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Influences Of Local Factors On Long-term Annual And Intra-annual Water Balances across 25 major river basins in India

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Abstract

- Water yield plays a significant role in advancement of human communities and thus evaluation of hydrology at basin scale (partitioning of precipitation to actual evapotranspiration and runoff) becomes an inevitable study to obtaining availability of water.
- We develop a regional model for India, considering local basin parameters (slope, elevation, normalized difference vegetation index) and geo-positioning aspects, which covers small to large scale catchments (across 25 major river basins covering whole India) for predicting the basin parameter ω in Fu's equation. In addition, seasonality factor is incorporated in the model due to intra-annual variability in vegetation across India.
- The basin parameter ω, estimated from the present model is presenting far better consistency with the optimized ω (approximately $R^2 = 0.9$), obtained from climatic variables using Budyko hypothesis (Fu's equation), than the estimated ω obtained from previously developed models.
- The previously developed global NN model failed to capture the local water-energy partitioning in Indian context merely because of considering a small portion of Indian subcontinent (Indus basin) which excludes the vast range of basin characteristics.

Background

- Partitioning of precipitation and available energy at the surface are determined by inherent catchment properties like soil properties, vegetation covers, topographical characteristics etc. that are predominantly altered by anthropogenic activities (Wagener et al., 2010).
- Budyko framework has been incorporated in many studies that effortlessly elucidates the intricate hydrological processes (Milly, 1994; Williams et al., 2012) compared to various Land Surface Models (LSMs) that uses large amount of datasets for simulation of energy and water fluxes among the atmosphere, vegetation and land surface (Pitman, 2003; Rodell et al., 2004).
- Only Basin Indus that overlaps with a very small portion of Indian territory was included in the previous study by Xu et al., (2013) to model catchment characteristics at global scale.
- NDVI is an important catchment characteristic that determines the terrestrial hydrological processes and the influence may vary with seasons of high and low NDVI period.

Study Area

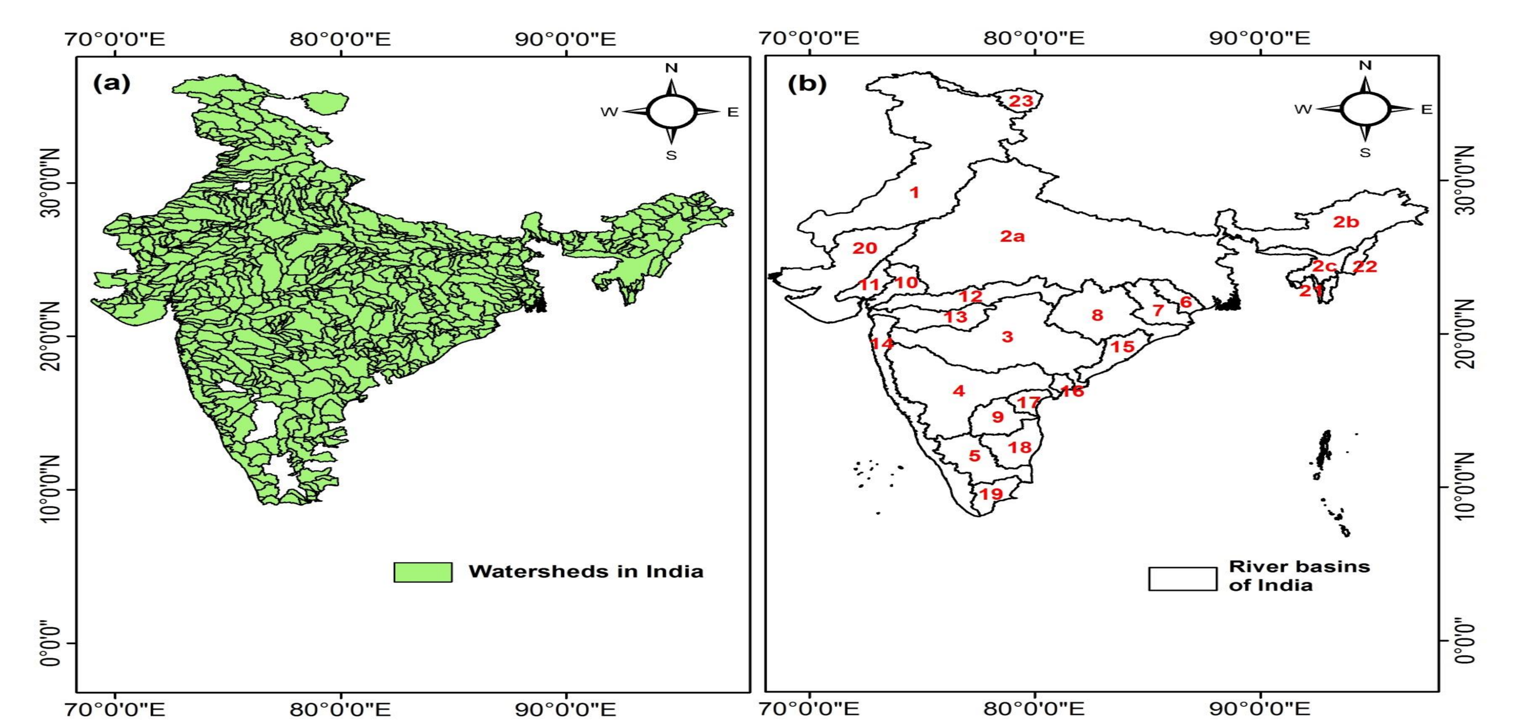

Fig 1. Study Area

Data and Methodology

Hydro-Meteorological Data	Surface Data	River Basins
• Precipitation (IMD) • Potential Evapotranspiration (PET: MOD16A2 product) • Actual Evapotranspiration (AET: MOD16A2 product)	• DEM Data (SRTM) • NDVI Data (MODIS)	• Major River basins (India-WRIS) • 768 watersheds (WaterBase)

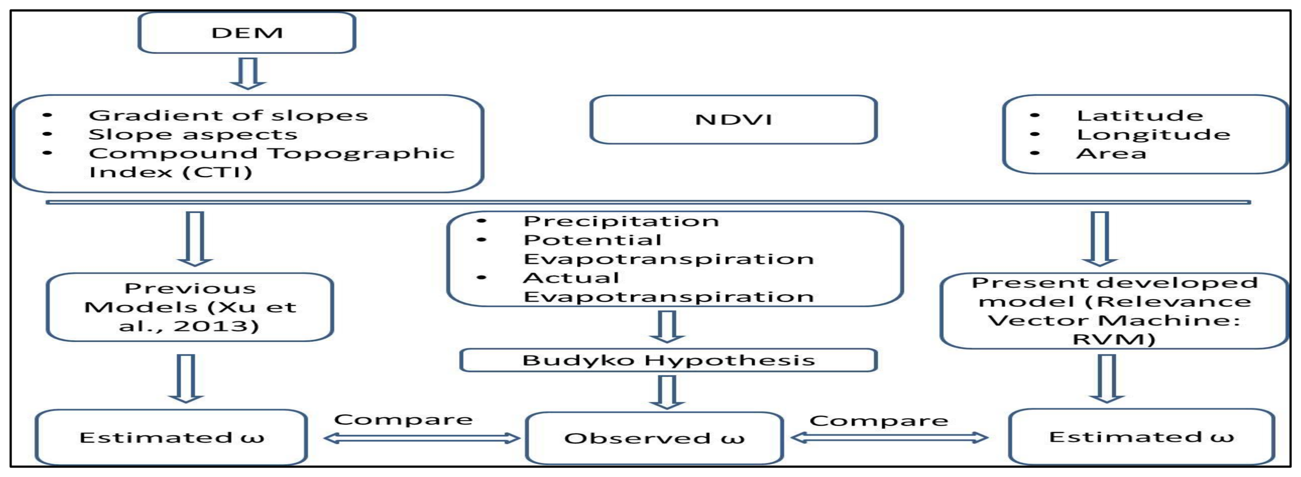

Fig 2. Flow chart of the study

Budyko Hypothesis

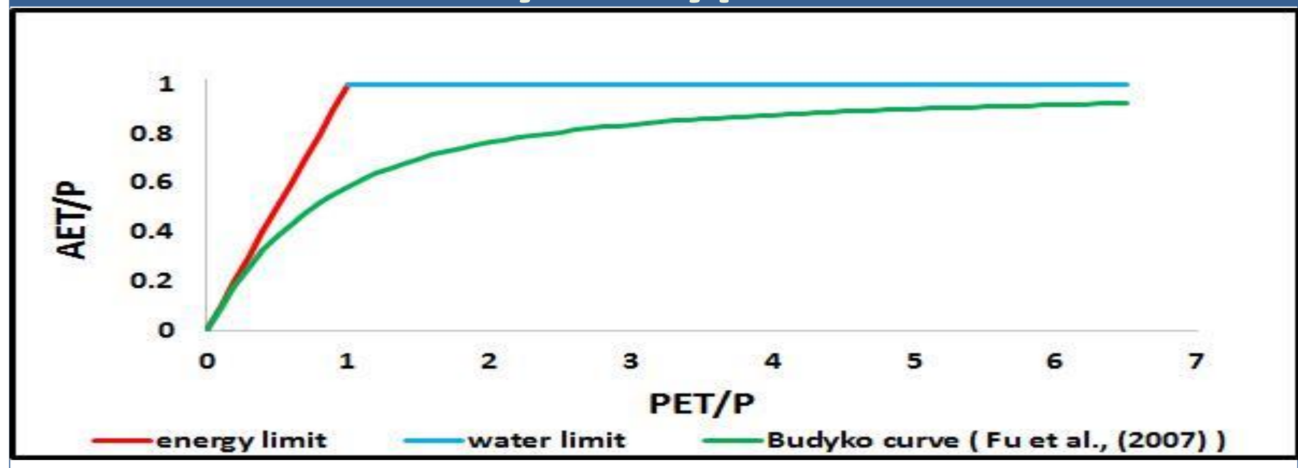

Fig 3. Budyko Curve

Budyko Curve Equation: $\frac{AET}{P} = 1 + \frac{PET}{P} - \left(1 + \left(\frac{PET}{P}\right)^{\omega}\right)^{\frac{1}{\omega}}$

(Fu, 1981)

Energy Limit: AET ≤ PET

Water Limit: AET≤ P

Results & Discussion

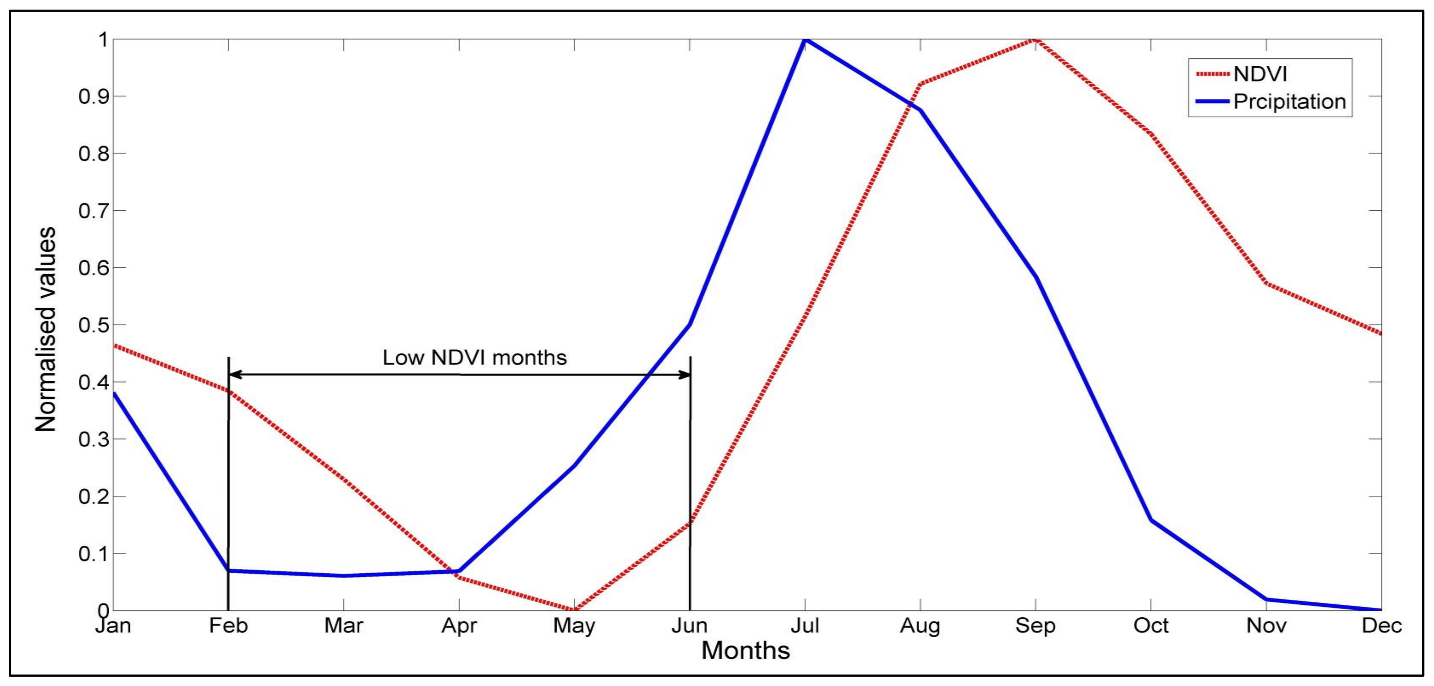

Fig 4. Selection of low and high NDVI months

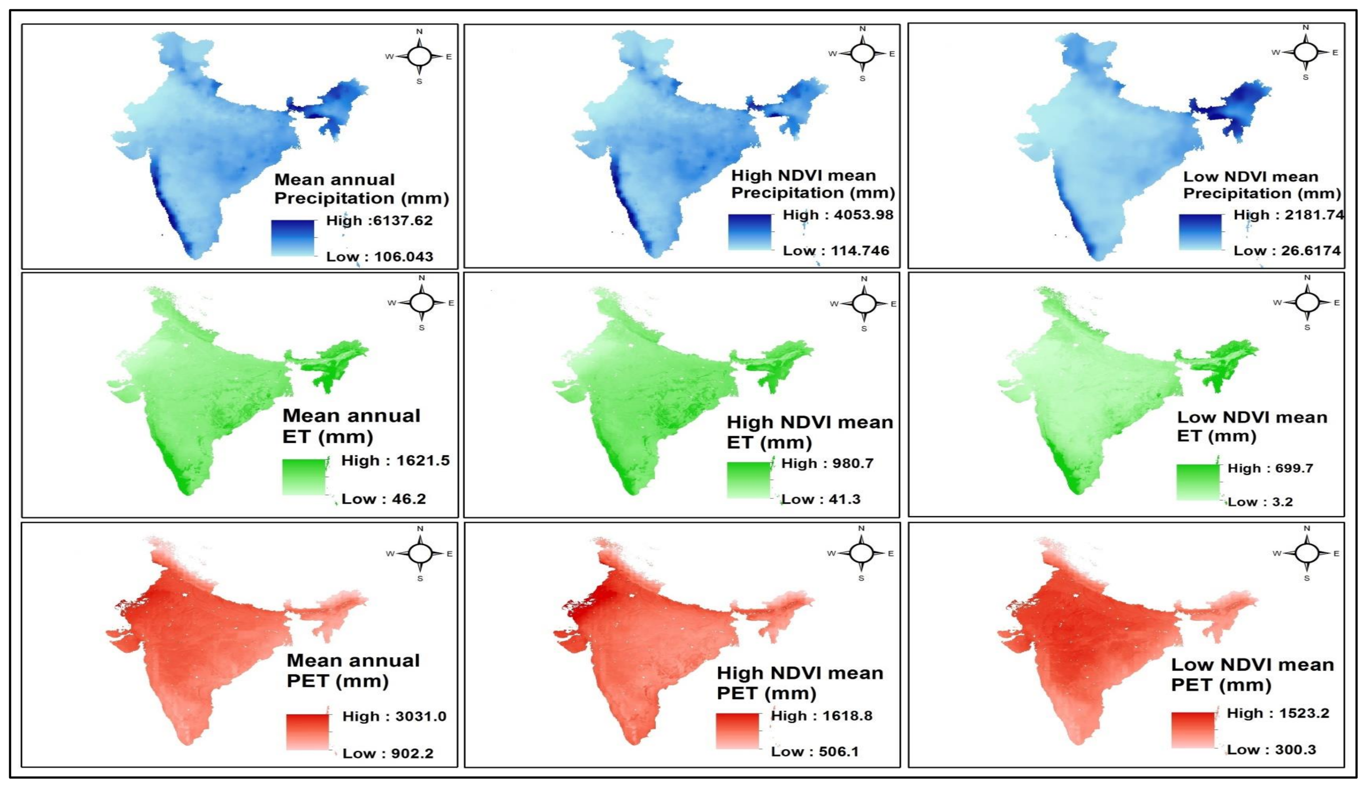

Fig 5. Spatial distribution of Precipitation, ET and PET for annual and intra-annual time scales

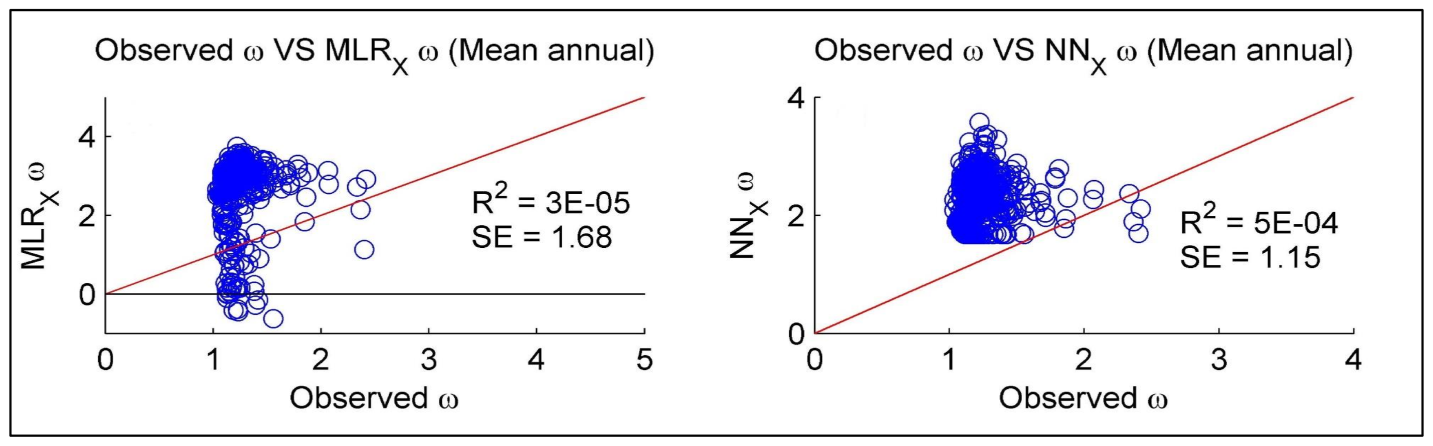

Fig 6. Scatter plots of computed ω from previous models and observed ω for annual scale

MLR$_X$: Multiple Linear Regression model

ω = 3.50412 – (0.09311 × slope) – (0.03288 × latitude) + (1.12312 × NDVI) – (0.00205 × longitude) – (0.00026 × elevation)

(Xu, 2013)

NN$_X$: Trained Artificial Neural Network (ANN) model.

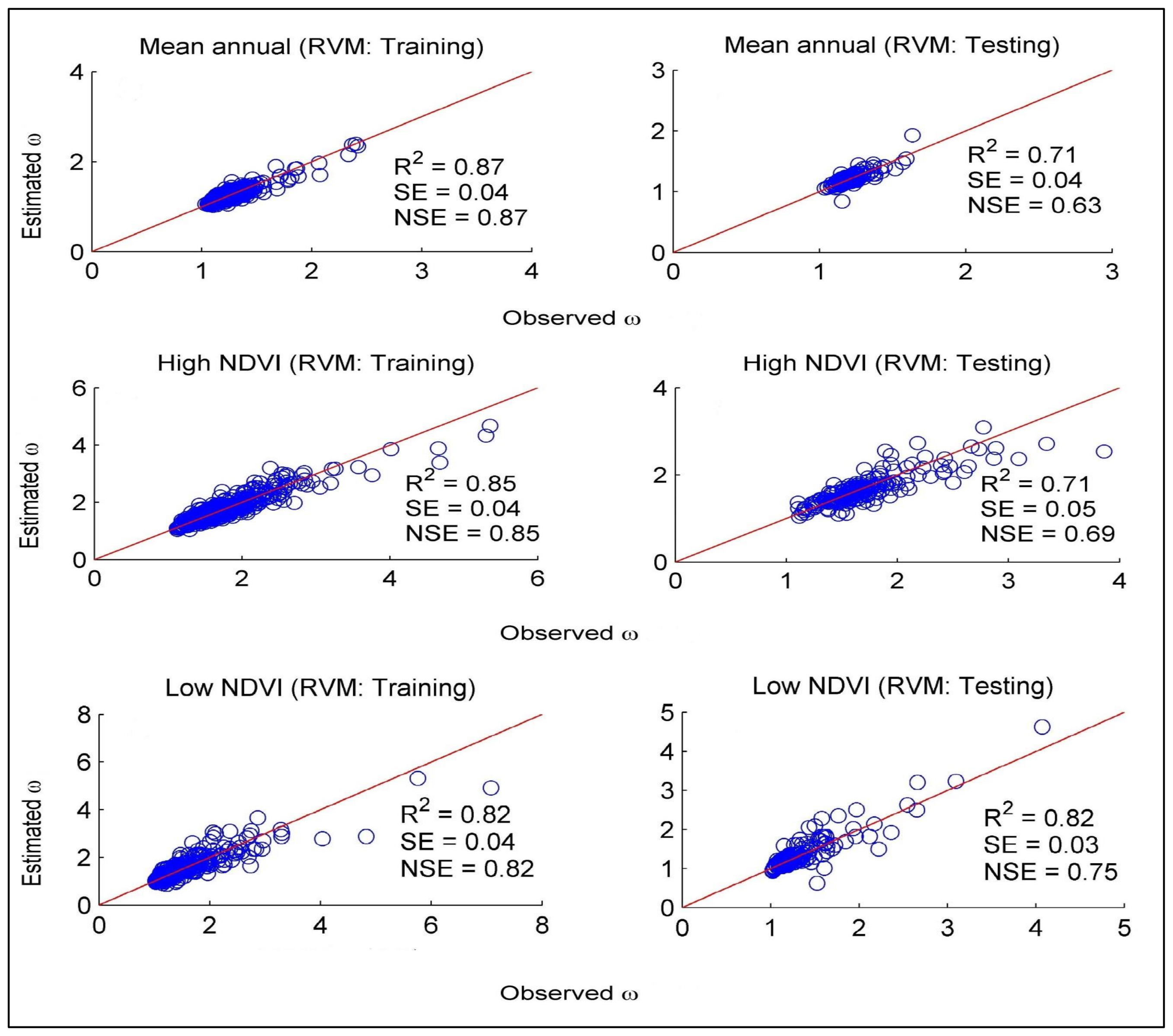

Fig 7. Scatter plots of observed and estimated ω for training-testing datasets of RVM (Relevance Vector Machine) model for annual and intra-annual time scales

Conclusions

- Obtaining information on inherent catchment attributes is of upmost importance for ungauged basins to assess the dynamics of water flux at the surface.
- The present developed local model has correctly captured the influences of surface characteristics in explaining the partitioning of precipitation and energy.
- Monsoonal variations in precipitation is reflected in the NDVI values as precipitation provides the required water for plant growth.
- NDVI has higher ability in explaining the variance in the observed datasets in the low NDVI months compared to high NDVI months.

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