Vorticity Budget in Developing Typhoon Nuri (2008)[1]

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Vorticity budget

- Flux form of vorticity equation:

$$\text{vorticity tendency} = \text{convergence+tilting+friction}$$

- Vorticity convergence term:

$$\text{convergence} = \text{advection+stretching}$$

- Vorticity balance (ignore tilting):

$$\text{convergence+friction} \approx 0$$

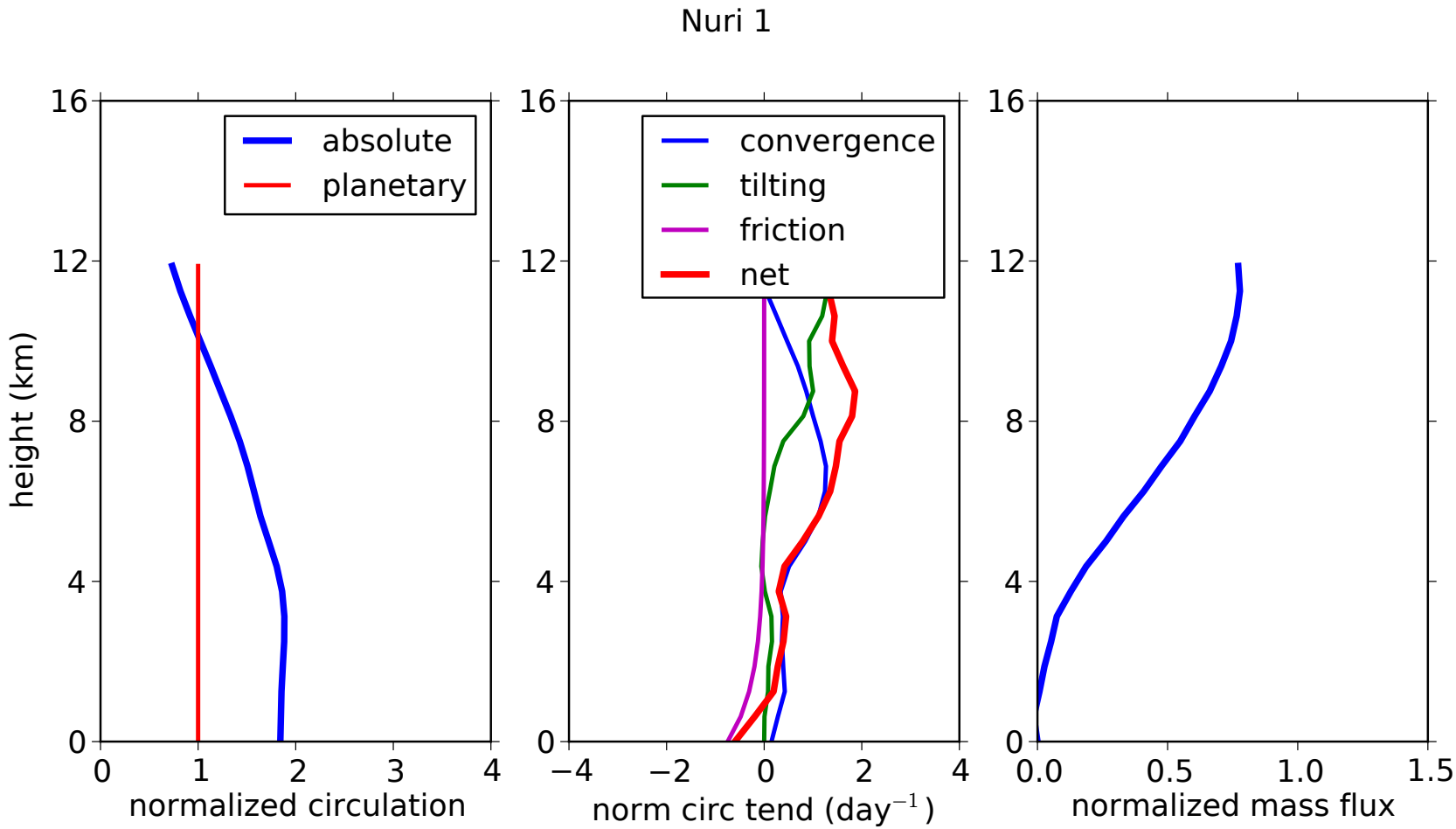
- Vorticity balance is a gradient-wind-like generalization of Ekman balance.

Convert to circulation budget

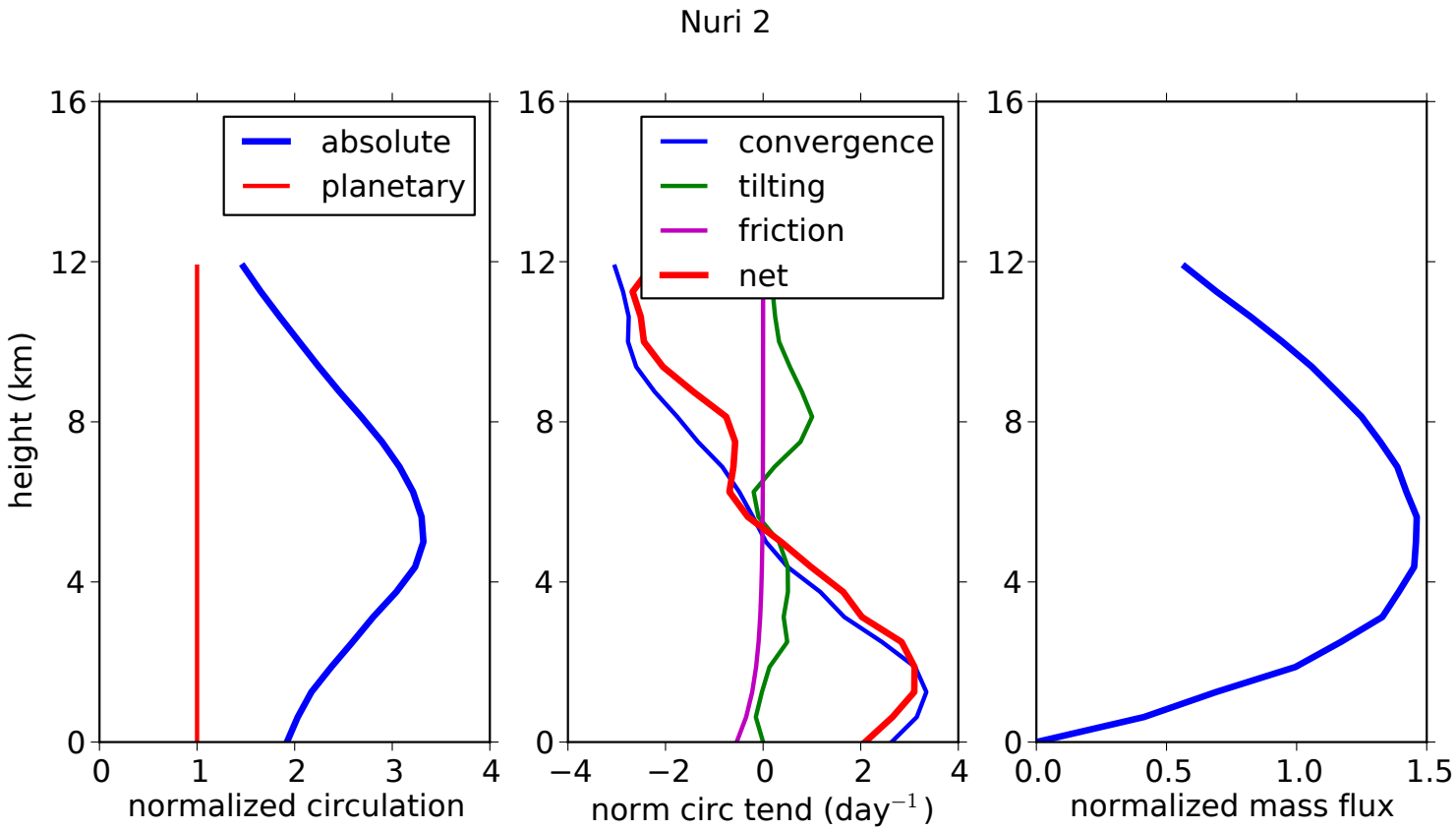
- Integrate over area of system to get absolute circulation tendency.
- Normalize everything by the planetary circulation:

$$\Gamma_p = \int f dA$$

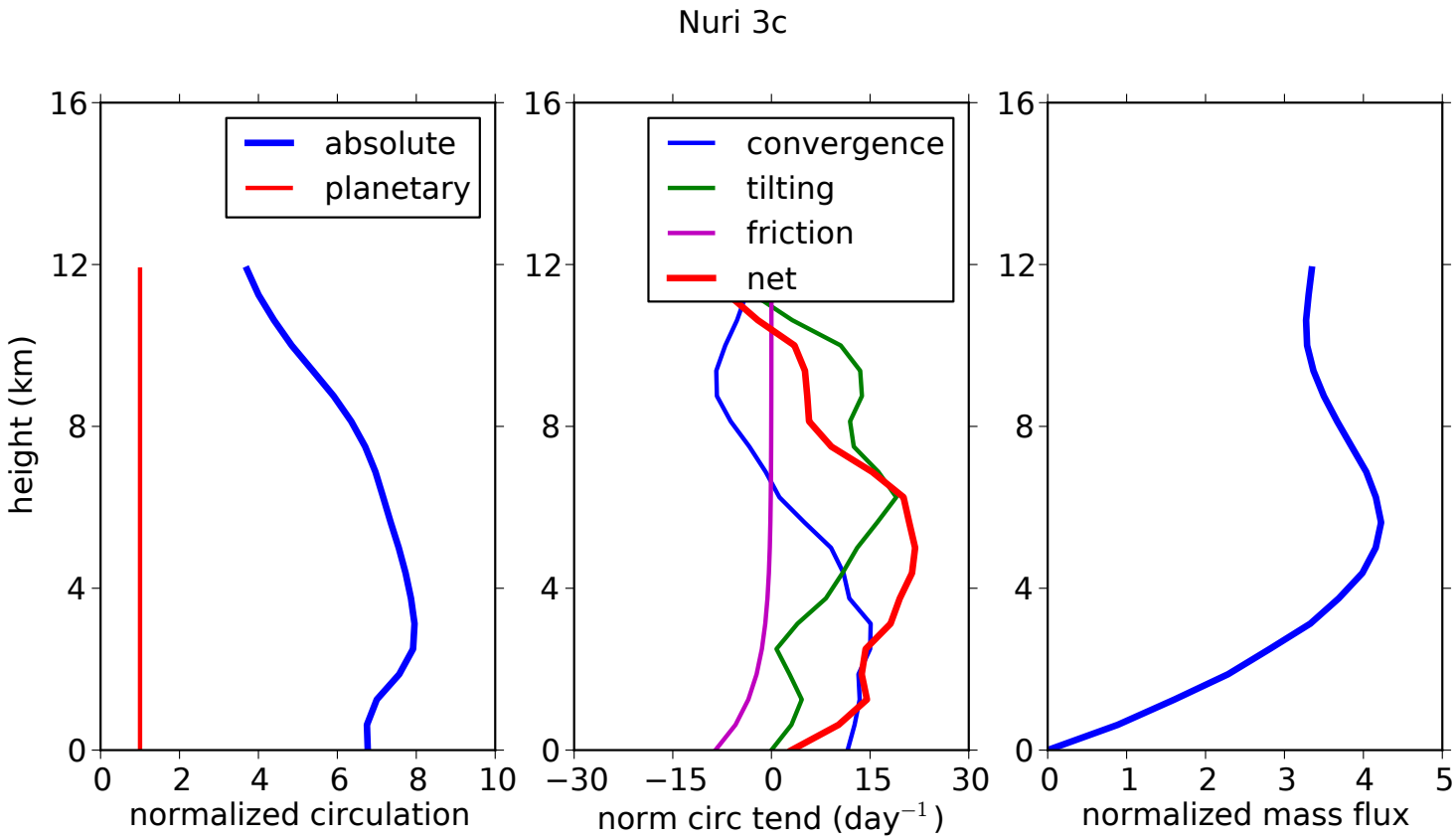
Nuri 1 (tropical wave)



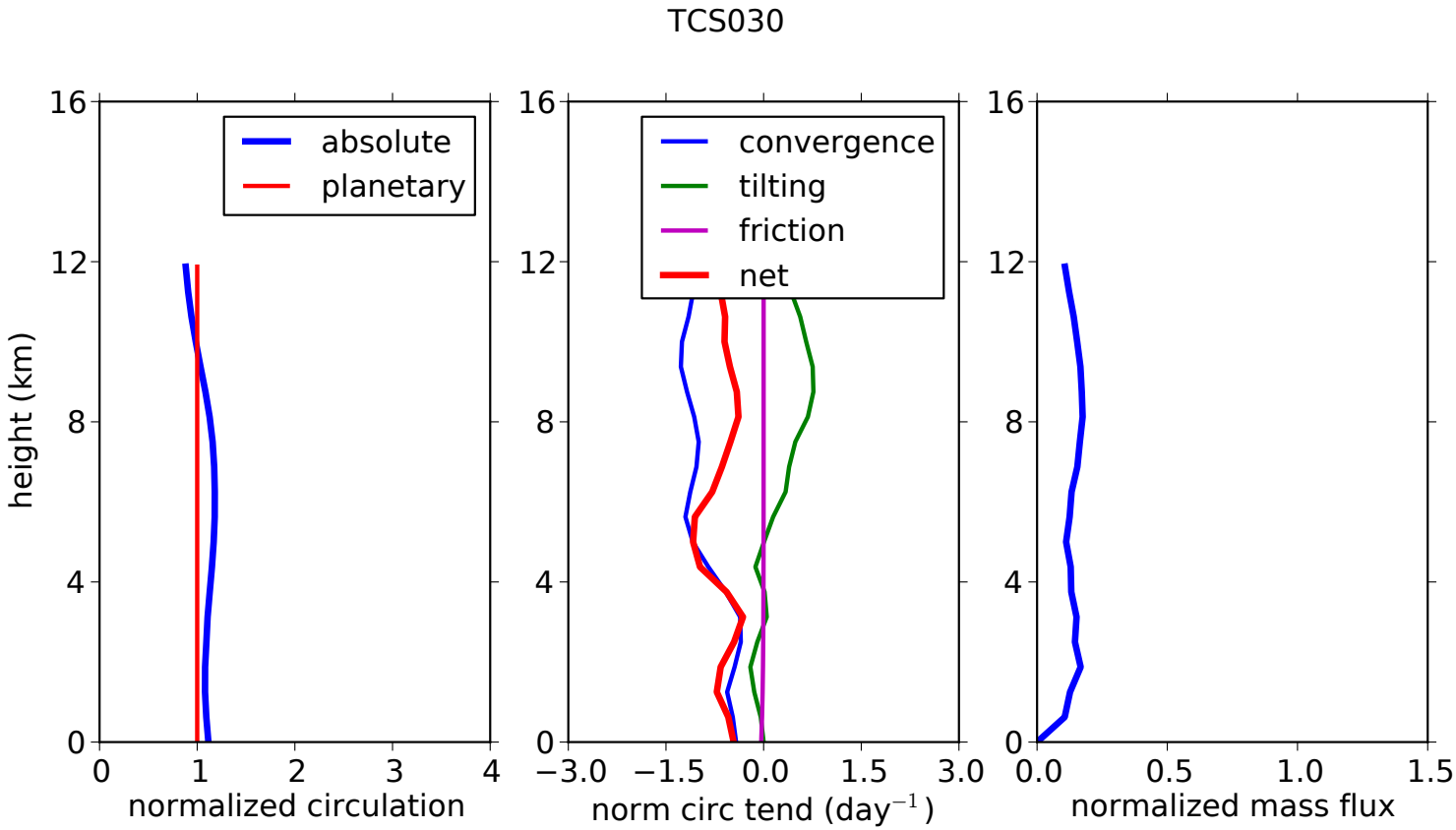
Nuri 2 (tropical depression)



Nuri 3 central region (tropical storm)



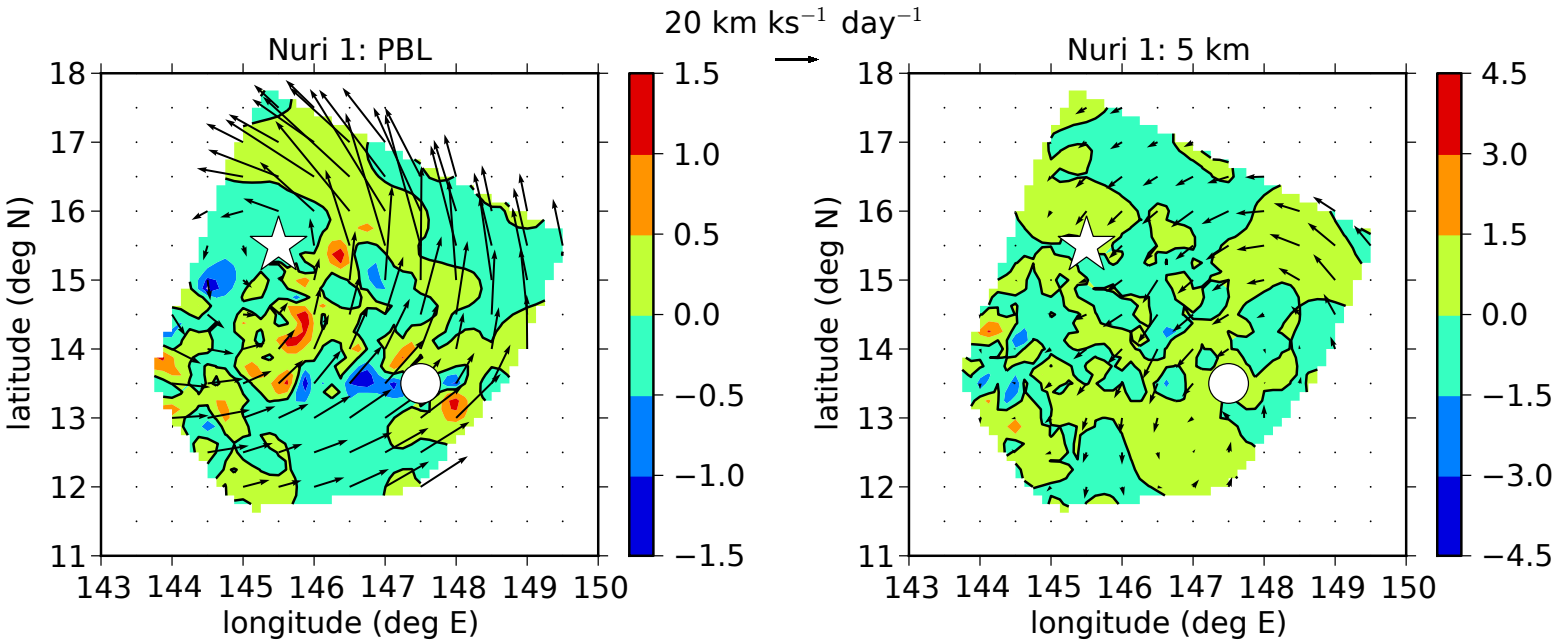
TCS030 (non-developing wave)



Hypothesis (similar to Dunkerton et al. 2009):

- Development occurs in regions protected from the intrusion of dry environmental air.
- Closed circulations in the system-relative reference frame provide this protection.

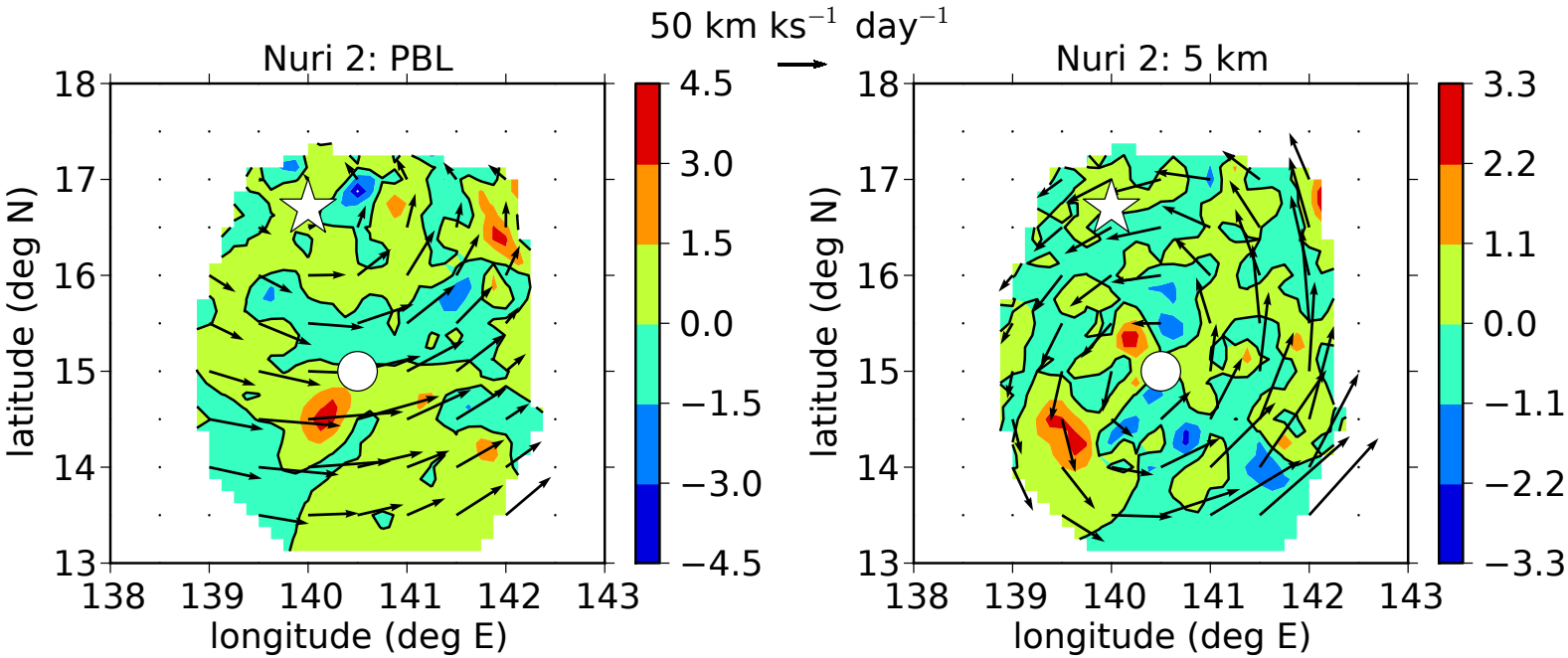
Vorticity flux and stretching – Nuri 1



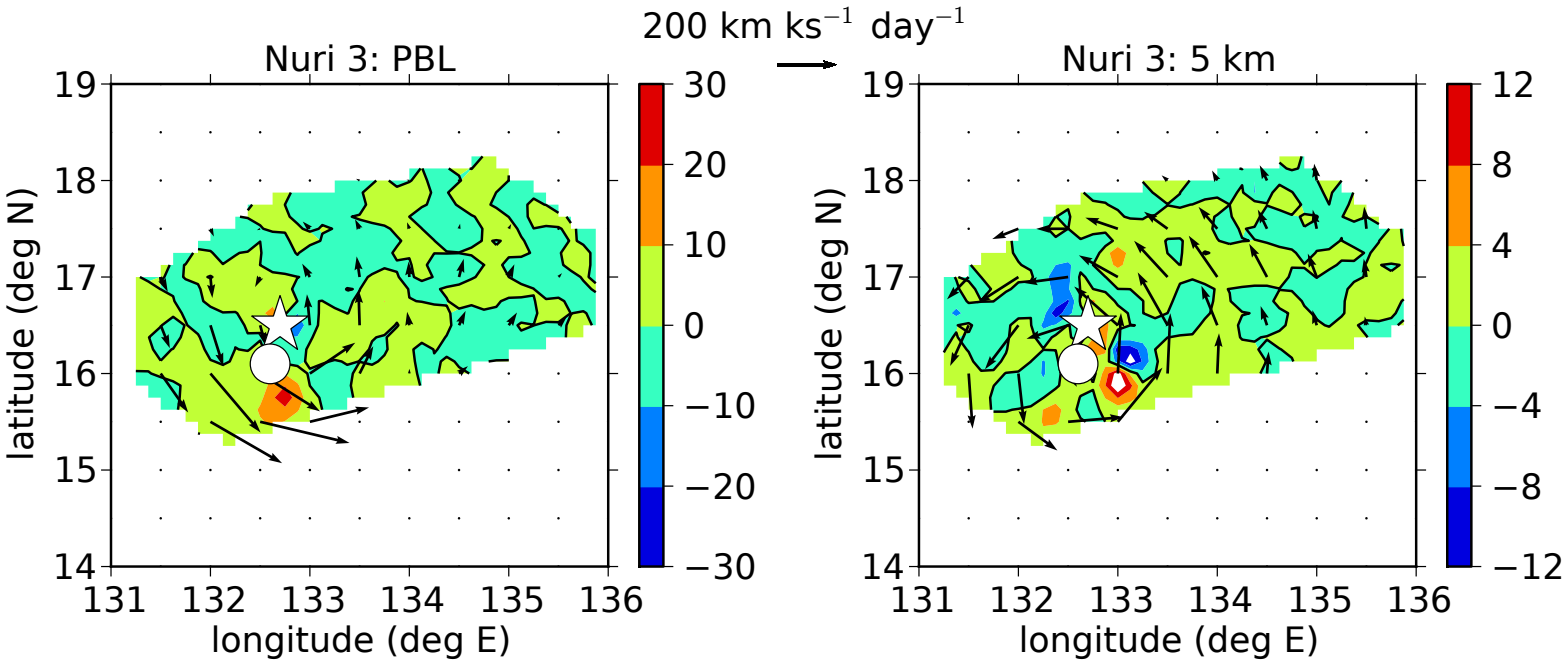
Star: PBL circulation center

Circle: 5 km circulation center

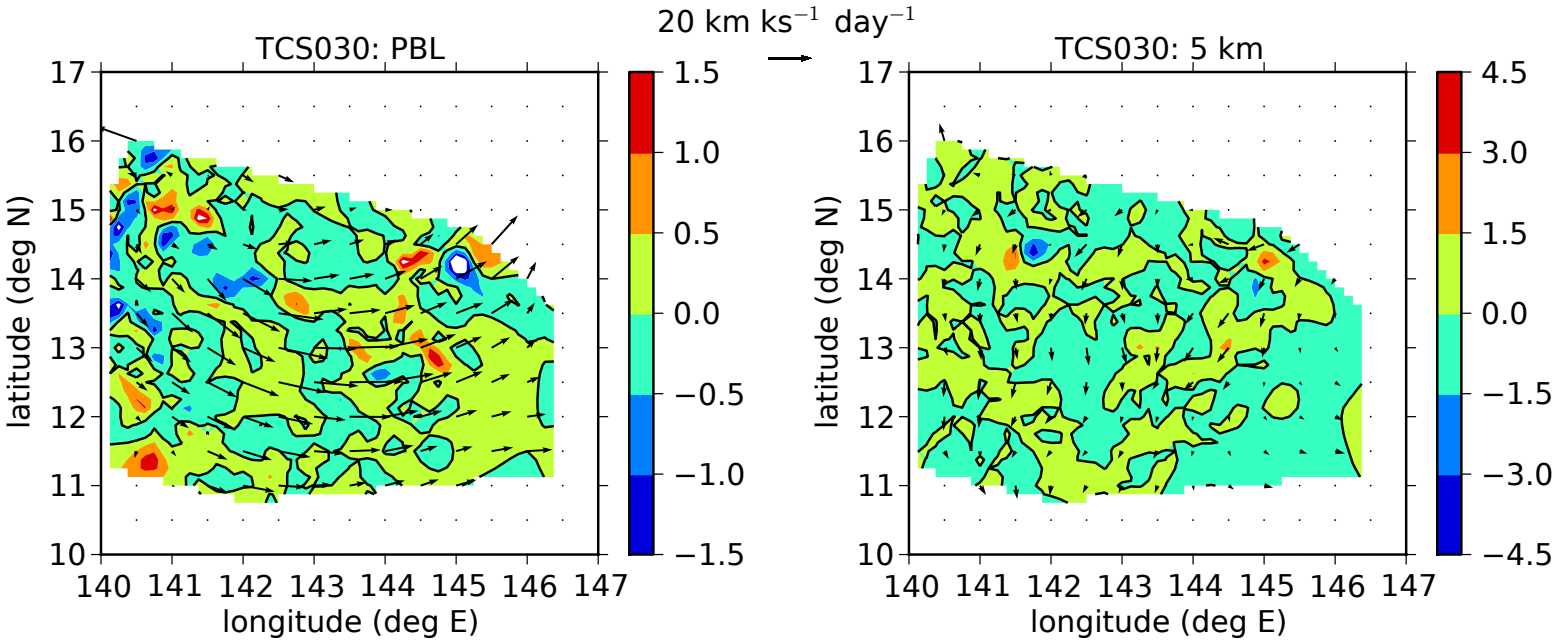
Vorticity flux and stretching – Nuri 2



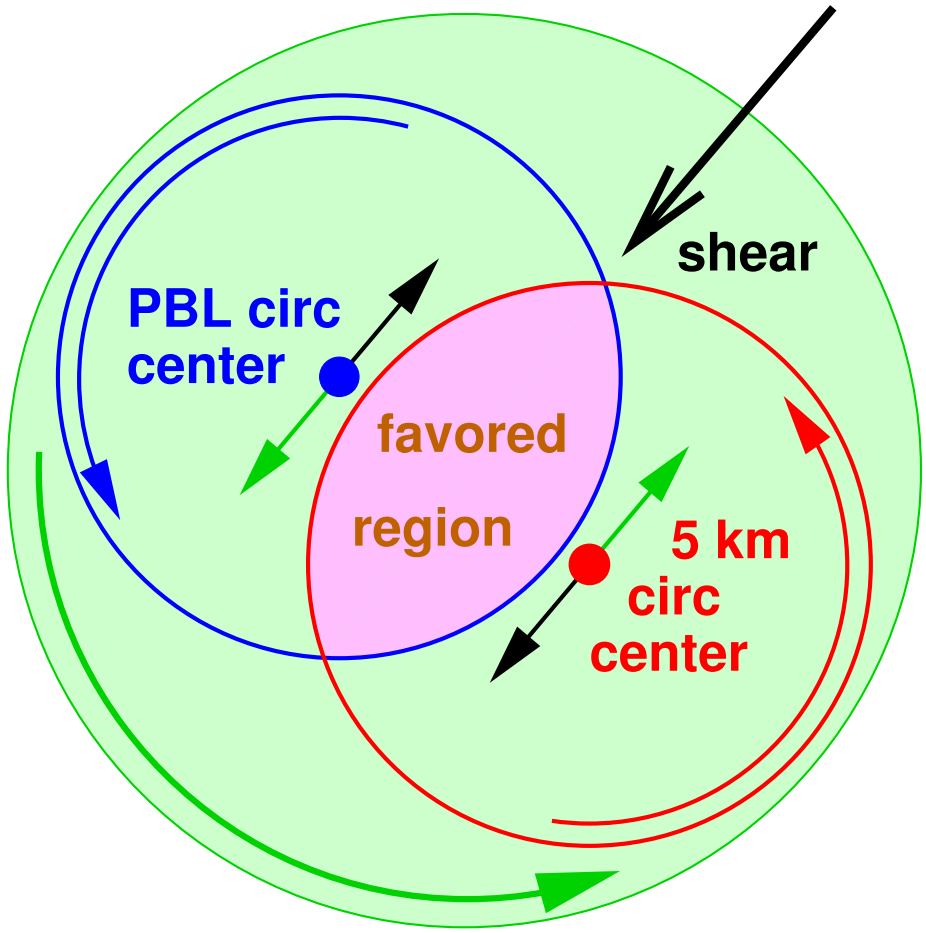
Vorticity flux and stretching – Nuri 3



Vorticity flux and stretching – TCS030



Overlapping closed circulations



Conclusions

- At tropical wave and depression stages, Nuri was far from vorticity balance. Hence the hypothesis of convective forcing by Ekman pumping is problematic at this stage of Nuri. So, what controls convection???
- Spinup occurred in Nuri during periods of strong, low-level convergence (convective burst). This convergence is likely related to the existence of strong, deep convection in protected regions with high relative humidity.
- Overlapping, system-relative closed circulations at the surface and 5 km in Nuri provided a column protected from intrusions of environmental air, thus promoting high humidity. TCS030 lacked these circulations.