Soil Moisture – Precipitation Feedback over East Asia using IGRA2 Observation Data

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1. Introduction

♦ Background

– Soil moisture (SM) is a key regulator of land–atmosphere interactions, influencing precipitation (Pr) across climate regimes. Despite its importance, SM–Pr coupling mechanisms remain unclear.

–In East Asia, observation-based studies on SM–Pr feedbacks are particularly limited. Improved understanding is needed to constrain regional hydroclimate.

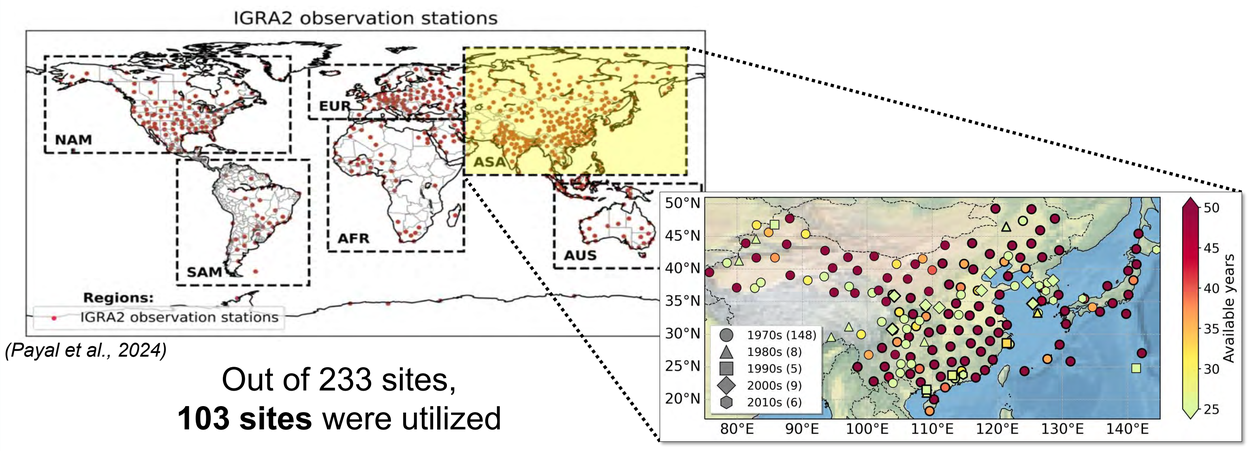
♦ Purpose of study

– This study examines the influence of SM on atmospheric conditions and Pr over East Asia using radiosonde data.

2. Data and Method

♦ In situ observation

The Integrated Global Radiosonde Archive Version 2 (IGRA2)



(Payal et al., 2024)

Out of 233 sites,
103 sites were utilized

♦ Datasets

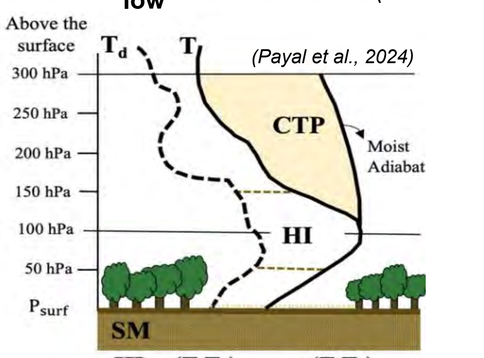
	Temporal resolution	Spatial resolution	Used variables
IGRA2	12hourly	Point data	CTP, HI_{low} (T2m, D2m, q)
ERA5	Daily	0.25°x0.25°	u, v, q
ERA5-Land	Hourly	0.1°x0.1°	Soil moisture (SM)
MSWEP	3hourly	0.1°x0.1°	Precipitation (Pr)

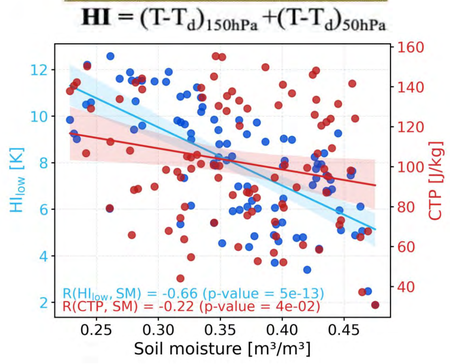
Morning times (06-12LST), ***Afternoon times*** (12-21LST)

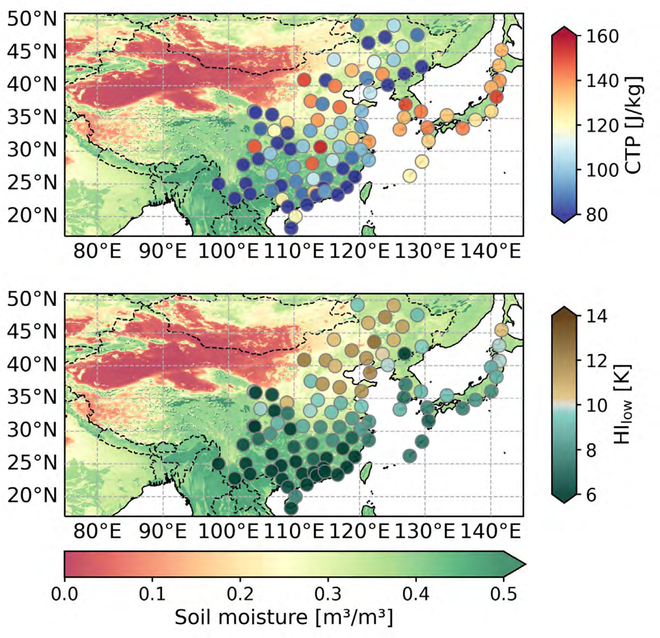
– *Days with no morning Pr but afternoon Pr were selected* to assess the impact of SM on Pr.

– All variables were analyzed for *May–September (1979–2022).*

♦ CTP-HI_{low} framework *(Findell & Eltahir, 2003)*



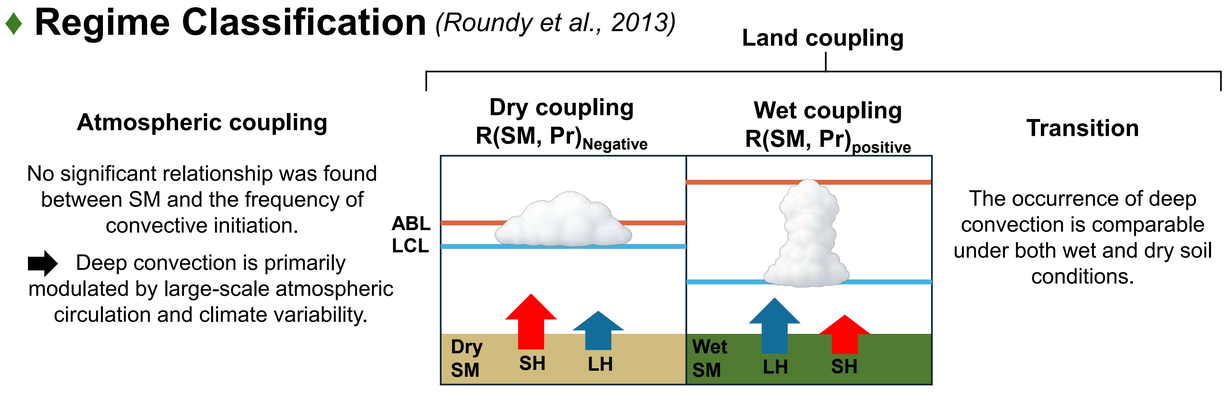


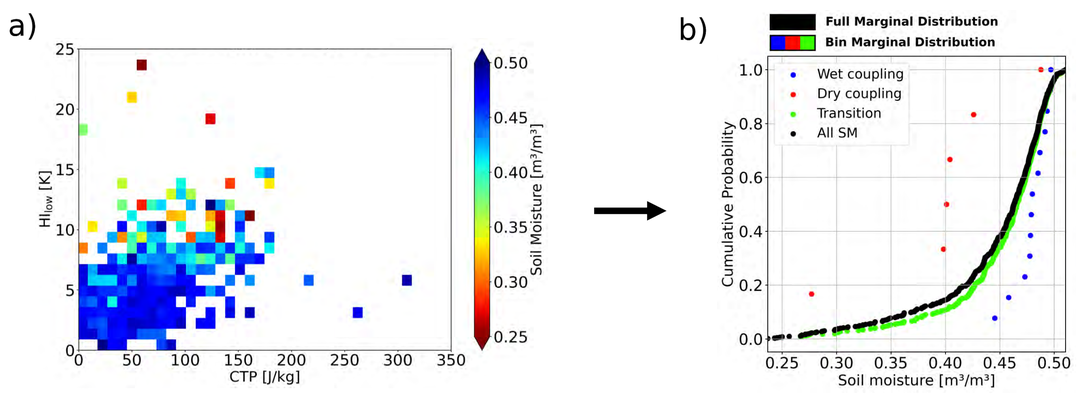


– Atmospheric instability and near-surface humidity were quantified by the convective triggering potential (CTP) and low-level humidity index (HI_{low}), respectively.

– HI_{low} showed a stronger negative correlation with soil moisture than CTP, *suggesting that near-surface humidity is more sensitive to SM variability.*

♦ Regime Classification *(Roundy et al., 2013)*

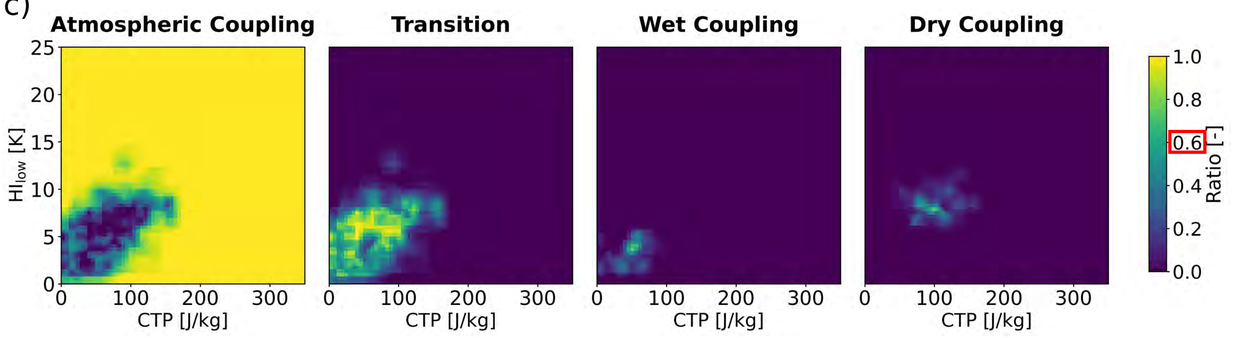




2. Data and Method

The bin sizes of all ensemble results are *standardized to 65 by 65.*

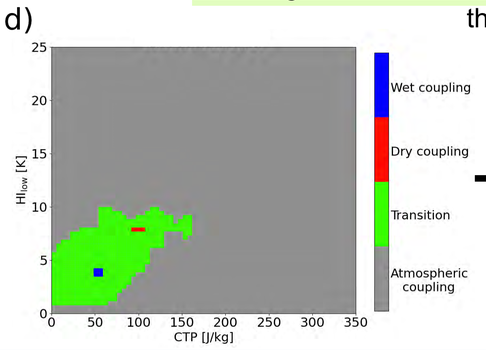
c)



$$(Regime\ ratio) = \frac{(Number\ of\ regime)}{(Number\ of\ total\ ensemble\ result)}$$

If the regime ratio exceeds 0.6, the bin is classified as dominated by the respective regime.

d)



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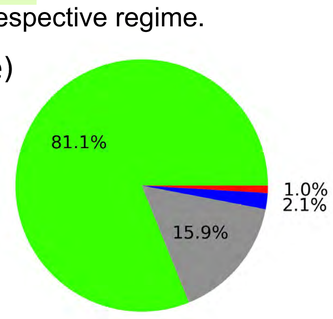
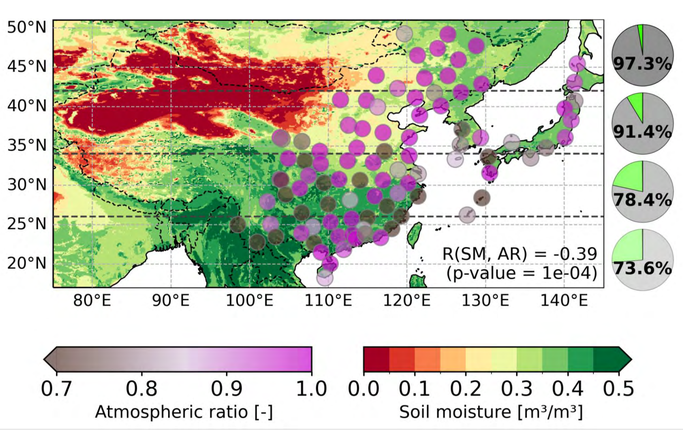
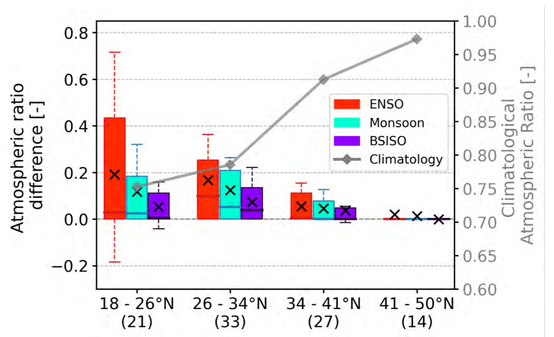


The range and percentage of each regime can be determined for each site.

The proportion of datapoints within each regime was calculated and visualized as a pie chart.

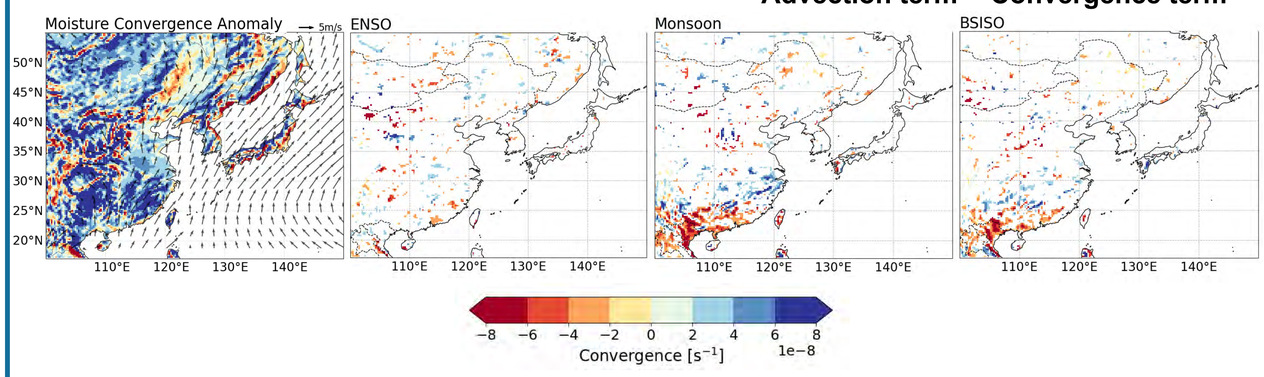
3. Result





$$Moisture\ Convergence\ Flux\ (MFC) = -u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y} - q\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)$$

Advection term **Convergence term**



– The coupling ratio is high at northern latitudes, suggesting weaker SM–Pr interactions in these regions.

– *Moisture convergence is enhanced in East Asia,* particularly in southeast and northeast China.

– To assess the influence of climate modes with different temporal variabilities on East Asian summer Pr, we analyze ENSO, the monsoon, and BSISO as representative modes. *ENSO exerts the most notable impact on summer Pr, while the effects of all three modes tend to weaken at higher latitudes.*

– *East Asian summer afternoon Pr is primarily controlled by moisture convergence,* with its influence most significant at low latitudes during active climate mode phases.

– *At higher latitudes, Pr is predominantly governed by atmospheric processes, and the influence of climate modes becomes comparatively limited.*

4. Conclusion

– *Atmospheric humidity in East Asia is more sensitive to SM variability* than to atmospheric instability.

– East Asian summer Pr is strongly influenced by large-scale atmospheric circulation, *especially by moisture convergence.*

– *ENSO appears to have significant influence on summer Pr in East Asia, while the impacts of all climate modes generally diminish at higher latitudes.*

– *Large-scale circulation during climate modes enhances moisture convergence mainly in southern regions,* with limited changes in the north.

– These results indicate that *summer Pr linked to land–atmosphere interactions in East Asia is strongly influenced by large-scale circulation, emphasizing the need to consider these processes in regional hydroclimate assessments.*