*Supplement of*

# Probabilistic Analysis of Future Drought Propagation, Persistence, and Spatial Concurrence in Monsoon-Dominant Asian Region under Climate Change

Dineshkumar Muthuvel[1], Xiaosheng Qin[1*]

[1] School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Ave, Singapore 639798

*Correspondence to*: Xiaosheng Qin (xsqin@ntu.edu.sg)

## Table Caption List

**Table S1:** Eight possible scenarios of inter-seasonal droughts defined by trivariate joint probabilities

## Figure Caption List

**Figure S1**: Monthly comparison of observed and ensembled historical GCM soil moisture data across four demarcated regions.

**Figure S2:** Monthly comparison of observed, ensembled, and individual climate model historical precipitation data across four demarcated regions. Grid-wise analysis shows that some models overestimate or underestimate values, with lower weights assigned to such models using Bayesian Model Average (BMA).

**Figure S3:** Monthly comparison of observed, ensembled, and individual climate model historical soil moisture data across four demarcated regions. Models with significant overestimation or underestimation are assigned lower weights through Bayesian Model Average (BMA).

**Figure S4:** Spatial maps of propagation durations (timescale, TS) across different seasons and timeframes.

**Figure S5:** Maps showing the most important variable (highest importance value in a Random Forest model) across timeframes in the study area.

**Figure S6:** Spatial concurrent return period between region pairs involving TIB across timeframes. The random variables (percentage of area under drought annually) are shown as black dots.

**Figure S7:** Correlation between temperature and soil moisture during monsoon season.

**Table S1. Eight possible scenarios of inter-seasonal droughts defined by trivariate joint probabilities**

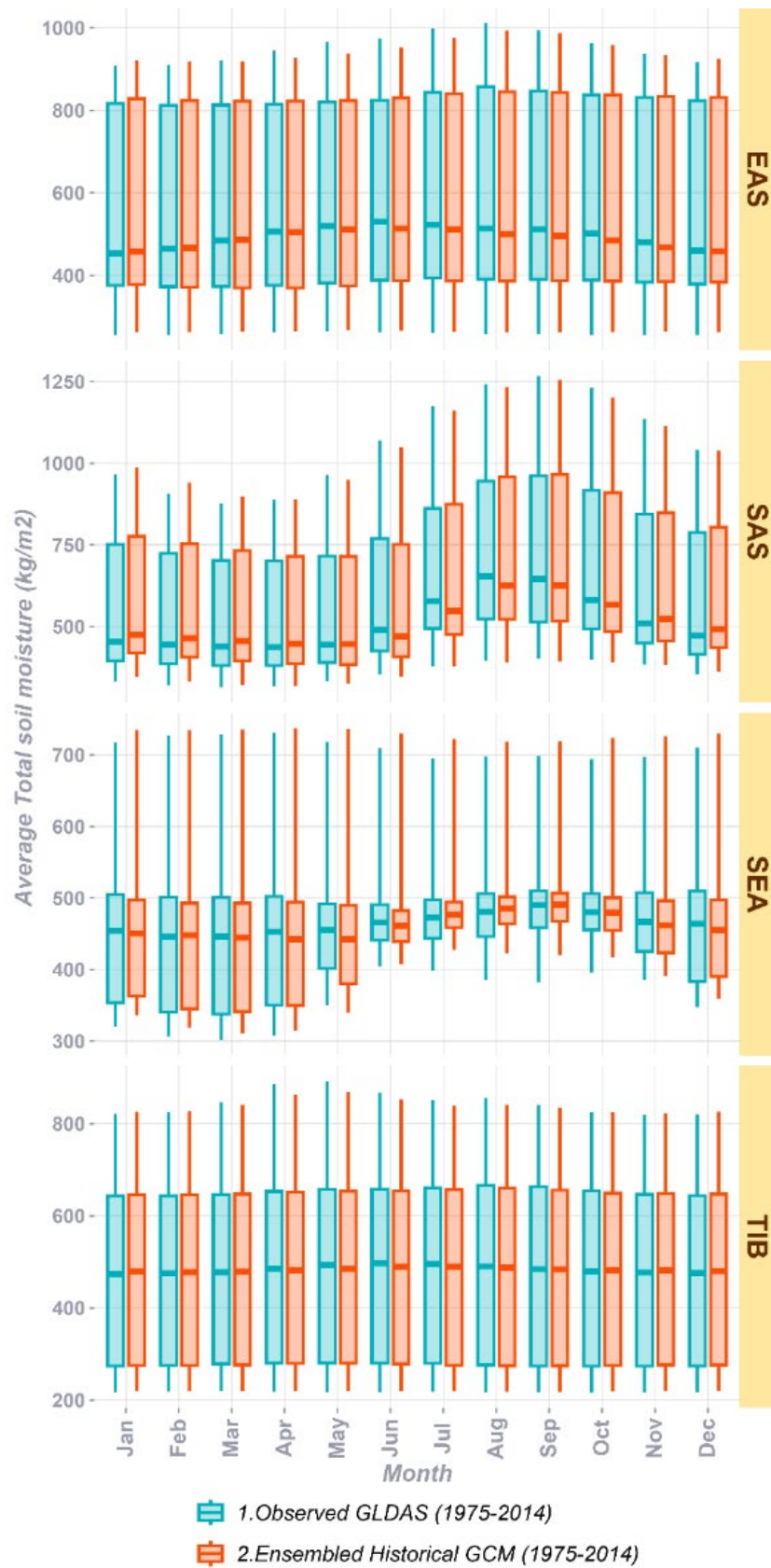| Scenario | Joint probabilities | Remarks |
|---|---|---|
| 1 | $P(SSI_{Pre-Monsoon} \leq i, SSI_{Monsoon} \leq i, SSI_{Post-Monsoon} \leq i) = \{C(F(i), G(i), H(i))\}$ | Persistent all-season droughts |
| 2 | $P(SSI_{Pre-Monsoon} \geq i, SSI_{Monsoon} \leq i, SSI_{Post-Monsoon} \leq i) = \{C(G(i), H(i)) - C(F(i), G(i), H(i))\}$ | Monsoon and post-monsoon droughts |
| 3 | $P(SSI_{Pre-Monsoon} \leq i, SSI_{Monsoon} \leq i, SSI_{Post-Monsoon} \geq i) = \{C(F(i), G(i)) - C(F(i), G(i), H(i))\}$ | Pre-monsoon and monsoon droughts |
| 4 | $P(SSI_{Pre-Monsoon} \geq i, SSI_{Monsoon} \leq i, SSI_{Post-Monsoon} \geq i) = \{G(i) - C(F(i), G(i)) - C(G(i), H(i)) + C(F(i), G(i), H(i))\}$ | Isolated monsoon droughts |
| 5 | $P(SSI_{Pre-Monsoon} \leq i, SSI_{Monsoon} \geq i, SSI_{Post-Monsoon} \leq i) = \{C(F(i), H(i)) - C(F(i), G(i), H(i))\}$ | Pre-monsoon and post-monsoon droughts |
| 6 | $P(SSI_{Pre-Monsoon} \geq i, SSI_{Monsoon} \geq i, SSI_{Post-Monsoon} \leq i) = \{H(i) - C(F(i), H(i)) - C(G(i), H(i)) + C(F(i), G(i), H(i))\}$ | Isolated post-monsoon droughts |
| 7 | $P(SSI_{Pre-Monsoon} \leq i, SSI_{Monsoon} \geq i, SSI_{Post-Monsoon} \geq i) = \{F(i) - C(F(i), G(i)) - C(F(i), H(i)) + C(F(i), G(i), H(i))\}$ | Isolated pre-monsoon droughts |
| 8 | $P(SSI_{Pre-Monsoon} \geq i, SSI_{Monsoon} \geq i, SSI_{Post-Monsoon} \geq i) = \{1 - F(i) - G(i) - H(i) + C(F(i), G(i)) + C(F(i), H(i)) + C(G(i), H(i)) - C(F(i), G(i), H(i))\}$ | Above-normal wet season annually. |

**Figure S1. Monthly comparison of observed and ensembled historical GCM soil moisture data across four demarcated regions.**
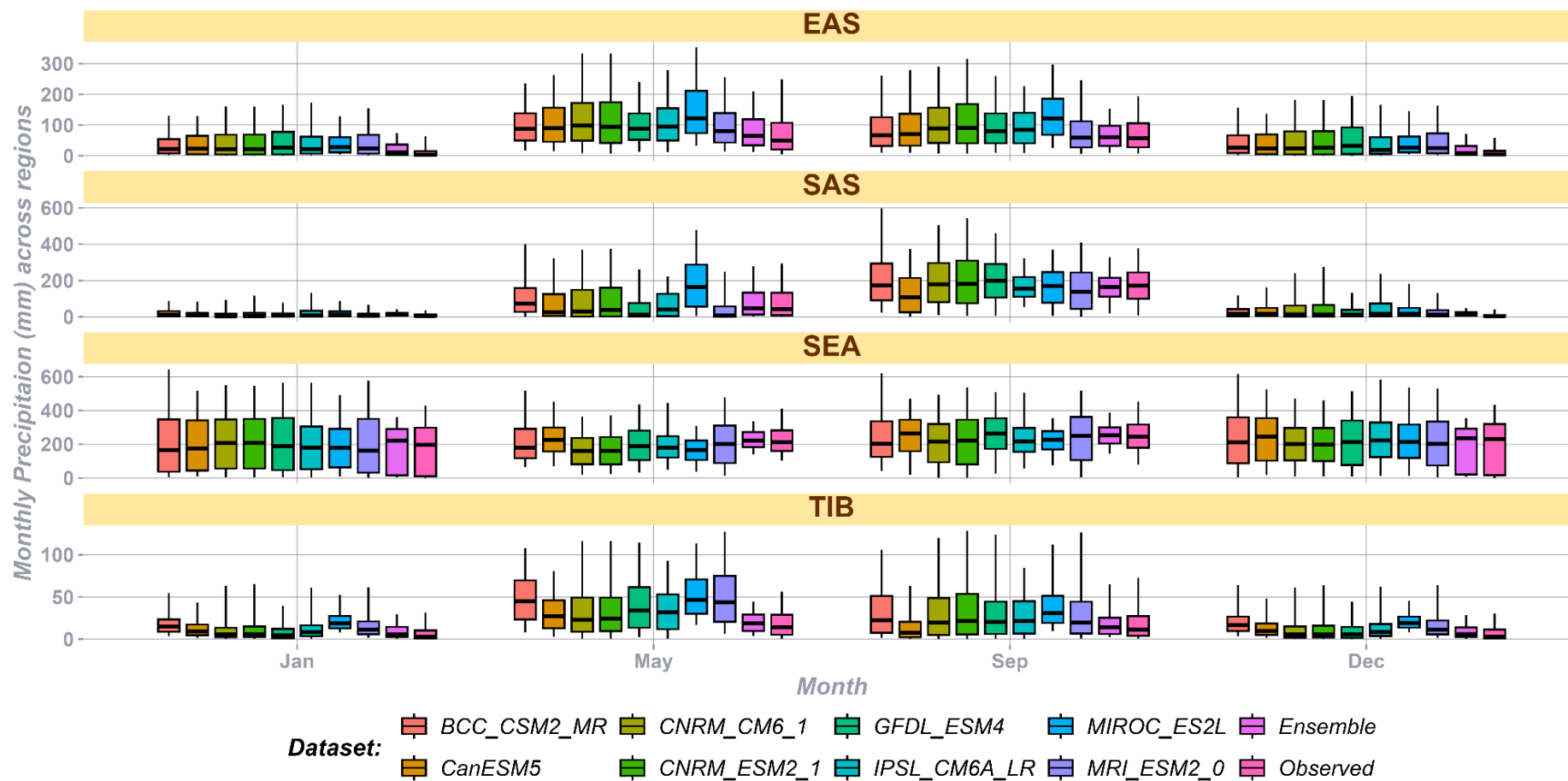
**Figure S2. Monthly comparison of observed, ensembled, and individual climate model historical precipitation data across four demarcated regions. Grid-wise analysis shows that some models overestimate or underestimate values, with lower weights assigned to such models using Bayesian Model Average (BMA).**
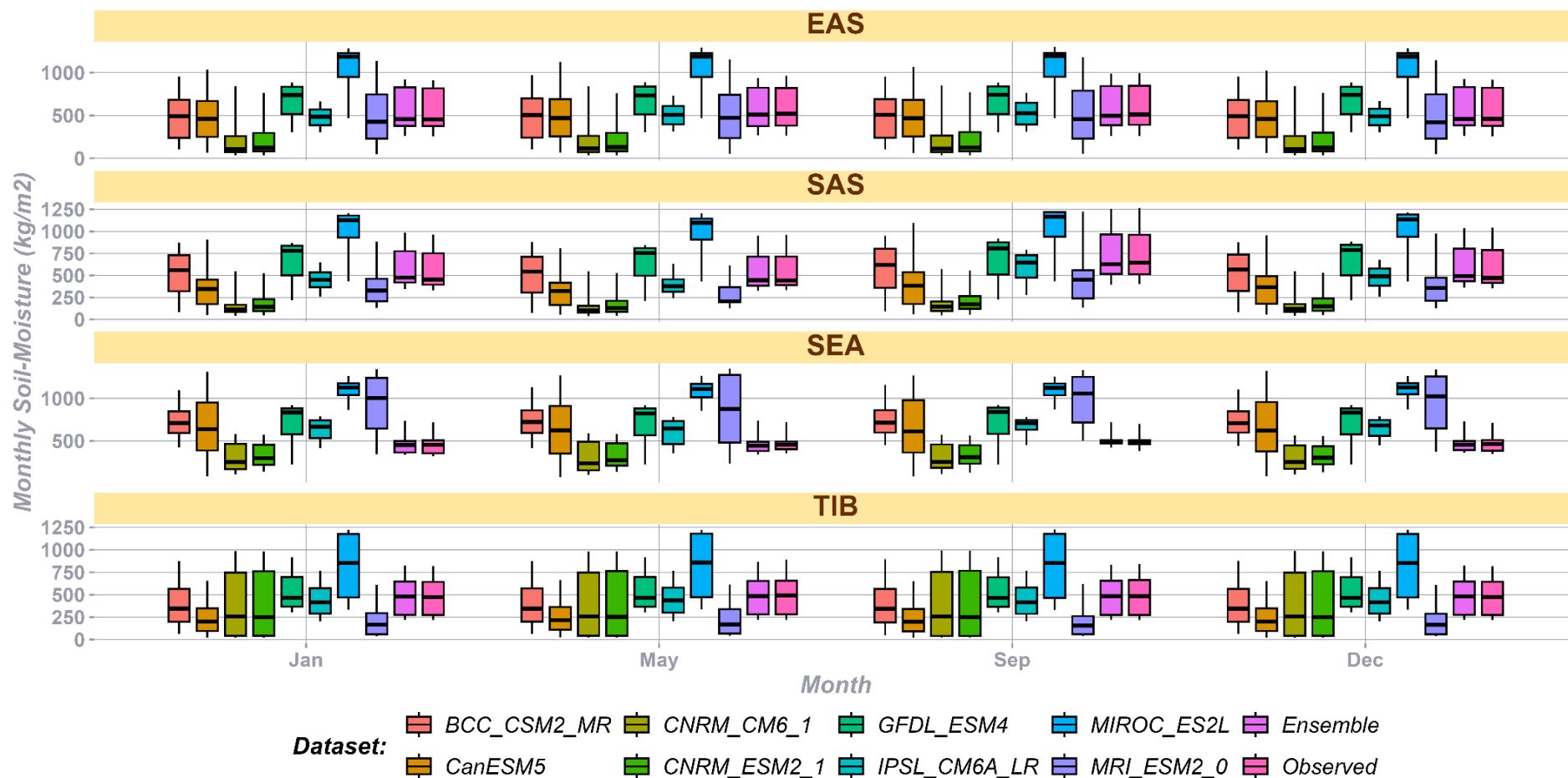
**Figure S3. Monthly comparison of observed, ensembled, and individual climate model historical soil moisture data across four demarcated regions. Models with significant overestimation or underestimation are assigned lower weights through Bayesian Model Average (BMA).**
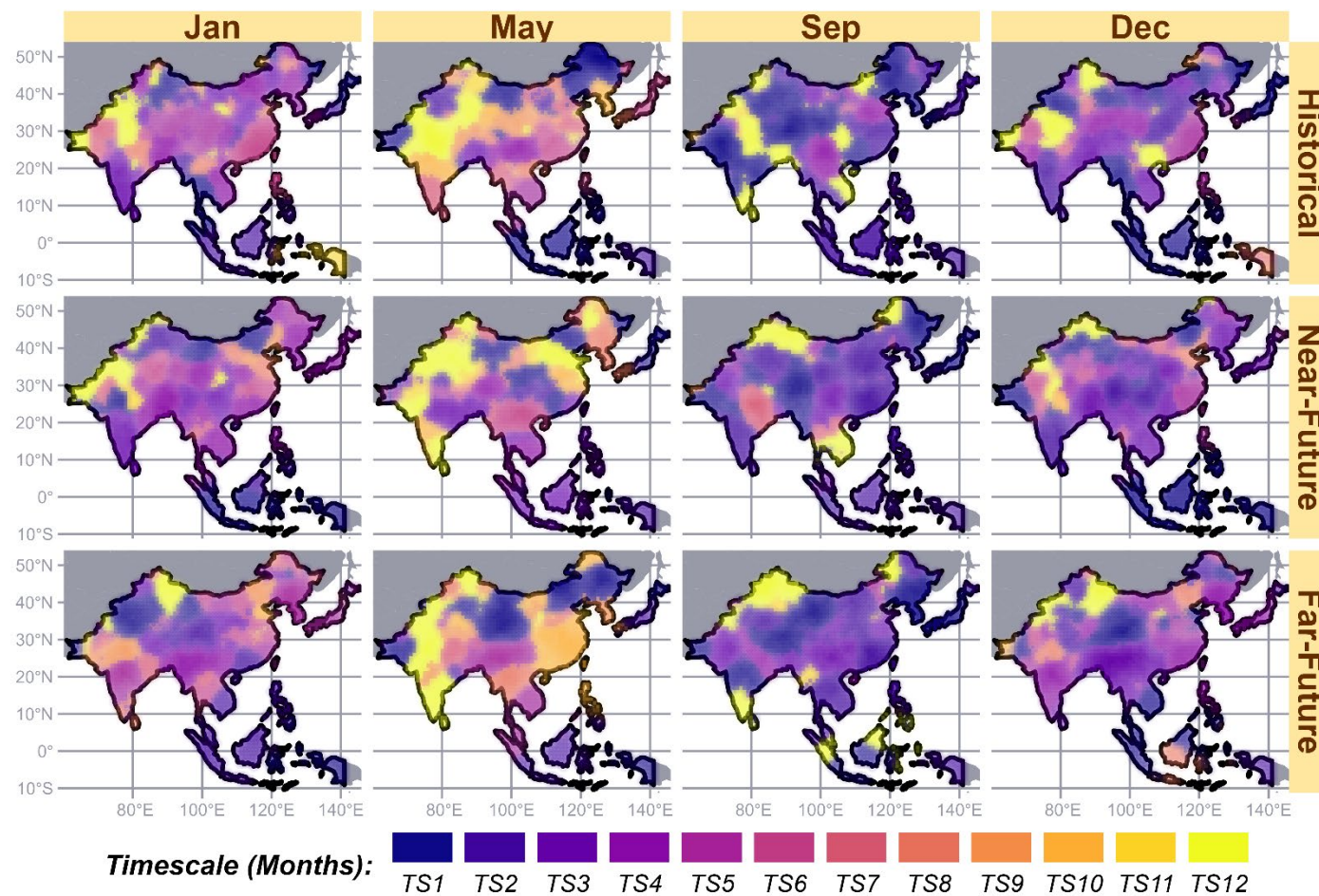
**Figure S4. Spatial maps of propagation durations (timescale, TS) across different seasons and timeframes.**
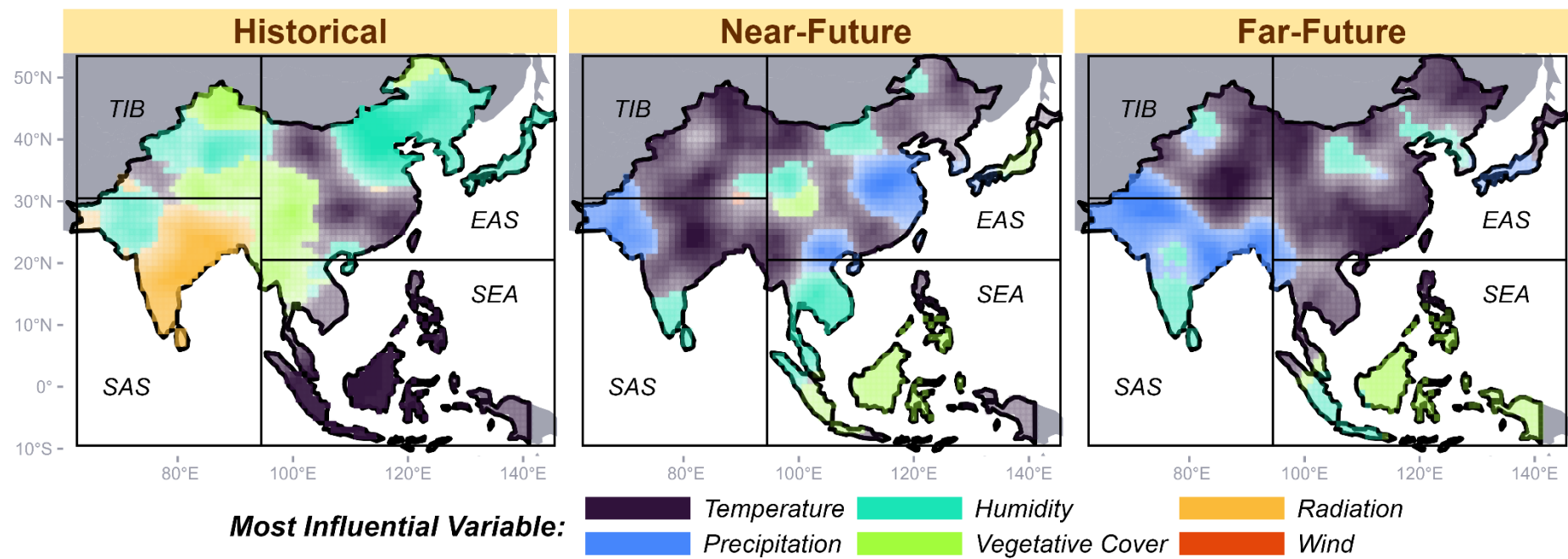
**Figure S5. Maps showing the most important variable (highest importance value in a Random Forest model) across timeframes in the study area.**
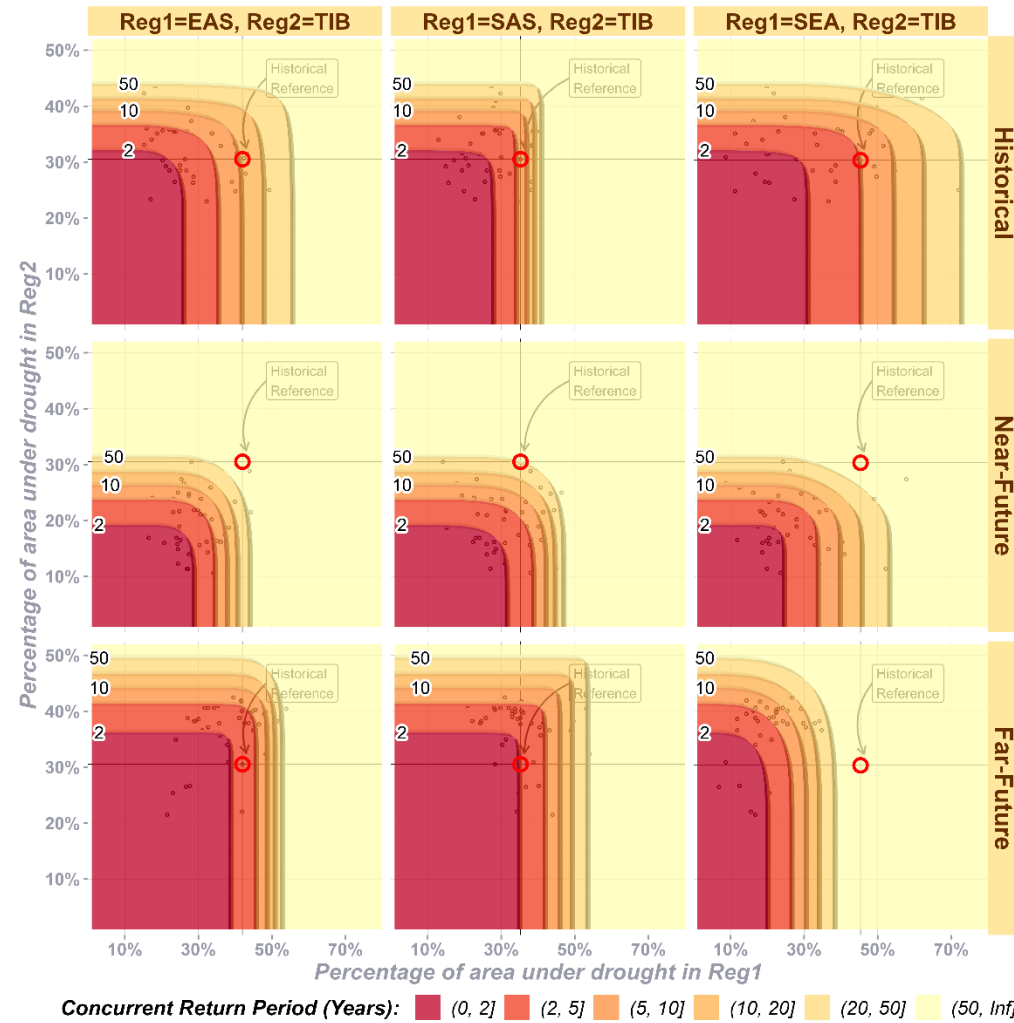
**Figure S6: Spatial concurrent return period between region pairs involving TIB across timeframes. The random variables (percentage of area under drought annually) are shown as black dots.**
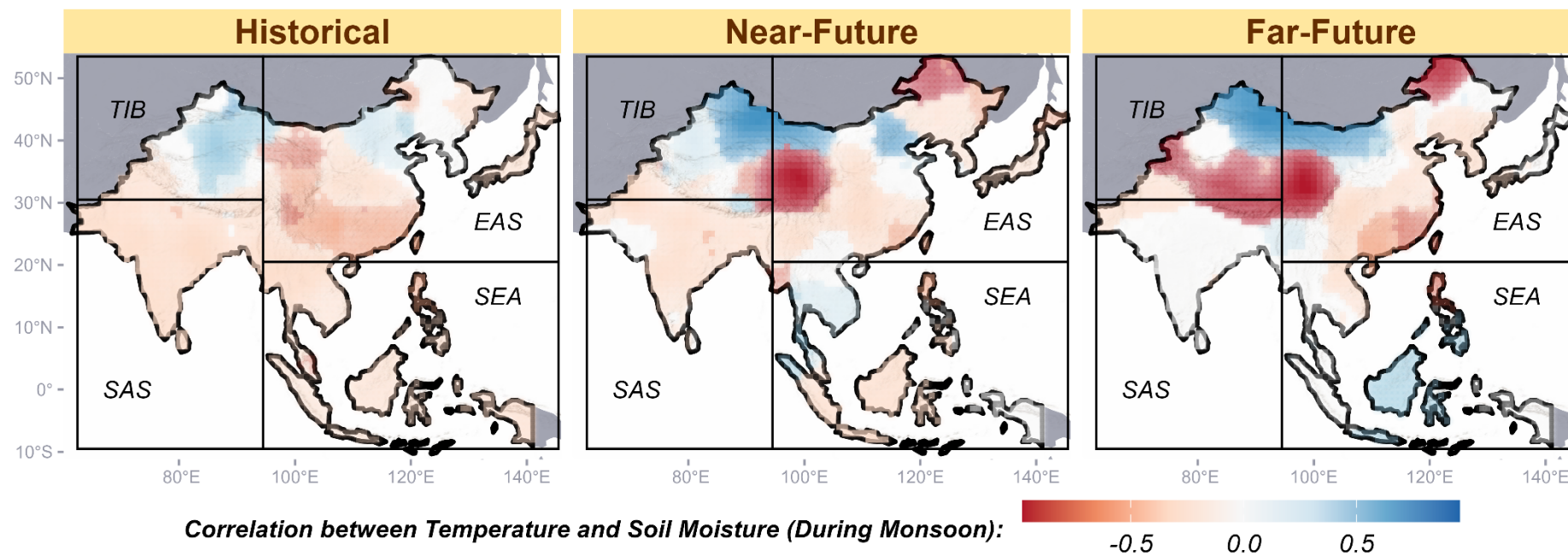
**Figure S7. Correlation between temperature and soil moisture during monsoon season.**