

Frequency-Driven Intensification and Spatial Synchronization of Heatwaves in Ghana under Large-Scale Climate Forcing

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1. Introduction

Heatwaves are an increasing climate risk in West Africa, yet their evolution and large-scale drivers remain insufficiently constrained for effective early warning and climate services. This study assesses the spatiotemporal characteristics, spatial synchronization, and climate controls of heatwaves in Ghana using daily station data from 1980–2020. Events are identified using the Excess Heat Factor (EHF), TX90p (warm days), and TN90p (warm nights), capturing compound, daytime, and nighttime extremes.

2. Objectives

- Characterize heatwave variability across Ghana using EHF, TX90p and TN90p.
- Analyse frequency, duration, intensity, seasonal timing and trends.
- Assess spatial synchronization and multi-station heatwave occurrence.
- Identify large-scale climate controls using lagged and partial correlations and Random Forest modelling.

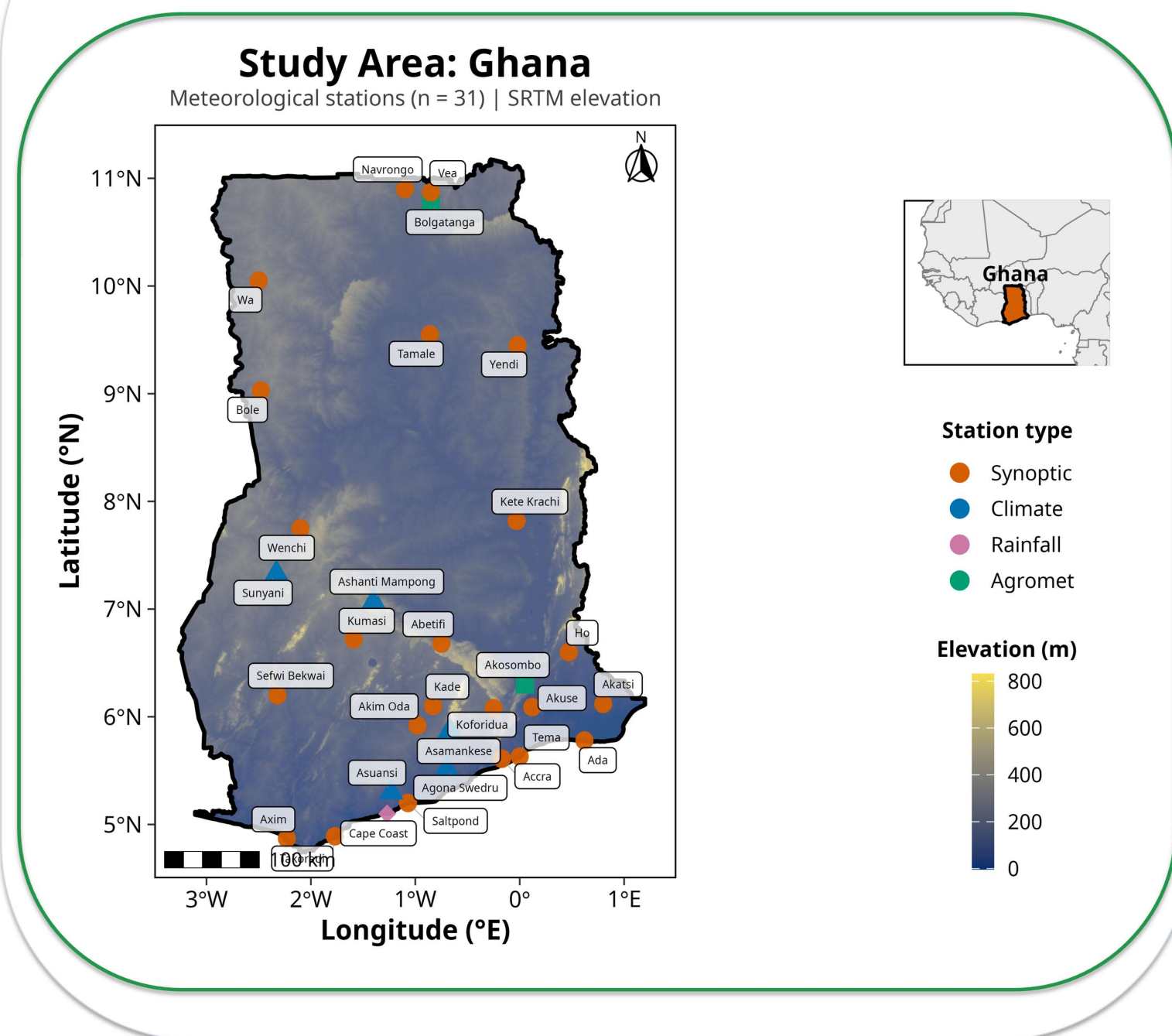
3. Data

- Daily Tmax and Tmin, 1980–2020, Ghana Meteorological Agency.
- 31 meteorological stations across Ghana.
- Climate indices: AMO, AMM, TSA, TNA, DMI, MEI and selected Niño indices.

4. Methods

- Heatwave indices: EHF, TX90p and TN90p.
- Metrics: frequency, duration, intensity and seasonal timing.
- Trends: Mann–Kendall and Sen's slope.
- Spatial coherence: pairwise station correlations and network analysis.
- Climate forcing: lagged and partial correlations.
- Random Forest: relative predictor importance and model performance.

5. Study Area



Acknowledgement

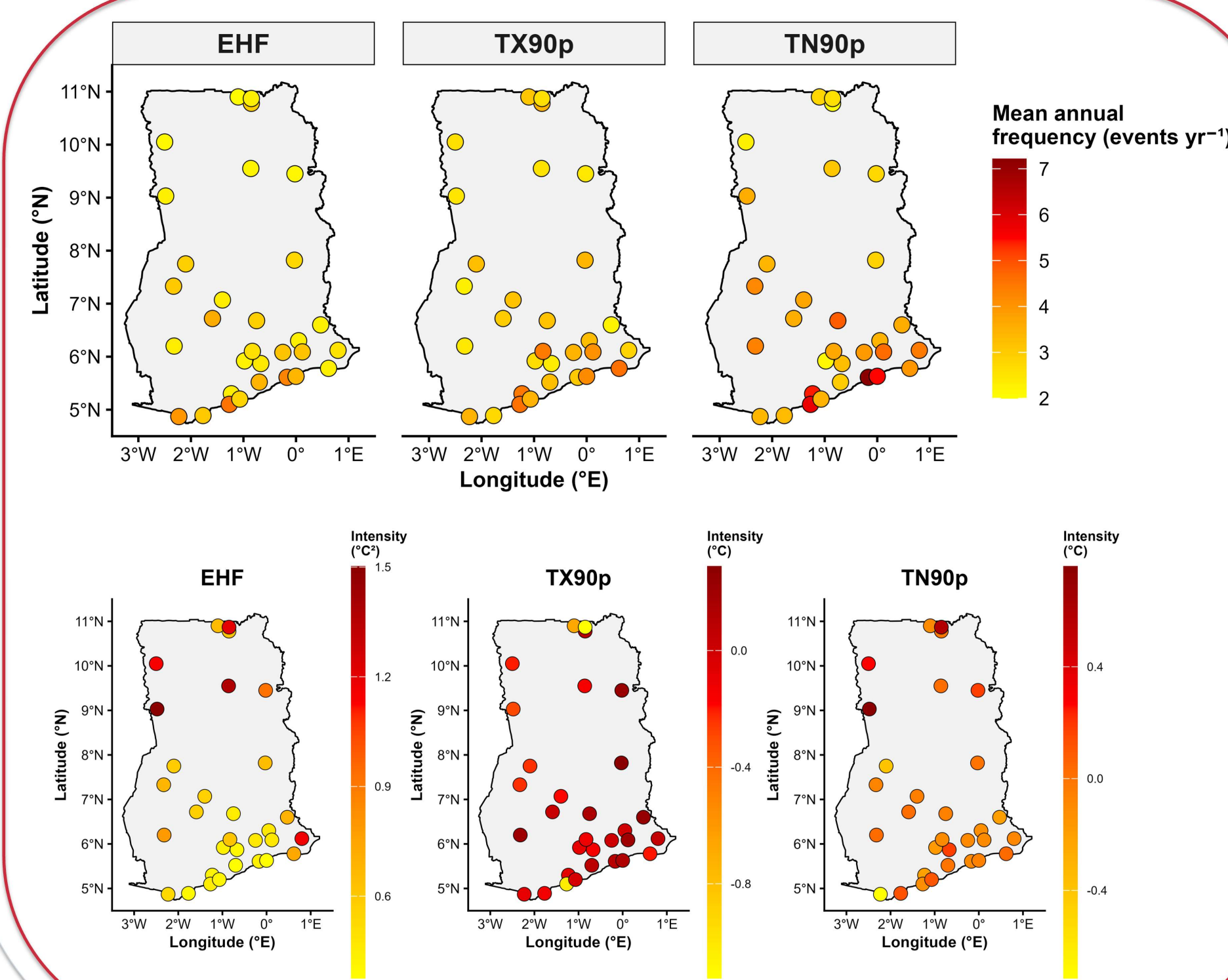
I sincerely acknowledge and appreciate the **APARC 2026 General Assembly** for their generous travel support, which enabled me to attend and participate in this meeting.



6. RESULTS

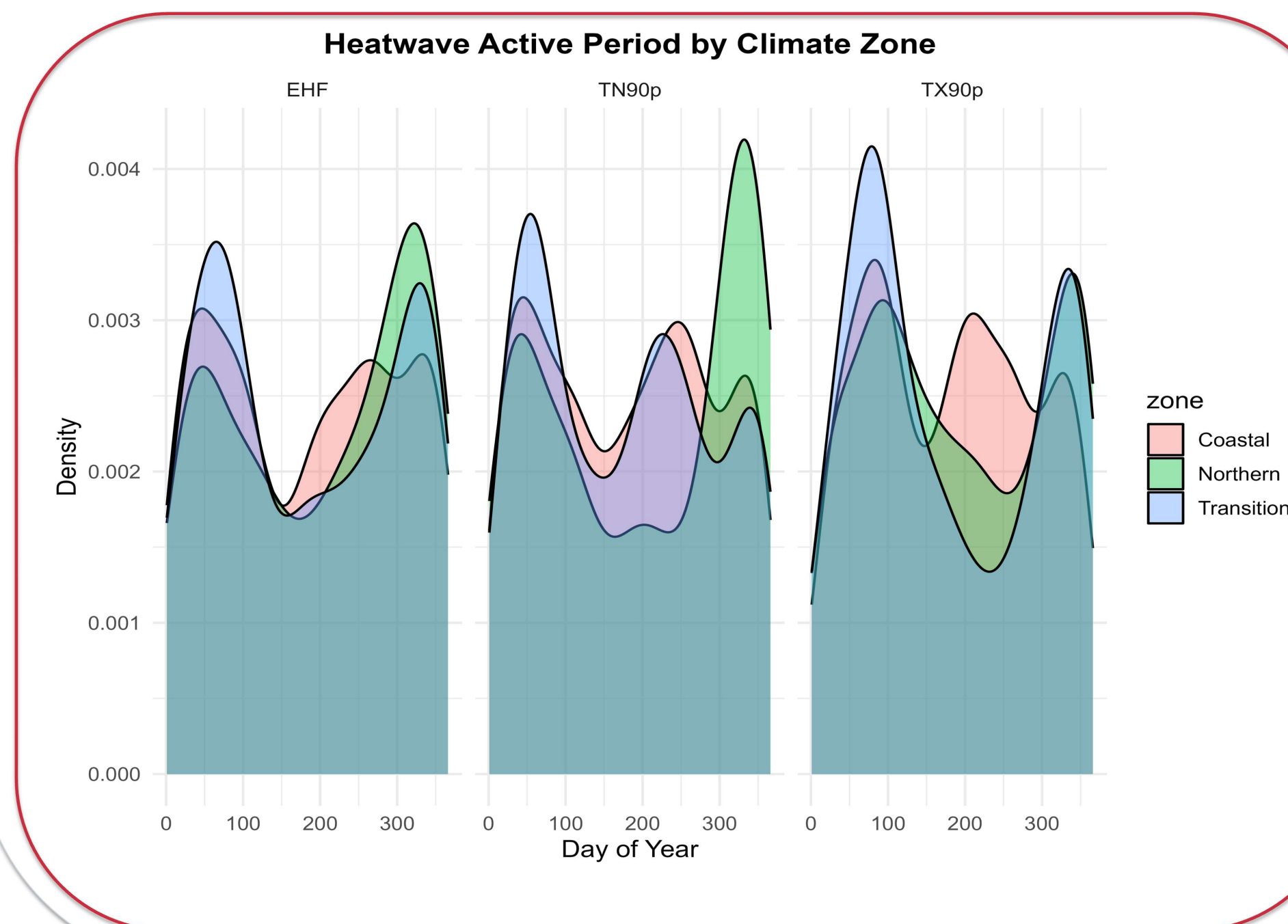
6.1 Spatial Patterns

Heatwave frequency and duration are generally higher in southern and southeastern Ghana, while stronger intensity occurs in northern Ghana.



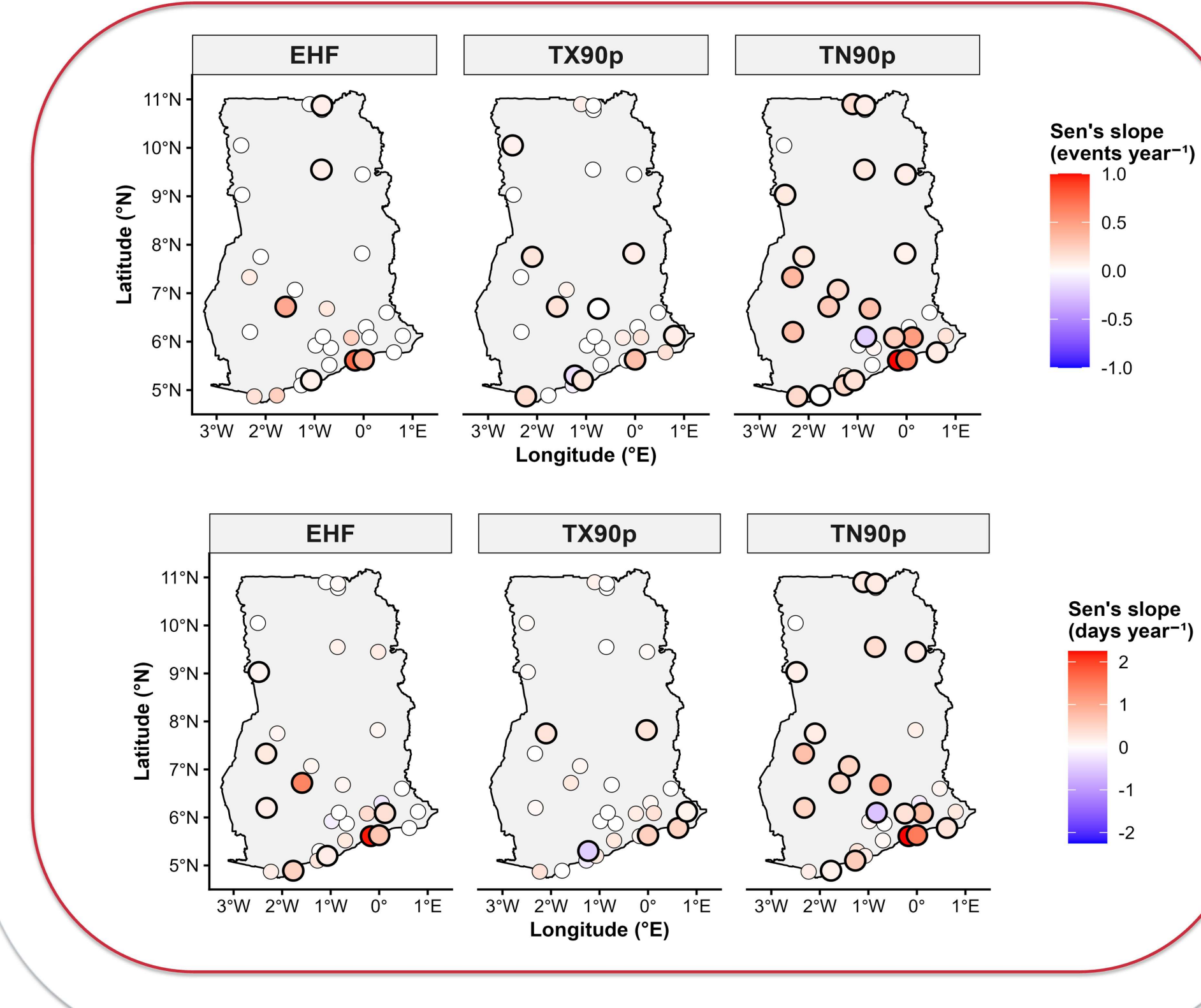
6.2 Seasonal Variation

Heatwaves peak during the late dry season (February–April), weaken during the monsoon (June–September), and re-emerge in association with nighttime extremes.



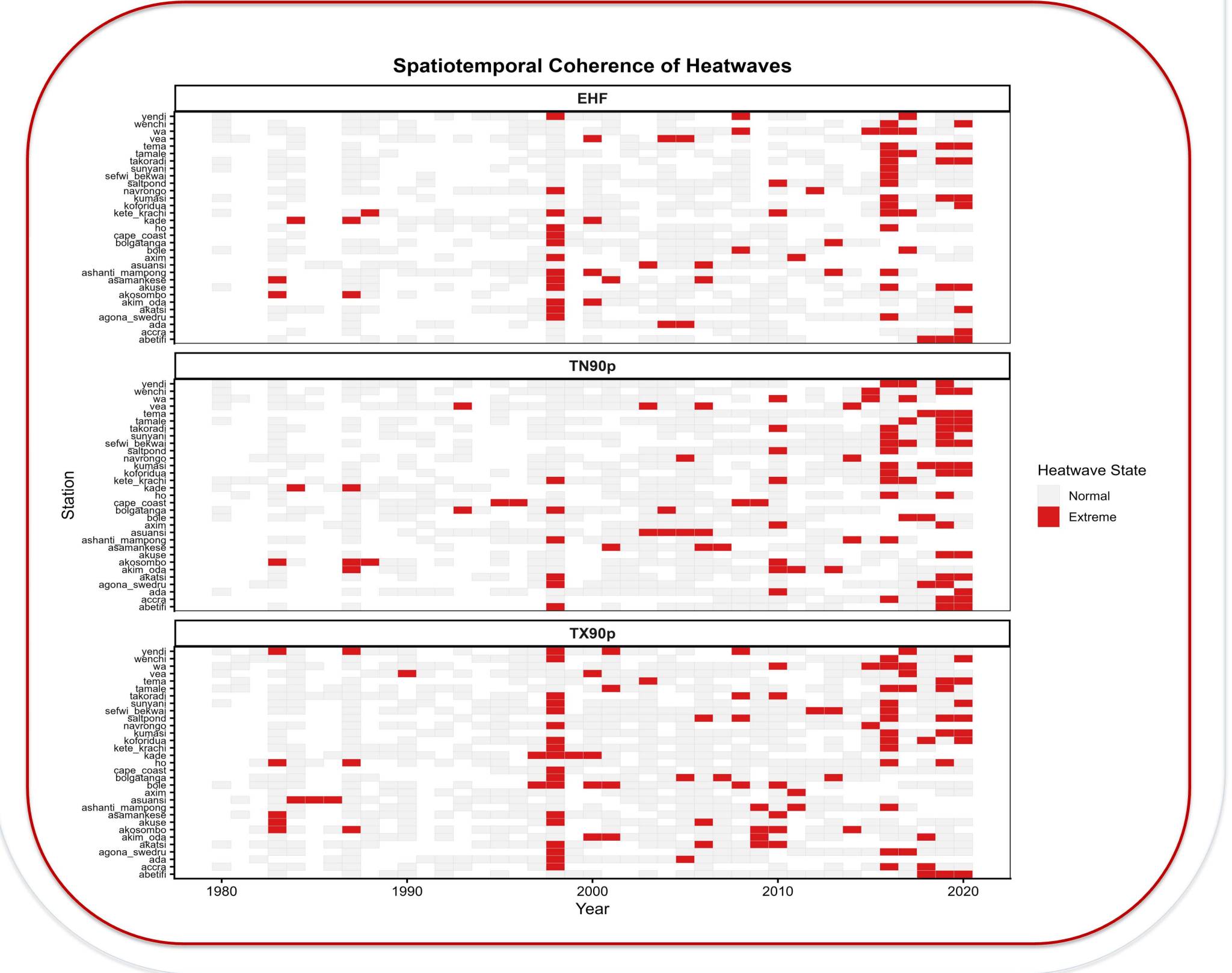
6.3 Long-term Trends

Intensification is primarily driven by increasing frequency and duration, while changes in intensity remain comparatively weak. Warm-night heatwaves show the most rapid increase.



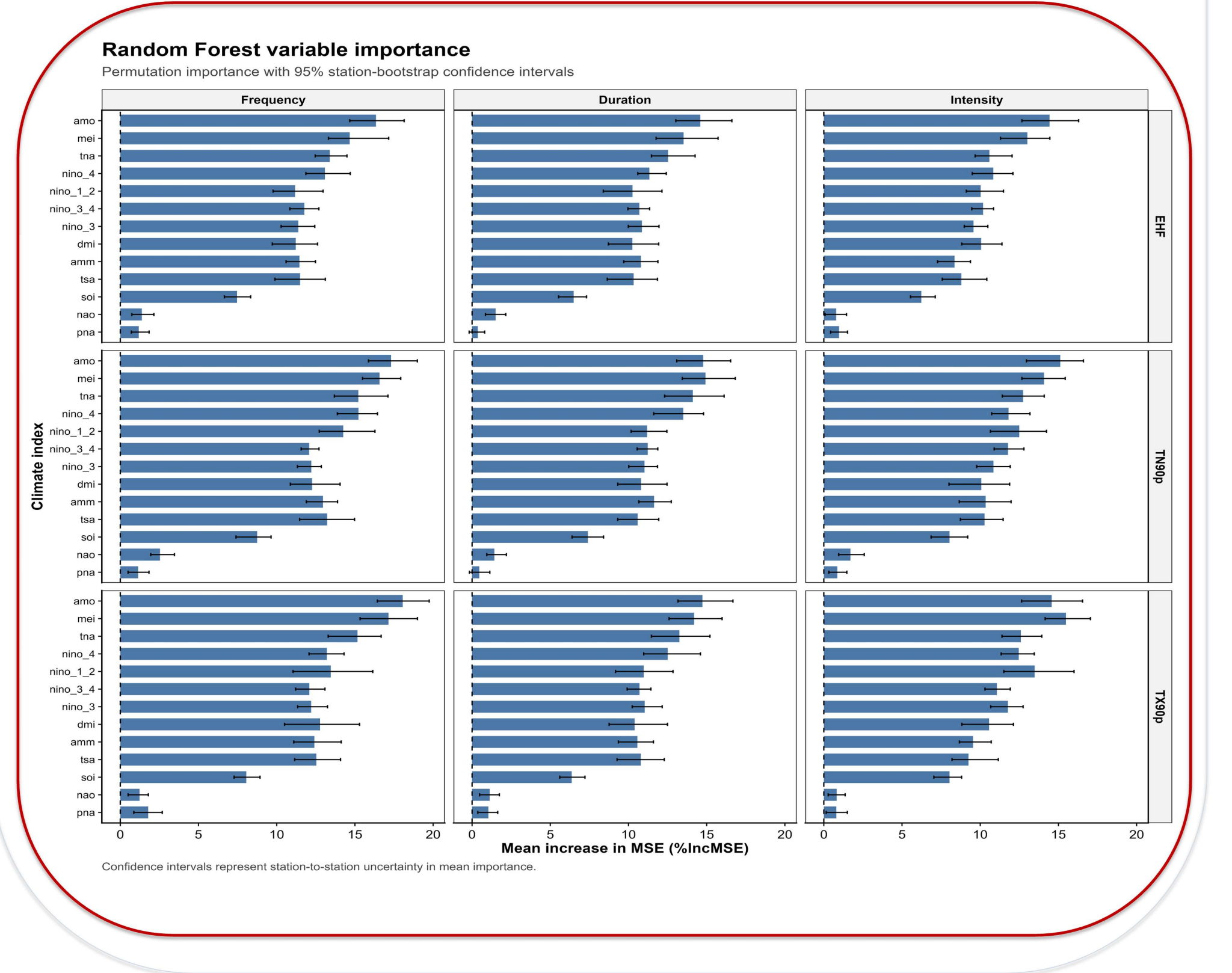
6.4 Spatial Coherence

A key finding is the growing spatial synchronization of heatwaves, with more frequent multi-station events in recent decades, indicating a shift toward system-wide heat risk.



6.5 Teleconnection Drivers

Teleconnection analysis reveals a hierarchical forcing structure, with tropical Atlantic variability (AMO, AMM, TSA and TNA) exerting dominant control, particularly on nighttime extremes, and ENSO playing a secondary role.



6. Key Findings

- Frequency and duration are the main dimensions of intensification.
- Warm-night heatwaves show the most rapid increase.
- Frequency and persistence are toward the coast; intensity is stronger in the northerhighern interior.
- Spatial synchronization is increasing, with more frequent multi-station events in recent decades.
- Tropical Atlantic variability is dominant; ENSO is secondary.

Conclusion

These findings provide actionable insights for subseasonal-to-seasonal prediction and early warning, supporting climate resilience, public health planning, and national adaptation strategies in Ghana and West Africa.