

# Challenges in Improving QPE Directed Toward Improving Flash Flood Warning Guidance

Ken Howard  
Hydrometeorology





# Q2 Vision

*“While tremendous progress has been made in the last quarter-century in many areas of QPE and VSTQPF, **significant gaps continue to exist in both knowledge and capabilities that are necessary to produce accurate high-resolution precipitation estimates at the national scale for a wide spectrum of users.**”*

*“To meet the nation's needs for the precipitation information effectively, the authors herein propose a **community-wide integrated approach for precipitation information that fully capitalizes on recent advances in science and technology, and leverages the wide range of expertise and experience that exists in the research and operational communities.**”*



## ARTICLES

### IMPROVING QPE AND VERY SHORT TERM QPF

An Initiative for a Community-Wide Integrated Approach

BY STEVEN V. VASIOFF, DONG-JUN SEO, KENNETH W. HOWARD, JIAN ZHANG, DAVID H. KITZMILLER, MARY G. MULLUSKY, WITOLD F. KRAJEWSKI, EDWARD A. BRANDES, ROBERT M. RABIN, DANIEL S. BERKOWITZ, HAROLD E. BROOKS, JOHN A. MCGINLEY, ROBERT J. KULIGOWSKI, AND BARBARA G. BROWN

A multisensor applications development and evaluation system at the National Severe Storms Laboratory addresses significant gaps in both our knowledge and capabilities for accurate high-resolution precipitation estimates at the national scale.

**W**ater is a precious resource and, when excessive or in short supply, a source of many hazards. It is essential to monitor and predict water-related hazards, such as floods, droughts, debris flows, and water quality, and to determine current and future availability of water resources. Accurate quantitative precipitation estimates (QPE) and very short term quantitative precipitation forecasts (VSTQPF) provide key input to these assessments. [QPE and VSTQPF are hereafter referred to

collectively as quantitative precipitation information (QPI).] To meet these needs at the national scale, accurate QPI is needed at various temporal and spatial scales for the entire United States, its territories, and immediate surrounding areas. Temporal scales range from minutes to several hours for flash flood prediction. QPI products can then be aggregated to support longer-term applications for water supply prediction. Spatial scales range from a few square kilometers or less for urban flash flood prediction,

**AFFILIATIONS:** VASIOFF, HOWARD, RABIN, AND BROOKS—NOAA/National Severe Storms Laboratory, Norman, Oklahoma; SEO—NOAA/NWS/Office of Hydrologic Development, Silver Spring, Maryland, and University Corporation for Atmospheric Research, Boulder, Colorado; ZHANG—Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, and NOAA/OAR National Severe Storms Laboratory, Norman, Oklahoma; KITZMILLER—NOAA/NWS/Office of Hydrologic Development, Silver Spring, Maryland; MULLUSKY—NOAA/NWS/Office of Climate, Water, and Weather Services, Silver Spring, Maryland; KRAJEWSKI—IHR—The University of Iowa, Iowa City, Iowa; BRANDES AND BROWN—National Center for Atmospheric Research, Boulder, Colorado; BERKOWITZ—NOAA/WSR-88D Radar Operations Center, Norman, Oklahoma;

MCGINLEY—NOAA/Earth System Research Laboratory, Boulder, Colorado; KULIGOWSKI—NOAA/National Environmental Satellite, Data, and Information Service, Camp Springs, Maryland  
**CORRESPONDING AUTHOR:** Steven Vasiloff, NOAA/National Severe Storms Laboratory, National Weather Center, 120 David L. Boren Blvd., Norman, OK 73072  
E-mail: steven.vasiloff@noaa.gov

The abstract for this article can be found in this issue, following the table of contents.

DOI:10.1175/BAMS-88-12-1899

In final form 15 June 2007  
©2007 American Meteorological Society

AMERICAN METEOROLOGICAL SOCIETY

DECEMBER 2007 BAMS | 1899



# Q2 Implementation

Q2 exists today as a scientific and community-based convergence towards accurate very high-resolution **multi-sensor** precipitation estimates on a national scale.

Q2 is a continuation of NSSL's departure from a radar-centric approach to precipitation estimation towards a integration of radar, satellite, model, and surface observations.

Q2 goal is to glean the best practices and techniques from the NOAA's River Forecast Centers, Forecast Offices, Office of Hydrology, domestic and international organizations and universities.





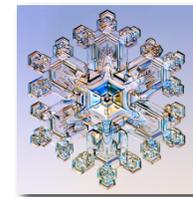
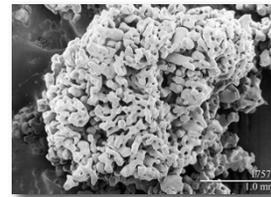
# Q2 Philosophy

Real-time means real world - Q2 R&D concepts and techniques are implemented in a 'real time' system

Transparency - We can explain and document what we are doing and why.

Operations centric - R&D focused on operational challenges and needs for critical decision support.

## Challenges:





## Q2 *Vision Developmental Core Technologies*

1. National Basin Delineation Project and Repository
2. Radar Reflectivity Comparison Tool
3. Q2 National Mosaic and Quantitative Precipitation Estimation System
4. Central Weather Bureau of Taiwan - International Collaboration

# National Basin Delineation

Objective: To create a national dataset of flash-flood-scale basins delineated from high-resolution digital elevation data to support the NWS Flash Flood Monitoring and Prediction (FFMP) program.



➤ This effort has spanned the past 10 years.

➤ NSSL has had ongoing interaction and coordination with:

- Every Weather Forecast Office
- FFMP developers (MDL)
- OCWWS, OHD
- RFCs and other dataset users

➤ Significant accomplishments include:

- Creation of a national seamless flash-flood-scale basin and stream dataset

**Publication:**

Arthur, A. T., G. M. Cox, N. R. Kuhnert, D. L. Slayter, K. W. Howard, 2005: The National Basin Delineation Project. Bulletin of the American Meteorological Society, 86, 1443-1452.

## USGS National Elevation Dataset (NED)

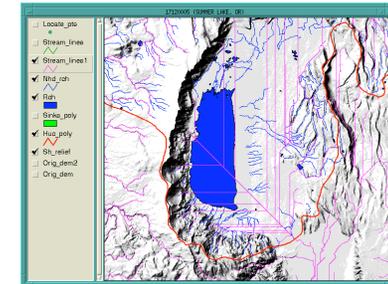
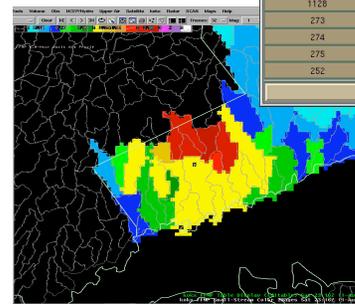


The high level of quality of the NED base data enabled the use of a mostly automated GIS delineation process.

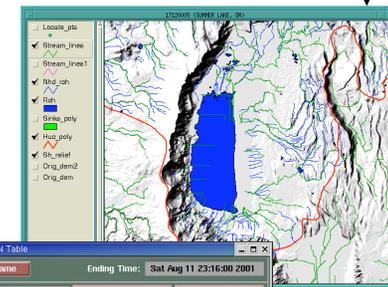


Resulting basin boundary datasets are used in FFMP average basin rainfall calculations and displays.

## NWS FFMP



Specialized techniques were used to improve results in areas such as natural sinks.



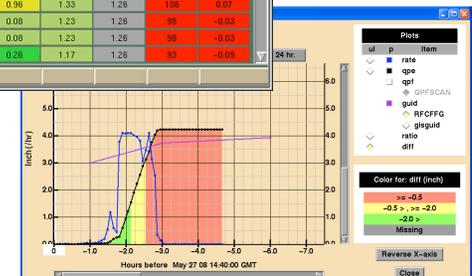
KOKX: FFMP Threat BASIN Table

Ending Time: Sat Aug 11 23:16:00 2001

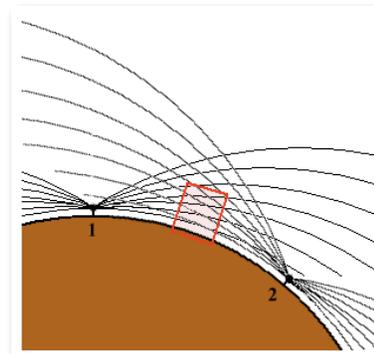
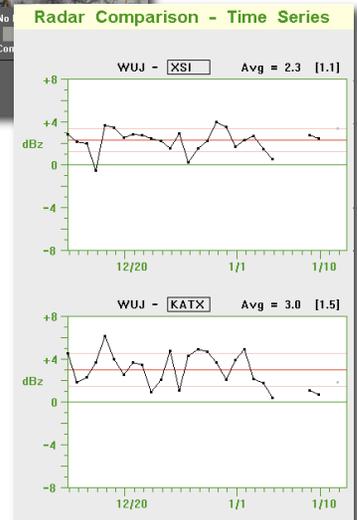
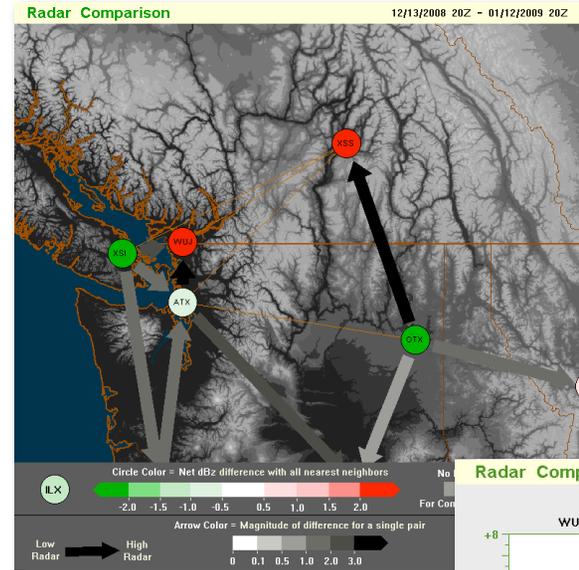
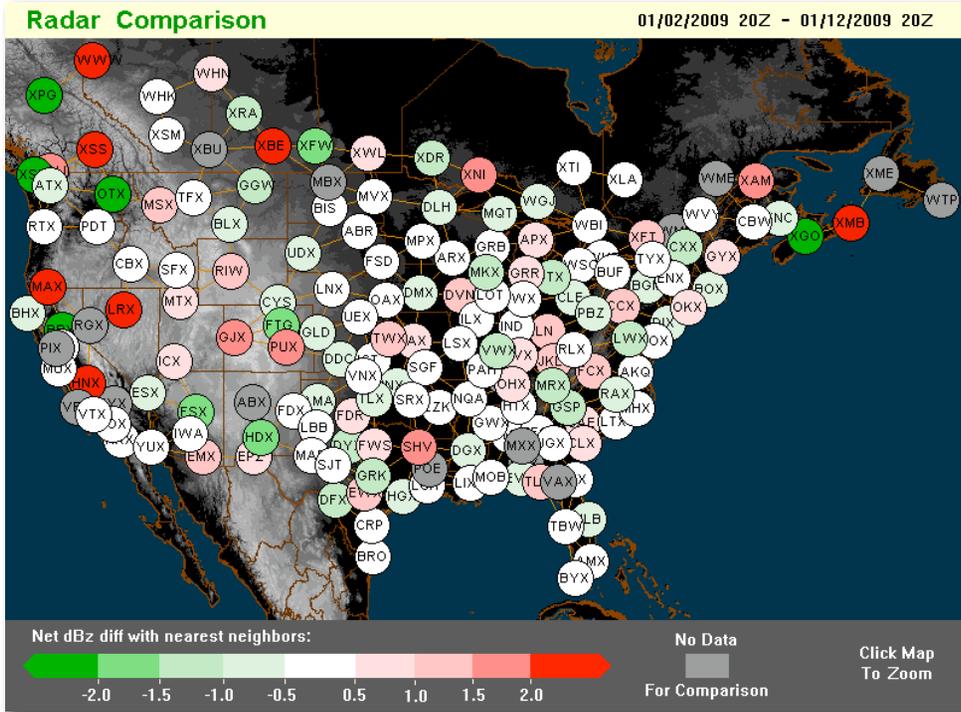
Refresh D2D | Display Rate | Thresh Type: princp | Sources: DRR

County: CT-FAIRFIELD | Durations (hr): 1.00

Area_id	Rate	Precip	FFG	Ratn	Dff
285	1.47	2.51	1.26	200	1.28
284	1.98	2.20	1.26	174	0.84
1132	0.72	2.15	1.26	174	0.93
1128	0.57	2.15	1.26	170	0.89
1131	0.49	2.03	1.26	161	0.77
1126	0.17	1.93	1.26	153	0.67
273	0.96	1.33	1.26	106	0.07
274	0.08	1.23	1.26	98	-0.03
275	0.08	1.23	1.26	98	-0.03
252	0.26	1.17	1.26	83	-0.09



# Radar Reflectivity Comparison Tool (RRCT)



Objective: A real time system to monitor the quality of base level data to determine potential calibration offsets and transmitter drift.



# Q2

Real time platform to develop, test, and assess advance techniques in quality control, data integration and precipitation estimation and short term forecasting.

## NATIONAL MOSAIC & MULTI-SENSOR QPE (NMQ)

Advancing the science and science-to-operations of QPE and very short-range QPF

Home	Inventory	Mosaic3D Levels	Mosaic3D Derived	VPR	RUC
QPE	QPF	Gauge	Satellite	Diagnostics	Time Series

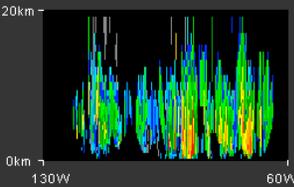
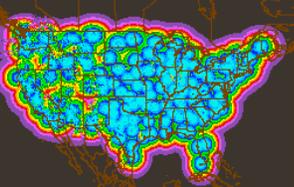
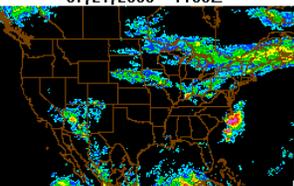
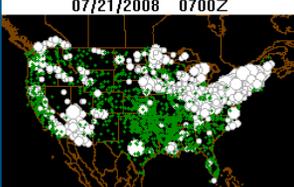
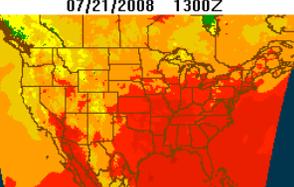
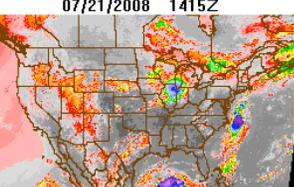
**National Mosaic and QPE (NMQ)**

[NSSL Main Page](#)  
[NMQ Tutorial](#)

The NMQ project is a joint initiative between the National Severe Storms Laboratory, Federal Aviation Administration, National Weather Service/Office of Hydrologic Development, the Office of Climate, Water and Weather Services and the University of Oklahoma Cooperative Institute in Mesoscale Meteorological Studies.

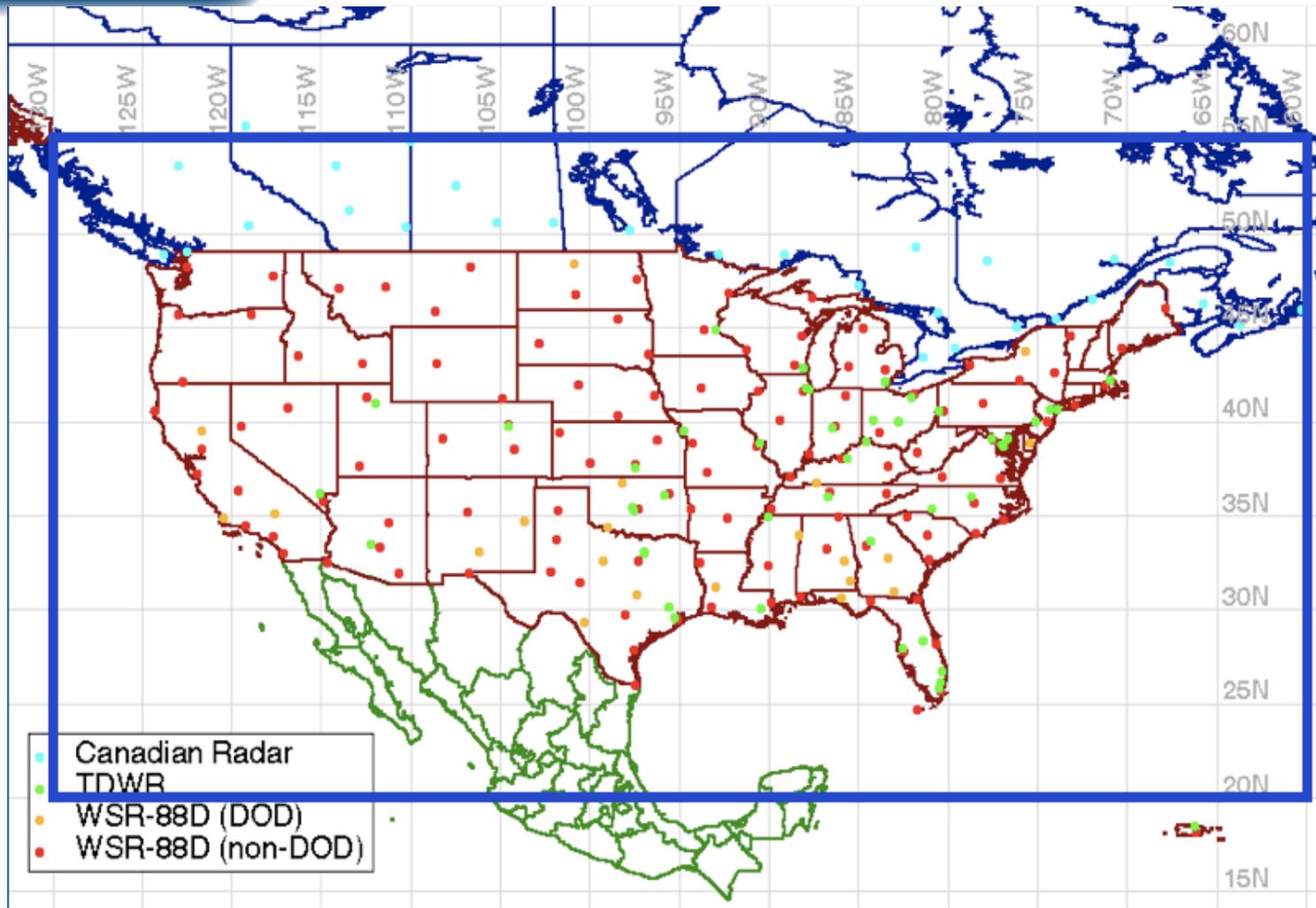
The NMQ serves as an international testbed for research, development, evaluation and science to operations infusion of high resolution 3D Mosaic of multiple radars and radar networks for model assimilation and aviation applications, Quantitative Precipitation Information (QPI) including Multiple Sensor Quantitative Precipitation Estimation (MSQPE) and Very Short Term Quantitative Precipitation Forecasts (VSTQPF) for the monitoring and warnings of floods and flash floods and in support of comprehensive hydrology and ecosystem modeling.

[NOAA Privacy Policy](#)  
[NSSL Disclaimer](#)

<b>Composite Radar Reflectivity</b> 07/21/2008 1415Z 	<b>Mosaic 3D - West/East Cross Section</b> 07/21/2008 1415Z 	<b>Hybrid Scan Reflectivity Height</b> 07/21/2008 1415Z 
<b>24 hr Radar (Hybrid Scan) Derived QPE</b> 07/21/2008 1400Z 	<b>24 hr Satellite Derived QPE</b> 07/21/2008 1100Z 	<b>Mosaic 3D Derived VPR</b> 07/21/2008 1410Z 
<b>24 hr Gauge Reports</b> 07/21/2008 0700Z 	<b>RUC Model Surface Temperature</b> 07/21/2008 1300Z 	<b>Satellite IR</b> 07/21/2008 1415Z 

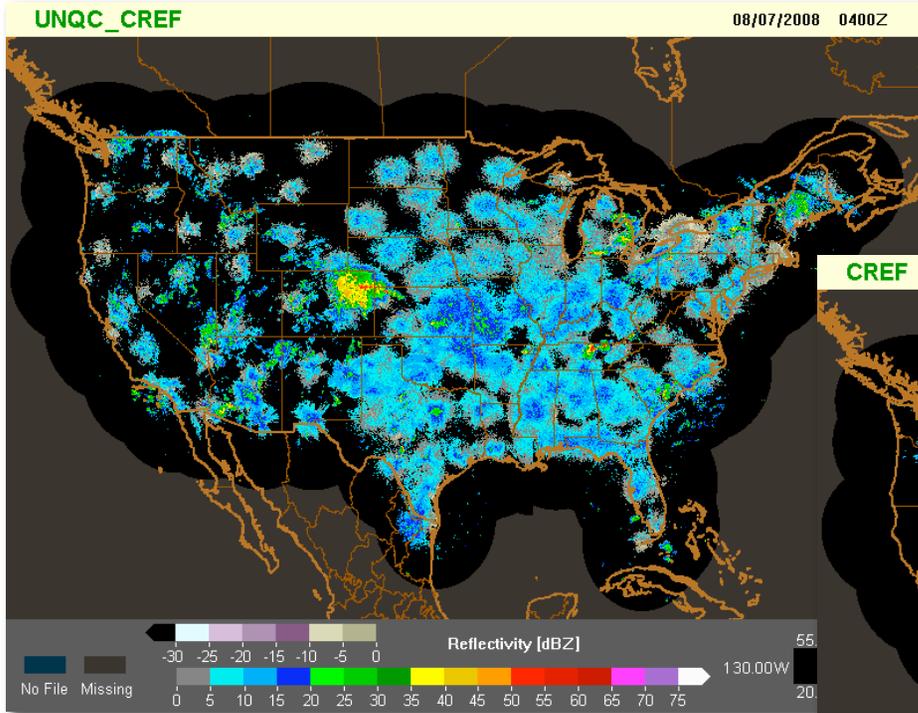
<http://nmq.ou.edu>

# Q2 Domain

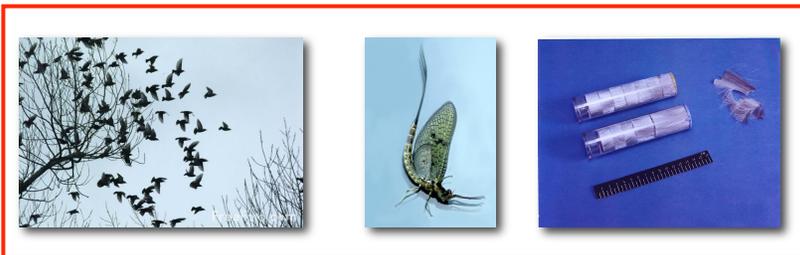
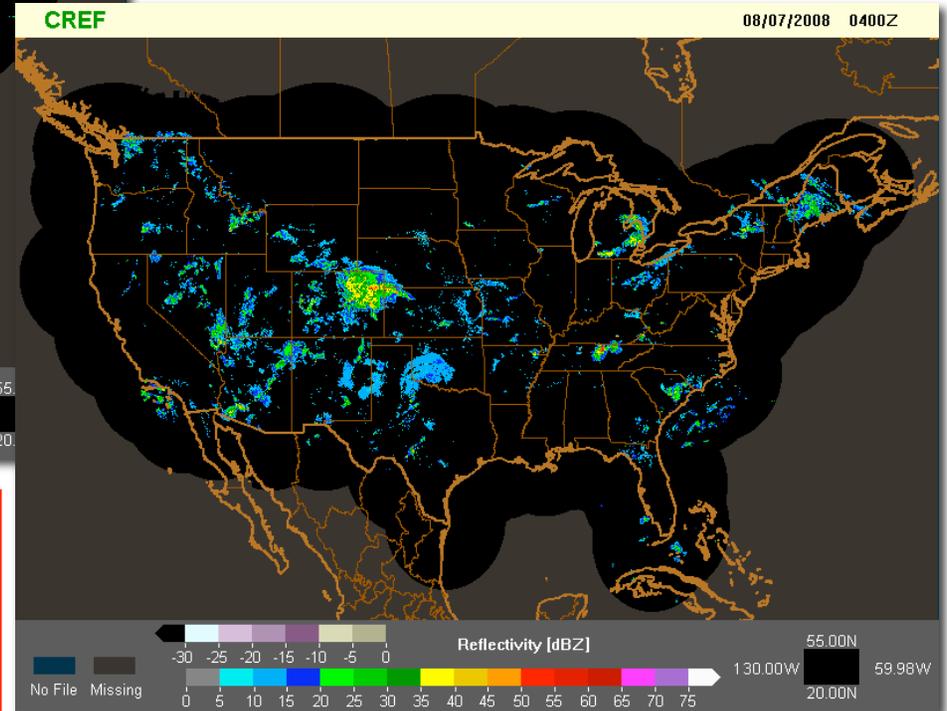


~140 WSR-88D, 31 Canadian, 2 TDWR, 1 TV station radar

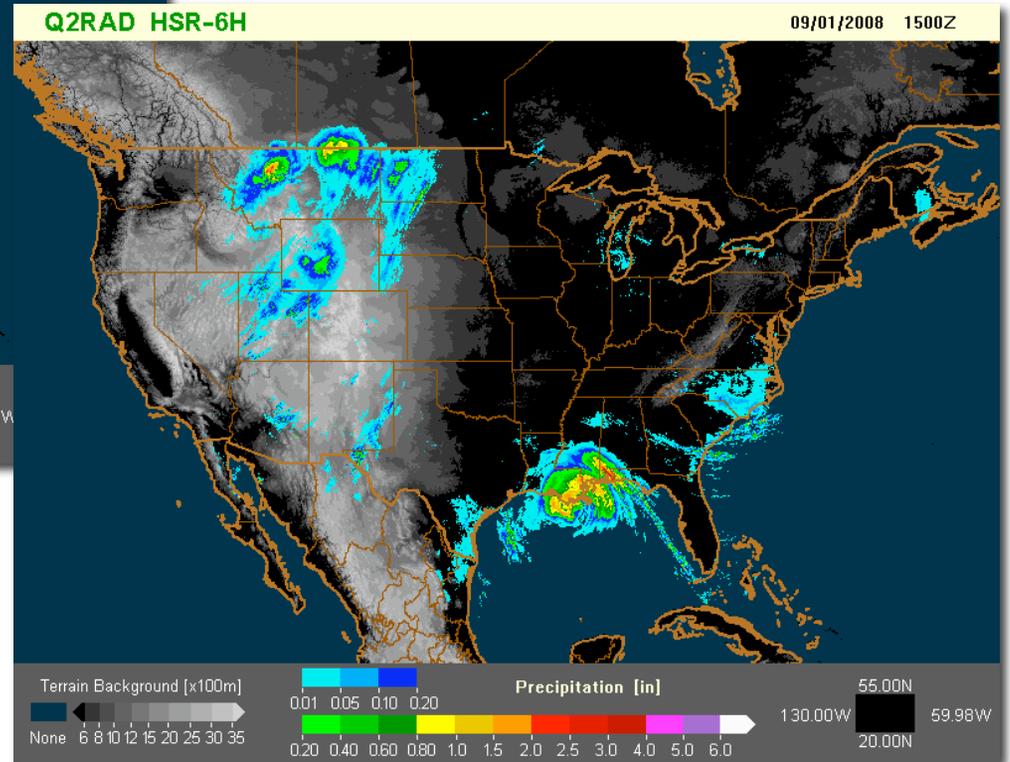
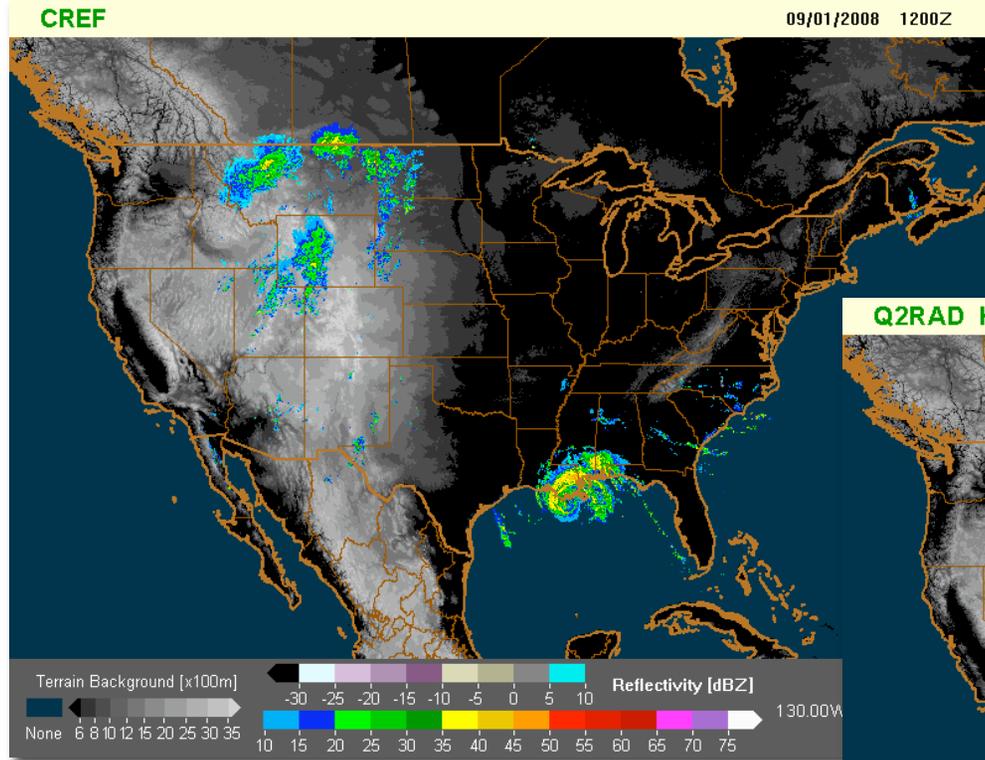
# Bugs, birds and all that glitters....



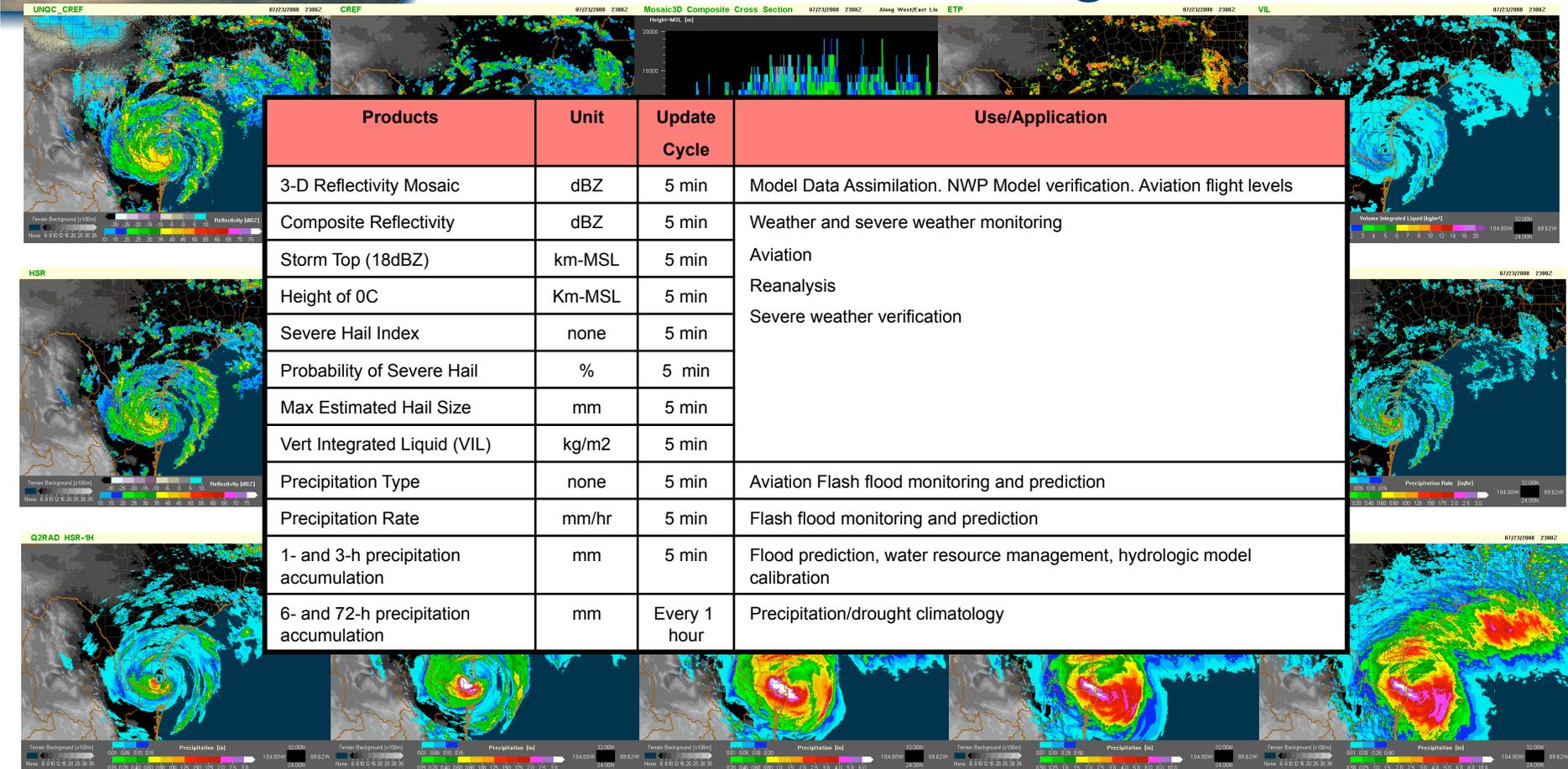
*Nearly 60% of our Q2 basic research and development has been focused on issues related to quality control.*



# Q2 National Mosaic & QPE

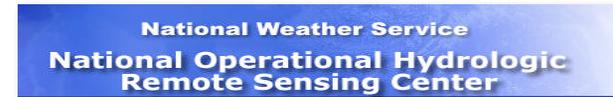
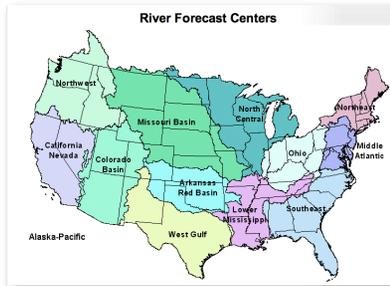


# Q2 Precipitation & Diagnostic Grids

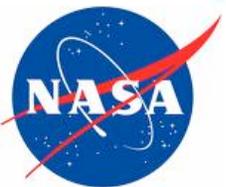


NSSL produces and disseminates a suite of high resolution grids depicting the type and amount of precipitation reaching the earth's surface over North America (**1-km, 5-minutes**)

# Q2 Collaborators



Environment Canada / Environnement Canada

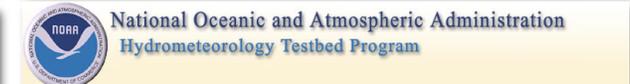


**Q2  
Precipitation  
Products  
And  
Diagnostics**



Salt River Project

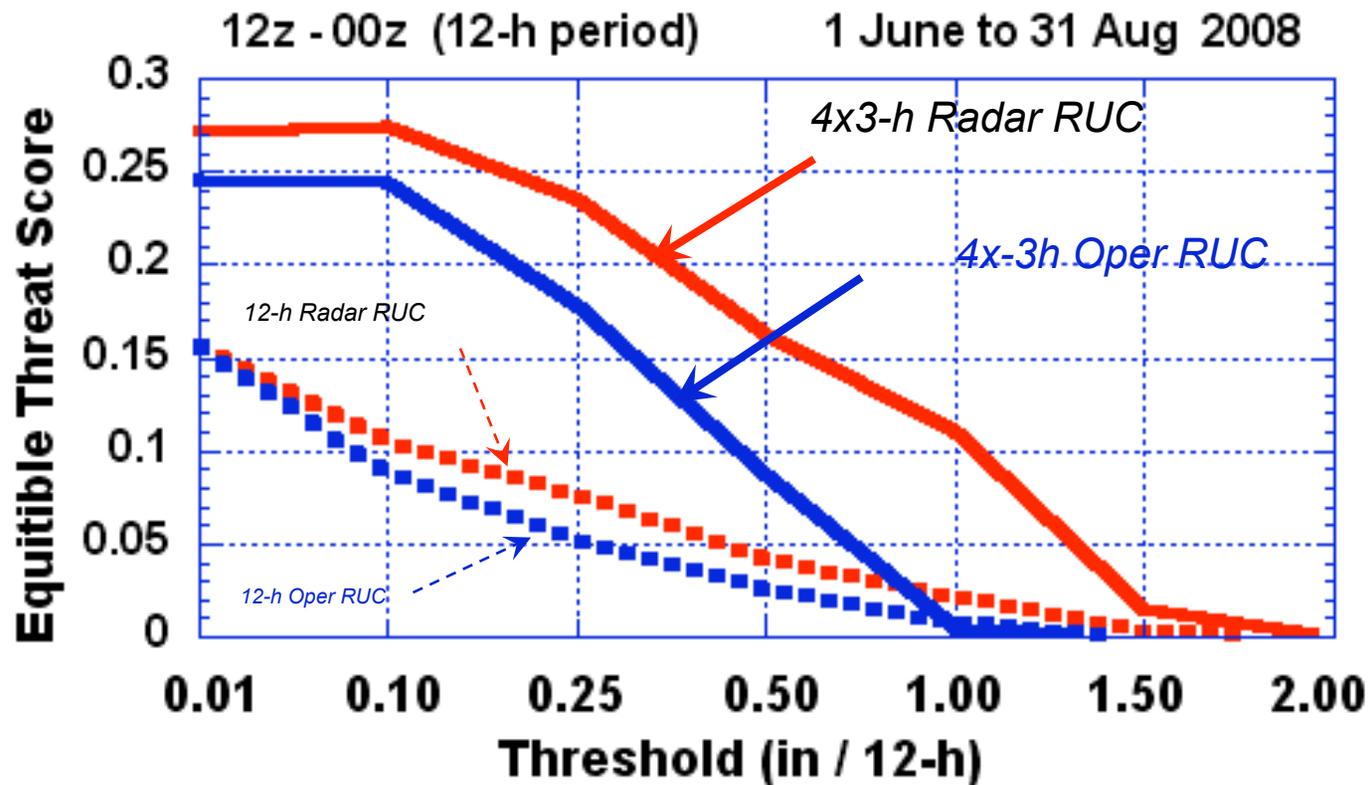
Stand Alone Q2 System



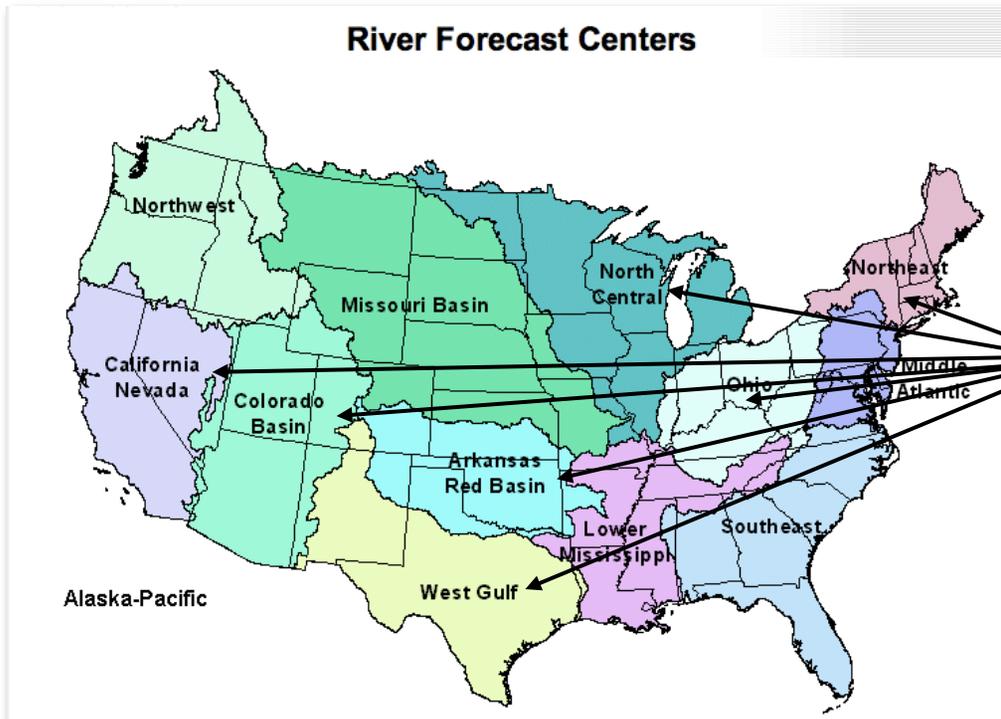
# National Radar Mosaic

## *Operational Impact*

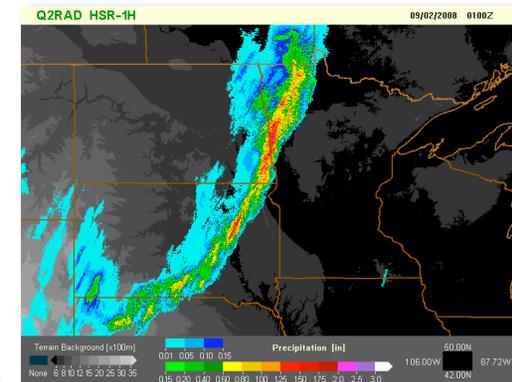
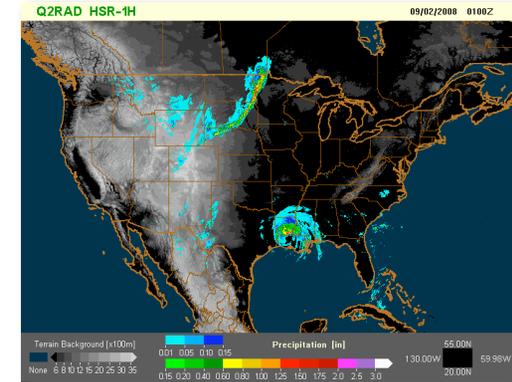
Courtesy Weygandt et al. 2009



# Interactions with River Forecast Centers



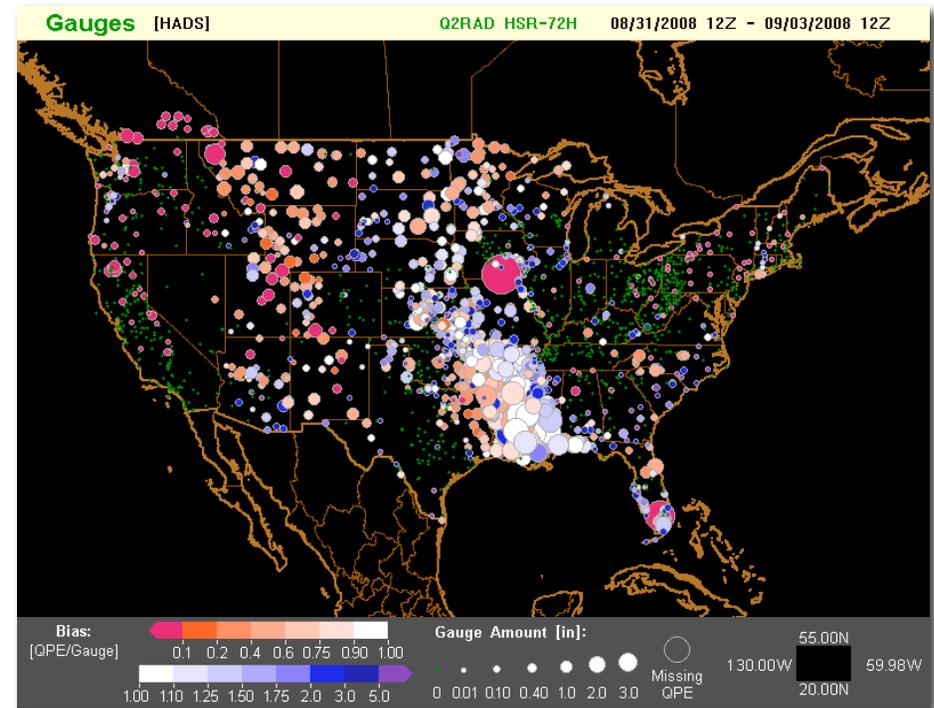
NSSL



```
> From: Thomas Adams <Thomas.Adams@noaa.gov>
> Date: Fri, 11 Apr 2008 11:21:07 -0400
> To: steven vasiloff <Steven.Vasiloff@noaa.gov>
> Cc: Kenneth Howard <Kenneth.Howard@noaa.gov>, Jian Zhang
> <Jian.Zhang@noaa.gov>, Carrie Langston <Carrie.Langston@noaa.gov>, James Noel
> <James.Noel@noaa.gov>
> Subject: Re: Recent Rainfall Event for MPE and Q2
>
> Steve,
>
> We clearly see those Q2 benefits and we are integrating the use of the
> Q2 estimates into our operational MPE now. What we are doing is
```

NSSL researchers receive feed back, comments and ideas from the operational personal, private sector and other researchers to improve the quality and accuracy of the precipitation estimates.

# Verification

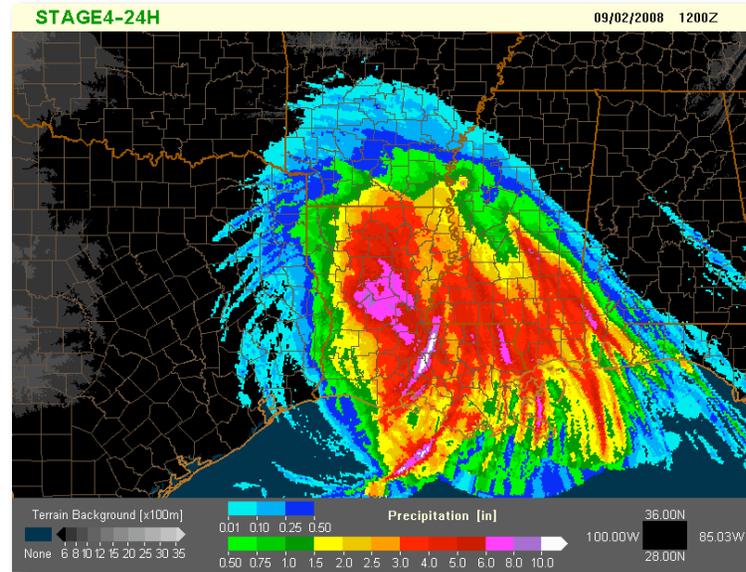
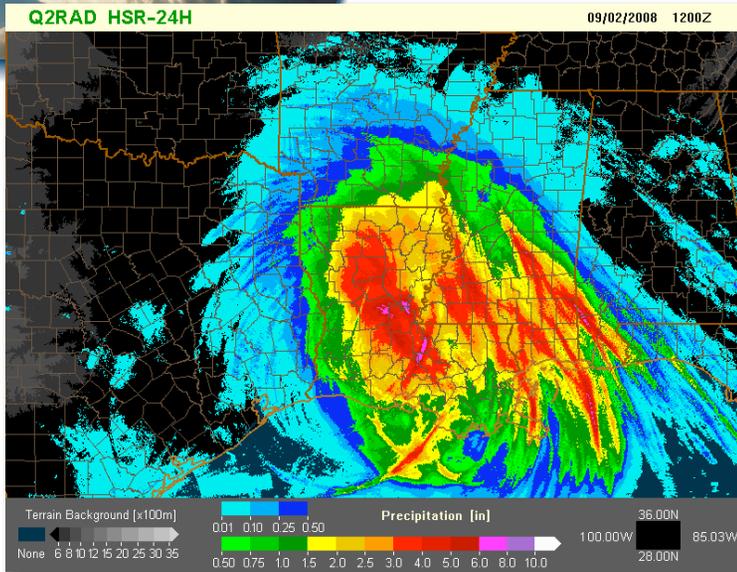


Loop

NSSL researchers and collaborators can assess and compare the quality of the precipitation estimates using a spectrum of independent observing networks and techniques.

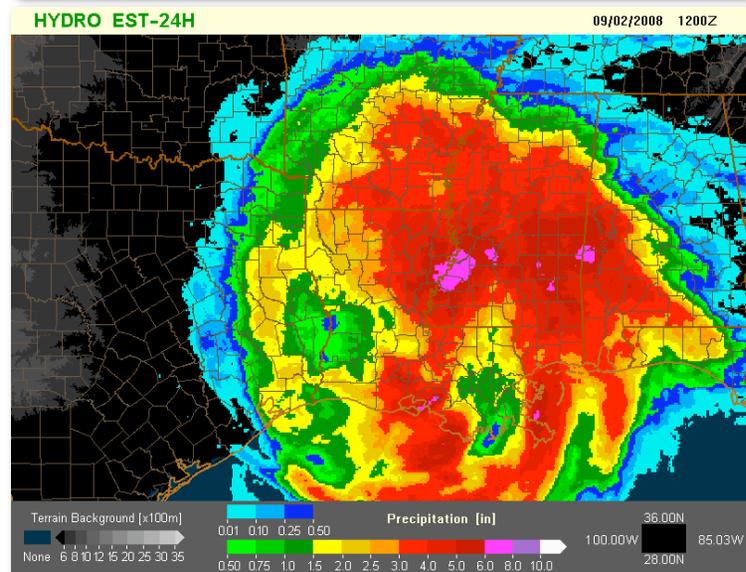
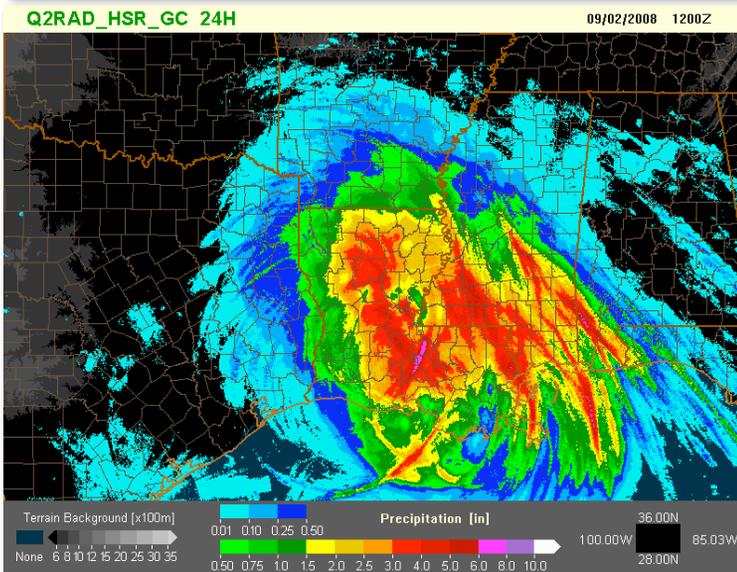
# Verification

Q2  
Radar  
Only



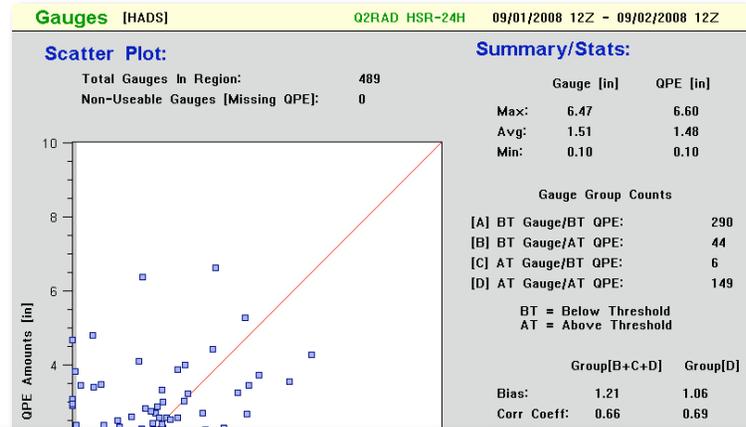
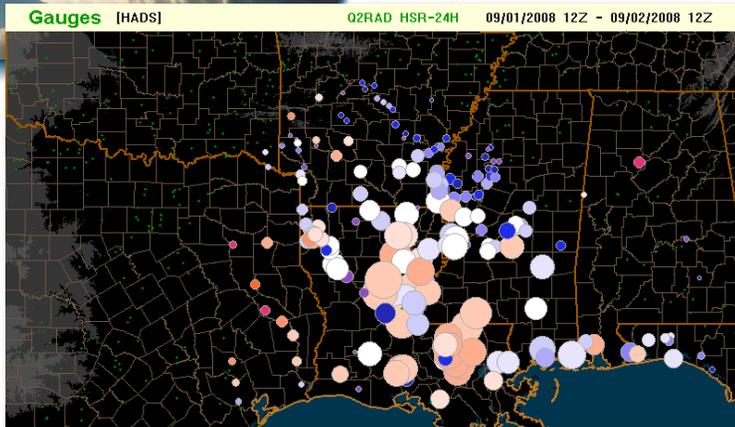
NWS  
RFC  
Stage 4

Q2  
Gauge  
Correct

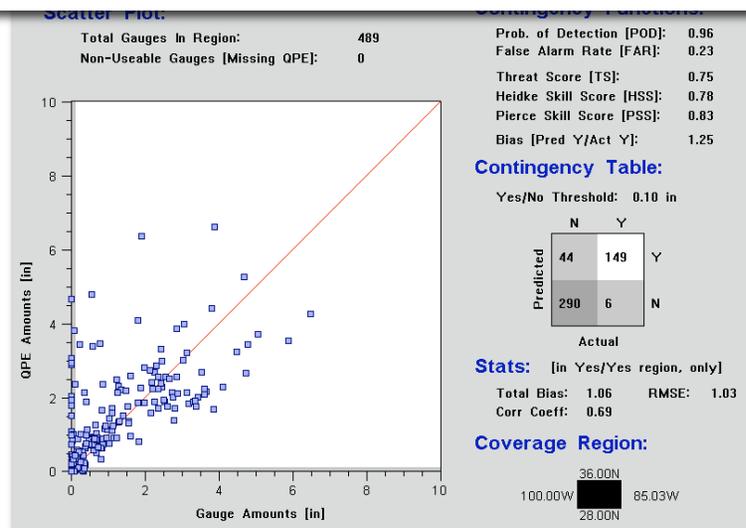
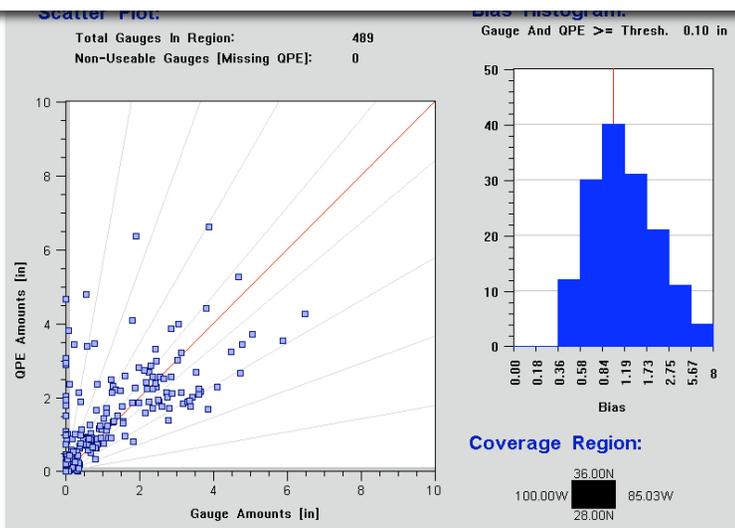


NESDIS  
HydroEst

# Verification



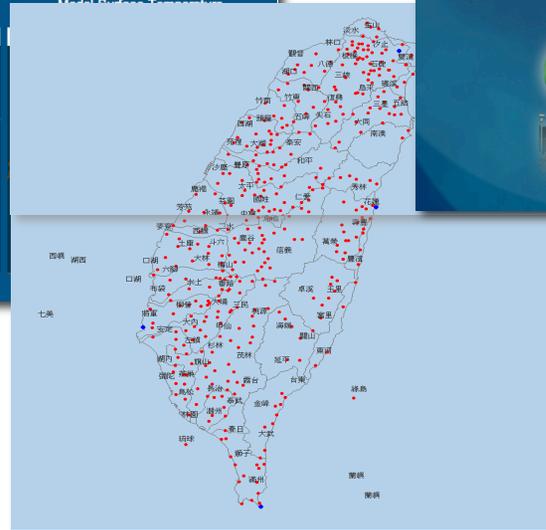
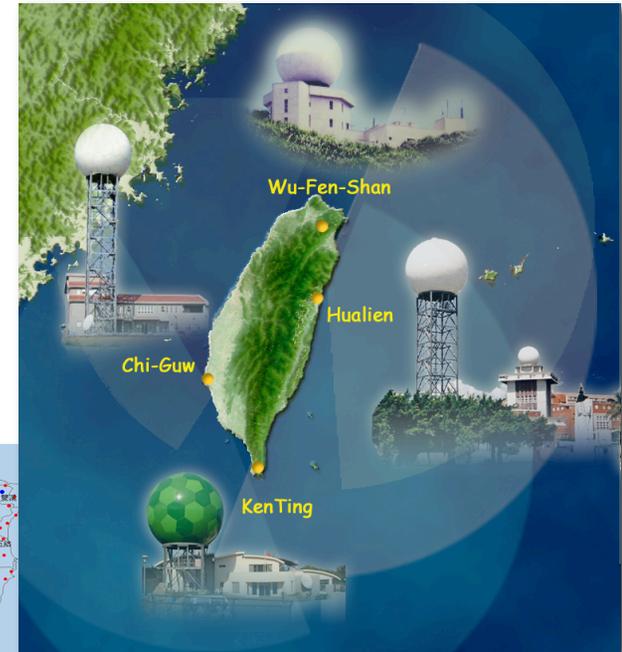
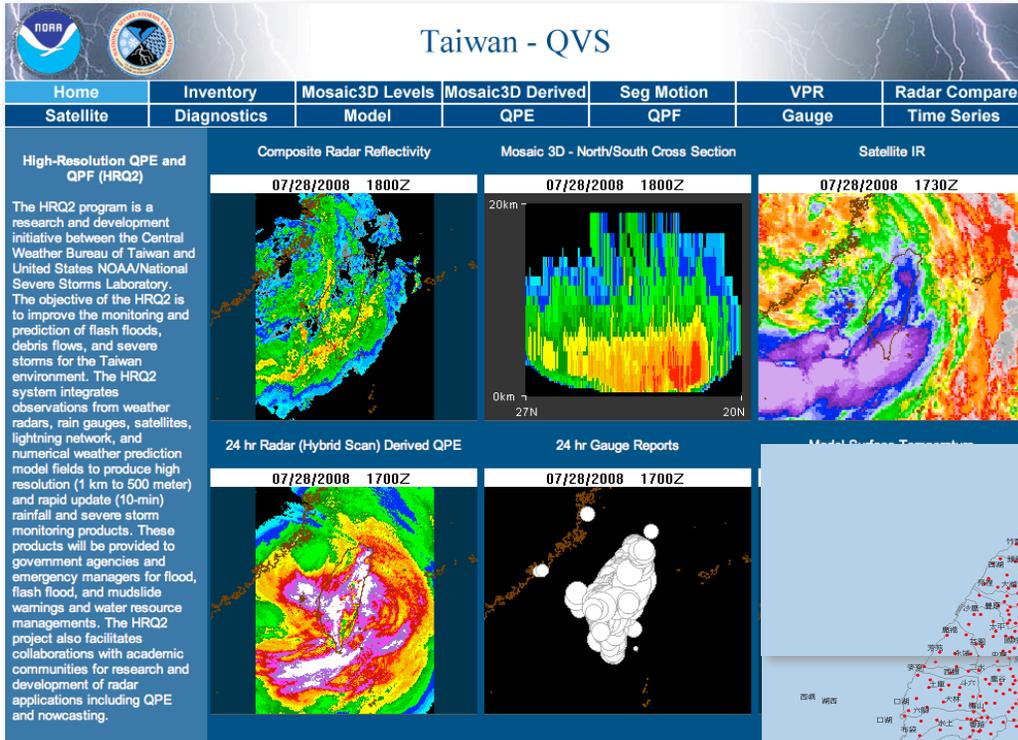
On a daily basis we verify 7600+ Q2/gauge pairs



# International Collaborations



Central Weather Bureau  
Taipei, Taiwan



**471 Gauges**  
**10 Minutes**

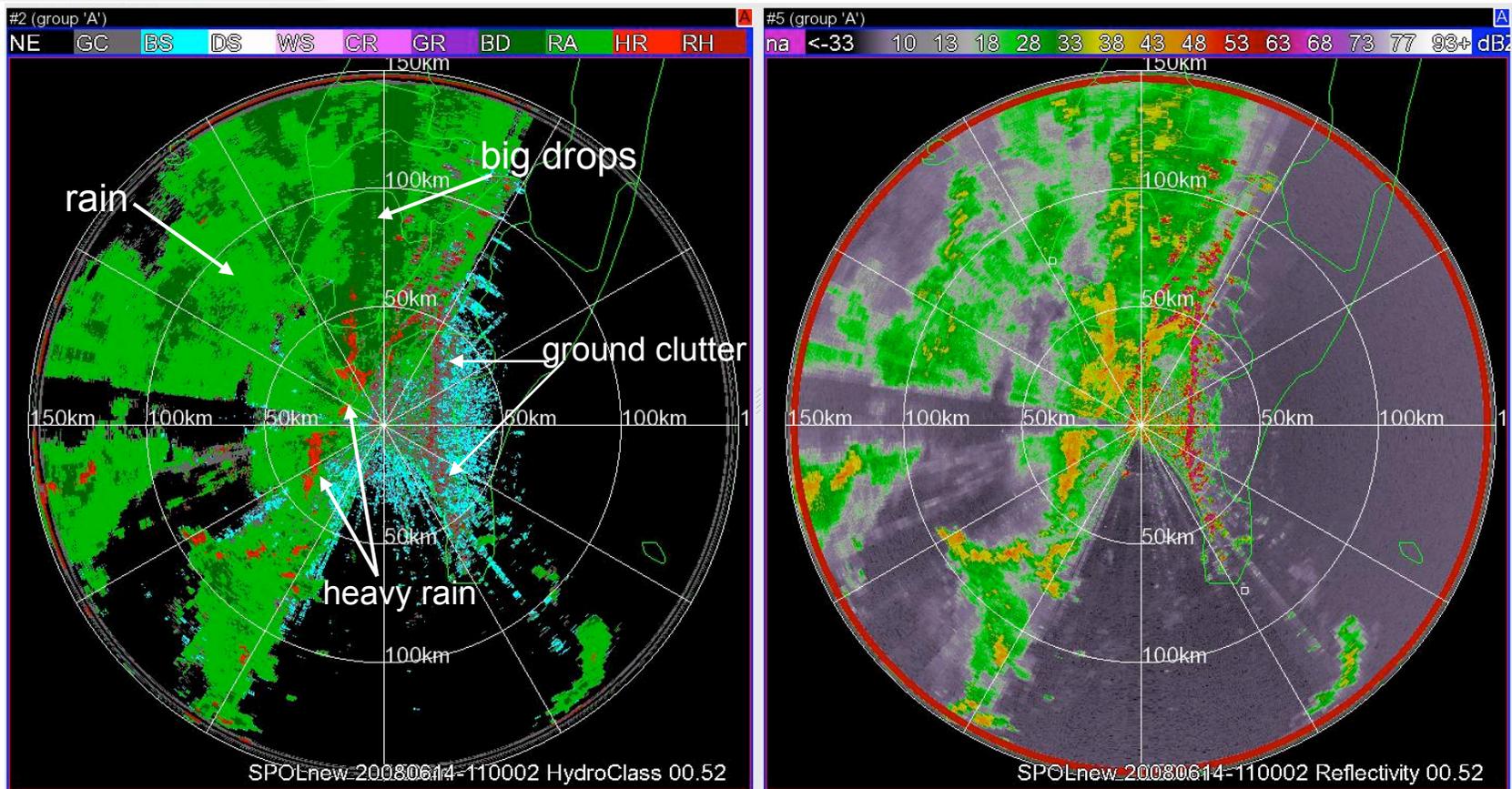
High Quality

Taiwan warm season hydrometeorological challenges are possibly the most difficult in the world.



# Hydrometeor Classification Results

(20080614 1100 UTC)



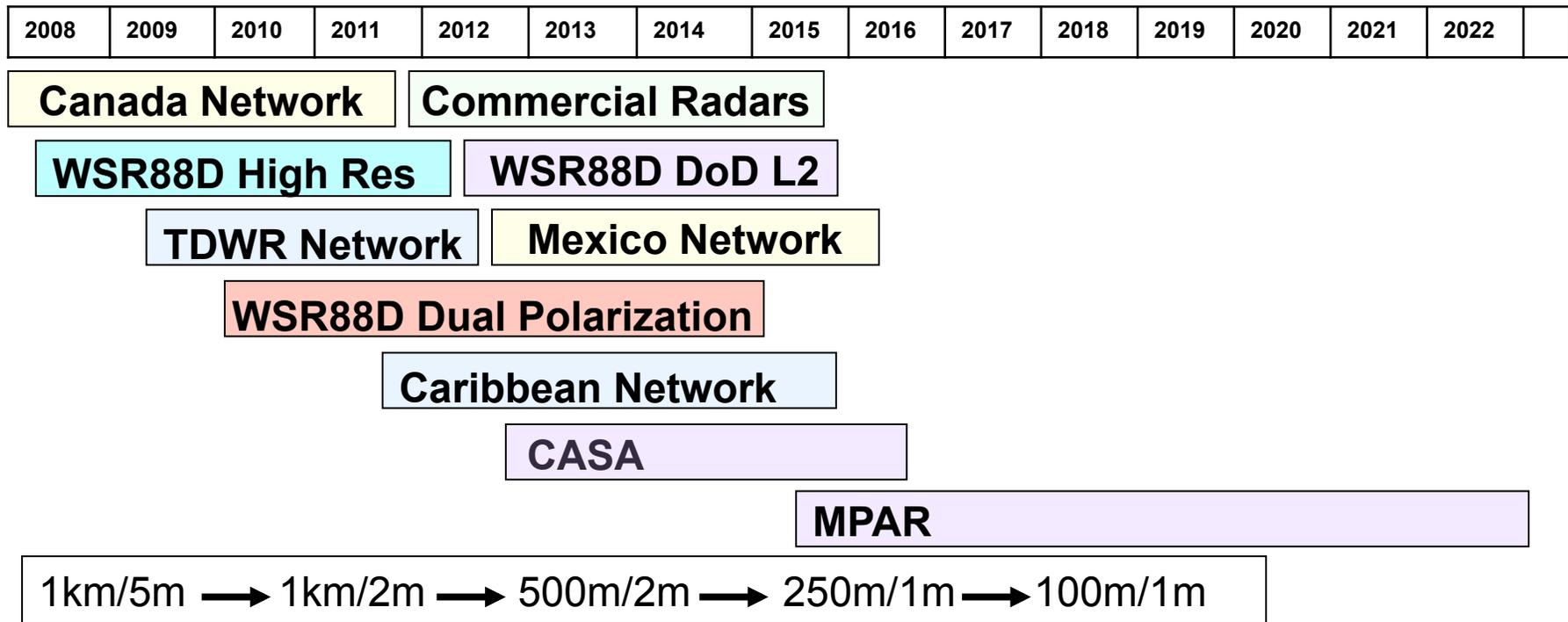
GC: Ground Clutter  
 BS: Biologic Scatterers  
 DS: Dry Snow  
 WS: Wet Snow

CR: Crystals  
 GR: Graupals  
 BD: Big Drops  
 RA: Rain

HR: Heavy Rain  
 RH: Rain/Hail

# Q2 Future Research Activities

## Seamless Integration of Radar Advances, Systems, and Networks



## North America Resolution and Refresh Rate



# Q2 Future Research Activities

## **Q2 system and/or components infusion into NWS operations**

Integration of dual polarization moments and techniques into the Q2 framework

- enhance quality control
- enhance QPE performance

Seamless integration of radar systems and radar networks - forward compatibility

Higher resolution in both space and time to address the urban flash floods

**Q2 as a national hydromet testbed for 'real time' hydromet technique development and product evaluation**