Kelvin Waves and Tropical Cyclogenesis in a Lagrangian Framework

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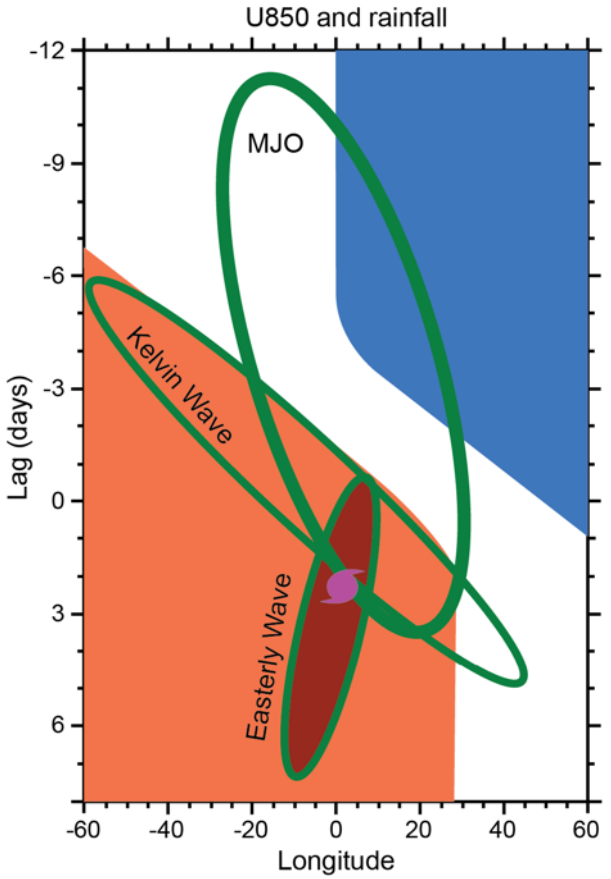
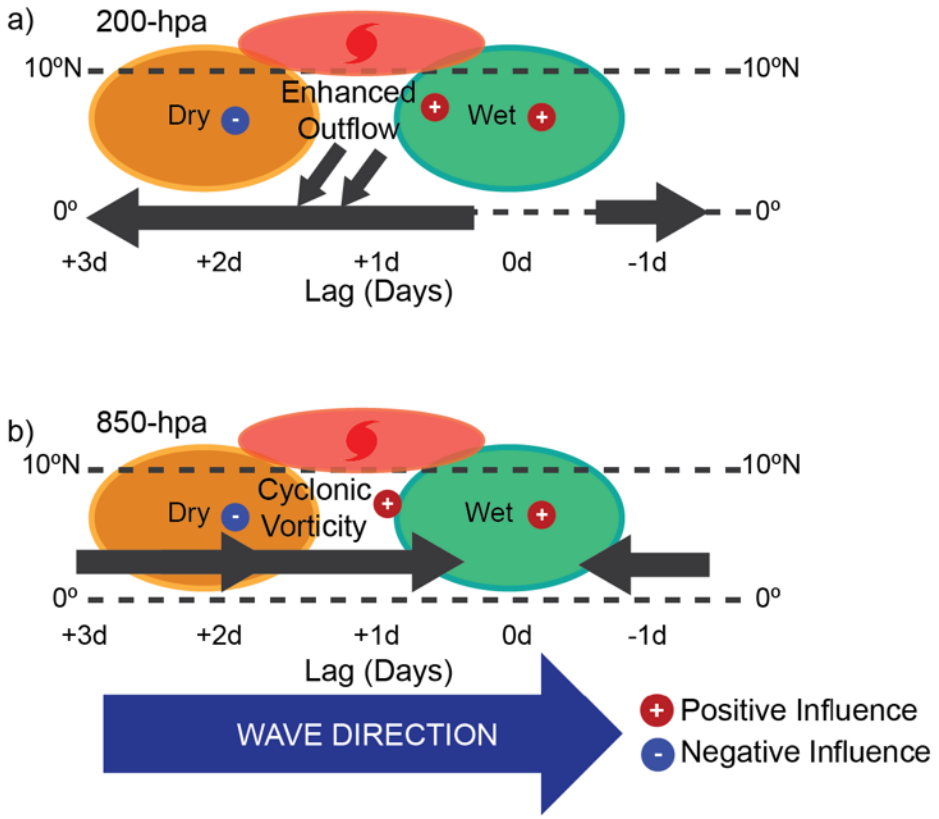
Kelvin Waves and Tropical Cyclogenesis

- Convectively Coupled Kelvin Waves
  - Eastward propagation at 10–20 m s−1
  - 3–10 day period, 2000–4000 km wavelength
- Storms typically form 0–3 days after the Kelvin wave's convective peak
- Often interacting with MJO and Easterly Waves during genesis



Schreck (2015, MWR)

Effects on Genesis



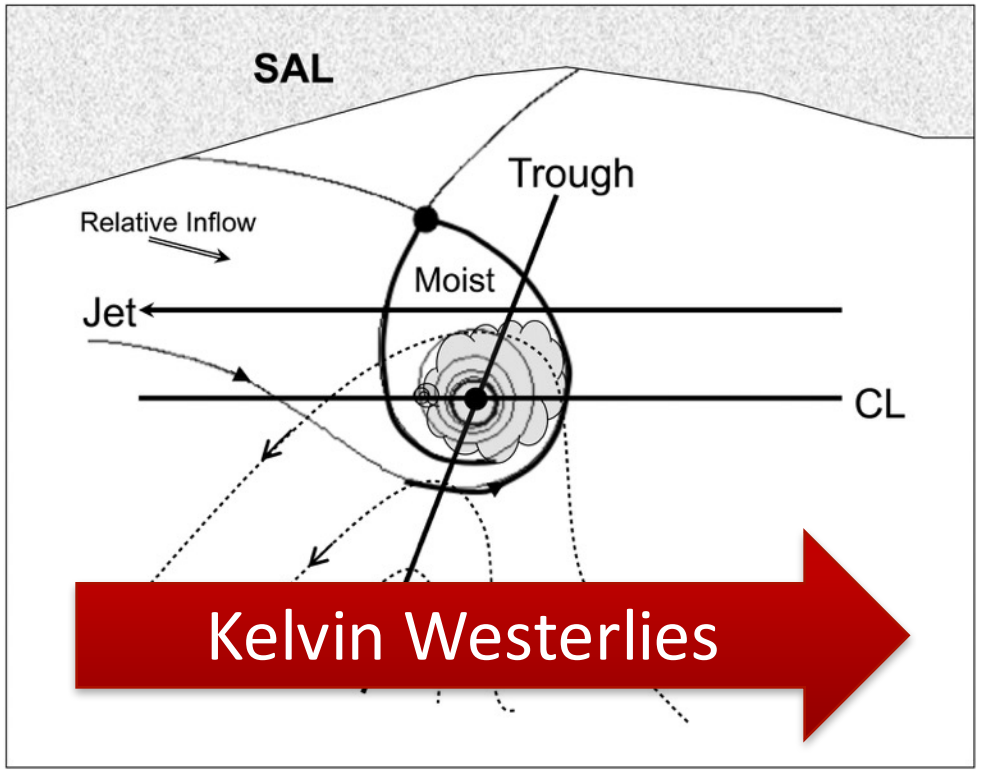
Schreck (2015, MWR)

- Kelvin waves modulate key ingredients for genesis
  - Low-level vorticity
  - Convection
  - Vertical Shear
- Kelvin winds persist after the convection becomes suppressed

Kelvin Waves and Pouches

Given that Kelvin waves often interact with Easterly Waves in genesis…

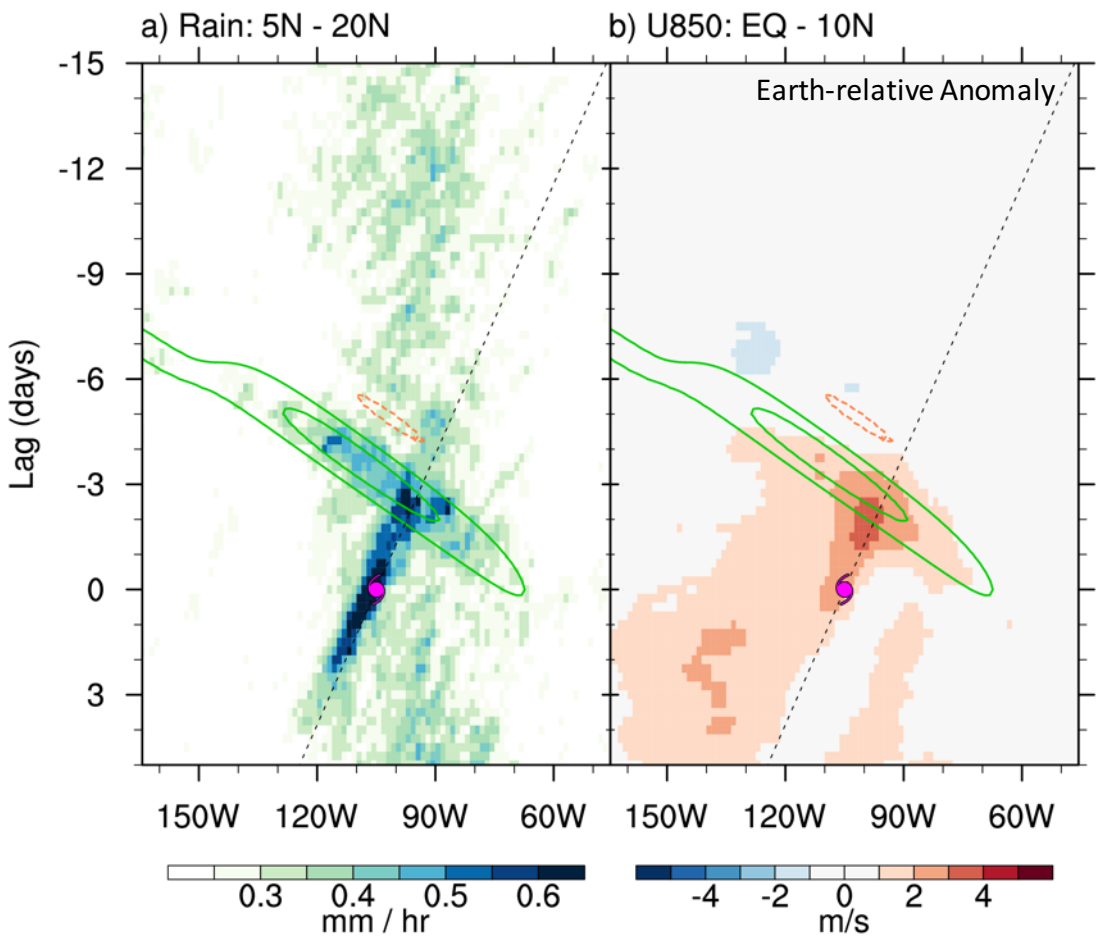
Could the Kelvin waves be playing a role in closing the Easterly Waves semi-Lagrangian Circulation?



*Schematic of an easterly wave's pouch. Adapted from Wang et al. 2010, J. Atmos. Sci., **67**, 1711-1729).*

Estimating Phase Speed

East Pacific: 40 storms



- Composite Hovmöllers of storms forming at the most favorable lags from Kelvin wave crest
- Estimate 5-m s^{-1} phase speed from these composites
- Examine semi–Lagrangian evolution by subtracting this speed from composite zonal winds

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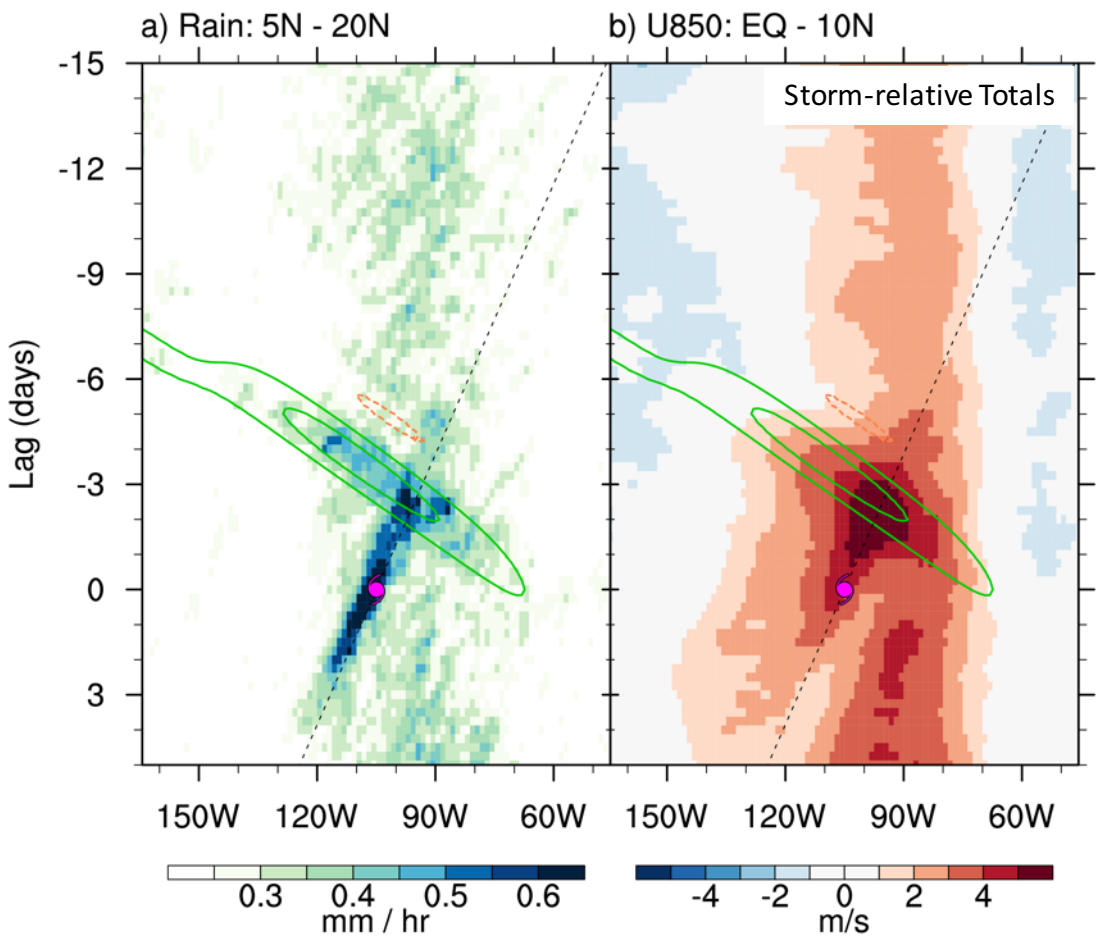

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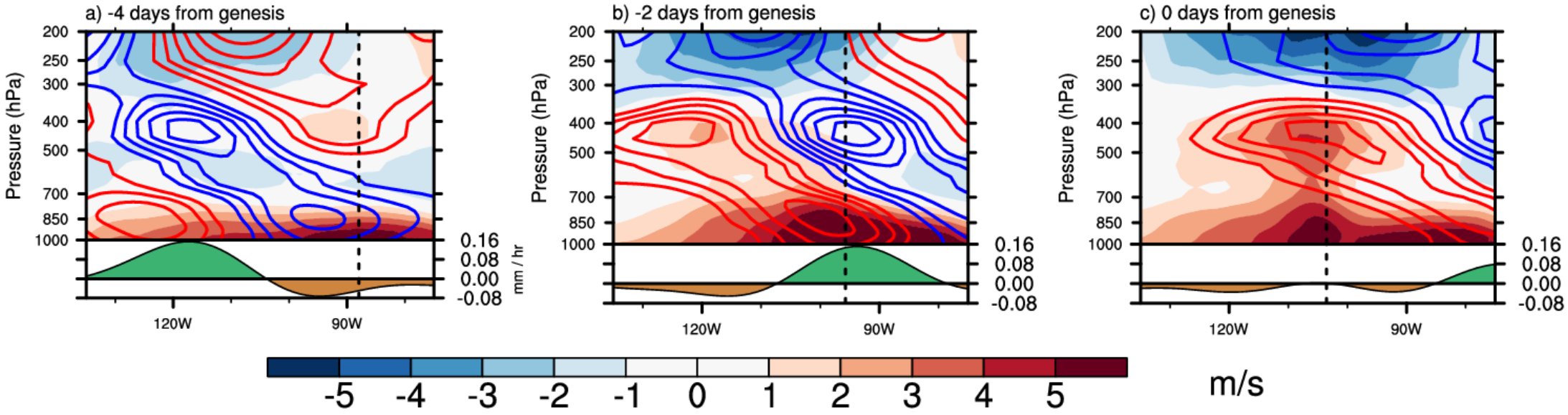
Vertical Structure

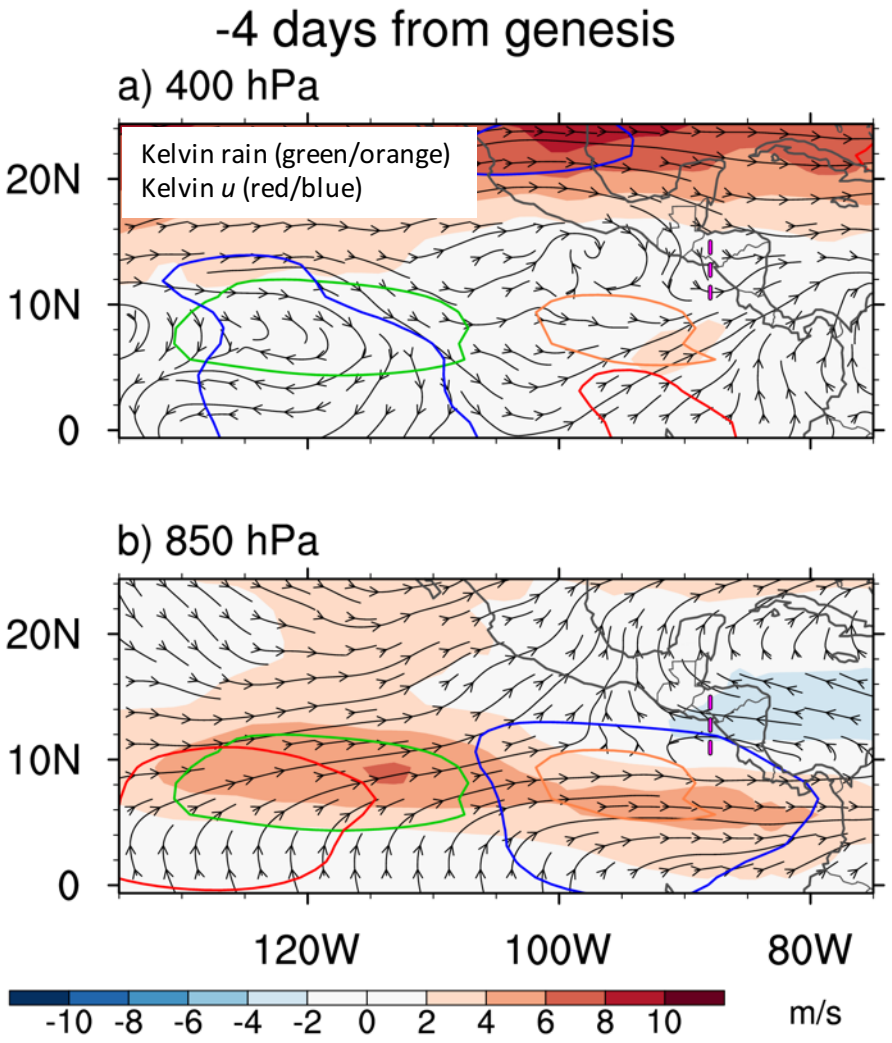
East Pacific Zonal Wind Eq–10°N



- Convection and storm-relative westerlies intersect easterly wave 2 days before genesis
- Easterly wave circulation builds upward as the Kelvin wave propagates

- Kelvin tilt might explain lag in genesis from convection
  - 400-hPa is 30° longitude behind 850-hPa
  - Kelvin speed of 15 m s^{-1} gives a 2.5-day lag between 850 hPa and 400 hPa

Storm-Relative Zonal Winds



- Broad, persistent 850-hPa Westerlies
- 400-hPa westerlies develop with Kelvin wave

- 2 Days before Genesis
  - Kelvin wave enhances 850-hPa westerlies and rain
  - Kelvin easterlies at 400-hPa counter Easterly wave
- At Genesis:
  - Kelvin wave no long effects 850-hPa winds or rainfall
  - At 400-hPa, Kelvin wave helps close circulation

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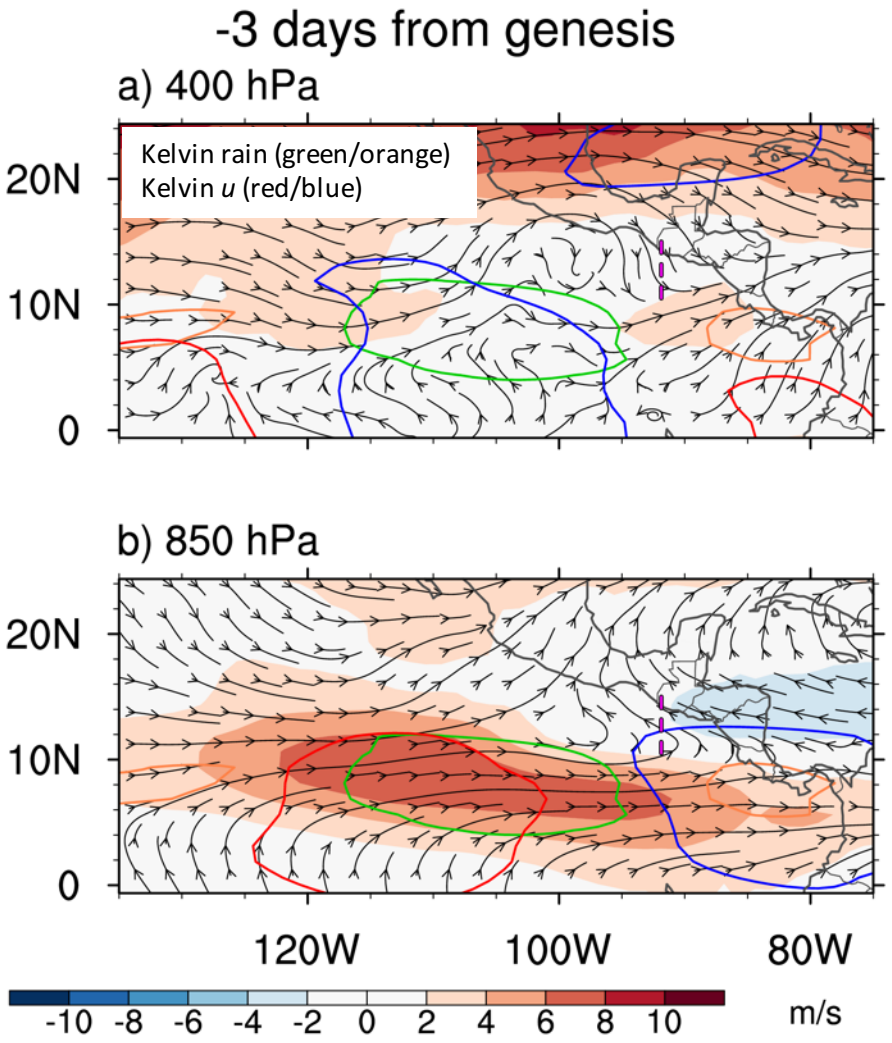

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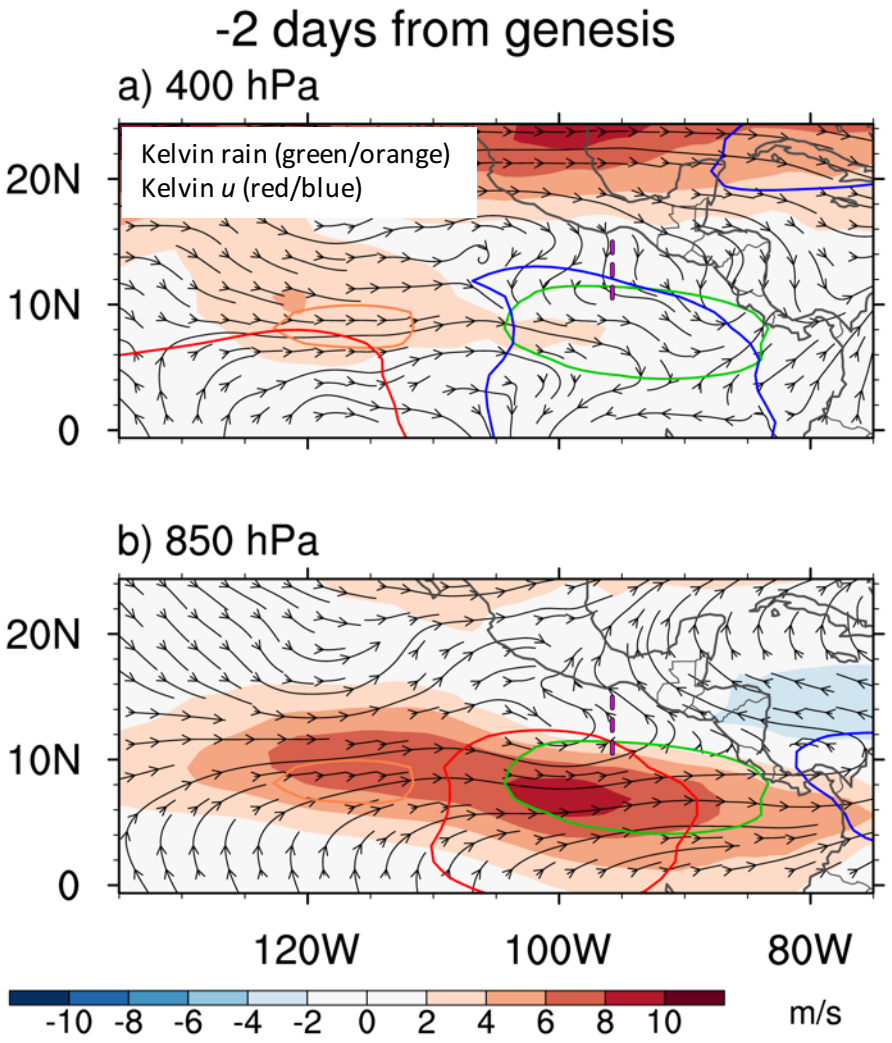

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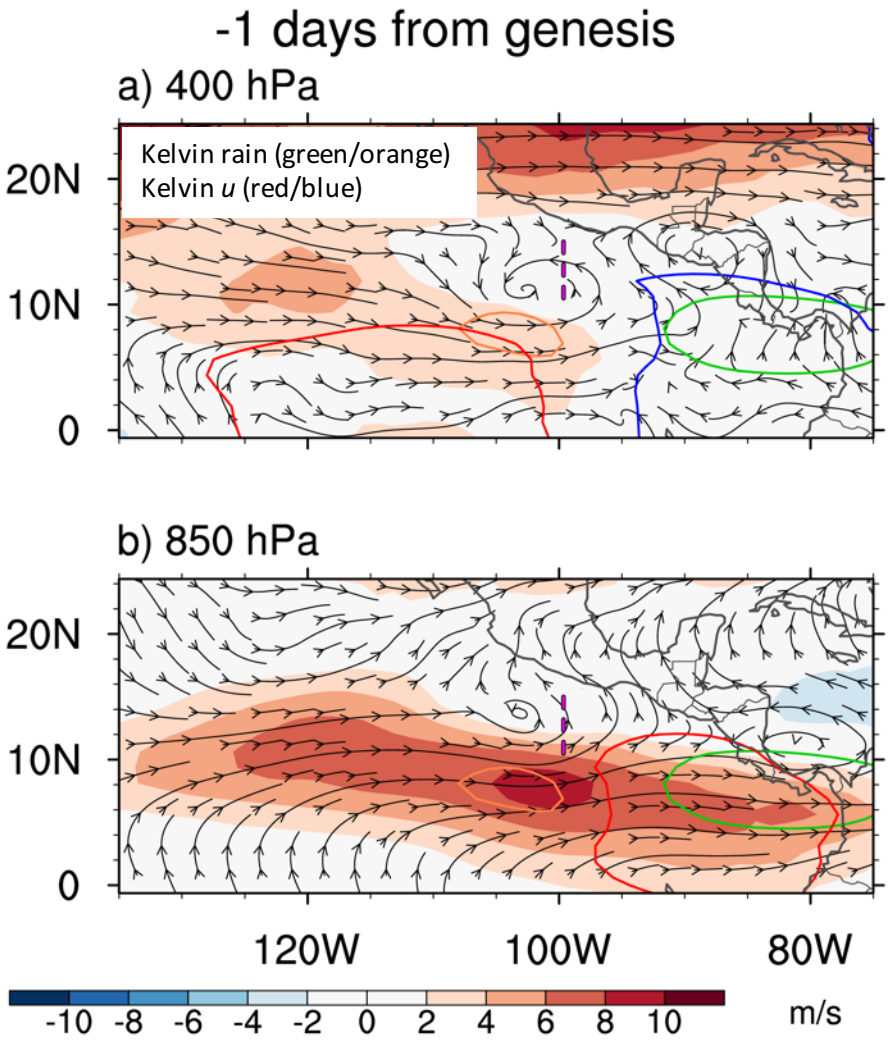

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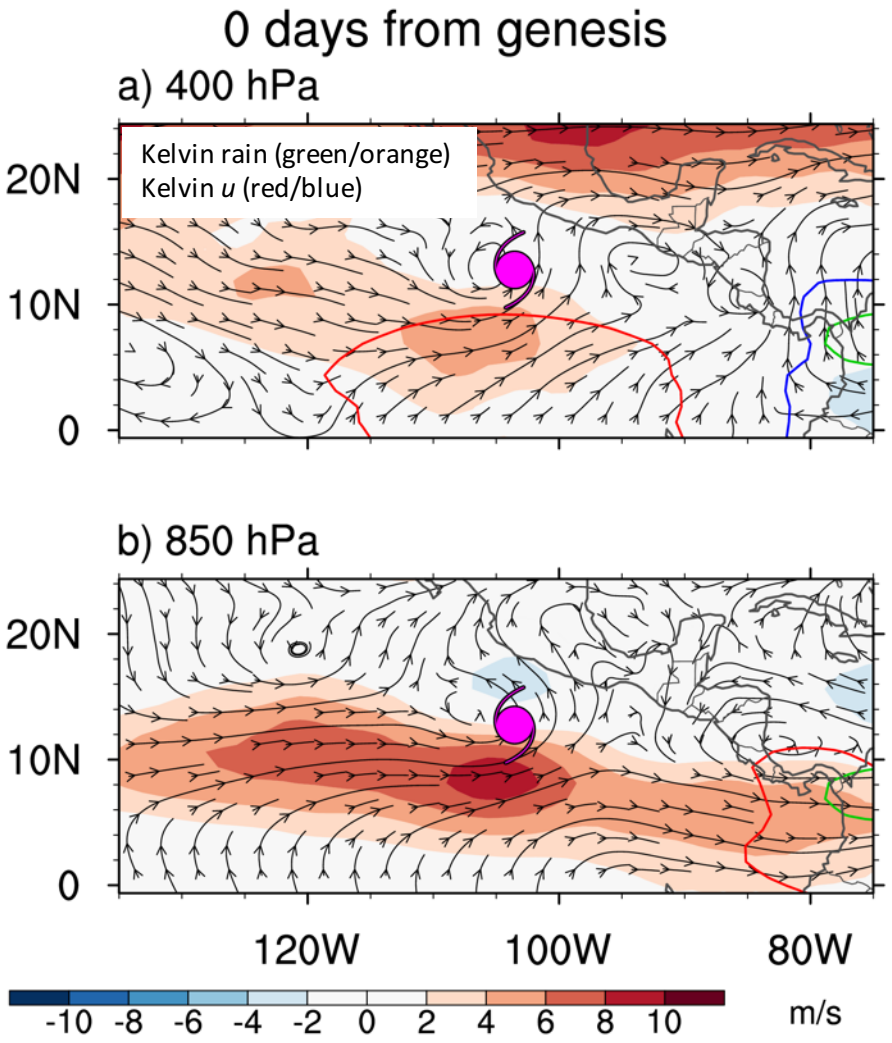

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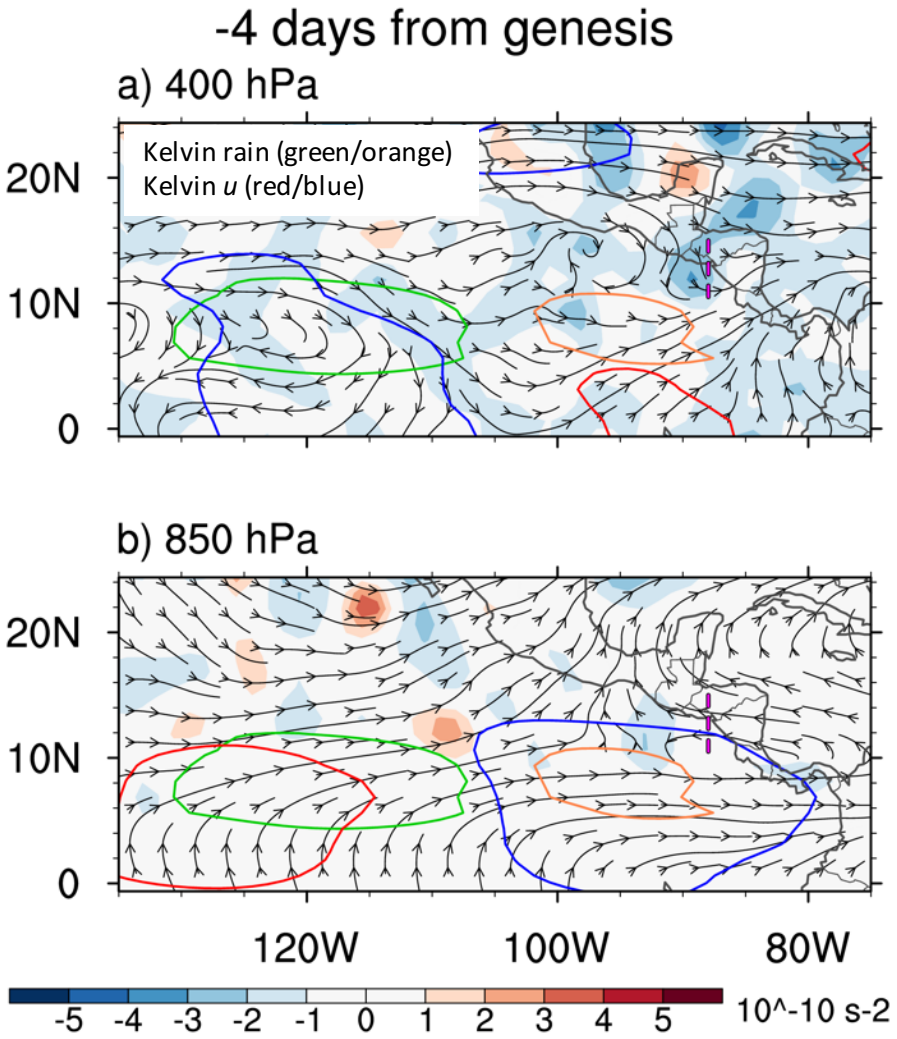
Okubo–Weiss Parameter



- Positive values first appear at 850-hPa when intersecting with the Kelvin wave 2 days before genesis

- 400-hPa positive values develop as the Kelvin wave approaches 1 day before genesis

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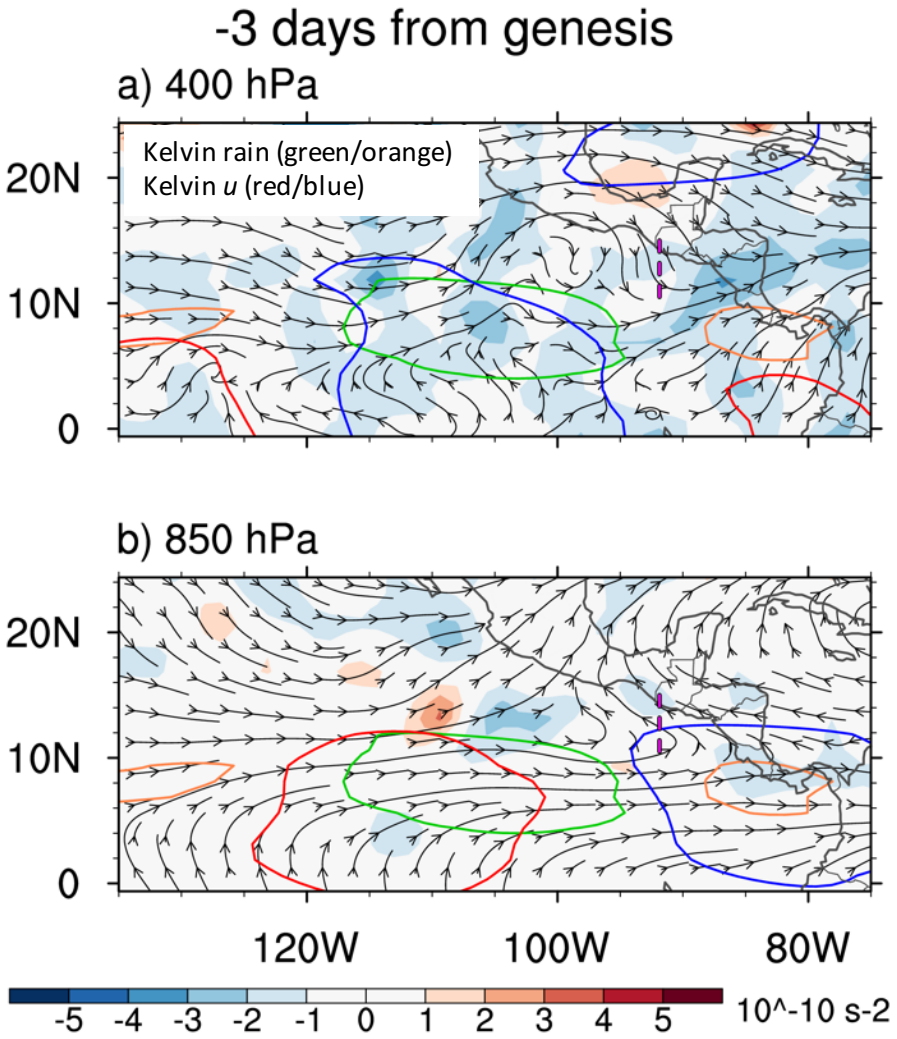

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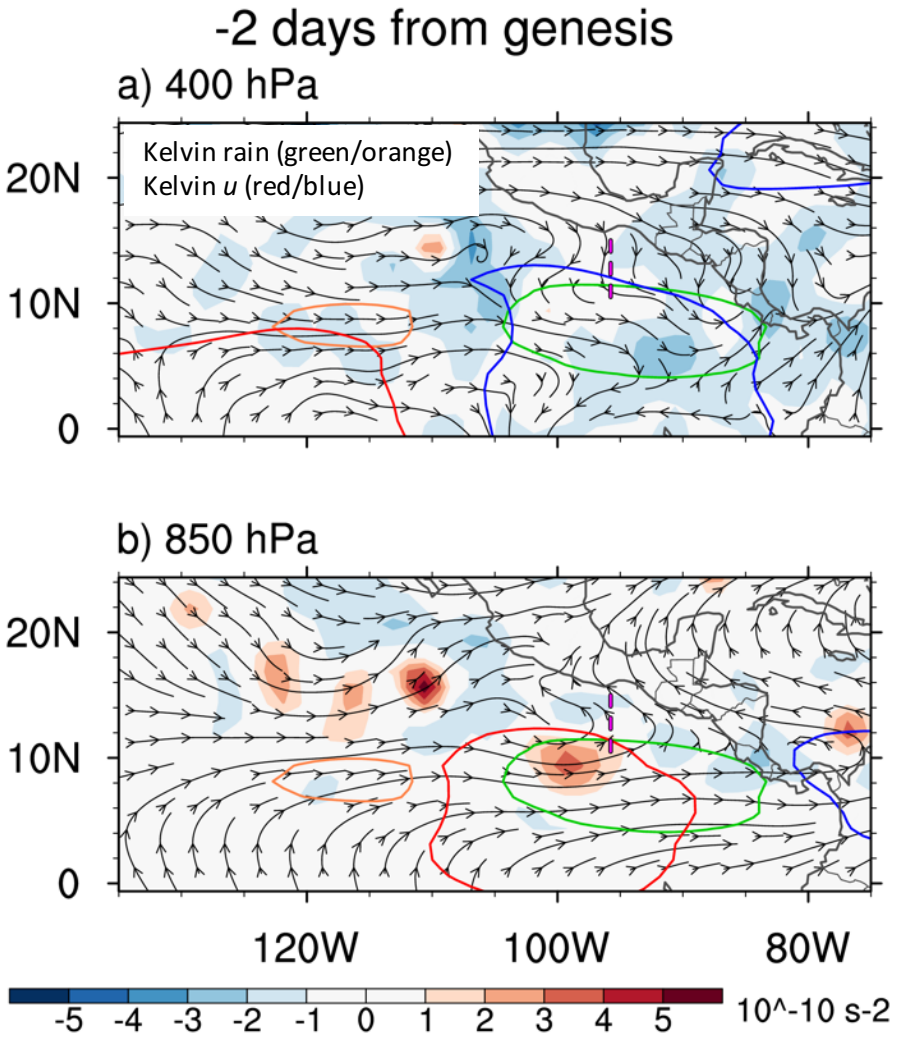

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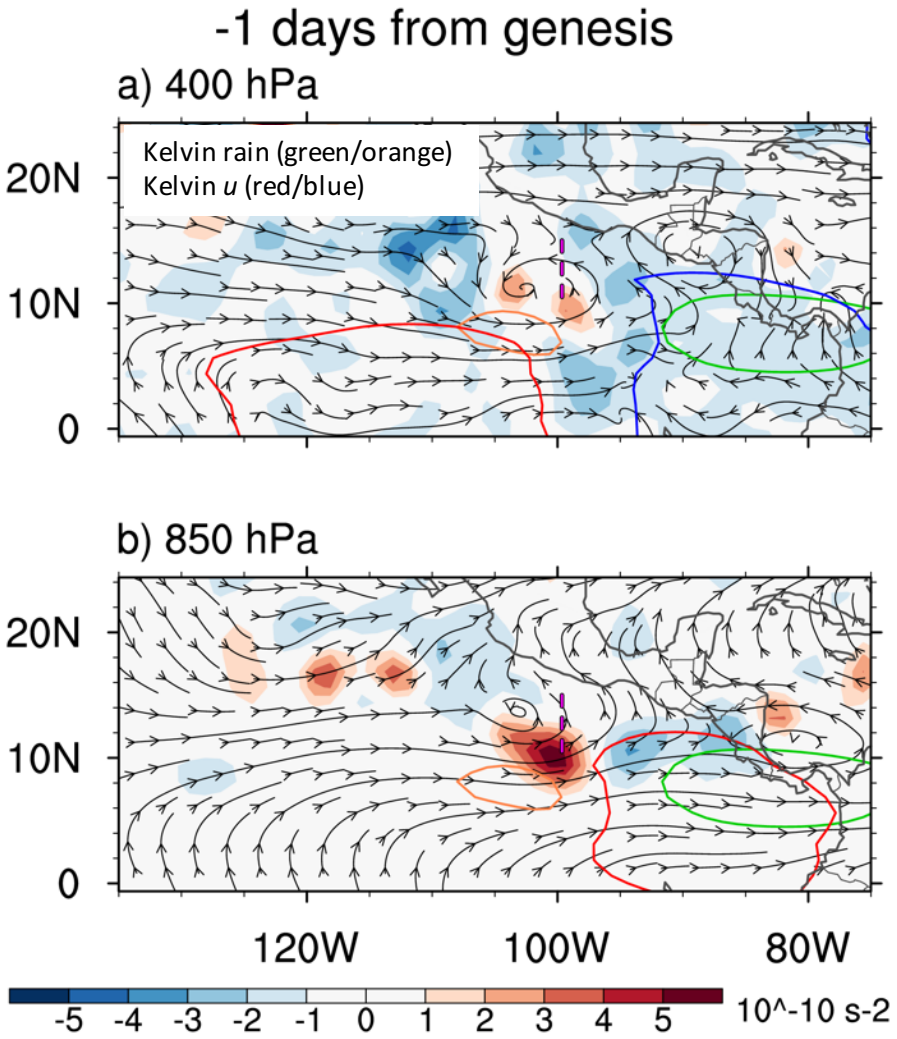

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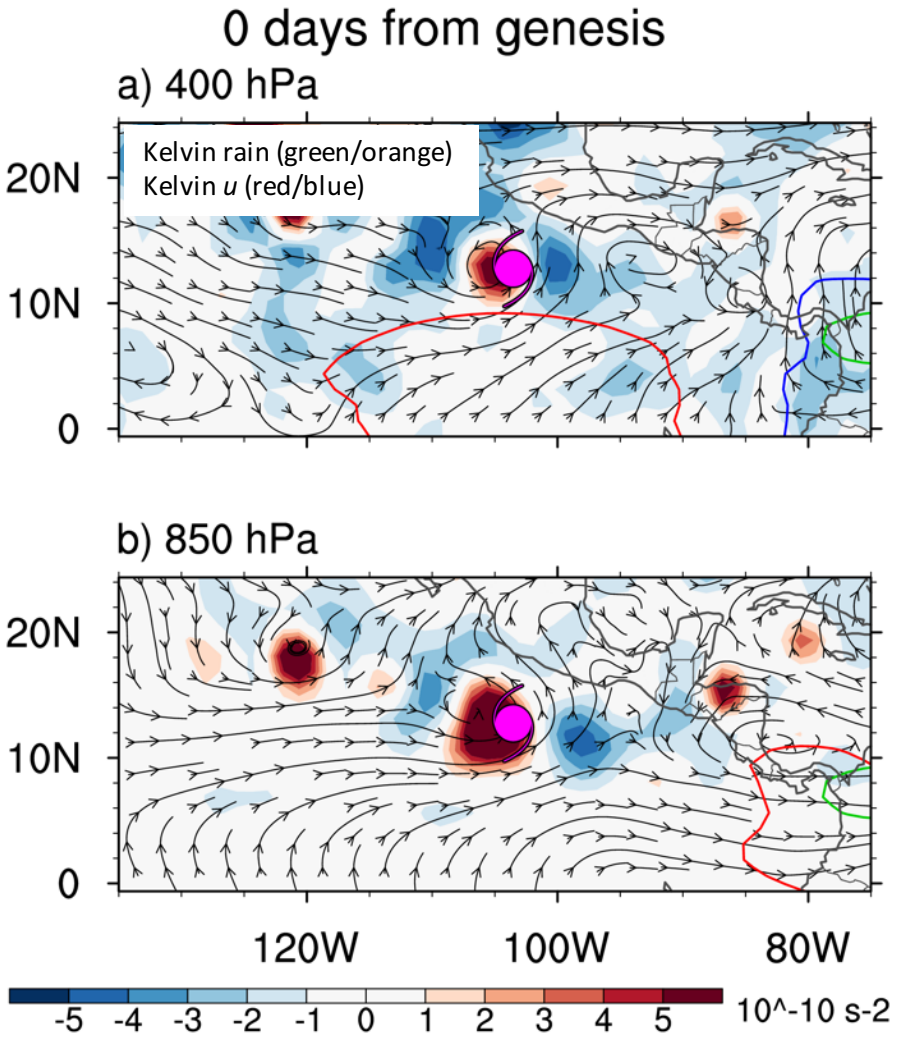

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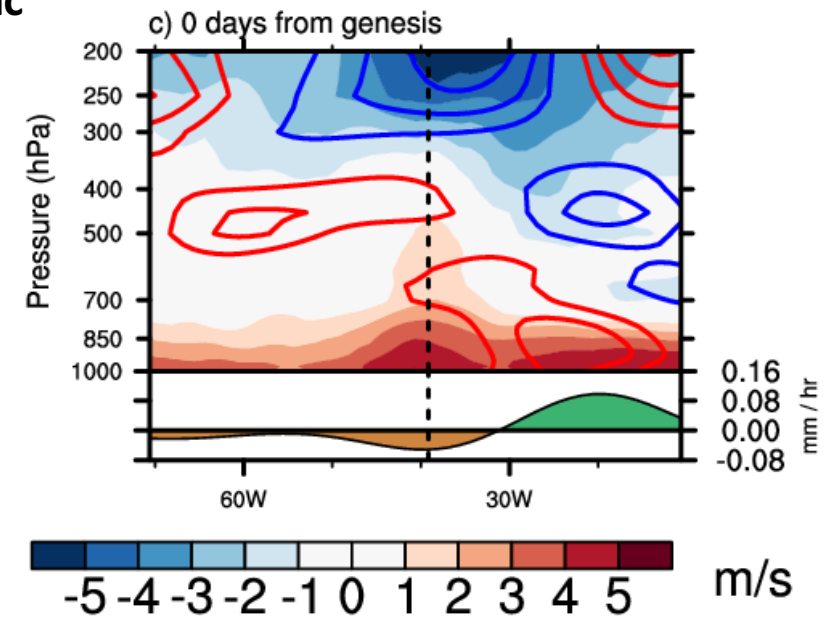
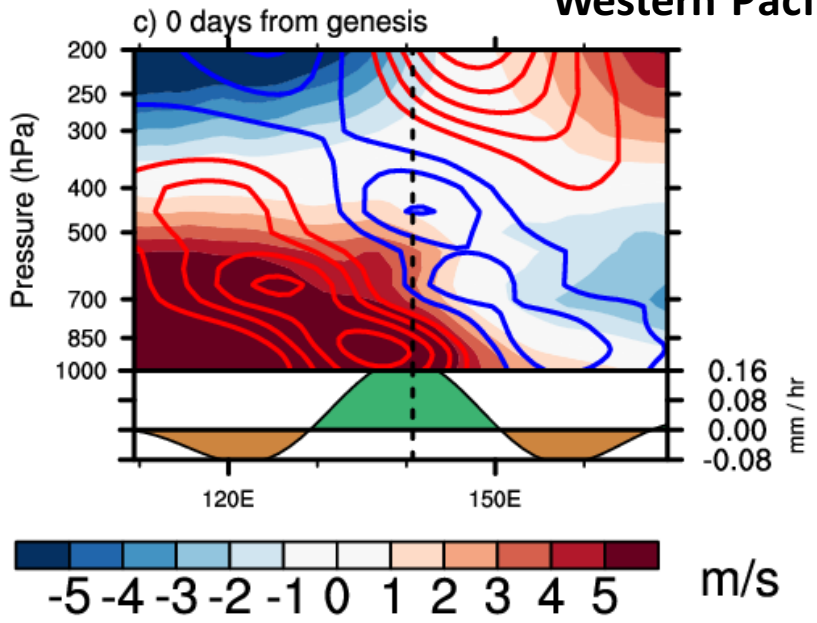
Other Basins

Atlantic



- Similar to Eastern Pacific, but the Kelvin waves are weaker

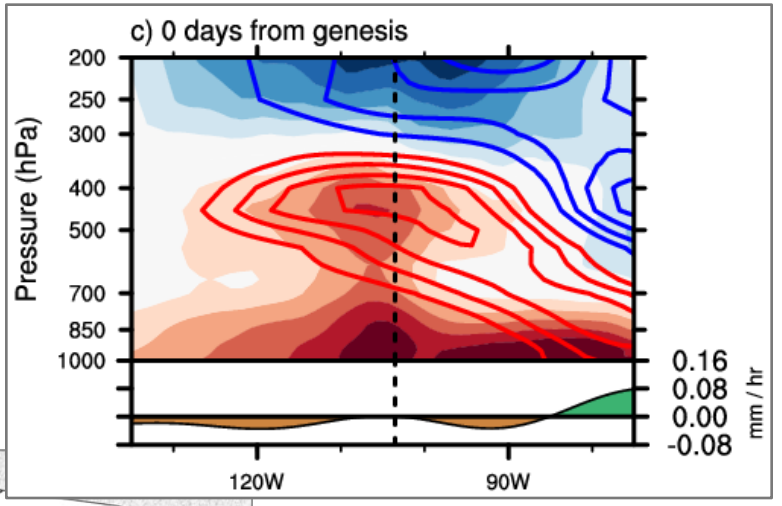
Western Pacific

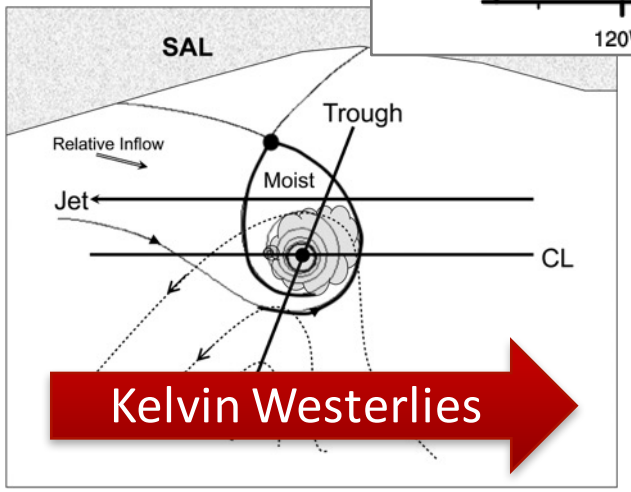


- Western Pacific storms develop near the monsoon confluence point of the low-level winds

Summary

- Vertical tilt of Kelvin waves may explain lag between convection and genesis
  - Kelvin waves tilt westward with height
  - Cyclogenesis happens when Kelvin westerlies reach 400 hPa
- Semi-Lagrangian framework shows Kelvin westerlies developing the easterly wave circulation upward





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