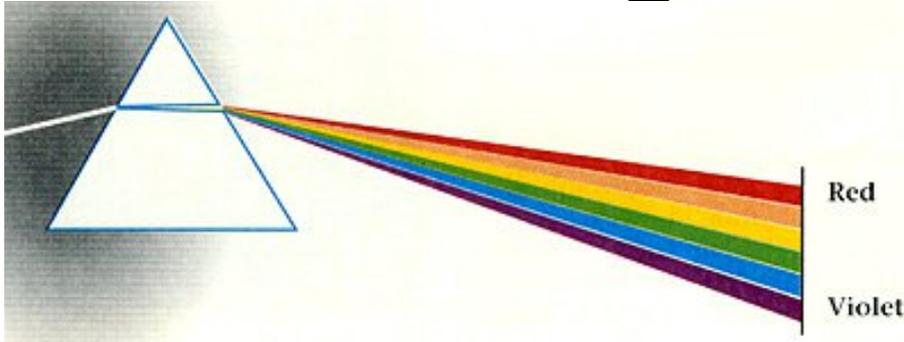


# A global look at satellite data and monitoring

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Earth Observation Group  
NOAA National Geophysical Data Center  
Boulder, Colorado 80305 USA  
[chris.elvidge@noaa.gov](mailto:chris.elvidge@noaa.gov)

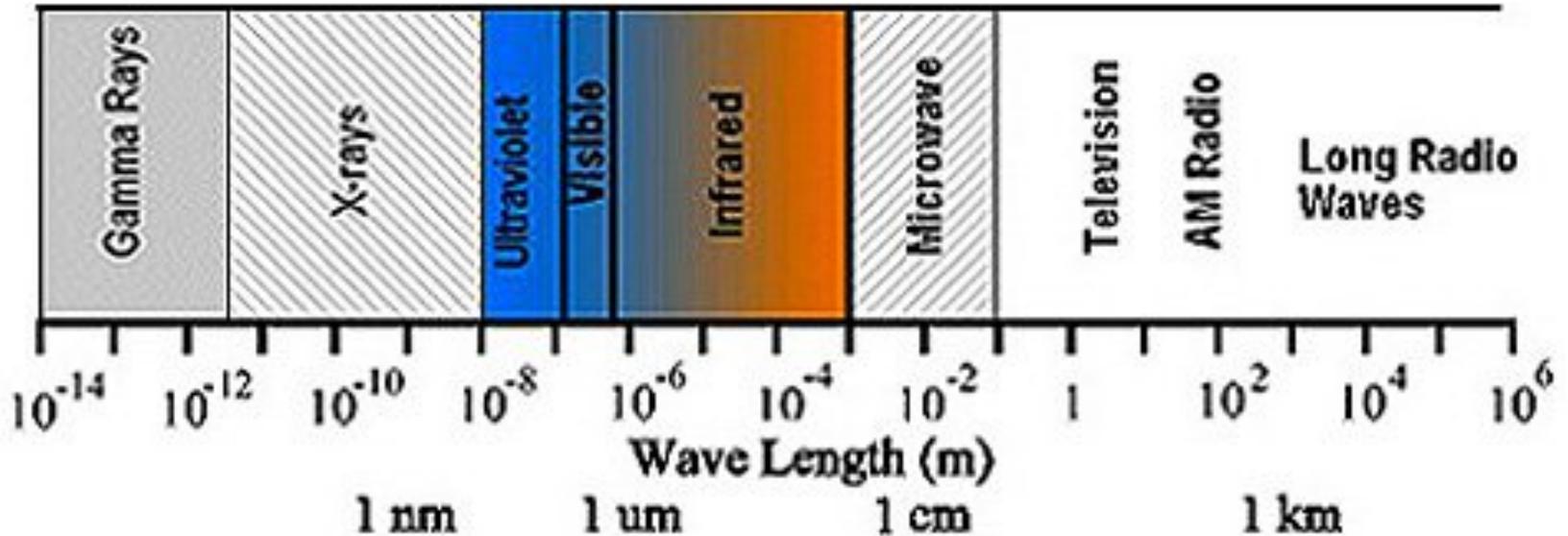
August 19, 2014

# Electromagnetic Radiation (Light)

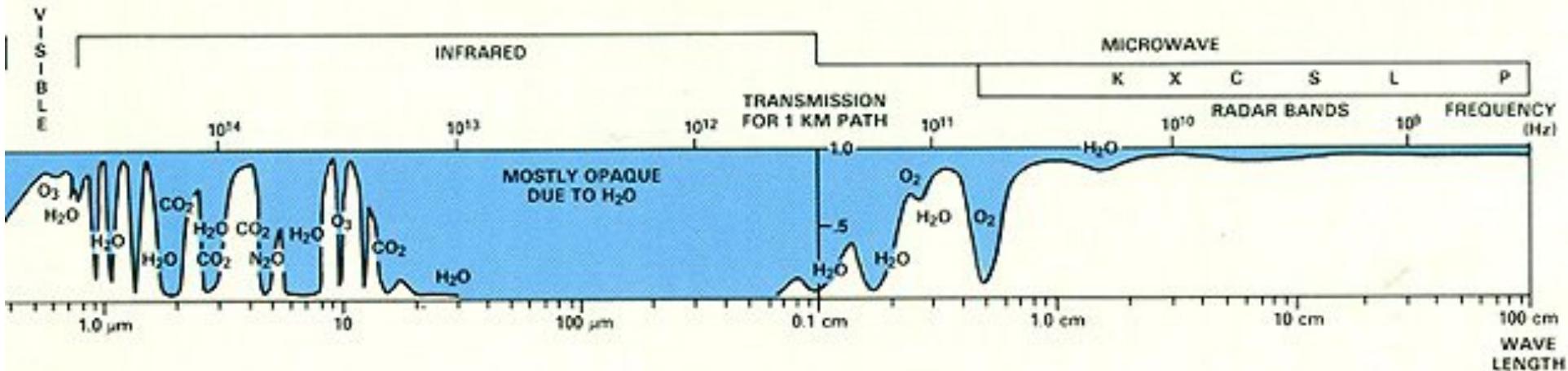


Human vision covers wavelengths 0.4 to 0.7 micrometers

Remote sensing spans the UV to microwave



# Atmospheric Windows



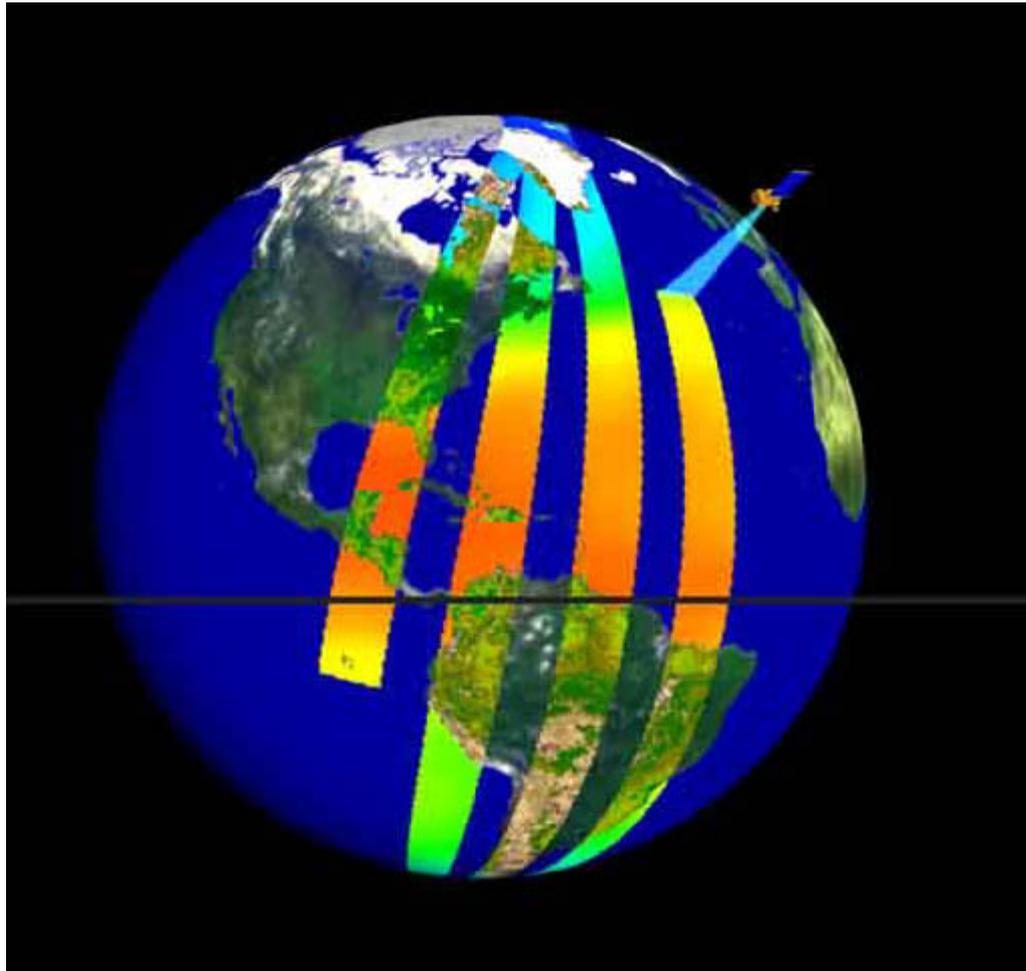
Observation of the earth surface in clear atmospheric windows. The individual windows are the locations of “see to the ground spectral bands”. Spectral ranges outside the atmospheric windows can be used to measure atmospheric water, greenhouse gases, temperature and pressure profiles.

# Active versus passive remote sensing

- Most remote sensing systems are passive, relying on sunlight or emissions from the objects themselves.
- In visible, near infrared, short-wave infrared sunlight can be used as the illumination source – passive remote sensing. Earth surface features only detectable during daylight hours and are blocked by clouds.
- In long-wave infrared and microwave the objects emit based on their temperature and composition suitable for day and night passive remote sensing. LWIR view of the earth surface is blocked by clouds. Some MW channels see through clouds, but spatial resolution is coarse.
- Active remote sensing: synthetic aperture radars, LIDARs. These are typically fee based services. SAR systems can see through clouds.

# Spatial and Temporal Resolution

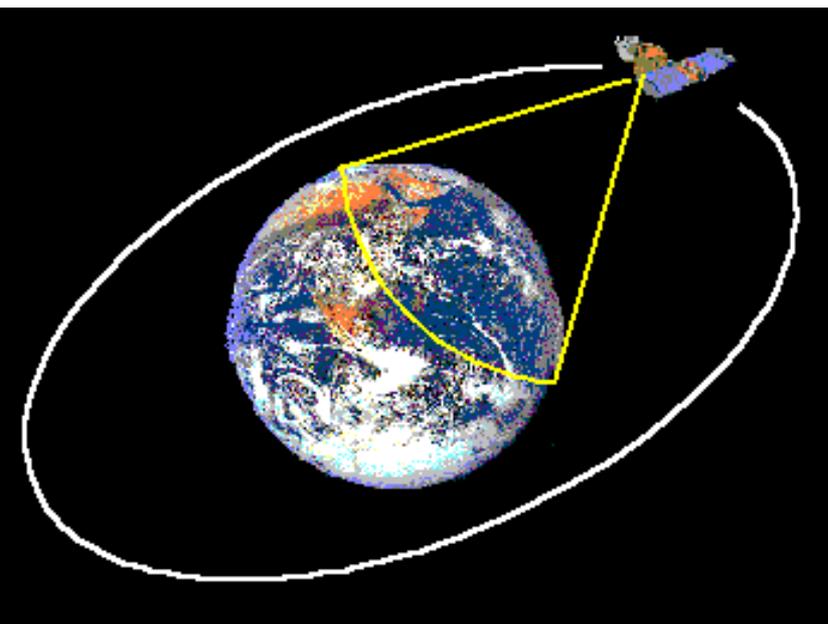
- High spatial resolution data is typically a fee based commercial service.
- 30 meter Landsat 8 data are freely available, but have a 16 day repeat cycle.
- ~1 km data from NASA and NOAA satellites each collect twice per day (day and night).  
Open access data and environmental products.



# Polar Orbits

In polar orbits, satellite fly over the north and south poles at elevations ranging from 400 to 1000 km altitude. Easier to obtain higher spatial resolution, but limits the number of daily observations.

Examples: Landsat, MODIS, VIIRS.

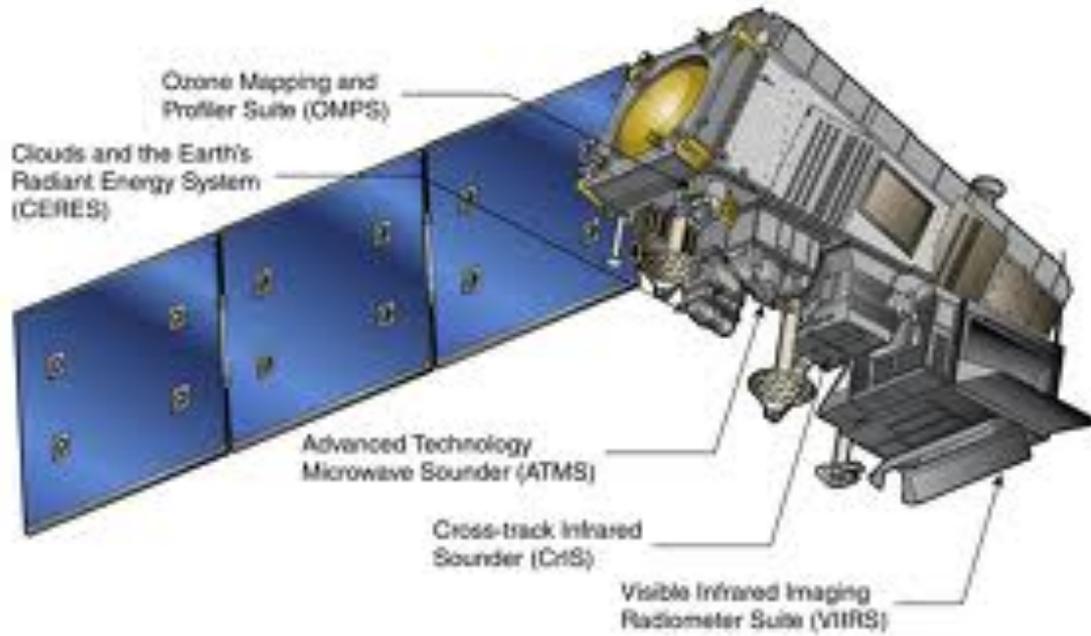


# Geostationary Orbits

Geostationary systems stay in a fixed position 36,000 km above a single position above the equator. This orbit is favored by meteorological satellites. MTSAT collects data of the Mekong Region.

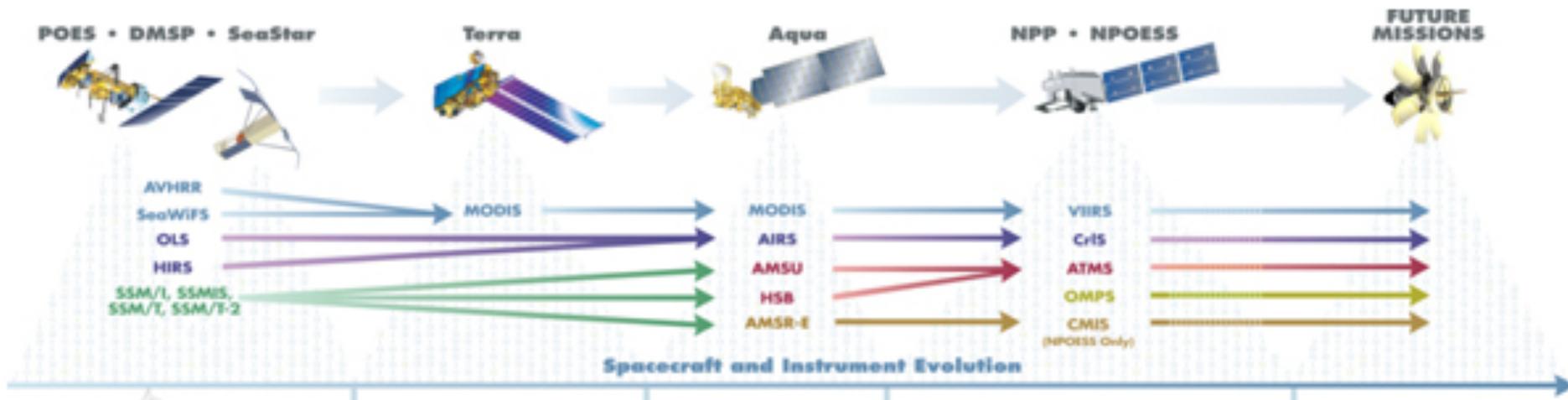
# Local versus global data collection

- NASA, NOAA, USGS collect global data from on-board recorders from high latitude ground stations. Data distribution delayed by ~12 hours.
- NASA and NOAA satellites broadcast the sensor data in-flight. It is possible to collect the data with a local ground station to reduce the temporal latency and bypass intercontinental data transfer.
- Landsat ground stations licensed by USGS.



NASA/NOAA  
Suomi National  
Polar Partnership  
(SNPP) satellite  
was launched  
October 28,  
2011.

# SNPP is the USG's 3<sup>rd</sup> Generation Polar Orbiting Environmental Satellite



The NASA/NOAA Suomi National Polar Partnership (SNPP) satellite was launched October 28, 2011. NGDC serves as one of two archives for SNPP data. The full stream of image data and products are received at NGDC 8-10 hours from collection.



Svalbard  
Ground  
Station

# SNPP Data Flow

National Geophysical Data Center



Other Users



NOAA National Satellite  
Operations Facility  
(NSOF), Suitland, MD



National Weather Service



## VIIRS bands and bandwidths

VIIRS Band	Central Wavelength ( $\mu\text{m}$ )	Bandwidth ( $\mu\text{m}$ )	Wavelength Range ( $\mu\text{m}$ )	Band Explanation	Spatial Resolution (m) @ nadir
M1	0.412	0.02	0.402 - 0.422	Visible	750 m @ nadir
M2	0.445	0.018	0.436 - 0.454		
M3 (blue)	0.488	0.02	0.478 - 0.488		
M4 (green)	0.555	0.02	0.545 - 0.565		
M5 (red)	0.672	0.02	0.662 - 0.682		
M6	0.746	0.015	0.739 - 0.754	Near IR	
M7	0.865	0.039	0.846 - 0.885	Shortwave IR	
M8	1.240	0.020	1.23 - 1.25		
M9	1.378	0.015	1.371 - 1.386		
M10	1.61	0.06	1.58 - 1.64		
M11	2.25	0.05	2.23 - 2.28	Medium-wave IR	
M12	3.7	0.18	3.61 - 3.79		
M13	4.05	0.155	3.97 - 4.13	Longwave IR	
M14	8.55	0.3	8.4 - 8.7		
M15	10.763	1.0	10.26 - 11.26		
M16	12.013	0.95	11.54 - 12.49		
DNB	0.7	0.4	0.5 - 0.9	Visible	750 m across full scan
I1	0.64	0.08	0.6 - 0.68	Visible	375 m @ nadir
I2	0.865	0.039	0.85 - 0.88	Near IR	
I3	1.61	0.06	1.58 - 1.64	Shortwave IR	
I4	3.74	0.38	3.55 - 3.93	Medium-wave IR	
I5	11.45	1.9	10.5 - 12.4	Longwave IR	

M = Moderate-resolution bands

I = Imagery-resolution bands

DNB = Day-Night Band (or Near Contrast Band)

# VIIRS Spectral Bands

## **VIIRS**

Albedo (Surface)  
Cloud Base Height  
Cloud Cover/Layers  
Cloud Effective Part Size  
Cloud Optical Thickness  
Cloud Top Height  
Cloud Top Pressure  
Cloud Top Temperature  
Land Surface Temp  
Surface Type  
Ocean Color/Chlorophyll  
Suspended Matter  
Vegetation Index  
Aerosol Optical Thickness  
Aerosol Particle Size  
Ice Surface Temperature  
Imagery  
Sea Ice Characterization  
Snow Cover/Depth  
Sea Surface Temperature

## **CrIS/ATMS**

ATM Vert Moist Profile  
ATM Vert Temp Profile  
Pressure (Surface/Profile)

## **OMPS**

O<sub>3</sub> Total Column (also CrIS)  
O<sub>3</sub> Profile

## **CERES**

Down LW Radiance (Sfc)  
Down SW Radiance (Sfc)  
Net Solar Radiation (TOA)  
Outgoing LW Rad (TOA)

# SNPP Environmental Products

# VIIRS data are freely available from NOAA in HDF5 format

NOAA HOME WEATHER OCEANS FISHERIES CHARTING SATELLITES CLIMATE RESEARCH COASTS CAREERS

NOAA COMPREHENSIVE LARGE ARRAY-DATA STEWARDSHIP SYSTEM (CLASS) NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

» CLASS Home » Login » Register » Help » About CLASS » **RSS** CLASS Help All NOAA  » SEARCH

» Please select a product to search  » GO

**Around CLASS**

- » Home
- » Search for Data
- » Upload Search
- » Search Results
- » Shopping Cart
- » Order Status
- » Help
- User Account**
- » User Profile
- » User Preferences
- Advanced Options**
- » Download Keys
- Release Info**
- » Version 6.3.3.2.1  
July 24, 2014
- Other Links**
- » CLASS Home
- » NODC
- » NCDC
- » NCEP

**Image source: Suomi NPP VIIRS**



**NEWS**

**Attention S-NPP Users (08/05/14):**  
Beginning on August 11-13, 2014, CLASS will begin receiving the majority of S-NPP data in gzip compressed format from JPSS for ATMS, CRIS, CRIMMS, OMPS and VIIRS. All other data types will remain uncompressed. Please see the Notes section of a particular product on or after 8/6/14 to read additional details on the compression. The file names will remain the same. Other than the file size being smaller, users do not need to make any changes to their software to use the data. If you have any questions please email [CLASS Help Desk](#).

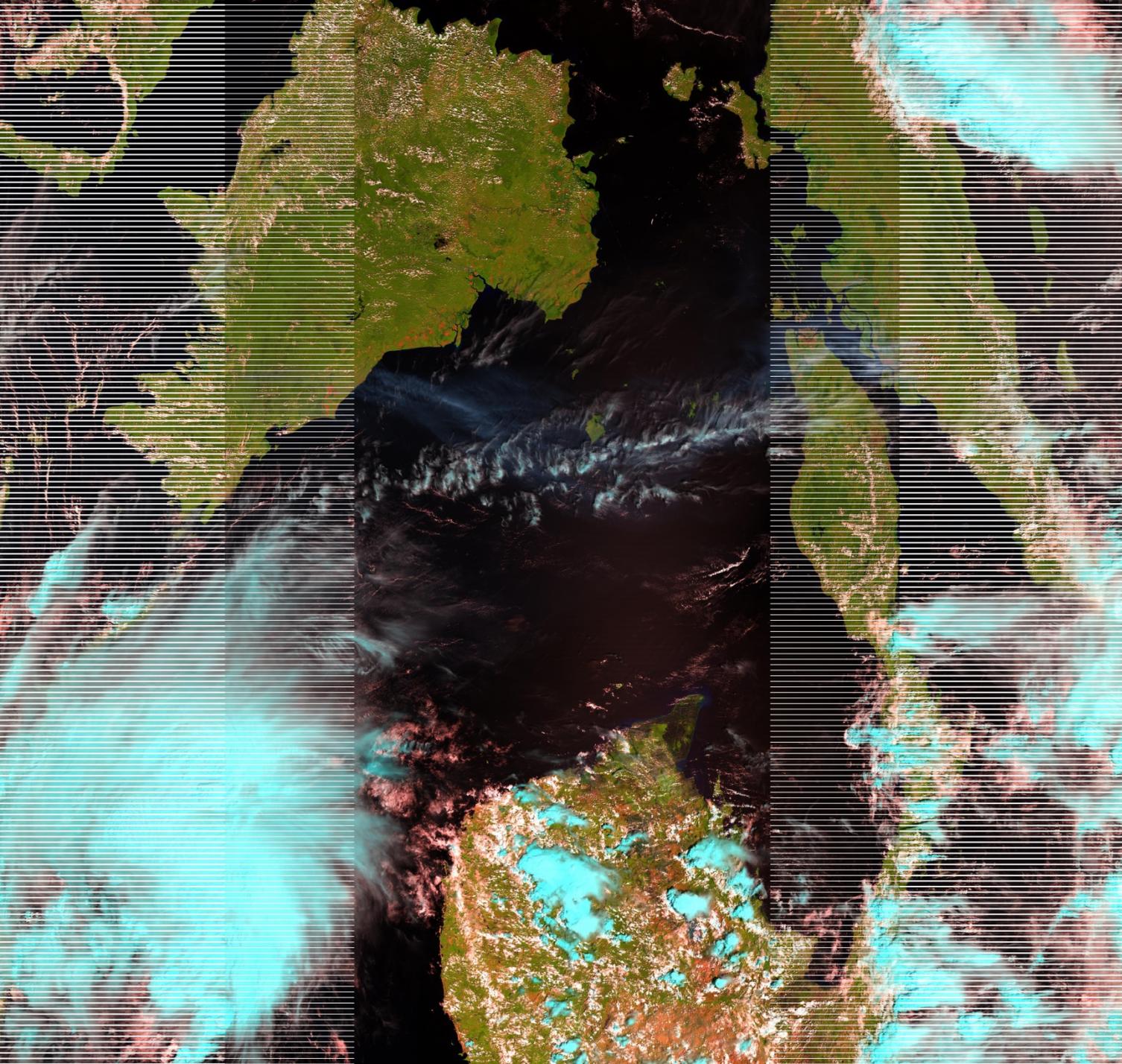
**Attention All CLASS users (06/23/14):**  
Recently, you may have heard about a new internet security weakness, known as [Heartbleed](#), which is impacting some websites. There is no indication that Heartbleed has been used against [www.class.noaa.gov](#) or that any personal information has ever been at risk. However, we are asking users to change their current password out of an abundance of caution to ensure the protection of your information.

**SEARCH FOR DATA**

- + Environmental Data from Polar-orbiting Satellites
- + Environmental Data from Geostationary Satellites
- + Defense Meteorological Satellite Program (DMSP)
- + Suomi National Polar-orbiting Partnership (NPP)
- + Sea Surface Temperature data (SST)
- + RADARSAT
- + Altimetry / Sea Surface Height Data (JASON-2)
- + Global Navigation Satellite Systems (GNSS)
- + Other - Miscellaneous products in CLASS

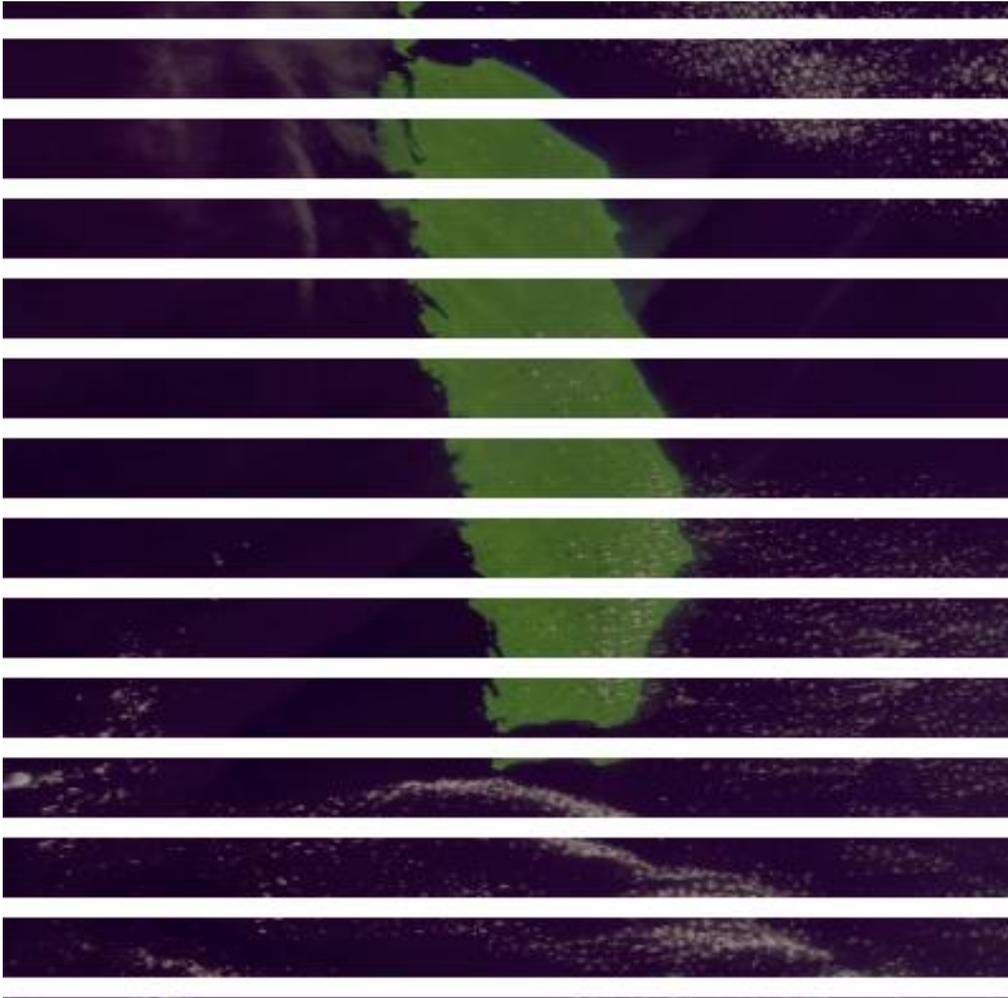
**SEARCH COLLECTION METADATA**

» GO



VIIRS Data  
Aggregate  
June 19,  
2013

# Panoramic Bowtie Effect



Nias  
Island,  
Sumatra

Note the  
repetition  
of shoreline  
features

# Why SNPP Data Are Difficult to Use

- Few systems able to open HDF5 format.
- Stacking of metadata balloons file sizes.
- VIIRS data
  - Daytime data are “upside down”.
  - have latitude / longitude locations separate from image data (geolocation has not been performed).
  - VIIRS data and products have line deletions and redundant Earth features at edge of scan. The exception is the day/night band which has constant 742 meter pixels across full scan.
  - Regional study areas will be covered by multiple 5 minute aggregates and orbits.

# What Array Data Are Inside the HDF5?

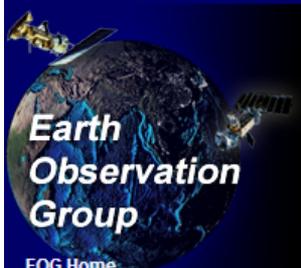
- Radiances or data values. These are often unsigned integers that must be multiplied by a coefficient to obtain the radiance or environmental data value (e.g. degrees K).
- Solar zenith angle
- Solar azimuth angle
- Satellite zenith angle
- Satellite azimuth angle
- Satellite range (distance from pixel on ground to satellite)
- Quality flag
- Terrain corrected longitude
- Terrain corrected latitude

# Solution

- NGDC identifies the data covering East Asia as they arrive for archiving
- Coefficients are applied to obtain physical data values.
- VIIRS data are projected into 15 arc second grids: north is up, line deletions are screened out, bowtie duplicates removed.
- Output as geotiff.
- Post for download.

# Data Access Page Has Been Established

← → ↻ ngdc.noaa.gov/eog/viirs/download\_thailand.html



**Earth  
Observation  
Group**  
EOG Home.

- DMSP Archive Description
- Description of DMSP Sensors
- Data Availability
- Data Services and Pricing
- Data Download
- Online Maps and Web Services
- Nighttime Lights Posters
- Presentations
- Publications
- News & Media
- Items of Interest

## VIIRS Data Products of Thailand

SNPP is the Suomi National Polar Partnership satellite flown by NASA and NOAA. It is the next generation polar orbiting satellite, collecting both daytime and nighttime data worldwide each day. The primary imager on SNPP is the Visible Infrared Imaging Radiometer Suite (VIIRS). The source data are produced in HDF5 format and are available through NOAA's CLASS archive. To reduce the data volume and to increase the usability of the data - NGDC has developed a service to geolocate VIIRS images and environmental products. At this site we will provide access to VIIRS data collected over the Thailand region requested by the Thailand Hydro-Agro Informatics Institute and Thailand Department of Fisheries.

Last Update: 08/17/2014/20:20:54

Readme file can be downloaded [here](#).  
You can view files in our interactive map system or download from the drop list.  
[Interactive map system](#)

[Expand All](#) | [Contract All](#)

- 2014/August
  - 20140817
  - 20140816
  - 20140815
  - 20140814
  - 20140813
  - 20140812
  - 20140811
  - 20140810
  - 20140809

# Product Type Directory Tree

The screenshot displays a web browser window with the address bar showing `ngdc.noaa.gov/eog/viirs/download_thailand.html`. The page content is a directory tree of satellite data products. On the left, a dark blue sidebar contains navigation links such as "Data Services and Pricing", "Data Download", "Online Maps and Web Services", "Nighttime Lights Posters", "Presentations", "Publications", "News & Media", "Items of Interest", "Documents About DMSP", "Nighttime Lights Temporal Loops", "Nightsat", "McMurdo Ground Project Data Resources", and "FAQ".

The main content area shows a directory tree structure:

- [Expand All](#) | [Contract All](#)
- 2014/August
  - 20140818
    - Day\_Ascending
      - Aerosols
      - Cloud Products
      - Day-Night Band Imagery
      - Imaging-Band Imagery
      - Terrestrial Products
      - Moderate-Band Imagery
      - NET\_CDF Atmospheric Parameters
      - Ocean Products
  - 20140817
    - Day\_Ascending
    - Night\_Descending
      - Aerosols
      - Cloud Products
      - Day-Night Band Imagery
      - Imaging-Band Imagery
      - VIIRS Night-fire Product
      - Terrestrial Products
      - NET\_CDF Atmospheric Parameters
      - Ocean Products
  - 20140816
  - 20140815
  - 20140814
  - 20140813

The Windows taskbar at the bottom shows the Start button, several application icons, and the system tray with the date and time: 5:28 PM, 8/18/2014.

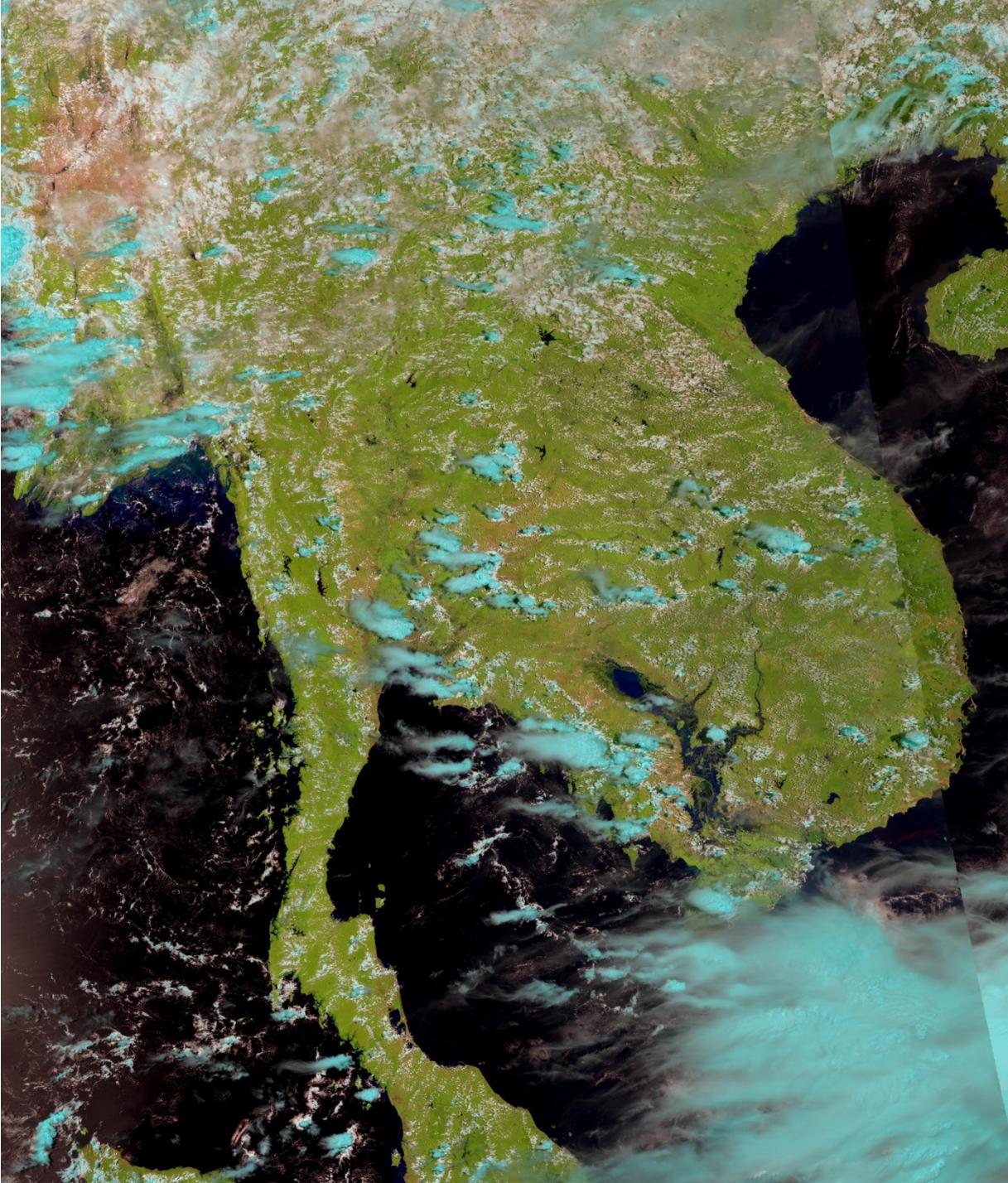
# File Listing

NOAA/NGDC - Earth Observ...

ngdc.noaa.gov/eog/viirs/download\_thailand.html

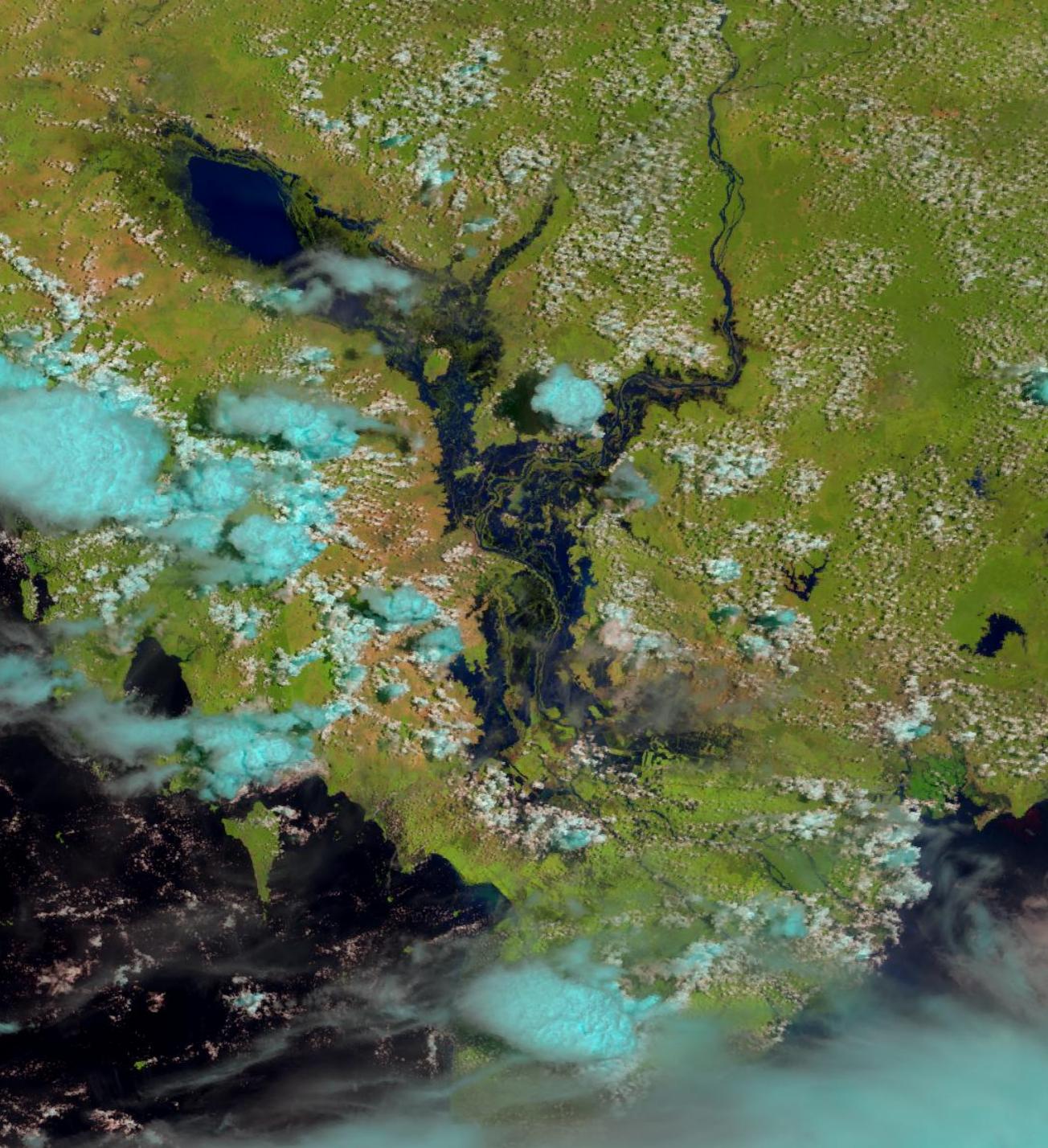
[Expand All](#) | [Contract All](#)

- 2014/August
  - 20140818
    - Day\_Ascending
      - Aerosols
      - Cloud Products
      - Day-Night Band Imagery
      - Imaging-Band Imagery
        - [SVI01-SVI02-SVI03\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.pgw](#)
        - [SVI01-SVI02-SVI03\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.pgw](#)
        - [SVI01-SVI02-SVI03\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.png](#)
        - [SVI01-SVI02-SVI03\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.png](#)
        - [SVI01\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI01\\_npp\\_d20140818\\_t0643287\\_e0649091\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI01\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI02\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI02\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI02\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI02\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI03\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI03\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI04\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI04\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI05\\_npp\\_d20140818\\_t0506447\\_e0512251\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
        - [SVI05\\_npp\\_d20140818\\_t0643287\\_e0654507\\_b14540.a.thailand\\_mos.rad.tif.gz](#)
      - Terrestrial Products
      - Moderate-Band Imagery
      - NET\_CDF Atmospheric Parameters

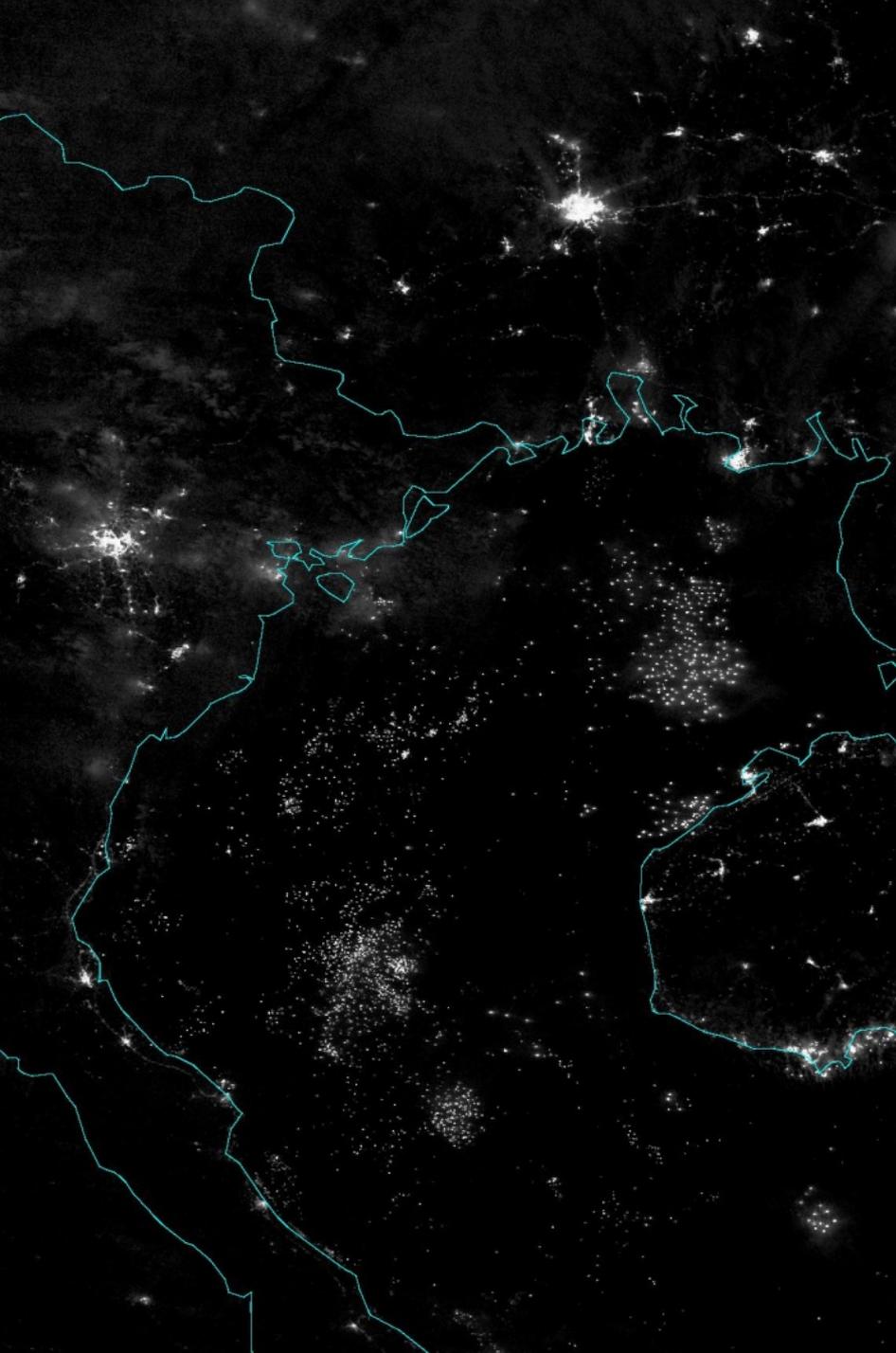


## VIIRS imaging band data from August 17, 2014

Raw imaging band  
data for four HDF5  
aggregates = 9 GB.  
From NGDC service  
as geotiff = 450 MB.  
A 95% data volume  
reduction.

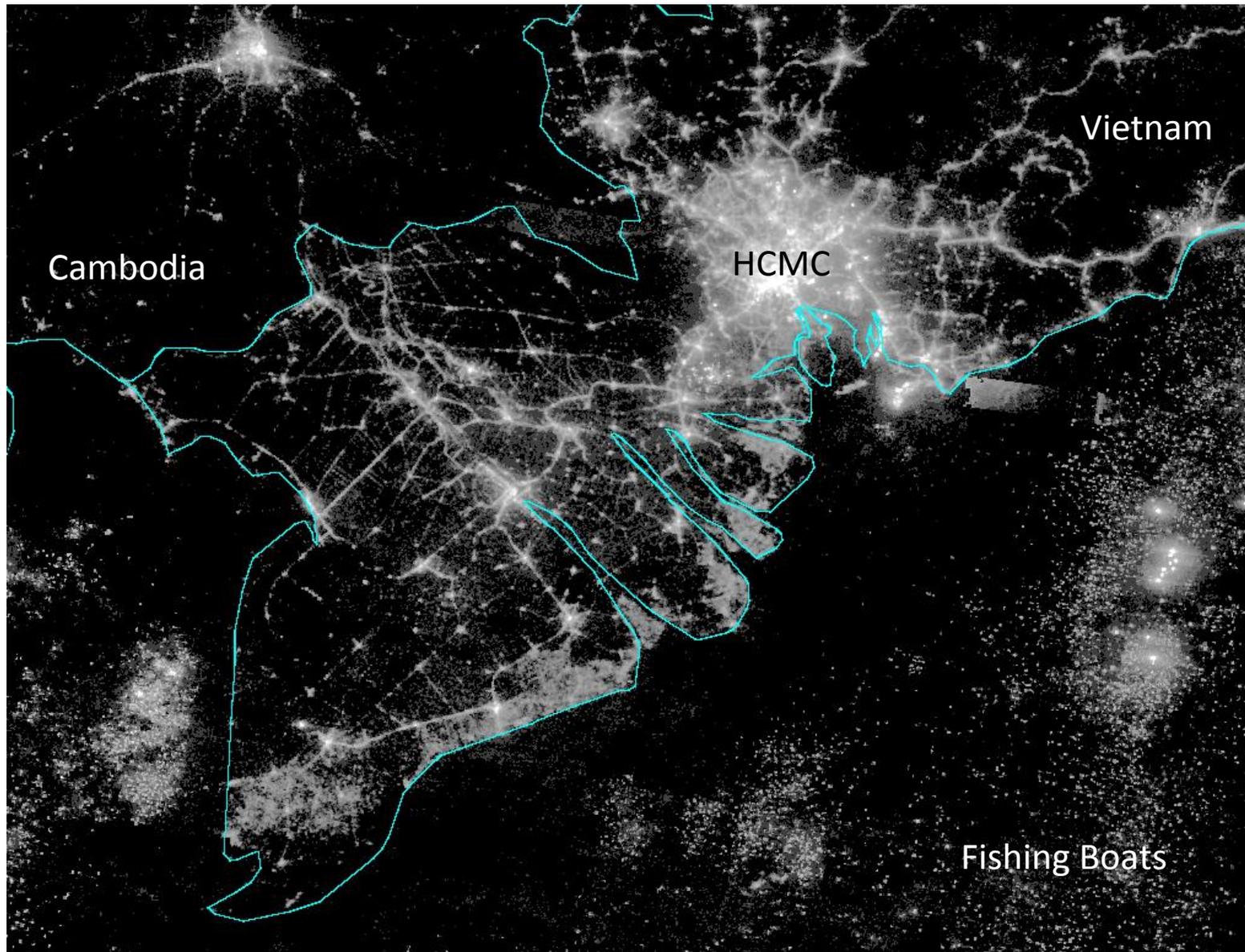


Flooding in  
Cambodia and  
Vietnam  
August 17, 2014  
VIIRS imaging  
bands 3,2,1 as  
red, green, blue



# VIIRS DNB boat detections – August 17, 2014

# NGDC's VIIRS DNB Composite – May, 2014



# VIIRS Nightfire

The screenshot displays the Google Earth Pro interface with a map of Vietnam. A red pin on the coast indicates a nightfire detection. The left sidebar shows the 'Places' and 'Layers' panels. The central data panel provides the following information:

**Combustion parameters:**  
ID=VNF\_npp\_d20140817\_t1801019\_e1806423\_b14533\_x1079712E\_y099728N\_I0213\_s0812\_v21  
Lat=9.972832 Lon=107.971153 deg. Time=2014/08/17 18:02:00  
Temperature source=1629 deg. K Temperature background=269 deg. K  
Radiant heat intensity=8.18 W/m<sup>2</sup> Radiant heat=7.98 MW  
Source footprint=20.02 m<sup>2</sup>  
Cloud state=cloudy Atmosphere corrected=no

The graph, titled 'IR source radiance', plots radiance (W/m<sup>2</sup>/sr/um) against wavelength (um). The y-axis ranges from 0 to 6, and the x-axis ranges from 0 to 12. The legend indicates:

- Blue asterisk: no detection
- Red asterisk: detection
- Green asterisk: used as constraint
- Blue line: dual curve model
- Red line: IR source
- Black line: background

The graph shows a red line for the IR source peaking at approximately 2 um, a black line for the background peaking at approximately 4 um, and a blue line for the dual curve model peaking at approximately 10 um. Green asterisks are placed at approximately 8.5 um and 11.5 um, indicating where the model was constrained by observations.

At the bottom of the data panel, the coordinates are: lat 9.973902° lon 103.003937° elev 0 ft. The bottom right corner shows the eye alt as 660.16 mi and the system clock as 7:27 PM on 8/18/2014.

# Water Disasters

- Flooding (inundation)
  - Heavy precipitation with insufficient drainage
  - Coastal storm surge
  - Coastal tsunami
  - Dam and levee failures
- Drought
  - Insufficient precipitation

# Basic remote sensing observables related to flooding and drought

- Inundation mapping with optical and radar sensors
- Typhoon movement, wind speed, temperature
- Rain rates from thermal and microwave sensors
- Response of land surface to drought
- Damage assessment with high spatial resolution imagery

# Water Disaster Management Phases

## Using Remote Sensing Data

- Prediction and warning
  - Rain rates
  - Storm track and storm surge prediction
  - Generation of digital topographic data
  - Maps of constructed surface densities
- Observation of the severity of disaster events
  - Extent and depth of flooding
  - Extent of drought
  - Affected population
- Damage assessment / Recovery
  - Damage to infrastructure (buildings and roads)
  - Interruption of electric power service
  - Damage to crops

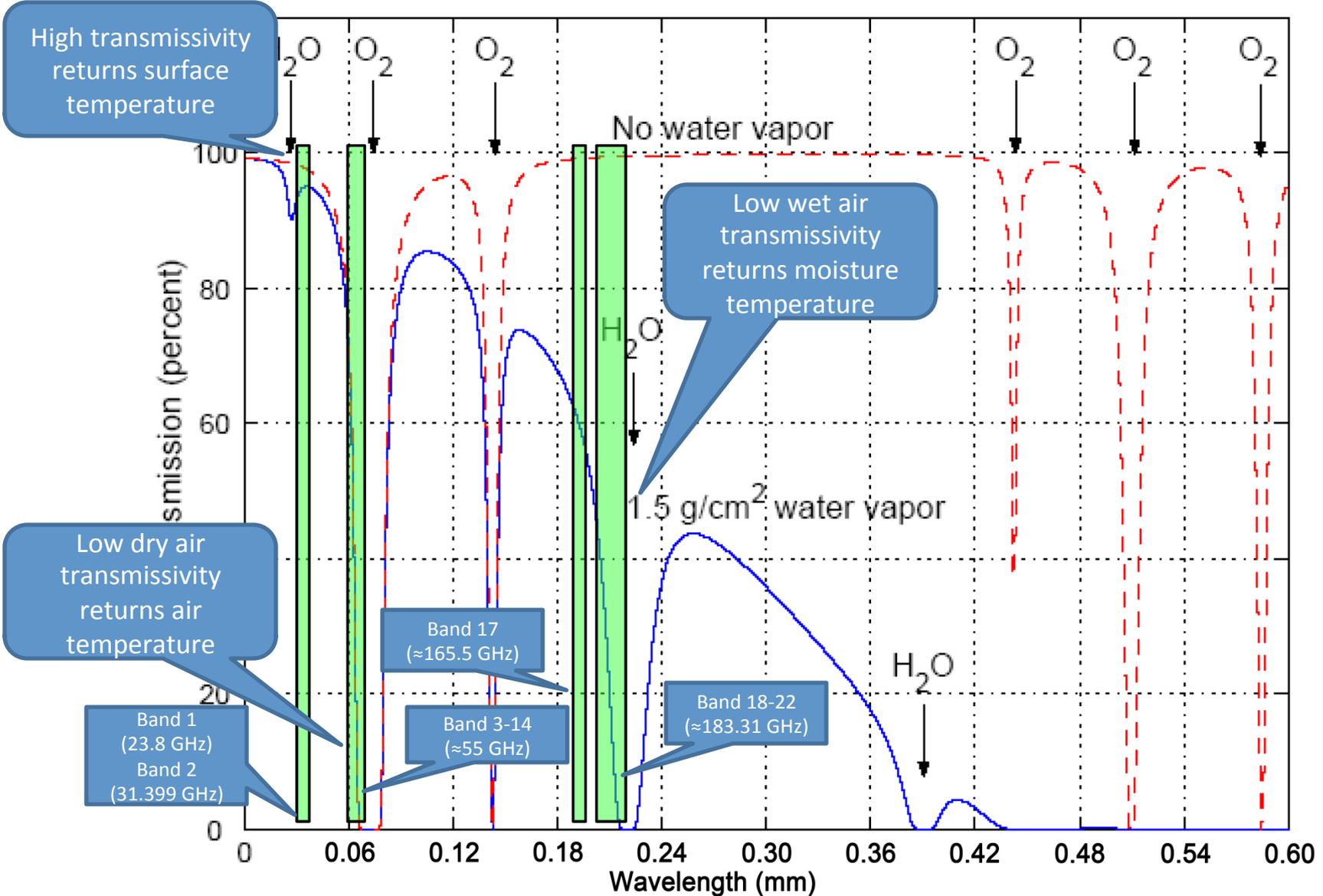
# Microwave Rain Rates

- The earth surface radiates microwave energy.
- Rain rates are estimated by measuring the absorption of certain microwave frequencies. See-to-the-ground frequencies are used as reference.
- Current satellites do not provide continuous global monitoring of rain rates by microwave sensing, but provide a sampling, with multiple observations of most areas each day.

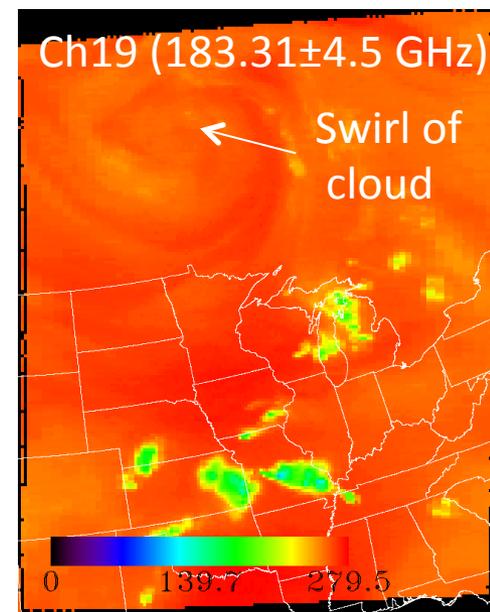
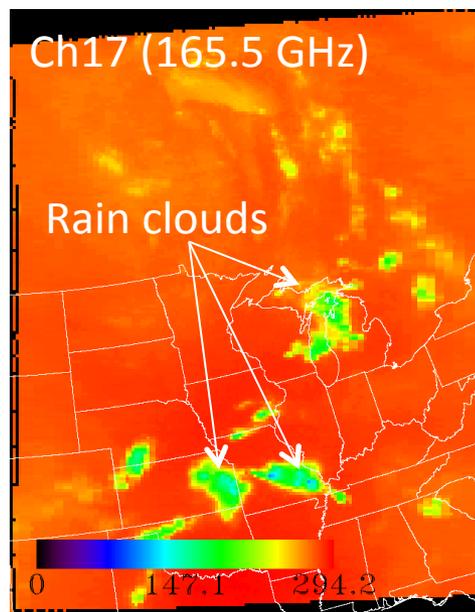
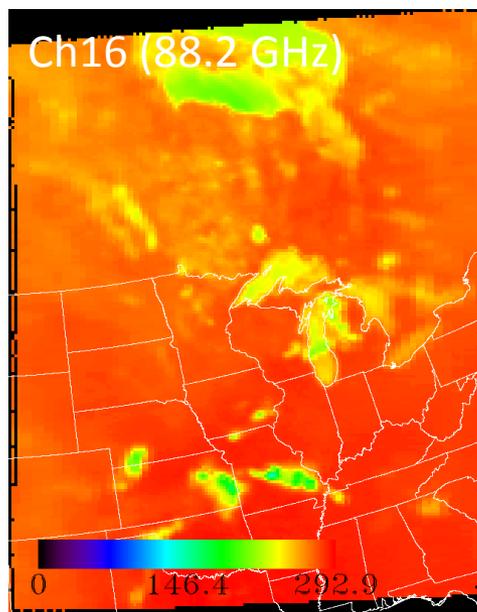
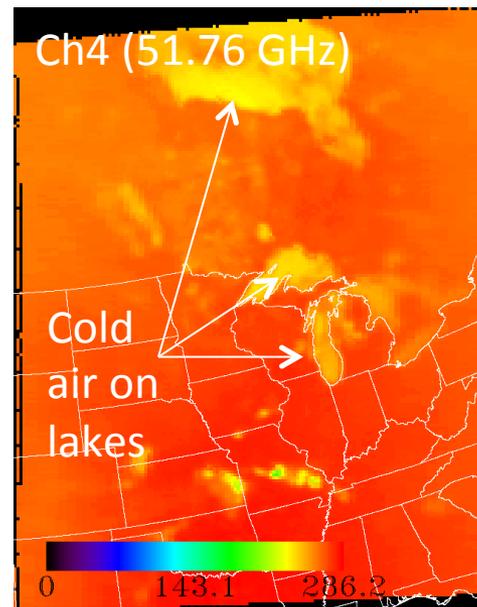
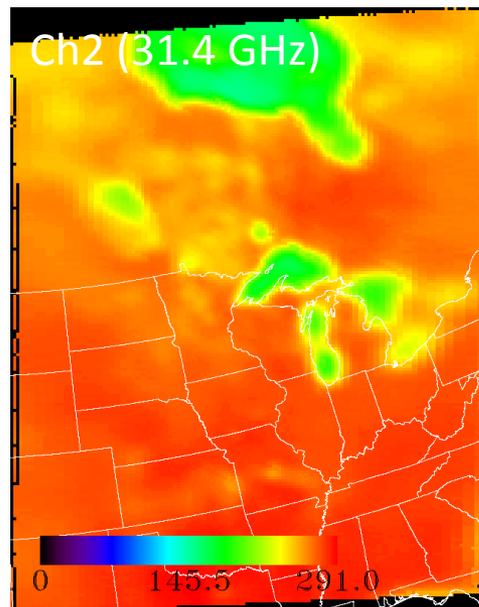
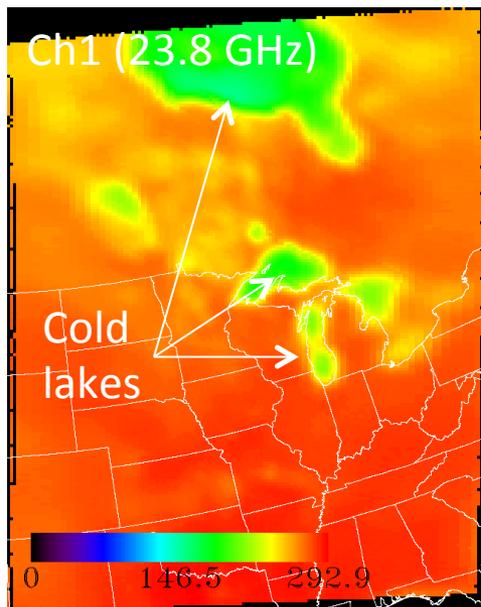
# Atmospheric Transmission at Microwave Wavelengths

Dry air versus air with water vapor (missing liquid water spectrum)

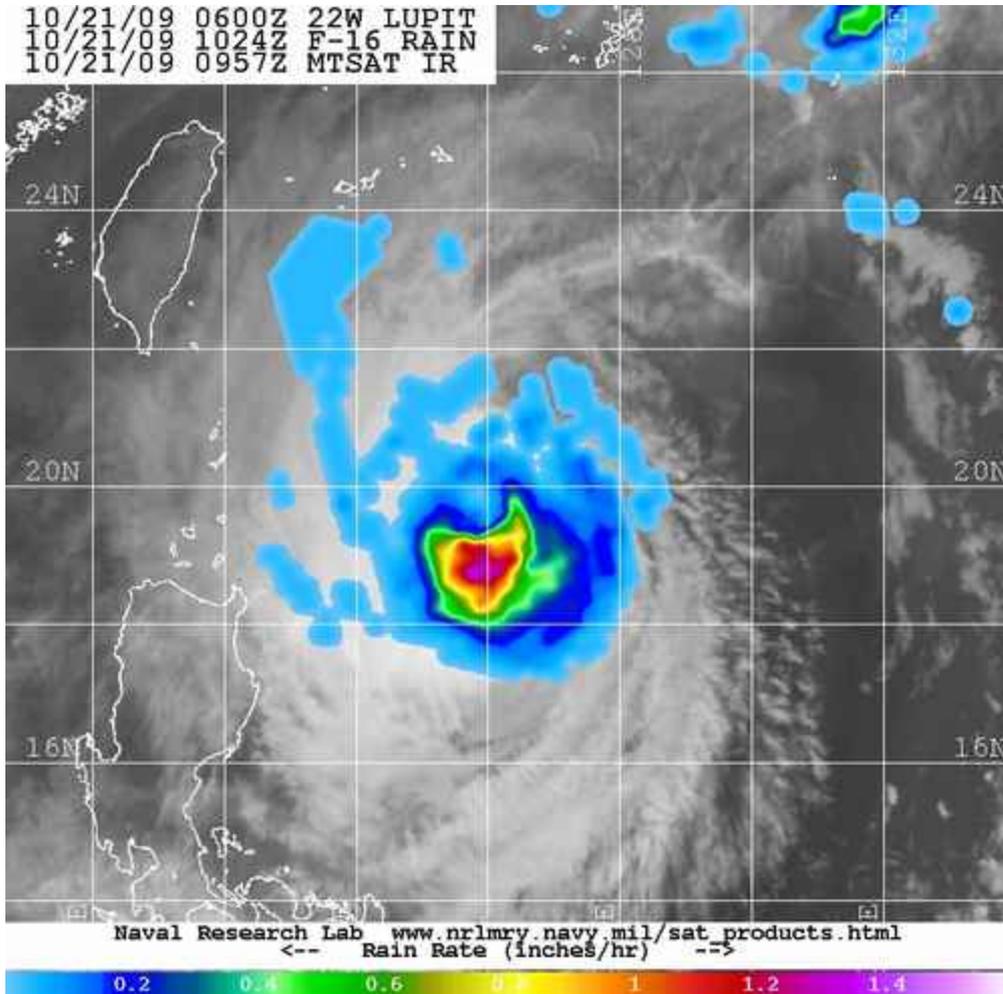
## ATMS Channels



# SNPP ATMS Inter-channel Comparison



# Thermal Infrared Rain Rates



There is a general relationship between cloud top temperature and rain rate.

# Best source for satellite rain rates

## JAXA GLOBAL RAINFALL WATCH

世界の雨分布速報

日本語

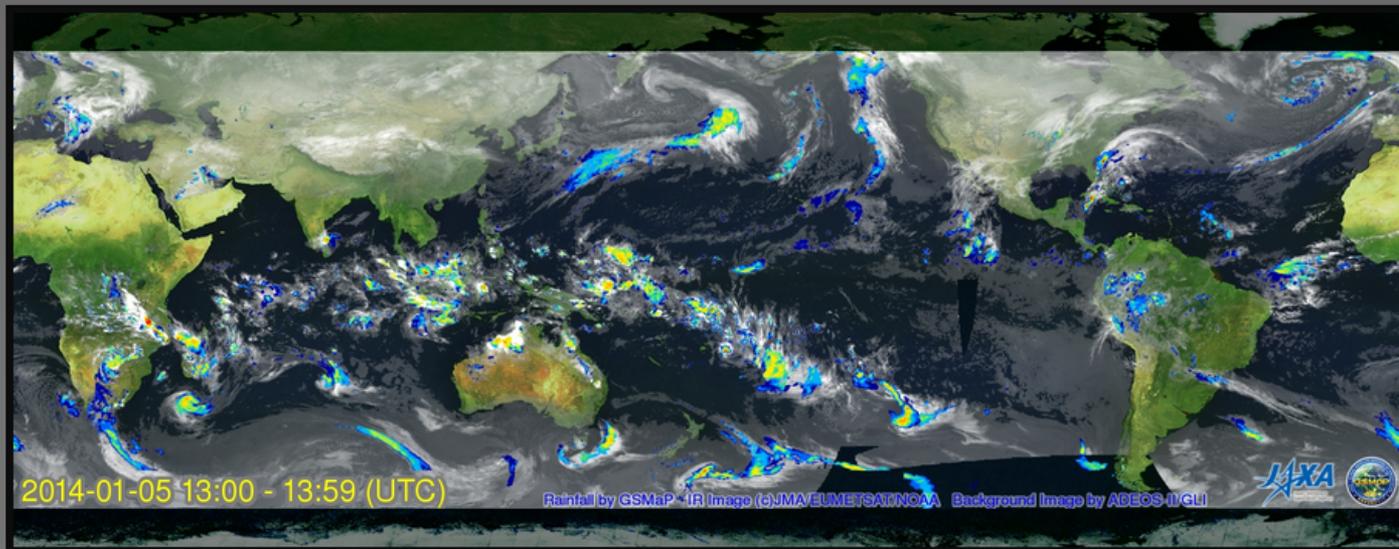
Last Update: 5 Jan 2014 18:30:48 UTC



衛星全球降水マップ  
**GSMaP**  
GLOBAL SATELLITE MAPPING OF PRECIPITATION

Date: 2014 / 1 / 5 13:00-13:59 UTC Submit  
« Prev Latest Next »

Global Data Google Maps Layer



2014-01-05 13:00 - 13:59 (UTC)

Rainfall by GSMaP-IR Image (c)JMA/EUMETSAT/NOAA Background Image by ADEOS II GLI

Rain 0.1 0.5 1.0 2.0 3.0 5.0 10.0 15.0 20.0 25.0 30.0 [mm/hr]

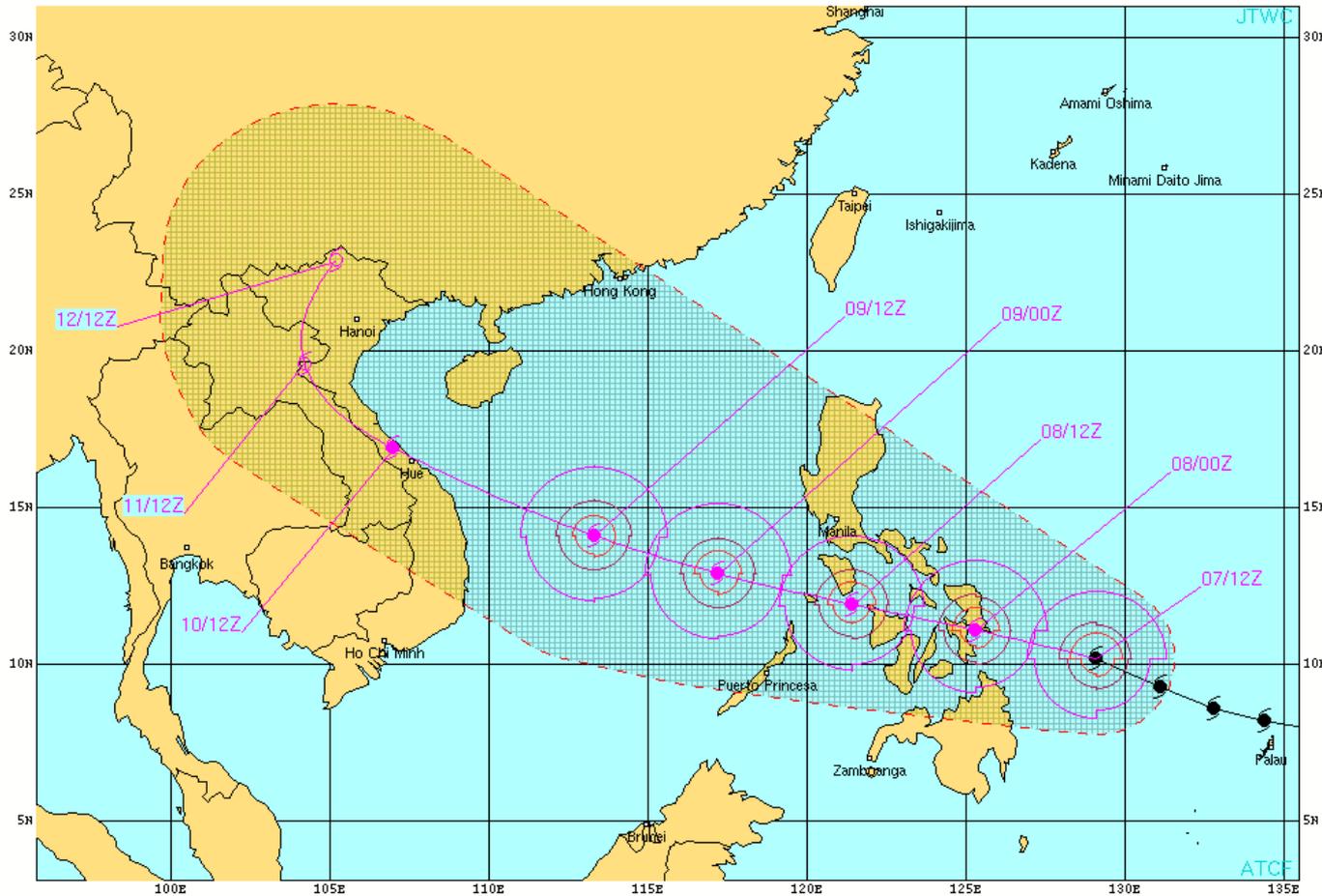
Latest10h MWR coverage 24h Animation

Access to hourly global rainfall maps in near real time (about four hours after observation) using the combined MW-IR algorithm with TRMM TMI, Aqua AMSR-E, GCOM-W1 AMSR2, DMSP SSM/I and SSMIS, NOAA-19 AMSU, MetOp-A AMSU and GEO IR data.

# Input into prediction and warning models

- Observation of storms
  - Prediction of storm tracks
  - Rain rates
  - Wind speeds, wind directions
  - Storm surge predictions
- Geostationary weather satellites provide many observations in a day. Repeat cycles range from hours to minutes. MTSAT covers this region. High orbits limit spatial resolution. Poor coverage of polar regions.
- Polar orbiting weather satellites provide data twice daily.
- To reduce temporal latency collect data with local ground station.

# Typhoon Haiyan Track Prediction



**SUPER TYPHOON 31W (HAIYAN) WARNING #18**  
 WTPN33 PGTW 071500  
 071200Z POSIT: NEAR 10.2N 129.1E  
 MOVING 295 DEGREES TRUE AT 22 KNOTS  
 MAXIMUM SIGNIFICANT WAVE HEIGHT: 50 FEET

07/12Z,	WINDS 165 KTS,	GUSTS TO 200 KTS
08/00Z,	WINDS 150 KTS,	GUSTS TO 180 KTS
08/12Z,	WINDS 130 KTS,	GUSTS TO 160 KTS
09/00Z,	WINDS 125 KTS,	GUSTS TO 150 KTS
09/12Z,	WINDS 115 KTS,	GUSTS TO 140 KTS
10/12Z,	WINDS 090 KTS,	GUSTS TO 110 KTS
11/12Z,	WINDS 060 KTS,	GUSTS TO 075 KTS
12/12Z,	WINDS 045 KTS,	GUSTS TO 055 KTS

---

CPA TO:	NM	DTG
ZAMBOANGA	285	08/07Z
MANILA	152	08/15Z
SUEVIC_BAY	153	08/17Z
PUERTO_PRINCESA	164	08/18Z
HO CHI MINH_CITY	333	10/03Z
DA_NANG	12	10/06Z
HANOI	92	12/03Z

---

BEARING AND DISTANCE	DIR	DIST (NM)	TAU (HRS)
MANILA	172	164	24
SUEVIC_BAY	158	188	24
PUERTO_PRINCESA	050	207	24
ZAMBOANGA	352	303	24

○ LESS THAN 34 KNOTS  
 ◐ 34-63 KNOTS  
 ◑ MORE THAN 63 KNOTS  
 PAST 6 HOURLY CYCLONE POSITS IN BLACK  
 FORECAST CYCLONE POSITS IN COLOR





# National Weather Service National Hurricane Center

Home News Organization

## Sea, Lake, and Overland Surges from Hurricanes (SLOSH)

[Surge Overview](#) | [Storm Surge Unit](#) | [SLOSH](#) | [Surge Products](#) | [Local Impacts](#) | [FAQ](#) | [Resources](#)

### Contents

- [SLOSH Model](#)
  - [Introduction](#)
  - [Modeling Approaches](#)
  - [Reference Level](#)
  - [Surge Inundation](#)
  - [Basin Coverage](#)
  - [Basin Updates](#)
  - [Strengths and Limitations](#)
- [SLOSH Display Program](#)

### SLOSH Model

#### Introduction

The Sea, Lake and Overland Surges from Hurricanes (SLOSH) model is a computerized numerical model developed by the National Weather Service (NWS) to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data. These parameters are used to create a model of the wind field which drives the storm surge.

The SLOSH model consists of a set of physics equations which are applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads, levees and other physical features.

#### Modeling Approaches

Local forecast by "City, St" or "ZIP"

Alternate Formats  
[Text](#) | [Mobile](#)  
[Email](#) | [RSS](#)  
[About Alternates](#)

Cyclone Forecasts  
[Latest Advisory](#)  
[Past Advisories](#)  
[Audio/Podcasts](#)  
[About Advisories](#)

Marine Forecasts  
[Atlantic & E Pacific](#)  
[Gridded Marine](#)  
[About Marine](#)

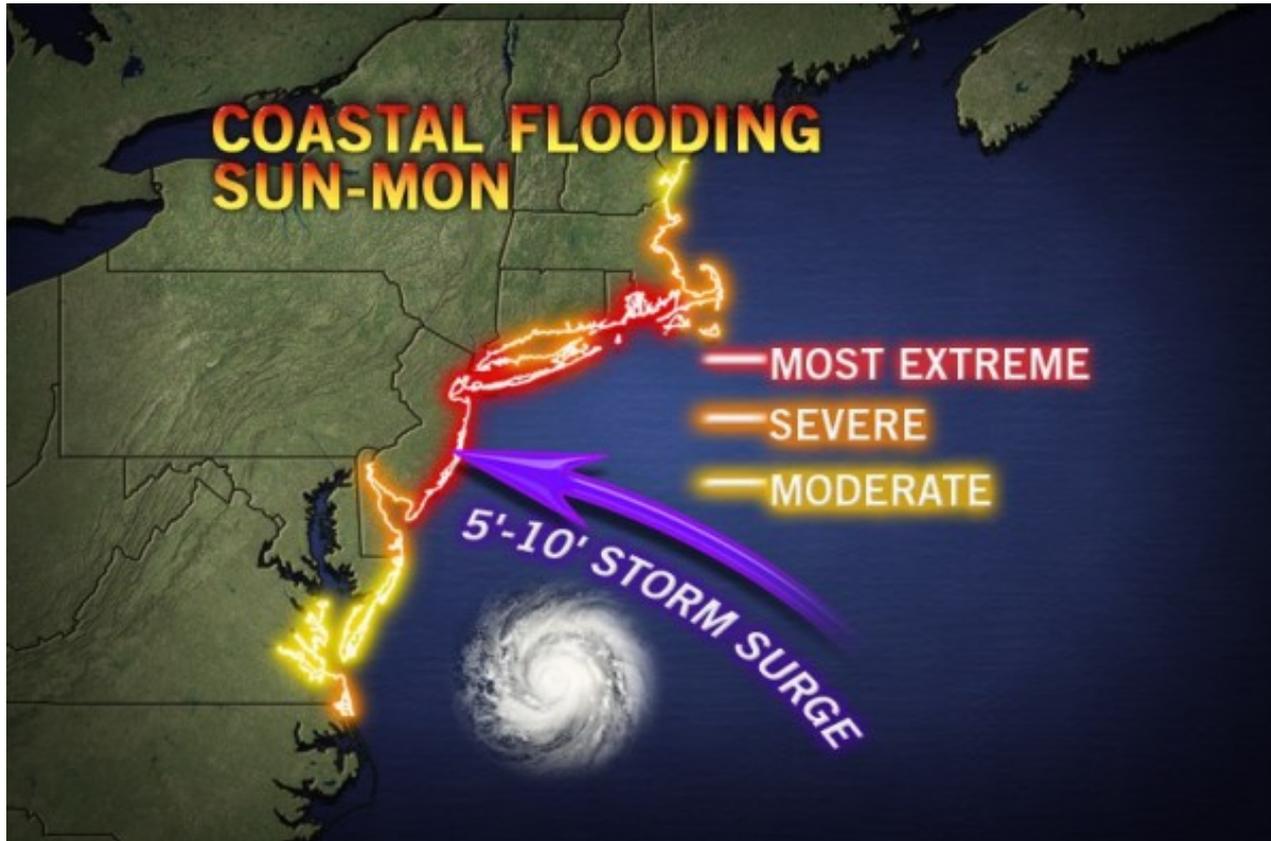
Tools & Data  
[Satellite | Radar](#)  
[Analysis Tools](#)  
[Aircraft Recon](#)  
[GIS Datasets](#)  
[Data Archive](#)

Development  
[Experimental](#)  
[Research](#)  
[Forecast Accuracy](#)

Outreach & Education  
[Prepare](#)  
[Storm Surge](#)  
[About Cyclones](#)  
[Cyclone Names](#)  
[Wind Scale](#)  
[Most Extreme](#)

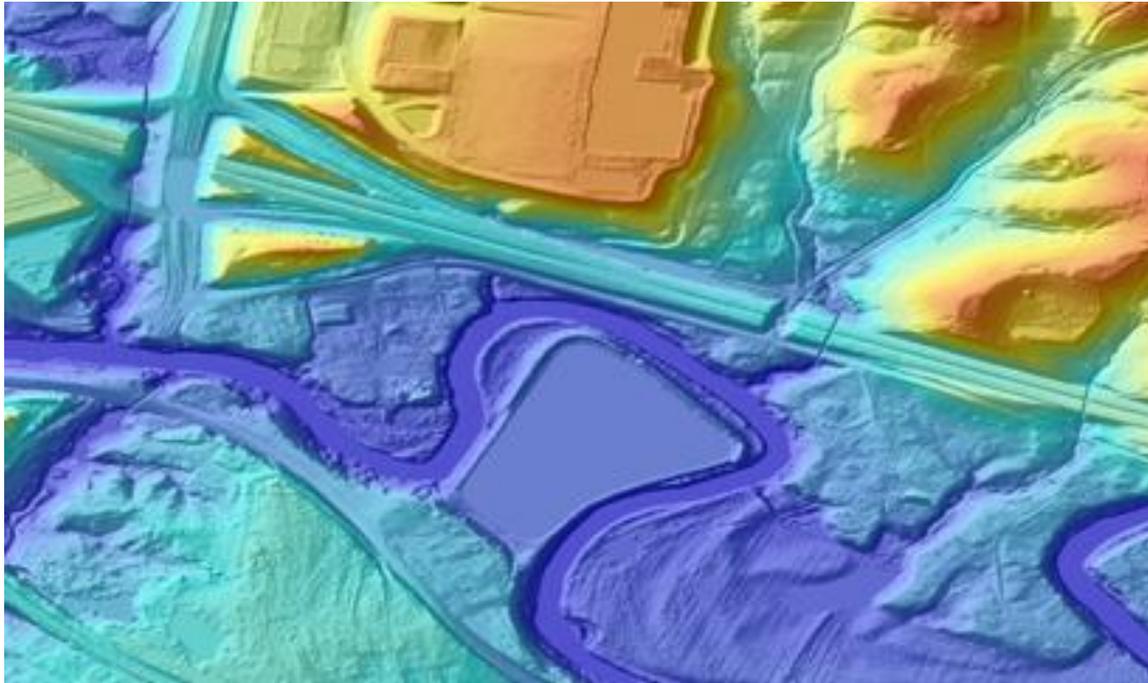
# Storm Surge Prediction Model

# Storm Surge Prediction



In the northern hemisphere storm rotate counterclockwise. Wind drives a bulge in the sea surface. Surge is worst in the right-forward quadrant of the storm.

# Input into prediction and warning models Topographic Data Are Essential For Flood Prediction



LIDAR (light detection and ranging) systems are producing the best topographic data.

# Input into prediction and warning models Constructed Surface Density Grids Are Essential For Flood Prediction in Urban Areas



Various  
techniques  
are used.

■ Impervious Surface areas (pixel value 1)

Non-Impervious Surface areas (pixel value 0)  
are represented by the white background.

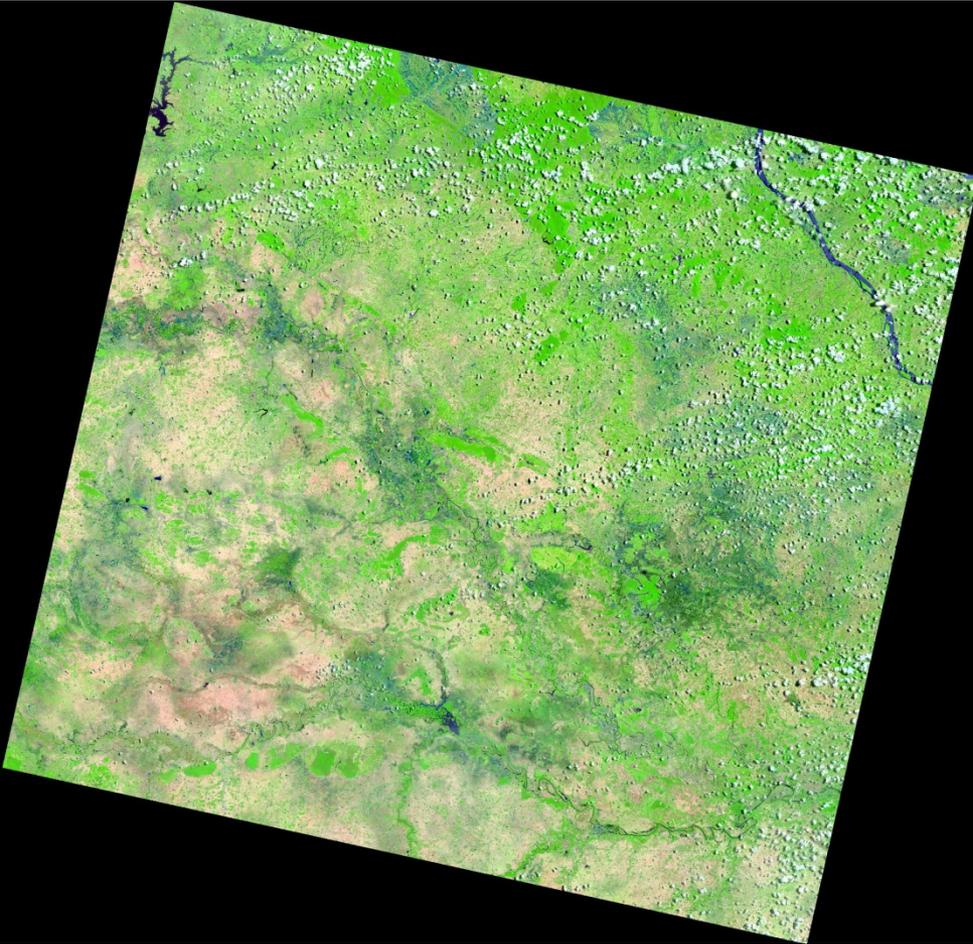
# Observation of the severity of disaster events

## Observation of Inundation

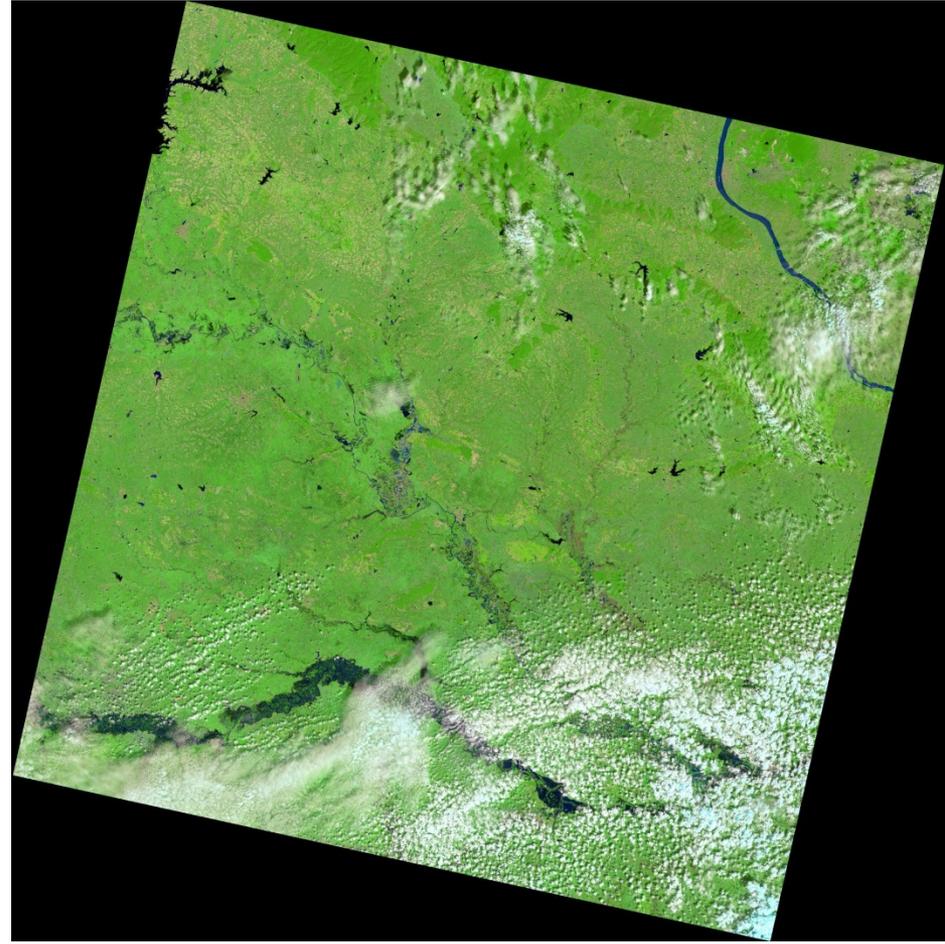
- Low reflectivity of water in optical imagery
  - Even muddy water has low (near zero) reflectivity in near-infrared and short-wave infrared
  - Wide range of sources with varying spatial resolutions. Inverse relationship between spatial resolution and repeat cycle, cost
  - Only works in day
  - Low tolerance to cloud cover

# Landsat 8 detection of inundation in Cambodia

June 9, 2013



October 31, 2013



# Landsat 8 detection of inundation in Cambodia

June 9, 2013

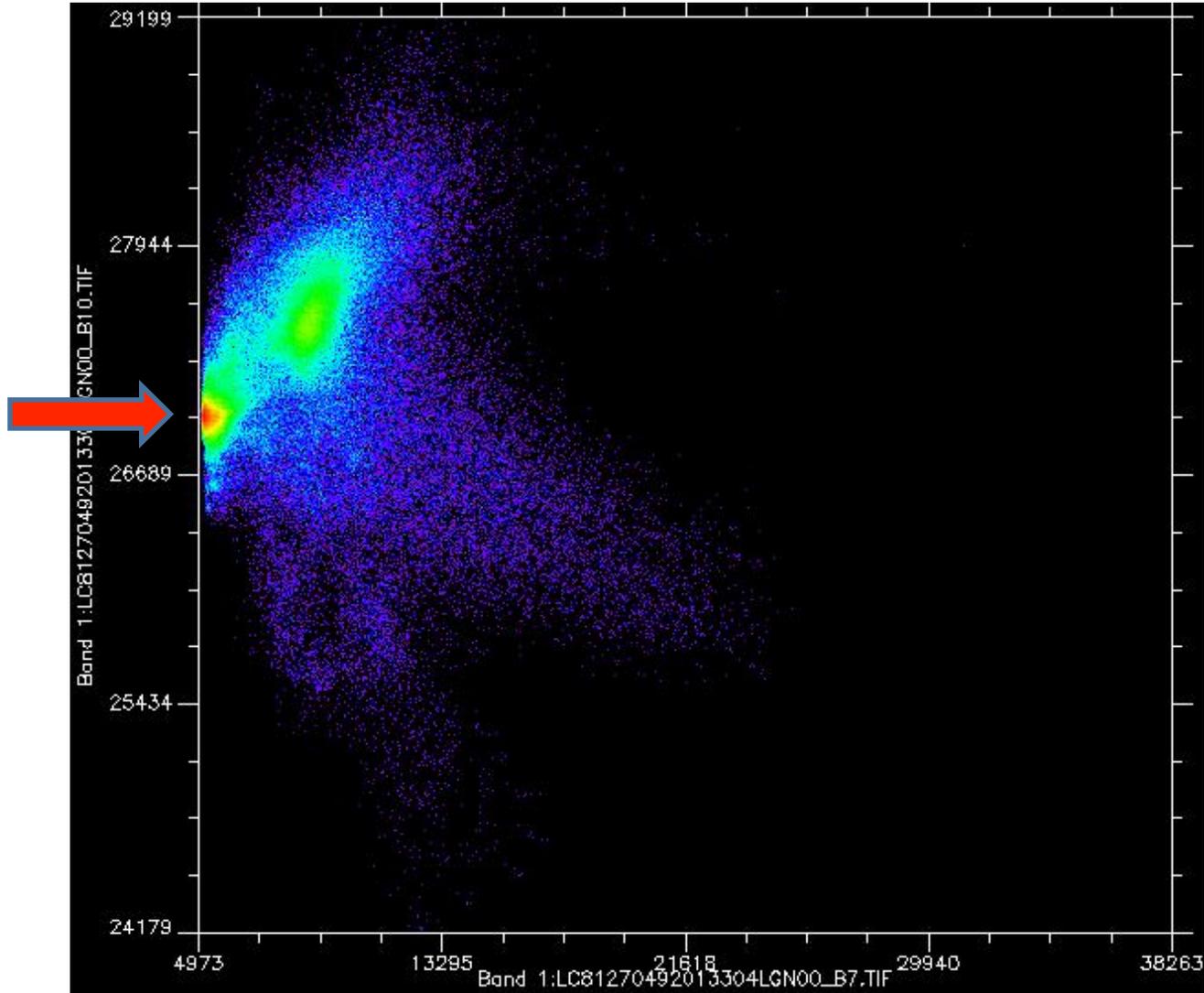


October 31, 2013



# Scattergram B7 vs B10

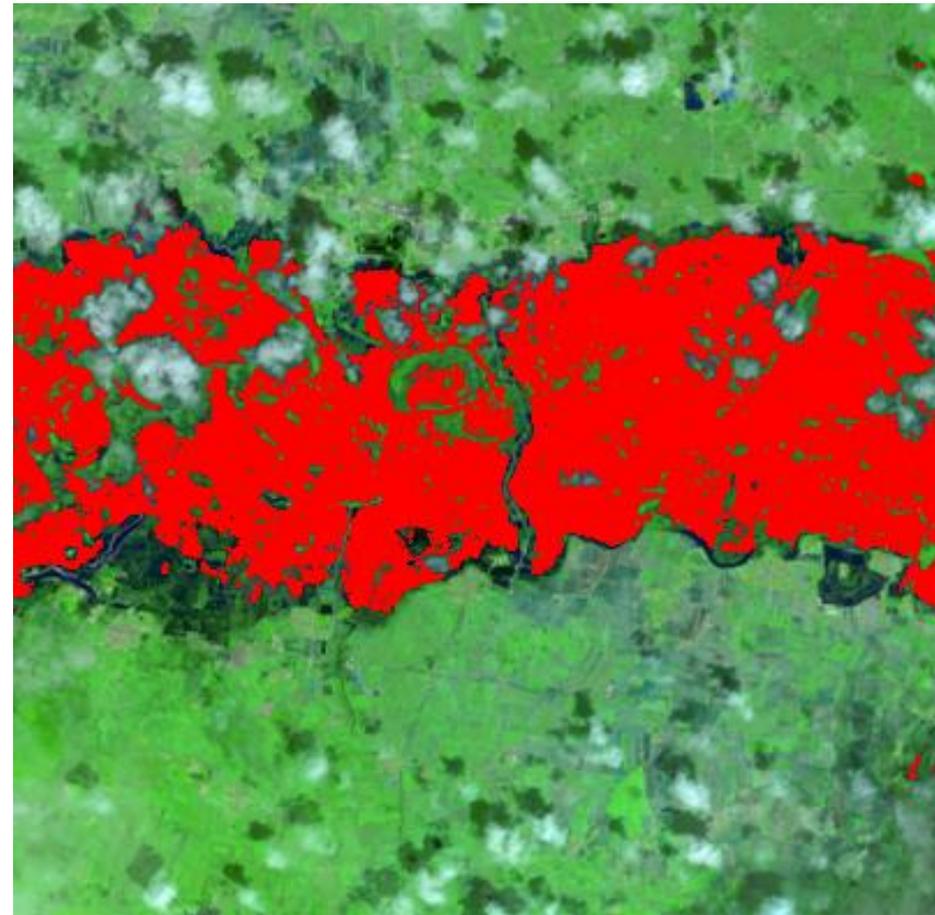
Open  
water



# Landsat 8 detection of inundation in Cambodia

October 31, 2013

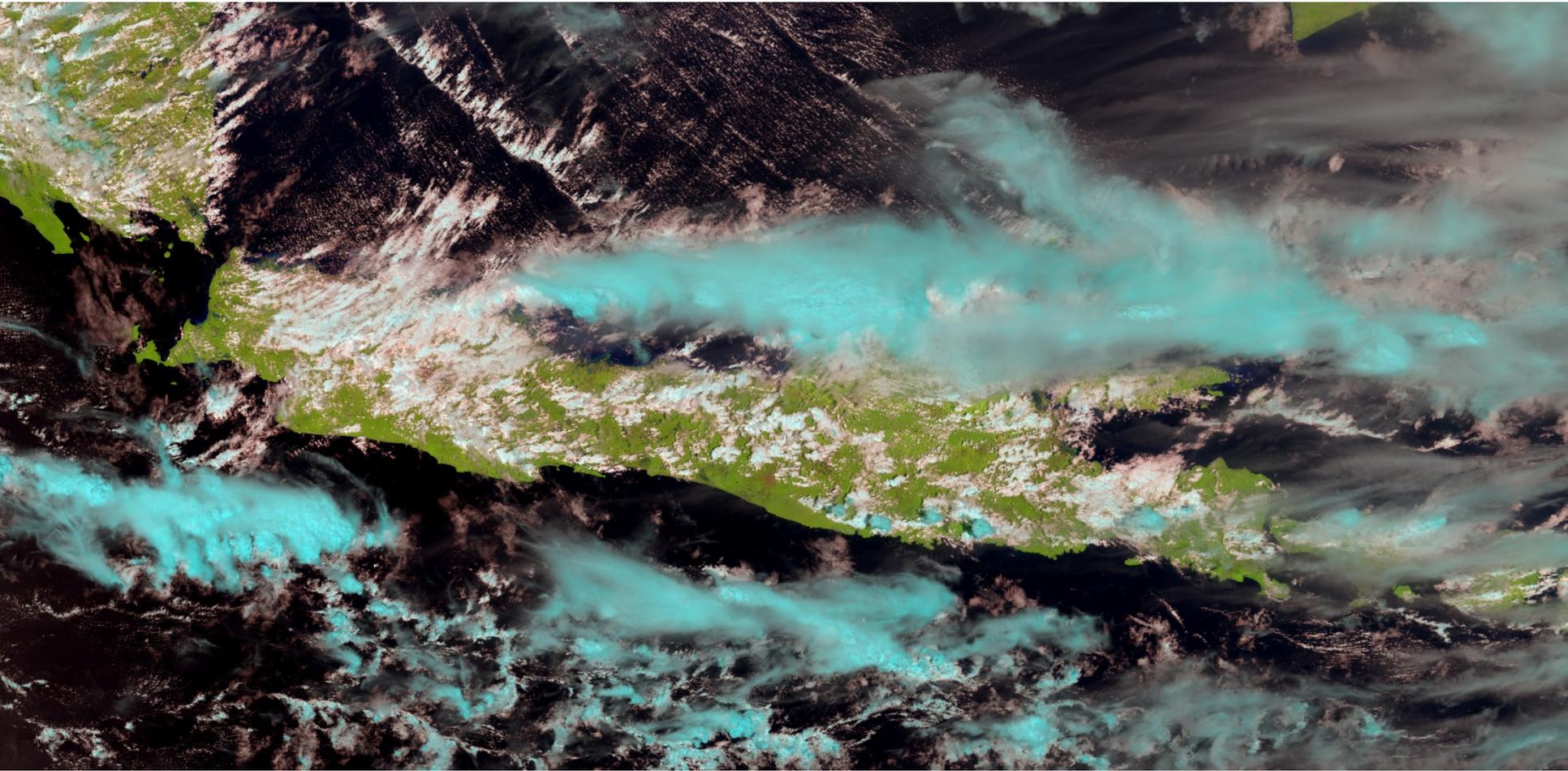
Flooded areas identified from  
SWIR versus TIR scattergram



Flooded areas and cloud shadows are dark in SWIR  
Thermal is used to distinguish flooded areas from cloud shadows

# Java image from VIIRS Jan. 22, 2014

[http://ngdc.noaa.gov/eog/viirs/download\\_indonesia.html](http://ngdc.noaa.gov/eog/viirs/download_indonesia.html)



Imaging spectral bands provide 400 meter resolution data

# RADAR detection of flooding

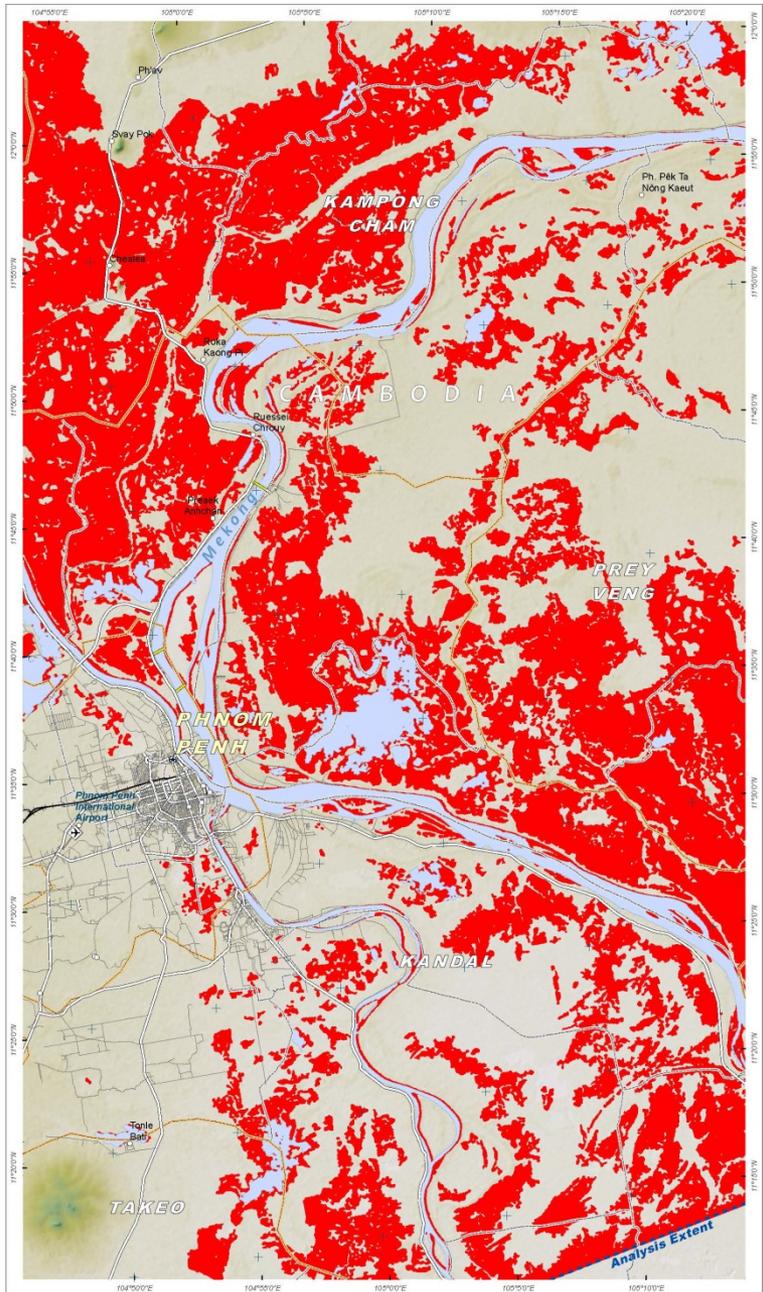


*RADARSAT-2 June 22, 2013 13:56 UTC, Wide 1*

- Low backscatter of water in radar imagery
  - Water covered areas are dark
  - Primarily from commercial sources
  - Radar works day or night in all weather conditions

# UPDATE 3: FLOOD WATERS OVER PHNOM PENH CITY, CAMBODIA

Analysis with Radarsat-2 Data Acquired 28 October 2013 and DMC Data Acquired 01 February 2013



**Flooding**  
 Production Date: 24/10/2013  
 Version 1.0  
 Glide Number: FL20131021KHM



This map illustrates a time series analysis of satellite-detected areas of flood waters and flood affected land around Phnom Penh city, Cambodia using Radarsat-2 data acquired 28 October 2013. Seasonal floods have caused heavy flooding in the region. The arrival of Typhoon Nari increased the heavy rains resulting in flashfloods. It is likely that flood waters have been systematically underestimated along highly vegetated areas along main river banks, and within built-up urban areas because of the special characteristics of the satellite data used. This analysis has not yet been validated in the field. Please send ground feedback to UNITAR/UNOSAT.

- LEGEND**
- ⊙ Capital
  - Town/Village
  - ✈ Airport
  - Bridge
  - Railroad
  - Primary Road
  - Local Road
  - International Border
  - Province Border
  - District Border

**FLOOD WATER EXTENT ANALYSIS (Satellite-Based Classification)**

- Probable Standing Flood Waters: Radarsat-2, 28 October 2013
- Pre-Crisis Water Extent: DMC, 01 February 2013

Disaster coverage by the International Charter 'Space and Major Disasters'. For more information on the Charter, which is about assisting the disaster relief organizations with multi-satellite data and information, visit [www.disasterscharter.org](http://www.disasterscharter.org)



Satellite Data (1): Radarsat-2  
 Imagery Date: 28 October 2013  
 Resolution: 25m  
 Copyright: MDA  
 Source: Canadian Space Agency  
 Satellite Data (2): DMC  
 Imagery Date: 01 February 2013  
 Resolution: 22m  
 Copyright: (c) COPYRIGHT, DMC International Imaging Ltd. (DMC)  
 Source: DMC International Imaging Ltd.  
 Road Data: OSM / ESRI  
 Other Data: USGS, UNCS, NASA, NGA  
 Analysis: UNITAR / UNOSAT  
 Production: UNITAR / UNOSAT  
 Analysis conducted with ArcGIS v10.1

Coordinate System: Zone UTM48N  
 Projection: Transverse Mercator  
 Datum: WGS 1984  
 Units: Meter

The depiction and use of boundaries, geographic names and related data shown here are not warranted to be error-free nor do they imply official endorsement or acceptance by the United Nations. UNOSAT is a program of the United Nations Institute for Training and Research (UNITAR), providing satellite imagery and related geographic information, research and analysis to UN humanitarian and development agencies and their implementing partners.

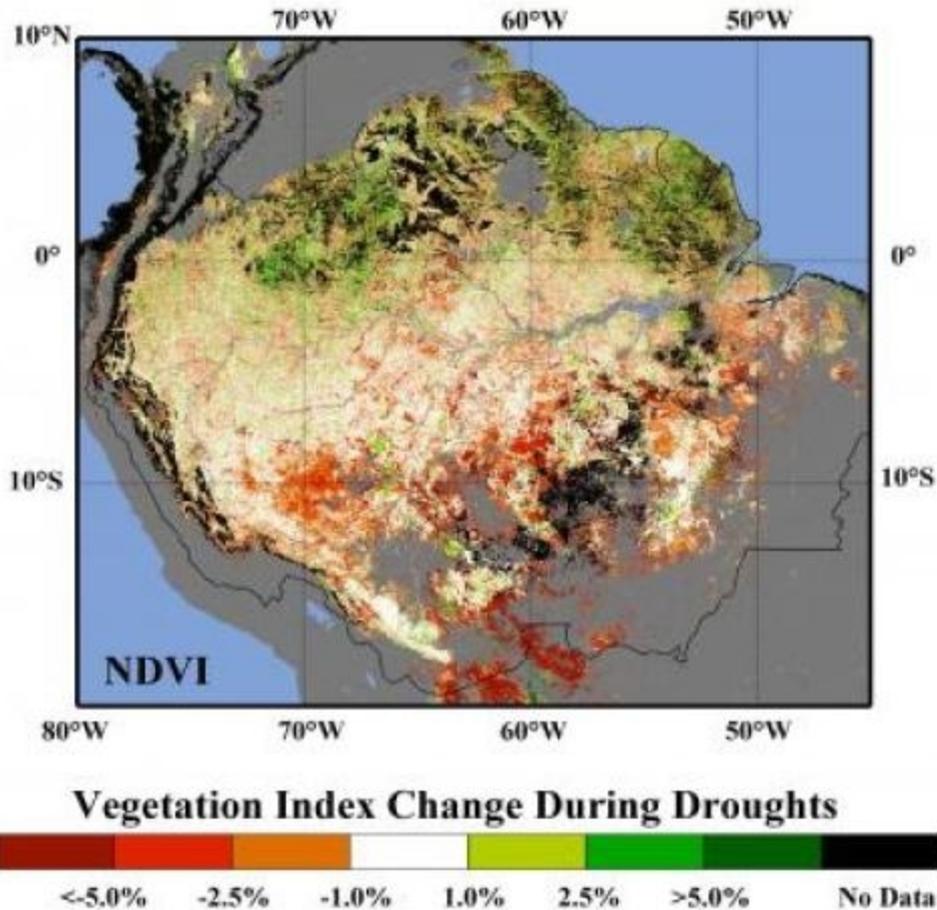
This work by UNITAR/UNOSAT is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.

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[www.unitar.org/unosat](http://www.unitar.org/unosat)

# Radarsat map of Cambodia flooding

# Observation of the severity of disaster events

## Drought

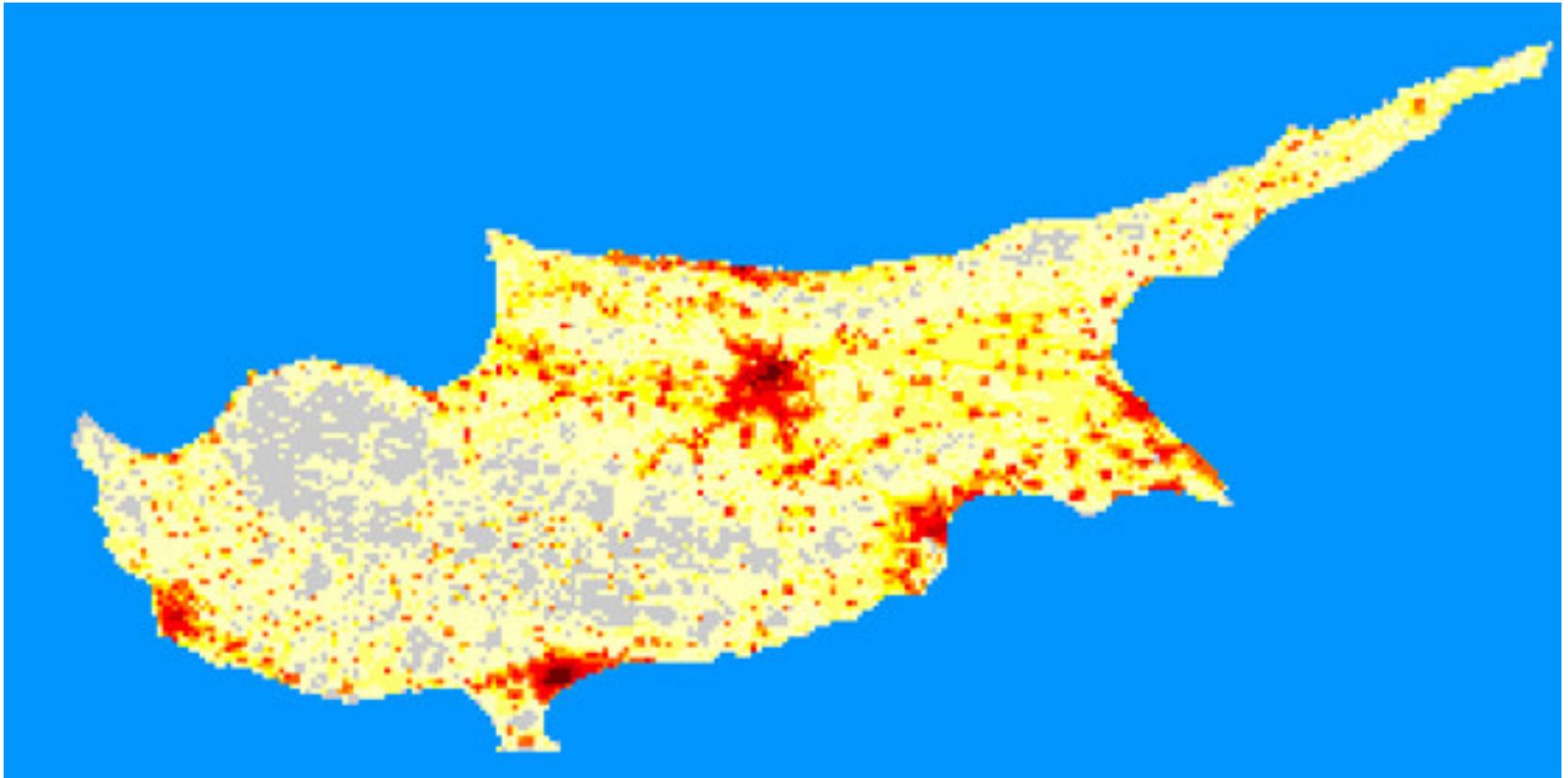


- Prediction based on rain rates and surface temperature patterns
- Severity measured with NIR/red vegetation index declines

# Observation of the severity of disaster events

## Affected Population

- Overlay affected area with population grid



U.S. Department of Energy Landscan population count grid

# Damage assessment

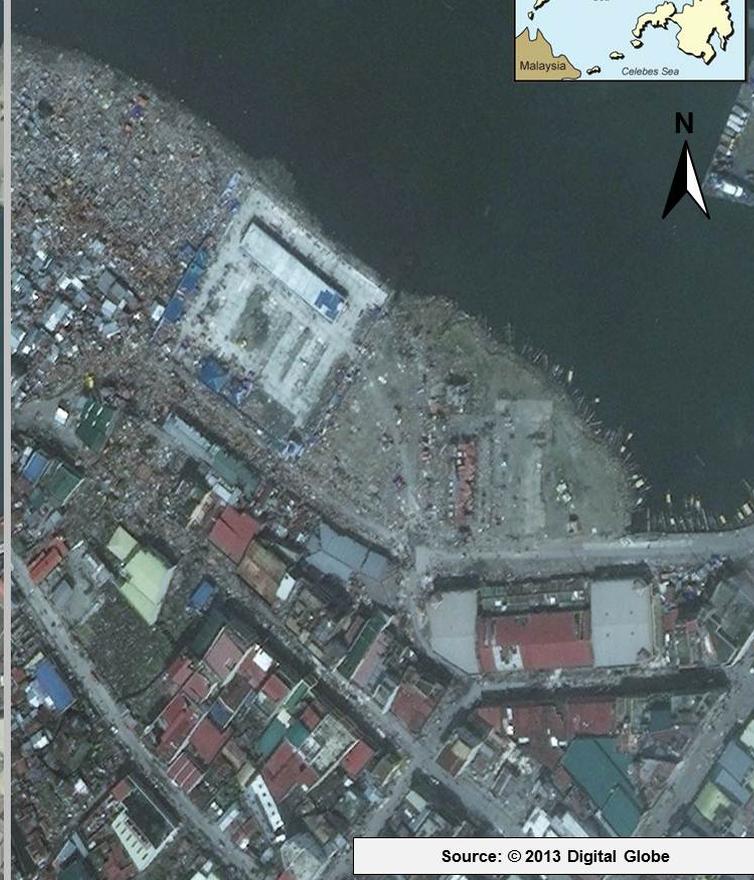


Damage from Super Typhoon Haiyan (Yolanda)  
Village South of Tacloban, Leyte Province, Philippines

Pre-event



Post-event



Source: © 2013 Digital Globe

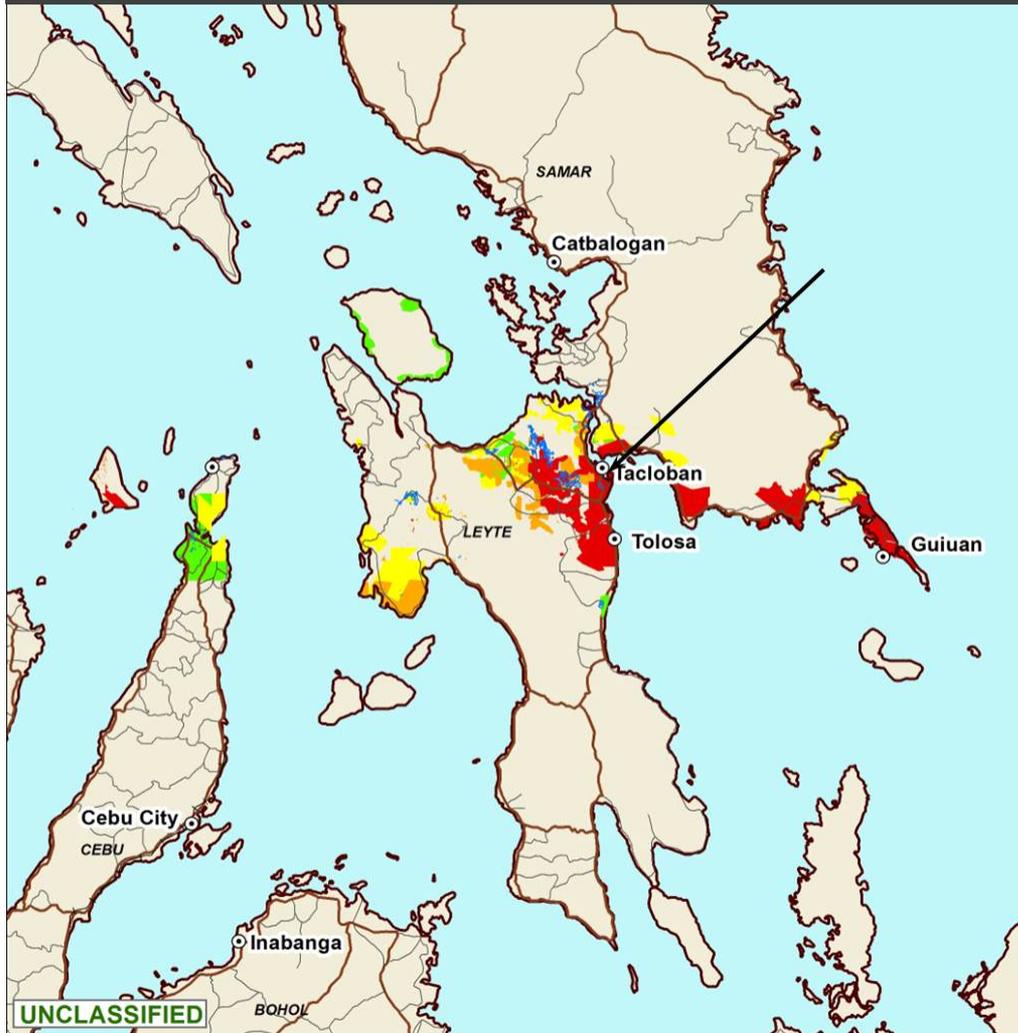
Source: © 2013 Digital Globe

Visual assessment using high spatial resolution imagery from commercial providers. Problems with cloud obscuration and small image coverage areas.

# Damage assessment



## Super Typhoon Haiyan (Yolanda) Preliminary Damage Assessment Tacloban, Leyte, Samar, and Cebu, Philippines



### Super Typhoon 31W HAIYAN (YOLANDA)

○ City/Town

#### Damage Assessment

Flooded/Saturated Damage

Limited Damage

Moderate Damage

Moderate-Extensive Damage

Extensive-Catastrophic Damage

Major Highways

Street Network

Railroad

\*Note: Damage levels within the shaded areas may vary from the overall assessment.

0 20 40 80 Kilometers

UNCLASSIFIED

PHILIPPINES: Panay Island, Near Sigma City, Nov. 16, 2013

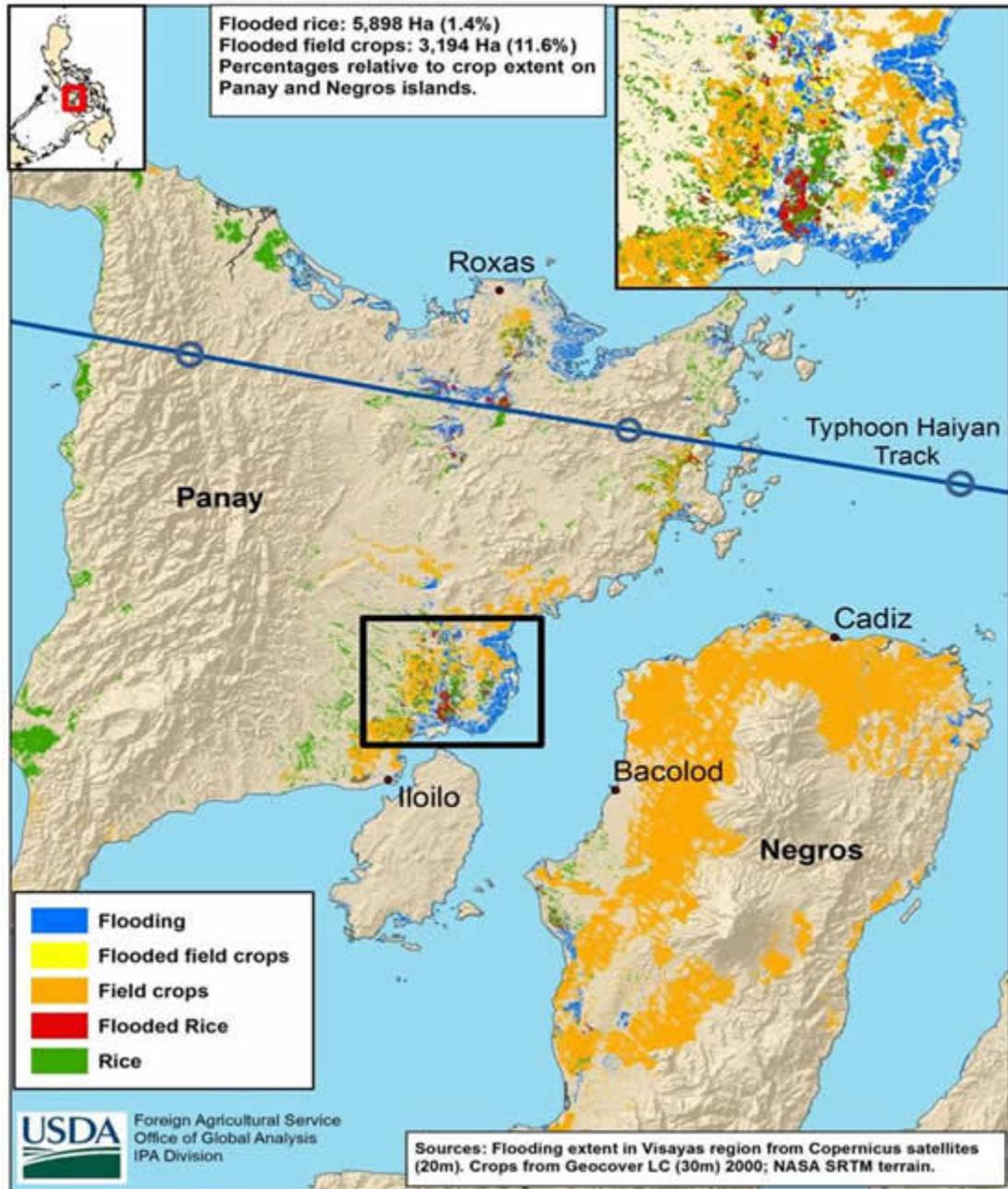


Imagery courtesy of DigitalGlobe, World View 2 (2meter)

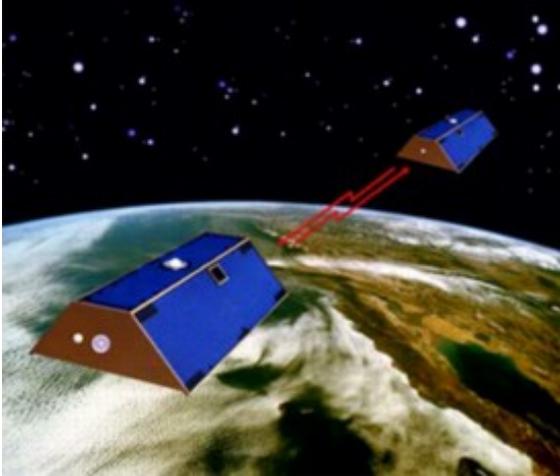
# Crop damage assessment

The satellite images is displayed in a manner (false color infrared) which portrays vegetation as a range of red colors. Humans can distinguish more variations of the color red than any other, and thus falsecolor infrared imagery is especially useful to agricultural analysts by highlighting subtle differences in crop conditions. The sample images provided here (above and below) were annotated to show examples a few of the discernable characteristics which are widely evident in various areas throughout the images (H=harvested; E=emerging; M=maturing; C=cultivated; D=damaged; N=non-crop vegetation).

# PHILIPPINES: Panay Island – Flooded Agricultural lands



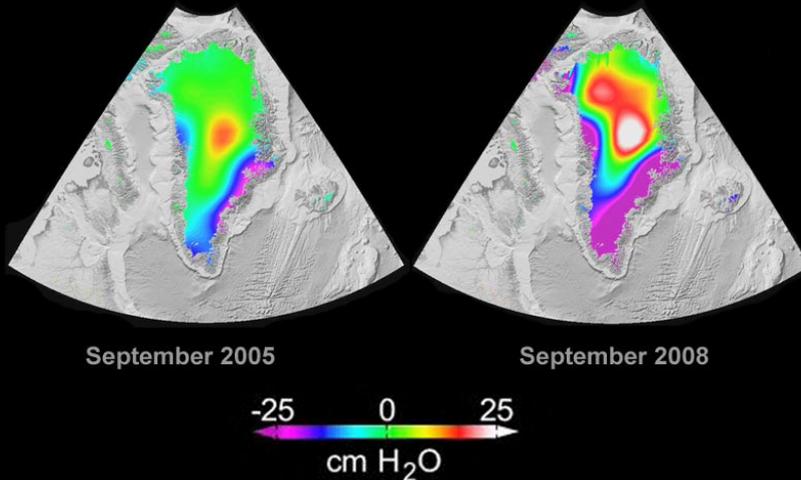
# Crop damage assessment



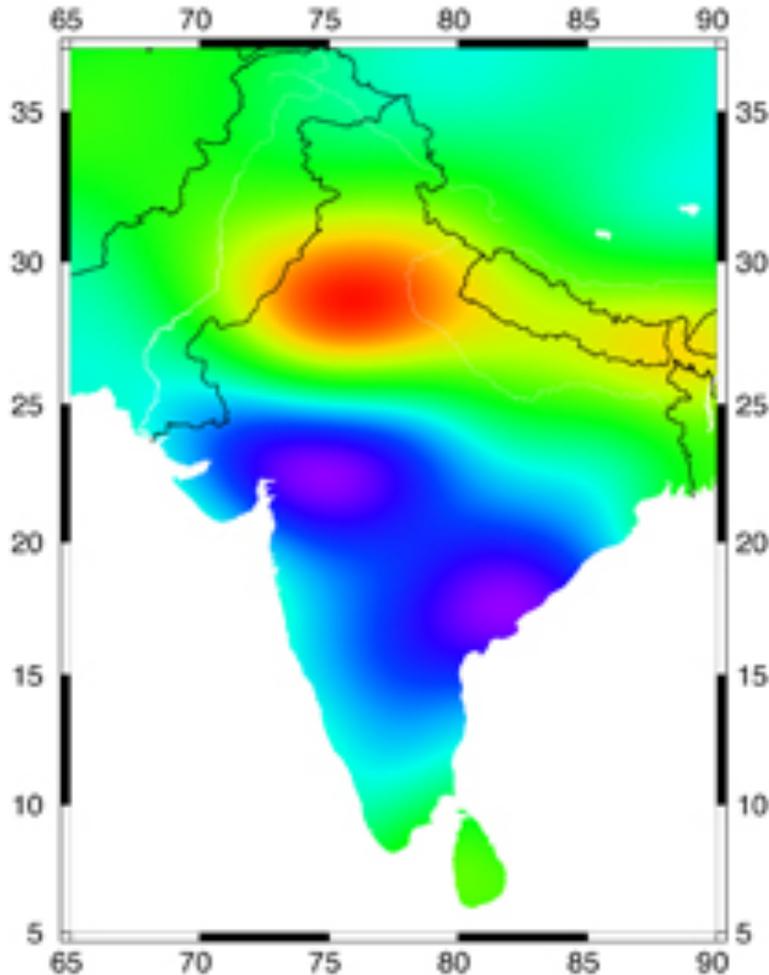
## Gravity Recovery and Climate Experiment (GRACE) NASA/JPL and the German Aerospace Center

GRACE, twin satellites launched in March 2002, are making detailed measurements of Earth's gravity field which will lead to discoveries about gravity and Earth's natural systems. These discoveries could have far-reaching benefits to society and the world's population.

Greenland Ice Mass Change



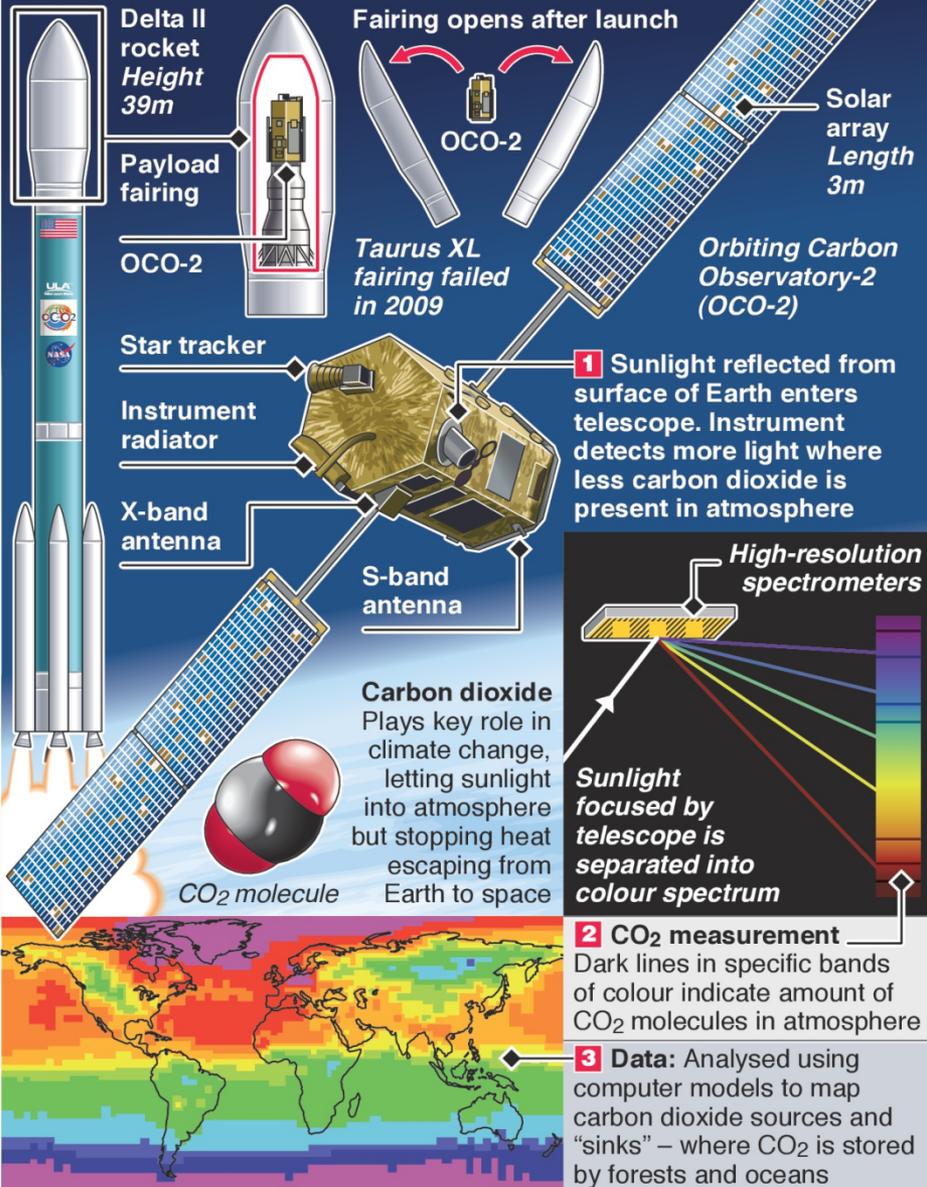
# GRACE Observation of groundwater



The map shows groundwater changes in India during 2002-08, with losses in red and gains in blue, based on GRACE satellite observations. The estimated rate of depletion of groundwater in northwestern India is 4.0 centimeters of water per year, equivalent to a water table decline of 33 centimeters per year. Increases in groundwater in southern India are due to recent above-average rainfall, whereas rain in northwestern India was close to normal during the study period. **Credit:** I. Velicogna/UC Irvine

# Mission to study Earth's CO<sub>2</sub> from space

OCO-2 is NASA's second attempt to measure atmospheric carbon dioxide using a dedicated Earth observing satellite. The original spacecraft failed to reach orbit in 2009



NASA/JPL Orbital Carbon Observatory (OCO-2) is designed to provide global data on atmospheric carbon dioxide levels at spatial resolutions suitable for regional source / sink analyses.

# Summary

- A wide range of remote sensing systems collect data over the Lower Mekong region.
- Meteorological satellite data – geostationary and polar
  - Rain rates, storm track predictions, surge predictions, drought predictions
  - Flooding (limited to daytime / cloud free observations)
  - Drought losses in green vegetation
- Moderate resolution satellite data (e.g. Landsat 8)
  - Flooding
  - Damage assessment of crops
  - Density of constructed surfaces
- High spatial resolution remote sensing data
  - Damage assessment for infrastructure and crops
  - Generation of topographic data
  - Density of constructed surfaces
- Specialized sensors provide unique data: GRACE, OCO-2, VIIRS DNB.