Use of GV data to evaluate and improve uses of satellite-rainfall in hydrologic modeling of complex terrain floods

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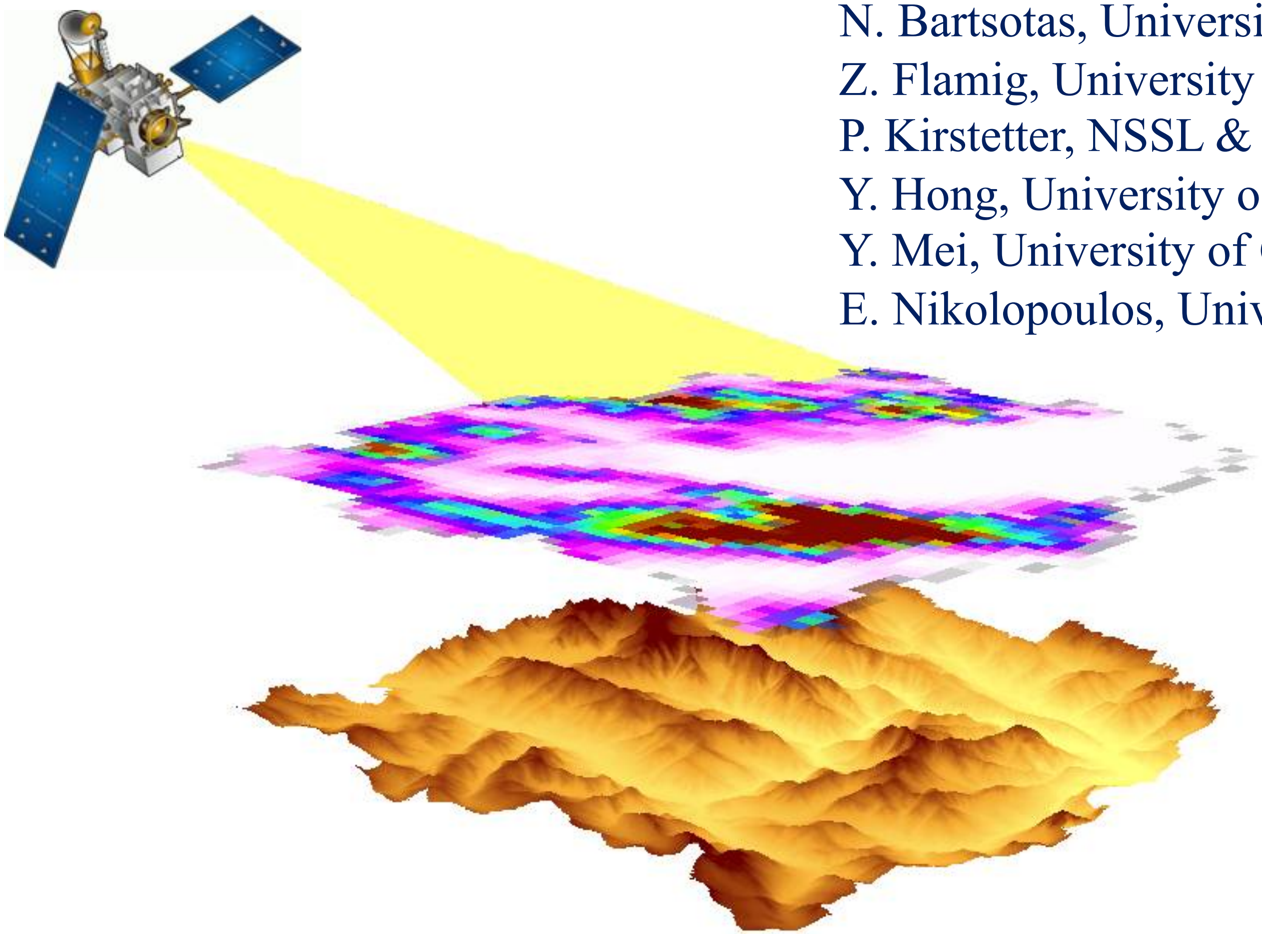
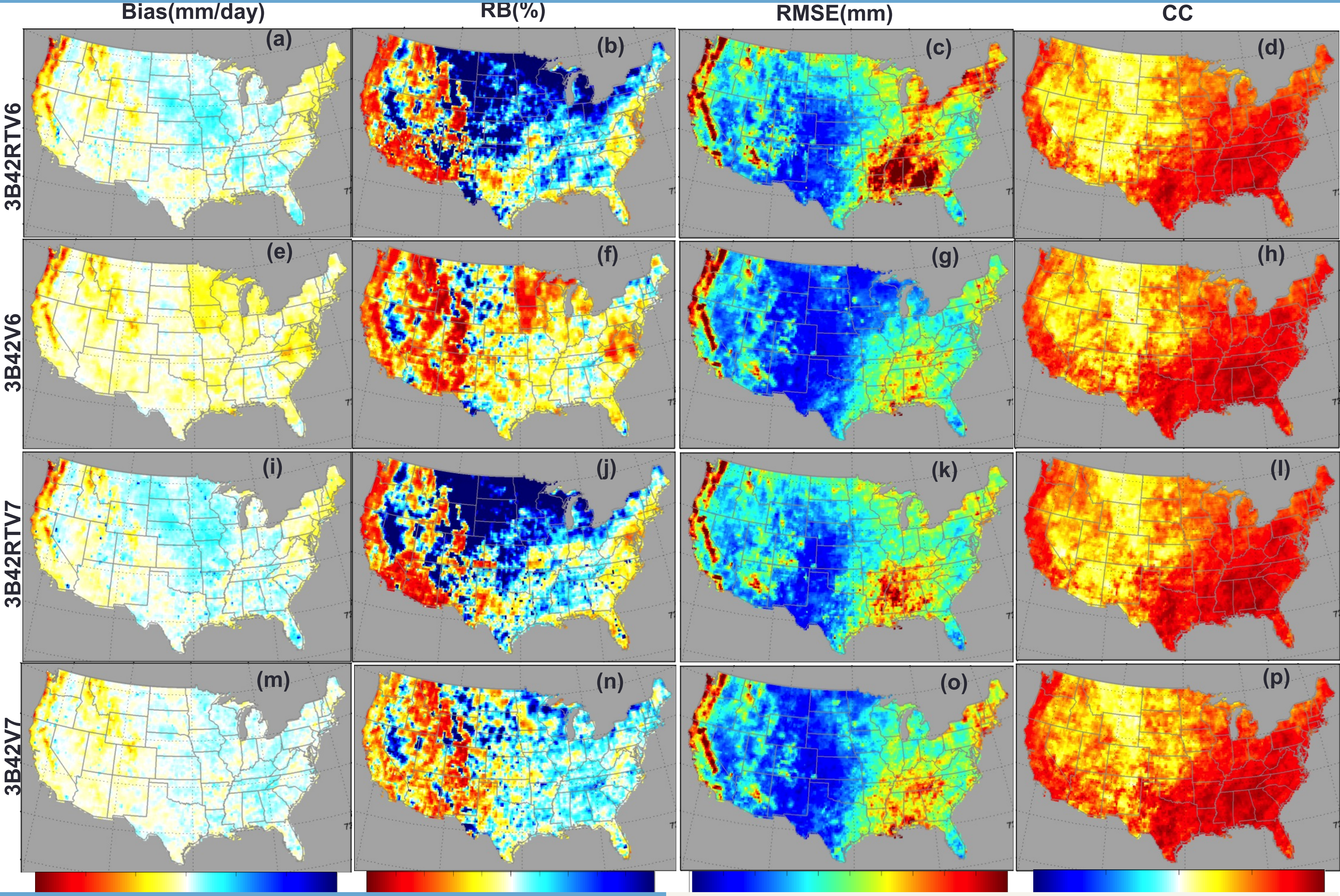
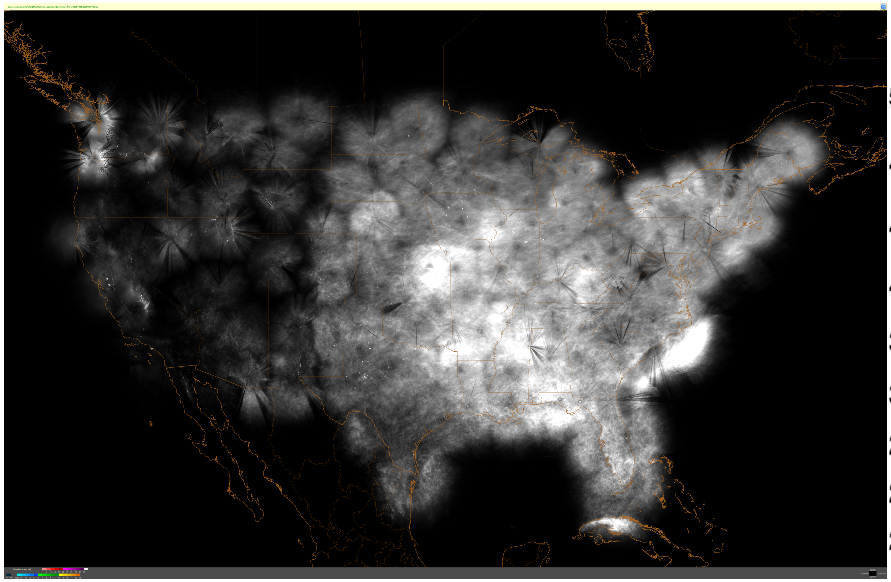
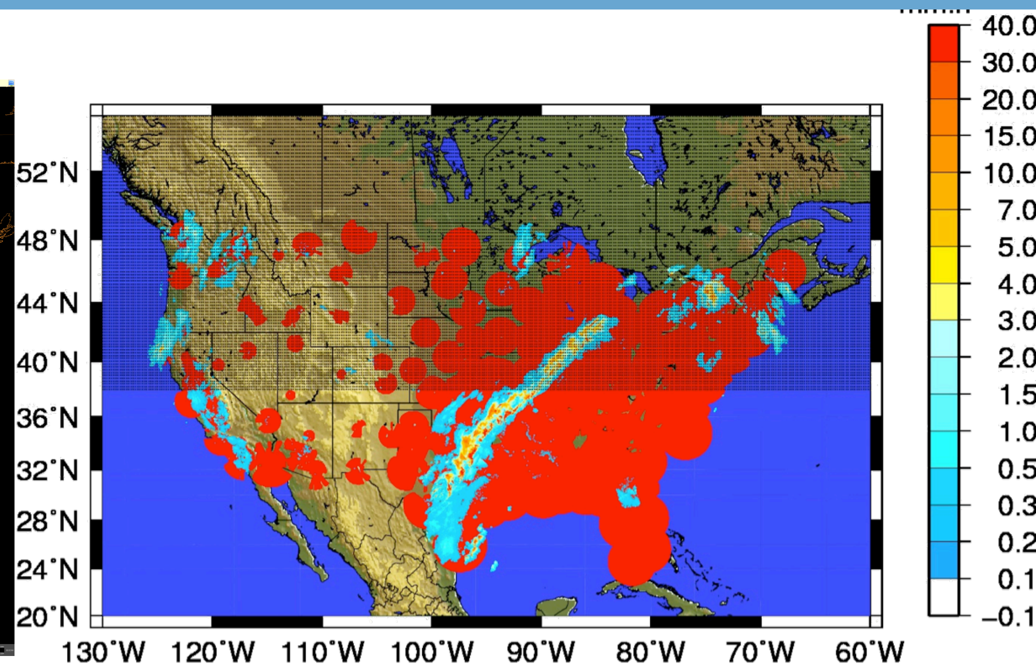


3-Year Evaluation of TRMM V6 and V7 Products over US



Framework for evaluating rainfall from low-earth orbiting platforms
- National Mosaic and QPE system (NMQ)





Real-time radar products have problems in similar areas

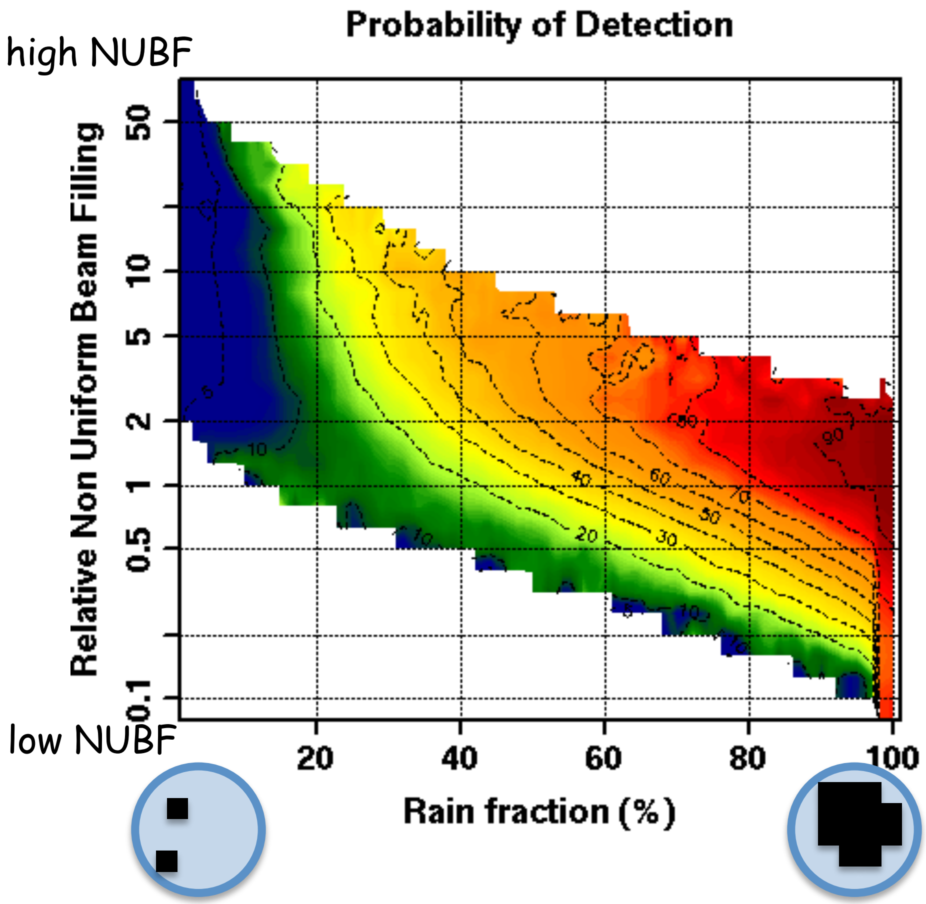
Significant post-processing needed to use ground radar network for evaluating level II rainrate products

1. Bias-corrected Q2 (raingauge; hourly bias applied to 5mn; quantitative quality control)
2. Best sampling conditions filtered with Radar Quality Index (qualitative quality control)

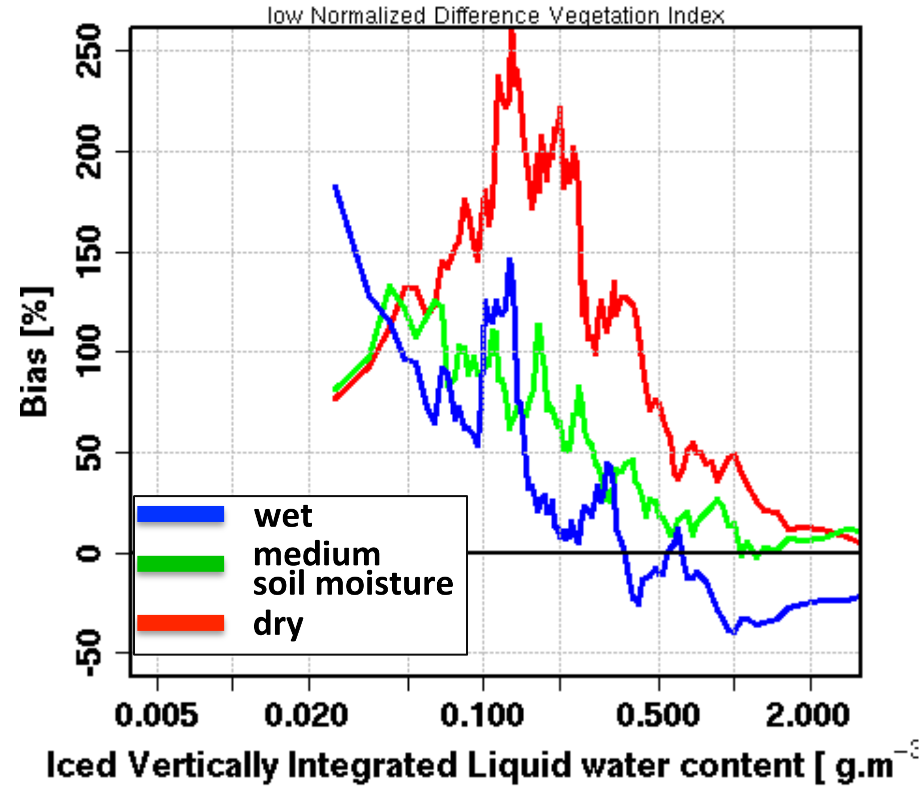
Kirstetter, P.E., Y. Hong, J. J. Gourley, et al. 2012: Toward a framework for systematic error modeling of spaceborne radar with NOAA/NSSL ground radar-based National Mosaic QPE. *Journal of Hydrometeorology*. doi:10.1175/JHM-D-11-0139.1

What has been learned from TMI/PR evaluations?

PR/2A25: influence of
the NUBF, the rain type and rain rate



TMI/2A12: influence of
the surface (soil moisture), the vegetation and
the vertical structure of rainfall (iced VIL)



Research Questions

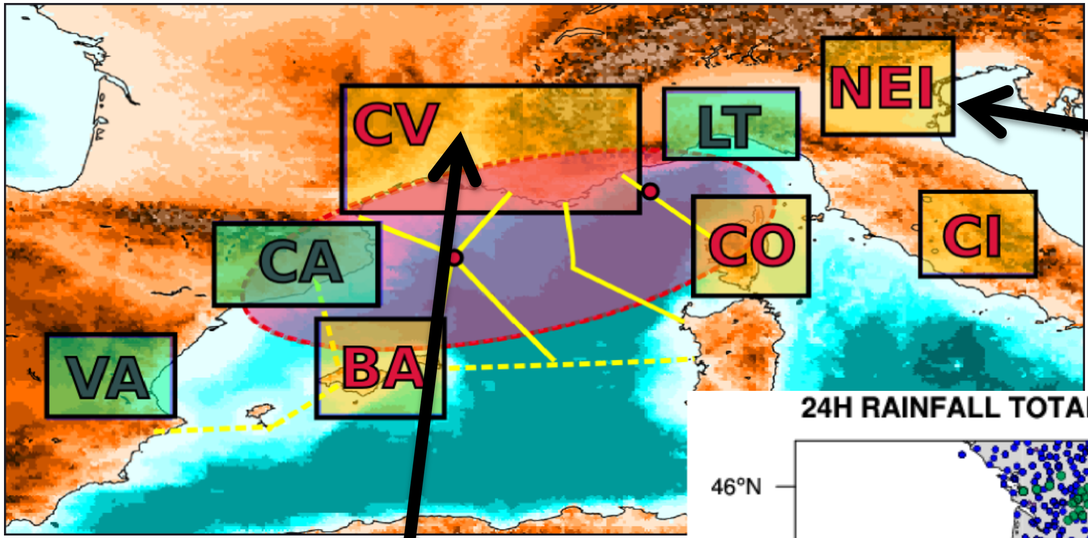
What are the error characteristics of PMW and combined high-resolution satellite products over complex terrain (mountainous) areas?

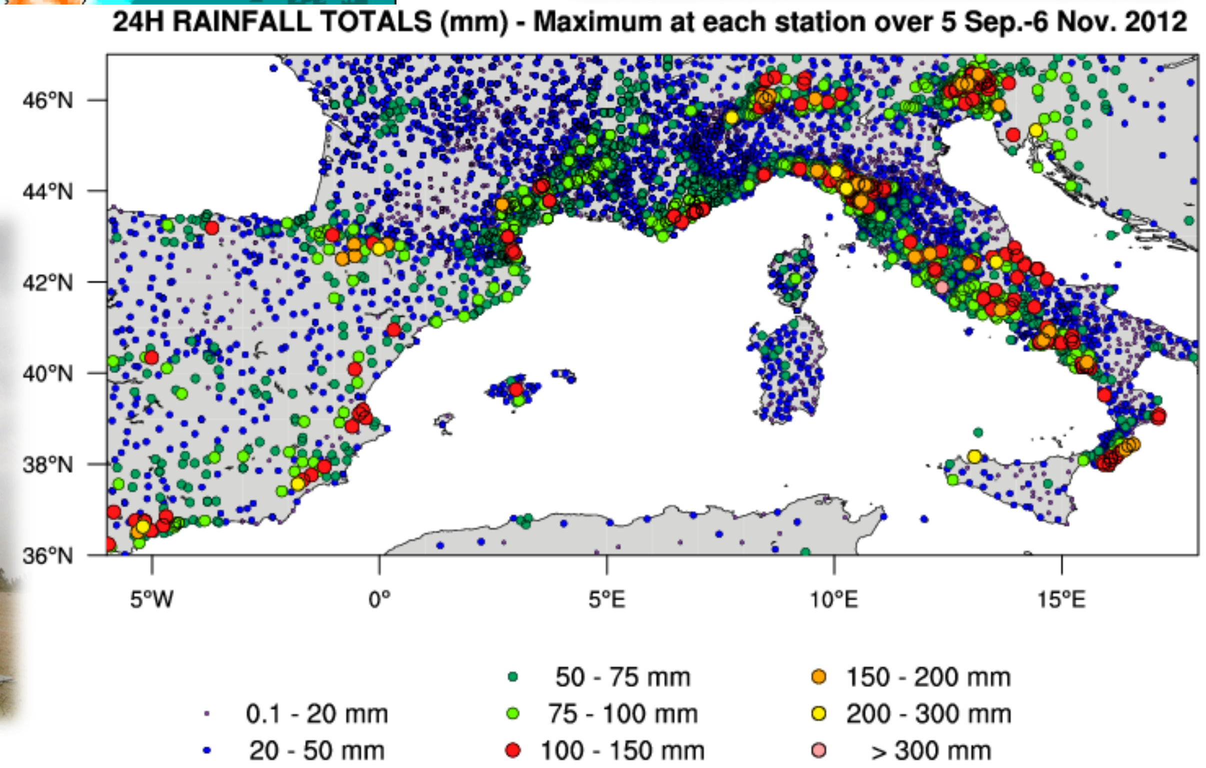
- ✓ *What is the error dependence on rainfall magnitude, vertical structure, or elevation?*
- ✓ *What are the effects of rainfall estimation uncertainty (bias, random error) and product resolution on flood simulation uncertainty; how those error effects vary across basin scales and event magnitude*

What improvements are obtainable in satellite rainfall estimates to improve uses in flood modeling?

- ✓ *How can we achieve those error corrections in absence of ground reference data?*
- ✓ *How can errors in satellite retrievals be accounted for in combination with uncertainties in hydrologic model simulations?*

Study Areas – Representing Heavy Precipitation Events (HPEs) and Complex Terrain Floods in HyMeX

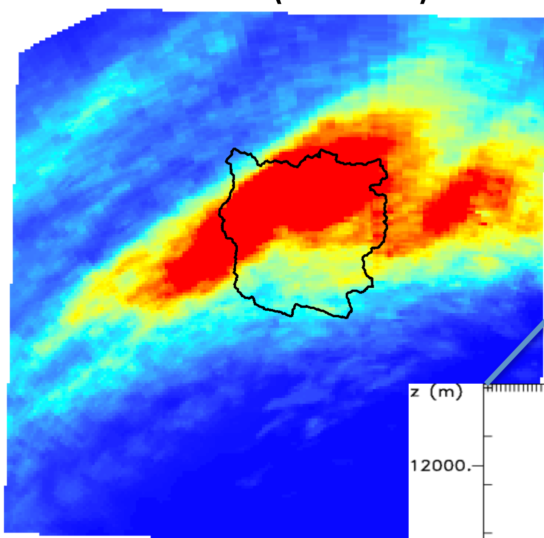


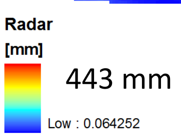


Complex Terrain Rainfall Error Analysis - NEI Observatory

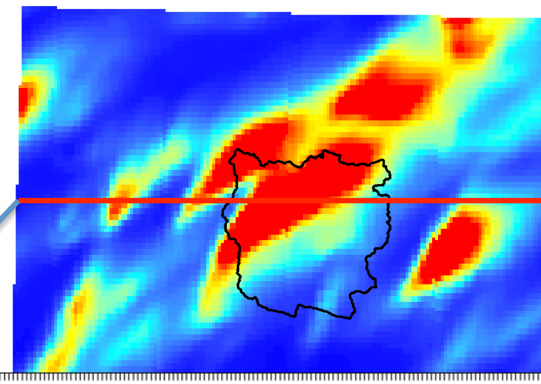
Radar and NWP based error analysis of HPE (>500 yr flood) – Fella 2003

Radar (0.5 km)

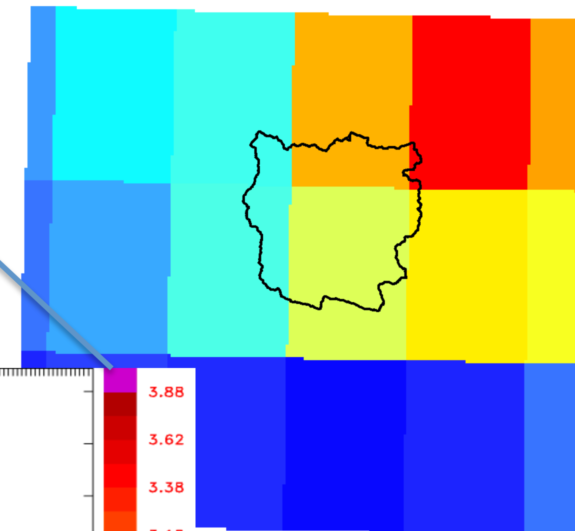


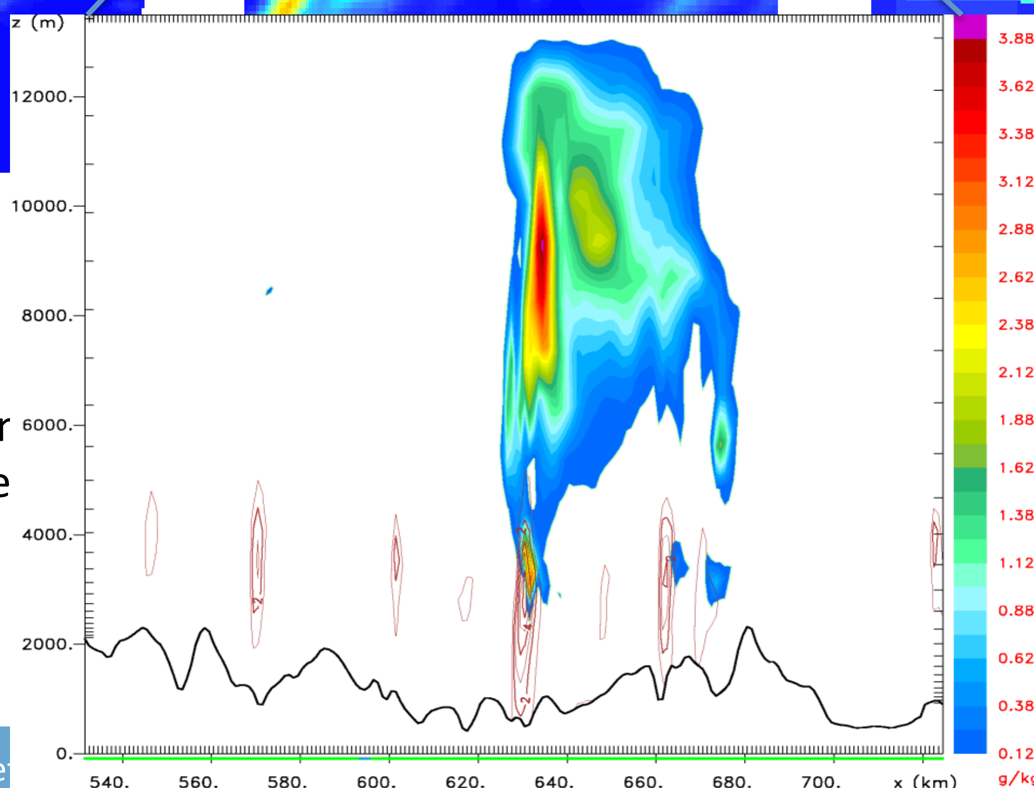


NWP* (1 km)



3B42V7 (25 km)





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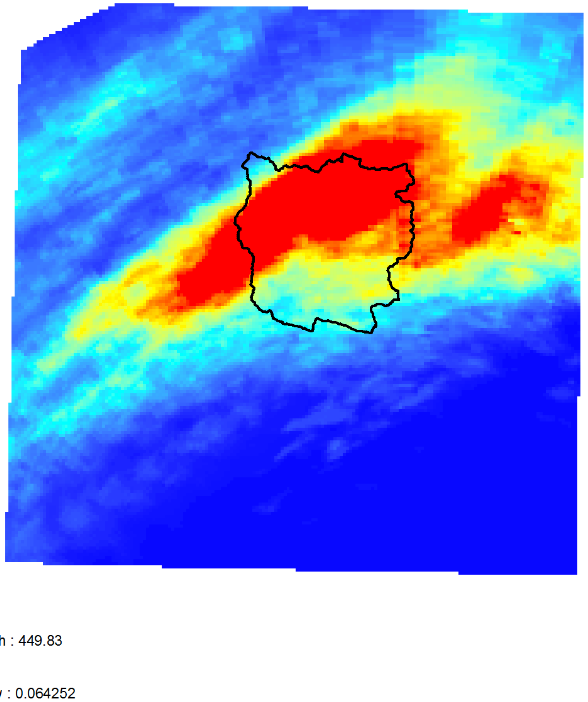
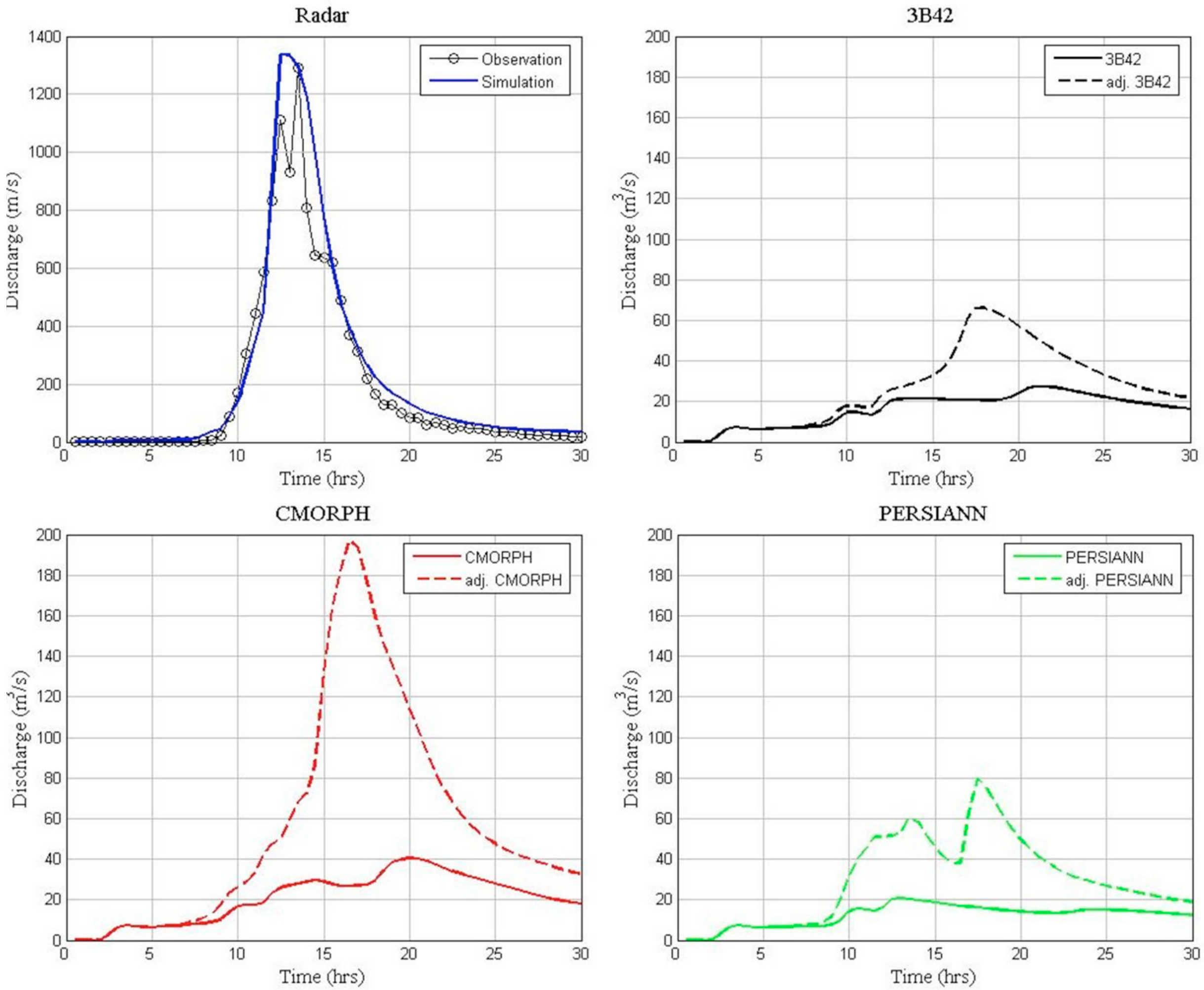
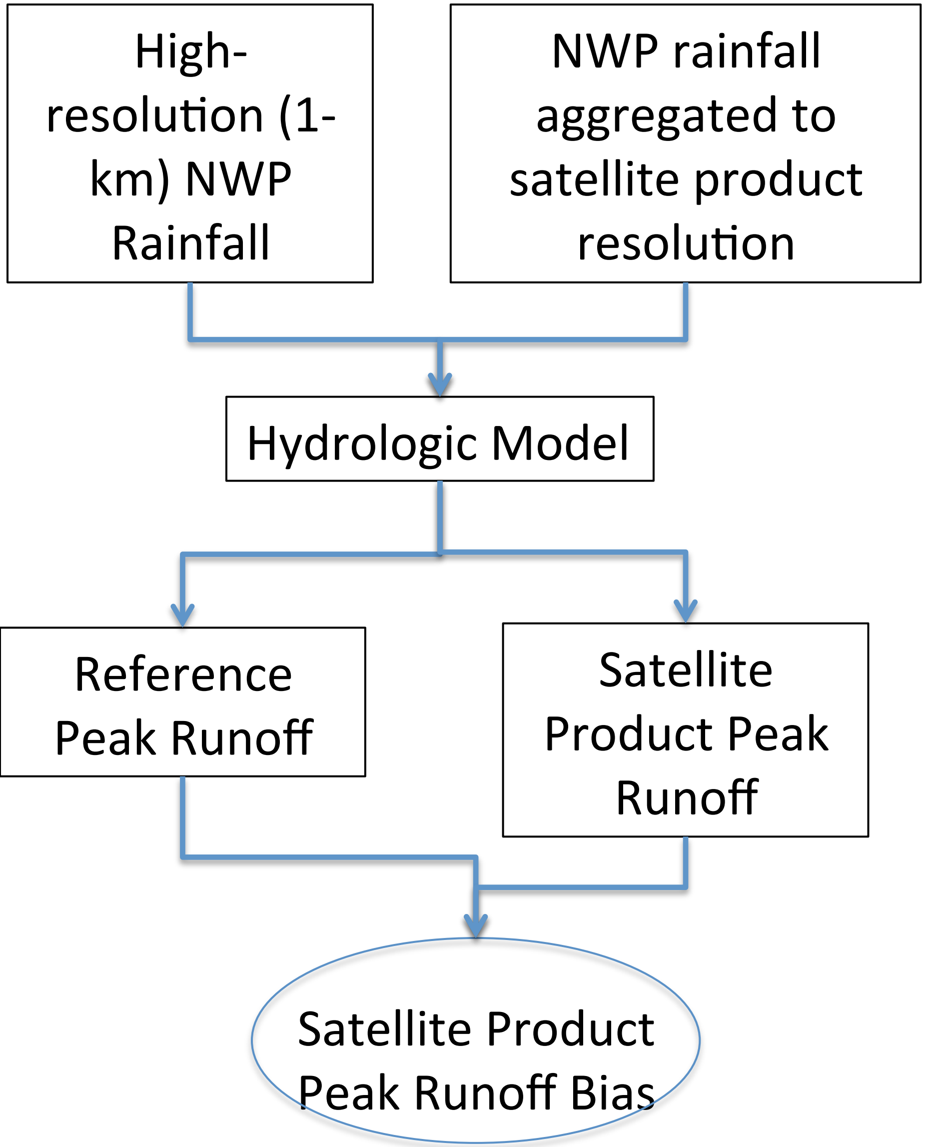
HYDROLOGIC ERROR PROPAGATION (FELLA 2003)

Fella 2003





NWP-based Analysis of Rainfall-Runoff Error Propagation



Resolution Effect

	Bias in Peak Runoff	
	Dry cond.	Wet cond.
PERSIANN (4km)	0.88	0.98
CMORPH (8km)	0.73	0.92
3B42 (25km)	0.22	0.75

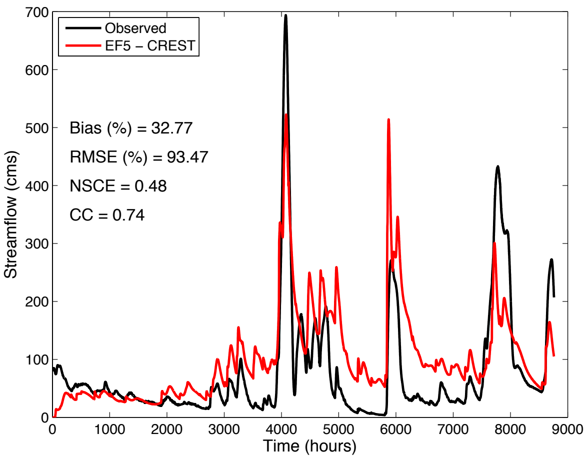
Satellite Rainfall Bias

	Original data	**NWPadjustment**
3B42	0.34	0.70
CMORPH	0.46	0.70
PERSIANN	0.14	0.70

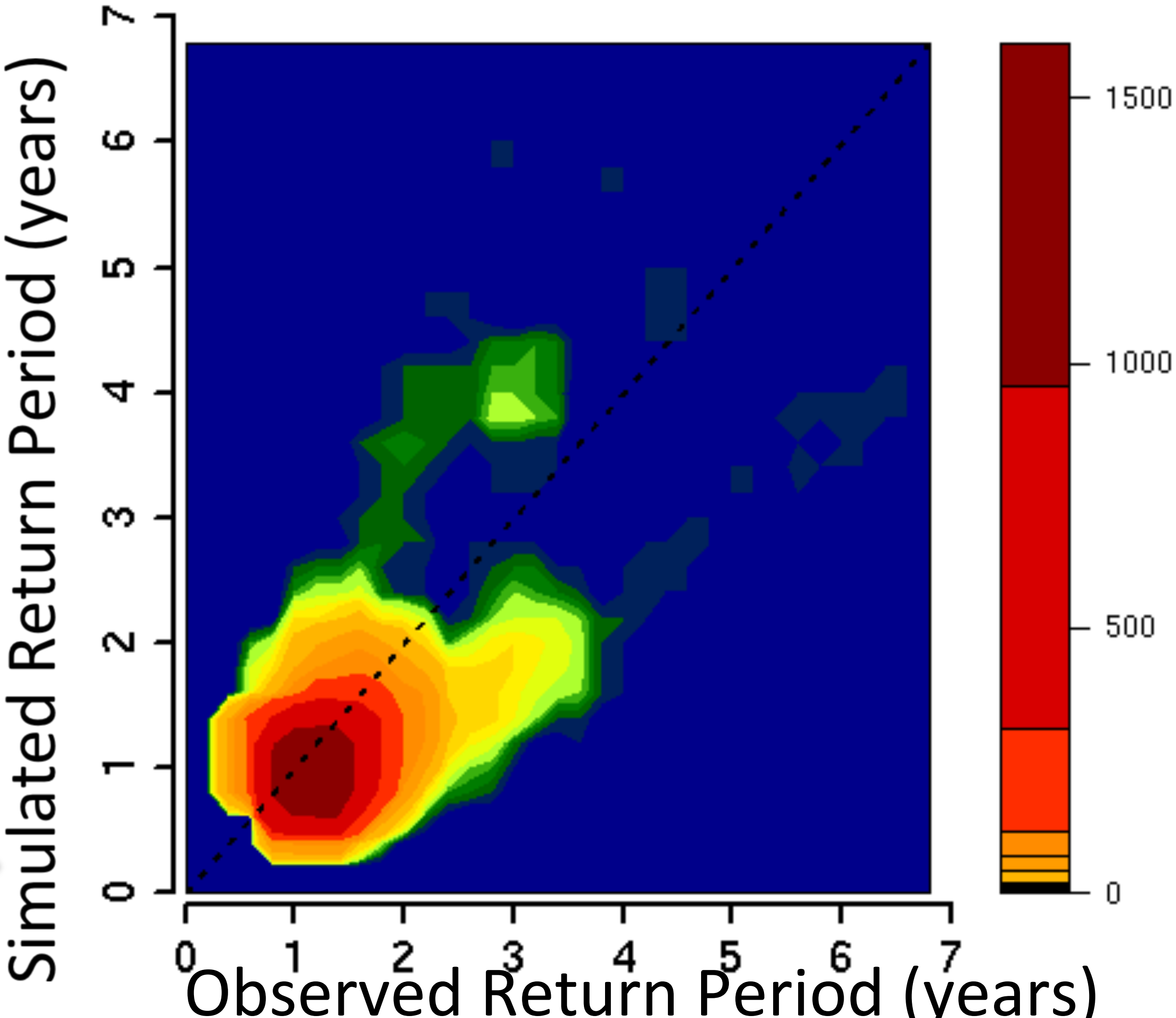
Steps for Developing a hydrologic Framework for Probabilistic Diagnostics (and Prognostics)

1. Aggregate reference rainfall product up to the space-time resolution of the satellite product
2. Run hydrologic model with a-priori parameters for lengthy period using gridded precip record (~ 1 decade for NEXRAD)
3. Convert time series of streamflow to return period
4. Compare observed & simulated time series and adjust time series by maximizing correlation coefficient (to correct for routing errors)
5. Fit GAMLSS error model
6. Evaluate diagnostic skill of model + precip
7. Provide probabilistic predictions of flooding via Bayes' theorem

- Scatter/Density plots, made from time series

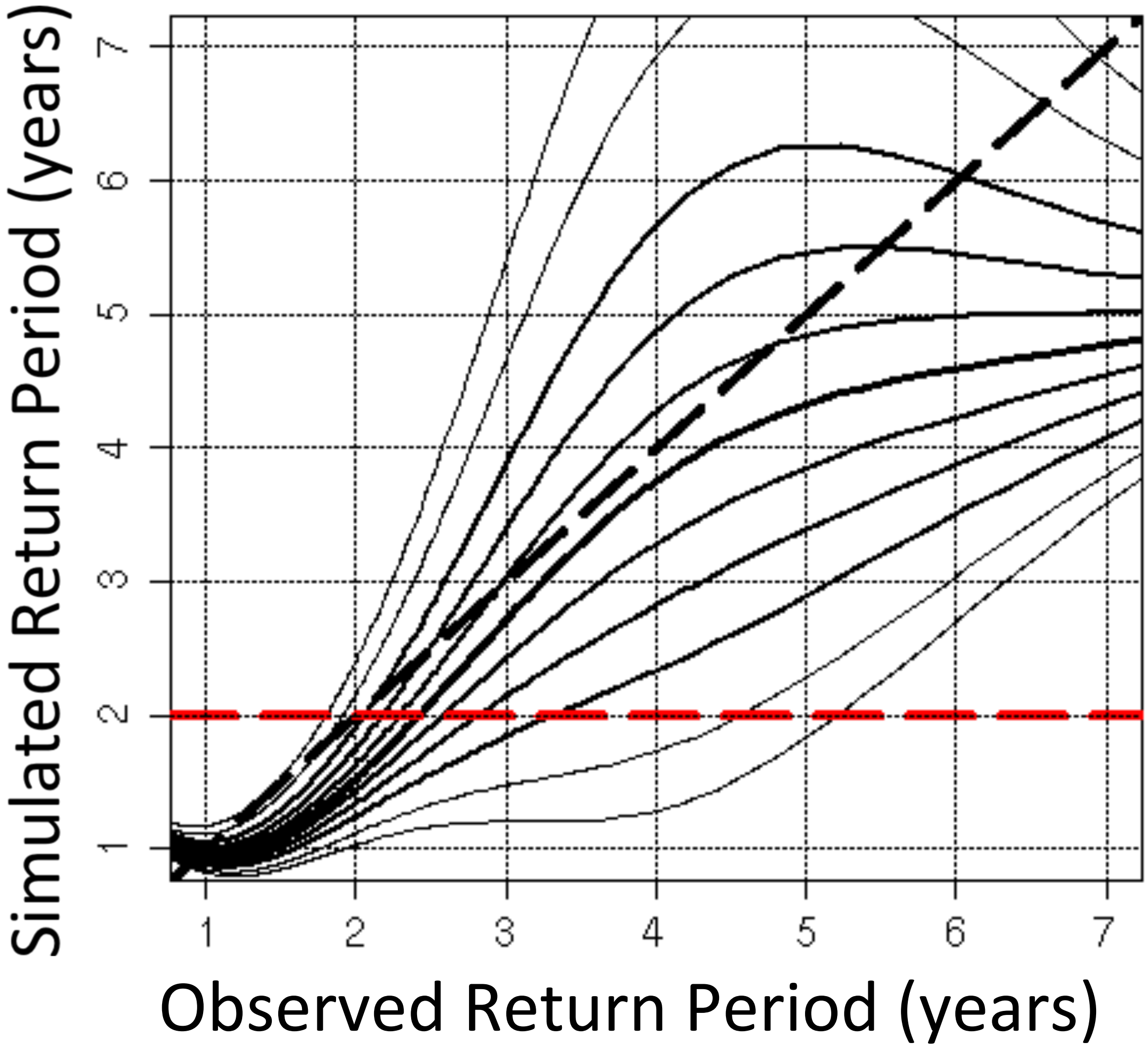


Normalize discharge (obs and sim) by converting to return periods

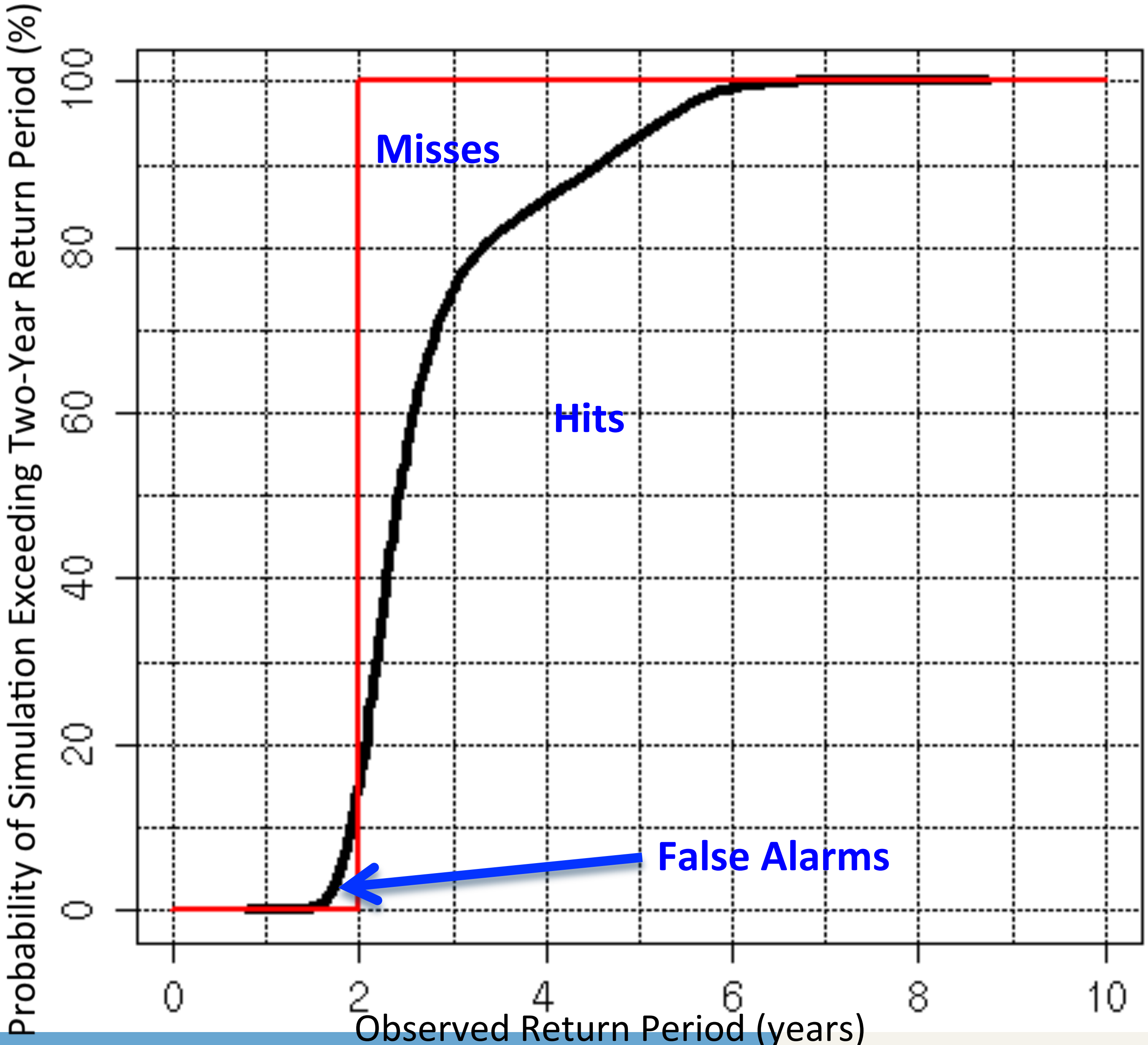


Fit an error model using the observed and simulated data

- Generalized Additive Model for Location, Scale and Shape (GAMLSS)
- Plot shows the quantiles computed from the error model (thickest is the median)



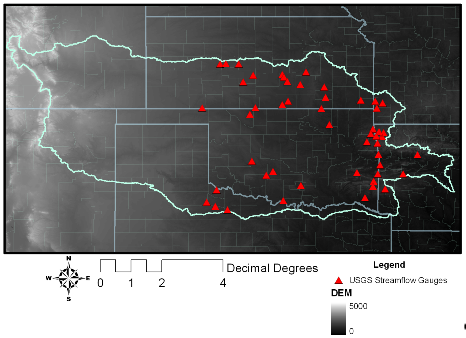
EXAMPLE DIAGNOSTIC PLOT FOR A 2-YR RETURN PERIOD

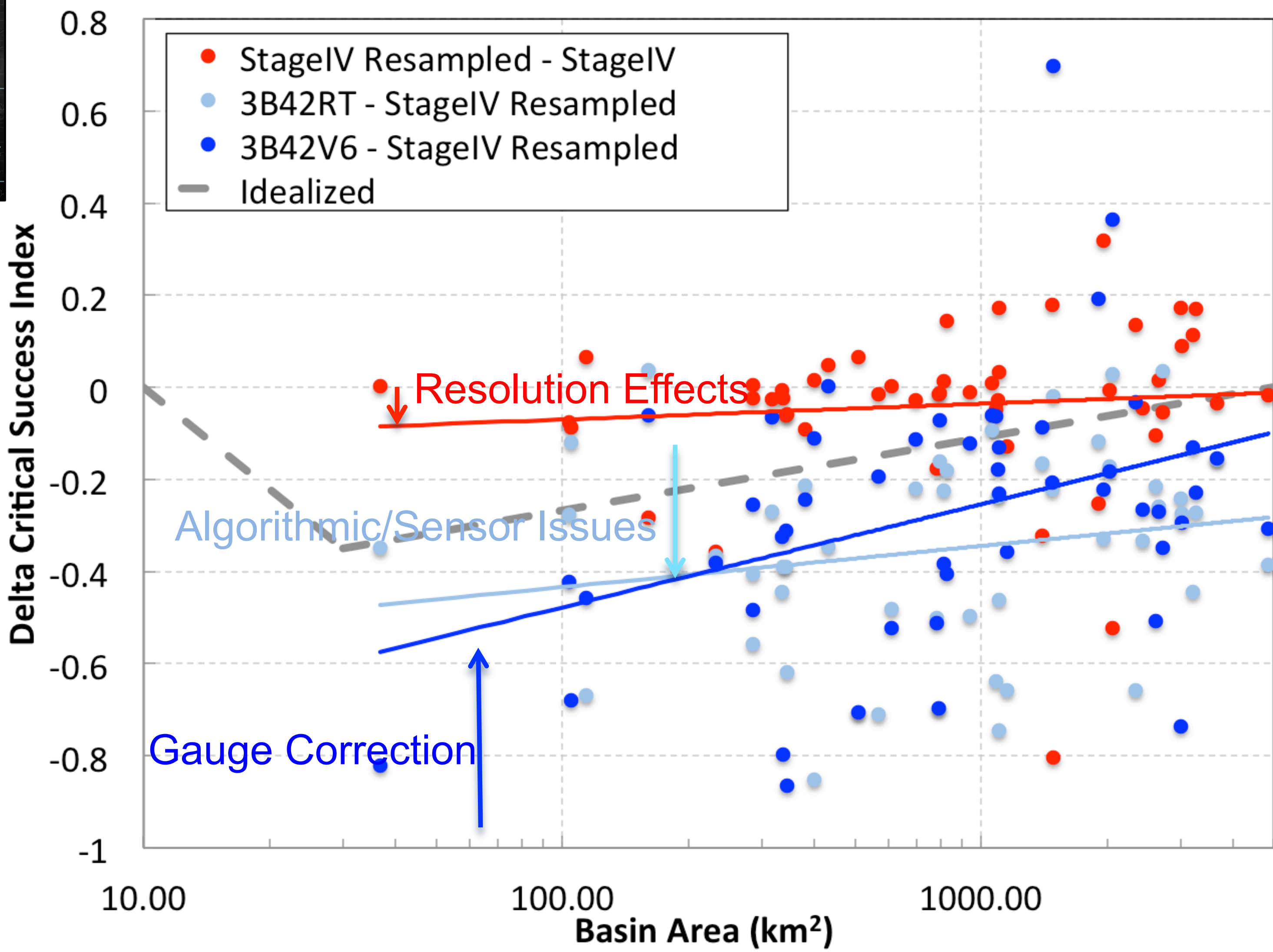


Red Line = Perfect

CSI = Hits / (Hits + Misses + False Alarms)

Compare simulations from 2002-2010 for all gauged basins in the Arkansas-Red river basin





Concluding Remarks

- Flood simulations for the complex terrain floods [e.g., Fella (2003) event] show some correlation with reference, but strong underestimation (5-10 times) of peak runoff; mean-field bias correction could not resolve the underestimation due to resolution effects

- Use of fine-scale (sub-pixel) ground-based radar (where available) and high-resolution NWP analysis can quantify satelllite retrieval error characteristics and resolution effects when using in hydrologic applications

- **Satellite precipitation products will never be error free;** application-oriented frameworks must account for uncertainty in the retrievals, resolution effects, and how they combine with physical basin characteristics, scales and model structure