National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

NASA Flood Monitoring and Mapping Tools

Outline

- Overview of Flood Monitoring Tools Based on Remote Sensing Observations
  - Global Flood Monitoring System (GFMS)
  - Extreme Rainfall Detection System-2 (ERDS2)
  - MODIS Near Real Time (NRT) Flood Mapping
  - Dartmouth Flood Observatory (DFO)

- Demonstration of GFMS, ERDS2, MODIS NRT and DFO

Examples of Flood Monitoring Tools Based on Remote Sensing Observations

NASA Remote Sensing Observations for Flood Monitoring

https://arset.gsfc.nasa.gov/disasters/webinars/advfloodwebinar

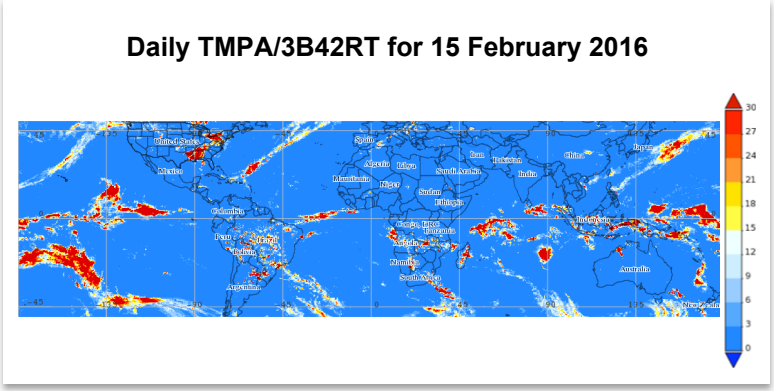
There are three approaches to using remote sensing observations for flood monitoring:

1. Hydrology models that derive streamflow & runoff, using rainfall and weather data from satellites.
2. Infer flooding conditions using satellite-derived precipitation
3. Detect flood water on previously dry land surfaces using satellite-derived land-cover observations

NASA Rainfall Observations Used in Flood Monitoring Tools

TRMM Multi-satellite Precipitation Analysis (TMPA)

- Combines precipitation from TRMM and several national/international satellites to obtain 3-hourly, 0.25°x0.25° resolution data with **global coverage between 50°S to 50°N**
- TMPA will be replaced with Integrated Multi-SatellitE Retrievals (IMERG) for Global Precipitation Measurement (GPM)



data with half-hourly, 0.1°x0.1° resolution and **global coverage between 65°S to 65°N**

Note: TRMM is no longer flying, but TRMM-based calibration is used to provide near real-time rainfall from a constellation of national & international satellites for flooding applications. Near real-time IMERG data is also available from: ftp://jsimpson.pps.eosdis.nasa.gov

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    - Global Flood Monitoring System (GFMS) http://flood.umd.edu

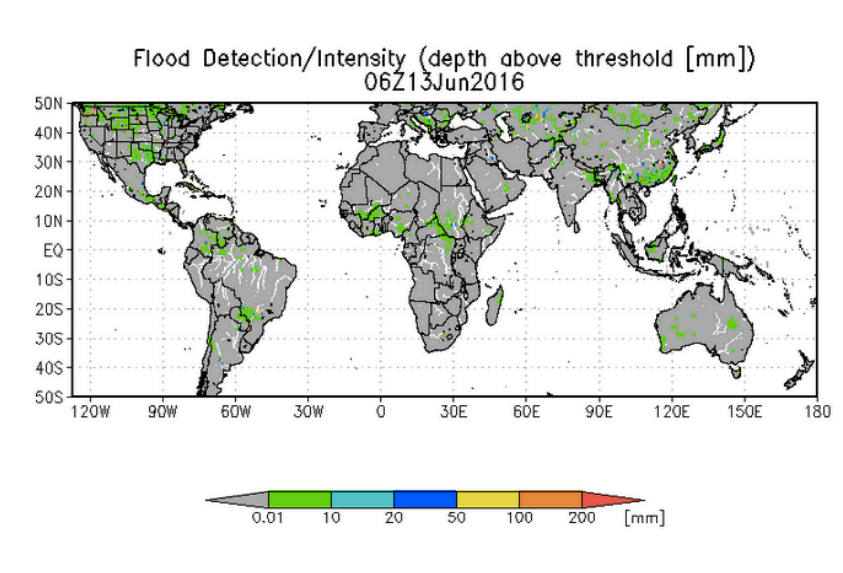
Global Flood Monitoring System (GFMS)

GFMS

http://flood.umd.edu

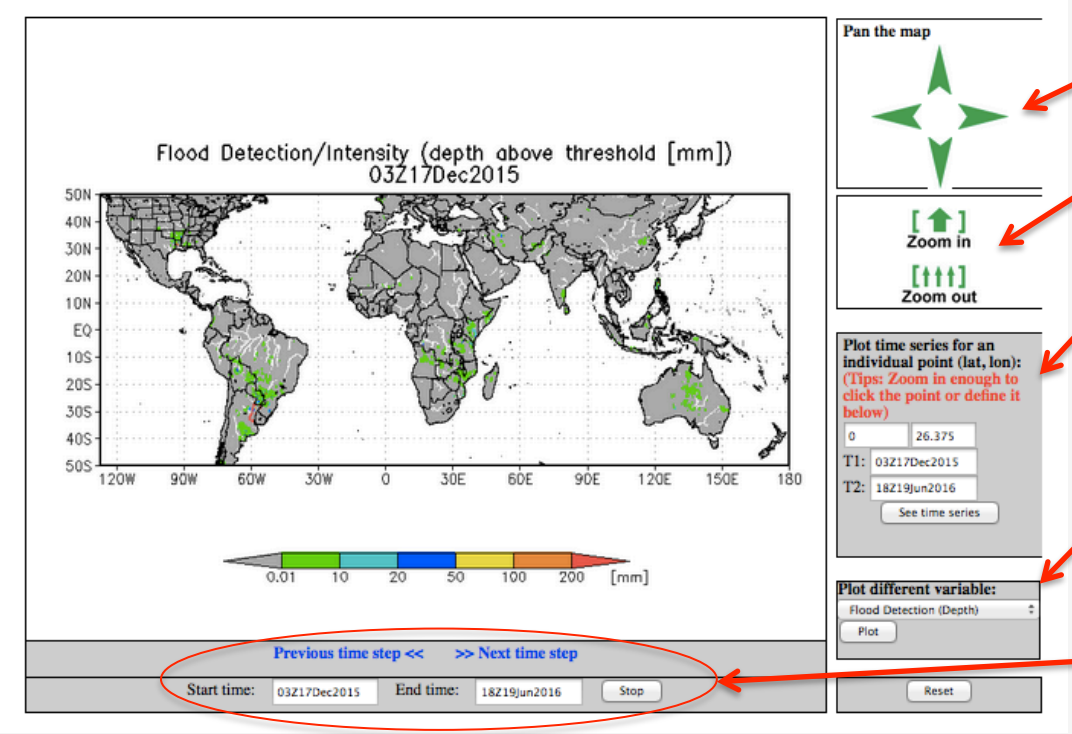
Provides global maps, time series, and animations (50°S-50°N) of:

- Instantaneous Rain
- Accumulated rain over 24, 72, and 168 hours
- Streamflow rates and flood detection at 1/8th degree (~12 km) and also at 1 km



GFMS Features

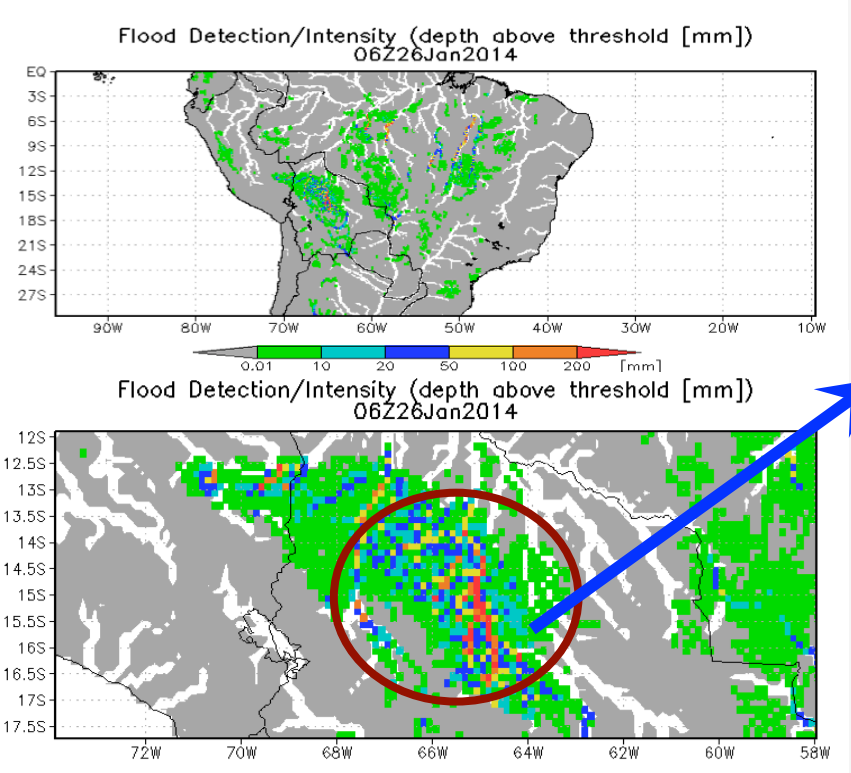
http://flood.umd.edu

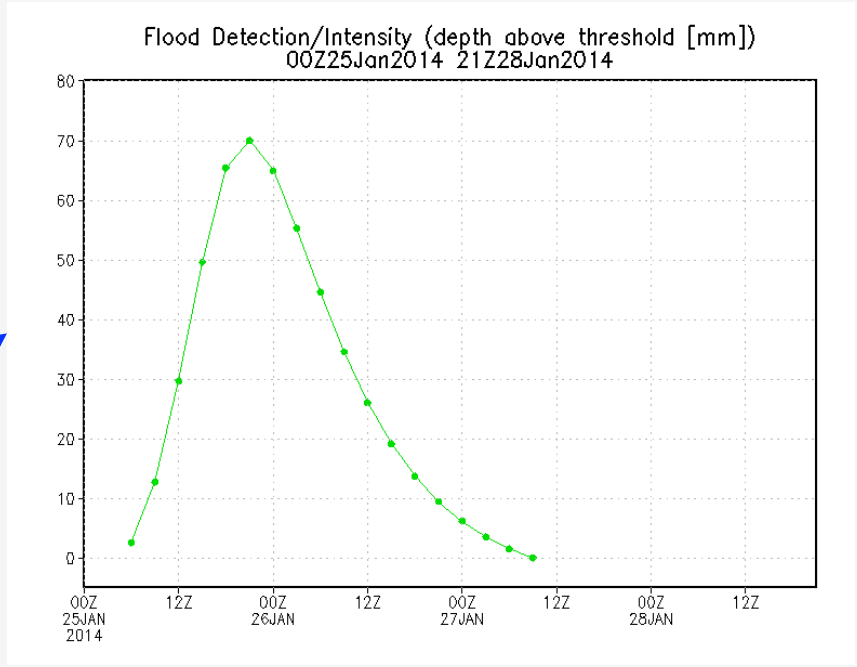


- Map navigation
- Zoom in/out
- Select individual grid point for data for time sequence
- Plot different variables
- 3-hourly output

Flooding in Bolivia – January 26, 2014

http://flood.umd.edu





NASA Remote Sensing Observations for Flood Monitoring

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There are three approaches to using remote sensing observations for flood monitoring:

2. Infer flooding conditions using satellite-derived precipitation

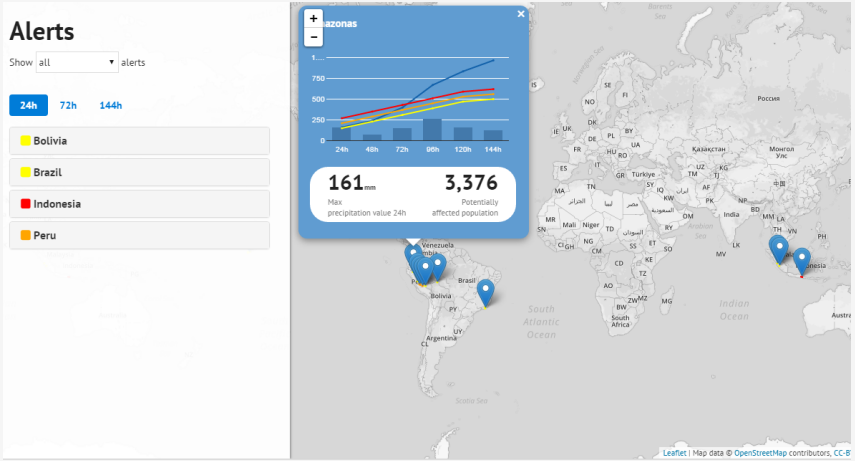
    - Extreme Rainfall Detection System (ERDS): http://erds.ithacaweb.org/

Extreme Rainfall Detection System (ERDS)

ERDS

http://erds.ithacaweb.org/

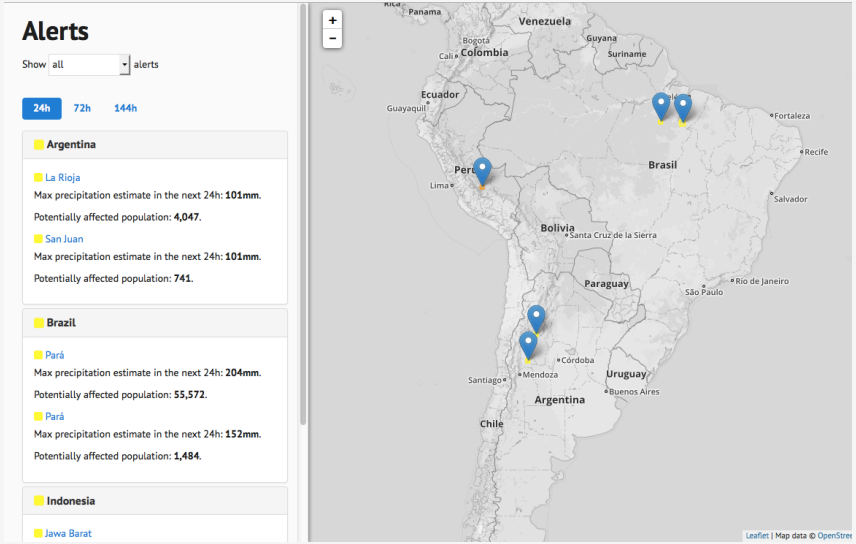
- Near real-time TRMM and NOAA-Global Forecasting System (GFS) data for monitoring & forecasting accumulated rainfall
- TRMM historical archive is used for calculation of extreme rainfall thresholds
- TRMM near real-time rainfall amount, GFS forecasted rainfall information, & reference data combine to generate flooding event-specific information



ERDS

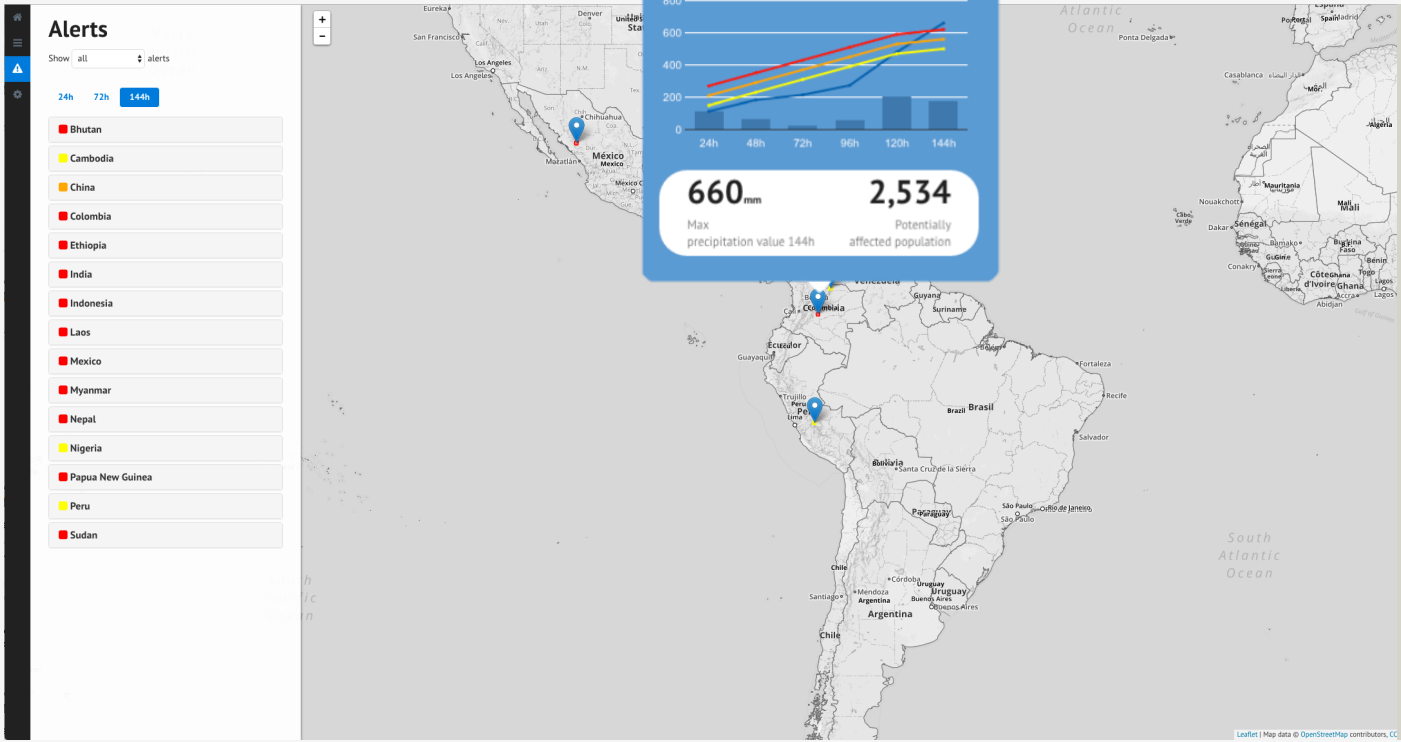
http://erds.ithacaweb.org/

- Global maps and time series of near real-time (50°S-50°N) and forecasted accumulated rainfall over 24, 48, 72, 96, 120 & 144 hours
- Extreme rainfall alerts at 0.25°x0.25° level and at administrative districts level
- Event-specific information, including:
  - the list of the affected countries
  - an estimation of the affected population
- Currently the ERDS system is one of the tools used by OMEP, UN World Food Programme (WFP) Emergency Preparedness Unit



ERDS Alerts

http://erds.ithacaweb.org



72-hour alert in Meta River, Colombia, provided on 27th June 2016

Maximum Rain forecast and potentially affected population

Inundation Mapping

Using Satellite-Derived Land-Cover Observations

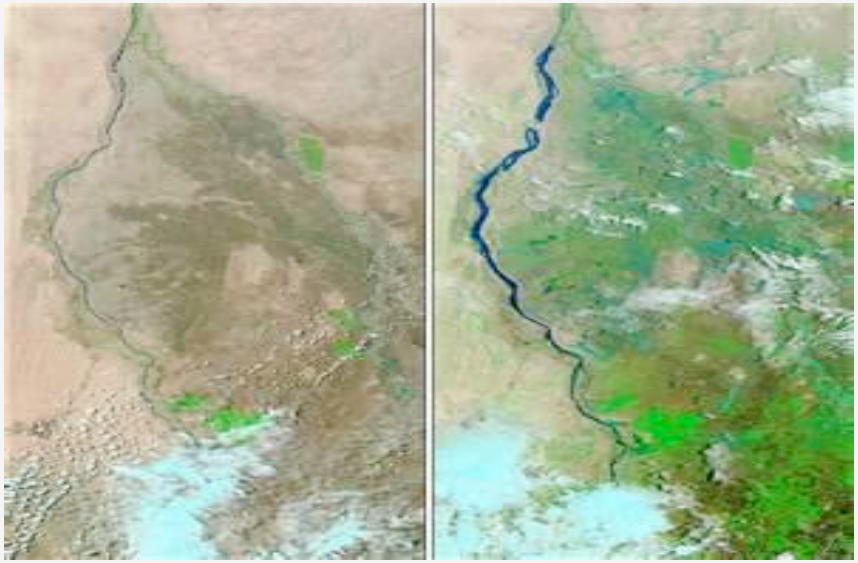
3. Detect flood water on previously dry land surfaces by using satellite-derived land-cover observations
   - **MODIS NRT Global Flood Mapping:** http://oas.gsfc.nasa.gov/floodmap
   - Dartmouth Flood Observatory: http://floodobservatory.colorado.edu

Inundation Mapping

Using Terra/Aqua MODerate Resolution Imaging Spectroradiometer (MODIS)

- MODIS provides observations of land surface
- Reflectance from bands indicate presence of water on previously dry land
  - 1 (620-670nm)
  - 2 (841-876 nm)
  - 7 (2105-2155nm)
- Global reference database of water bodies formed at 250m resolution
- MODIS cannot see the surface through clouds

Flooding along the White Nile, Sudan
earthobservatory.nasa.gov



MODIS-Aqua
6/19/2003

MODIS- Terra
8/11/2003

MODIS Near Real-Time Global Flood Mapping

MODIS NRT Global Flood Mapping

- Flood mapping based on MODIS reflectance at 250m resolution
- Composited on 2, 3, and 14 days
- Flood maps available in 10°x10° tile
- Permanent water and surface flood water data available
- Cloud shadows or terrain shadows can be misinterpreted as surface water

Provides near real-time and past flood mapping from April 2011.
http://oas.gsfc.nasa.gov/floodmap

MODIS NRT Global Flood Mapping: Available Quantities

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

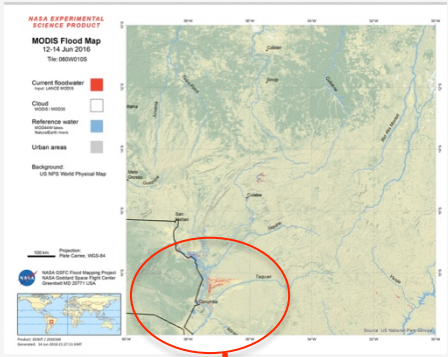
Products		Available Downloads	
MODIS Flood Map	MFM	png	
MODIS Flood Water	MFW	shapefile (.zip)	KMZ
MODIS Surface Water	MSW	shapefile (.zip)	KMZ
MODIS Water Product	MWP	geotiff	
README		pdf	txt

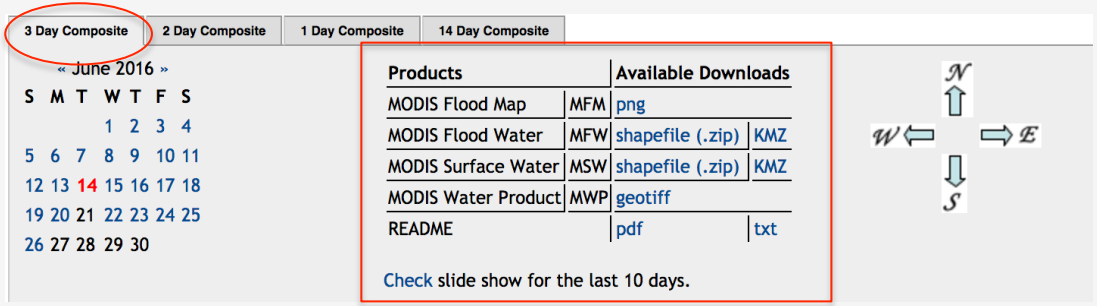
Check slide show for the last 10 days.

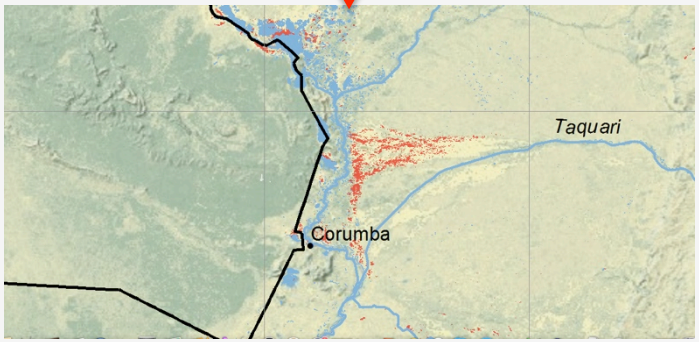
10-day Slides

MODIS Flood Mapping: Flooding in Southern Brazil June 12-14, 2016

3-day Composite







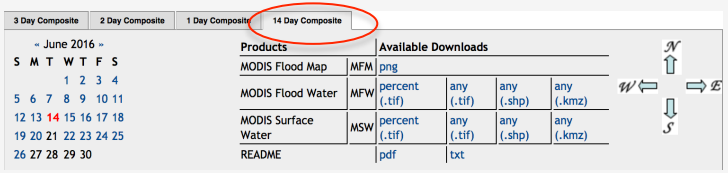
Filename Convention:

PRODUCT_DATE_TILE_COMPOSITE_XTRA.EXT

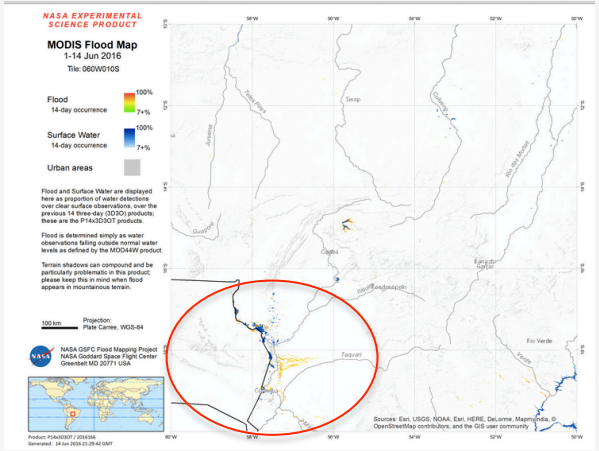
MSW_2012009_020E000S_3D3**O**_V.shp
MFM_2012009_020E000S_2D2**O**.png

(yyyydoy lon-lat 2 or 3 day **O**bservations
(Year and day of year)

MODIS Flood Mapping: Flooding in Southern Brazil 12-14 June, 2016



Composites of the previous 14 days' 3-day product



Similar filename convention with additional processing for composite field:

N: No shadow masking

T: Terrain shadow masking

C: Cloud shadow masking

S: Both terrain & shadow masking

e.g. 2D2OT:
2 days imagery, 2 observations required, terrain shadow masking applied

- Provides occurrence of water as % clear observations over the last 14 days' products
  - GeoTIFF are 0-1 images (1 if % water is >0)

Inundation Mapping

Using Satellite-Derived Land-Cover Observations

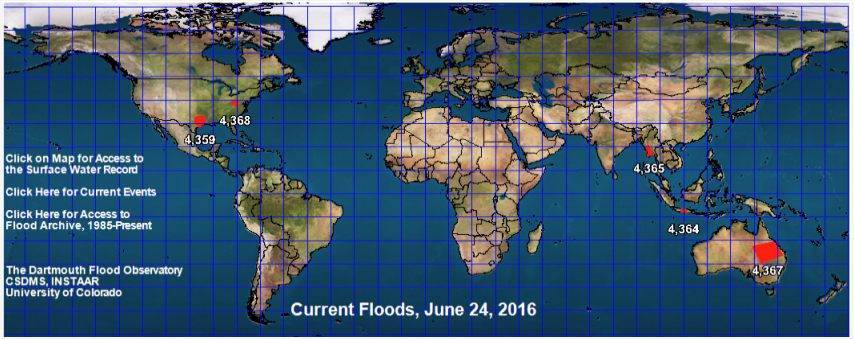
3. Detect flood water on previously dry land surfaces by using satellite-derived land-cover observations
   - MODIS NRT Global Flood Mapping: http://oas.gsfc.nasa.gov/floodmap
   - **Dartmouth Flood Observatory**: http://floodobservatory.colorado.edu

The Dartmouth Flood Observatory (DFO)

DFO

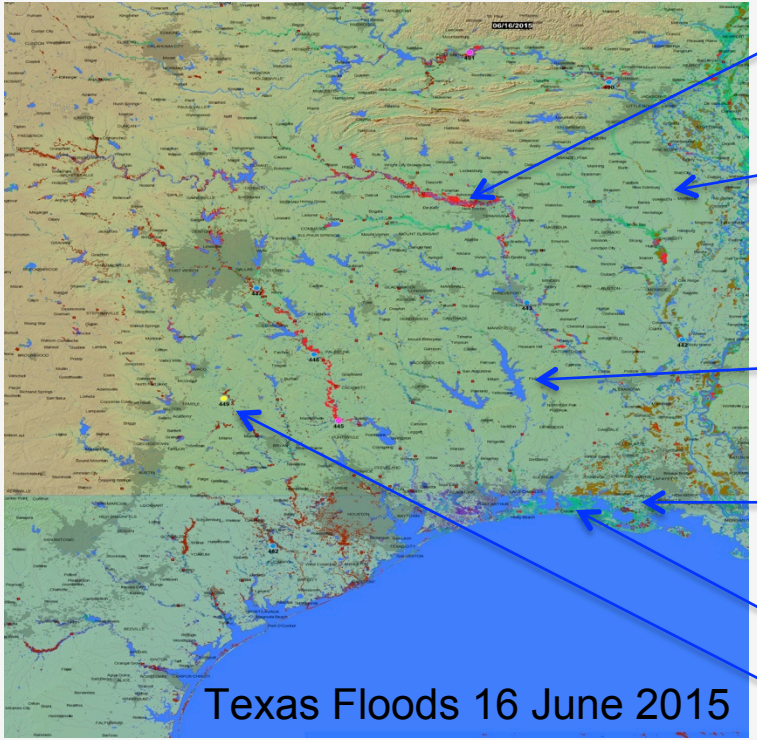
http://floodobservatory.colorado.edu

- Uses flood mapping based on MODIS reflectance
- Also uses Landsat-8 and EO-1 images and COSMO-SkyMed and Sentinel-1 synthetic aperture radar (SAR) images when available
- Experimental river discharge obtained by using Microwave data (AMSR, AMSR-2, TMI, GMI0 and a run-off model)



Provides near-real time flood mapping and current/past flood event mapping

DFO Flood Event Mapping



Red: Flooding within past 14 days (MODIS animated product)

Light Red: Flooding during this event (earlier MODIS coverage of non-automated MODIS mapping)

Dark Blue: Permanent water, Feb 2000 (Shuttle Water Boundary Data)

Darker Red: Flooded areas (High resolution SAR or Landsat 8 data)

Bright Green: Past Floods

Colored dots show *access River Watch Site*

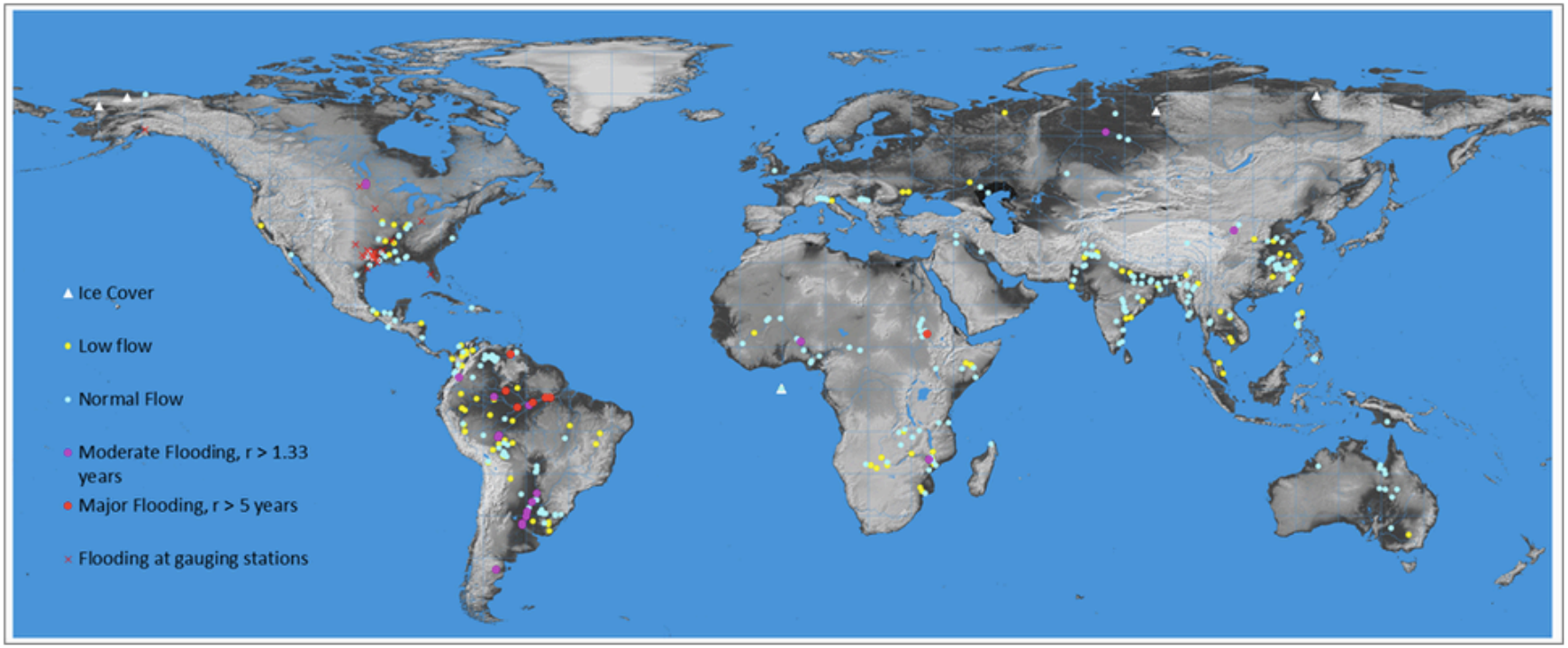
DFO Experimental River Watch

http://floodobservatory.colorado.edu

- Sensitive to portions of water and dry land:
  - Advanced Microwave Scanning Radiometer-2 from GCOM-W (Japanese Space Agency Mission)
  - TRMM Microwave Imager (ended 8 April 2015)
  - GPM Microwave Imager
- **These microwave observations are converted to actual river discharge** by combining them with surface discharge measurements and then to runoff by using a Water Balance Model (WBM)
- Runoff calculations are available starting in 2003, seven-day runoff deviation started in 2003-2007
- Mean runoff is mapped to indicate low, normal, moderate, and major flooding

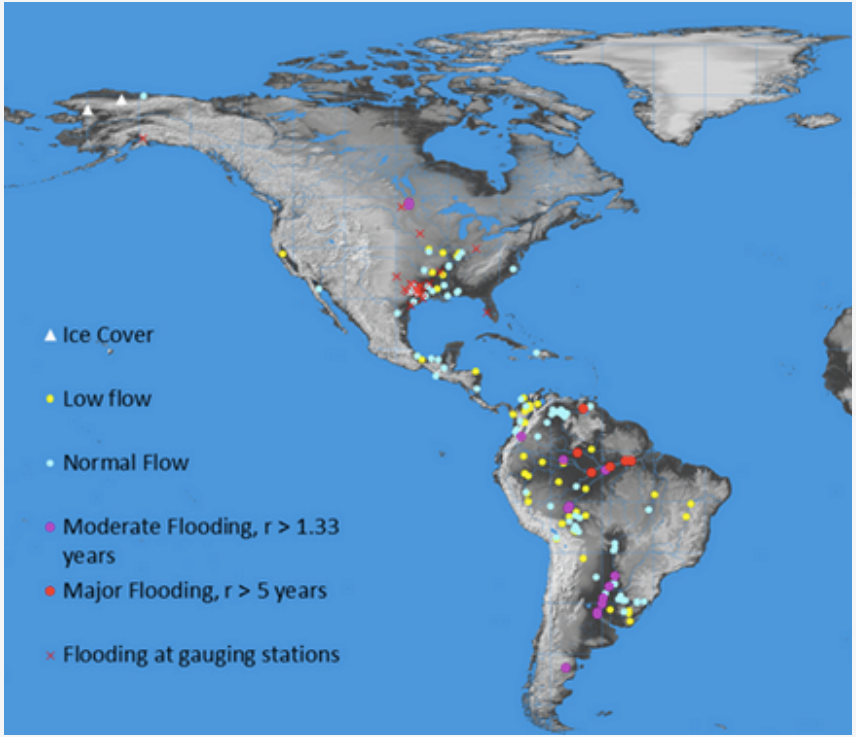
DFO River Watch Locations

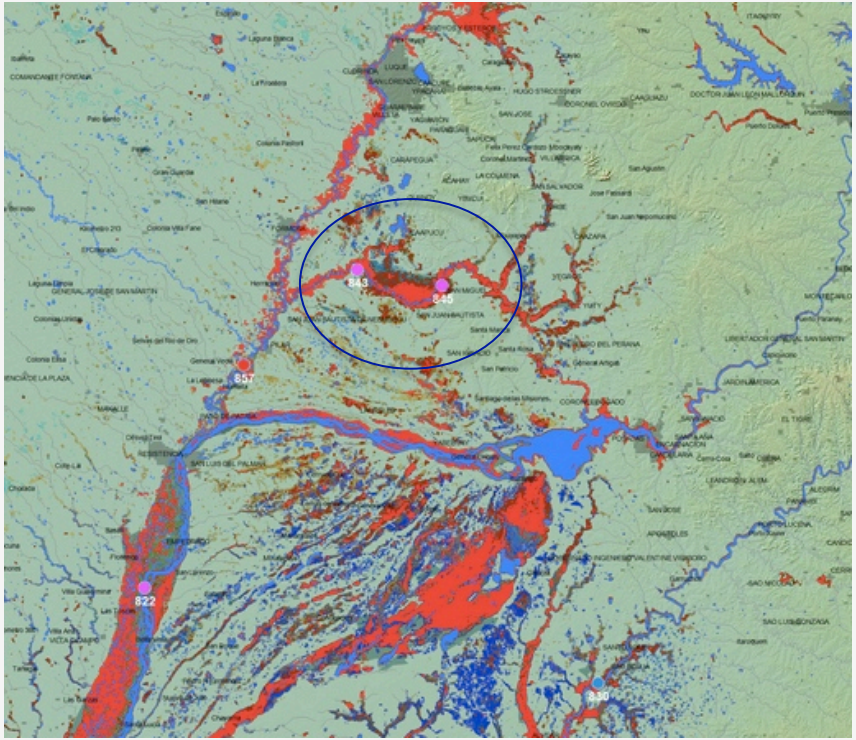
http://floodobservatory.colorado.edu



DFO River Watch Paraguay

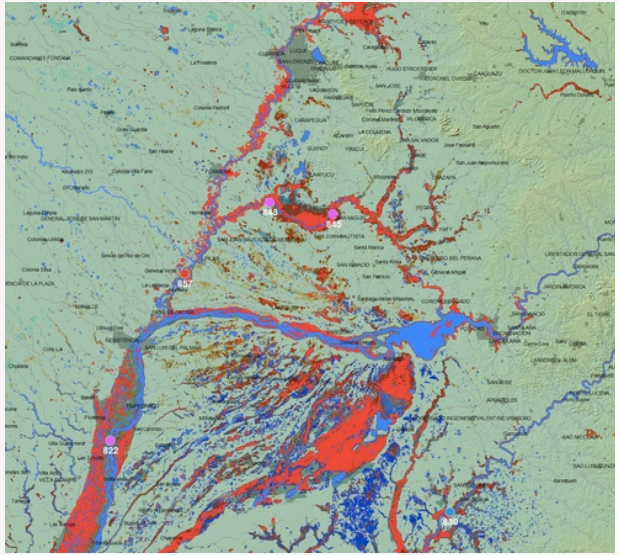
http://floodobservatory.colorado.edu





DFO River Watch Paraguay

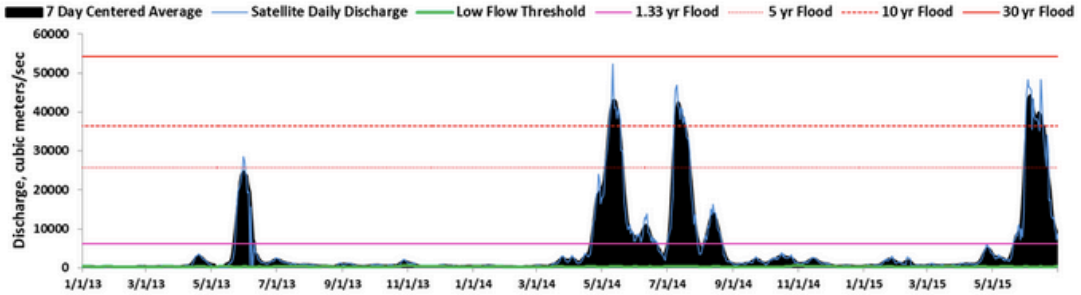
http://floodobservatory.colorado.edu



River Watch Version 2

Experimental Satellite-Based River Discharge Measurements using passive microwave radiometry

DFO Site Number	Site 854 (Paraguay)		Tebicuary	Center:	-57.194	Long.
GFDS Site Number	845		River	Center:	-26.505	Lat.
DRAFT			Paraguay		67905	sq km WBM contributing area
Last measured:	19-Jun-16				Obtain Data	
Average Discharge:	**562**	m3/sec	Status:	**2**	(1, low flow; 2, normal flow; 3, moderate flood; 4, major flood, r >5 yr)	
7-day Runoff	**#N/A**	mm		**#N/A**	(7-day runoff compared to 10 yr average for this date, 2003-2012)	
Recent Record					Technical Summary	



Questions

1. Which flooding tool presented could be used to monitor streamflow?

2. In stormy condition MODIS may NOT provide inundation information. Why?

3. Does the MODIS inundation tool use rainfall information from MODIS for flood detection?

4. Which of the following tools are useful for flood alerts: GFMS, ERDS, DFO?

Live Demonstration: GFMS

Live Demonstration: MODIS NRT

Overview Demo: ERDS

Overview Demo: DFO

Next:

Hands-on Exercise of Flood Mapping