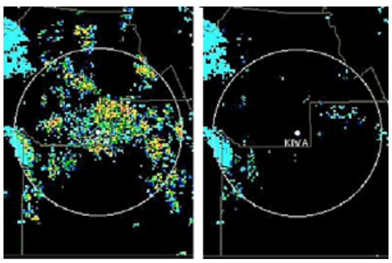
national severe storms laboratory

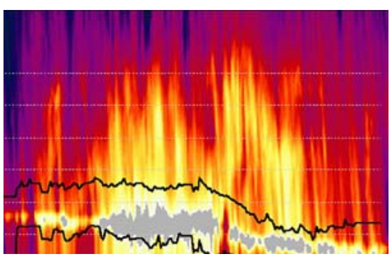
Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE-SUMS)

The latest technology in rainfall estimation

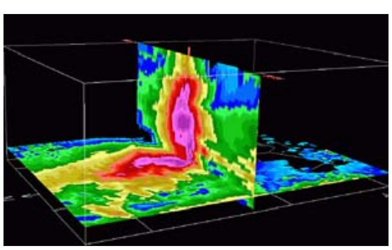
Researchers at the NOAA National Severe Storms Laboratory in Norman, Oklahoma study a wide variety of severe weather. Challenges in estimating precipitation type and amount due to mixed-phase sampling, improper Z-R relationships, non-weather echos, and beam blockage in the western United States has led one group to investigate the computation, analysis and display of high-resolution radar data and radar-derived products to achieve accurate rainfall and snowfall estimates. The result, QPE-SUMS, uses a multisensor, physics-based approach to estimate precipitation type and rate through an optimal blend of model output with high-resolution radar, satellite, lightning, and gauge rainfall data. The outcome of this work is high-quality input to hydrologic models for national and international flash flood forecasting, new data interrogation products, and innovative data integration techniques.



Radar data quality control before and after correction



Algorithm results are overlaid on a time series of reflectivity from an independent, vertically-pointing research radar.



Vertical cross-section of reflectivity on a composite reflectivity layer.

- **Radar Data Quality Control**

  Radar reflectivity data must be corrected to account for anomalous beam propagation (A), ground clutter, and returns from non-weather echoes. These contaminants are removed from radar reflectivity maps upon examination of vertical reflectivity structures and velocities at each grid point.

- **Bright Band Identification**

  As frozen hydrometeors fall through the melting layer, their cross-sections often increase due to aggregation and water coating. This in turn results in an artificially high layer of reflectivity that is known to contaminate radar precipitation estimates. The Bright Band Identification algorithm has been devised to search for the melting layer and ultimately remove it from precipitation maps.

  PAYOFF: This feature prevents contamination and overestimation of rainfall rates.

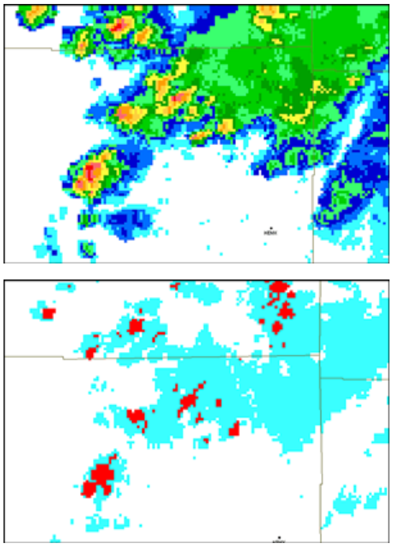
- **3-D Reflectivity Mosaic**

  A 3-D volume of reflectivity with a horizontal resolution of 1km or less and at least 21 vertical layers is produced every five minutes. Reflectivity data are converted to Cartesian coordinates using an adaptive Barnes interpolation scheme. Data from multiple radars are then put into a mosaic on a common grid using a Cressman, inverse distance weighting technique.

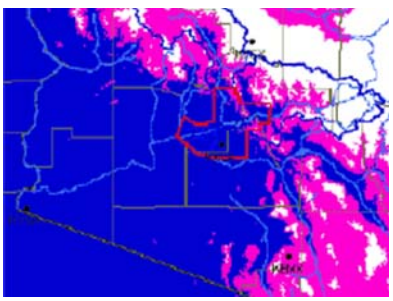
  PAYOFF: The 3-D reflectivity mosaic provides better visualization of storm structure and improved radar-derived products.

- **Convective/Stratiform Identification**

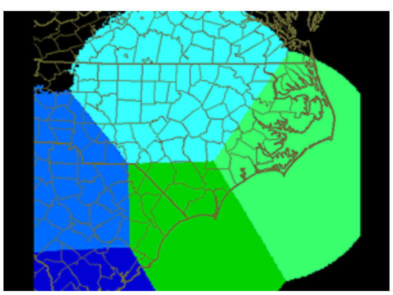
  Differing drop size distributions that are a function of geography, season, storm type, and storm lifecycle result in both under- and over-estimation of rainfall when a single radar reflectivity to rainfall conversion (Z-R relationship) is applied to all regions. In an attempt to minimize these Z-R errors, QPE-SUMS utilizes a convective/stratiform identification component. This module segregates convective from



Radar reflectivity image (top) and convective/stratiform segregation results (bottom); Red indicates convective regions and blue indicates stratiform.



Precipitation phase product using RUC-2 model 0C heights



QPE-SUMS uses a mosaic of radar data based on the best available coverage above ground.

stratiform echo on a grid point-by-grid point basis by examining reflectivity magnitudes relative to atmospheric thermodynamic properties. High reflectivity at cold temperatures is suggestive of convective activity. Such grid points receive appropriate Z-R equations, while stratiform grid points are handled differently.

PAYOFF: Allowing differential Z-R on each gridpoint of data allows for a more physically-based radar reflectivity-to-rainfall conversion.

- **Precipitation Typing**

  Recently, analyses from the RUC-2 model have been integrated into QPE-SUMS in order to assist in the segregation of frozen, liquid, and mixed precipitation. 0C heights from the model are ingested hourly and compared to terrain heights at each grid point. This information allows QPE-SUMS to adjust its precipitation scheme to accommodate different precipitation types.

  PAYOFF: Identification of the rain/snow line supplies initial conditions for hydrologic modeling, supports snow removal operations for transportation purposes, and assists in watershed management.

- **Hybrid Scan Mosaic**

  In the precipitation estimation component of QPE-SUMS, radar data are combined into a mosaic depending on which radar provides the best coverage above the ground. This mitigates "below beam effects" such as evaporation, phase changes, precipitation growth, and advection. This hybrid scan look-up table is also adaptive in the sense that radar coverages change depending on which radars are ingested on a five-minute basis. For example, a given radar will cover a larger region if data from an adjacent radar fail to arrive on time.

  PAYOFF: QPE-SUMS exploits the overlapping regions of multiple radars by using the best quality data for any given point.

- **Multisensor QPE**

  The most distinguishing characteristic of QPE-SUMS is the real-time calibration of satellite cloud-top temperatures using collocated radar rainfall rates. A regression equation is formed in real time that describes the relationship between satellite and radar rainfall. This adaptive regression is then applied to the satellite field so that realistic precipitation rates are applied every five minutes on a 1x1-km grid.

  PAYOFF: More accurate precipitation estimates are vital, especially in the cool season where radar-only estimates are known to be problematic.

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