Exploiting SNPP VIIRS Day Night Band (DNB) for Tropical Cyclone Monitoring

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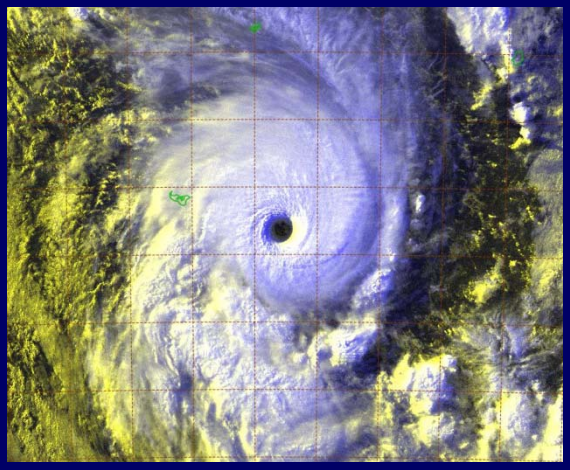

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Suomi NPP VIIRS

Spacecraft: **Suomi National Polar-orbiting Partnership (NPP)**

Sensor: **Visible Infrared Imager Radiometer Suite (VIIRS)**

Launch Date: **October 28, 2011**

Heritage: **AVHRR, OLS, MODIS**

Channels: **22 including day/night band (DNB)**

Swath Width: **~3000 km**

Application Enhancements:

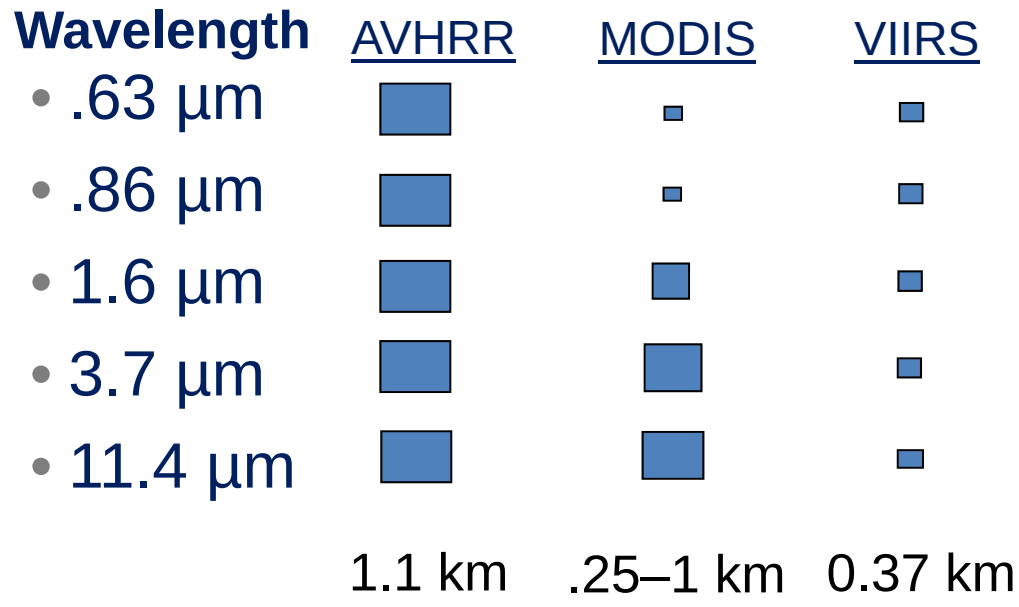
a) **22 channels**

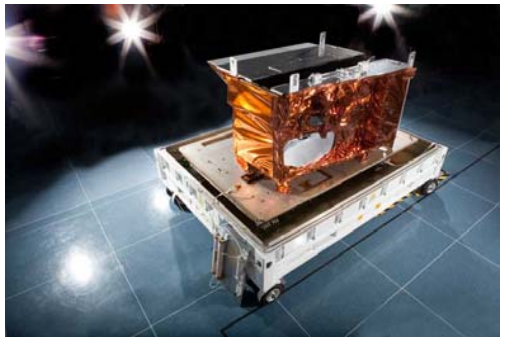
b) **14-bit digitization**

c) **Wider swath**

d) **DNB – night time visible (740 m)**

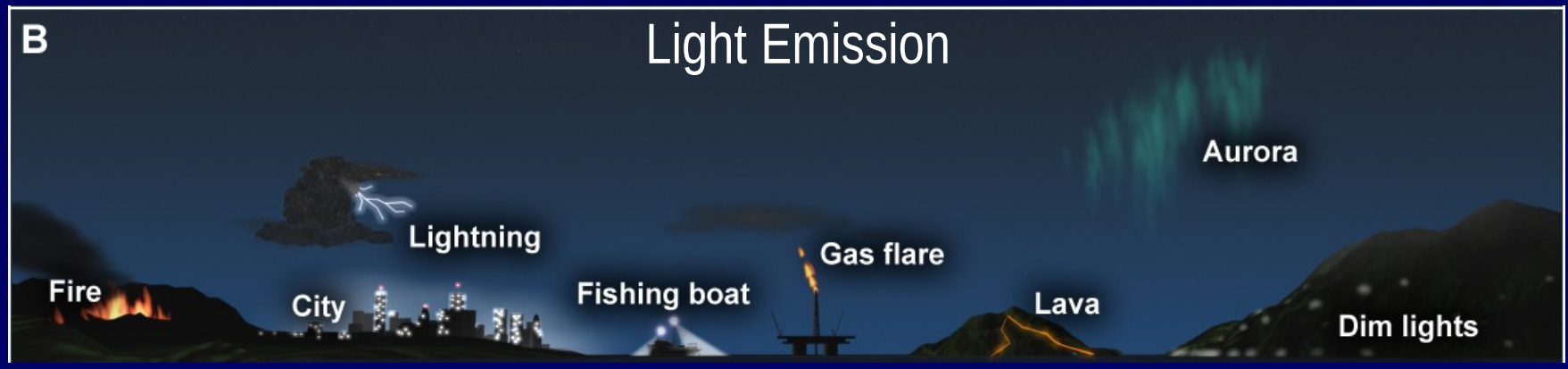
e) **Retain resolution to scan edge**

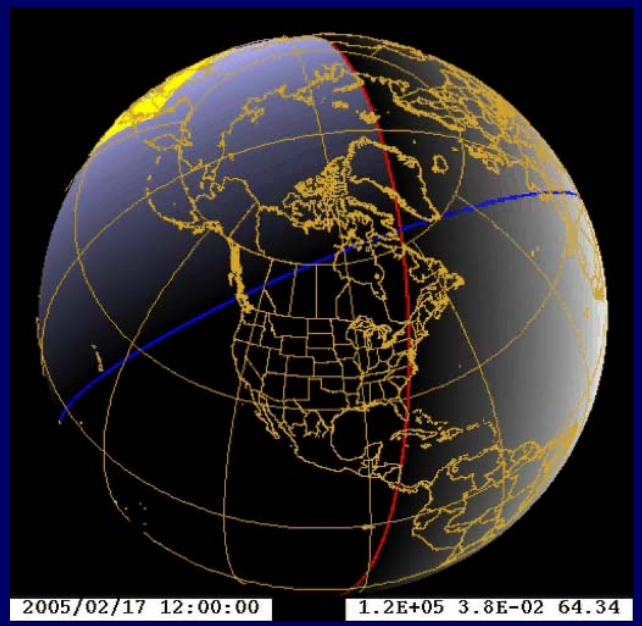




Courtesy of Raytheon Space and Airborne Systems

Night Time Low Light Imaging





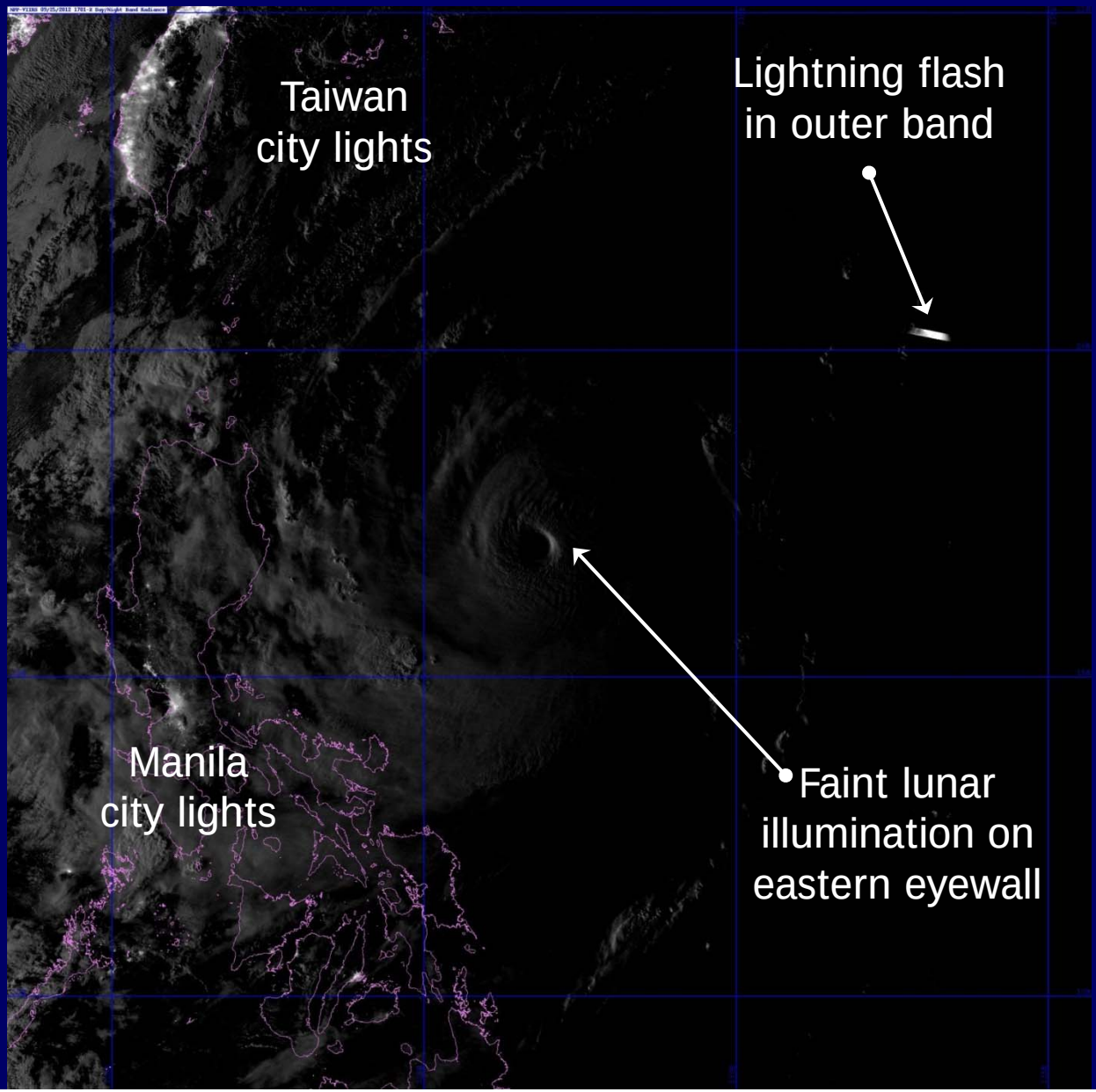
Gray / Blue shading = Solar / Lunar illumination
Red / Blue lines = Solar / Lunar terminators

- **~40% of nighttime data offer lunar coverage > ¼ moon (annual average; 0930 orbit).**
- **Current low-light system: DMSP/OLS photomultiplier tube enables detection of light levels ~5 orders of magnitude lower than conventional VIS sensors.**
- **SNPP/VIIRS Day Night Band (DNB) has major advances to nighttime imagery capability (resolution, calibration, digitization.)**

DNB night time radiance imagery

Typhoon Jelawat, 9-25-12 17Z shown here… →

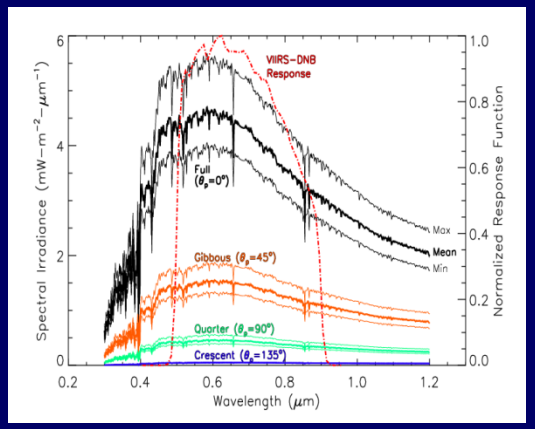
Moon is setting in the west during this DNB nighttime overpass.



VIIRS DNB Quantitative Lunar Applications

- A lunar irradiance prediction model to allow conversion from DNB radiance to reflectance units

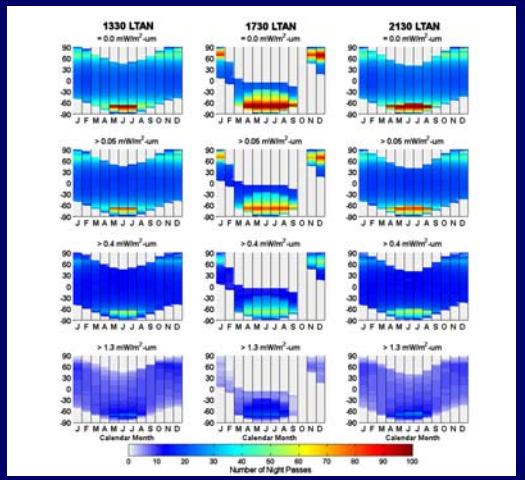
$$R = \pi I^{\uparrow} / [\cos(\theta_m)\mathbf{E_m}]$$



- Enables quantitative applications from measurements of reflected moonlight

Miller and Turner, 2009. *IEEE Trans. Geosci. Rem. Sens.*, **47**(7), 2316-2329.

A lunar availability assessment for the VIIRS/DNB to determine when and where nighttime lunar applications are possible for NPP and other polar orbits.



- ~45% all nights at mid-latitudes offer sufficient levels of moonlight

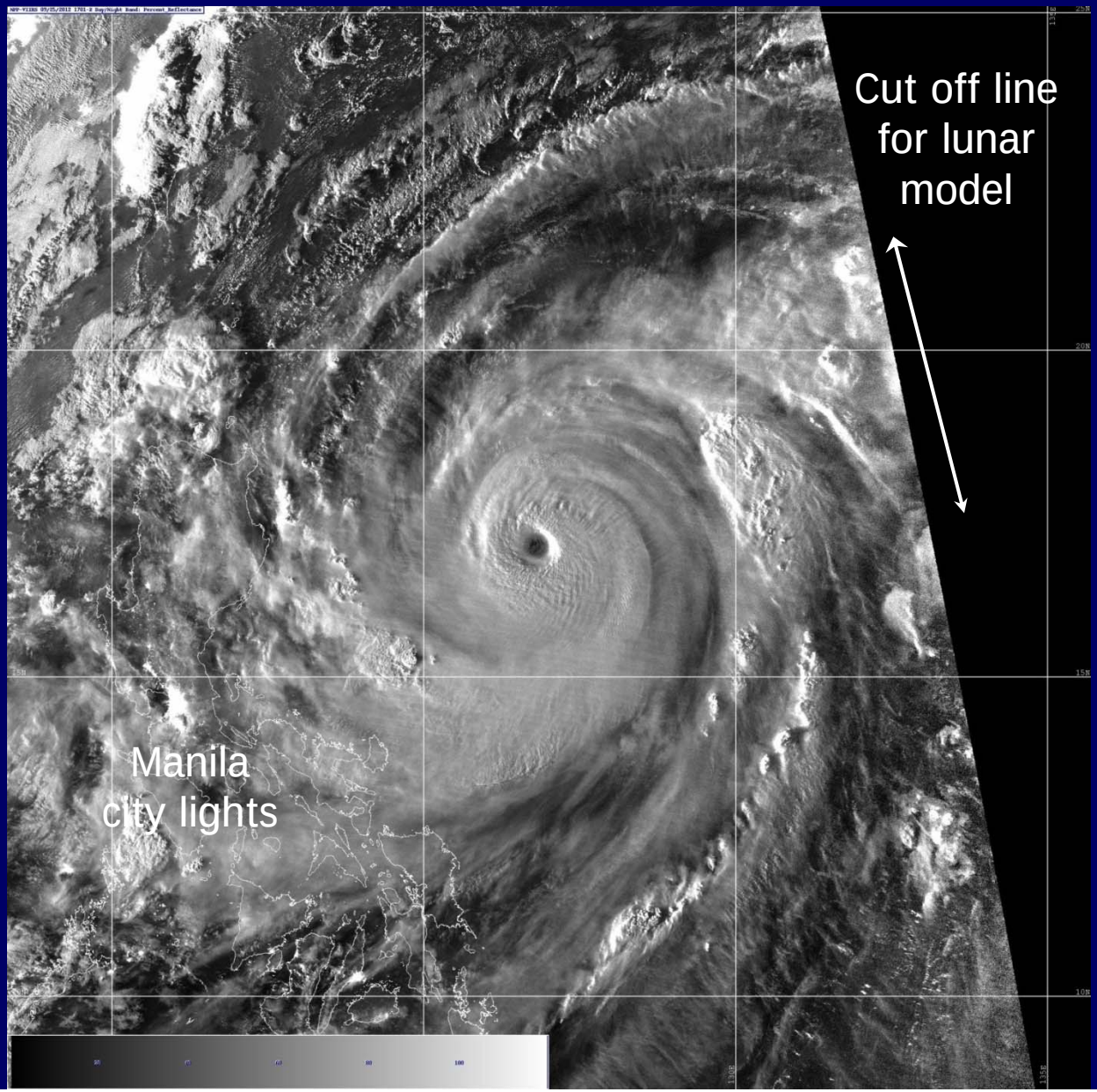
Miller et al.. 2012. *J. Atmos. Ocean. Tech., 29, 538-557.*

Lunar Reflectance Impact

Lunar model is used to produce a form of near constant contrast (NCC) imagery.

Not applicable to the day/night terminator where solar signal is present.

Moon phase: 80%

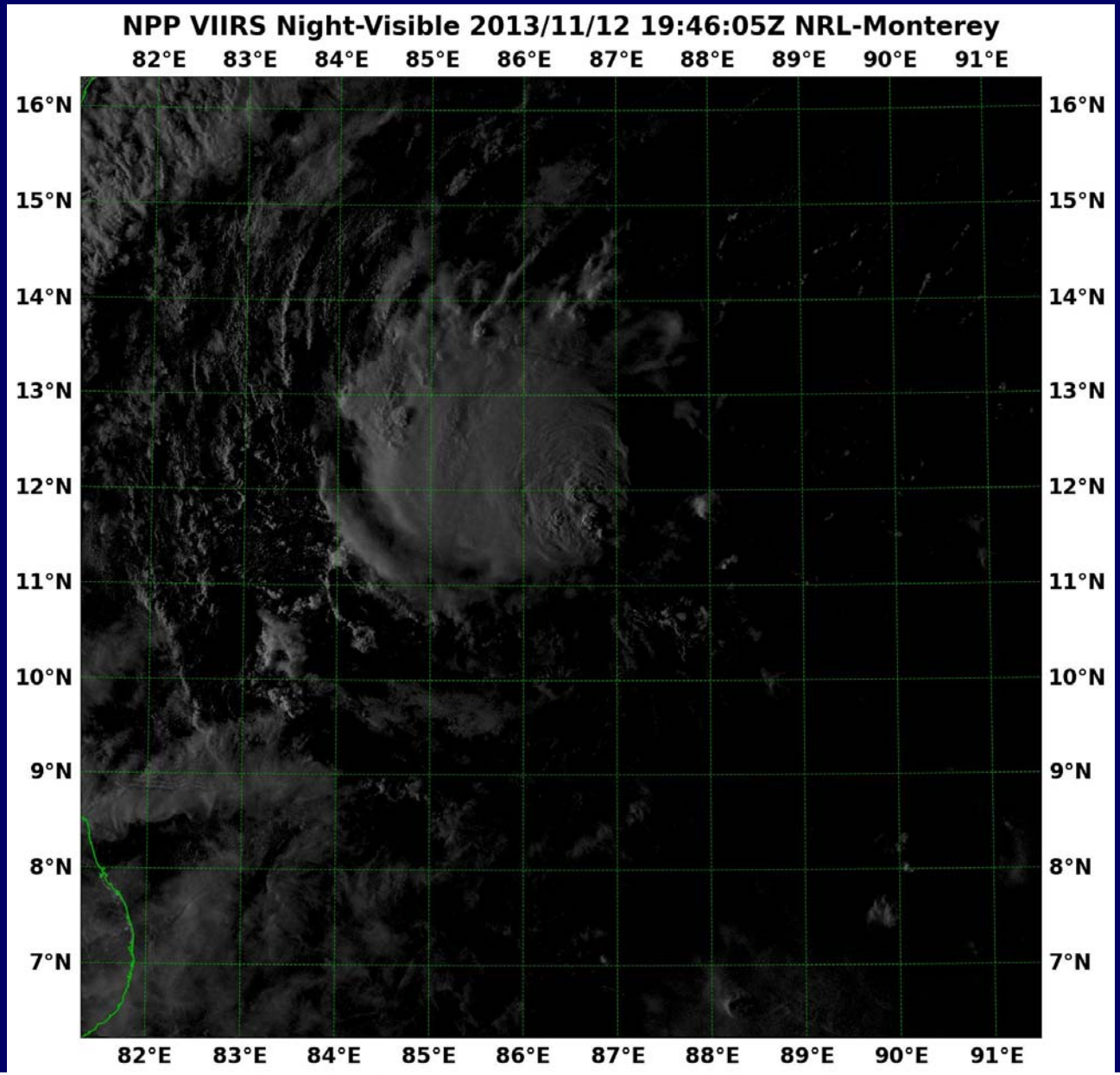


DNB night time radiance imagery

Tropical Depression 30W, 11-12-13 19Z shown here… →

DNB radiance image, overshooting tops near “apparent center”, but can’t view cloud field reliably on eastern ½ due to lack of illumination

Moon phase: 81%, but moon setting to the west



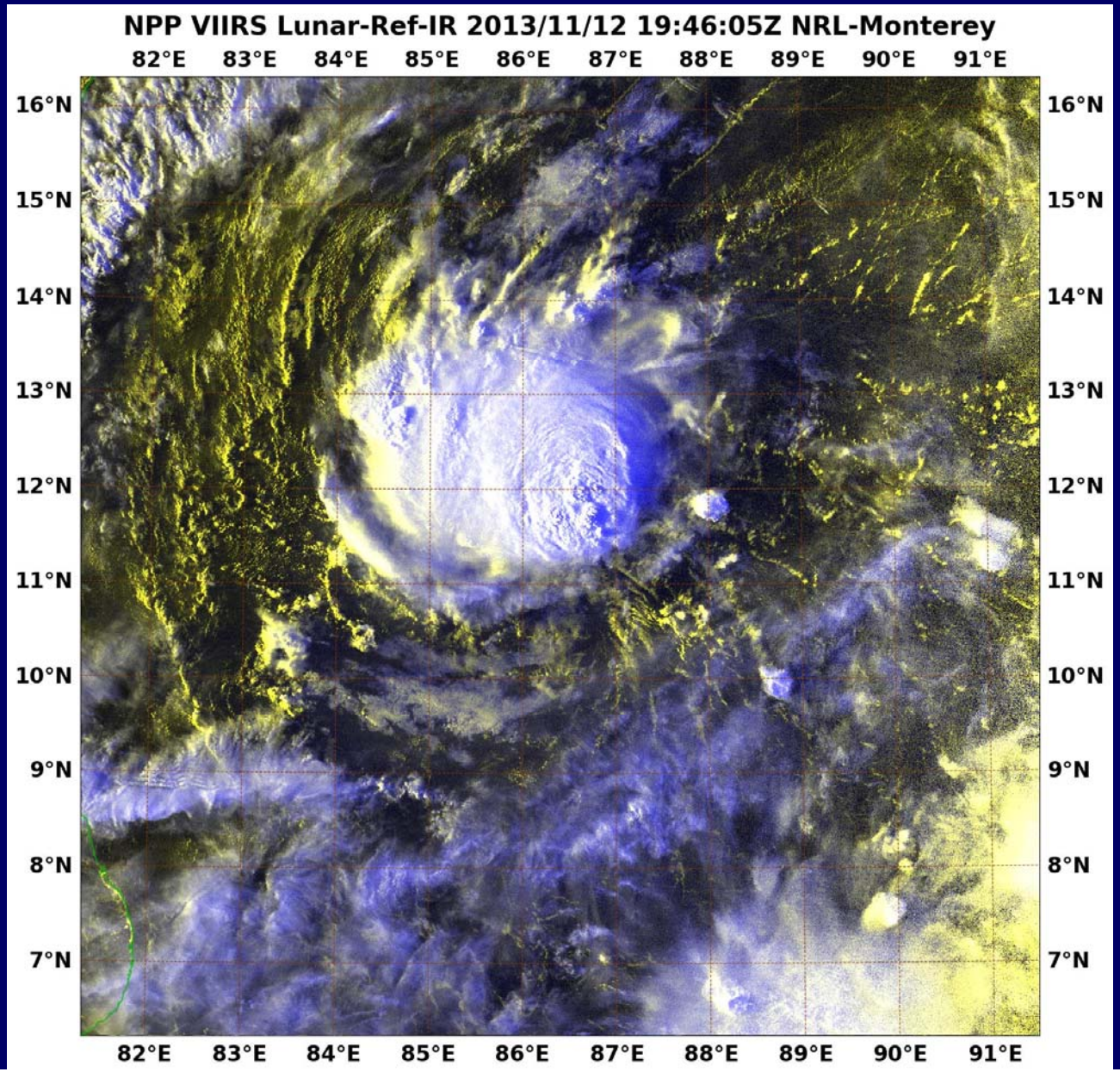
DNB night time radiance imagery

Tropical Depression 30W, 11-12-13 19Z shown here… →

DNB “reflectance”, using the NRL-MRY lunar model to convert the radiances + IR

Low clouds – yellow
High clouds – white/cyan

Analyst now able to better comprehend the 3-D cloud structure



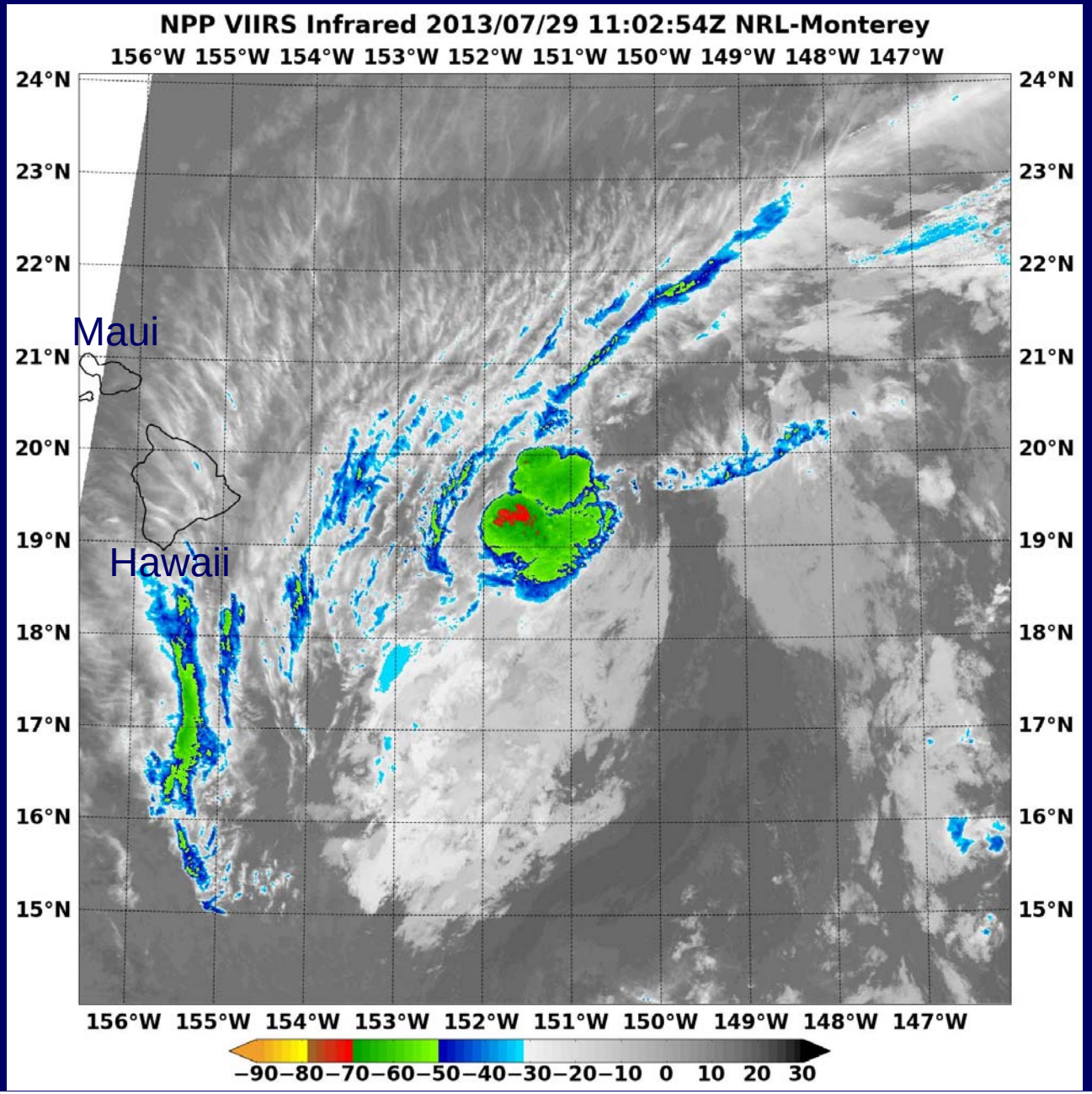
DNB Night time TC monitoring

Tropical Storm Flossie

7-29-2013 1102Z

Longwave IR

Storm “heading” towards Big Island (Hawaii) landfall with future track WNW

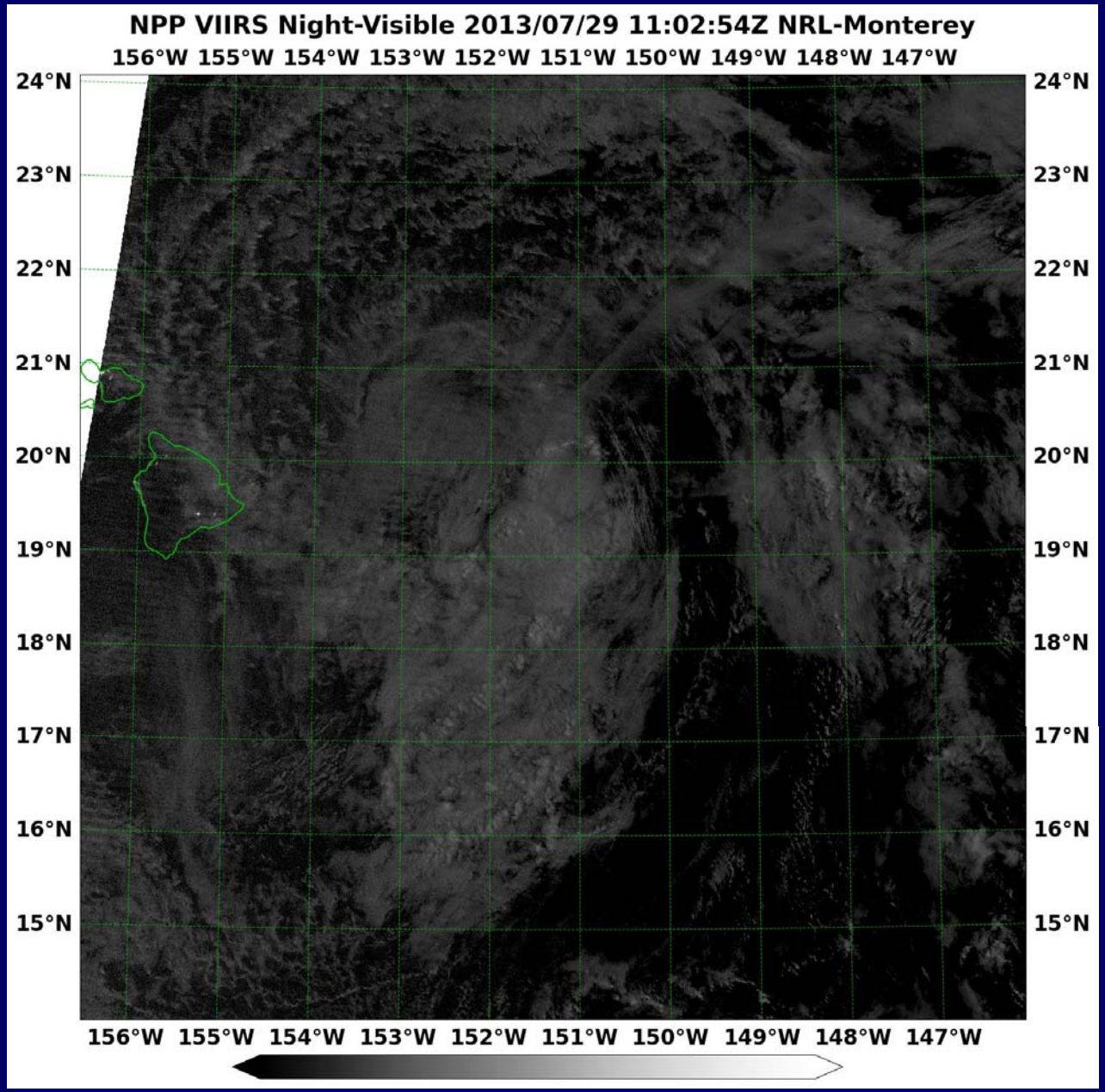


DNB Night time TC monitoring

VIIRS DNB radiance image coincident with previous IR

Can see through thin cirrus to low level clouds below

740 m spatial resolution across the entire 3000 km swath (note edge of swath over Maui)



DNB Night time TC monitoring

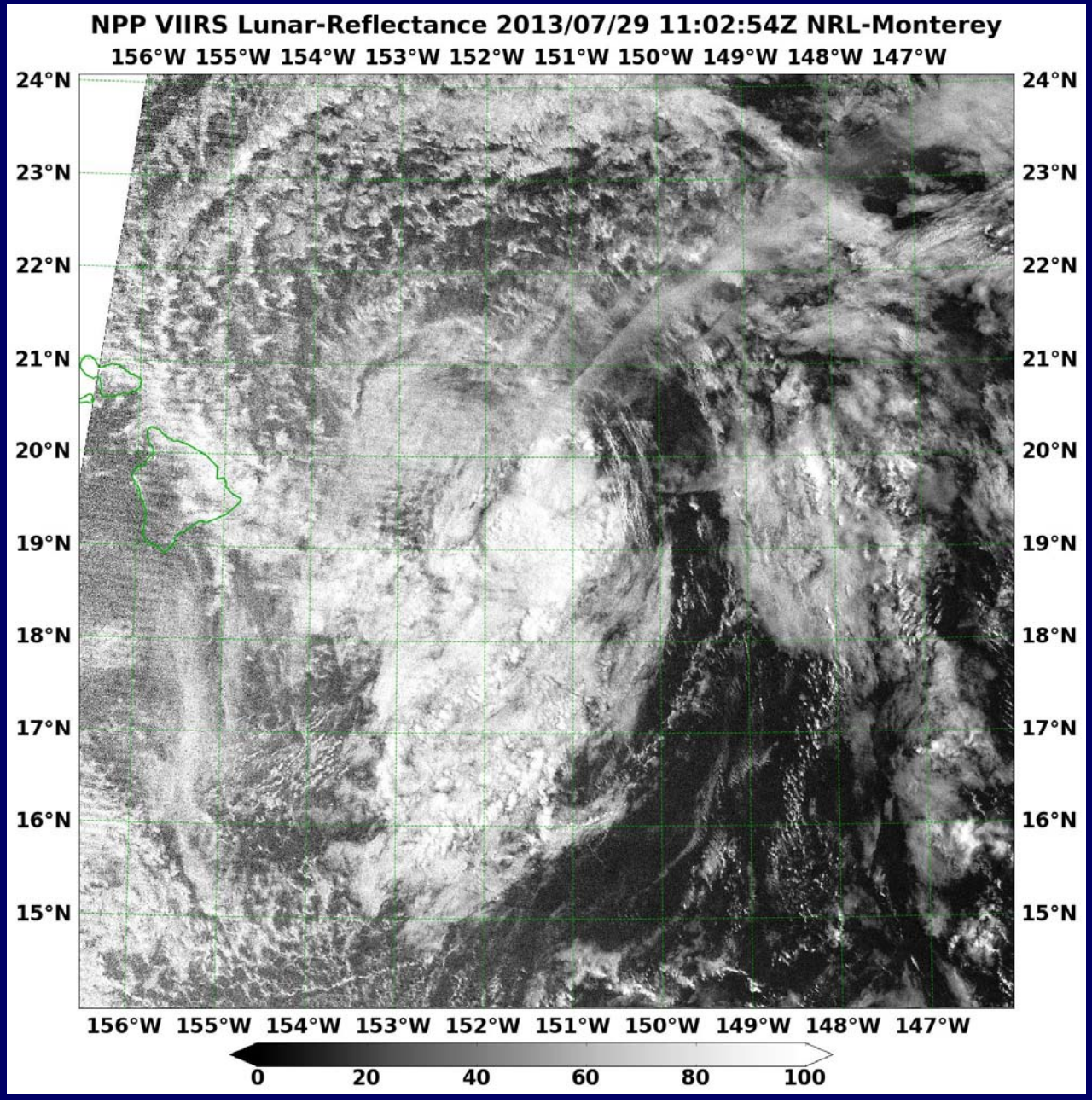
VIIRS DNB reflectance image after correction via the NRL-MRY lunar model:

Takes into account:

a) Lunar phase

b) Moon-satellite-storm viewing geometry

Only done when sufficient lunar illumination available

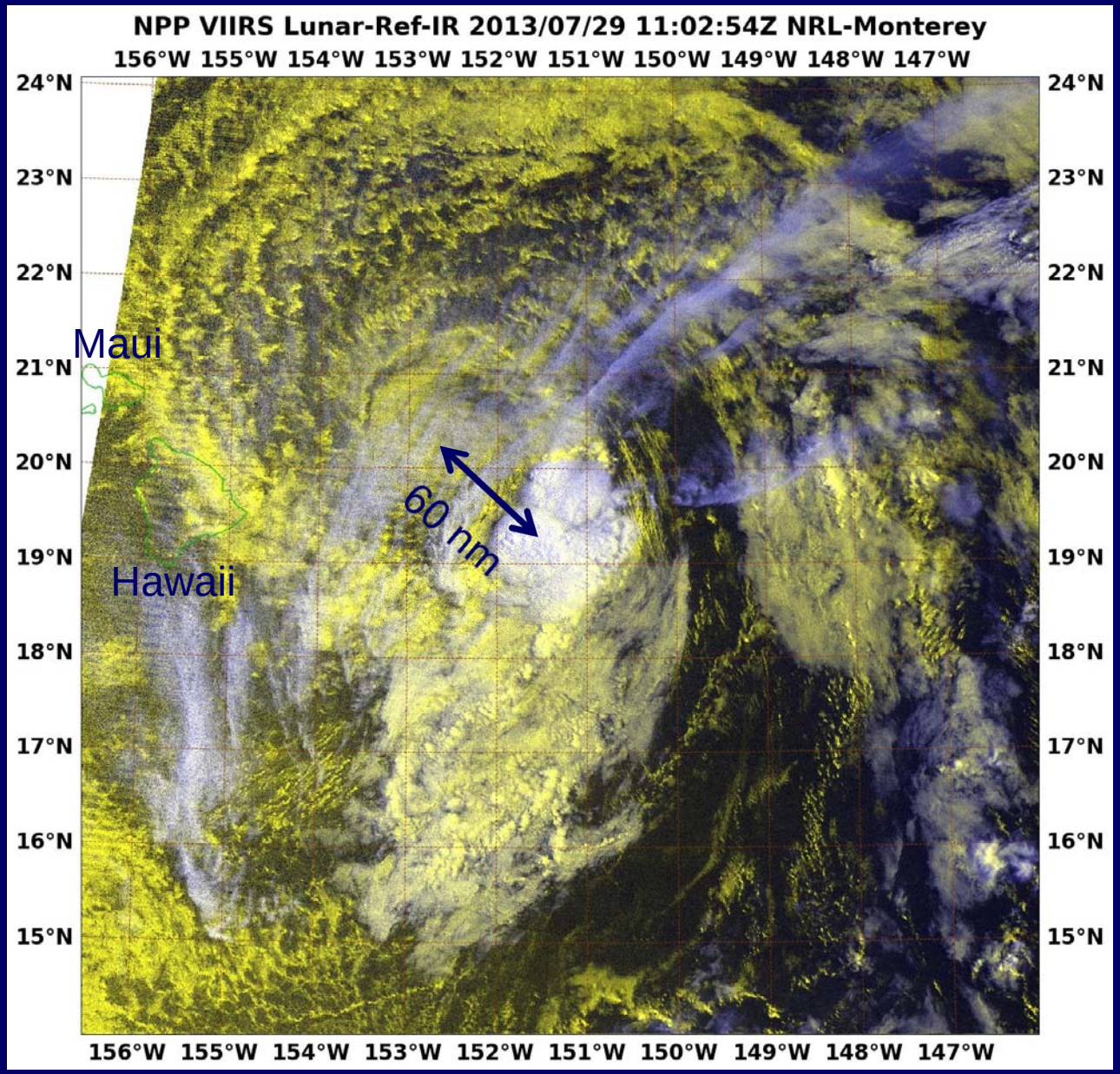


DNB Night time TC monitoring

VIIRS DNB reflectance + IR reveals LLCC displaced ~60 nm from IR mid-level convection center, low clouds – yellow, high clouds white/cyan.

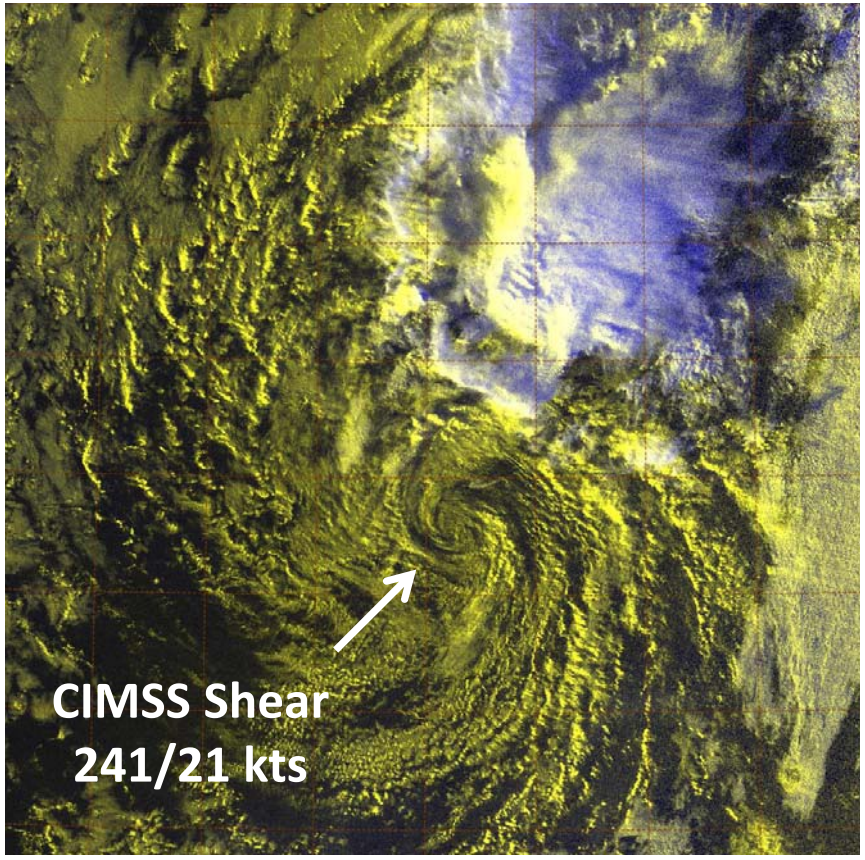
CPHC Warning :

- Relocated TS Flossie center fix well north
- Landfall no longer on island of Hawaii
- Revised track now impacts area along northern coasts

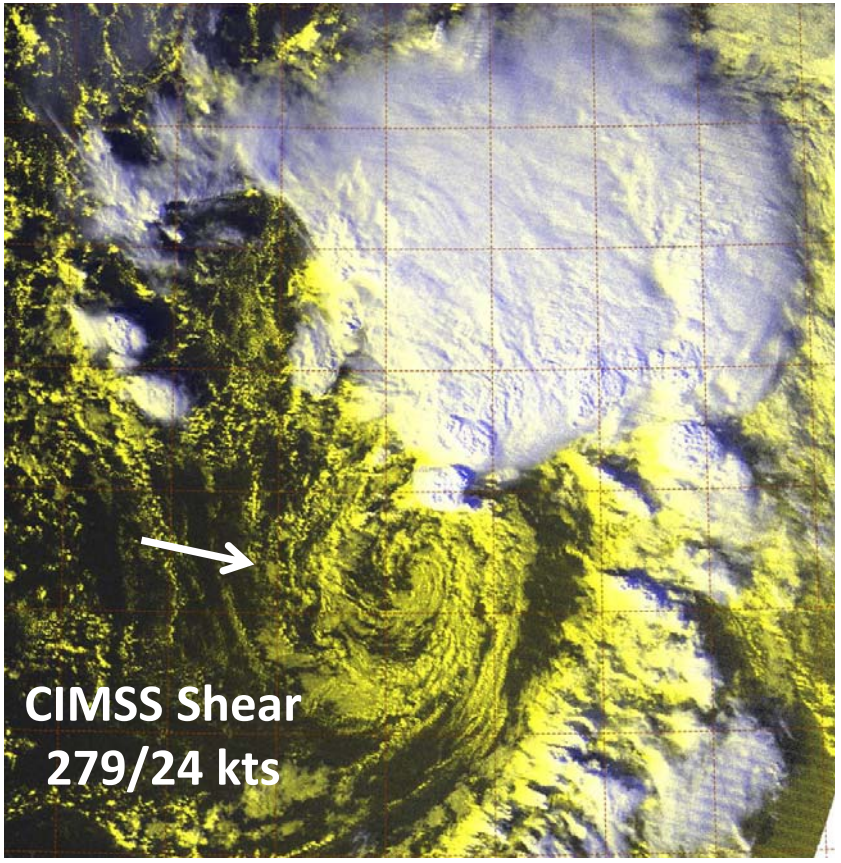


Shear & Low-Level Circulation Centers

05L Erin 08-18-13



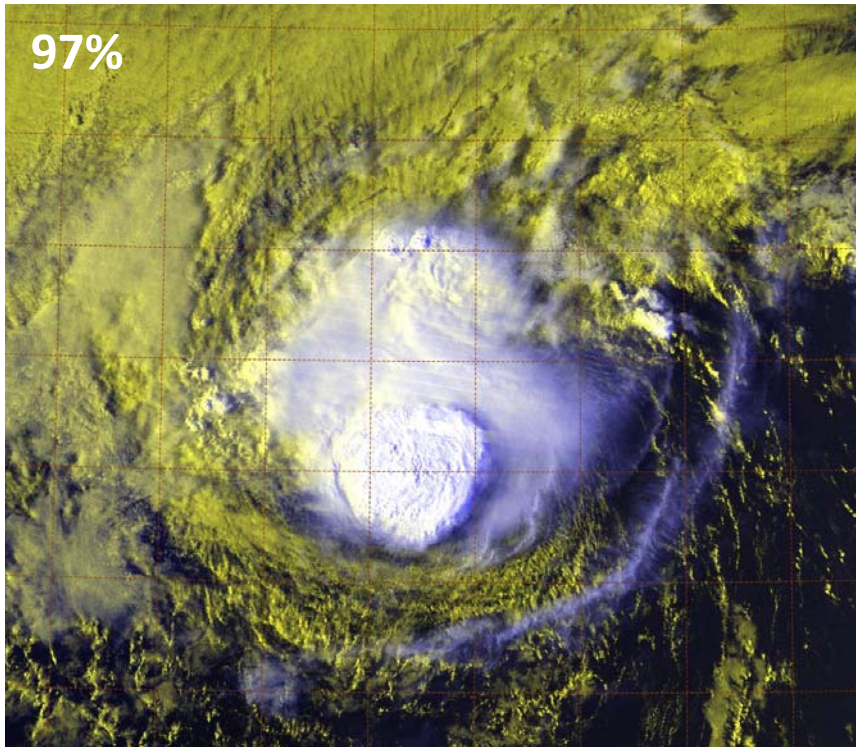
09L Humberto 09-17-13



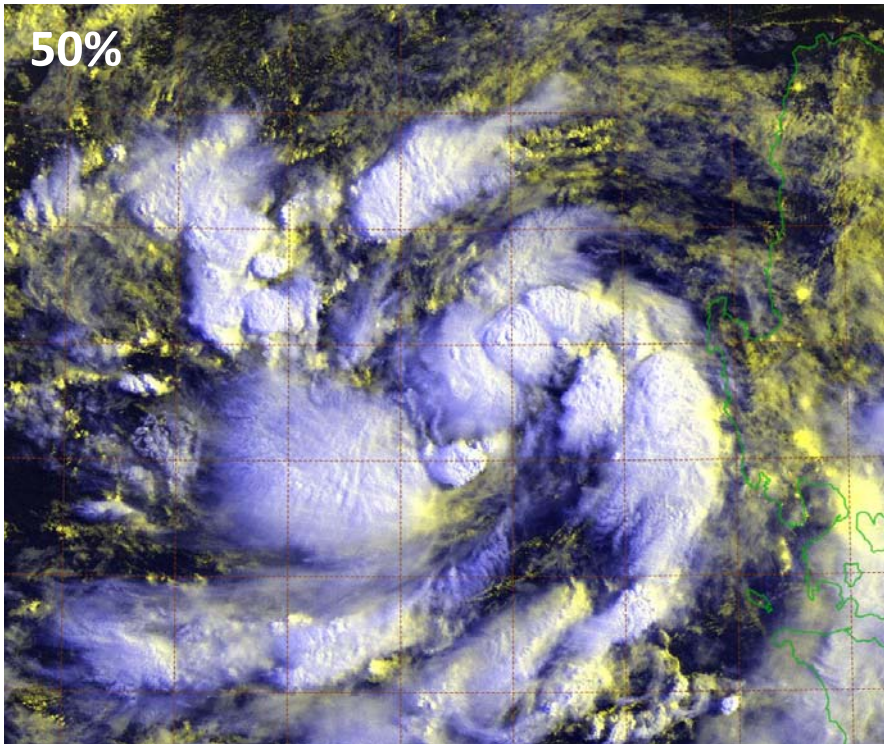
VIIRS DNB reflectance + IR excellent tool for detecting low-level circulation centers (LLCC) due to shear

Hot Towers & Overshooting Tops

16E Priscilla 10-16-13



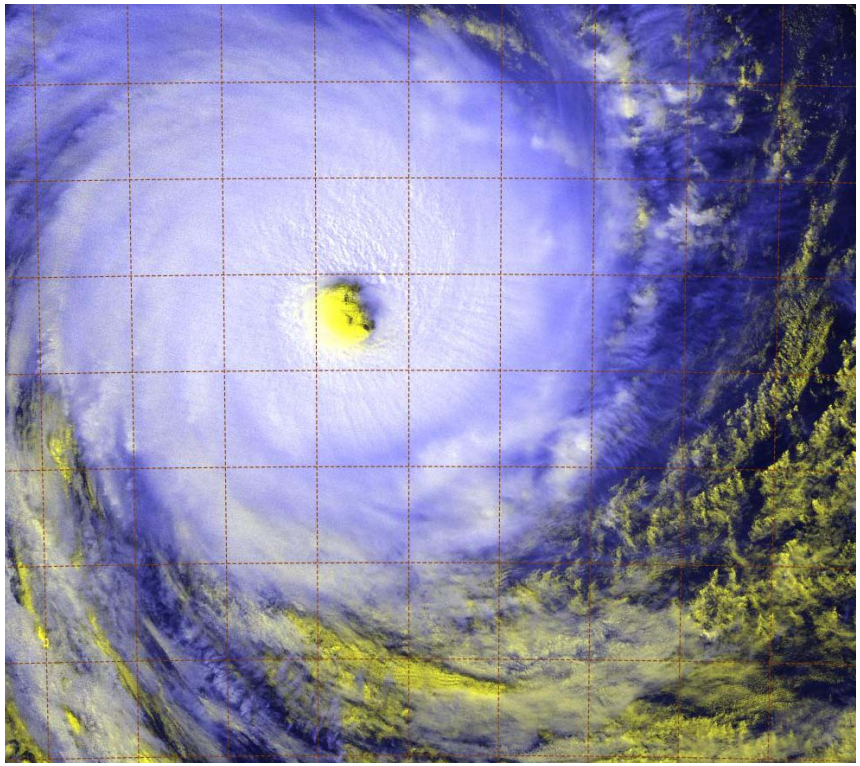
20W Twenty 09-26-13



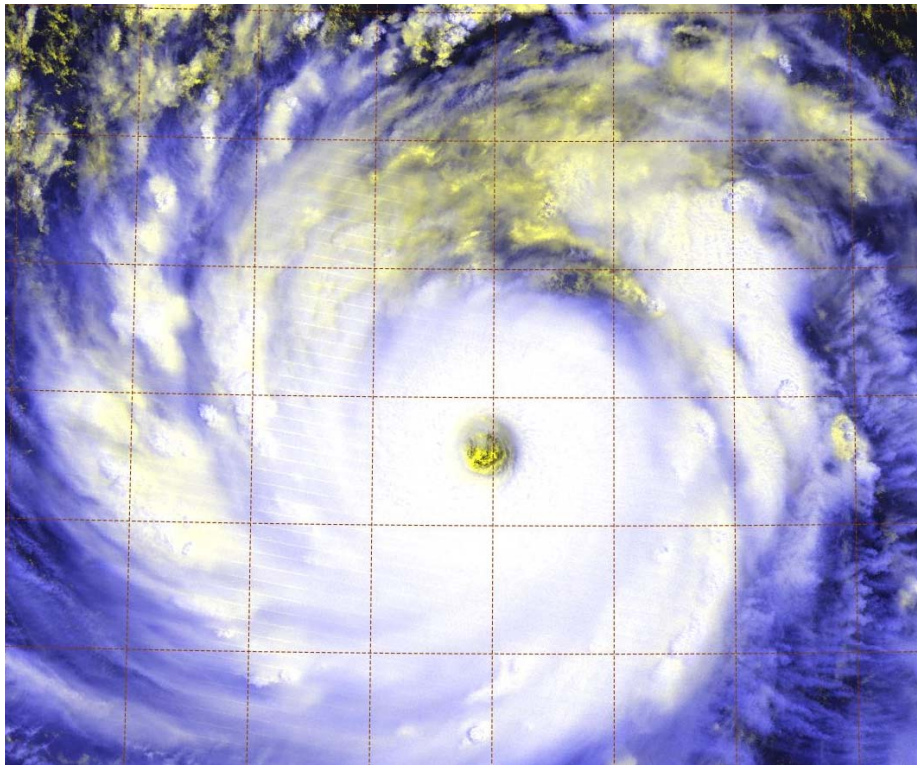
VIIRS DNB reflectance products can isolate convective bursts (hot towers) associated with intensity changes

Tropical Cyclone Eyes

04S Bruce 12-21-13



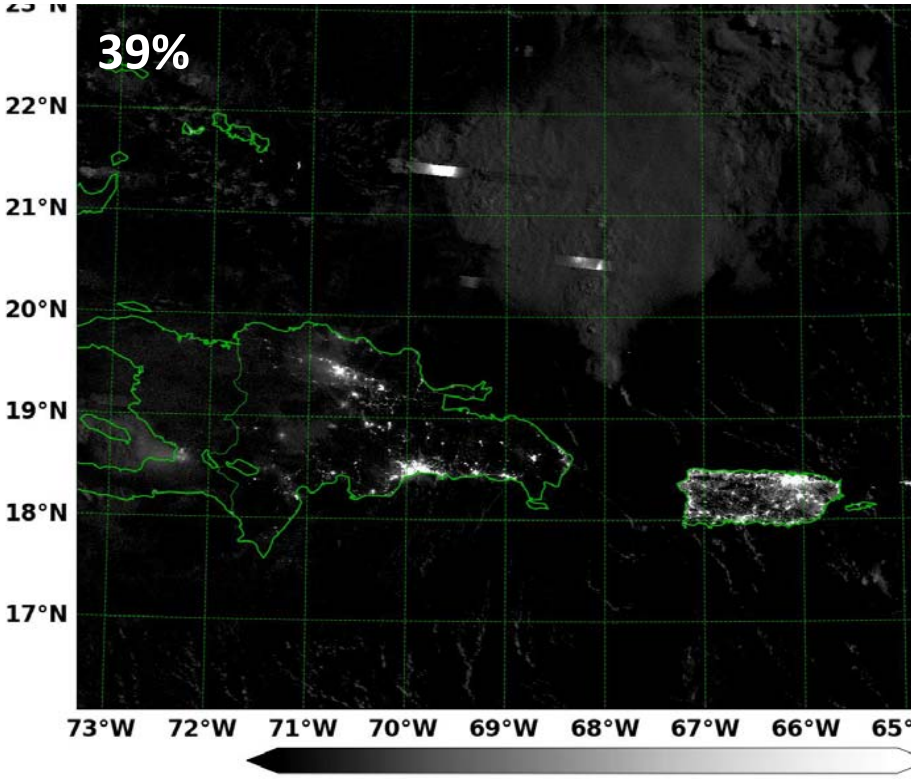
28W Lekima 10-23-13



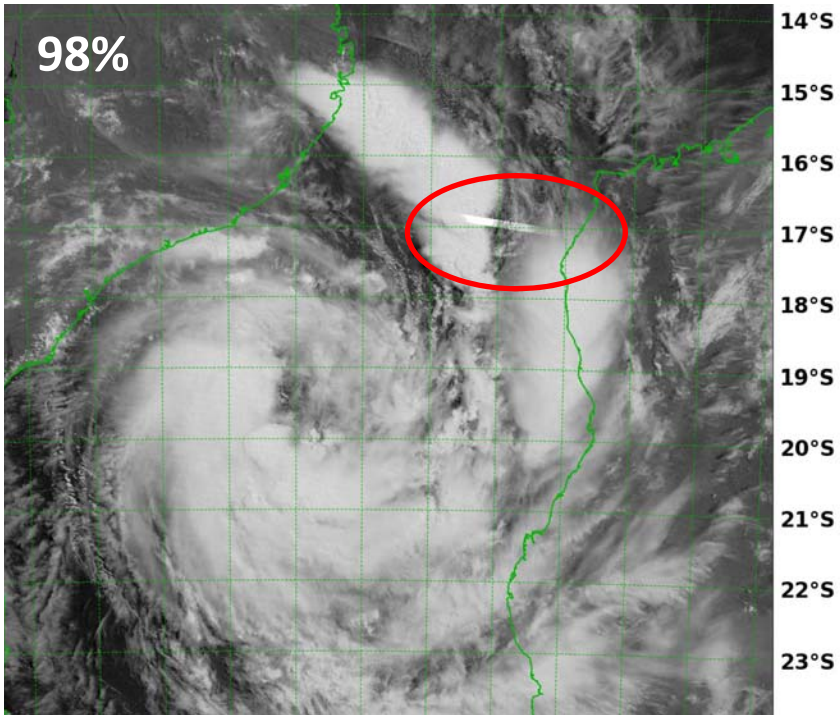
DNB night time visible can assist IR in determining eye structure, eye size, and tilt

Lightning

91L Invest 07-30-13



09L Humberto 09-17-13



VIIRS DNB lightning detection captures a small % of total flashes due to scene scanning realities

Nighttime TC Monitoring Via DNB

Summary

- VIIRS DNB has “unique” TC monitoring features
- DNB fills a visible data void at night
- Excellent tool for viewing low-level circulation centers LLCC (sheared and genesis systems)
- Assists in detecting TC 3-D cloud structure
- Highlights overshooting tops (hot towers)
- Helps view TC “clear or open” eyes with IR data
- Identifies isolated lightning flashes
- Will add ~ 10 months of DNB data to NRL TC page shortly

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