# Monitoring Heat Extremes over India Using Earth Observations and Data Driven Approaches

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## Introduction

**Heat Extremes: A prolonged period of abnormally high temperature relative to normal conditions.**

- ✓ **India 2022 heatwave -90+ deaths, 3M tonnes wheat yield loss**

**Crop yield reduction**

**Water scarcity**

## Methodology

### Flowchart

**Inputs**
- ✓ MODIS LST
- ✓ MODIS NDVI
- ✓ LULC
- ✓ Elevation
- ✓ NOAA station (Temp. data)
- ✓ Distance to coast
- ✓ Latitude
- ✓ Longitude
- ✓ Julian Day

**ML Models**
- ✓ RF
- ✓ XGBoost

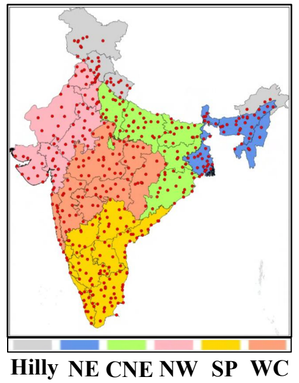
**Tmax prediction**
- ✓ Spatial Tmax over India

**Heat extreme identification**
- ✓ Percentile threshold
- ✓ STI

**Validation**
- ✓ HR
- ✓ FAR
- ✓ CSI
- ✓ RMSE
- ✓ $R^2$

Image Source : NASA Earthdata
Icon Source : Flaticon

## Study Area




### Statistics

- ✓ Study period: 2000 – 2024
- ✓ NOAA stations: 446
- ✓ Spatial res.: 1 km (MODIS LST & NDVI)
- ✓ Temporal res.: Monthly
- ✓ Regions: 6 climate zones

### Feature Importance Variable Sensitivity Analysis

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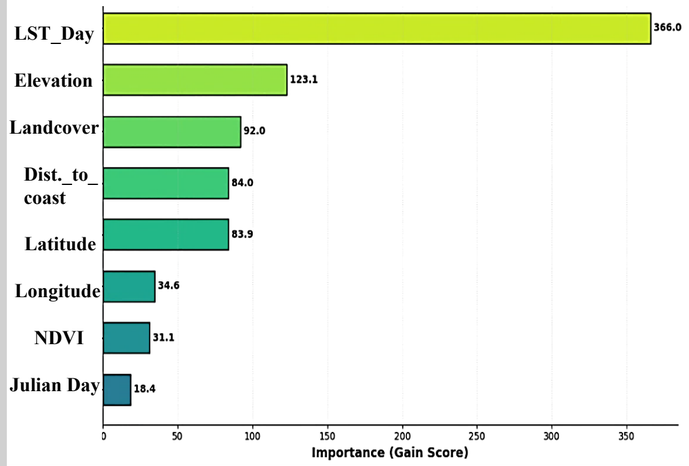
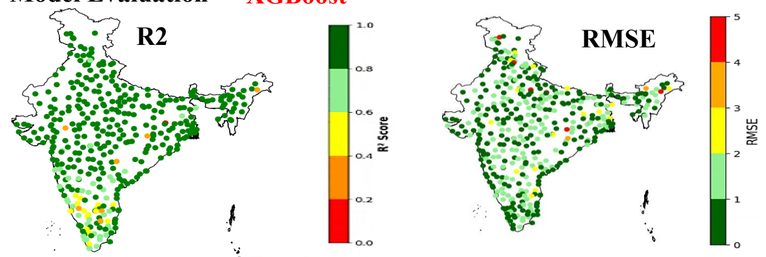
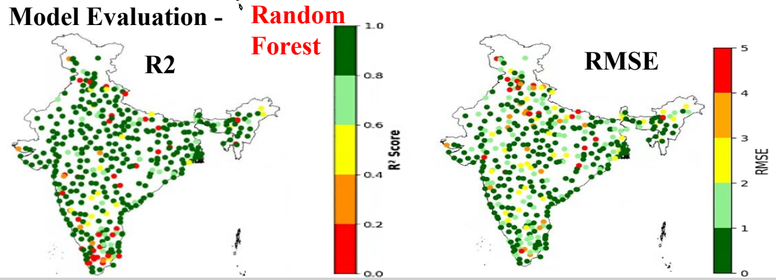



## Results

**Model Evaluation - XGBoost**




**Model Evaluation - Random Forest**

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**XGBoost outperforms RF, achieving a higher $R^2$ of 0.89 (vs. 0.84) and a lower RMSE of 1.02 °C (vs. 1.32 °C).**

### Extreme Event Detection

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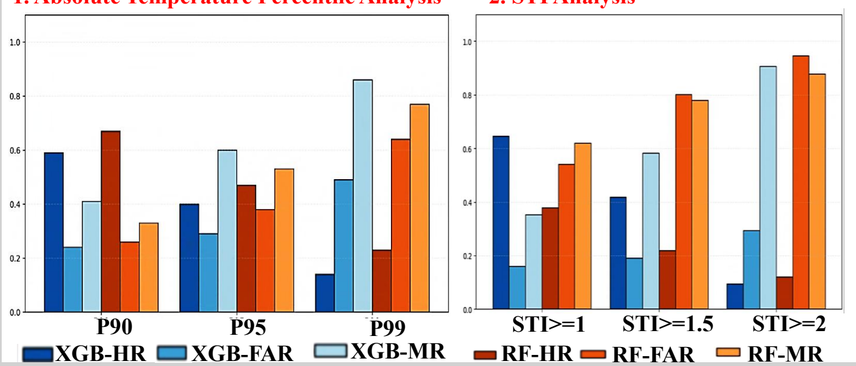
**1. Absolute Temperature Percentile Analysis** **2. STI Analysis**




**XGBoost better captures moderate heat extremes - Higher Hit rate and lower False Alarm Ratio**

## Conclusions

- •XGBoost outperforms Random Forest in temperature prediction and extreme event detection, achieving higher accuracy, lower error, and improved reliability.
- •XGBoost better captures moderate heat extremes (STI ≥ 1.0–1.5), while both models show reduced skill for rare and severe events (STI ≥ 2.0).
- •Model performance varies spatially and declines with increasing severity, with lower accuracy in coastal/high-variability regions and at higher STI thresholds.

## Reference

**Joy, A., Satheesan, K., & Paul, A. (2025).** High-resolution maximum air temperature estimation over India from MODIS data using machine learning. *Remote Sensing Applications: Society and Environment, 37*, 101463. https://doi.org/10.1016/j.rsase.2025.101463