Diurnal cycle of wind speed and precipitation over the northern Australia coastal region: CYGNSS observations

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Diurnal cycle of wind speed and precipitation over the northern Australia coastal region: **CYGNSS observations**

- ~ 50% of mean precipitation
- Previous studies:
  - focus on precipitation and circulation
  - scatterometer-based measurement

How surface wind speed and enthalpy flux modulate the diurnal cycle?

New satellite observation from CYGNSS

Moist static energy (MSE) budget

CYGNSS – Cyclone Global Navigation Satellite System

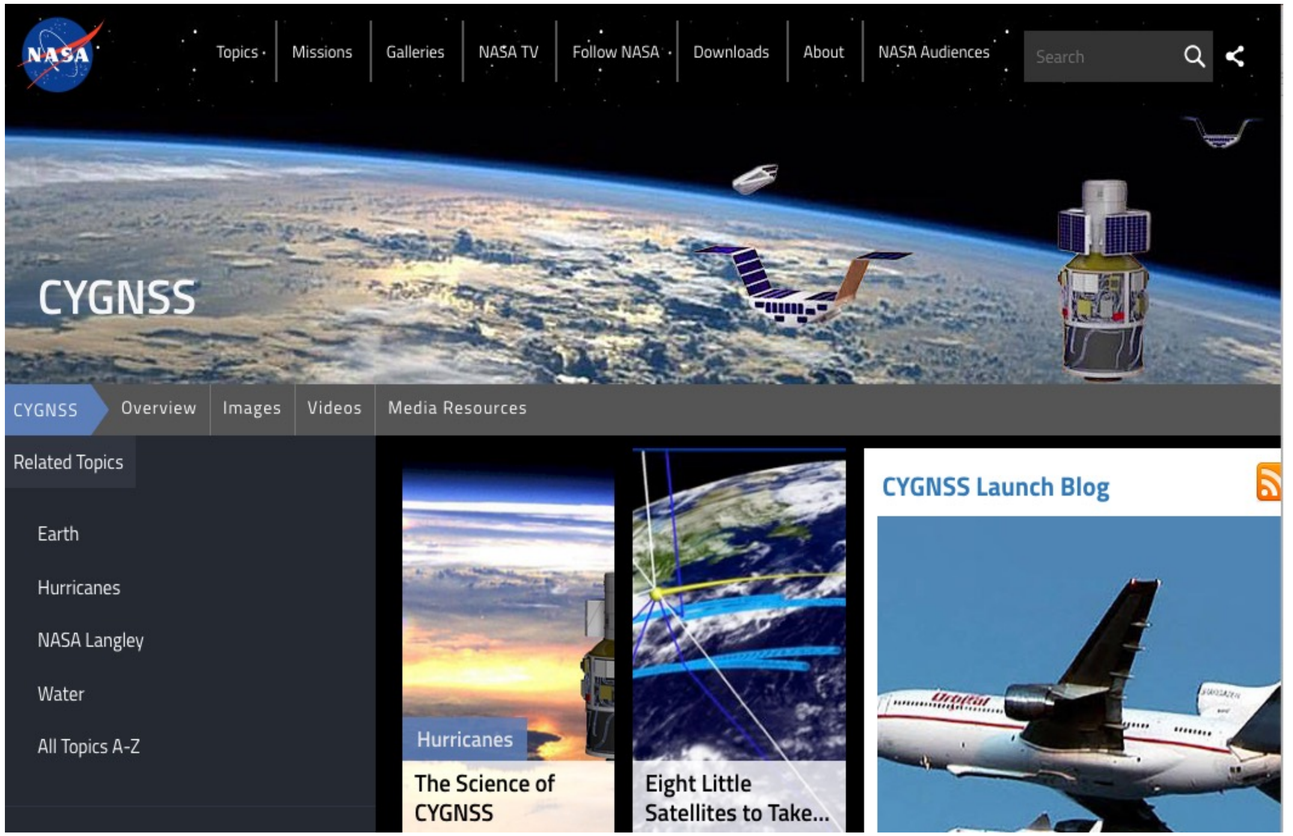
Launch date: 15 Dec 2016

Measurement: Ocean surface winds

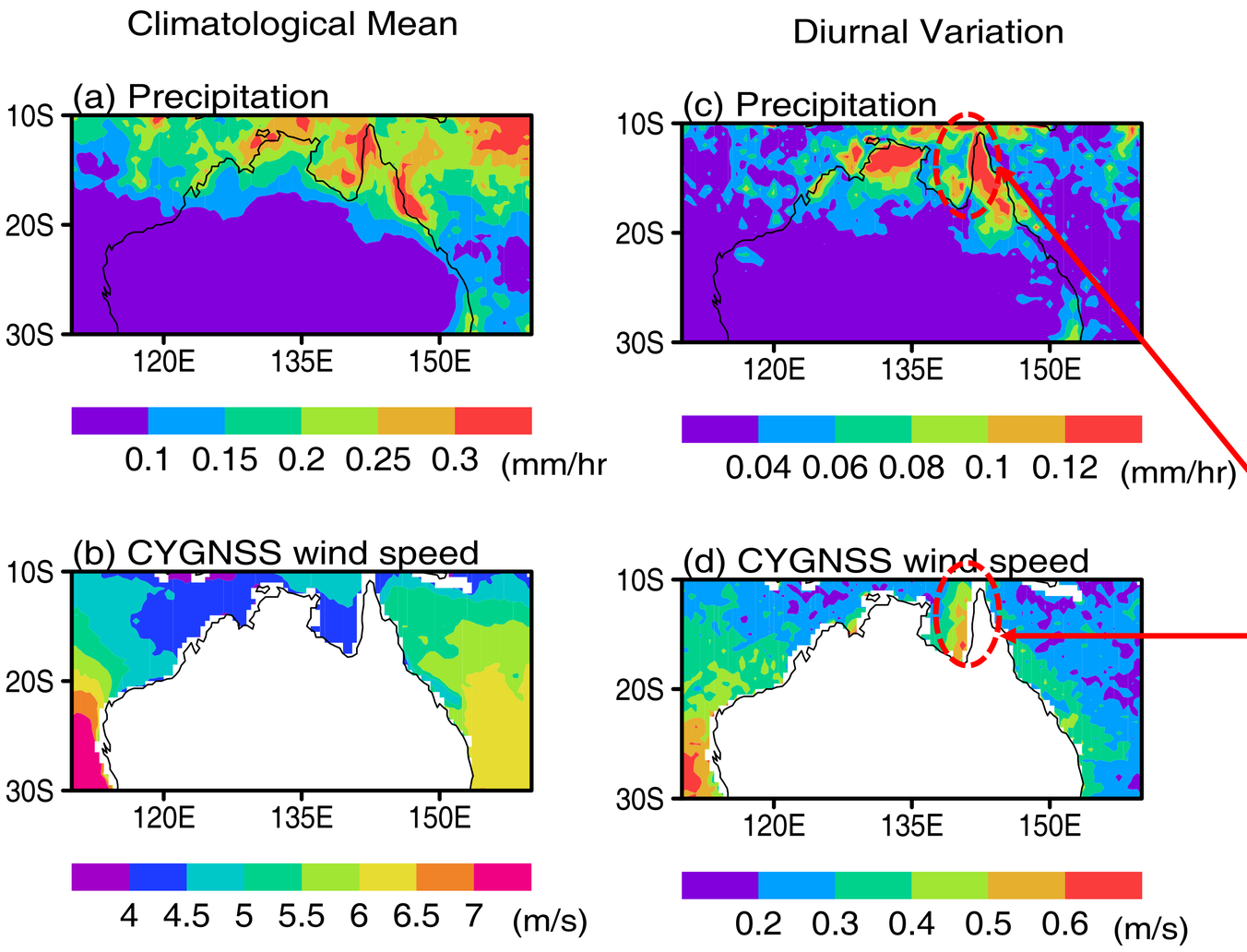
Coverage: 38°S-38°N

Advantages: Not affected by rainfall, high temporal and spatial resolution

https://www.nasa.gov/cygnss



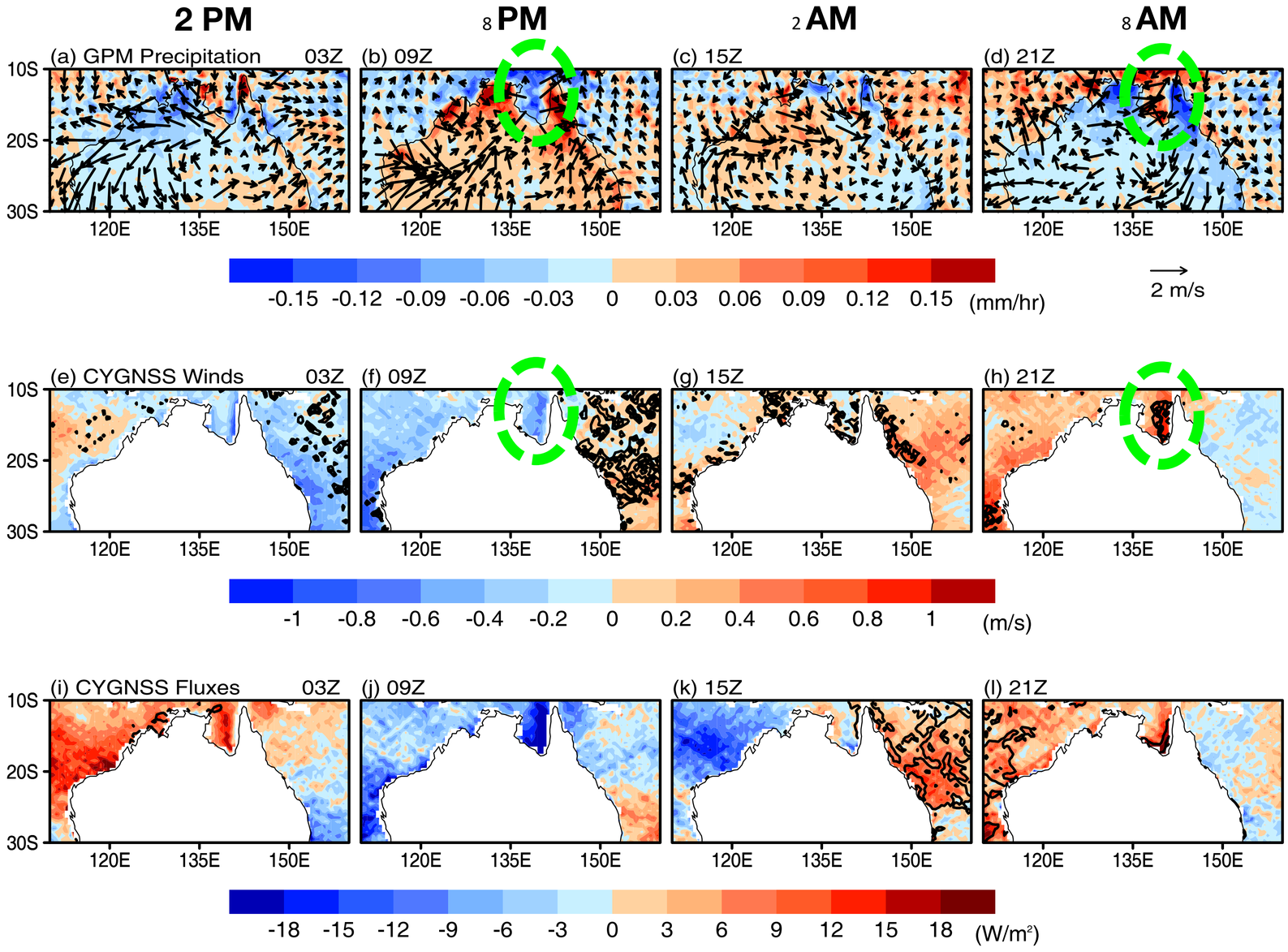
Climatological mean and Diurnal variation



- GPM precipitation & CYGNSS wind speed
- Nov-Apr 2018-2022
- Enhanced diurnal cycle of precipitation is associated with a strong diurnal cycle of wind speed

Composite diurnal cycle

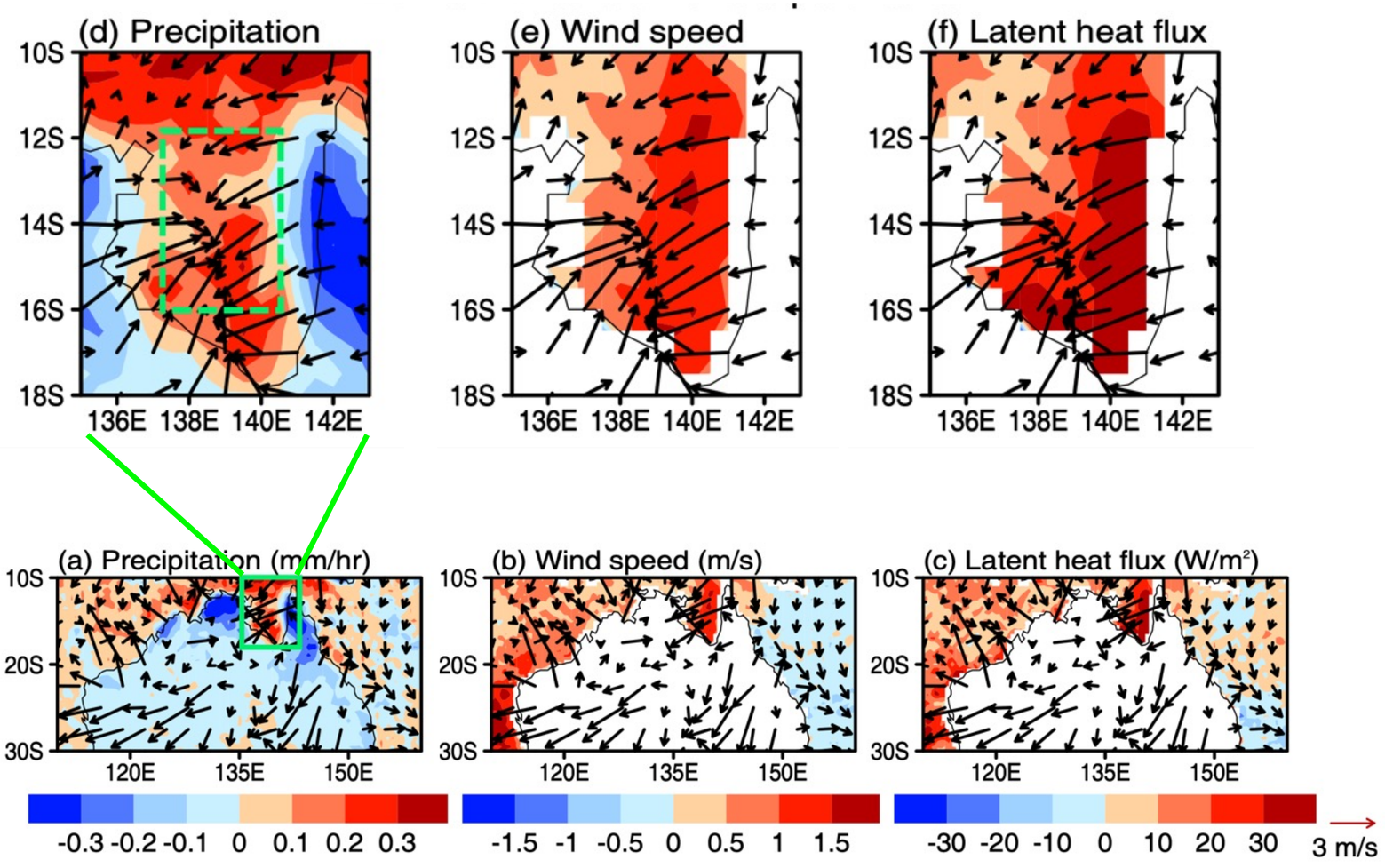
(daily mean was subtracted from the composite 3-hourly data)



- strong differences between land and ocean and between morning and evening
- stronger wind anomalies associated with positive precipitation anomalies
- consistent pattern between latent heat flux and wind speed

increased wind speed
→ enhance the moisture supply
→ support diurnal precipitation

Difference between the evening and the morning (8PM vs. 8AM)



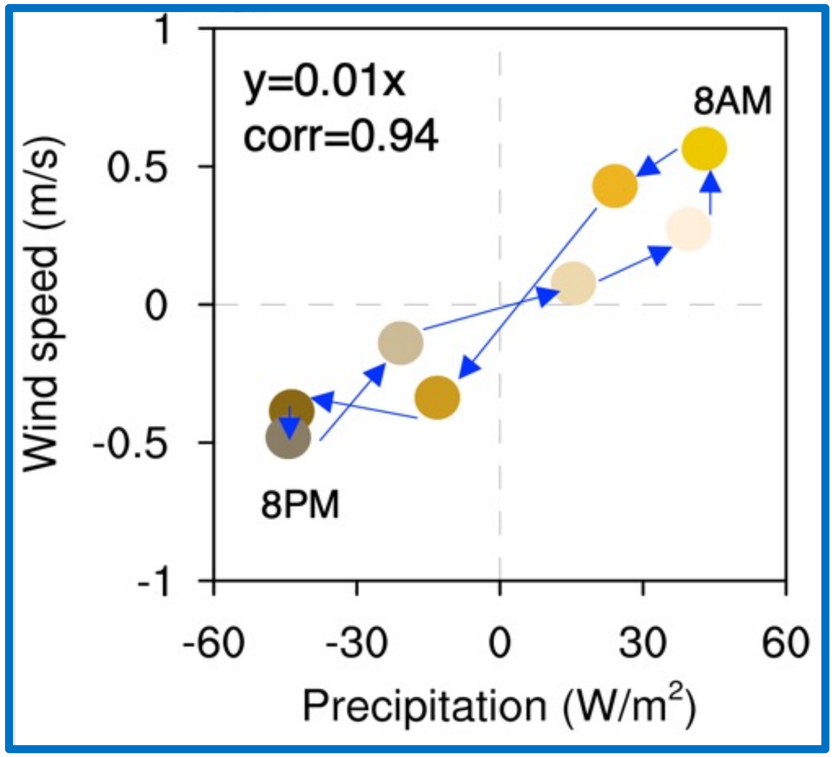
→ diurnal rainfall produces a large fraction of the total precipitation

→ strong land breeze directed from Cape York toward the Gulf

→ positive flux anomalies show a similar pattern to the positive surface wind speed and precipitation anomalies

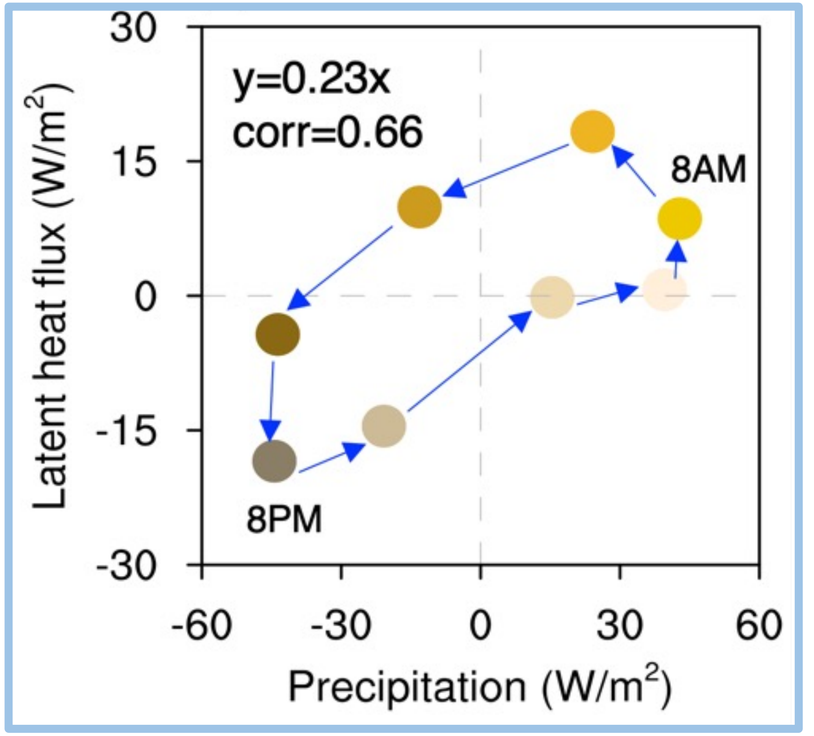
Wind-induced surface heat exchange (WISHE) mechanism ?

Phase relationship between precipitation and wind speed



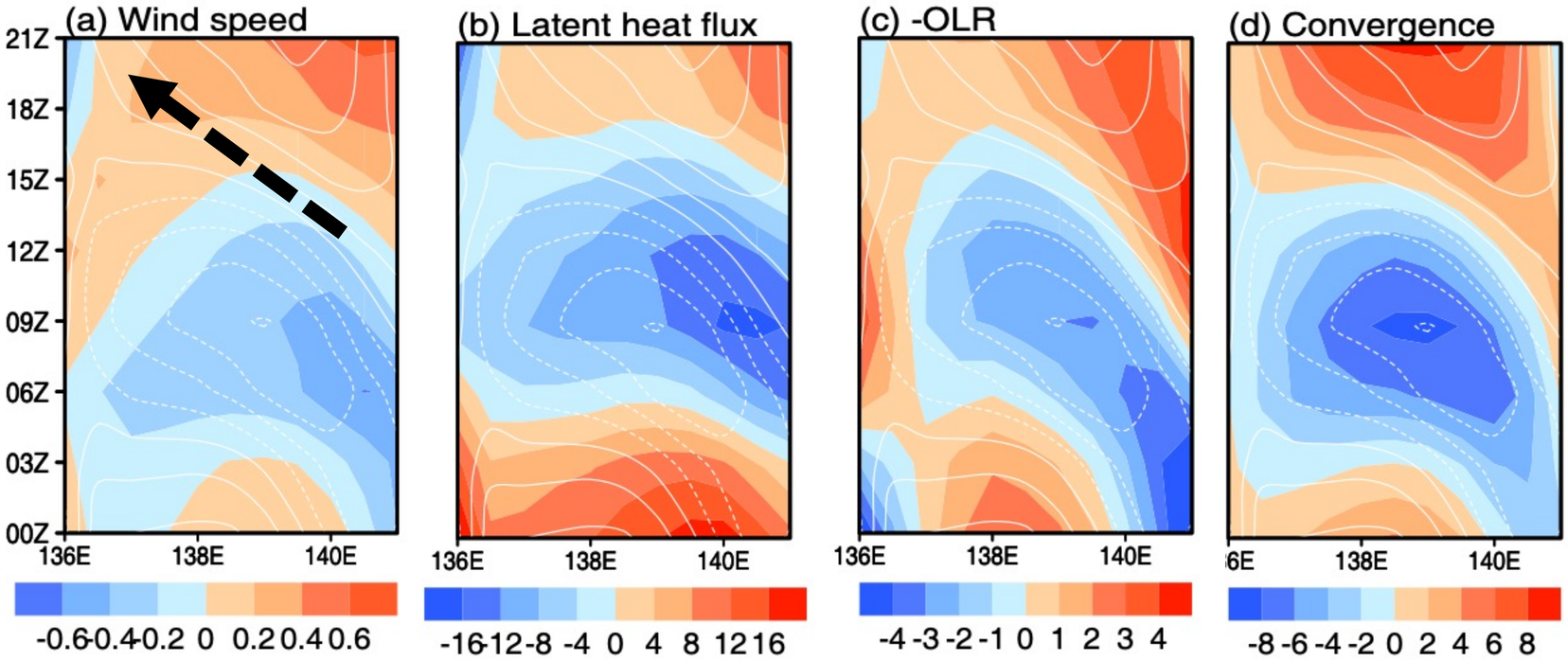
- wind speed and precipitation perturbations are in phase → the land breeze forces/modulates the diurnal cycle of precipitation

(averaged over the Gulf of Carpentaria)



- surface latent heat flux shows a lag of about 3 hours relative to precipitation and surface wind speed

Westward propagation



- Precipitation grows as they move westward
- Wind speed, OLR, surface convergence

increase in wind speed → support the diurnal convective features through flux anomalies and convergence

What fosters offshore propagation of the signal?

Moist static energy (m) budget

temperature — geopotential height

$$m = C_p T + Lq + gz$$

humidity

vertical MSE advection — Net fluxes into the atmosphere

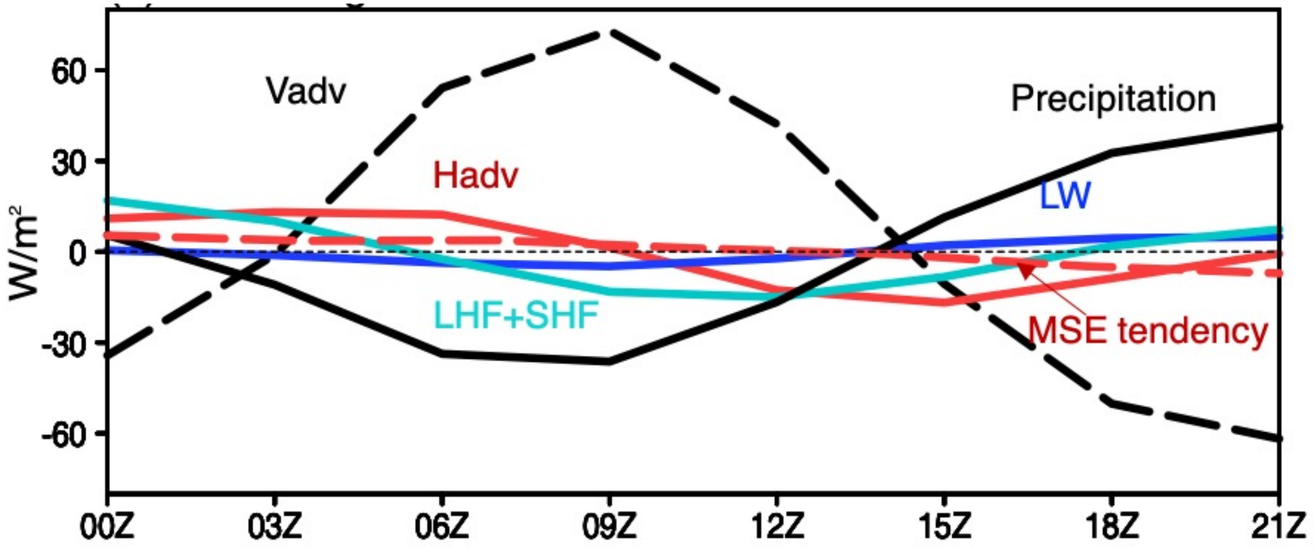
$$\left\langle \frac{\partial m}{\partial t} \right\rangle = -\left\langle \omega \frac{\partial m}{\partial p} \right\rangle - \left\langle v \cdot \nabla m \right\rangle + \mathbf{F^{net}} + \boldsymbol{Residual}$$

MSE tendency — horizontal MSE advection — surface heat fluxes (latent + sensible) + longwave + shortwave

⟨ ⟩ represents mass-weighted integration through the troposphere from 1000 to 100 hPa

What parts of the budget support precipitation?

$$MSE\ tendency = Vadv + Hadv + Fnet + res.$$



(averaged over the Gulf of Carpentaria)

MSE tendency:
- recharge before the peak of precipitation
- discharge during and after the peak

Vadv:
- large & positive before the peak
- negative during and after the peak

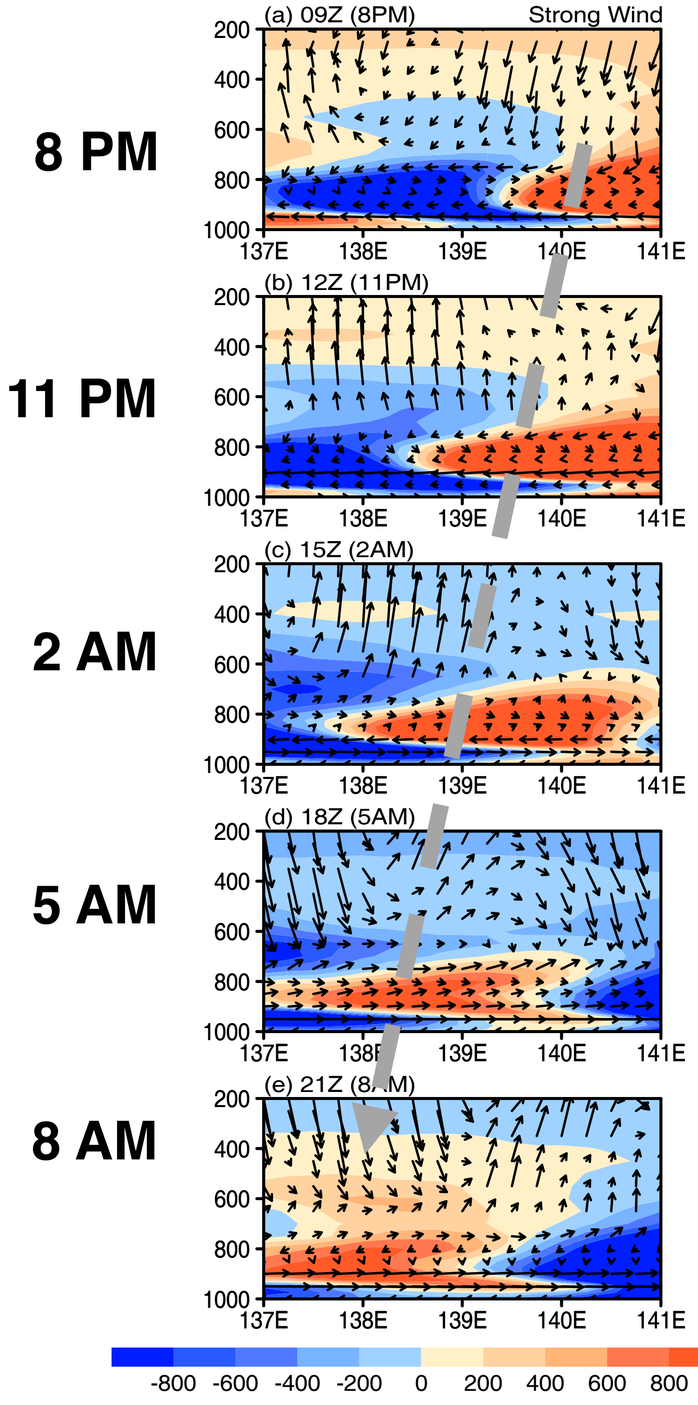
Hadv:
- out of phase with precipitation
- smaller than Vadv

Fluxes:
- consistent with the phase relationship
- support precipitation

→ shallow convection (low-level convergence) is important for moistening the lower troposphere before the onset of deep convection

Is this shallow signal only occurring on days with little offshore precipitation signal?

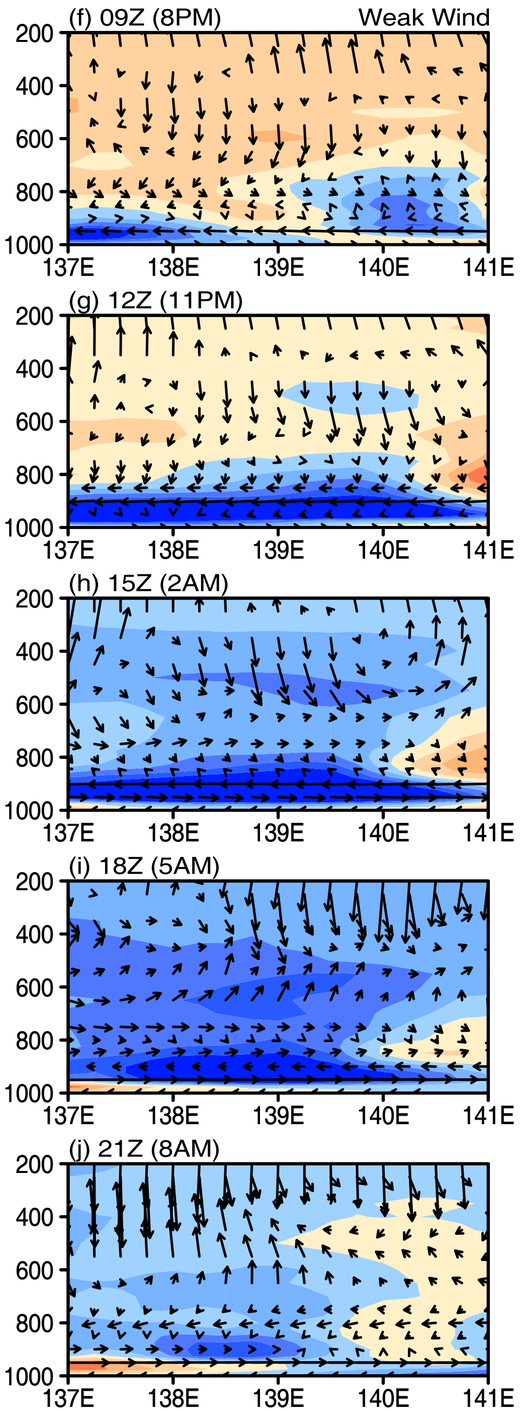
Differences in MSE: strong vs. weak ambient winds



- Ambient winds: ERA5 850 hPa wind (i.e., shore-orthogonal wind)
- Strong: > mean + 1σ
- Weak: < mean – 1σ

- tilted upward and outward from the coast
- downward phase propagation

- low-level moistening near the coast
- develops and moves further westward



Conclusions

CYGNSS wind speeds and latent heat fluxes are used to study the diurnal cycle over the northern Australia coastal region

Enhanced diurnal precipitation is associated with enhanced surface wind speed and convergence

Diurnal precipitation and surface wind speed signals propagate westward in tandem from the Cape York Peninsula – MSE budget analysis

Thank you!