Real-time Global Flood Monitoring and Forecasting using an Enhanced Land Surface Model with Satellite and NWP model based Precipitation

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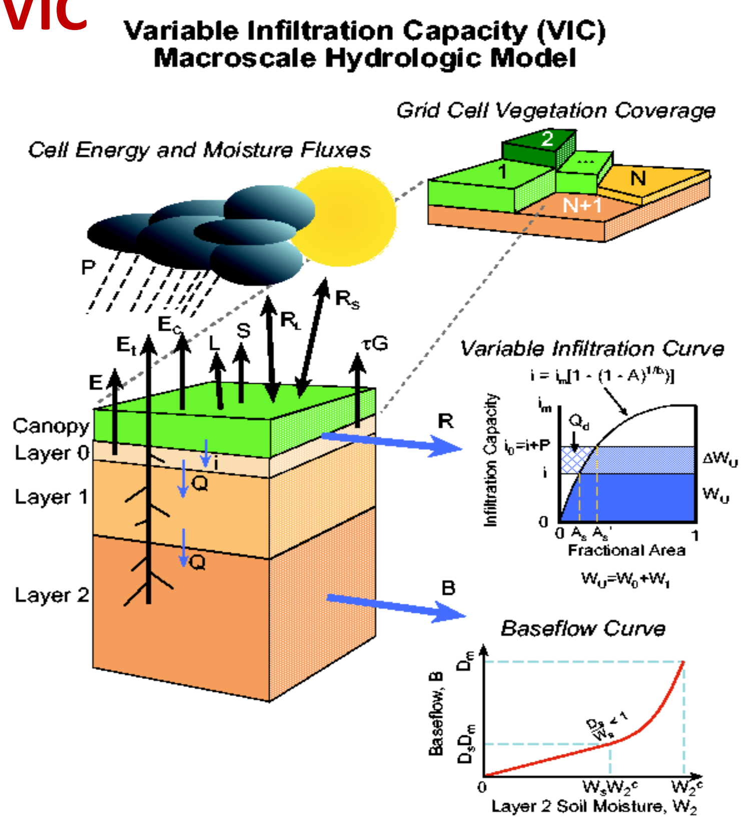
Dominant river tracing-Routing Integrated with VIC Environment (DRIVE) model

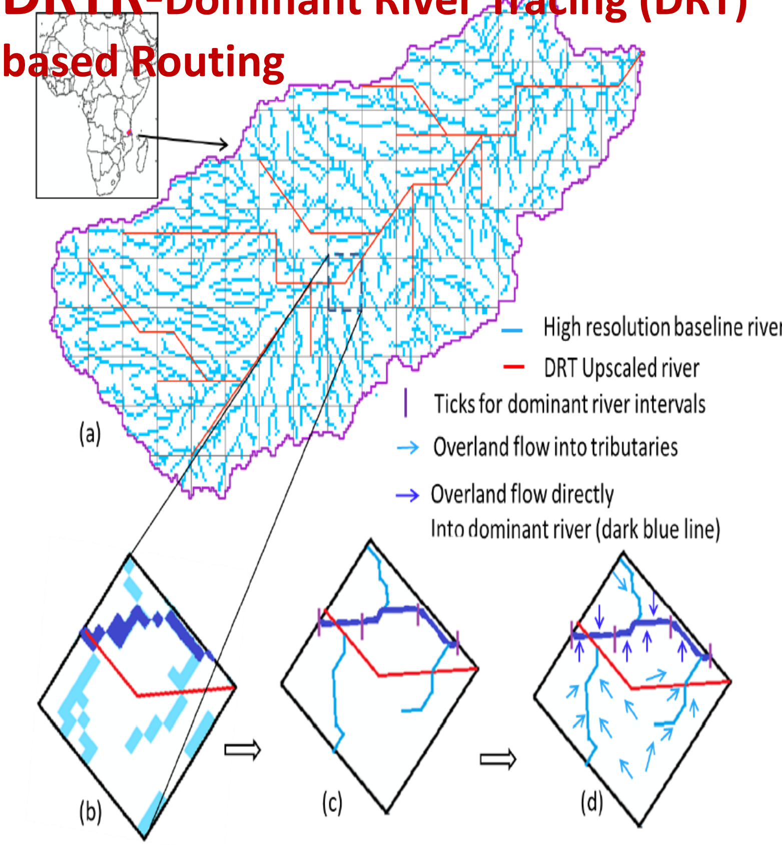
(Wu et al., 2011, 2012, 2013 *Water Resources Research*)

VIC



Coupled

DRTR-Dominant River Tracing (DRT) based Routing



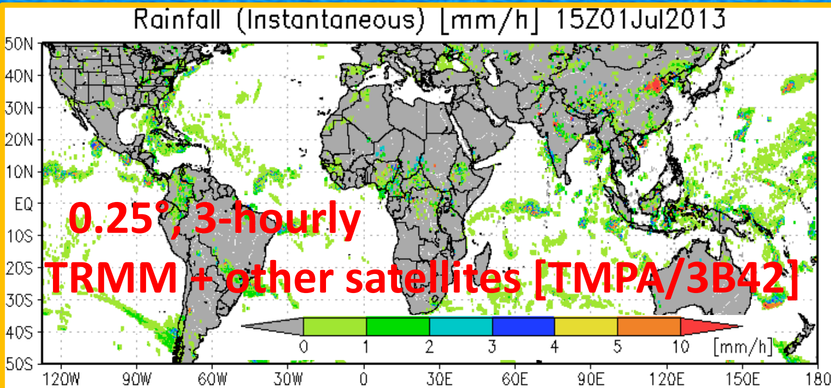
University of Washington

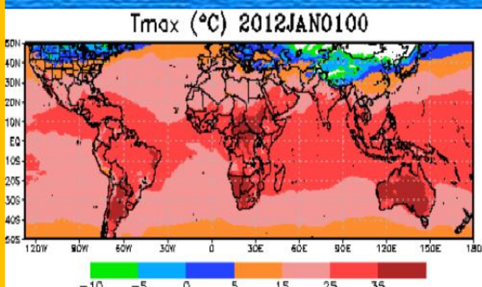
University of Maryland

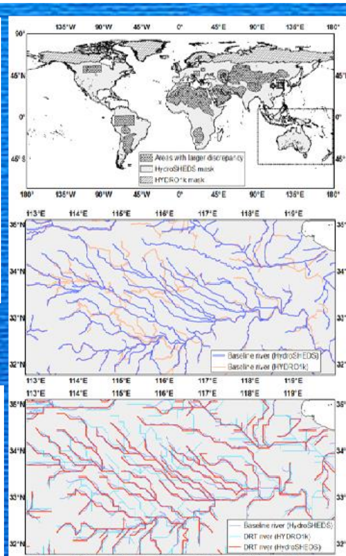
Global Flood Monitoring System (GFMS) *is running quasi-globally (50°S-50°N) every three hours at 1/8th degree, and routing is also running at 1km resolution.*

Global Flood Monitoring System (GFMS)/DRIVE model

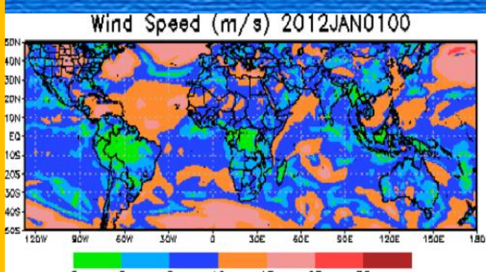
http://flood.umd.edu







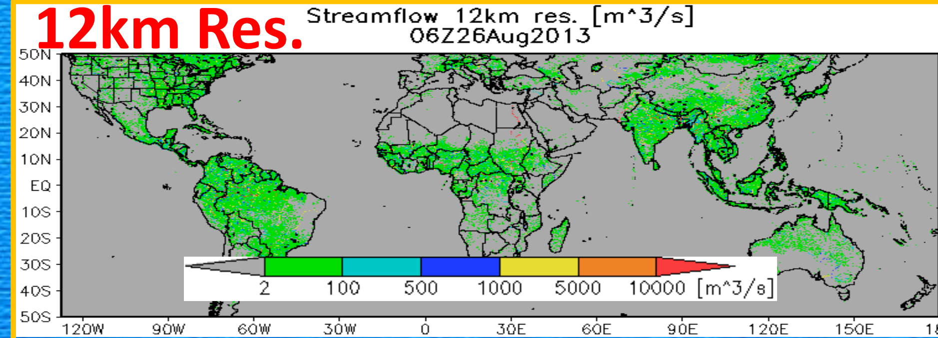
MERRA

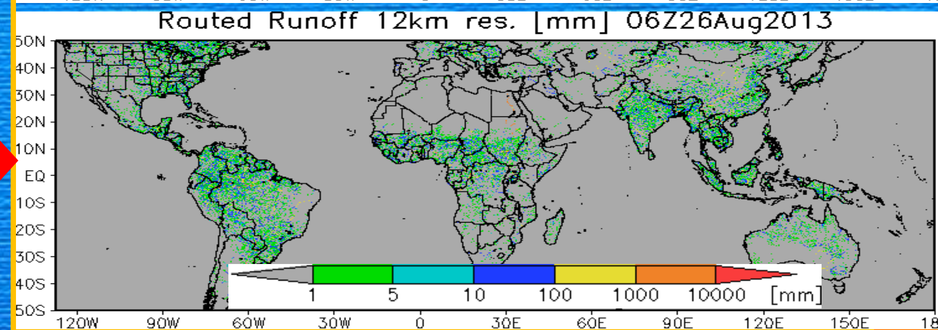


DRT, Wu et al., 2011,2012

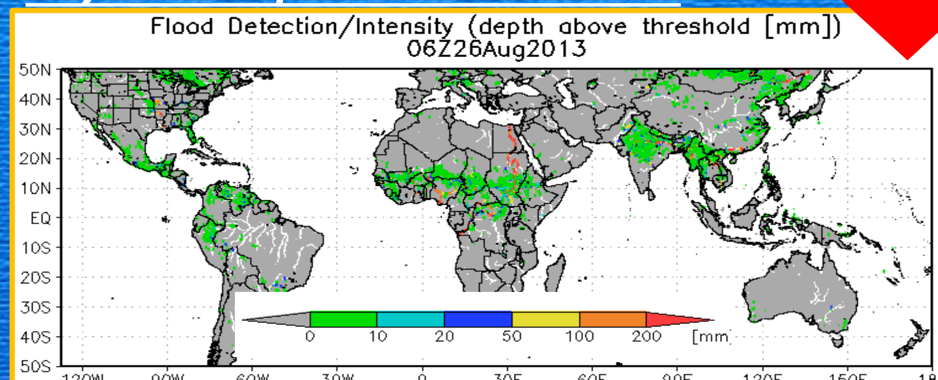
Soil, Vegetation, Snowbands (Princeton)

DEM (1km, HydroSHEDS)





15yr Retrospective simulation



Flooding at a point, if:

$$R > P_{95} + \delta \text{ and } Q > 10\ m^3/s$$

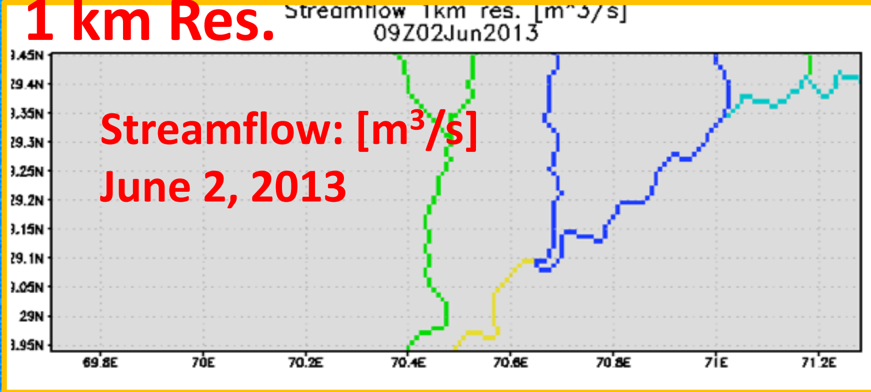
R: *routed runoff (mm);*

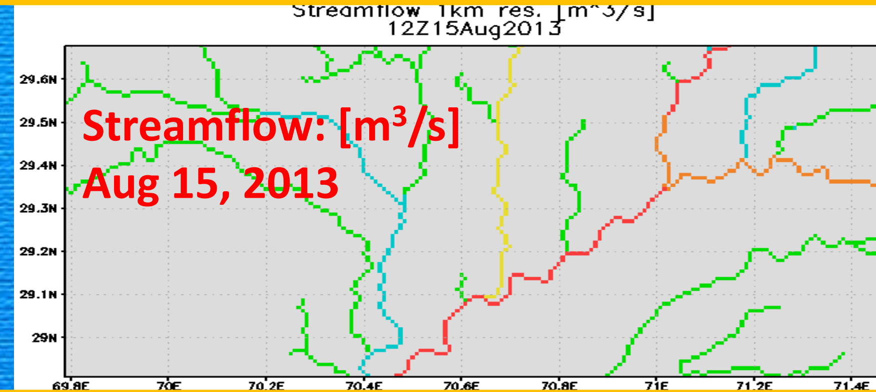
P_{95}: *95th percentile value of routed runoff;*

δ: *temporal standard deviation of routed runoff;*

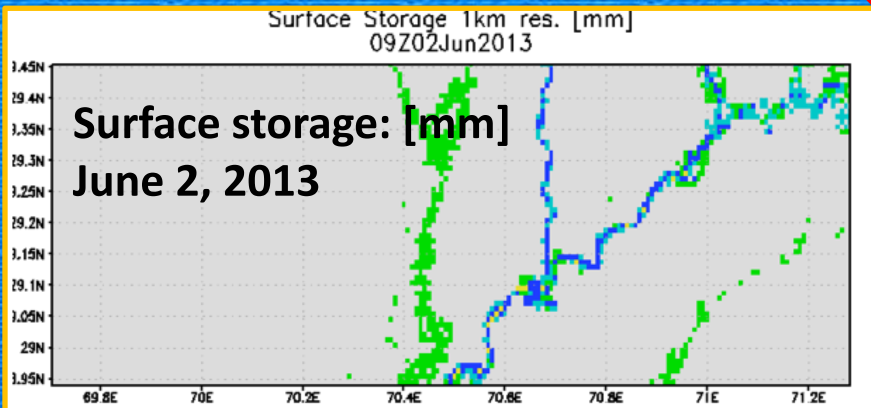
Q: *discharge (m^3/s)*

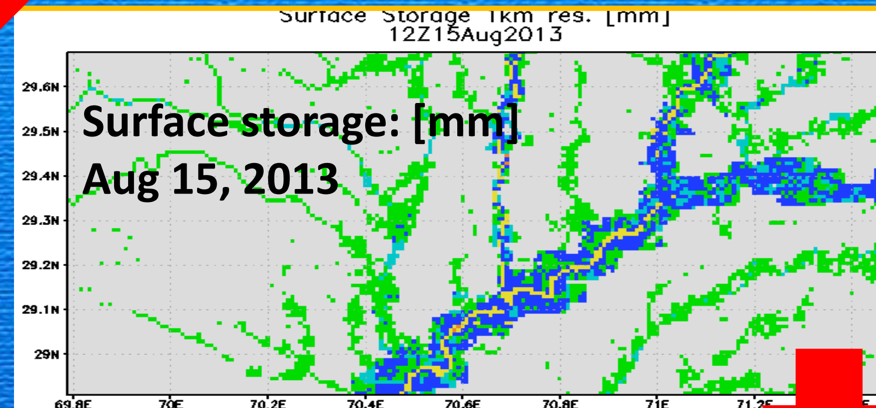
1 km Res.





DRIVE/Inundation module

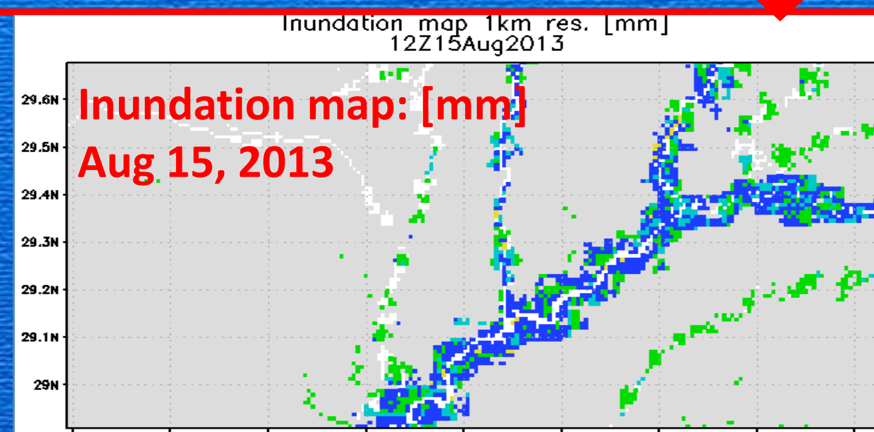




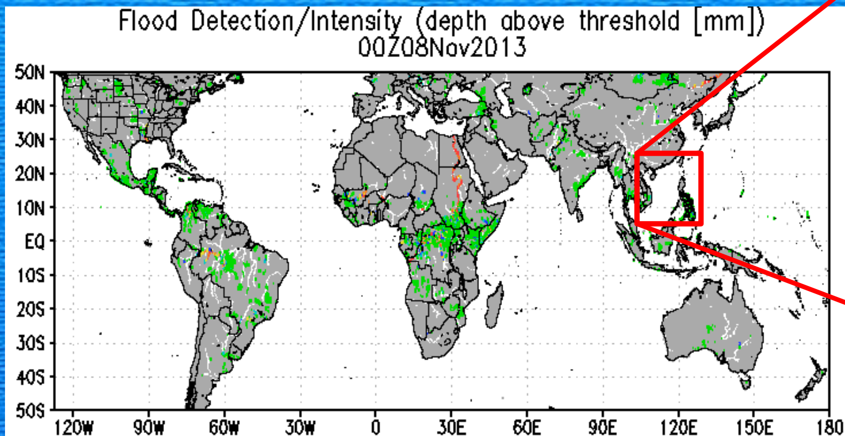
Experimental Inundation Mapping:

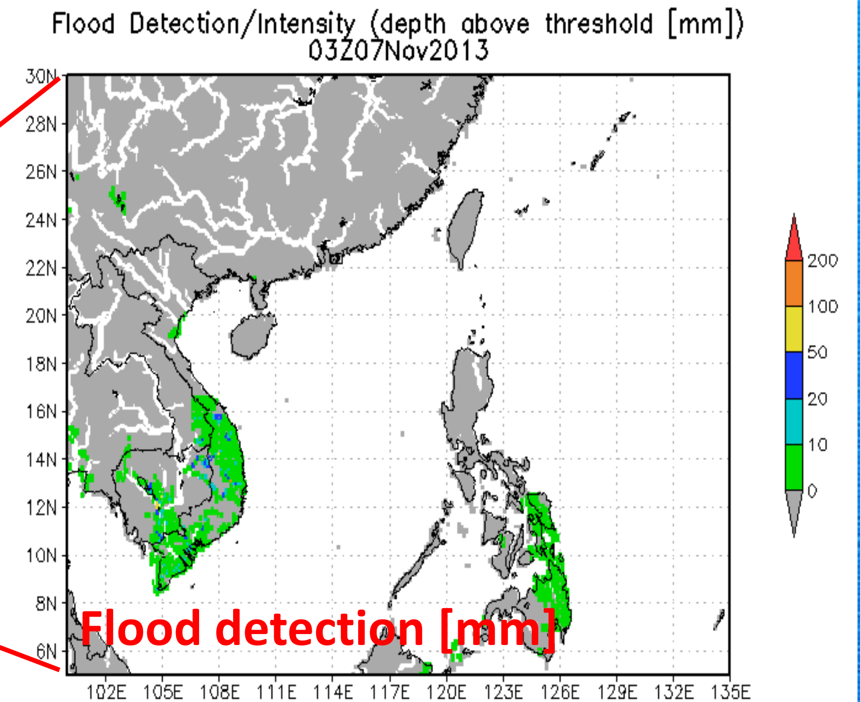
(1) Define a referential water coverage based on retrospective model simulation;

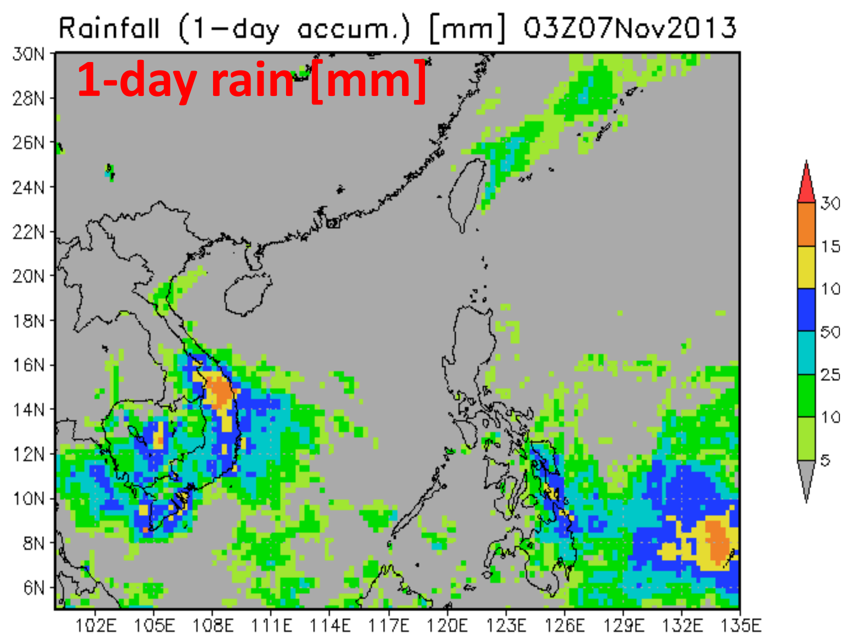
(2) Apply a small threshold to consider a certain water capacity of each pixel.

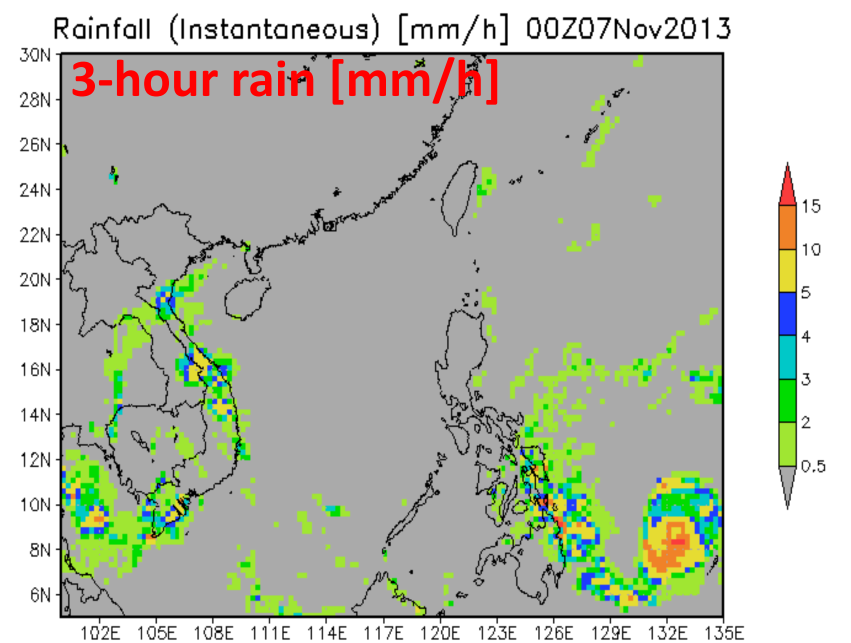


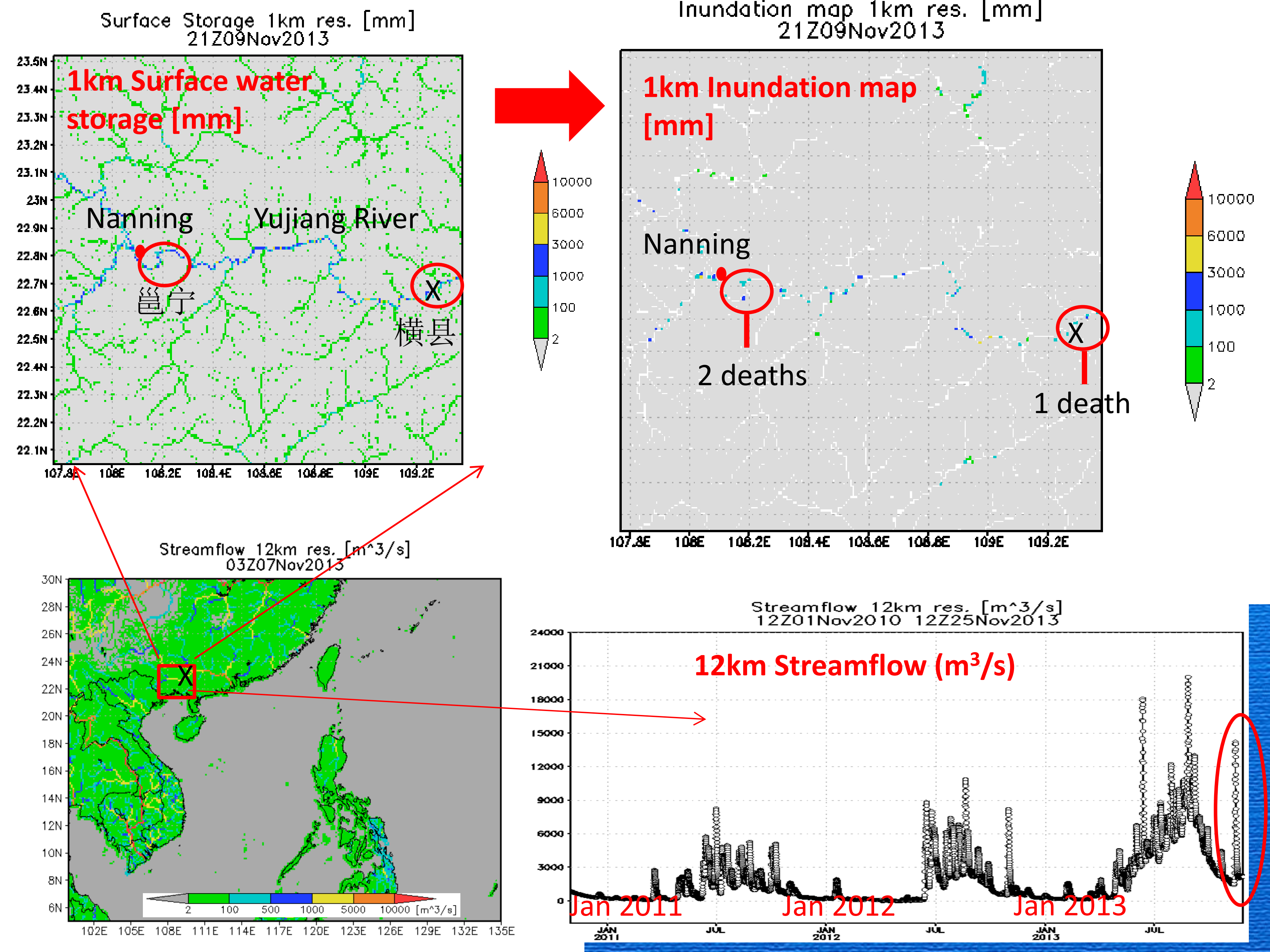
Example of Global to Regional Flood Detection: Recent Flooding caused by "Haiyan" Typhoon (Nov, 2013)







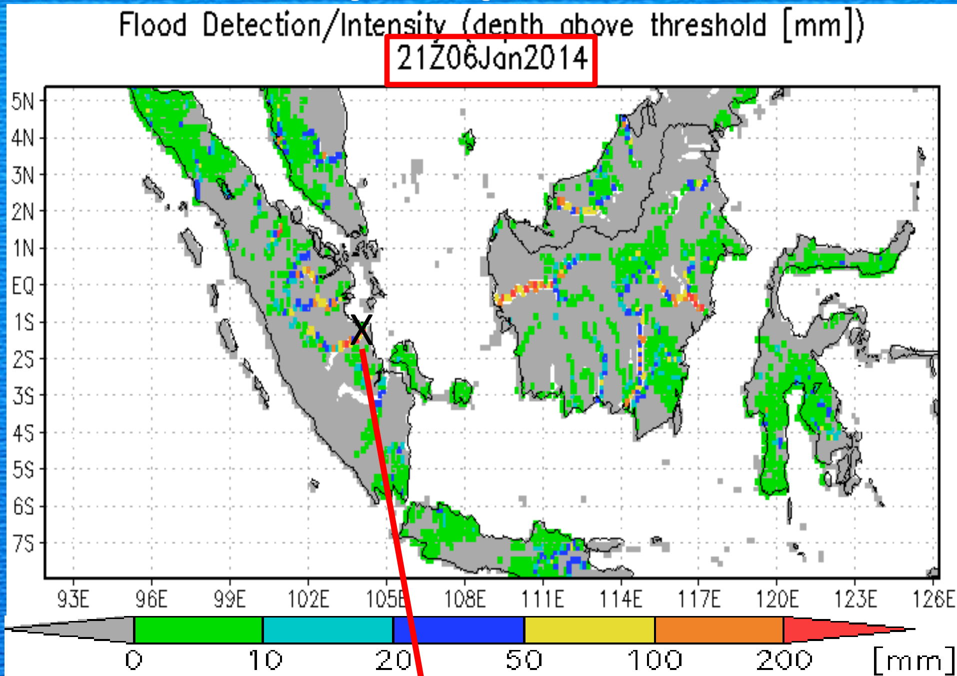


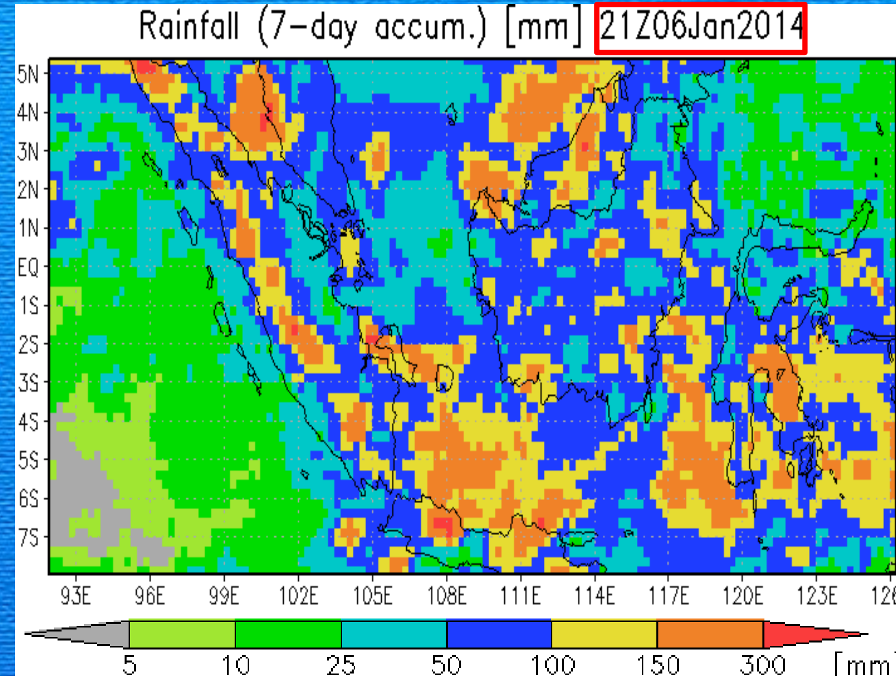


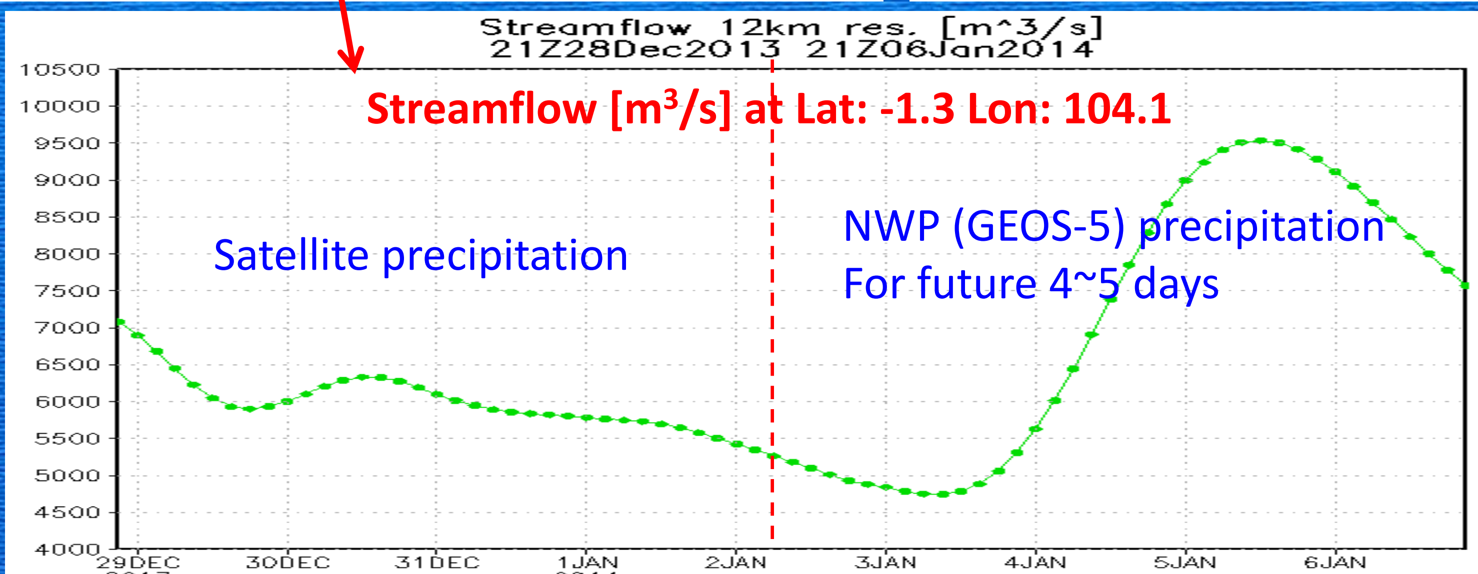
Surface Storage 1km res. [mm]
21Z09Nov2013
1km Surface water storage [mm]
Nanning
Yujiang River
邕宁
X
横县
10000
6000
3000
1000
100
2
Inundation map 1km res. [mm]
21Z09Nov2013
1km Inundation map [mm]
Nanning
2 deaths
X
1 death
Streamflow 12km res. [m^3/s]
03Z07Nov2013
X
2 100 500 1000 5000 10000 [m^3/s]
Streamflow 12km res. [m^3/s]
12Z01Nov2010 12Z25Nov2013
12km Streamflow (m³/s)
Jan 2011
Jan 2012
Jan 2013

Western Indonesia Flooding

Short term precipitation and flood forecast on Jan 2, 2014







Global evaluation TMPA real-time (DRIVE-RT) and research (rain gauge adjusted, DRIVE-V7) [15yrs (1998~), 3-hrly, 1/8° res.]

(1) Flood event based evaluation using 2,086 archived flood events by Dartmouth Flood Observatory

(2) Streamflow based evaluation at 1,121 river gauges by GRDC, across the globe.

Real-time Global Flood Estimation using Satellite-based Precipitation and a Coupled Land Surface and Routing Model (2013). Wu, Adler et al. Submitted to WRR
[manuscript available on http://flood.umd.edu/]

Flood event based evaluation

Flooding at a point

$R > P_{95} + \delta$

and

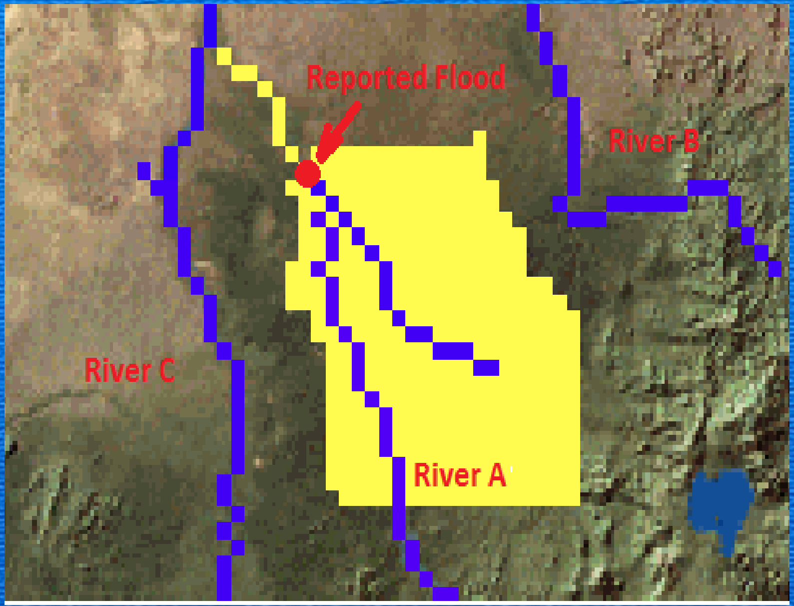
$Q > 10\ m^3/s$

R: routed runoff (mm)
P_{95}: 95^{th} percentile value of routed runoff
δ: temporal standard deviation of routed runoff
Q: discharge (m^3/s)

Matching floods between simulated and reported

Temporal window: ±1 days

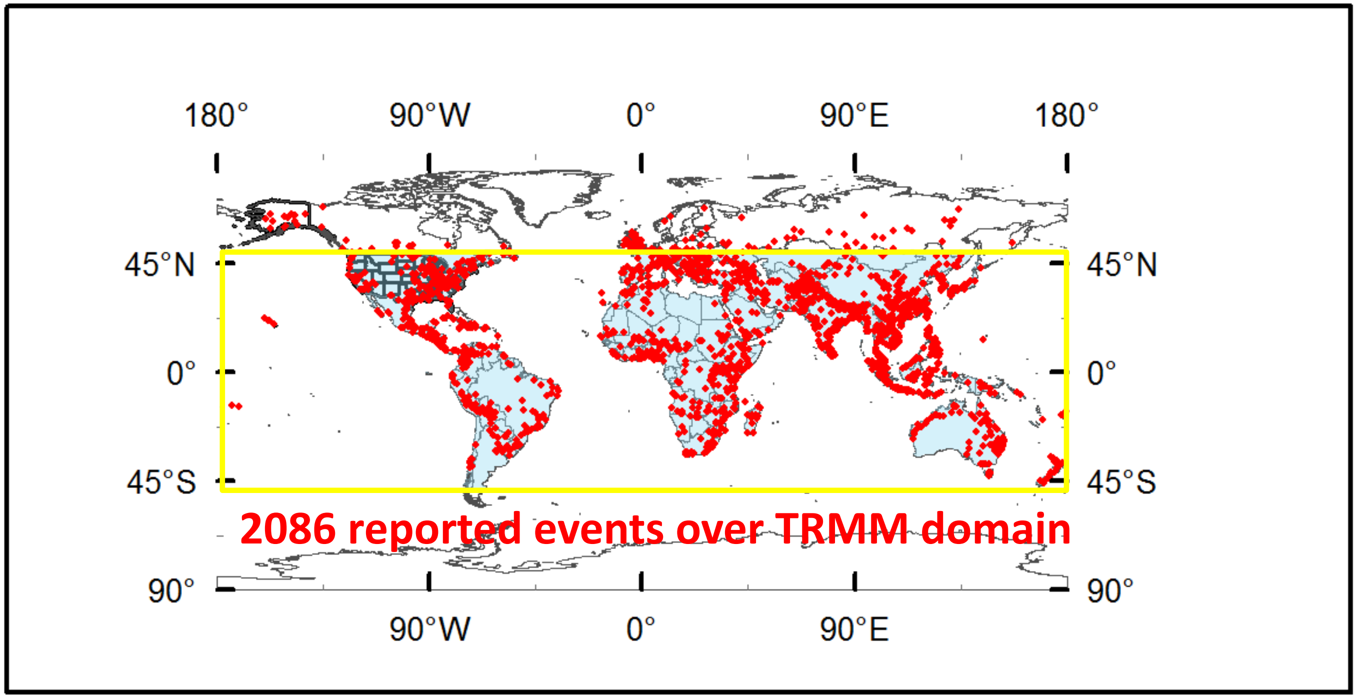
Spatial window: all upstream basin area within ~200 km & ~100 km downstream stem river



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.

Flood detection verification against the Dartmouth Flood Observatory (DFO) flood database with 2,086 flood events during 2001-2011, over the TRMM domain

DFO archived flood events (from satellites, news …)

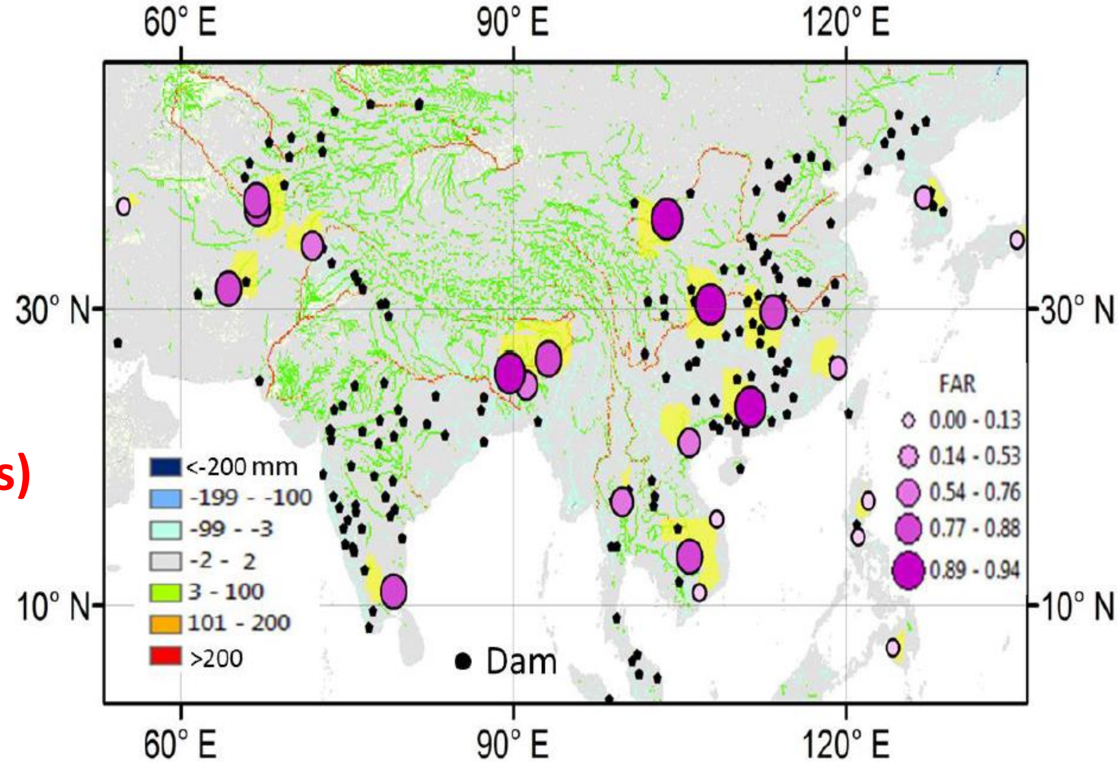


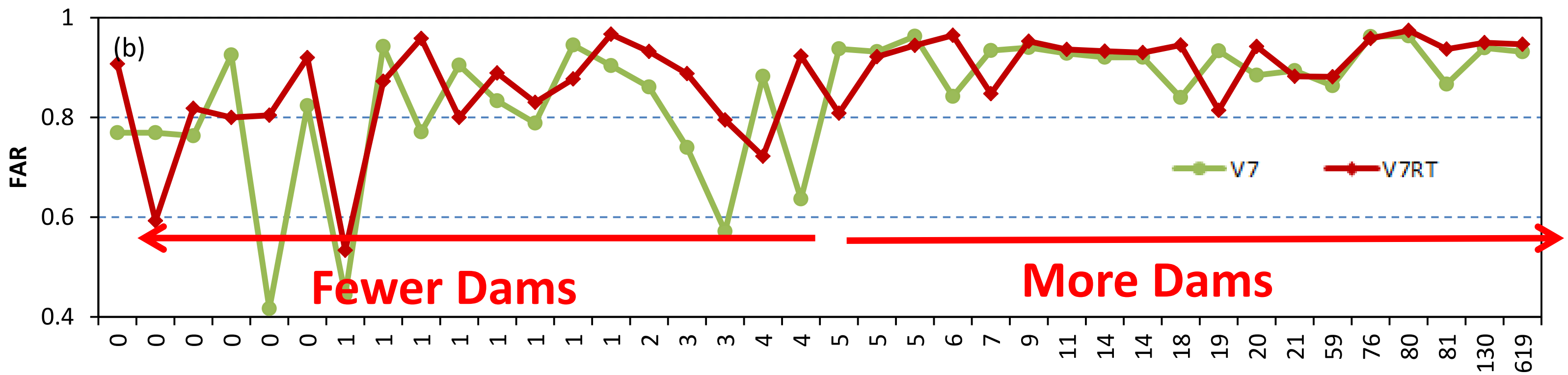
Probability of Detection (POD):

DRIVE-V7: 1,820 (87.2%)

DRIVE-RT: 1,799 (86.2%)

<u>Flood detection verification</u> **against the Dartmouth Flood Observatory (DFO) flood database over the 38 Well Reported Areas (WRAs) for floods with duration more than <u>3 days</u>.**





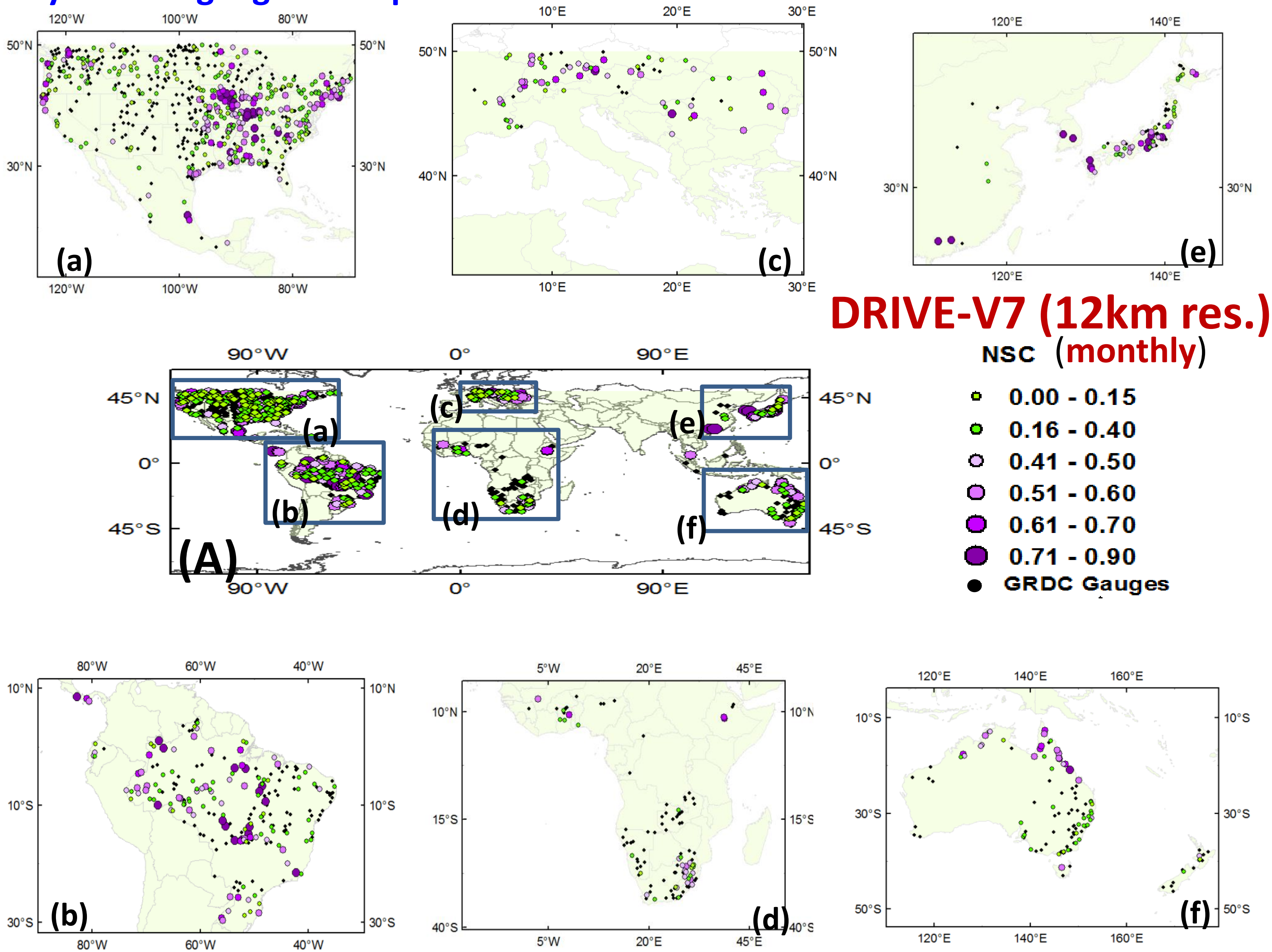
Bottom line--For 3-day floods in basins with few dams using RT rainfall:

POD ~ 0.9   FAR ~ 0.7

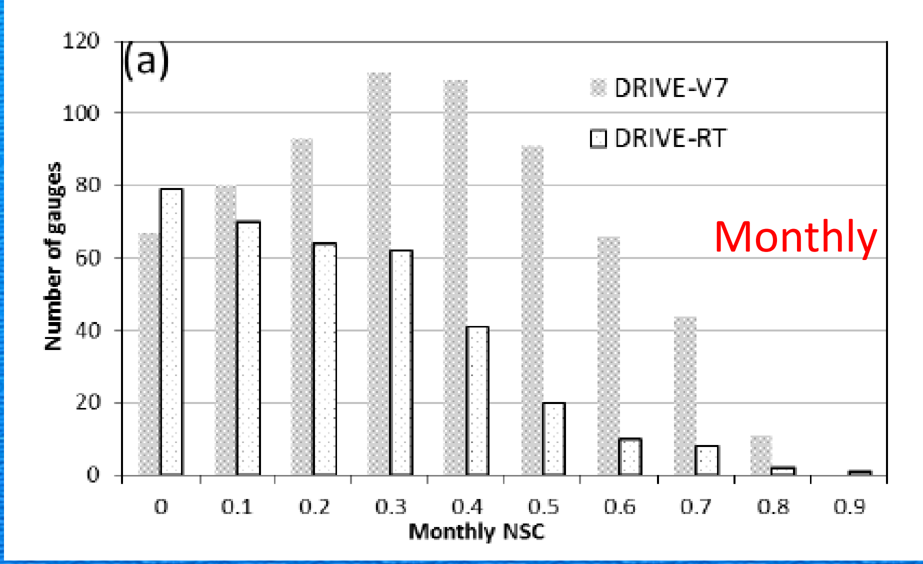
Comparison with 1,121 GRDC Streamflow Gauges-Nash-Sutcliffe (NSC)

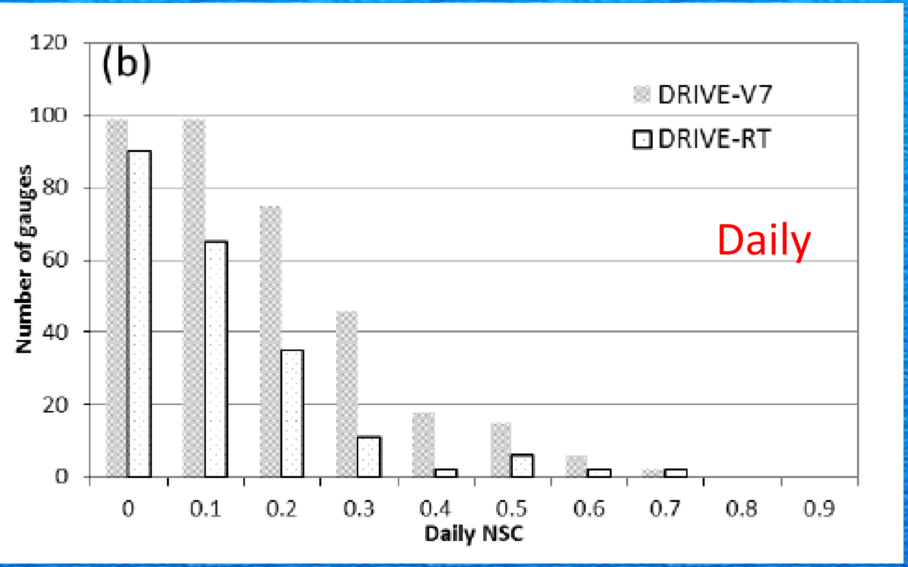
Daily: 32% of gauges with positive values with mean of 0.22

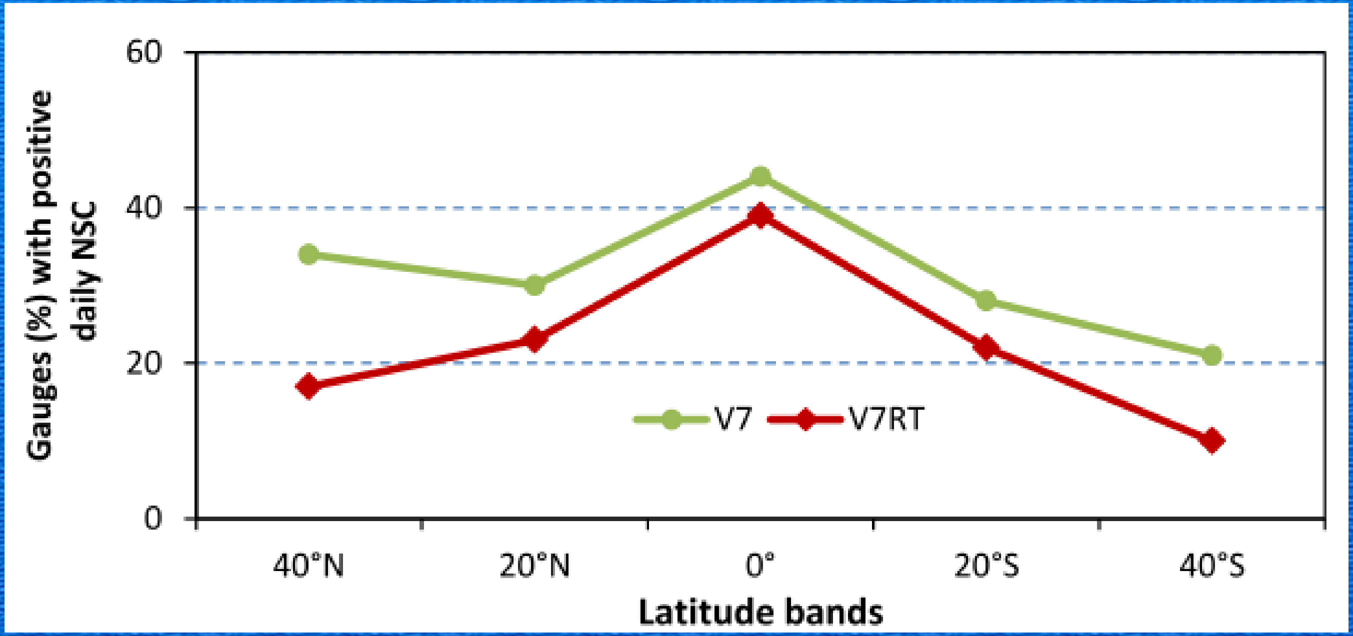
Monthly: 60% of gauges with positive values with mean of 0.39



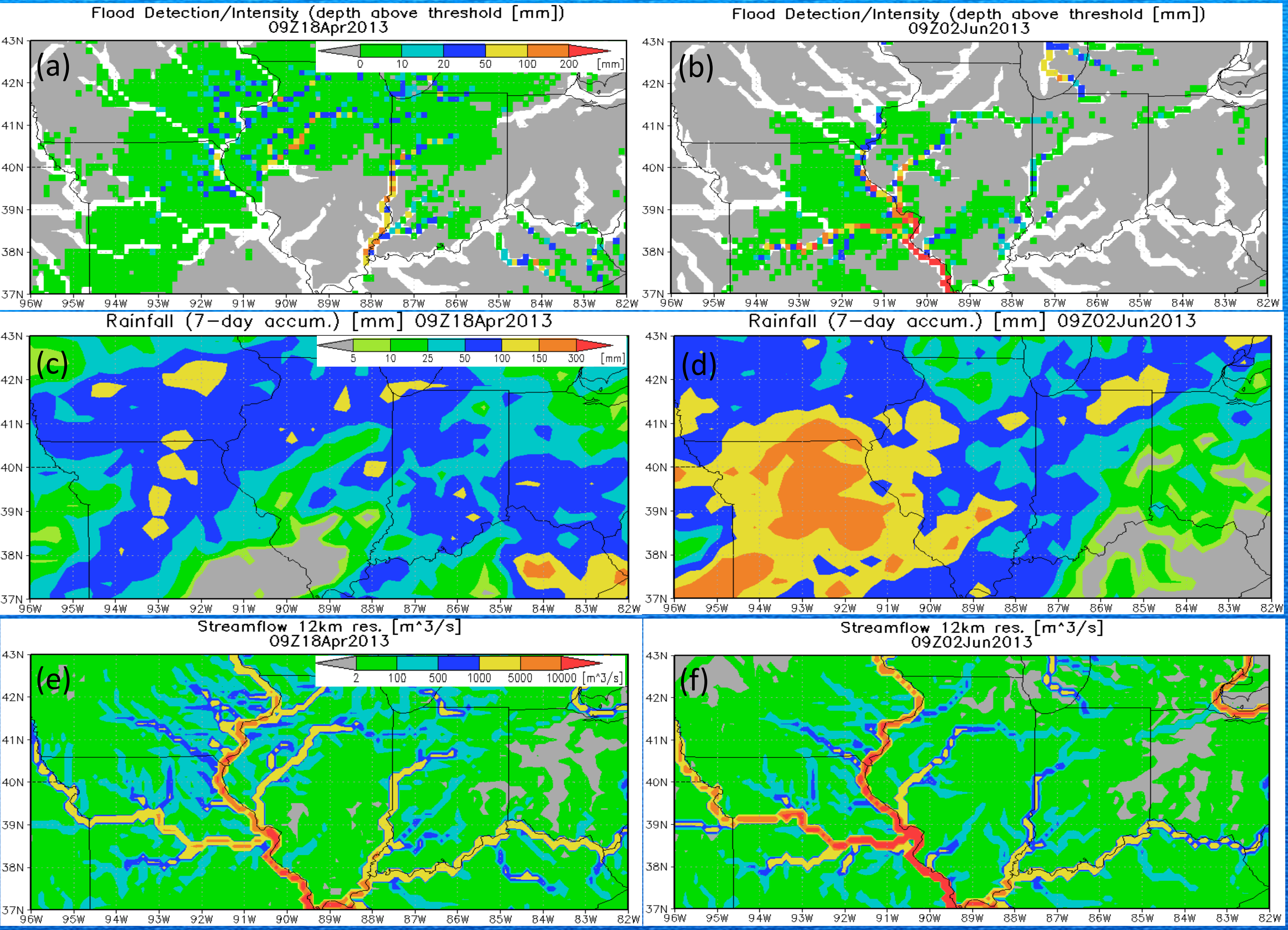
Distribution of the number of gauges with positive monthly and daily NSC metrics for DRIVE-V7 and DRIVE-RT simulation for 2001-2011, respectively



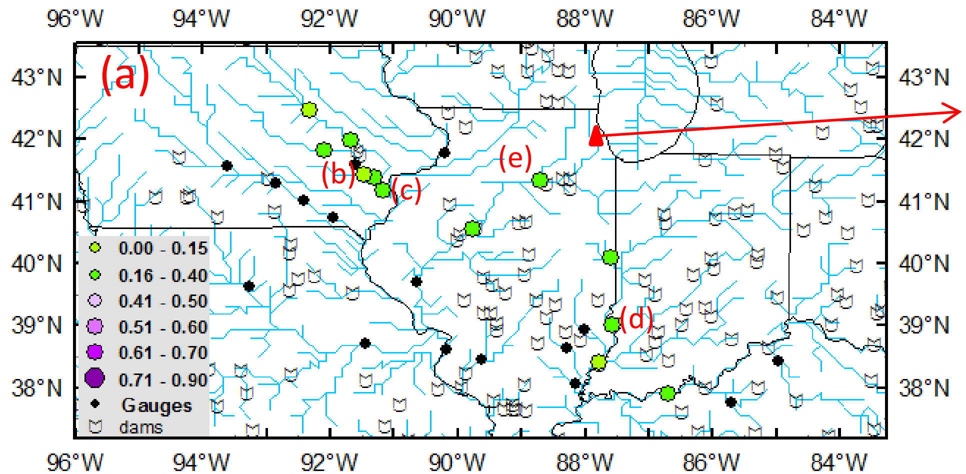




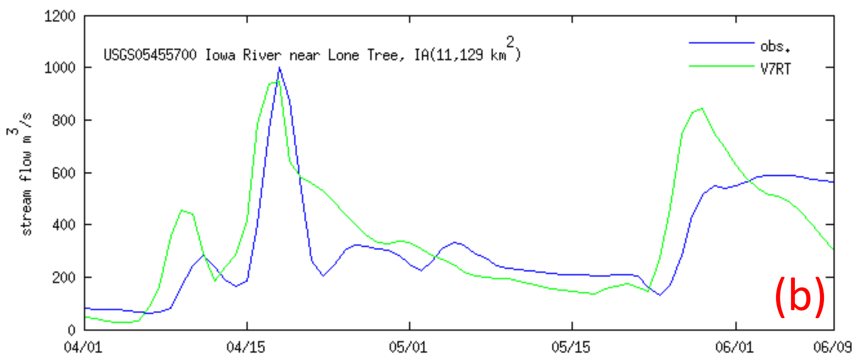
Real-time Evaluation of on-line events

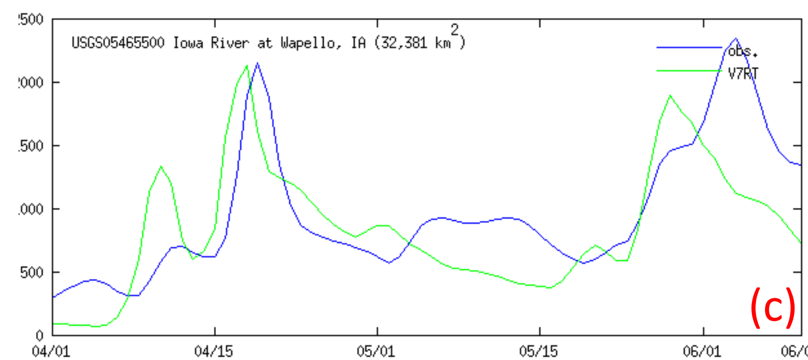


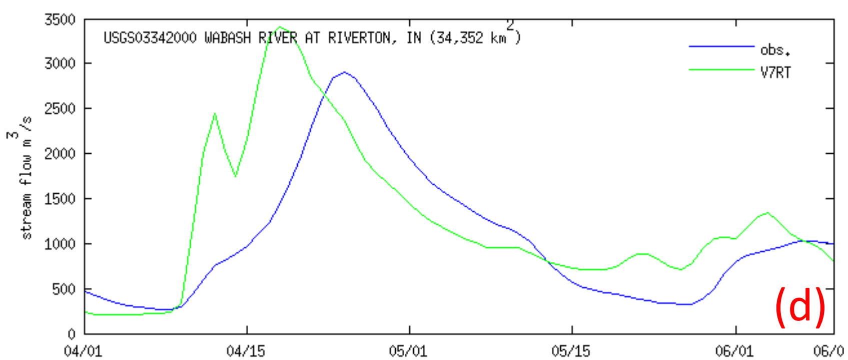
41% (12) out of 29 gauges with daily NSC>0 with mean of 0.23

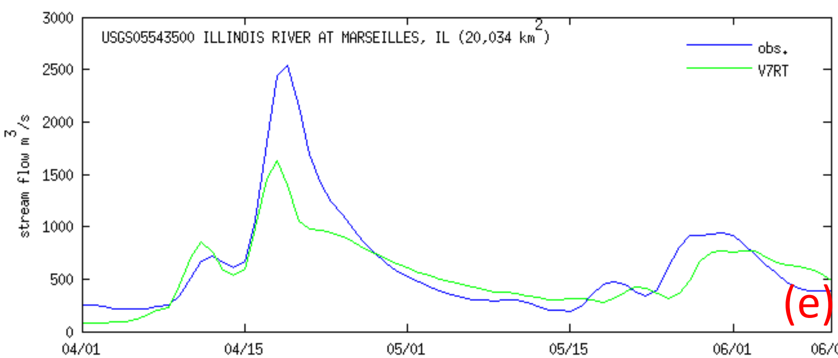


Internet source: April 19, 2013, Des Plaines, IL

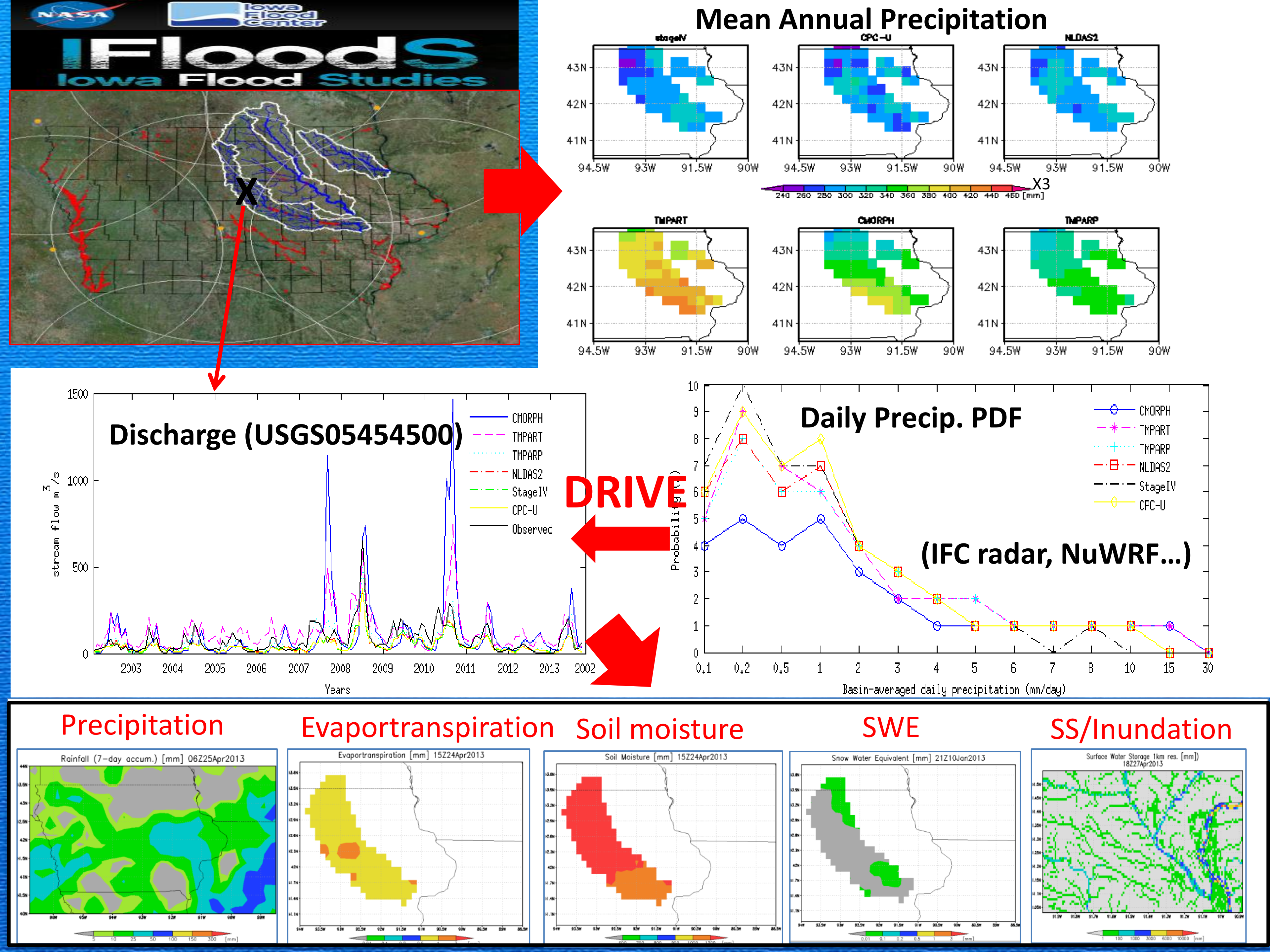








USGS/NOAA WaterWatch program http://waterwatch.usgs.gov


IFloodS
Iowa Flood Studies
Iowa Flood Center
NASA
X
Mean Annual Precipitation
stageIV
CPC-U
NLDAS2
TMPART
CMORPH
TMPARP
43N
42N
41N
94.5W
93W
91.5W
90W
X3
240 260 280 300 320 340 360 380 400 420 440 460 [mm]
Discharge (USGS05454500)
stream flow m^3/s
1500
1000
500
0
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2002
Years
CMORPH
TMPART
TMPARP
NLDAS2
StageIV
CPC-U
Observed
DRIVE
Daily Precip. PDF
(IFC radar, NuWRF…)
Probability (%)
0 1 2 3 4 5 6 7 8 9 10
0.1 0.2 0.5 1 2 3 4 5 6 7 8 10 15 30
Basin-averaged daily precipitation (mm/day)
CMORPH
TMPART
TMPARP
NLDAS2
StageIV
CPC-U
Precipitation
Evaportranspiration
Soil moisture
SWE
SS/Inundation
Rainfall (7-day accum.) [mm] 06Z25Apr2013
Evaportranspiration [mm] 15Z24Apr2013
Soil Moisture [mm] 15Z24Apr2013
Snow Water Equivalent [mm] 21Z10Jan2013
Surface Water Storage 1km res. [mm])
18Z27Apr2013

Summary and Future

1. A new version of the Global Flood Monitoring System (GFMS) has been implemented for real-time application using the U. of Washington VIC community Land Surface Model and a new physically based DRTR routing model from the U. of Maryland for more accurate flood calculation and greater flexibility, including 1 km routing. The VIC/DRTR combination is called the Dominant river Routing Integrated with VIC Environment (DRIVE) system.

2. The evaluation of the DRIVE model shows promising performance in retrospective runs vs. observed streamflow records and in flood event detection against global flood event statistics. Results show impact of dams (higher FAR), potential improvement with improved accuracy of satellite precipitation and greater skill with longer floods.

3. High resolution (1 km) routing and water storage calculations will lead to high resolution inundation mapping for comparison with high resolution visible and SAR imagery of floods.

4. For the future we will also:
   - be implementing a "dam module" to try to include the impact of man-made structures on the calculations
   - be evaluating the use of alternative satellite precipitation products and forecast precipitation info. from numerical models (adjusted by the satellite estimates).

Thanks!