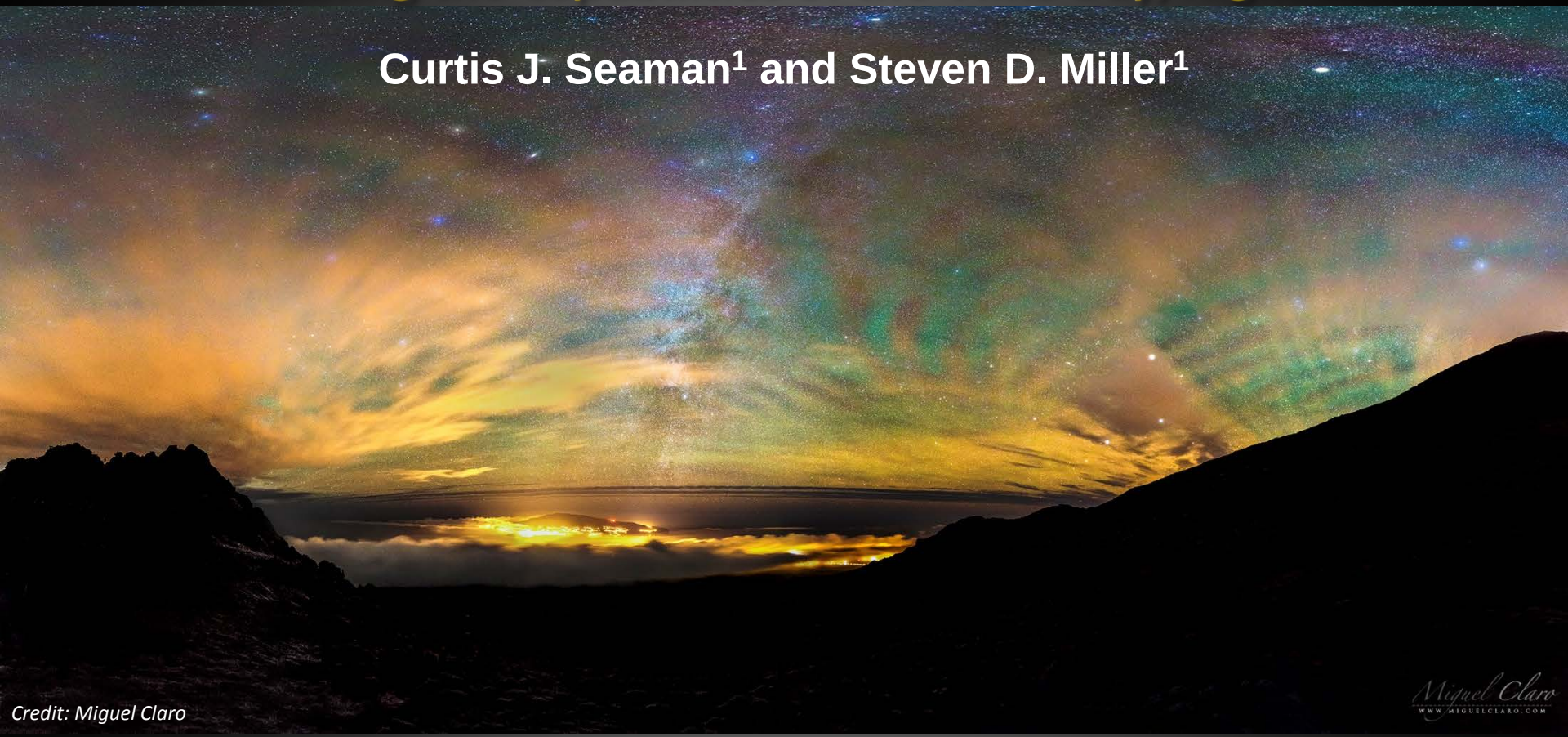
Night Vision:

Illuminating the Capabilities of the VIIRS Day/Night Band

Curtis J. Seaman[1] and Steven D. Miller[1]



Credit: Miguel Claro

1 CIRA Cooperative Institute for Research in the Atmosphere
2 CIMSS
3 NOAA NESDIS STAR Center for Satellite Applications and Research

With contributions from:
William Straka III[2], Daniel T. Lindsey[3] and Jorel Torres[1]

4th Annual STAR JPSS Science Team Meeting, College Park, MD

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VIIRS Bands

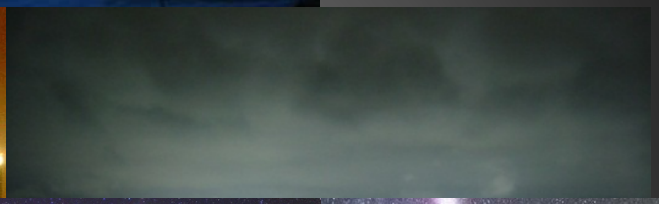
- VIIRS has 22 bands
- Traditionally, only mid- and longwave IR bands were available at night
- But, the Day/Night Band opens up a world of possibilities…

VIIRS Band	Central Wavelength (μm)	Band Explanation	Spatial Resolution (m) @ nadir
M12	3.7	Medium-wave IR	
M13	4.05		
M14	8.55	Longwave IR	
M15	10.76		
M16	12.01		
I4	3.74	Medium-wave IR	
I5	11.45	Longwave IR	

Nothing to be afraid of













- → The night is not as dark as you might think…
- → The VIIRS Day/Night Band is exploiting these light sources to better characterize our environment at night

Advances Over Heritage Night-Vis

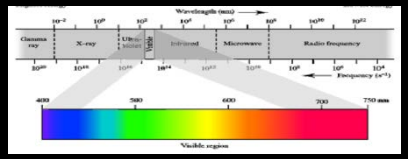
Attribute	DMSP/OLS*	VIIRS/DNB on Suomi NPP*
Orbit	Sun-synchronous, ~850 km	Sun-synchronous, 827 km
Nighttime Nodal Overpass Time	~1930 UTC	~0130 UTC
Swath Width	3000 km	3000 km
Spectral Response (FWHM)	Panchromatic 500-900 nm	Panchromatic 500-900 nm
Instantaneous Field of View	5 km (nadir) / ~7 km (edge)	0.740 ± 0.043 km (Scan) 0.755 ± 0.022 km (track)
Spatial Resolution (Ground Sample Distance)	2.7 km; 'smooth' data	< 0.820 km (Scan) < 0.750 km (track)
Minimum Detectable Signal	4×10^{-5} W m^{-2} sr^{-1}	3×10^{-5} W m^{-2} sr^{-1}
Noise Floor	$\sim5\times10^{-6}$ W m^{-2} sr^{-1}	$\sim5\times10^{-7}$ W m^{-2} sr^{-1}
Radiometric Quantization	6 bit	13 - 14 bit
Accompanying Spectral Bands	1	11 (night) / 21 (day)
Radiometric Calibration	None	On-Board Solar Diffuser
Saturation	In Urban Cores	None

DMSP = Defense Meteorological Satellite Program
OLS = Operational Linescan System

NPP = National Polar-orbiting Partnership (NOAA/NASA)
VIIRS = Visible/Infrared Imaging Radiometer Suite
DNB = Day/Night Band

Advances Over Heritage

SPECTRAL



OLS: 2 Bands
(VIS & IR)

VIIRS: 22 Bands
(0.4 – 12.0 μm)

RADIOMETRIC

OLS 6-bit (64 shades)



Min Max

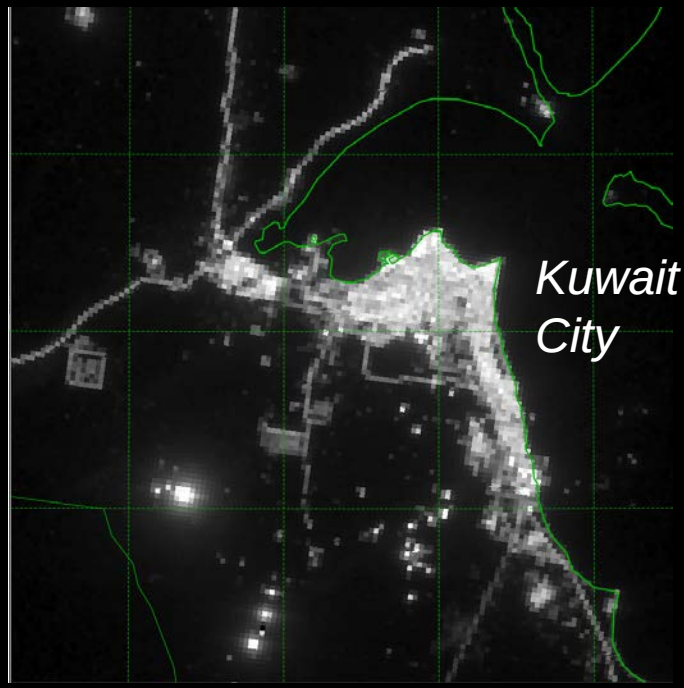
DNB 14-bit (16,384)



Min Max

SPATIAL

DMSP 5km vs. DNB 0.742m → 45x



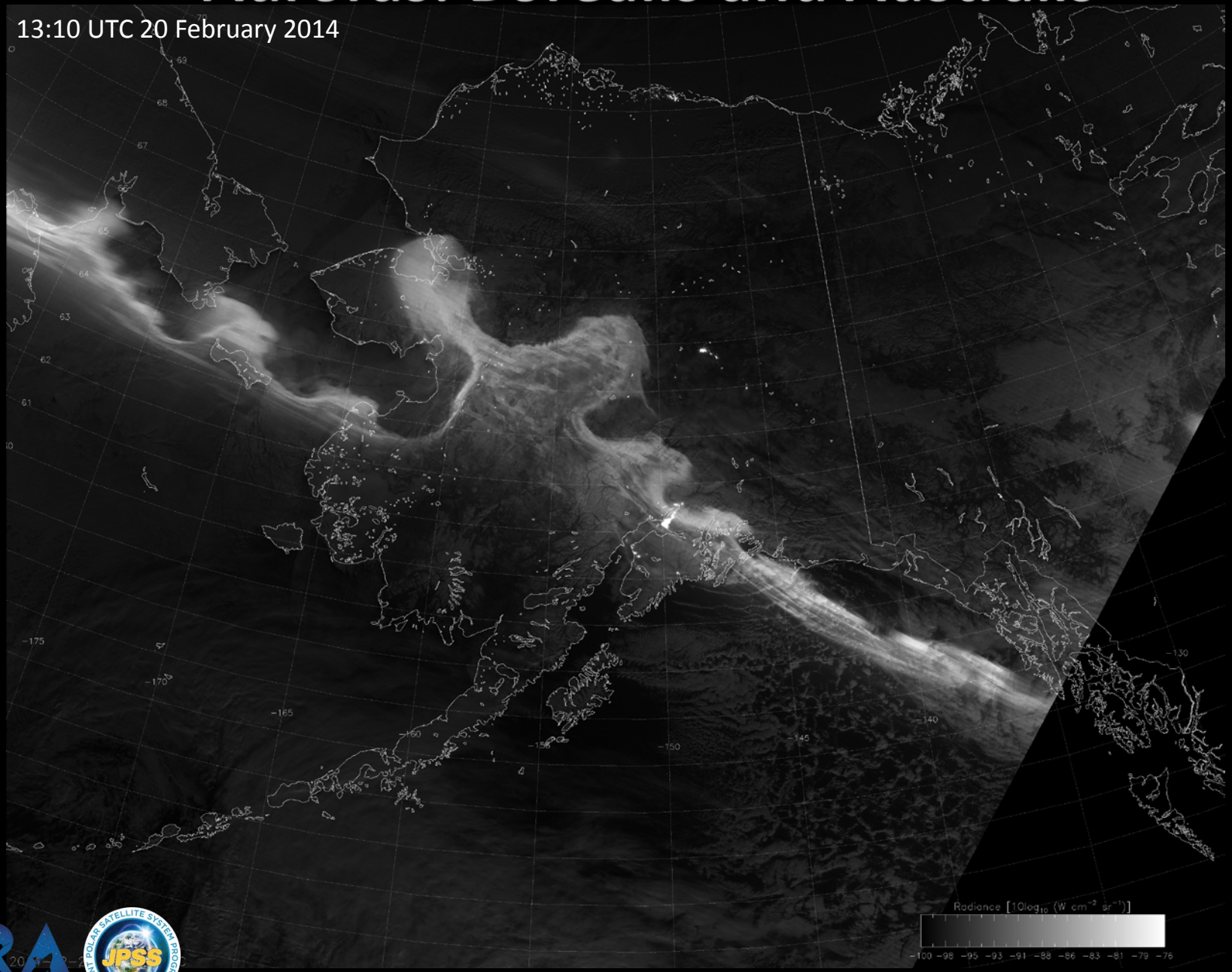
→ *The DNB offers a 'revolution of resolution' vis-à-vis heritage DMSP/OLS capabilities*

Hurricane Isaac (2012)



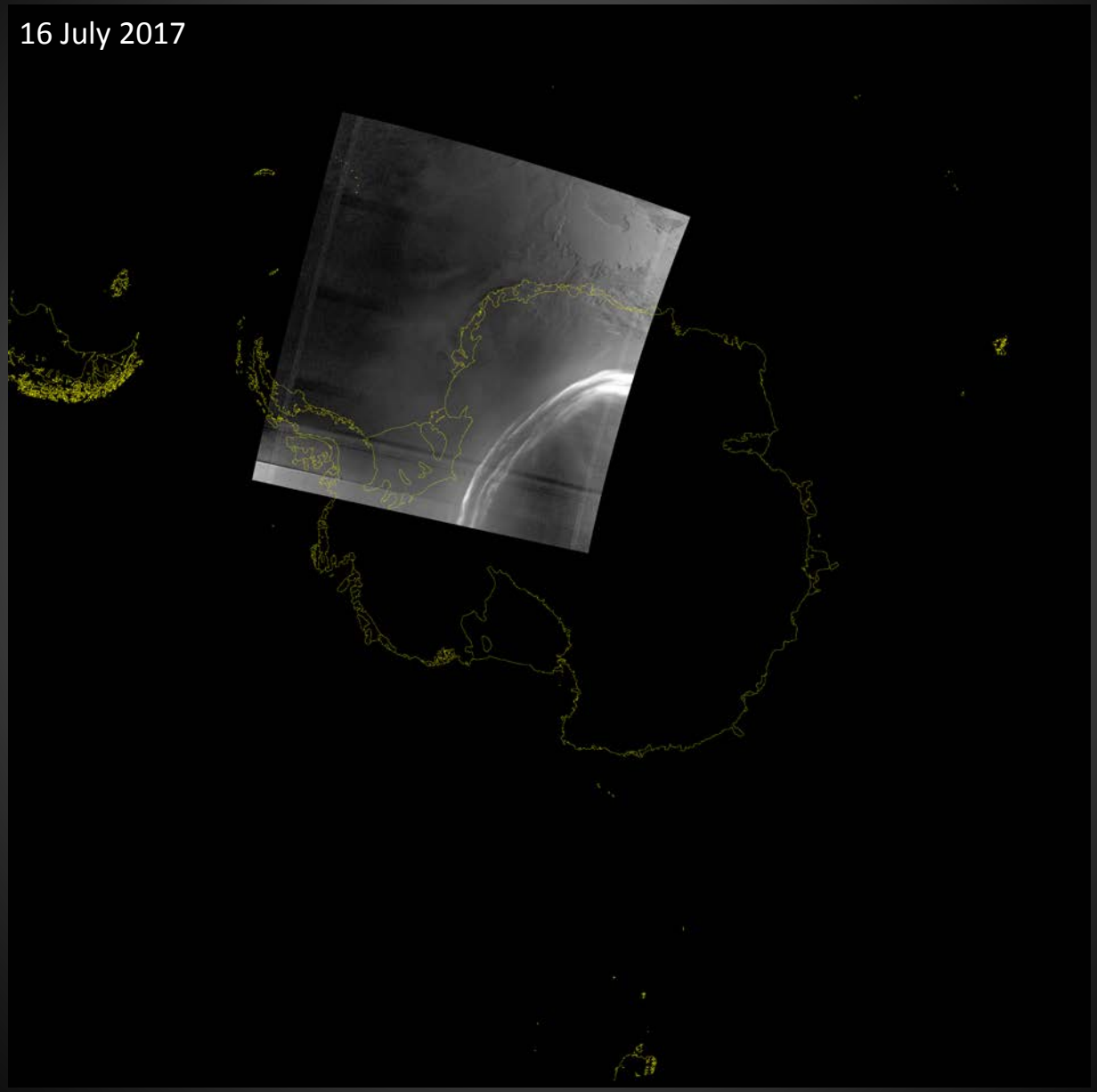
Cooperative Institute for Research in the Atmosphere

Auroras: Borealis and Australis



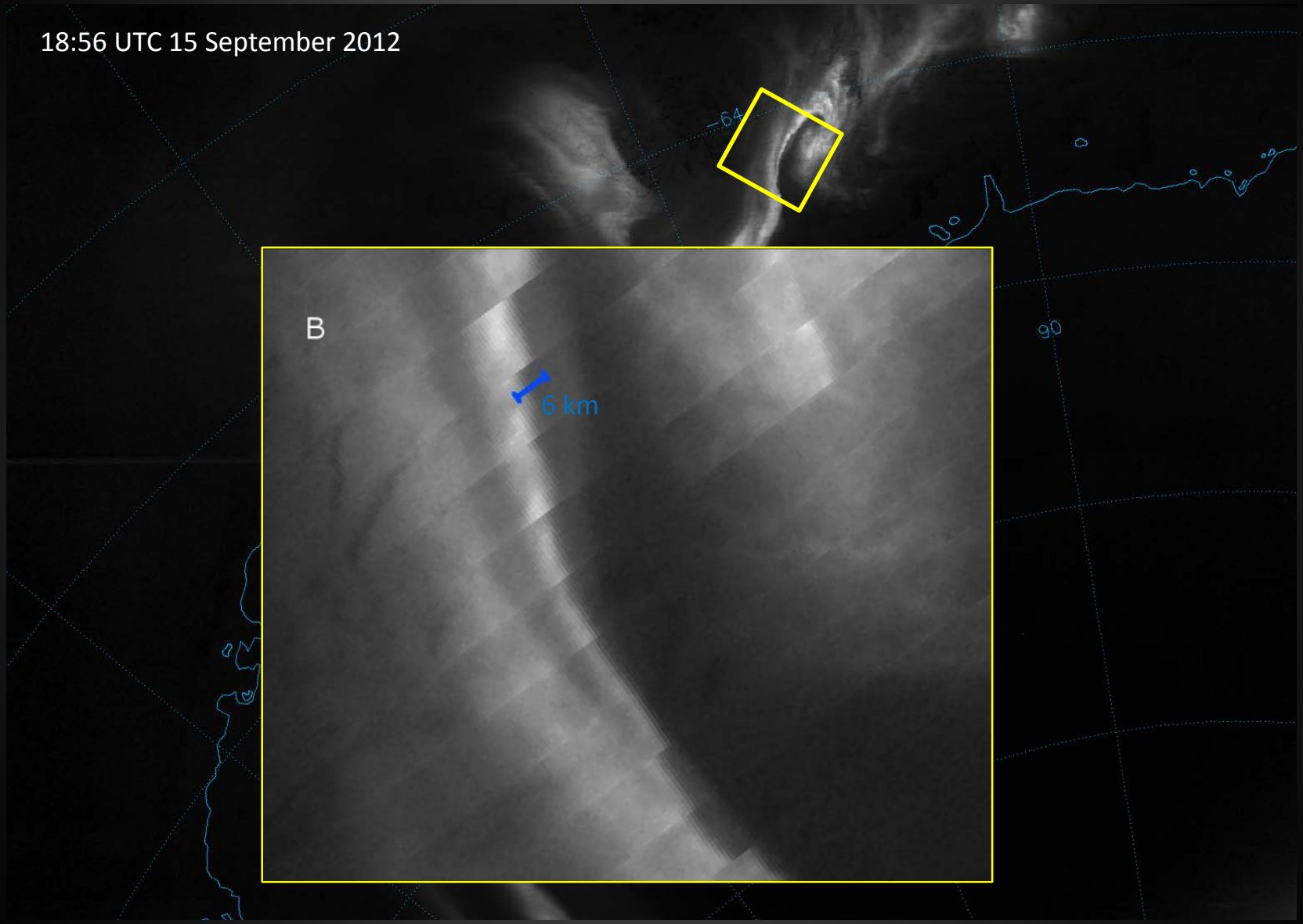
Seaman and Miller (2013): VIIRS Captures Aurora Motions. *Bulletin of the AMS*, **94**, 1491-1493.

Auroras: Borealis and Australis



Seaman and Miller (2013): VIIRS Captures Aurora Motions. *Bulletin of the AMS*, **94**, 1491-1493.

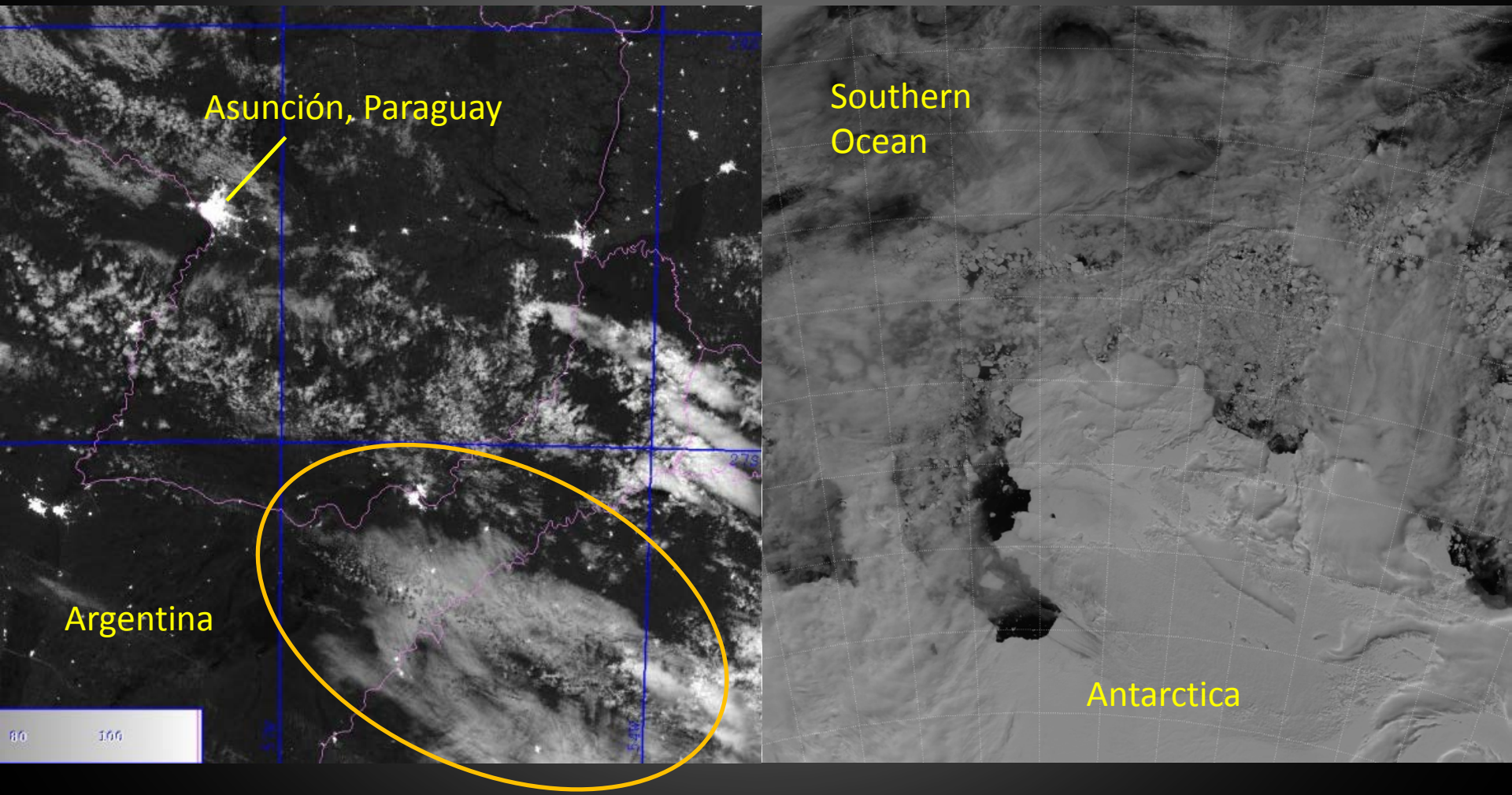
Auroras: Borealis and Australis



Seaman and Miller (2013): VIIRS Captures Aurora Motions. *Bulletin of the AMS*, **94**, 1491-1493.

What Lies Beneath…

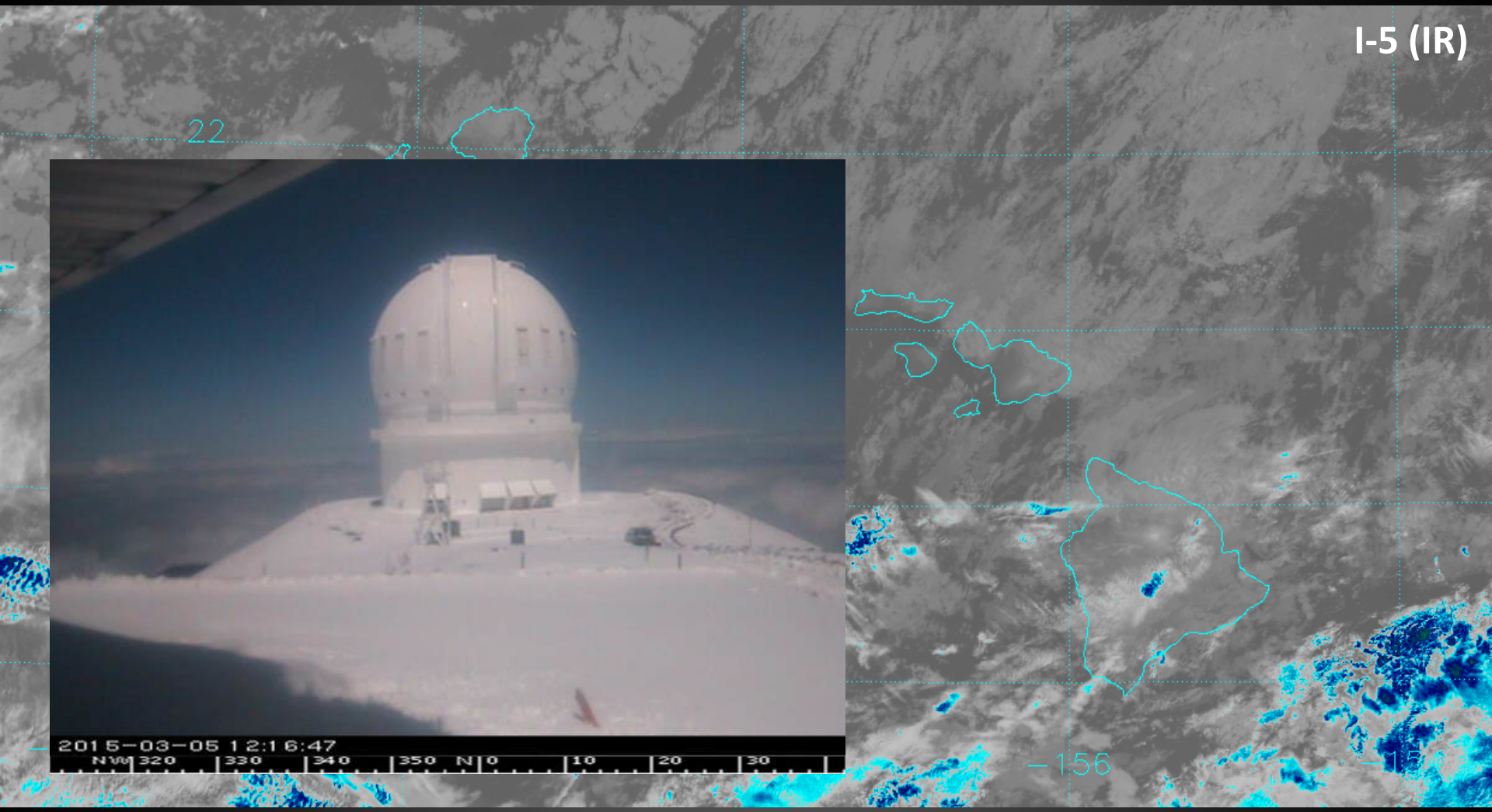
Strong scattering (low absorption) of cloud particles at visible wavelengths makes cirrus optically thin and hence semi-transparent



DNB reveals low clouds/fog missed by infrared!

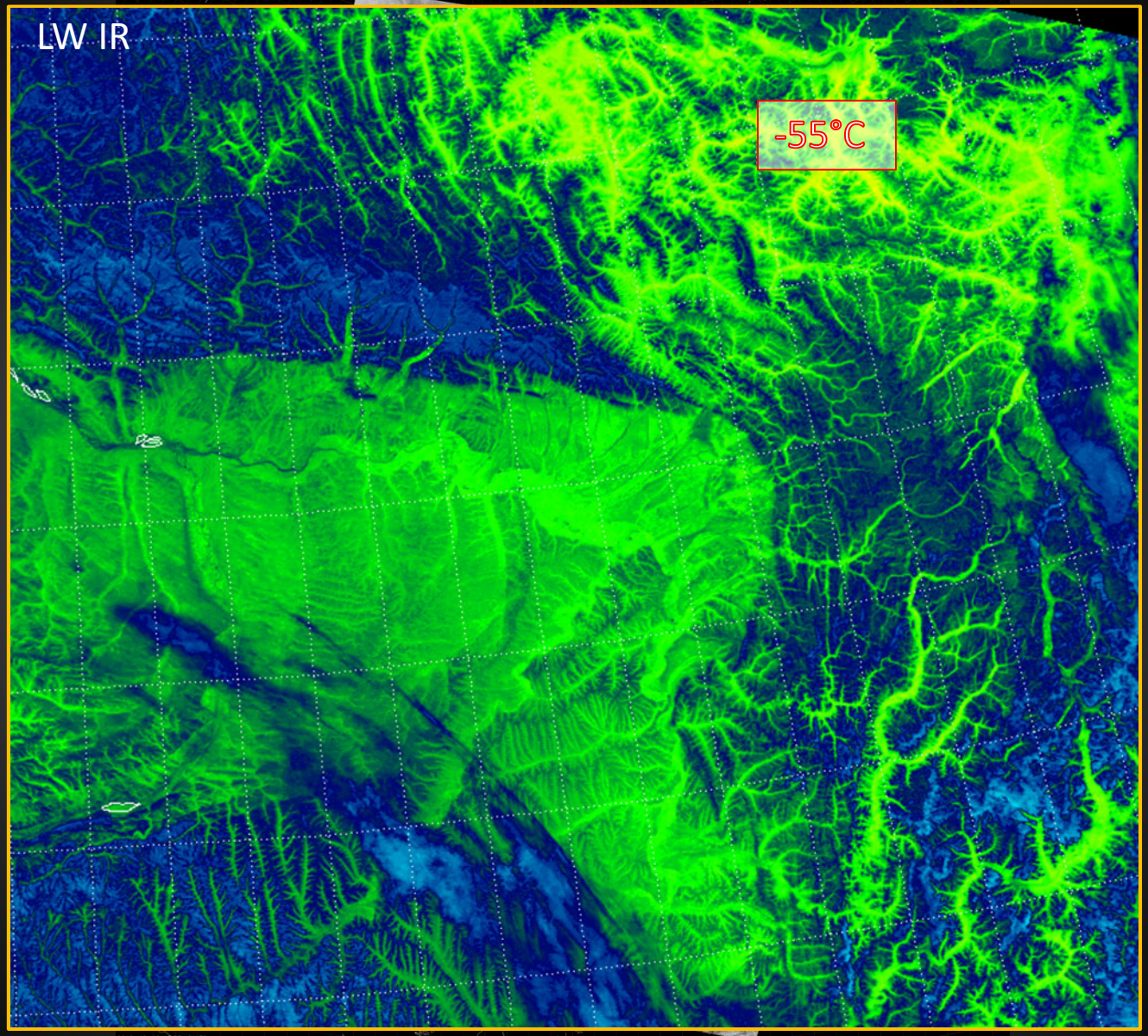
…and sea ice below clouds!

A Tropical Winter Wonderland



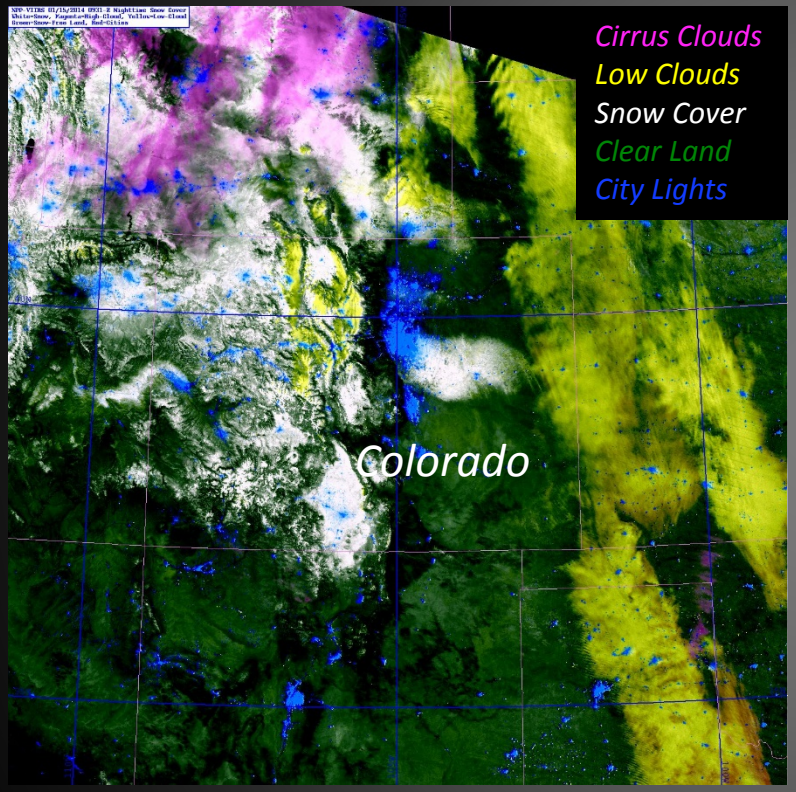
DNB detects snow on Mauna Kea and makes clouds more visible on Maui, Molokai and Kauai

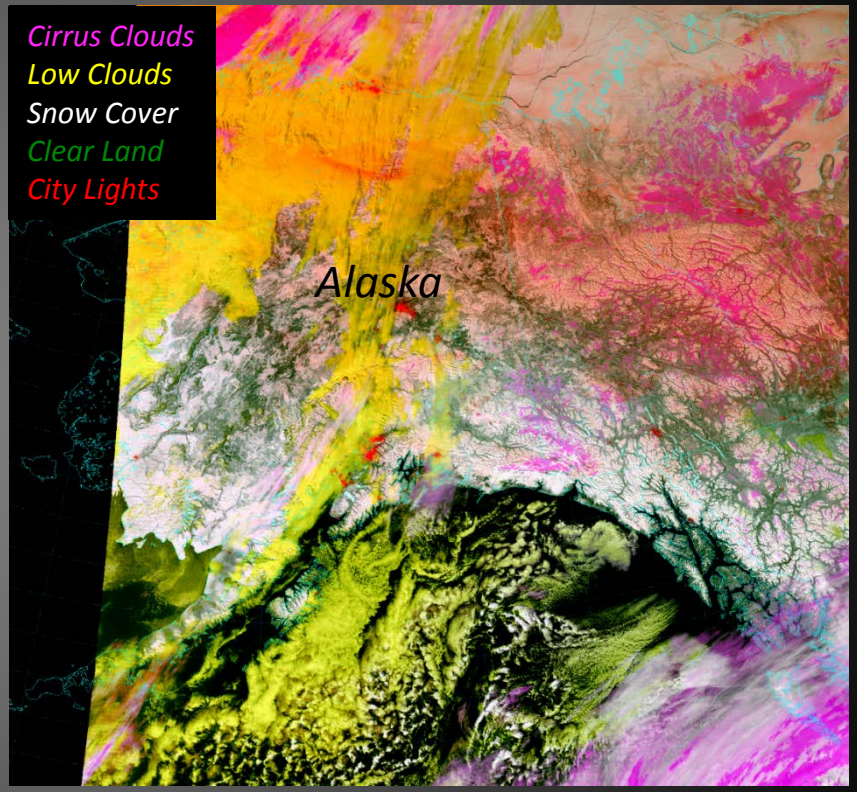
Arctic Chill



DNB compliments IR when the background surface is colder than the clouds

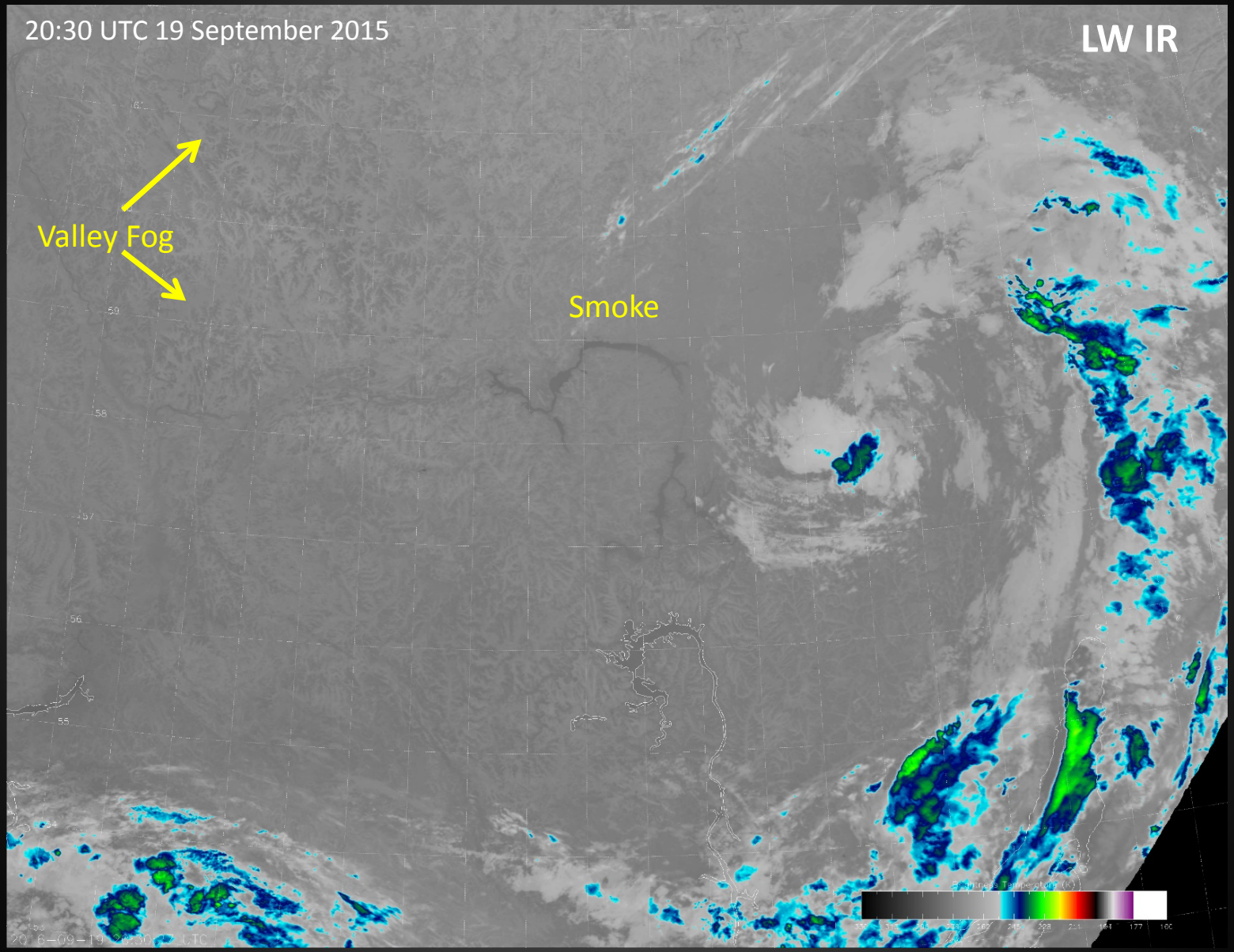
Identifying Snow at Night: The Snow/Cloud Discriminator



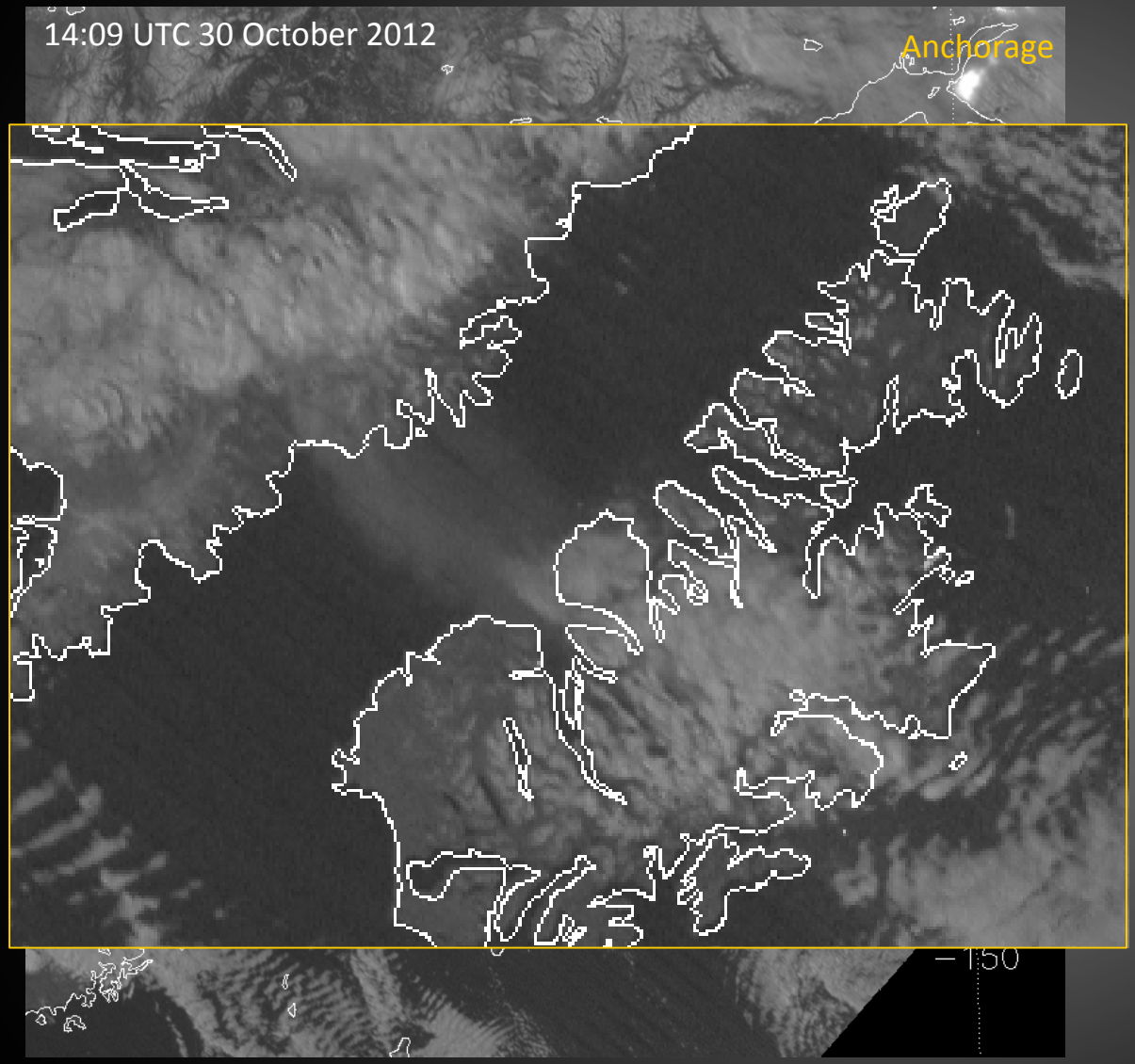


→ Sensible and latent heat fluxes over snow-covered surfaces are very different than snow-free ones. Relevant to forecasting low temperatures and areas of fog formation/suppression.

Where There's Smoke and Light Emissions



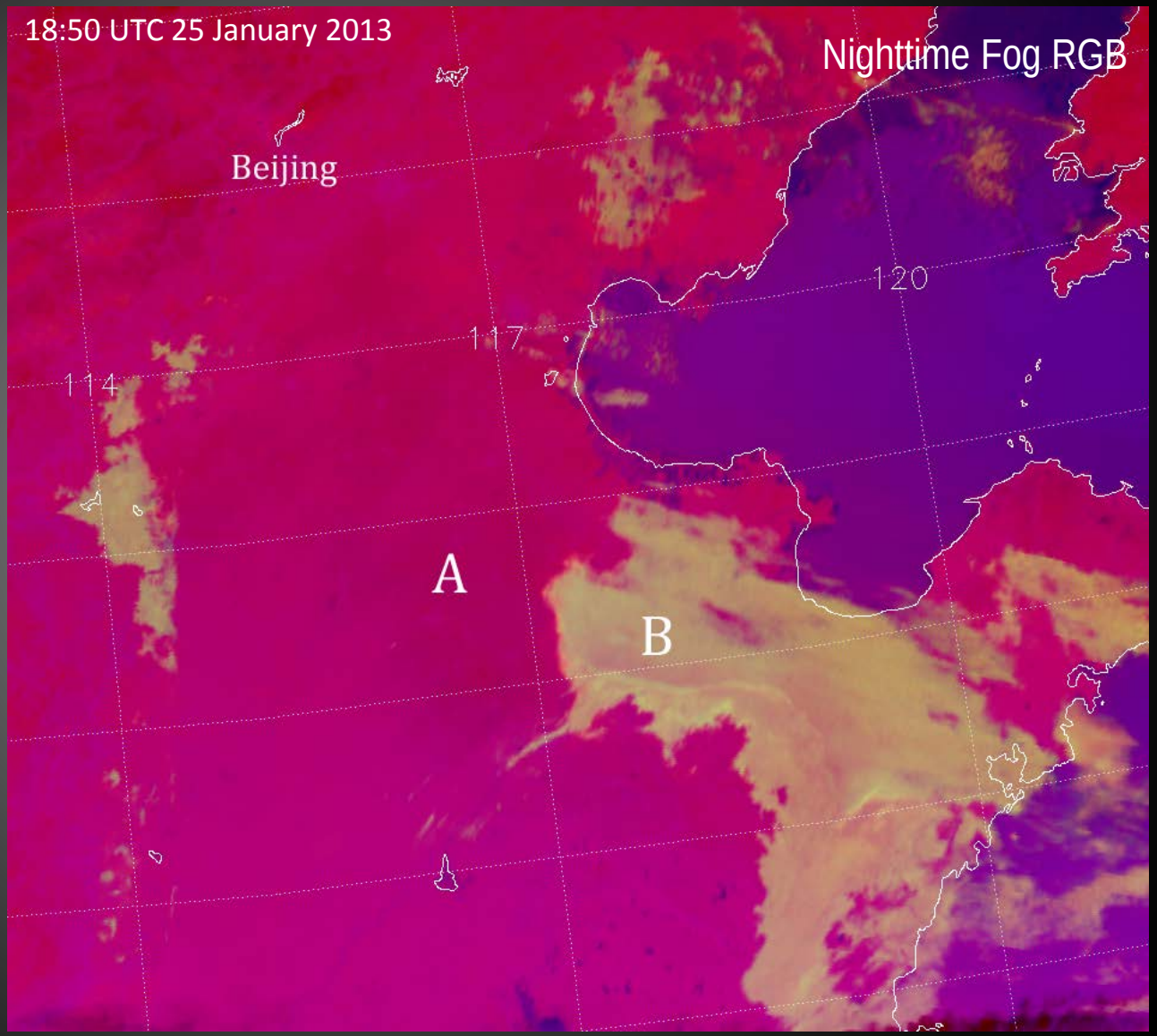
100-year-old Ash



Volcanic ash leftover from the 1912 eruption of Novarupta is lofted over Kodiak Island in strong winds

Chinese Super-Smog

- *DNB detects reflection off of atmospheric particles around points A and B.*
- *EUMETSAT nighttime fog RGB applied to VIIRS identifies low cloud at point B.*
- *DNB reflectivity around point A is due to optically thick smog in the moonlight.*



Portugal Wildfire: 17-20 June 2017

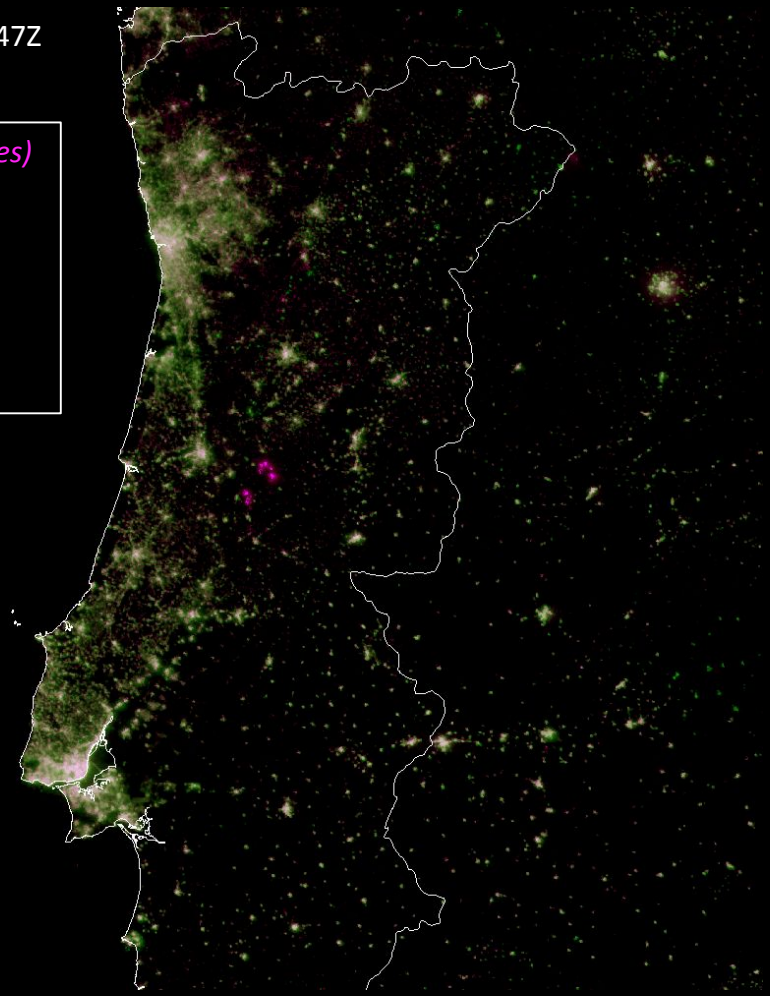


21 June 2017 0247Z

New Lights (Fires)

Stable Lights (Unchanged)

Stable Lights (Obscured)

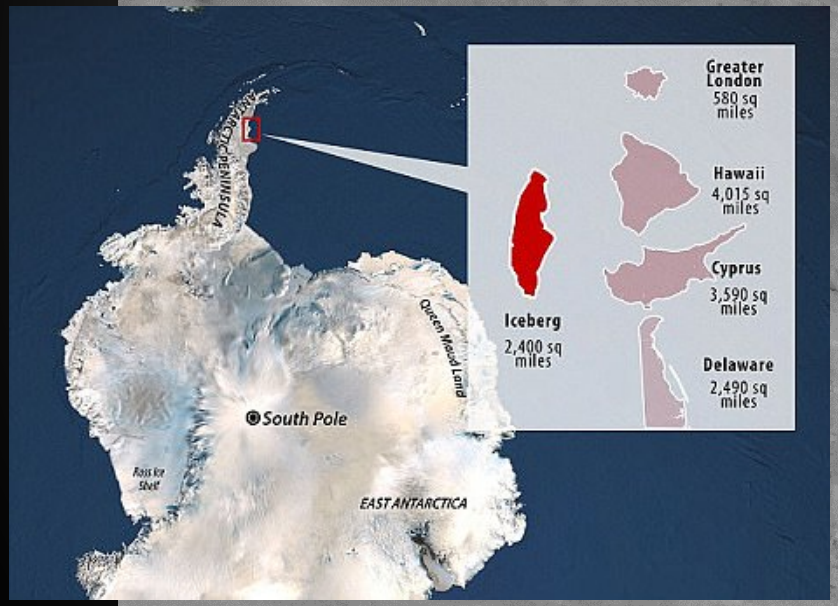


→ Light-change products enlist Chris Elvidge's (NOAA/NESDIS) nighttime stable lights product based on composite DNB data.

Larsen-C

Delaware-sized chunk of ice separating from Larsen-C Ice Sheet (Jul-Aug 2017)

ANTARCTICA

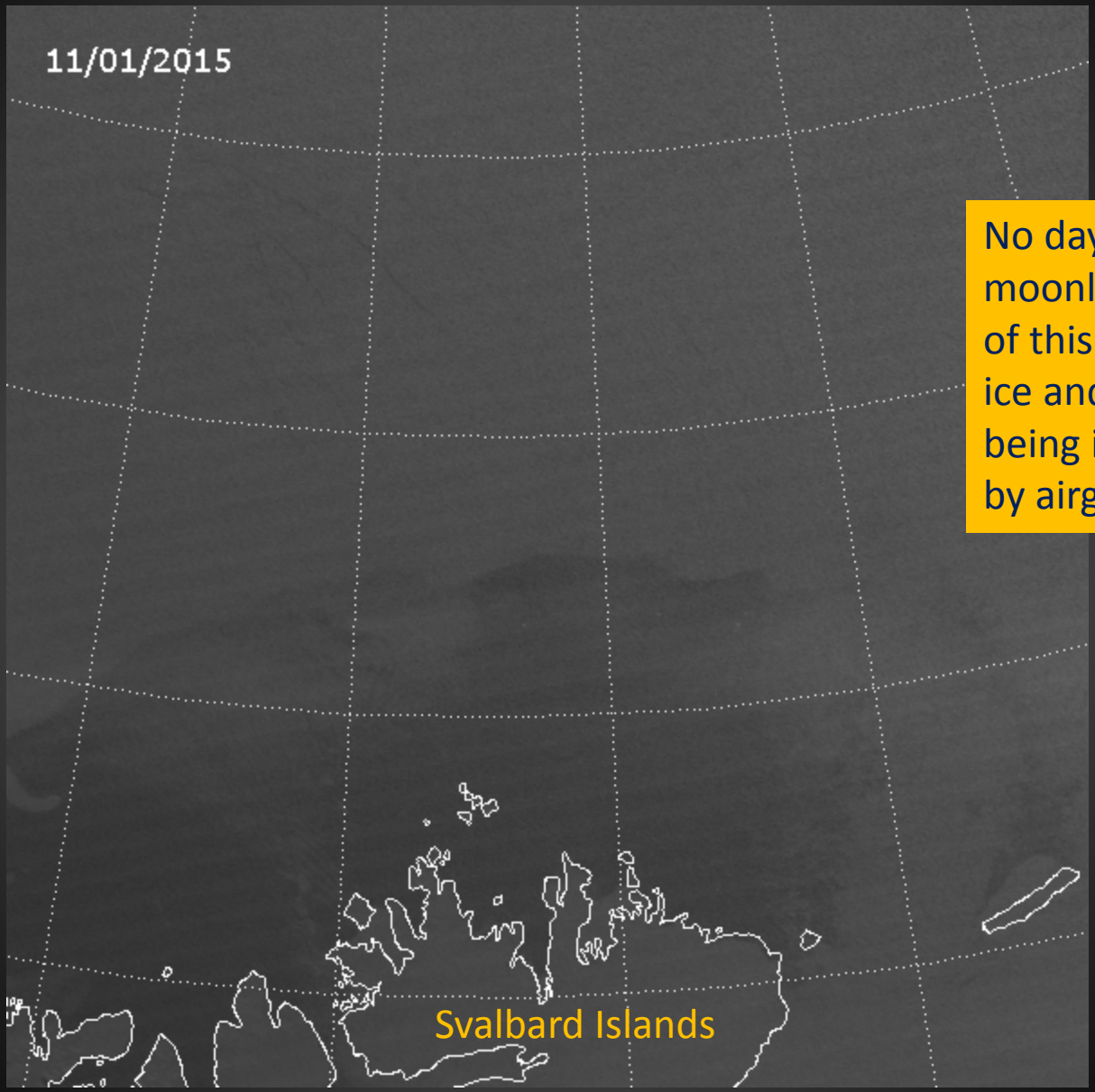


NOAA/NASA CIMSS/SSEC

VIIRS – Day Night Band
12 July 2017, 0326 UTC

http://globalcryospherewatch.org/interesting/archive/larsenc2017/

Tracking Arctic Ice

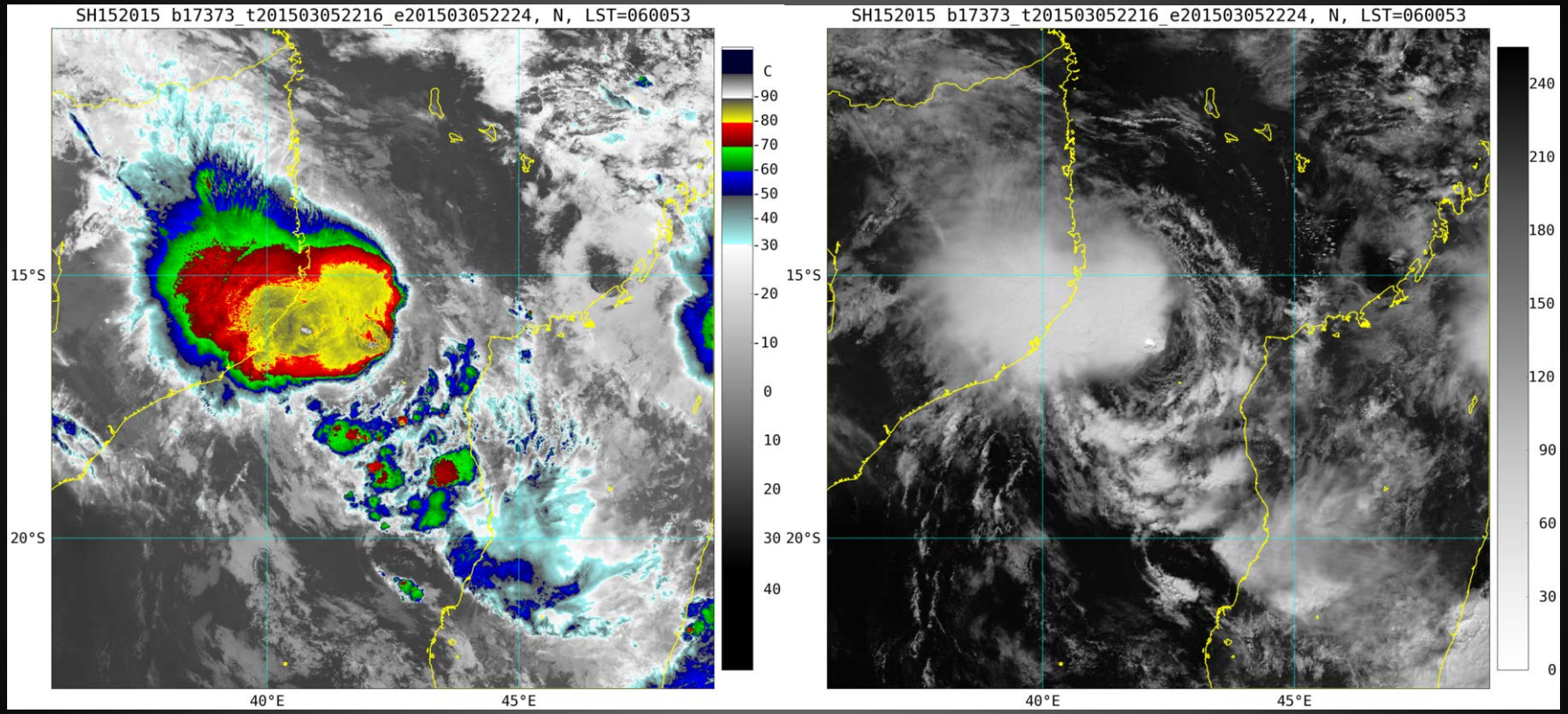


No daylight and no moonlight for most of this period. The ice and clouds are being illuminated by airglow!

http://rammb.cira.colostate.edu/projects/alaska/blog/index.php/uncategorized/the-nice-and-dedicated-people-of-n-ice/

From the Arctic to the Tropics

SH15 2015

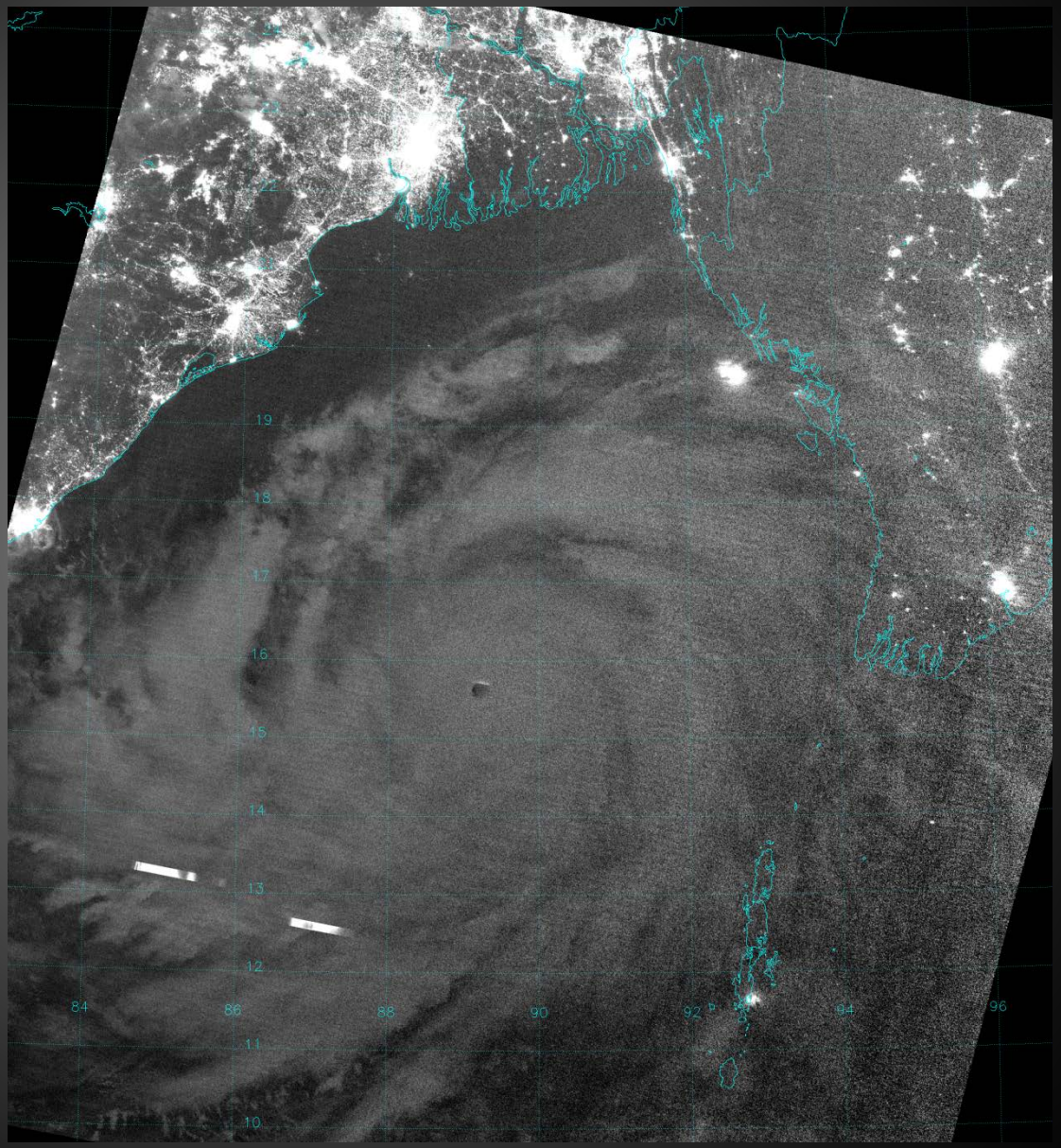


The DNB helps identify the low-level center of tropical cyclones when the IR view is ambiguous. This improves the forecast and saves lives!

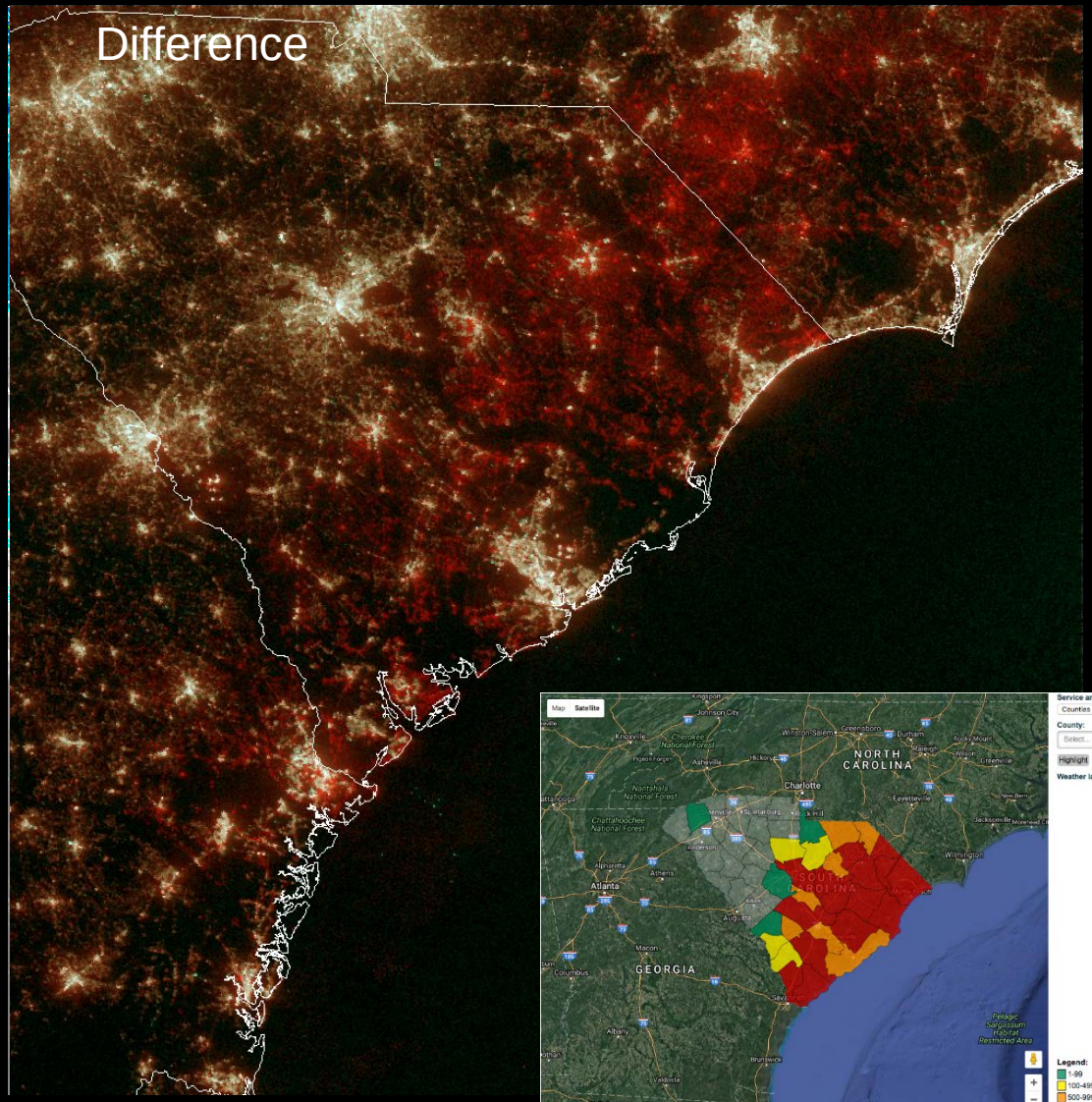
Phailin: Ghost in the Night

Super Cyclone Phailin (2013) illuminated entirely by airglow.

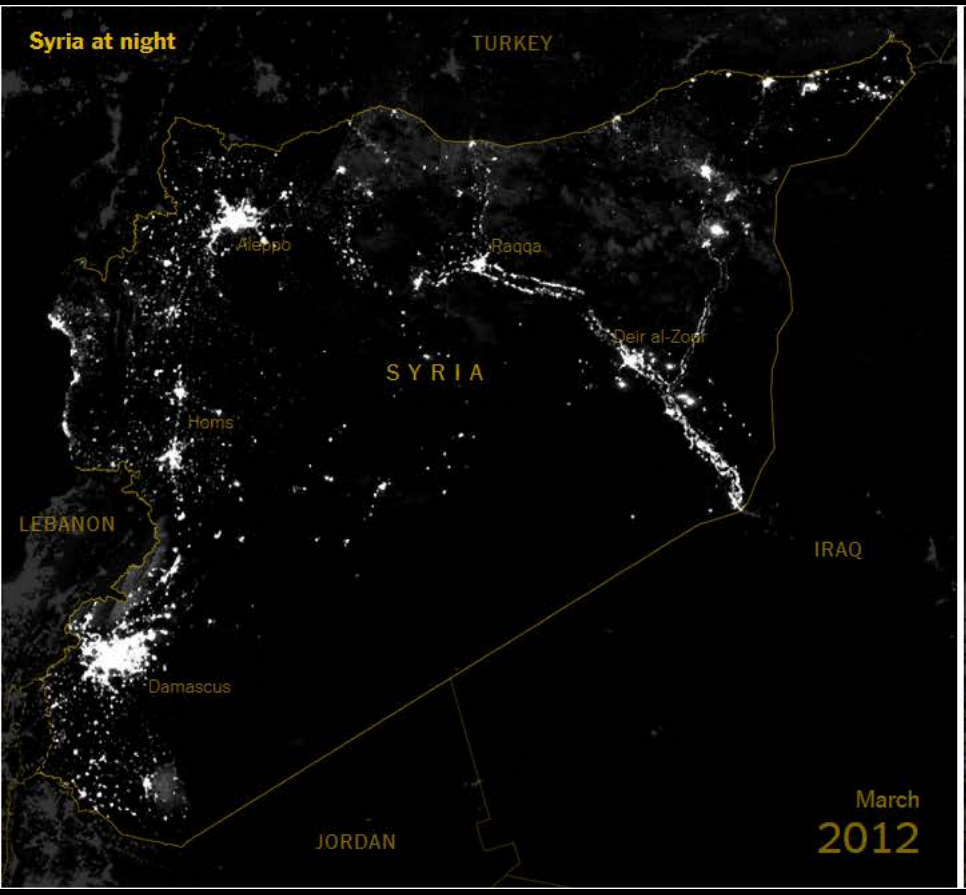
No moon needed!

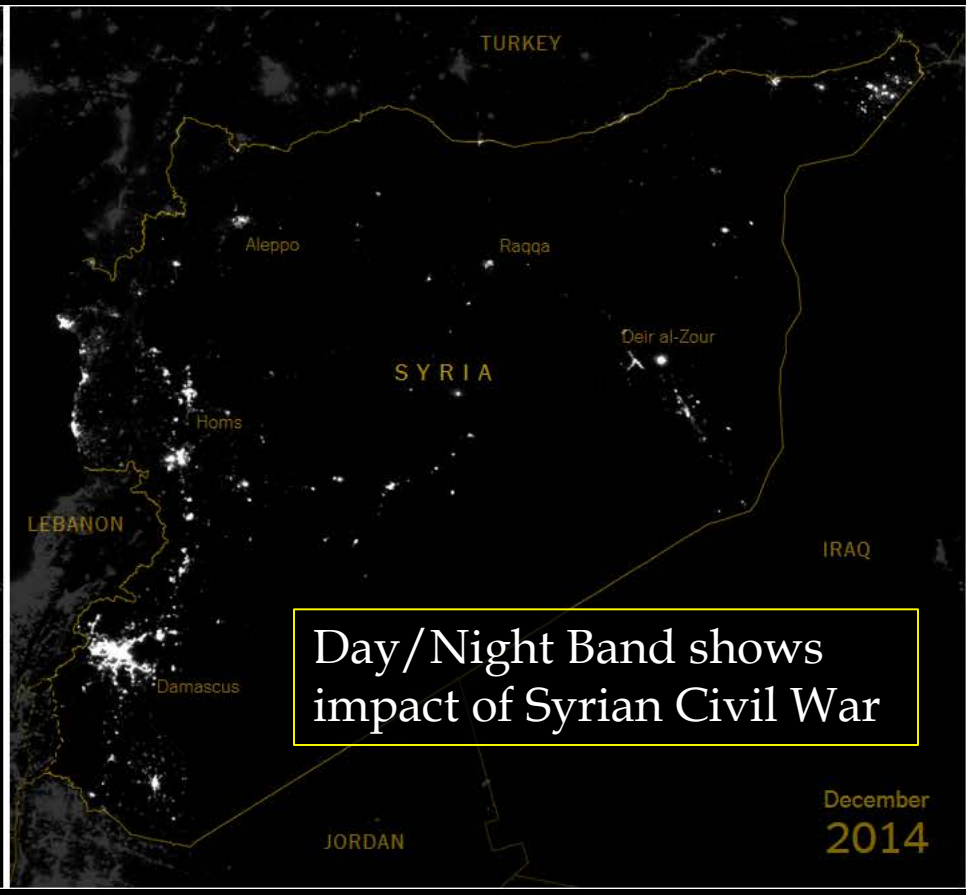


Below Hurricane Matthew: Widespread Power Outages



Power Outages and Surges

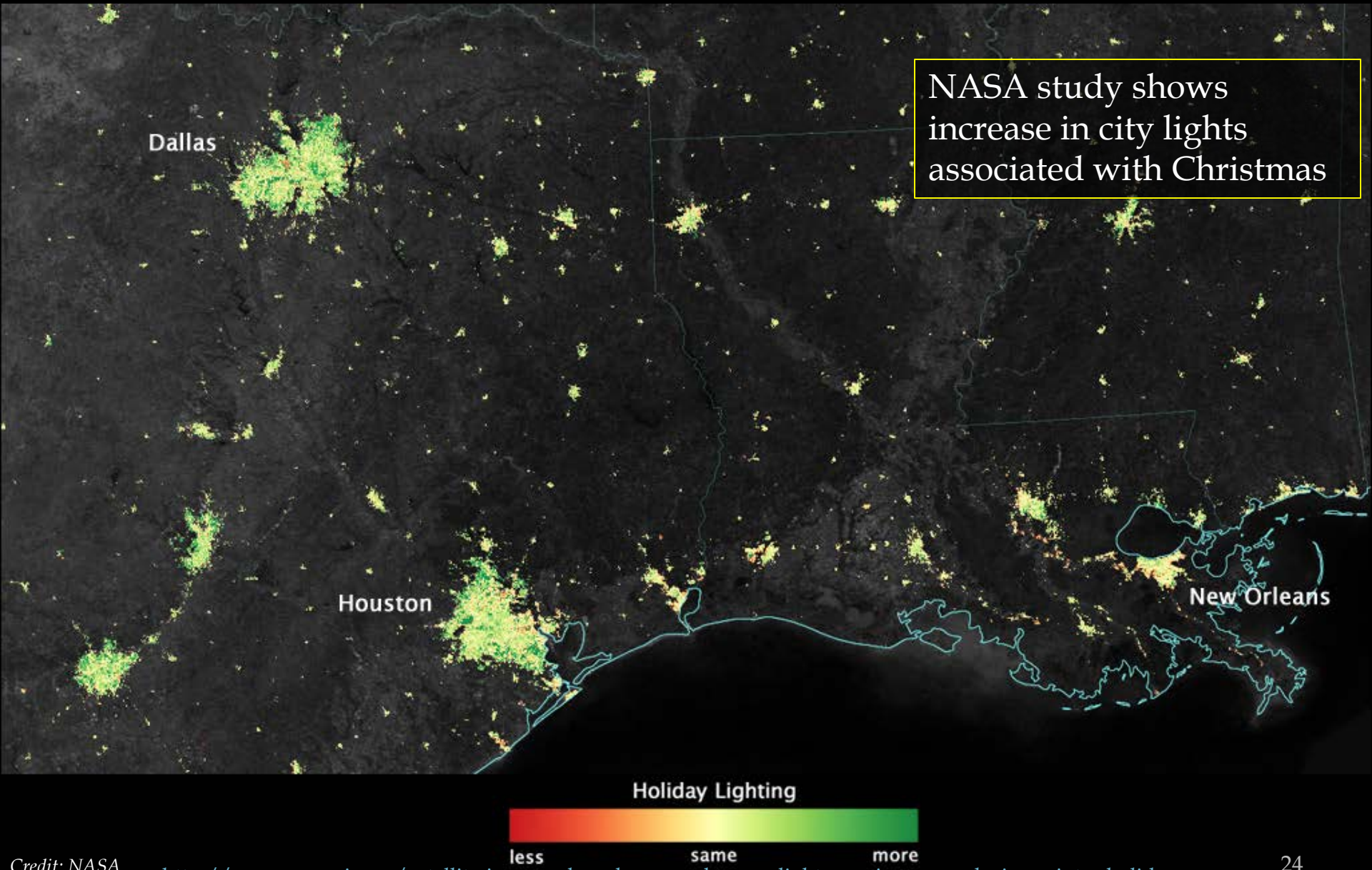




Day/Night Band shows impact of Syrian Civil War

Credit: New York Times

Power Outages and Surges



NASA study shows increase in city lights associated with Christmas

Credit: NASA

http://www.popsci.com/satellite-images-show-how-much-more-light-americans-use-during-winter-holidays

Ship Lights/Tracking

2015 Norwegian Young Sea Ice Cruise (N-ICE 2015)

Credit: Tor Ivan Karlsen



Above Hurricane Matthew: Lightning, Sprites, & Gravity Waves

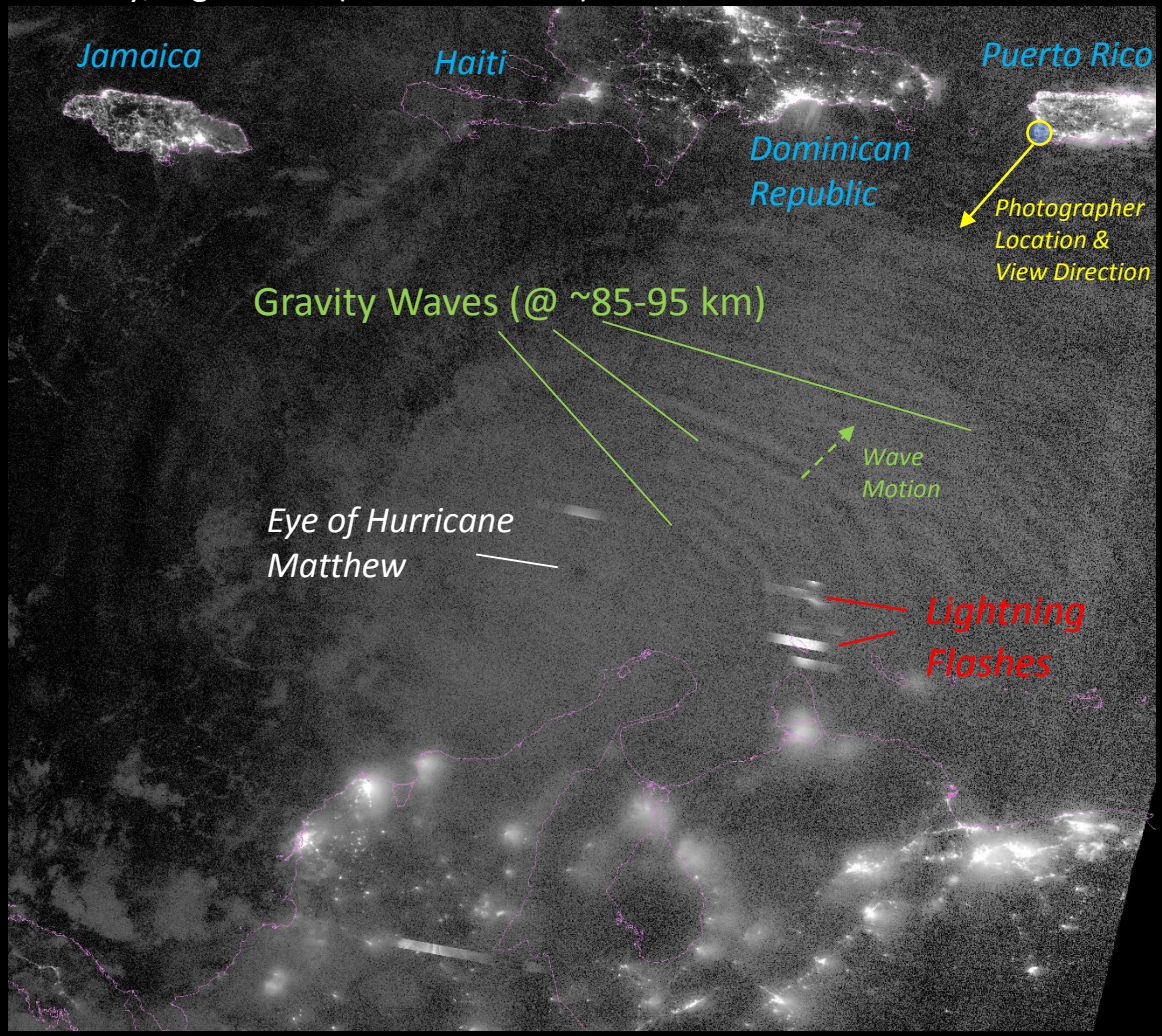
Cabo Rojo, Puerto Rico (18.03°N, 67.06°W)



→ Strong convection forces gravity waves in the lower atmosphere which propagate upwards. Detectable by the DNB on moonless nights as the waves modulate the nightglow layer (~90 km AMSL).

DNB View of Gravity Waves

VIIRS Day/Night Band (0651-0654 UTC)



Bangladesh Thunderstorm

4/27/2015 1935 UTC

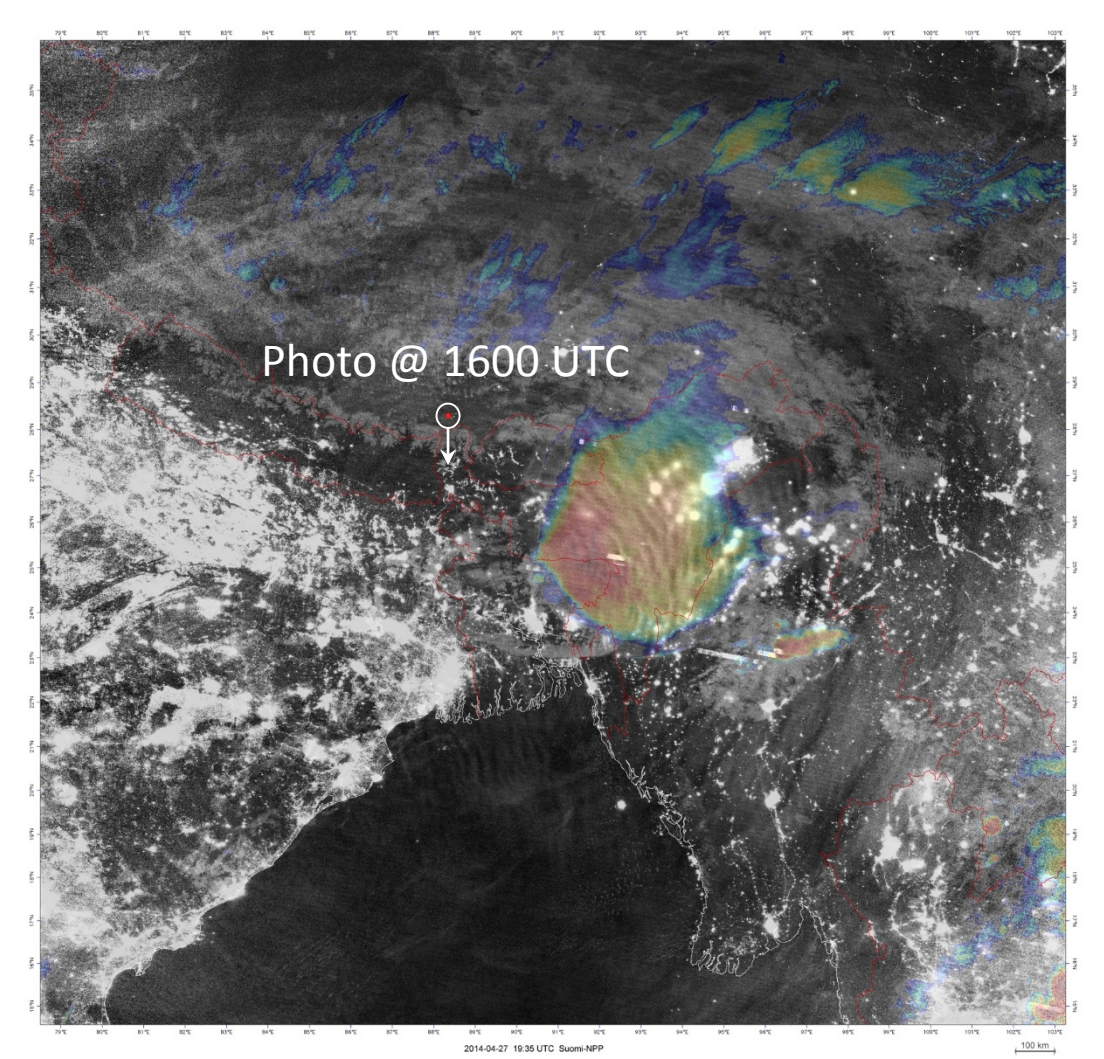
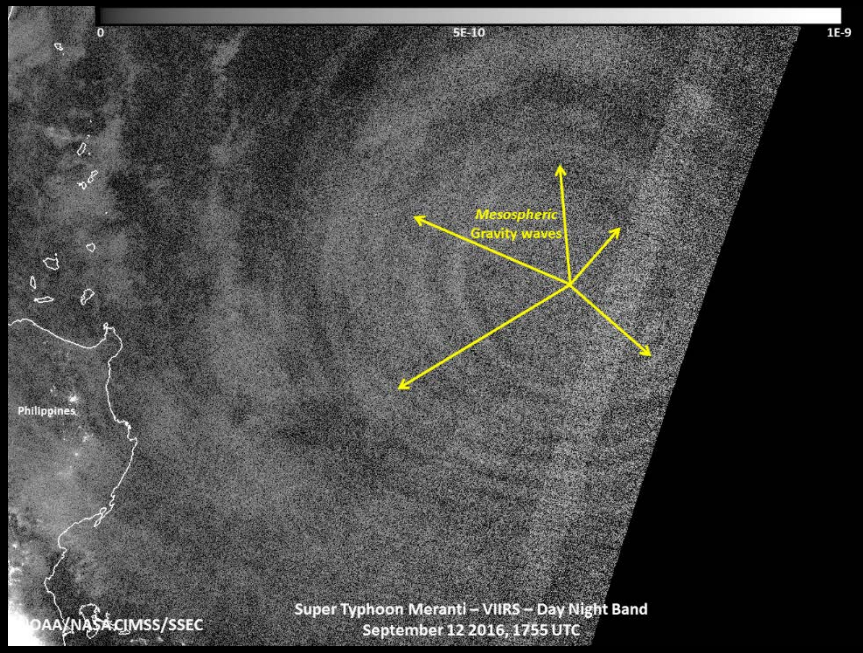
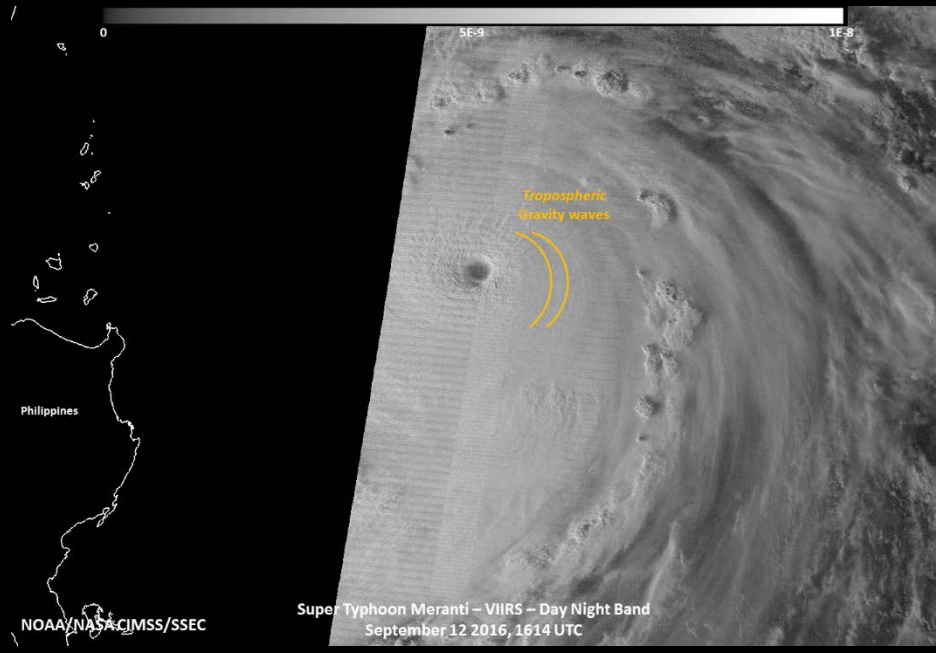


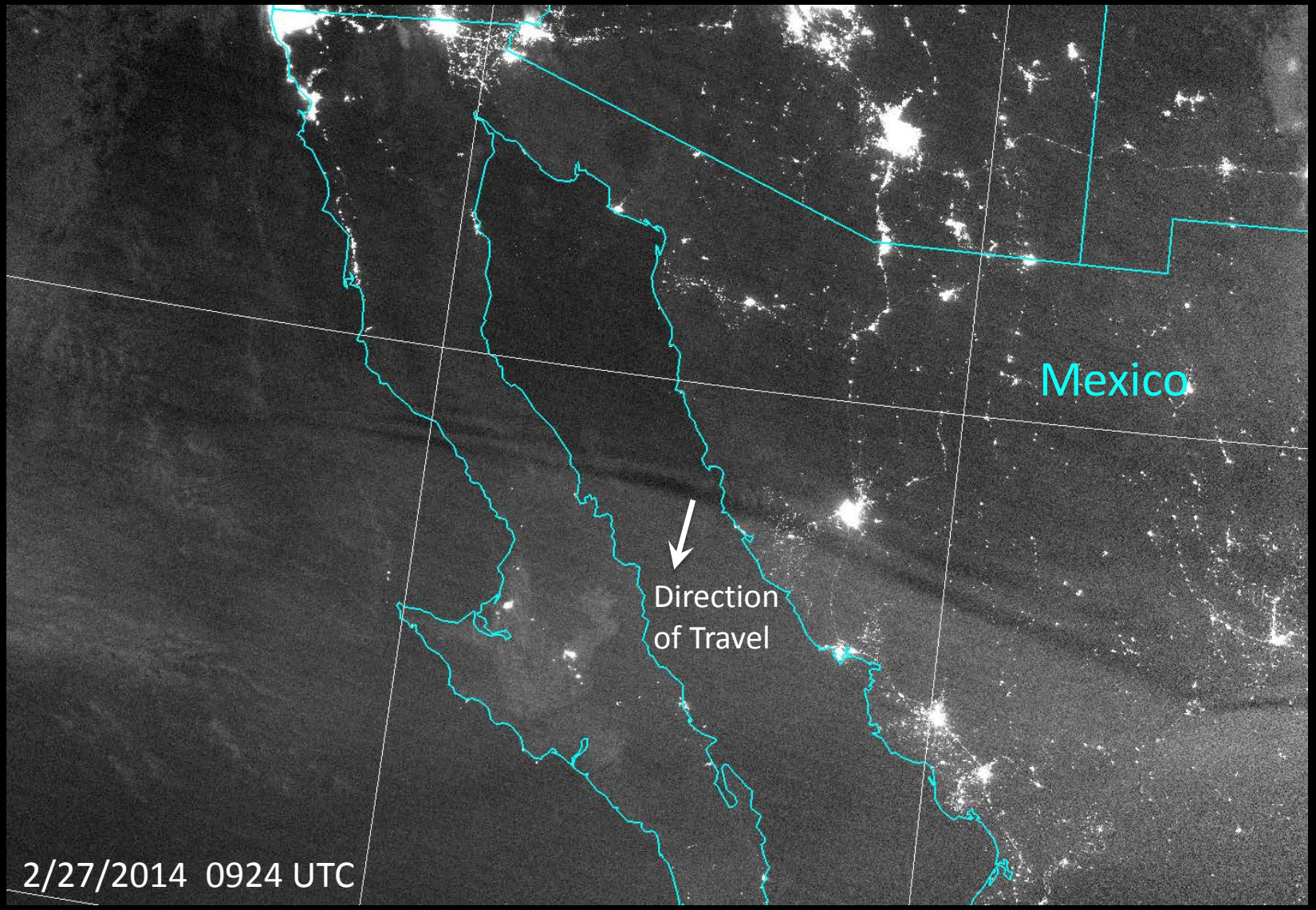

Photo @ 1600 UTC
© Jeff Dai 2014

Super Typhoon Meranti

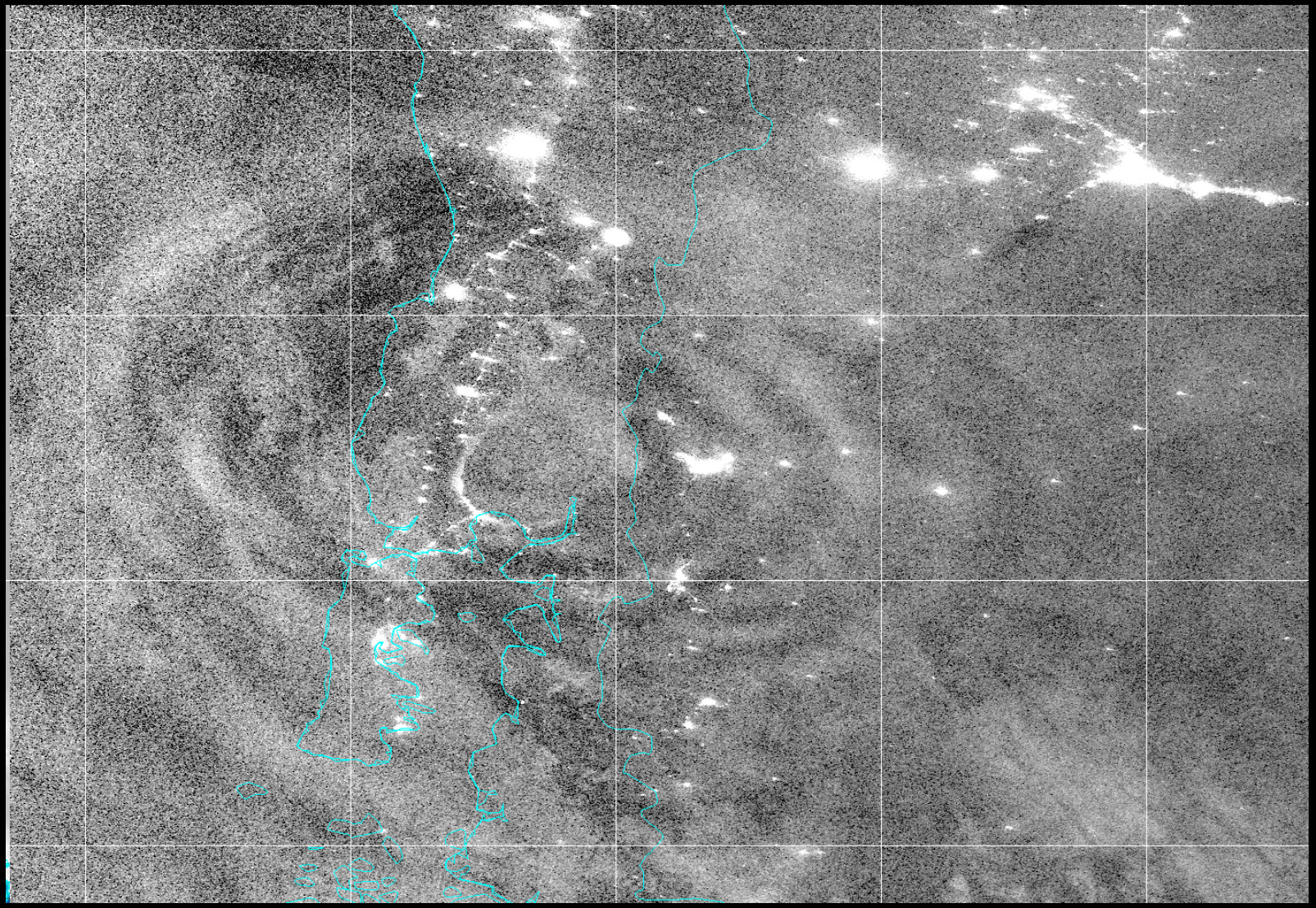




Mesospheric Bore: Baja, CA



Calbuco Volcano Eruption, Chile



→ *This is the first documented evidence of a volcanically induced gravity wave in mesospheric nightglow!*

Gravity Waves in Nightglow

- These waves, launched by numerous processes, are a principal form of energy transfer between the lower & upper atmosphere.
- Wave breaking in upper atmosphere deposits momentum, induces drag, drives the circulation.
- DNB provides unprecedented perspective on the global distribution and high-resolution structure of gravity waves near the mesopause.
  - For the Suomi NPP orbit, detections occur on moonless nights, from roughly 2 nights after Last Quarter until 2 nights after First Quarter lunar phase.

A New Mystery Named Steve



Credit: Dave Markel

http://rammb.cira.colostate.edu/projects/npp/blog/index.php/uncategorized/steve-and-the-color-purple/

Conclusions

- Don’t fear the night! It’s brighter than you think.
- The VIIRS Day/Night Band has surpassed all expectations as a complement to traditional emissive bands at night.
- New tools are maximizing the utility of these novel measurements for both imagery and quantitative applications.
- Unexpected capabilities are presenting exciting new pathways for research and discovery!

Thanks!

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Miller, Steven D., William Straka III, Stephen P. Mills, Christopher D. Elvidge, Thomas F. Lee, Jeremy Solbrig, Andi Walther, Andrew K. Heidinger, and Stephanie C. Weiss (2013). "Illuminating the Capabilities of the Suomi National Polar-Orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band." Remote Sensing 5, no. 12.

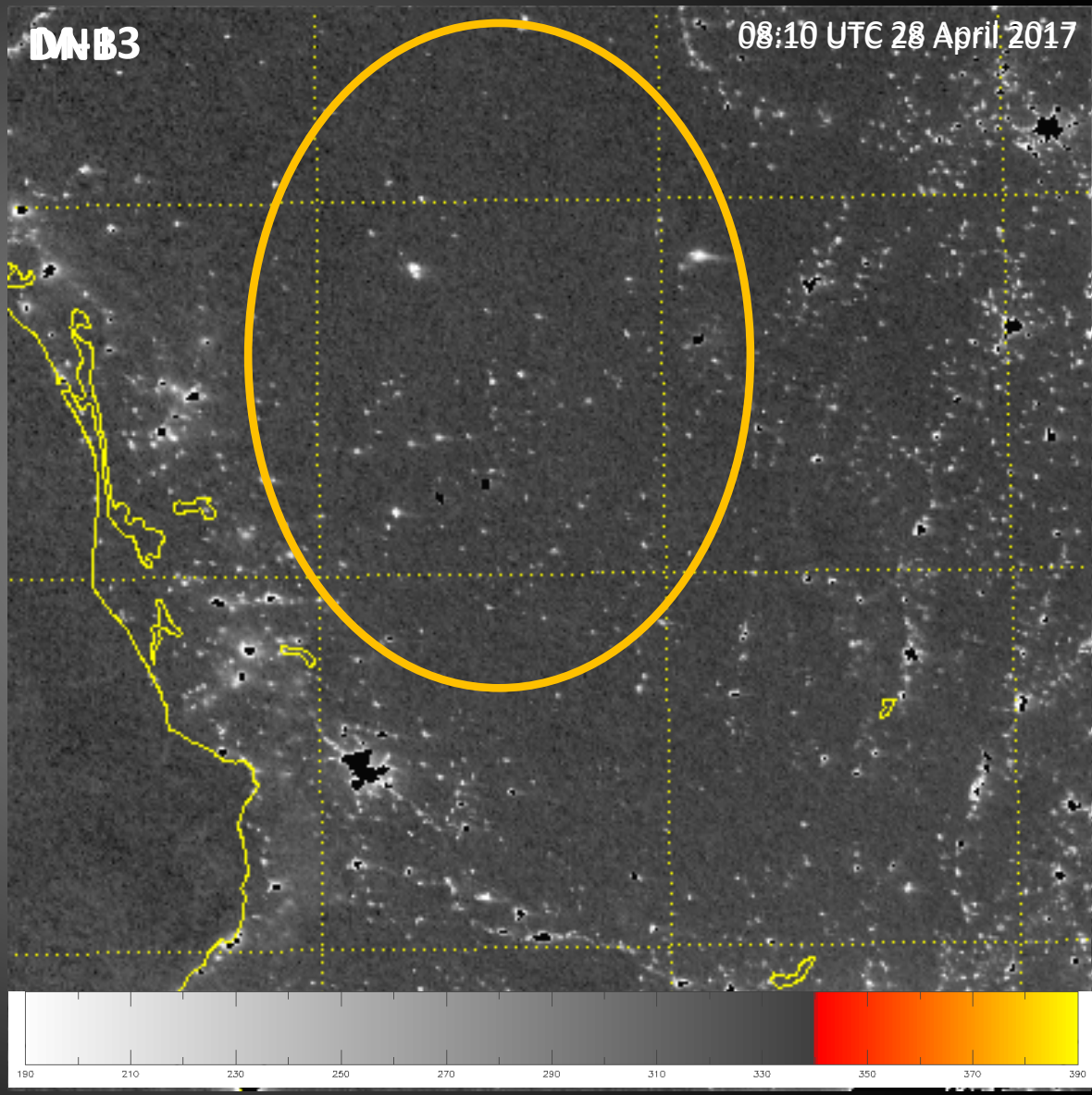
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Straka III, W. C., C. J. Seaman, K. Cole, S. D. Miller and E. Stevens (2014). “Utilization of the Suomi National Polar-Orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band for Arctic Ship Tracking and Fisheries Management.” Remote Sensing, 7, 971-989, doi: 10.3390/rs70100971.

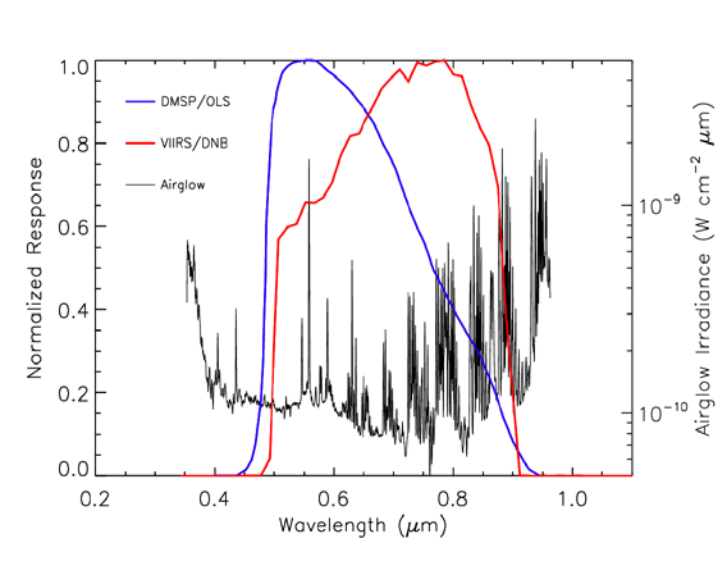
Seaman, C. J. and S. D. Miller (2015). “A dynamic scaling algorithm for the optimized digital display of VIIRS Day/Night Band imagery. International Journal of Remote Sensing.” 36 [7], 1839-1854, doi: 10.1080/01431161.2015.1029100.

Improving Fire Detection

- *M-13 (4.0 μm) detects numerous hot spots over Durango, Mexico (23 May 2017)*
- *DNB detects many more light sources*
- *Masking out known city lights shows these are not towns (C. Elvidge et al. Nighttime Lights Database)*
- *Comparison with 28 April 2017 confirms lack of lights*
- *The DNB may be more sensitive to fires at night than M-13 (more study needed)*



Sensitivity to Nightglow





→ *Entirely unanticipated capability—the atmosphere as a source of illumination, provides a form of visible imagery on moonless nights!*