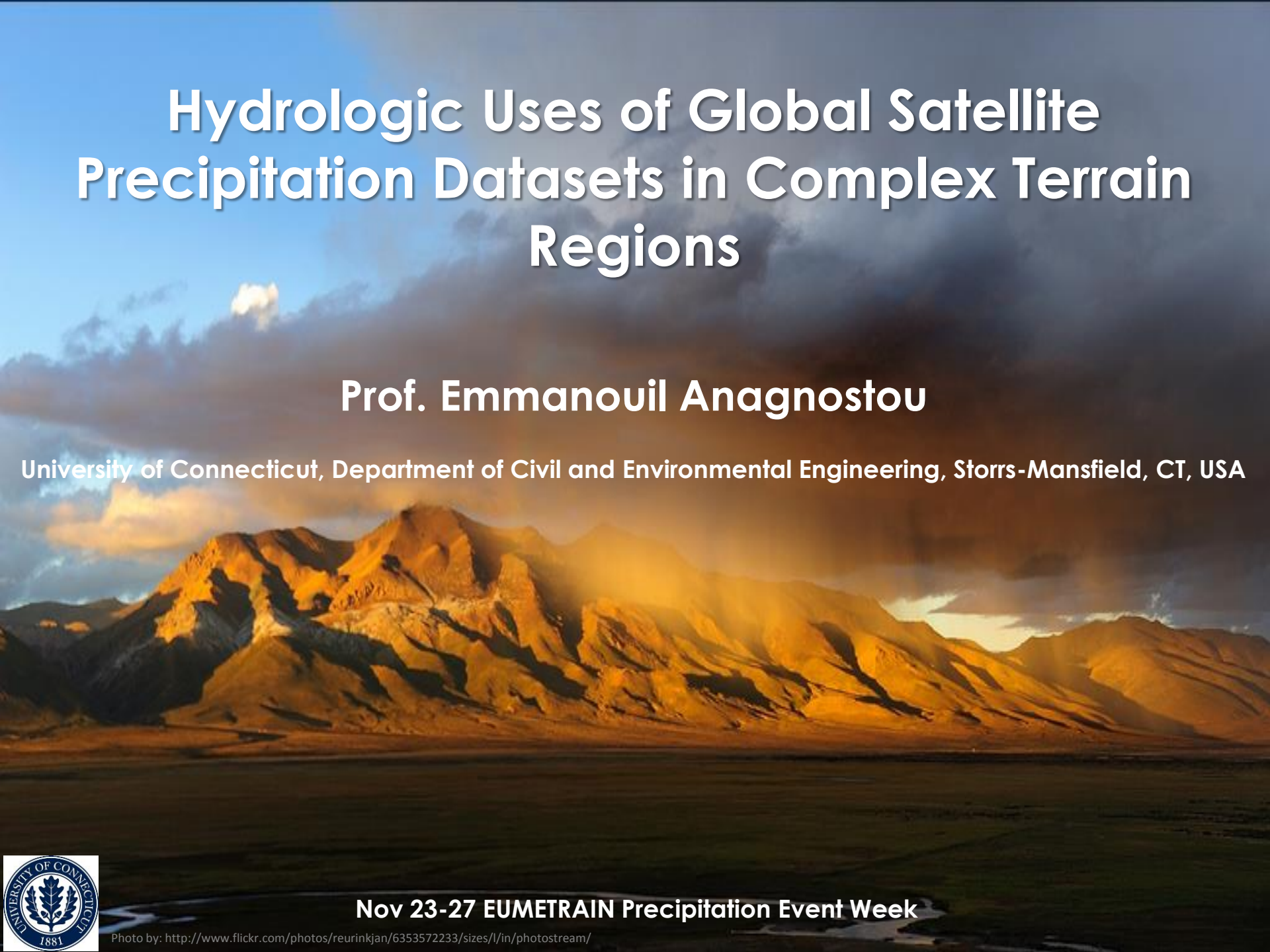
Hydrologic Uses of Global Satellite Precipitation Datasets in Complex Terrain Regions

Prof. Emmanouil Anagnostou

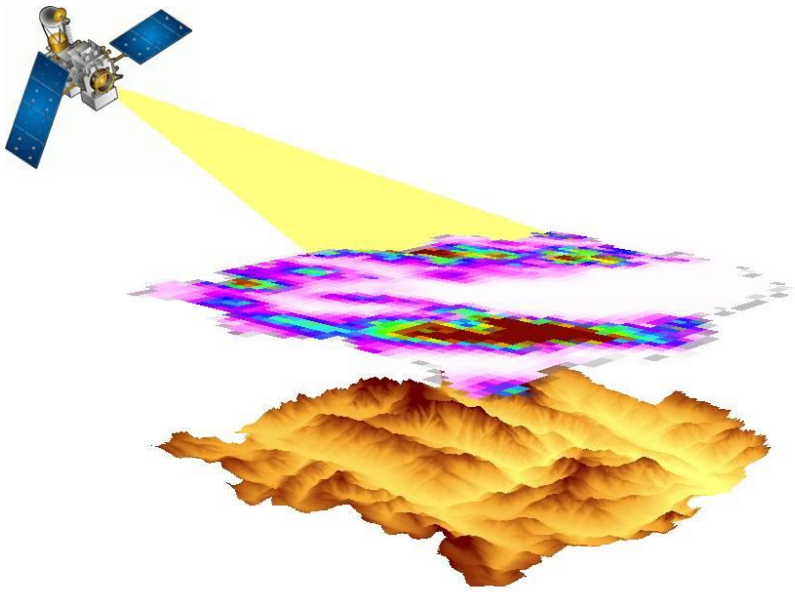
University of Connecticut, Department of Civil and Environmental Engineering, Storrs-Mansfield, CT, USA



Nov 23-27 EUMETRAIN Precipitation Event Week

Photo by: http://www.flickr.com/photos/reurinkjan/6353572233/sizes/l/in/photostream/

Research Questions

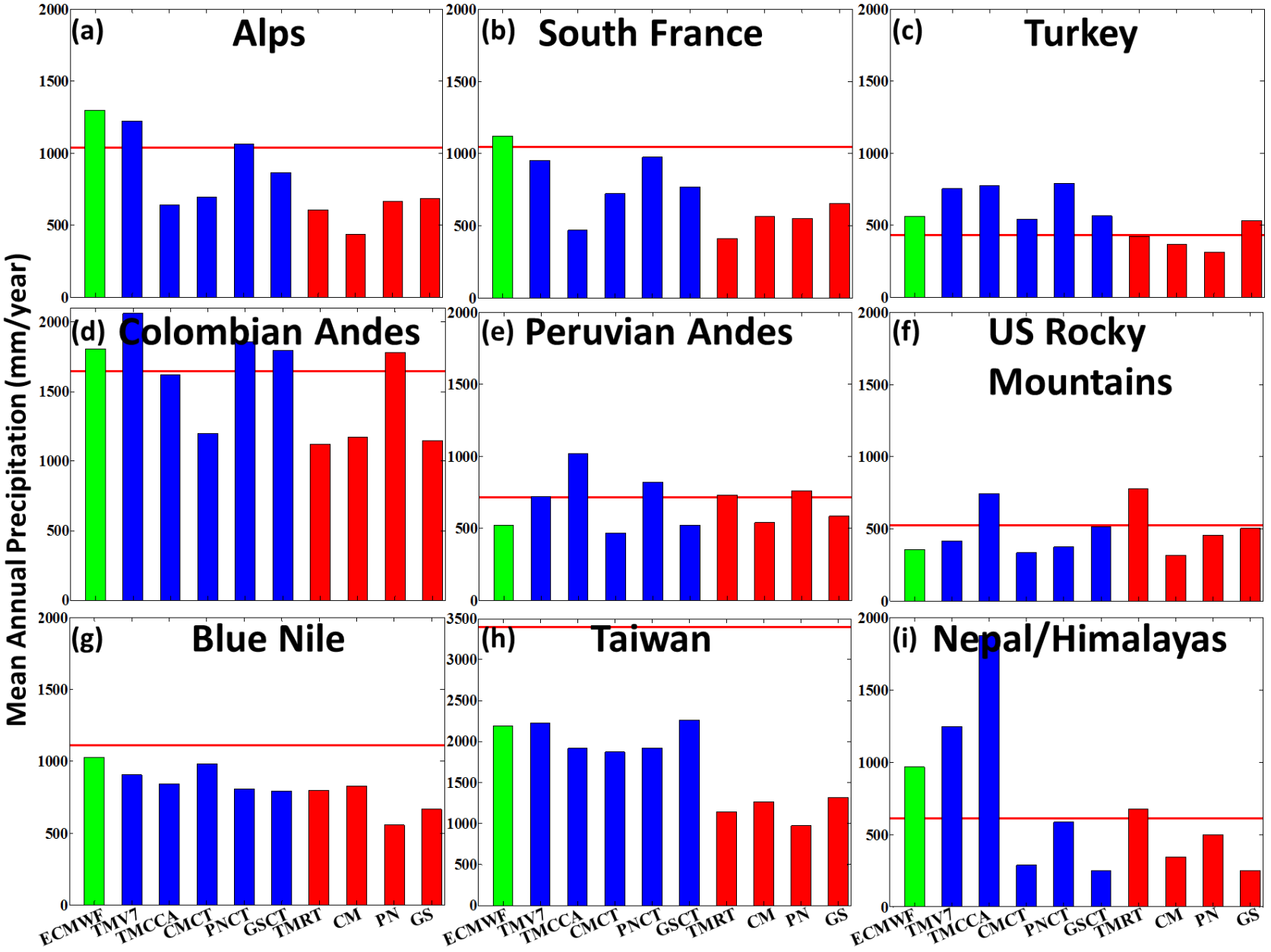


What are the uncertainty characteristics in satellite retrievals and how are those errors propagate in hydrologic simulations

What improvements are obtainable in satellite rainfall estimation of mountainous heavy precipitation events and how those improvements impact flood modelling?

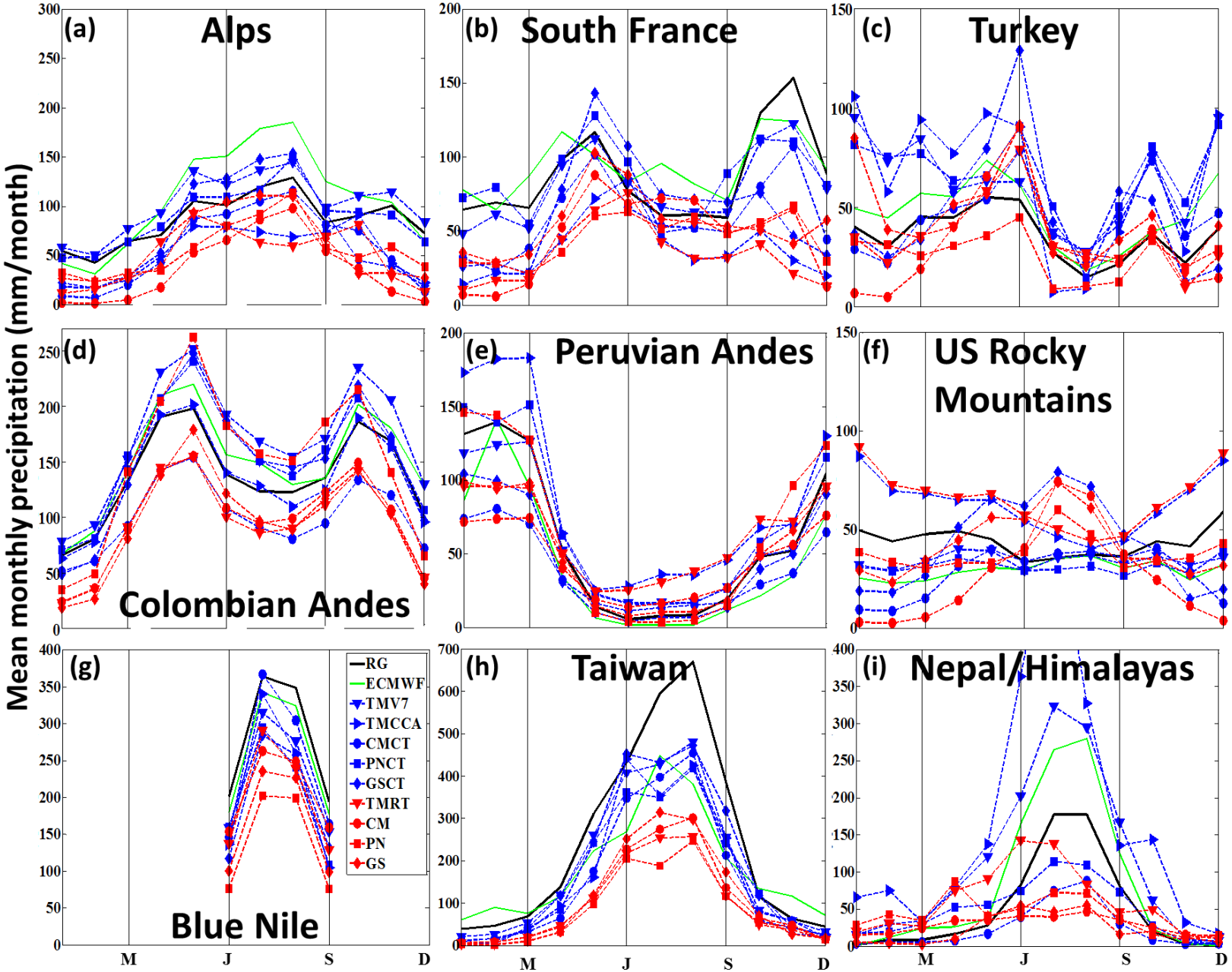
- ✓ *How to apply error corrections of satellite rainfall products in absence of ground reference data?*
- ✓ *What kind of hydrologic modeling, or parameter estimation procedure, is most appropriate in the case of satellite rainfall forcing data considering satellite data uncertainty and spatial resolution.*

Multiregional Evaluation of Satellite Products



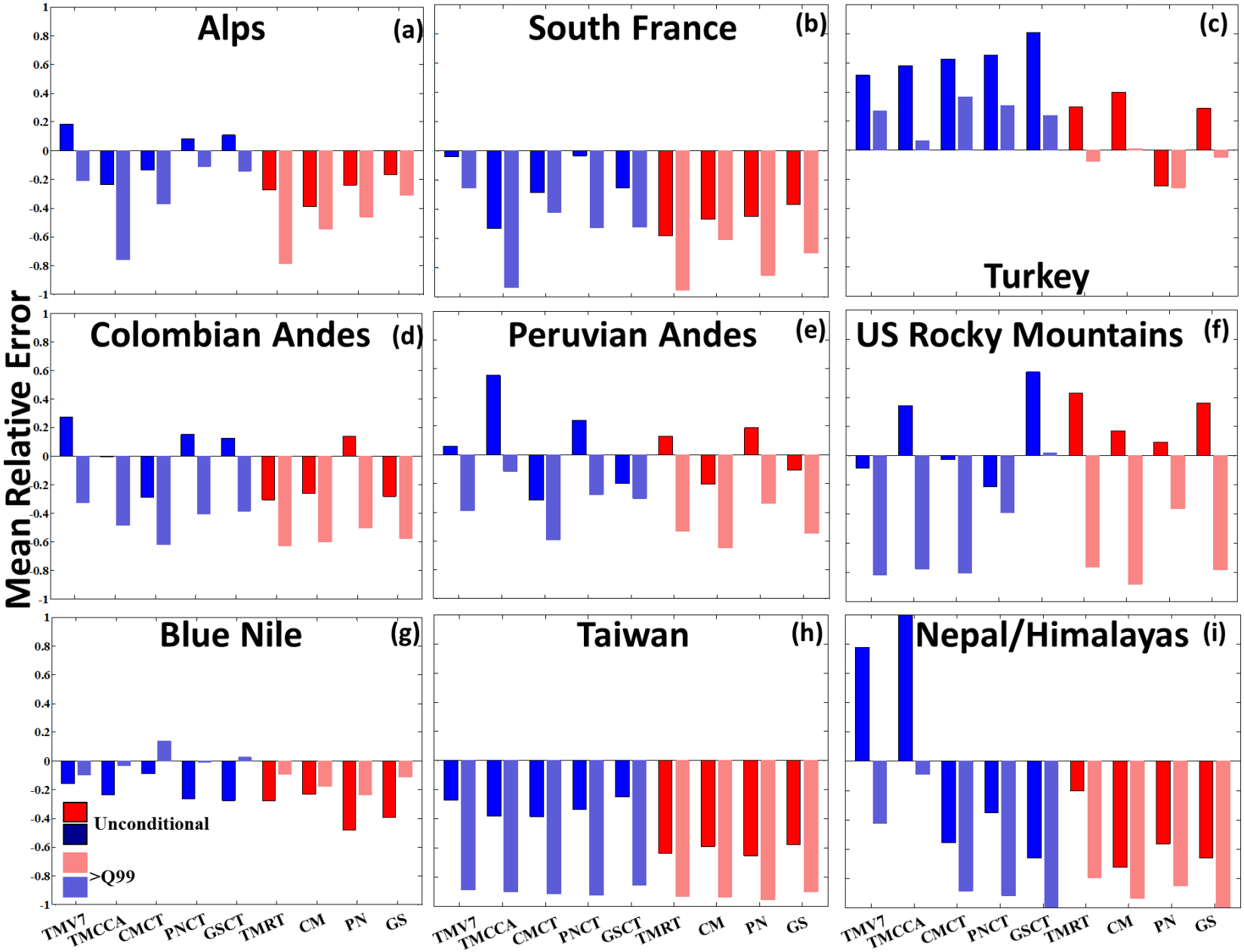
[*Derin et al. 2015, JHM*]

Multiregional Evaluation of Satellite Products



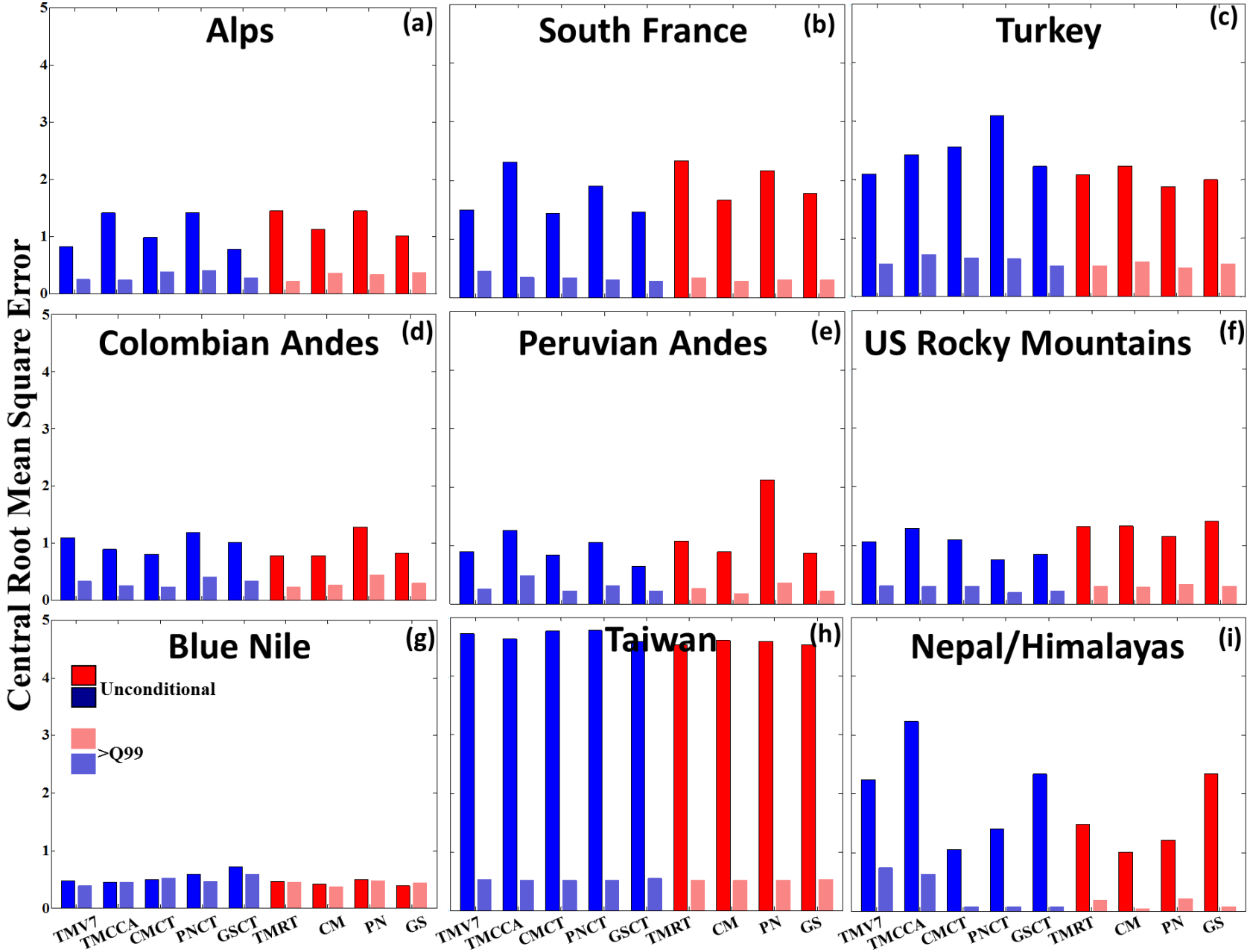
[*Derin et al. 2015, JHM*]

Multiregional Evaluation of Satellite Products



[*Derin et al. 2015, JHM*]

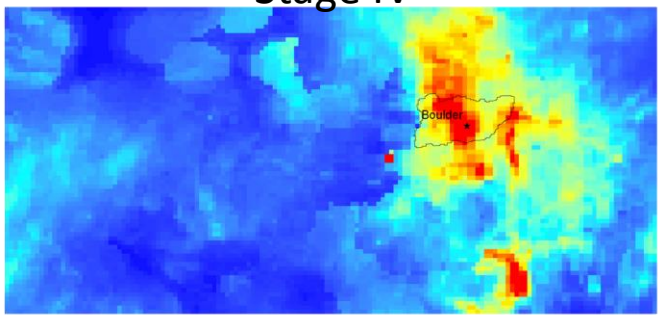
Multiregional Evaluation of Satellite Products



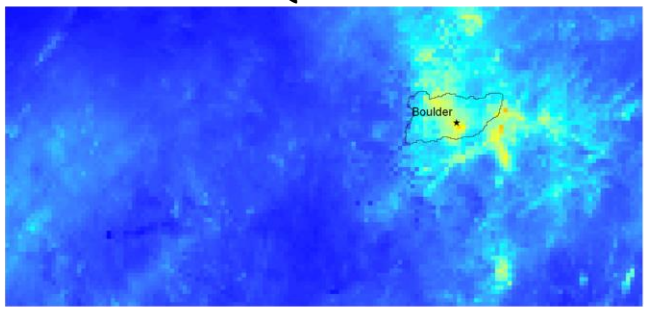
[*Derin et al. 2015, JHM*]

Event Based Analysis: Colorado Floods – September 2013

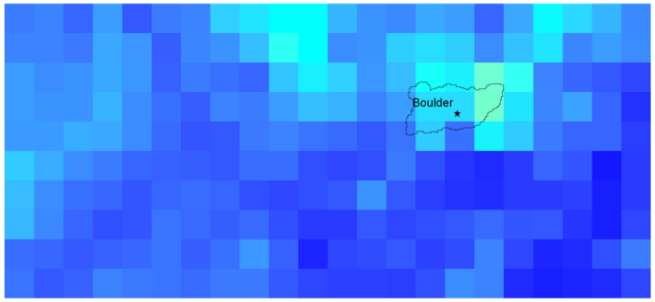
Stage IV



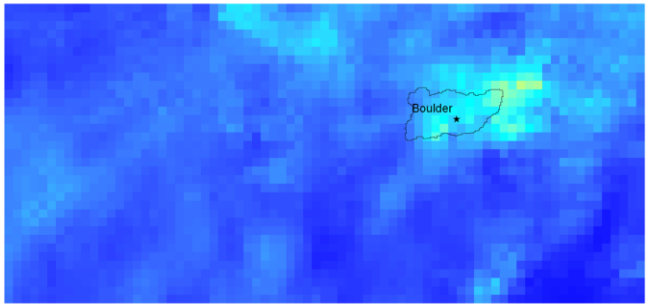
Q3



3B42RT



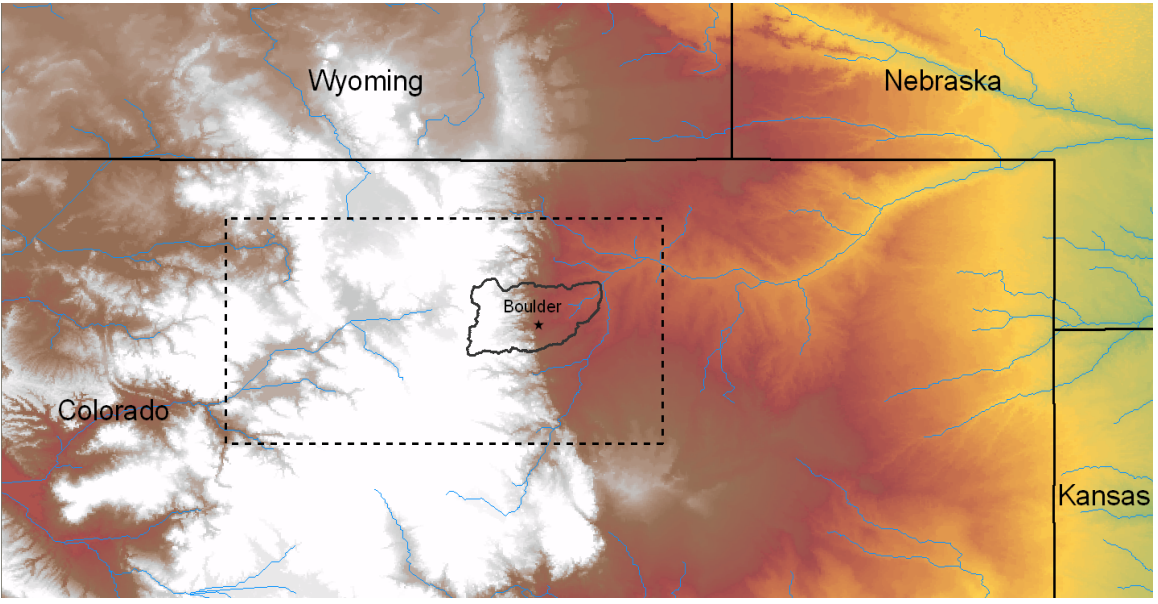
CMORPH



Tota Rainfall [mm]

High : 200

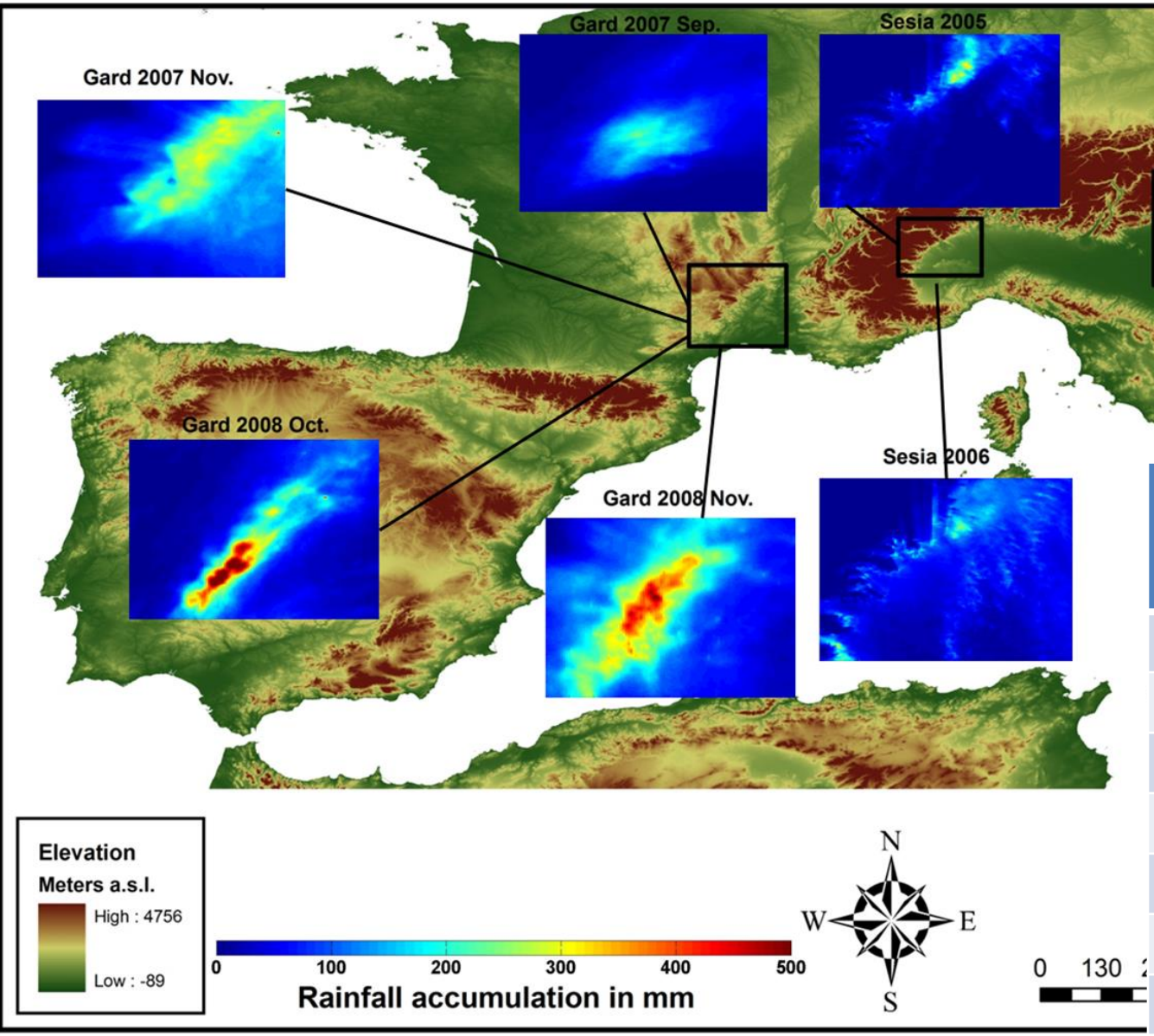
Low : 0



Accumulation Period: 09/08-14

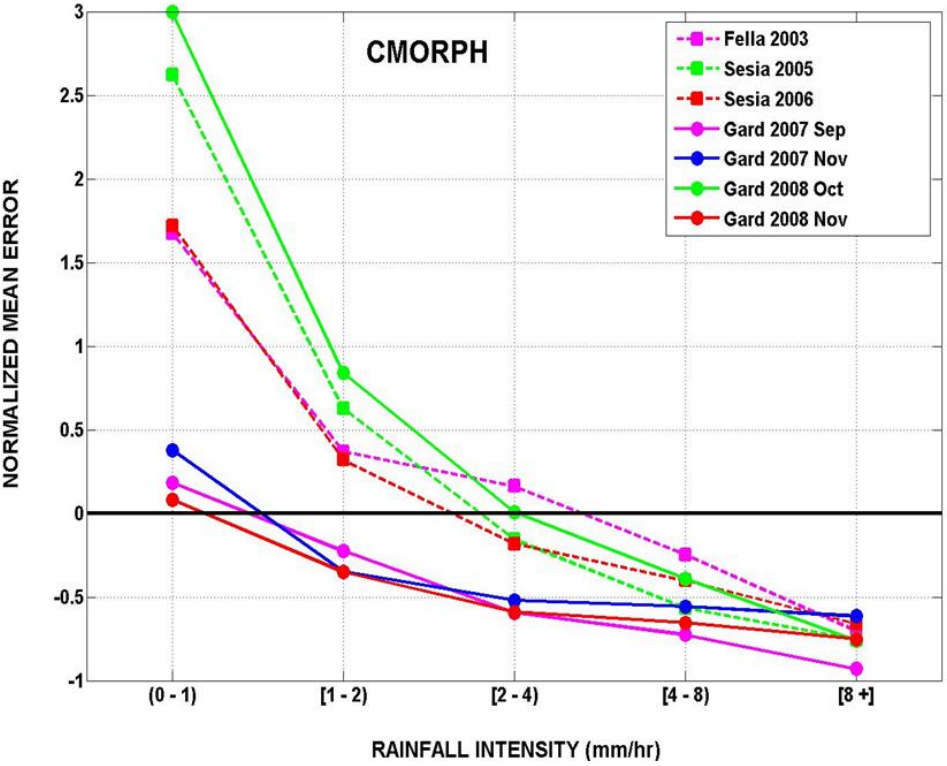
Rainfall Product	Basin-Average Rainfall Accumulation (mm); basin area 2500km^2
Stage IV	160
Q3	78
CMORPH	58
3B42RT	52

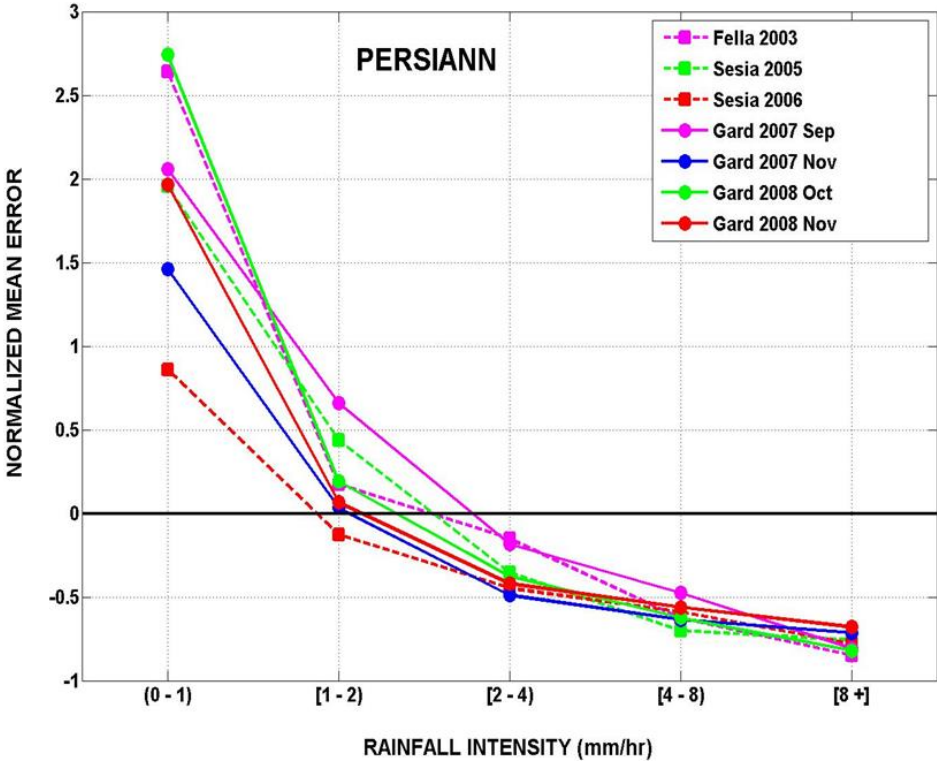
Event Based Analysis – Mediterranean Flash Flood Events



Storm Event and Site	Storm Total Accumulation (mm)
Fella 2003	329
Sesia 2005	222
Sesia 2006	181
Gard 2007 Sep	200
Gard 2007 Nov	286
Gard 2008 Oct	384
Gard 2008 Nov	434

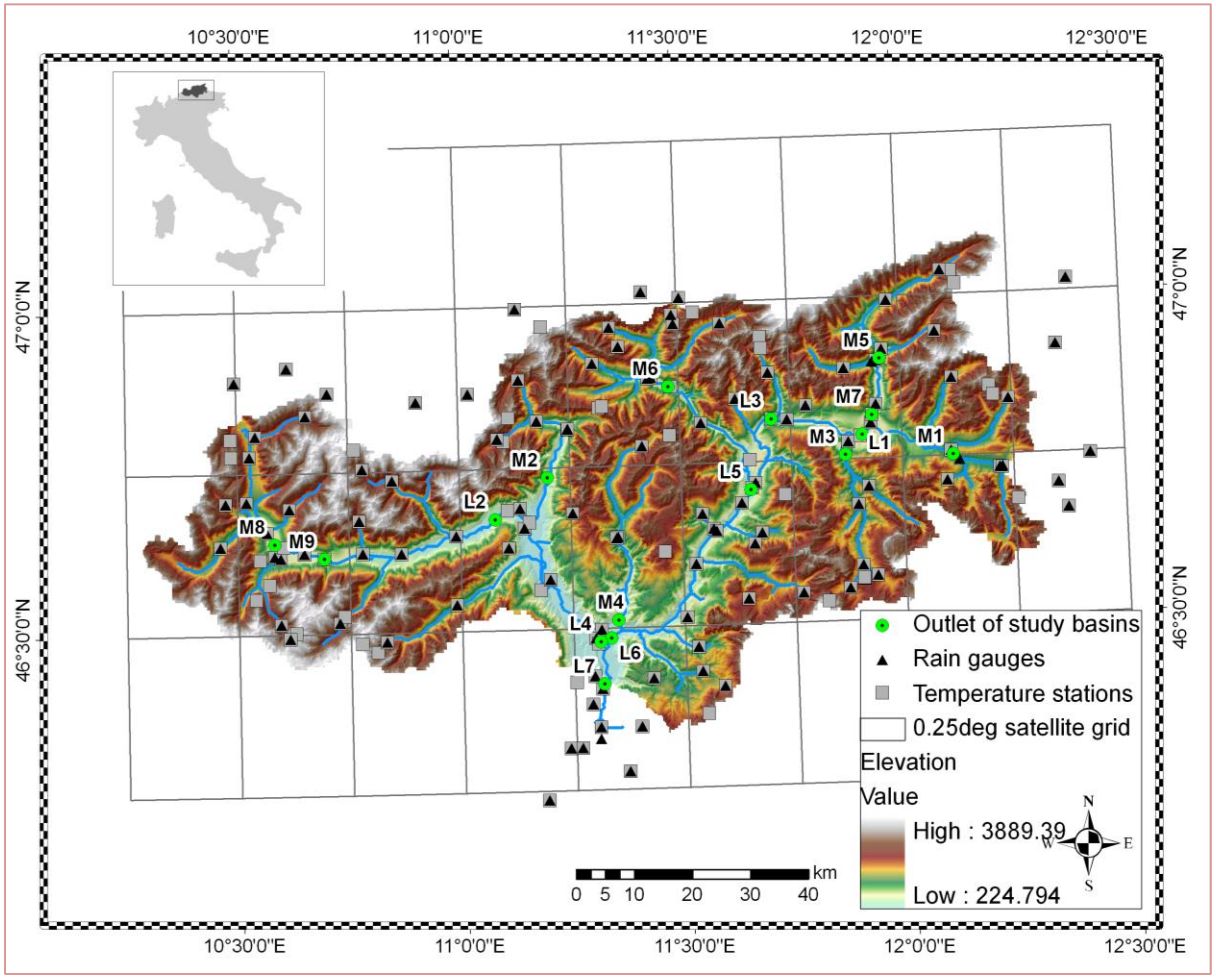
RAINFALL ERROR VS. MAGNITUDE





[*Stampoulis and Anagnostou, JoH, 2013*]

Hydrologic Error Propagation

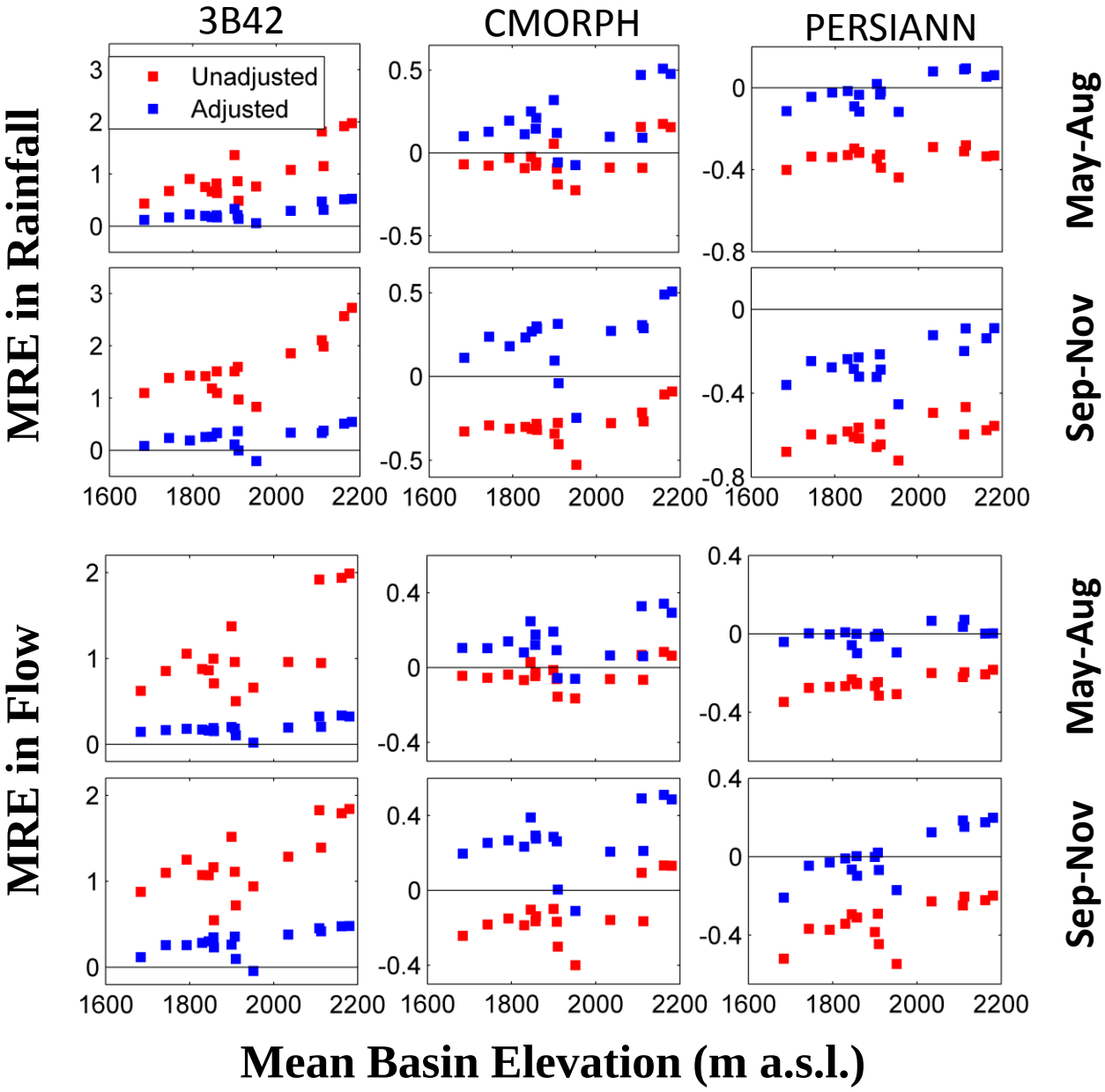


Upper Adige River Basin (6967 km2);

- 104 rain gauges and 143 temperature stations;
- Integrated Catchment Hydrological Model (ICHYMOD):
- snow routine, soil moisture routine, flow routine

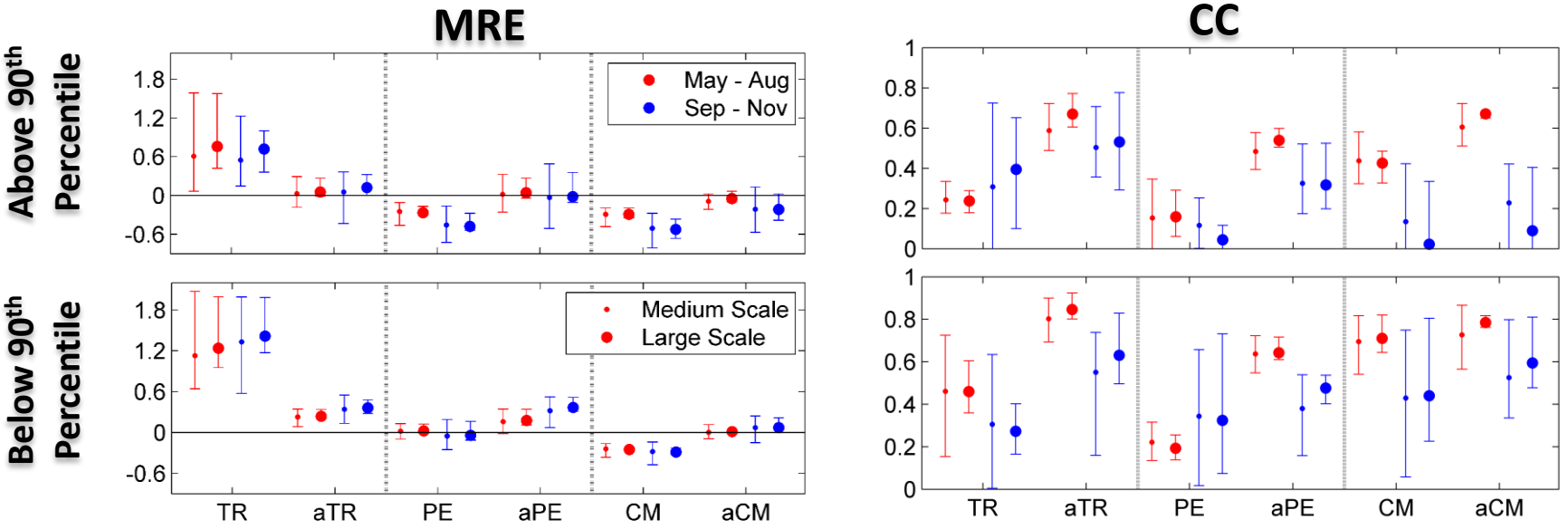
[*Mei et al. 2015, JHM*]

ROLE OF ELEVATION ON SYSTEMATIC ERROR



[*Mei et al. 2015, JHM*]

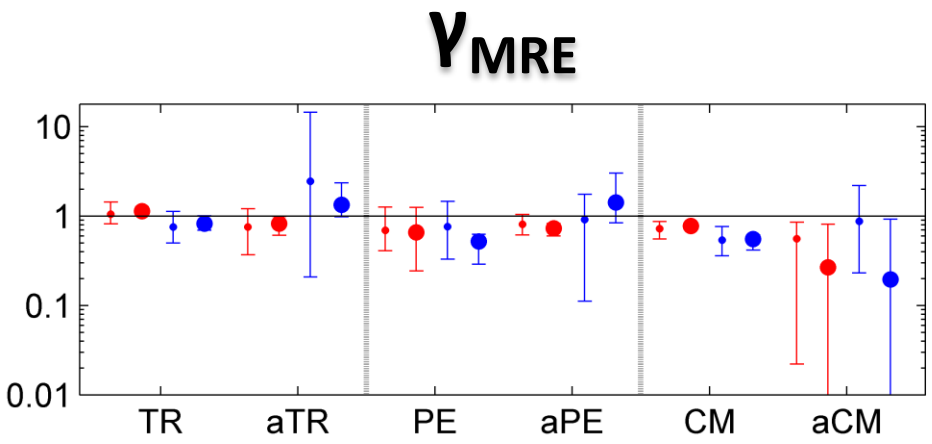
EFFECTS OF BASIN SCALE, SEASONALITY AND FLOW SEVERITY

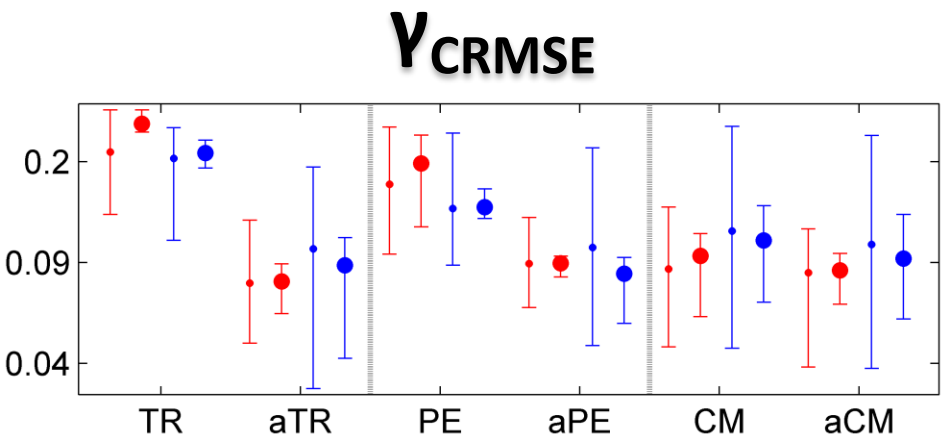


Satellite Precipitation Products

[*Mei et al. 2015, JHM*]

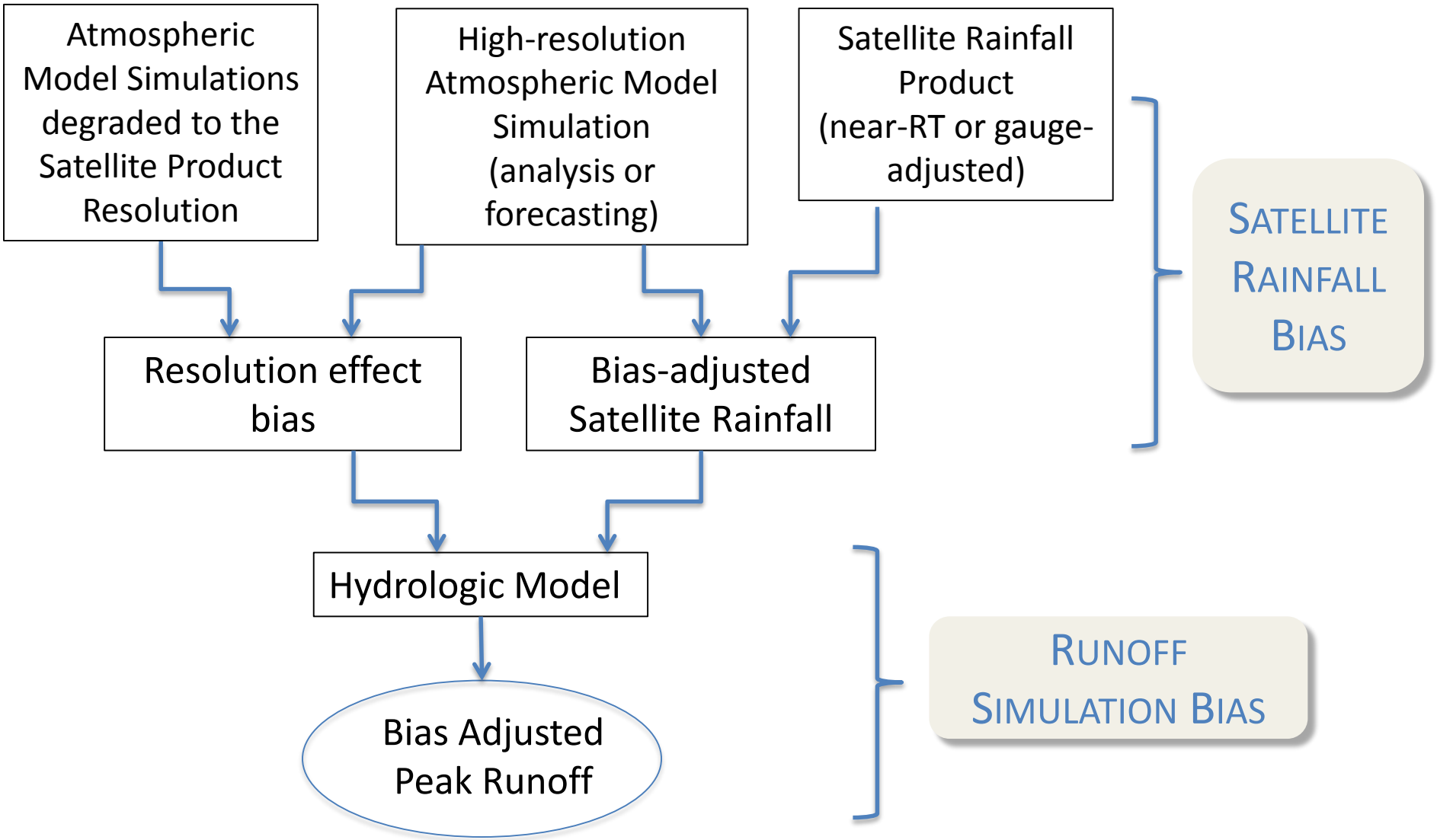
Error Ratios (Runoff to Precipitation)





[*Mei et al. 2015, JHM*]

Error Adjustment Framework



[*Zhang et al. 2013, 2015 JHM; Nikolopoulos et al. 2015, JHM*]

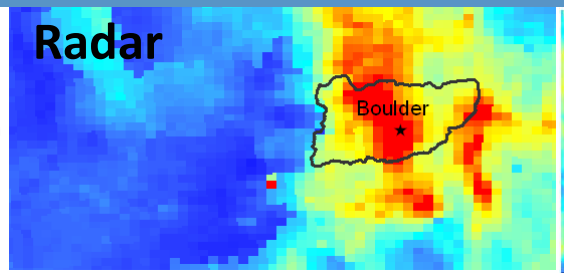
Case Study 1: Mountainous Flash Floods

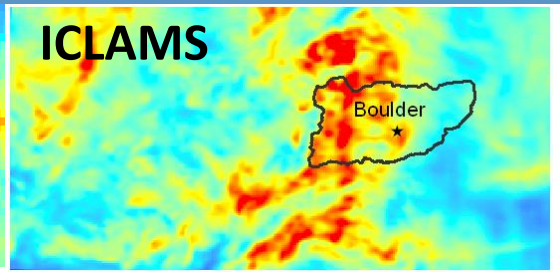
Boulder 2013
Area mean (mm): 142 | 130
Max (mm): 278 | 313

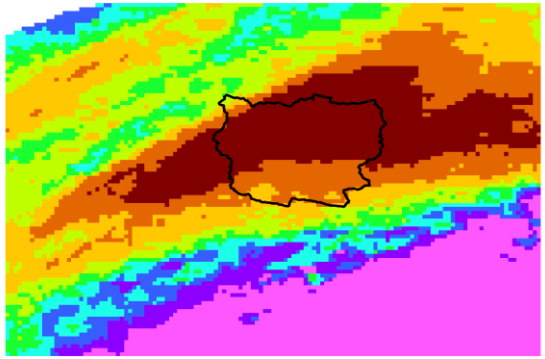
Fella 2003
Area mean (mm): 212 | 120
Max (mm): 441 | 419

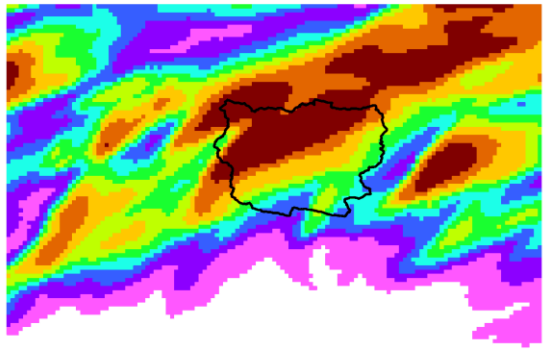
Sesia 2002
Area Mean (mm): 126 | 110
Max (mm): 429 | 419

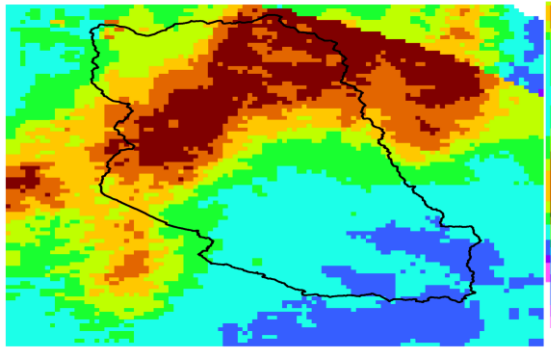
Sesia 2005
Area Mean (mm): 66 | 32
Max (mm): 333 | 225

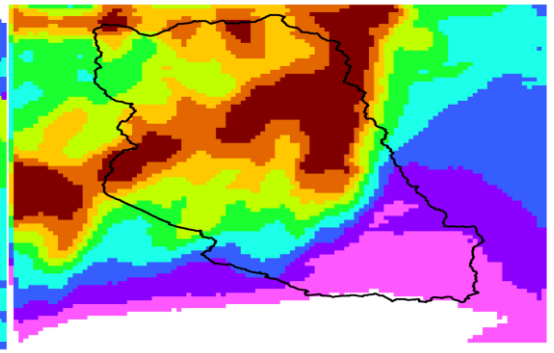


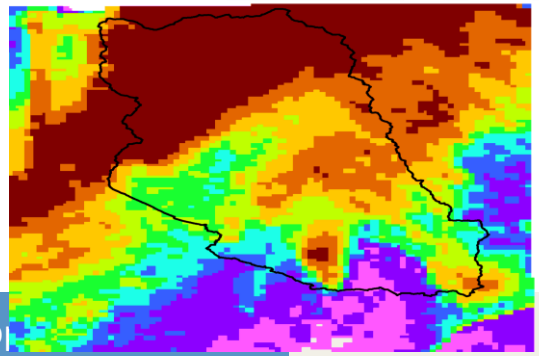


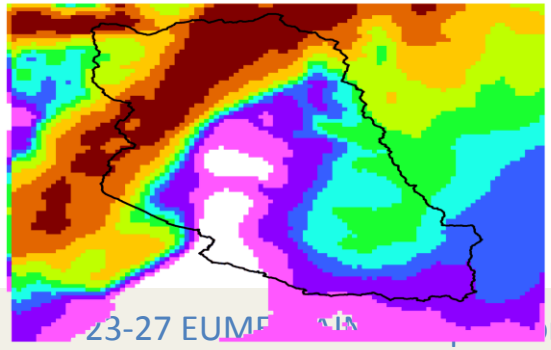


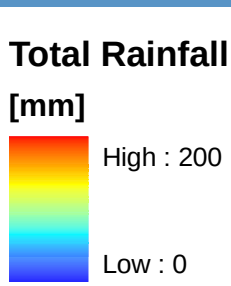






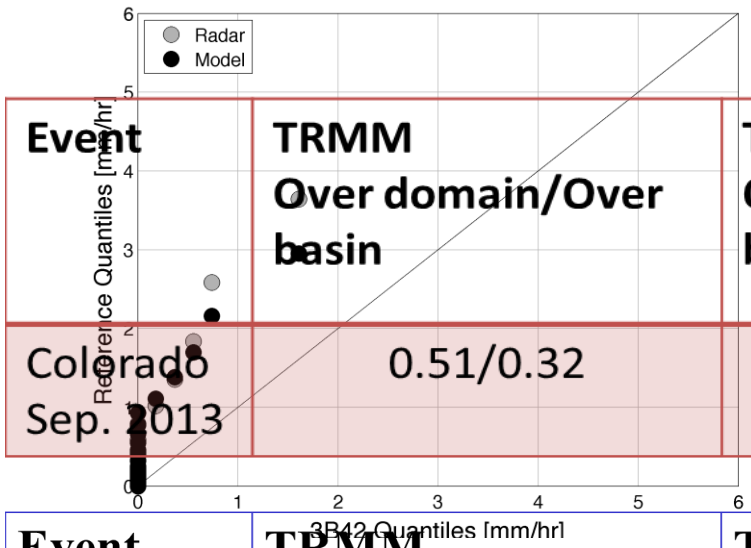






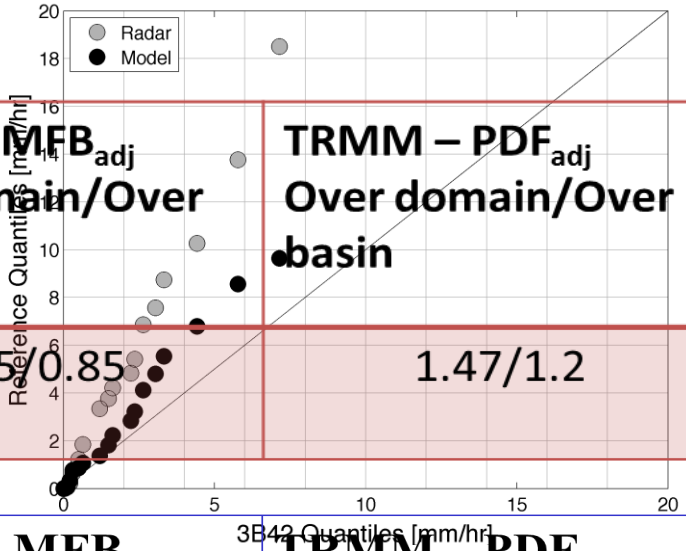
Radar vs. NWP-Satellite Rainfall Error Assessment

Boulder 2013



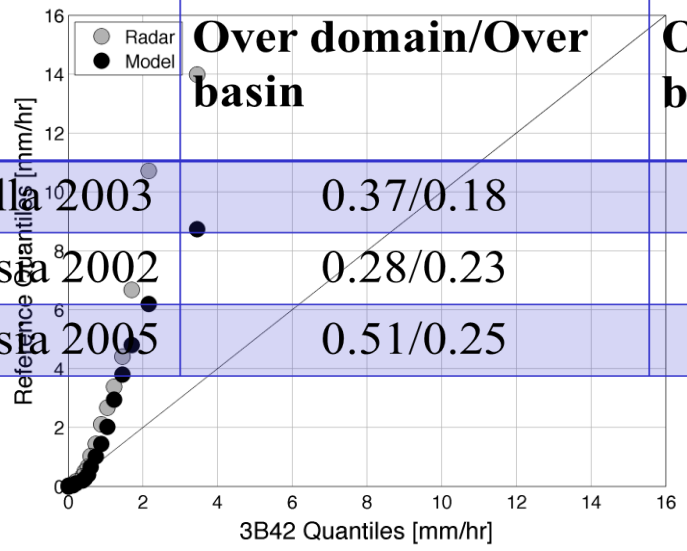
Event	TRMM Over domain/Over basin	TRMM – MFB$_{adj}$ Over domain/Over basin	TRMM – PDF$_{adj}$ Over domain/Over basin
Colorado Sep. 2013	0.51/0.32	1.35/0.85	1.47/1.2

Fella 2003

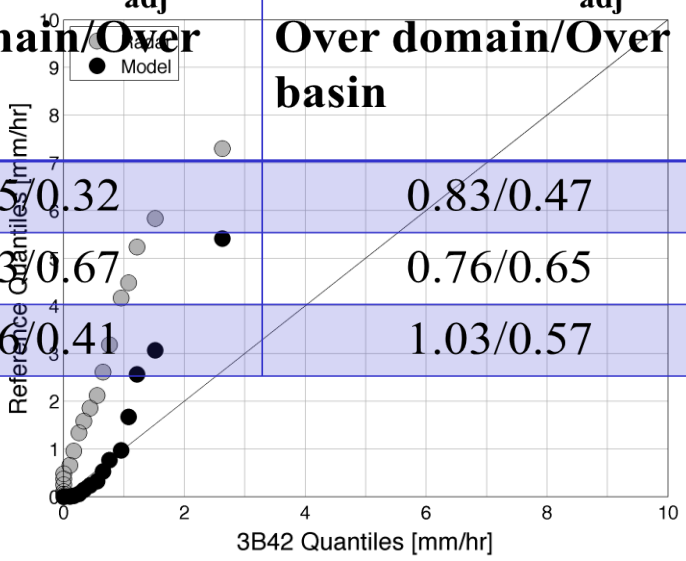


Sesia 2002

Event	TRMM Over domain/Over basin	TRMM – MFB$_{adj}$ Over domain/Over basin	TRMM – PDF$_{adj}$ Over domain/Over basin
Fella 2003	0.37/0.18	0.65/0.32	0.83/0.47
Sesia 2002	0.28/0.23	0.83/0.67	0.76/0.65
Sesia 2005	0.51/0.25	0.86/0.41	1.03/0.57

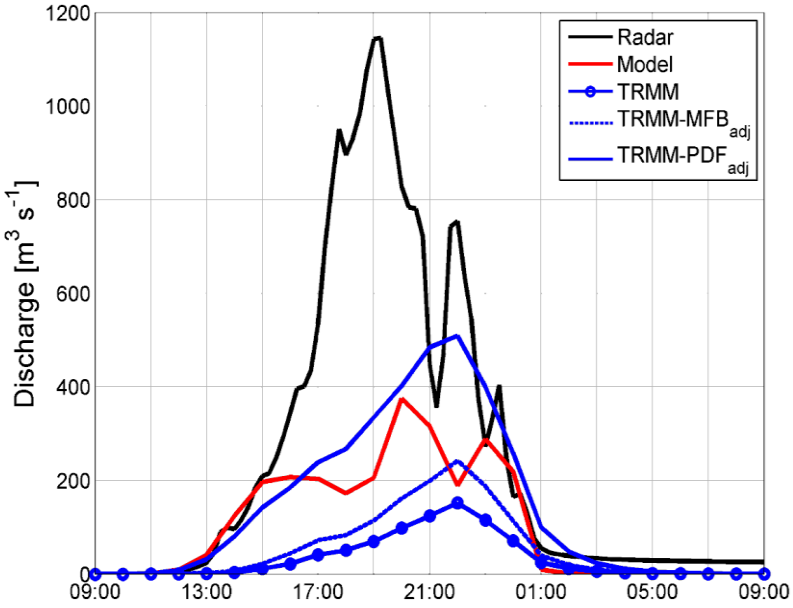


Sesia 2005

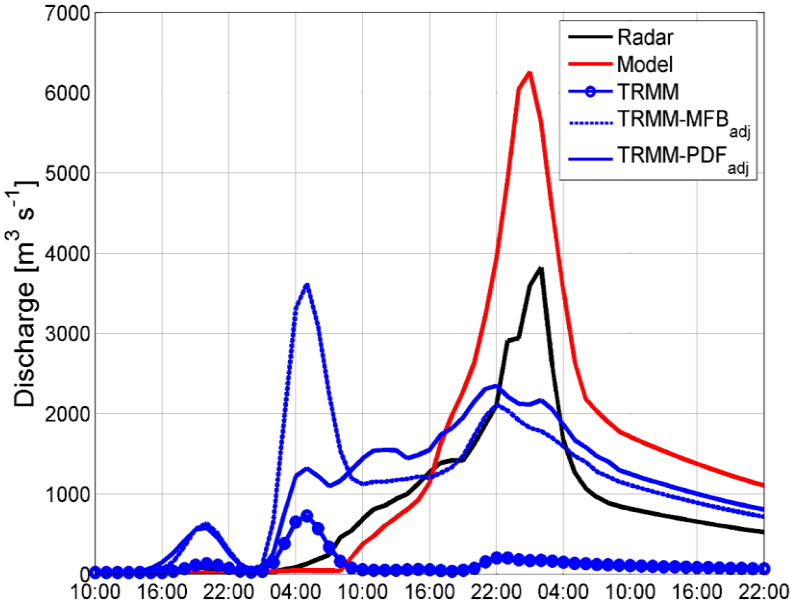


Rainfall-Runoff Simulations – Only Rainfall Bias Adjustment

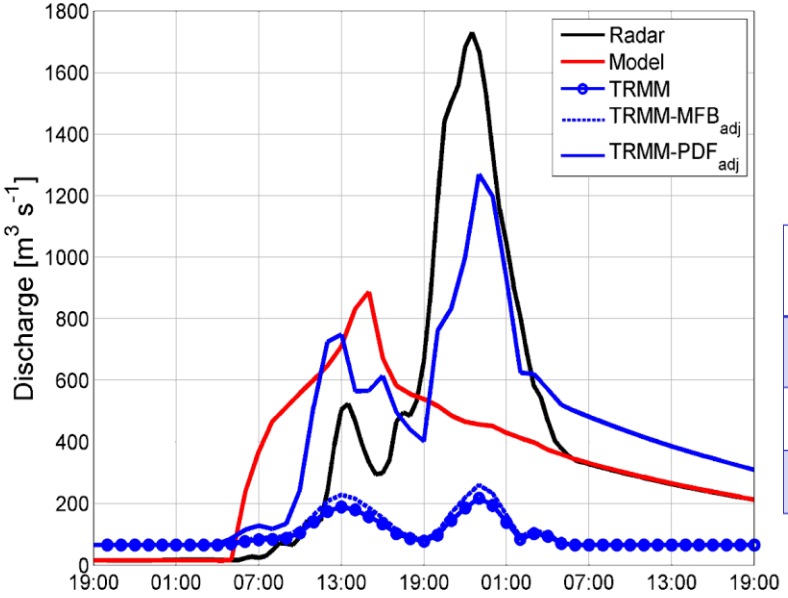
Fella 2003



Sesia 2002



Sesia 2005

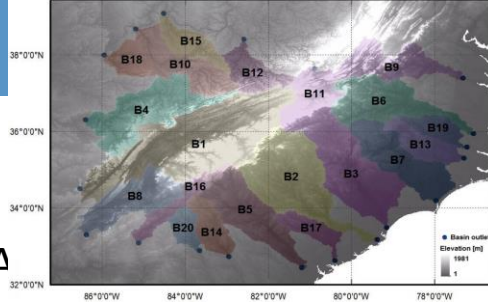


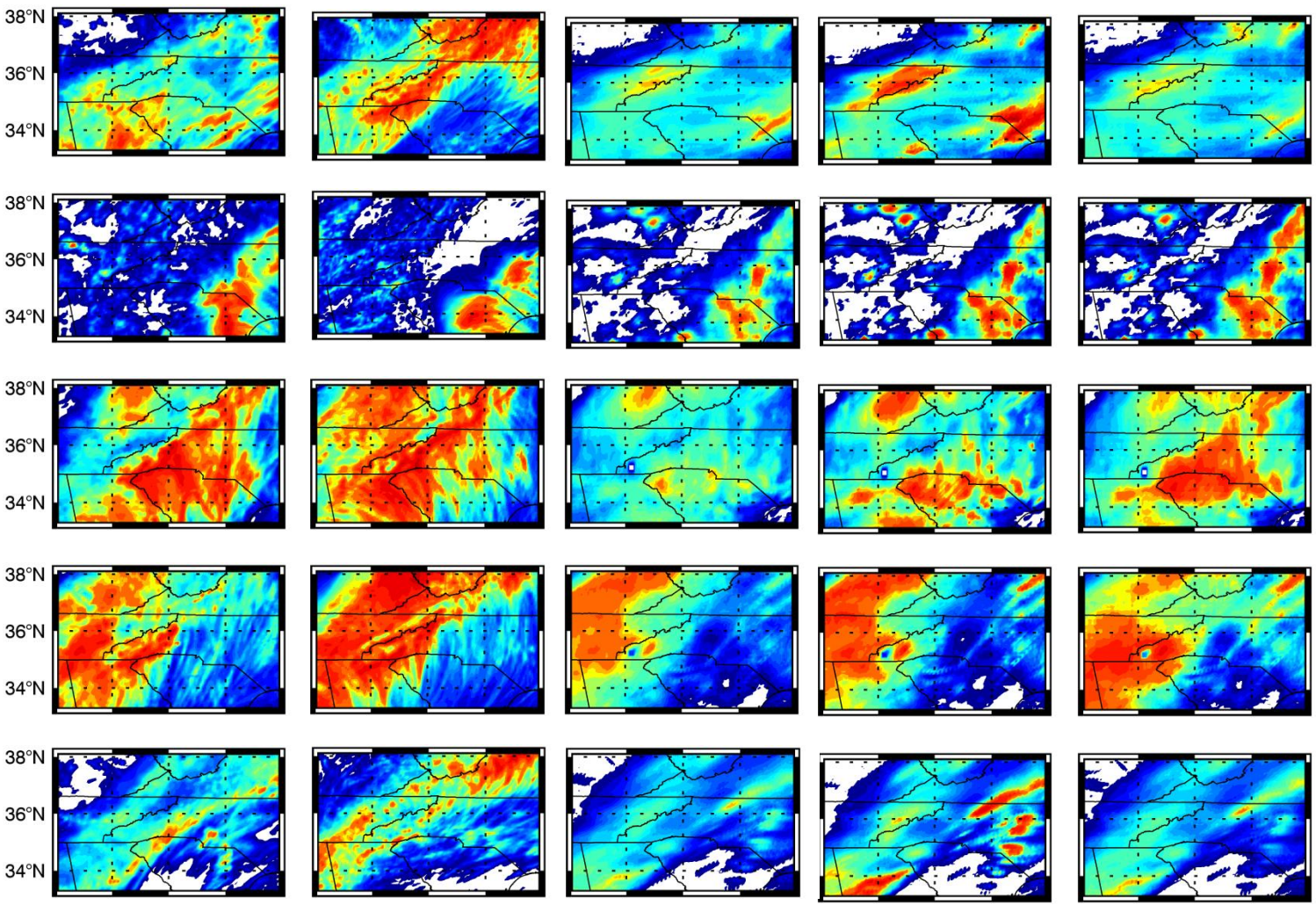
Peak Flow Simulated Bias

Event	*TRMM	*TRMM – MFB_{adj}	*TRMM – PDF_{adj}	Model
Fella 2003	0.15	0.2	0.45	0.34
Sesia 2002	0.19	0.97	0.60	1.67
Sesia 2005	0.12	0.13	0.76	0.52

Case Study 2: Mid-Atlantic Hurricanes

[*Zhang et al. 2015 JHM*]





Bill
2003-07-01
to 2003-07-03

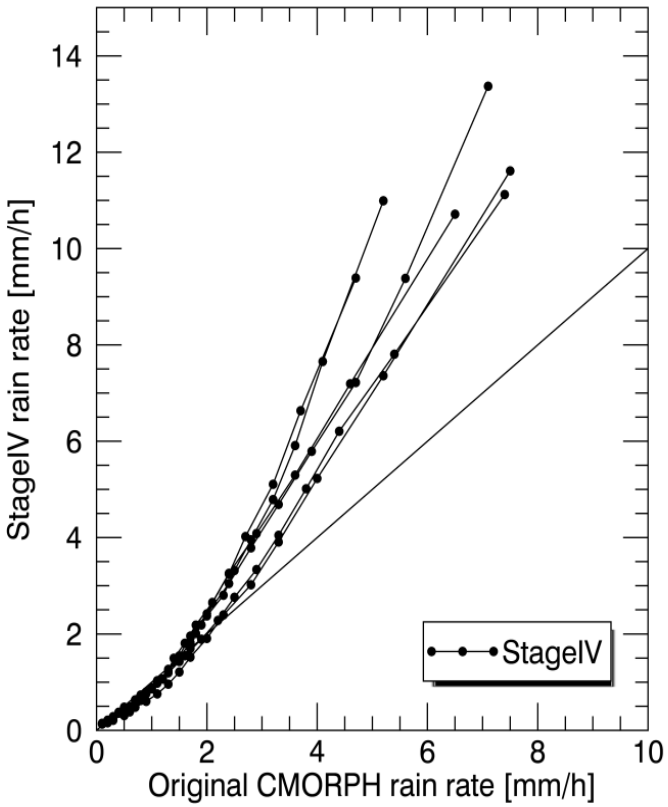
Gaston
2004-08-29
to 2004-08-31

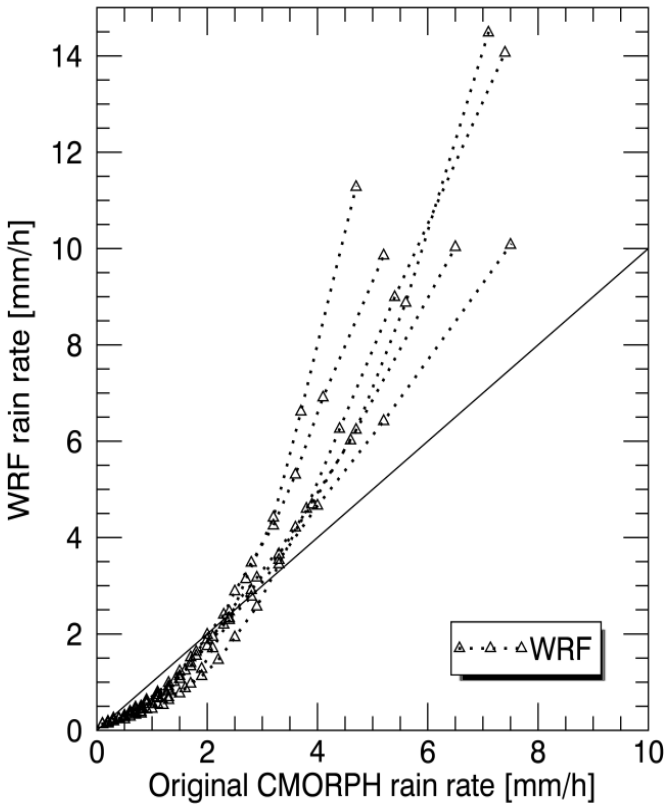
Frances
2004-09-07
to 2004-09-09

Ivan
2004-09-16
to 2004-09-18

Cindy
2005-07-06
to 2005-07-09

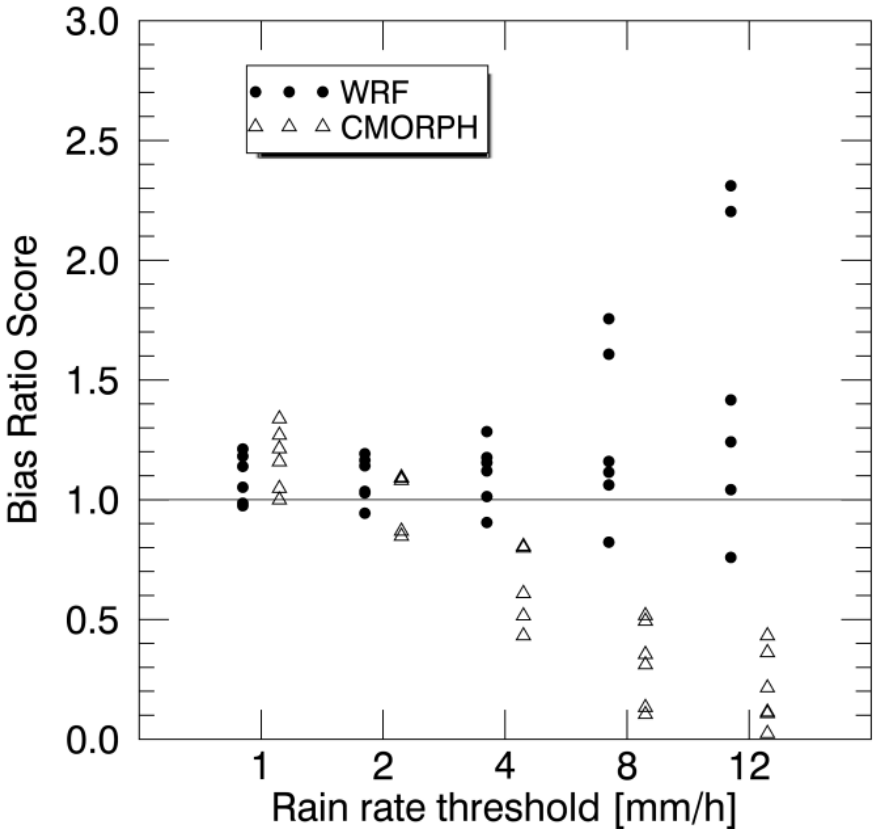
Error Correction function

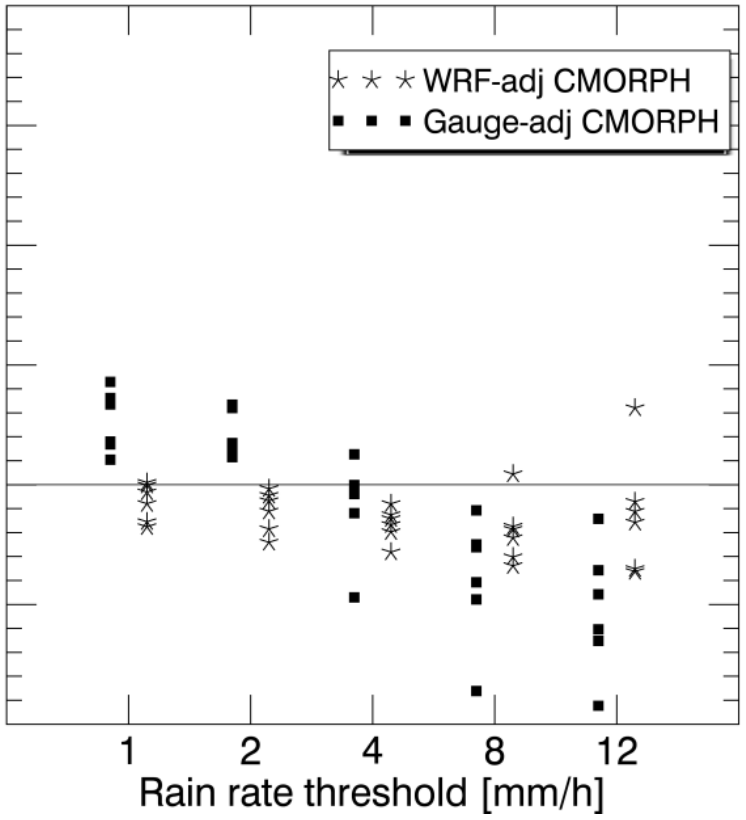




[*Zhang et al. 2015 JHM*]

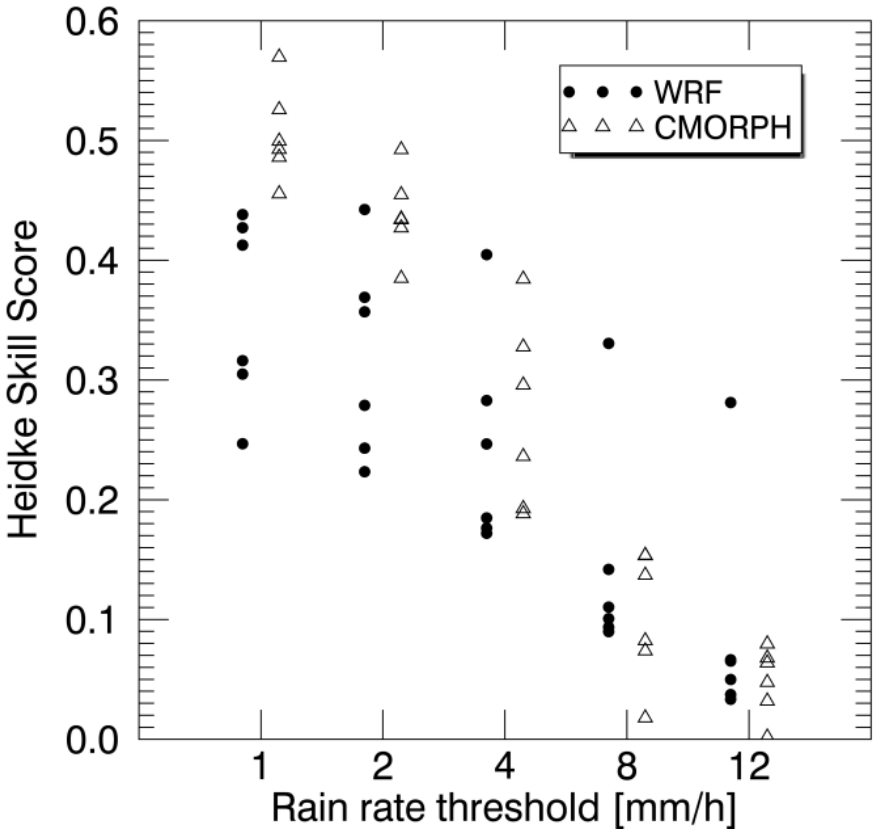
Error Metrics

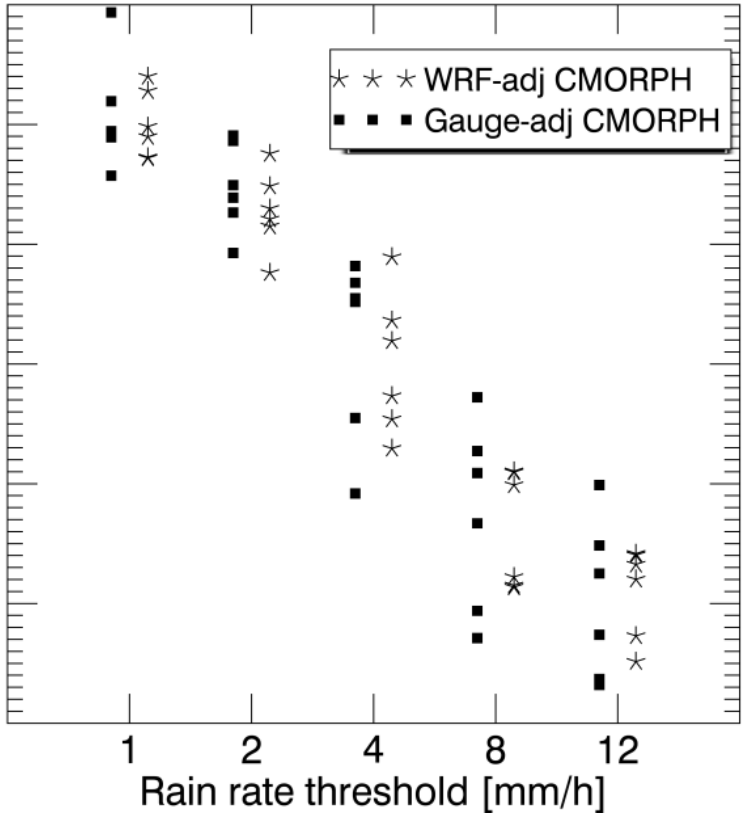




[*Zhang et al. 2015 JHM*]

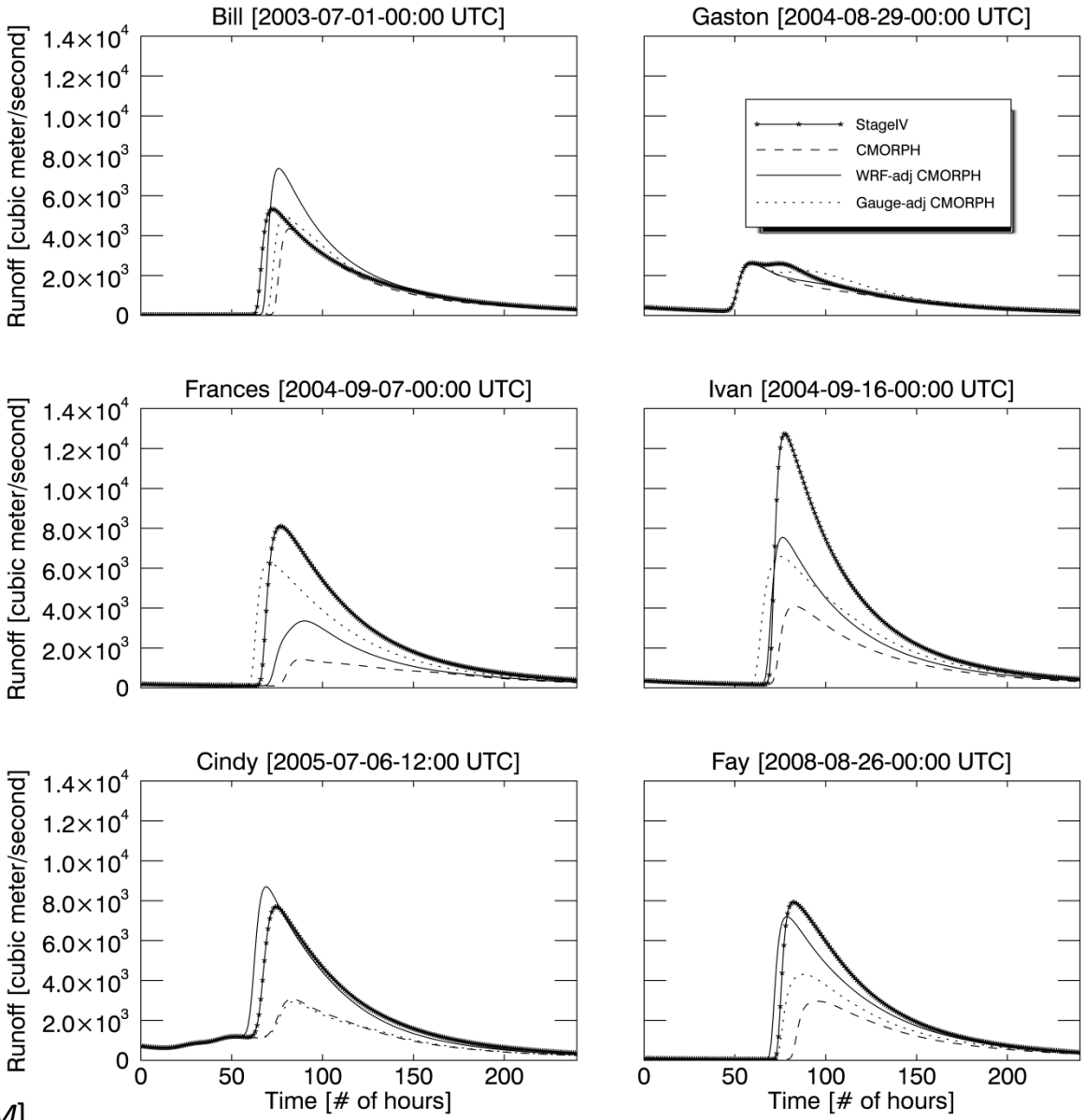
Error Metrics





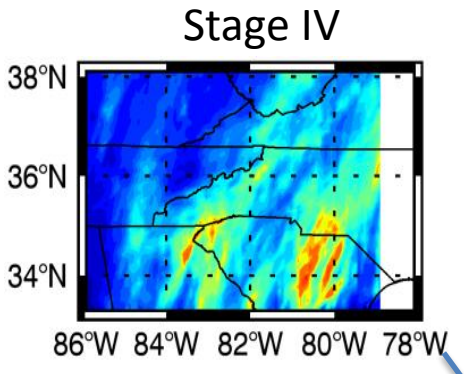
[*Zhang et al. 2015 JHM*]

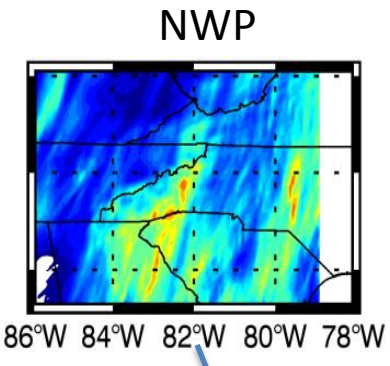
Error Metrics

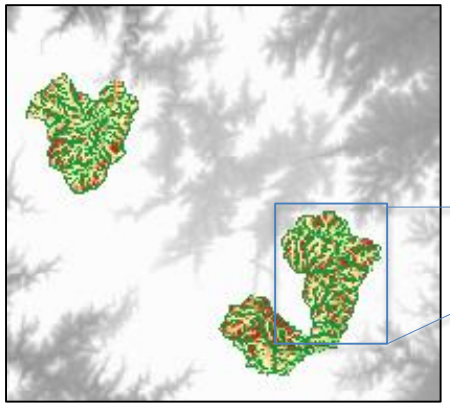


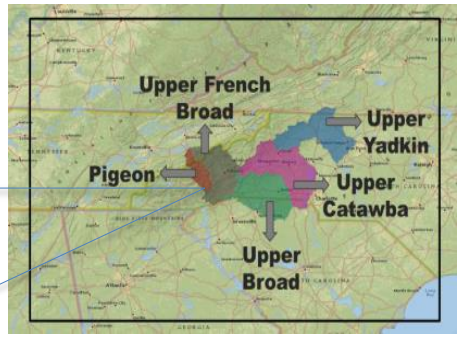
[*Zhang et al. 2015 JHM*]

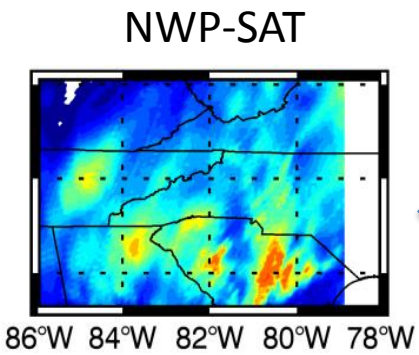
Runoff Error Analysis - May 15 2014 IPHeX Case

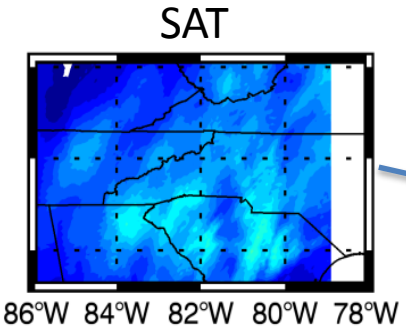


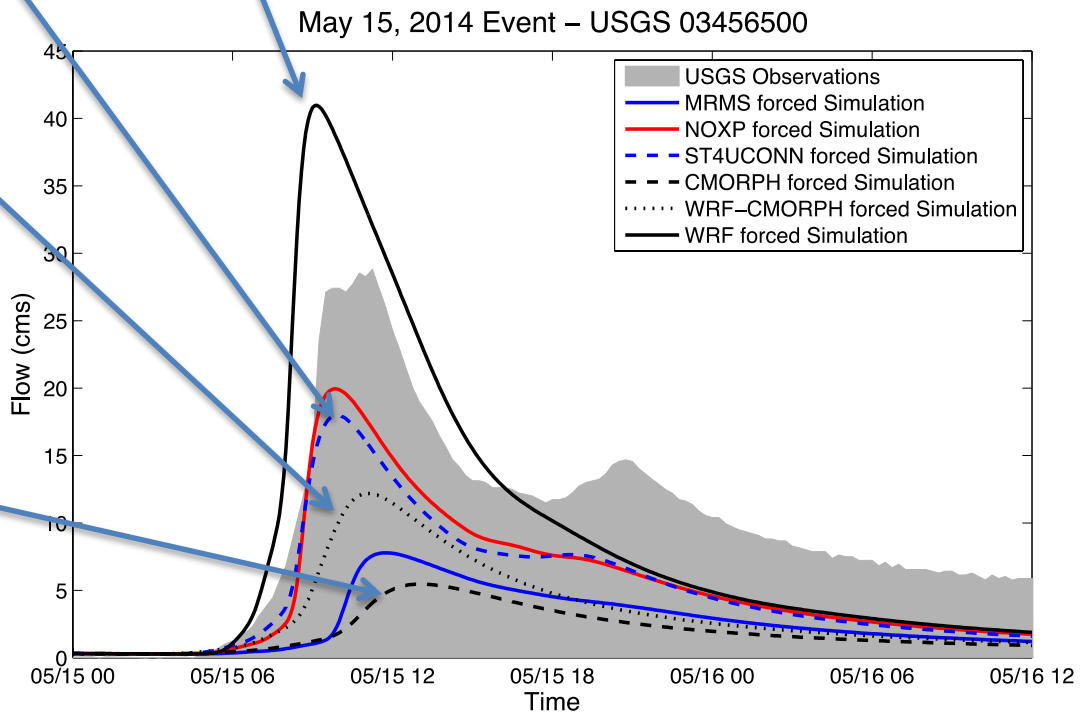












Concluding Remarks

Overall error analyses results show that satellite precipitation exhibits complex error propagation characteristics in flood simulations including dependencies on basin scale, elevation and storm type and severity.

High-resolution (<2km) NWP simulations of mountainous heavy precipitation events can provide realistic rainfall fields that can be used to derive adjustments to satellite estimates.

More realistic hydrologic simulations are achieved using rainfall forcing from the NWP-adjusted satellite estimates relative to non-adjusted satellite or NWP rainfall fields.