中山大學 大气科学学院
SUN YAT-SEN UNIVERSITY School of Atmospheric Sciences

UN-SPIDER

Advances and Challenges in Observation and Modeling of Floods for Disaster Risk Reduction

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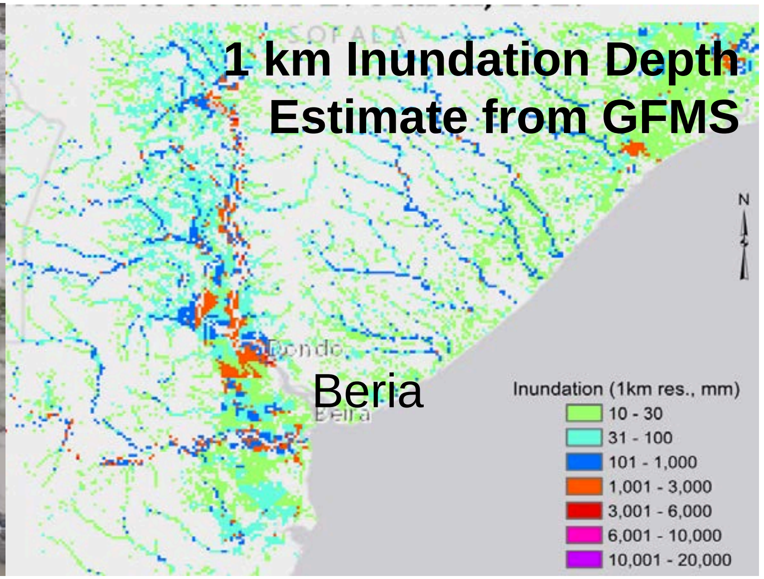
Hydrometeorological Extremes simulatioN Group (HENG),
School of Atmospheric Sciences, Sun Yat-sen University (SYSU)

HENG
Hydrometeorological Extremes simulatioN Group

GFP
global flood partnership

Robert Adler (U. Maryland), Lorenzo Alfieri and Peter Salamon (JRC),
Albert Kettner and Robert G. Brakenridge (U. Colorado), Patrick Matgen (LIST),
Guy Shalev (Google)



Mozambique

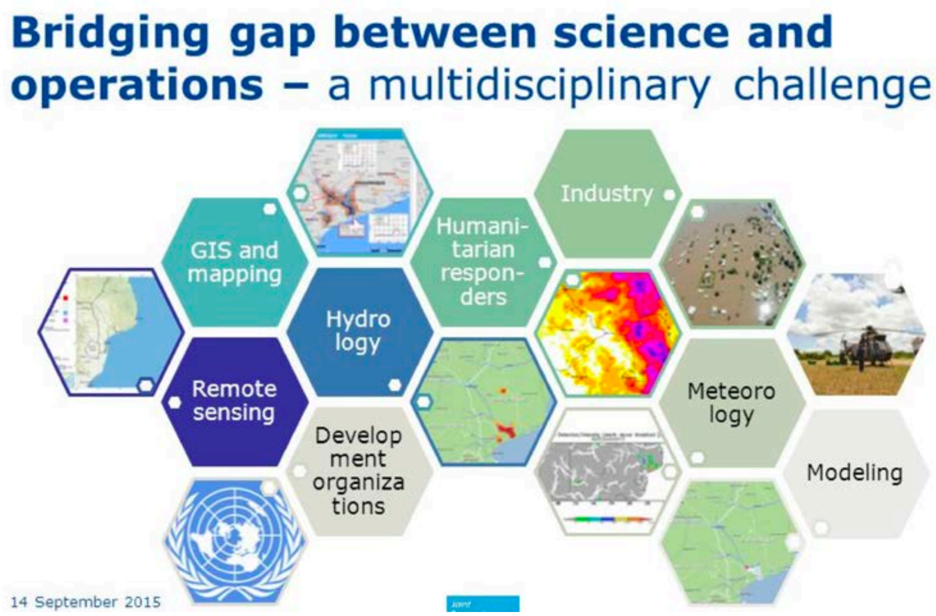
Cyclone Idai

14-19 March 2019

GFP

global flood partnership

A global network initiated by scientists, users, from private and public organizations, active in global flood monitoring, forecasting, response and risk management.

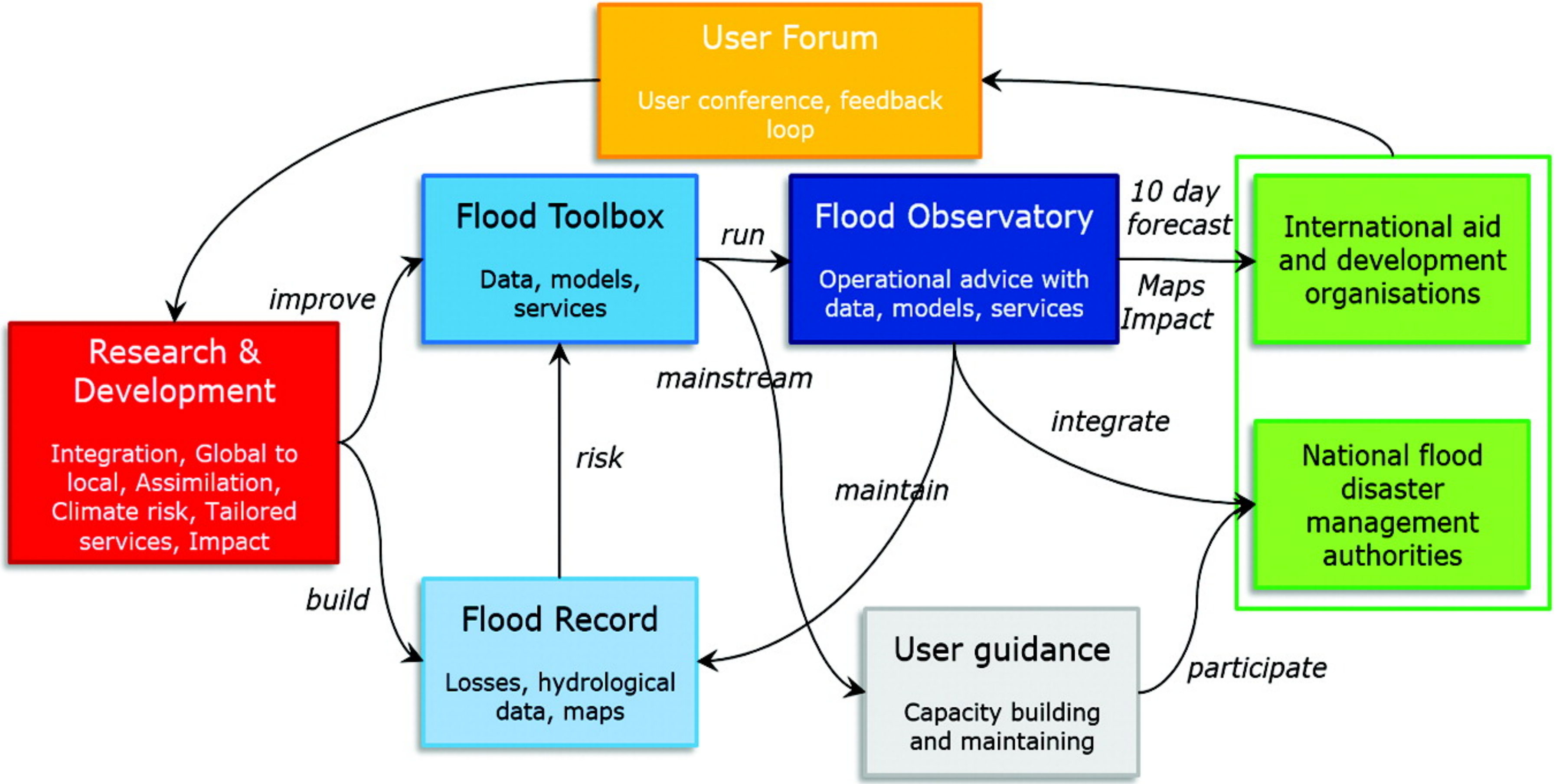


GROUP ON EARTH OBSERVATIONS

JOINING FORCES IN A GLOBAL FLOOD PARTNERSHIP

BY T. DE GROEVE, J. THIELEN-DEL POZO, R. BRAKENRIDGE, R. ADLER, L. ALFIERI, D. KULL, F. LINDSAY, O. IMPERIALI, F. PAPPENBERGER, R. RUDARI, P. SALAMON, N. VILLARS, AND K. WYJAD

Bulletin of the American Meteorological Society, 2015



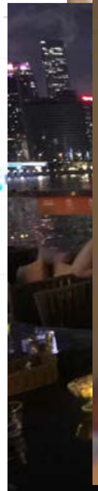
GFP Community development

Launching the Global Flood Partnership

Partnering for global flood forecasting, monitoring and impact assessment to strengthen preparedness and response and to reduce disaster losses

Global Flood Working Group, 4-6 March 2014, ECMWF, UK

- 2011: JRC, Ispra, Italy (working group)
- 2012, Deltares, Delft, Netherlands
- 2013: ESSIC/GSFC NASA, Maryland, USA
- 2014: ECMWF, Reading, UK (informal partnership)
- 2015: NCAR, Colorado, USA (formal partnership)
- 2016, JRC, Ispra, Italy
- 2017: Tuscaloosa, Alabama, USA
- 2018: Delft, Netherland
- 2019: SYSU, Guangzhou, China



Guangzhou
June 10-13, 2019

A global network for operational flood risk reduction

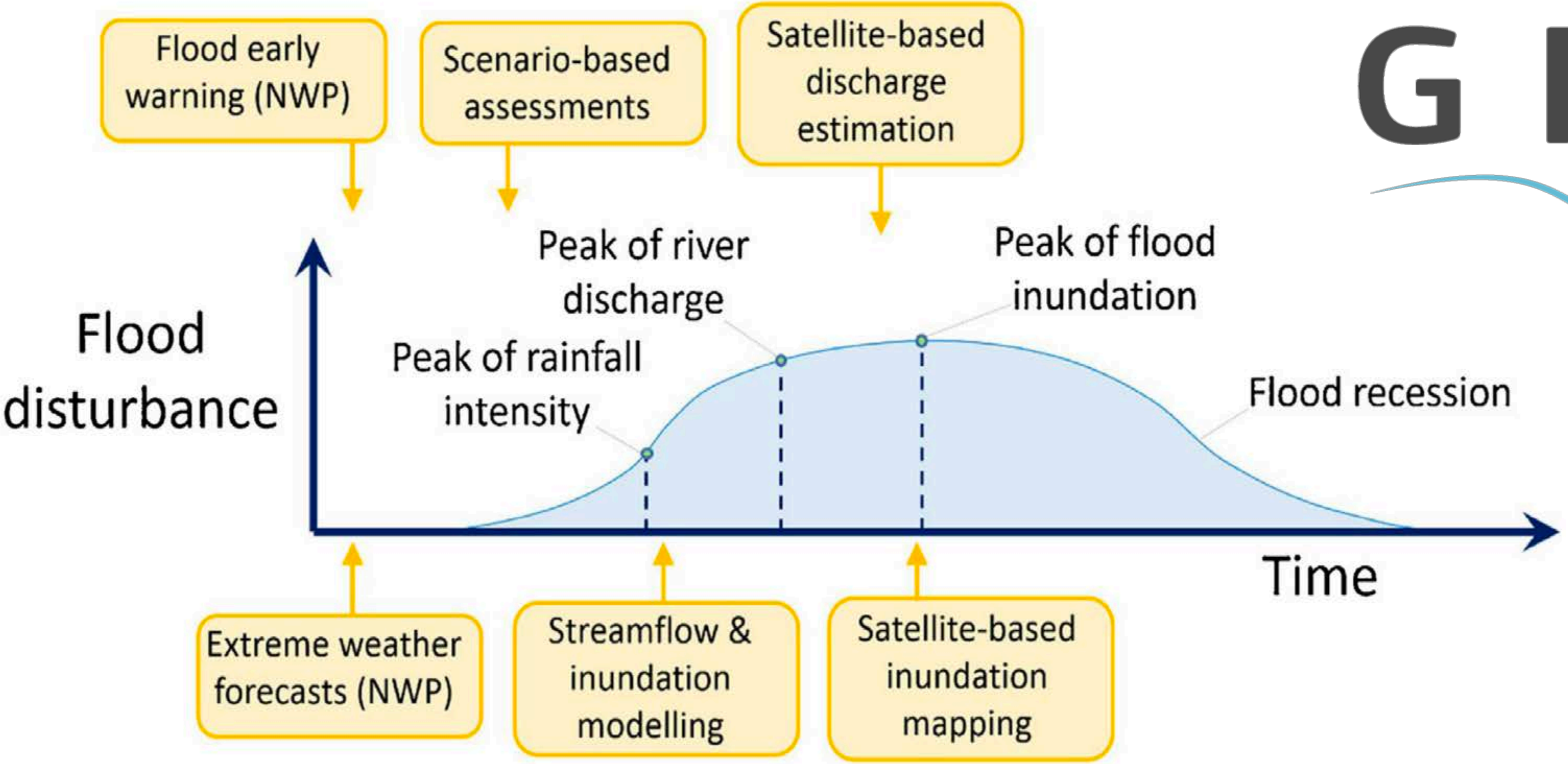
Environmental Science and Policy

Lorenzo Alfieri[a,*], Sagy Cohen[b], John Galantowicz[c], Guy J-P. Schumann[d,e], Mark A. Trigg[f], Ervin Zsoter[g], Christel Prudhomme[g,h,i], Andrew Kruczkiewicz[j,k], Erin Coughlan de Perez[j,k,l], Zachary Flamig[m], Roberto Rudari[n], Huan Wu[o,p], Robert F. Adler[q], Robert G. Brakenridge[r], Albert Kettner[r], Albrecht Weerts[s,t], Patrick Matgen[u], Saiful A.K.M Islam[v], Tom de Groeve[a], Peter Salamon[a]

ELSEVIER

2018

GFP
global flood partnership



Rapid-response flood mapping during *Hurricane Harvey* by the *Global Flood Partnership (GFP)*

GFP global flood partnership

Sagy Cohen*, *University of Alabama (sagy.cohen@ua.edu)*; Robert Adler, *University of Maryland*; Lorenzo Alfieri, *EU Joint Research Centre*; G Robert Brakenridge, *University of Colorado*; Erin Coughlan, *VU University Amsterdam*; Zac Flamig, *University of Chicago*; John Galantowicz, *Atmospheric and Environmental Research*; Yang Hong, *University of Oklahoma*; Albert Kettner, *University of Colorado*; Patrick Matgen, *Luxembourg Institute of Science and Technology (LIST)*; Son V Nghiem, *Jet Propulsion Laboratory, California Institute of Technolog*; Ana Prados, *University of Maryland*; Roberto Rudari, *CIMA Foundation*; Peter Salamon, *EU Joint Research Centre*; Mark Trigg, *University of Leeds*; Albrecht Weerts, *Deltares*; *Huan Wu, Sun Yat-sen University*

Hurricane Harvey made landfall as a Category 4 storm at the Texas Gulf Coast (near Rockport) on August 25, 2017, causing wind damage and storm surge-induced coastal flooding. The storm slowly moved east along the coast (meandering in and out of Gulf waters), in effect, stalling over southeast Texas and southwest Louisiana until September 1st. The slow-moving storm produced historically high amounts of rain over the region, with maximum accumulated rainfall of over 1,500 mm in southeast Texas. This led to catastrophic riverine and flash flooding in the region. Houston Metropolitan area (Texas) received over 750 mm of rainfall between August 24 and September 1, leading to widespread urban flooding, displacing scores of people and damaging properties and infrastructure. It was estimated that the Hurricane Harvey was the costliest natural disasters in US history, with a total estimated damage of over $180 billion.

GFP is not regularly activated for flooding events in first-world countries, as these typically have established flood prediction and observation capabilities. GFP activation for this event evolved as its magnitude became apparent. Below we provide a chronology of GFP activities during Hurricane Harvey:

Aug 25 — Aug 27 — Aug 28 — Aug 29 — Aug 30 — Aug 31 — Sep 1 — Sep 2 onward

Aug 25

Landfall

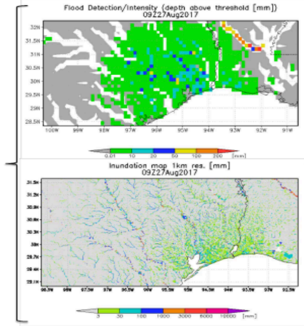
Source: National Weather Service; NASA Geostationary Operational Environmental Satellite; International Best Track Archive for Climate Stewardship (via nytimes.com)

Aug 27

GFP Partial Activation:
Dartmouth Flood Observatory (DFO) sent a limited-distribution email (not via GFP mailing list) informing about the activation of the 'International Charter', setting up of a DFO event webpage, and outlining available satellite imagery resources from before the flooding. The email led to inclusion of the recipients in the FEMA daily Remote Sensing Coordination and Geospatial Coordination calls which was later proved instrumental in connecting GFP products to the hurricane response community (including for the following flood events in Florida and Puerto Rico). The email was shared with NOAA National Water Center. A few hours following the initial email, precipitation and inundation predictions from GFMS were shared.

DFO Event webpage

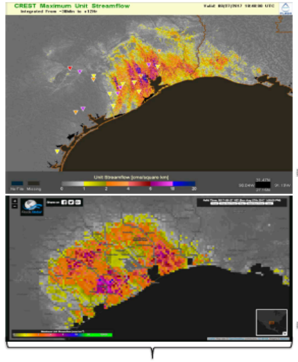
GFMS Predictions



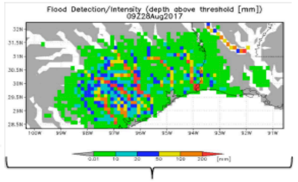
Acknowledgments for Son V Nghiem : "The research carried out at the Jet Propulsion Laboratory (JPL), California Institute of Technology, was supported by the NASA Land-Cover and Land-Use Change Program and by the NASA Terrestrial Hydrology Program. These results contained modified Copernicus Sentinel data (2017). Thanks to D. T. Nguyen of JPL for SAR data processing to produce flood maps

Aug 28

Flooding in Houston
GFP Full Activation:
The first email was sent to the GFP mailing list, proposing using this event as a case study to study GFP-members flood prediction systems. The same email also included streamflow predictions from the Flooded Locations And Simulated Hydrographs Project (FLASH). These predictions were re-distributed to a range of stakeholders (e.g. FEMA, NASA), an action which thereafter became standard operating procedure, with growing list of recipients.



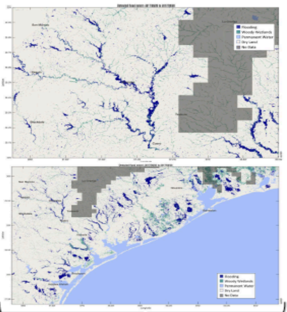
FLASH Products



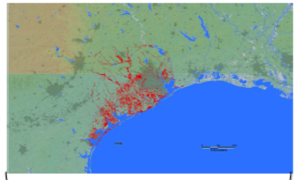
GFMS Predictions

Aug 29

Initial Remote Sensing Mapping:
DFO shared (via FEMA Geospatial Coordination email distribution) an update on flood mapping and modeling efforts, including using Radarsat images (from Aug 28) to map flooding, and sharing JPL-produced flood maps from the ALOS-2 satellite. The confidence in these products were relatively low. Atmospheric and Environmental Research (AER) shared (via GFP mailing list) a large-scale 90-m resolution flood map of the impacted area, analyzed from the AMSR2 (passive microwave) sensor using an experimental configuration of the FloodScan system. Link between DFO/GFP to the State Operations Center of the Texas Division of Emergency Management (TDEM) was established which initiated data sharing via the TDEM data server (restricted access).



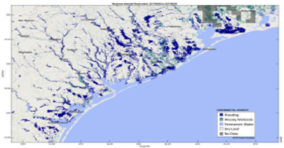
AER FloodScan



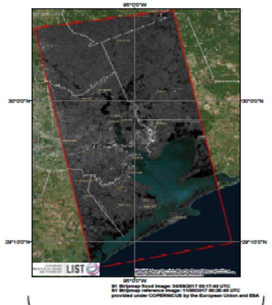
DFO Flood map

Aug 30

SAR-based Mapping:
Following a pass by Sentinel-1 satellite, SAR-based flood maps were shared by Luxembourg Institute of Science and Technology (LIST), JPL and DFO. DFO ftp server was used to store and distribute the GIS files of these, and future, products relating to this event. AER produced an updated maximum flood map for the region using new AMSR2 imagery, which was shared via the GFP mailing list. It was then distributed to the FEMA Geospatial Coordination mailing list (now over 300 recipients) and was uploaded to the TDEM data server.



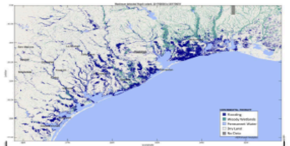
AER FloodScan



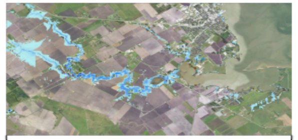
LIST

Aug 31

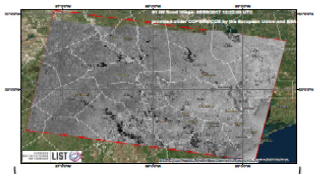
Additional Sentinel-1 imagery was shared by LIST via the GFP mailing list. DFO provided an updated inventory of GFP-produced flood maps and links to its event-dedicated web-portal and ftp server. The Surface Dynamics Modeling Lab (SDML) shared a floodwater depth map based on the AER maximum flood extent map and a DEM. AER shared updated large-scale maximum flood extent maps incorporating AMSR2 data from August 30 and set up a FloodScan web interface with daily Hurricane Harvey maps. LIST shared SAR-based flood map covering the Houston area from a 30 August Sentinel-1 pass. Aerial photography was becoming available via NOAA but with limited coverage outside the coast.



AER FloodScan



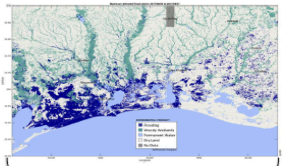
SDML Floodwater Depth



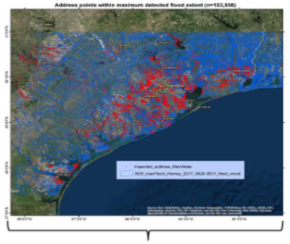
LIST

Sep 1

AER shared updates from AMSR2 passes on 31 August, revealing the extent of flooding in east Texas (Beaumont area). SDML shared a building impact map based on AER maximum flood extent map and address points layer from the TDEM server (uploaded by University of Texas, Austin).



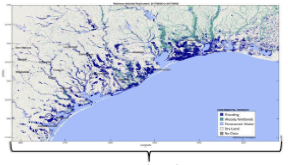
AER FloodScan



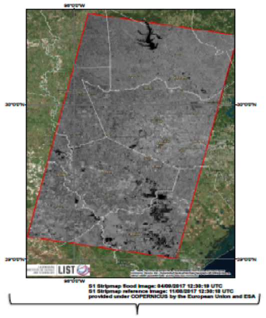
SDML Floodwater Depth and building impact

Sep 2 onward

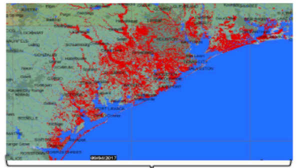
AER shared final maximum flood extent estimates incorporating all AMSR2 data 26 August - 2 September with expanded coverage into Louisiana. LIST shared flood maps from two Sentinel-1 passes on 4 September. DFO shared a maximum extent map based on Sentinel-1 imagery. DFO website was updated to include these and other final products: http://floodobservatory.colorado.edu/Events/2017USA4510/2017USA4510.html



AER FloodScan



LIST



DFO Flood map

GFP global flood partnership

https://gfp.jrc.ec.europa.eu

GFMS

https://gfp.jrc.ec.europa.eu/support-service

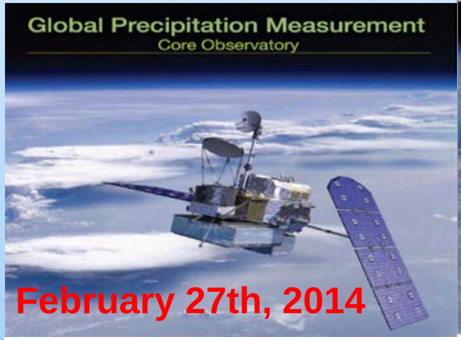
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION | GODDARD SPACE FLIGHT CENTER

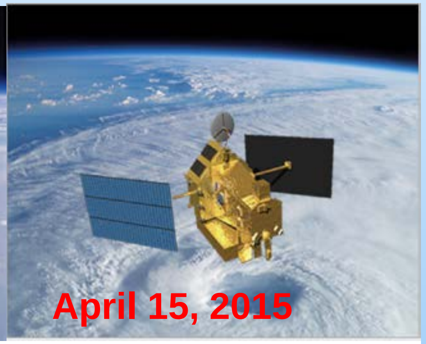
GFMS from TRMM to GPM

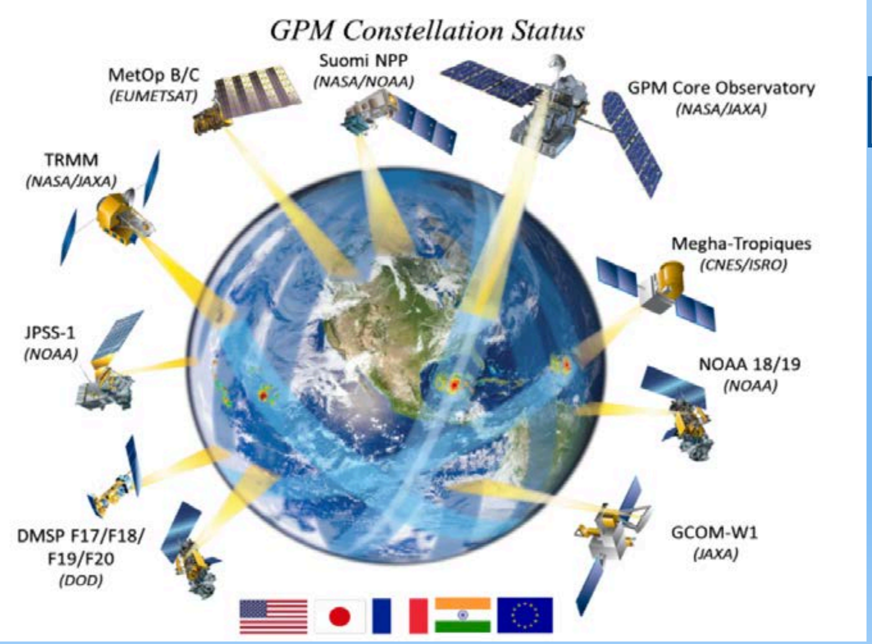
Search

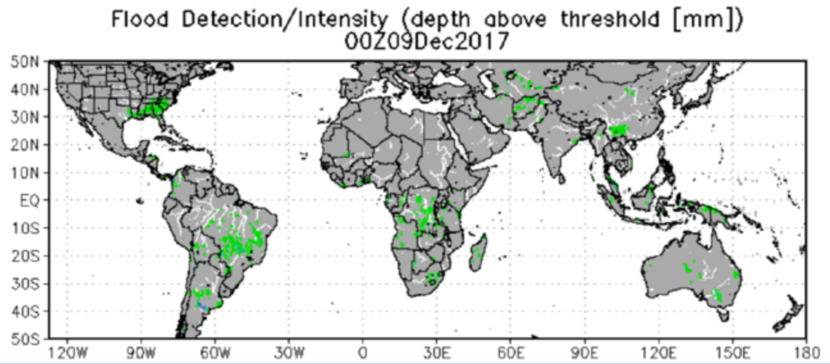
PRECIPITATION MEASUREMENT MISSIONS

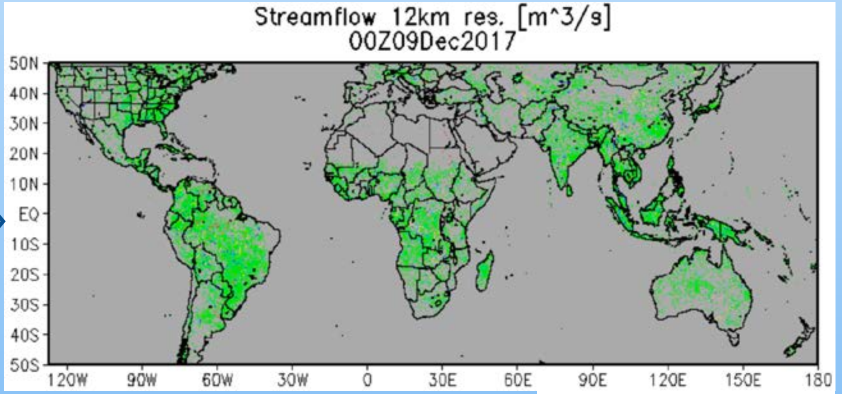
3-hourly, 8th and 1km global flood detection and inundation mapping with hydrological model

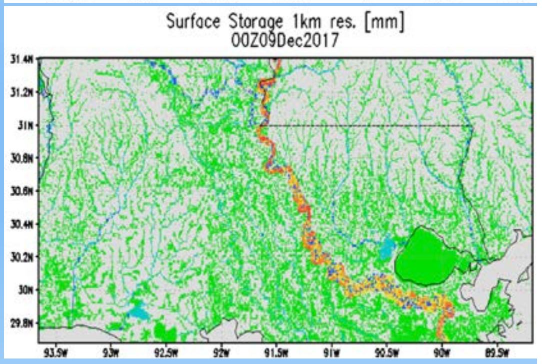


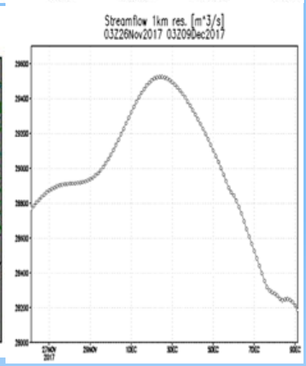






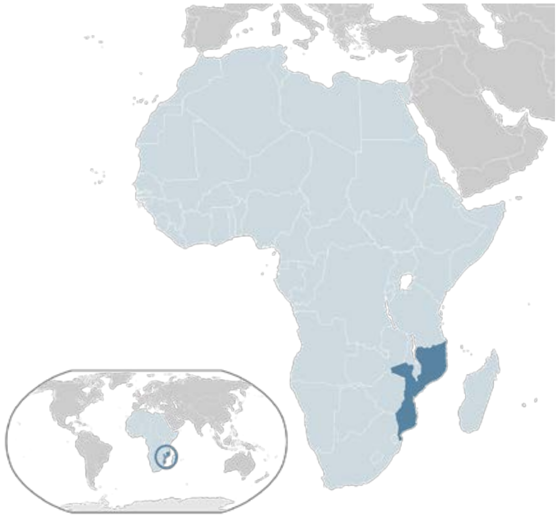


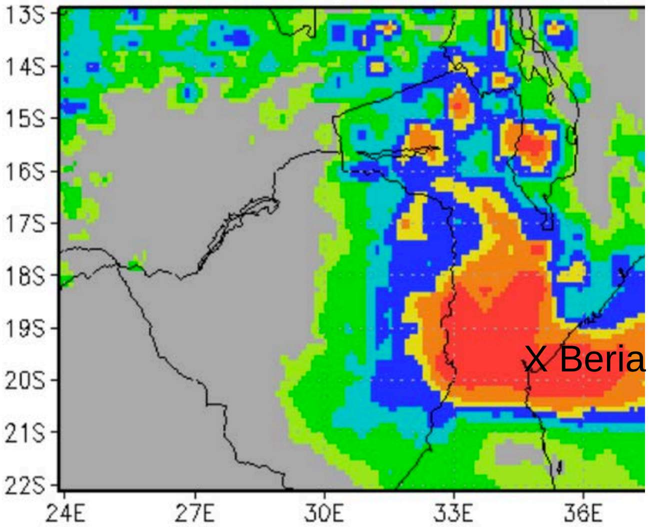




Global Flood Monitoring System (GFMS)

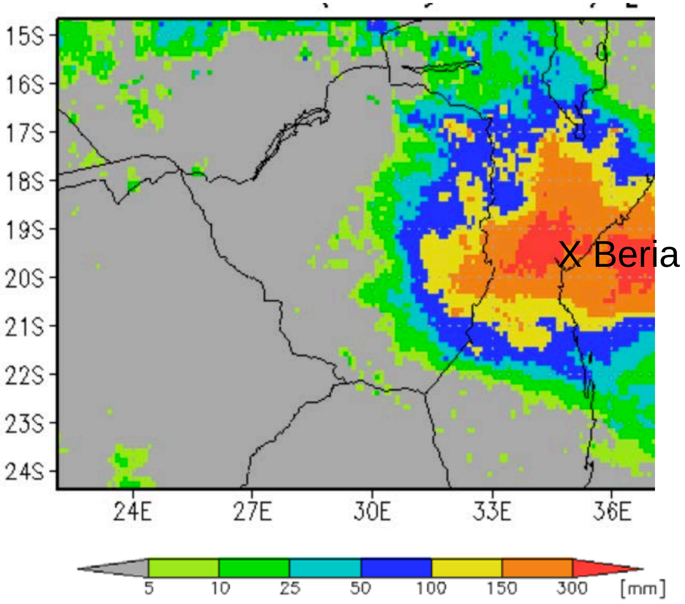
Forecast Rain Before Cyclone Hit





3-Day Forecast Rain from 14 March (from NASA GEOS NWP model)

NWP forecast peak totals were ~ 1000 mm, while peak satellite estimates (IMERG) were ~ 600 mm. Ground validation was missing/questionable.



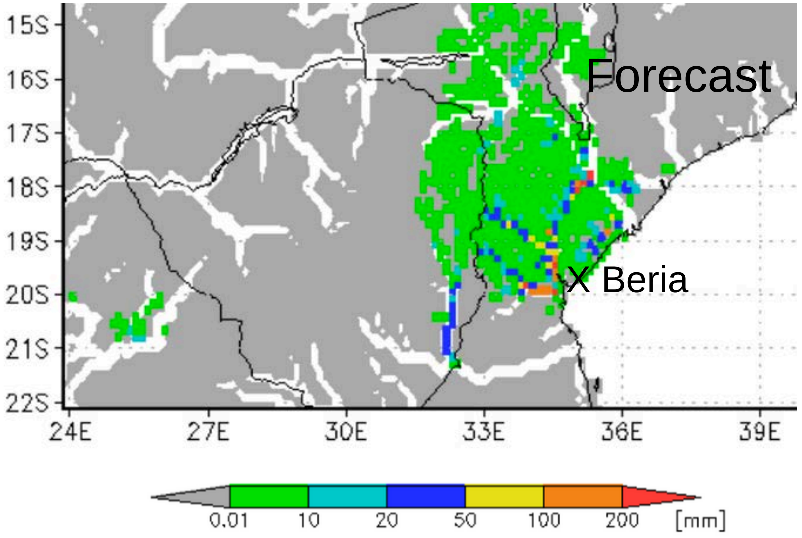
3-Day Satellite-based Rain from 14-17 March

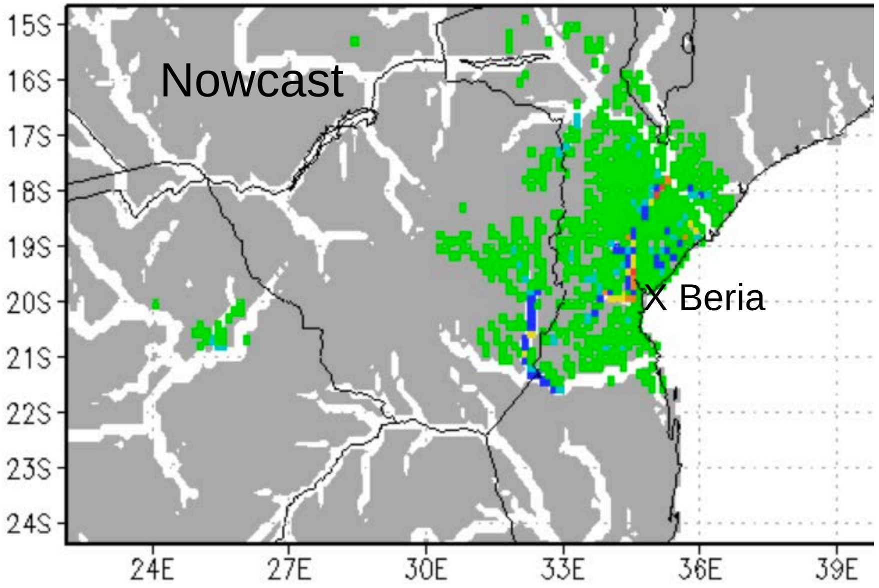
Flood Forecasts from NWP Rain vs. Nowcast Using Satellite Rain

Forecast from 14 March
for 17 March

Nowcast using Satellite Rainfall
for 17 March

Flood Detection/Intensity (Depth)

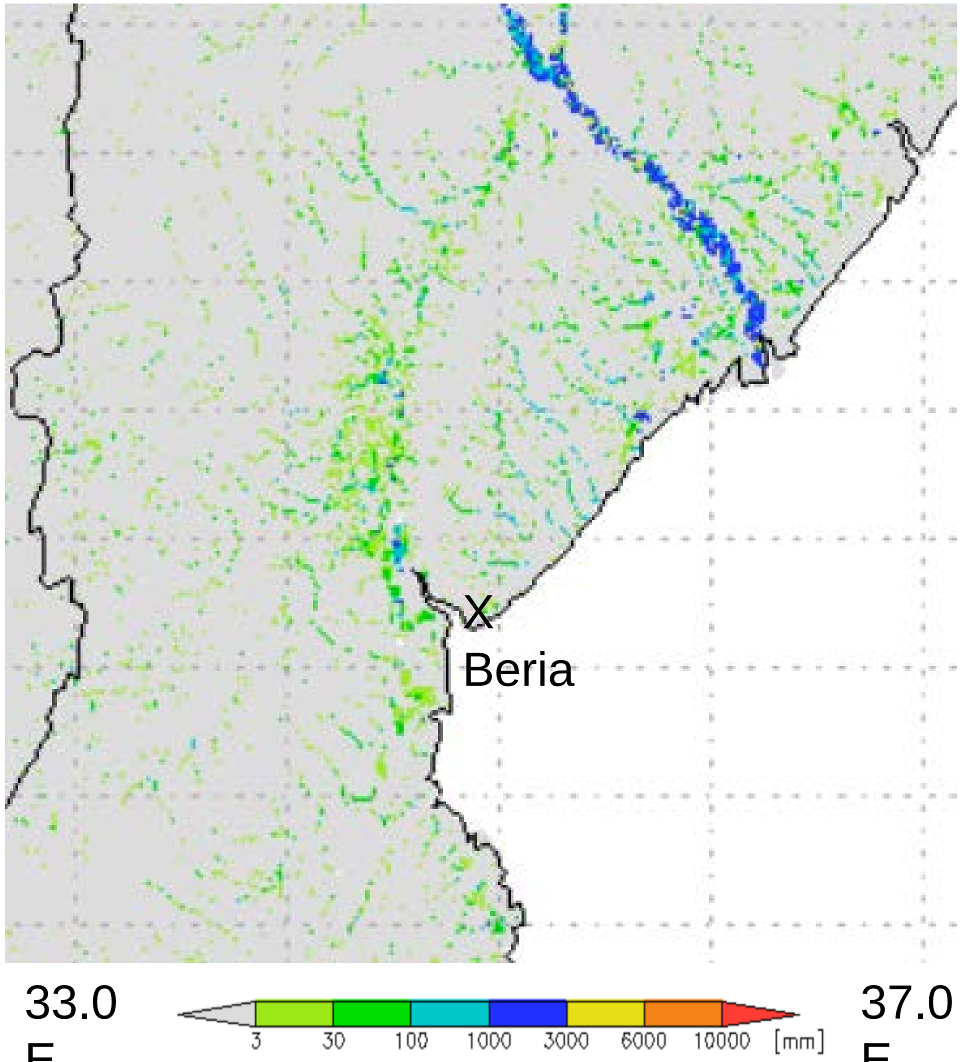




Forecast at coarse (12 km) resolution gives good warning of where flooding may occur both in Mozambique and Zimbabwe, with less intensity due to difference in peak rain amounts

First Estimate of Inundation—from GFMS

15 March



Timeline of Useful Inundation Maps

15 March--GFMS 1 km (calculation based on Satellite rainfall and land-surface/routing models—every 3 hrs.)

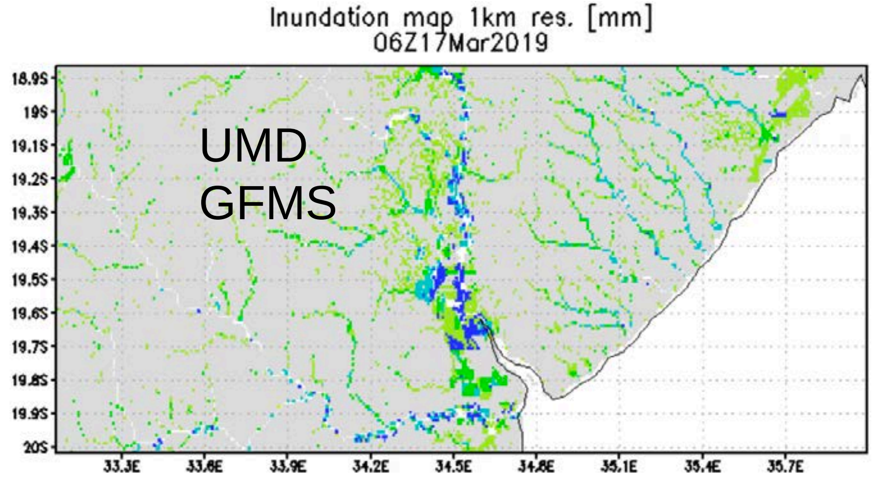
17 March—AER FloodScan (surface passive microwave signal disaggregated spatially by terrain, but obscured by rain [not cloud]

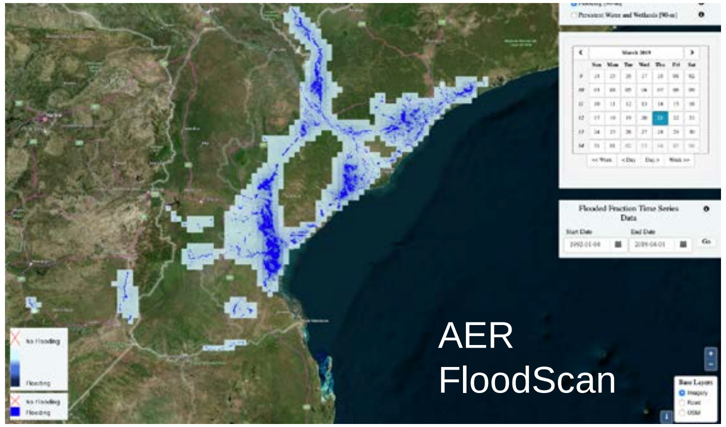
20 March—Synthetic Aperture Radar (SAR) published by UNOSAT from Sentinel-1 data 19-20 March. *Number of groups analyzing Sentinel and other SAR data*

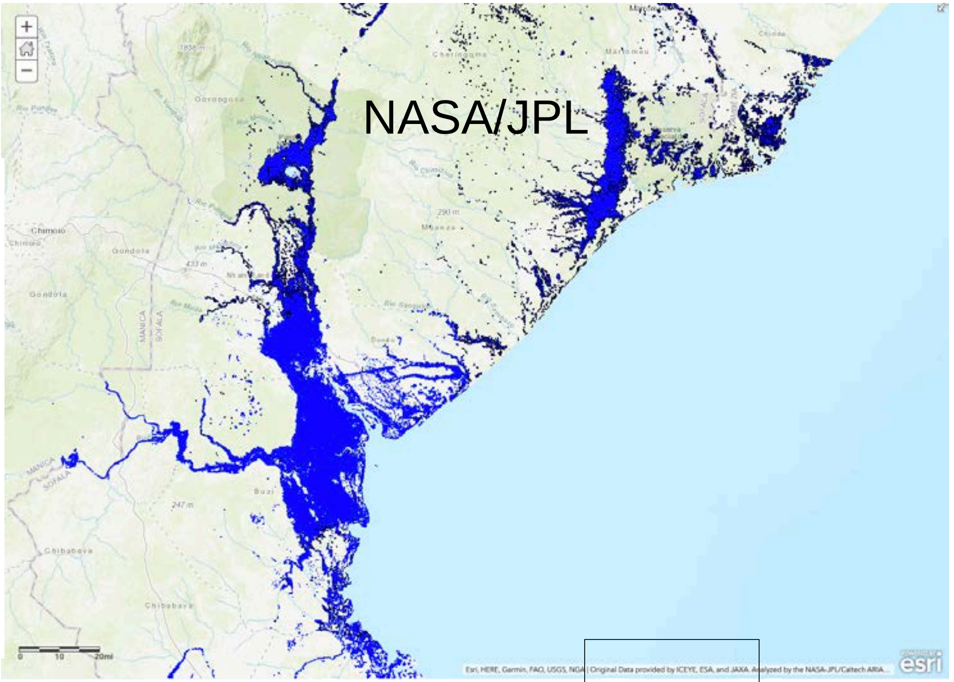
Later—Optical (e.g., MODIS) obscured by clouds

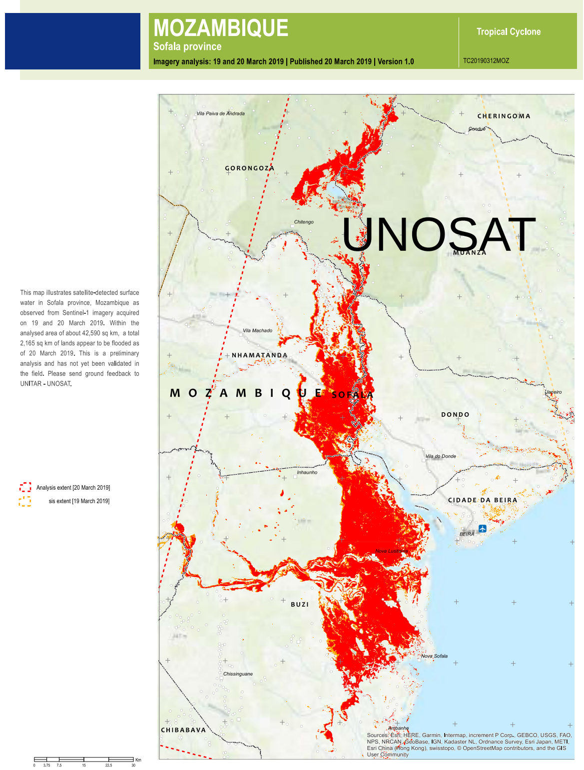
Mozambique Cyclone Idai March 2019

SAR-based Inundation Maps

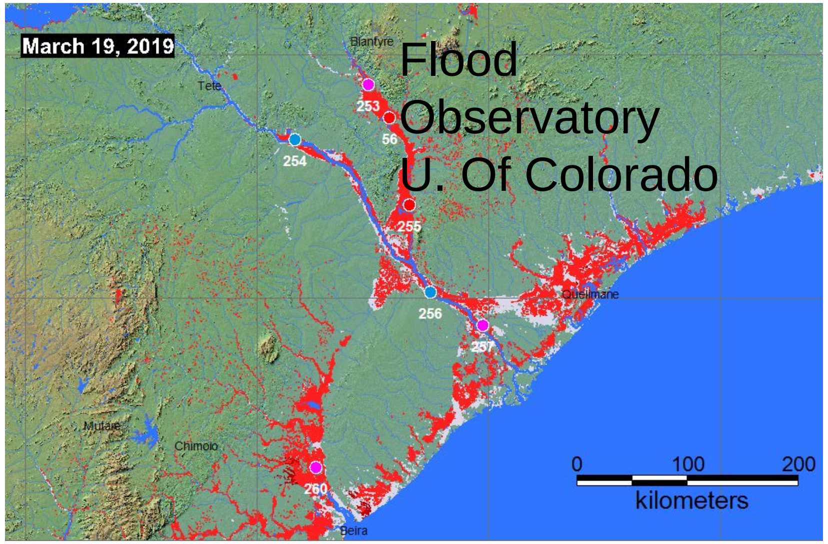








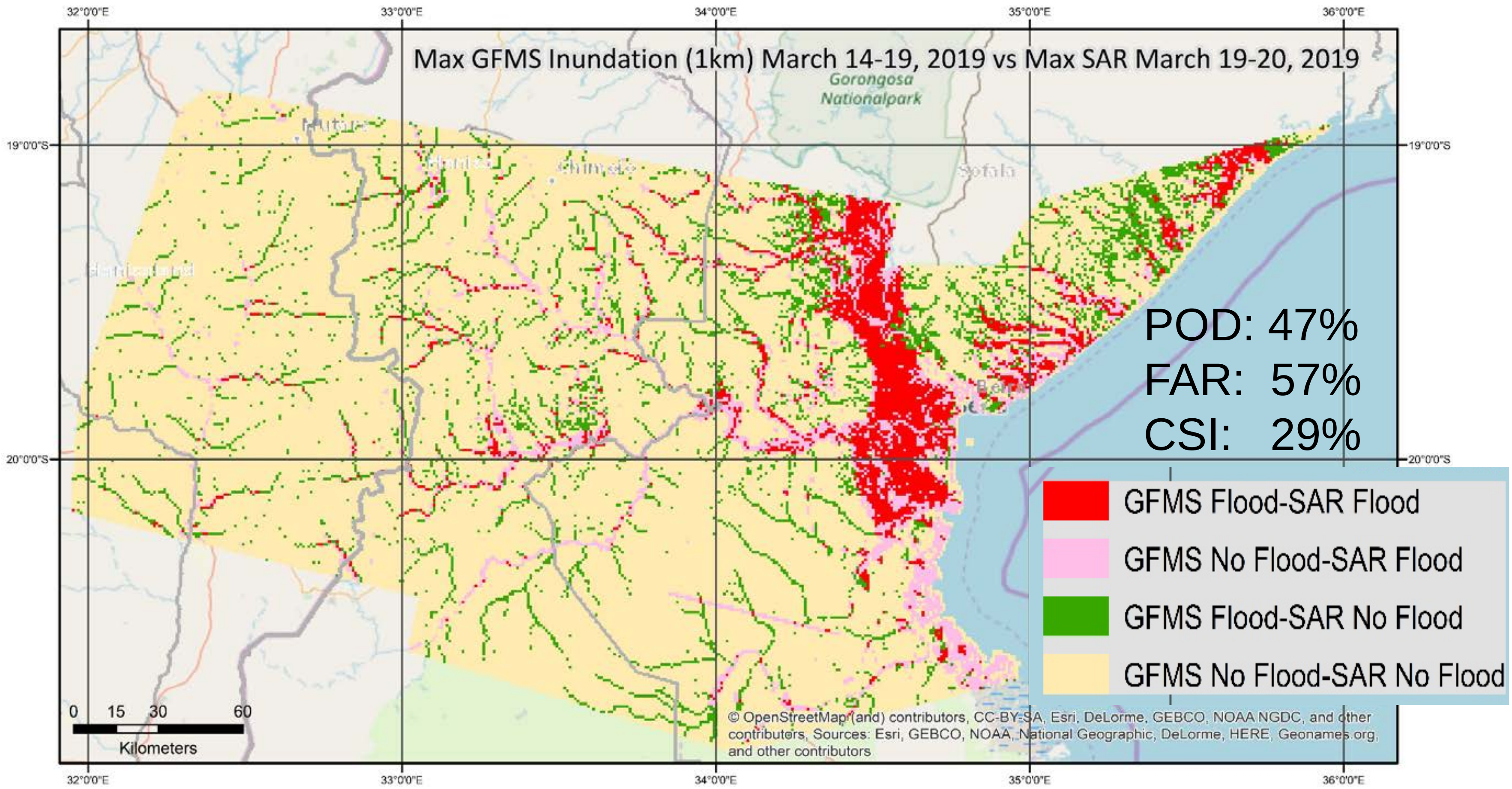
LIST
Luxembourg



Numerous Remote Sensing-based flood products

Time Integrated Inundation from GFMS

Maximum Inundation from GFMS (14-19 March) vs. Max Inundation from SAR (LIST)

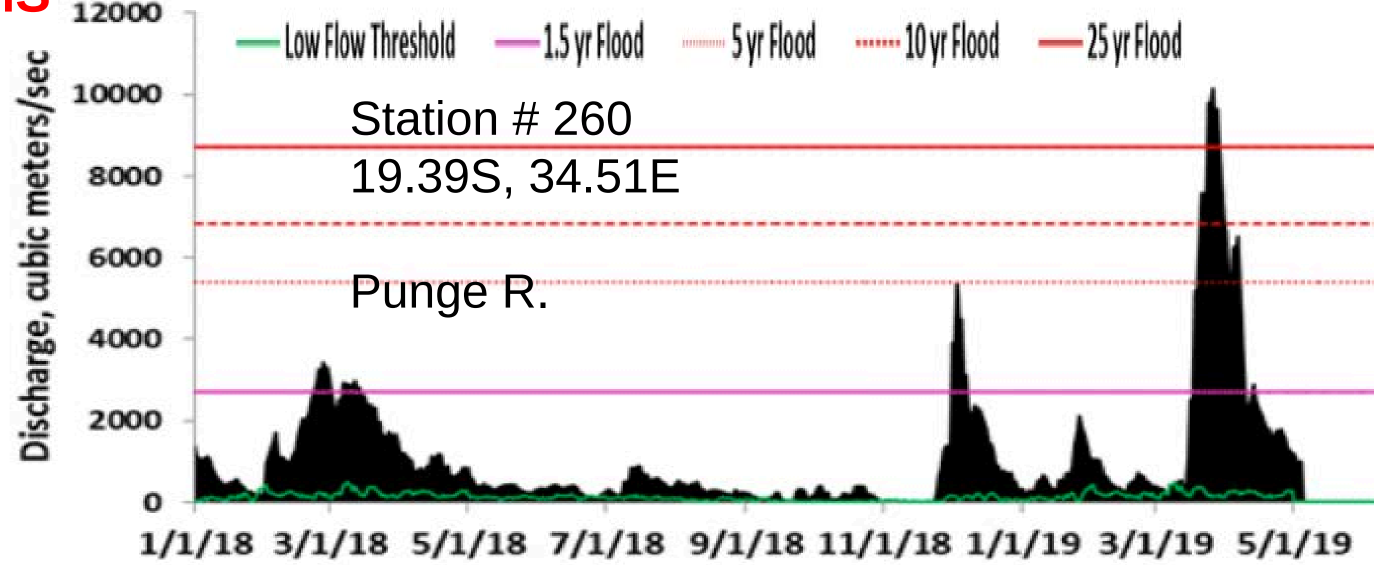


Better agreement with SAR—Higher POD, but lower FAR

Streamflow/Flood Estimates from RiverWatch (Flood Observatory) and GFMS

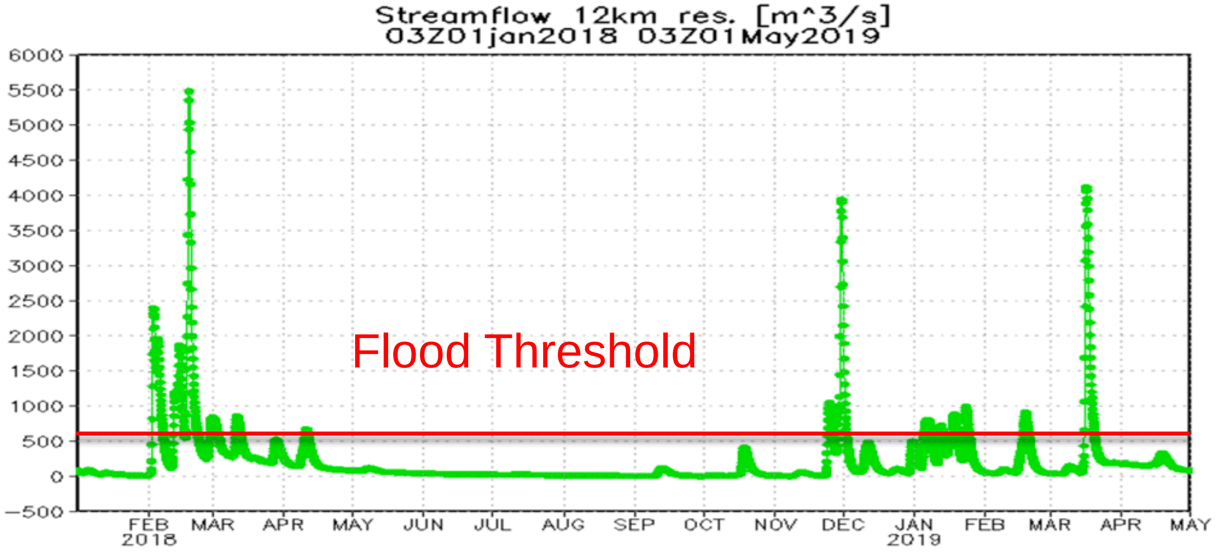
RiverWatch

Uses surface microwave observations related to streamflow



GFMS
Streamflow

Satellite rainfall into land surface/routing models



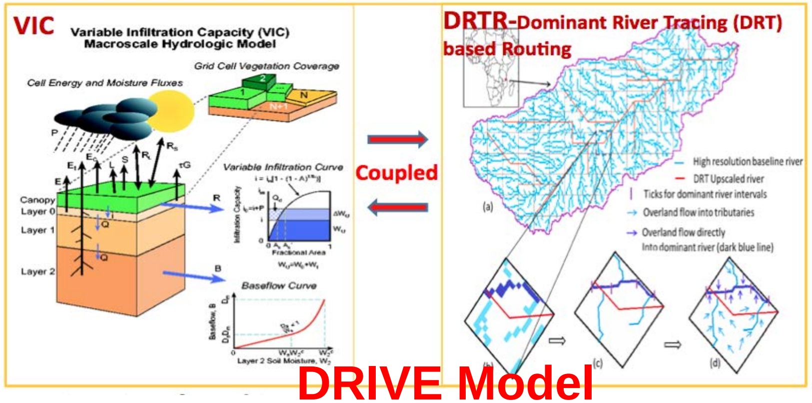
Mozambique Flood Example → what do we learn?

- Real-time users need accurate information, quickly. Multiple sources are available, at different time and space resolutions (and different latencies) and with different positive qualities and limitations. With multiple sources, users need info. to be "easy to compare" or integrated.

- ***How to use these resources in an integrated fashion taking into account timelines and quality??***

Hydrograph

DEM



DRIVE Model

Precipitation

Air temperature, wind

soil

DEM

vegetation

…

中山大學 大气科学学院
SUN YAT-SEN UNIVERSITY School of Atmospheric Sciences

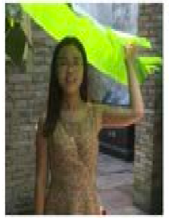
HENG
Hydrometeorological Extremes simulatioN Group

HENG's Mission & Keywords

- **Challenge one:** Global Validation of flood models
- **Challenge Two:** Precipitation Uncertainty and its impact on flood prediction
- **Challenge Three:** Global drainage network derivation ar parameterization
- **Challenge Four:** Global optimization (calibration) of floo models
- **Challenge Five:** Baseline global flood event database
- **Challenge Six:** Human activity impacts on floods: urbanization, dam/reservoir
- **Challenge Seven:** Climate change and LUCC impacts on flood prediction and the uncertainty in the assessment

❑ ***Working together with wide provider and user community!***

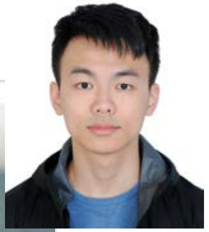












Take home message

Integrating Products

- Individual products (e.g., inundation estimates) will continue to improve with better observations, algorithms and modeling—but there will always be limitations in accuracy, availability, etc. So we also need to be working toward melding or integrating our multiple estimates into a “best” estimate.

- For inundation, one possible approach: Daily, model-based estimate as base, with optical and SAR products as additional options where/when available. All remapped and available as layers (if available); possible merger or best estimate as separate product.

- A technical starting point is simple comparisons to understand strengths/weaknesses, with possible product approaches driven by user interests.

- This type of work needs programmatic integration too; a great place for leadership by certain funding agencies working together, but also “steering” jointly by entities like the Global Flood Partnership (GFP), UN-SPIDER.

HENG
Hydrometeorological Extremes simulatioN Group

GFP
global flood partnership

Thanks！

HENG
Hydrometeorological Extremes simulatioN Group

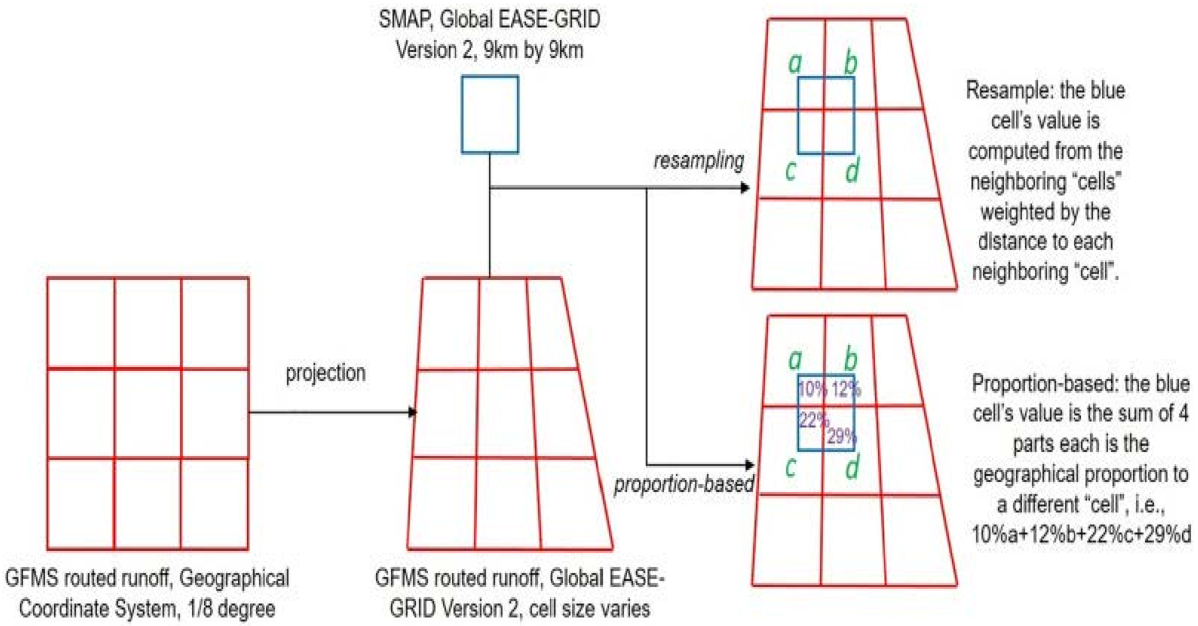
ELSEVIER

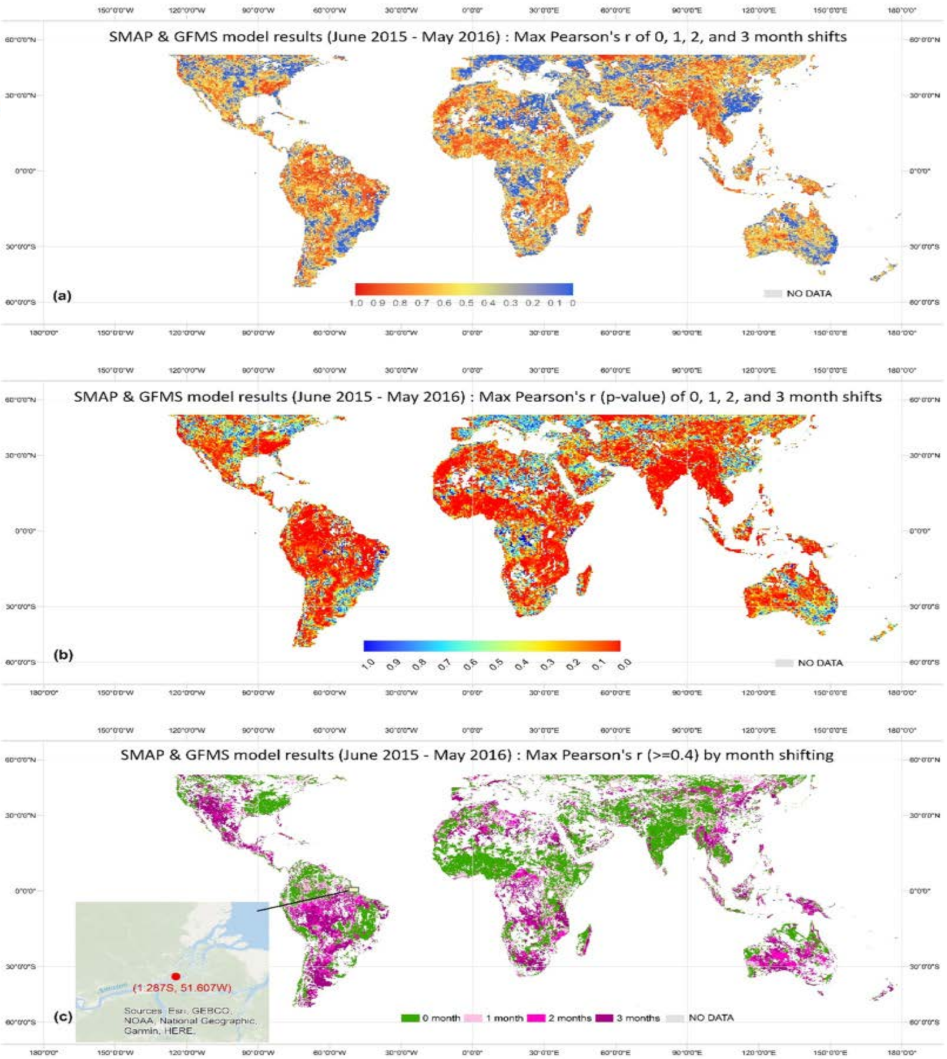
Remote Sensing of Environment
Volume 233, November 2019, 111360

GFP global flood partnership

Evaluation of real-time global flood modeling with satellite surface inundation observations from SMAP

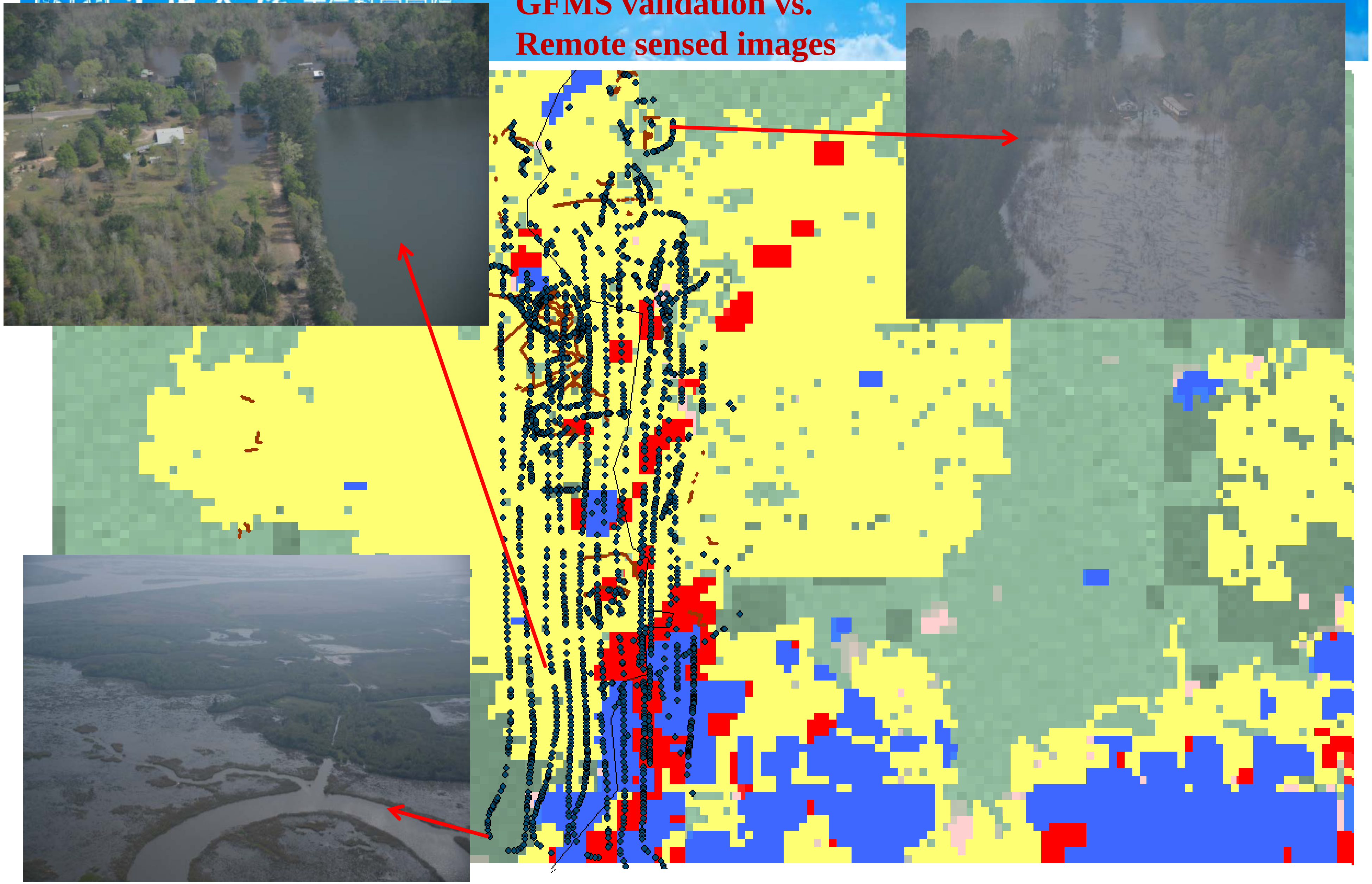
Huan Wu [a, b], John S. Kimball [c], Naijun Zhou [d], Lorenzo Alfieri [e], Lifeng Luo [f], Jinyang Du [c],





Wu et al., Remote Sensing of Environment (IF=8.12),2019

GFMS validation vs. Remote sensed images



Yellow: modified MODIS flooding area

Wu et al., 2019 in review

Challenge Six: urbanization, dam/reservoir

中山大學 SUN YAT-SEN UNIVERSITY

HENG Hydrometeorological Extremes simulatioN Group

GFP global flood partnership

Urban Flood Monitoring Using an Integrated River Basin-Urban Flood Modeling Approach: A Case Study in Haikou City, Hainan, China

Weitian Chen[1,2], Huan Wu[1,2*], Naijun Zhou[3], Si Shi[4], Qinbo Cai[4], Yingchun Tao[5], Shihu Zhao[6]

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2) Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, Sun Yat-sen University, Guangzhou, China

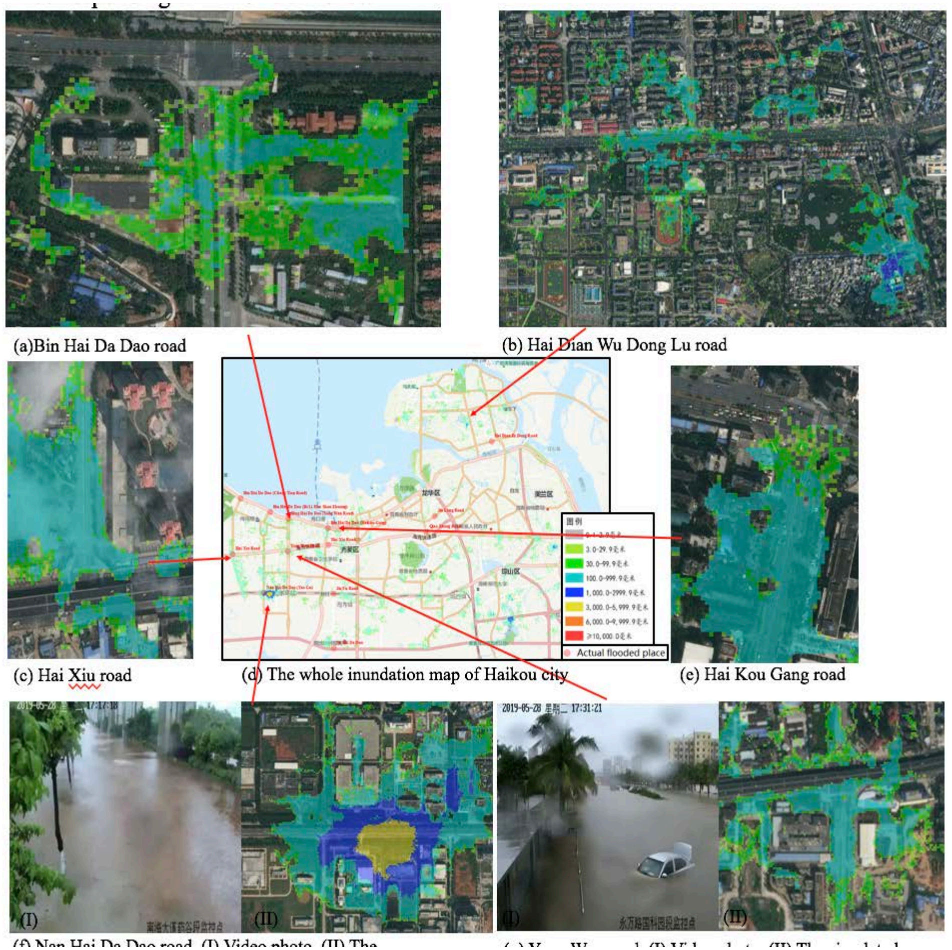
3) Department of Geographical Sciences, University of Maryland, College Park, MD, USA

4) Meteorological Observatory of Hainan Province, Haikou, China

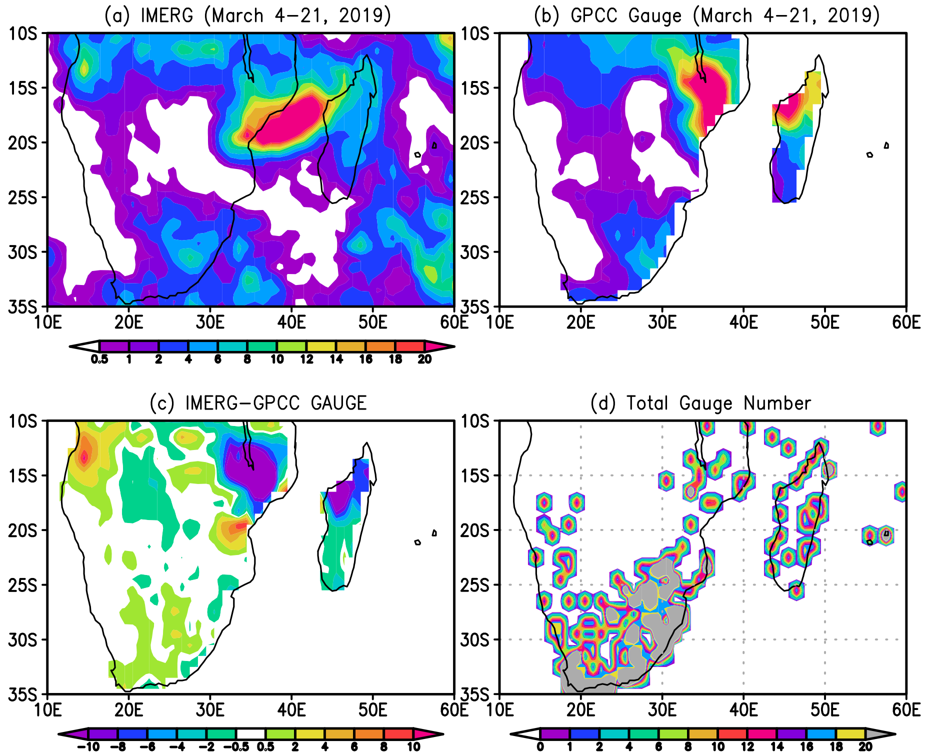
5) Beijing Institute of Surveying and Mapping, Beijing, China

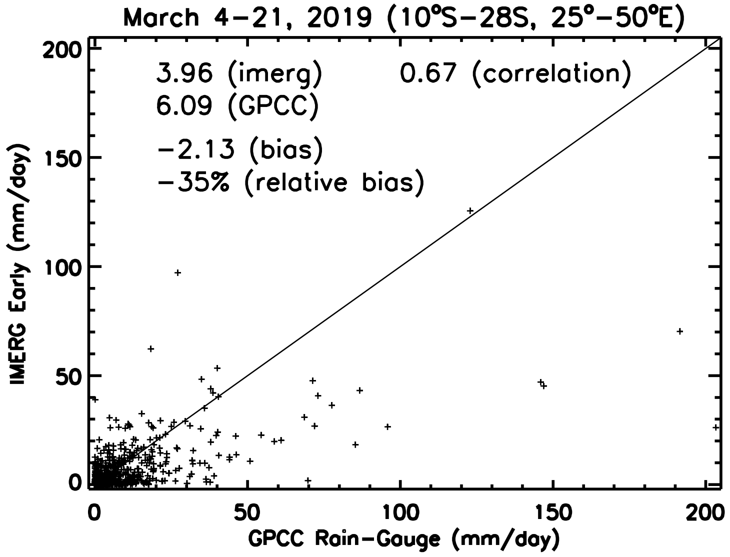
6) Satellite Surveying and Mapping Application Center, NASG, Beijing, China

Poster 5:

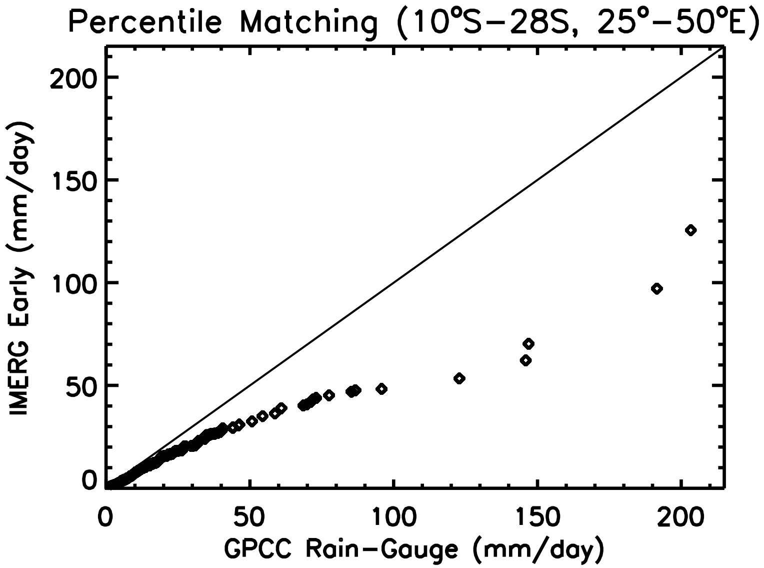


Mean Rainfall During March 4-21, 2019
IMERG (satellite) vs GPCC (gauges)



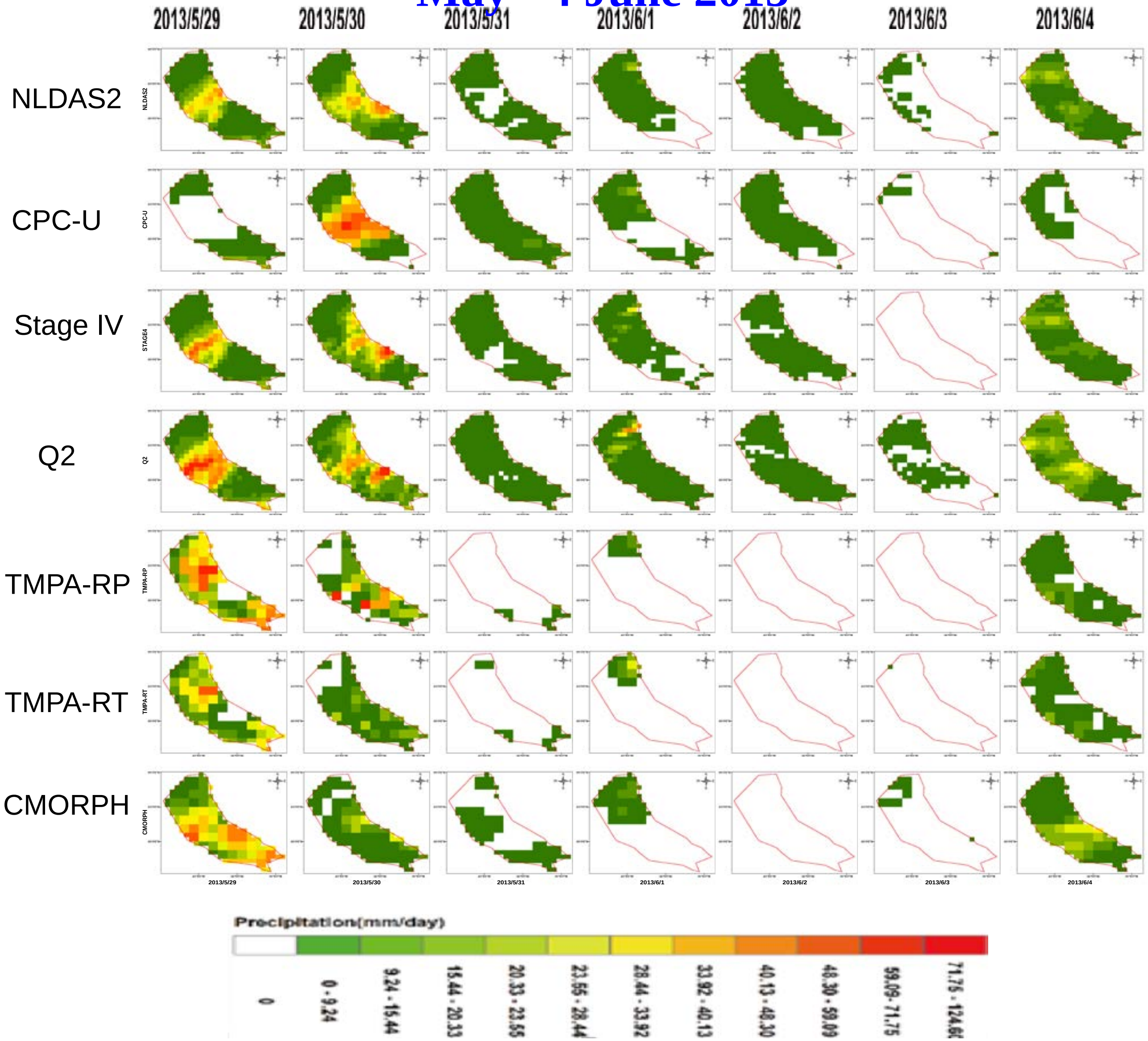


Although validation (gauges) are missing/questionable, it appears IMERG underestimated, especially at high end.



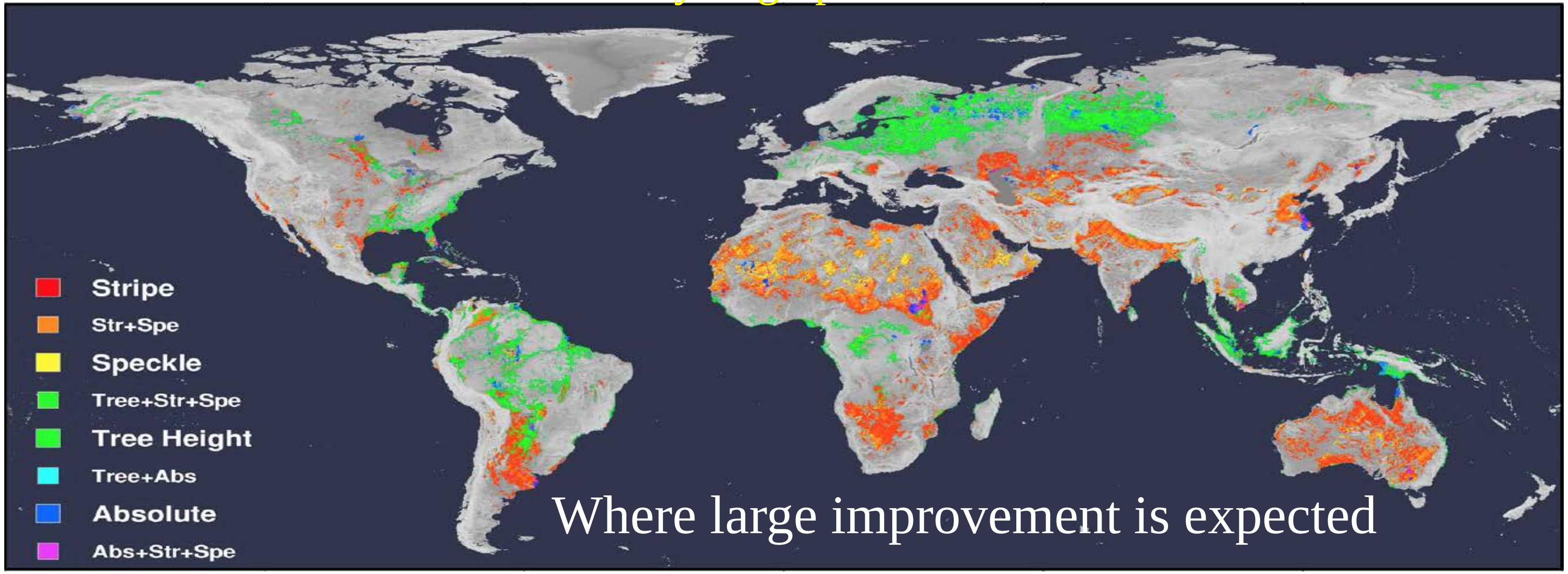
At least one gauge in each 1° grid

Daily precipitation over Iowa-Cedar River Basin during the period between 29 May - 4 June 2013



Challenge: Elevation Maps

MERIT DEM + DRT = A new global hydrographic database



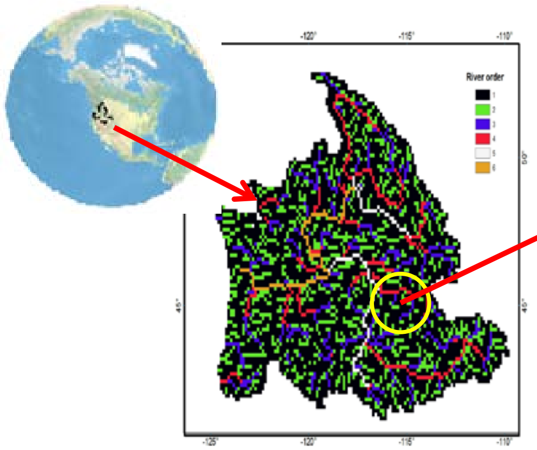
For slope-sensitive application, MERIT DEM is recommended.

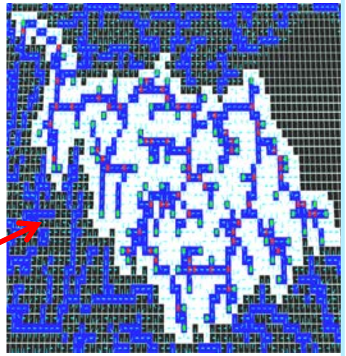
We applied the DRT algorithms to the MERIT global DEM and fine-scale hydrography derivations and produced a new upscaled global hydrographic dataset at multiple spatial resolutions from 1/120°(or 1km) to 1°.

We are comparing the MERIT DEM and HydroSHEDS in flow direction, flow accumulation, network, flow distance, slope, etc. , and the corresponding upscaled results.

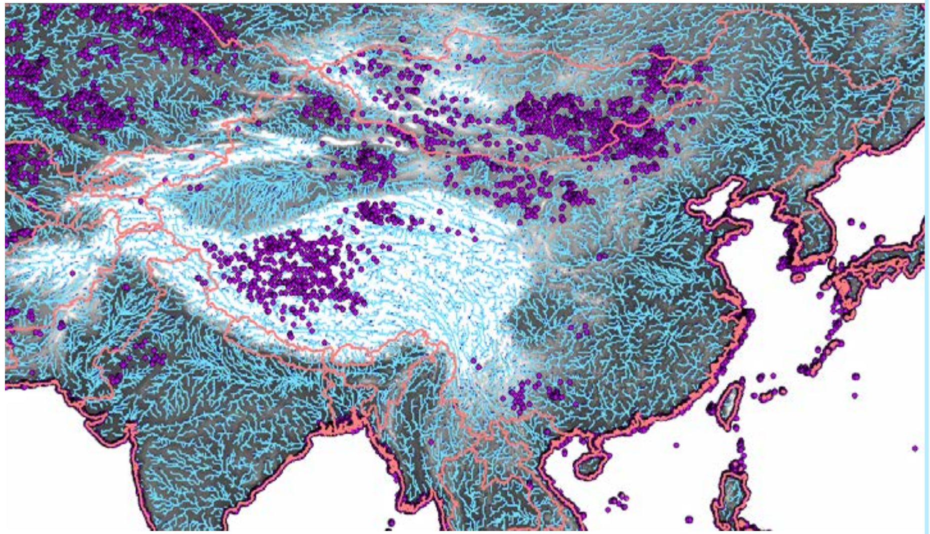
Challenge Three: Global Drainage Networks

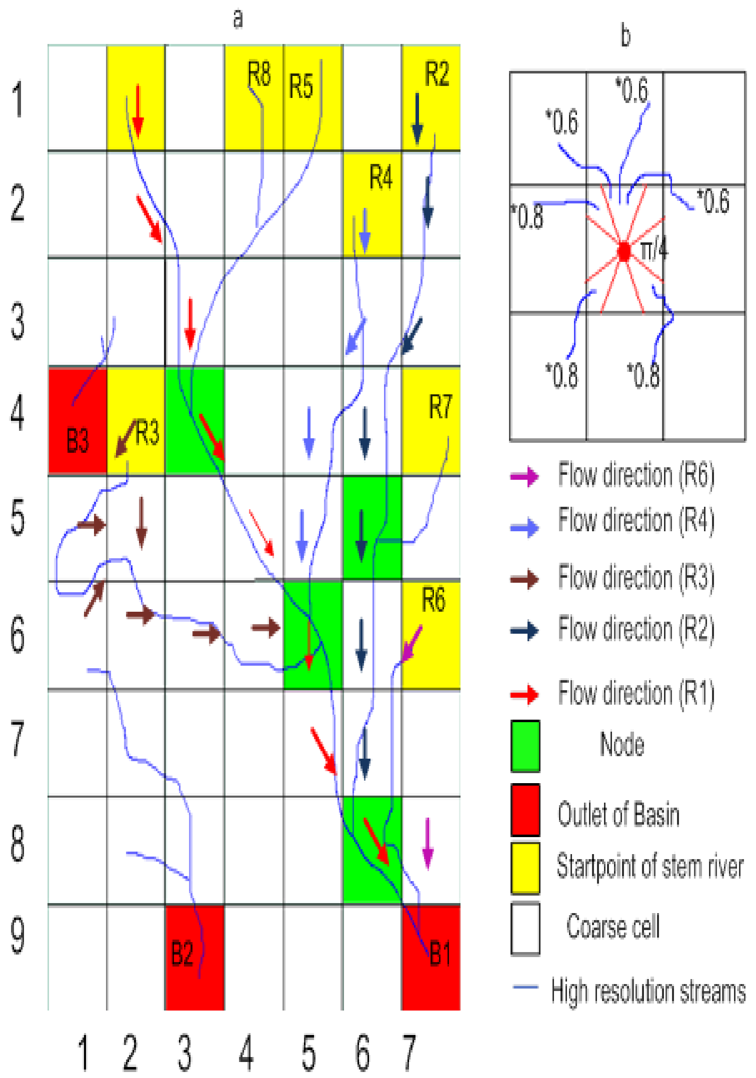
1/20，1/16，1/12，1/10，1/8，1/4，1/2，1， 2 degrees





河网分级拓扑关系





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

Challenge Five: global flood database

A Multi-Sourced Flood Inventory in Contiguous United States During TRMM Era

Zhijun Huang[1], Huan Wu[1,2,*]

[1] Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, and School of Atmospheric Sciences, Sun Yat-Sen University, China
[2] Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA

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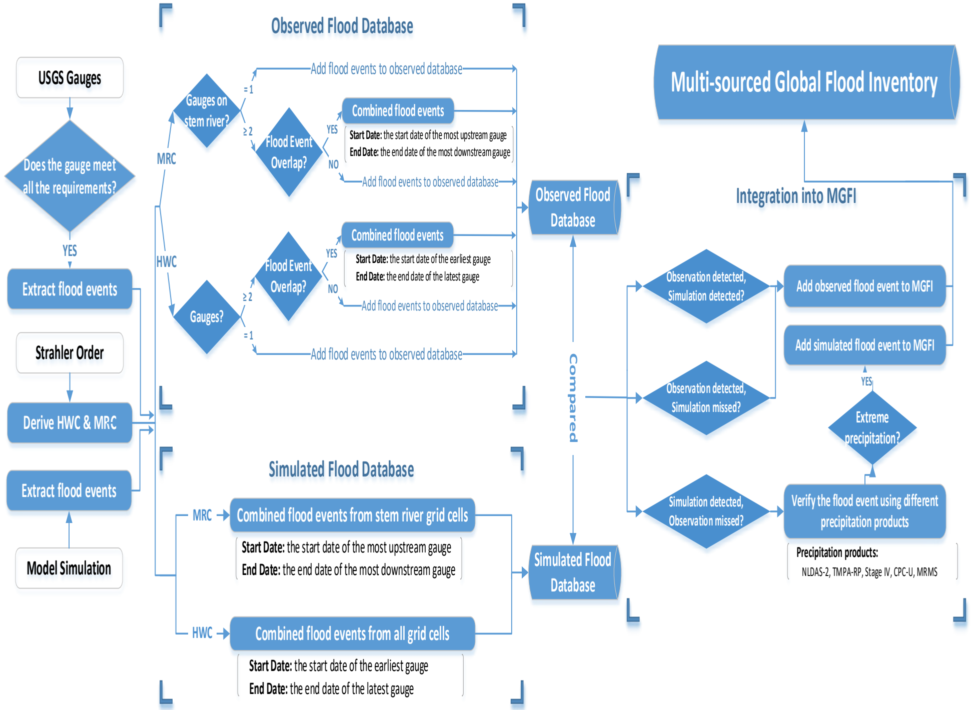
Poster 4:



HWC: Head water catchment
MRC: Major river catchment

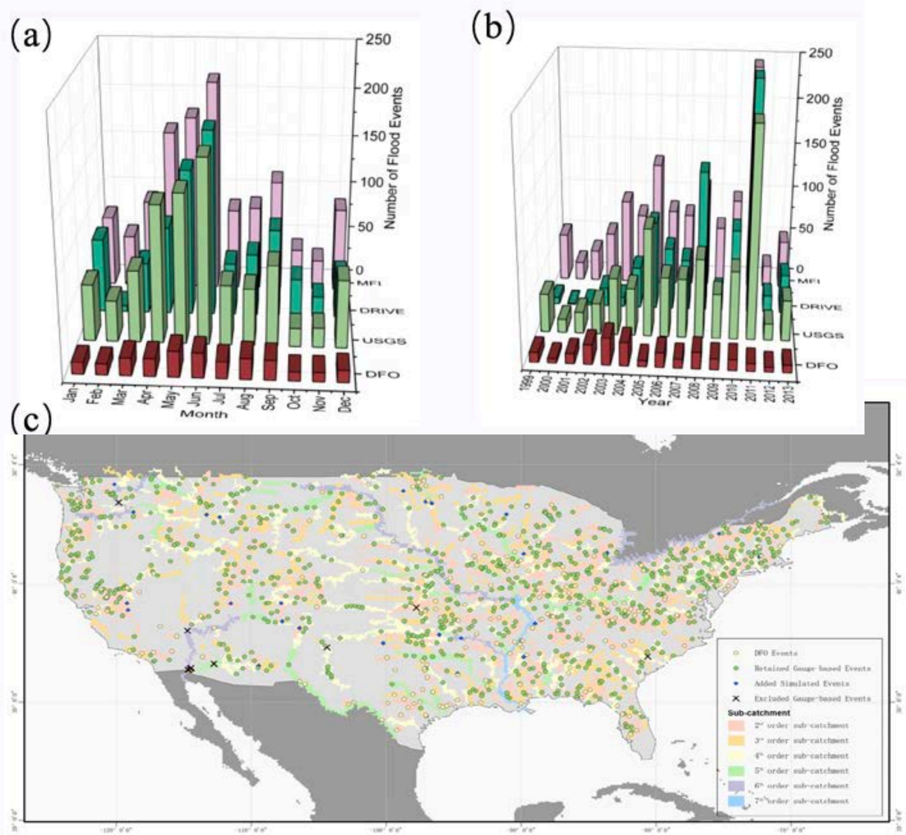


Fig 4. The distribution of preserved events, discarded events and recovered events

Multi-source Global Flood Inventory (MGFI)