



Enhanced Multisensor Precipitation Estimator and Nowcaster

Improving WFO Flash Flood Services

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NWS Office of Science and Technology Seminar Series

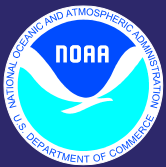
April 5, 2006



The *Current* Multisensor Precipitation Estimator (MPE)

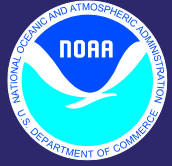
- An automated & interactive algorithm that estimates **one-hour rainfall ending at the top of the hour on a ~4-km HRAP grid** using WSR-88D Precip. Processing System's (PPS) Digital Precipitation Array (DPA) products
- **Multisensor**...uses rain gauges and GOES satellite to reduce existing biases in WSR-88D rainfall estimates and produces a suite of radar-gauge-satellite rainfall products
- Produces **regional mosaics** from any desired number of WSR-88Ds

For more details, see the Lab's MPE Training Workshop at <http://www.nws.noaa.gov/oh/hrl/papers/papers.htm#wsr88d>



The *Current* Multisensor Precipitation Estimator (MPE) (cont.)

- **Delivered in AWIPS to RFCs in 2002, WFOs in 2004, to replace and improve upon the existing Stages II & III Precipitation Processing algorithms**
- **Designed primarily for RFC use**
- **Primary input to RFC and WFO hydrologic forecast models (NWS River Fcst System NWSRFS and Site Specific Hydr. Predictor SSHP ... but not Flash Flood Monitoring & Prediction FFMP)**



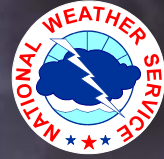
MPE Product Suite



- **Radar-only rain mosaic**
- **Gauge-only rain mosaic**
- **Satellite-only rain mosaic (from NESDIS)**
- **Mean field bias-adjusted radar rain mosaic using rain gauges**
- **Local bias-adjusted radar rain mosaic using rain gauges (two different methods)**
- **Multisensor merged radar+gauge mosaic**
- **Multisensor merged radar+gauge+satellite mosaic (coming soon)**



WFO vs. RFC Requirements for Precipitation Products



RFC

- Mainstem river forecasting
- 4 km resolution (HRAP)
- 1 hour updates of hourly rain
- Multisensor mosaics of rainfall accumulation
- Routine manual quality control is modus operandi
- MPE products

WFO

- Flash flood monitoring & warning
- 1 km resolution (1/4 HRAP)
- 5-15 minute updates of sub-hourly and longer rain
- Multisensor mosaics of rainfall and rain rates
- Routine manual quality control may not be feasible
- **Enhanced MPE (EMPE) products**
- **Multisensor Precipitation Nowcaster (MPN) products**

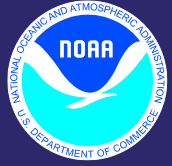


Enhanced MPE (EMPE) is an Experimental Prototype with New Features for WFOs



Same multisensor rainfall estimation technology & products as in MPE, but with ...

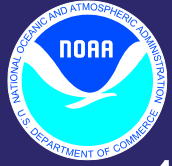
- **Higher spatial resolution – ¼ HRAP (~1 km)**
 - *vs. 1 HRAP (~4 km) in current MPE*
- **Higher temporal rainfall resolution – 5-15+ minute rainfall duration**
 - *vs. one hour in current MPE*
- **More frequent updates - 5-15 minutes**
 - *vs. once per hour at top of hour in current MPE*
- **Greater flexibility**
 - *User configurable and “backward compatible”*



History & Status of EMPE



- Initial need identified and AHPS EMPE funding proposal written by Fulton in 2002 and funded FY 2003-2006
- Project plan developed and distributed for review in 2002
- Initial EMPE prototype was completed in 2004 by HSMB's Hydrometeorology Group (F. Ding, S. Guan, R. Fulton)
- In 2004, we set up a real-time 24x7 demonstration in HL for 5 WSR-88Ds in mid-Atlantic region (Sterling KLWX, Pittsburgh KPBZ, Charleston KRLX, Blacksburg KFCX, Wakefield KAKQ)
 - *Web page displays real-time graphical output products*
- EMPE project is in OSIP Stage 2



Radar-only 15-min. Rainfall Mosaic

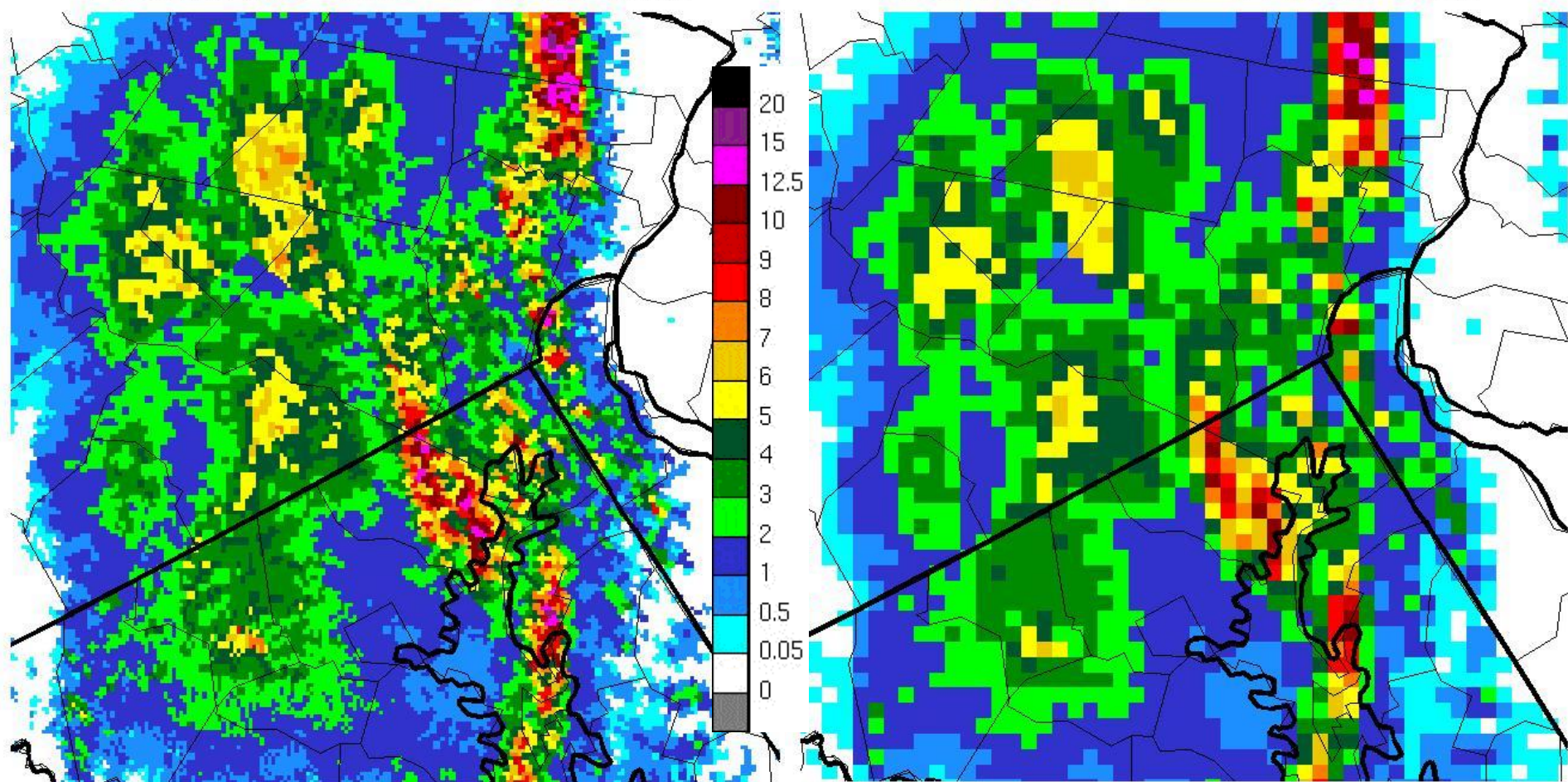


1-km grid (EMPE)

4-km grid (MPE)

RMOSAIC (mm) 15min 12/17/2000 10:45Z

RMOSAIC (mm) 15min 12/17/2000 10:45Z

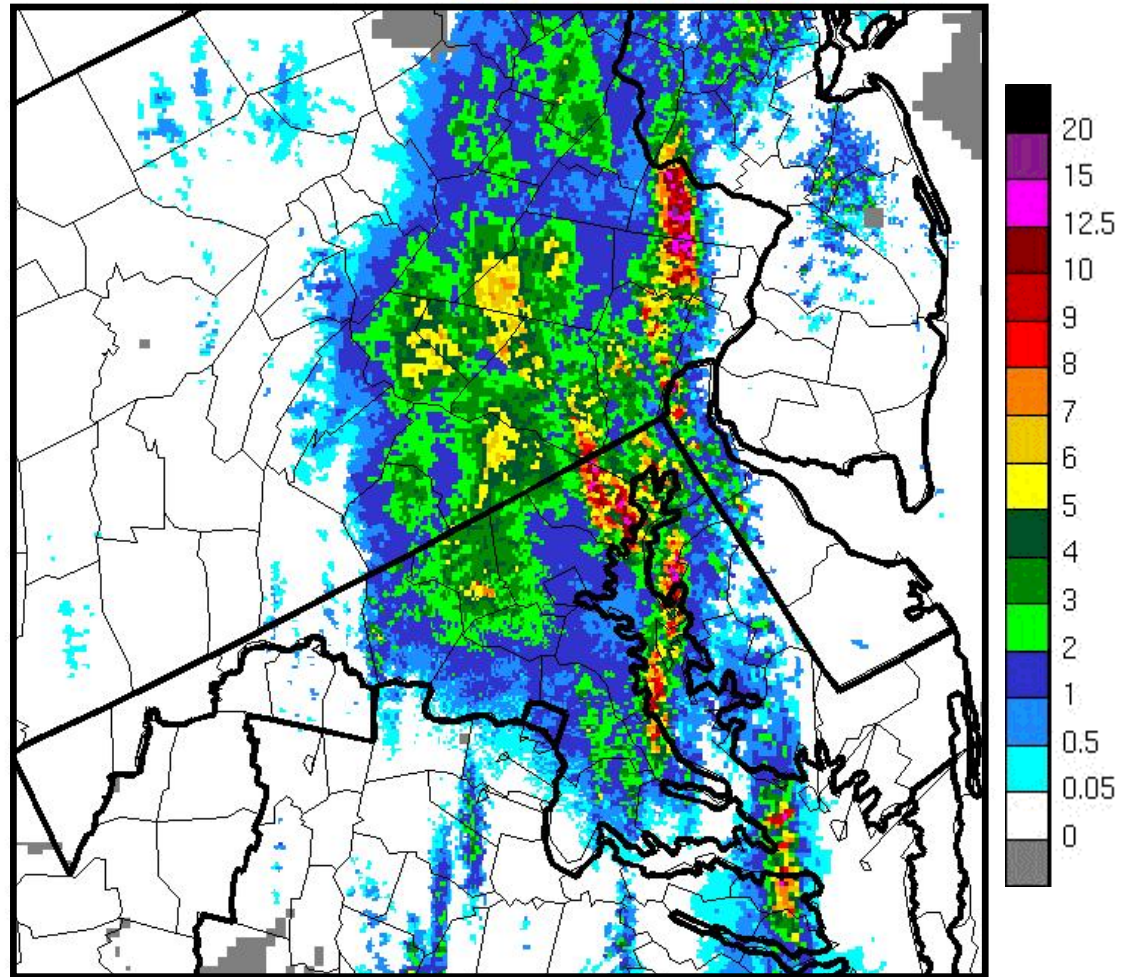




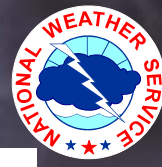
1-km Radar-only 15-min. Rainfall Mosaic



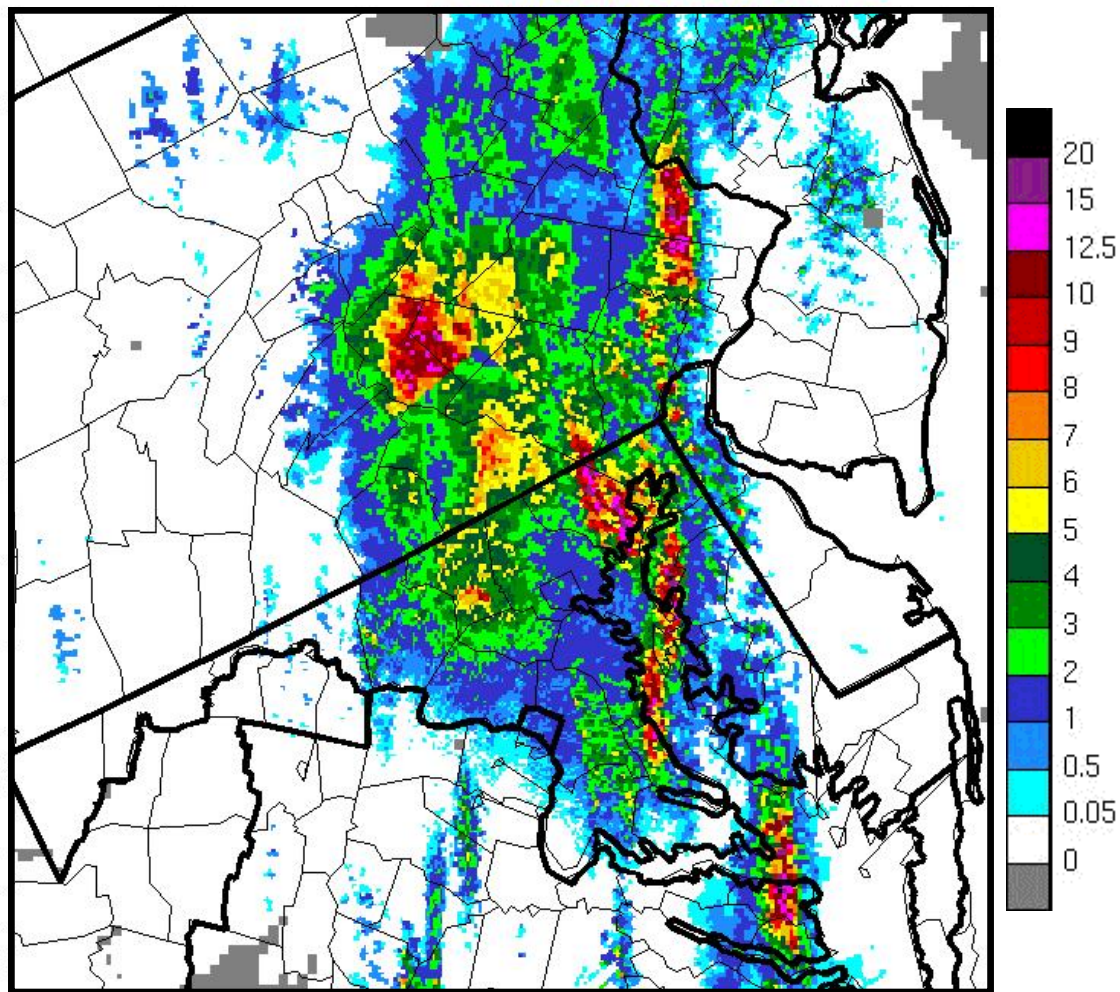
RMOSAIC (mm) 15min 12/17/2000 10:45Z

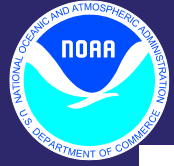


1-km Mean field bias-adjusted Radar 15-min. Rainfall Mosaic



BMOSAIC (mm) 15min 12/17/2000 10:45Z

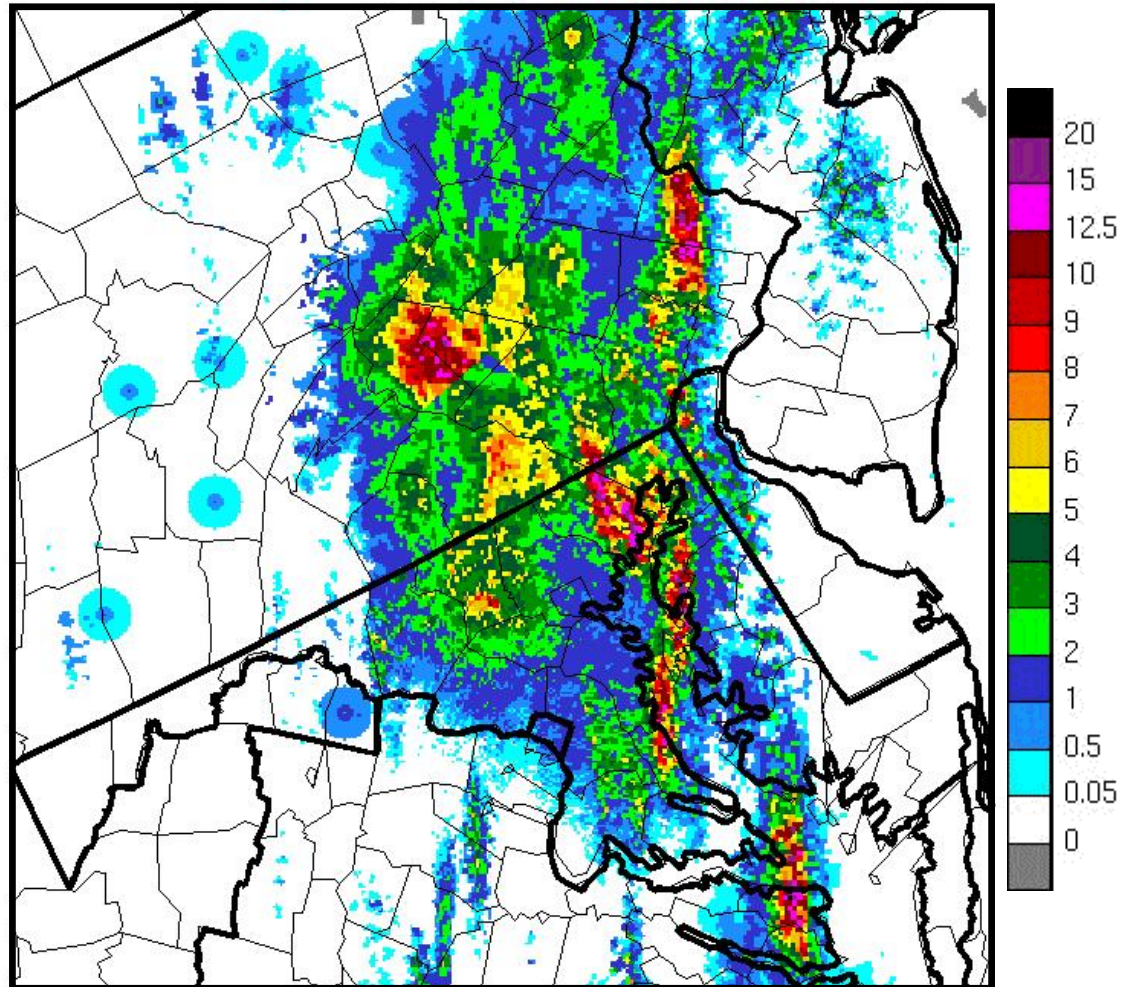


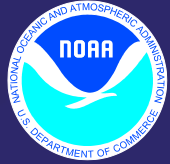


1-km Multisensor 15-min. Rainfall Mosaic



MMOSAIC (mm) 15min 12/17/2000 10:45Z





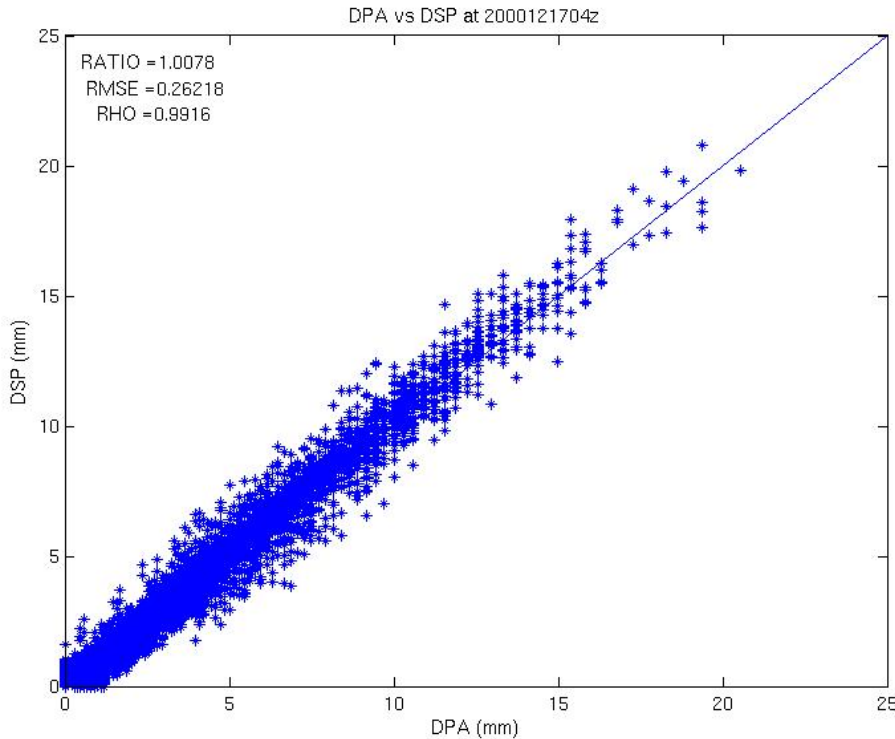
EMPE Details



- Uses PPS's **Digital Storm-total Precipitation (DSP)** products from multiple radars covering CWA as input
 - *Cumulative rainfall updated every volume scan (~ 5 minutes)*
 - *1 deg x 2 km (higher resolution than 4-km DPA)*
 - 1 deg x 1 km in future (existing HOSIP project)
 - *Digital 256-level equivalent to the Storm Total Precip (STP) 16-level graphical product*
- Differencing of DSPs produces rainfall durations of any arbitrary duration (5 min. to 24+ hours)
 - *DPA's cannot provide durations other than whole 1, 2, 3, ... hrs.*
- Demonstrated ability of differenced DSPs to replicate DPA hourly rainfall on HRAP grid
- Also uses PPS's **Digital Hybrid Scan Reflectivity (DHR)** products to compute instantaneous rain rates
- Both are remapped and mosaicked onto $\frac{1}{4}$ HRAP grid (~1 km)

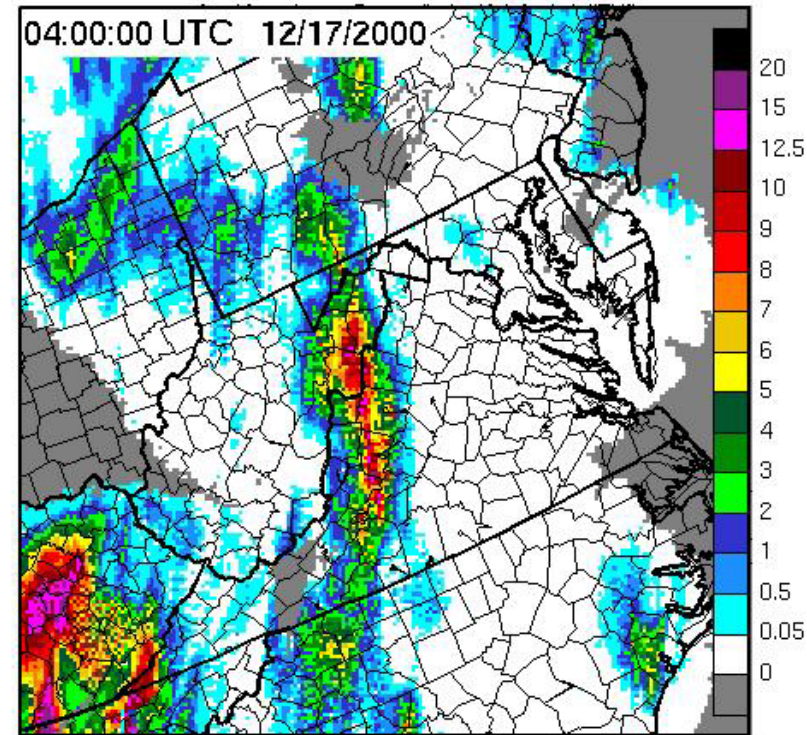


Hourly Rainfall from DPAs and Differenced DSPs Matches Well



One-hour rainfall for mid-Atlantic regional mosaic on 4-km HRAP grid

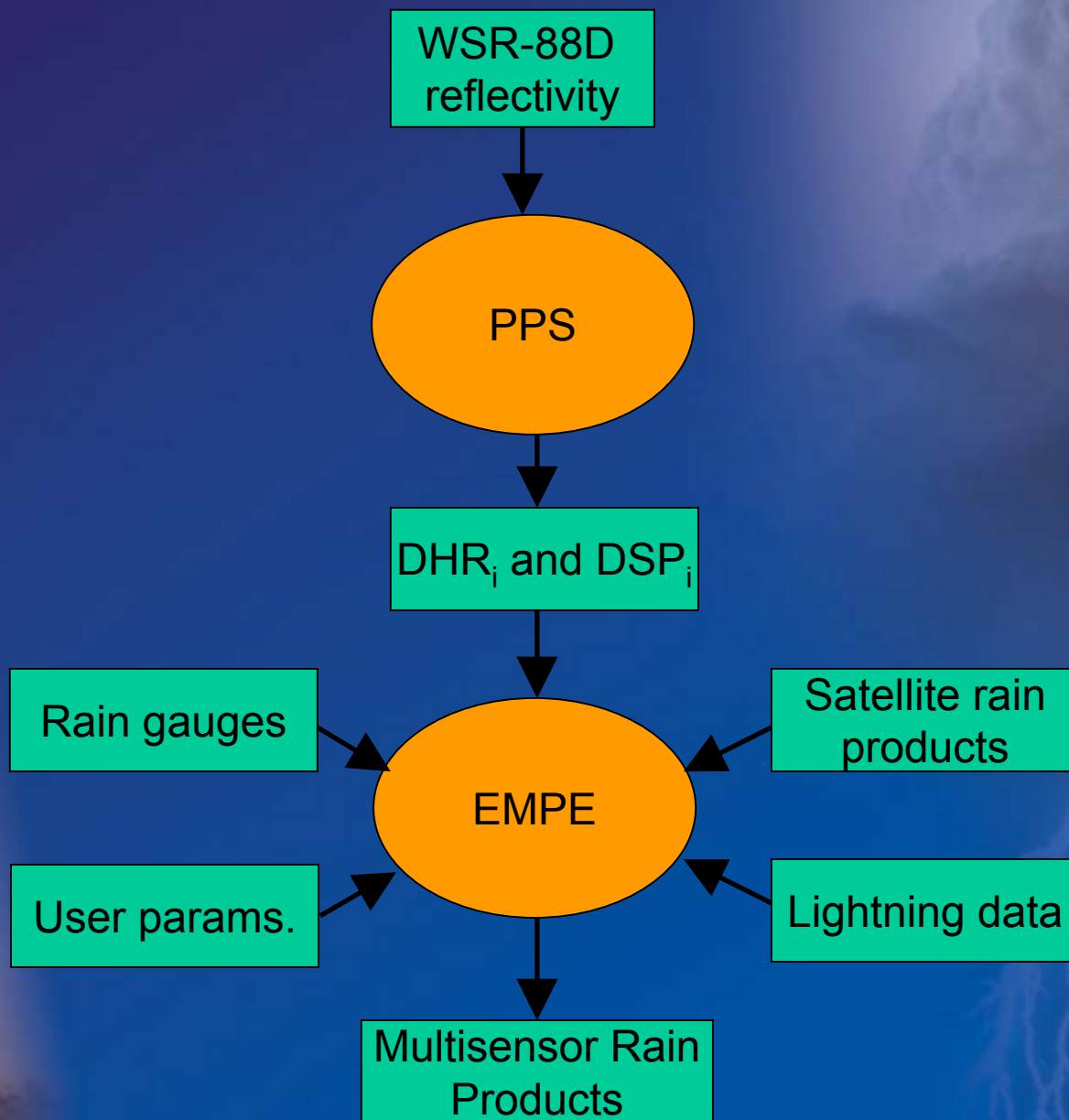
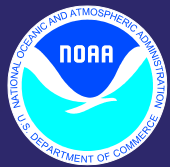
1-HR OBSERVED RAINFALL (mm)



Random differences may be due to:

- 1) Slight differences in polar-to-HRAP remapping software between PPS and EMPE
- 2) Temporal interpolation

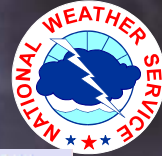
EMPE Data Flow





Real-time Web Page

http://www.nws.noaa.gov/ohd/hrl/hag/empe_mpn/



NOAA's National Weather Service
 Multisensor Precipitation Estimation and Nowcasting for Flash Floods
 Experimental Real-Time Images

Site Map News Organization Search

Algorithm and Product Description

- EMPE Observations**
 - 1 km MFB Rainrate Loop
 - 15-min 1 km Rad Rain Loop
 - 15-min 1 km MFB Rain Loop
 - 15-min 1 km MS Rain Loop
 - 1-hr Radar Rain Loop
 - 12-hr Radar Rain Loop
- MPN**
 - Storm Motion Loop
 - Storm-Relative Motion Loop
 - Storm Growth/Decay Loop
 - Prob. FFG Exceedence Loop
 - Critical Rainfall Prob. Loop
 - 1-hr FFG Loop
 - 3-hr FFG Loop
 - 6-hr FFG Loop
- 1 Hour Forecasts**
 - Rainrate Loop
 - 1-hr Rainfall Loop
 - Prob. FFG Exceedence Loop
 - Critical Rainfall Prob. Loop
- Forecast Verification**
 - Rainrate Loop
 - 1-hr Rainfall Loop

Multisensor Precipitation Estimation and Nowcasting for Flash Floods

A Radar Nowcasting Demonstration Project
 to Improve Flash Flood Forecast and Warning Services
 of the National Weather Service

Introduction

Quantitative precipitation estimation and nowcasting are important components of National Weather Service (NWS) flash flood warning services. They refer to the estimation of rainfall up to the current time using multiple sensors (WSR-88D, rain gauges, satellite data). It is in this new era of data that the current observed forecast skill than lesser precipitation

Sample EMPE products

The Enhanced Multisensor Precipitation Estimator (E-MPE) is a new prototype algorithm developed by the Hydrology Laboratory (HL) based on the existing operational Multisensor Precipitation Estimator (MPE) that is running at most River Forecast Centers and Weather Forecast Offices. However it has the advantage of higher spatial and temporal resolution than the current MPE, a factor that is necessary if the products are to be useful for flash flood monitoring and warning purposes. Instead of one-hour multisensor rainfall estimates at a nominal 4-km (HRAP) grid scale with updates once per hour as with the current MPE, the E-MPE is more flexible and generates multi-duration rainfall products on a 1-km grid (1/4th HRAP) with updates as often as every 5-15 minutes based on what the user chooses. Details of the current MPE algorithm can be found under the "MPE Training Workshop" link at <http://www.nws.noaa.gov/oh/hrl/papers/papers.htm#wsr88d>.

The Multisensor Precipitation Nowcaster (MPN) algorithm is a prototype rainfall nowcasting algorithm that produces regional, gridded, one-hour rainfall nowcasts using input data generated by the E-MPE. The MPN is an enhancement of the Flash Flood Potential (FFP) algorithm, also developed at the HL, that uses current and recent-past WSR-88D radar data to estimate the future location of storms, their associated rainfall, and flash flood threat up to one hour into the future.

These E-MPE and MPN products can be used as input to distributed hydrologic forecast models or other flash flood monitoring tools at the Weather Forecast Offices. Short-term rainfall nowcasts can provide forecasters with additional



EMPE User Configuration

Vision is One Configurable EMPE
that Serves both WFOs and RFCs

- Choose desired spatial grid resolution
 - $\frac{1}{4}$ HRAP or 1 HRAP
- Choose desired rainfall durations
 - Rainrates, 15 min., 30 min., 1 hr., etc. rainfall durations
- Choose desired run-time delay (~minutes)
 - May depend on each product
 - Gauge-adjusted products may need longer time delays
- Choose a product generation schedule that satisfies your requirements...



EMPE User Configuration (cont.)



A Sample Product Generation Schedule

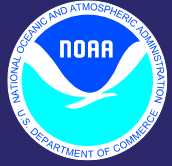
Time (min.)	EMPE Products				
	Rain Rate (mm/hr)	RMOSAIC 15 min (mm)	BMOSAIC 30 min (mm)	BMOSAIC 60 min (mm)	MMOSAIC 60 min (mm)
H+0	✓	✓	✓	✓ ✓	✓
H+5	✓				
H+10	✓				
H+15	✓	✓			
...	✓				
H+30	✓	✓	✓		
...	✓				
H+45	✓	✓			
...	✓				
H+55	✓				

Etc.

RMOSAIC: Radar Mosaic

BMOSAIC: Bias-adjusted Radar

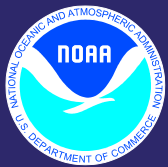
MMOSAIC: Multisensor Mosaic



EMPE Considerations

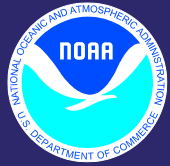


- **Increased CPU, memory, disk space, and communication bandwidth requirements**
- **Digital Storm-total Precipitation (DSP) product issues**
 - ***Wide area distribution is necessary from multiple non-associated radars for mosaicking (DHR also)***
 - **Revising an existing WSR-88D Request for Change (RC)**
 - ***Don't apply G-R bias to DSP***
 - **PPS code needs to be revised; RC was submitted in Feb.**
- **Rain gauge issues**
 - ***Rain gauge data is a double-edged sword that requires QC before use***
 - ***WFOs often don't have resources to do real-time manual gauge QC as at RFCs***
 - ***Automated quality control methods are critical***
 - ***Anticipated use of RFC QC'ed precipitation analyses for previous 1-6 hours***



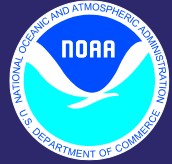
EMPE will be Integrated within NWS Hydrologic Operations

- **On-going science infusion in PPS will be reflected in downstream EMPE products (e.g., Range Correction Algorithm RCA, rainrate-dependent bias adjustment, dual polarization)**
- **Science infusion in MPE is on-going (e.g., probabilistic QPE, satellite QPE)**
- **Provides all necessary input to drive the Multisensor Precipitation Nowcaster**
- **Enables/enhances high resolution distributed hydrologic forecast modeling and other flash flood tools (distributed hydrologic forecast models, FFMP, flood inundation mapping)**



Types of Radar QPE Adjustments

- **Adjustments using radar data**
 - ***Range-related biases***
 - Experimental Range Correction Algorithm (RCA)
 - Beam broadening
 - ***Rain rate-dependent biases***
 - see Probabilistic QPE final report on our web page
- **Adjustments using rain gauges**
 - ***Radar-wide mean field bias (MPE's Bmosaic)***
 - ***Local bias (MPE's Lmosaic, P3)***
 - ***Multisensor merging (MPE's Mmosaic)***
- **Adjustments using satellite QPE**
 - ***Multisensor merging (radar+gauge+satellite; under development for MPE)***



Proposed End-to-End Sequence of Bias Correction Procedures in EMPE/MPN

ORPG

AWIPS

Rainfall

PPS

Radar Total Rain "DSP"

- single radar
- polar grid
- no adjustments

PPS

Range-corrected Radar Total Rain "DSPR"

- apply RCA corrections scan-to-scan in PPS if desired

EMPE

Range-corrected Radar Increm. Rain "RainR_d"

- compute incremental rain for any duration d by differencing

EMPE

Range-corrected Inc. Rain Mosaic "RmosaicR"

- mosaic multi-radars on 1/4th HRAP grid

Rain rates

PPS

Radar Rainrates "DHR"

- single radar
- polar grid
- no adjustments

EMPE

Range-corrected Rainrates "DHRR"

- Apply RCA corrections if desired

EMPE

Range-corrected Rainrate Mosaic "RRmosaicR"

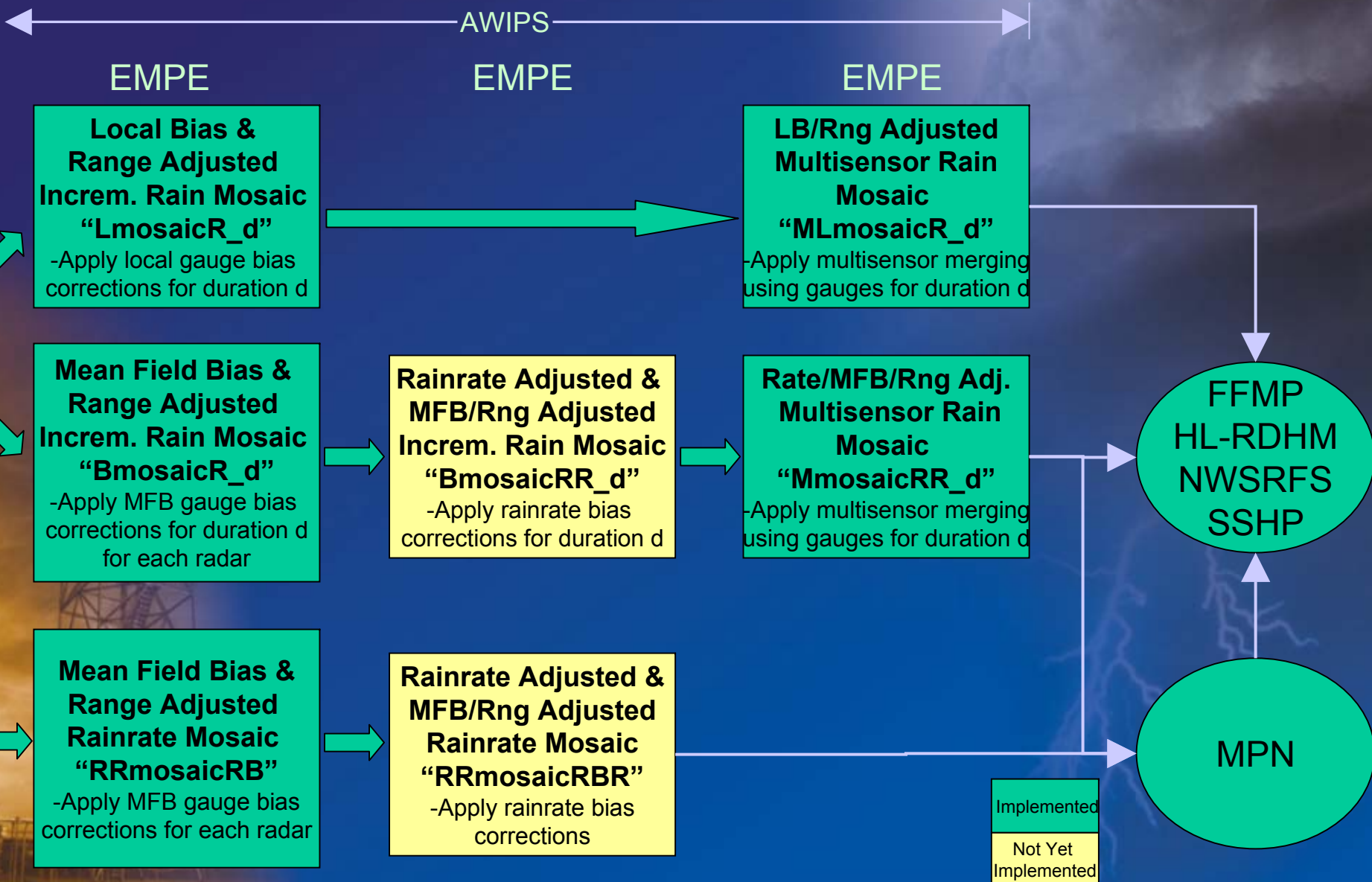
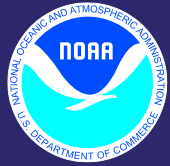
- mosaic multi-radars on 1/4th HRAP grid

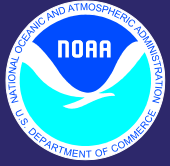
RCA/CSSA

Range Adjustment Factor Array "AFA"

Implemented
Not Yet Implemented

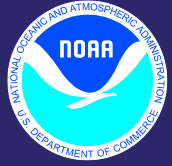
Proposed End-to-End Sequence of Bias Correction Procedures in EMPE/MPN (cont.)





Looking into the Future to Increase Flash Flood Warning Lead Times

- **Rainfall nowcasting:** Extrapolating current (radar) rainfall observations into the very near future (1-3 hours)
 - *Predictability of rain depends on predictability of rainfall system...convective vs. stratiform & seasonal dependence*
- **NWS currently has no rainfall nowcasting capability that is integrated quantitatively within hydrologic fcst operations**
 - *SCAN Categorical QPF algorithm, WSR-88D Storm Cell Identification and Tracking (SCIT) used for visual analysis only*
 - *UK Met Office has been doing this for a while*
- **Even simpler automated nowcast techniques have potential to move us to the next flash flood warning performance level (possibly ~ten minutes vs. current few minutes)**
 - *We can automate and quantify what goes on in a forecaster's head when they view radar loops*



Multisensor Precipitation Nowcaster (MPN)



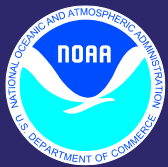
- For Flash Flood Forecasting -

- **Automatically produces deterministic 1-hr rainfall forecasts and flash flood threat probabilities using extrapolation techniques**
- **4-km forecast grids, updated every 5-15 minutes as needed**
- **Multisensor – uses WSR-88D radar with rain gauge-based mean field bias adjustments**
- **Regional – uses mosaicked WSR-88Ds covering the county warning area**
- **Is integrated with EMPE; EMPE produces all necessary input data to drive it**



History and Status of MPN

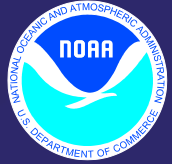
- **MPN is an extension of HL's Flash Flood Potential (FFP) algorithm**
 - *FFP was originally single-radar, single-sensor*
 - *AHPS supported the upgrade to multiradar, multisensor using EMPE product input*
- **Initial AHPS funding proposal for MPN written by Fulton in 2002 and funded FY 2003-2006**
- **Project plan developed and distributed for review in 2002**
- **Initial MPN prototype was completed in 2004 by HSMB's Hydrometeorology Group (S. Guan, F. Ding, R. Fulton)**
- **In 2004, we set up a real-time 24x7 demonstration in HL for 5 WSR-88Ds in mid-Atlantic region (Sterling KLWX, Pittsburgh KPBZ, Charleston KRLX, Blacksburg KFCX, Wakefield KAKQ)**
- **Web page shows real-time graphical output products**
- **MPN project is in OSIP Stage 2**



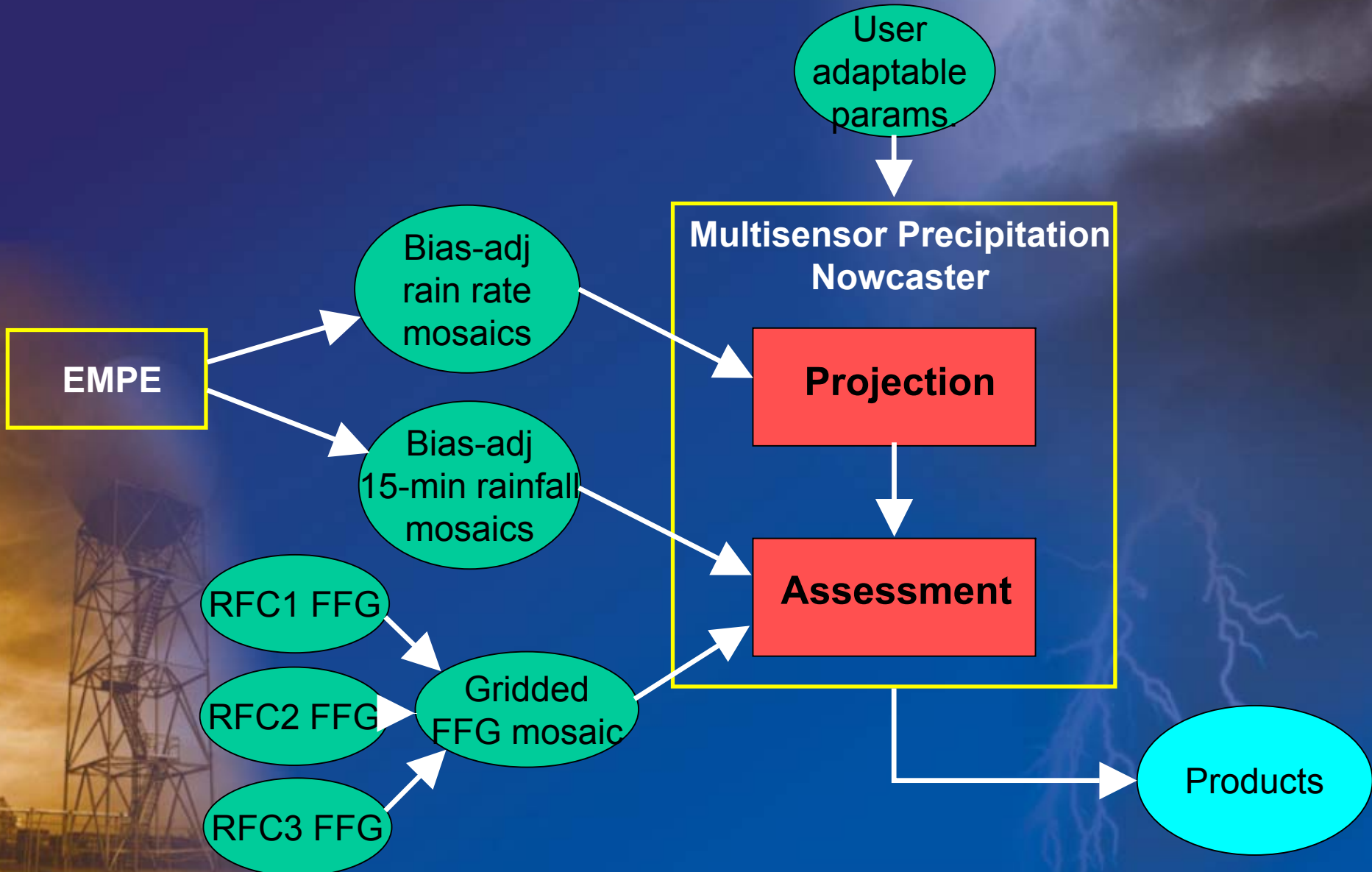
MPN has Two Components



- **Rainfall Projection** algorithm
 - *Produces 1-hour gridded rainfall nowcasts based on extrapolation of recent WSR-88D and rain gauge observations*
- **Flash Flood Threat Assessment** algorithm
 - *Computes observed and forecasted gridded probabilities of exceeding 1-, 3-, and 6-hr Flash Flood Guidances (FFG)*



MPN Data Flow





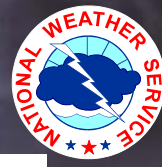
MPN Details

Pt. 1: Rainfall Projection Algorithm

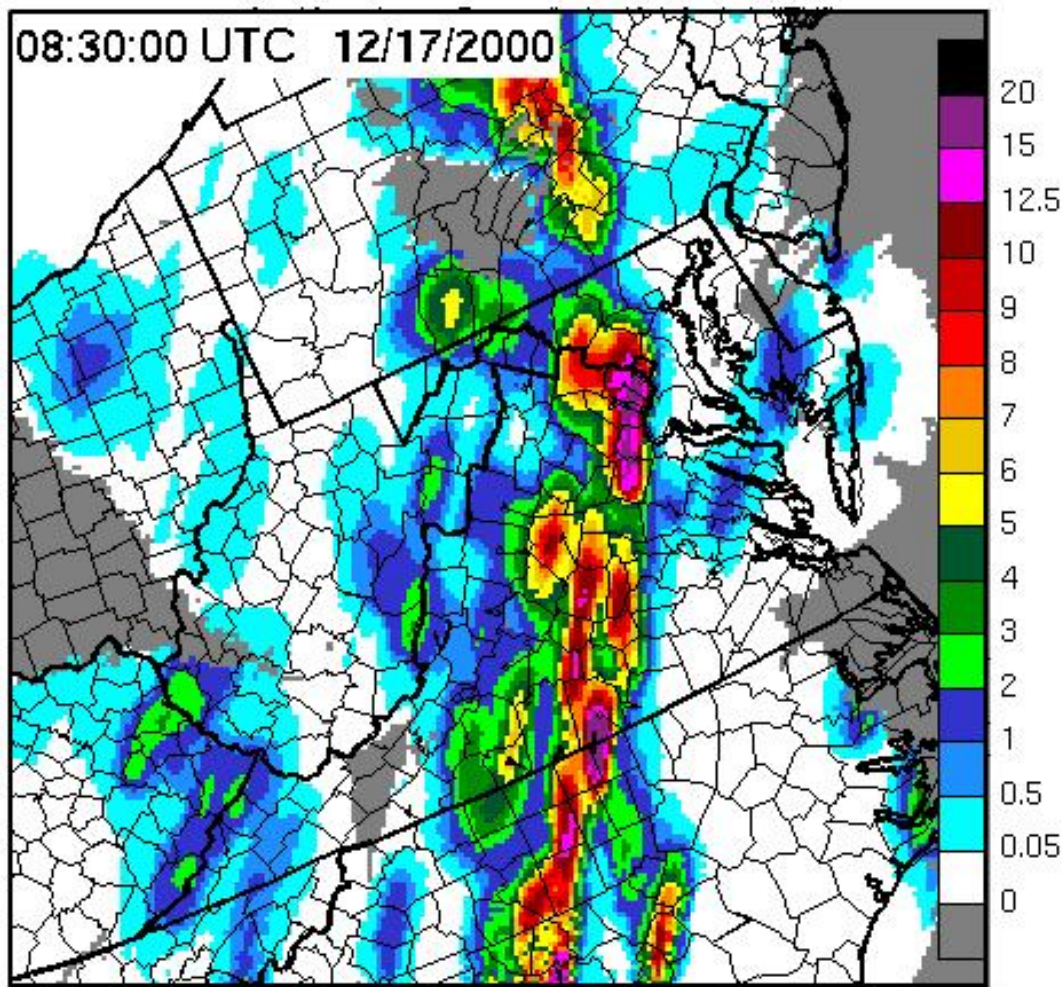
- **Generates one-hour rainfall nowcasts on HRAP grid (~4 km) with 5-15 minute update frequency as needed**
 - *Meager justification currently for going to higher spatial resolution*
 - *Extending forecasts beyond 1 hour is easily doable, but accuracy degrades quickly beyond ~1 hour in summer convection*
- **Local pattern matching technique using two consecutive gridded radar rain rate mosaics ~15-20 minutes apart produces local storm motion vectors**
 - *Vectors delineate storm motion at a ~20 km grid scale*
 - *Automated vector quality control*
- **Advect and integrate current mean field bias-adjusted rain rate mosaic one hour into future using observed storm vectors**
 - *Several progressive spatial smoothing options are available to minimize forecast error*
- **Local lagrangian storm growth and decay can be accounted for in forecasts if desired**

MPN Projection Products

One-hour Rainfall Forecast



1-HR FORECAST RAINFALL (mm)

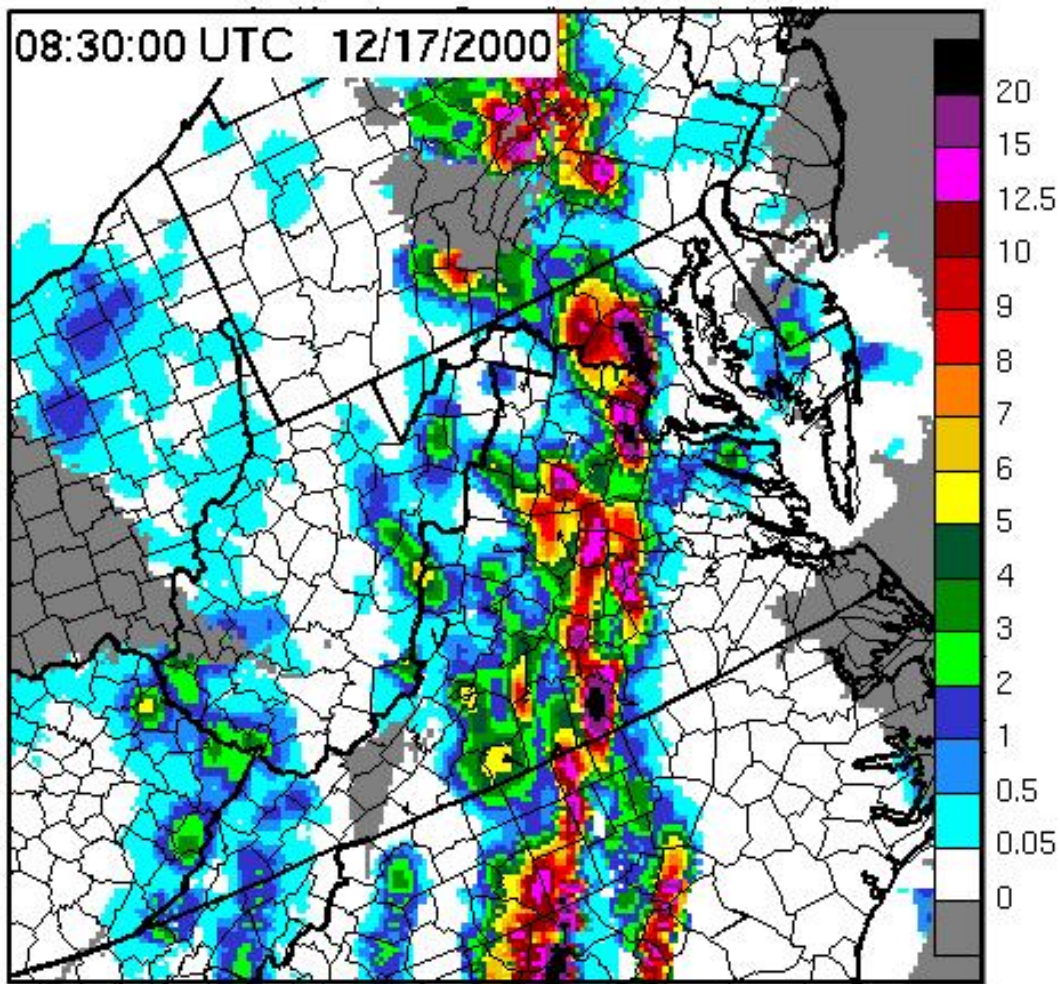


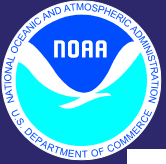
MPN Projection Products

One-hour Rain Rate Forecast



1-HR RAINRATE FORECAST (mm/hr)



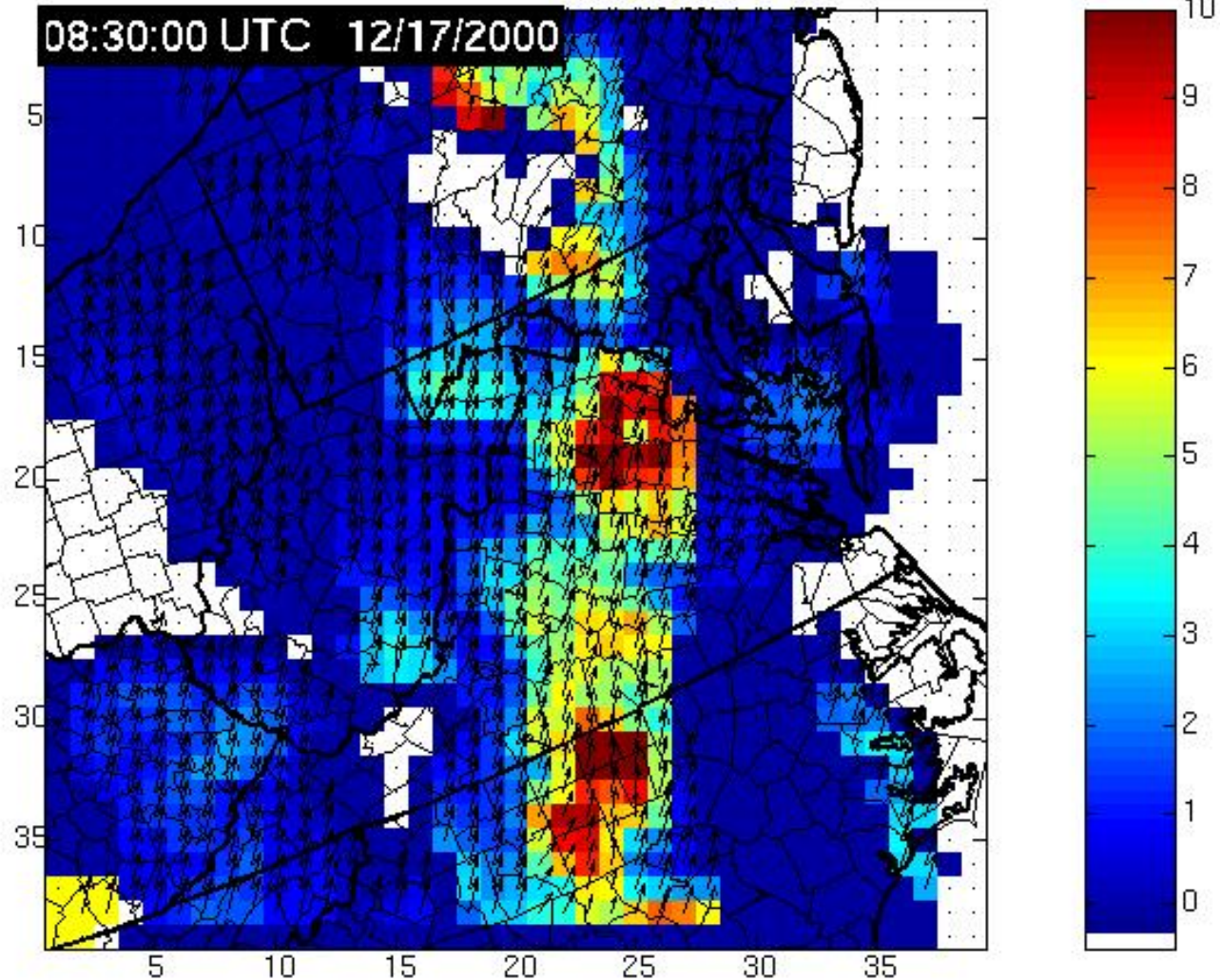


MPN Projection Products

Storm Motion Vectors and Reliability



STORM CELL MOTION AND RELIABILITY





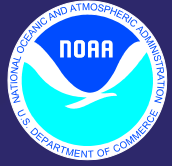
MPN Details

Pt. 2: Flash Flood Threat Assessment Algorithm

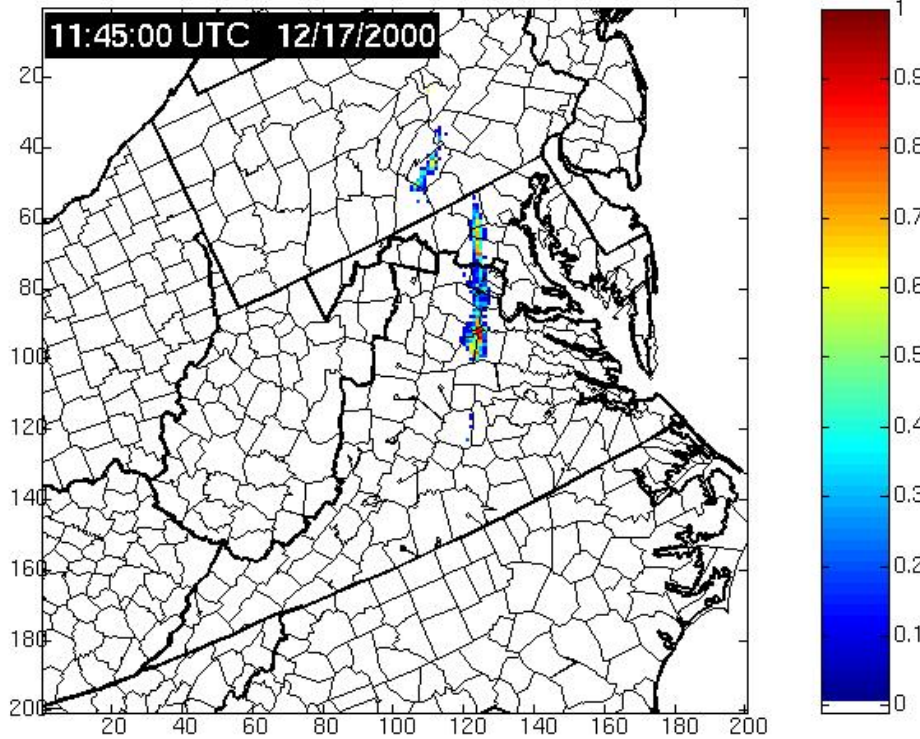
- **Compares both observed and forecasted rainfall with 1, 3, and 6-hr FFGs on the HRAP grid**
 - ***Could be enhanced to do basin averaging if integrated into FFMP***
- **Computes both observed and forecasted gridded probabilities of exceeding FFGs**
 - ***Maximum exceedance probabilities of all three durations (1-hr, 3-hr, 6-hr),***
 - **e.g., 3-hr forecast exceedance probabilities are computed from 2 hours of past observed rain and 1 hour of forecast rain and then compared with 3-hr FFGs**
 - ***“Storm-total” exceedance probabilities (Critical Rainfall Probabilities)***

MPN Assessment Products

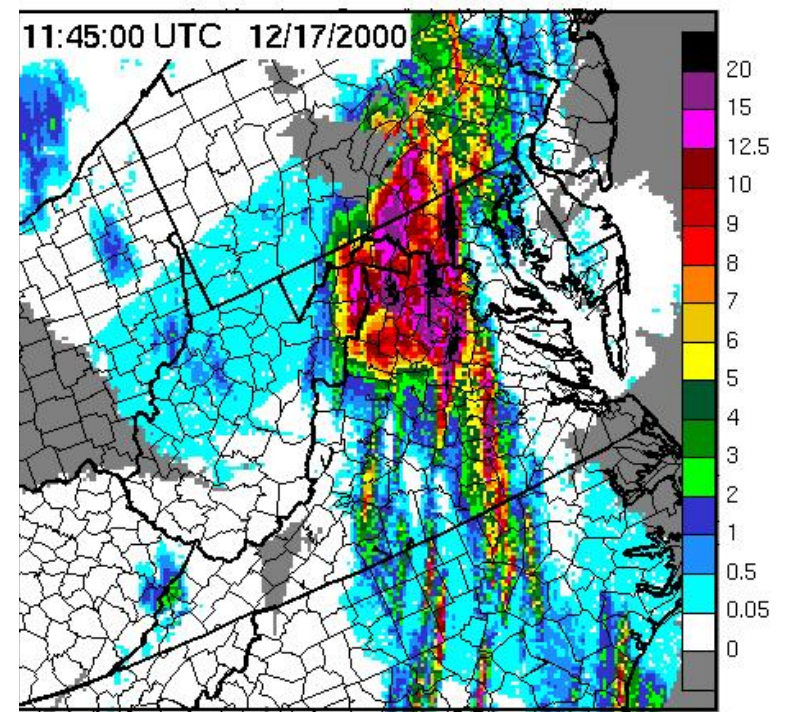
FFG Exceedance Probabilities



MAX OBS+PROJ PROBABILITY OF FFG EXCEEDANCE



1-HR OBSERVED RAINFALL (mm)

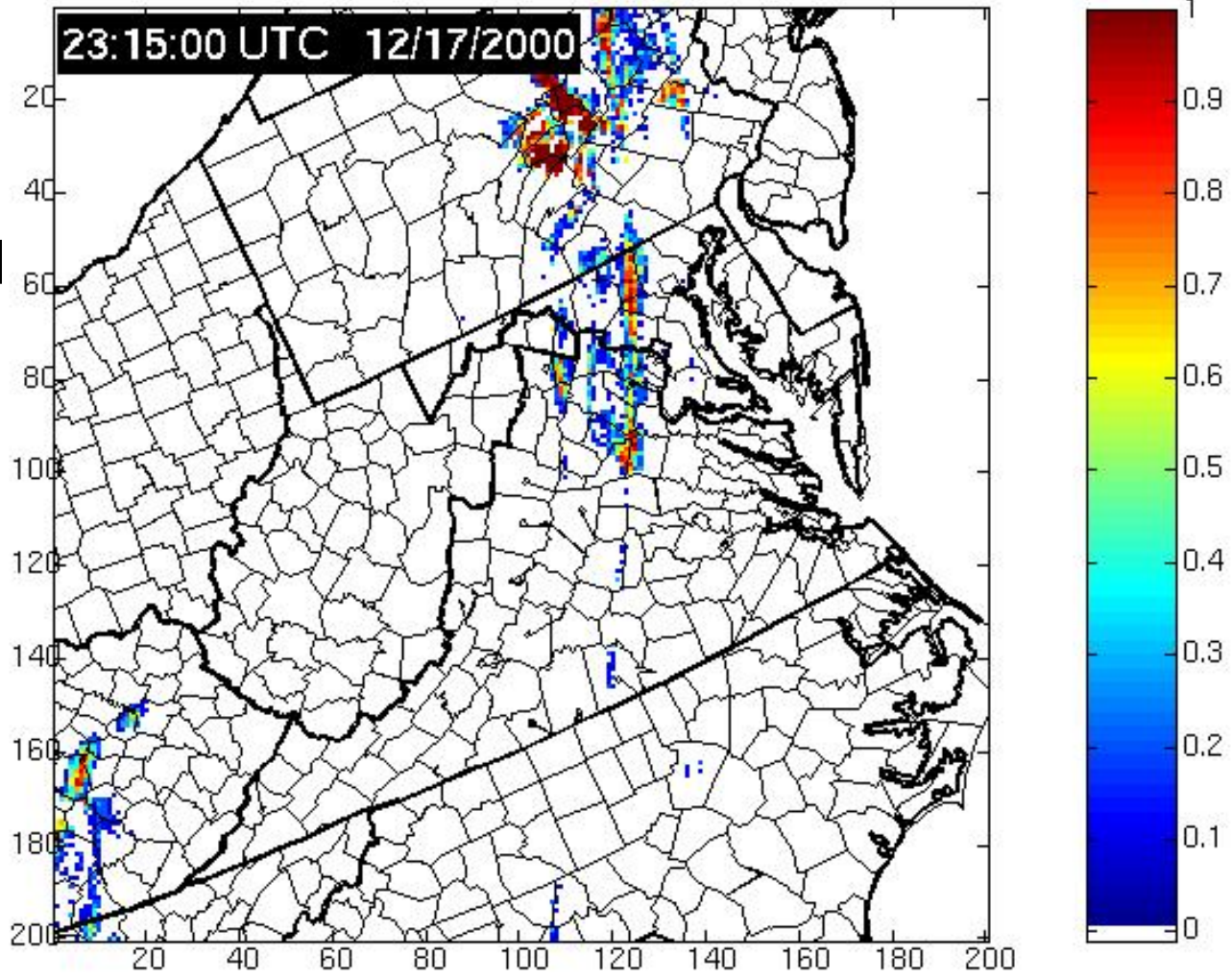


MPN Assessment Products

Critical Rainfall Probabilities



MAX OBS CRITICAL RAINFALL PROBABILITY



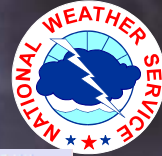
At end
of the
rain
event





Real-time Web Page

http://www.nws.noaa.gov/ohd/hrl/hag/empe_mpn/



NOAA's National Weather Service Multisensor Precipitation Estimation and Nowcasting for Flash Floods Experimental Real-Time Images

Site Map

News

Organization

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Algorithm and Product Description

EMPE Observations

1 km MFB Rainrate	Loop
15-min 1 km Rad Rain	Loop
15-min 1 km MFB Rain	Loop
15-min 1 km MS Rain	Loop
1-hr Radar Rain	Loop
12-hr Radar Rain	Loop

MPN

Storm Motion	Loop
Storm-Relative Motion	Loop
Storm Growth/Decay	Loop
Prob. FFG Exceedence	Loop
Critical Rainfall Prob.	Loop
1-hr FFG	Loop
3-hr FFG	Loop
6-hr FFG	Loop

1 Hour Forecasts

Rainrate	Loop
1-hr Rainfall	Loop
Prob. FFG Exceedence	Loop
Critical Rainfall Prob.	Loop

Forecast Verification

Rainrate	Loop
1-hr Rainfall	Loop

Multisensor Precipitation Estimation and Nowcasting for Flash Floods

A Radar Nowcasting Demonstration Project
to Improve Flash Flood Forecast and Warning Services
of the National Weather Service

Introduction

Quantitative precipitation estimation and nowcasting are important components of National Weather Service (NWS) flash flood warning services. They refer to the estimation of rainfall up to the current time using multiple sensors (WSR-88D, rain gauges, satellite estimates) and the estimation of rainfall in the future based heavily on current observed data. It is in this near real-time context that the current MPE products have lesser precipitation forecast skill than expected.

MPN products

The Enhanced Multisensor Precipitation Estimator (E-MPE) is a new prototype algorithm developed by the Hydrology Laboratory (HL) based on the existing operational Multisensor Precipitation Estimator (MPE) that is running at most River Forecast Centers and Weather Forecast Offices. However it has the advantage of higher spatial and temporal resolution than the current MPE, a factor that is necessary if the products are to be useful for flash flood monitoring and warning purposes. Instead of one-hour multisensor rainfall estimates at a nominal 4-km (HRAP) grid scale with updates once per hour as with the current MPE, the E-MPE is more flexible and generates multi-duration rainfall products on a 1-km grid (1/4th HRAP) with updates as often as every 5-15 minutes based on what the user chooses. Details of the current MPE algorithm can be found under the "MPE Training Workshop" link at <http://www.nws.noaa.gov/oh/hrl/papers/papers.htm#wsr88d>.

The Multisensor Precipitation Nowcaster (MPN) algorithm is a prototype rainfall nowcasting algorithm that produces regional, gridded, one-hour rainfall nowcasts using input data generated by the E-MPE. The MPN is an enhancement of the Flash Flood Potential (FFP) algorithm, also developed at the HL, that uses current and recent-past WSR-88D radar data to estimate the future location of storms, their associated rainfall, and flash flood threat up to one hour into the future.

These E-MPE and MPN products can be used as input to distributed hydrologic forecast models or other flash flood monitoring tools at the Weather Forecast Offices. Short-term rainfall nowcasts can provide forecasters with additional



MPN Verification: Are the Nowcasts Any Good?

- **Verification of forecasted instantaneous rain rates and hourly forecast accumulations...**
 - ***Against radar observations (completed)***
 - **Fulton and Seo (2000)**
 - **Guan, Ding, Fulton, Kitzmiller (2005)**
 - ***Against rain gauge observations (in progress)***

Fulton and Seo, 2000: A prototype operational 0-1 hour radar-based Flash Flood Potential algorithm. 15th Hydrology Conference.

Guan, Ding, Fulton, Kitzmiller, 2005: Preliminary results for the 0-1 hour Multisensor Precipitation Nowcaster. 32nd Radar Meteorology Conference.

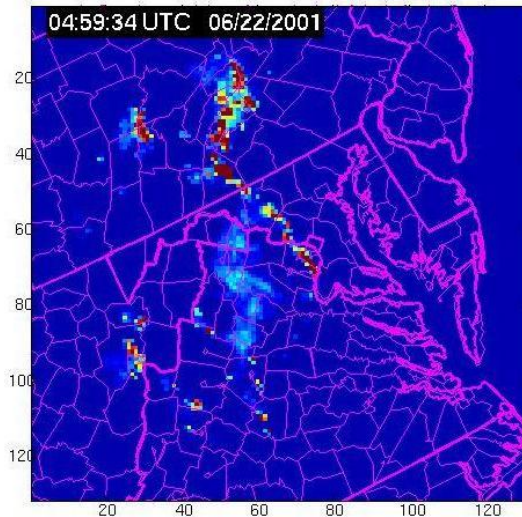
Example 1 – Visually Comparing Forecasts and Observations



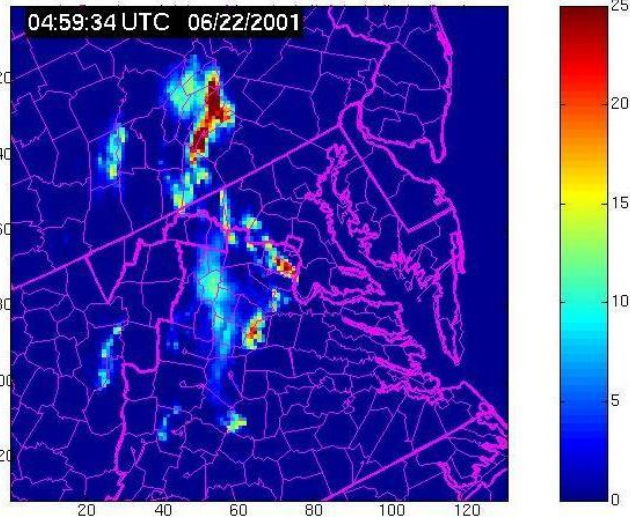
Obs.

Fcst.

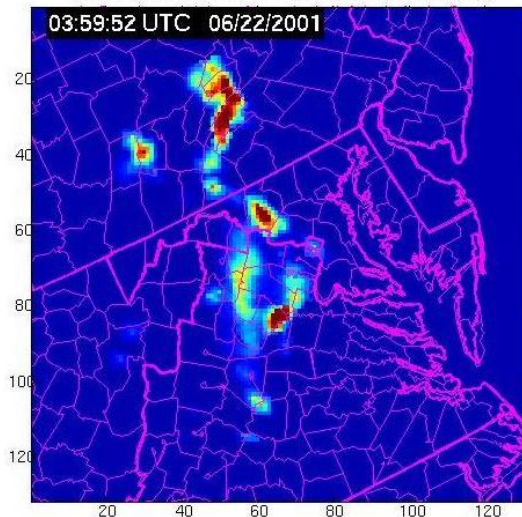
RAINRATE (mm/hr)



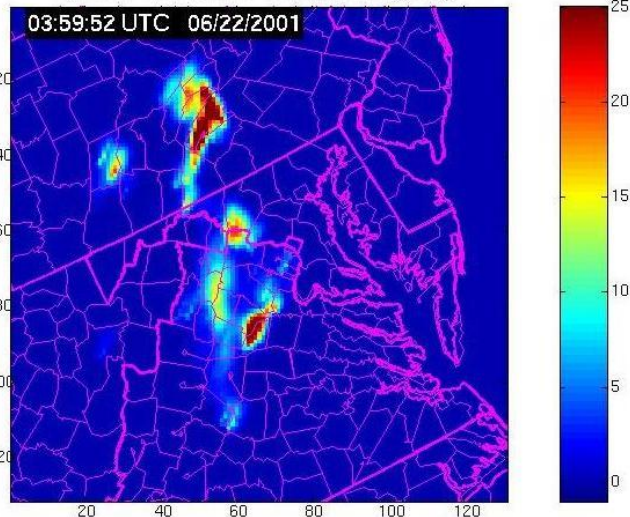
1-HR OBSERVED RAINFALL (mm)



1-HR RAINRATE FORECAST (mm/hr)



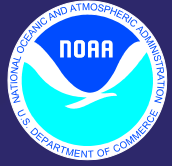
1-HR FORECAST RAINFALL (mm)



Case 5

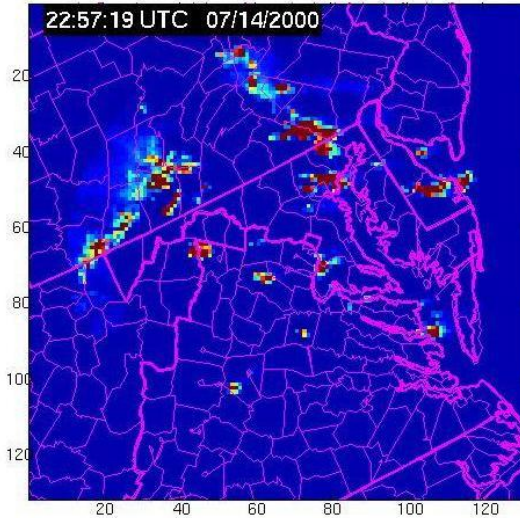
NFL

Example 2 – Visually Comparing Forecasts and Observations

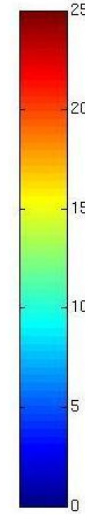
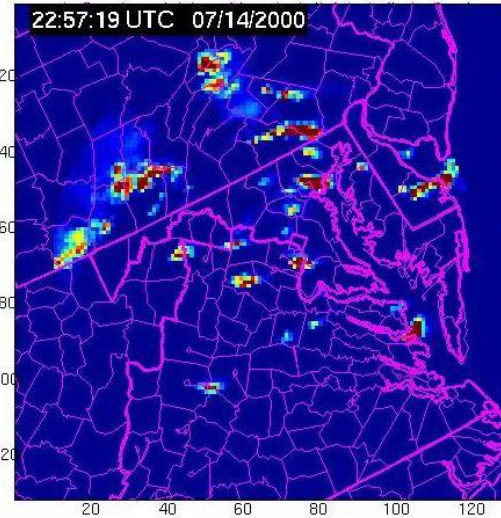


Obs.

RAINRATE (mm/hr)

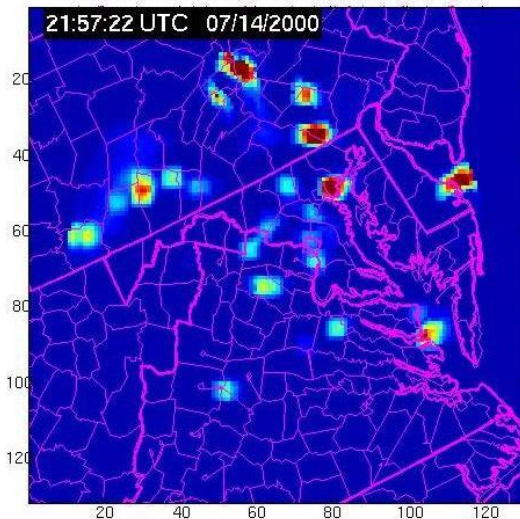


1-HR OBSERVED RAINFALL (mm)

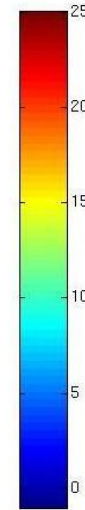
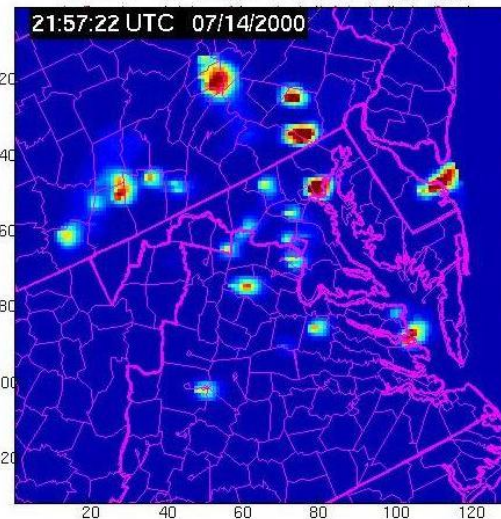


Fcst.

1-HR RAINRATE FORECAST (mm/hr)

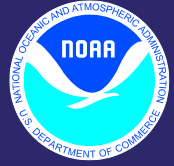


1-HR FORECAST RAINFALL (mm)



Case 3

NFL



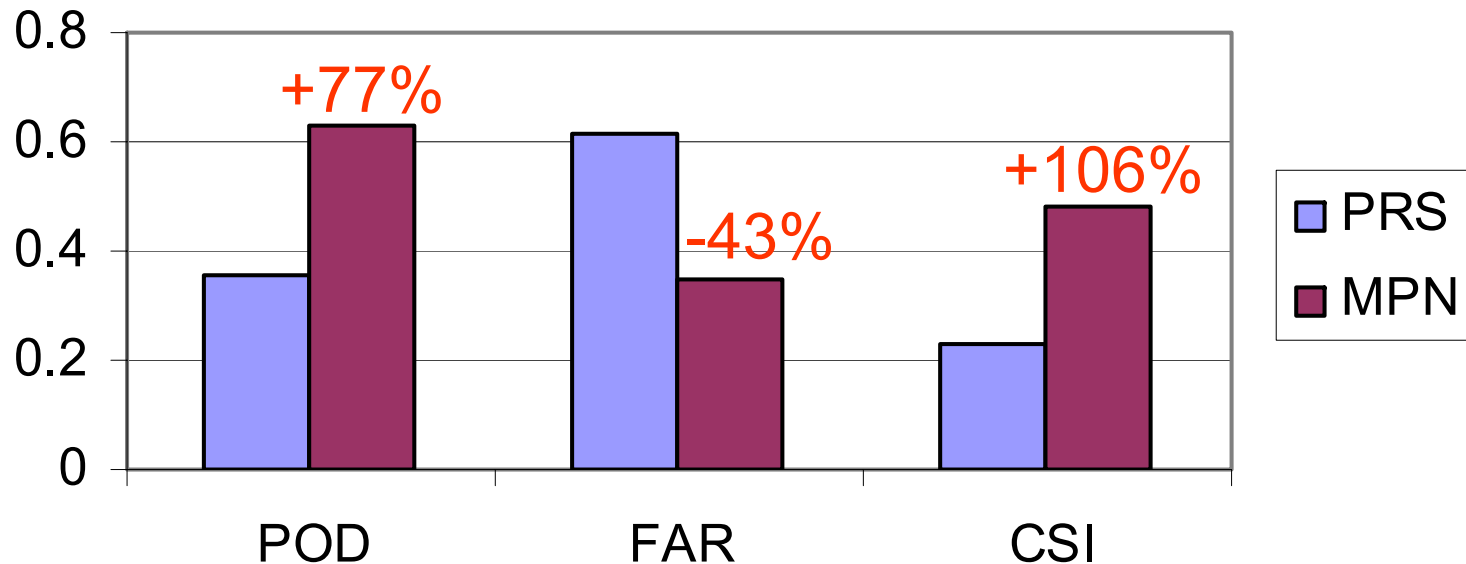
MPN Forecast Verification Against Radar Rainfall Observations: 1-hr Rainfall

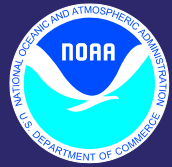


27 historical flash flood events examined from 18 locations around the U.S. over ten years

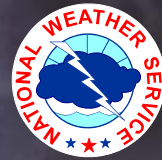
Statistics computed on HRAP grid

Comparison of average POD, FAR, and CSI of 1-hour accumulated precipitation forecast > 5 mm between persistence and MPN

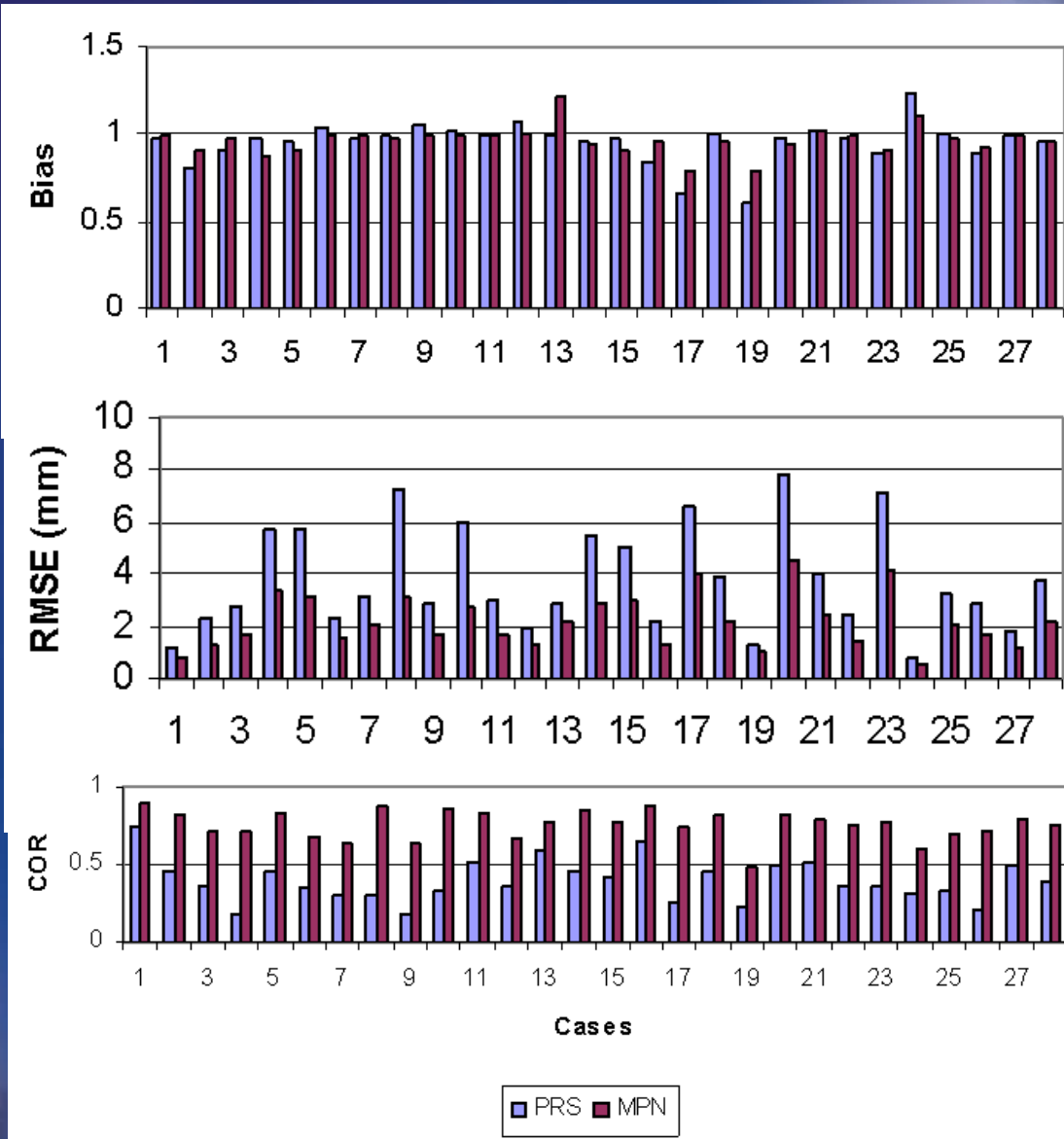




MPN Forecast Verification Against Radar Rainfall Observations: 1-hr Rainfall



Rain gauge data was not used



Bias = $\frac{\sum(\text{fcst rain})}{\sum(\text{obs rain})}$



Using Rainfall Nowcasts in a Distributed Hydrologic Forecast Model (HL-RDM)

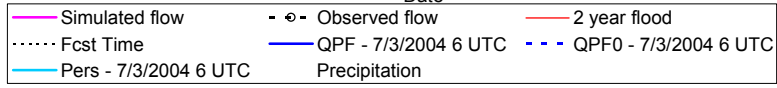
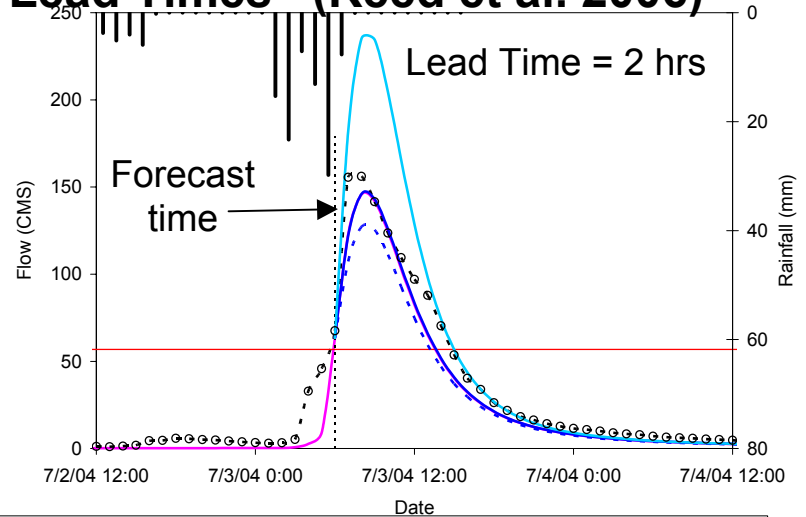
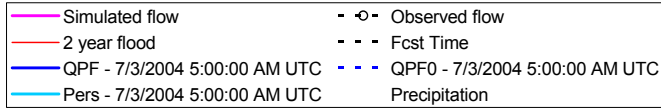
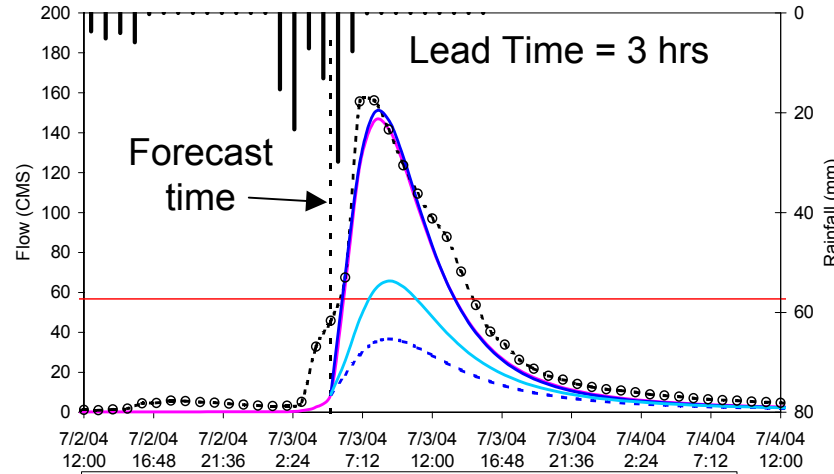
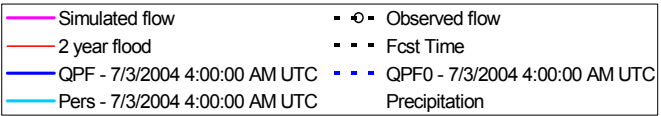
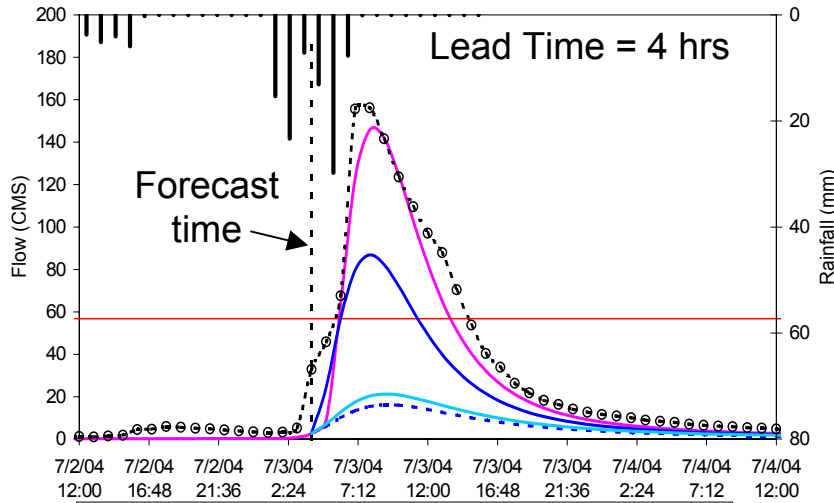


- **Forecast hydrographs using 1-hr MPN rain nowcasts are consistently better than assuming zero QPF based on 9 intense rain events**
 - *Reed, Fulton, Zhang, Guan (2006)*
- **Demonstrated potential flash flood lead time gained**
- **A component of S. Reed's HOSIP project "Distributed Hydrologic Modeling for Flash Flood Forecasting"**
- **Potential for use in Site Specific Hydrologic Predictor (SSHP)**
- **Potential for linking hydro forecasts to high-res GIS-based flood inundation mapping capabilities for emergency managers**

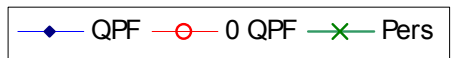
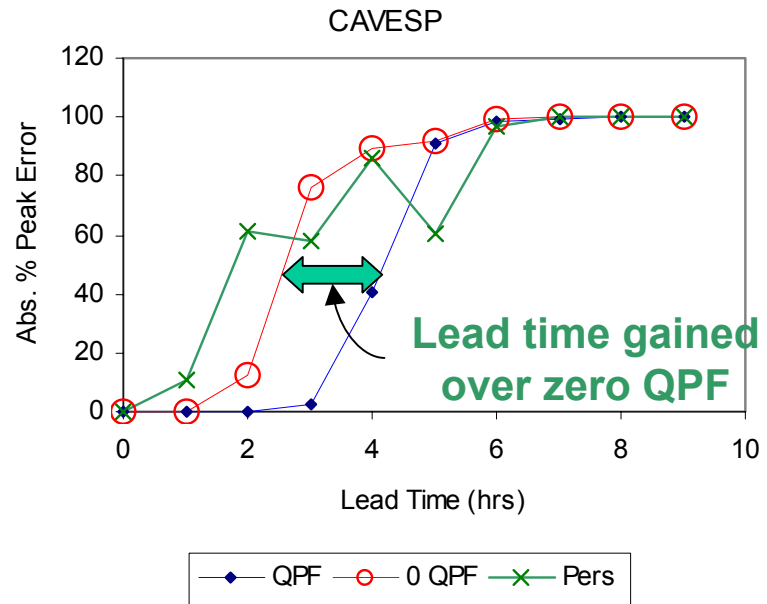
Reed, Fulton, Zhang, Guan, 2006: Use of 4-km, 1-hr precipitation forecasts to drive a distributed hydrologic model for flash flood prediction. 20th Hydrology Conference.

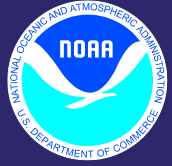
Hydrograph Forecast Accuracy at Different Lead Times (Reed et al. 2006)

- Lead times are computed relative to the simulated peak time.
- All results shown are for CAVESP (90 km²) and single Event (7/2004)

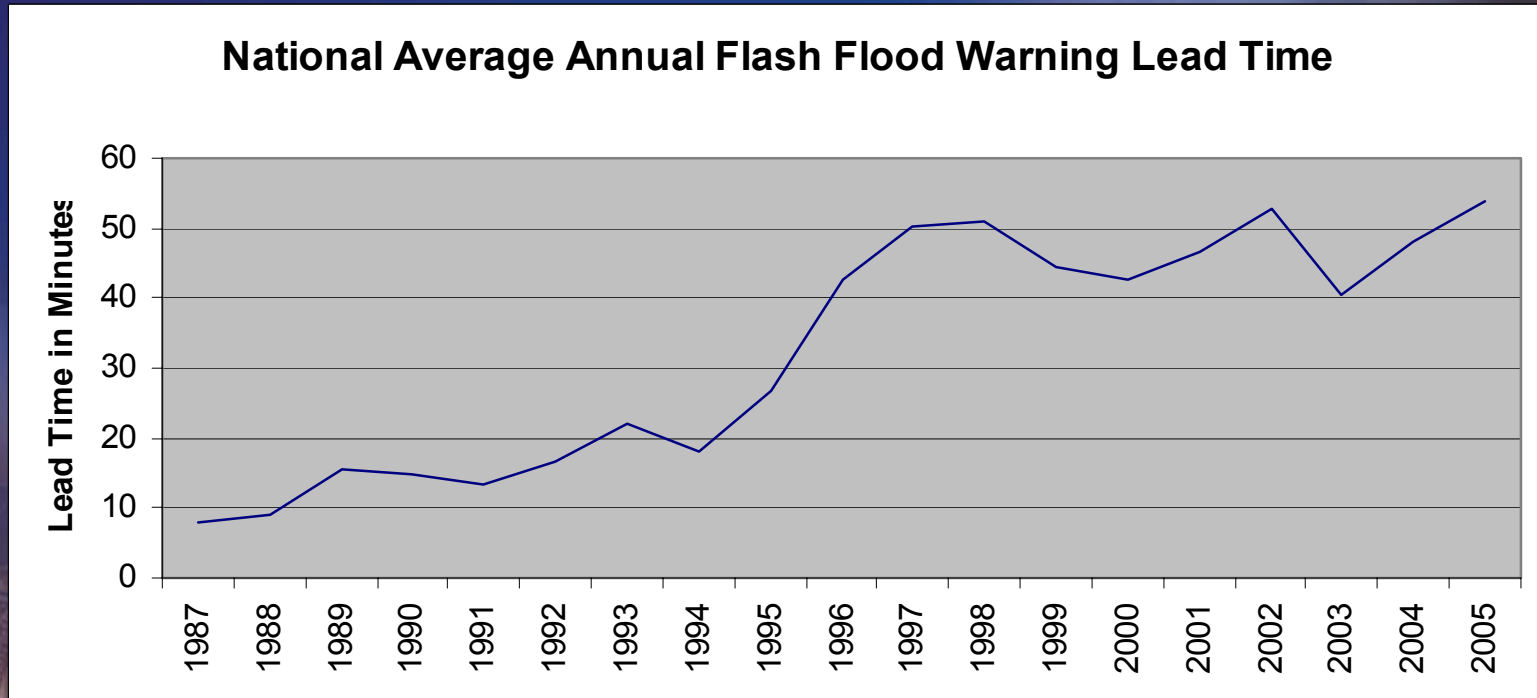


Peak errors of different forecasts relative to simulated flows as a function of lead time





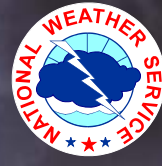
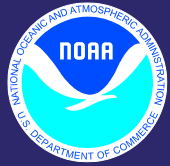
Historical Performance of NWS Flash Flood Warning Lead Time



**NEXRAD
Implementation**



**FFMP
Implementation**

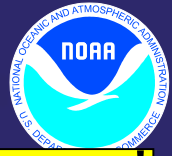


Recent and Projected WFO Flash Flood Warning Performance

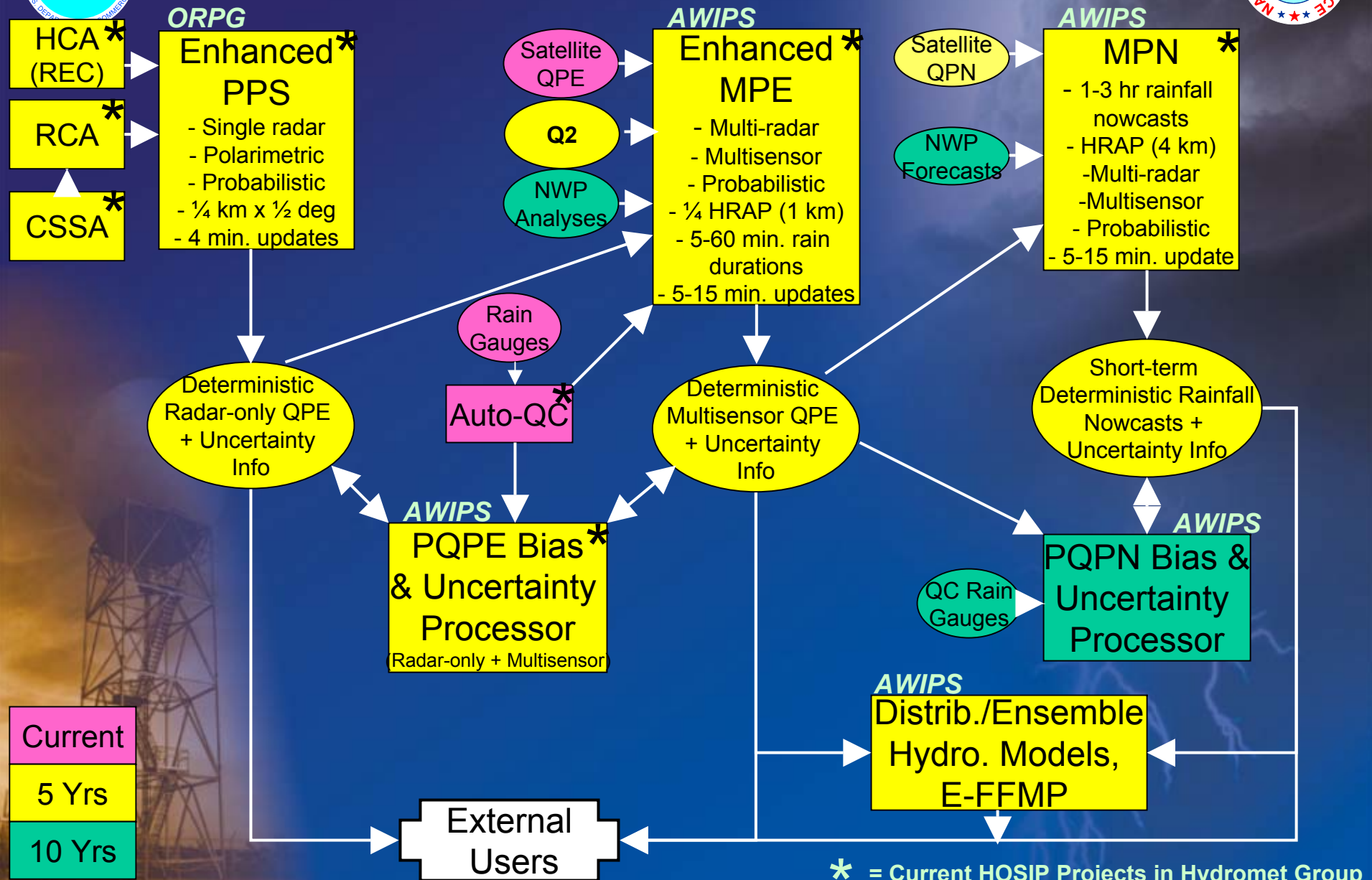
- *Flash Flood Warning verification statistics are based on product issuance information and confirmation of actual flash floods by the local WFOs*
 - *Flash Flood Warning Lead Time*
 - *Flash Flood Warning Accuracy*

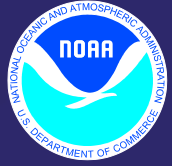
	<i>FY03</i>	<i>FY04</i>	<i>FY05</i>	<i>FY06</i>	<i>FY12</i>
	<i>Actual</i>	<i>Actual</i>	<i>Actual</i>	<i>Goal</i>	<i>Goal</i>
<i>Lead Time (minutes)</i>	41	48	54	48	51
<i>Accuracy (%)</i>	89	89	88	89	91

EMPE and MPN, when integrated with other WFO hydrology tools, have the potential to greatly increase future performance



An Integrated Future Vision for QPE/QPN

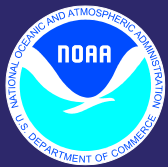




Conclusion



- **The Enhanced Multisensor Precipitation Estimator and Nowcaster can enable improved WFO performance results and new diverse flash flood services**



For more information on activities to improve WSR-88D rainfall estimation in the Hydrology Lab...

- **Visit the Hydromet Group's web page**
 - <http://www.nws.noaa.gov/oh/hrl/hag/hag.htm>
- **Visit our WSR-88D publications web page**
 - <http://www.nws.noaa.gov/oh/hrl/papers/papers.htm#wsr88d>
 - All the papers referenced herein are located there

The End