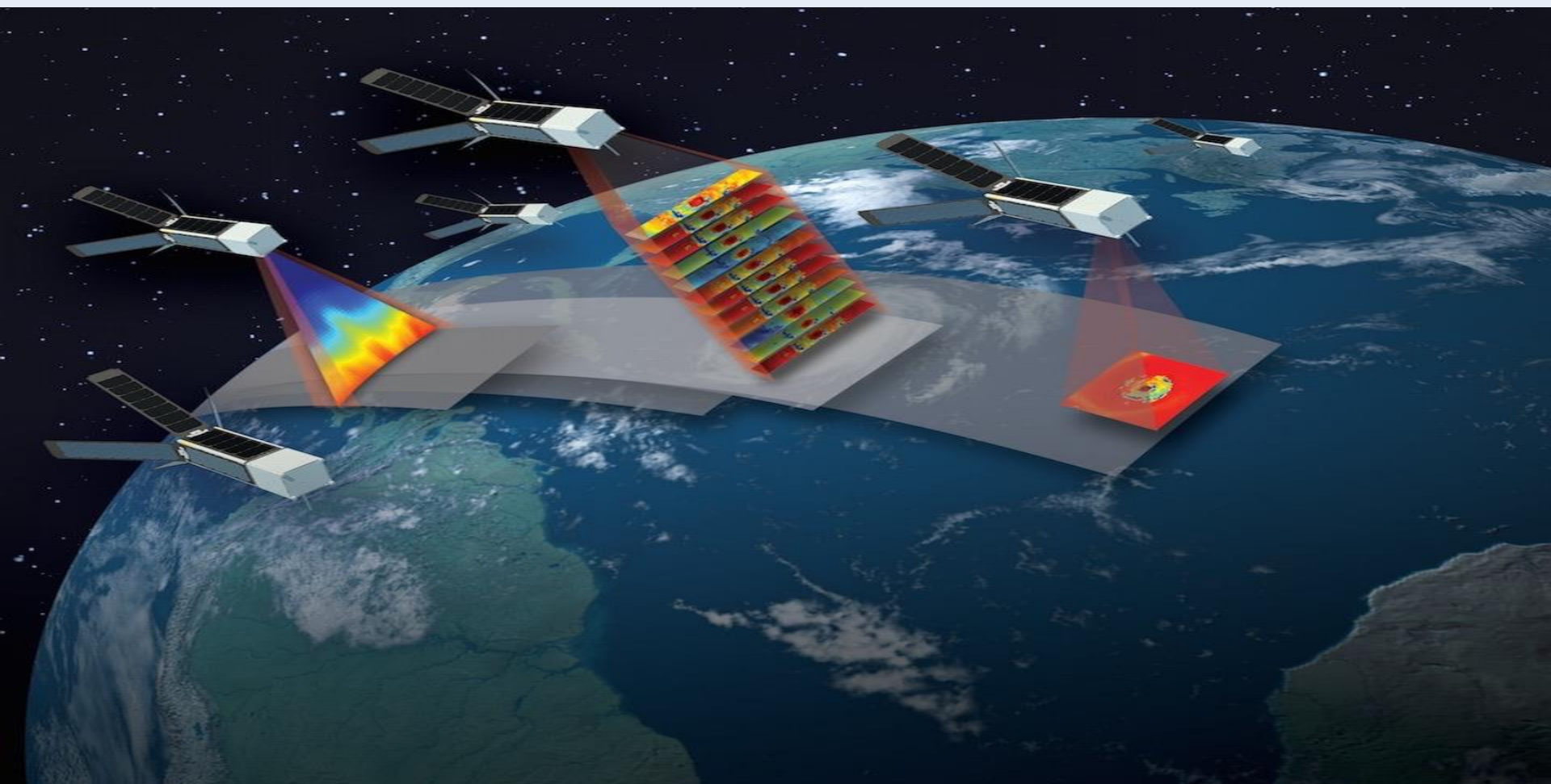


# The Tropical Cyclone Diurnal Cycle: Applications to NASA TROPICS

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# Discussion Outline

## Motivation

- Understand & describe the TC diurnal cycle...likely a fundamental TC process
- Address TROPICS science objective:
  - *relate precipitation structure evolution, including the **diurnal cycle**, to upper-level warm core evolution & associated intensity changes*

## TC Diurnal Cycle

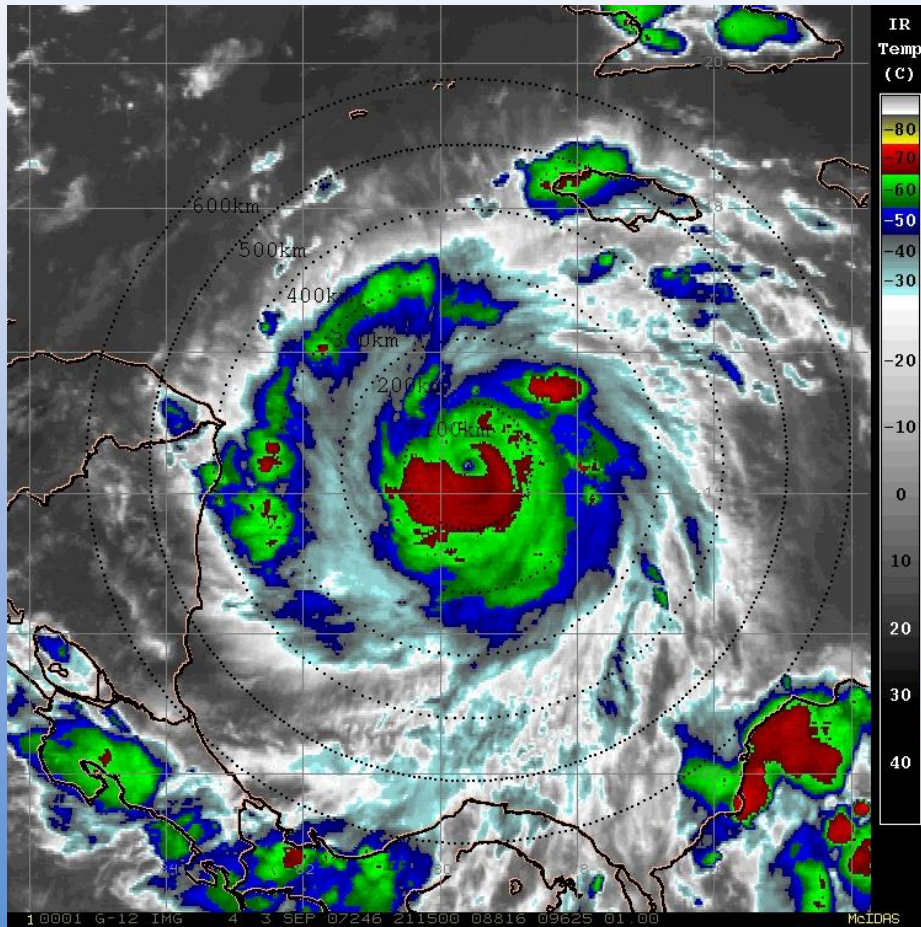
- Satellite Perspective
- Modeling Perspective

## Conclusions

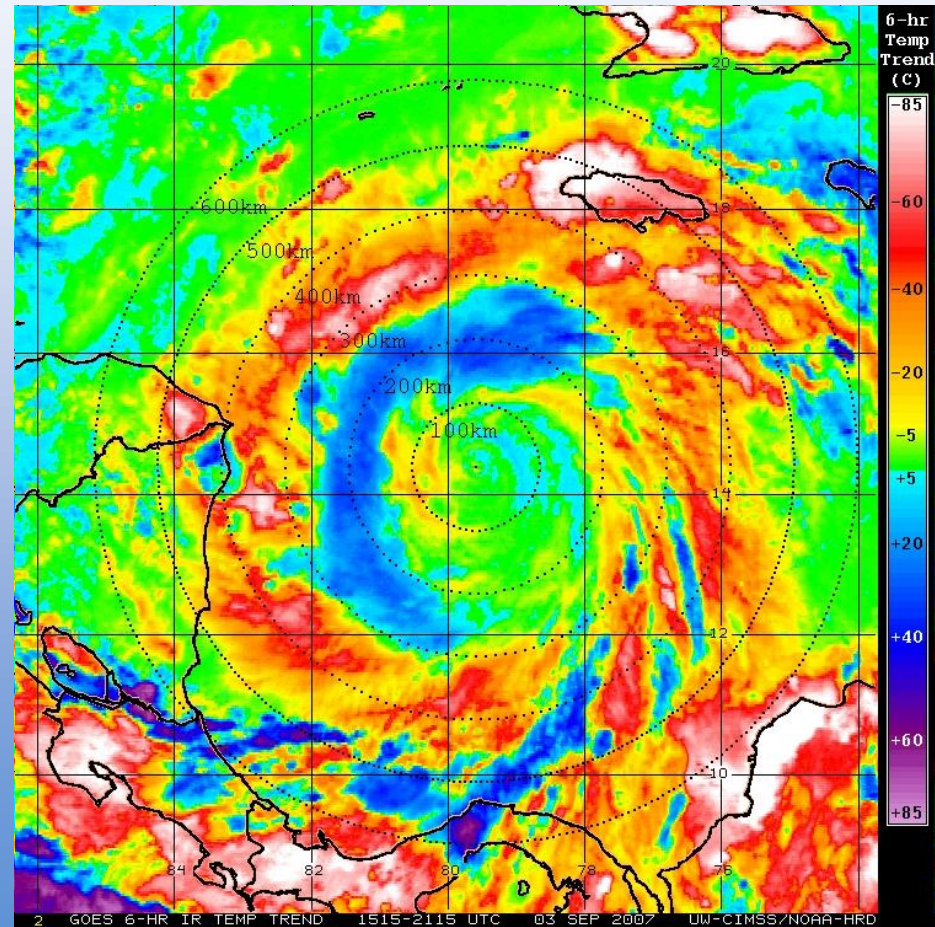
# Tropical Cyclone Diurnal Cycle

*Hurricane Felix: 02-03 Sept 2007*

*GOES Infrared: 11  $\mu$ m*

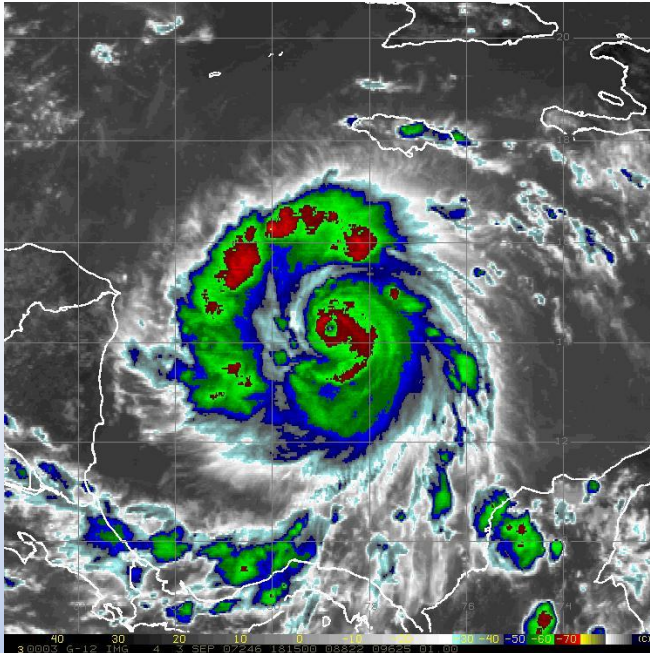


*GOES IR 6-hr Temperature Trend*

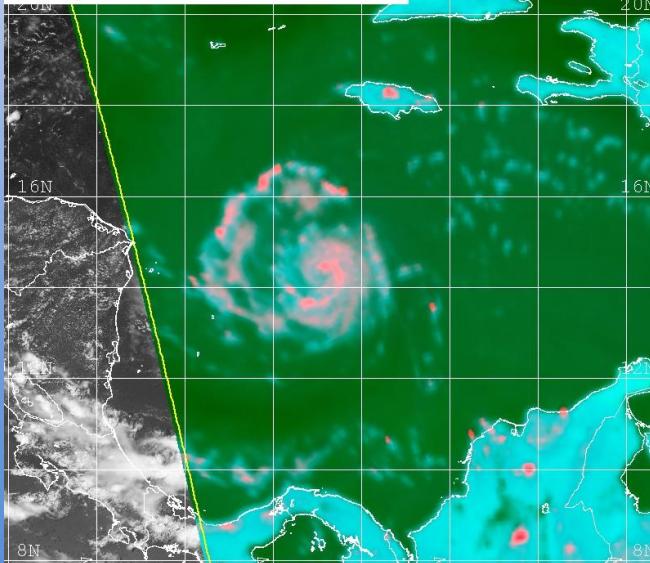


# Hurricane Felix: 03 Sept 2007

GOES IR



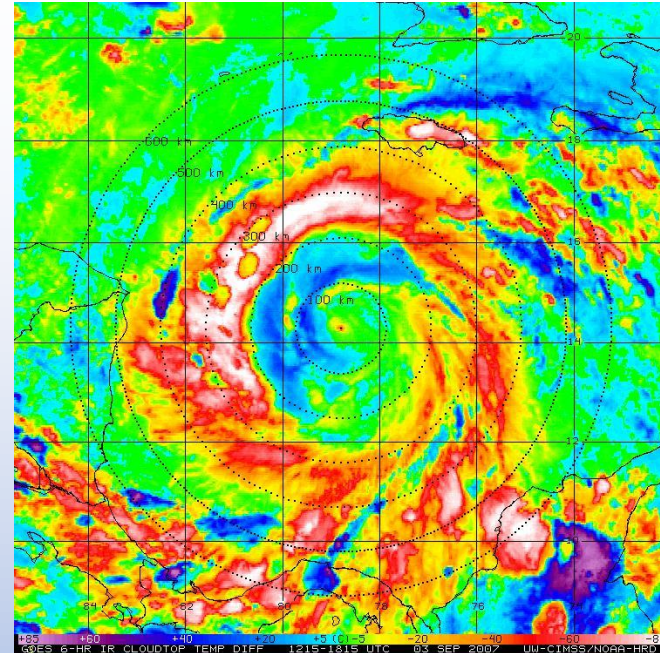
09/03/07 1800Z 06L FELIX  
 09/03/07 1829Z AQUA-1 COMPOSITE  
 09/03/07 1815Z GOES-12 VIS



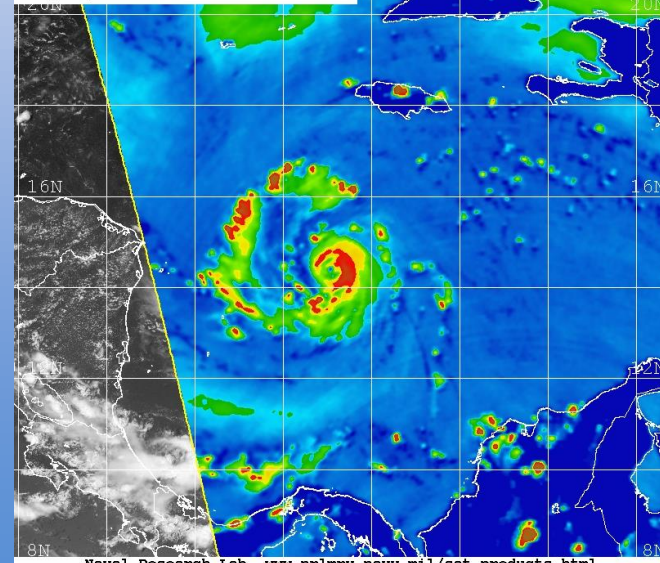
Naval Research Lab [www.nrlmry.navy.mil/sat\\_products.html](http://www.nrlmry.navy.mil/sat_products.html)  
 Red=36PCT Green=36V Blue=36H

37 GHz

GOES IR  
 6-hr Temp  
 Trend



09/03/07 1800Z 06L FELIX  
 09/03/07 1829Z AQUA-1 89H  
 09/03/07 1815Z GOES-12 VIS



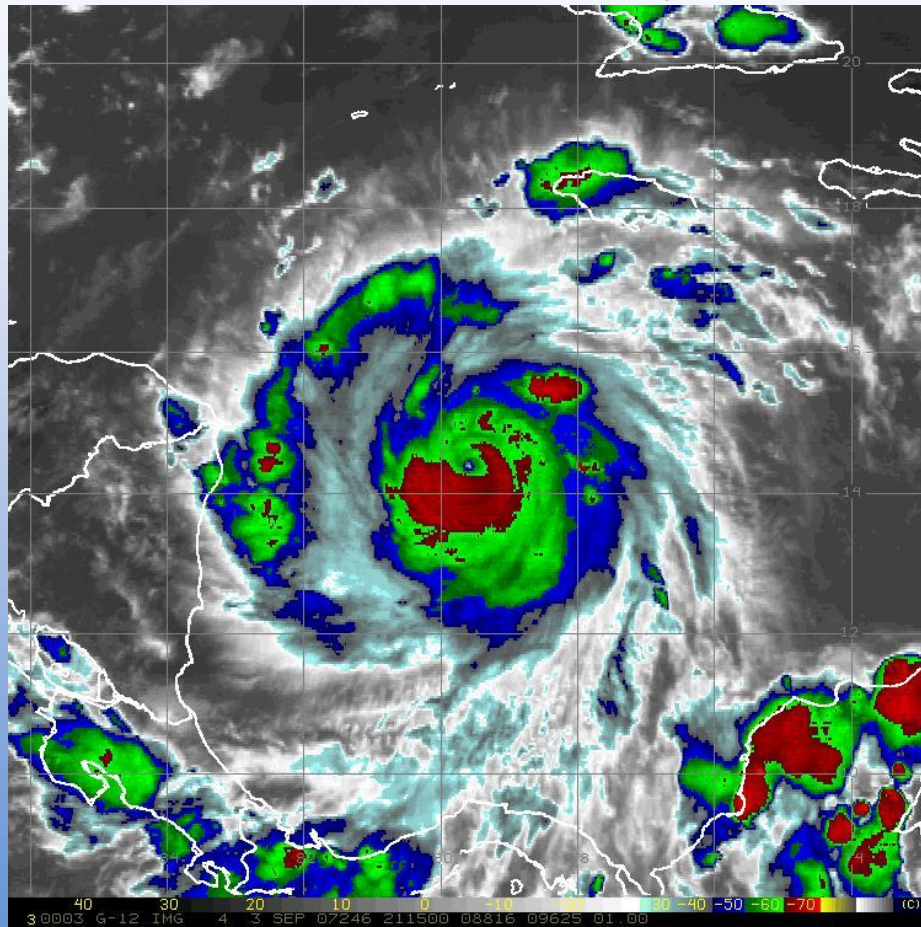
Naval Research Lab [www.nrlmry.navy.mil/sat\\_products.html](http://www.nrlmry.navy.mil/sat_products.html)  
 <-- 89H Brightness Temp (Kelvin) -->

89/91 GHz

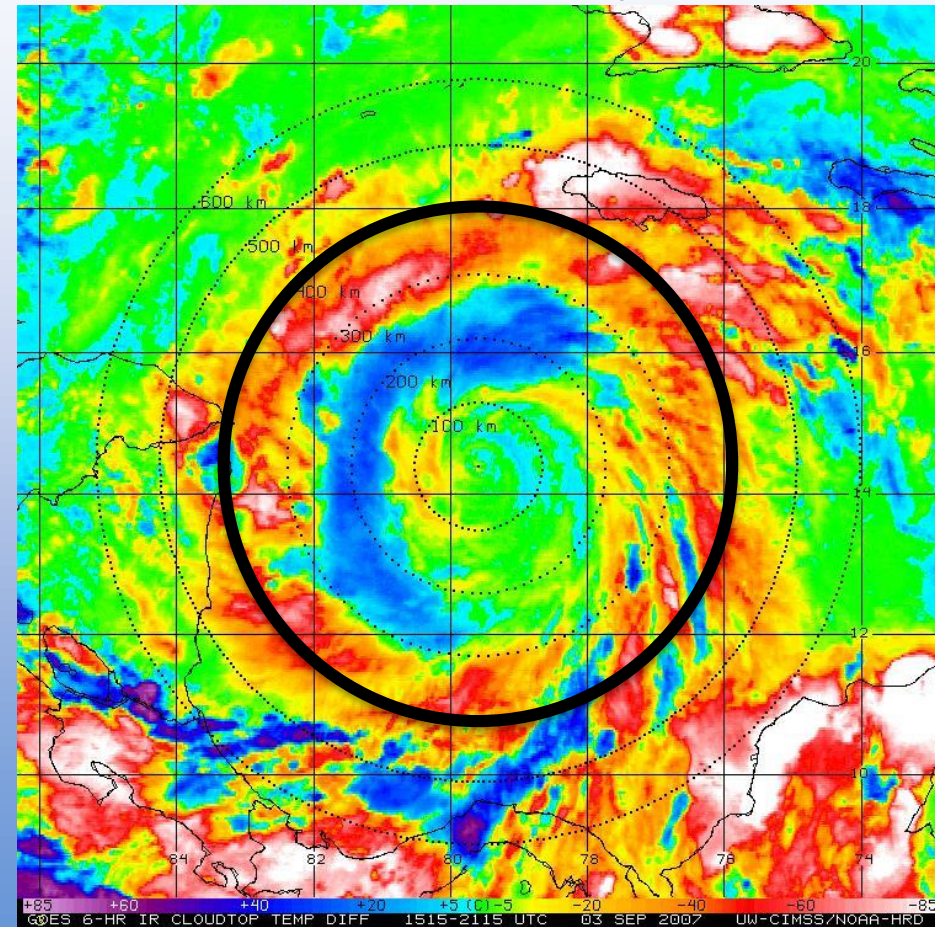
# TC Diurnal Cycle: Azimuthal Analyses

Hurricane Felix: 03 September 2007

GOES Infrared: 11  $\mu\text{m}$



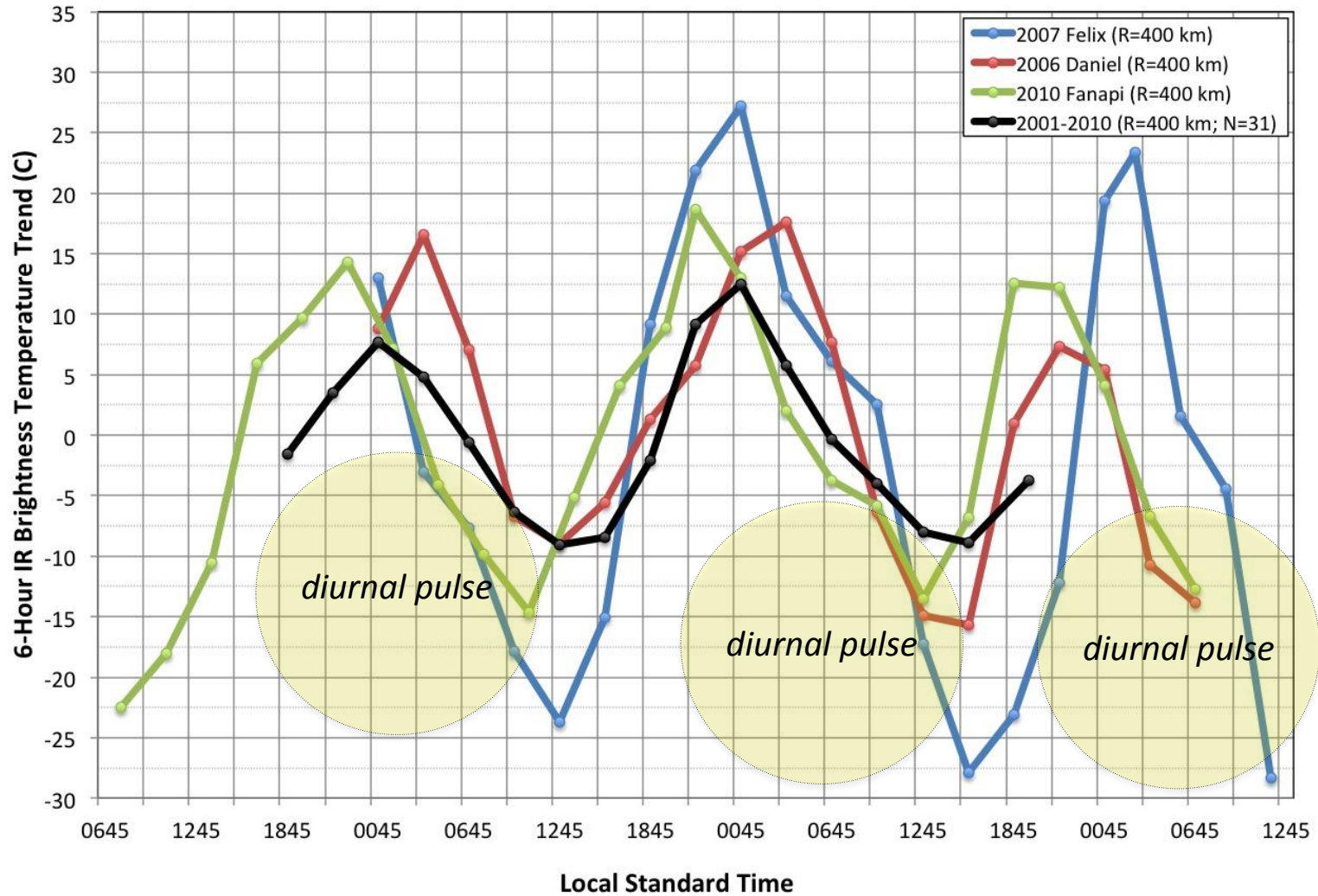
GOES IR 6-hr Temp Trend



- 1) Mature TCs ( $\geq$ Cat 2;  $\geq$ 83 kt)
- 2) Vertical Shear  $\leq$ 15 kt
- 3) Distance to land  $\geq$ 300 km

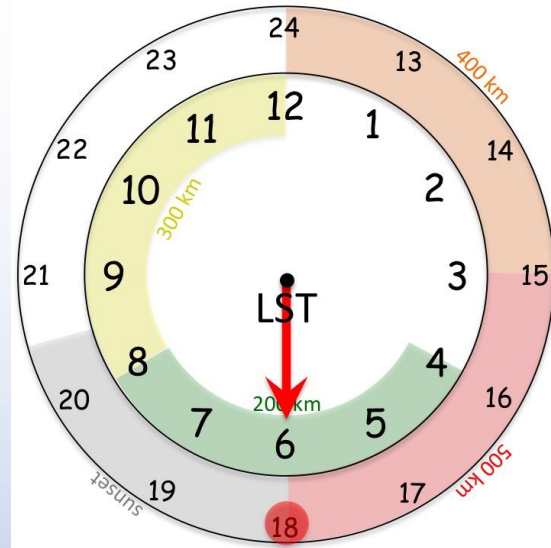
# TC Diurnal Cycle Heartbeat

*think globally, act locally*

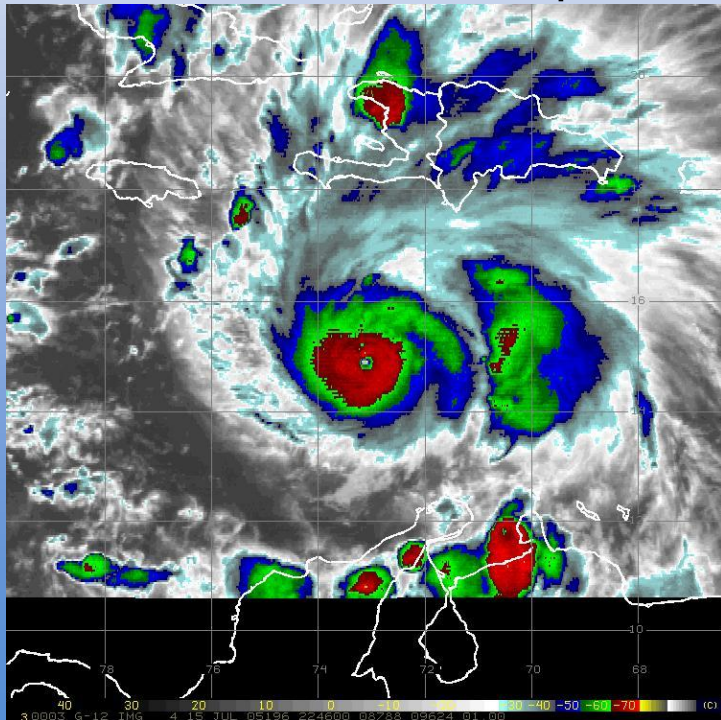


2005 Emily

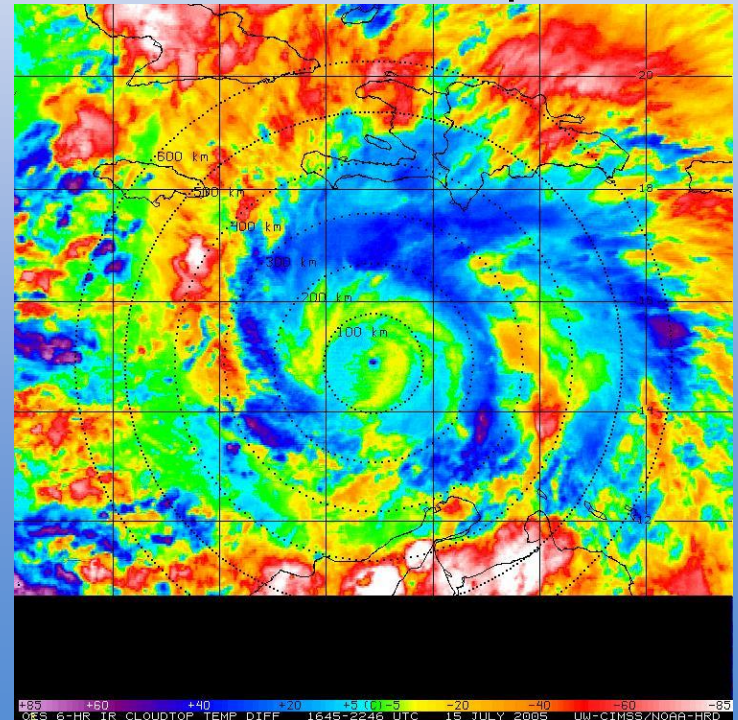
# The TC Diurnal Clock: Hurricane Emily (15 July 2005)



GOES Infrared: 11  $\mu\text{m}$

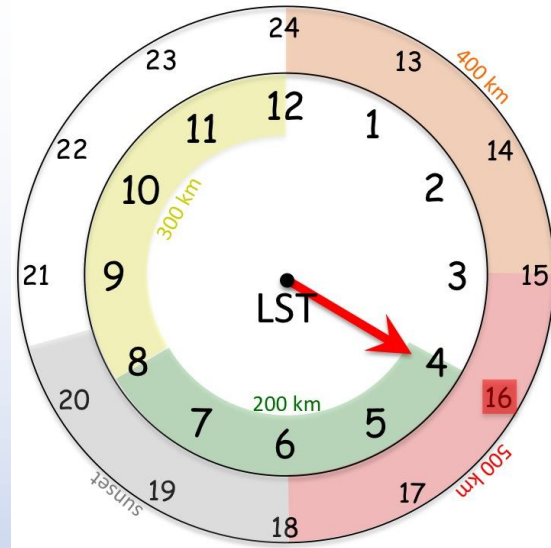


GOES IR 6-hr Temp Trend

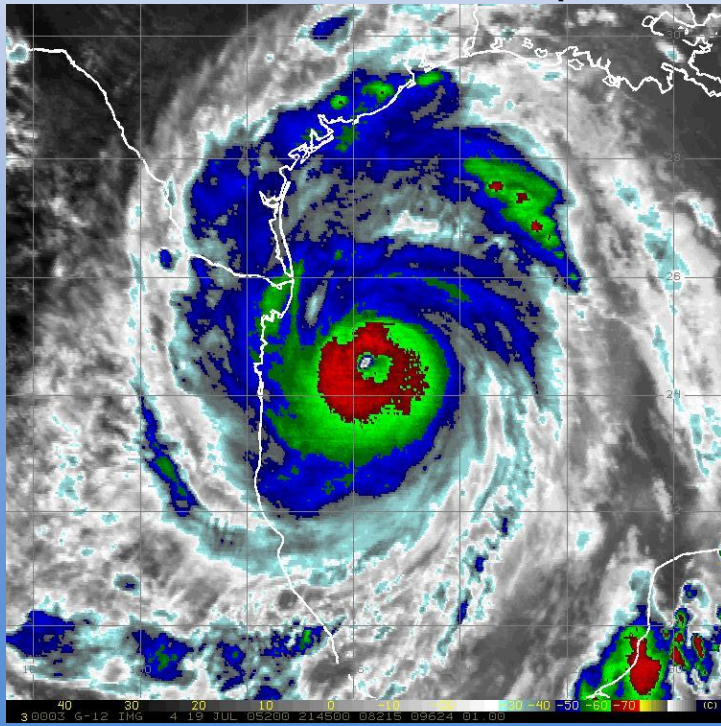




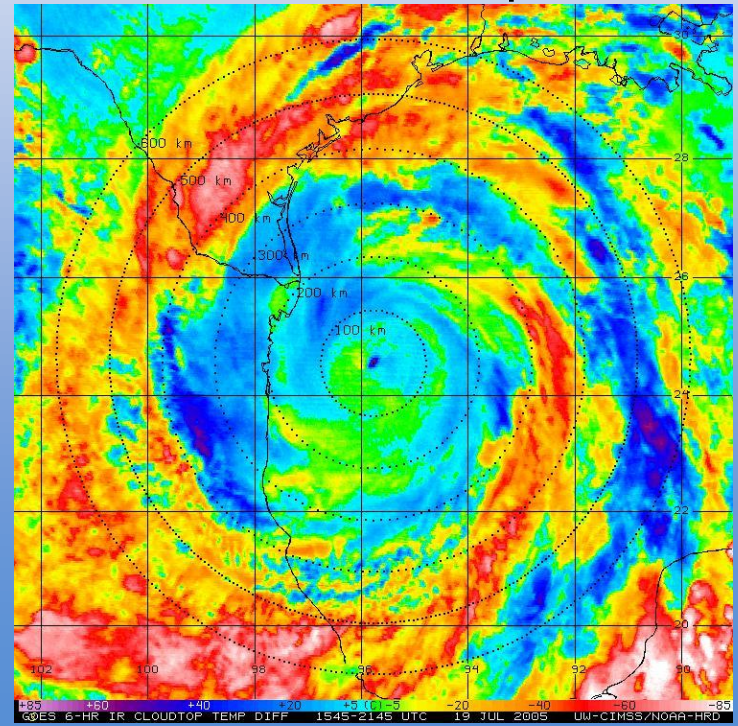
# The TC Diurnal Clock: Hurricane Emily (19 July 2005)



GOES Infrared: 11  $\mu\text{m}$



GOES IR 6-hr Temp Trend

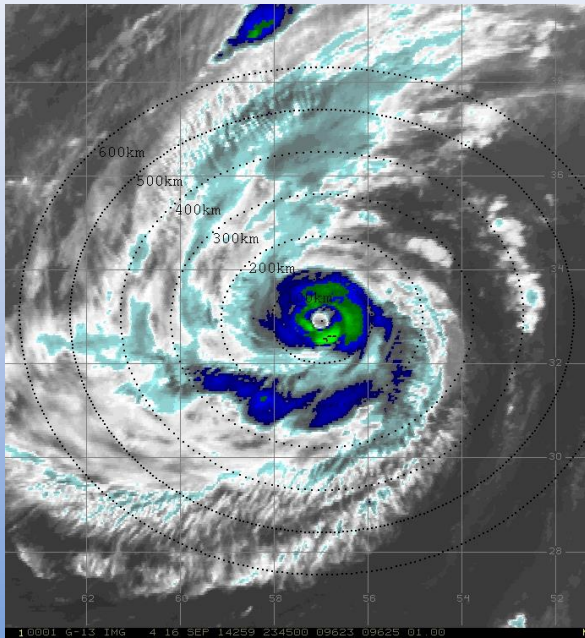


2014 Edouard

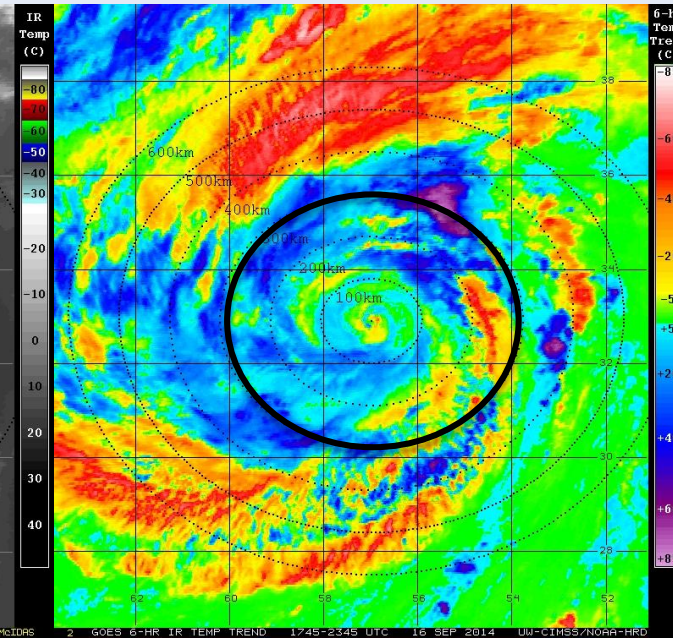
# Hurricane Edouard: 16 Sep 2014

## TC Diurnal Cycle

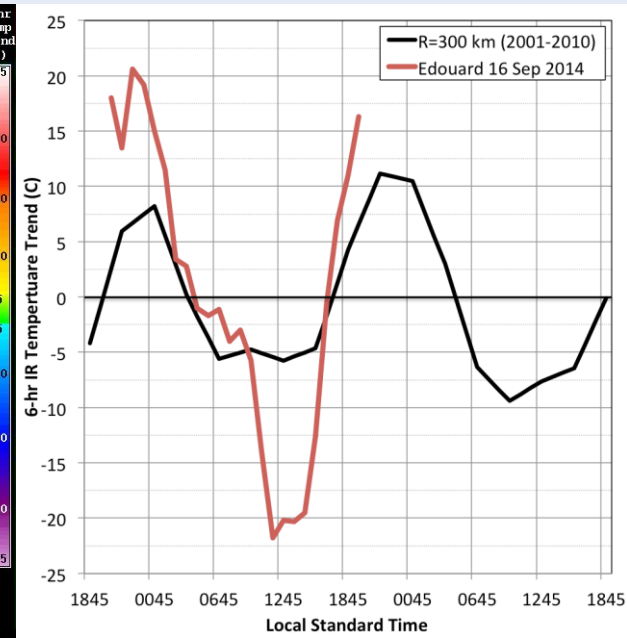
GOES  
Enhanced IR



GOES IR 6-hr  
Temperature Trend



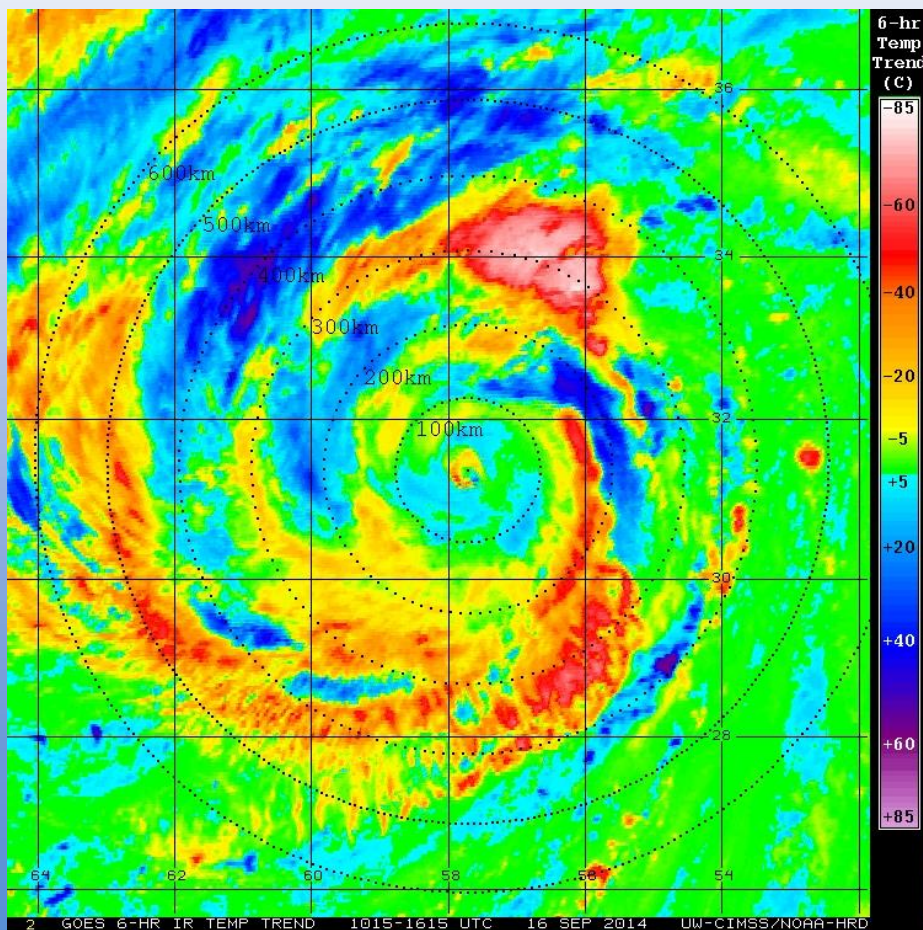
TC Diurnal  
Heartbeat



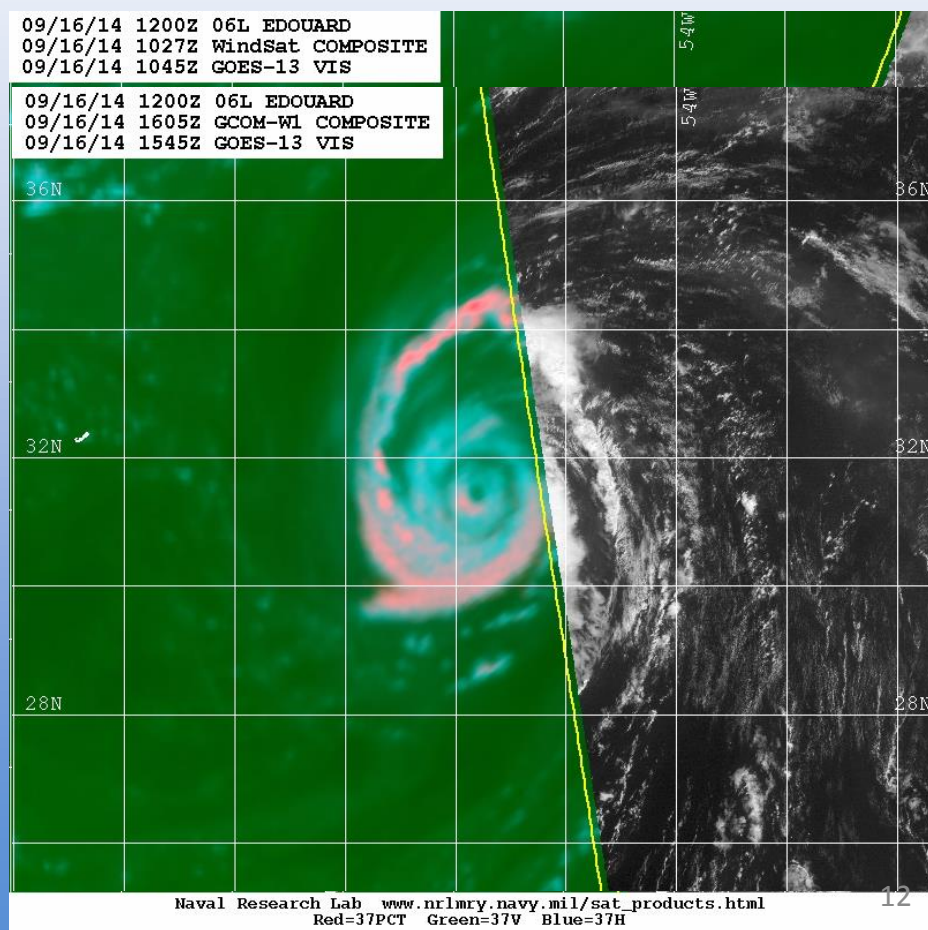
# Edouard 16 Sep 2014

## TC Diurnal Cycle

### GOES IR 6-hr Temp Trend



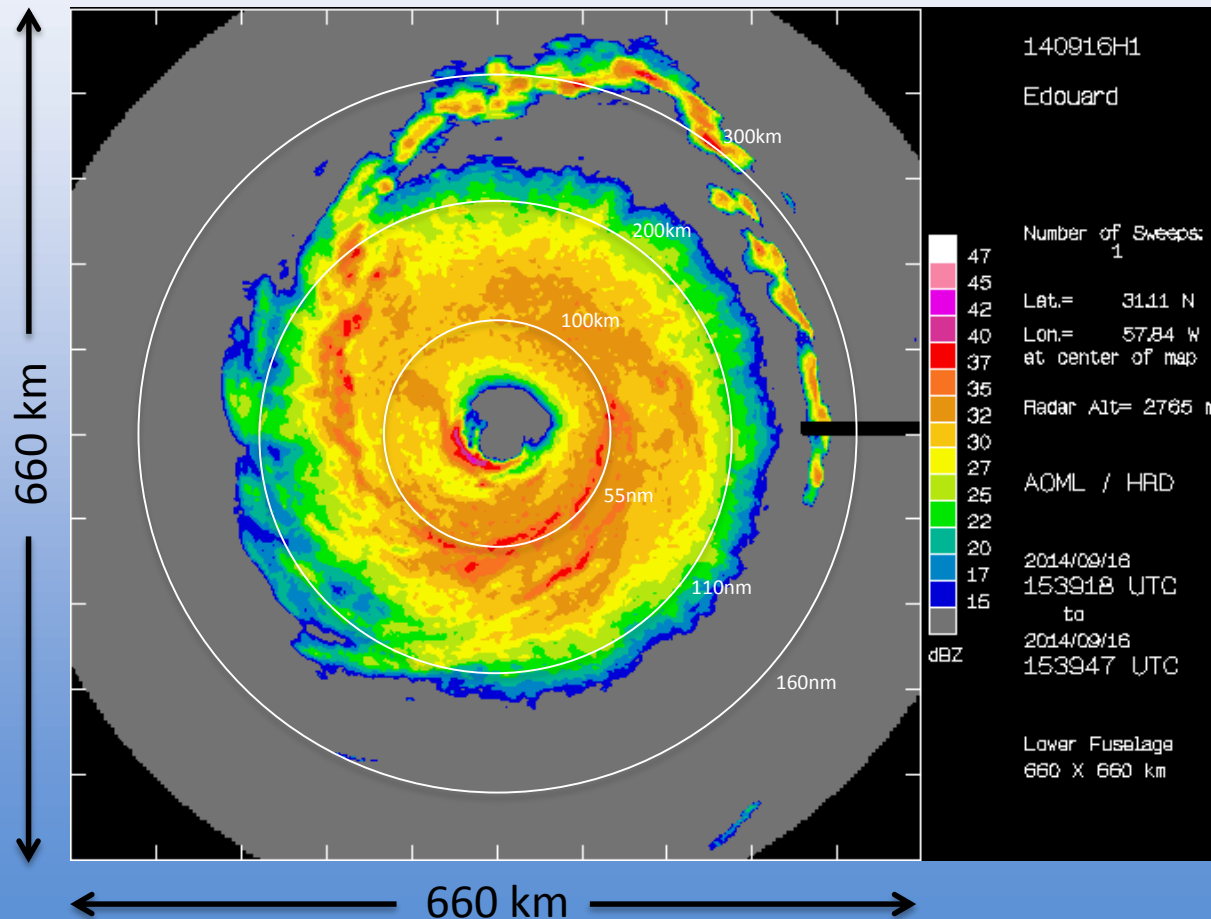
### 37 GHz Composite Imagery



# Hurricane Edouard 16 Sep 2014

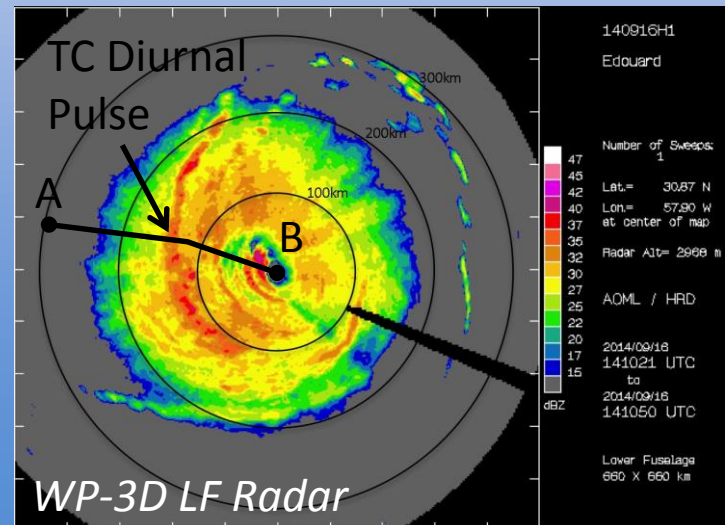
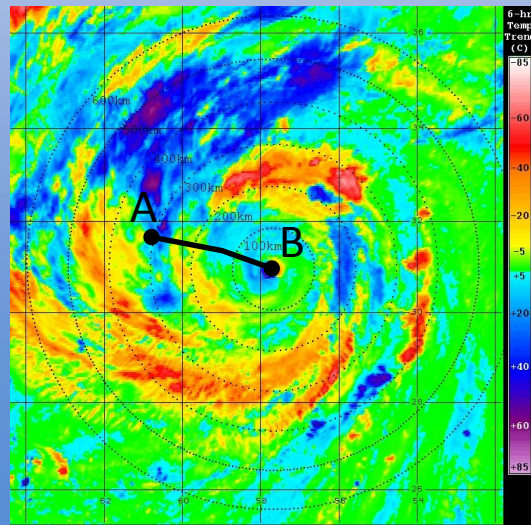
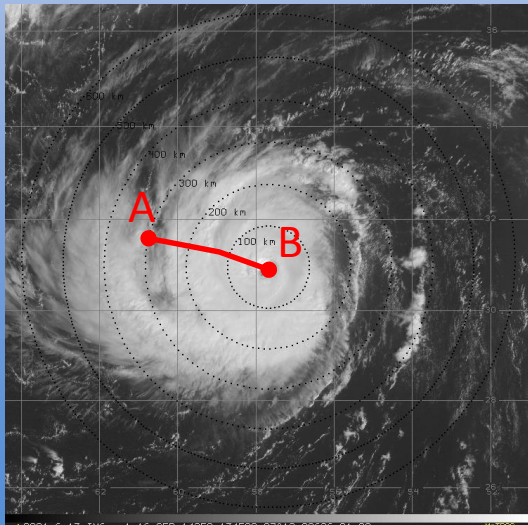
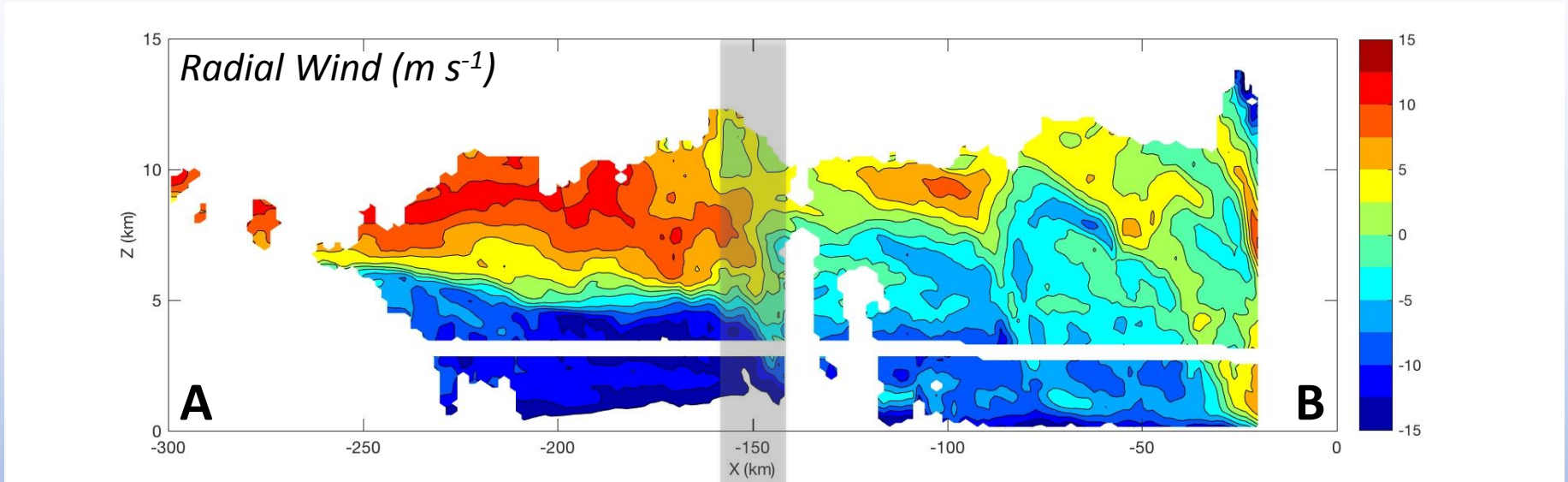
NOAA P-3 (42) LF Radar

1322-1821 UTC/0922-1421 LST (660 x 660 km)



# Hurricane Edouard: 16 Sep 2014

*TC Diurnal Cycle (1120 – 1216 LST)*

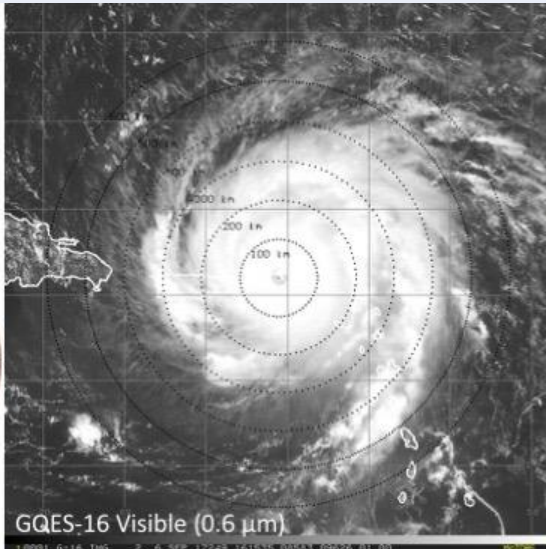
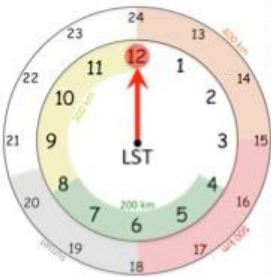


2017 Irma

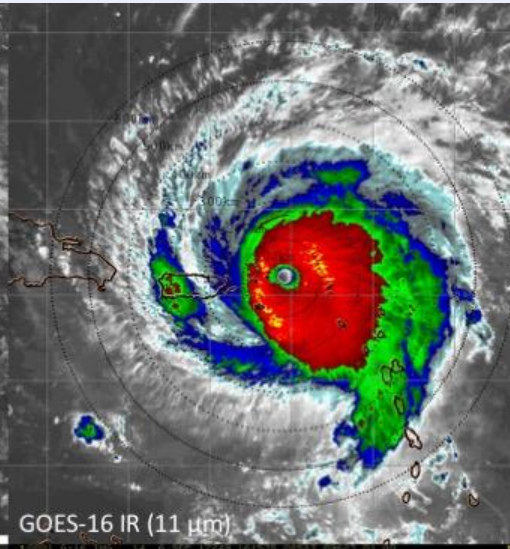
# Hurricane Irma

## 06 September 2017

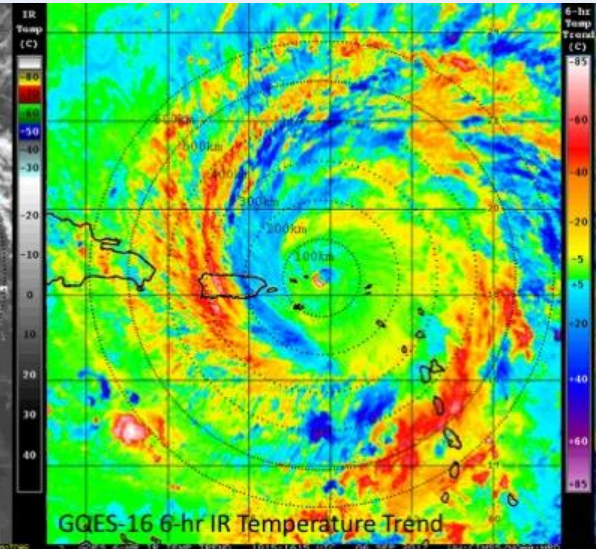
Hurricane Irma  
06 Sep 2017  
1615 UTC



GQES-16 Visible (0.6 μm)



GOES-16 IR (11 μm)



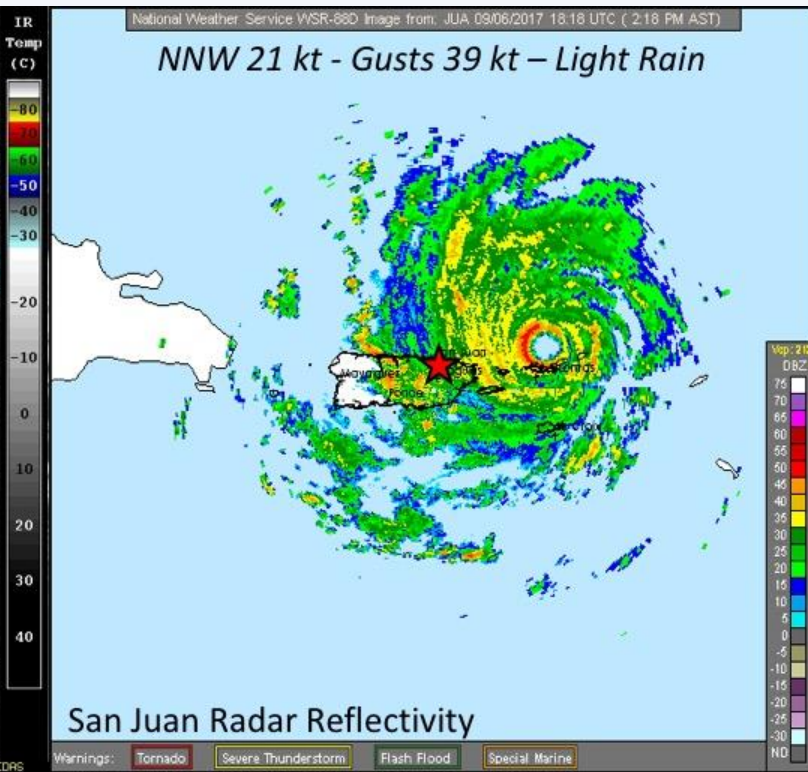
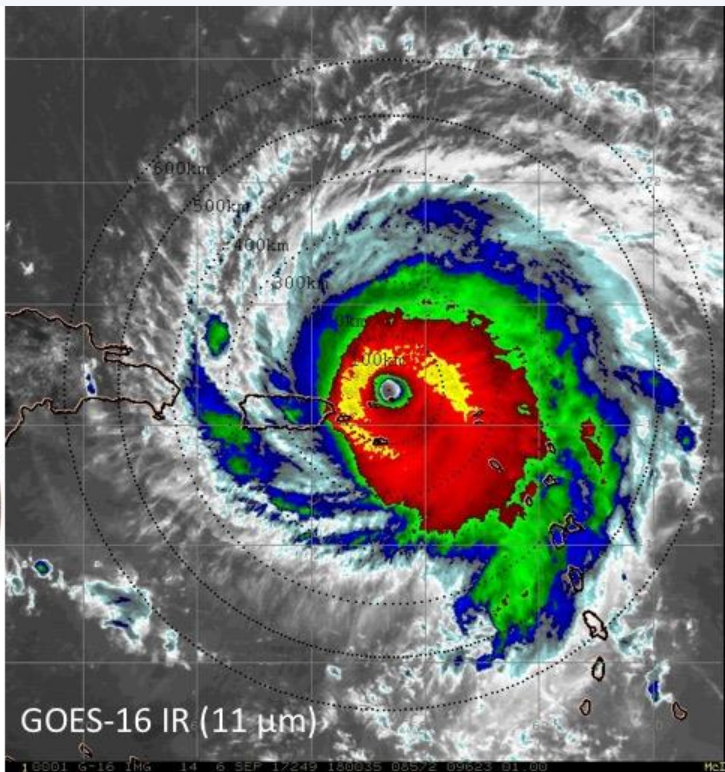
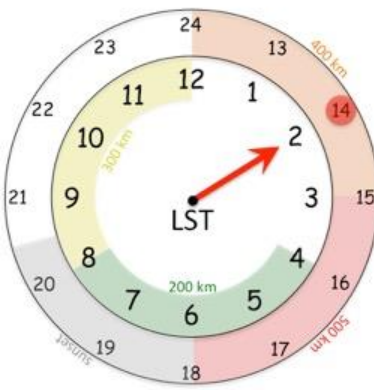
GOES-16 6-hr IR Temperature Trend



# Hurricane Irma

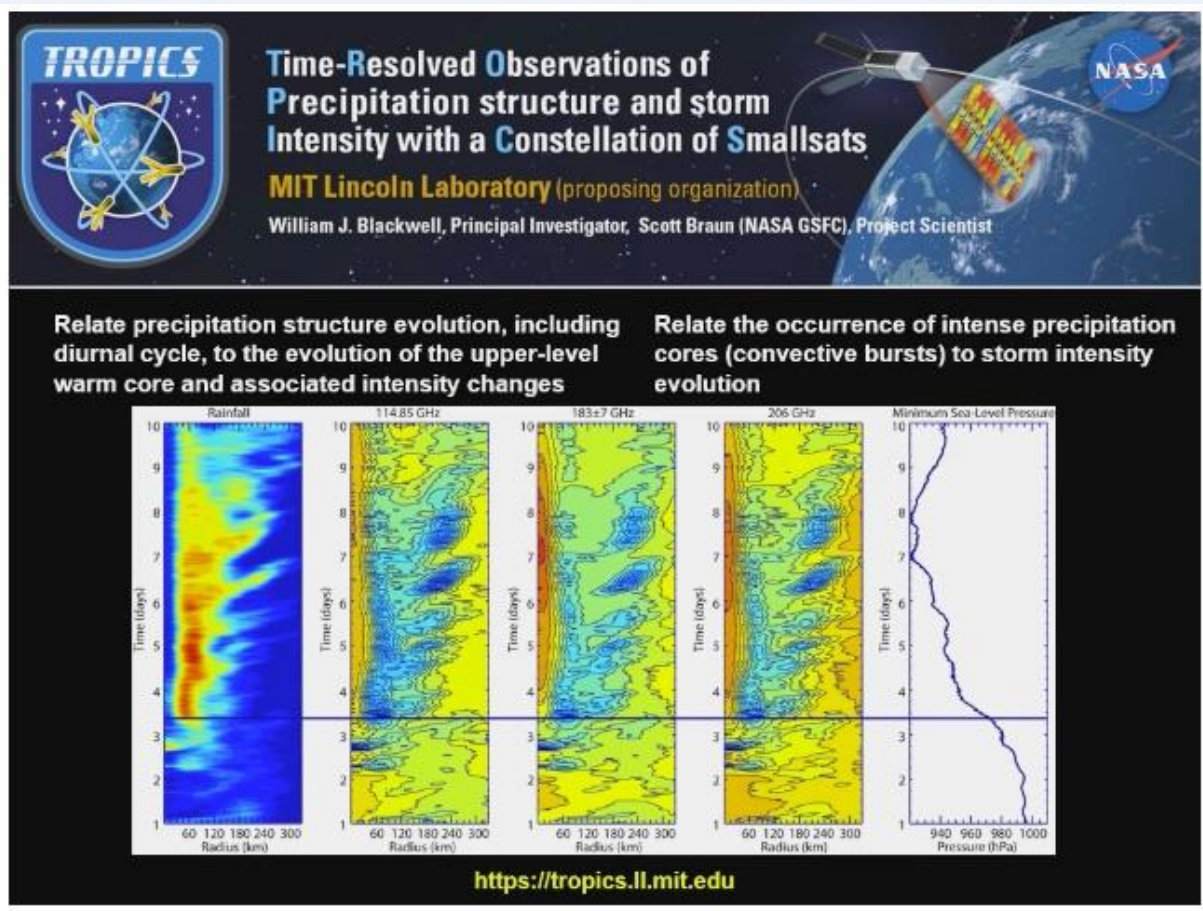
## 06 September 2017

Hurricane Irma  
06 Sep 2017  
1815 UTC



# Tropical Cyclone Diurnal Cycle Signals in a Hurricane Nature Run

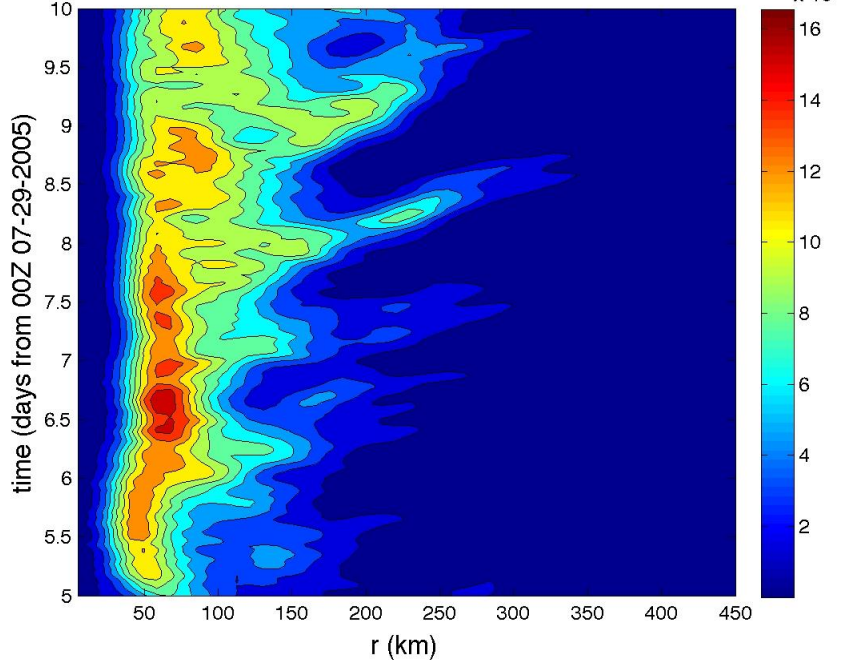
Nolan et al. 2013



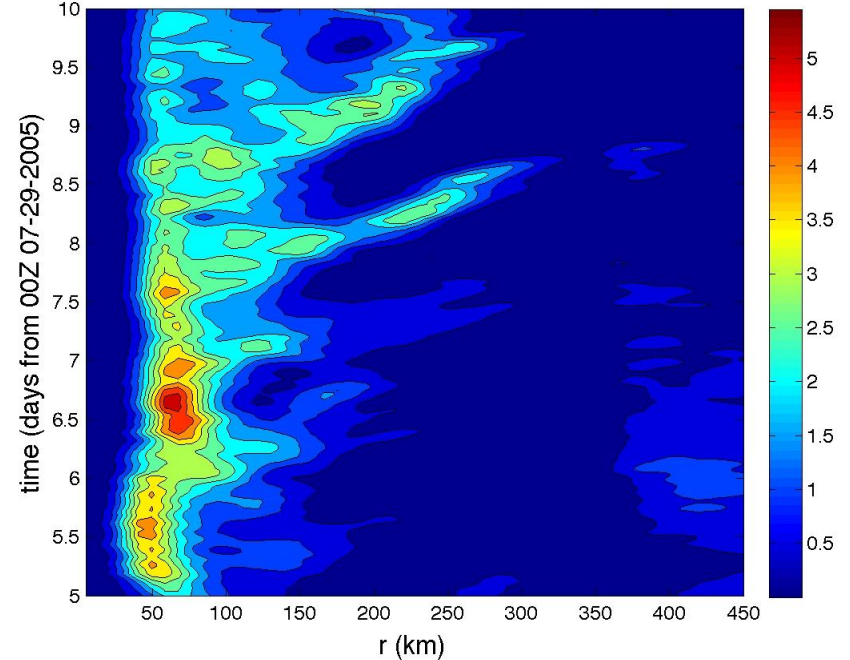
# Hurricane Nature Run

*Hovmollers: Q-Condensate & Rain Rate (z=1 km)*

Qcond (kg/kg) z=0.84km max=1.66e-03, min=1.24e-07, int=1.51e-04  $\times 10^{-4}$



Rain Rate (mm/hr) z=0.84km max=5.45e+00, min=2.80e-04, int=4.96e-01



1) Intensity (Cat 2+): Day 5-10

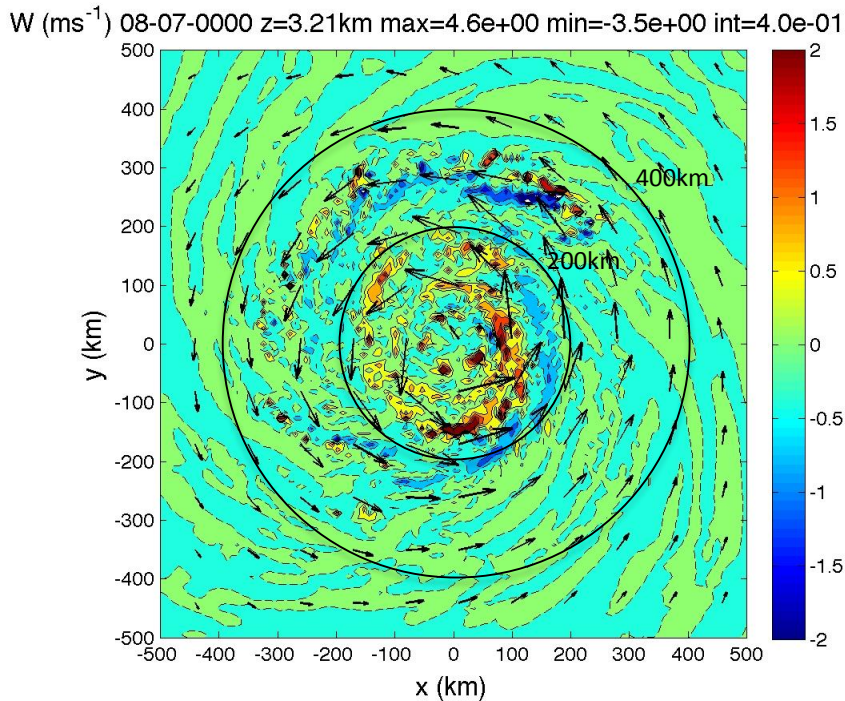
2) Shear  $\leq 15$  kt: All

3) Dx to land  $\geq 300$  km: All

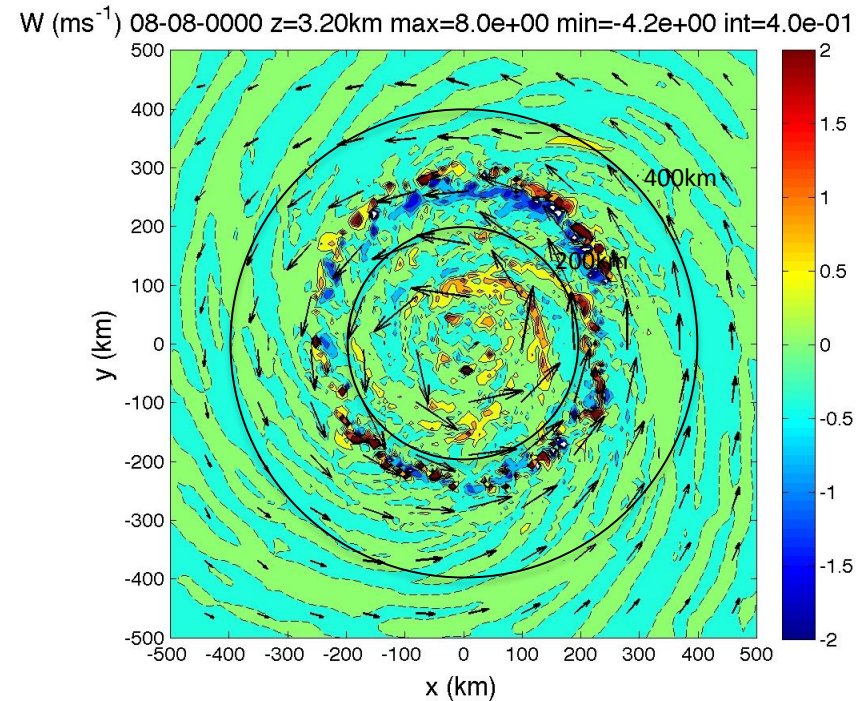
# Hurricane Nature Run

*2-D plots: 700 hPa Vertical Velocity*

06 August



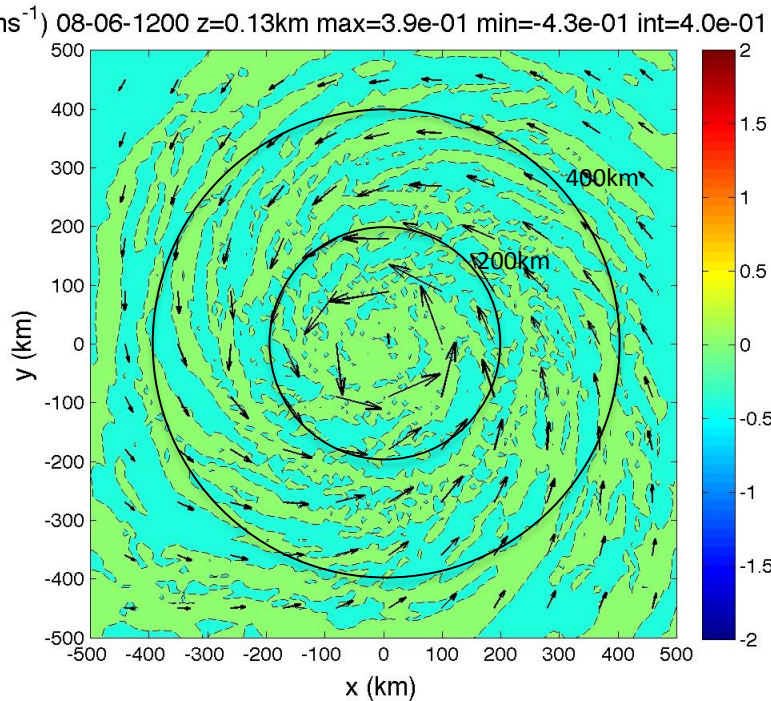
07 August



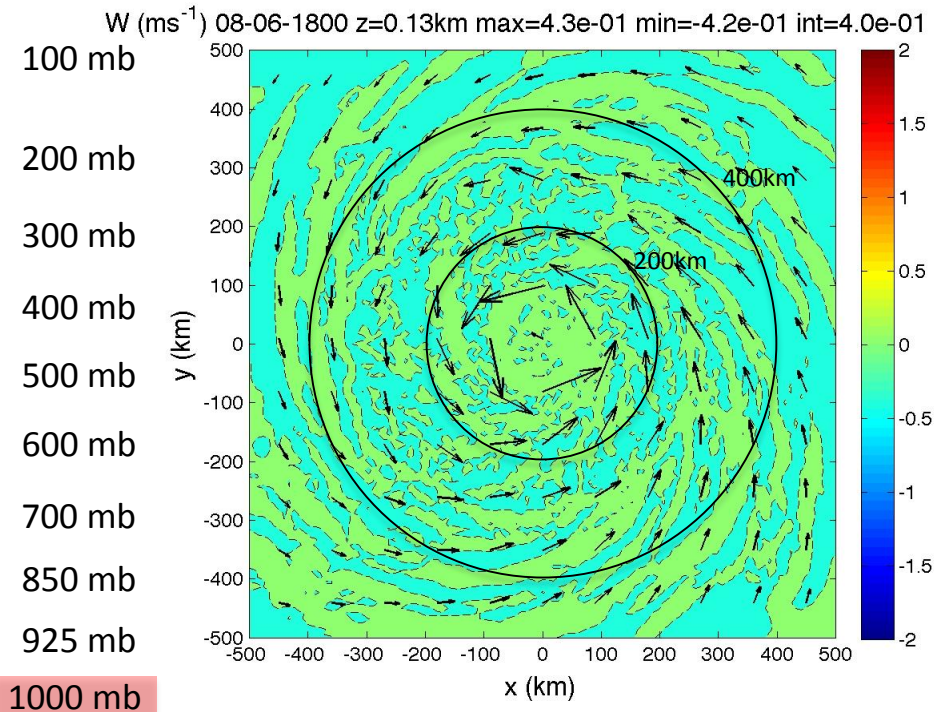
# Hurricane Nature Run

*2-D plots: Vertical Velocity (Surface to 100 hPa)*

06 August 0800 LST

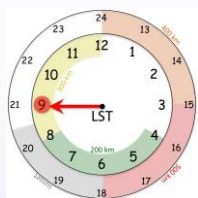


06 August 1400 LST



# The Tropical Cyclone Diurnal Cycle

...thinking about the hurricane symbol



1992 Andrew



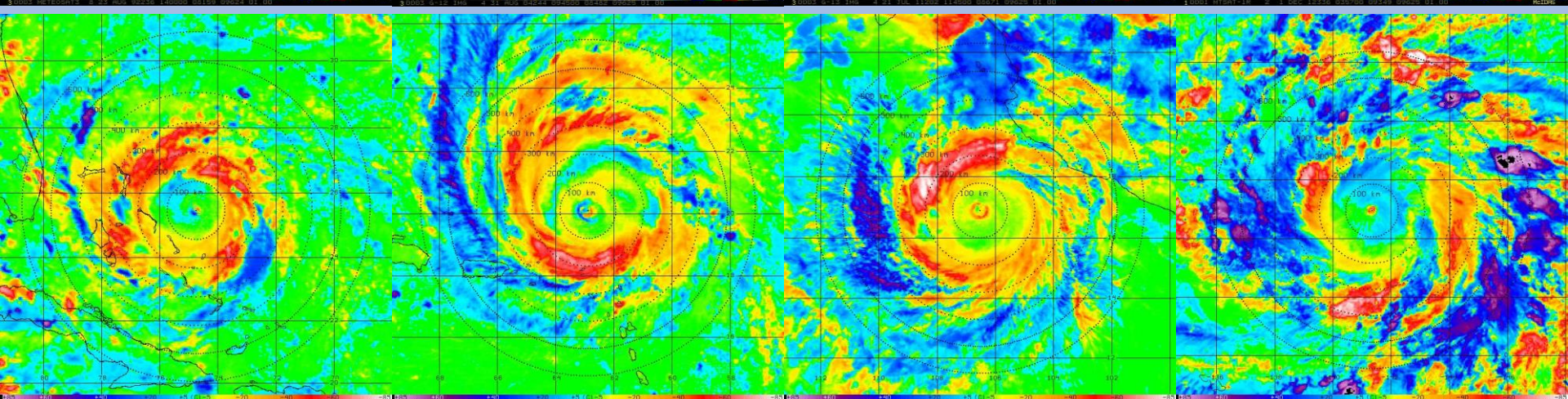
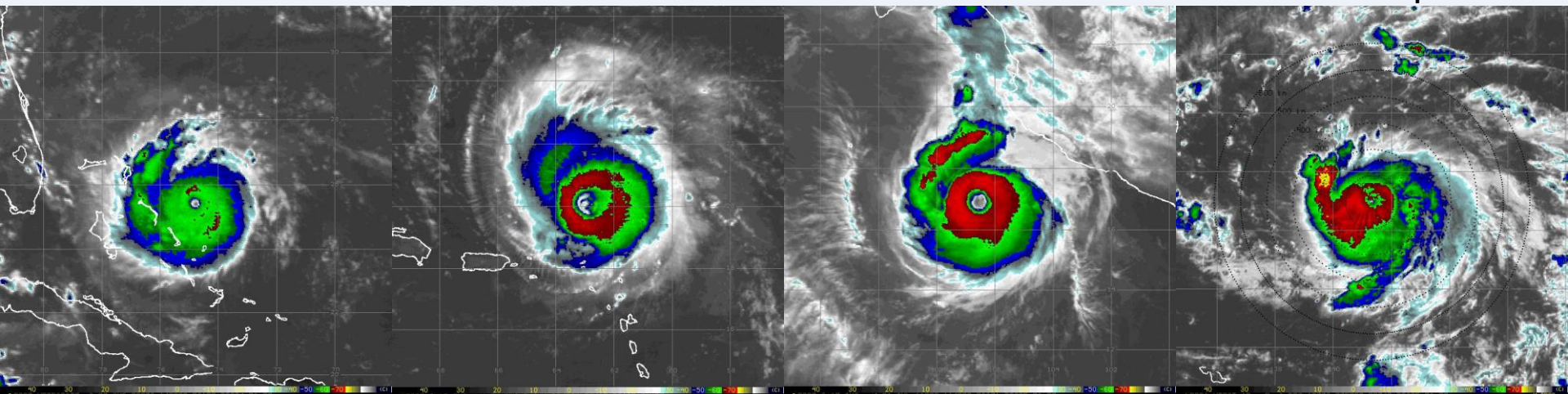
2004 Frances



2011 Dora



2012 Bopha



North Atlantic

North Atlantic

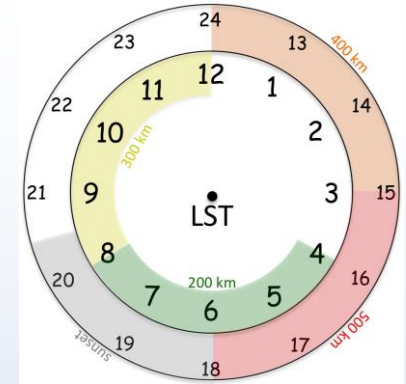
Eastern N. Pacific

Western N. Pacific

# Take-Aways (CliffsNotes)

TC diurnal pulses:  
a main feature of  
the TC diurnal cycle  
...possibly  
fundamental

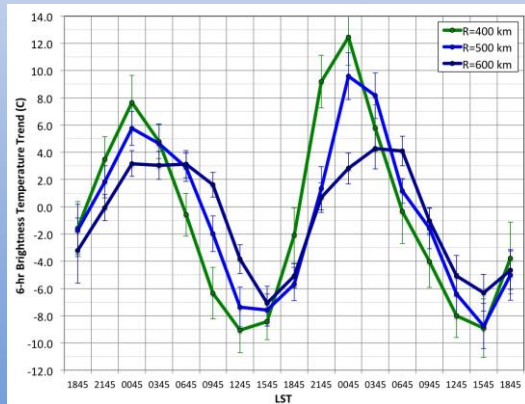
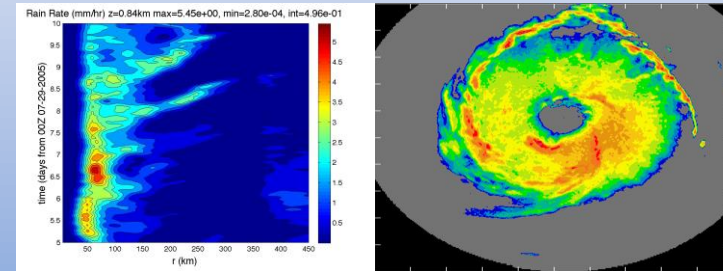
TC diurnal cycle  
conceptual clock:  
predicts its  
evolution in  
time & space (4-d)



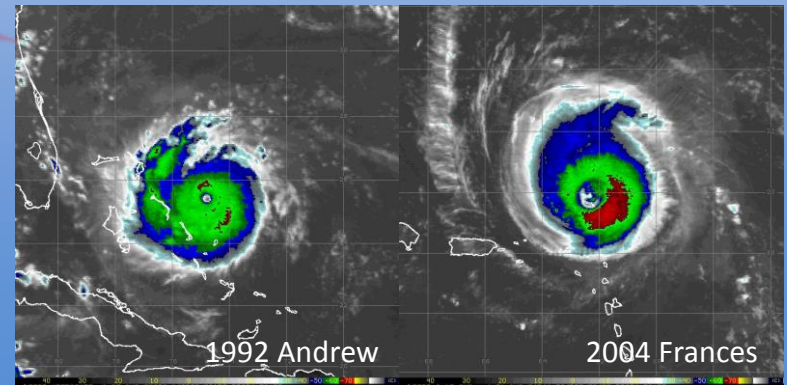
TCDC signals: WRF Nature Run  
(precip, thermo, winds) & P3 LF  
radar >> deep layer of the atm

TROPICS constellation:  
ideal for TCDC studies

- *med refresh rate: ~1 hr*
- *118/183/206 GHz*
- *nadir/avg res: ~17/24 km*



The TCDC &  
TC structure:  
precipitating  
“convective  
arms” as TC  
“reaches out”



IR imagery >> a predictable,  
evolving “diurnal heartbeat”;  
Strongest signal >> mature TCs,  
light shear, over ocean

Questions?