EVALUATING THE JOINT INFLUENCE OF THE MJO AND THE STRATOSPHERIC POLAR VORTEX ON NORTHERN HEMISPHERE WINTER WEATHER PATTERNS

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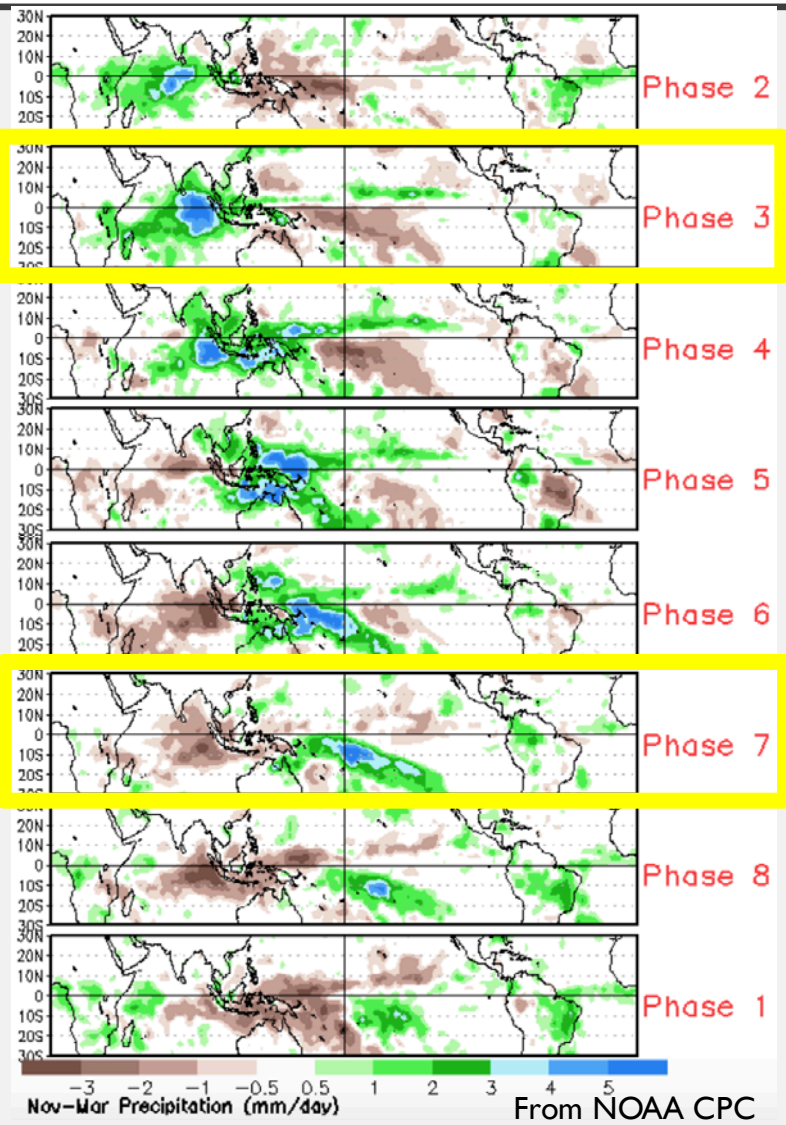
MAPP Modeling, Analysis, Predictions, and Projections

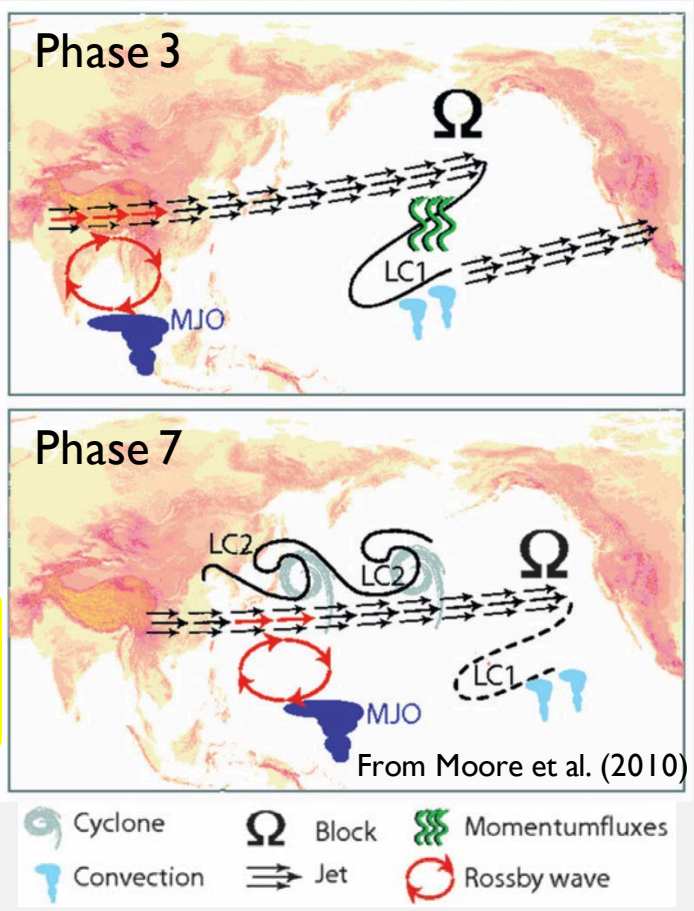
MOTIVATION

- Research in short range events and long-term climate.
- Resulting in greater predictability and forecast accuracy.
- **Subseasonal to seasonal gap**
- Better understand and forecast for events on this timescale.
- **Madden Julian Oscillation** and **Stratospheric Polar Vortex** separately linked to predictions on this timescale.

MADDEN JULIAN OSCILLATION (MJO)



From NOAA CPC

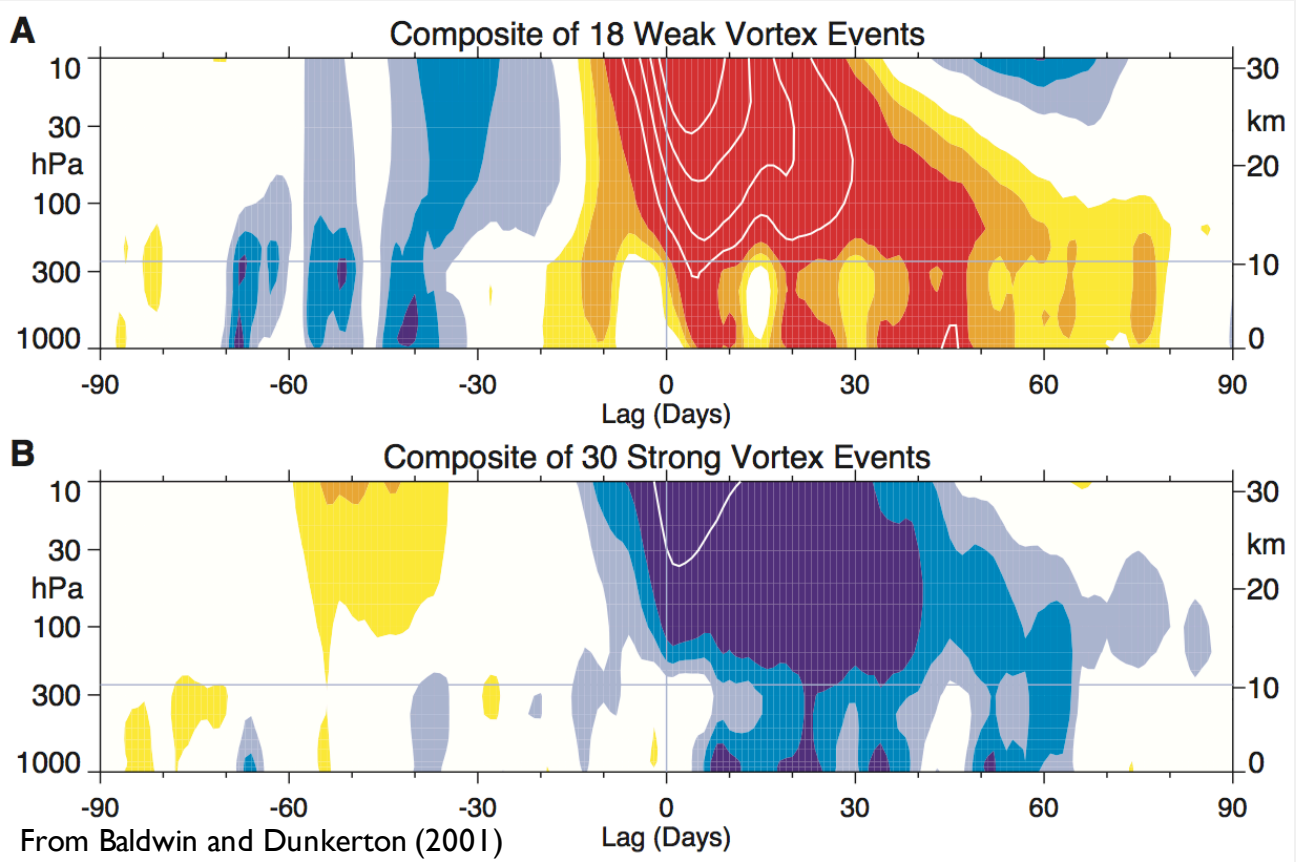


From Moore et al. (2010)

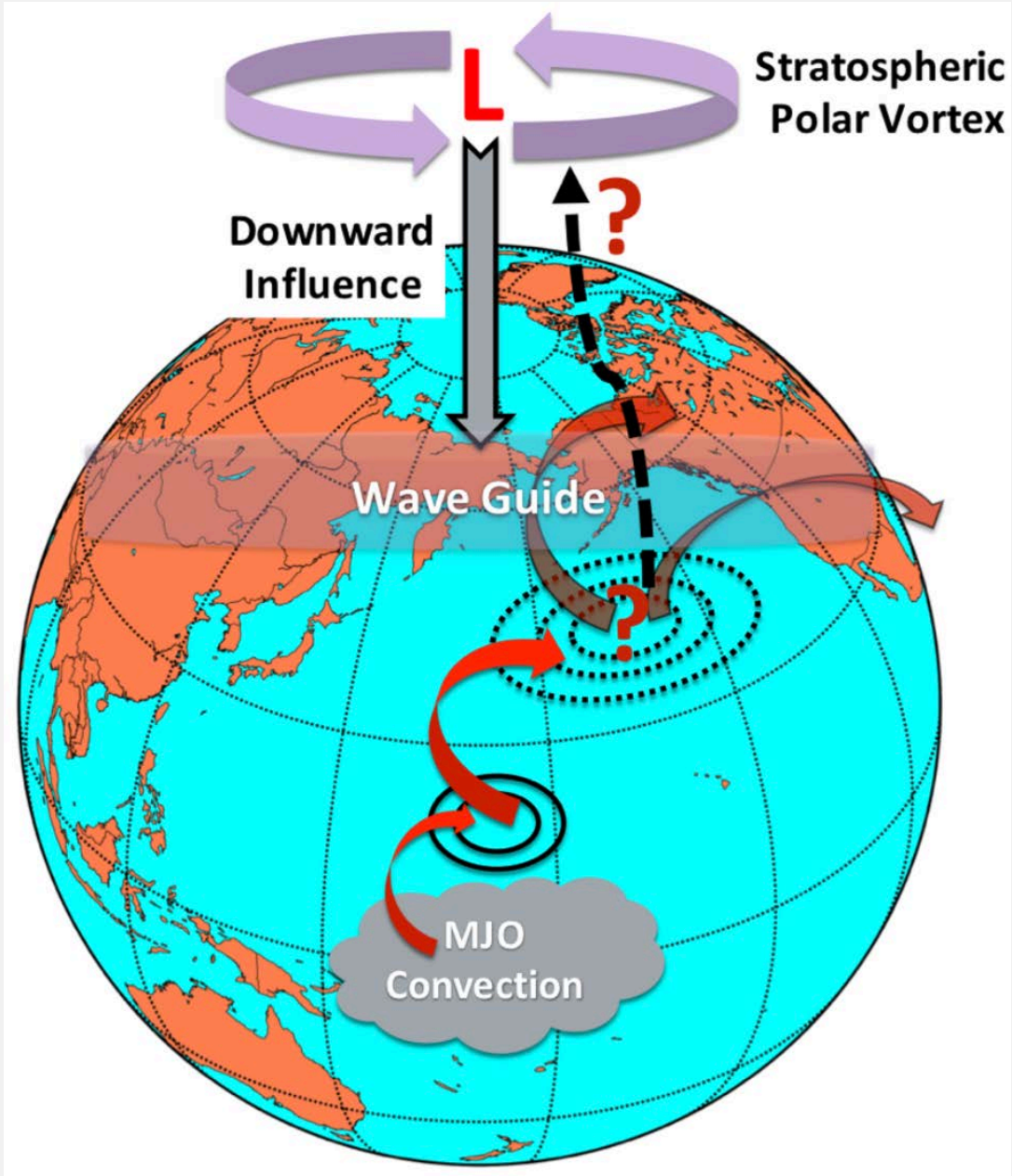
- Comprised of convective centers
- Spans from western Indian Ocean to central Pacific Ocean (Madden and Julian, 1972)
- Excites Rossby waves that propagate upward and to the north
- Impacts downstream weather patterns (Matthews et al., 2004) and (Moore et al., 2010)

STRATOSPHERIC POLAR VORTEX

- Annular circulation about the Northern Hemisphere (NH)
- Variations can impact speed and position of tropospheric jet stream (Baldwin and Dunkerton, 2001)
- Vortex itself is influenced by vertically propagating Rossby waves (Kidston et al. 2015)
- Also referred to as **Northern Annular Mode** (NAM)



Red = negative NAM values
Blue = Positive NAM values



What is the **JOINT** influence of the **MJO** and the **Stratospheric Polar Vortex** on the winter weather patterns in the **NH**?

DATA & METHODOLOGY

- ERA-Interim Reanalysis dataset (daily data from 1979-2016)
- **NAM** defined as leading EOF of GPH at each pressure level
  - Index is 1st Principal Component
- **MJO** index obtained from the Bureau of Meteorology
- Primary focus is on months October-April
- MJO and Vortex Events analyzed
  - Composite Analysis:
    - MJO (Vortex neutral) $\sigma \geq 1$ for all phases
    - Strong Vortex (MJO neutral) at **100 hPa NAM** index $\sigma \geq 1$
    - Weak Vortex (MJO neutral) at **100 hPa NAM** index $\sigma \leq -1$
  - Overlapping Composites:
    - MJO w/ Strong Vortex for all phases
    - MJO w/ Weak Vortex for all phases

ECMWF

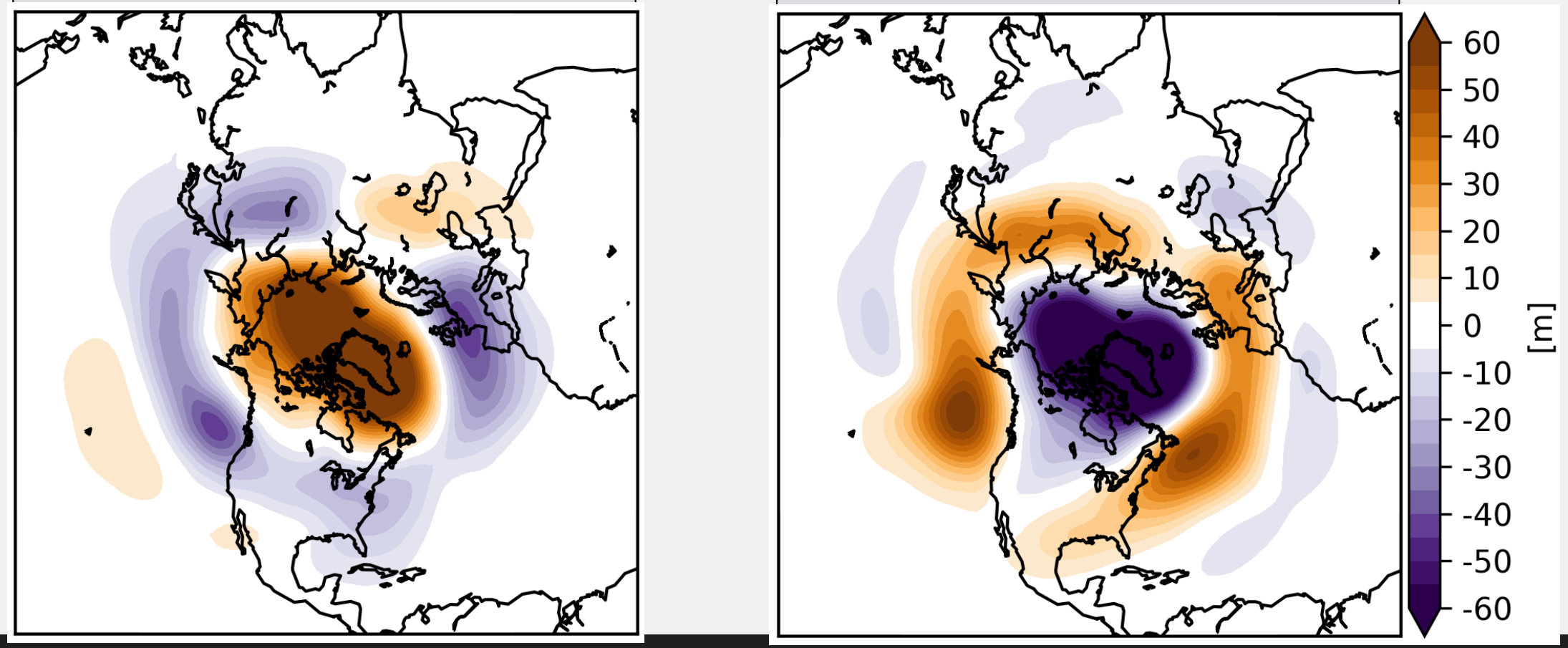
Australian Government
Bureau of Meteorology

UPPER-AIR PATTERNS FOR **VORTEX** EVENTS

500 hPa Geopotential Height Anomalies

Weak Vortex

Strong Vortex

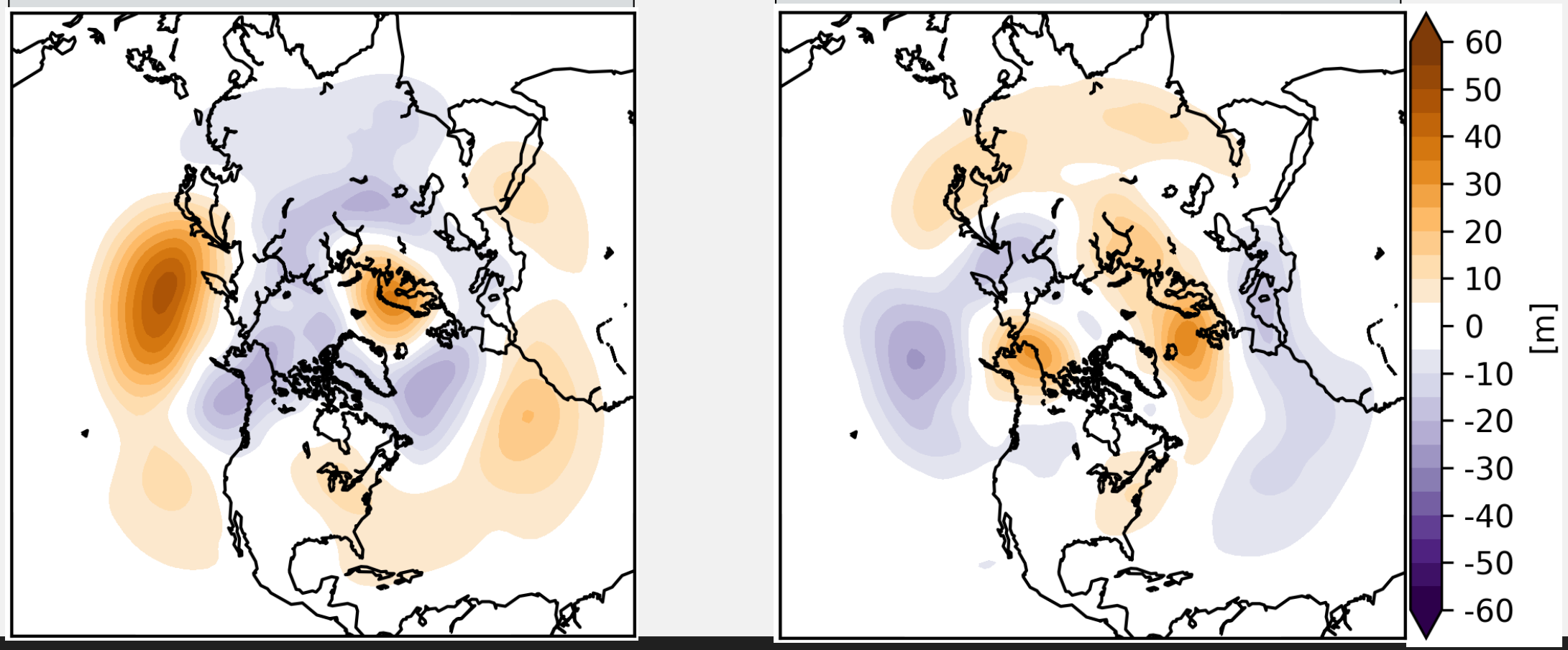


UPPER-AIR PATTERNS FOR **MJO** EVENTS

500 hPa Geopotential Height Anomalies

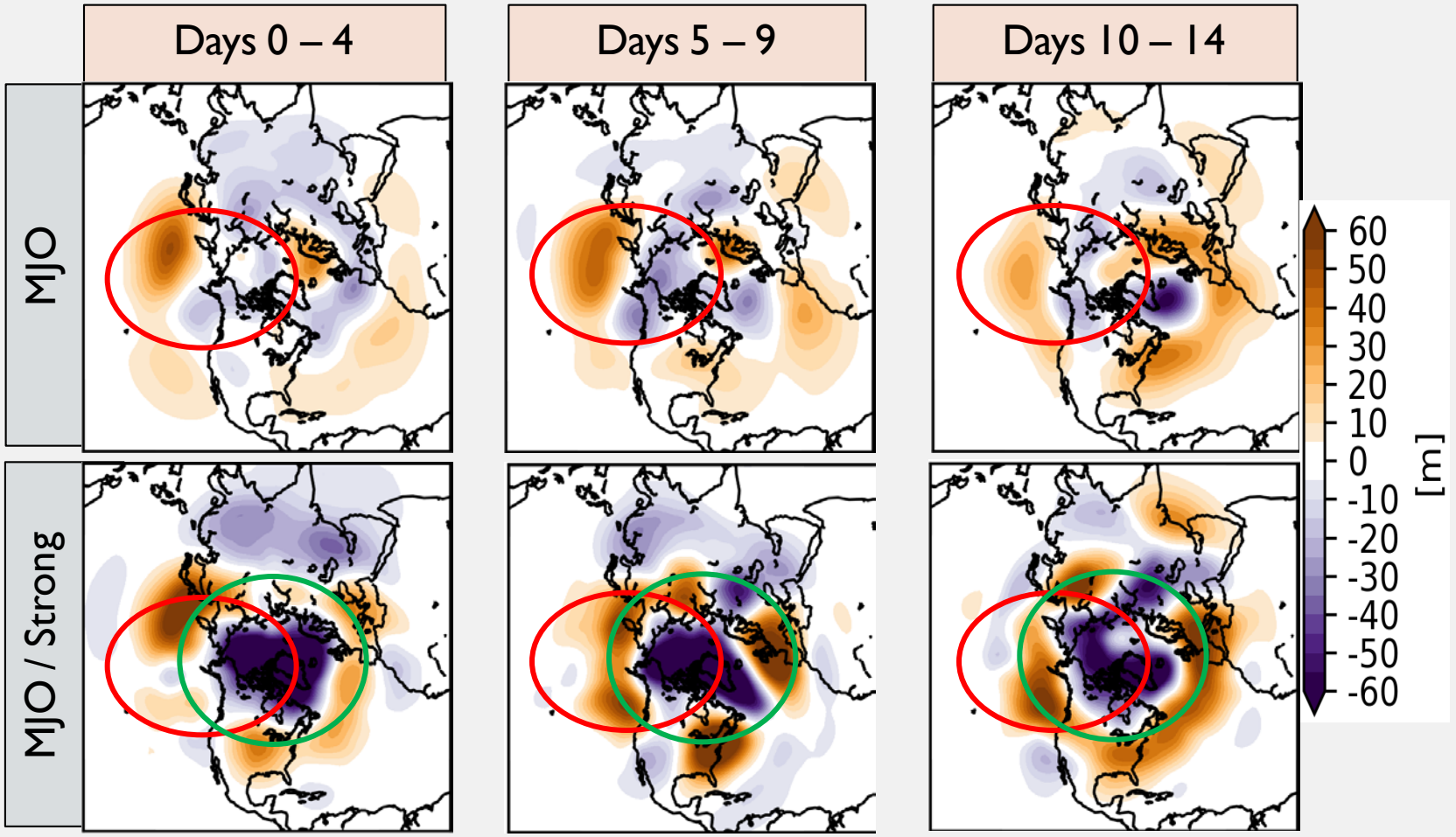
Phase 3

Phase 7



UPPER-AIR PATTERNS FOR **MJO 3 / STRONG VORTEX** EVENTS

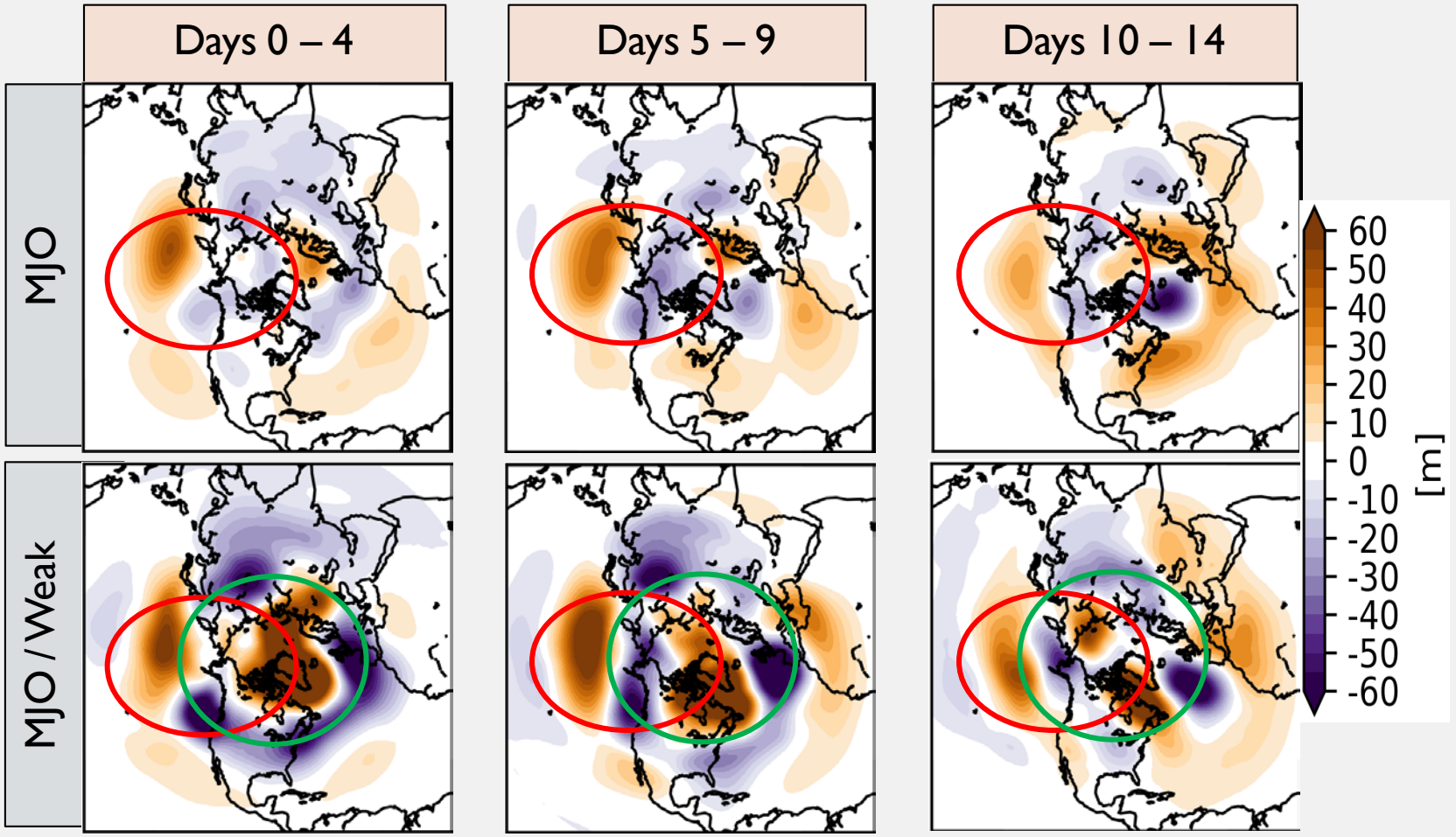
500 hPa Geopotential Height Anomalies



- Strong vortex pattern very consistent
- MJO 3 Pacific pattern in MJO/Vortex plots

UPPER-AIR PATTERNS FOR **MJO 3 / WEAK VORTEX** EVENTS

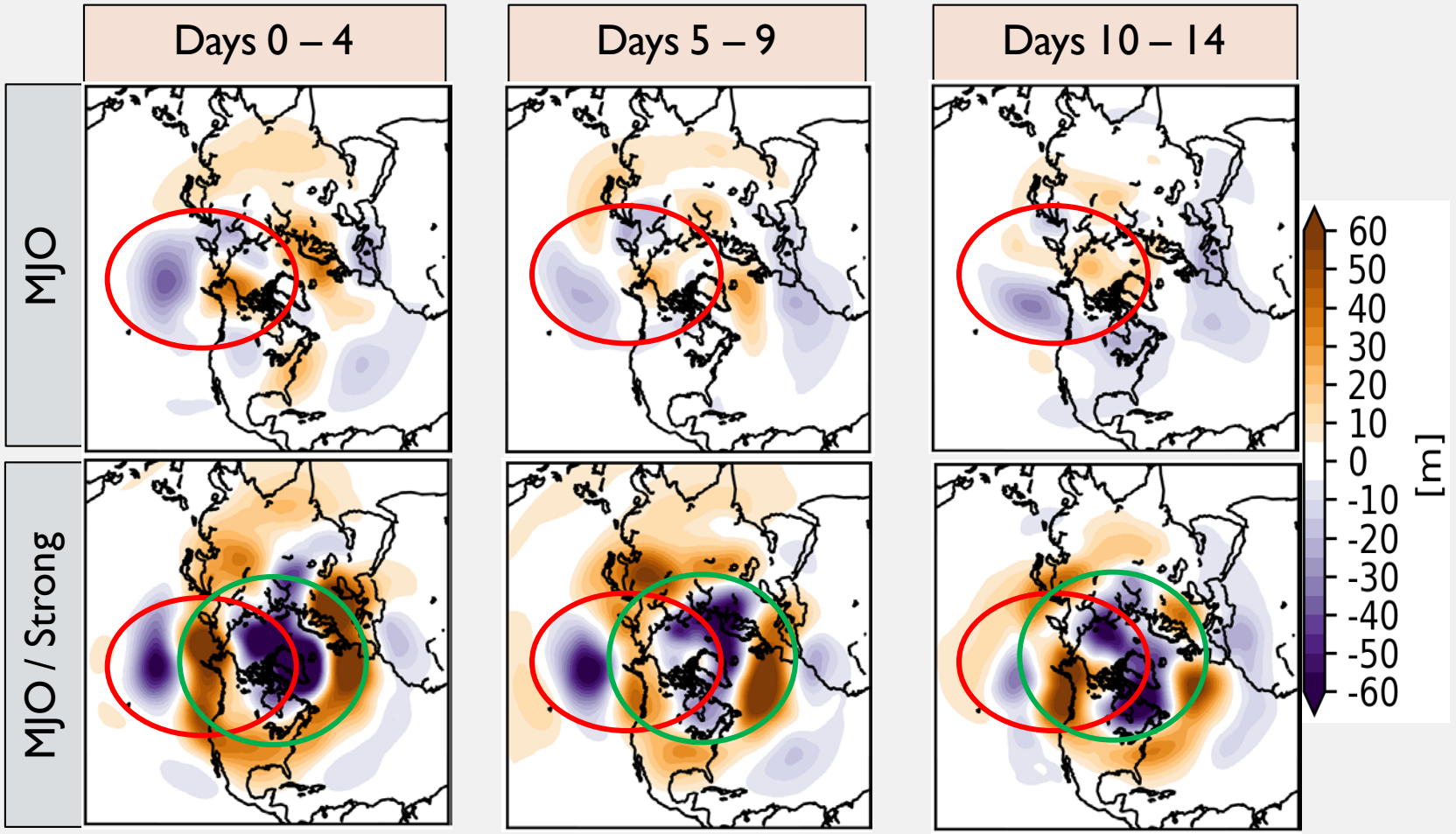
500 hPa Geopotential Height Anomalies



- Weak vortex pattern weakened by days10 – 14
- MJO 3 pattern is consistent within combined cases

UPPER-AIR PATTERNS FOR **MJO 7 / STRONG VORTEX** EVENTS

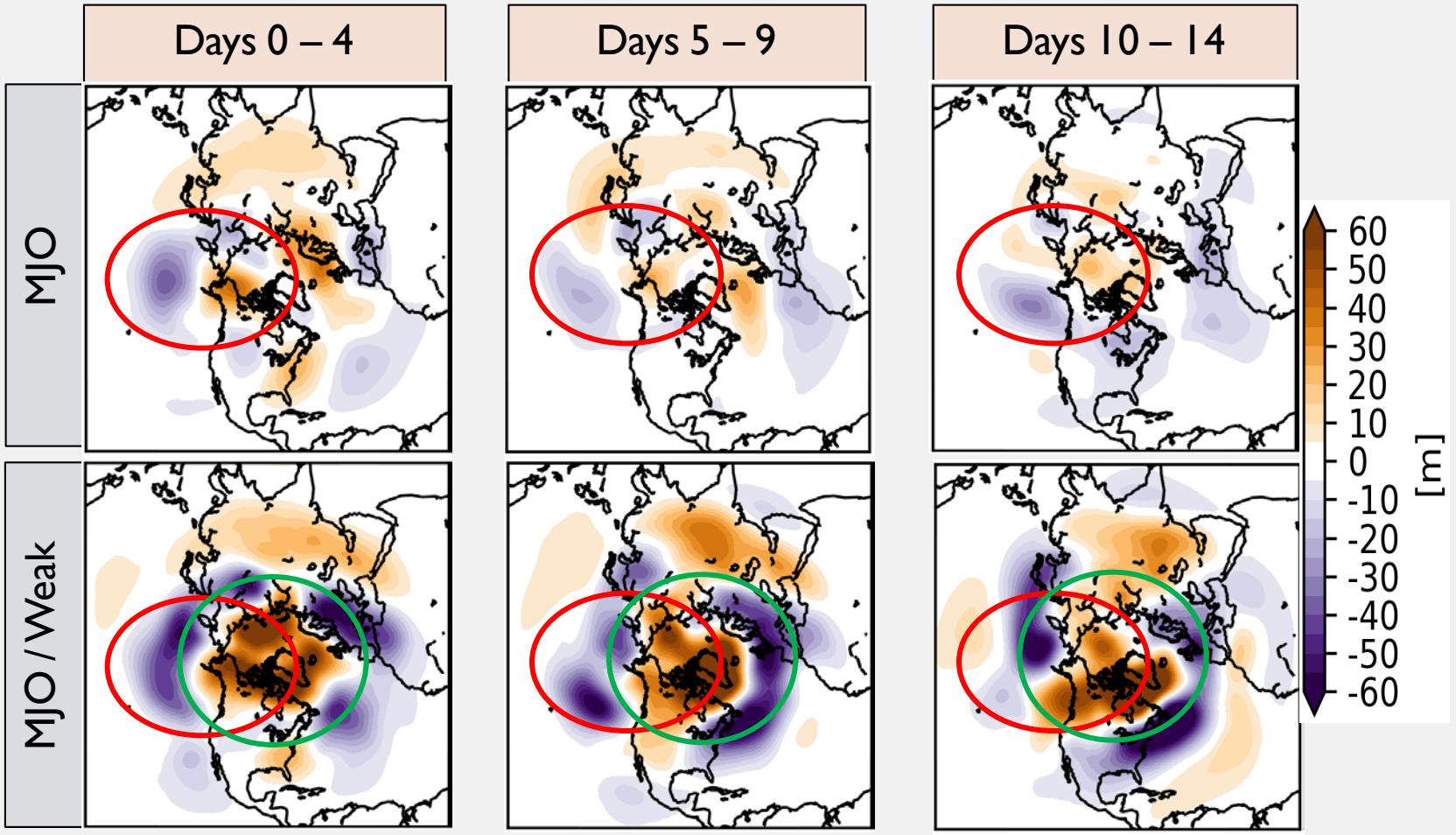
500 hPa Geopotential Height Anomalies



- Strong vortex pattern is now weakened by days 10 – 14
- MJO 7 Pacific pattern in MJO/Vortex plots

UPPER-AIR PATTERNS FOR **MJO 7 / WEAK VORTEX** EVENTS

500 hPa Geopotential Height Anomalies



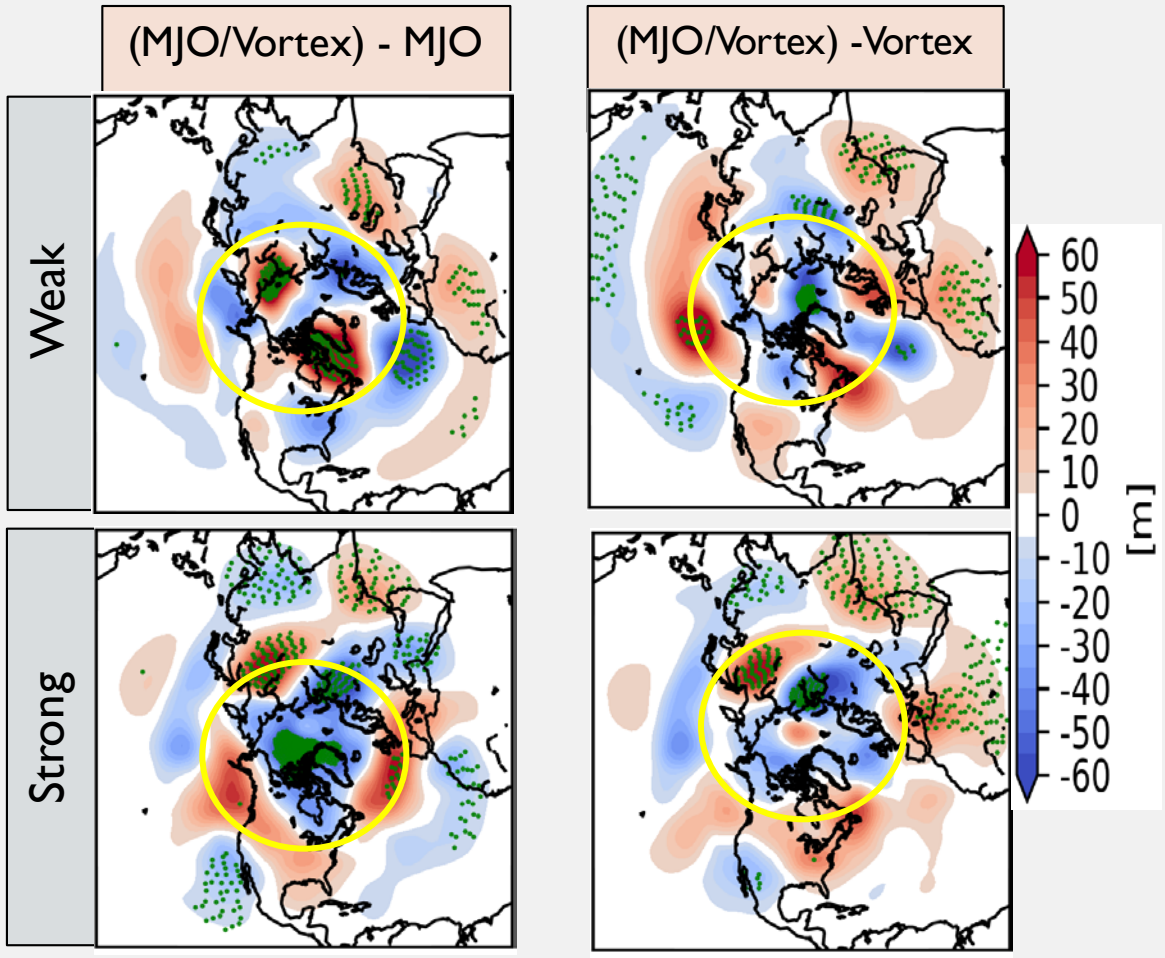
- Weak vortex pattern is consistent through days 10 – 14
- MJO 7 negative height anomalies consistent in MJO/Vortex plots

DIFFERENCE OF **MJO 3 / VORTEX** EVENTS

500 hPa Geopotential Height Anomalous Differences

For Days 10 – 14 from start dates

Monte Carlo simulations with 1000 iterations at 90% confidence interval



- MJO/vortex observes vortex patterns more than MJO only
  - Over Arctic and N. Atlantic
- MJO/Vortex observes MJO pattern more than Weak Vortex only
  - N. Pacific

DIFFERENCE OF **MJO 7 / VORTEX** EVENTS

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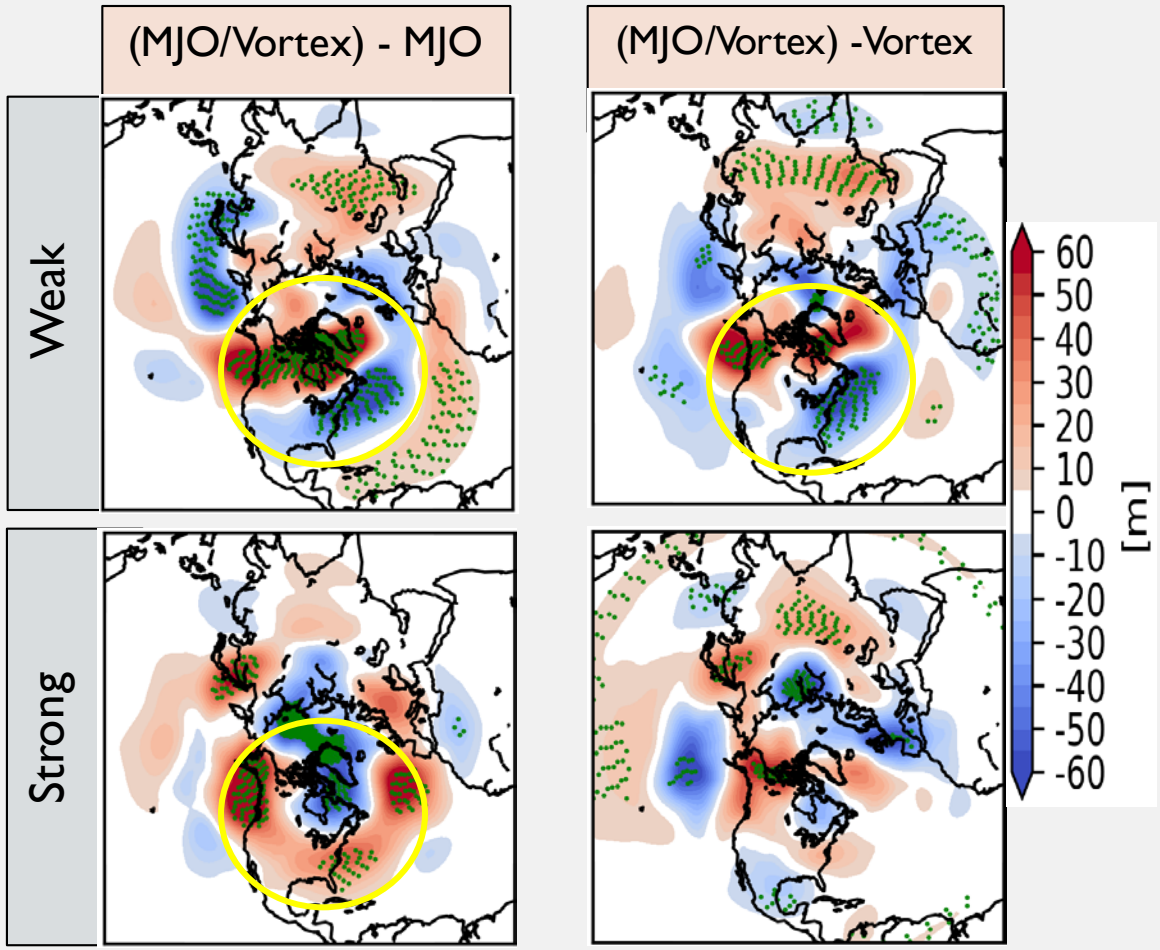


- MJO/Vortex observes Vortex patterns over N. America and Atlantic
- Also sees Pacific patterns assoc. with MJO that Vortex only patterns do not produce


Understanding the **IMPACTS**

IMPACTS FOR **MJO 3 / VORTEX** EVENTS

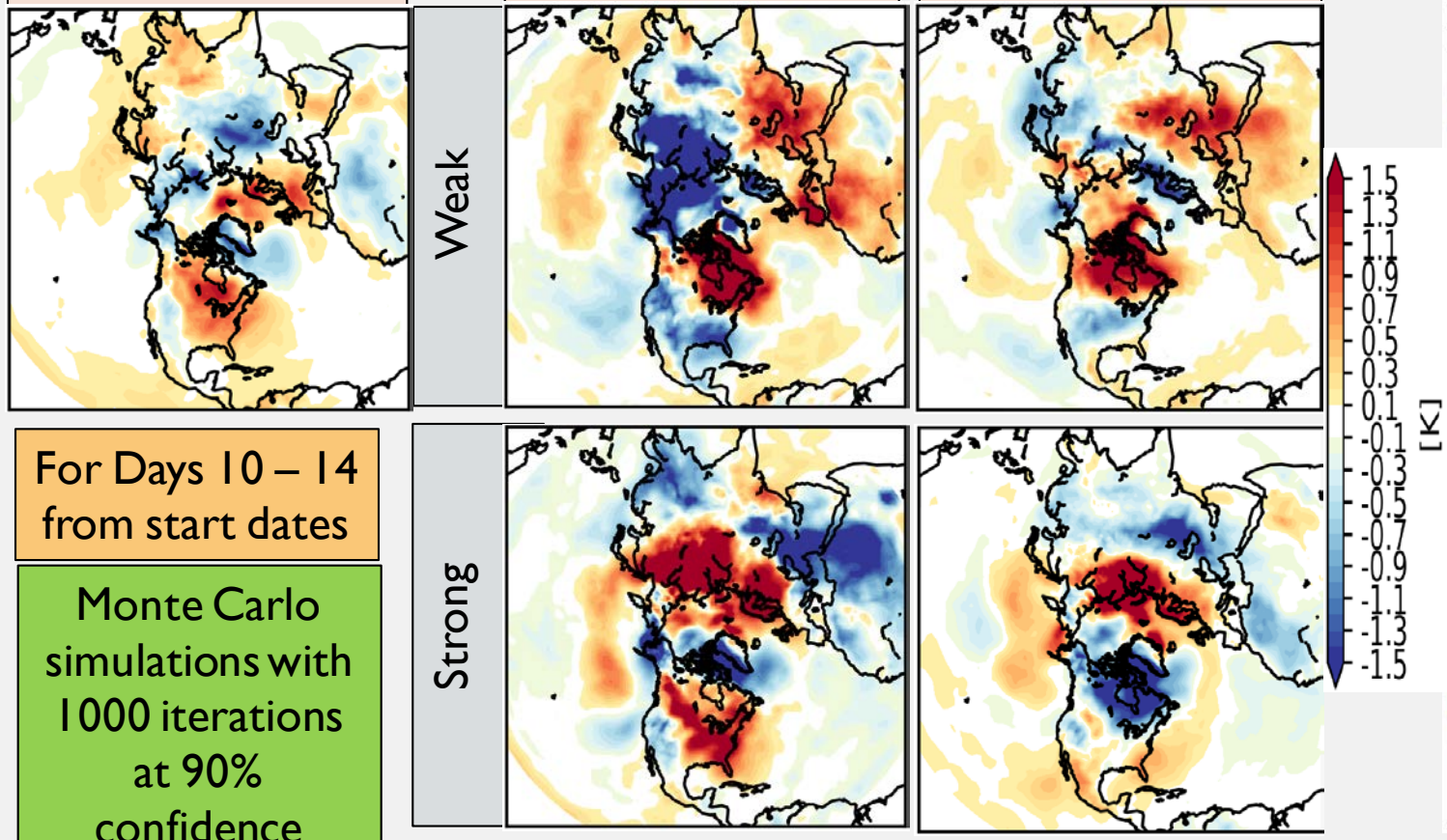
Surface Air Temperature Anomalies

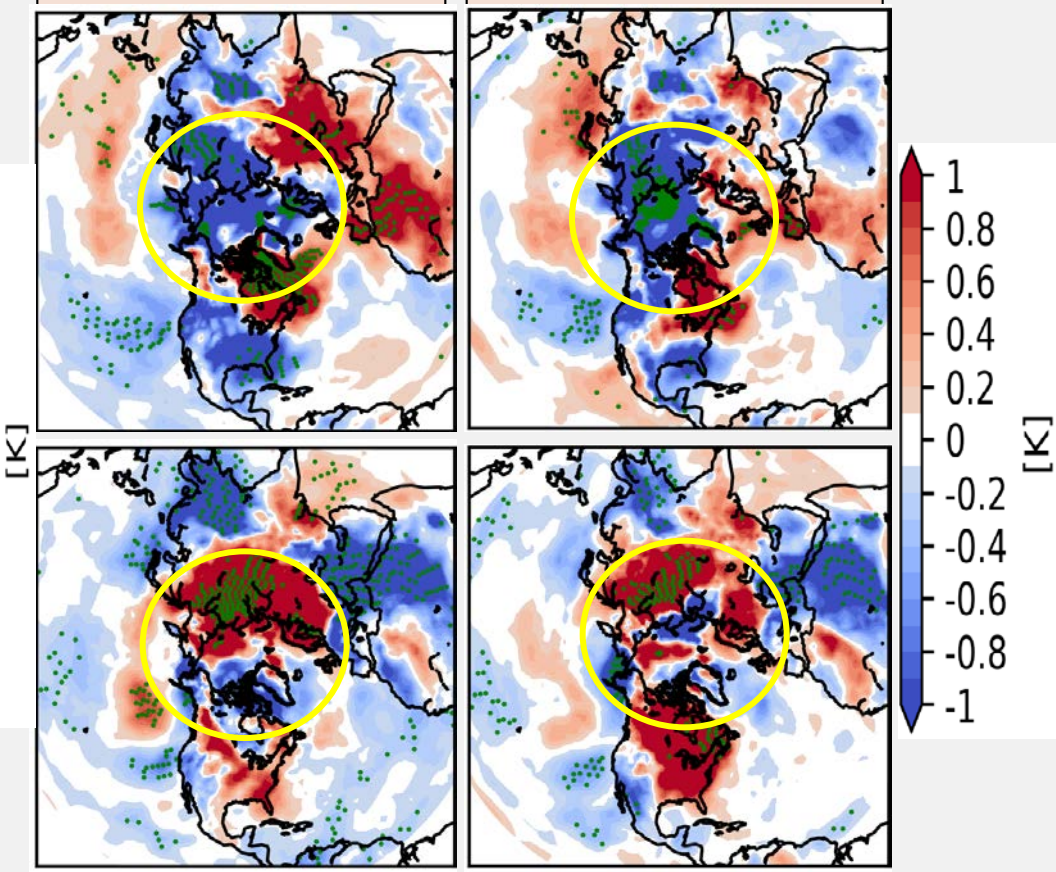
Differences

MJO Phase 3 | MJO 3 / Vortex | Vortex | (MJO/Vortex) - MJO | (MJO/Vortex) -Vortex

Weak

Strong





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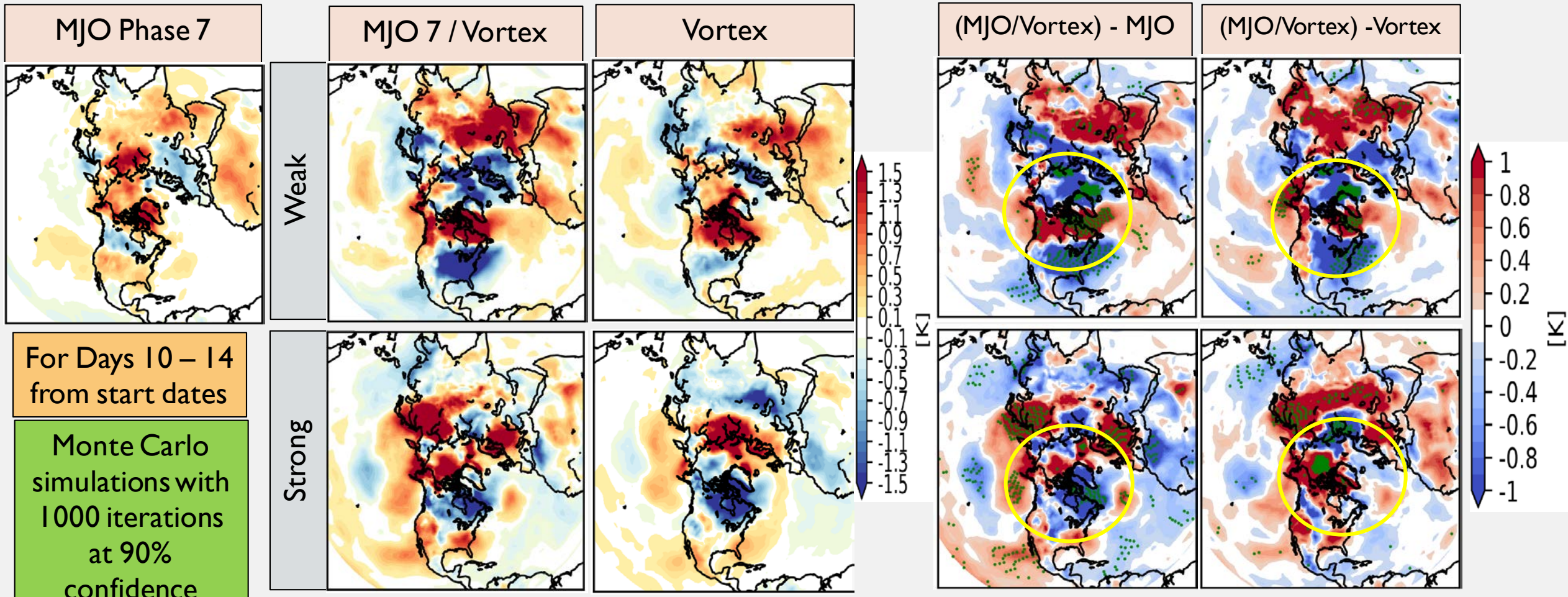
Monte Carlo simulations with 1000 iterations at 90% confidence interval

IMPACTS FOR **MJO 7 / VORTEX** EVENTS

Surface Air Temperature Anomalies

Differences



For Days 10 – 14 from start dates

Monte Carlo simulations with 1000 iterations at 90% confidence interval

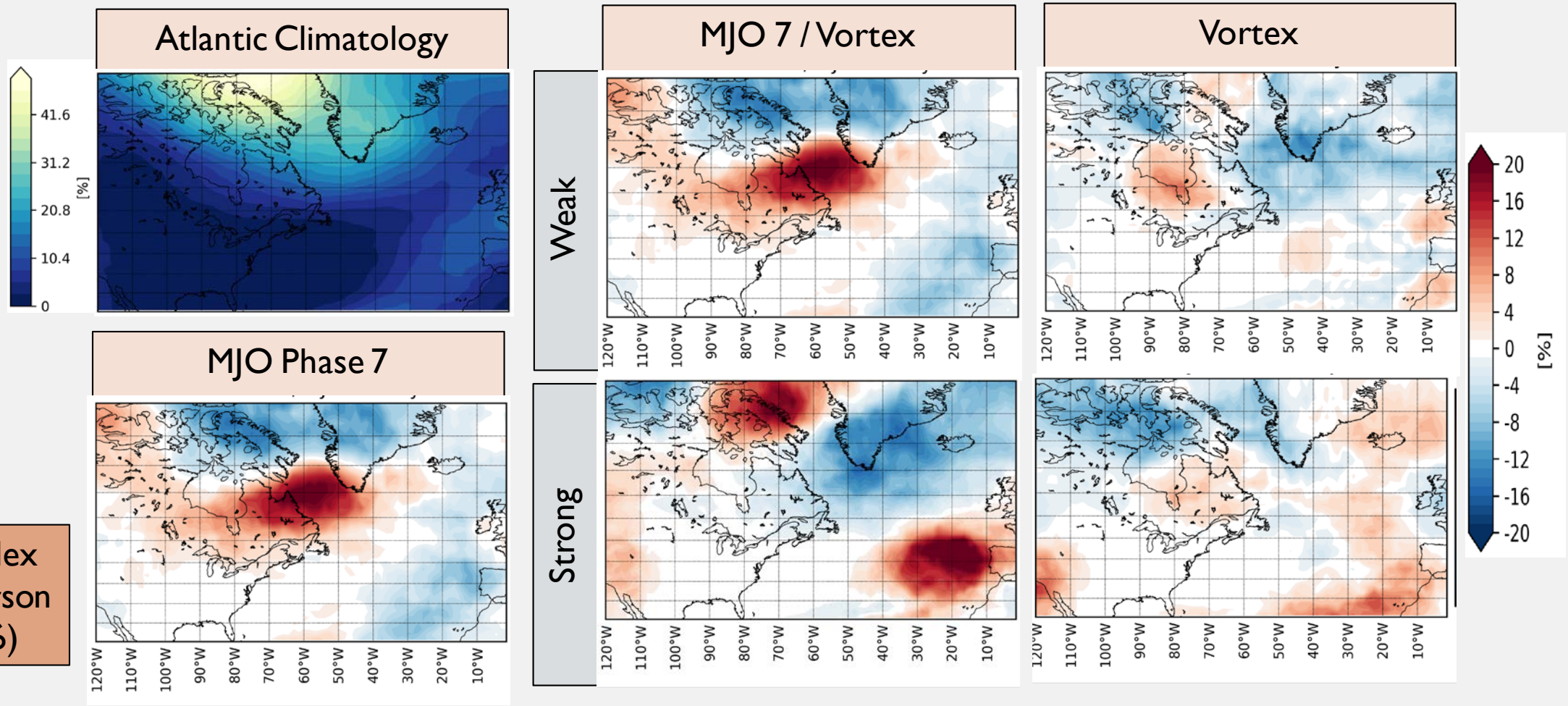
CONCLUSIONS

- **MJO** maintains strong control of the pattern observed in the northern Pacific Ocean.
- **Stratospheric Polar Vortex** maintains control of the North Atlantic and Europe.
- **MJO/Vortex** adds valuable information that is not present through only the **MJO** or the **Stratospheric Polar Vortex** separately.

- **Future Work**:
  - How does the **MJO** modulate the **Stratospheric Polar Vortex**?
  - Use blocking indices to investigate weather patterns
  - How are winter storm tracks influenced?

BLOCKING INDEX

Anomalous Blocking from 500 GPH



Blocking Index from Henderson et al. (2016)

THANK YOU

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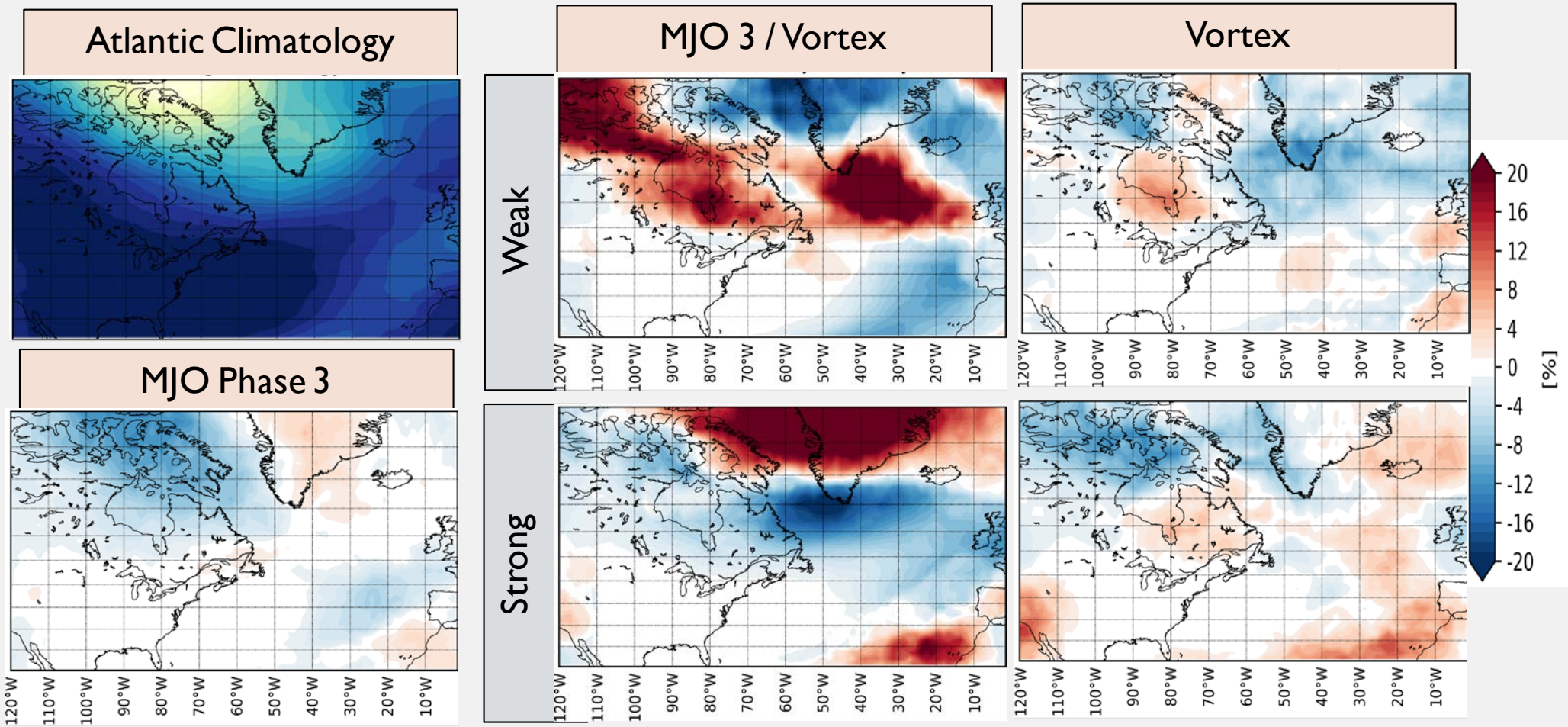
BLOCKING INDEX

Anomalous Blocking from 500 GPH



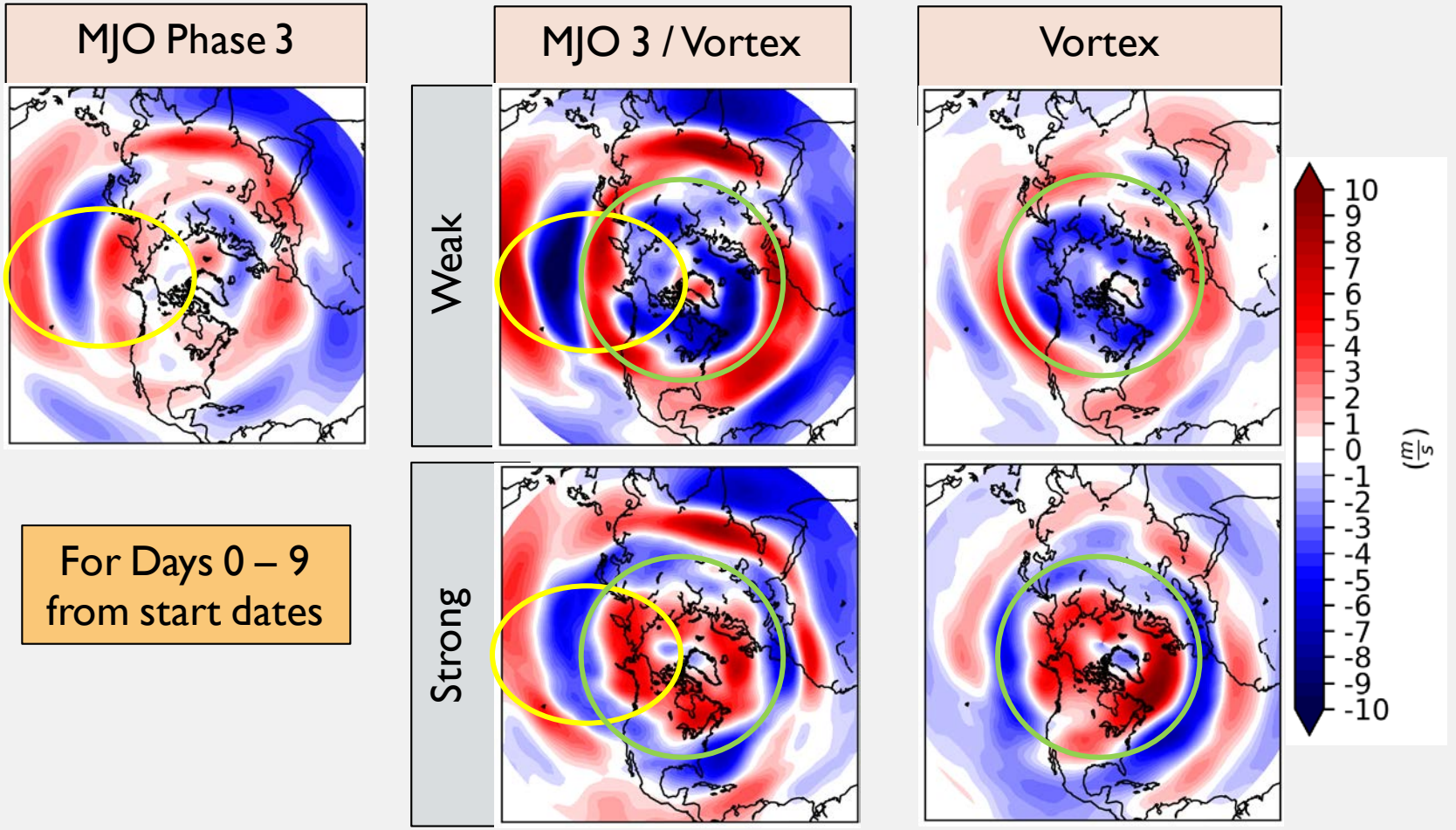
Blocking Index from Henderson et al. (2016)

Sample Size for each condition for each MJO phase w/ NAM @ 100hPa

Phase	MJO	MJO & Weak	MJO & Strong	Weak	Strong
1	530	184	180	500	438
2	577	146	220		
3	734	130	190		
4	689	170	170		
5	763	160	150		
6	711	220	166		
7	723	170	160		
8	606	196	128		

UPPER-AIR PATTERNS FOR **MJO 3 / VORTEX** EVENTS

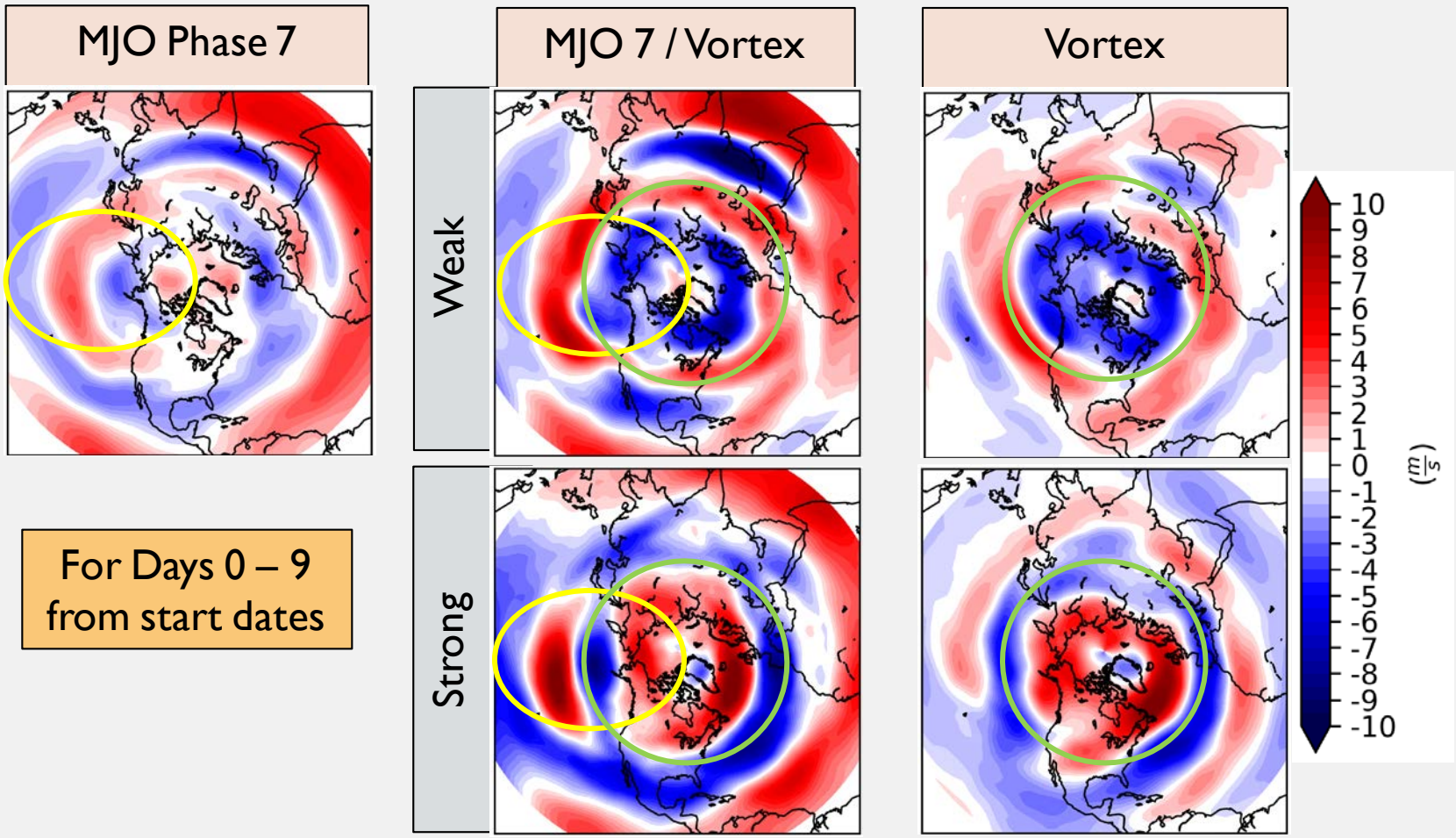
250 hPa U-wind Anomalies



For Days 0 – 9 from start dates

UPPER-AIR PATTERNS FOR **MJO 7 / VORTEX** EVENTS

250 hPa U-wind Anomalies



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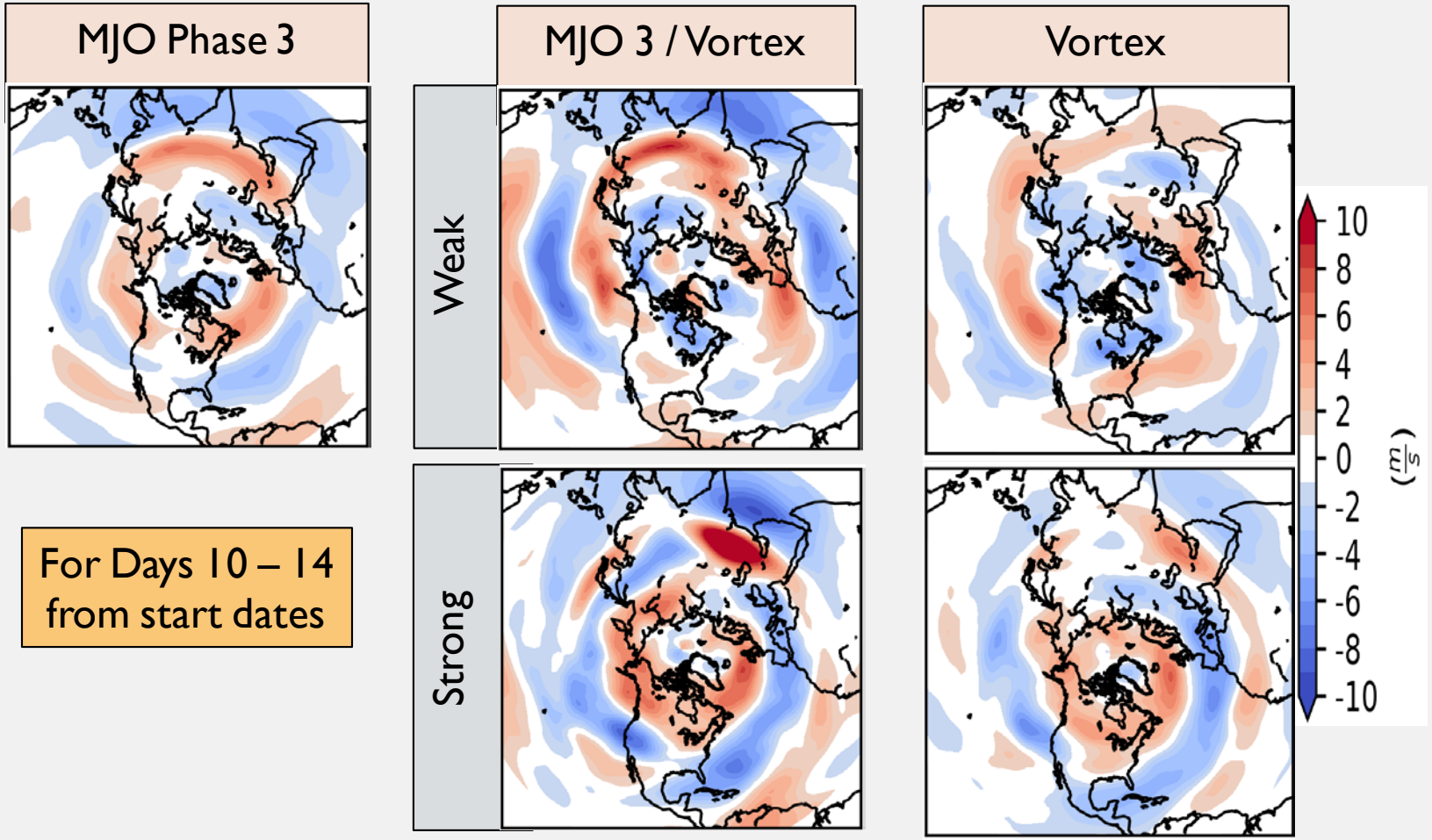

For Days 10 – 14 from start dates

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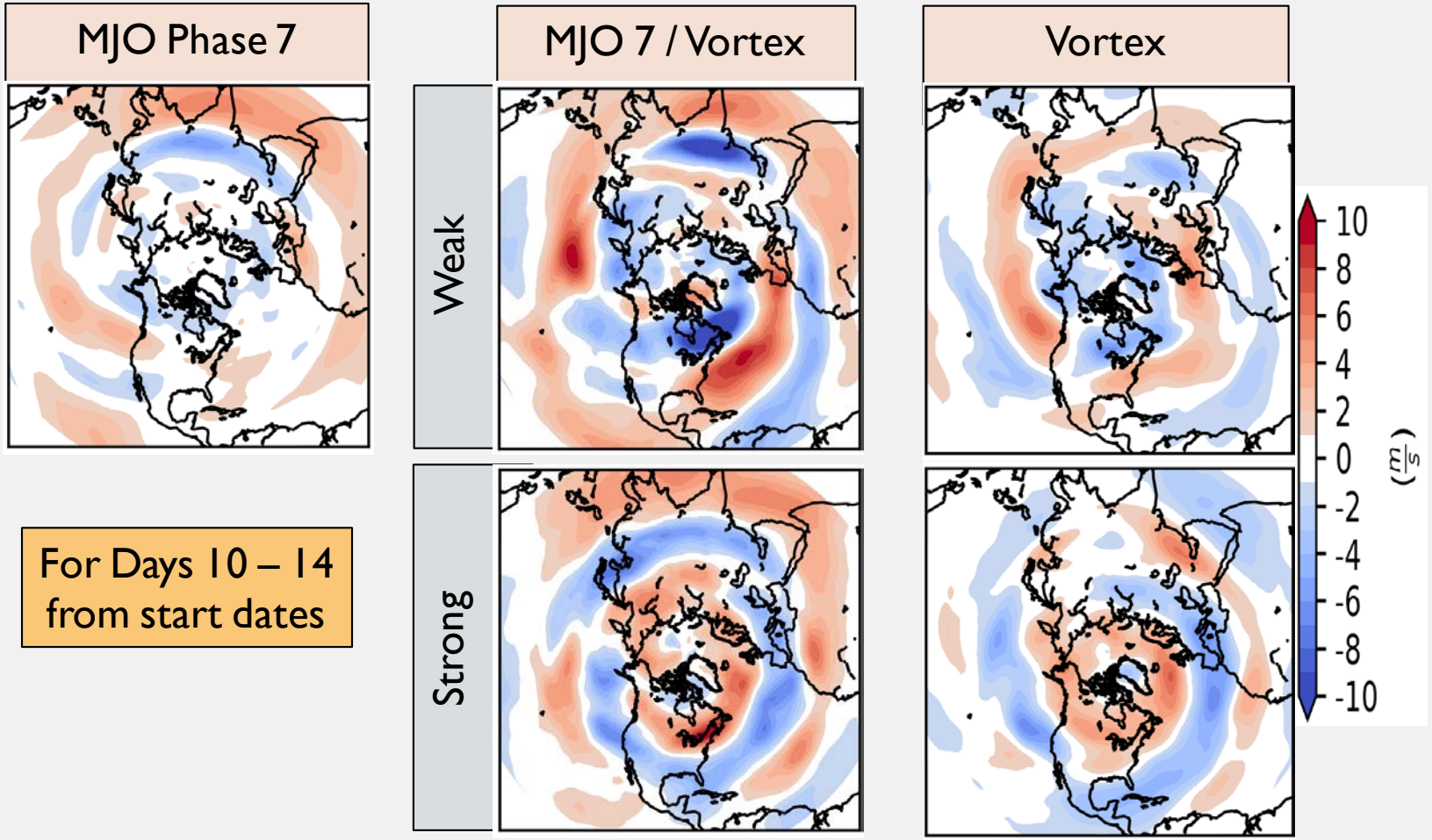
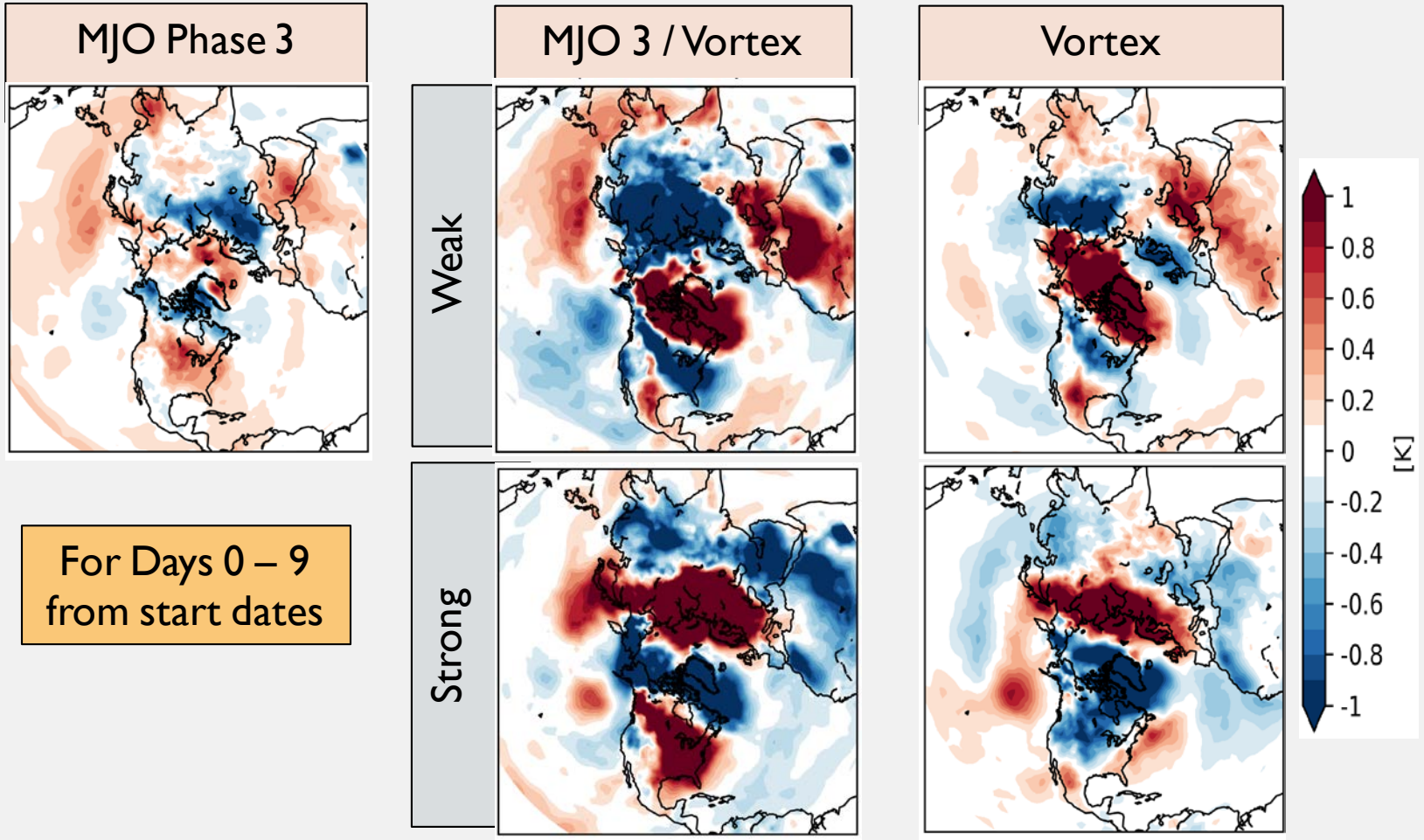
250 hPa U-wind Anomalies



For Days 10 – 14 from start dates

IMPACTS FOR **MJO 3 / VORTEX** EVENTS

Surface Air Temperature Anomalies



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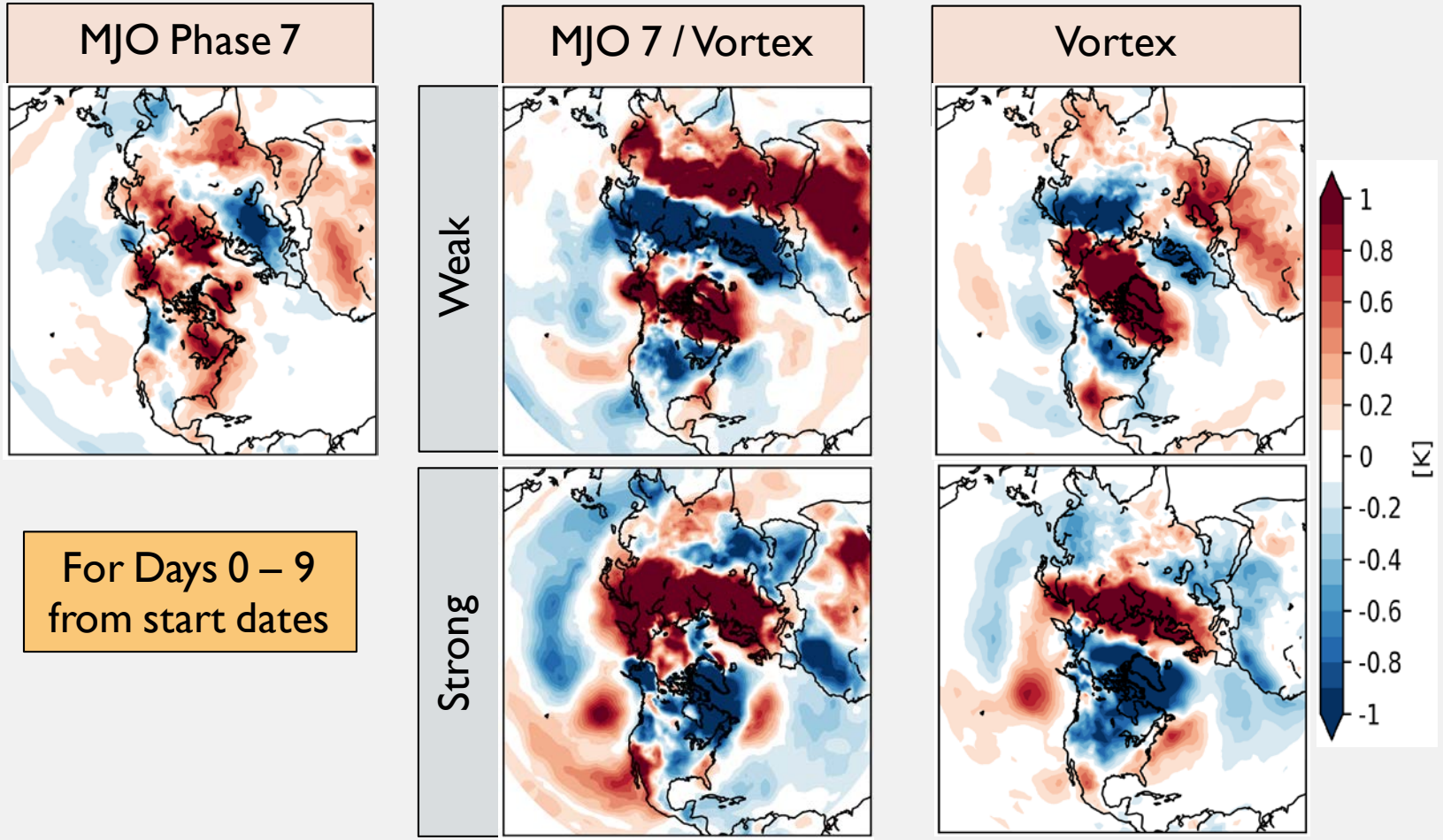

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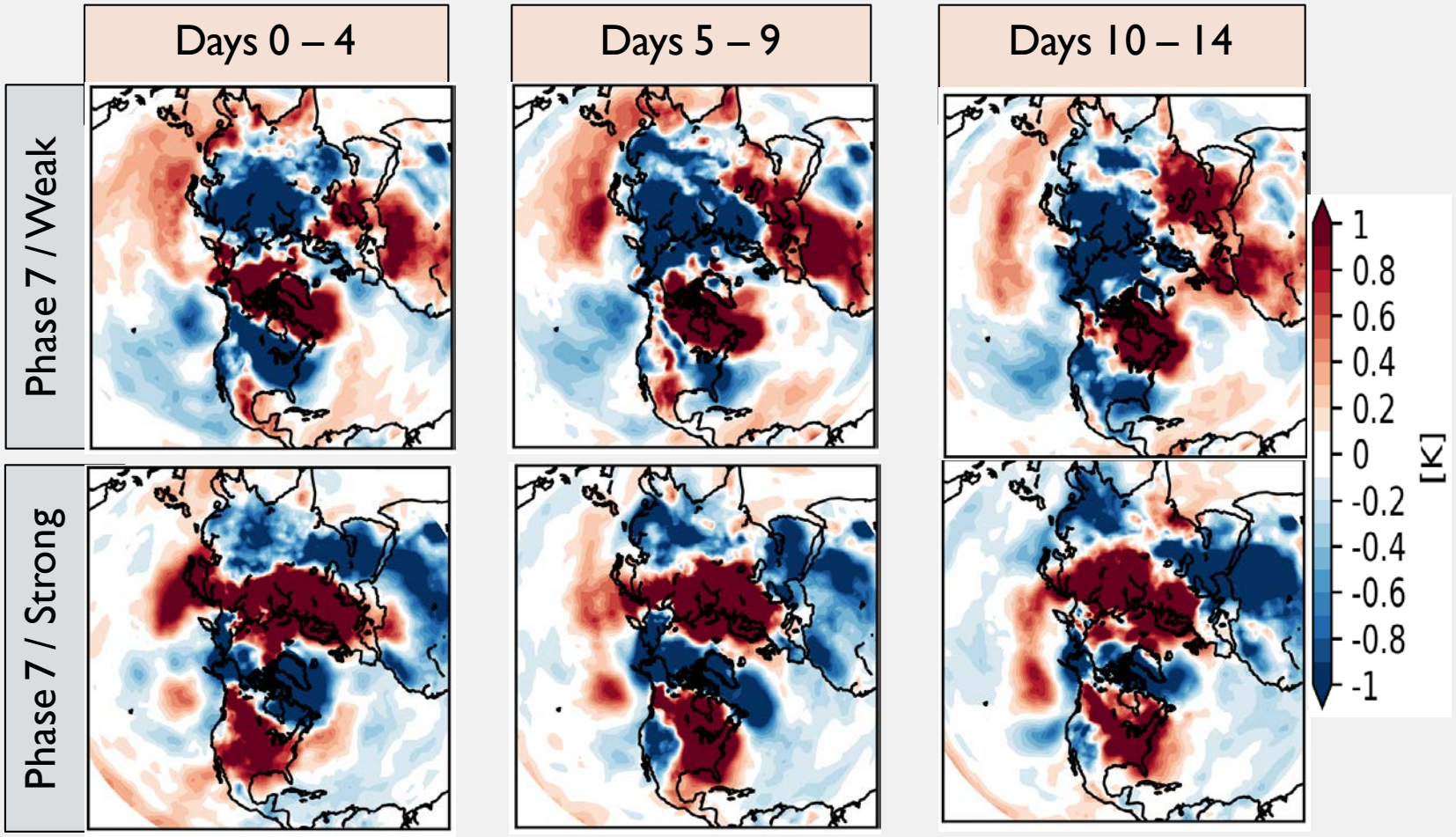
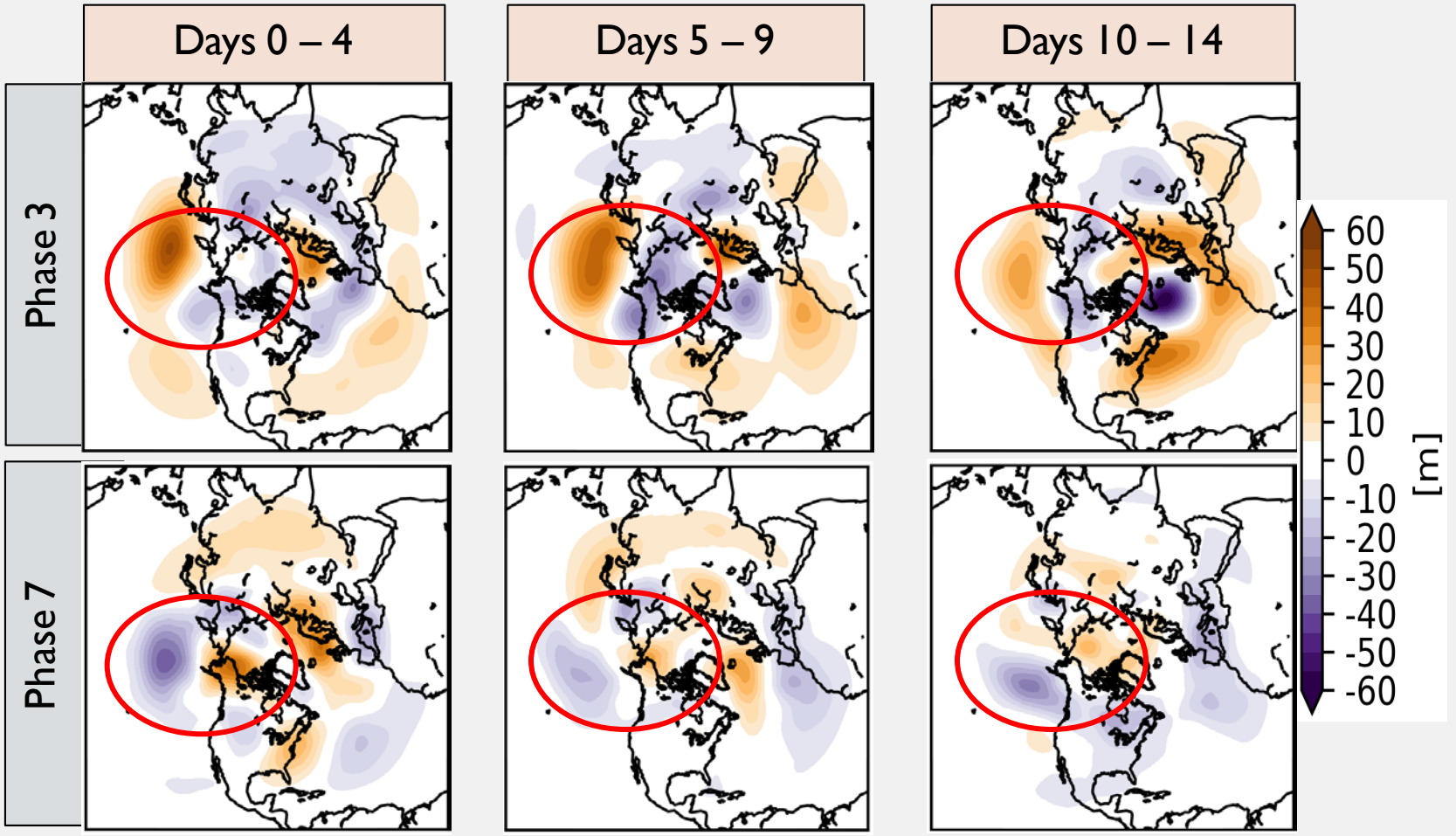
Surface Air Temperature Anomalies



UPPER-AIR PATTERNS FOR **MJO** EVENTS

500 hPa Geopotential Height Anomalies



- Focus in on the pattern in the North Pacific
- Phase 3 eastward propagating positive anomaly
- Phase 7 eastward propagating negative anomaly