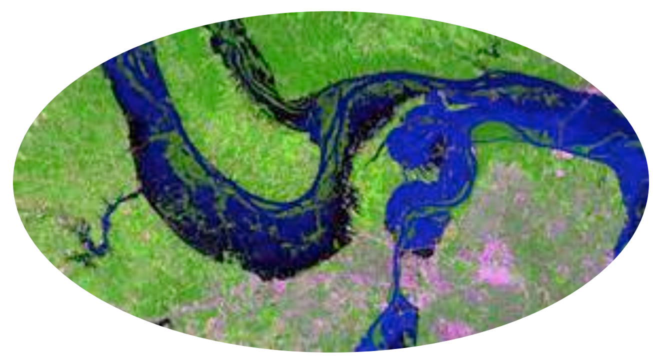
WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET) WEBINAR SERIES

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



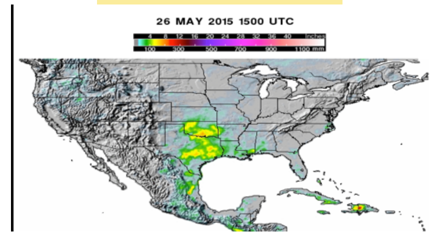
Applied Remote Sensing Training

Webinar Outline

Week 1

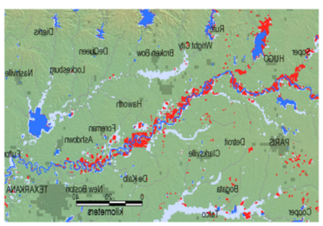
NASA Remote Sensing Data for Flood Management, Introduction to Flood Monitoring Tools

Week 2



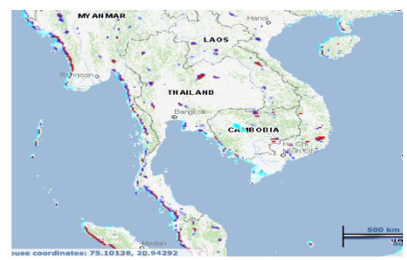
TRMM-based Flood Monitoring Web-tools

Week 3



Regional Flood Management over Africa, Demonstration of the MODIS-based Inundation Mapping

Week 4



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

Training Team

Instructors:

- Amita Mehta (ARSET): amita.v.mehta@nasa.gov
- Brock Blevins (ARSET): bblevins37@gmail.com

Guest Speakers:

- Ashutosh Limaye (NASA): ashutosh.limaye@nasa.gov (Week-3)
- John Bolten (NASA): john.bolten@nasa.gov (Week-4)

Spanish Translation:

- David Barbato (ARSET): barbato1@umbc.edu

General inquiries about ARSET:

- Brock Blevins (ARSET) bblevins37@gmail.com
- Ana Prados (ARSET) aprados@umbc.edu

Important Information

Certificate of Completion (upon request):

You must attend all 4 live sessions

You must submit the homework assignment

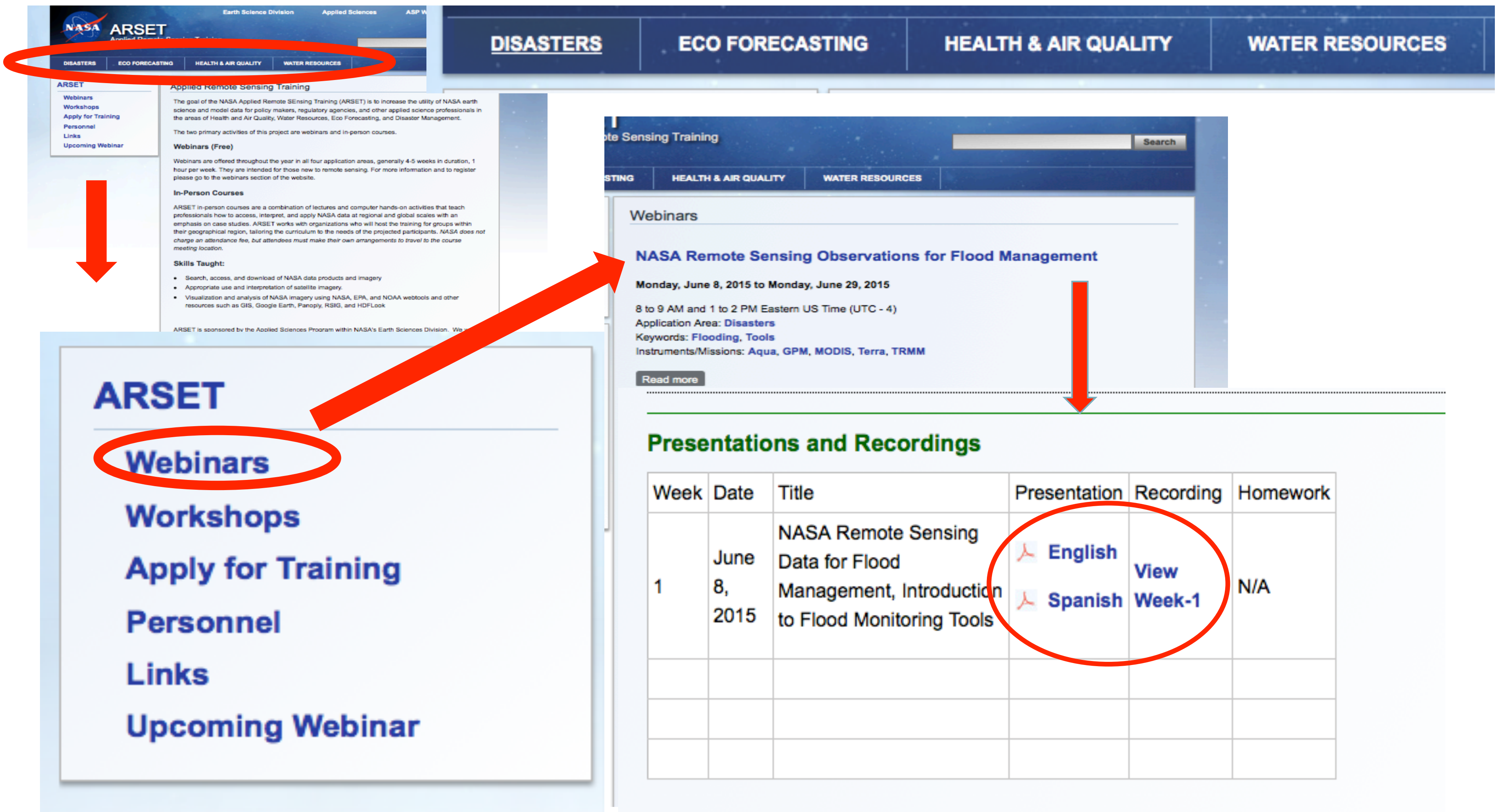
(homework assignment link will be provided after Week-4)

Contact : Marines Martins

Email: marines.martins@ssaihq.com

Access to ARSET Trainings

http://arset.gsfc.nasa.gov



Agenda for Week-2

Overview of the TRMM-based Flood Tools

- Overview of TRMM and GPM
- Overview of TRMM-based Flood Tools:

  i) Current Heavy Rain, Flood, and Landslide Estimates

  ii) Extreme Rainfall Detection System 2

  *iii) (**Experimental River Discharge)** Dartmouth Flood Observatory and The Flood Observatory and Global Disaster Alert and Coordination System/Global Flood Detection System*

  iv) Global Flood Monitoring System (Live Demo)

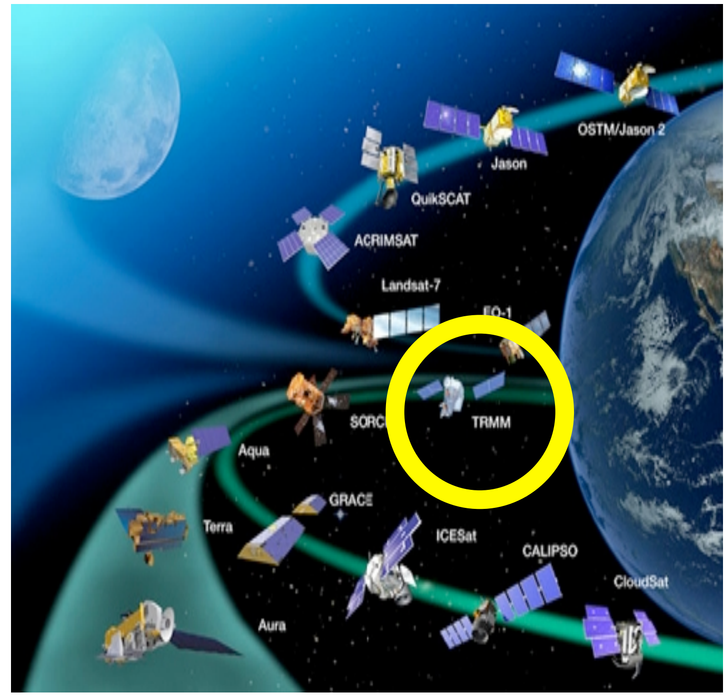
Overview of TRMM and GPM

Joint missions between NASA and the Japan Aerospace Exploration Agency (JAXA)

TRMM: Tropical Rainfall Measuring Mission

http://trmm.gsfc.nasa.gov

- The first satellite mission **dedicated to measuring tropical and subtropical rainfall** - Launched on 27 November 1997
- **First satellite to carry a microwave Precipitation Radar**
- Predecessor to Global Precipitation Measurement (GPM)



TRMM ended in April 2015

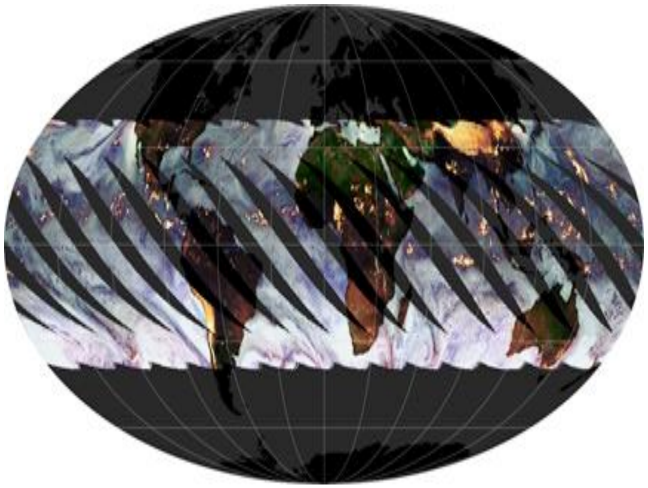
TRMM

http://trmm.gsfc.nasa.gov

- **A non-polar, low inclination orbit**
  Revisit time ~11-12 hours, but time of the observation changes daily

- There are 16 TRMM orbits a day **covering global tropics between 35° S to 35°N latitudes**

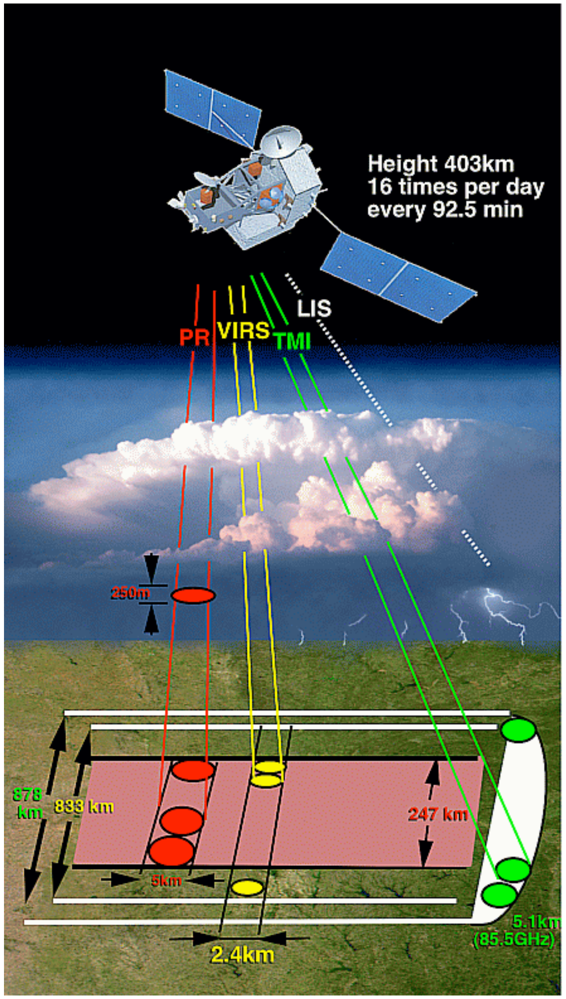
- Altitude - of approximately 350 Km, raised to 403 Km after 23 August 2001



TRMM

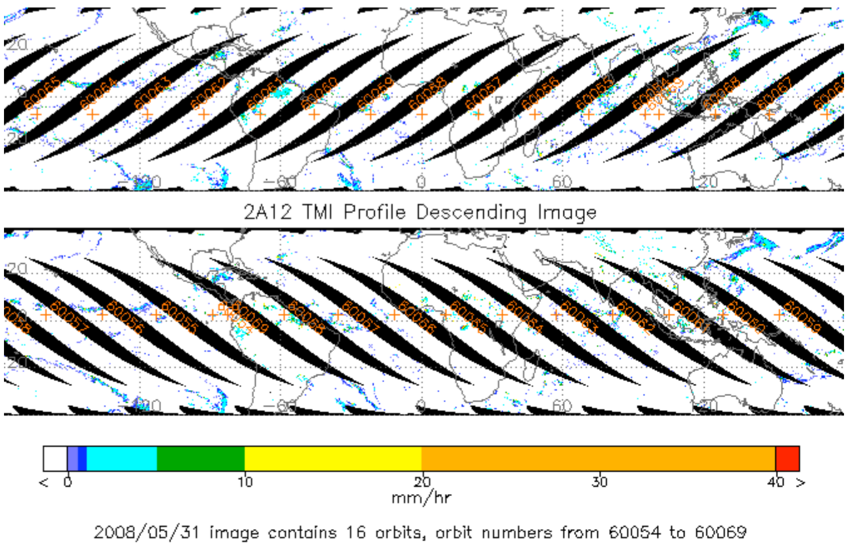
http://trmm.gsfc.nasa.gov

- Multiple sensors
- One active and two passive rain sensors
  *Precipitation Radar (**PR**)*
  *TRMM Microwave Imager (**TMI**)*
  *Visible and Infrared Scanner (**VIRS**)*
- Multiple rain products available from individual sensors, at varying spatial resolutions

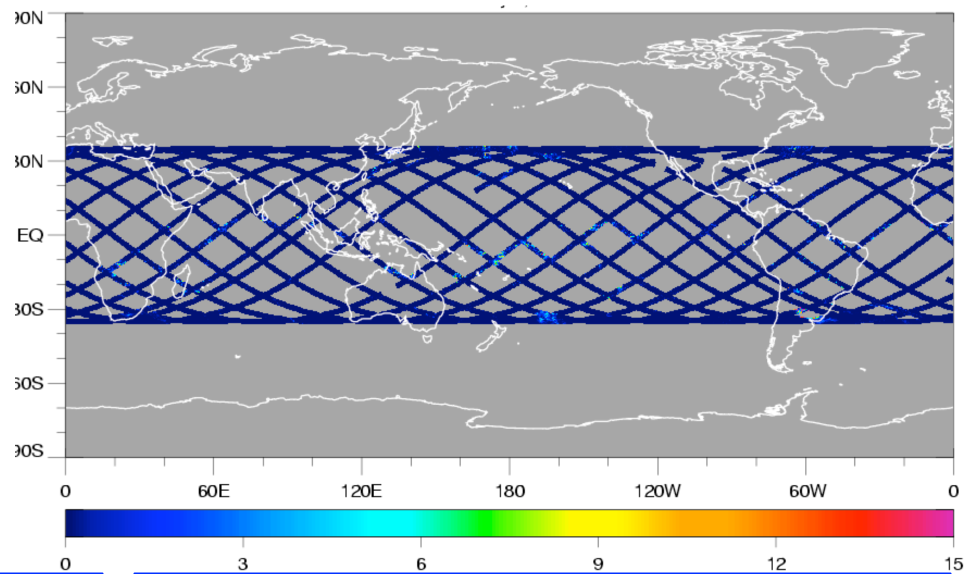


TRMM TMI and PR Measurements

TMI



PR+



Frequencies: 10.7, 19.4, 21.3, 37, 85.5 GHz
Swath: 760 km (870* km)
Resolution: 5 to 45 km (channel-dependent)

Frequencies: 13.6 GHz
Swath: 220 km (247* km)
Resolution: 5 km

* After the orbit was raised in August 2001 +Stopped after October 7, 2014

Strength: High pixel resolution, Accurate measurements
Limitation: **No global, diurnal coverage on daily basis**

TRMM Multi-satellite Precipitation Analysis (TMPA)

(Widely used for Flood Monitoring)

Also referred to as TRMM 3B42 combines data from TRMM and several other satellites to get improved spatial/temporal coverage:

- Combines PR and TMI rain rates
- Inter-calibrates passive microwave rain rates from other satellite sensors
  SSM/II, AMSR and **AMSU-B**
- Inter-calibrates with national and international **geostationary and NOAA low earth orbiting satellites infrared measurements** by using **VIRS**
- Final rain product is calibrated with rain gauge analyses on monthly time scale.

Temporal Resolution :
3-hourly

Spatial Resolution:
0.25°x0.25°

Spatial Coverage:
Global 50°S to 50°N

SSM/I: Special Sensor Microwave Imager – sensor on Defense Meteorology Satellite Project
AMSR: Advanced Microwave Scanning Radiometer – a sensor on NASA Aqua satellite
AMSU:Advanced Microwave Sounding Unit – a sensor on NOAA operational satellite

Global Precipitation Measurement Mission (GPM) Designed to extend, enhance, and improve TRMM Precipitation Data

TRMM Data Limitations:

The mission has ended!

Did not provide measurements beyond 35°S-35°N

TRMM sampling frequency was 15 hours to 4 days at any point which introduces substantial uncertainties in rain estimates

TRMM provided rain measurements but not frozen precipitation, also can not detect light rain (<0.5 mm/hr)

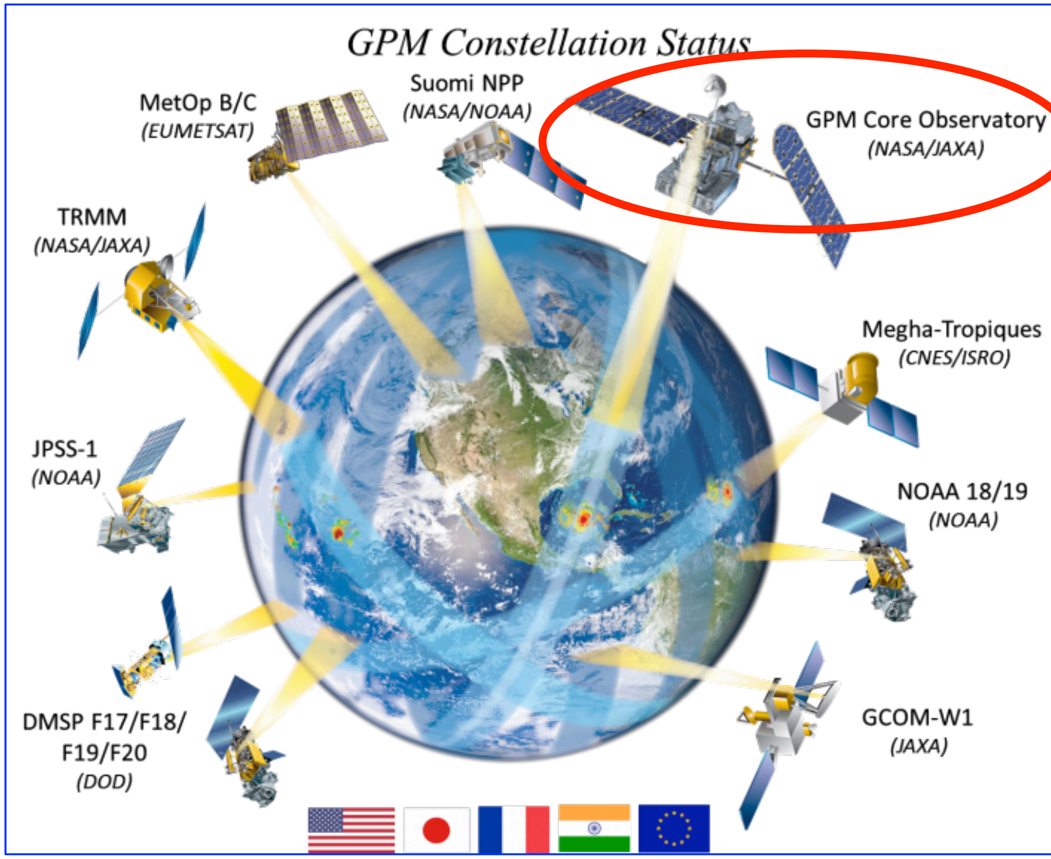
GPM is designed to obtain measurements over tropics and higher latitudes, with advancement of observing light rain and snow

Global Precipitation Measurement (GPM)

http://pmm.nasa.gov/GPM

- An international network of satellites with GPM Core satellite designed to provide global observations of rain and snow
- Initiated by NASA and the JAXA as a successor to TRMM

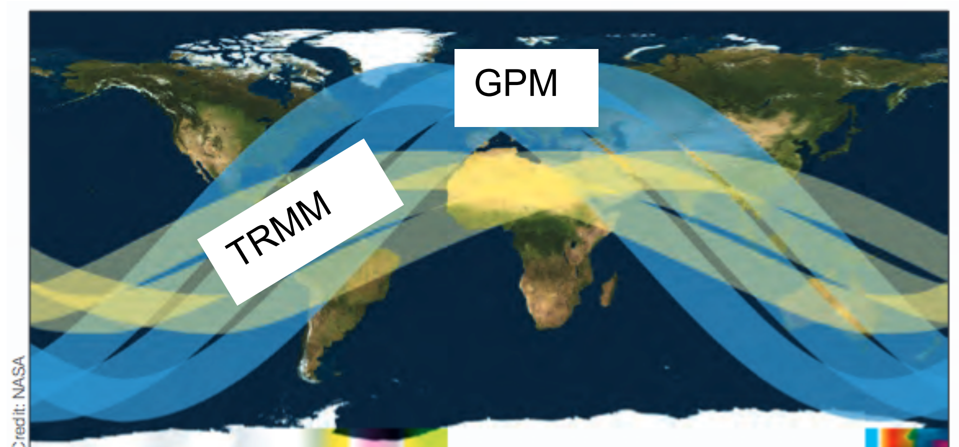
GPM Core satellite was launched on February 27th, 2014



GPM

http://pmm.nasa.gov/GPM

- GPM Core satellite is in a **non-polar orbit,** but along with the constellation satellites has a revisit time of 1-2 hours over land
- There are 16 orbits per day **covering region between 65° S to 65°N latitudes**
- Altitude – 407 km



Area covered by three TRMM orbits [yellow] versus orbits of the GPM Core Observatory [blue]

GPM measurements span middle and high latitudes

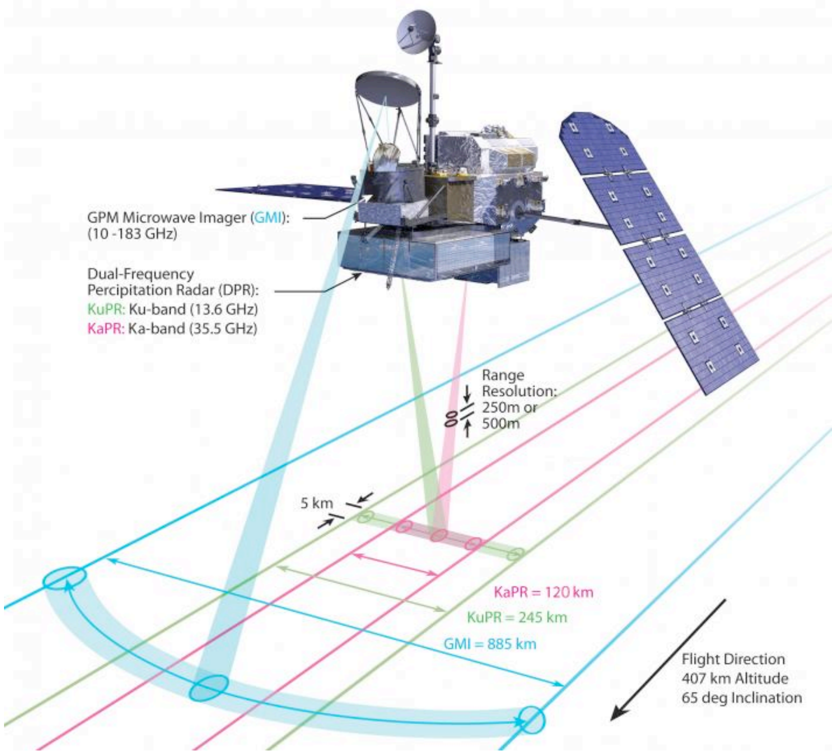
GPM

http://pmm.nasa.gov/GPM

- Multiple Sensors
- One active and one passive rain sensor

  Dual-frequency *Precipitation Radar (**DPR**)*

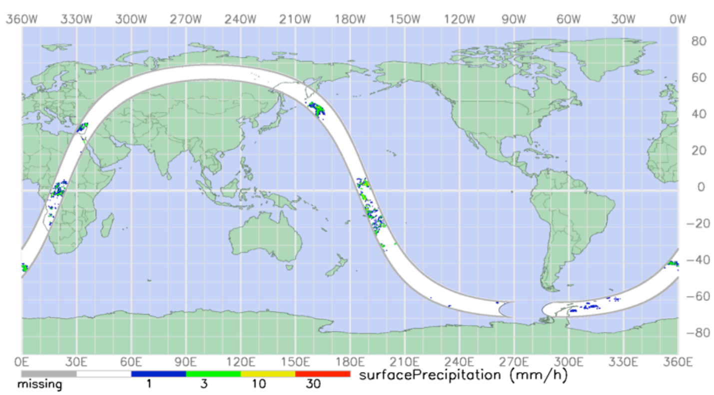
  *GPM Microwave Imager (**GMI**)*
- DPR and GMI – improvement over TRMM PR and TMI



GPM GMI and DPR Measurements

http://pmm.nasa.gov/GPM

GMI



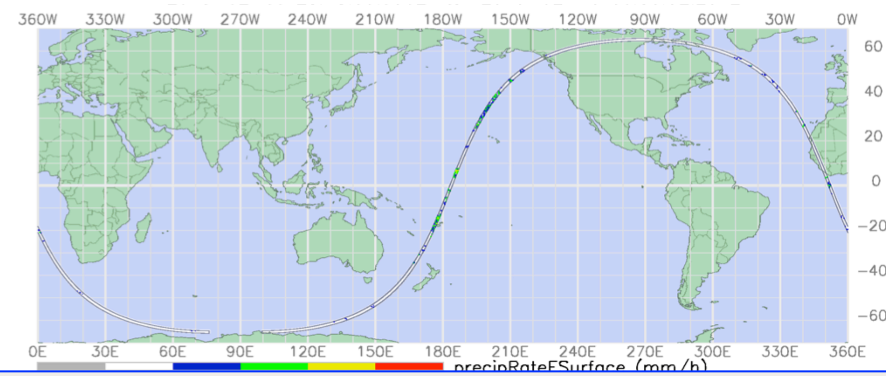
GMI Frequencies:
10.6,18.7,23.8,36.5,89,166 & 183 GHz

Swath width 885 km

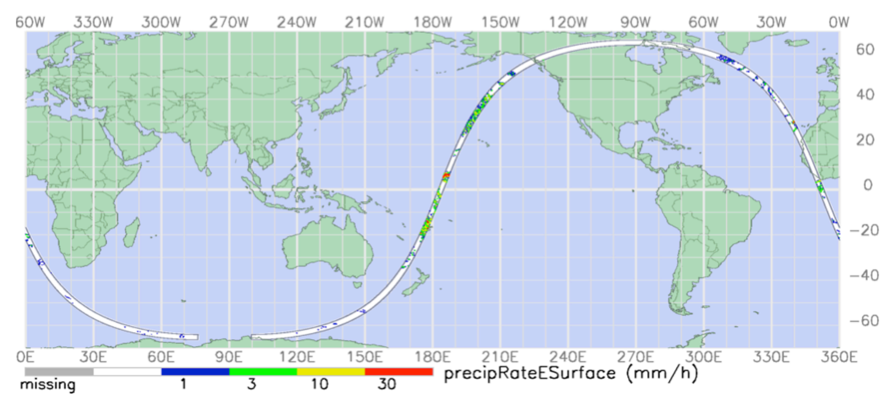
Resolution: 19.4km x 32.2km (10 GHz)
to 4.4km x 7.3km (183 GHz)

Higher spatial resolutions than TMI
High frequencies help measure snow

DPR



Ka 35.5 GHz, Swath Width 120 km, Resolution 5.2 km



Ku 13.6 GHZ, Swath Width 245 km, Resolution 5.2 km

GPM GMI and DPR Measurements

http://pmm.nasa.gov/GPM

GMI

Compared to TRMM TMI:

- Higher spatial resolutions
- Improved light rain and snow detection
- Reference for constellation radiometers calibration

DPR

Compared to TRMM PR:

- Higher sensitivity to light rain and snow
- Better accuracy of measurements
- Better identification of liquid, ice, mixed-phase precipitation particles
- Reference standard for inter-calibration of constellation precipitation measurements

IMERG: Integrated Multi-satellitE Retrievals for GPM

Conceptually similar to TRMM TMPA, combines GPM GMI/DPR data with the GPM constellation satellites to yield improved spatial/temporal precipitation estimates:

	IMERG	TMPA
Temporal Resolution :	30-minutes	3 hours
Spatial Resolution:	0.1°x0.1°	0.25°x0.25°
Spatial Coverage:	Global 60°S to 60°N	Global 50°S to 50°N

Constellation Satellites:
GCOM-W, DMSP, Megha-Tropiques, MetOp-B, NOAA-N', NPP, NPOESS

TMPA and IMERG

Many flood monitoring tools and flood models use TRMM TMPA and will be transitioning to GPM IMERG

TRMM satellite 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 are now also available from **ftp://jsimpson.pps.eosdis.nasa.gov**

Please view ARSET Webinar on TRMM and GPM http://arset.gsfc.nasa.gov/disasters/webinars/global-precipitation for more details bout GPM data and access

Overview of TRMM-based Flood Tools:

i) Current Heavy Rain, Flood, and Landslide Estimates

ii) Extreme Rainfall Detection System 2

iii) The flood Observatory and Global Disaster Alert and Coordination System/Global Flood Detection System

iv) Global Flood Monitoring System (Live Demo)

Overview of Current Heavy Rain, Flood and Landslide Estimates

http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html

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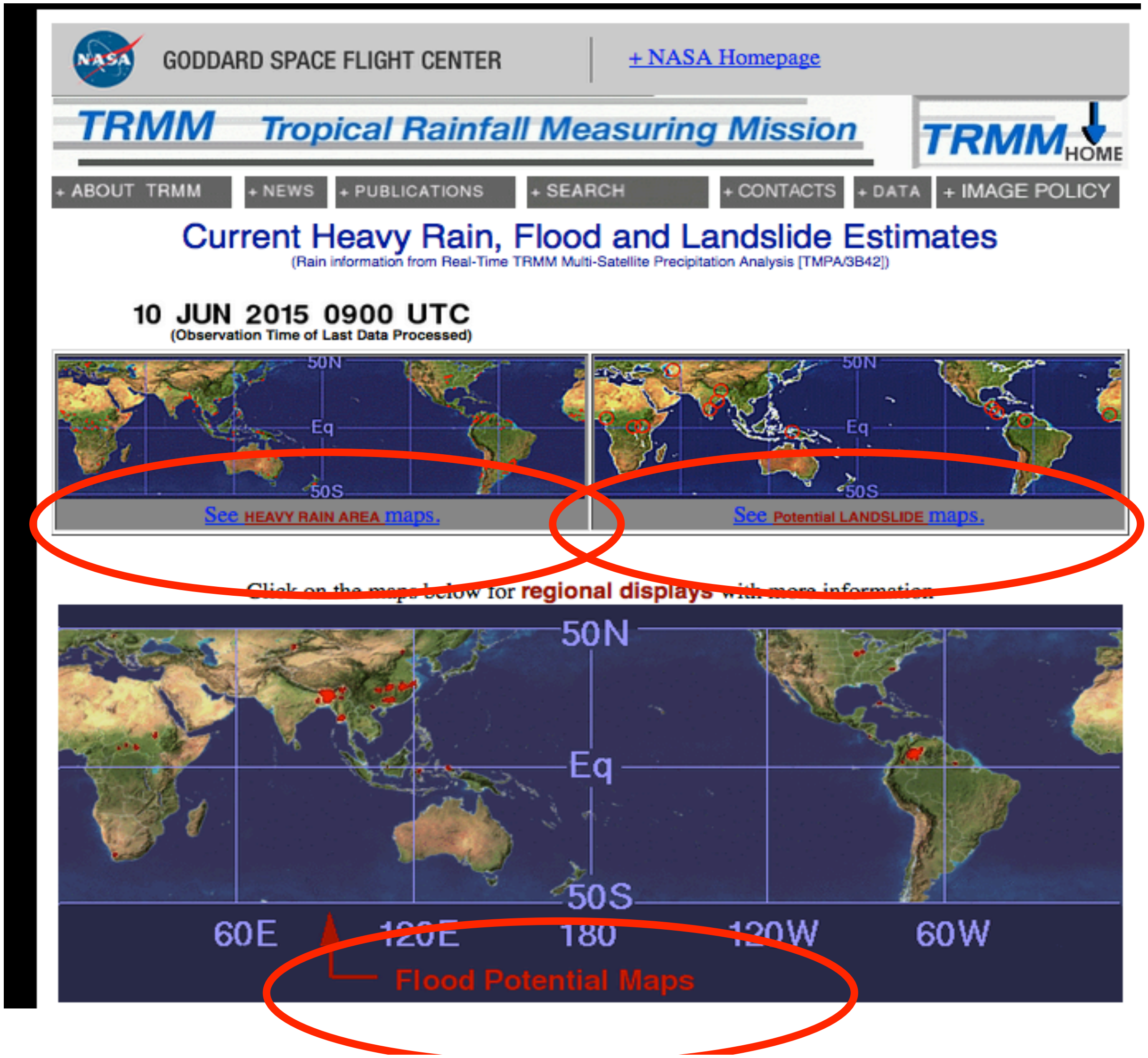

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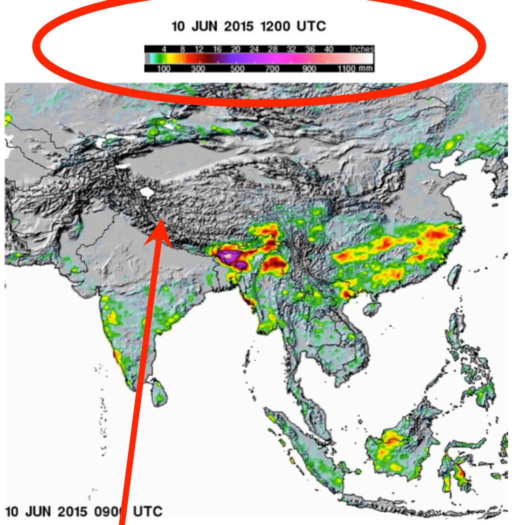
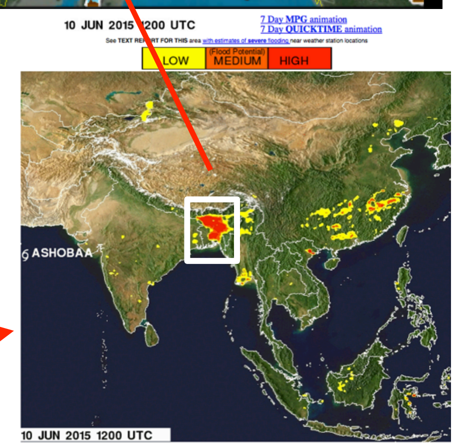


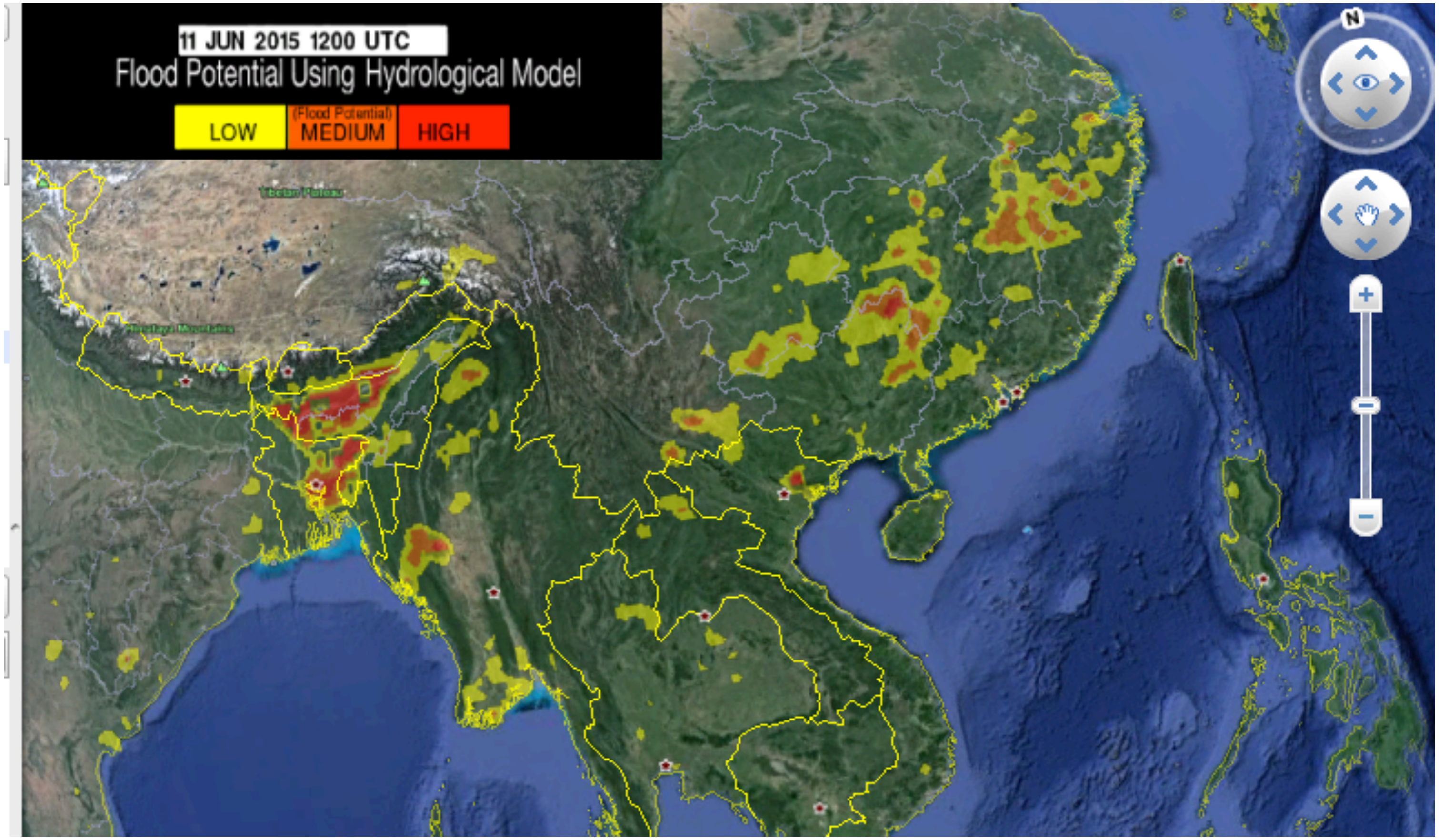


Provides global maps (50°S-50°N) of:

- **Heavy rain**
- **Accumulated rain over 24, 72 and 168 hours**
- **Potential Landslide**
- **Flood Potential**

http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html

24-hour Flood Potential Forecast



Maps available on Google Earth

Extreme Rainfall Detection System (ERDS)

http://playground.ithacaweb.org/apps/world/leaflet/erds2.html#7/30.751/-110.413

Elena CRISTOFORI [1,2], ***Adriana ALBANESE*** [1,3],

[1] ITHACA - Information Technology for Humanitarian Assistance, Cooperation and Action, Torino, Italy

[2] Politecnico di Torino, Torino, Italy

[3] World Food Programme (WFP) - Emergency Preparedness and Response Branch (OMEP), Roma, Italy,

MISSION AND COMPETENCES

Provide scientific analysis and services to the World Food Programme and the broader humanitarian community in support of environmental emergencies for disaster preparedness and response

1. remote sensing
2. hydrology
3. meteorology
4. cartography
5. GIS

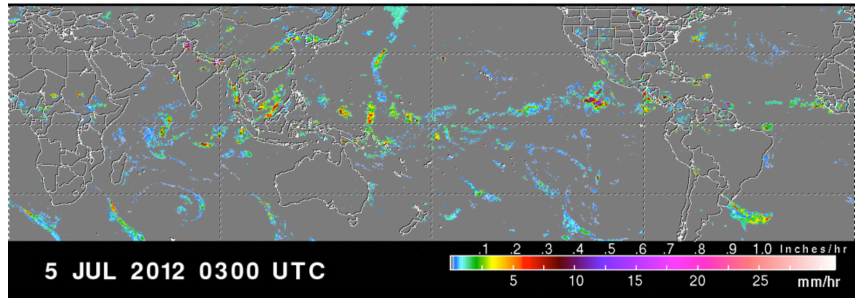
ERDS – Extreme Rainfall Detection System

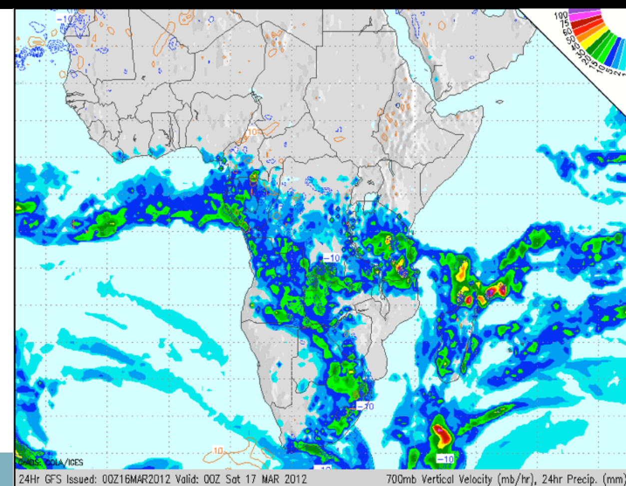
The **Extreme Rainfall Detection System (ERDS)** is a service aimed at providing **timely** and **easy to understand alerts** related to **exceptional rainfalls** and **potential flood events** at a global scale.

INPUT DATA

1. Tropical Rainfall Measuring Mission (TRMM) Multisatellite Precipitation Analysis (TMPA) necessary for the **near-real time detection** of heavy rainfall (0.25° spatial resolution)
2. NOAA-GFS (Global Forecast System) deterministic model necessary for **forecasted precipitation alerts** (0.5° spatial resolution)

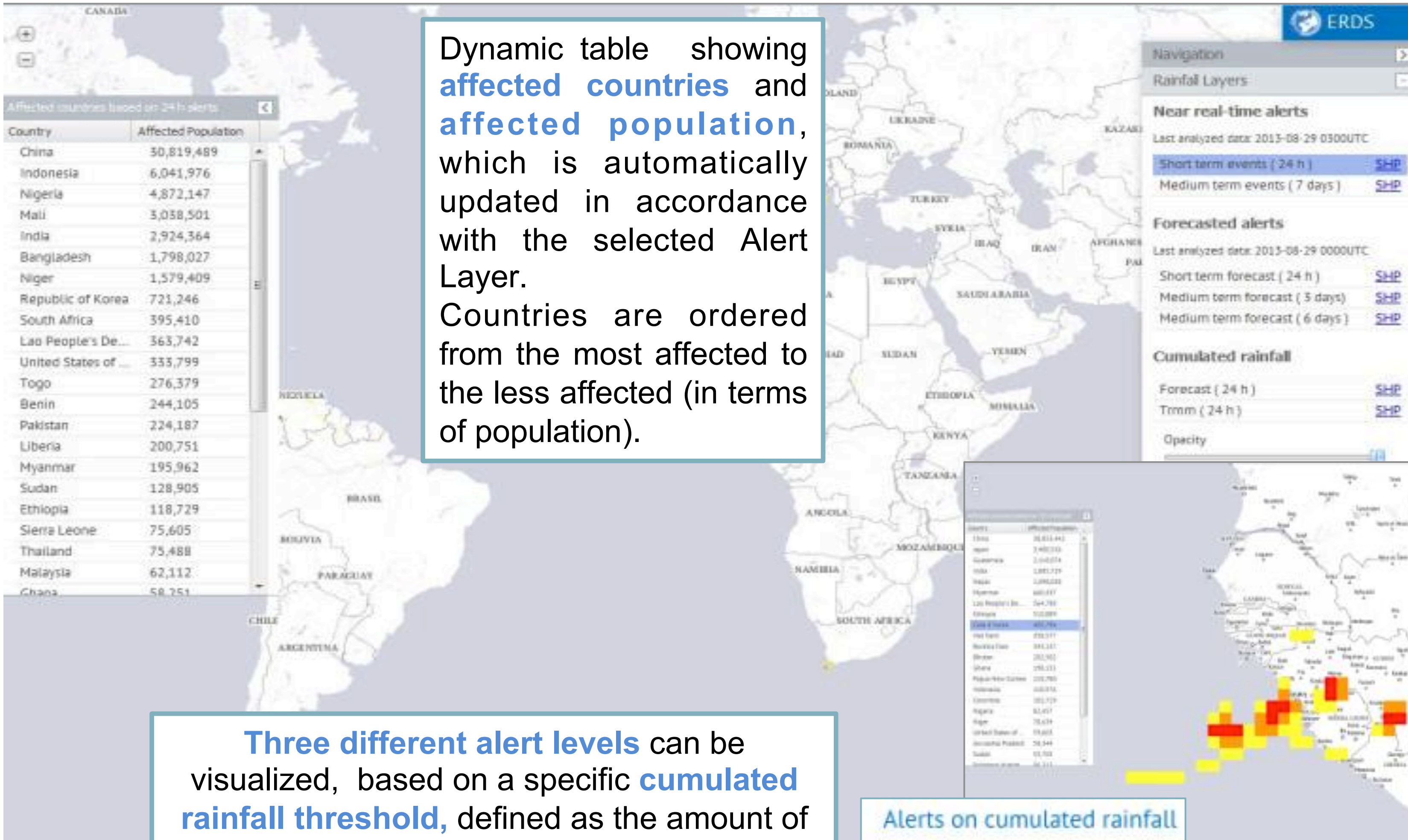
OPEN SOURCE DATA





OUTPUTS

http://playground.ithacaweb.org/apps/world/leaflet/



Dynamic table showing **affected countries** and **affected population**, which is automatically updated in accordance with the selected Alert Layer.
Countries are ordered from the most affected to the less affected (in terms of population).

Alert Layers:
near-real time
and
forecasting alerts.

Three different alert levels can be visualized, based on a specific **cumulated rainfall threshold,** defined as the amount of precipitation for a given duration over a specific climatic area

TRMM/GPM-based Experimental River Discharge

- *Dartmouth Flood Observatory (DFO)*
- *Global Disaster Alert and Coordination System/Global Flood Detection System (GDACS/GFDS)*

Note: DFO also provides inundation mapping. GDACS, in addition to flooding, provides information about other disaster events (e.g. earthquakes and cyclones) using additional remote sensing and in situ data

The Dartmouth Flood Observatory

http://floodobservatory.colorado.edu/

River Watch

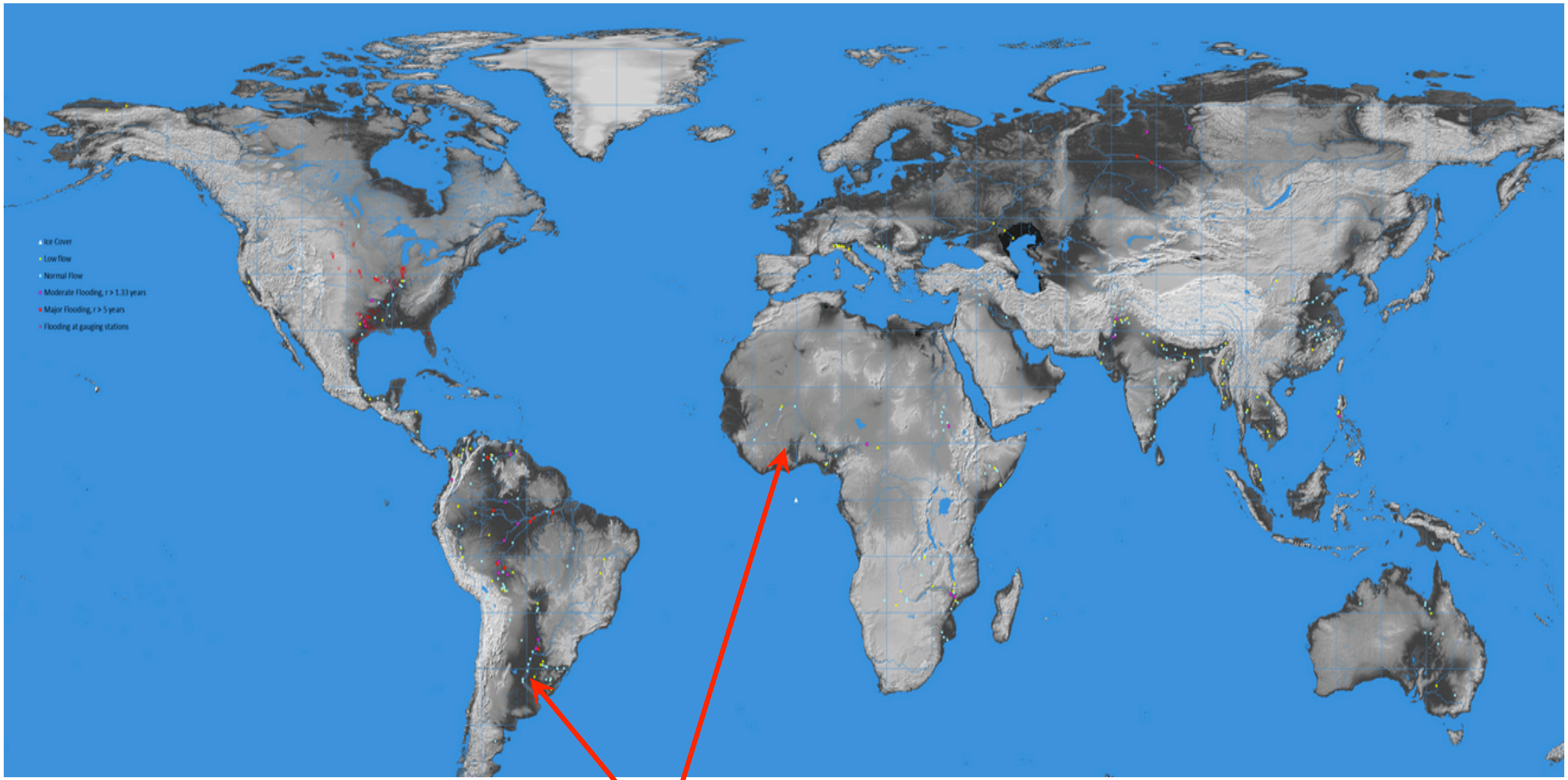
- Advanced Microwave Scanning Radiometer-2 from GCOM-W (a Japanese Space Agency mission), TRMM Microwave Imager, and GPM Microwave Imager observations are sensitive to the proportion of water and dry land.

- **These Microwave observations are converted to actual river discharge** (similar to streamflow, cubic meter of water flowing per second) 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 flooding, and major flooding.

River Watch Version 2
Satellite River Discharge Measurements

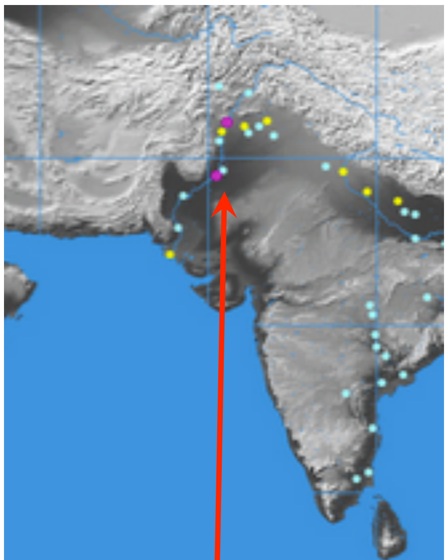
http://floodobservatory.colorado.edu/DischargeAccess.html

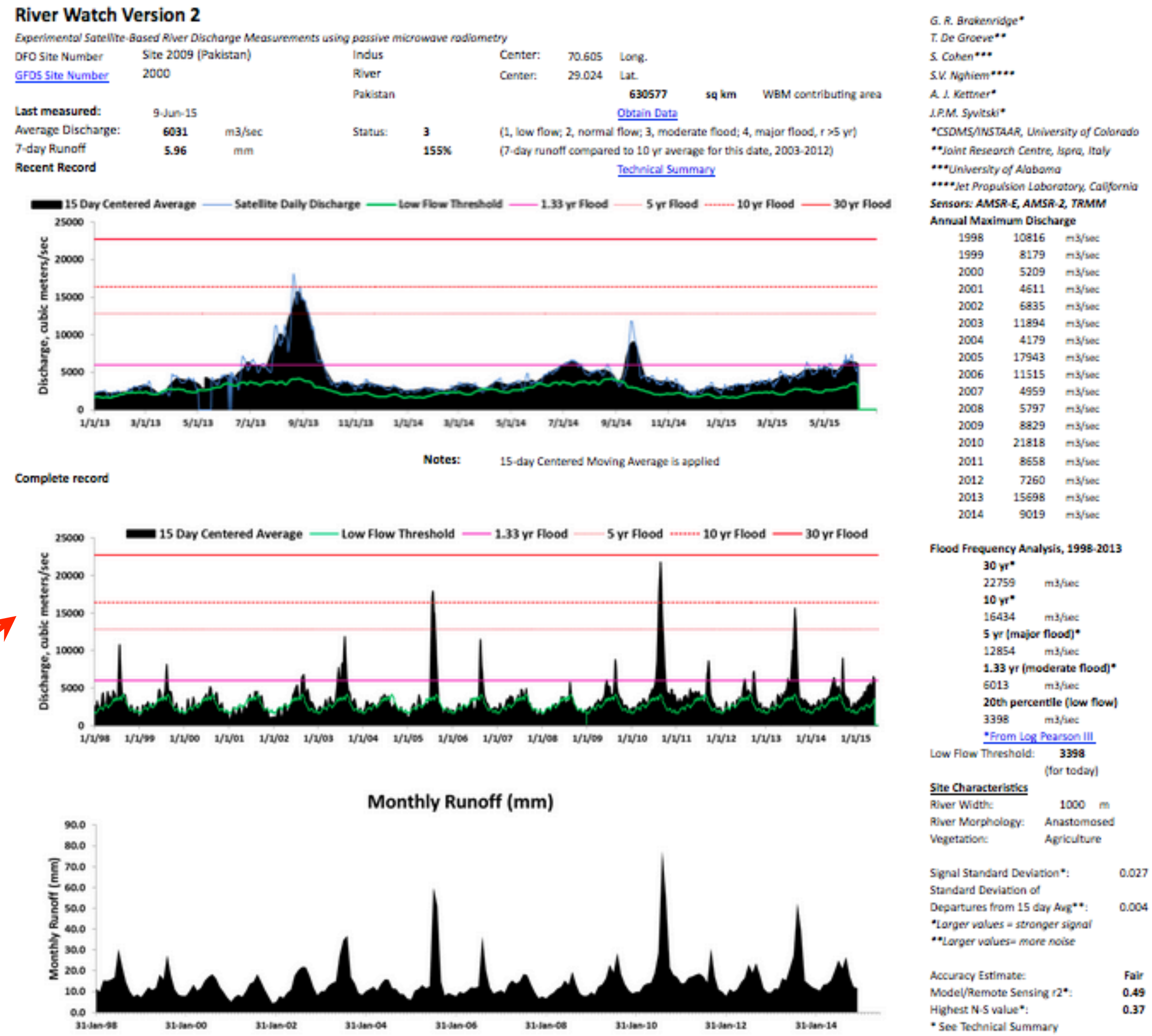


Clickable Dots to see River Discharge Time Series

River Watch Version 2
Satellite River Discharge Measurements

http://floodobservatory.colorado.edu/DischargeAccess.html





River Watch Version 2

Experimental Satellite-Based River Discharge Measurements using passive microwave radiometry

DFO Site Number	Site 2009 (Pakistan)	Indus	Center:	70.605	Long.
GFDS Site Number	2000	River	Center:	29.024	Lat.
		Pakistan	630577	sq km	WBM contributing area

Obtain Data

Last measured:	9-Jun-15			
Average Discharge:	**6031** m3/sec	Status:	**3**	(1, low flow; 2, normal flow; 3, moderate flood; 4, major flood, r >5 yr)
7-day Runoff	**5.96** mm		**155%**	(7-day runoff compared to 10 yr average for this date, 2003-2012)

Technical Summary

Recent Record

Notes: 15-day Centered Moving Average is applied

Complete record

Monthly Runoff (mm)

*G. R. Brakenridge**

*T. De Groeve***

*S. Cohen****

*S.V. Nghiem*****

*A. J. Kettner**

*J.P.M. Syvitski**

**CSDMS/INSTAAR, University of Colorado*

***Joint Research Centre, Ispra, Italy*

****University of Alabama*

*****Jet Propulsion Laboratory, California*

Sensors: AMSR-E, AMSR-2, TRMM

Annual Maximum Discharge

1998	10816	m3/sec
1999	8179	m3/sec
2000	5209	m3/sec
2001	4611	m3/sec
2002	6835	m3/sec
2003	11894	m3/sec
2004	4179	m3/sec
2005	17943	m3/sec
2006	11515	m3/sec
2007	4959	m3/sec
2008	5797	m3/sec
2009	8829	m3/sec
2010	21818	m3/sec
2011	8658	m3/sec
2012	7260	m3/sec
2013	15698	m3/sec
2014	9019	m3/sec

Flood Frequency Analysis, 1998-2013

30 yr*
22759 m3/sec

10 yr*
16434 m3/sec

5 yr (major flood)*
12854 m3/sec

1.33 yr (moderate flood)*
6013 m3/sec

20th percentile (low flow)
3398 m3/sec

*From Log Pearson III

Low Flow Threshold: **3398** (for today)

Site Characteristics

River Width:	1000 m
River Morphology:	Anastomosed
Vegetation:	Agriculture

Signal Standard Deviation*:	0.027
Standard Deviation of Departures from 15 day Avg**:	0.004

**Larger values = stronger signal*

***Larger values= more noise*

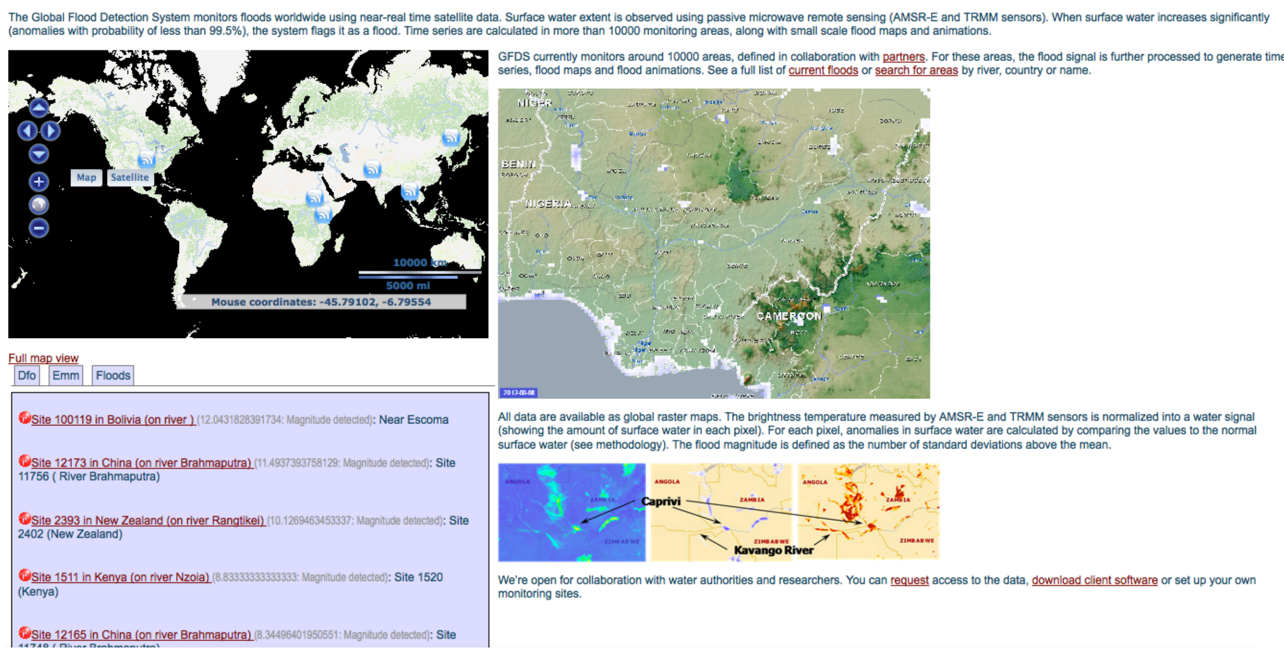
Accuracy Estimate:	**Fair**
Model/Remote Sensing r2*:	**0.49**
Highest N-S value*:	**0.37**

* See Technical Summary

River Discharge at a river site in Pakistan

Global Flood Detection System

http://www.gdacs.org/flooddetection/



- Information about current floods
- Global flood maps
- Data Download
- Interactive Maps

Global Flood Detection System

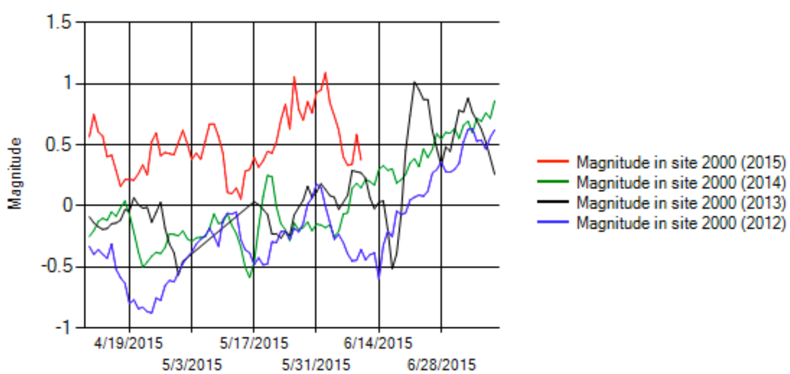
http://www.gdacs.org/flooddetection/

Flood Detection and River Discharge Based on GPM GMI and GCOM-W Brightness Temperatures (Similar to the FDO)

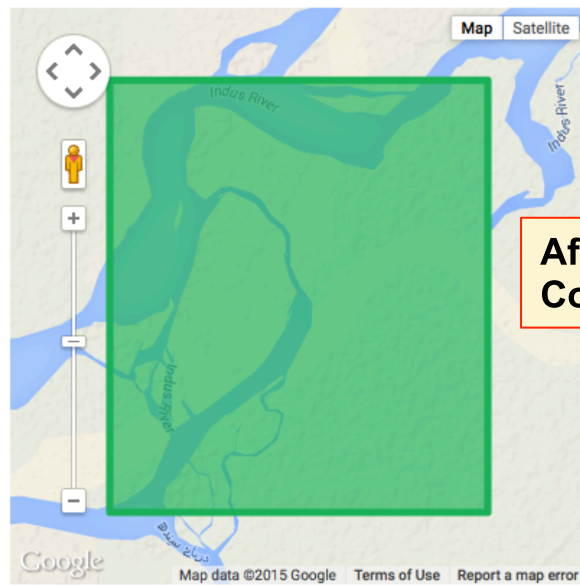
Current Data

The flood magnitude is a measure of the size of the flood. Since lower signals generally accounts for increased water coverage, extreme events, or major floods, should represent anomalies in the time series of a given site. The reference value for normal flow is calculated as the average signal for the site since June 2002. Flood magnitude is defined as the number of standard deviations (sd) from the mean (avg). Read more...

Site 2009 (Pakistan) (2000) from 2015-04-10 to 2015-07-10 (coordinates 70.6, 29.02)



Customize this graph | Download data: HTML RSS



Site coordinates: Latitude:29.024, Longitude:70.605. See on Google Maps.

Affected by Flood Conditions

Comparison with previous years

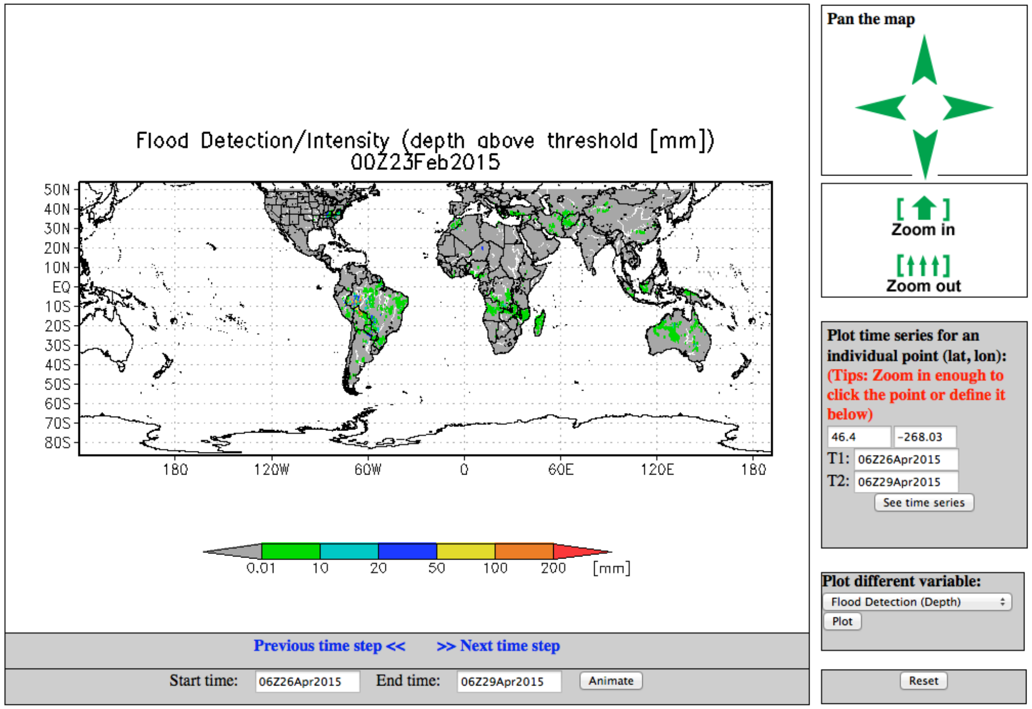
River Discharge

River Discharge at a river site in Pakistan

Global Flood Monitoring System (GFMS)

Global Flood Monitoring System (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**

From: Robert Adler, Huan Wu, University of Maryland

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

Uses a hydrological model together with remote sensing data for flood detection

- **Inputs: TRMM and Multi-satellite Precipitation (TMPA)**
  Surface temperature and winds from MERRA
- Runoff generation from U. Washington Land Surface Model (Variable Infiltration Capacity - VIC)
- Runoff routing model from the U. Maryland

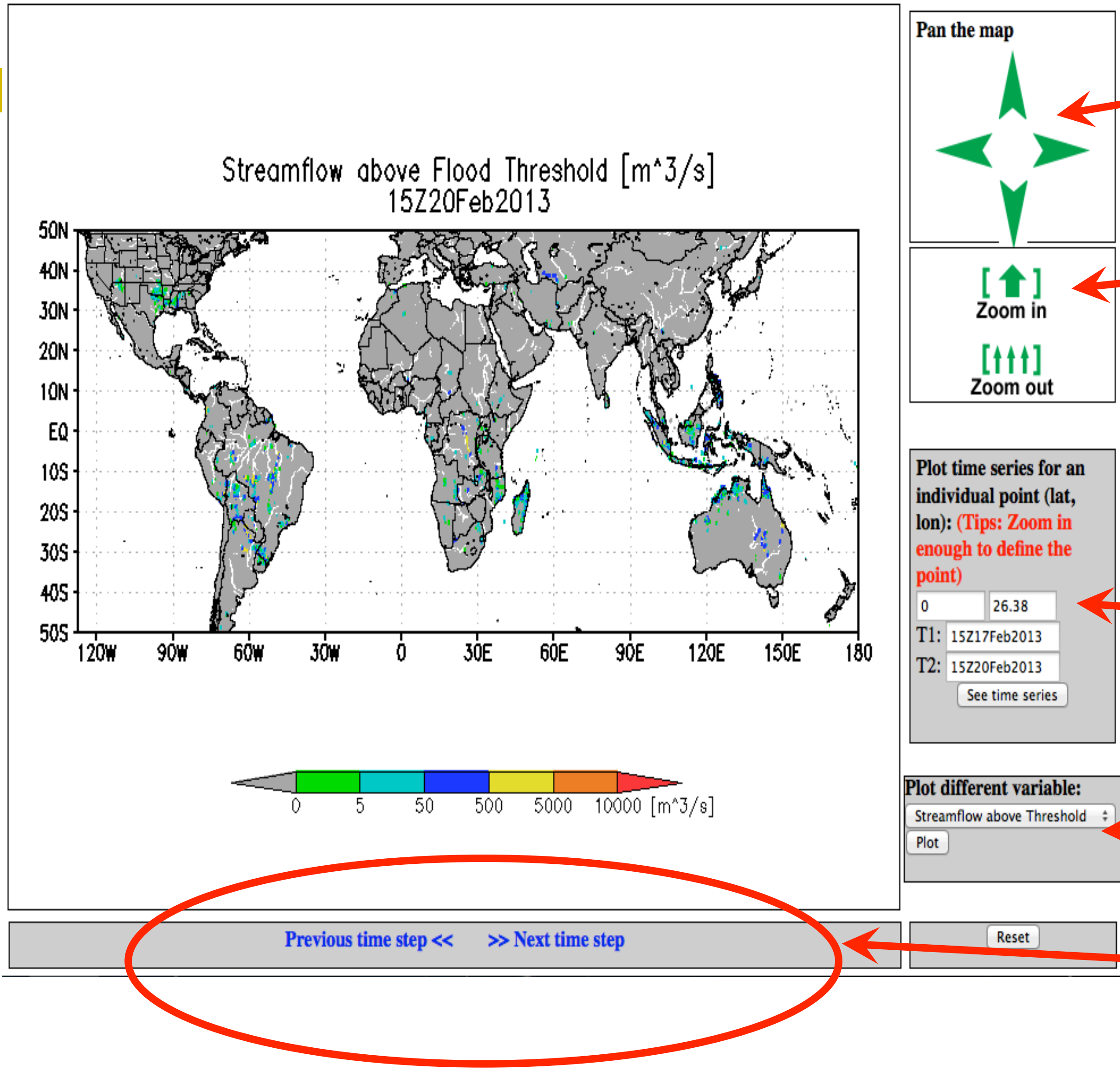
For details see:

Wu, H., R. F. Adler, Y. Tian, G. J. Huffman, H. Li, and J. Wang (2014), Real-time global flood estimation using satellite-based precipitation and a coupled land surface and routing model, Water Resour. Res., 50, 2693.2717, doi:10.1002/2013WR014710.

Wu H., R. F. Adler, Y. Hong, Y. Tian, and F. Policelli (2012), Evaluation of Global Flood Detection Using Satellite-Based Rainfall and a Hydrologic Model. J. Hydrometeor, 13, 1268.1284

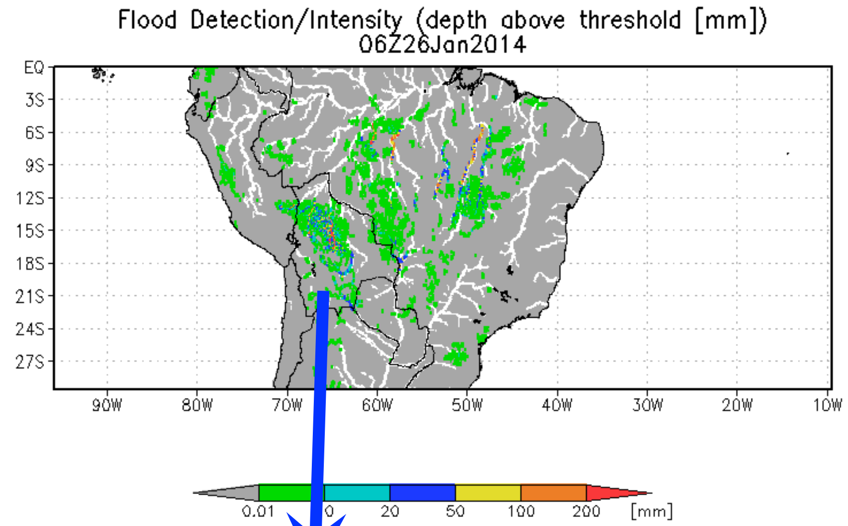
Global Flood Monitoring System (GFMS)

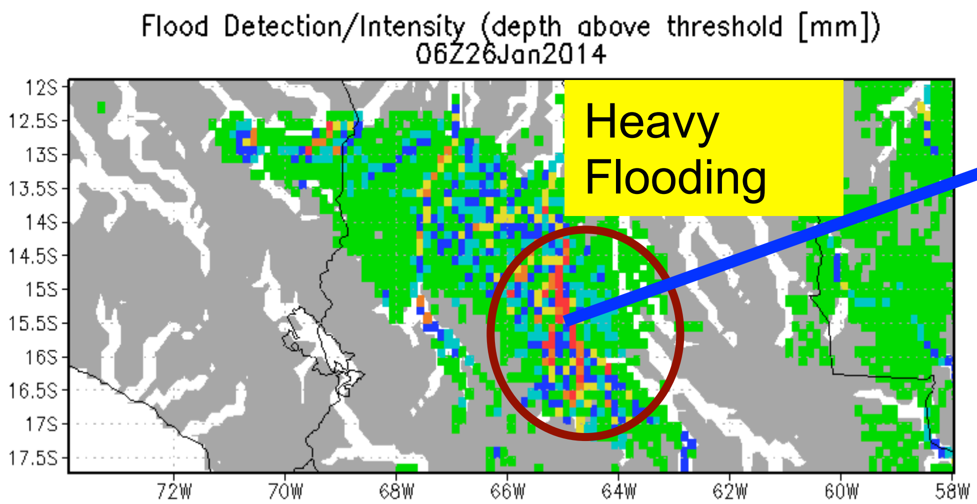
http://flood.umd.edu

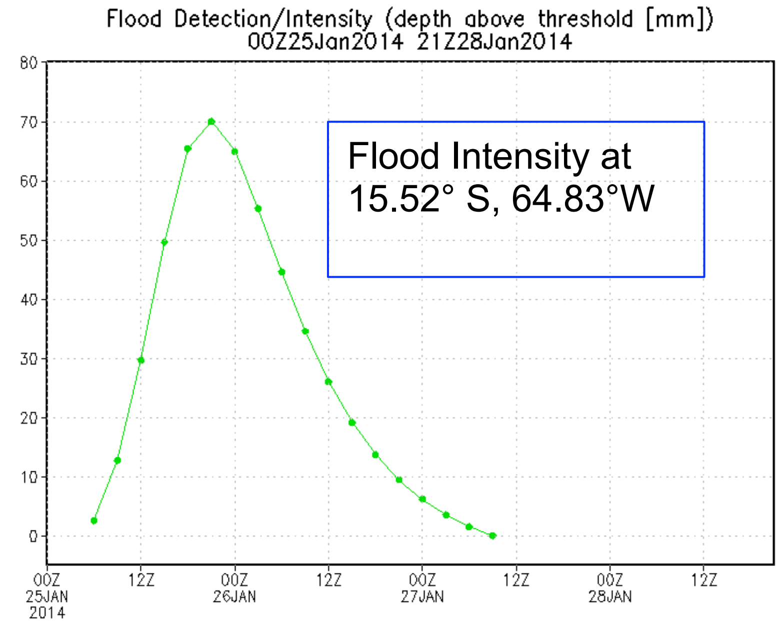


- **Map navigation**
- **Zoom in/out**
- **Select individual grid point for data for time sequence**
- **Plot different variables**
- **3-hourly output**

GFMS: Flood Intensity in Bolivia
26 January, 2014







Live Demonstration of GFMS

Case 1: Floods **in** Pakistan, September 7, 2014

Case 2: Flood over Philippines due to Typhoon Hagupit, December 7, 2014

Please see the following link for the Data useful for flood modeling:

http://arset.gsfc.nasa.gov/sites/default/files/users/S5_P1_HydrologyModel_final.pdf

Next Week:

1) Example of Regional Flood Management over Africa, Overview

2) Demonstration of the MODIS Inundation Mapping Tool and the Dartmouth Flood Observatory

Thank You!

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