Next-generation Probabilistic WSR-88D Rainfall Algorithms in the National Weather Service

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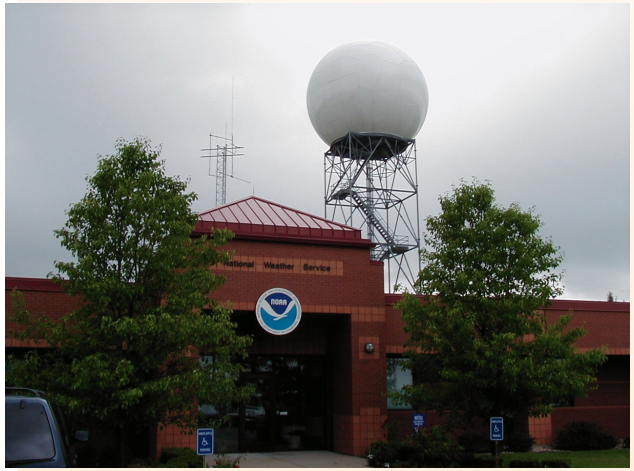
Outline

- Where are we now?
- Where do we want to go?
- Why do we want to do this?
- How do we get there from here?

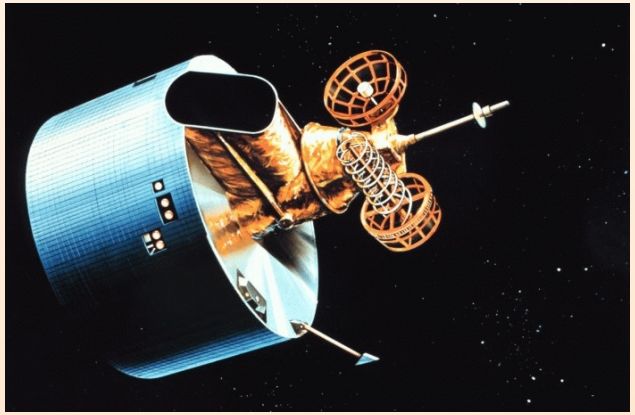
Quantitative Precipitation Estimation in the National Weather Service

Multisensor Approach to Optimally Combine Information from Multiple Sensors



WSR-88D Radar

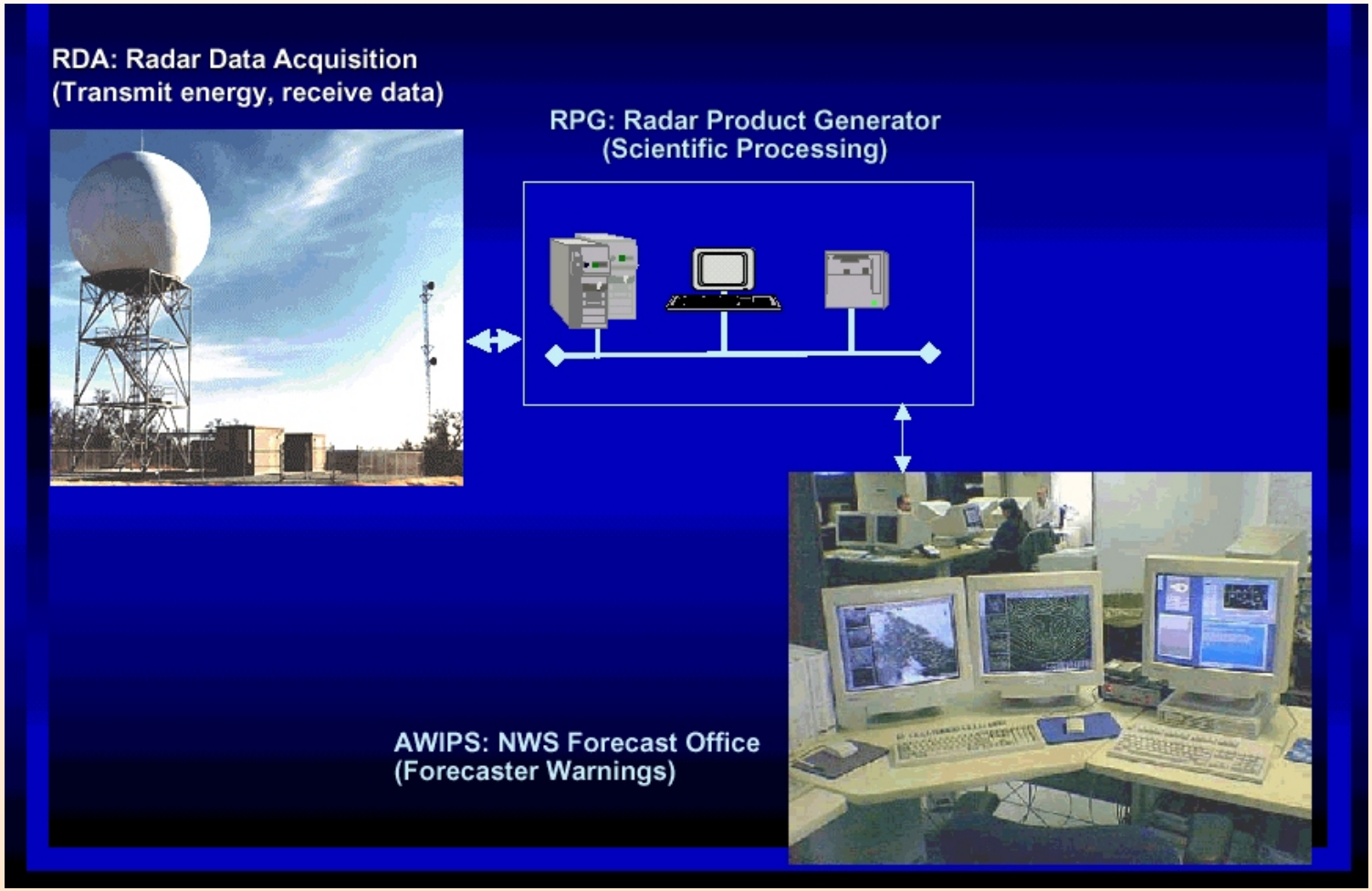
Rain Gauges



Satellite

Quantitative Precipitation Estimation in the NWS

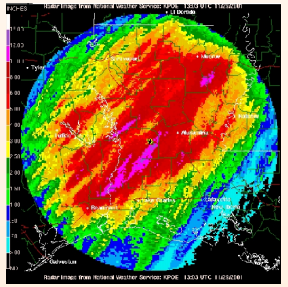
A Blend of Automated & Interactive Procedures

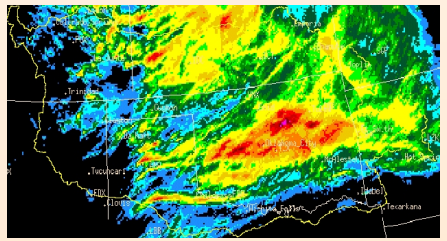


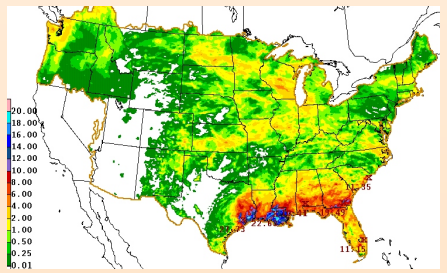
Quantitative Precipitation Estimation in the NWS

Integrated Sequential Processing from Local to Regional to National Levels

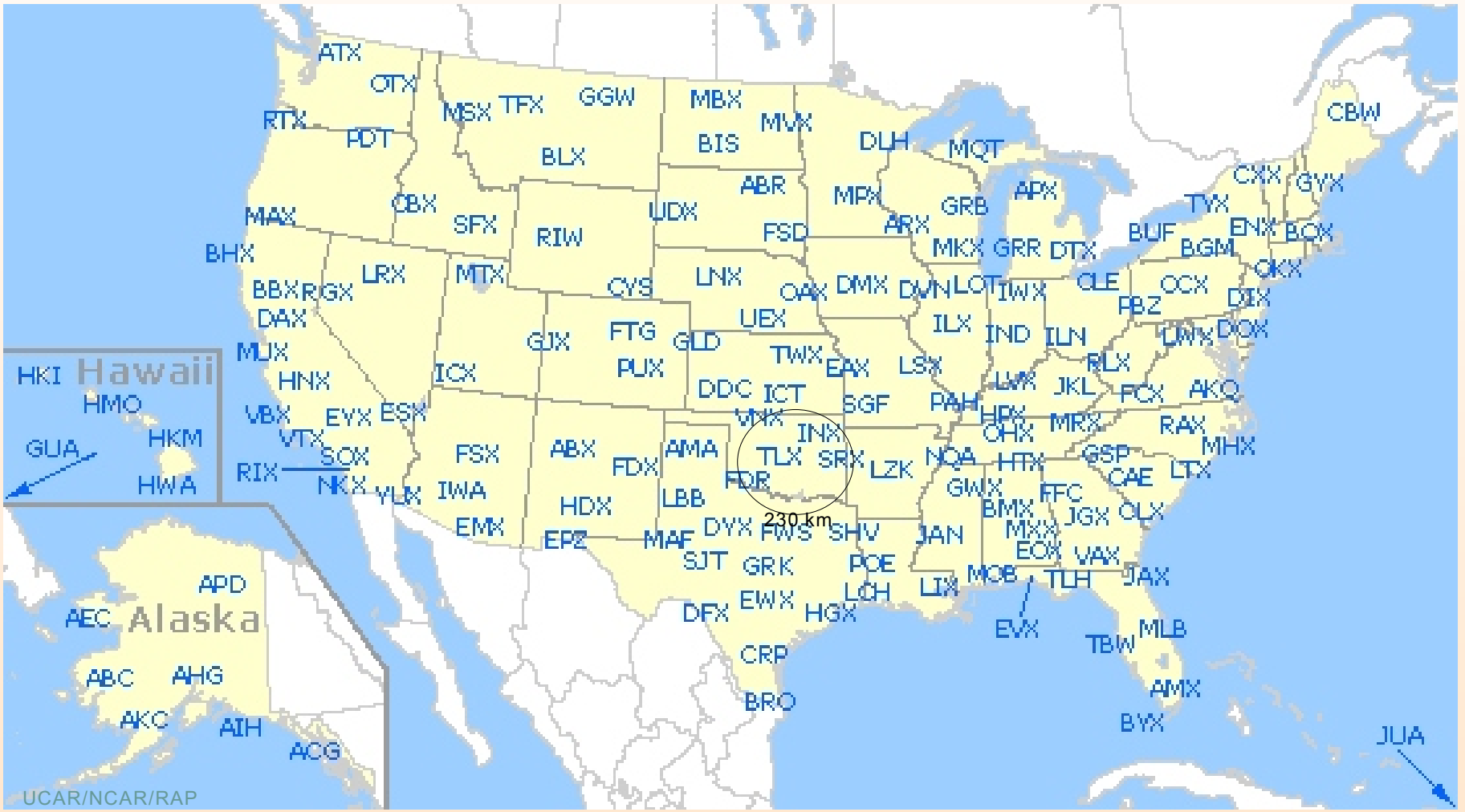
- Local Weather Forecast Offices (WFO)
  - Precipitation Processing System (PPS) (=Stage I)
  - Stage II Precipitation Processing (old paradigm)
  - Multisensor Precipitation Estimator (MPE) (new paradigm)
- Regional River Forecast Centers (RFC)
  - Stage II and III Precipitation Processing (old paradigm)
  - Multisensor Precipitation Estimator (new paradigm)
- National Center for Environmental Prediction (NCEP)
  - Stage IV Precipitation Processing







160 WSR-88D Doppler Radars



122 Weather Forecast Offices

First Step (Local)

Generate single-radar rainfall products
at each WFO every 5-10 minutes using
Precipitation Processing System (PPS)

- Quality control near-ground radar reflectivity data
- Account for beam blockages by terrain
- Compute and apply range-based corrections due to vertical reflectivity gradients (coming soon)
- Convert reflectivity to rainrate to accumulation
- Apply mean-field raingauge-radar bias correction to account for radar-specific calibration and/or Z-R errors
- Generate deterministic digital and graphical rainfall products for follow-on processing steps
- **Fulton et al., 1998: The WSR-88D rainfall algorithm. *Weather and Forecasting*, 13, 377-395.**

National Weather Service

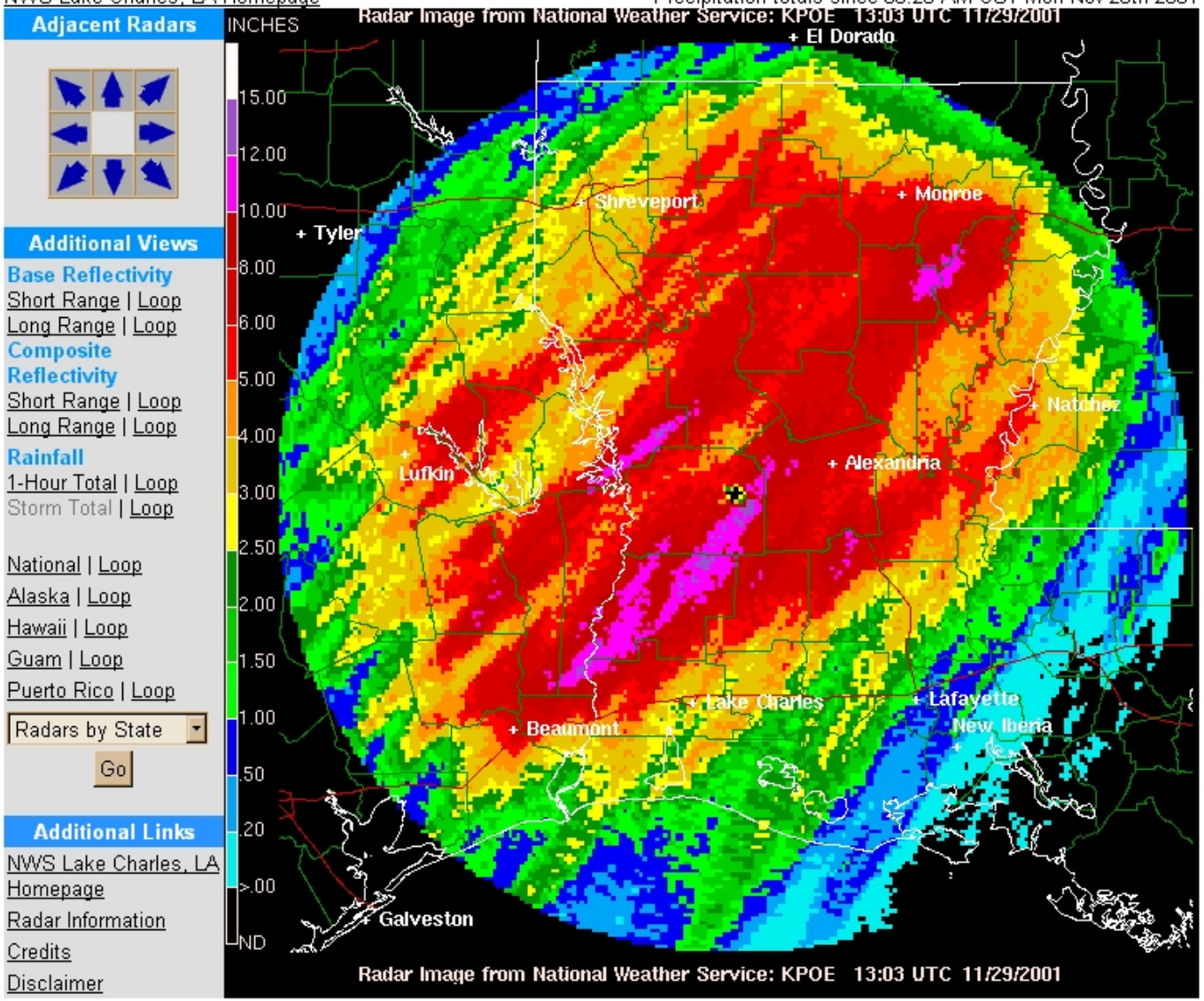
Fort Polk, LA Radar

Storm Total Precipitation

07:17 AM CST Thu Nov 29th 2001

NWS Lake Charles, LA Homepage

Precipitation totals since 06:20 AM CST Mon Nov 26th 2001



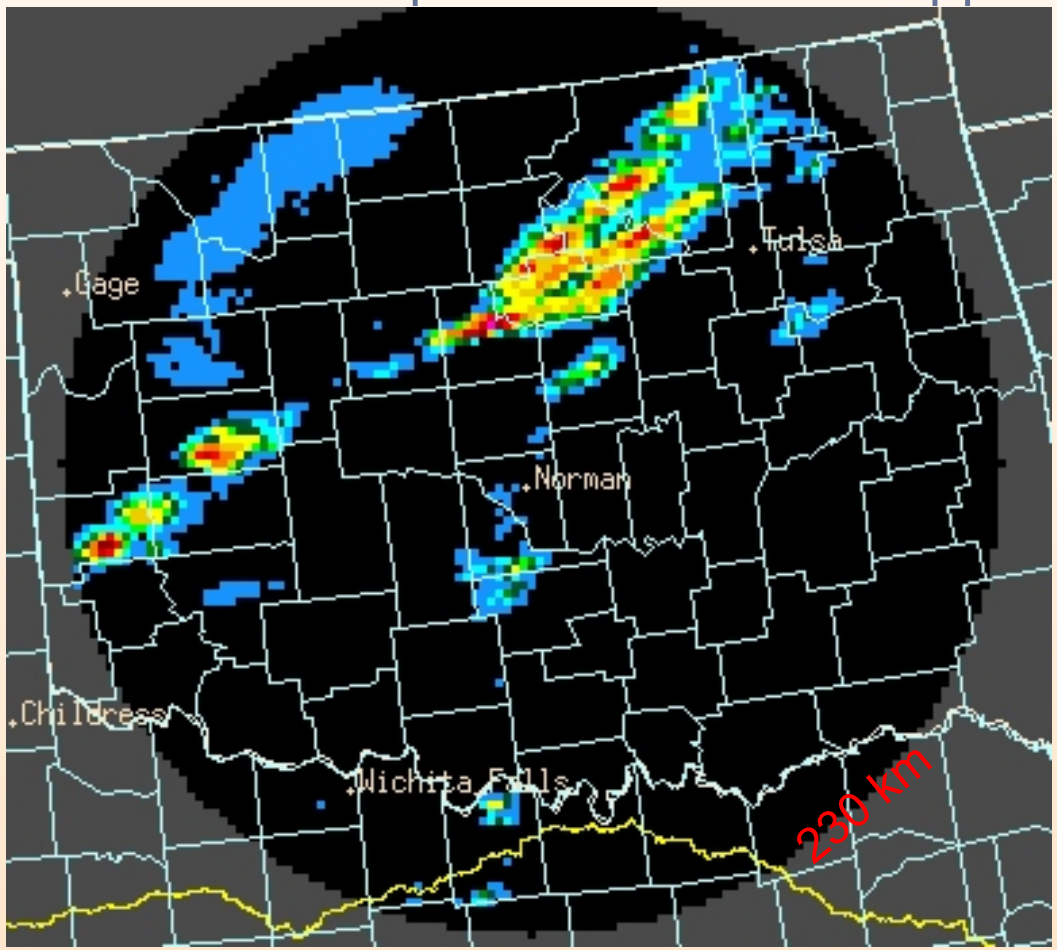
Time and date in red indicates image is at least one hour old.

Graphical 16-level image products

1-hr, 3-hr, storm-total, & user-defined accumulation periods

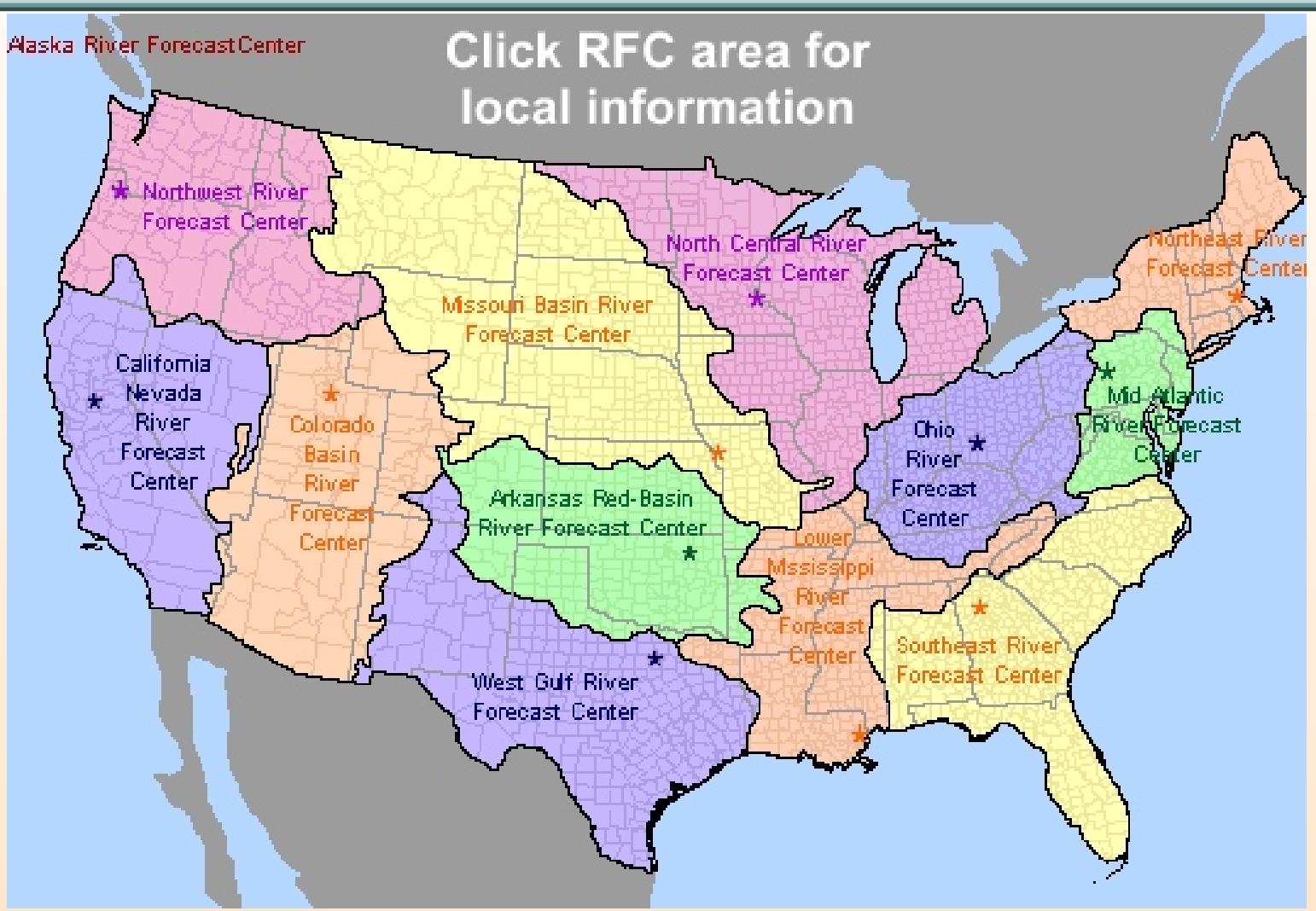
Hourly Digital Precipitation Array (DPA) Product

- Rectilinear 4-km national polar stereographic grid (HRAP)
- 256 rainfall data levels
- Used in follow-on quantitative rainfall applications



* A new Digital Storm-total Precipitation (DSP) product is coming in ORPG Build 3

13 River Forecast Centers



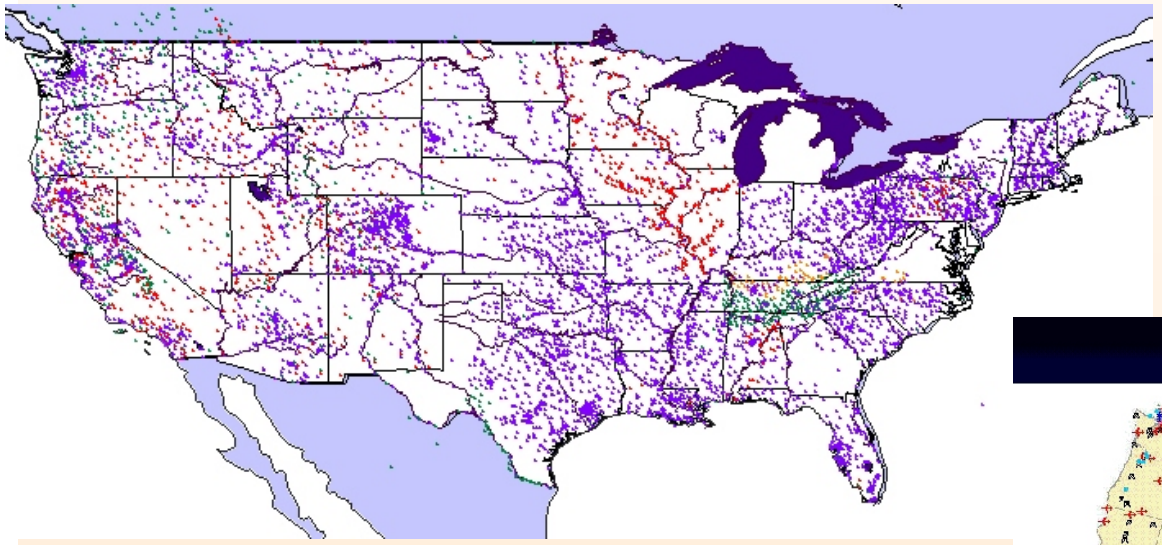
Second Step (Regional)

Generate 4-km regionally-mosaicked hourly
multisensor rainfall products at each RFC and WFO
using Multisensor Precipitation Estimator (MPE)

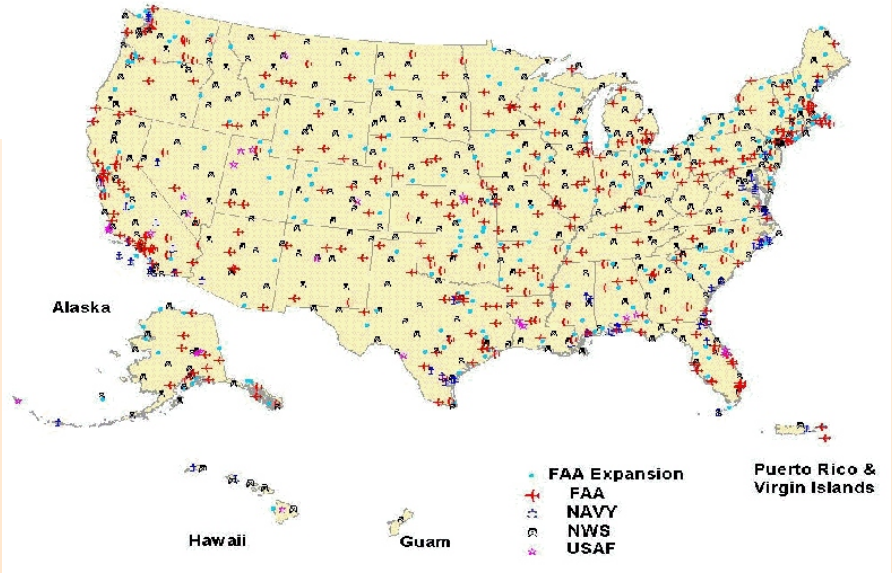
- Compute & apply hourly mean-field raingauge-radar corrections for each WSR-88D radar
- Regionally mosaic these hourly rainfall products
- Merge radar, gauge, and satellite rainfall estimates to generate multisensor rainfall grids
- Interactively quality control real-time rain gauge, radar & satellite rainfall estimates. Iterate the above if needed
- Generate deterministic, hourly, regional, multisensor rainfall mosaic products on the 4-km HRAP grid
- **http://www.nws.noaa.gov/oh/hrl/presentations/mpe_training_wkshp_0601/course_outline.htm**

Utilize available real-time automated hourly rain gauge data

GOES Data Collection Platform Locations

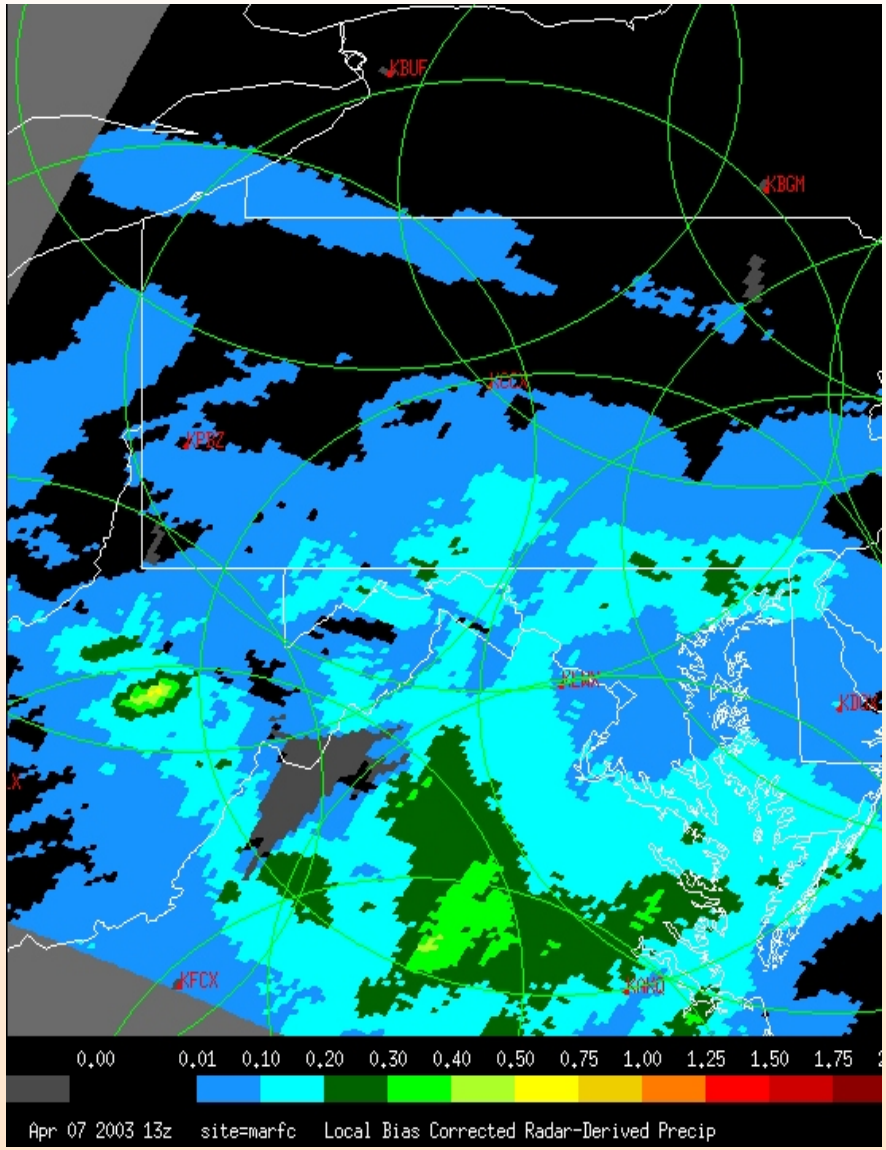


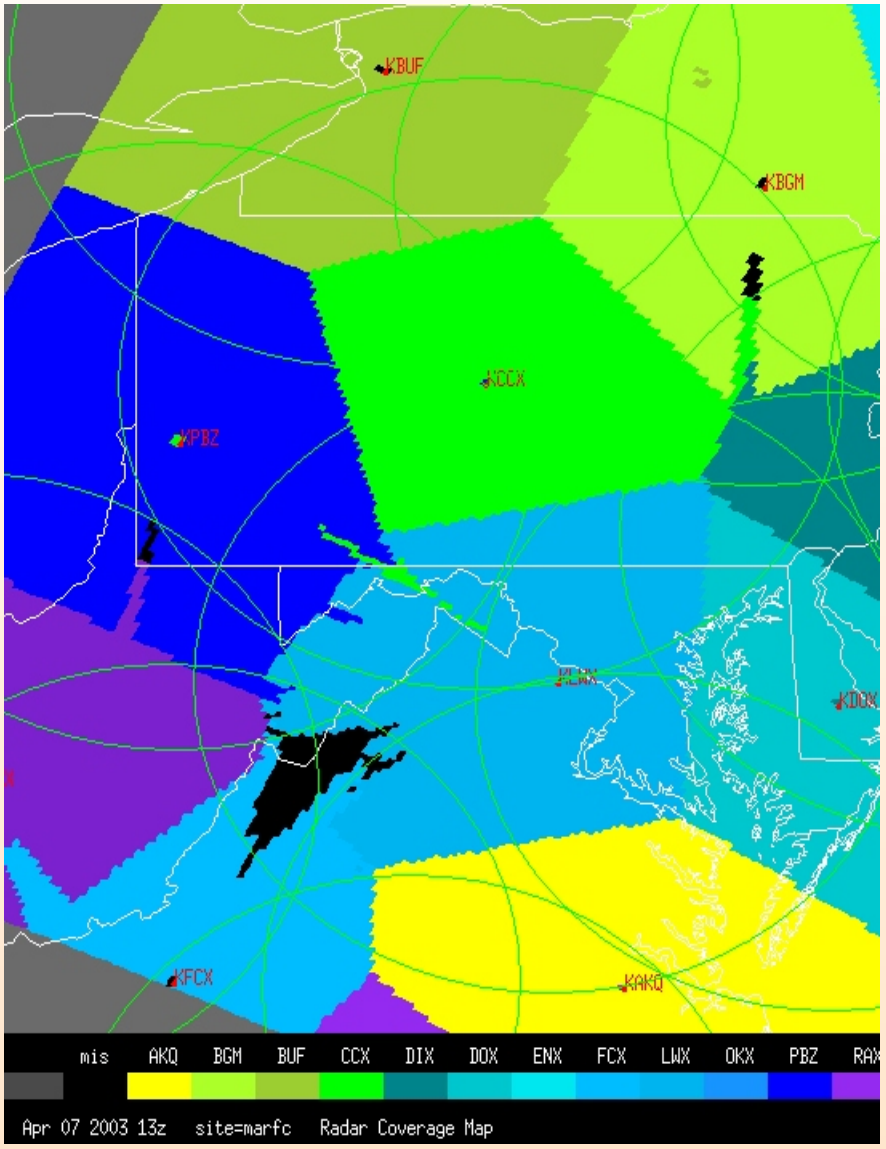
ASOS Locations



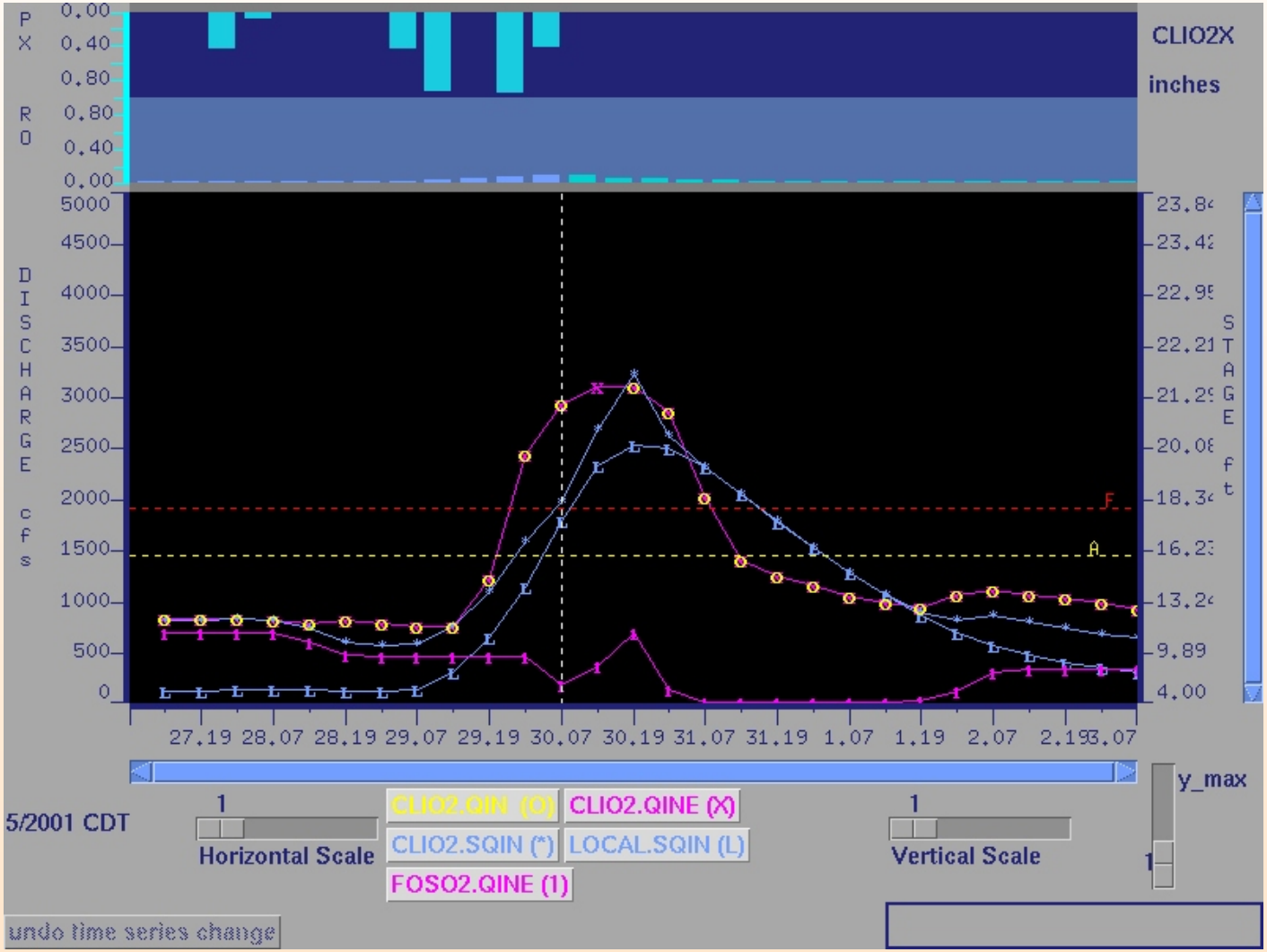
Other networks:
ALERT, IFLOWS, local networks

Example of MPE Hourly Rainfall Mosaicked Product from MARFC





Regional hourly multisensor rainfall products may then be used as input to RFC hydrologic forecast models of the River Forecast System

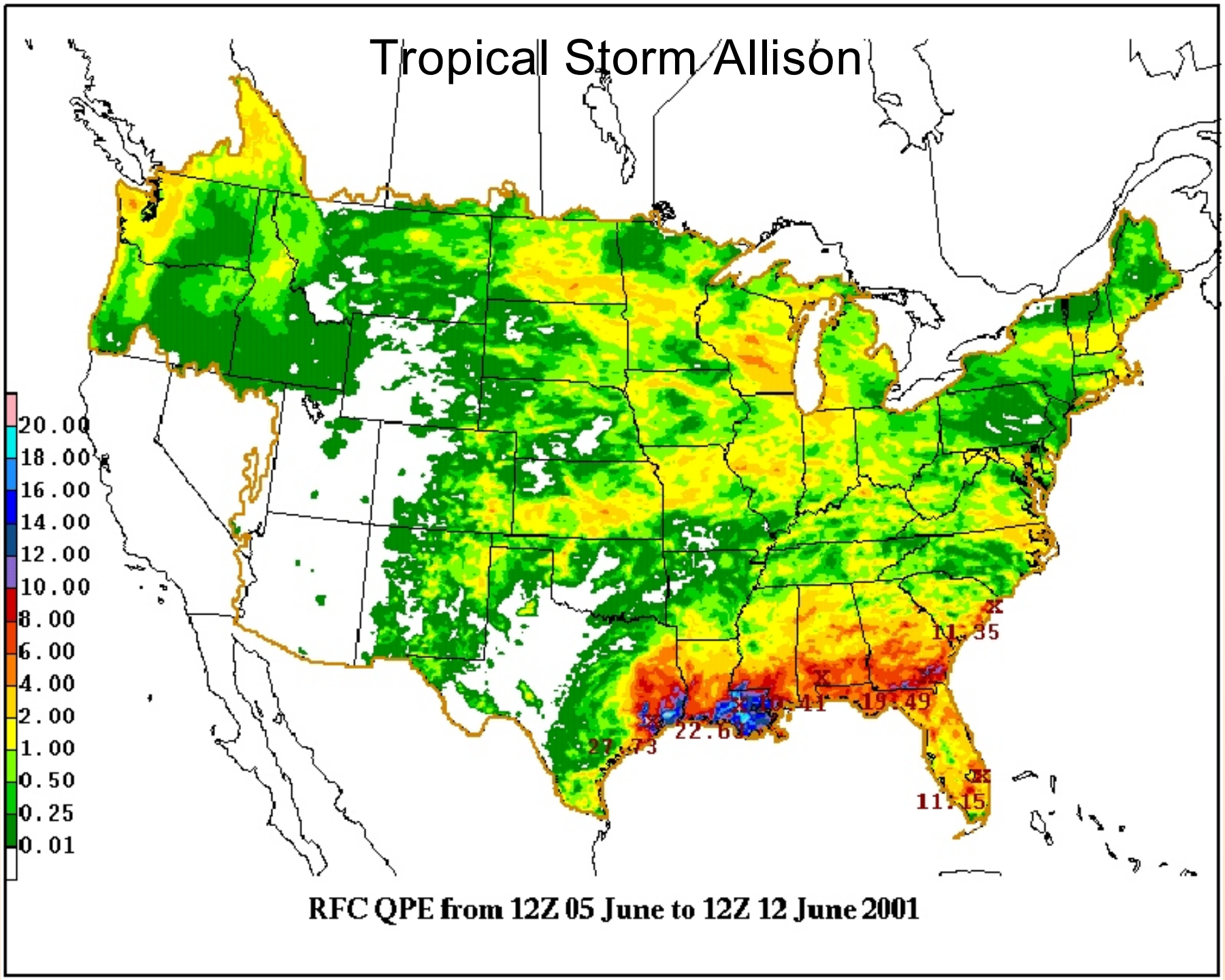


Third Step (National)

Generate National Mosaic of Hourly Rainfall Products using
Stage IV Precipitation Processing algorithm

- NWS/NCEP/EMC performs national radar-gauge rainfall mosaicking
  - http://wwwt.emc.ncep.noaa.gov/mmb/ylin/pcpanl/
  - **See *Baldwin and Mitchell, 1997: The NCEP hourly multisensor U.S. precipitation analysis for operations and GCIP research. Preprints, 13th AMS Conference on Hydrology, 54-55***
- Used as input to NWS numerical weather prediction models to improve quality of:
  - 4-d data assimilation of precipitation (Eta Data Assimilation System) and short-term Eta model precipitation forecasts
  - Other water cycle components, e.g., soil moisture
  - **See *Lin et al., 2001: Spring 2001 changes to NCEP Eta analysis and forecast system: Assimilation of observed precipitation data. Preprints, 9th Conf. Meso. Proc., J92-J95***
- Used for verification of QPFs from NCEP NWP models, HPC and RFC forecasters
  - http://www.hpc.ncep.noaa.gov/npvu/

Tropical Storm Allison



Where Do We Want to Go?

- A radar-based precipitation algorithm that produces *uncertainty information* in addition to the estimates themselves
- An *operationally-viable and robust* algorithm implementable within NWS computer systems using NWS data
- Probabilistic precipitation products that span a *wide range of space and time scales* from short-fuse flash flooding events to large-scale river flooding to seasonal water supply applications over diverse climate regimes in the US
- Probabilistic precipitation products that both scientists and non-technical people *understand and know how to use*

Why Do We Want to Do This?

American Meteorological Society's Statement on
Enhancing Weather Information with Probability Forecasts
(Bulletin of the AMS, Vol. 83, January 2002)

"Much of the informational content of meteorological data, models, techniques, and forecaster thought processes is not being conveyed to the users of weather forecasts. Making and disseminating forecasts in probabilistic terms would correct a major portion of this shortcoming. It would allow the user to make decisions based on quantified uncertainties with resulting economic and social benefits. Widespread implementation of probability forecasts would require forecasters to become more familiar with user needs, and users to be educated on probability forecasts and how to make optimum use of this new information. The American Meteorological Society endorses probability forecasts and recommends their use be substantially increased."

Why Do We Want to Do This?

- Radar rainfall estimates are exactly that...estimates with an associated non-zero error
- We know from experience when radar rainfall estimates are typically good and bad....let's quantify this
- PPS has over 50 input adaptable parameters that are difficult to deterministically tune for all radars, regions, & seasons...and forecasters have little guidance on how to properly tune them
- Provide additional uncertainty information to hydrologic forecasters and water resource managers for improved cost-benefit decision making
- Assimilation of probabilistic rainfall estimates into ensemble hydrologic and atmospheric forecast models
- Ensemble modeling is a focus of the new NWS Advanced Hydrologic Prediction Services (AHPS) program

How Do We Get There from Here?

- Identify funding and establish a 3-year external competitive contract
  - Advanced Hydrologic Prediction Services (AHPS) and Radar Operations Center (ROC) provide funding
  - University of Iowa IIHR won the competition in Sept. 2002
- Establish a PQPE project with practical, implementable results for the NWS Hydrology Program
- Build on recent fundamental research in radar rainfall uncertainty estimation
- Partner with Univ. of Iowa IIHR and others for collaborative strategic planning and path finding
- NWS desires an initial version of an operationally-viable and robust PQPE software algorithm at end of Year 3

Some Technical Challenges

- Radar-only vs. radar+gauge+satellite uncertainty algorithms?
- On-going enhancements to NWS precip. estimation algorithms
  - **Upcoming WSR-88D Range Correction Algorithm (RCA) to adjust rainfall for non-uniform vertical reflectivity profiles**
  - **Upcoming WSR-88D snow accumulation algorithm**
- Transition to higher-resolution dual-polarized radar precipitation algorithms within five years
- How to present & display PQPEs to NWS customers (forecasters, water resource and emergency managers, non-technical external users,...)?
- How to quantitatively use PQPEs in our forecast models and flood warning operations at WFOs and RFCs?

Some Technical Challenges (cont.)

- How to quantitatively validate PQPE algorithms and products?
- Operational limitations in NWS
  - **Limited amount and imperfect quality of real-time data (e.g., rain gauges)**
  - **Busy operational forecaster schedules, esp. during high-impact weather events**
  - **Limited computer power**
- Technology transfer from IIHR to NWS
- Customer training on PQPE

Conclusion

- There is no better time than the present to begin developing next-generation NWS radar-based precipitation algorithms and products