Evaluation of TMPA-RT v6 and v7 Precipitation for Flood Prediction

(and their improvement through assimilation of soil moisture)

Eric F Wood

Princeton University

PMM Science Team Meeting

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The challenges of real-time flood forecasting using real-time (GPM) satellite precipitation

- The need: At present, there is no capability to predict floods and droughts globally, due to reasons like the sparse in-situ precipitation measurements in under developed regions. Many groups are working on this (e.g. Bob Adler)
- The potential: GPM offers the opportunity for global near real-time precipitation measurements.
- The challenge: Are the real-time data of sufficient accuracy (intensity and duration) to be used for flood prediction? (IFloodS will contribute to answering this). Can other Earth Observations (e.g. soil moisture from SMAP, SMOS or AMSR2) be used to improve real-time satellite precipitation and therefore flood predictions?

The focus of the current project and this presentation

Flood prediction requires:

- Real time rainfall.
- Accurate estimates of rainfall accumulations over periods up to 48 hours that lead to floods.

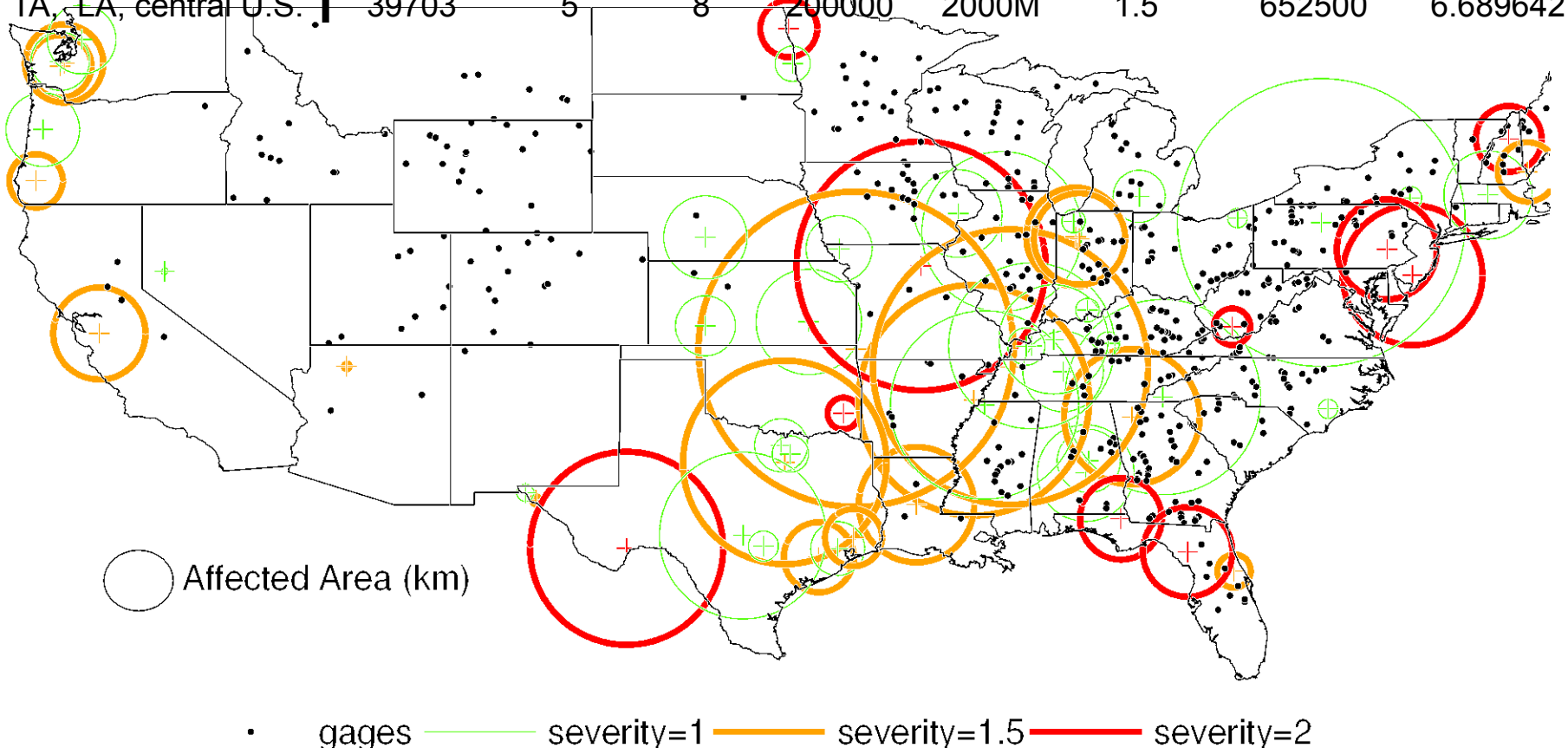
So the talk will present:

1. **Some previous analysis showing the quantitative weaknesses in TMPA RT products for flood forecasting**.
2. Some comparisons between TMPA RT versions 6 and 7 with precipitation from the NLDAS archive (Stage IV radar-gauge product) over the US.
3. Use multi-sensor EO (soil moisture from AMSR-E) within a data assimilation framework to determine if the real-time precipitation retrievals can be improved so as to improve flood forecasts.

Earlier analysis using TMPA-RT (v6) to predict major flood events

(from 2005 to 2010)

Detailed Locations	Began	Duration	Dead	Displaced	Damage	Severity	Affected km^2	Magnitude
Midwest	39524	47	18	1000		1.5	928700	7.816065
WI, IA, IN, IL, MI	39604	29		38000	1500M	2	759800	7.644127
TA, MN, OK, WI, MI, …	39310	12	26	2800		1.5	1217000	7.340563
TA, OK, KS, MS	39259	28	8	5000		1.5	507800	7.328942
IN, AK,TA,OH,MS	39097	20	24	0		1	434400	6.93892
TA, NM	39650	9	1	180		2	457300	6.915474
NV	38814	58	0	0		1	85040	6.693051
TA, LA, central U.S.	39703	5	8	200000	2000M	1.5	652500	6.689642



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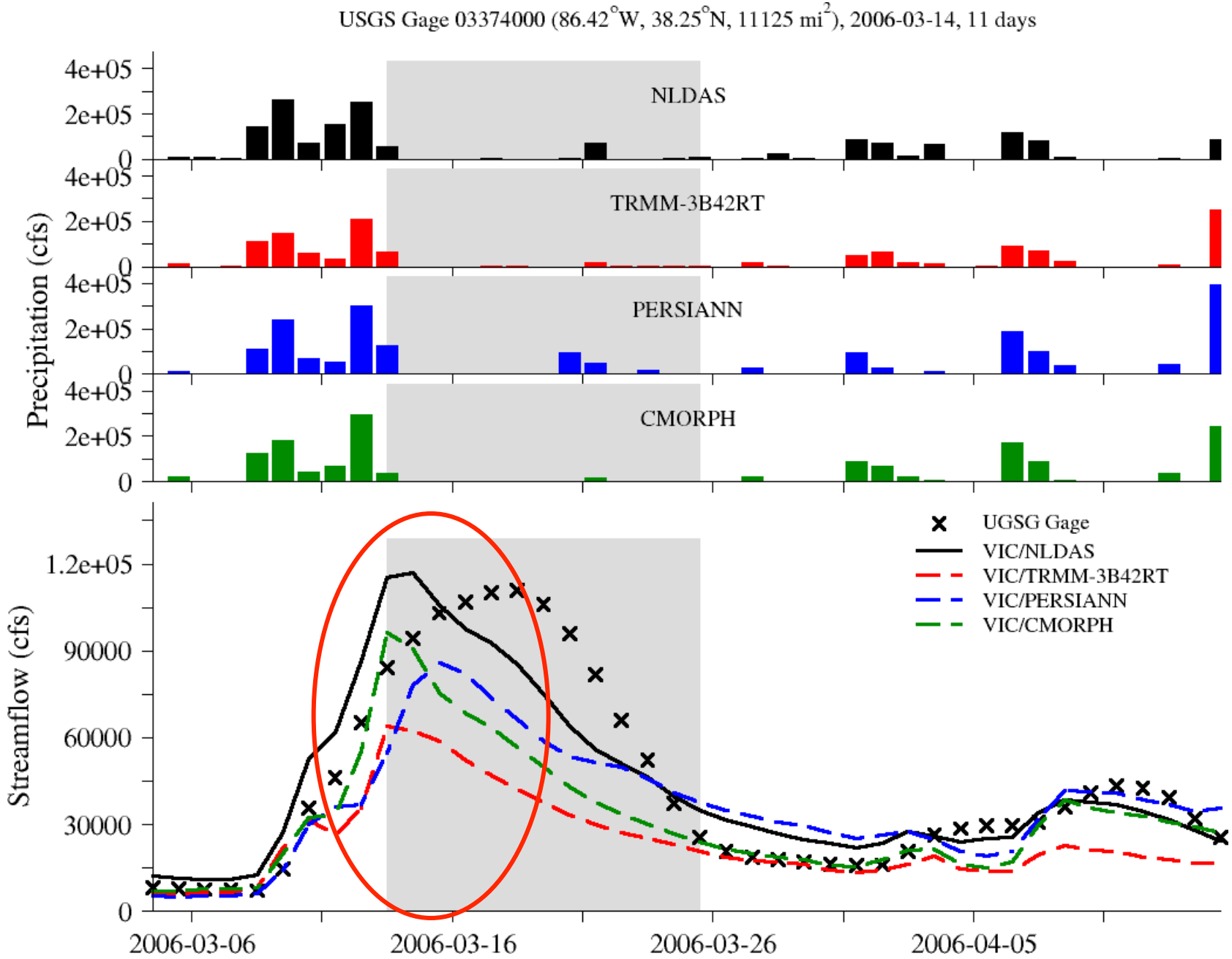
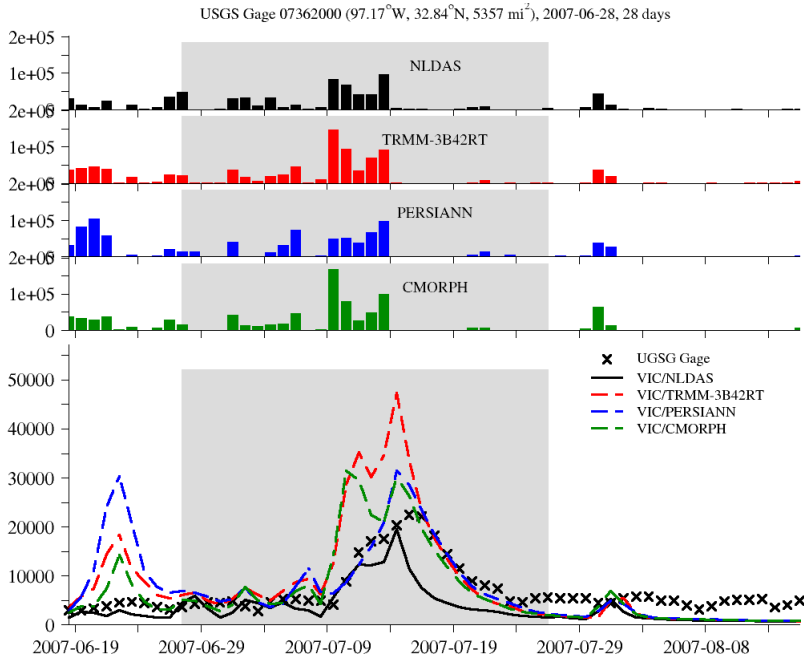
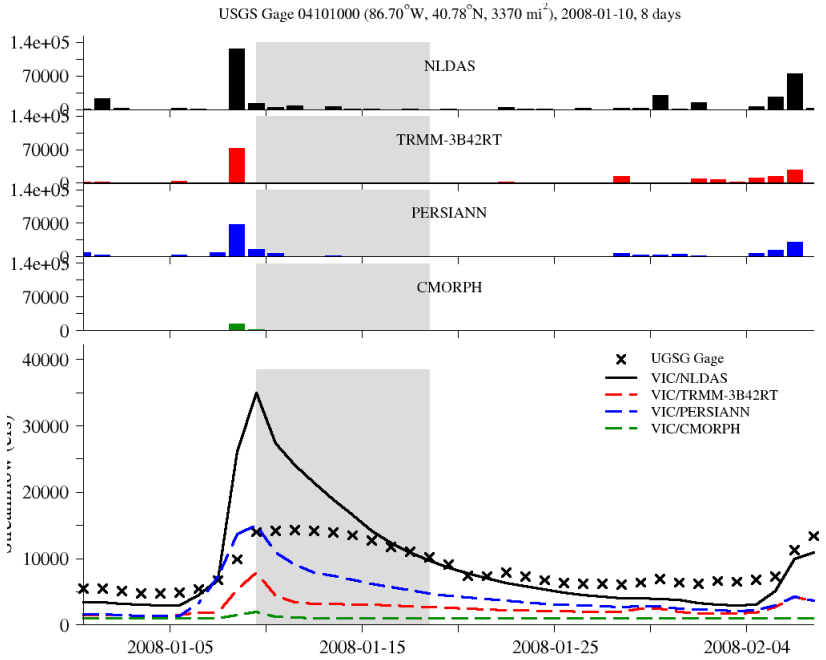
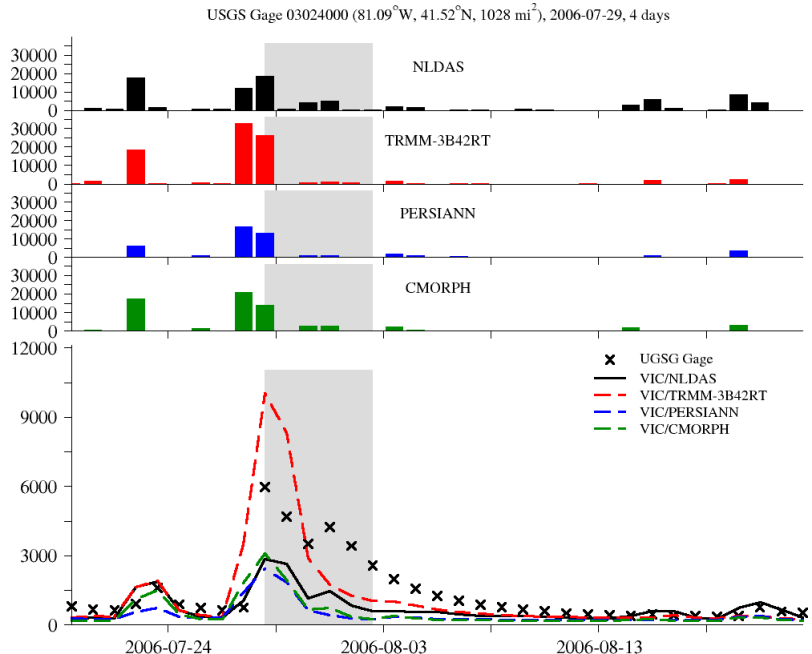
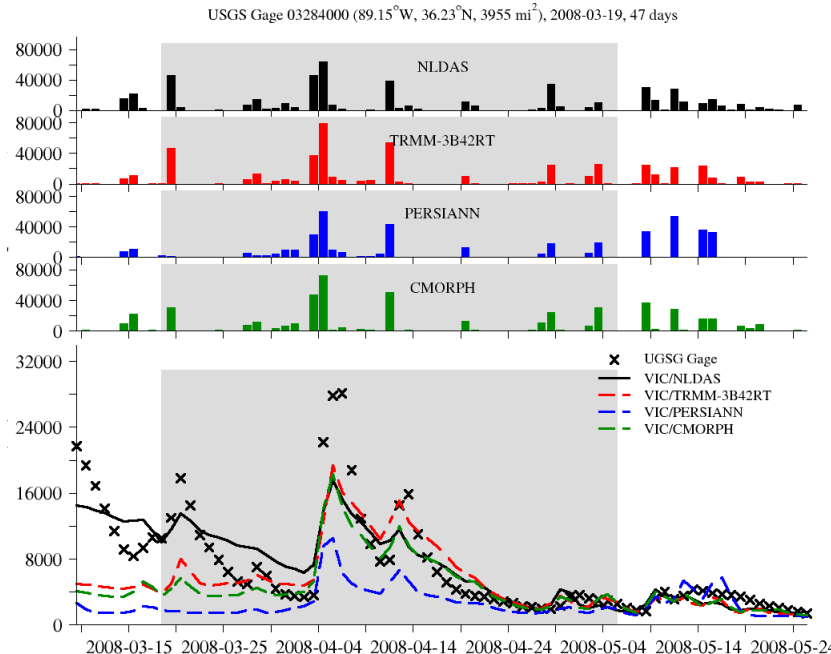


Earlier analysis: Experiments over United States









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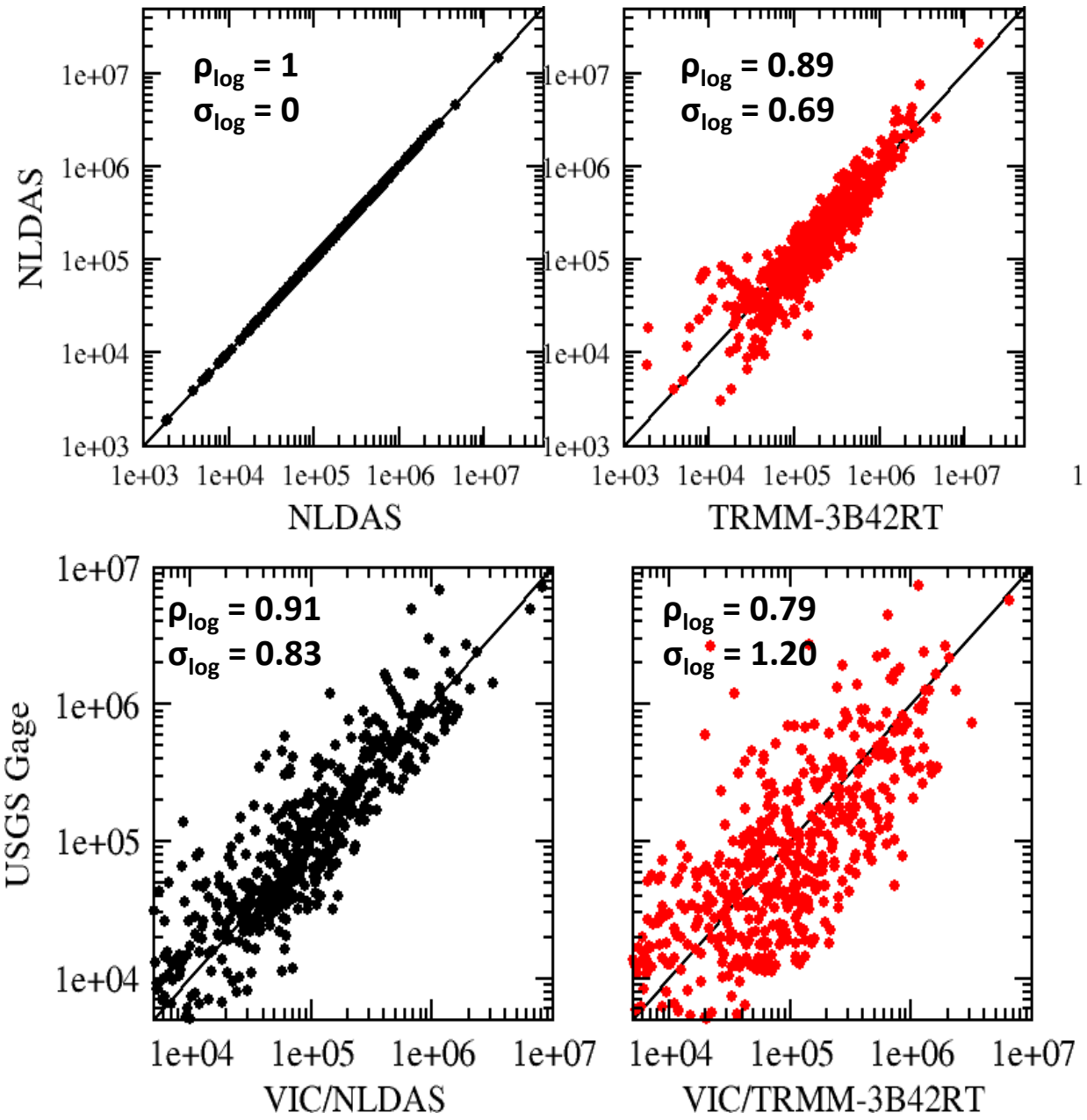

Propagation of Rainfall Errors into River Streamflow Errors

Top right: Satellite rainfall vs. ground estimates; Bottom: VIC streamflow vs. USGS gage records

Conclusion: Rainfall errors contribute **>50%** of total streamflow errors

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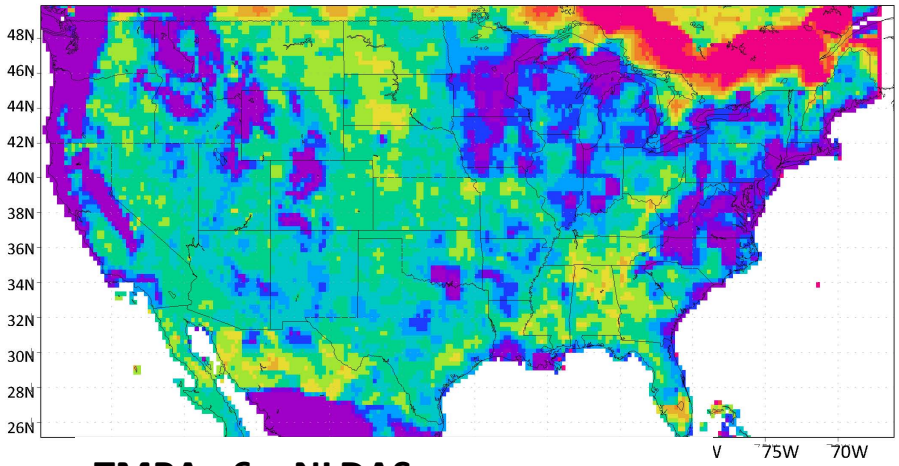
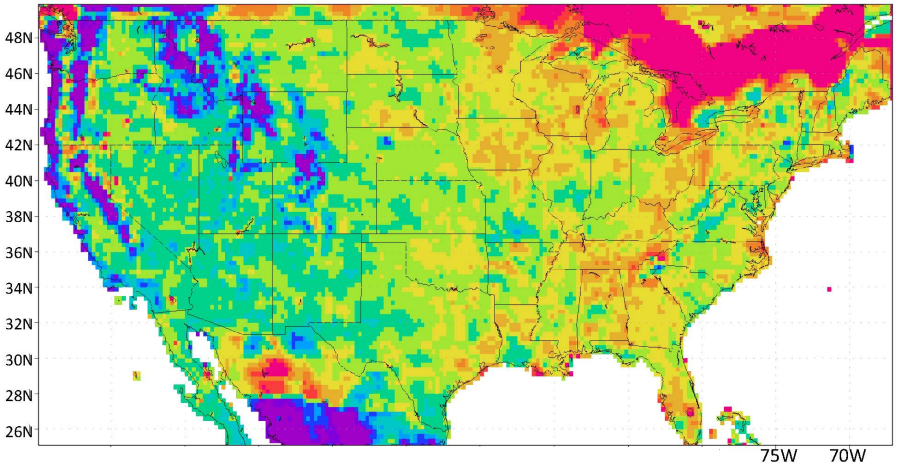
2. **Some comparisons between TMPA RT versions 6 and 7 with precipitation from the NLDAS archive (Stage IV radar-gauge product) over the US.**
3. Use multi-sensor EO (soil moisture from AMSR-E) within a data assimilation framework to determine if the real-time precipitation retrievals can be improved so as to improve flood forecasts.

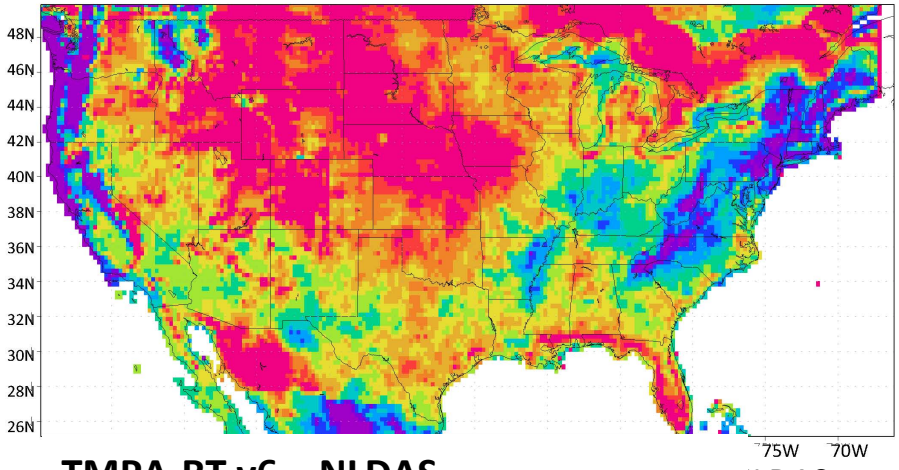
Differences in mean annual precipitation (mm/day) between TMPA-RT and NLDAS (radar-gauge) product



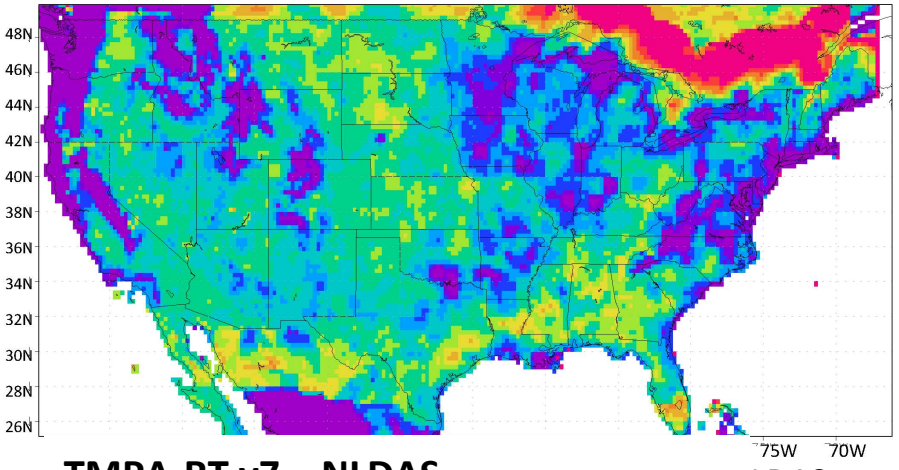
TMPA v6 – NLDAS



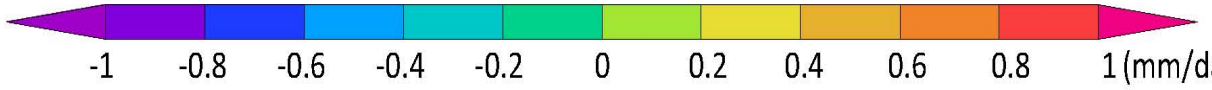
TMPA v7 – NLDAS



TMPA-RT v6 – NLDAS

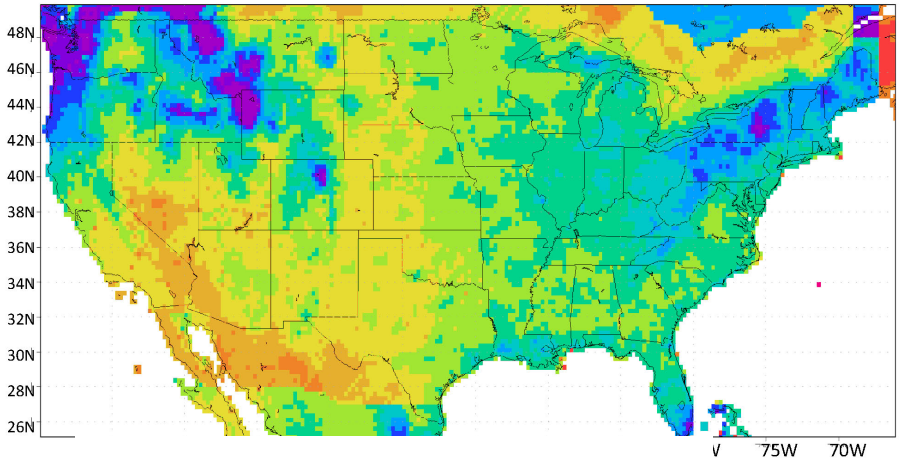


TMPA-RT v7 – NLDAS

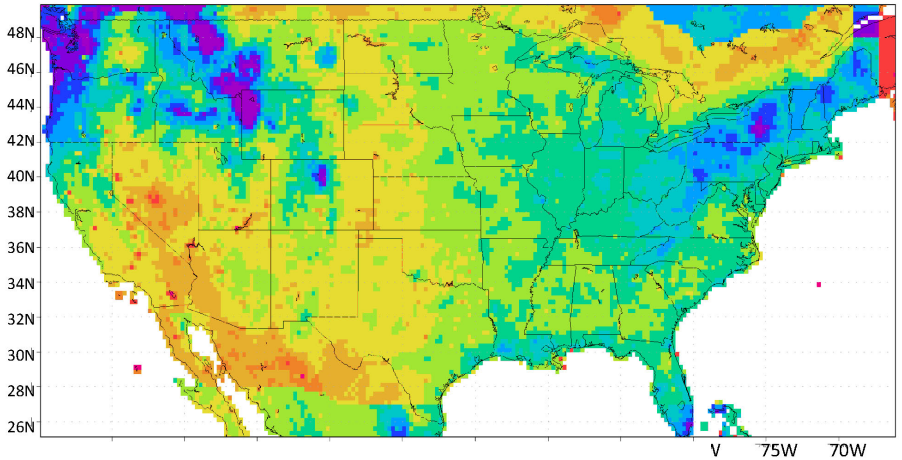


Annual Mean Precipitation Difference between TMPA and NLDAS

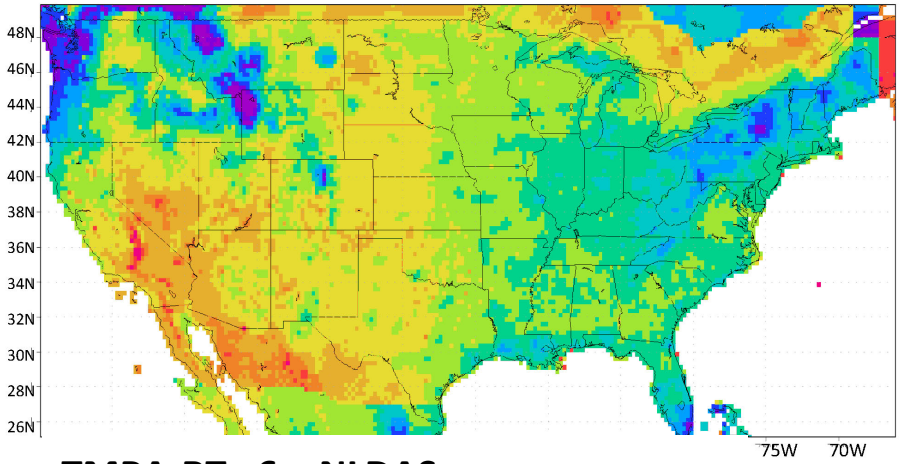
Differences in annual mean rain hours between TMPA RT and NLDAS (radar-gauge) product



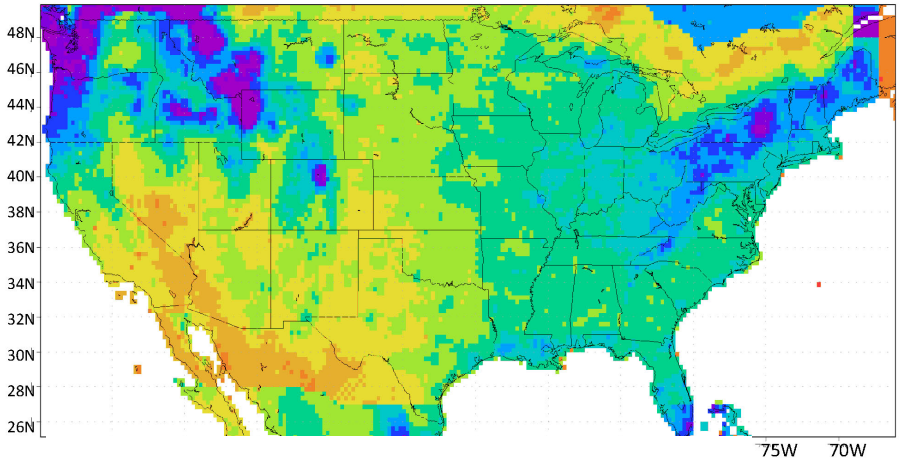
TMPA v6 – NLDAS



TMPA v7 – NLDAS



TMPA-RT v6 – NLDAS

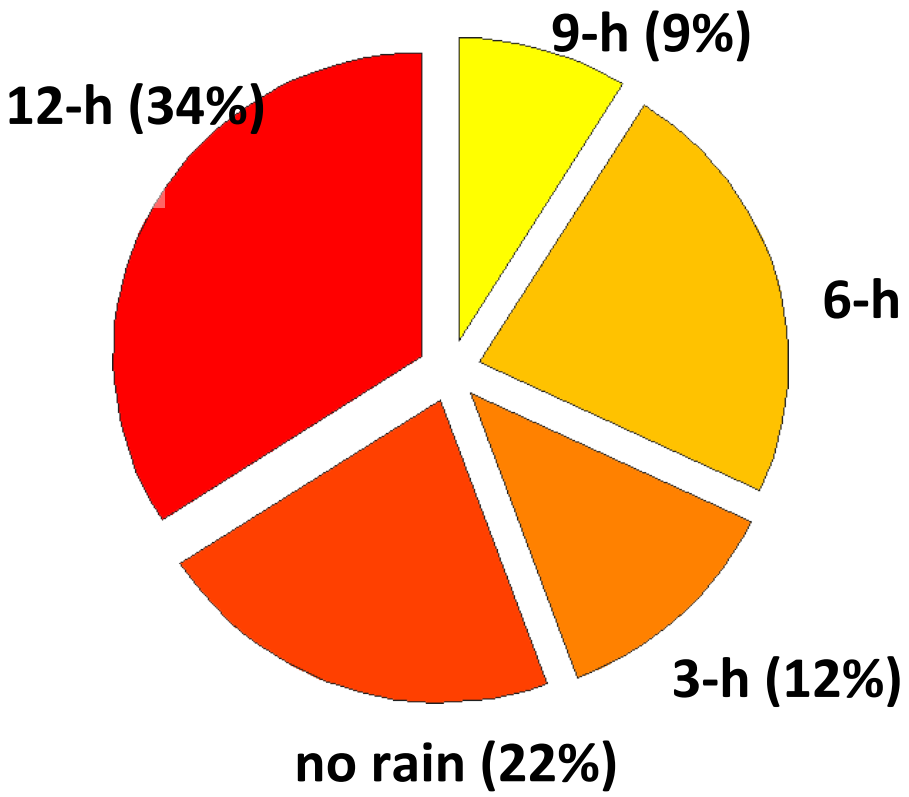


TMPA-RT v7 – NLDAS

-40 -35 -30 -25 -20 -15 -10 -5 0 5 10

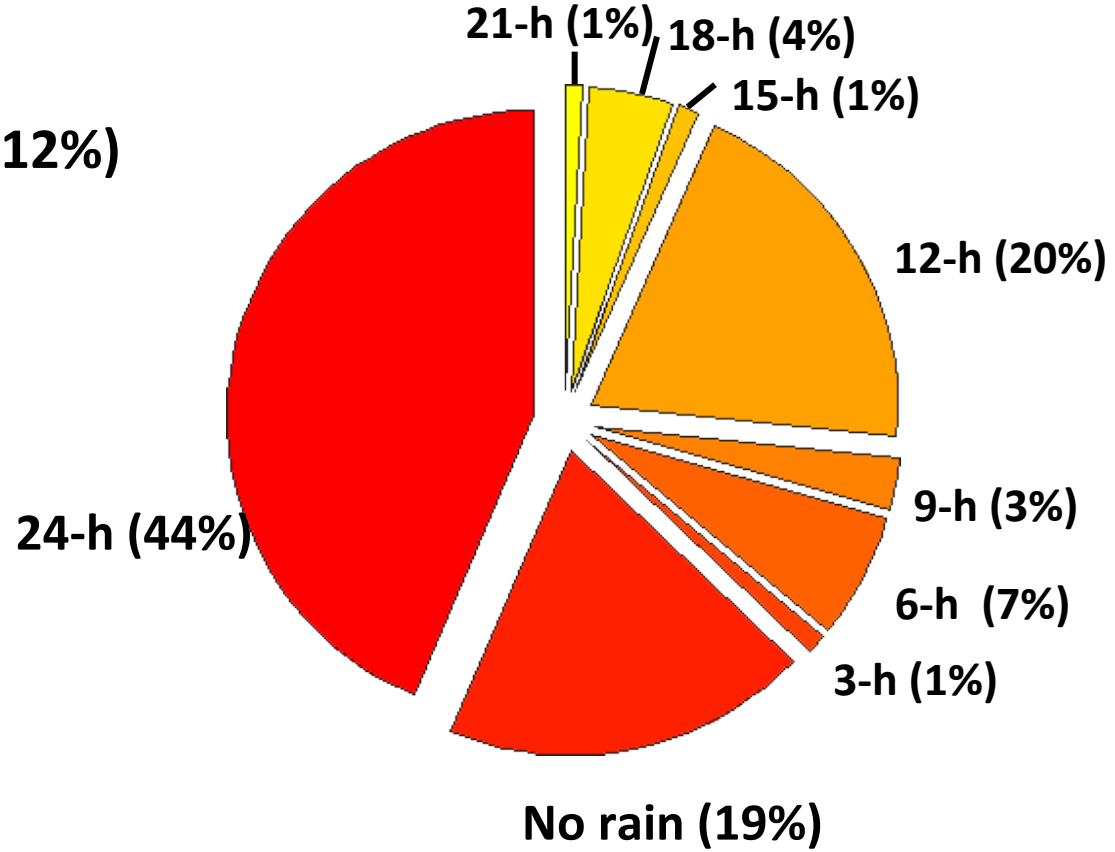
Percentage of Rain Hours Difference between TMPA and NLDAS

TMPA-RT v7 Rainfall durations
Given 12-hr (24-hr) rainfall events in NLDAS



12-hr NLDAS events

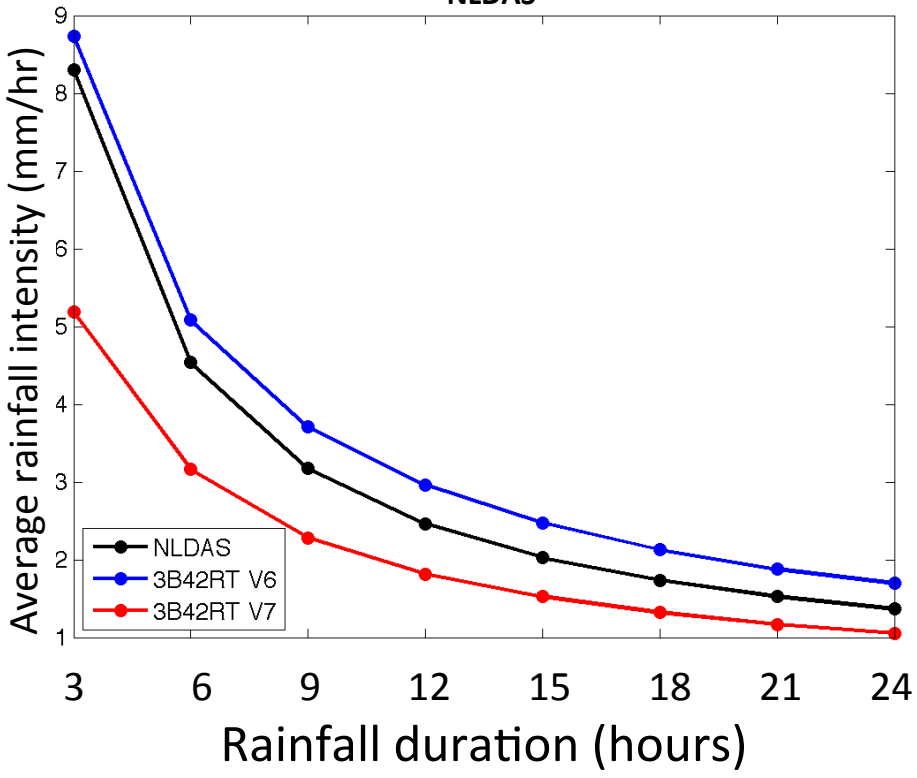
24-hr NLDAS events



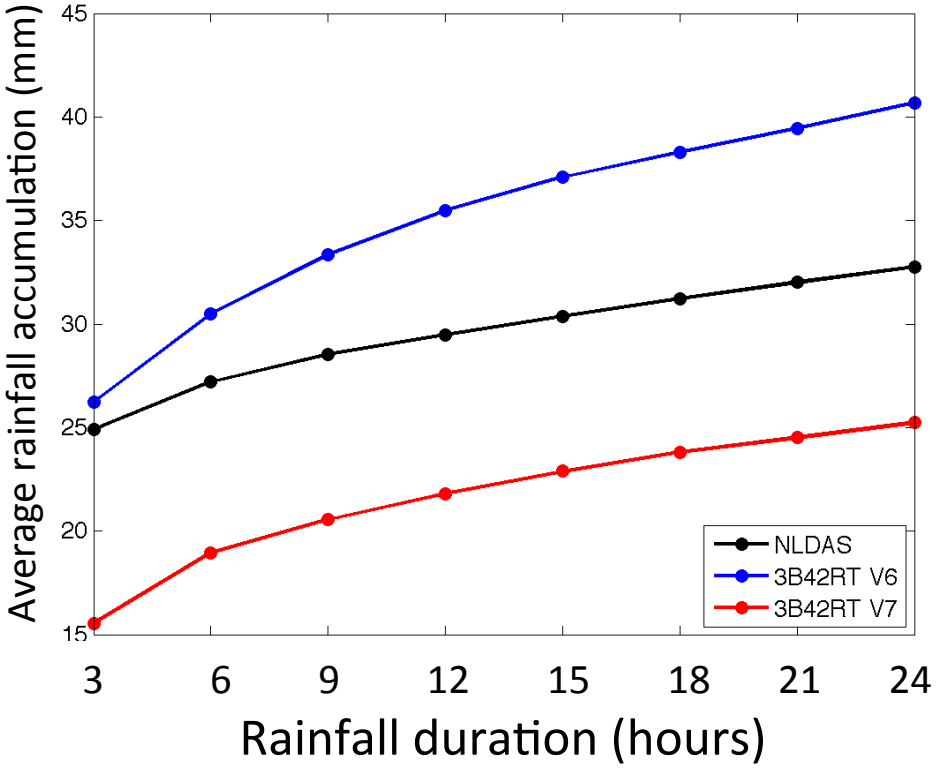
Analysis of rainfall intensity, accumulation and duration for heavy events.

Grid: 33.375, 98.875W

Average rain intensity when $Prec_{NLDAS}$ >15mm



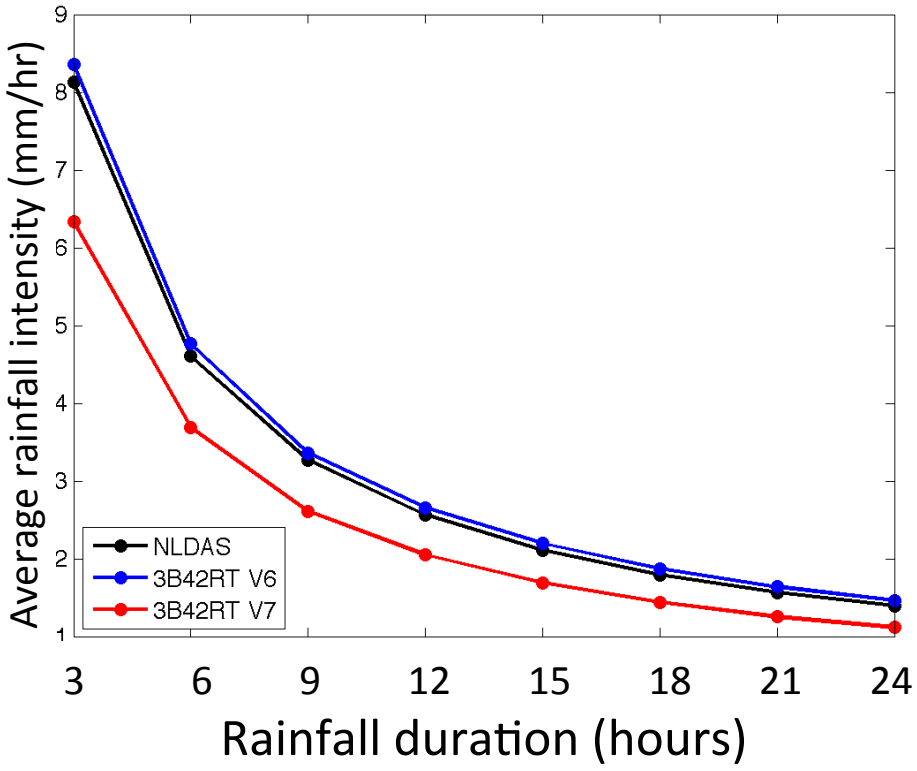
Cumulated rain depths when $Prec_{NLDAS}$ >15mm



Analysis of rainfall intensity, accumulation and duration for heavy events.

Grid: 36.625, 92.875W

Average rain intensity when $Prec_{NLDAS}$ >15mm



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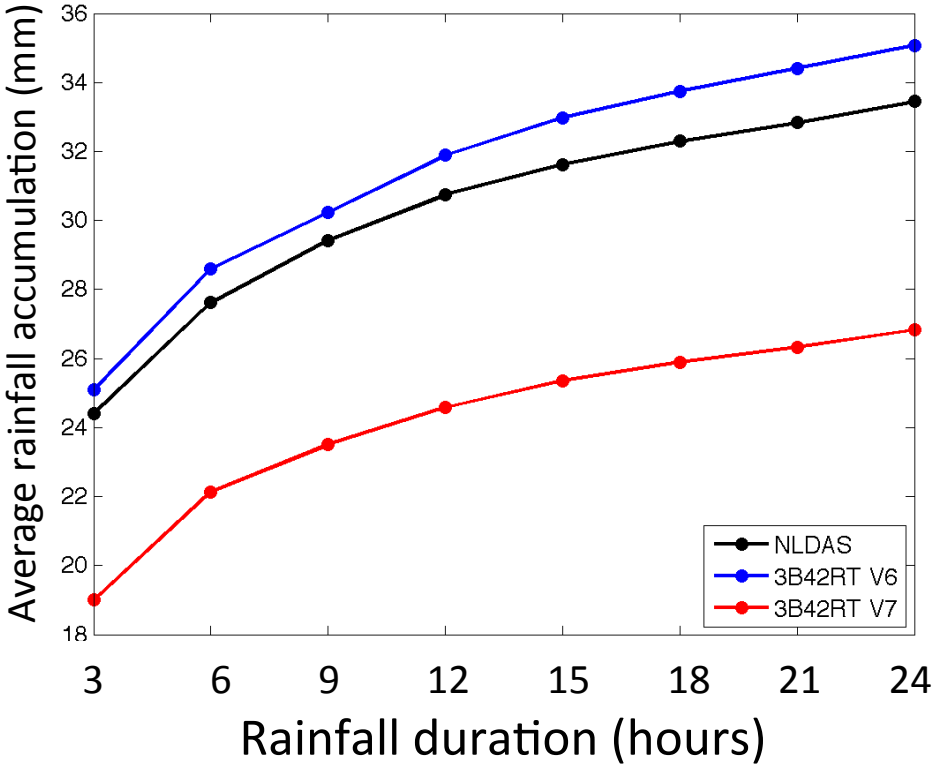

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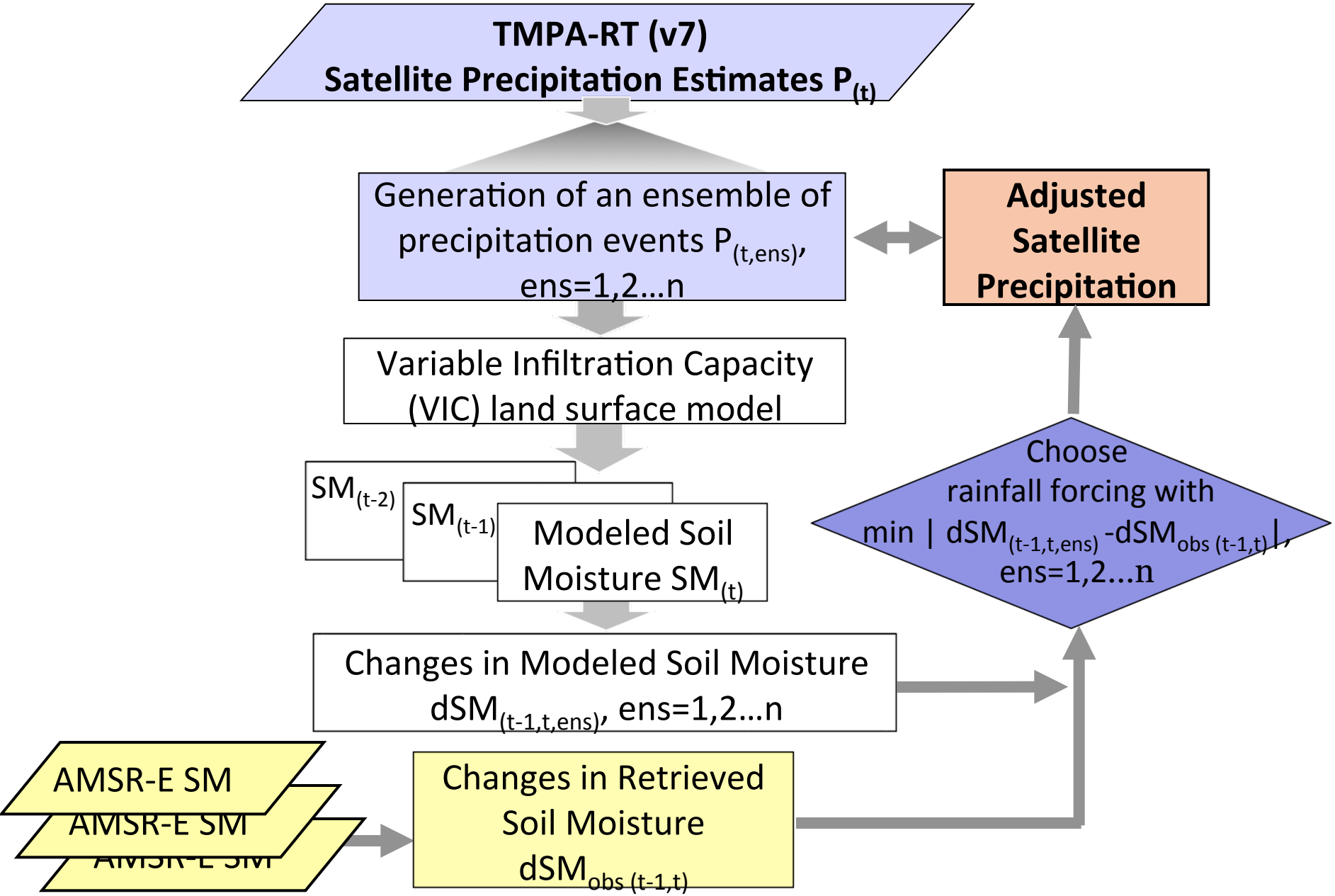
Improving satellite precipitation estimates by assimilating soil moisture retrievals

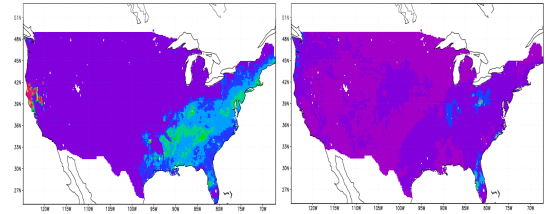


Using the improving satellite precipitation estimates for flood forecasting

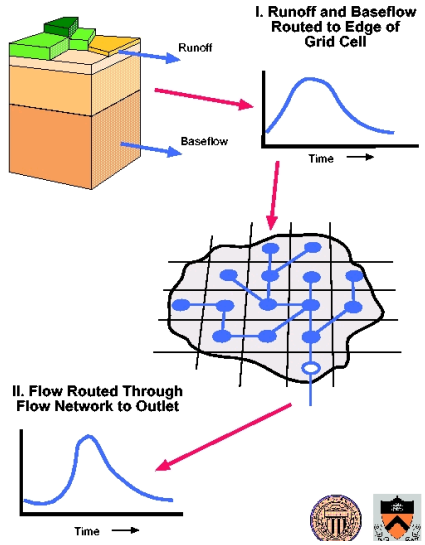
Adjusted RT Satellite Precipitation

Variable Infiltration Capacity (VIC) land surface model

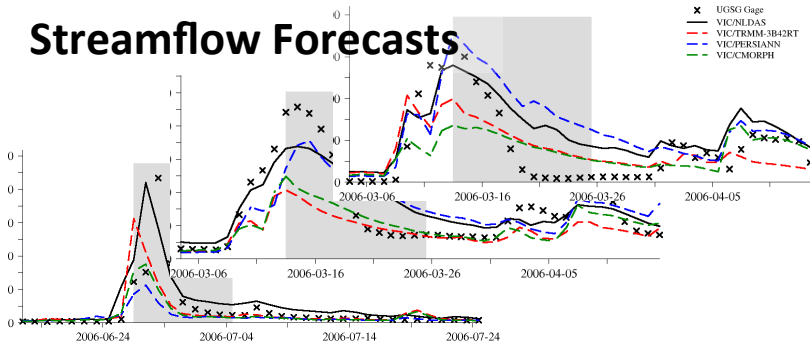
Surface & Subsurface Runoff



River Routing Model



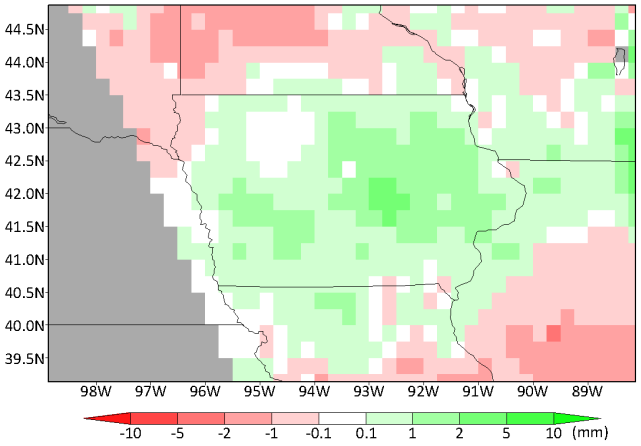
Streamflow Forecasts



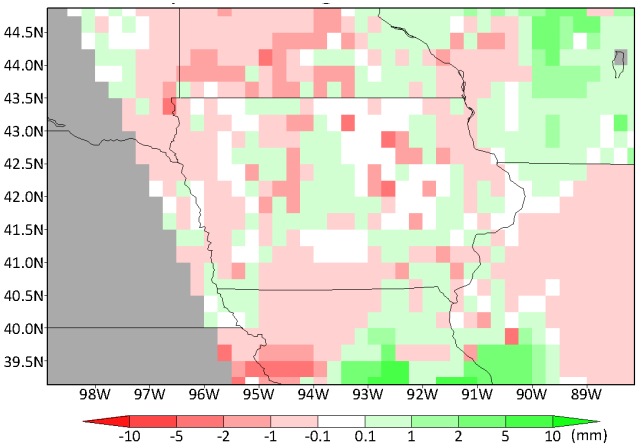
USGS Gauge Streamflow

Adjusted precipitation based on changes in retrieved soil moisture ---- Results

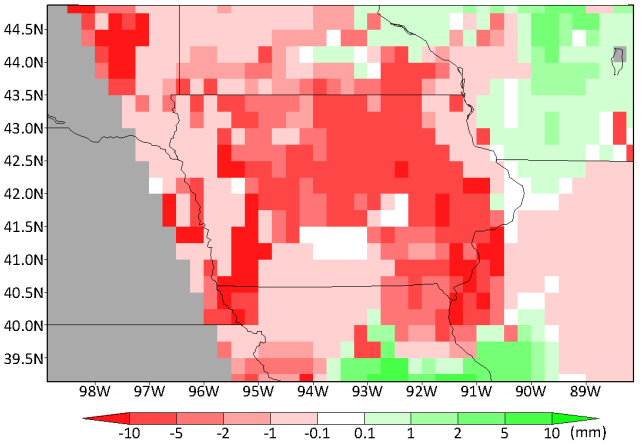
Change in retrieved SM



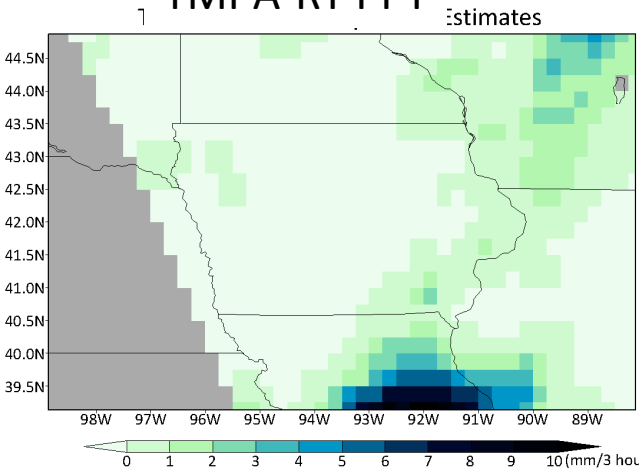
Adjusted change in SM



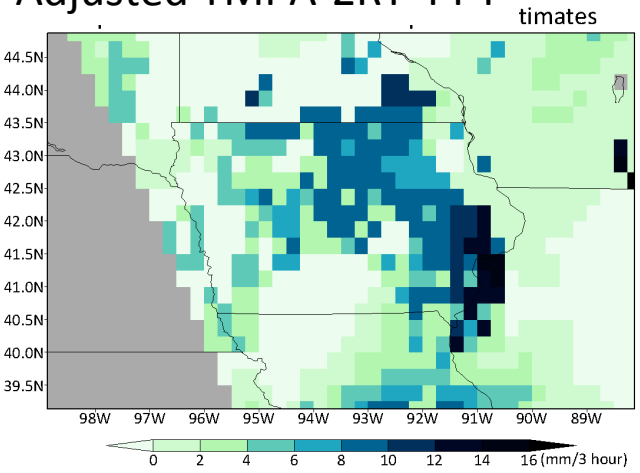
Difference in modeled SM



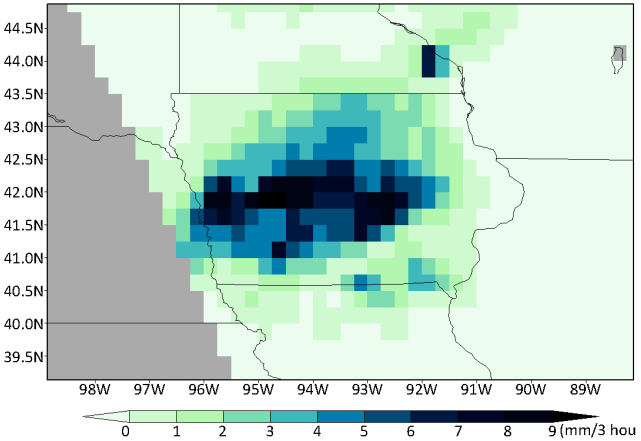
TMPA-RT PPT



Adjusted TMPA-2RT PPT



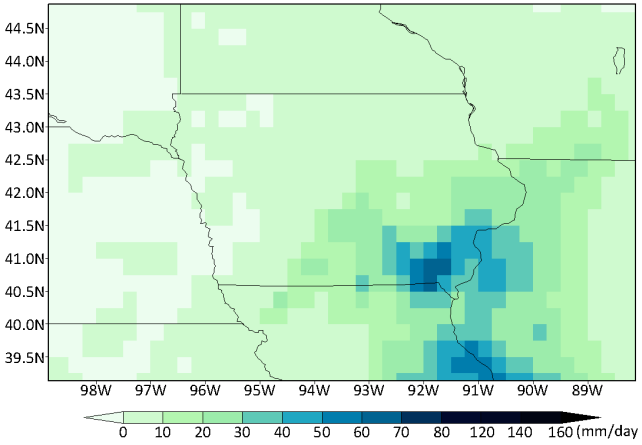
NLDAS PPT



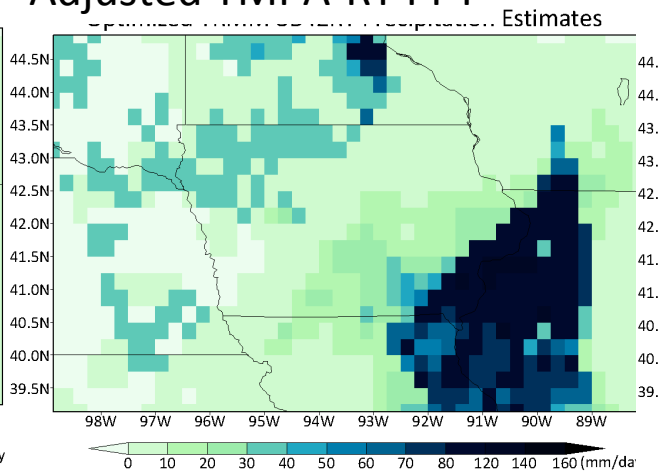
2002-06-12, 12:00-15:00

Adjusted precipitation based on changes in retrieved soil moisture ---- Results

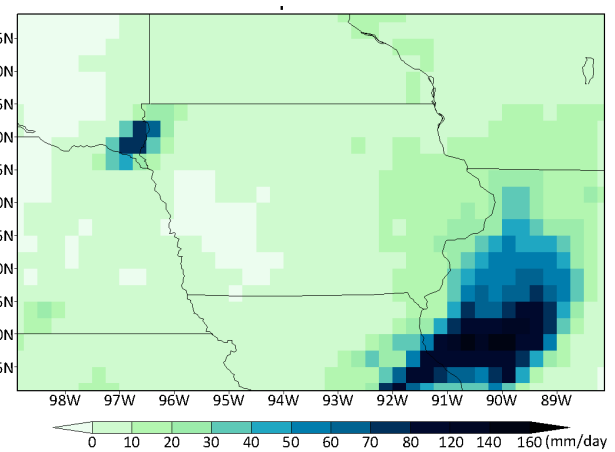
TMPA-RT PPT



Adjusted TMPA-RT PPT

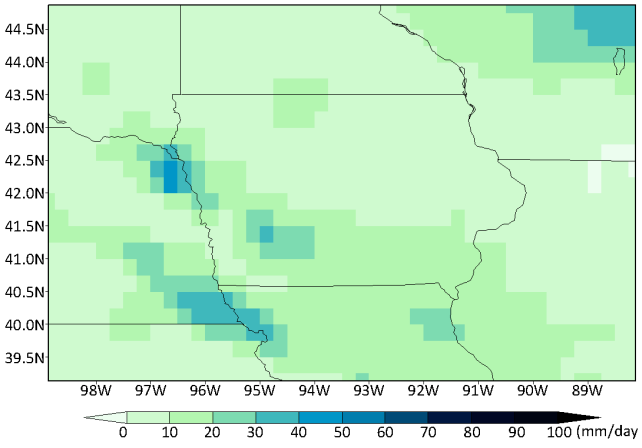


NLDAS PPT

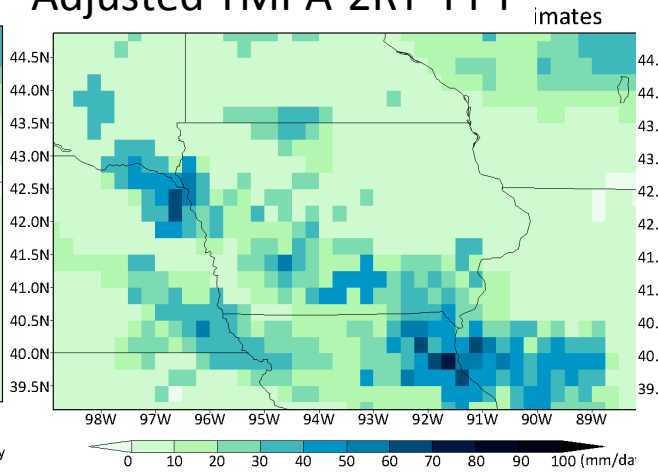


2003-06-26

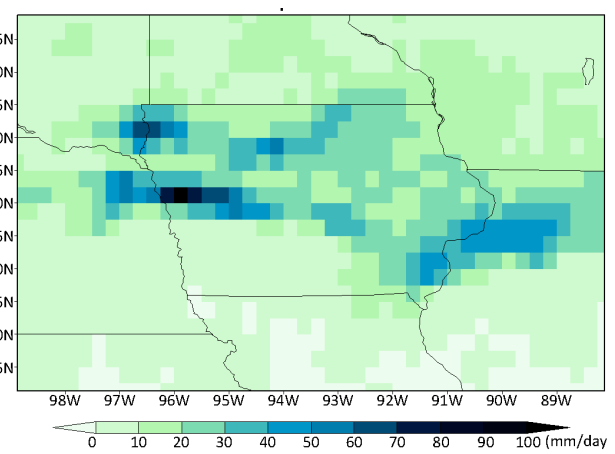
TMPA-RT PPT



Adjusted TMPA-2RT PPT



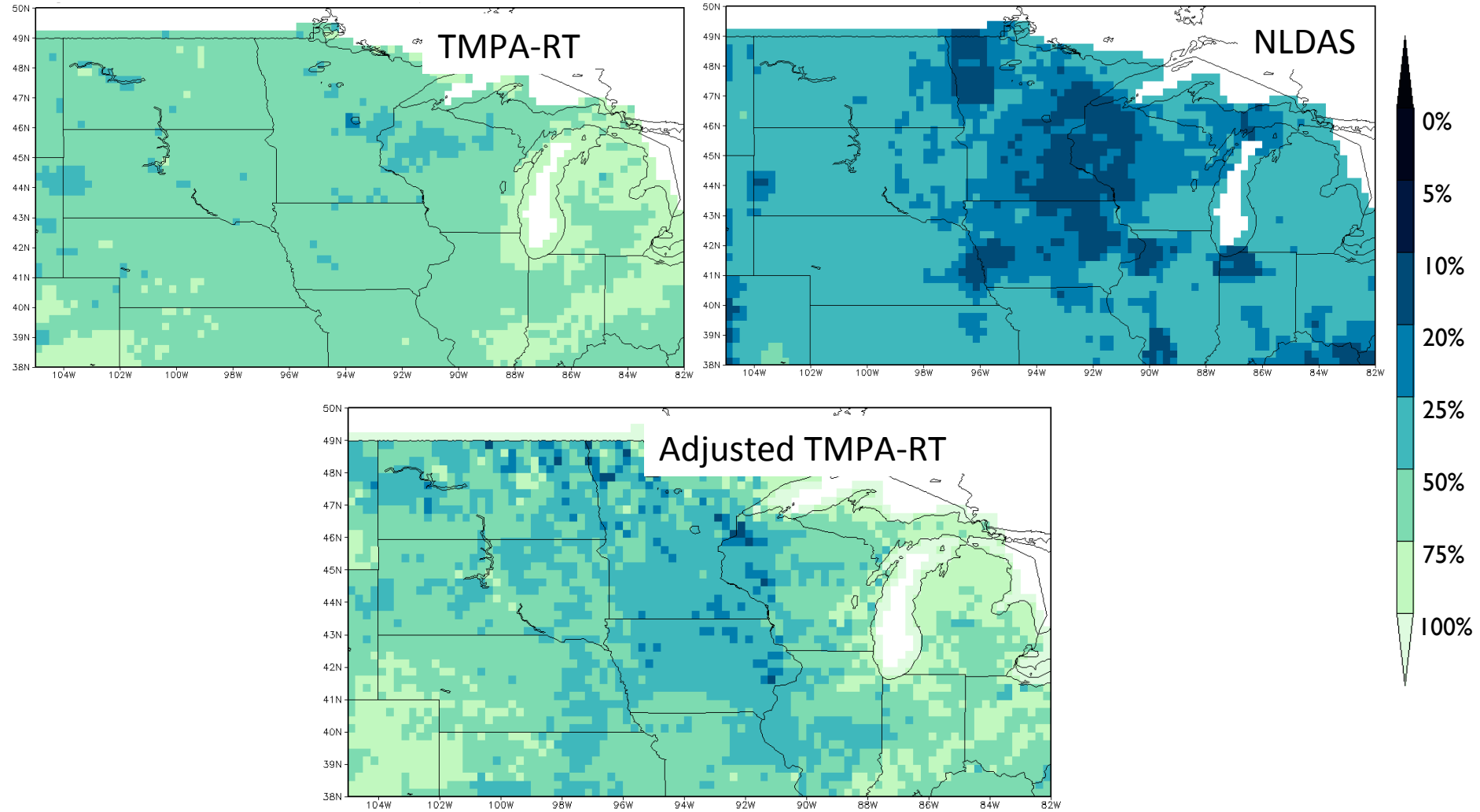
NLDAS PPT



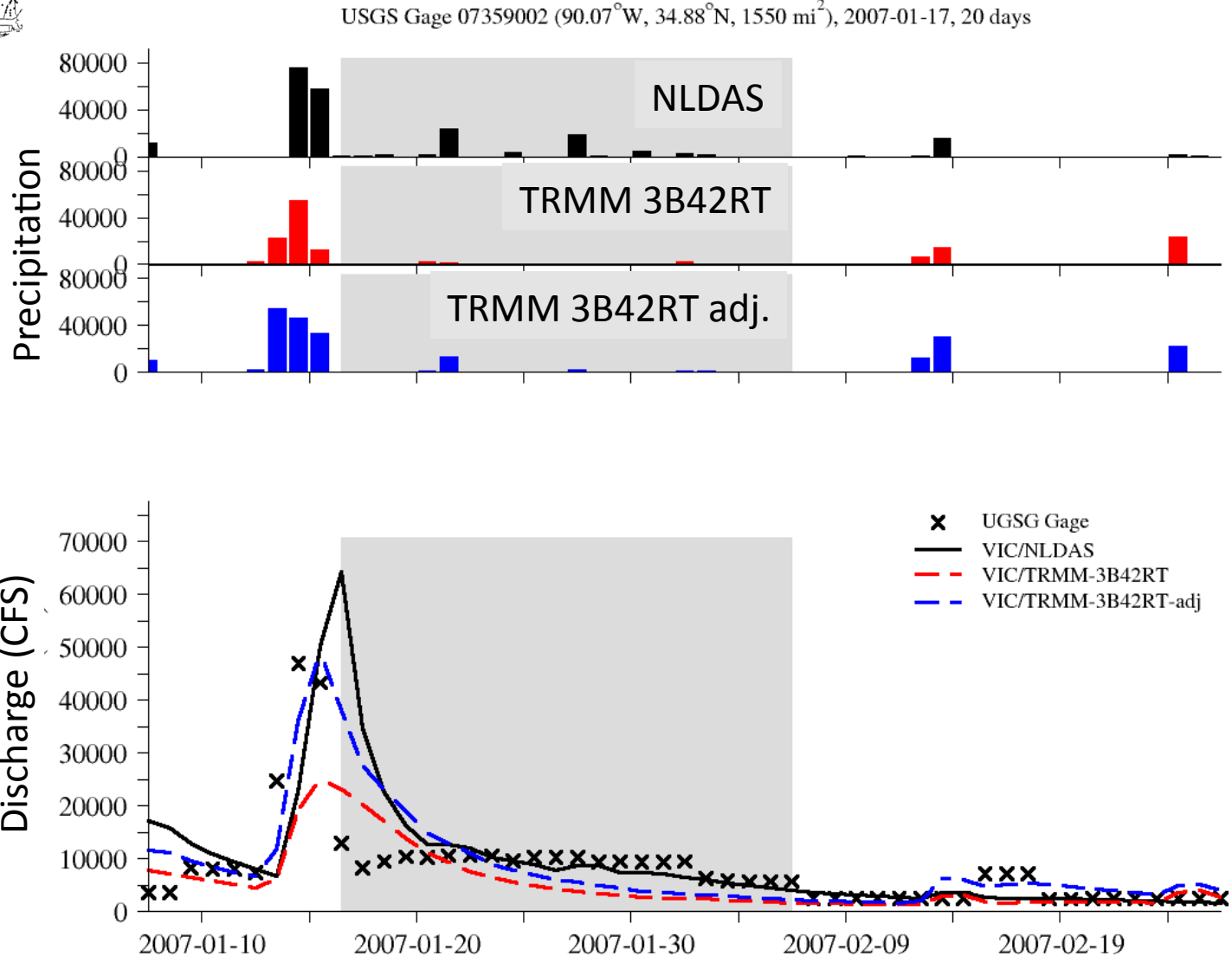
2003-06-10

Adjusted precipitation based on changes in retrieved soil moisture – Results July-Sept, 2002-2007

Mean Summer Rain Hours



Flood forecasts using TMPA-RT and adjusted TMPA-RT precipitation



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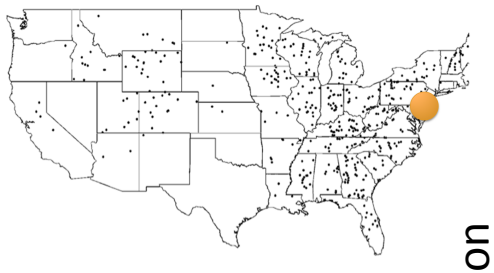
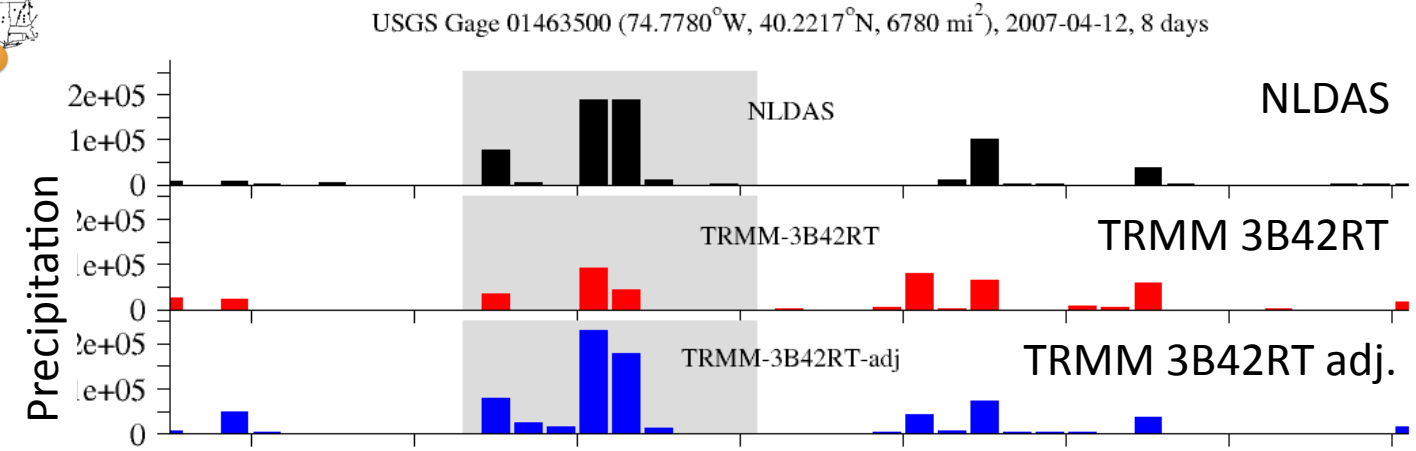
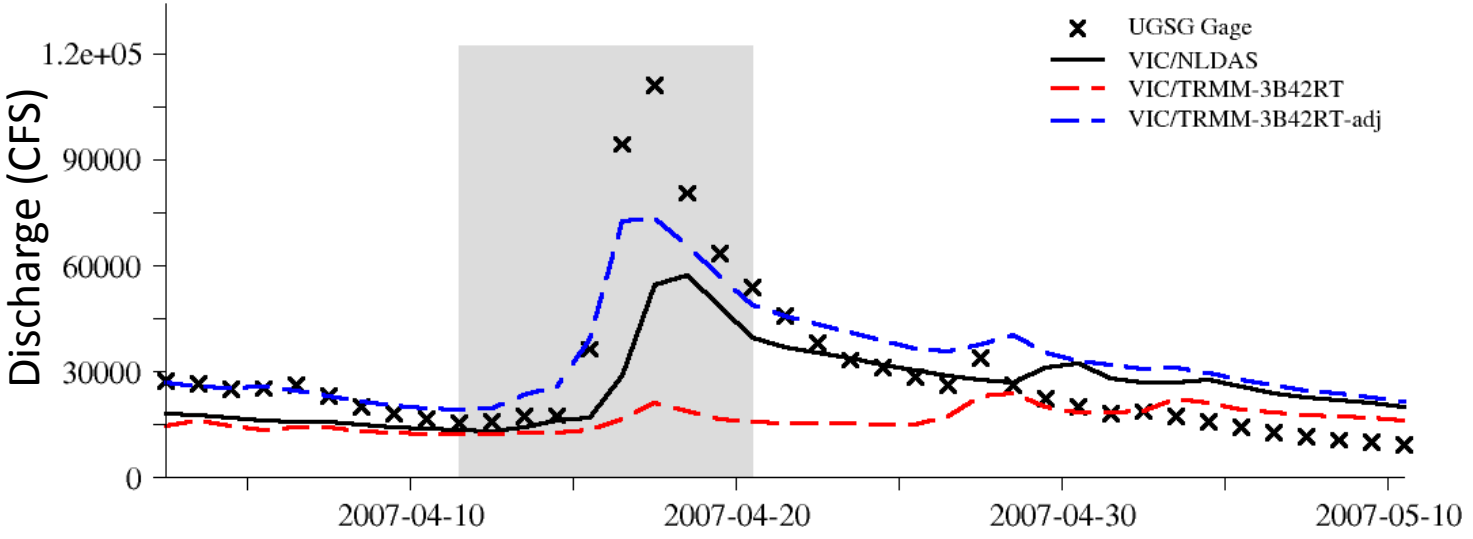
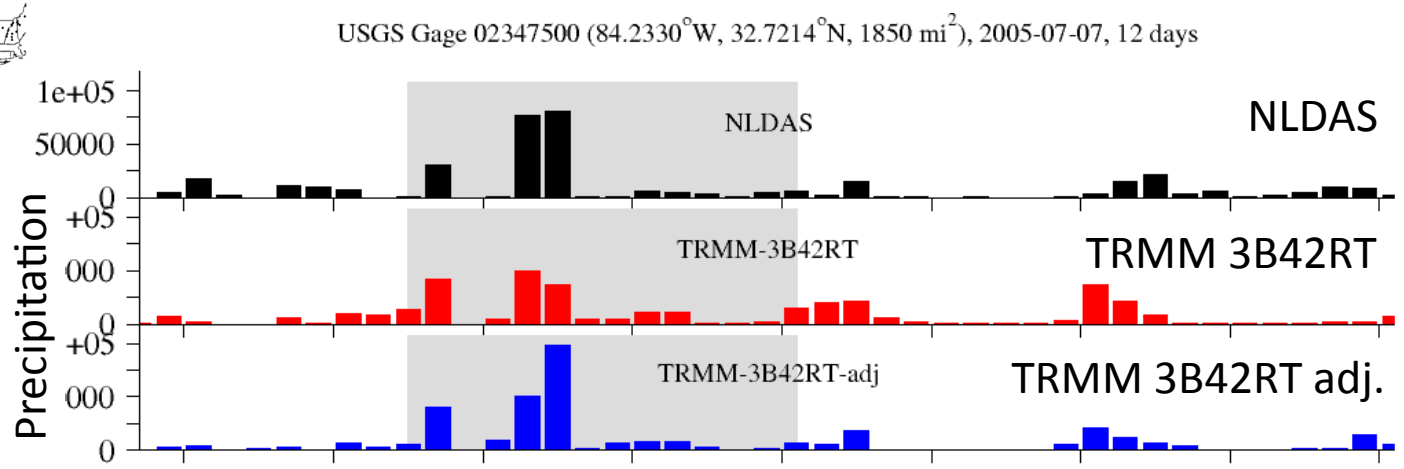
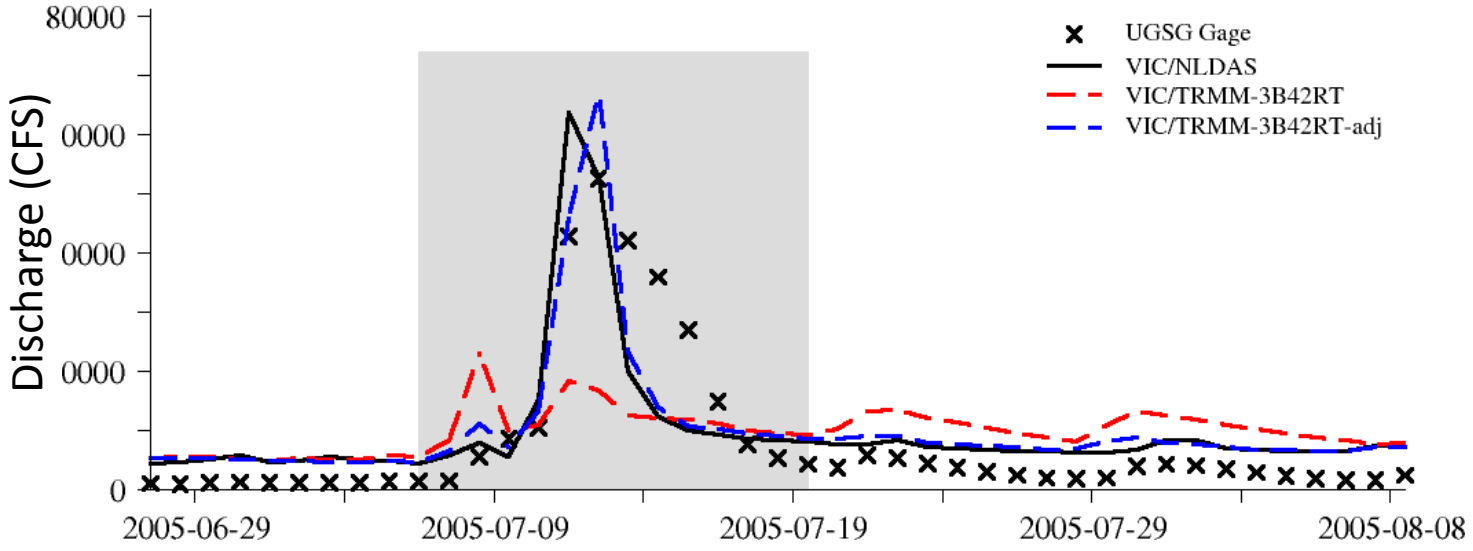




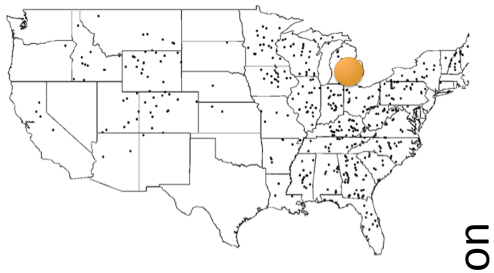


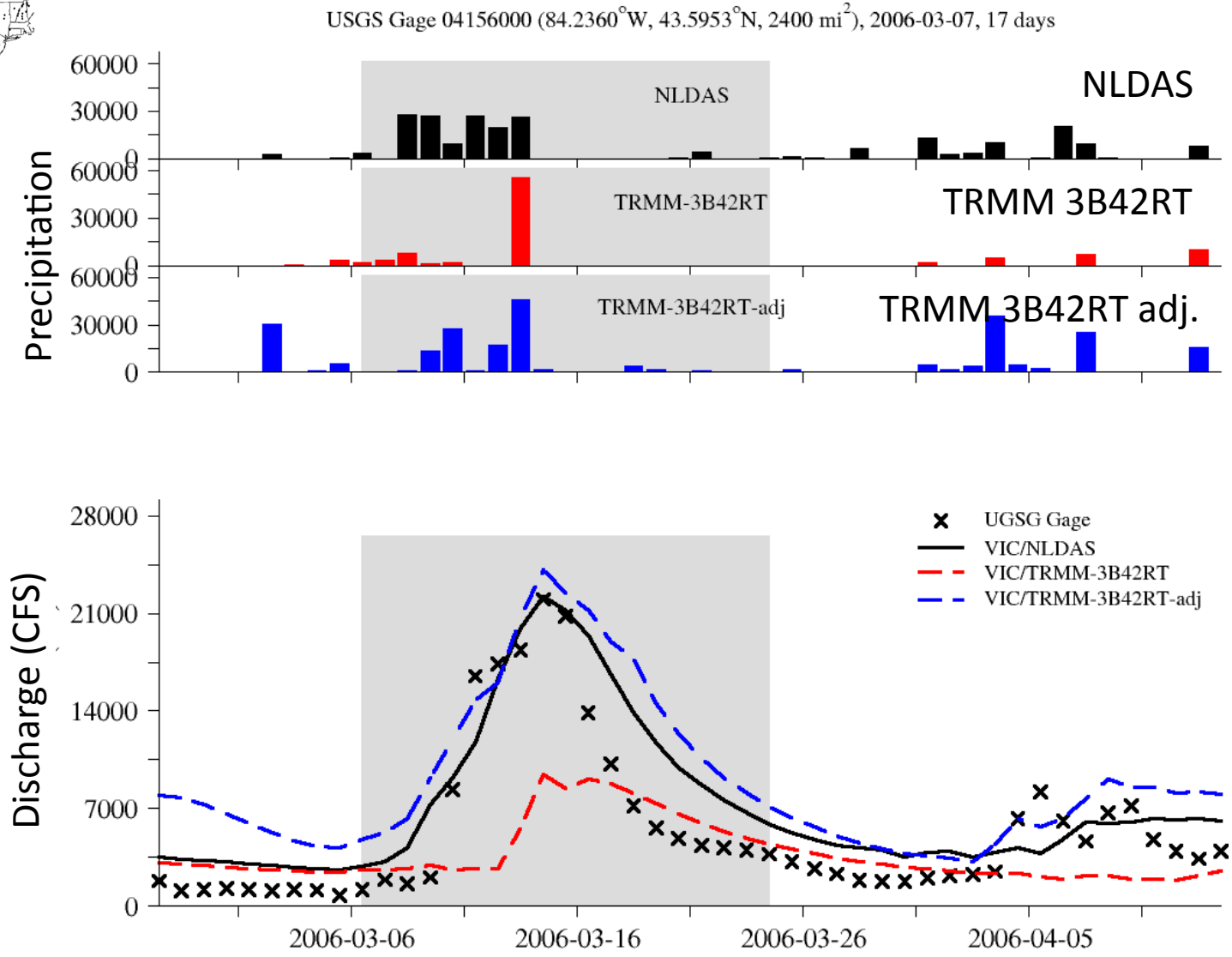
Flood forecasts using TMPA-RT and adjusted TMPA-RT precipitation





Flood forecasts using TMPA-RT and adjusted TMPA-RT precipitation





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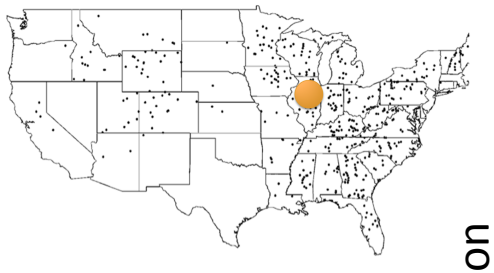
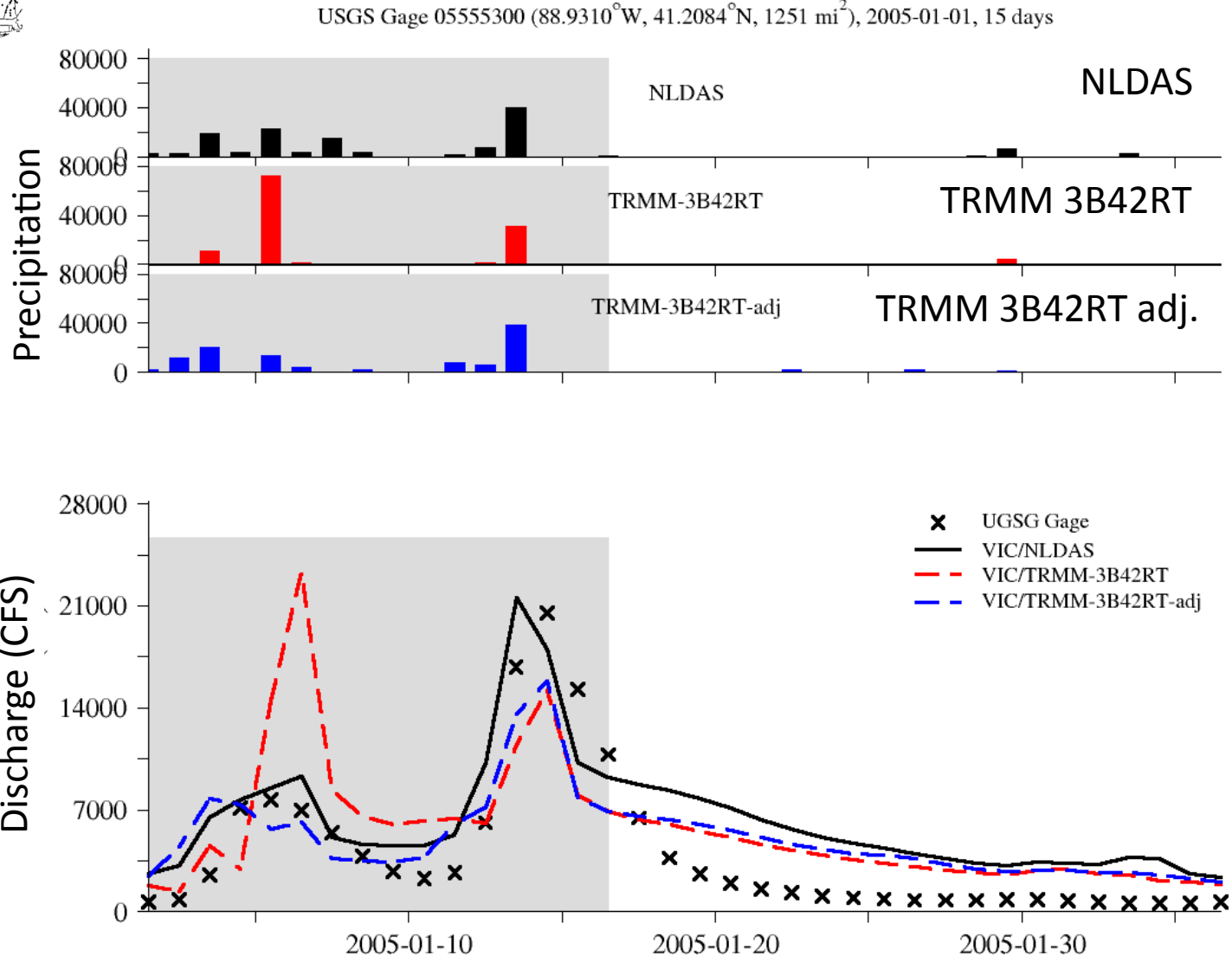
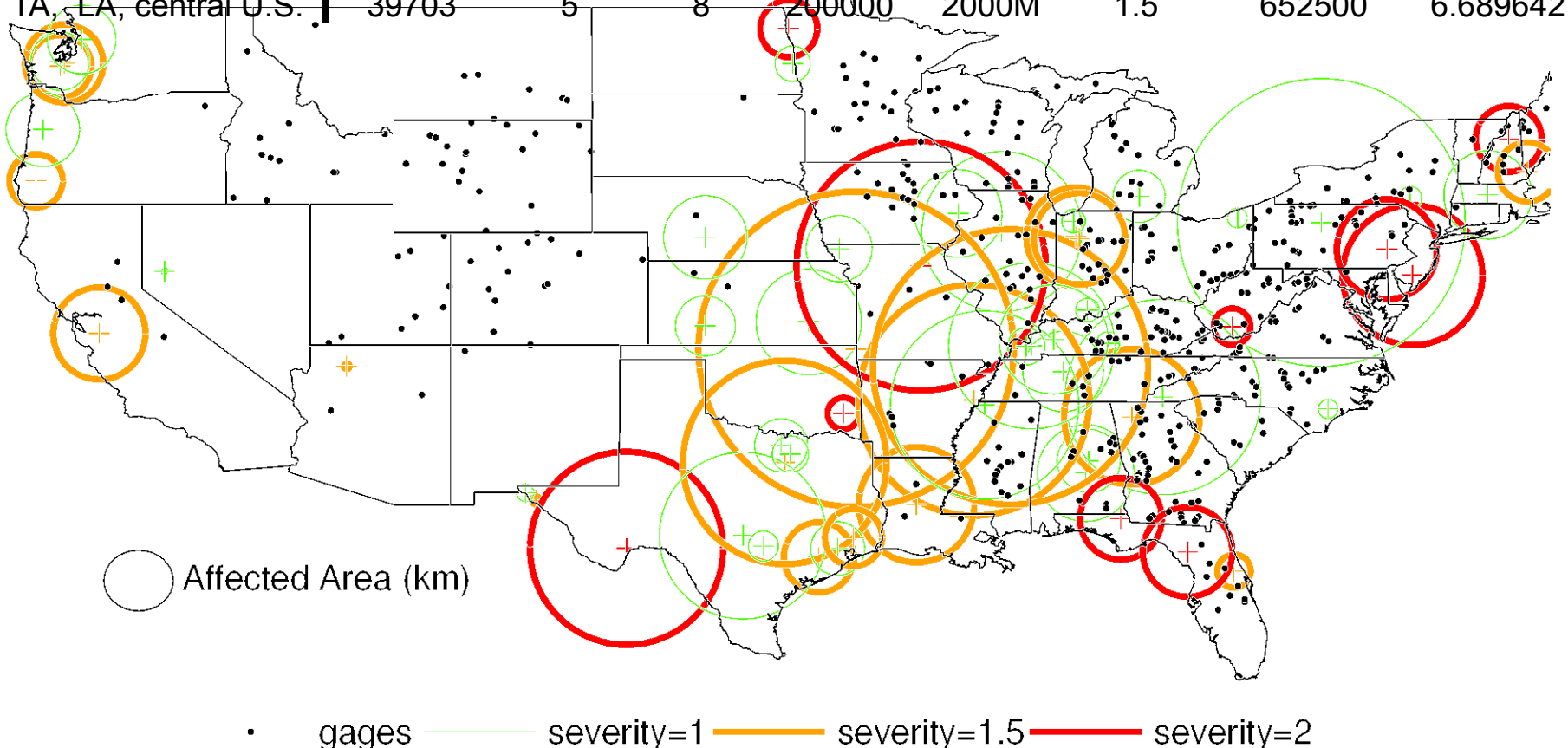




Major flood events that will be used to assess the approach (from 2005 to 2010)

Detailed Locations	Began	Duration	Dead	Displaced	Damage	Severity	Affected km^2	Magnitude
Midwest	39524	47	18	1000		1.5	928700	7.816065
WI, IA, IN, IL, MI	39604	29		38000	1500M	2	759800	7.644127
TA, MN, OK, WI, MI, …	39310	12	26	2800		1.5	1217000	7.340563
TA, OK, KS, MS	39259	28	8	5000		1.5	507800	7.328942
IN, AK,TA,OH,MS	39097	20	24	0		1	434400	6.93892
TA, NM	39650	9	1	180		2	457300	6.915474
NV	38814	58	0	0		1	85040	6.693051
TA, LA, central U.S.	39703	5	8	200000	2000M	1.5	652500	6.689642



Summary

Using satellite precipitation for real-time flood forecasting presents significant challenges that include:

Inconsistencies when compared to radar and in-situ networks that include (1) rain rate differences, especially at heavy rain rates; (2) rain duration differences

Using other Earth Observations – especially soil moisture retrievals – offers the potential of assimilating these EO into land surface models to adjust the real-time satellite precitation and subsequently real-time flood forecasts.