The Effects of Gap Wind Induced Vorticity, the ITCZ, and Monsoon Trough on Tropical Cyclogenesis

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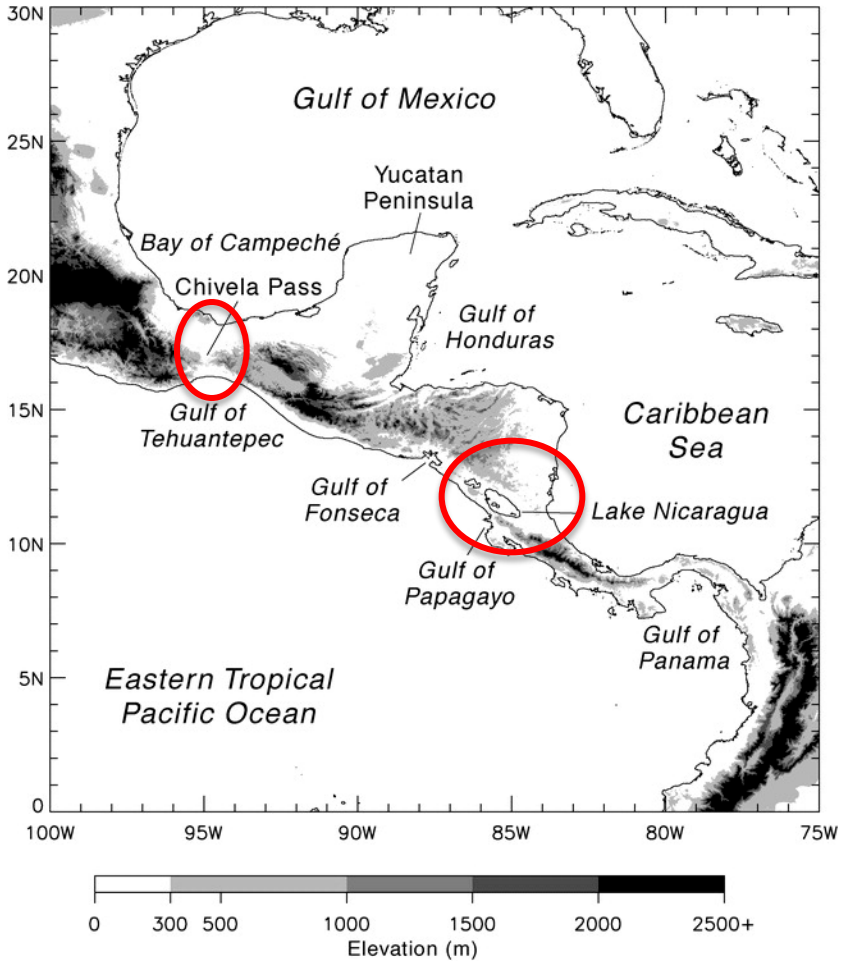
Objectives

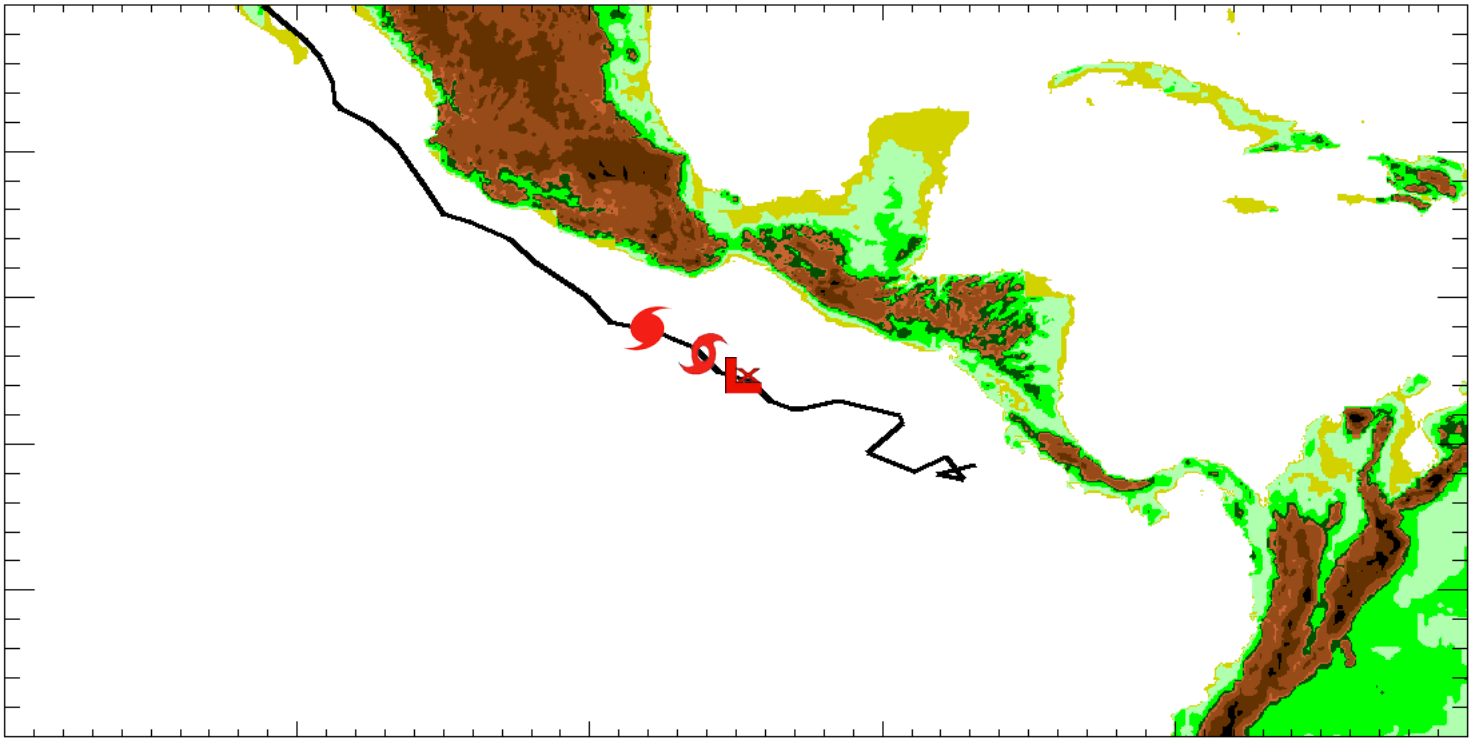
- How do gap winds over the Gulf of Tehuantepec and Gulf of Papagayo contribute to tropical cyclogenesis in the Eastern Pacific basin?
- How do the Monsoon Trough and ITCZ interact with the gap winds to influence tropical cyclogenesis in the Eastern Pacific?
- Observational study



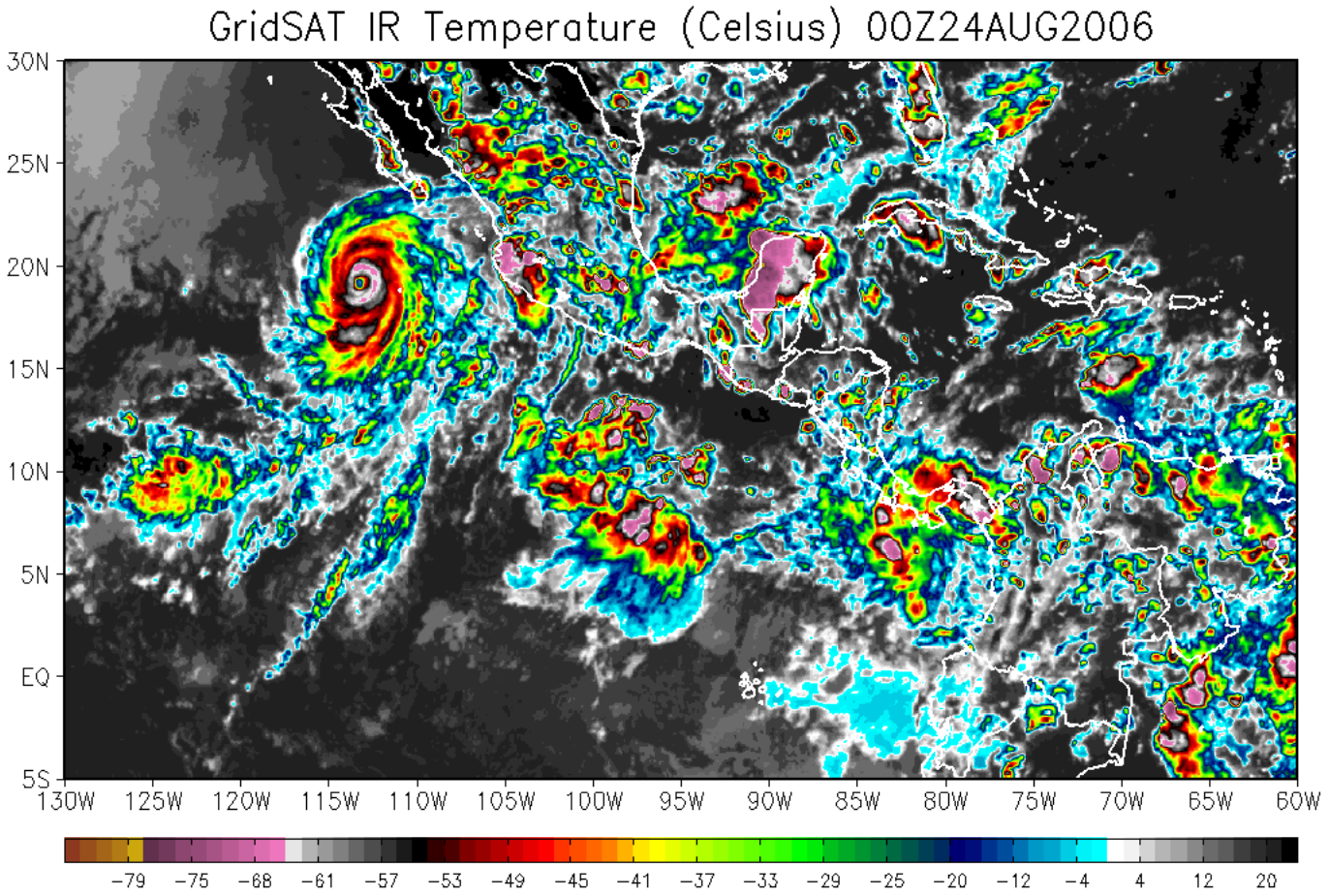
Chelton et al., 2000, MWR

Example Case

2006 Hurricane John



GridSAT IR (2006 Hurricane John)

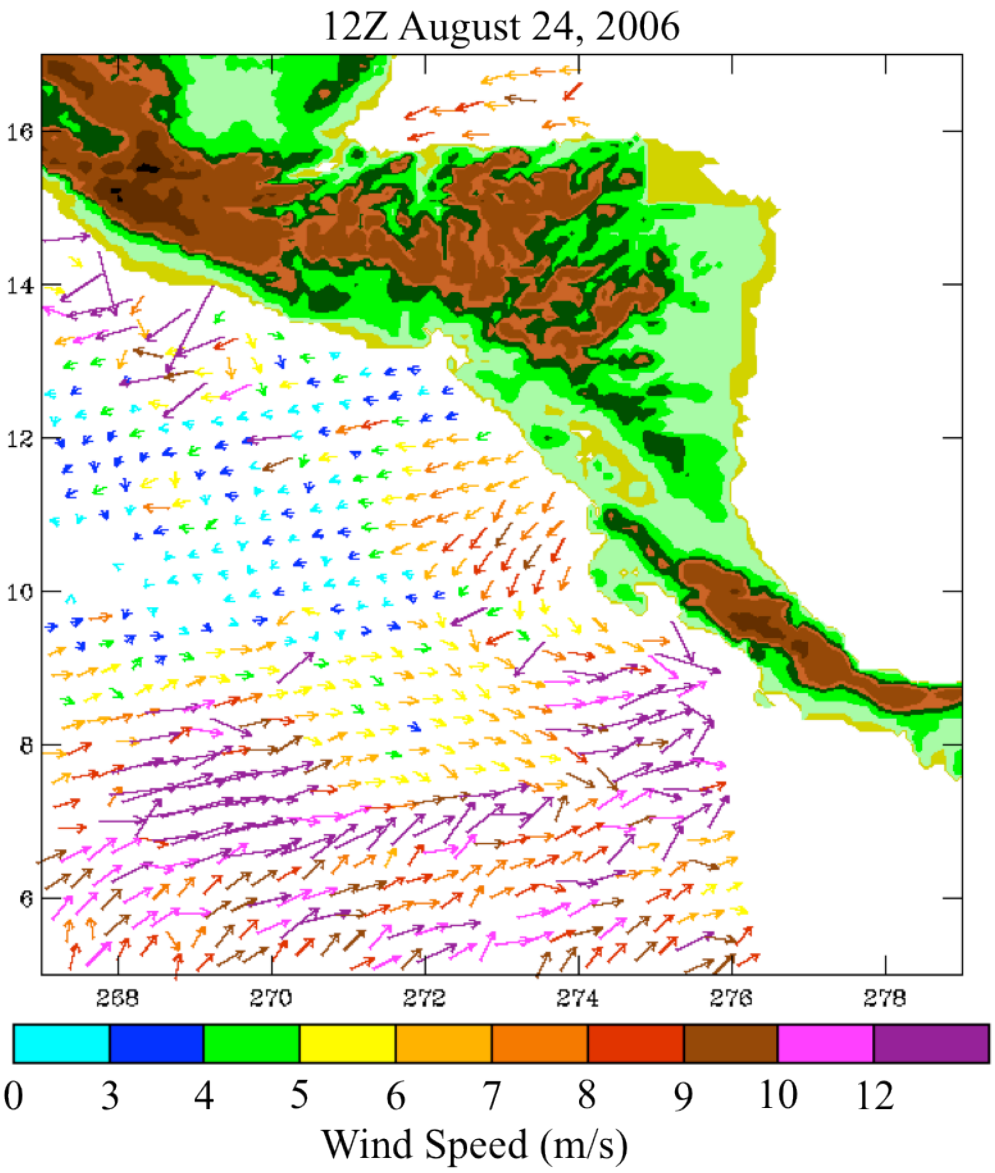


IR Brightness Temperature
(° C)

2006 Hurricane John

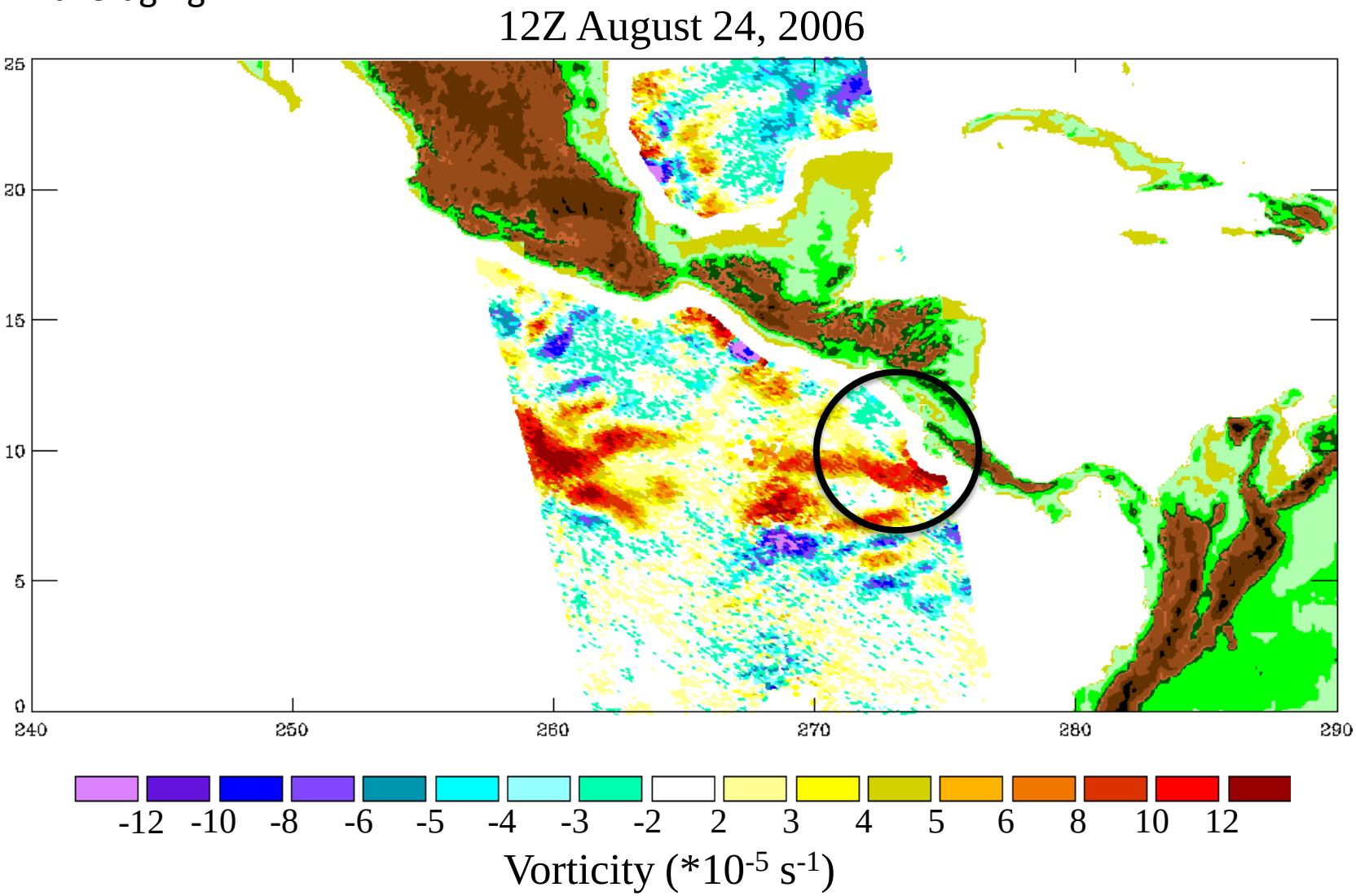
12.5 km JPL L2B
Version 2 QSCAT

37.5 km Spacing

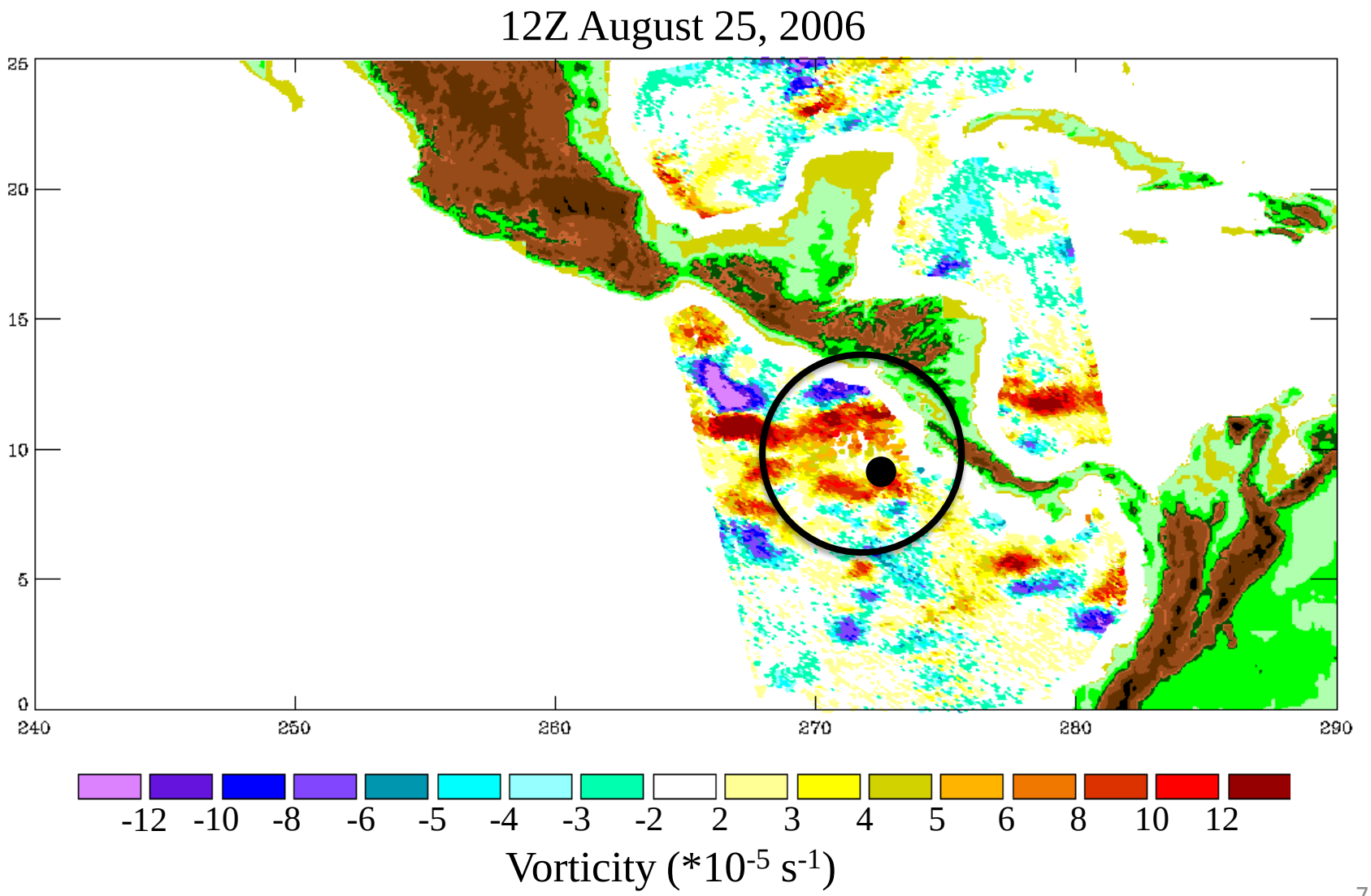


Surface Vorticity (2006 Hurricane John)

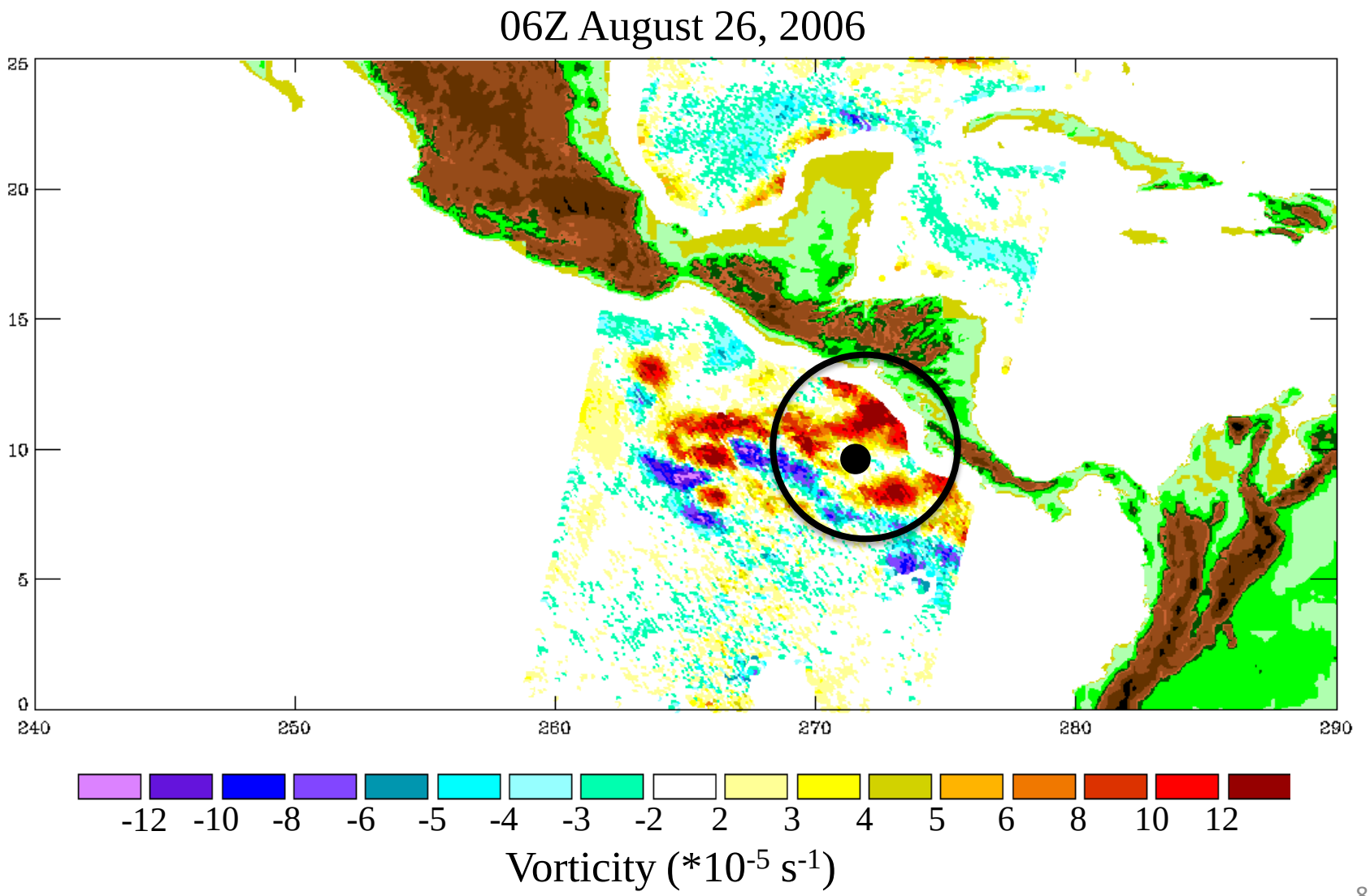
125 km averaging



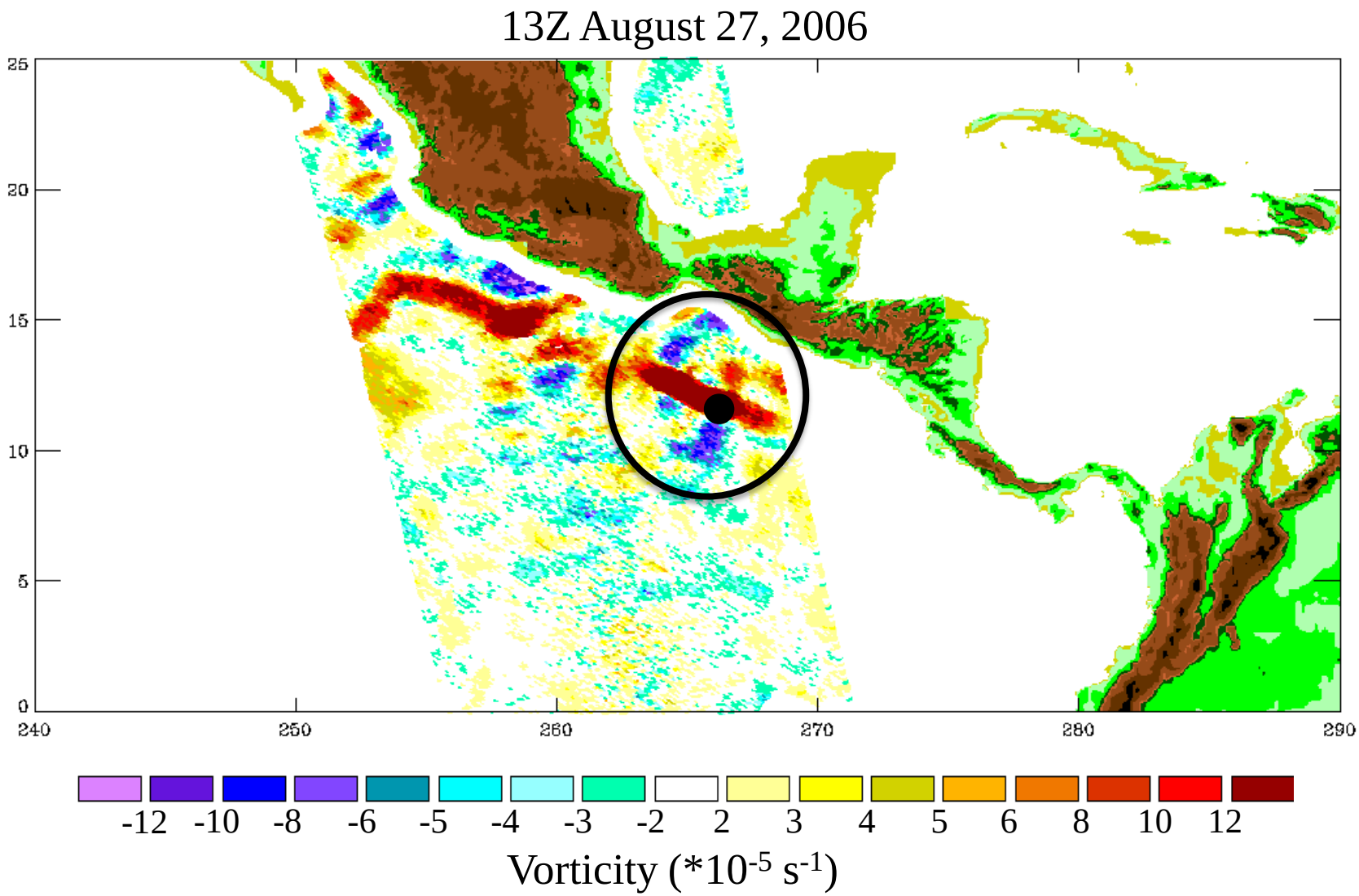
Surface Vorticity (2006 Hurricane John)



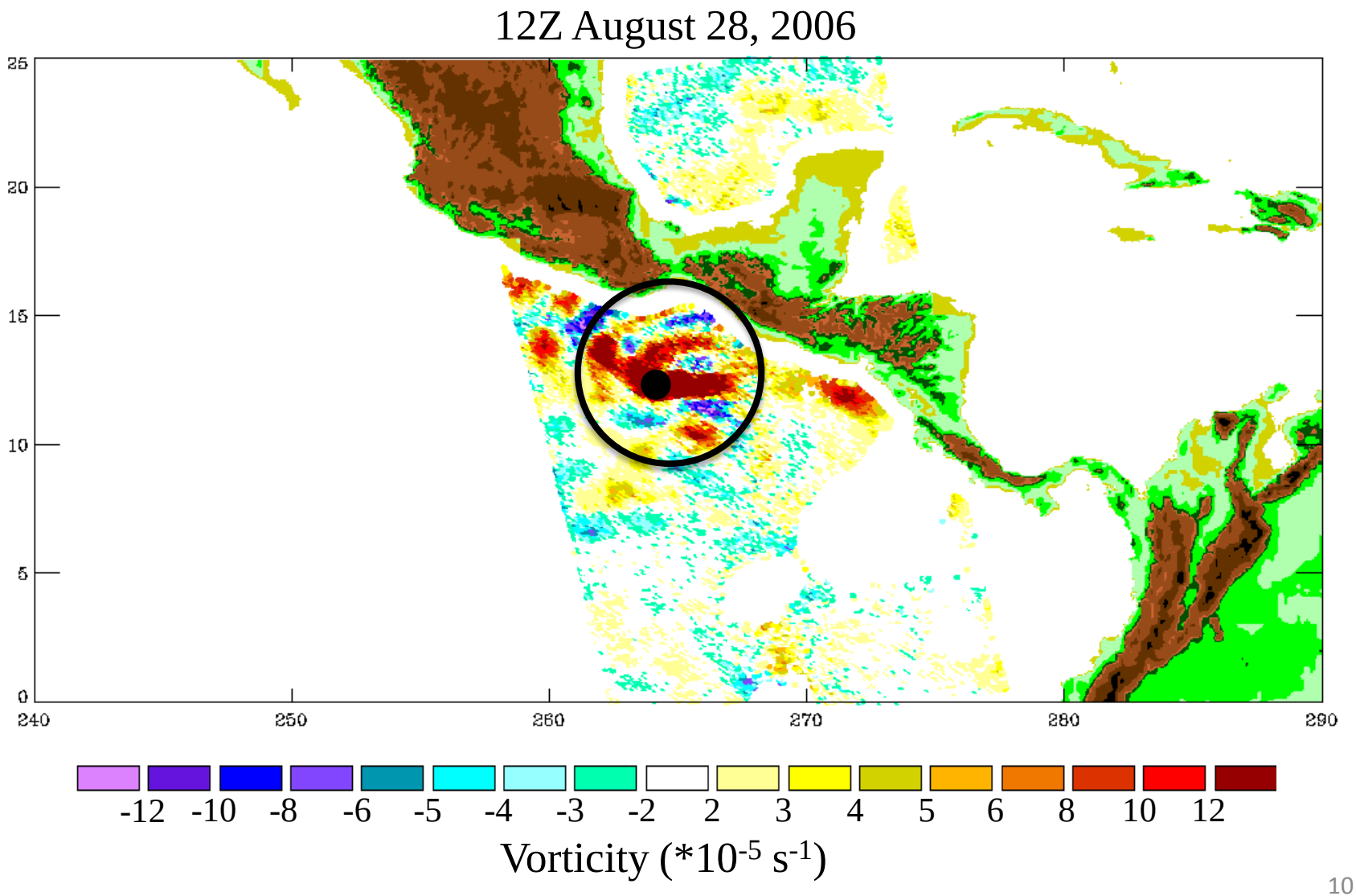
Surface Vorticity (2006 Hurricane John)



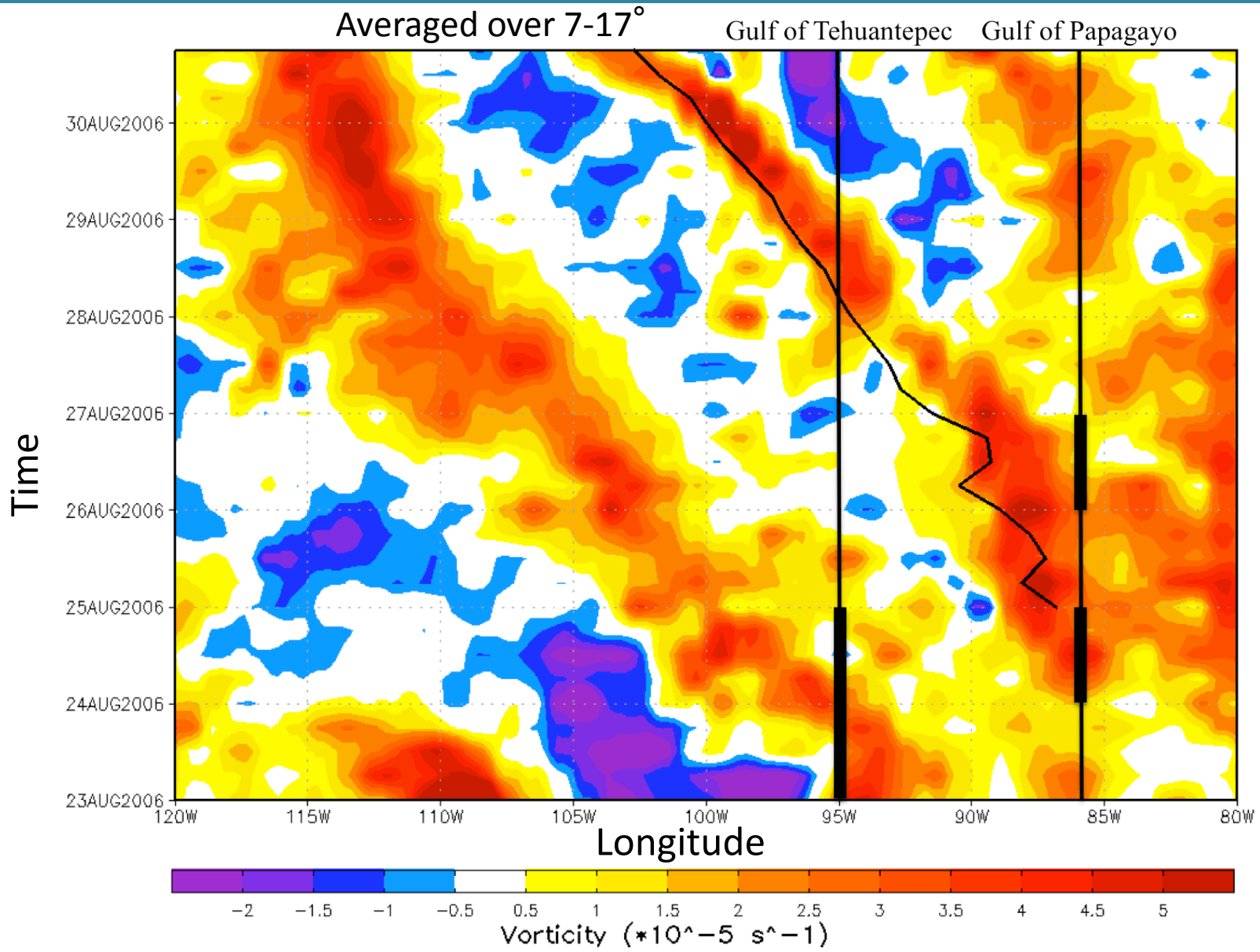
Surface Vorticity (2006 Hurricane John)



Surface Vorticity (2006 Hurricane John)

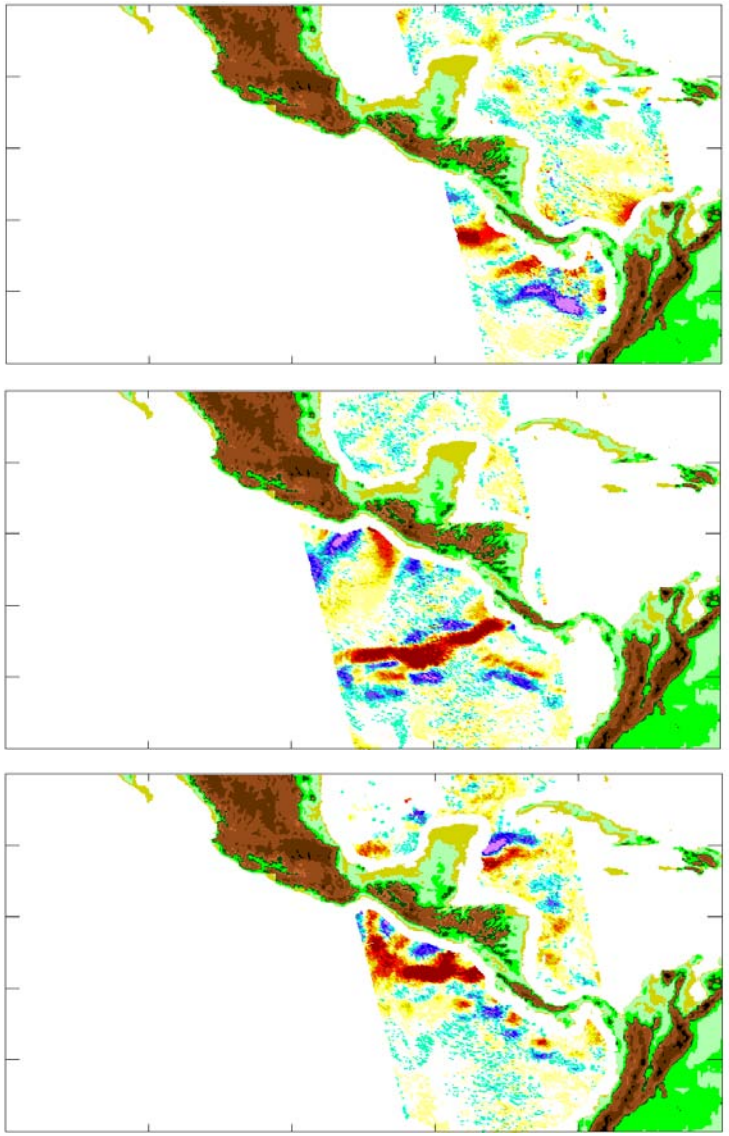


CCMP Vorticity Hovmöller (2006 Hurricane John)

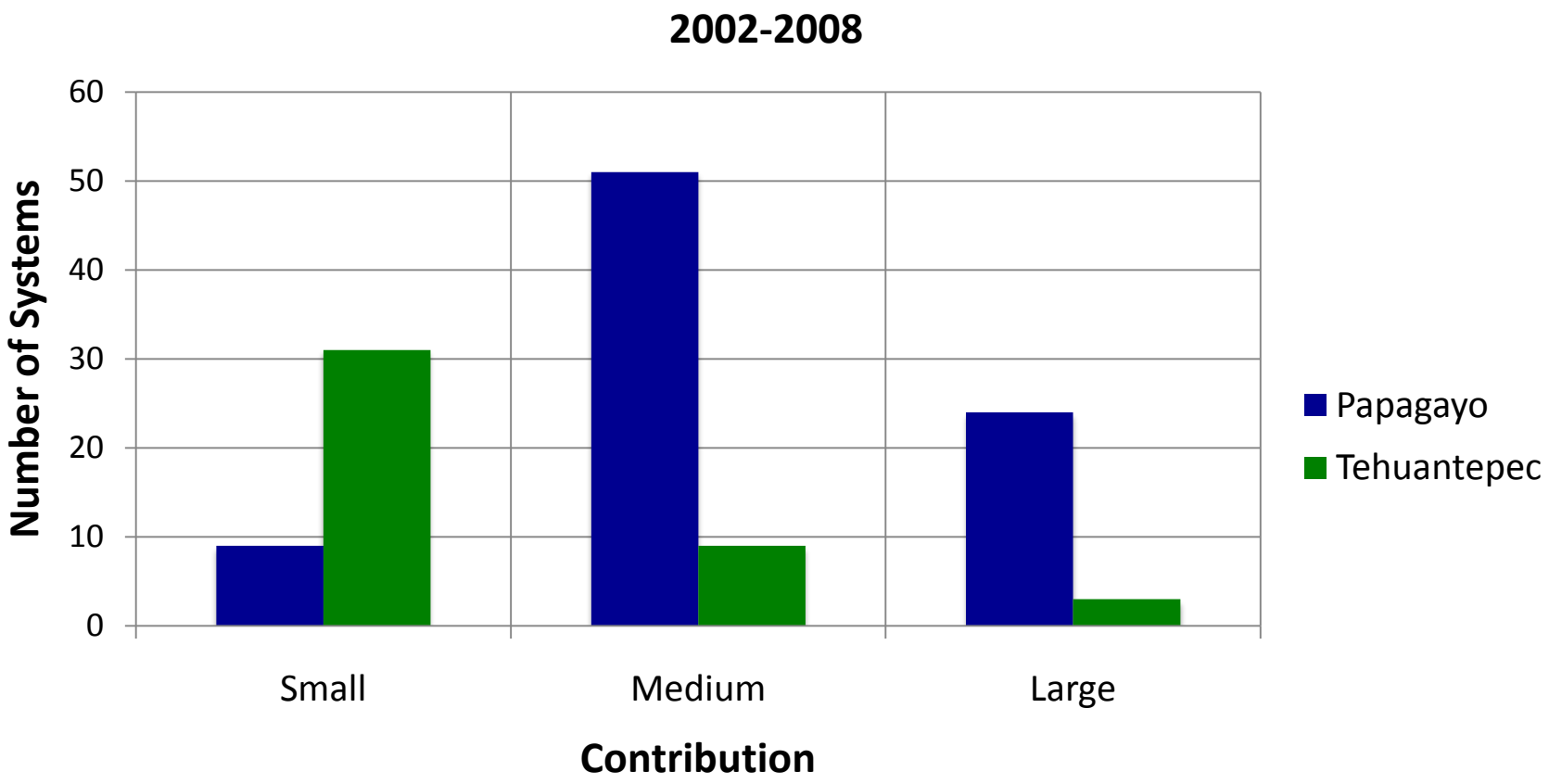


Gap Wind Contribution Categories

- Large: Gap winds produce the main source of initial surface cyclonic vorticity
- Medium: Gap winds produce some of the initial surface cyclonic vorticity along with another substantial source not associated with gap winds
- Small: Gap winds contribute vorticity to an existing region after development begins

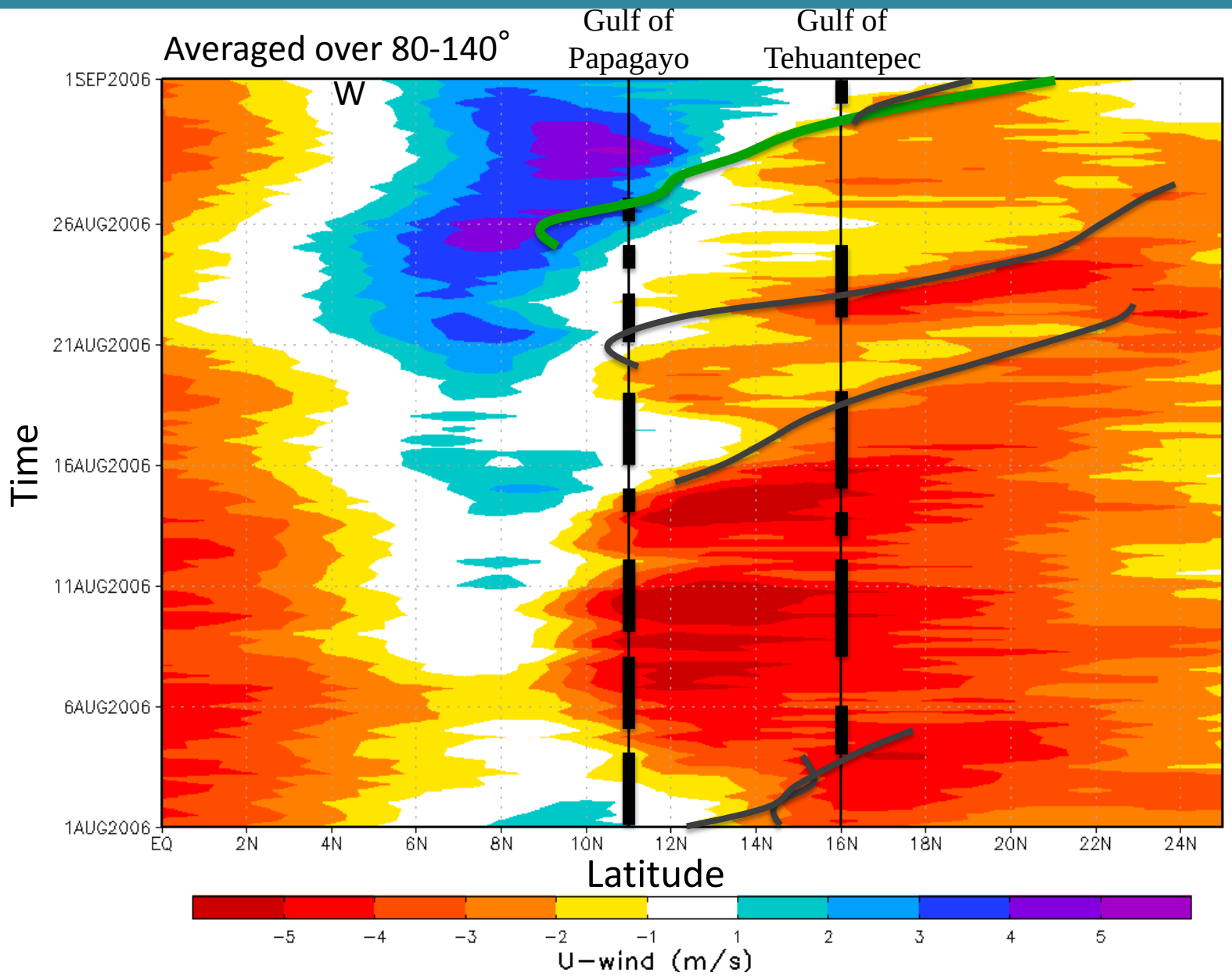


Summary of Gap Wind Contributions

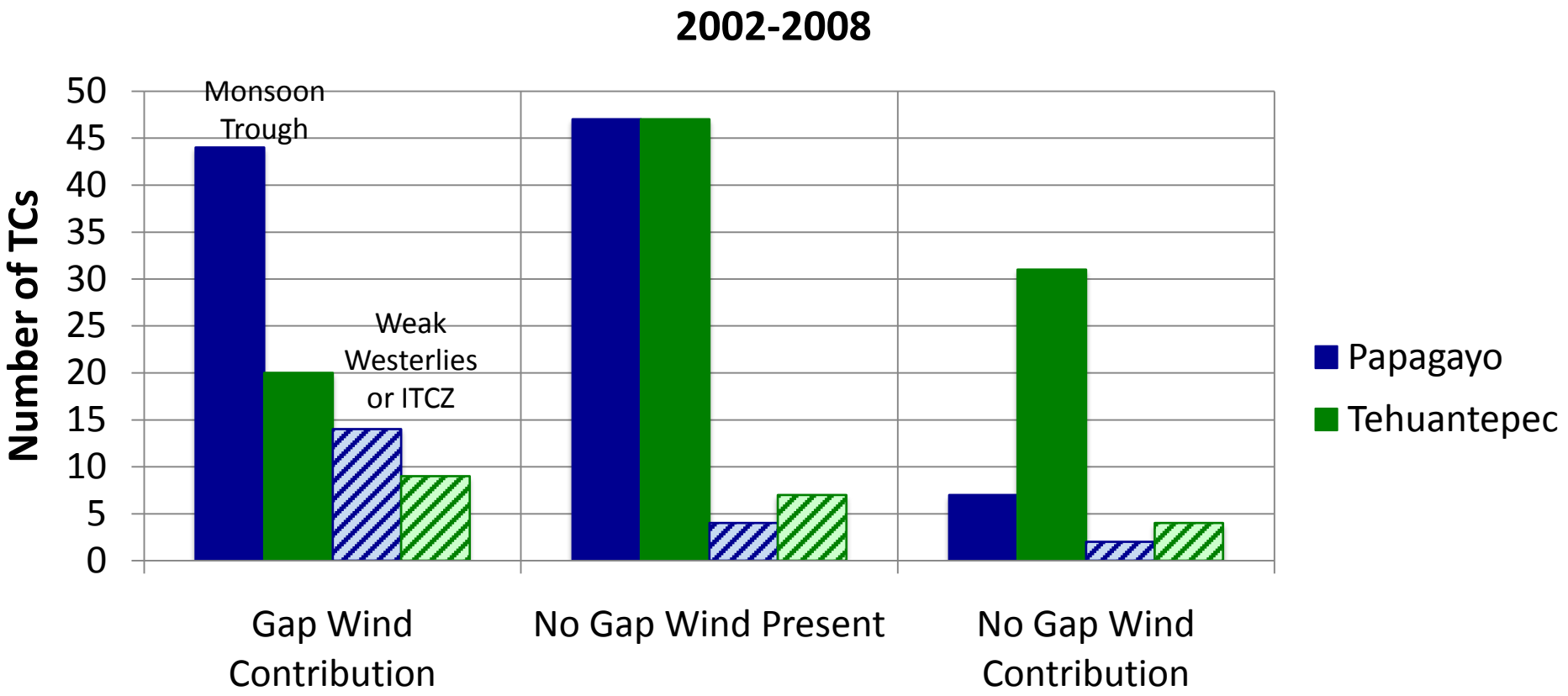


- Tehuantepec gap winds contributed vorticity to 29 out of 118 TCs investigated
- Papagayo gap winds contributed vorticity to 58 out of 118 TCs investigated

Zonal wind Hovmöller (2006 Hurricane John)



Summary of Monsoon Trough and ITCZ Comparison



- 98 out of 118 (83%) TCs form when the monsoon trough is present.
  - 20 out of 118 (17%) TCs form when weak westerlies or ITCZ is present.
- When monsoon trough is present, Gulf of Papagayo contributes more often than Gulf of Tehuantepec.

Conclusion

- QSCAT provides observational data needed to complete a study
  - Temporal resolution still presents a problem
  - Rain contamination is an issue
- Gap winds generate surface cyclonic vorticity that contributes to the development of tropical cyclones.
  - Tehuantepec gap winds contributed to ~25% of TCs investigated
  - Papagayo gap winds contributed to ~49% of TCs investigated
- Gap winds are not sufficient for cyclogenesis to occur
- Majority of storms form when the monsoon trough is present.
  - ~76% (44/58) of contributions from Papagayo gap winds occurred while the monsoon trough is present
  - ~69% (20/29) of contributions from Tehuantepec gap winds occurred while the monsoon trough is present

Questions?

Backup Slides

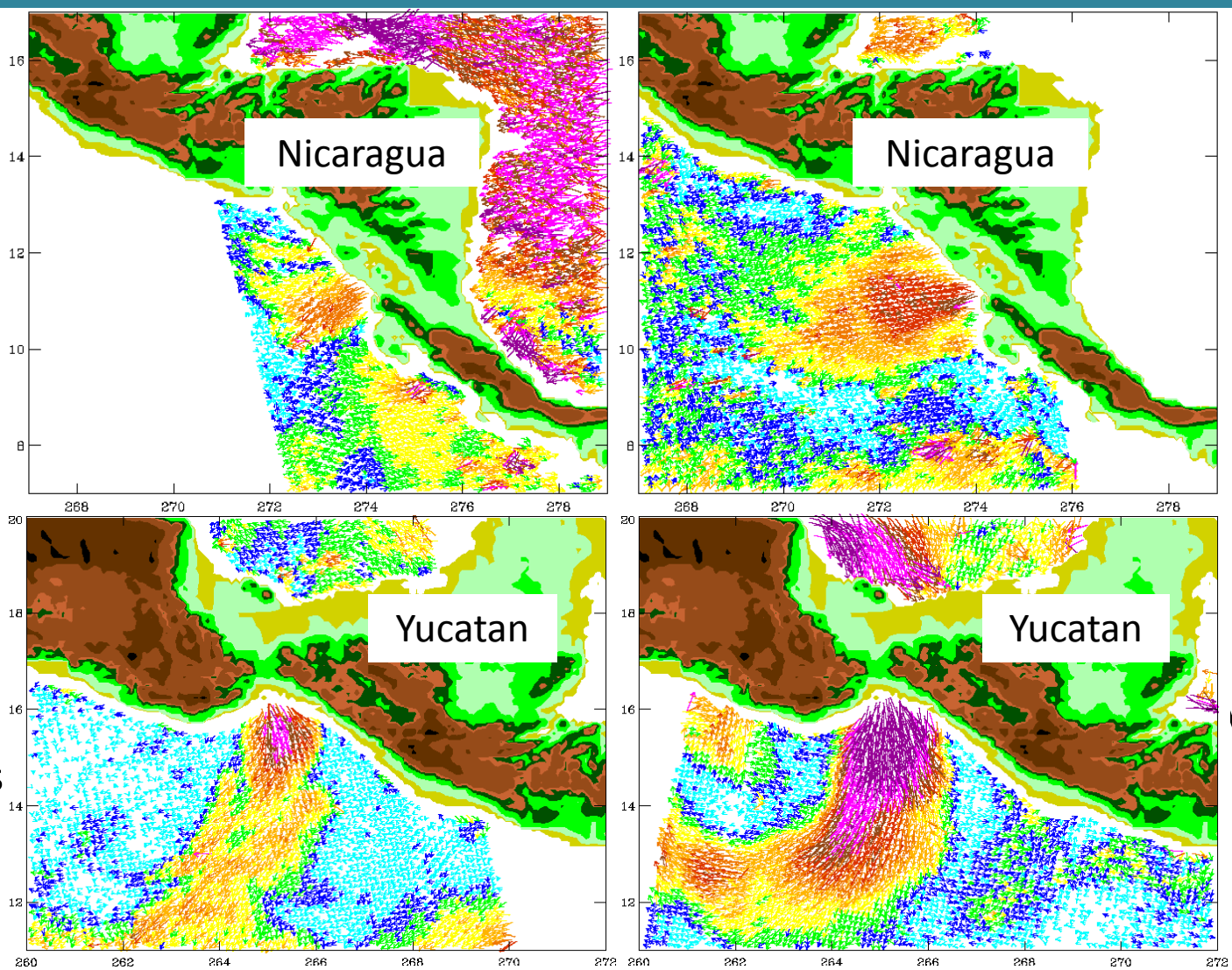
Gap Wind Strengths

Weak:
6 - 8 m/s

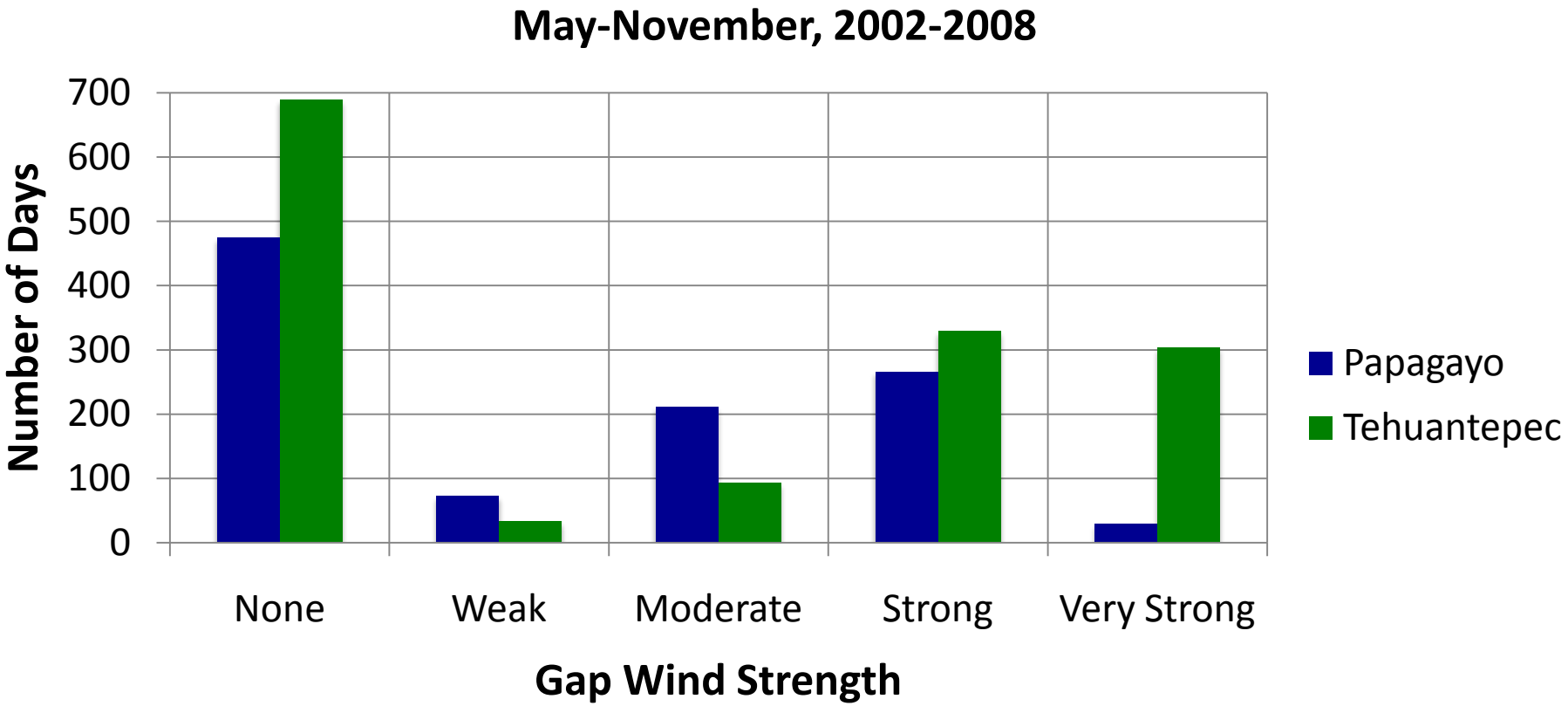
Moderate:
8 - 10 m/s

Strong:
10 - 12 m/s

Very Strong:
≥ 12 m/s

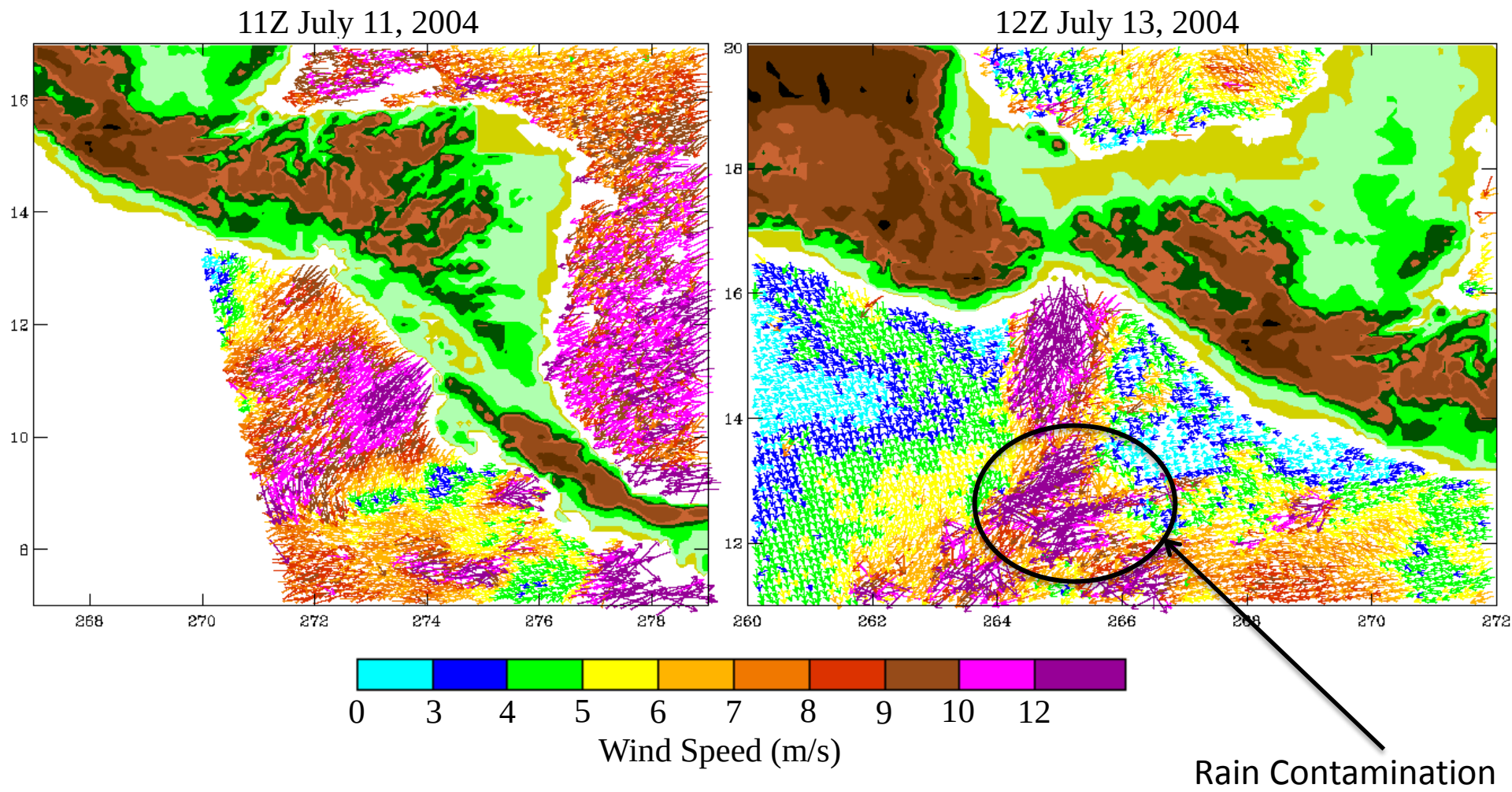


Summer Gap Winds

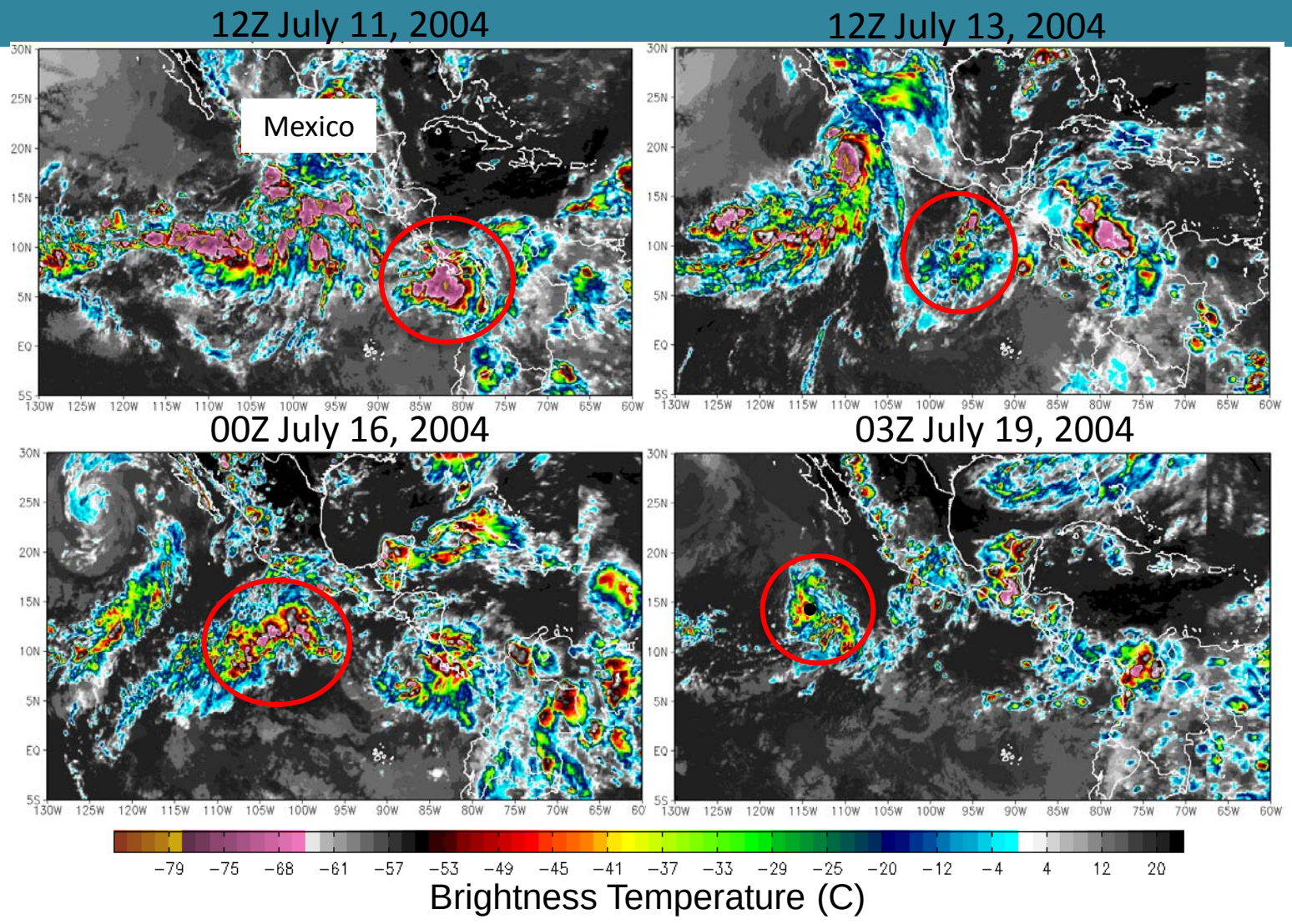


- Papagayo: 578 (~55%) Gap wind days
  - Majority moderate and strong
- Tehuantepec: 758 (~52%) Gap wind days
  - Majority strong and very strong

2004 Hurricane Celia



GridSAT IR and Dvorak Fix Archive

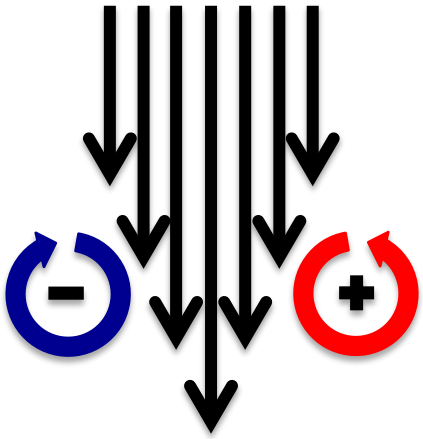


GridSAT: Knapp et al., 2011, BAMS

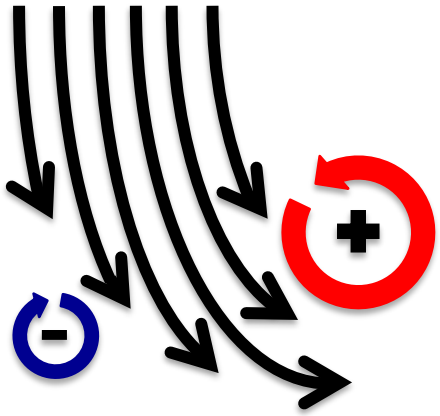
Dvorak Fix Archive: Cossuth, 2010, personal communication

Vorticity Mechanisms

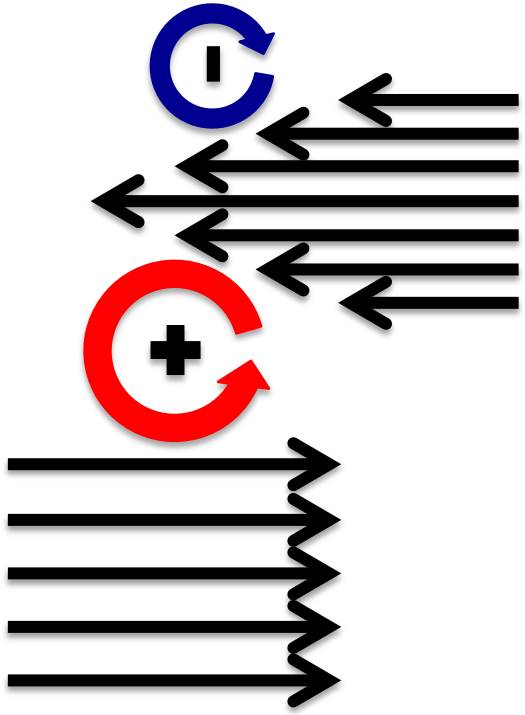
Shear



Shear + Curvature



Monsoon Trough

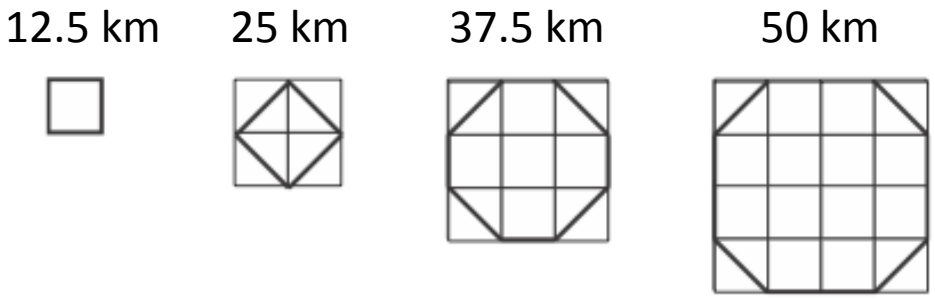


Area-averaged Surface Relative Vorticity

- Adapted from *Bourassa and McBeth-Ford* (2010)
  - Added spline fit for winds

$$\zeta = \frac{C}{A} \qquad C = \oint \vec{v} \cdot d\vec{l}$$

ζ: Relative Vorticity
C: Circulation
A: Area
$\vec{v}$: velocity along closed contour
$\vec{l}$: length tangent to contour

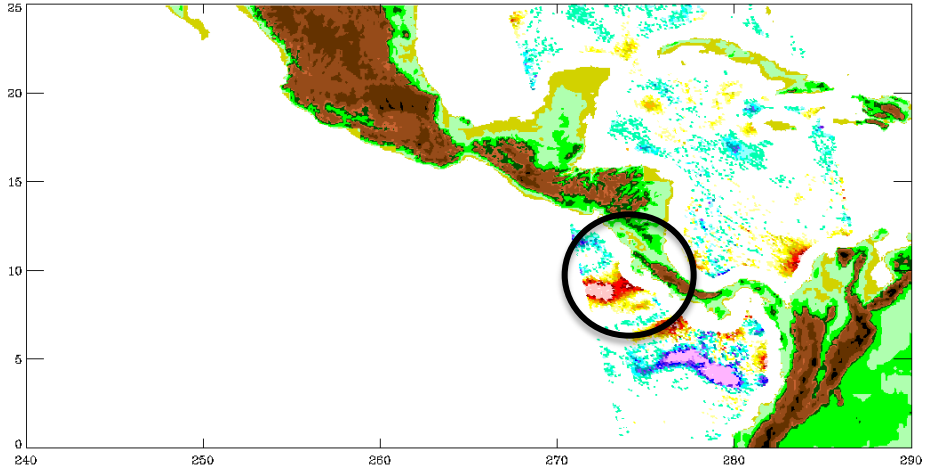


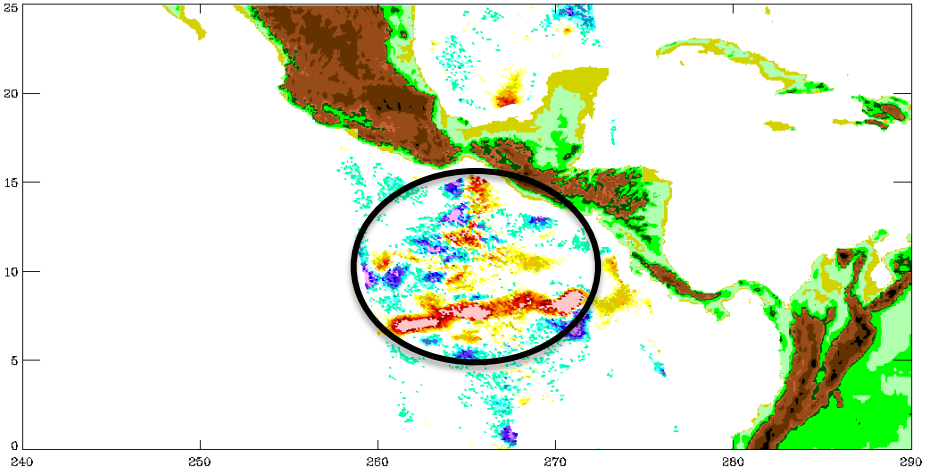
- Averaging over larger area reduces random error and noise in calculation
- We use a diameter of 125 km

Surface Relative Vorticity

11Z July 11, 2004

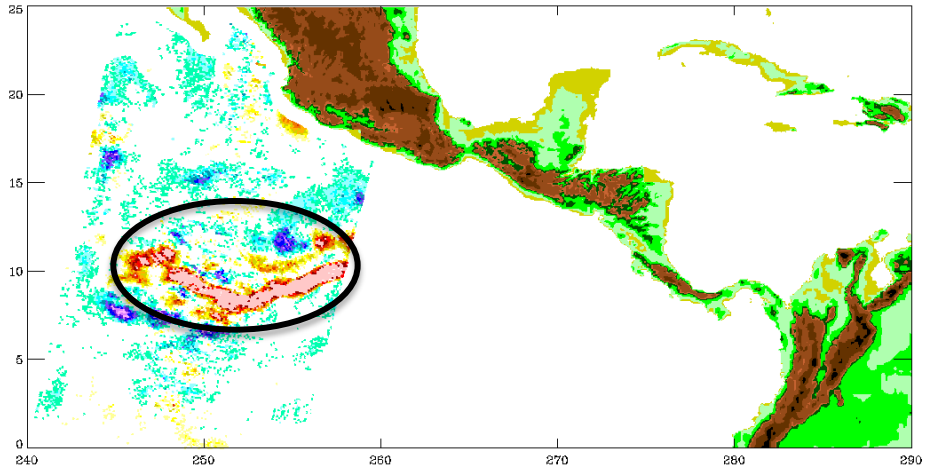
12Z July 13, 2004

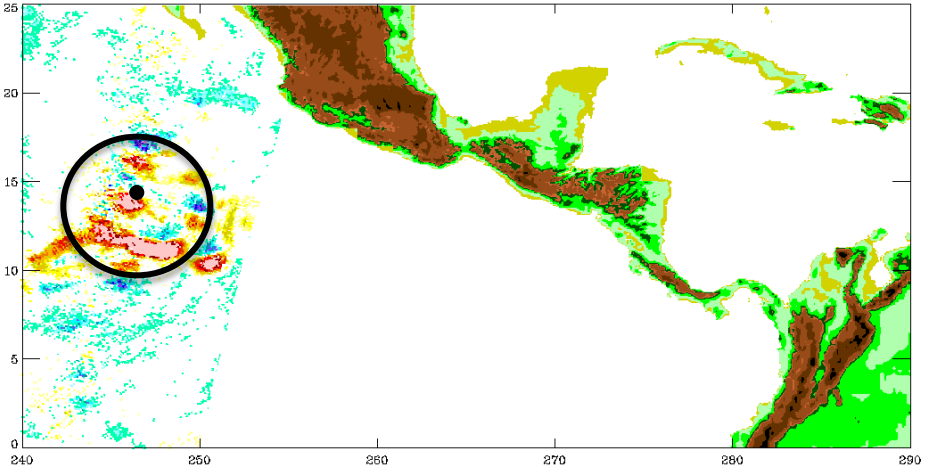


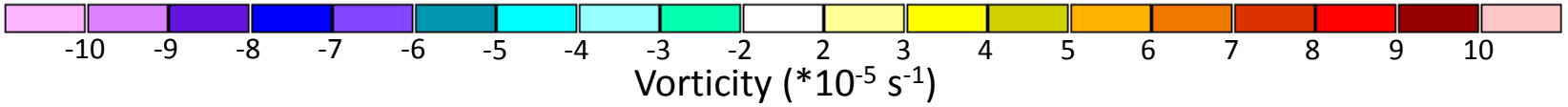


01Z July 16, 2004

02Z July 19, 2004







Vorticity ($*10^{-5}$ s^{-1})

- Vorticity calculation adapted from Bourassa and McBeth-Ford, 2010, J.A.O.T.

Gap Wind Contribution Categories

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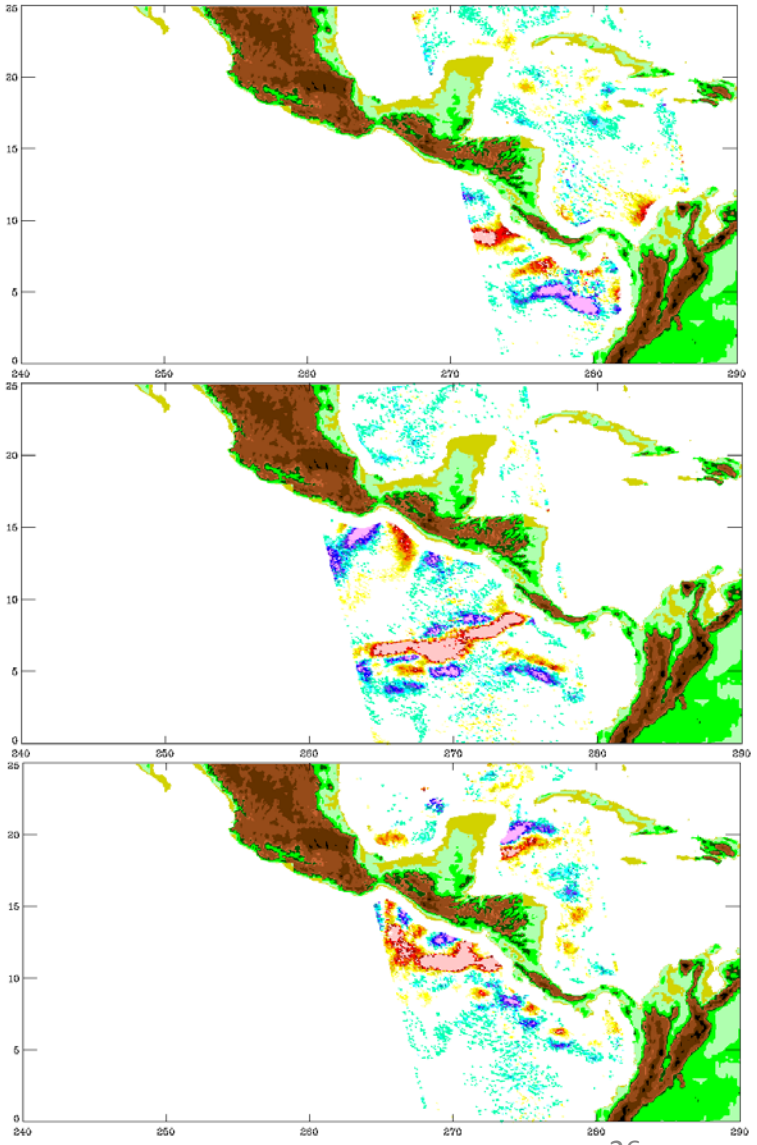
- Small: Gap winds contribute a small amount of vorticity to initial source or contribute vorticity to an existing region after development begins



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