The NWS National QPF Verification Program

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OFFICE OF CLIMATE, WATER, AND WEATHER SERVICES

HPC

Introduction

- “Verification of direct NWP model, statistical, and forecaster value-added QPFs and PoPs is *necessary* to quantify and improve the skill of QPF/PQPF and PoP forecasts, and to assess the value-added to these forecasts at each step of the NWS [End-to-End] Forecast Process.” - Office of Meteorology (1999)
- “One of the most important components of an effective national QPF program is a comprehensive objective comparative verification system” - National Weather Service (1999)

Outline

- QPF Verification

  Subjective - visually compare area/pattern/magnitude of observed to forecast precipitation

  Model Biases - forecaster experience

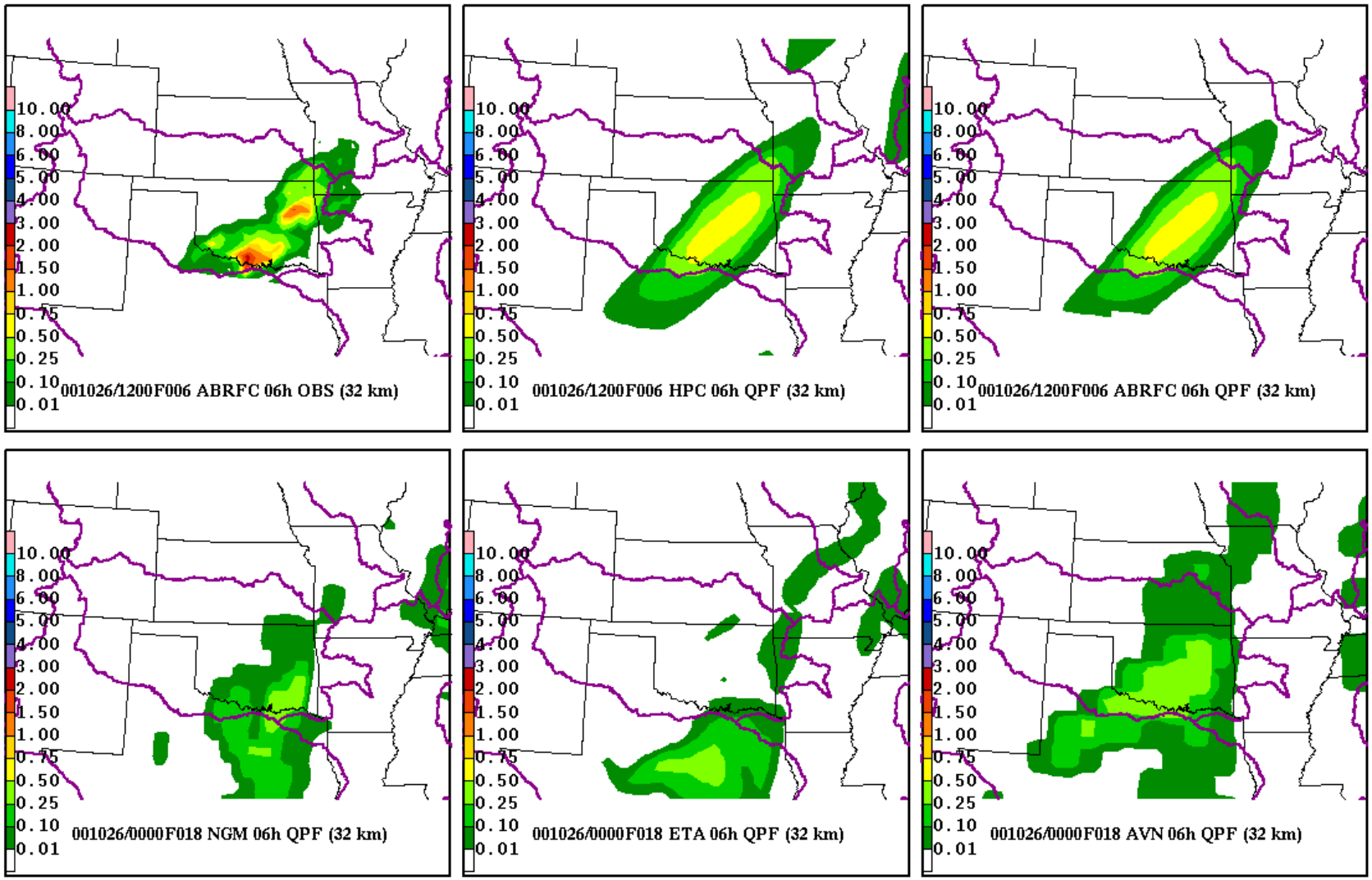
  Comparison Plots

  Objective - **comparative quantitative statistics** (measures of bias, accuracy, and/or skill) **to assess the quality** (degree of correspondence) **of QPFs** (Katz & Murphy 1997)

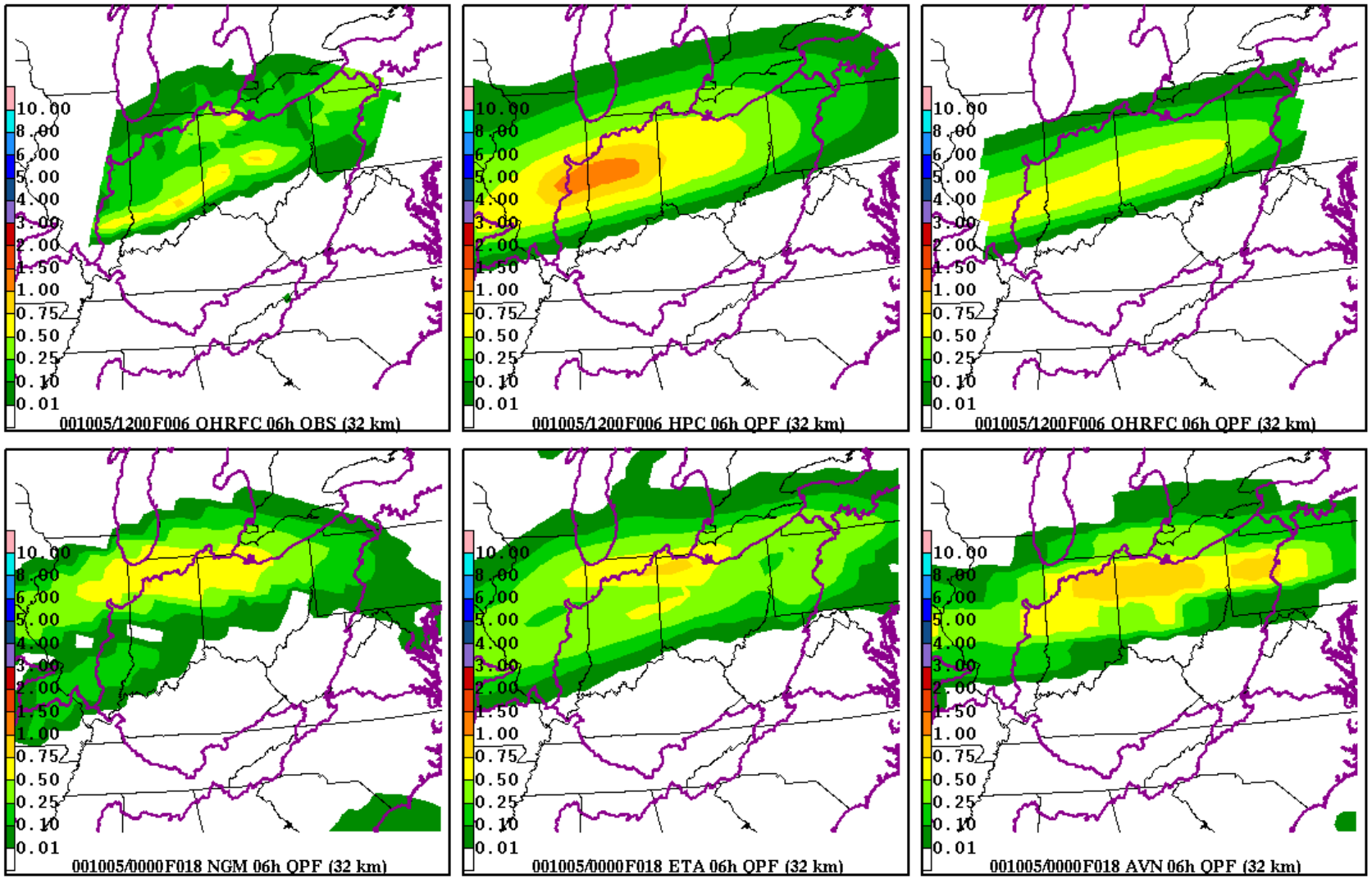
  HPC QPF Verification

  The National Precipitation Verification Unit (NPVU)

Comparison Plots



Comparison Plots (cont.)



Objective Verification

- HPC QPF Verification

  06-hour QPF Verification

Point verification system

As of Jan. 1999, no year-round, high-quality CONUS 06-hour gridded precipitation analysis existed.....yet

Uniformly distributed (almost) **600+ METAR** obs over CONUS

OBS points **QC**'d by HPC forecasters - have opportunity to modify OBS or designate as missing by comparing reports with EMC Stage IV multi-sensor precipitation estimates and other QPEs

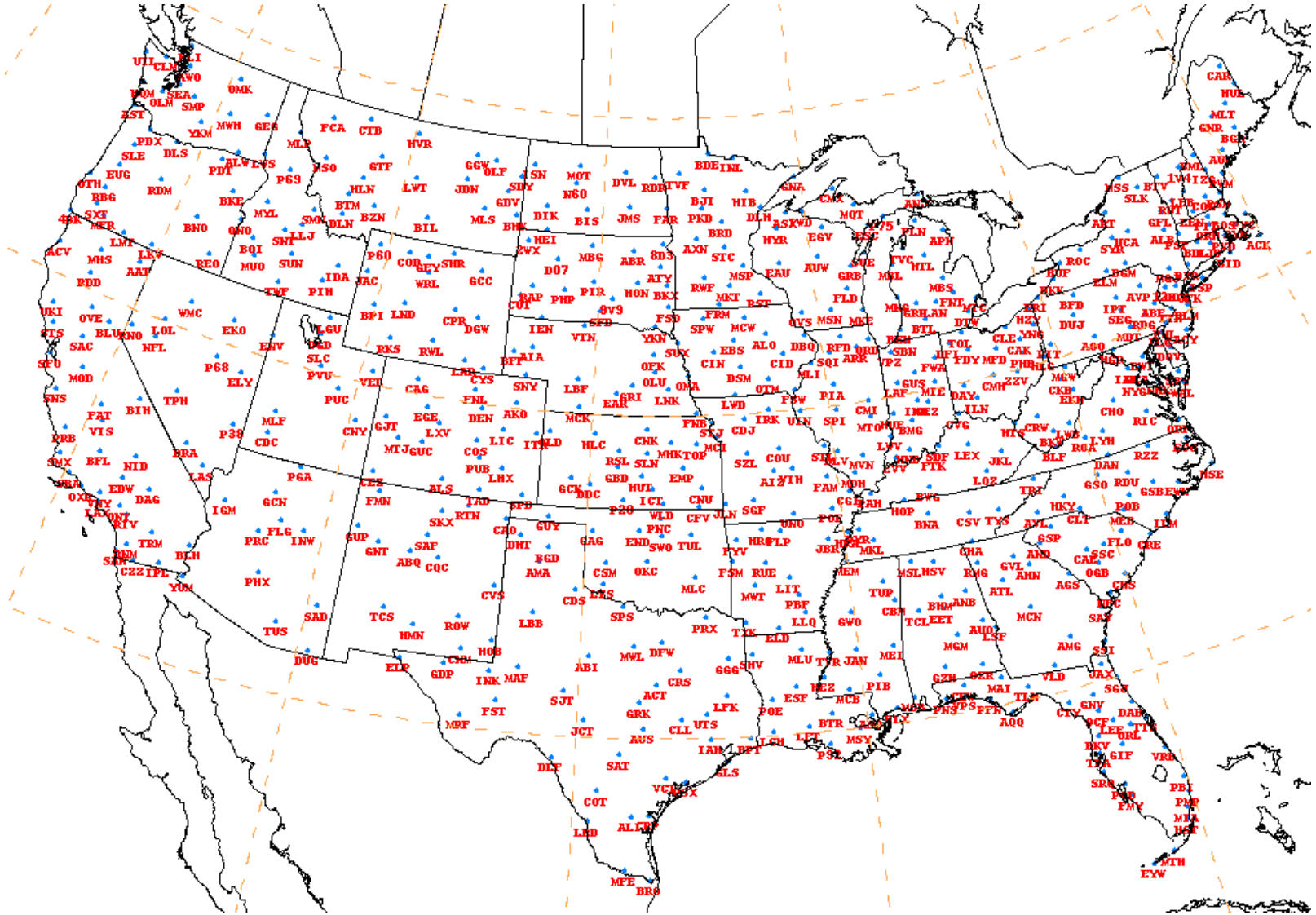
Concentrate on 0.25" and above - problems with ASOS precipitation reports

Convert All QPFs (HPC, Eta, NGM, AVN, MM5, RUC2, Eta-KF, COAMPS) to points via bilinear interpolation

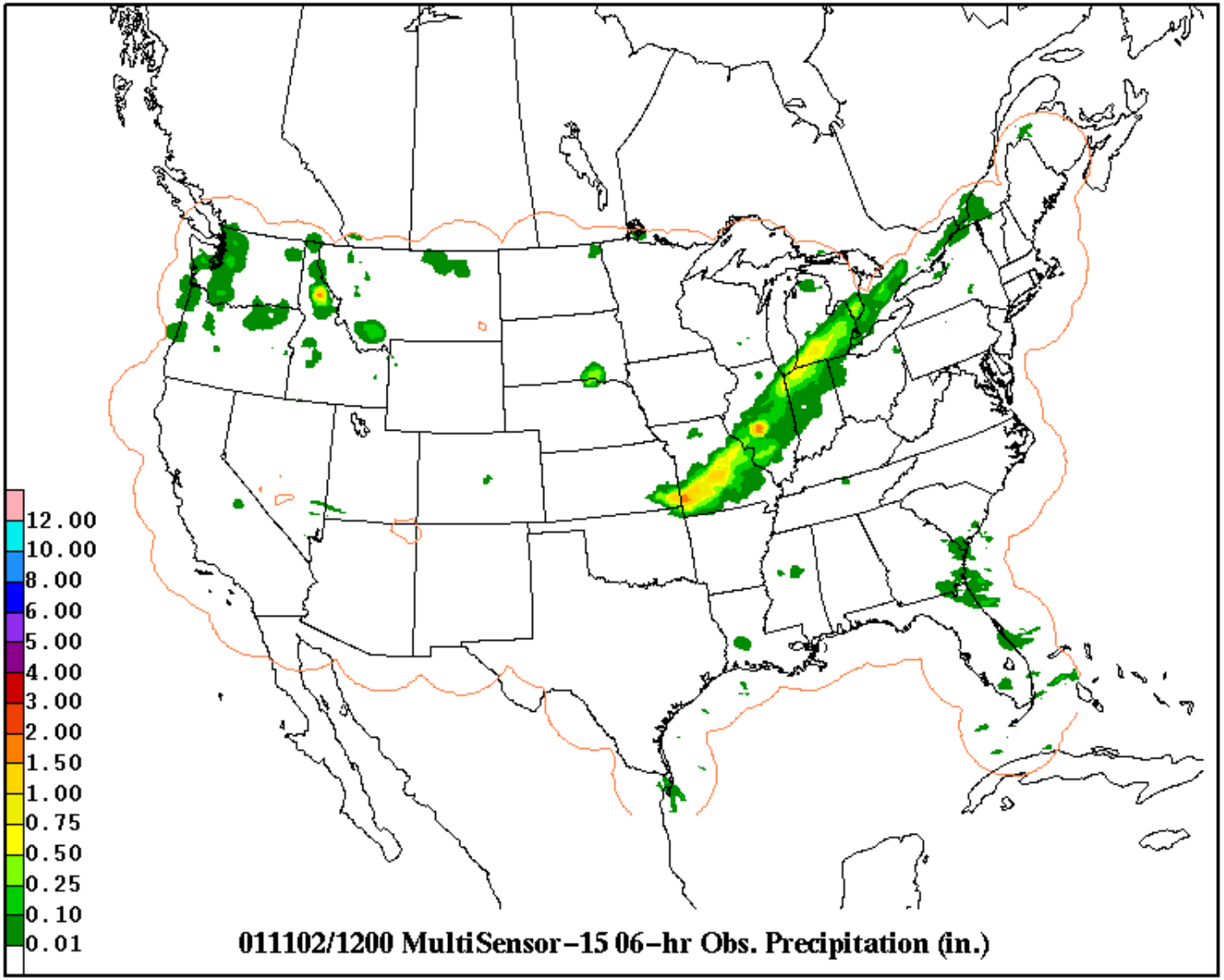
Compute Threshold Statistics beginning at 0.25" (.25", .50", 1.0", 2.0")

Threat Score, Bias Score, POD, FAR, ETS

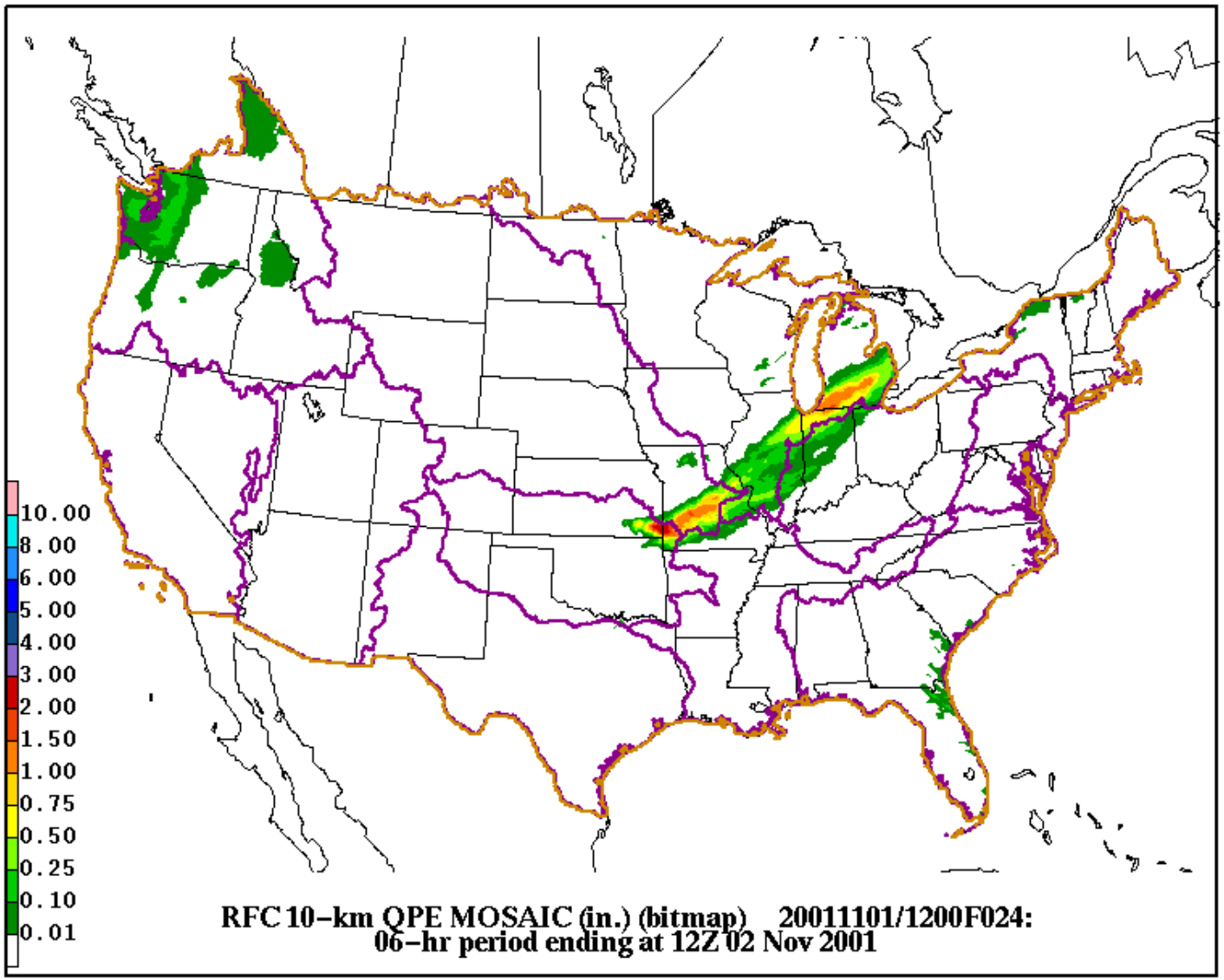
HPC QPF Verification (cont.)



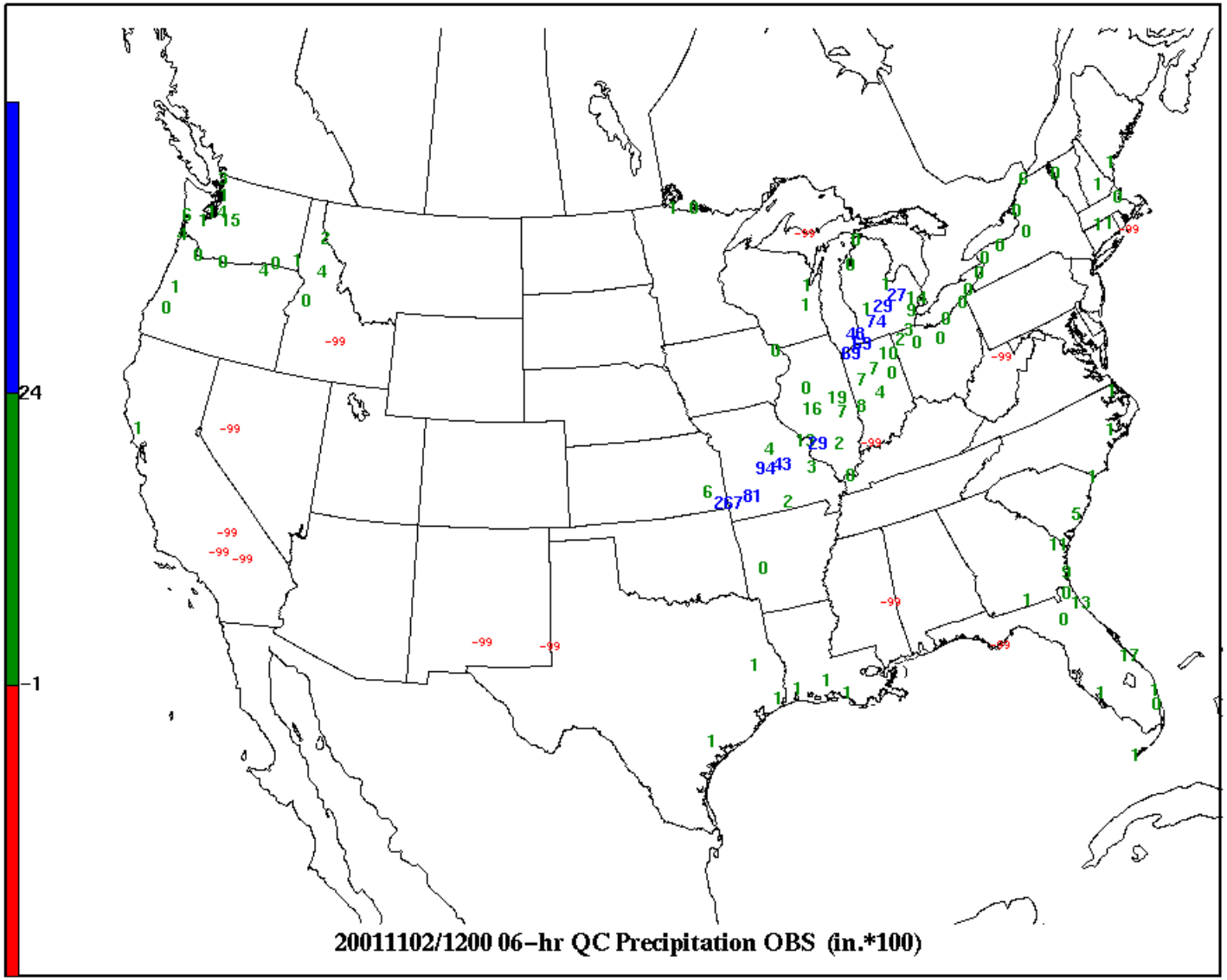
HPC QPF Verification (cont.)



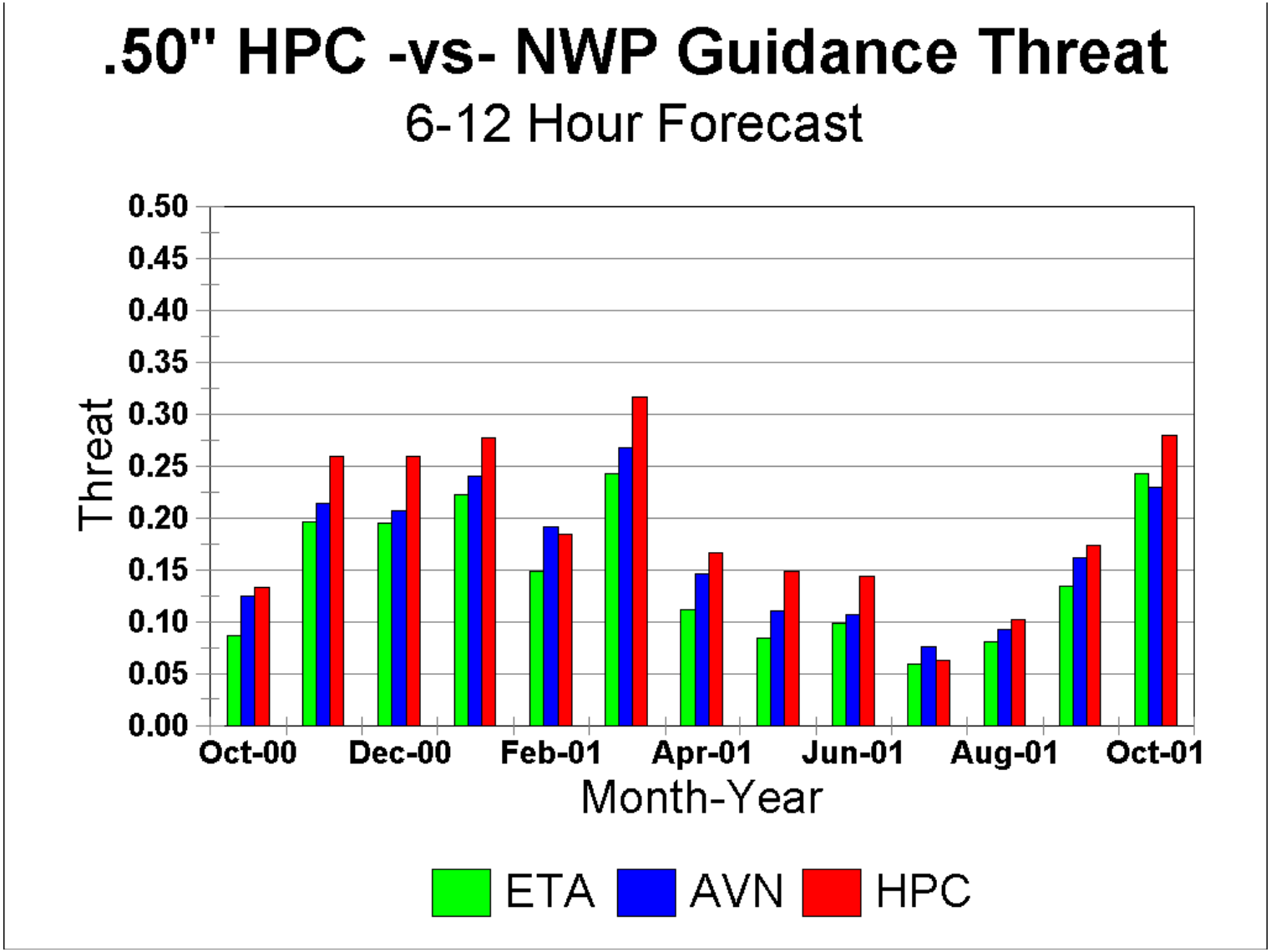
HPC QPF Verification (cont.)



HPC QPF Verification (cont.)



HPC QPF Verification (cont.)



HPC QPF Verification (cont.)

24-hour QPF Verification - 30+ years

Gridded verification system

Up until Dec. 1998, Polar Stereographic **30 km** Grid with normalization
Since Jan. 1999, Lambert Conformal **32 km** Grid with normalization
CONUS land & near-coastal water areas

First Guess Analysis Field

24-hour gauge-only precipitation observations on IBM SP
EMC Stage III analysis algorithm on 4 km grid remapped to 32km grid
or CPC 0.25 degree analysis remapped to 32km grid

HPC Manual Modification of First Guess using 24-hr gauge observations

CPC data - HYD bulletins, STP Summaries, etc.
METAR & SYN OBS
CNRFC & NWRFC QC'd obs
Analyze 0.50", 1.00", 2.00", etc. contours

HPC QPF Verification (cont.)

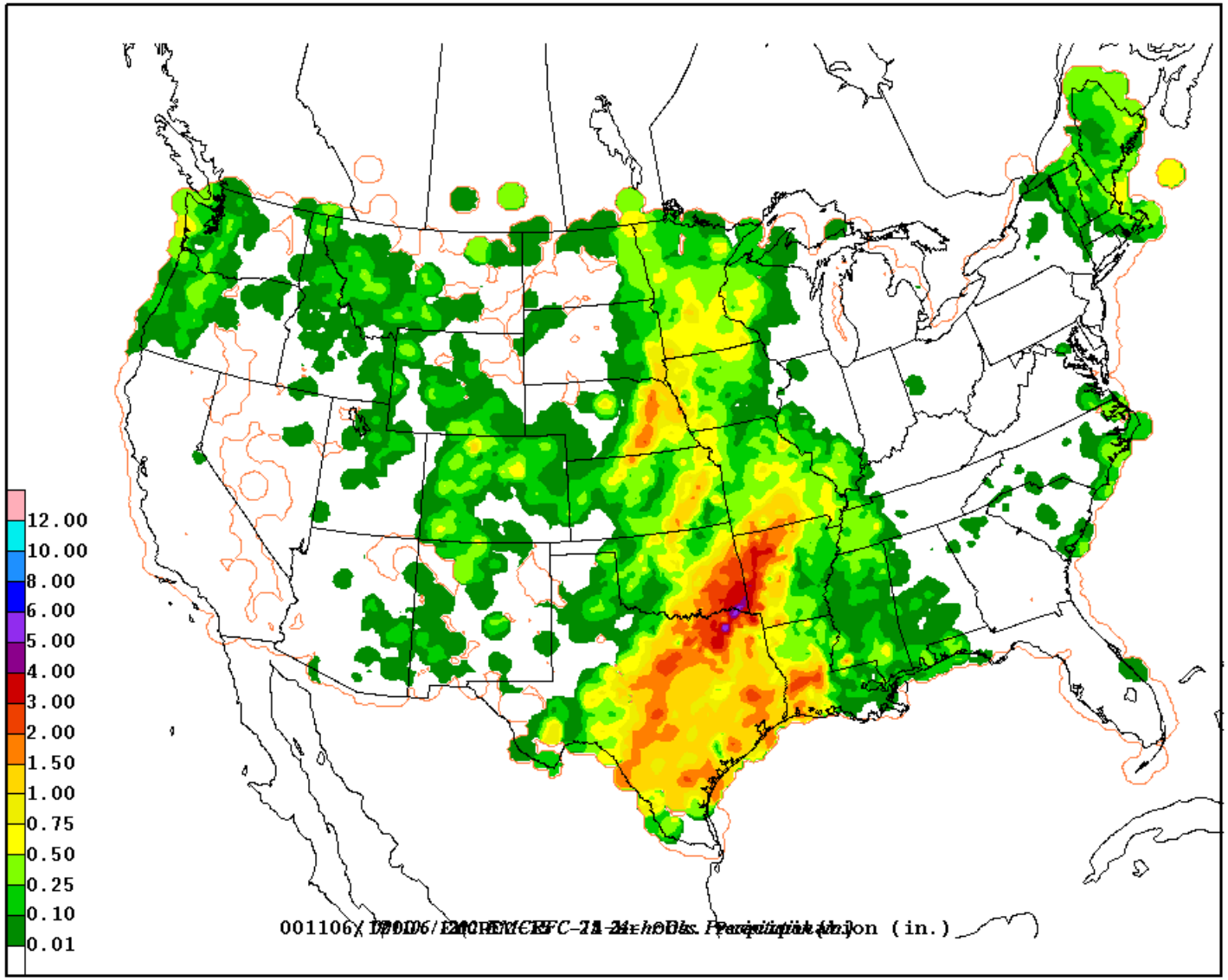
Convert Final Analysis to 32 km Verification Grid
- NAWIPS “Graph-to-Grid”

Remap All Forecast Products to 32 km Verification Grid
- HPC, Eta, NGM, AVN, Eta-KF, MM5, COAMPS
- Area-Preservation Technique (EMC - Mesinger, Baldwin)

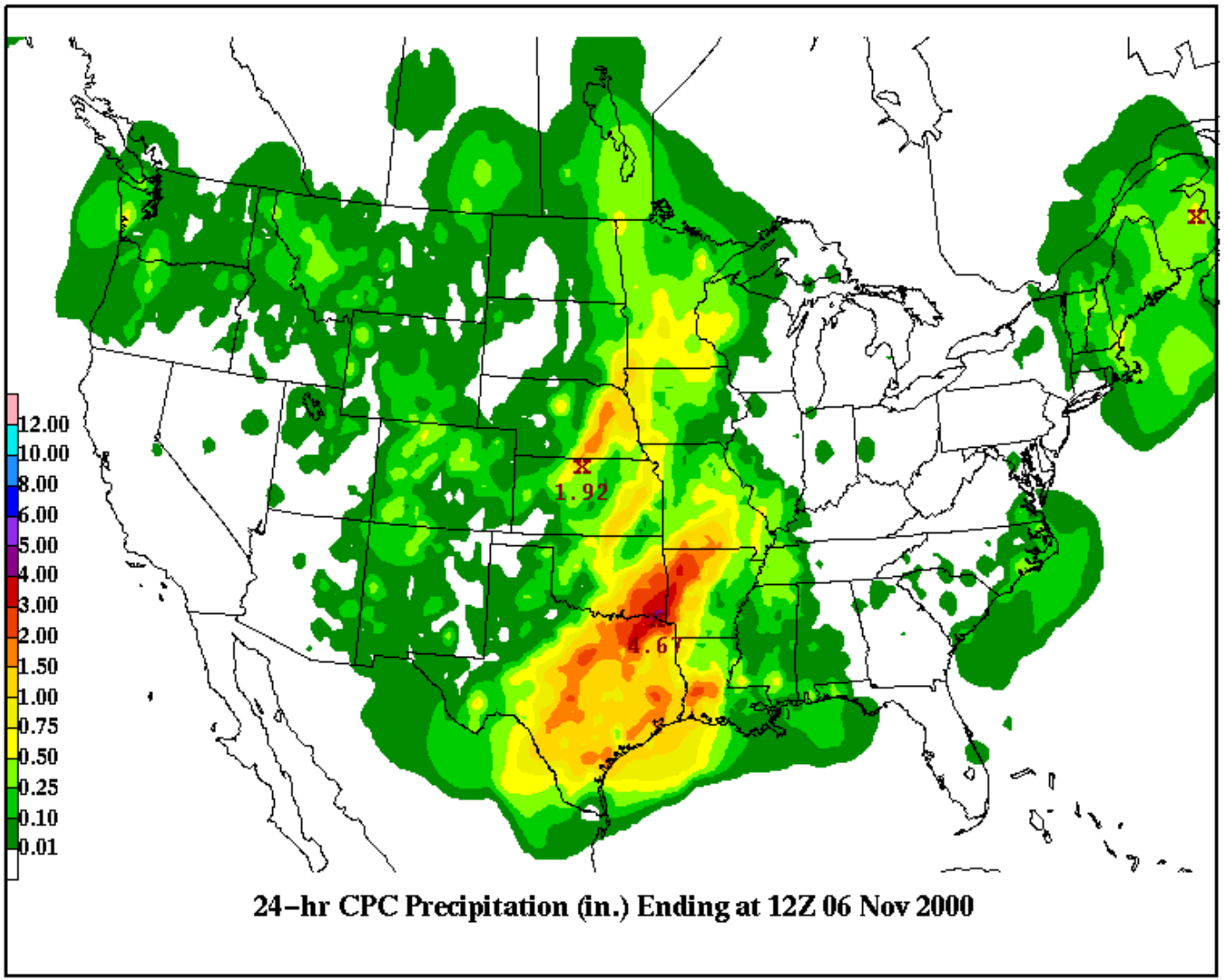
Compute Threshold Statistics beginning at 0.50” (.50”, 1.0”, 2.0”,..., 6.0”)
- Threat Score, Bias Score, POD, FAR, ETS

Available at **http://www.hpc.ncep.noaa.gov/html/hpcverif.html**

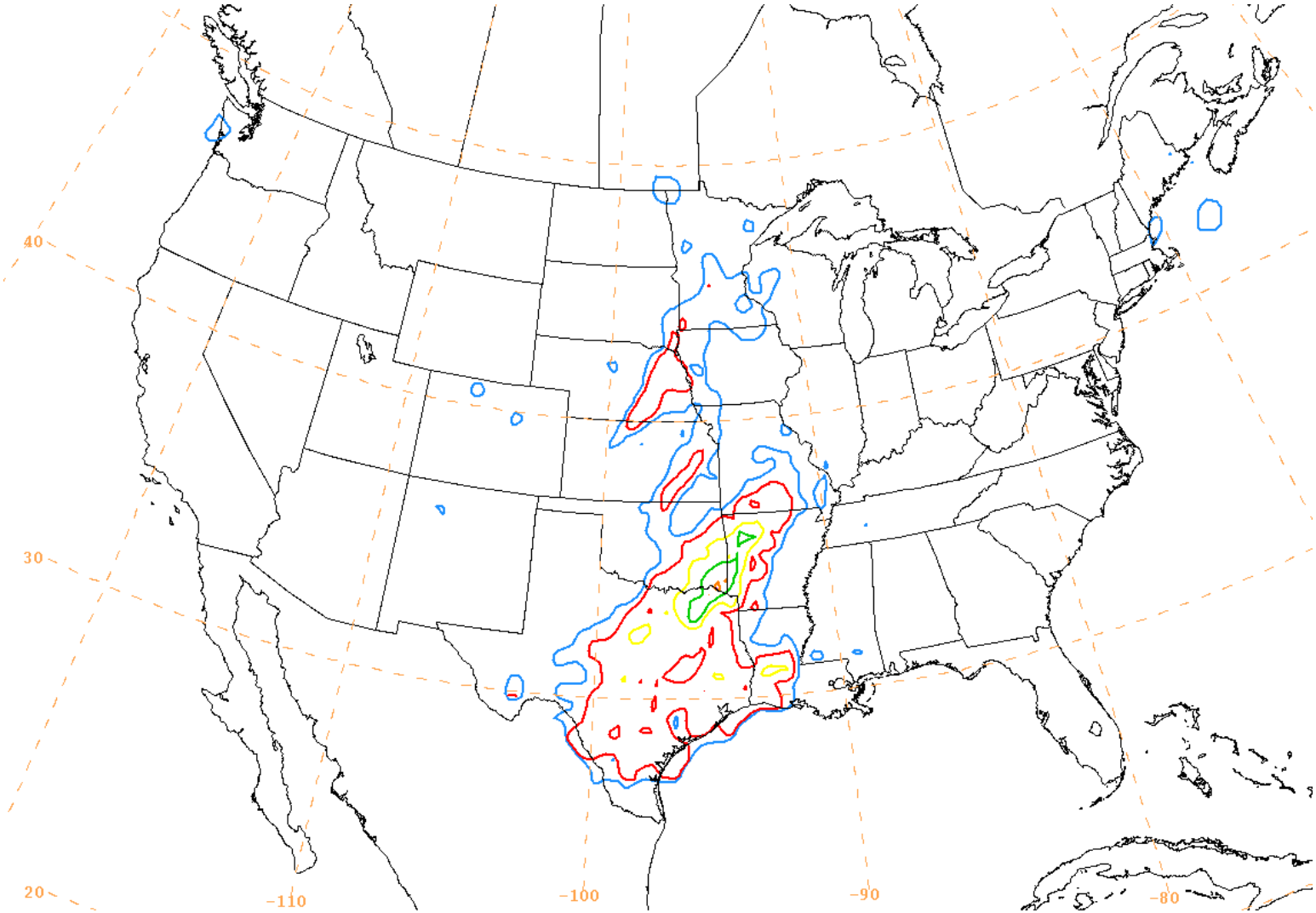
HPC QPF Verification (cont.)



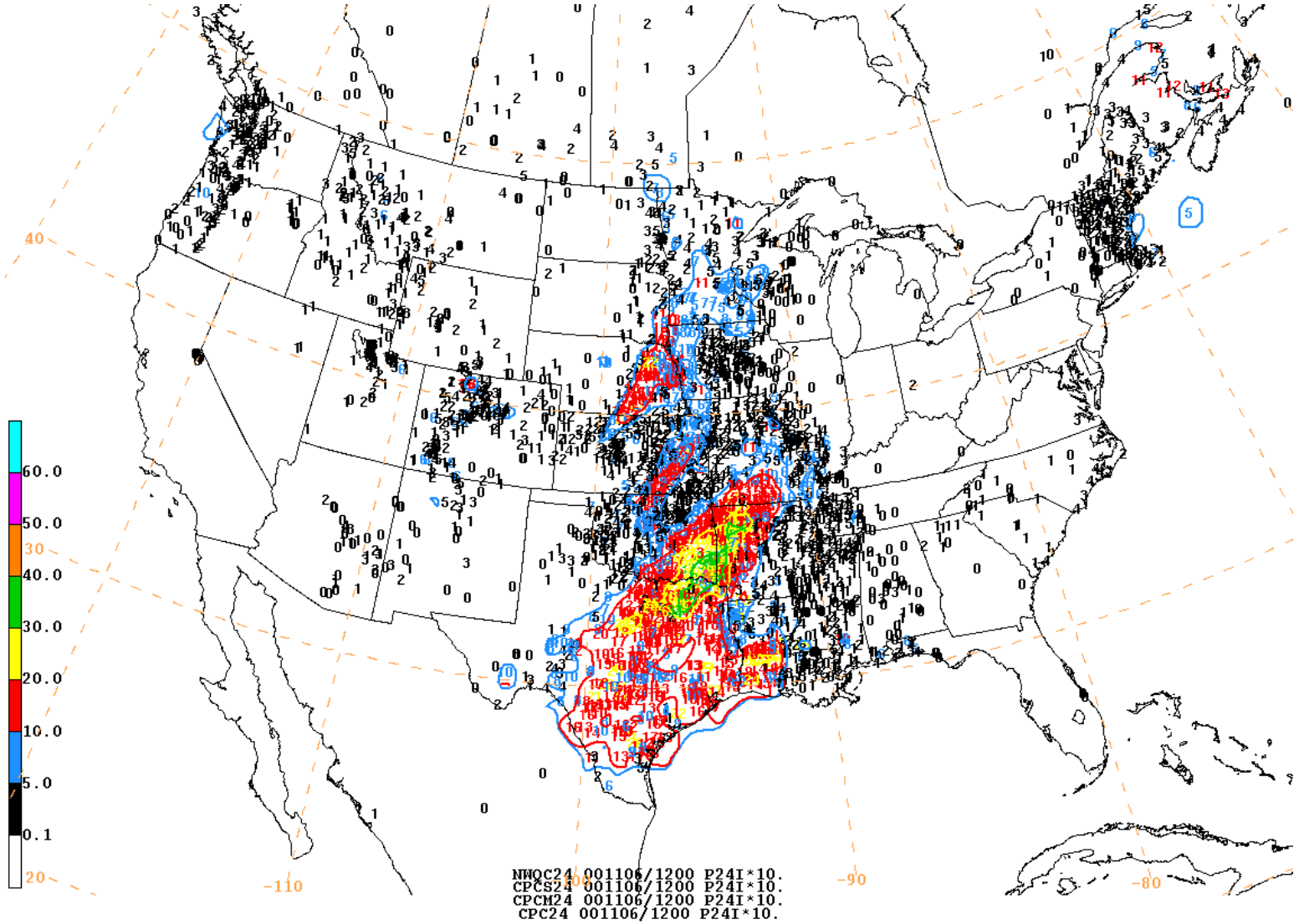
HPC QPF Verification (cont.)



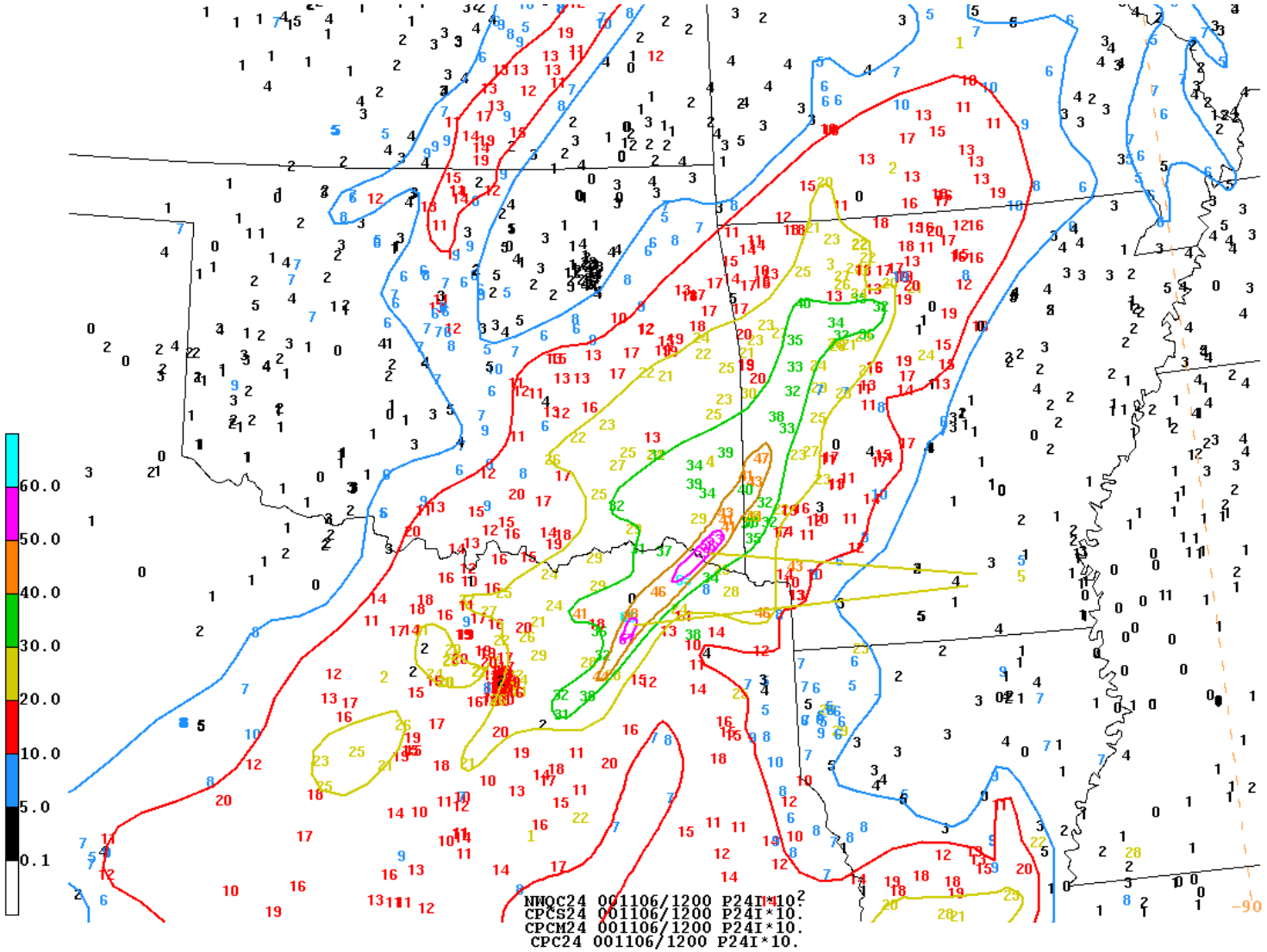
HPC QPF Verification (cont.)



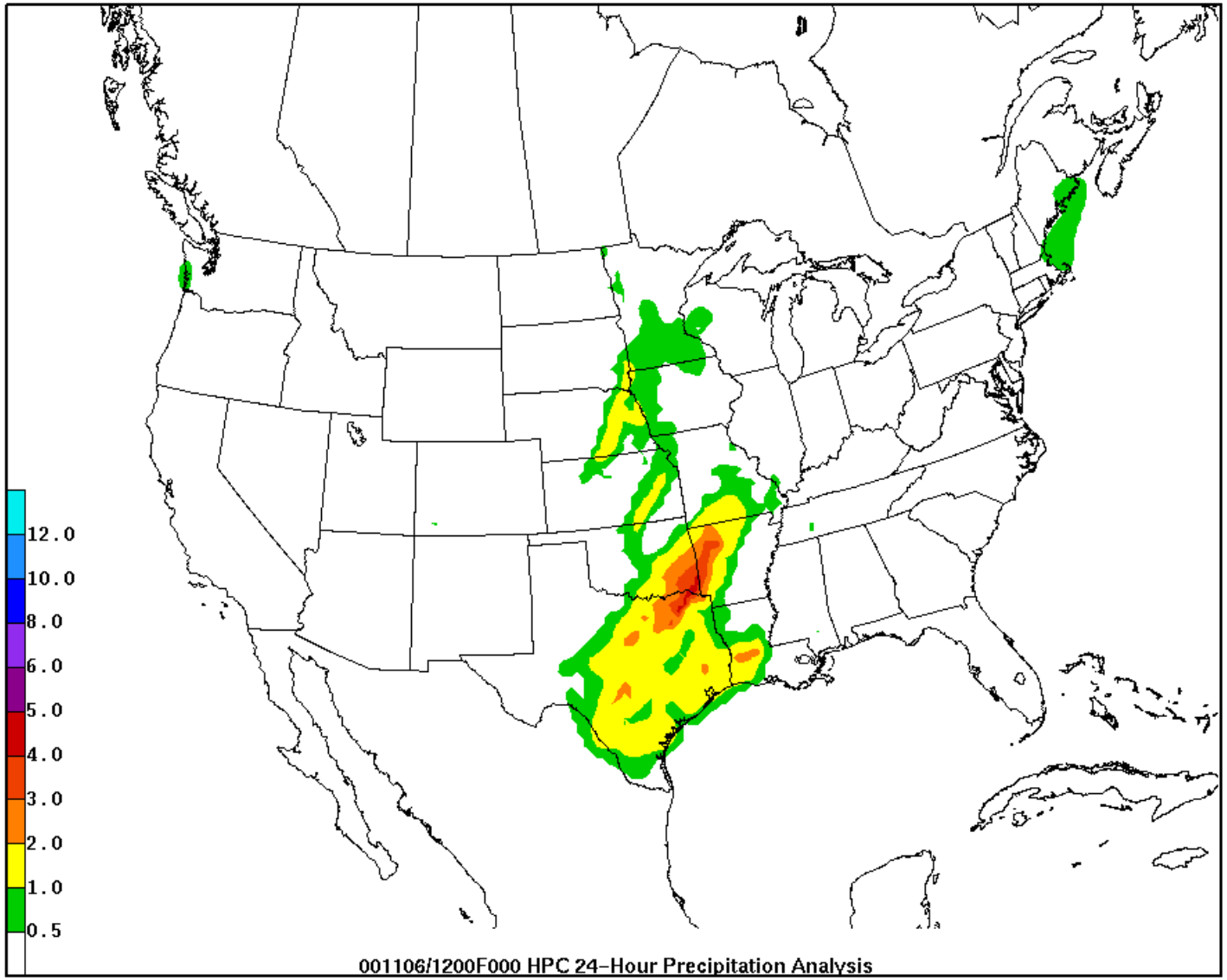
HPC QPF Verification (cont.)



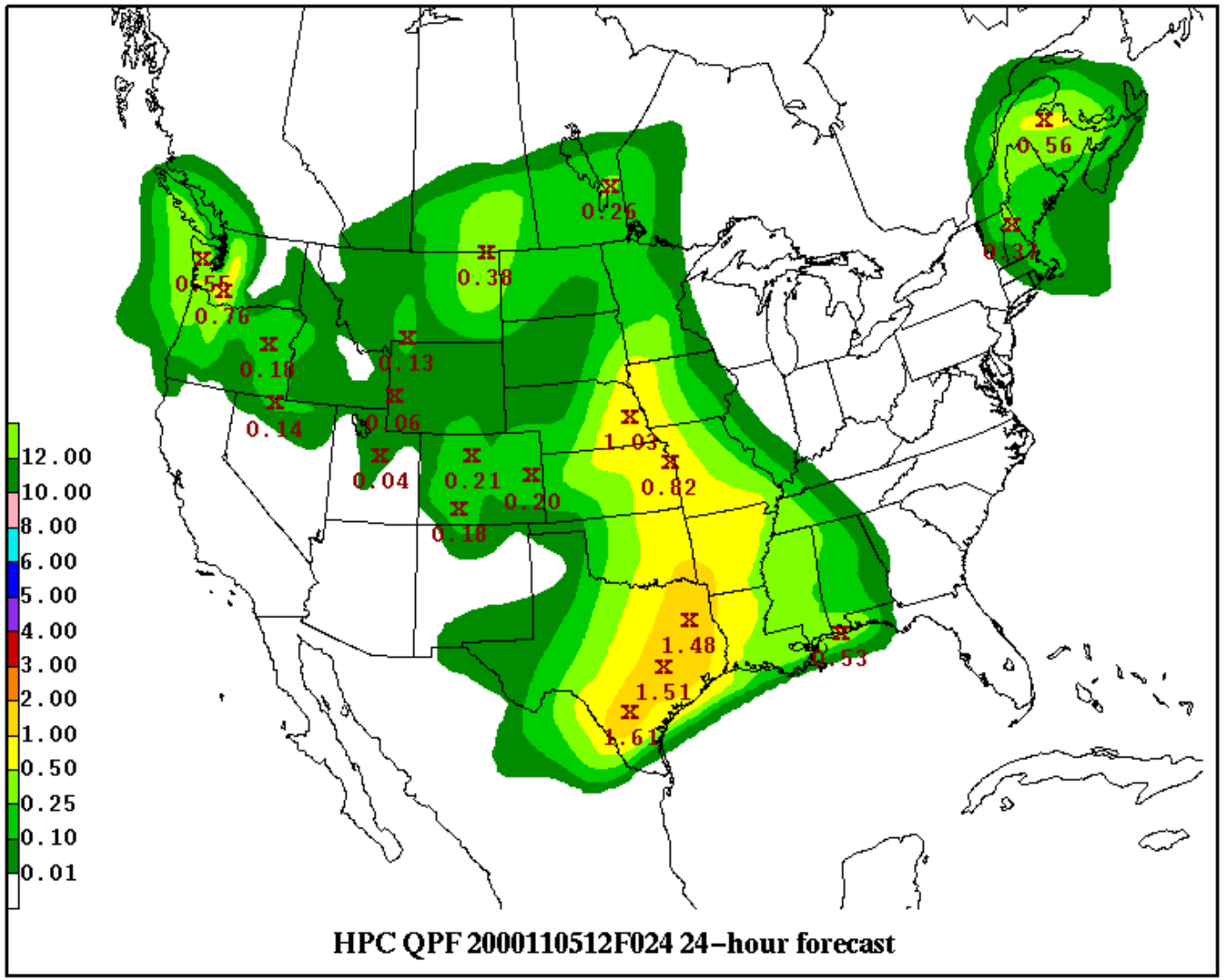
HPC QPF Verification (cont.)



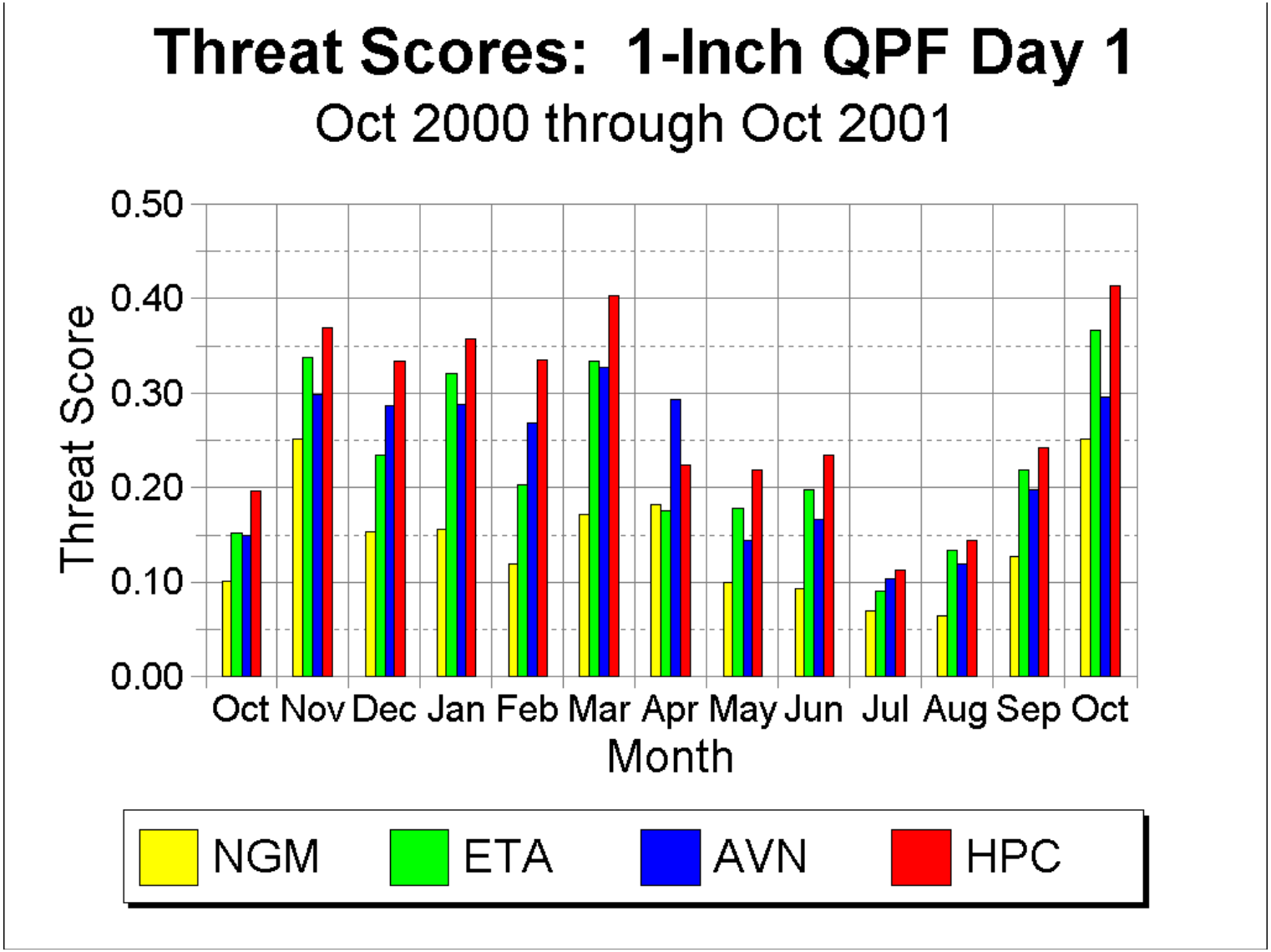
HPC QPF Verification (cont.)



HPC QPF Verification (cont.)



HPC QPF Verification (cont.)



Objective Verification (cont.)

- The National Precipitation Verification Unit (NPVU)

  Established & administered by the NWS Office of Climate, Water, and Weather Services

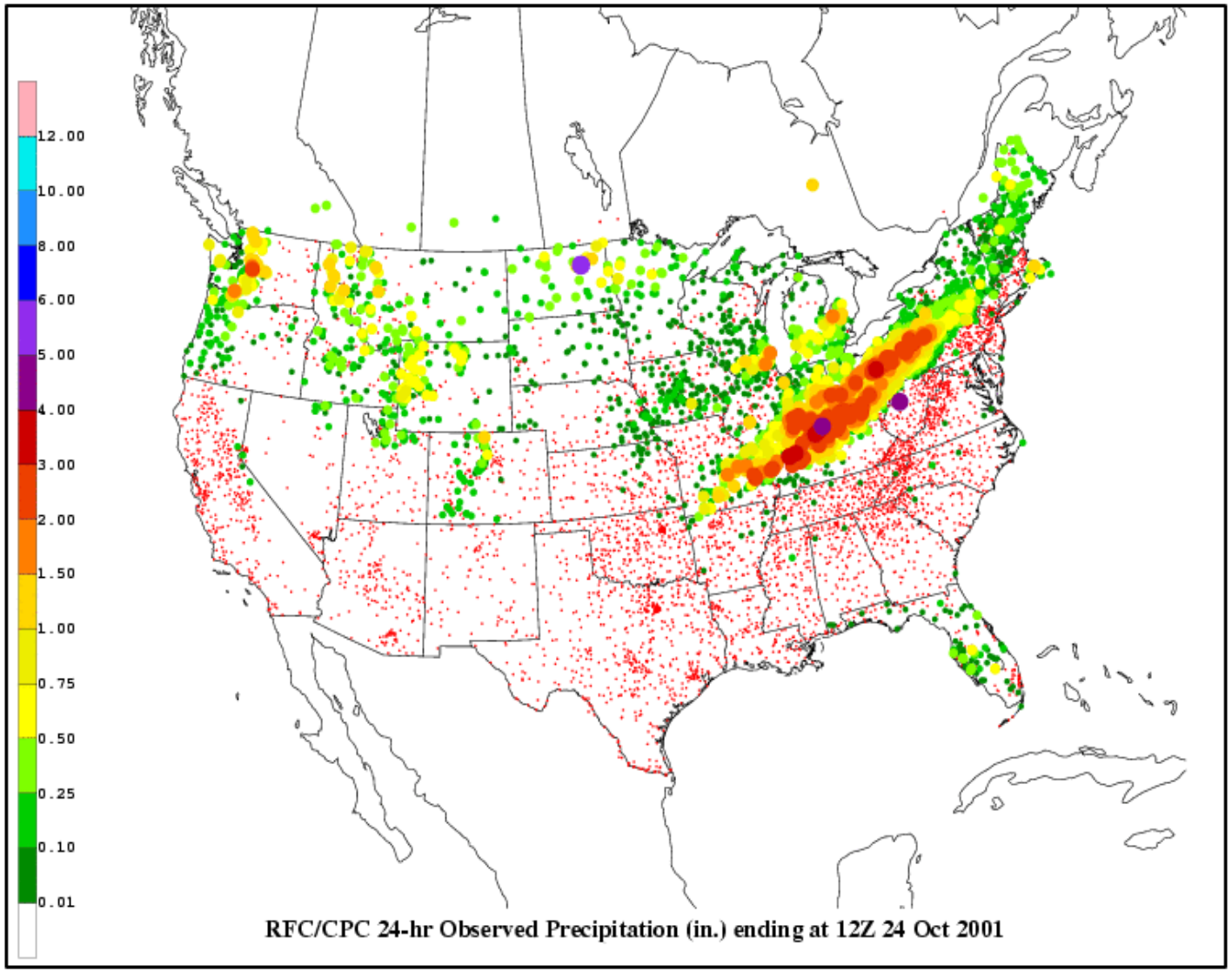
  Located at & co-managed by the NCEP Hydrometeorological Prediction Center

  Purpose is to provide **timely & informative** QPF verification scores to HPC, RFC, & WFO forecasters, EMC & MDL modelers, and NWS management

NPVU

- Uniform QPF Verification Program
  - Prototype development for the QPF Process Assessment & Western Region Follow-on Assessment
  - Central location where verification statistics are computed in the same manner everywhere
  - Raw Data decoded into GEMPAK file formats - both types are archived
- Data Ingest & Archival - Observations
  - Point Observations:
    - RFC HYD Bulletins
    - 06- and/or 24-hour amounts
    - Quality Controlled
    - SHEF -> GEMPAK surface files

NPVU (cont.)


12.00
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RFC/CPC 24-hr Observed Precipitation (in.) ending at 12Z 24 Oct 2001

NPVU (cont.)

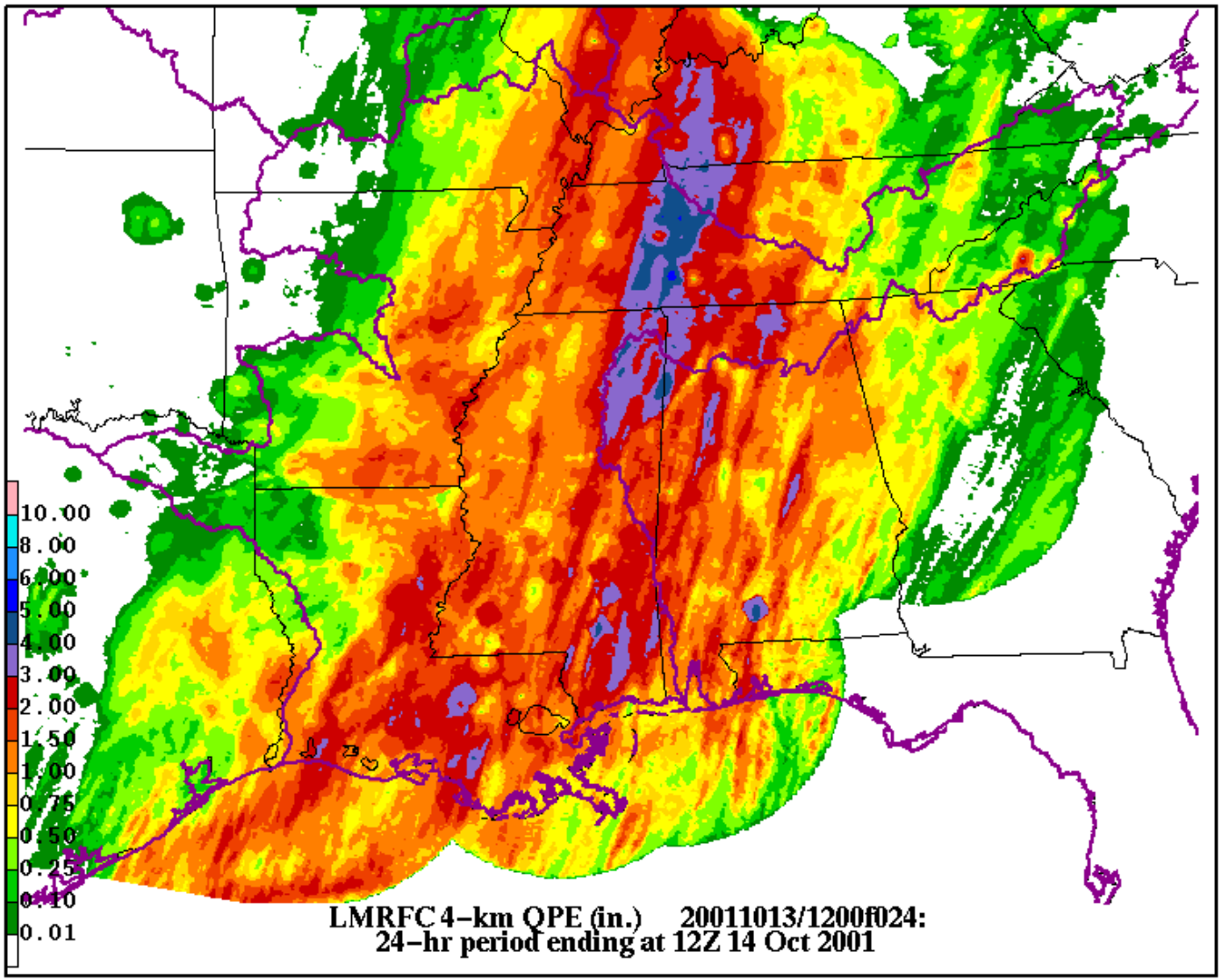
Gridded Quantitative Precipitation Estimates (QPEs):

- From the River Forecast Centers
- Multi-Sensor Data from Stage III, RFC-Wide, P1, or Mountain Mapper
- **Q**uality **C**ontrolled
- HRAP grid (4 km) resolution of 06-hr amounts
- Mosaic RFC QPEs together (using bitmaps of RFC domains) for CONUS - sent out on AWIPS in Build ?.?
- Remap 4 km grids to 32 km verification grid using Grid-Averaging Technique
- GRIB -> GEMPAK gridded files

Mean Area Precipitation (MAP) Amounts:

- From the River Forecast Centers (NPVU does/will not generate MAPs because process differs at each RFC)
- SHEF -> GEMPAK surface files

NPVU (cont.)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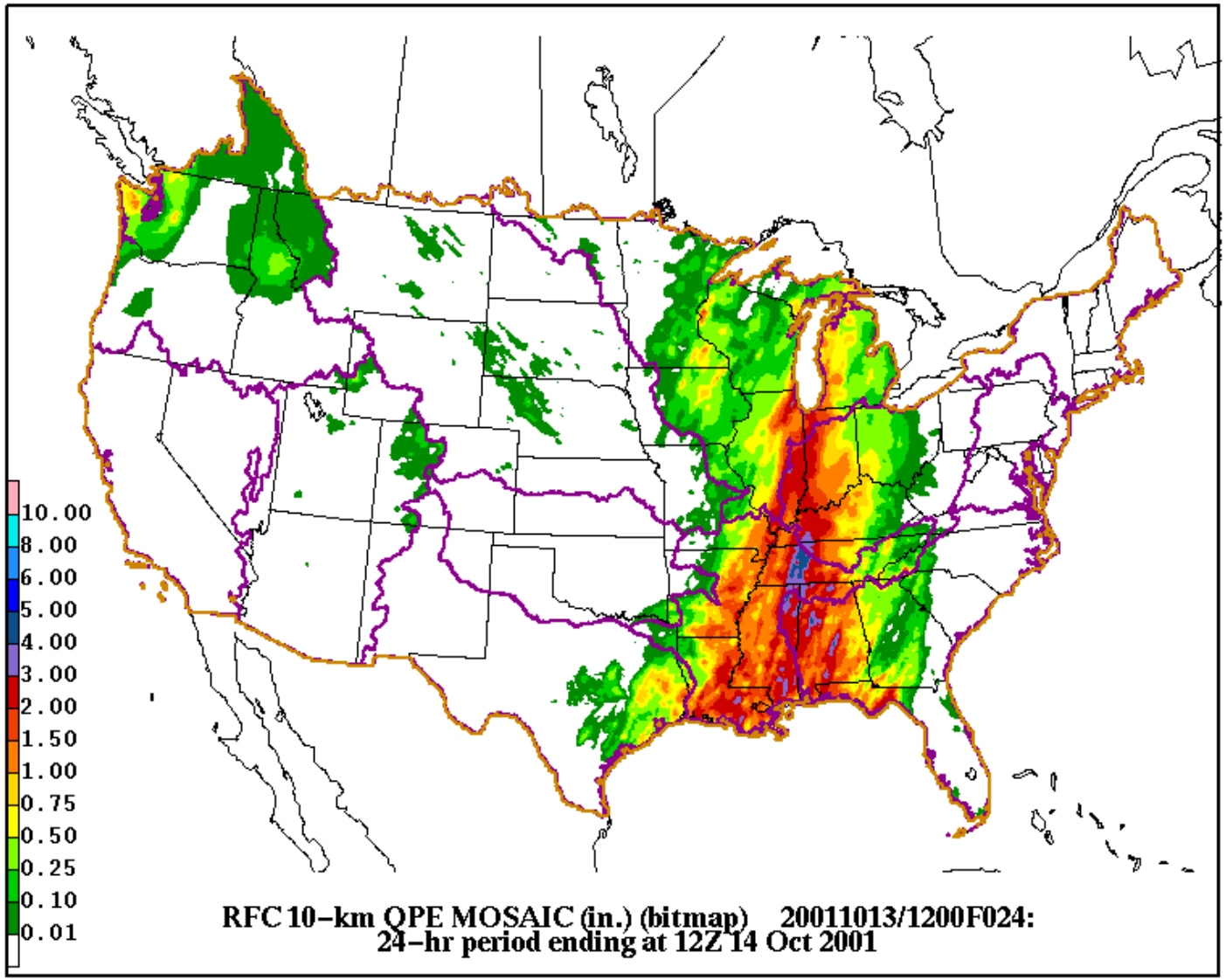
0.01
LMRFC 4-km QPE (in.) 20011013/1200f024:
24-hr period ending at 12Z 14 Oct 2001

NPVU (cont.)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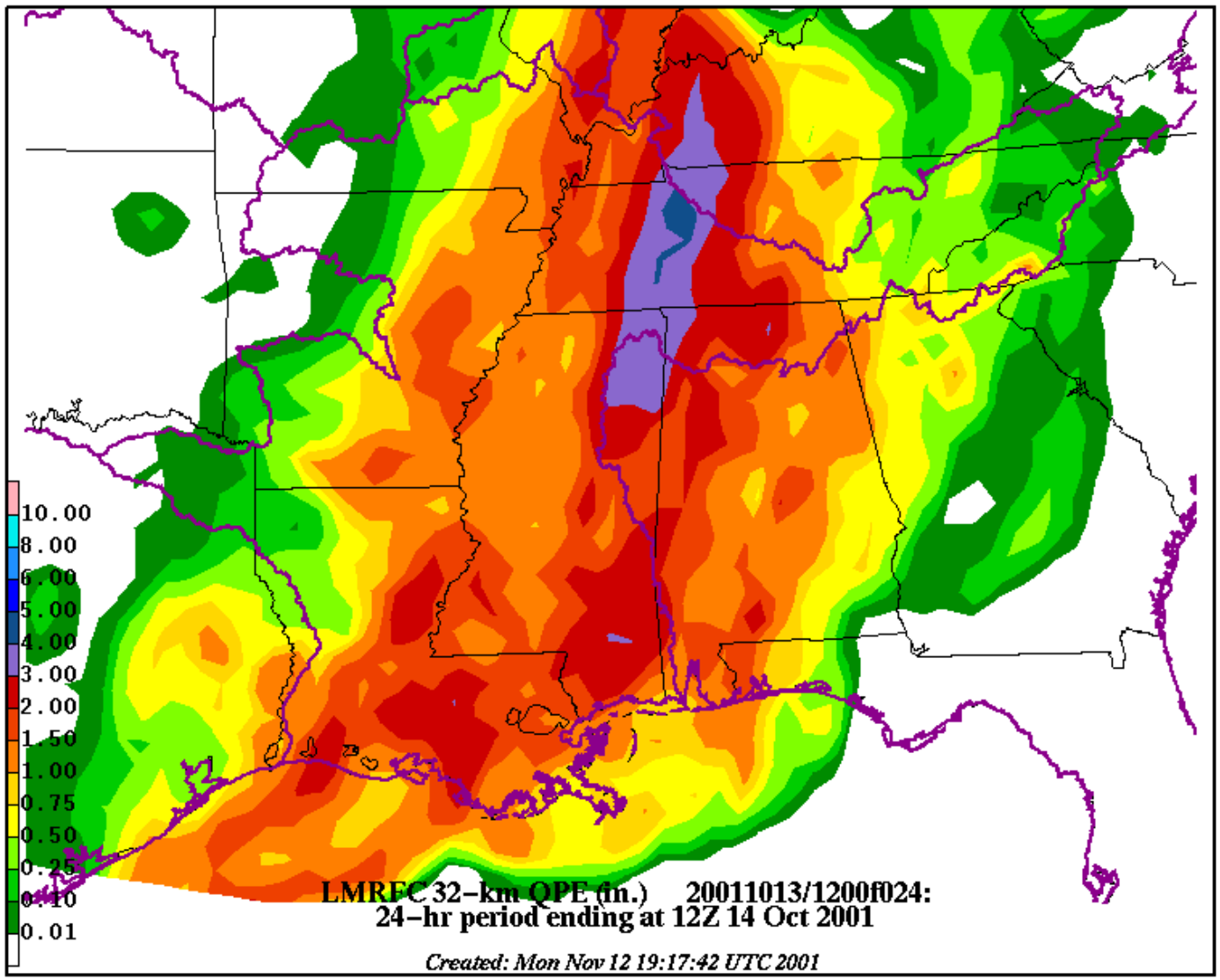
RFC 10-km QPE MOSAIC (in.) (bitmap) 20011013/1200F024:
24-hr period ending at 12Z 14 Oct 2001

NPVU (cont.)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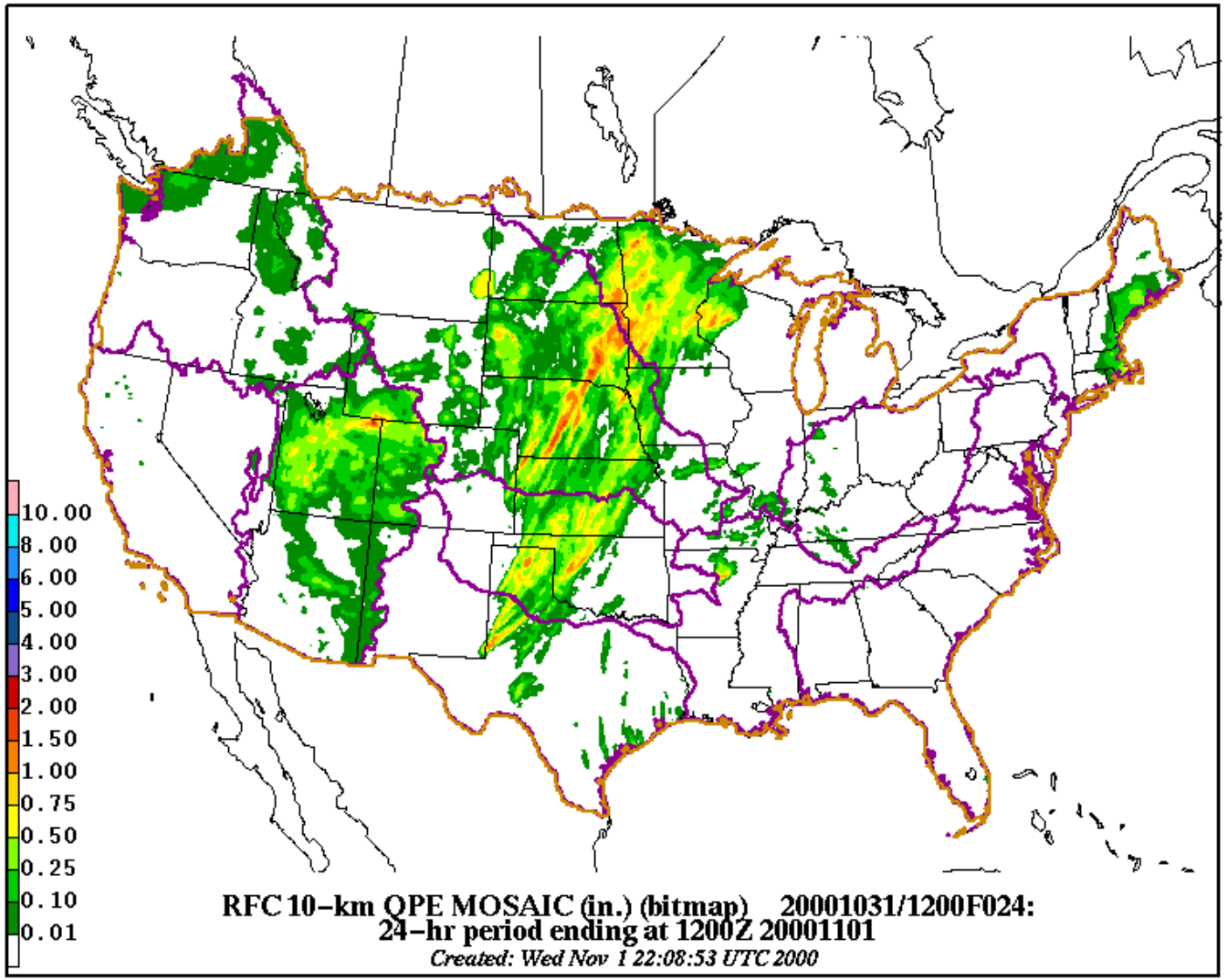
LMRFC 32-km QPE (in.) 20011013/1200f024:
24-hr period ending at 12Z 14 Oct 2001
Created: Mon Nov 12 19:17:42 UTC 2001

NPVU (cont.)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0.50
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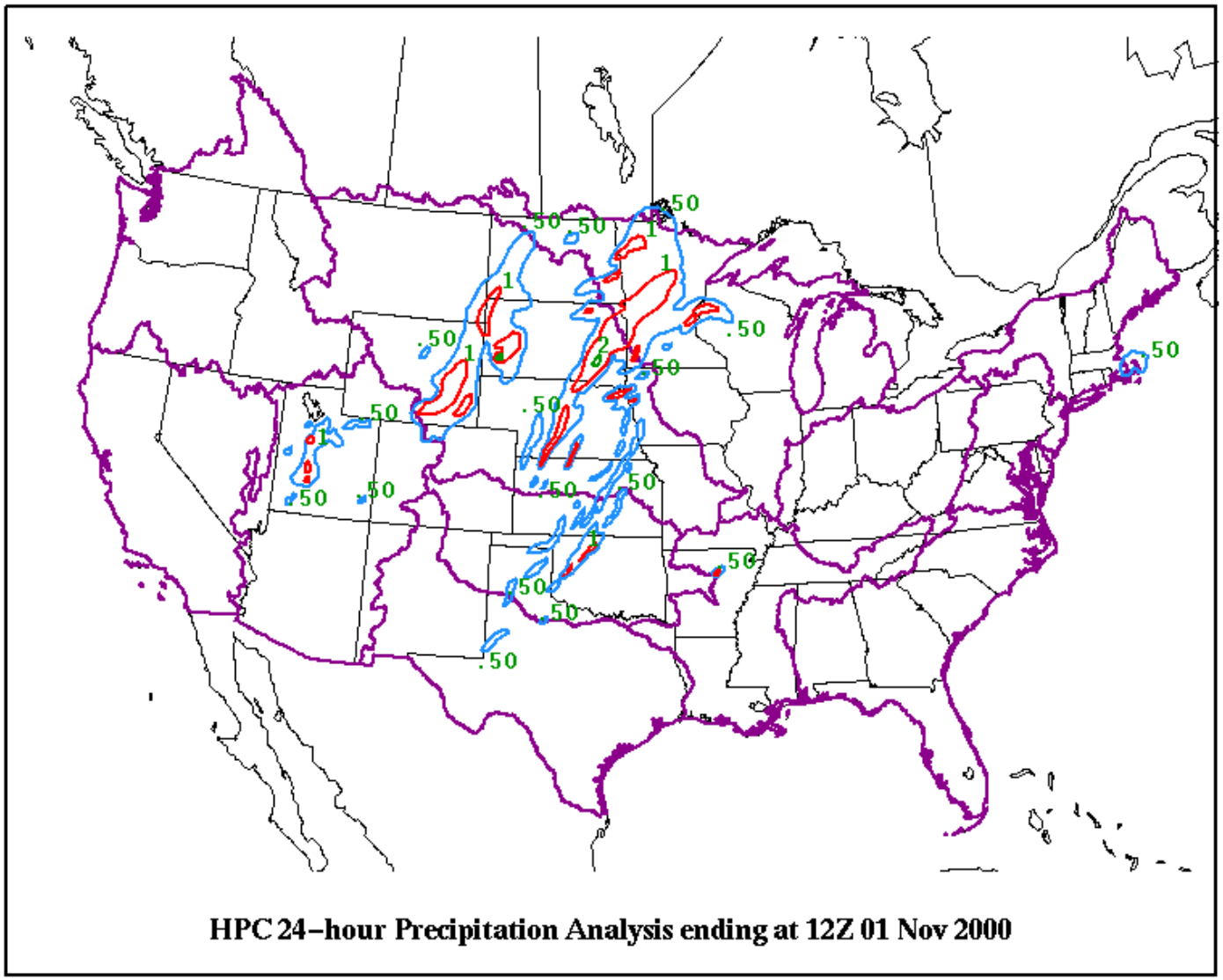
RFC 10-km QPE MOSAIC (in.) (bitmap) 20001031/1200F024:
24-hr period ending at 1200Z 20001101
Created: Wed Nov 1 22:08:53 UTC 2000

NPVU (cont.)


.50
1
2
HPC 24–hour Precipitation Analysis ending at 12Z 01 Nov 2000

NPVU (cont.)

- Data Ingest & Archival - Forecasts

NWP Model QPFs -

NGM, Eta, AVN

Retrieve GRIB files directly from IBM SP on highest resolution grids possible

HPC QPFs -

Now - Receive .vgf & .info files directly ->
Run “Graph-to-Grid” ->
32 km Grid

Future - Receive and decode GRIB files

Create point QPFs in WR using bilinear interpolation

NPVU (cont.)

RFC QPFs -

Creating using NMAP or Mountain Mapper
10-km QPF GRIB files sent to IBM SP via AWIPS
Mosaic RFC QPFs together (using bitmaps of RFC domains) for CONUS -> sent out on AWIPS
Remap to 32 km verification grid using APT

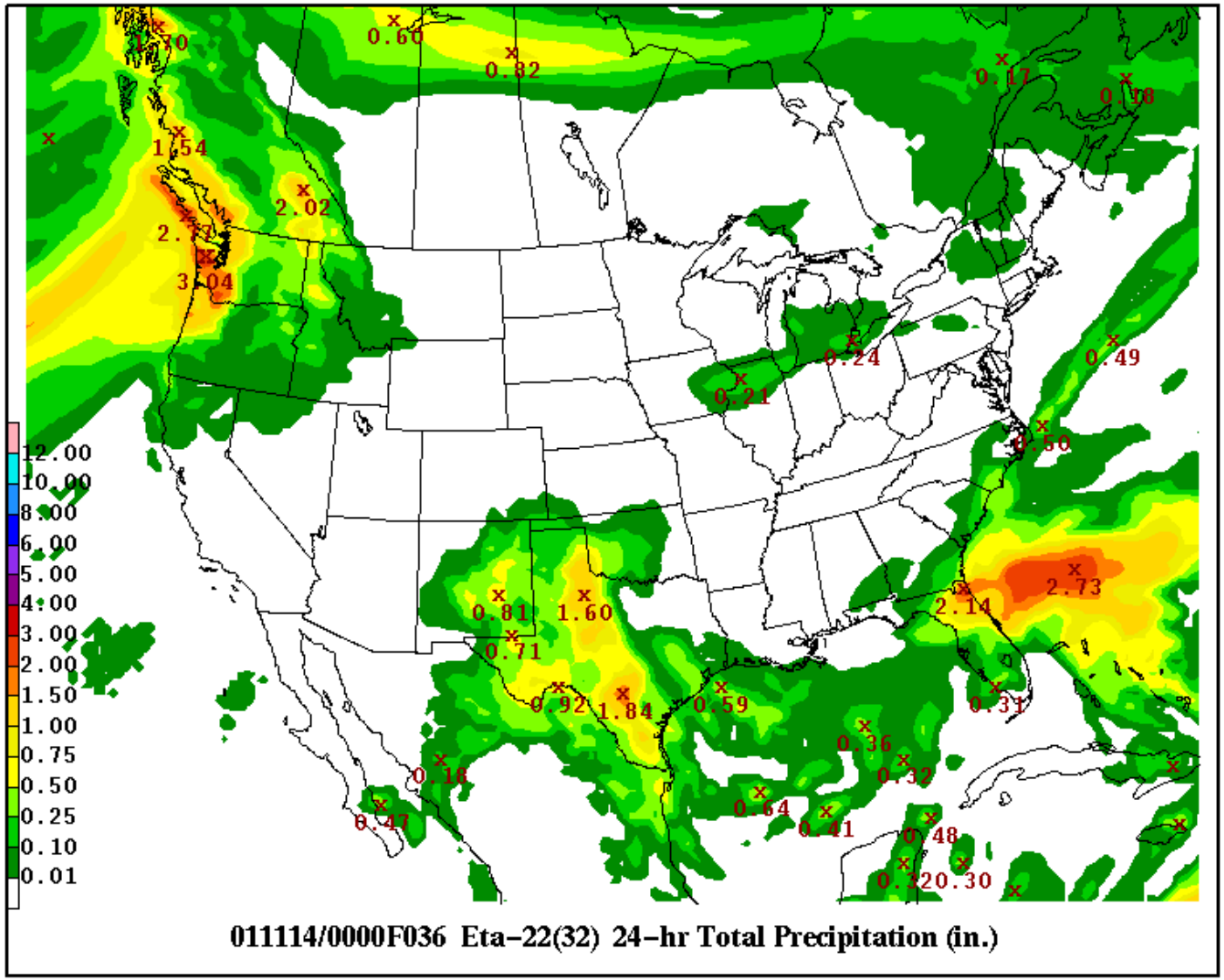
WR QPF points via SHEF files (QPS)

WFO QPFs - IFPS?

- Climatology

PRISM

NPVU (cont.)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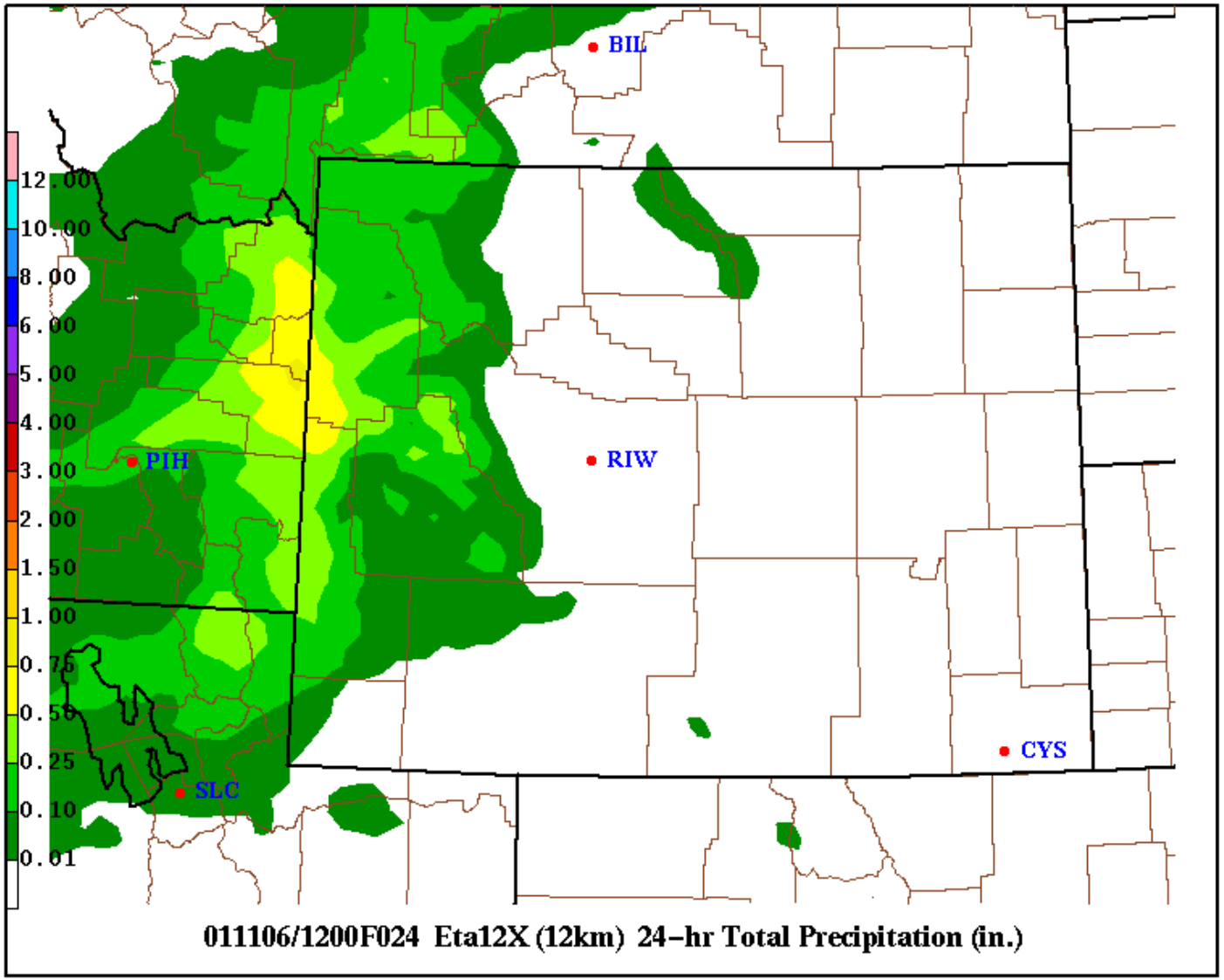
0.25
0.10
0.01
0.60
0.82
0.17
0.18
1.54
2.02
3.04
0.24
0.21
0.49
0.50
2.73
2.14
0.81
1.60
0.71
0.92
1.84
0.59
0.31
0.36
0.32
0.16
0.47
0.64
0.41
0.48
0.30
011114/0000F036 Eta-22(32) 24-hr Total Precipitation (in.)

NPVU (cont.)


BIL
RIW
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CYS
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5.00
4.00
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2.00
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1.00
0.75
0.50
0.25
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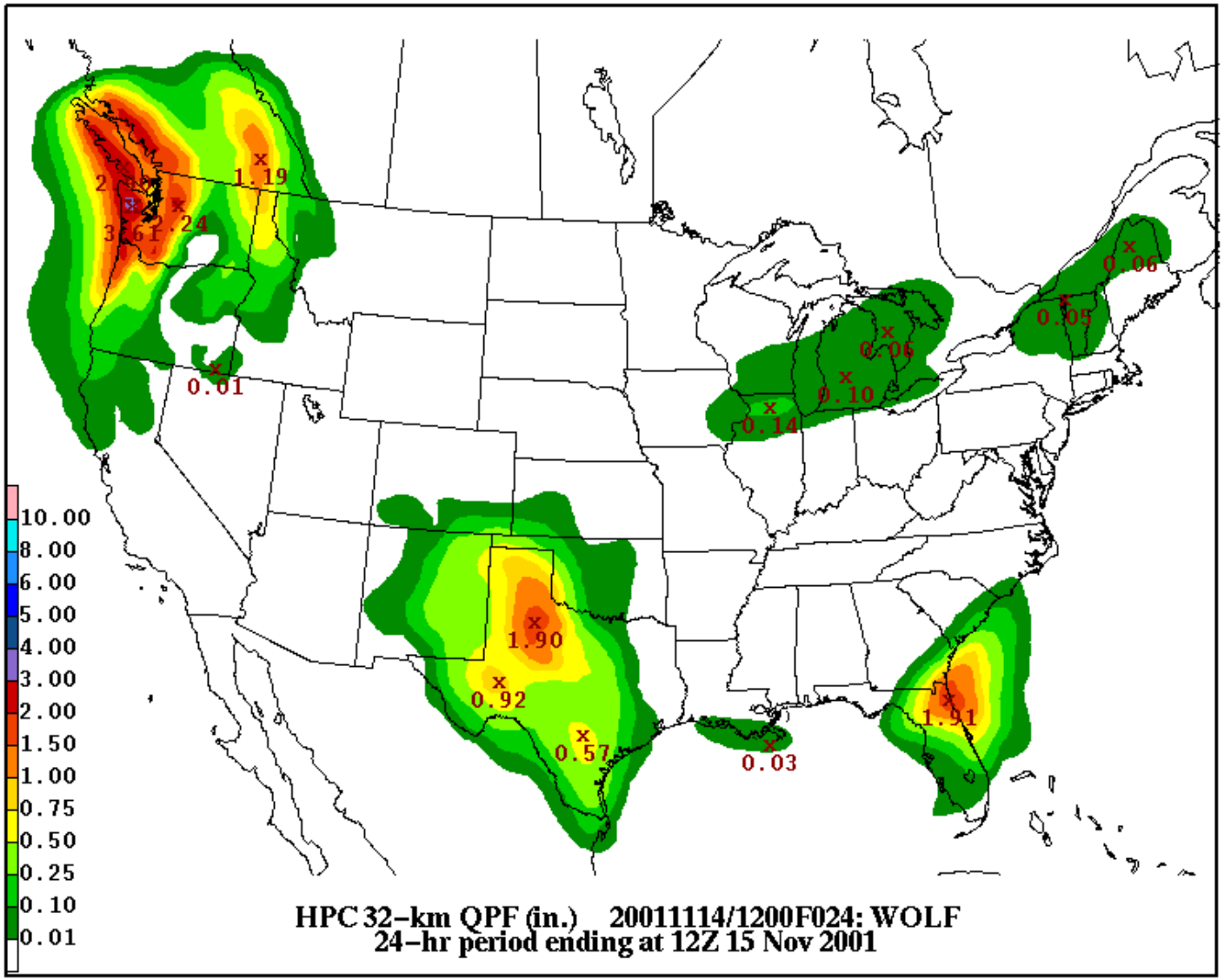
0.01
011106/1200F024 Eta12X (12km) 24-hr Total Precipitation (in.)

NPVU (cont.)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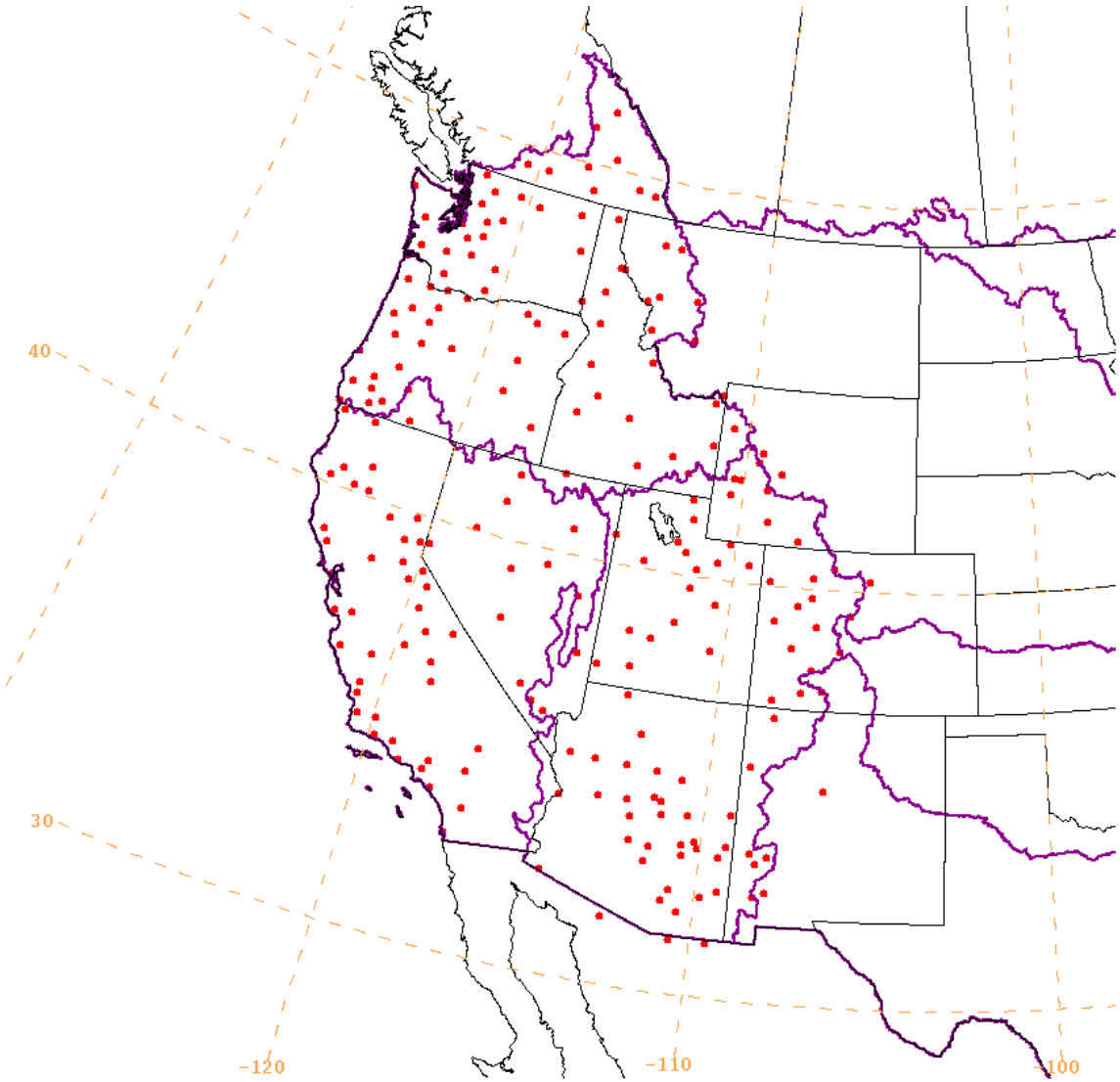
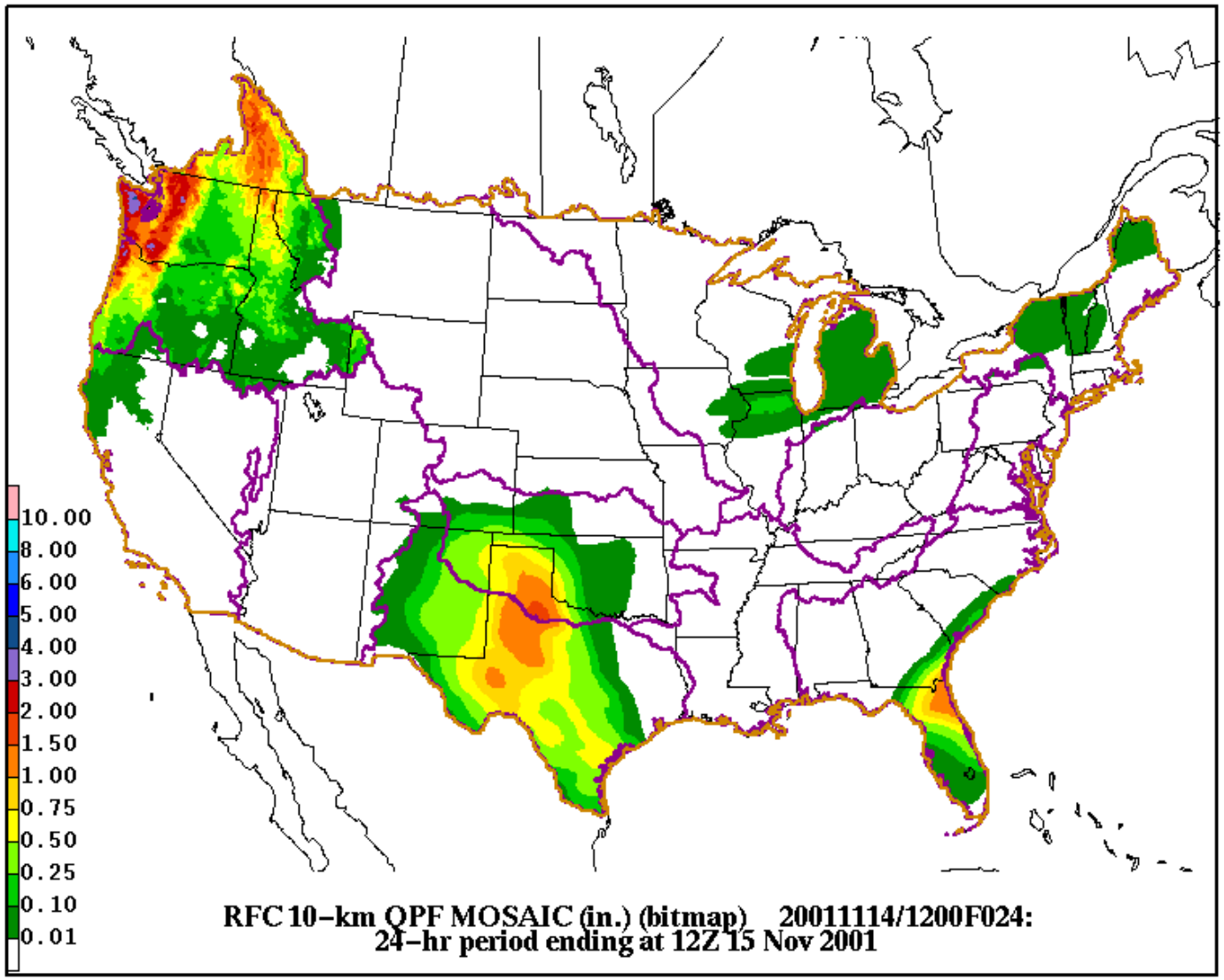
0.75
0.50
0.25
0.10
0.01
1.19
2.24
0.01
0.06
0.06
0.05
0.10
0.14
1.90
0.92
0.57
0.03
1.91
HPC 32-km QPF (in.) 20011114/1200F024: WOLF
24-hr period ending at 12Z 15 Nov 2001

NPVU (cont.)



NPVU (cont.)


10.00
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1.00
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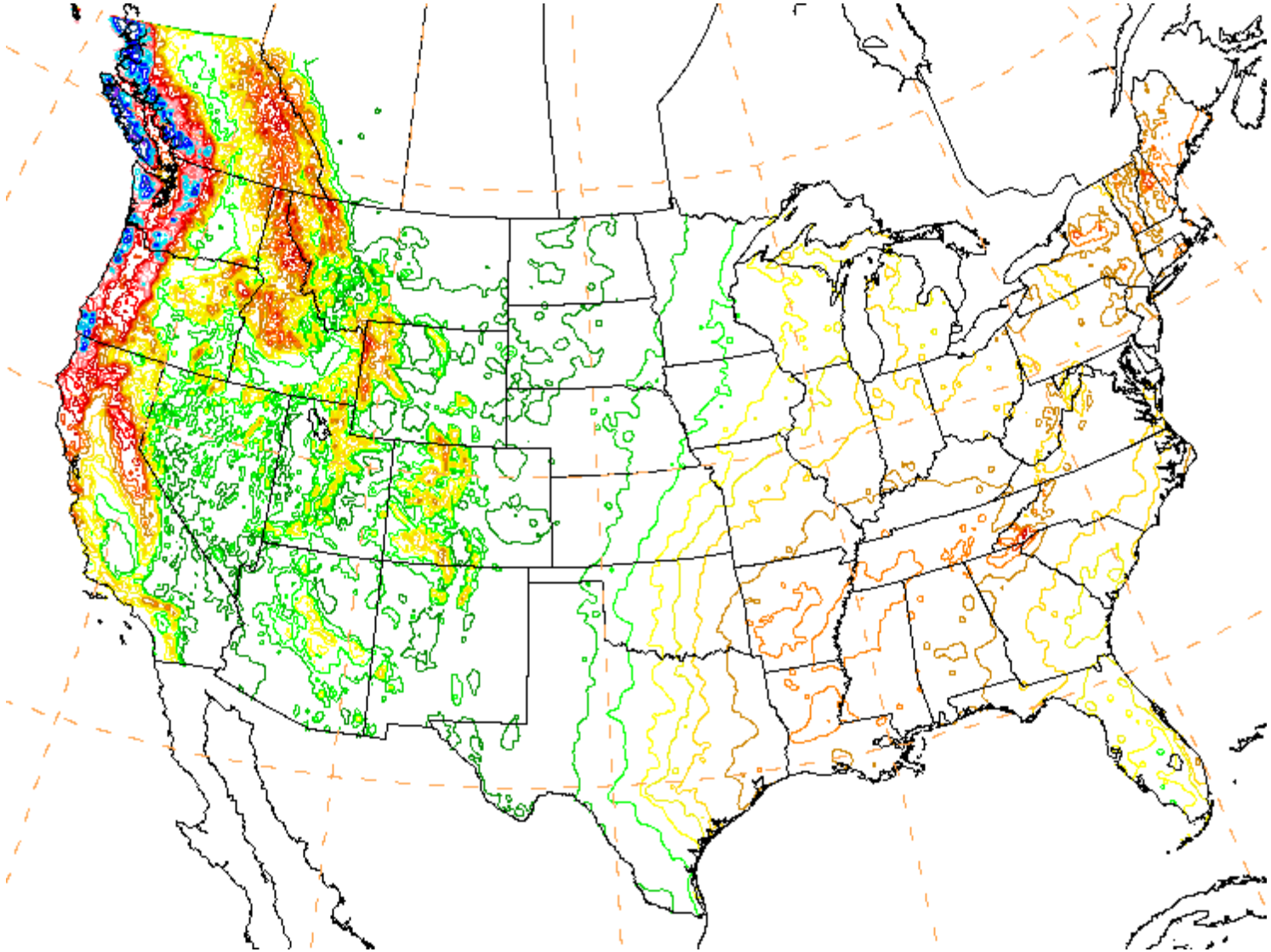
0.50
0.25
0.10
0.01
RFC 10-km QPF MOSAIC (in.) (bitmap) 20011114/1200F024:
24-hr period ending at 12Z 15 Nov 2001

NPVU (cont.)



NPVU (cont.)

Verification statistics computed from QPFs for possible combinations of the following *as appropriate* (as a unit and by individual forecaster):

- Primary Methodology - gridded, with a spatial resolution of ~32 km (Points and MAPs supplemental - N/A)
- Forecast Increments: 6-, 24-, & 72-hr, etc.
- Forecast Projections: 1st 6-hr period, Day1, etc.
- Spatial Domains: nation, region, RFC, state, HSA, etc.
- Temporal Domains: forecast period, forecast cycle, event, week, month, season, year, etc.

NPVU (cont.)

- Performance Measures:

  Interval & Threshold Distributions
  Error Statistics -
    Mean Error
    Mean Absolute Error
    Root-Mean-Squared Error
  Threshold Statistics -
    Threat Score
    Bias Score
    Probability of Detection
    False Alarm Rate
    Equitable Threat Score

NPVU (cont.)

Error Statistics -

$$ME = \frac{1}{N} \sum_{i=1}^{N} (f_i - o_i)$$

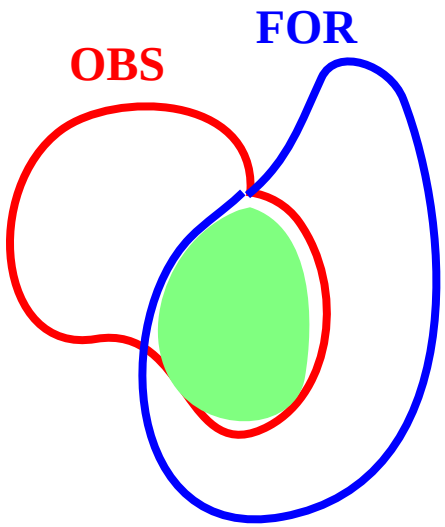
$$MAE = \frac{1}{N} \sum_{i=1}^{N} \left| f_i - o_i \right|$$

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (f_i - o_i)^2}$$

Statistics are typically computed (grouped) according to observed amounts. They can also be computed according to the forecast amounts... or...computed by grouping according to both the observed and forecast amounts (i.e., looping through the sample two times and placing the “error” into bins according the observed and forecast amounts).

NPVU (cont.)

Threshold Statistics -



FOR \ OBS	Y	N
Y	A	B
N	C	D

For = A + B

Obs = A + C

Hits = A

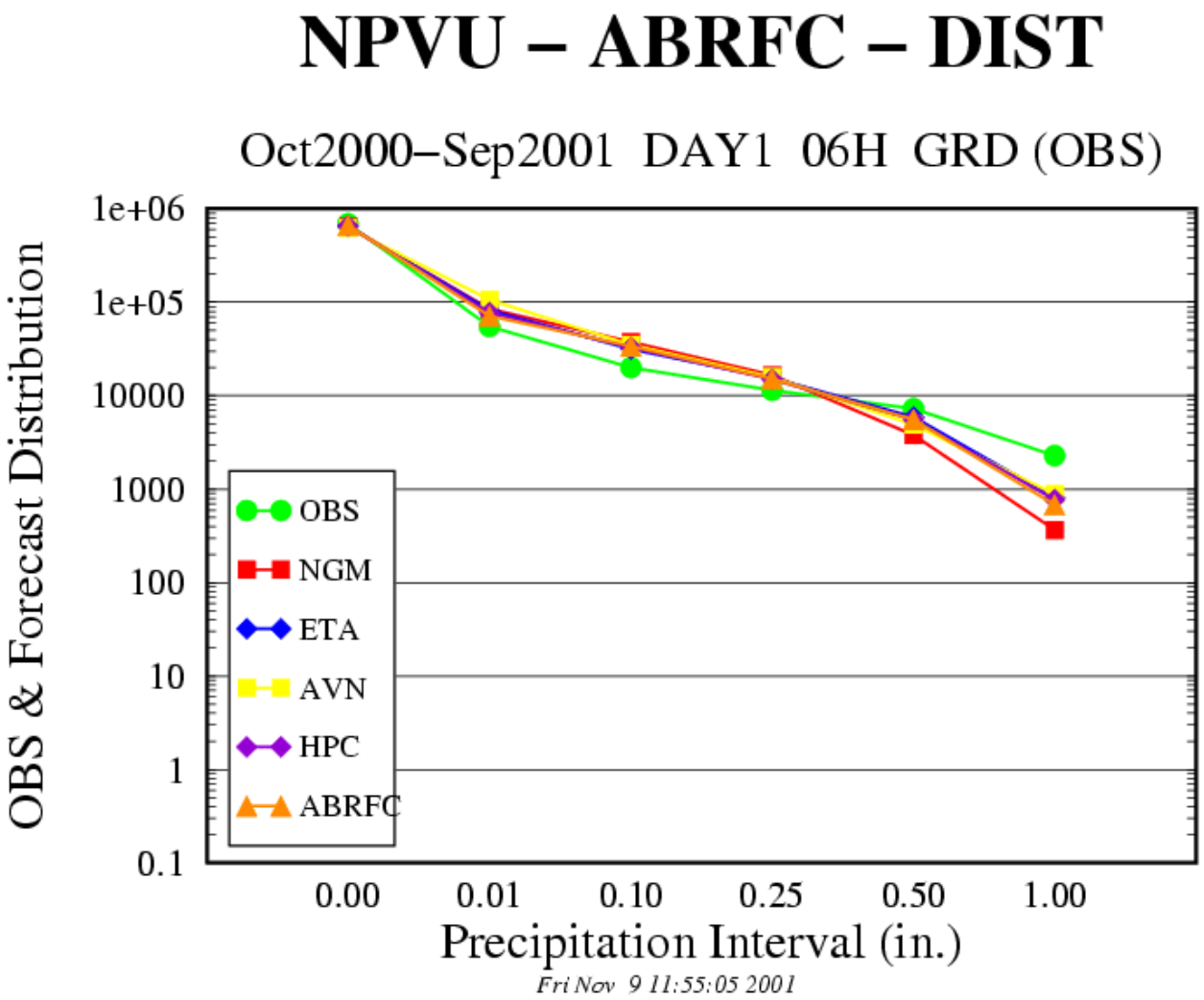
Misses = B

$$\text{Bias Score} = \frac{\text{For}}{\text{Obs}} \qquad \text{POD} = \frac{\text{Hits}}{\text{Obs}} \qquad \text{FAR} = \frac{\text{Misses}}{\text{For}}$$

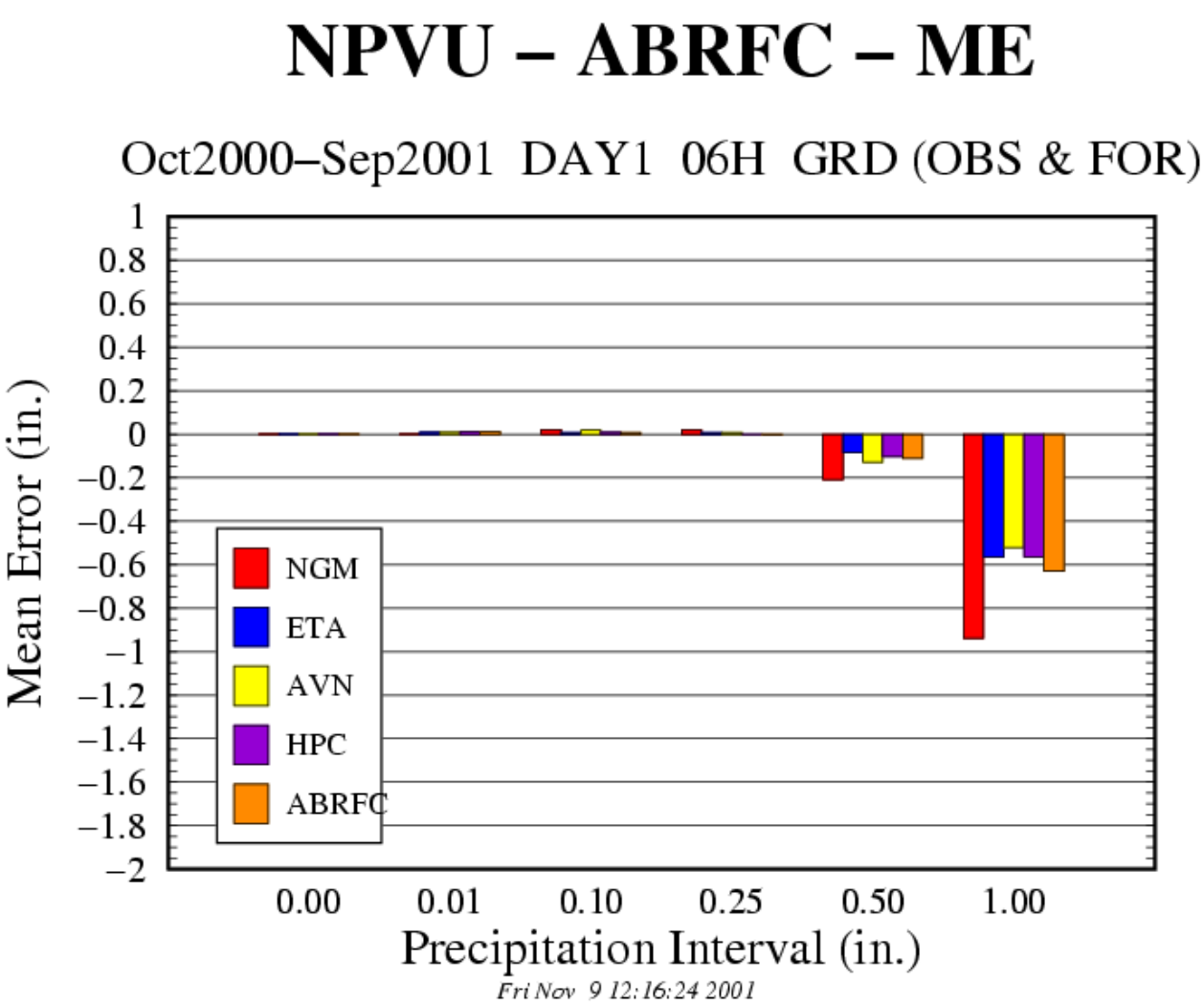
$$\text{Threat Score} = \frac{\text{Hits}}{\text{For} + \text{Obs} - \text{Hits}} \qquad \text{Chance} = \frac{\text{For} \times \text{Obs}}{\text{Total}}$$

$$\text{Equitable Threat Score} = \frac{\text{Hits} - \text{Chance}}{\text{For} + \text{Obs} - \text{Hits} - \text{Chance}}$$

NPVU (cont.)

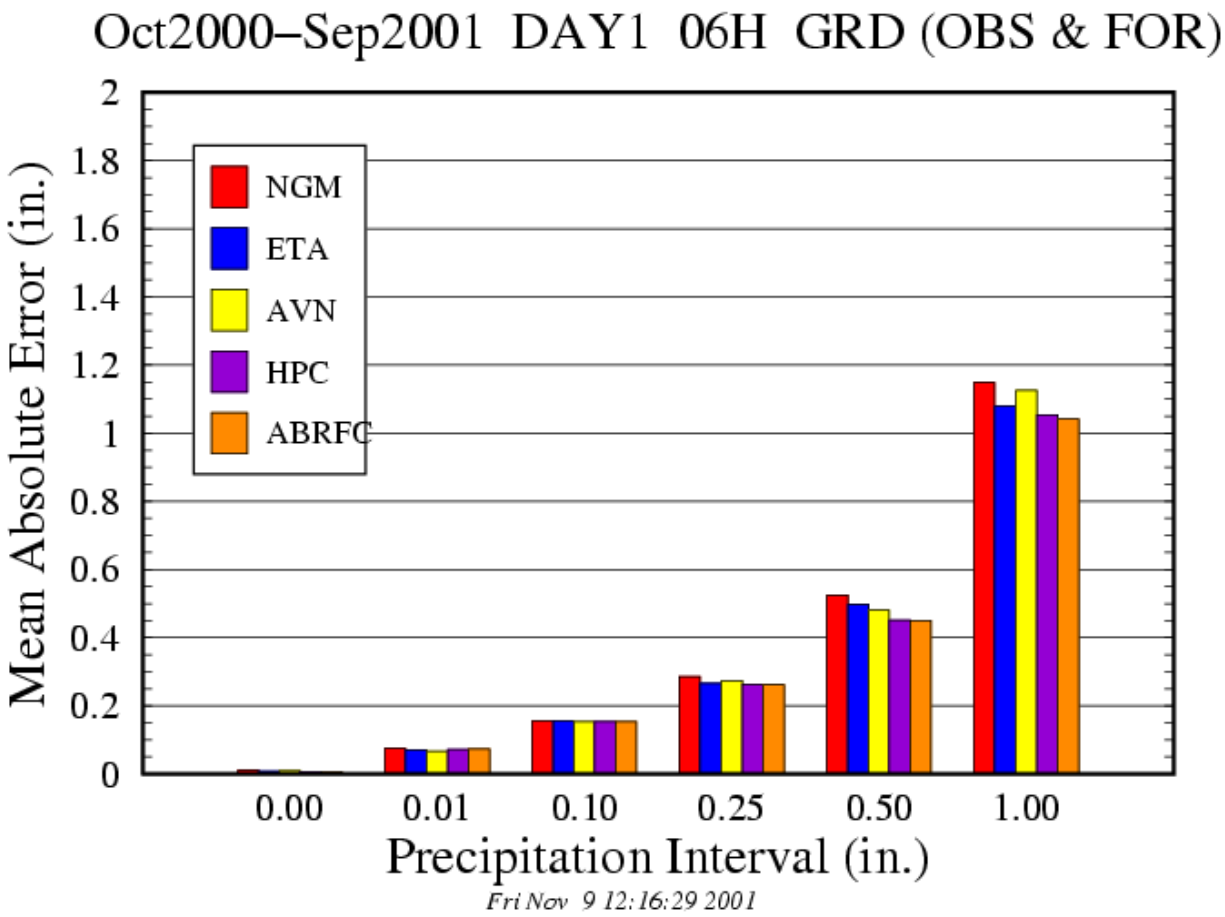

NPVU – ABRFC – DIST
Oct2000–Sep2001 DAY1 06H GRD (OBS)
OBS & Forecast Distribution
1e+06
1e+05
10000
1000
100
10
1
0.1
OBS
NGM
ETA
AVN
HPC
ABRFC
0.00
0.01
0.10
0.25
0.50
1.00
Precipitation Interval (in.)
Fri Nov 9 11:55:05 2001

NPVU (cont.)

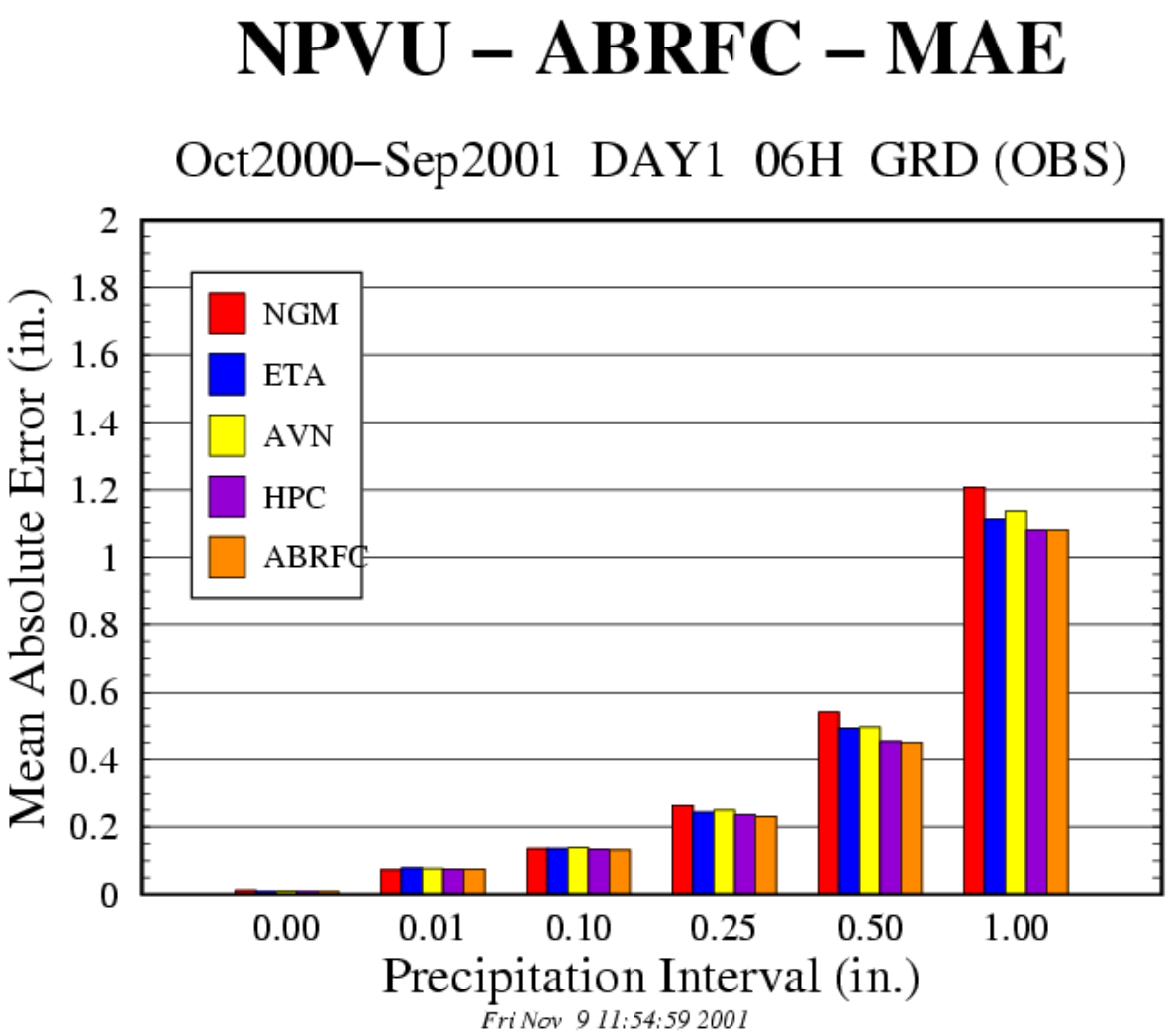

NPVU – ABRFC – ME
Oct2000–Sep2001 DAY1 06H GRD (OBS & FOR)
Mean Error (in.)
1
0.8
0.6
0.4
0.2
0
–0.2
–0.4
–0.6
–0.8
–1
–1.2
–1.4
–1.6
–1.8
–2
NGM
ETA
AVN
HPC
ABRFC
0.00
0.01
0.10
0.25
0.50
1.00
Precipitation Interval (in.)
Fri Nov 9 12:16:24 2001

NPVU (cont.)

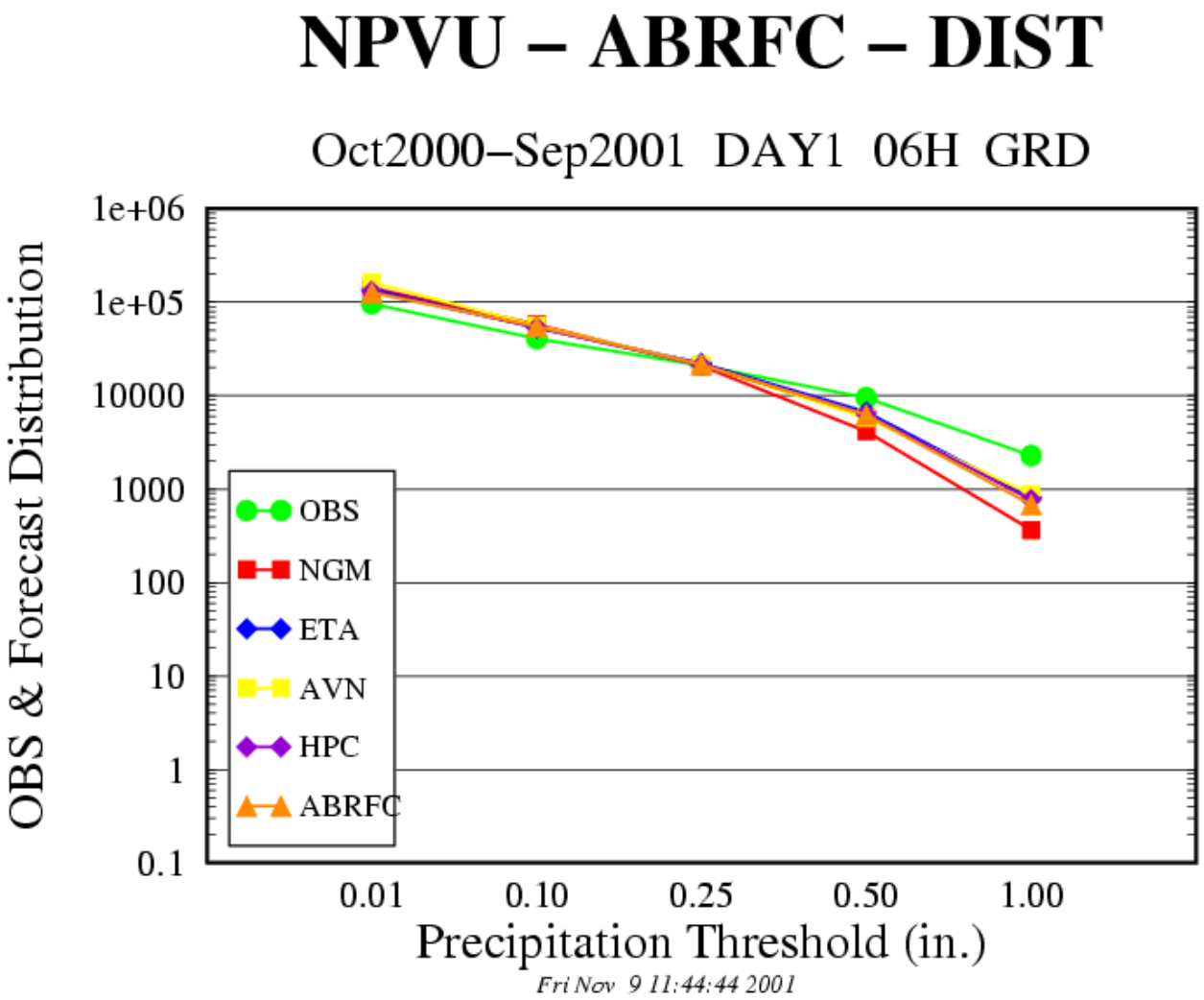
NPVU – ABRFC – MAE



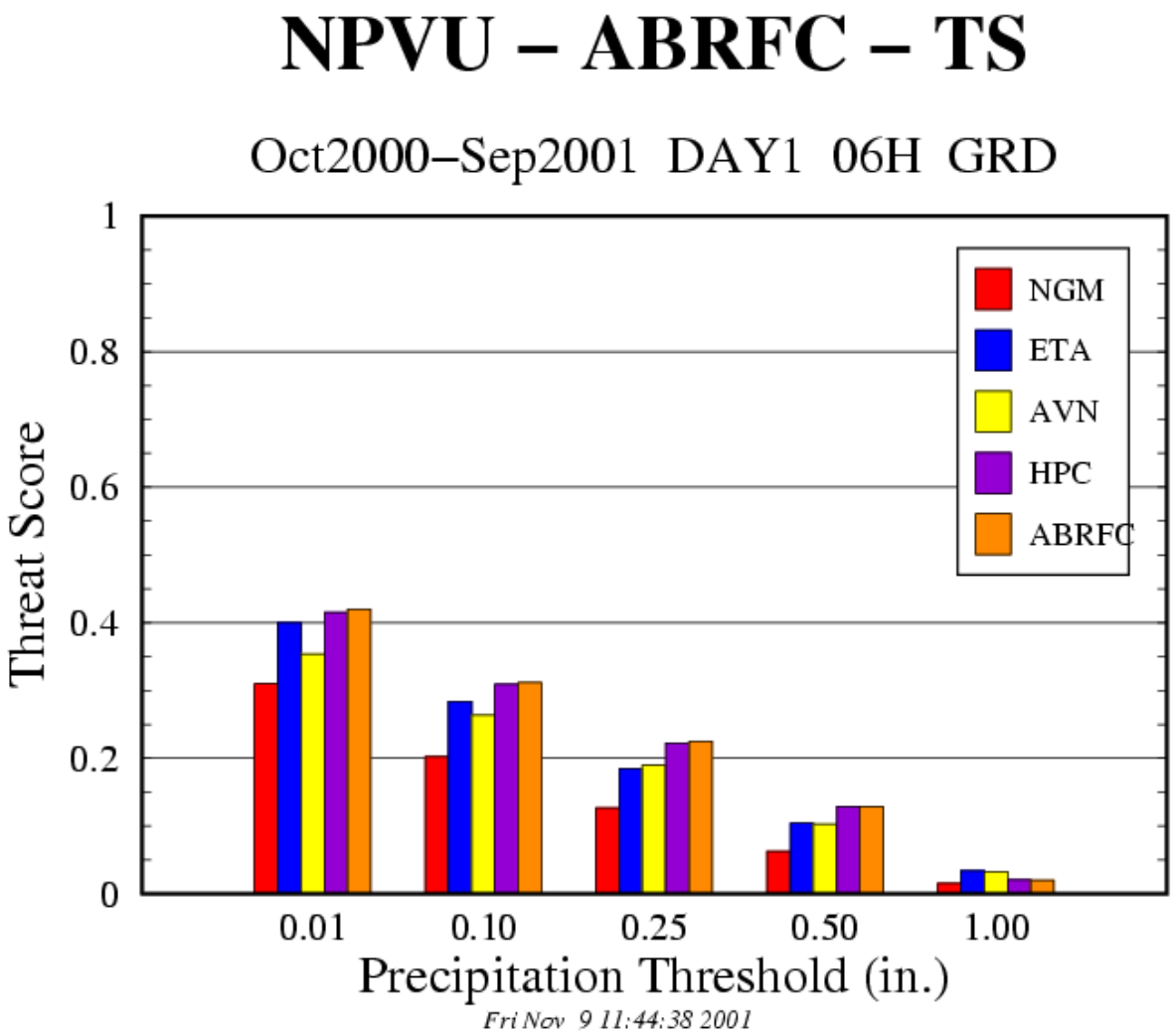
NPVU (cont.)


NPVU – ABRFC – MAE
Oct2000–Sep2001 DAY1 06H GRD (OBS)
Mean Absolute Error (in.)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
NGM
ETA
AVN
HPC
ABRFC
0.00
0.01
0.10
0.25
0.50
1.00
Precipitation Interval (in.)
Fri Nov 9 11:54:59 2001

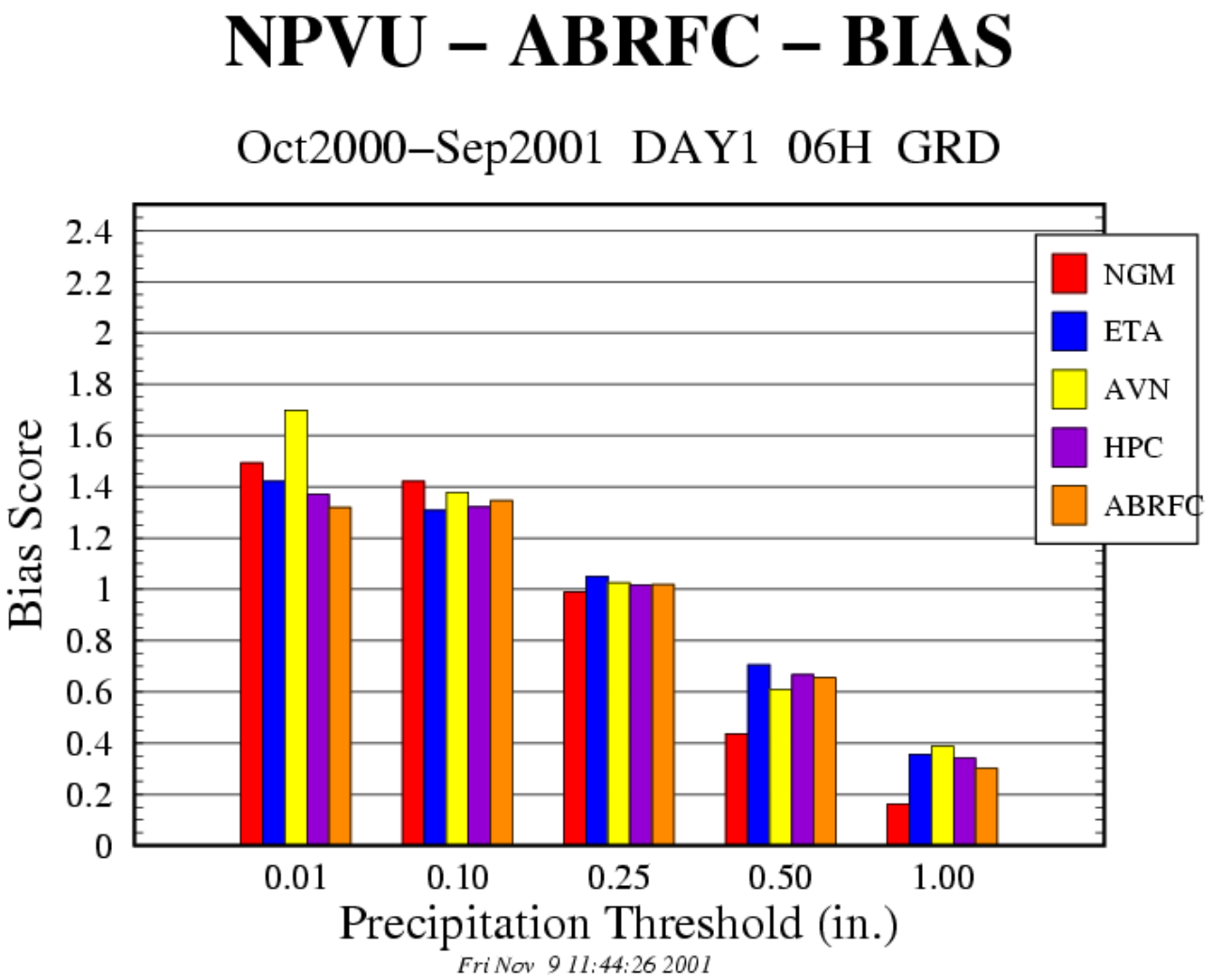
NPVU (cont.)


NPVU – ABRFC – DIST
Oct2000–Sep2001 DAY1 06H GRD
OBS & Forecast Distribution
1e+06
1e+05
10000
1000
100
10
1
0.1
OBS
NGM
ETA
AVN
HPC
ABRFC
0.01
0.10
0.25
0.50
1.00
Precipitation Threshold (in.)
Fri Nov 9 11:44:44 2001

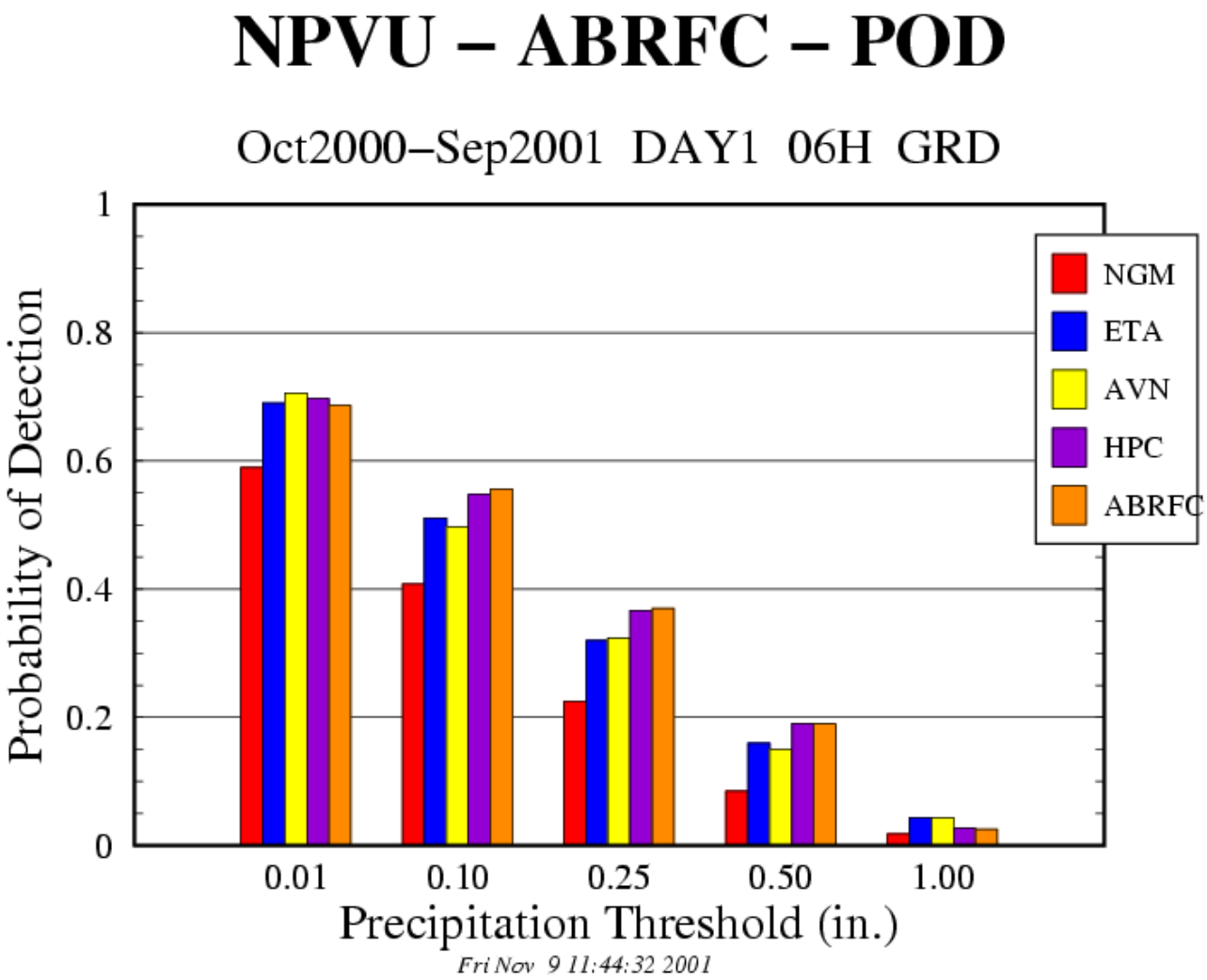
NPVU (cont.)


NPVU – ABRFC – TS
Oct2000–Sep2001 DAY1 06H GRD
Threat Score
1
0.8
0.6
0.4
0.2
0
NGM
ETA
AVN
HPC
ABRFC
0.01
0.10
0.25
0.50
1.00
Precipitation Threshold (in.)
Fri Nov 9 11:44:38 2001

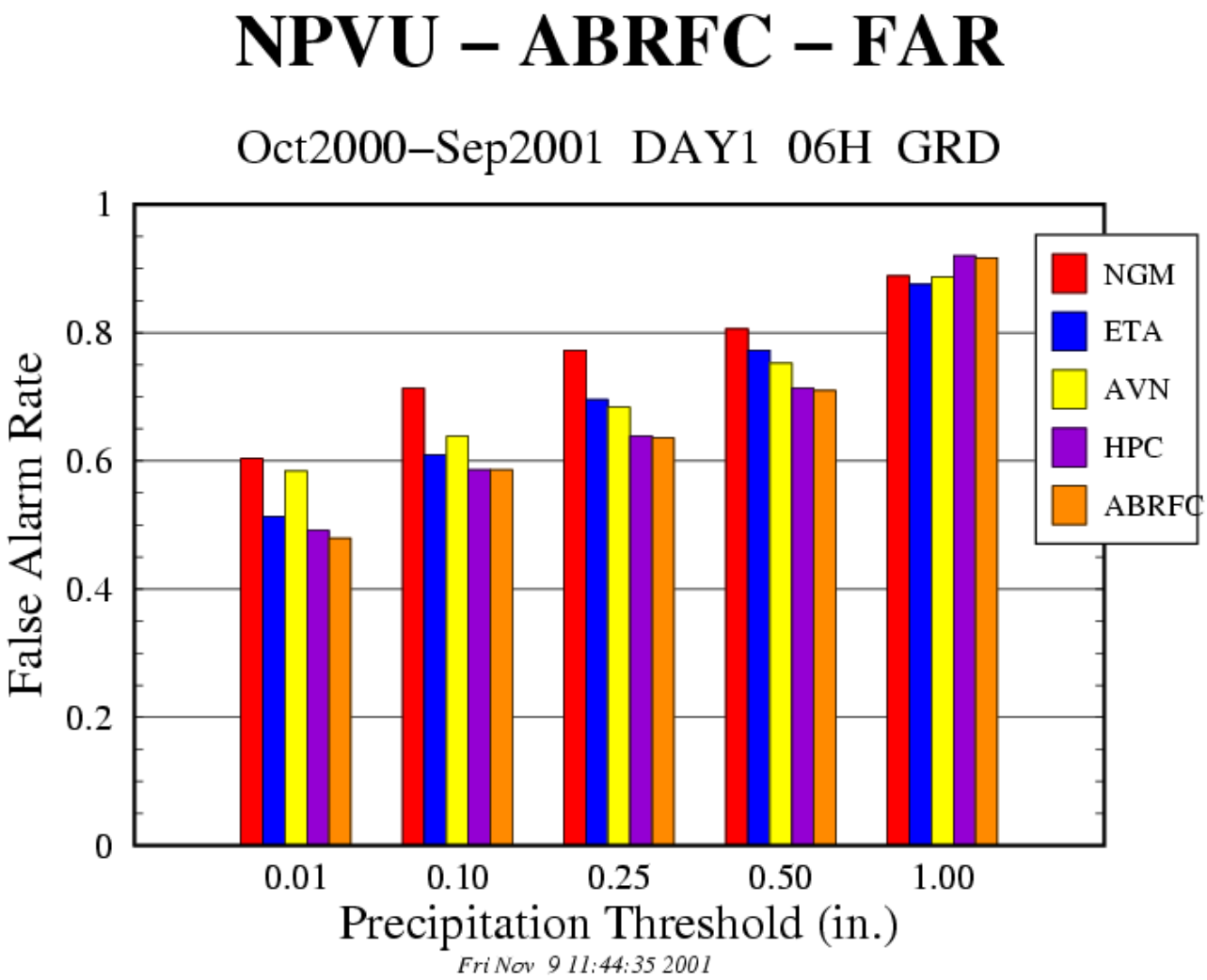
NPVU (cont.)


NPVU – ABRFC – BIAS
Oct2000–Sep2001 DAY1 06H GRD
Bias Score
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
NGM
ETA
AVN
HPC
ABRFC
0.01
0.10
0.25
0.50
1.00
Precipitation Threshold (in.)
Fri Nov 9 11:44:26 2001

NPVU (cont.)


NPVU – ABRFC – POD
Oct2000–Sep2001 DAY1 06H GRD
Probability of Detection
1
0.8
0.6
0.4
0.2
0
NGM
ETA
AVN
HPC
ABRFC
0.01
0.10
0.25
0.50
1.00
Precipitation Threshold (in.)
Fri Nov 9 11:44:32 2001

NPVU (cont.)


NPVU – ABRFC – FAR
Oct2000–Sep2001 DAY1 06H GRD
False Alarm Rate
1
0.8
0.6
0.4
0.2
0
0.01
0.10
0.25
0.50
1.00
Precipitation Threshold (in.)
NGM
ETA
AVN
HPC
ABRFC
Fri Nov 9 11:44:35 2001

NPVU (cont.)

- Display & Feedback

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  AWIPS?