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

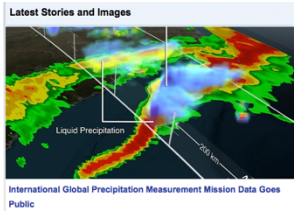
Applied Remote Sensing Training

Webinar Outline

Week 1

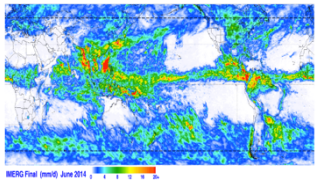
NASA Remote Sensing Data for Flood Management, Introduction to Flood Monitoring Tools

Week 2



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

Week 3



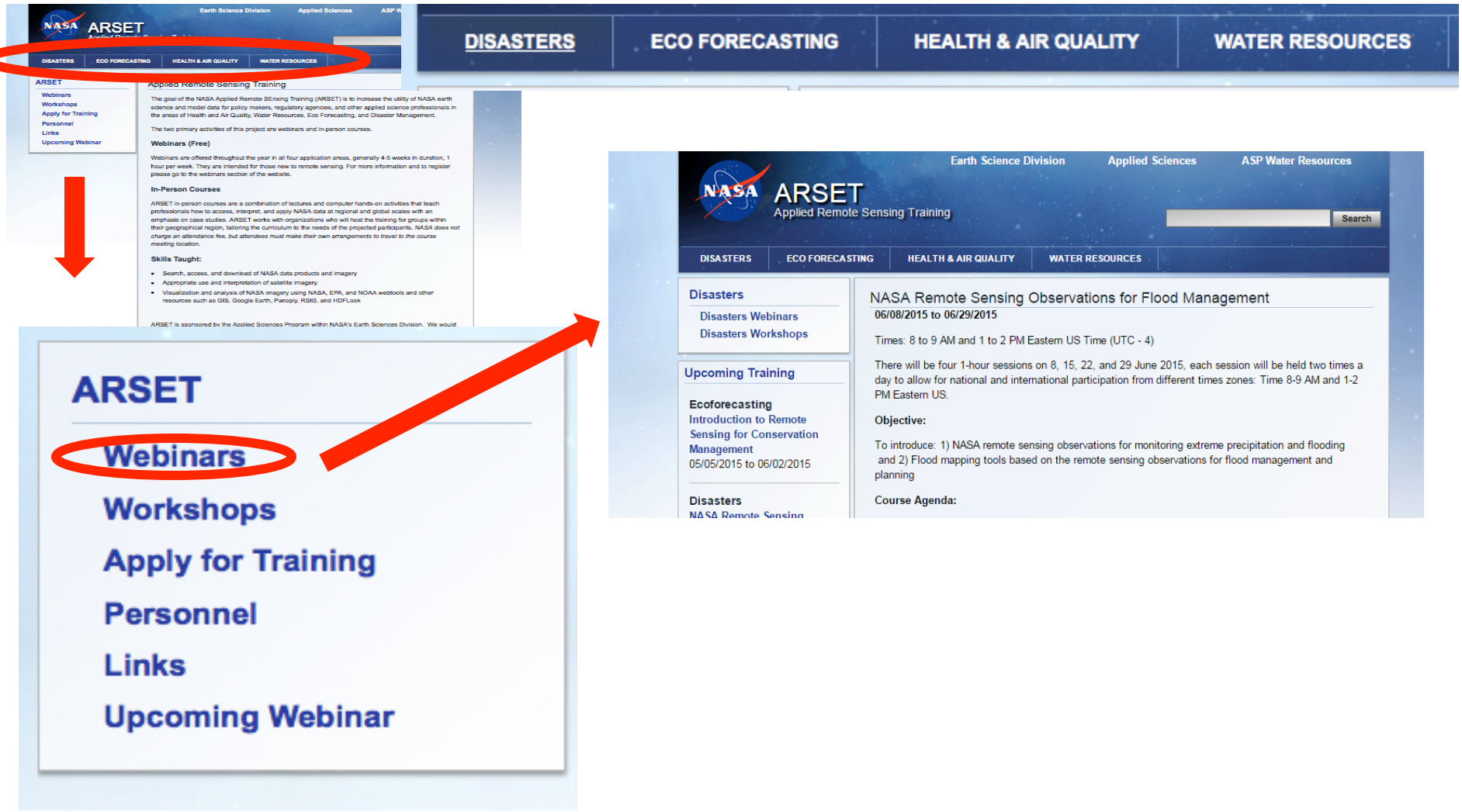
Regional Flood Management over Africa, Demonstration of the MODIS Inundation Mapping Tool and the Dartmouth Flood Observatory

Week 4

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

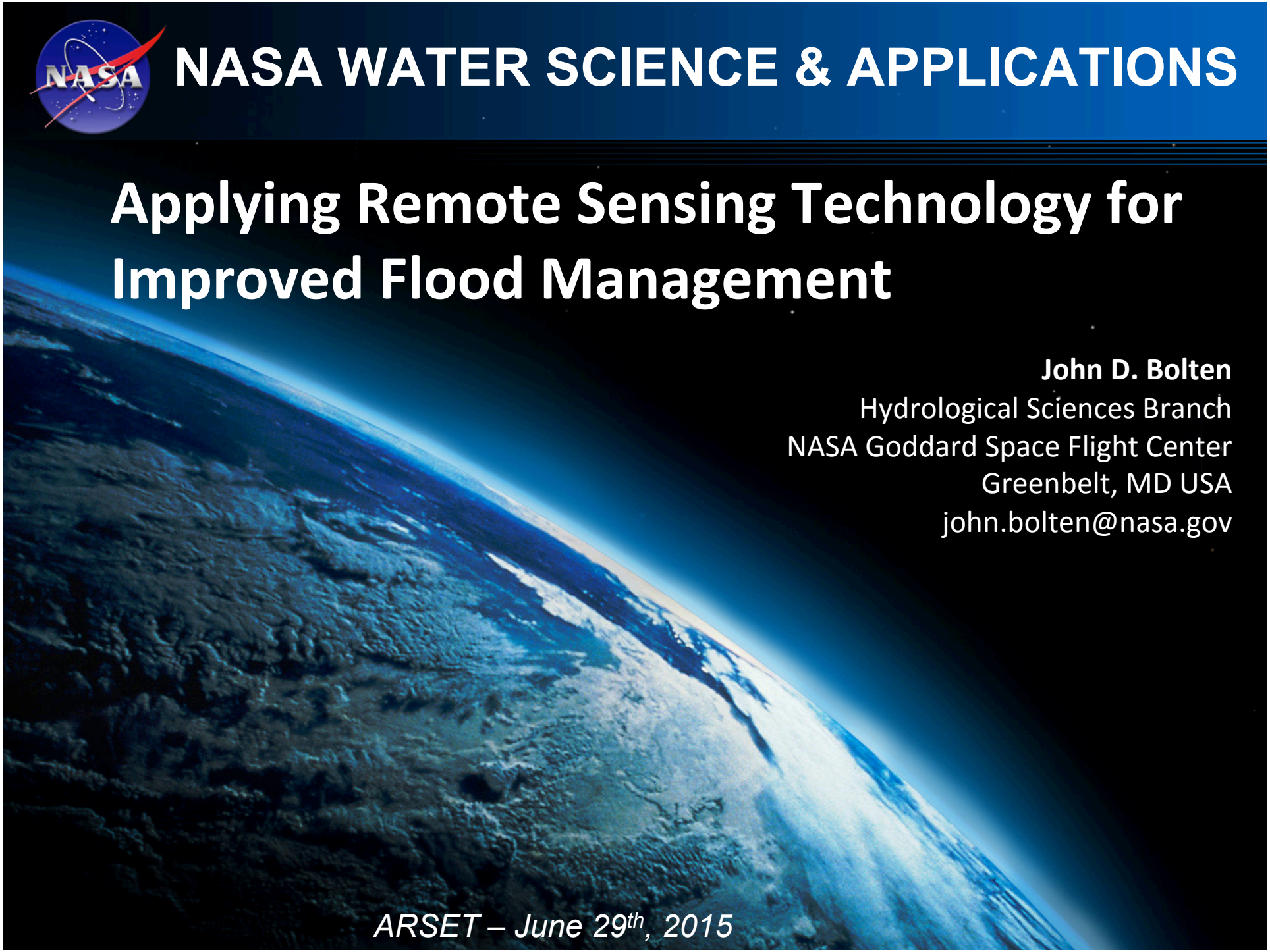
ARSET Webinars Website

http://arset.gsfc.nasa.gov



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

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NASA Goddard Space Flight Center
Greenbelt, MD USA
john.bolten@nasa.gov

ARSET – June 29th, 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?

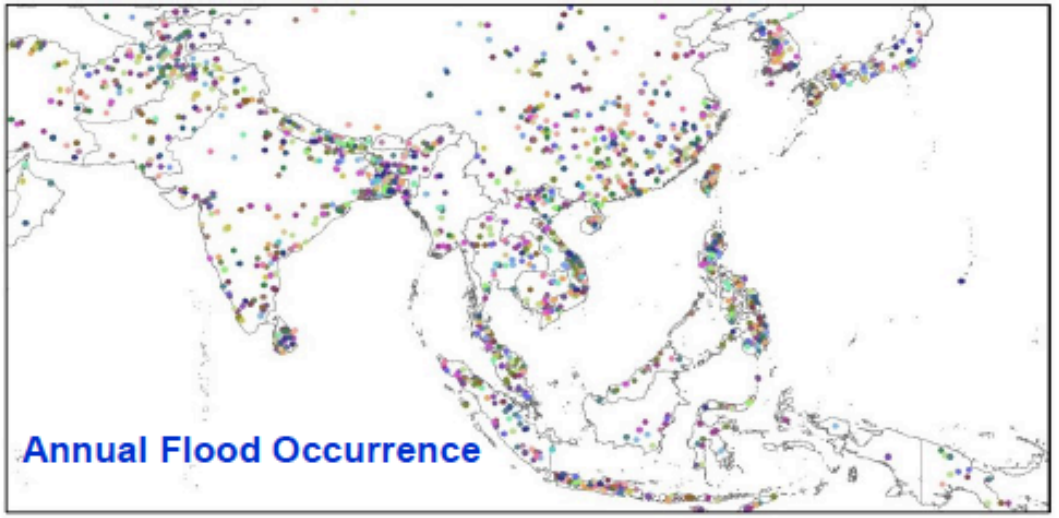
- Occur all over the world
- Both benefits and costs
- Losses increasing due to greater exposure and vulnerability with population and economic growth (IPCC)
- Global flood risk likely to increase in the future with climate change (IPCC)
    - Especially in South, Southeast, and Northeast Asia; tropical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

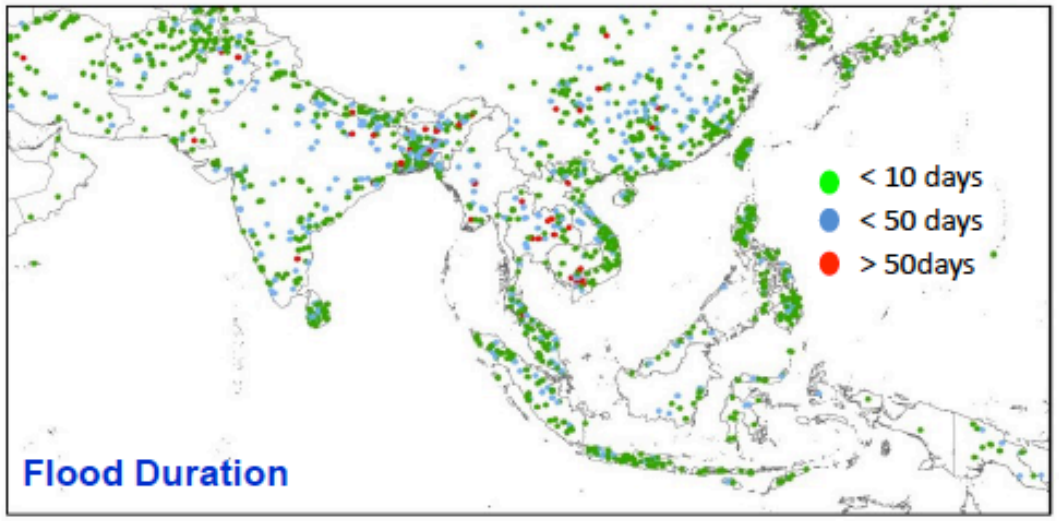
CATASTROPHIC FLOODS IN ASIA: 1900-2011

- 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?

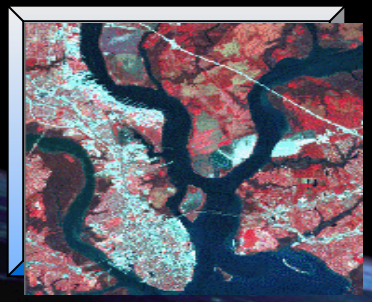
Benefits

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

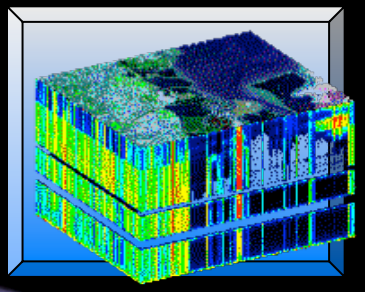
Costs

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

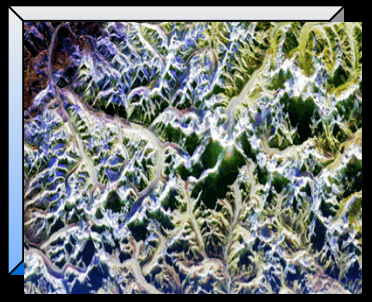
Remote Sensing Techniques



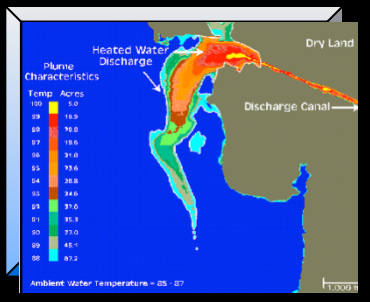
Multispectral



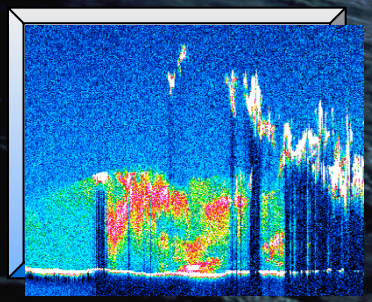
Hyperspectral



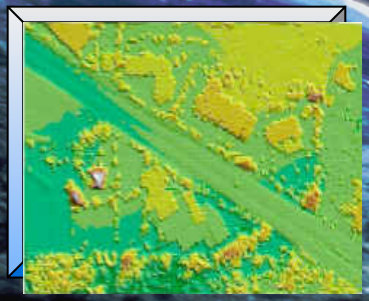
RADAR / SAR



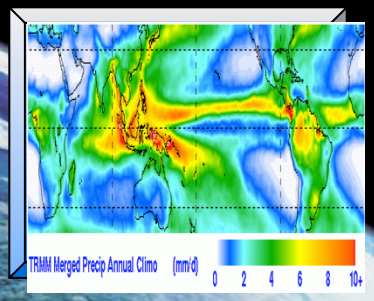
Thermal



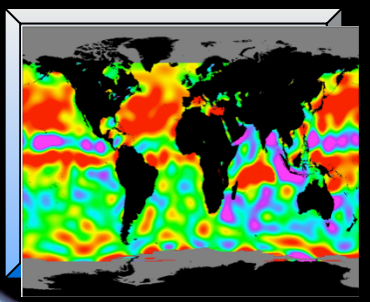
Atmospheric LIDAR



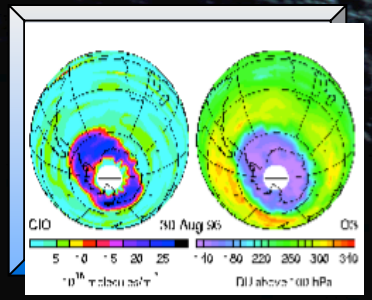
Surface LIDAR



Passive Microwave

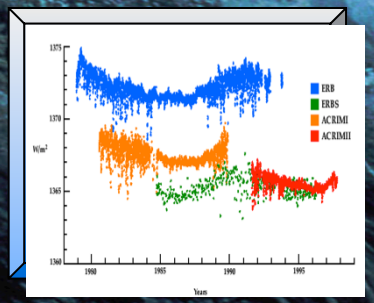


RADAR Altimetry

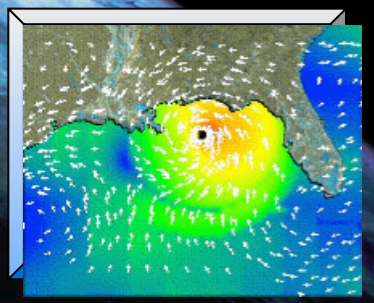


Limb Sounding

Microwave Ranging

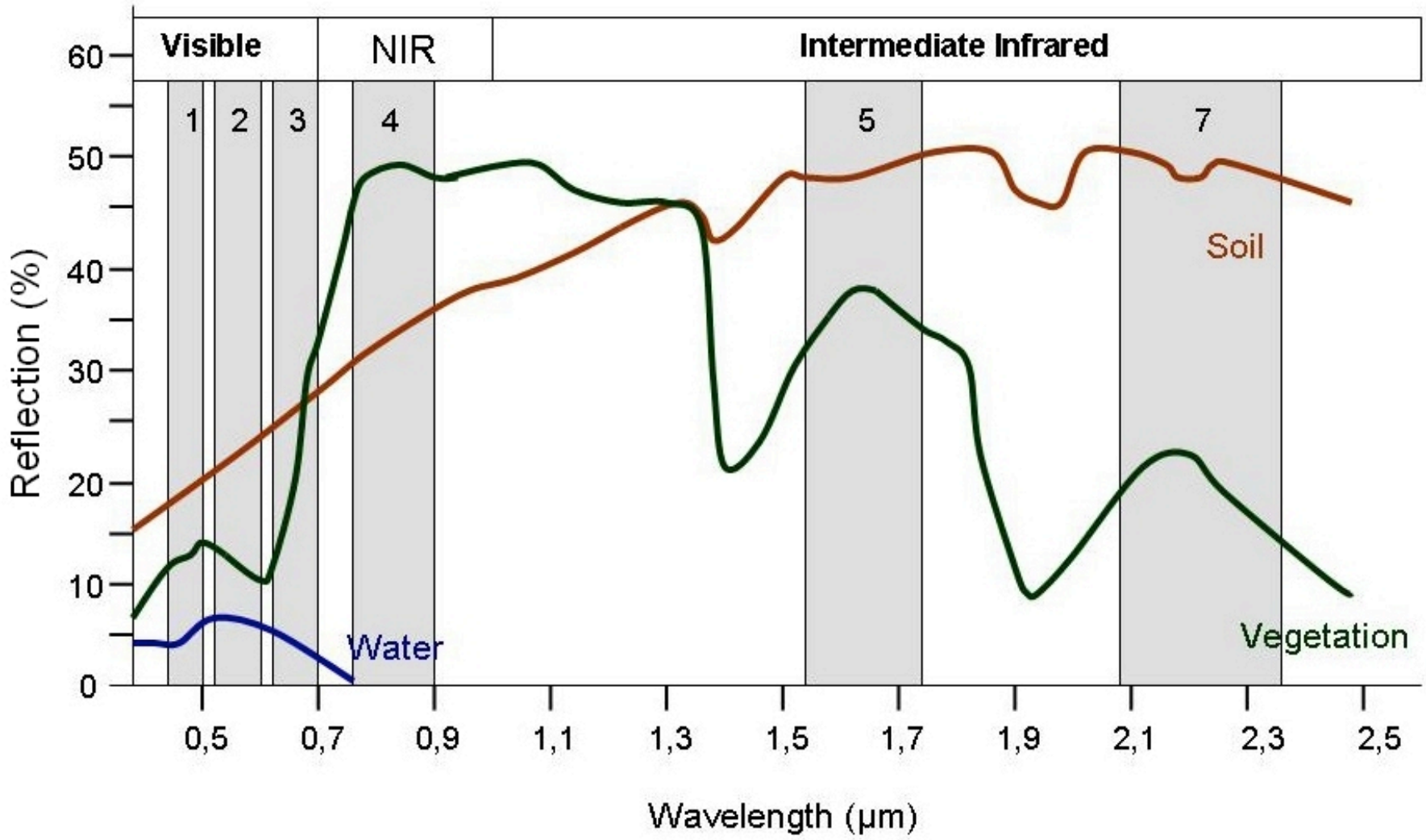


Irradiance/Photometry



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

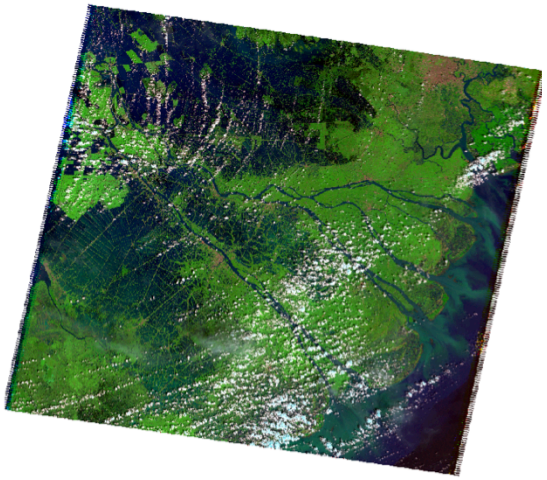
NEW DATA FORMS- Merging data sets of differing wave lengths, polarizations, etc

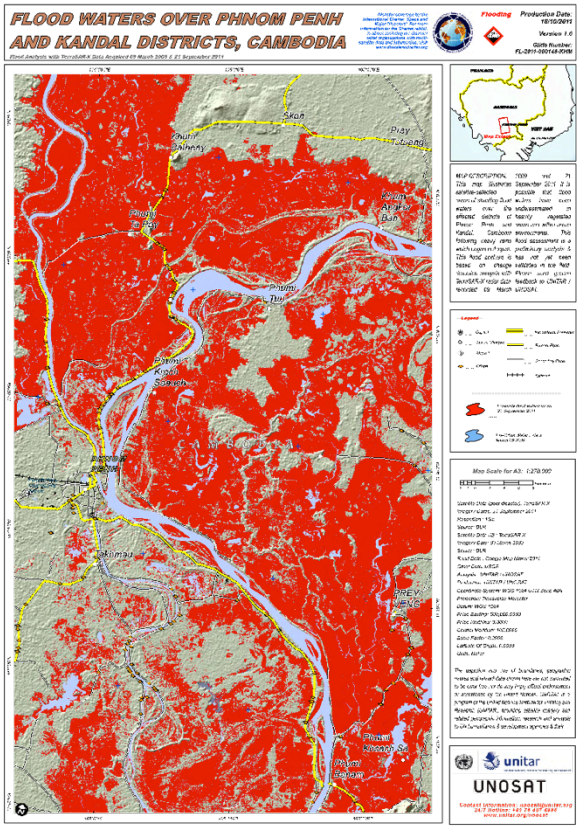
TEMPORAL DATA- Frequent measurements able develop a time series, regional climatologies

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

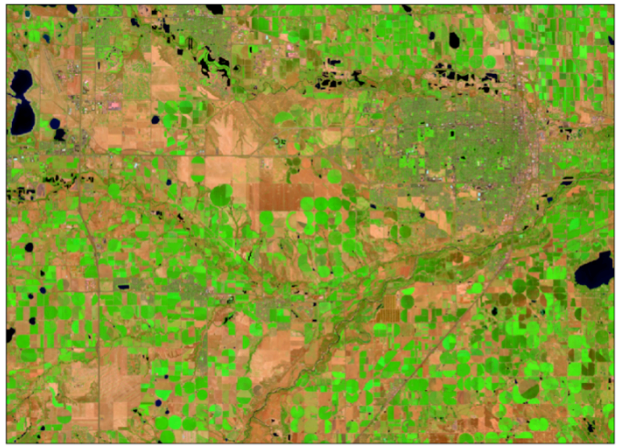
Classification of Multi-spectral Data

Classification Algorithms

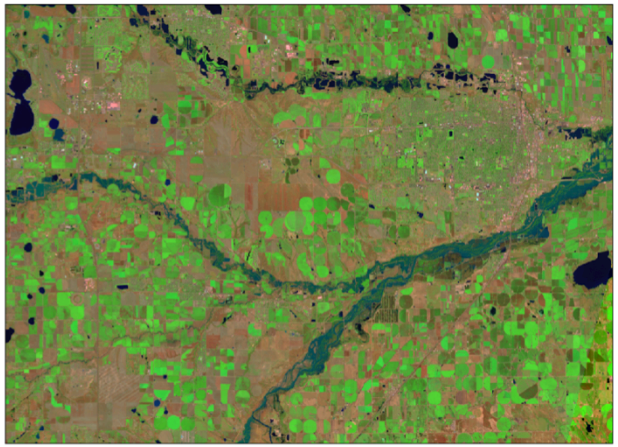
- Unsupervised
  - ISODATA
  - K-Means
- Supervised
  - Maximum likelihood (MLC)
  - Minimum-distance
  - Support Vector Machines (SVM)
  - Decision Tree

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



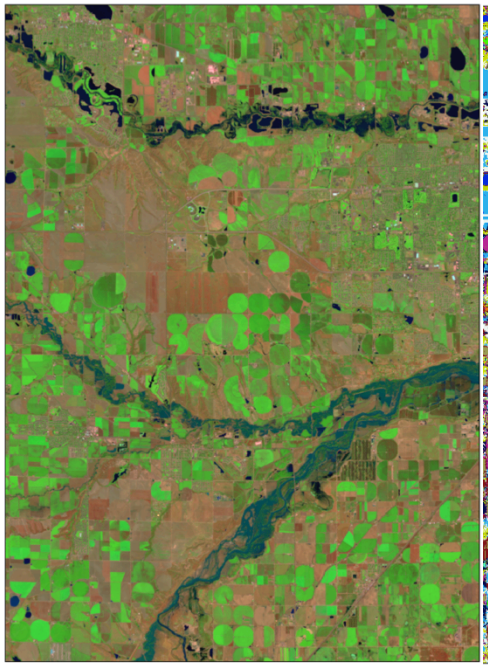
Landsat 8 (RGB 753): Colorado, 8/25/2013



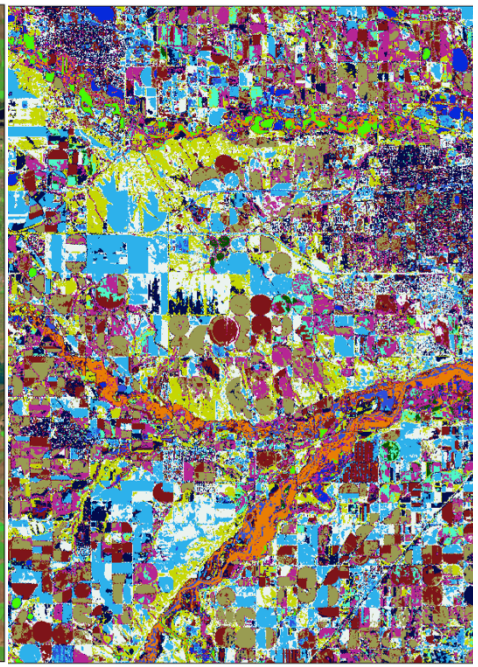
Landsat 8 (RGB 753): Colorado, 9/17/2013

Classification of Multi-spectral Data

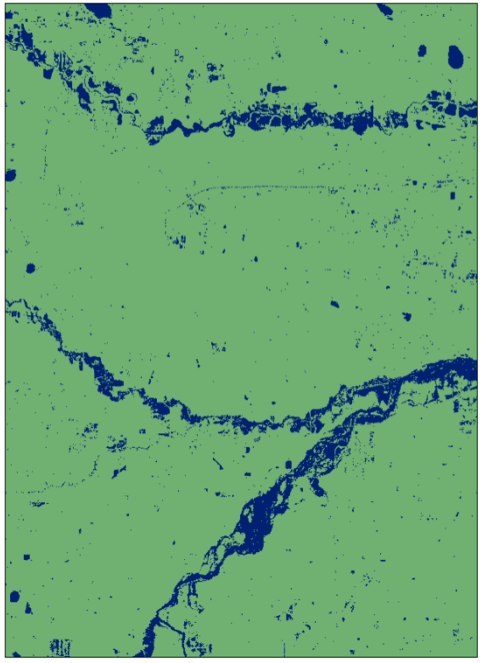
1. Download data (EarthExplorer, GloVis, etc.)
2. Load into software (ArcGIS, ENVI, ERDAS, scripting language, etc.)
3. Apply Classification
4. Combine water classes if necessary
5. Check for mis-classification (cloud shadows, etc.)
6. Compare to non-flooded scene to reveal flood water



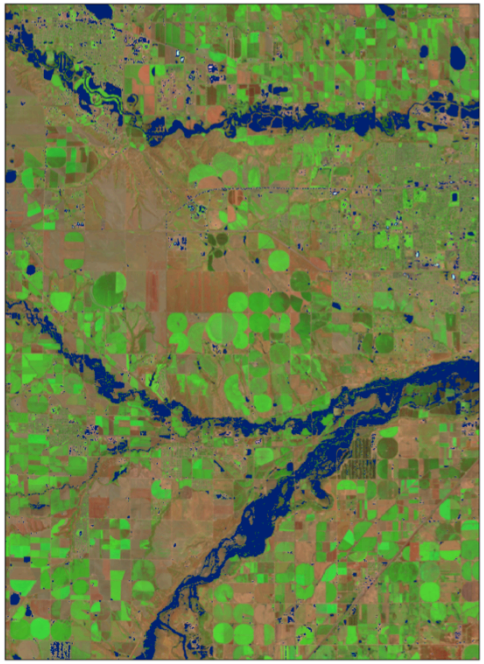
Landsat 8 (RGB 753)
9/17/2013



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

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

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

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

• • •

- 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.

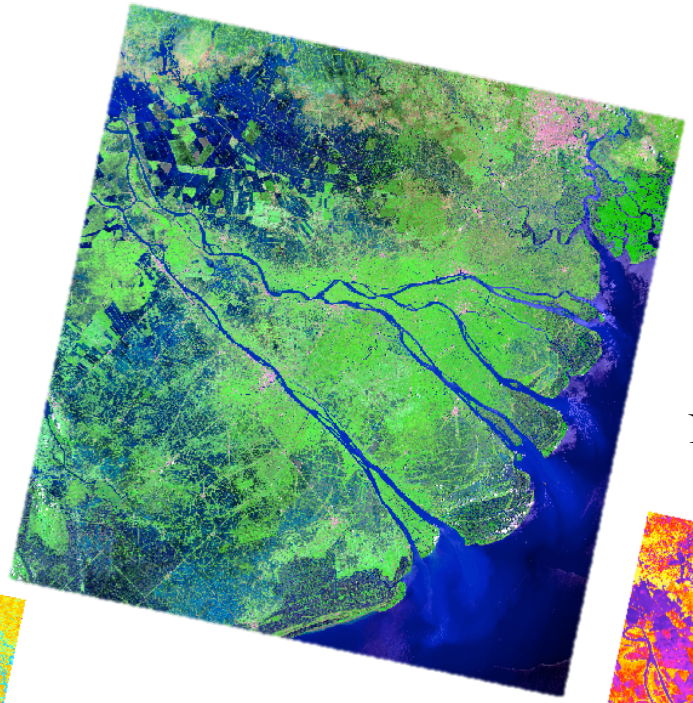
Table 1. List of spectral vegetation indices proposed for water detection.

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	$NDII = \frac{\rho_{858} - \rho_{1650}}{\rho_{858} + \rho_{1650}}$	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

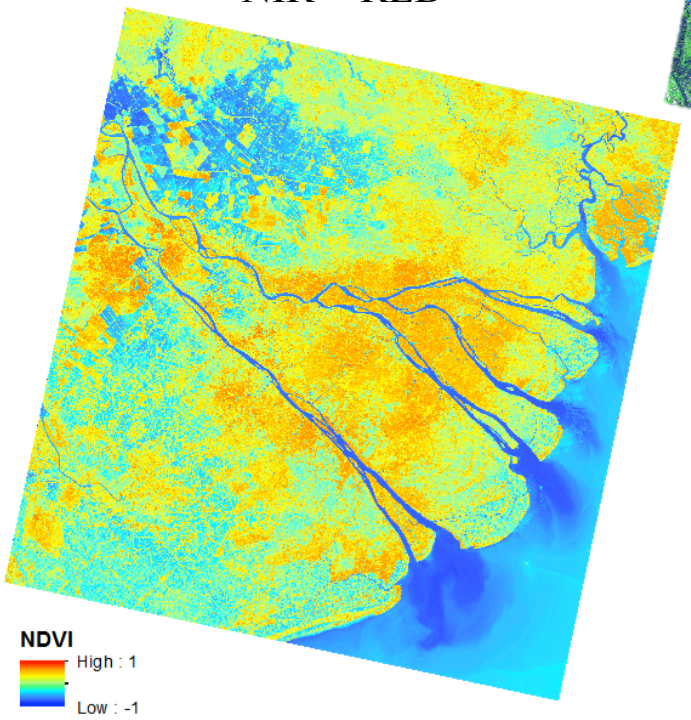
Examples of Spectral Indices

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



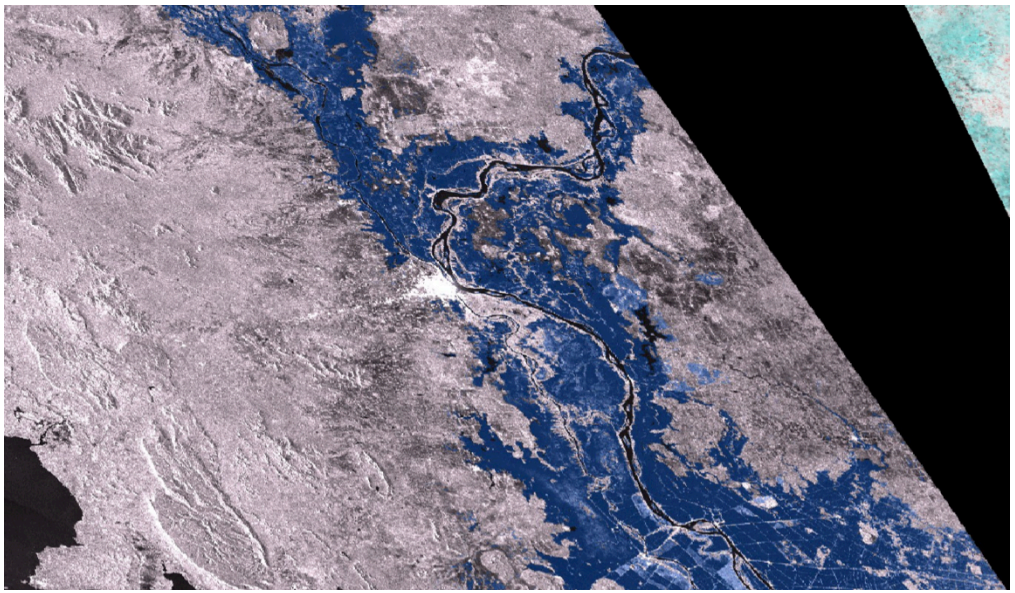
Landsat 8 OLI (RGB 753)
Vietnam Delta
September 18, 2014

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



Example of Radar Application

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

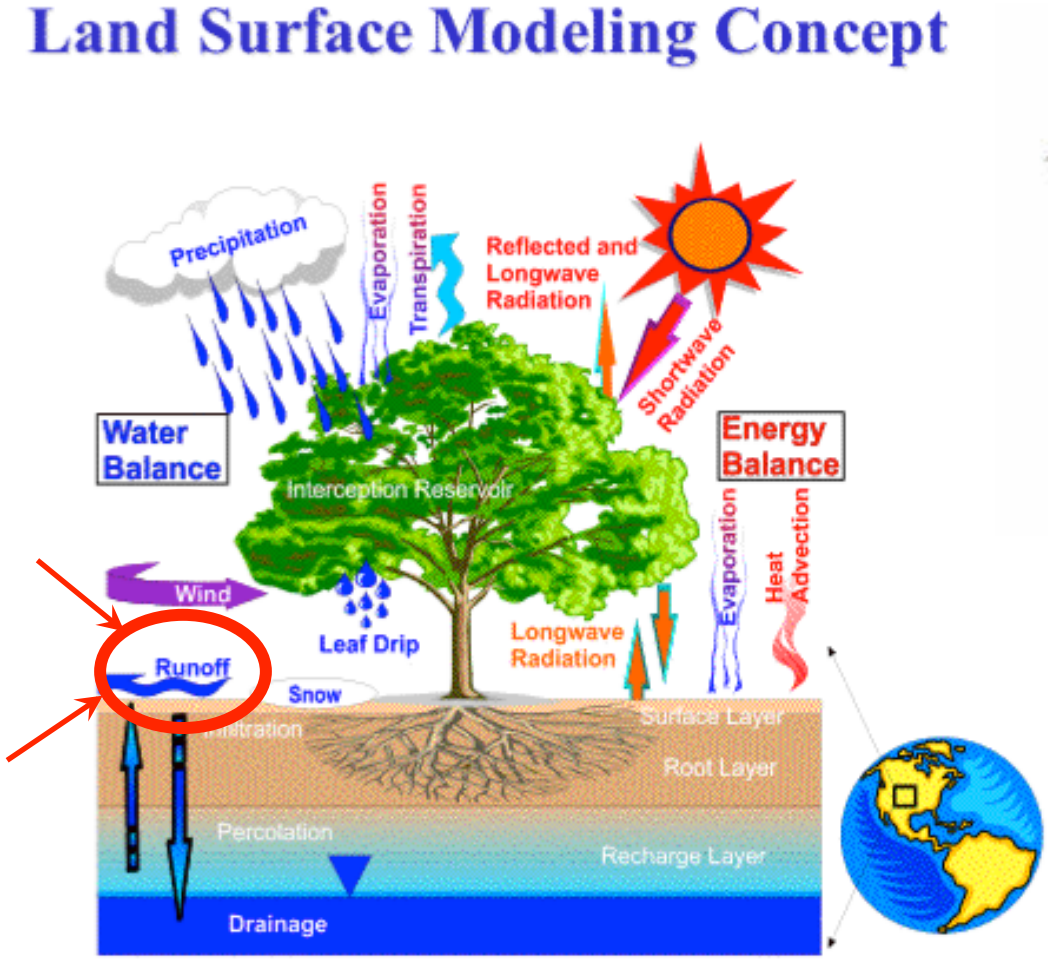


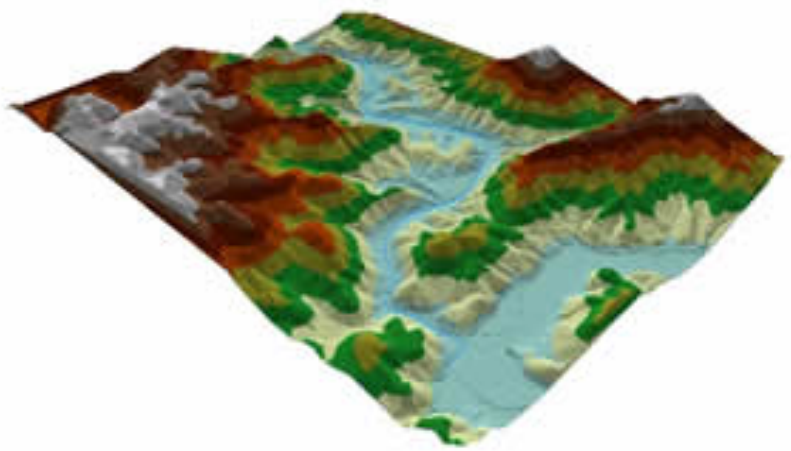
Flooding in the Mekong derived from change detection (August vs. March, 2006) of radar data

Techniques

- Thresholding
- Classification
- Change detection

Hydrological Modelling

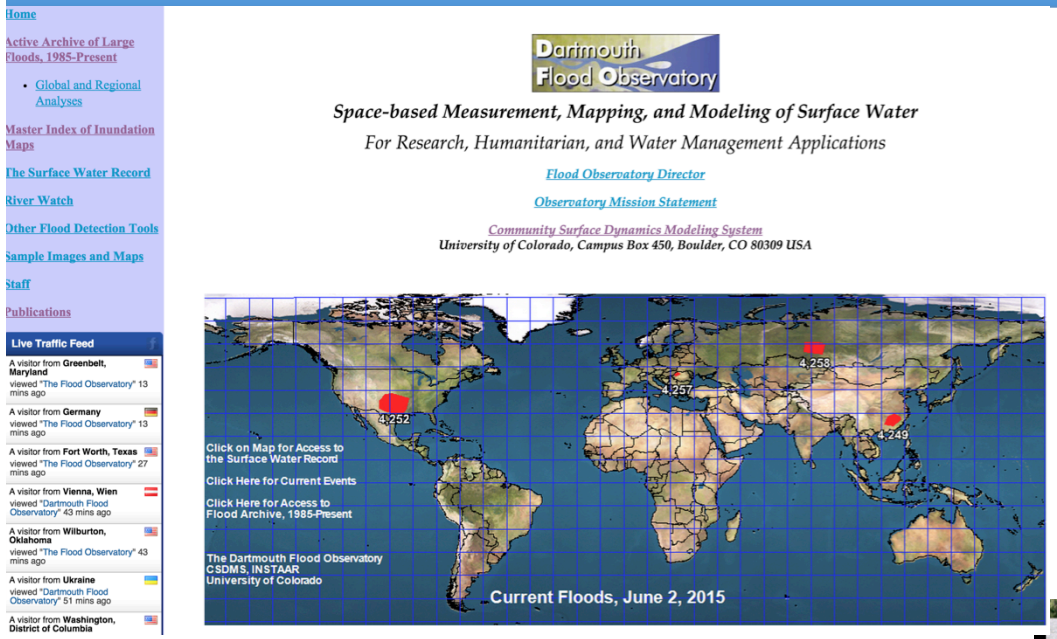


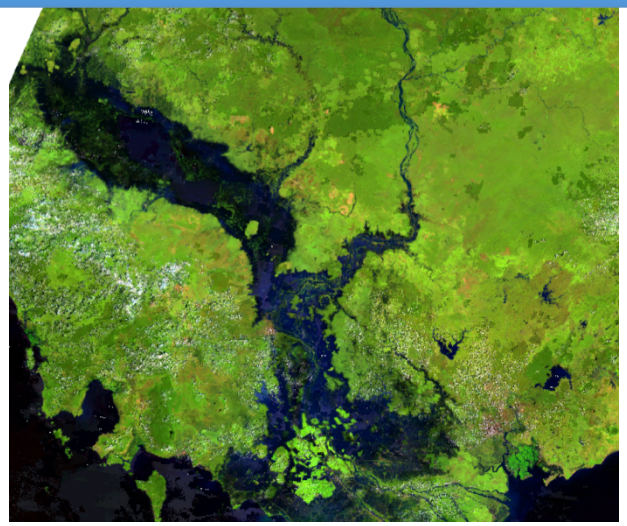


Calculate **runoff**, feed into routing model with DEM to estimate inundation extent and depth

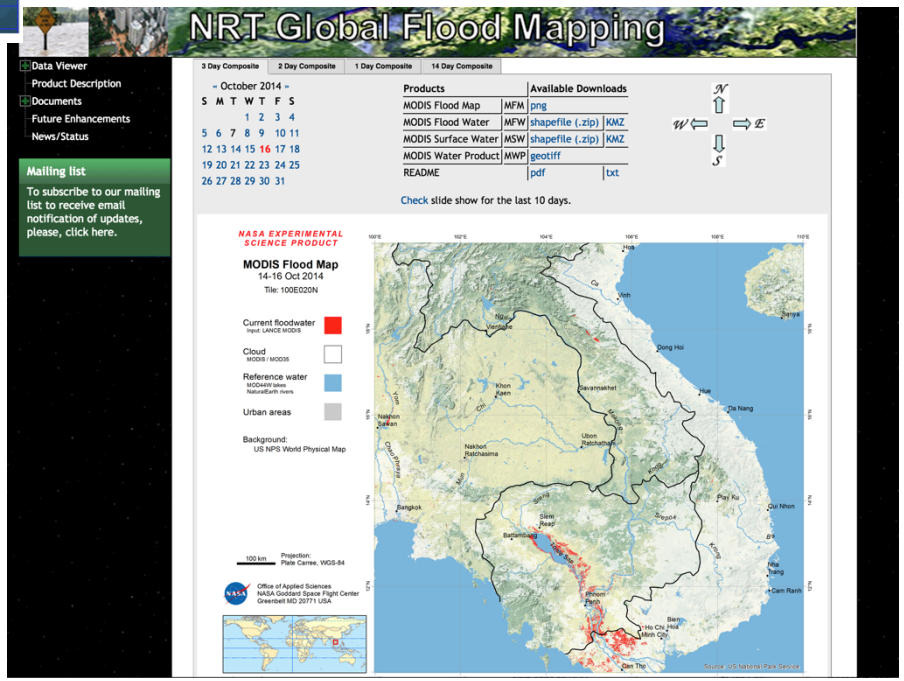
Near Real-time Global Flood Mapping Project

Dartmouth Flood Observatory and GSFC





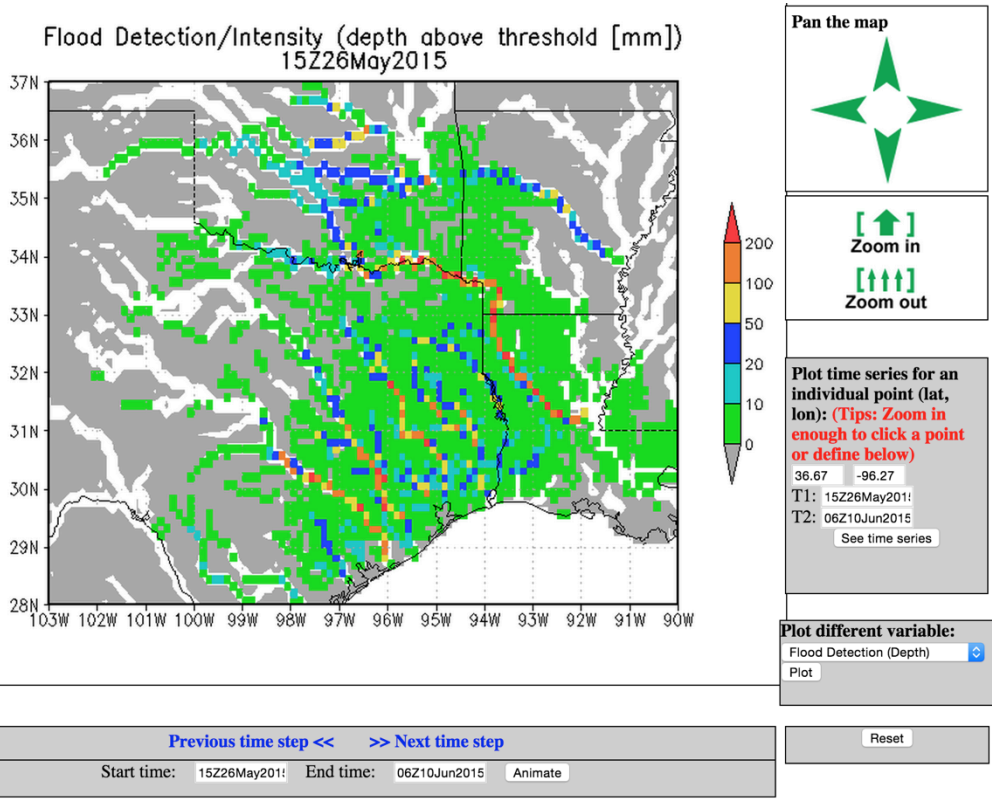
Terra MODIS false color (above)



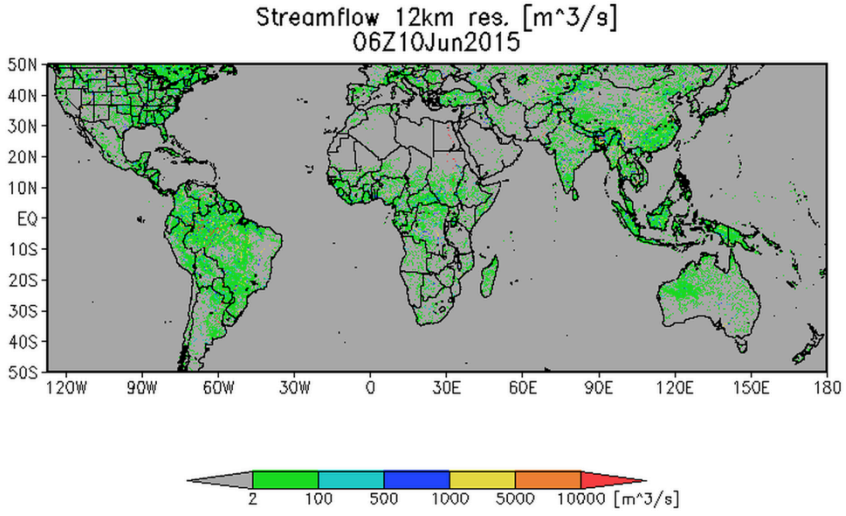
- Dartmouth Flood Observatory algorithm
- MODIS 250 m band ratios
- Updated daily (2 day, 3 day, 14 day)
- Detects surface water

Global Flood Monitoring System
University of Maryland

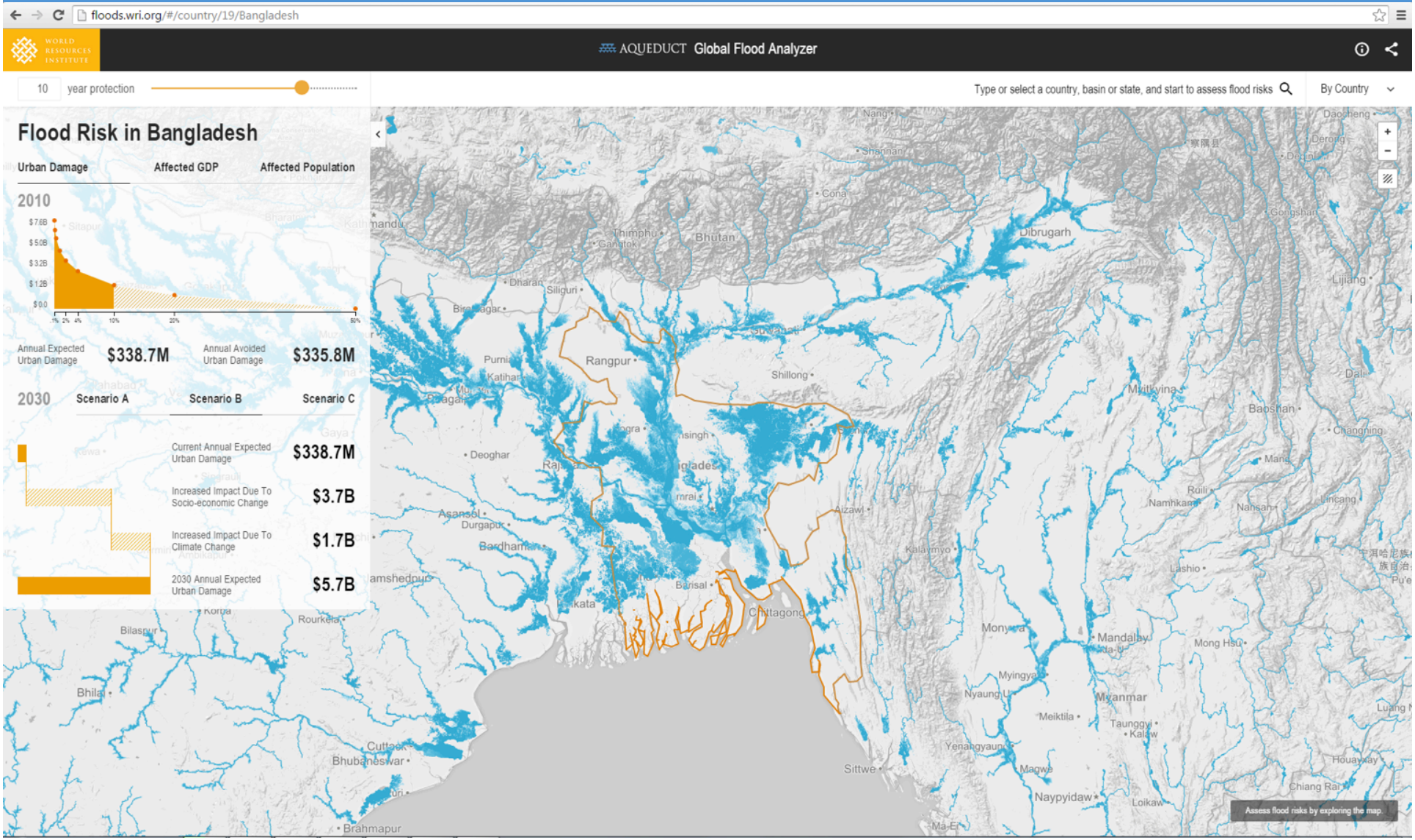
- Based on TRMM Multi-satellite Precipitation Analysis and hydrological model
- 1 km resolution
- Updates every 3 hours
- Estimates inundation depth



Texas Flooding: May 26, 2015



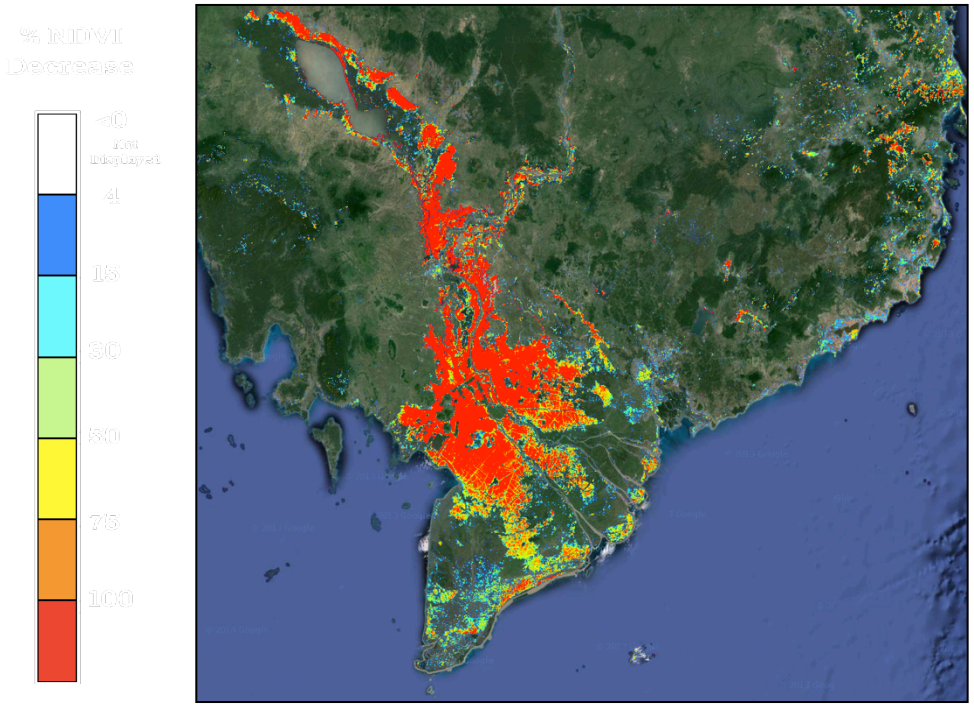
World Resources Institute – Global Flood Analyzer

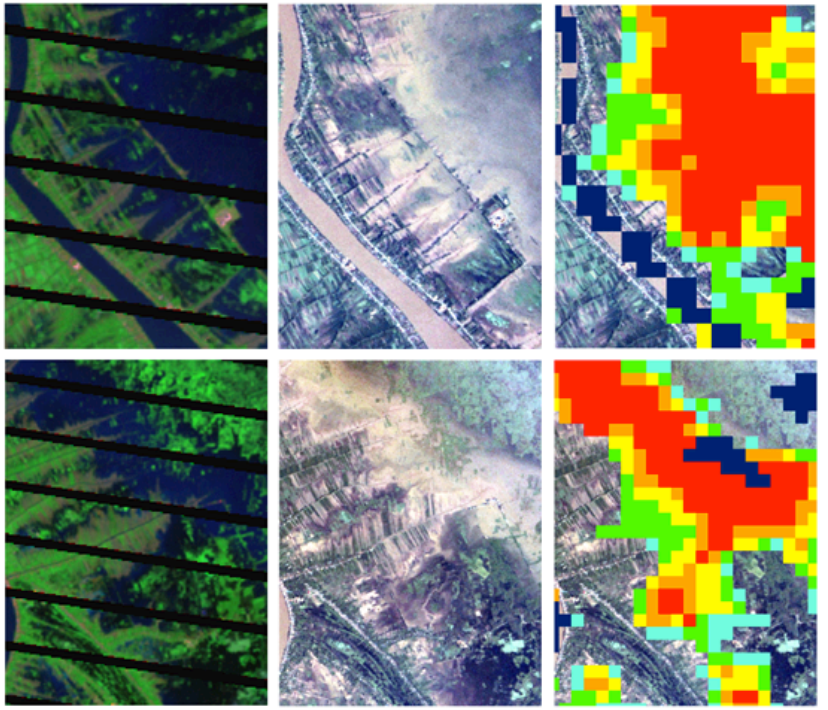


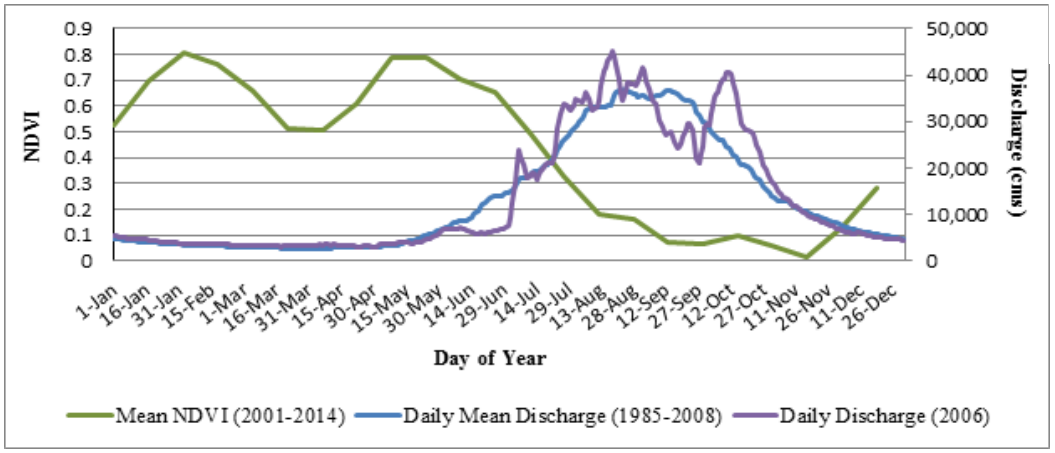
World Resource Institute provides the Global Flood Analyzer to assess potential damage of various magnitudes of floods world-wide. Based on historical precipitation and land-surface models

Southeast Asia MODIS Near Real-time Flood Impact

GSFC



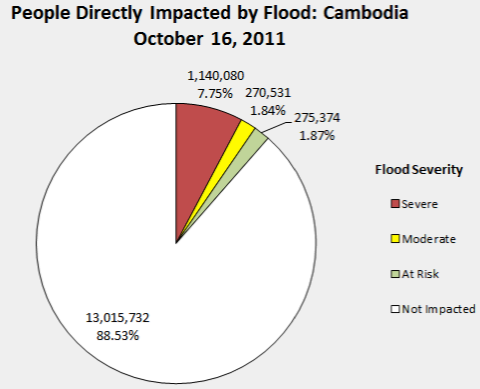


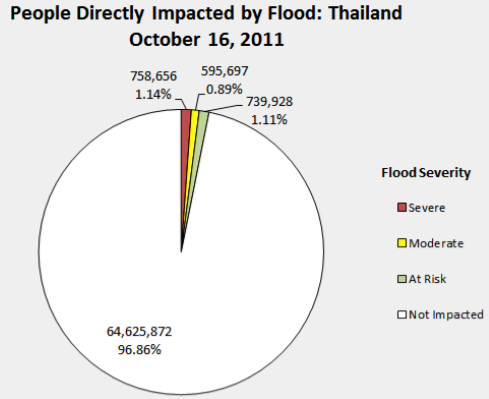


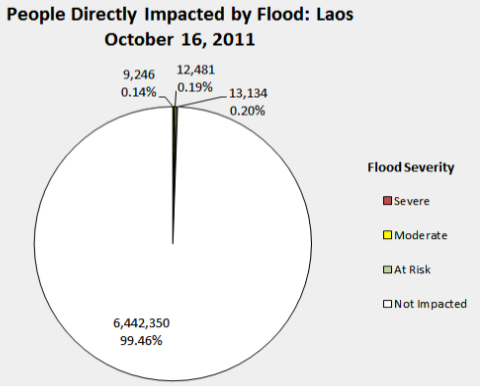
- Detects relative anomalies in NDVI from MODIS 250-m data with threshold on SWIR
- Updates 2 times a day
- Detects flood impact

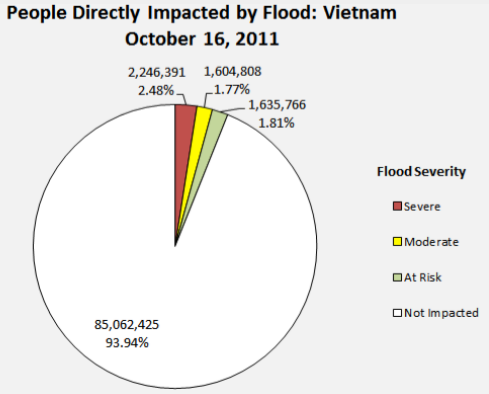
Bolten, NASA GSFC

How can we move from data to decision making?









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 Landscan 2011 Global Population dataset produced by Oak Ridge National Laboratory.

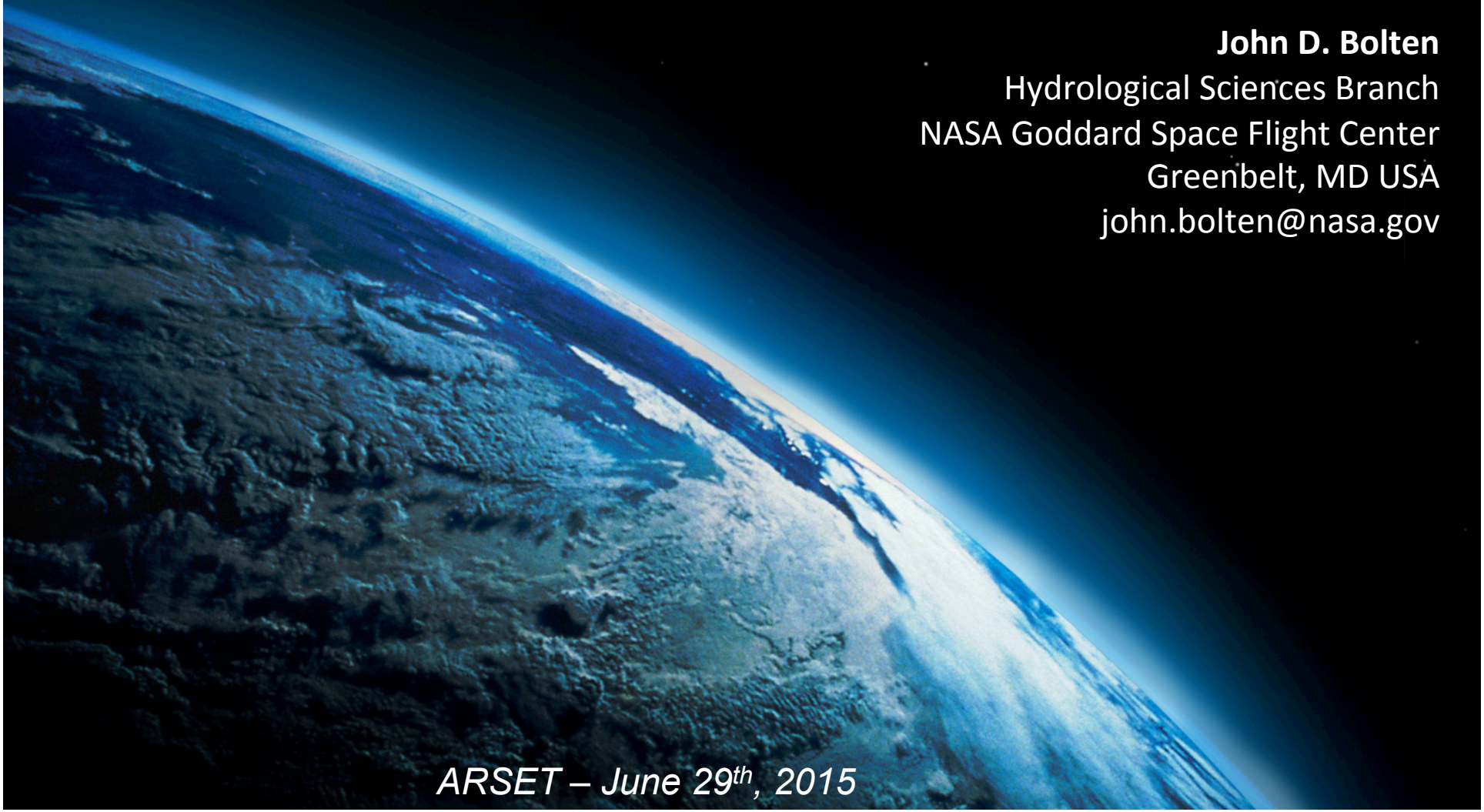
Country	At Risk	Moderate	Severe	Total Affected	Total Population	Percent Pop Affected
Cambodia	275,374	270,531	1,140,080	1,685,986	14,701,717	11.47%
Thailand	739,928	595,697	758,656	2,094,281	66,720,153	3.14%
Laos	13,134	12,481	9,246	34,862	6,477,211	0.54%
Vietnam	1,635,766	1,604,808	2,246,391	5,486,966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



ARSET – June 29th, 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:

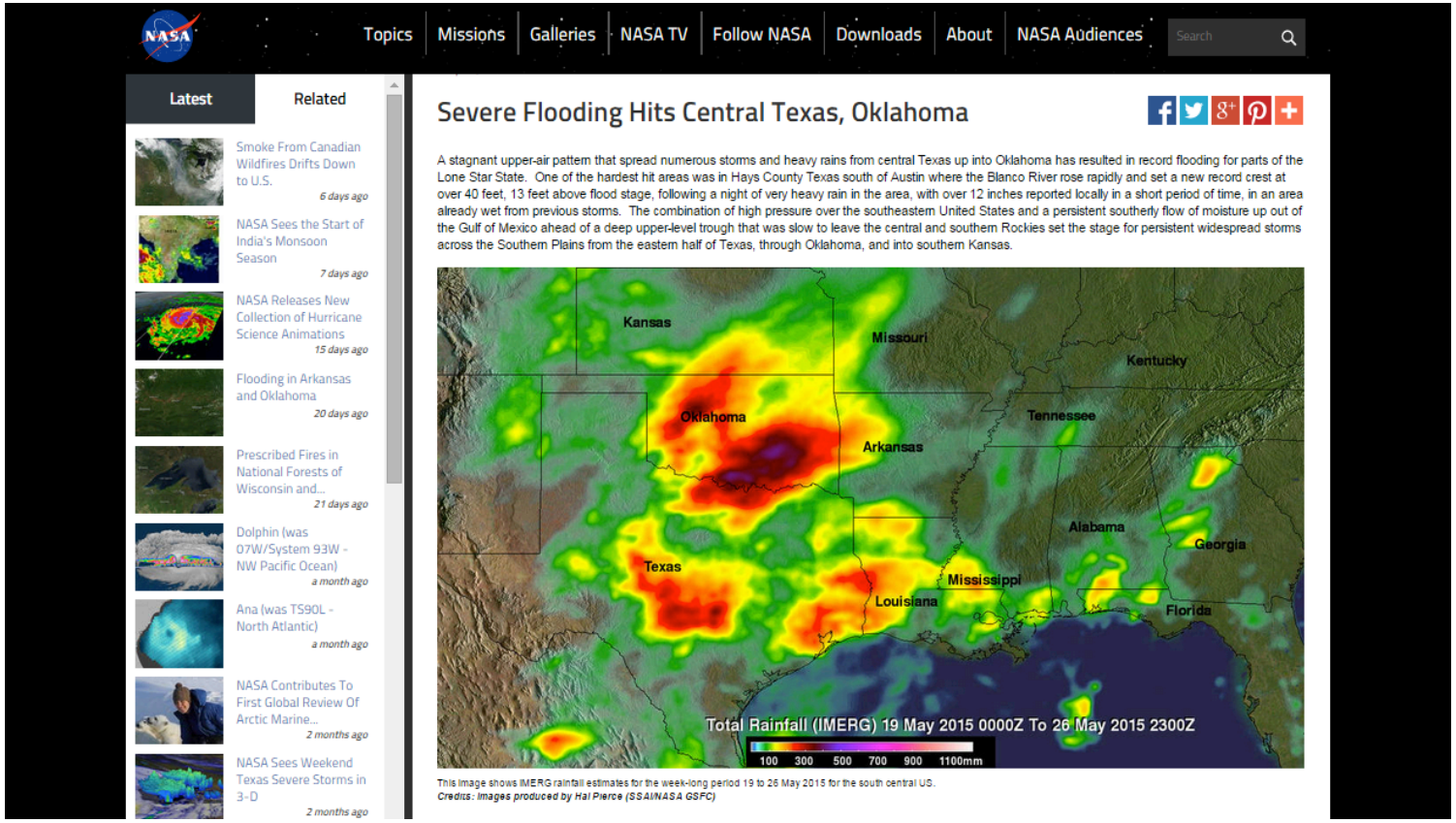
- precipitation
- stream flow
- inundation (flooded lands) shapefiles and rasters
- terrain data

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

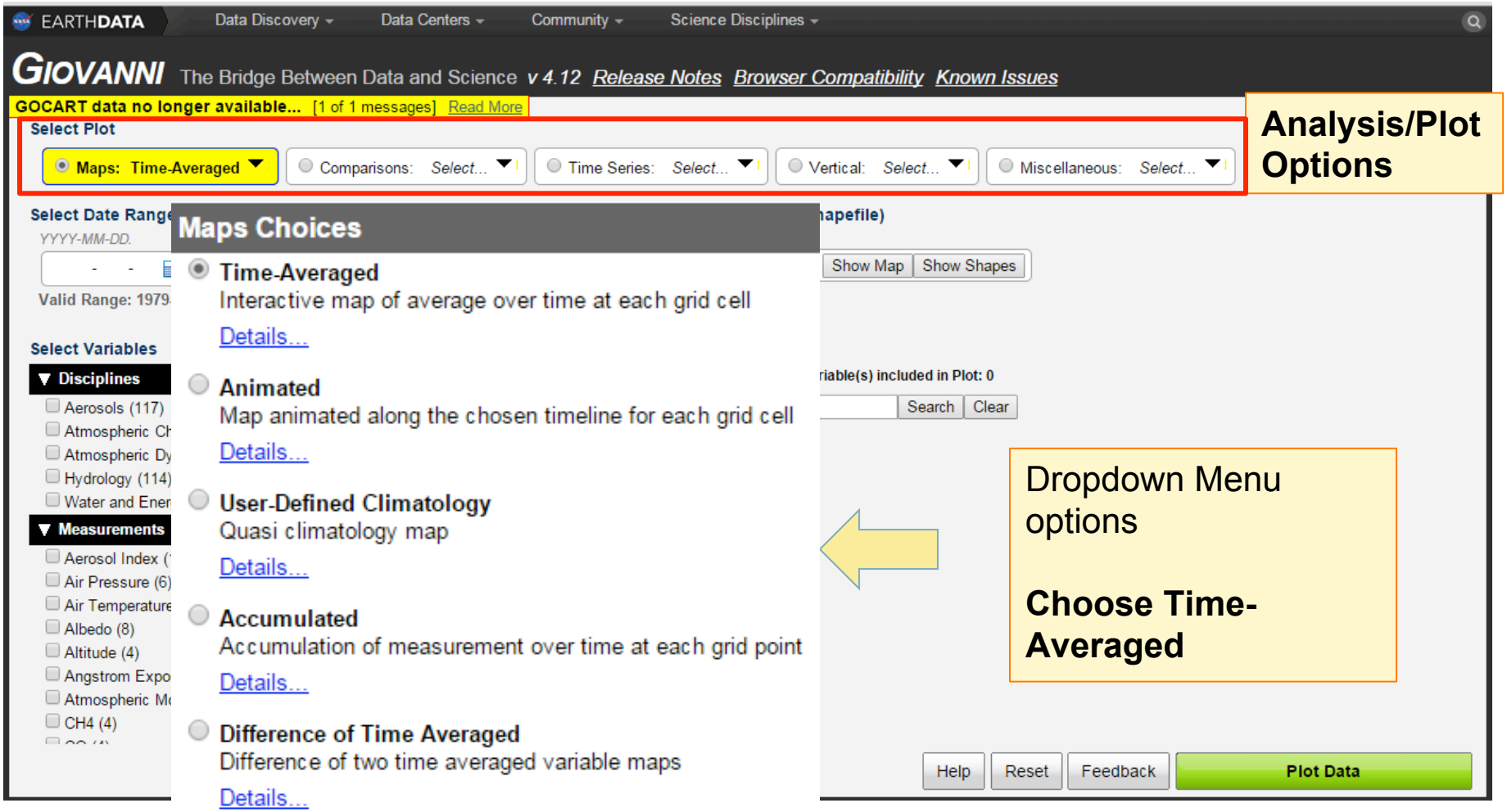


Heavy precipitation began early May, 2015 and lasted over a month causing increased stream flow and inundated lands.

Giovanni data portal

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

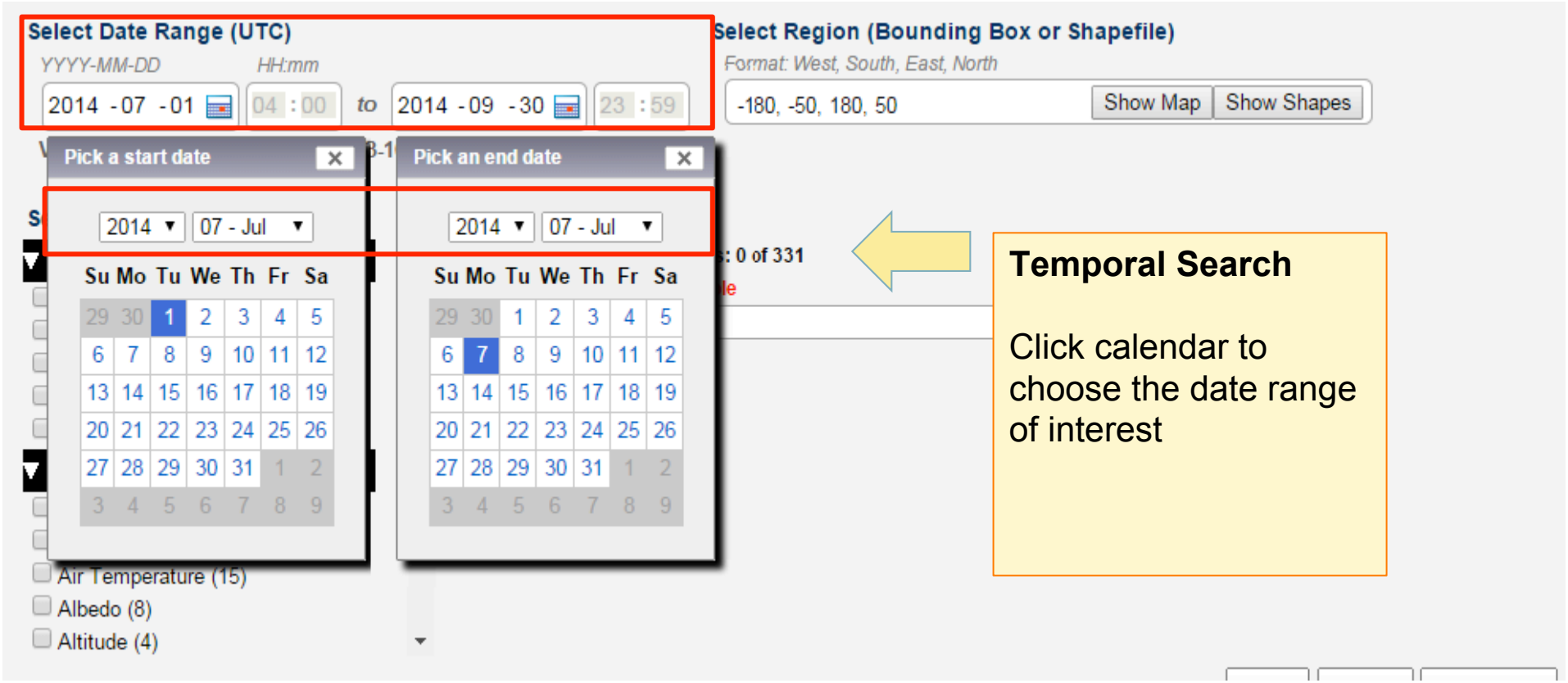
Precipitation data visualization



Giovanni data portal

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

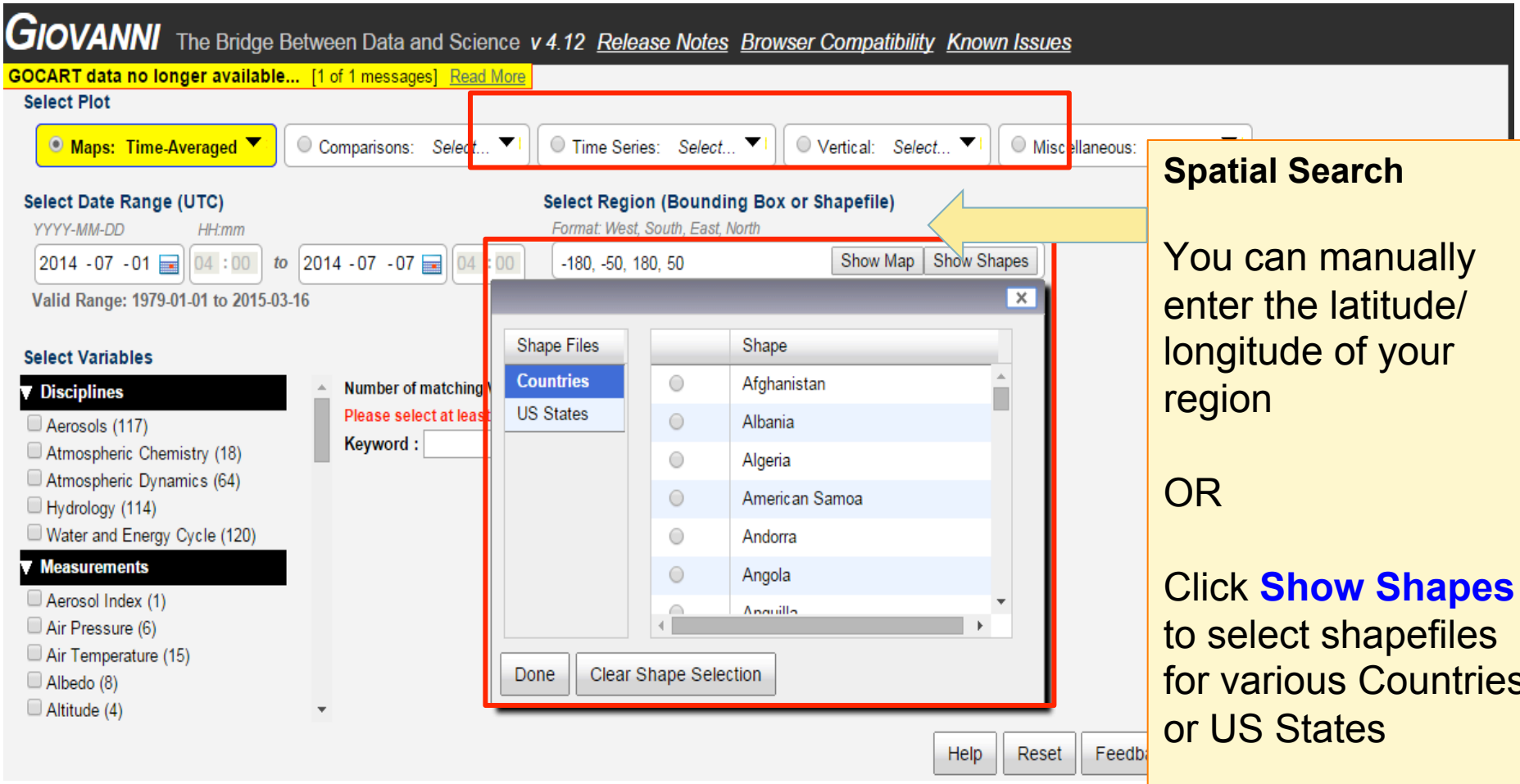
Precipitation data visualization



Giovanni data portal

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

Precipitation data visualization



Spatial Search

You can manually enter the latitude/ longitude of your region

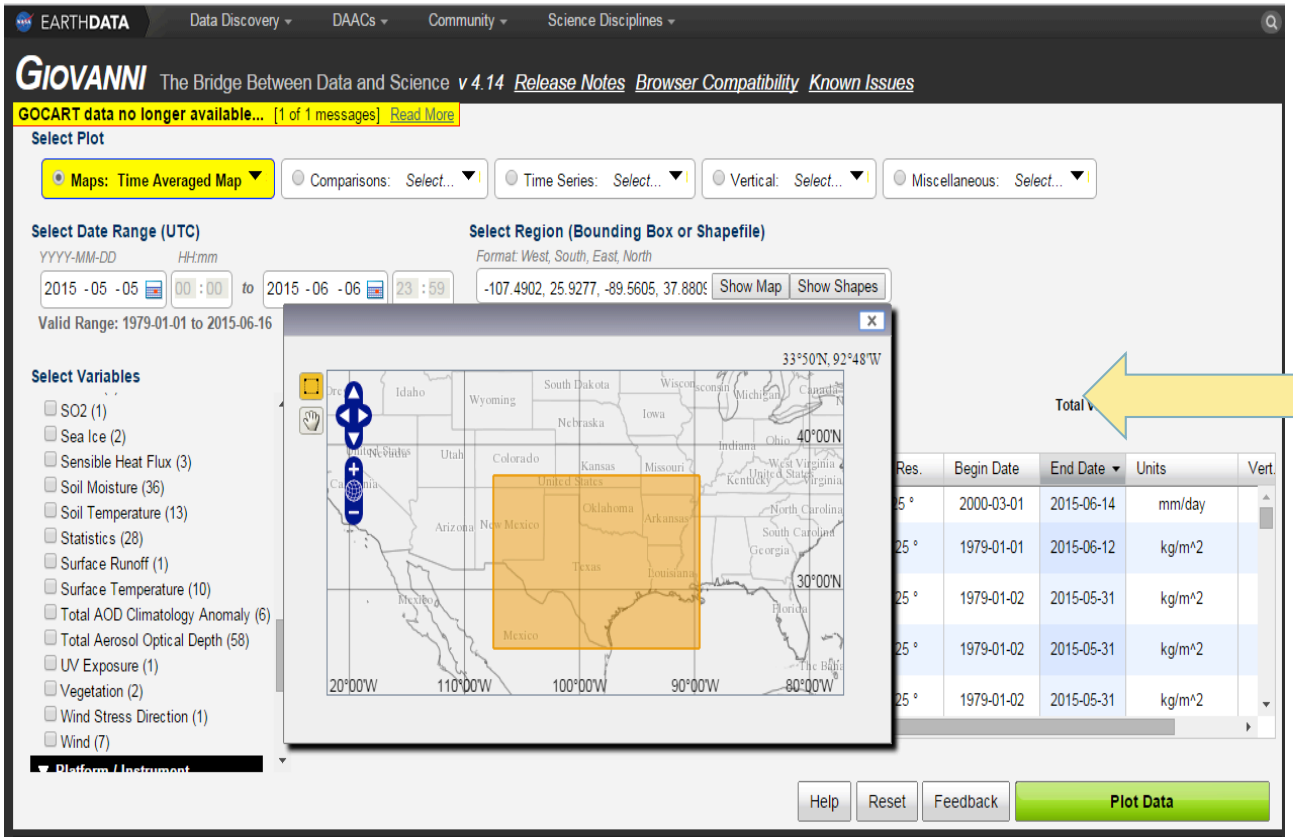
OR

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

Giovanni data portal

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

Precipitation data visualization



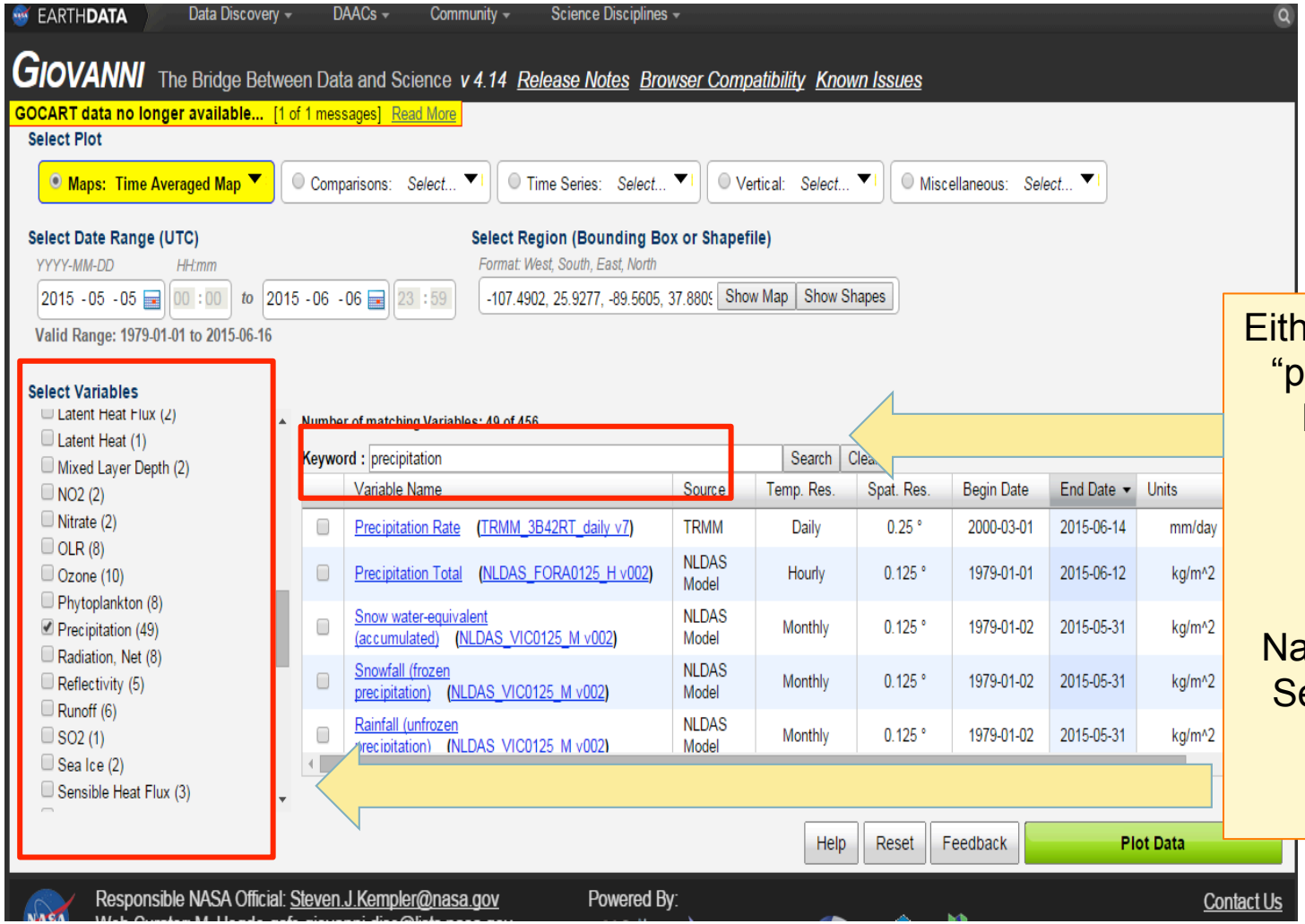
Spatial Search

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



Either type the variable "precipitation" in the Keyword search

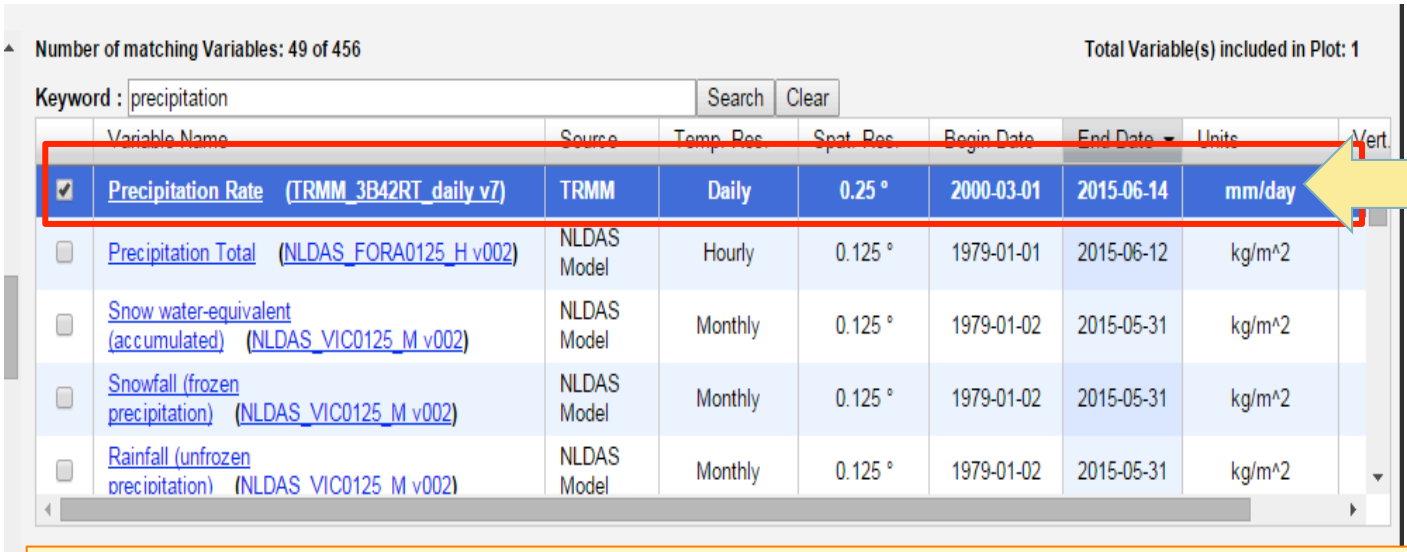
OR

Navigate through the Select Variables list

Giovanni data portal

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

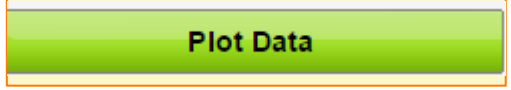
Precipitation data visualization



Select
Precipitation Rate
(TRMM_3B42RT_daily v7)

Daily, mm/day

Click **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.

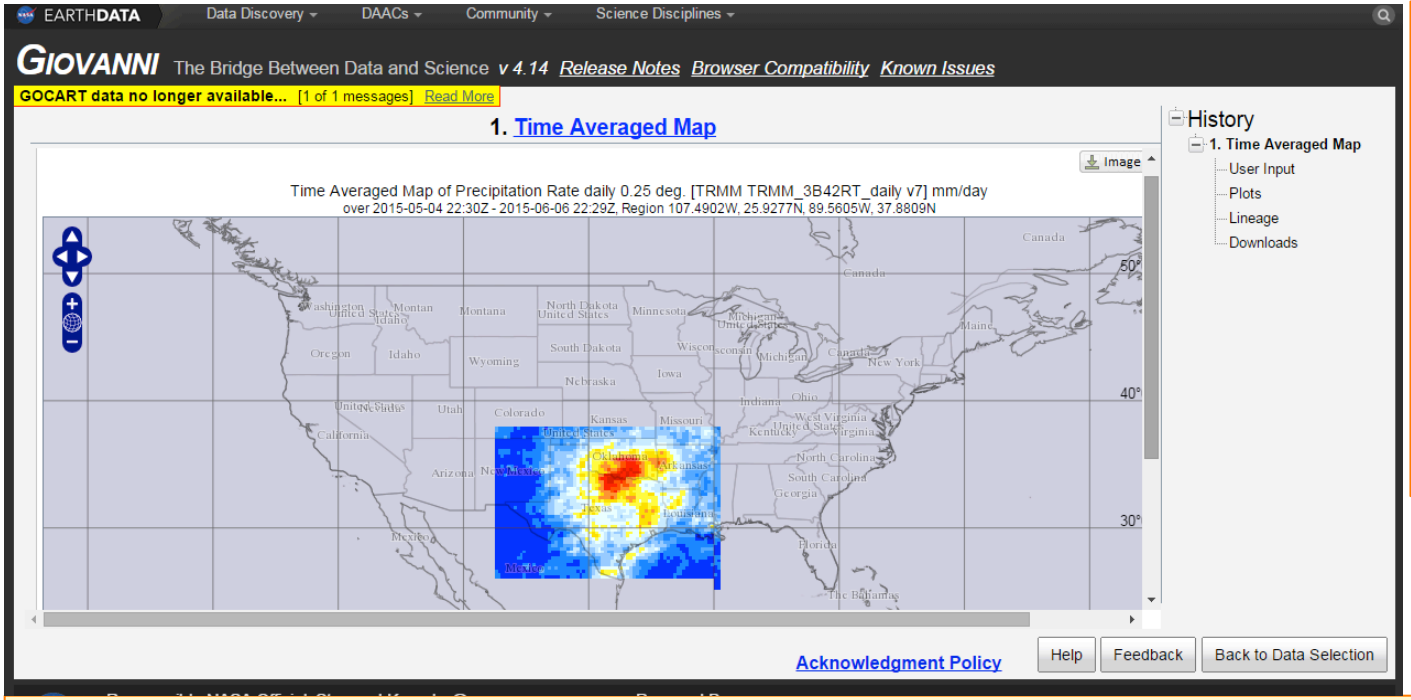
However, in the coming months, GPM IMERG half-hourly data will be available.

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

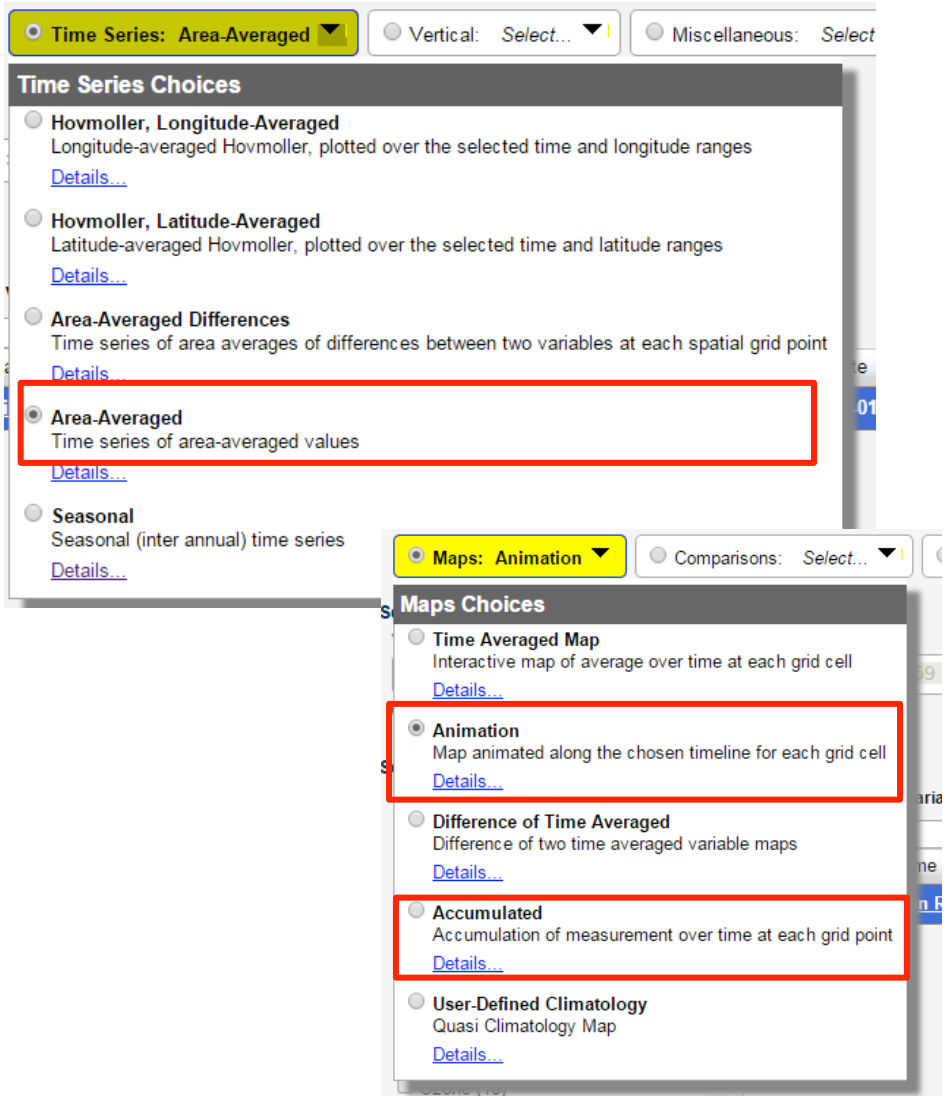
To return to Data Selection screen to choose from a variety of different visualizations and plots to narrow down the data you wish to download

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/



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

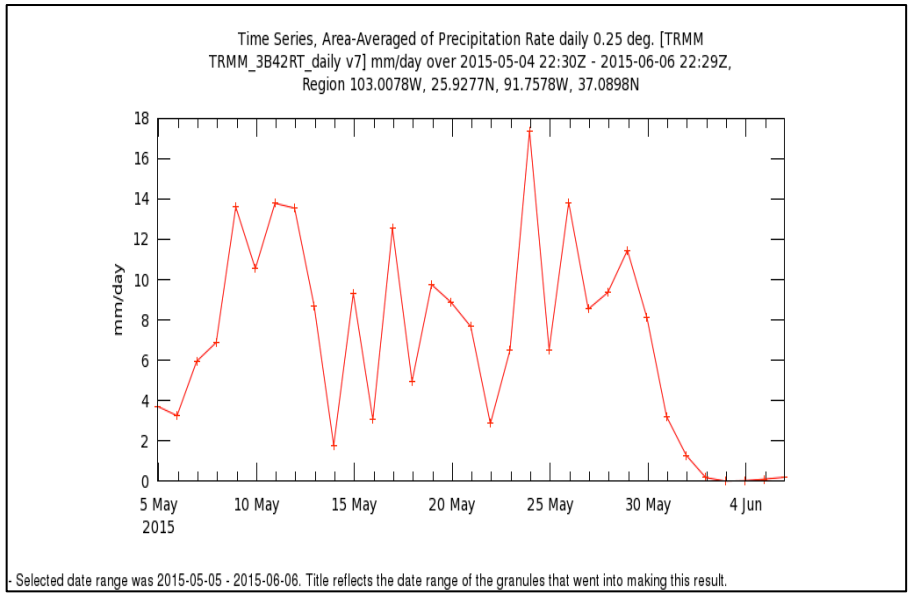
Or ***Animation*** for a map plot of average over time at each grid cell

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

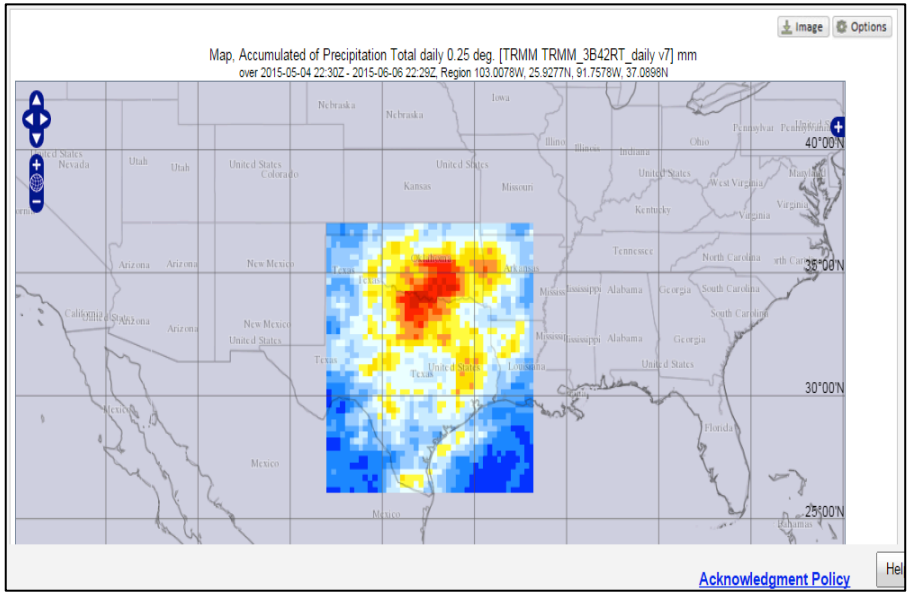
Giovanni data portal

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

Time Series (Area-Averaged)



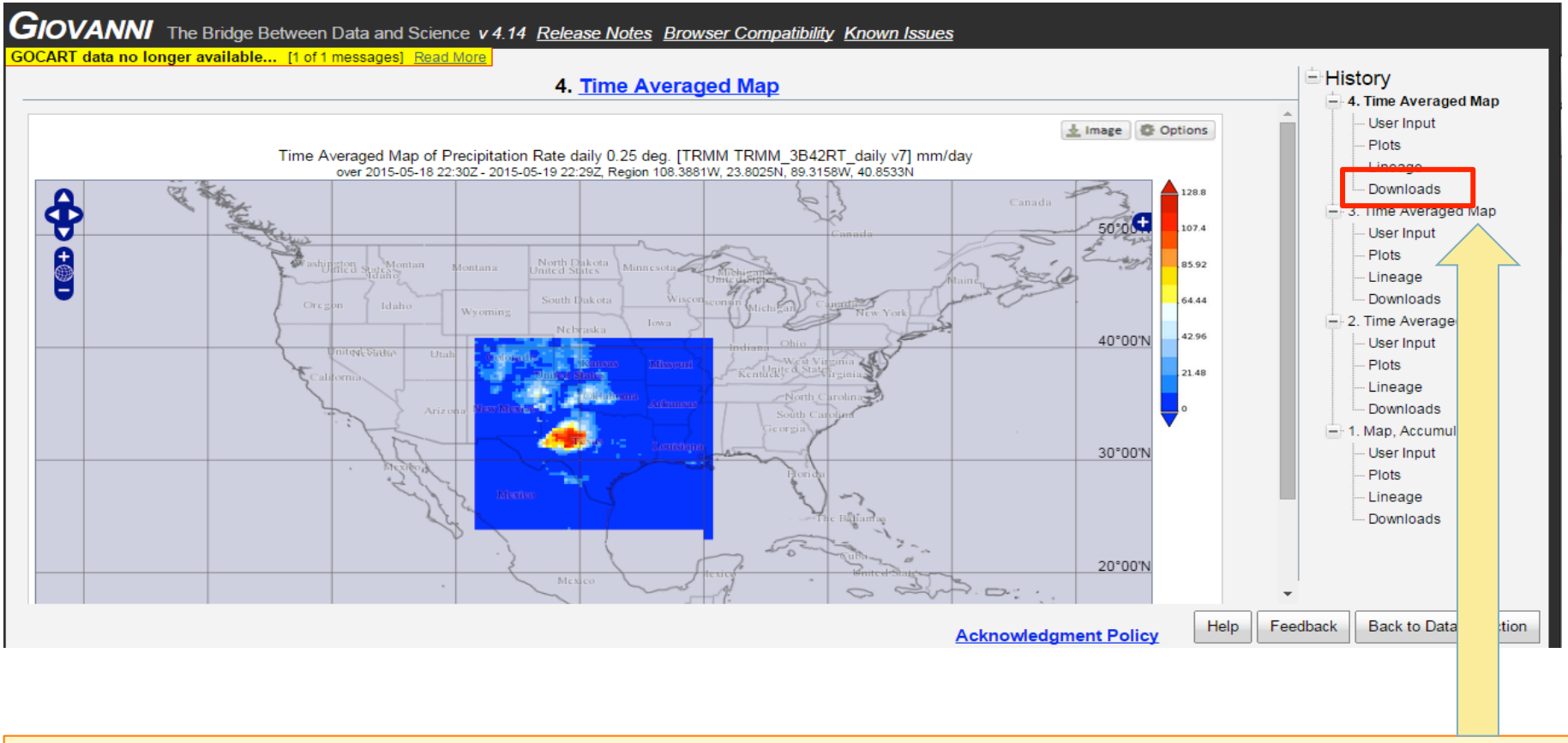
Map, Accumulated of Precipitation Total



Giovanni data portal

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

Precipitation data download



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

Giovanni data portal

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

Precipitation data download

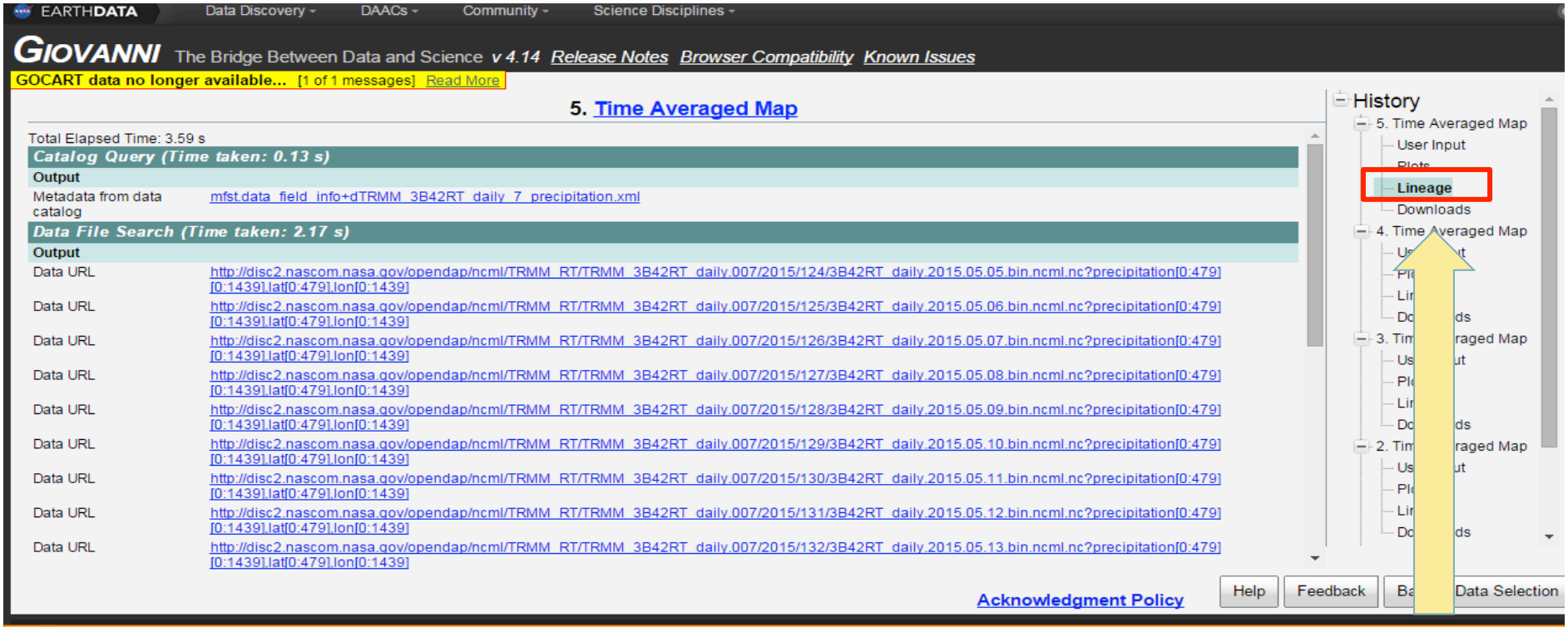
You can download the data files in either NetCDF, GeoTIFF or PNG formats.
NetCDF format is easily imported into ArcMap.
Click the link to download to your desired location on your computer.
For the demonstration today we will download the NetCDF file.

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

Giovanni data portal

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

Precipitation data download



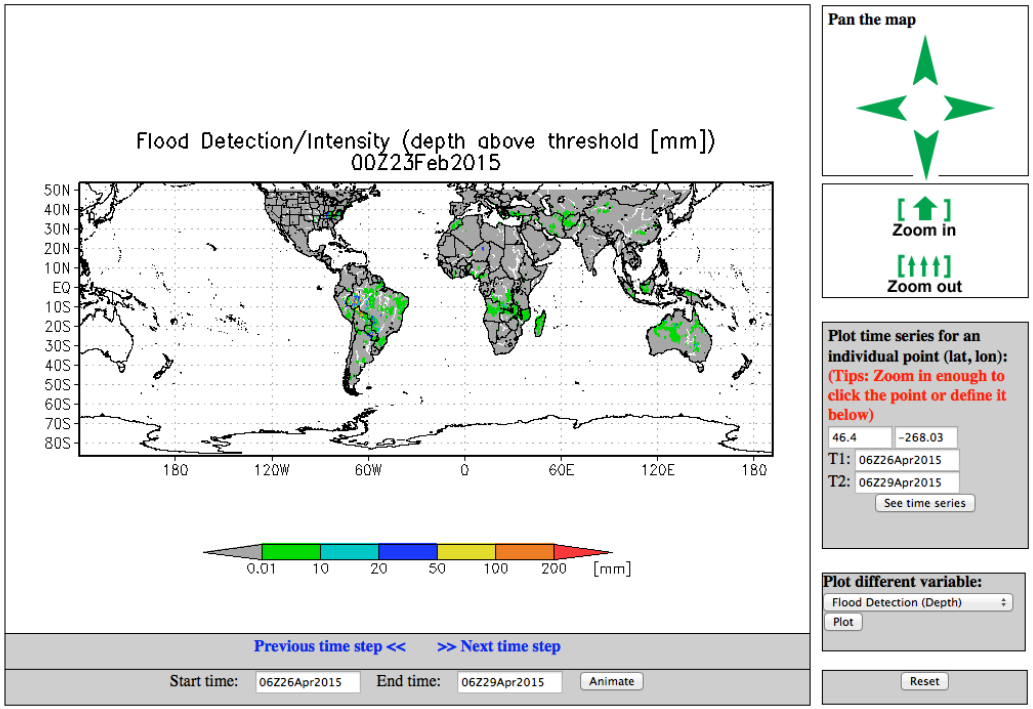
By clicking Lineage, multiple files that were used to construct the time average map can be available for download yet these will not be spatially subsetted to the user bounding box and will be global in extent

Global Flood Monitoring System (GFMS)

http://flood.umd.edu

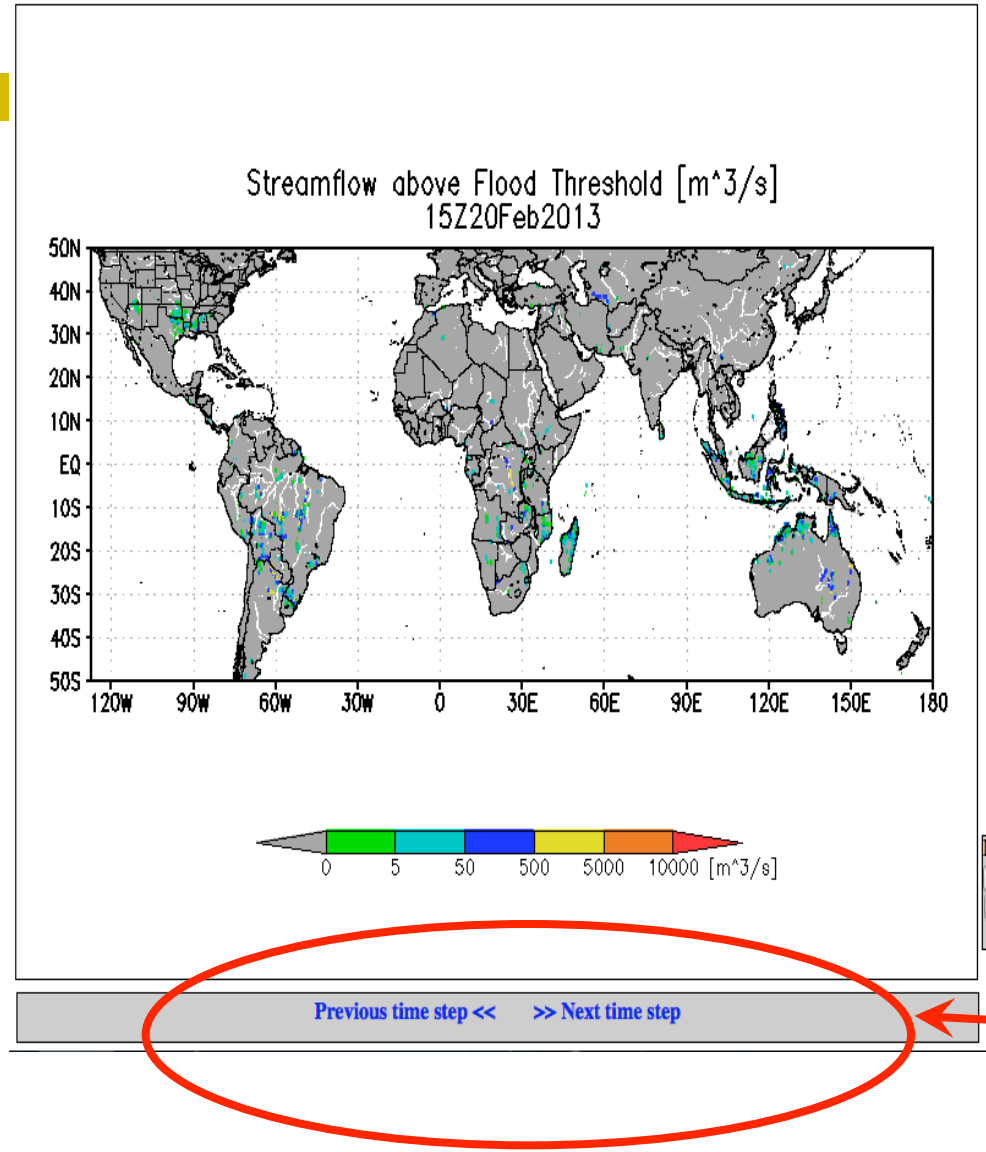
We have obtained precipitation data for our event

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)

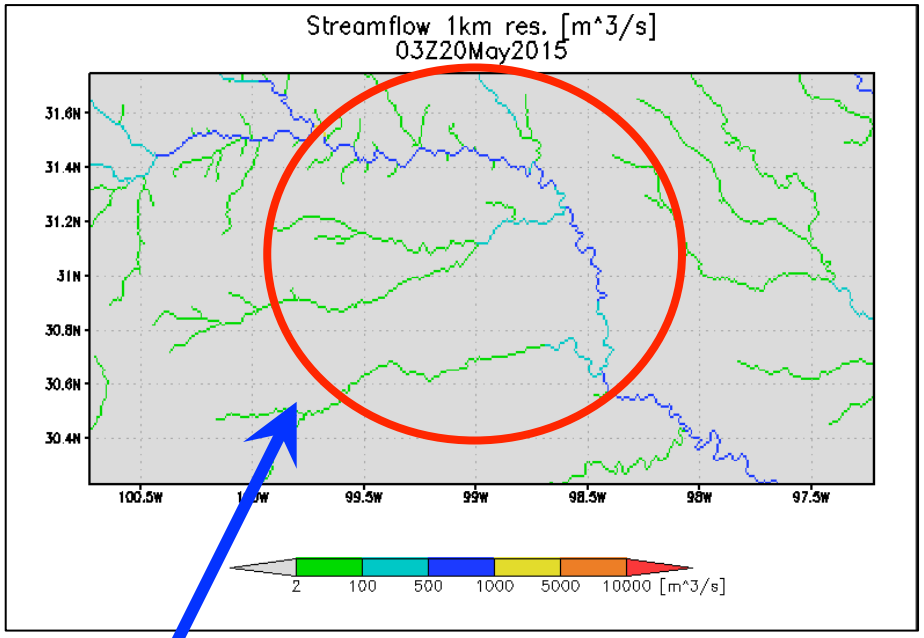
http://flood.umd.edu



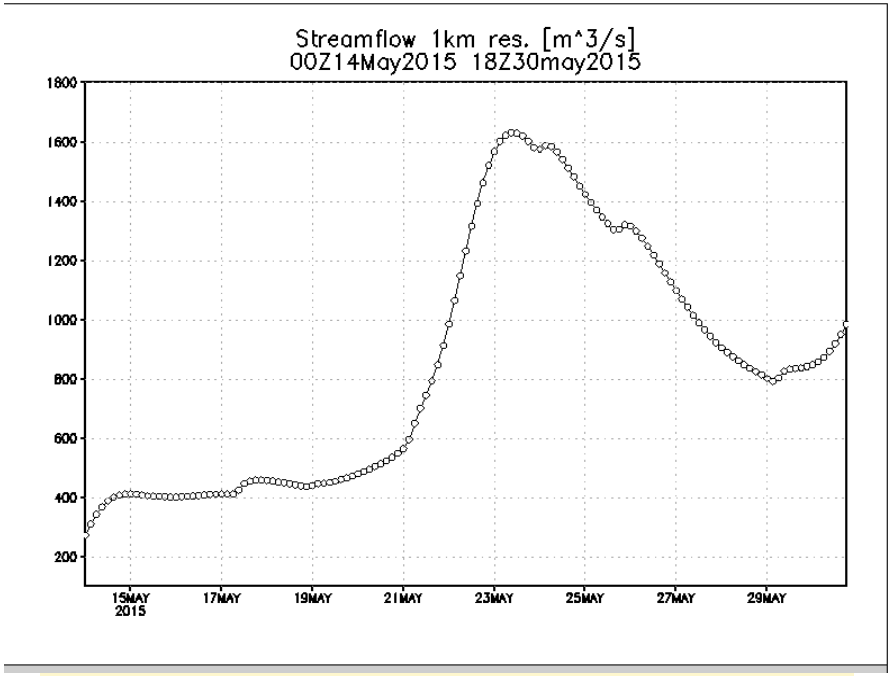
- Map navigation
- Zoom in/out
- Select individual grid point for data for time sequence
- Plot different variables
- 3-hourly output

Global Flood Monitoring System (GFMS)

http://flood.umd.edu



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

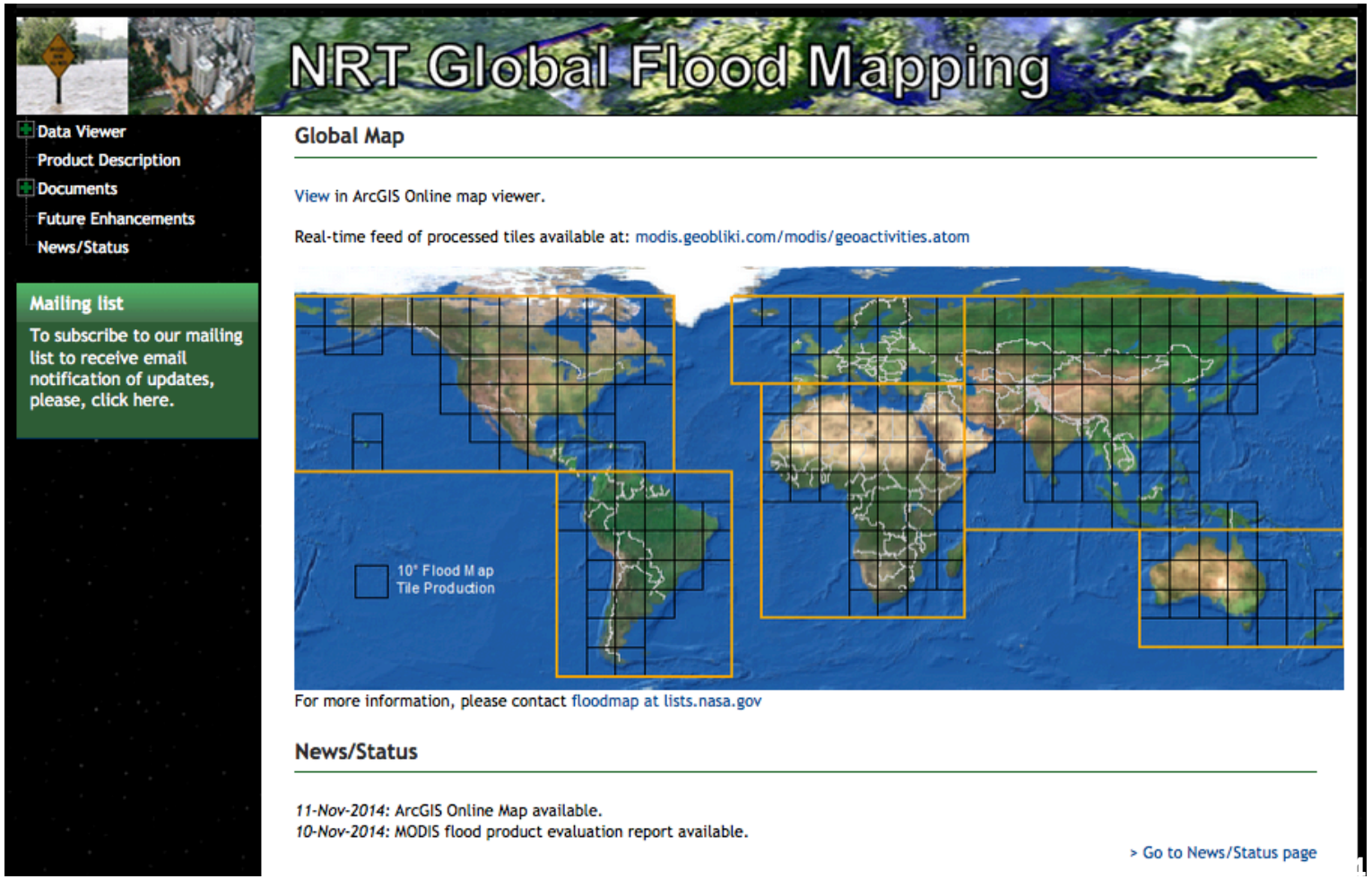


This can be monitored at NEAR real time during heavy rain periods to plan for and respond to flooding events.

MODIS Inundation Mapping

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

Inundation data visualization

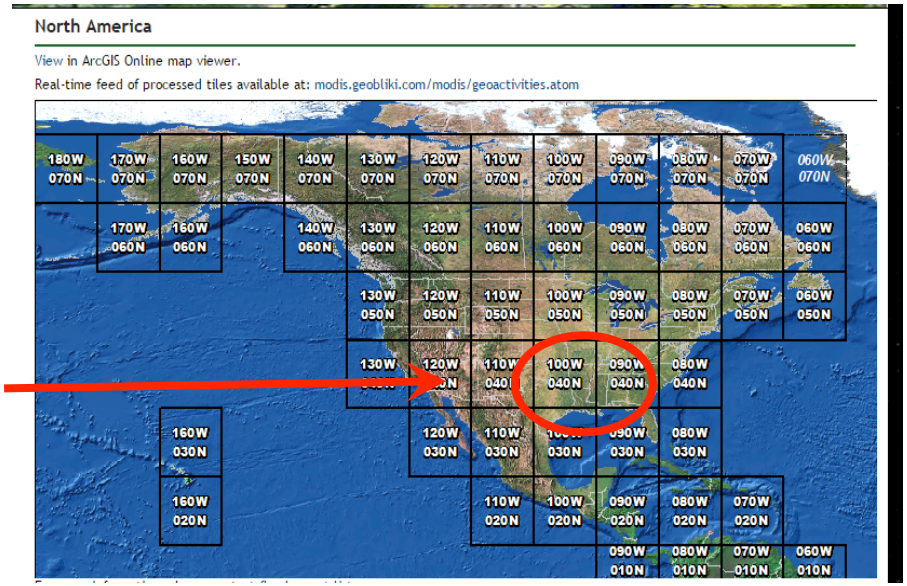


MODIS Inundation Mapping

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

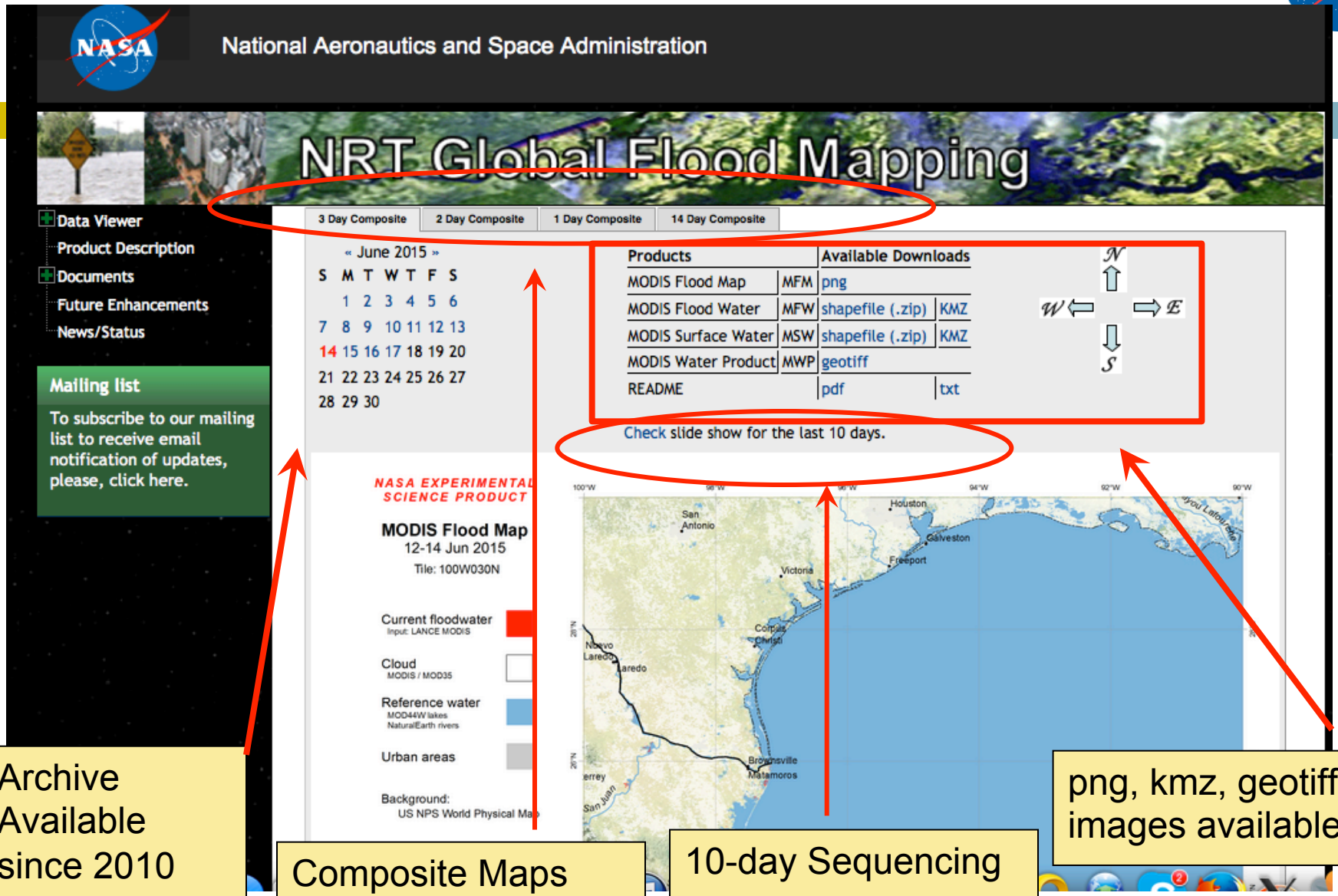
Inundation data visualization

Click on the continent that contains your region of interest



Click on the tile that contains your region of interest

MODIS Inundation Mapping



Archive Available since 2010

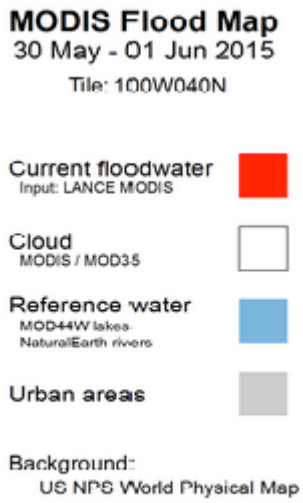
Composite Maps

10-day Sequencing

png, kmz, geotiff images available

MODIS Inundation Mapping

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



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.

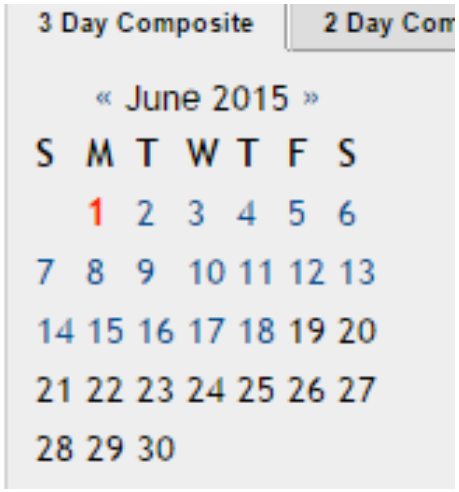
MFW: MODIS Flood Water – Obtained by subtracting Reference Water from MSW.

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/

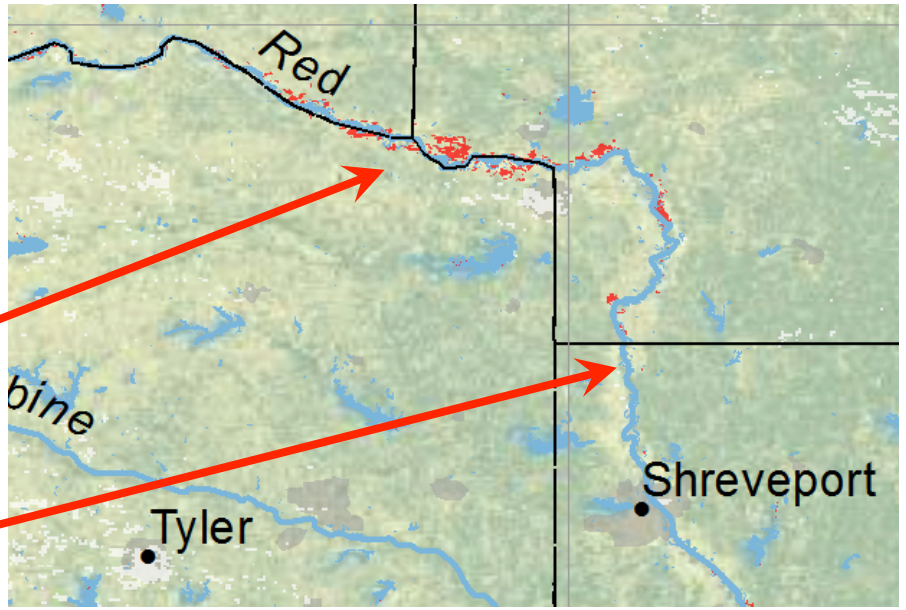
Inundation data visualization



Use the calendar to navigate to visualize the dates of inundation

Red Shading Shows Inundated Surface

Blue Shading Shows Reference Water

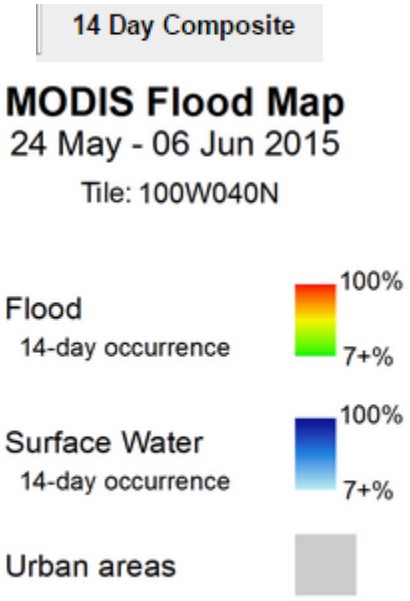


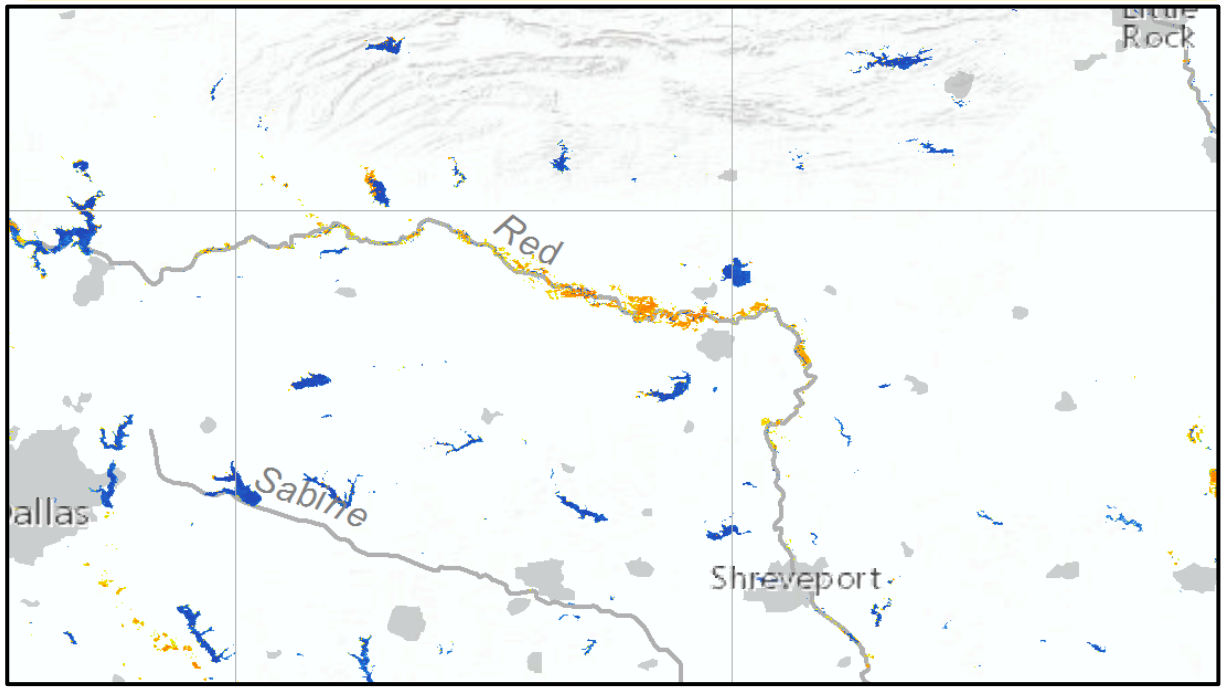
MODIS Inundation Mapping

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





MODIS Inundation Mapping

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

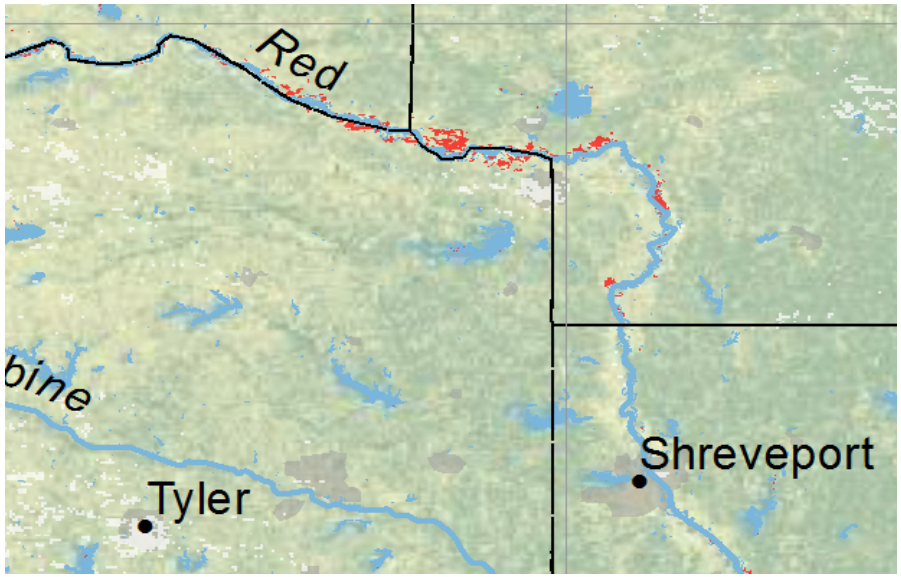
Inundation data download

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)

USGS

Sources of NASA Terrain Data

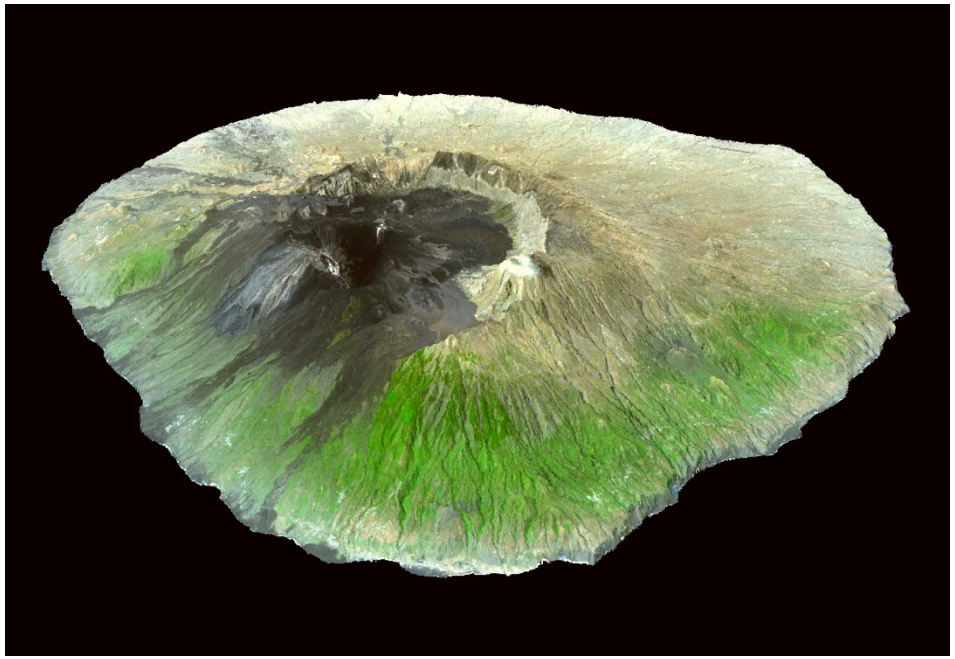
Radar: Shuttle Radar Topography Mission (SRTM)

Radiometer: Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

Useful for Mapping
- Hazardous terrain

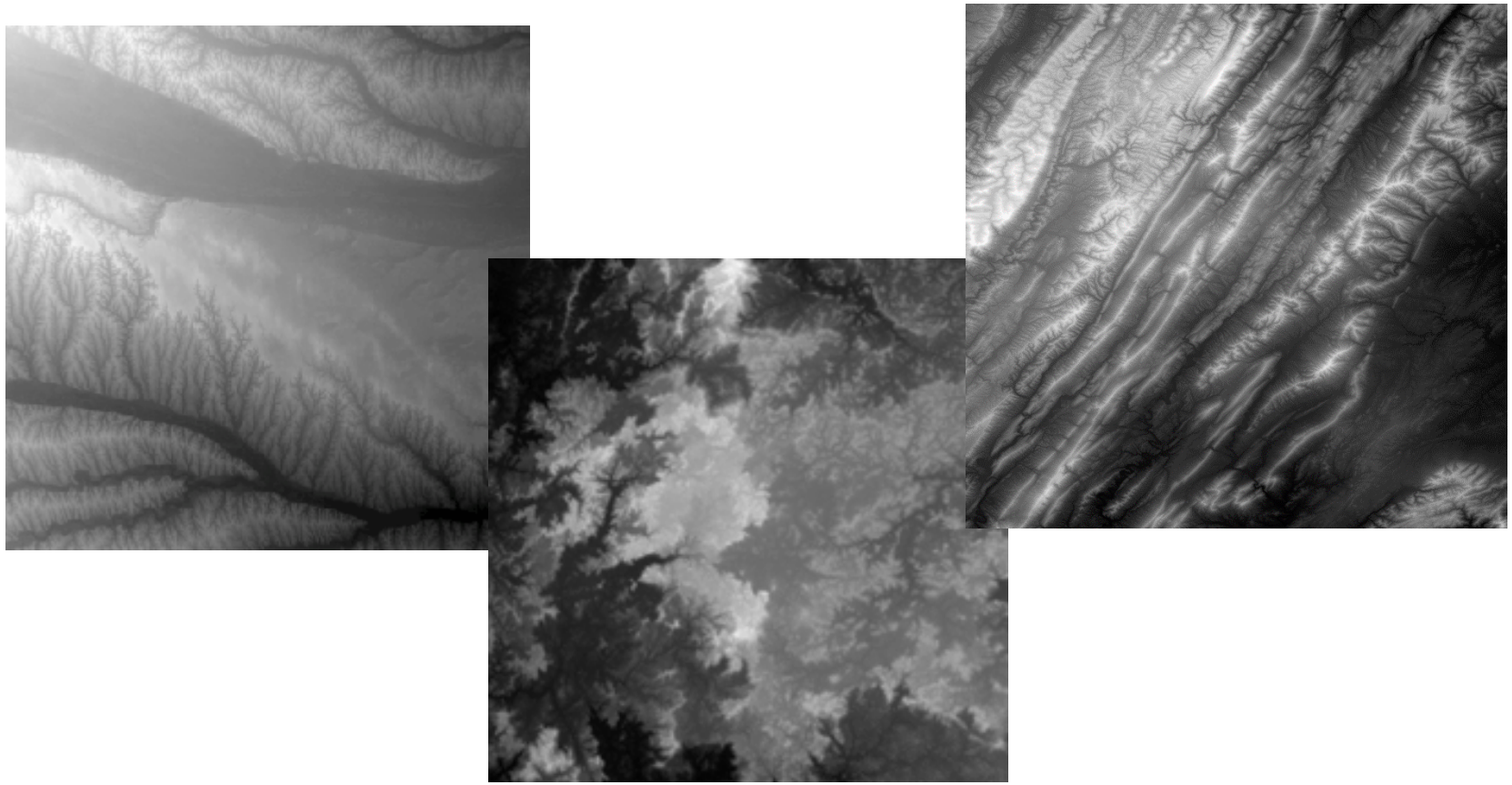
Calculating
- Slope and aspect
- Catchment area
- Forest canopy height

Modeling
- Runoff
- Stream networks
- Landslides



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

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



https://lpdaac.usgs.gov/products/measures_products_table

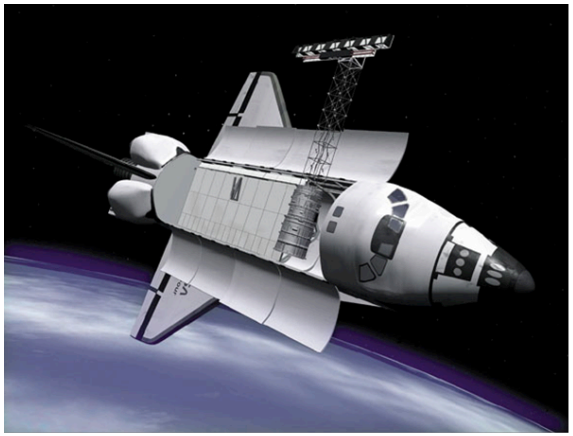
USGS NASA

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

What is SRTM?

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

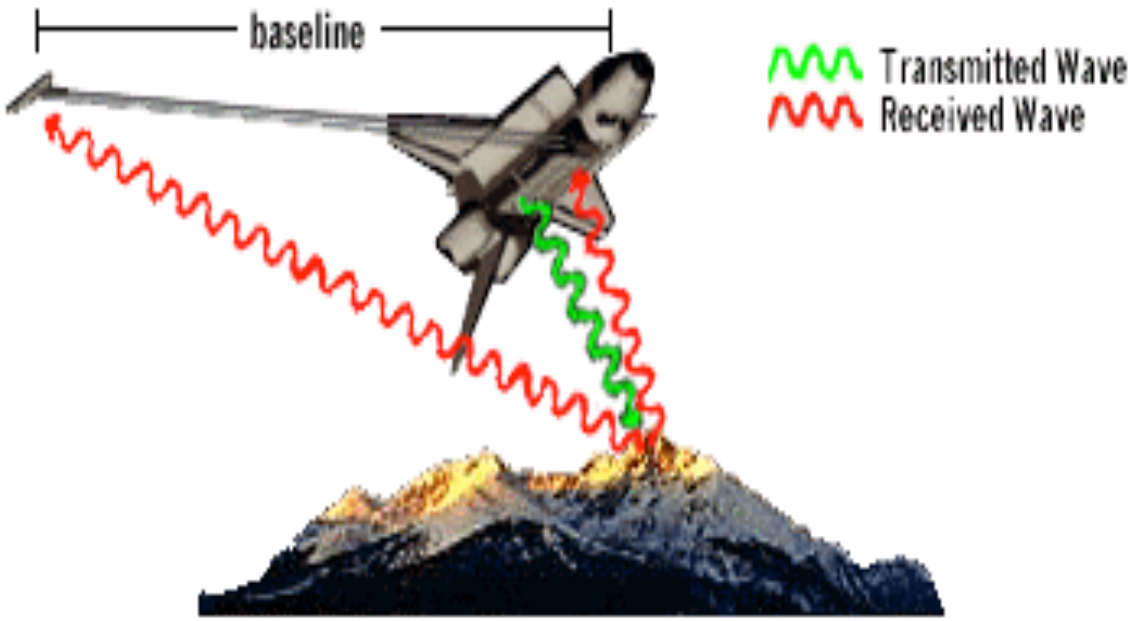
- NASA mission completed in February 2000
- Consisted of 176 orbits around Earth in 11 days
- Acquired Digital Elevation Model (DEM) of all land between 60°N and 56°S latitude, about 80% of Earth's total land mass



USGS

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

NASA SRTM Version 3.0 (SRTM Plus)



Radar signals being transmitted and recieved 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

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

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)

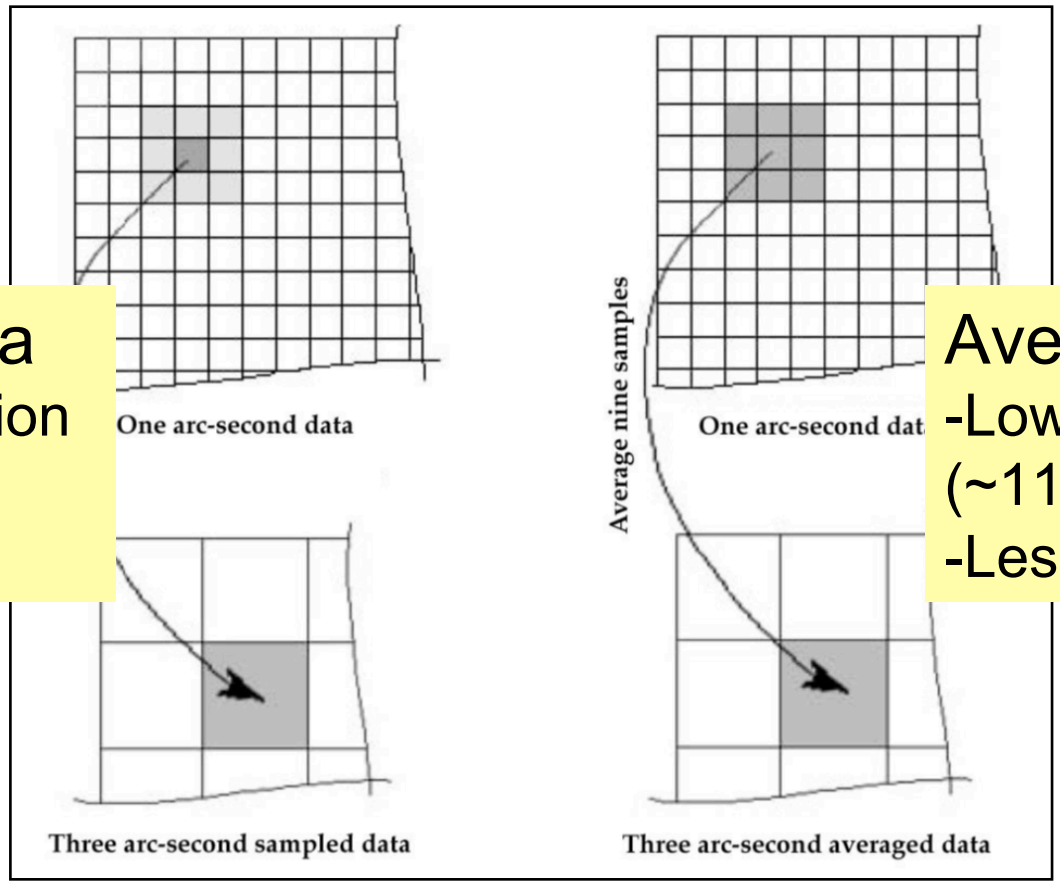
NASA SRTM v3 Products

Short Name	Collection	MEaSUREs Data Product	Spatial Resolution
SRTMGL1	SRTM	SRTM Global 1 arc second	1 arc-second
SRTMGL1N	SRTM	SRTM Global 1 arc second number	1 arc-second
SRTMGL3	SRTM	SRTM Global 3 arc second	3 arc-second
SRTMGL30	SRTM	SRTM Global 30 arc second	30 arc-second
SRTMGL3N	SRTM	SRTM Global 3 arc second number	3 arc-second
SRTMGL3S	SRTM	SRTM Global 3 arc second sub-sampled	3 arc-second
SRTMSWBD	SRTM	SRTM Water Body Data Shapefiles & Raster Files	1 arc-second
SRTMUS1	SRTM	SRTM US 1 arc second	1 arc-second
SRTMUS1N	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

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

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
- More information: SRTM v3 User Guide
  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)

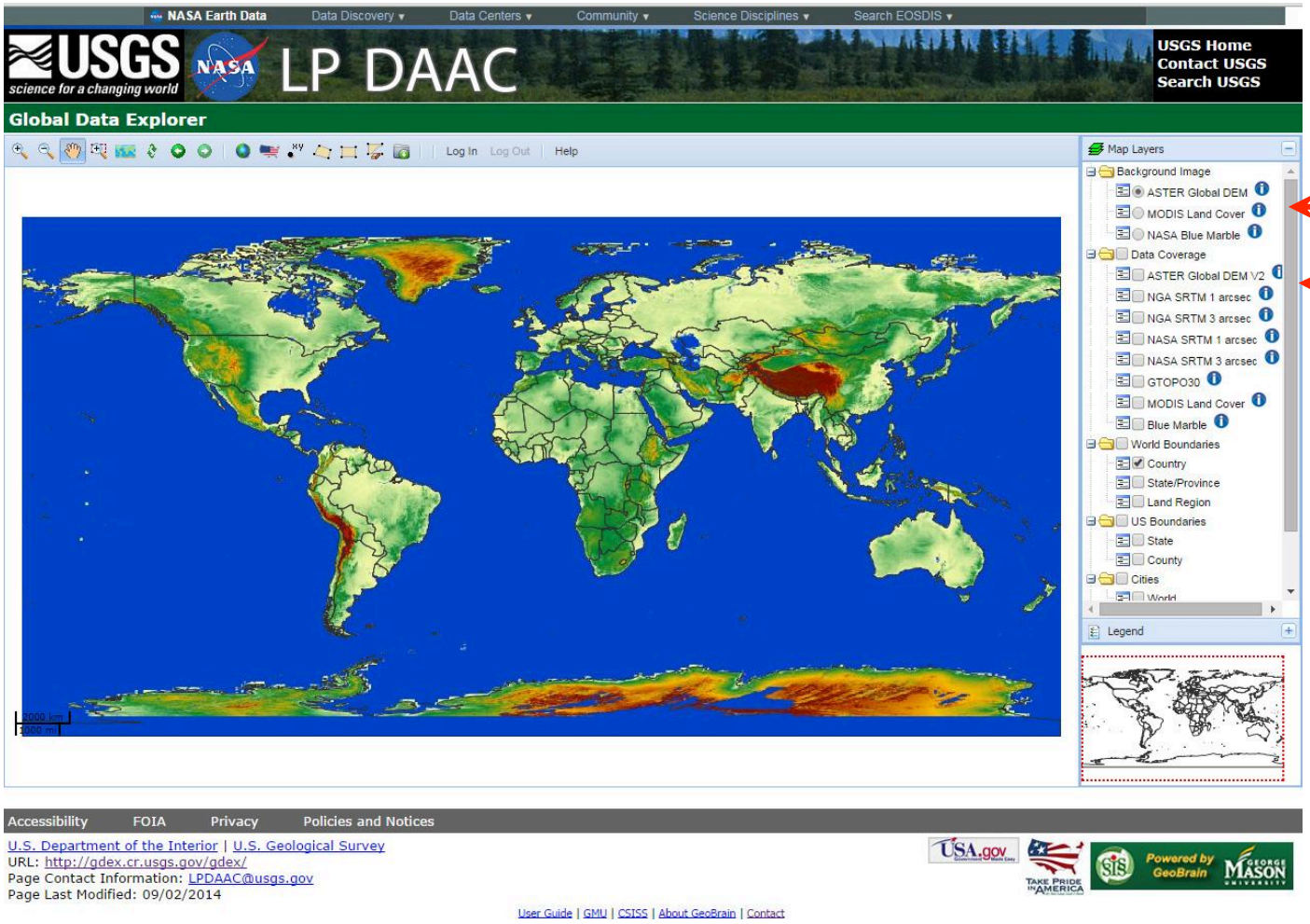
GDEx Features and Functions

- 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

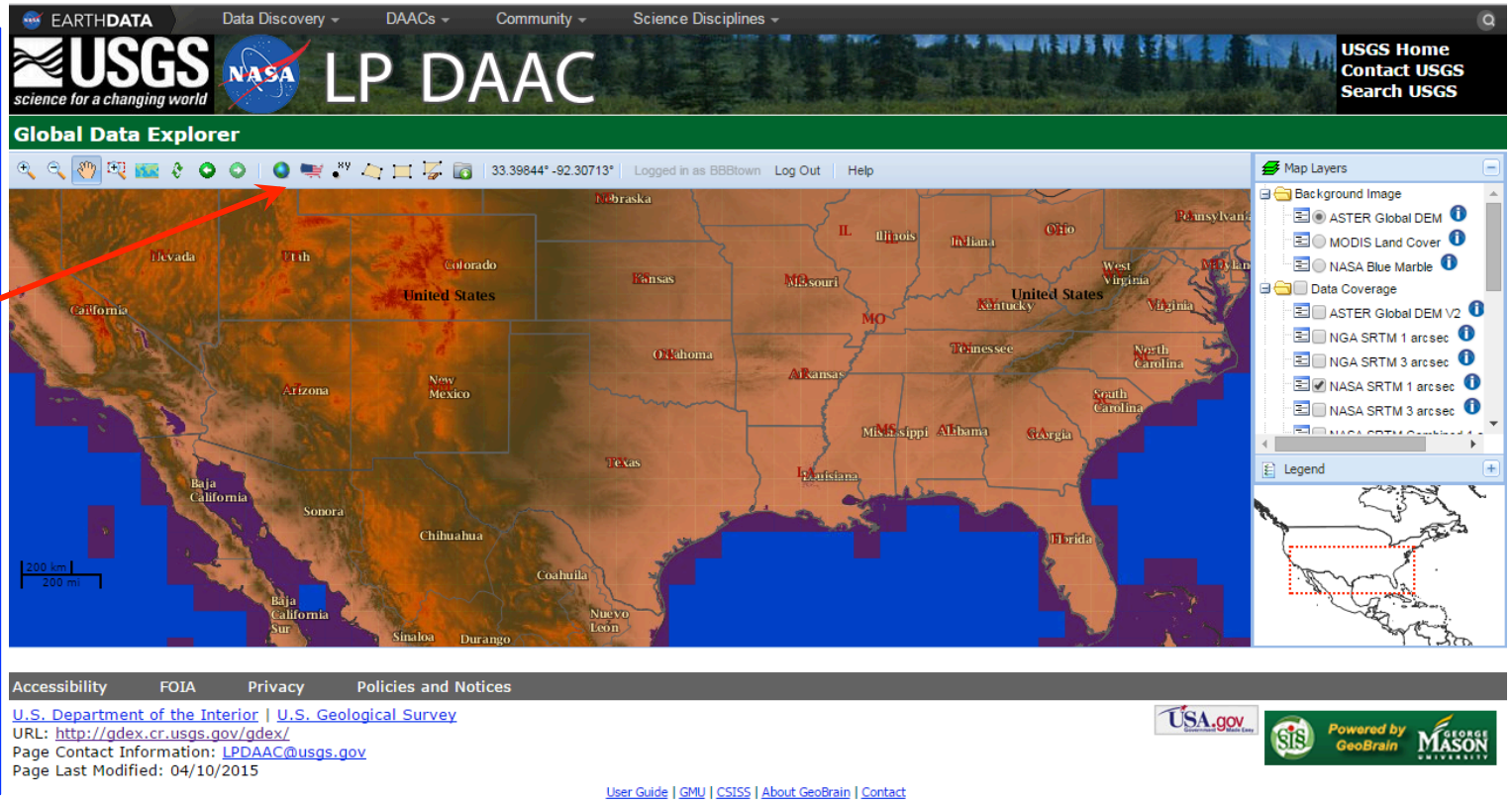
SRTM data coverage layers to select

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)



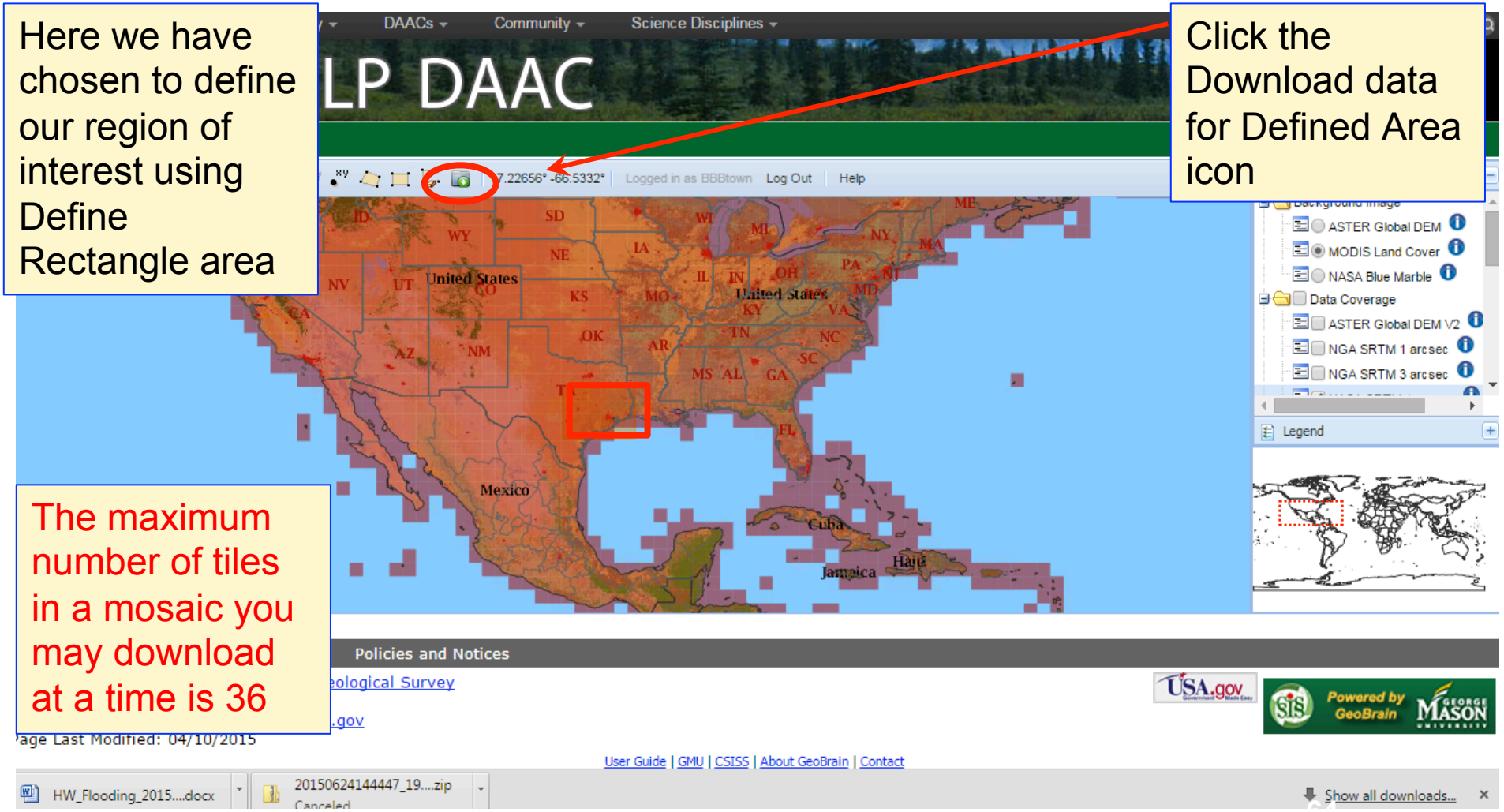
GDEx

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

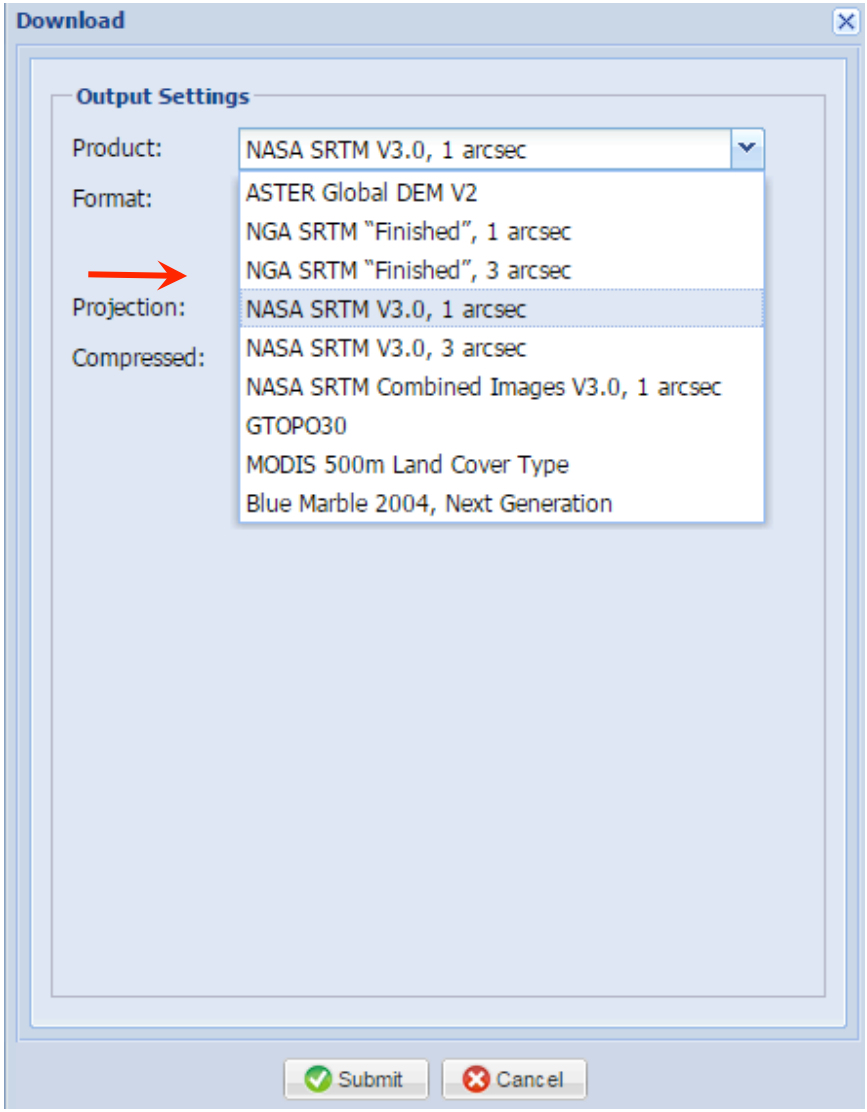
The maximum number of tiles in a mosaic you may download at a time is 36



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

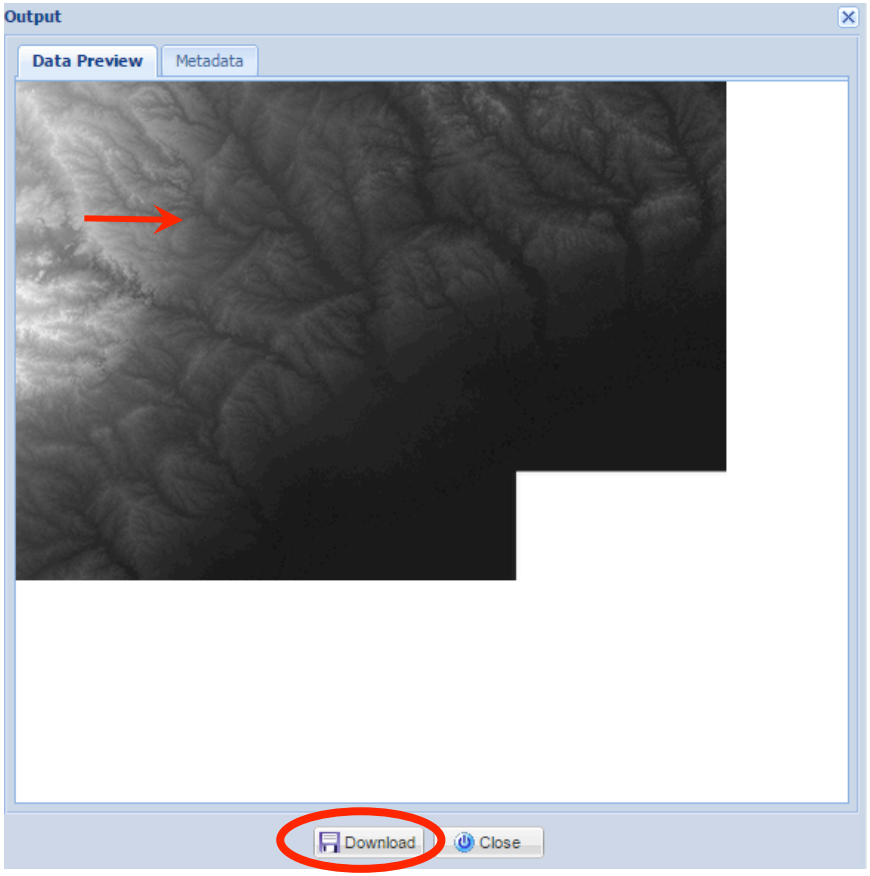


Next, select the format to be downloaded (GeoTIFF), the Projection (lat/long or UTM) and check "compressed .zip" (optional) and Click **Submit.**

GDEx

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

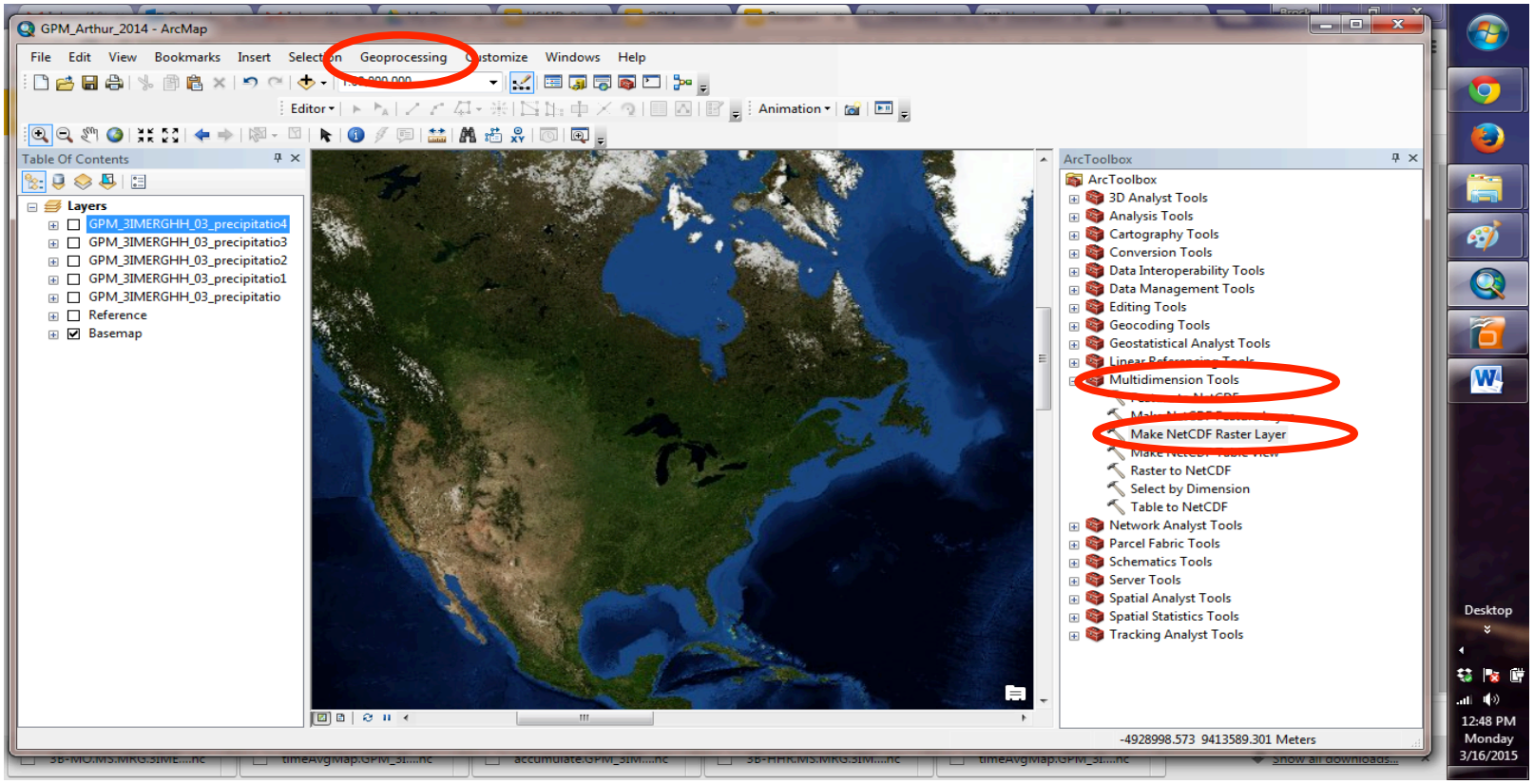
Once processed you will see a pop up window with a preview of the data



Click Download

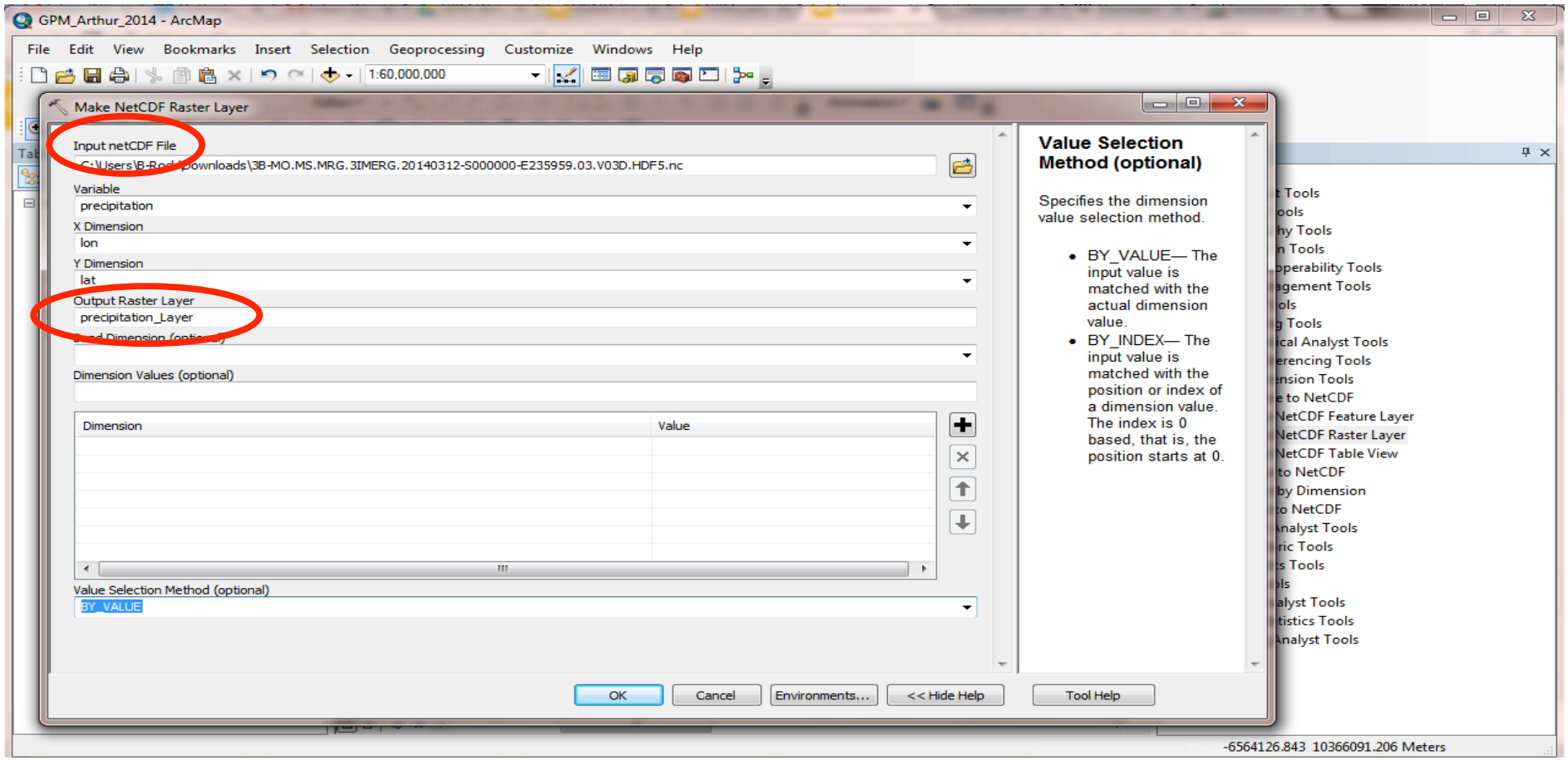
Now that we have acquired our data, let us

Import into GIS (ArcMAP): Precipitation



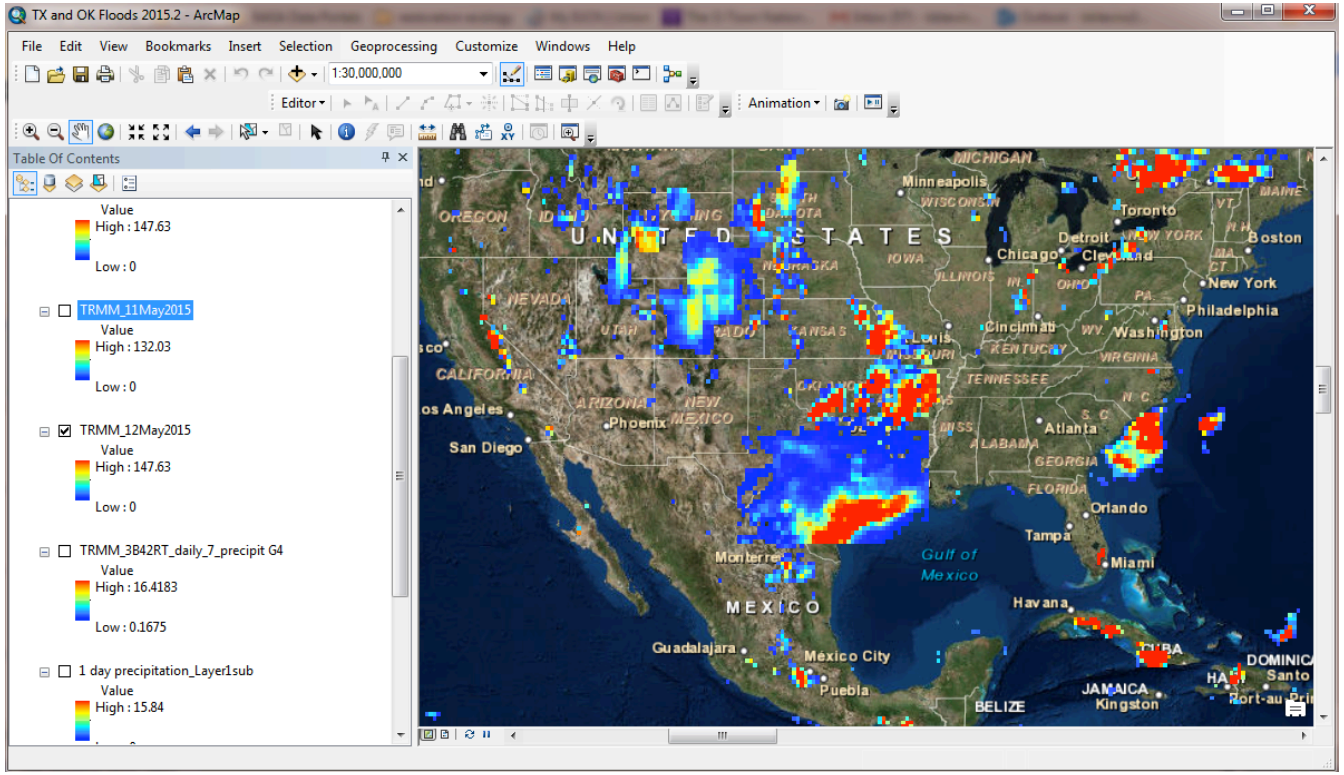
Import TRMM precipitation data - Under the Geoprocessing Tab, Open the ArcToolbox.Open the Multidimensional toolbox, choose the **Make NetCDF Raster Layer tool**

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



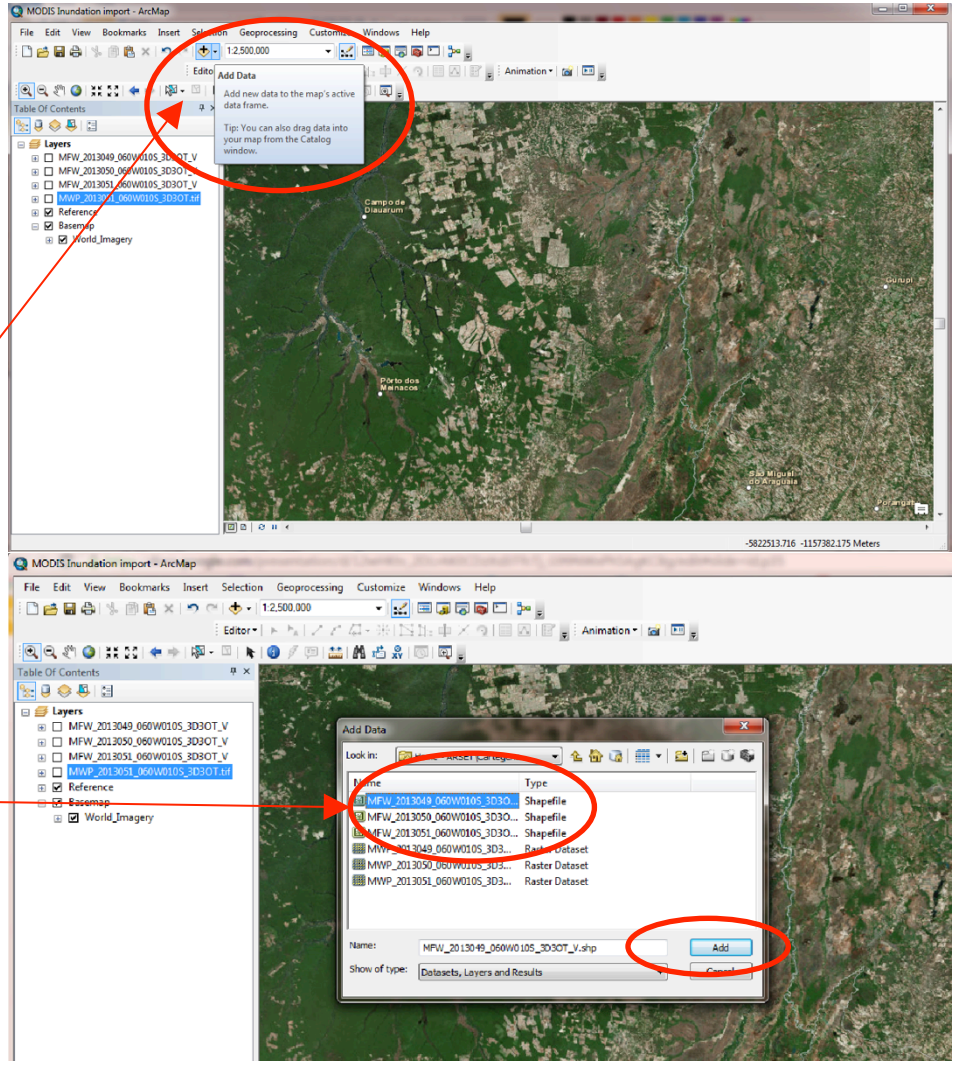
The result will be in raster format in ArcMAP. Rater files are ideal for spatial analysis tools

Display MODIS Inundation in ArcMap

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

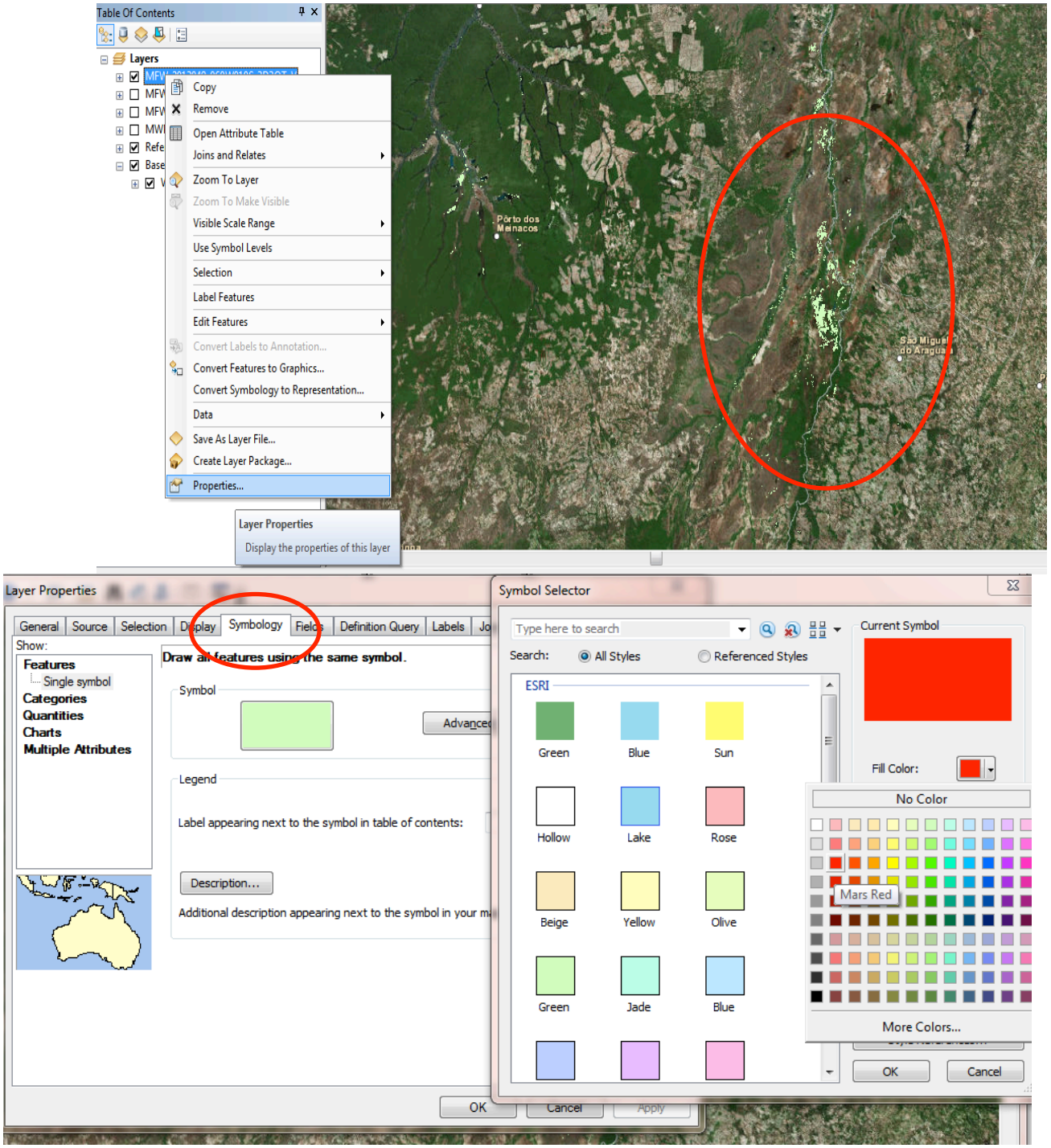
Open the Add data icon and click Add Data

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)

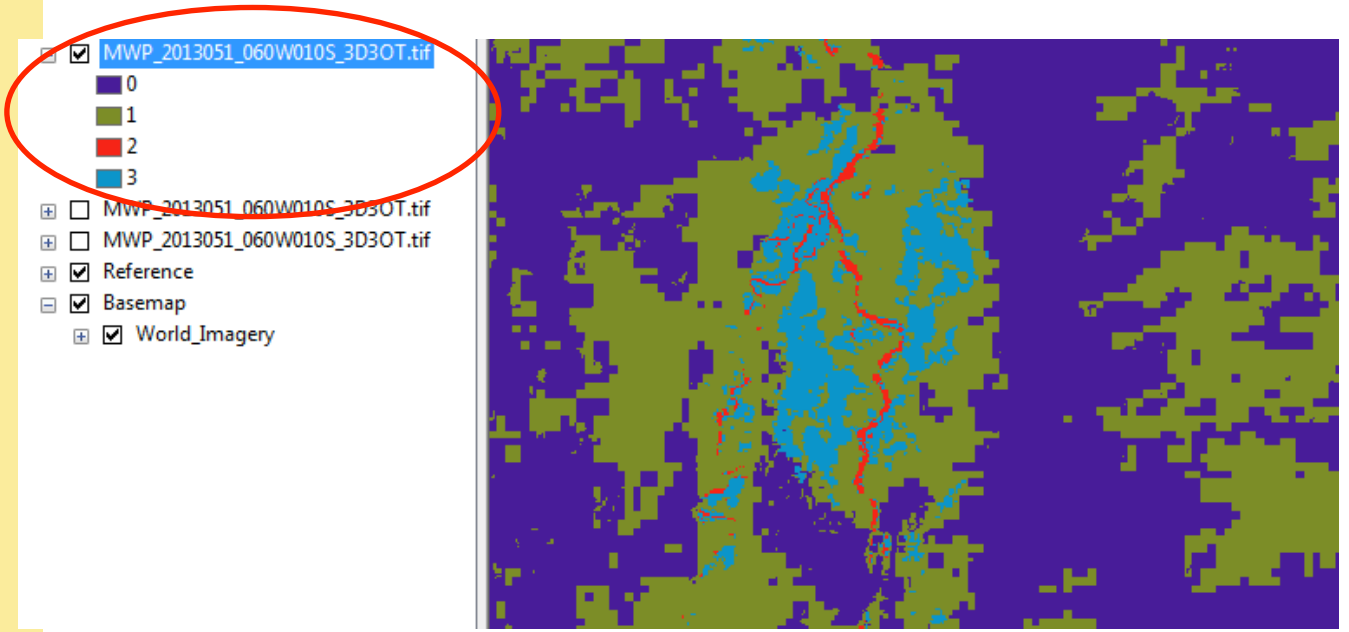
1 = No water detected

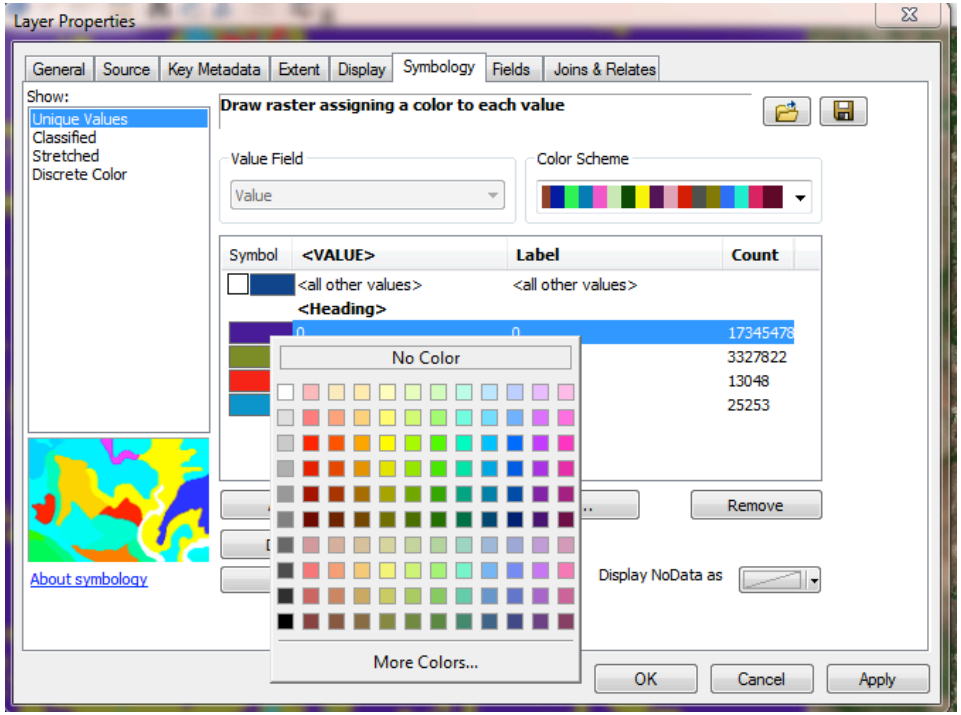
2 = Water detected AND coinciding with reference water (e.g., not flood)

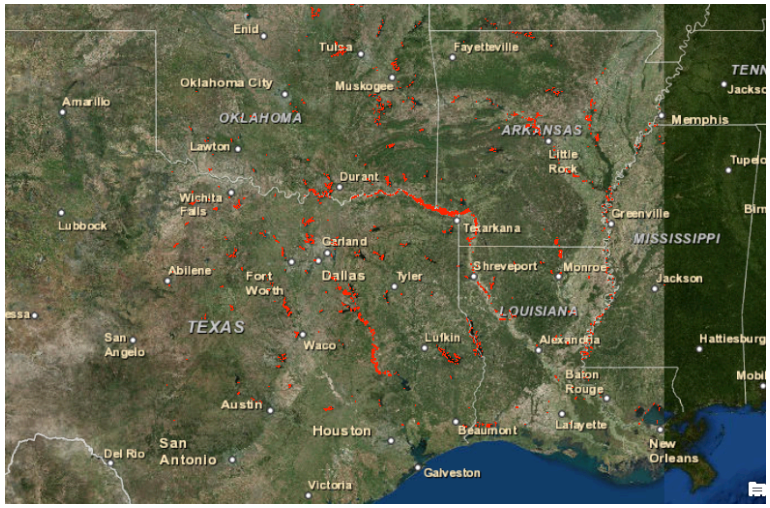
3 = Water detected, beyond reference water, so is likely flood

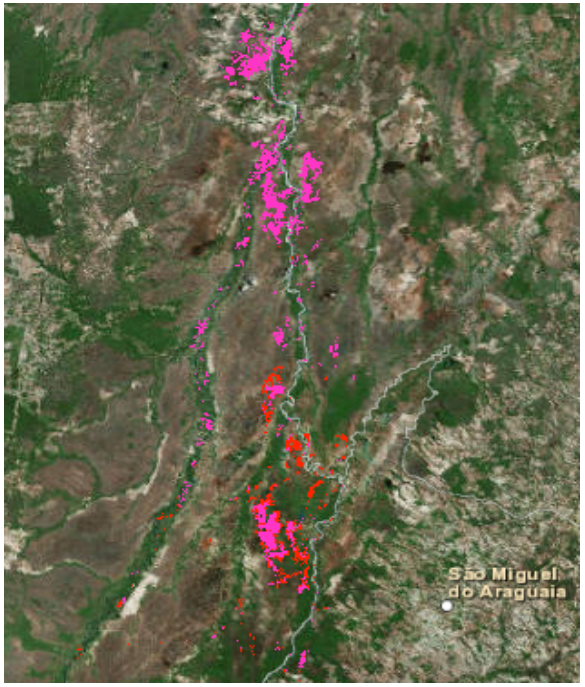
You can adjust the symbology of the geotiff file through through the layer properties, symbology tab. Within the Show window, choose Unique Values and alter the colors assigned to each pixel category.

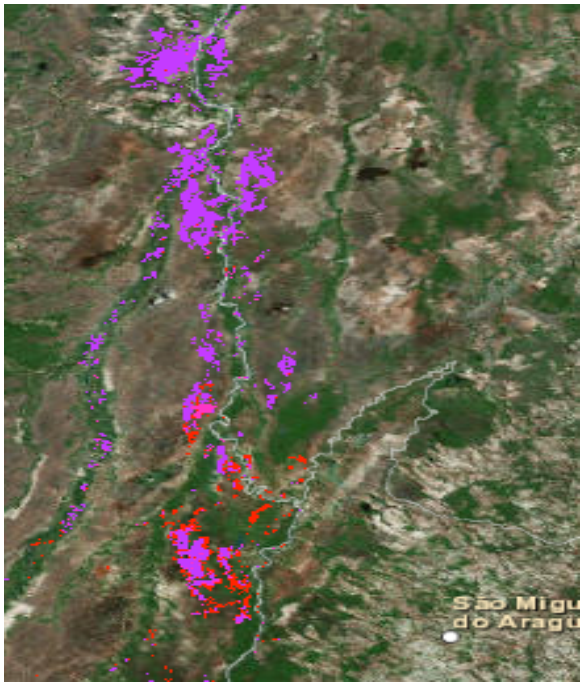
For example :
0=No color
1=No color
2=Blue
3=Red











Repeat the process for all files for your chosen dates

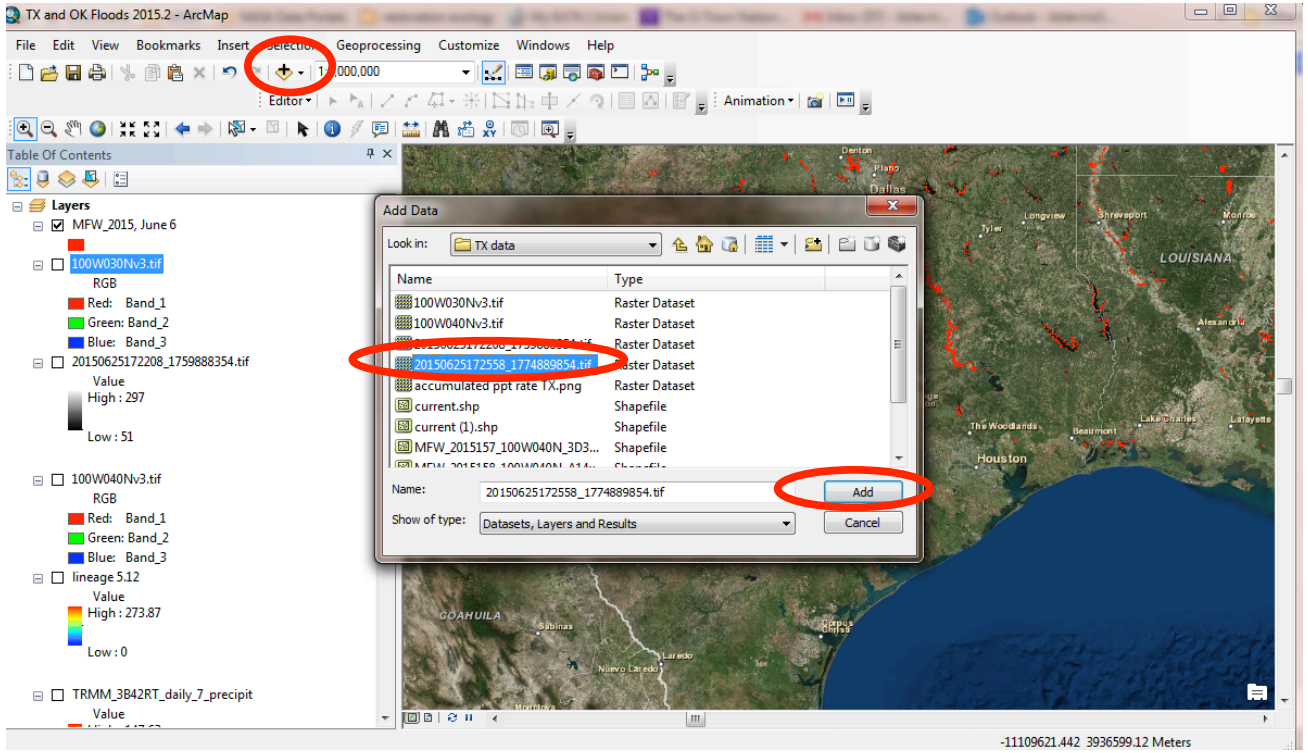
Assigning different colors for each of the following dates can assist in visualizing inundated lands over time.

Import into GIS (ArcMAP): SRTM terrain data

SRTM geotiff files can be easily imported into ArcMap.

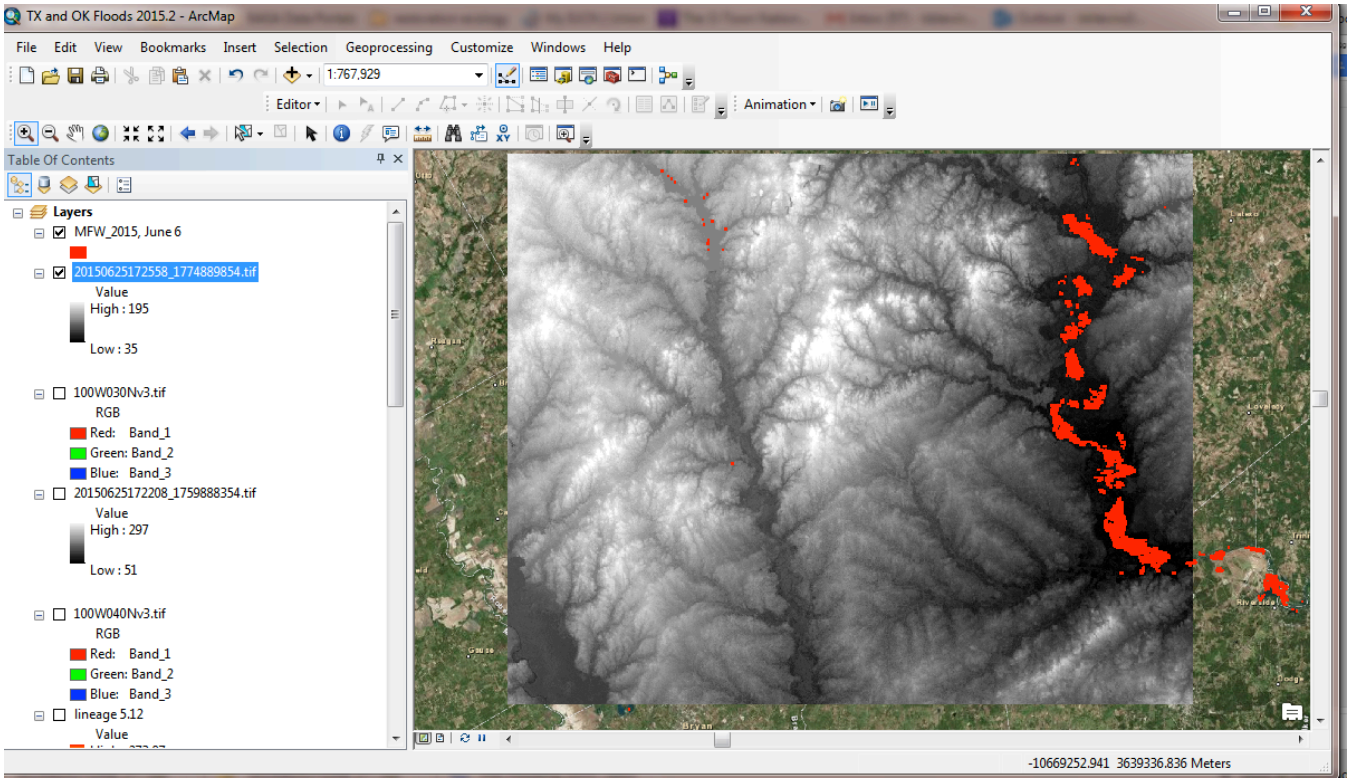
Open the Add data icon and click Add Data

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

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 ERDS	TRMM/ TMPA-RT TRMM/ TMPA-RT	Rain Rate Rain rate	NRC-CN[1] ----------
GFMS	TRMM/ TMPA-RT MERRA	Rain Rate Surface Temperature Winds	VIC- UMD DRTR[2]

[1]Natural Resources Conservation Service (NRCS) runoff curve number (CN) method
[2]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-housr 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 DFO &GDACS/ GFDS Experimental	Global 250 m and 10 km	Same as MODIS NRT. River discharge data derived from TMI (now GMI) and AMSR/ AMSR2*

*AMSR : Advanced Microwave Scanning Radiometer flying on Aqua satellite (2002-2011) and 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

Homework Assignment Link

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

Due by July 20, 2015

Certificate of Completion

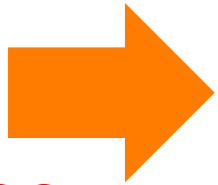
In order to obtain a certificate of participation for attending this training, follow this link and fill out the online form:

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

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Thank You!