Global Flood Monitoring with GPM IMERG

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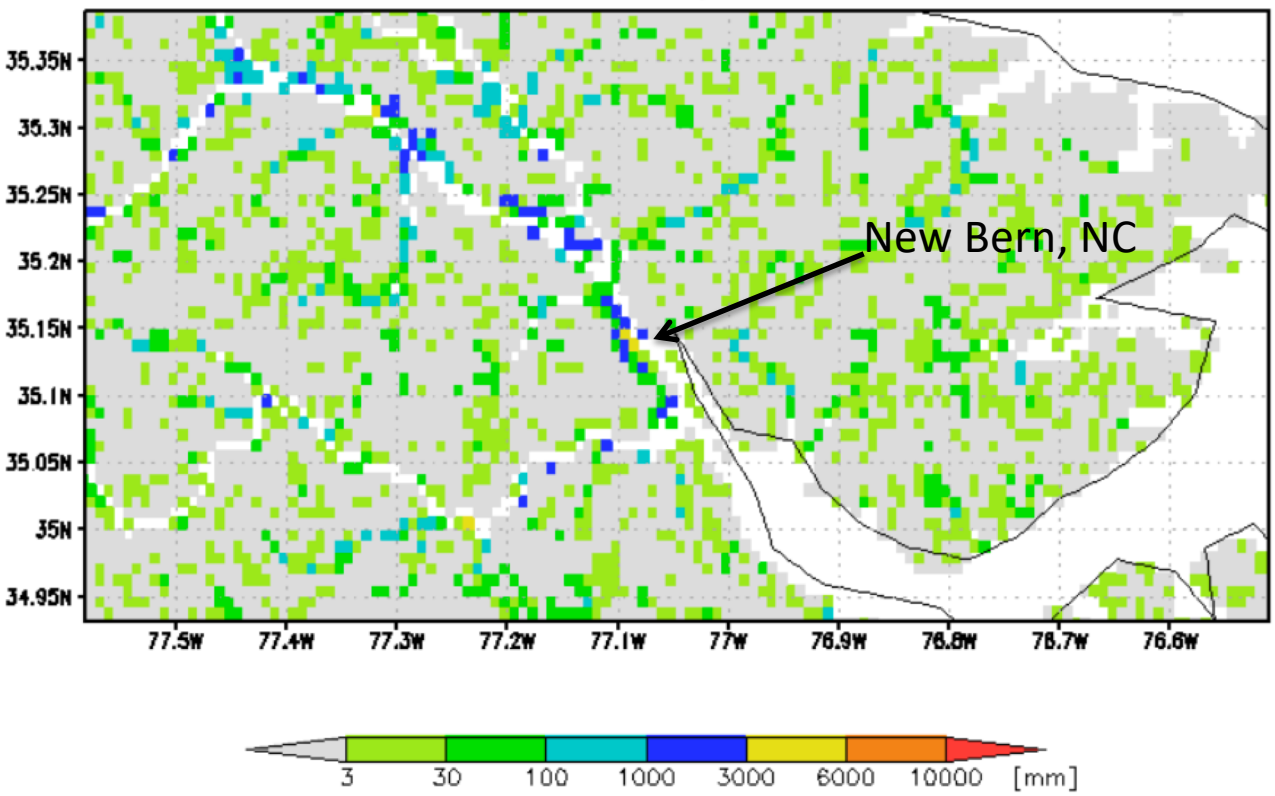
University of Maryland

1 km Inundation Estimate from GFMS

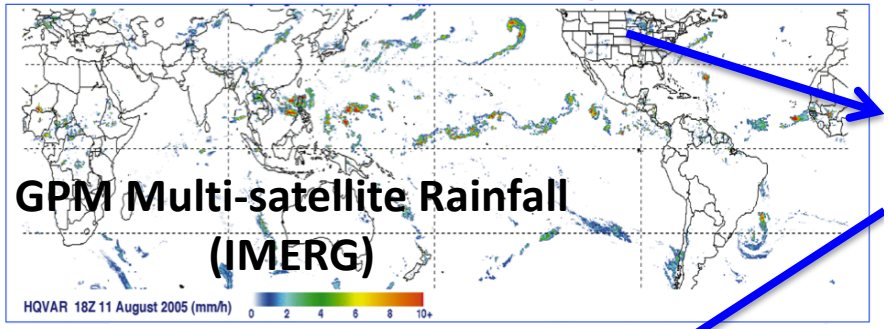


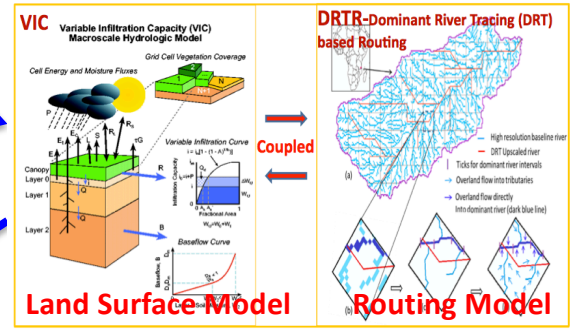
Hurricane Florence

16 September 2018

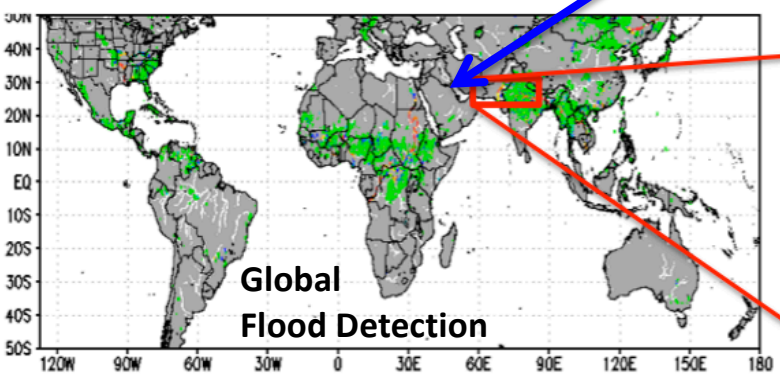
Global Flood Monitoring System (GFMS)

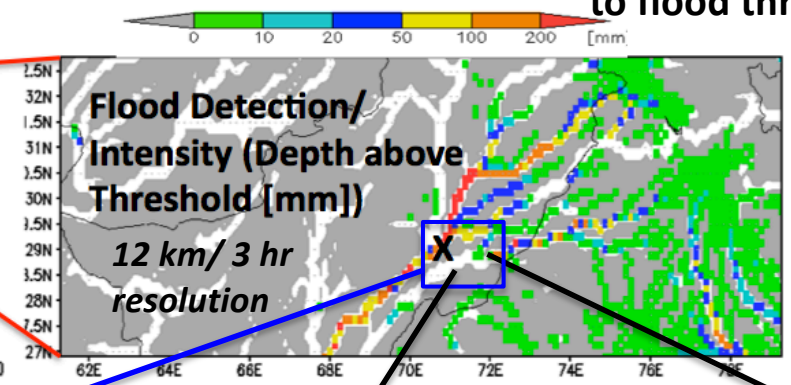
Global Real-time Flood Calculations Using Satellite Rainfall and Hydrological Model



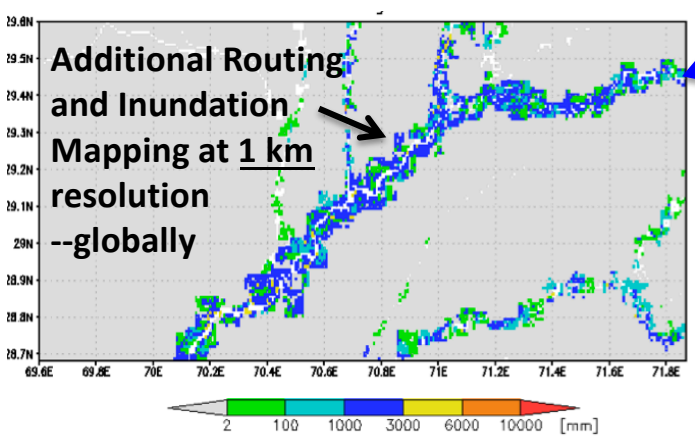


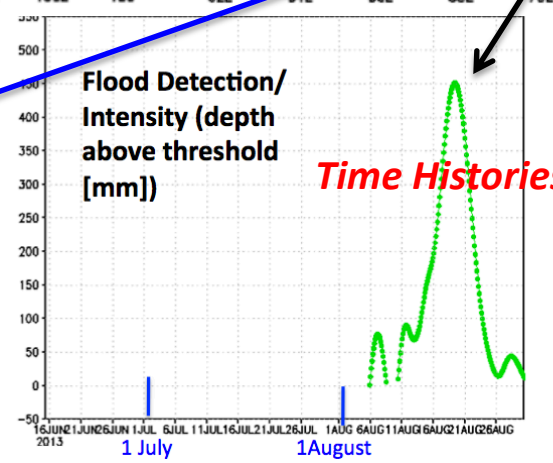
TRMM/GPM rainfall into land surface and routing models for water depth and streamflow calculations compared to flood thresholds

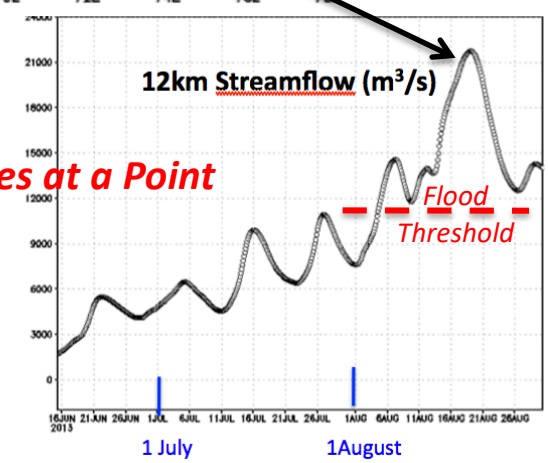




Indus River basin







GFMS developed by Huan Wu, now at Sun Yat-sen Univ.

http://flood.umd.edu/

Global Flood Monitoring System (GFMS)

- GFMS now uses GPM IMERG in "real-time" system after years of using TMPA, although some flood thresholds use TMPA-based values based on running long-term calculations

- IMERG is used at 1/8th degree lat./long., 3-hour resolution

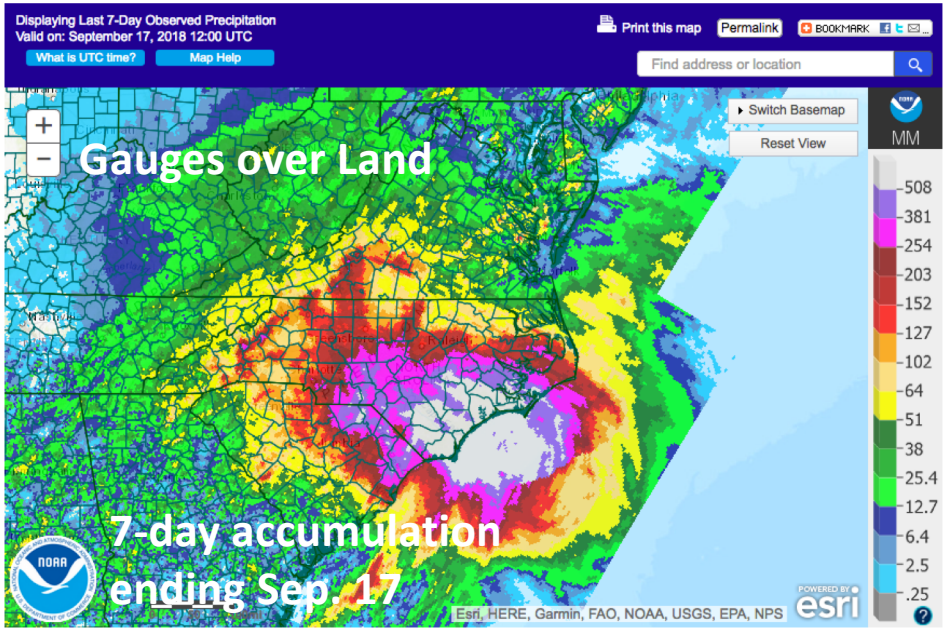
- Analyses are available at flood.umd.edu and various data are available for download

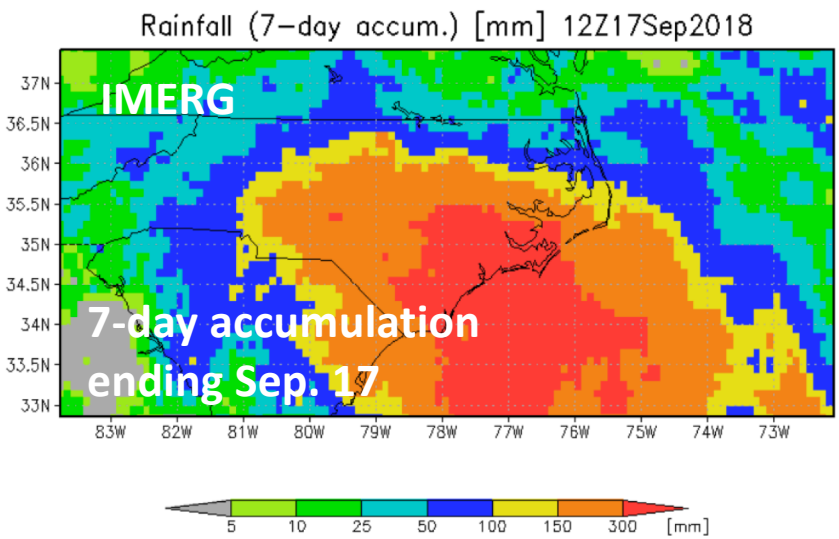
- GFMS results are connected to GPM website, NASA Disasters Portal, Flood Observatory (U. of Colorado), Global Flood Partnership (GFP)

- **Focus in this project is on applicability and accuracy of IMERG in flood events**

- **In this talk—Examine a few recent cases for IMERG rain and flood results**

Hurricane Florence September 2018

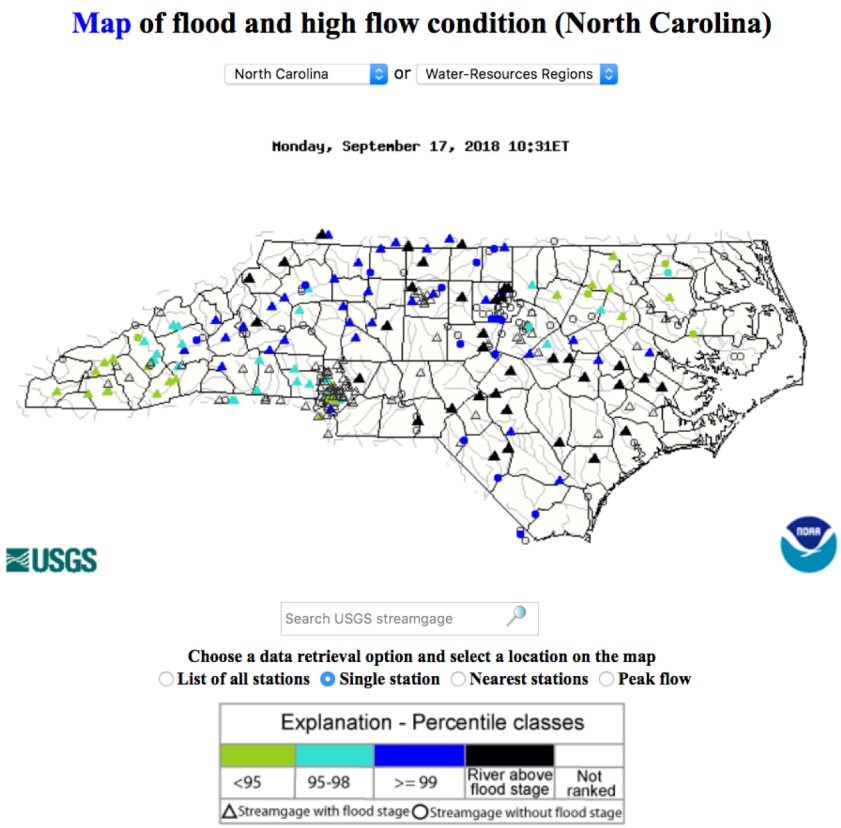


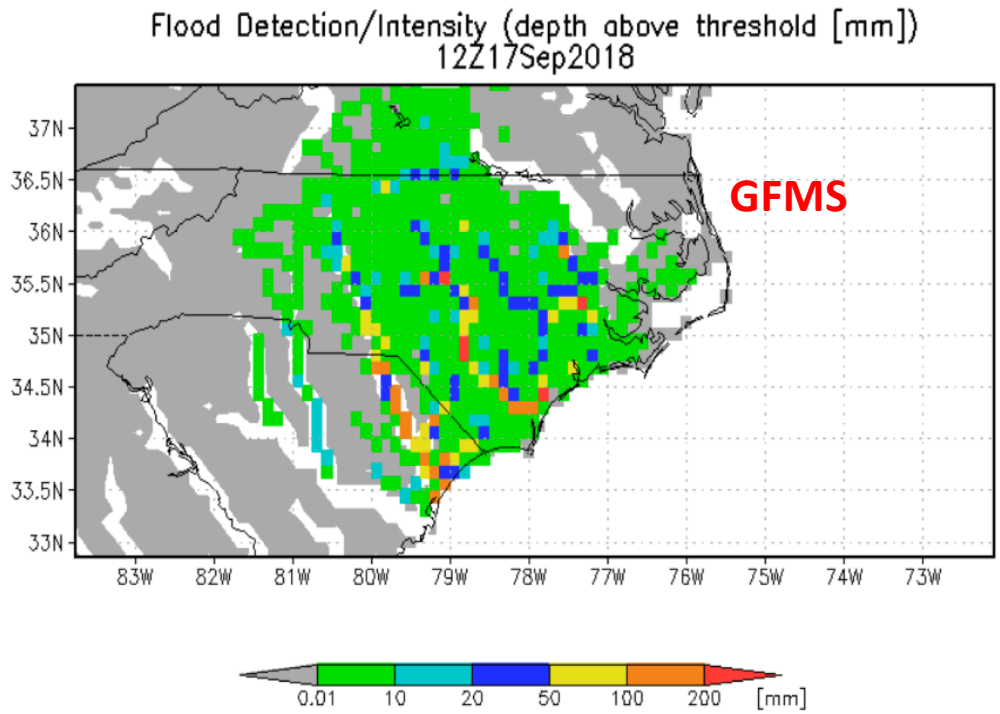


Overall IMERG has patterns and accumulations about right up to about 200 mm; at higher totals IMERG tends to underestimate.

Peak numbers:
IMERG: ~500 mm
Gauges: ~700 mm

Flood Conditions in NC from Streamgauges and from GFMS

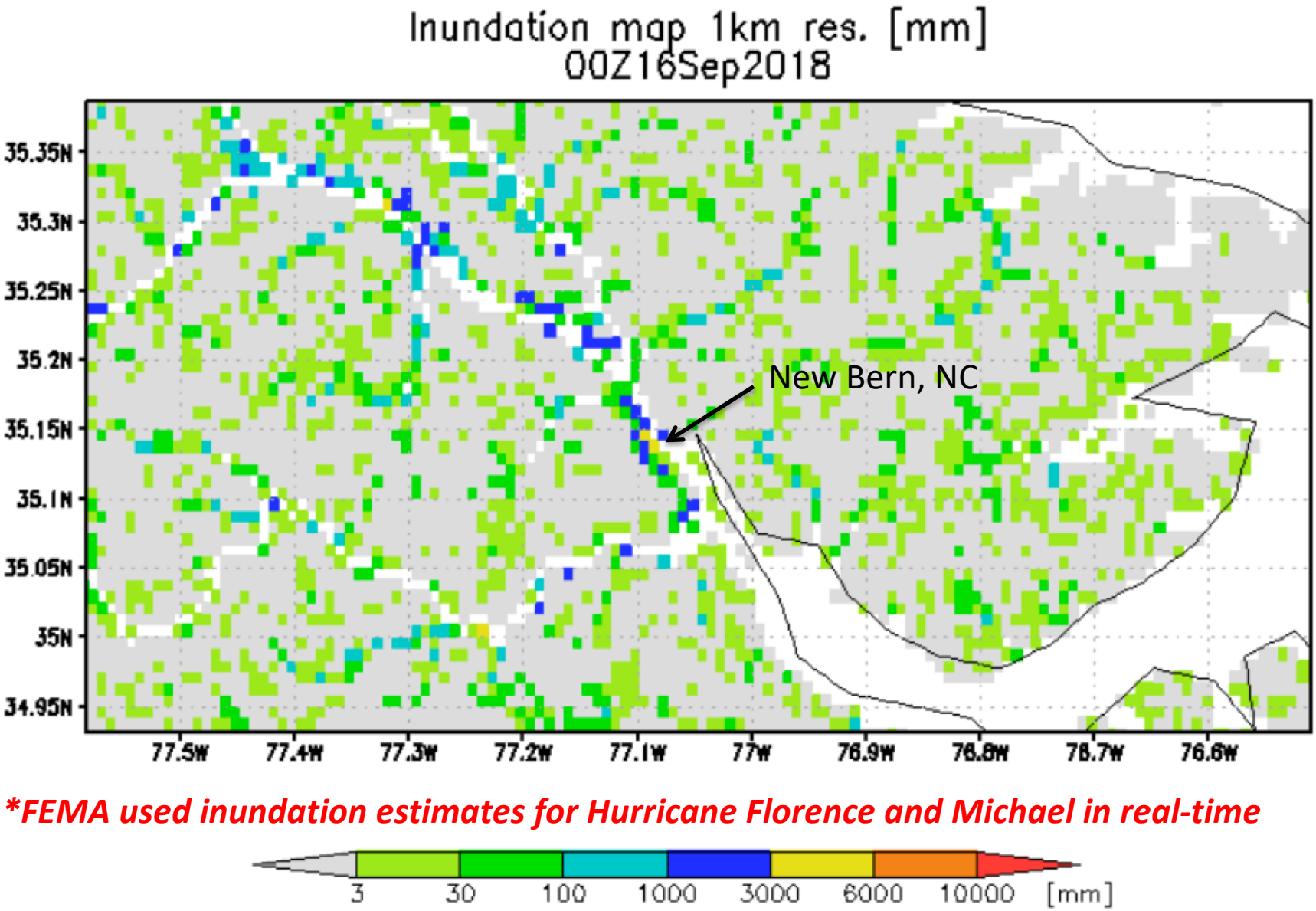




September 17, 2018

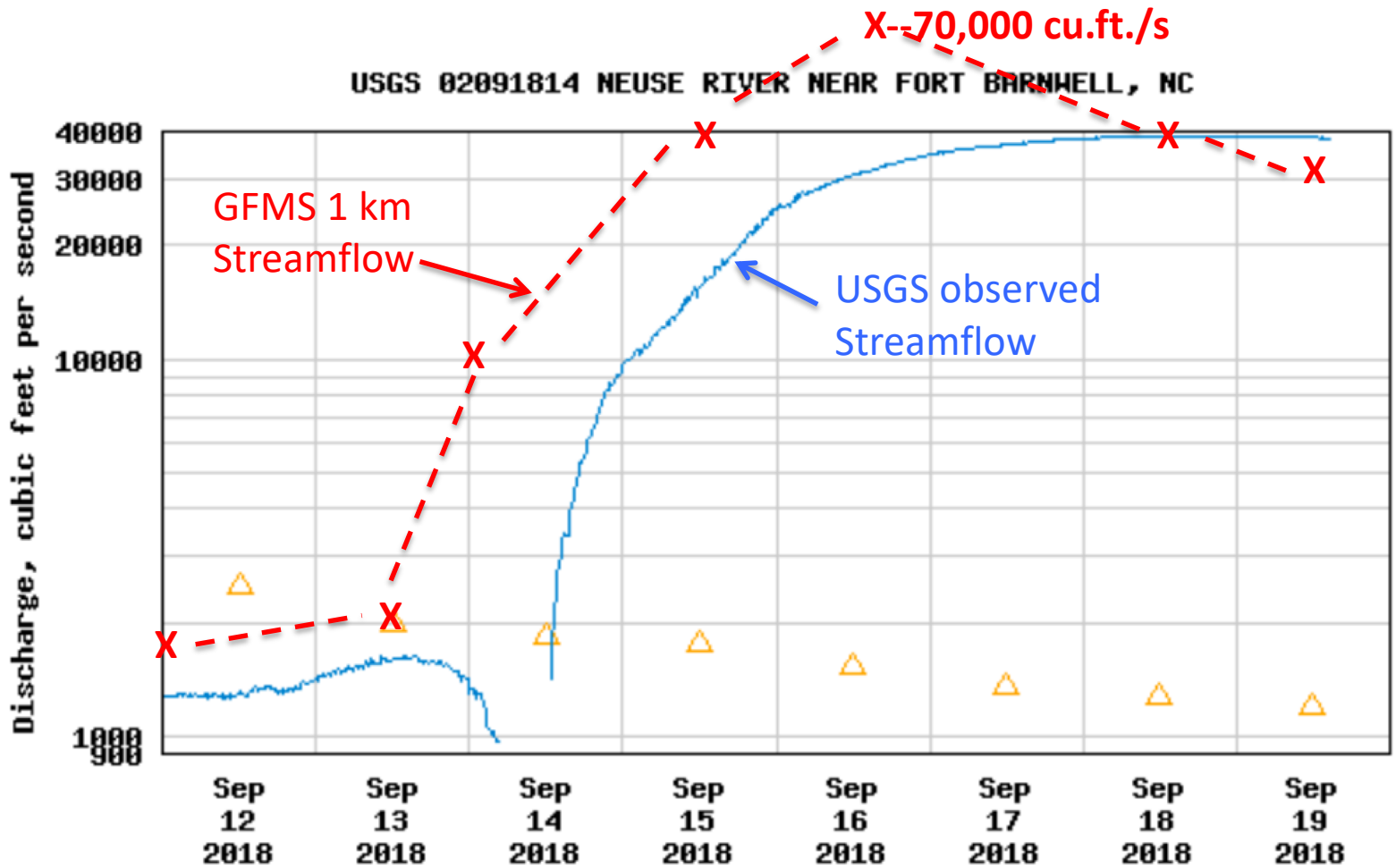
- **GFMS provides reasonable estimates of floods related to Hurricane Florence**

Inundation Calculations (1 km) based on Routing at 1 km (global)



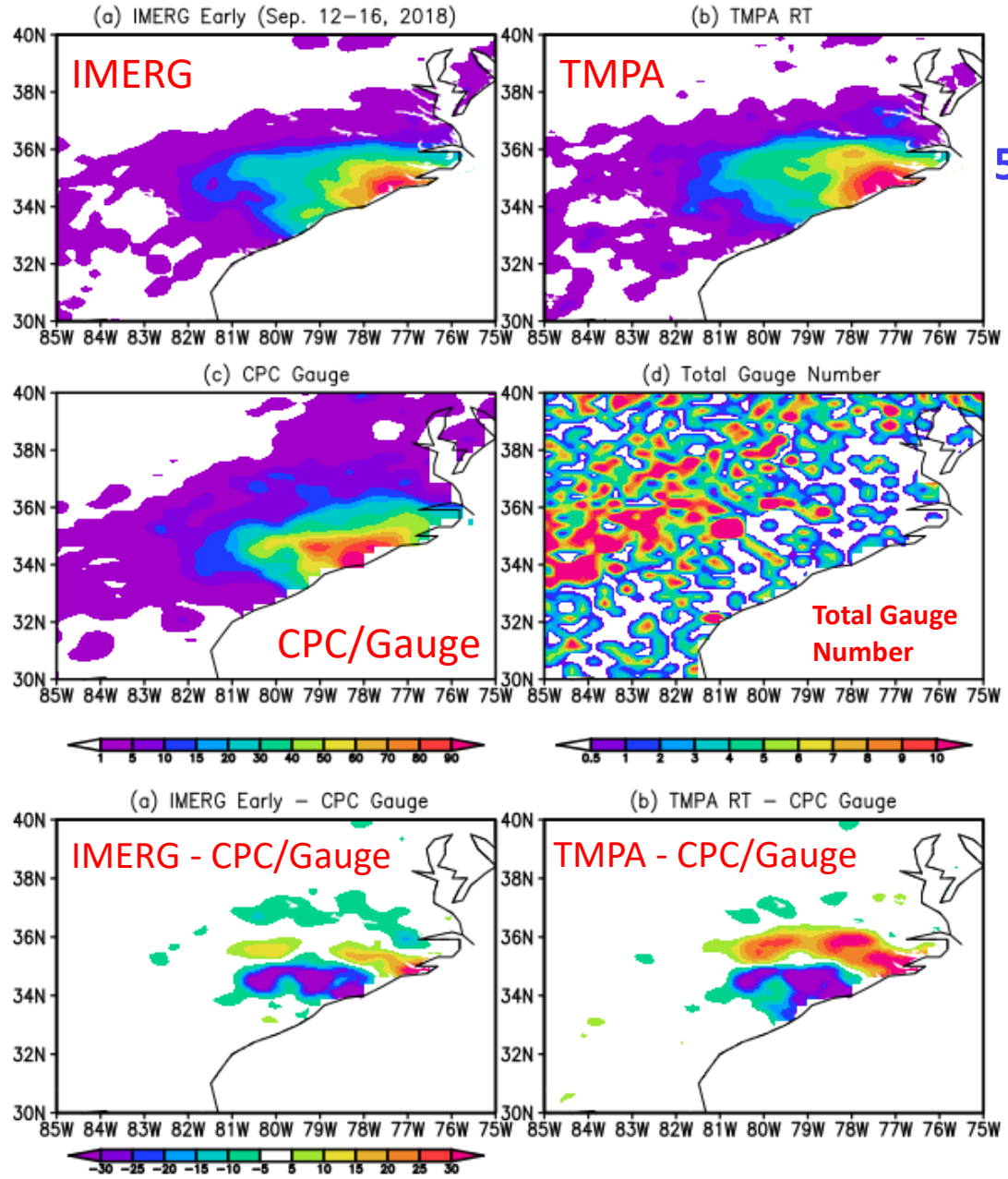
FEMA used inundation estimates for Hurricane Florence and Michael in real-time

Streamflow Comparison Upstream of New Bern, NC



- **GFMS peaks early with higher maximum flow—integration might equalize the volume calculation to the observation**

IMERG/TMPA vs CPC ¼ degree, daily gauge



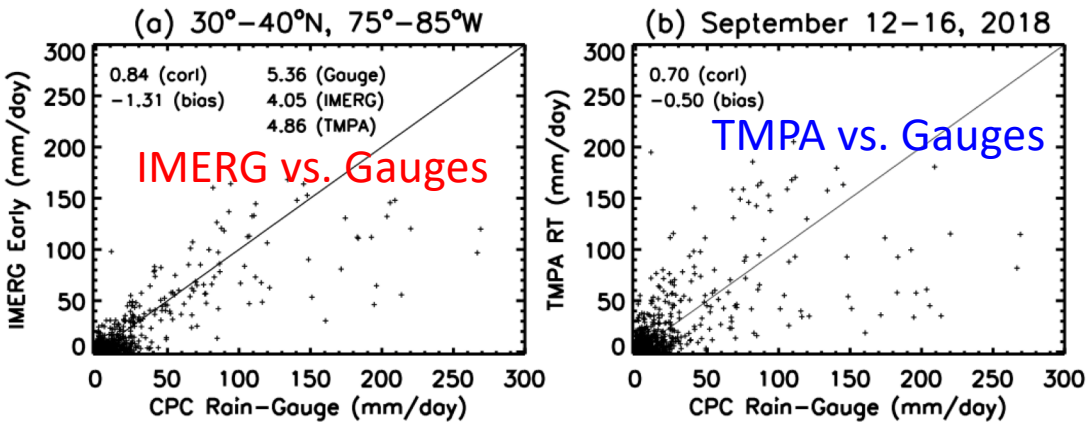
5-day-average (Sept. 12-16)

- **Shift of maximum precipitation?**

IMERG compared to CPC ¼ degree, daily gauge analysis

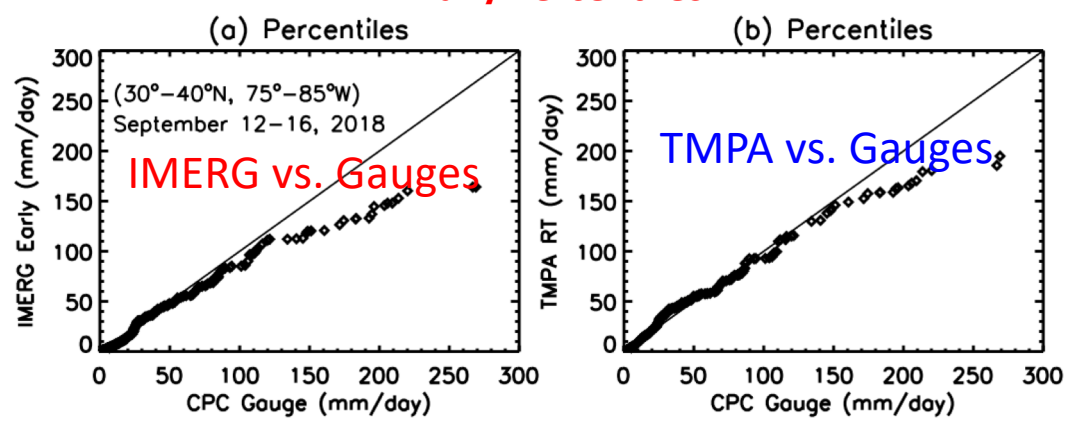
(Grids without gauges are not included)

Scatterplots of Daily Rain-rates



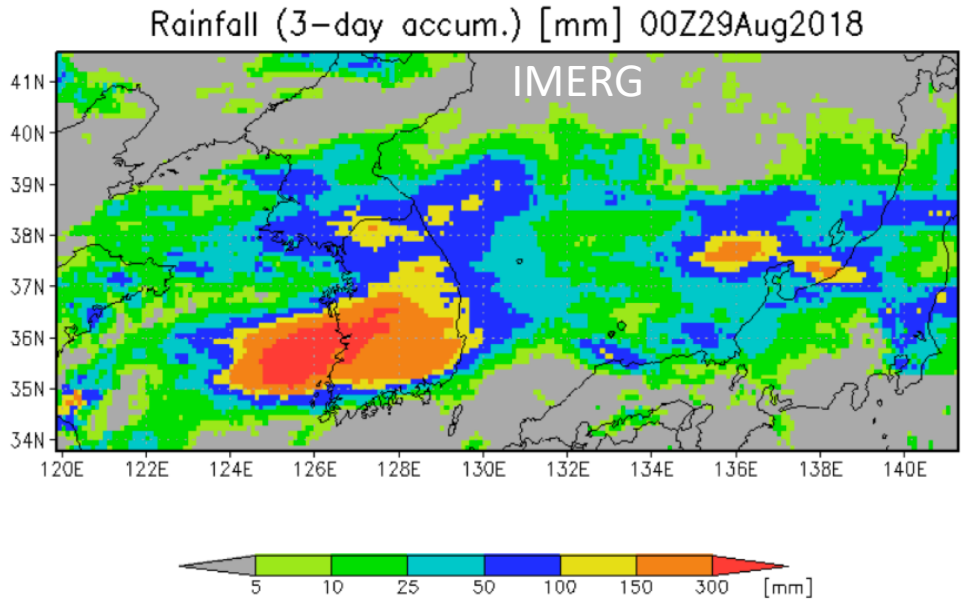
5-day-aggregate
(Sept. 12-16)
[30°-40°N, 75°-85°W]

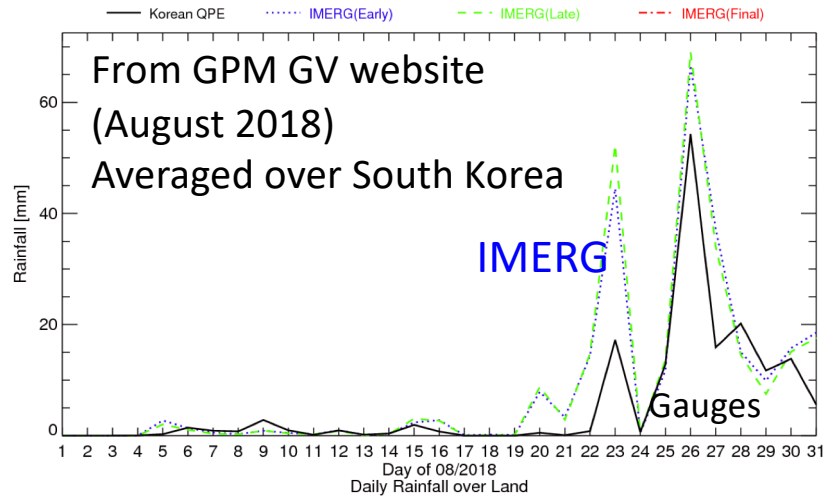
Daily Percentiles

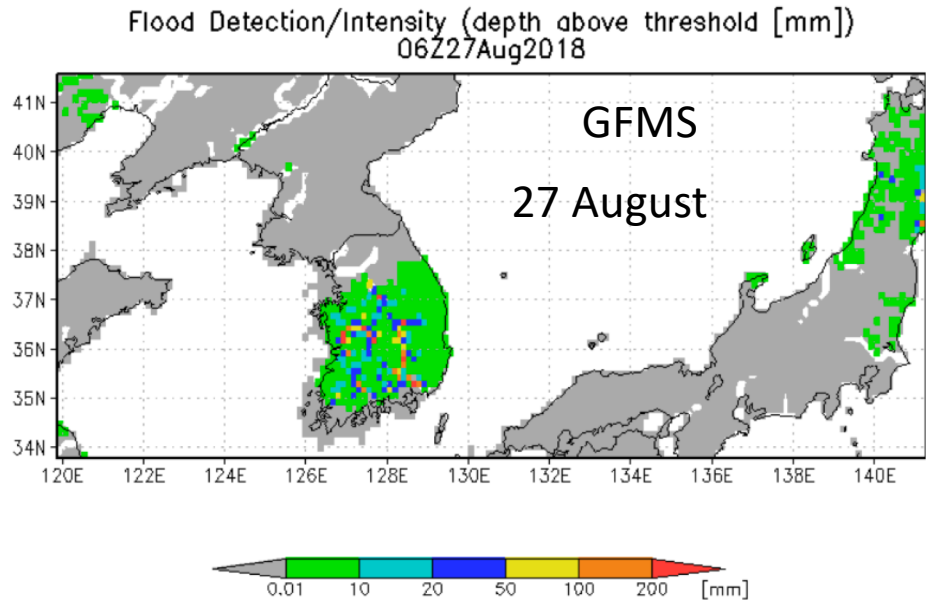


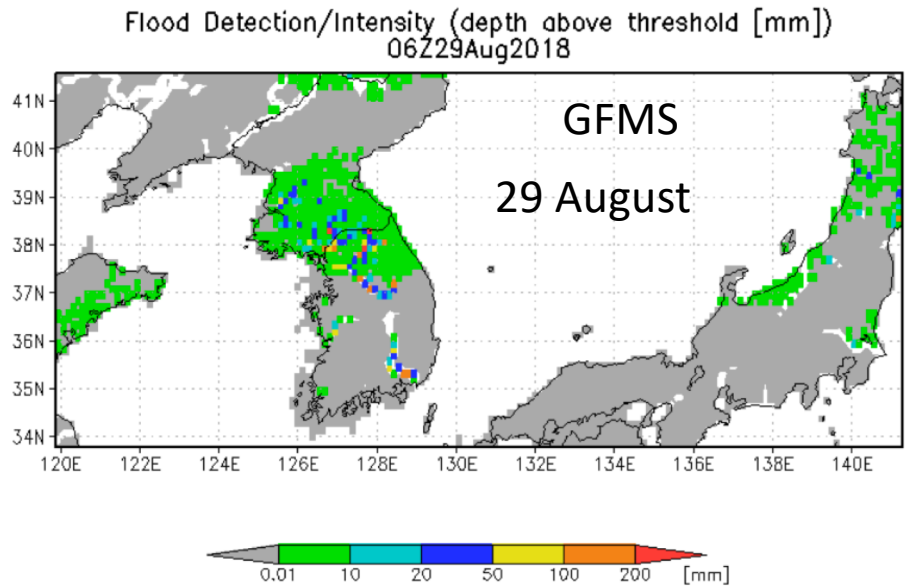
- **Both IMERG & TMPA underestimate at the high end, compared to CPC gauges**

Floods over Korean Peninsula (26-30 August, 2018)

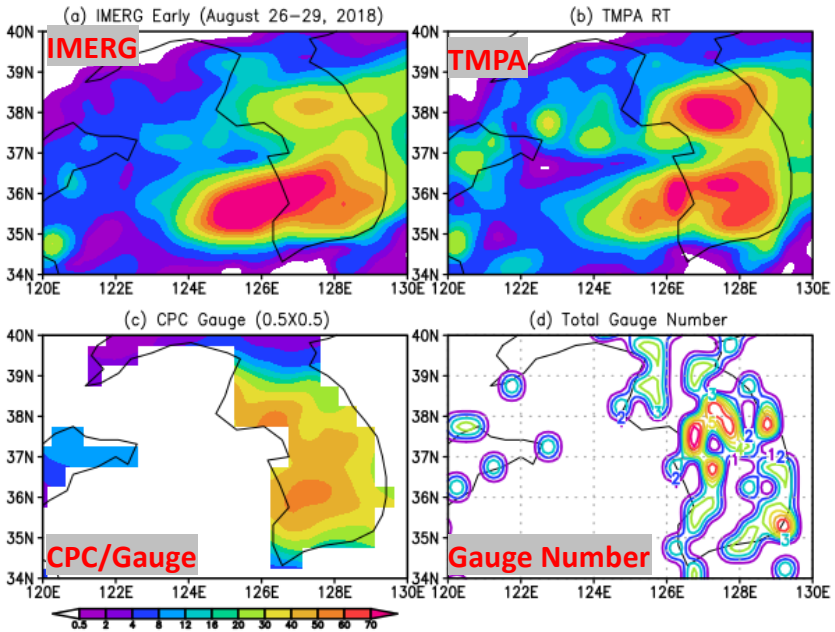


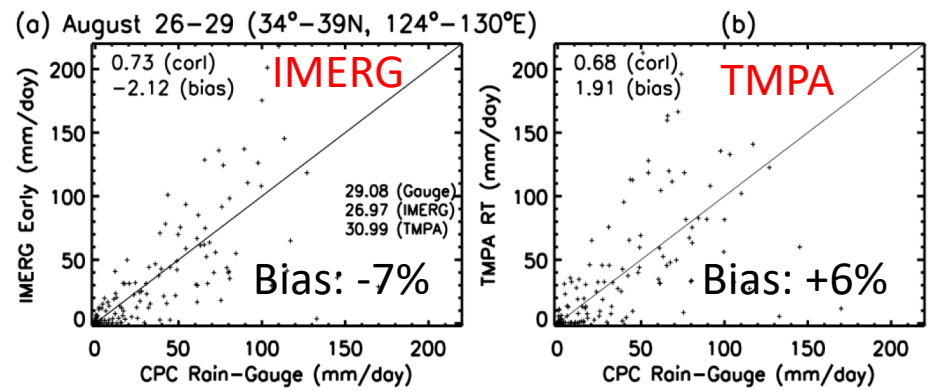






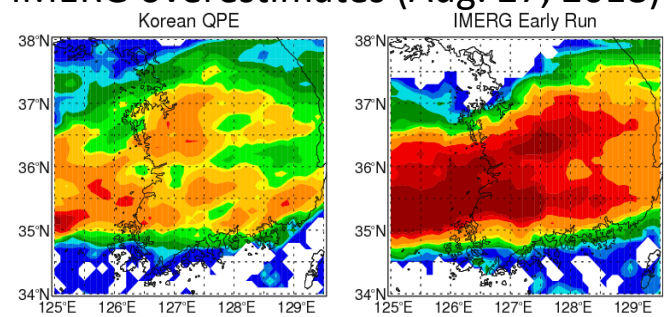
IMERG, TMPA, and CPC Gauge (Aug. 26-29, 2018)



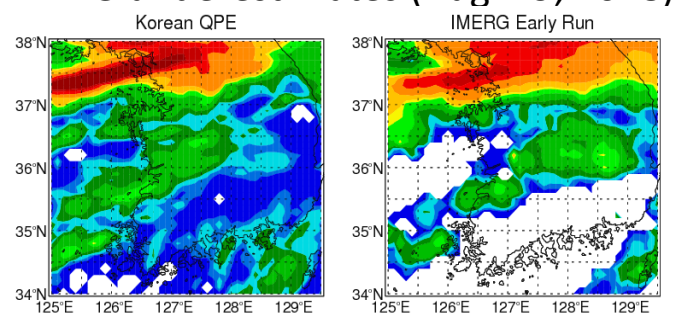


CPC 1/2°, Daily

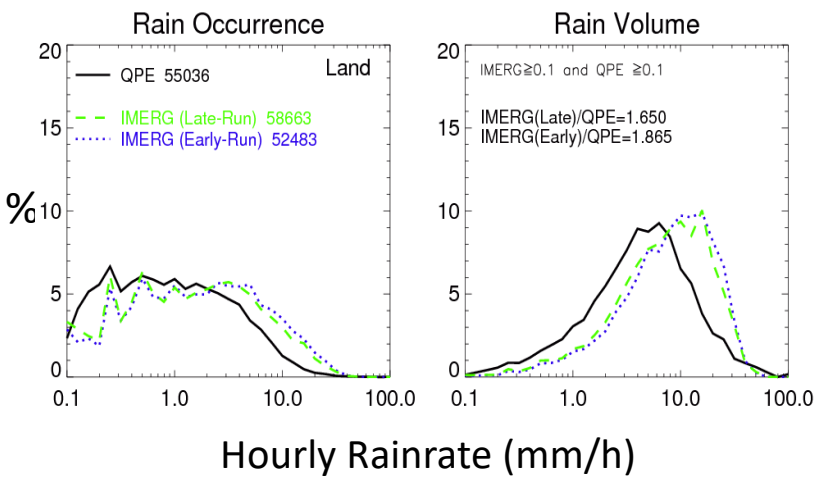
IMERG overestimates (Aug. 27, 2018)

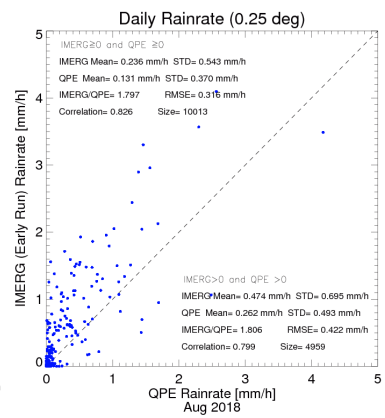


IMERG underestimates (Aug. 29, 2018)



From GPM GV website 0.1 deg./hourly (August 2018)





Summary of Current Global Flood Project

- GFMS is running with IMERG in quasi-real-time 50°N-50°S, providing reasonable flood results;
- Obvious event-based discrepancies exist between current IMERG/TMPA precipitation and surface observations, either overestimating or underestimating in different regions, directly affecting the accuracy of GFMS flood calculations;
- More evaluations of GFMS estimates are needed as part of hydrological validation of IMERG;
- Further GFMS development is necessary to take advantage of IMERG resolution and coming precipitation algorithm/product improvements

New Directions

Floods ⟵ **Precipitation & Precipitation Extremes**

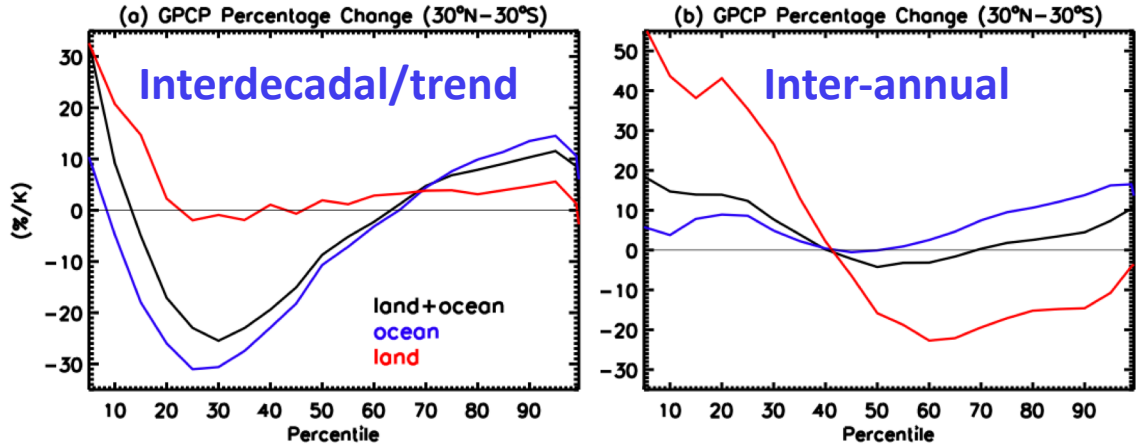
- **Variations/changes of precipitation extremes on interannual-decadal time scales:** **precipitation intensity & frequency**

- **Using observations (satellite/gauge-based) with (quasi-) global coverage:** **monthly & daily/sub-daily temporal resolution**

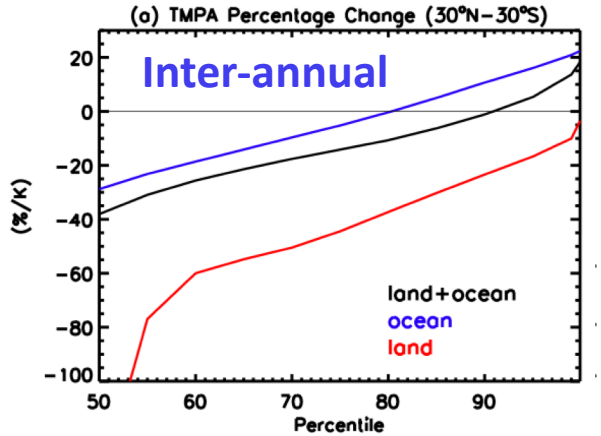
Changes of Precipitation Intensity (30°N-30°S) with Ts

Percentiles

Intensity



GPCP monthly



TMPA daily

Percentage changes of (GPCP) monthly intensity on interdecadal/trend time scale:

- Positive (negative) changes for higher (intermediate) percentiles;
- Positive changes in mean precipitation being much weaker than high percentiles;
- General consistencies can be found in CMIP5 model outputs

Gu and Adler, 2018: Precipitation intensity changes in the tropics from observations and models. *J. Climate*, **31**, 4775-4790.

Percentage changes of (TMPA) daily intensity on interannual time scale:

- Positive (negative) response of high (intermediate/low) percentiles to surface temperature;
- Larger percentage changes in magnitude in the high/intermediate percentiles than in mean precipitation

Precipitation Intensity Changes (30°N-30°S, Land+Ocean) in Relation to Surface Temperature Changes

	Mean Precipitation	High Percentile	Intermediate Percentile
Interdecadal/Trend-<u>Monthly</u> (GPCP, 1988-2015)	+5.0 %/K	+13.3 %/K *95th Percentile*	-31.4 %/K *30th Percentile*
Interannual Var.-<u>Daily</u> (TMPA, 1998-2013)	+6.0 %/K	+14.1 %/K *99th Percentile*	-22.3 %/K *70th Percentile*

- Much more intense changes in magnitude appear in the high (increase) and lower (decrease) percentiles than in mean precipitation on both time scales (interdecadal/trend & interannual);
- Despite different processes on different temporal scales (interdecadal/trend vs interannual), intensity changes (monthly vs daily) tend to have similar statistics in relation to surface temperature changes

Summary of next-step work:

- **Extending explorations (of variations/changes in precipitation intensity, frequency & extremes and their sensitivity to surface temperature change) to more TRMM/GPM products:**

  1) IMERG on daily/subdaily scales covering the entire TRMM/GPM period (1998-present);

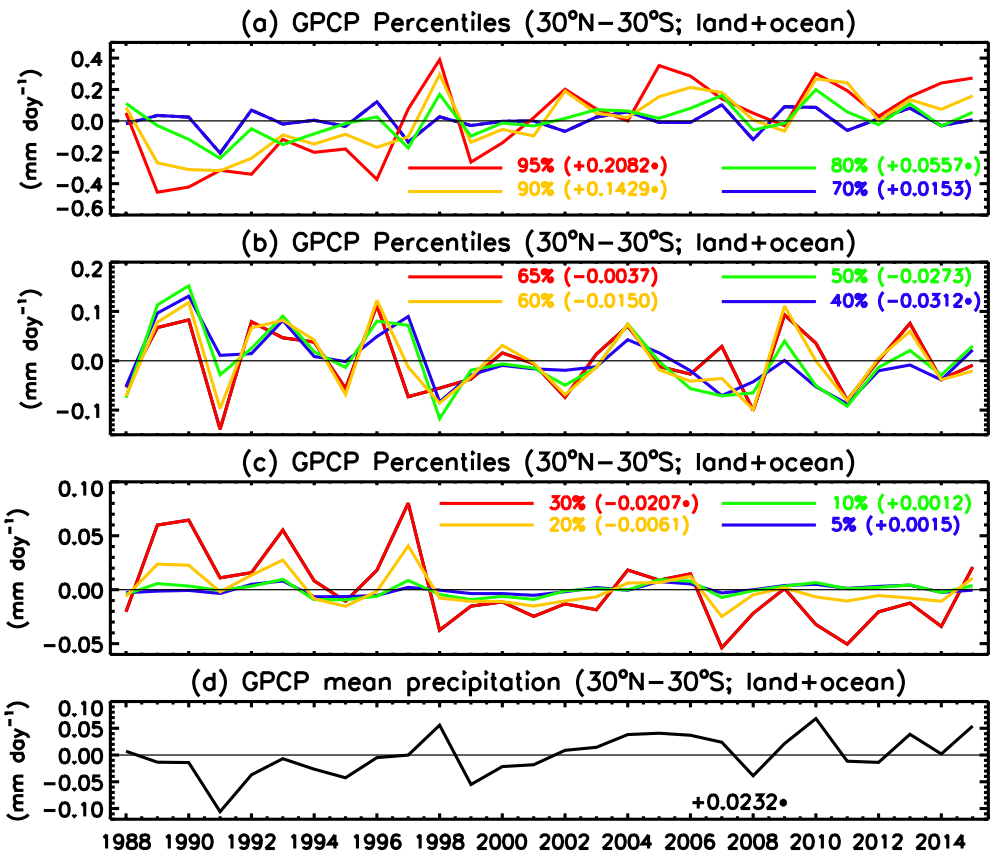
  2) TRMM/GPM level-2 (passive-microwave and spaceborne radar) products at instantaneous scale;

  3) GPM constellation precipitation products such as SSMI/SSMIS GPROF at instantaneous and daily scales for exploring both interdecadal/trend and interannual variability

- **Comparing with other precipitation products (GPCP-1DD, PERSIANN-CDR) and reanalysis (MERRA)/climate model (CMIP5/6) outputs**

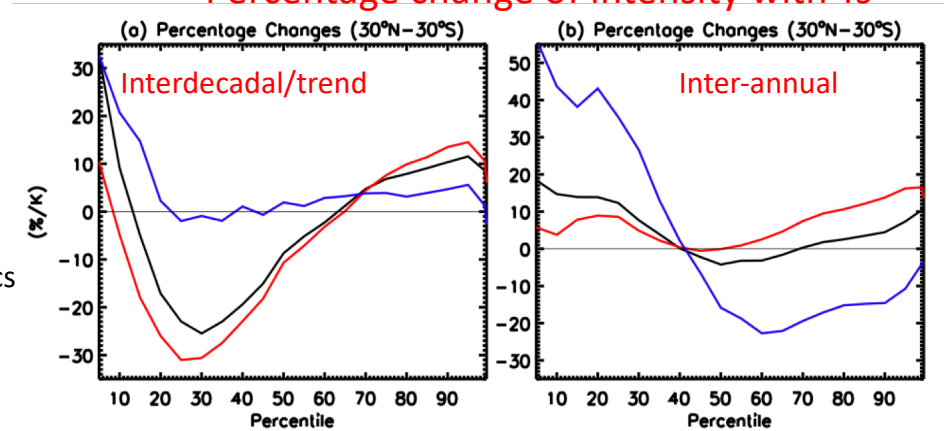
Extra Slides

Monthly GPCP Percentiles (30°N-30°S; Land+Ocean)



- Positive trend, statistically significant for Pct ≥ 80th;
- Negative trend for the middle percentiles, significant for 30th - 40th (edge of moderate to dry regions);
- P_{mean} has positive trend, but smaller than high percentiles

Percentage change of intensity with Ts

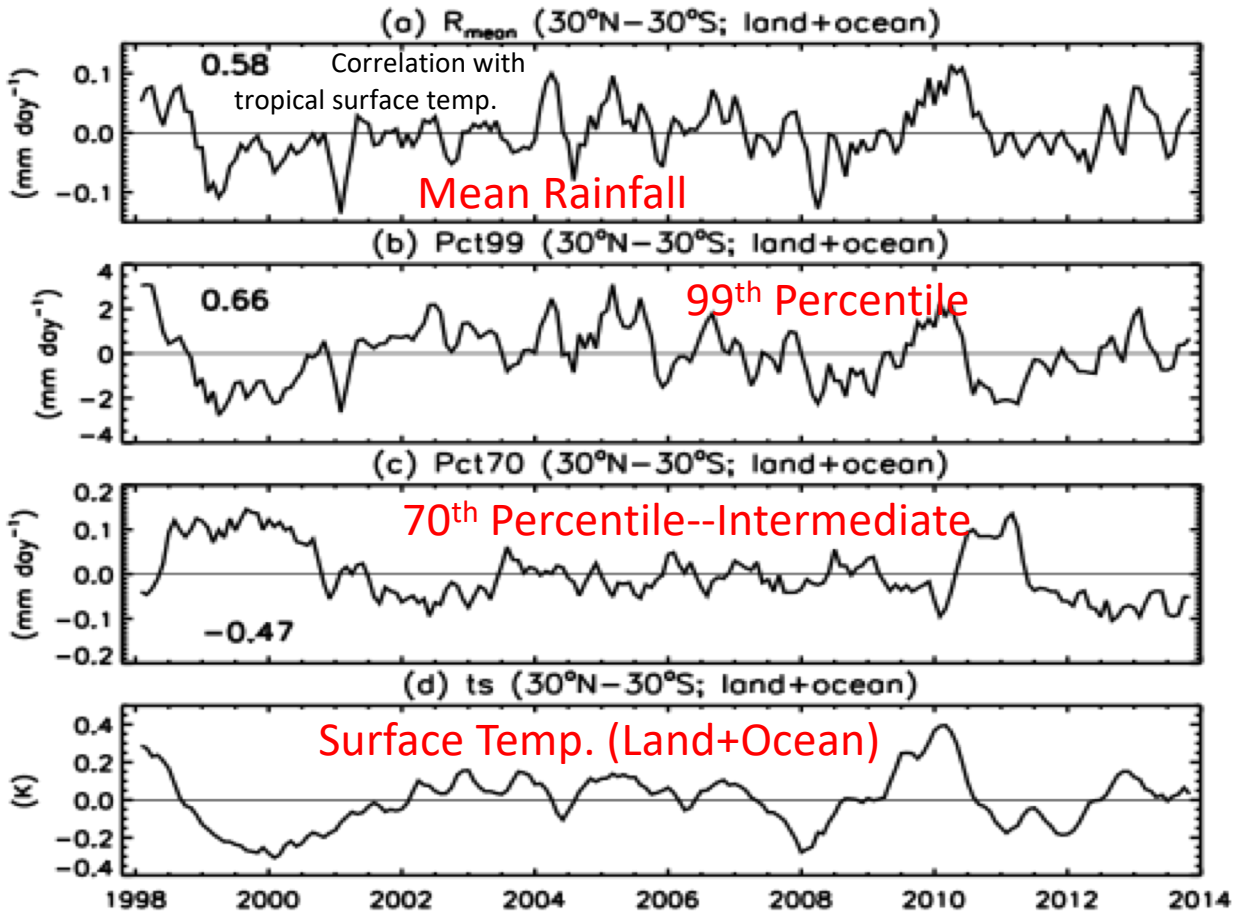


Gu and Adler, 2018: Precipitation intensity changes in the tropics from observations and models. *J. Climate,* **31**, 4775-4790.

Daily Rain Percentiles (30°N-30°S; Land+Ocean) Using TRMM/TMPA (adjusted by GPCP Monthly)

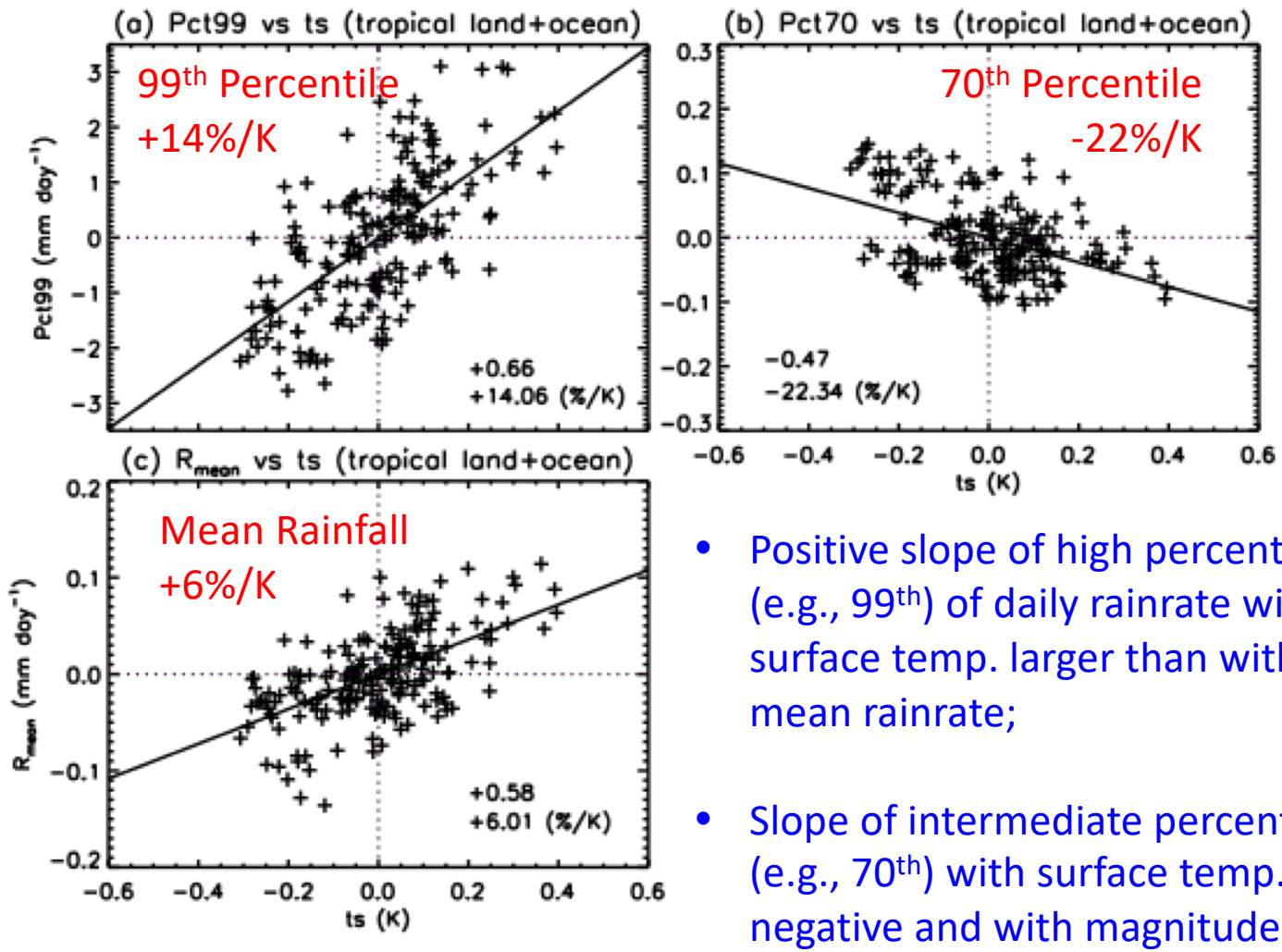
1.0°x1.0° Lat. Long.

Inter-Annual Variations



- Mean rainfall and high percentiles correlated positively with tropical surface temperature;
- Intermediate percentiles have negative correlation

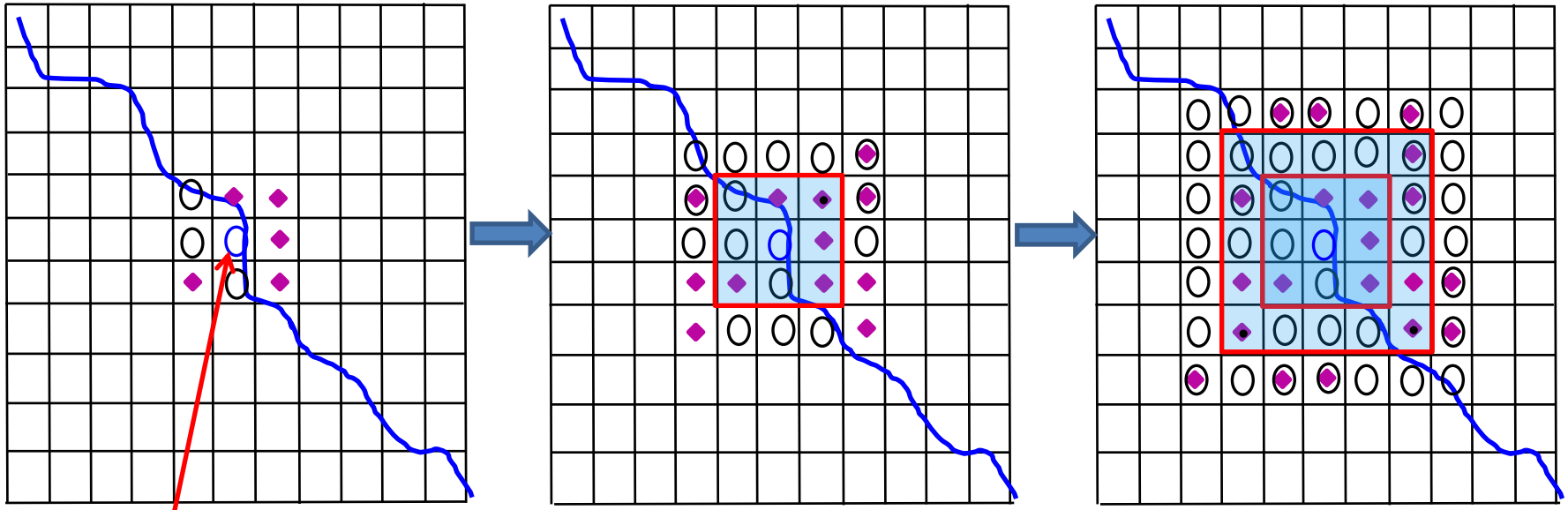
Monthly Anomalies of TMPA Daily Rainfall Statistics vs. Surface Temp. Anomalies

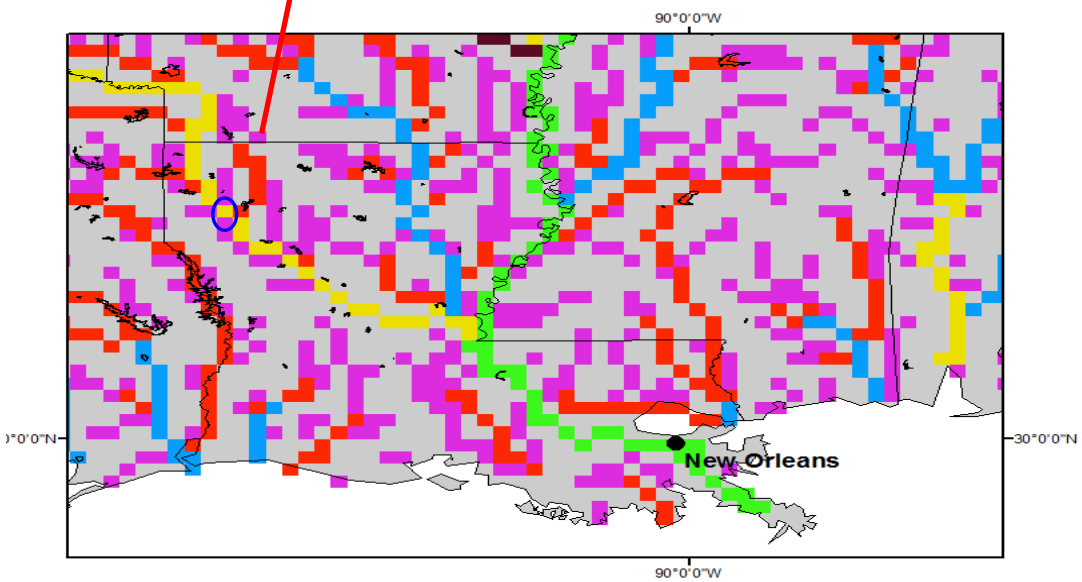


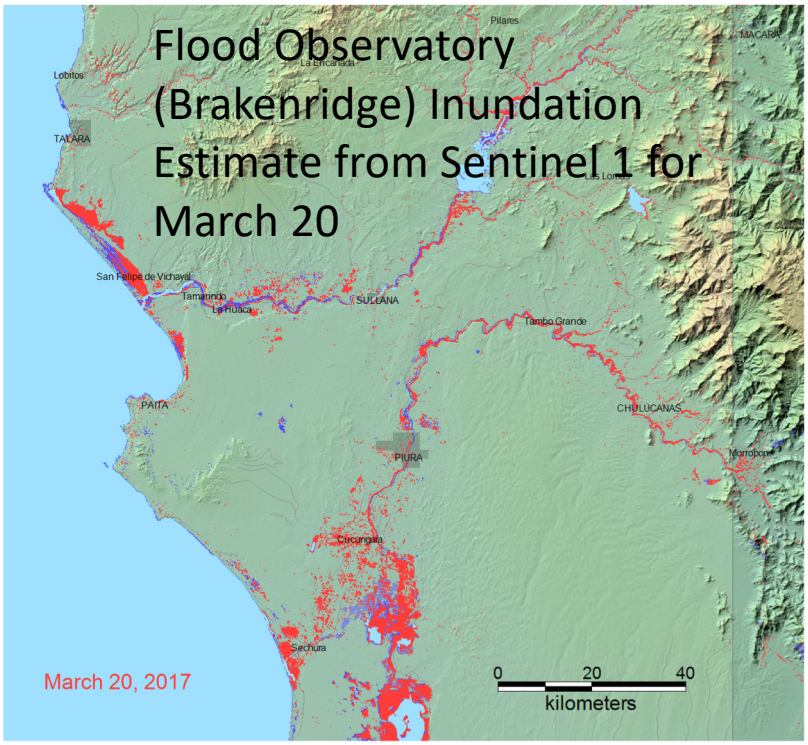
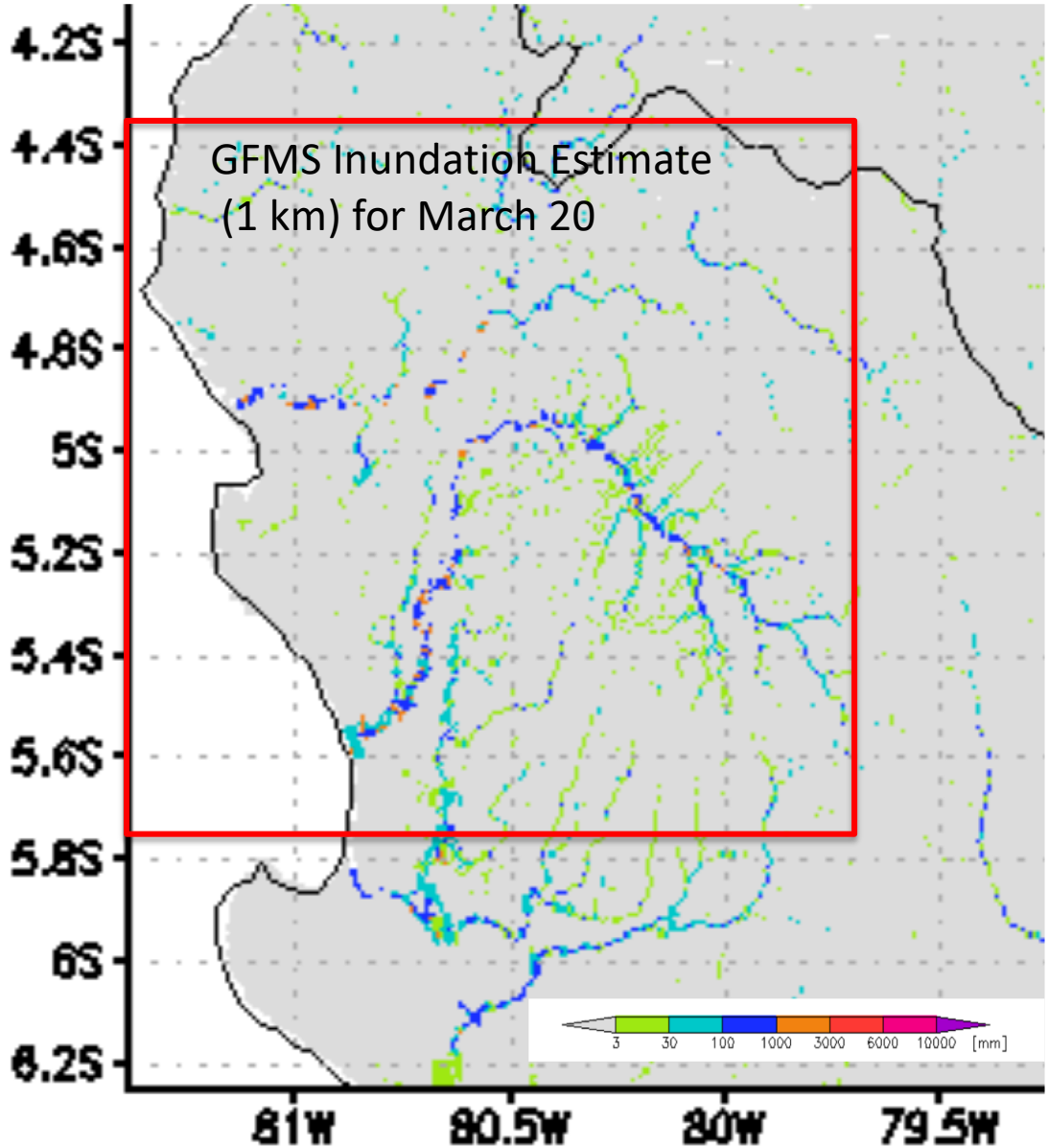
- Positive slope of high percentiles (e.g., 99th) of daily rainrate with surface temp. larger than with mean rainrate;
- Slope of intermediate percentiles (e.g., 70th) with surface temp. is negative and with magnitude greater than mean or 99th

GFMS
Inundation Algorithm
1 km Streamflow

- Overbank flooding
- Not inundated
- Inundated cell
- Inundated cell without expanding
- Non-inundated potential flooding





Criteria and assumption: (1) mass balance; (2) inundation only happens in floodplain across the river reach with a level water surface; (3) inundation process finishes within the same time interval as the routing model; (4) inundation buffer area doesn't include the grid cells with higher river order.

Comparison of Sentinel and GFMS Inundation Estimates