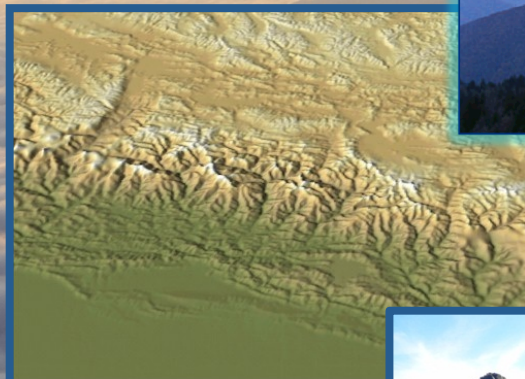
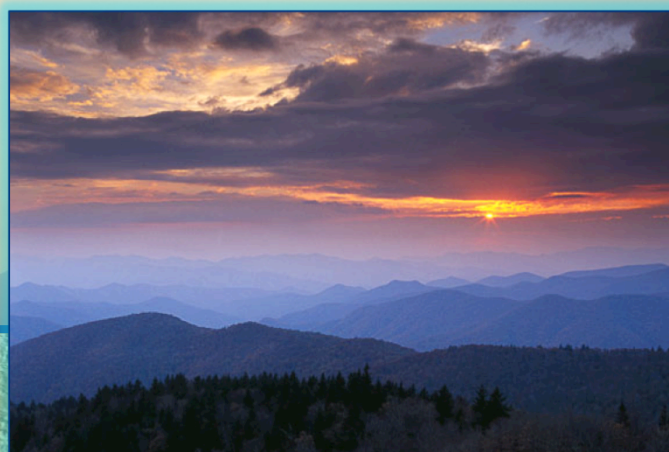




Ground Validation in Regions of Complex Topography

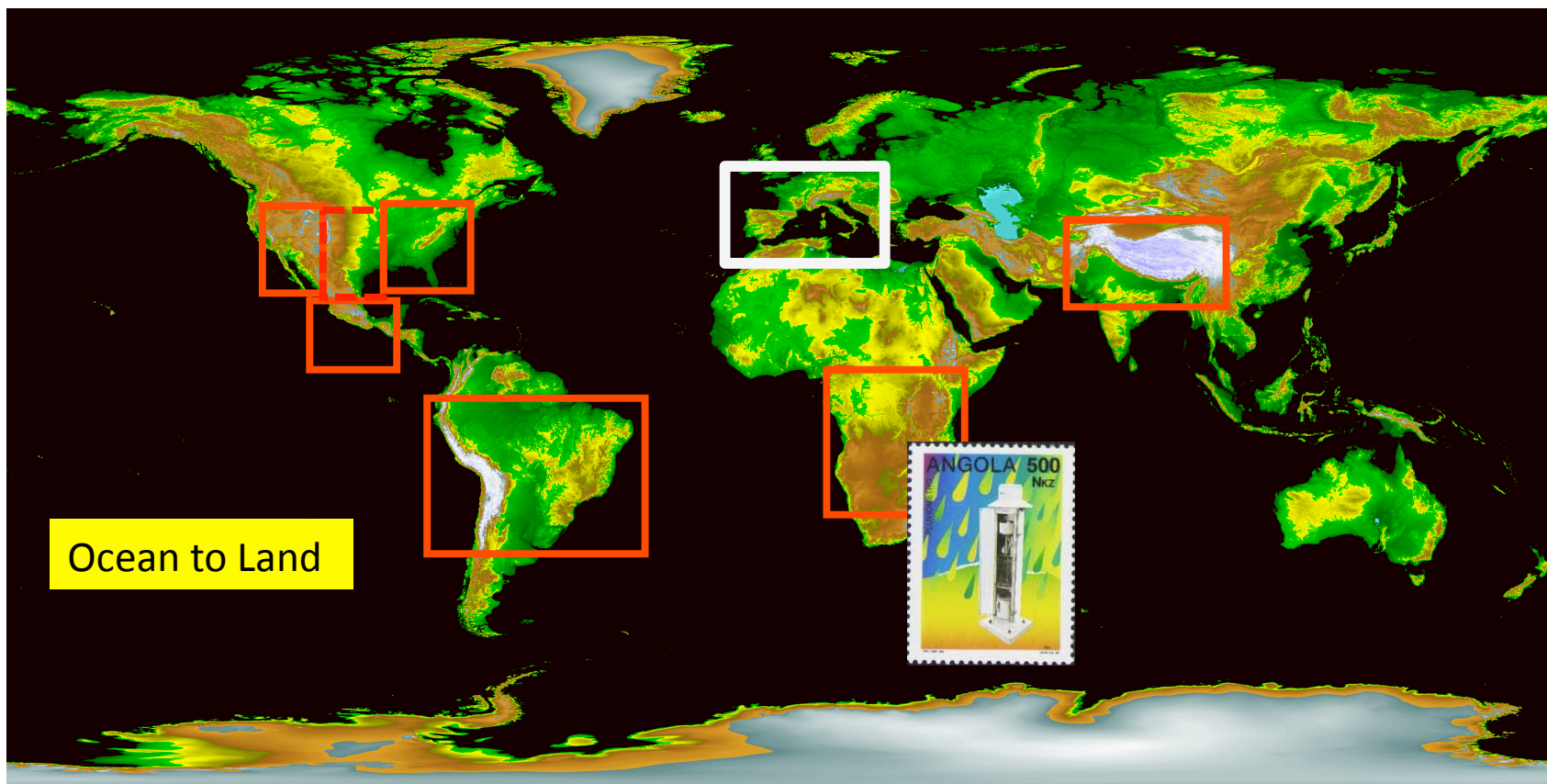
Mapping the 4D structure of rainfall : implications for hydrologic services and water resources management



Ana P. Barros
Duke University

PMM 2011, November 9 2011

“GPM 2014 -2024”

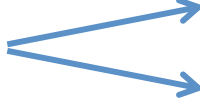


Ocean to Land

Heavy to Light to Snow



Flat to Complex

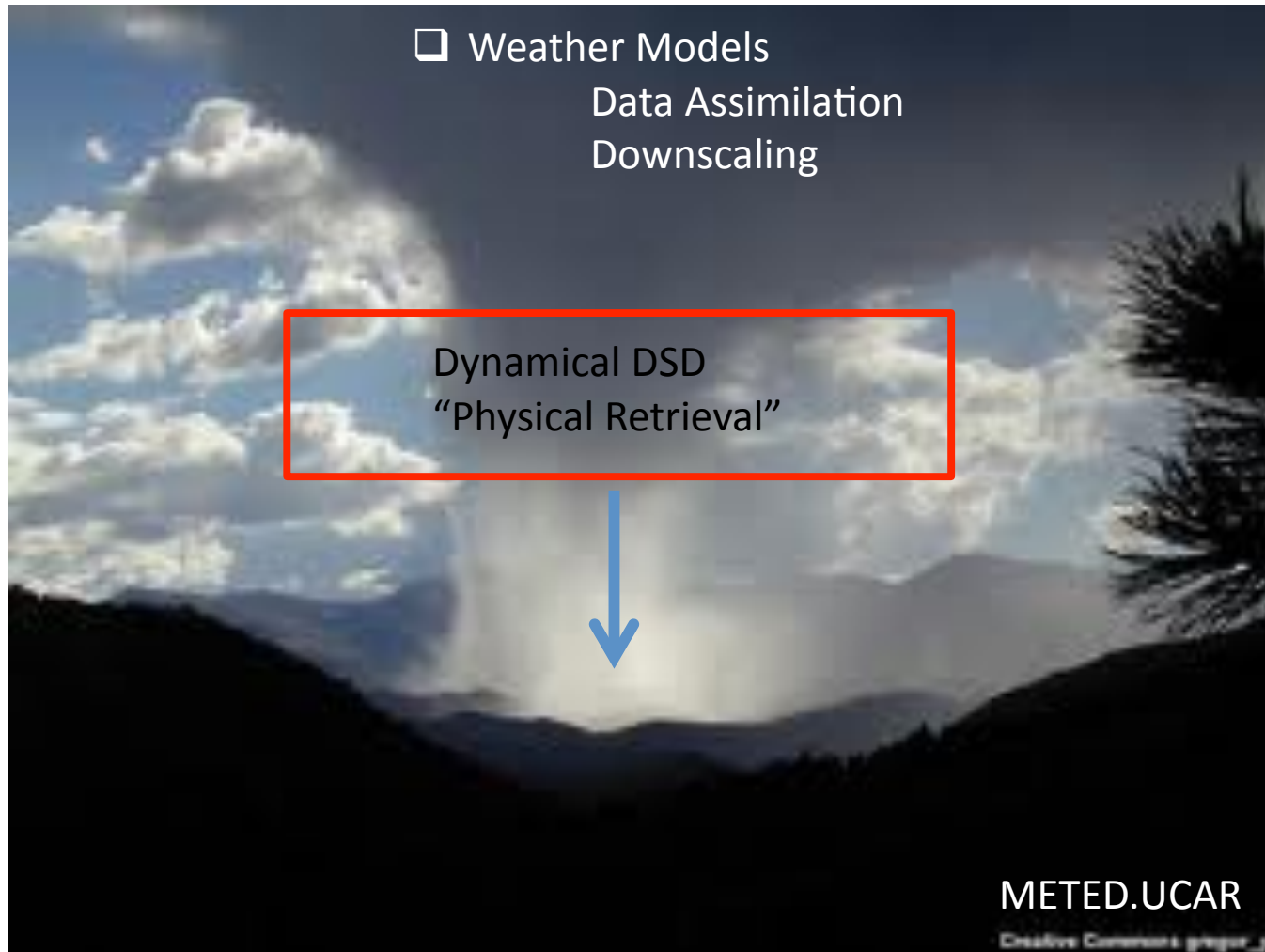


Foothills
Mid-Mountains
Plateaus
Cordilleras

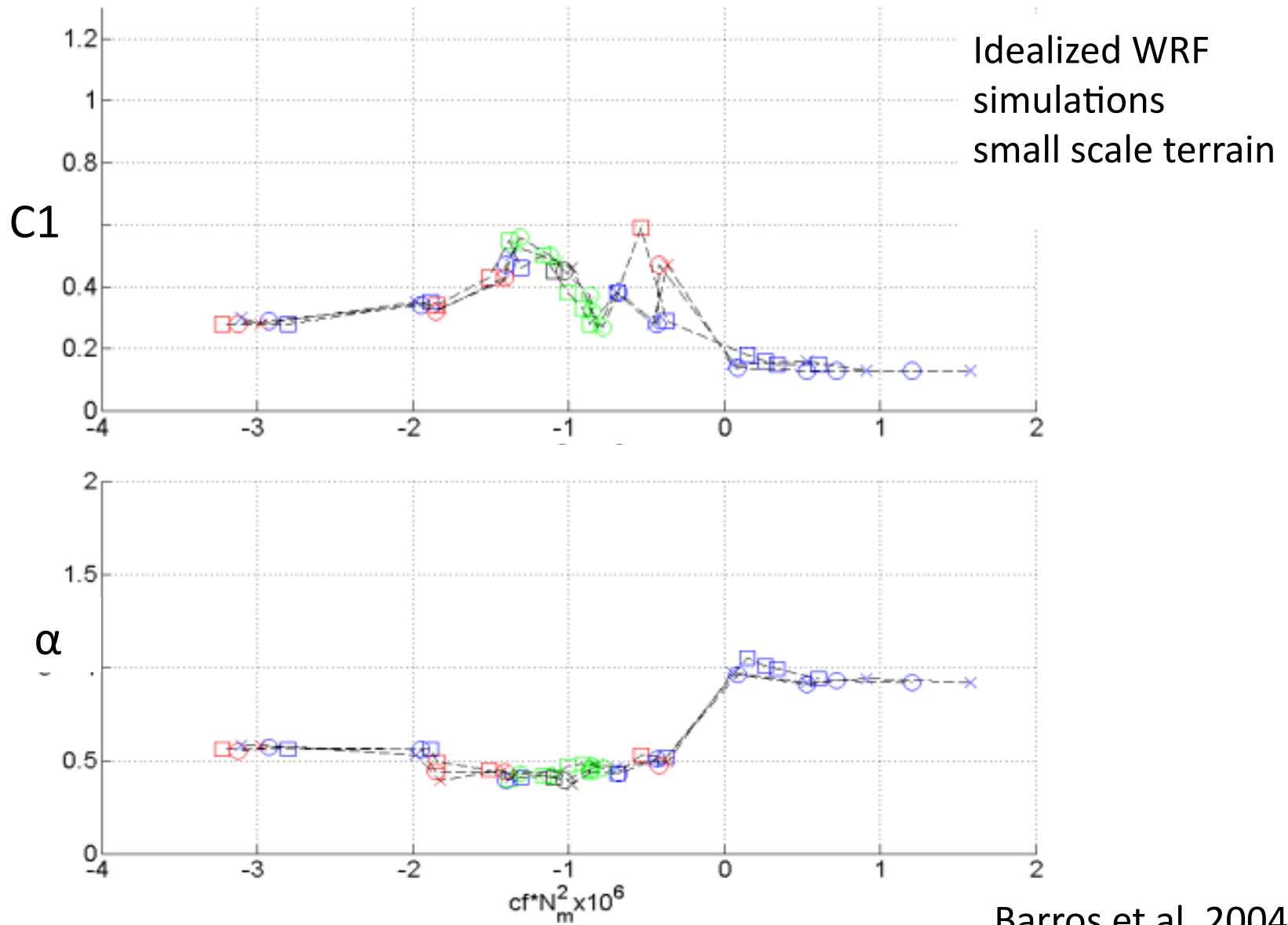


4D Structure Of Rainfall

- Hydrology
- Satellite Based Estimation



Scaling Behavior of Shallow Embedded Convection



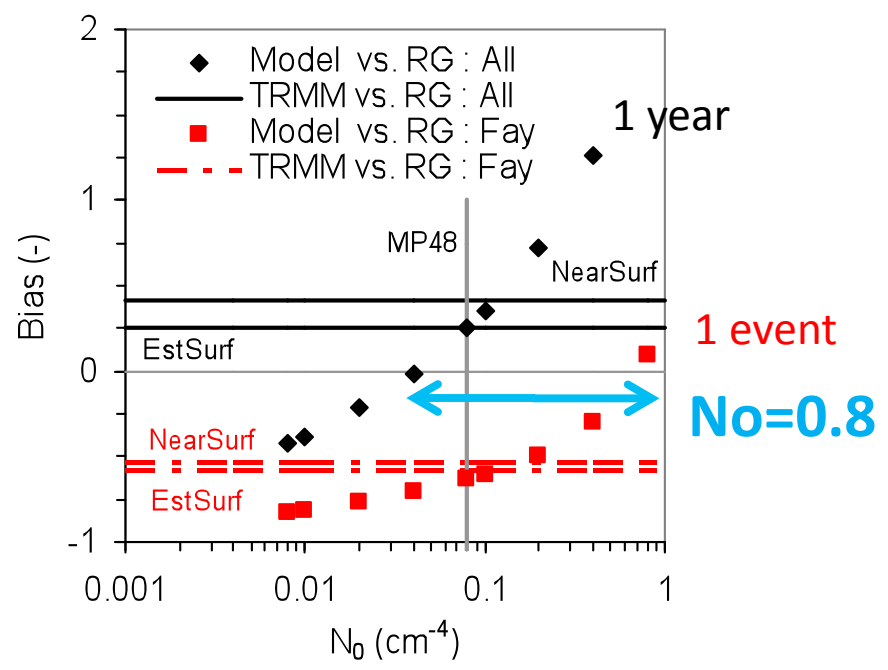
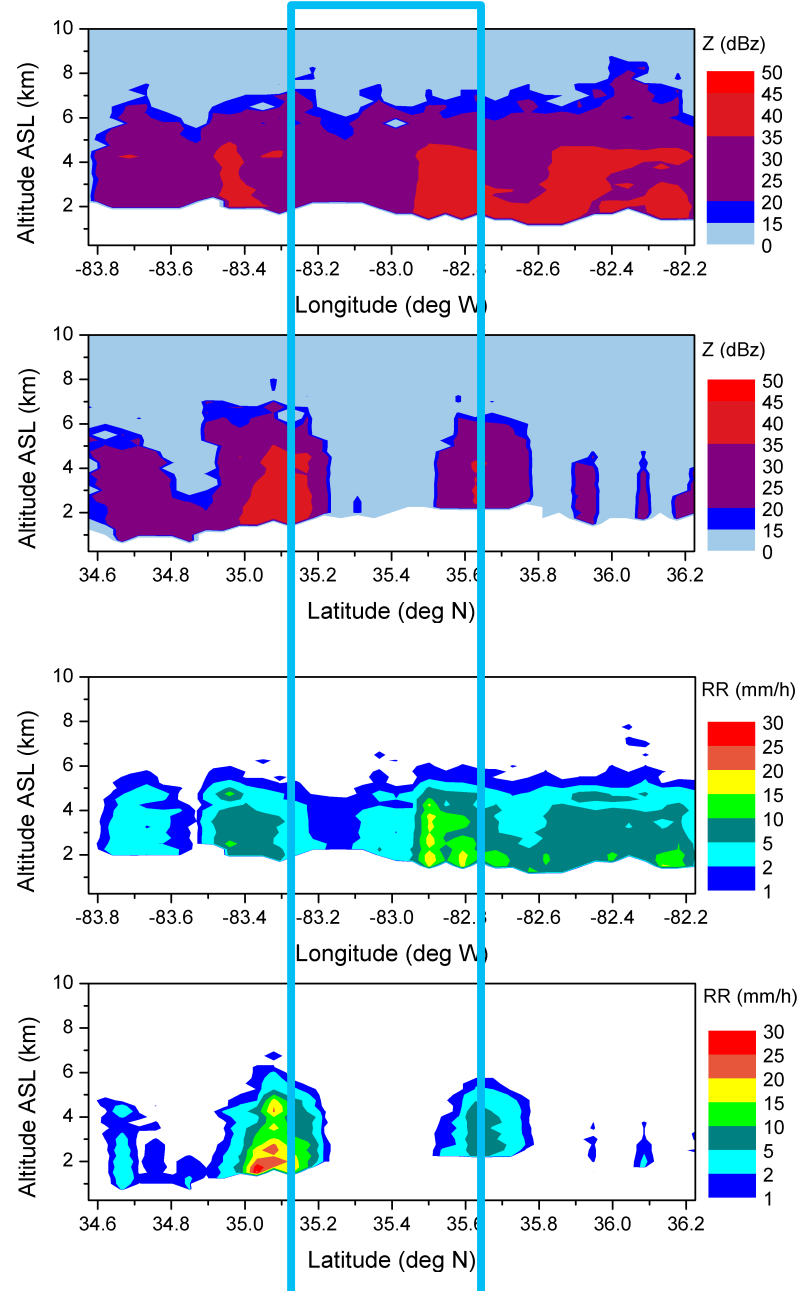
“Realized Instability”

Barros et al. 2004
Nogueira et al. 2011



TRMM-PR

2007-2008

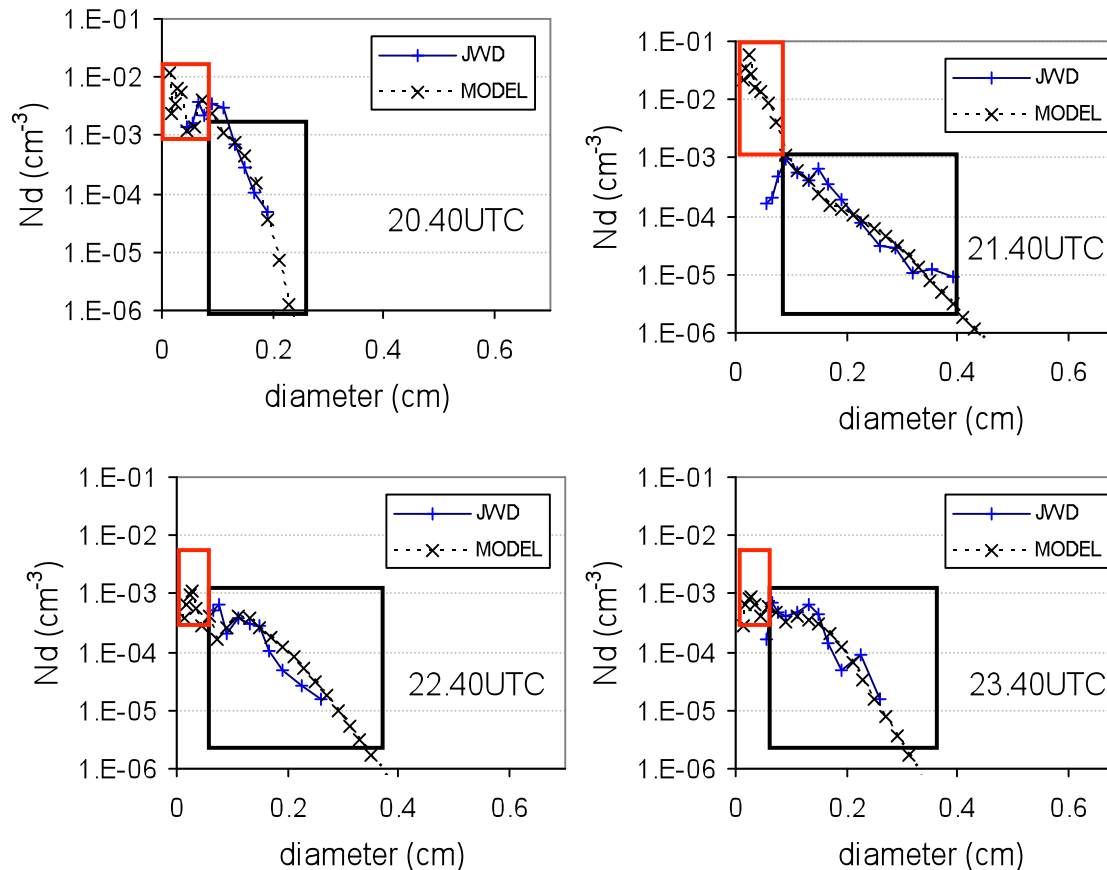


Prat and Barros 2010b

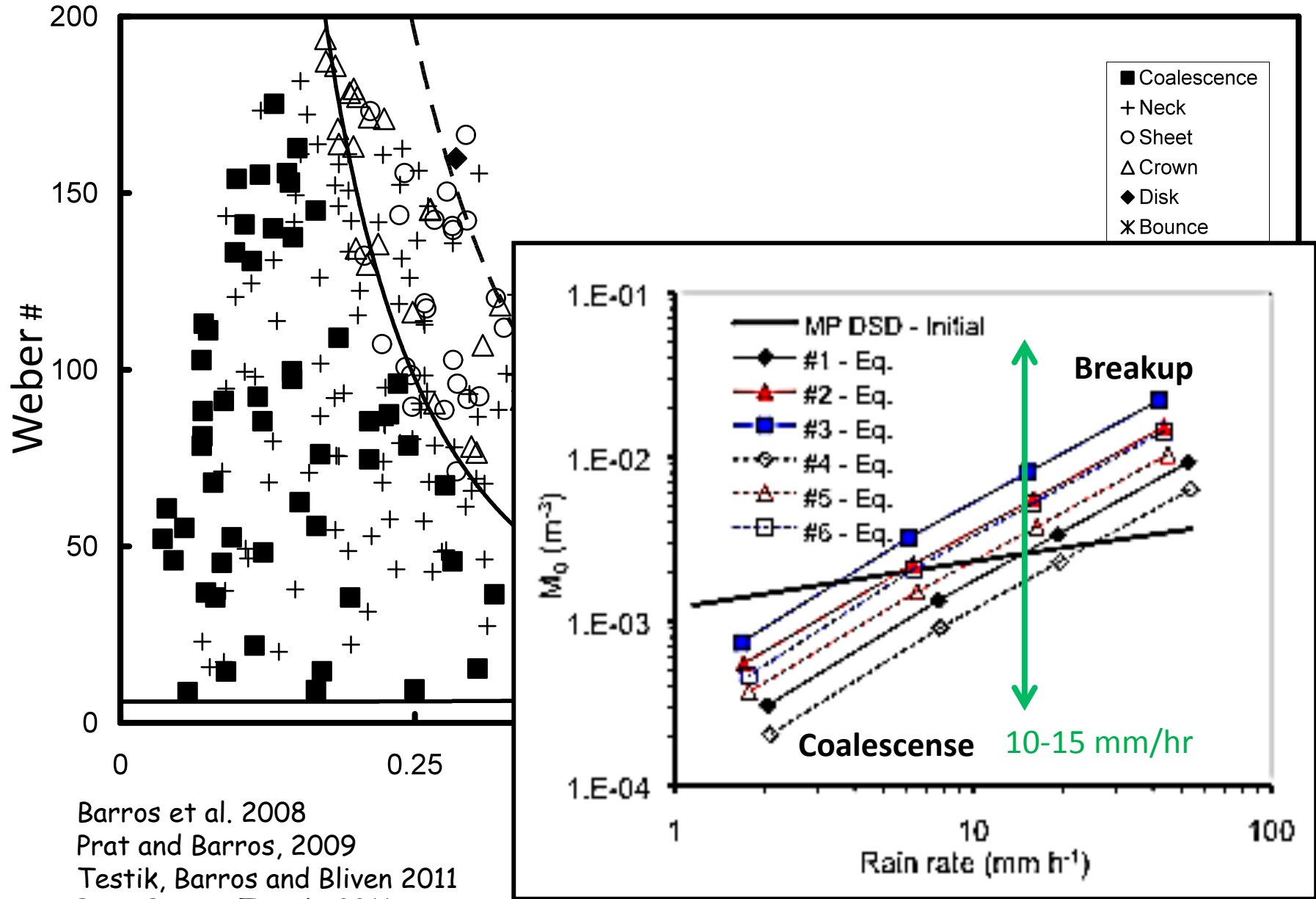
1D-Model/Disdrometer DSD Comparison for TWP-ICE



- For $d > 0.1\text{cm}$, numerical results forced by VPR and JWD data match closely drop number concentrations down to $1.E-05\text{ cm}^{-3}$.

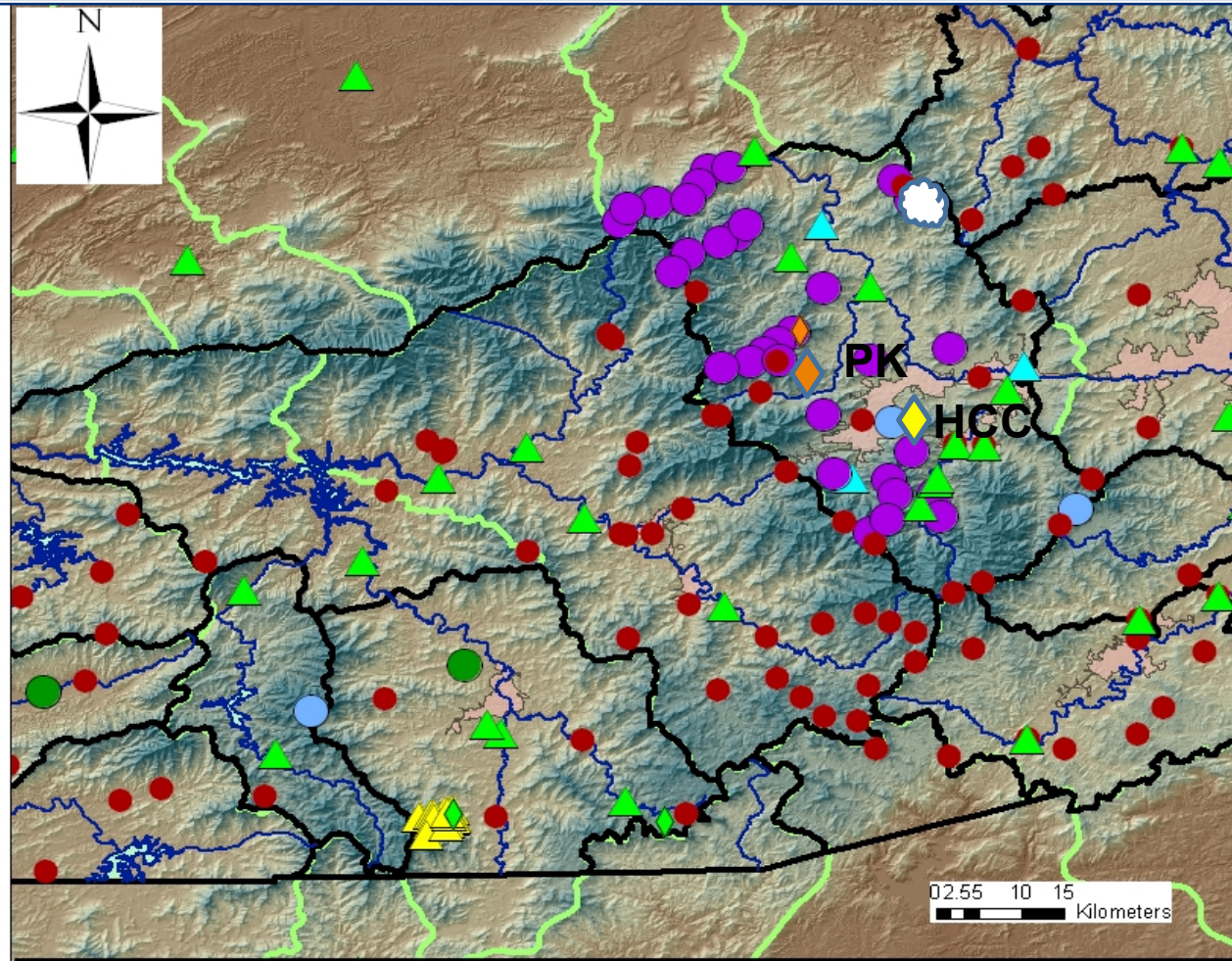


- Major differences model/JWD DSD are found in the left-hand side of the spectra ($d < 0.03\text{cm}$). What is the "real" error?

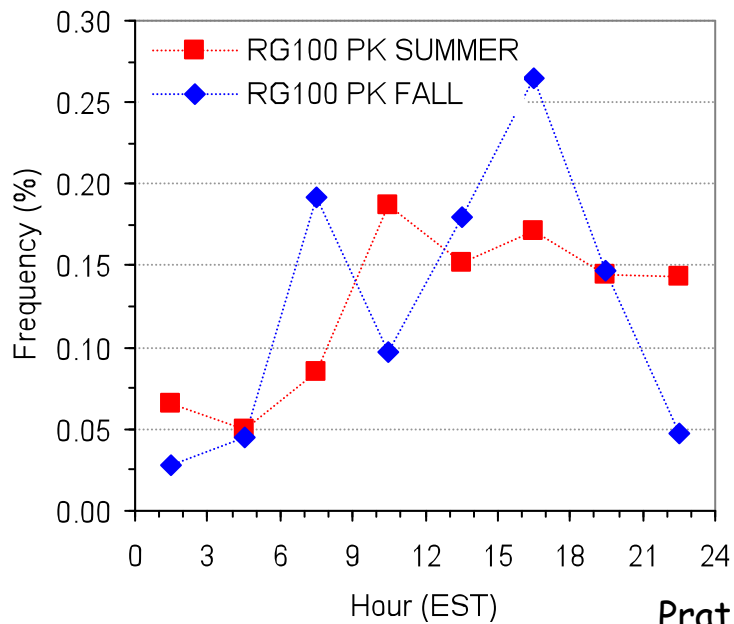
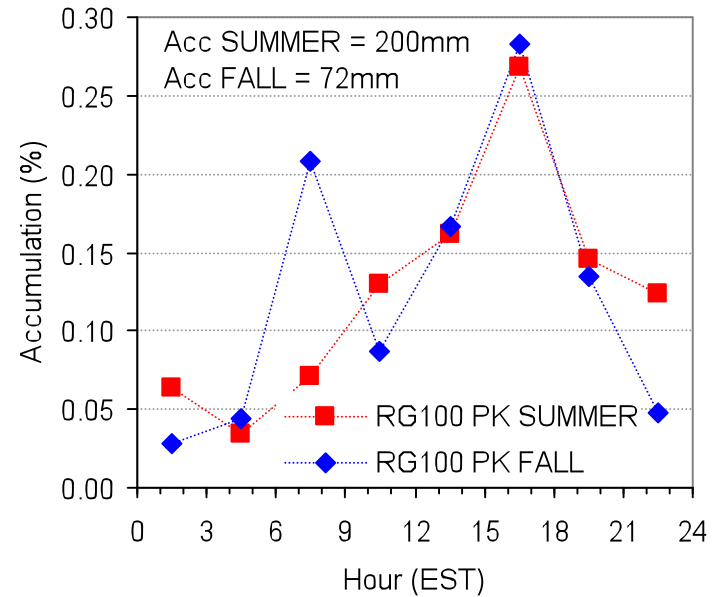
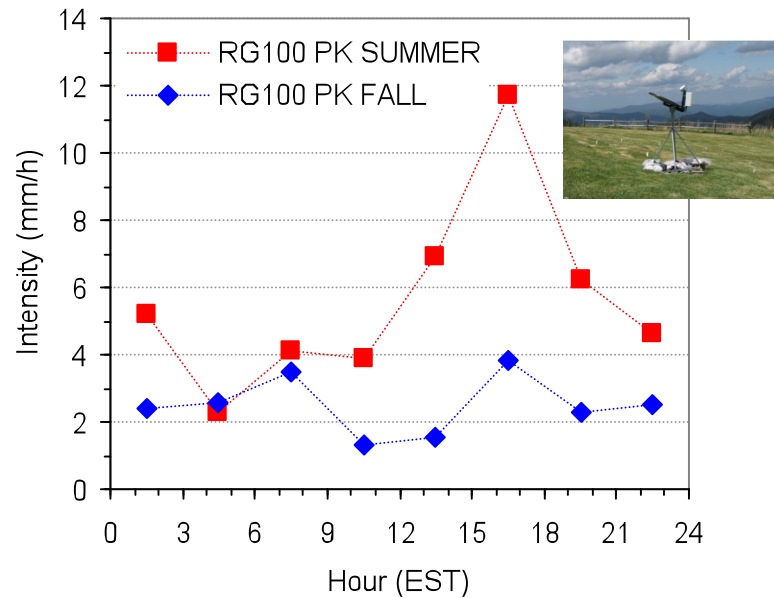




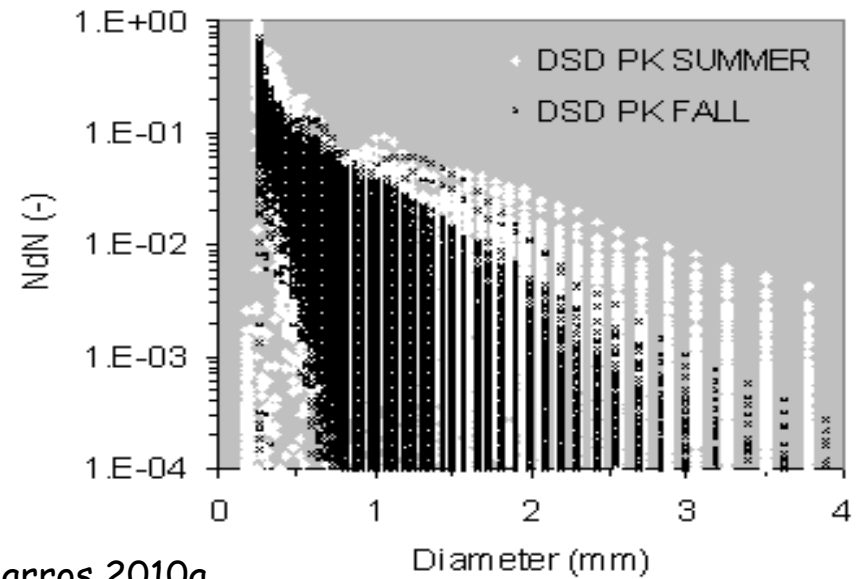
Purchase Knob Research Station



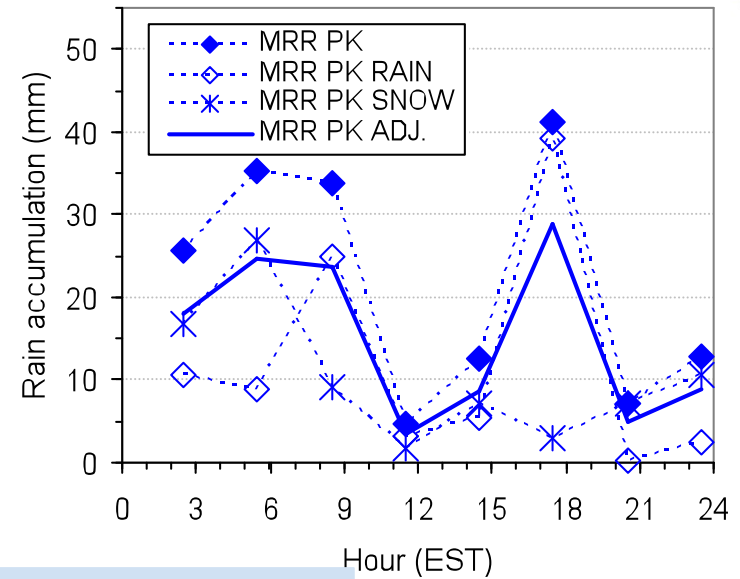
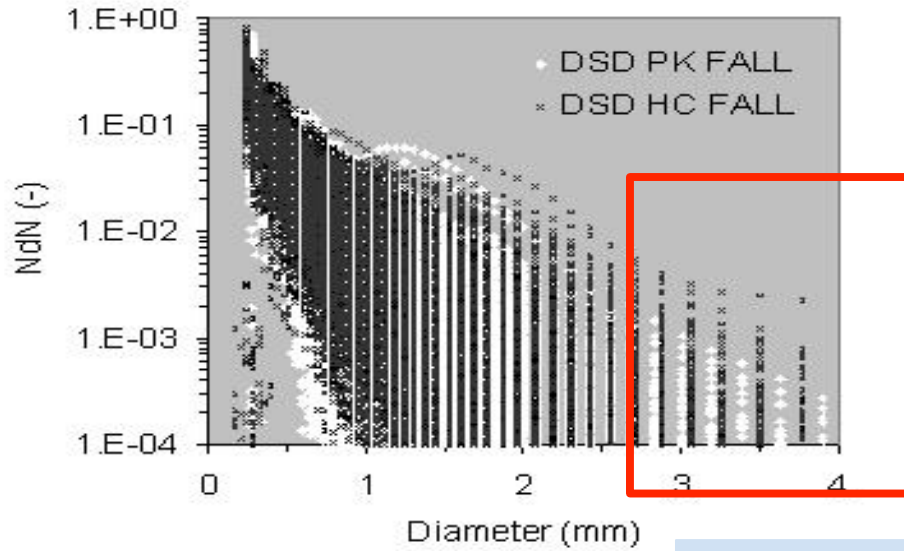
- | | | | |
|--|--------------------------------|----------------------|--------------------|
| | Coweeta LTER Weirs | | Hydrologic Network |
| | Tennessee Valley Authority | | Urban Area |
| | Purchase Knob Research Station | | NC River Subbasins |
| | Additional Research Stations | | TN River Subbasins |
| | Flood Warning System | Elevation (m) | |
| | AWOS | | High : 2025 |
| | ASOS | | Low : 184 |
| | ECONET | | |



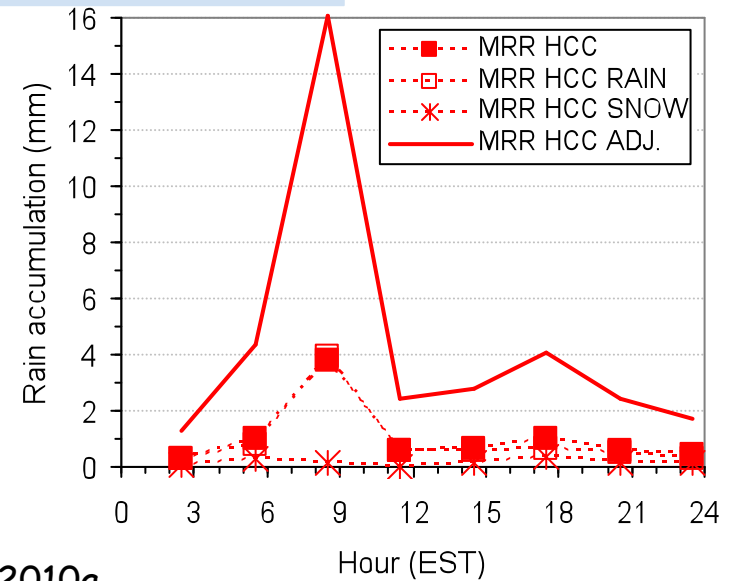
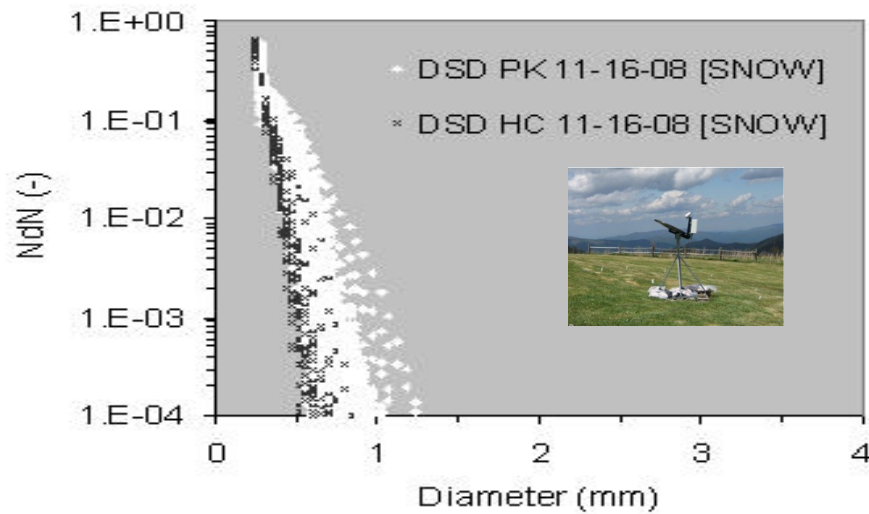
Mountain Ridge : Summer / Fall



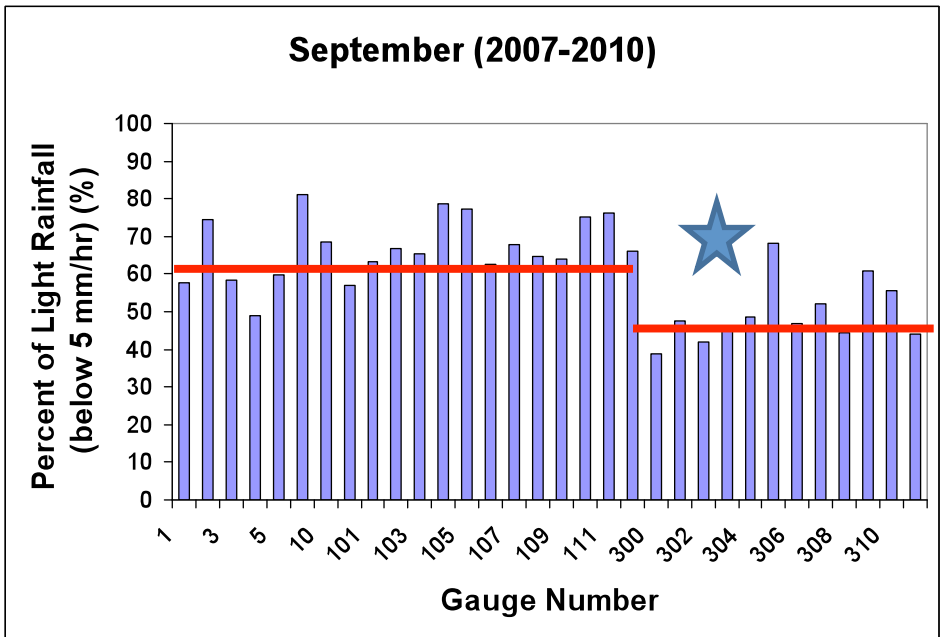
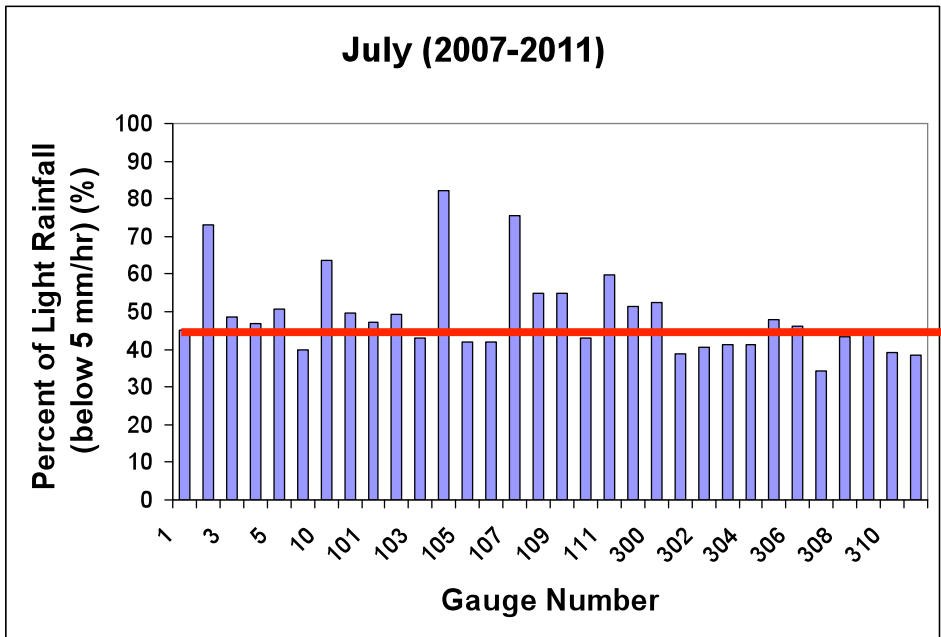
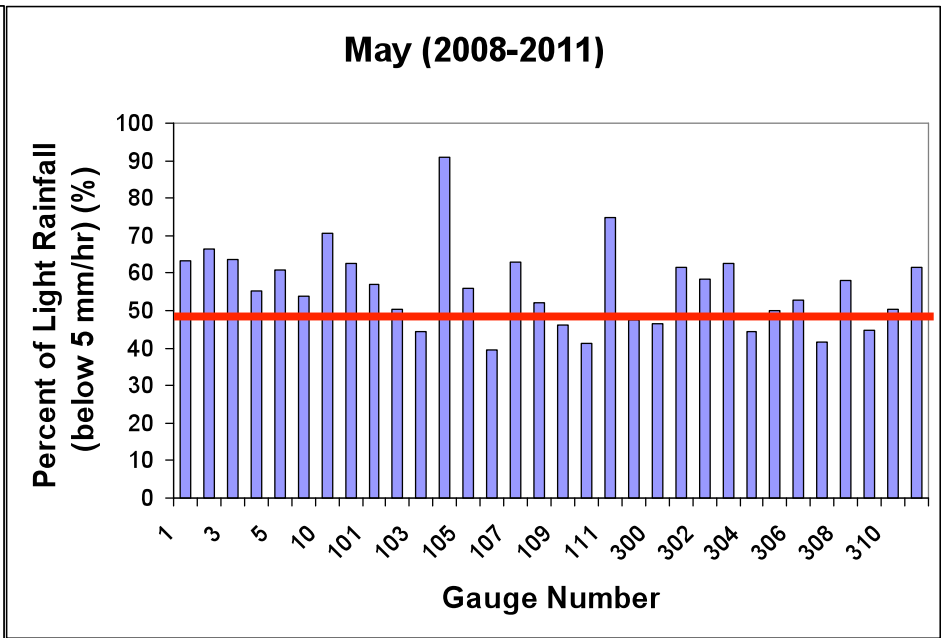
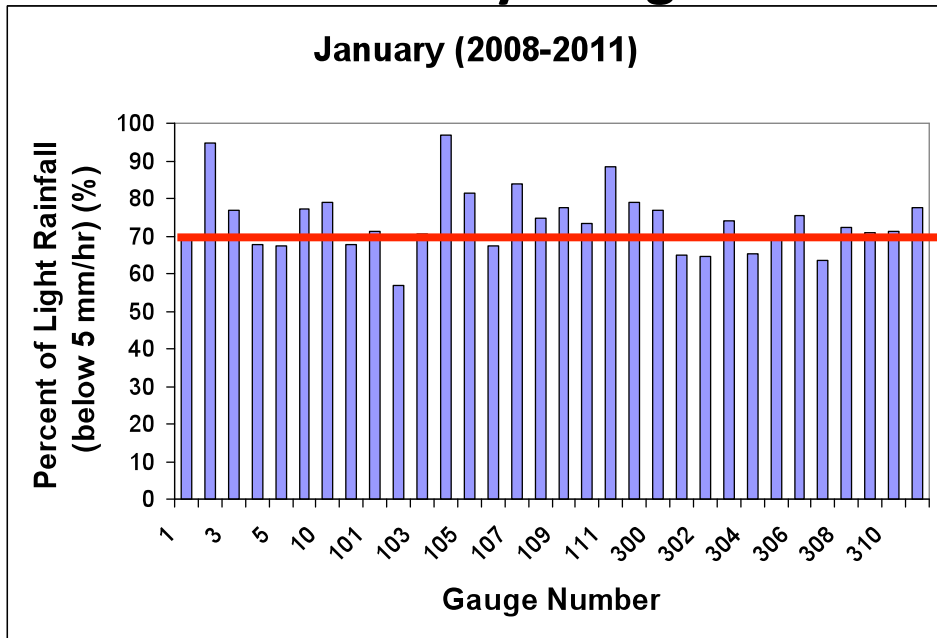
Fall : Mountain Ridge / Valley

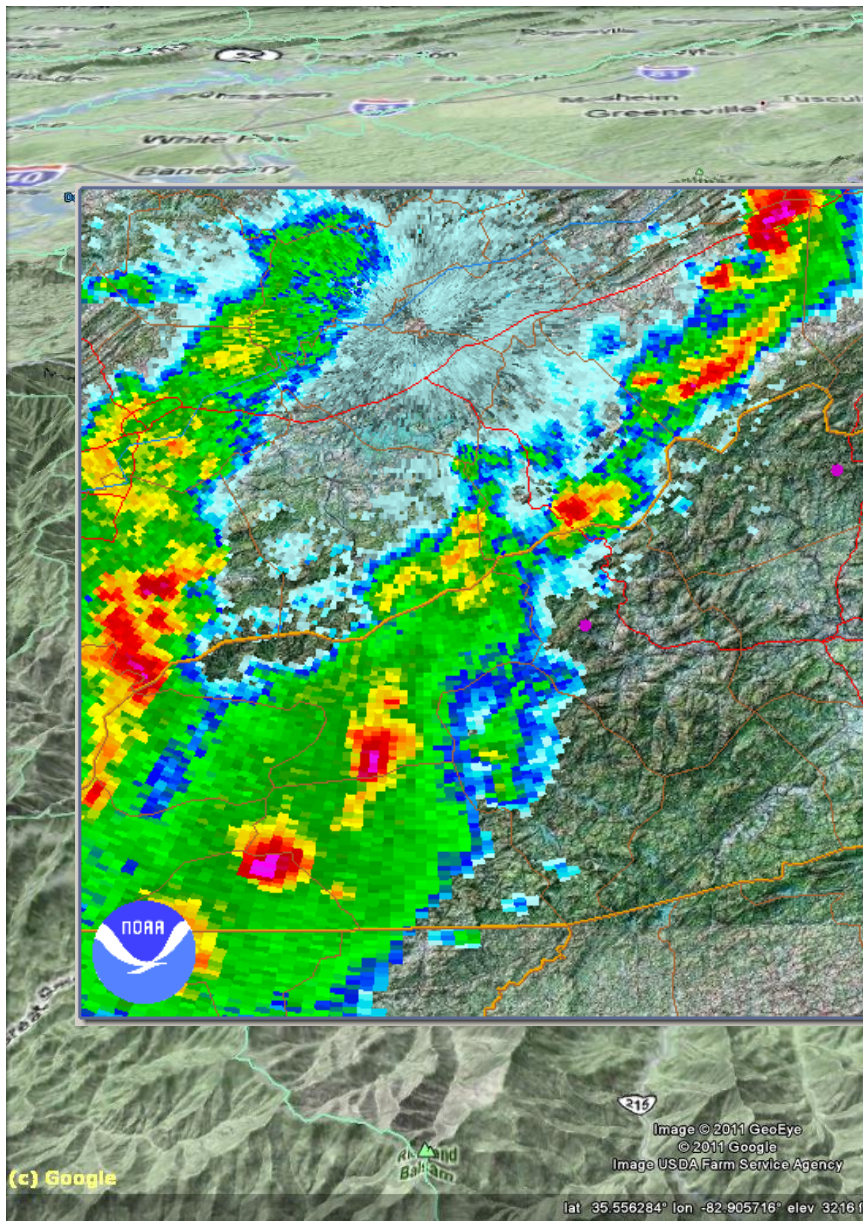


Seeder-Feeder/"Fog"

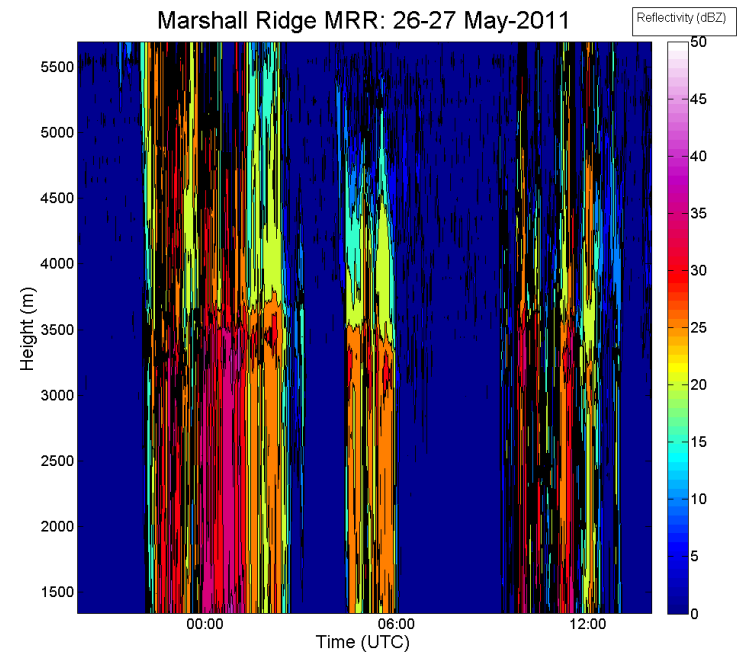


Seasonal Variability of Light Rainfall

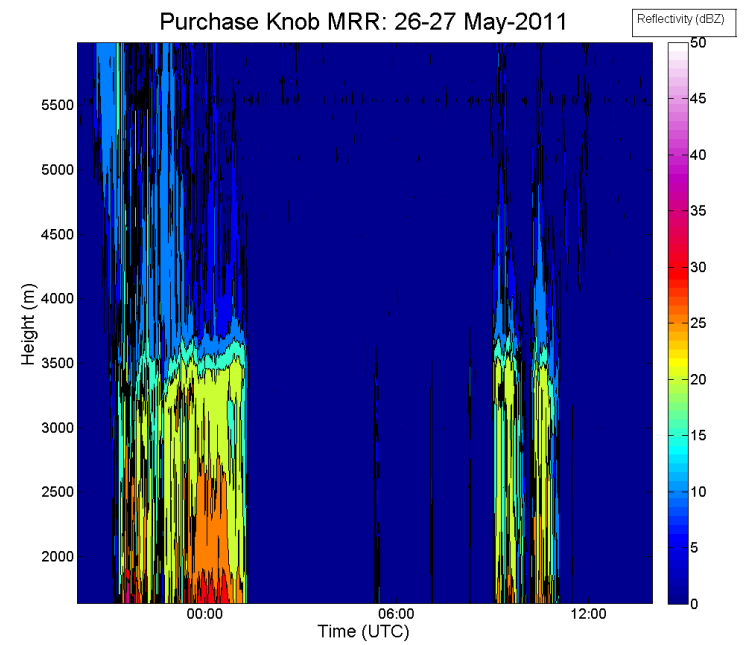




Marshall Ridge MRR: 26-27 May-2011

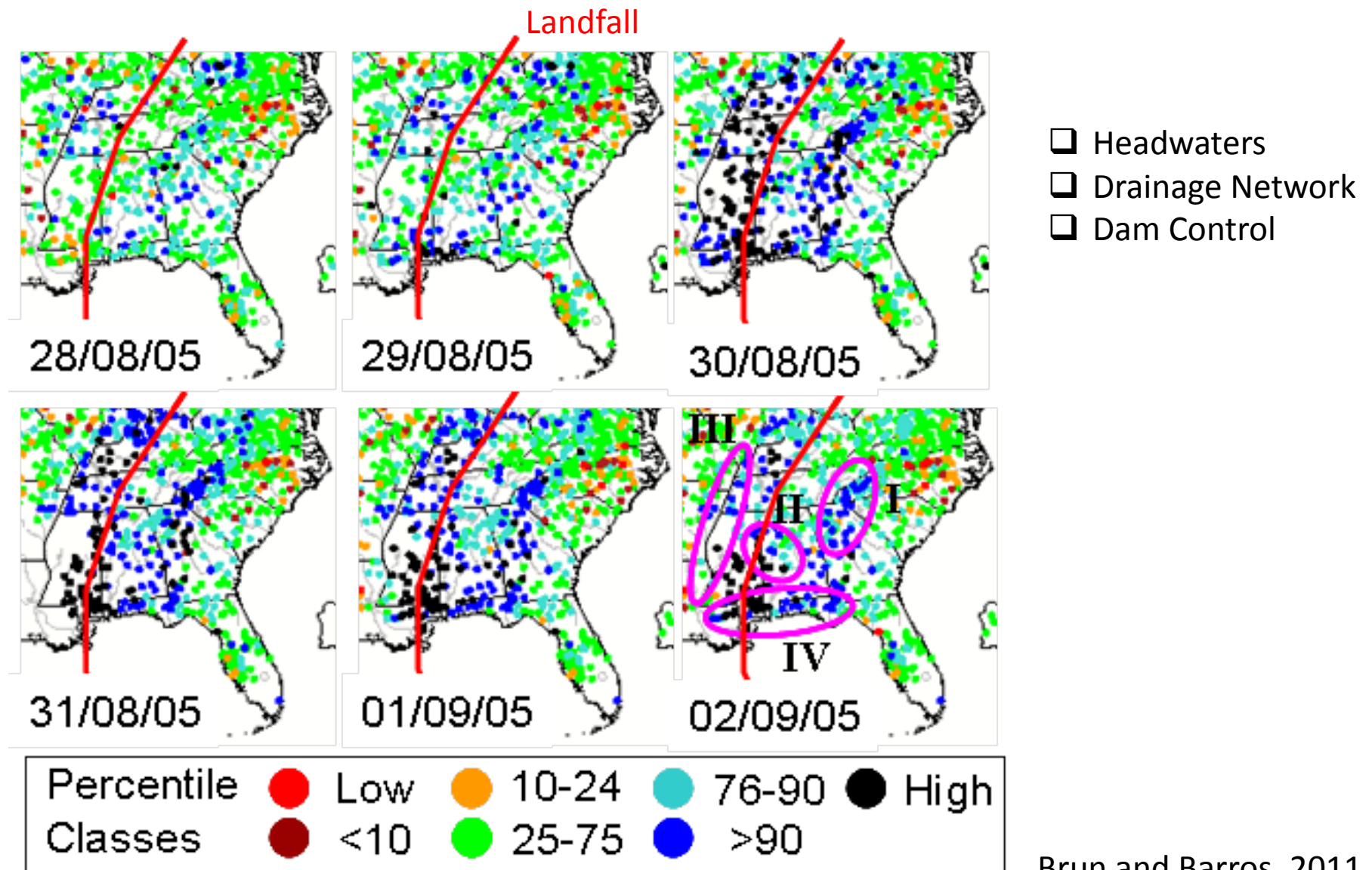


Purchase Knob MRR: 26-27 May-2011



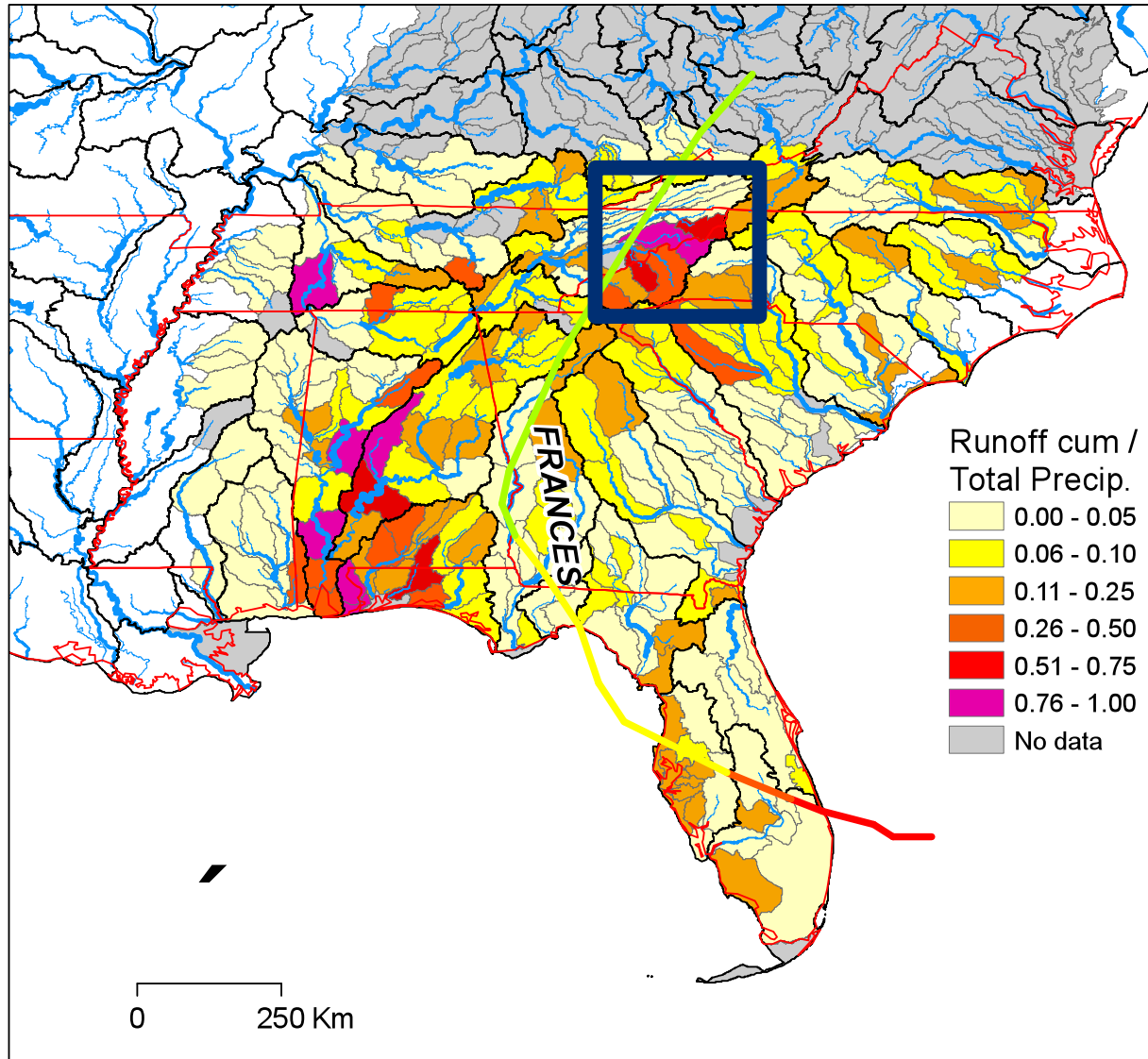
Hurricanes – Tropical Storms

Katrina Flood Response



Brun and Barros, 2011
Adapted from USGS

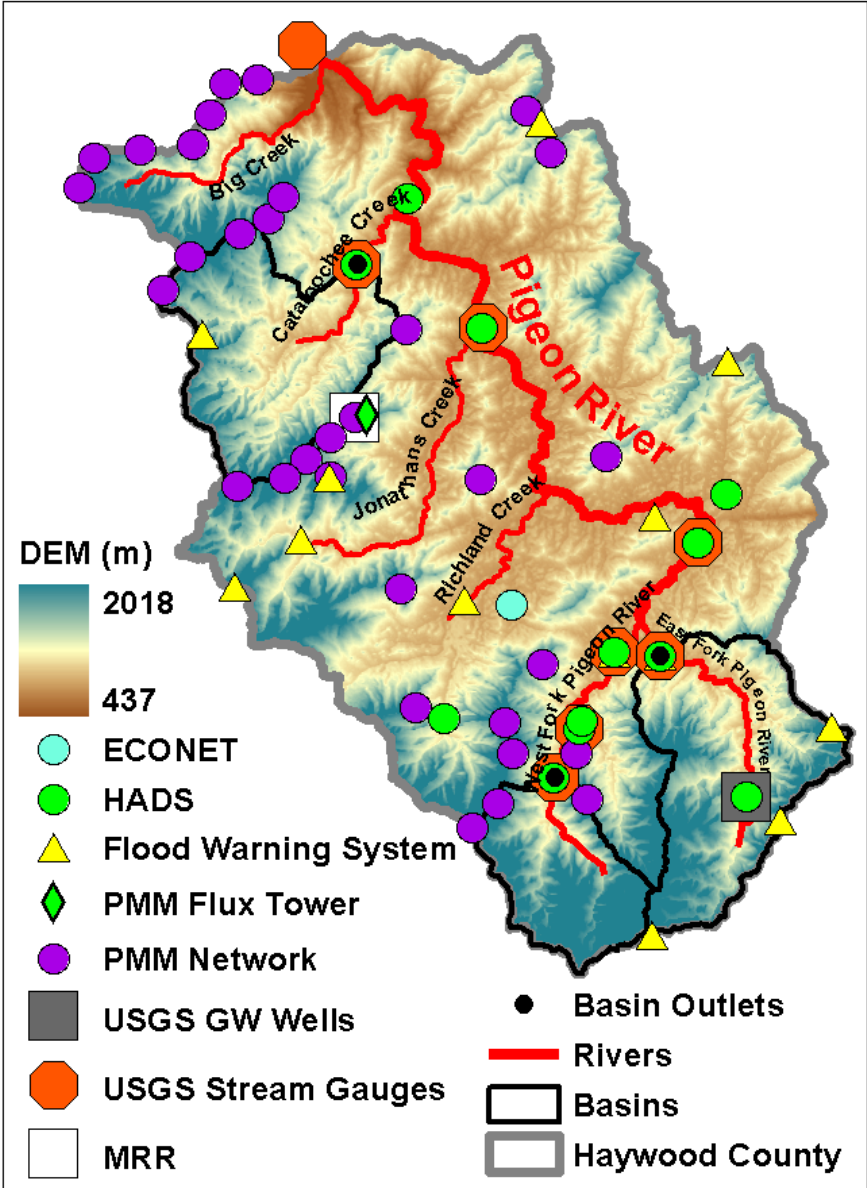
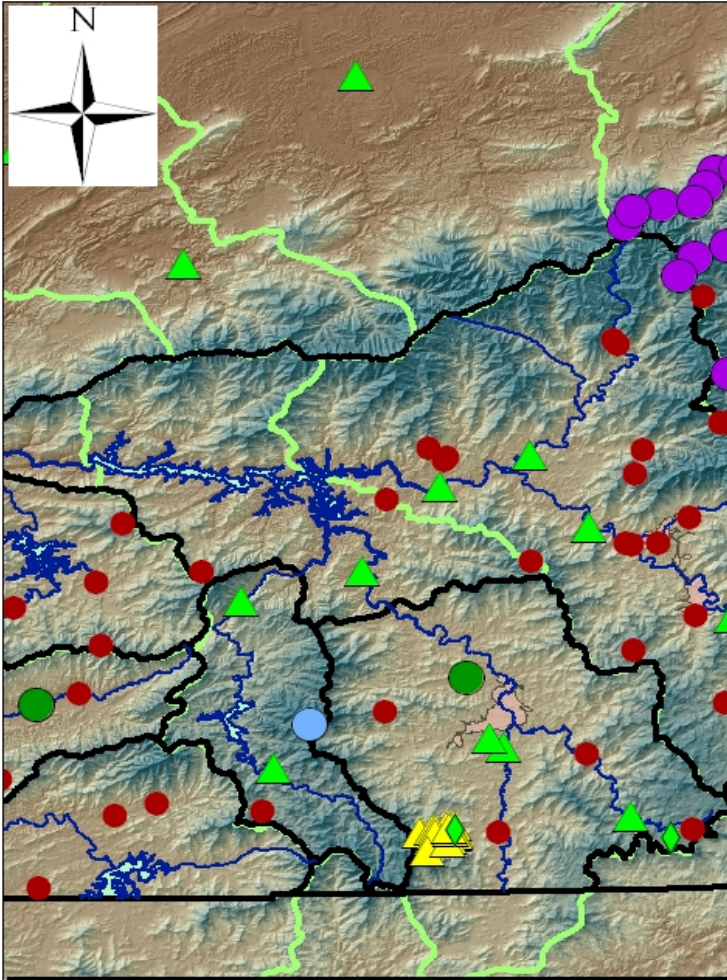
Water Balance – Hurricane Frances



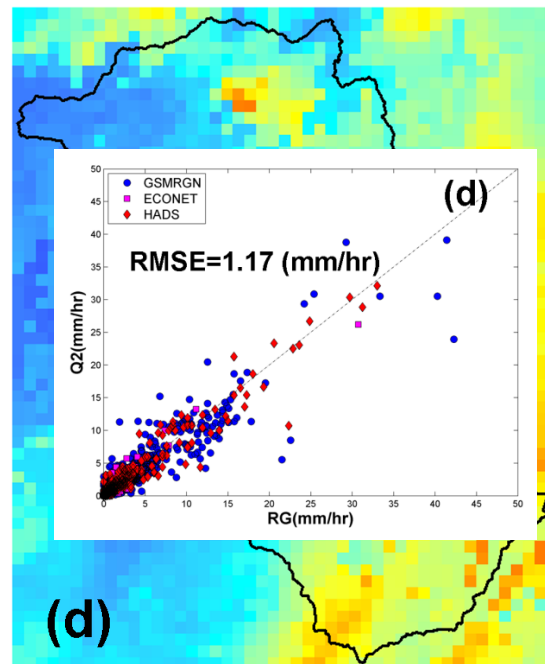
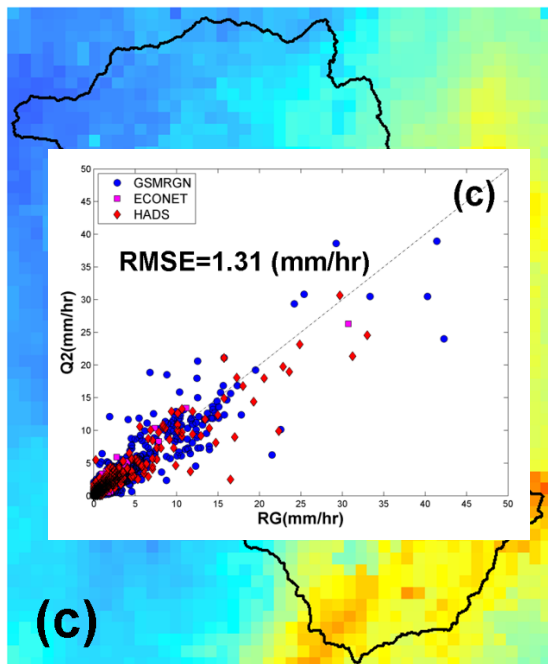
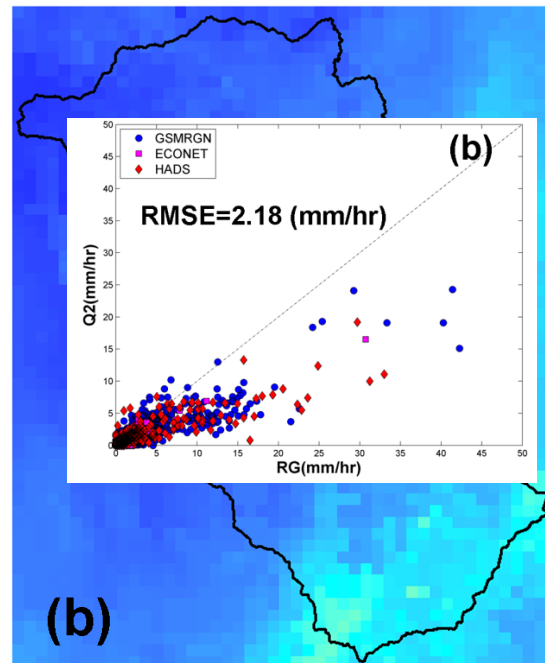
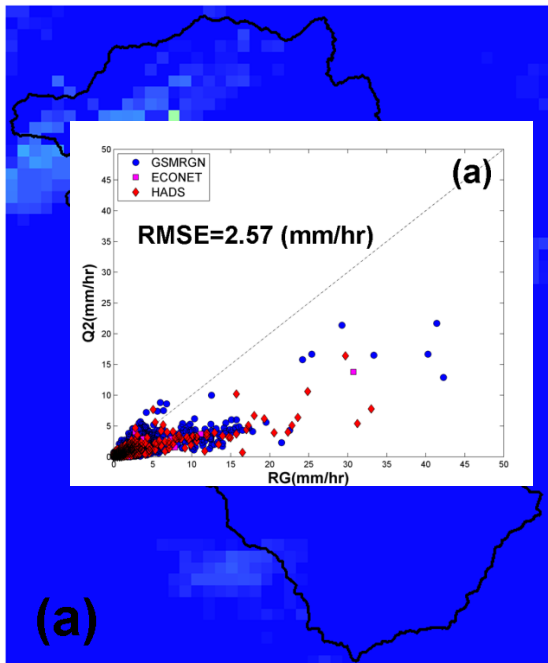
- ☐ Surface-GW Interactions
- ☐ Recharge
- ☐ TCs as Drought Busters
- ☐ Headwaters Control

Catchment-Scale Hydrological Response to Tropical Storms

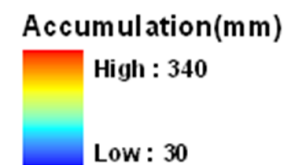
Natural LULC



Tropical Storm Fay....

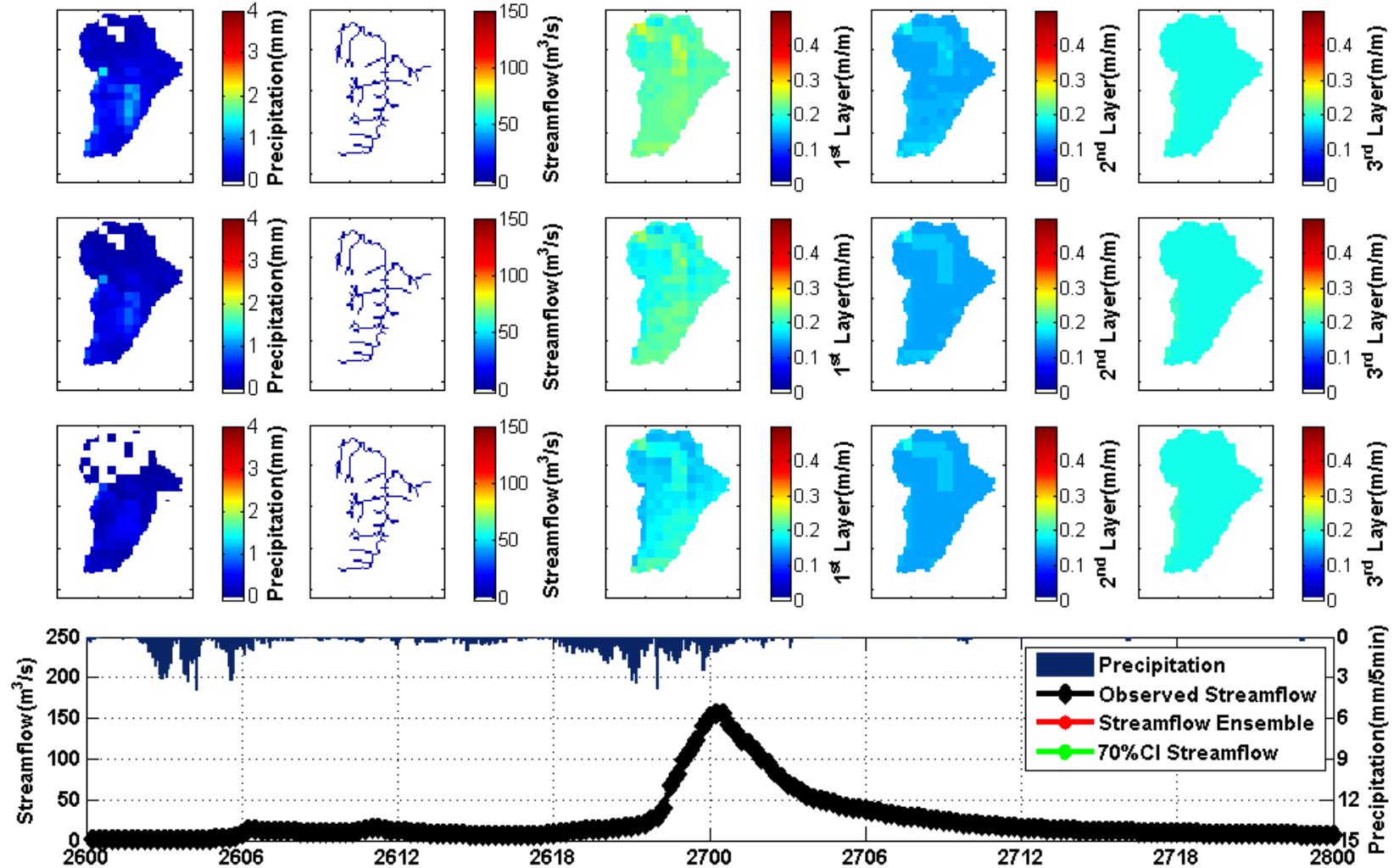


- (a) Q2RAD_HSR
- (b) Q2RAD_HSR_GC
- (c) Adjusted Q2RAD_HSR_GC (Method1)
- (d) Adjusted Q2RAD_HSR_GC (Method2)

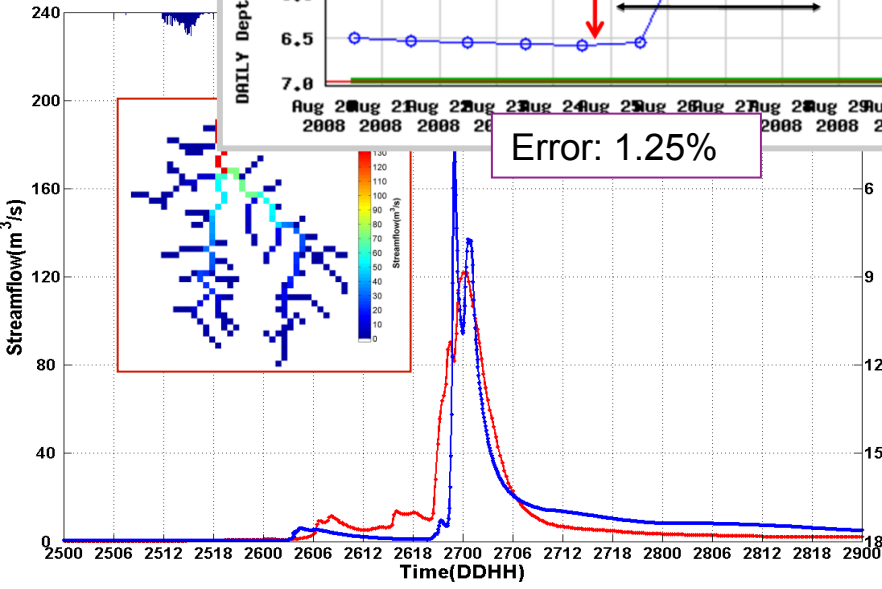
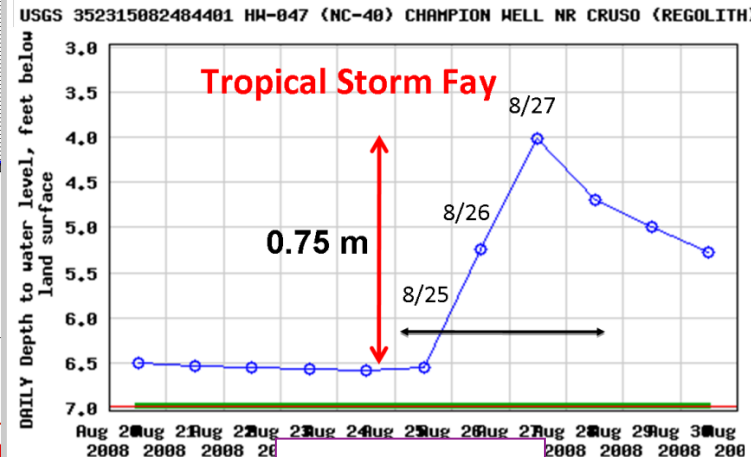
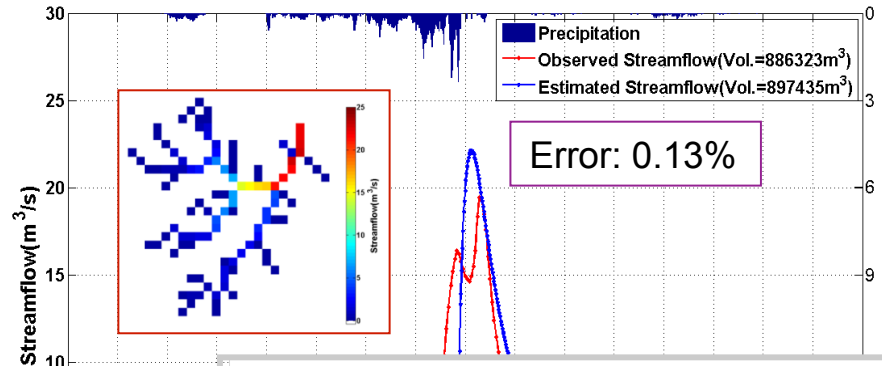


East Fork of the Pigeon River Basin

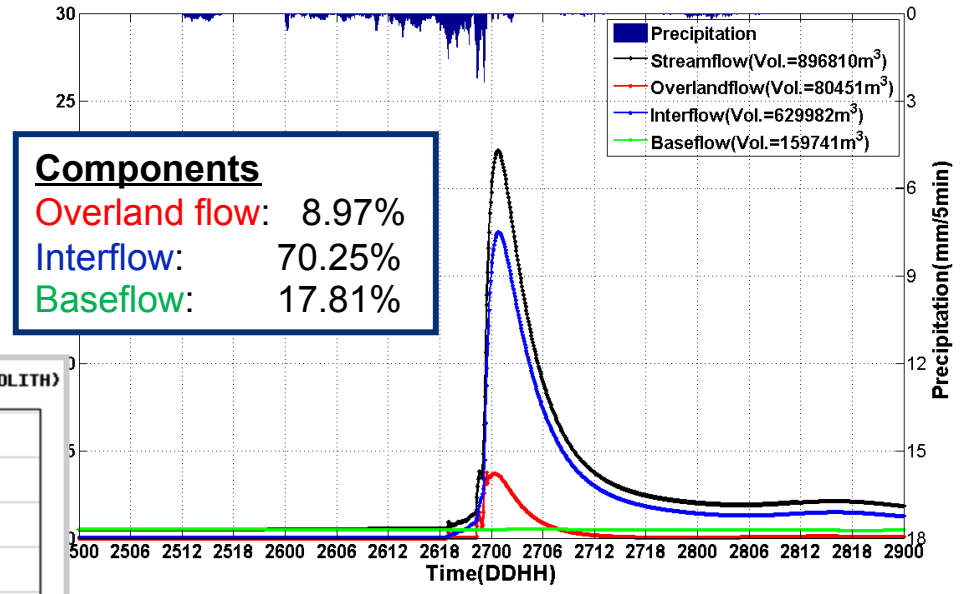
200808260000(UTC)



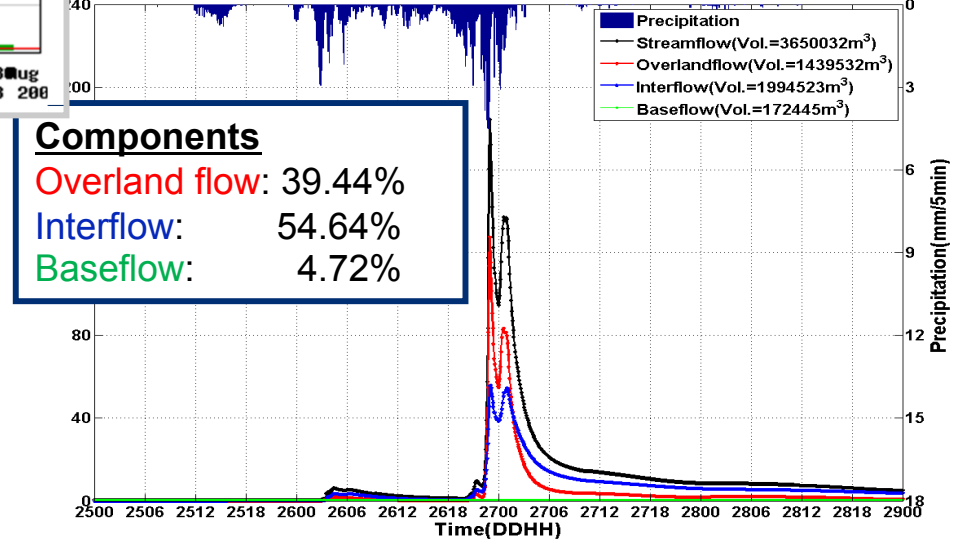
Cataloochee Creek Basin



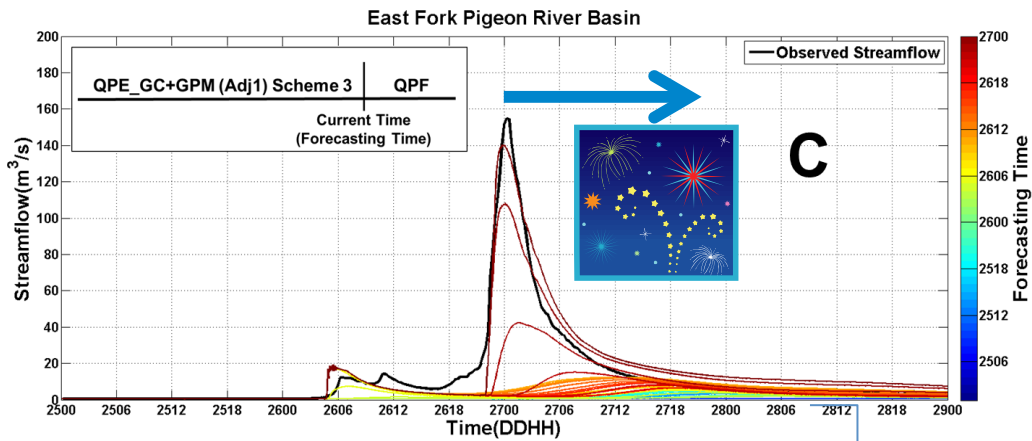
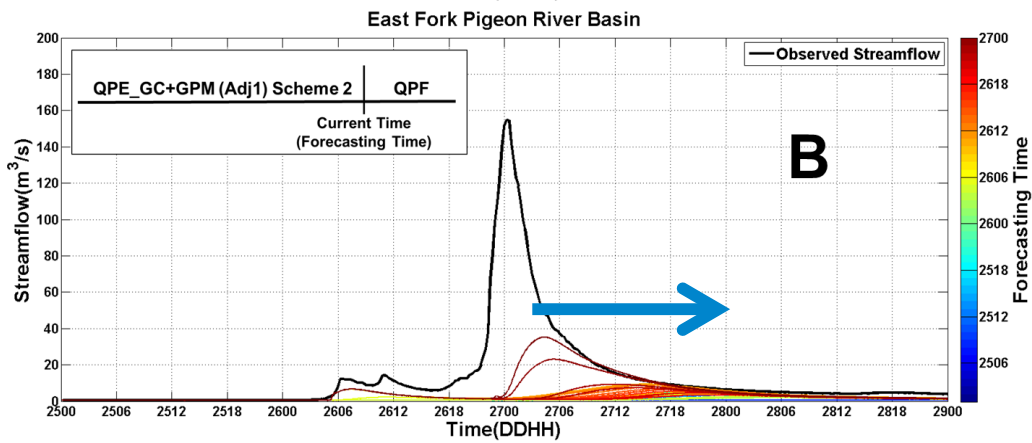
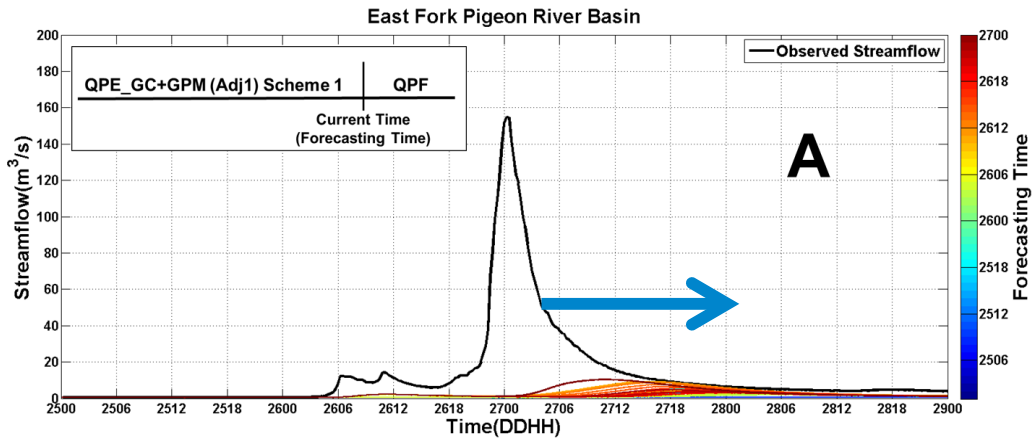
Cataloochee Creek Basin



West Fork Pigeon River Basin



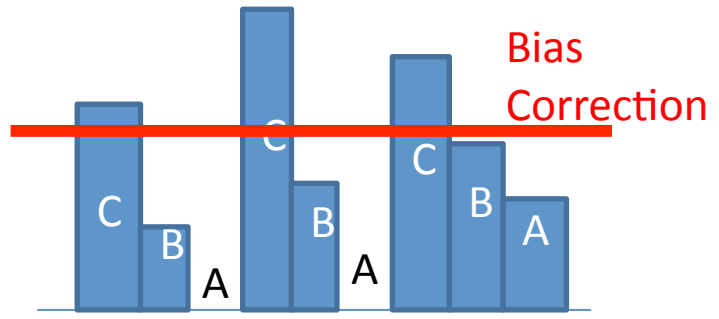
What is the Utility of "Instantaneous" Spatial Observations?



6 hours

GPM "Simulator" 3 hourly
 QPE and QPF [NFDB]
 (Larry Lee, NWS)

Sampled from hourly Q2-GC-Adj*
 Using Temporal Statistical Downscaling



Toward a Climatology of Extreme Events – Flash Floods ,Landslides, Debris Flows

Understanding the Space-Time Organization of Orographic Convection

Anatomy of a “Cloud Burst” on Balsam Ridge

Charlotte Observer - **September 11, 1992** - 1C METRO

HUNDREDS ARE EVACUATED AS WALL OF WATER RUSHES DOWN N.C. RIVER

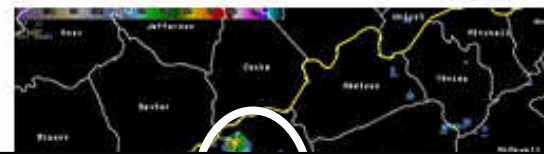
Emergency workers in the mountains of Swain County scrambled Thursday night to evacuate residents from the path of a flash flood surging down the Oconaluftee River. “We’re in the process of evacuating now, with about an 11-foot wall” of water headed toward Bryson City, county emergency coordinator David Hyatt said at 11:20 p.m. A wall of water reported at up to **20 feet high hit the Cherokee Indian** reservation at about 8 p.m. Thursday. Worst...

[Thousands of fish killed at Cherokee Fish Hatchery - The Daily ...](#)

[www.reflector.com/ap/.../thousands-fish-killed-**cherokee**-fish-hatcher...](http://www.reflector.com/ap/.../thousands-fish-killed-cherokee-fish-hatcher...) [Cached](#)
You +1'd this publicly. [Undo](#)

The Associated Press. Sunday, **July 17, 2011** ... **CHEROKEE, N.C. (AP)** — Thousands of fish were killed when a wall of water swept through the *Cherokee* ... Hatchery supervisor Doug Reed says the *flash flood* Thursday night washed nearly 3000 ... **8-feet wall of water.**Midnight

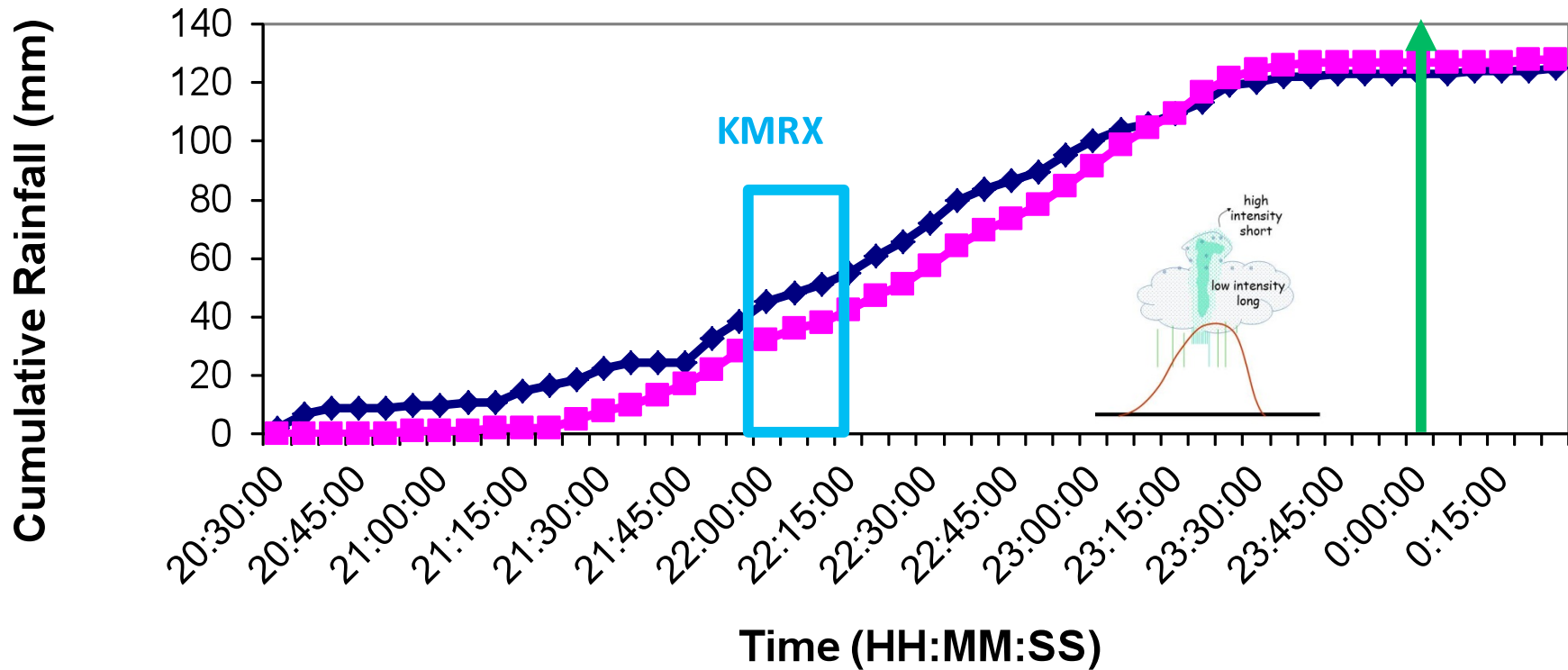
KMRX



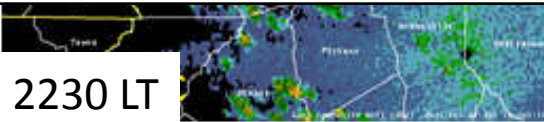
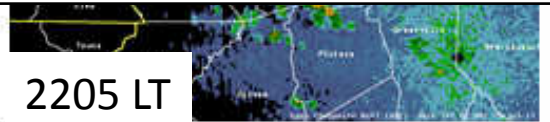
July 14 2011

Balsam Mountain 14-15 July 2011, 5-min Accumulations

Flash Flood
Cherokee Hatchery

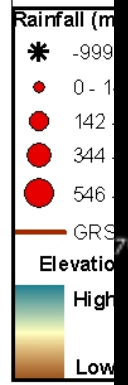
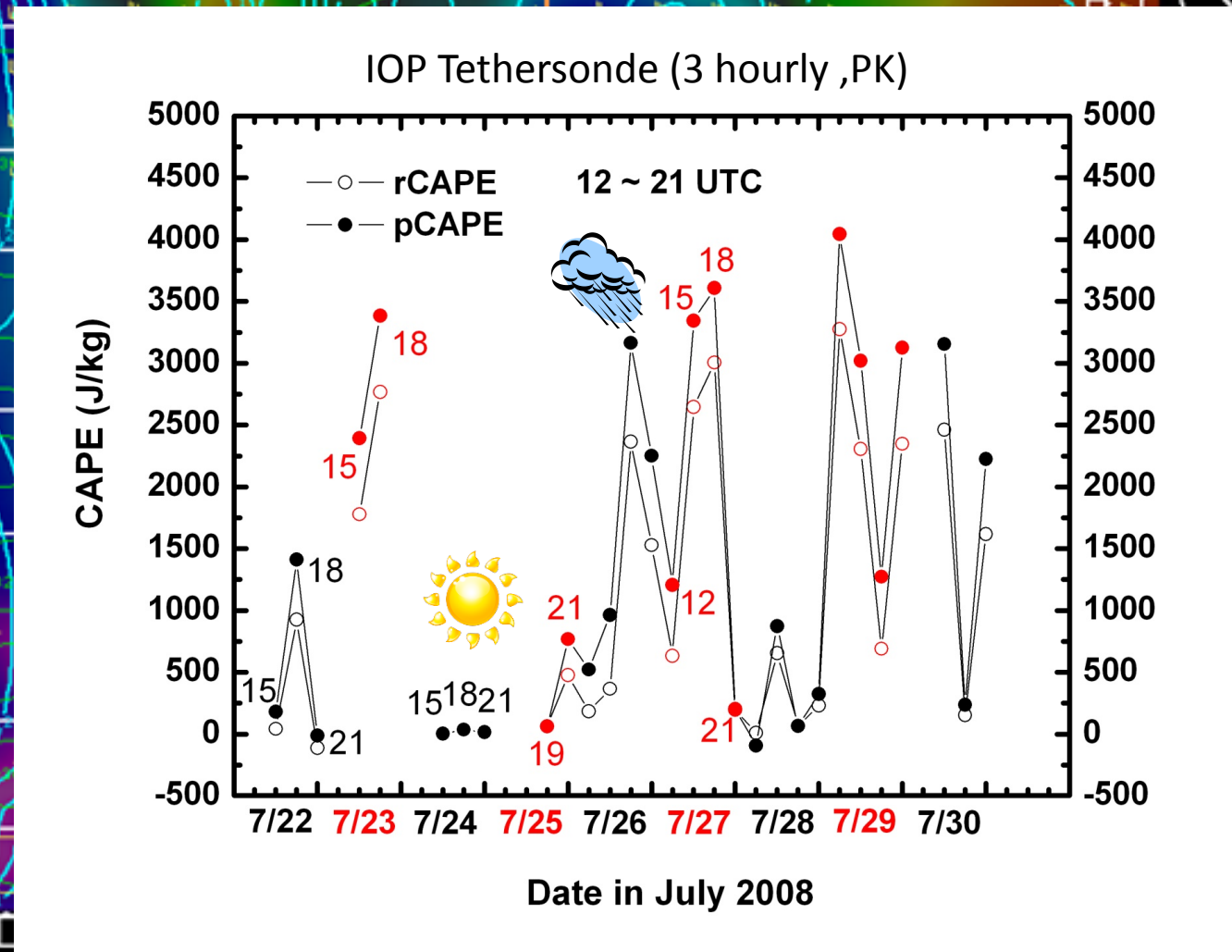


◆ 304 (1624 m) ■ 307 (1820 m)



LT=20+UTC

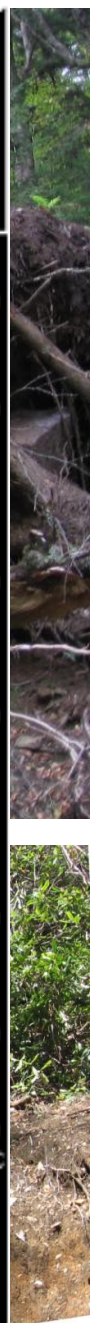
WTN



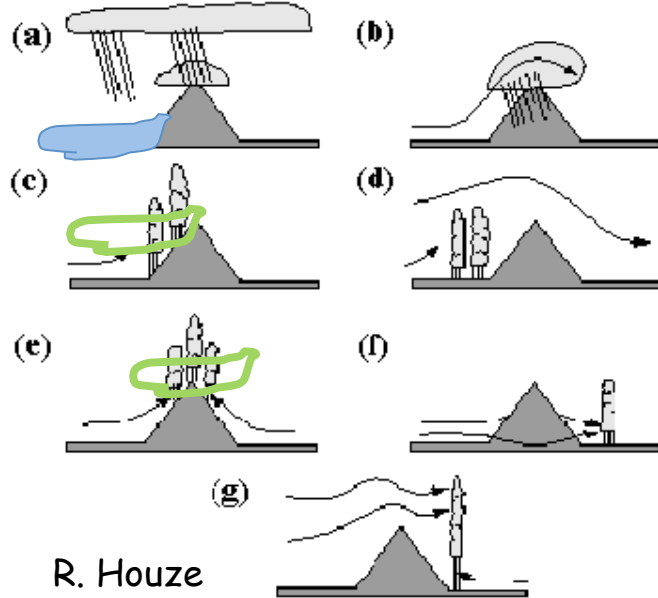
Storm Postmortem
Larry Lee, NWS

RUC13 lineC	Rel Humidity Ing(%)	15.00	1-11
RUC13 lineC	Potential Temp (K)	15.00	1-11
RUC13 lineC	Rel Humidity (%)	15.00	1-11
RUC13 lineC	Wind (kts)	15.00	OHR Fri 00:00Z 15-Jul-11
RUC13 lineC	Omega (-ubar/s)	15.00	OHR Fri 00:00Z 15-Jul-11

2000 LT July 14



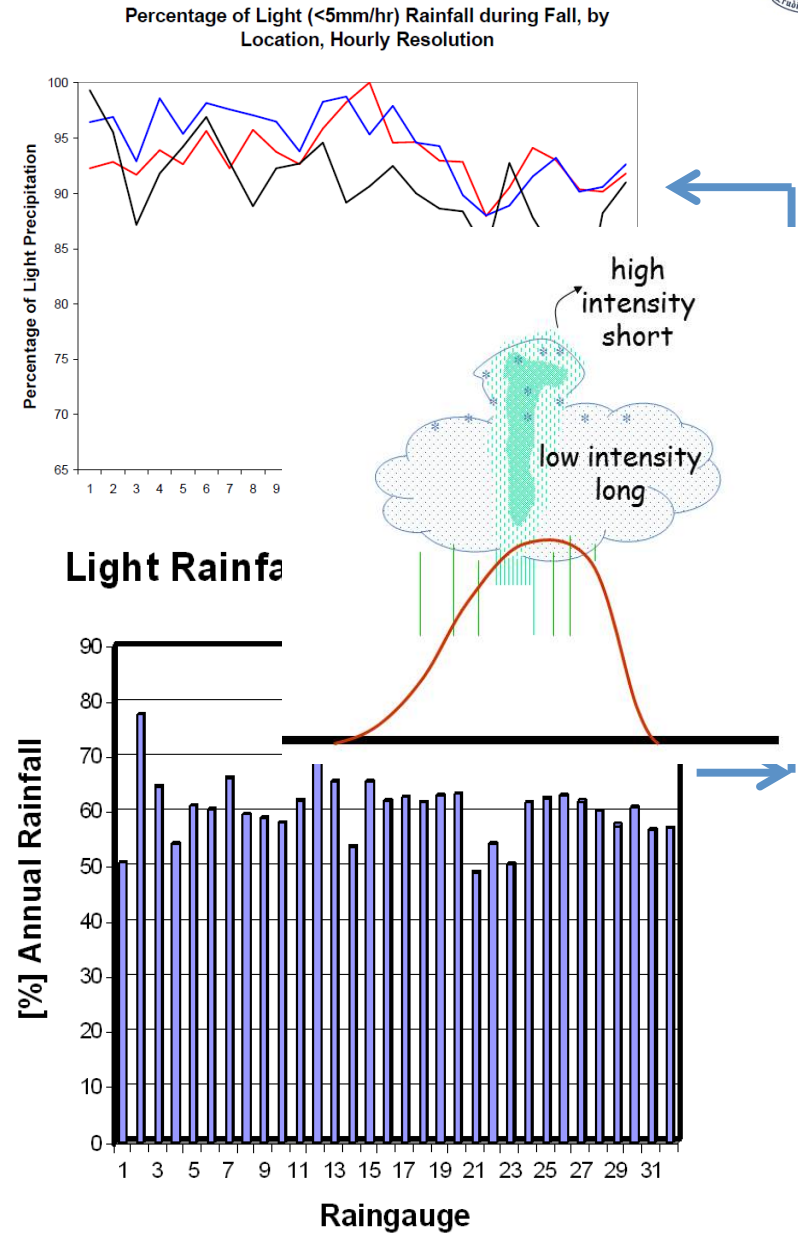
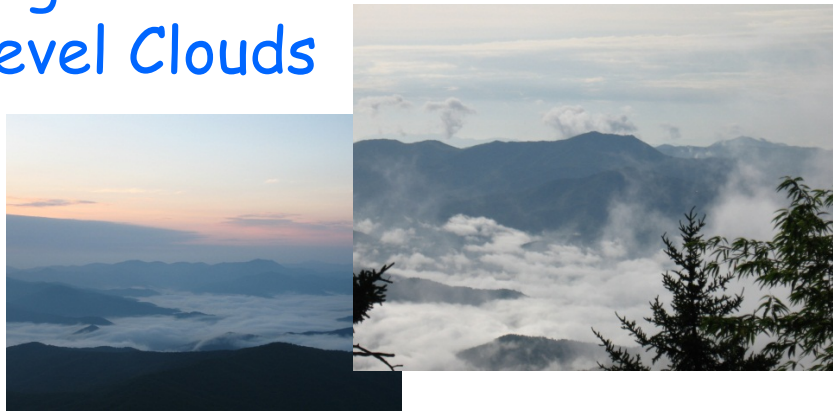
Orographic Rainfall Processes



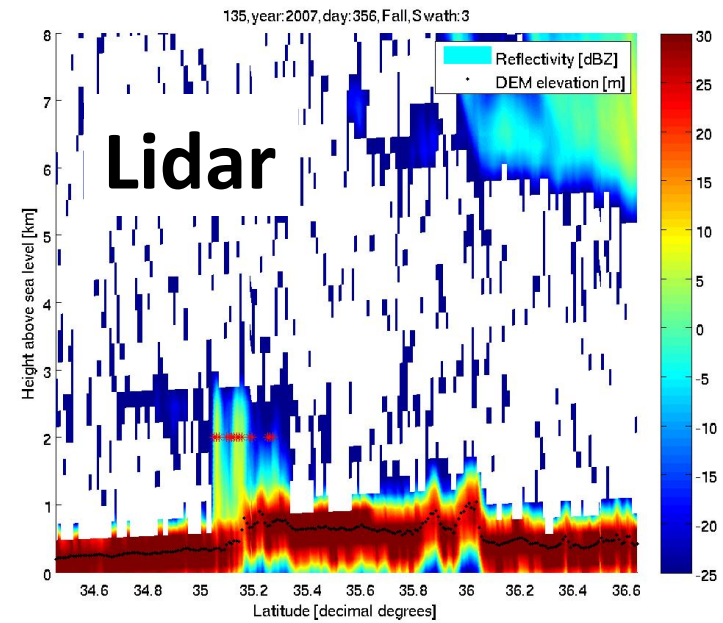
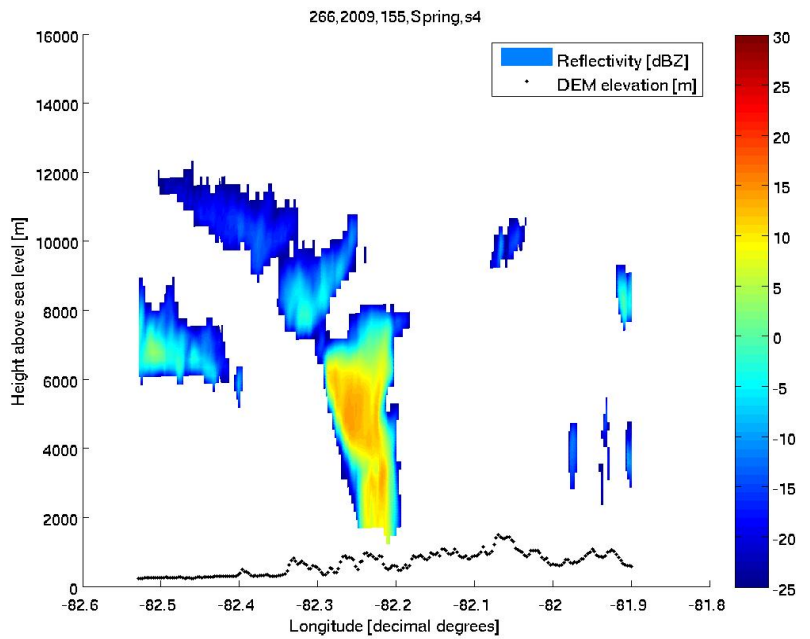
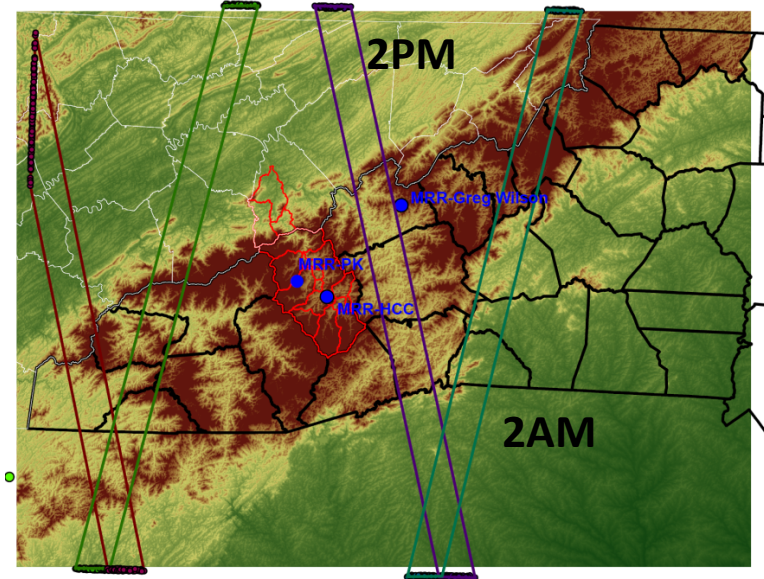
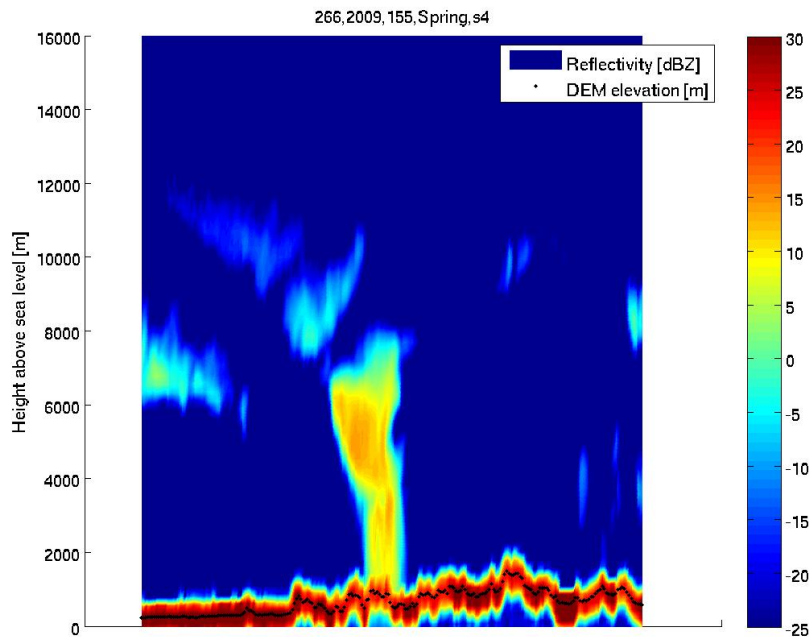
Snow

R. Houze

Fog and Low Level Clouds



CLOUDSAT Low Cloud Detection Algorithm



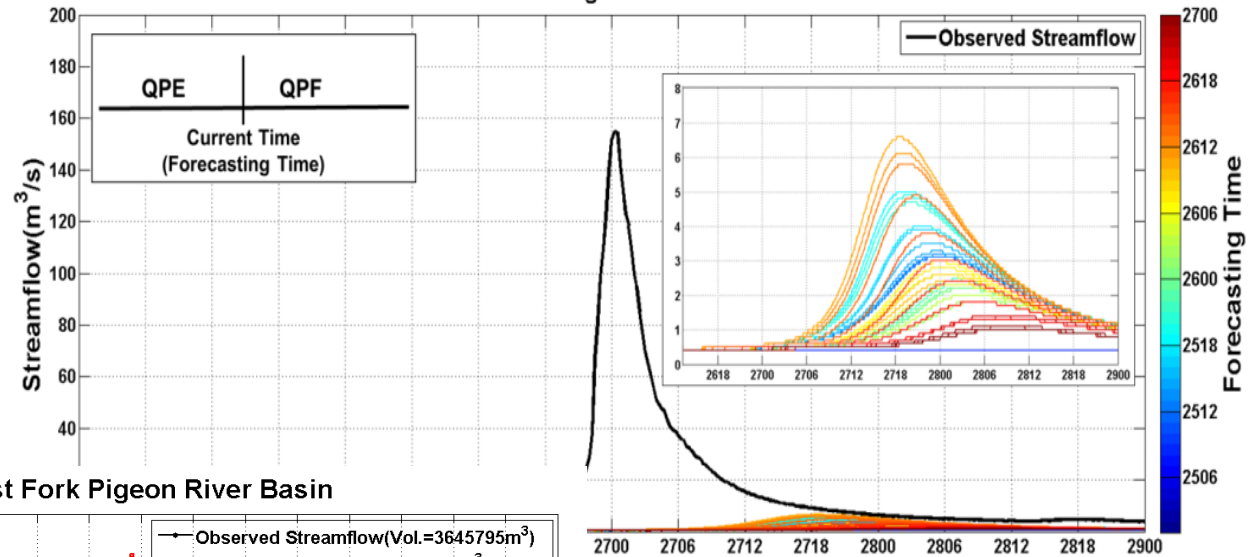
Kevin Olson

FlashFlood QPE Operational Demo

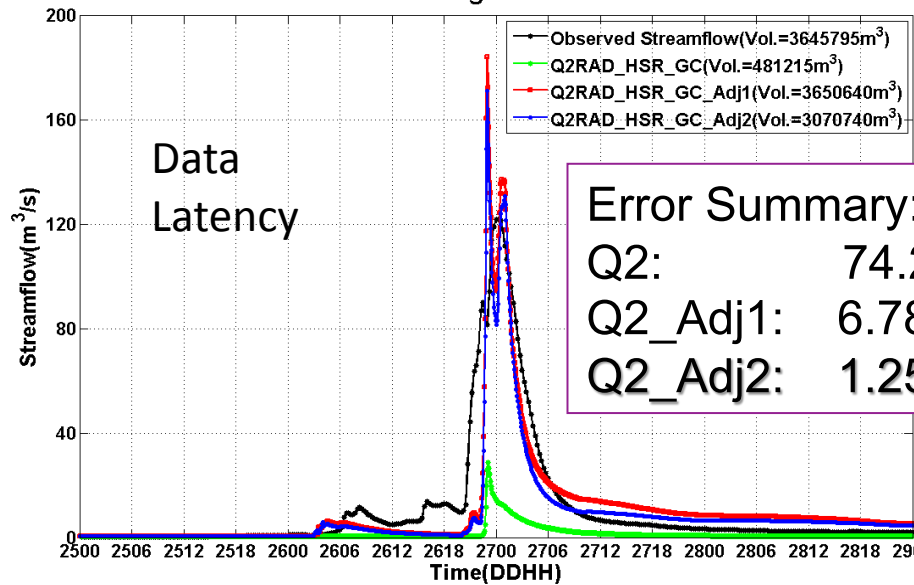
Tropical Storm Fay

QPE and QPF [NFDB]
(Larry Lee, NWS)

East Fork Pigeon River Basin



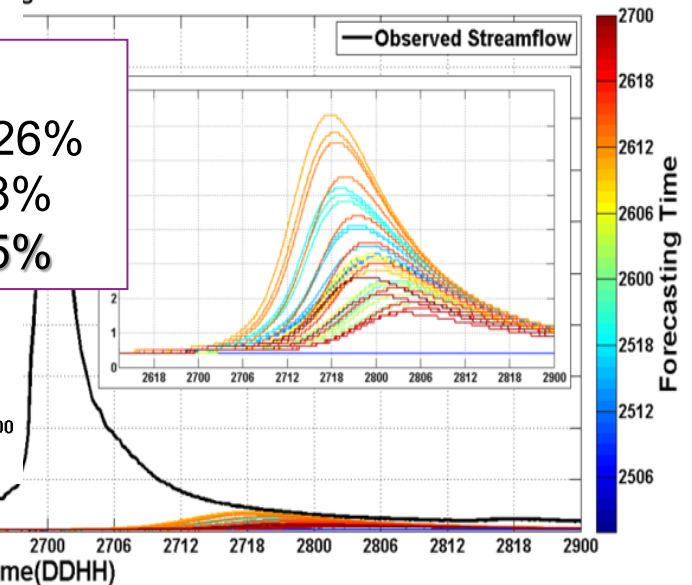
West Fork Pigeon River Basin



Error Summary:

Q2:	74.26%
Q2_Adj1:	6.78%
Q2_Adj2:	1.25%

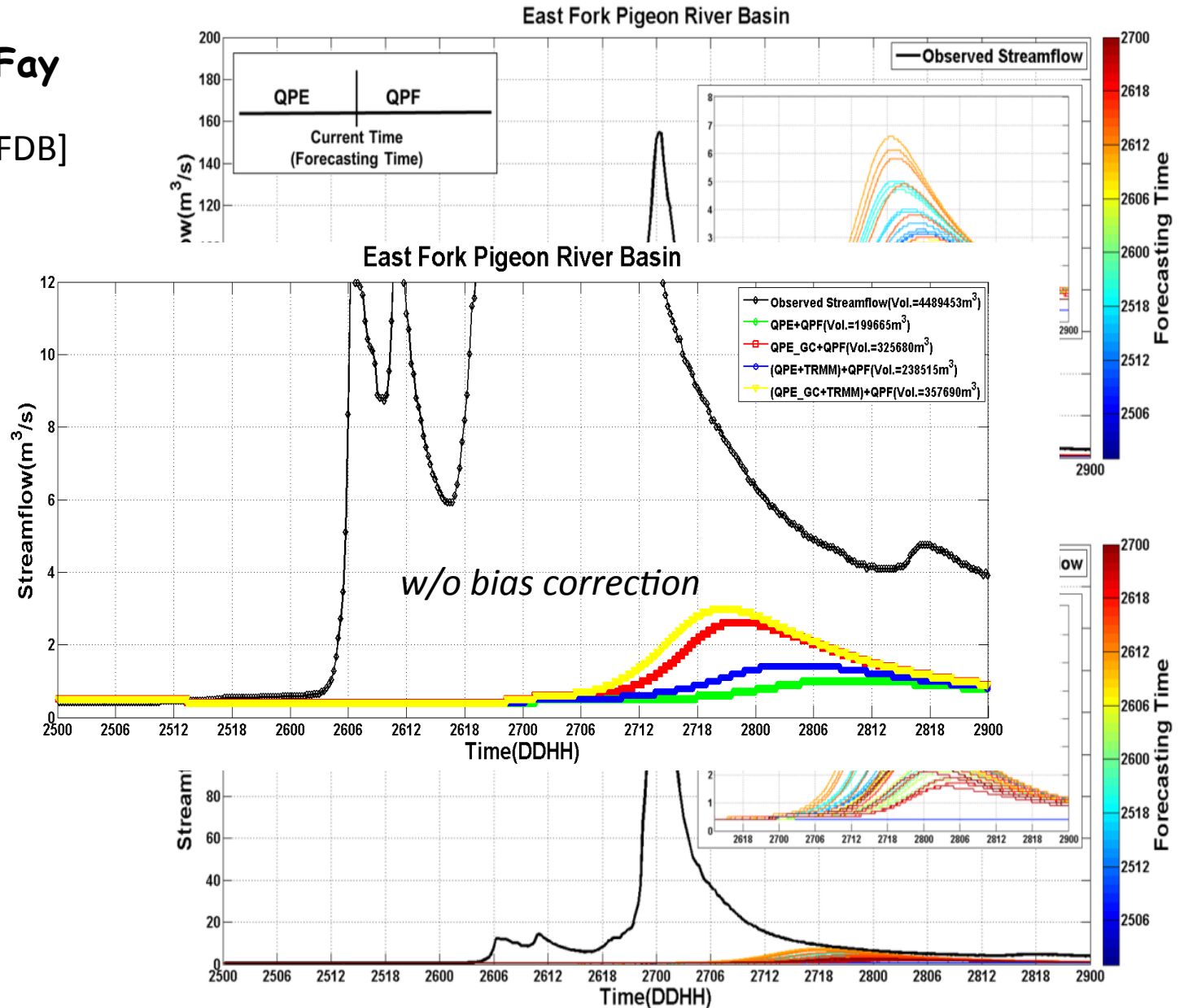
East Fork Pigeon River Basin



FlashFlood QPE Operational Demo

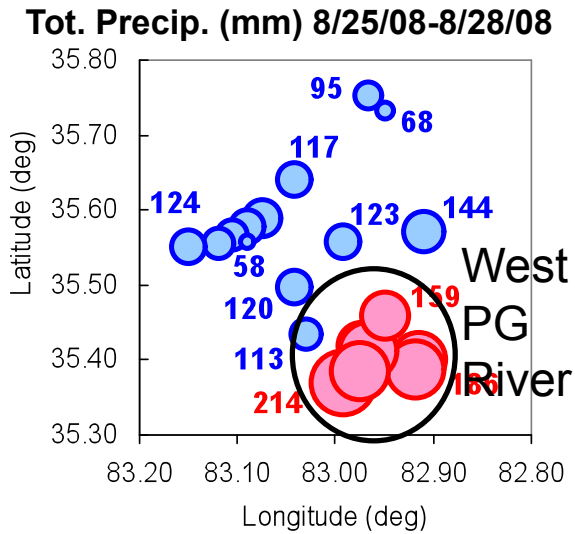
Tropical Storm Fay

QPE and QPF [NFDB]
(Larry Lee, NWS)

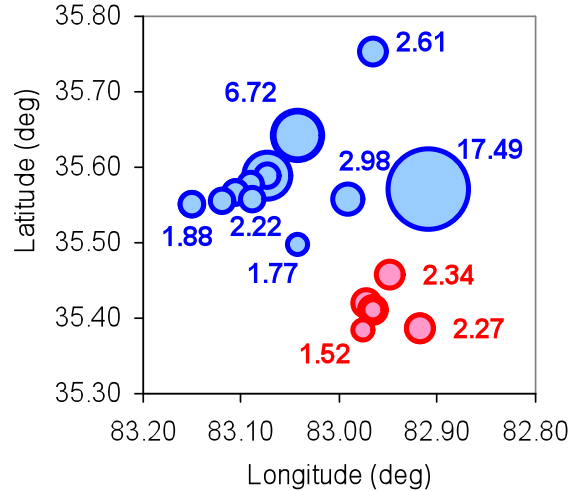


RG/TRMM Comparison for Tropical Storm Fay (08/2008)

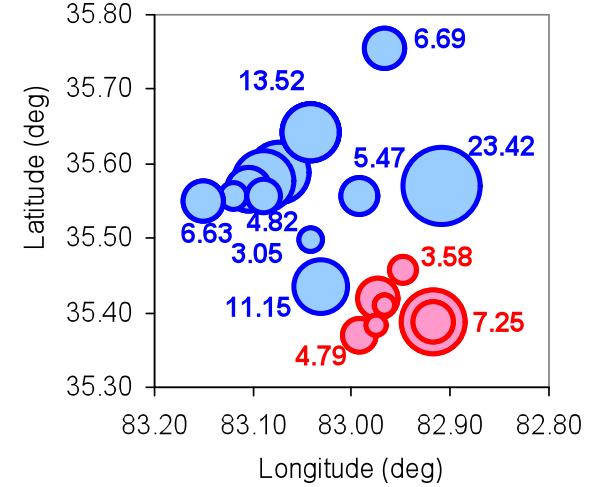
► Tot. Precip. (58- to 214-mm)



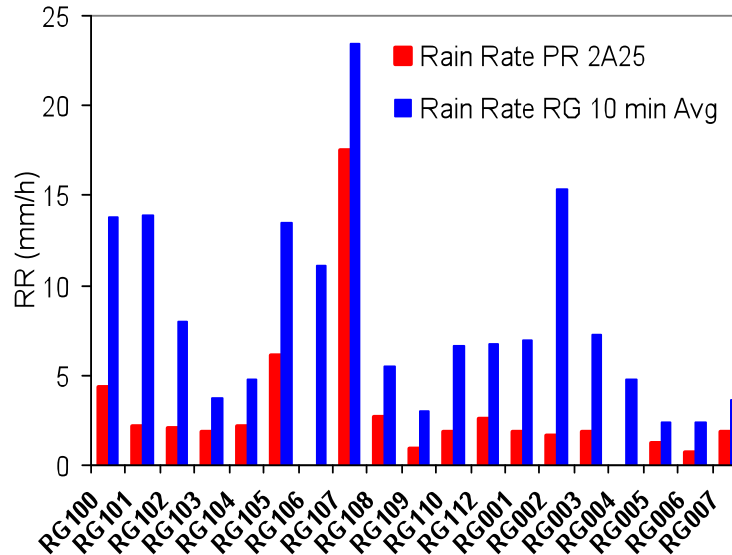
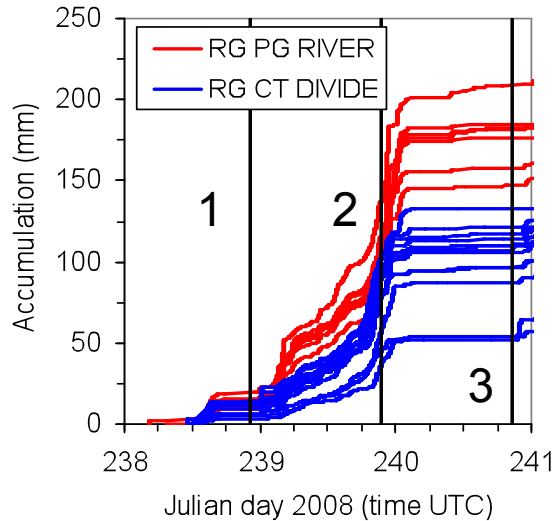
TRMM PR 2A25 RR (mm/h)



RG 10min Averaged RR (mm/h)



► 3 TRMM Overpasses



► **Average bias**
TRMM/RG = - 66%

