Multi-Sensor Precipitation Reanalysis

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Outline

- **Multi-sensor Reanalysis (MPR) Objectives**
- **Multi-Sensor Precipitation Estimation Algorithm**
- **Input Datasets**
  - **Radar**
  - **Gauge**
- **Data biases and Projection Issues**
- **Summary and Conclusions**

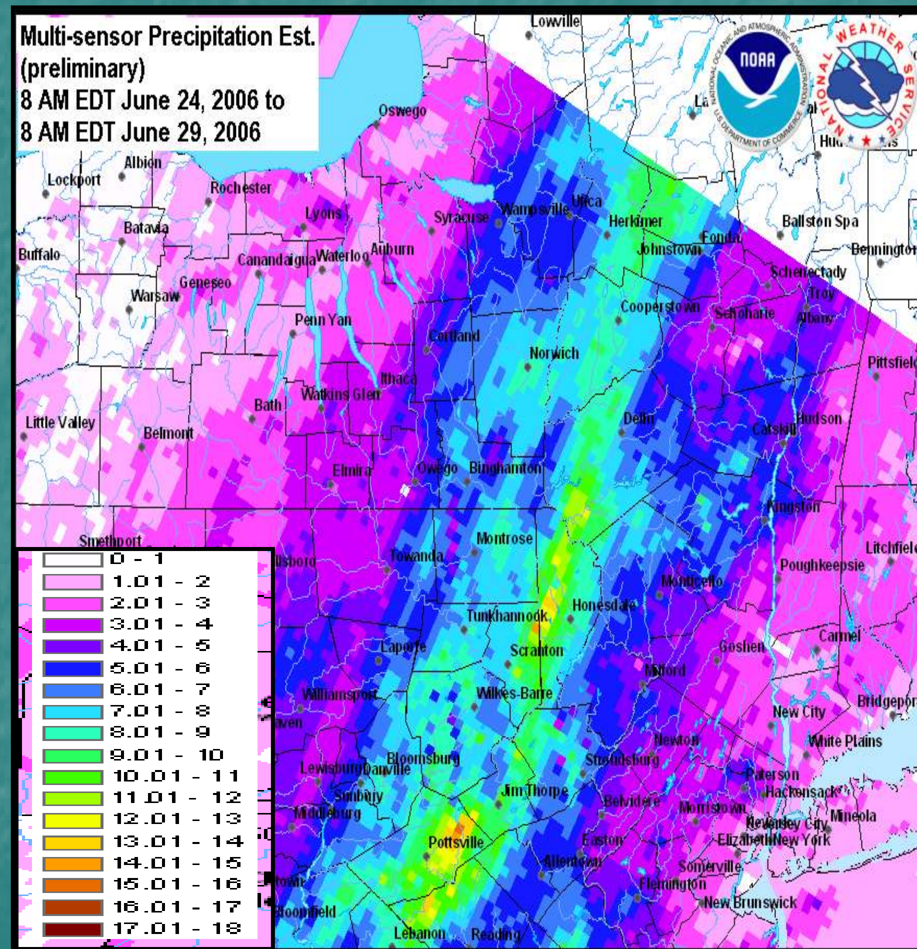
Multi-Sensor Precipitation Reanalysis (MPR)

- Objective: develop historical precipitation dataset specifically applicable to climate investigations
- Datasets of fundamental importance to numerous investigations including drought studies, flood management, water supply, and hydrologic design
- Rainfall estimates used in reanalysis derived through the Multi-sensor Precipitation Estimation (MPE) algorithm
- Success of product dependent on input of high resolution datasets and performance of algorithm
- Reduction of potential biases within input data and effective re-tuning of algorithm are key to success

Nelson et al., 2006

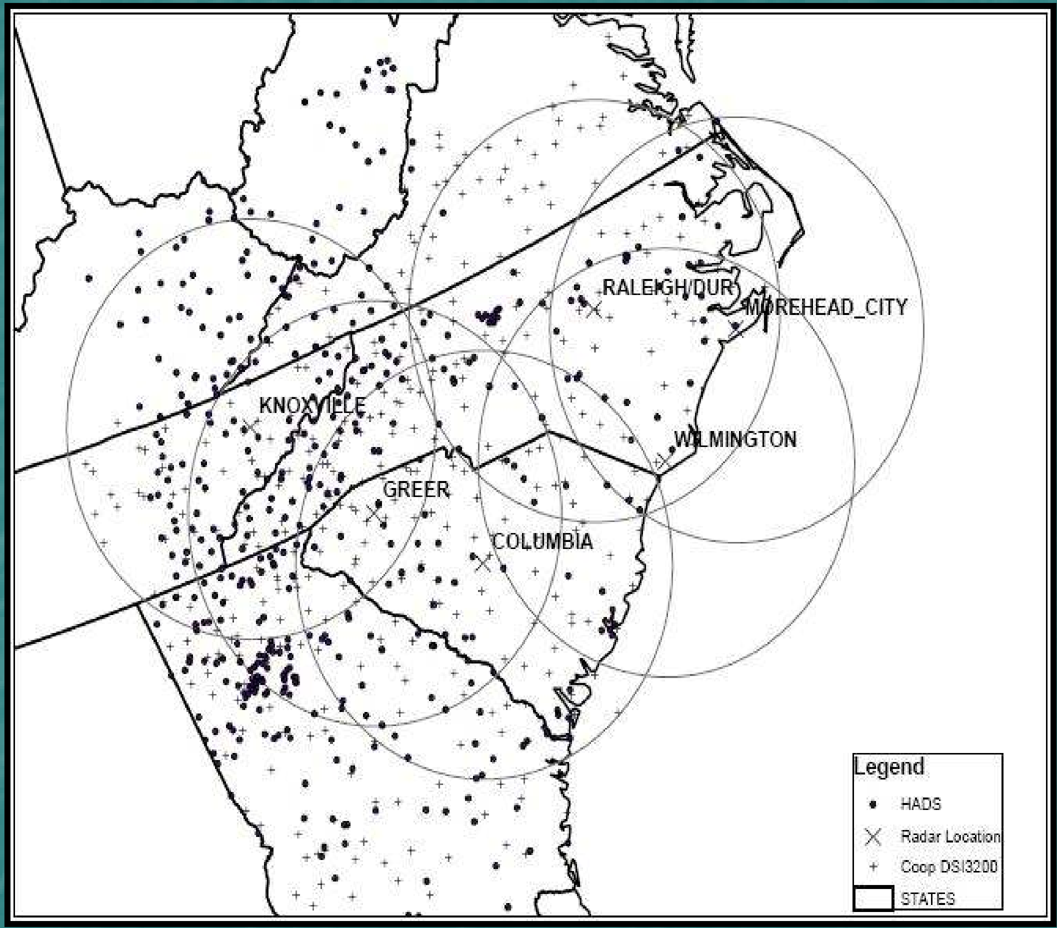
Multi-sensor Precipitation Estimation (MPE)

- **Used since 2002 for the development of high resolution precipitation estimates derived from gauge corrected NEXRAD radar data**
- **MPE is currently used to verify rain forecasts and to provide real-time gauge corrected precipitation estimates to initialize forecast models at 10 minute intervals**
- **Specifically designed to eliminate potential biases inherent in radar and rain gauge data**
- **Efforts of reanalysis will be re-tuning parameters of the MPE algorithm for better performance in long term climate analysis**



MPR Data Sources

- **Radar data:**
  - **High resolution radar reflectance data (NEXRAD) from 158 sites**
  - **Digital Precipitation Array (DPA):**
    - **Hourly running total of NEXRAD radar precipitation estimates**
- **Gauge data**
  - **Hydrologic Automated Data System (HADS):**
    - **NWS supported system providing real-time data acquisition and distribution**

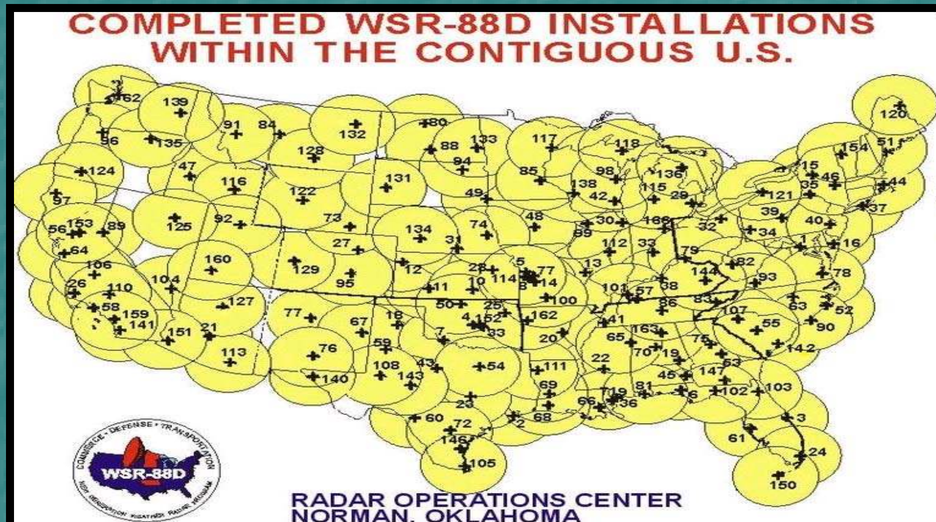


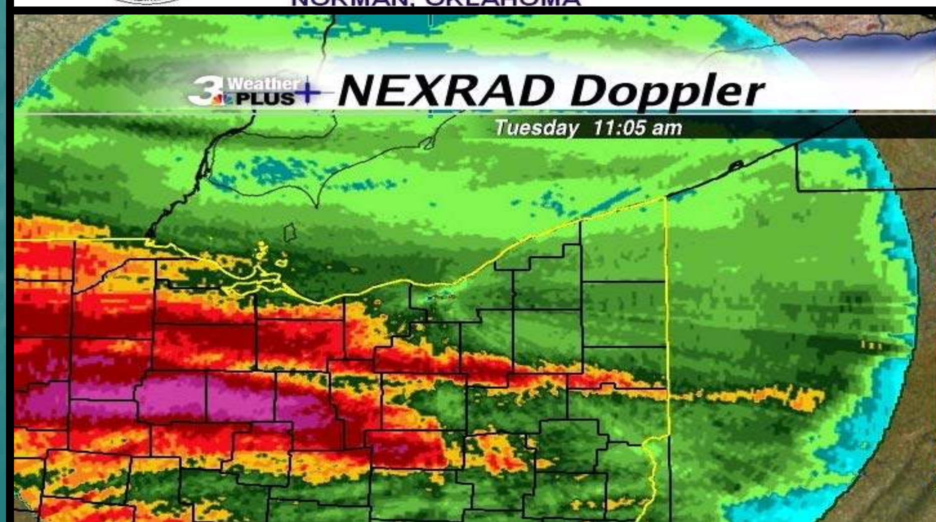
Location of gauge and radar sensors within study site

Nelson et al., 2006

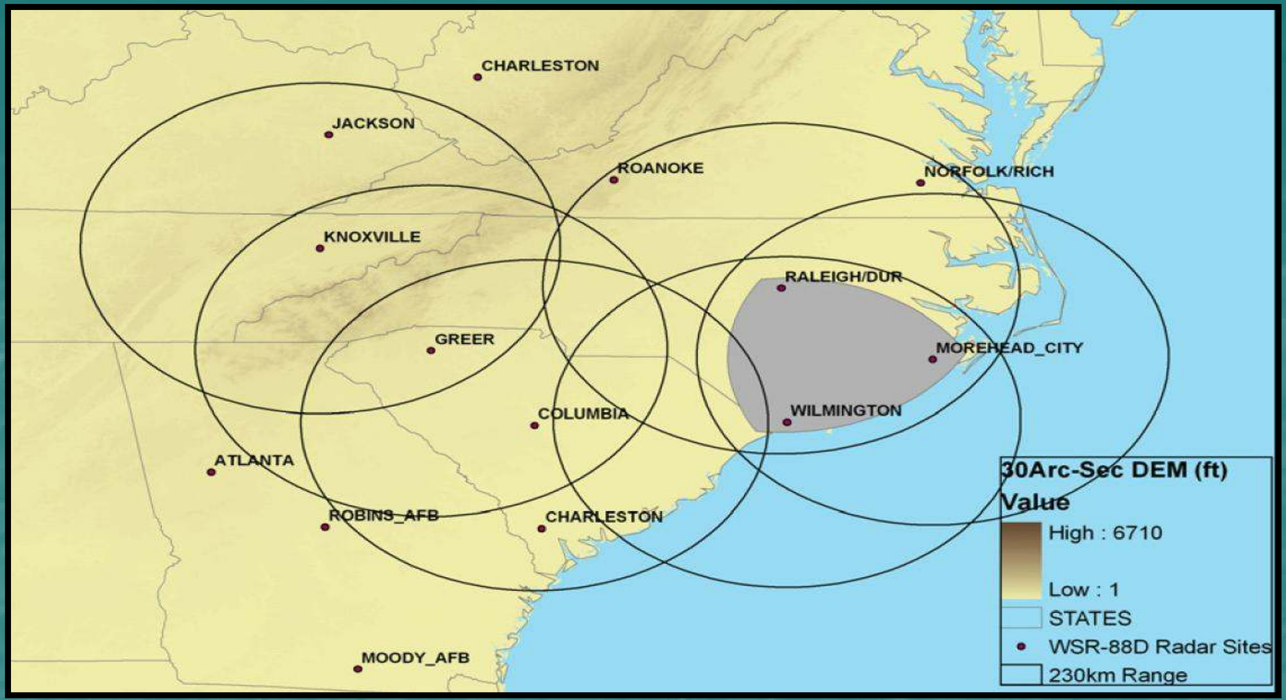
Next Generation Weather Radar (NEXRAD)

- **158 sites in Continental U.S. active for over 10 years**
- **Known by designation: WSR-88D (Weather Surveillance Radar 88 Doppler)**
- **Collects radar reflectivity estimates in order to compute rainfall forecasts**
- **Produces radar-derived rainfall products for National Weather Service available at 10 minute intervals**
- **Provides high resolution gridded 4x4 km per-pixel precipitation estimates at hourly intervals spanning a 10 year period**





Nelson et al., 2006



Doppler Radar System

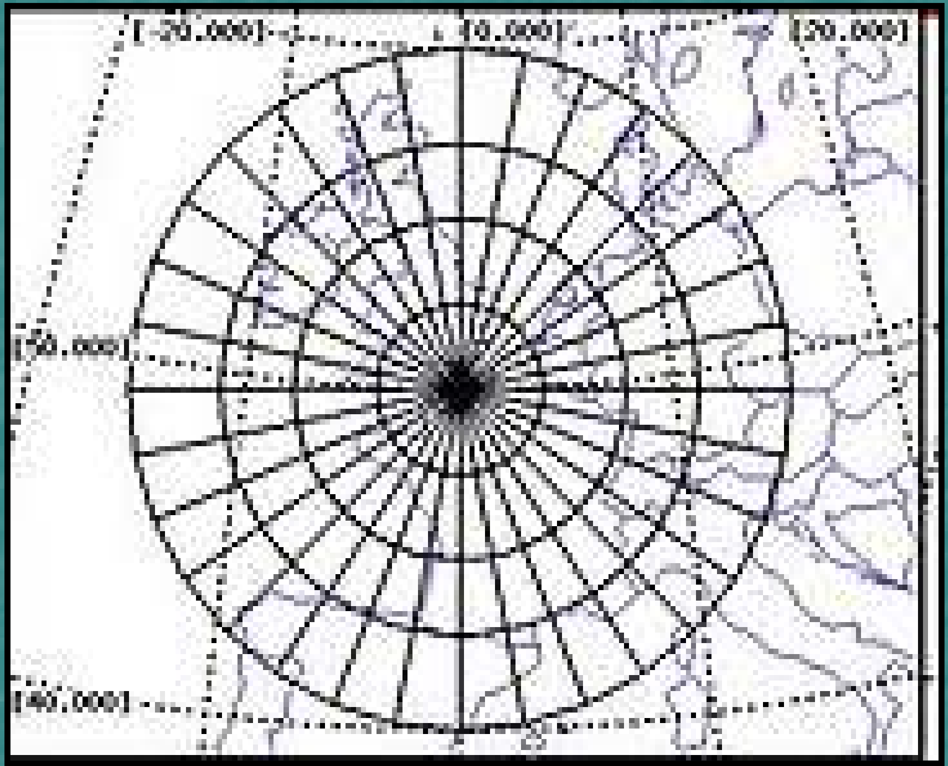
- Radar coverage from of MPR study site over North and South Carolina with a circular range of 230 km in diameter
- The gray overlap region has radar coverage from the KRAX, KMHX and KLTX radar systems
- Due to the importance of product verification and the identification of input data bias data from overlap region has been used in developing the MPR product

Nelson et al., 2006

NEXRAD Projection Issues

- Radar sensors collect data radially and are therefore referenced in a polar coordinate system
- Data grid consists of 250 mile radius circle sliced into pieces measuring 1 degree of arc and 2 km in radius length
- Pixels closer to sensor are smaller (higher resolution) while pixels furthest away have a lower resolution and may introduce bias
- National mosaics of radar returns is created as a raster grid and which covers continental US in 4 km or 6 km cells

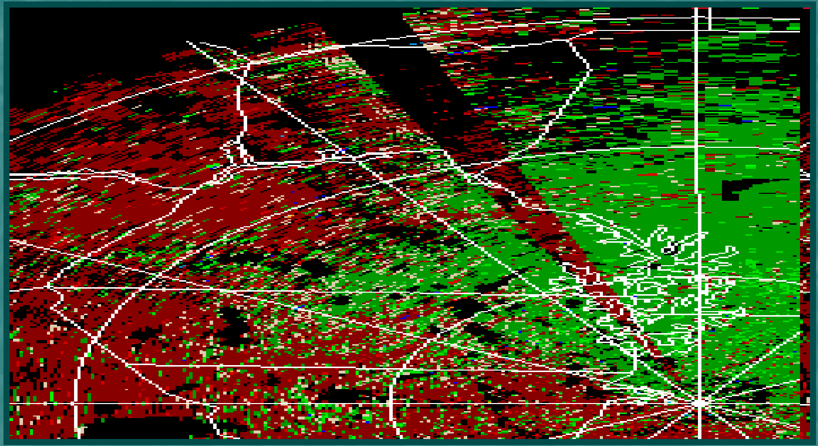
(Tenenbaum, 2008)



Example of radar projection in polar coordinate system

Radar Biases

- Geophysical factors such as beam blockage and bright band contamination
- Non-precipitating reflectivity resulting from birds, insects, and aircraft
- Range dependence and hardware limitations

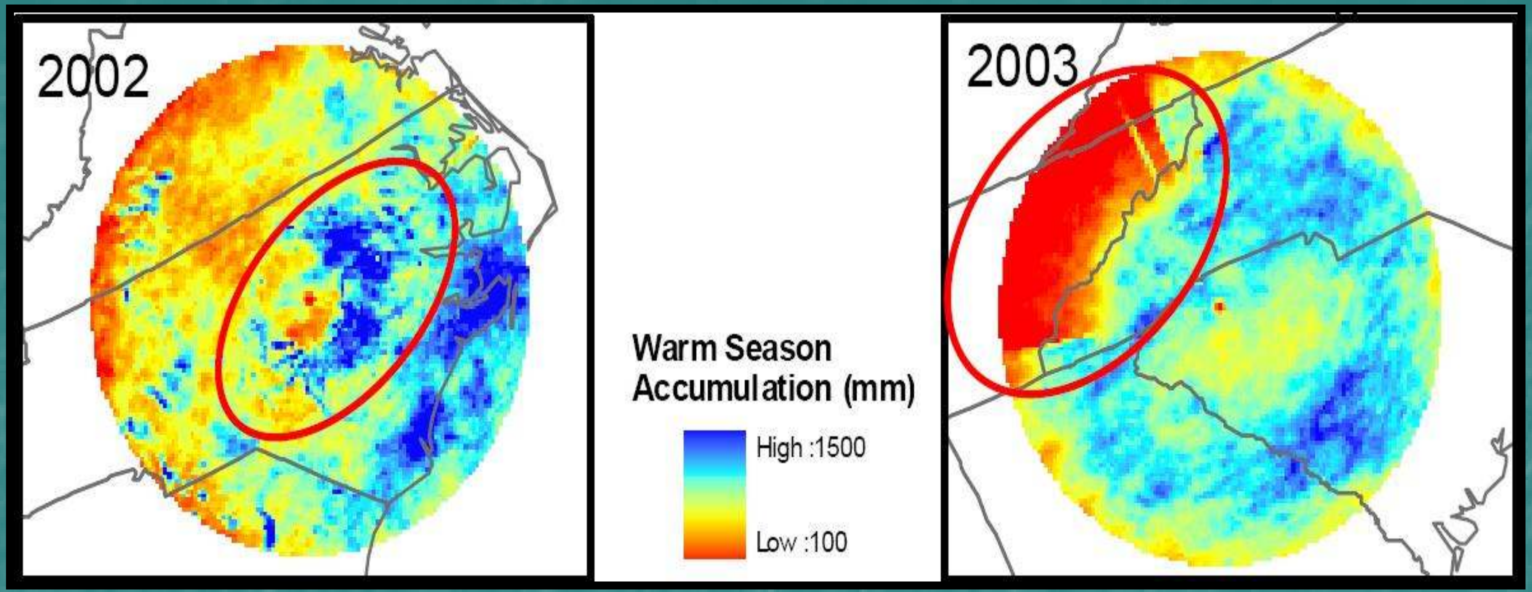


Example of beam blockage caused by water tower northwest of radar station

Birds and Planes can cause a false radar return

Nelson et al., 2006

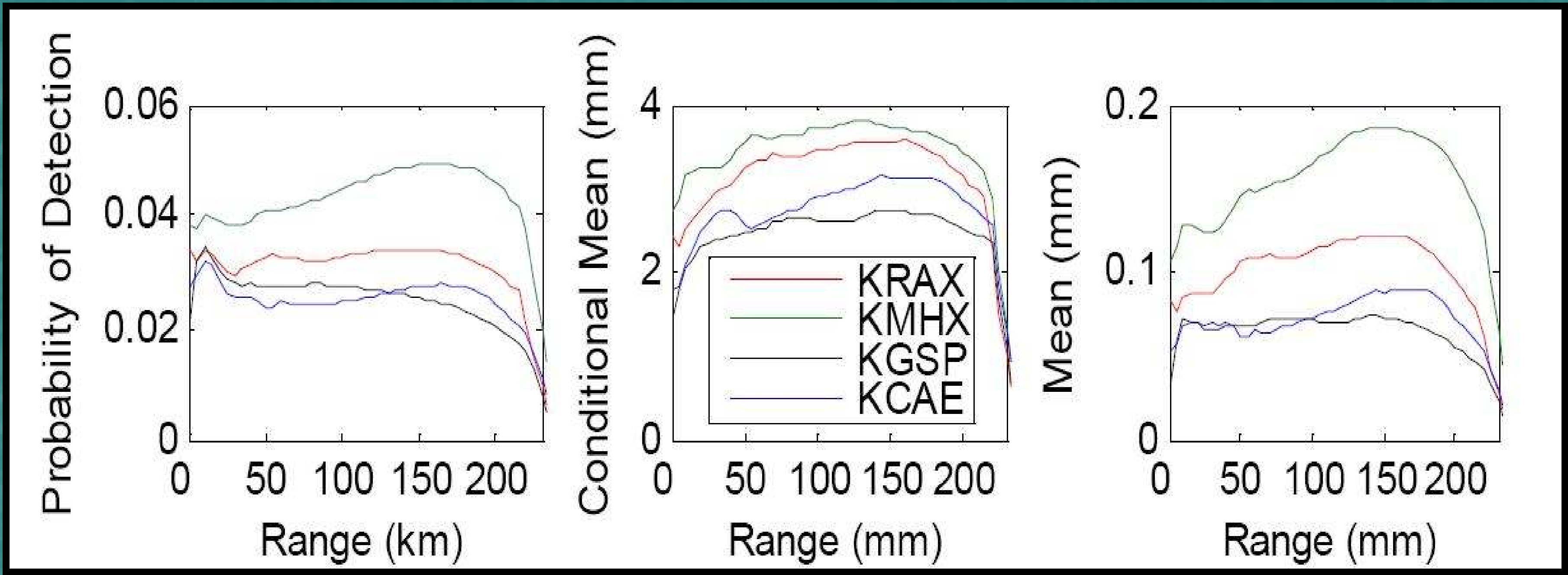
Radar Derived DPA Bias



- Biases of DPA product difficult to observe on daily basis but seasonally more apparent
- Left image shows bias caused by band contamination observed at the KRAX radar station
- Right image indicates bias caused by beam blockage from KGSPP radar located in Greer, SC.

Nelson et al., 2006

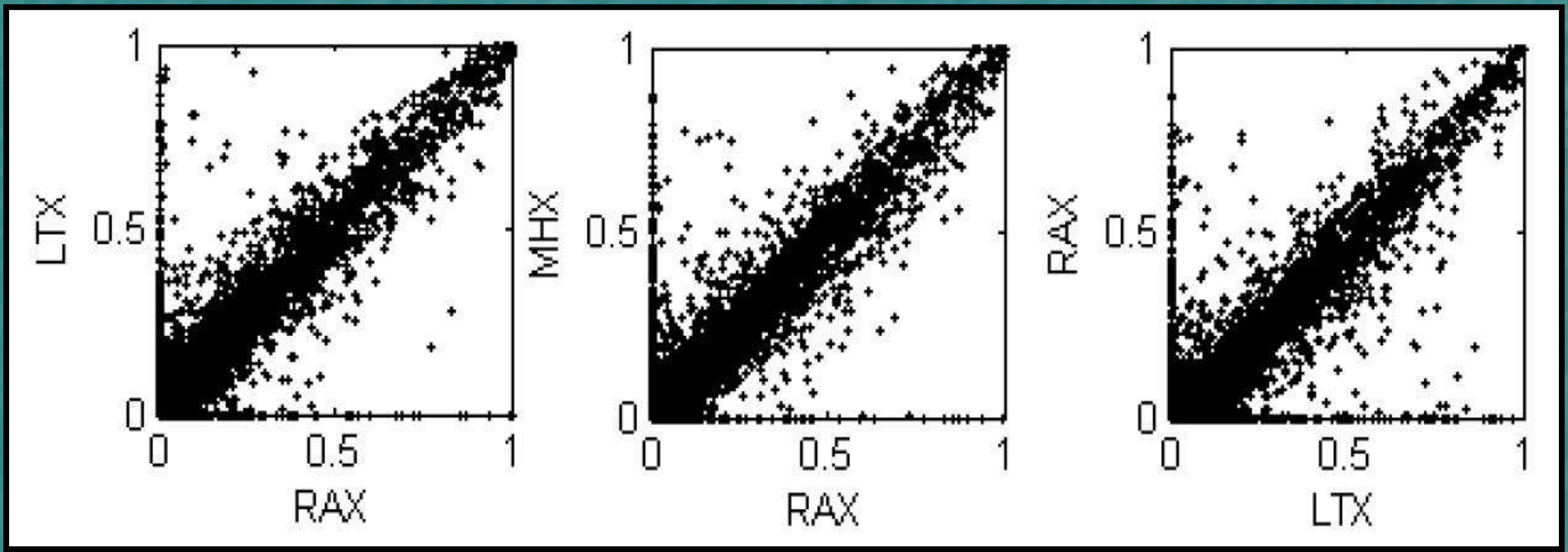
Distance Related Bias



- **Probability of detection of mean rainfall as a function of range from four radars in study region.**
- **Bias is introduced in precipitation estimates when recorded beyond 170 km**

Nelson et al., 2006

Non-Precipitating Reflectivity Bias



- Data shows numerous instances where one radar reports rain while others due not
- Bias due to non-precipitating reflectivity such as insects or birds which cause abnormal radar returns
- Each non-precipitating returns introduces a strong and growing bias in long term climate studies

Nelson et al., 2006

Gauge Data

HADS
Hydrometeorological Automated Data System

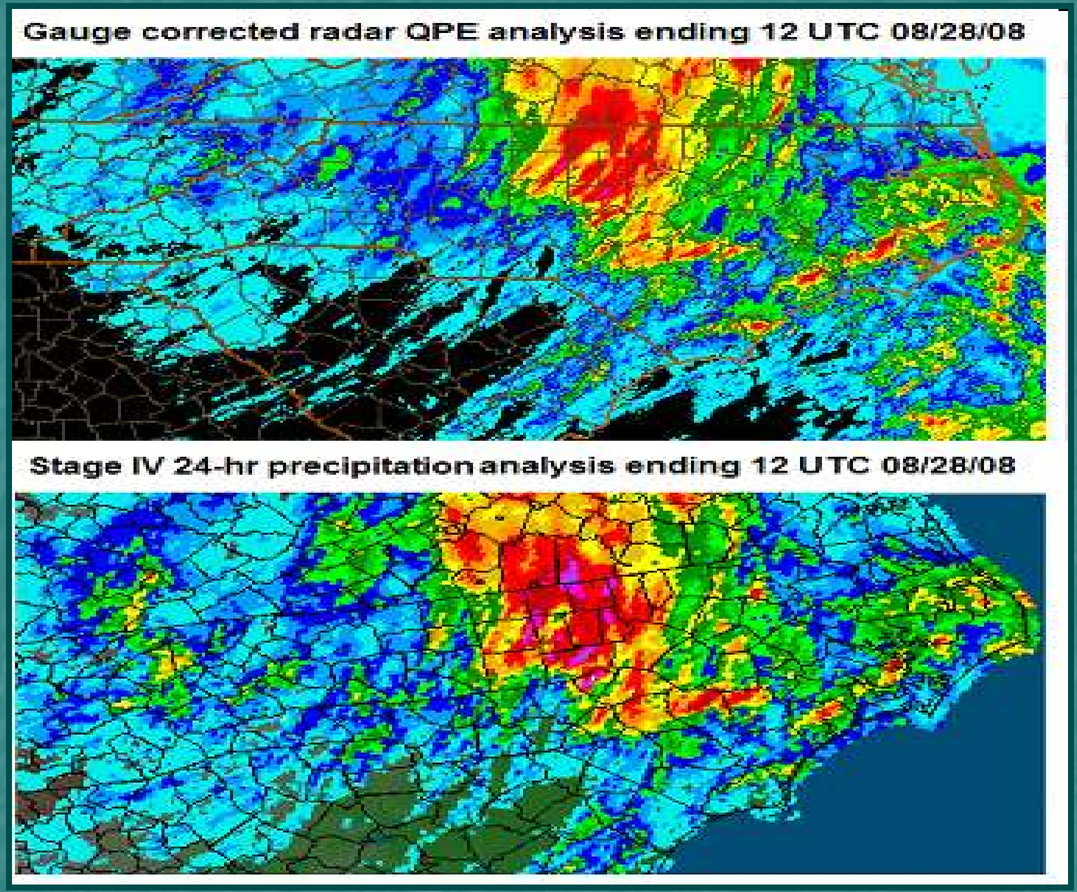
- National Weather Service's (NWS) operates over 10,000 gauges in continental U.S.
- HADS provides real-time data acquisition, processing, and distribution products

Typical HADS rain gauge

Over 14,200 data points in above image represent HADS sensors incorporated in MPE algorithm (www.weather.gov)

Importance of Gauge Corrected Radar Data

- Integrating rain gauge data into MPE algorithm dramatically improves resolution of radar estimates
- Numerous investigations have shown it is crucial to input high quality rain gauge data in the MPE algorithm (e.g. Steiner et al., 1999).
- Authors of this paper put extensive efforts into verifying the high quality of the HAD data

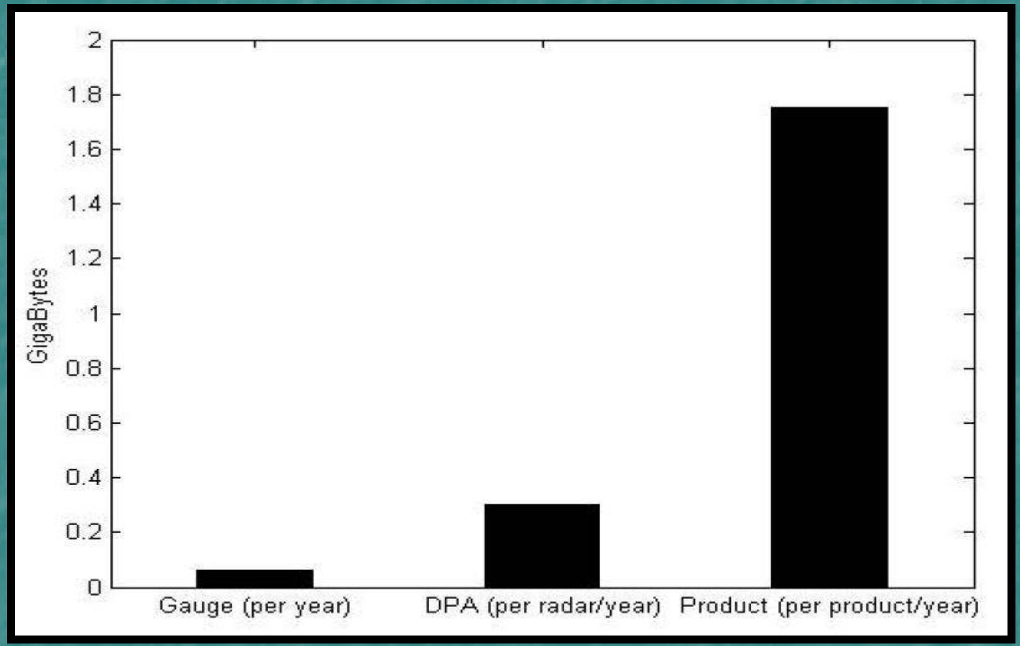


Comparison of gauge corrected rainfall estimates (above) with non-corrected radar data (below).

Nelson et al., 2006

MPR Product
Technical Requirements

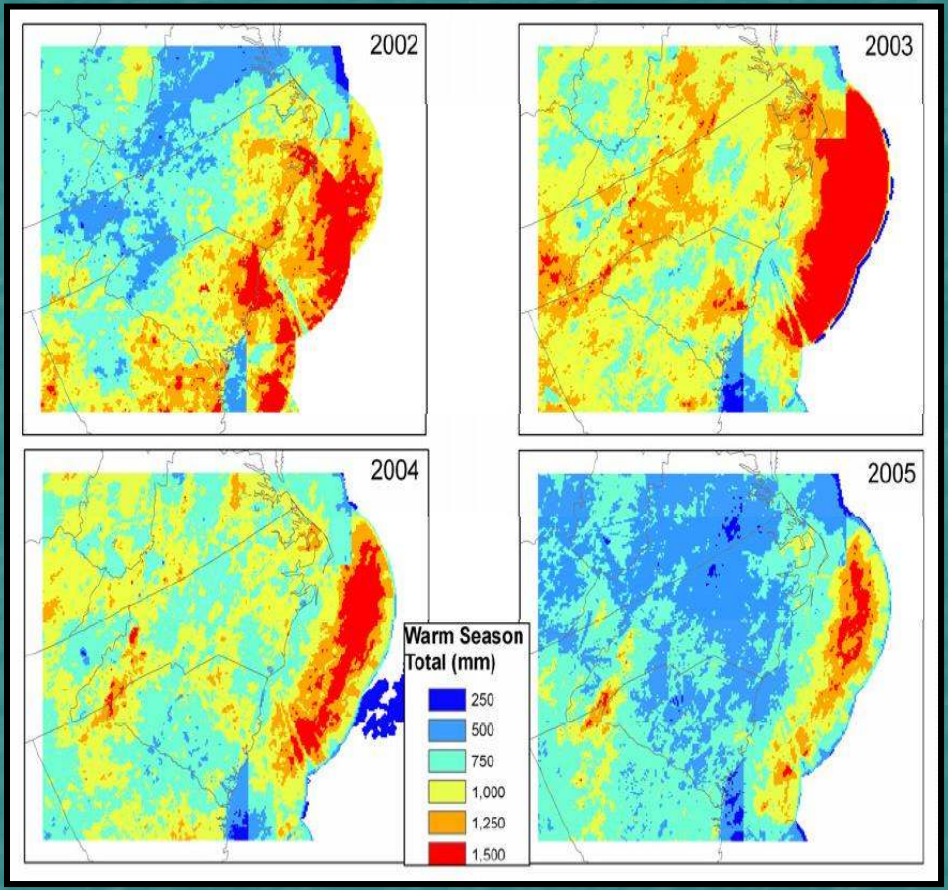
- Effective parameter tuning for MPE algorithm will require extensive sensitivity analysis prior to product output
- Validation of MPR Product will be crucial as users will require accurate per-pixel/ per hour measure of uncertainty values
- Data organization, storage, and management will be difficult when product integrated in the CONUS hourly rainfall estimates



MPE Products developed for the study site required almost two GB of storage space per product year

MPR Conclusions

- Study developed methods to create a high resolution historical precipitation dataset suitable for climate applications
- The MPE algorithm has dramatically improved precipitation estimates through the integration of gauge corrected radar data and the reduction of potential data biases
- Further reducing input data biases and effective tuning MPE algorithm crucial for success
- The gridded dataset will provide 10 years of hourly rainfall estimates at a 4x4 km per pixel resolution highly valuable to numerous investigations



MPR product showing four years of precipitation estimates within study site

Nelson et al., 2006


QUESTI ONS?