Guntu, R. K., Rathinasamy, M., Agarwal, A., & Singh, V.P (2020).* Accounting for temporal variability for improved precipitation regionalization based on self-organizing map coupled with information theory. *Journal of Hydrology, https://doi.org/10.1016/j.jhydrol.2020.125236 (https://doi.org/10.1016/j.jhydrol.2020.125236)*

ABSTRACT

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