

TROPICAL CYCLONE USES OF VIIRS

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VIIRS DATA FOR TROPICAL CYCLONE FORECASTING

- VIIRS data have multiple applications for TC analysis and forecasting and can be critical for operational forecasters.
- Important features:
 1. Day Night Band: **visible-like imagery at nighttime**
 2. IR, VIS: **very high resolution** of I-bands, including IR window band (I05, 11.45 μm , 375 m resolution)
 3. 3040 km swath width: **no gaps between the consecutive orbits**, even at the equator

CIRA TROPICAL CYCLONES NEAR REAL TIME STORM-CENTERED VIIRS IMAGERY

An experimental near real-time application displaying storm-relative VIIRS DNB, visible, and IR imagery in the vicinity of TCs has been developed and is available on RAMMB- CIRA's TC Real Time page: http://rammb.cira.colostate.edu/products/tc_realtime/

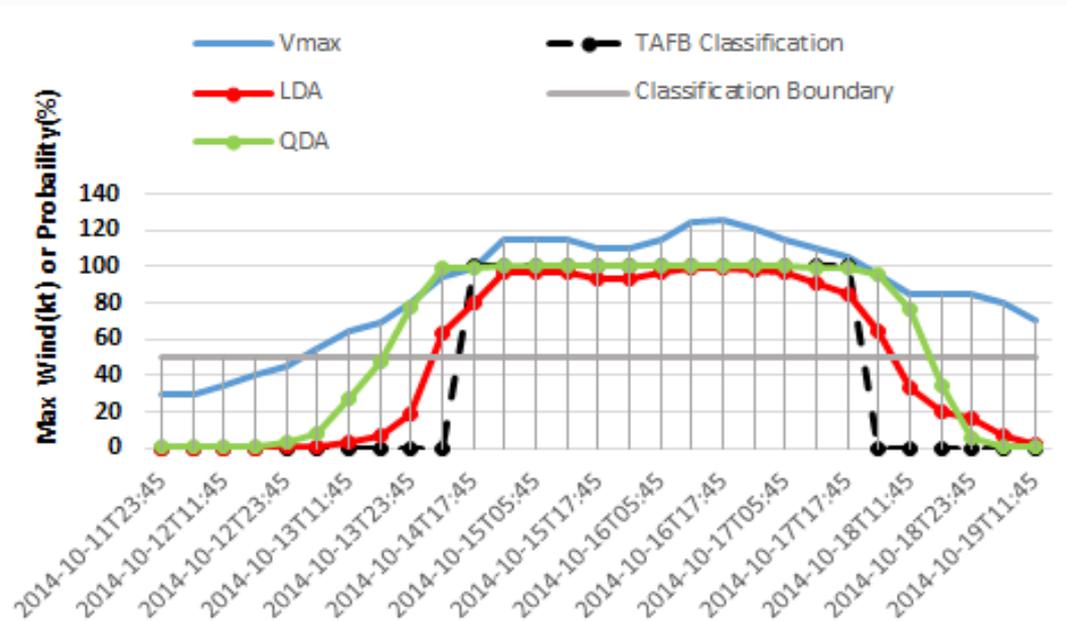
- 3 VIIRS products available online:
 1. **Alternating DNB (at night) and VIS (during day)** [2 hr latency]
 2. **DNB imagery** during both day and night [1.5 hr latency]
 3. **High-resolution IR window band** (I05, 11.45 μ m, 375 m resolution) [2 hr latency]

- Product description:
http://rammb.cira.colostate.edu/products/tc_realtime/about.asp

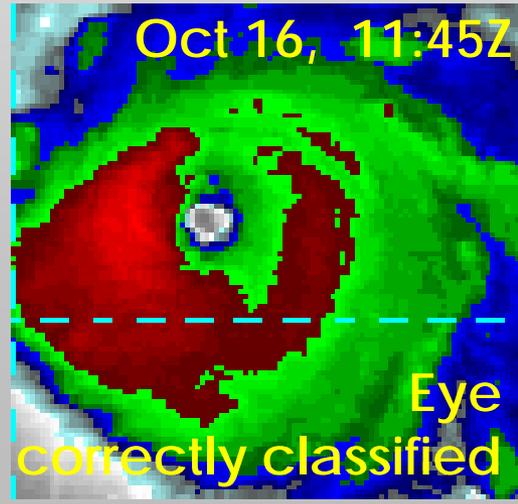
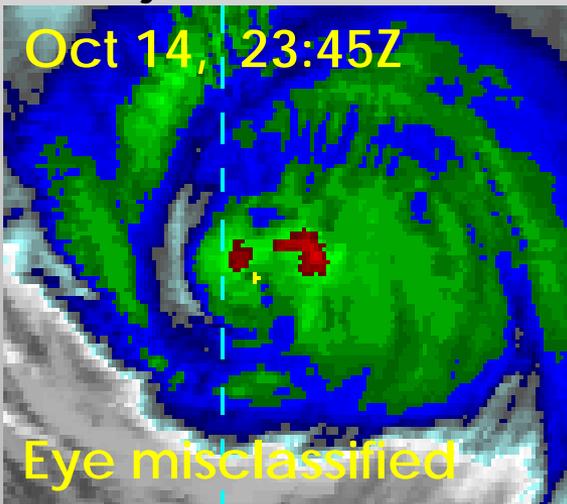
TC USE OF HIGH-RESOLUTION IR WINDOW AND VISIBLE CHANNELS

- High-resolution window **IR I05** band:
 - 11.45 μm , 375 m resolution
- High-resolution **VIS I01** band:
 - 0.64 μm , 375 m resolution
- Use in the **algorithm for automated eye-detection**
- Provide **detail about the eye-structure** not visible on GOES imagery

AUTOMATED OBJECTIVE EYE-DETECTION



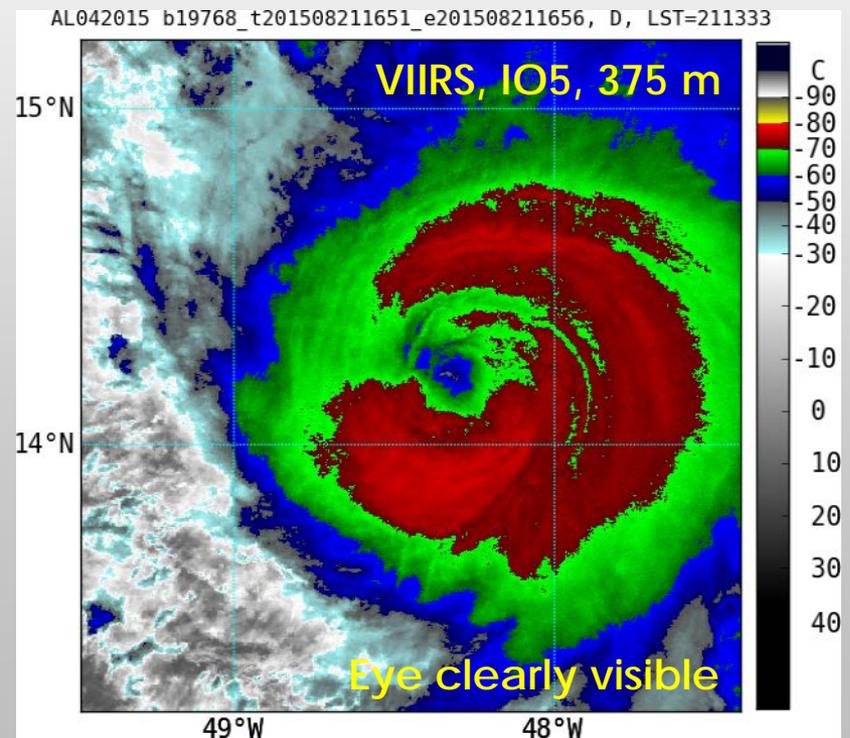
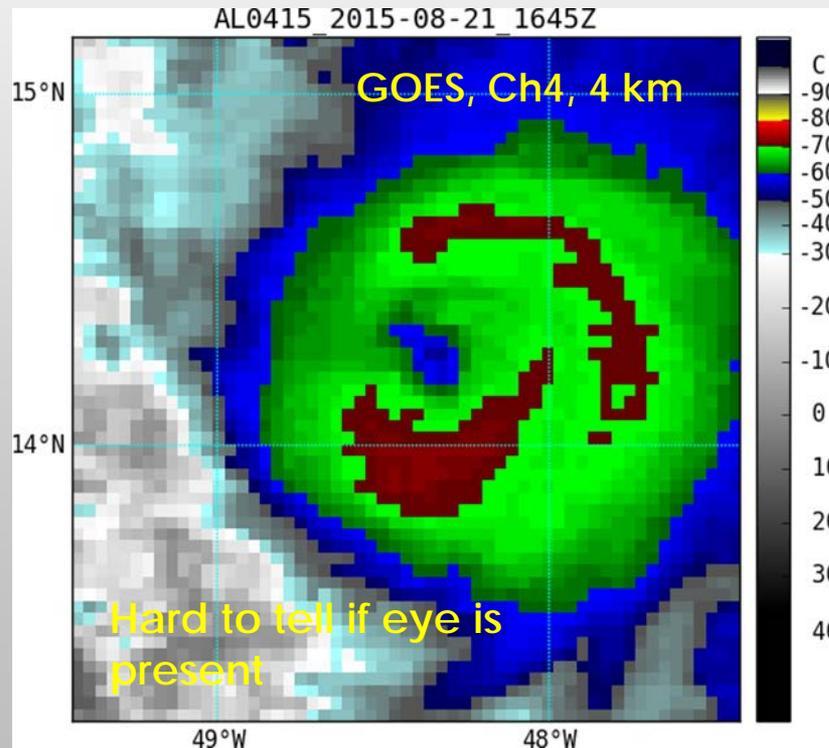
Major Hurricane Gonzalo, al082014



- The hybrid (IR+ Best Track) automated objective eye-detection algorithm correctly classifies about 90% of the cases
- Best performance: when storm is either weak (no-eye) or strong (eye already formed)
- Worst performance: when eye is about to form or just formed. That time is also challenging for human observer
- The probabilistic version of the algorithm could be used as:
 - standalone application
 - input to the Rapid Intensification Index (RII)
 - to forecast eye formation

AUTOMATED OBJECTIVE EYE-DETECTION

- Further algorithm improvement: use VIIRS high-resolution data for borderline cases
- Example: hurricane Danny, al04 2015 had a very small eye that is visible on VIIRS imagery but hard to detect on GOES

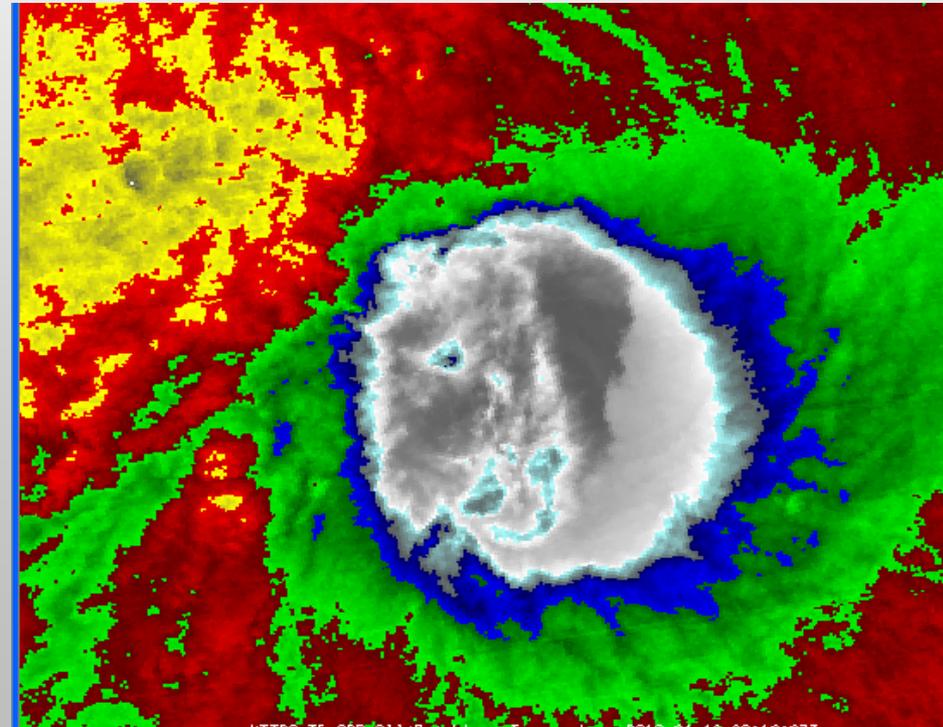
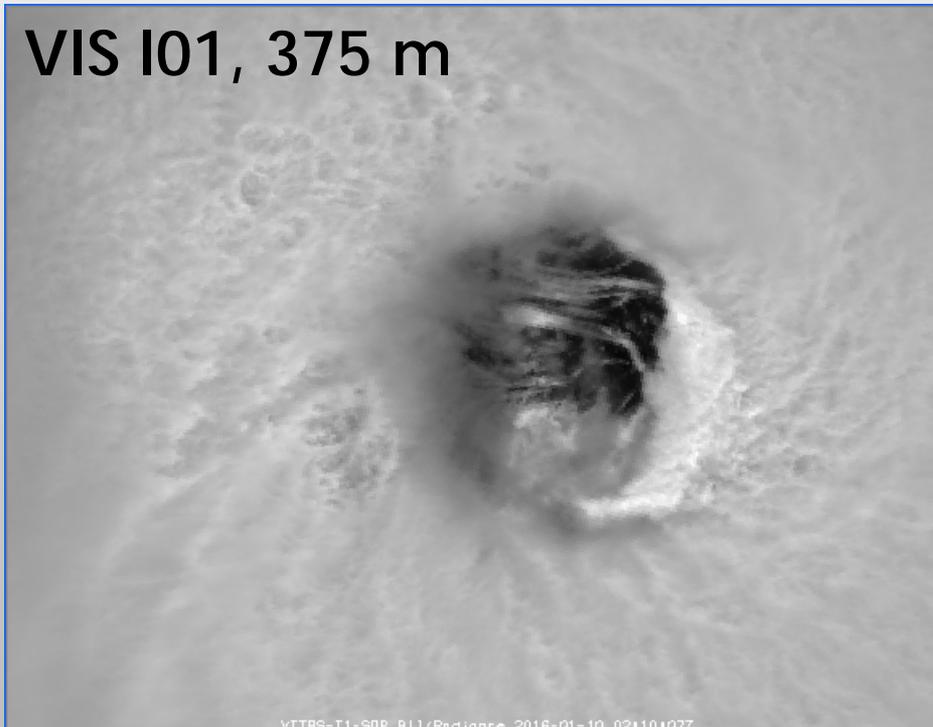


VIEWING THE EYE STRUCTURE

- The fine structure of the eye , such as mesovortices and the shape of the eye-wall are clearly resolved by I05 but not necessary seen in the GOES imagery
- The details about the eye-structure might be useful for determining the storm intensity

IR Window I05, 375 m

VIS I01, 375 m

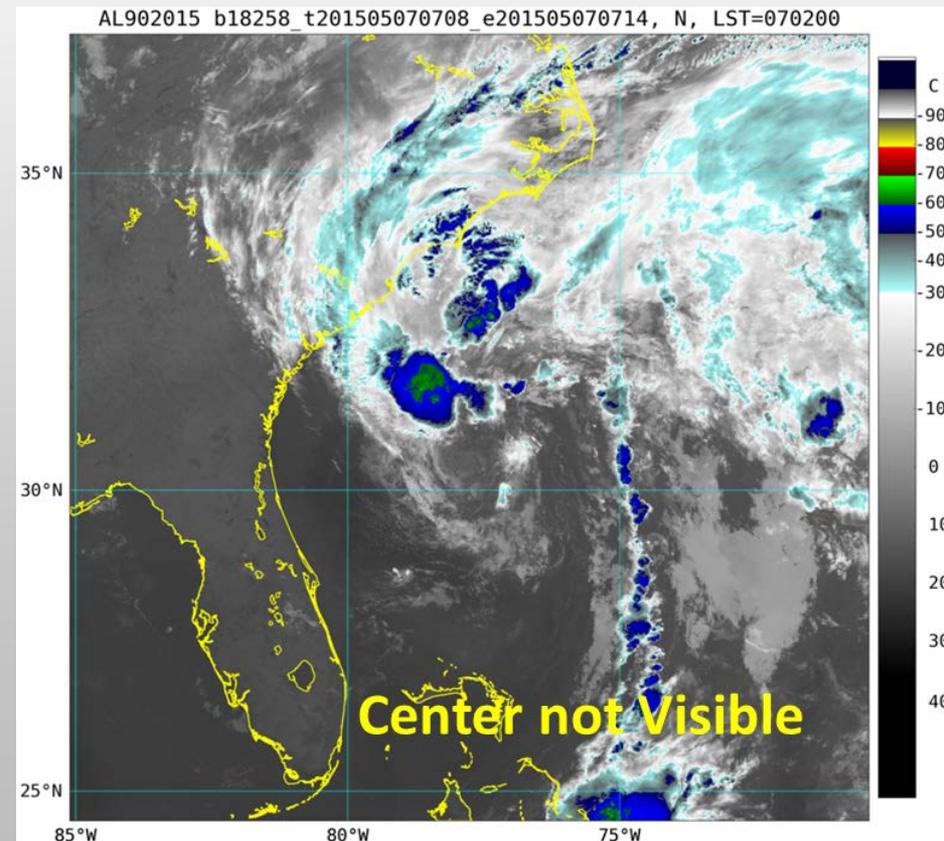
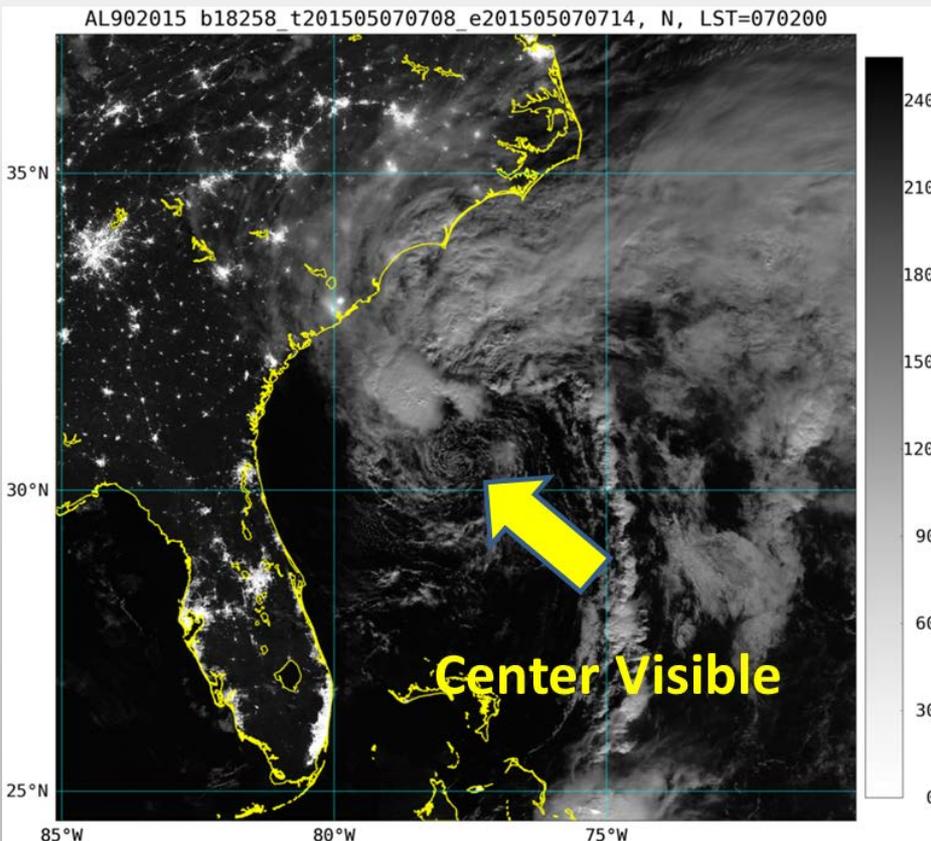


TC USE OF DAY-NIGHT BAND (DNB) CHANNEL

- DNB imagery primary use
 - determine the presence of the eye in cases when the eye is small or is obscured by thin cirrus and not obvious in infrared (IR) imagery
 - perform center-fixing and **has been used by forecast centers** to refine nighttime storm center locations
- DNB imagery can also be used to
 - detect night-glow waves that occur in the stratosphere and not seen in other imagery
 - detect instantaneous lightning: lightning location could be an indication of intensifying or weakening storm
- The DNB's nighttime capabilities are **especially important for**
 - **weaker TCs**: are less organized, have multiple circulation centers, and are generally more difficult to locate
 - **sheared TCs**: the low-level circulation center is exposed and/or elongated and is hard to determine from the IR imagery or animations of IR imagery

VIIRS DNB CENTER FIXING

- Low level circulation center visible only on DNB image
- Hard to see the center location from the IR image alone



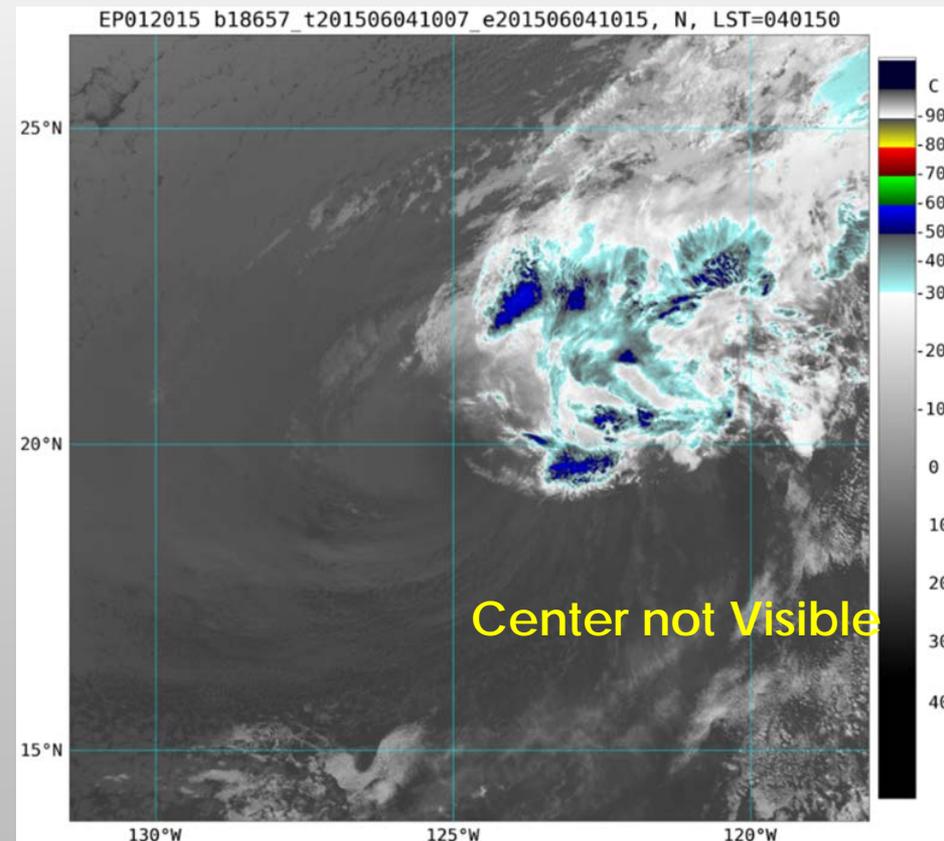
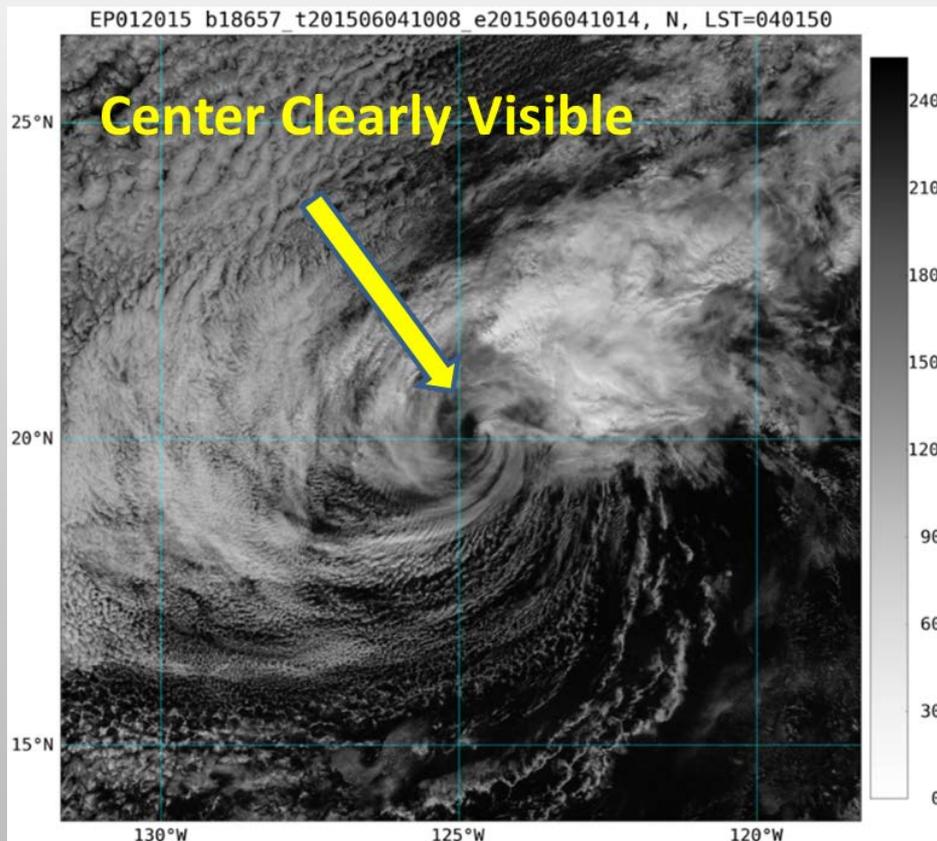
Invest al902015 (right before becoming Tropical Storm ANA)

COMMENTS ON CENTER FIXING

- The center is typically the **starting point for intensity estimation**
- Location is **important for warnings** and the running of guidance
- Weaker storms often have **multiple centers**
- Storm **symmetry is often poor in weaker systems** making center fixing challenging
- Sheared tropical cyclones have **displaced centers** which are difficult to find at night

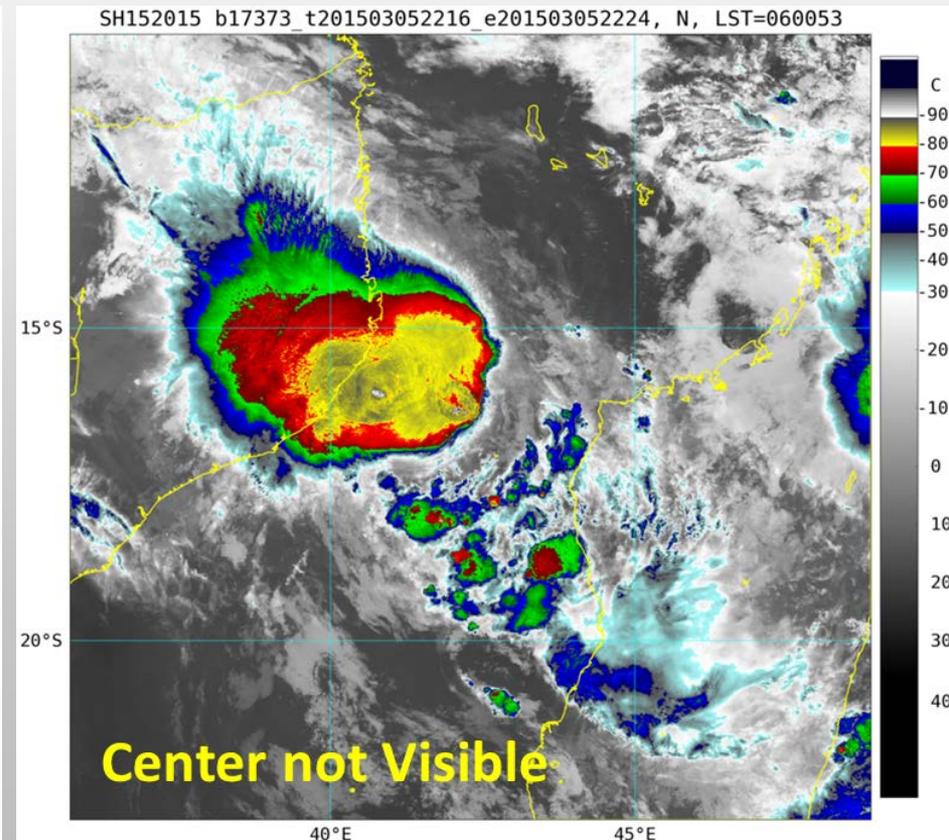
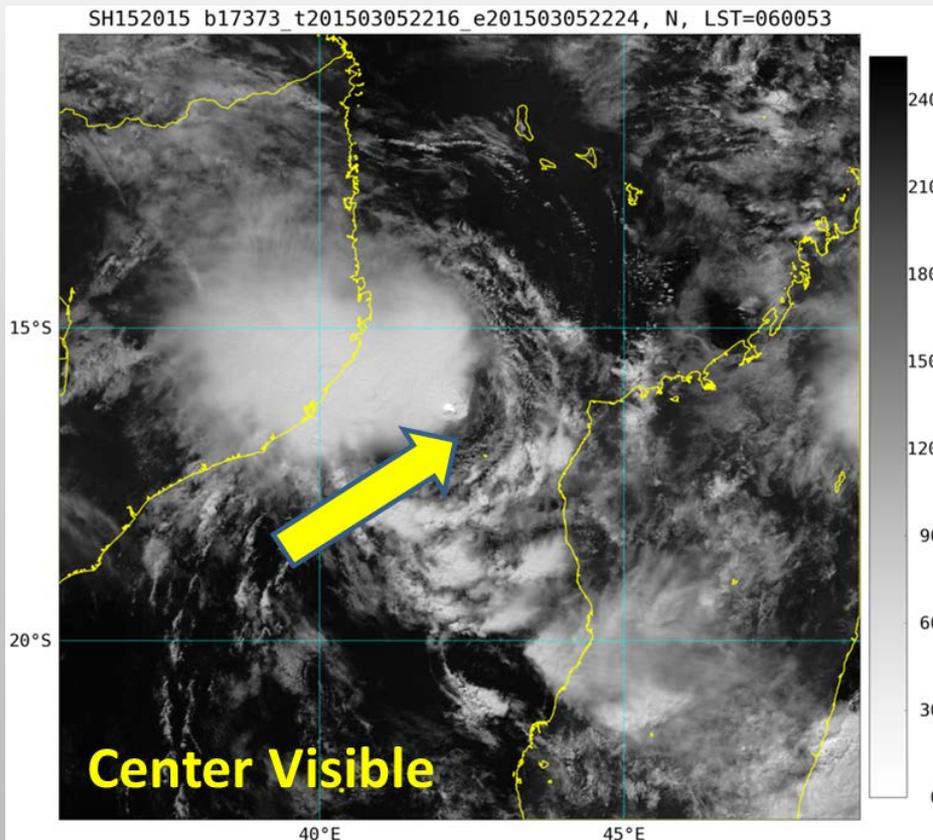
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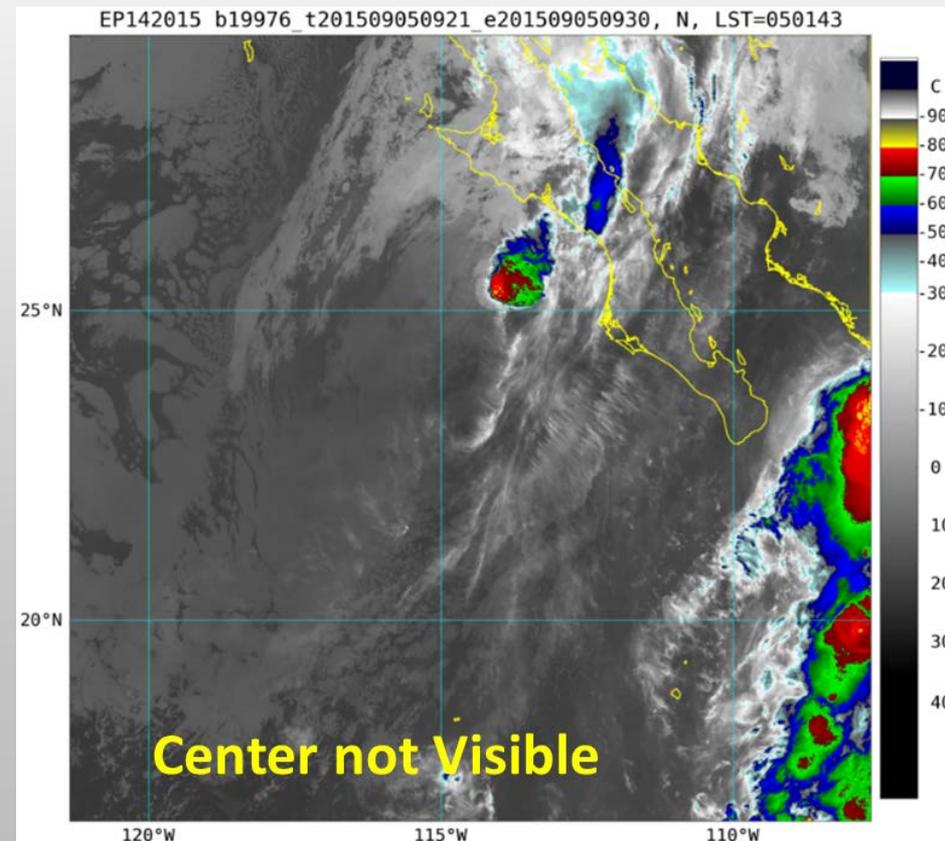
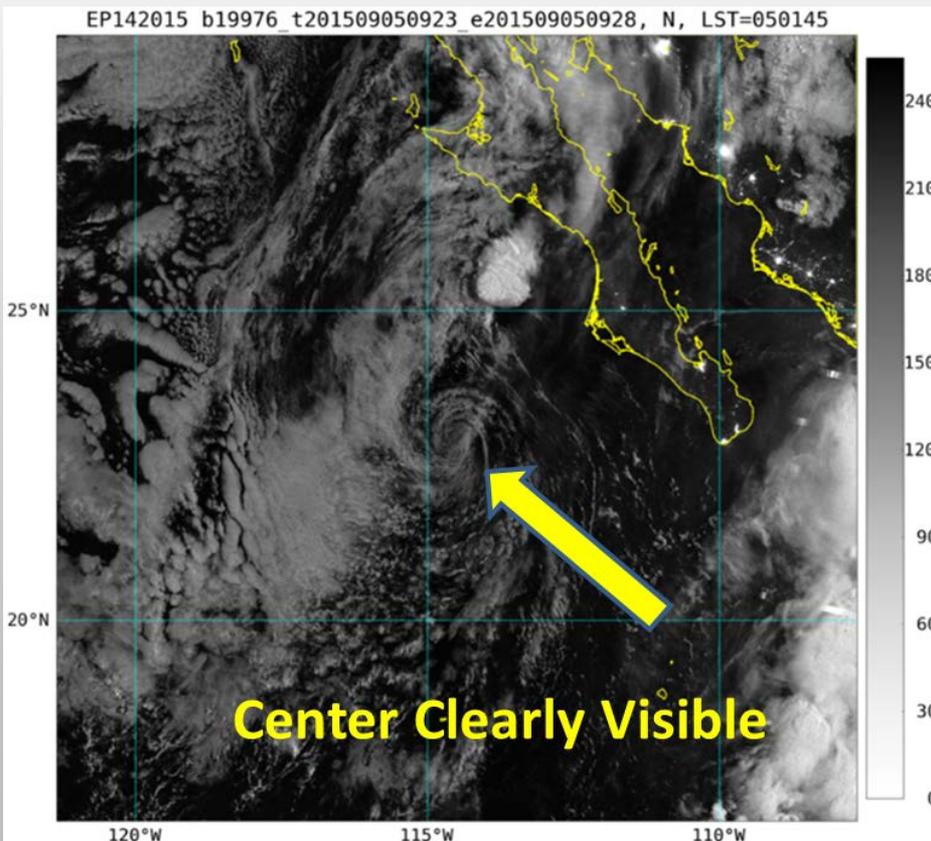
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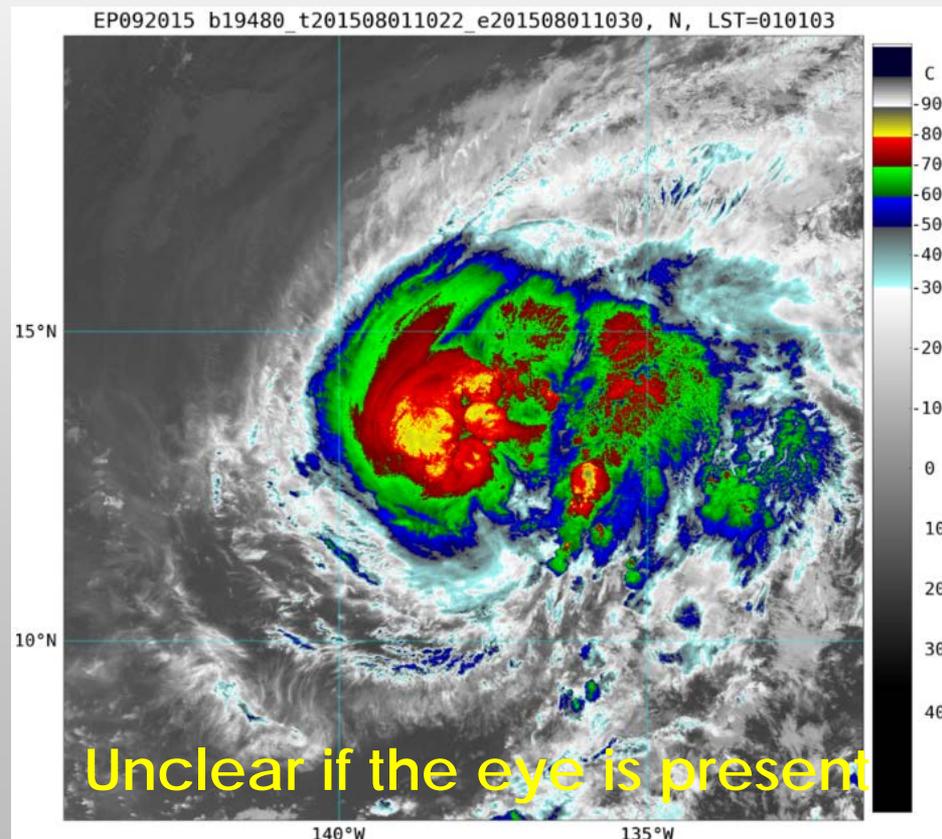
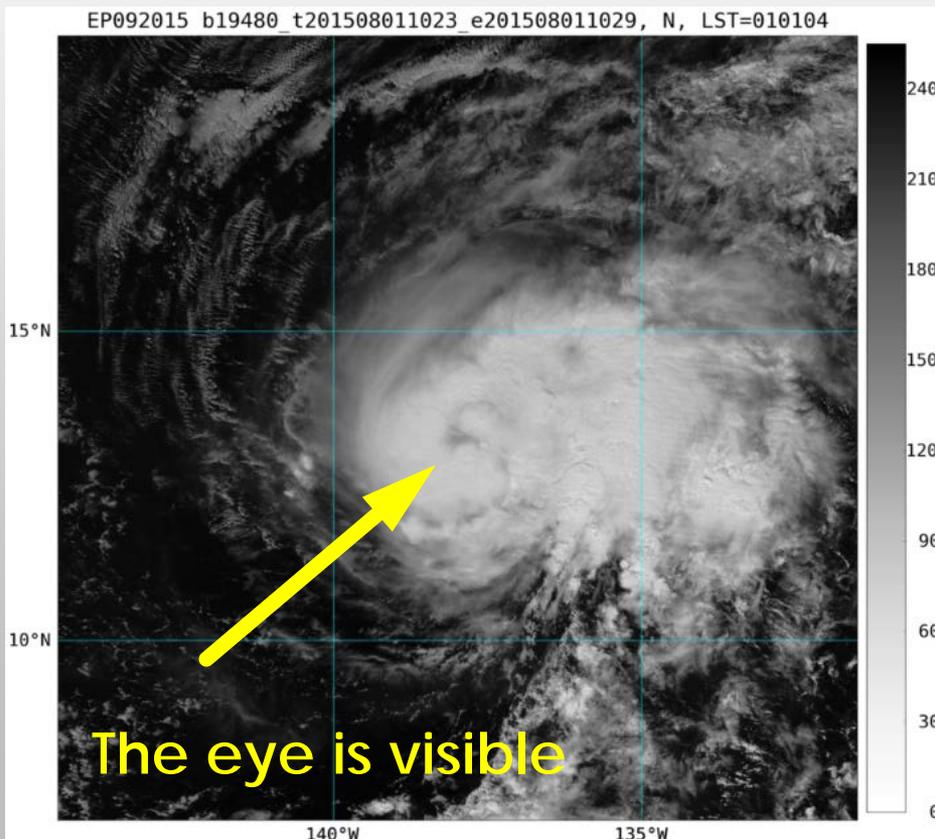
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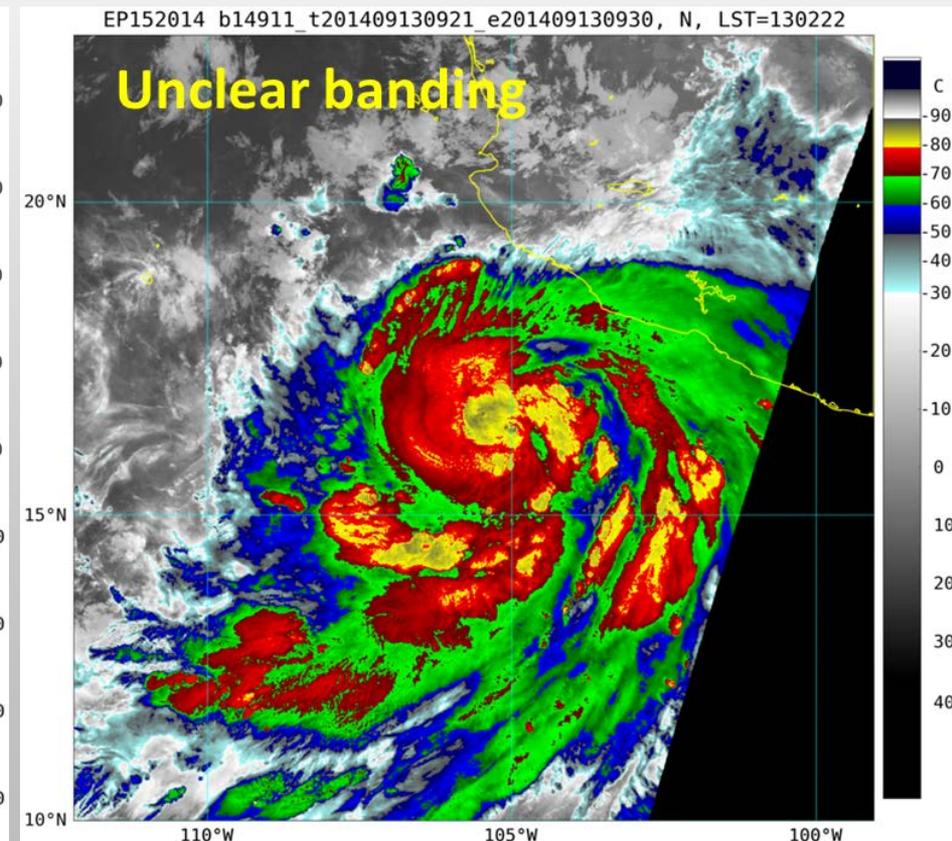
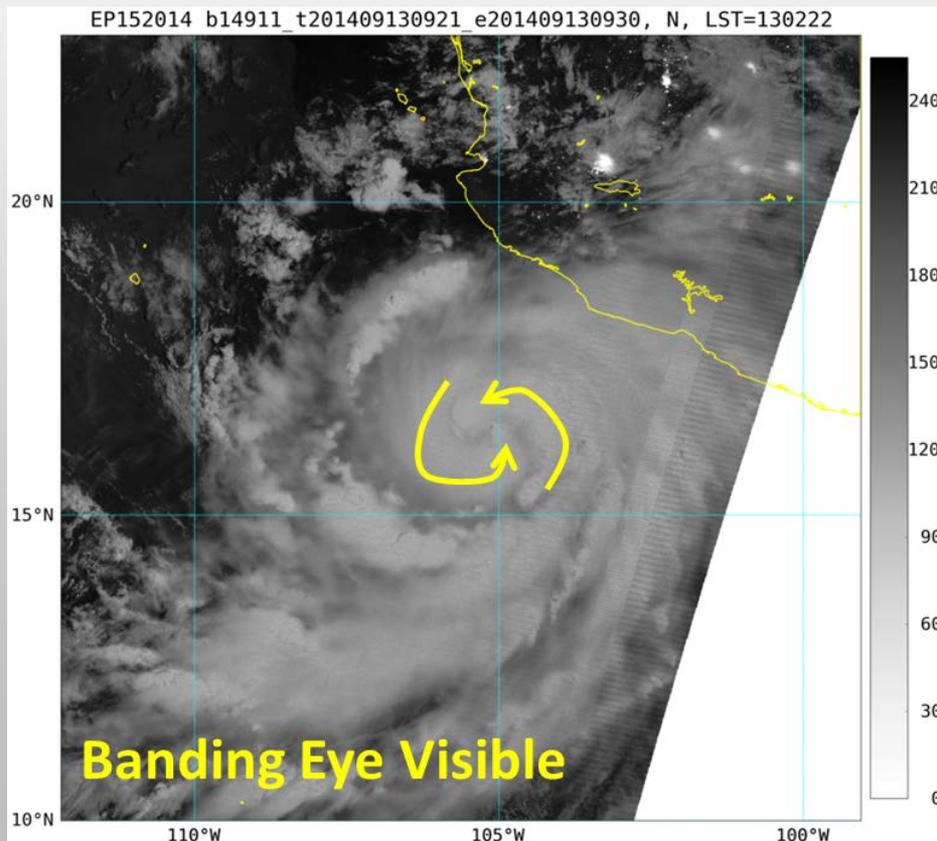
VIIRS DNB EYE-DETECTION

- Eye is clearly visible on DNB image
- Eye presence is not obvious from the IR image



VIIRS DNB EYE-DETECTION

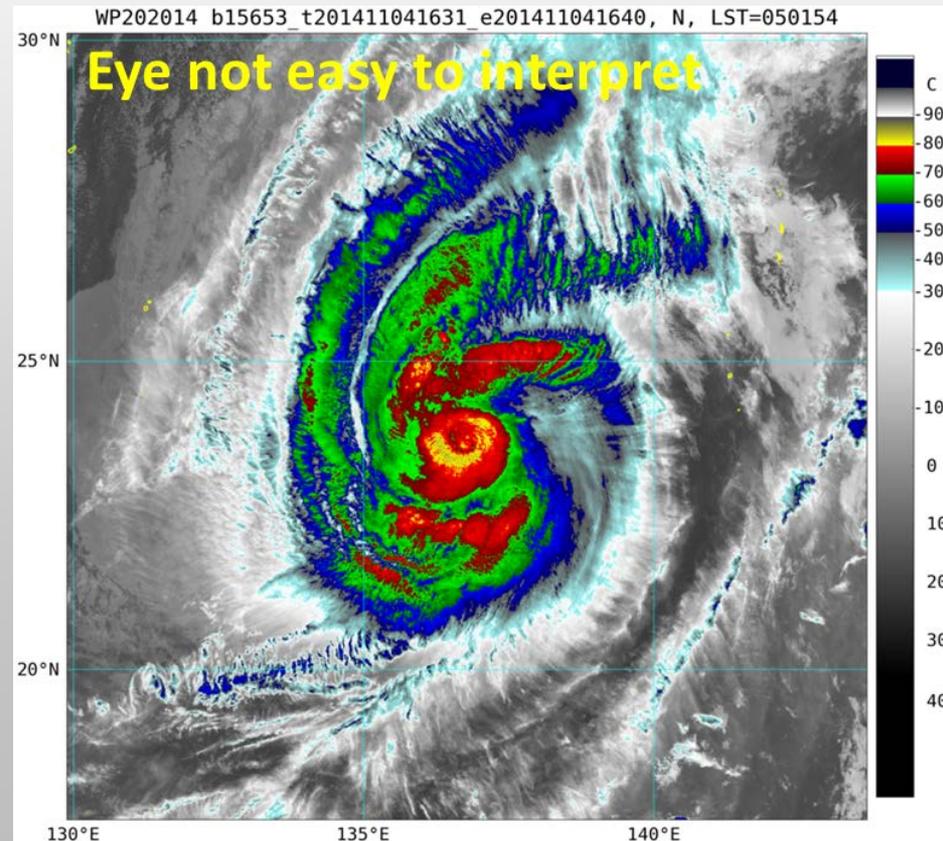
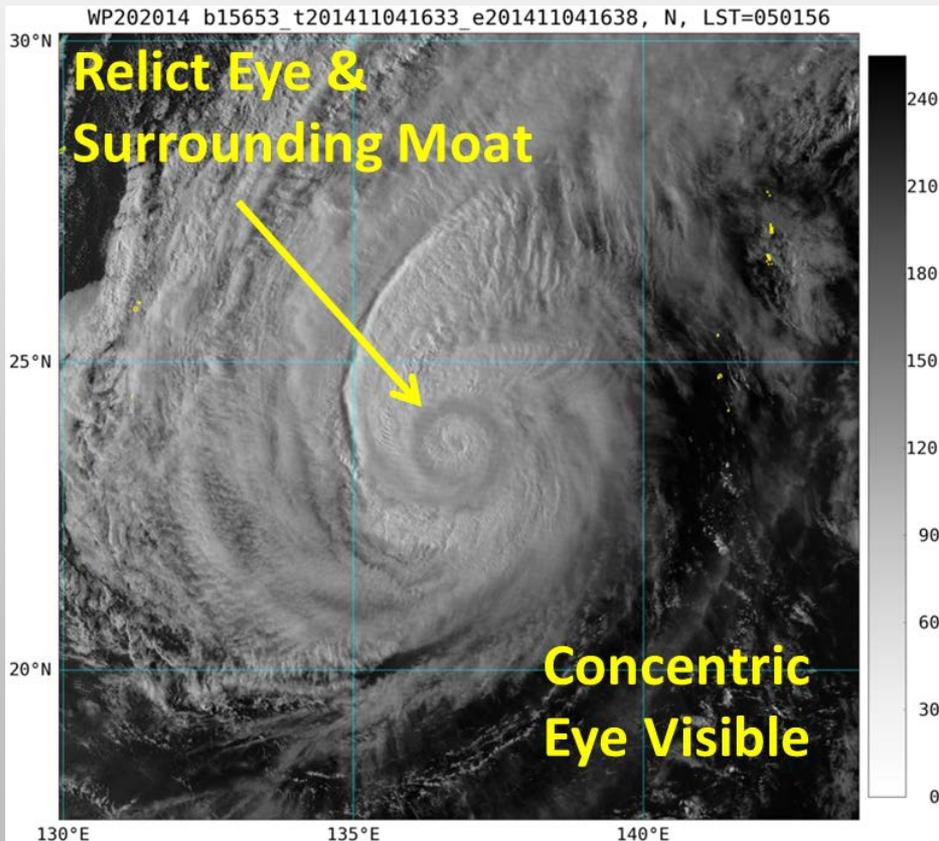
- **Banding eye** is an indication of the intensifying storm
- Banding eye apparent in the night-time DNB image
- No banding indicated in the IR image alone



ep152014 Major Hurricane ODILE

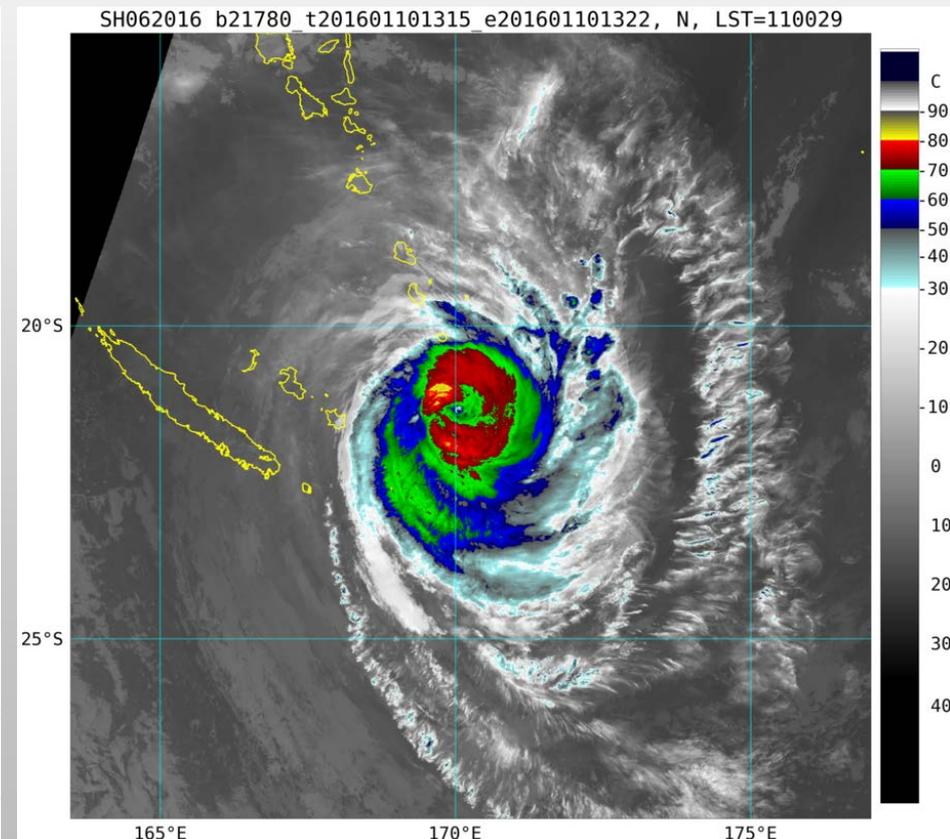
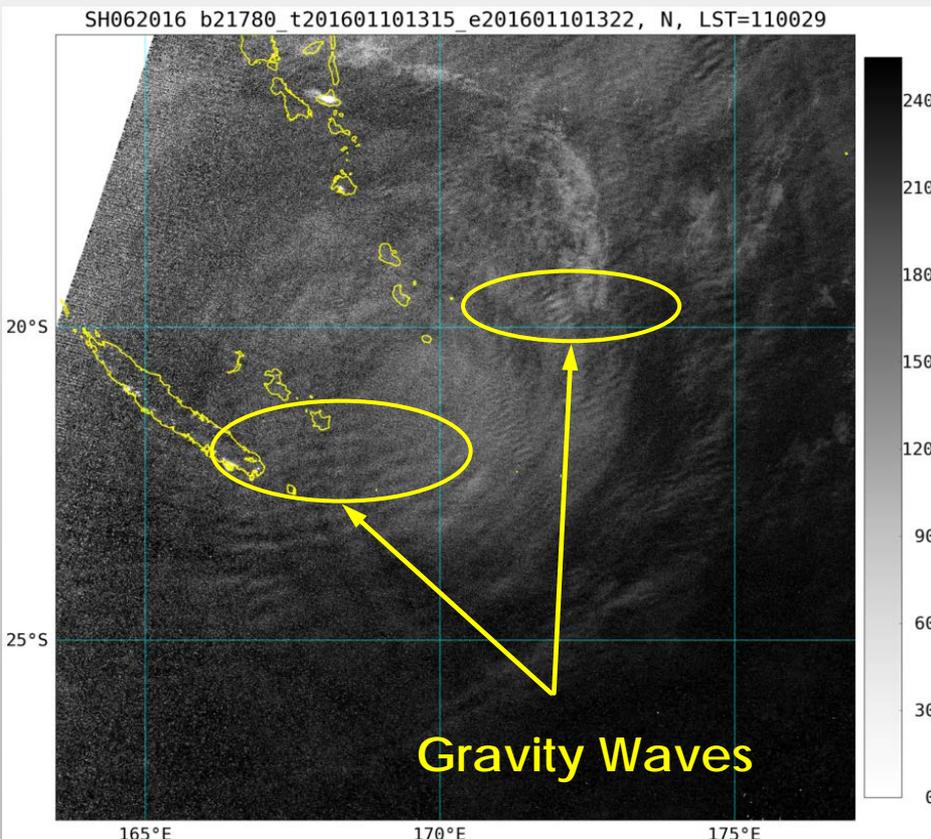
VIIRS DNB EYE-DETECTION

- **Concentric eye** is a sign of the secondary eyewall formation; it likely indicates the storm will not be intensifying in the short-term (12 hours)
- Concentric eye is evident in night-time DNB image
- The concentric nature of the eye is more difficult to infer in the IR



NIGHTGLOW WAVES

- Gravity waves observed in nightglow on DNB images (Yue et al. 2014)



CIRA TC-CENTERED NEAR REAL TIME DNB AND IR IMAGERY AT THE NATIONAL HURRICANE CENTER (NHC)

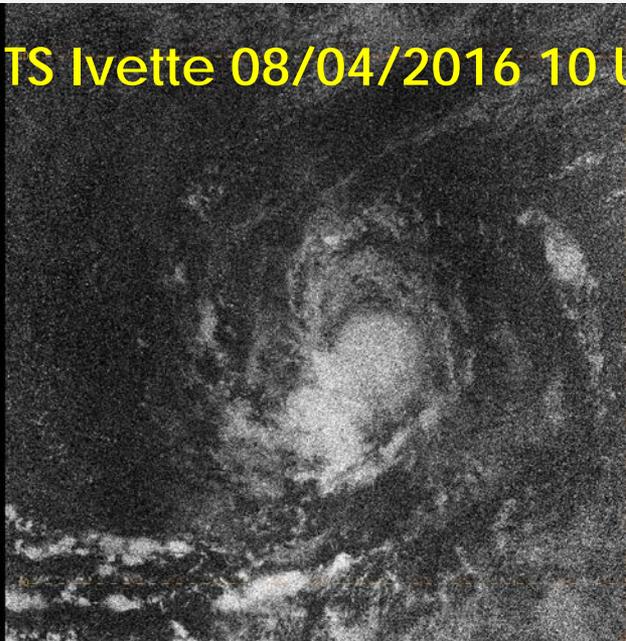
- CIRA's storm-centered VIIRS imagery has been utilized in the NHC Proving Ground since 2015 and has shown utility for TC analysis
- **In August, 2016 CIRA started providing the NAWIPS version of the storm centered imagery to NHC via LDM in near-real time**
- **Two products are being sent to NHC in near-real time:**
 - 1. DNB imagery during both day and night [1.5 hr latency]**
 - 2. VIIRS high-resolution IR windows band (I05, 11.45 μ m, 375 m resolution) [2 hr latency]**
- **Working on producing the same imagery using direct broadcast data** to reduce latency

CIRA TC-CENTERED NEAR REAL TIME DNB AND IR IMAGERY AT THE NATIONAL HURRICANE CENTER (NHC)

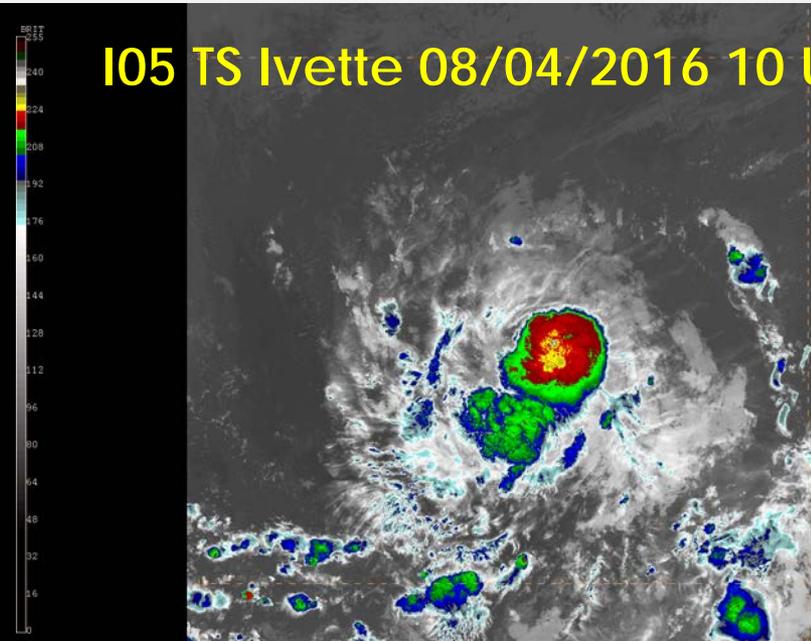
- Use **existing LDM feed** to send data
- Imagery created specifically for **display in NAWIPS**
- **DNB scaling is tuned to the storm area**
- Can **combine** together **different data sources** (2 DB sites, or DB + high-latency data) to create full storm image
- Small **data storage requirements**: NHC can keep a longer history of real time data on line and **save the data for each storm for post-season analysis** for the tropical cyclone reports
- Forecasters **can readily get information about when the data is available for each storm**. That proved to be very helpful on the 1st week of August when there were storms in both Atlantic and East Pacific

CIRA TC-CENTERED NEAR REAL TIME DNB AND I05 IMAGERY AT THE NATIONAL HURRICANE CENTER NAWIPS SYSTEM

DNB TS Ivette 08/04/2016 10 UTC



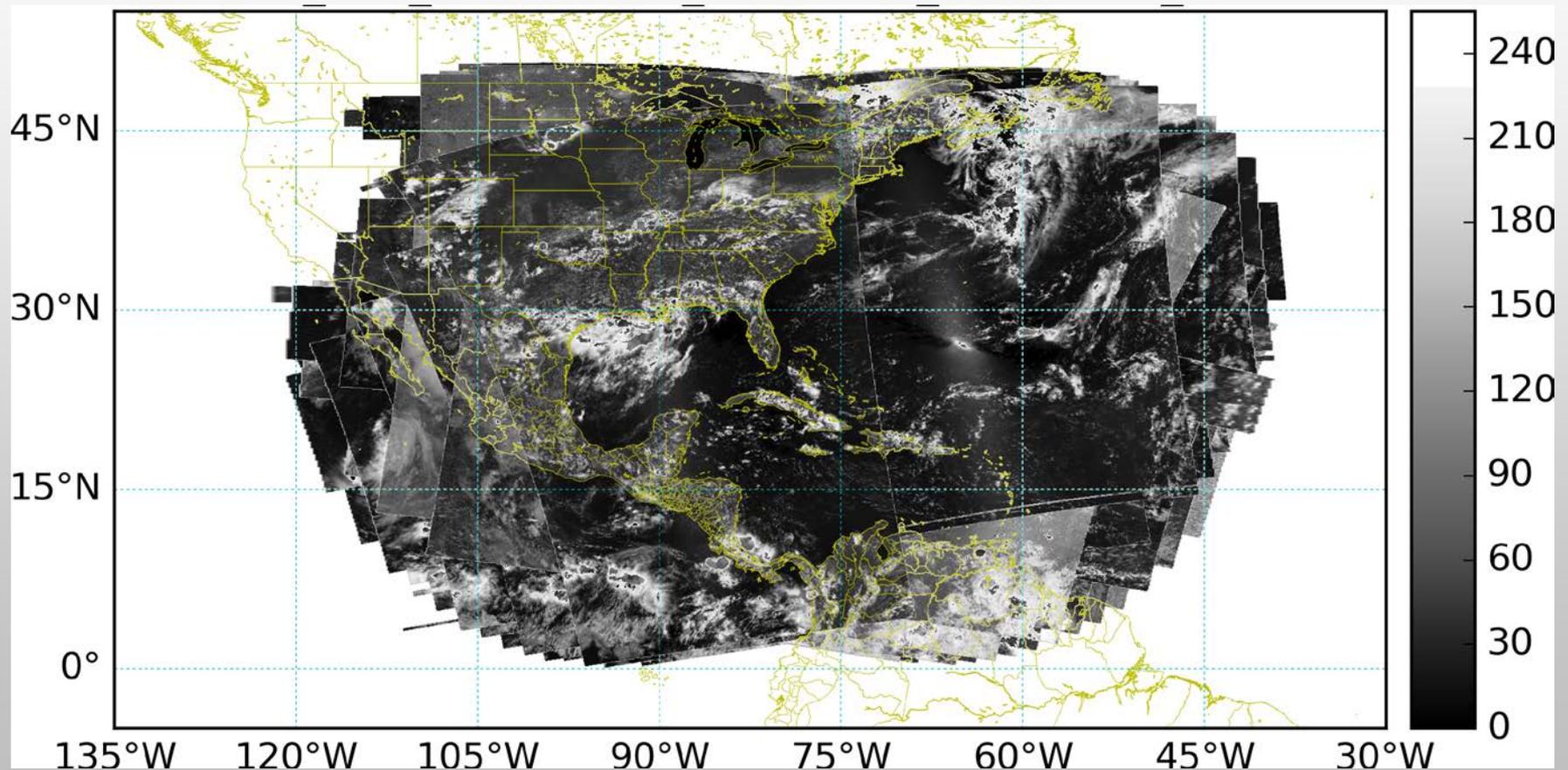
I05 TS Ivette 08/04/2016 10 UTC



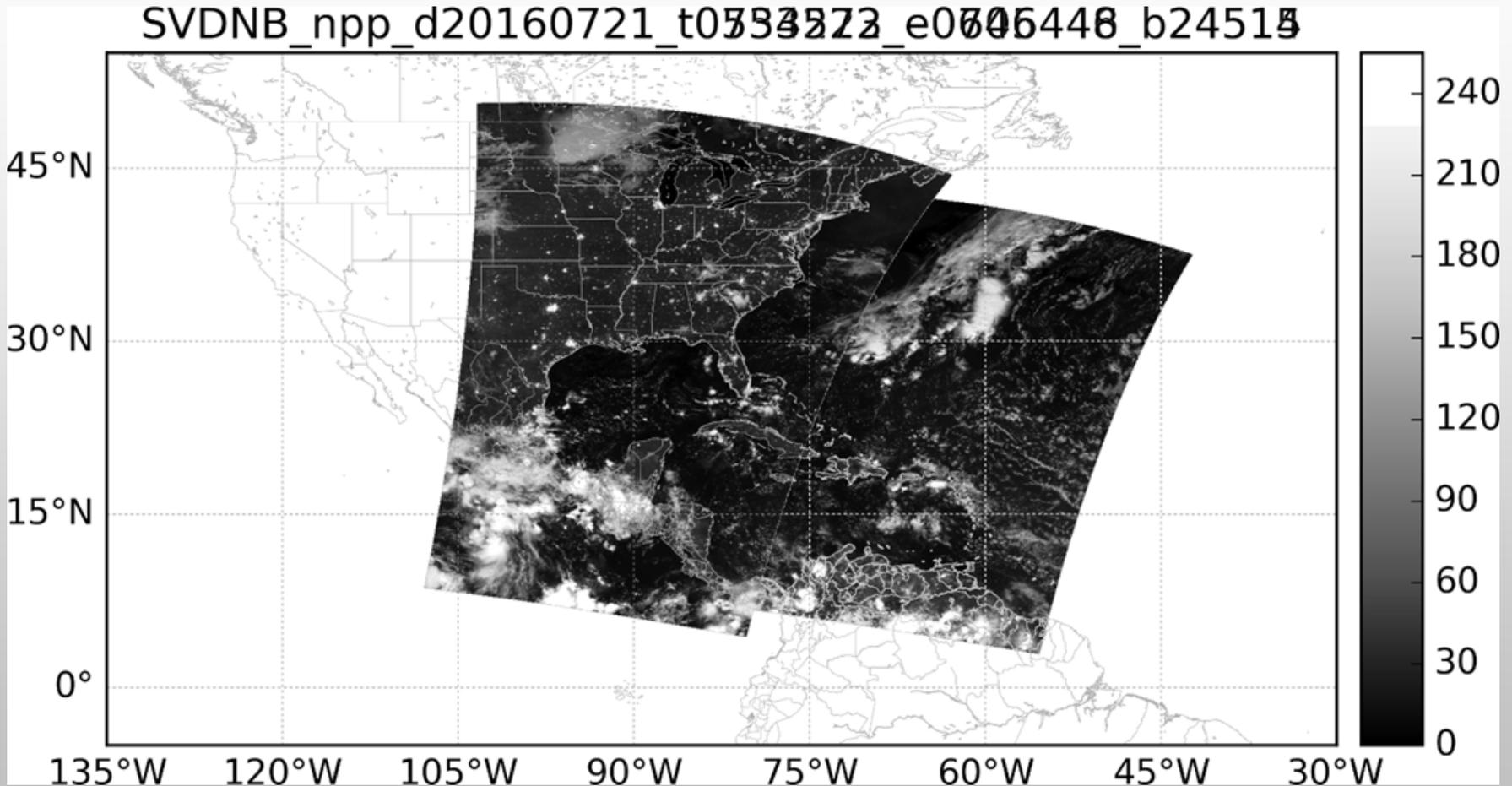
- DNB and I05 images of the tropical storm Ivette, ep102016 displayed on NAWIPS at NHC on August 4th, 2016

DELIVERING AOML DIRECT BROADCAST DATA TO NHC

- DNB data from the AOML DB ground station
- Combined coverage from July 11 to July 26, 2016



DELIVERING AOML DIRECT BROADCAST DATA TO NHC



➤ Night-time total coverage on July 21, 2016

SUMMARY

- **VIIRS DNB and high-resolution VIS and IR window channels** show a number of features that are important for TC analysis and forecasting and cannot be seen on other imagery
- The **most important** applications are :
 - **Center - fixing**
 - **Eye - detection**
- **CIRA storm - centered TC imagery** has proven useful for NHC and is currently **delivered to NHC via LDM** in NAWIPS-ready format
- **CIRA is working on providing the same imagery to NHC from direct broadcast sites** to reduce latency

CIRA AND VISIT RESOURCES FOR VIIRS IMAGERY

VISIT:

- VIIRS SATELLITE IMAGERY IN AWIPS.
[HTTP://RAMMB.CIRA.COLOSTATE.EDU/TRAINING/VISIT/TRAINING_SESSIONS/VIIRS_SATELLITE_IMAGERY_IN_AWIPS/](http://rammb.cira.colostate.edu/training/visit/training_sessions/viirs_satellite_imagery_in_awips/)
- VIIRS IMAGERY INTERPRETATION OF SUPER TYPHOON VONGFONG
[HTTP://RAMMB.CIRA.COLOSTATE.EDU/TRAINING/VISIT/TRAINING_SESSIONS/VIIRS_IMAGERY_INTERPRETATION_OF_SUPER_TYPHOON_VONGFONG](http://rammb.cira.colostate.edu/training/visit/training_sessions/viirs_imagery_interpretation_of_super_typhoon_vongfong)
- USE OF VIIRS IMAGERY FOR TROPICAL CYCLONE FORECASTING
[HTTP://RAMMB.CIRA.COLOSTATE.EDU/TRAINING/VISIT/TRAINING_SESSIONS/USE_OF_VIIRS_IMAGERY_FOR_TROPICAL_CYCLONE_FORECASTING/](http://rammb.cira.colostate.edu/training/visit/training_sessions/use_of_viirs_imagery_for_tropical_cyclone_forecasting/)

CIRA:

- SUOMI NPP (NATIONAL POLAR-ORBITING PARTNERSHIP) VIIRS IMAGERY AND VISUALIZATION TEAM
[HTTP://RAMMB.CIRA.COLOSTATE.EDU/PROJECTS/NPP](http://rammb.cira.colostate.edu/projects/npp)