Impact of Diurnal Radiation Cycle during Different Stages of Hurricane Edouard (2014)

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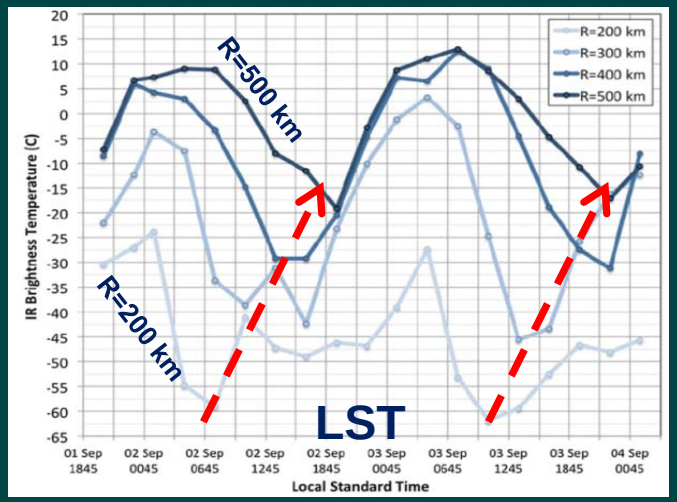
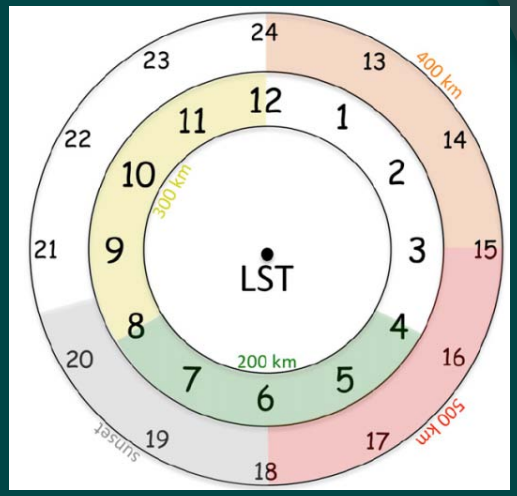
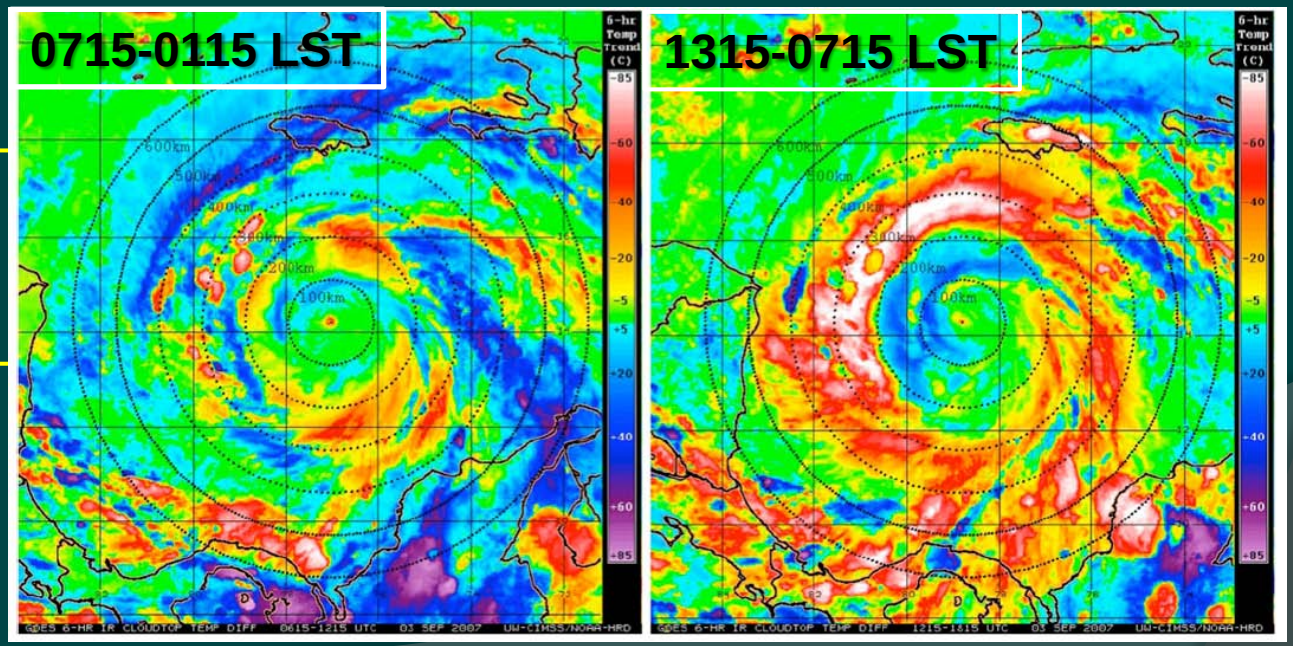
Tropical Cyclone Diurnal Cycle: Hurricane Felix (2007)

IR brightness temperature





6-hr differencing images



(Dunion et al. 2014)

PSU WRF/EnKF Real-time

hfip.psu.edu/realtime/AL2014/forecast_track.html

ADAPT APSU HWRF NWS WUG HS3 TCsat CIMSS GOES RALtc FZ SCI Papers soccer PREDICT Groupmeeting 88D MPEX DYNAMO

PSU WRF/EnKF Real-time Atlantic Hurricane Forecast

Track&Intensity Ensemble Storm Environment All Models D2010 D2011 D2012 D2013 ADAPT NHC

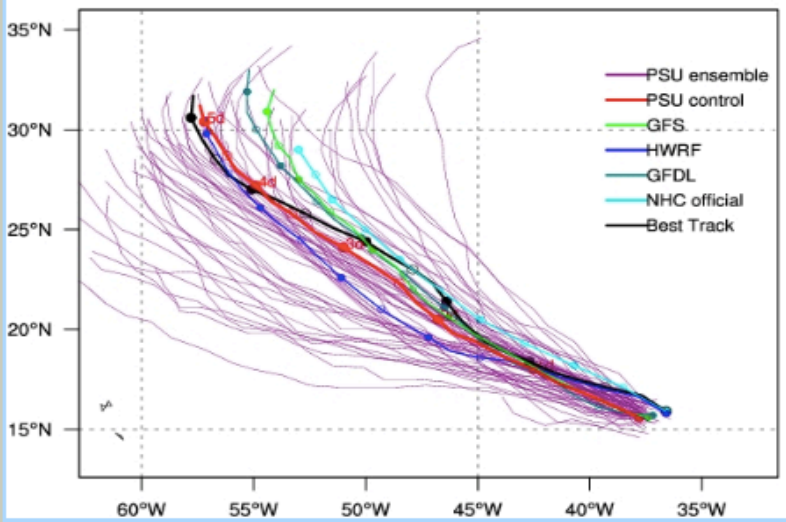
Select an active storm

SELECT ACTIVE STORM
EDOUARD
INVEST92

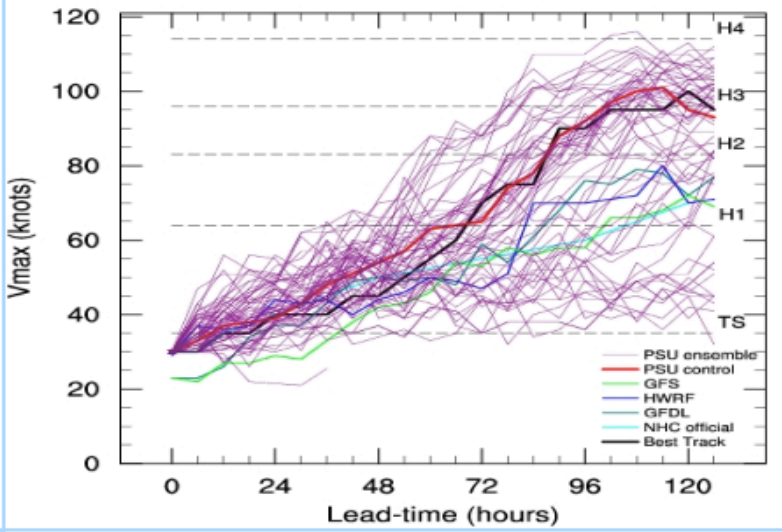
Forecast initial time
2014091112
<< previous (-6hr)
next (+6hr) >>

Select initial time
2014 Sep
11 12Z

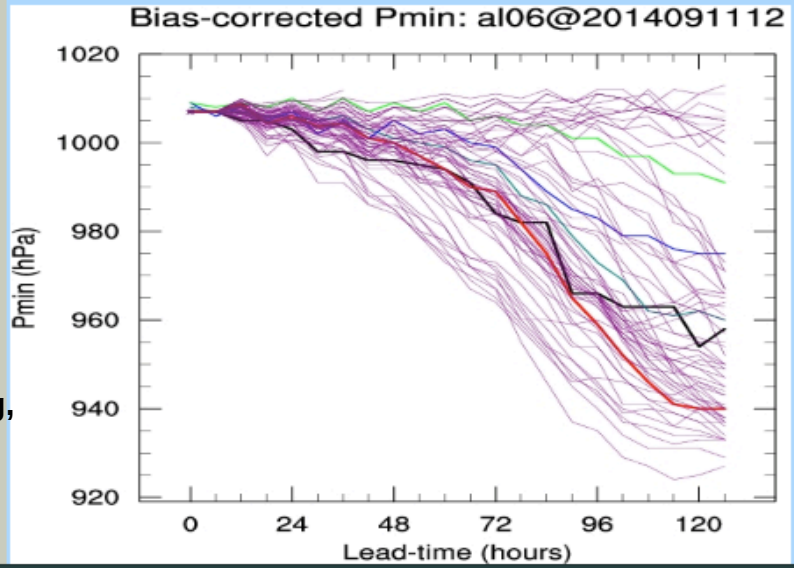
Track Forecasts: al06@2014091112



Bias-corrected Vmax: al06@2014091112

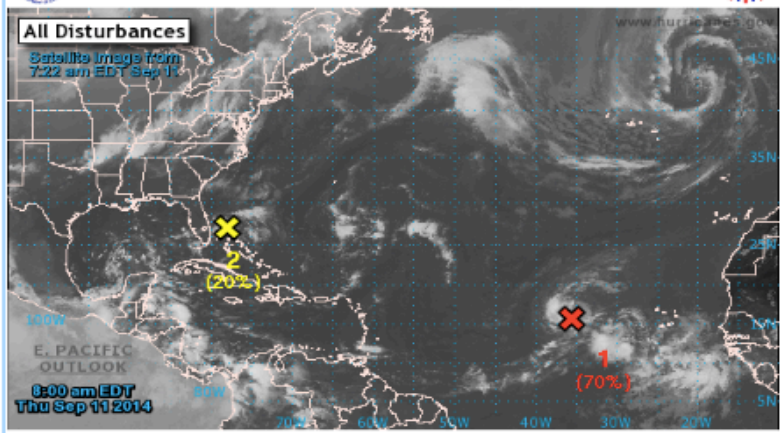


Bias-corrected Pmin: al06@2014091112



2-Day Graphical Tropical Weather Outlook

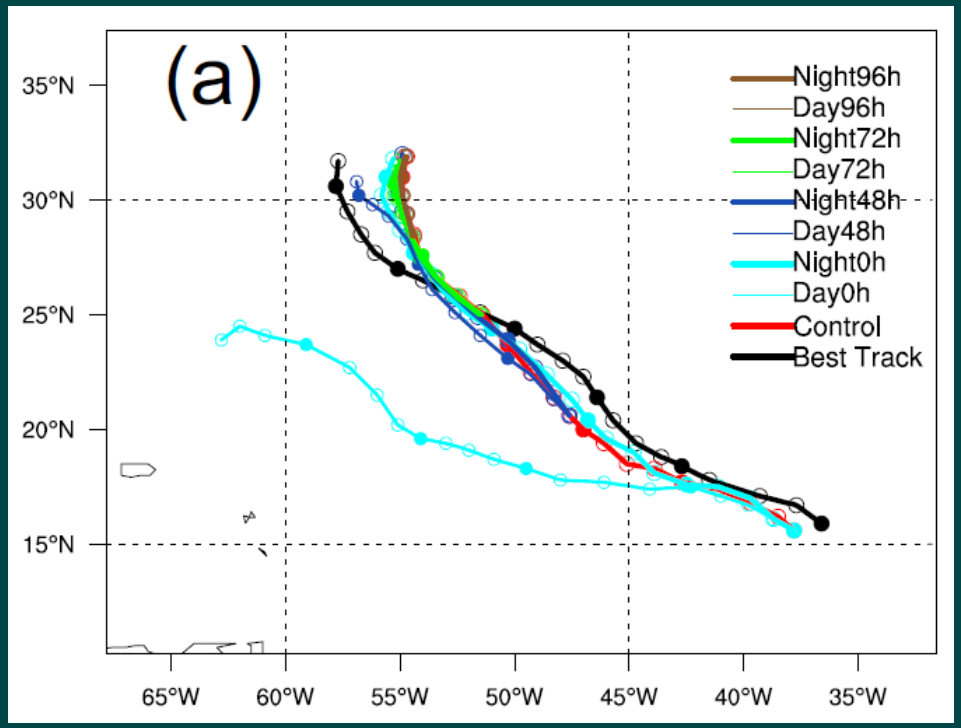
National Hurricane Center Miami, Florida

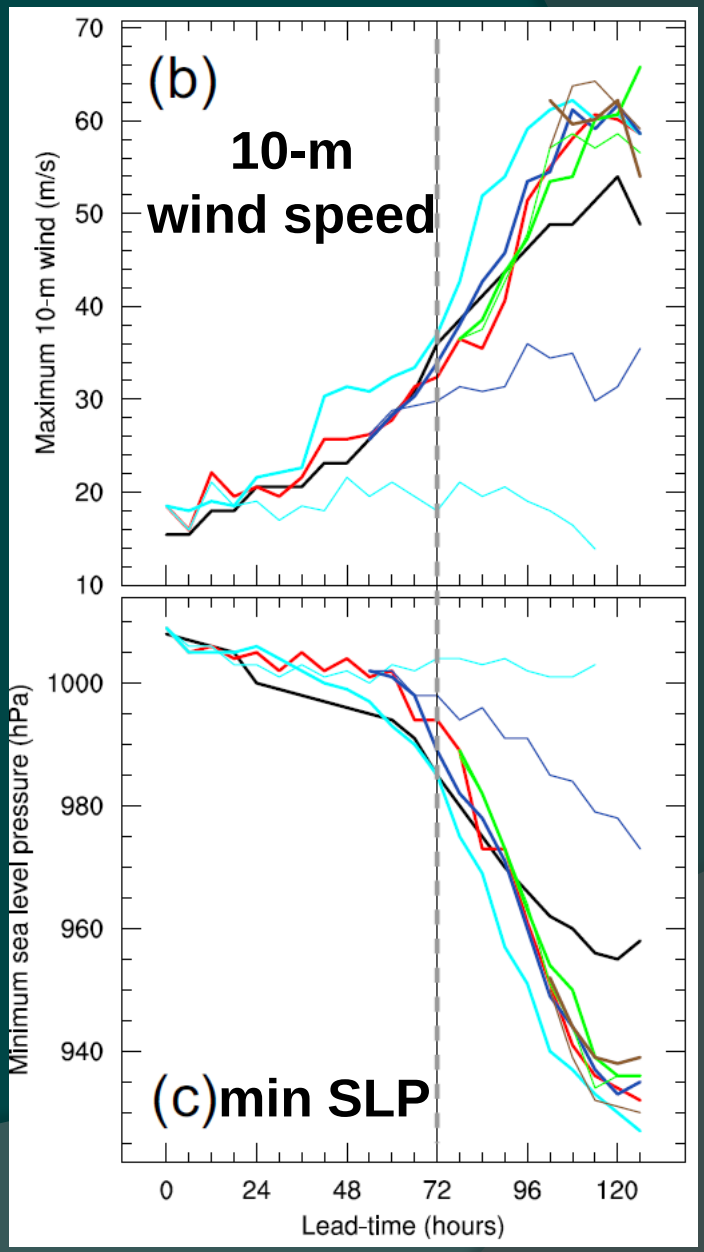


Current Disturbances and 2-Day Cyclone Formation Chance: < 30% 30-50% > 50%
Tropical or Sub-Tropical Cyclone: Depression Storm Hurricane
Post-Tropical Cyclone Remnants

(Zhang and Weng, 2015, BAMS)

Experimental design





CNTL: normal diurnal cycle initialized from 10 best member composite ICs

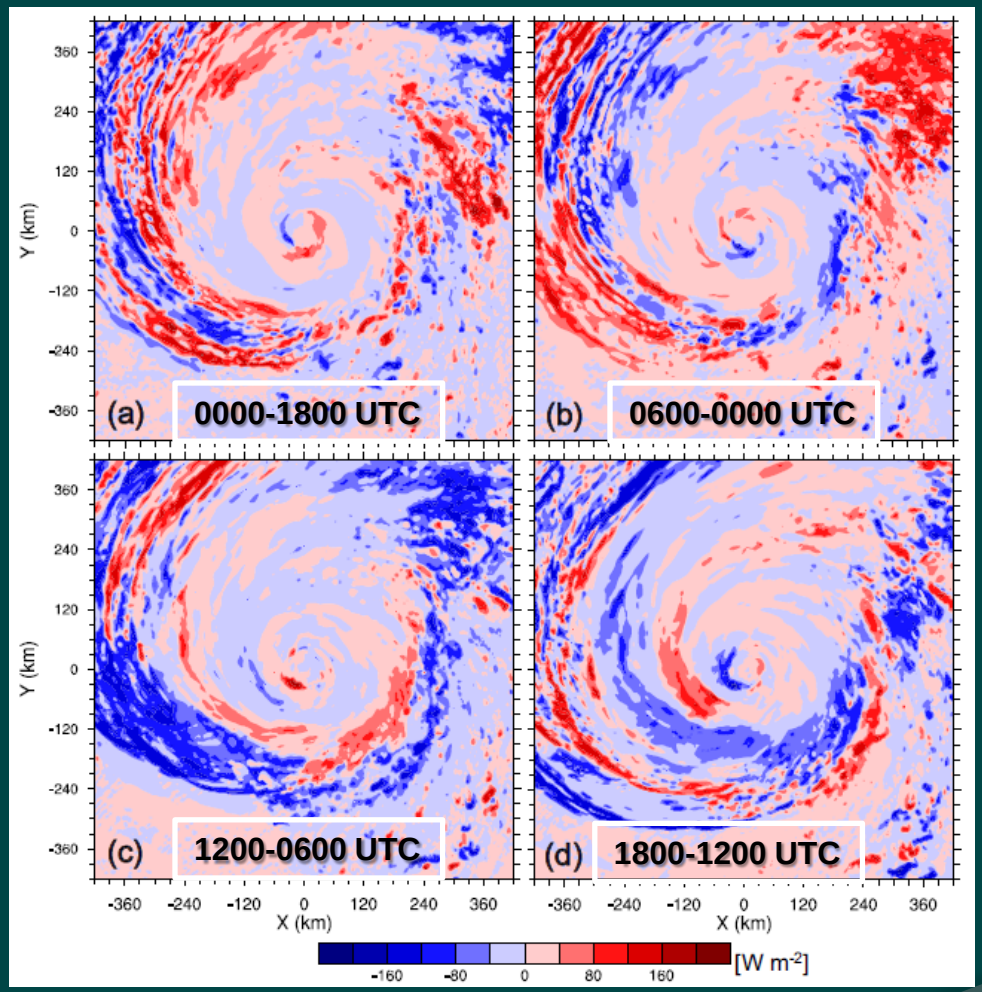
DayOnly: solar insolation fixed at noon

NightOnly: no solar insolation

Same long-wave radiation for all expts

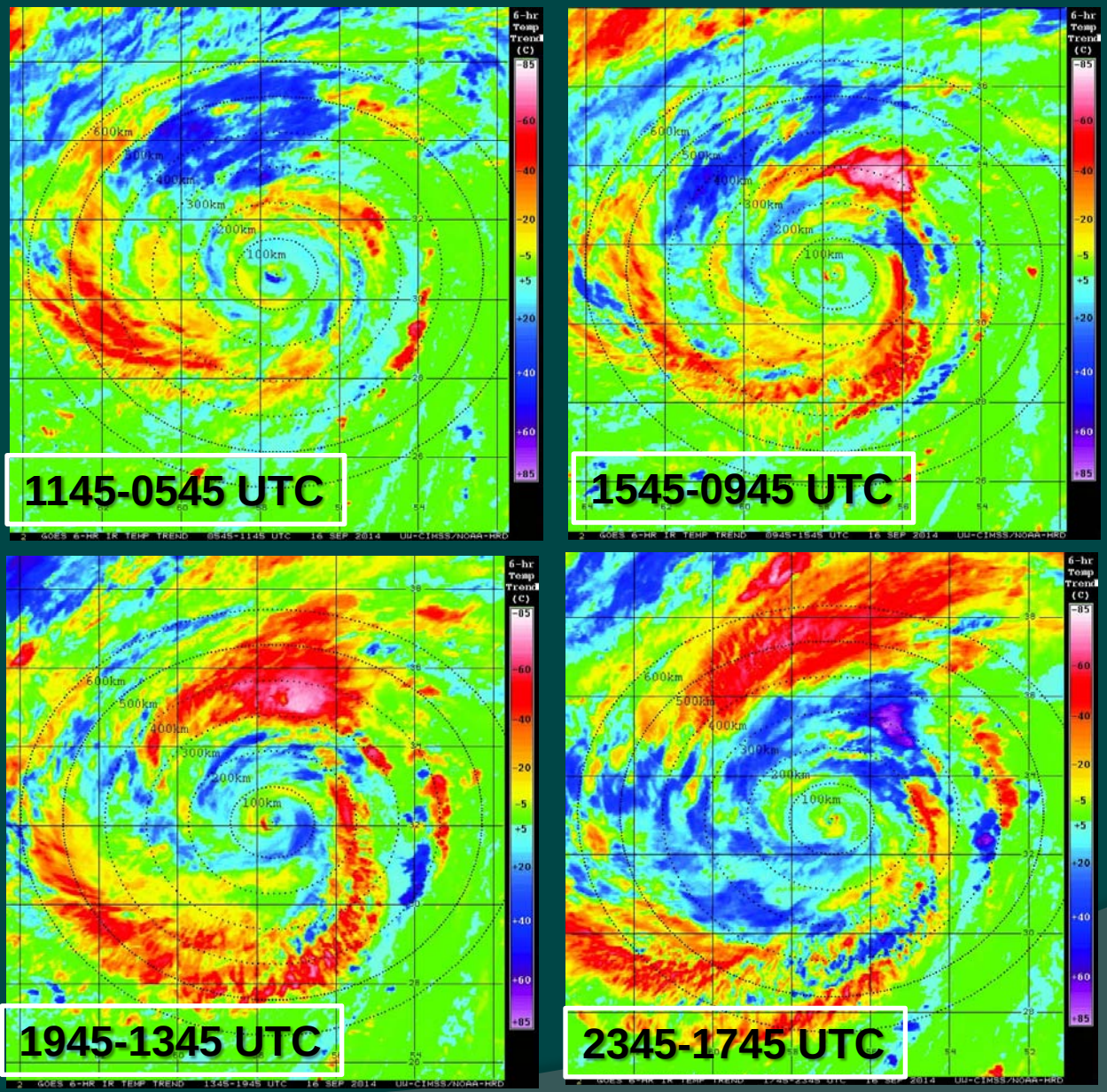
Simulated diurnal cycle of Hurricane Edouard: Sept 16

6-h OLR differencing images for control run



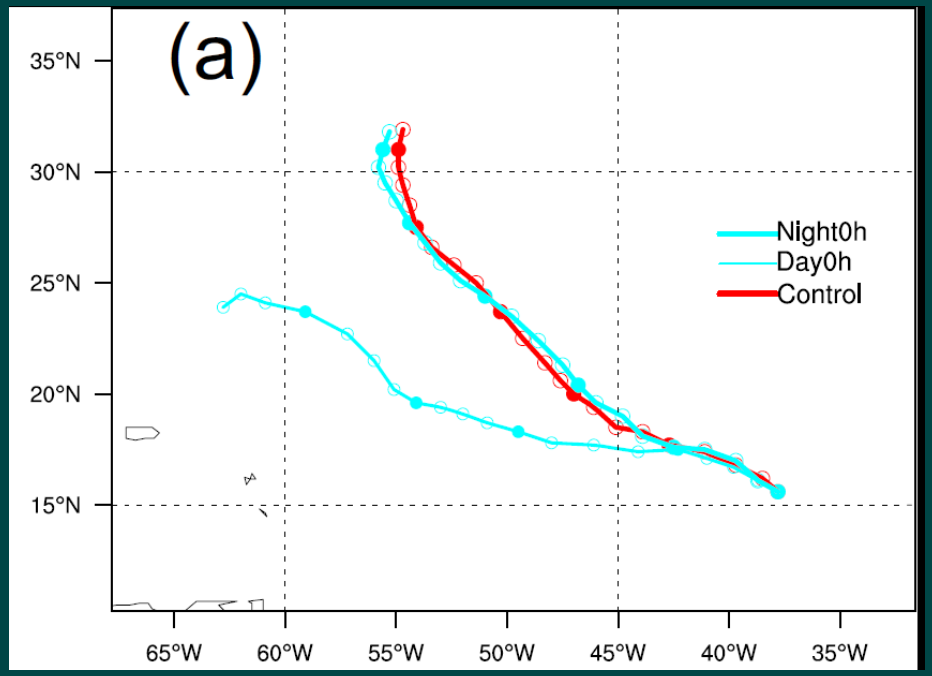
✓Simulated diurnal cycle in mature stage, which is simliar with observation

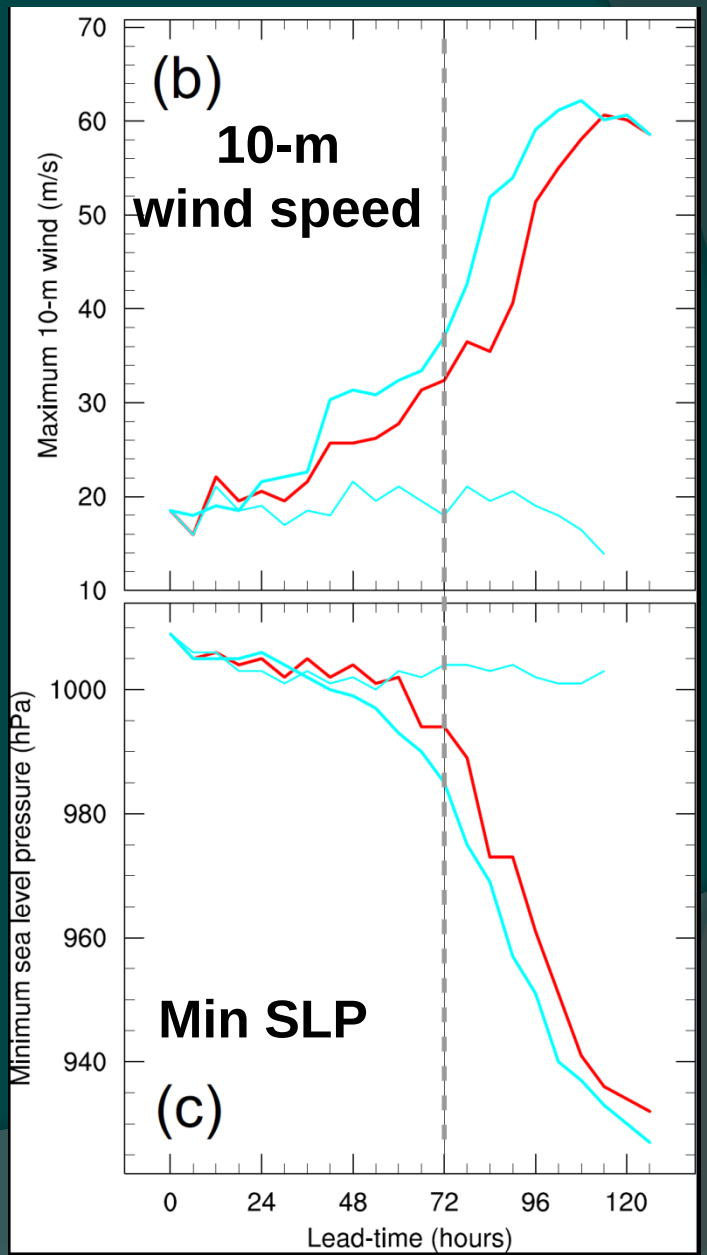
Observed diurnal cycle of Hurricane Edouard: Sept 16



(Courtesy of Jason Dunion)

Impact of solar radiation cycle on Edouard's formation



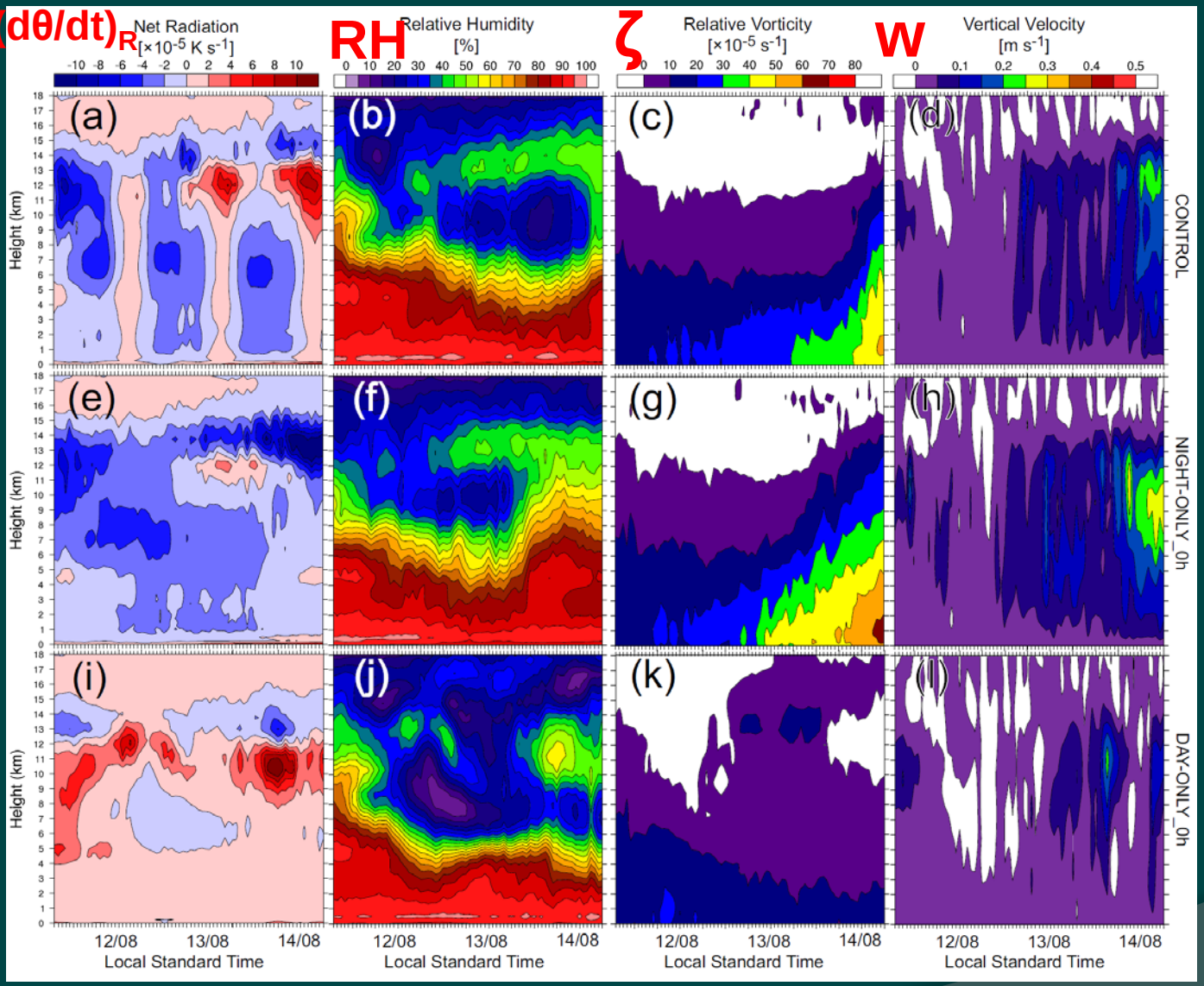


✓Day0h didn't develop, tropical low drifted far leftward of observed track

✓CNTL and Night0h both develop

✓Net nighttime radiative cooling crucial for the storm's formation

Net nighttime radiative cooling role to the storm's formation



CONTROL

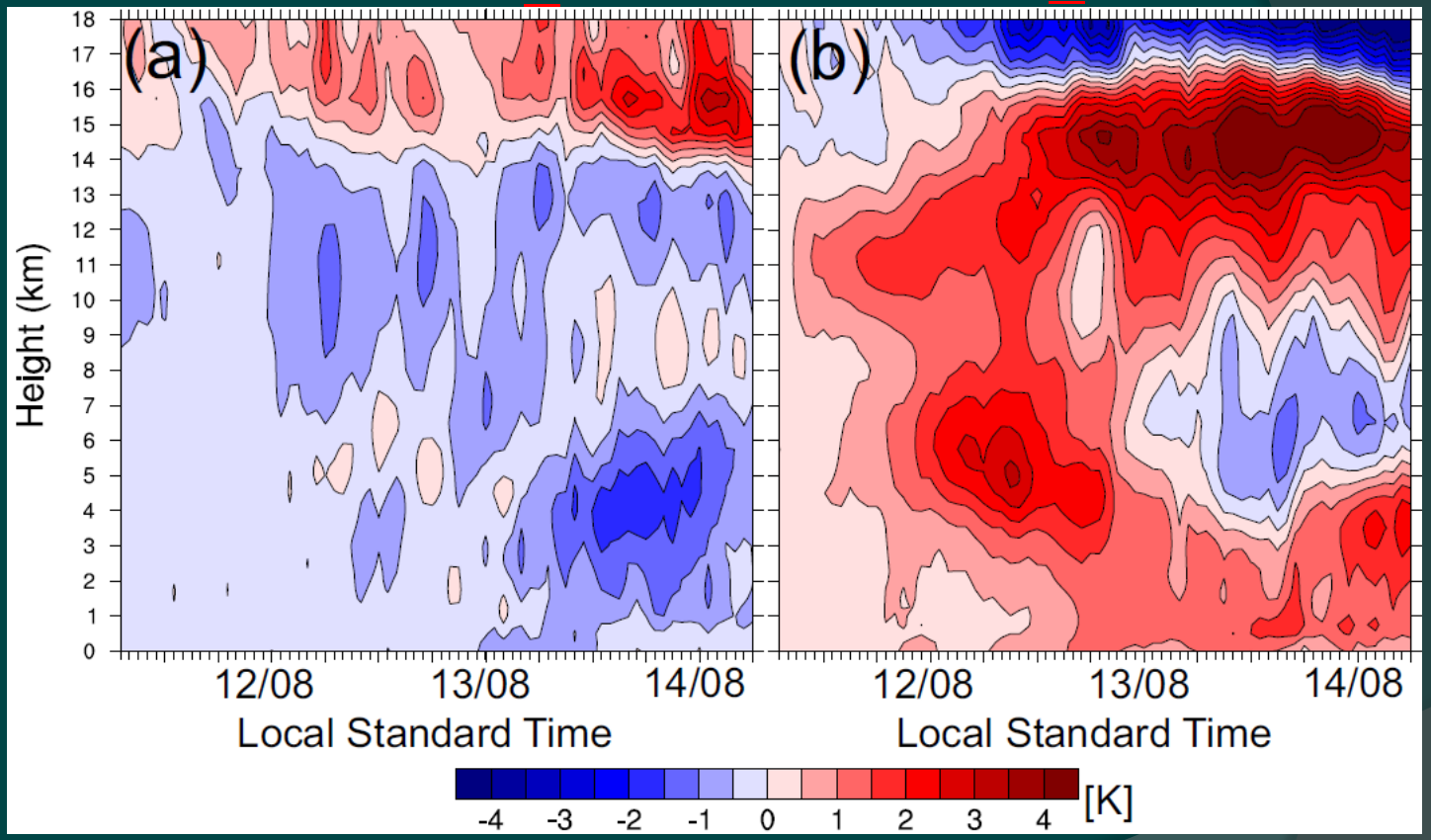
NIGHT_0h

DAY_0h

- ✓ Net nighttime radiation cooling leads to lower T and higher RH
- ✓→ Enhancement of moist convection in nighttime
- ✓→ Enhancement of the low-level vorticity and upper-level updraft in NightOnly

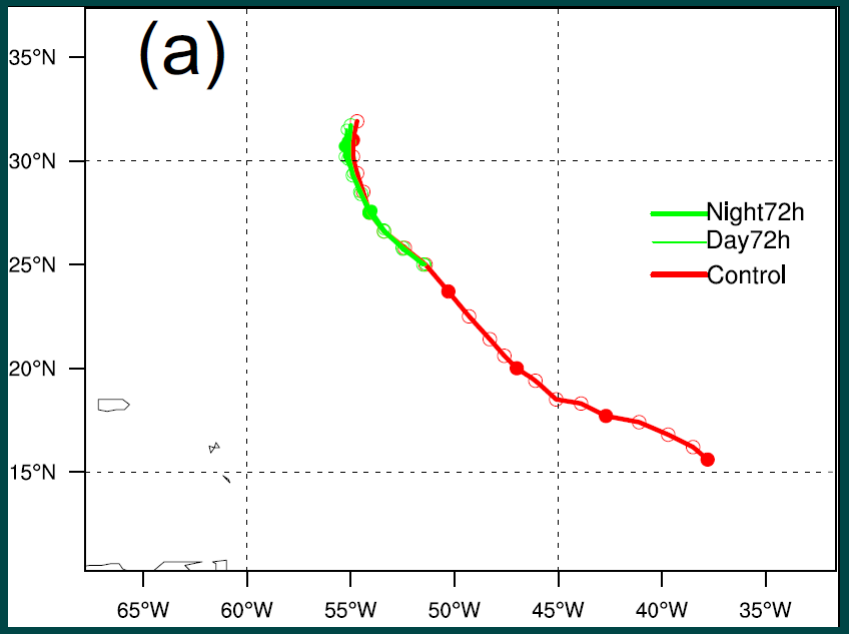
Net nighttime radiative cooling role to the storm's formation

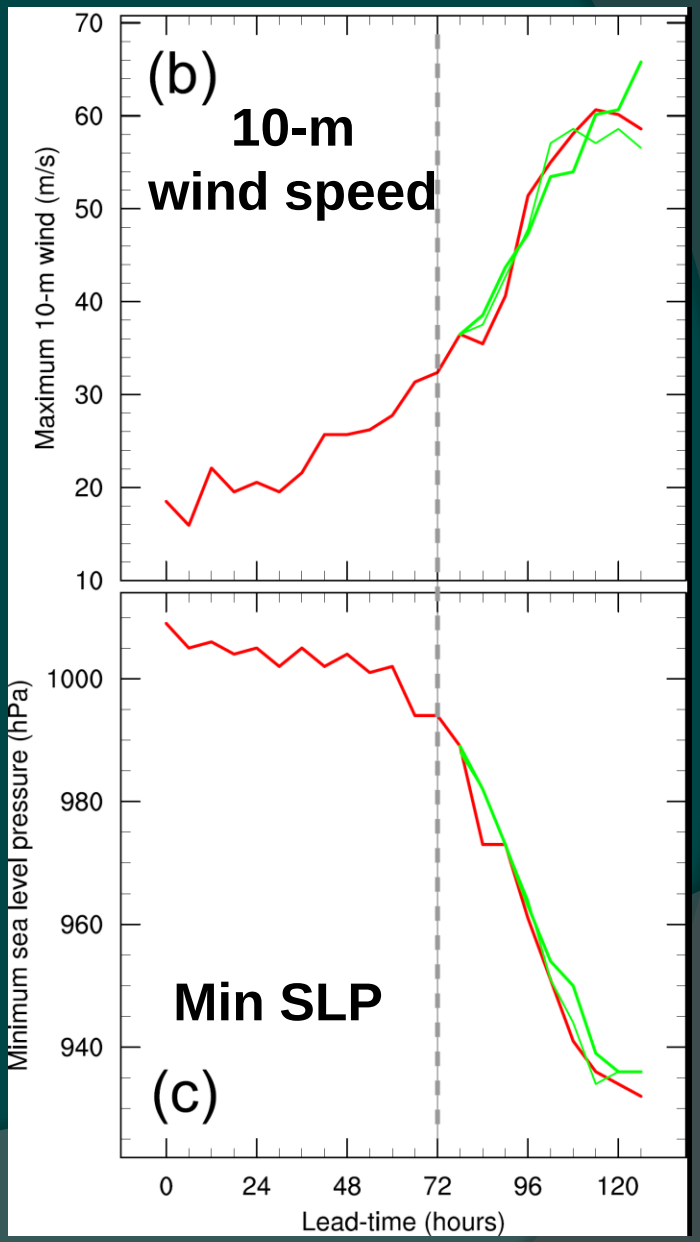
Temperature difference with CNTL



✓ **The temperature is lower/higher in the middle levels for the Night/DayOnly.**

Impact of diurnal radiation on the mature hurricane



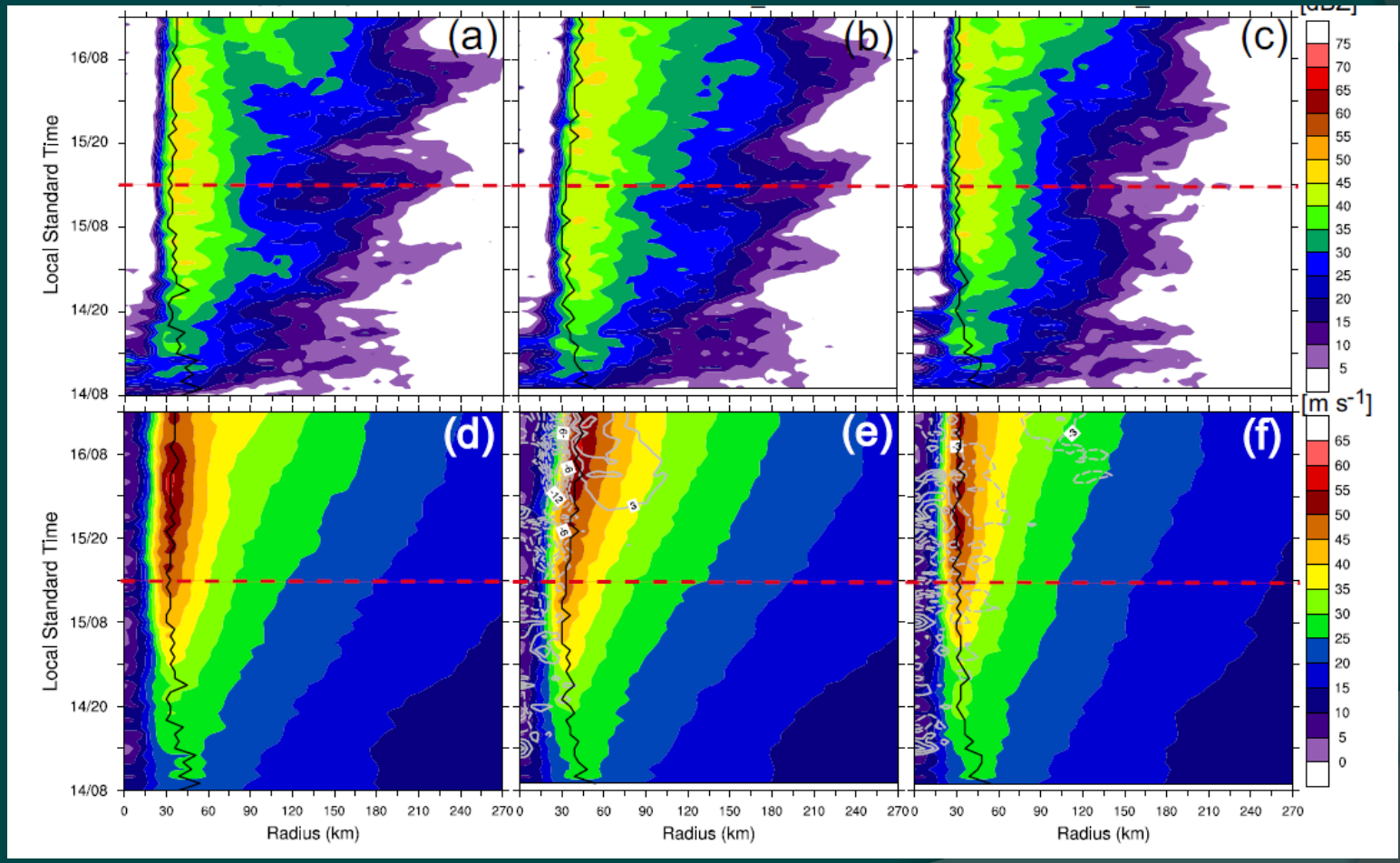


✓After RI, little impact on track, maximum wind speed and SLP

✓However, considerable change in structure and outer rainband (next)

Different structure and outer rainband of mature hurricane

CONTROL NIGHT_72h DAY_72h



radar reflectivity 10-m wind speed

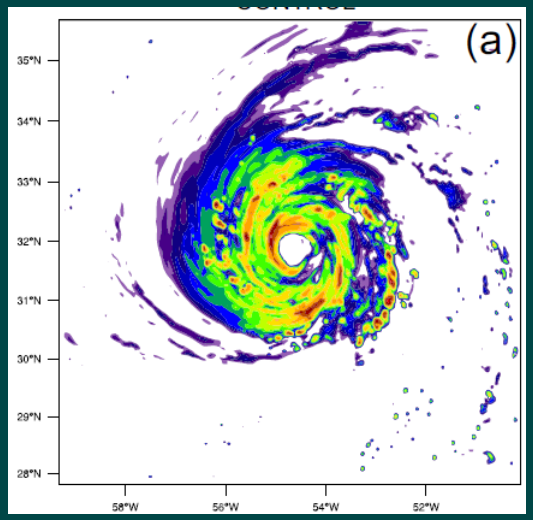
✓Control run undergoes secondary eyewall formation as observed

✓Stronger strength and bigger size for NightOnly

Different structure and outer rainband of mature hurricane

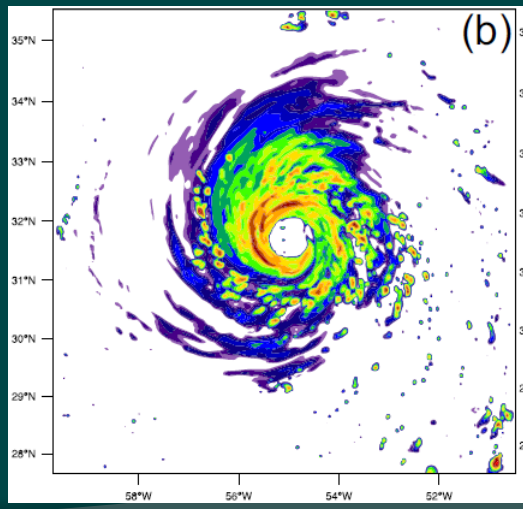
Concentric eyewall in CONTROL only

CONTROL

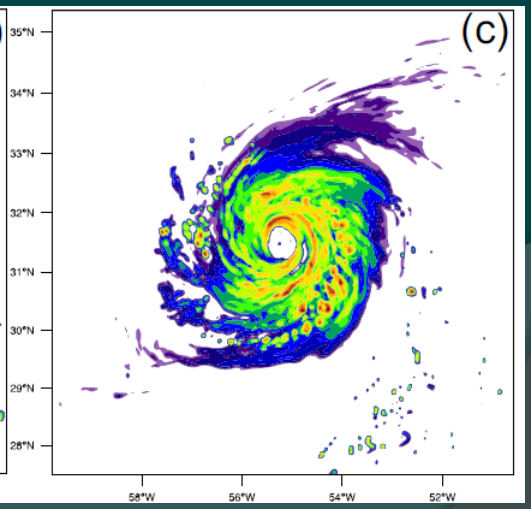


Bigger eye and more active rainbands in NightOnly

NIGHT_72h



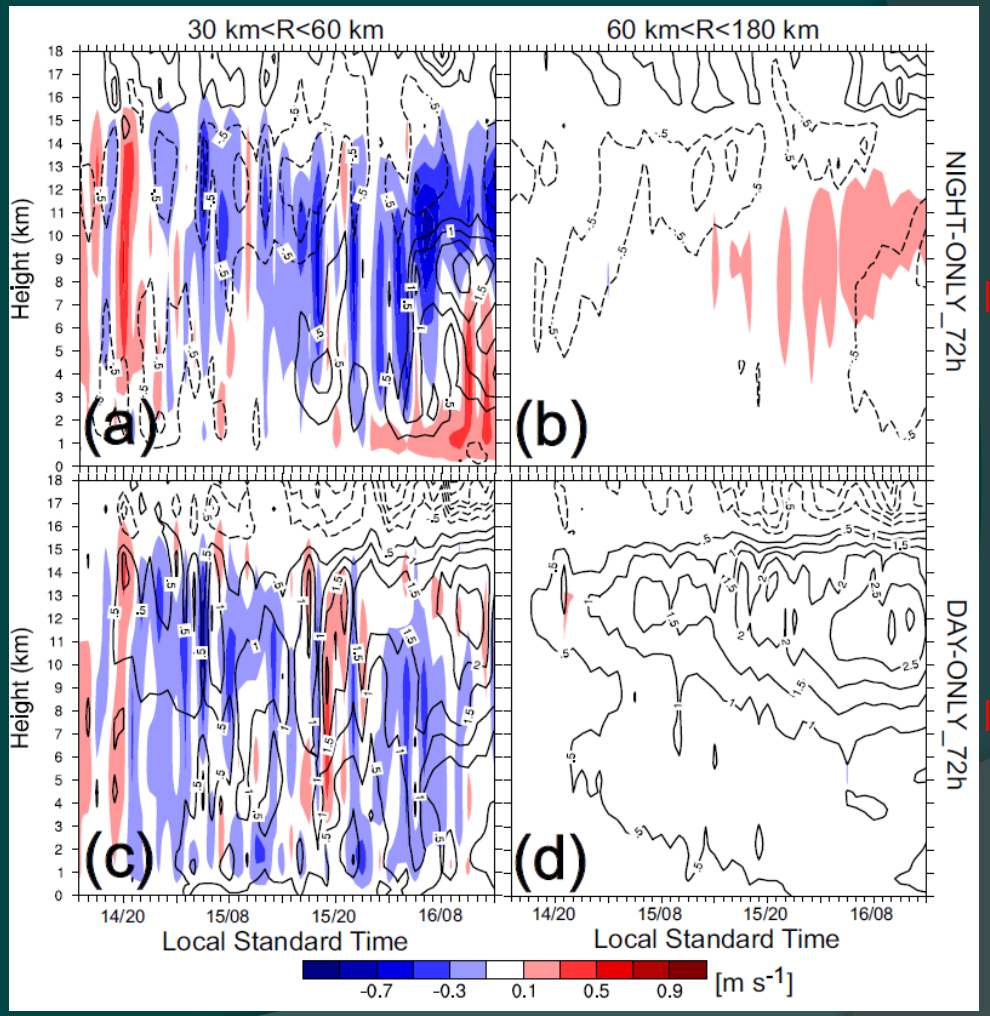
DAY_72h



Radar reflectivity on 1800UTC 16 Sept.

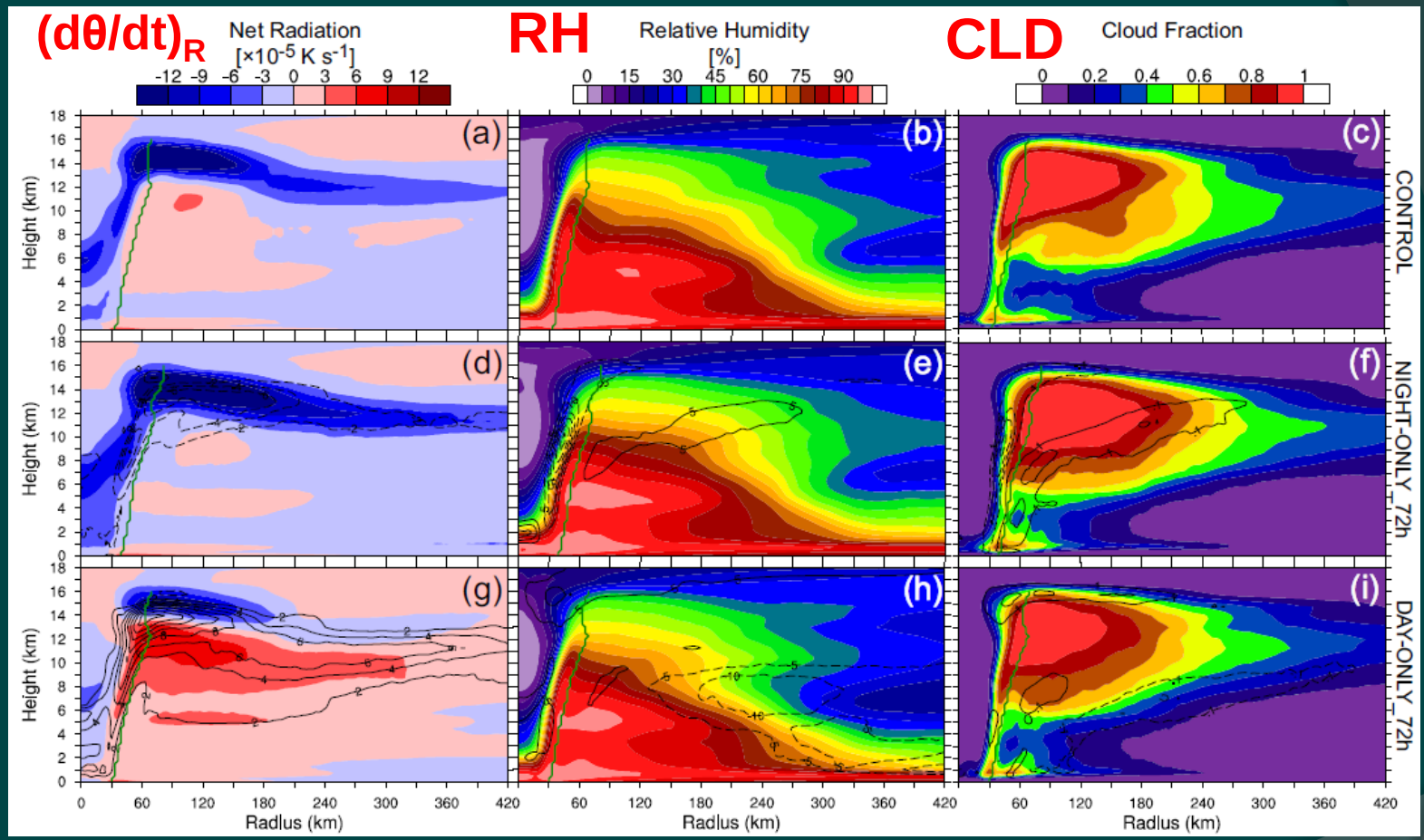
Net nighttime radiative cooling role to mature hurricane

- ✓ Temperature increasing at high levels in DayOnly
- ✓ Destabilization of outer core, more deep moist convection in the NightOnly
- ✓ The decreasing vertical velocity in (a) is due to the eyewall expanding



Vertical profiles differences of vertical velocity (shading) and temperature (contour)

Different structure induced by radiation



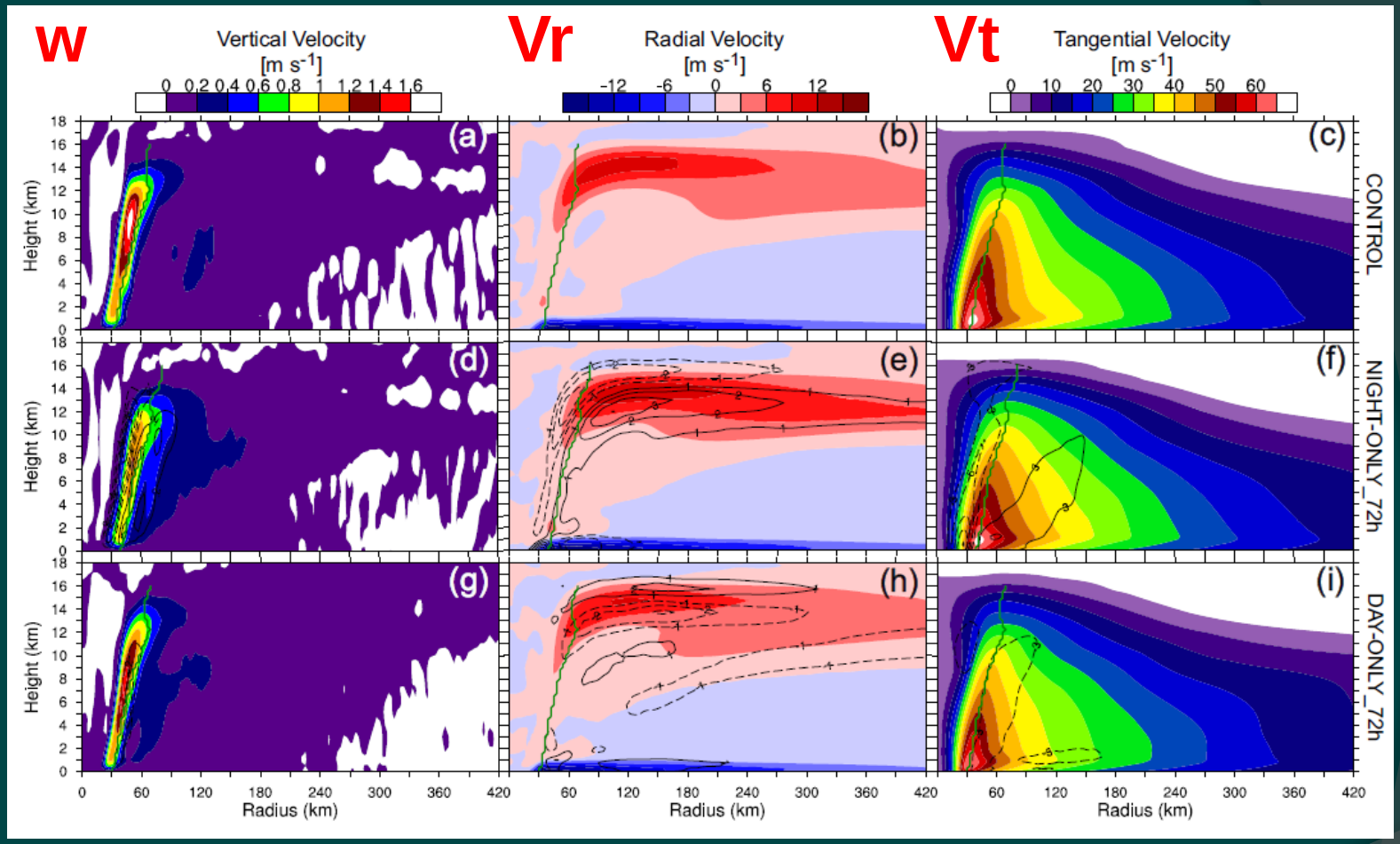
NightOnly :

✓**Prominent cooling along the cloud top; higher RH and Cloud Fraction outside of eyewalll;**

DayOnly:

✓**Warming within the cloud; lower RH and Cloud Fraction in outer region of low level**

Different structure induced by radiation



NightOnly :

✓**Stronger updraft, upper/low level radial outflow/inflow, and tangential wind outside of eyewalll;**

✓**More outward tilting primary eyewall**

DayOnly:

✓**Weeker updraft, upper/low level radial outflow/inflow, and tangential wind besides eyewalll**

✓**More upright primary eyewall**

Concluding Remarks

- Formation stage: nighttime radiative cooling → destabilization → promote deep moist convection → storm genesis
  - The storm track may be altered by changing the initial vortex strength
- Mature stage: nighttime radiative cooling → increase convective activities outside of eyewall → stronger/broader rainbands and larger storm size
  - Little impact on maximum surface wind speed
  - Potential role of the radiative impact to concentric eyewall formation