Towards Global scale flood risk assessments
Utilizing Remote Sensing and Advanced Modeling to monitor and forecast flooding

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Dartmouth Flood Observatory

Flooding is the most common natural hazard worldwide

Floods impact 21 million people every year and affect the global GDP by $96 billion

Increases in frequency of river floods in Europe: predicted to double in coming 3 decades

Alfieri et al., 2015.

Knowledge gap

Most rivers experience flooding as seasonal discharge varies ~ 2 - 3 orders of magnitude

Floodplain within the alluvial plain of the Waimakariri River, New Zealand.

We lack adequate geospatial information on a ***global basis*** defining floodplains within the ***mean annual*** flood limit, or 25 - 50 - 100 year floodplains.

Understanding the Assumed Geographic Impact of Floods

The Flood Observatory

~2 decades of water related products

1) Flood archive: Describing over 4400 floods

Utilize satellite derived data to provide daily:

2) River discharge (AMSR-E/2, Microwave 1998 -> (17yr))
3) Flood extents (MODIS, Optical 2000 ->(15yr))

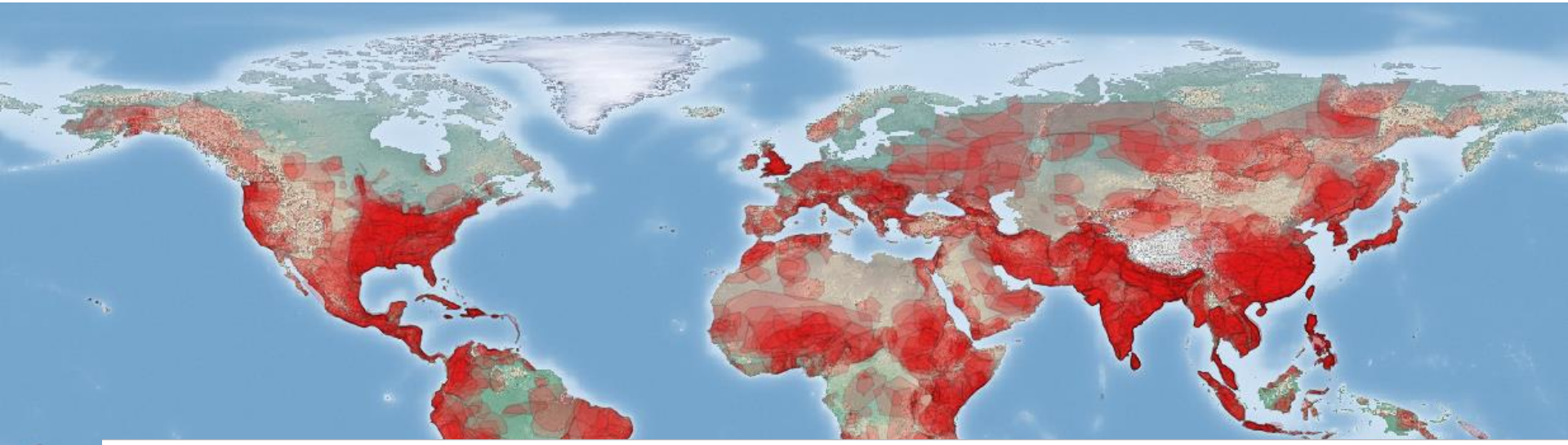
Advances using Satellites:

a) Daily, global coverage

b) Consistent use of methods globally

c) Space based gauging stations monitor also during floods

Flood archive

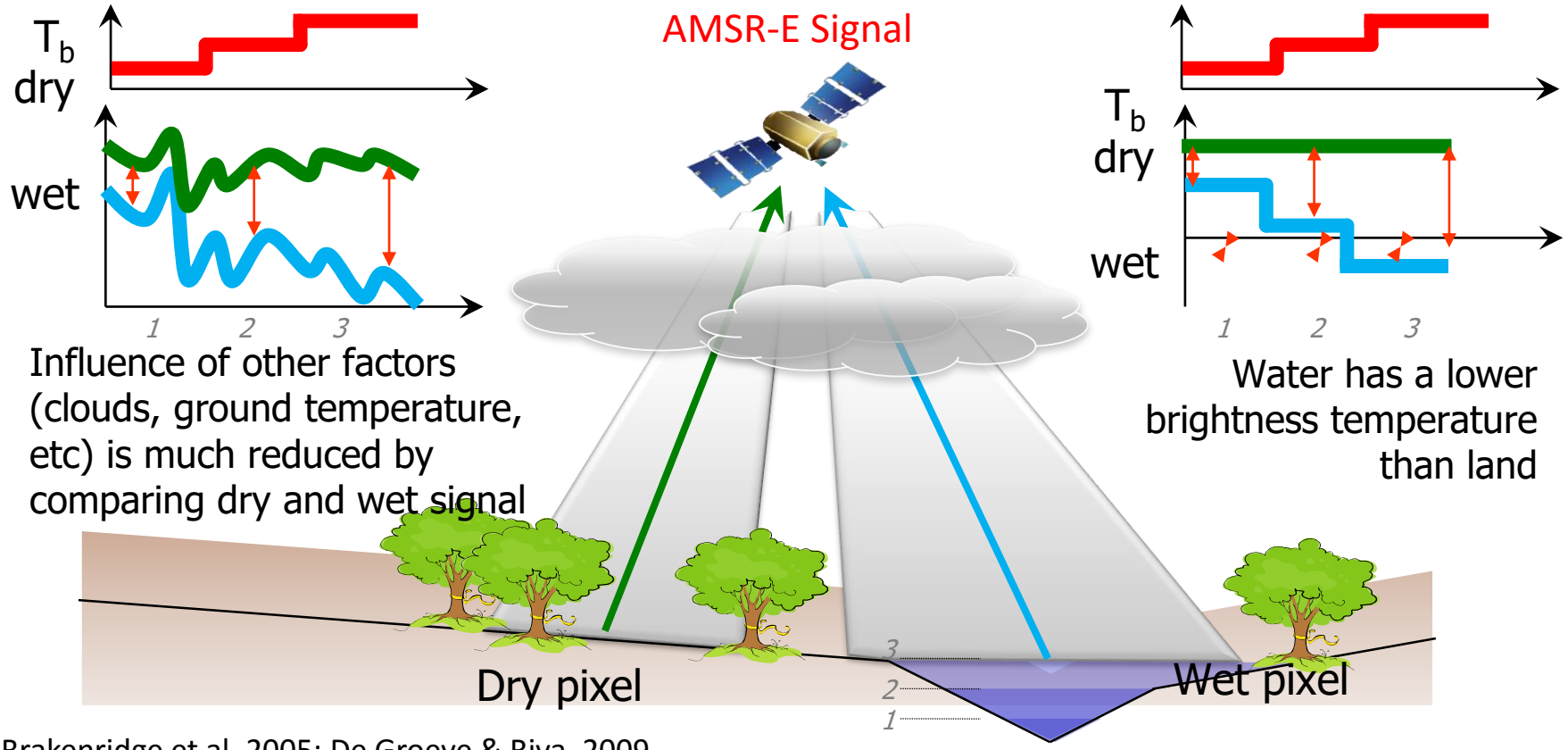


Register #	Annual DFO # (discontinued)	Glide #	Country	Other	Nations	Affected	Detailed Locations (click on active links to access inundation extents)	Validation (post event #3503)	Began	Ended	Duration in Days	Dead	Displaced	Damage (US
4410		0	Vietnam	0	#N/A	#N/A	Four central provinces	News	9-Oct-16	16-Oct-16	8	21	100000	
4409		0	Australia	0	#N/A	#N/A	South Australia, north of Adelaide	News	1-Oct-16	16-Oct-16	16	1	0	
4408		0	Romania	Albania	#N/A	#N/A	Eastern Romania, Albania	News	9-Oct-16	16-Oct-16	8	1	300	
4407		0	Spain	0	#N/A	#N/A	Barcelona Province	News	12-Oct-16	16-Oct-16	5	1	0	
4406		0	Ukraine	0	#N/A	#N/A	Odessa Region	News	12-Oct-16	16-Oct-16	5	3	200	
4405		0	India	0	#N/A	#N/A	Andhra Pradesh	News	21-Sep-16	16-Oct-16	26	17	3000	

http://floodobservatory.colorado.edu

Containing major floods from 1985 ->

AMSR-E/AMSR-2 River discharge Measurement Method



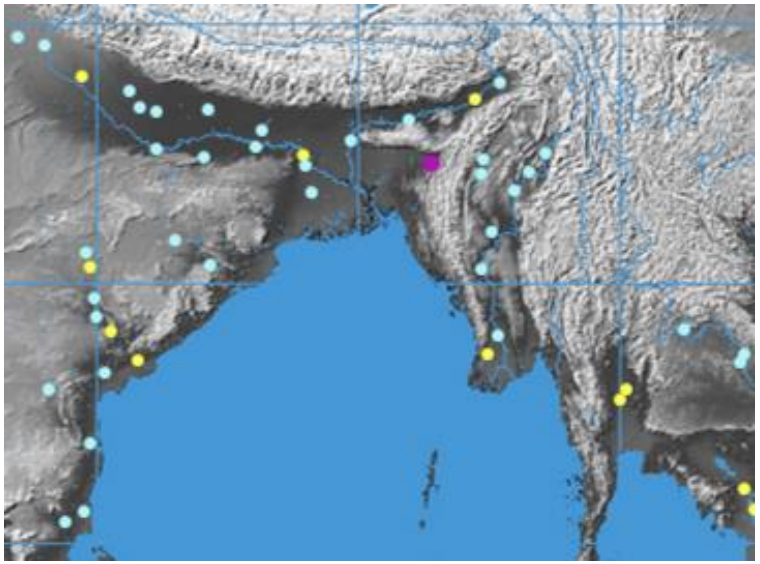
Brakenridge et al, 2005; De Groeve & Riva, 2009

Dartmouth Flood Observatory

GDACS

Cooperative work including EU's **J**oint **R**esearch **C**entre (GDACS, Dr. Tom De Groeve) and DFO has resulted in a ***global*** network of satellite river gauging sites, with records extending on daily basis from 1998 up to today. Online display (click on dots).

- Low flow
- Normal Flow
- Moderate Flooding, r > 1.33 years
- Major Flooding, r > 5 years

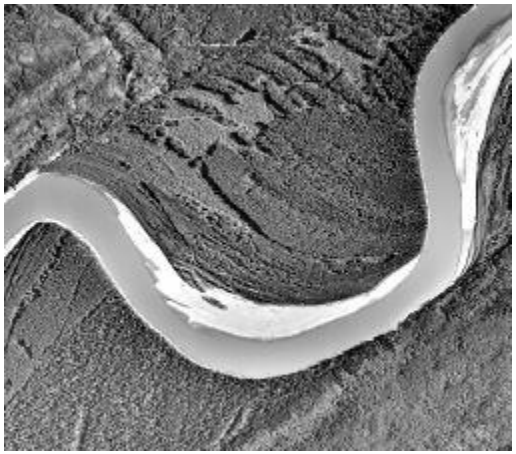


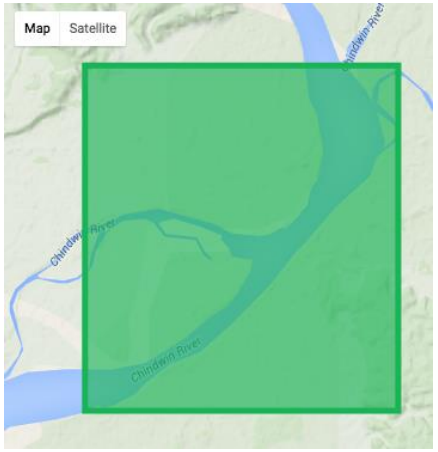
River discharge

Q = Width x Depth x Velocity

When rivers rise (discharge, Q, m^3/sec, increases), flow width and water surface area also increase.

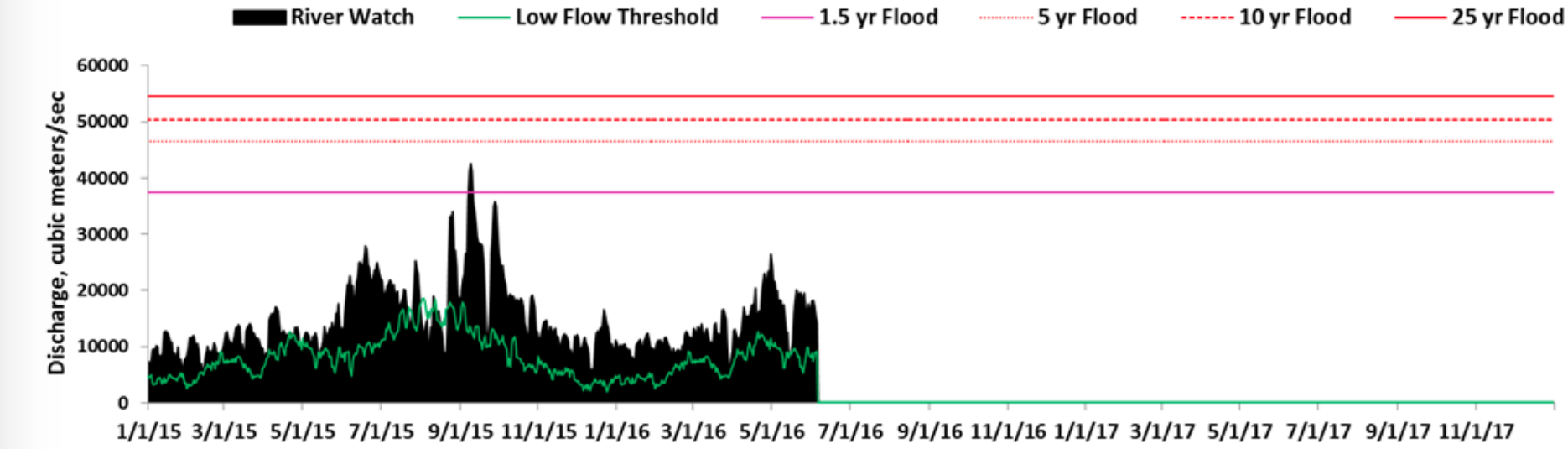
River Watch sites use satellite passive microwave radiometry to sensitively monitor this in-pixel surface water change.





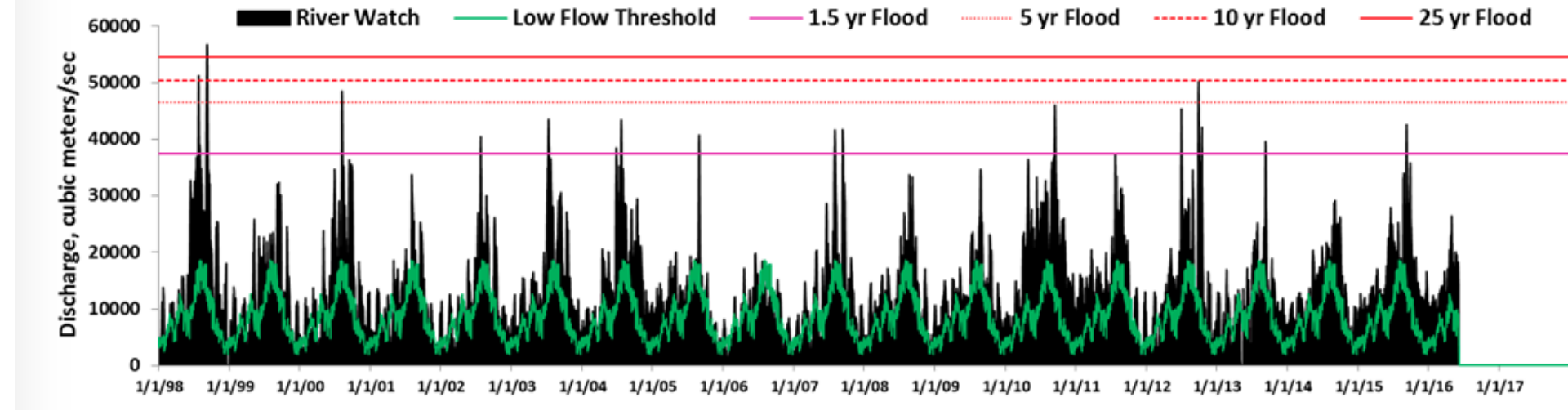
Recent Record

Technical Summary



Complete record

Low flow threshold is 20th percentile discharge for this day, 2003-2013.



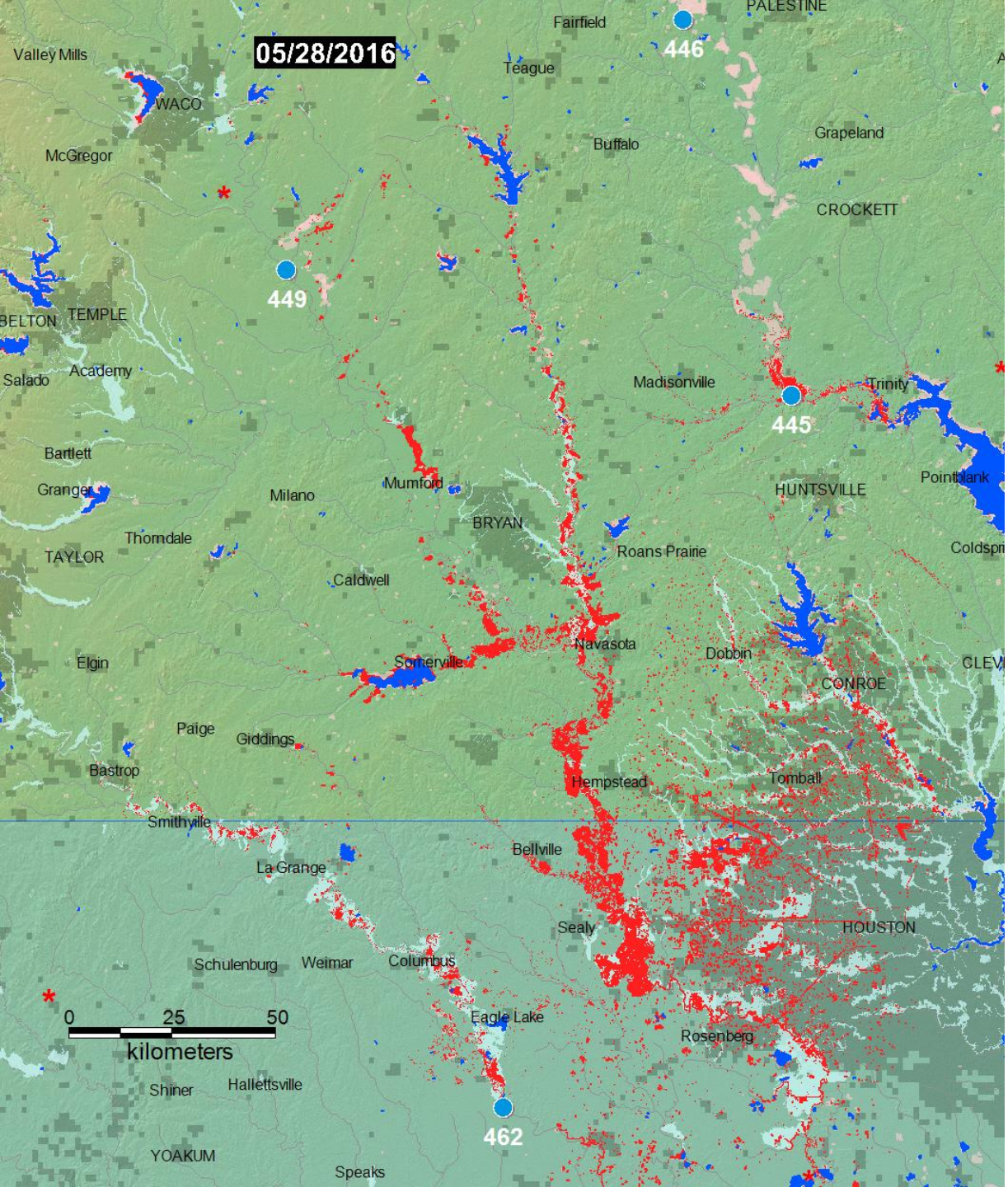
Flood extent measuring method

Automated: daily, globally

- Water mapping using NASA's two MODIS sensors (2000 ->)
- Optical bands are used to classify water, applying a ratio (Band2 + A) / (Band1 + B)
- NASA Goddard Spaceflight Center has automated this to deliver Near-Real-Time water extents (< 3 hours)

Per event (major flood)

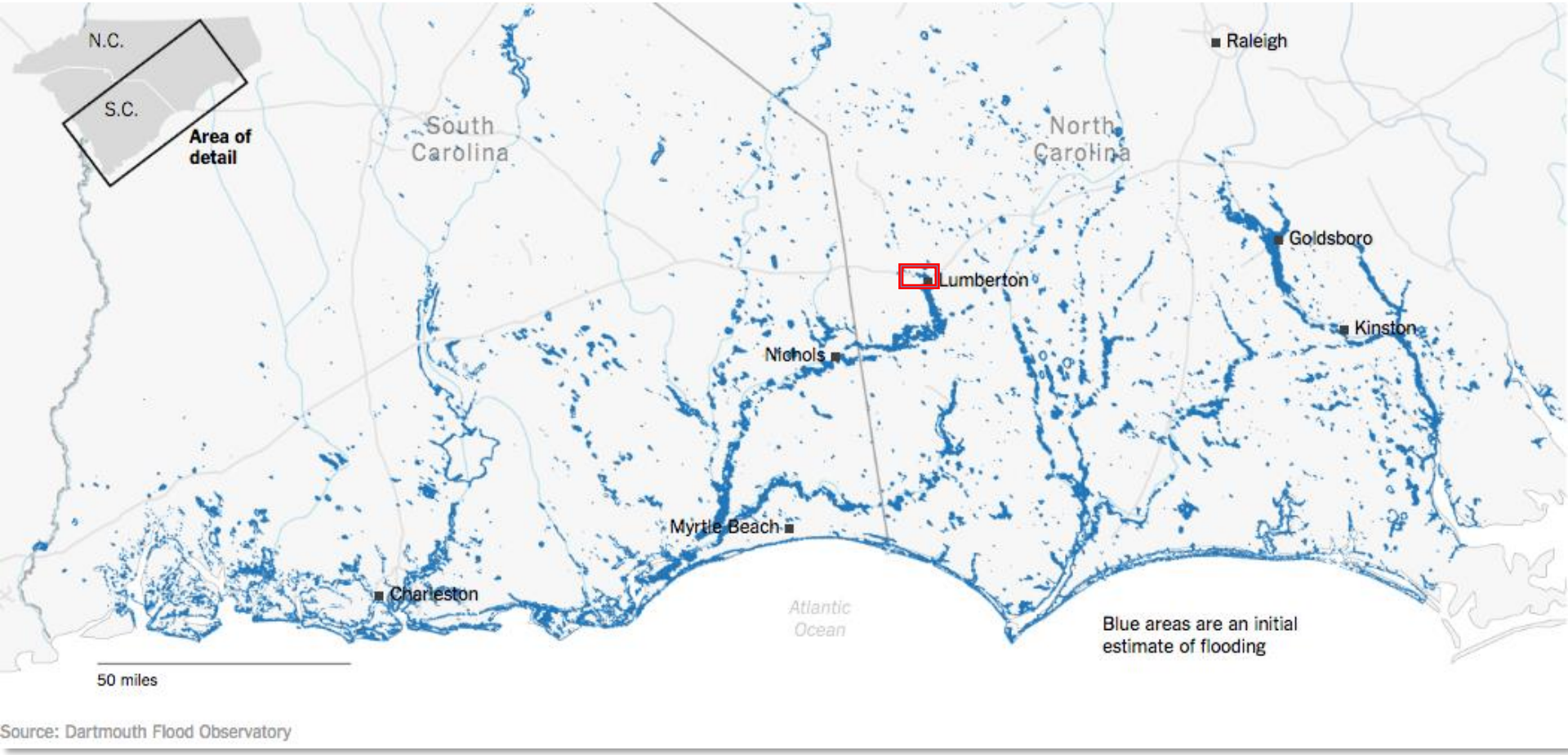
- MODIS / VIIRS / SAR / RadarSAT / LandSat



Texas floods

- Red: May 28th flooding
- Blue: Permanent water
- Light blue: Fema 100yr
- Light red: Previous years observed floods

Per flood event: Matthew, East Coast US



New York Times
October 12th, 2016

Combining the discharge information with optical imaging and mapping of flood extent provides a robust way to evaluate new flood severity, on a reach basis.

The Ganges River (site 1936)

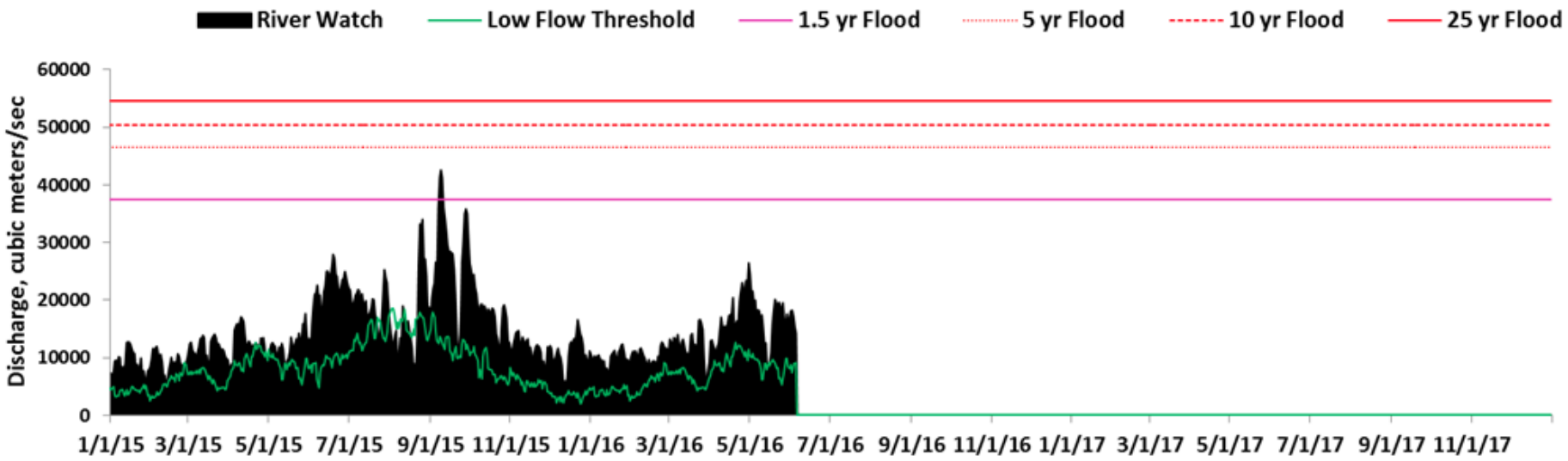
Dartmouth Flood Observatory

G F P global flood partnership

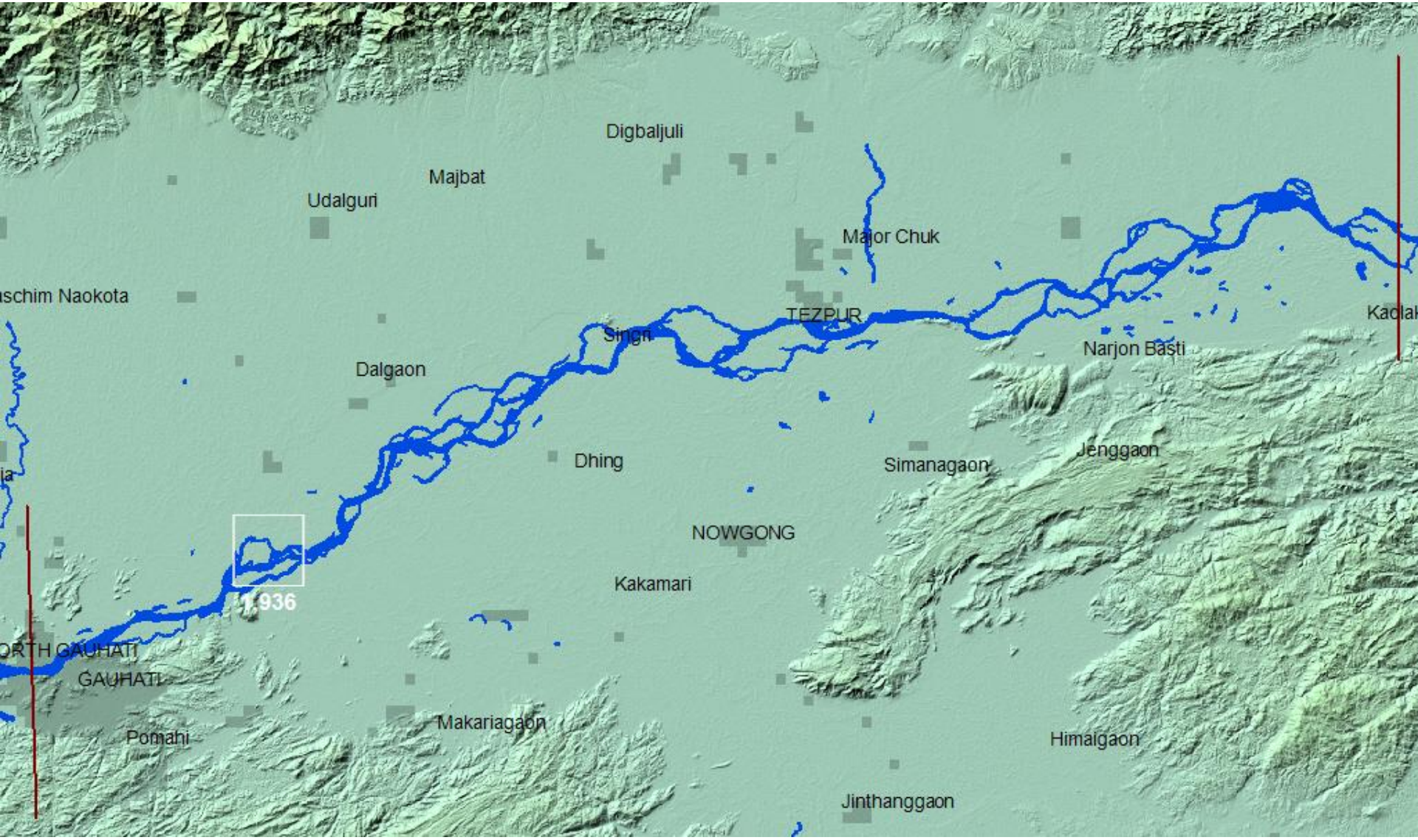
NASA

Predicted Flooded Area

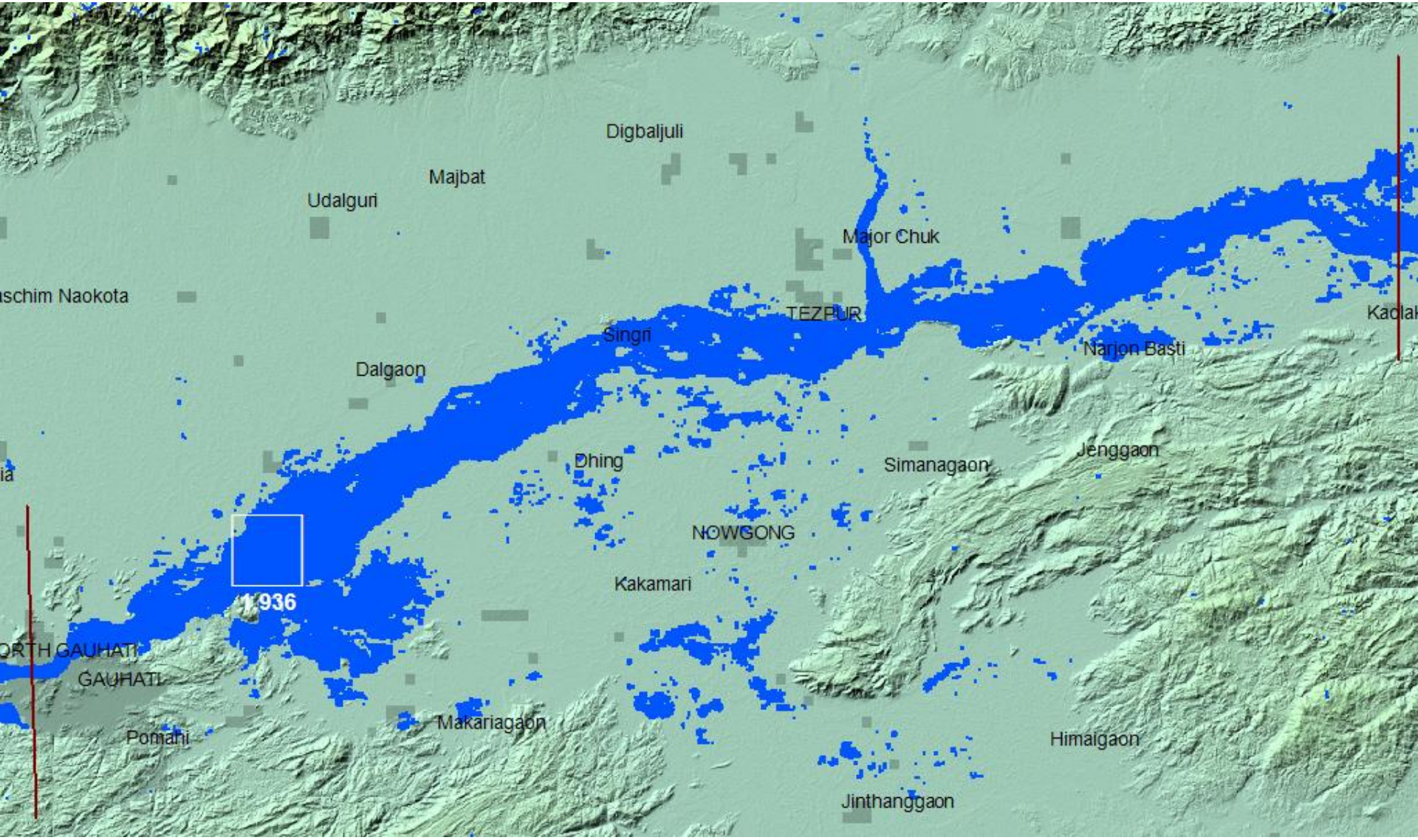
River Watch Gauging Site 1936



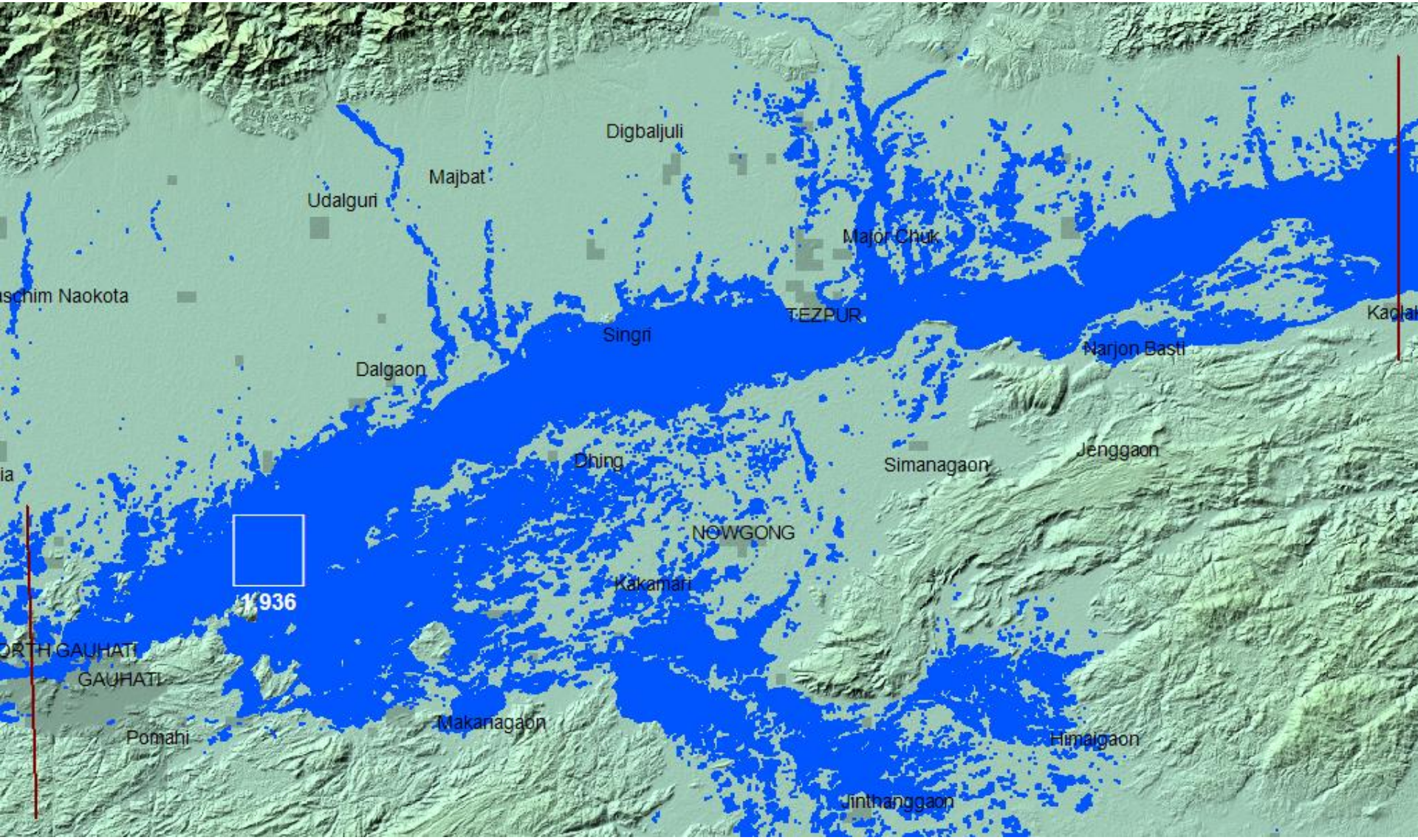
Flooded area for Normal Flow, Winter (~ 6100 m3/sec, observed February 11-22, 2000)



Flooded area for Moderate Flooding, r = 1.8 yr (37,000 m^3/s, observed summer, 2013)

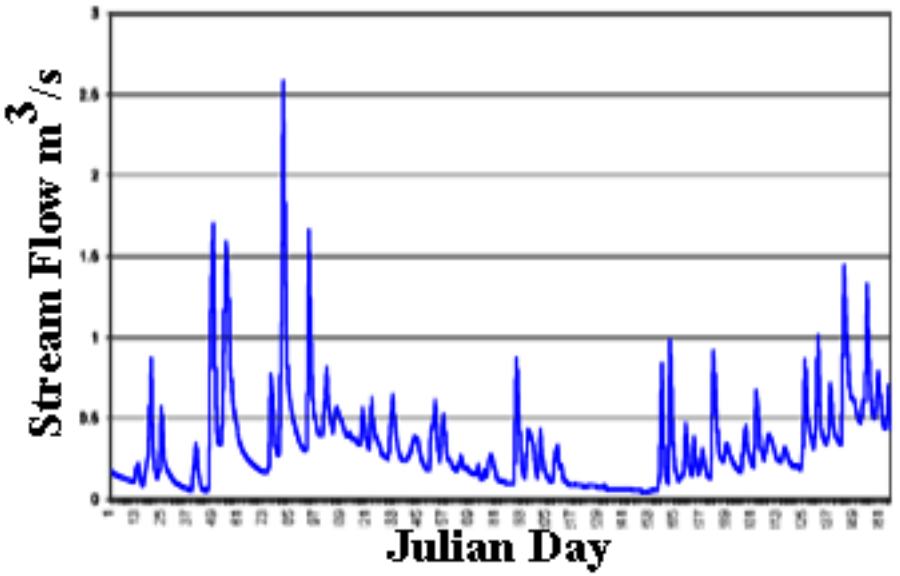


Flooded area for Moderate Flooding, r = 3 yr (44,000 m^3/s, observed summer, 2007



Modeling floods

Water Balance Model (WBM): Fully coupled global hydrological model that simulates vertical terrestrial and atmospheric water exchange and the horizontal overland water transport along a prescribed river network.



LISFLOOD-FP: Two-dimensional flood inundation modelling. Uses gridded discharges to estimate inundated area.

LISFLOOD_FP ingests ***WBM*** discharges to estimate inundated area.

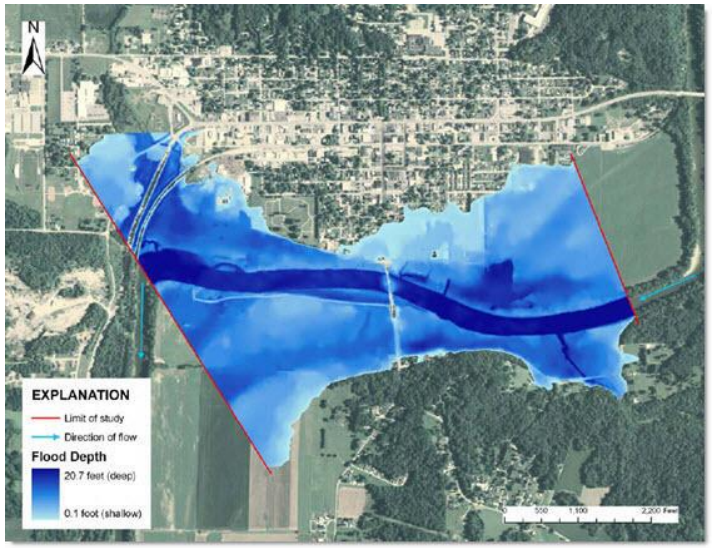


Image from USGS, flood mapping example

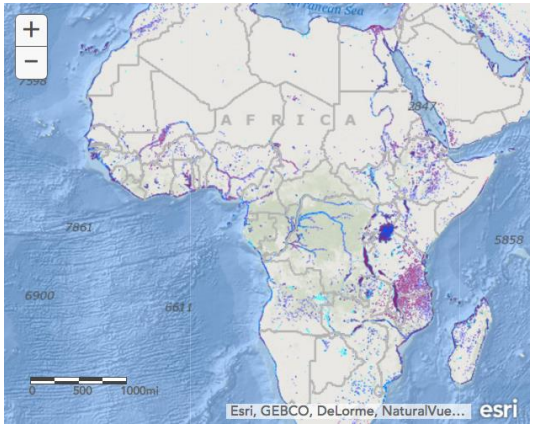
Dissemination of DFO data

- **DFO website** All flood extent & discharge data available, including archive: http://floodobservatory.colorado.edu/

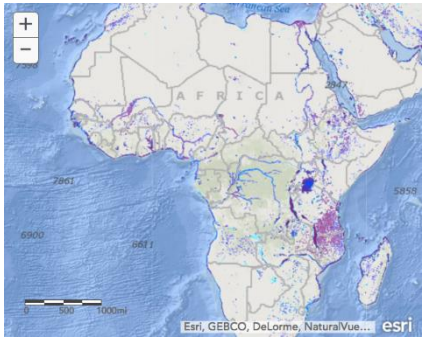
- **Web Map Service** – Supported by Global Facility for Disaster Reduction and Recovery (**GFDRR**).

  Currently with a focus on Africa with the goal to get global coverage. (*Inc. daily-, 2weekly-, January to current-, annual flood extents as well as flood frequency and flood duration maps*)

- **Flood GIS Portal** – Support from **GFDRR**.



Future efforts of DFO



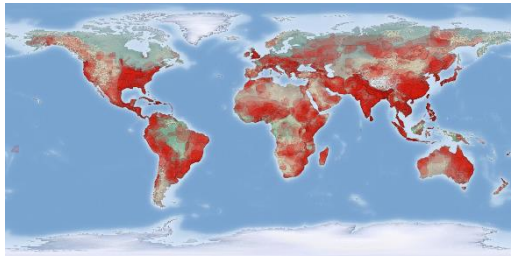
1. Global WMS – **GFDRR**

2. Flood alert system based on GloFAS -
   JRC discharge predictions. Test for Latin America – **CAF**

3. High resolution Urban flood mapping. Partnership with ***DigitalGlobe*** & SAR data **– CAF**

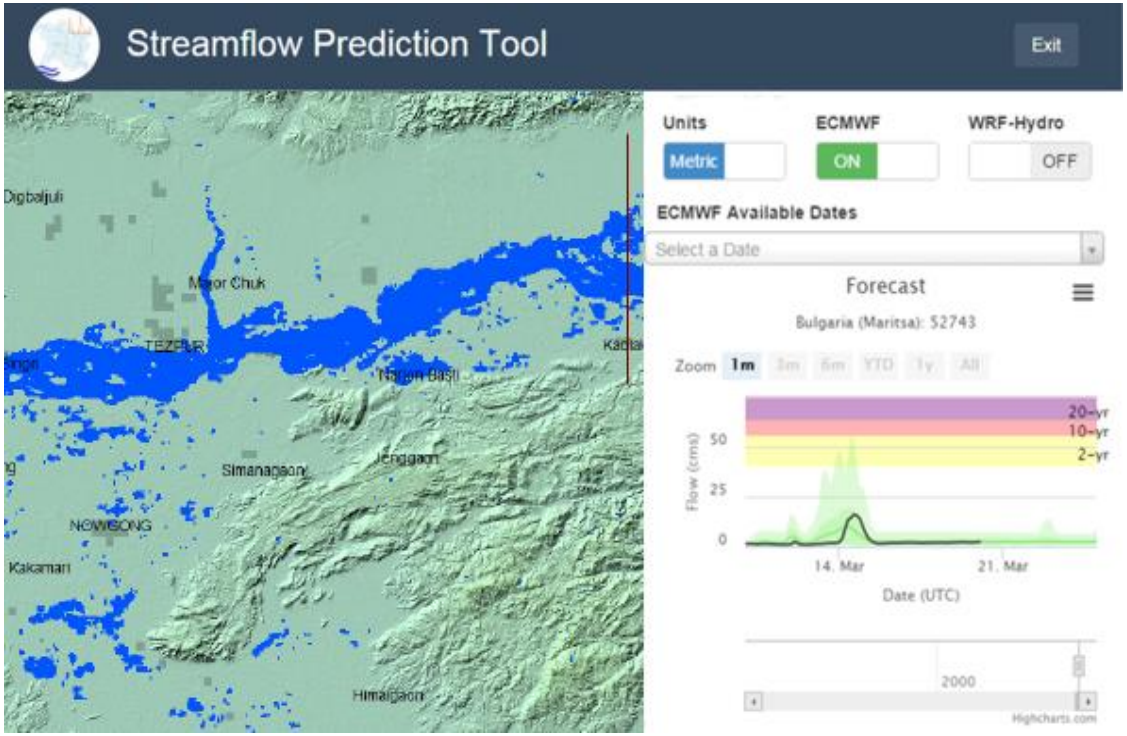
4. Mapping of all flood events in flood archive – **Google**

5. Flood severity index – **WFP**



Flood Forecasts / early warning system

- Incorporating GloFAS (JRC) water discharge forecasts
- Use DFO water extent archive to show potential extent of flood



Flood severity index

Hurricane intensity:

The Saffir-Simpson Scale
(*1971 Herbert Saffir & Robert Simpson*)

Saffir–Simpson hurricane wind scale	
Category	Wind speeds
Five	≥70 m/s, ≥137 knots ≥157 mph, ≥252 km/h
Four	58–70 m/s, 113–136 knots 130–156 mph, 209–251 km/h
Three	50–58 m/s, 96–112 knots 111–129 mph, 178–208 km/h
Two	43–49 m/s, 83–95 knots 96–110 mph, 154–177 km/h
One	33–42 m/s, 64–82 knots 74–95 mph, 119–153 km/h
Additional classifications	
Tropical storm	18–32 m/s, 35–63 knots 39–73 mph, 63–118 km/h
Tropical depression	<17 m/s, <34 knots <38 mph, <62 km/h

Earthquake intensity:

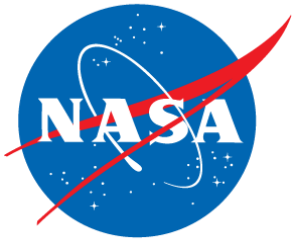
- The Moment Magnitude Scale succeeded in the 70's Richter scale

- The Modified Mercalli (MM) Intensity Scale (1931 Harry Wood and Frank Neumann) Used in the United States.

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Damage	None	None	None	Very slight	Light	Moderate	Moderate/ heavy	Heavy	Very heavy
Peak Acc	<0.17	0.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
Peak Vel	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16 -31	31-60	60-116	>116

Peak Acc = Peak ground acceleration (g), Peak Vel = Peak ground velocity (cm/s)

Thank you!


NASA

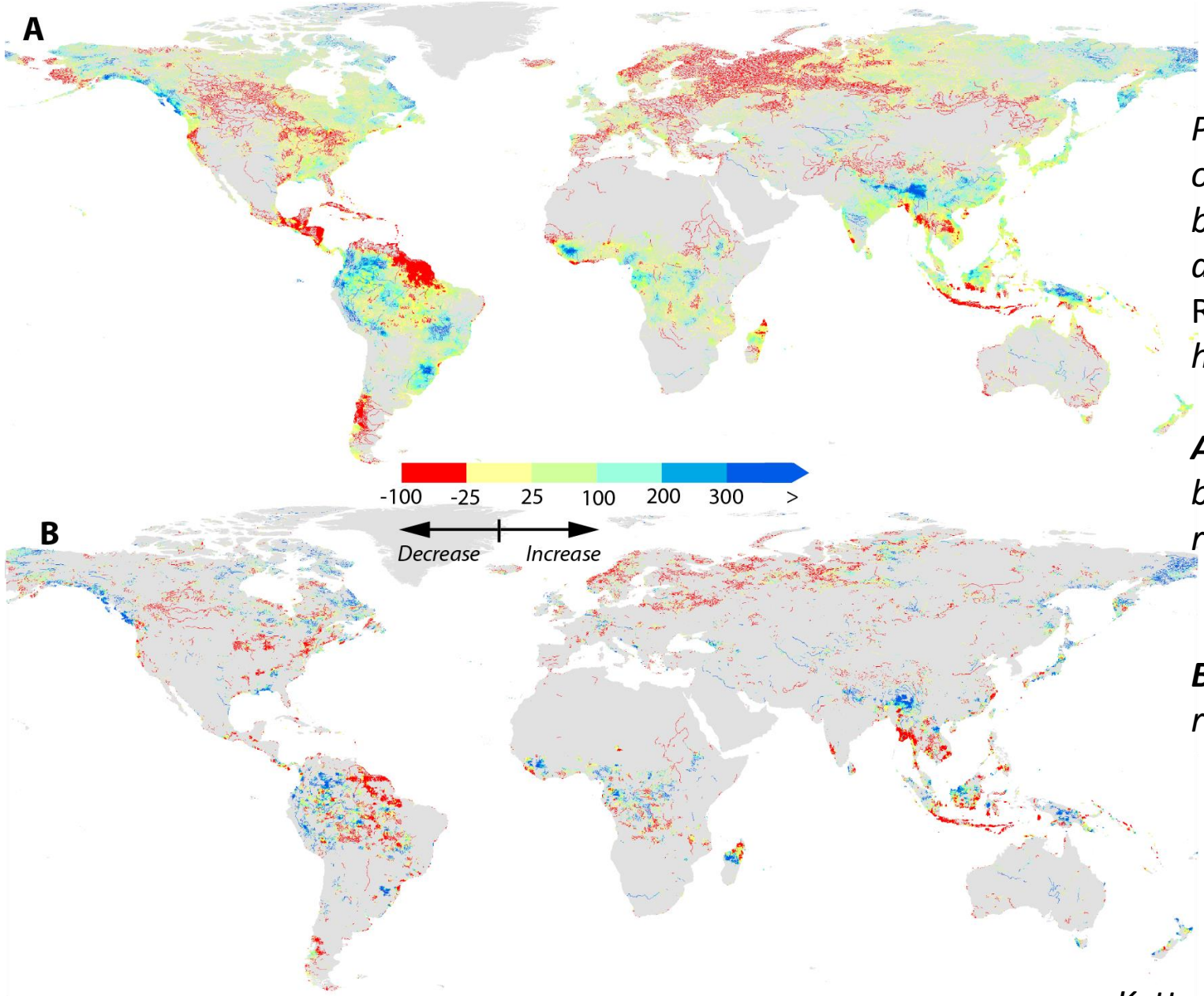

GFDRR
Global Facility for Disaster Reduction and Recovery


DEVELOPMENT BANK
OF LATIN AMERICA


Google


G F P
global flood partnership

WBM: discharge changes over time



Percentage change of flood frequency between the 2000s and 2100s for using RCP 4.5 *floods that have:*

***A**) a larger than the bank full (2-y) recurrence interval*

***B**) larger than 100-y recurrence interval.*

Kettner et al., submitted