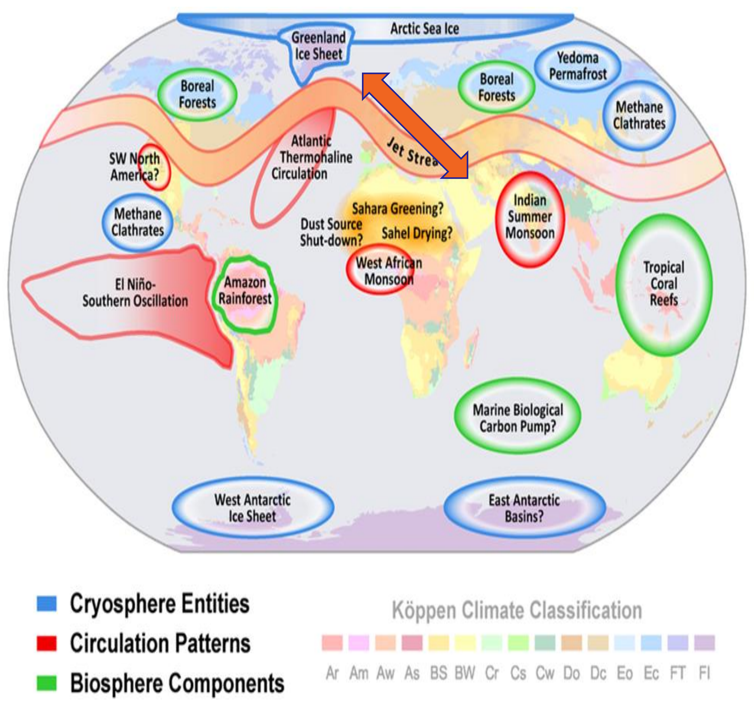
Coupled ocean/atmosphere prediction

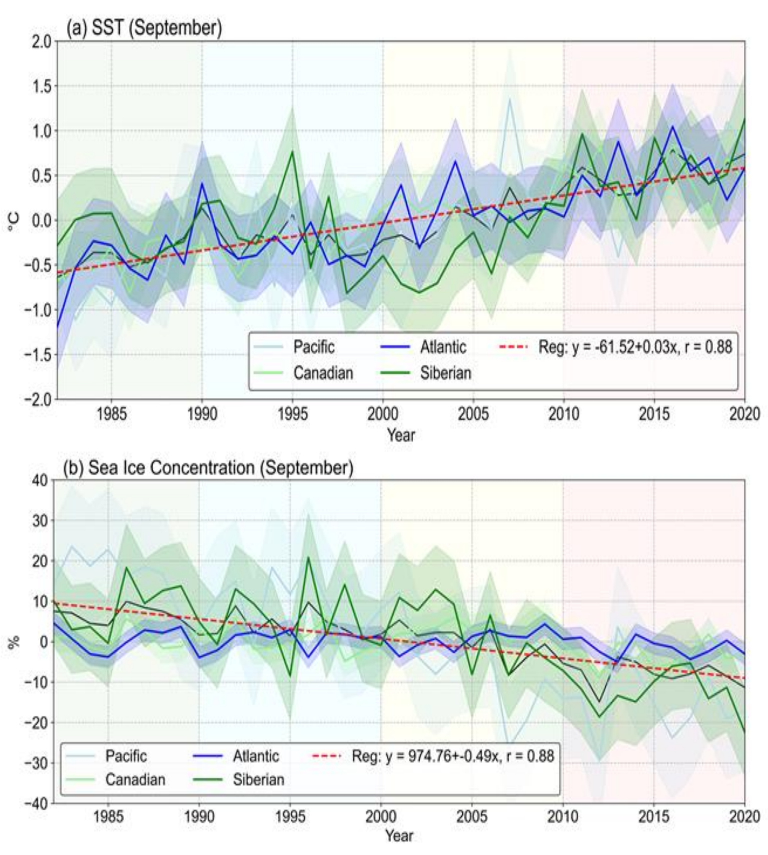
The Complex Teleconnections and Feedback Mechanisms between Mainland Indochina's Southwest Monsoon and Arctic Ocean Climate Variability

Kyaw Than Oo
School of Atmospheric Sciences,
Nanjing University of Information Science and Technology

Introduction

- Components are part of a larger network of climate processes that, if disrupted, can lead to tipping points with far-reaching consequences for our climate system.
- Examines the connection between Mainland Indochina Southwest Monsoon (MSWM) and the decrease in sea ice in the Arctic in September.
- Factors influencing MSWM include ENSO, Indian Ocean Dipole, winter snow cover in Eurasia, NPO, and NAO.
- ENSO has a multi-decadal impact on sea ice variability, while NPO and NAO influence it on interannual and seasonal to decadal-scale variation.
- Investigates the connection between sea ice variability during September and the intensity of large-scale MSWM circulation.
- Examines data from **1981** to **2020** to understand the effects of strong and weak intensity MSWM on sea ice.
- Shows a tropical-polar teleconnection between interannual sea ice variability and southwest monsoon intensity (SMII).

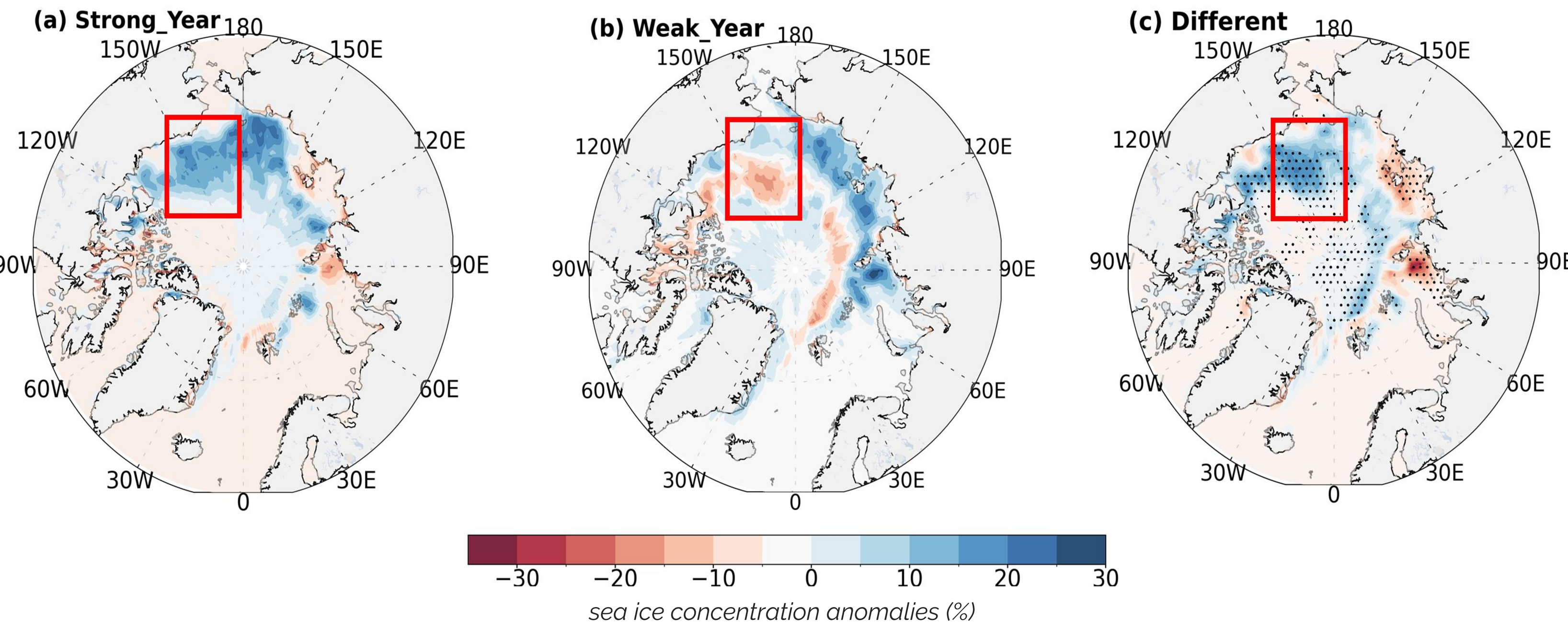


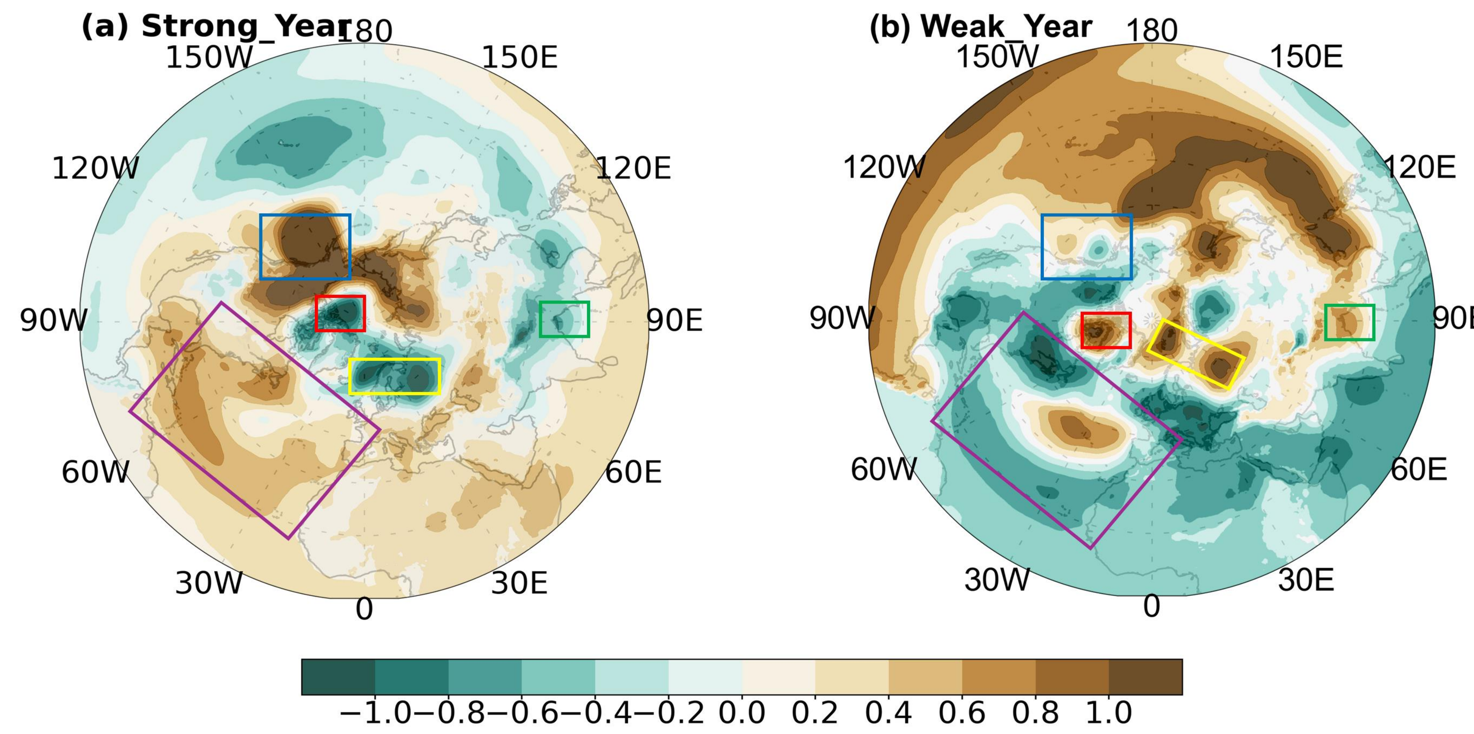


Interannual variation of Arctic sea (a and b)

Results

The research indicates that many strong SMII years are associated with less sea ice in the eastern Arctic and more in the northwestern Arctic, while weak SMII years show the opposite trend by global scale pressure differential. (below Figures)





Composites (June–September) 850 hPa geopotential anomaly, with 90% confidence dotted area, (a) strong SMII years, (b) weak SMII years, The main regions of significant different between strong and weak SMII were represented by a rectangle box: the North Atlantic (purple), North Pacific (blue), Beaufort Sea and North Eurasia (red), Greenland-Iceland (yellow), and mainland Indochina (green).

Conclusion

The study aims to understand the teleconnection of Mainland Indochina Southwest Monsoon (MSWM) intensity variability with sea ice variability in the Arctic region in September.

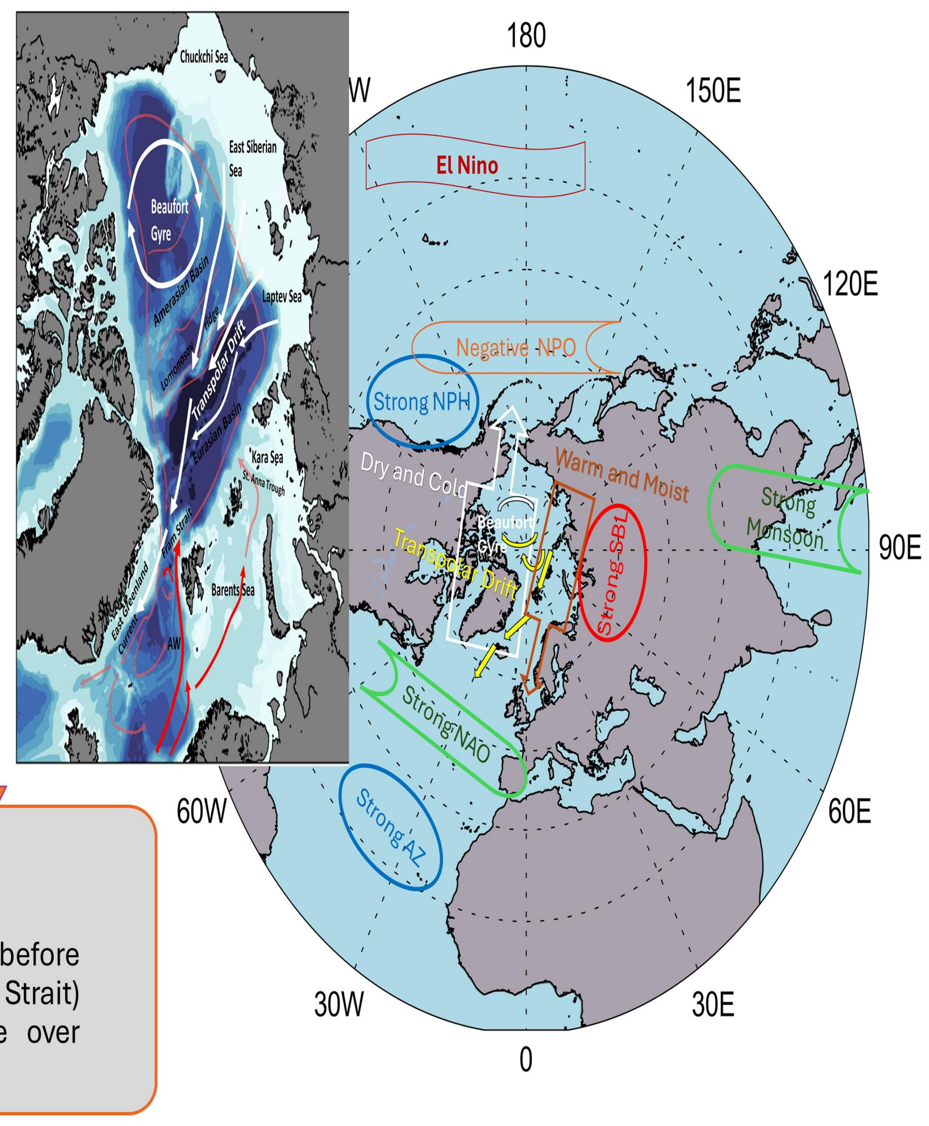
- Datasets from multiple sources were evaluated over a 40-year period (1981-2020).
- Findings show that MSWM intensity influences sea-ice concentrations in the Beaufort Sea, the Laptev Sea, and the Kara Sea area.
- Strong (weak) SMII impacts the summer North Atlantic Oscillation (NAO) due to monsoon-driven adiabatic processes and diabatic heating related to MSWM.
- These changes affect sea-ice and atmospheric circulation pattern over the Arctic region, leading to less sea ice at the Beaufort Sea area.
- The study suggests that the weakening of SMII and increase extreme rainfall in northern Indochina and Southwestern China since 2005 may have contributed to the rapid decline in Arctic sea ice after 2000.
- Future studies will test this hypothesis, determine if MSWM intensity index can predict Arctic sea ice changes, explore why MSWM and the North Atlantic Oscillation are weakening, and understand the related feedback mechanisms.

Strong (Weak) SMII, Azores high (AZH), North Pacific High (NPH) through Monsoon Mechanism during JJAS

Strong (weak) AZH and NPH high leads to Positive(Negative) NAO and Negative (Positive) NPO during JJAS

Positive (Negative) NAO and Negative (Positive) NPO during JJAS weakens (strengths) the Beaufort Sea High (BSH) which alters the Arctic wind pattern and Transpolar Drift

Weak (Strong) BSH causes
(1) Less(More) warm air advection and
(2) Transpolar drift to flow towards the Beaufort Sea before exporting sea ice to Fram Strait (directly to the Farm Strait) but also slow down causing More (Less) sea ice over Chukchi-Beaufort sea region.



Methodology

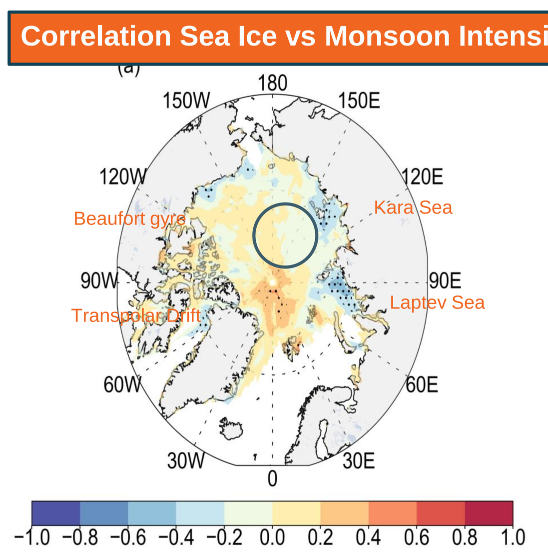
Utilized statistical methods like standardization, anomaly computations, correlation, and composite analysis.
- Composite analyses performed on sea ice concentration, sea-level pressure, and air temperature.
- Conducted significant analysis tests to validate feature reliability.
- Climate Data Operator used for computation and data manipulation.
- Python used for plotting figures and statistical two-tailed test.

Data For Monsoon
- CPC Rainfall (2.5 x 2.5)
- ERA5 (0.25 x 0.25)
- NCEP Reanalysis 2 (2.5 x 2.5)

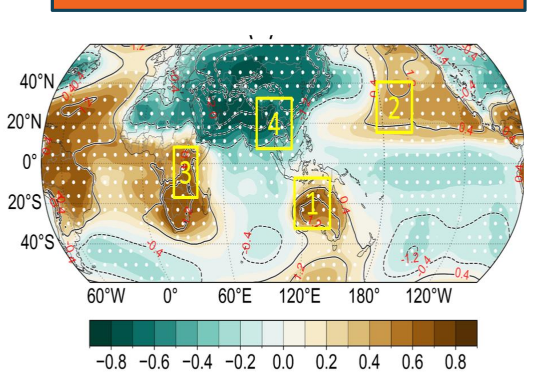
Statistics Methods
- Mean
- Anomalies
- EOF
- Correlation
- Regression
- Composite Analysis

Data for Arctic
- NOAA Optimum Interpolation (OI) SST V2 (1 x 1)
- Sea ice concentration daily gridded data from 1978 to present derived from satellite observations (0.25 x 0.25)

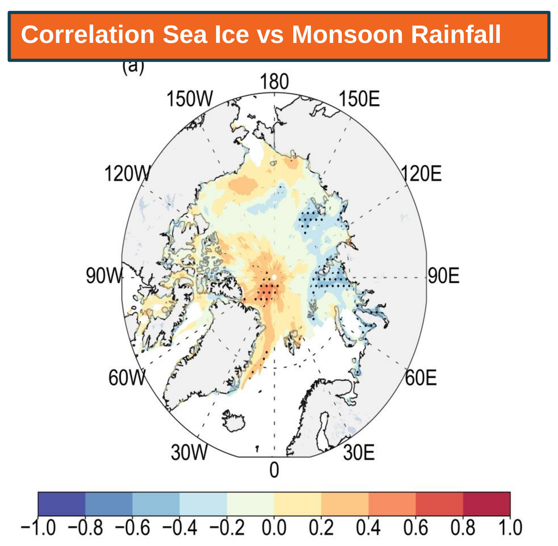
Correlation Sea Ice vs Monsoon Intensity



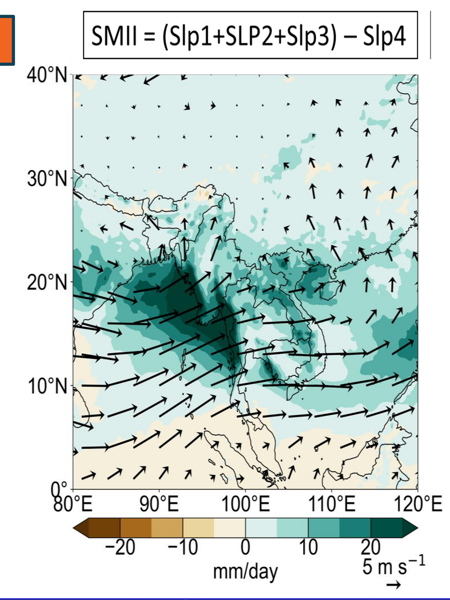
Monsoon Rainfall and Intensity



Correlation Sea Ice vs Monsoon Rainfall



SMII = (Slp1+SLP2+Slp3) – Slp4



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