HydroMet Decision Support System

WDT's Quantitative Precipitation Estimation and Forecast (QPF) Capability

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WDT Profile

- **Founded in January, 1999, spun out of University of Oklahoma, fully operational, April, 2000.**

- **The founders of WDT are all leading scientists from world renowned weather research organizations in Norman:**
  - National Severe Storms Laboratory (NSSL)
  - University of Oklahoma's Center for Analysis and Prediction of Storms (CAPS)
  - Oklahoma Climatological Survey.

- **WDT Utilizes This Expertise to Provide Unique Applications, Services and Systems to our Partners**
  - Short-term weather prediction services (tornado, hail, lightning, precipitation, flooding, etc.)
  - Weather Decision Support Systems™
  - Numerical Weather Prediction Systems and Services
  - Internet-Based Meteorological Analysis Tools and Displays
  - United States Precision Lightning Network

WDT Profile

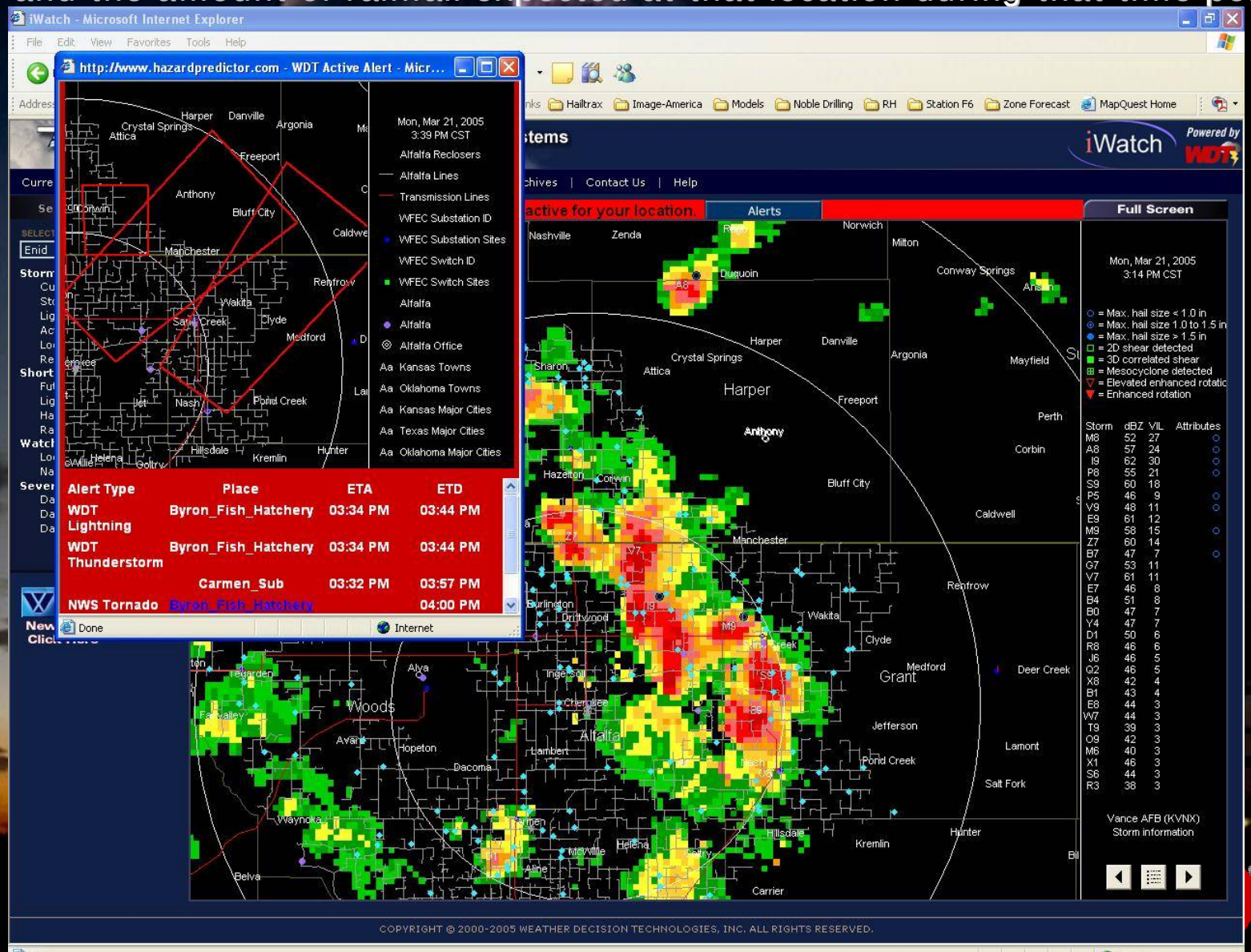
- Solid Business
  - **Recently Awarded Inc. 500 Status – 80% Annual Growth first 4 years.**
  - **OKC Chamber Metro 50 Award past three years.**
  - **Twice Venture of the Year Finalist by Oklahoma Venture Fund**
  - **Oklahoma Journal Innovator of the Year - 2003**
  - **Solid Financial backing from Enterprise Oklahoma Venture Fund, MetaFund, and Bank of Oklahoma (BOK)**
- Company Information
  - **25 Employees**

WDT Technologies and Products

- iWatch
- Weather Decision Support Systems™
- United States Precision Lightning Network (USPLN, in partnership with TOA Systems)
- Hydromet Decision Support System

iWatch Weather Decision Support System™

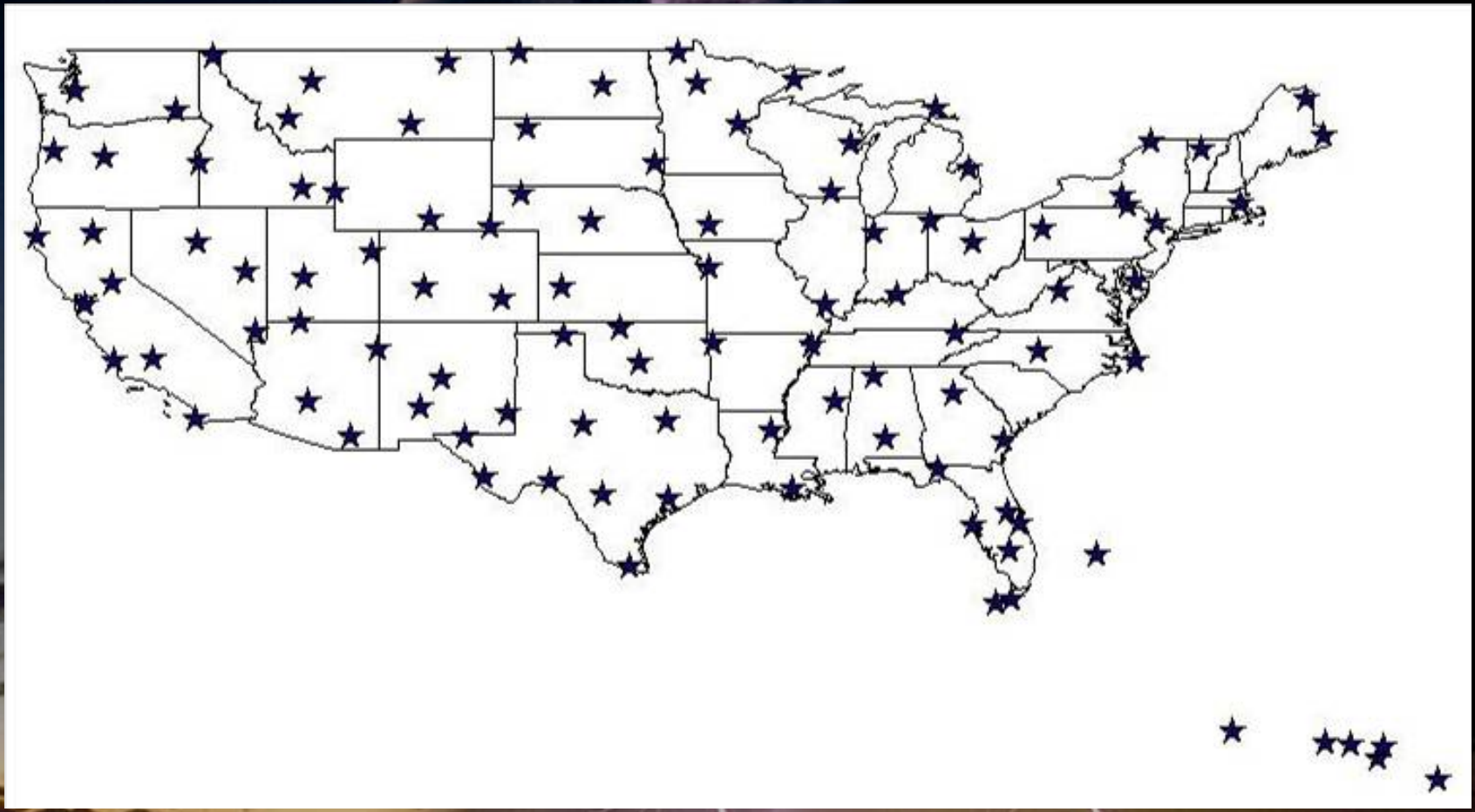
Example of ETA/ETD Alerting Capability and Site Specific Information, e.g. for a given location the time that heavy rainfall, lightning, and other hazards will begin, the time it will end, and the amount of rainfall expected at that location during that time period.



US Precision Lightning Network

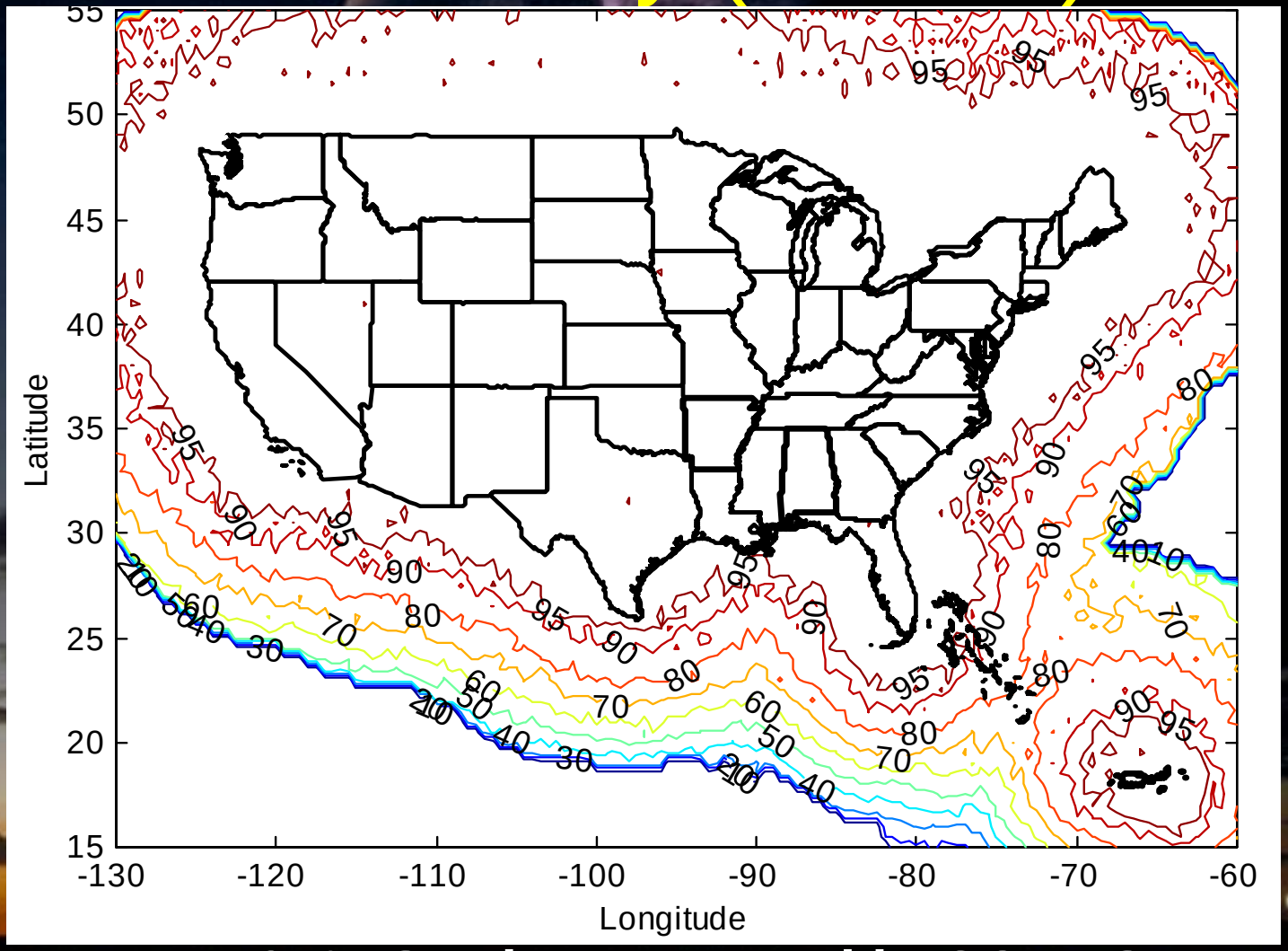
WDT has partnered with TOA Systems a leader in worldwide lightning detection technologies to build a cost effective US national lightning detection network

The number (106) and location of PLS sensors that make up the USPLN.



The USPLN provides excellent coverage over the full CONUS.

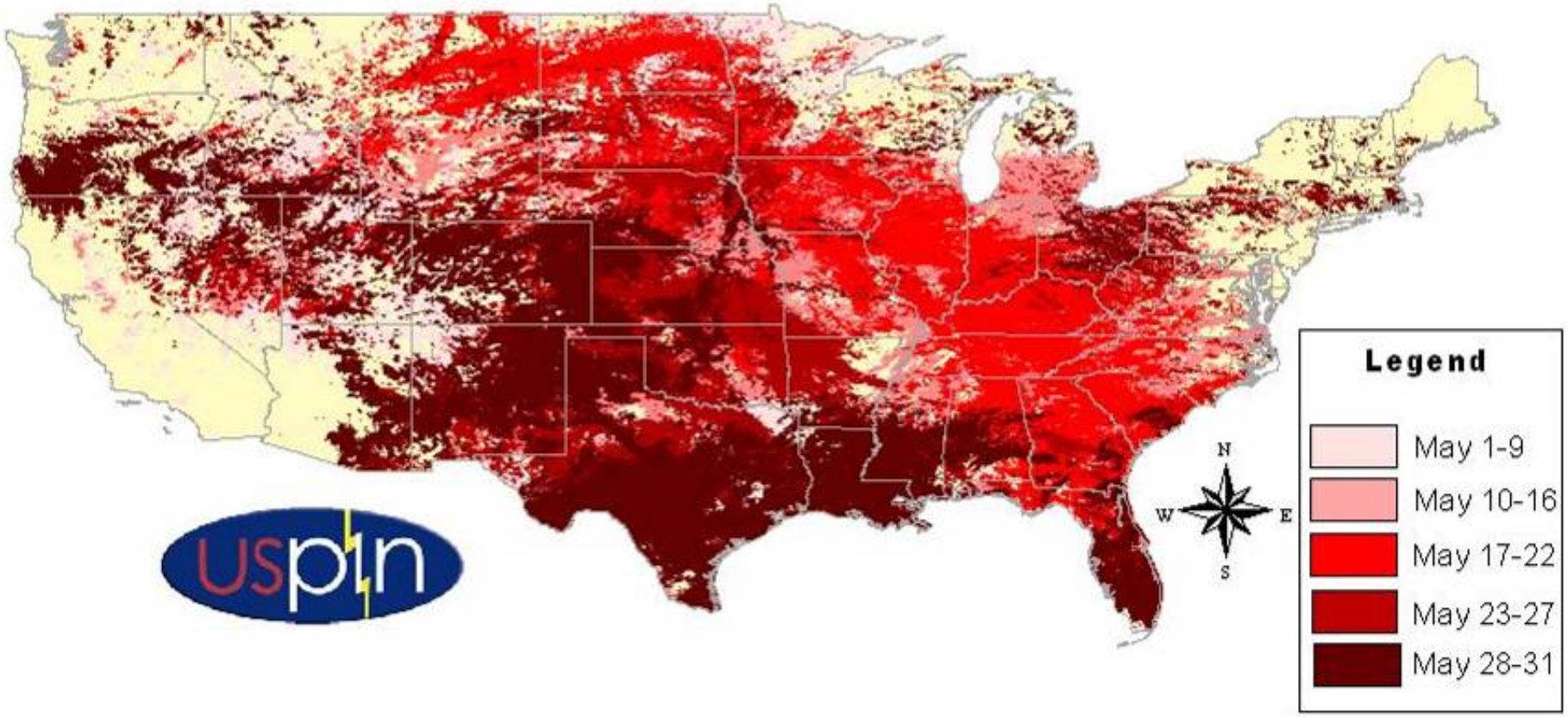
USPLN Cloud-to-Ground Detection Efficiency (% POD)



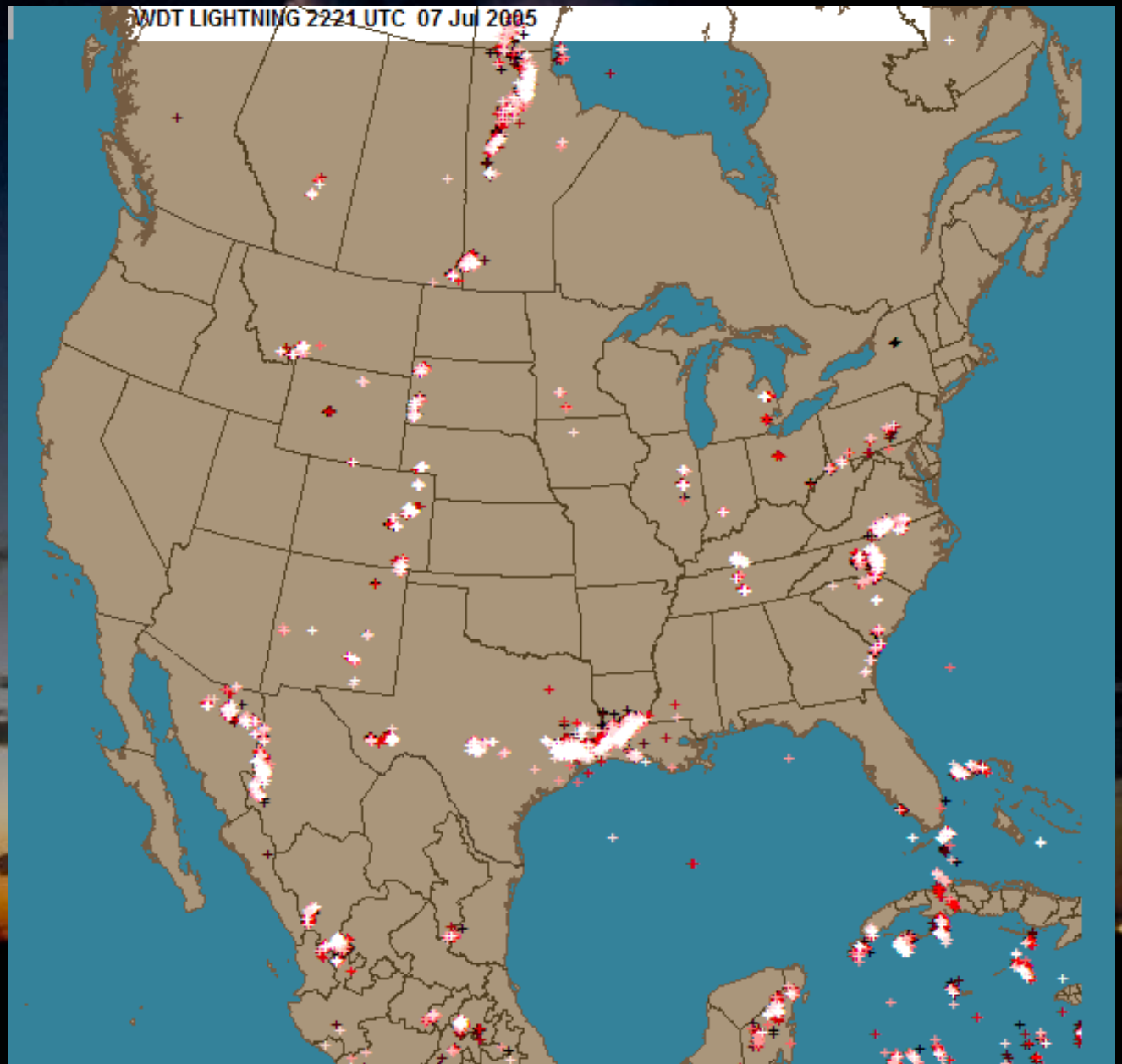
>95% Strokes Detected in CONUS and the Southern Half of Canada

5,036,161 Strokes Detected by the USPLN in the CONUS during May!

USPLN Lightning Strokes: May 1 - May 31, 2005

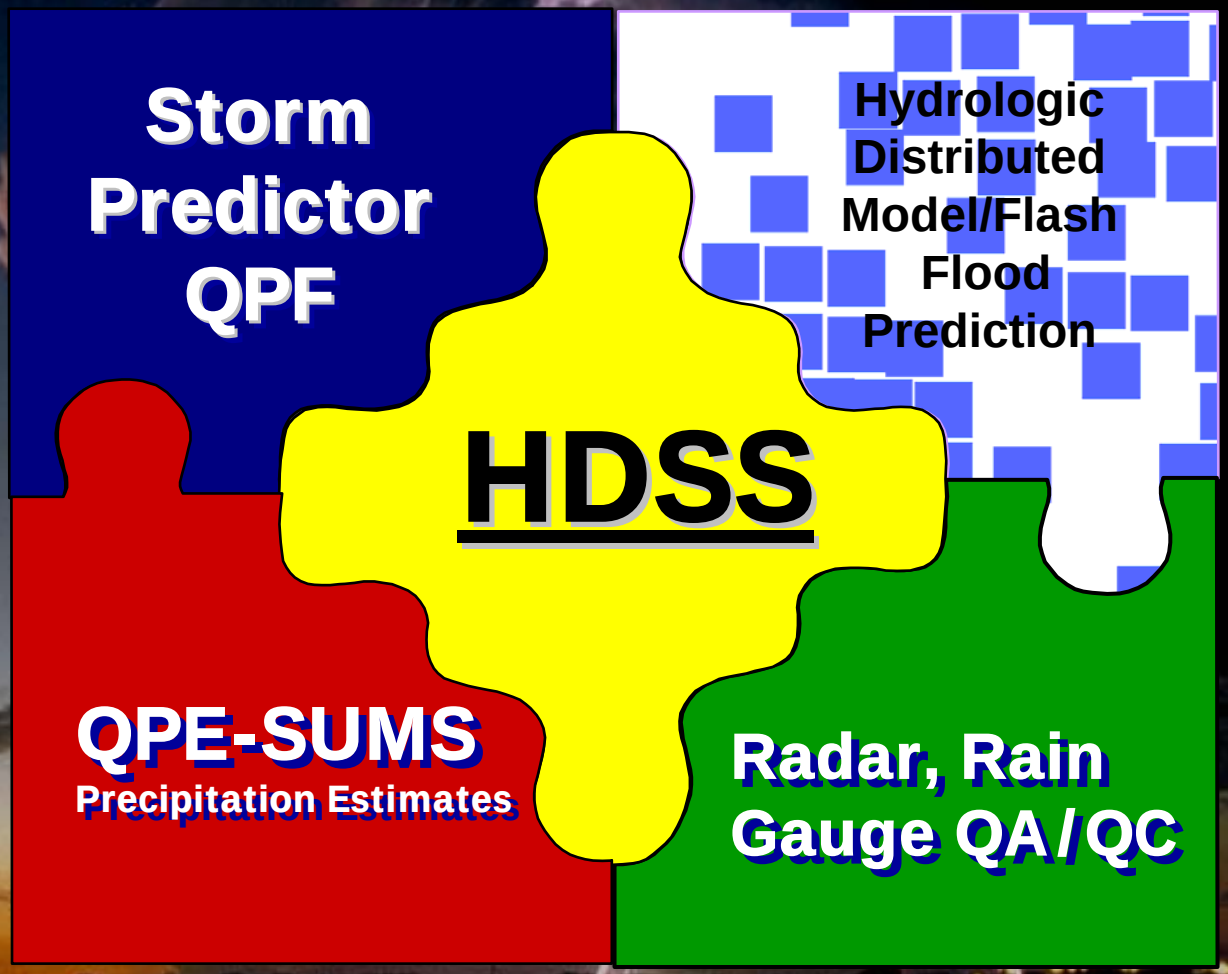


Example of North American Coverage



HydroMet Decision Support System

Developed jointly by WDT, National Severe Storms Laboratory, and McGill University under Cooperative Research Agreements



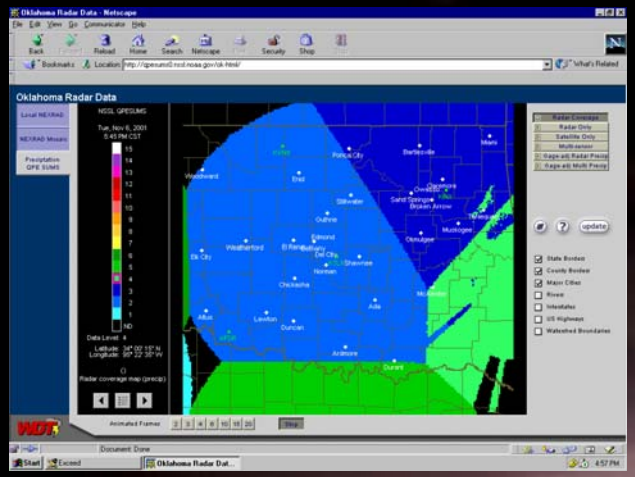
HydroMet Decision Support System Applications

- Managing dams, canals, streams, rivers and rain run-off systems on a routine basis and during extreme events.
- Managing Hydro-electric facilities.
- Predicting Flash Floods and warning the public.
- Forecasting River Flooding.

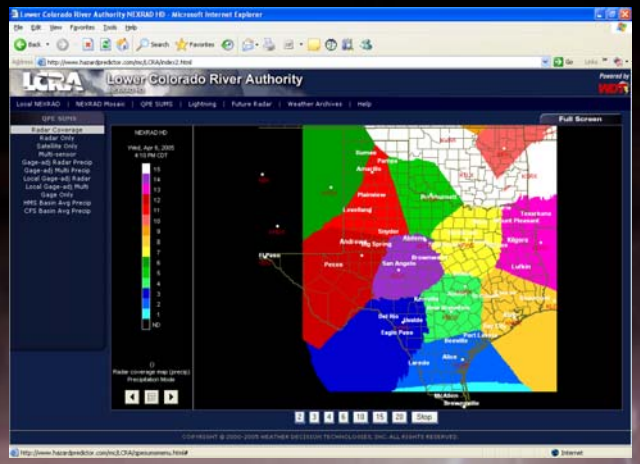
HydroMet Decision Support System Components

- **3D Mosaic Algorithm**
  - Produces an artifact-free 3D grid of radar data from any and all available radars
  - Updates grid every 5 minutes or less.
- **NSSL Quantitative Precipitation Estimation** Using Multiple Sensors (QPE-SUMS)
  - Integrates radar, satellite, model, lightning and rain gauge data to provide estimates of instantaneous and accumulated rainfall
- **McGill Algorithm for Precipitation Nowcasting** Using Semi-Lagrangian Extrapolation (MAPLE)
  - Produces a forecast of reflectivity and precipitation (QPF) up to 4 hours in advance on a high-resolution grid (< 1 km), updating every 5 minutes
- **Flash Flood Prediction Algorithm**
  - Computes basin average rainfall amounts and predicted amounts using output of QPE-SUMS and MAPLE
  - Compares these amounts with antecedent flash flood guidance to alert users of impending flash floods.
- **GIS Asset Monitoring System**
  - Provides location specific information and alerts, an example is: "expect 2.5 cm of rainfall to occur starting at 10:20 a.m. ending at 11:15 a.m. at your location"

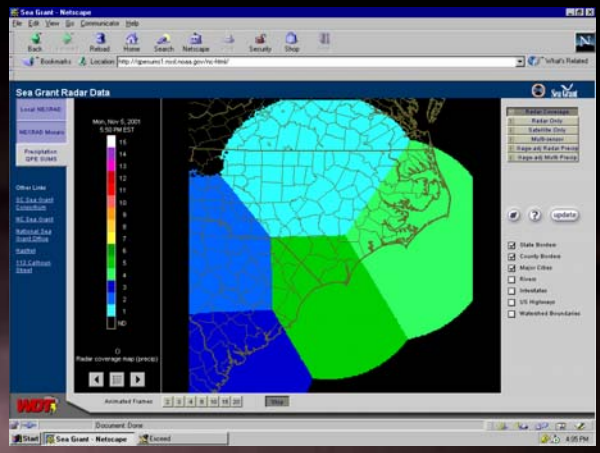
Largest US HDSS Deployments



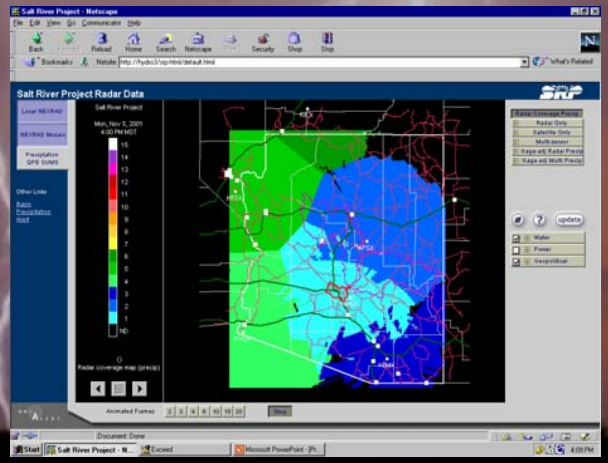
Texas/Oklahoma Weather Modification Project



Lower Colorado River Authority

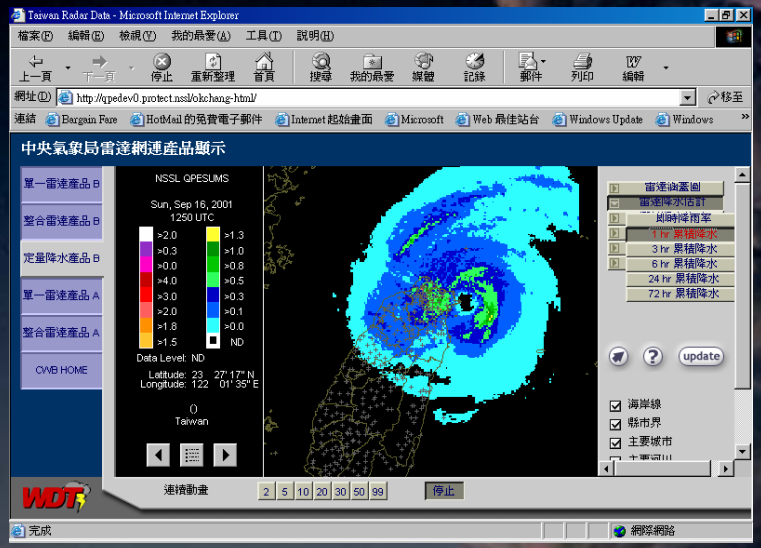


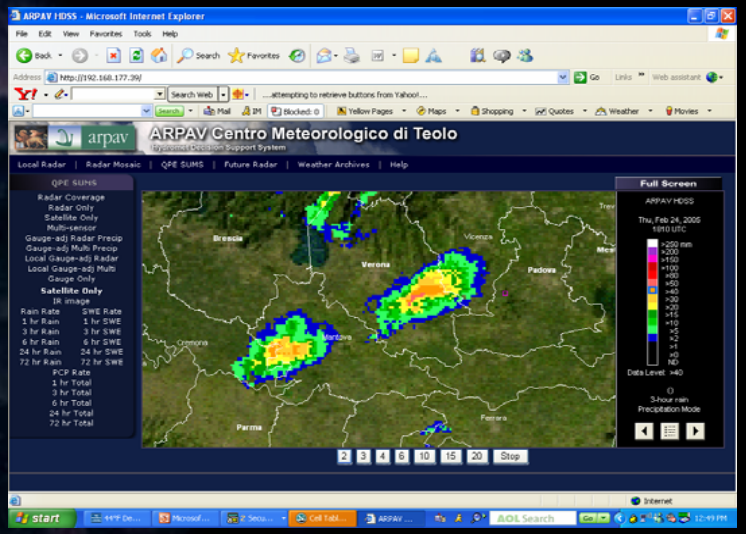
NOAA Sea Grant North Carolina



Salt River Project Arizona

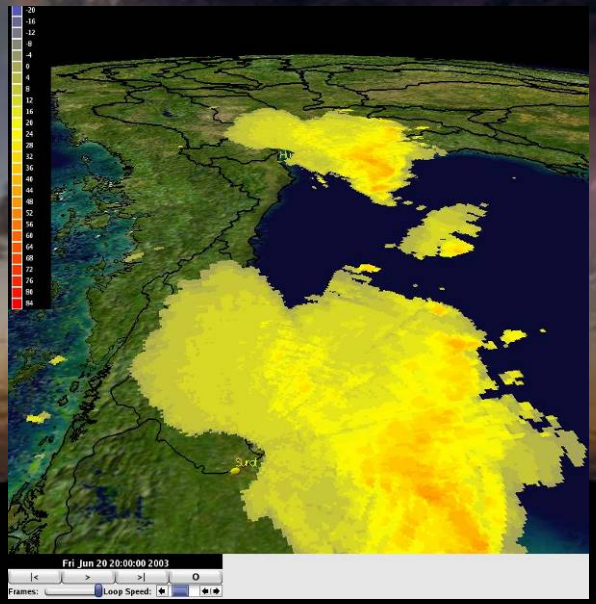
International Deployments





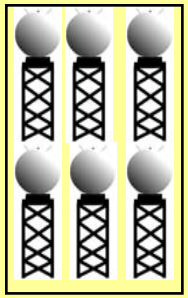
Taiwan

ARPAV, Italy

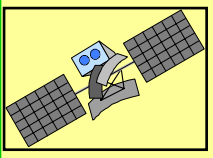


Thailand

QPE SUMs



Radar

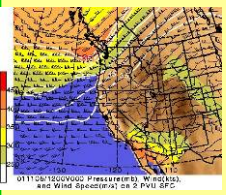


Satellite IR

Surface Obs

Upper Air Obs

Lightning



Model

INGEST POLAR DATA AND RUN ALGS

PRECIP ESTIMATION

MOSAIC

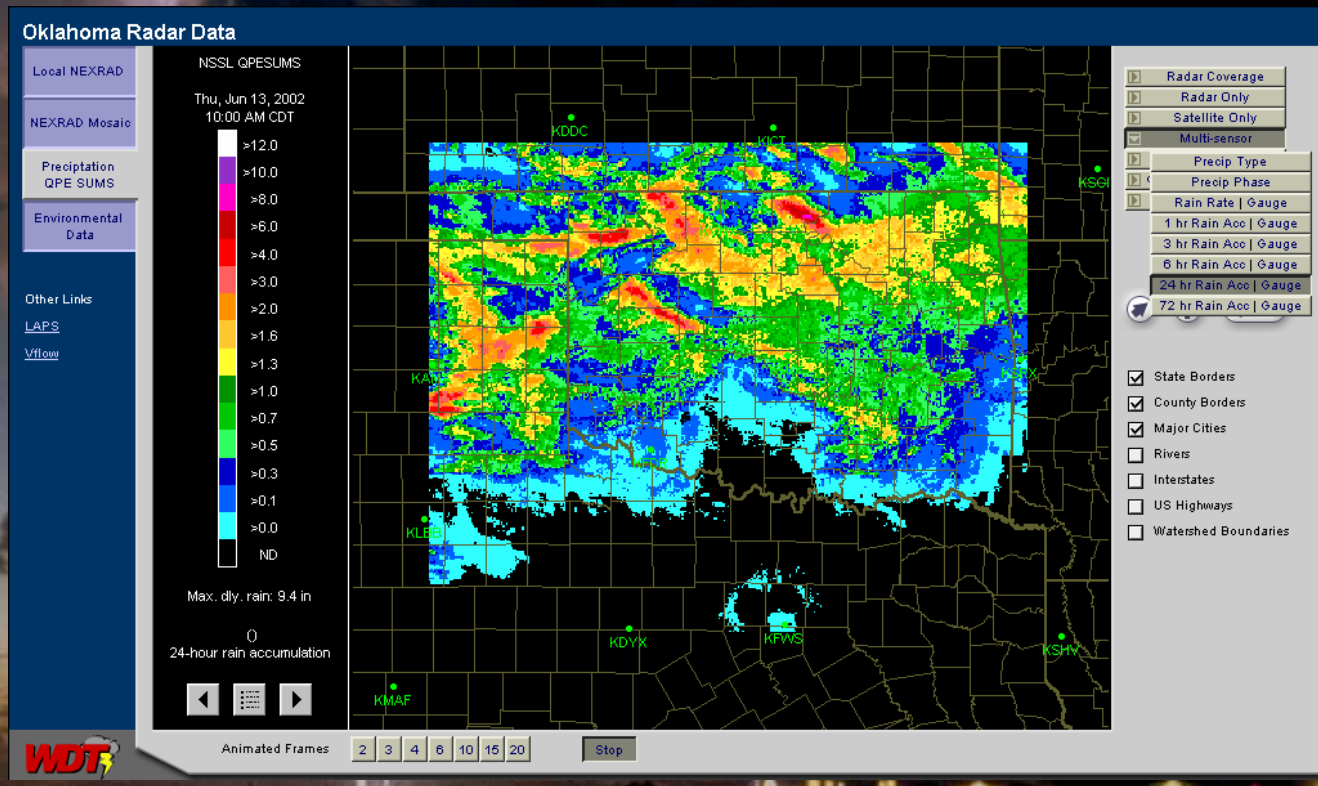
QPE SUMS Algorithm

- Quantitative Precipitation Estimation and Segregation Using Multiple Sensors
  - Real-time *precipitation* algorithm
  - Grid covers any size region at very high resolution (1x1 km resolution)
  - Developed at the National Severe Storms Laboratory over past 6 years, licensed and enhanced by WDT.
- Offers the following improvements:
  - Utilizes available meteorological sensors to estimate precipitation (rain gauge, satellite, radar, lightning data, model output, etc.)
  - Optimally weights data from multiple sensors.

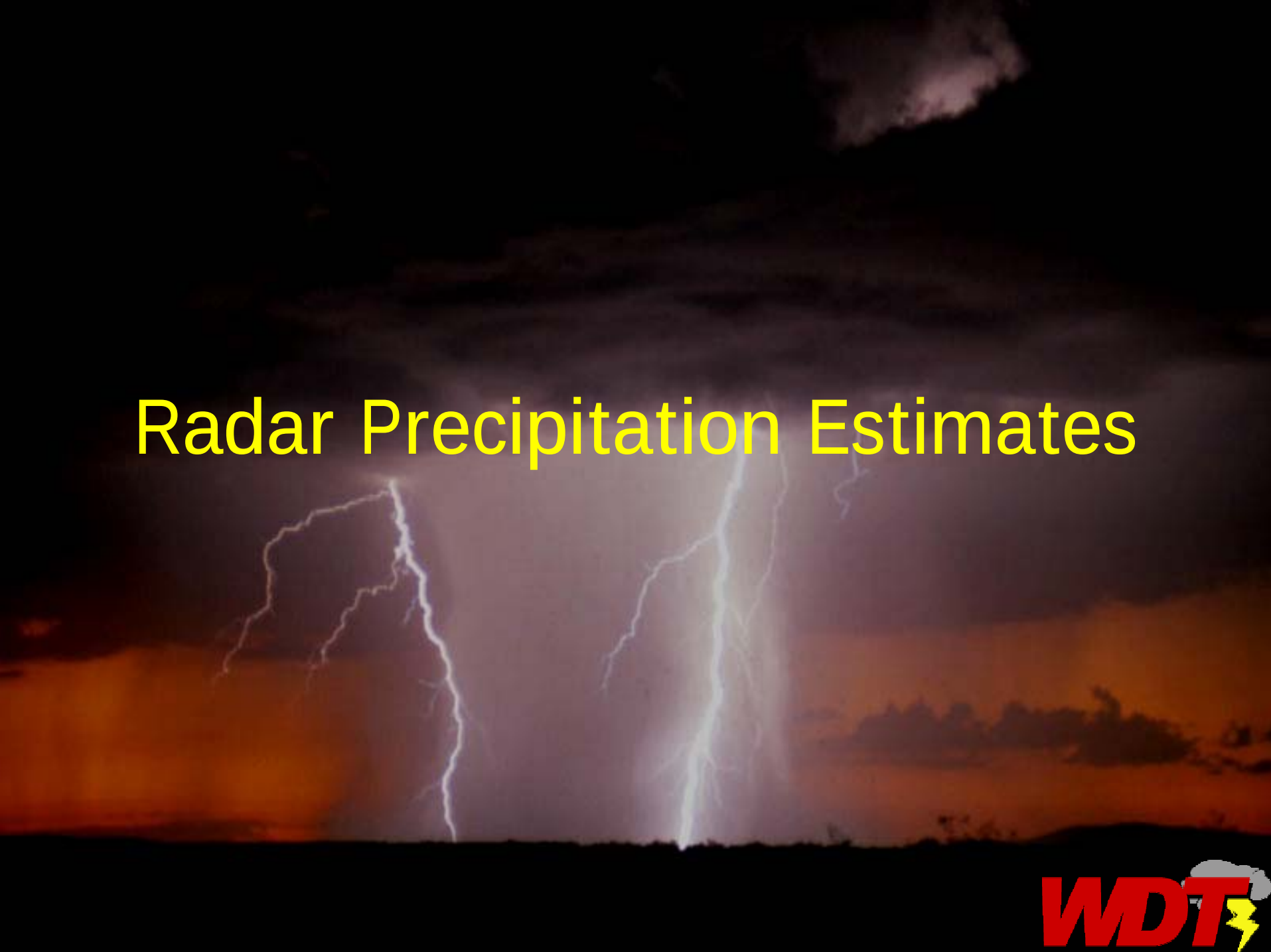
QPE SUMS Rainfall Products

Products are from satellite only, rain gauge only, or radar only, or from a combination of any of the 3 sensors

- 5 Minute Products:
  - Radar coverage map
  - Precipitation rate
  - Precipitation type
  - 1 hour rain accumulation
  - 3 hour rain accumulation
- Hourly Accumulation Products:
  - 6 hour
  - 24 hour
  - 72 hour

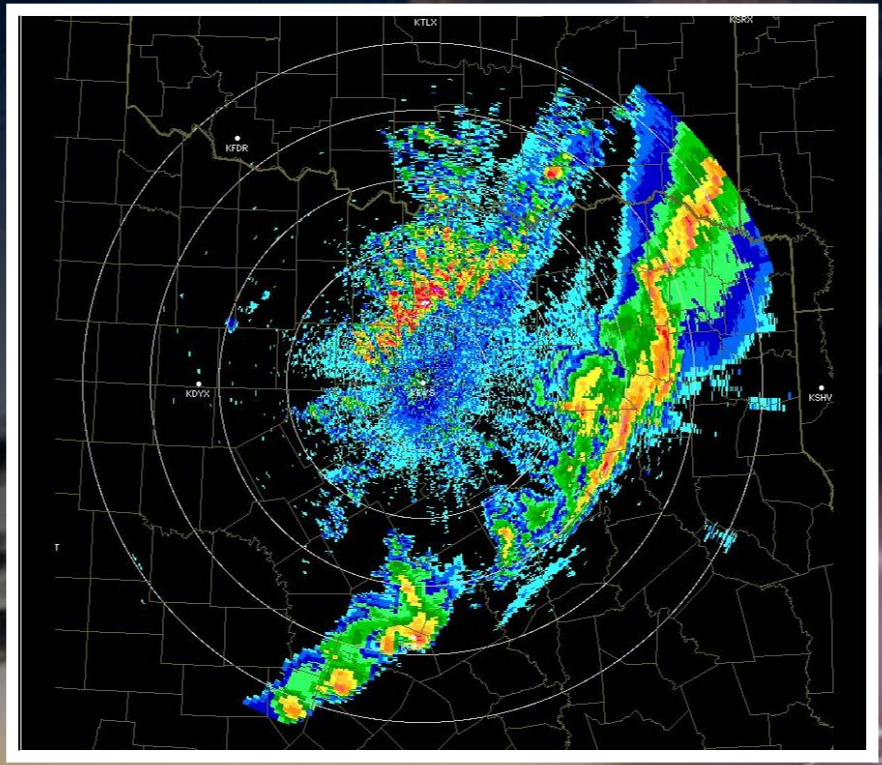


Radar Precipitation Estimates



HDSS Radar Quality Control

Anomalous Propagation and Ground Clutter Removal



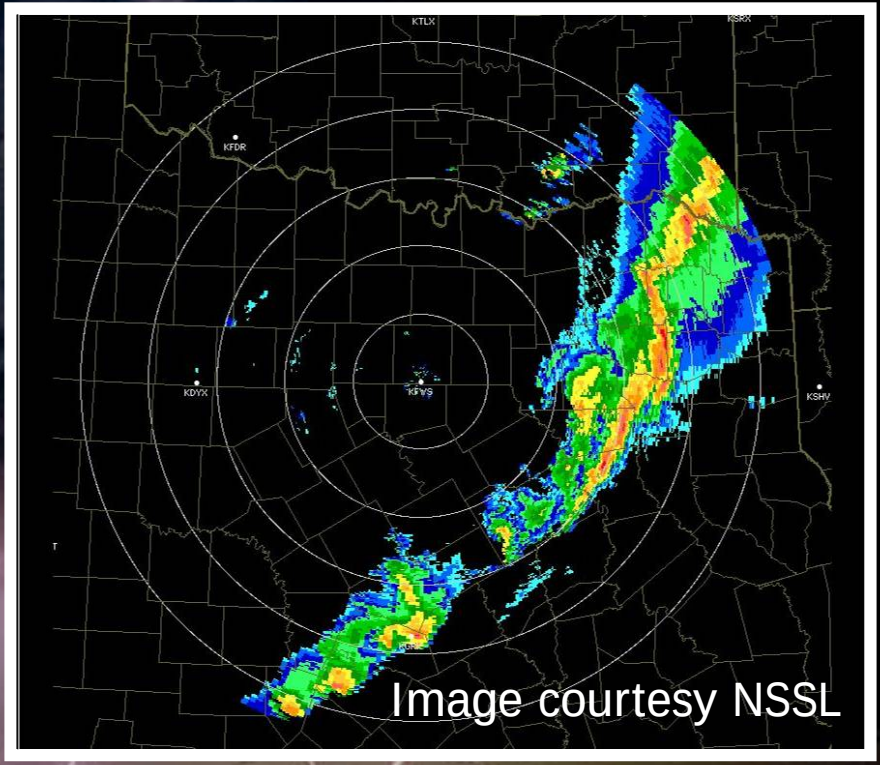
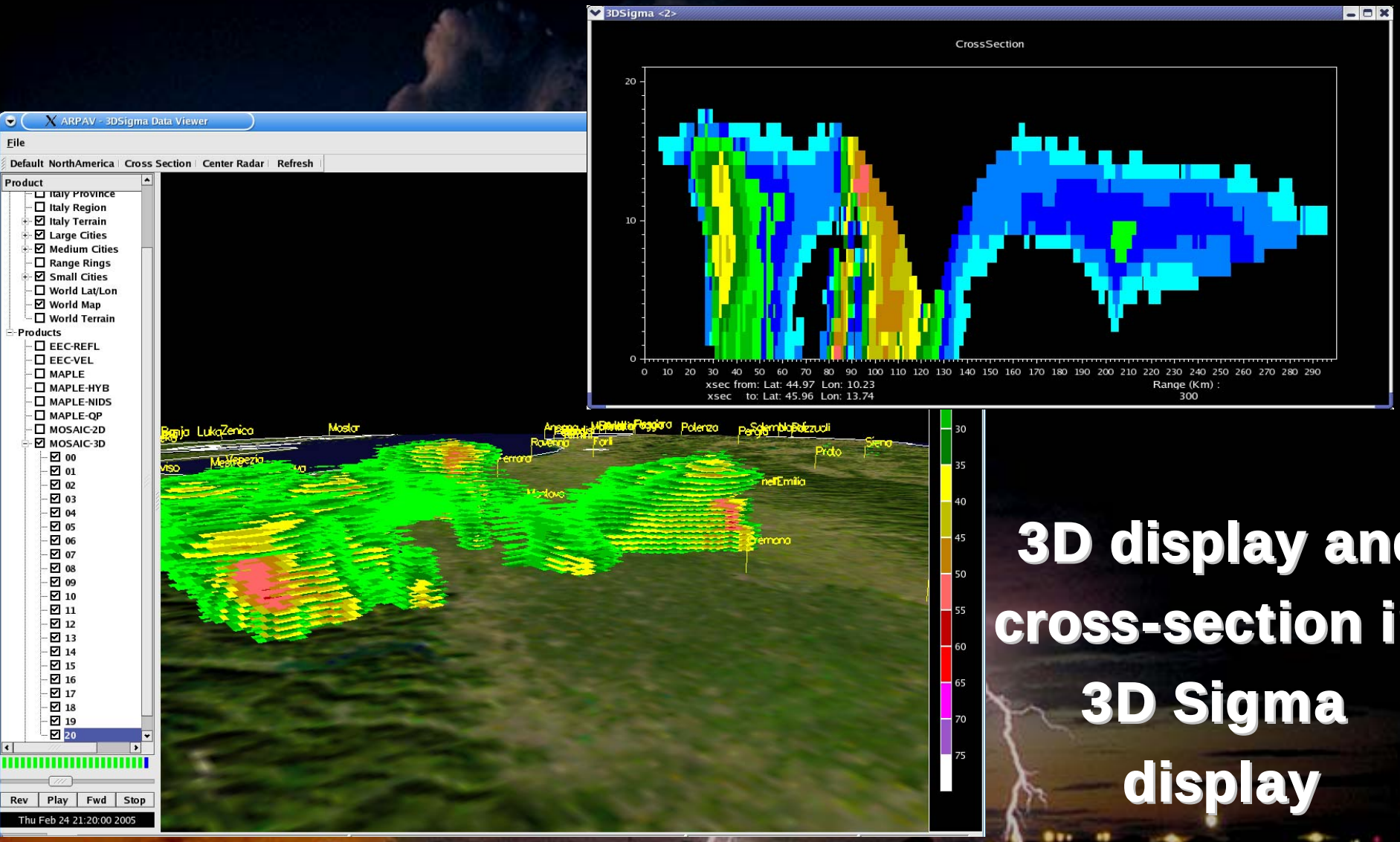


Image courtesy NSSL

- ✓ Hybrid Reflectivity Scan
- ✓ Vertical Continuity
- ✓ Nonzero Velocity
- ✓ Neural Net with 28 inputs

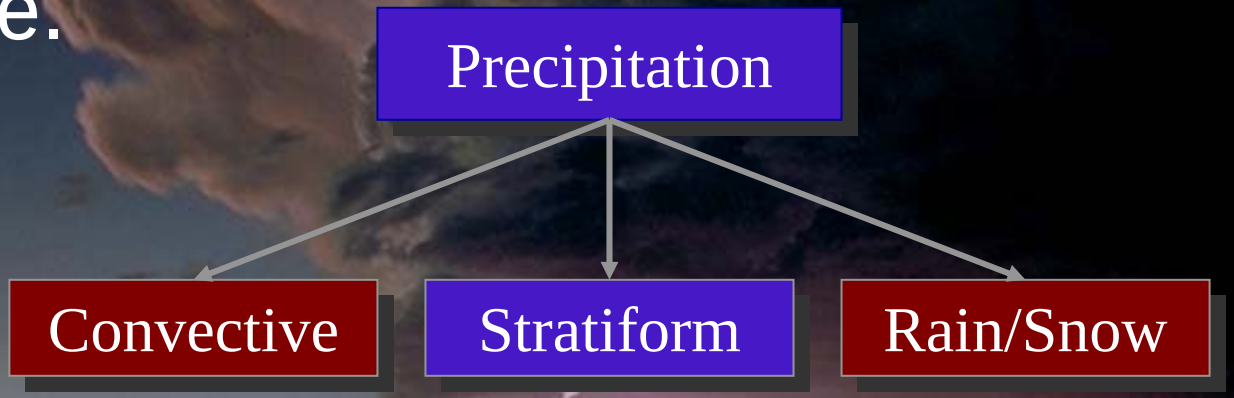
3D Mosaic Output



3D display and cross-section in 3D Sigma display

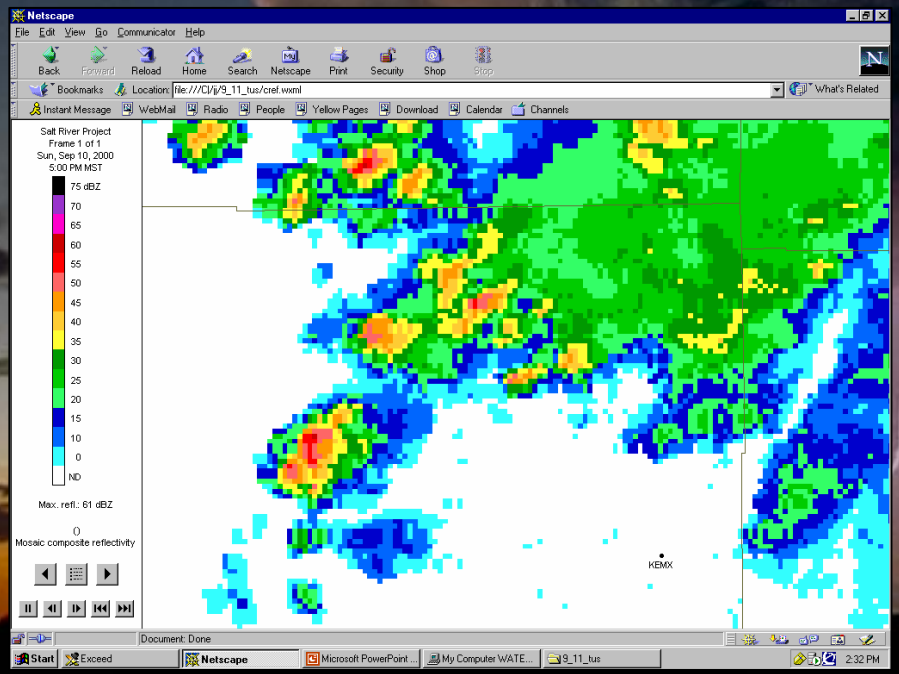
Precipitation Typing

- Identifies and segregates precipitation type.

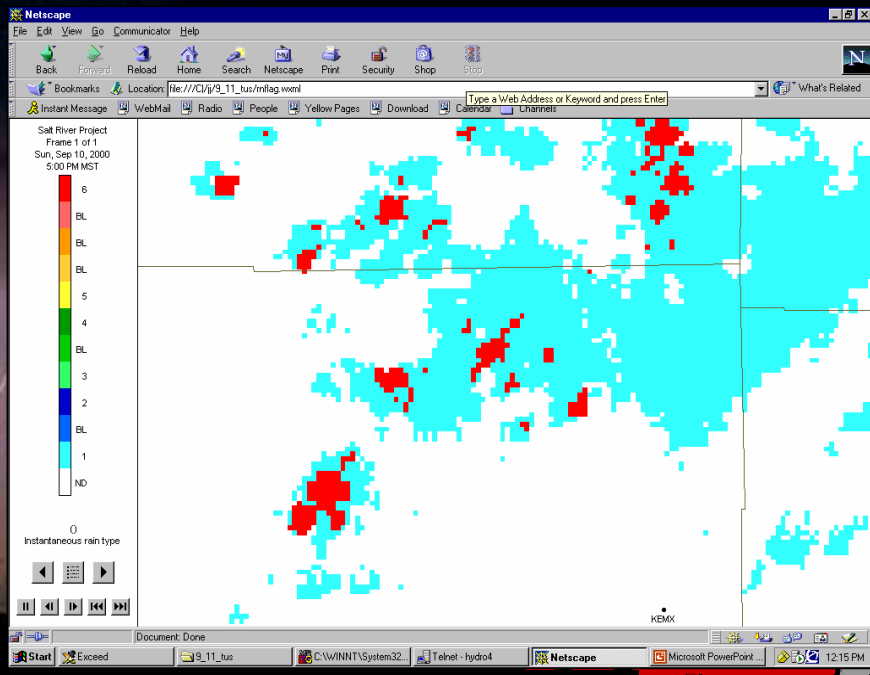


Convective/Stratiform Segregation

- dBZ > 50 in any bin or,
- dBZ > 30 at temperatures < -10 C or,
- 1 lightning flash

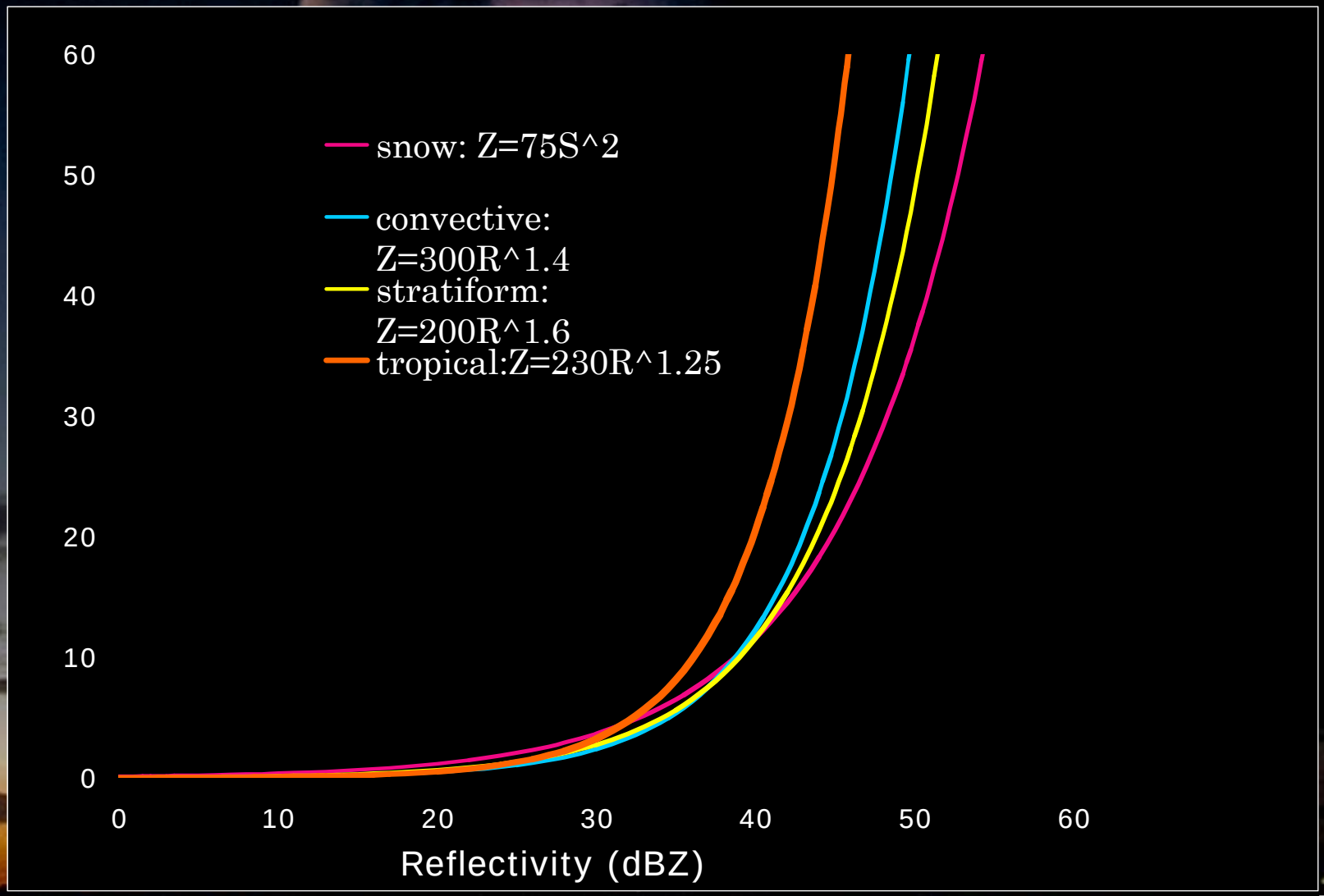


Polar Composite Reflectivity



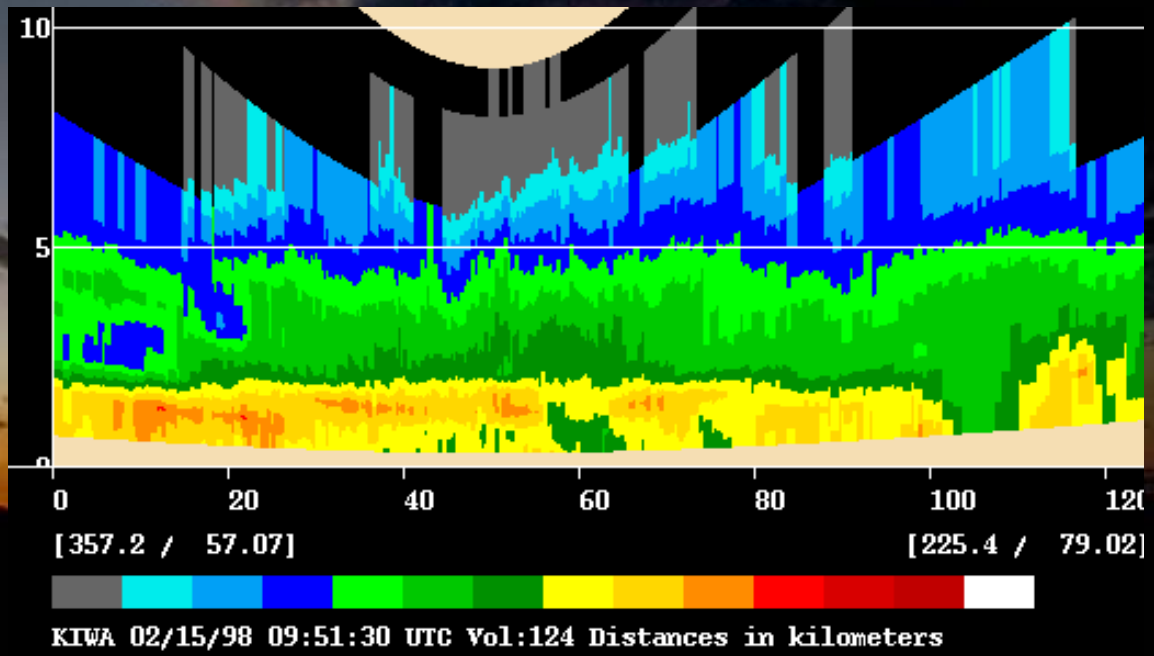
Precip Flags

Z-R Relationships



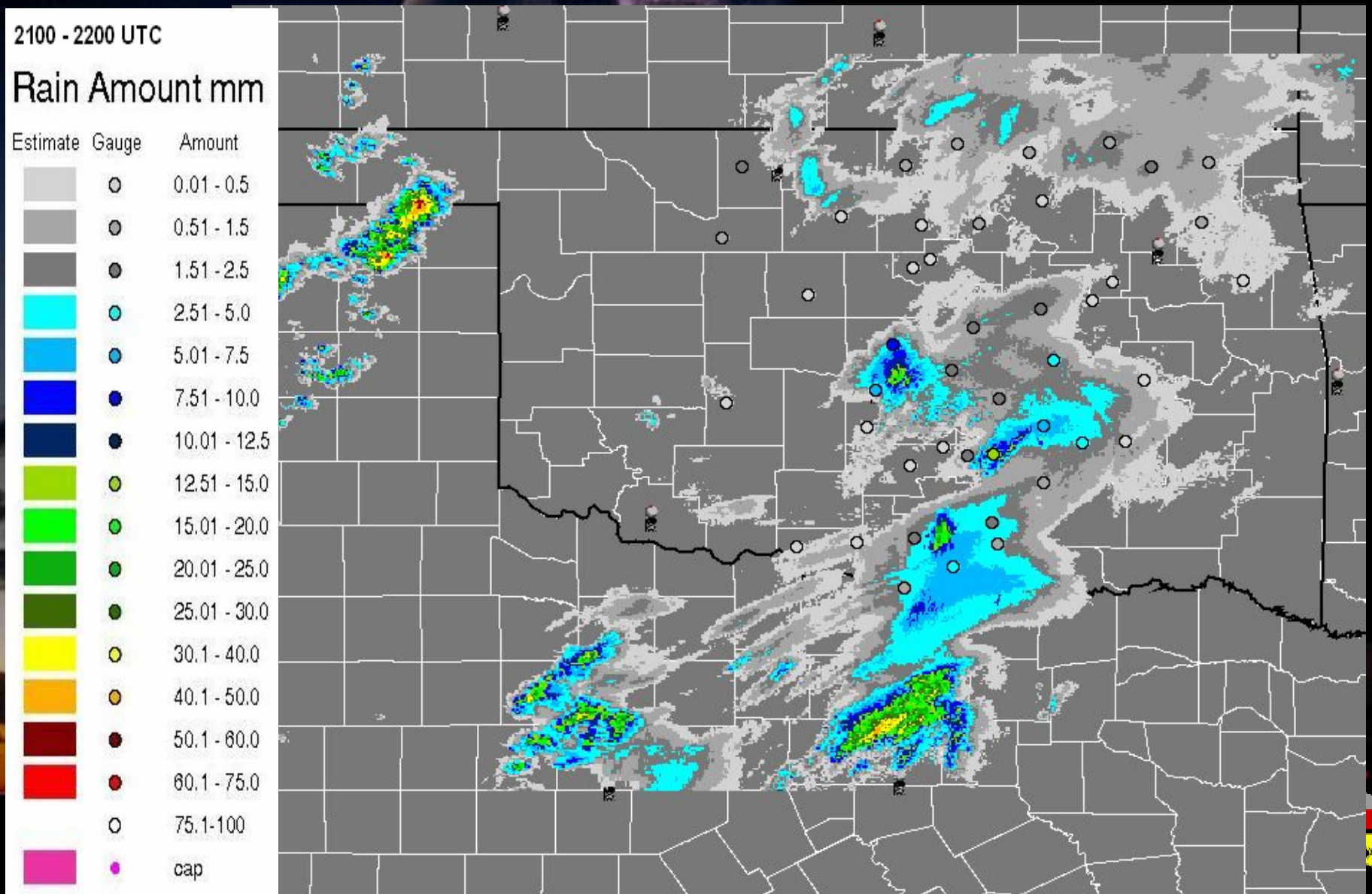
Bright Band Identification

- 3-D Reflectivity Field
- ID Layer of Higher Reflectivity
- Vertical Reflectivity Gradient
- Spatial/Temporal Smoothing
- 3D Mosaic performs vertical adaptive Barnes analysis plus horizontal gap filling



Polar

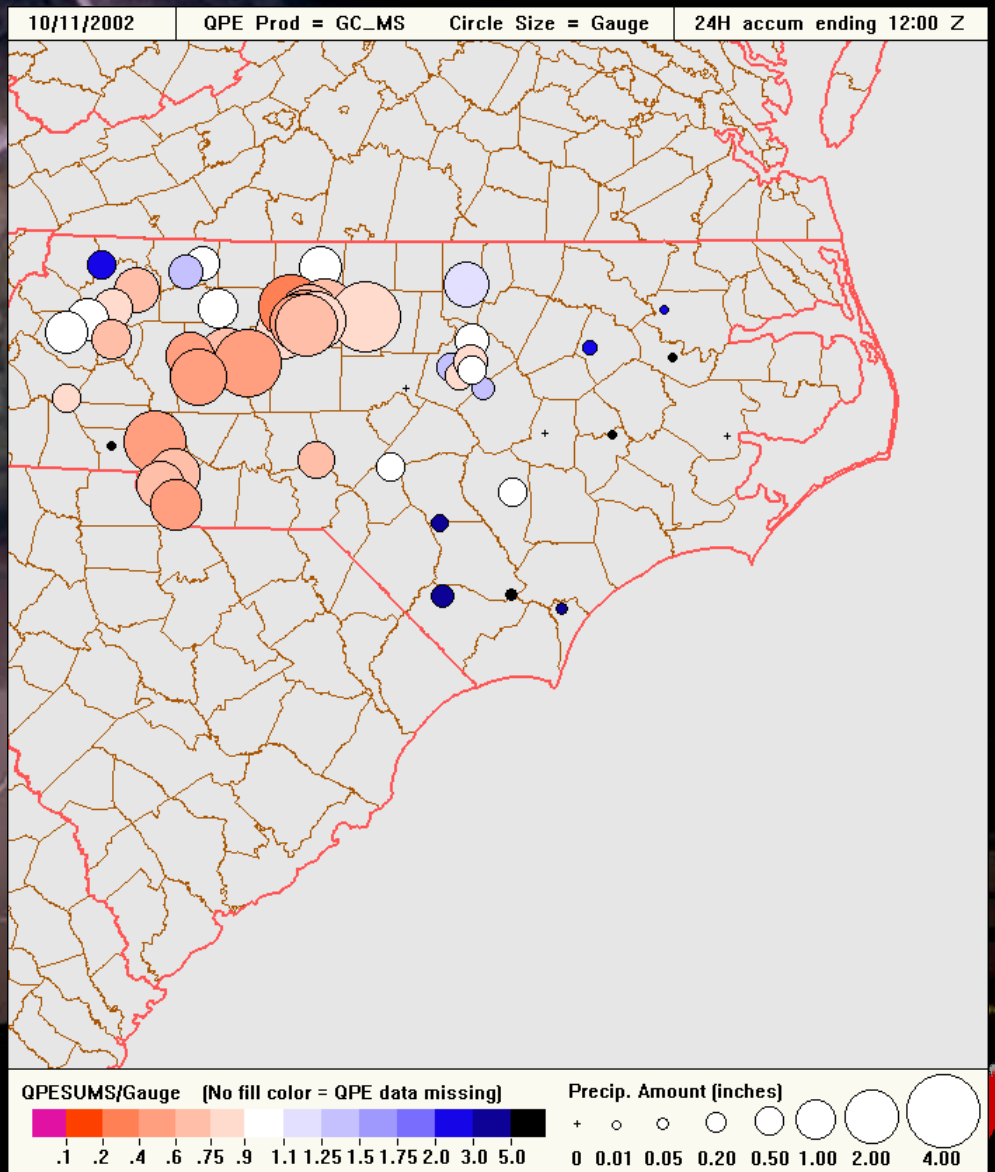
QPESUMS Products
Radar Only Example – 1 Hour



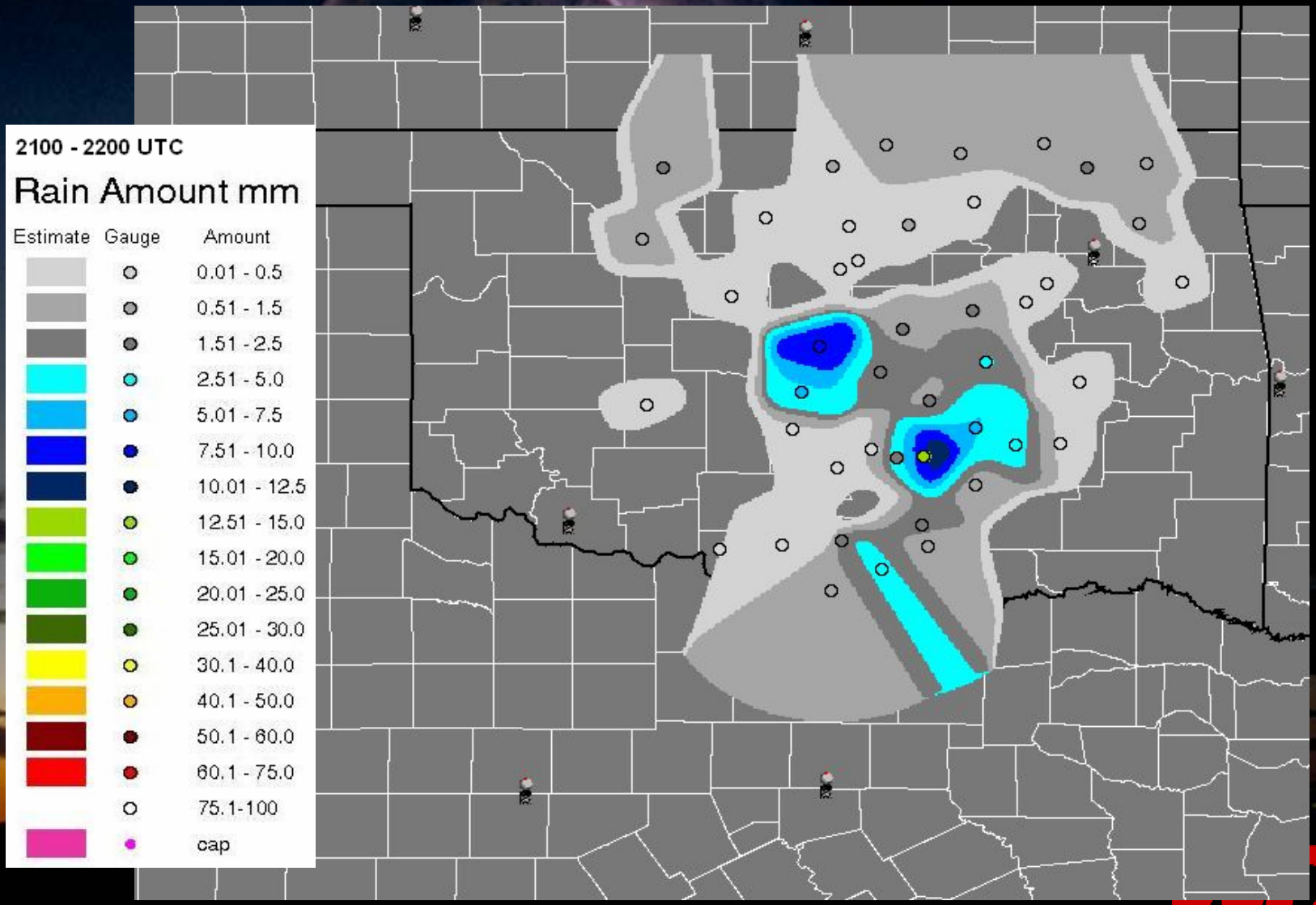
Rain Gauge Analysis and Bias Calculation

- Rain Gauge data are used to calculate a rain gauge only estimate by analyzing the data to a 1 km grid using a Barnes Analysis

- To calculate biases, at each gauge location the rain gauge estimate is compared to the nearest radar estimate and a bias is determined. These biases are then gridded using a Barnes Analysis.

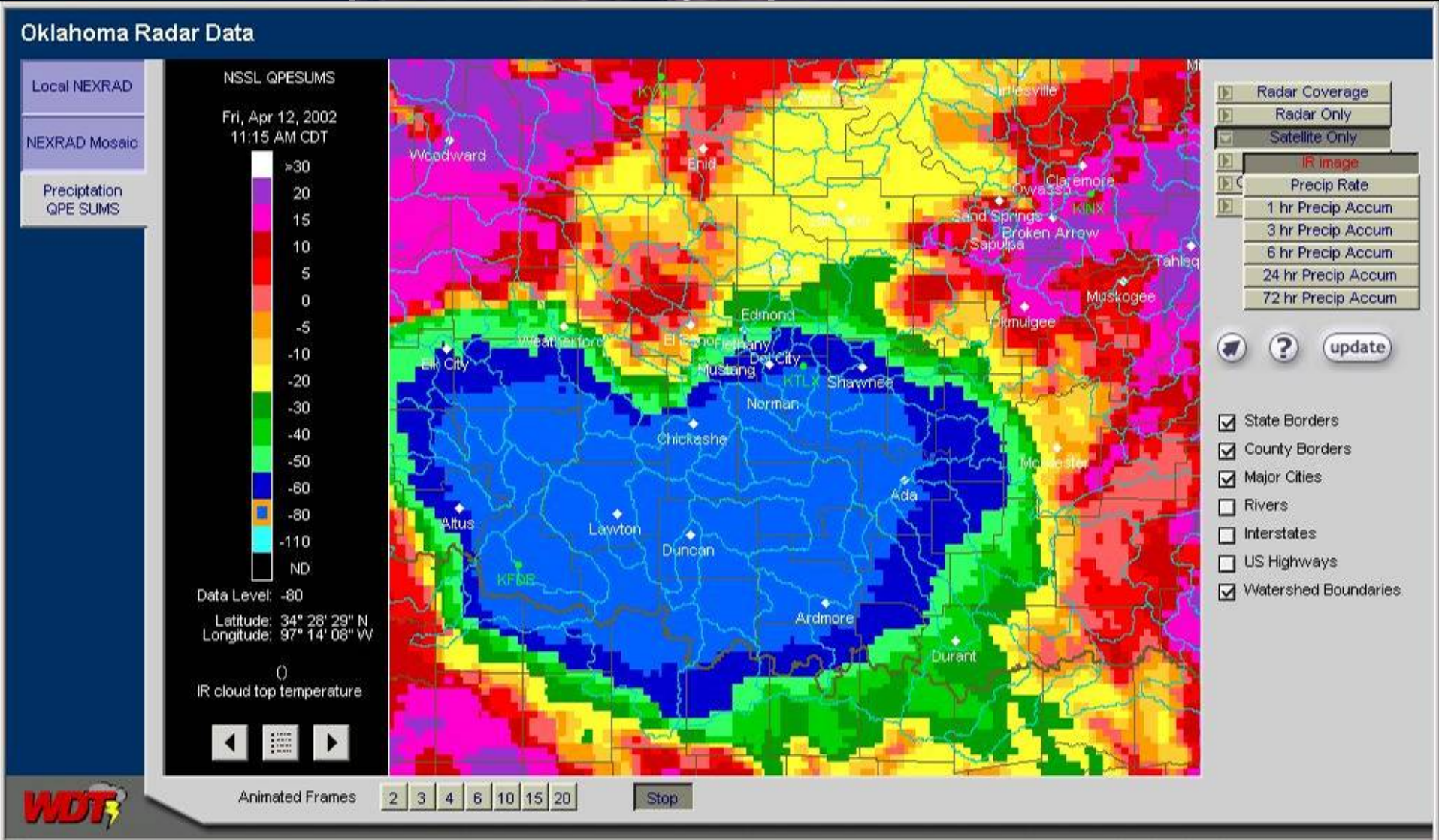


Example of Gauge Only Precipitation Field



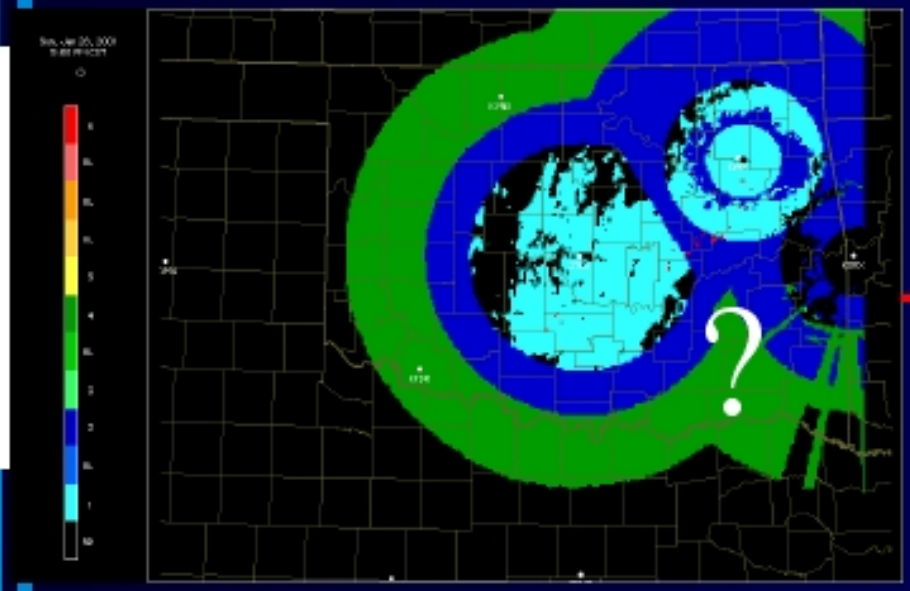
QPE-SUMS Satellite-Based Rainfall Estimates

Important for Filling Gaps Between Radars

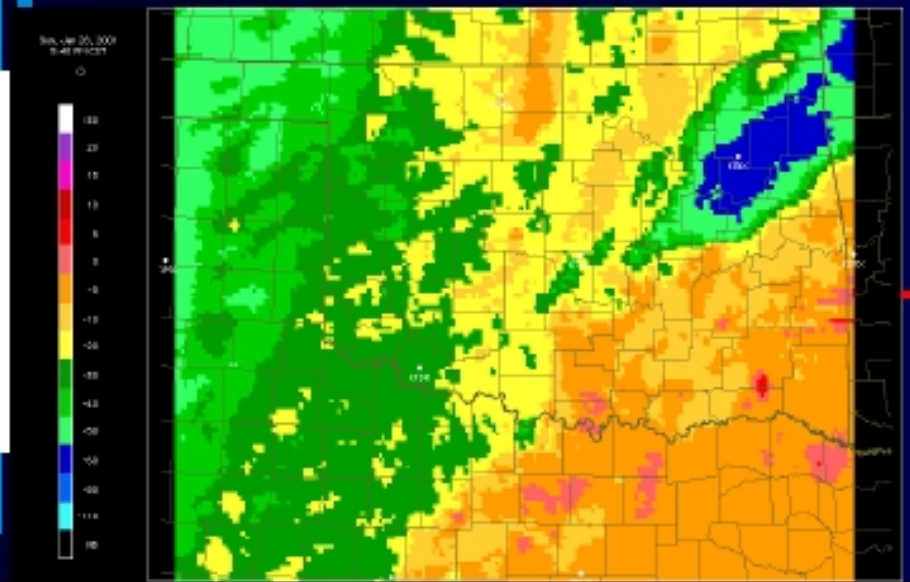


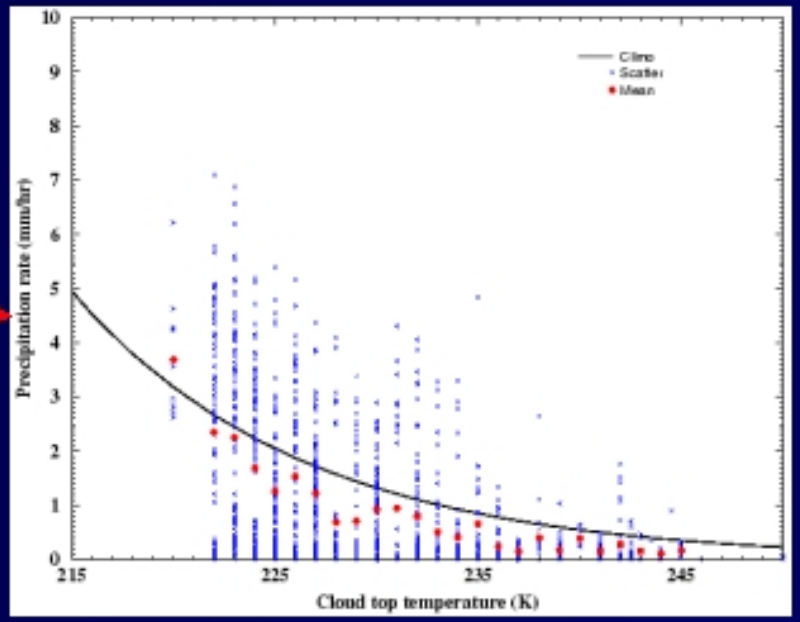
Satellite/Radar Regression

Radar Rainrate



Satellite CTT

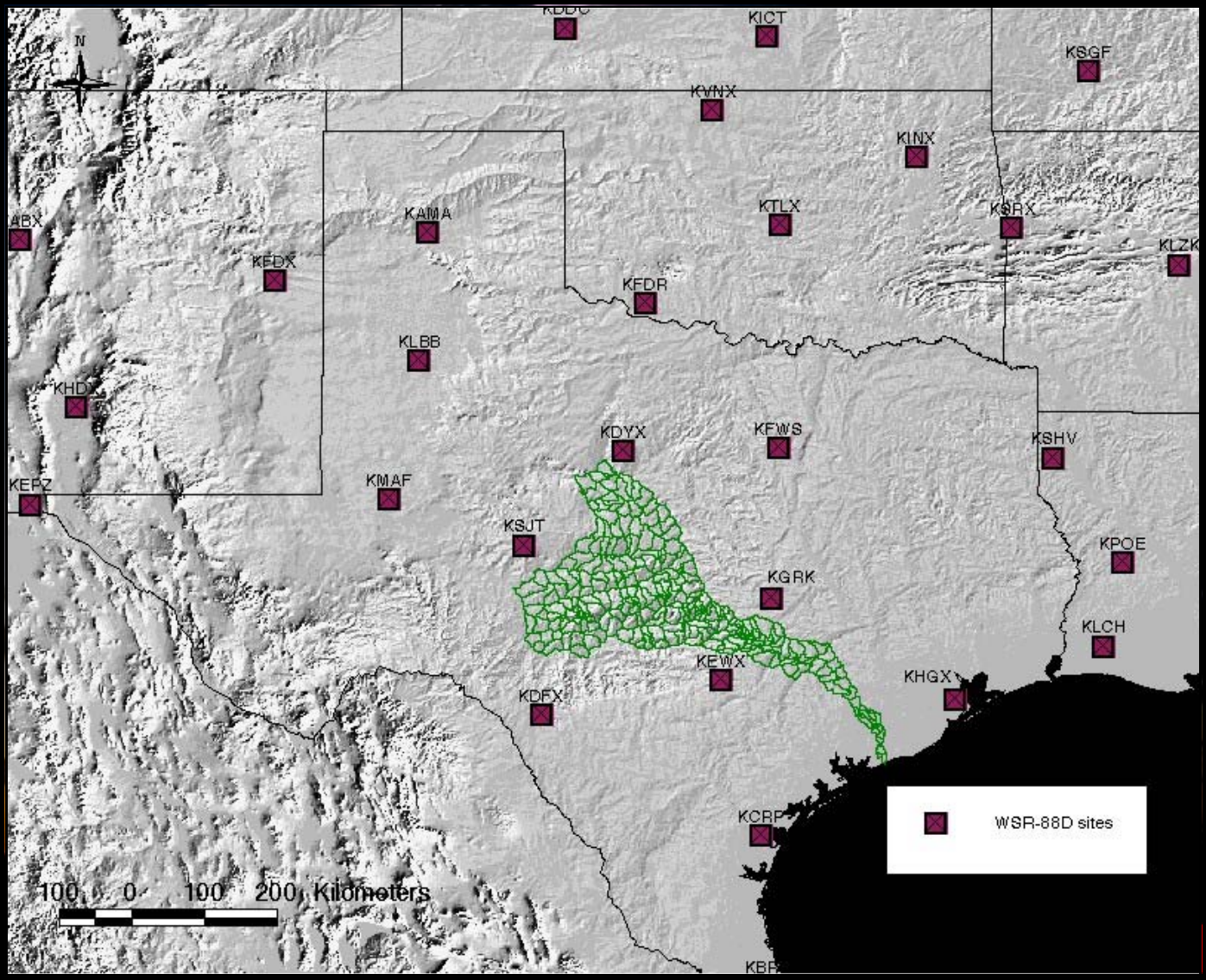




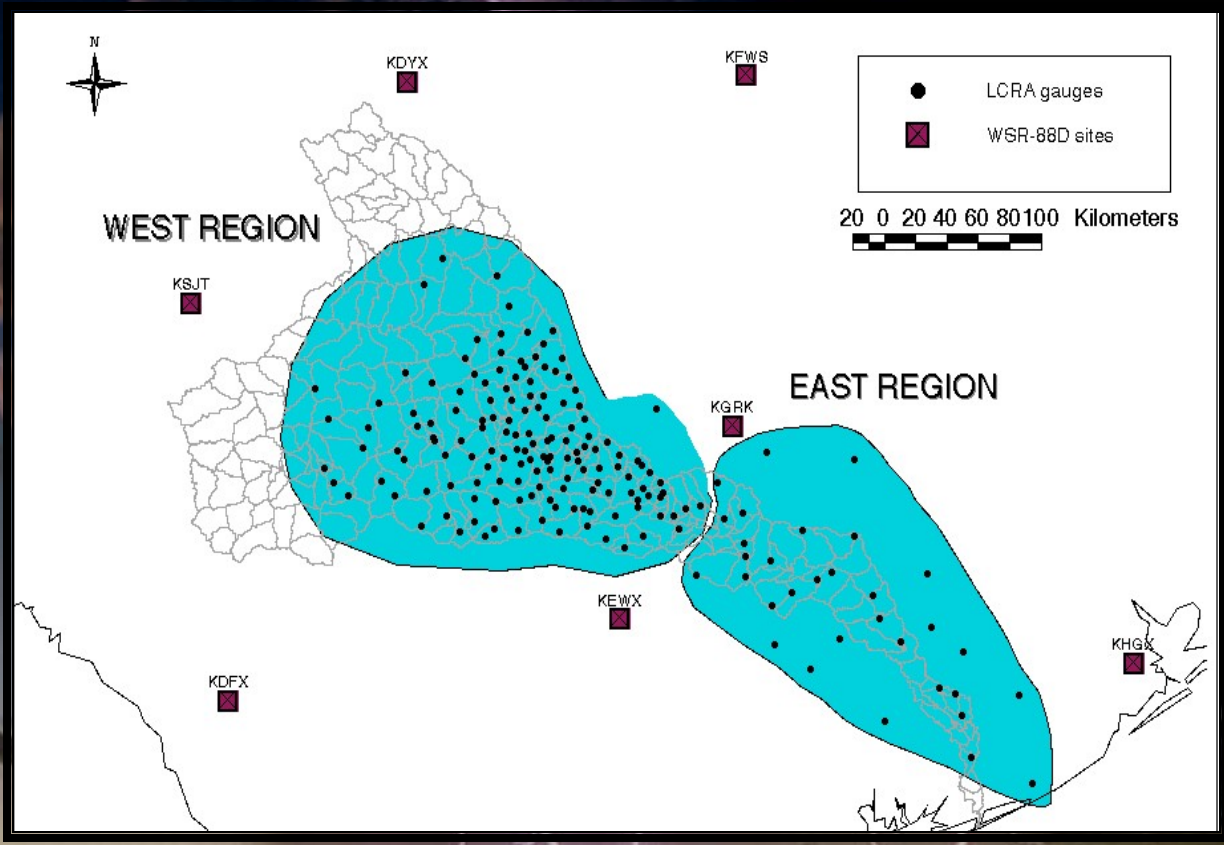
Regression Equation

LCRA Case Study

WDT Real-time QPE/QPF System
Uses Data from 25 radars and 193 Gauges

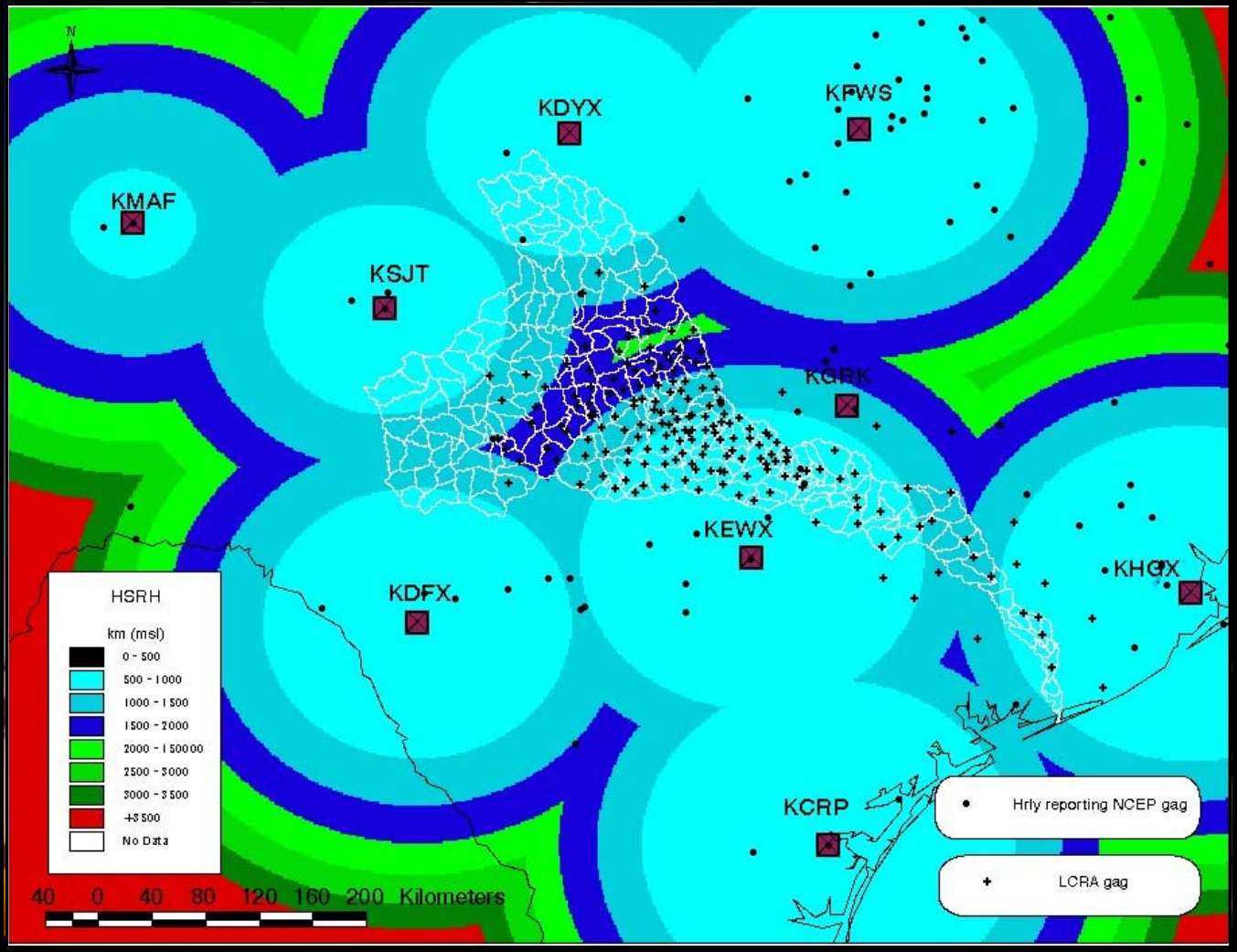


LCRA Basins and Gauges



- Total 193 gauges
- Average distance between gauges in the West = 8km and East = 20 km

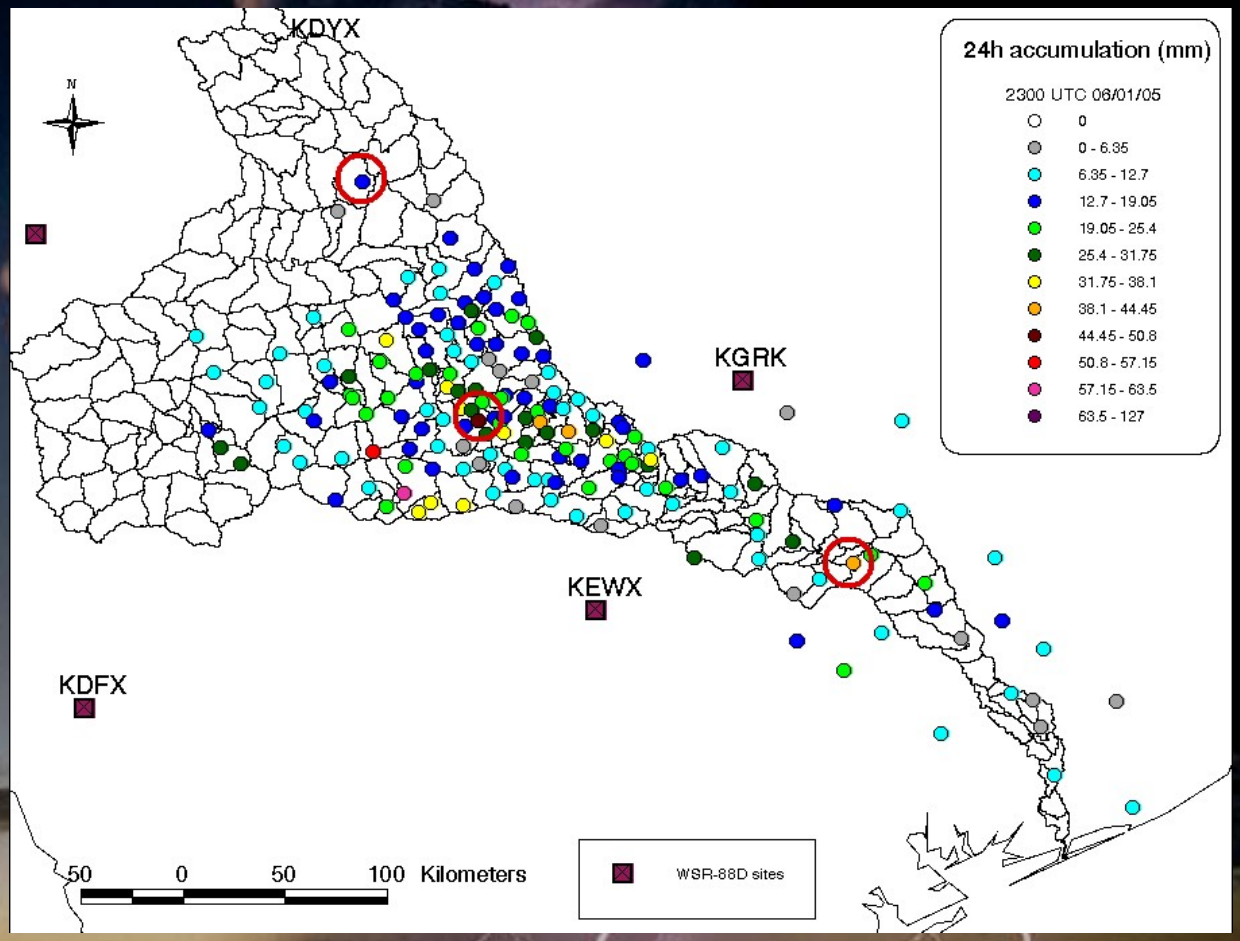
Hybrid Scan Reflectivity Heights



LCRA Rain Gauges and Basins

Mean 24 hour rainfall = 17 mm

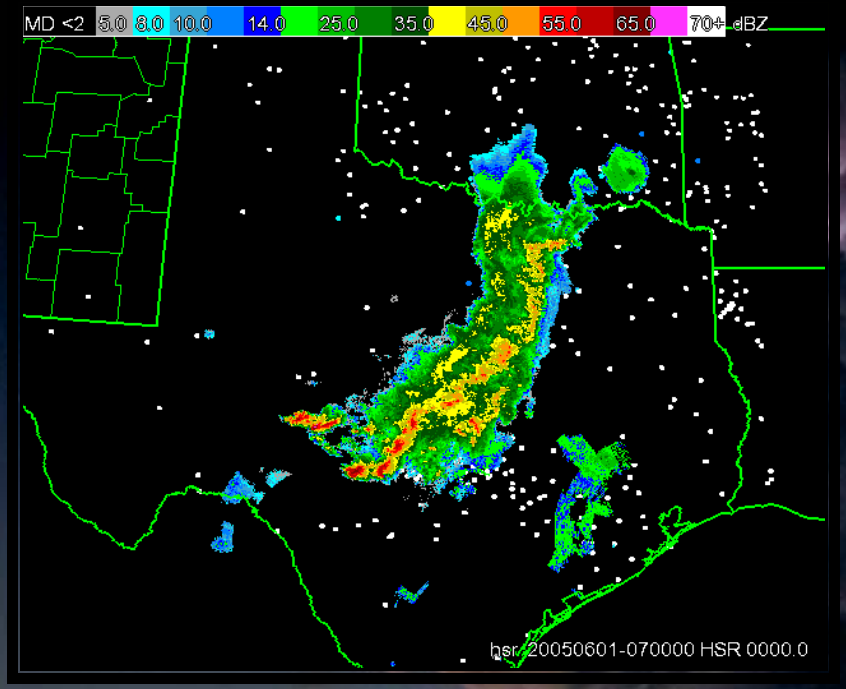
West = 143 reporting gauges



East = 32 reporting gauges

Total of 193 LCRA gauges, 175 reported and 3 gauges were removed by quality control

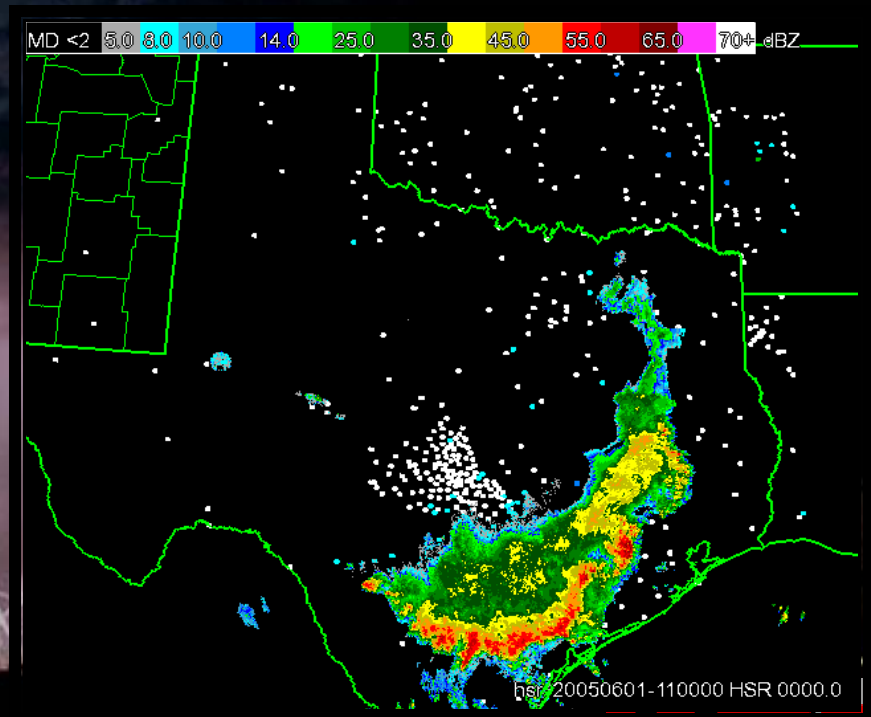
The Case Study: 05/31/05



0700 UTC

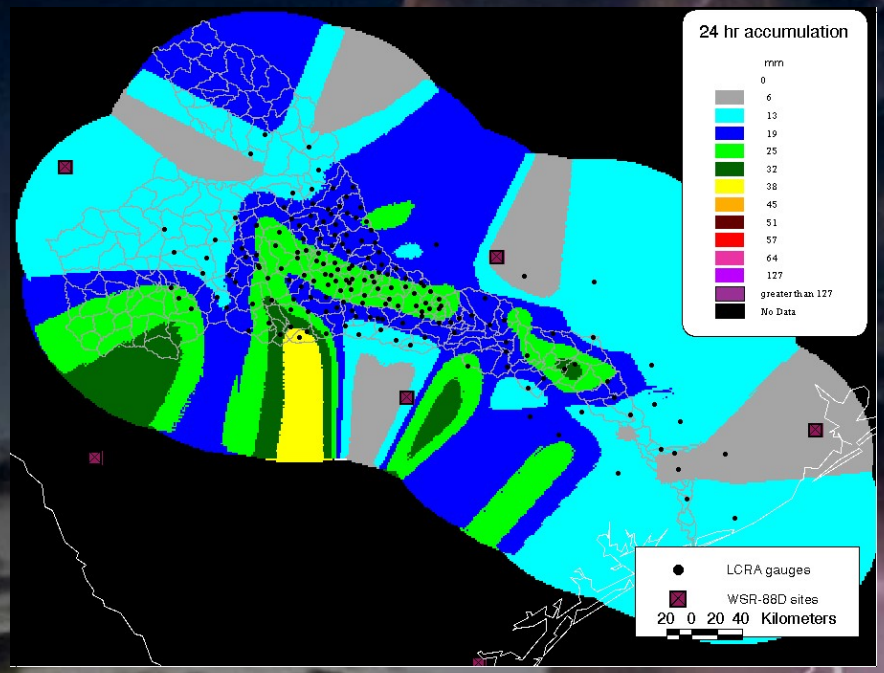
Hybrid Scan Reflectivity

1100 UTC



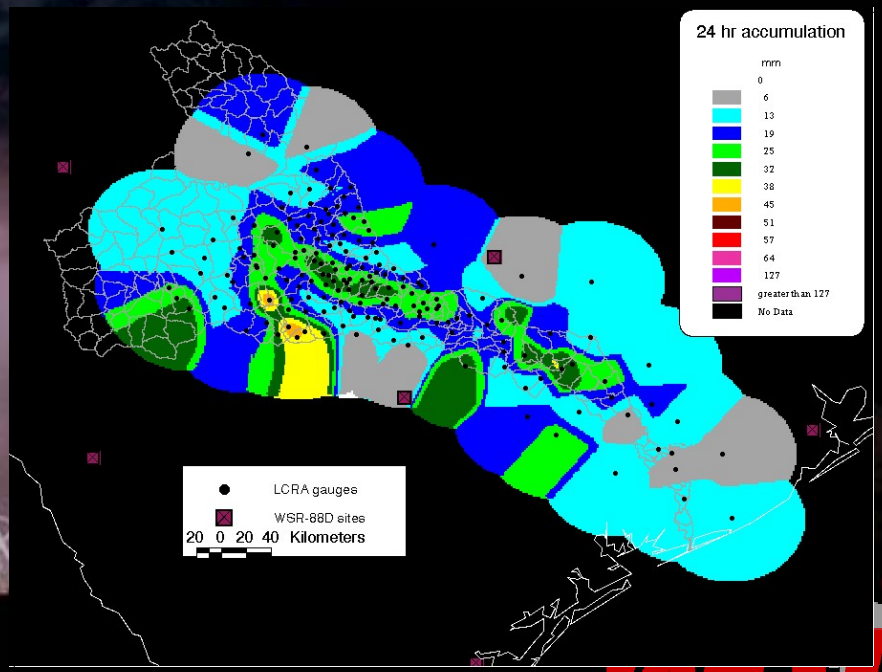
Optimized Weighting Function

The importance of Tuning the Network to the Gauge Distribution, Radar Coverage, and Terrain



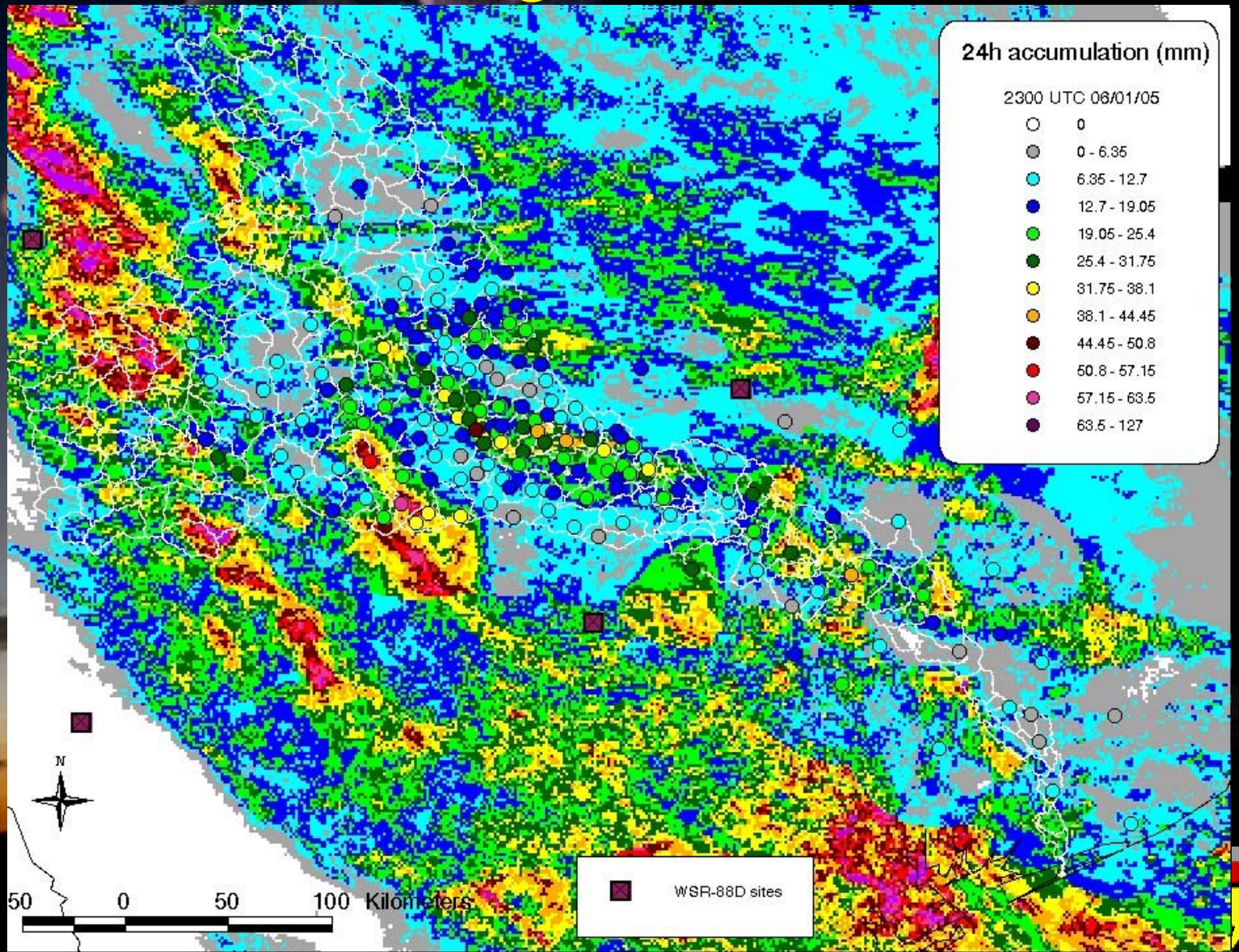
Before Tuning

Optimized



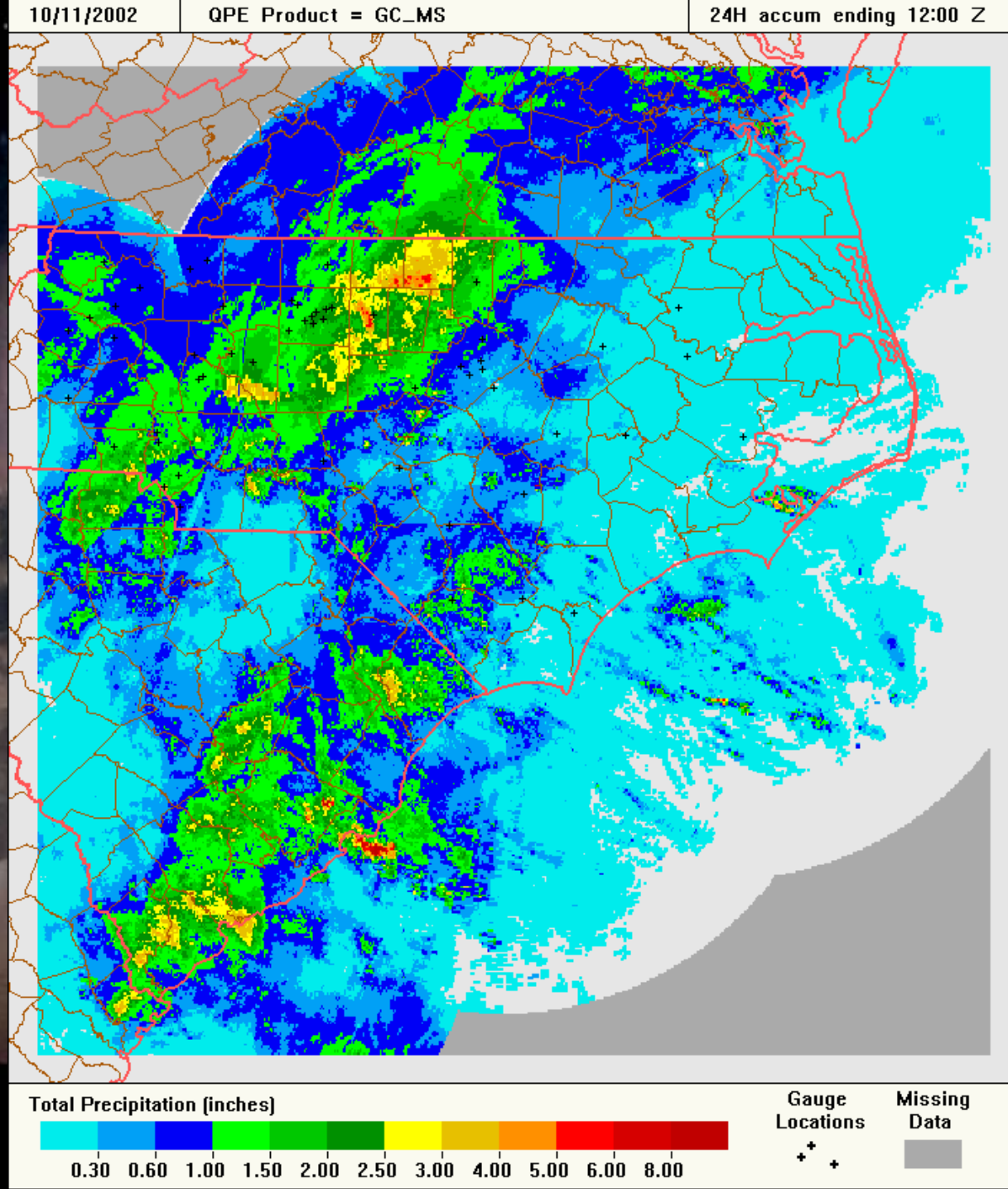
Precipitation Estimates from Radar with Rain Gauge Correction

Bias for this event after gauge correction was <10%.



Example of Multi-Sensor Precipitation Estimate from Tropical Cyclone Kyle

Precipitation Estimates are from a combination of rain gauge and radar data.
These estimates had a verified bias of only 3%!



Quantitative Precipitation Forecasting

- Uses McGill University MAPLE technology
- Provides reflectivity forecasts up to 2 hours for smaller areas (a few 1000 km**2)
- Provides up to 6 hour forecasts for larger continents.
- Uses variable Z-R relationships to calculate Quantitative Precipitation Forecasts (QPF)

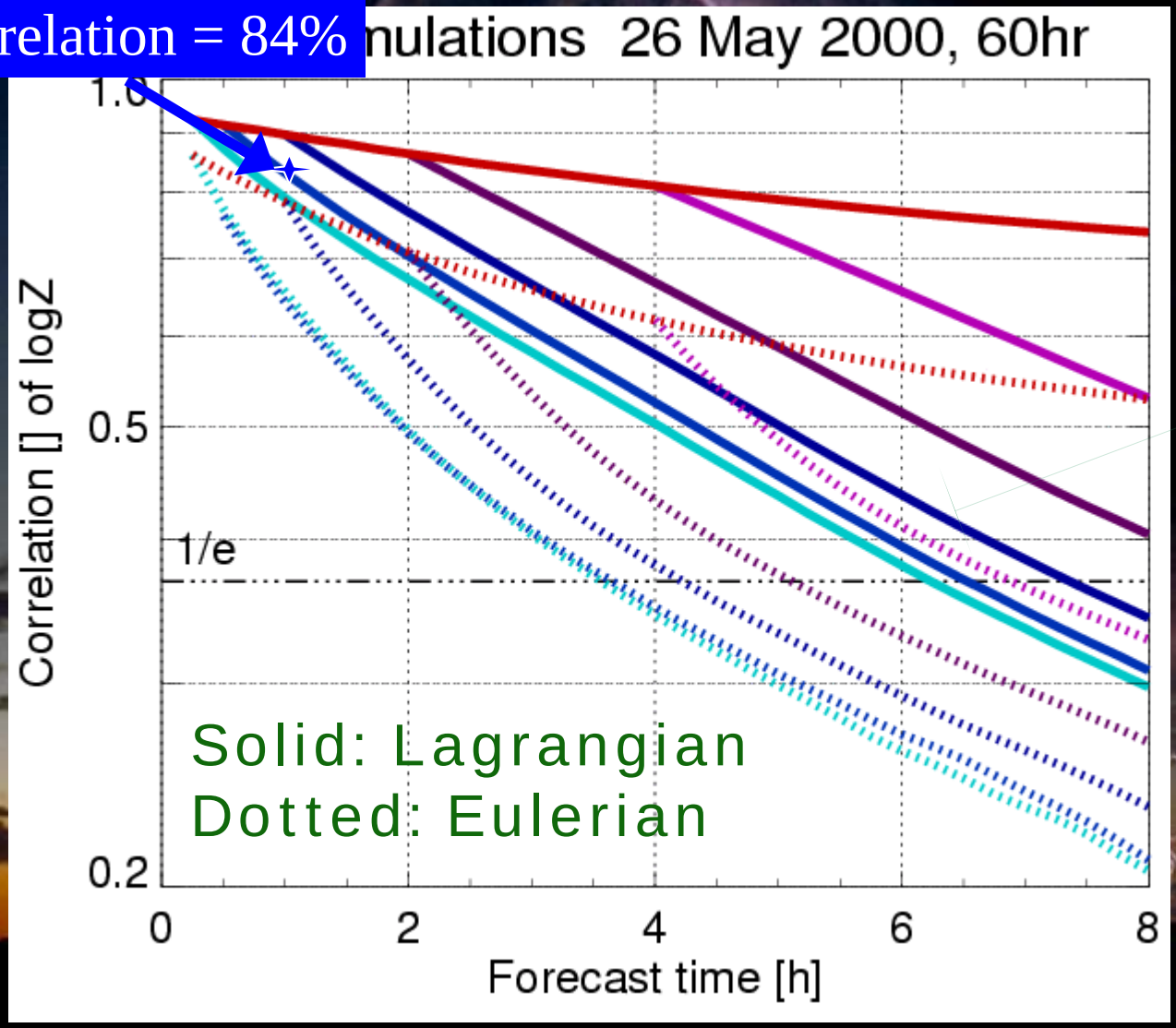
Quantitative Precipitation Nowcasting (QPF) at McGill: Lagrangian Persistence, A method for very short term forecasting of precipitation

Few hours

Isztar Zawadzki
J. S. Marshall Radar Observatory
McGill University

Forecasting Precipitation Skill

60 min accum.
Correlation = 84%

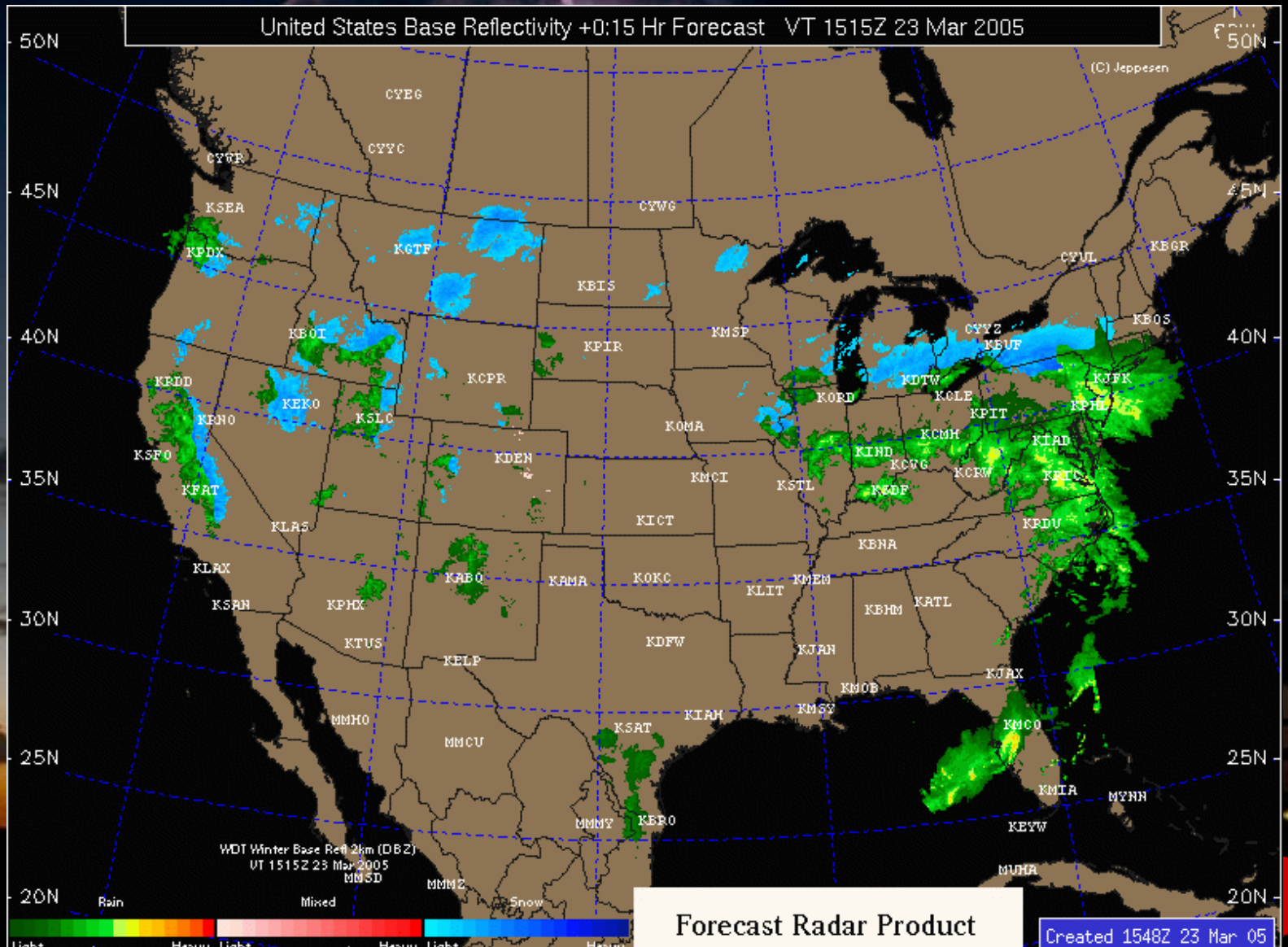


Accumulation of rainfall

Note that 1 hour forecasts correlate extremely well with observed precipitation amounts

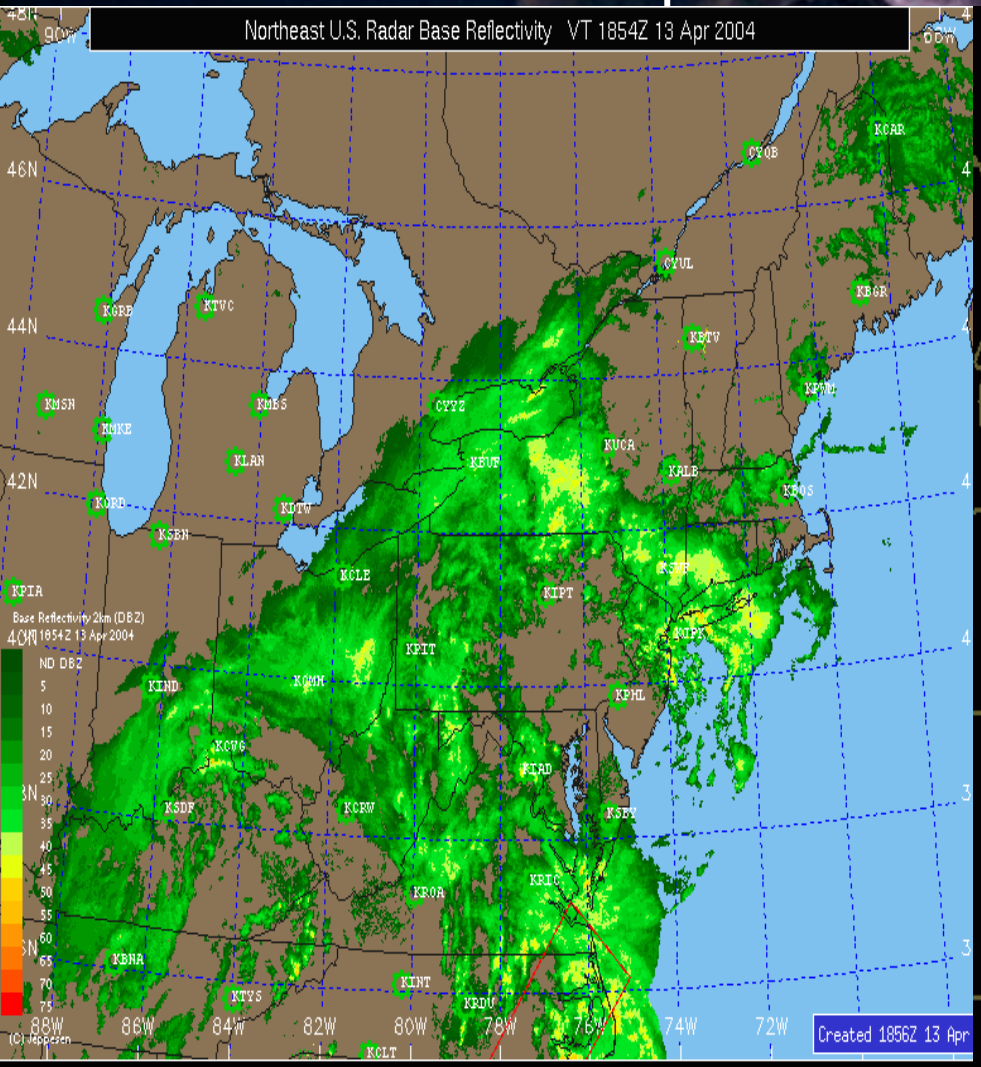
Sample Storm Predictor 4 Hour Forecast of Reflectivity

Areas with Blue Scale are Snow

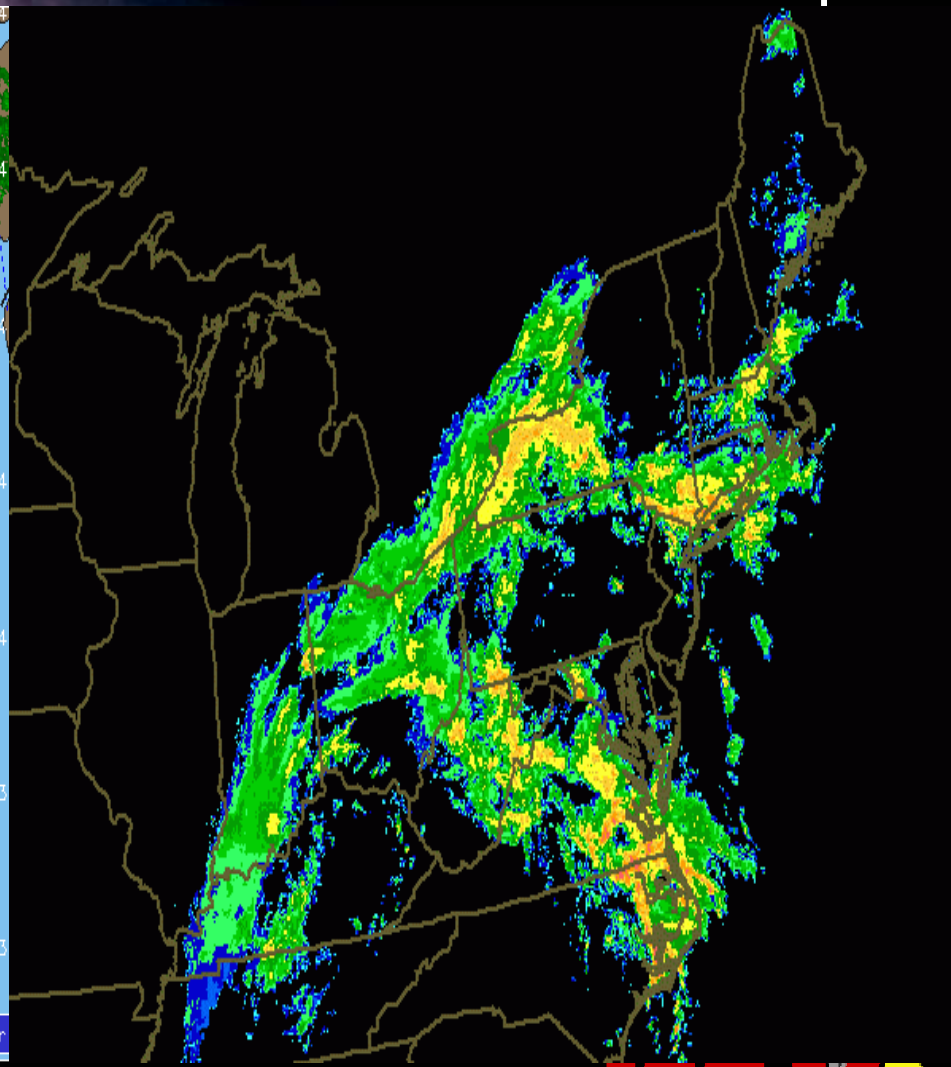


Verification of 2 Hour MAPLE Forecast

Radar Analysis
Valid 1900 UTC 13 Apr

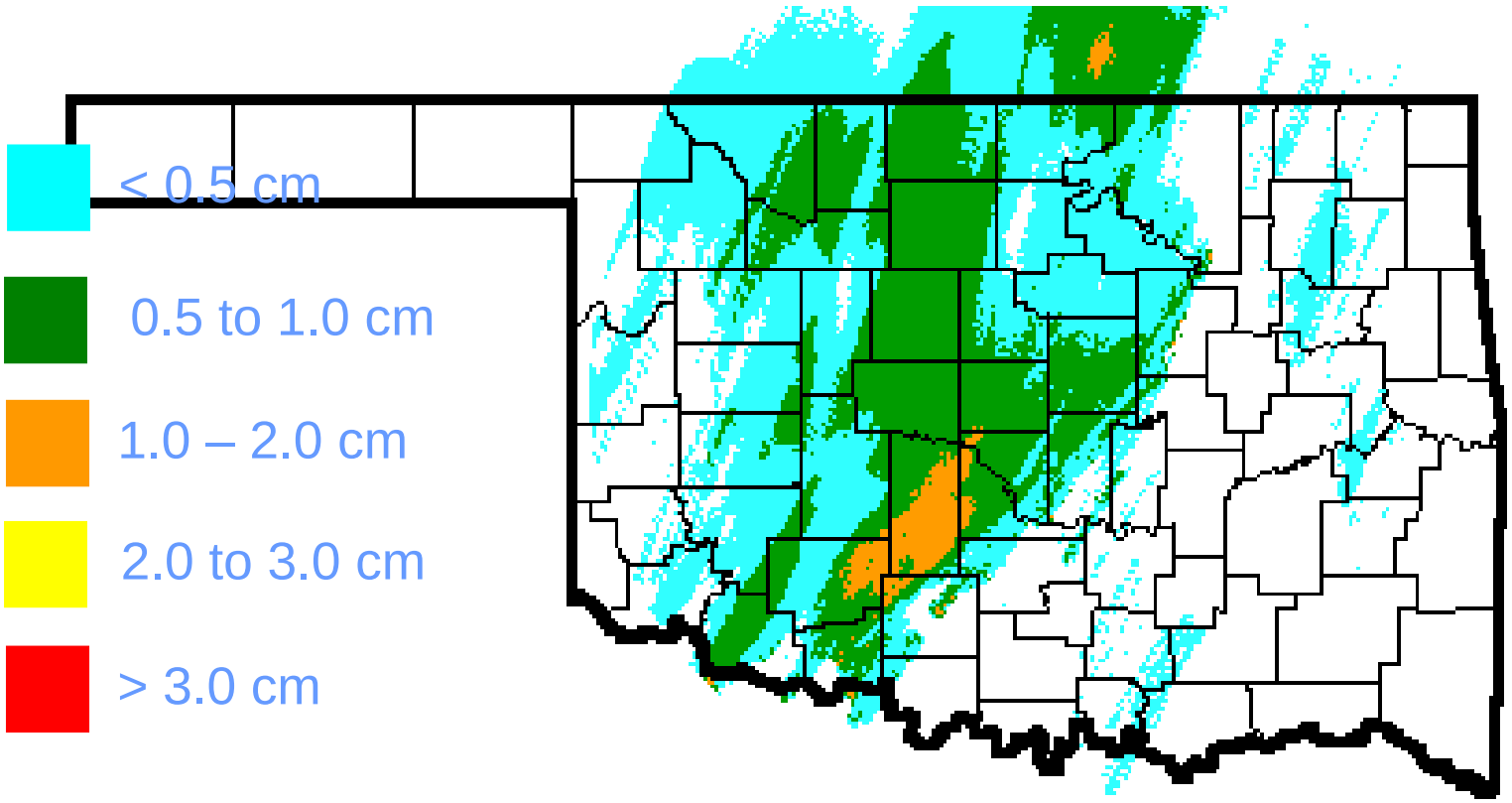


MAPLE 2 HR FCST
Valid 1900 UTC 13 Apr



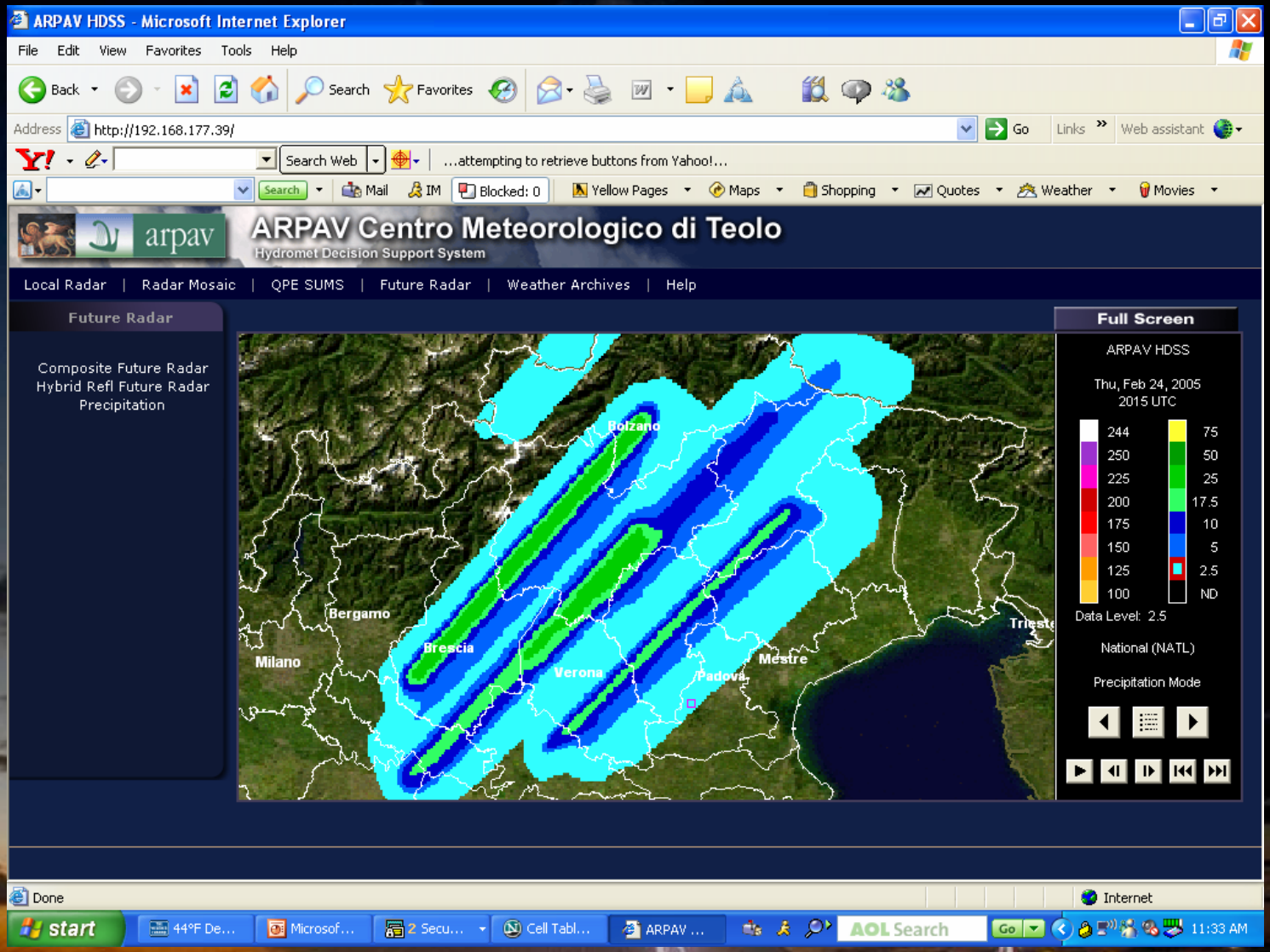
Rain Predictor: High-Resolution Precipitation Prediction

The input to this model is the time series of reflectivity estimates from MAPLE and the rain gauge bias information from QPE-SUMS.



2 hour Rainfall Prediction Example

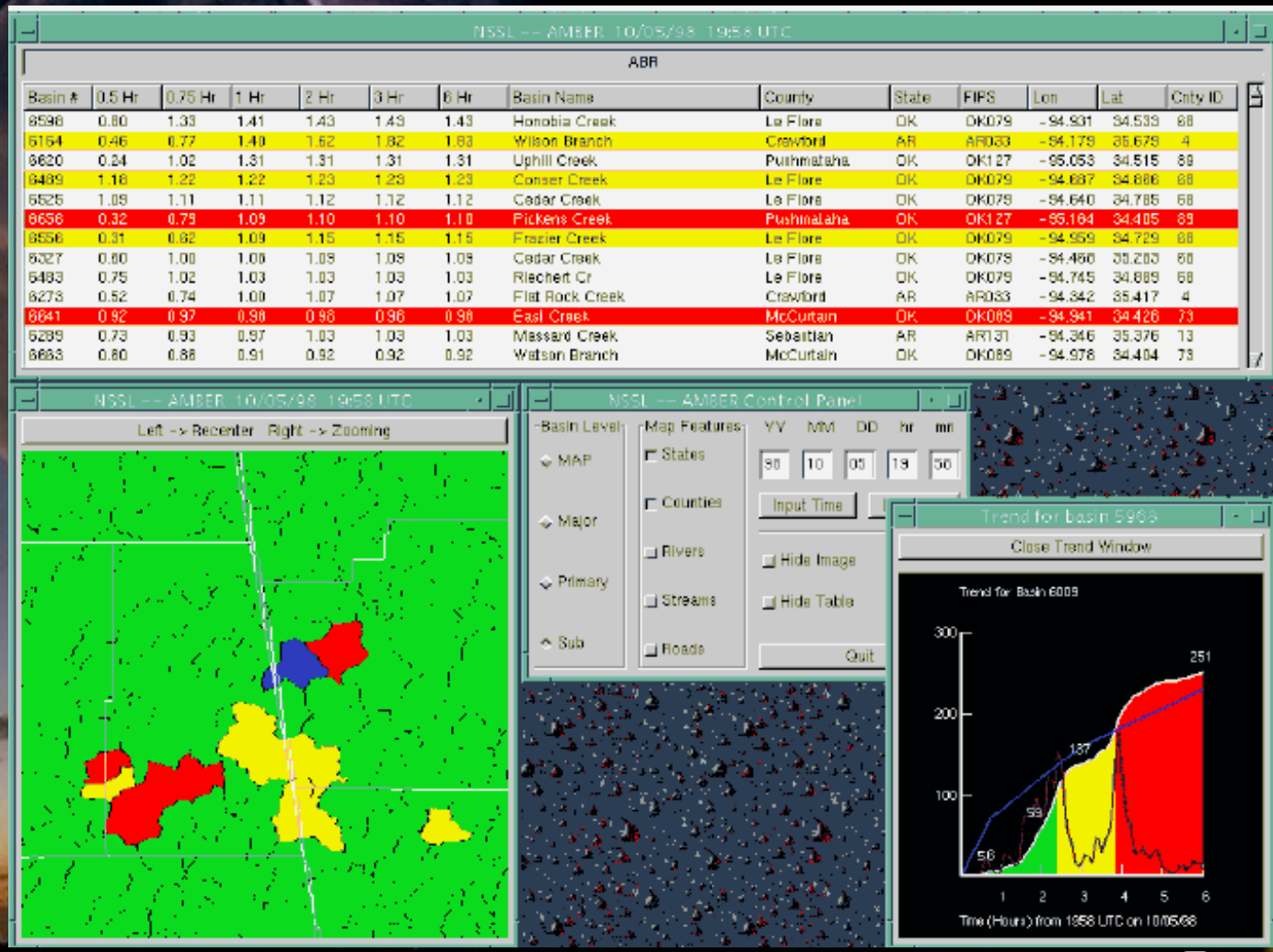
Rain Predictor in Italy



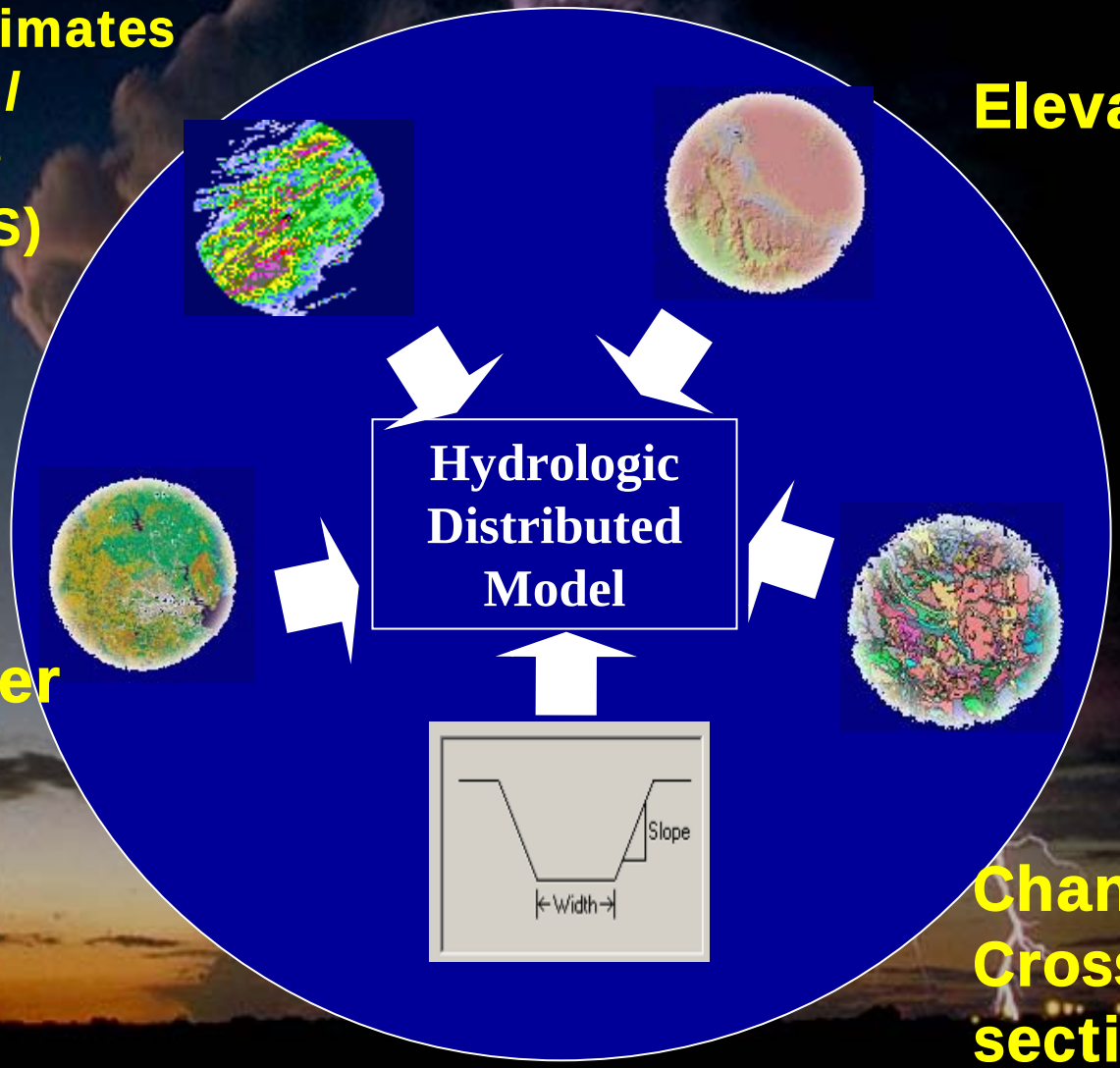
Example of 2 hour forecast of total rainfall shown in WxScope display

Flash Flood Prediction Algorithm

- Uses QPE and QPF estimates from QPE-SUMS and MAPLE
- Provides basin average rainfall estimates and forecasts in small basins.
- Compares these basin averages to pre-set thresholds to provide flash flood alerts and warnings.



Distributed Hydrologic Model integrating QPE & GIS Data sets



Rainfall Estimates from Radar / Rain Gauge (QPE-SUMS)

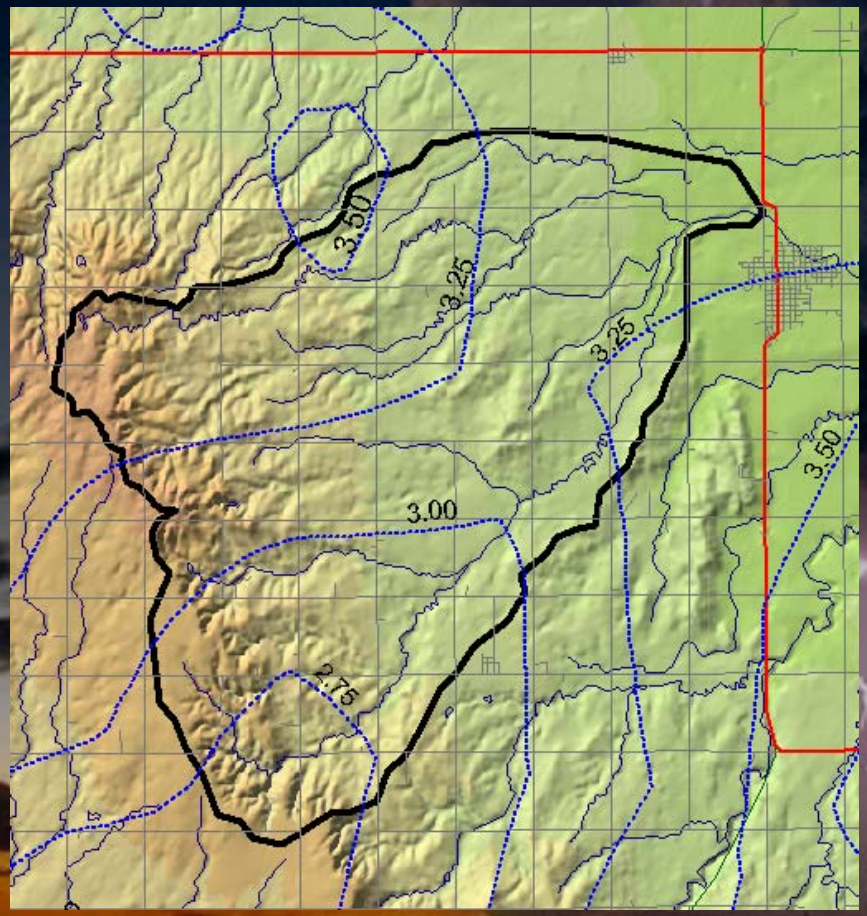
Elevation

Land cover

Soils

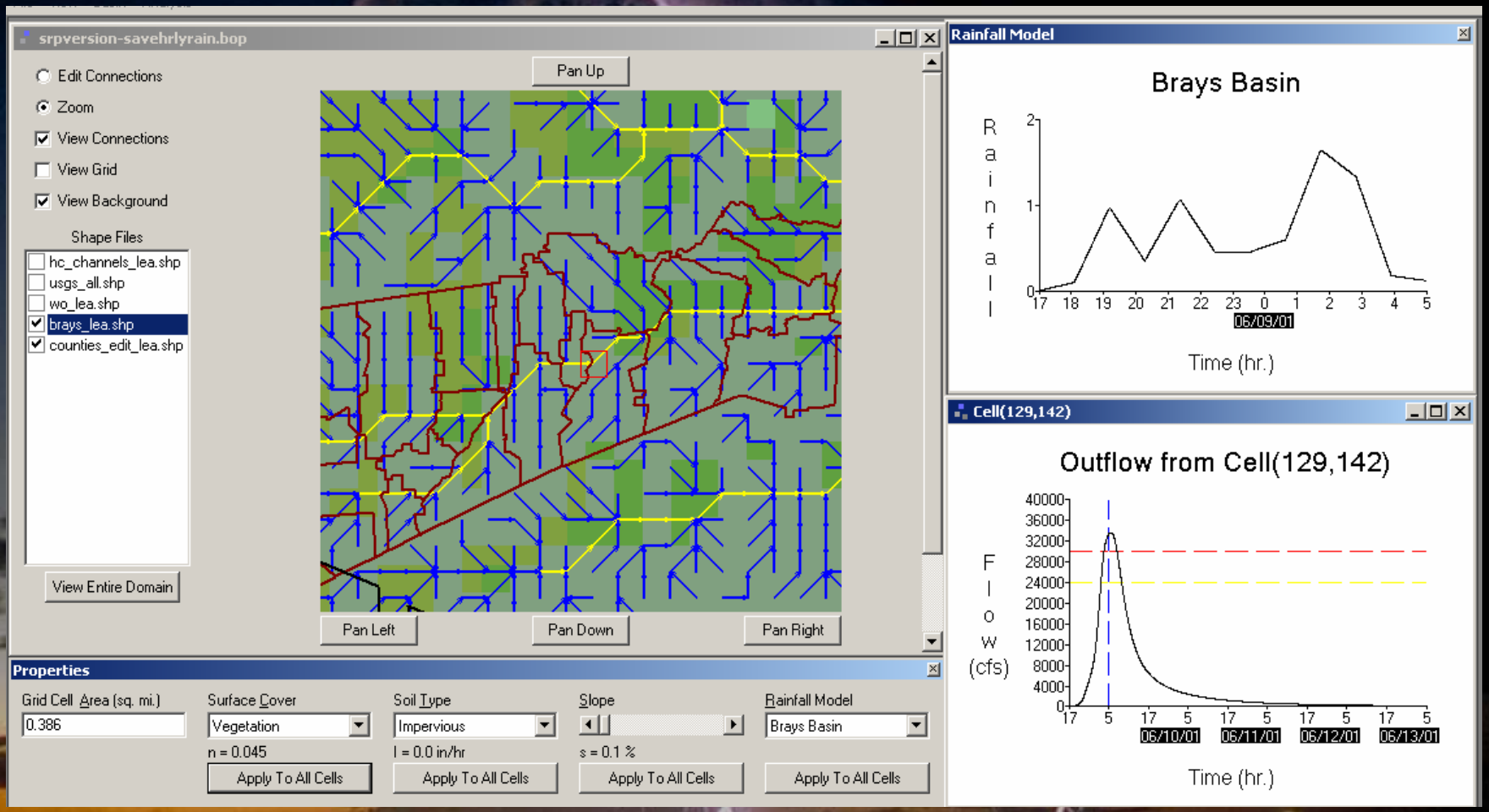
Channel Cross sections

Distributed Model Specifics



- Digital elevations form the basis for model equations
- Each grid cell is connected with a finite element
- Entire spatial information content is used
- Digital data is becoming readily available worldwide
- QPE-SUMS input to distributed hydrologic model provides both flash flood modeling and stream and river modeling.

Brays Model June 8-9th, 2001 Hydrograph Houston, TX



Summary

- WDT's HDSS is a field-proven, state-of-the-science operational system.
- HDSS optimally integrates all available rainfall data (rain gauge, satellite, radar, lightning data, etc.)
- Important tool for managing dams, canals, streams, rivers and rain run-off systems and warning of flash floods