The WSR-88D Radar As a Flood Forecasting Tool

How the River Forecast Center Generates Estimates of Mean Areal Precipitation

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This is the type of weather disaster that gets all the news

•Fort Worth, Texas tornado March 28, 2000

But most weather-related deaths are from floods

•Dallas, Texas May 3, 1990

There were 43 flood related deaths in Texas in 2007.

Precipitation Estimates from the WSR-88D are the primary source of calculating Mean Areal Precipitation

Why use them?

Prior to the WSR-88D:

Only Rain Gauge data was Used!

- Only a few rain gauges existed in some river sub-basins
- 24-hour cooperative observer reports
- Hydrologic models only ran, generally, once daily after the 24 hour reports arrived
- A lot of heavy rain can fall between the gauges in a convective environment

Prior to Using Radar Precipitation Estimates

- Mean Areal Precipitation was not real precise where rain gauges were sparse
- Used Theissan weighting from rain gauges to determine mean areal precipitation
- Rain gauges have influence over a large area
- Little temporal resolution to the rain gauge data

Radar Precipitation Estimates

Why Use Them?

With the WSR-88D:

Better Spatial and Temporal resolution

- Radar shows better distribution of rainfall
- Timing of the rainfall in a river sub-basin is more easily determined due to availability of hourly estimates

Better Mean Areal Precipitation

- Determined from a better spatial distribution of rainfall
- Determined every six hours for direct input into hydrologic models
- ***VERY Important to the RFC that we have accurate rainfall estimates that yield accurate estimates of runoff.***

Radar Precipitation Estimates

- The program which assimilates radar precipitation estimates for use in the hydrologic models is the Multisensor Precipitation Estimator Processing System (MPE).
- Problem: The WSR-88D radar precipitation estimates can be in considerable error. What causes these errors?

Factors which lead to inaccurate radar rainfall estimates

- **Radar Reflectivity Calibration**

  A change of 1 dBZ in power return leads to an average error of 17% in rainfall rate

- **Proper Use of the Adaptable Parameters in the Precipitation Algorithm**

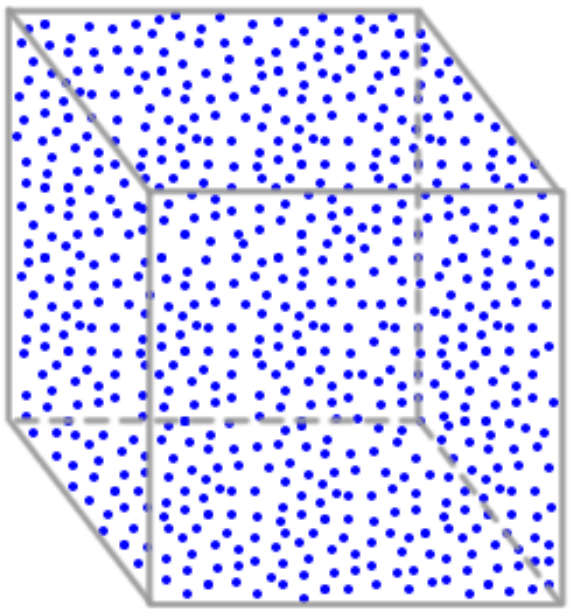
  Default Z/R Relationship vs. Tropical Z/R Relationship. At 45 dBZ power return, the default Z/R yields an estimate of 1.10" per hour, while the tropical Z/R yields 2.22" per hour

  MAXPRA. Maximum hourly rainfall rate can be raised from 4.09" per hour to 6.00" per hour

Factors which lead to inaccurate radar rainfall estimates

- Drop Size Distribution
- More sensitivity to drop diameter than drop density

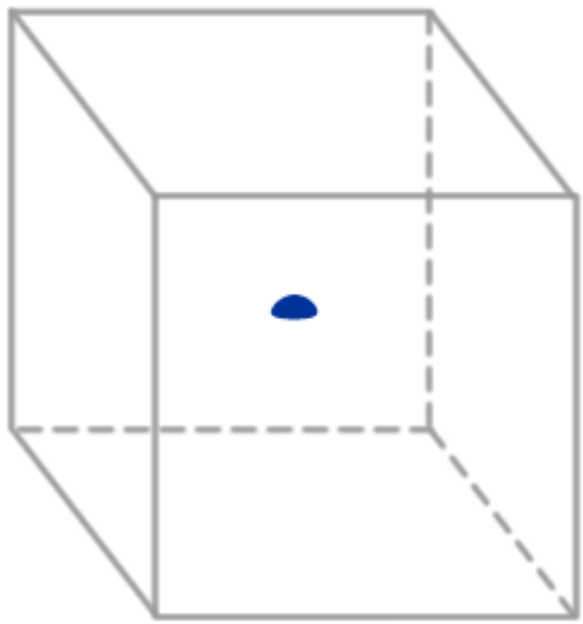
Sample Volume: 1 m^3



729 1 mm drops: Z=29 dBZ
Actual Rainrate R=0.22 in/hr

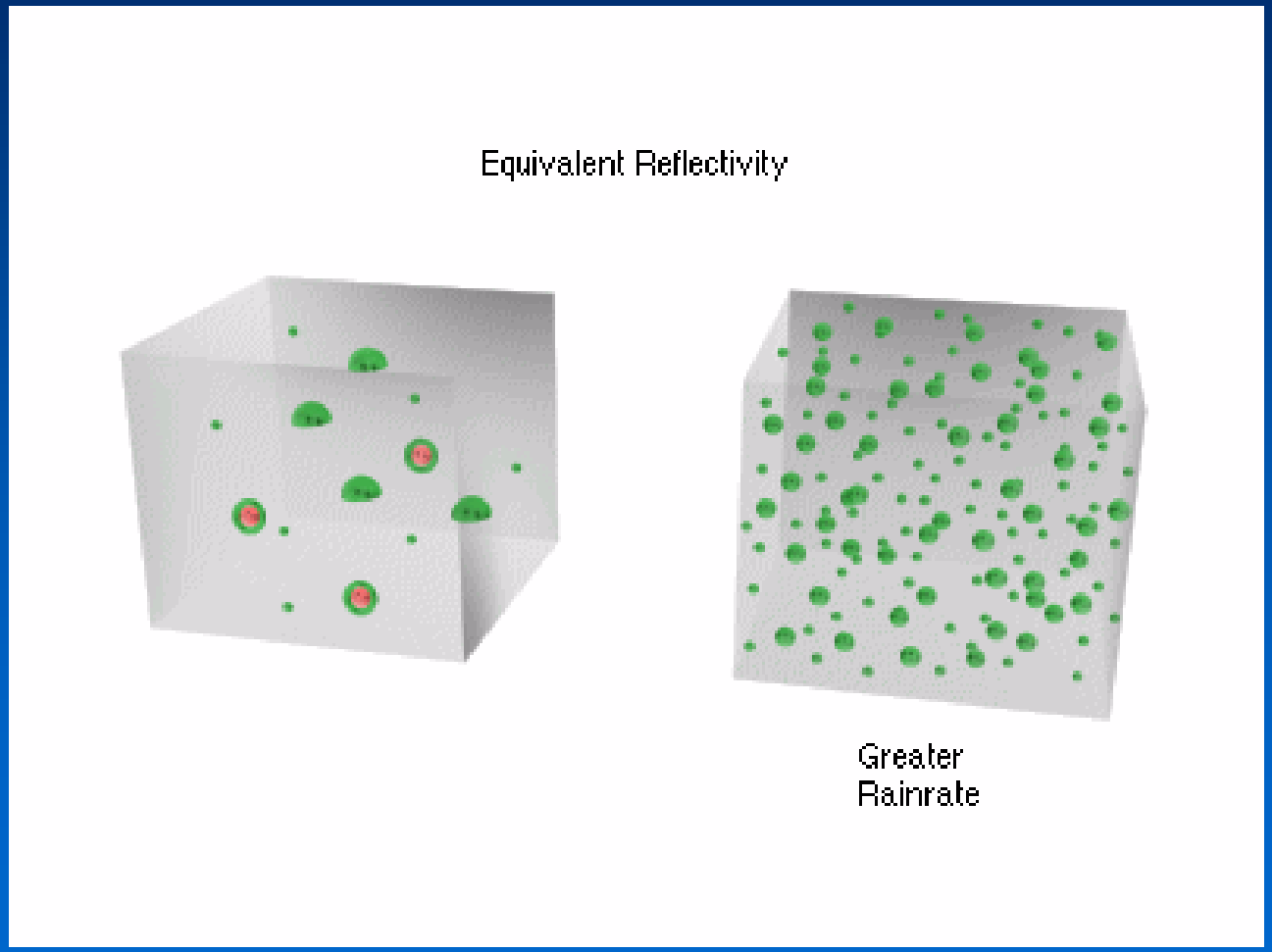
Same Reflectivity, Vastly Different Rain rates. Rainfall rate from radar is 0.08 in/hr.

Sample Volume: 1 m^3



1 3mm drop: Z=29 dBZ
Actual Rainrate R=.02 in/hr

Impact of Drop Size Distribution on Radar QPE



A few large rain drops return as much power Z to the radar as many small rain drops, but it is raining harder with the smaller drops

Factors which lead to inaccurate radar rainfall estimates (cont)

- **Beam Blockage**

  More of a problem over mountainous terrain - leads to underestimation

- **Evaporation Effects**

  Leads to overestimation, but is usually small over Texas

- **Attenuation**

  Usually small for 10 cm wavelength radars

- **Polarization**

  Only horizontal linear polarization employed

  Dual Pol will help greatly (FY09)

Factors which lead to inaccurate radar rainfall estimates (cont)

- **Hail Contamination in thunderstorms, Bright Band Contamination in the cold season, and Snow**

  Hail causes overestimation, the bright band from melting ice crystals also causes overestimation, and snow is poorly sampled and is underestimated

- **Range Degradation**

  Leads to underestimation at far distances from the radar

- **Anomalous Propagation ("AP") and Ground Clutter Suppression**

Radar Precipitation Estimates

How do HAS Forecasters Improve these Estimates?

- **The HAS Forecasters do this by closely monitoring radars and rain gauges**
- **HAS Forecasters use several tools:**

  Compare radar rainfall estimates between local radars (AWIPS);

  The Multisensor Precipitation Estimation Processing System; and

  24-hour MPE precipitation totals *compared with* 24- hour rain gauge reports i.e. "Monday morning quarterbacking" (using Co-Op and CoCoRaHS rain gauge data)

Radar Precipitation Estimates

How do HAS Forecasters improve these estimates?

- **The MPE program is the most important tool**

Starts with the radar ingest (Hourly Digital Precipitation Estimates from 24 WSR-88Ds)

Next, the radar estimates are compared to the rain gauges and a radar/rain gauge bias adjustment factor is applied to the radar estimates. A rain gauge only field is also created

Lastly, the rain gauge-only analysis is incorporated with the **bias-adjusted radar estimates** to create a multisensor analysis.

The MPE Program

HAS Forecasters will quality control:

- **Rain gauges using the Gauge Table. Bad gauge readings can be eliminated. Additional gauges can be added.**
- **Radar Biases. Unrepresentative bias adjustment factors can be changed in real time**
- **Can add satellite precipitation estimates where radar and rain gauge estimates do not exist**

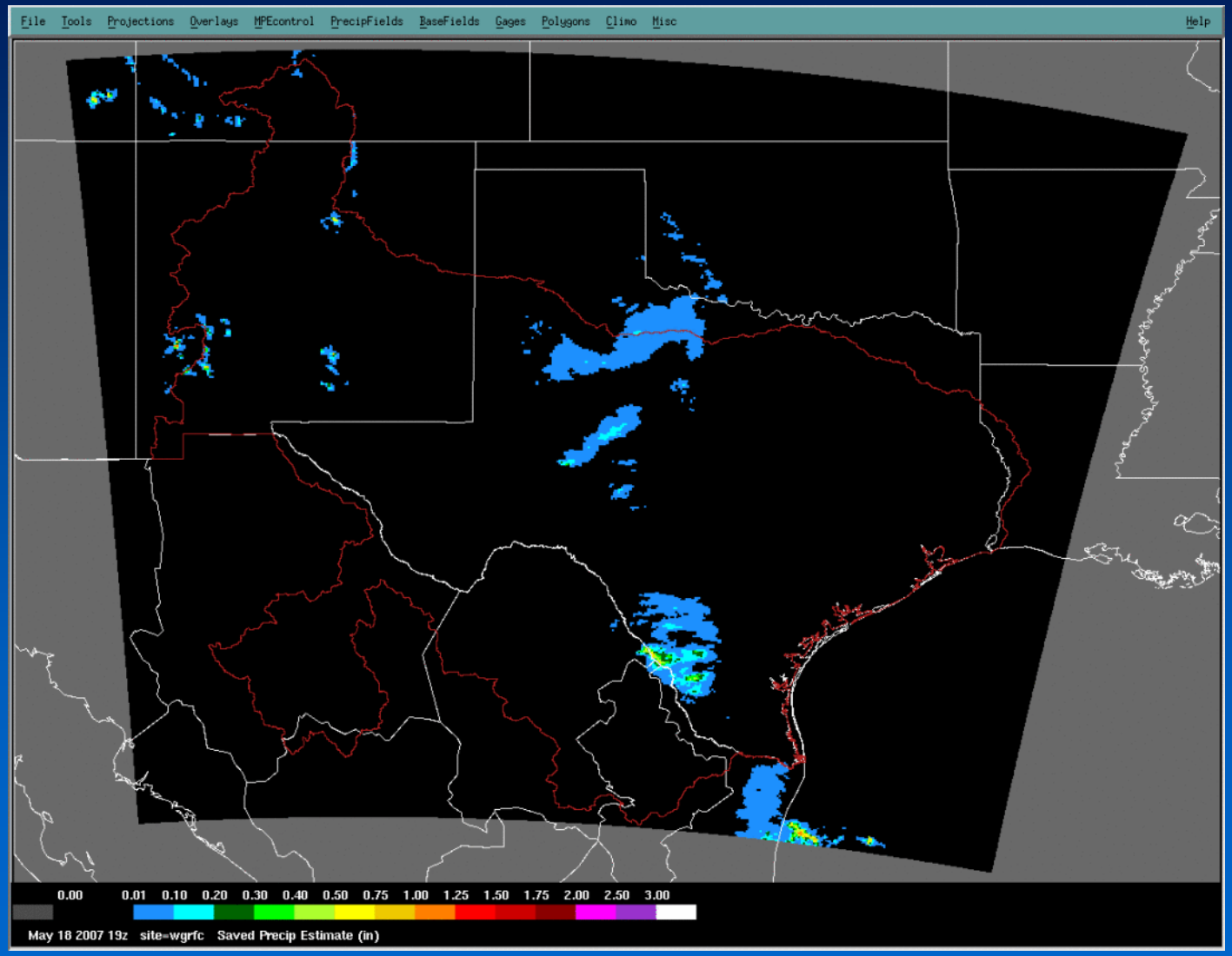
Radar Precipitation Estimates

- MPE is run every hour

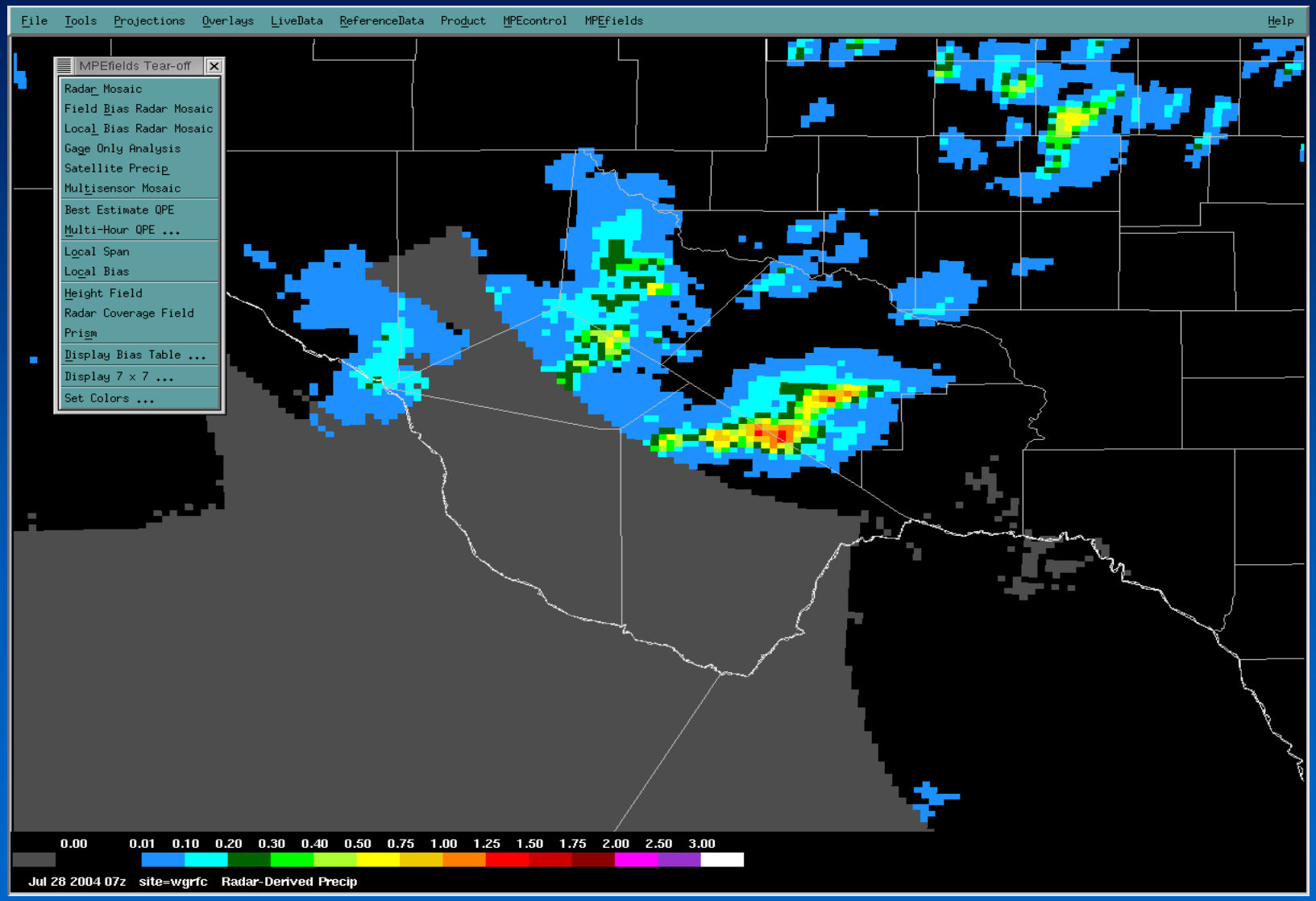
Program is run not only for the current hour, but for the previous 3 hours to incorporate all available hourly rain gauge data

- At the synoptic times (00, 06, 12, and 18Z), a program takes 6 hours of MPE precipitation data and calculates 6 hour values of mean areal precipitation (MAP) for each river sub-basin
- MAP values serve as input to the hydrologic models

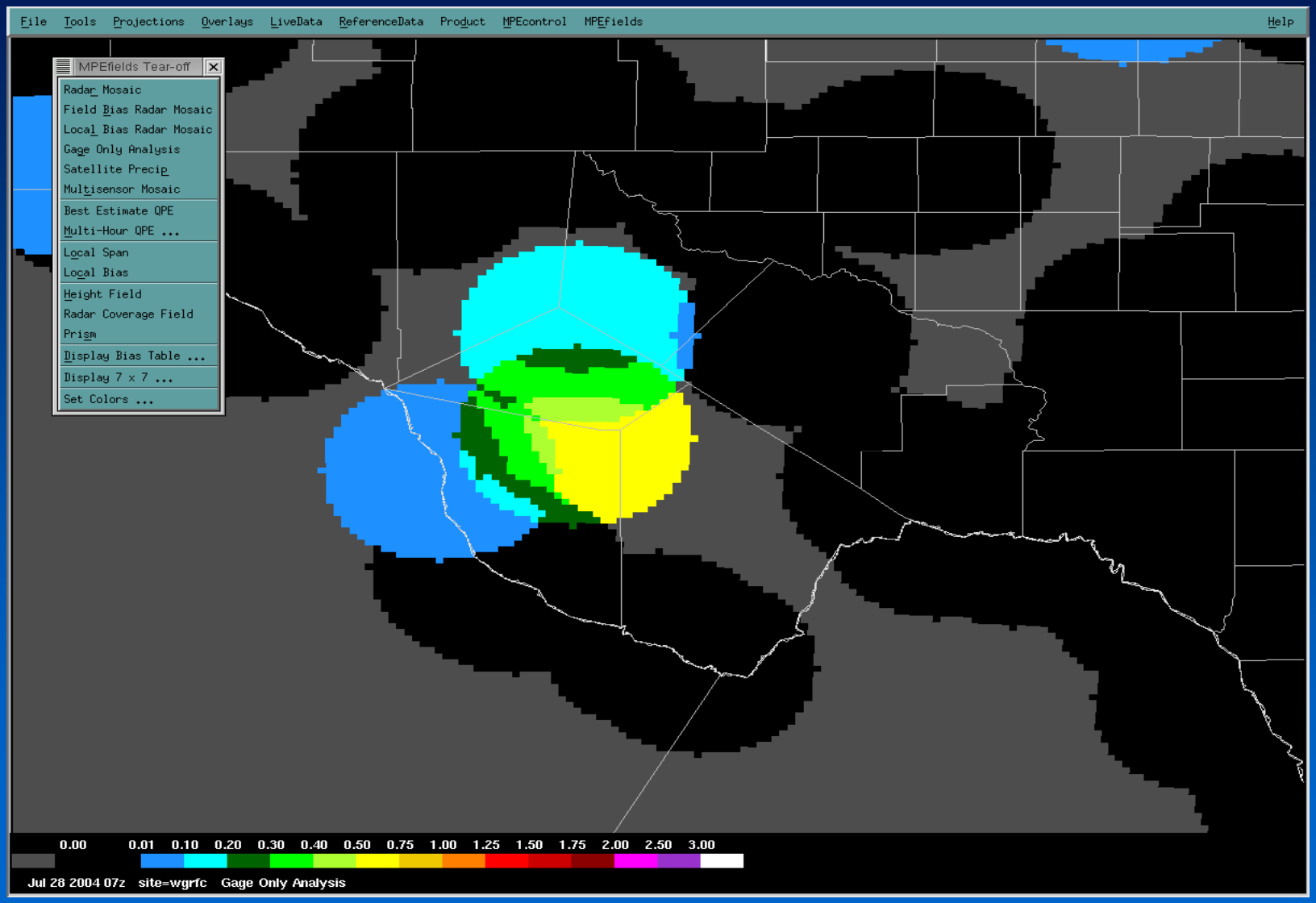
MPE Primary Display



Case #1 Big Bend Region - 07/28/04

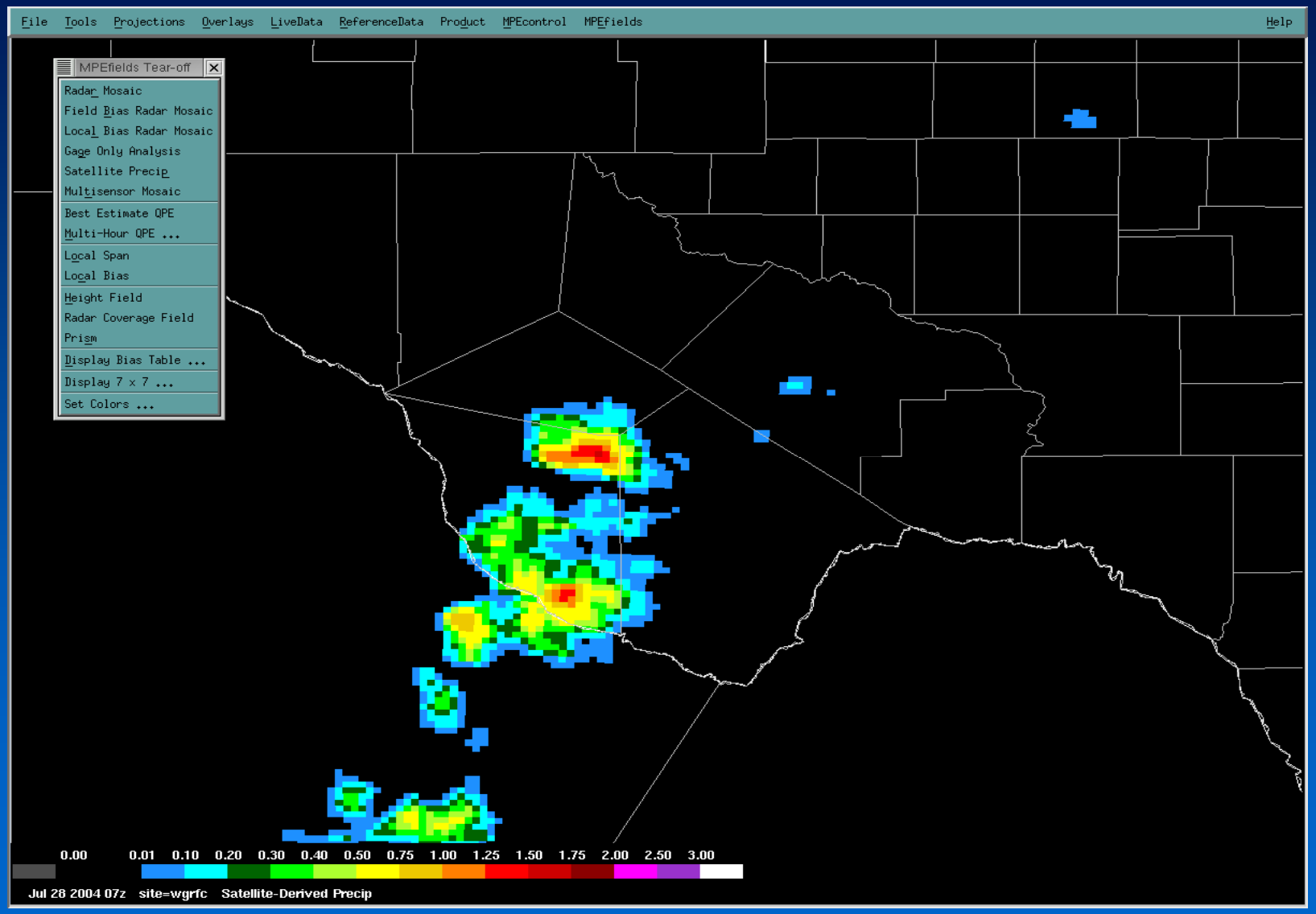


Big Bend Region - 07/28/04



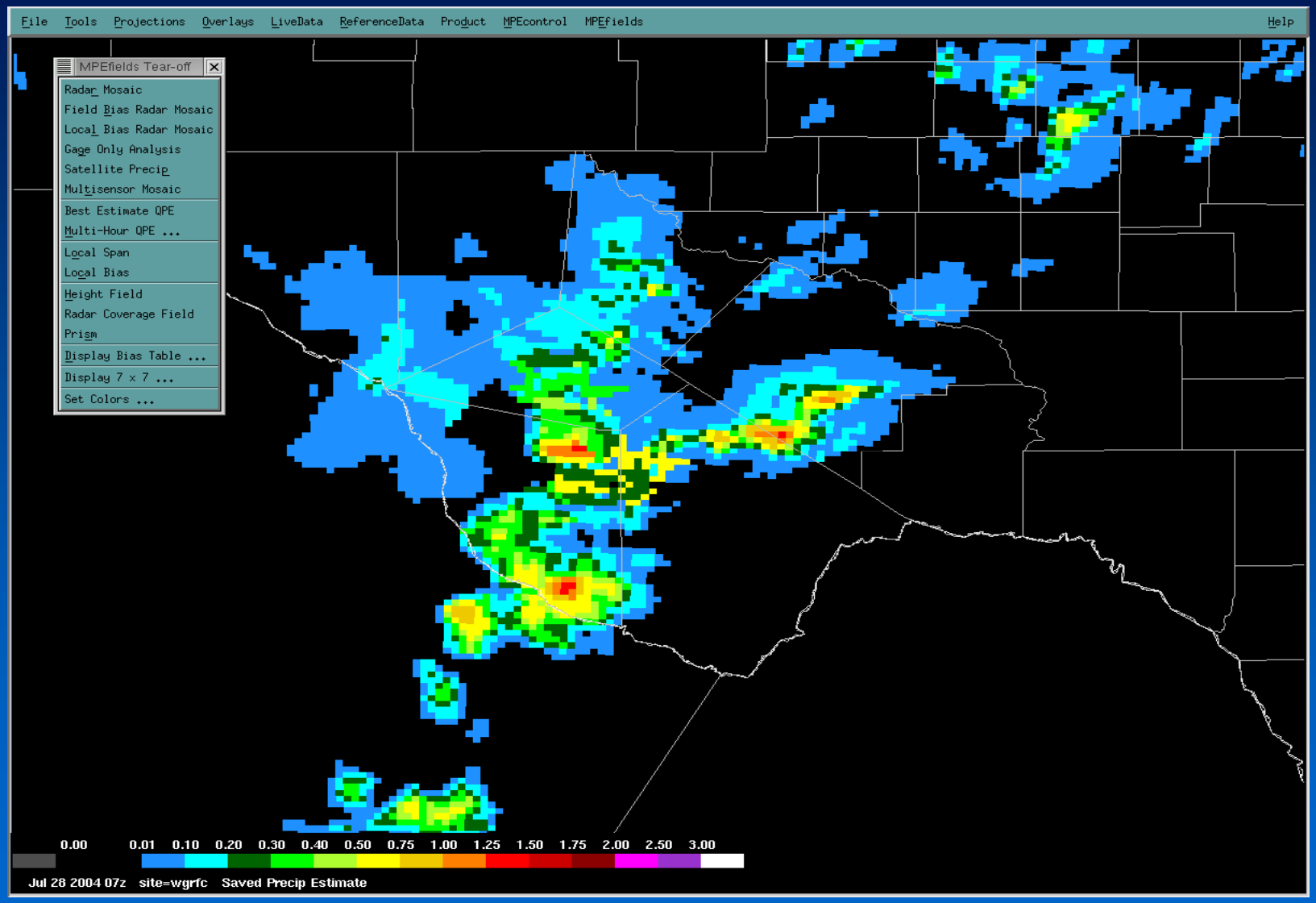
Gauge Only Field

Big Bend Region - 07/28/04



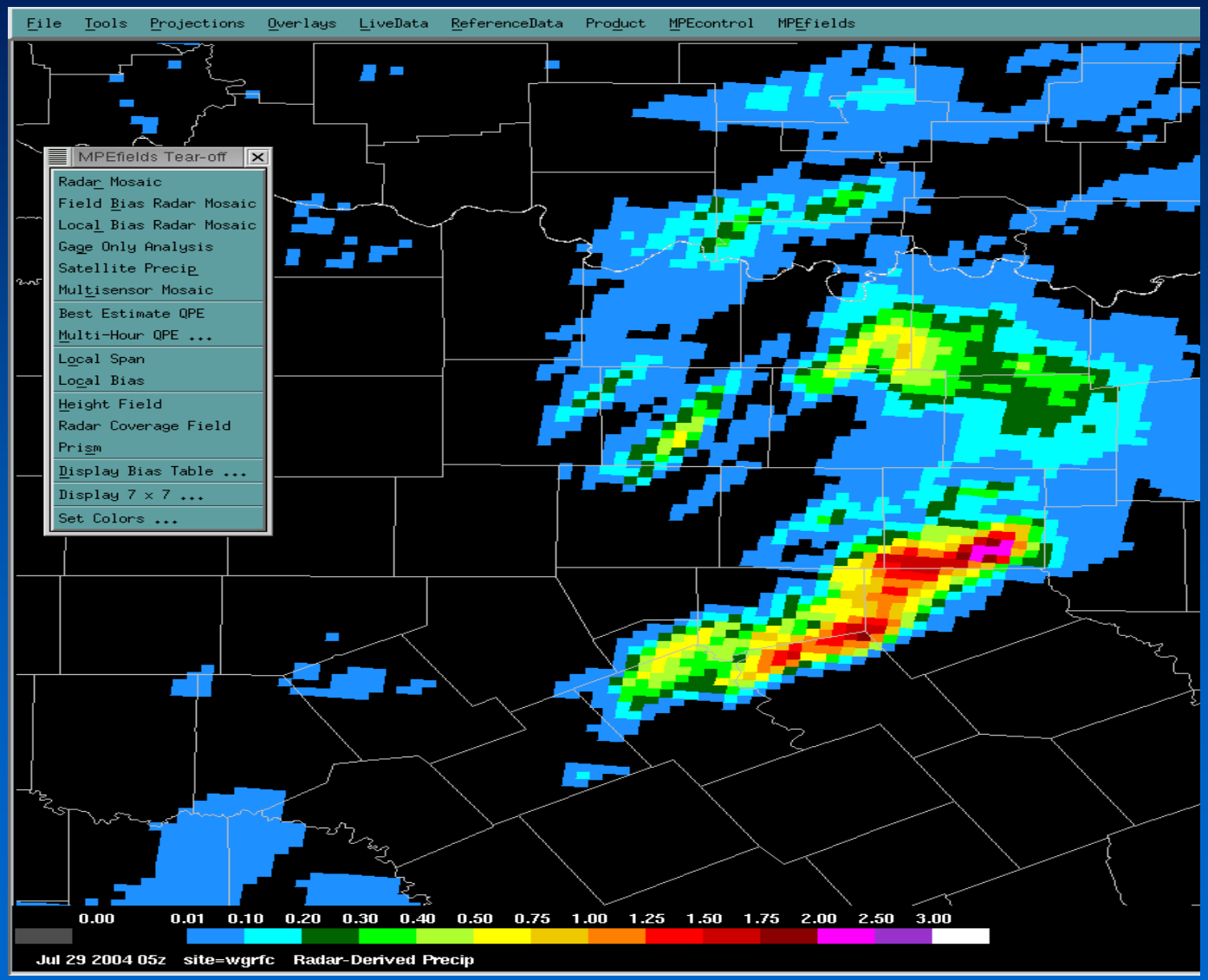
Satellite Derived Precipitation

Big Bend Region - 07/28/04



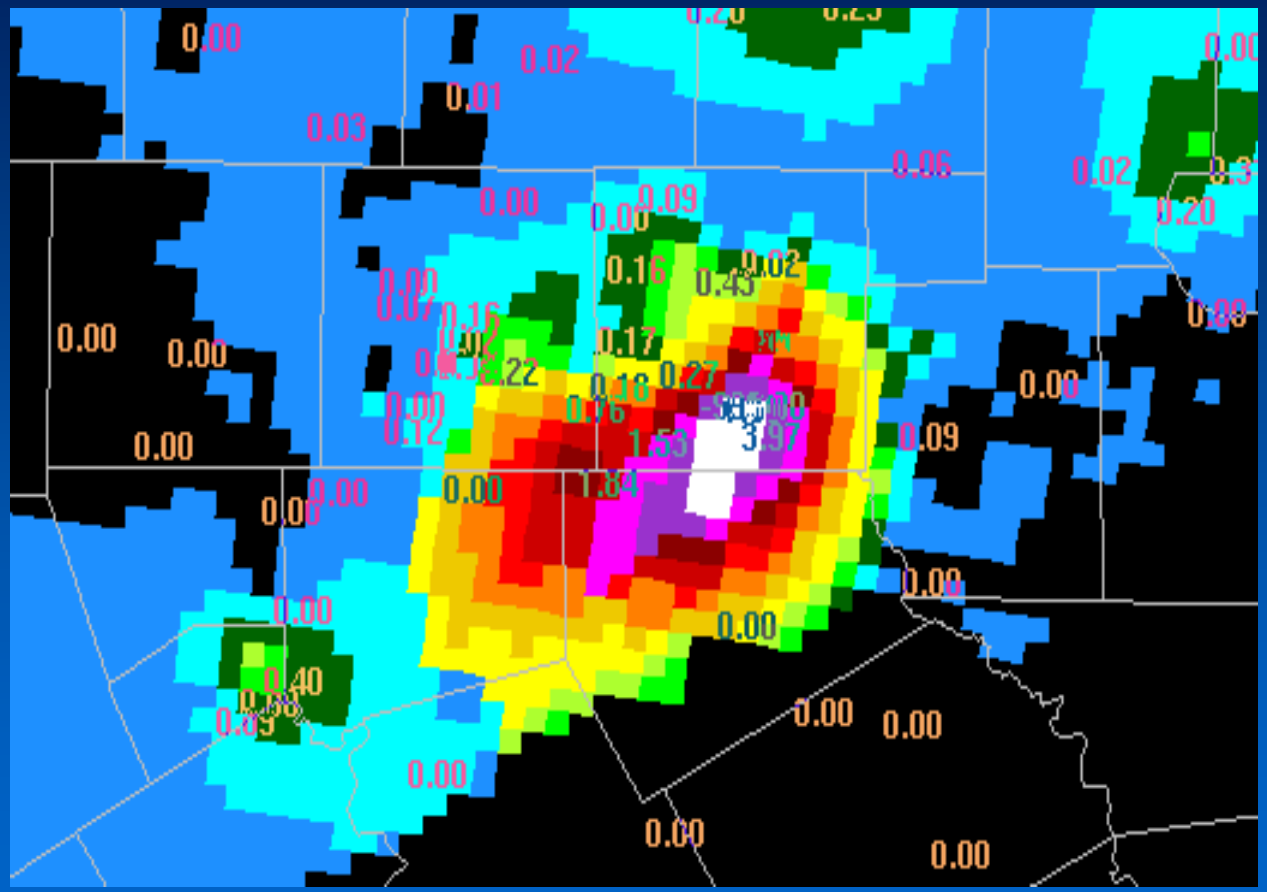
Best Estimate QPE (Multi-sensor Field)

Case #2 Dallas, TX - 7/29/04



Raw Radar Field - No bias applied

MPE Zoomed in with Rain Gauges



Dallas, TX - 7/29/04

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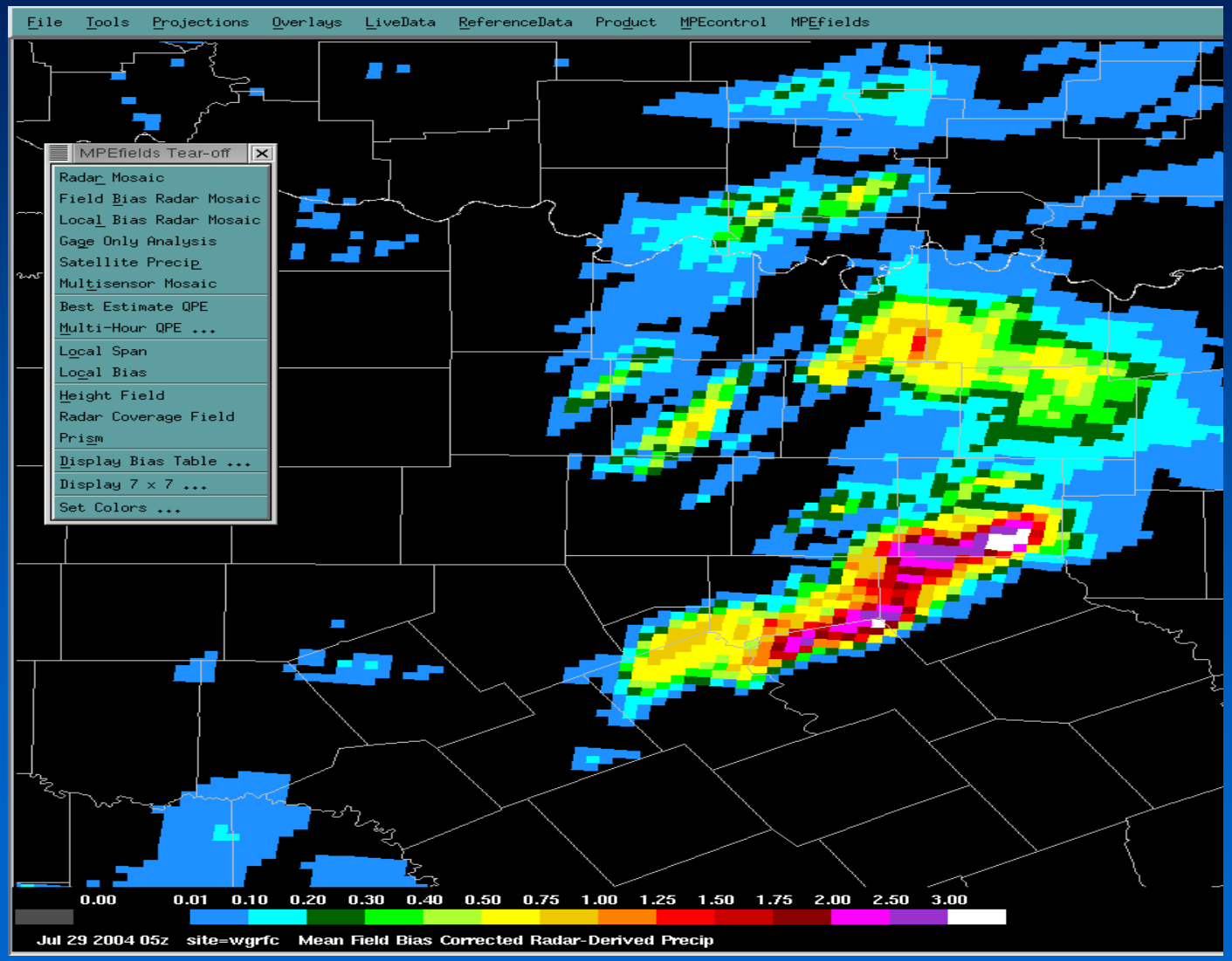
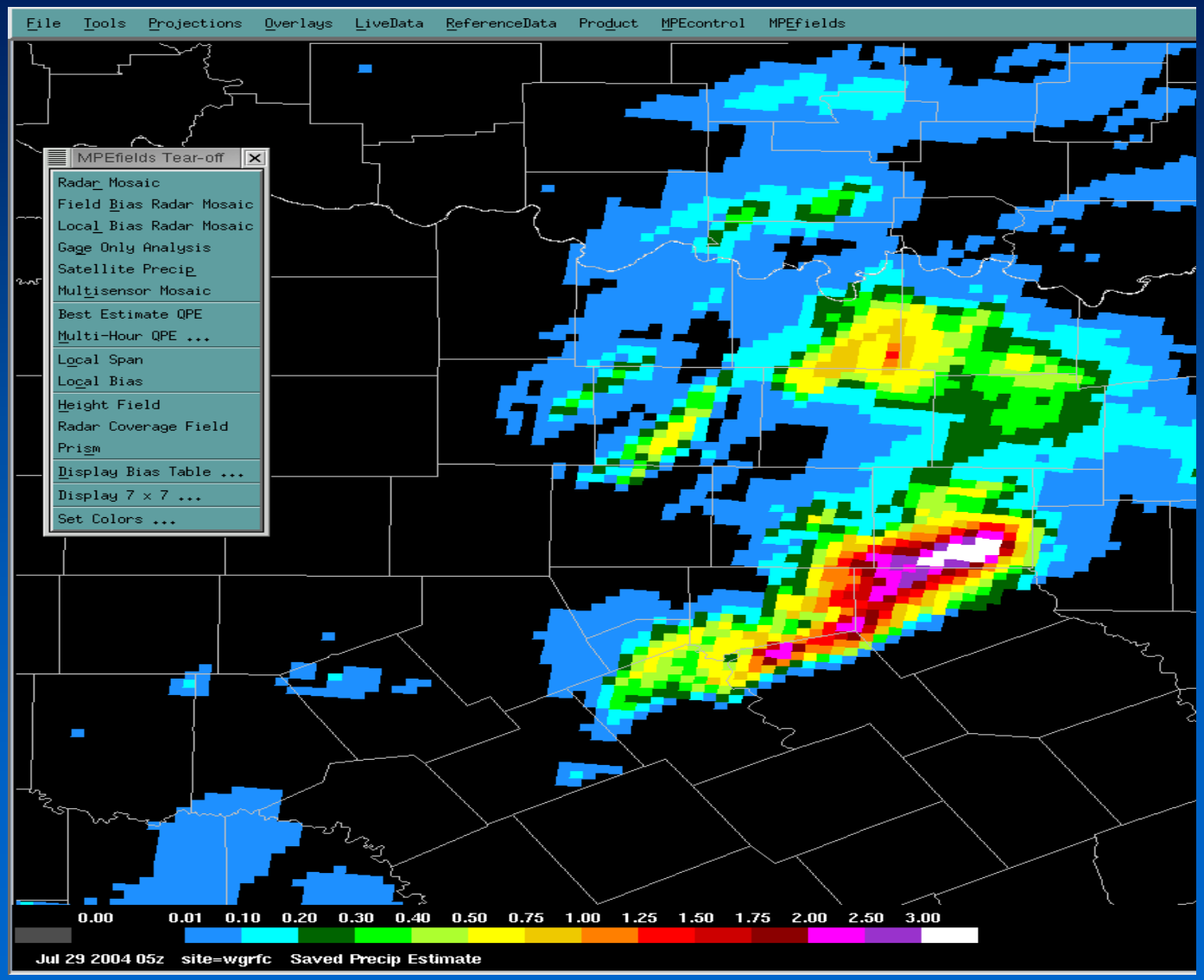


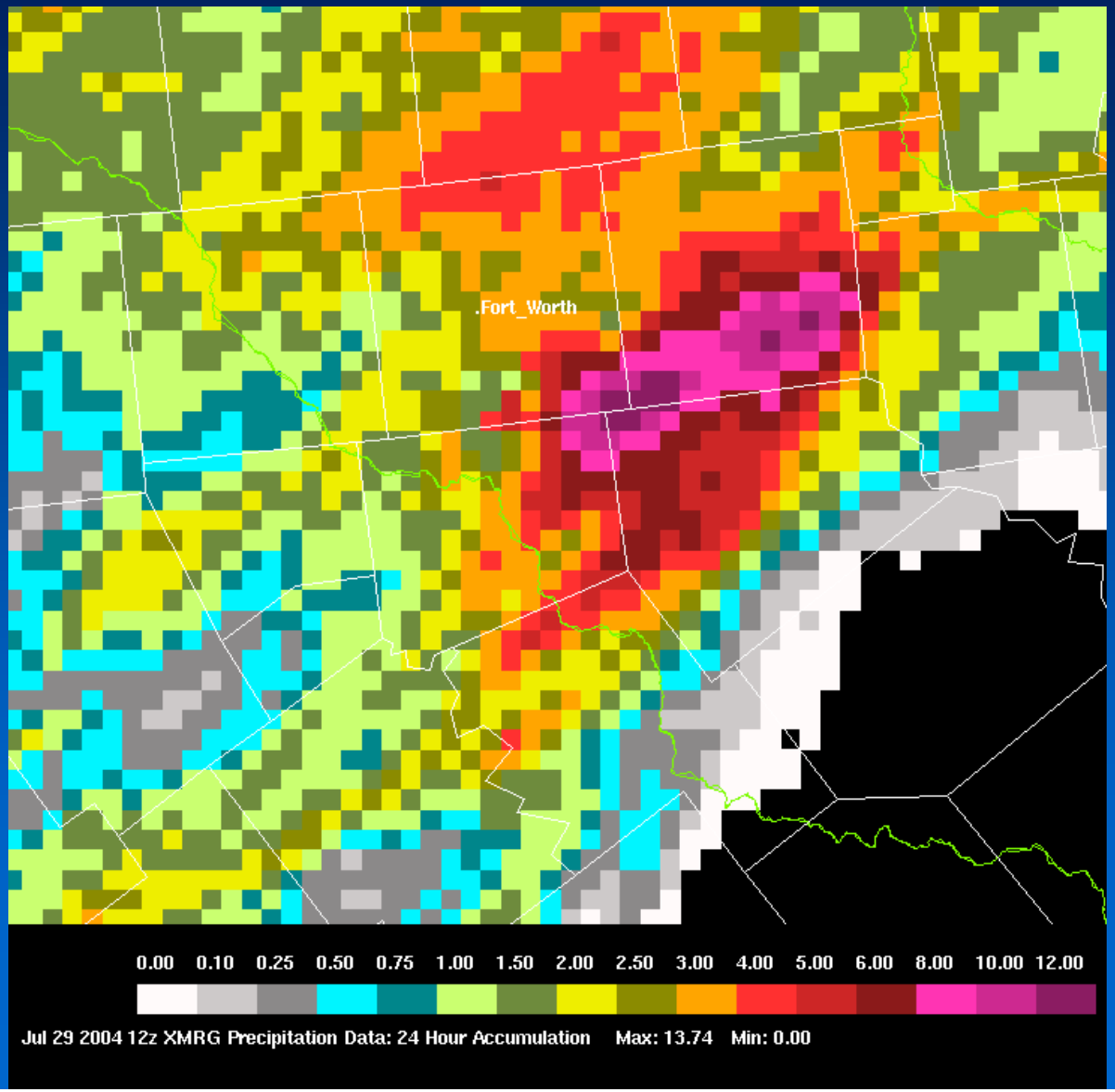
Mean Bias Field - One bias value applied to the entire radar umbrella

Dallas, TX - 7/29/04



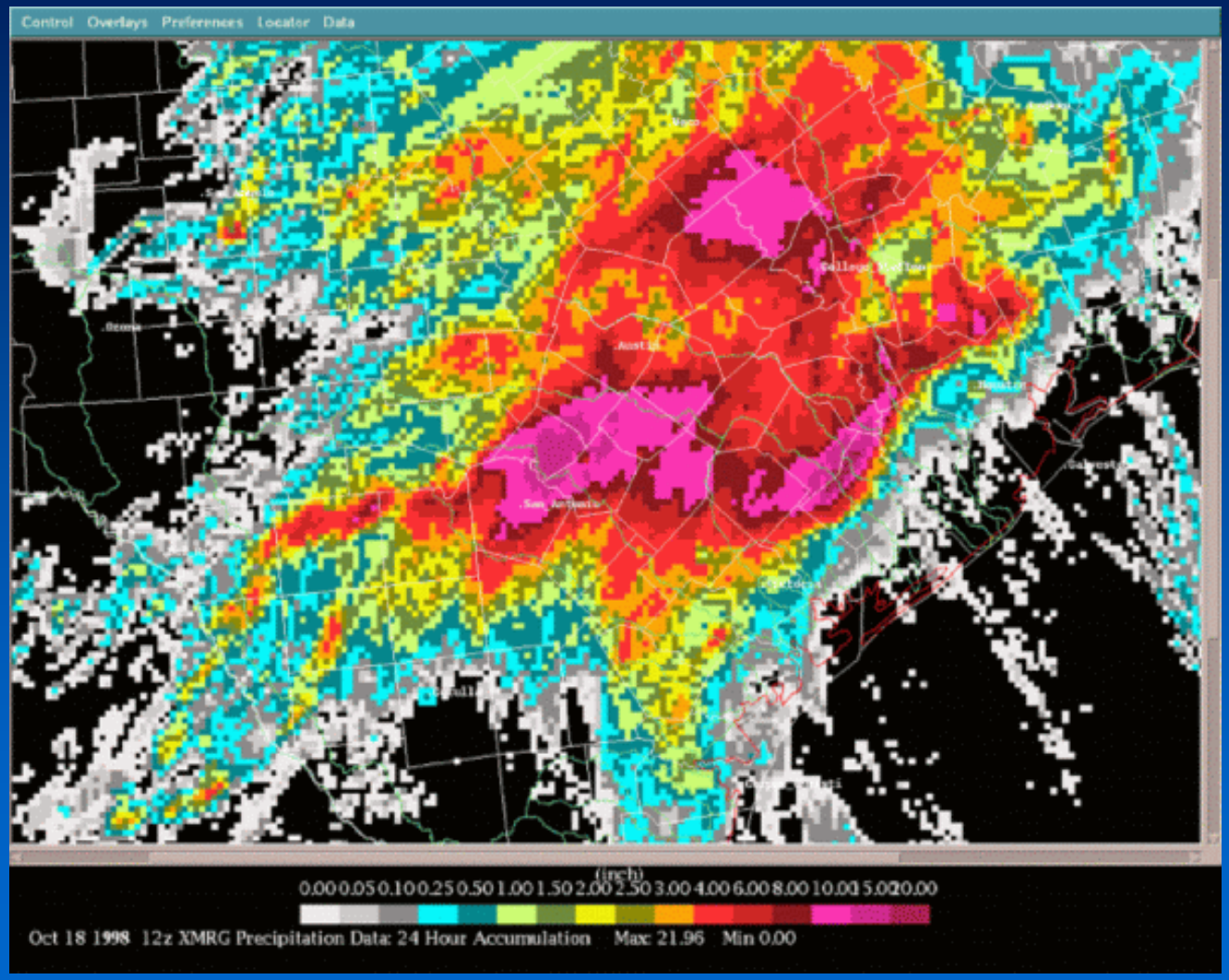
- Best Estimate QPE
- Saved Multi-sensor Field

Dallas, TX - 7/29/04



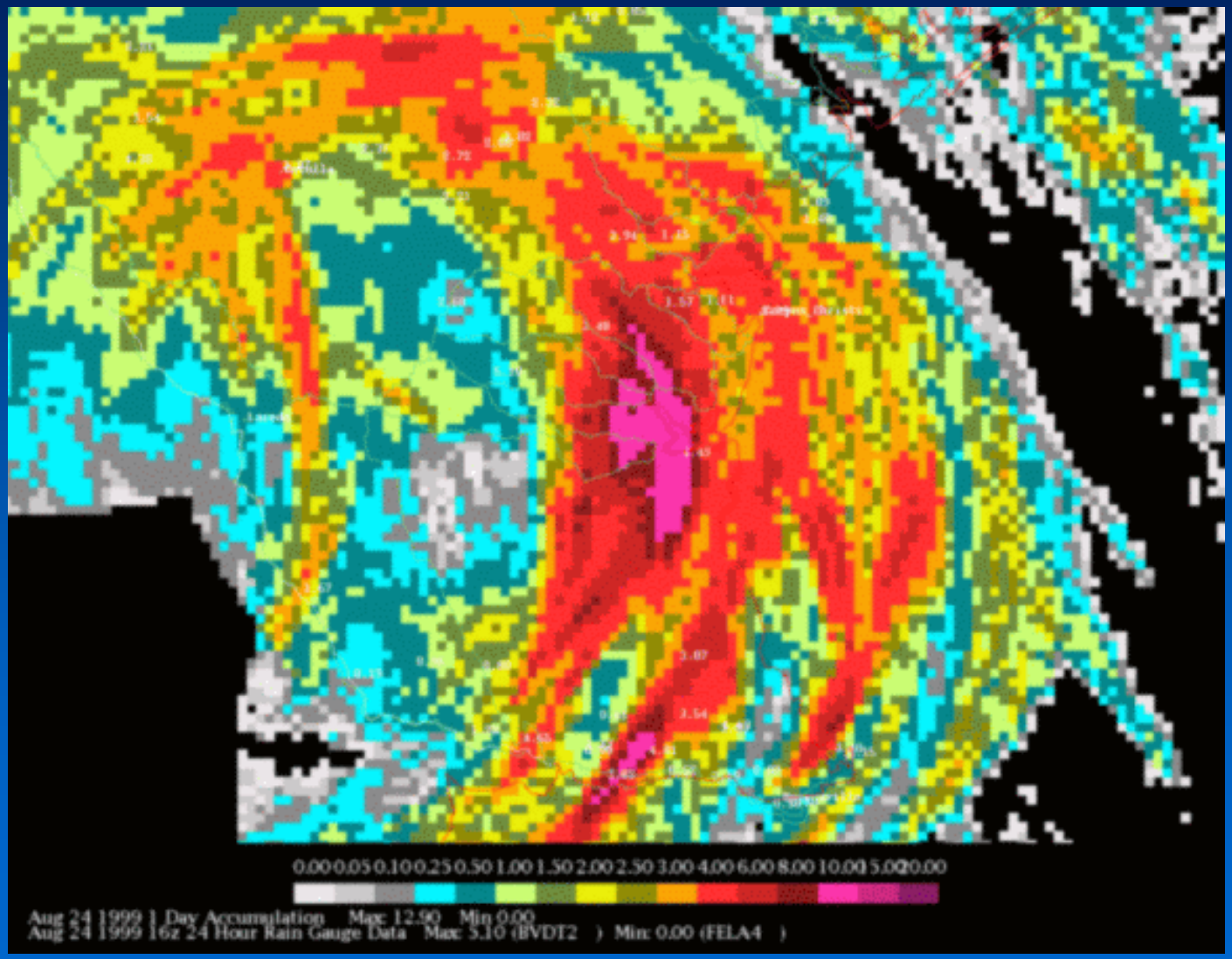
24 Hour Total Rainfall Estimate Ending 12z 7/29/04.
MPE estimate was 13.74” near Mansfield, Texas
Rain gauges confirmed 13.65”

Another Example - MPE 24 Hour Total 18 Oct 1998



Major Flooding on the Guadalupe River.
30 people killed from flooding in one day!

Hurricane Bret 24 August 1999



New on the Internet…the Latest Bias Information from our MPE

- Shows which radars our MPE program indicates to be overestimating or underestimating the rainfall
- Shows the current Z/R relationship which is being used
- Located through our WGRFC home page at

http://www.srh.noaa.gov/wgrfc/mpebias.php

An example follows…

http://www.srh.noaa.gov/wgrfc/mpe/radarbias/biasreport.09z - Windows Internet Explorer

http://www.srh.noaa.gov/wgrfc/mpe/radarbias/biasreport.09z

NEXRAD Precipitation Bias Calculated from the Multi Precipitation
Estimator for RADARS in the WGRFC Area for 2007-05-21 09:00:00 GMT.

Radar ID	Bias	Based on	#Pairs	/Gage Sum	/Radar Sum	Z=(a)R^(b)		ZR type
ABX	0.96	010 hrs	16	/ 1.36	/ 1.42	300	1.4	Convective
AMA	0.71	002 hrs	11	/ 2.00	/ 2.80	300	1.4	Convective
BRO	0.72	168 hrs	34	/ 1.34	/ 1.87	300	1.4	Convective
CRP	0.74	168 hrs	119	/ 2.37	/ 3.18	300	1.4	Convective
DFX	0.38	002 hrs	10	/ 0.52	/ 1.39	300	1.4	Convective
DYX	0.98	168 hrs	720	/ 2.51	/ 2.58	300	1.4	Convective
EPZ	0.72	168 hrs	164	/ 2.03	/ 2.80	300	1.4	Convective
EWX	0.90	010 hrs	17	/ 2.08	/ 2.31	300	1.4	Convective
FDR	0.62	168 hrs	889	/ 2.37	/ 3.85	300	1.4	Convective
FDX	0.37	002 hrs	10	/ 2.03	/ 5.45	300	1.4	Convective
FTG	1.34	168 hrs	21	/ 1.33	/ 0.99	300	1.4	Convective
FWS	0.91	168 hrs	693	/ 2.59	/ 2.84	300	1.4	Convective
GJX	1.33	168 hrs	28	/ 1.32	/ 0.99	300	1.4	Convective
GRK	1.12	168 hrs	596	/ 3.51	/ 3.14	300	1.4	Convective
HDX	0.72	168 hrs	80	/ 1.31	/ 1.83	300	1.4	Convective
HGX	0.70	168 hrs	229	/ 4.37	/ 6.21	300	1.4	Convective
LBB	0.57	002 hrs	15	/ 1.72	/ 3.02	300	1.4	Convective
LCH	0.46	168 hrs	202	/ 3.95	/ 8.59	300	1.4	Convective
MAF	0.58	002 hrs	11	/ 1.57	/ 2.71	300	1.4	Convective
POE	0.41	168 hrs	212	/ 2.92	/ 7.20	300	1.4	Convective
PUX	0.75	168 hrs	100	/ 1.36	/ 1.82	300	1.4	Convective
SHV	0.64	168 hrs	325	/ 2.80	/ 4.35	300	1.4	Convective
SJT	0.82	010 hrs	13	/ 1.13	/ 1.38	300	1.4	Convective
TLX	0.77	168 hrs	1050	/ 2.81	/ 3.66	300	1.4	Convective

* The bias values are calculated from the MPE (Multi Precipitation
Estimator) which uses 'pairs' of RADAR and rain gage data. MPE
requires at least 10 gage/radar pairs in order to calculate a bias.

Done

Radar Precipitation Estimates

Conclusions

- Hydrologic models use radar precipitation estimates from the Multisensor Precipitation Estimator Processing System for ingest
- In MPE, rain gauge networks are important to compute a bias adjustment factor which raises or lowers radar precipitation estimates
- Inaccurate precipitation estimates lead to inaccurate river forecasts

Radar Precipitation Estimates

Conclusions

- **HAS Forecasters can assist in getting better radar precipitation estimates by monitoring the adaptable parameters of each WSR-88D**
  - **HAS Forecasters do this by coordinating with NWS offices**
  - **Forecasters can anticipate the meteorological conditions which in the past have caused radar rainfall estimation inaccuracies**

Any questions?

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- Internet http://www.srh.noaa.gov/wgrfc