

Quantitative Precipitation Estimation: Emerging Needs

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Outline

- **Where are we now?**
 - Current QPE capabilities
- **What are the gaps?**
 - Evaluation of QPE algorithms
 - Gaps in retrieval methods
 - Smart integration of different sensors techniques
 - Gaps in observing systems
 - Impact of dual polarization observations
 - Distributed networks

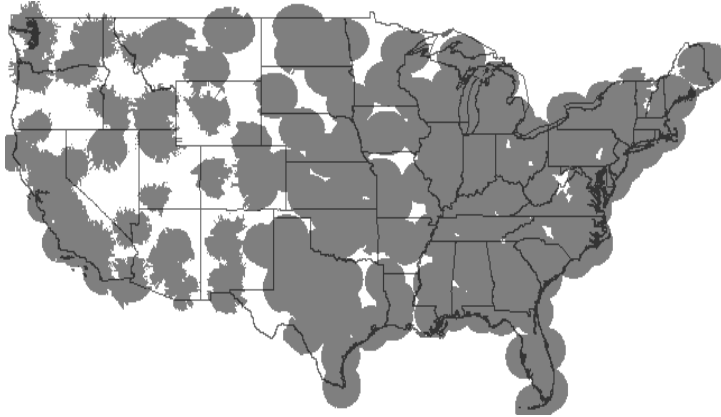
Current QPE

We now have a multitude of satellite, radar, and gauge data available so the QPE issues should be solved...

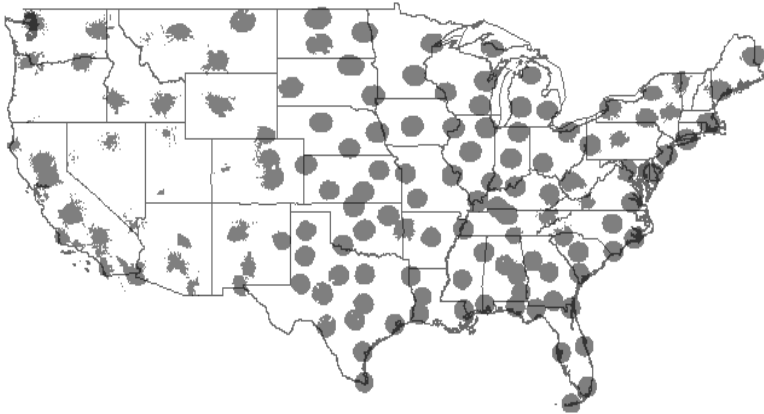
- Some Problems
 - Considering gauge data as ground truth may not be good assumption
 - Radar is good at capturing spatial patterns of rainfall but not always so good about the amounts (measuring in the cloud – not the ground)
 - Snow?
 - Lots of satellite data available using IR and microwave retrievals techniques
 - IR uses cloud top temperature which is not well correlated with instantaneous rain (in mountains, may not see low level clouds associated with shallow rain processes)
 - Microwave data provides information on the amount of water in the column but have to assume how the liquid/ice is distributed. Also, time resolution is poor due to orbit frequency

Current NEXRAD Coverage

From McLaughlin et al. 2009

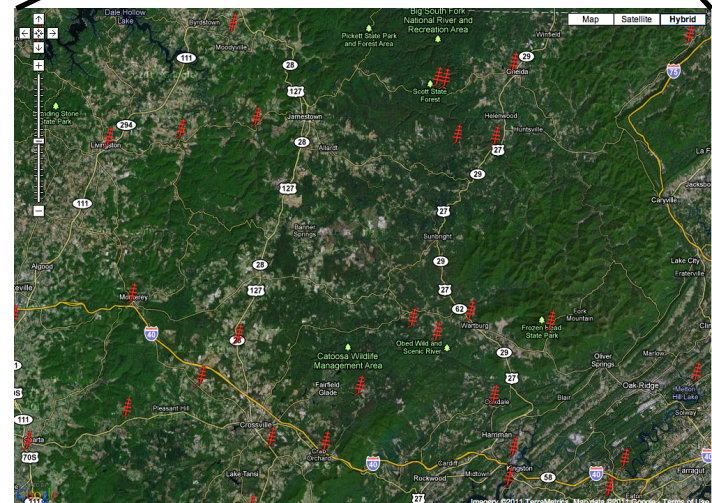
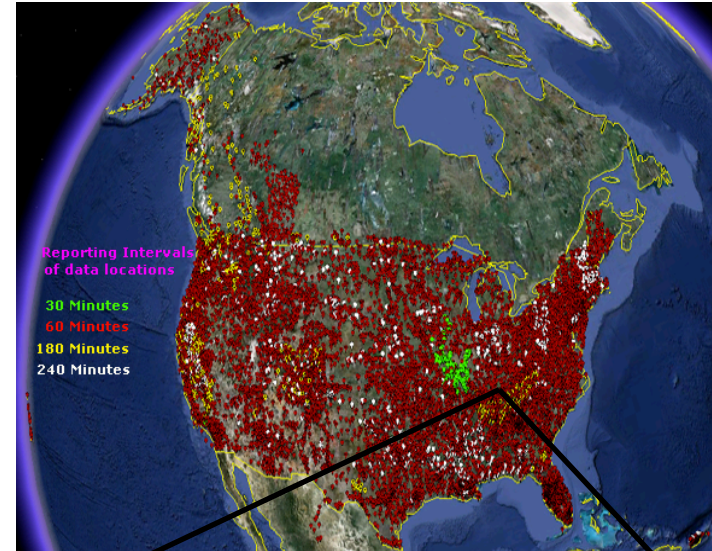


NEXRAD coverage at 3 km (10,000 ft) AGL.



NEXRAD coverage at 1 km (~3200 ft) AGL.

Current HADS Network

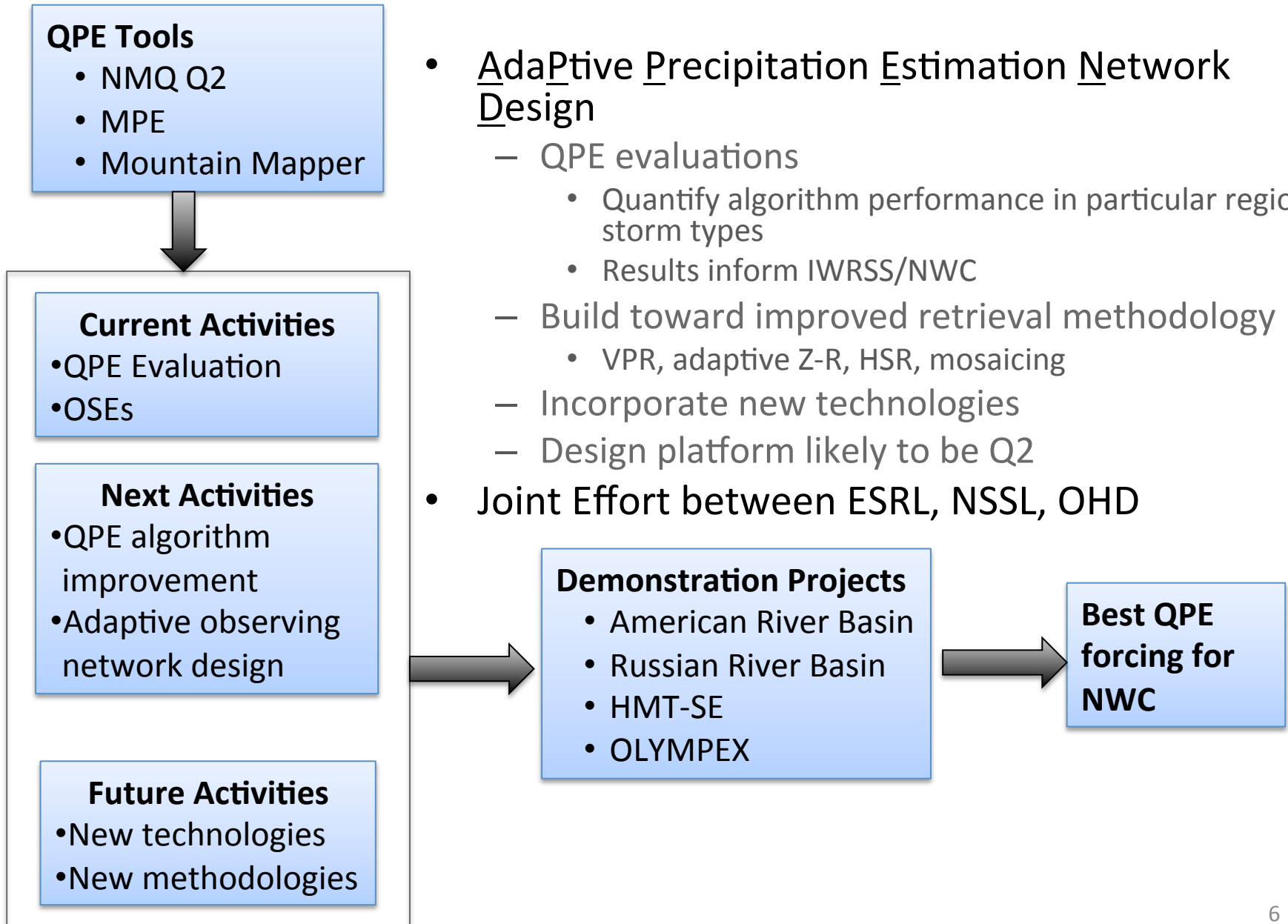


- Even in dense gauge network, lots of gaps

QPE Algorithms

- Many QPE products available
 - Multi-Sensor Precipitation Estimator(MPE)
 - National Mosaic and Multi-Sensor QPE (NMQ)
 - Mountain Mapper
- MPE and NMQ are suites of products using radar, gauge and satellite information
 - NMQ radar QPE includes a VPR but does not currently integrate satellite with radar, gauge data
 - MPE radar QPE does not include a VPR
- Mountain Mapper is a gauge-only product
 - Assumes PRISM climatology for spatial interpolation

APPEND QPE Strategy

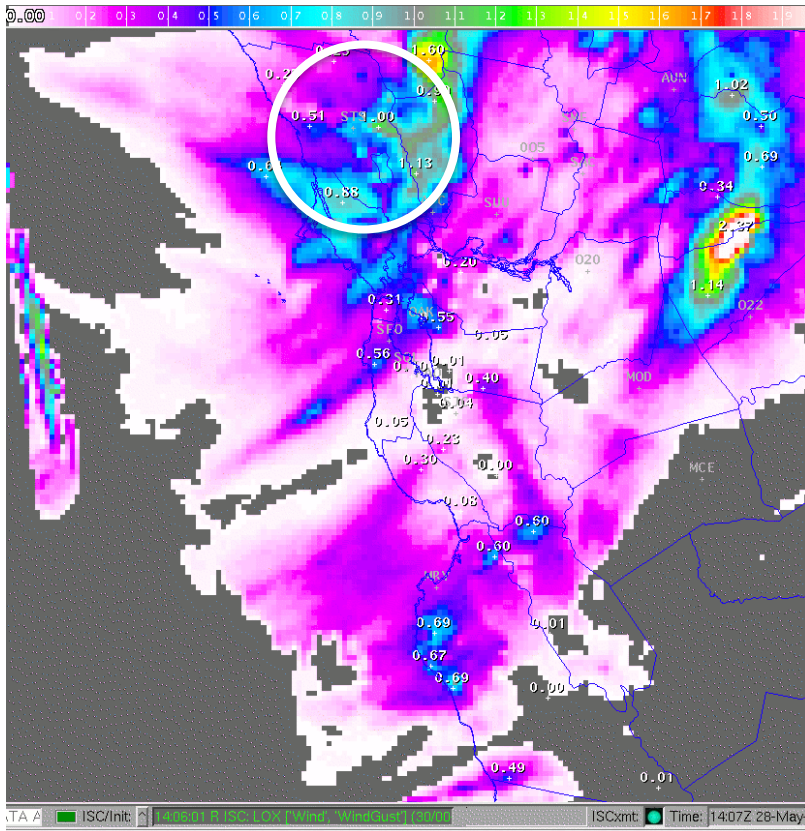


Need for QPE Evaluations

- Evaluation of different QPE products is critical for determining which sensors have the most skill in different regions/storm types
- Radar data used extensively in the eastern US where blockage issues are less severe compared to the west
- In the west, gauge data used extensively with interpolations to a grid based on PRISM
 - How well does PRISM represent the actual spatial gradients in different storm types?
 - What role can/should radar play?

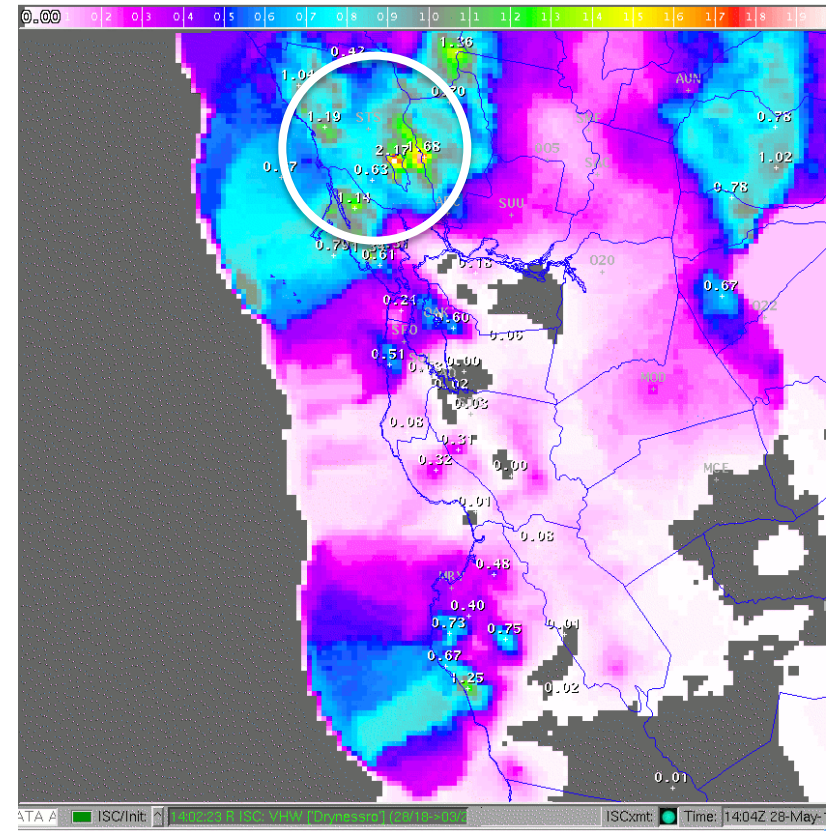
MPE QPE Comparison: 28 May 2010 12Z

24-hr radar-gauge QPE



NW Sonoma County is a blind spot for radar coverage

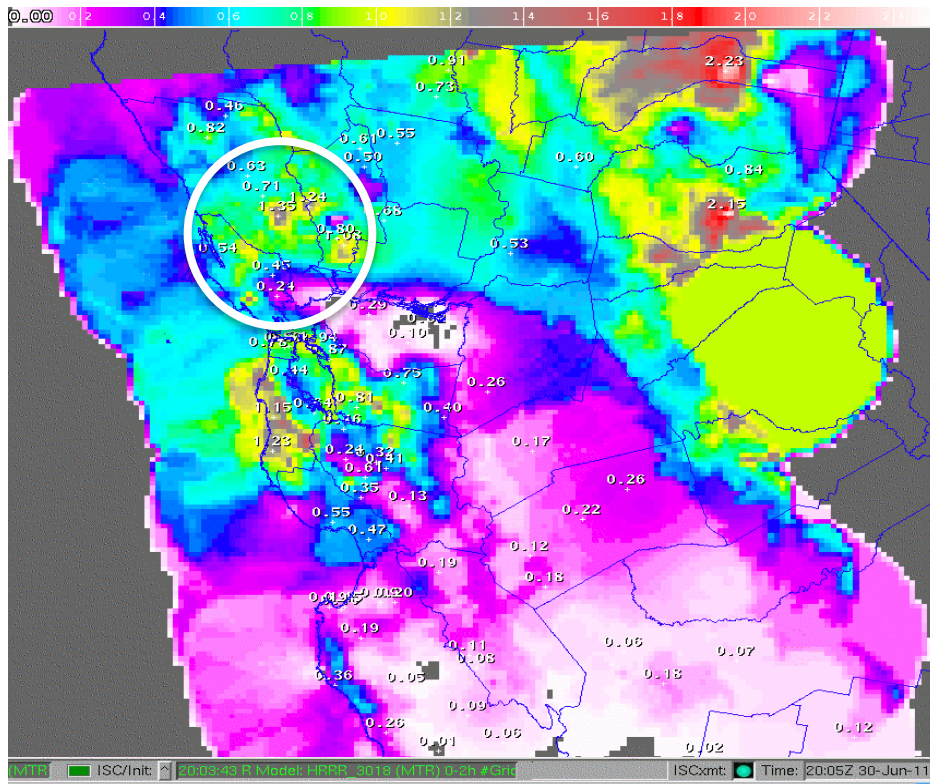
24-hr gauge QPE



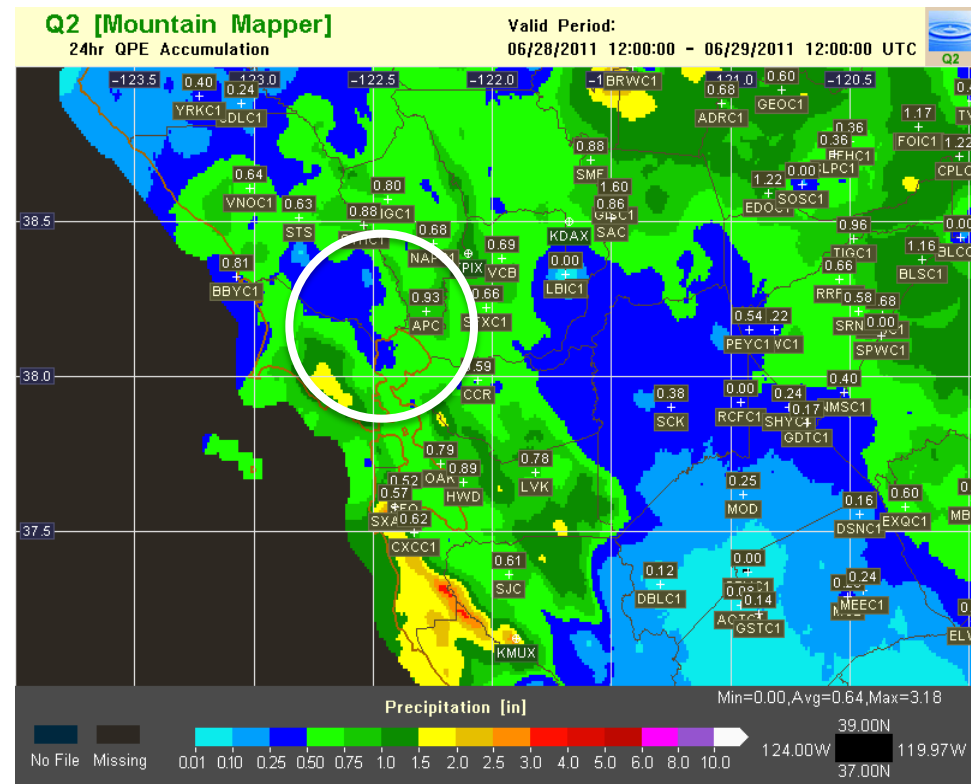
Gauge QPE uses PRISM climatology to distribute precipitation on windward faces of terrain

24-hour Total Ending 29 June 2011 12Z

MPE Gauge-Only QPE+PRISM



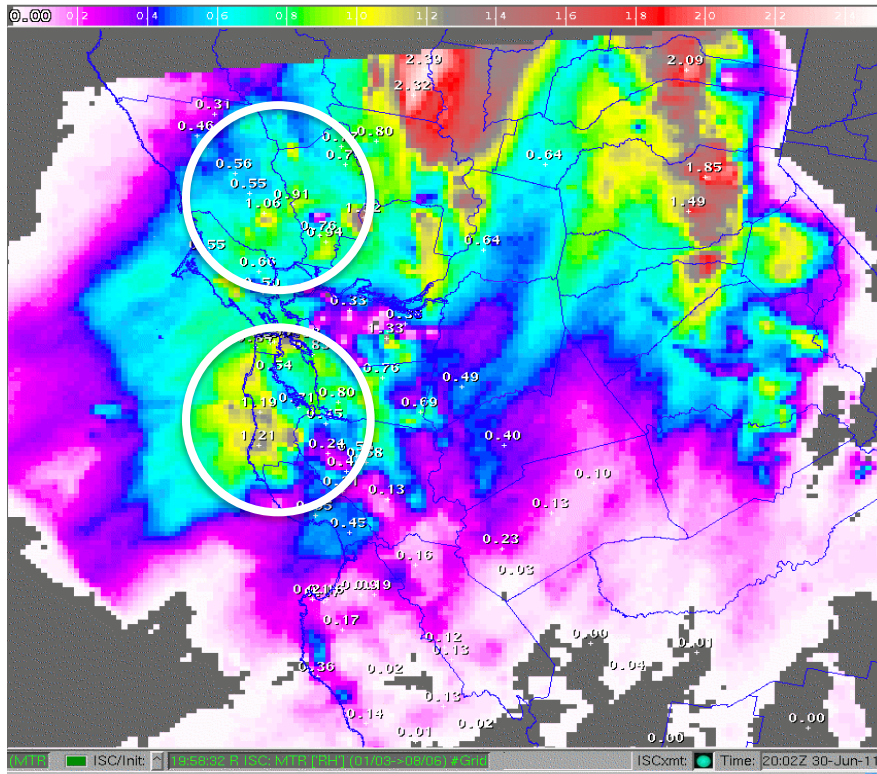
Q2 Gauge-Only QPE+PRISM



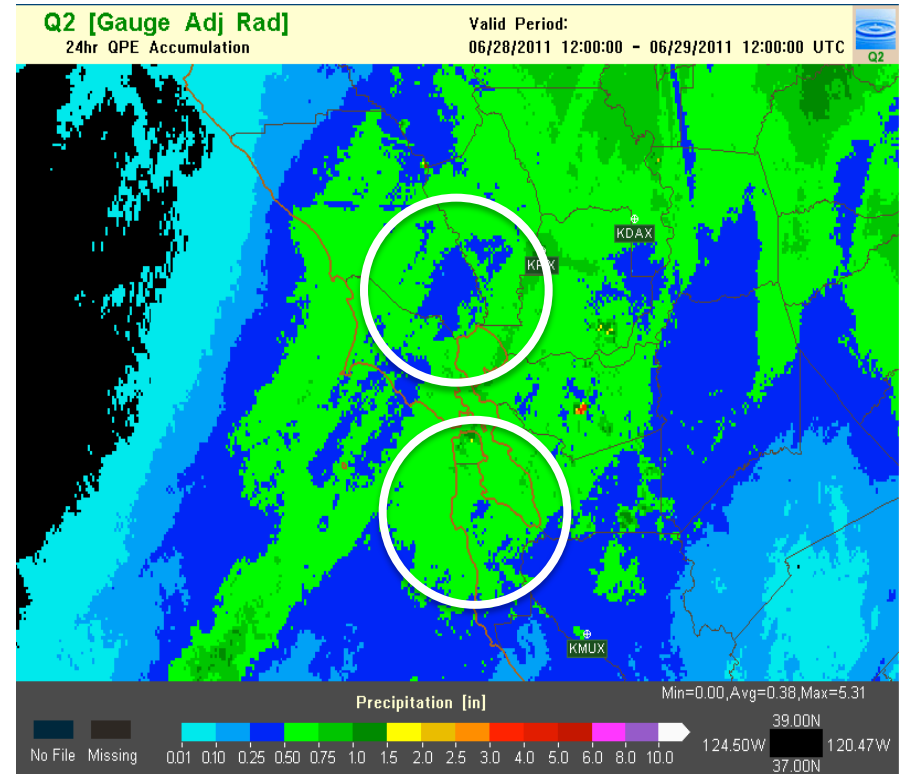
- QPE pattern can vary depending on which gauges are used
- MPE uses ALERT data, Q2 uses HADS data

24-hour Total Ending 29 June 2011 12Z

MPE: Combined Gauge-Radar



Q2: Gauge Adj Radar



Q2 HADS network does not include gages in Santa Cruz mountains

Impact of Dual Polarization

- Dual pol's major impact will be on removal of clutter (non-precipitating echo)
- In convection, dual pol rain will be important for hydrometeor identification (HID) and QPE
- In stratiform echo, QPE improvement will be modest (at S-band)

Comparison of Dual and Single Pol QPE Performance

Convective and Stratiform

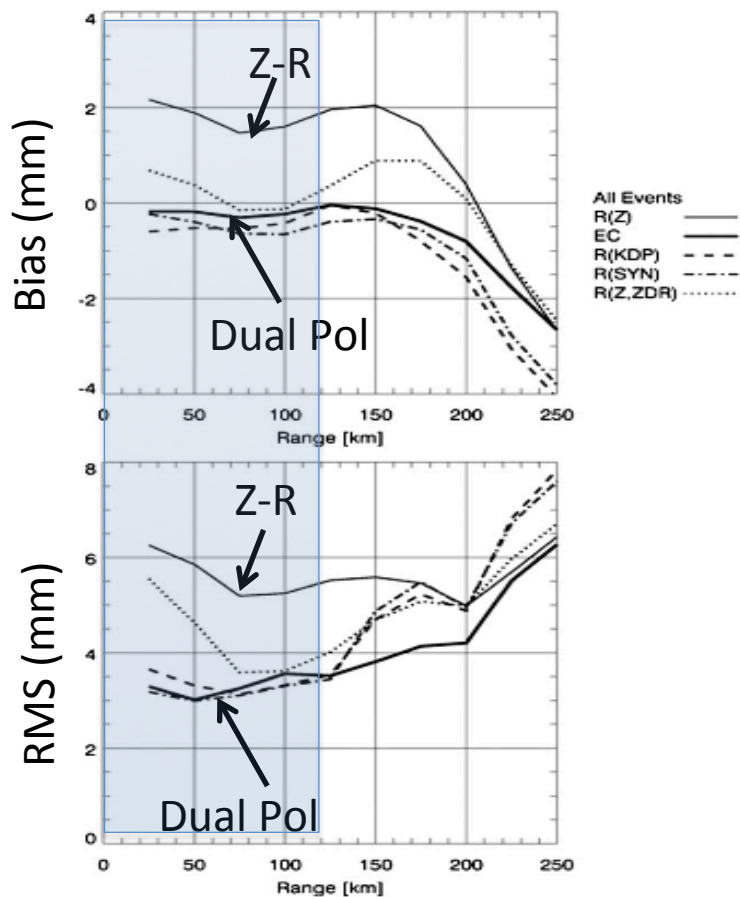


FIG. 12. (top) Mean bias and (bottom) RMS error of different radar estimates as a function of range (43 rain events, 179 h of observation).

Stratiform-Only

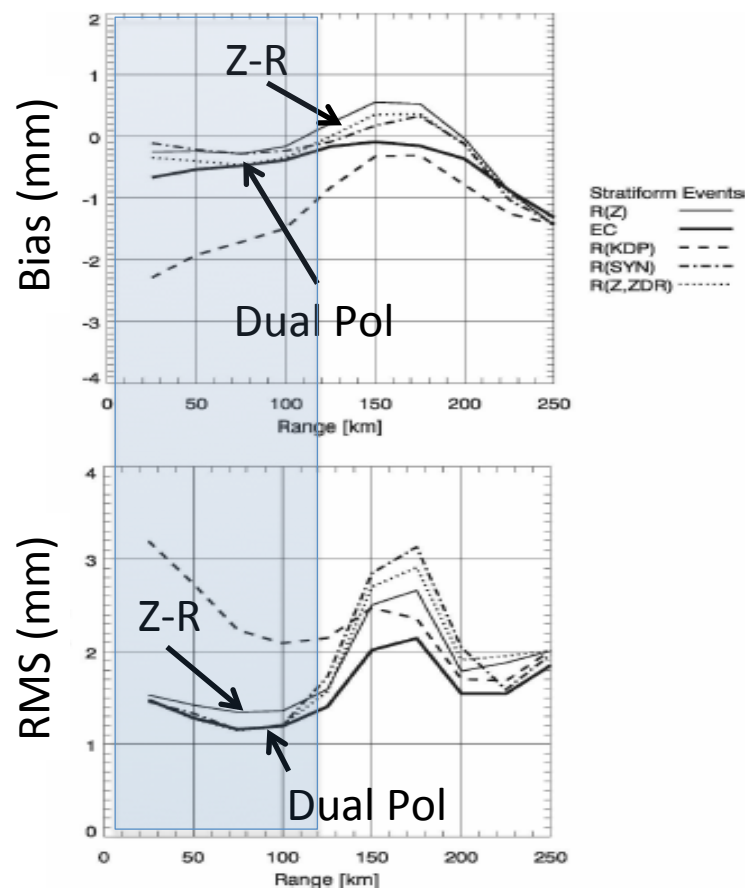


FIG. 13. As in Fig. 12, but for stratiform events with an absence of convective signatures (9 rain events, 26 h of observation).

From Giangrande and Ryzhkov 2008

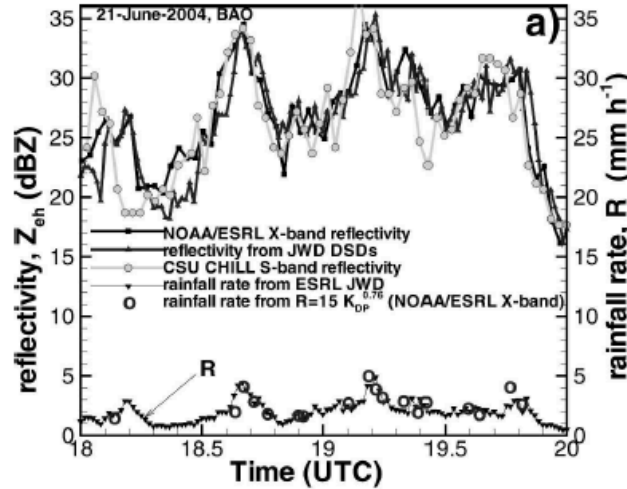
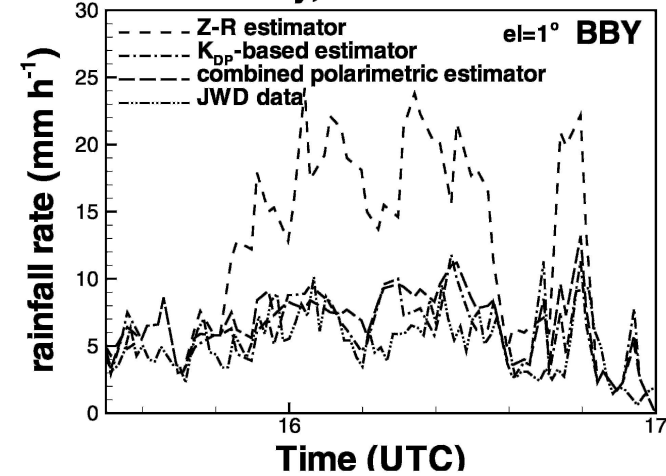
- Dual pol shows substantial improvement over single pol in convection
- Dual and single pol both show severe degradation in QPE at distance > 120 km

NOAA X-band Polarimetric: Stratiform Rainfall

HMT-West 2004

GPM Pilot Study 2004

2 February, 2004

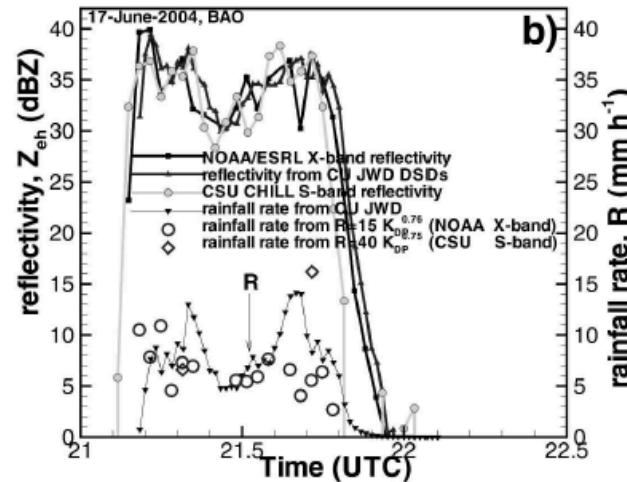
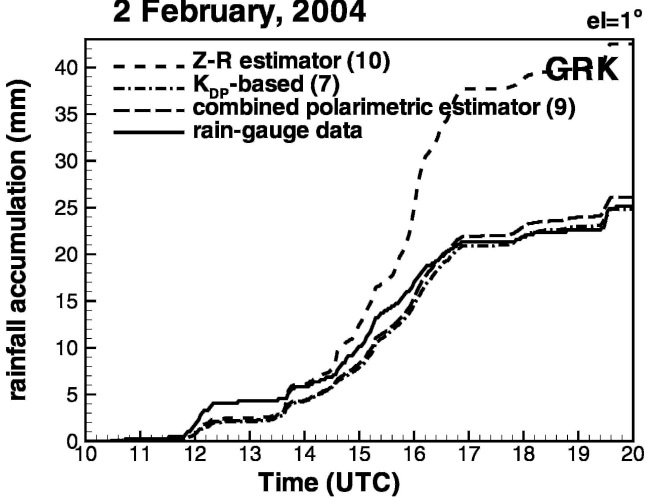


- (left) X-band dual pol information can provide superior QPE compared to Z-R
- (right) Phase sensitivity at X-band much greater than at S-band

- (right) X-band dual pol information can be useful in light rain

FIG. 9. An example of instantaneous rainfall retrievals over the Bodega Bay site.

2 February, 2004

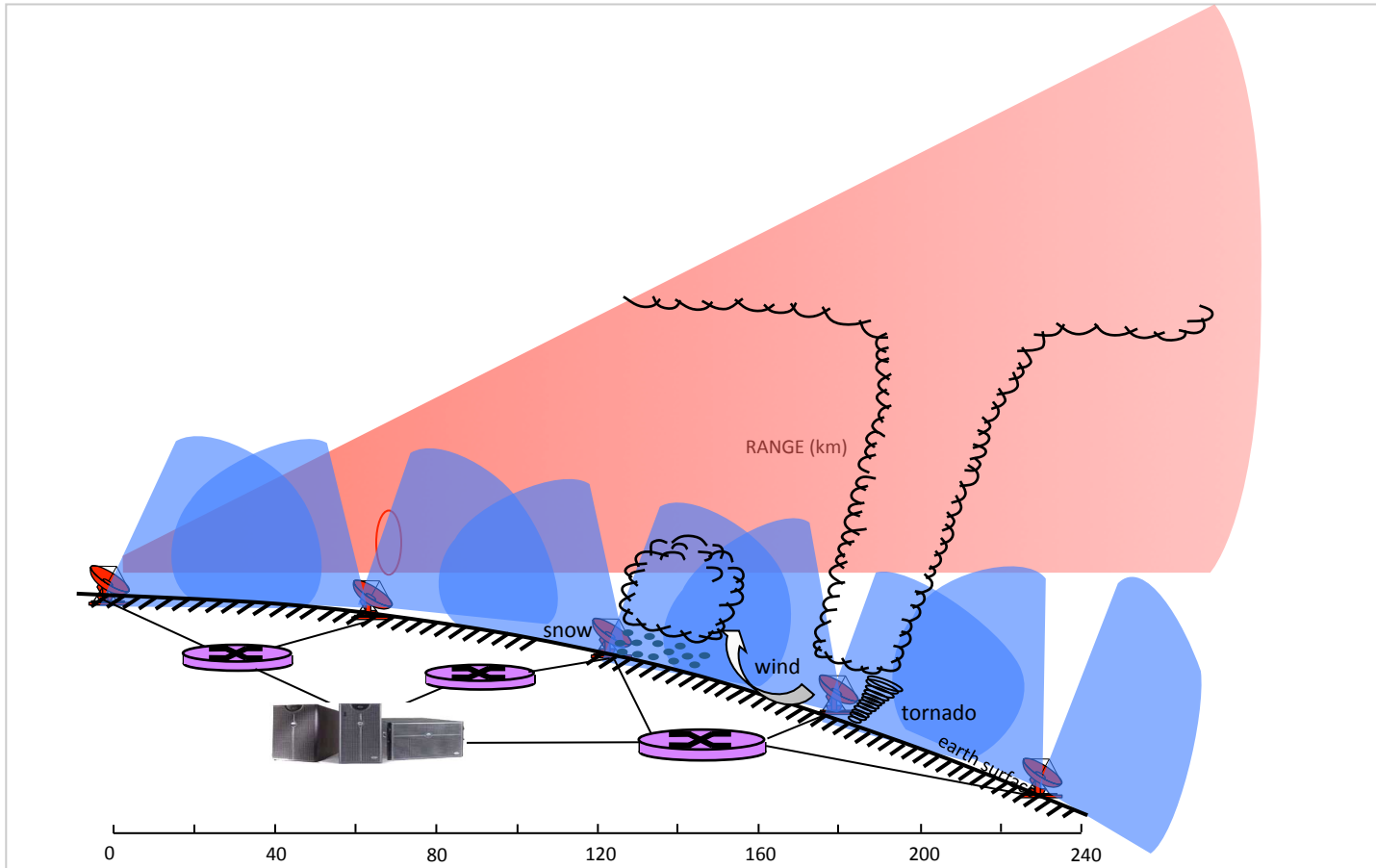


From Matrosov et al. 2005

From Matrosov et al. 2006

Distributed Radar Networks

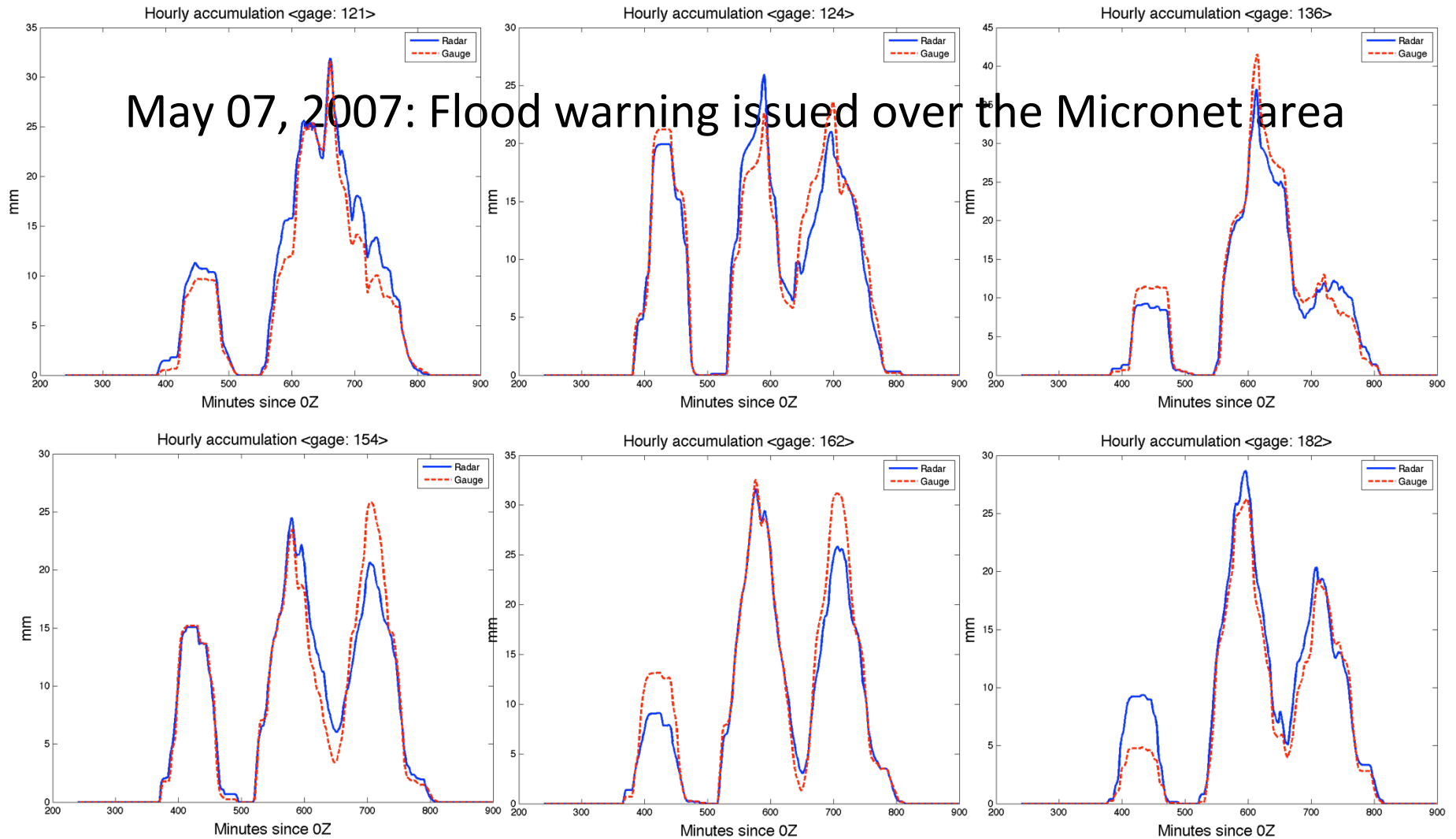
- How to handle QPE at far ranges from radar?
- CASA-Type Solution
 - Dense networks of low power, dual pol, multi-Doppler, X-band radars
 - High spatial and temporal resolution (250m and 1 minute)
 - Smart scans based on weather, user needs and radar capabilities



From V. Chandrasekar

CASA Hourly Rainfall Accumulation

May 07, 2007: Flood warning issued over the Micronet area



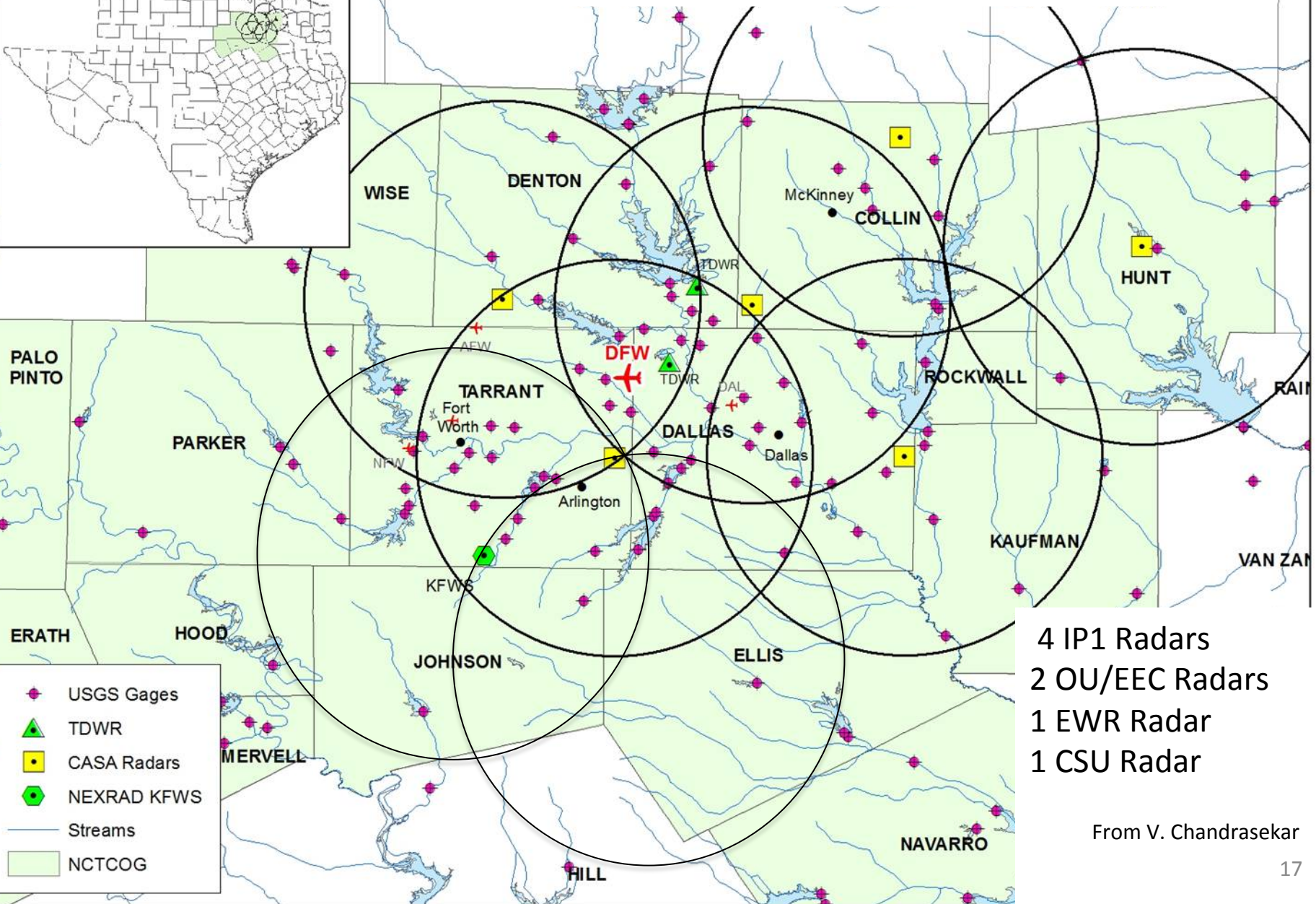
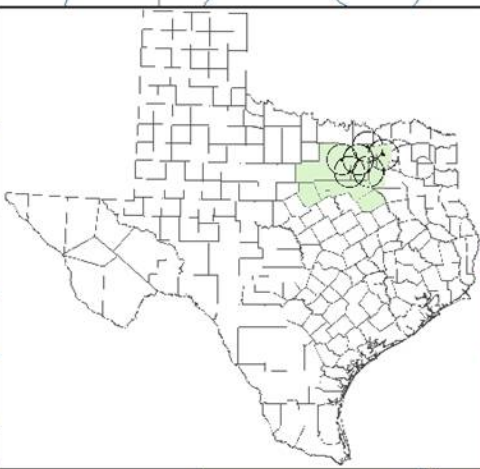
From V. Chandrasekar

Urban QPE

- Urban areas need high resolution QPE for water management needs
 - Time of concentration approaches zero
- Input into hydraulic models
 - Balance storm water runoff and sewage discharge
- Distributed radar networks can sample close to the ground at high resolution and eliminate single point of failure issues



Example Radar Layout



- 4 IP1 Radars
- 2 OU/EEC Radars
- 1 EWR Radar
- 1 CSU Radar

From V. Chandrasekar

Some Wrap-Up Thoughts on QPE

- Evaluation of current algorithms is paramount
 - When and where does satellite QPE make sense?
 - More gauges or more radars?
- Algorithm improvement may require regional solutions
 - Microphysical process in complex terrain may require unique VPR, Z-R selection, mosaicing techniques
- Distributed networks can help supplement operational radar QPE
 - Far range
 - Urban environments