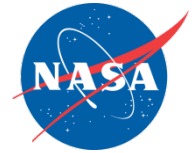


**WELCOME TO  
NASA APPLIED REMOTE SENSING TRAINING  
(ARSET) WEBINAR SERIES**



**NASA REMOTE SENSING OBSERVATIONS FOR  
FLOOD MANAGEMENT**

**COURSE DATES: EVERY MONDAY, JUNE 8, 15, 22, 29**  
**TIME: 8 TO 9 AM AND 1 TO 2 PM EDT**

Applied Remote Sensing Training



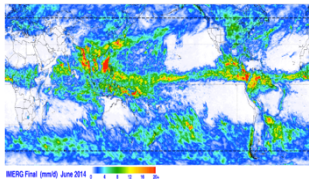
# Webinar Outline

## Week 1



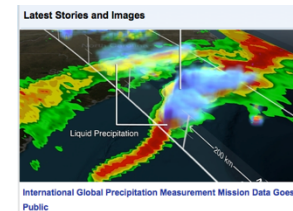
**NASA Remote Sensing Data for Flood Management, Introduction to Flood Monitoring Tools**

## Week 3



**Regional Flood Management over Africa, Demonstration of the MODIS Inundation Mapping Tool and the Dartmouth Flood Observatory**

## Week 2



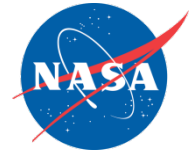
**Global Flood Monitoring System, Near-real Time Global Flood Mapping Tool, Global Disaster Alert and Coordination System/Global Flood Detection System**

## Week 4

**Floodplain Management of the Mekong River, Demonstration of Selected Flooding Cases using Multiple Web-Tools and GIS**

# ARSET Webinars Website

<http://arset.gsfc.nasa.gov>



The screenshot shows the ARSET website interface. At the top, there are navigation tabs for 'DISASTERS', 'ECO FORECASTING', 'HEALTH & AIR QUALITY', and 'WATER RESOURCES'. A sidebar on the left contains a menu with 'Webinars' circled in red. A red arrow points from this menu to a larger view of the 'Webinars' page. This page features a header with the NASA logo and 'ARSET Applied Remote Sensing Training'. Below the header is another set of navigation tabs. The main content area is divided into two columns. The left column lists 'Disasters' (with sub-links for 'Disasters Webinars' and 'Disasters Workshops') and 'Upcoming Training' (with sub-links for 'Ecoforecasting Introduction to Remote Sensing for Conservation Management' and 'Disasters NASA Remote Sensing'). The right column displays details for a specific webinar: 'NASA Remote Sensing Observations for Flood Management' from 06/08/2015 to 06/29/2015. It includes session times (8 to 9 AM and 1 to 2 PM Eastern US Time), an objective, and a course agenda.

# Outline



- Application of Remote Sensing for Improved Flood Management
- Live Demonstration of Selected Flooding Cases using Multiple Web-Tools and GIS
- Course Summary



# NASA WATER SCIENCE & APPLICATIONS

## Applying Remote Sensing Technology for Improved Flood Management

**John D. Bolten**

Hydrological Sciences Branch

NASA Goddard Space Flight Center

Greenbelt, MD USA

[john.bolten@nasa.gov](mailto:john.bolten@nasa.gov)

*ARSET – June 29<sup>th</sup>, 2015*

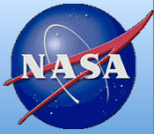
# What are the impacts of floods?



- Reported flood damages (adjusted for inflation) have increased from an average of US\$7 billion per year in the 1980s to about US\$24 billion per year in 2011 (Kundzewicz et al., 2013).
- Economic, including insured, flood disaster losses are higher in developed countries, while fatality rates and economic losses expressed as a proportion of gross domestic product are higher in developing countries. Since 1970, the annual number of flood-related deaths has been in the thousands, with more than 95% in developing countries (Handmer et al., 2012).



# What are the impacts of floods?



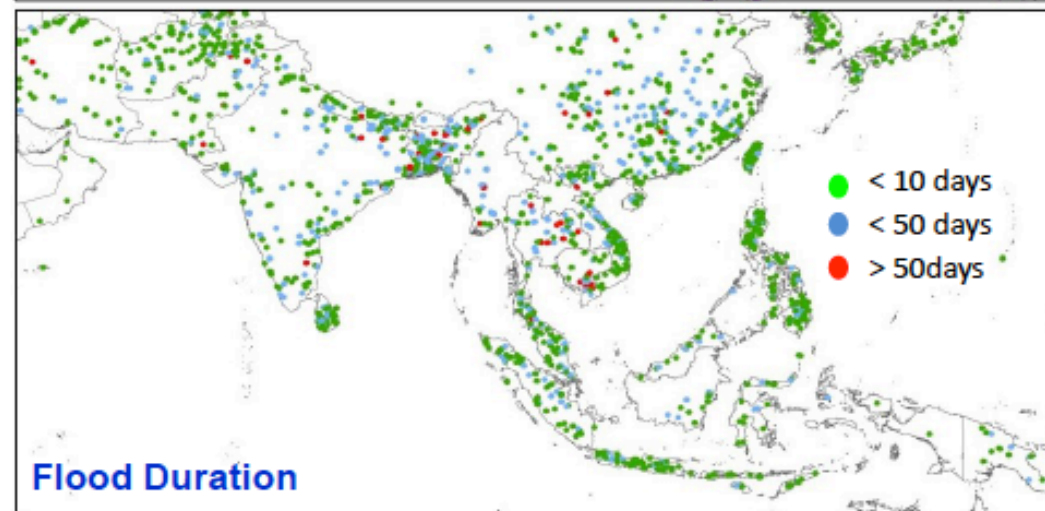
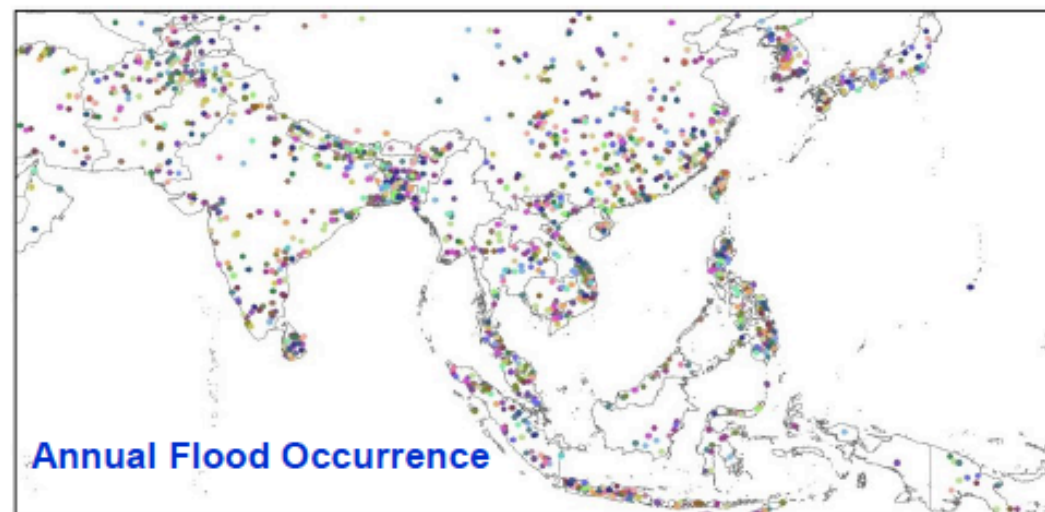
- Occur all over the world
- Both benefits and costs
- Losses increasing due to greater exposure and vulnerability with population and economic growth (IPCC)
- Global flood risk likely to increase in the future with climate change (IPCC)
  - Especially in South, Southeast, and Northeast Asia; tropical Africa; and South America



## CATASTROPHIC FLOODS IN ASIA: 1900-2011

- Collated from 6 global sources
- >4000 floods globally
- Around 35% - in Asia

Country	Flood Occurrence
India	237
China P Rep	209
United States	155
Indonesia	142
Philippines	116
Brazil	112
Bangladesh	83
Iran Islam Rep	72
Pakistan	72
Vietnam	67



Source : DFO, SAARC, Sentinel Asia, NDMA etc.



# What are the Cost/Benefits of Flooding?



## Benefits

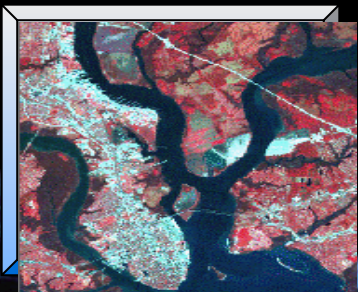
- Replenish soils for agriculture
- Support fishing industry
- Restore groundwater and reservoirs

## Costs

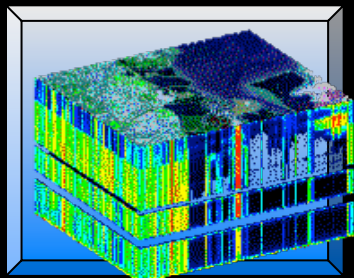
- Loss of life
- Damage to infrastructure
- Damage and loss of crops
- Disruption of transportation



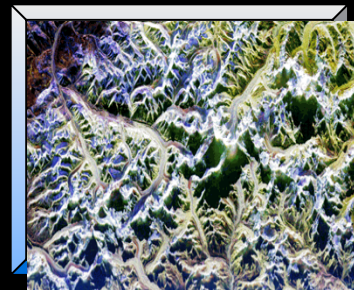
# Remote Sensing Techniques



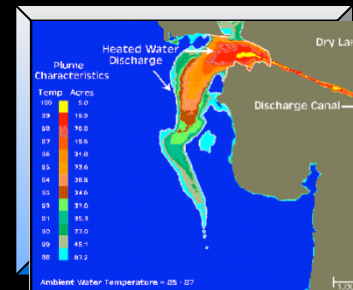
**Multispectral**



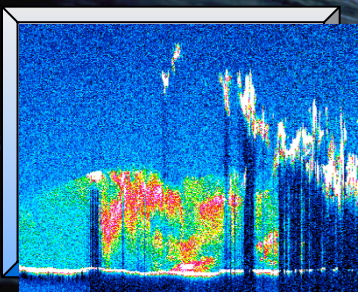
**Hyperspectral**



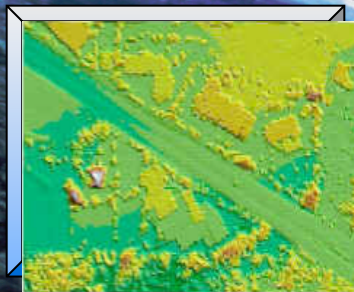
**RADAR / SAR**



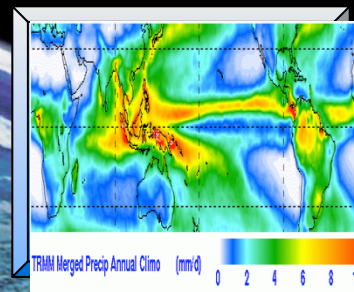
**Thermal**



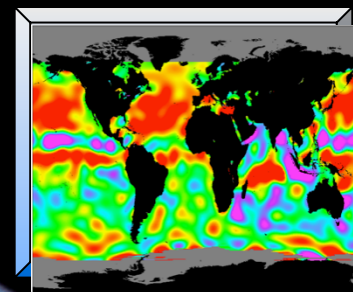
**Atmospheric LIDAR**



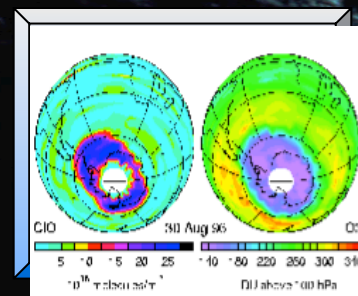
**Surface LIDAR**



**Passive Microwave**



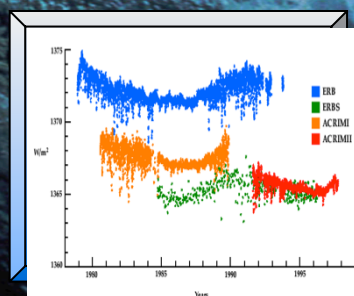
**RADAR Altimetry**



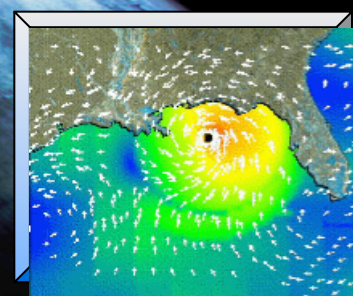
**Limb Sounding**



**Microwave Ranging**

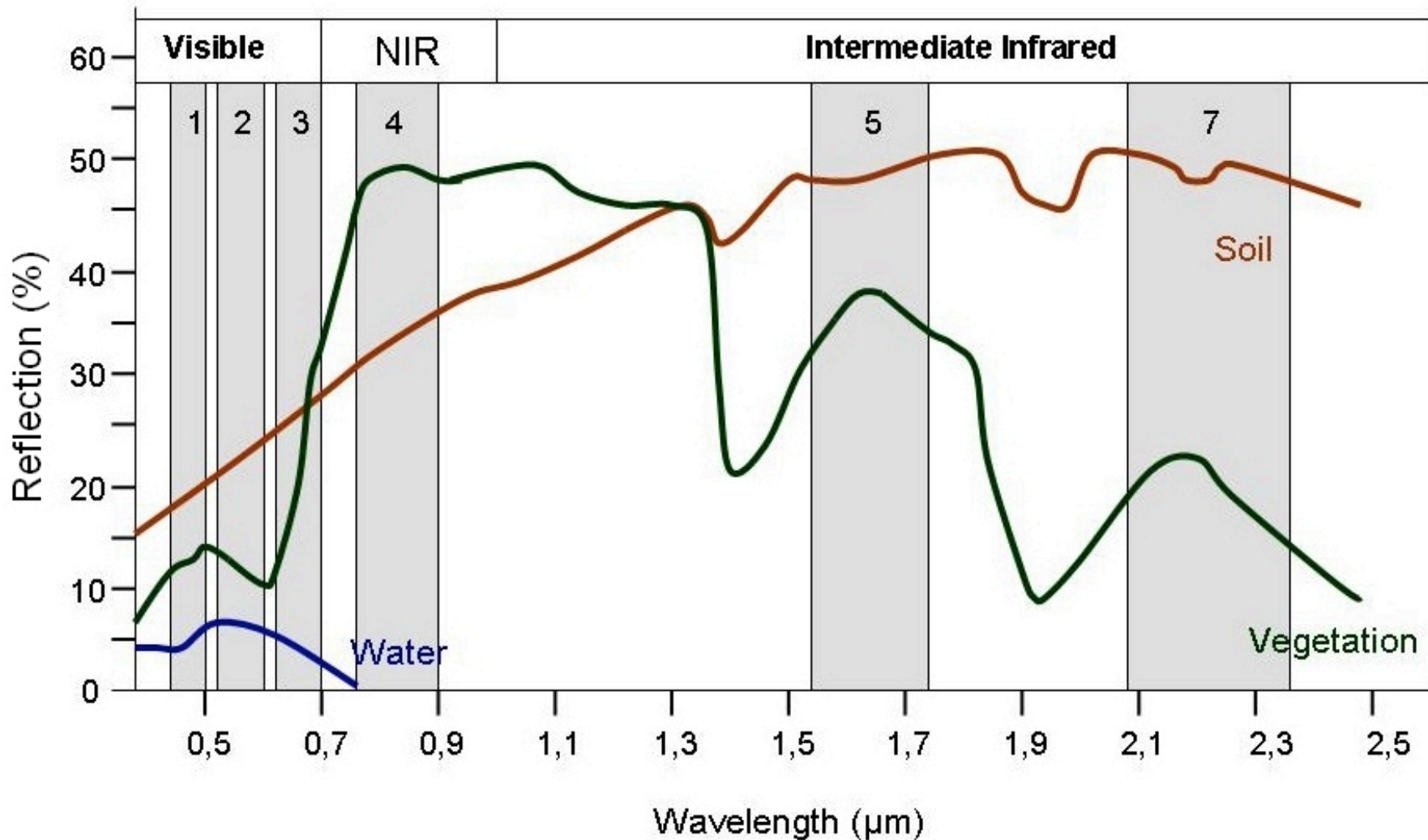


**Irradiance/Photometry**



**Scatterometry**

# How Do We Detect Flooded Areas Using Remote Sensing?





# Unique Properties of Remote Sensing

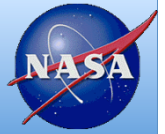
AREA VS POINT DATA- Data representing an area in which spatial variability has been integrated, overcomes transboundary issues.

SYSTEM STATES- Microwaves have unique responses to hydrologic properties

NEW DATA FORMS- Merging data sets of differing wave lengths, polarizations, etc

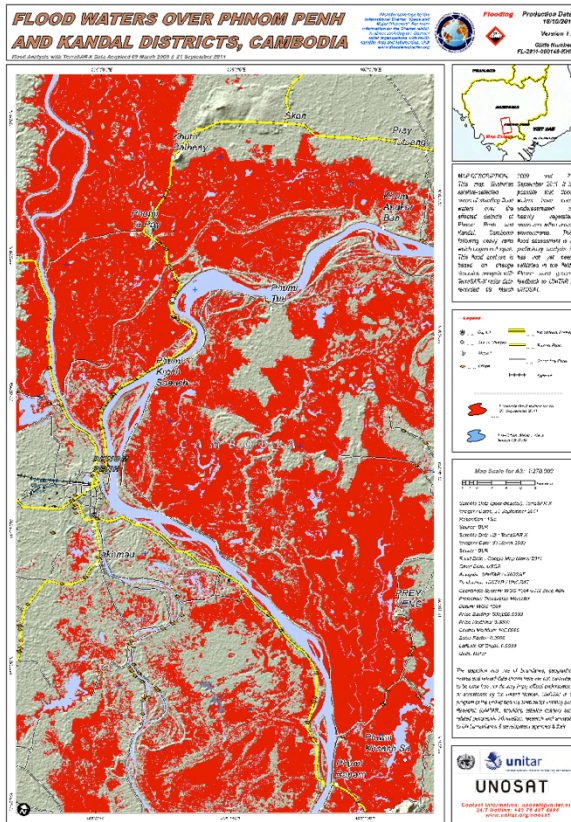
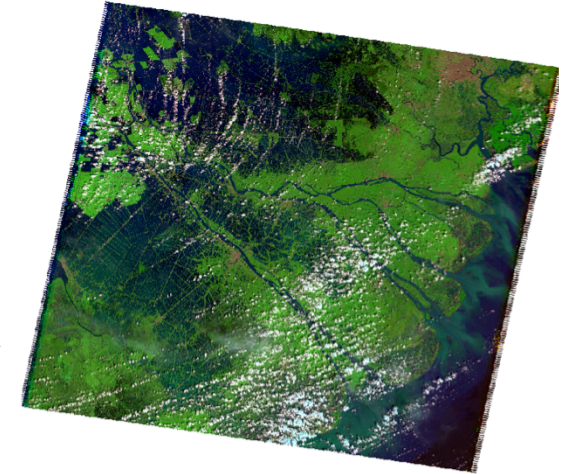
TEMPORAL DATA- Frequent measurements able develop a time series, regional climatologies

But we must consider wavelength, polarization, spatial scale, ability to relate to land surface processes, etc...!



# Flood Detection Methods

- **Vis/ NIR - MODIS, Landsat, or higher resolution multi-spectral**
  - Many water and flood indices, classifications, decision trees
  - Medium to high resolution, accuracy, and acquisition frequency
  - Limited by cloud and atmospheric conditions



2011 Cambodia flood extent derived from TerraSAR-X produced by UNITAR/UNOSAT

- **Microwave Radar**

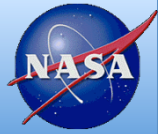
- High resolution and accuracy
- Not affected by clouds
- Limited data availability

- **Microwave Radiometer**

- Low resolution and accuracy
- Not affected by clouds
- Limited data availability

- **Hydrological Models**

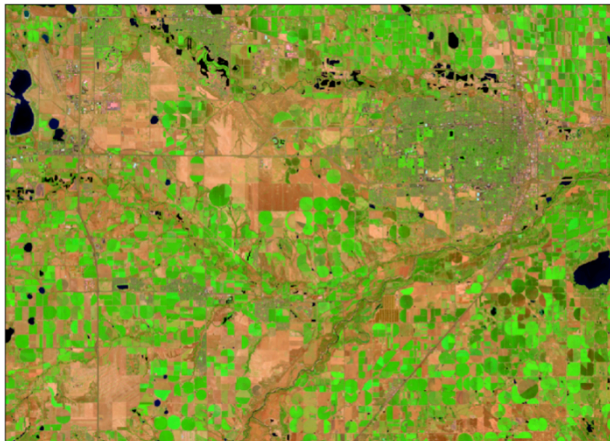
- Use precipitation and land surface models to estimate water accumulation
- Resolution dependent on data
- Accuracy depends on models and data used



# Classification of Multi-spectral Data

## Classification Algorithms

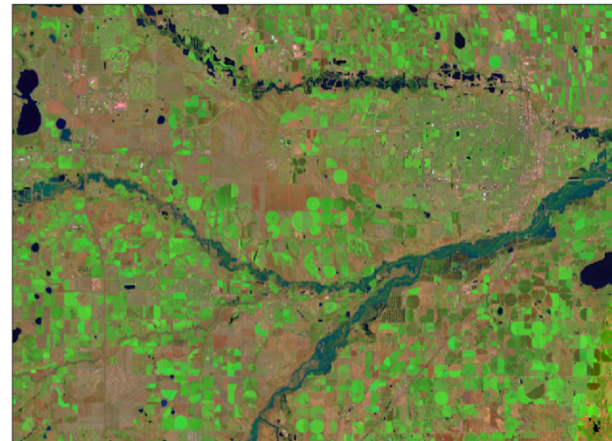
- Unsupervised
  - ISODATA
  - K-Means
- Supervised
  - Maximum likelihood (MLC)
  - Minimum-distance
  - Support Vector Machines (SVM)
  - Decision Tree



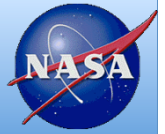
Landsat 8 (RGB 753): Colorado, 8/25/2013

## Satellite Data

- Landsat
  - 5 TM, 7 ETM+, 8 OLI/TIRS
  - 30 m resolution
  - 16 day revisit
- MODIS
  - Terra, Aqua
  - Red and NIR at 250 m, 7 bands at 500 m, and many more at 1 km
  - Daily revisit

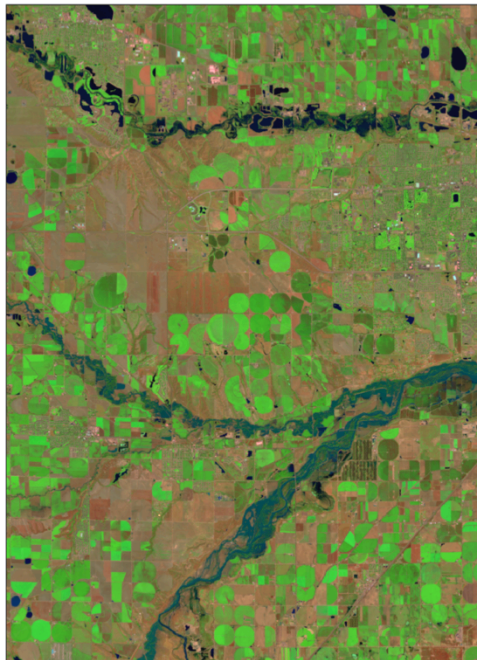


Landsat 8 (RGB 753): Colorado, 9/17/2013

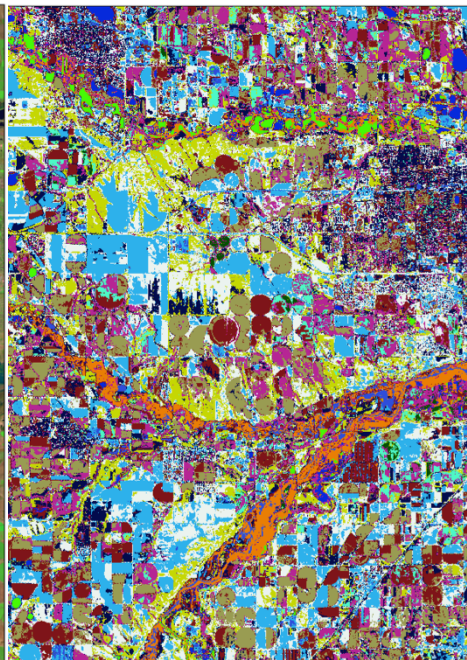


# Classification of Multi-spectral Data

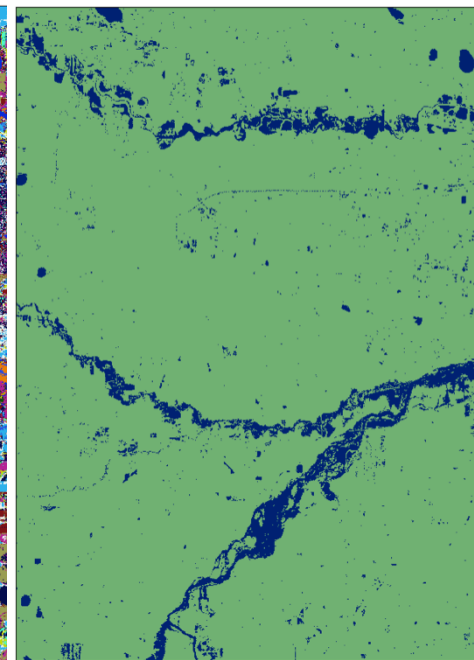
1. Download data (EarthExplorer, GloVis, etc.)
2. Load into software (ArcGIS, ENVI, ERDAS, scripting language, etc.)
3. Apply Classification
4. Combine water classes if necessary
5. Check for mis-classification (cloud shadows, etc.)
6. Compare to non-flooded scene to reveal flood water



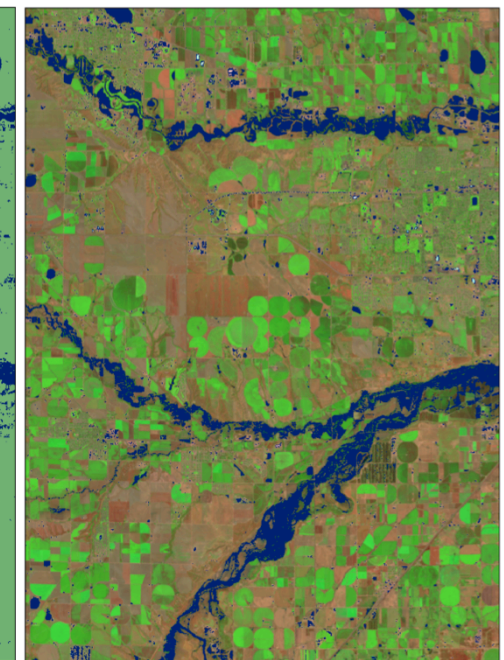
Landsat 8 (RGB 753)  
9/17/2013



Iso-cluster (ArcGIS)  
25 Classes



Iso-cluster combined  
water vs. not water



Classified water  
overlain on Landsat



# Spectral Indices

Many spectral indices have been developed for monitoring vegetation and water

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

$$NDWI = \frac{RED - SWIR}{RED + SWIR}$$

$$NDWI = \frac{GREEN - SWIR}{GREEN + SWIR}$$

• • •

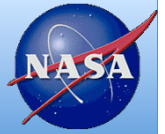
- Can use Landsat, MODIS, EO-1, etc.
- Visualize scaled index
- Threshold index
- Change detection of index
- Boschetti *et al.*, 2014 provides useful review

Table from: M. Boschetti, F. Nutini, G. Manfron, P. A. Brivio, A. Nelson, "Comparative Analysis of Normalised Difference Spectral Indices Derived from MODIS for Detecting Surface Water in Flooded Rice Cropping Systems," *PLoS ONE*, vol. 9, no. 2, 2014.

Table 1. List of spectral vegetation indices proposed for water detection.

PANEL A				
Spectral range	SI	Original purpose	Equation	MODIS bands
NIR-NIR	Normalised difference water index	Vegetation liquid water	$NDWI = \frac{\rho_{858} - \rho_{1240}}{\rho_{858} + \rho_{1240}}$	b2, b5
	Normalised difference moisture index	Forest analysis and detection	$NDMI = \frac{\rho_{858} - \rho_{1240}}{\rho_{858} + \rho_{1240}}$	b2, b5
	Shortwave infrared water stress index	Vegetation water content	$SIWSI = \frac{\rho_{1240} - \rho_{858}}{\rho_{1240} + \rho_{858}}$	b5, b2
NIR-SWIR	Normalised difference infrared index	Vegetation water content	$NDII = \frac{\rho_{858} - \rho_{650}}{\rho_{858} + \rho_{650}}$	b2, b6
	Normalised difference shortwave-infrared index	Identification of burn scar	$NDSWIR = \frac{\rho_{858} - \rho_{1640}}{\rho_{858} + \rho_{1640}}$	b2, b6
	Shortwave infrared water stress index	Vegetation water content	$SIWSI = \frac{\rho_{1640} - \rho_{858}}{\rho_{1640} + \rho_{858}}$	b6, b2
	Normalised difference water index	Change on lake shorelines	$NDWI_3 = \frac{\rho_{858} - \rho_{1640}}{\rho_{858} + \rho_{1640}}$	b2, b6
	Normalised burn ratio	Burn severity	$NDWI = \frac{\rho_{858} - \rho_{2130}}{\rho_{858} + \rho_{2130}}$	b2, b7
VIS-SWIR	Normalised difference water index	Open water detection	$NDWI = \frac{\rho_{555} - \rho_{1640}}{\rho_{555} + \rho_{1640}}$	b4, b6
	Modified NDWI	Water detection	$MNDWI = \frac{\rho_{555} - \rho_{1640}}{\rho_{555} + \rho_{1640}}$	b4, b6
	Normalised difference pond index	Detection of small water bodies	$MDPI = \frac{\rho_{1640} - \rho_{555}}{\rho_{1640} + \rho_{555}}$	b6, b4
	Normalised difference water index	Water end member selection	$NDWI = \frac{\rho_{645} - \rho_{1640}}{\rho_{645} + \rho_{1640}}$	b1, b6
	Normalised difference water index	Open water detection	$NDWI = \frac{\rho_{555} - \rho_{2130}}{\rho_{555} + \rho_{2130}}$	b4, b7
	Normalised difference flood index_2	Flood condition	$NDFI_2 = \frac{\rho_{645} - \rho_{2130}}{\rho_{645} + \rho_{2130}}$	b1, b7
VIS-NIR	Normalised difference water index	Open water detection	$NDWI = \frac{\rho_{555} - \rho_{858}}{\rho_{555} + \rho_{858}}$	b4, b2
	Normalised difference water index	Open water detection	$NDWI = \frac{\rho_{555} - \rho_{1240}}{\rho_{555} + \rho_{1240}}$	b4, b5
	Normalised difference flood index_1	Flood condition	$NDFI_1 = \frac{\rho_{645} - \rho_{1240}}{\rho_{645} + \rho_{1240}}$	b1, b5
	Normalised difference vegetation index	Water Mapping	$NDVI = \frac{\rho_{858} - \rho_{645}}{\rho_{858} + \rho_{645}}$	b2, b1

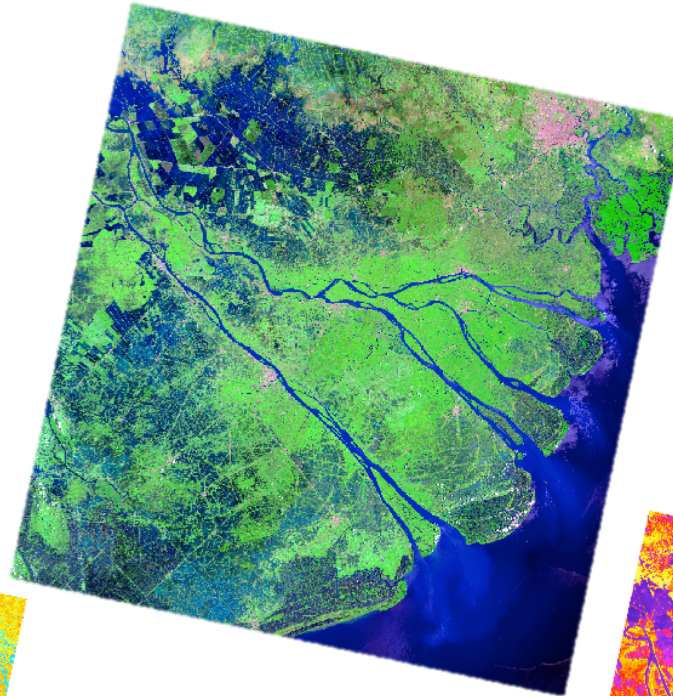




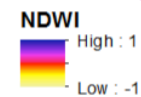
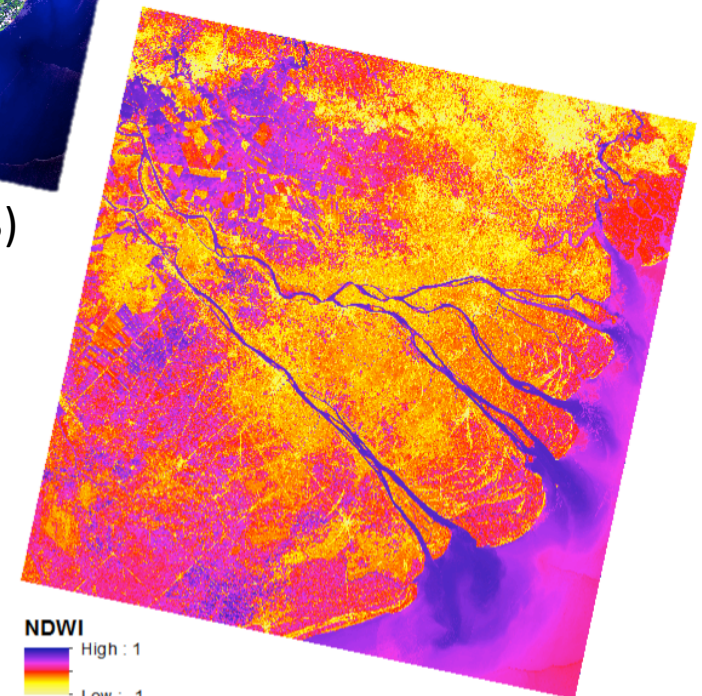
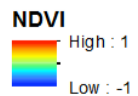
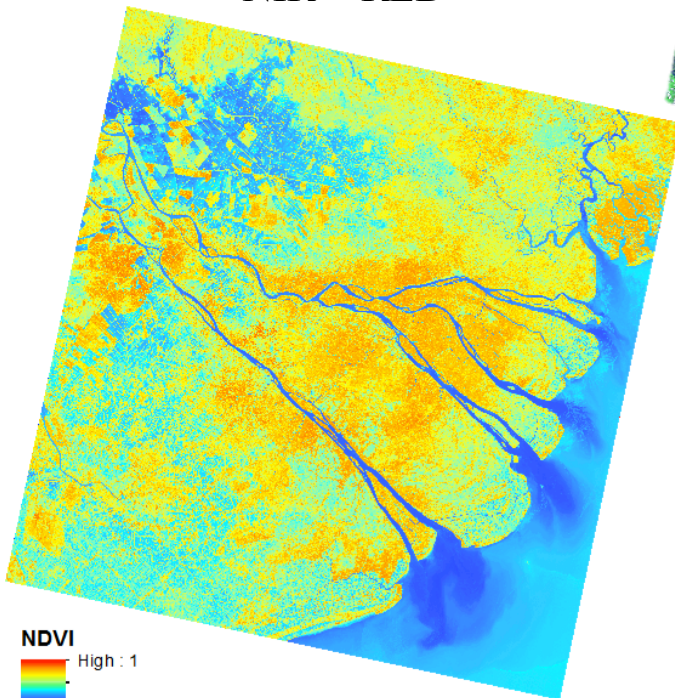
# Examples of Spectral Indices

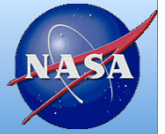
$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}$$

$$\text{NDWI} = \frac{\text{GREEN} - \text{SWIR}}{\text{GREEN} + \text{SWIR}}$$



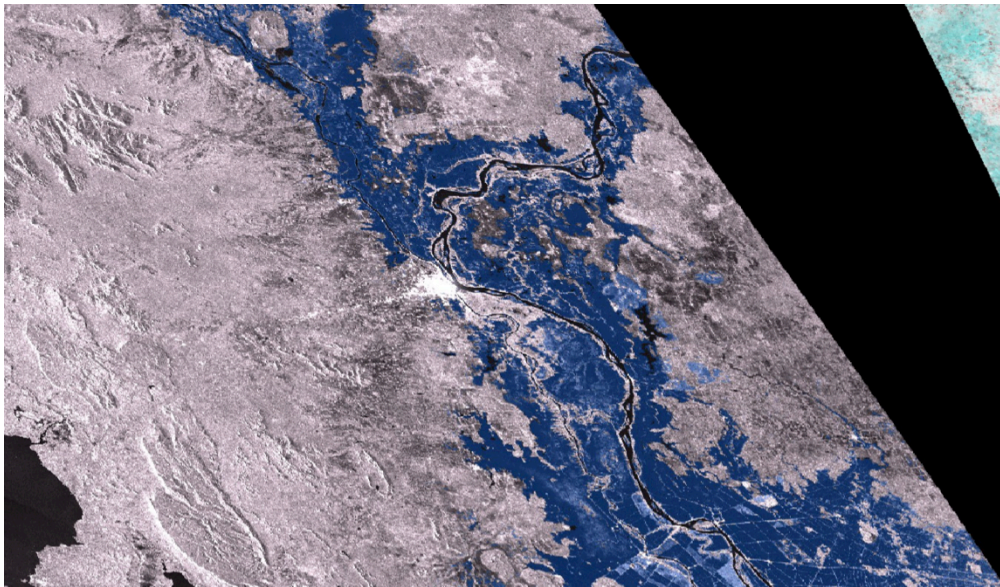
Landsat 8 OLI (RGB 753)  
Vietnam Delta  
September 18, 2014





# Example of Radar Application

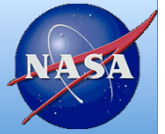
- Penetrates clouds
- Medium to high resolution
- TerraSAR-X, RADARSAT, ENVISAT, etc.



Flooding in the Mekong derived from change detection (August vs. March, 2006) of radar data

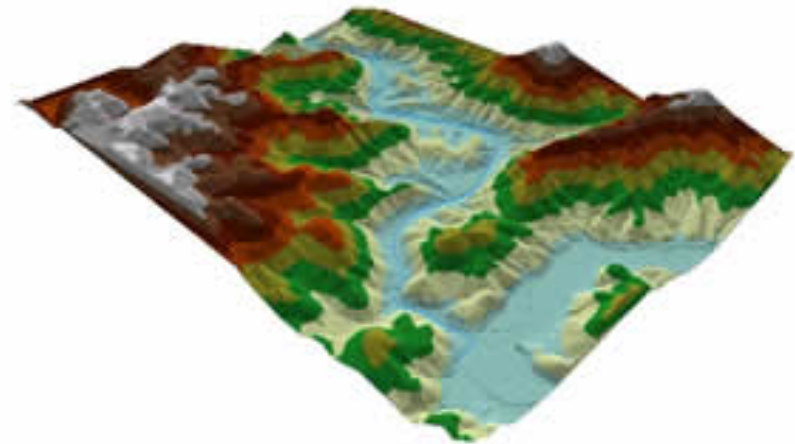
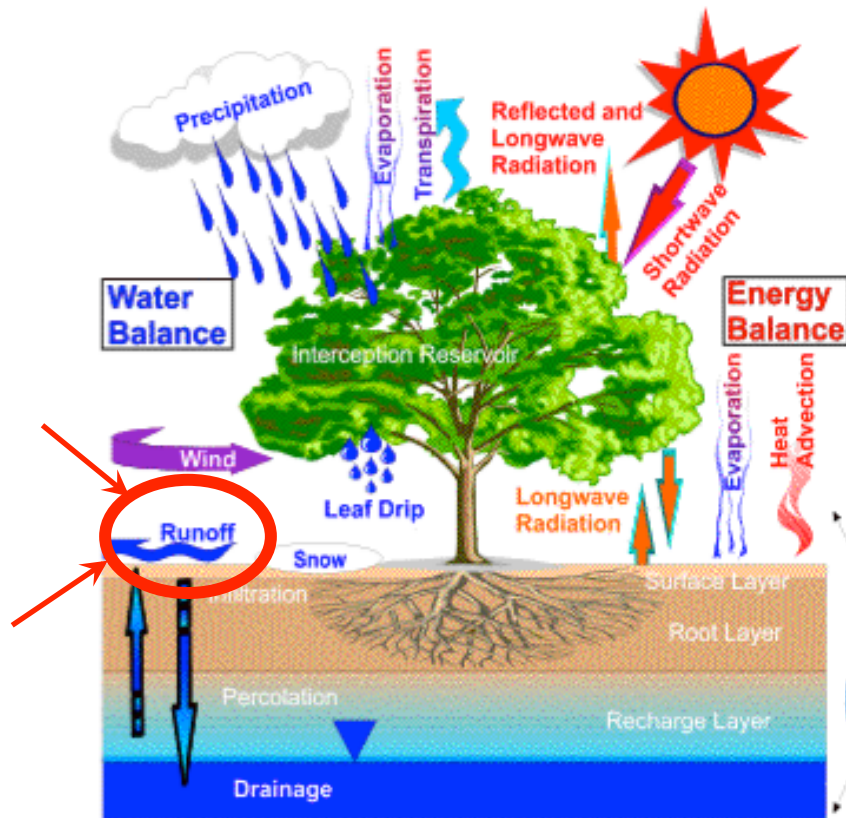
## Techniques

- Thresholding
- Classification
- Change detection



# Hydrological Modelling

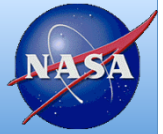
## Land Surface Modeling Concept



Calculate **runoff**, feed into routing model with DEM to estimate inundation extent and depth

# Near Real-time Global Flood Mapping Project

## Dartmouth Flood Observatory and GSFC



- Home
- Active Archive of Large Floods, 1985-Present
  - Global and Regional Analyses
- Master Index of Inundation Maps
- The Surface Water Record
- River Watch
- Other Flood Detection Tools
- Sample Images and Maps
- Staff
- Publications
- Live Traffic Feed
  - A visitor from Greenbelt, Maryland viewed "The Flood Observatory" 13 mins ago
  - A visitor from Germany viewed "The Flood Observatory" 13 mins ago
  - A visitor from Fort Worth, Texas viewed "The Flood Observatory" 27 mins ago
  - A visitor from Vienna, Wien viewed "Dartmouth Flood Observatory" 43 mins ago
  - A visitor from Wilburton, Oklahoma viewed "The Flood Observatory" 43 mins ago
  - A visitor from Ukraine viewed "Dartmouth Flood Observatory" 51 mins ago
  - A visitor from Washington, District of Columbia



**Space-based Measurement, Mapping, and Modeling of Surface Water**  
For Research, Humanitarian, and Water Management Applications

[Flood Observatory Director](#)  
[Observatory Mission Statement](#)

*Community Surface Dynamics Modeling System*  
University of Colorado, Campus Box 450, Boulder, CO 80309 USA



Click on Map for Access to the Surface Water Record  
Click Here for Current Events  
Click Here for Access to Flood Archive, 1985-Present

The Dartmouth Flood Observatory  
CSDMS, INSTAAR  
University of Colorado

Current Floods, June 2, 2015



Terra MODIS false color (above)

### NRT Global Flood Mapping

- Data Viewer
- Product Description
- Documents
- Future Enhancements
- News/Status

**Mailing list**

To subscribe to our mailing list to receive email notification of updates, please, click here.

3 Day Composite		2 Day Composite		1 Day Composite		14 Day Composite	
October 2014							
S	M	T	W	T	F	S	
		1	2	3	4		
5	6	7	8	9	10	11	
12	13	14	15	16	17	18	
19	20	21	22	23	24	25	
26	27	28	29	30	31		

Products	Available Downloads	
MODIS Flood Map	MFM	png
MODIS Flood Water	MFW	shapefile (.zip) KNZ
MODIS Surface Water	MSW	shapefile (.zip) KNZ
MODIS Water Product	MWP	geotiff
README	pdf	txt

Check slide show for the last 10 days.

**NASA EXPERIMENTAL SCIENCE PRODUCT**

**MODIS Flood Map**  
14-18 Oct 2014  
Tile: 100E020N

Current floodwater  
Input: LANCE MODIS

Cloud  
MODIS / MODIS

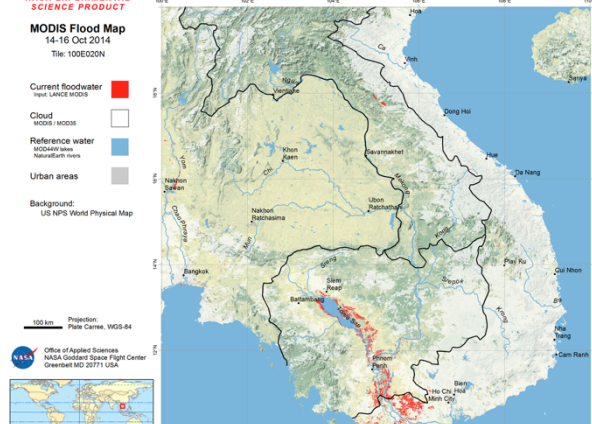
Reference water  
MODIS view  
Natural Earth rivers

Urban areas

Background:  
US NPS World Physical Map

100 km Projection: Plate Carree, WGS-84

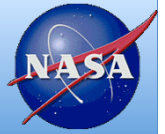
Office of Applied Sciences  
NASA Goddard Space Flight Center  
Greenbelt MD 20771 USA



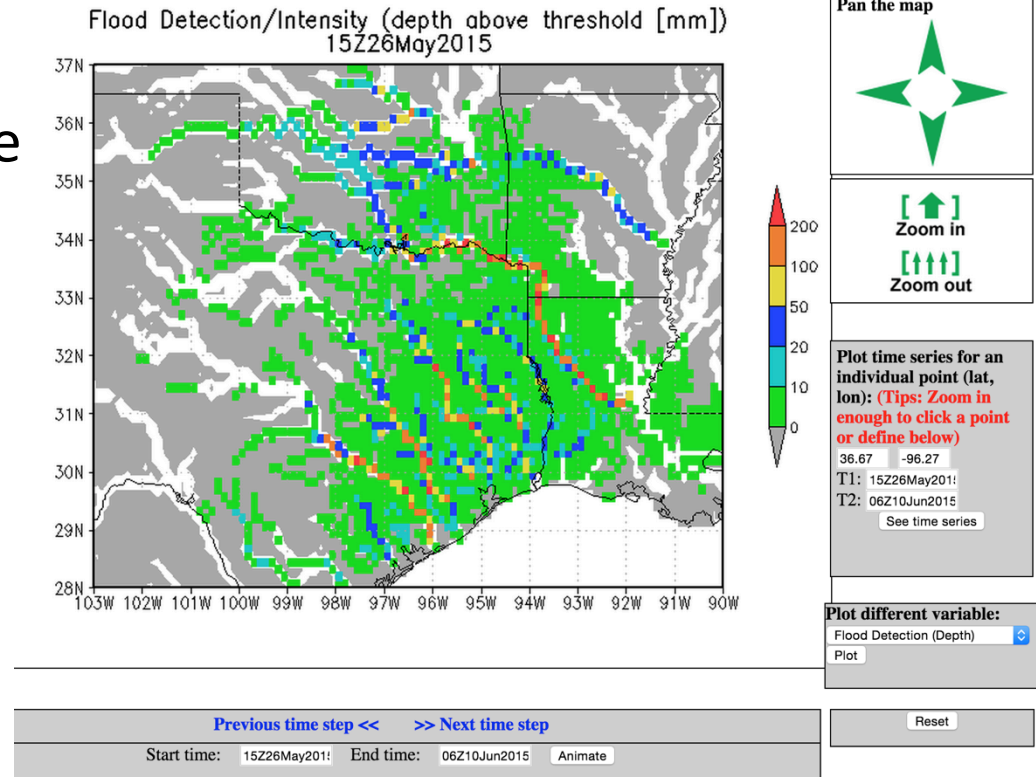
- Dartmouth Flood Observatory algorithm
- MODIS 250 m band ratios
- Updated daily (2 day, 3 day, 14 day)
- Detects surface water

# Global Flood Monitoring System

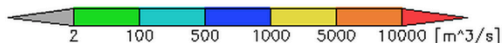
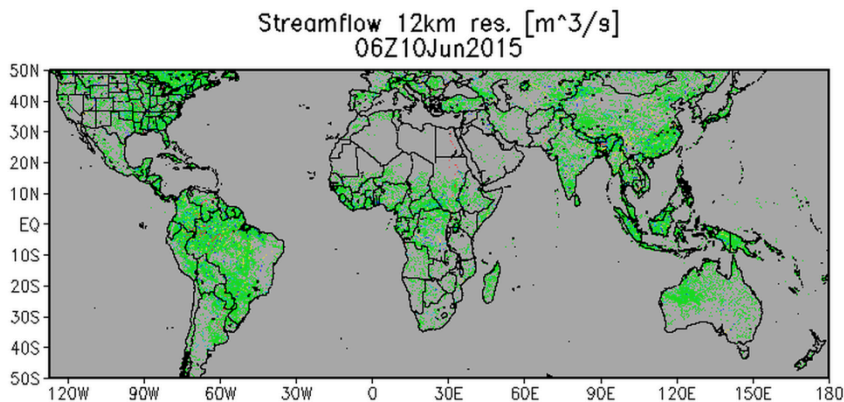
## University of Maryland



- Based on TRMM Multi-satellite Precipitation Analysis and hydrological model
- 1 km resolution
- Updates every 3 hours
- Estimates inundation depth



Texas Flooding: May 26, 2015



# World Resources Institute – Global Flood Analyzer



floods.wri.org/#/country/19/Bangladesh



AQUEDUCT Global Flood Analyzer

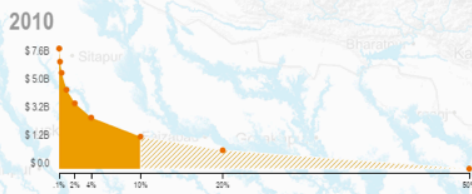
Type or select a country, basin or state, and start to assess flood risks

By Country

10 year protection

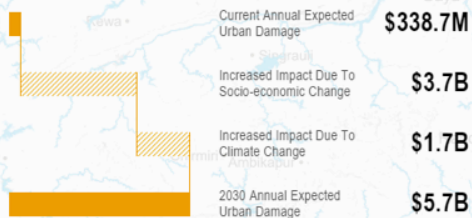
## Flood Risk in Bangladesh

Urban Damage    Affected GDP    Affected Population



Annual Expected Urban Damage **\$338.7M**    Annual Avoided Urban Damage **\$335.8M**

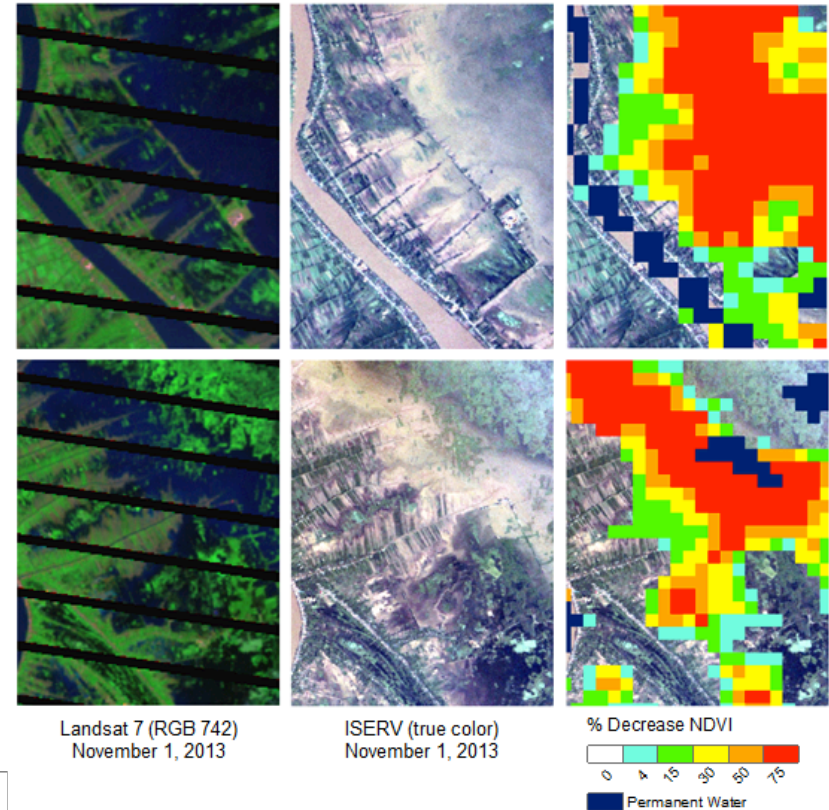
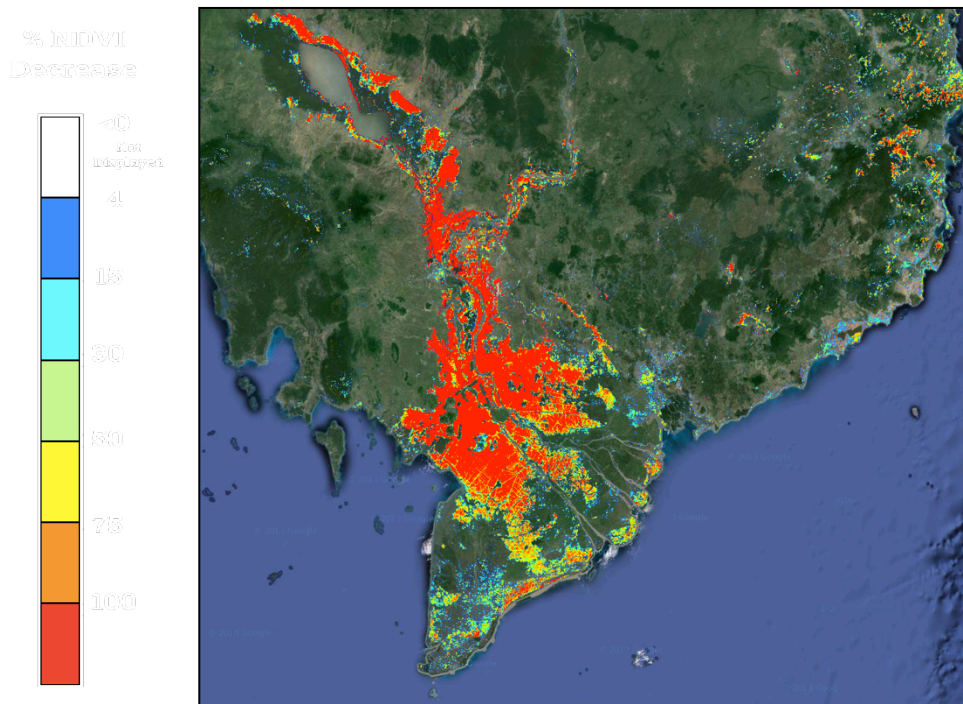
2030 Scenario A    Scenario B    Scenario C



World Resource Institute provides the Global Flood Analyzer to assess potential damage of various magnitudes of floods world-wide. Based on historical precipitation and land-surface models

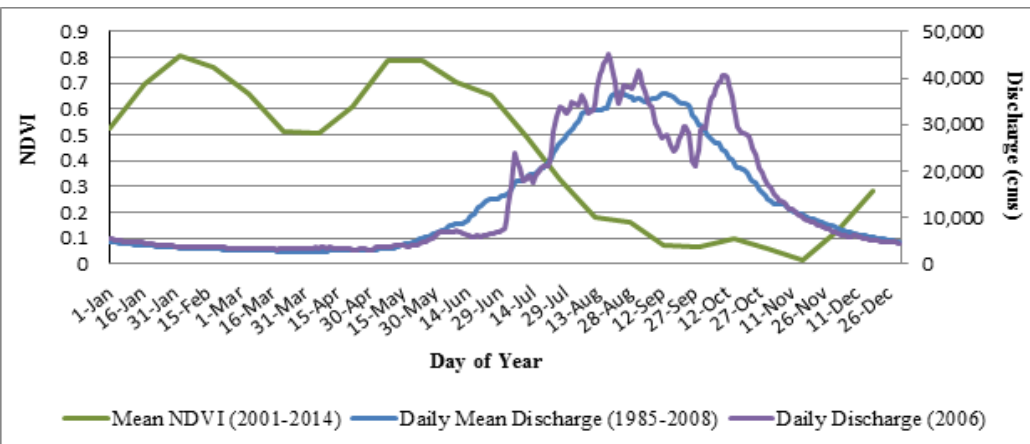
# Southeast Asia MODIS Near Real-time Flood Impact

## GSFC



Landsat 7 (RGB 742)  
November 1, 2013

ISERV (true color)  
November 1, 2013

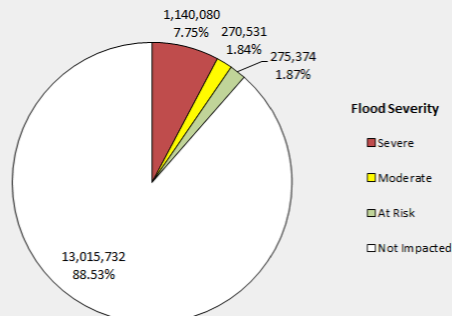


- Detects relative anomalies in NDVI from MODIS 250-m data with threshold on SWIR
- Updates 2 times a day
- Detects flood impact

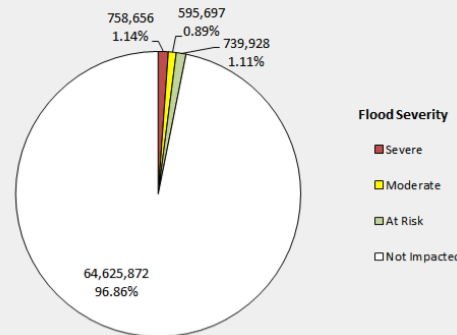
Bolten, NASA GSFC

# How can we move from data to decision making?

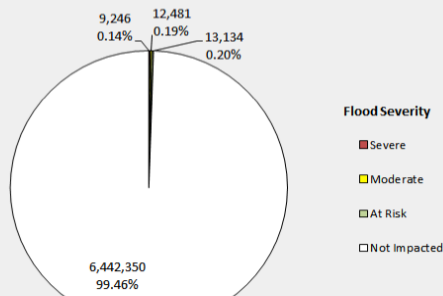
People Directly Impacted by Flood: Cambodia  
October 16, 2011



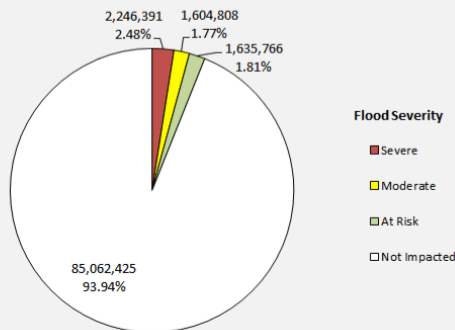
People Directly Impacted by Flood: Thailand  
October 16, 2011



People Directly Impacted by Flood: Laos  
October 16, 2011



People Directly Impacted by Flood: Vietnam  
October 16, 2011

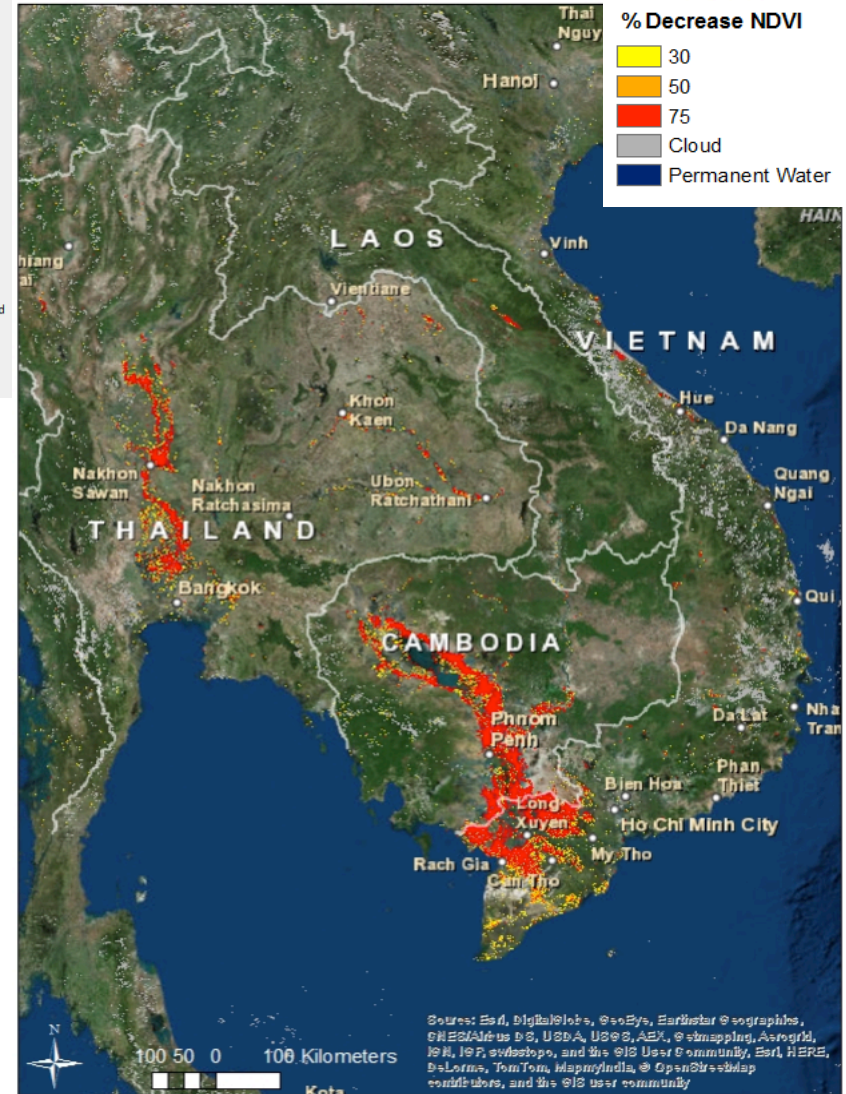


## Flood Map

This flood map was produced from Aqua and Terra MODIS 8-day composites (250 m) from October 16-23, 2011. The larger the decrease in NDVI, the more likely that area is severely inundated. Warmer colors indicate areas more severely impacted by flooding.

## Population Data

The population data used for impact estimates is from the Landsat 2011 Global Population dataset produced by Oak Ridge National Laboratory.



Country	At Risk	Moderate	Severe	Total Affected	Total Population	Percent Pop Affected
Cambodia	275,374	270,531	1,140,080	1,685,986	14,701,717	11.47%
Thailand	739,928	595,697	758,656	2,094,281	66,720,153	3.14%
Laos	13,134	12,481	9,246	34,862	6,477,211	0.54%
Vietnam	1,635,766	1,604,808	2,246,391	5,486,966	90,549,390	6.06%

Source:  
Bolten, NASA GSFC





# NASA WATER SCIENCE & APPLICATIONS

**Thanks!**

**John D. Bolten**

Hydrological Sciences Branch

NASA Goddard Space Flight Center

Greenbelt, MD USA

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*ARSET – June 29<sup>th</sup>, 2015*



## **Recent Flooding in Oklahoma and Texas, USA**

Live Demonstration of data visualization, acquisition, import to GIS

This live demonstration will be framed around an extreme rainfall and flooding event.

We will visualize and download data that is useful to analyze the event such as:

- precipitation
- stream flow
- inundation (flooded lands) shapefiles and rasters
- terrain data

This data can be used in the response, recovery, and mitigation phases to:

- assess areas at risk
- establish evacuation routes and direct aid
- construct flood risk maps
- input into models

# Severe Flooding Hits Central Texas, Oklahoma



<http://www.nasa.gov/feature/goddard/severe-flooding-hits-central-texas-oklahoma>

**Severe Flooding Hits Central Texas, Oklahoma**

A stagnant upper-air pattern that spread numerous storms and heavy rains from central Texas up into Oklahoma has resulted in record flooding for parts of the Lone Star State. One of the hardest hit areas was in Hays County Texas south of Austin where the Blanco River rose rapidly and set a new record crest at over 40 feet, 13 feet above flood stage, following a night of very heavy rain in the area, with over 12 inches reported locally in a short period of time, in an area already wet from previous storms. The combination of high pressure over the southeastern United States and a persistent southerly flow of moisture up out of the Gulf of Mexico ahead of a deep upper-level trough that was slow to leave the central and southern Rockies set the stage for persistent widespread storms across the Southern Plains from the eastern half of Texas, through Oklahoma, and into southern Kansas.

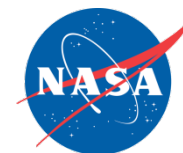
**Total Rainfall (IMERG) 19 May 2015 0000Z To 26 May 2015 2300Z**

This image shows IMERG rainfall estimates for the week-long period 19 to 26 May 2015 for the south central US.  
Credits: Images produced by Hal Pierce (SSAINASA GSFC)

Heavy precipitation began early May, 2015 and lasted over a month causing increased stream flow and inundated lands.

# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data visualization

The screenshot displays the Giovanni data portal interface. At the top, there is a navigation bar with 'EARTHDATA' and several menu items: 'Data Discovery', 'Data Centers', 'Community', and 'Science Disciplines'. Below this is the 'GIOVANNI' logo and the tagline 'The Bridge Between Data and Science v 4.12', along with links for 'Release Notes', 'Browser Compatibility', and 'Known Issues'. A yellow banner at the top left reads 'GOCART data no longer available... [1 of 1 messages] Read More'. The main content area is divided into several sections. On the left, there is a 'Select Date Range' section with a date input field and a 'Valid Range: 1979' indicator. Below that is a 'Select Variables' section with two expandable categories: 'Disciplines' and 'Measurements'. The 'Disciplines' category is expanded, showing a list of variables with checkboxes. The 'Measurements' category is also expanded, showing a list of variables with checkboxes. In the center, there is a 'Maps Choices' section with a title bar and a list of map types, each with a radio button and a 'Details...' link. The 'Time-Averaged' option is selected. On the right, there is a 'Select Plot' section with a dropdown menu set to 'Maps: Time-Averaged' and several other options: 'Comparisons: Select...', 'Time Series: Select...', 'Vertical: Select...', and 'Miscellaneous: Select...'. A red box highlights this 'Select Plot' section. To the right of the 'Select Plot' section, there is a yellow box with the text 'Analysis/Plot Options'. Below the 'Maps Choices' section, there is a 'Shapefile' section with 'Show Map' and 'Show Shapes' buttons. At the bottom right, there is a 'Variable(s) included in Plot: 0' section with 'Search' and 'Clear' buttons. A yellow arrow points from a yellow box containing the text 'Dropdown Menu options' and 'Choose Time-Averaged' to the 'Maps: Time-Averaged' dropdown menu. At the bottom of the interface, there are buttons for 'Help', 'Reset', 'Feedback', and a large green 'Plot Data' button.

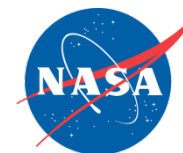
**Analysis/Plot Options**

**Dropdown Menu options**

**Choose Time-Averaged**

# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data visualization

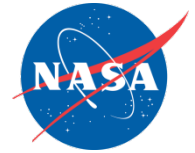
The screenshot displays the Giovanni data portal interface. At the top, there are two main sections: "Select Date Range (UTC)" and "Select Region (Bounding Box or Shapefile)".

**Select Date Range (UTC)**: This section includes a form for specifying a date range. The format is YYYY-MM-DD HH:mm. The current range is 2014 -07 -01 04:00 to 2014 -09 -30 23:59. Below this, there are two calendar pop-ups: "Pick a start date" and "Pick an end date". Both calendars are set to 2014 and July. The "Pick a start date" calendar has the 1st of July selected, and the "Pick an end date" calendar has the 7th of July selected. A yellow arrow points from a text box to the "Pick an end date" calendar.

**Select Region (Bounding Box or Shapefile)**: This section includes a form for specifying a bounding box. The format is West, South, East, North. The current bounding box is -180, -50, 180, 50. There are buttons for "Show Map" and "Show Shapes".

**Temporal Search**: A yellow text box on the right contains the text "Temporal Search" and "Click calendar to choose the date range of interest". A yellow arrow points from this text box to the "Pick an end date" calendar.

At the bottom left, there are several checkboxes for data types: "Air Temperature (15)", "Albedo (8)", and "Altitude (4)".



# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>

## Precipitation data visualization

**GIOVANNI** The Bridge Between Data and Science v 4.12 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

**GOCART data no longer available...** [1 of 1 messages] [Read More](#)

**Select Plot**

Maps: Time-Averaged  Comparisons: Select...  Time Series: Select...  Vertical: Select...  Miscellaneous:

**Select Date Range (UTC)**

YYYY-MM-DD HH:mm

2014 -07 -01 04 : 00 to 2014 -07 -07 04 : 00

Valid Range: 1979-01-01 to 2015-03-16

**Select Region (Bounding Box or Shapefile)**

Format: West, South, East, North

-180, -50, 180, 50

Show Map Show Shapes

**Select Variables**

**Disciplines**

- Aerosols (117)
- Atmospheric Chemistry (18)
- Atmospheric Dynamics (64)
- Hydrology (114)
- Water and Energy Cycle (120)

**Measurements**

- Aerosol Index (1)
- Air Pressure (6)
- Air Temperature (15)
- Albedo (8)
- Altitude (4)

Number of matching:   
Please select at least:   
Keyword:

**Shape Files**

- Countries**
- US States

Shape
<input type="radio"/> Afghanistan
<input type="radio"/> Albania
<input type="radio"/> Algeria
<input type="radio"/> American Samoa
<input type="radio"/> Andorra
<input type="radio"/> Angola
<input type="radio"/> Anguilla

Done Clear Shape Selection

Help Reset Feedback

**Spatial Search**

You can manually enter the latitude/longitude of your region

OR

Click **Show Shapes** to select shapefiles for various Countries or US States



# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>

## Precipitation data visualization

**Select Plot**

Maps: Time Averaged Map | Comparisons: Select... | Time Series: Select... | Vertical: Select... | Miscellaneous: Select...

**Select Date Range (UTC)**

YYYY-MM-DD HH:mm to YYYY-MM-DD HH:mm  
2015 -05 -05 00:00 to 2015 -06 -06 23:59  
Valid Range: 1979-01-01 to 2015-06-16

**Select Region (Bounding Box or Shapefile)**

Format: West, South, East, North  
-107.4902, 25.9277, -89.5605, 37.8805 | Show Map | Show Shapes

**Select Variables**

- SO2 (1)
- Sea Ice (2)
- Sensible Heat Flux (3)
- Soil Moisture (36)
- Soil Temperature (13)
- Statistics (28)
- Surface Runoff (1)
- Surface Temperature (10)
- Total AOD Climatology Anomaly (6)
- Total Aerosol Optical Depth (58)
- UV Exposure (1)
- Vegetation (2)
- Wind Stress Direction (1)
- Wind (7)

Res.	Begin Date	End Date	Units	Vert.
5 °	2000-03-01	2015-06-14	mm/day	
25 °	1979-01-01	2015-06-12	kg/m <sup>2</sup>	
25 °	1979-01-02	2015-05-31	kg/m <sup>2</sup>	
25 °	1979-01-02	2015-05-31	kg/m <sup>2</sup>	
25 °	1979-01-02	2015-05-31	kg/m <sup>2</sup>	

Buttons: Help, Reset, Feedback, Plot Data

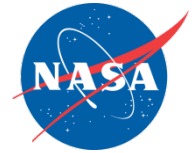
### Spatial Search

Using the interactive map tools, zoom into your region of interest and select your bounding box for data retrieval



# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data visualization

The screenshot shows the Giovanni data portal interface. At the top, there are navigation menus for "EARTHDATA", "Data Discovery", "DAACs", "Community", and "Science Disciplines". The main header includes the "GIOVANNI" logo and the tagline "The Bridge Between Data and Science v 4.14", along with links for "Release Notes", "Browser Compatibility", and "Known Issues". A yellow banner indicates "GOCART data no longer available... [1 of 1 messages] Read More".

The "Select Plot" section has a dropdown menu set to "Maps: Time Averaged Map" and several other options: "Comparisons: Select...", "Time Series: Select...", "Vertical: Select...", and "Miscellaneous: Select...".

The "Select Date Range (UTC)" section shows a date range from "2015 -05 -05 00:00" to "2015 -06 -06 23:59". The "Select Region (Bounding Box or Shapefile)" section shows a bounding box of "-107.4902, 25.9277, -89.5605, 37.8805" with "Show Map" and "Show Shapes" buttons.

The "Select Variables" section is highlighted with a red box and contains a list of variables with checkboxes. "Precipitation (49)" is checked. Other variables include Latent Heat Flux, Latent Heat, Mixed Layer Depth, NO2, Nitrate, OLR, Ozone, Phytoplankton, Radiation, Net, Reflectivity, Runoff, SO2, Sea Ice, and Sensible Heat Flux.

The search results table shows 49 matching variables. The "Keyword" field contains "precipitation". The table columns are "Variable Name", "Source", "Temp. Res.", "Spat. Res.", "Begin Date", "End Date", and "Units". The first few rows are:

Variable Name	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Units
<input type="checkbox"/> Precipitation Rate (TRMM_3B42RT_daily v7)	TRMM	Daily	0.25 °	2000-03-01	2015-06-14	mm/day
<input type="checkbox"/> Precipitation Total (NLDAS_FORA0125_H v002)	NLDAS Model	Hourly	0.125 °	1979-01-01	2015-06-12	kg/m^2
<input type="checkbox"/> Snow water-equivalent (accumulated) (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-05-31	kg/m^2
<input type="checkbox"/> Snowfall (frozen precipitation) (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-05-31	kg/m^2
<input type="checkbox"/> Rainfall (unfrozen precipitation) (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-05-31	kg/m^2

At the bottom, there are buttons for "Help", "Reset", "Feedback", and a green "Plot Data" button.

Either type the variable "precipitation" in the Keyword search

OR

Navigate through the Select Variables list

# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data visualization

Number of matching Variables: 49 of 456 Total Variable(s) included in Plot: 1

Keyword :

<input type="checkbox"/>	Variable Name	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Units	Vert.
<input checked="" type="checkbox"/>	<a href="#">Precipitation Rate (TRMM_3B42RT_daily v7)</a>	TRMM	Daily	0.25 °	2000-03-01	2015-06-14	mm/day	
<input type="checkbox"/>	<a href="#">Precipitation Total (NLDAS_FORA0125_H v002)</a>	NLDAS Model	Hourly	0.125 °	1979-01-01	2015-06-12	kg/m^2	
<input type="checkbox"/>	<a href="#">Snow water-equivalent (accumulated) (NLDAS_VIC0125_M v002)</a>	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-05-31	kg/m^2	
<input type="checkbox"/>	<a href="#">Snowfall (frozen precipitation) (NLDAS_VIC0125_M v002)</a>	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-05-31	kg/m^2	
<input type="checkbox"/>	<a href="#">Rainfall (unfrozen precipitation) (NLDAS_VIC0125_M v002)</a>	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-05-31	kg/m^2	

Select **Precipitation Rate (TRMM\_3B42RT\_daily v7)**

**Daily, mm/day**

Click **Plot Data**

**Plot Data**

**Note, for this demo we will be obtaining the data product to TRMM Multi-satellite Precipitation Analysis (TMPA) visualize rainfall over our region.**

**However, in the coming months, GPM IMERG half-hourly data will be available.**

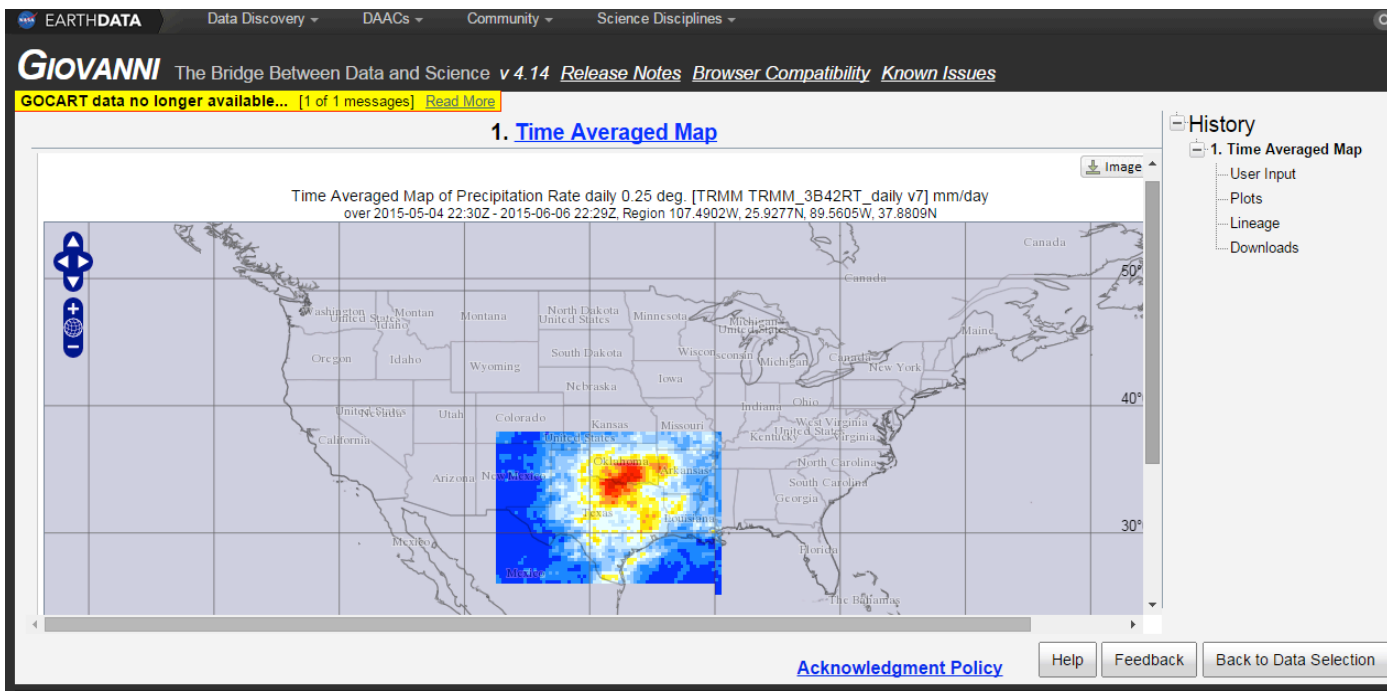
# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data visualization

A Time Averaged Map will be generated with precipitation displayed in mm/hr over May 5 - June 6, 2015.



Click

[Back to Data Selection](#)

To return to Data Selection screen to choose from a variety of different visualizations and plots to narrow down the data you wish to download

Note, for this demo we will be obtaining the data product to TRMM Multi-satellite Precipitation Analysis (TMPA) visualize rainfall over our region.

However, in the coming months, GPM IMERG half-hourly data will be available.

# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



Time Series: Area-Averaged  Vertical: Select...  Miscellaneous: Select...

### Time Series Choices

- Hovmoller, Longitude-Averaged  
Longitude-averaged Hovmoller, plotted over the selected time and longitude ranges  
[Details...](#)
- Hovmoller, Latitude-Averaged  
Latitude-averaged Hovmoller, plotted over the selected time and latitude ranges  
[Details...](#)
- Area-Averaged Differences  
Time series of area averages of differences between two variables at each spatial grid point  
[Details...](#)
- Area-Averaged  
Time series of area-averaged values  
[Details...](#)
- Seasonal  
Seasonal (inter annual) time series  
[Details...](#)

Maps: Animation  Comparisons: Select...

### Maps Choices

- Time Averaged Map  
Interactive map of average over time at each grid cell  
[Details...](#)
- Animation  
Map animated along the chosen timeline for each grid cell  
[Details...](#)
- Difference of Time Averaged  
Difference of two time averaged variable maps  
[Details...](#)
- Accumulated  
Accumulation of measurement over time at each grid point  
[Details...](#)
- User-Defined Climatology  
Quasi Climatology Map  
[Details...](#)

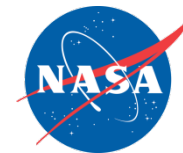
You can choose the **Area Averaged time series**

Or **Animation** for a map plot of average over time at each grid cell

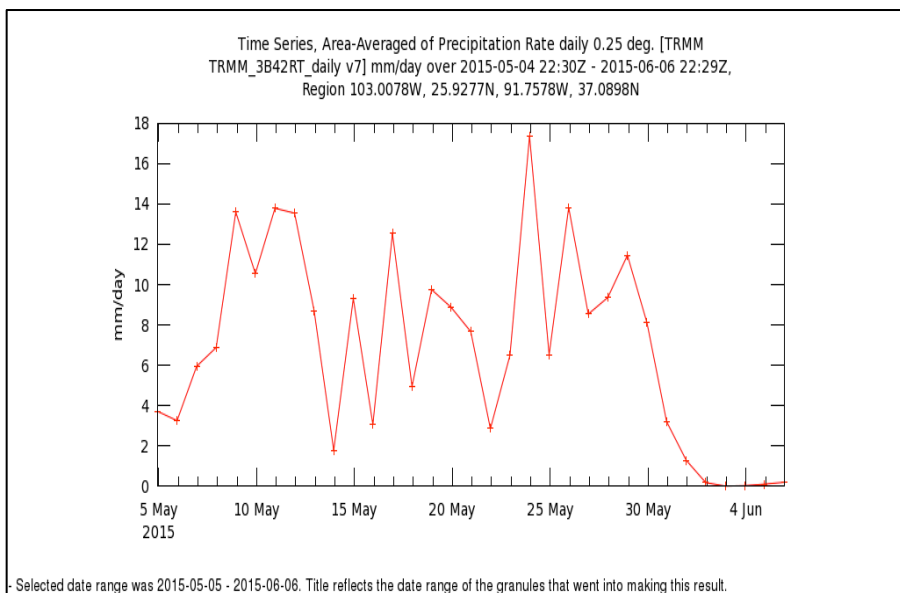
Or **Accumulated** to visualize the accumulated precipitation over time at each grid point

# Giovanni data portal

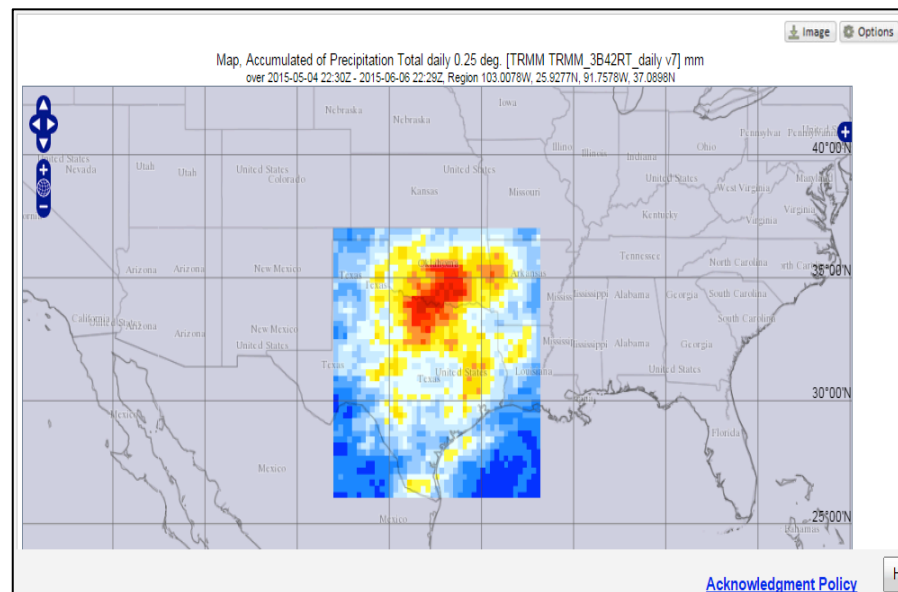
<http://giovanni.gsfc.nasa.gov/giovanni/>



## Time Series (Area-Averaged)

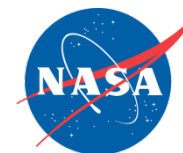


## Map, Accumulated of Precipitation Total



# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data download

**GIOVANNI** The Bridge Between Data and Science v 4.14 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)  
GOCART data no longer available... [1 of 1 messages] [Read More](#)

### 4. Time Averaged Map

Time Averaged Map of Precipitation Rate daily 0.25 deg. [TRMM TRMM\_3B42RT\_daily v7] mm/day  
over 2015-05-18 22:30Z - 2015-05-19 22:29Z, Region 108.3881W, 23.8025N, 89.3158W, 40.8533N

History

- 4. Time Averaged Map
  - User Input
  - Plots
  - Lineage
  - Downloads**
- 3. Time Averaged Map
  - User Input
  - Plots
  - Lineage
  - Downloads
- 2. Time Average
  - User Input
  - Plots
  - Lineage
  - Downloads
- 1. Map, Accumul
  - User Input
  - Plots
  - Lineage
  - Downloads

[Acknowledgment Policy](#) [Help](#) [Feedback](#) [Back to Data](#) [ation](#)

Click Downloads to display links to data files ready for downloading.

# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data download

**GIOVANNI** The Bridge Between Data and Science v 4.14 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

GOCART data no longer available... [1 of 1 messages] [Read More](#)

### 5. Time Averaged Map

Click on file links to download. Files contain data portrayed in the plot images.

**NetCDF Format:**  
[q4.timeAvgMap.TRMM\\_3B42RT\\_daily\\_7\\_precipitation.20150505-20150606.108W\\_23N\\_89W\\_40N.nc](#)

**Images (GeoTIFF):**  
[q4.timeAvgMap.TRMM\\_3B42RT\\_daily\\_7\\_precipitation.20150505-20150606.108W\\_23N\\_89W\\_40N.geotiff](#)

**Images (PNG):**  
[q4.timeAvgMap.TRMM\\_3B42RT\\_daily\\_7\\_precipitation.20150505-20150606.108W\\_23N\\_89W\\_40N.png](#)

**History**

- 5. Time Averaged Map
  - User Input
  - Plots
  - Lineage
  - Downloads
- 4. Time Averaged Map
  - User Input
  - Plots
  - Lineage
  - Downloads
- 3. Time Averaged Map
  - User Input
  - Plots
  - Lineage
  - Downloads
- 2. Time Averaged Map
  - User Input
  - Plots
  - Lineage
  - Downloads

You can download the data files in either NetCDF, GeoTIFF or PNG formats.  
NetCDF format is easily imported into ArcMap.

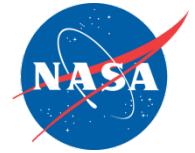
Click the link to download to your desired location on your computer.

For the demonstration today we will download the NetCDF file.

Repeat this step for all time periods you wish to download.

# Giovanni data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>



## Precipitation data download

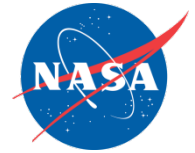
The screenshot shows the Giovanni data portal interface. At the top, there's a navigation bar with 'EARTHDATA', 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. Below that, the 'GIOVANNI' logo is followed by the tagline 'The Bridge Between Data and Science' and version 'v 4.14'. A yellow banner indicates 'GOCART data no longer available...'. The main content area is titled '5. Time Averaged Map'. It shows a 'Catalog Query' with a time taken of 0.13 s and an 'Output' section with metadata from a catalog. Below that, a 'Data File Search' with a time taken of 2.17 s is shown, followed by a list of 10 data URLs. On the right side, there's a 'History' panel with a tree view of actions. The 'Lineage' option is highlighted with a red box, and a yellow arrow points to it. At the bottom right, there are buttons for 'Help', 'Feedback', and 'Data Selection'.

By clicking Lineage, multiple files that were used to construct the time average map can be available for download yet these will not be spatially subsetted to the user bounding box and will be global in extent



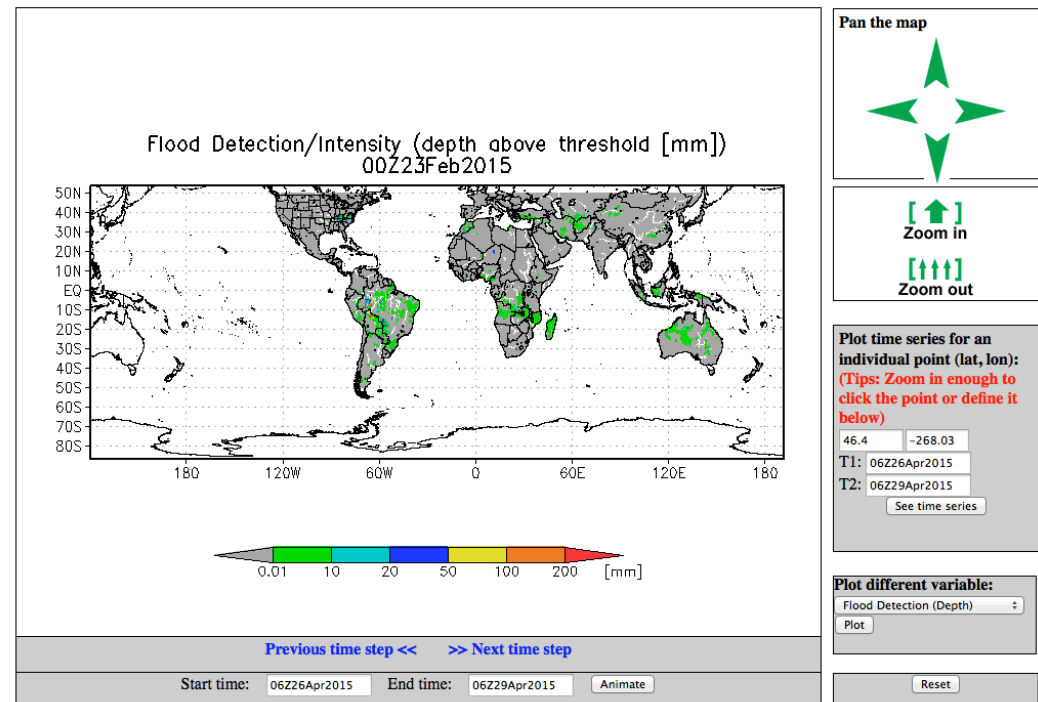
# Global Flood Monitoring System (GFMS)

<http://flood.umd.edu>



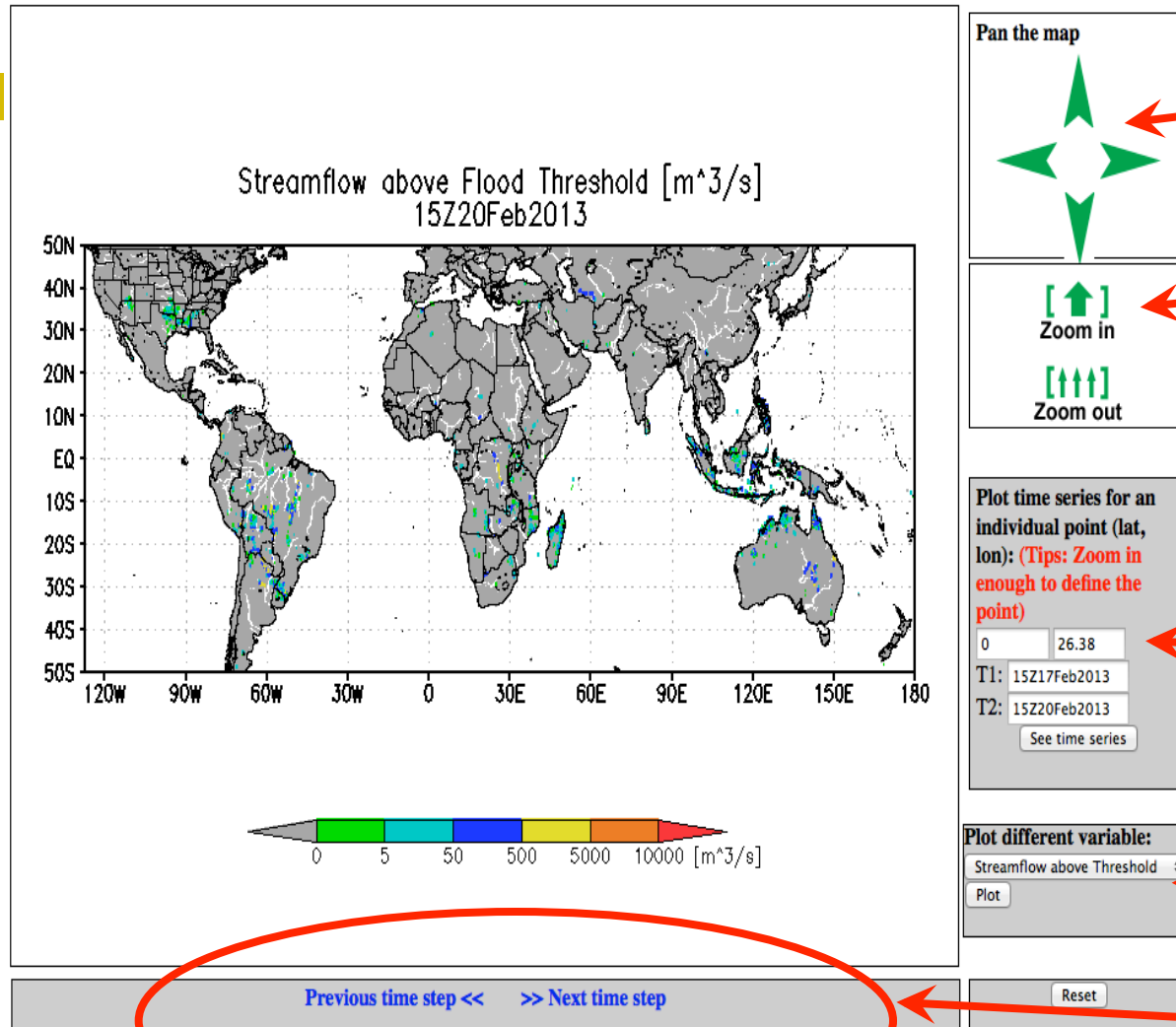
We have obtained precipitation data for our event

Next we can visualize how that precipitation is affecting streamflow ( $m^3/s$ ) at 12 km and 1 km resolutions and well as Flood Detections/Intensity (depth above threshold (mm))



# Global Flood Monitoring System (GFMS)

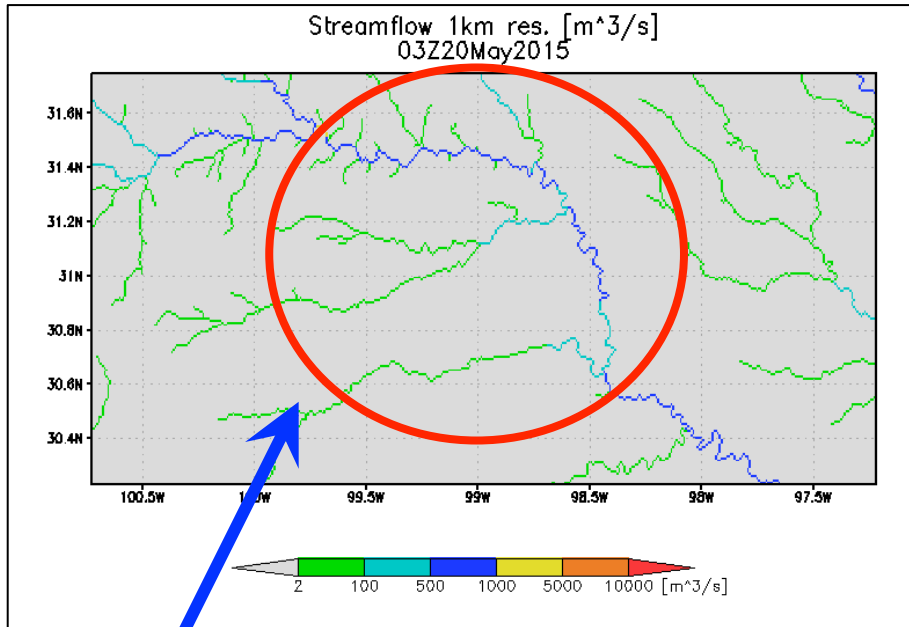
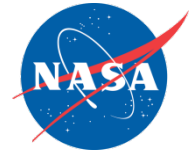
<http://flood.umd.edu>



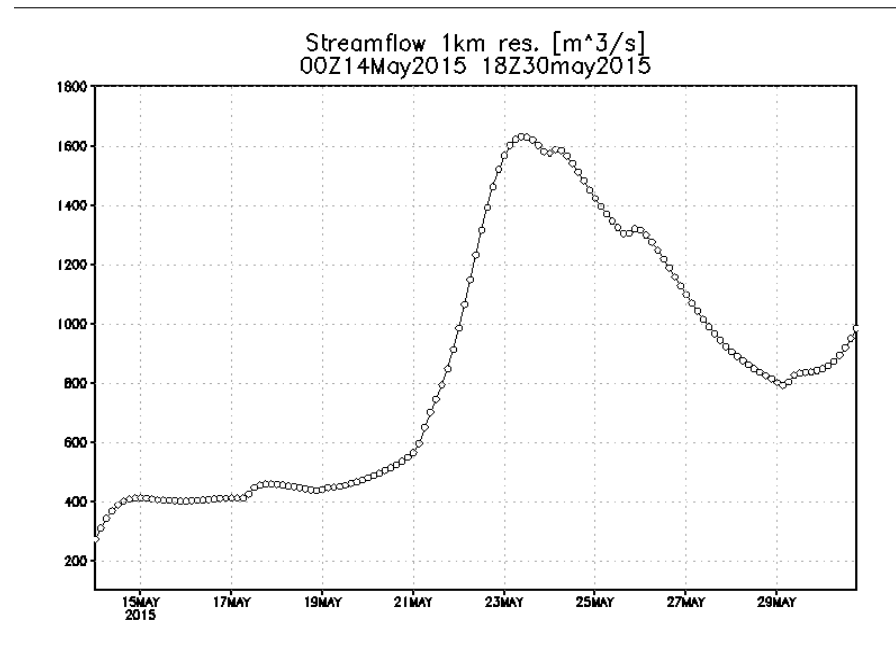
- Map navigation
- Zoom in/out
- Select individual grid point for data for time sequence
- Plot different variables
- 3-hourly output

# Global Flood Monitoring System (GFMS)

<http://flood.umd.edu>



Streamflow raises from a ranges of 500-1000  $\text{m}^3/\text{s}$  to 1000-5000  $\text{m}^3/\text{s}$  between May 19th and May 25th rivers and streams causing heavy flooding



This can be monitored at NEAR real time during heavy rain periods to plan for and respond to flooding events.

# MODIS Inundation Mapping

<http://oas.gsfc.nasa.gov/floodmap/>



## Inundation data visualization

The screenshot shows the 'NRT Global Flood Mapping' web application. At the top, there is a header with the title 'NRT Global Flood Mapping' and a satellite-style map background. Below the header, there is a navigation menu on the left side with the following items: 'Data Viewer', 'Product Description', 'Documents', 'Future Enhancements', and 'News/Status'. A 'Mailing list' section is also present, with a green background and white text that reads: 'To subscribe to our mailing list to receive email notification of updates, please, click here.' The main content area is titled 'Global Map' and contains the following text: 'View in ArcGIS Online map viewer.' and 'Real-time feed of processed tiles available at: [modis.geobliti.com/modis/geoactivities.atom](http://modis.geobliti.com/modis/geoactivities.atom)'. Below this text is a world map with a grid overlay, showing the global distribution of flood mapping tiles. A legend in the bottom left corner of the map area indicates '10° Flood Map Tile Production'. At the bottom of the map area, there is a note: 'For more information, please contact floodmap at [lists.nasa.gov](mailto:lists.nasa.gov)'. Below the map area, there is a 'News/Status' section with the following text: '11-Nov-2014: ArcGIS Online Map available.' and '10-Nov-2014: MODIS flood product evaluation report available.' In the bottom right corner of the page, there is a link: '> Go to News/Status page'.

# MODIS Inundation Mapping

<http://oas.gsfc.nasa.gov/floodmap/>

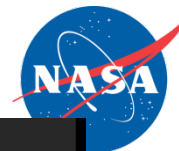


## Inundation data visualization

Click on the continent that contains your region of interest

Click on the tile that contains your region of interest

# MODIS Inundation Mapping



National Aeronautics and Space Administration

## NRT Global Flood Mapping

**Data Viewer**

- Product Description
- Documents
- Future Enhancements
- News/Status

**Mailing list**

To subscribe to our mailing list to receive email notification of updates, please, click here.

3 Day Composite
2 Day Composite
1 Day Composite
14 Day Composite

« June 2015 »

S	M	T	W	T	F	S
1	2	3	4	5	6	
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Products		Available Downloads	
MODIS Flood Map	MFM	png	
MODIS Flood Water	MFW	shapefile (.zip)	KMZ
MODIS Surface Water	MSW	shapefile (.zip)	KMZ
MODIS Water Product	MWP	geotiff	
README		pdf	txt

N

↑

← W → E

↓

S

[Check slide show for the last 10 days.](#)

NASA EXPERIMENTAL  
SCIENCE PRODUCT

**MODIS Flood Map**  
12-14 Jun 2015  
Tile: 100W030N

- Current floodwater  
Input: LANCE MODIS
- Cloud  
MODIS / MOD35
- Reference water  
MOD44W lakes  
NaturalEarth rivers
- Urban areas
- Background:  
US NPS World Physical Map

Archive Available since 2010

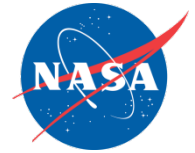
Composite Maps

10-day Sequencing

png, kmz, geotiff images available

# MODIS Inundation Mapping

<http://oas.gsfc.nasa.gov/floodmap/>



## MODIS Flood Map

30 May - 01 Jun 2015

Title: 100W040N

Current floodwater  
Input: LANCE MODIS



Cloud  
MODIS / MOD35



Reference water  
MOD44W lakes  
NaturalEarth rivers



Urban areas



Background:  
US NPS World Physical Map

## PRODUCTS Available

**MFM:** MODIS Flood Map = annotated 10x10 degree map/graphic product (currently available in png format).

**MSW:** MODIS Surface Water (Pixel classified with presence of water = **Reference Water** + Flood Water). This is based on a ratio of MODIS bands 1, 2, and 7 reflectance values.

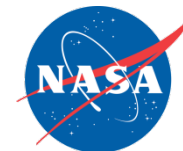
**Reference Water:** based on MODIS reflectance and Shuttle Radar Topography Mission Water Body Data.

**MFW:** MODIS Flood Water – Obtained by subtracting Reference Water from MSW.

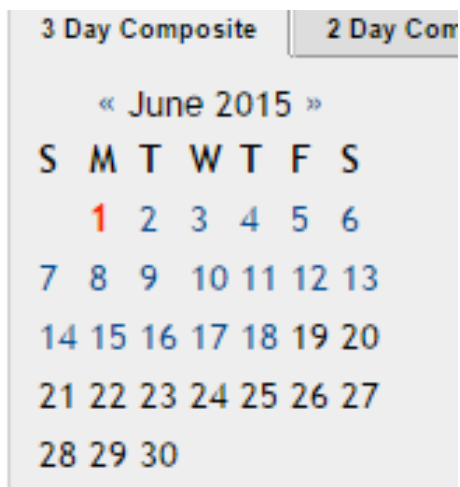
**MWP:** MODIS Water Product (Each pixel is assigned a number to identify as either undecided, water not detected, reference water detected, flood water detected where there is no reference water present) - **essentially the same as MFW but in geotiff format**

# MODIS Inundation Mapping

<http://oas.gsfc.nasa.gov/floodmap/>



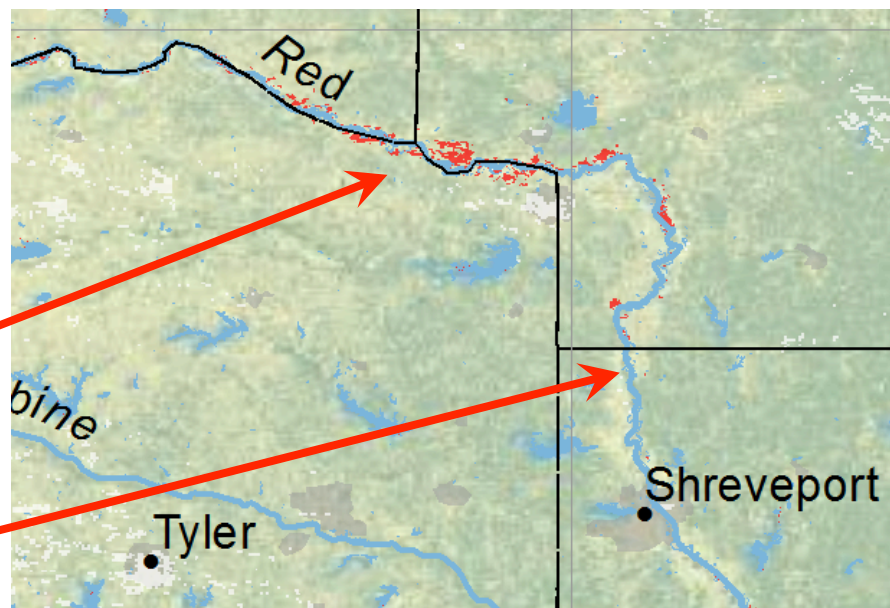
## Inundation data visualization



Use the calendar to navigate to visualize the dates of inundation

Red Shading Shows Inundated Surface

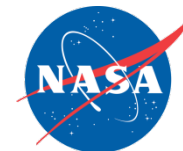
Blue Shading Shows Reference Water





# MODIS Inundation Mapping

<http://oas.gsfc.nasa.gov/floodmap/>



## Inundation data visualization

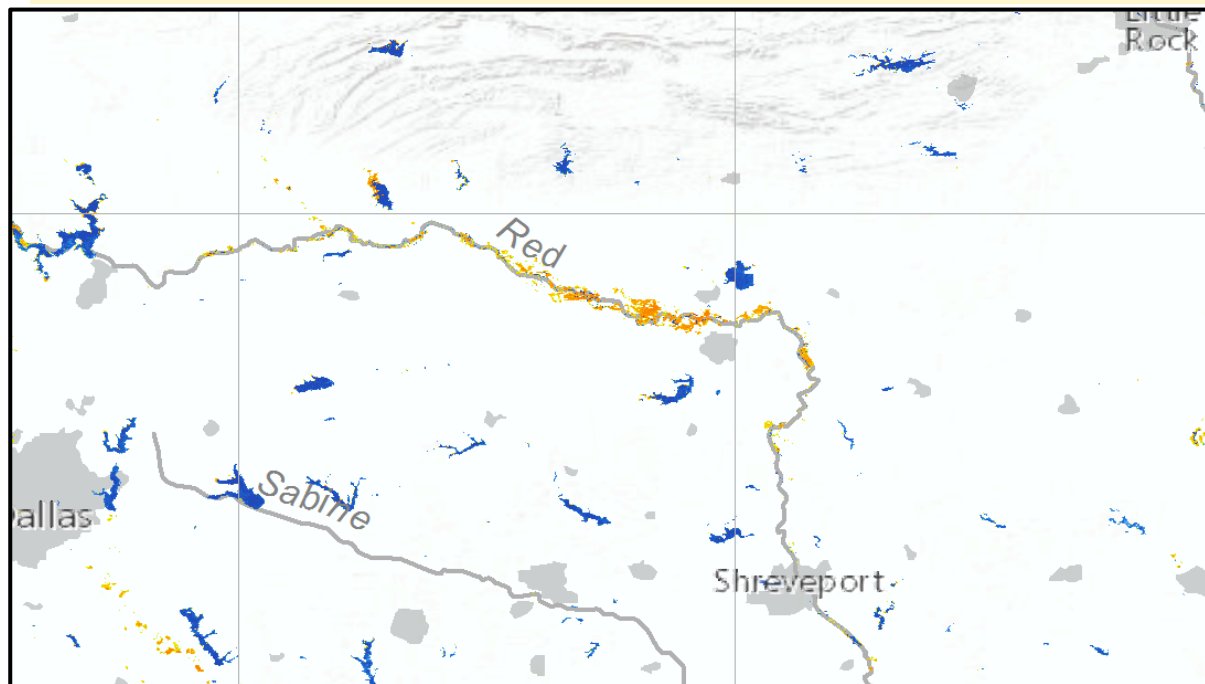
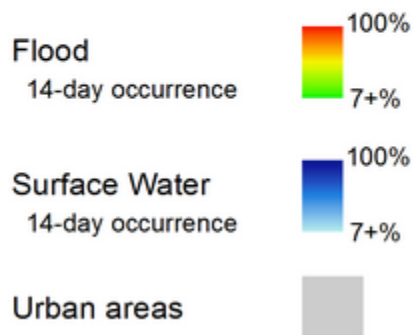
MODIS imagery cannot penetrate cloud cover. Click on the 14 day composite tab in order to visualize inundated lands if cloud cover is a problem in your region

14 Day Composite

### MODIS Flood Map

24 May - 06 Jun 2015

Tile: 100W040N



# MODIS Inundation Mapping

<http://oas.gsfc.nasa.gov/floodmap/>



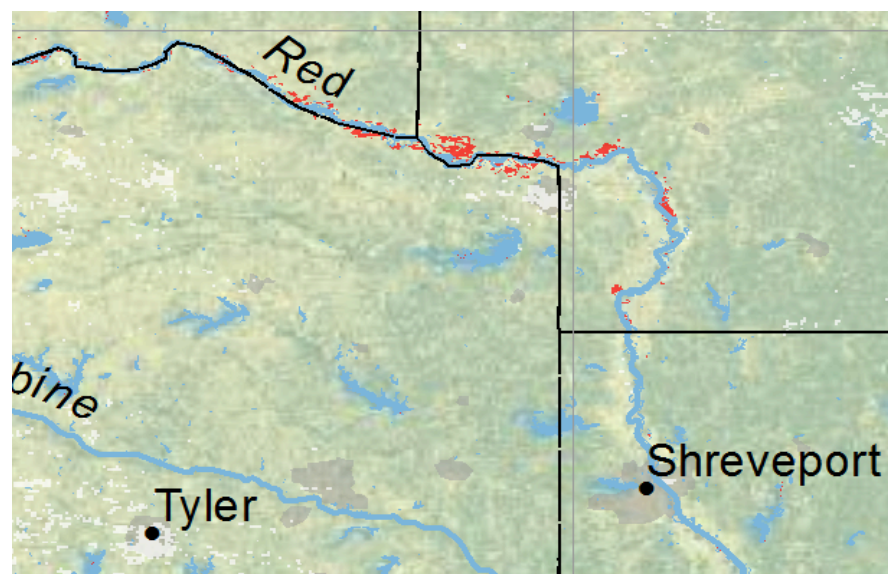
## Inundation data [download](#)

Products		Available Downloads	
MODIS Flood Map	MFM	png	
MODIS Flood Water	MFW	shapefile (.zip)	KMZ
MODIS Surface Water	MSW	shapefile (.zip)	KMZ
MODIS Water Product	MWP	geotiff	
README		pdf	txt

Download the MODIS Flood Water shapefile, KMZ, and MODIS Water Products data products

Repeat for all dates of interest

Near real time will have a latency of about 24 hours





## Terrain Data

From Shuttle Radar Topography Mission (SRTM)

Another very important data product relevant to flood risk maps and modeling is **terrain data**

**Terrain will determine the flow and displacement of water over land**

**Acknowledgement:** Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)



# Sources of NASA Terrain Data



Radar: Shuttle Radar Topography Mission (SRTM)

Radiometer: Terra Advanced Spaceborne Thermal Emission  
and Reflection

Radiometer (ASTER)

## Useful for Mapping

Hazardous terrain

## Calculating

Slope and aspect

Catchment area

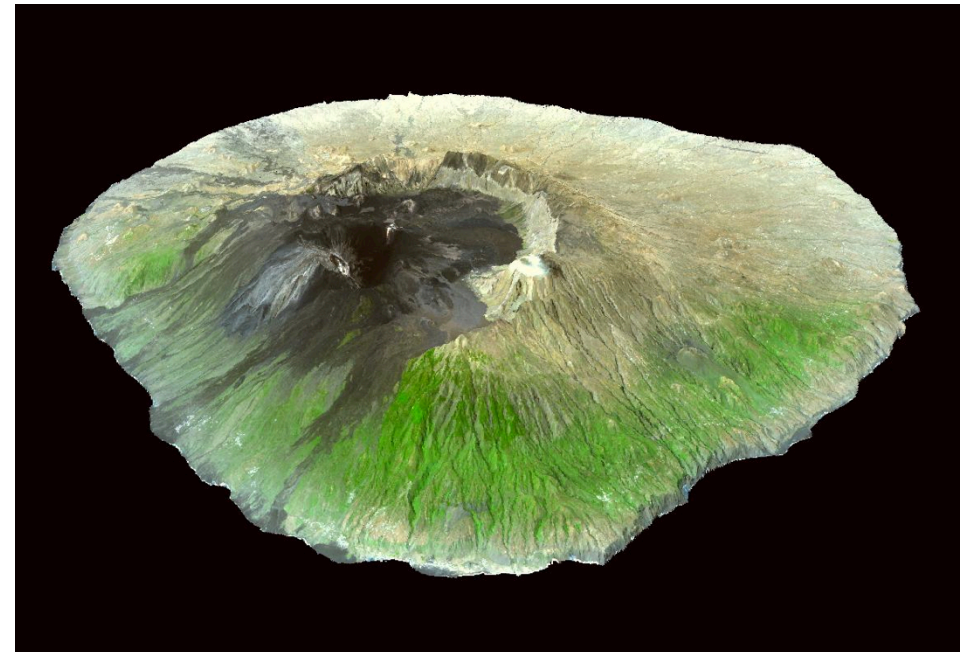
Forest canopy height

## Modeling

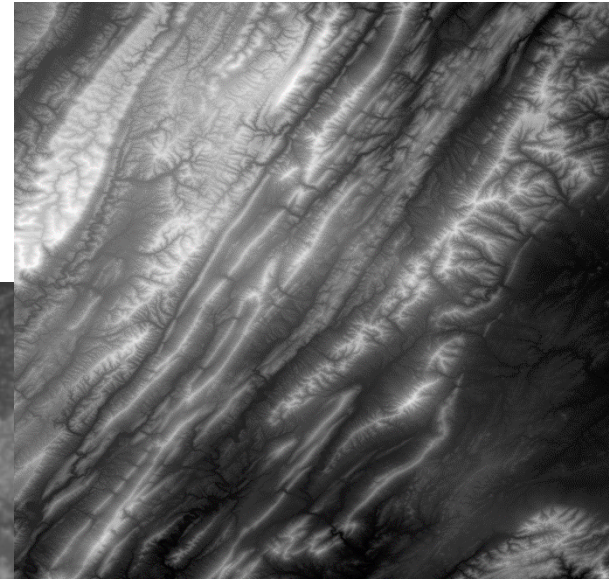
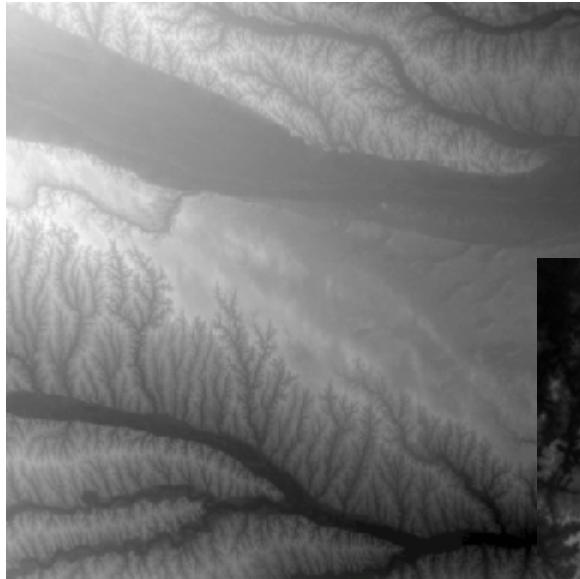
Runoff

Stream networks

Landslides



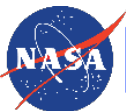
# Shuttle Radar Topography Mission (SRTM) Version 3.0 (SRTM Plus)



[https://lpdaac.usgs.gov/products/measures\\_products\\_table](https://lpdaac.usgs.gov/products/measures_products_table)



USGS



Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)



# What is SRTM?

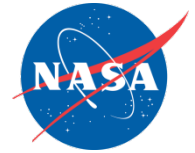
<http://www2.jpl.nasa.gov/srtm/>

- NASA mission completed in February 2000
- Consisted of 176 orbits around Earth in 11 days
- Acquired Digital Elevation Model (DEM) of all land between 60°N and 56°S latitude, about 80% of Earth's total land mass

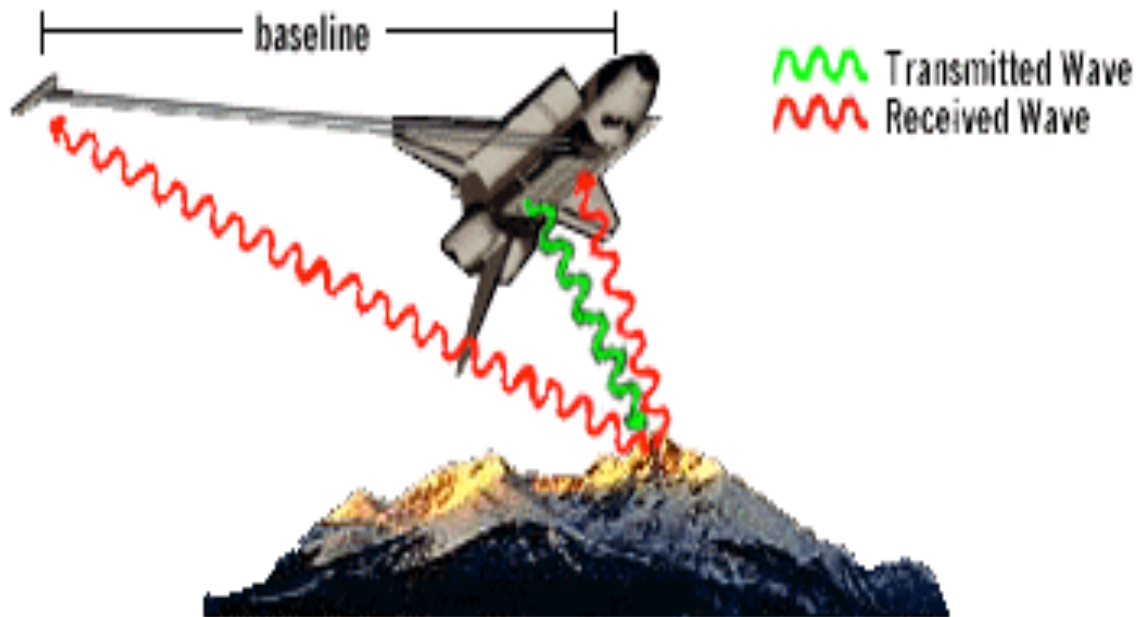


USGS

Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)



# NASA SRTM Version 3.0 (SRTM Plus)



Radar signals being transmitted and received in the SRTM mission (image not to scale).

<http://srtm.usgs.gov/data/interferometry.php>

- Created by the Jet Propulsion Laboratory (JPL) as part of the NASA MEaSUREs program
- Principal Investigator: Michael Kobrick, JPL
- Eliminated voids in the SRTM data by filling with ASTER GDEM2, USGS GMTED2010, or USGS National Elevation Dataset (NED)
- Collected at 1 arc second and resampled to 3 arc seconds
- November 2013: US & Territories 1 arc sec and Global 3 arc sec
- October 2014: Africa 1 arc second



# NASA SRTM v3 Characteristics

Tile size	1° by 1°	New version released in 2014 has high resolution
Pixel size	1 arc second (~30 meters) or 3 arc seconds (~90 meters)	
Geographic coordinates	Geographic latitude and longitude	
Output format	DEMS: .HGT, 16-bit signed integer, in units of vertical meters Number: .NUM	
Geoid reference	WGS84/EGM96	
Special DN values	N/A - No voids in v3	
Coverage	60°N to 56°S latitude U.S. and Territories Africa	

Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)



# NASA SRTM v3 Products



<a href="#">Short Name</a>	<a href="#">Collection</a>	<a href="#">MEaSURES Data Product</a>	<a href="#">Spatial Resolution</a>
<a href="#">SRTMGL1</a>	SRTM	SRTM Global 1 arc second	1 arc-second
<a href="#">SRTMGL1N</a>	SRTM	SRTM Global 1 arc second number	1 arc-second
<a href="#">SRTMGL3</a>	SRTM	SRTM Global 3 arc second	3 arc-second
<a href="#">SRTMGL30</a>	SRTM	SRTM Global 30 arc second	30 arc-second
<a href="#">SRTMGL3N</a>	SRTM	SRTM Global 3 arc second number	3 arc-second
<a href="#">SRTMGL3S</a>	SRTM	SRTM Global 3 arc second sub-sampled	3 arc-second
<a href="#">SRTMSWBD</a>	SRTM	SRTM Water Body Data Shapefiles & Raster Files	1 arc-second
<a href="#">SRTMUS1</a>	SRTM	SRTM US 1 arc second	1 arc-second
<a href="#">SRTMUS1N</a>	SRTM	SRTM US 1 arc second number	1 arc-second

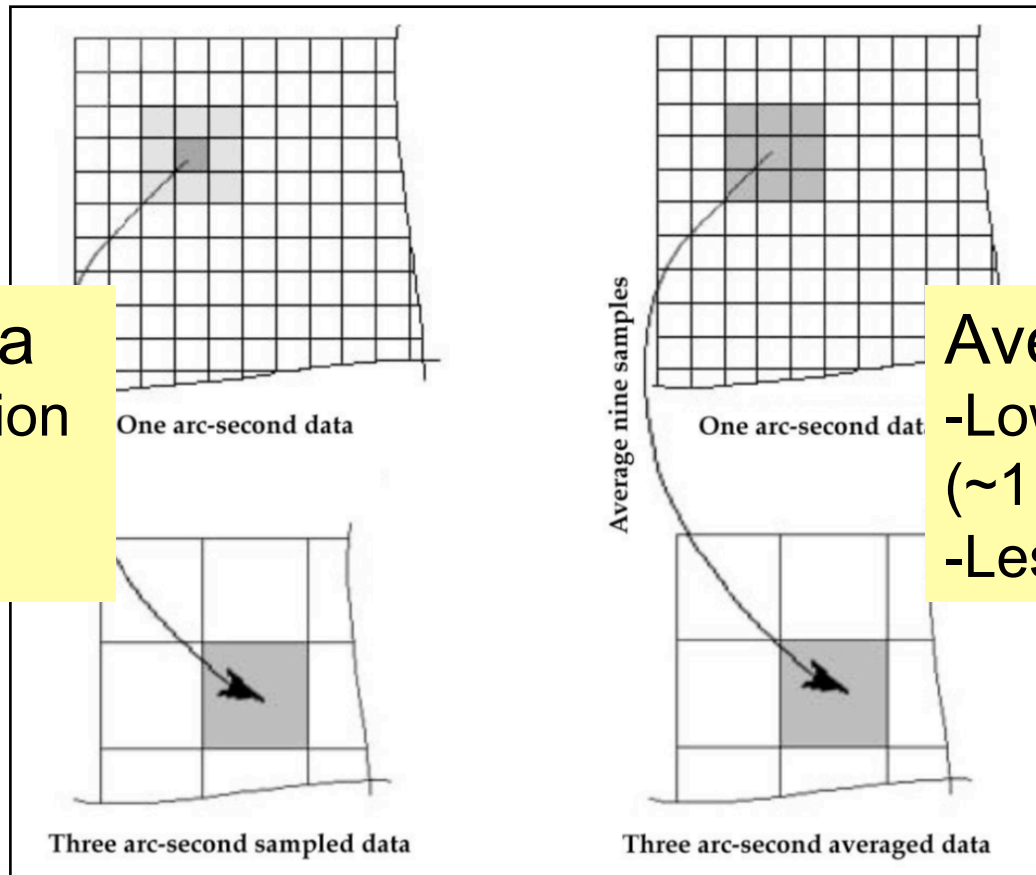
Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)

# Sampling Methods: Global 3 arc second data

## SRTMGL3S

### Sampled data

- Higher resolution (~100 meters)
- More noise



### Averaged data

- Lower resolution (~112 meters)
- Less noise



# How to Access NASA SRTM v3

- Reverb:

<http://reverb.echo.nasa.gov/reverb>

- GDEx:

<http://gdex.cr.usgs.gov/gdex/>

- Data Pool and DAAC2Disk:

[https://lpdaac.usgs.gov/data\\_access/data\\_pool](https://lpdaac.usgs.gov/data_access/data_pool)

- More information: SRTM v3 User Guide

[https://lpdaac.usgs.gov/sites/default/files/public/measures/docs/NASA\\_SRTM\\_V3.pdf](https://lpdaac.usgs.gov/sites/default/files/public/measures/docs/NASA_SRTM_V3.pdf)

Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)

# Global Data Explorer (GDEX)

<http://gdex.cr.usgs.gov/gdex/>



- Funded through NASA ROSES 2005 ACCESS Program
- A collaboration between the LP DAAC and George Mason University's Center for Spatial Information Science and Systems
- A seamless data viewer providing access to multiple sources of digital elevation data sets
- Users can subset and download data by area of interest in multiple formats and projections

Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)



# GDEx Features and Functions

- NASA ECHO/Reverb user account required to download data
- Product documentation and User Guide
- Square or polygonal area of interest
- Pre-defined areas of interest (state, county)
- Advanced, on-the-fly processing
  - Mosaic tiles coverage clipped to area of interest
  - Reformat to GeoTIFF, ArcASCII, or JPEG
  - universal transverse Mercator (UTM) or LAT/LON projection
- Preview data before download

Courtesy: Cynthia Schmidt (NASA-ARSET), Lindsey Harriman (USGS), Kelly Lemig (USGS)

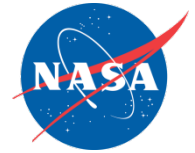


# GDEX

<http://gdex.cr.usgs.gov/gdex/>

Base layers to choose from

SRTM data coverage layers to select



# GDEx

<http://gdex.cr.usgs.gov/gdex/>

Using the tools here zoom into your region →

Define your region of interest using these options (by bounding box, by state, country, or lat/long)

Global Data Explorer

33.39844° -92.30713° | Logged in as BBBtown | Log Out | Help

U.S. Department of the Interior | U.S. Geological Survey  
URL: <http://gdex.cr.usgs.gov/gdex/>  
Page Contact Information: [LPDAAC@usgs.gov](mailto:LPDAAC@usgs.gov)  
Page Last Modified: 04/10/2015

USA.gov | GeoBrain | Powered by GEORGE MASON UNIVERSITY

User Guide | GMU | CSISS | About GeoBrain | Contact



# GDEx

<http://gdex.cr.usgs.gov/gdex/>

Here we have chosen to define our region of interest using Define Rectangle area

Click the Download data for Defined Area icon

The maximum number of tiles in a mosaic you may download at a time is 36

Page Last Modified: 04/10/2015

[User Guide](#) | [GMU](#) | [CSISS](#) | [About GeoBrain](#) | [Contact](#)

Taskbar showing file operations: HW\_Flooding\_2015....docx, 20150624144447\_19....zip Canceled, and Show all downloads... x





# GDEx

<http://gdex.cr.usgs.gov/gdex/>

A pop up window will appear and you can use the dropdown arrow to choose your Product to download. In this case we will download NASA SRTM V3.0, 1 arcsec

**Download**

**Output Settings**

Product: NASA SRTM V3.0, 1 arcsec

Format: ASTER Global DEM V2  
NGA SRTM "Finished", 1 arcsec  
NGA SRTM "Finished", 3 arcsec

Projection: NASA SRTM V3.0, 1 arcsec

Compressed: NASA SRTM V3.0, 3 arcsec  
NASA SRTM Combined Images V3.0, 1 arcsec  
GTOPO30  
MODIS 500m Land Cover Type  
Blue Marble 2004, Next Generation

Submit Cancel

Next, select the format to be downloaded (GeoTIFF), the Projection (lat/long or UTM) and check "compressed .zip" (optional) and Click **Submit**.

Format:  GeoTIFF  ArcASCII  
 GeoTIFF - 1x1 Tiles  JPEG

Projection: Lat/Lon

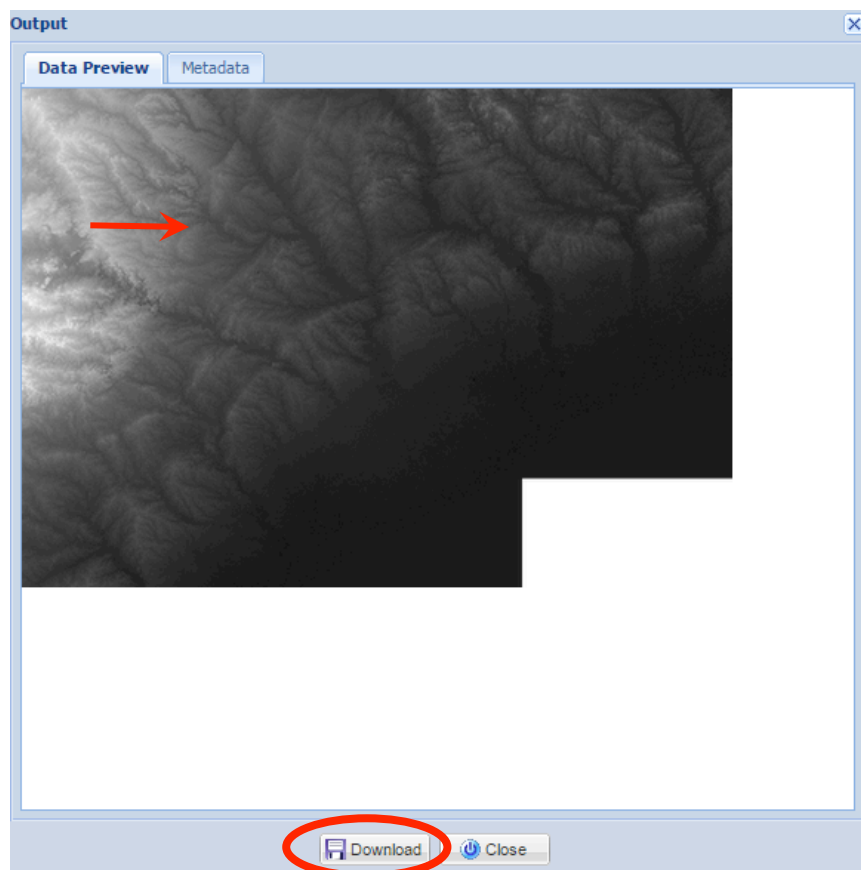
Compressed:  .zip



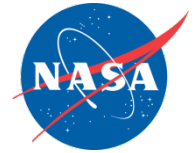
# GDEx

<http://gdex.cr.usgs.gov/gdex/>

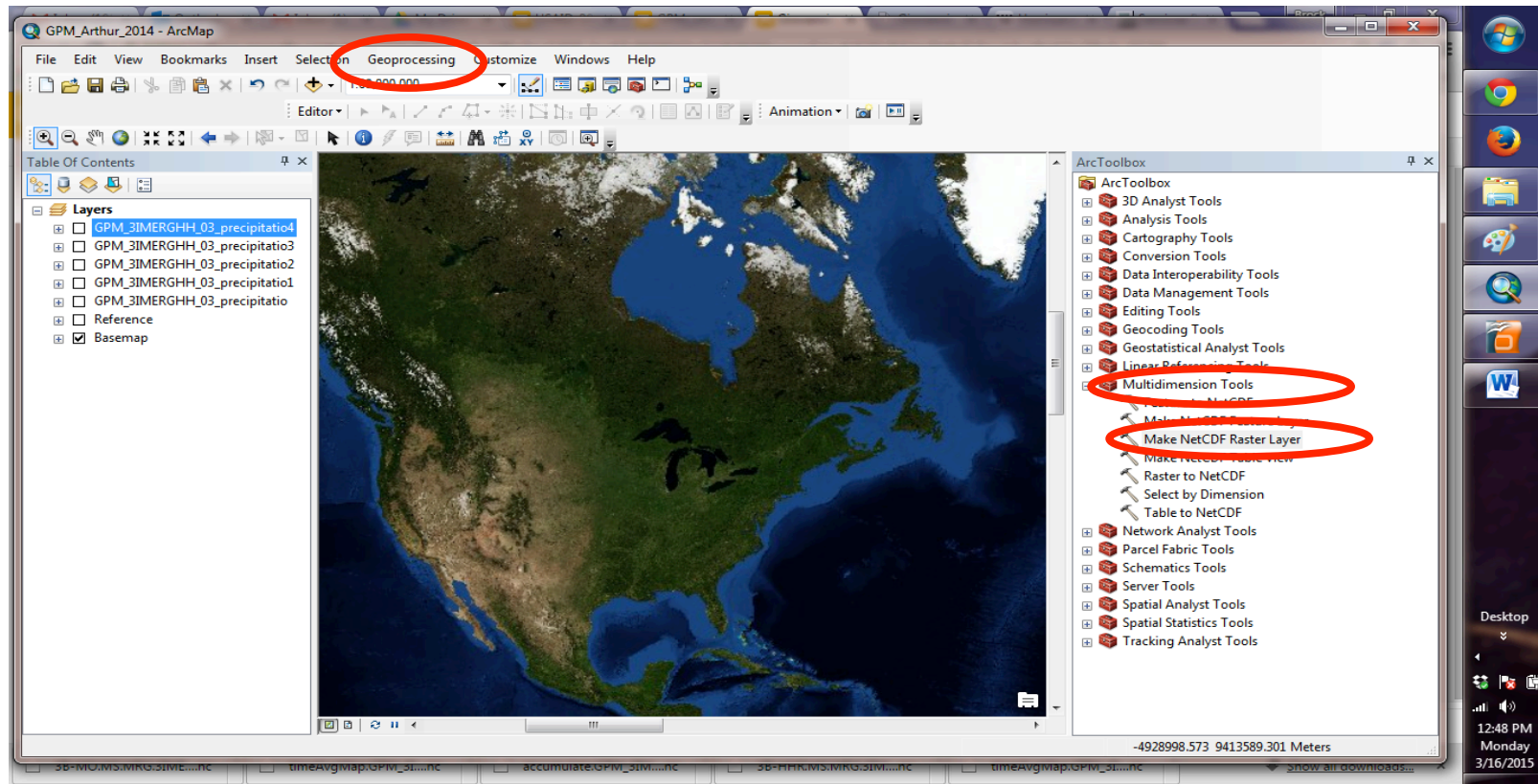
Once processed you will see a pop up window with a preview of the data



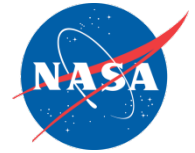
Click Download



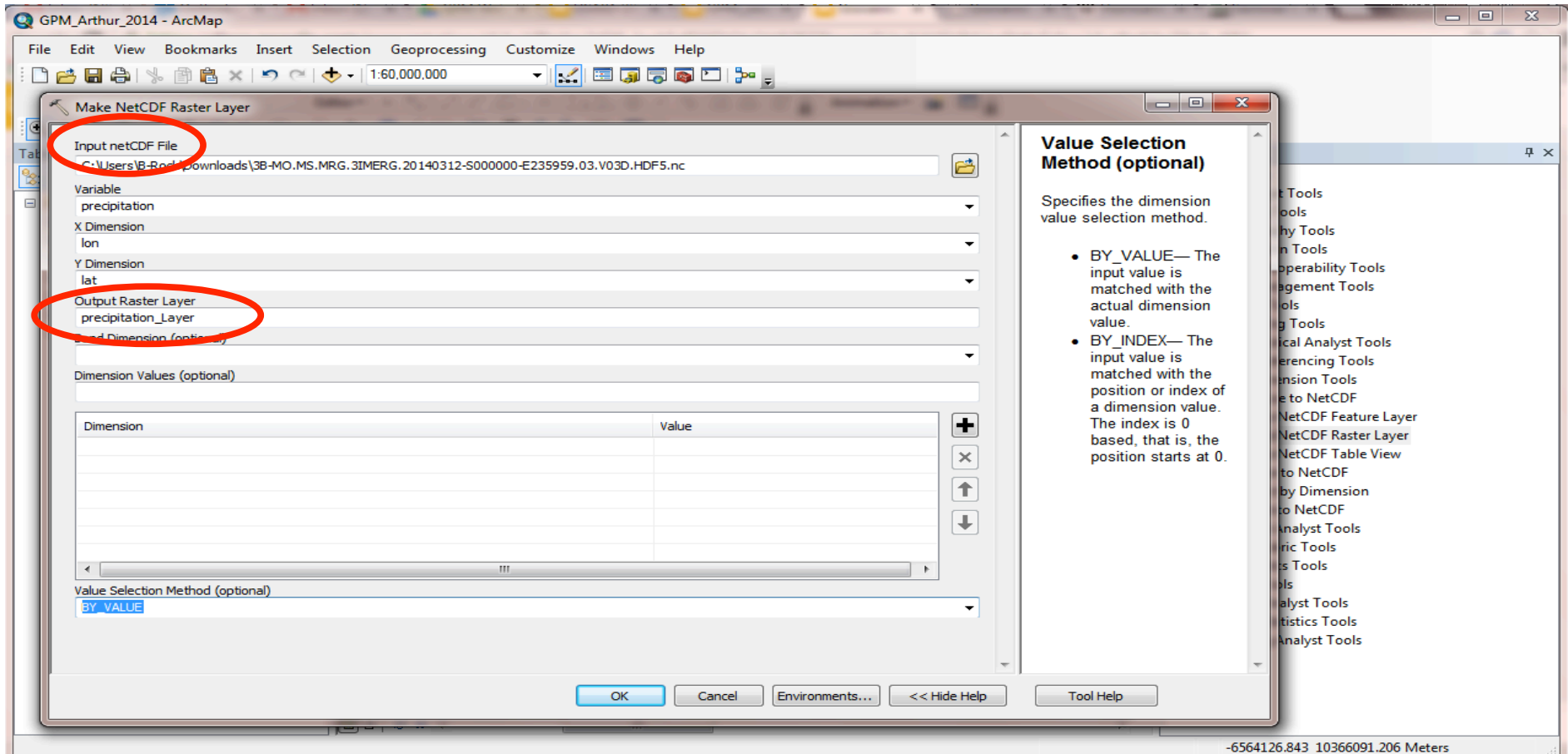
# Now that we have acquired our data, let us Import into GIS (ArcMAP): Precipitation



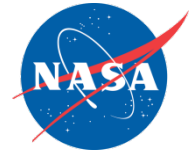
Import TRMM precipitation data - Under the Geoprocessing Tab, Open the ArcToolbox. Open the Multidimensional toolbox, choose the **Make NetCDF Raster Layer** tool



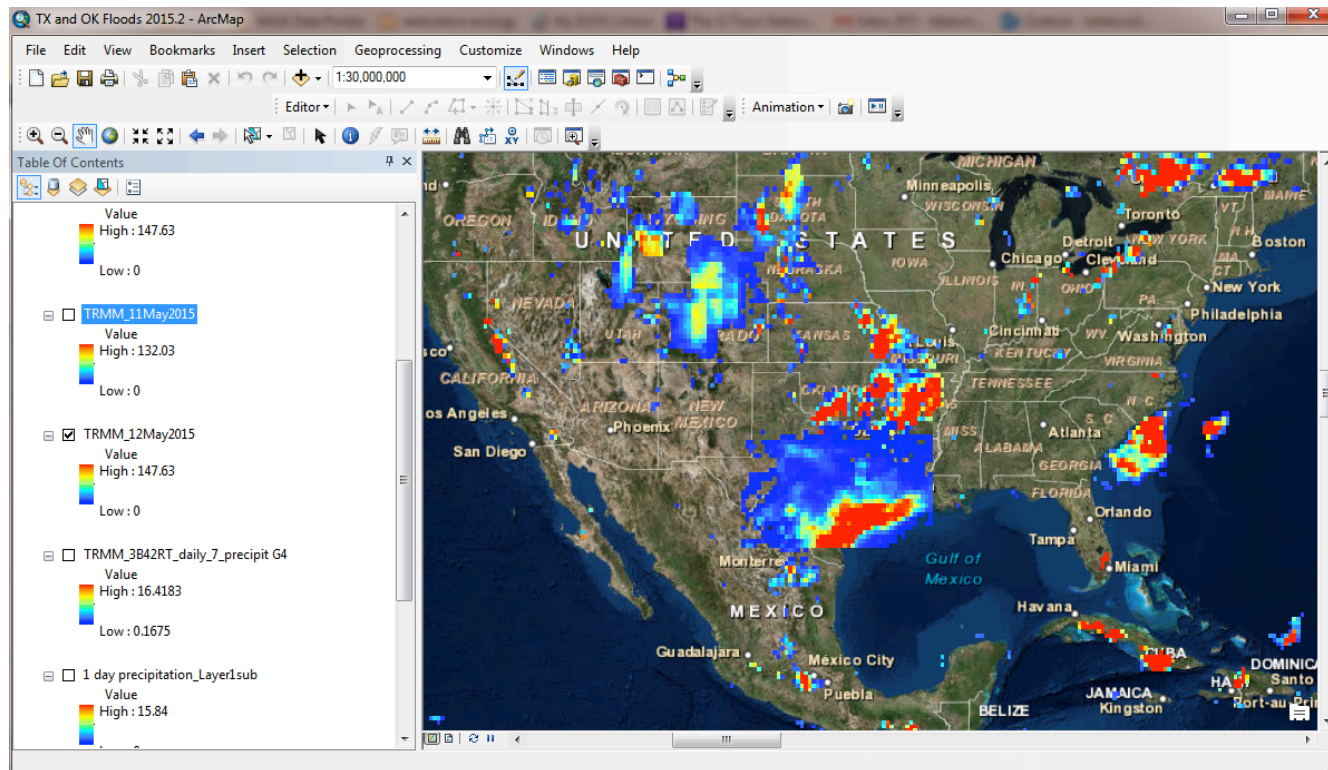
# Import into GIS (ArcMAP): Precipitation



For the input field, **Input netCDF File**: Navigate to and click on the previously downloaded GPM precipitation file. The remaining fields will fill in accordingly, KEEP the default values. You may change the output file name if you choose. Click OK.



# Import into GIS (ArcMAP): Precipitation



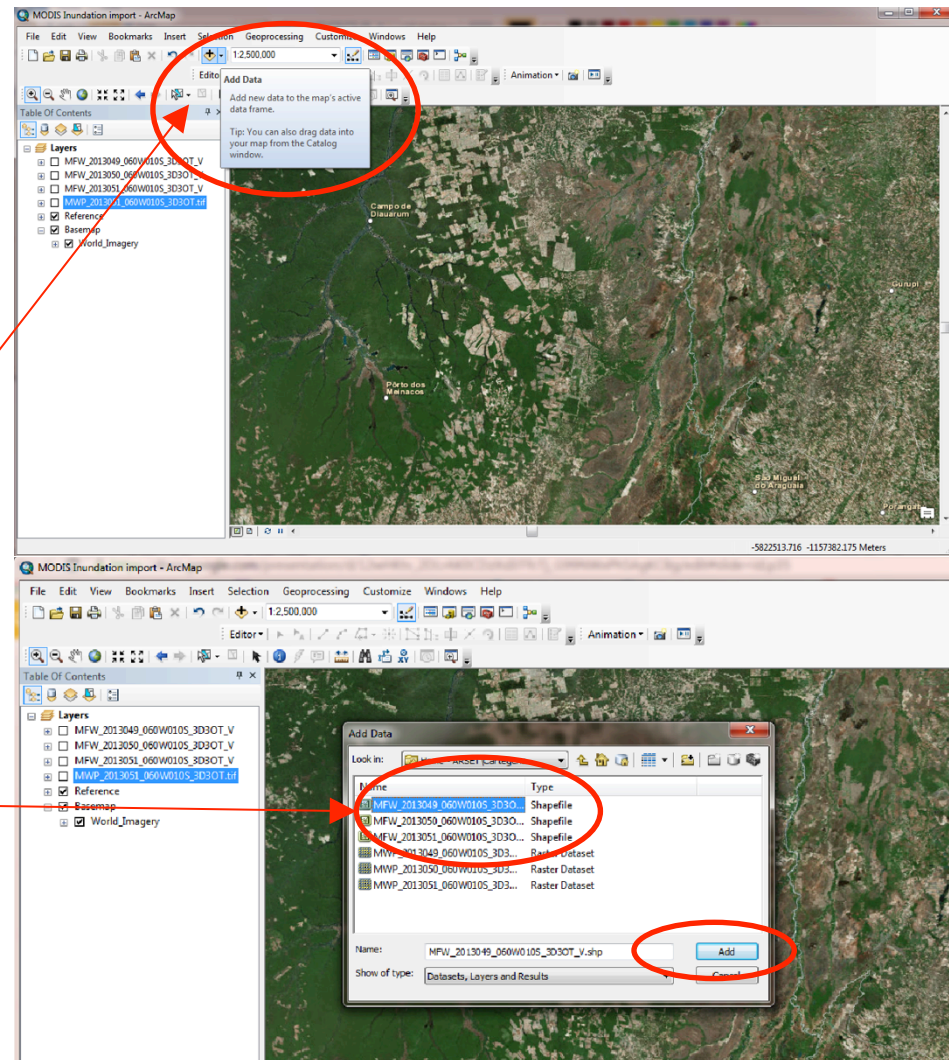
The result will be in raster format in ArcMAP. Raster files are ideal for spatial analysis tools

# Display MODIS Inundation in ArcMap

MFW shapefiles and MWP geotiff files can be easily imported into ArcMap.

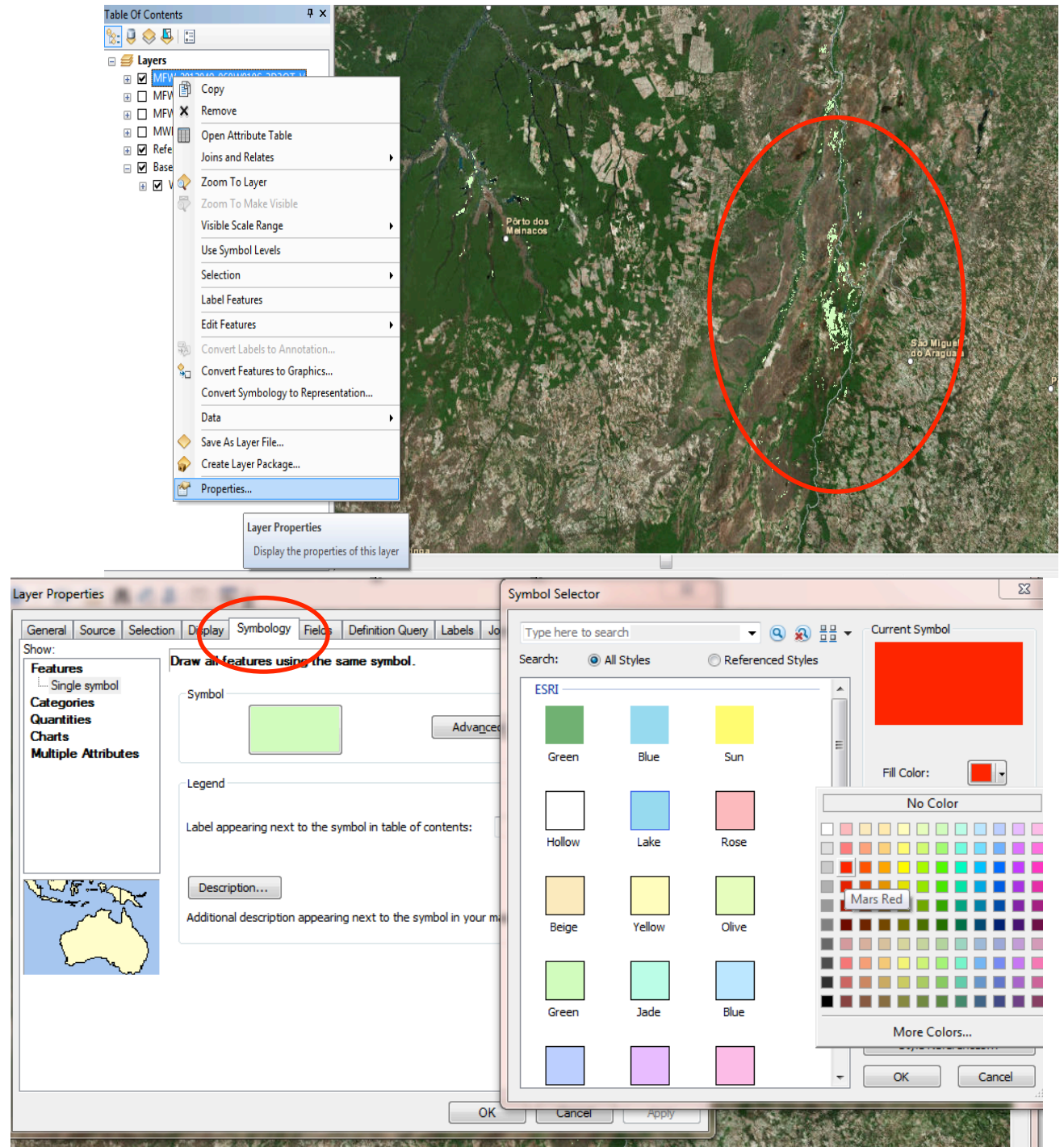
Open the Add data icon and click Add Data

Select the MFW (MODIS Flood Water) shapefile or the MWP geotiff file and click Add.



The shapefiles have been imported. You may wish to adjust the symbology color in order to visualize the inundated lands better.

Right click the layer, navigate to layer properties, Symbology tab, click the symbol color and choose the desired color. Click ok.



MWP: MODIS Water Product  
(geotiff file) layers  
pixel designations

0 = Insufficient data to make  
water determination (cloudy,  
missing images, swath gaps  
swaths, or bad data values)

1 = No water detected

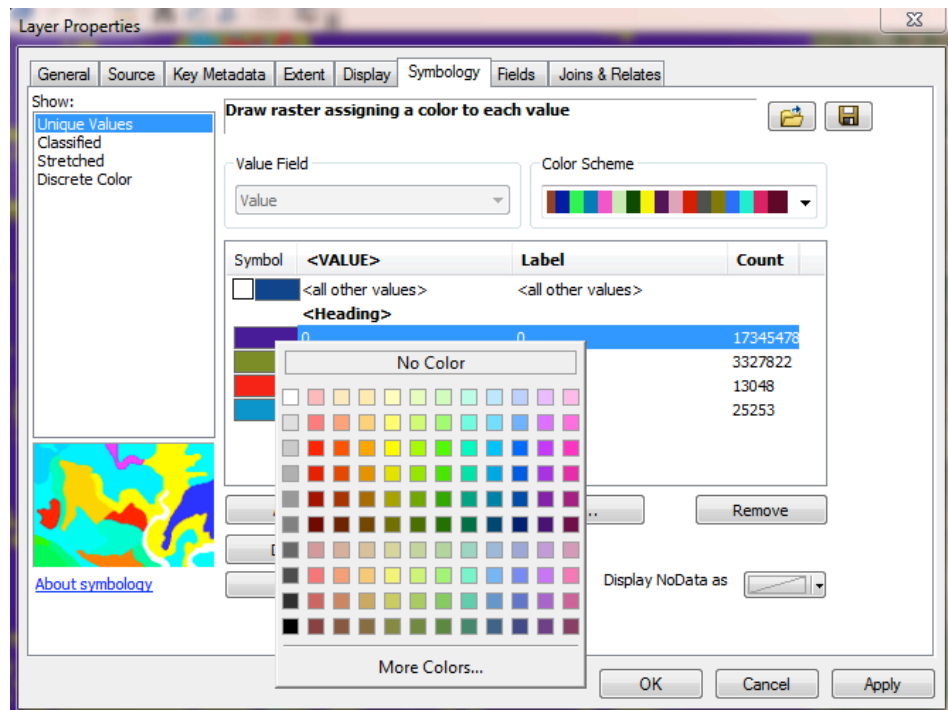
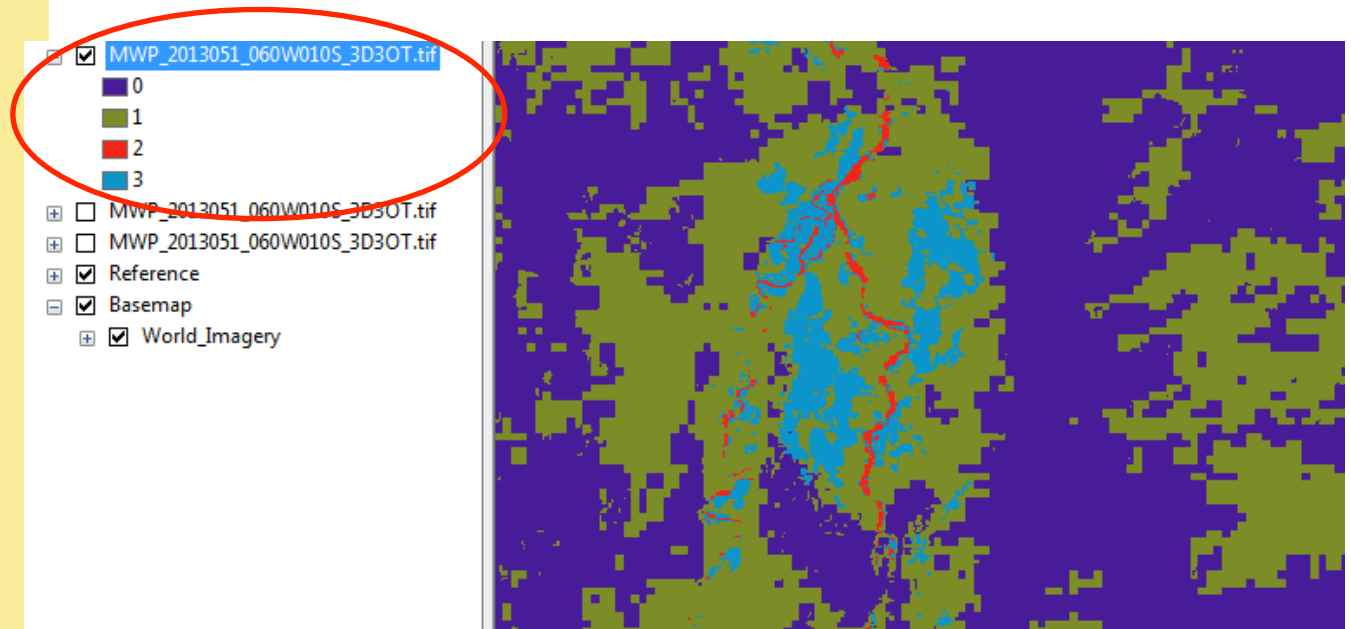
2 = Water detected AND  
coinciding with reference water  
(e.g., not flood)

3 = Water detected, beyond  
reference water, so is likely flood

You can adjust the symbology of  
the geotiff file through through  
the layer properties, symbology  
tab. Within the Show window,  
choose Unique Values and alter  
the colors assigned to each pixel  
category.

For example :

0=No color  
1=No color  
2=Blue  
3=Red

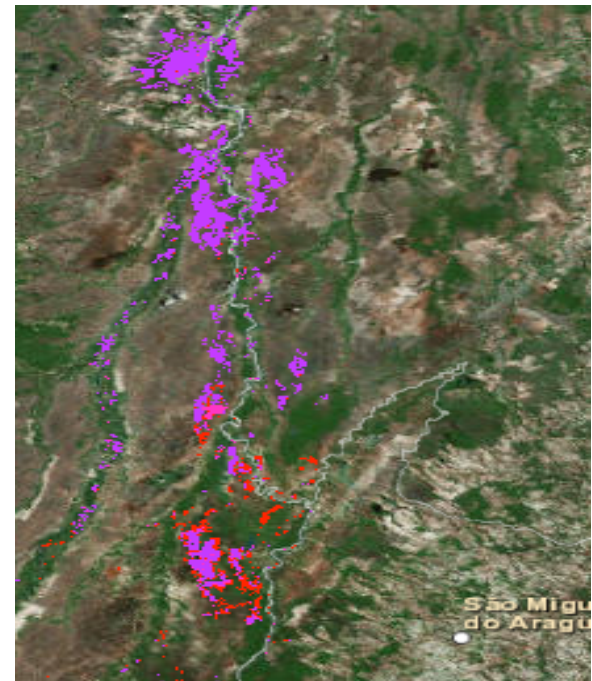
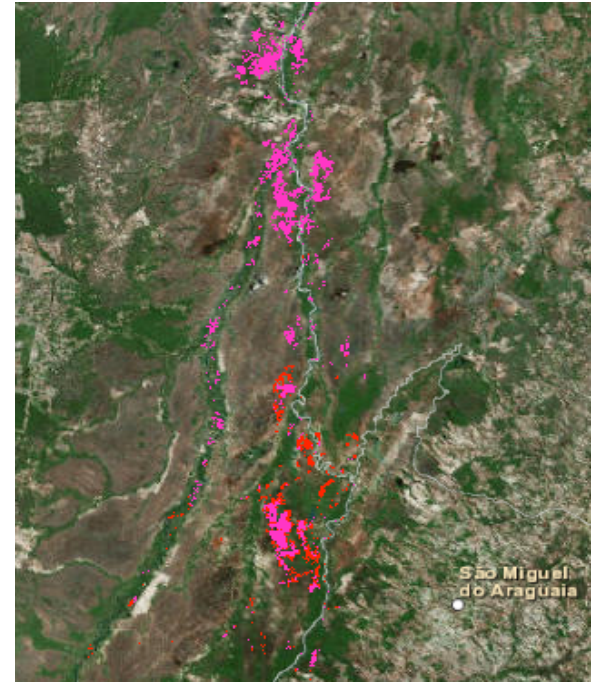






Repeat the process for all files for your chosen dates

Assigning different colors for each of the following dates can assist in visualizing inundated lands over time.



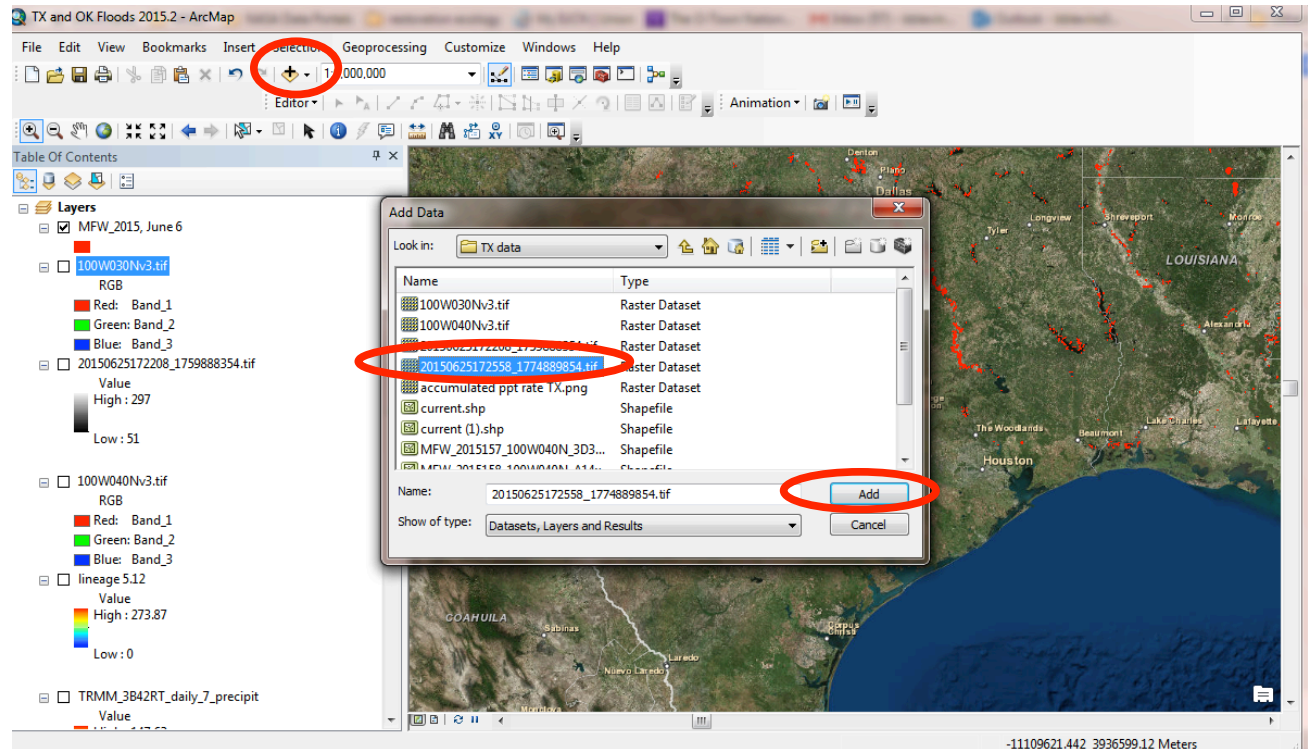
# Import into GIS (ArcMAP): SRTM terrain data



SRTM geotiff files can be easily imported into ArcMap.

Open the Add data icon and click Add Data

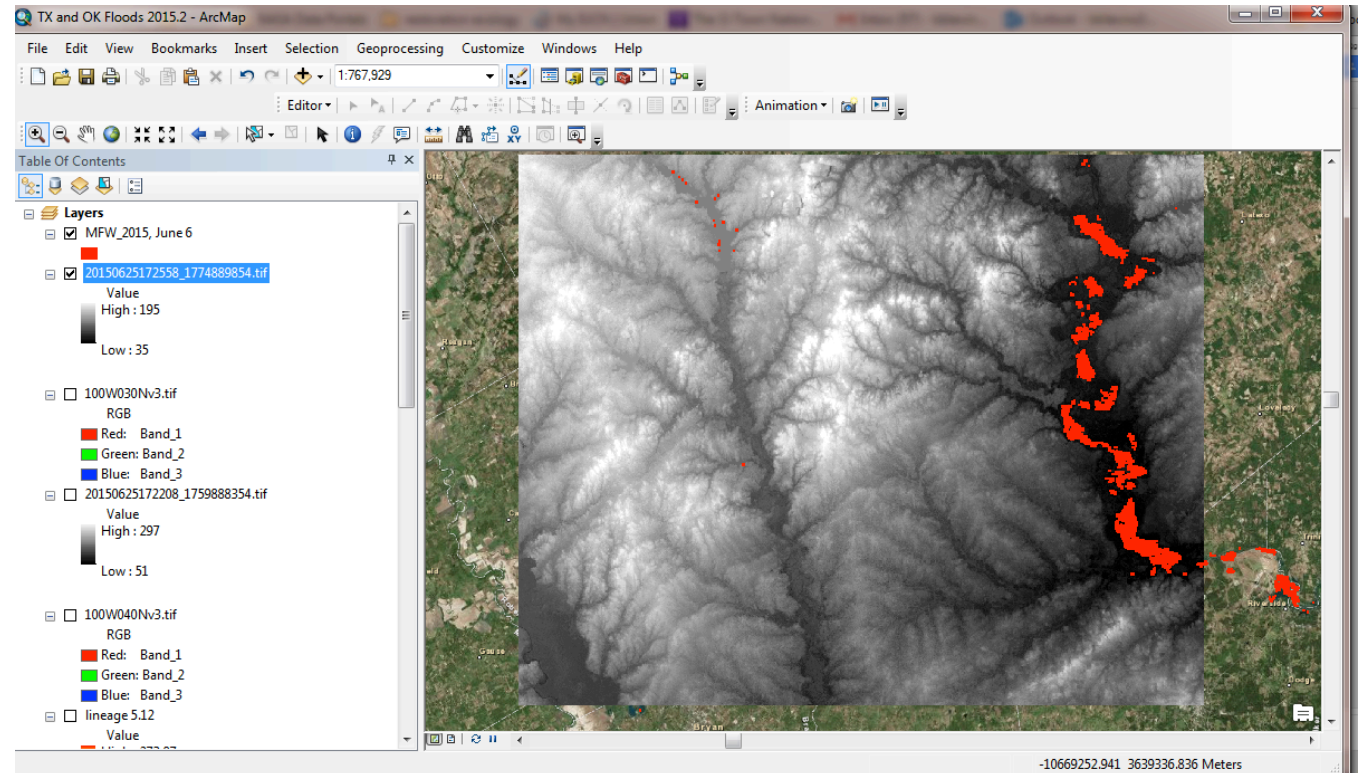
Select the SRTM data and click ADD



# Import into GIS (ArcMAP): SRTM terrain data



Repeat for all terrain data needed in your region.



This data can be used in the response, recovery, and mitigation phases to:

- assess areas at risk
- establish evacuation routes and direct aid
- construct flood risk maps
- input into models

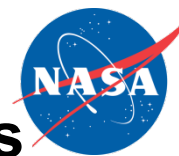


## Common GIS Data Layers

Rivers/Basins	USGS HydroSHEDS	<a href="http://hydrosheds.cr.usgs.gov/">http://hydrosheds.cr.usgs.gov/</a>
Population	NASA Socioeconomic Data and Applications Center (SEDAC)	<a href="http://sedac.ciesin.columbia.edu/">http://sedac.ciesin.columbia.edu/</a>
Elevation	GDEx NASA LP DAAC Consortium for Spatial Information (CGIAR-CSI)	<a href="http://gdex.cr.usgs.gov/gdex/">http://gdex.cr.usgs.gov/gdex/</a> <a href="https://lpdaac.usgs.gov">https://lpdaac.usgs.gov</a> <a href="http://srtm.csi.cgiar.org/">http://srtm.csi.cgiar.org/</a>
Reservoirs	NASA Socioeconomic Data and Applications Center (SEDAC)	<a href="http://sedac.ciesin.columbia.edu/">http://sedac.ciesin.columbia.edu/</a>
Soil Type	ISRIC - World Soil Information	<a href="http://www.isric.org/">http://www.isric.org/</a>
Dams	NASA Socioeconomic Data and Applications Center (SEDAC)	<a href="http://sedac.ciesin.columbia.edu/">http://sedac.ciesin.columbia.edu/</a>



# Course Summary



# Flood Tools Using TRMM and Hydrologic Models

Most of these tools have interactive, near-real time flood mapping capability with flood potential and/or streamflow/run-off

Flood Tool	Satellite/ Instrument Or Model	Quantities Used as Inputs	Hydrological Model
NASA- TRMM	TRMM/ TMPA-RT	Rain Rate	NRC-CN <sup>1</sup>
ERDS	TRMM/ TMPA-RT	Rain rate	-----
GFMS	TRMM/ TMPA-RT  MERRA	Rain Rate  Surface Temperature Winds	VIC- UMD DRTR <sup>2</sup>

<sup>1</sup>Natural Resources Conservation Service (NRCS) runoff curve number (CN) method

<sup>2</sup>The University of Washington Variable Infiltration Capacity (VIC) land surface model coupled with the University of Maryland Dominant River Tracing Routing (DRTR) model

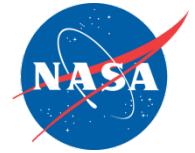
# MODIS-based Flood Inundation Mapping Tools



These tools have interactive, near-real time inundation mapping capability

Flood Tool	Satellite/ (Instrument	Quantity Used
MODIS NRT	Terra and Aqua/ MODIS	Reflectance Bands 1, 2, 7
DFO	Terra and Aqua / MODIS	Reflectance Bands 1, 2, 7

# Summary



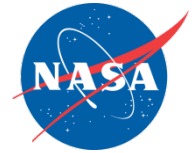
## Flood Monitoring Output

Flood Tool	Rainfall (Used as Input)	Flood potential/ Intensity	River Discharge/ Streamflow	Inundation Map
NASA- TRMM ERDS	X	X		
GFMS	X	X	X	
MODIS/NRT				X
DFO			X (Experimental limited number of river basins)	X

- MODIS provides surface inundation only, can not view the surface in the presence of clouds, mountain and cloud shadows may get interpreted as water
- TRMM Rain (**GPM will replace TRMM product in the near future**), used along with hydrologic model and other weather and surface data provide quantitative river streamflow and runoff information but regional calibration and validation are recommended with regional stream gauge data



# Summary



## More About the Flood Tools

Flood Monitoring Tool	Spatial Coverage and Resolution	Comment
NASA-TRMM NRT	50°S-50°N 12 Km	Includes GFMS, Landslide Potential, 24-hour Flood Forecast
GFMS	50°S-50°N 12 Km	Available also at 1Km resolution. Predictive capability will be added soon
MODIS NRT	Global 250 M	May not be effective in presence of clouds
DFO	Global 250 m and 10 km	Same as MODIS NRT.
DFO &GDACS/ GFDS Experimental		River discharge data derived from TMI (now GMI) and AMSR/ AMSR2*

\* AMSR : Advanced Microwave Scanning Radiometer flying on Aqua satellite (2002-2011) and AMSR2 is flying on Global Change Observation Mission (GCOM-W) satellite (May 2012 to present)

## Concluding Remarks

- ❑ NASA Applied Sciences Program offers 'research to application' opportunities through competitive grants/proposals program (<http://nspires.nasaprs.com/external/>)
- ❑ NASA DEVELOP program offers opportunities involving a team of professionals to partner up with organizations to develop methodologies, products, and research projects that focus on utilizing NASA Earth observations to address community concerns and public policy issues (<http://develop.larc.nasa.gov/>)

ARSET also provides advanced on-line and in-person trainings for Air Quality, Land, Water Resources and Disasters Management. If you are interested, you can request a training for your organization or region at <http://arset.gsfc.nasa.gov/training>

# Homework Assignment



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## Homework Assignment Link

English: <http://goo.gl/forms/TBDS77PE5o>

**Due by July 20, 2015**

# Certificate of Completion



**In order to obtain a certificate of participation for attending this training, follow this link and fill out the online form:**

**<http://goo.gl/forms/9eJU8F5AC6>**

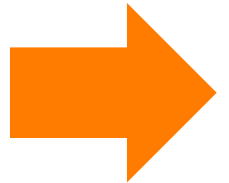
**You must have attended all weekly sessions and completed the assignment given in week 4 to be considered a full participant.**

# Course Survey



**To help us evaluate our trainings and determine future remote sensing training topics, please take a couple minutes now to fill out this short survey by clicking the link in the Q & A box to the right**

**We will pause to allow you to begin the survey.**

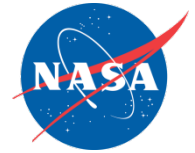


# ARSET ListServ



**For information on upcoming courses and program updates sign up to the listserv**

<https://lists.nasa.gov/mailman/listinfo/arset>



# Training Team

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- John Bolten (NASA): [john.bolten@nasa.gov](mailto:john.bolten@nasa.gov) (Week-4)

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Thank You!