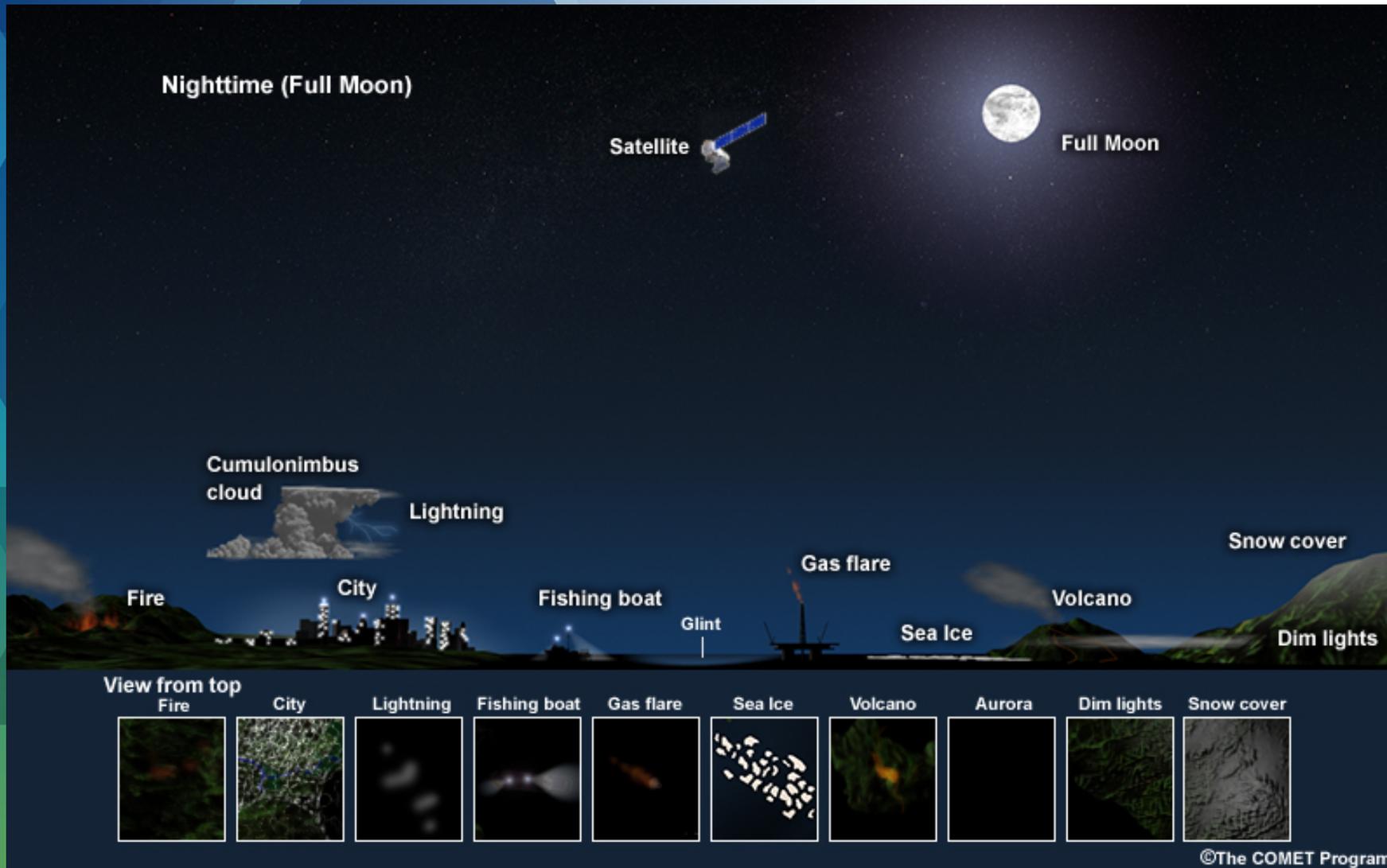


# NASA Black Marble Science Team Activities



## NASA's Black Marble Science Objective:

*To enable interdisciplinary research and applications of the VIIRS Day/Night Band on Suomi-NPP and NOAA-20*



## Key Program Elements:

- *Land/Atmosphere (A.37)*
- *Oceans (A.8)*
- *Disasters (A.50)*
- *Urban Sustainability (A.2)*
- *Energy/Electrification (A.50)*
- *Light Pollution (A.31)*

## Cal/Val Support (S-NPP)

*MALIBU/Lunar BRDF retrieval*

## Near Real-Time Products

*LANCE-NRT (EOSDIS)*

## Partnership Efforts

*Alphabet Inc / Google Voyager*

# Product Status

# Status of VIIRS Black Marble Nighttime Lights (VNP46)

## VIIRS Black Marble Product

Collection V001: **(Released 2019)**

- VNP46A1: daily at-sensor TOA radiance
- VNP46A2: daily lunar BRDF adjusted radiance

## Status and Updates:

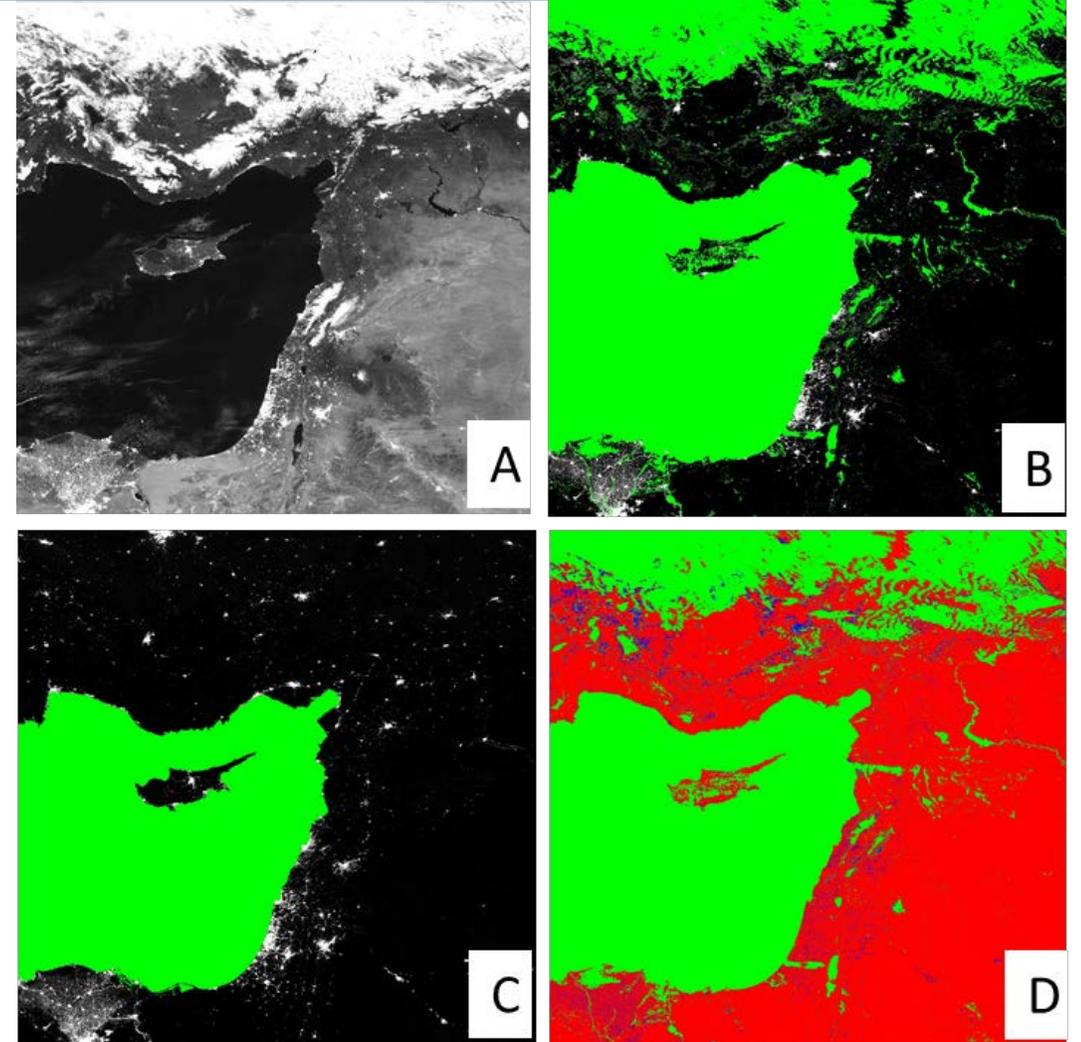
- VNP46A2 has been baselined for operational processing.
- Successful porting of Science PGEs into NOAA-20 VIIRS DNB.

## Known Issues:

- Nighttime cloud mask accuracy.

## Selected Publications:

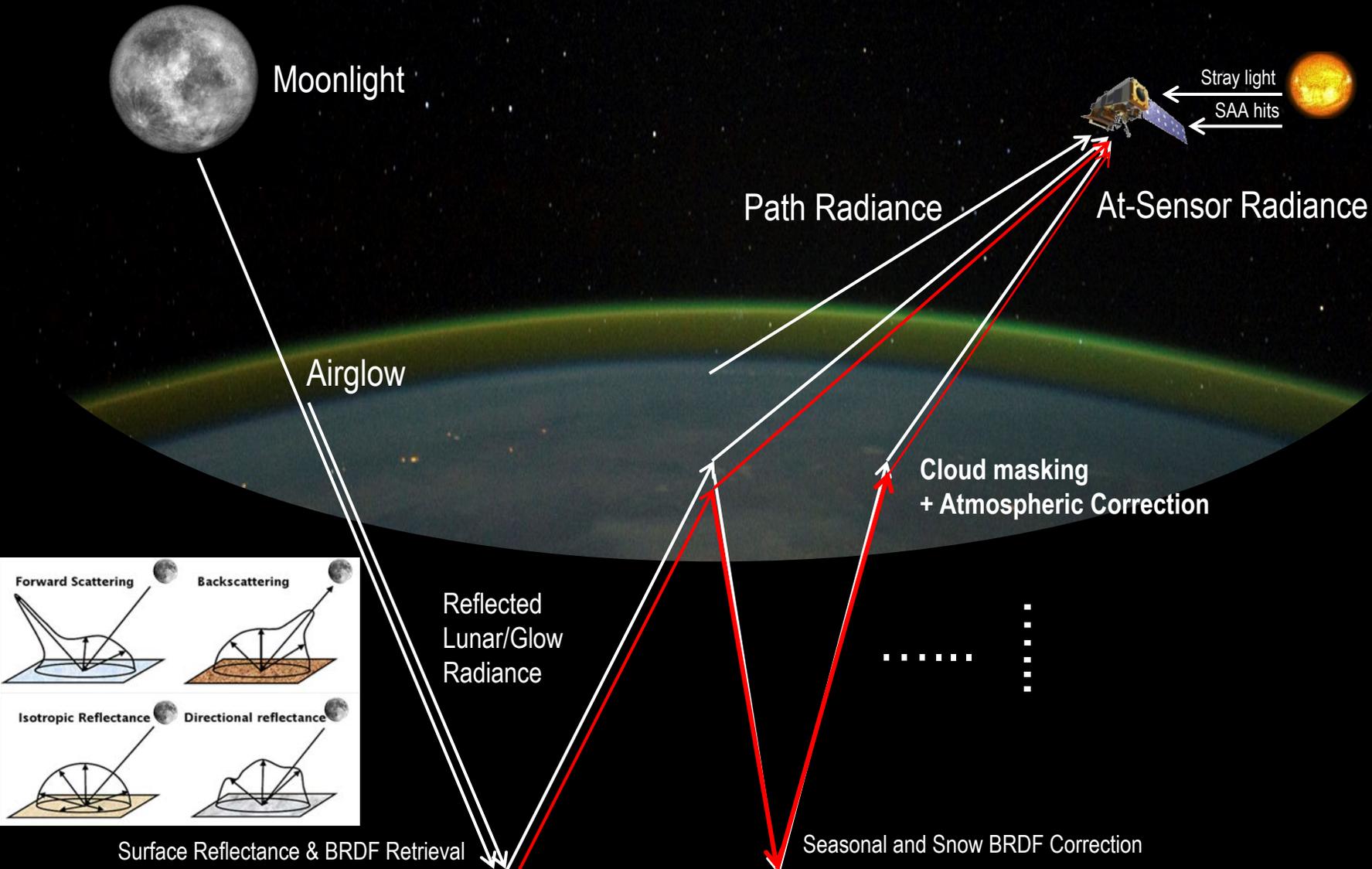
- Román et al., 2018. "NASA's Black Marble nighttime lights product suite." *Remote Sensing of Environment* 210 113-143 [doi:10.1016/j.rse.2018.03.017]
- Román et al., 2019. "Satellite-based assessment of electricity restoration efforts in Puerto Rico after Hurricane Maria." *PLoS ONE* 14 (6) [ doi:10.1371/journal.pone.0218883]



At-Sensor TOA radiance (A), lunar BRDF adjusted radiance (B), Gap-filled lunar BRDF adjusted radiance (C), and Quality assurance (D) (Red: high quality; Blue: low quality; Green: No retrieval)  
Level 3 Tile: h21v05, DOY: 2012-068.

# NASA's Black Marble Algorithm Theoretical Basis

[https://viirsland.gsfc.nasa.gov/PDF/VIIRS\\_BlackMarble\\_ATBD\\_V1.0.pdf](https://viirsland.gsfc.nasa.gov/PDF/VIIRS_BlackMarble_ATBD_V1.0.pdf)



## Methodology

- When moonlight is present at the time of satellite observation, the surface upward radiance from artificial light emissions (seen in red), can be extracted from at-sensor nighttime radiances at top-of-atmosphere.

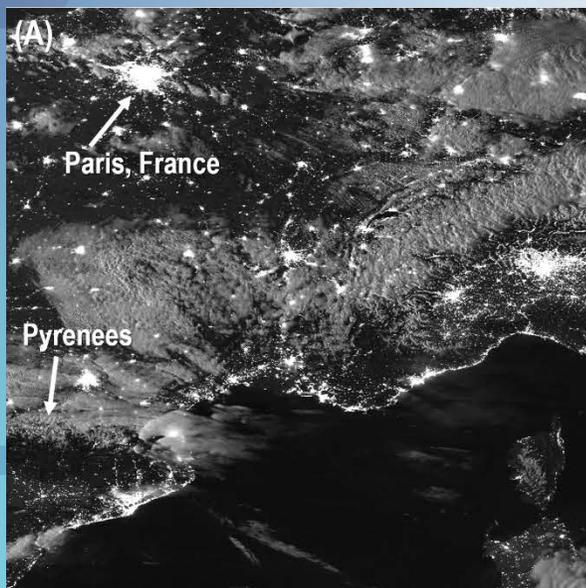
## Key parameters used

- Nighttime path radiance
- VIIRS-DNB derived actual surface albedo
- Atmospheric backscatter
- Total transmittances along the lunar-ground and ground-sensor paths

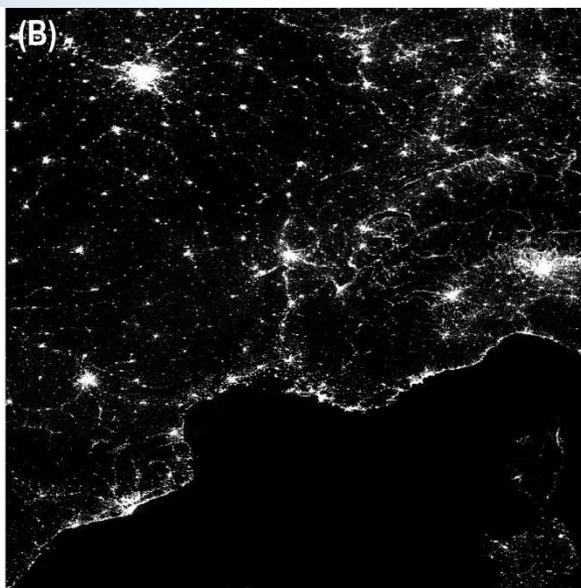
## Additional features

- Terrain Correction
- Snow BRDF Correction
- Removal of Stray light and South Atlantic Anomaly (SAA) hits

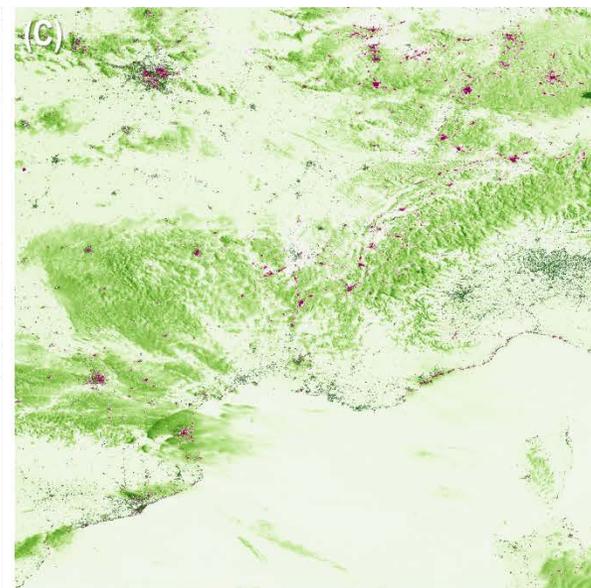
Román et al., (2018), RSE.



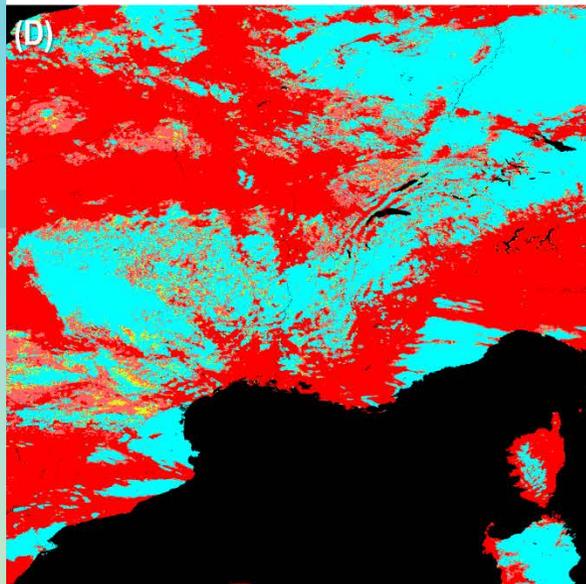
Daily At-Sensor TOA Radiance (VNP46A1)  
 0 5  $\geq 10 \text{ nW}\cdot\text{cm}^{-2}\cdot\text{sr}^{-1}$



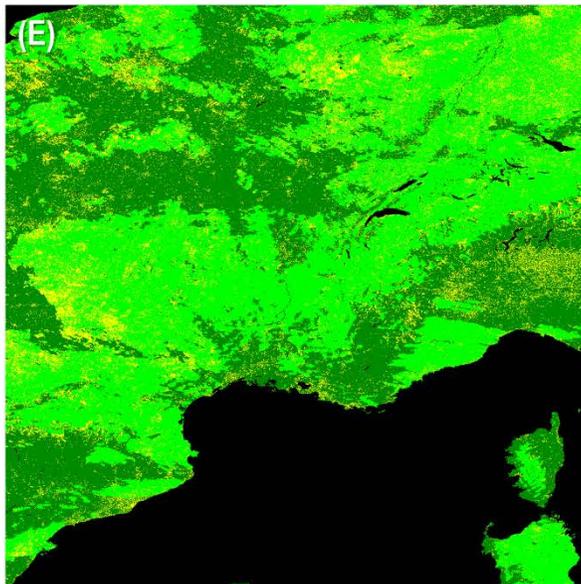
Daily Lunar BRDF Adjusted Nighttime Lights (VNP46A2)  
 0 5  $\geq 10 \text{ nW}\cdot\text{cm}^{-2}\cdot\text{sr}^{-1}$



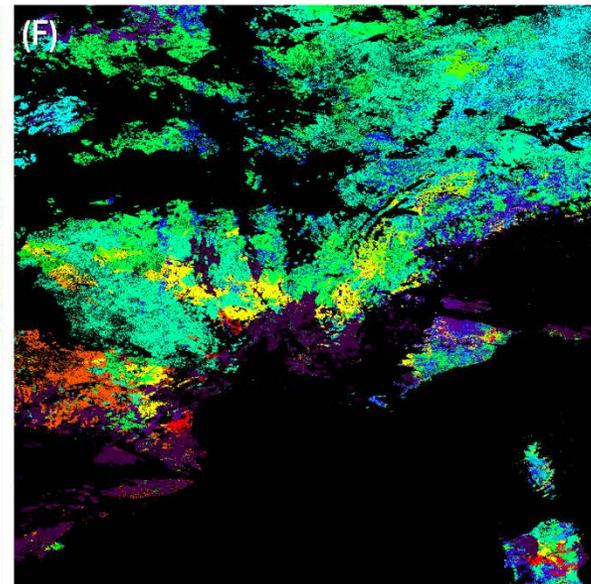
(VNP46A1 - VNP46A2)  
 $\leq -10$  0  $\geq 10 \text{ nW}\cdot\text{cm}^{-2}\cdot\text{sr}^{-1}$



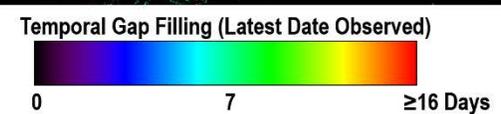
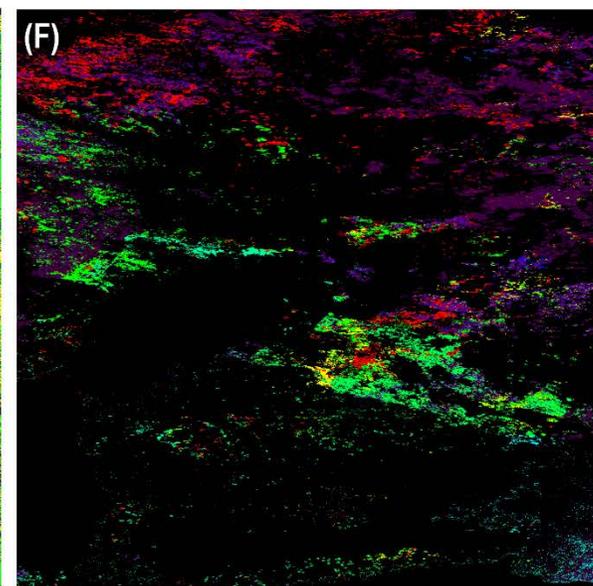
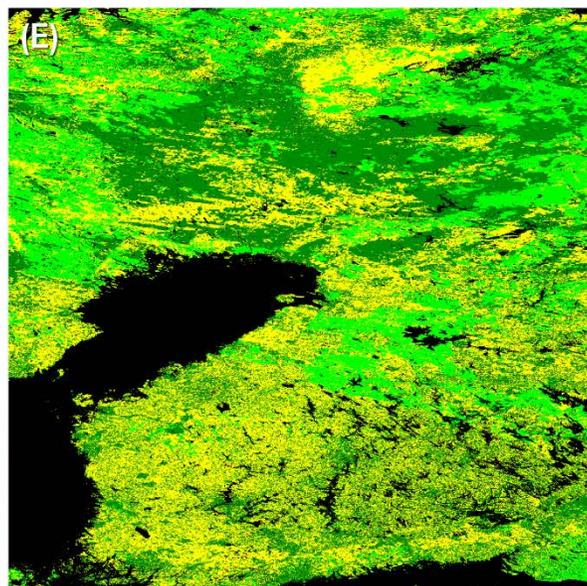
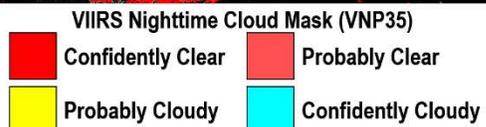
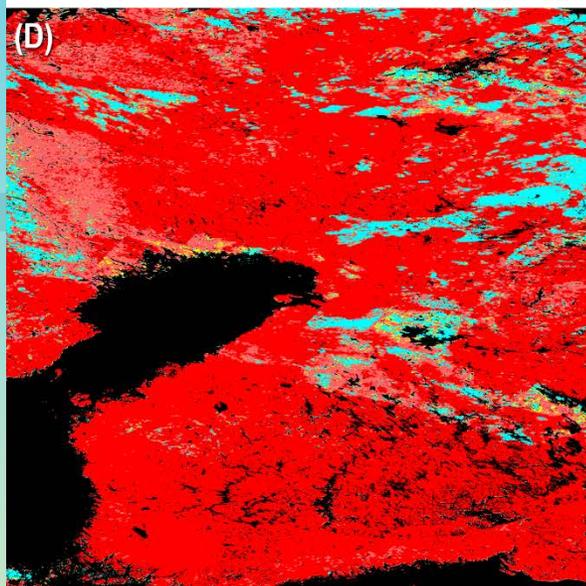
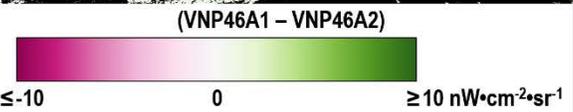
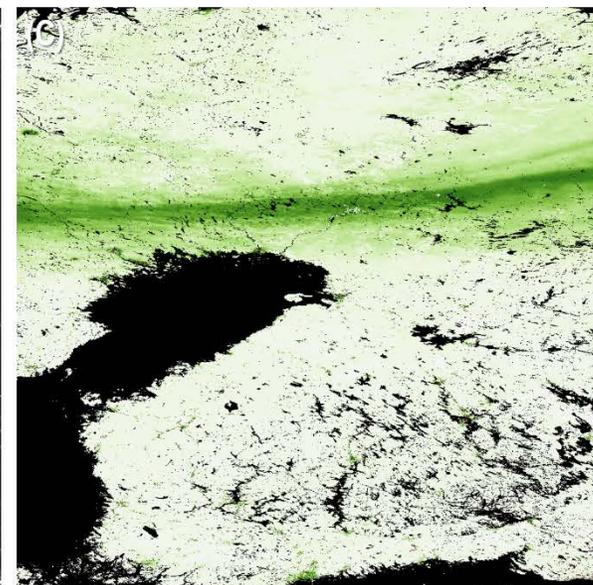
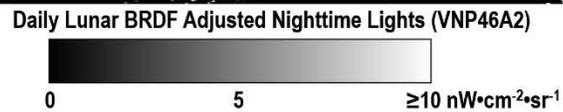
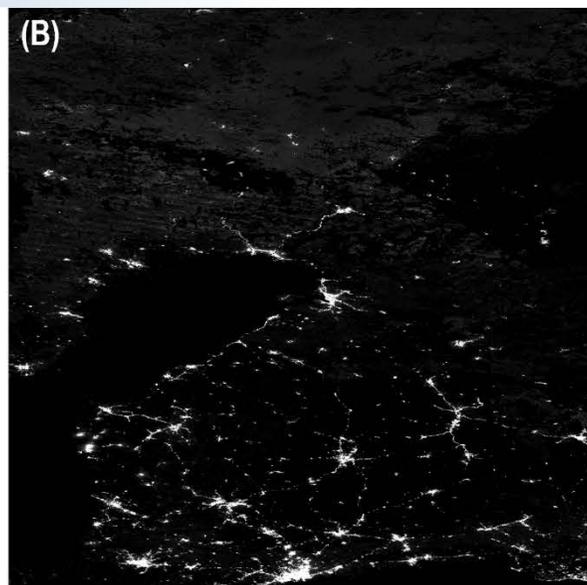
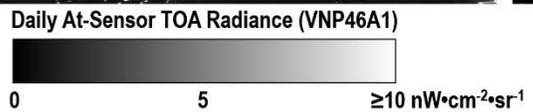
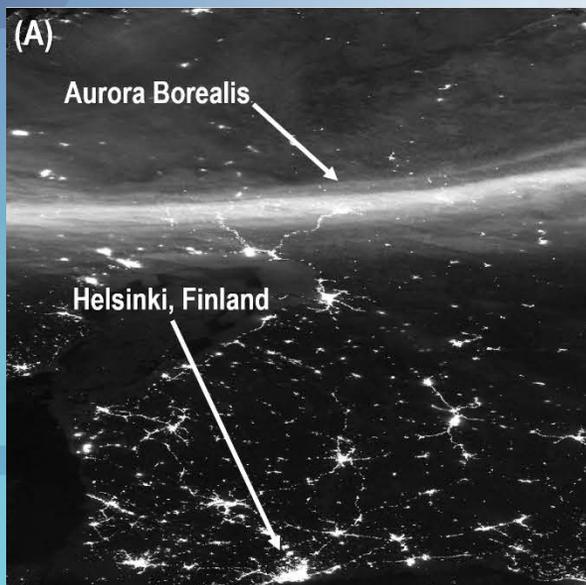
VIIRS Nighttime Cloud Mask (VNP35)  
 Confidently Clear Probably Clear  
 Probably Cloudy Confidently Cloudy



Mandatory Quality Assurance (QA)  
 Main Algorithm Temporal Gap-Filling  
 Outlier Removal Fill Value / Water Pixel



Temporal Gap Filling (Latest Date Observed)  
 0 7  $\geq 16$  Days



# MALIBU (Multi AngLe Image BRDF Unmanned aerial system)

## MALIBU system:

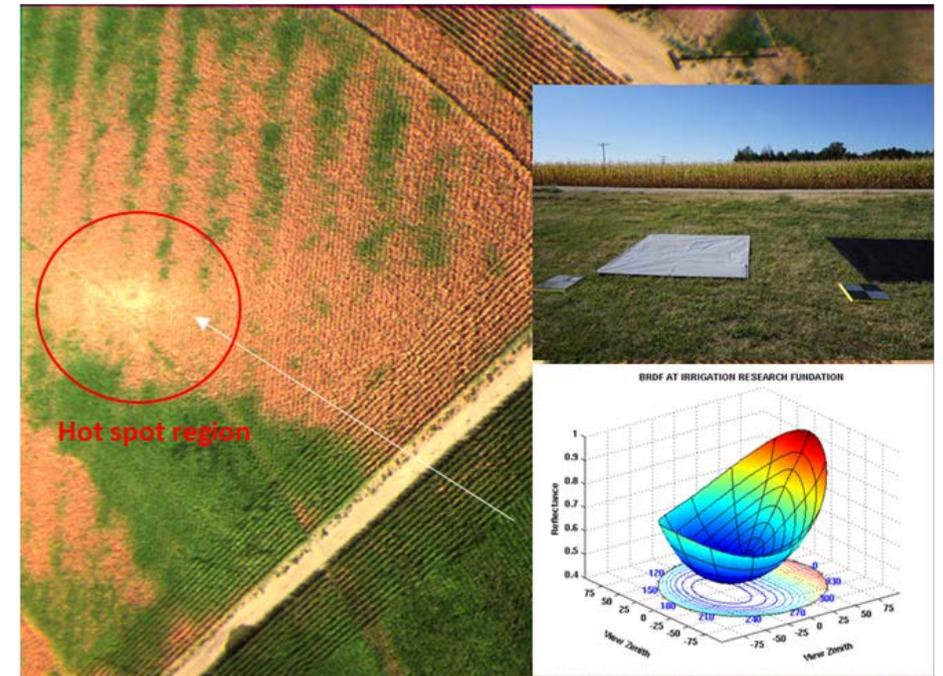
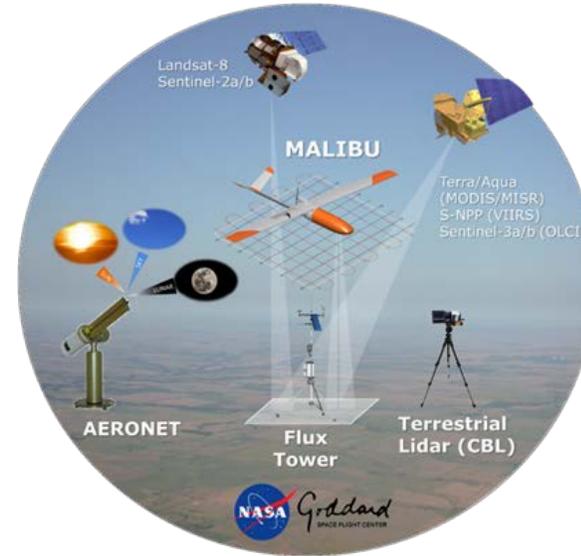
Two multispectral imagers oriented at two different viewing geometries (i.e., port and starboard sides) to capture the intrinsic surface reflectance anisotropy and albedo.

## Specifications:

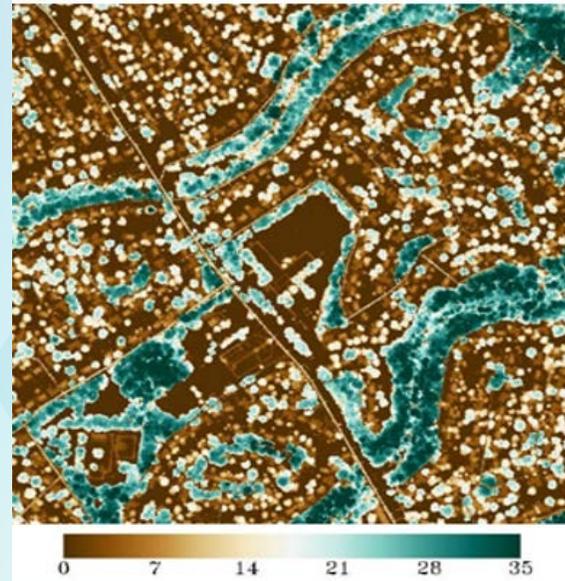
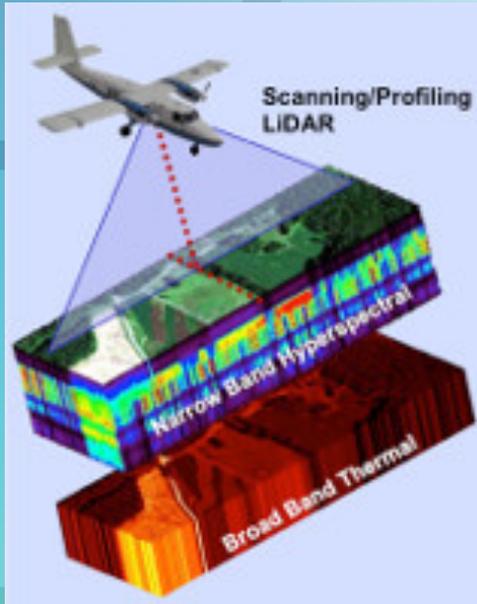
- Spectral channels : 442nm, 490nm, 531nm, 560nm, 650nm, 860nm
- Field of View (FOV): 58.5 degree (per camera)
- GSD: Un-aggregated: 5-25 cm
- Calibration: Integrating sphere at NASA GSFC

## Validation Plan:

Deploy over various land types covering different time periods. Improve VIIRS DNB BRDF/Albedo retrieval and higher-order seasonal biases.



# Addressing Seasonal Variation in Nighttime Lights



Tree heights from G-LiHT

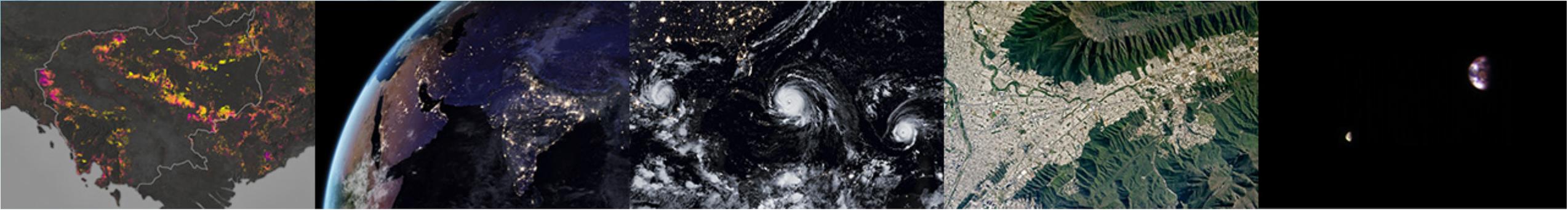


Leaf-off tree structure was collected from ground based Lidar in Maryland, March 2019. The leaf-on Lidar scanning is scheduled in July, 2019. The ground based Lidar data will be combined with airborne Lidar measurements from NASA G-LiHT which cover large area to analyze the vegetation effects on nighttime light.

The background features a central white horizontal band. Above and below this band are decorative patterns of overlapping hexagons. The top section is a gradient of blue, with darker hexagons on the left and lighter ones on the right. The bottom section is a gradient of green, with darker hexagons on the left and lighter ones on the right.

# **Metrics Reporting and Research Highlights**

# Top 5 stories by EO on Facebook



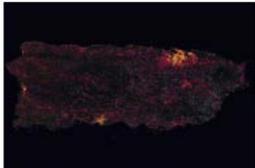
## Black Marble Stories on Earth Observatory



A Break in the Clouds for Europe



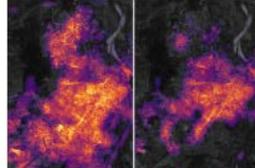
It's Valley Fog Season



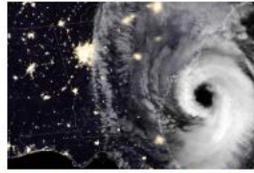
Night Lights Show Slow Recovery from Maria



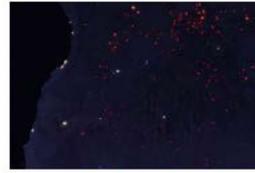
Bright Auroras Light Up the Sky and the Land



Lights Out after Cyclone Fani



Dorian Reaches South Carolina



Seasonal Fires are Burning in Angola



Night Lights Change in the Middle East



Nighttime Glow at Mount Etna



Galloway Forest Park



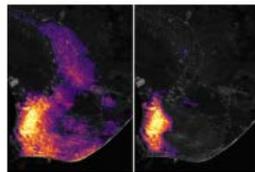
Lights Out in Michael's Wake



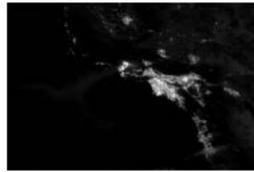
Urban Patterns in Snow and Light



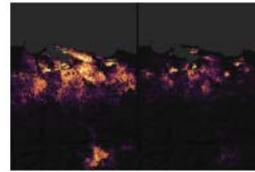
New Year's Night



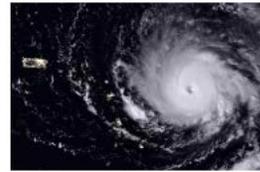
Darkness in the Wake of Idal



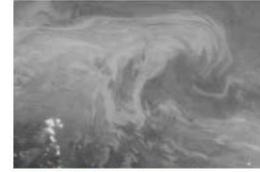
Wildfire Lights Up Ventura



Pinpointing Where Lights Went Out in Puerto Rico

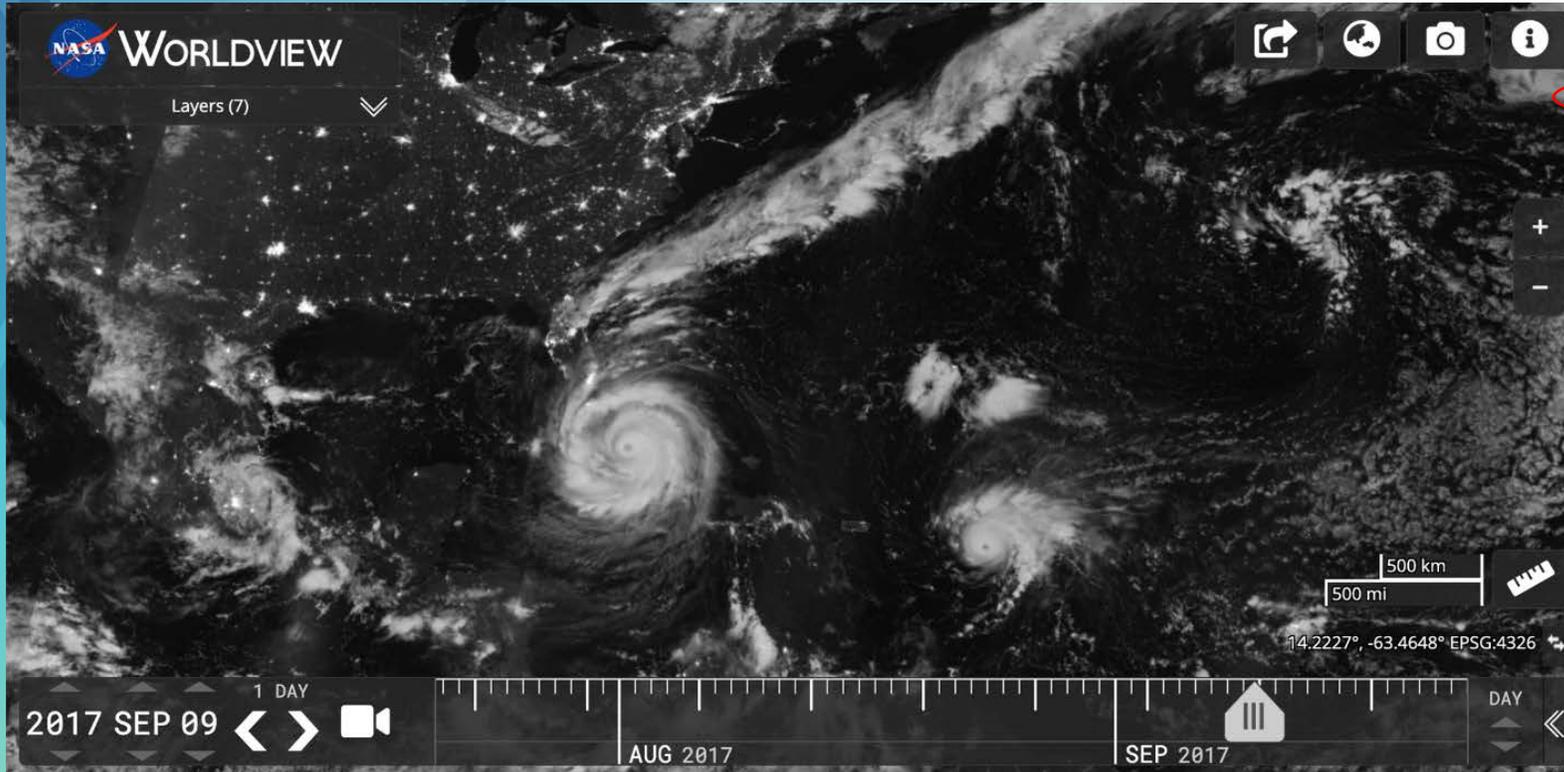


Hurricane Irma Strengthens



Lights in the Darkness

# NASA's Worldview "Top 10\*" Layers



VIIRS Suomi-NPP Nighttime imagery in Worldview showing Hurricane Irma. LANCE NRT Corrected Reflectance imagery from MODIS and VIIRS is the most viewed imagery in GIBS and Worldview followed by VIIRS Nighttime imagery.

[See LANCE team poster for more info.](#)

Layers	Percent*
VIIRS SNPP Day/Night Band ENCC	30.32%
MODIS Aqua Surface Reflectance Bands 143	9.78%
MODIS Terra Surface Reflectance Bands 721	5.00%
MODIS Aqua Aerosol Optical Depth 3km	4.99%
MODIS Terra Surface Reflectance Bands 143	4.97%
MODIS Aqua Surface Reflectance Bands 721	4.20%
MODIS Combined Value Added AOD	3.36%
VIIRS SNPP Brightness Temp Band15 Night	2.57%
AMSR2 Wind Speed Day	1.98%
MODIS Terra Surface Reflectance Bands 121	1.69%

\* - % queries for non-MODIS/VIIRS Corrected Reflectance layers



Page ?	Pageviews ? ↓
<b>VIIRS Land site visits Nov, 2019</b>	
	2,123 % of Total: 0.00% (59,751,778)
1. <a href="https://viirsland.gsfc.nasa.gov/index.html">viirsland.gsfc.nasa.gov/index.html</a>	513 (24.16%)
2. <a href="https://viirsland.gsfc.nasa.gov/products/nasa/blackmarble.html">viirsland.gsfc.nasa.gov/products/nasa/blackmarble.html</a>	483 (22.75%)
3. <a href="https://viirsland.gsfc.nasa.gov/products/nasa/nasaprod.html">viirsland.gsfc.nasa.gov/products/nasa/nasaprod.html</a>	98 (4.62%)
4. <a href="https://viirsland.gsfc.nasa.gov/products/nasa/lstesdr.html">viirsland.gsfc.nasa.gov/products/nasa/lstesdr.html</a>	56 (2.64%)
5. <a href="https://viirsland.gsfc.nasa.gov/products/nasa/firesdr.html">viirsland.gsfc.nasa.gov/products/nasa/firesdr.html</a>	53 (2.50%)
6. <a href="https://viirsland.gsfc.nasa.gov/products/nasa/viesdr.html">viirsland.gsfc.nasa.gov/products/nasa/viesdr.html</a>	52 (2.45%)
7. <a href="https://viirsland.gsfc.nasa.gov/tools.html">viirsland.gsfc.nasa.gov/tools.html</a>	52 (2.45%)



# EO Content on Google Voyager



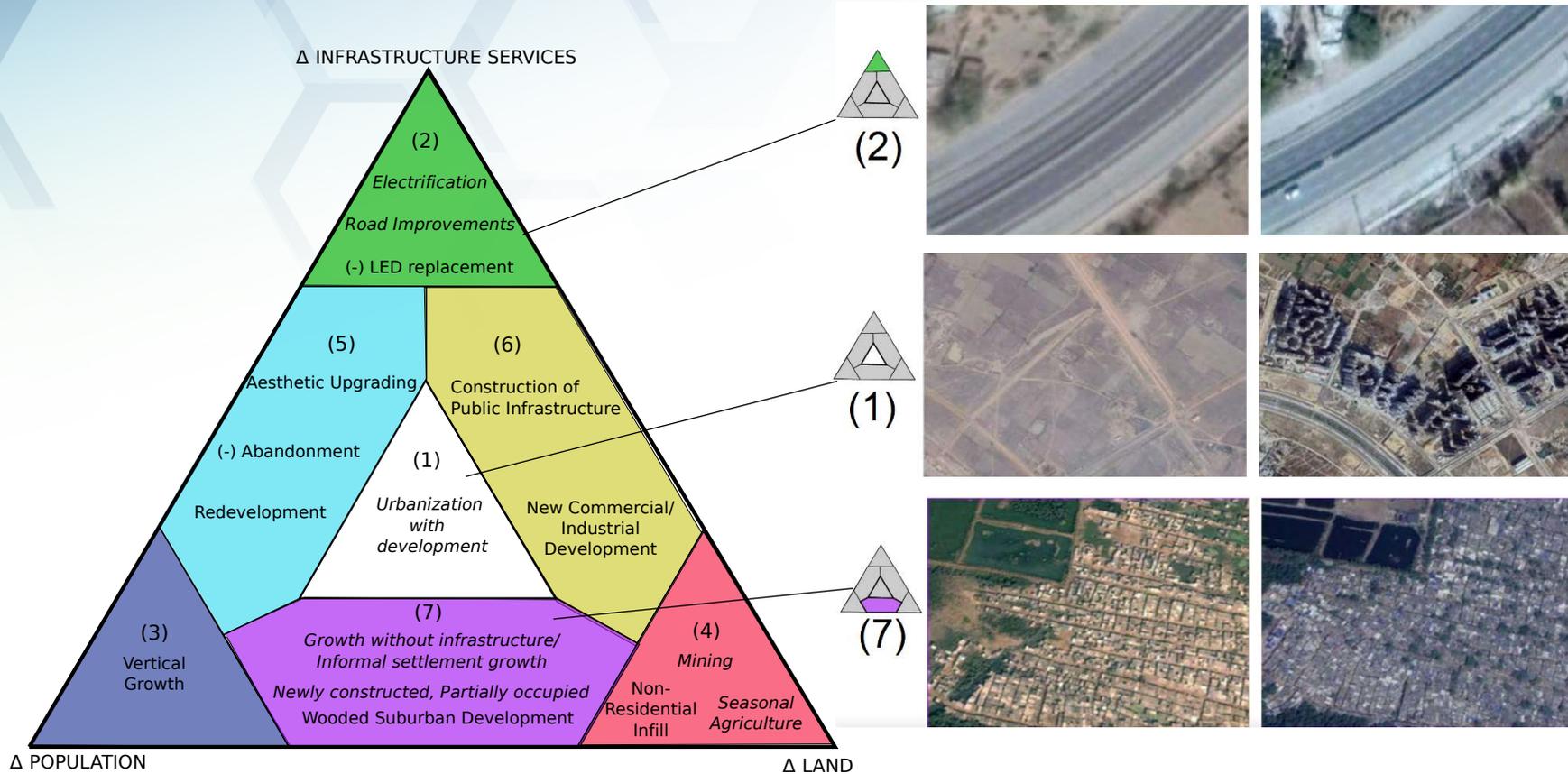
Google Earth Booth at #GEOWeek19

- Total views: 1.7M
  - **Earth at Night: 618,457**
  - Eclipse: 495,581
  - ABCs: 304,616
  - Clouds: 263,686
  - Scenes: 24,386
- 
- Three of NASA's four stories were in the top 20 Voyager stories viewed (out of 222 total stories).



# Characterizing Urban Infrastructural Transitions for the SDG's Using Multi-Temporal Land, Population, and Nighttime Light Data

Eleanor C. Stokes and Karen C. Seto, RSE, DOI: [10.1016/j.rse.2019.111430](https://doi.org/10.1016/j.rse.2019.111430)

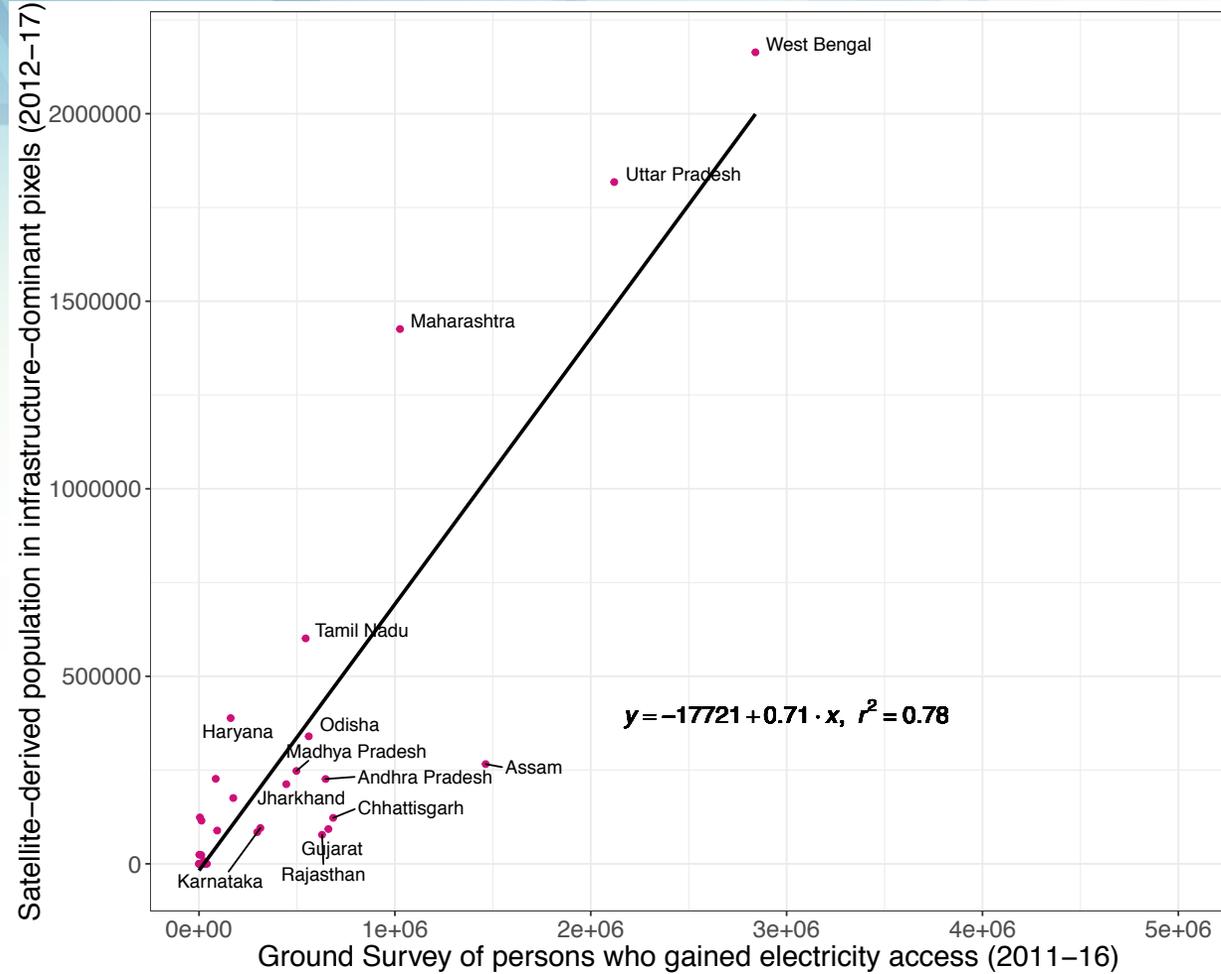


Though urbanization is often linked to development gains, some regions in Asia, Latin America, and Sub-Saharan Africa have grown in urban population, while remaining bereft of basic services like reliable electricity. Daytime optical remote sensing has tracked urban land cover change for decades, but few studies have monitored whether infrastructure is keeping pace with demographic and land transitions. This study fuses multi-temporal population and land data with nighttime lights data, derived from the Suomi-NPP VIIRS Day Night Band, classifying different types of urban development processes in India and the US.



# Characterizing Urban Infrastructural Transitions for the SDG's Using Multi-Temporal Land, Population, and Nighttime Light Data

Eleanor C. Stokes and Karen C. Seto, RSE, DOI:[10.1016/j.rse.2019.111430](https://doi.org/10.1016/j.rse.2019.111430)



The new classes developed relate directly to human well-being as they describe when infrastructural transitions have kept pace with land and demographic transitions. In India, the class “electrification” tracks the national electrification projects in West Bengal and Uttar Pradesh over the past decade. Regression results above show that estimates of rural population gaining access to electricity between 2011 and 2017 based on the remote-sensing classification closely match estimates based on ground surveys.

EDITION IN THE HUFFINGTON POST

NEWS POLITICS ANALYSIS BUSINESS ENTERTAINMENT LIFESTYLE BLOGS MORE

**NEWS**  
**NASA Releases New Global Maps Of Earth's 'Night Light' And India Looks Absolutely Stunning**  
 Clearest yet composite view.  
 13/04/2017 3:13 PM IST | Updated 1 hour ago

PTI

**TRENDING**

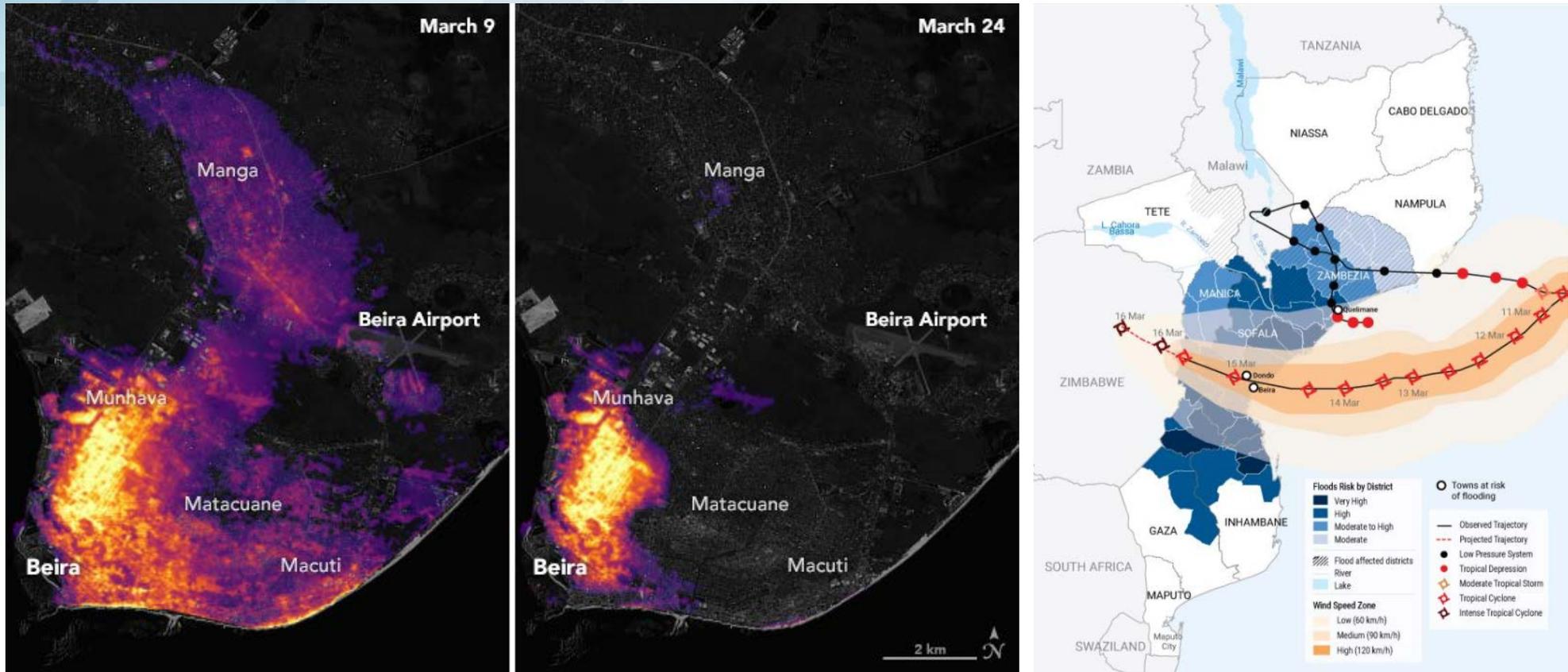
- Shah Rukh Khan Had A Verry Unconvincing Defense When Asked About Endorsing Fairness Creams In 2016
- Pratyusha Banerjee Was Forced Into Prostitution By Boyfriend Rahul Raj Singh, Says Her Lawyer
- 30 Offbeat Indian Destinations That Will Blow Your Senses
- NASA Releases New Global Maps Of Earth's 'Night Light' And India Looks Absolutely Stunning



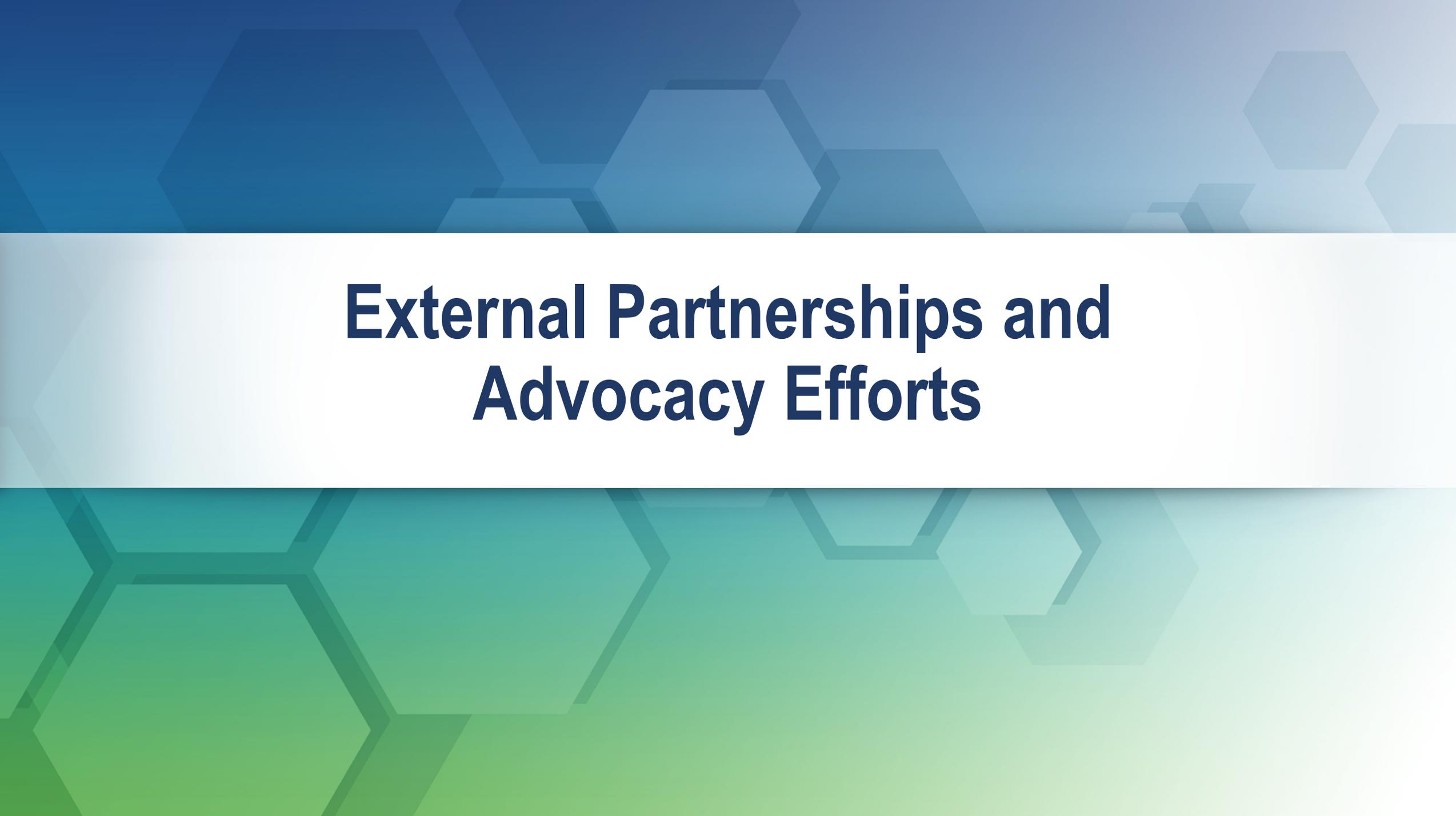
# Advanced analysis of displacement based on NASA's Black Marble

Markus Enenkel, Ranjay Shrestha, Eleanor Stokes, Miguel Román, Zhuosen Wang, et al. 2019

IBM Journal of Research and Development , DOI: [10.1147/JRD.2019.2954404](https://doi.org/10.1147/JRD.2019.2954404)



This study aimed to support the monitoring of displacement via satellite-derived observations of night time lights (NTL) from NASA's Black Marble product suite along with an SMS-based emergency survey after cyclone Idai had made landfall in Beira (Mozambique) in March 2019. Information about anomalies in NTL has the potential to support humanitarian decision-making via estimations of people affected or the coordination of rapid response teams. We found that around 90 percent of Beira's power grid had been affected. In collaboration with the [Internal Displacement Monitoring Center \(IDMC\)](#) we used these findings to establish a framework that links NTL observations with existing humanitarian decision-making workflows to complement ground-based survey data and other satellite-derived information, such as flood or damage maps.

The background features a central white horizontal band. Above and below this band are decorative patterns of overlapping hexagons. The top section is a gradient of blue, transitioning from a darker blue on the left to a lighter blue on the right. The bottom section is a gradient of green, transitioning from a darker green on the left to a lighter green on the right. The hexagons are semi-transparent and vary in size and opacity, creating a layered, geometric effect.

# **External Partnerships and Advocacy Efforts**



Members of the Black Marble Alliance convened their kickoff meeting on October 29 2019. Partners expressed their collective commitment to addressing cross-cutting priorities to: **(1)** Strengthen Urban Resilience; **(2)** Optimize Supply-Chain Risk Management; and **(3)** Improve Disaster Risk Management.

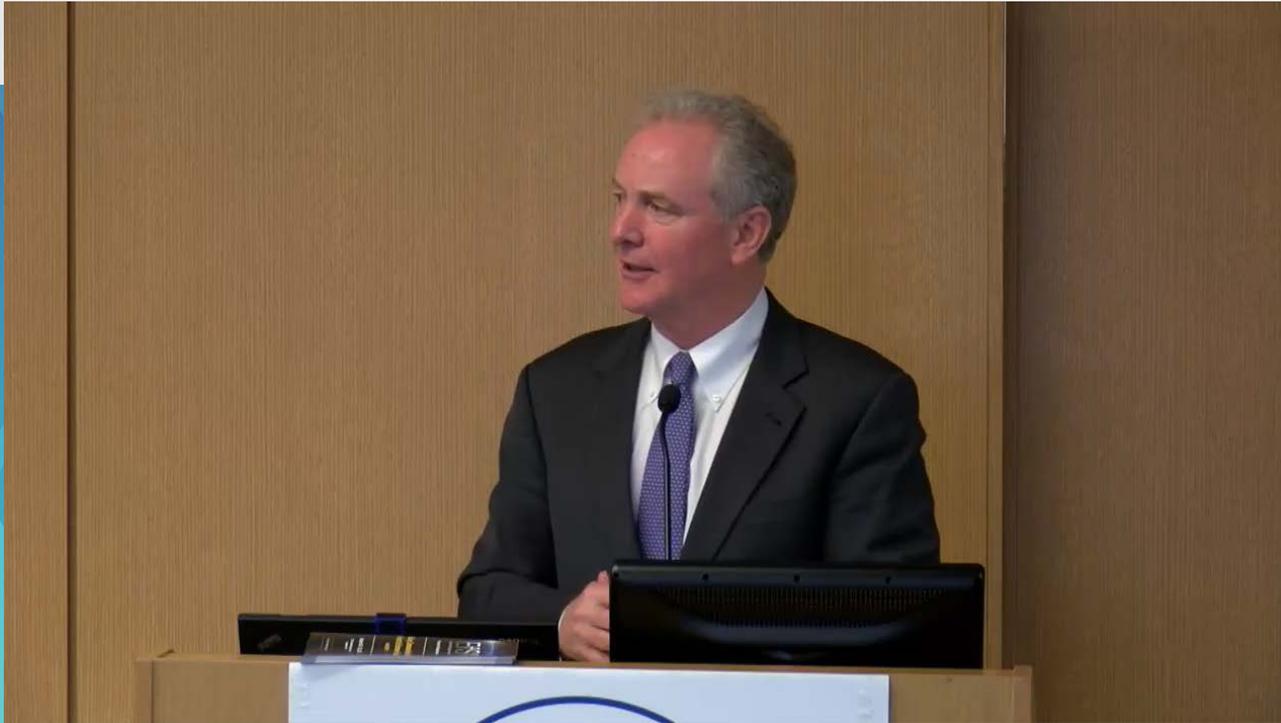


Inaugural Symposium:  
**Making Communities More Resilient to Extreme Flooding**



The inaugural EfSI-2019 symposium event was the first of a series of biennial symposia that will continue to strengthen our framework of cooperation to foster scientific contributions to the decision-making process in the fields of disaster risk management and community resilience (<https://efsi.usra.edu>.)

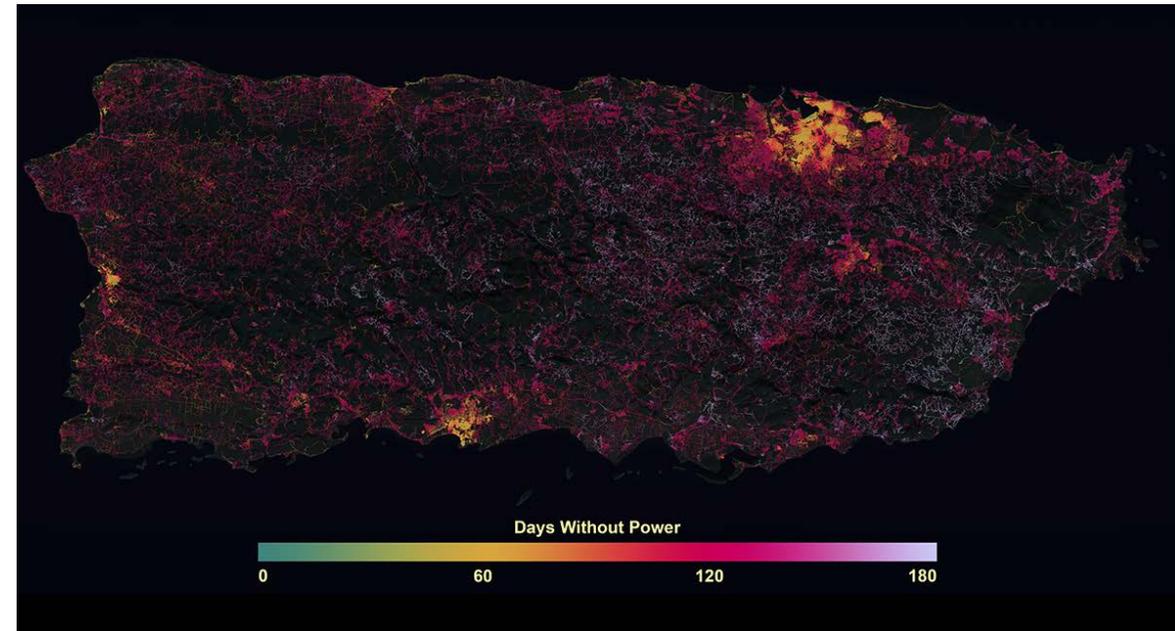
# Opening Remarks by Senator Chris Van Hollen (D-MD)



## Satellite-based assessment of electricity restoration efforts in Puerto Rico after Hurricane Maria

Miguel O. Román , Eleanor C. Stokes  , Ranjay Shrestha, Zhuosen Wang, Lori Schultz, Edil A. Sepúlveda Carlo, Qingsong Sun, Jordan Bell, Andrew Molthan, Virginia Kalb, Chuanyi Ji, Karen C. Seto, Shanna N. McClain, Markus Enenkel

Published: June 28, 2019 • <https://doi.org/10.1371/journal.pone.0218883>



## \$1.4 Billion:

- 200,000 households with small rooftop PV systems.
- Reduces Puerto Rico's blackout by 173 days.
- Reduces fuel costs by \$157 million / year.

Román et al., (2019), PLOS One

<https://events.tvworldwide.com/Events/Earth-from-Space-Institute-2019/>

# What's next for Black Marble?

## Algorithm Improvements

Monthly/ annual composites

Combine Suomi-NPP and NOAA-20 for better daily observations

Improve cloud mask

Aurora Masking using Machine Learning Methods (NPP Postdoc based at GSFC)

Improved nighttime aerosol retrievals (in collaboration with UND and Colorado State)

## Urban structure/change

- Study of urban vertical characteristics and change through nightlights
- Analysis of urban accessibility to service centers
- Light pollution, urbanization, and biodiversity

## Energy, Electrification, and Infrastructure

- PG&E outages and wildfire prevention
- Validation of outage customer estimates with ground utility data during Hurricane Sandy
- Creation of Energy reliability metrics

## Disasters Risk Reduction Efforts (work with USRA/EfSI and Black Marble Alliance)