Use of TRMM/GPM Rainfall in Real-time Global Flood and Landslide Calculations

Using Satellite Rainfall and Hydrological Models to Estimate Flooding (and Landslides) across the Globe

Robert Adler
University of Maryland, USA

http://flood.umd.edu/

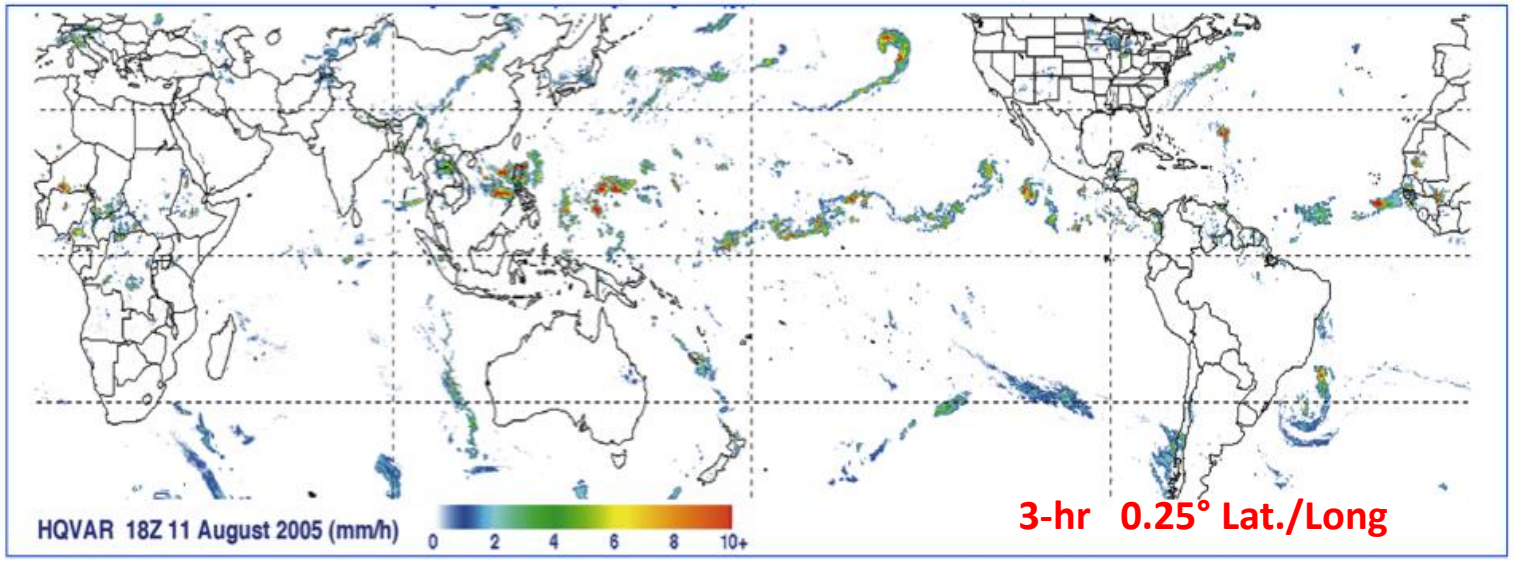
http://trmm.gsfc.nasa.gov/publications_dir/potential_landslide.html

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, doi:10.1002/2013WR014710.

Global Flood Calculations Using Satellite Rainfall and Hydrological Model

Rainfall input from satellite information---Currently using TRMM Multi-satellite Precipitation Analysis [TMPA/3B42] ***TRMM=Tropical Rainfall Measurement Mission***

(TRMM data used to adjust rain estimates from polar orbit PMW)

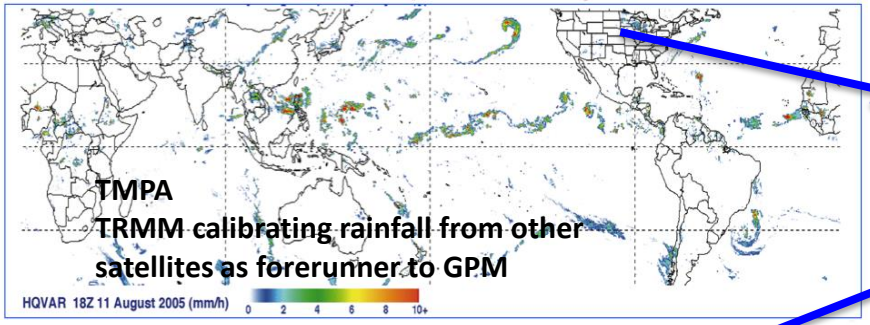


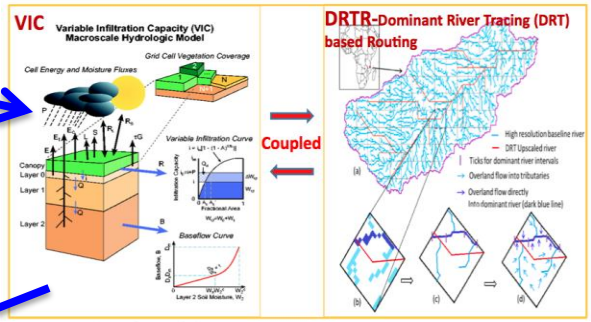
- ***Other available candidate rainfall products, e.g., CMORPH (NWS/CPC), GSMaP***
- ***Getting ready for Global Precipitation Measurement (GPM) IMERG multi-satellite product—automatic re-processing to beginning of TRMM era (1998) for consistent long record***
- ***Also using global NWP output to extend flood predictions out to 5 days or beyond***

Global Flood Monitoring System (GFMS)

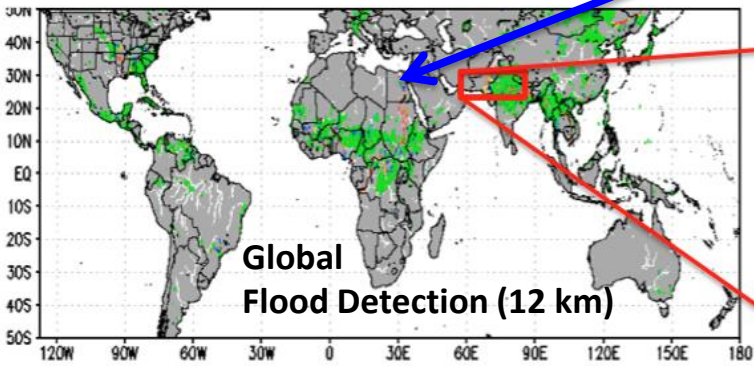
http://flood.umd.edu/

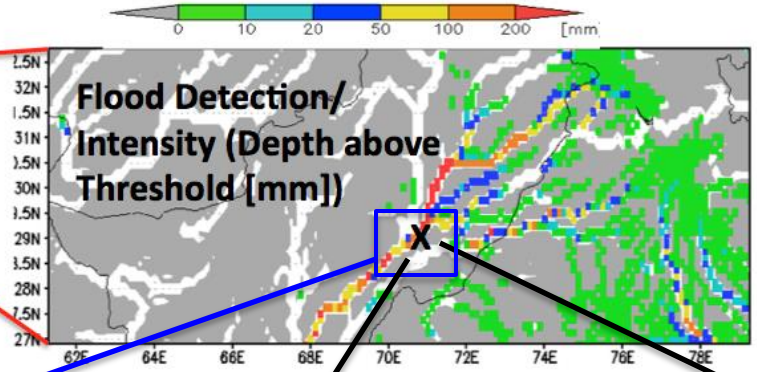
Global Real-time Flood Calculations Using Satellite Rainfall and Hydrological Model



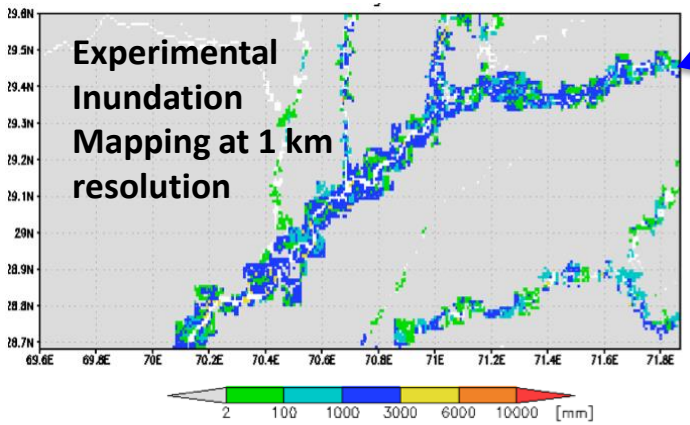


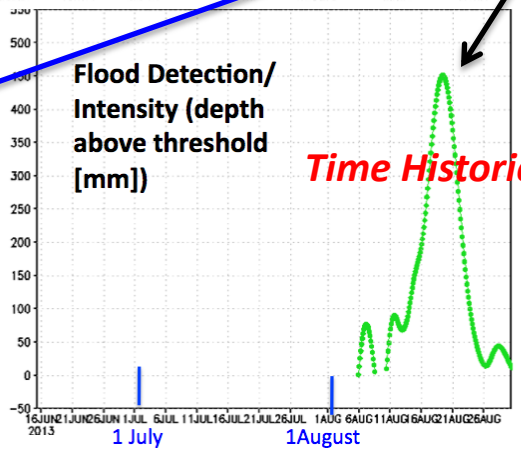
TRMM/GPM rainfall into land surface and routing models for water depth and stream flow calculations compared to flood thresholds

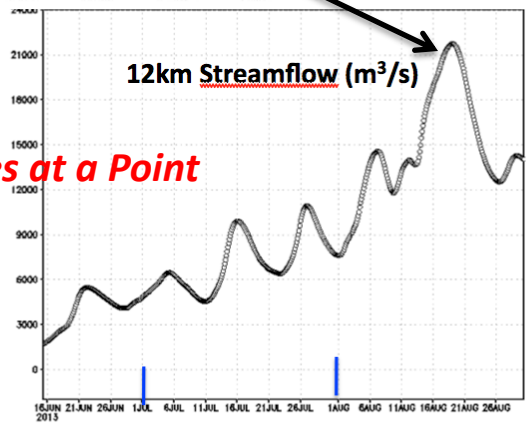




Indus River basin Aug. 20 2013





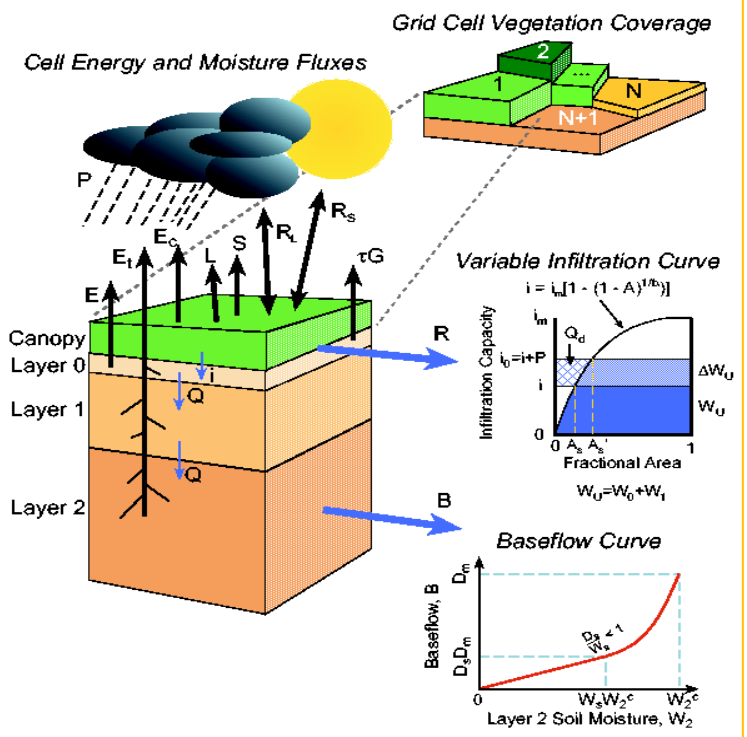


Dominant river tracing-Routing Integrated with VIC Environment (DRIVE) model

(Wu et al., 2011, 2012, 2014 *Water Resources Research*)

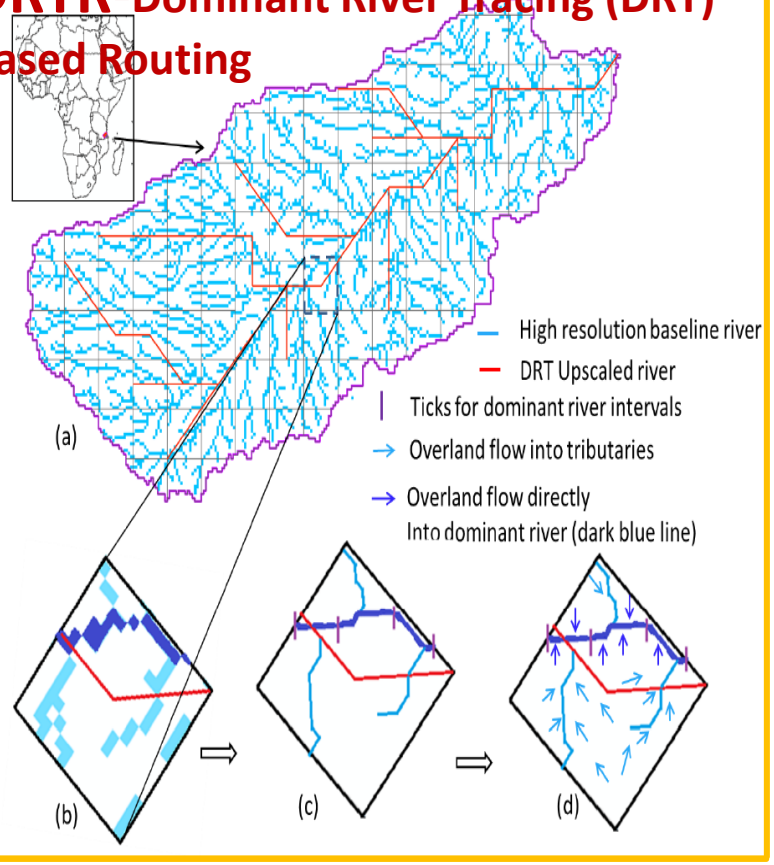
VIC

Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model



Coupled

DRTR-Dominant River Tracing (DRT) based Routing



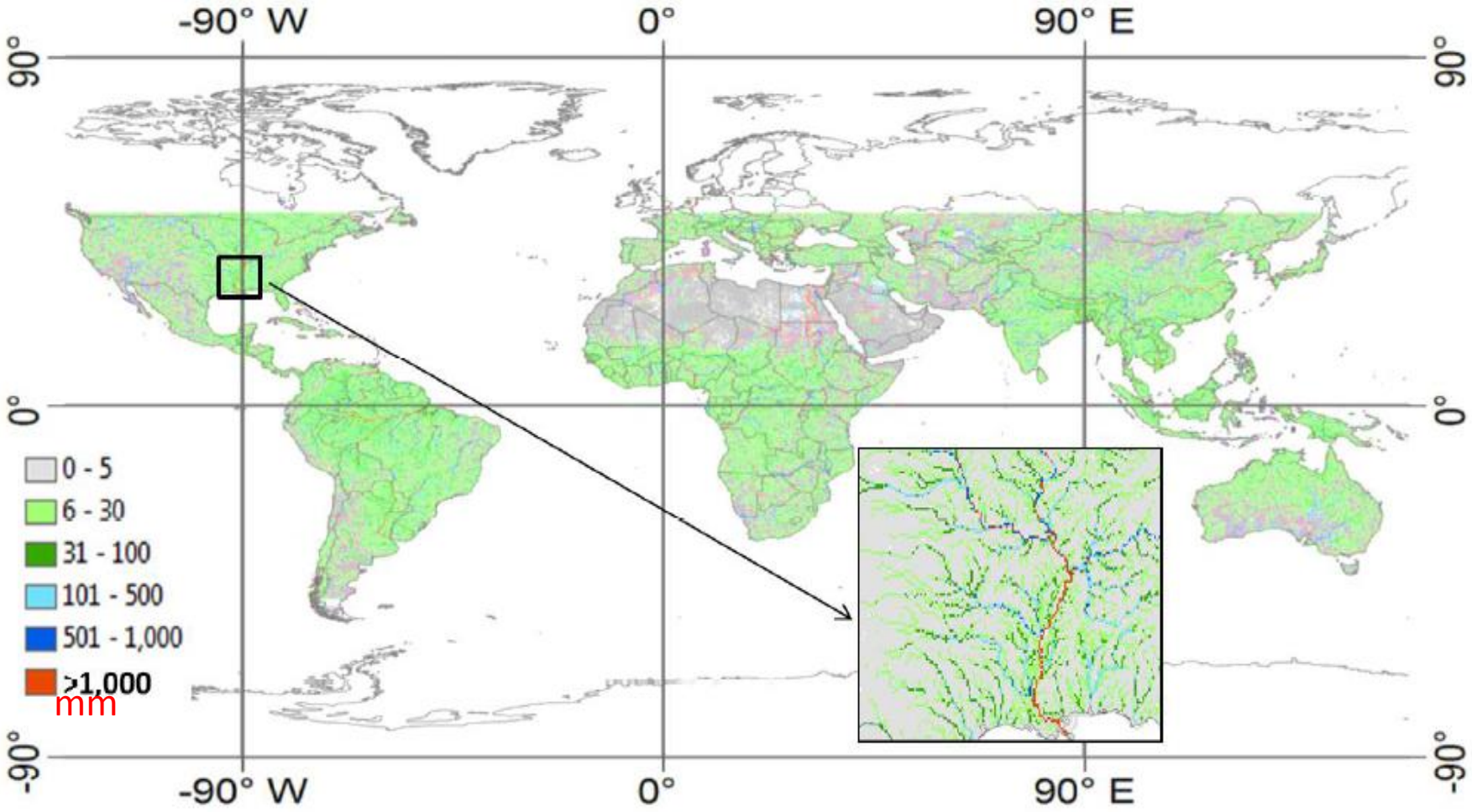
University of Washington **University of Maryland**

System is running quasi-globally every three hours at 1/8th degree, and routing is also running at 1km resolution. No Dams or Levees

Flood Threshold Map for Flood Detection/Intensity Parameter

Runoff (RR) > $RR_{95th\ Percentile}$ + δ and Q (streamflow) > 10 m^3/s,
where δ is temporal standard deviation of RR.

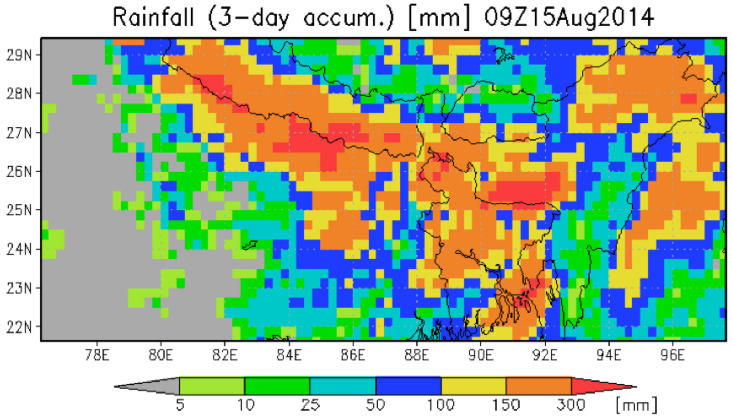
REFERENCE LEVEL at each grid calculated from 15-year global hydrology model run using satellite rainfall data



Same Approach is Used for Streamflow

Floods in India—15 August 2014

Heavy rains along Himalayan foothills (~450 mm—see map below) are producing floods in NE India (large change from 3 days ago—see maps to right) heading downstream into Bangladesh. Time history of flood parameter at Bihar (lower right) shows flooding starting 14 August, peaking there three days from now based on hydrological forecasting and NWP rainfall.



Over 100 Bihar villages flooded

IANS Patna, August 15, 2014 | UPDATED 21:00 IST

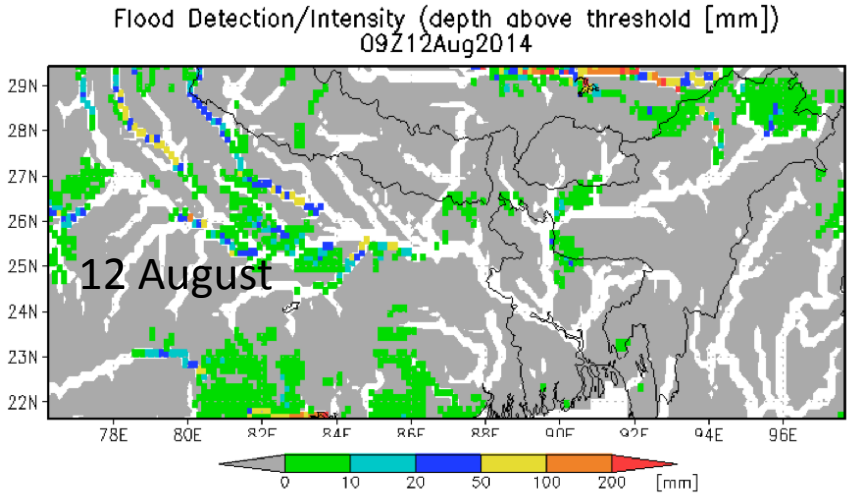
Flood water has entered over 100 villages in Bihar, forcing people to abandon their homes, and rising water level in most rivers is posing a threat to many other villages, officials said on Friday.

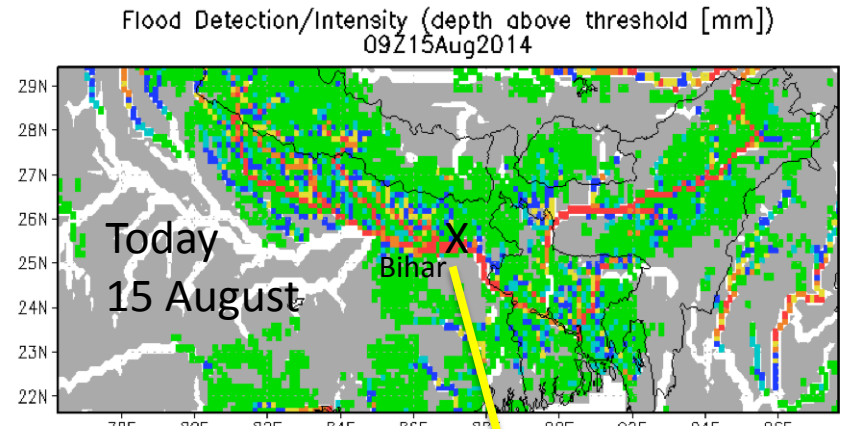
All the inundated villages are in flood-prone districts of Bagha, Gopalganj, Madhubani, Sitamarhi, Supaul, Saharsa, Khagaria, Darbhanga and Madhepura.

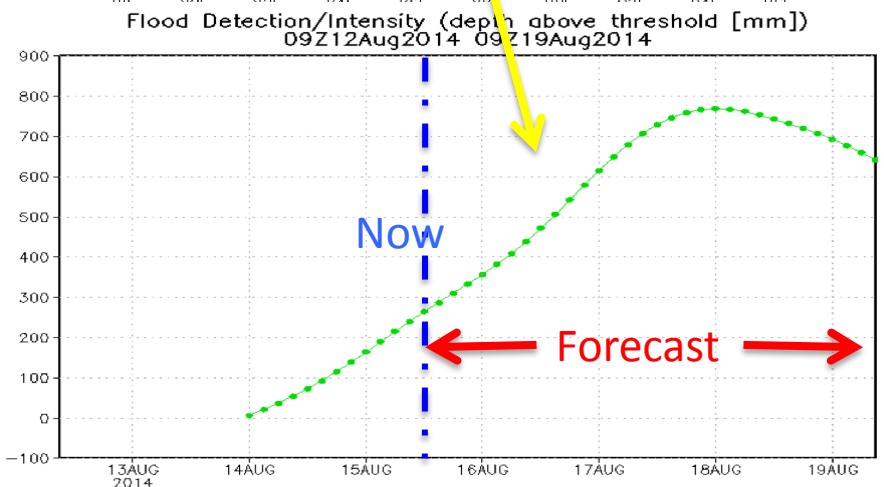
Principal secretary of state disaster management department Vayasji said major rivers in north Bihar, especially the Kosi, Gandak, Kamla Balan and Bagmati, are in spate following heavy rains in their catchment areas in Nepal. They are posing a threat of floods.

"Situation may worsen in the next 24 to 48 hours. Keeping this in view we have sounded high alert in districts of north Bihar," he said.

A water resource department official said: "Water entered these villages after levels rose in all the major rivers following heavy rain in the state and the catchment areas in Nepal."



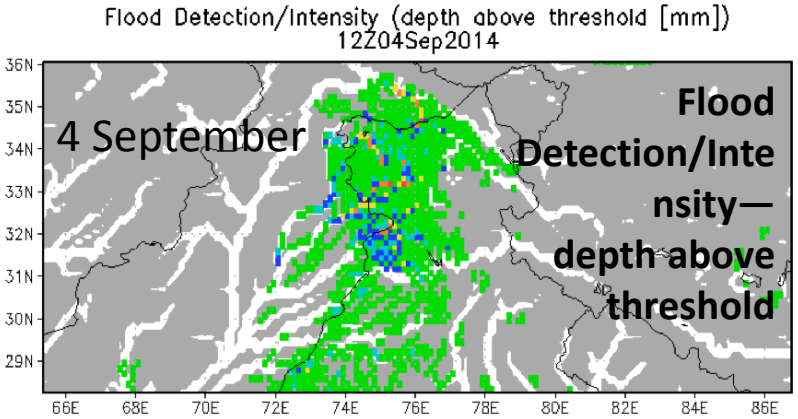


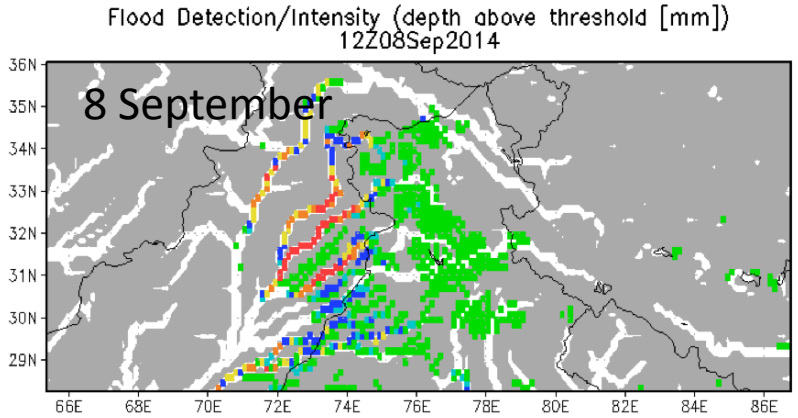


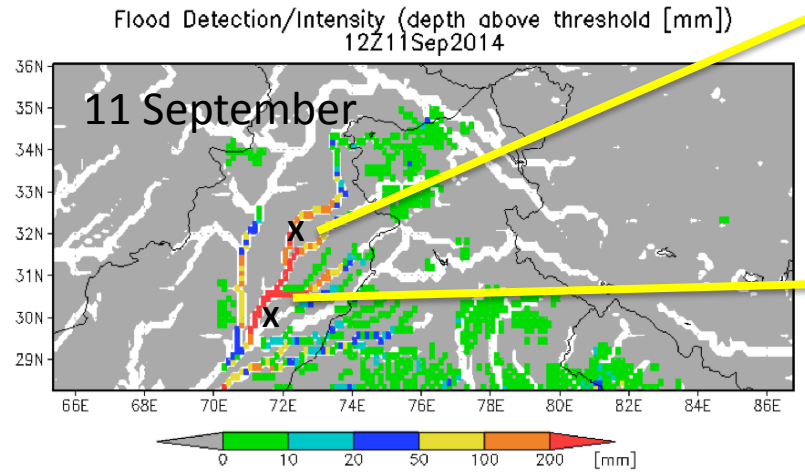
Global Flood Monitoring System (GFMS) Adler/Wu UMD

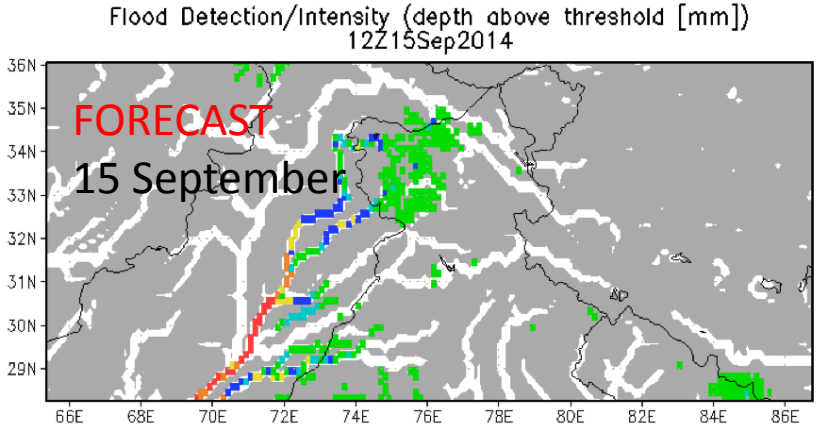
Time History and Forecast (4-15 Sep. 2014)

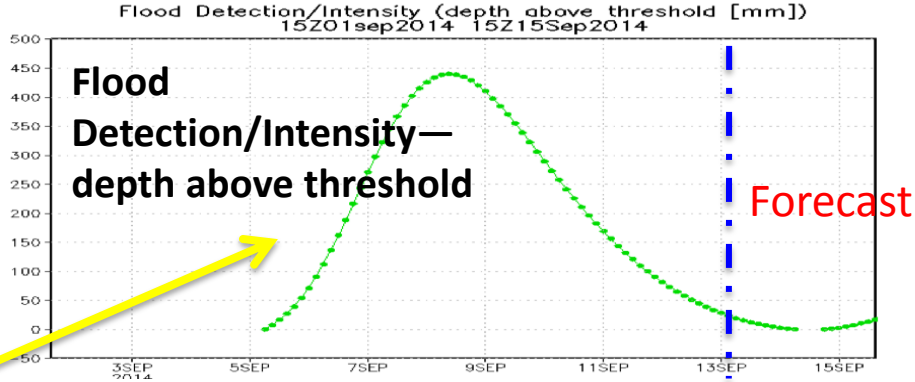
Floods begin in Kashmir, India (2-4 Sep.) and move downstream further into Pakistan by today (11 Sep.) with forecast further movement southward 15 Sep. and beyond.

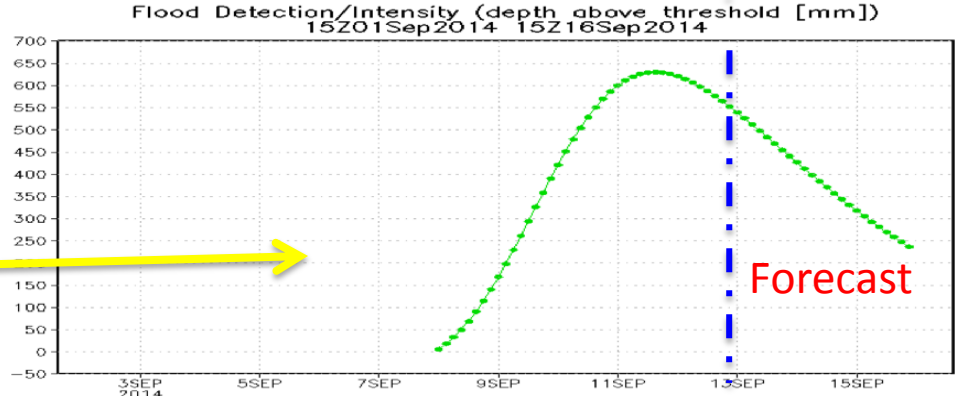






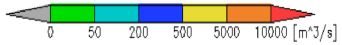


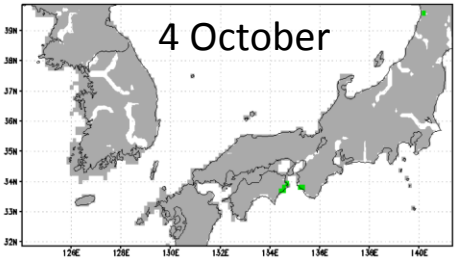


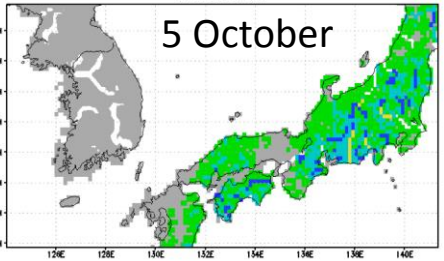


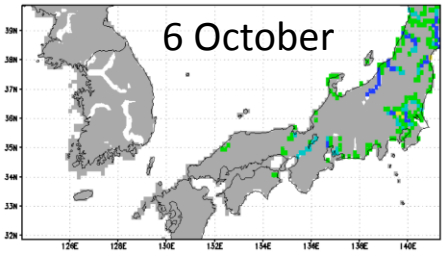
Rainfall and Flooding with Typhoons Phanfone and Vongfong (October 2014)

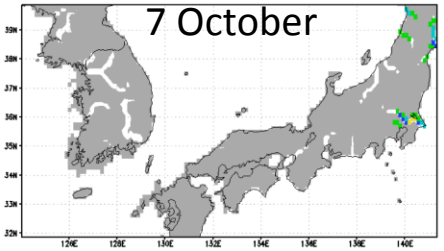
Streamflow above Flood Threshold (m^3/s)



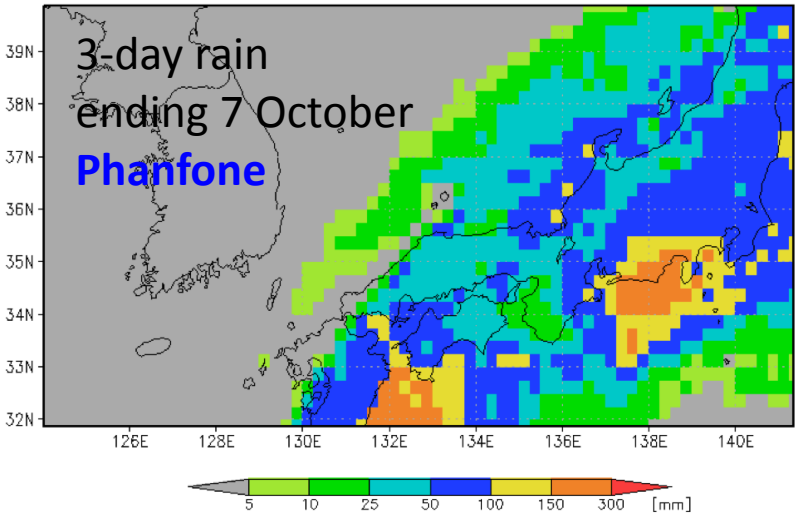


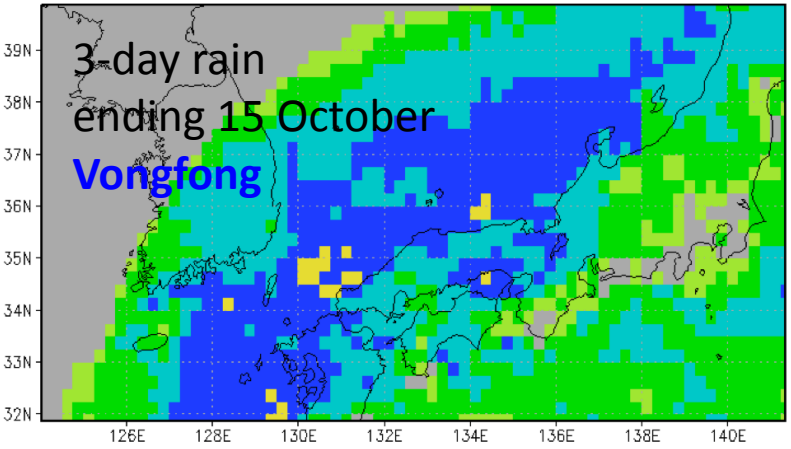




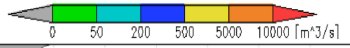


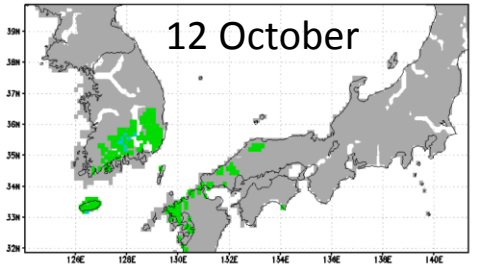
3-day rain

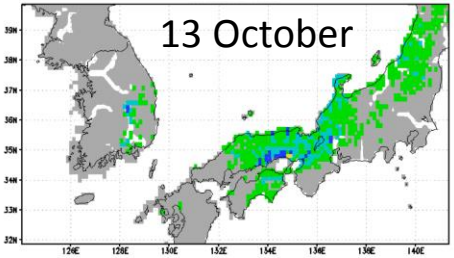


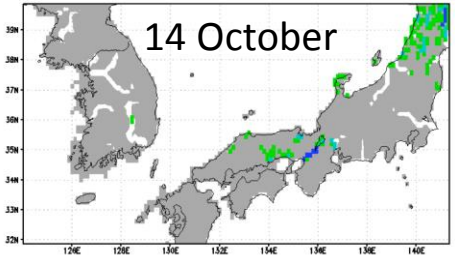


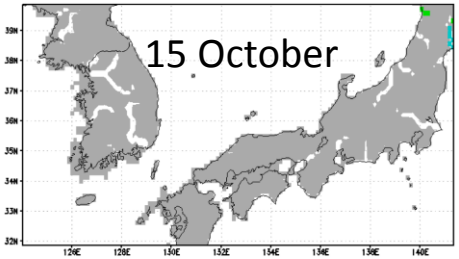
Streamflow above Flood Threshold (m^3/s)



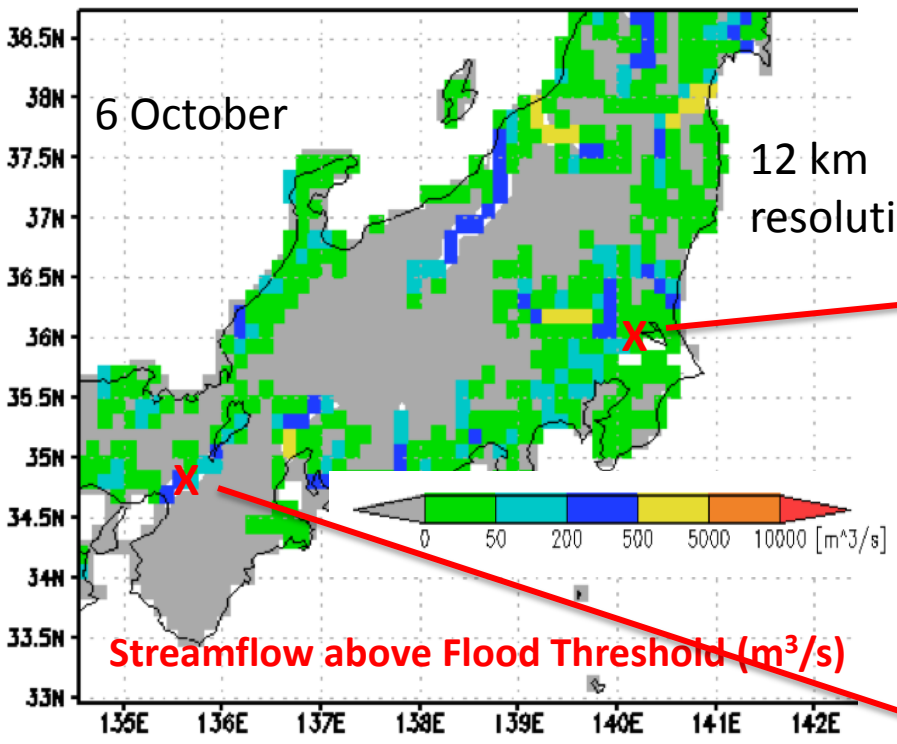


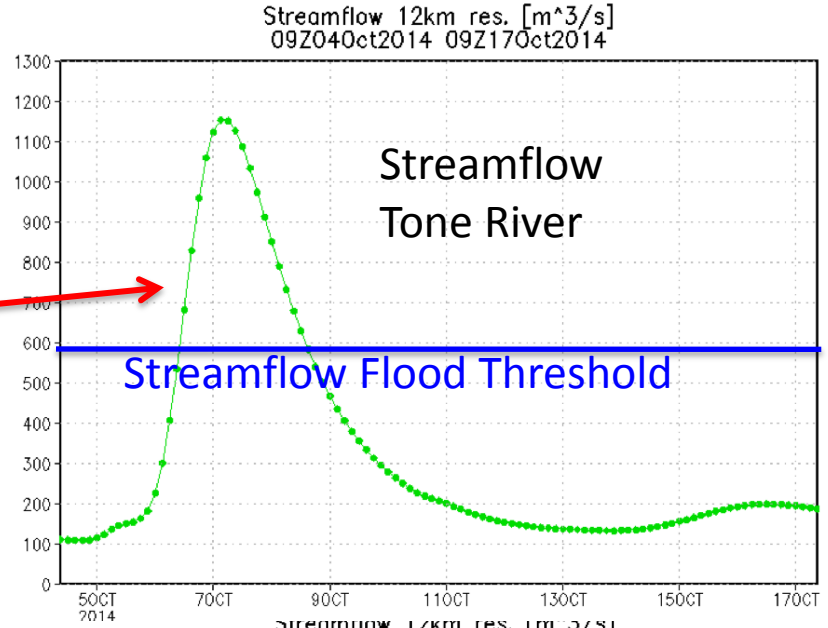


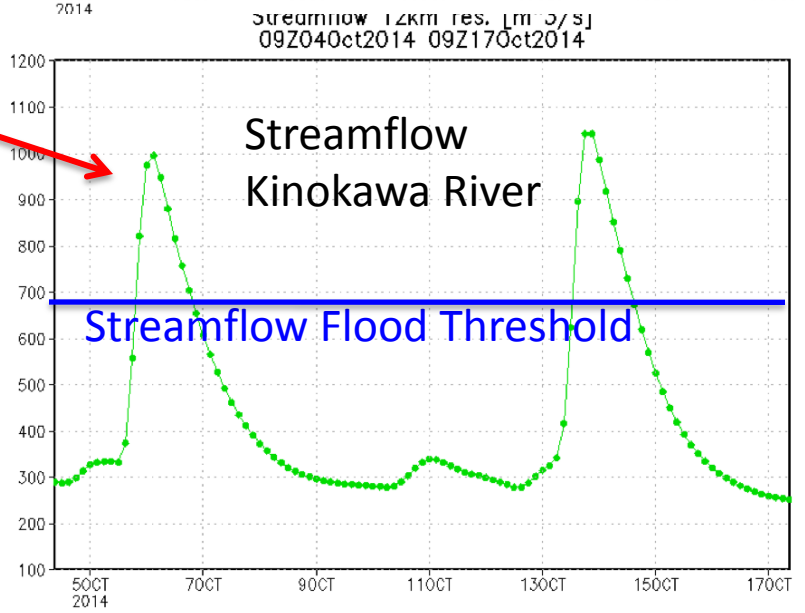




Time Histories of Streamflow at Two rivers in Japan (3-17 Oct.)

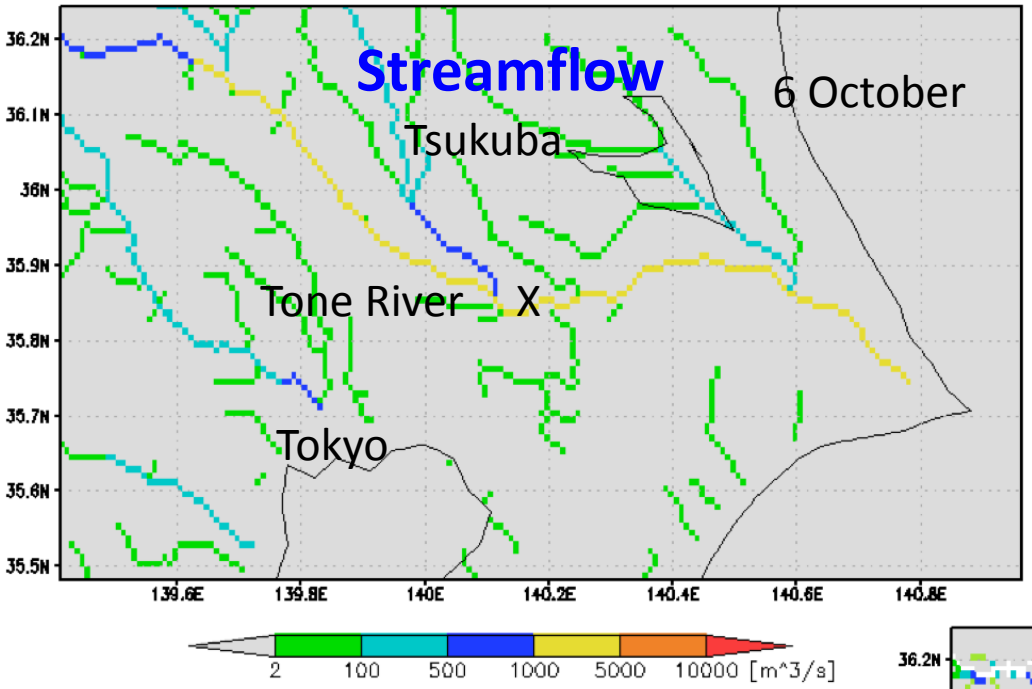




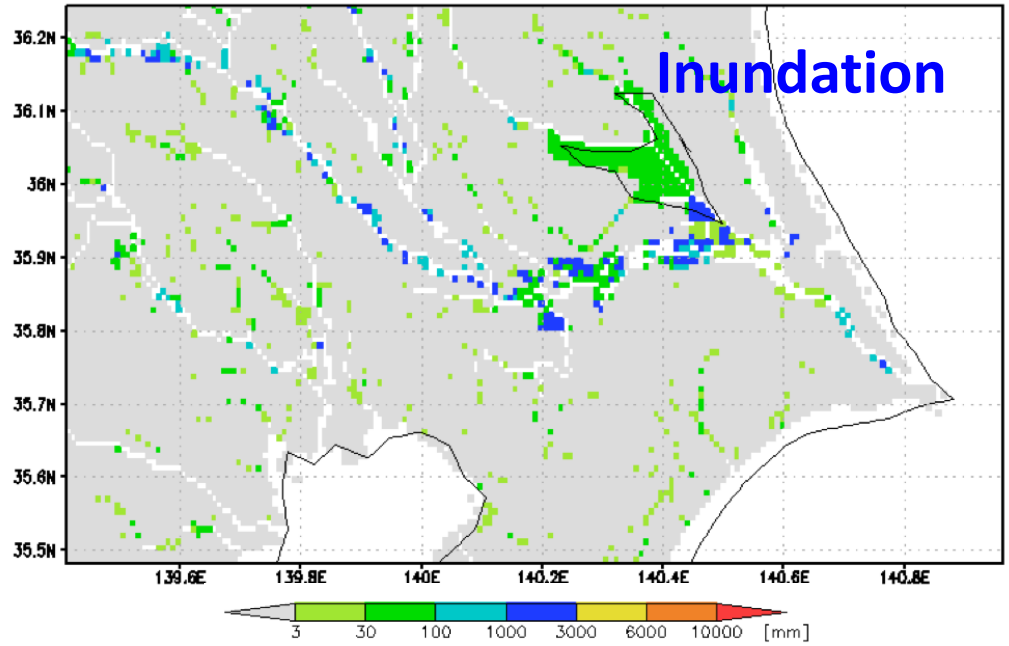


Panels at right show time histories of calculated streamflow in two Japan rivers indicating impact of the two typhoons, with earlier storm (Phanfone) showing higher values in Tone River (near Tsukuba). Also seen is time shift from south to north as storms travel across Japan.

Streamflow and Inundation Calculations at 1km Resolution

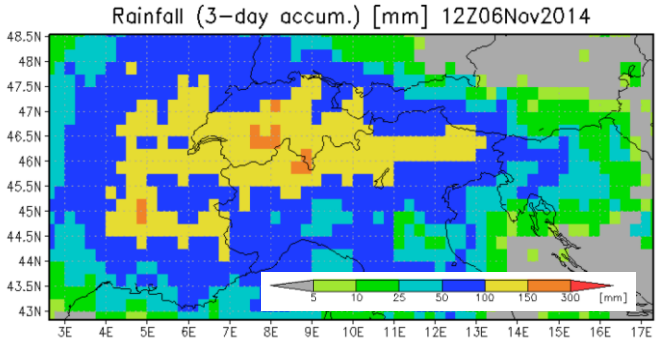


Typhoon Phanfone swept through and produced some flooding, particularly north of Tokyo (see calculated inundation map [1 km resolution]).

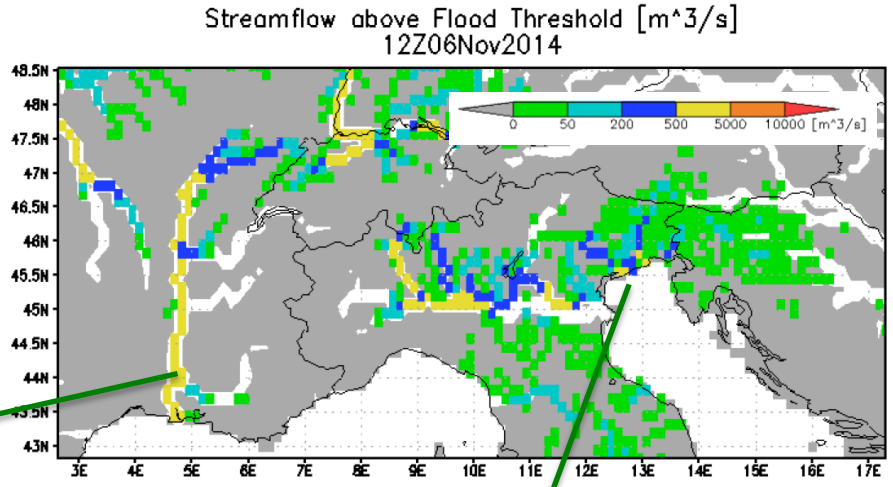


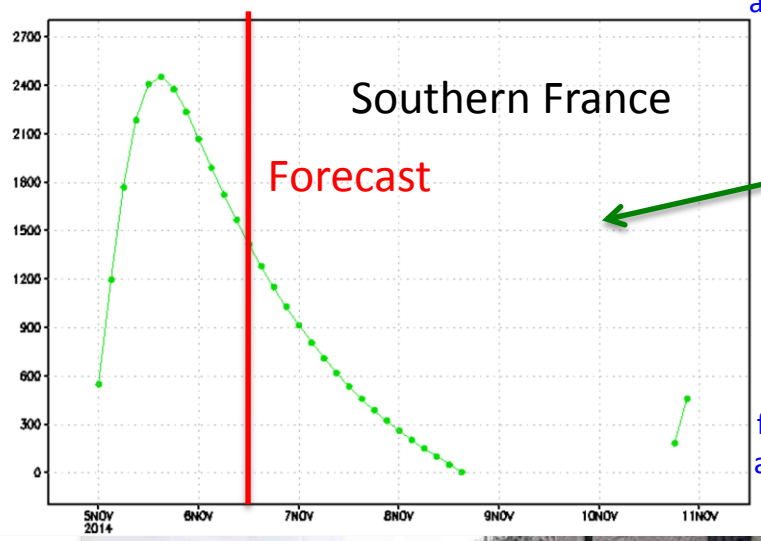
Flooding in Southern Europe (November 6, 2014)

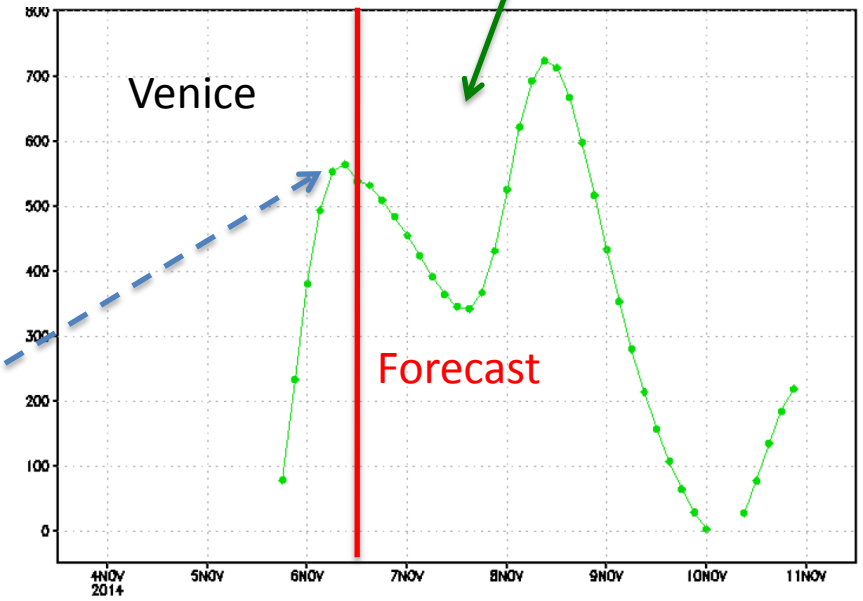
Flooding, first in France and currently in parts of northern Italy, has affected cities and agricultural areas.



Heavy rains struck southern France (peaking Tuesday-Wednesday and then parts of northern Italy. Calculations based on TRMM/GPM rainfall are extended in time using GEOS-5 rain forecasts with a second peak forecast for Venice for Saturday.







Global Flood Monitoring System (GFMS) Adler/Wu U. of Maryland

GFMS Features and Capabilities

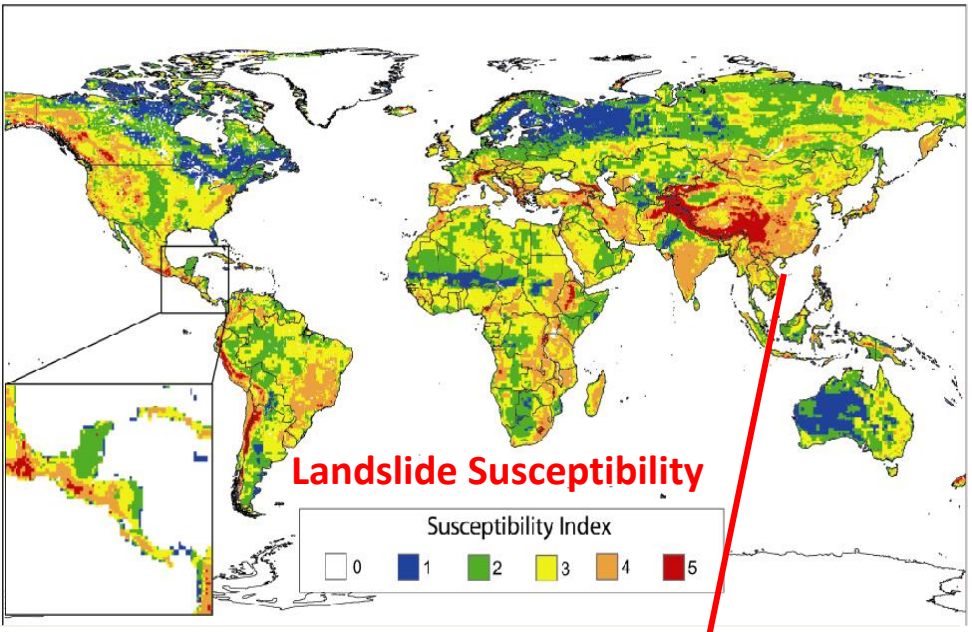
- Global views of precipitation, streamflow and flood parameters at 12 km resolution
- Zoom, roam on individual fields and switch from parameter to parameter
- Examine forecasts of all the parameters out to ~ 5 days
- Time history plots for current and historical events
- Zoom in to examine 1 km resolution streamflow and inundation estimates (no forecasts at 1 km resolution; one month revolving archive)

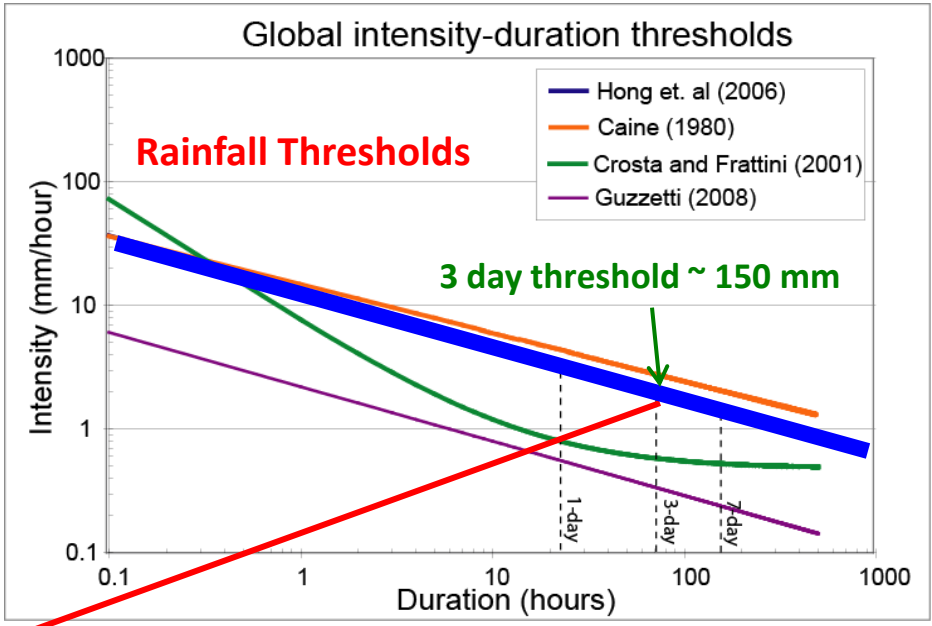
Recent (Oct.13-Nov 12, 2014) Visitors/Users of GFMS website (http://flood.umd.edu)

Weekly Stats Report: 15 Sep - 21 Sep 2014
Project: Global Flood Monitoring System

	Mon	Tues	Wed	Thur	Fri	Sat	Sun	Total	Avg
Pageloads	104	29	25	17	25	4	5	**209**	30
Unique Visits	50	28	21	16	15	4	5	**139**	20
First Time Visits	27	11	10	9	10	2	3	**72**	10
Returning Visits	23	17	11	7	5	2	2	**67**	10

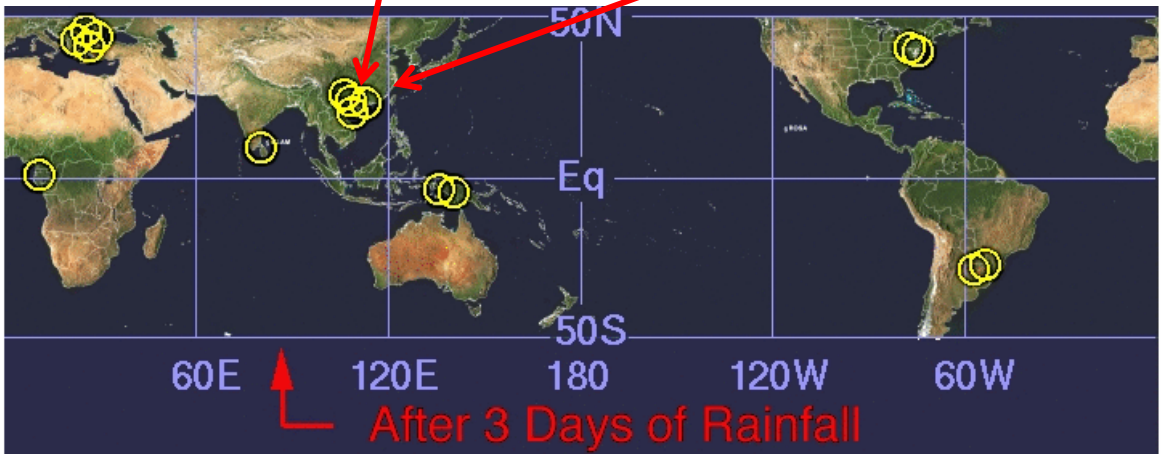
Estimating Landslide Occurrence Using Satellite Rainfall Data





Surface Data:

- Topographic variables
- Land cover
- Soil Type



Rainfall Data:
TRMM Multi-Satellite Precipitation Analysis (TMPA)
0.25° pixel resolution, 3-hourly

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

5 OCT 2014 1800 UTC

(Observation Time Of Last Data)

Landslide Potential

Summary

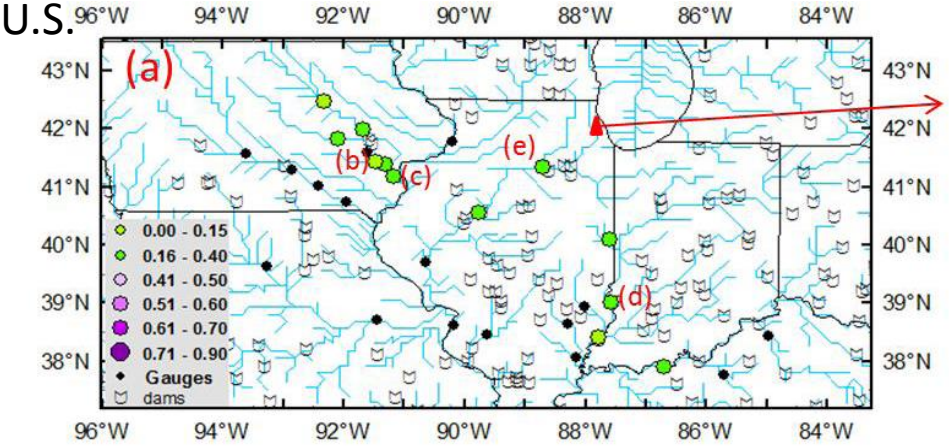
- Satellite rainfall information is used to drive hydrological models and algorithms to estimate flood conditions and areas of high potential for landslides

- Examples are shown to define capabilities and limitations of observations and models

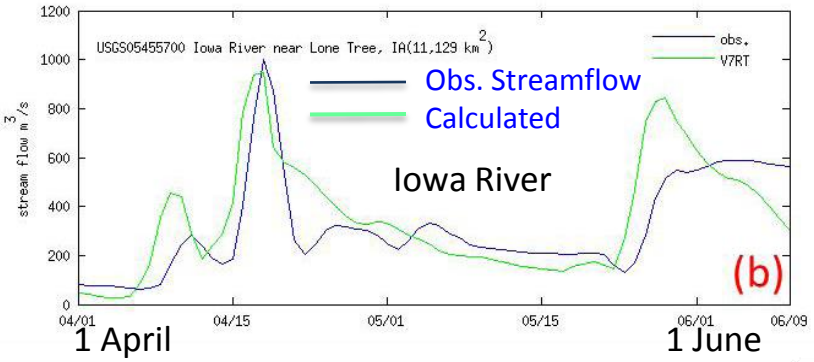
- Users include international and national agencies and others interested in monitoring disasters on a global scale

- Results should improve with better precipitation information, higher resolution and taking into account dams, etc.

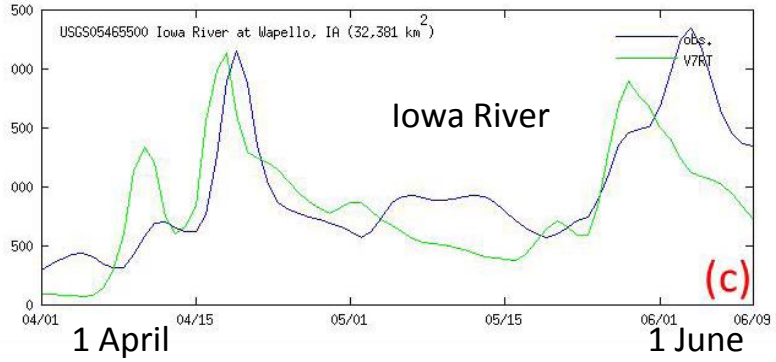
Streamflow Caluclations (1/8th Degree) Compared to Observations May 2013 over U.S.



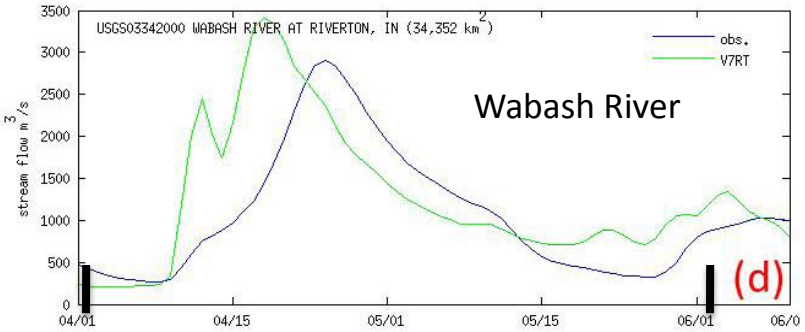
Internet source: April 19, 2013, Des Plaines, IL



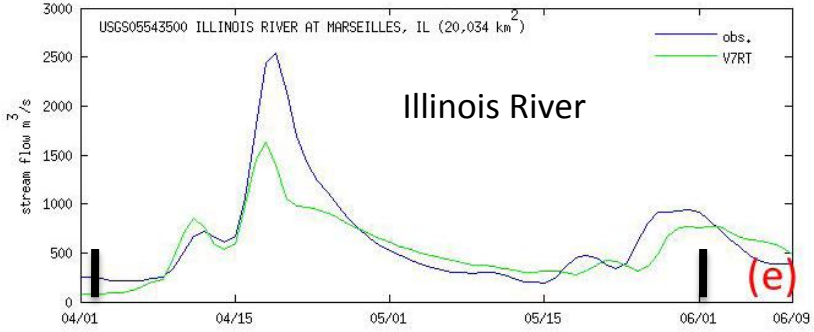
1 April 1 June



1 April 1 June



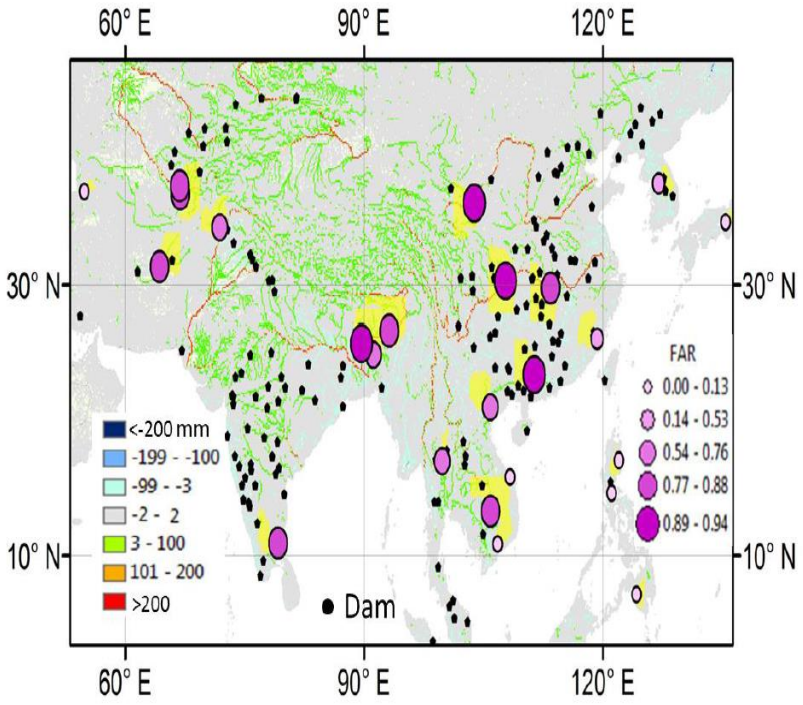
1 April 1 June



1 April 1 June

Flood detection verification against the Dartmouth Flood Observatory (DFO) flood database over the 38 Well Reported Areas (WRAs) for floods with duration of one or more days (not flash floods).

Metrics	POD	FAR	CSI
Metrics averaged over all the 38 WRAs			
DRIVE-V7RT	0.90	0.73	0.25
DRIVE-V7	0.93	0.65	0.34
Metrics averaged over the 20 WRAs with ≥ 5 dam			
DRIVE-V7RT	0.93	0.80	0.19
DRIVE-V7	0.94	0.73	0.26
Metrics averaged over the 18 WRAs with <5 dam			
DRIVE-V7RT	0.87	0.66	0.32
DRIVE-V7	0.92	0.56	0.43



Yellow regions are "Well Reported Areas" (WRA's)

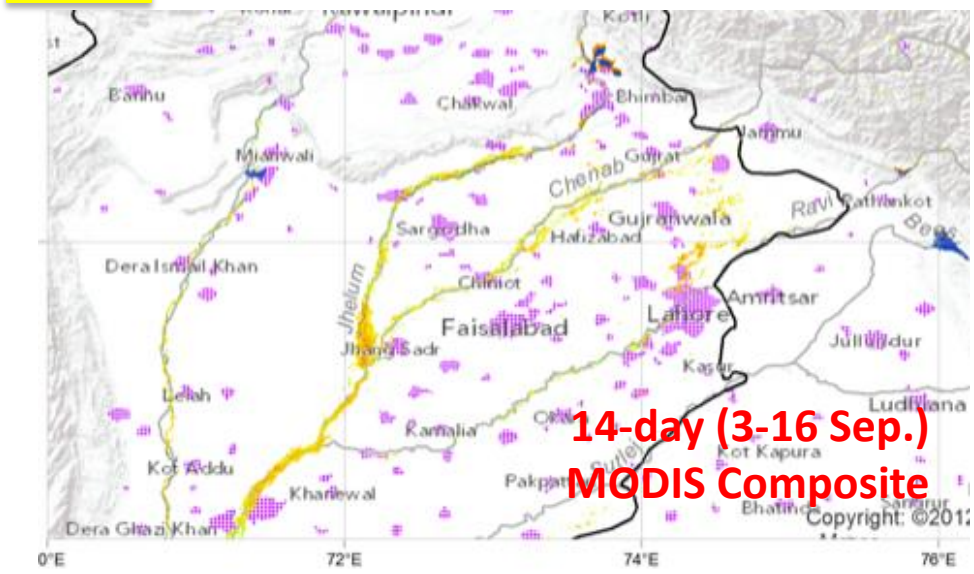
Dots are dams

Better flood detection statistics with "research" (instead of RT) rain and with fewer dams (drop in FAR)

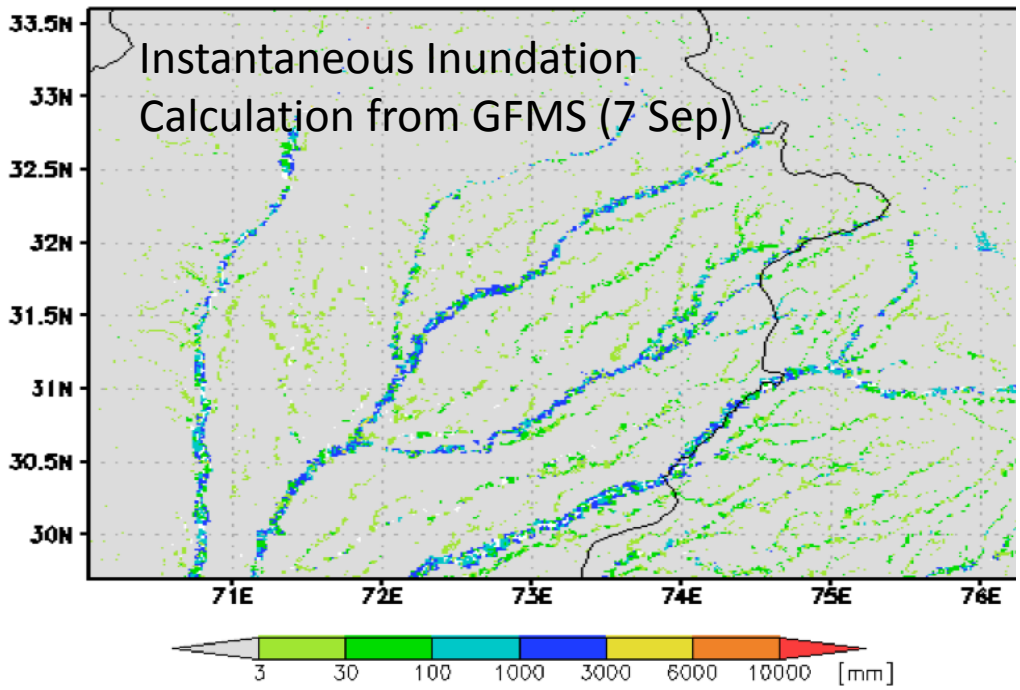
Bottom line—For 1+ day floods in basins with few dams using RT rainfall: POD ~ 0.9 FAR ~ 0.7

Wu et al., 2014 Water Resources Research

Inundated areas estimated from MODIS visible data



14-day (3-16 Sep.) MODIS Composite



Inundation Estimates from MODIS (GSFC) and GFMS (U. of Maryland)

Experimental inundation calculations from GFMS available every three hours for comparison with automated MODIS estimates (when available).

Results in this case show some similarities, but also differences.