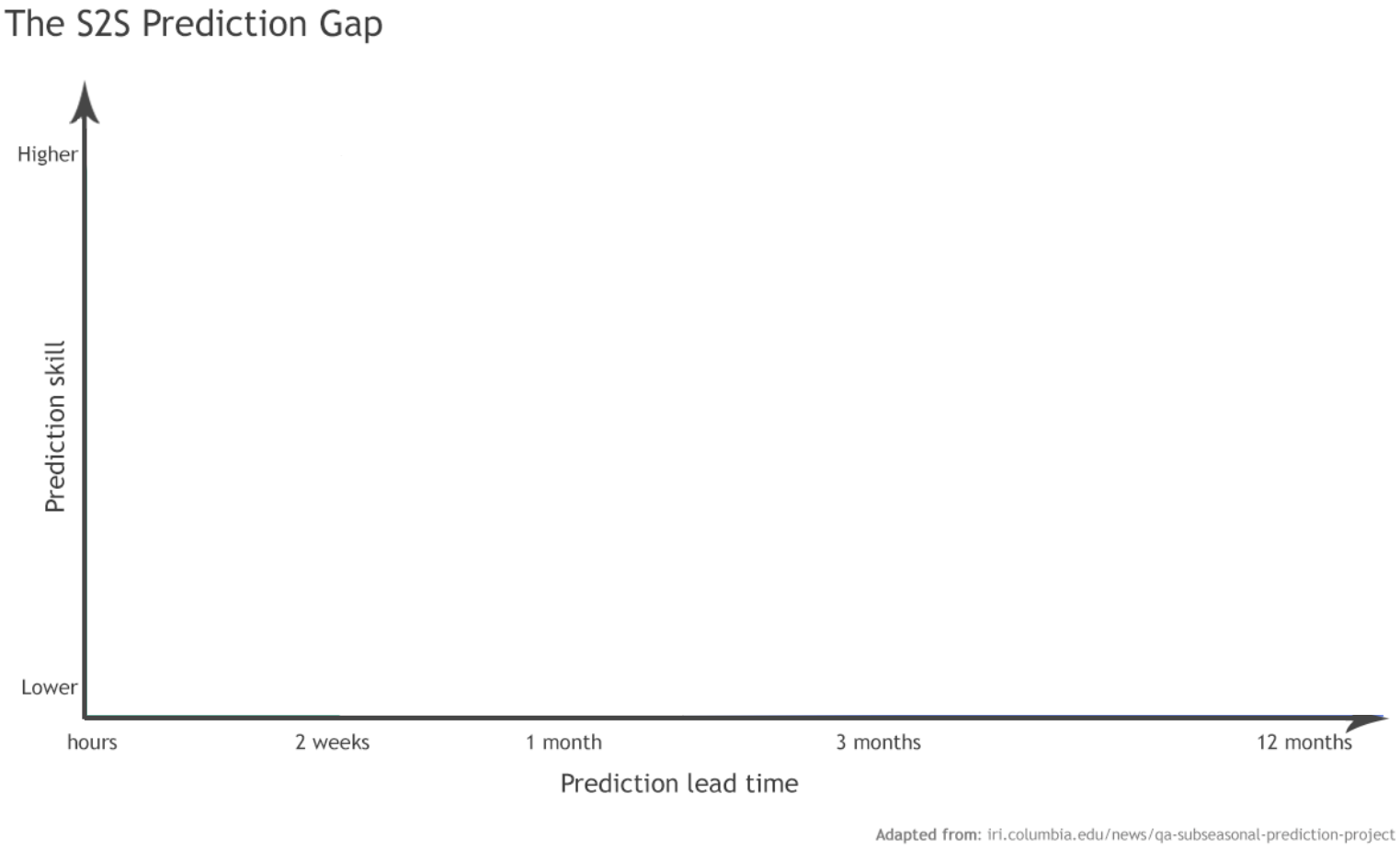
Forecasting North Pacific Height Anomalies with the MJO on S2S timescales

Kai-Chih Tseng, Elizabeth Barnes and Eric Maloney

Colorado State University

Motivation I

The traditional limits of model prediction skills



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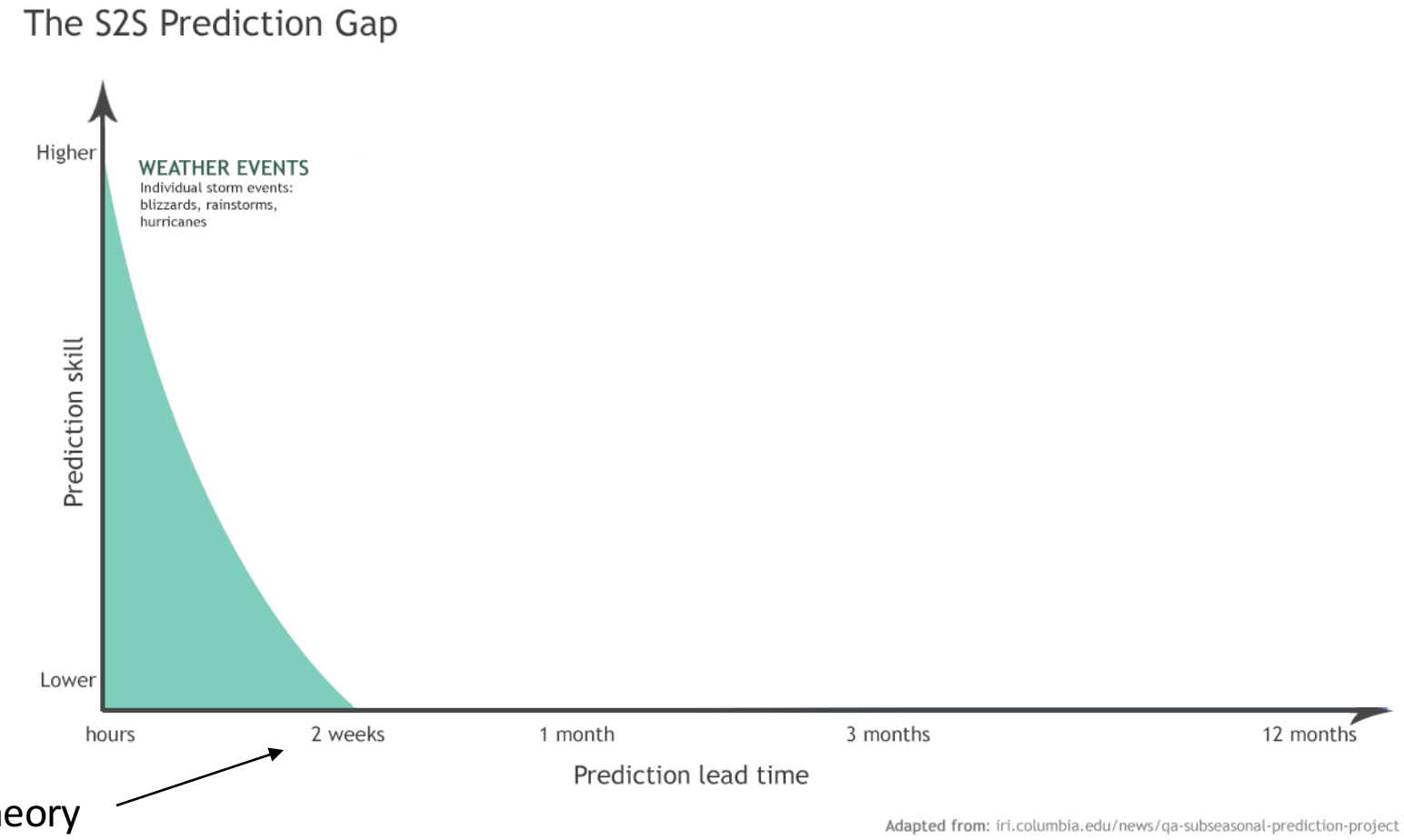

Synoptic wave theory

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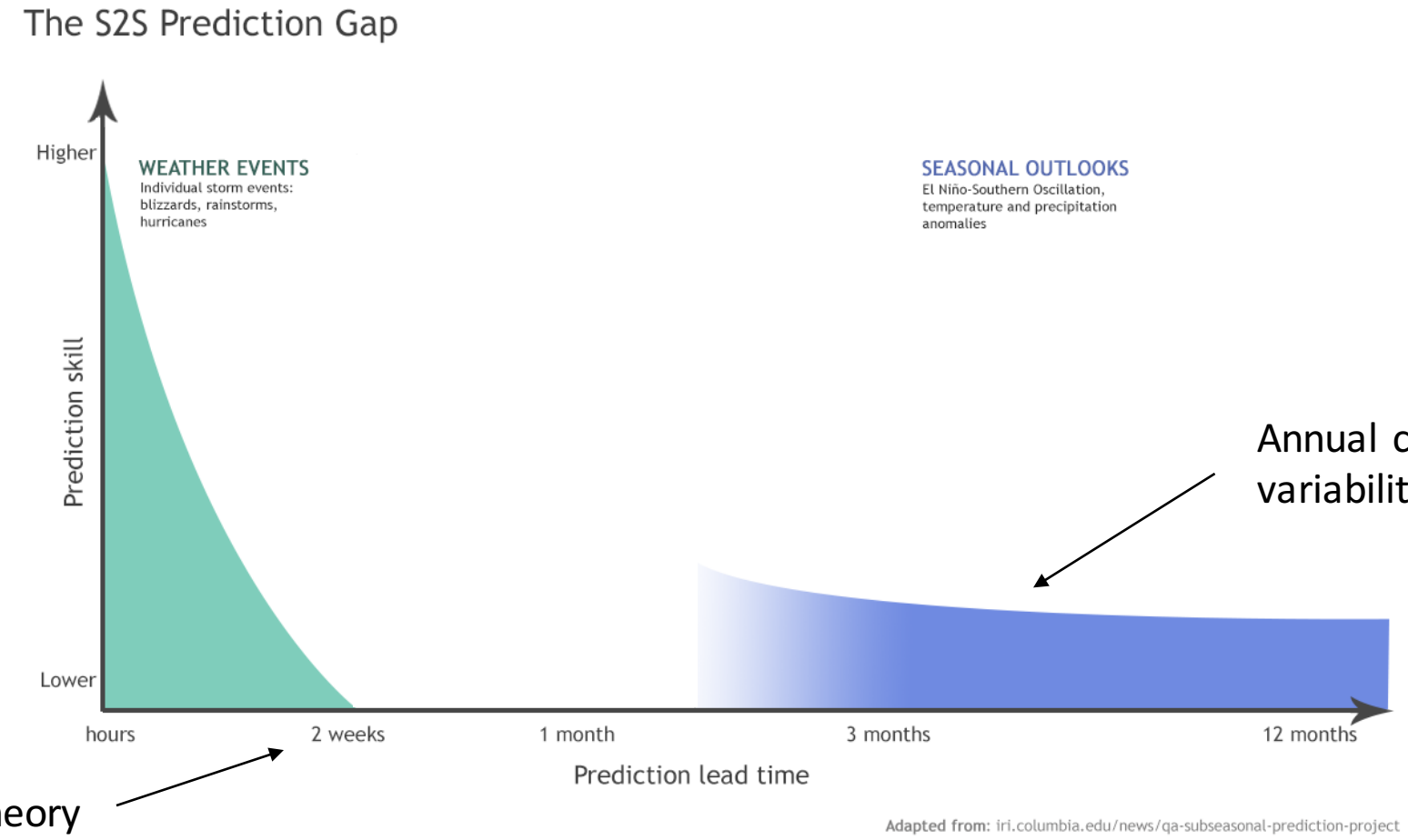

Annual cycle and interannual variability

Synoptic wave theory

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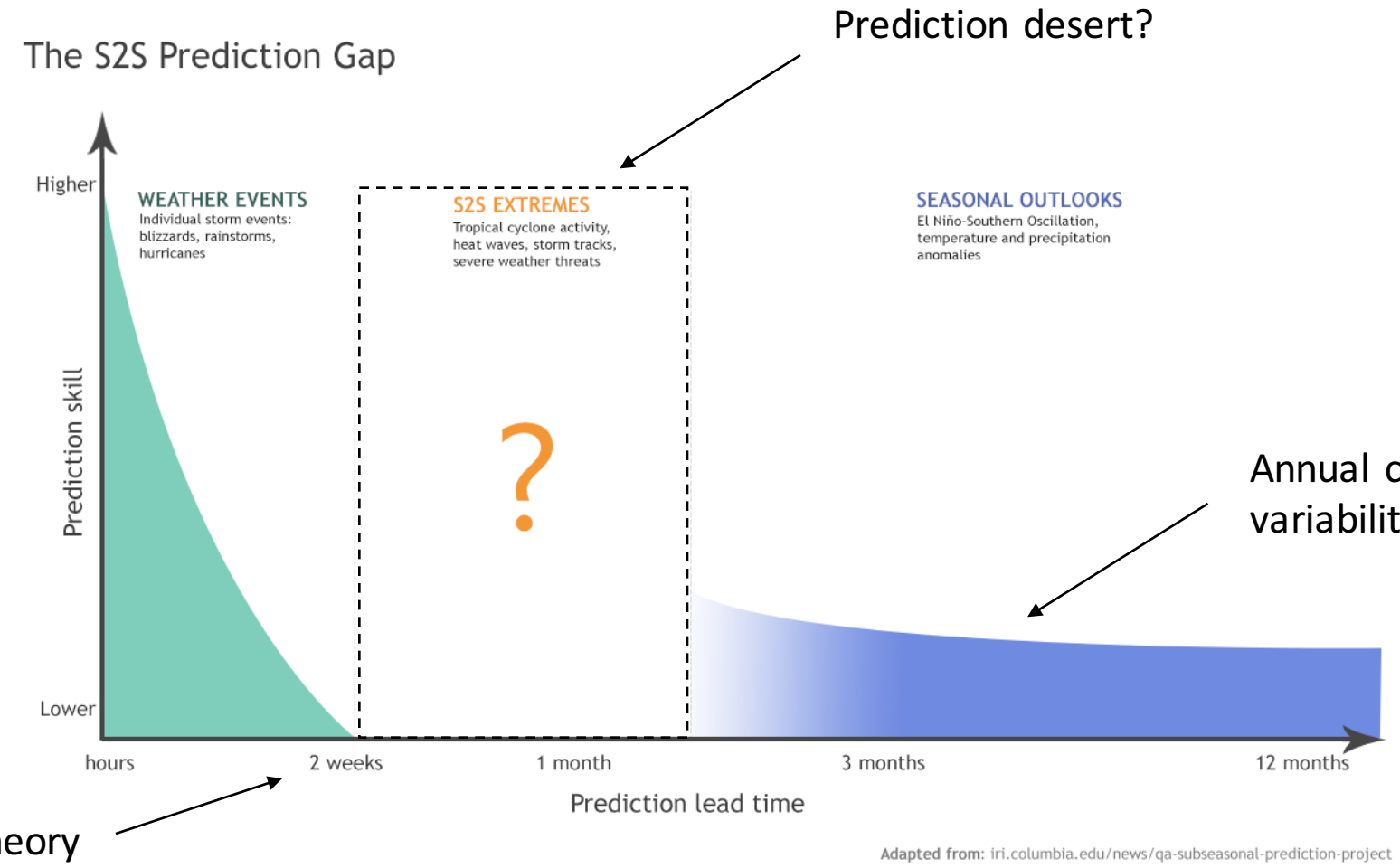
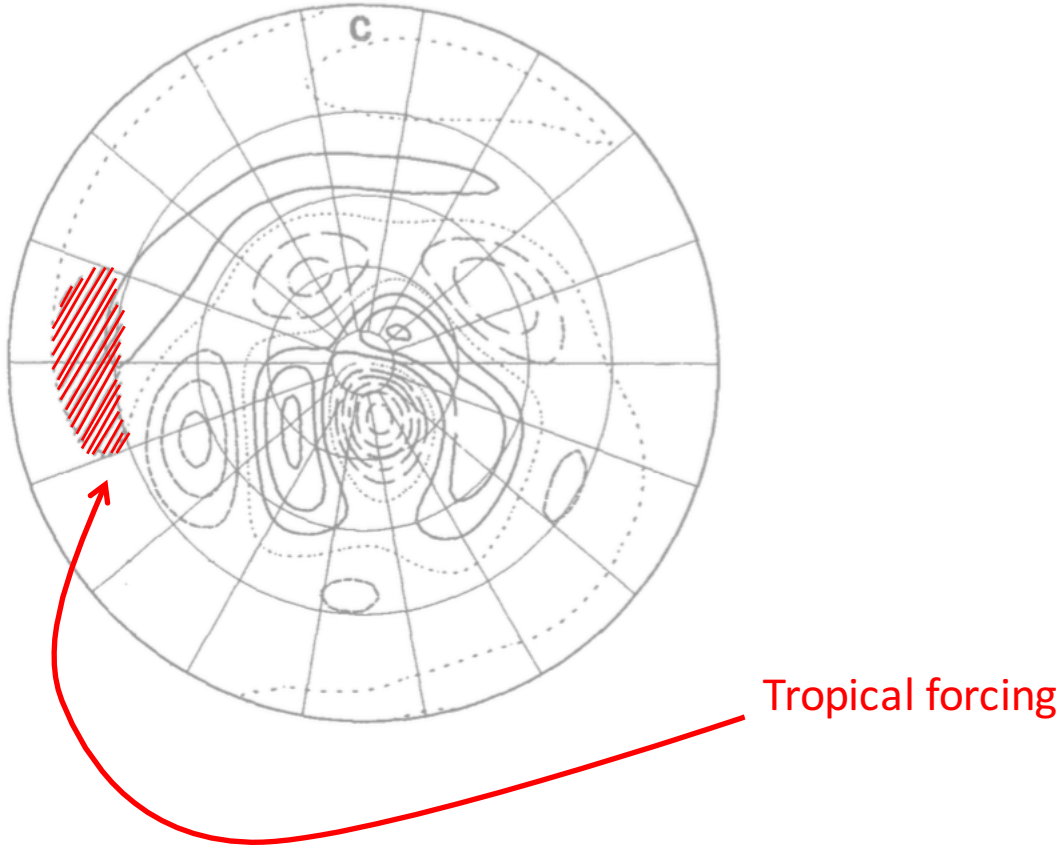


Motivation II

Since 1980s
We already know the relationship between tropical forcing and extra-tropical teleconnected response.



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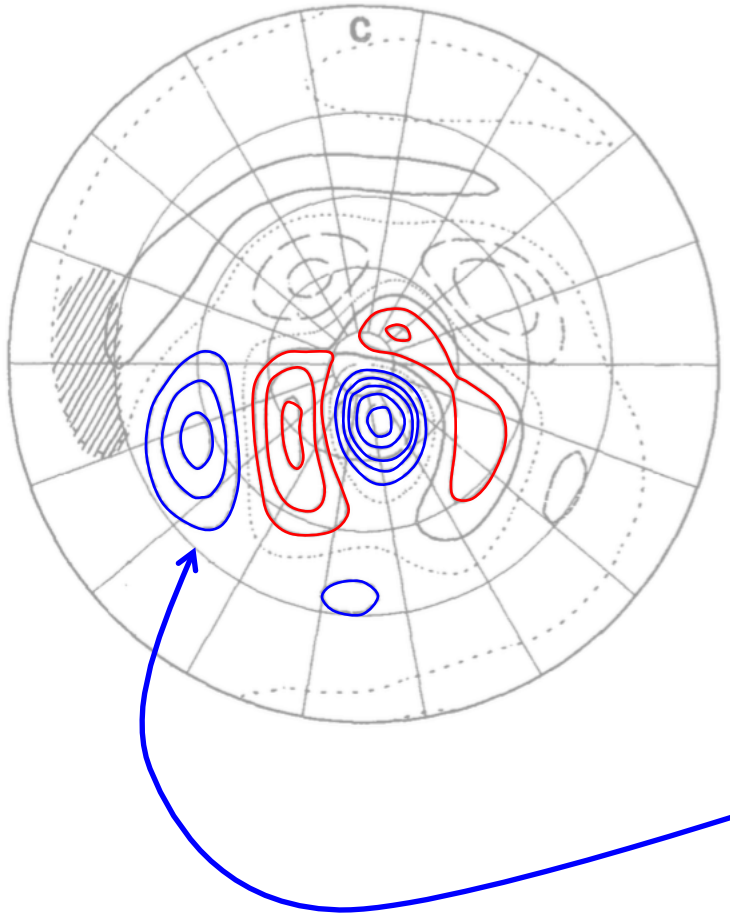

- Direct linear circulation response to diabatic heating or topography through poleward-propagating Rossby Waves.
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- Growth arising from the dynamical feedback of synoptic eddies.

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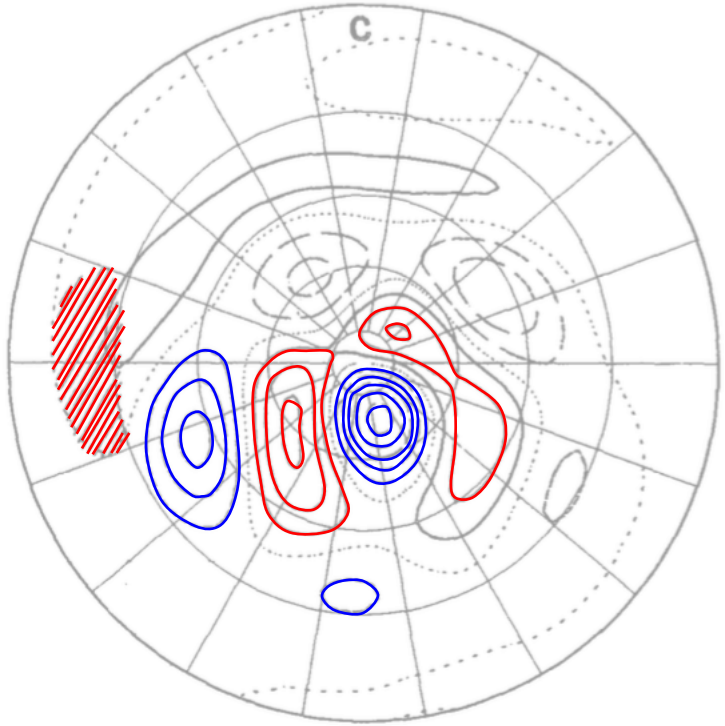

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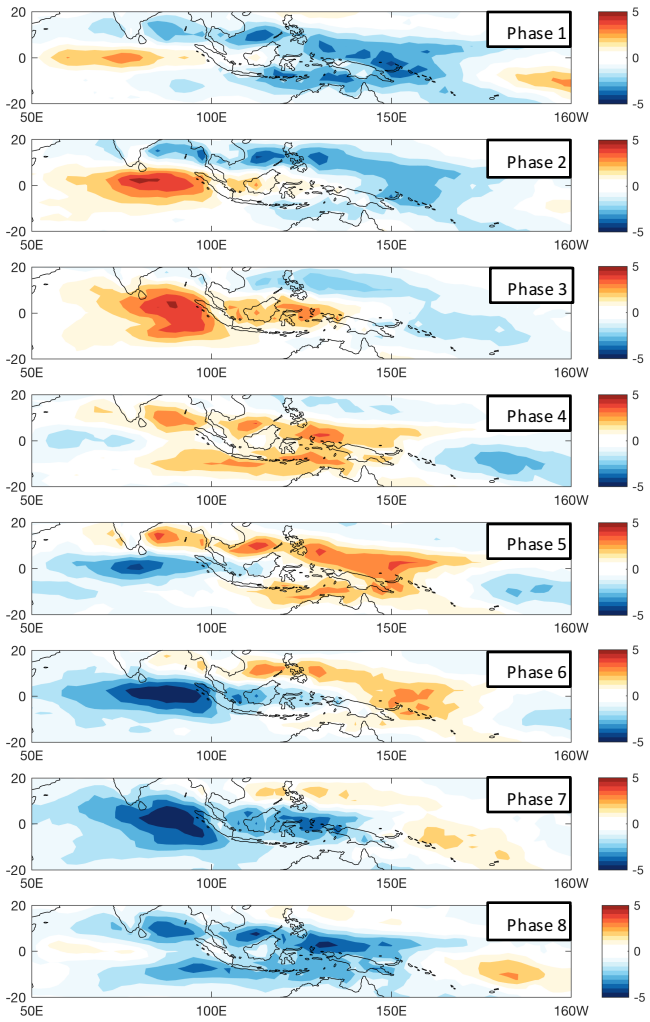
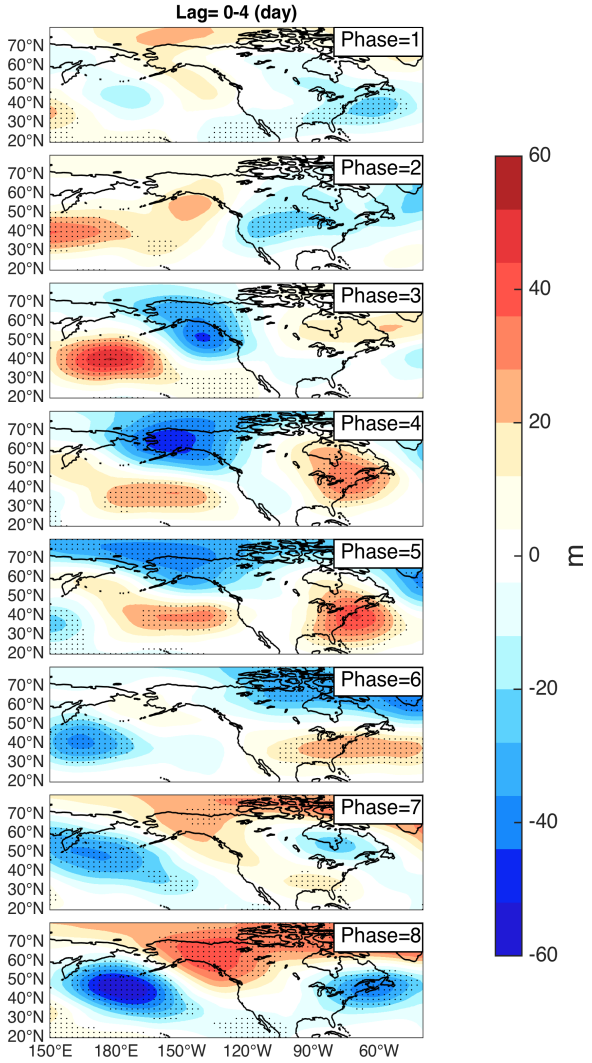
Heating and Teleconnected Response

Apparent heat source (Q_1, mm/day)



Geopotential Height Anomalies (m)



Cause and effect

Since Rossby waves take time to propagate into extra-tropical regions, the current geopotential height variations might result from previous phases of MJO.

Q1 is derived from ERA-Interim
Anomalous Z500 is derived from MERRA

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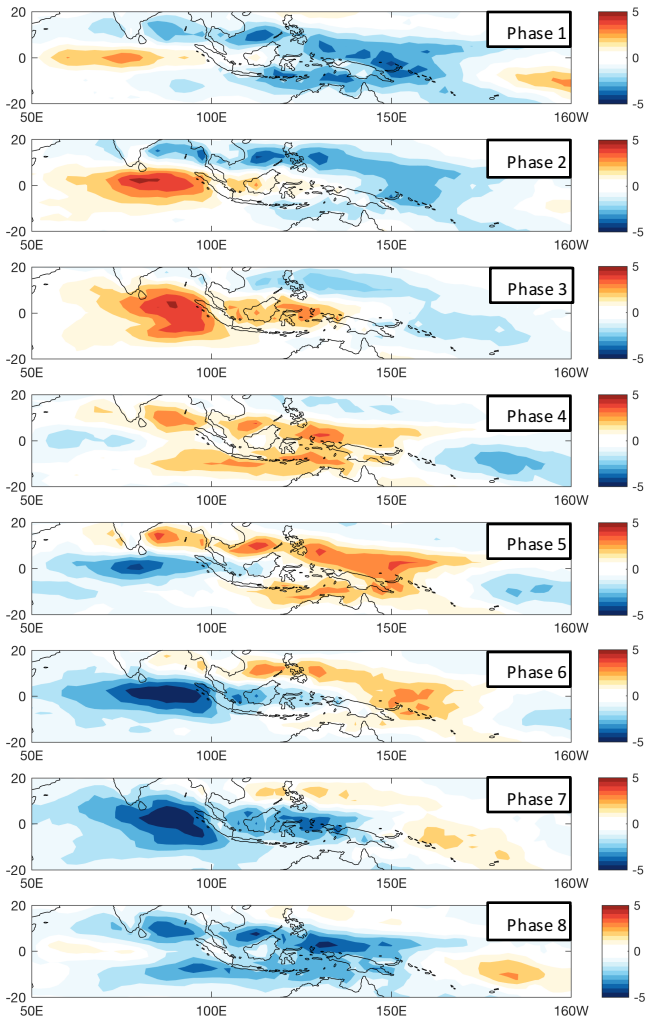

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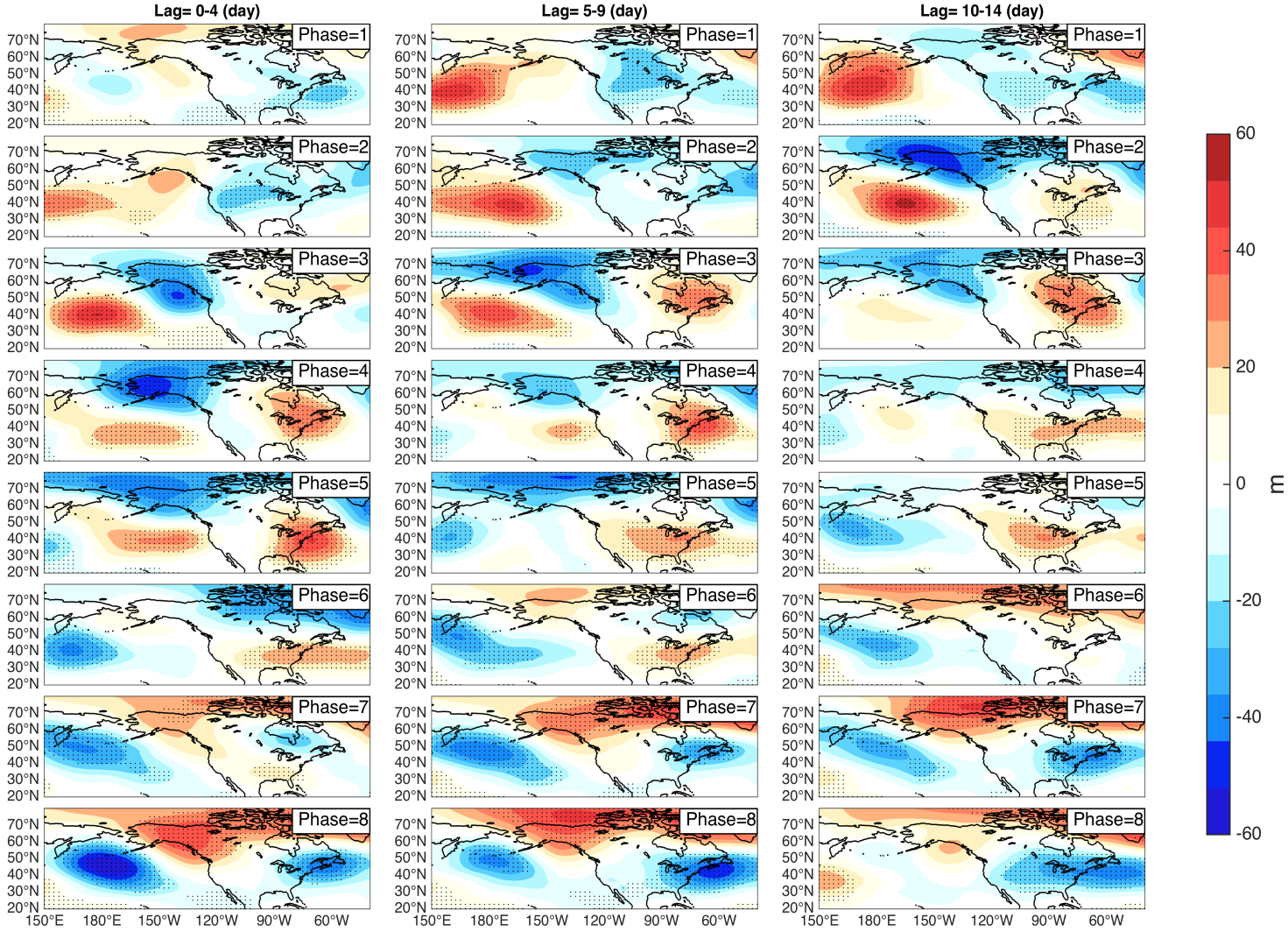

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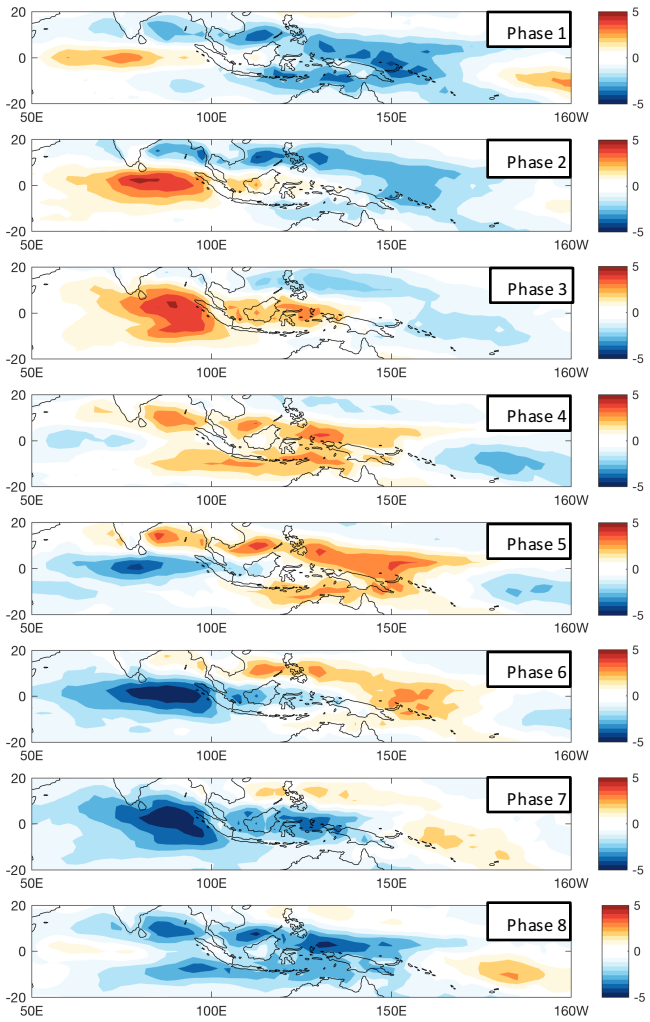

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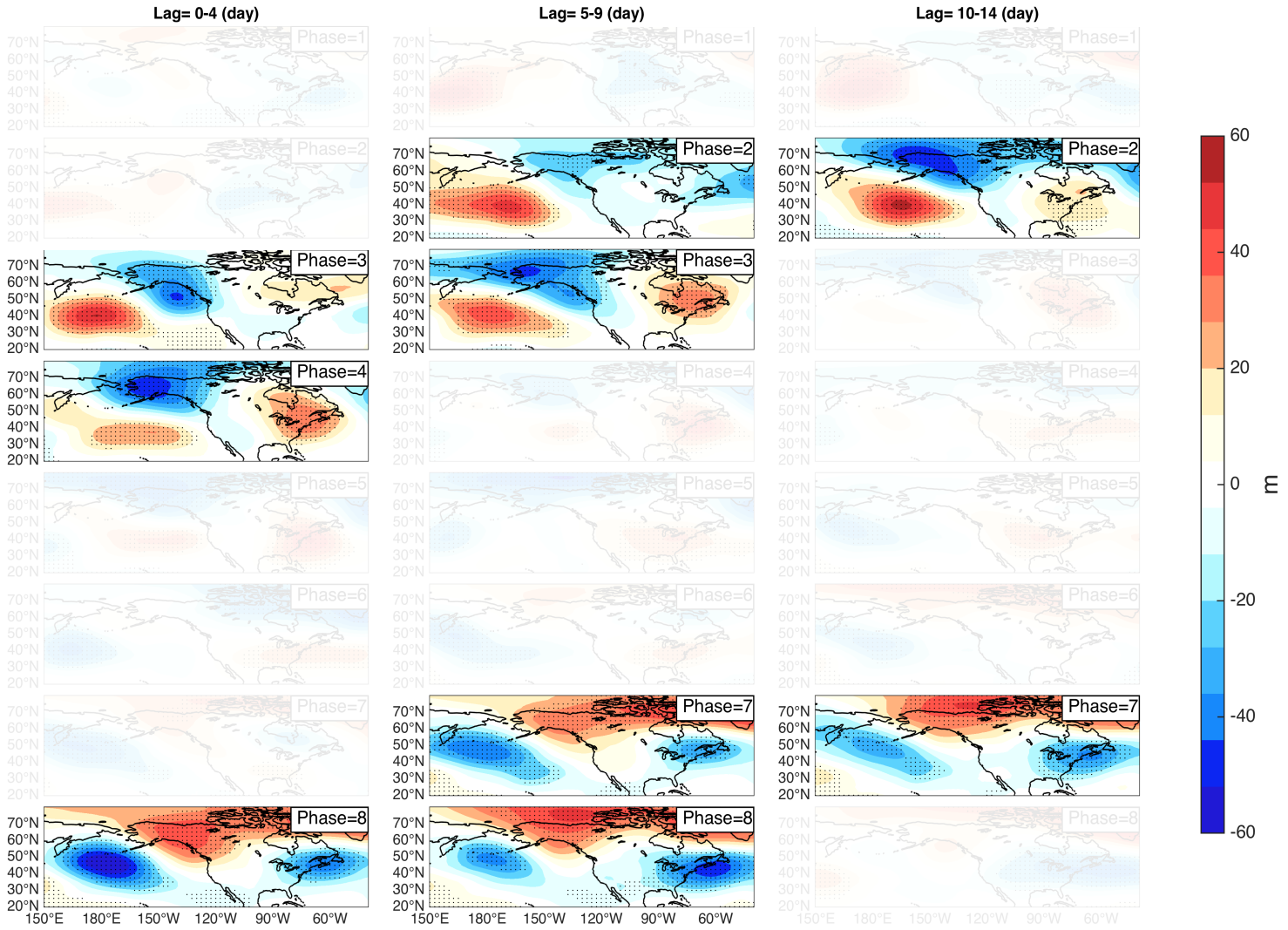

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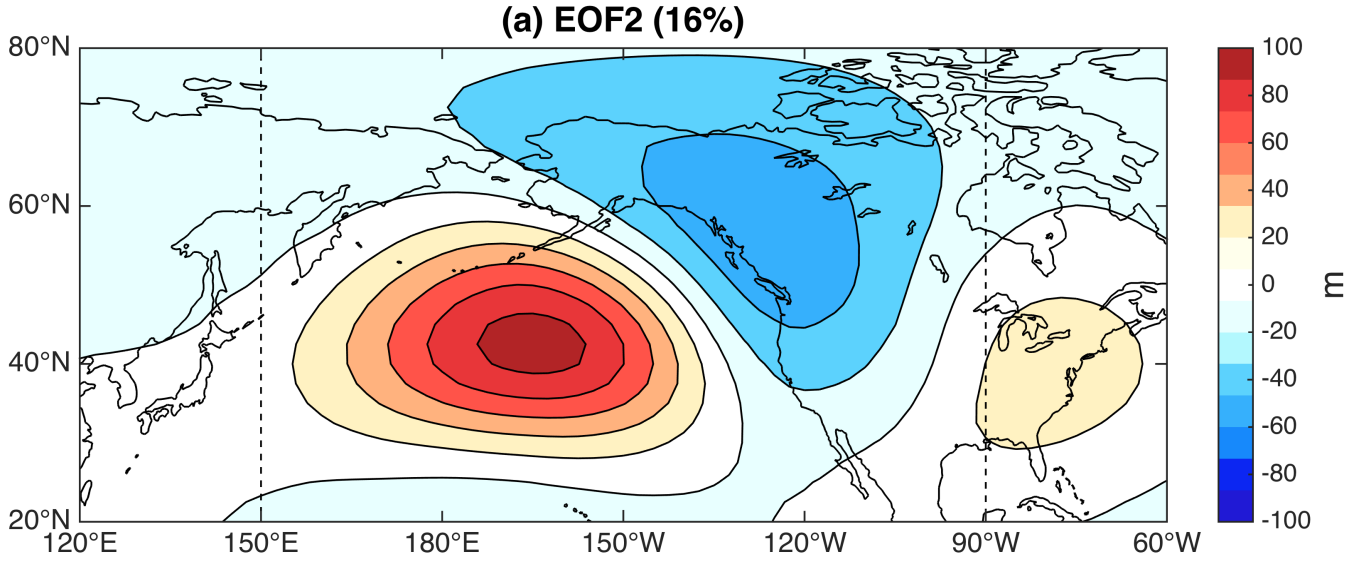
Quantifying the evolution and amplitude of teleconnection



By removing the first three harmonics of the annual cycle…
The second leading mode of the North Pacific height anomalies is related to MJO variations.

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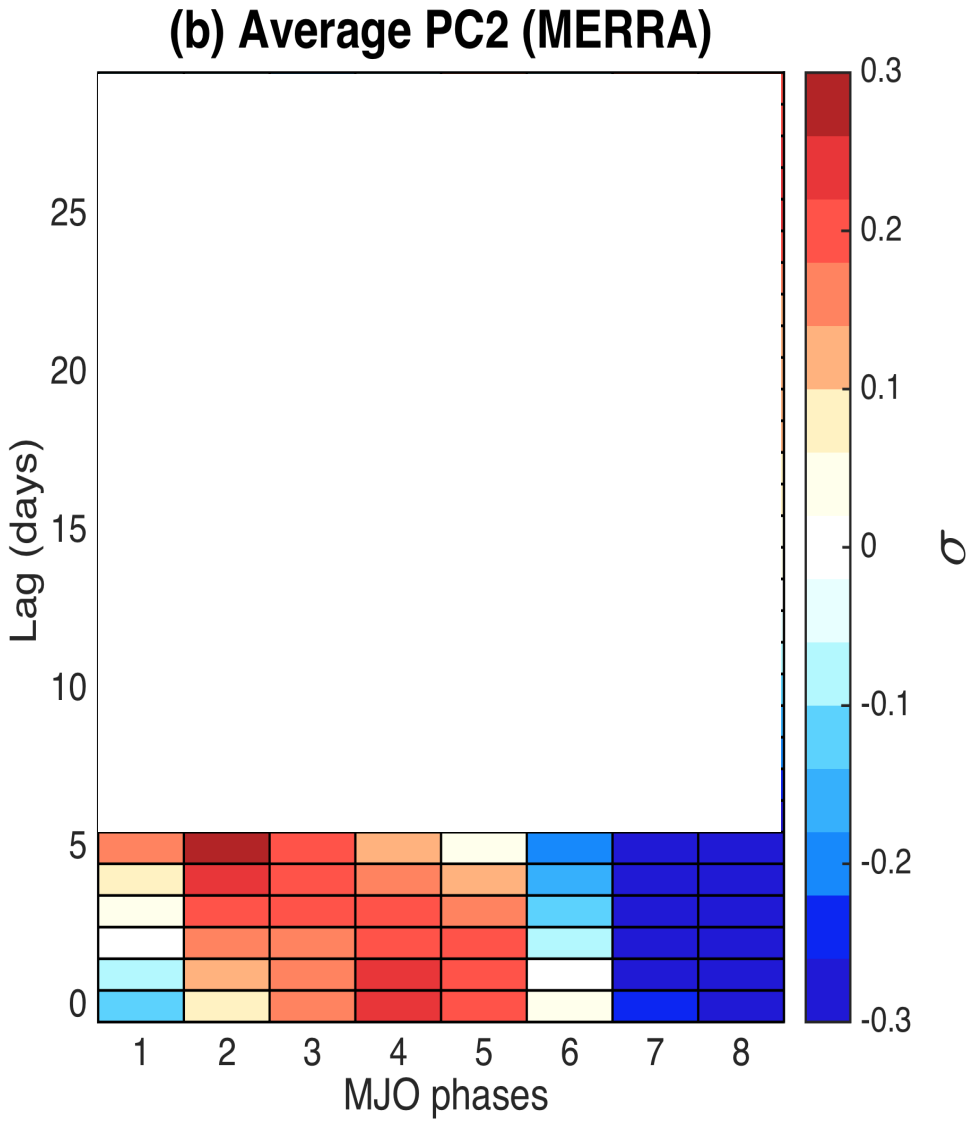

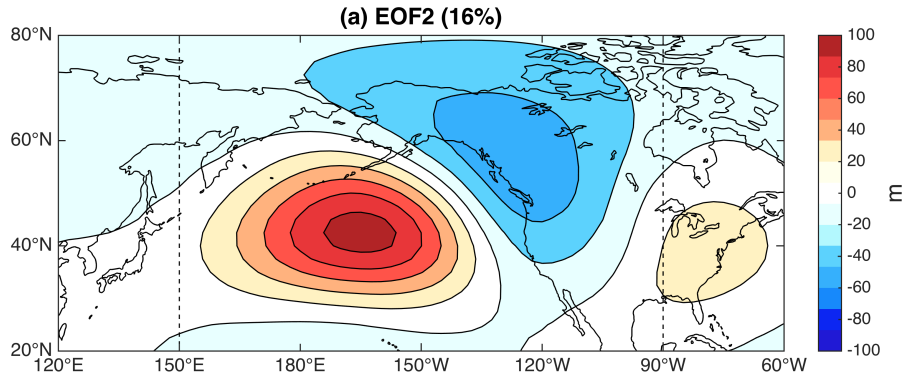

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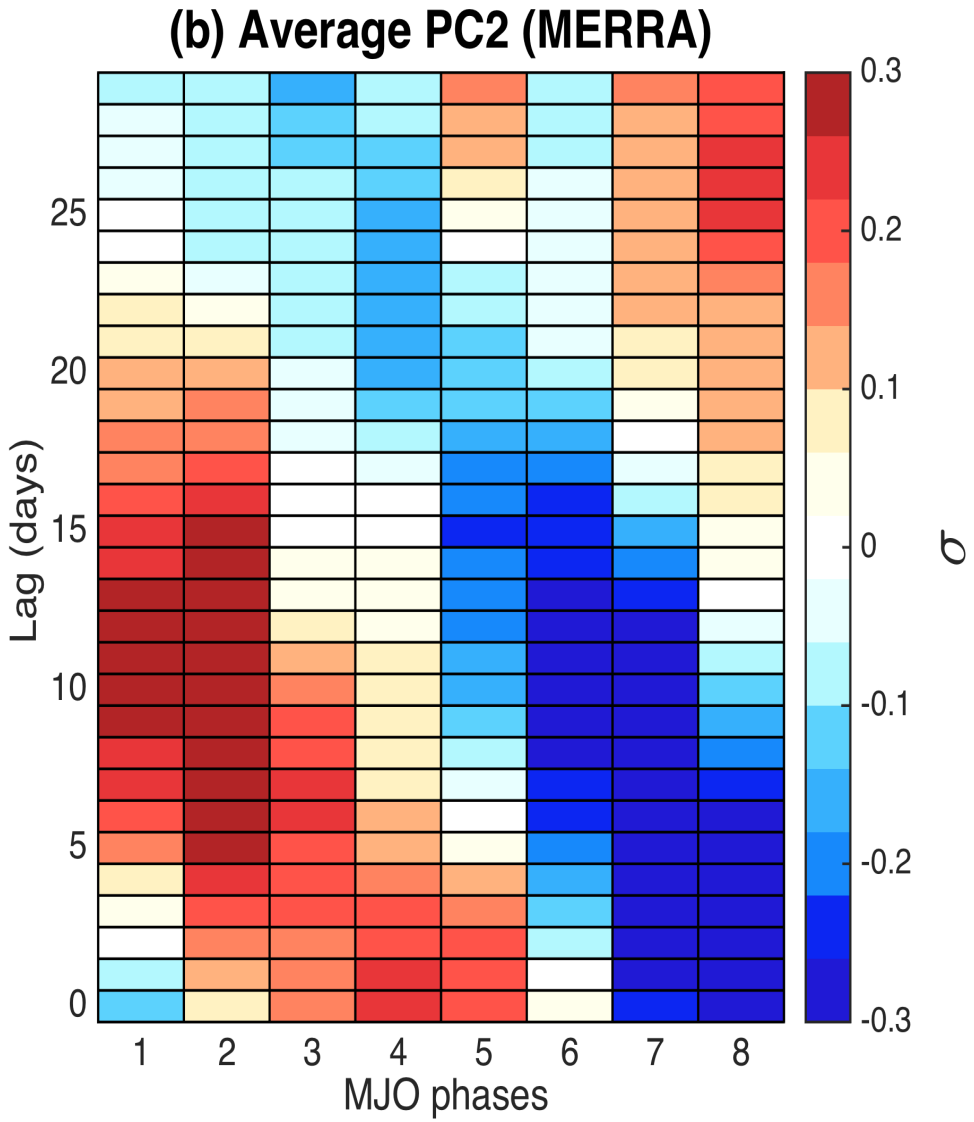

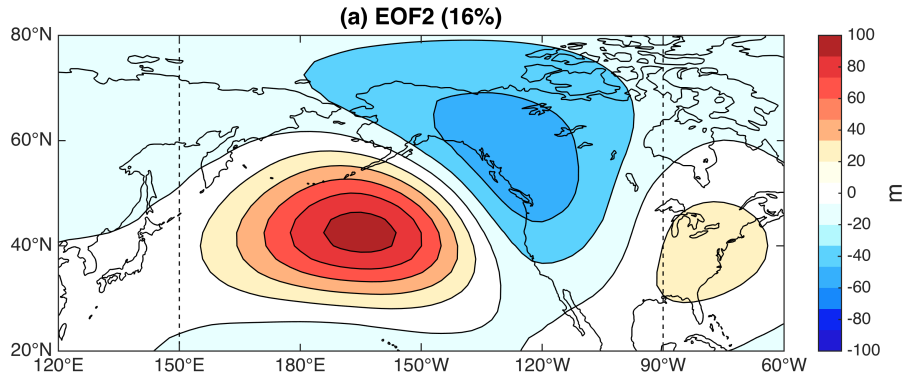

The averaged PC2 over different MJO phases and time lags shows two stair-like patterns.

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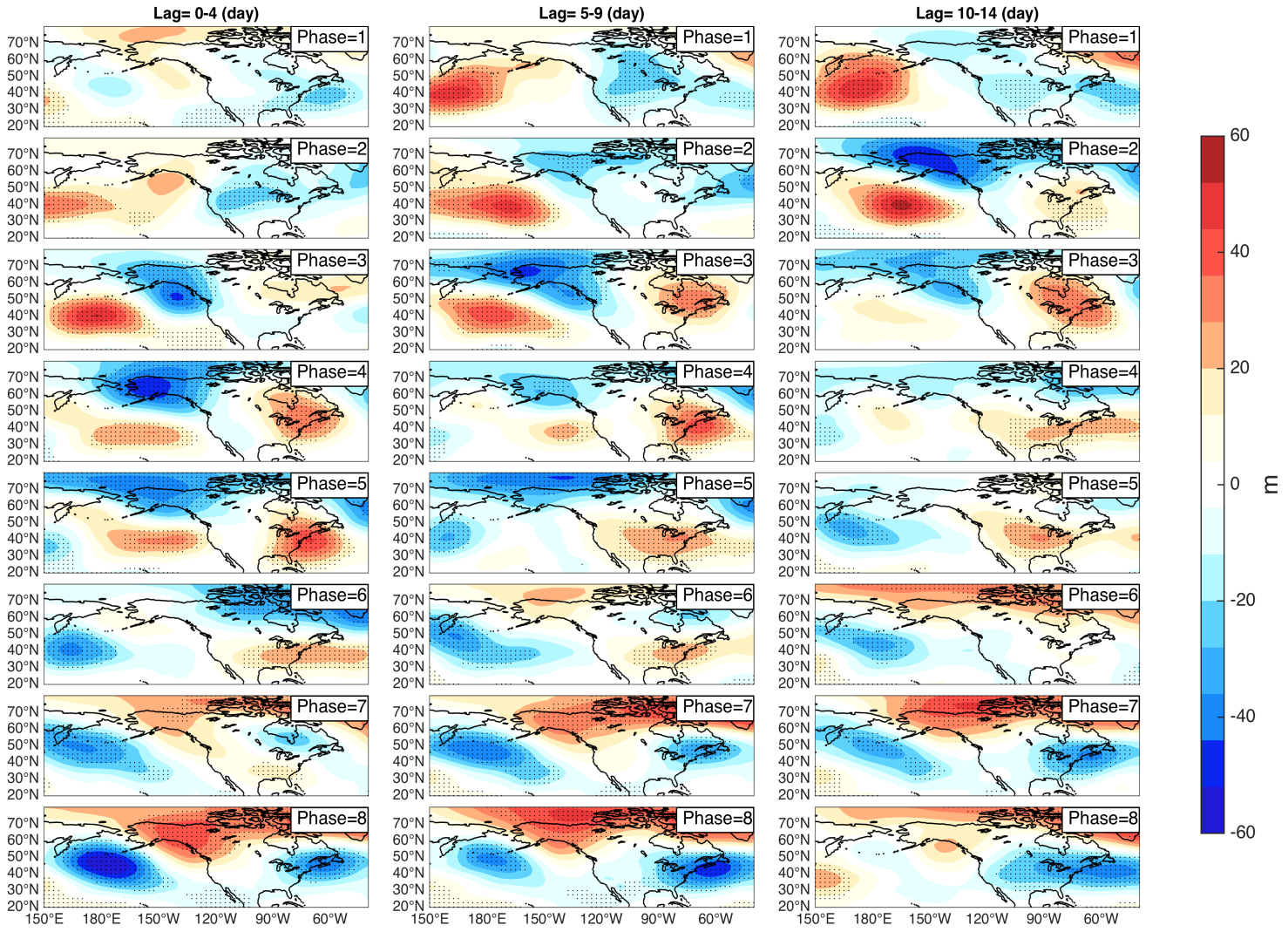
The modulation on anomalous Z500 by teleconnections



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The modulation on anomalous Z500 by teleconnections

Event 1

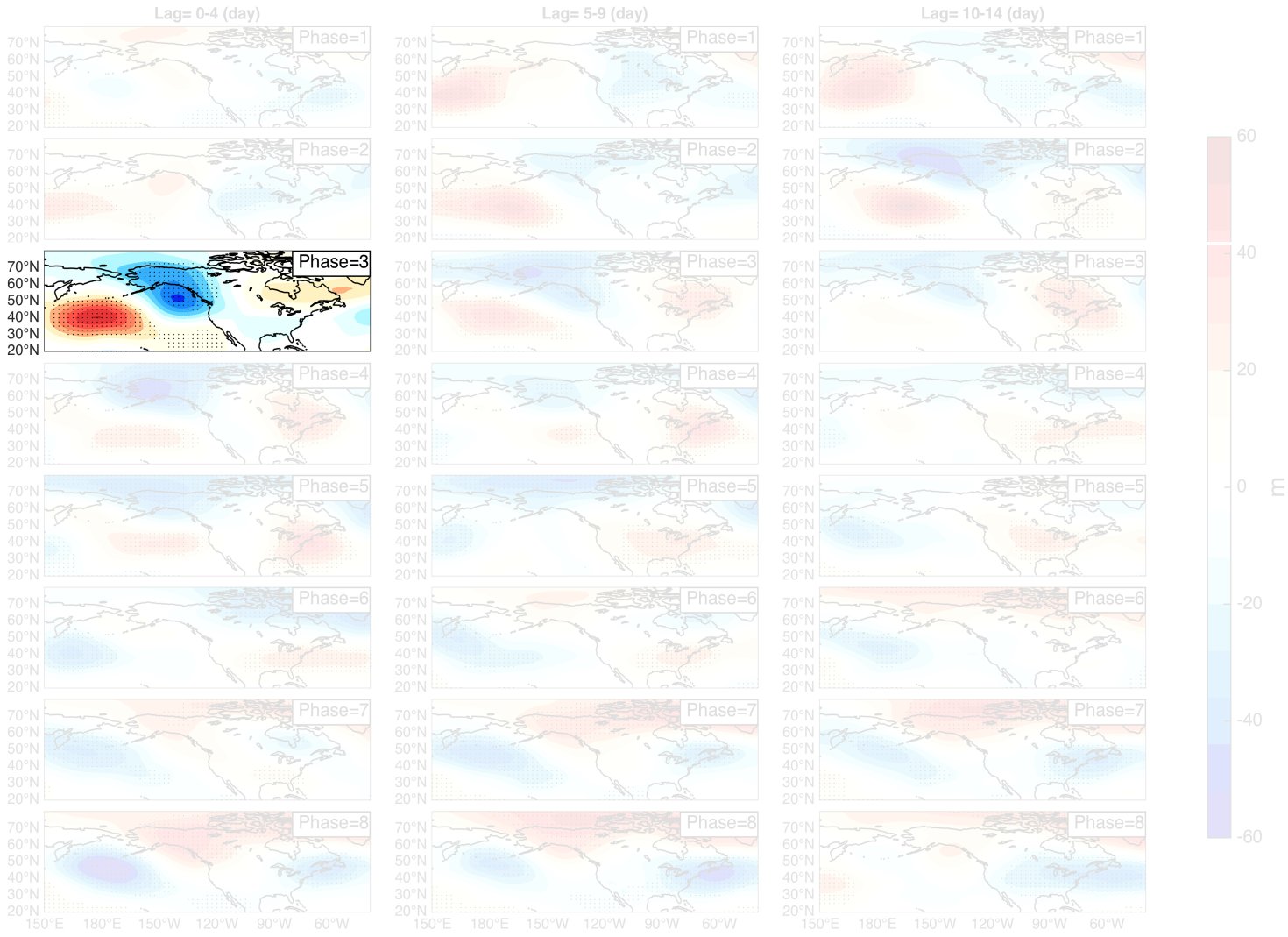
Event 2

Event 3

Event 4

⋮

Event N



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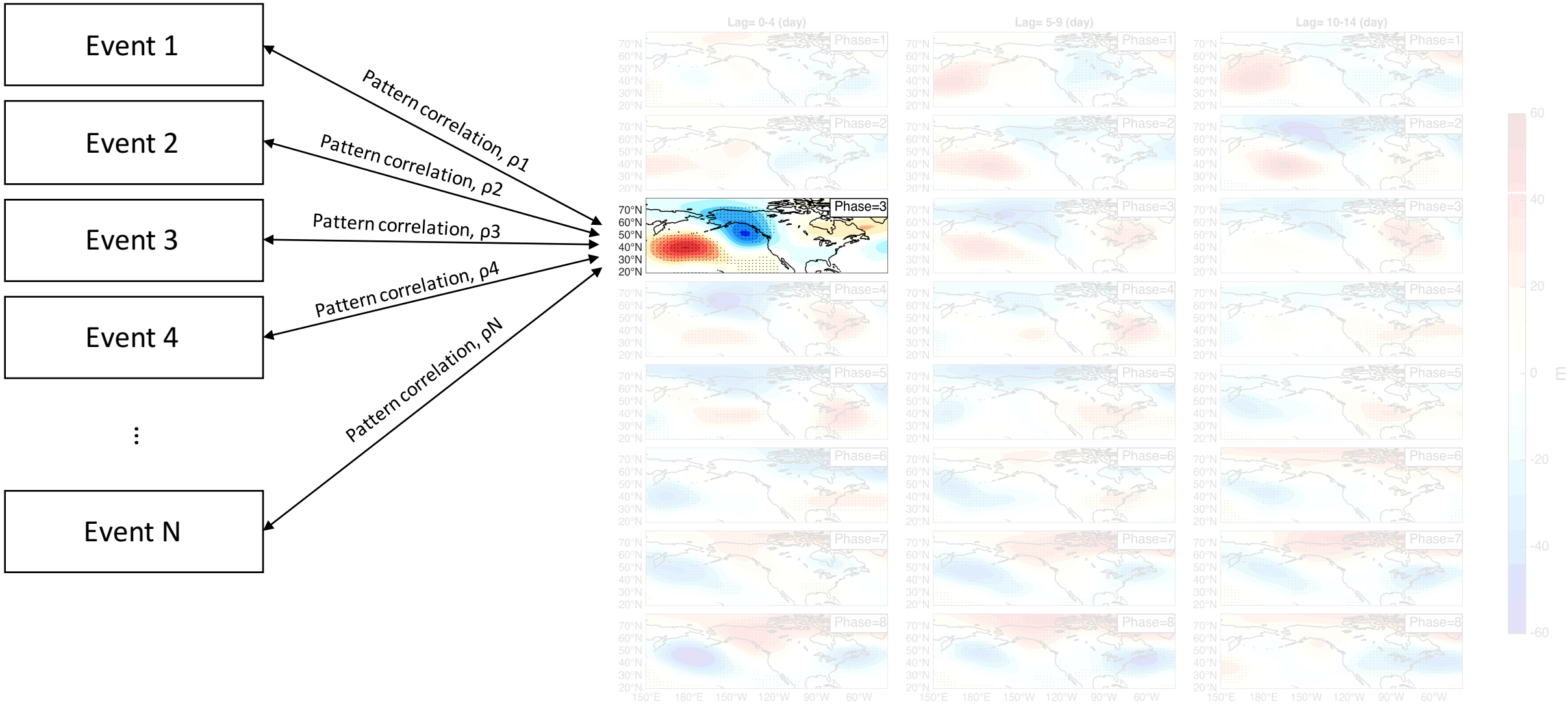

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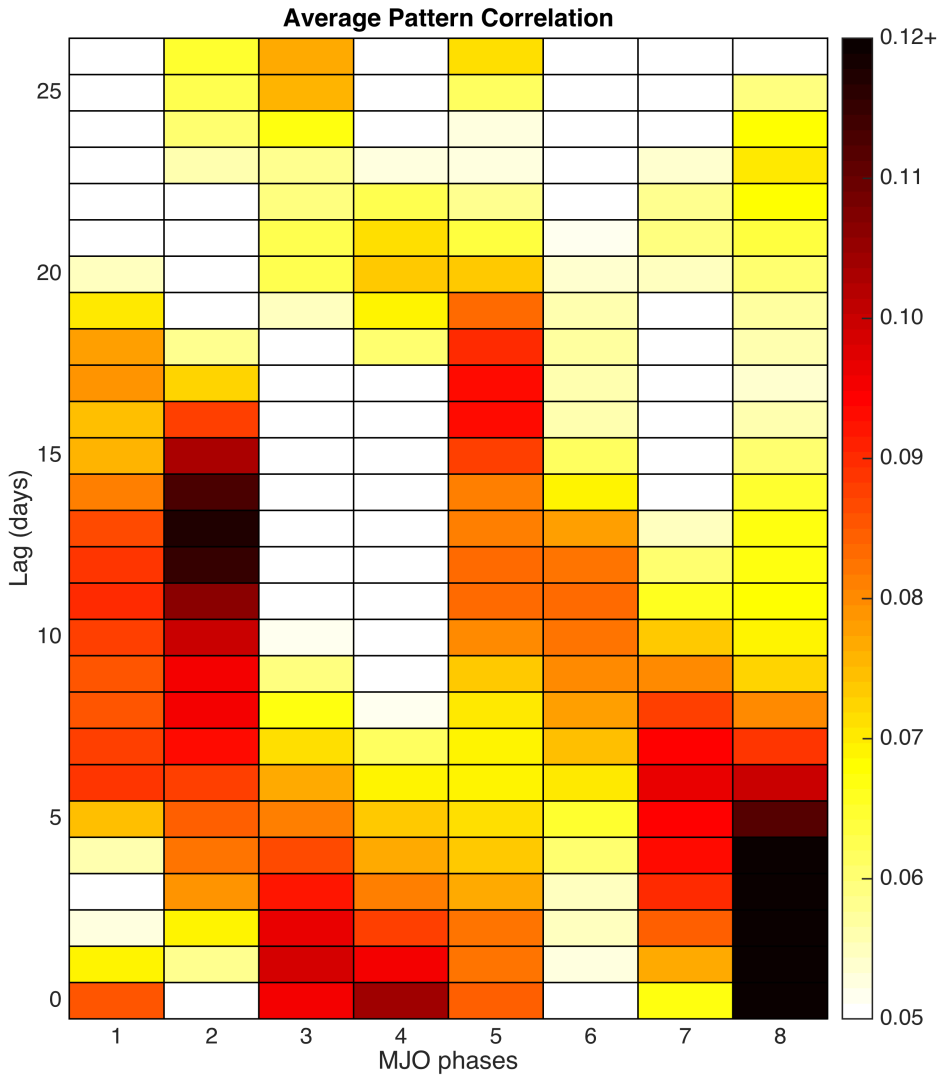

$$\bar{\rho} = \frac{1}{N} \sum_{i=1}^{N} \rho_i$$

The color indicates the strength of teleconnection's modulation on the variation of anomalous Z500.

Dark color -> robust modulation
Light color -> less robust modulation

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Conclusions of the first part :

- Teleconnections are more robust over specific phases and lags.
- When teleconnections are robust, the modulation on anomalous Z500 are strong as well.

Question:

Does idea works for hindcast ensembles (and forecast) ?

IF:

The teleconnections induced by MJO are only robust (consistently modulate anomalous Z500) over some phases and time lags.

Then:

The prediction skill is better over some phases and lags ?

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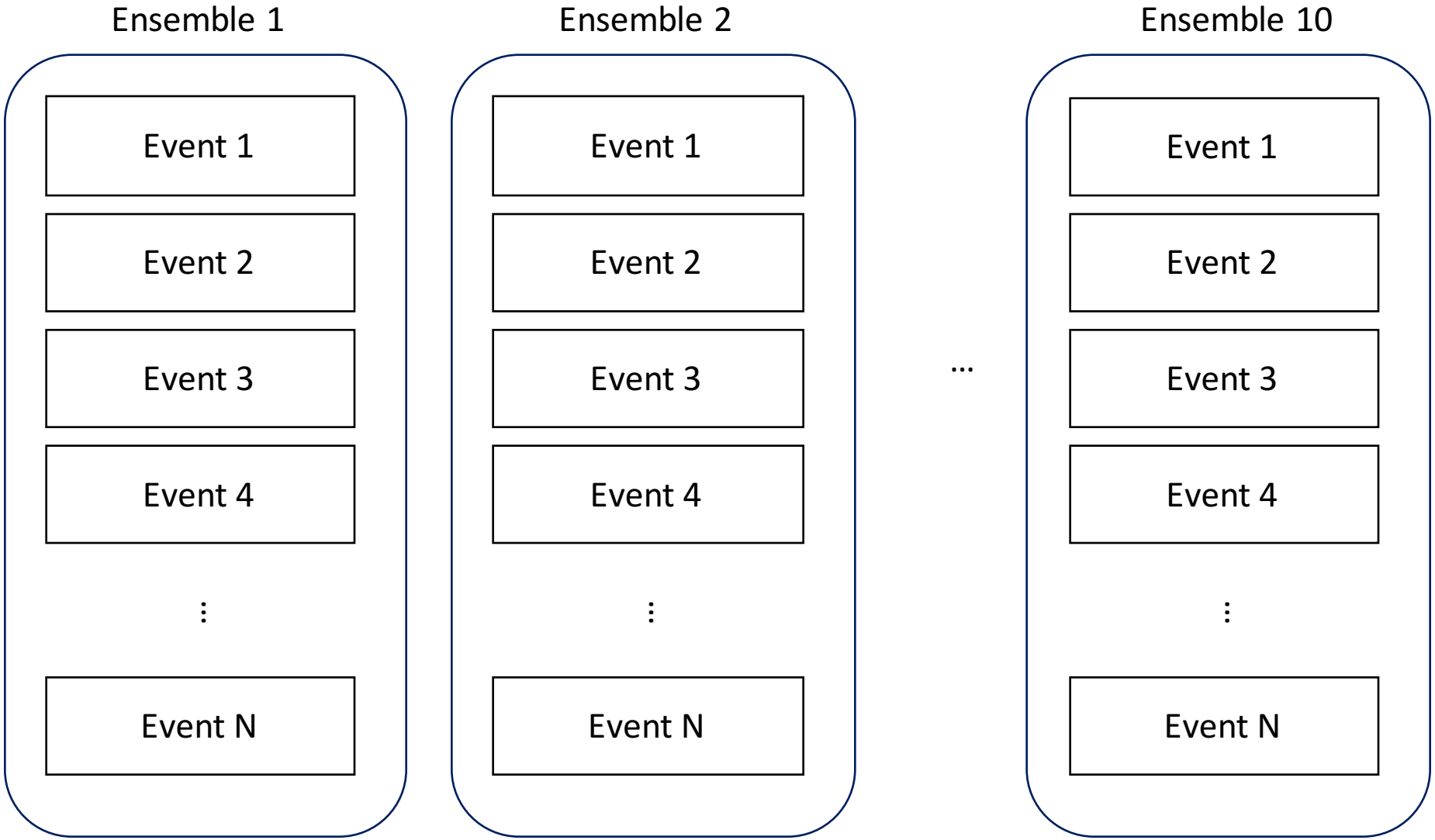
Composite sense

Two criteria :

- The first day of model initialization
- The first day of specific MJO phases



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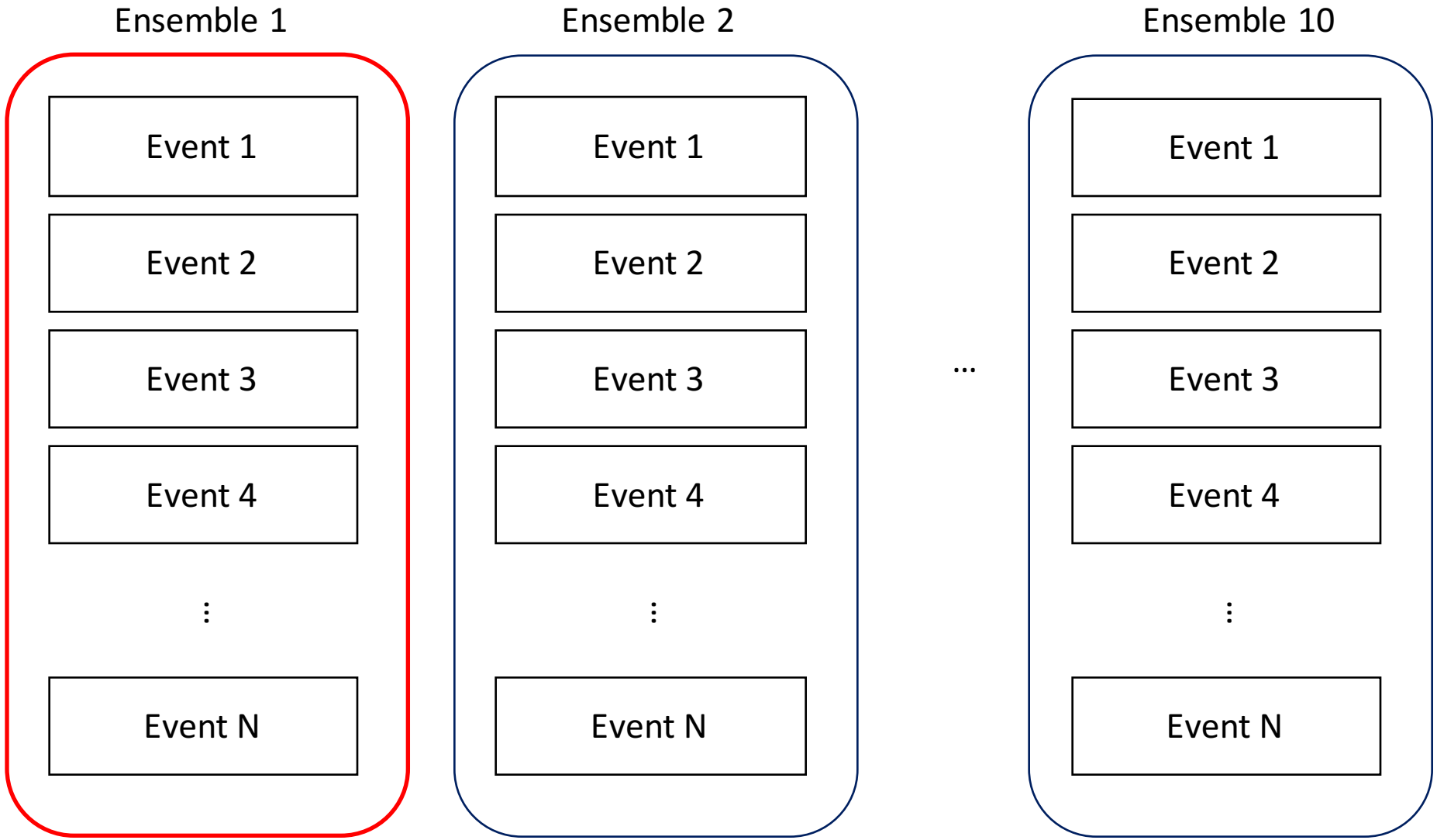

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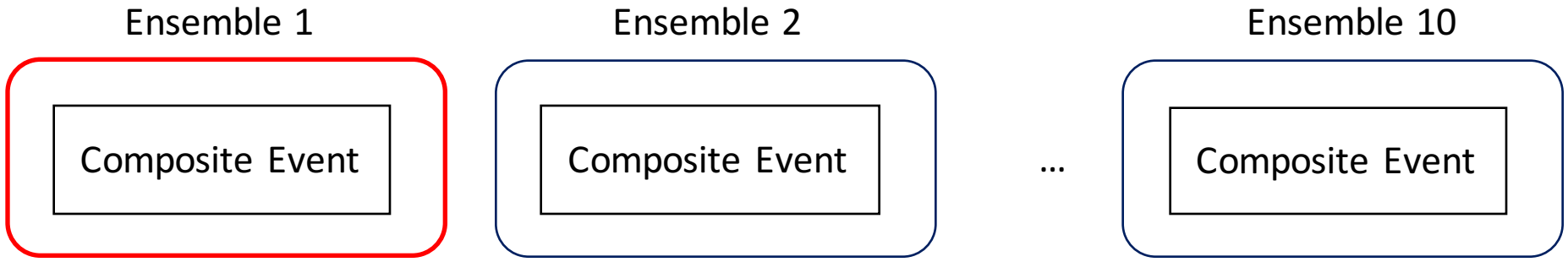

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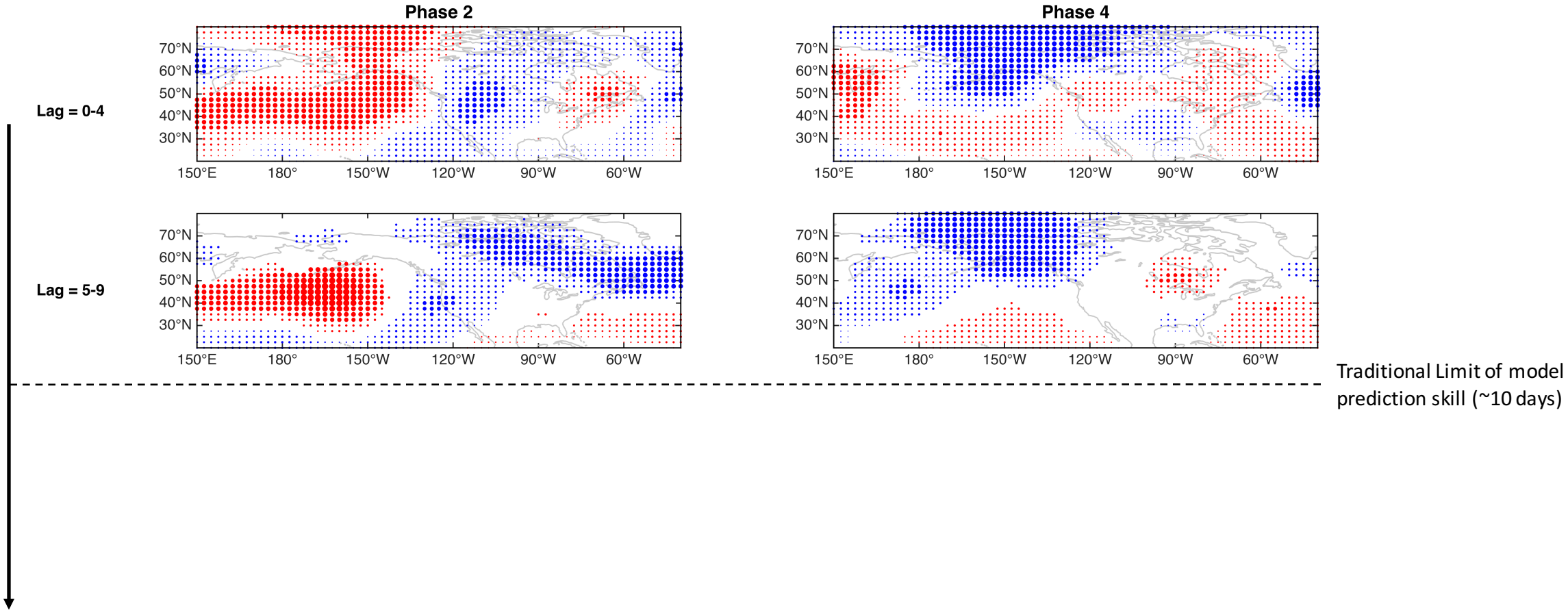

Dots indicate all of the ensemble member agree with a positive sign(+) or negative sign(-) of Z500.

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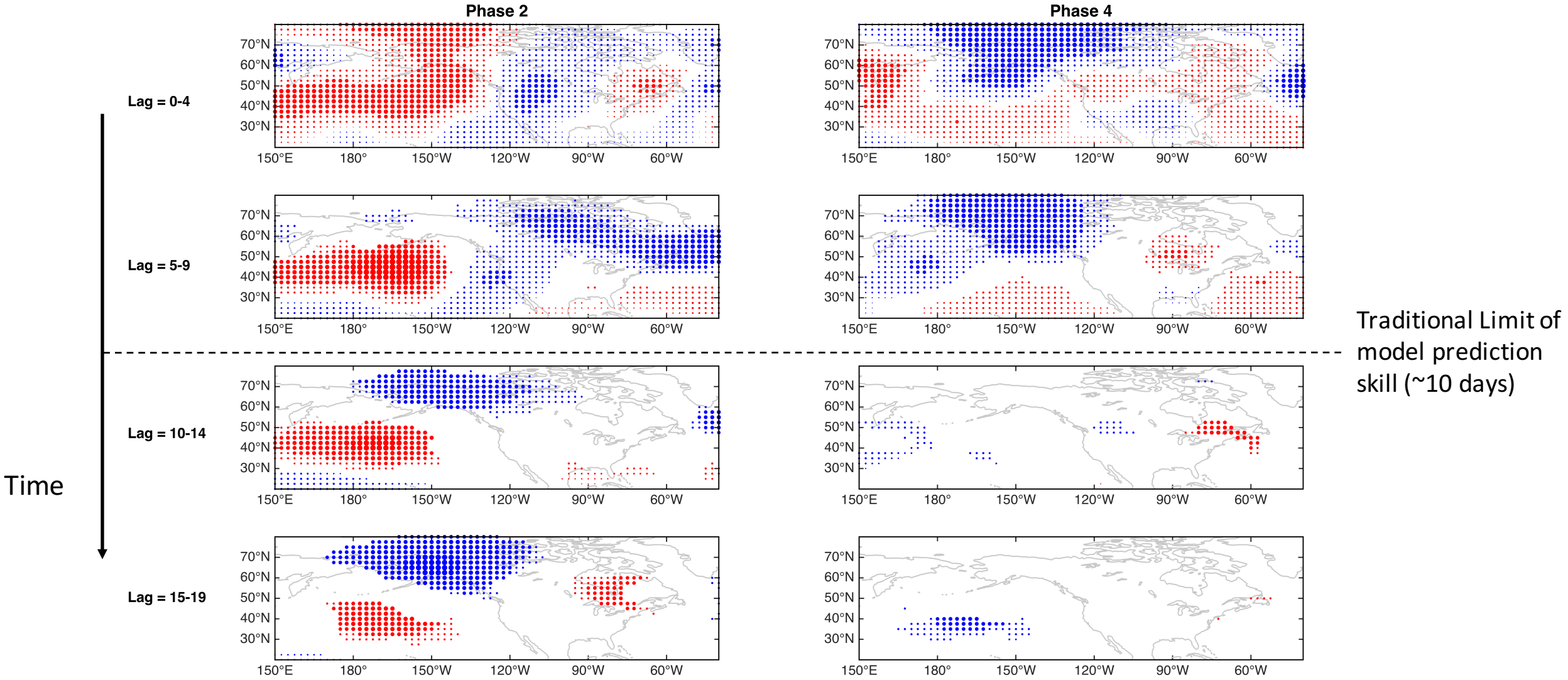

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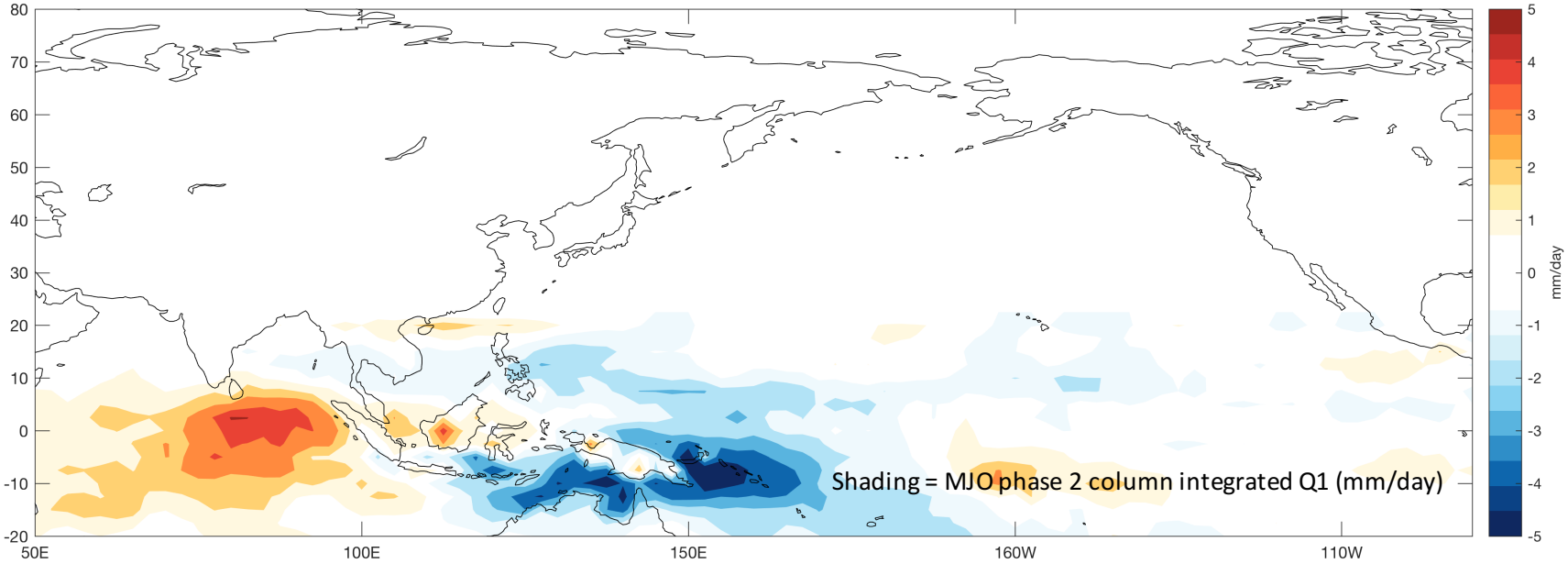
Conclusions – From Reanalysis …



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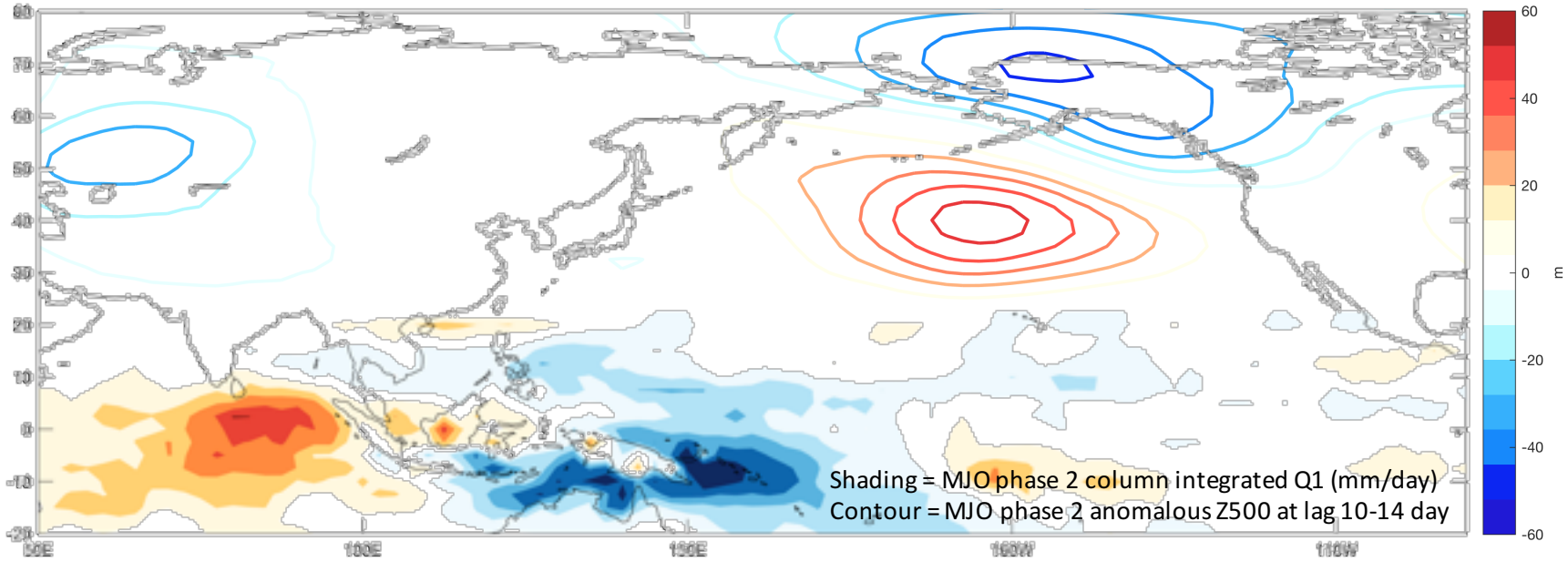

Some phases of MJO can generate robust teleconnected response.

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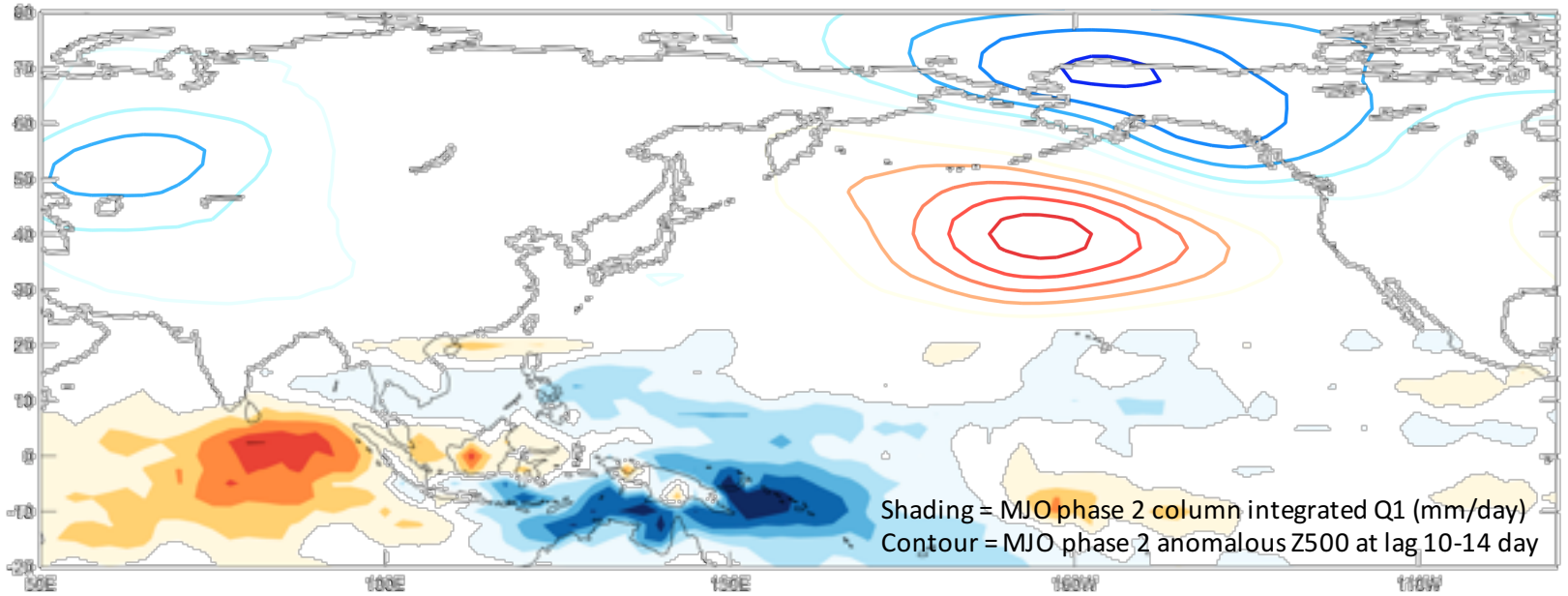


Event 1

Event 2

Event 3

Event 4

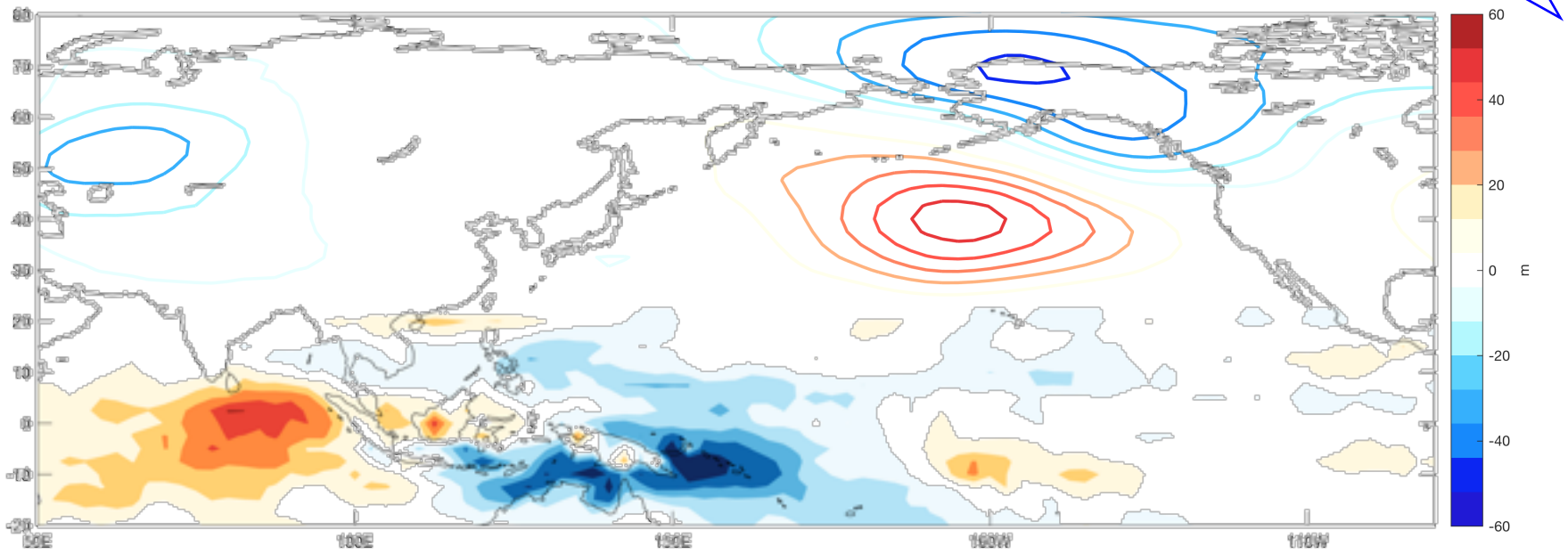
Event 5

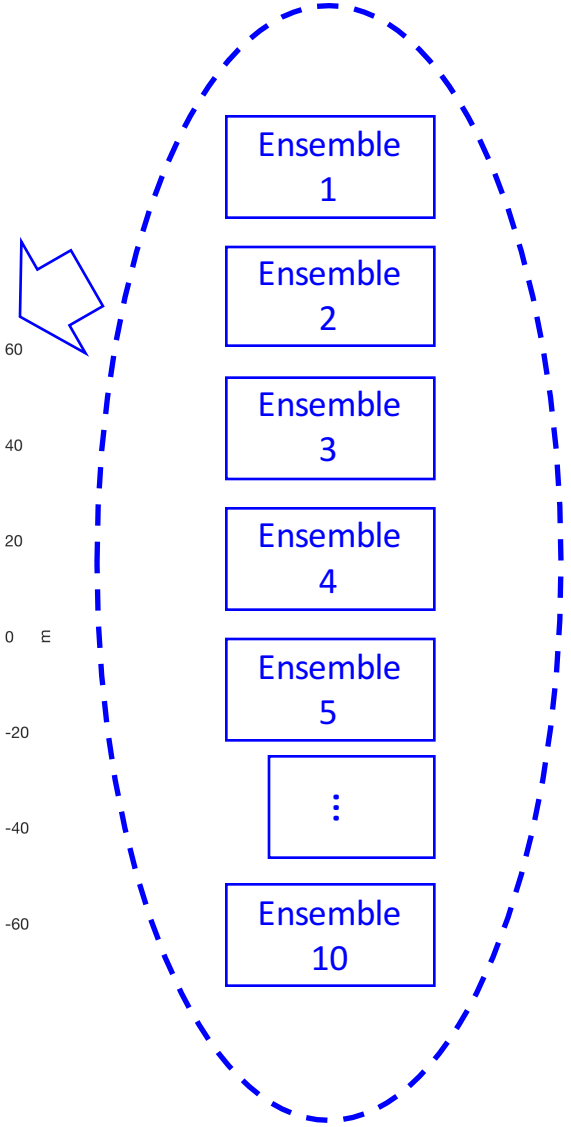
⋮

Event N

Robust teleconnected response can consistently modulate Z500 anomalies

Conclusions – From ensemble hindcasts





Robust teleconnections can also increase the agreement on Z500 over different ensemble members, which give us more confidence about the extended predictions.