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

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IR brightness temperature

6-hr differencing images

(Dunion et al. 2014)
PSU WRF/EnKF Real-time Atlantic Hurricane Forecast

(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 similar with observation
Observed diurnal cycle of Hurricane Edouard: Sept 16

1145-0545 UTC
1545-0945 UTC
1945-1345 UTC
2345-1745 UTC

(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

- 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
The temperature is lower/higher in the middle levels for the Night/Day Only.
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)

(a) [Graph showing wind speed and location]
(b) [Graph showing 10-m wind speed over time]
(c) [Graph showing minimum sea level pressure over time]
Different structure and outer rainband of mature hurricane

- Control run undergoes secondary eyewall formation as observed.
- Stronger strength and bigger size for NightOnly.

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

Bigger eye and more active rainbands in NightOnly

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 eyewall;

DayOnly:
✓ Warming within the cloud; lower RH and Cloud Fraction in outer region of low level
NightOnly:
- Stronger updraft, upper/low level radial outflow/inflow, and tangential wind outside of eyewall;
- More outward tilting primary eyewall

DayOnly:
- Weeker updraft, upper/low level radial outflow/inflow, and tangential wind besides eyewall;
- More upright primary eyewall

Different structure induced by radiation
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