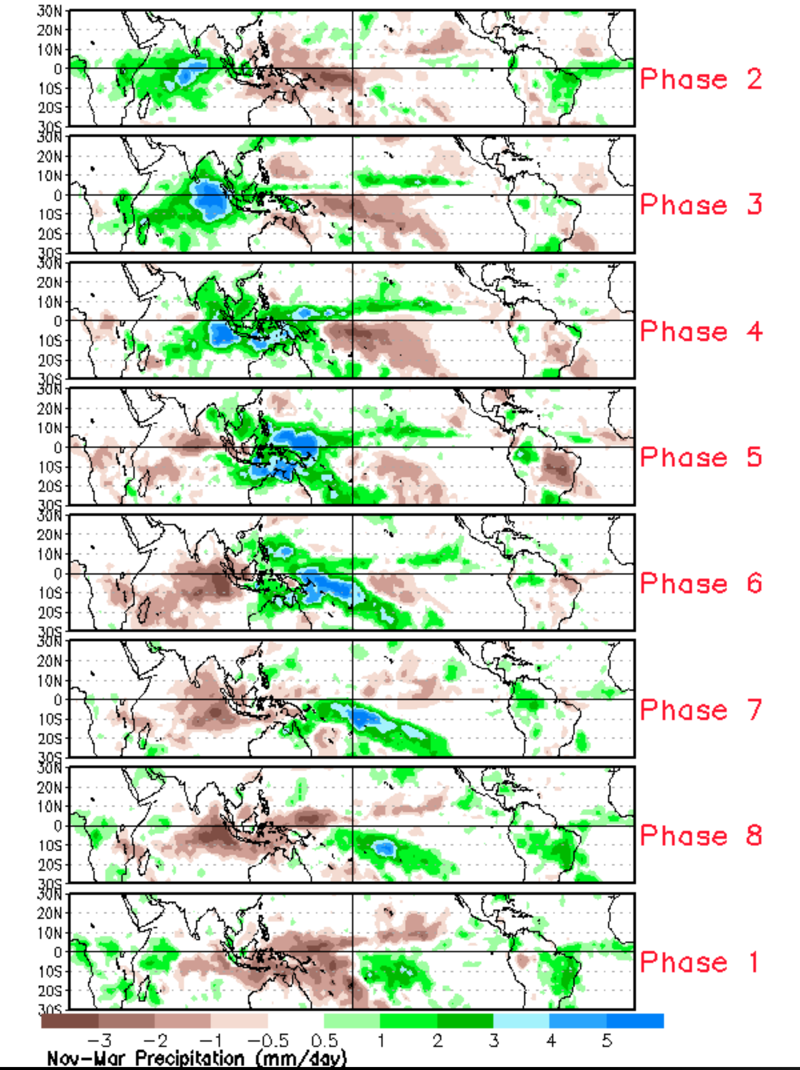
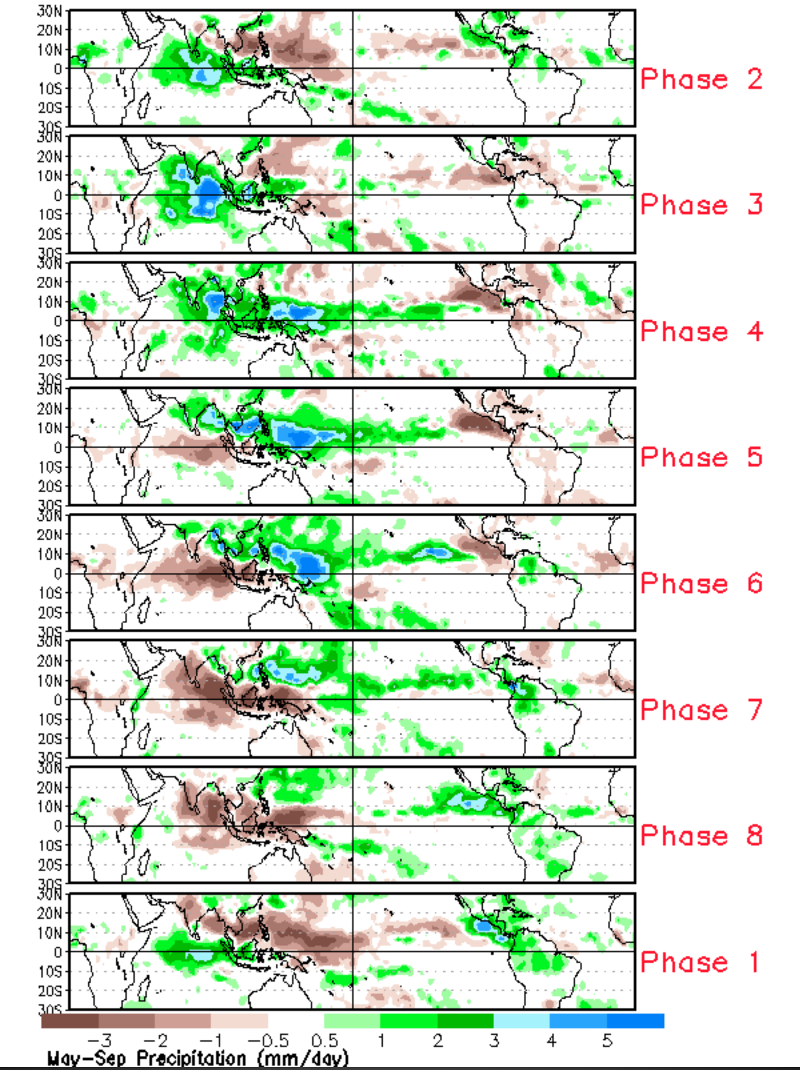
Impacts of The MJO

- Impacts on ENSO
- Impacts on Tropical Cyclones
- Impacts on the extratropical weather/climate

Boreal Winter (Nov-Mar)



Boreal Summer (May-Sep)



Precipitation

- The MJO provided an “envelope” of enhanced or suppressed convection that propagates eastward.
- The precipitation signals are particularly strong over the Asian-Australian monsoon regions, which are associated with the onset, “active” and “break” periods of Asian-Australian monsoon

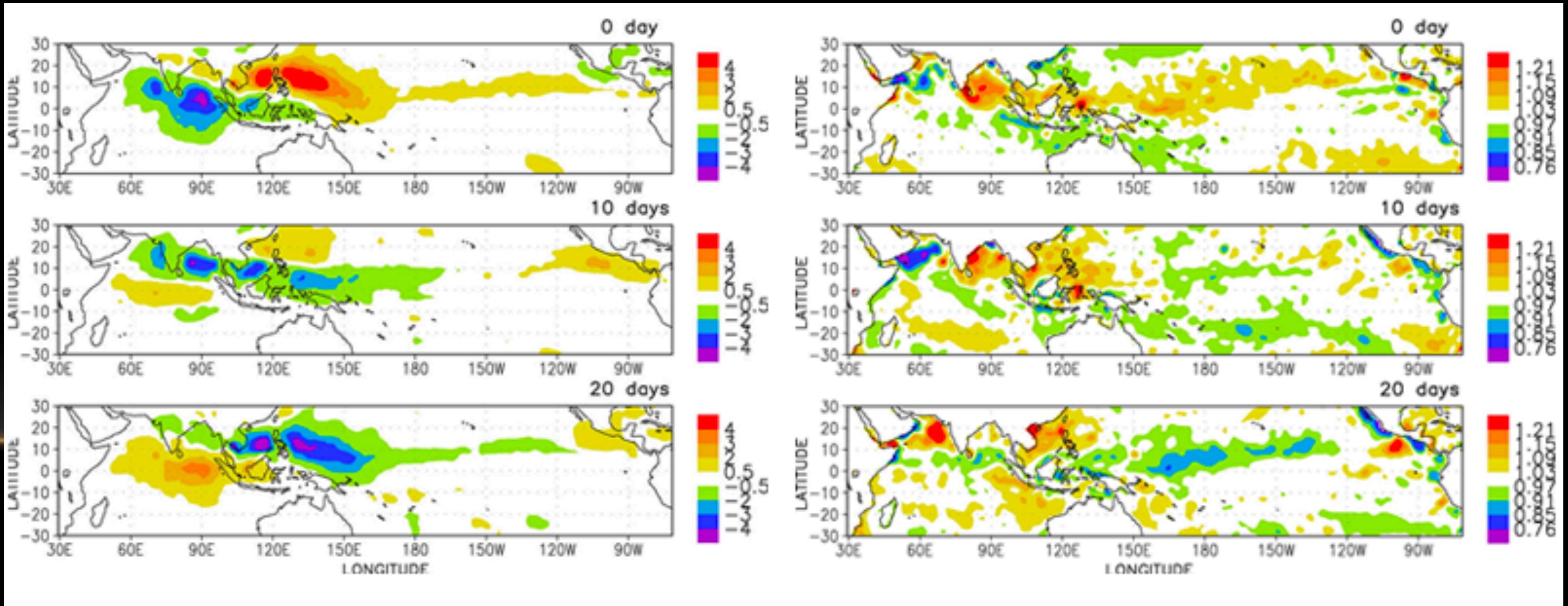
From NOAA CPC: https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/Composites/Tropical/precip.shtml

Impacts of the MJO on Ocean

- In the warm pool of the Indian and western Pacific Oceans, the MJO disturbs the ocean by modifying surface fluxes of momentum, heat, and freshwater (e.g., Zhang 1996; Hendon and Glick 1997; Jones et al. 1998); MJO induces intraseasonal perturbations in temperature, salinity, and currents of the mixed layer.
- Among the strongest signatures of oceanic responses to the MJO are intraseasonal Kelvin waves. They can be generated in the western Pacific by strong MJO events and propagate into the eastern Pacific (Kessler et al. 1995; Hendon et al. 1998). Vertical displacements of the thermocline depth associated with the Kelvin waves can induce fluctuations in sea surface temperatures (SSTs) in the central and eastern Pacific

Enhanced precipitation is associated with enhanced surface chlorophyll, with implications for the fishing industry.

(left) precipitation and (right) ocean surface Chlorophyll from SeaWiFS. From Waliser et al. 2005.



MJO and ENSO

- Impacts of MJO on the onset and growth of ENSO: Some studies suggested that MJO consists of the most effective patterns of stochastic forcing (stochastic optimals) to trigger ENSO (e.g., Lukas et al. 1984 and Lau 1985)
- MJO may contribute to ENSO activity:
  - Zonal currents forced by MJO advect warm water eastward
  - Excites oceanic Kelvin waves (downwelling, warm SSTA)

Time Series (1980-99)

Different panels represent different ENSO indices, 1+2, 3, 3.4 and 4. Thin lines represented Kelvin forcing by the MJO.

- Strong Kelvin wave forcing tends *to occur prior to the peaks of ENSO warm events for all major events.*
- Precursory signals of anomalously strong Kelvin wave forcing were absent from weak ENSO warm events (1992/93 and 1994/95) and cold events (1987/88 and 1998/99).
- Many strong Kelvin wave forcing episodes were not followed by any warm event.

- The MJO can accelerate the growth and amplify the strength of an ENSO warm event, although ENSO can occur without any MJO trigger.
- The timing and amplitude of an ENSO warm event might be better predicted if MJO activities are better represented in numerical models.

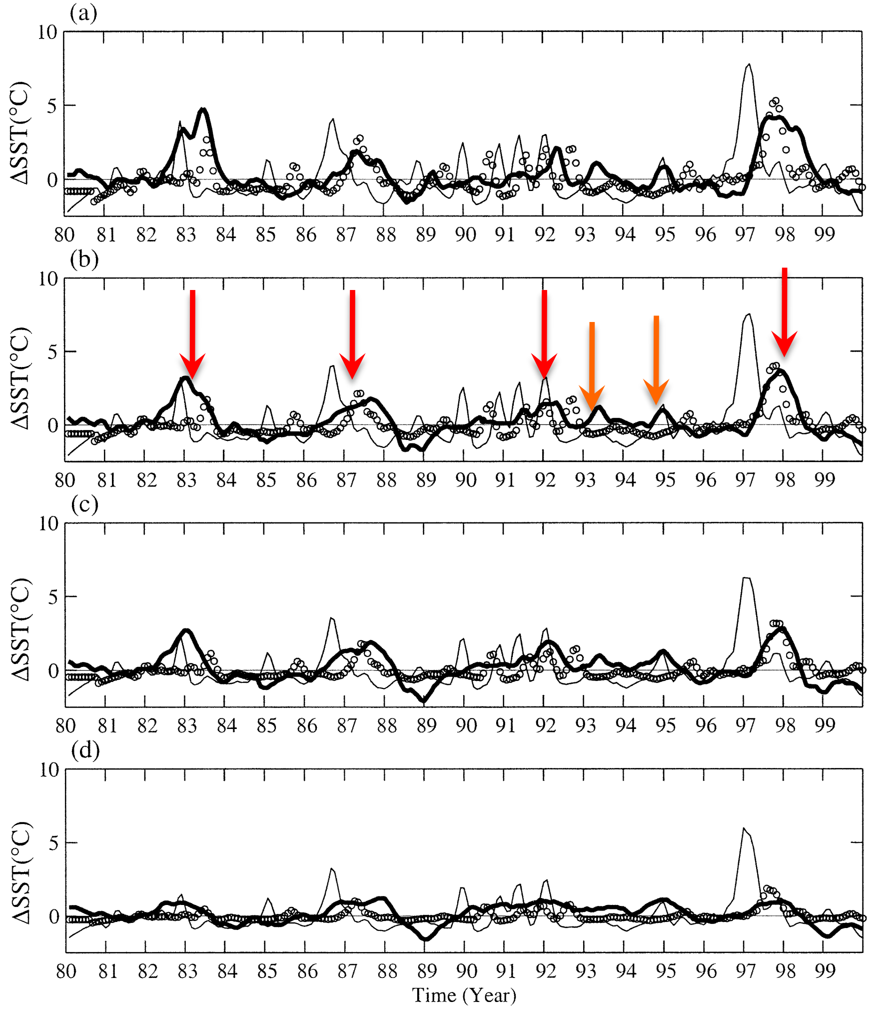
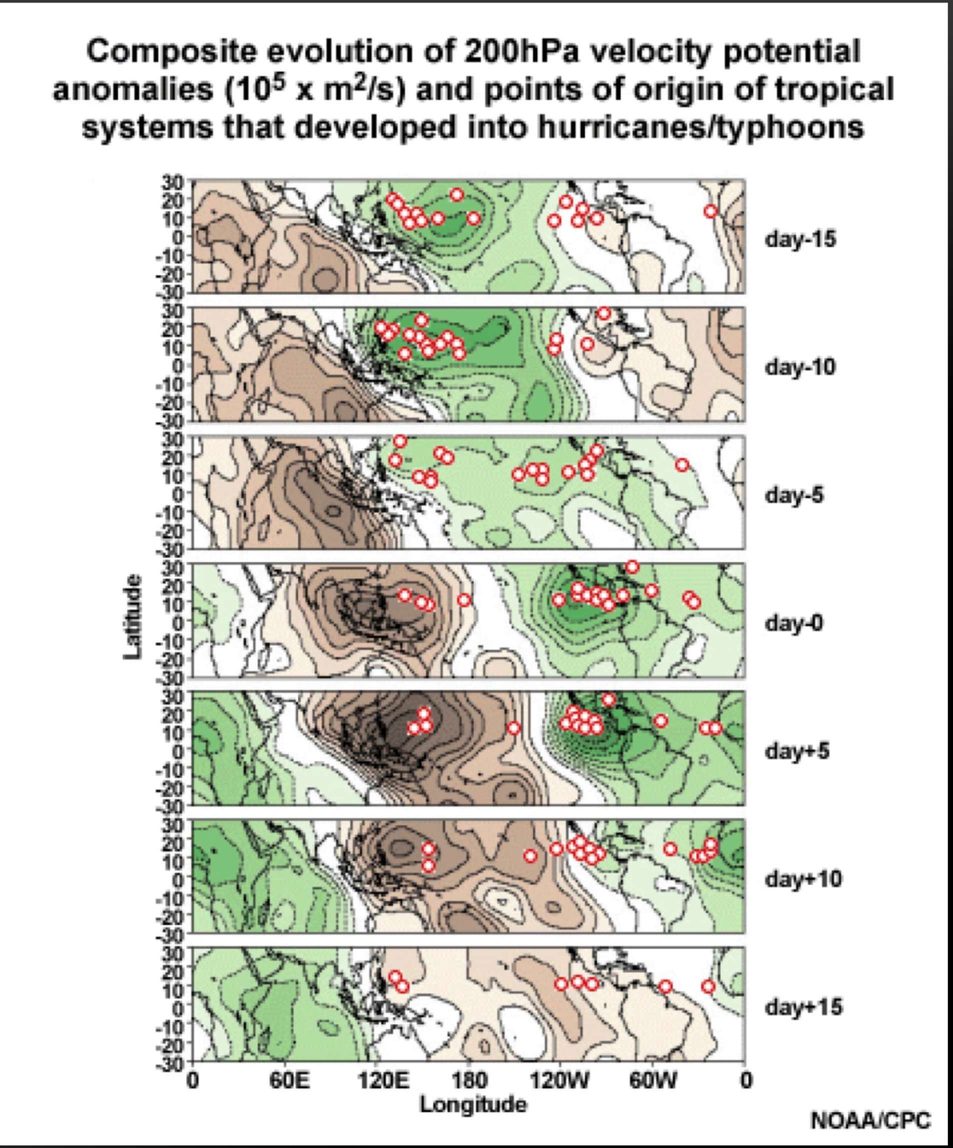


FIG. 5. Time series of interannual anomalies in seasonal variance of Kelvin wave forcing by the MJO ($\Delta\sigma_{K_{MJO}}$, thin solid lines), interannual anomalies in SST (ΔSST, thick solid), and regression of ΔSST upon $\Delta\sigma_{K_{MJO}}$ (circles) for regions of (a) Niño-1+2, (b) Niño-3, (c) Niño-3.4, and (d) Niño-4. The time series of $\Delta\sigma_{K_{MJO}}$ are from longitudes of maximum correlation shown in Fig. 4. Vertical axes are for temperatures in °C. Amplitudes of $\Delta\sigma_{K_{MJO}}$ are rescaled to fit in the figures.

MJO and Tropical Cyclones

- Tropical cyclogenesis is more likely in the region of active convection associated with the MJO.
- As the MJO progresses eastward, the favored region for tropical cyclone activity also shifts eastward from the western Pacific to the eastern Pacific and finally to the Atlantic basin.
- MJO can modulate tropical cyclone activity by changing the large-scale environment:
  - the MJO-related descending (ascending) motion tends to suppress (enhance) tropical cyclone development.
  - The MJO-related vertical wind shear and humidity anomalies can also modulate TC activity.



VP200 in shading. Green colors indicate the upper-level divergence or enhanced convection. Red circles represent TCG locations.

MJO and Atlantic Tropical Cyclones

- Maloney and Hartmann (2000) found that more than twice the number of tropical cyclones exist in phase 1 or phase 2 (>=56) than in phase 6 (27).
- In another study, Maloney and Hartmann (2000) found that hurricane genesis in Gulf of Mexico and western Caribbean is **four** times more likely when MJO wind anomalies in the lower troposphere are westerly in the eastern Pacific than when the MJO wind anomalies are easterly.
- The MJO is monitored routinely by both the National Hurricane Center and the Climate Prediction Center during the Atlantic hurricane season to aid in anticipating periods of relative activity or inactivity.

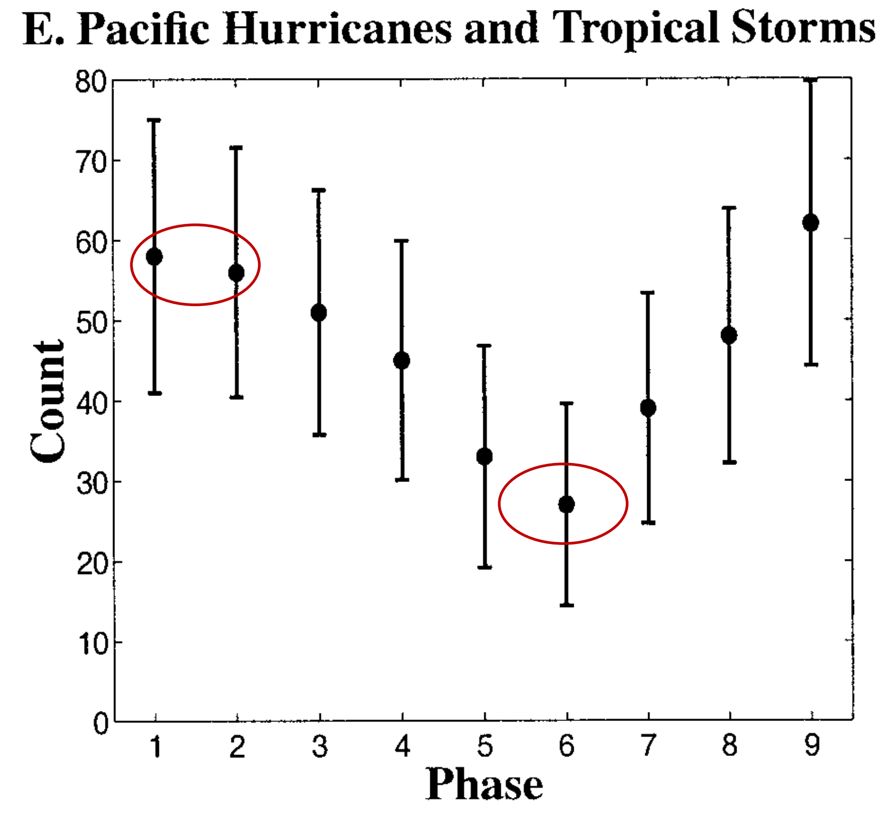


FIG. 10. Number of hurricanes and tropical storms as a function of MJO phase for the eastern Pacific Ocean hurricane region during May–Nov 1979–95. Error bars represent 95% confidence limits.

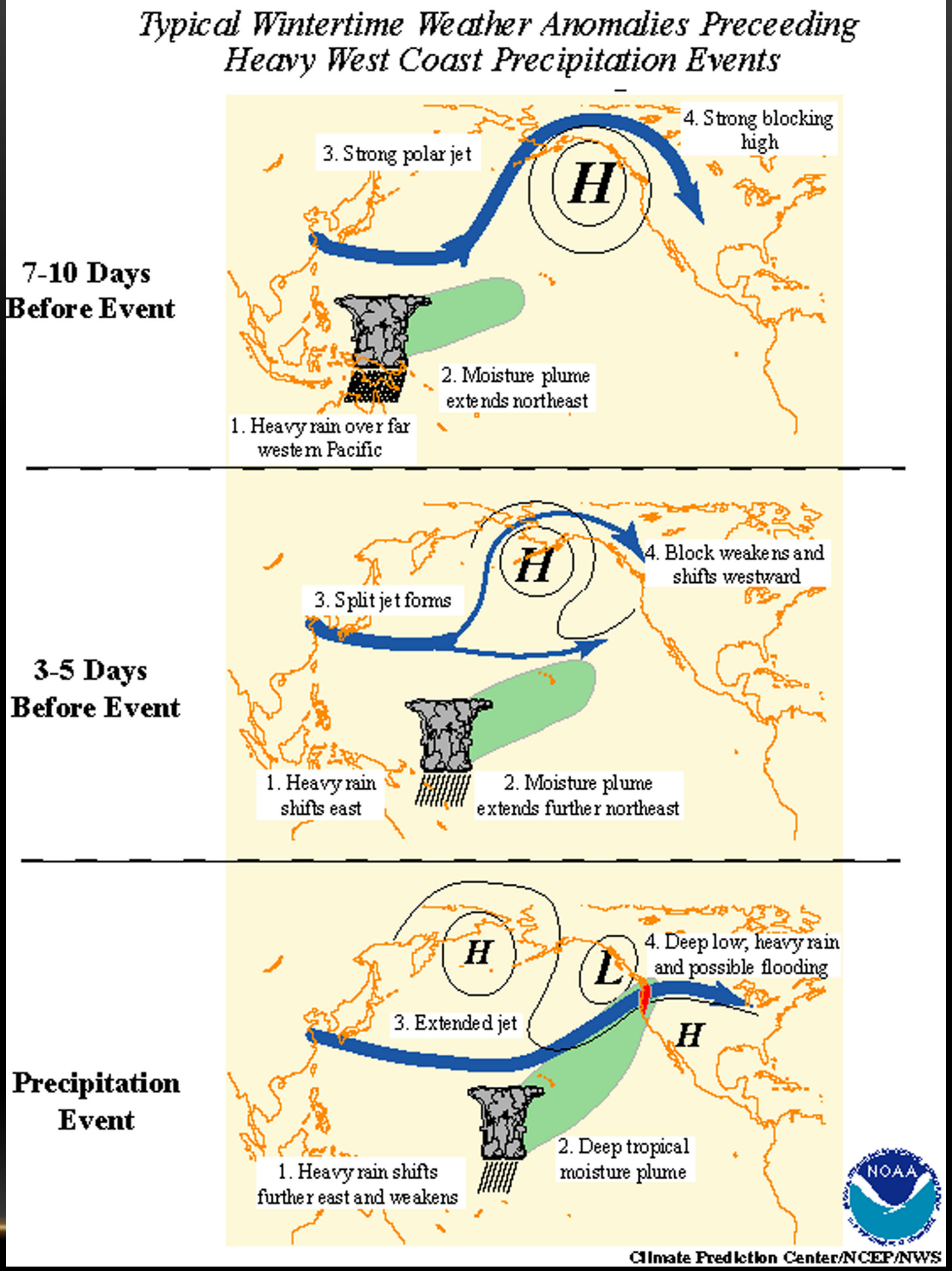
Impacts on Western North America

What is the typical scenario linking intraseasonal oscillations to heavy precipitation events in the western U.S.? (From NOAA CPC)

(1) 7-10 days prior to the heavy precipitation event: the MJO convection center shifts eastward from the eastern Indian Ocean to the western tropical Pacific. A moisture plume extends the Hawaiian Islands. A strong blocking anticyclone is located in the Gulf of Alaska with a strong polar jet stream around its northern flank.

(2) 3-5 days prior to the heavy precipitation event: Heavy tropical rainfall shifts towards the date line . The associated moisture plume extends further to the northeast. The strong blocking high weakens and shifts westward. A split in the North Pacific jet stream develops. A midlatitude trough develops to the east of the blocking high.

(3) The heavy precipitation event: As the pattern of enhanced tropical rainfall continues to shift further to the east and weaken, the deep tropical moisture plume extends to the west coast of North America. The jet stream enters North America in the northwestern United States. Deep low pressure located near the Pacific Northwest coast can bring up heavy rain and possible flooding. These events are often referred to as "pineapple express" events, so named because a significant amount of the deep tropical moisture traverses the Hawaiian Islands towards western North America.



MJO and Blocking (boreal winter)

- Blocking frequency in east Pacific and Atlantic blocking decreases significantly following phase 3 of the MJO, which is characterized by enhanced convection over the tropical East Indian Ocean.
- The phase 7 of MJO is followed by a significant increase in the East Pacific and Atlantic blocking.

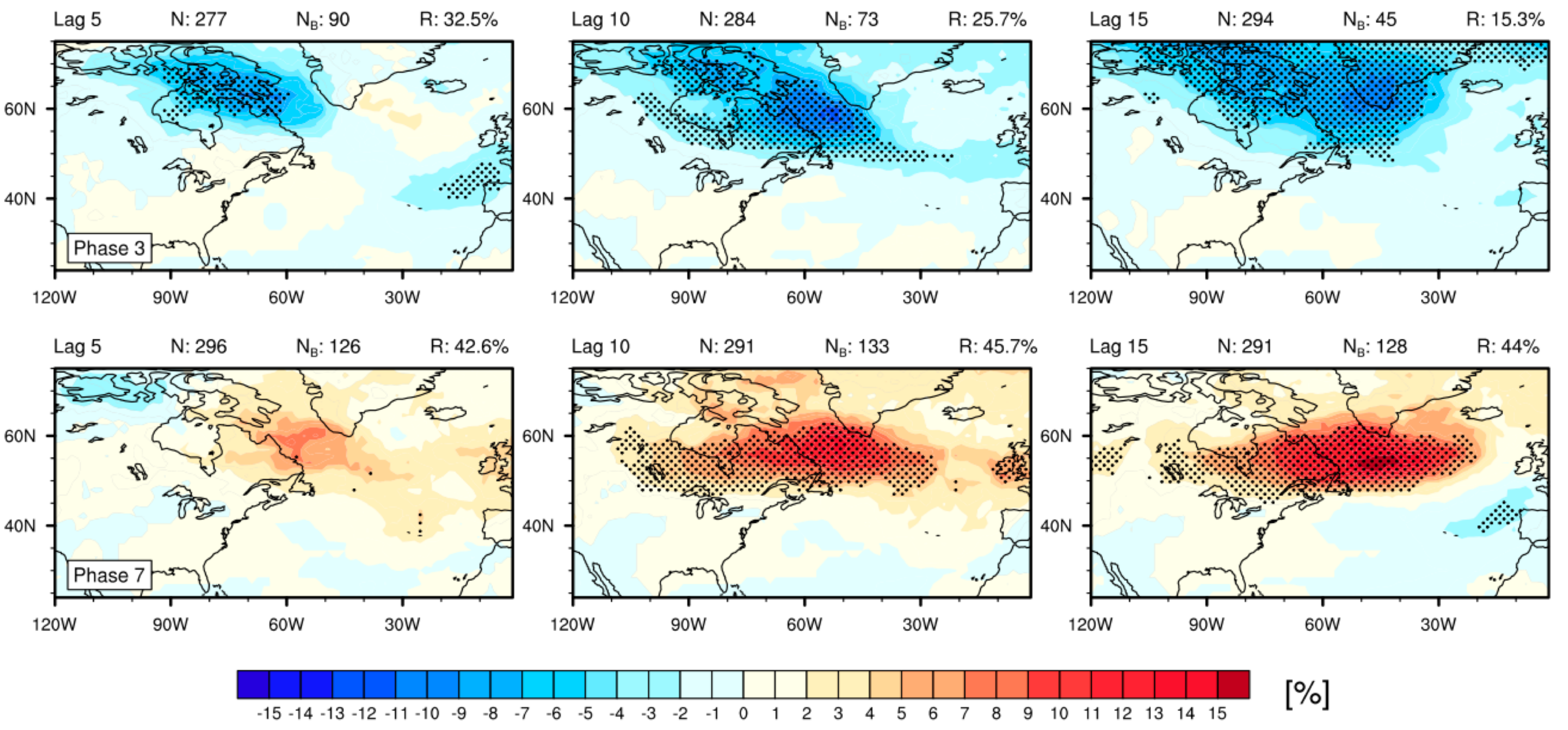


FIG. 7. Atlantic blocking frequency anomalies as determined by Eq. (1) for MJO phases (top) 3 and (bottom) 7. Shown are (left) lag 5, (middle) lag 10, and (right) lag 15, where a lag *n* represents the blocking frequency *n* days after the MJO phase. Blocking frequencies are shown as a deviation from the DJF mean. Black dotting demonstrates the anomalies found to be 95% significantly different from zero. For explanation of the values above each panel, see section 2c.

References

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