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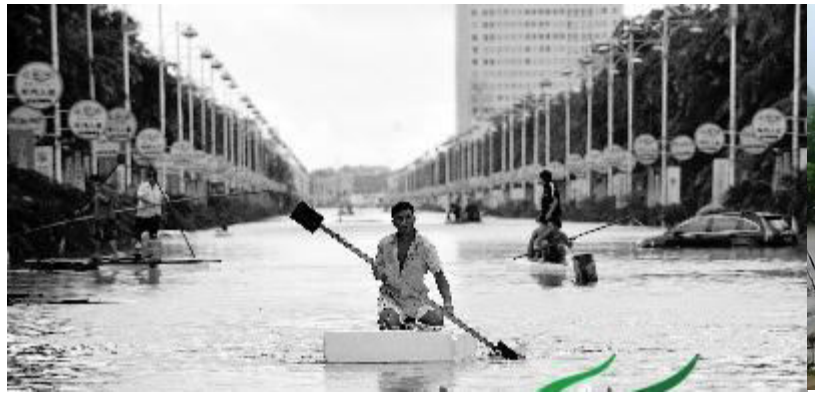
Factors Autumn Extreme rainfall Over Hainan Island



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Hainan Meteorological Service

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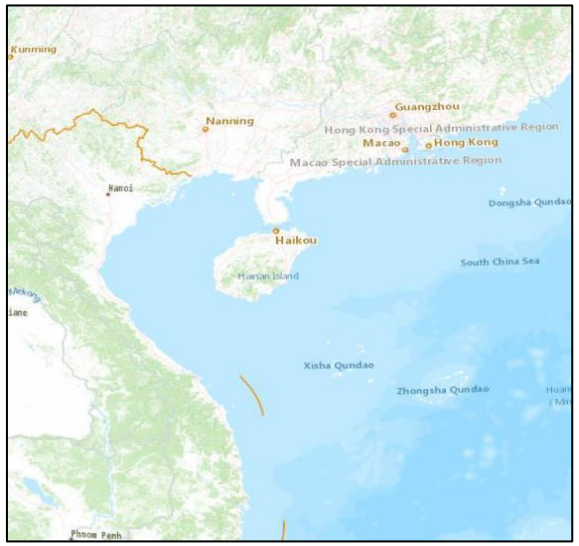
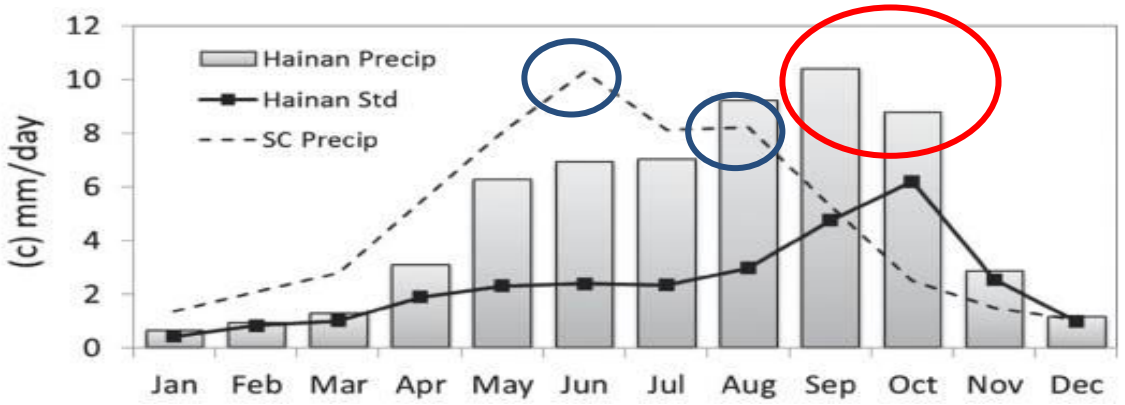
1.Overview





area-mean climatological monthly precipitation (mm day21) of Hainan (bar) and south China (dashed line) and the interannual standard deviation (mm day21) of monthly precipitation of Hainan (solid line).

(1)Autumn is the peak rainy season in Hainan

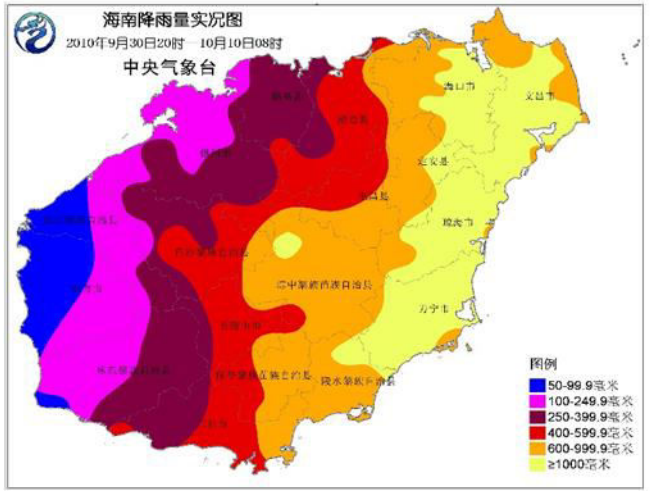
The seasonal precipitation over Hainan is different from the other regions of south China

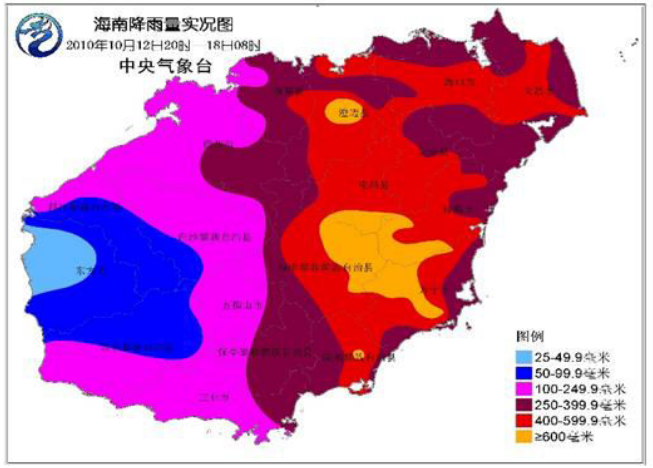
1.Overview

(2)The autumn extreme rainfall brings great challenges for water resource management.

The autumn precipitation events are typically prolonged ,flooding-related, and devastating, posing threats to public safety and property, agriculture, and damage prevention.

In October of 2010, during the Chinese Golden Week holiday, Hainan experienced the worst rainstorm in the last half century, which submerged 1160 villages and 3 cities, destroyed 4480 houses, ravaged 237 920 kha of cultivable land and trapped 600 000 people

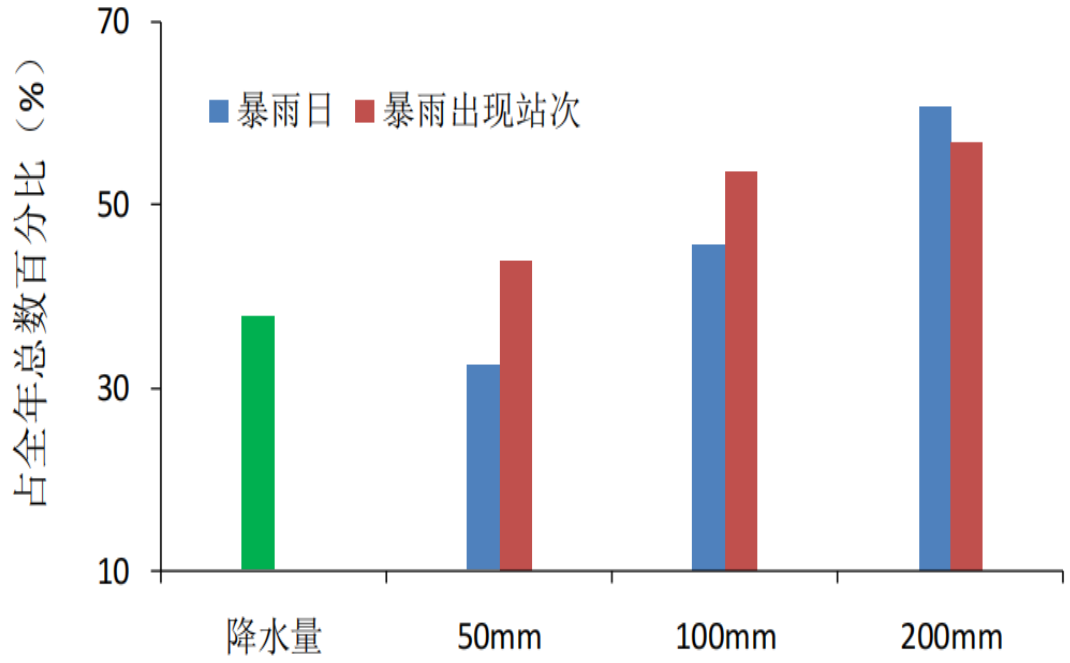




2.Climatic characteristics

- **Extreme rainfall events are the main contributors for autumn precipitation in Hainan**

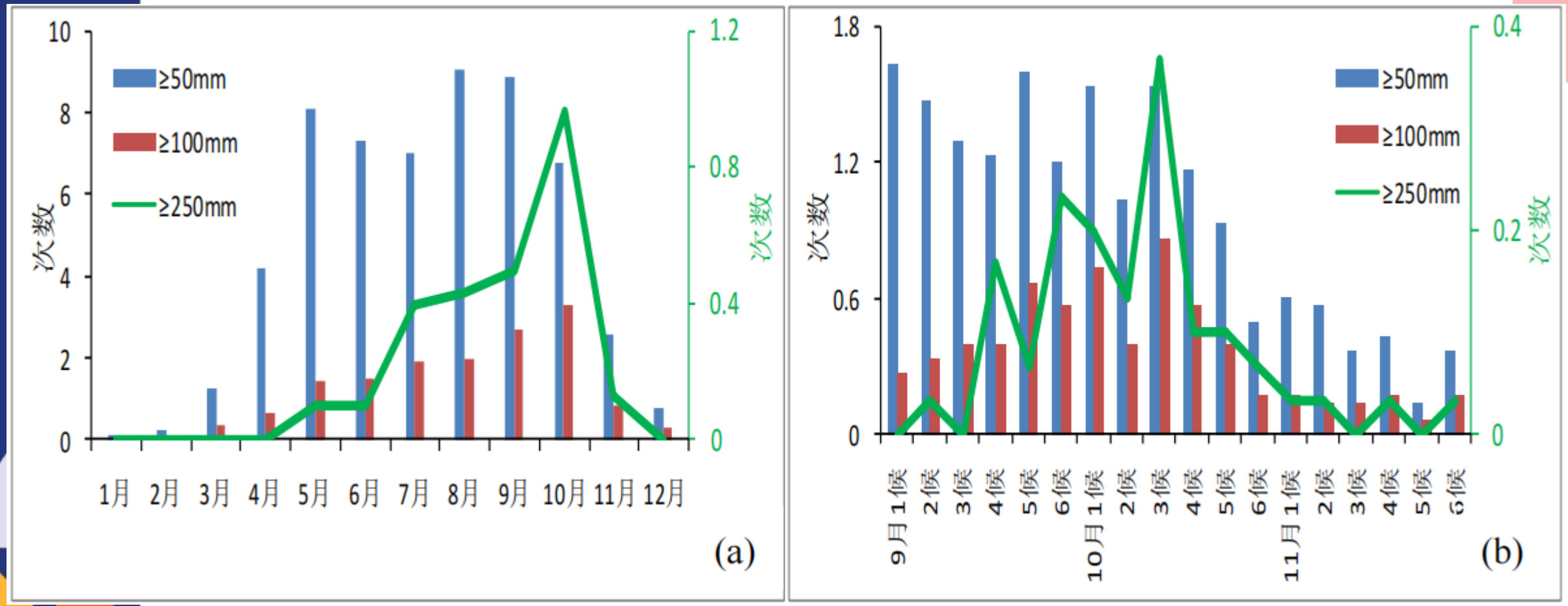
The precipitation in autumn flood season accounts for less than 40% of the whole year, but high-level rainstorm days and heavy rainfall stations are close to or more than 50% .



The proportion about total precipitation, days of different magnitude rainstorm in autumn to that in year round

The distribution of heavy rainfall days on Hainan Island is bimodal, but that of high magnitude rainstorm days is unimodal.

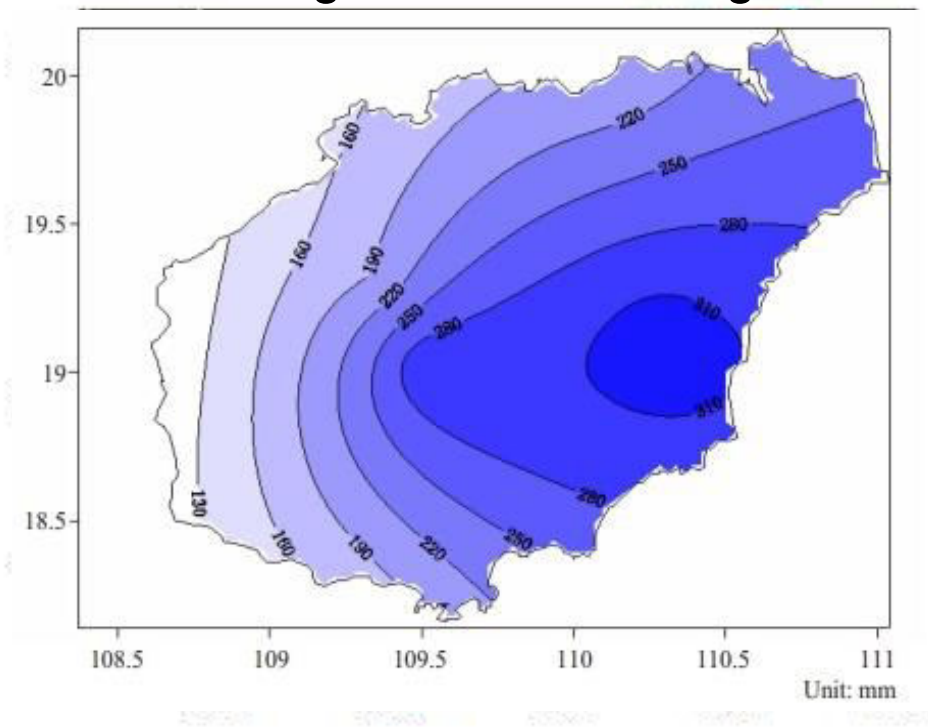
High magnitude rainstorm days mainly occurred in the second half of September to the first half of October



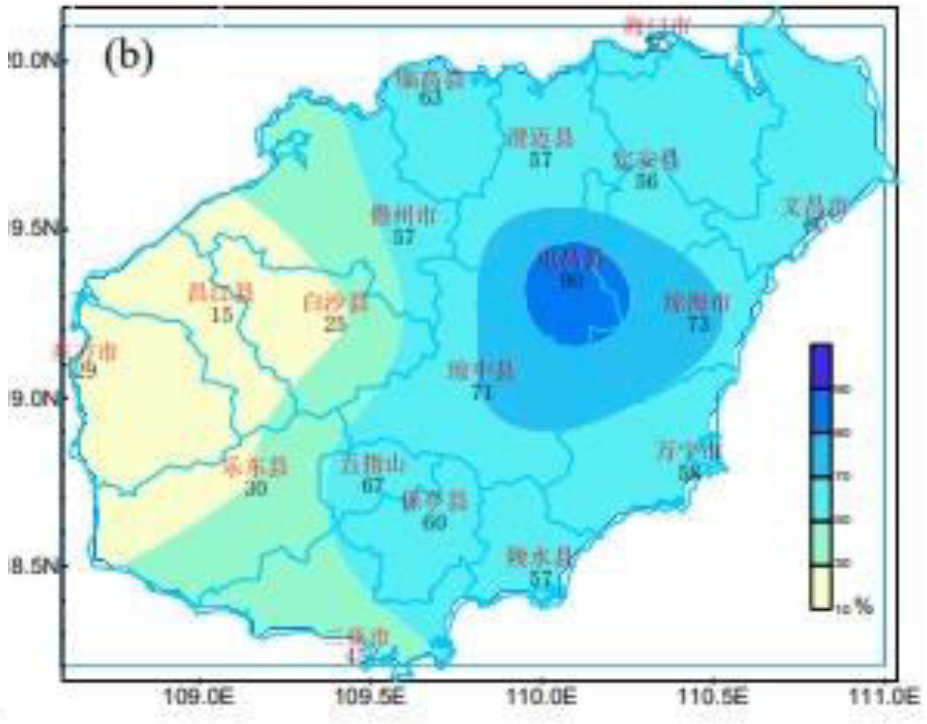
The monthly mean (left) and the pentad mean (right) distribution of rainstorm stational days with different magnitude on Hainan Island

The spatial distribution of autumn heavy rainfall

the heavy rainfall area mainly occurs in the central and eastern part of Hainan Island, with the precipitation center located in the eastern Wanning and Qionghai regions where the average process accumulative precipitation is over 300 mm.
the proportion autumn heavy rain days in the whole year is close to and over 60% , even reaching 90% in some regions.



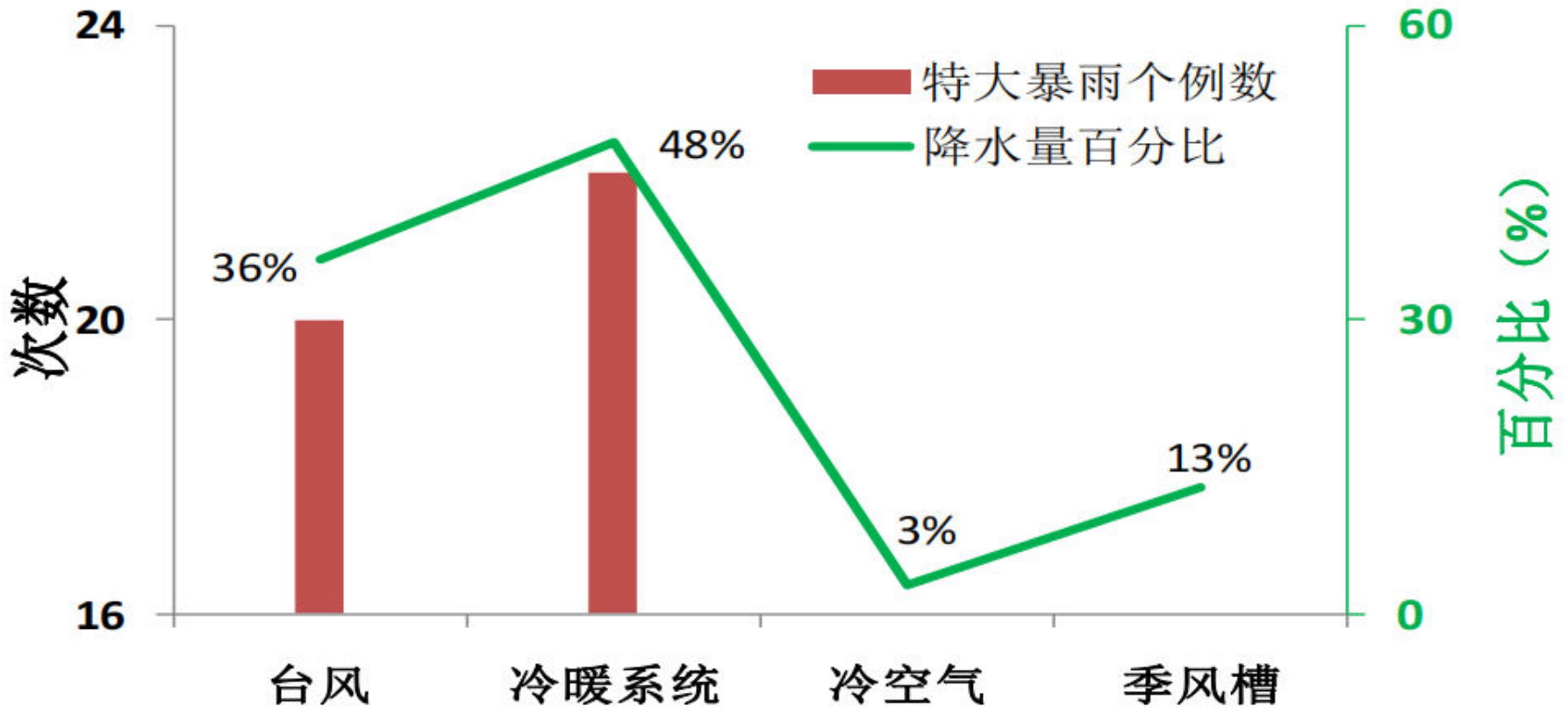
a. Spatial distribution of average accumulative precipitation of heavy rainfall in autumn during 1981-2014 (mm)



b. distribution of proportion of heavy rain days in autumn to that in year round

Weather systems that lead to autumn extreme rainfall

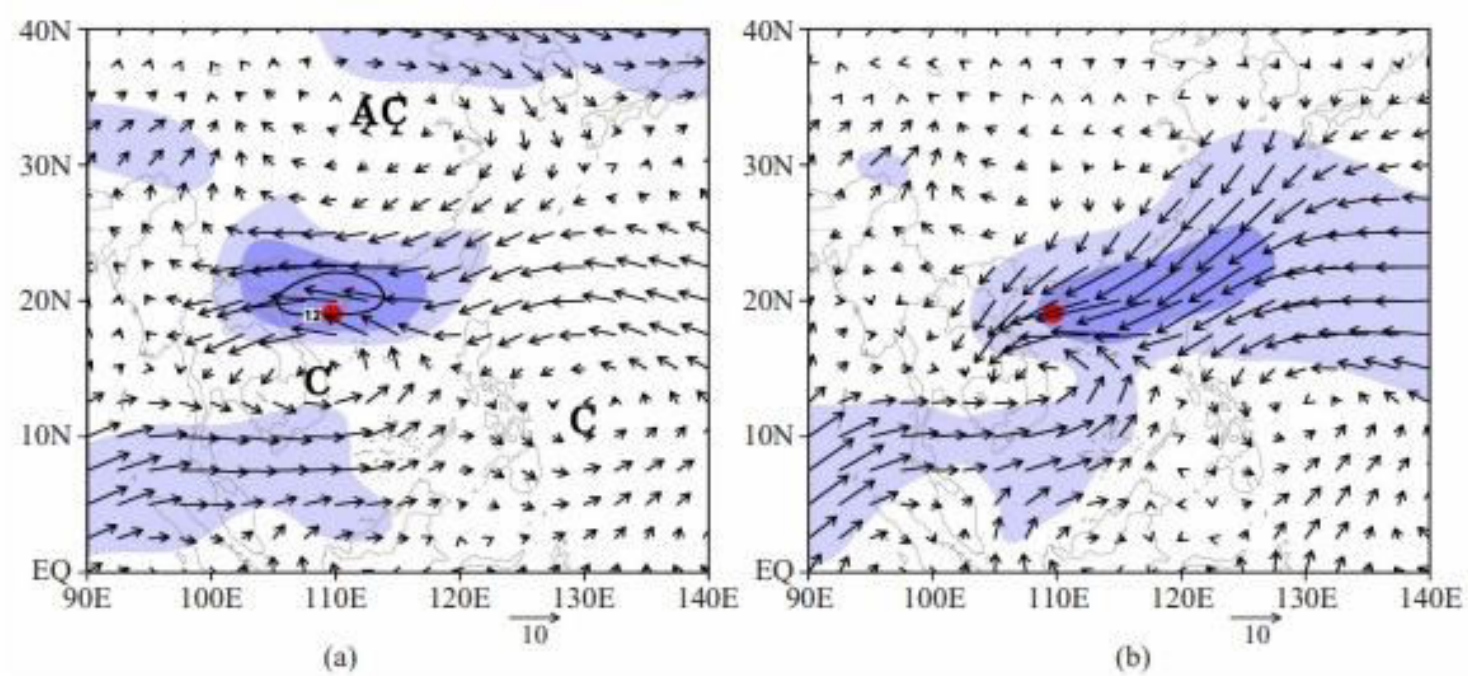
interactions of cold and warm air is the main cause of torrential rainfall



The percentage of precipitation and the torrential rain days with different weather systems in autumn

The circulation of autumn rainstorm

The easterly jet moved over Hainan Island, which is the circulation background of the rainstorm during the autumn in Hainan

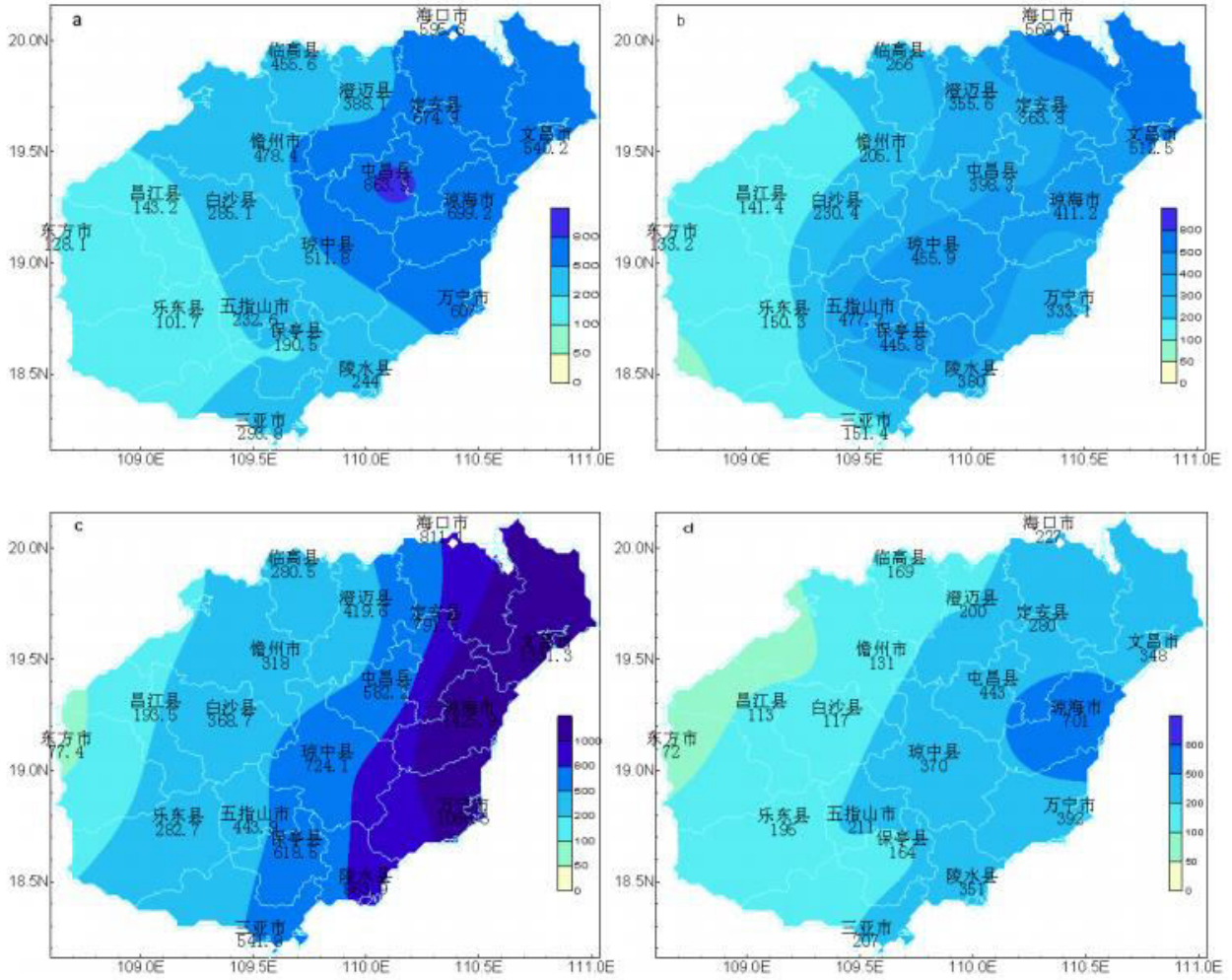


Wind field at 850 hPa (a) and vertically integrated water vapor transport flux (b) during autumn heavy rainfall events

Cases study

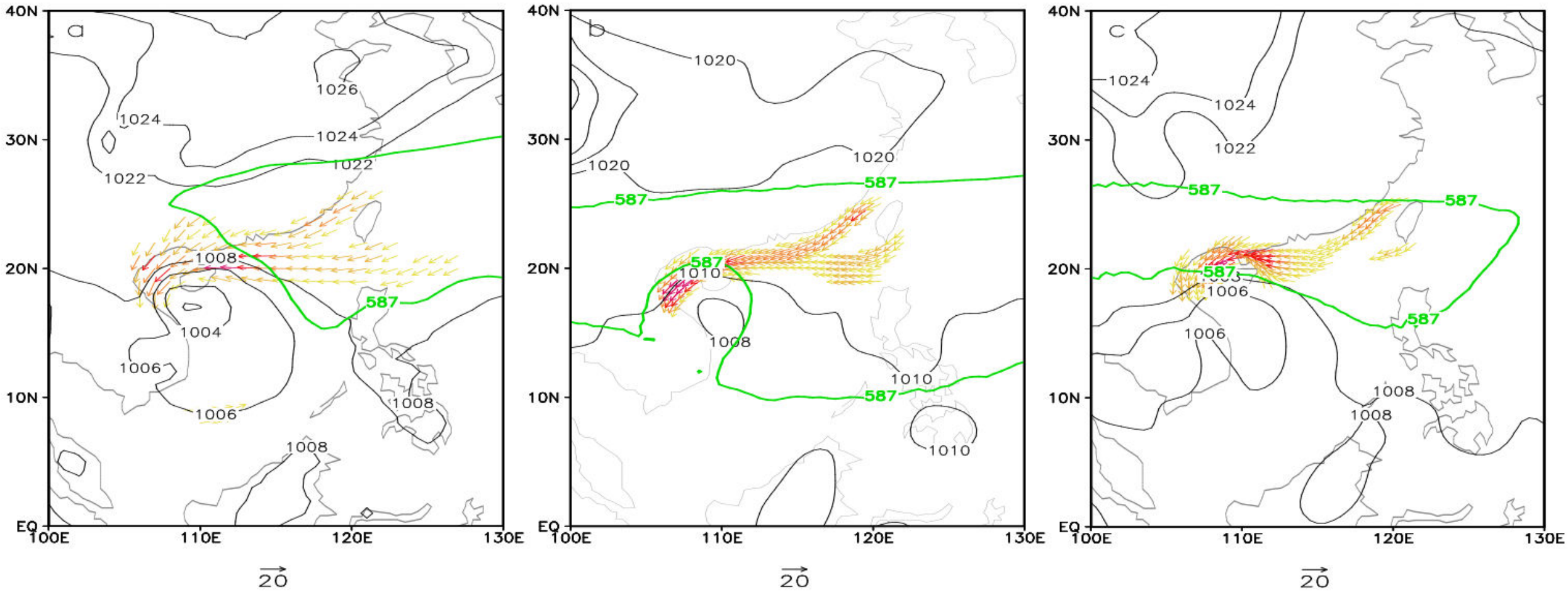
Three most strongest torrential rain events in recent 20 years:
Oct. 11-17,2000, 9 stations>500mm,3 stations >500;
Oct. 12-15,2008, eastern half Accumulative precipitation 300-600mm;
Oct. 1-9, 2010, Accumulative precipitation of 1385.4 mm in Wenchang, 1182.5 mm in Wanning, and 930.2 mm in Lingshu.

The spatial distribution of all the three events are similar.



Accumulative precipitation of three torrential rain events (a,b,c) and daily precipiation extremum distribution during autumn in recent 10 years

The low level easterly jets are the most prominent signals for autumn extreme rainfall



Sea level pressure field, wind field of 925hPa, and altitude field of 500hPa on heaviest rainfall day
a. 14 Oct. 2000, b. 12 Oct. 2008, c. 5 Oct. 2010

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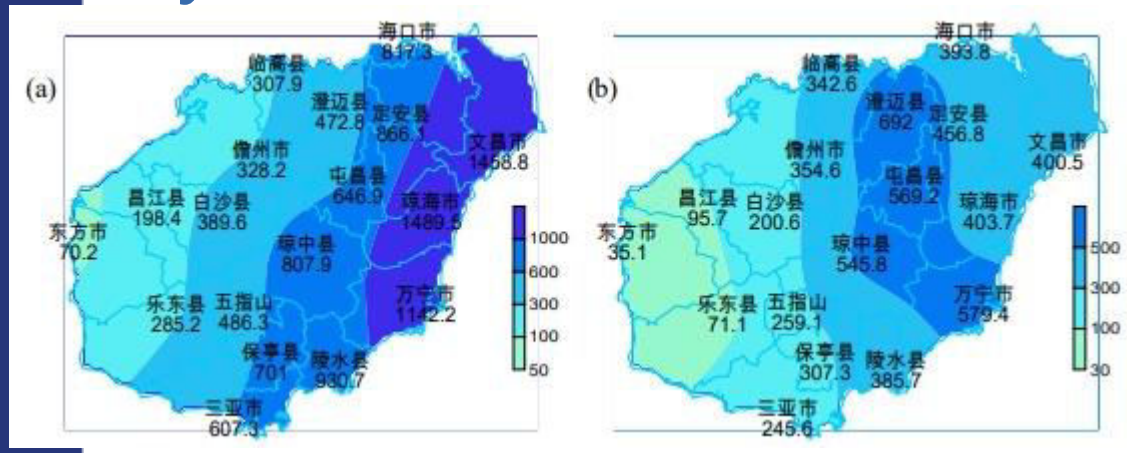
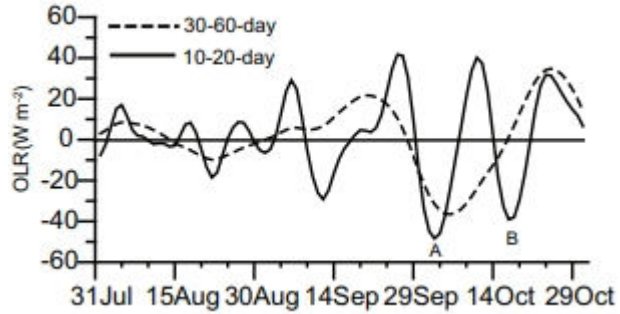
- Overview
- Climatic characteristics
- **Impact of the MJO on Autumn Heavy Rainfall**
- Interannual variation

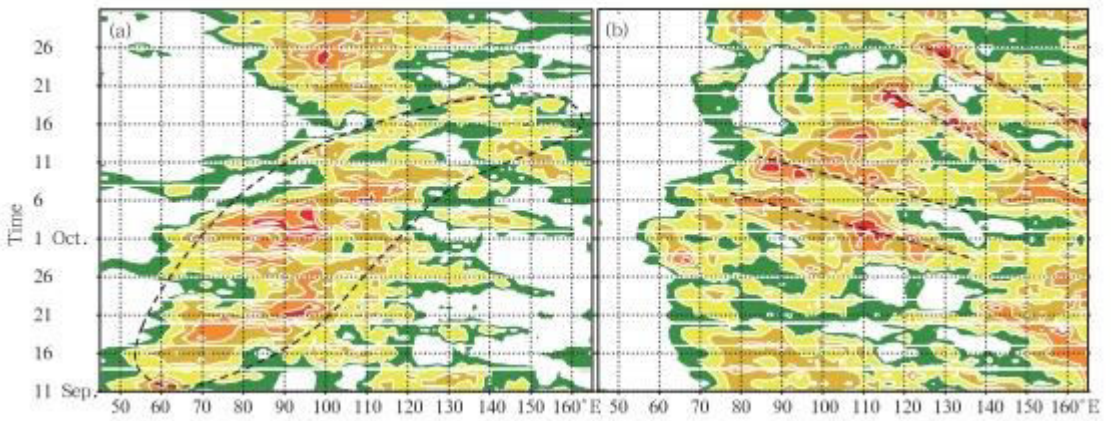
3. Impact of the MJO on Autumn Persistent Heavy Rainfall

Autumn extreme rainfall is a result of Multiple-Scale systems interactions



Accumulative precipitation of (a) 1-9,Oct. 2010;(b) 13-19,oct.2010



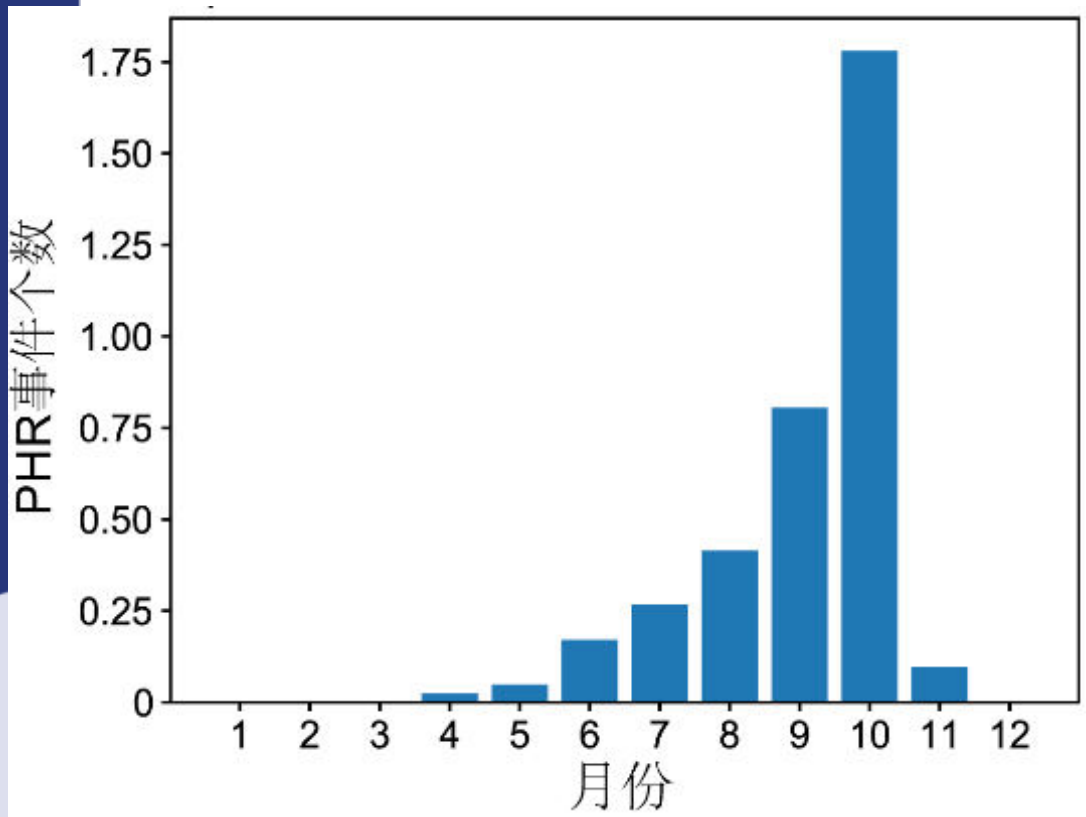


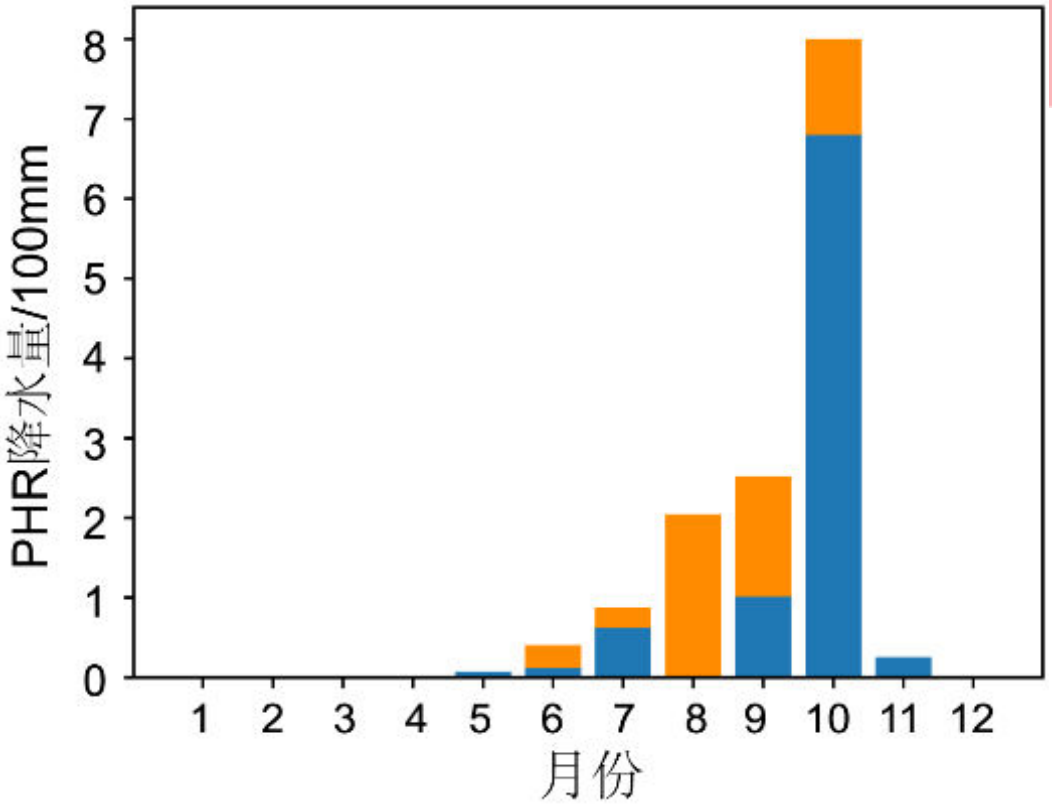
.Time-longitude diagrams of averaged TBB (K) for the period 11 September to 31 October 2010 between (a) 5◦N and 5◦S (a significant MJO is enclosed by the black dashed line), and (b) 20◦ and 5◦N (dotted lines emphasize the westward ISO)

.Time series of the 10–20-day and 30–60-day oscillations of OLR (units: W m−2) at (18◦N, 110◦E) from August to October 2010. “A” and “B” denote the two phases of the 10–20-day oscillation associated with the two rainstorm events in Hainan.

3. Impact of the MJO on Autumn Persistent Heavy Rainfall

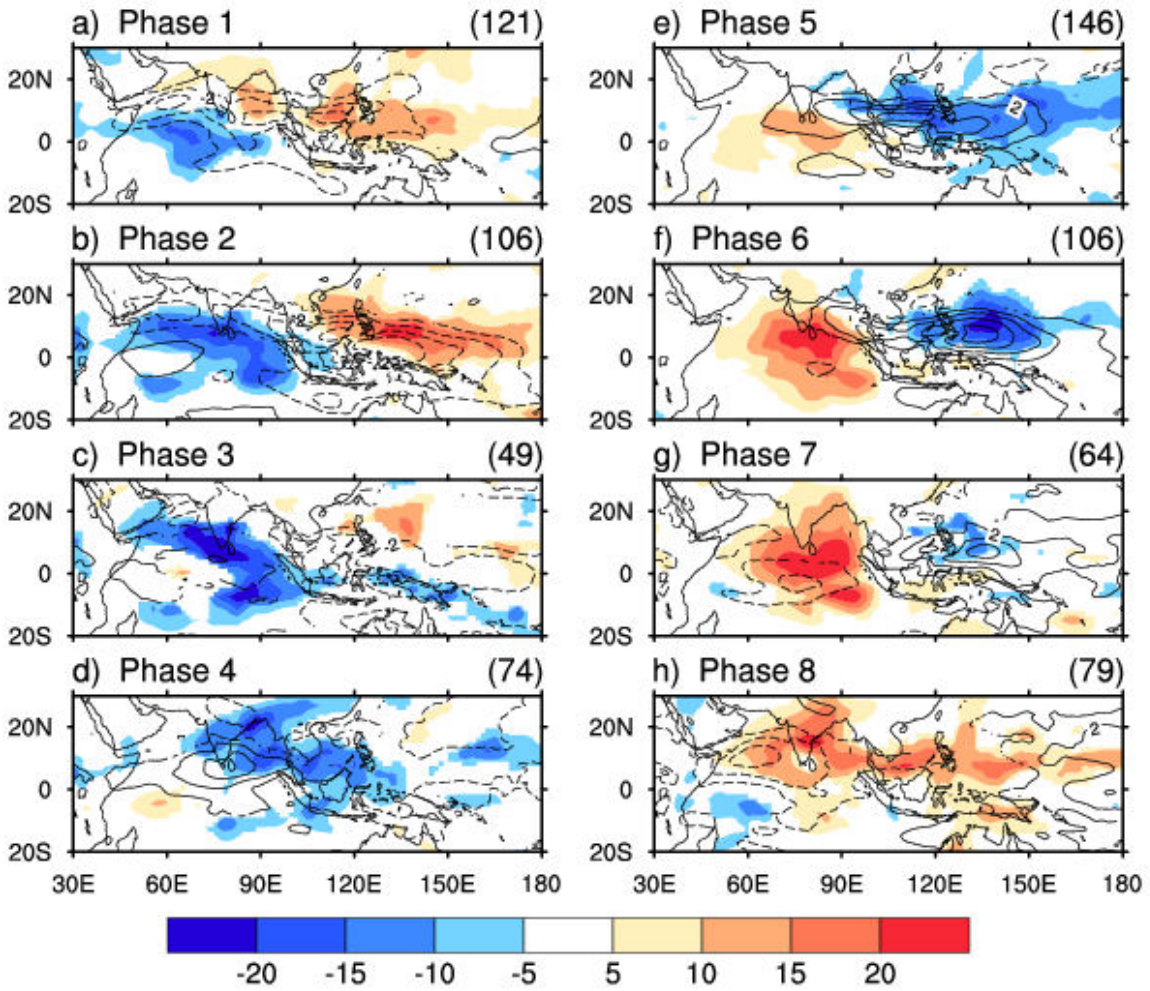
Persistent Heavy Rainfall(PHR):daily precipitation ≥ 50 mm and last for at least 72 hours





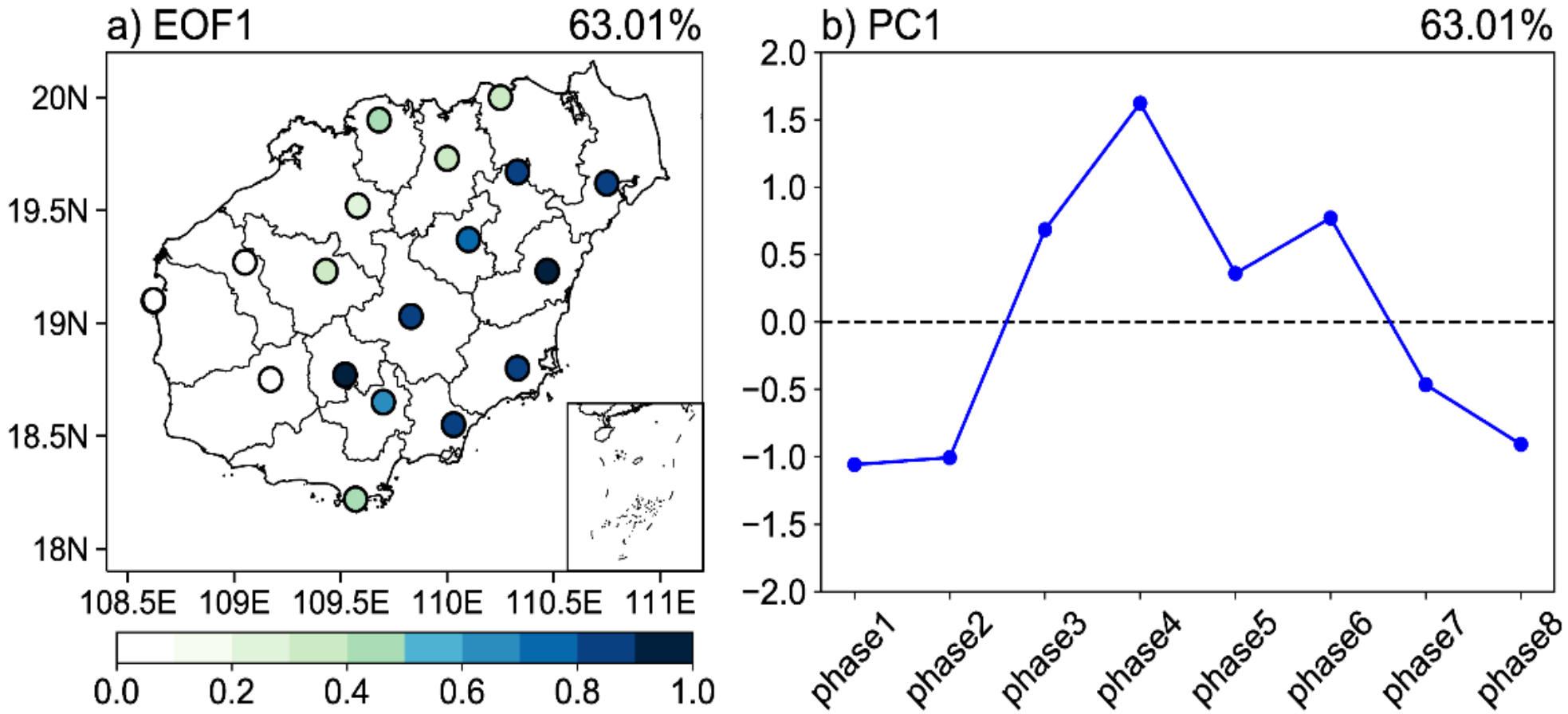
The average number of PHR events per month (left) and average monthly PHR precipitation in Hainan Island, where orange means the precipitation within 500 km from the typhoon center (right)

MJO phases in October



Composit map of OLR and 850hPa zonal wind field anomalies at each MJO phase
the top right digit represents the number of days used to synthesize

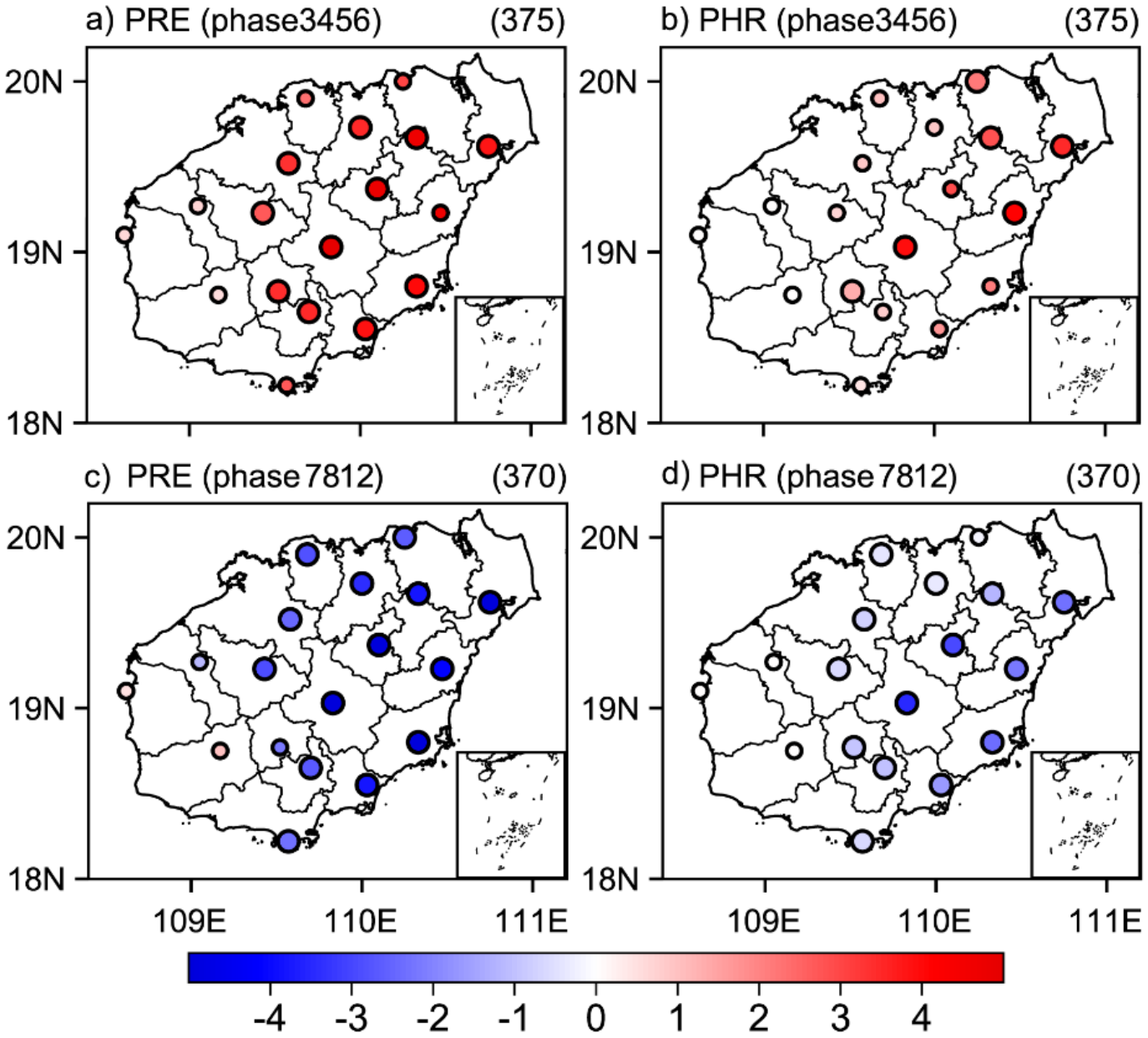
The difference in the contribution of MJO's phases about PHR in October



Empirical orthogonal EOF analysis of eight phase PHR precipitation anomalies of MJO in Hainan Island in October:

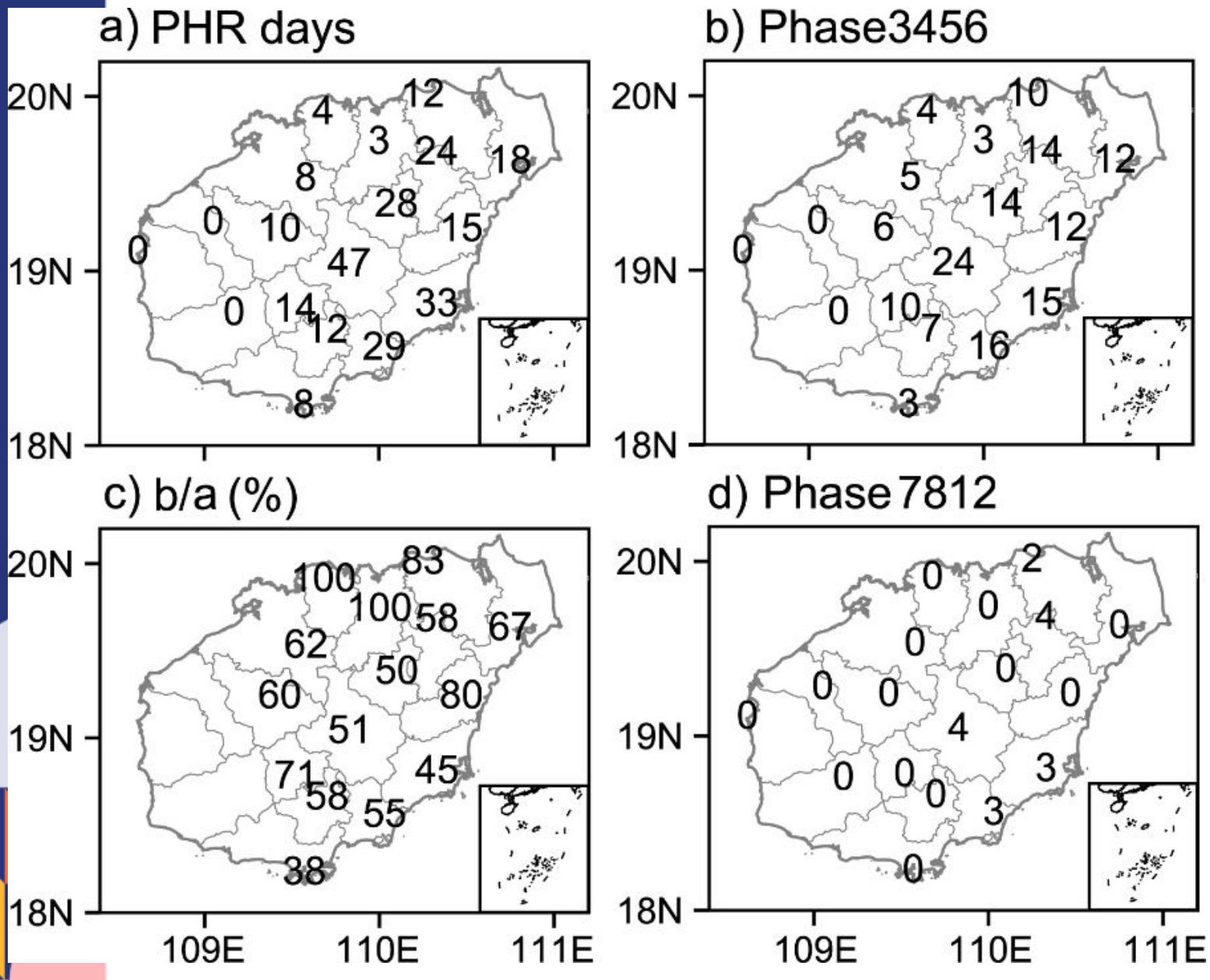
(a) is the result of the first principal component, and (b) is the time series

The difference in the contribution of MJO's phases about PHR in October



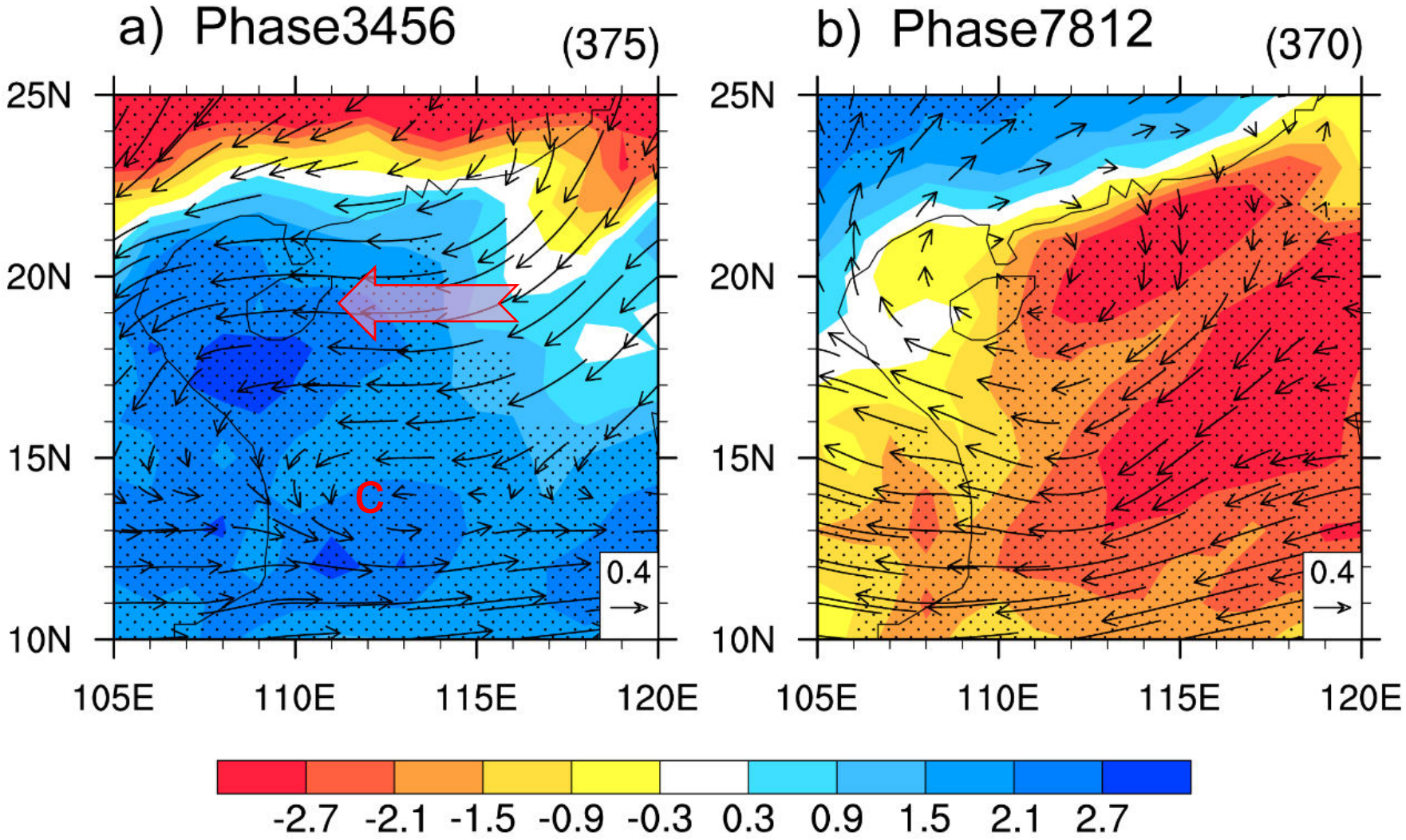
Composite map of MJO precipitation anomaly at different phases in Hainan Island in October. (a) and (b) are the synthesis of precipitation anomalies caused by total precipitation (PRE) and PHR at phase 3-6, respectively; (c) and (d) are the synthesis of precipitation anomalies caused by total precipitation (PRE) and PHR at phase 7, 8, 1 and 2, respectively. The number in the upper right represents the number of days used to synthesize, with the larger dot indicating that it passed the 90% significance T-test

The difference in the contribution of MJO's phases about PHR in October



(a) Distribution map of PHR occurrence days in Hainan Island National Station in October; (b) The number of PHR days during MJO phase 3-6; (c) The percentage (%) of the total number of PHR days during which phase 3-6 occurs, i.e. (b) divided by (a); (d) The number of PHR days during MJO phases 7, 8, 1 and 2.

Cause of MJO influence on PHR



The composite map of 850 hPa specific moisture anomalies and wind field anomalies at different phases of MJO in October (where the dot is specific humidity q passing 90% significance test). The number in the upper right corner indicates the number of days used to compose (a) is the MJO wet phase period, (b) is the MJO dry phase period.

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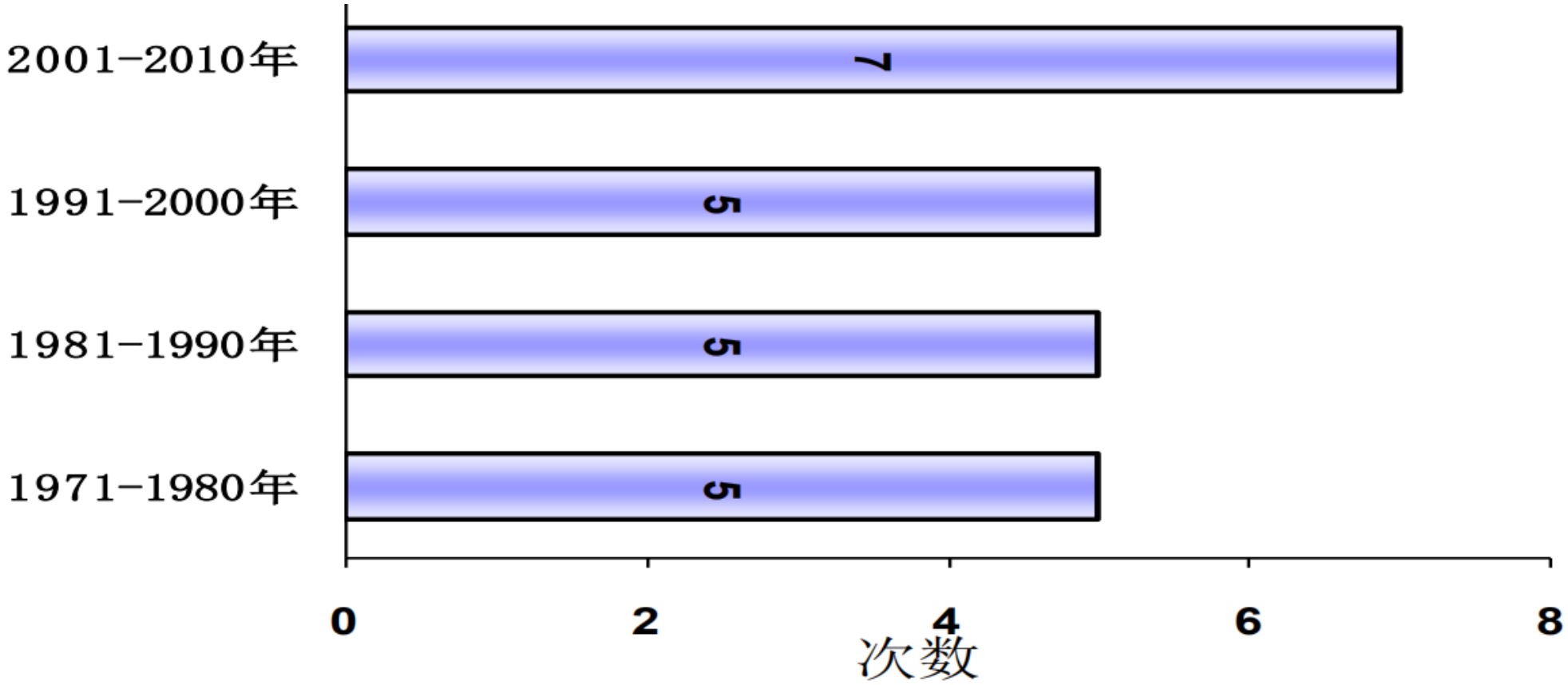
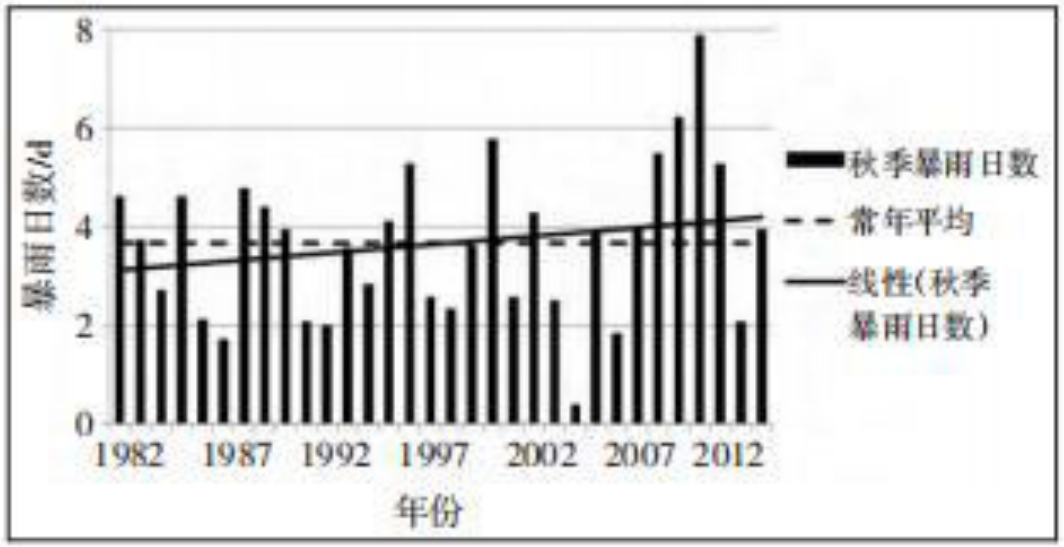
The number of torrential rain increased after 2000 in Hainan Island



Interdecadal frequency distribution of torrential rain events

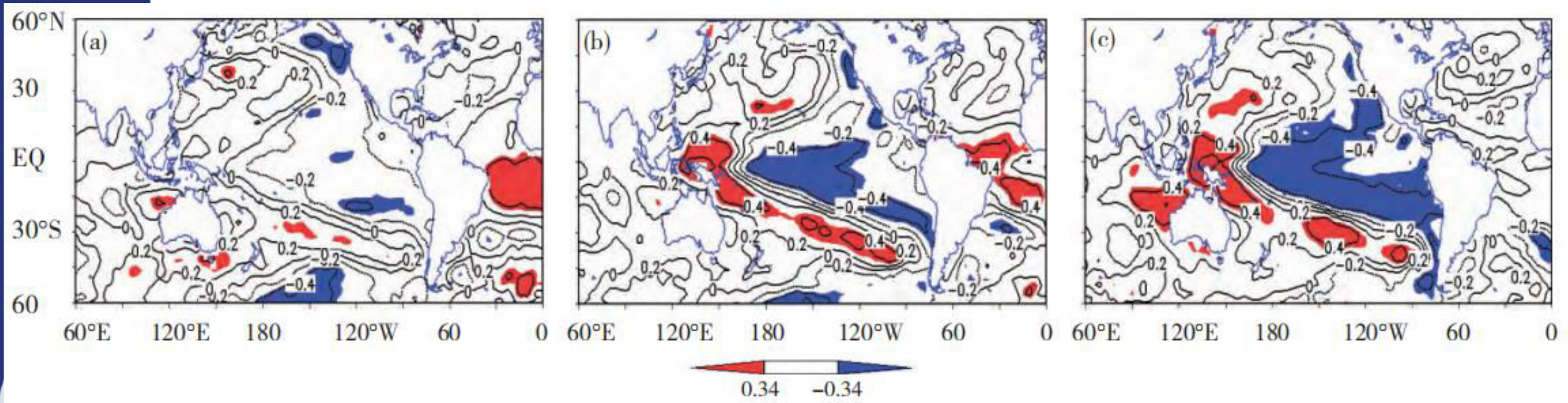
Interannual variation trend of rainstorm in autumn in Hainan Island

the days of rainstorm in autumn showed an increasing trend.



the days of rainstorm (right) in autumn in Hainan Island

Influencing factors on interannual variation of rainstorm in autumn in Hainan



Correlation between the number of rainstorm days in autumn and SST in previous spring (a), previous summer (b), the same term (c).

summary

1. the annual peak precipitation and nearly 50% of the large-scale extreme precipitation events occurred in the autumn flood season. The spatial distribution of precipitation is severely asymmetric, and the highest precipitation occurs in the eastern and central regions.
2. Three synoptic-scale systems—a cold surge, a tropical disturbance, and a low-level easterly jet which associated with the interaction of the cold surge and the tropical disturbance， are the key contributors to the extreme precipitation events.
3. The Madden-Julian oscillation event plays an important role in the maintenance and intensification of the rainfall.
4. The autumn precipitation on Hainan Island also shows significant interannual variability. It is revealed that abnormal SST leads to abnormal precipitation on Hainan Island by modifying the Walker circulation.

TAHANK YOU