Winter ENSO Signal as a Robust Seasonal Predictor of Southeast China Early Autumn Precipitation in the Post-2000 Period

Luancheng Xu[1] | Hui Su[1*] | William K. M. Lau[2]

[1]State Key Laboratory of Climate Resilience for Coastal Cities, Department of Civil and Environmental Engineering, Hong Kong University of Science and Technology, Hong Kong SAR
[2]Earth System Science Interdisciplinary Center, University of Maryland, USA

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Introduction

- Southeast China (SC) early autumn precipitation is highly variable and lacks reliable long-lead predictors.
- Historically, the ENSO-SC teleconnection decouples by late-summer, preventing early warnings.

This study reveals that the post-2000 shift in El Niño decay modes enables preceding winter ENSO to act as a robust predictor for SC early autumn rainfall, offering a significant 9-10 month lead time.

Data & Methods

Observational Datasets:

- Precipitation: GPCP v2.3 (2.5°×2.5°).
- Sea surface temperature: NOAA ERSSTv5 (2°×2°).
- Atmospheric variables (e.g., geopotential, winds, specific humidity): ERA5 reanalysis (0.25°×0.25°).

Processing & Statistics:

- Linear detrending applied to SST and precipitation.
- 10-year high-pass filter.
- Statistical significance: two-tailed Student's t-test at 90% confidence level.

Index Definitions

1. **Niño3.4_DJF:** Preceding winter (DJF) SST anomalies over the region (5°S–5°N, 170°W–120°W).
2. **SCPI:** September precipitation anomalies over Southeast China (20°–34°N, 114°–122°E).

Results

1. The Emergent Seasonal Predictor

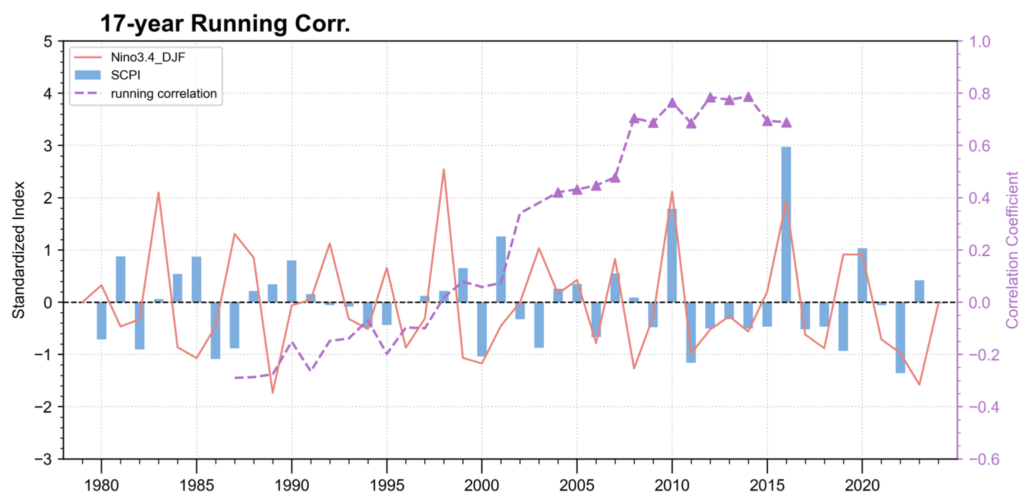

Fig. 1. (a) Standardized time series of the Niño3.4_DJF (red line) and SCPI (blue bars) for the entire period 1979-2024. 17-year running correlation between Niño3.4_DJF and SCPI (purple dashed line). Triangle markers indicate correlations significant at the 90% confidence level.

Interdecadal intensification of the relationship between preceding winter ENSO and SC early-autumn precipitation since the early 2000s.

Two study epochs
- **P1 (1979-2003): insignificant correlation**
- **P2 (2004-2024): strong correlation**

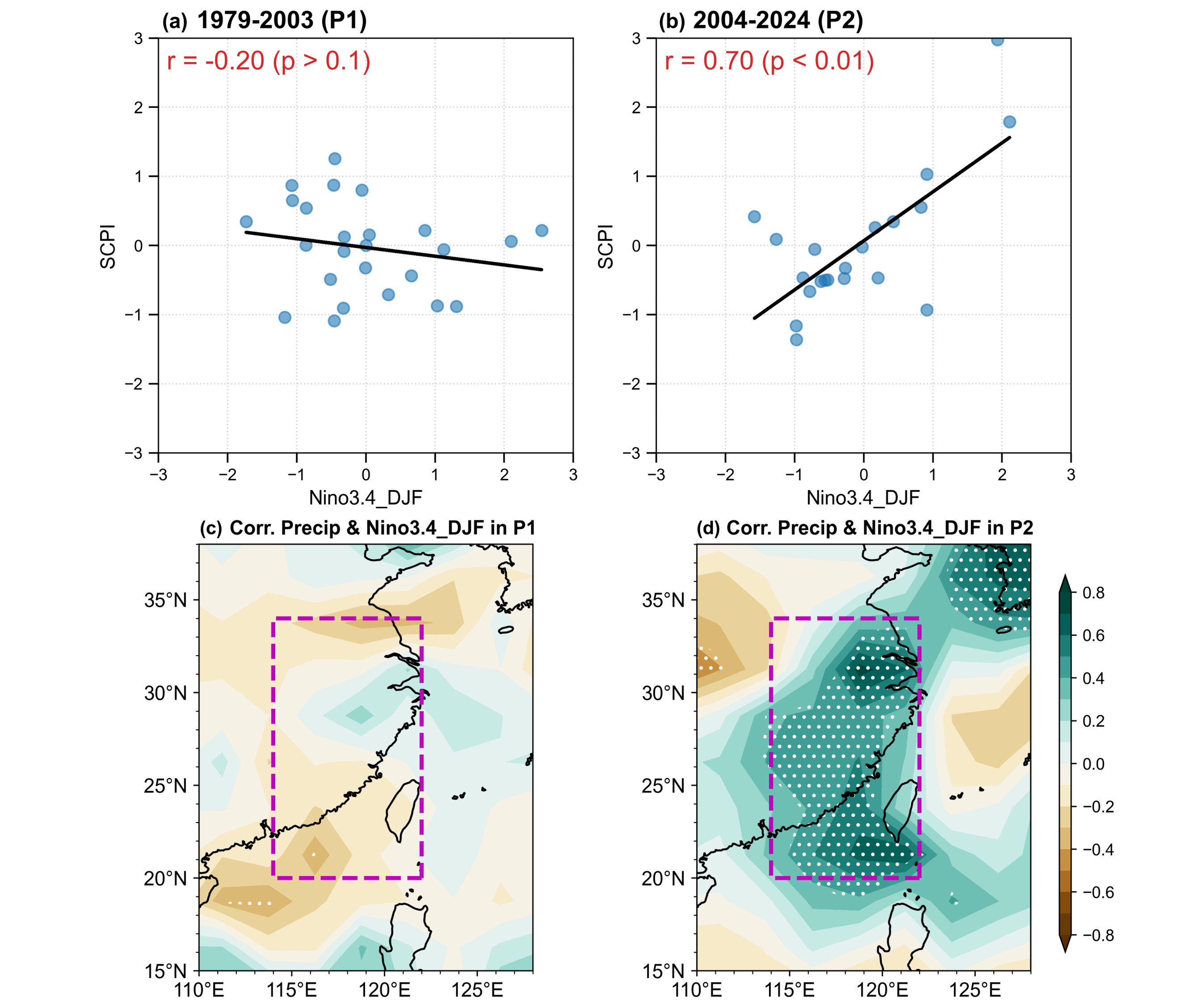

Fig. 2. (a, b) Scatter plots and linear regressions of the Niño3.4_DJF and SCPI. (c, d) Spatial distribution of correlation coefficients between the Niño3.4_DJF and SCPI.

- **P1 (1979-2003):** Weak correlations across SC region (r=-0.20).
- **P2 (2004-2024):** Broad and strong positive correlation across the entire SC region (r=0.70).

2. Oceanic Precursor & Accelerated ENSO Decay

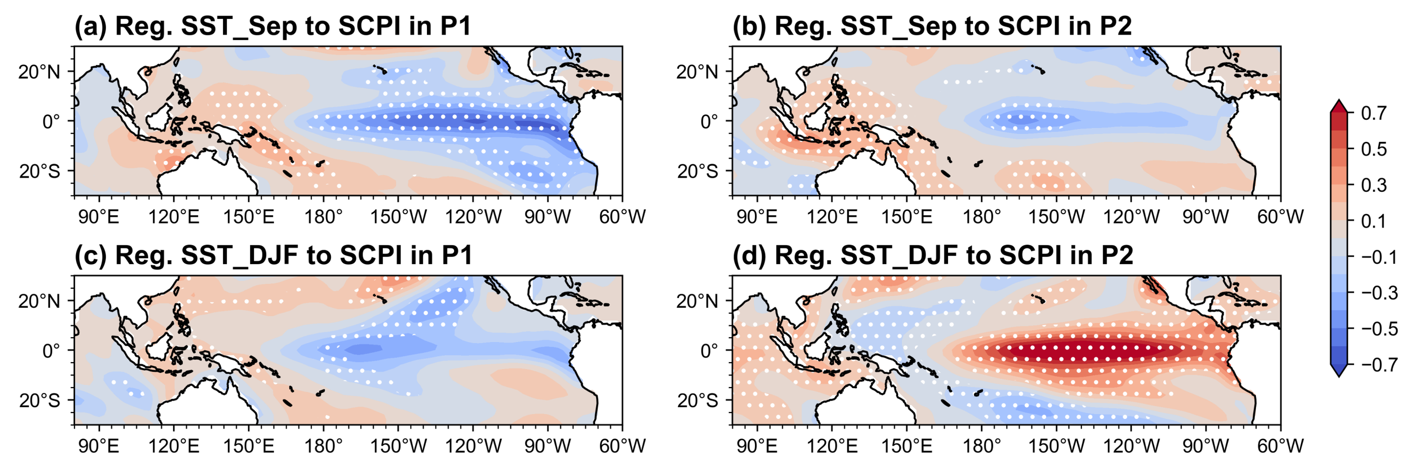

Fig. 3. (a, b) SSTA during the concurrent September regressed onto the SCPI for two sub-periods. (c, d) SSTA during the preceding winter (DJF) regressed onto the SCPI for two sub-periods.

Synchronous forcing (September):

- Equatorial Eastern Pacific (EEP) cooling
- Western Pacific (WP) warming

Such synchronous forcing provides little predictive lead time.

Predictability shift (Preceding winter):

- P1: Decoupled. Early-autumn SC precipitation is independent of preceding winter ENSO signals.
- P2: Coupled. A robust El Niño-like precursor, providing a 9-10 month seasonal lead time.

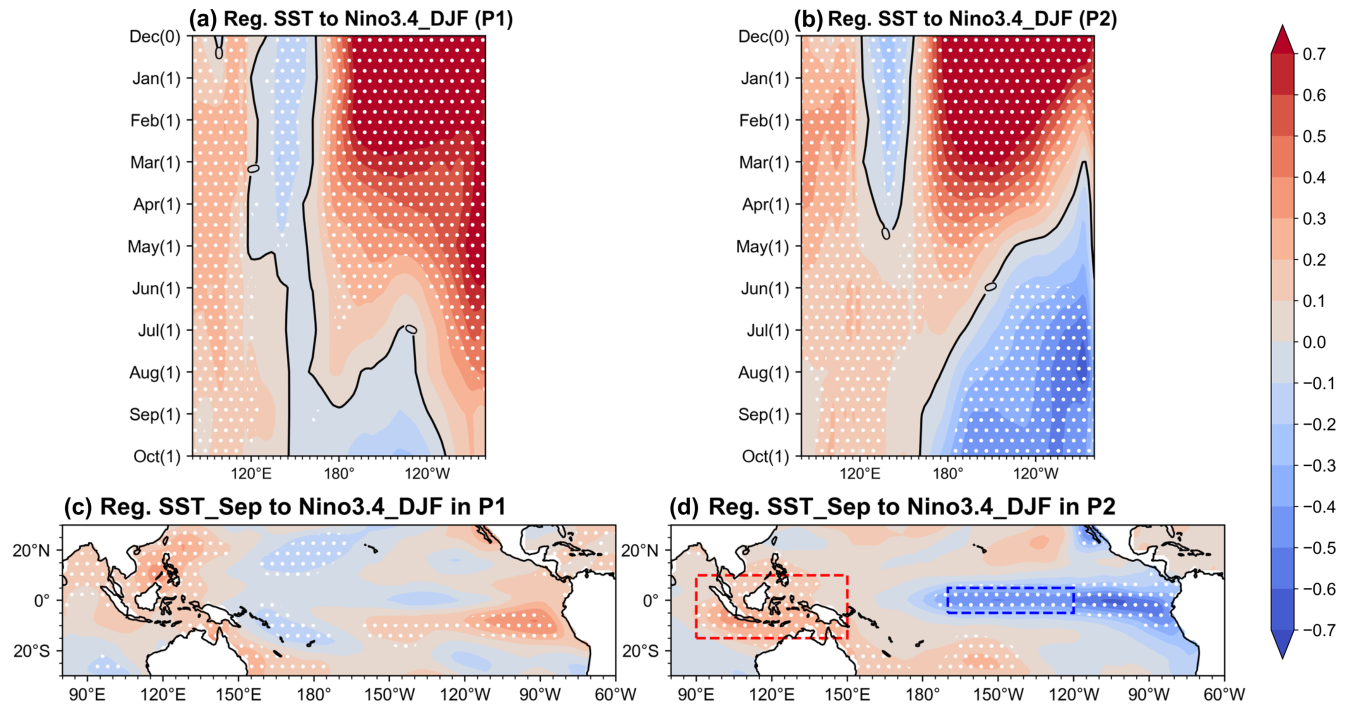

Fig. 4. (a, b) Latitude-time evolution of SSTA averaged over 5°S–5°N regressed onto the Niño3.4_DJF. (c, d) SSTA during the concurrent September regressed onto the Niño3.4_DJF.

- P1: Slow-decay mode. Residual warming persists through autumn.
- P2: Quick-decay mode. Rapid phase transition of ENSO, shifting from winter EEP warming to robust "EEP cooling & WP warming" pattern in September.

The accelerated decay establishes the robust seasonal footprint to unlock the long-lead predictability observed in recent decades.

3. Atmospheric Response to SST Forcing

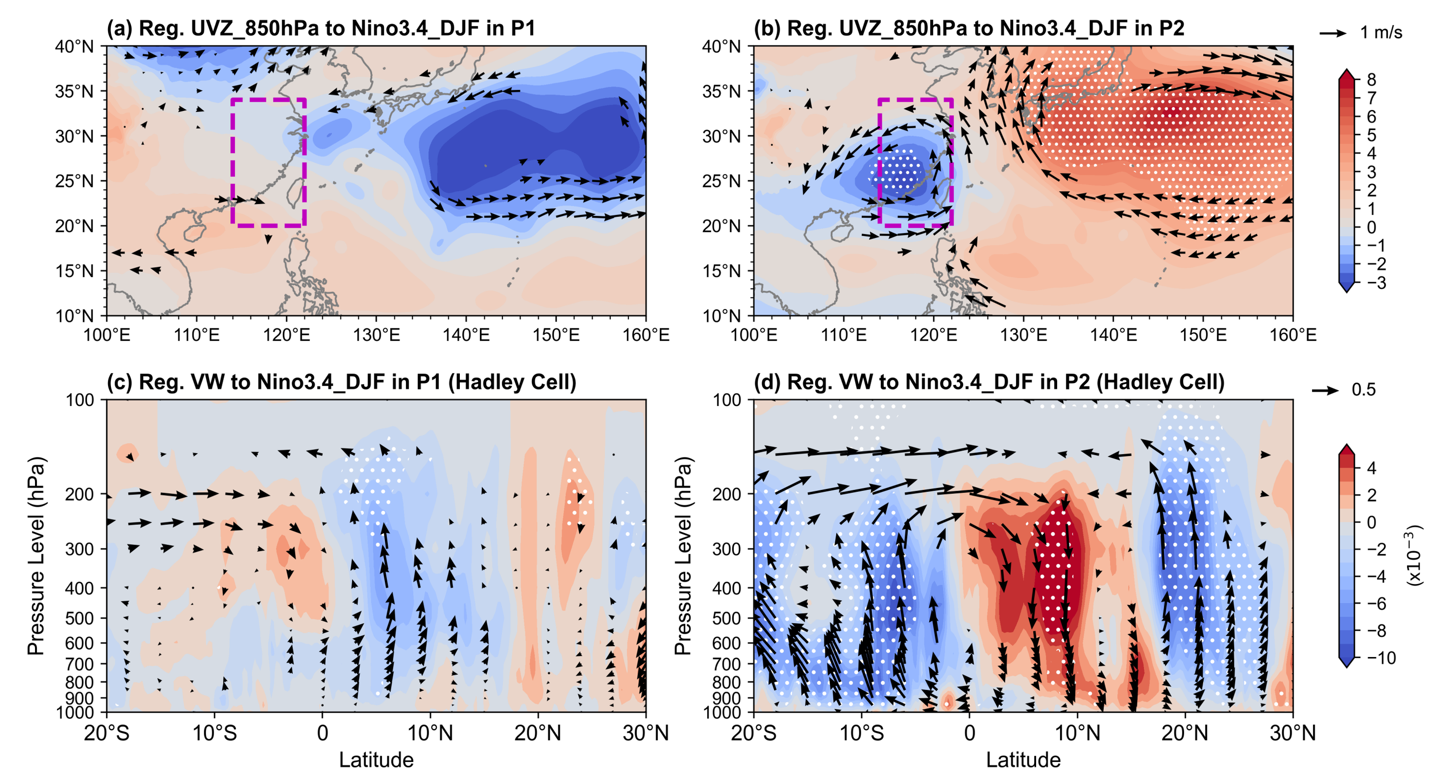

Fig. 5. (a, b) 850 hPa geopotential height (shading) and wind (vectors) anomalies in September regressed onto the Niño3.4_DJF. (c, d) Latitude-pressure cross-sections of vertical velocity (shading) and meridional-vertical circulation (vectors) averaged over 100°E–150°E in September regressed onto the Niño3.4_DJF.

- **WNPAC:** EEP cooling intensifies and sustains the Western North Pacific Anticyclone (WNPAC) via a Rossby wave response.
- **SC cyclone:** Concurrent WP warming triggers a local Hadley circulation, inducing a cyclonic anomaly over SC.

These systems work synergistically to enhance moisture transport and local dynamical lifting, favoring intensified SC precipitation.

Conclusions

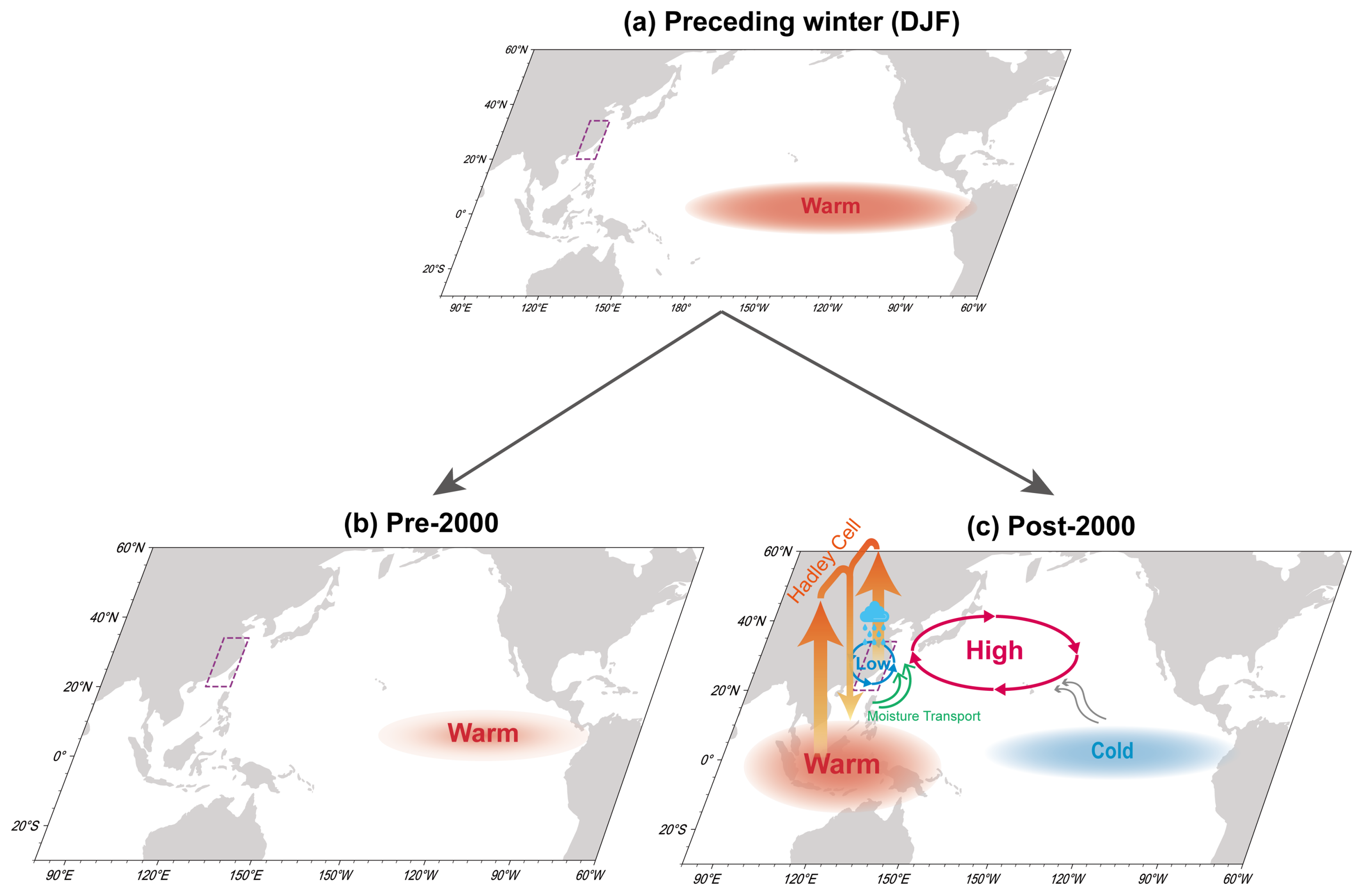

Fig. 6. Schematic figure of the interdecadal shift in ENSO teleconnections. (a) Preceding winter El Niño establishes initial warming in the EEP. (b) Pre-2000: The slow-decay mode results in residual autumn warming, leading to a decoupled relationship with SC regional precipitation in the following September. (c) Post-2000: The quick-decay mode triggers a synergistic relay of EEP cooling and WP warming, which sustains the WNPAC and shifts the local Hadley circulation. This configuration drives intensified September precipitation in SC.

- Since the early 2000s, preceding winter ENSO has emerged as a robust long-lead predictor for Southeast China (SC) early autumn precipitation, unlocking a 9-10 month lead time.
- The intensified predictability stems from an interdecadal shift of the ENSO lifecycle in recent decades.
- **Pre-2000 (slow-decay):** residual warming → weak forcing → decoupled SC early-autumn precipitation.
- **Post-2000 (quick-decay):** rapid ENSO phase transition → EEP cooling and WP warming → sustained WNPAC and shifted local Hadley circulation → coupled SC early-autumn precipitation.

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Contact Information

- **Email:** lxubd@connect.ust.hk
- **Address:** Room 2605, Academic Building, HKUST, Hong Kong SAR.
- **Research group website:** https://cehsu.people.ust.hk/index.html

Xu L., Su H., Lau W., Wang C., Wang Y., Yu S., Winter ENSO Signal as a Robust Seasonal Predictor of Southeast China Early Autumn Precipitation in the Post-2000 Period. (In Review)