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Influence of the Madden–Julian oscillation on Tibetan Plateau snow cover at the intraseasonal time-scale

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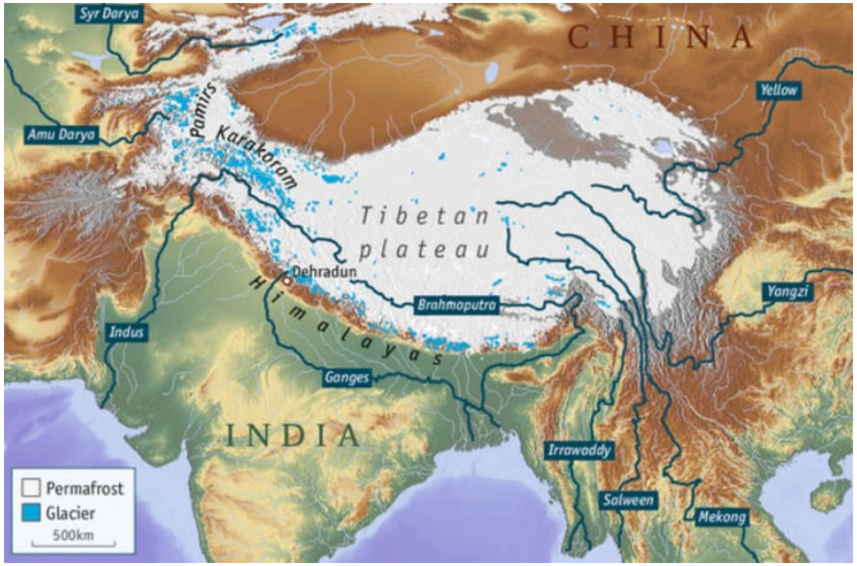
Outline

- **Background**
- Data and method
- Signatures of the eastward propagating MJO convection
- Relationships between the MJO and Tibetan Plateau snow cover
- Mechanism
- Summary

Background

- The Tibetan Plateau (**TP**) is the highest plateau, and is known as **the third pole**.
- Due to its high elevation, the TP is cold and has much snow cover.
- TP snow cover affects both weather and climate.
- However, the factors that generate intraseasonal TPSC are unclear.
- Here we found that the **MJO** influences **TP snow cover** at the **intraseasonal time-scale**.



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Data and method

Data

- The daily RMM index proposed by Wheeler and Hendon was used as a measure of the MJO.
- The daily snow cover data at 24-km resolution were obtained from the Interactive Multi-sensor Snow and Ice Mapping System (IMS) snow cover analysis.
- TRMM daily precipitation.
- ERA-Interim reanalysis.

Method

- A bandpass filter that isolates the 20–100-day components.
- Composite.

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Signatures of the eastward propagating MJO convection

About the MJO

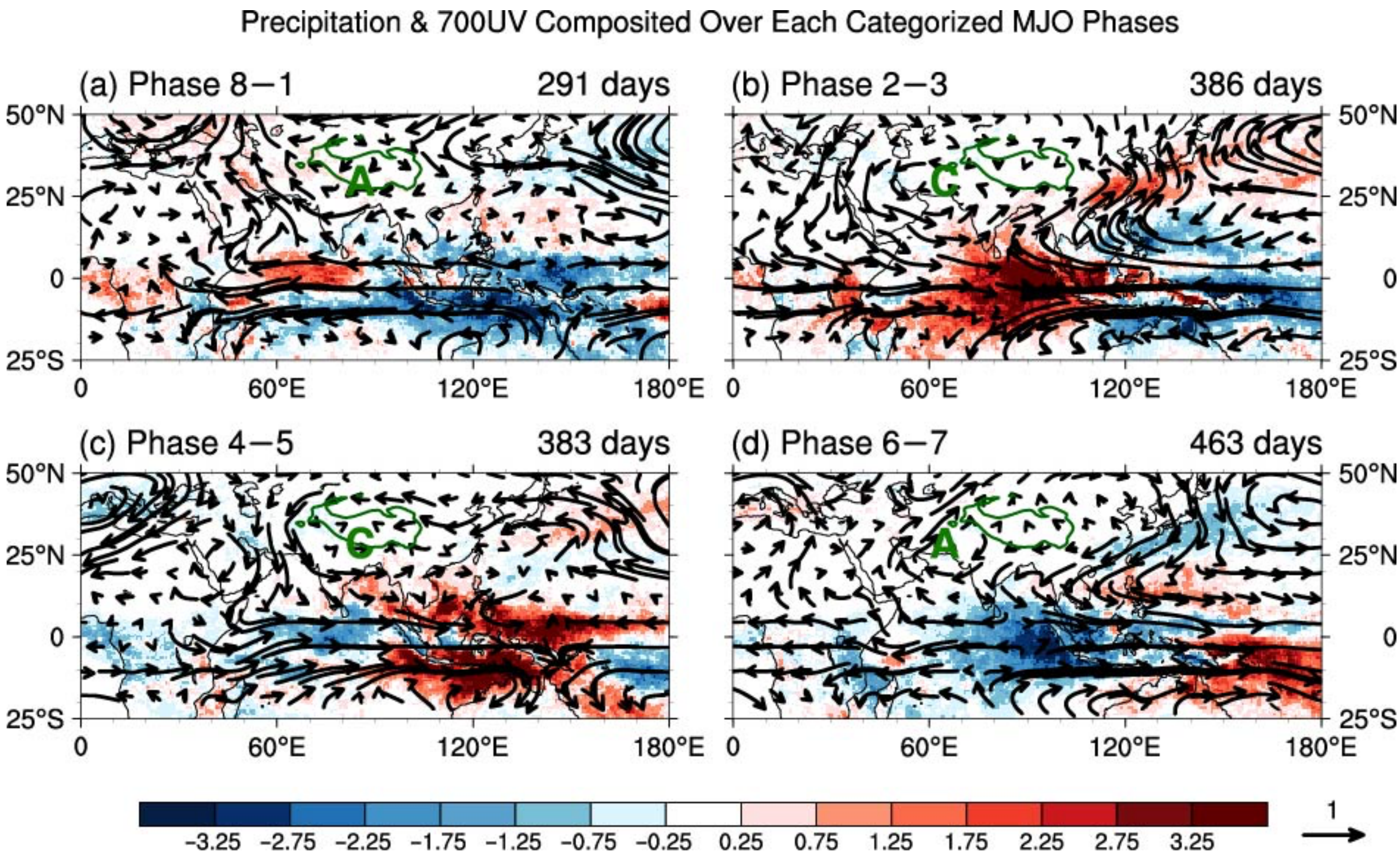
The Madden–Julian oscillation (MJO) is a important component of the tropical intraseasonal variability.

The MJO has planetary-scale signatures in atmospheric circulation systems coupled with deep convection and propagates eastwards slowly from the Indian Ocean to the Pacific Ocean.

During its eastward propagation, the circulation anomalies associated with the MJO interact with various weather and climate systems.

It is well known that tropical diabatic heating associated with the MJO excites subtropical planetary waves via barotropic vorticity perturbations which then propagate poleward.

Signatures of the eastward propagating MJO convection



Signatures of the eastward propagating MJO convection and corresponding responses of low-level large-scale atmospheric circulations.

Wintertime composites of the 20–100-day filtered daily anomalous precipitation (shading; unit: mm day^{-1}) and 700 hPa winds (vectors; unit: m s^{-1}) for the categorized phases. Red/blue colours correspond to enhanced/reduced convective activity and diabatic heating/cooling

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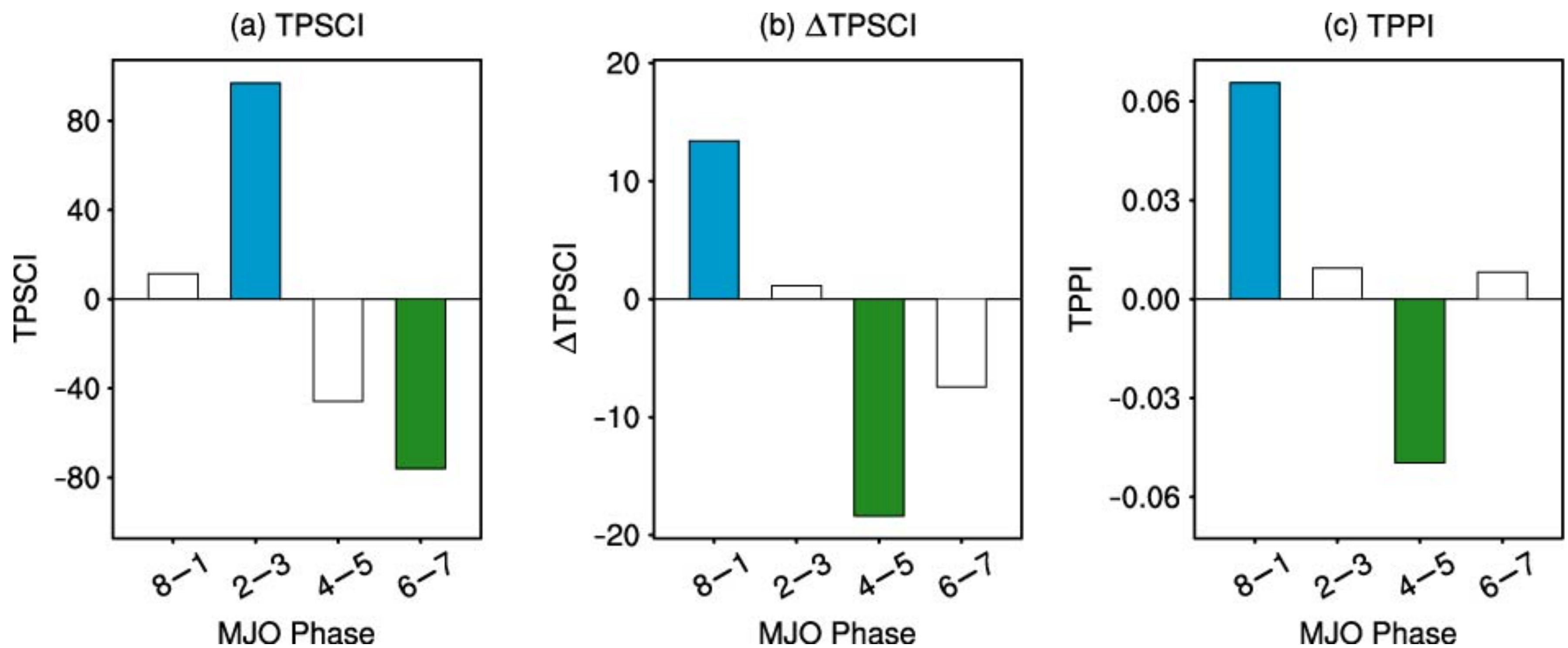
Relationships between the MJO and Tibetan Plateau snow cover



Relationships between the categorized phases of the eastward propagating MJO and the indices of snow cover, daily change of snow cover and precipitation over the Tibetan Plateau.

Wintertime composites of the 20–100-day filtered daily anomalous (**a**) Tibetan Plateau Snow Cover Index (TPSCI; unit: number of grid points); (**b**) daily change of the TPSCI (ΔTPSCI; unit: number of grid points); (**c**) Tibetan Plateau Precipitation Index (TPPI; unit: mm day^{-1}) for the categorized MJO phases. The coloured bars indicate the composites that are significant at the 99% confidence level based on the Monte Carlo test.

Relationships between the MJO and Tibetan Plateau snow cover

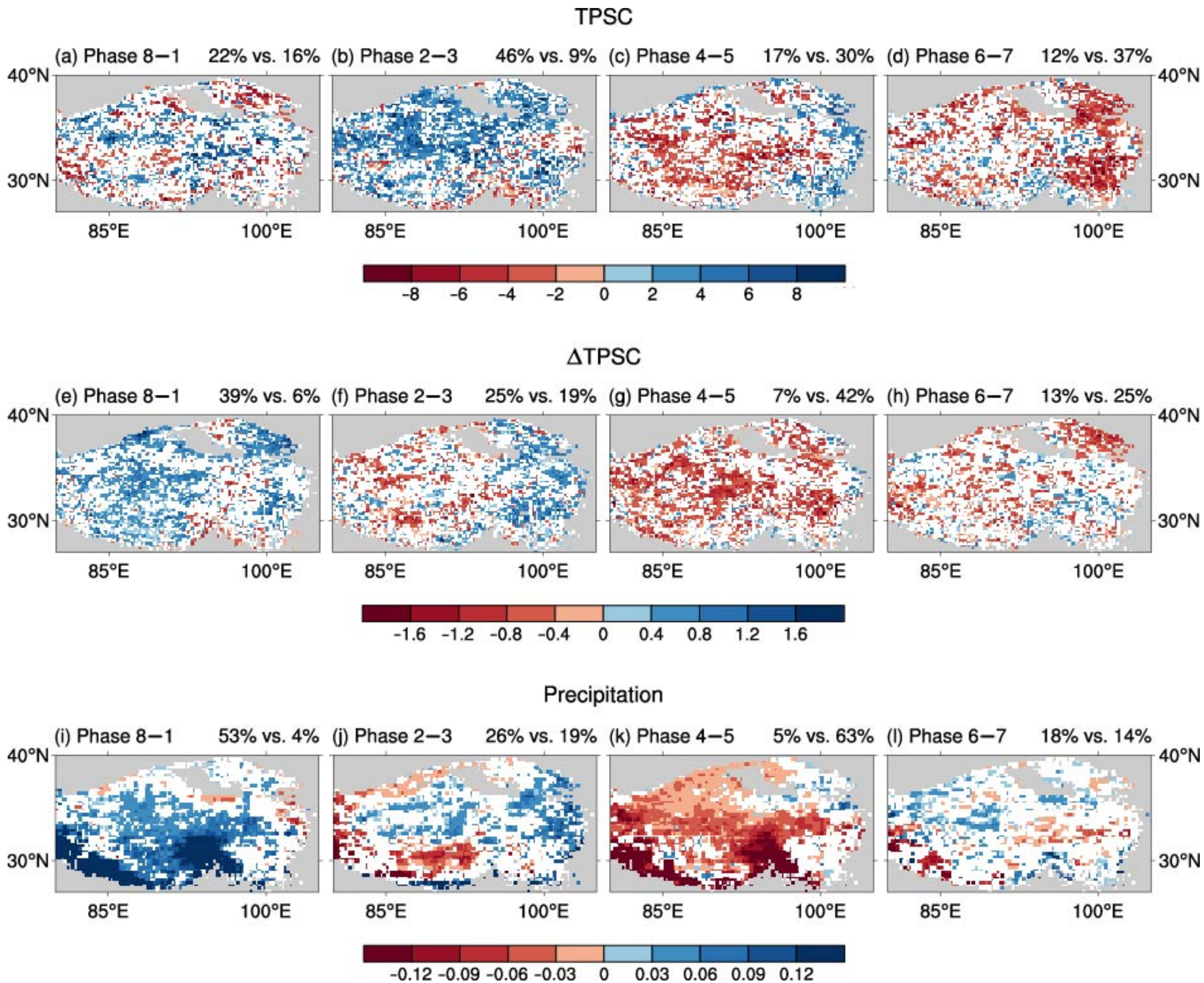


Figure : As the previous figure, the spatial distribution of the composites for each grid point.

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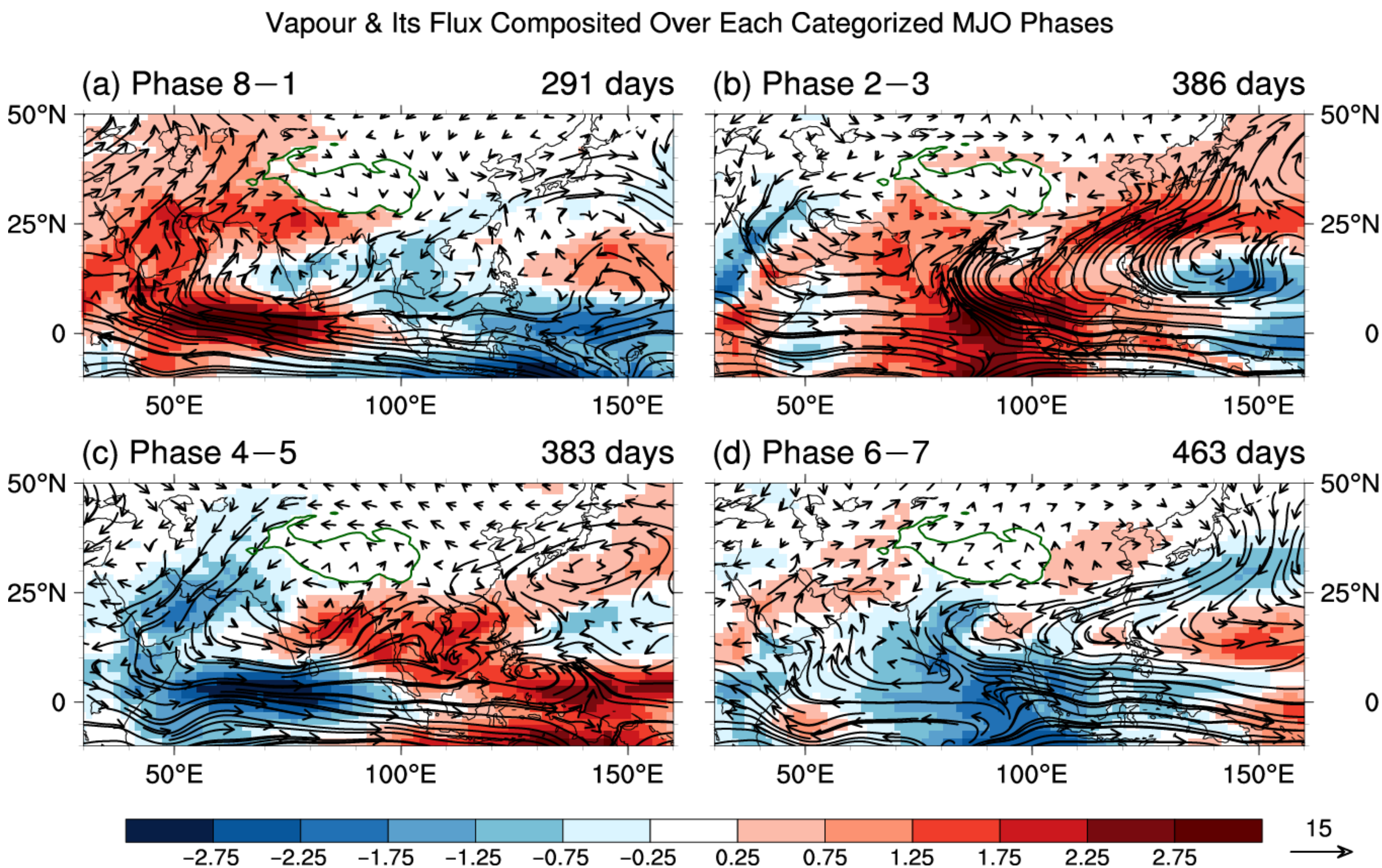
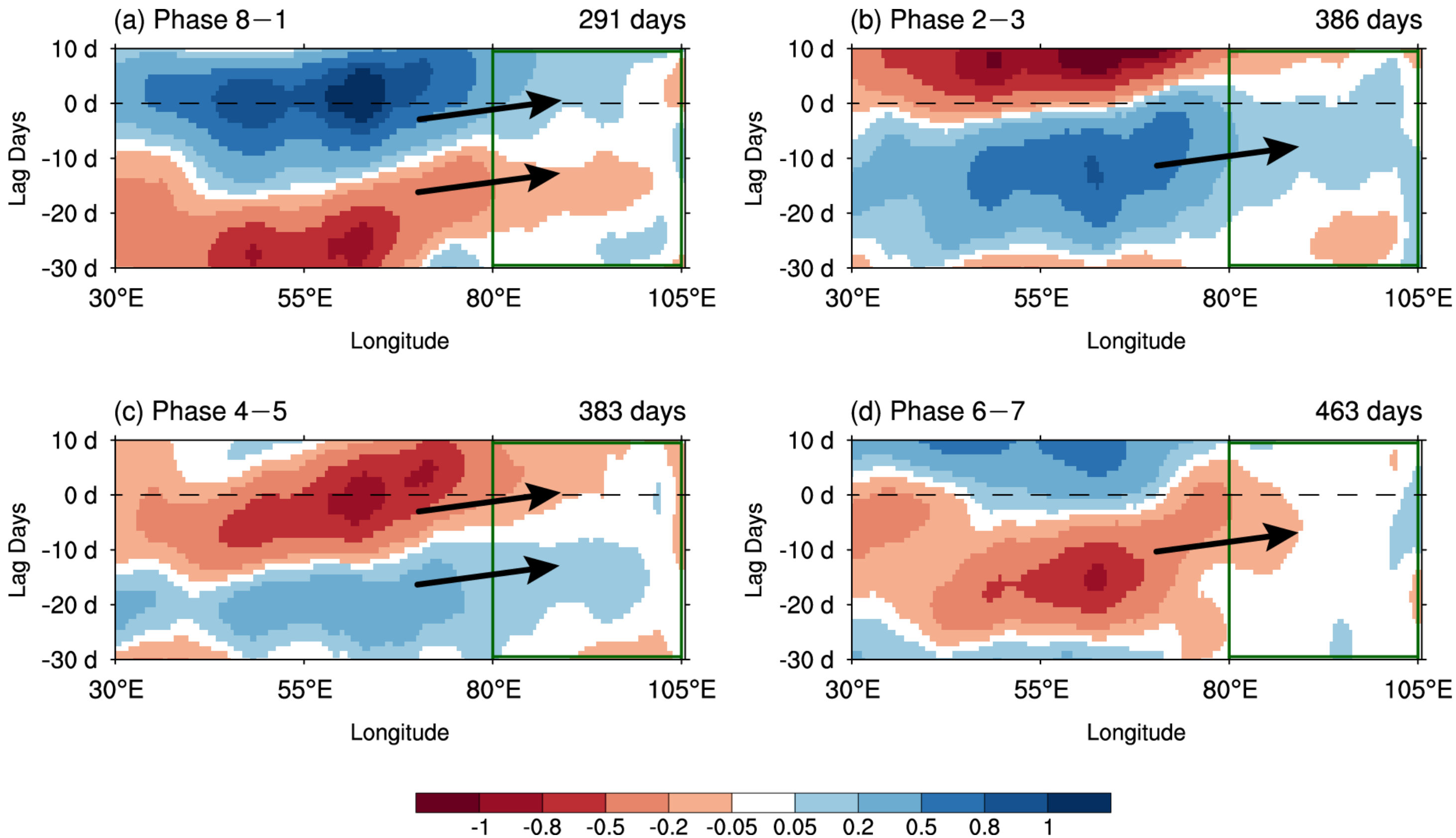
Mechanism



Relationships between the categorized phases of the eastward propagating MJO and the vertical integral of water vapour and its flux.

The 20–100-day filtered anomalous vertical integral of water vapour (shadings; unit: kg m^{-2}) and its flux (vectors; unit: kg m^{-1} s^{-1}) for categorized MJO phases is shown.

Mechanism



The zonal propagation of the anomalous vertical integral of water vapour from the area upstream of the Tibetan Plateau.

Hovmöller diagrams (time vs. longitude) of 20–100-day filtered daily anomalous vertical integral of water vapour (unit: kg m^{-2}) averaged over 27–40°N are shown. The x-axis represents longitude. The y-axis represents the lead-lag time between the anomalies and the categorised phases of the MJO.

Mechanism

The MJO suppressed/enhanced convection over the Maritime Continent

↓ Diabatic-cooling/heating

The classic Matsuno–Gill pattern

↓ Featuring an anticyclone/cyclone in the northwest of the convection

Southerly/northerly wind anomalies over the Arabian Sea

↓ Water vapour flux

Increased/decreased moisture over the area upstream of the Tibetan Plateau

↓ Moisture horizontal advection

Positive/negative anomalous water vapor over the Tibetan Plateau

↓ Increased/decreased precipitation

Increased/decreased Tibetan Plateau snow cover at the intraseasonal time-scale

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Conclusions:

- There is anomalous moisture advection over the upstream of the TP caused by MJO-excited large-scale atmospheric circulation.
- The advection process generates the low-frequency eastward-propagating anomalous water vapour from upstream to the TP that influences precipitation and, eventually, TP snow cover.

Highlight:

- Hopefully, this work brings attention to the fast subseasonal variability of snow cover (over TP or other regions).