The rise of the Indian Summer Monsoon long-term trends of precipitation extremes

Trends, tendencies, potential driving factors

Renaud Falga and Chien Wang

Laboratoire d'Aérologie - Paul Sabatier University, Toulouse, France

→ Have the monsoon extreme precipitation events significantly evolved in India since 1901 ?

→ What are the potential driving factors responsible for the evolution ?

Framework: Partitioning of study regions

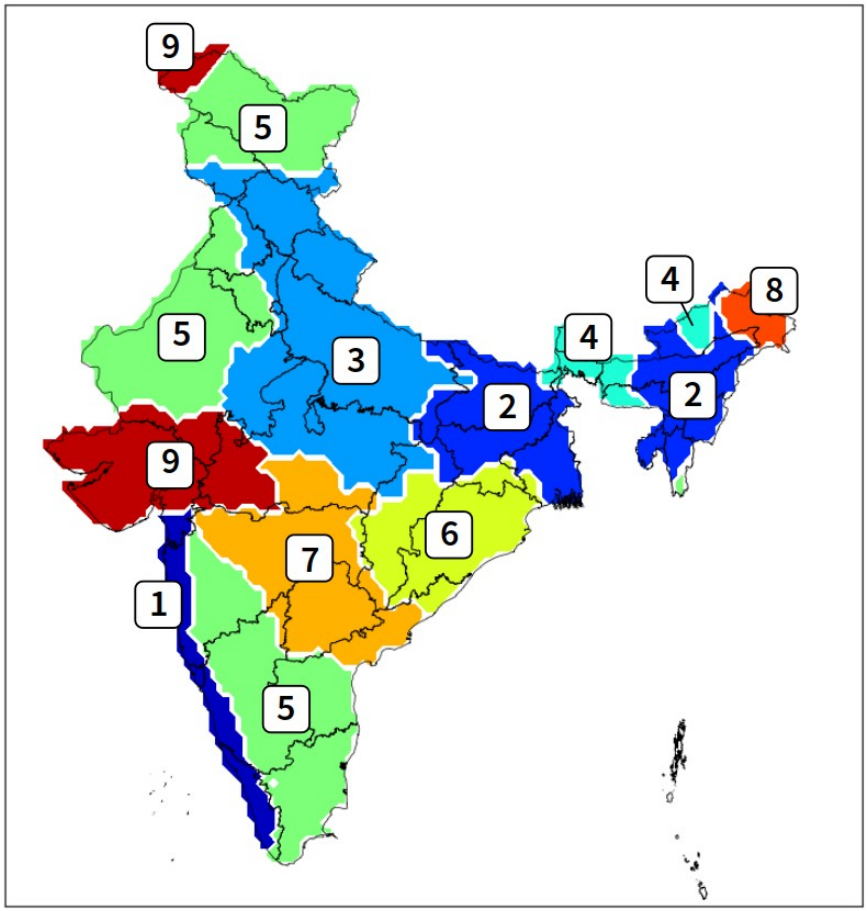
→ Study the whole India instead of one particular region

→ Partition the country based on a climatological criterion instead of predefined regions

Method: Ward's clustering method applied to the monsoon rainfall dataset (gridded IMD data):

- 9 regions with similar rainfall characteristics have been identified

- 7 regions used for analysis

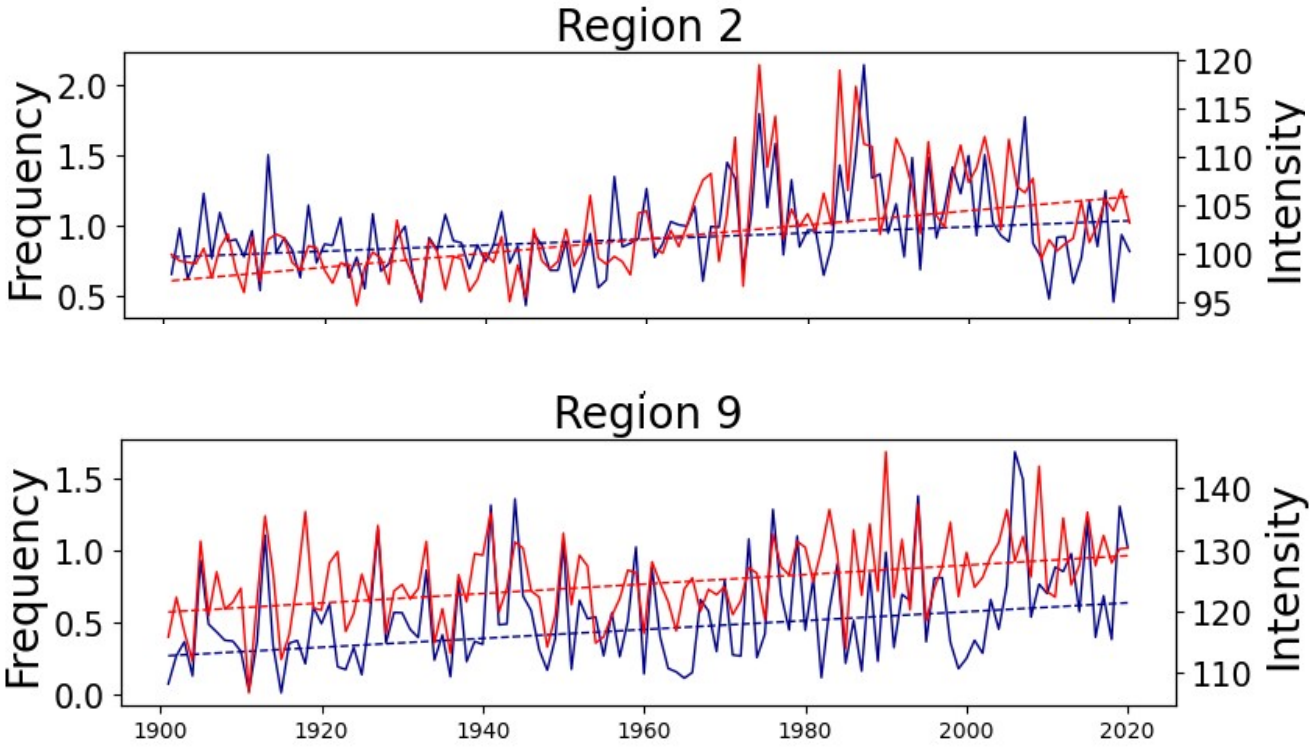


Frequency and Intensity trends

- Mann-Kendall trend test (5% significance level), Theil-Sen estimator to calculate slopes

- Among all 14 trends calculated: **12 are increasing, 1 is decreasing**

The remaining trend is statistically insignificant



Frequency in red, intensity in blue

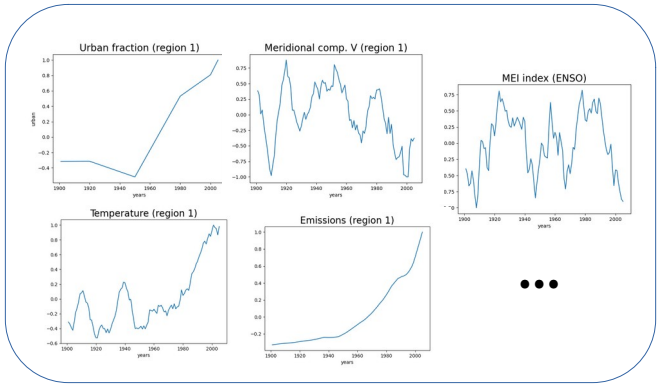
Identifying potential explanatory variables behind observed trends

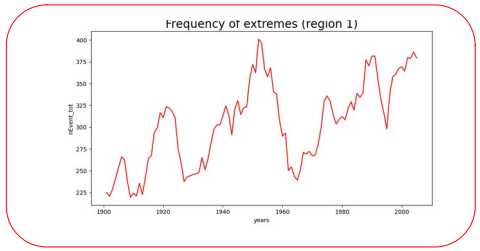
Multivariate regression analysis

- Most studies tend to link the rise in extremes to a single explanatory variable

- Multivariate regression: Compare the relative importance in the prediction of extremes of the different potential causes

→ Random forest regression and feature importance to determine which input features are the most important in the prediction



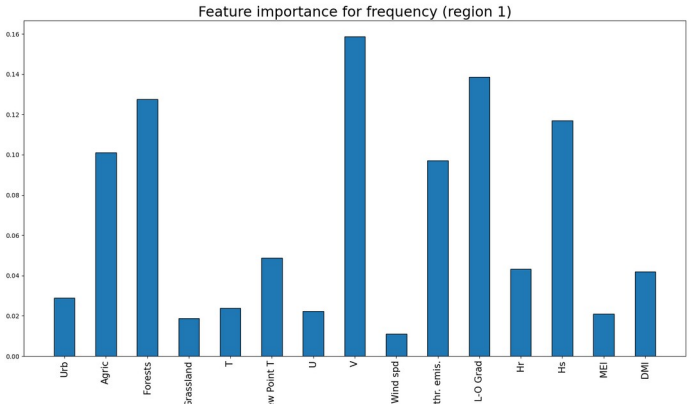


Input features

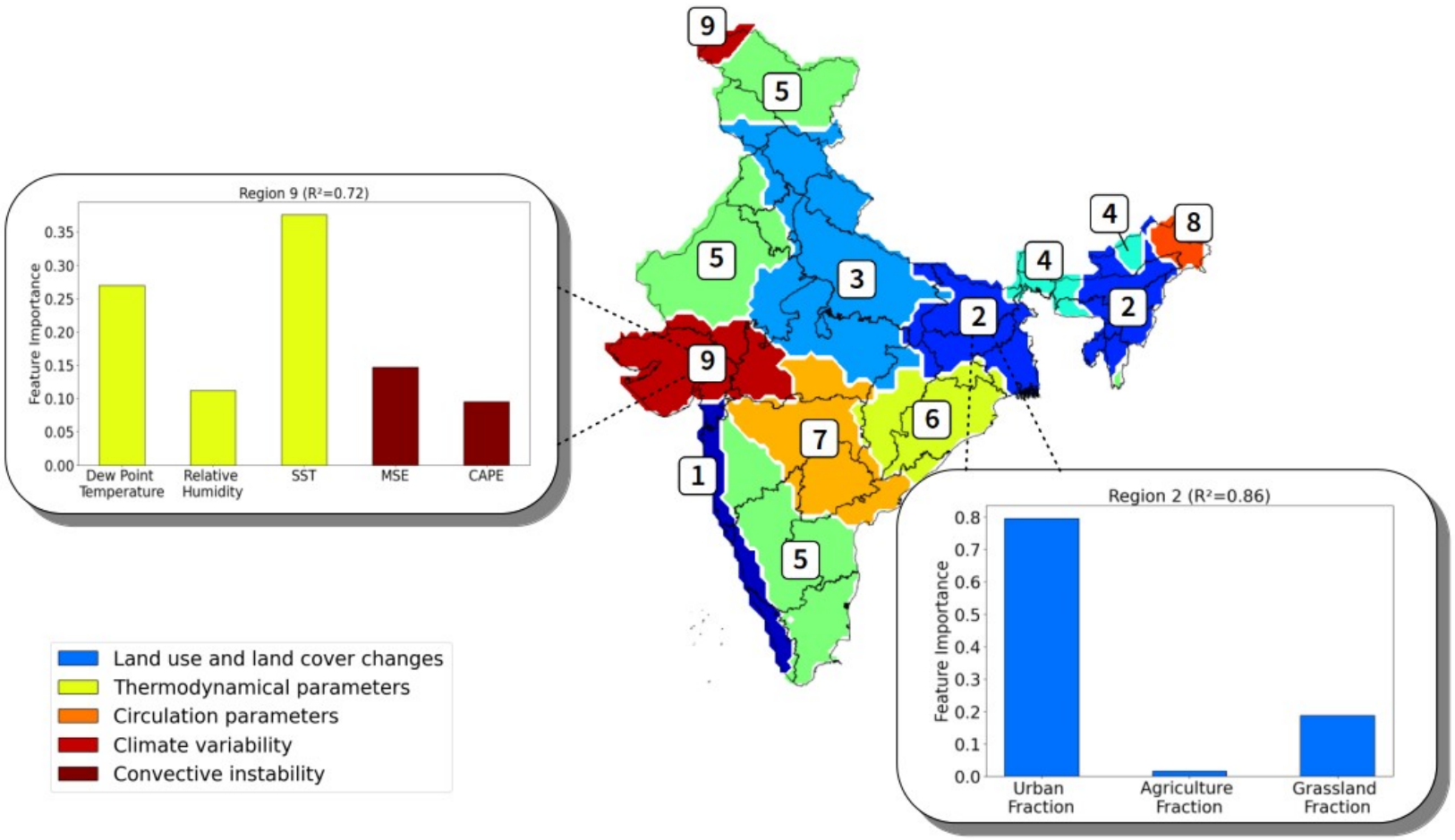
Extreme event trend

Random forest model

Feature Importance



Feature importance for Frequency in regions 2 and 9



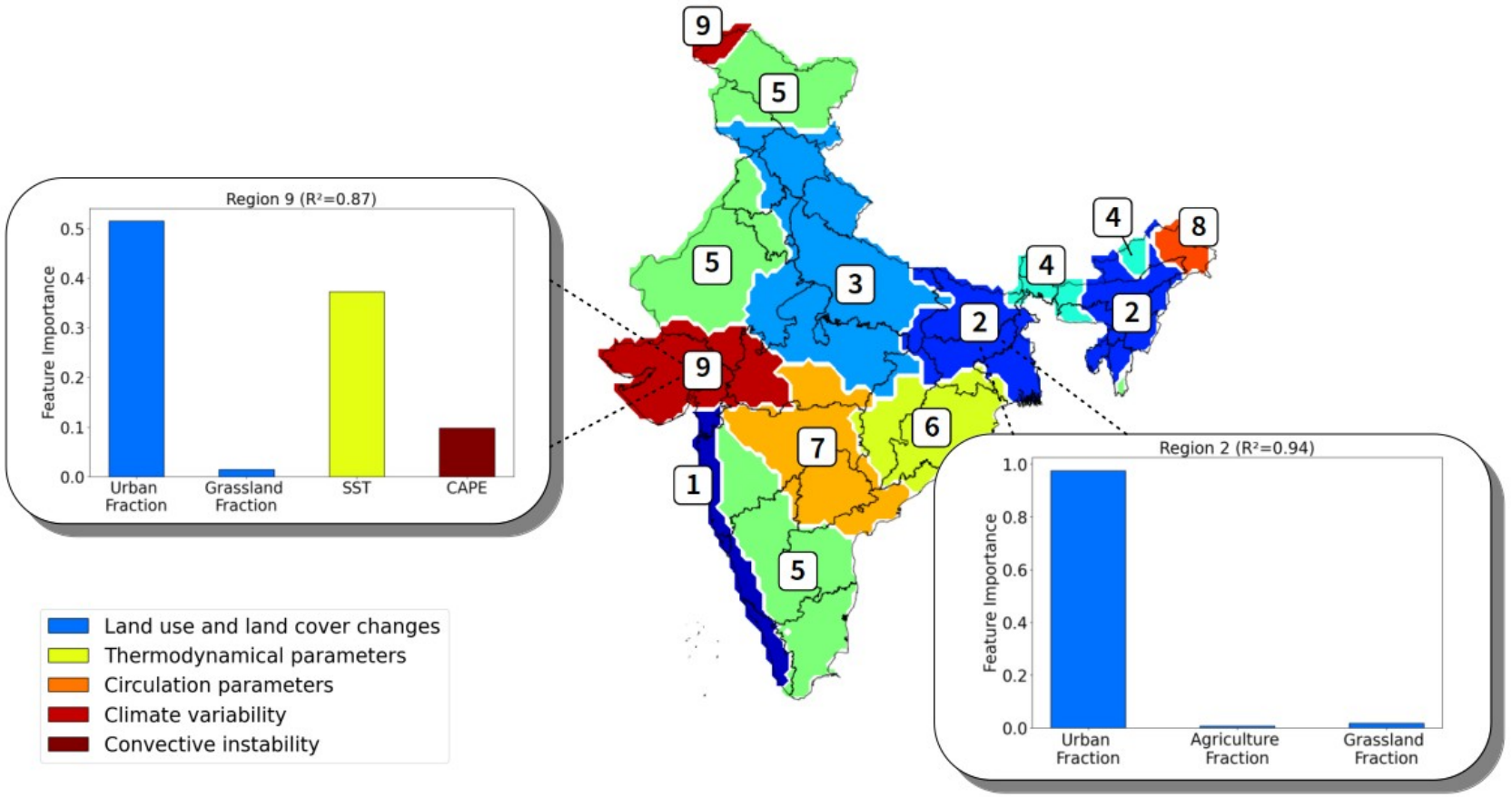
Only most predicting features are kept (feature selection)

- On the bar plots: Different colors for different physical parameters categories

→ Region 2, LULCCs most predicting factors (blue)

→ Region 9, thermodynamical parameters (yellow, especially the Sea surface temperature)

Feature importance for Intensity in regions 2 and 9



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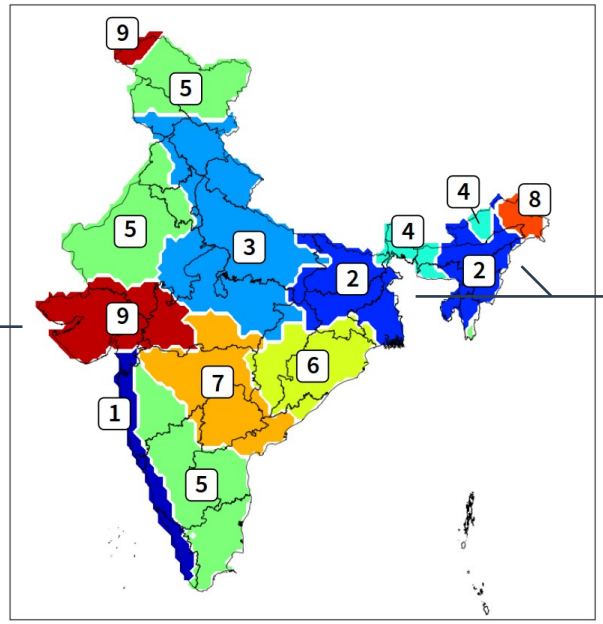
Summary

→ Extreme events have been increasing in the vast majority of India, but the causes of the increase seem to be spatially heterogeneous

→ Strong marker of local anthropogenic factors in every region, especially for intensity trends, while in some others thermodynamical

Potential driving factor:
Sea surface temperature



Potential driving factors: LULCC

→ Shows the importance of multivariate analysis and defining regions where the climate is relatively homogeneous