# TROPICAL CYCLONE DIURNAL CYCLE AND GRAVITY WAVE: HURRICANE EDOUARD (2014) CASE

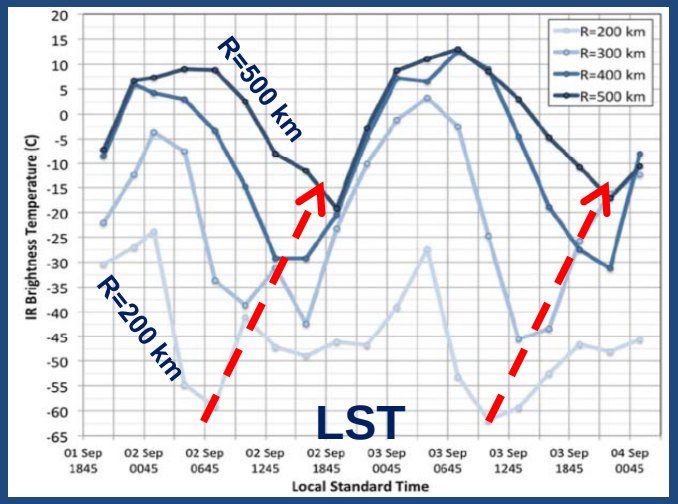
**Xiaodong Tang and Fuqing Zhang**

**Collaborators: Yonghui Weng, and Erin Munsell**

# Tropical Cyclone Diurnal Cycle

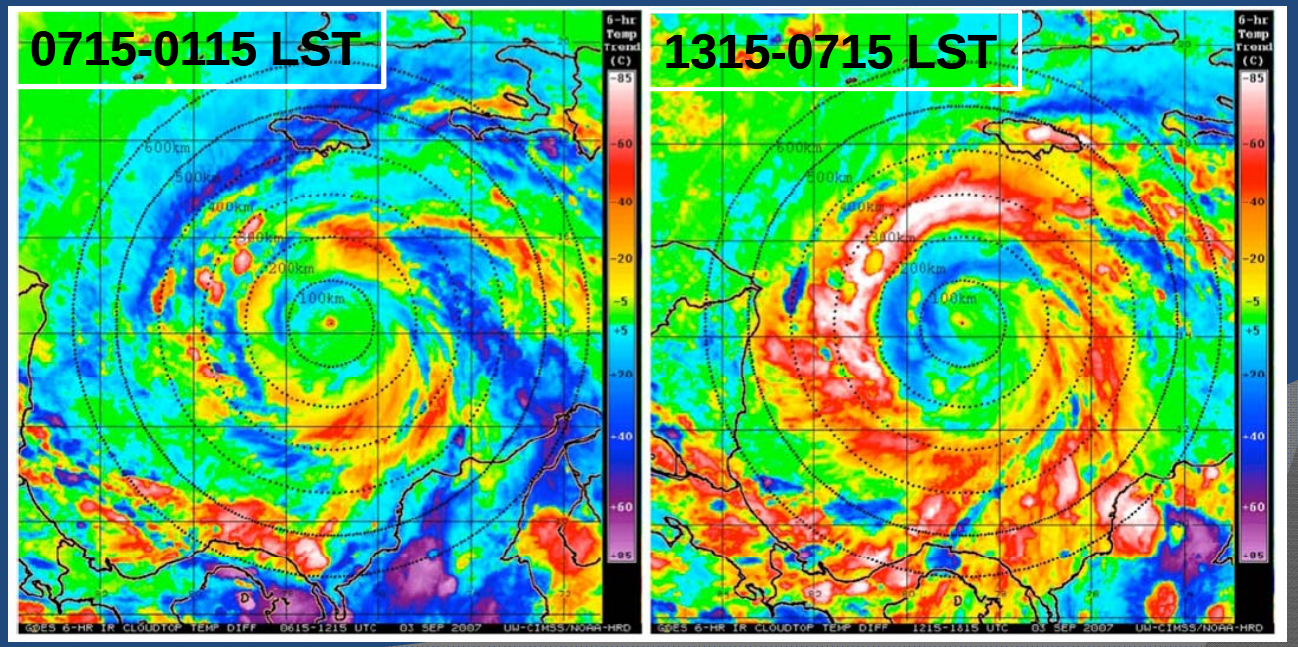
Hurricane Felix (2007)

**IR brightness temperature**




**Diurnal pulses begin forming in the inner core near sunset each day, and move outwards overnight, reaching several hundred KMs away by the following afternoon.**

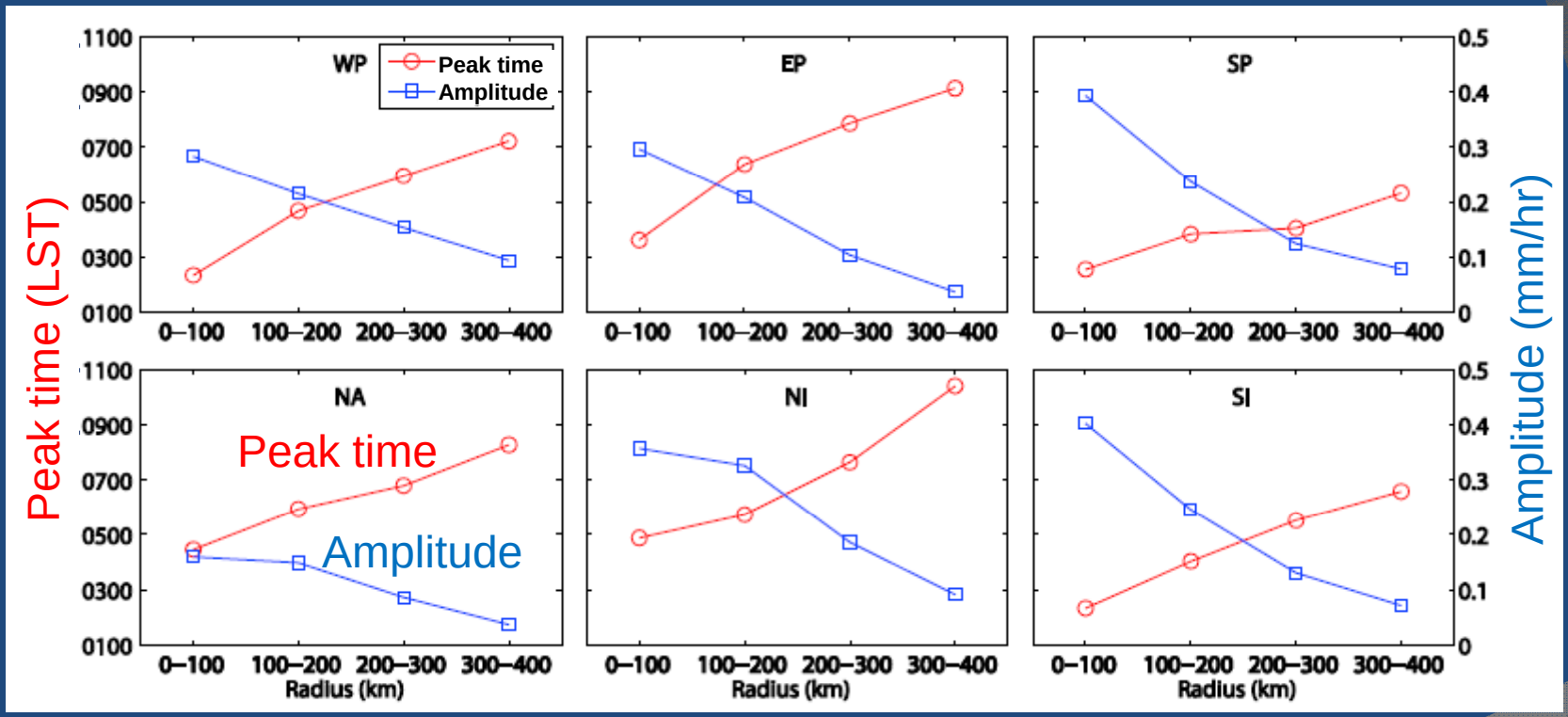
**6-hr differencing images**




(Dunion et al. 2014, MWR, Figs. 1 and 3)

# Tropical Cyclone Diurnal Cycle

## Precipitation




**With increasing radius, the diurnal amplitude of precipitation decreases, and the peak time progressively lags.**

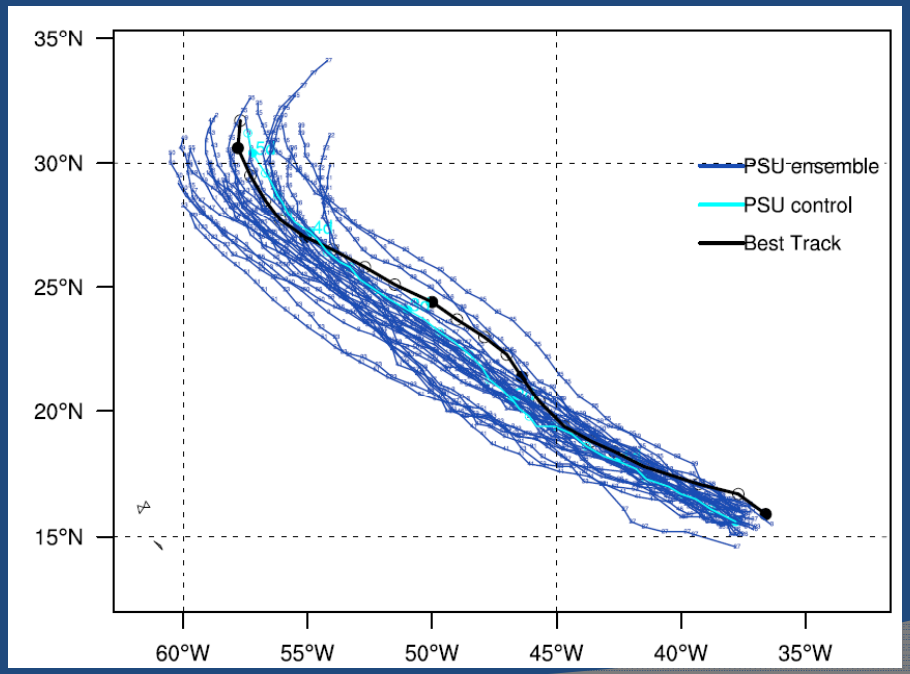
(Wu et al. 2014, JGR, Fig. 8)

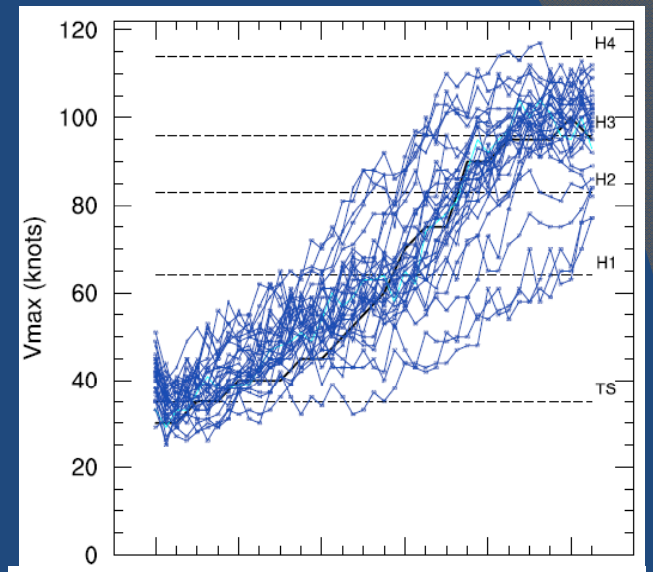
# Hypotheses

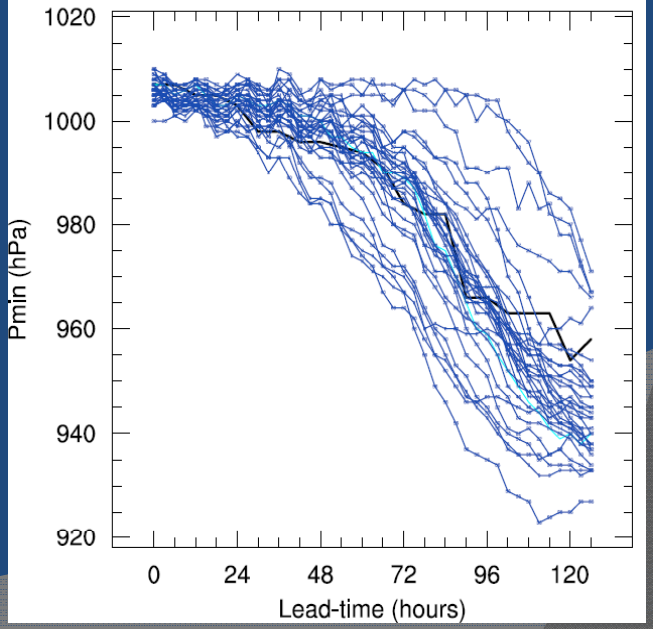
- Gravity waves (GW) radiate outward from the diurnally oscillating heat source of TC inner-core deep convection
- Diurnal GW motion contributes to the changes of structure, intensity and precipitation of TC in the outer core

# Methodology

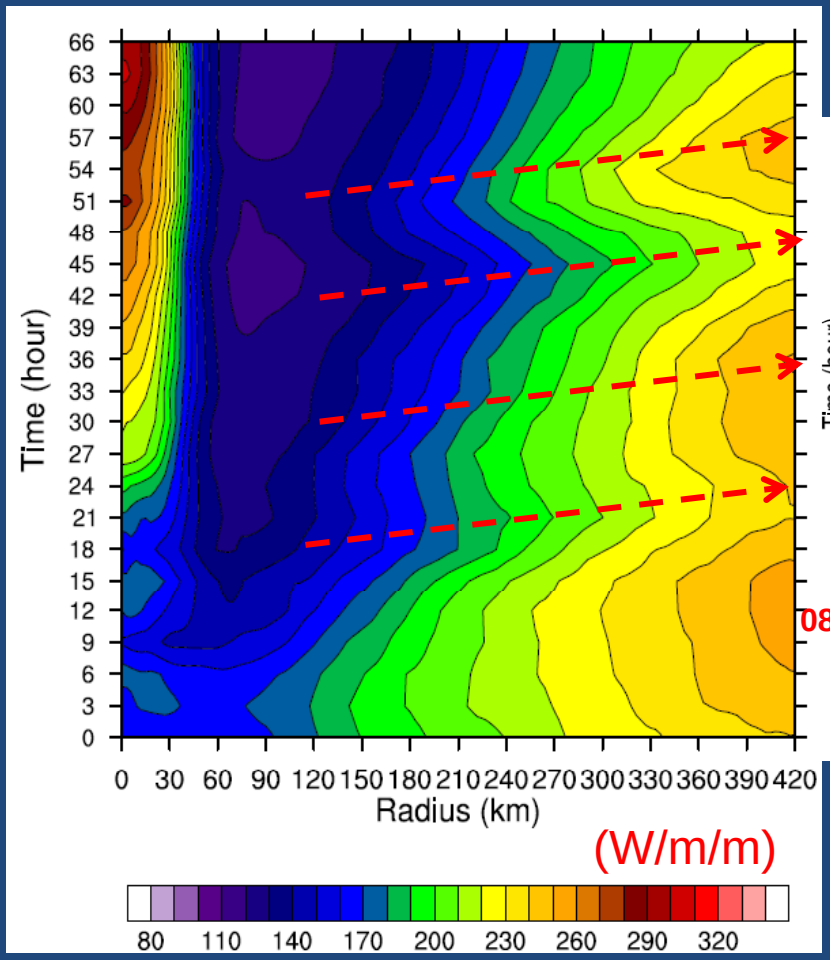
- **Ensemble modelling (27 members)**
- **24-hr band pass filtering of ensemble mean after detrending**



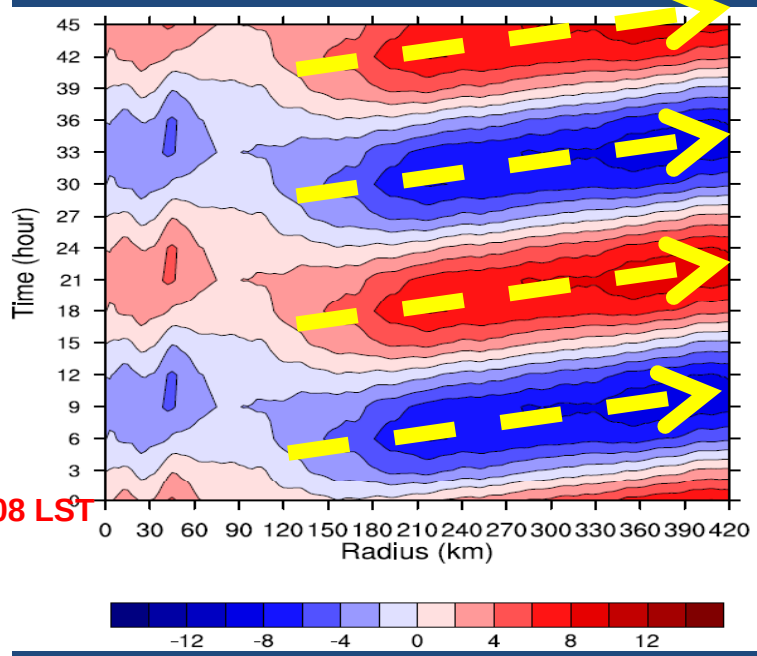



# Diurnal Outgoing Long-wave Radiation

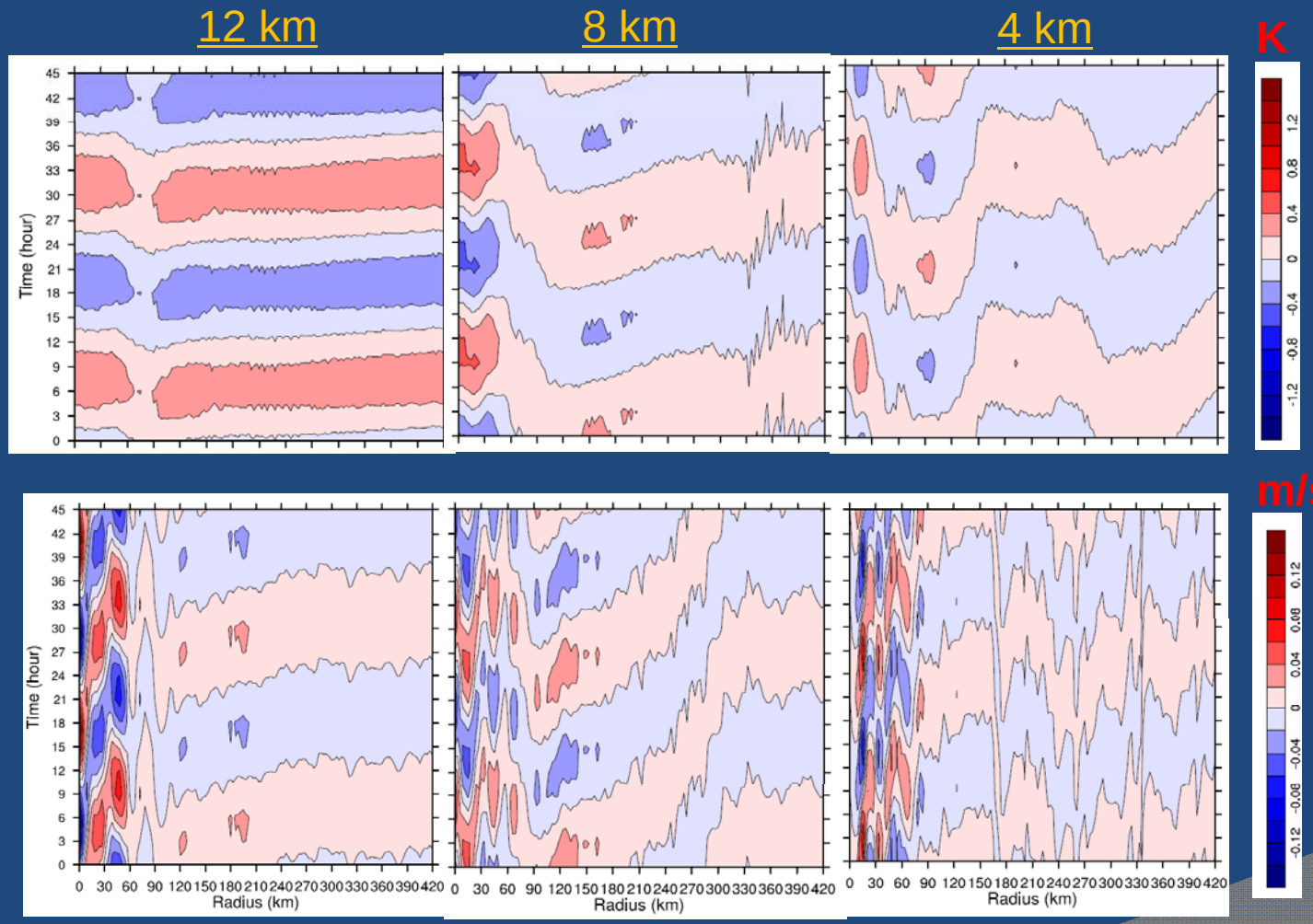



**24-hr Wave Filtered**




**In the inner core, Min of OLR is at 5-8 PM (LST) (near sunset time) and max at 5-8 AM. Diurnal pulse propagates outwards with a speed of ~15 m/s**

# Diurnal Oscillations at Levels

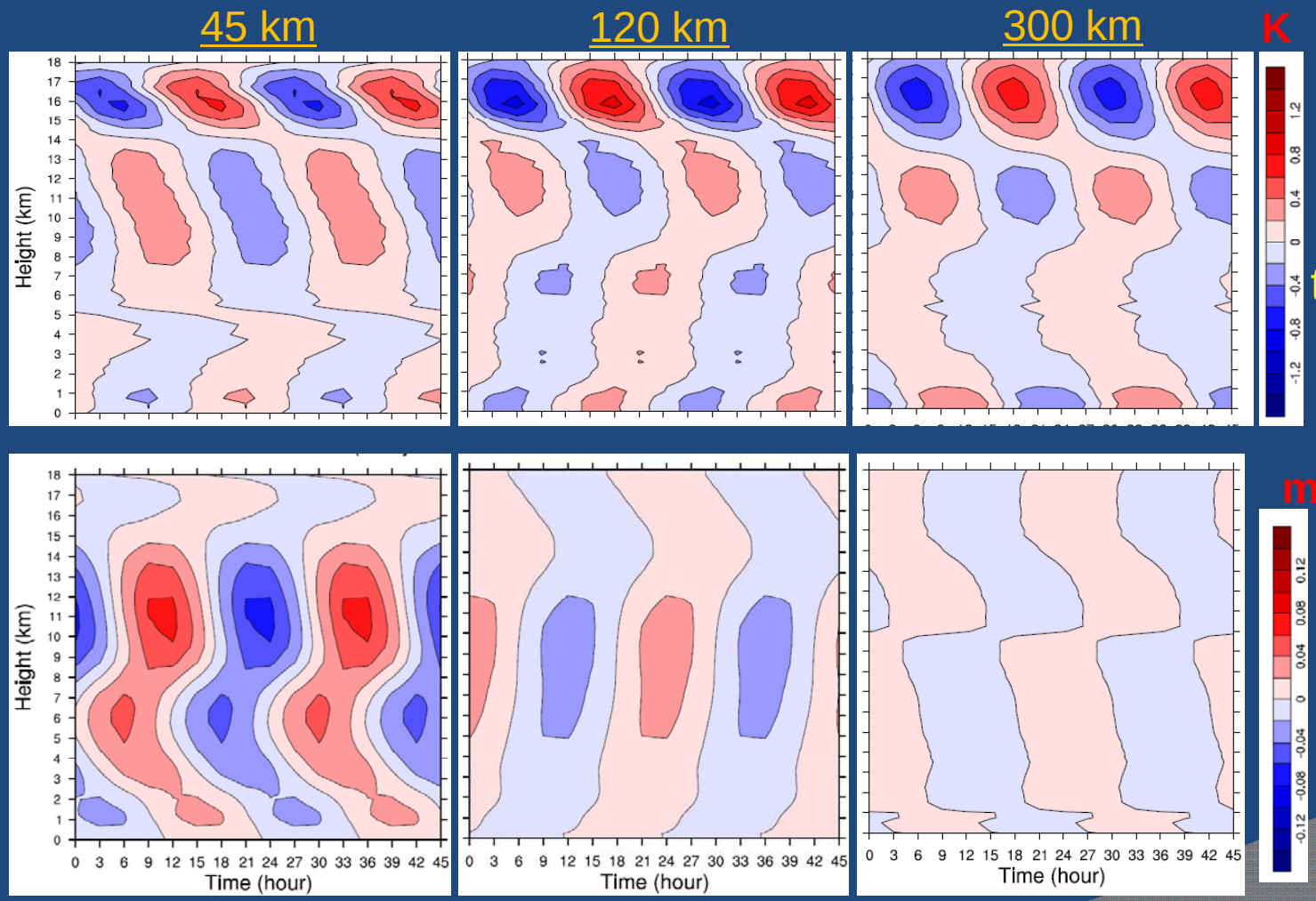



Equivalent potential temperature

Vertical velocity

Horizontal wave lengths and amplitudes decrease downwards and outwards in the outer core

# Diurnal Oscillations at Radii

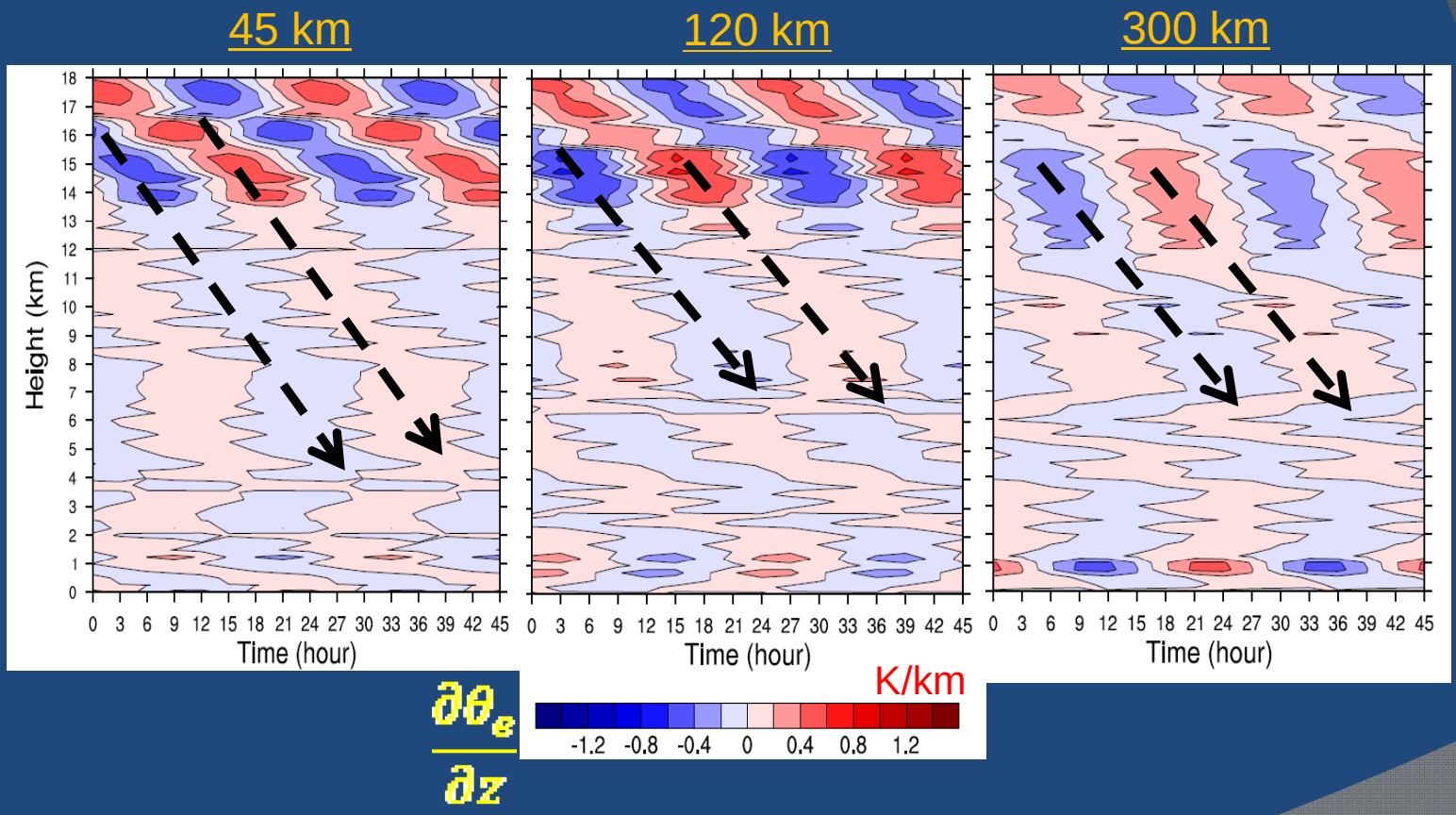



Equivalent potential temperature

Vertical velocity

Diurnal waves have different phases and amplitudes on different levels at the same radius

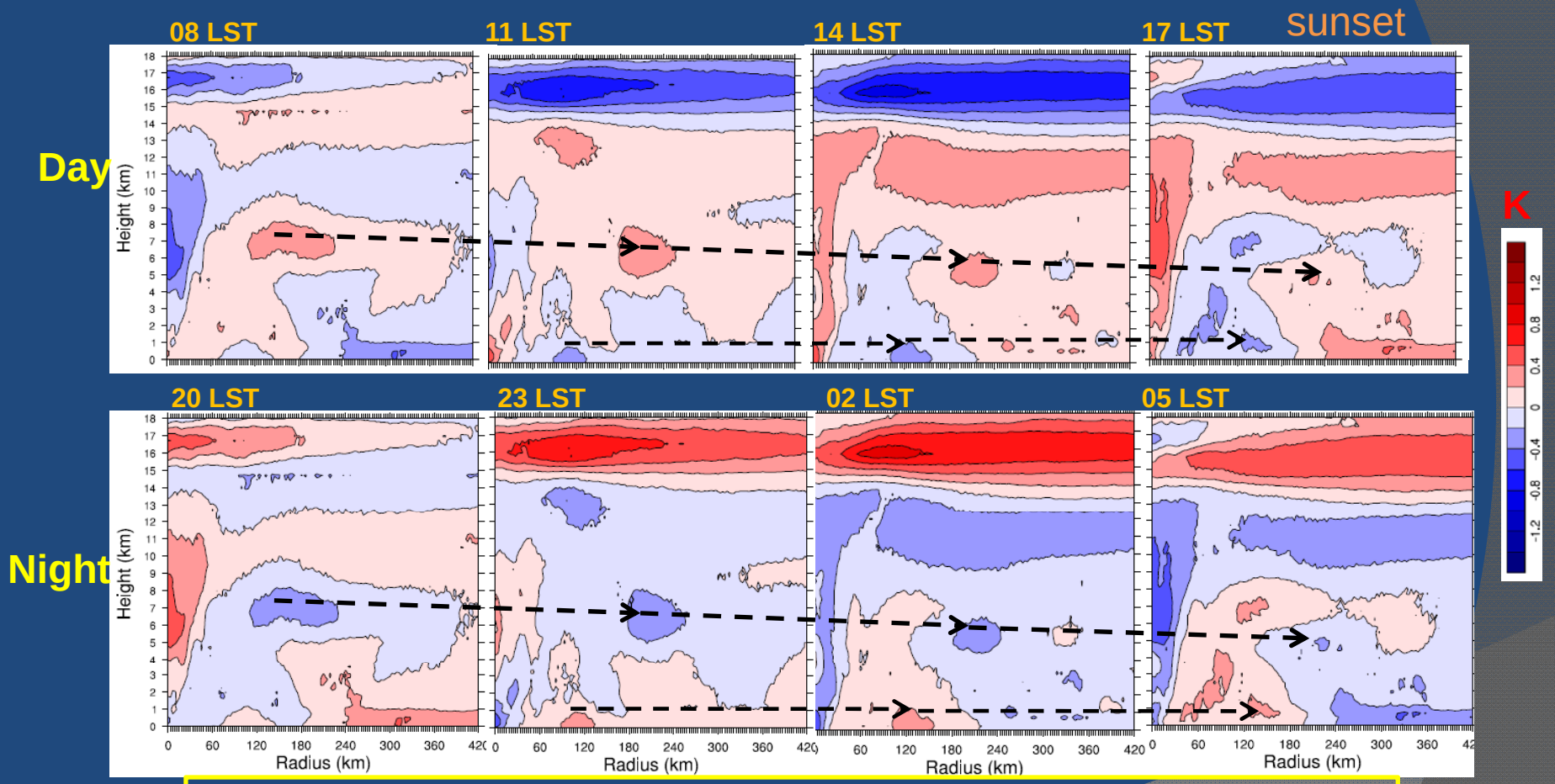
# Diurnal Oscillations of Convective Instability




Variations of convective instability originate from tropopause and propagate to middle and low troposphere

# Diurnal Cycle of Gravity Wave

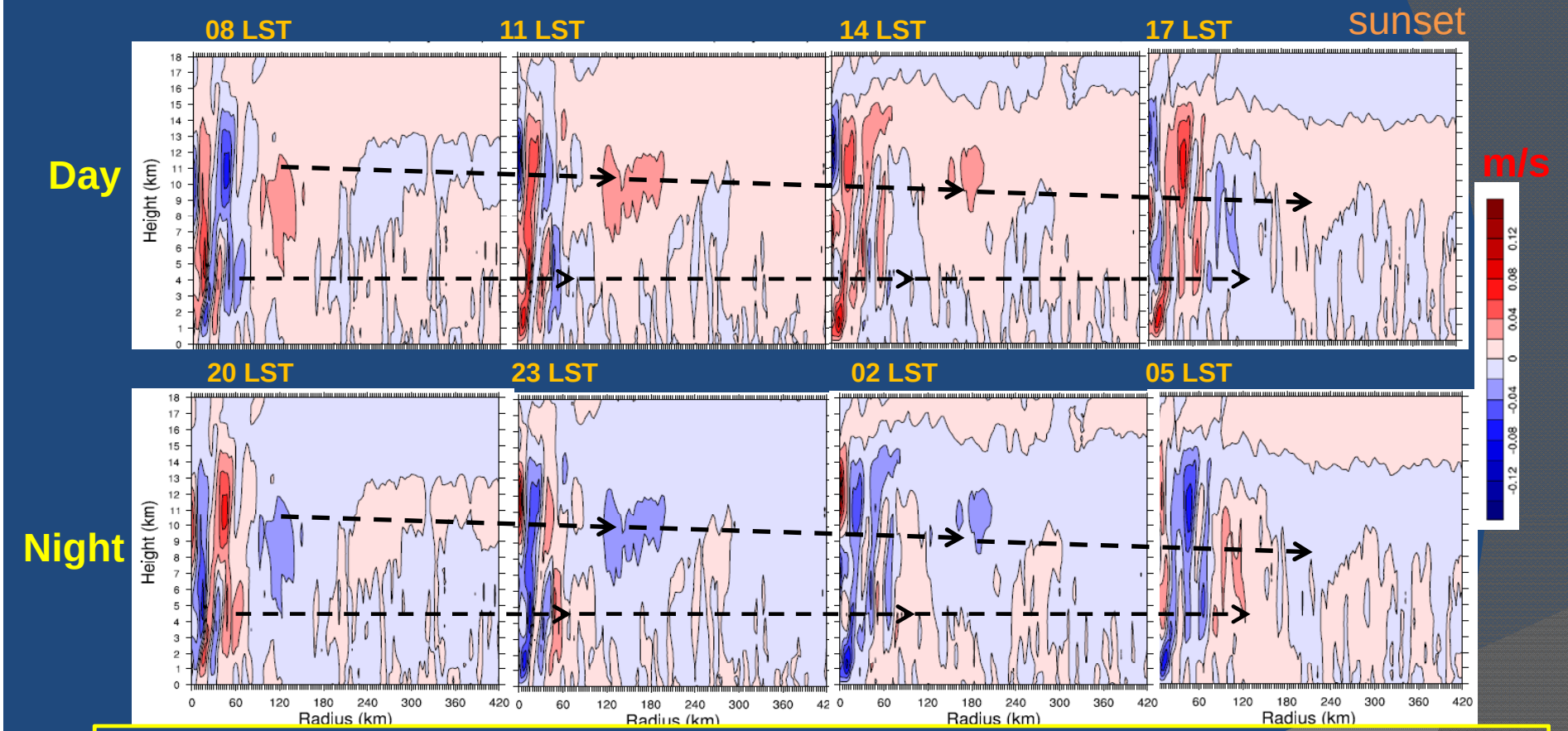
## Equivalent potential temperature




A pulse begins near the time of local sunset as a cooling region of inner-core cloud tops.
Relatively warmer inner-core cloud tops are evident in daytime.

# Diurnal Cycle of Gravity Wave

## Vertical velocity




After sunset, the inner core convection intensifies and continues to propagate outward at daytime, with descent (or decreasing ascent) on its inside edge. Diurnal pulses involve a relatively deep layer (from upper to low troposphere).

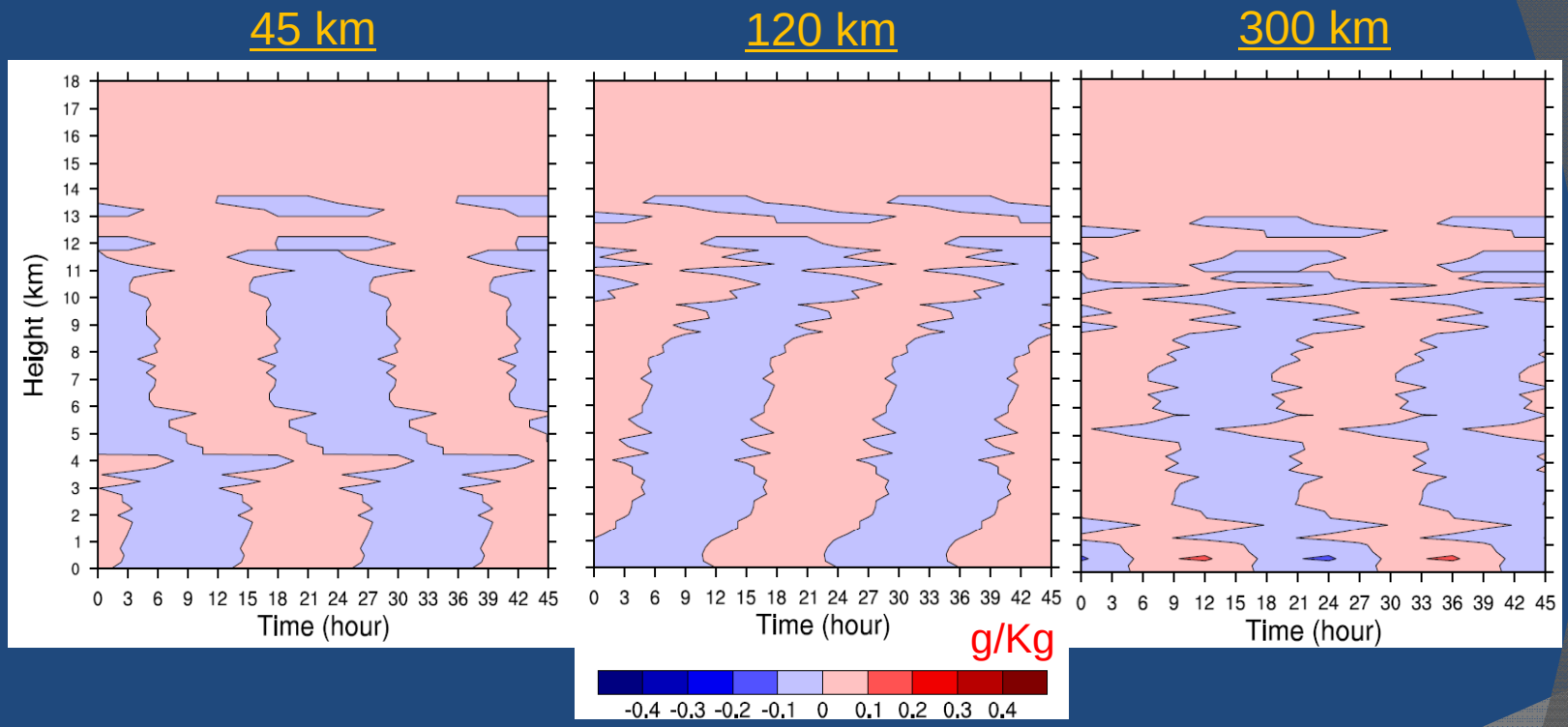
# Concluding Remarks

- TC diurnal pulse outwards propagation is diurnal GW radiation, and GW motion contributes to the TC structure change
- Wave speed at troposphere is ~10m/s, consistent with observations (Dunion et al. 2014; Wu et al. 2014)
- Horizontal wave lengths and amplitudes decrease downwards and outwards in the outer core
- Variations of convective instability originate from tropopause and propagate to middle and low troposphere

# Ongoing Work

- Sensitivity factors (e.g. TC intensity,…) of TC diurnal cycle
- Outputting radiative and latent heating from composite run
- Idealized experiments with diabatic heating forcing
- Further exploration of TC boundary layer diurnal cycle

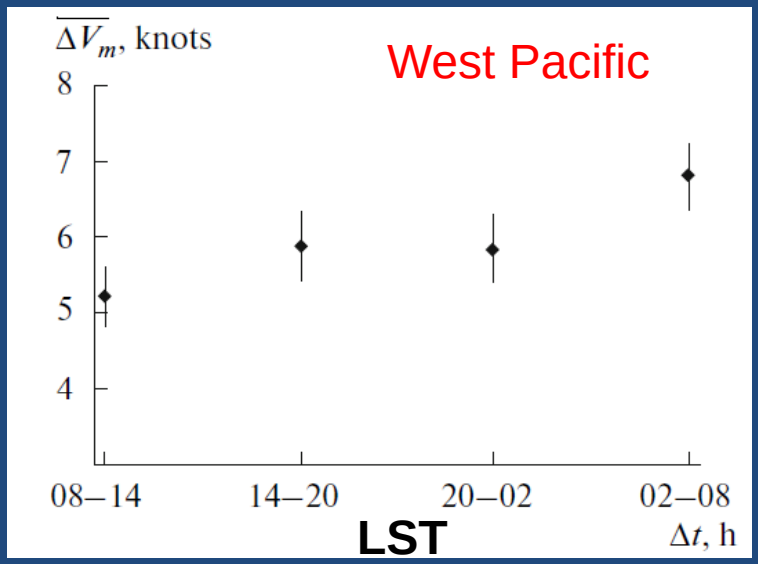
# Diurnal Oscillations of Water Vapor Mixing Ratio

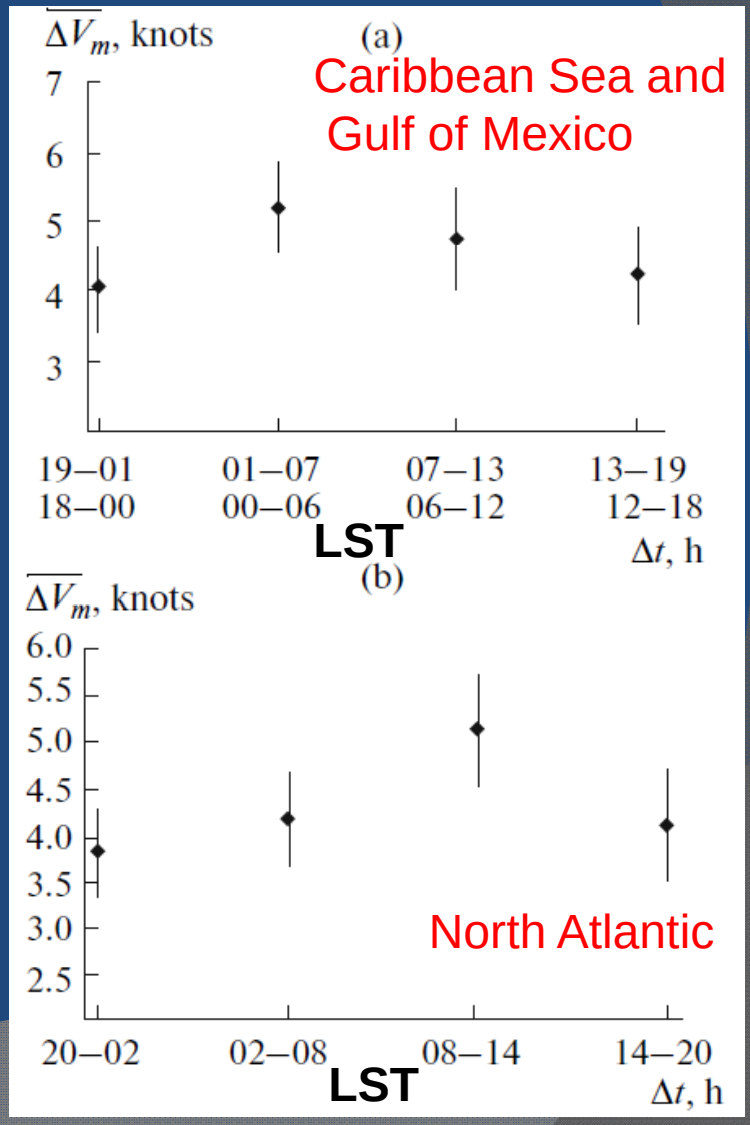



Diurnal oscillations of water vapor is basically in phase with equivalent potential temperature.

# Tropical Cyclone Diurnal Cycle

## Intensity




**Diurnal oscillations in the rate of variations of the maximum wind velocity**

(Yaroshevich and Ingel 2013, Izvestiya AOP, Figs. 1 and 3)