The Use of International and Chinese Satellites to Support Critical Applications in the Belt and Road Region

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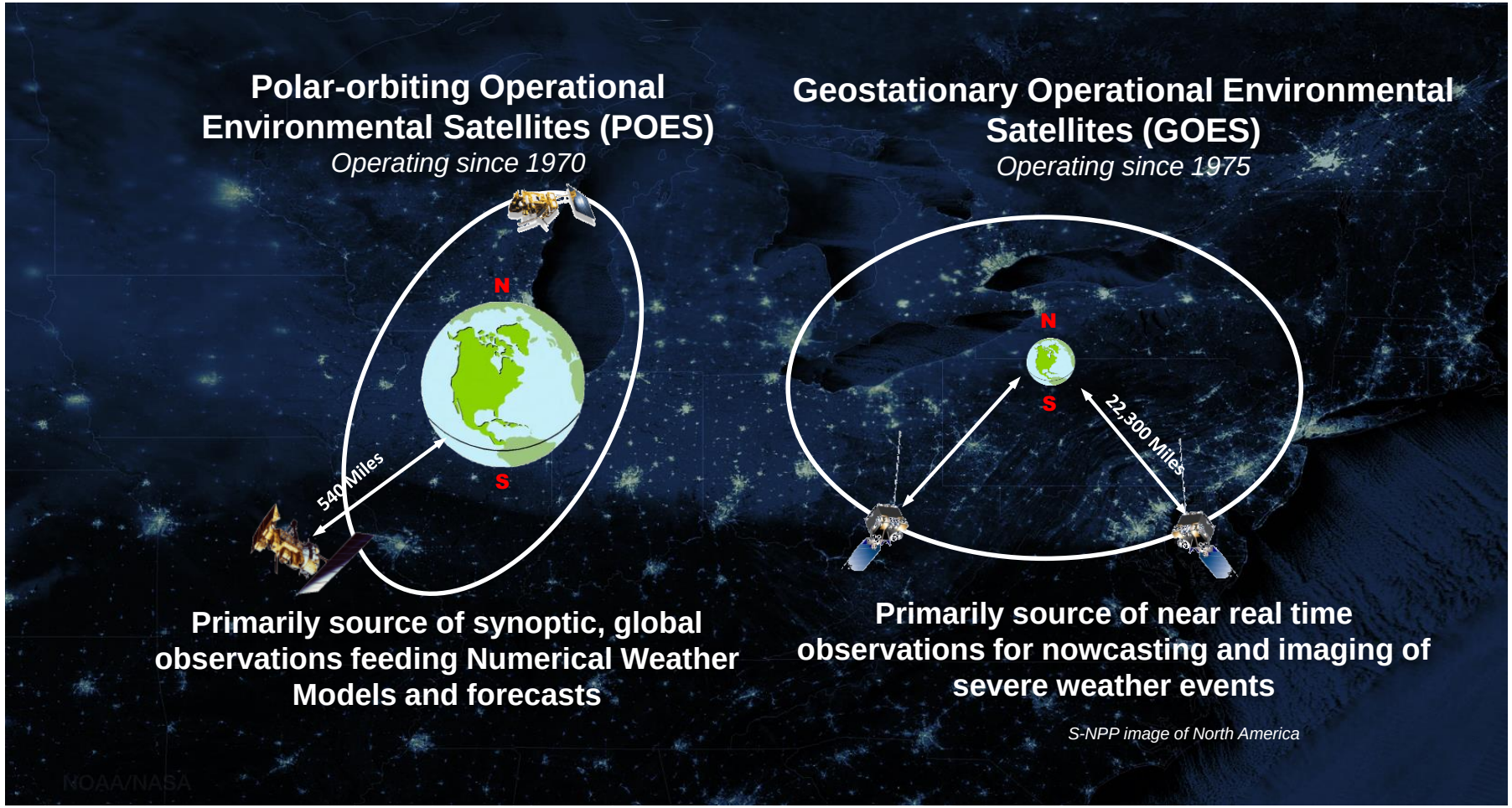
NOAA

Satellite and Information Service

15 Nov 2019

NOAA, CMA and EUMETSAT have the same important strategy: Operational Weather Polar and Geostationary Orbiting Satellites



We work together to support our user communities through direct access of critical satellite data and through training

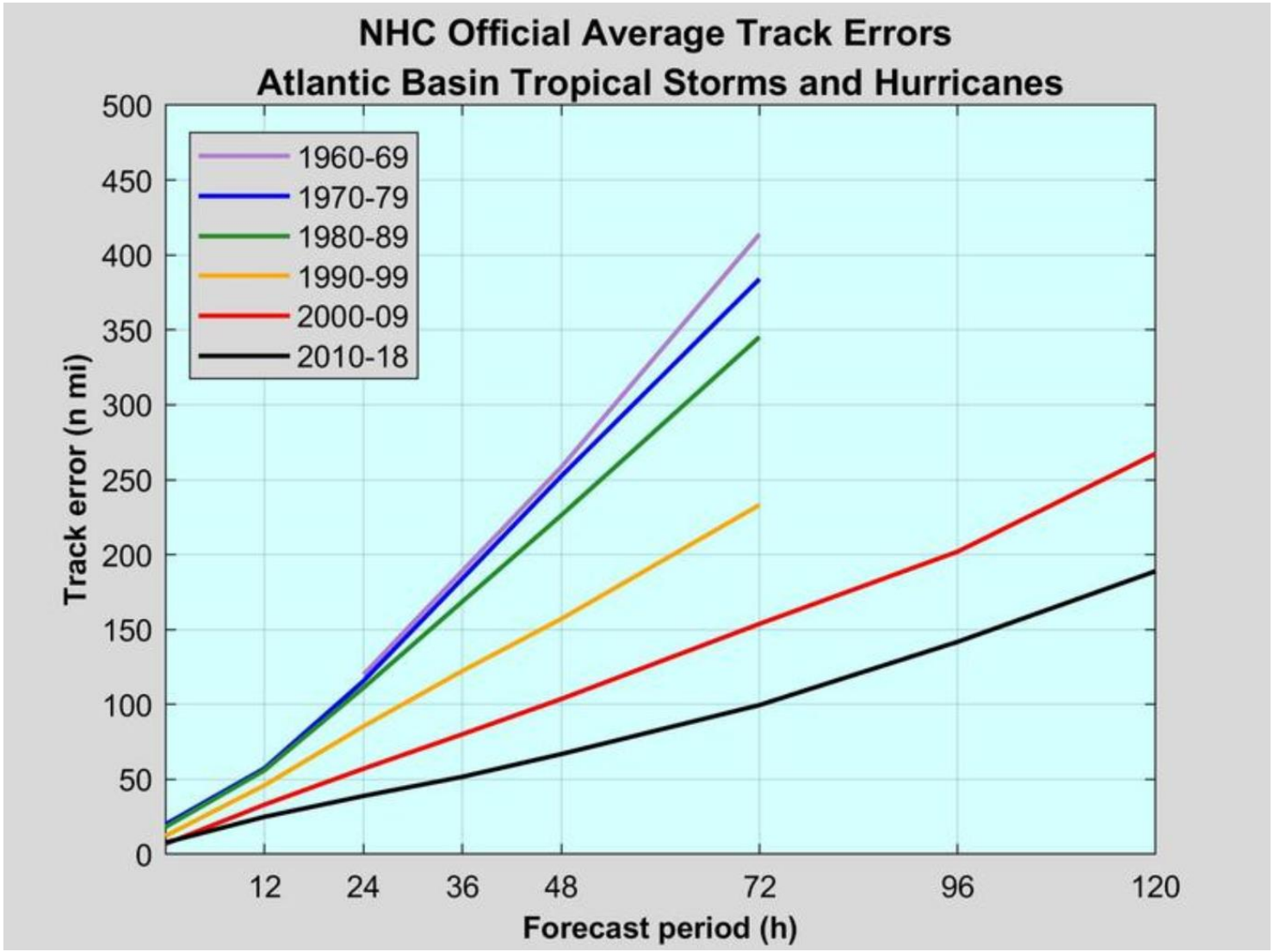
This approach has produced great returns over the years

- **Significant Improvements in 3 – 7 day weather forecasts**

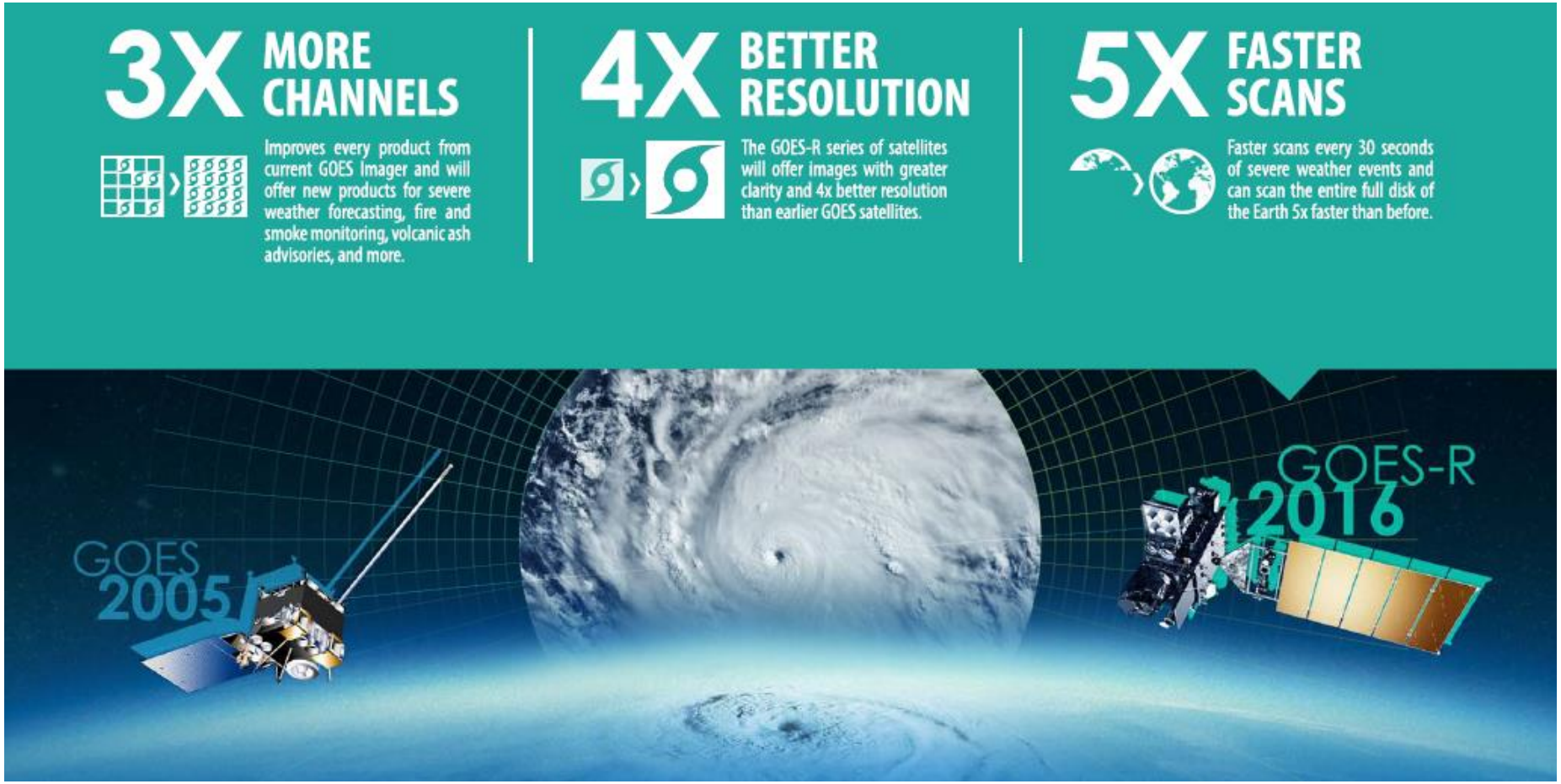
  Hurricane track errors significantly reduced

- **Improved severe storm warnings & alerts**

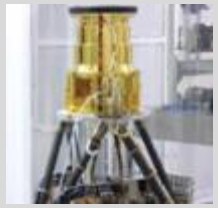
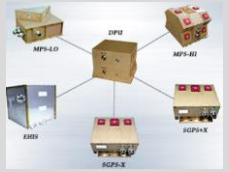
  Tornado warning lead time from 3 to 14 minutes since 1980



GOES-R Series: The Future of Forecasting



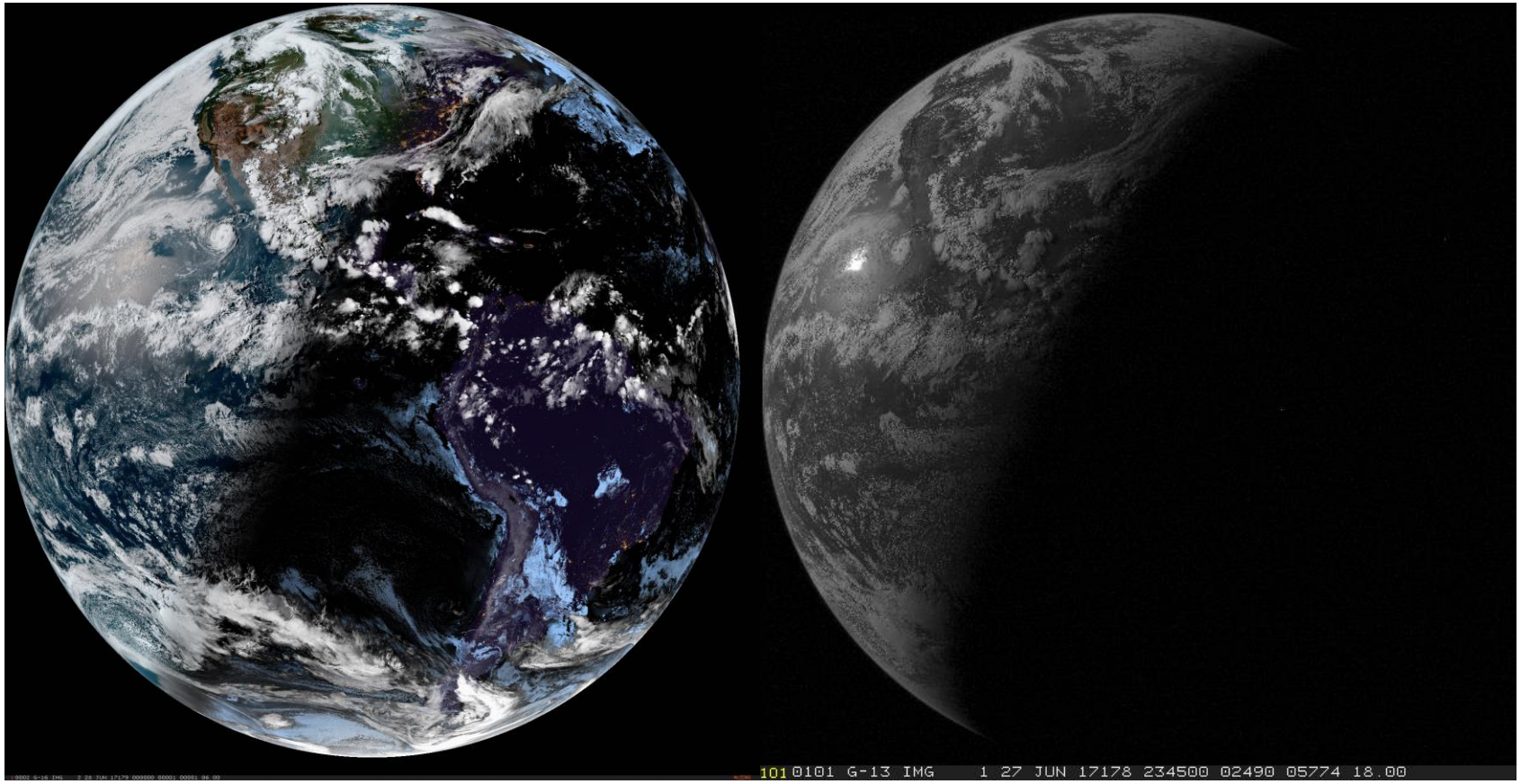
GOES-R Series Payload Capability

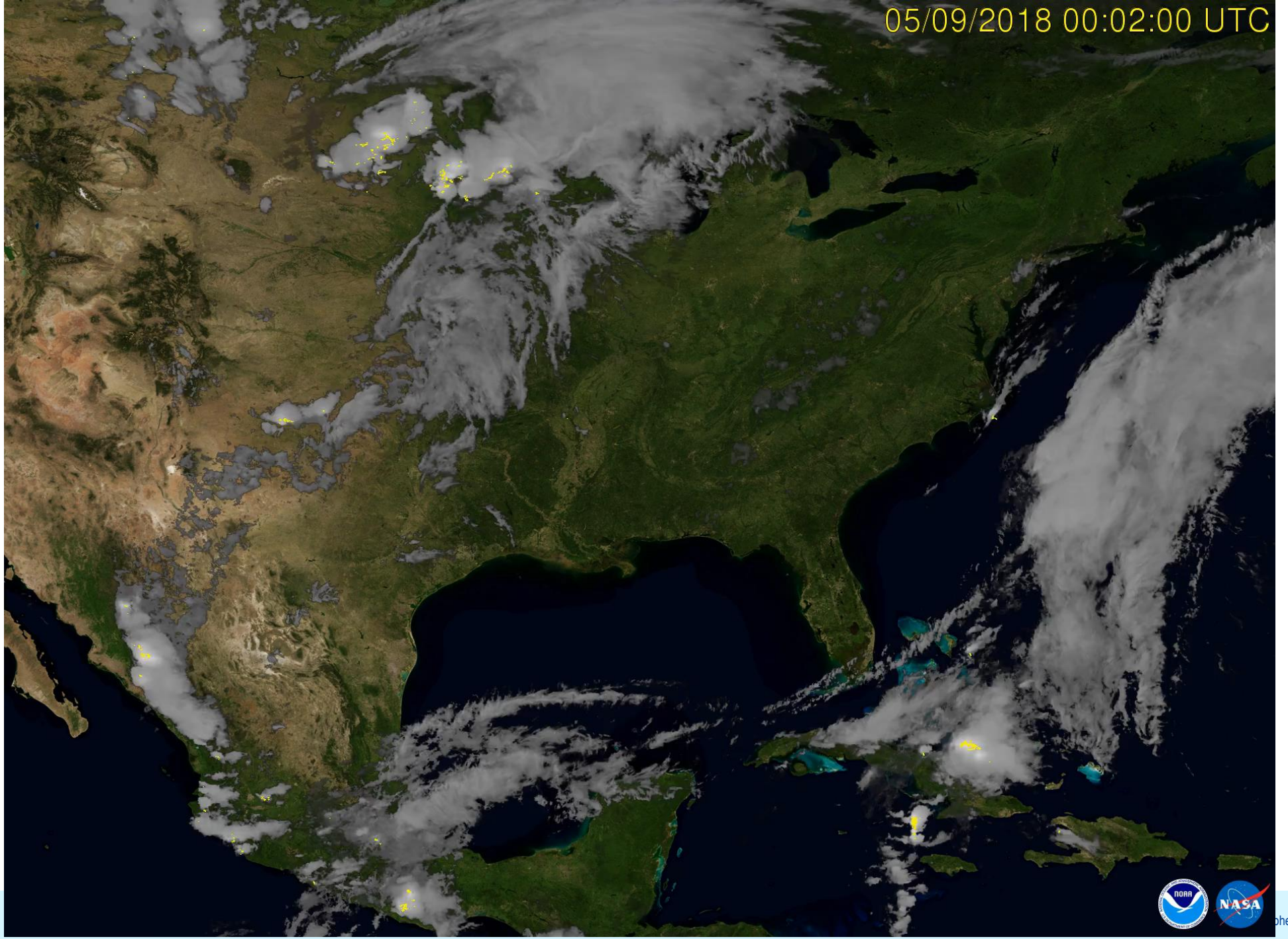
	GOES-R Series Instruments		Measurements & Products	Vendor
Earth-Observing		**ABI** – Advanced Baseline Imager	Provides Earth weather, climate, ocean, and environment imagery, 4x spatial resolution, 5x faster	Harris
		**GLM** – Geostationary Lightning Mapper	Maps in-cloud and cloud-to-ground lightning activity	Lockheed Martin
Solar-Observing		**SEISS** – Space Environment In-Situ Suite	Monitors proton, electron, and heavy ion fluxes	ATC
		**Magnetometer**	Measures space environment magnetic field	Lockheed Martin
		**EXIS** – Extreme Ultraviolet and X-Ray Irradiance Sensors	Monitors solar flares and solar variations	LASP
		**SUVI** – Solar Ultraviolet Imager	Observes coronal holes, solar flares, and coronal mass ejections	Lockheed Martin

Full Disk Imagery Increased From 8X to 96X per Day

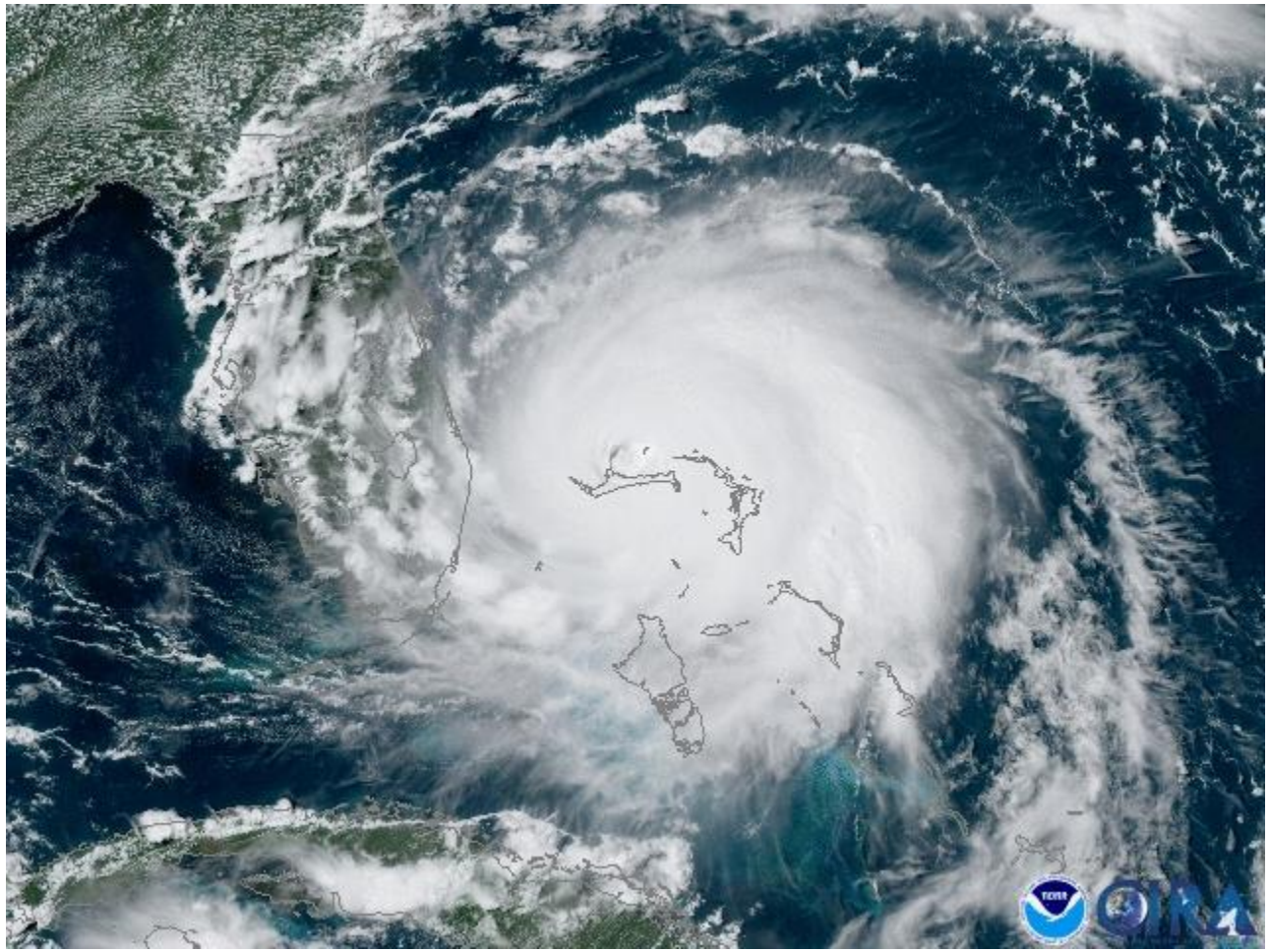
GOES-16 every 15 minutes

GOES-13 every 3 hours

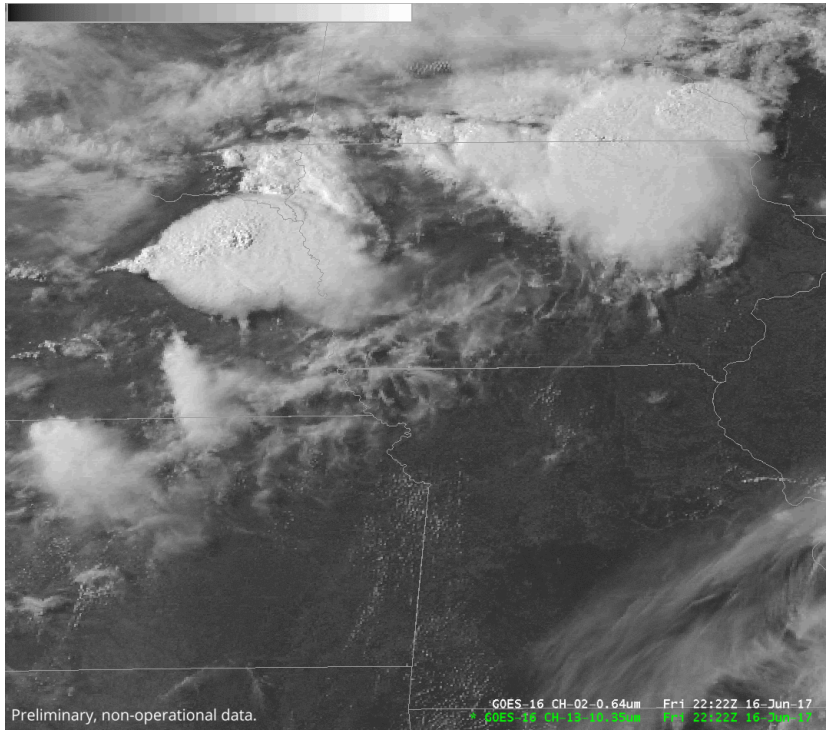


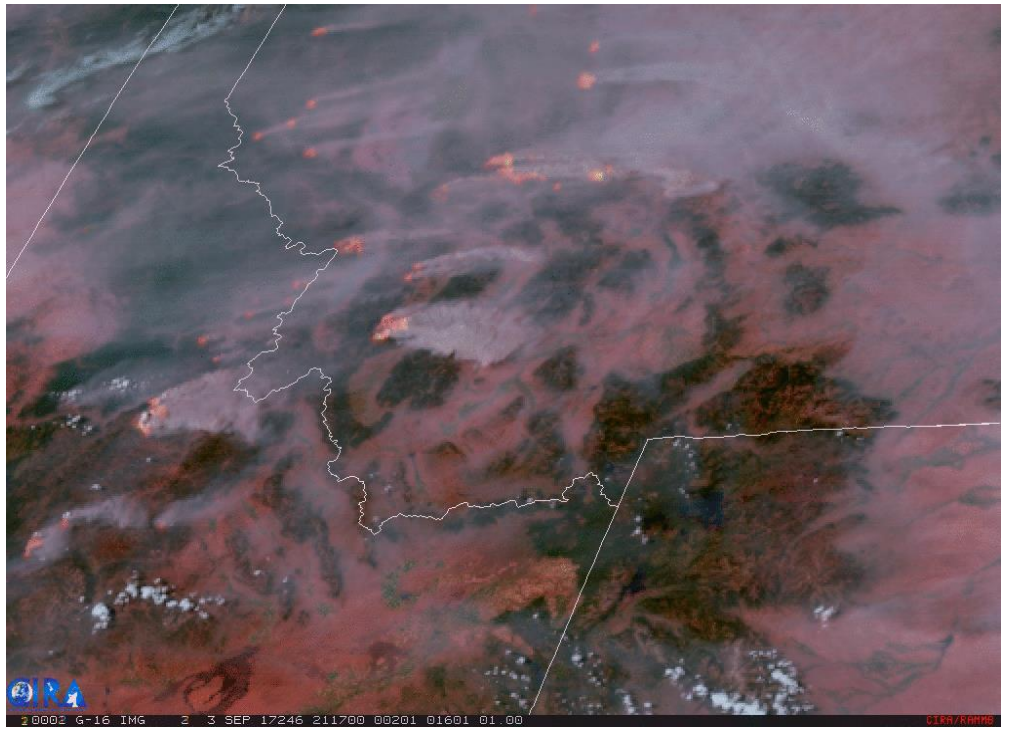

05/09/2018 00:02:00 UTC

Sentinel in the Sky - Watching Hurricane Dorian



GOES-16 Not Just Weather



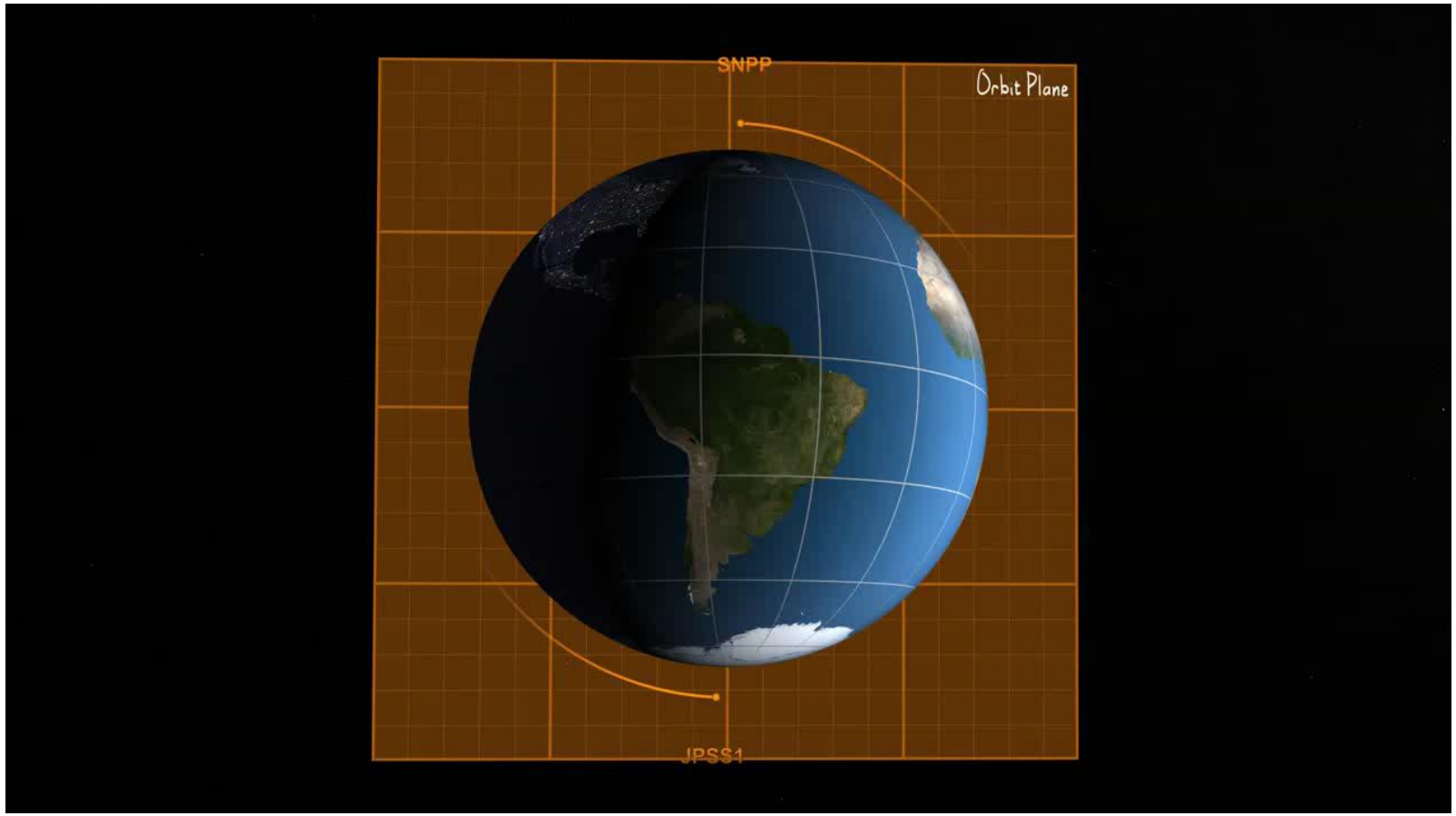


GOES-16 – Fire Temp. RGB + GeoColor – 3 Sept. 2017

Improving Forecast Accuracy & Timeliness

JPSS satellites:

- Circle the Earth from pole-to-pole and cross the equator 14 times daily in the afternoon orbit—providing full global coverage twice a day.
- Provide critical data to the numerical forecast models that produce 3- to 7-day mid-range forecasts.
- Provide support for zero to 3-day operational forecasting in Polar Regions

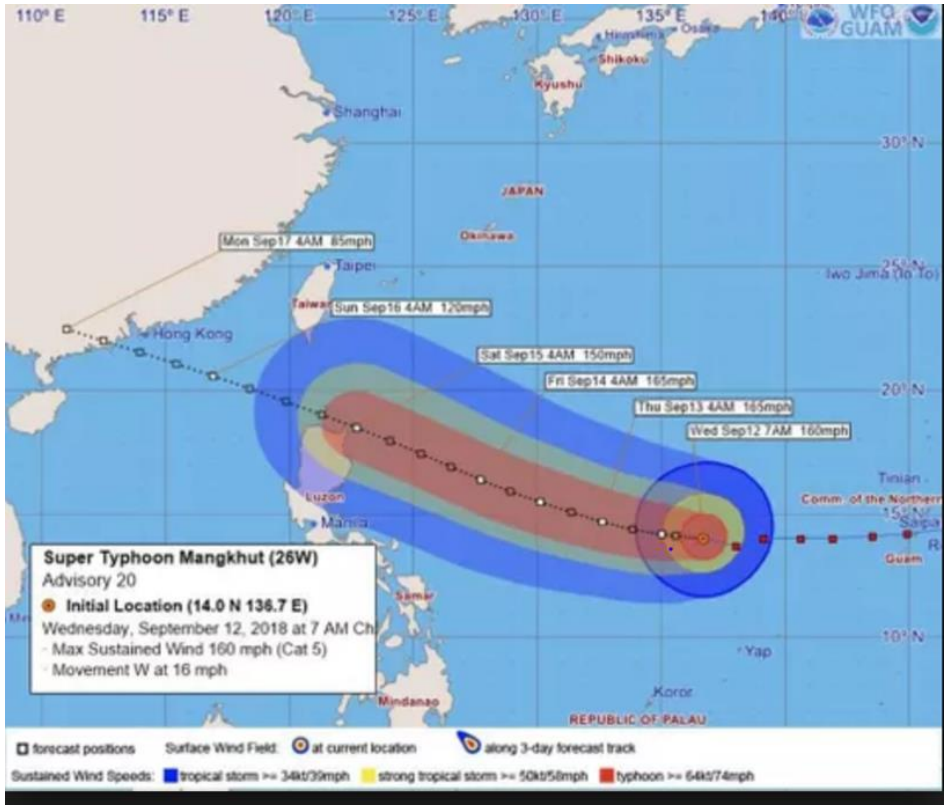


JPSS Payload Capability

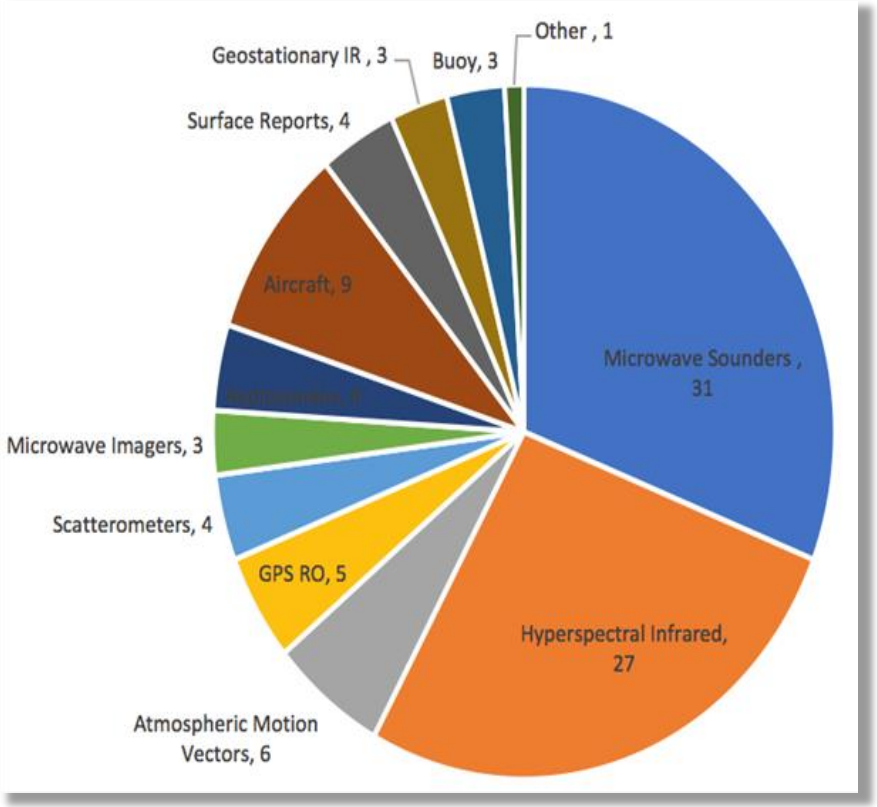
JPSS Instruments		Measurements & Products	Vendor
	**ATMS** – Advanced Technology Microwave Sounder	High vertical resolution temperature and water vapor information critical for forecasting extreme weather events, 5 to 7 days in advance	NGES
	**CrIS** – Cross-track Infrared Sounder		Harris
	**VIIRS** – Visible Infrared Imaging Radiometer Suite	Critical Imagery products, including snow/ice cover, clouds, fog, aerosols, fire smoke plume, vegetation health, phytoplankton abundance/chlorophyll	Raytheon
	**OMPS** – Ozone Mapping Profiler Suite (Nadir Mapper, Nadir Profiler, Limb - S-NPP, JPSS-2+)	Ozone spectrometers for monitoring ozone hole health, recovery of stratospheric ozone, and for UV index forecast	Ball Aerospace
	**CERES** – Clouds and the Earth's Radiant Energy System (S-NPP & JPSS-1) **New procurement** (JPSS-3, 4)	Scanning radiometer that supports studies of Earth Radiation	CERES – NGAS

Sounders are a Core Component of the Weather Forecast Enterprise

85% of all data used in forecast models are from polar-orbiting satellites and attribute to nearly 60% of the reduction in forecast error.

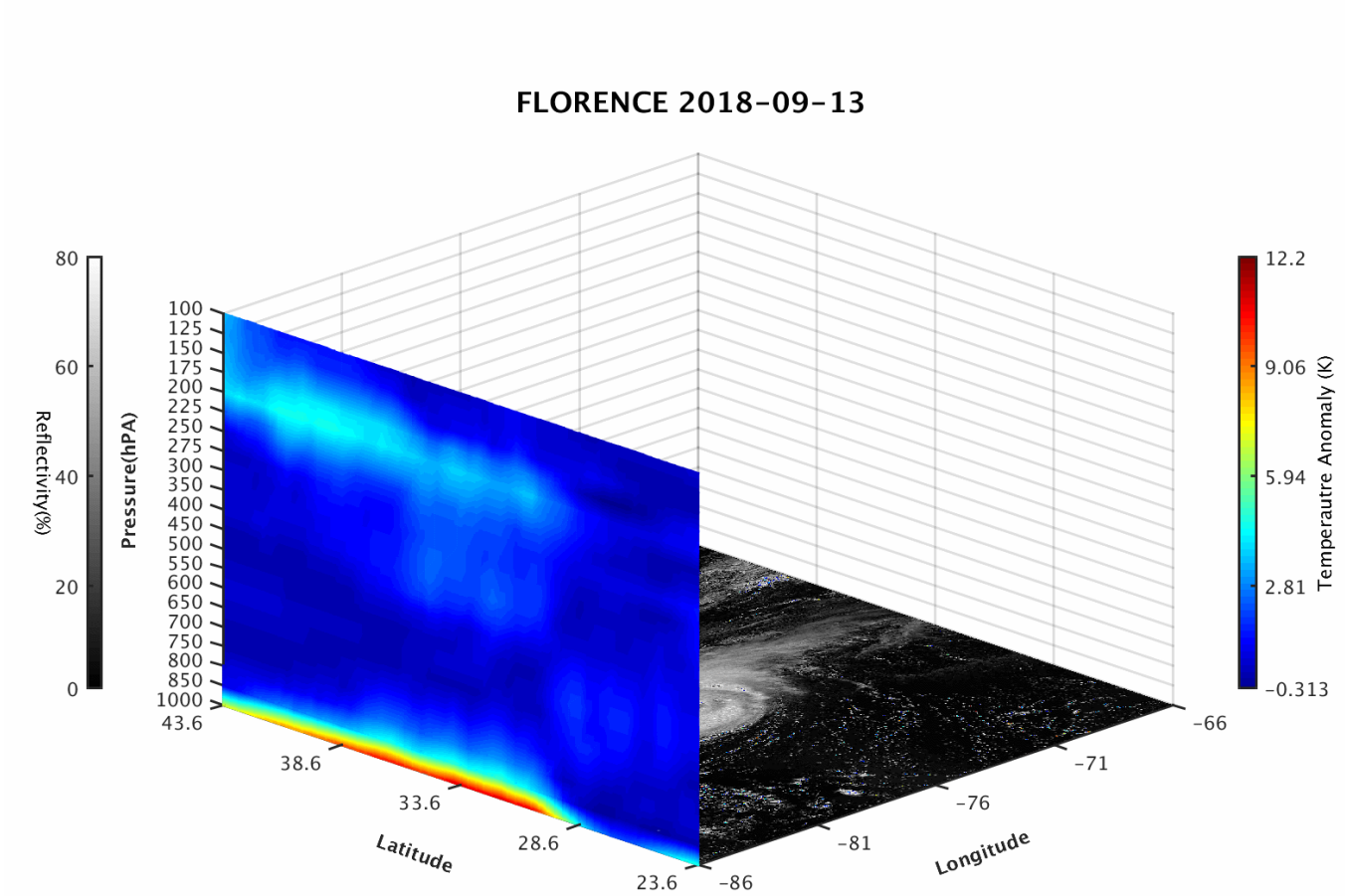


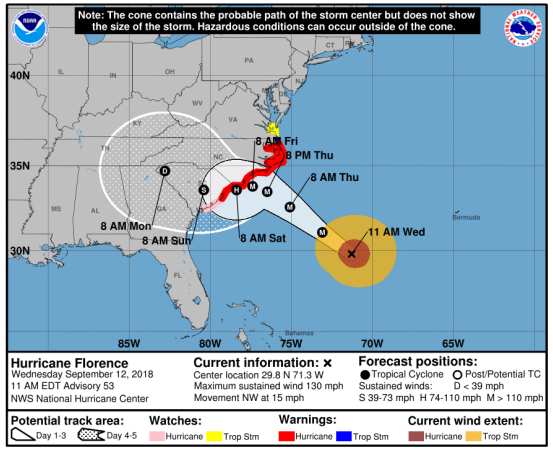
Observation type attributed to forecast error reduction



Derived from ECMWF data

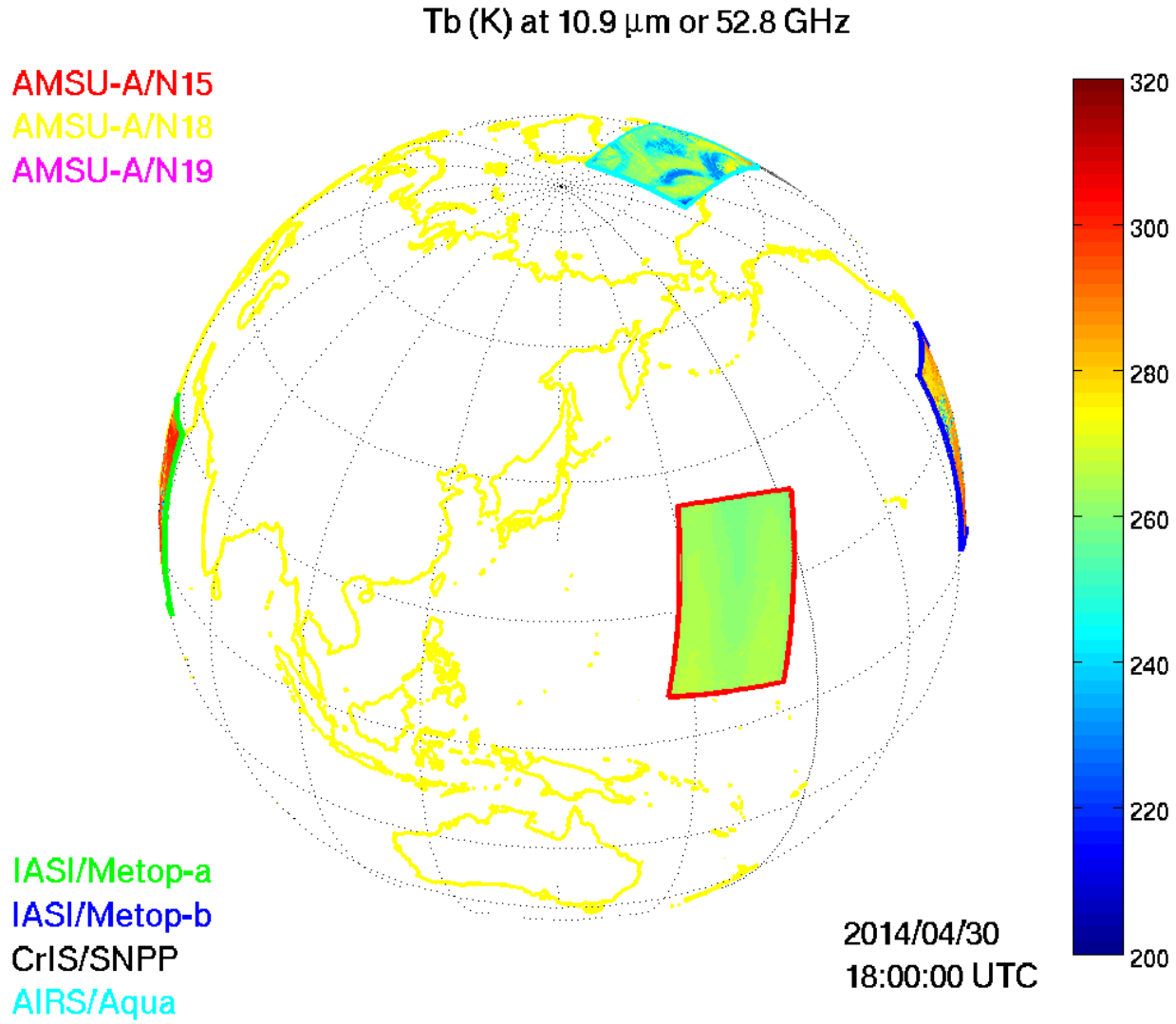
JPSS vertical sounding capability is critical for weather forecasting





Vertical temperature slices from ATMS soundings - warm core temperature anomaly can clearly be seen.

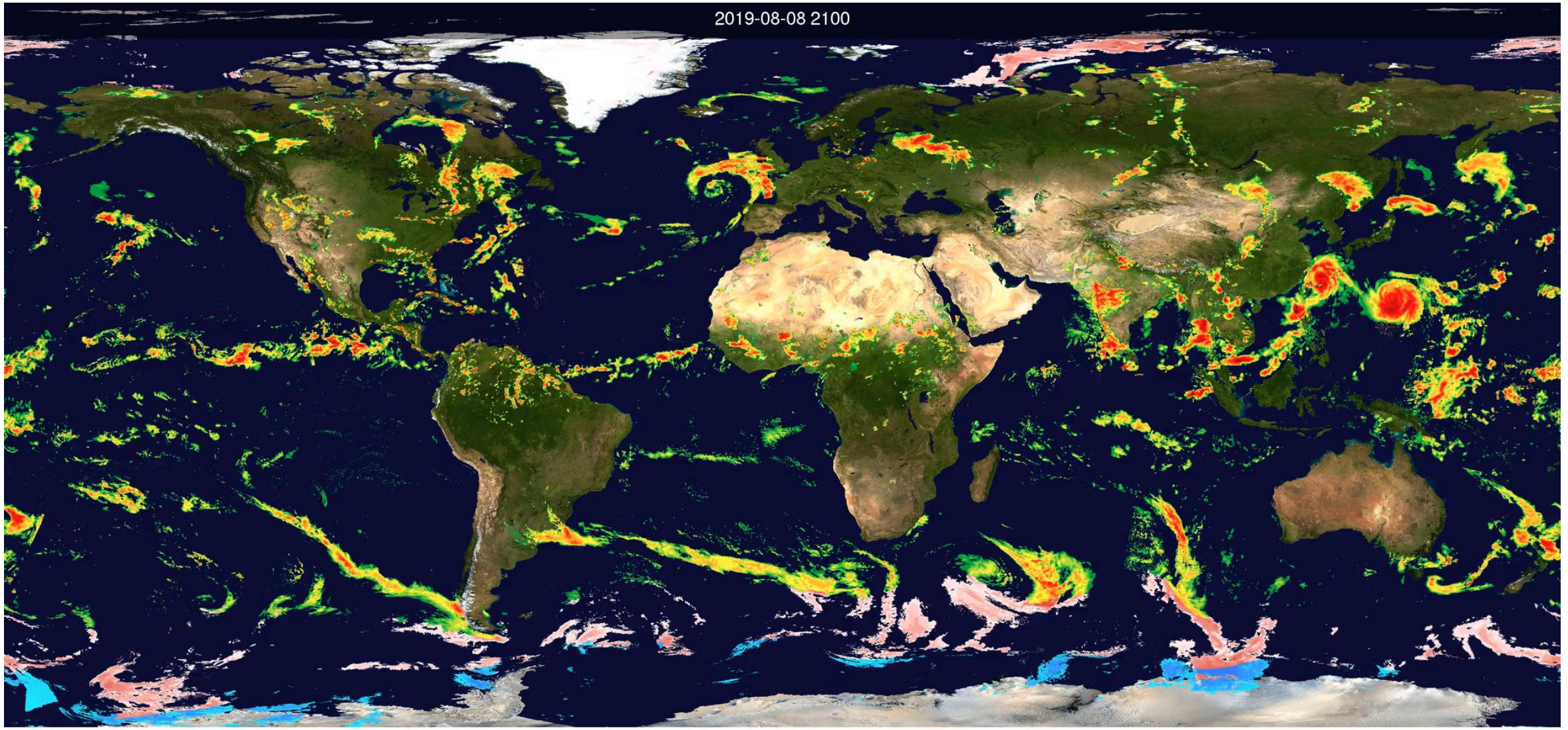
Constellation of LEO satellites vital for better temporal refresh.
7 Satellite example from 2014 -- In the 2020's we will have 3 CMA, 3 NOAA, 3 EUMETSAT and possibly more



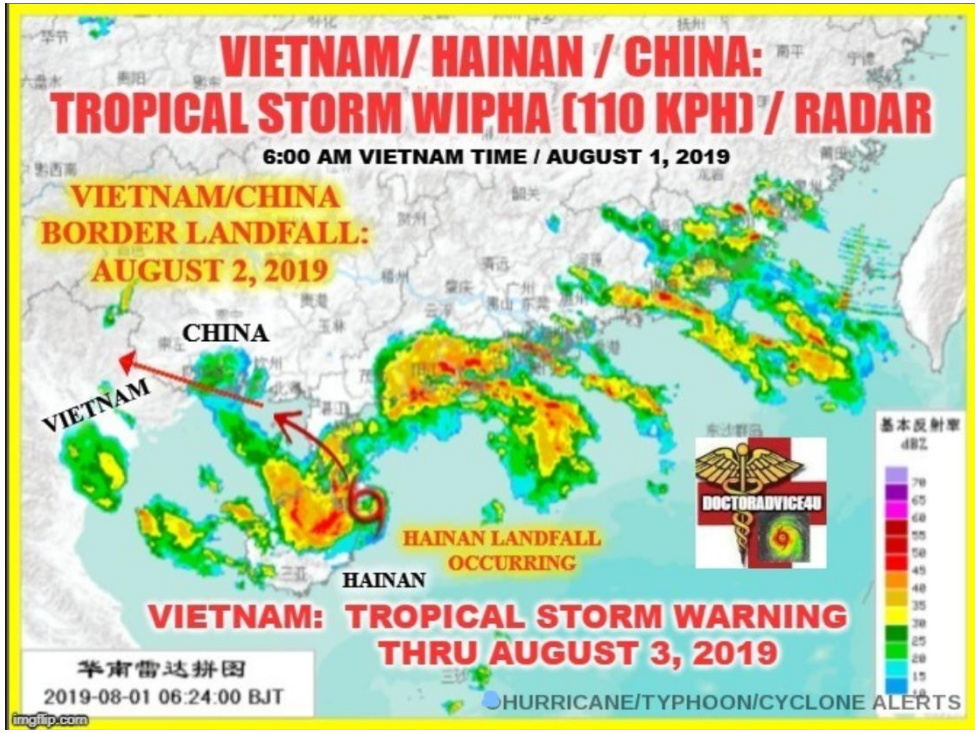
Together we measure critical variables for many applications

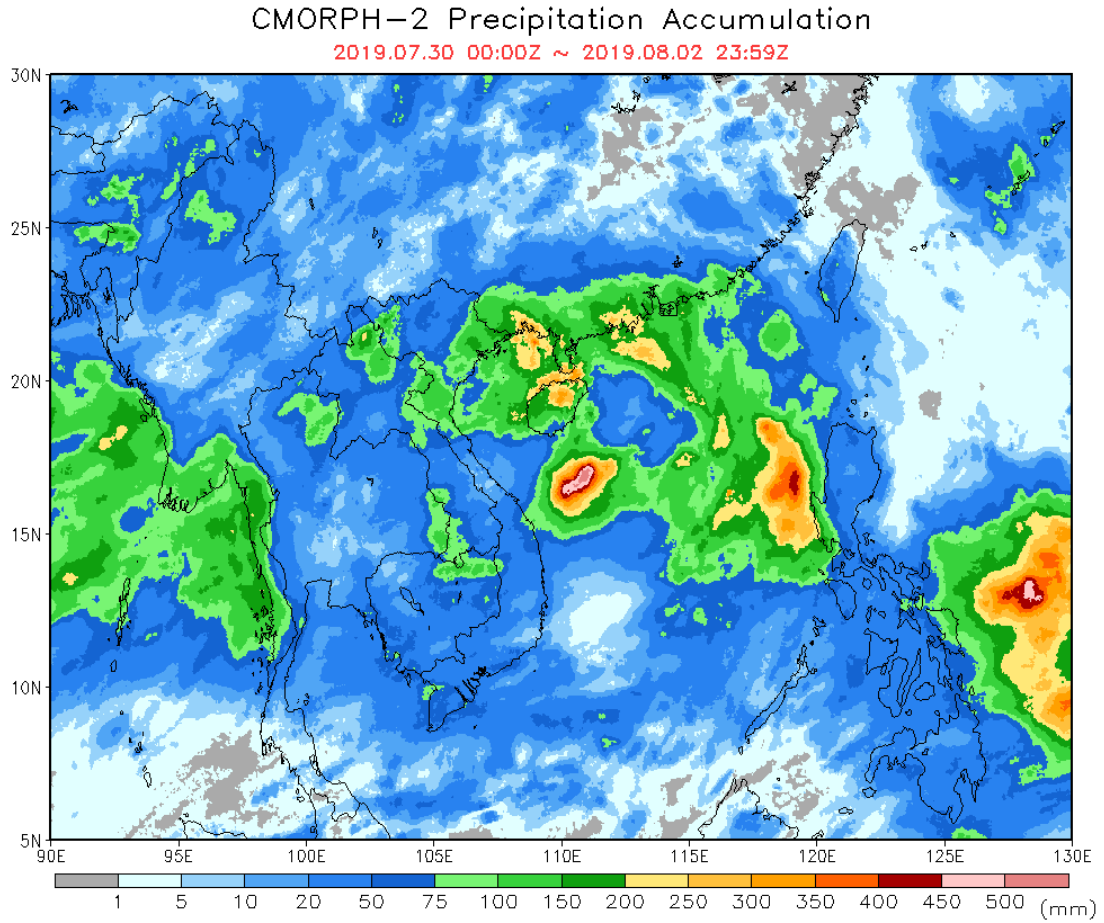
- Atmosphere
  - Temperature
  - Water Vapor
  - Ozone
  - Clouds
  - Lightning
  - Precipitation
  - Aerosols, Ash
  - Wind
  - CO, SO2, ……
- Land
  - Temperature
  - Soil moisture
  - Vegetation
  - Ice
  - Snow
  - Fires
  - Floods
  - Burnscars
- Ocean
  - Temperature
  - Ocean/Coastal Water quality
  - Sediments
  - Wind
  - Salinity

Data Fusion - 5 GEO and 12 LEO satellites – providing 30 minute temporal precipitation rates



Tropical Storm Wipha





Connecting with Users through Satellite Proving Grounds

What is a proving ground??

- “An environment that serves to demonstrate whether something, such as a theory or product, really works” Oxford Dictionary

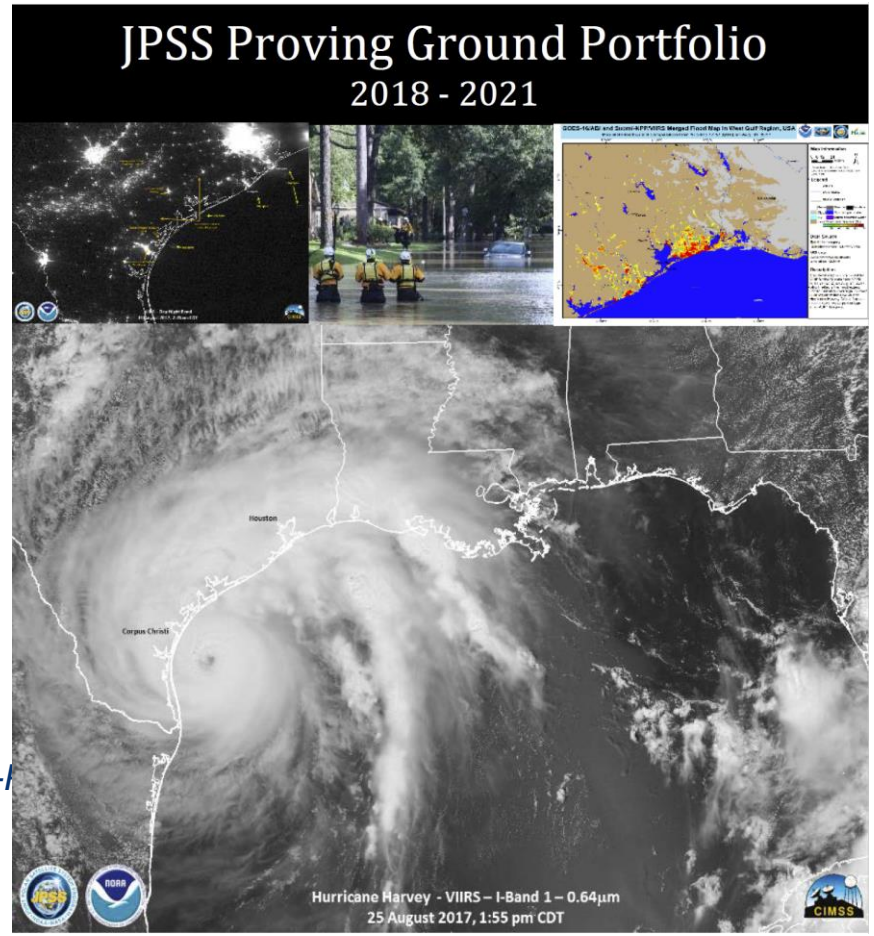
- The environment is usually at the service provider facility (e.g. Weather Forecast Office, National Marine Fisheries Lab)

- Service provider is the gateway to stakeholders (public, state and local governments, businesses, etc.)

The Initiatives

The initiatives comprise of a team of developers and users working together to improve an application in a testbed environment providing assessments of utility from the users and feedback to the developers.

- Arctic
- Aviation
- Fire and Smoke *- will include GOES-R in 2018*
- Hurricanes and Tropical Storms
- Hydrology
- NWP
- Oceans and Coasts *- includes Sentinel 3*
- River Ice and Flooding *- includes GOES-R since 2017*
- Sounding *- includes EUMETSAT MeTOP*
- Training
- Volcanic Hazards *- new and includes both JPSS and GOES-R*



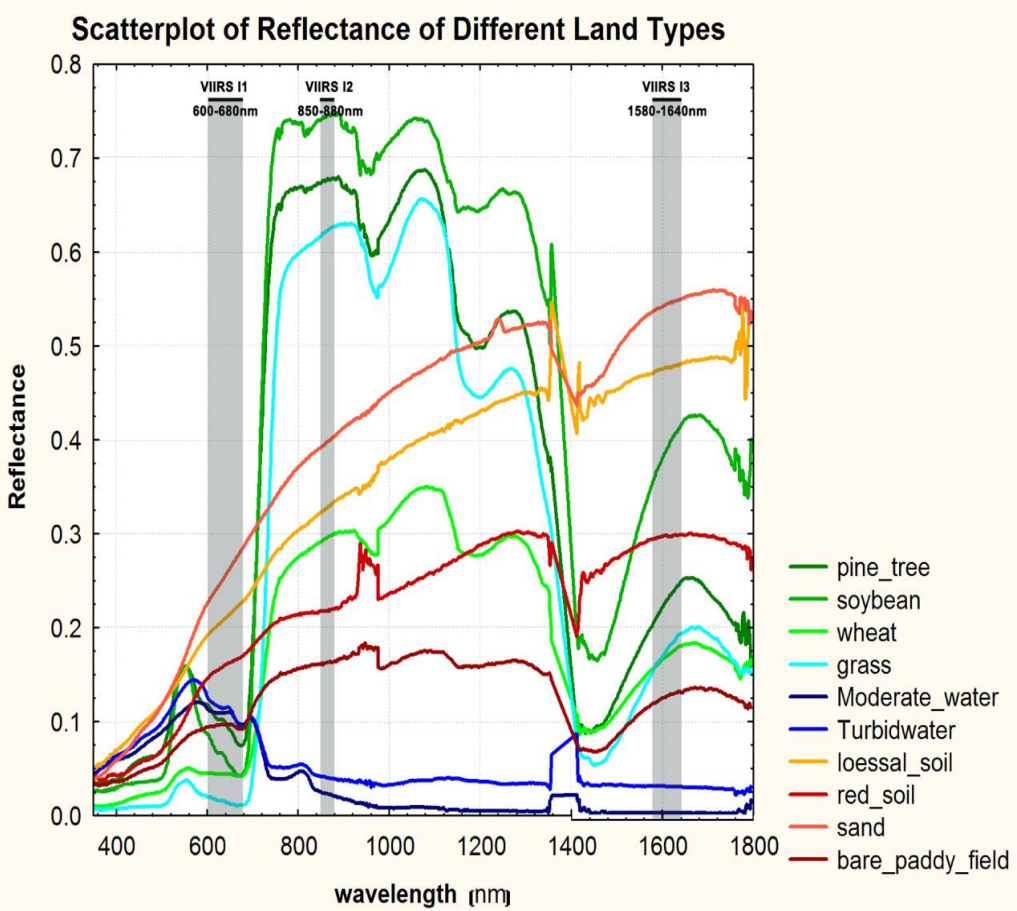
CMA – NOAA Flood Monitoring Partnership

- Floods events have the highest frequency and most damaging impact of all natural disasters.
- New operational weather satellites such as JPSS, GOES-R, HIMAWARI, FY3D, FY4A for the very first time have the spectral bands for inundation mapping and large geographic and temporal coverage.
- These satellites have real-time distribution capabilities allowing fast generation and utilization of disaster products for critical decision making.
- The operational polar satellites have direct broadcast and the geostationary satellites have direct broadcast, rebroadcast, and/or cloud services for immediate access to data.

JPSS VIIRS True Color Imagery - Before and After Hurricane Harvey

Sept 1, 2017

Methodology



- Decision-tree approach using the following variables: R_{Vis}, R_{NIR}, R_{SWIR}, NDVI, NDSI and NDWI based on different land cover types under different solar zenith angles.

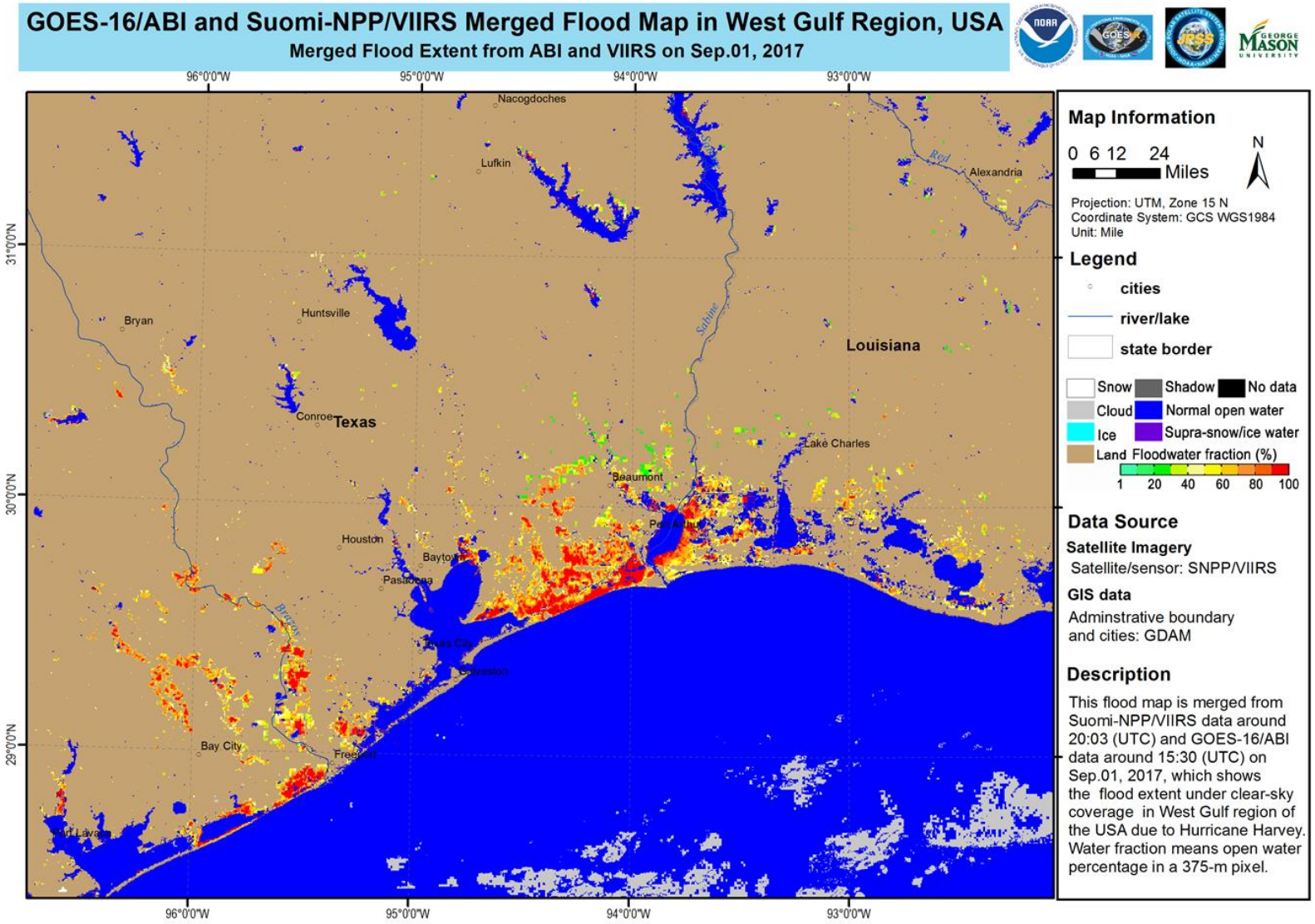
$$R = \sum_{i=1}^{n} f_i * R_i \qquad f_w = \frac{R_{ch\_land} - R_{ch\_mix}}{R_{ch\_land} - R_{ch\_water}}$$

$$\mathrm{NDVI} = \frac{R_{NIR} - R_{Vis}}{R_{NIR} + R_{Vis}}$$

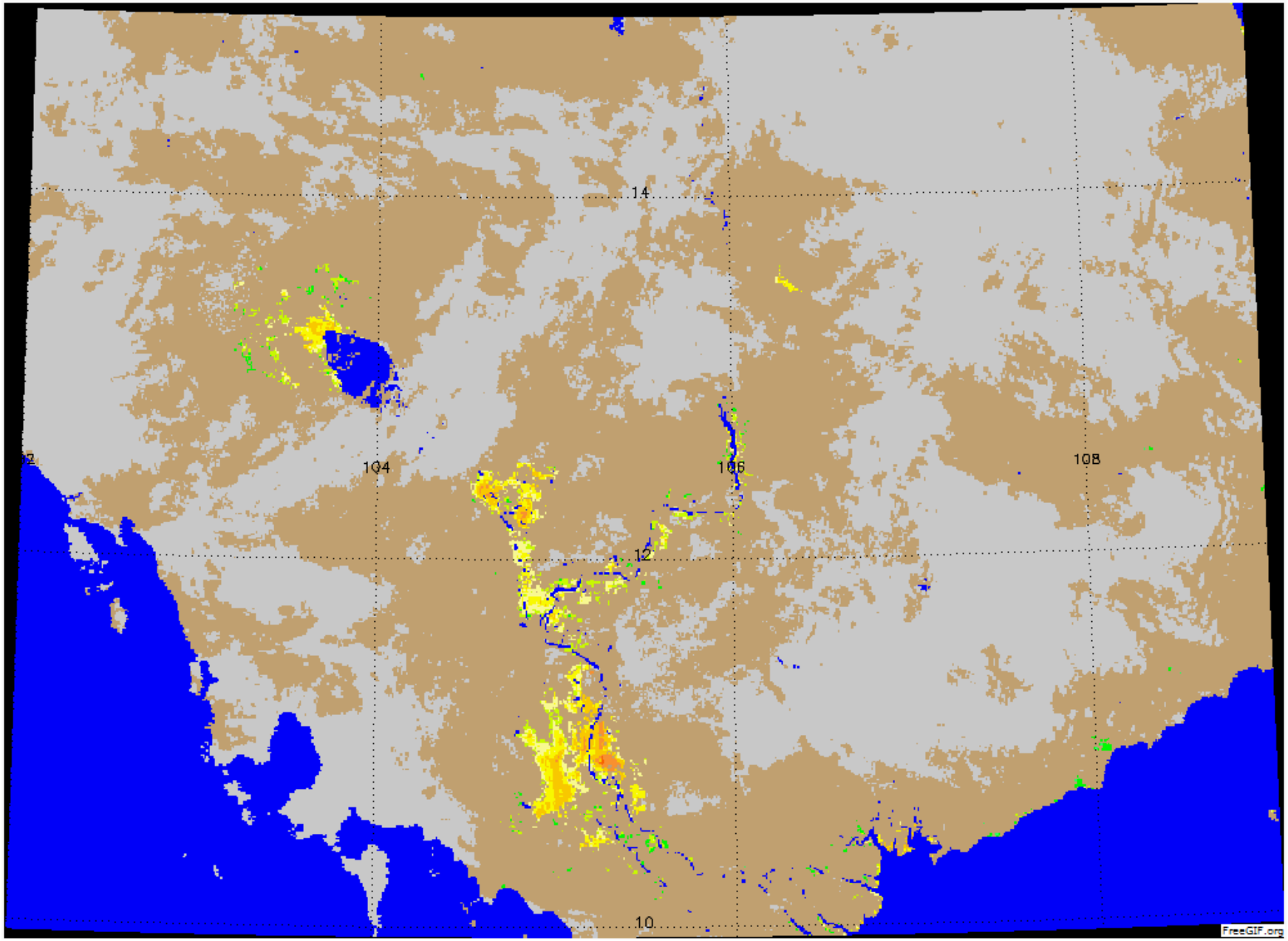
$$\mathrm{NDSI} = \frac{R_{Vis} - R_{SWIR}}{R_{Vis} + R_{SWIR}}$$

$$\mathrm{NDWI} = \frac{R_{NIR} - R_{SWIR}}{R_{NIR} + R_{SWIR}}$$

Flood maps

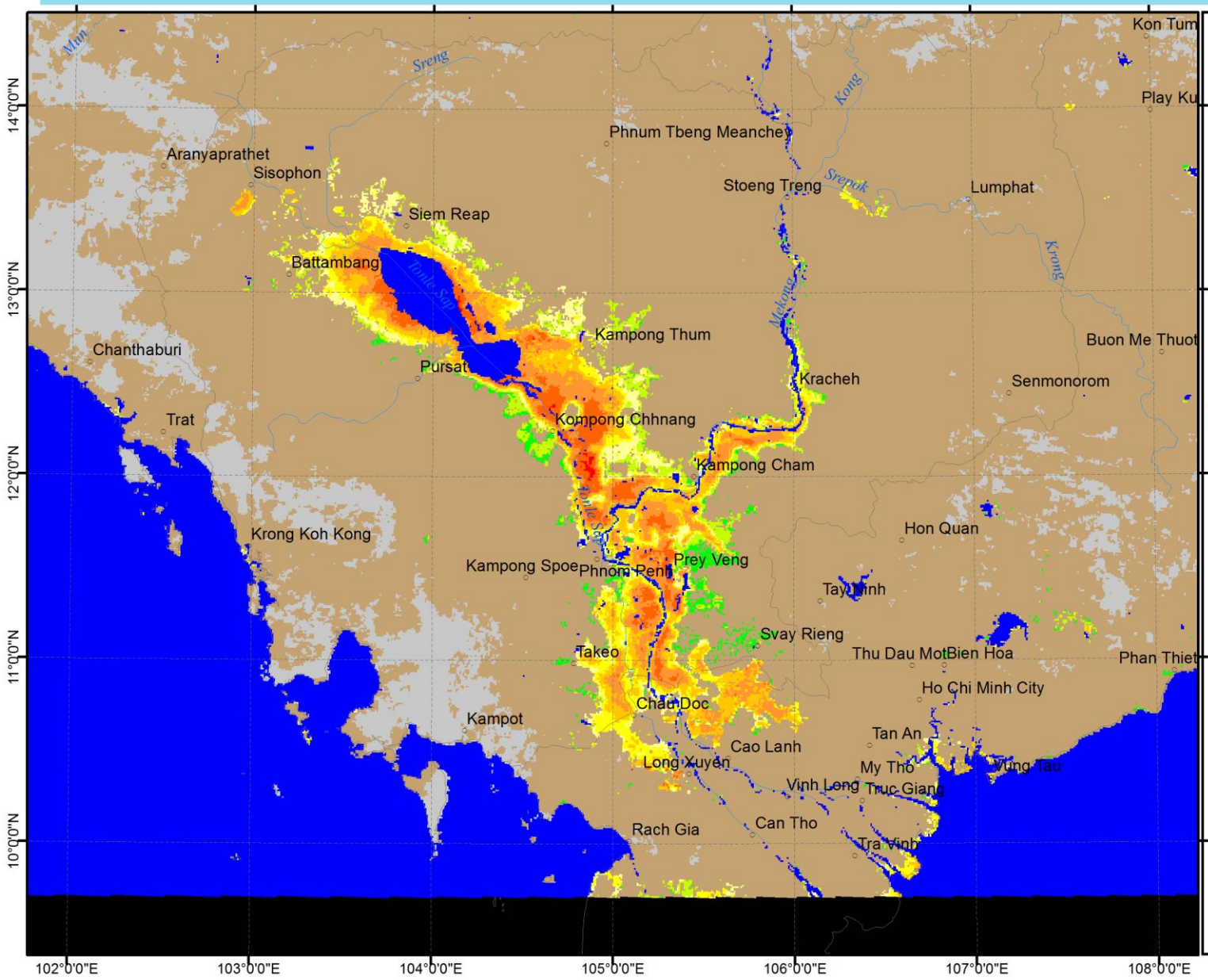

GOES-16/ABI and Suomi-NPP/VIIRS Merged Flood Map in West Gulf Region, USA
Merged Flood Extent from ABI and VIIRS on Sep.01, 2017
96°0'0"W
95°0'0"W
94°0'0"W
93°0'0"W
31°0'0"N
30°0'0"N
29°0'0"N
Nacogdoches
Lufkin
Alexandria
Bryan
Huntsville
Conroe
Texas
Louisiana
Lake Charles
Beaumont
Houston
Baytown
Pasadena
Texas City
Galveston
Bay City
Freeport
Port Lavaca
Map Information
0 6 12 24
Miles
N
Projection: UTM, Zone 15 N
Coordinate System: GCS WGS1984
Unit: Mile
Legend
cities
river/lake
state border
Snow
Shadow
No data
Cloud
Normal open water
Ice
Supra-snow/ice water
Land
Floodwater fraction (%)
1 20 40 60 80 100
Data Source
Satellite Imagery
Satellite/sensor: SNPP/VIIRS
GIS data
Adminstrative boundary and cities: GDAM
Description
This flood map is merged from Suomi-NPP/VIIRS data around 20:03 (UTC) and GOES-16/ABI data around 15:30 (UTC) on Sep.01, 2017, which shows the flood extent under clear-sky coverage in West Gulf region of the USA due to Hurricane Harvey. Water fraction means open water percentage in a 375-m pixel.

FY4A/AGRI Flood Map 20180821 00:34 to 01:15(UTC)



FY4A/AGRI Daily Composited Flood Map in Cambodia

Daily composition from 00:34 to 09:30 (UTC) on Aug. 21, 2018



Map Information

0 15 30 60 ml

N

Projection: UTM, Zone 46 N
Coordinate System: GCS WGS1984
Unit: meters

Legend

- cities
- rivers/lakes
- countries

Snow | Shadow | No data
Cloud | Normal open water
Ice | Supra-snow/ice water
Land | Floodwater fraction (%)

1 20 40 60 80 100

Data Source

Satellite Imagery

Satellite/sensor:
FY4A/AGRI

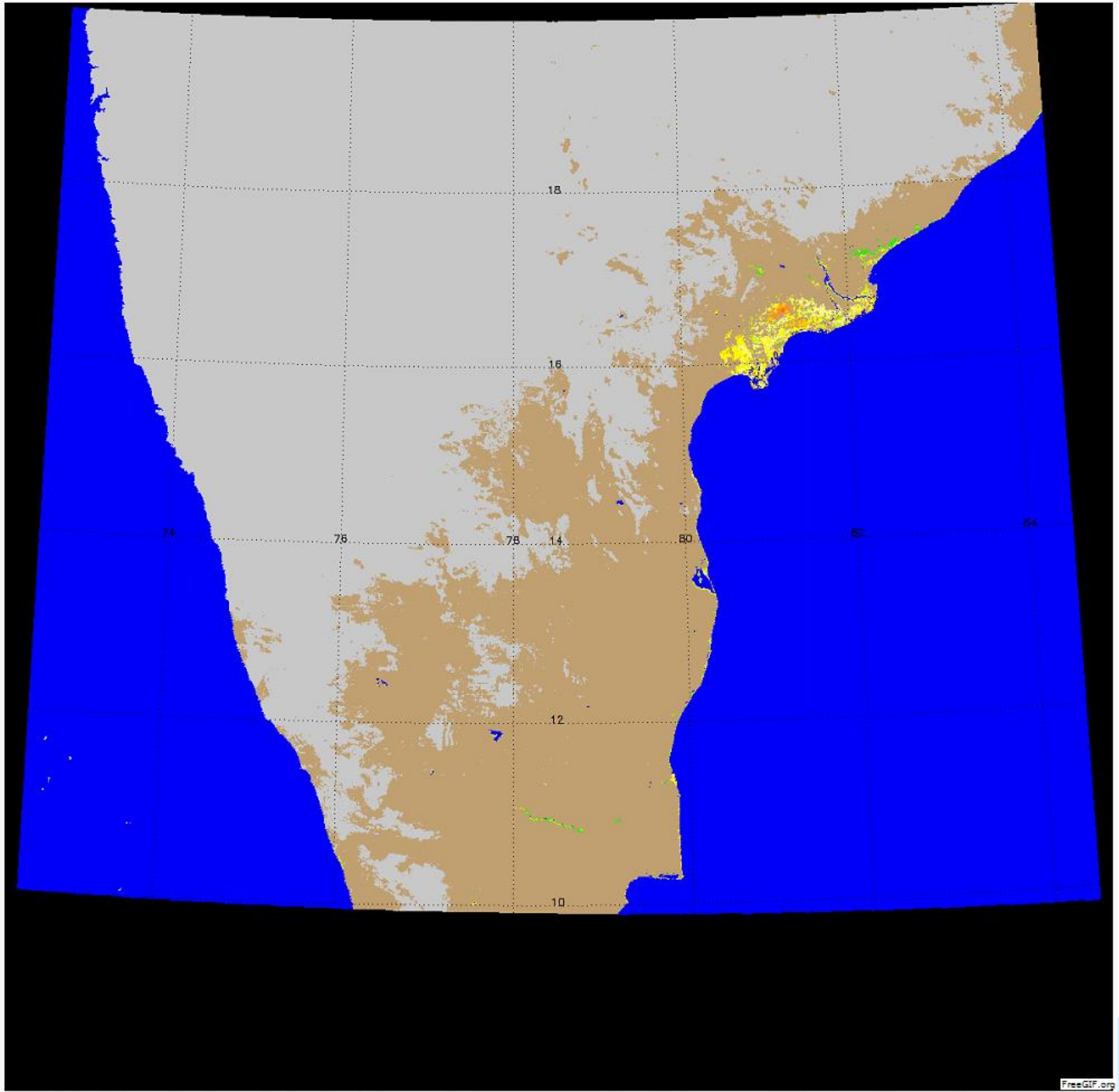
GIS data

Adminstrative boundary and cities: GADM

Description

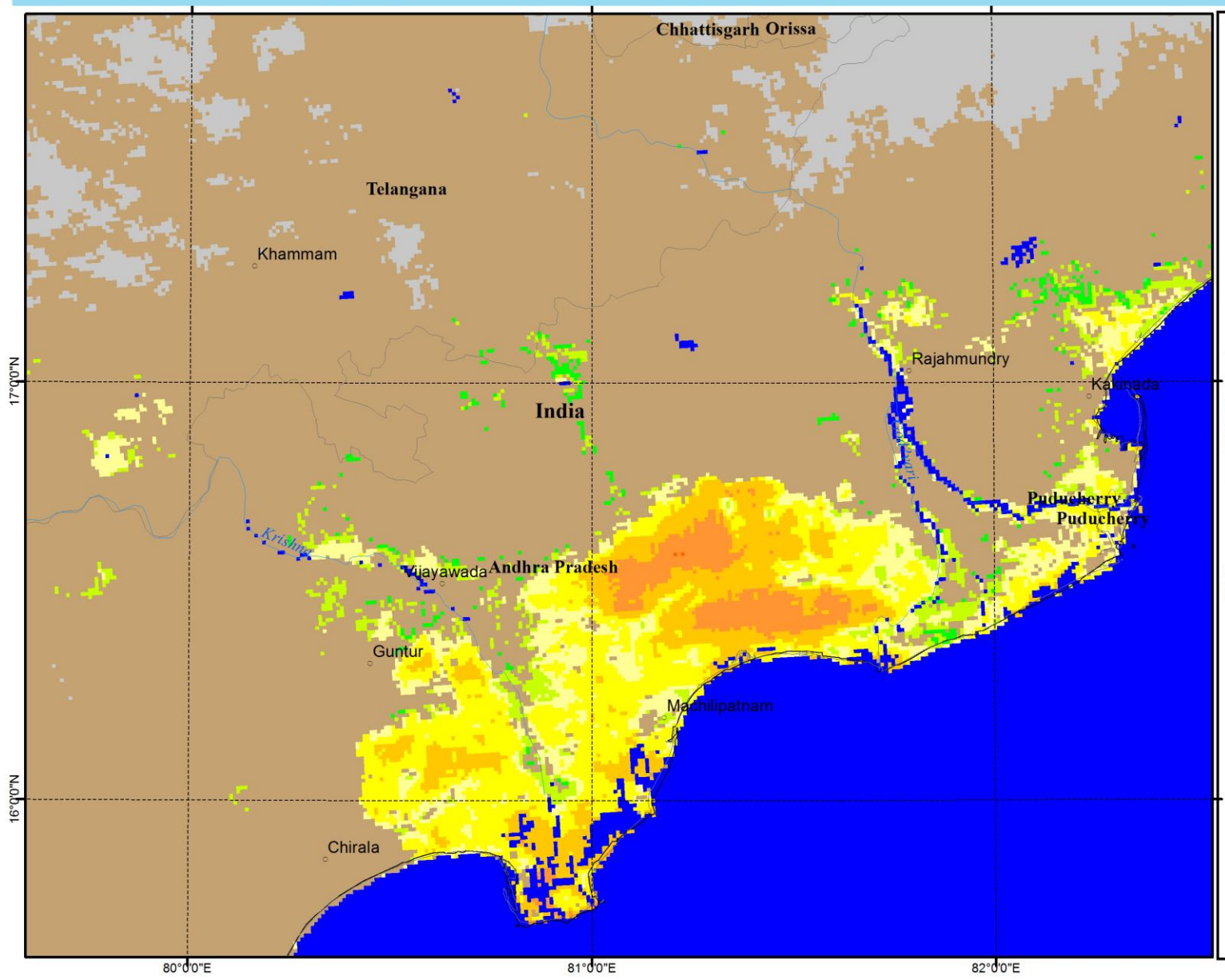
This flood map is genenrated using FY4A/AGRI data on Aug. 21, 2018 from 00:34 to 09:30 (UTC), which reflects themaximal flood extent in Cambodia on that day. Water fraction means open water percentage in a AGRI 2-km pixel.

FY4A/AGRI Flood Map 20180821 00:34 to 03:30(UTC)



FY4A/AGRI Daily Composited Flood Map in India

Daily Composition from 00:34 to 09:30 (UTC) on Aug. 21, 2018



Map Information

0 5 10 20 ml

N

Projection: UTM, Zone 46 N
Coordinate System: GCS WGS1984
Unit: meters

Legend

- cities
- rivers/lakes
- province border
- country border
- Snow
- Shadow
- No data
- Cloud
- Normal open water
- Ice
- Supra-snow/ice water
- Land
- Floodwater fraction (%): 1 20 40 60 80 100

Data Source

Satellite Imagery

Satellite/sensor: FY4A/AGRI

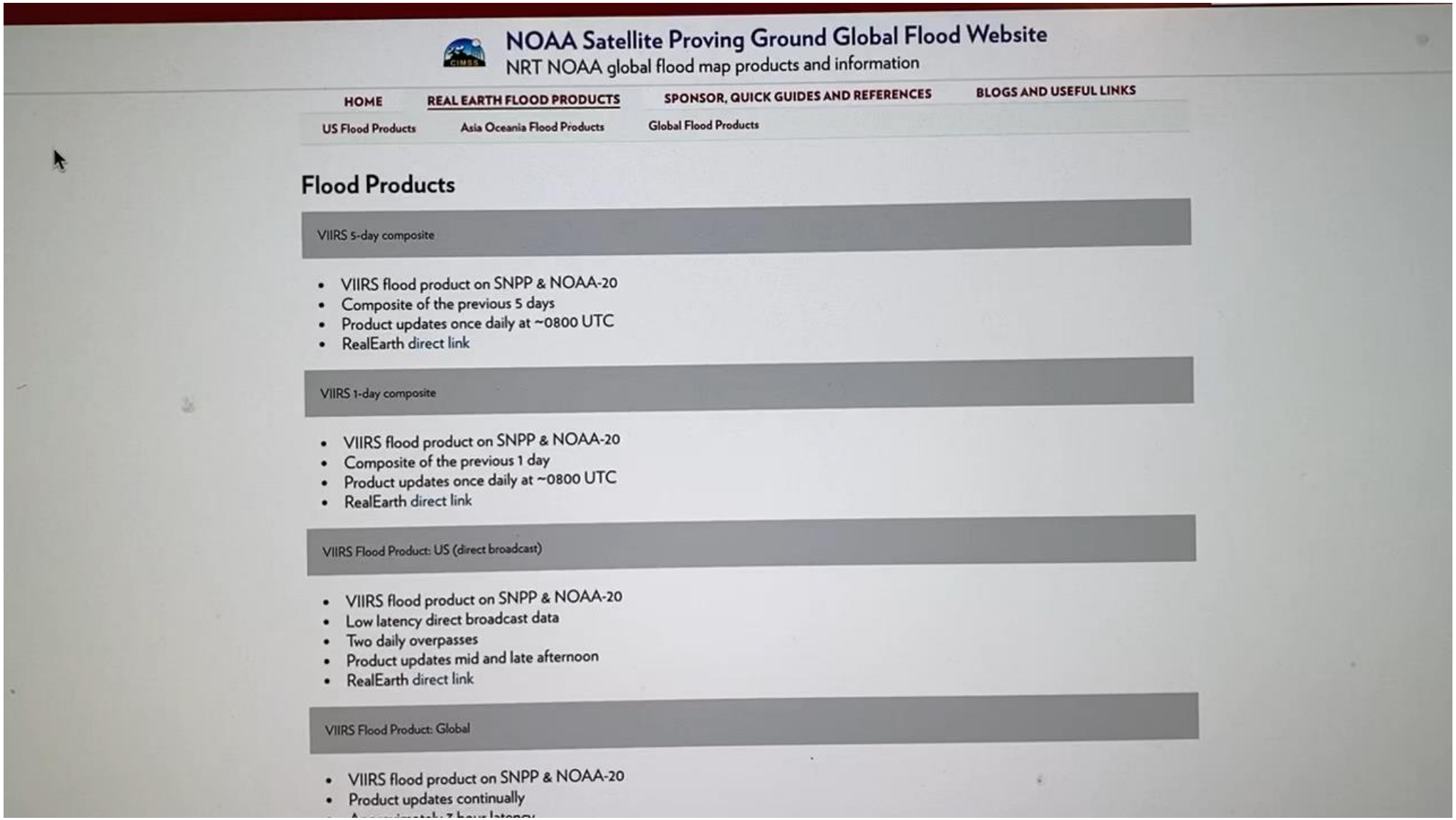
GIS data

Adminstrative boundary and cities: GADM

Description

This flood map is composited by FY4A/AGRI data from 00:34 to 09:30 (UTC) on Aug. 21, 2018, which reflects the flood extent on that day in India. Water fraction means open water percentage in an AGRI 2-km pixel.

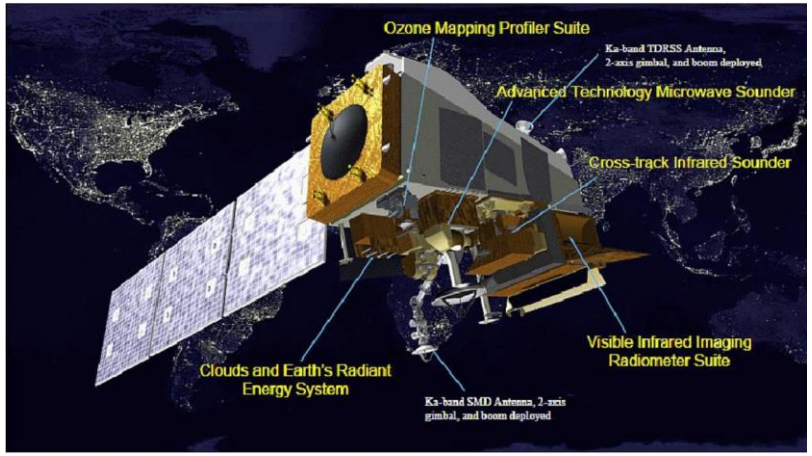
New Global Flood Mapping Website



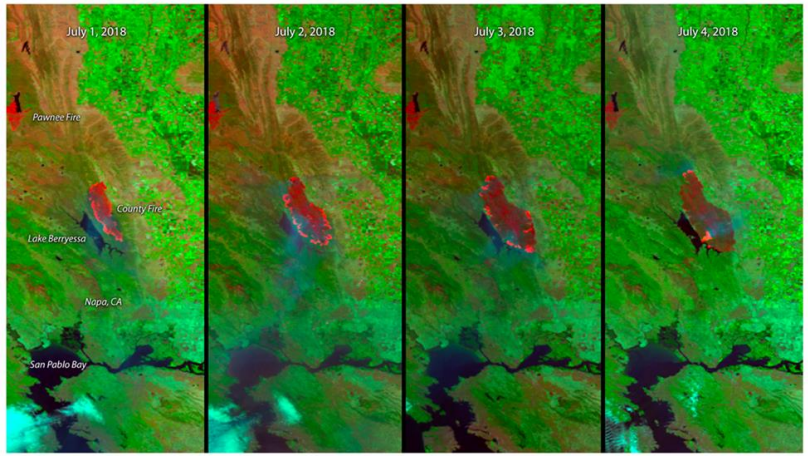
https://www.ssec.wisc.edu/flood-map-demo/flood-products/

Fire & Smoke Initiative

JPSS Program – Polar orbiting

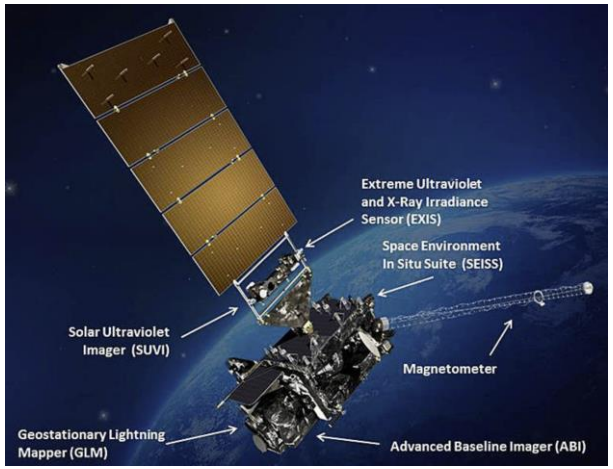


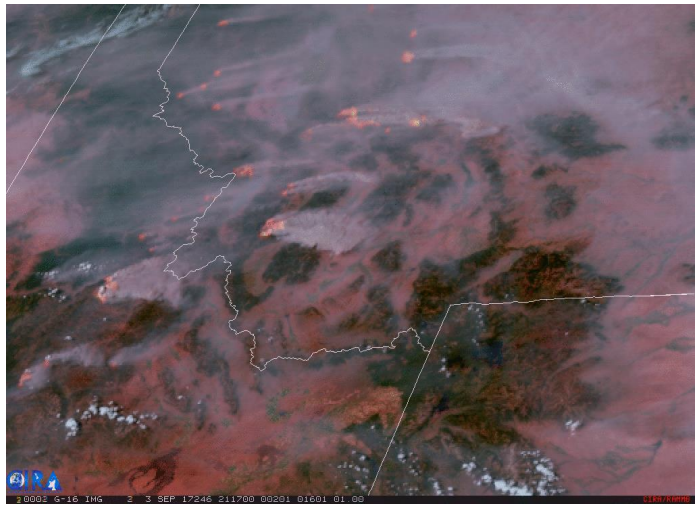
The Expanding County Fire in Northern California



JPSS provides high spatial resolution ~ 375 m used for identifying fire perimeters and for input to smoke forecast models

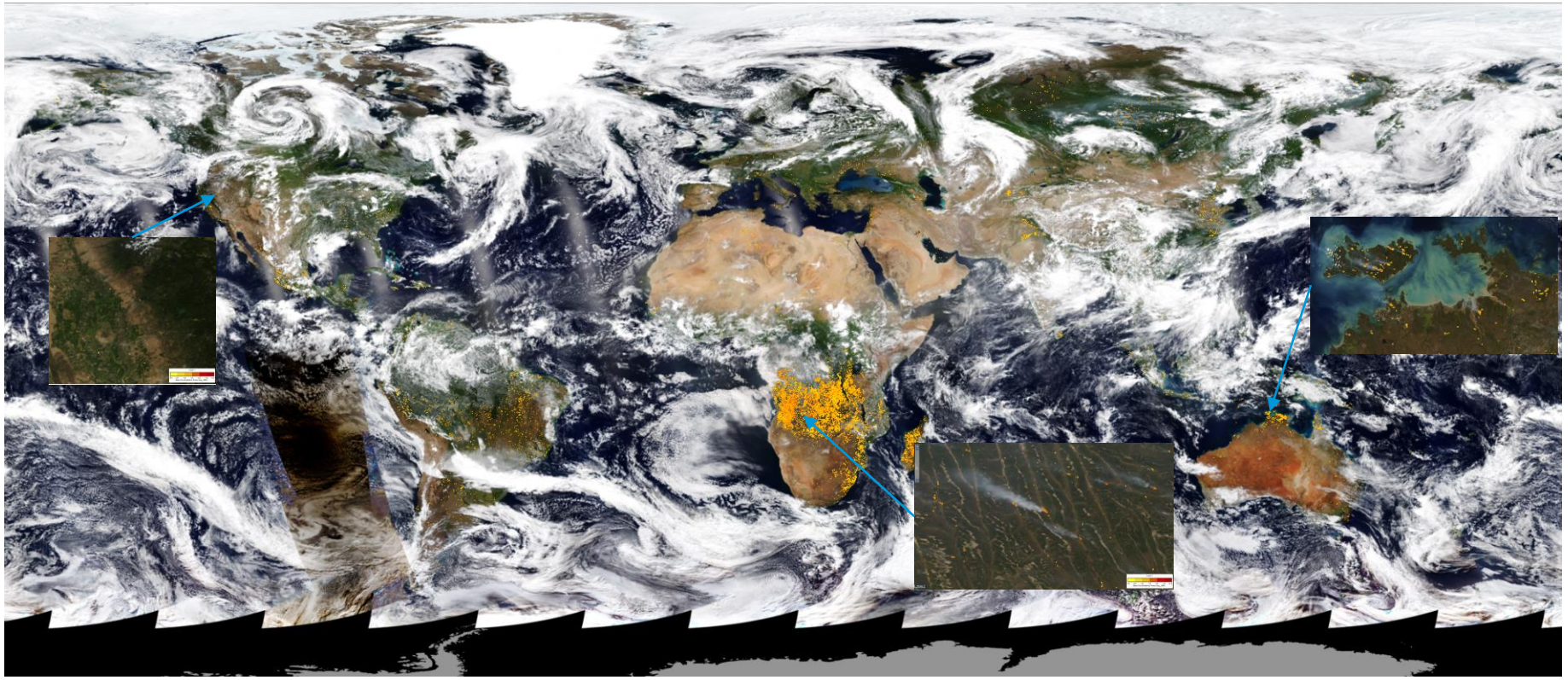
GOES-R Series - Geostationary





GOES-R provides nearly continuous observations of fires at a 2-3 km resolution (function of latitude ~ 6 km in central Alaska)

NOAA-20 VIIRS Global Fire Observations

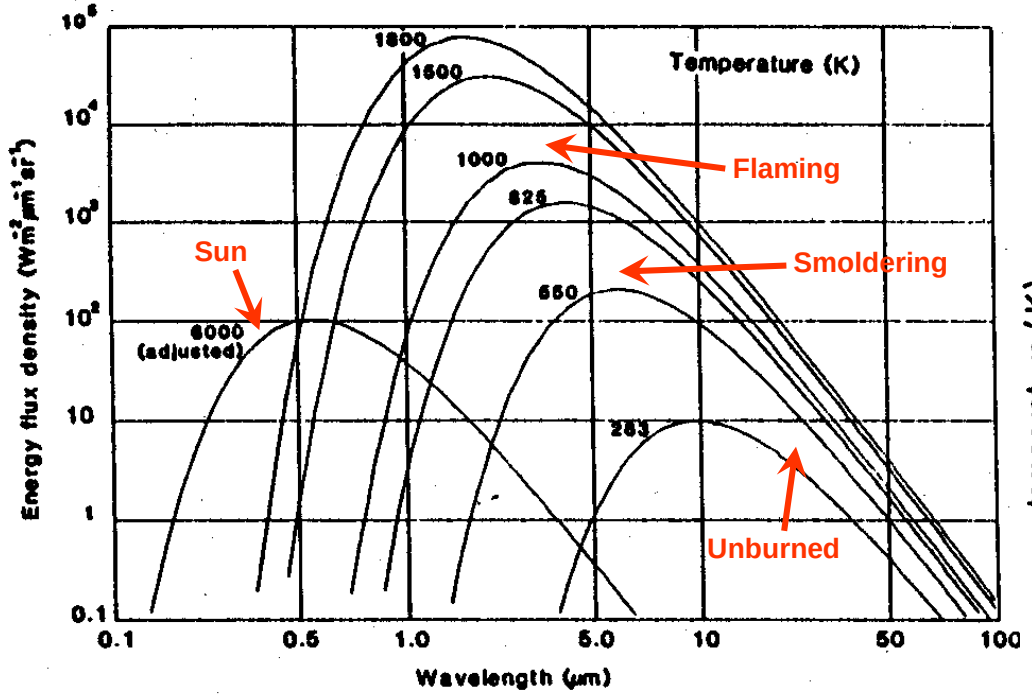


July 2, 2019

https://www.star.nesdis.noaa.gov/jpss/mapper/

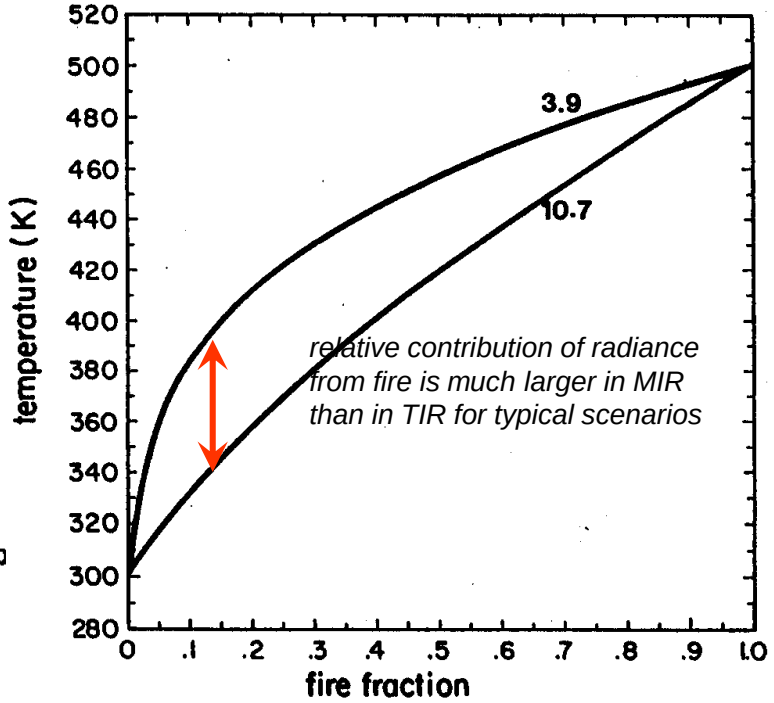
Basic Fire Detection Science

Reflected and Emitted Radiation - daytime



Robinson, 1991

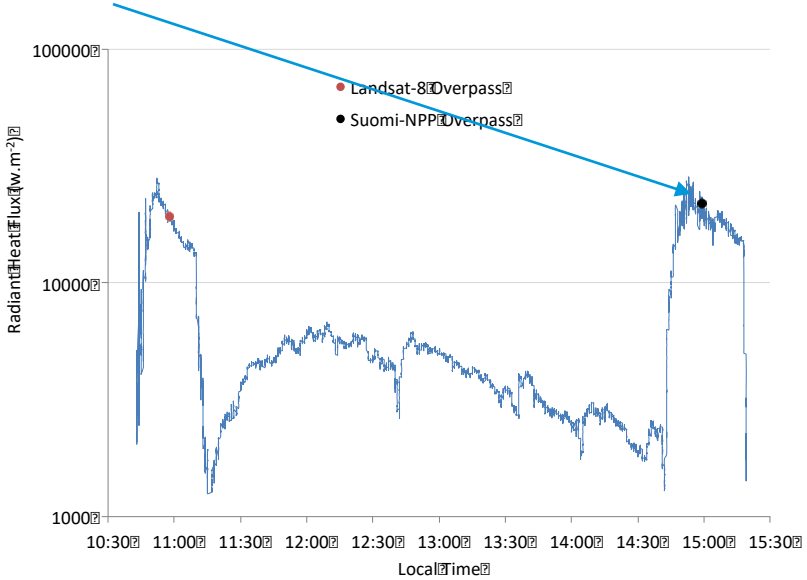
Dependence of Observed Brightness Temperature on Active Fire Fraction within the Satellite Pixel



Purdom et al. 1985

Active Fire Data Validation

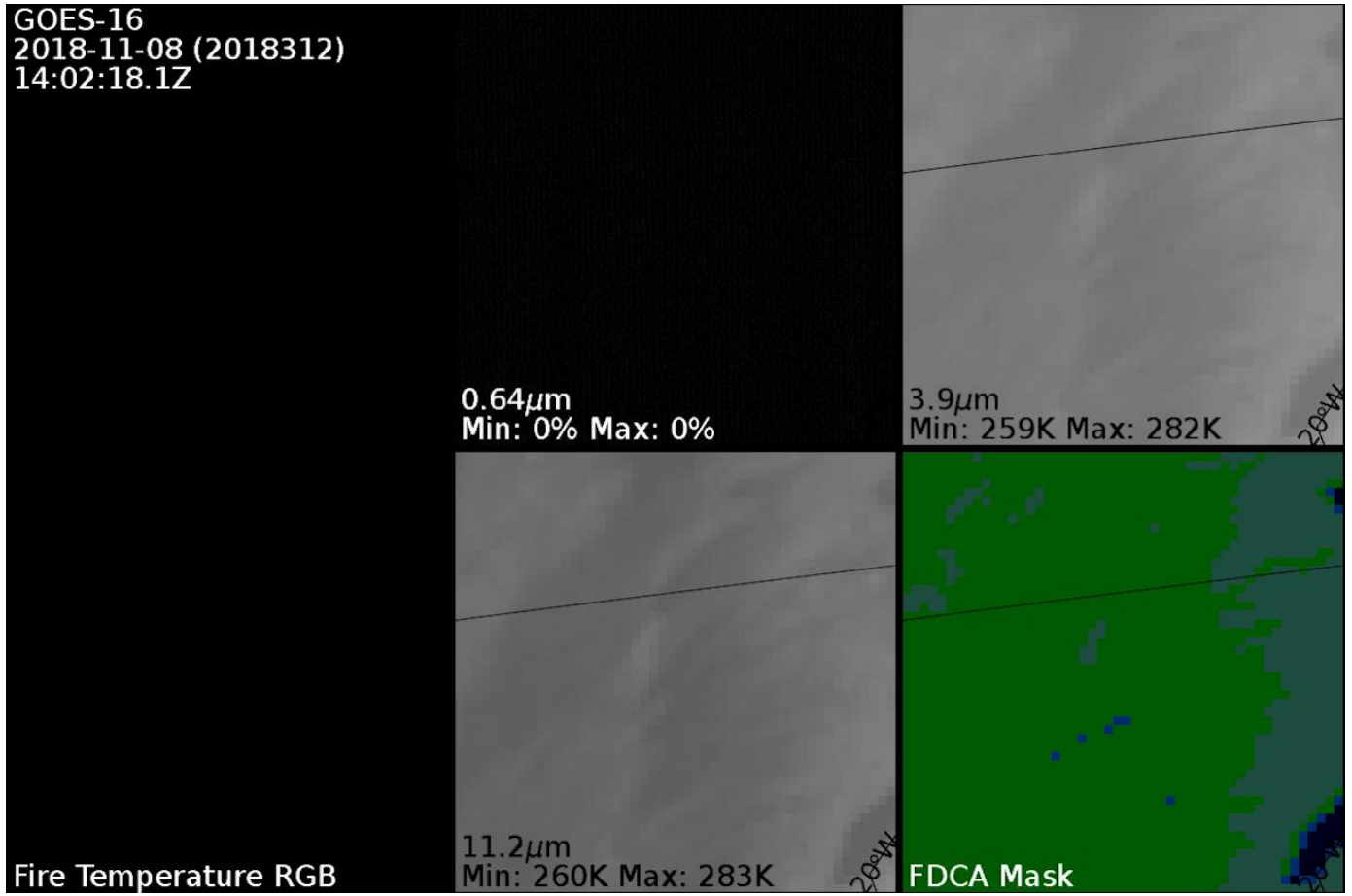
VIIRS can detect relatively small fires



A small experimental fire was implemented for the validation of same-day Landsat-8 and Suomi-NPP/VIIRS fire detection data in Brazil, January 2015. Tower-mounted radiometers provided 1Hz fire radiant flux data coincident with satellite overpasses.

W. Schroeder, OSPO

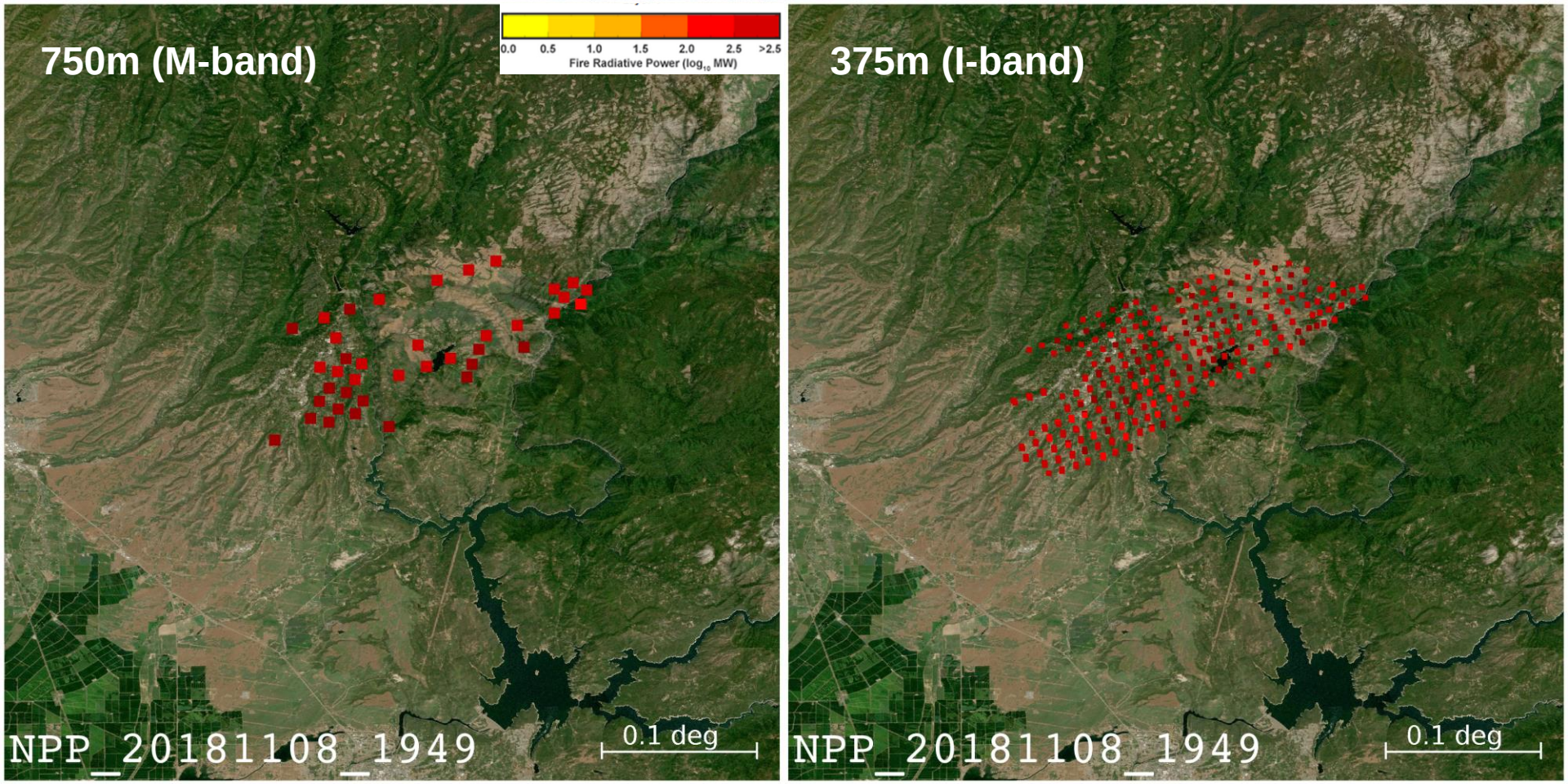
The Camp Fire – November 2018



Loop of the early hours of the Camp Fire on 8 November 2018.

Early in the day, GOES-16 observed the start of the Camp Fire

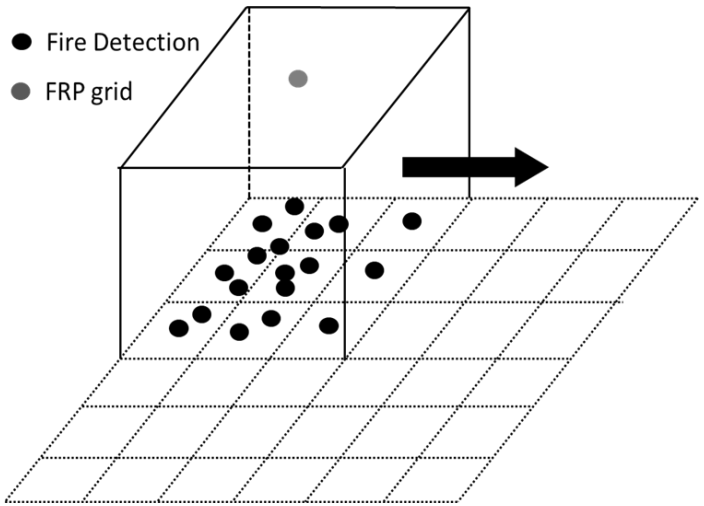
NOAA-20 and Suomi NPP VIIRS Detections of Camp Fire (CA) November 8-15, 2018

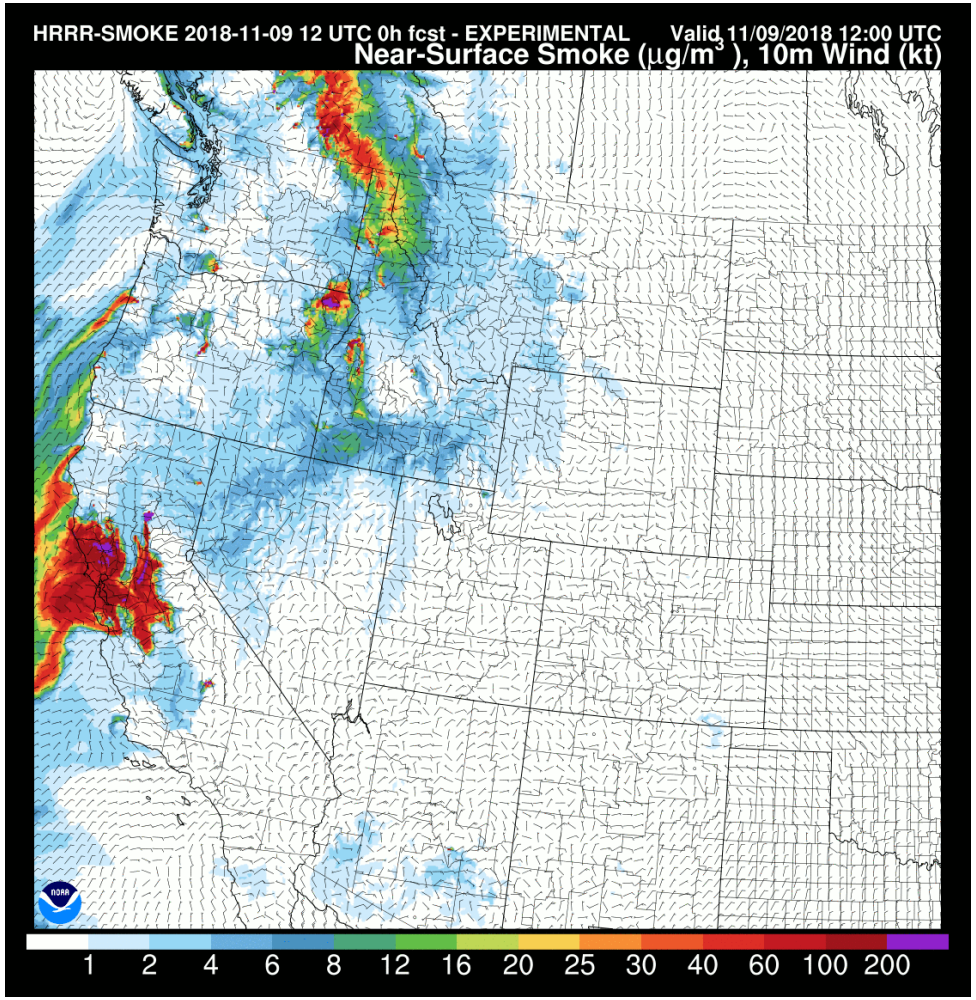


Later in the day, and for subsequent days, JPSS provided the relatively high spatial resolution needed for observing fire perimeters and smoke forecasting

High Resolution Rapid Refresh (HRRR) Smoke Forecasts from the Camp Fire

JPSS VIIRS higher spatial resolution fire radiative power observations are used in NOAA's HRRR model to provide smoke forecasts

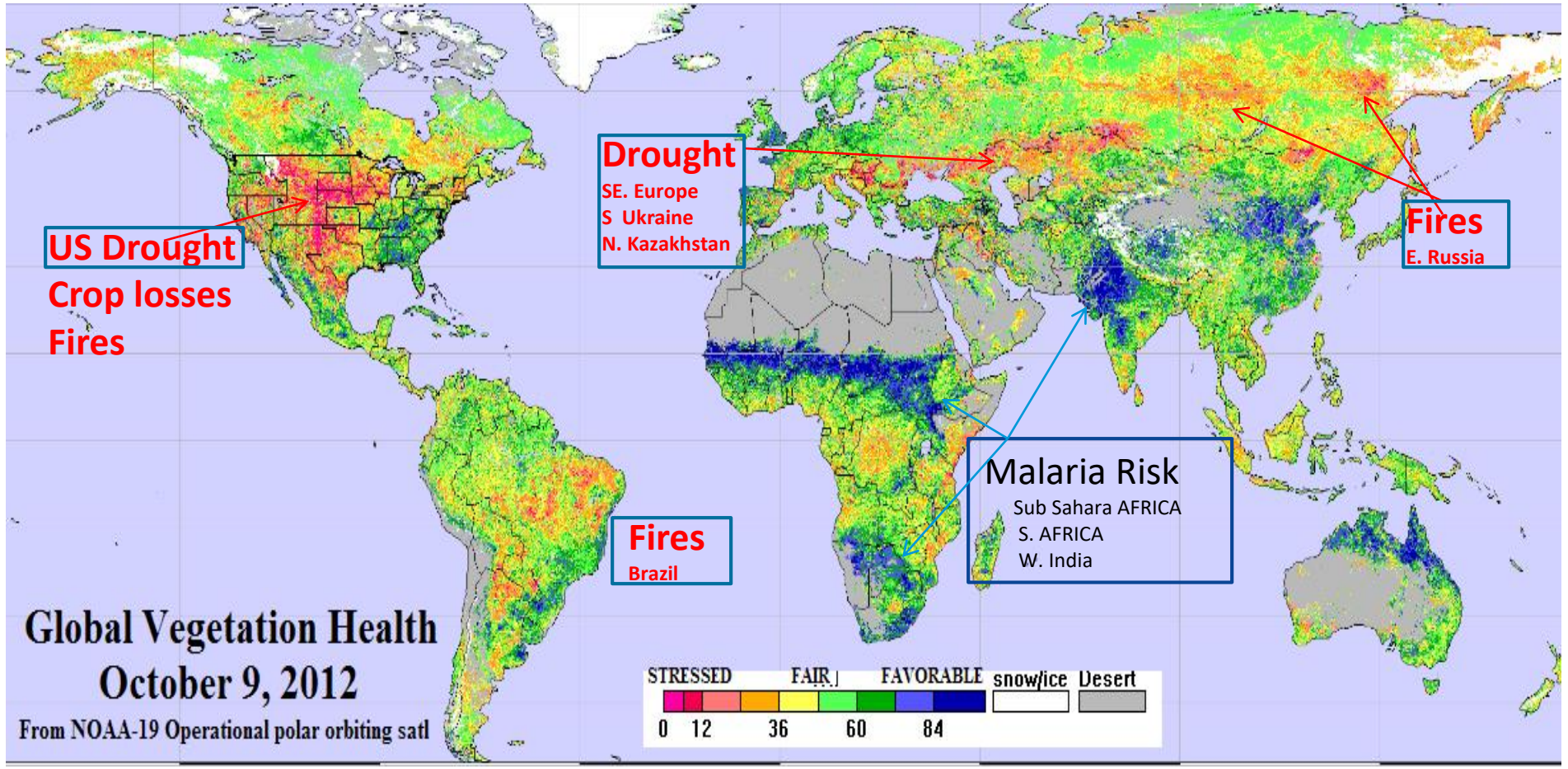




https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/

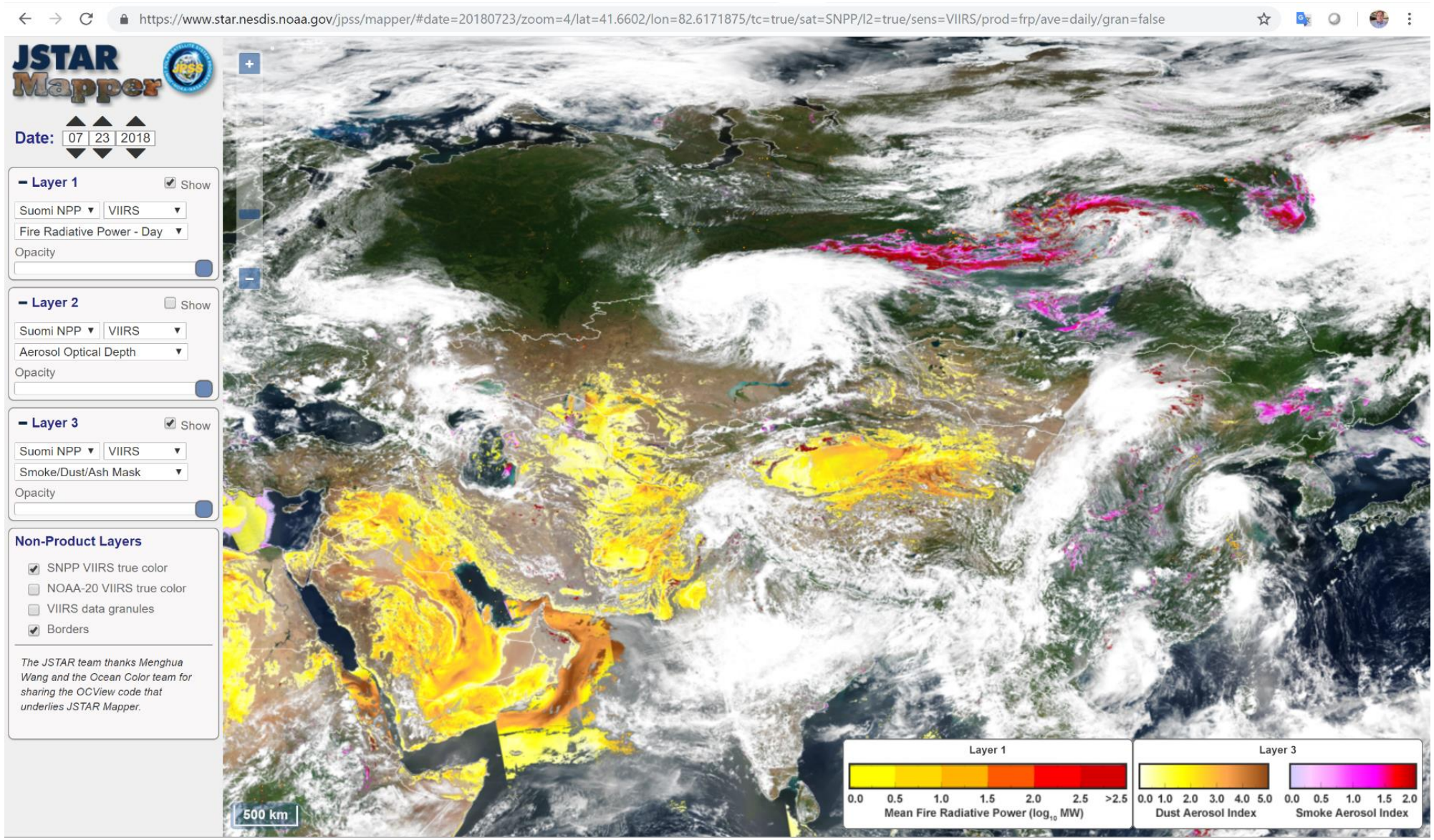
Global Vegetation Health (VH)

From AVHRR/NOAA-19 Operational Polar Orbiting Satellite

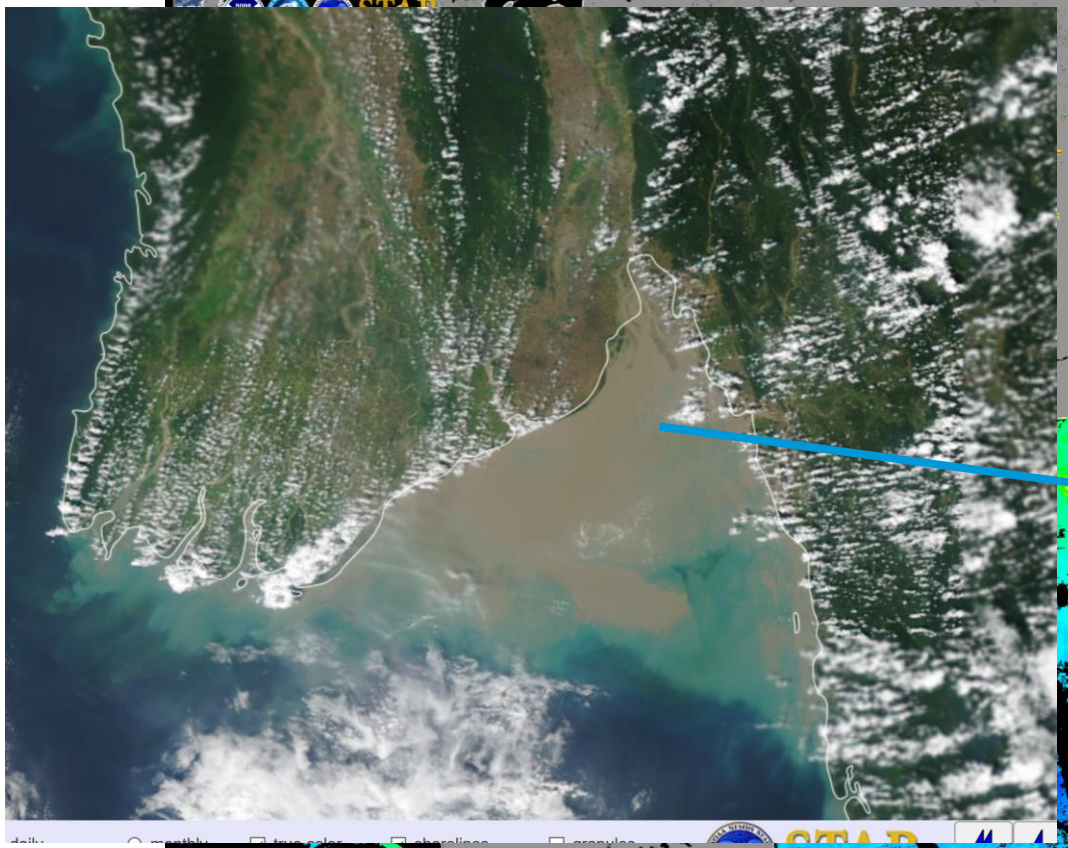


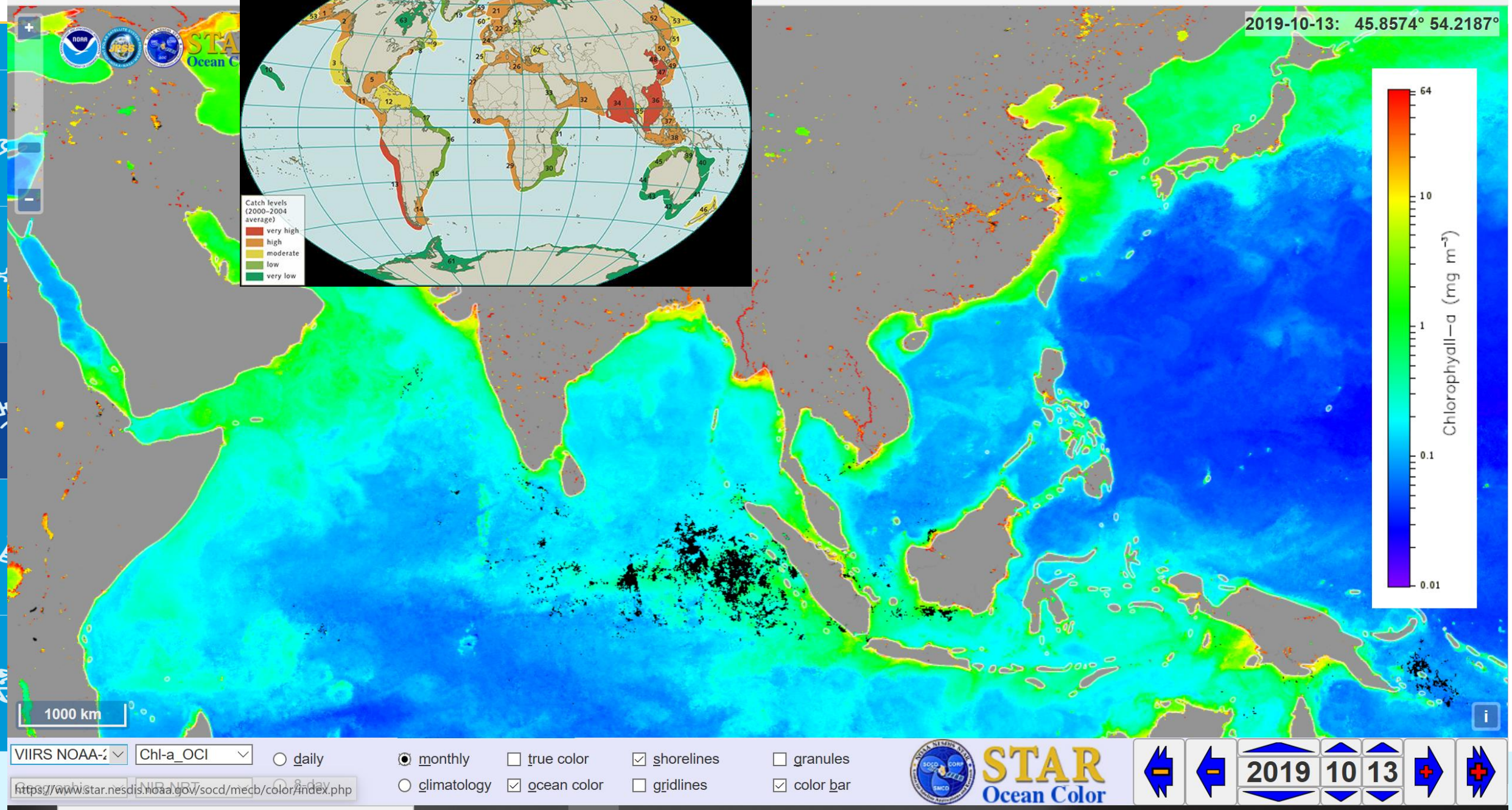
http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php

Air quality applications



Ocean and Coastal Water Quality (Nutrients) - Chlorophyll-A

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To see favorites here, select
rt favorites
2019-10-13: 45.8574° 54.2187°
Catch levels (2000–2004 average)
very high
high
moderate
low
very low
64
10
1
0.1
0.01
Chlorophyall—a (mg m⁻³)
1000 km
VIIRS NOAA-2
Chl-a_OCI
daily
monthly
climatology
true color
ocean color
shorelines
gridlines
granules
color bar
2019
10
13
STAR
Ocean Color
https://www.star.nesdis.noaa.gov/socd/mecb/color/index.php

Summary

- **CMA, NOAA and EUMETSAT through their constellations of LEO and GEO satellites and real-time data access:**
  - Provide many of the sustained observables needed to support a wide variety of critical applications and decisions impacting lives, property and the World's economy and security
  - Many opportunities to support the Belt and Road Region.
  - CMA has a major role in making real impact.


Thank you
Terima kasih
감사합니다!
谢谢
ありがとうございました
धन्यवाद
Спасибо
Trip the Lights Fantastic
A one year accumulation of VIIRS low light imaging data
This map showcases the astonishing details of human activities visible from space at night. From spectacular lights of cities, hustling shipping lanes, boats fishing with heavy lights, to heat sources from gas flares, wildfires and industry.
Using multiband observations, VIIRS (Visible Infrared Imaging Radiometer Suite) made at night, we are able to see social and economical behaviors that cannot be seen by remote sensing in daytime.
This map employs annual data of Nighttime Lights from 2015, VIIRS Boat Detections from 2017, and VIIRS Nightfire from 2017.
Legend
Nighttime Lights
VIIRS Nightfire (VNF)
VIIRS Boat Detection (VBD)
Data analysis and images created by
Background
CIRES
JPSS

https://www.star.nesdis.noaa.gov/jpss/mapper/#zoom=5/date=20191113/lat=23.9067/lon=92.2976/tcon=true/granon=false/bordon=true/view=asc/l1on=true/satval1=N20/sensval

To see favorites here, select ☆≡ then ☆, and drag to the Favorites Bar folder. Or import from another browser. Import favorites

JSTAR Mapper

If product image does not appear, please zoom out

11 13 2019

Projection: Global Day

Layer 1 Show

NOAA-20

Land

I-Band Fire Radiative Power

Opacity

Layer 2 Show

NOAA-20

Ocean

Chlorophyll-a

Opacity

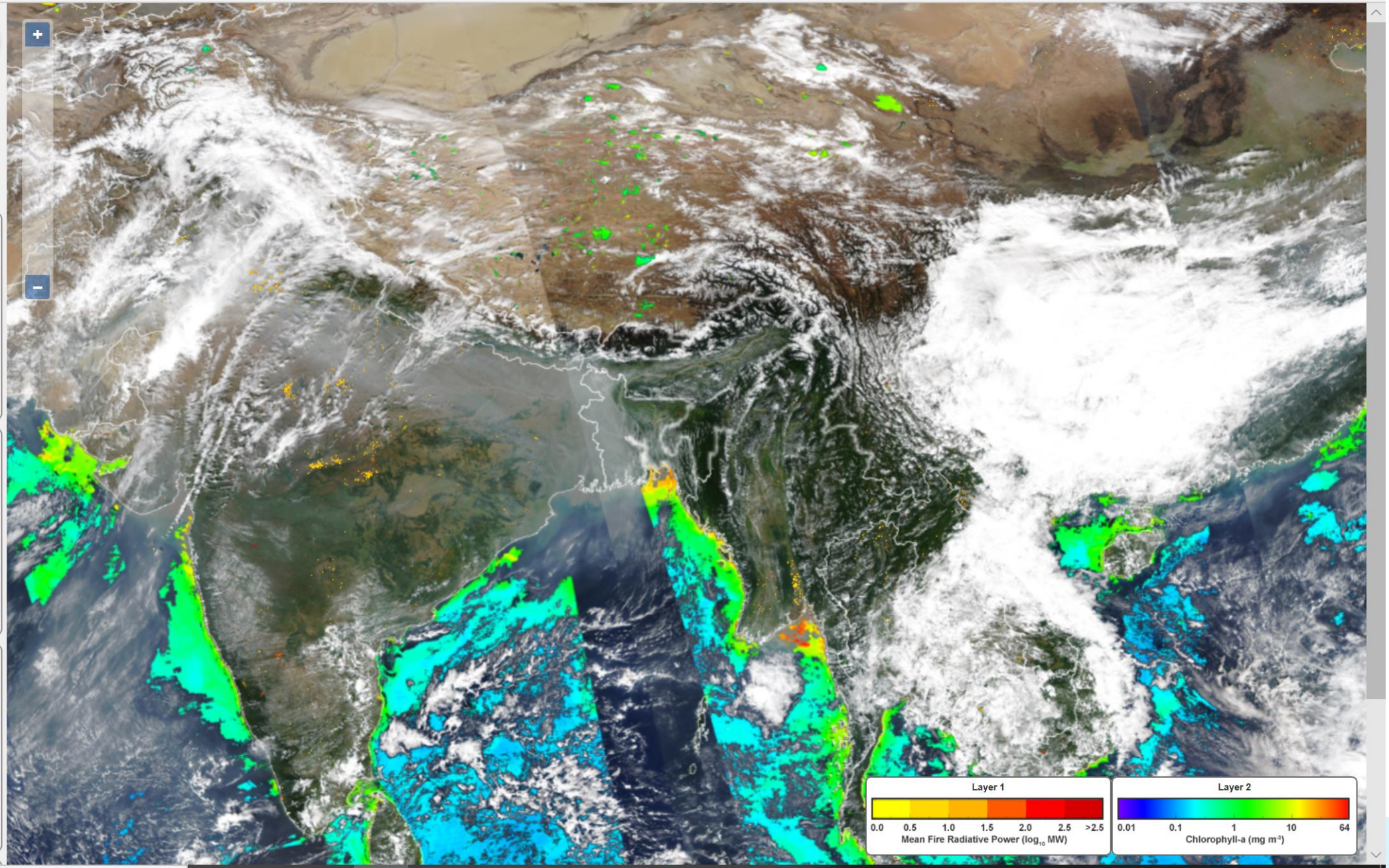
Layer 3 Show

NOAA-20

MIRS

Rainfall Rate

Opacity

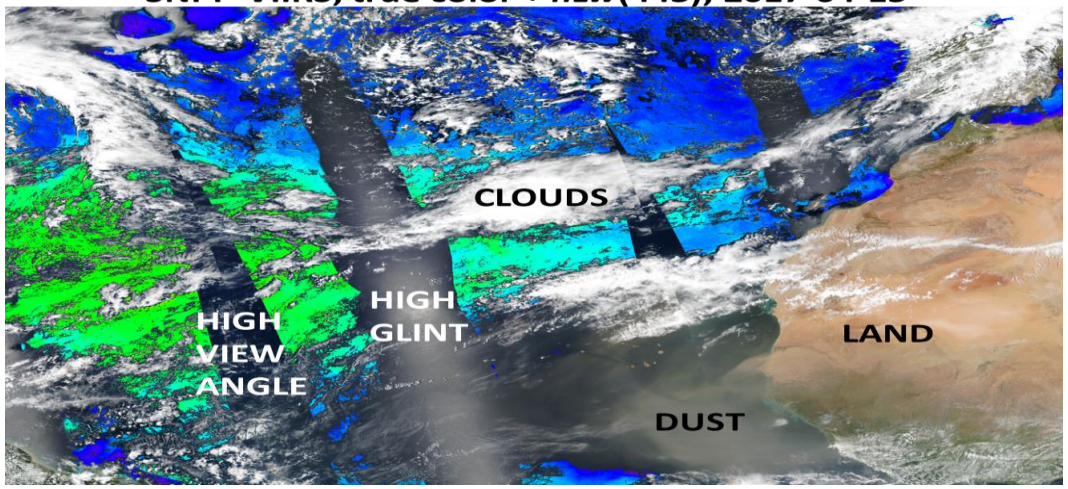


9:53 AM

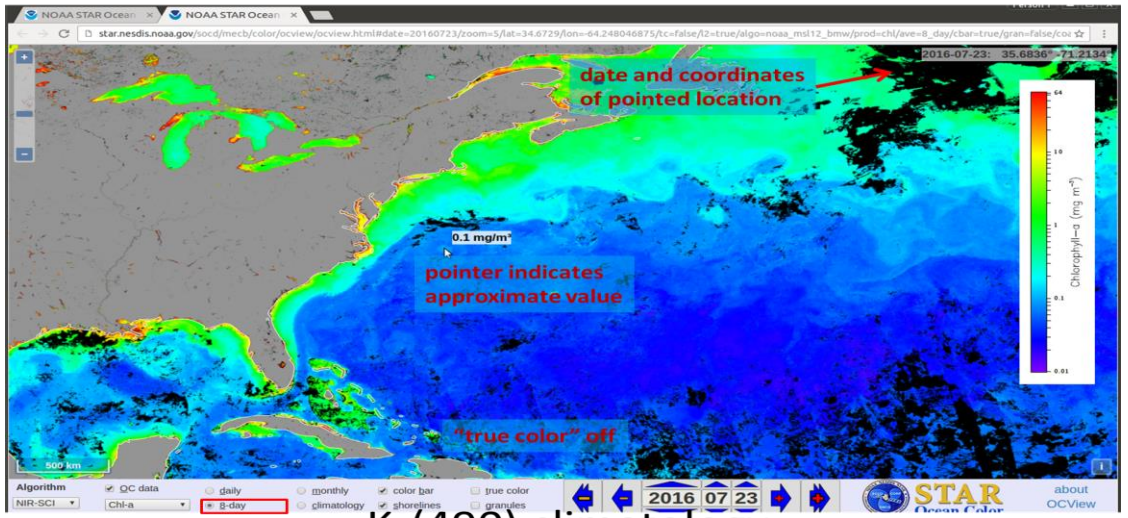
Ocean Monitoring - OCView – Ocean Color Viewer

www.star.nesdis.noaa.gov/socd/mecb/color/ocview/ocview.html

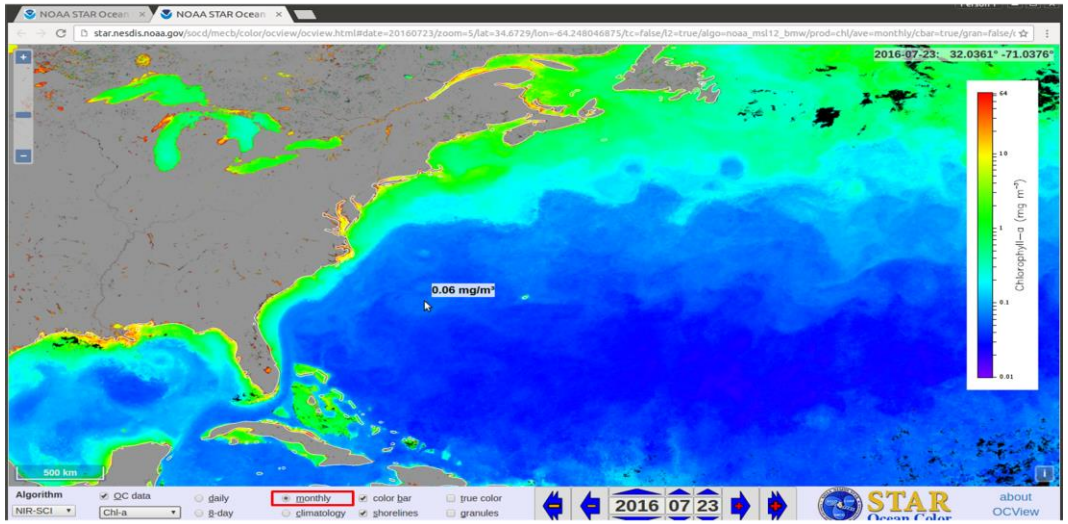
SNPP-VIIRS, true color + *nLw*(443), 2017-04-15



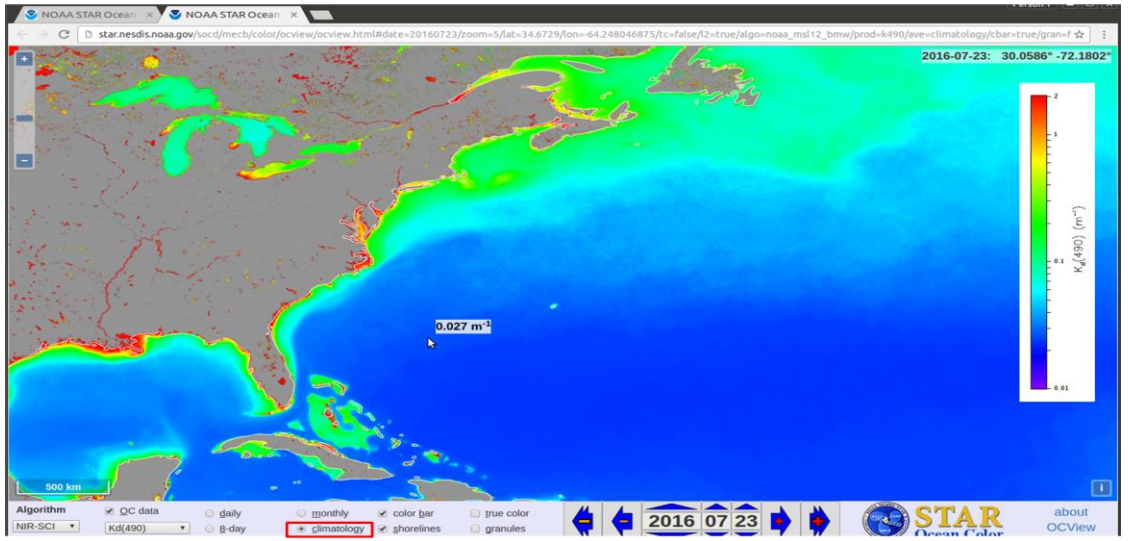
Chl-a 8 day time average



Chl-a monthly time average



K_d(490) climatology



https://www.star.nesdis.noaa.gov/sod/mecb/color/ocview/ocview.html#date=20191112/zoom=4/lat=20.6429/lon=77.4688/tc=false/l2=true/sens=OLCIB/proj=4326/algo=esa_olci_nr

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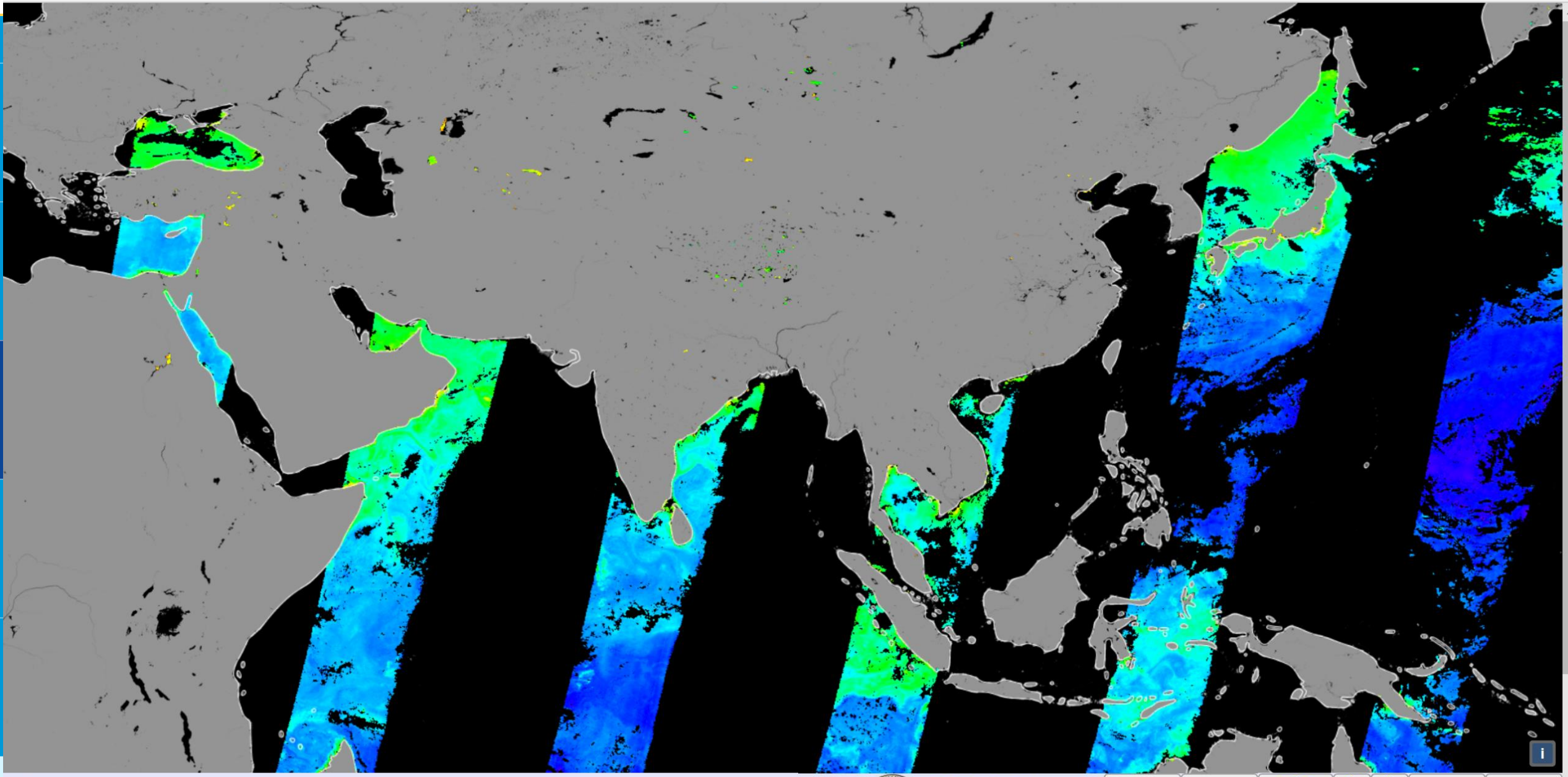

daily monthly true color shorelines granules

STAR

2019 11 12

Ocean and Coastal Water Quality (Nutrients) - Chlorophyll-A