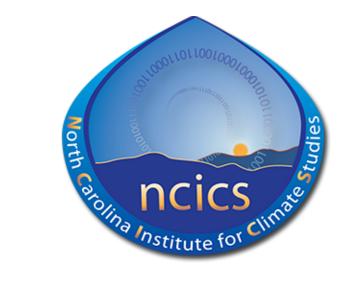


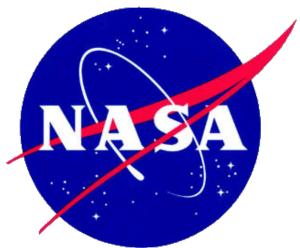
Cooperative Institute for Climate and Satellites–North Carolina Inspire. Advance. Engage.

Kelvin Waves and Tropical Cyclogenesis in a Lagrangian Framework



Carl Schreck

NASA PMM Grant NNX13AH47G





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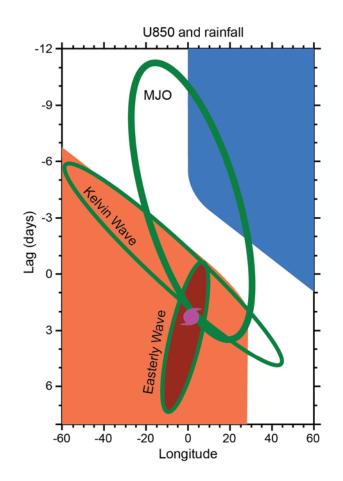
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Kelvin Waves and Tropical Cyclogenesis

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- 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

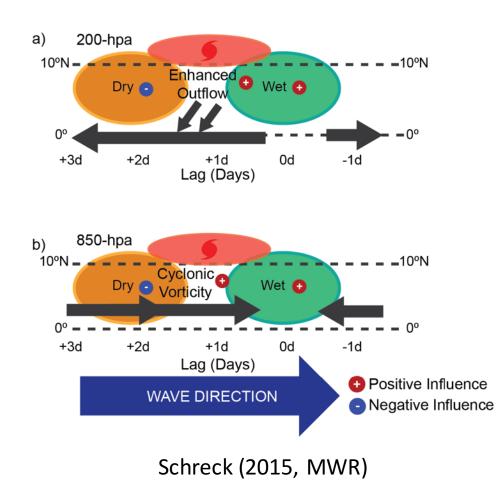


Schreck (2015, MWR)





Effects on Genesis



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



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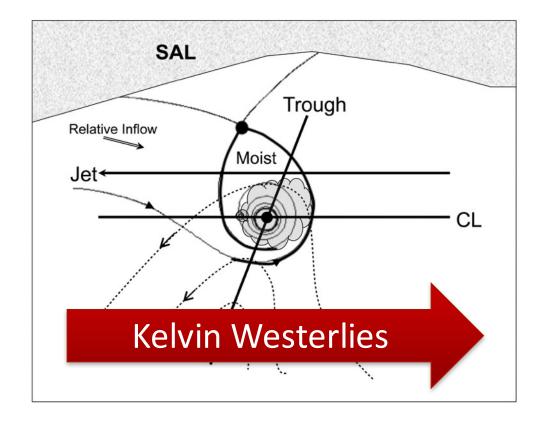
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Background

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).

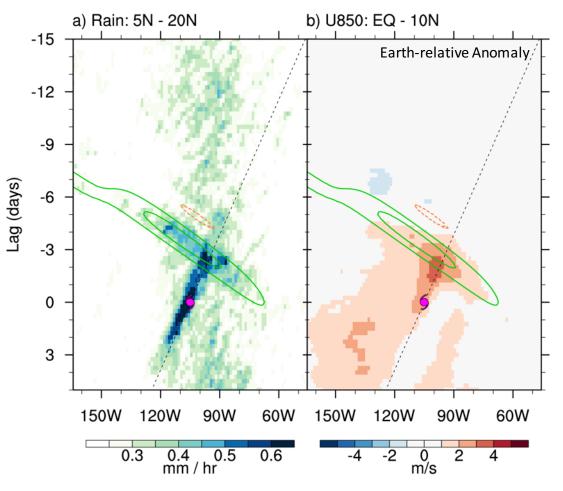




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Estimating Phase Speed

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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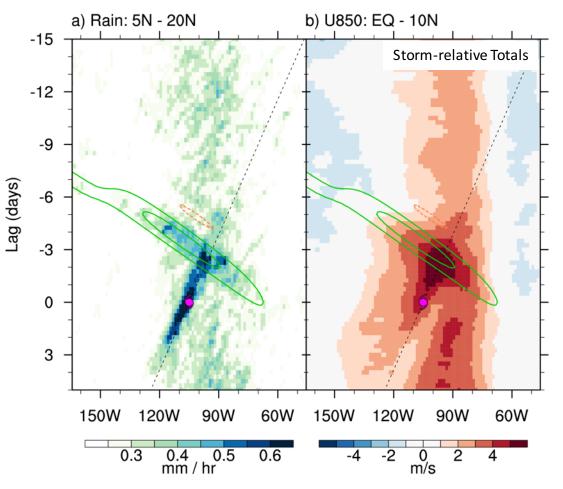
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Estimating Phase Speed

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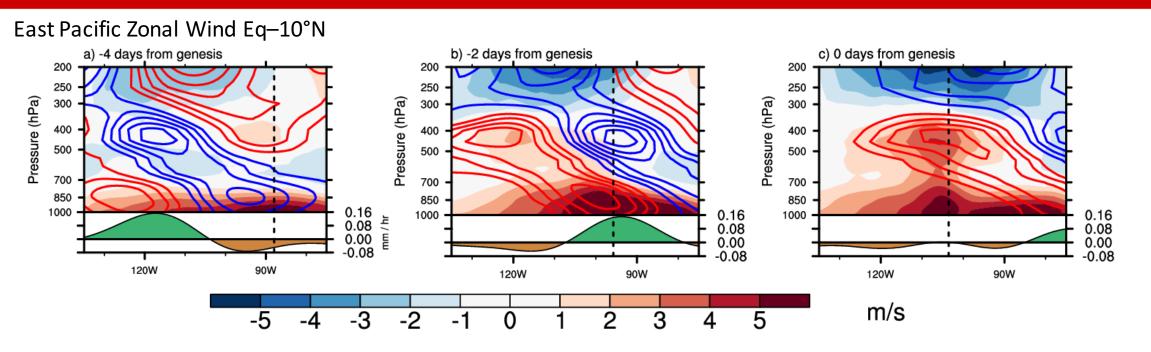
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Vertical Structure

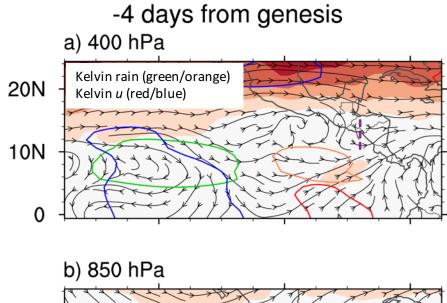


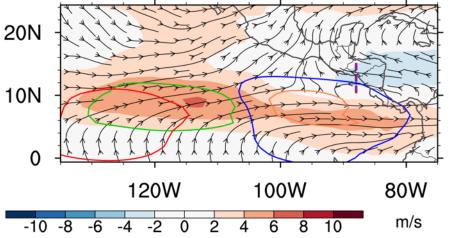
- Convection and storm-relative westerlies intersect easterly wave 2 days before genesis
- Easterly wave circulation builds upward as the Kelvin wave propagates
- Kelvin tilt might explain lag in genesis from convection
 - 400-hPa is 30° longitude behind 850-hPa
 - Kelvin speed of 15 m s⁻¹ gives a 2.5-day lag between 850 hPa and 400 hPa



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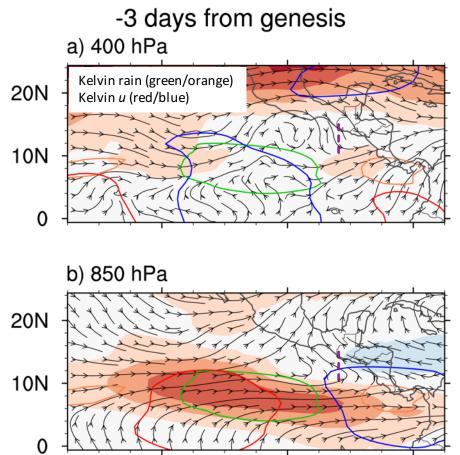
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- Broad, persistent 850-hPa Westerlies
- 400-hPa westerlies develop with • Kelvin wave
- 2 Days before Genesis
 - Kelvin wave enhances 850-hPa westerlies and rain
 - Kelvin easterlies at 400-hPa counter **Easterly wave**
- At Genesis:

- Kelvin wave no long effects 850-hPa winds or rainfall
- At 400-hPa, Kelvin wave helps close circulation





120W 100W 80W m/s -10 -8 -2 6 8 10

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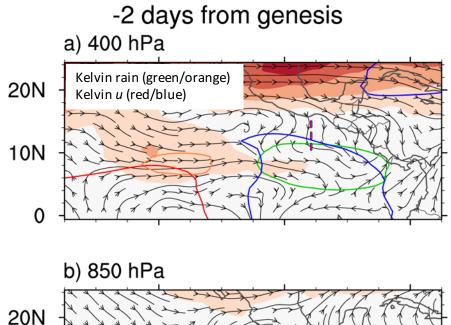
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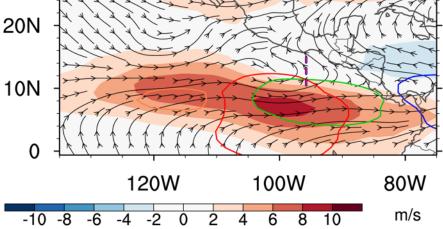
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9





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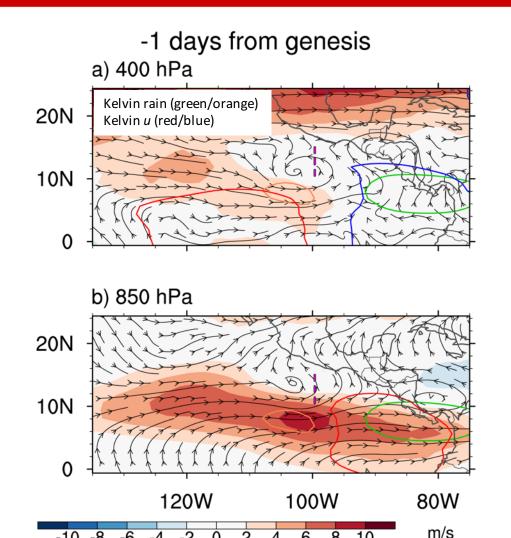
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6

8

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10

-10 -8 -2

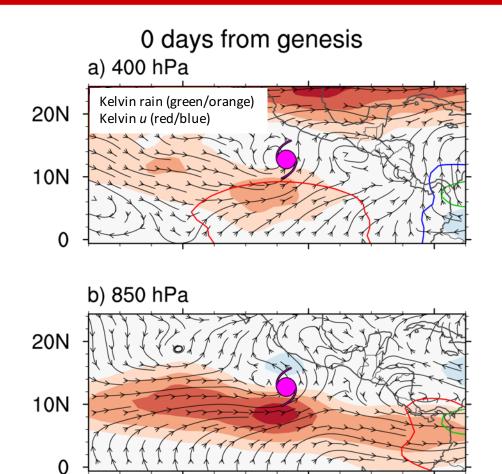
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100W

6

8

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10

80W

m/s

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120W

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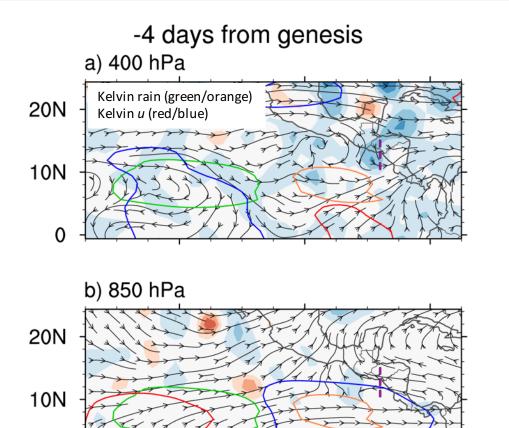
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-10 -8



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- 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



0

120W

-3

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2

100W

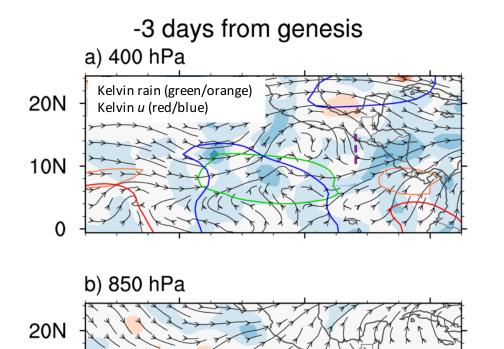
3

5

80W

10^-10 s-2

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10N

0

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2

100W

3

5

80W

10^-10 s-2

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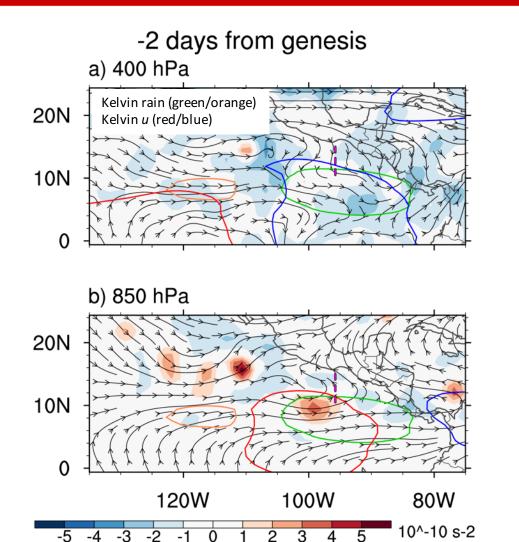
120W

-3

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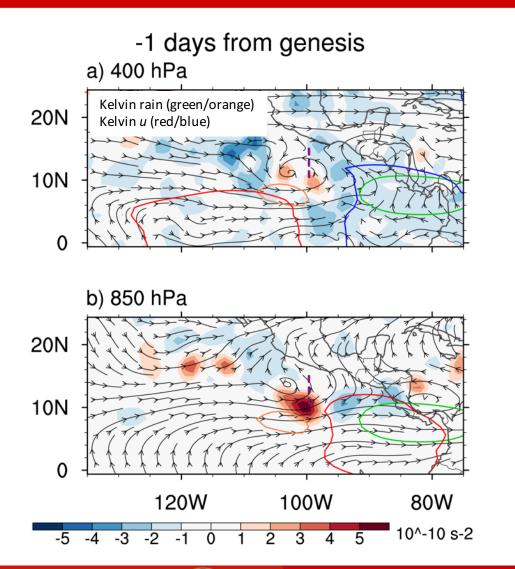


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Background

Vertical

Horizontal



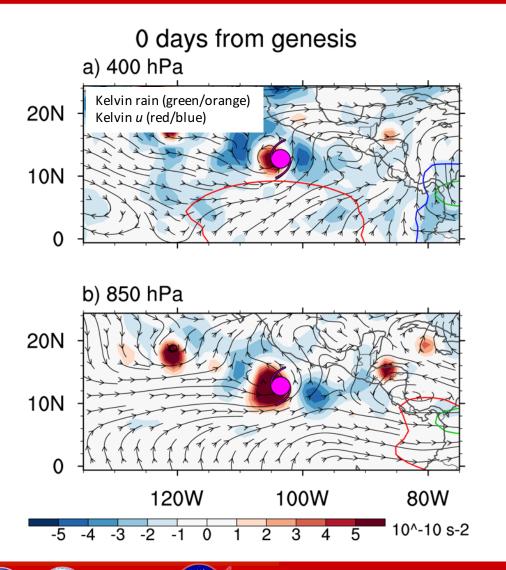
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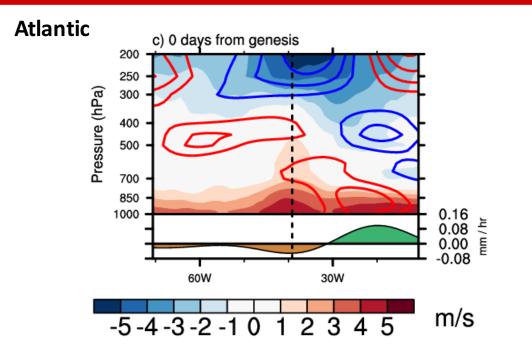


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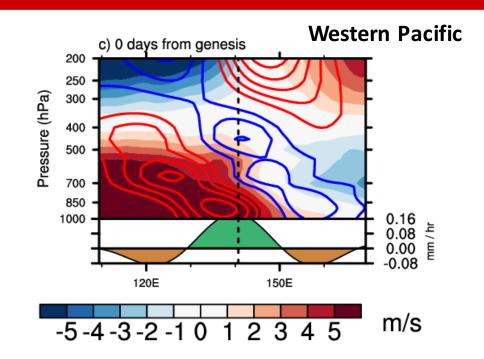


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Other Basins



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



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



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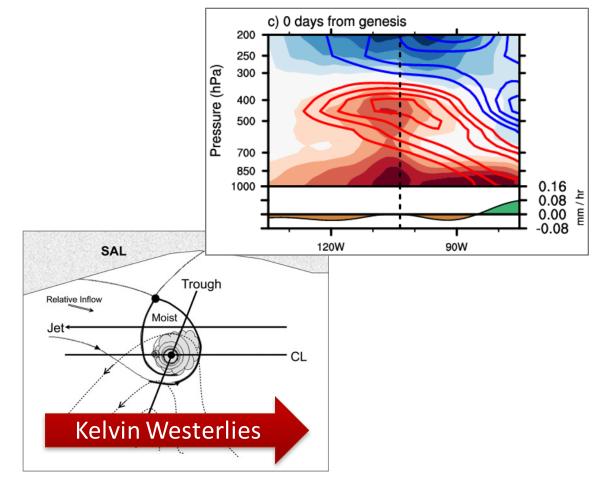
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Summary

- 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



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



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