Precipitation Forecasting at the Weather Prediction Center

David Roth
NOAA Weather Prediction Center
College Park, MD

August 26, 2015

Production Timeline

- 06z cycle – Six hour QPFs for Days 1-3 due 06z based on available 12z-00z model guidance
- 12z cycle – Six hour QPFs for Days 1-3 due 0830z after viewing the 00z ECMWF and based on WFO collaboration. Days 4-5 & 6-7 QPF due at 0830z
- 18z cycle – Six hour QPFs for Days 1-3 due 18z based on available 00z-12z model guidance
- 00z cycle – Six hour QPFs for Days 1-3 due 2230z after viewing 12z ECMWF and based on WFO collaboration. Days 4-5 & 6-7 QPF due at 2030z

Product Changes – July 15

Excessive Rainfall Outlooks

✓ Valid periods for the excessive rainfall outlooks, 12z-12z.

- Legacy

- New!

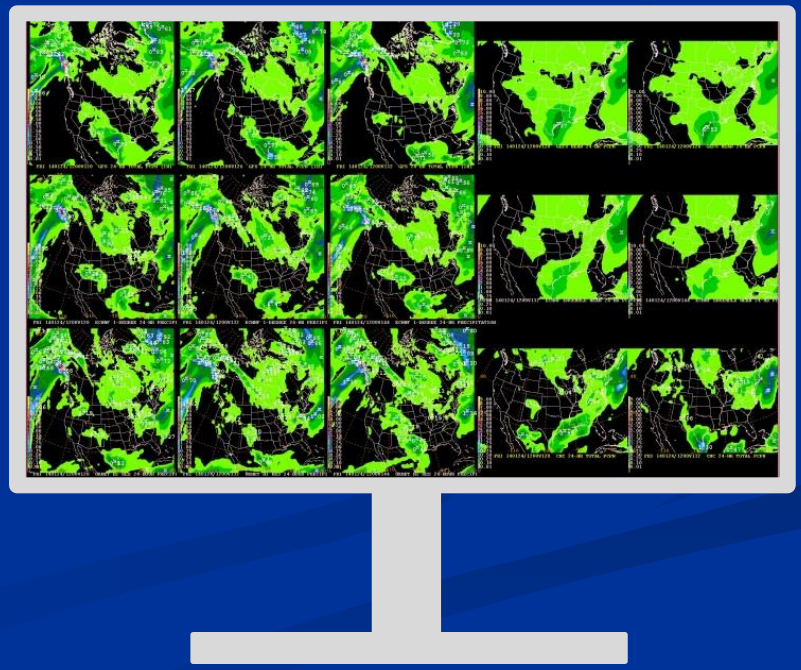
18z/06z Days 1-3 QPF, Winter Package.

Collaboration Window.

Final coordinated package At 2030z/0830z.

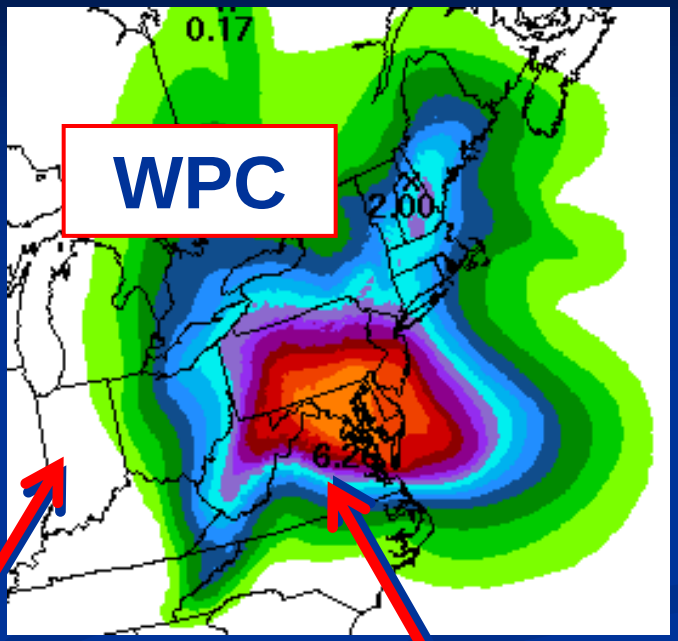
WPC's Unique Perspective

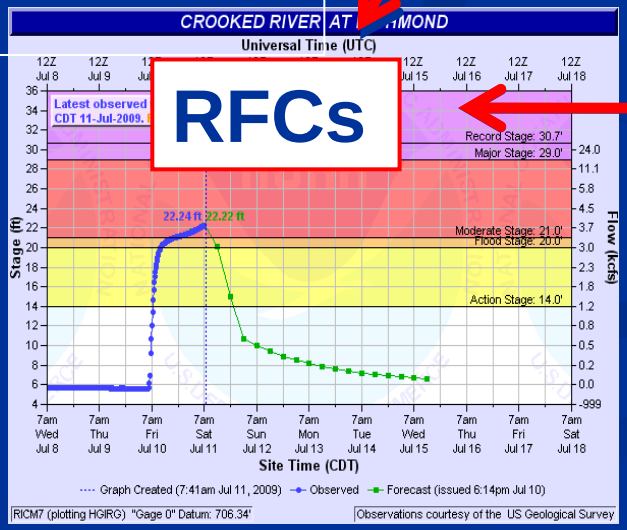
– CONUS domain / Frequent practice
– Calibration to model QPF performance/biases
– Workstation access to every model imaginable,
– Including parallel / beta
– Numerous runs / trends
– Probabilistic Output, post-processing to extract value
– Time & Focus

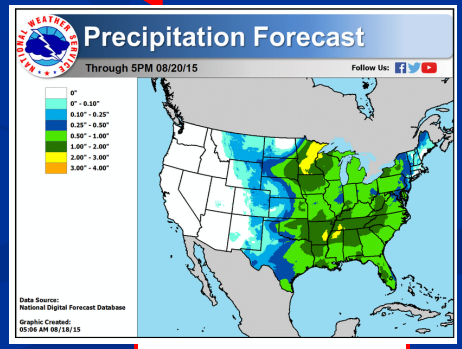


Deterministic QPF

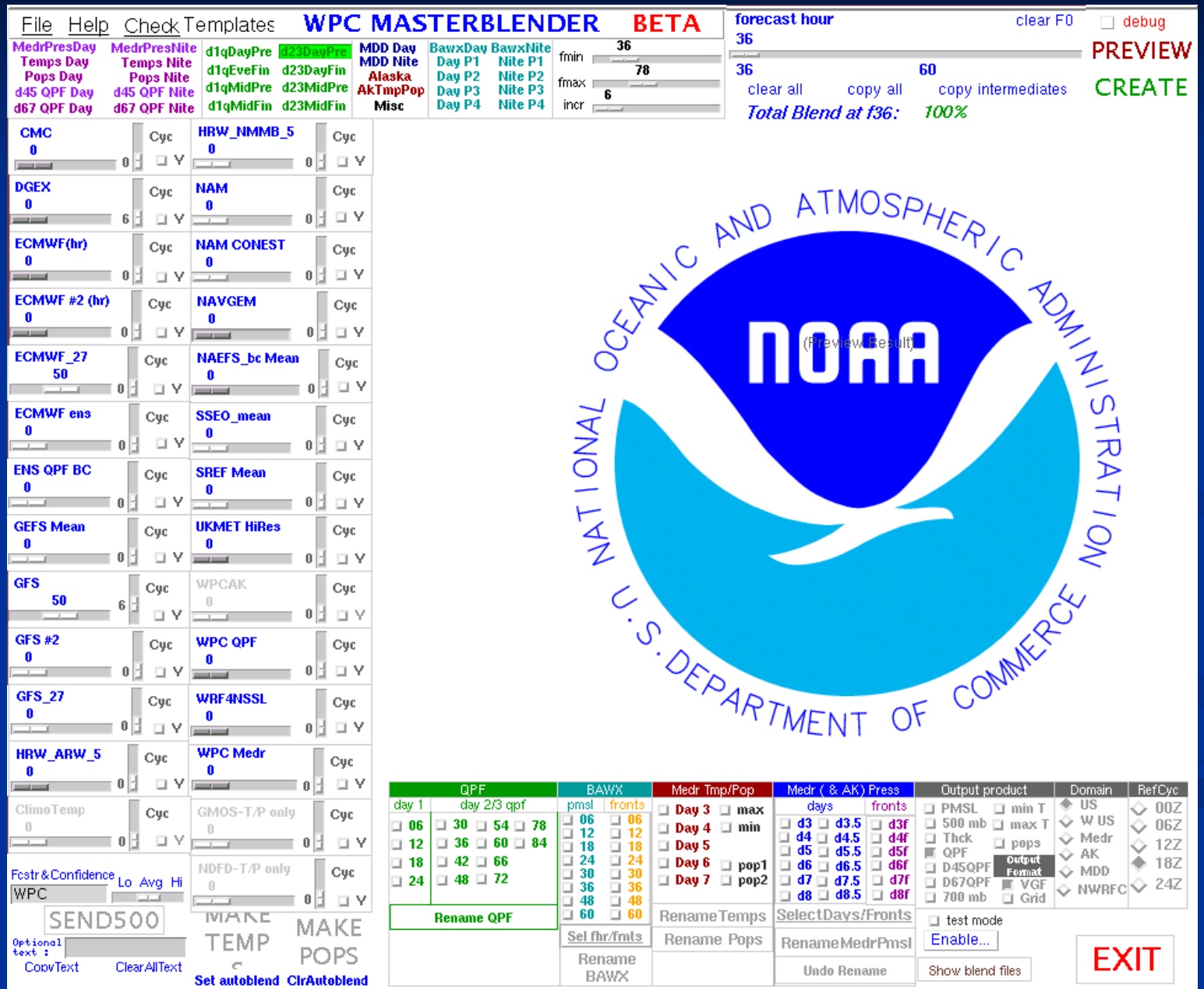
- 6-hourly to 84 hours
- 48-hour total days 4/5, 6/7
- Graphical, gridded, kml
- Associated discussions
- Manual product drawn at 20-km
- Downscaled to 5km



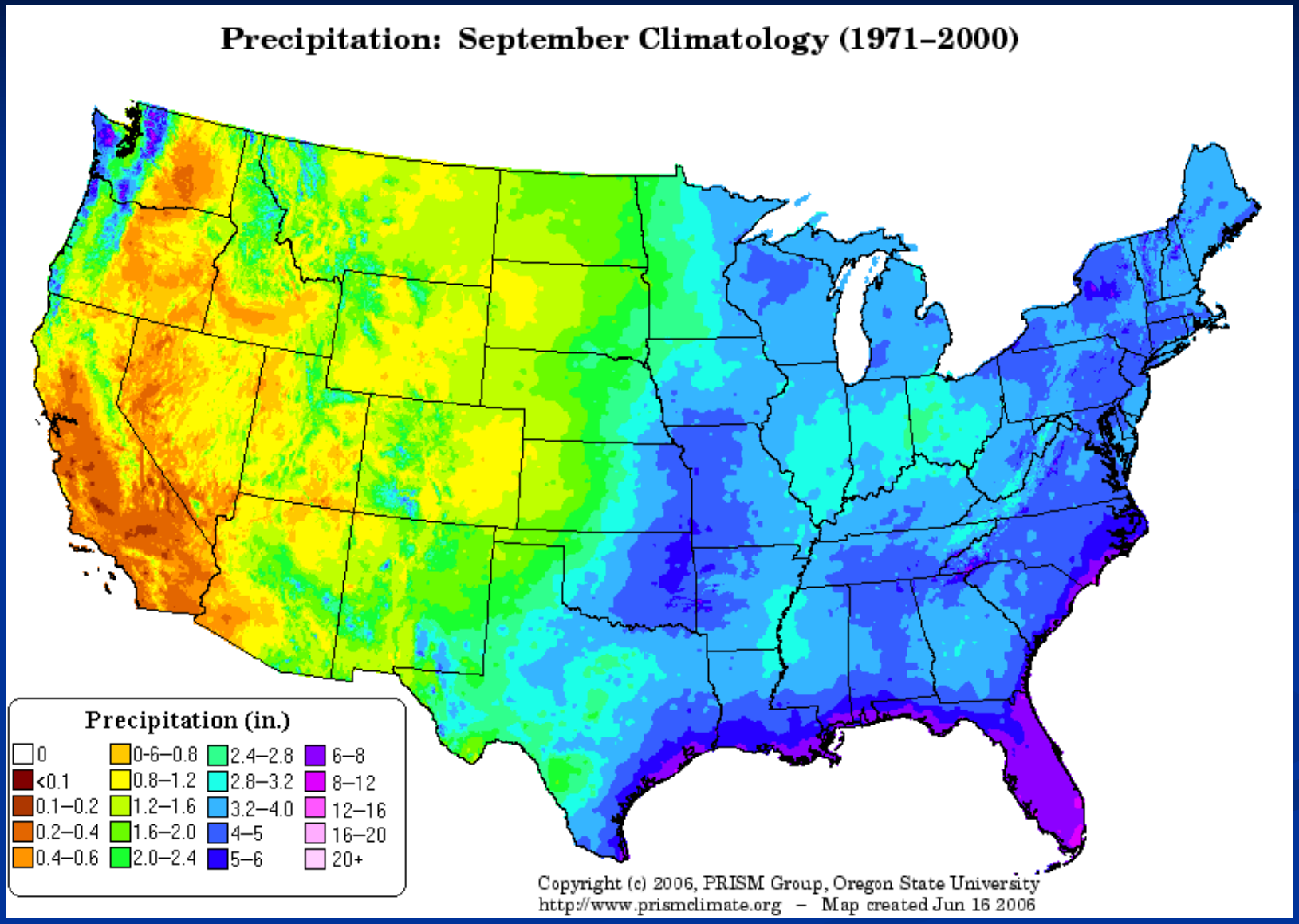




WPC Master Blender

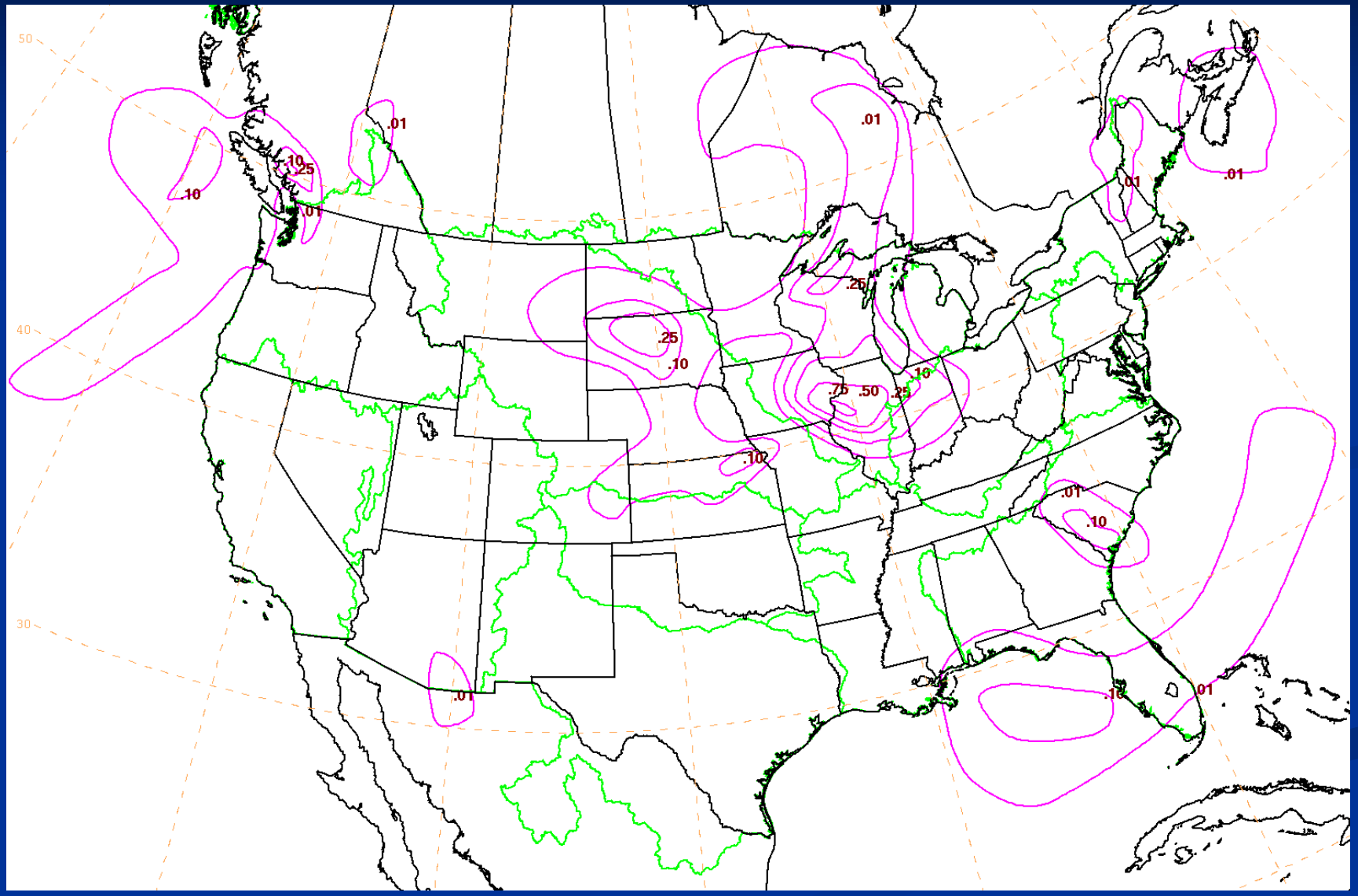


Mountains Impact On Rainfall Distribution



http://www.prism.oregonstate.edu/index.phtml

Six-hour QPF .vgf file

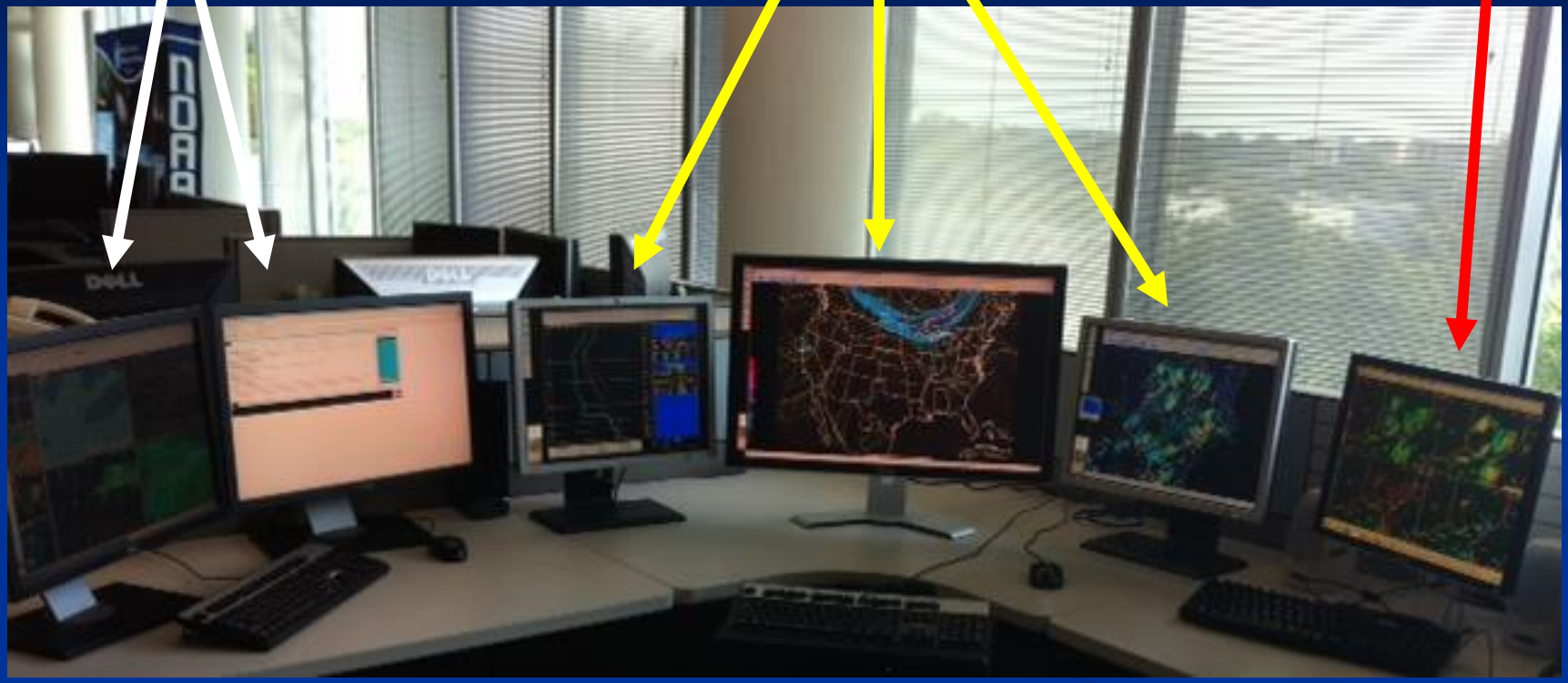


How is it done?

AWIPS-II

N-AWIPS

PC



CAVE
12Planet

NMAP2
NTRANS
NSHARP
NWX
Drawing Tools

Web browsing
GR Analyst (Metwatch)
Microsoft Office Tools

Models utilized for QPF

- GFS
- NAM
- UKMET
- NOGAPS
- SREF
- GEFS
- ECMWF
- Global ensemble means
- NAEFS mean
- Canadian (Global & Regional)
- Bias-corrected Ensemble QPF
- ARW
- NSSL ARW
- NAM CONEST
- WRF4NSSL
- SPCWRF
- RAP
- HRRR
- Storm Scale Ensemble of Opportunity (SSEO)
- NMM
- GFDL
- Hurricane WRF
- JMA

Model performance seems driven by:

Cold Season East of Rockies

***ENSQPFBC**
ECMWF
SREF Mean
GFS
UKMET
Canadian

Warm Season East of Rockies

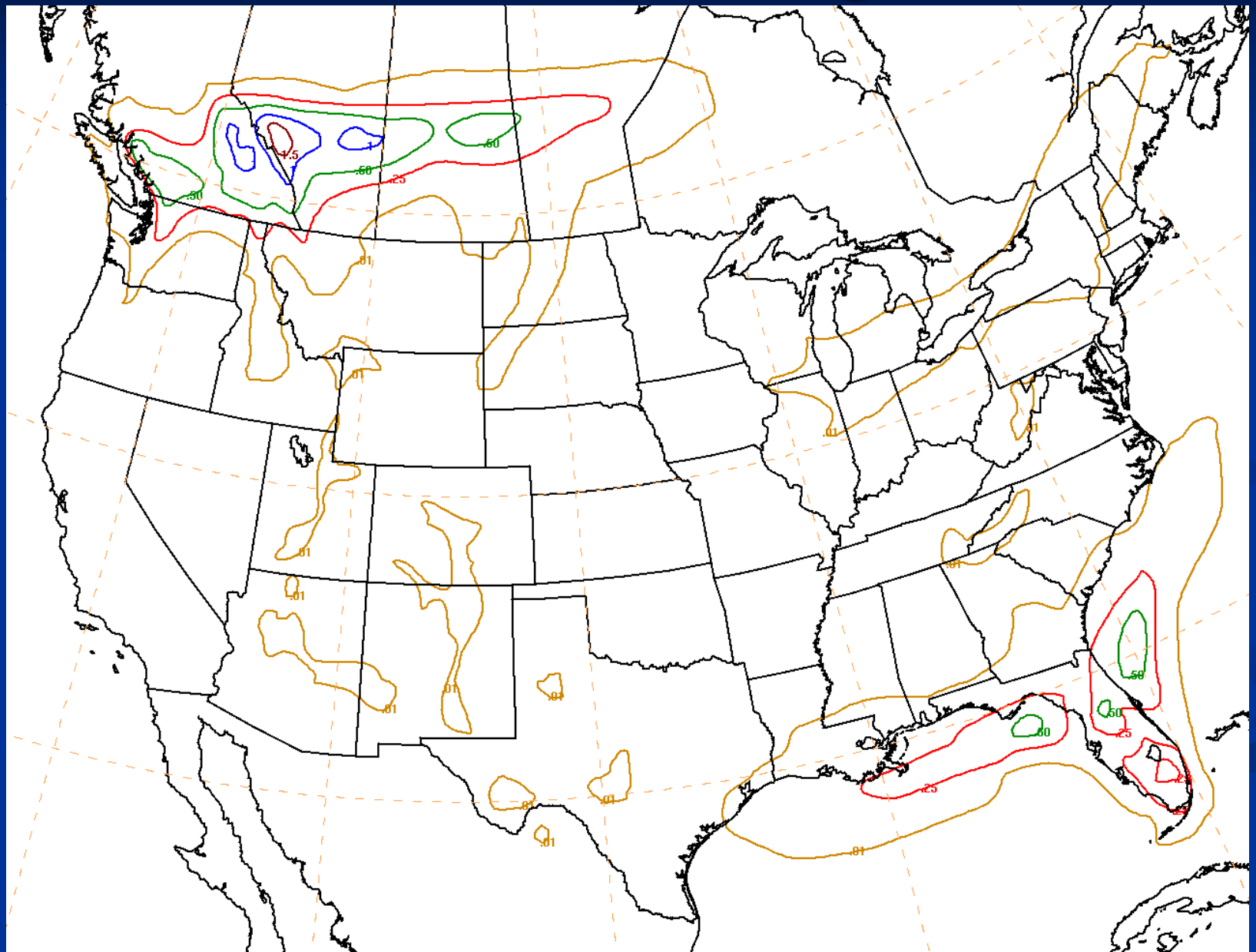
***ENSQPFBC**
GFS/ECMWF
SREF Mean
UKMET
Canadian

Any Season In the West

NAM
SREF Mean
GFS
ECMWF

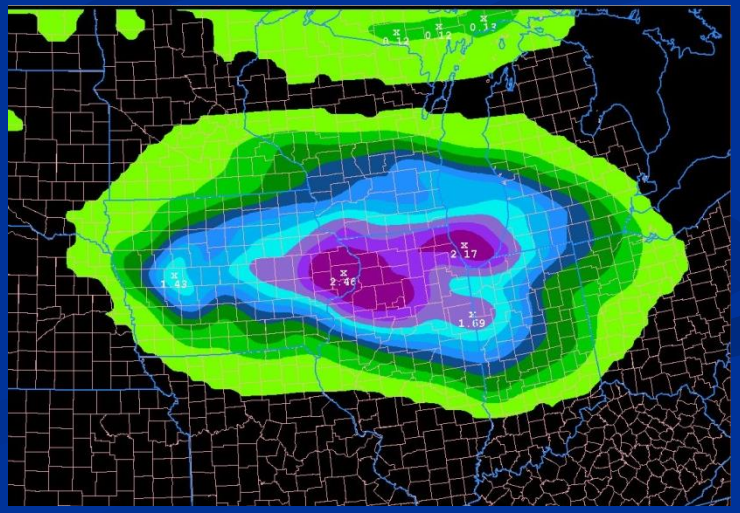
***ENSQPFBC…In-house product. Nice Threat Scores but high bias east of Rockies/low bias in the West**

24 hour QPF .vgf file



ENSQPFBC

- Calculate the weighted ensemble mean.
- Perform the pseudo bias correction.
- Apply downscaling using PRISM.
- Regularly update the weighting of models within the ensembles based on verification.

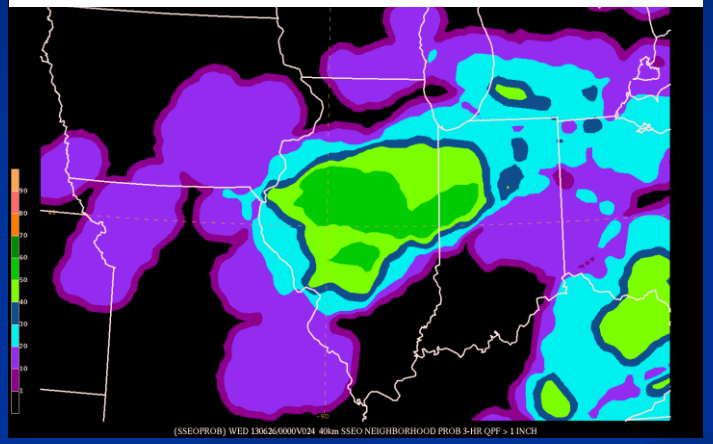


Ensemble Forecast Tools
Neighborhood Probabilities

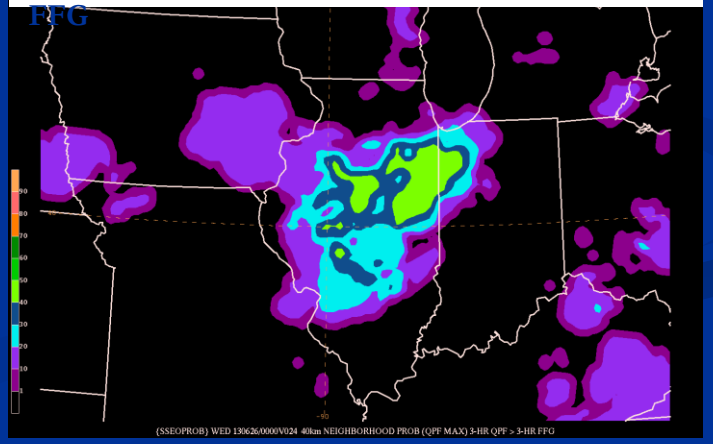
- Neighborhood Probability of an event occurring within a radius around a grid point
  - 20 km radius
  - 40 km radius

- Neighborhood maximum QPF
  - Probability of neighborhood maximum QPF exceeding flash flood guidance

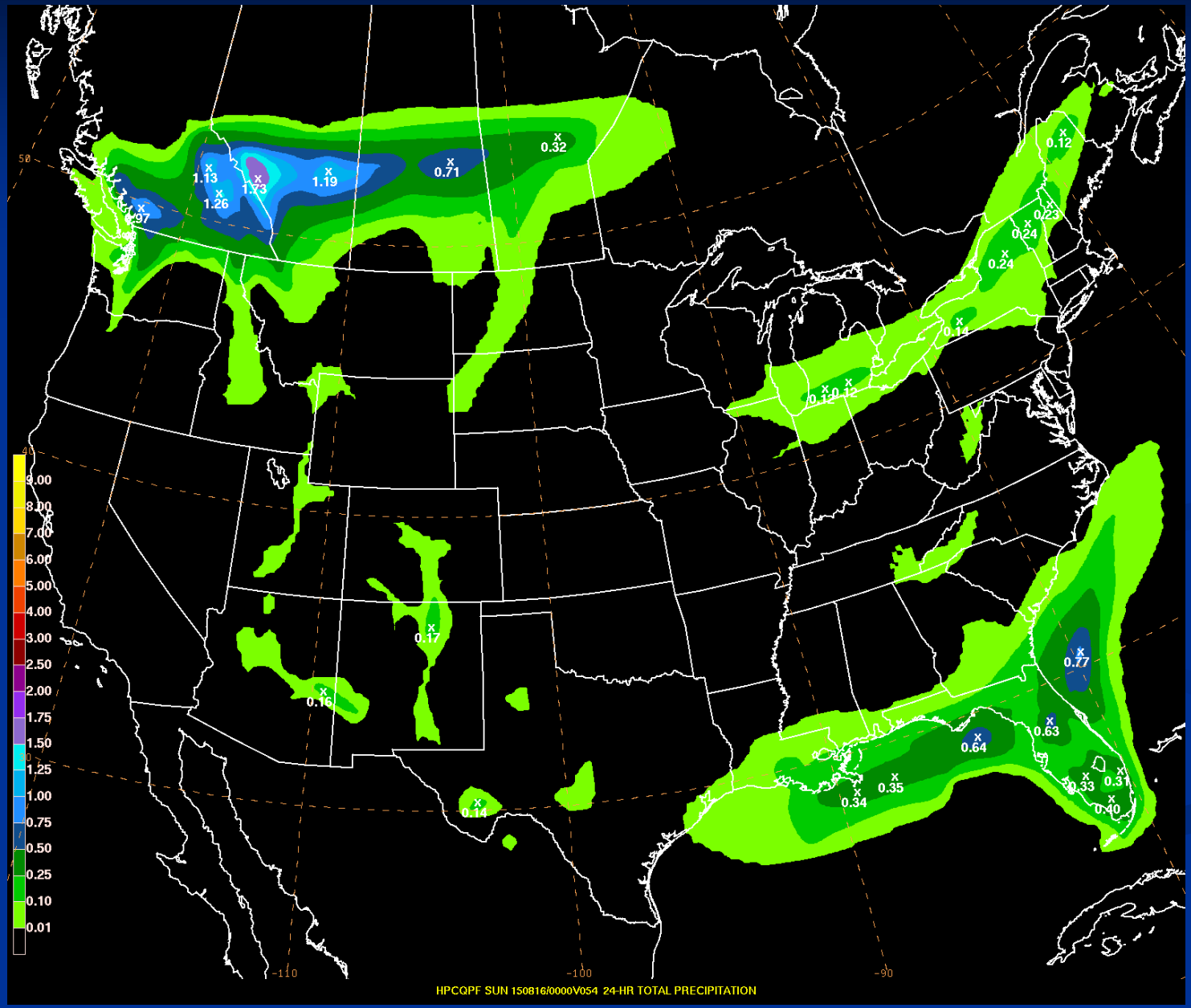
40 km neighborhood probability 3hr QPF > 1”



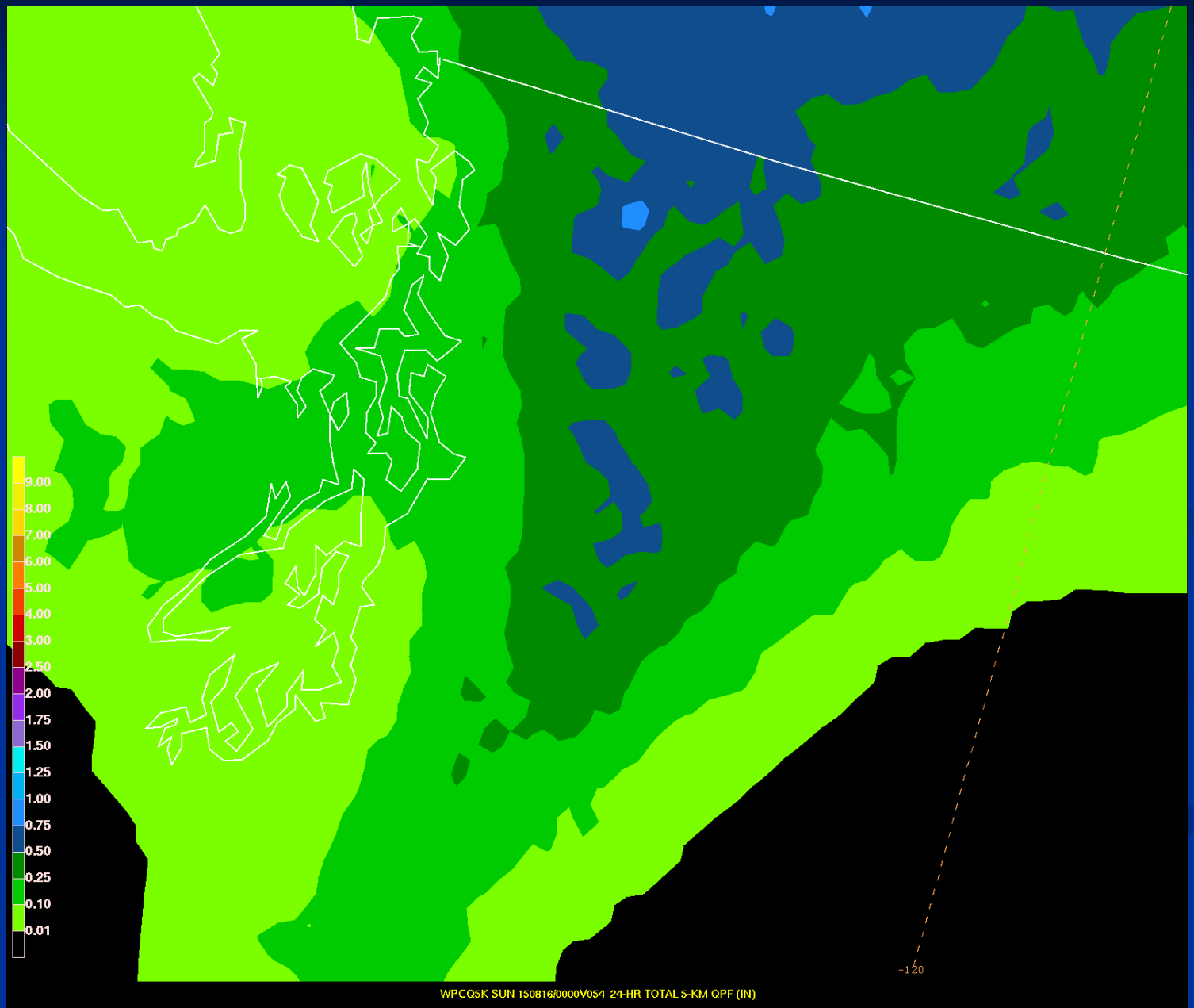
40 km neighborhood probability 3hr QPF > 3hr FFG



24 hour QPF 20 km QPF grid



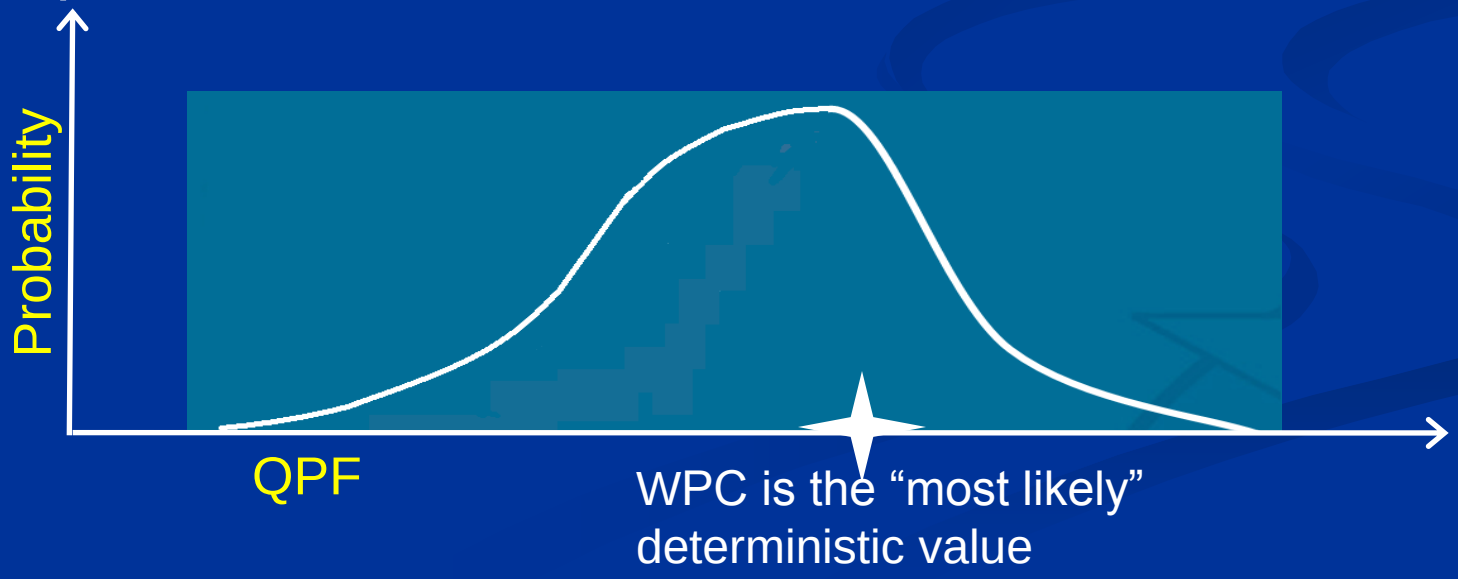
24 hour QPF 5 km QPF grid



Probabilistic QPF

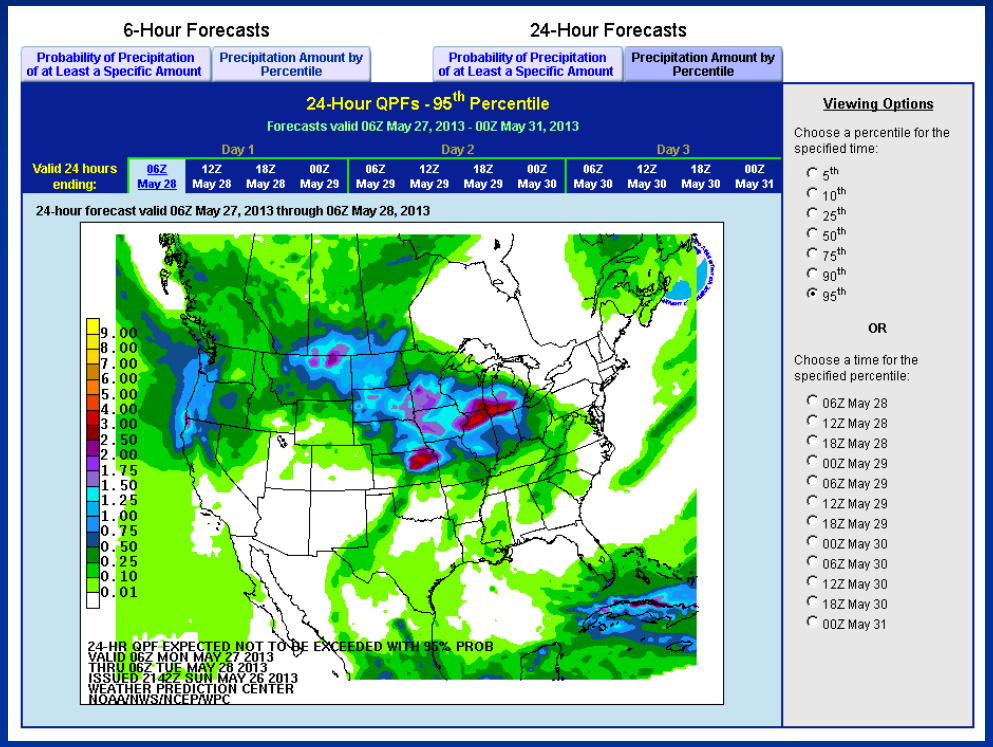
- When the manual WPC forecast is ready, it is lumped with the NAM, GFS, ECMWF, and SREF to form a 25 member ensemble.
- The probabilistic distribution is then forced into this format:

WPC deterministic QPF is the mode (most likely value), variance is that of the ensemble, and skew is based on the position of the WPC manual forecast

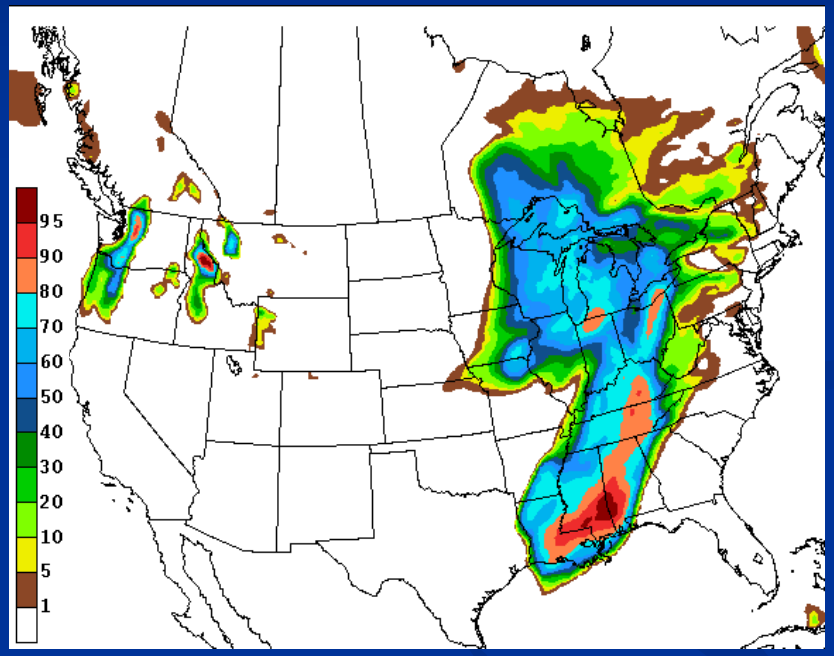


Probabilistic QPF

QPF by Percentile



Probability of QPF Exceeding a Threshold



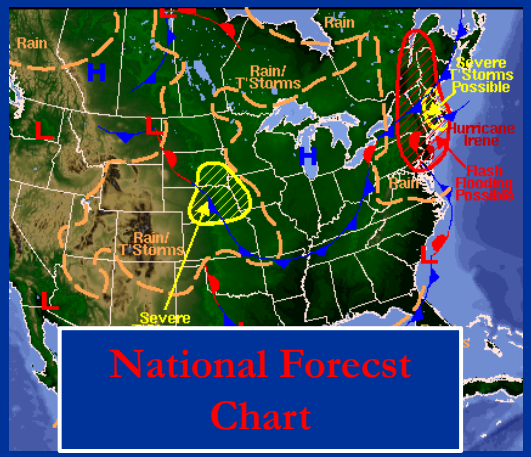
- *View 6- or 24-hourly*
- *PQPF and PWPF updates lag deterministic products by 1-2 hours*

Influence of Tropical Cyclones

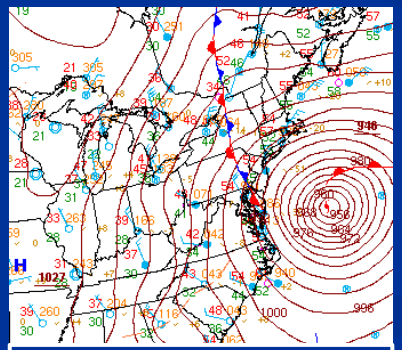
- WPC has the tools and focused mission to add value to the raw model output and frame local issues in a big-picture context

- Ramping up attention to the mesoscale… facilitating a collaborative process

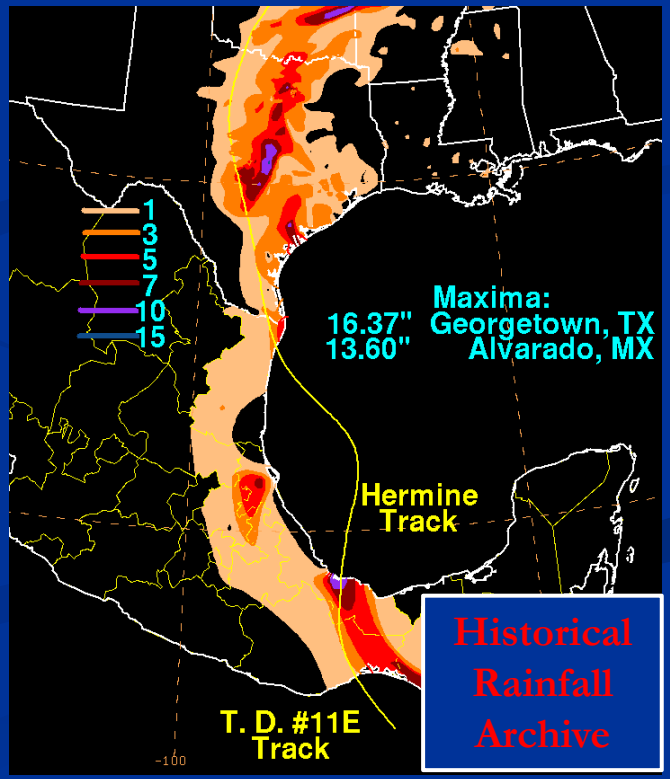
- Very attentive to tropical cyclones, as they influence all of our products



National Forecst Chart



WPC/NHC/OPC Unified Analysis

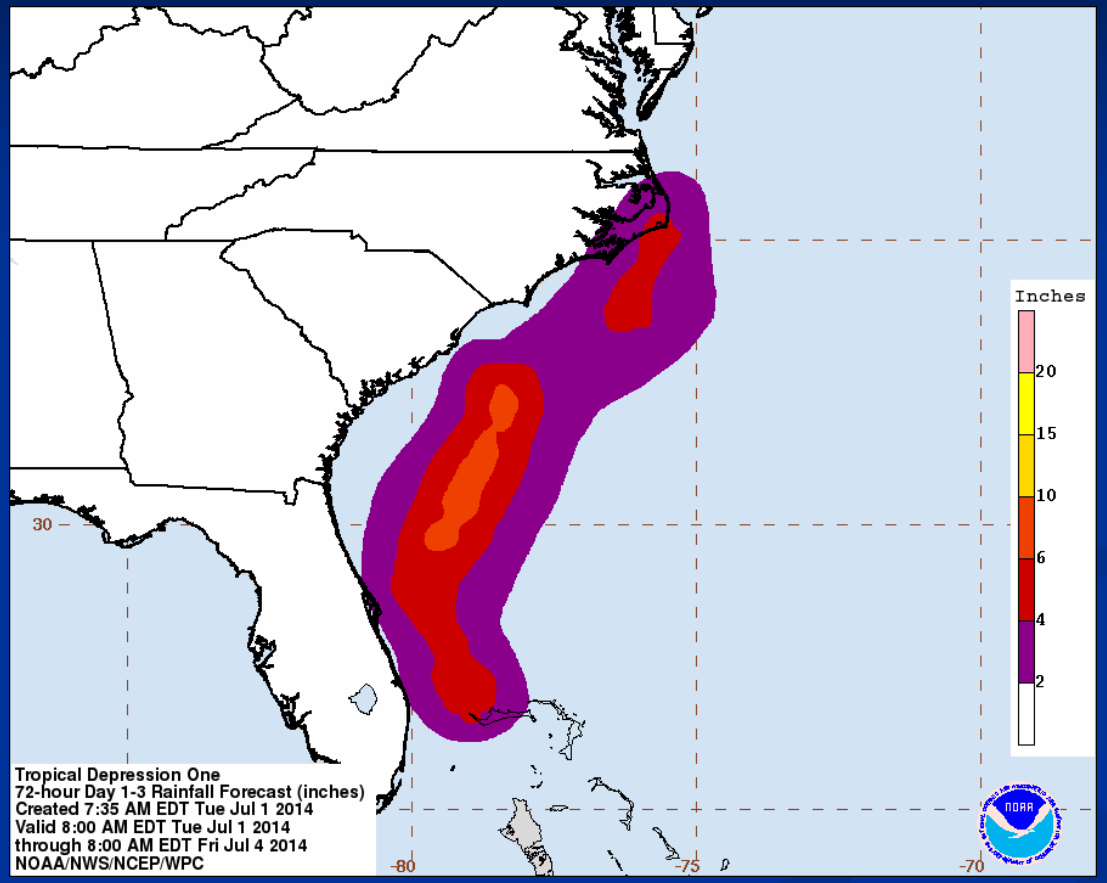


Historical Rainfall Archive

Tropical Cyclone Rainfall Graphic

WPC, NHC home page during tropical cyclones…

Variable duration summation – storm dependent

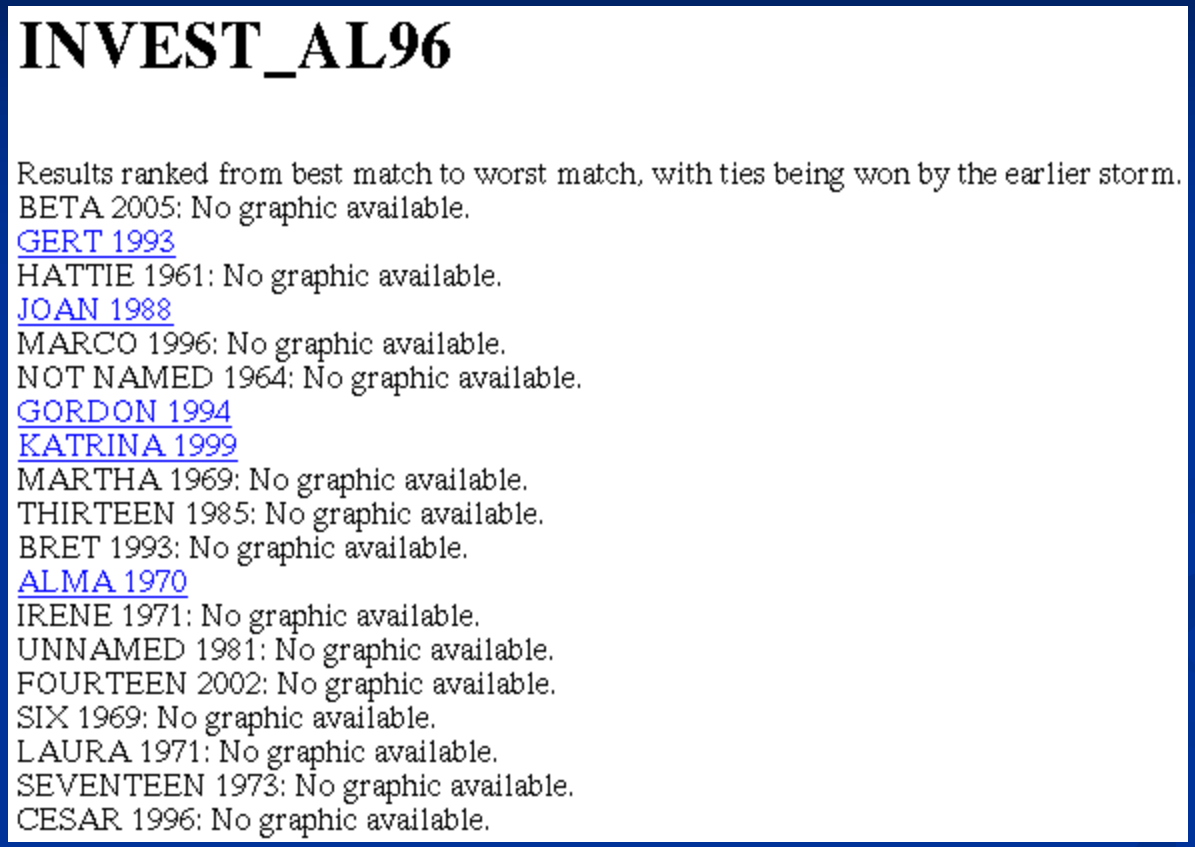


Note: Color scale and minimum contour of 2" was specified by FEMA. Alternate versions are now being considered.

CLIQR

- Scripts utilize extended best track database from NHC, modified by additional information from HPC/NHC map series and NHC Atlantic non-developing system database
- Storm matches made primarily upon current position, forward motion, and storm size. In 2009, NHC five day track will be included
- Uses a 9 point system. The system's point total can be seen in the last column of text output
- Output generated using CHGHUR/objective guidance messages from NHC, but can also be utilized using manual input
- Simplified output online for active systems at: http://www.hpc.ncep.noaa.gov/tropical/rain/web/cliqr.html

CLIQR matching storm list (Rainfall Matches hyperlink)



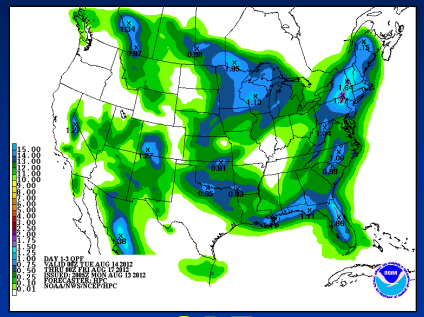
INVEST_AL96

Results ranked from best match to worst match, with ties being won by the earlier storm.
BETA 2005: No graphic available.
GERT 1993
HATTIE 1961: No graphic available.
JOAN 1988
MARCO 1996: No graphic available.
NOT NAMED 1964: No graphic available.
GORDON 1994
KATRINA 1999
MARTHA 1969: No graphic available.
THIRTEEN 1985: No graphic available.
BRET 1993: No graphic available.
ALMA 1970
IRENE 1971: No graphic available.
UNNAMED 1981: No graphic available.
FOURTEEN 2002: No graphic available.
SIX 1969: No graphic available.
LAURA 1971: No graphic available.
SEVENTEEN 1973: No graphic available.
CESAR 1996: No graphic available.

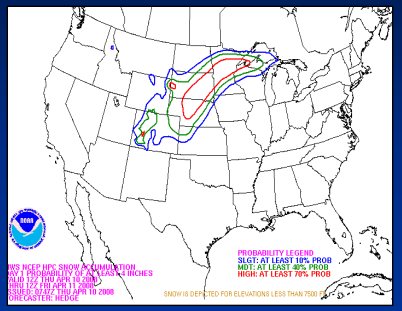
- Simplified list links to relevant storm total rainfall graphic through hyperlink
  http://www.wpc.ncep.noaa.gov/tropical/rain/web/cliqr.html

WPC Mesoscale Precipitation Discussions

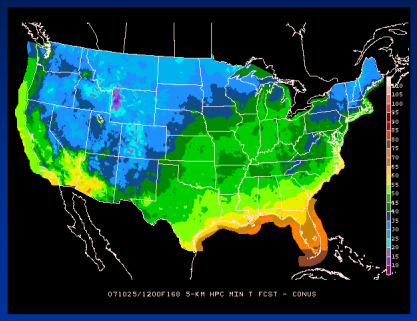
WPC Operational Desks



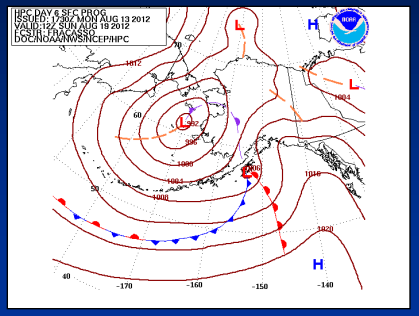
QPF



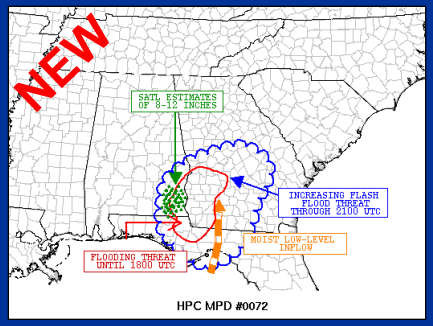
Winter Weather



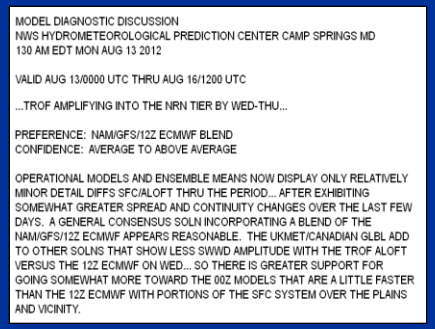
Medium Range



Alaska Med. Range



Met Watch


MODEL DIAGNOSTIC DISCUSSION
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
130 AM EDT MON AUG 13 2012

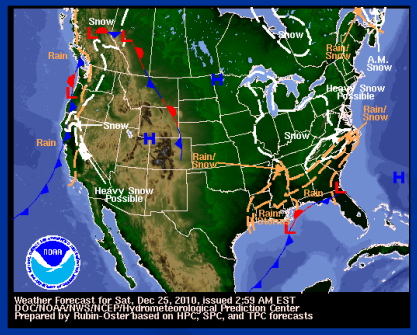
VALID AUG 13/0000 UTC THRU AUG 16/1200 UTC

...TROF AMPLIFYING INTO THE NRN TIER BY WED-THU...

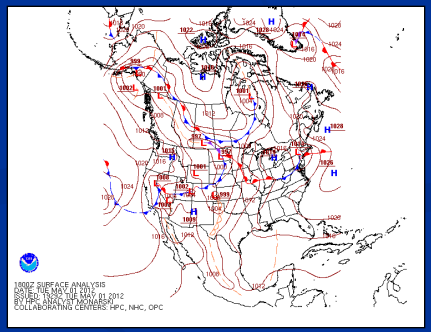
PREFERENCE: NAM/GFS/12Z ECMWF BLEND
CONFIDENCE: AVERAGE TO ABOVE AVERAGE

OPERATIONAL MODELS AND ENSEMBLE MEANS NOW DISPLAY ONLY RELATIVELY MINOR DETAIL DIFFS SFC/ALOFT THRU THE PERIOD... AFTER EXHIBITING SOMEWHAT GREATER SPREAD AND CONTINUITY CHANGES OVER THE LAST FEW DAYS. A GENERAL CONSENSUS SOLN INCORPORATING A BLEND OF THE NAM/GFS/12Z ECMWF APPEARS REASONABLE. THE UKMET/CANADIAN GLBL ADD TO OTHER SOLNS THAT SHOW LESS SWWD AMPLITUDE WITH THE TROF ALOFT VERSUS THE 12Z ECMWF ON WED... SO THERE IS GREATER SUPPORT FOR GOING SOMEWHAT MORE TOWARD THE 00Z MODELS THAT ARE A LITTLE FASTER THAN THE 12Z ECMWF WITH PORTIONS OF THE SFC SYSTEM OVER THE PLAINS AND VICINITY.

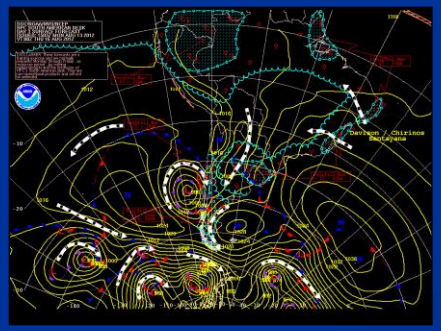
Model Diagnostics



Short Range



Surface Analysis



International

Tropical

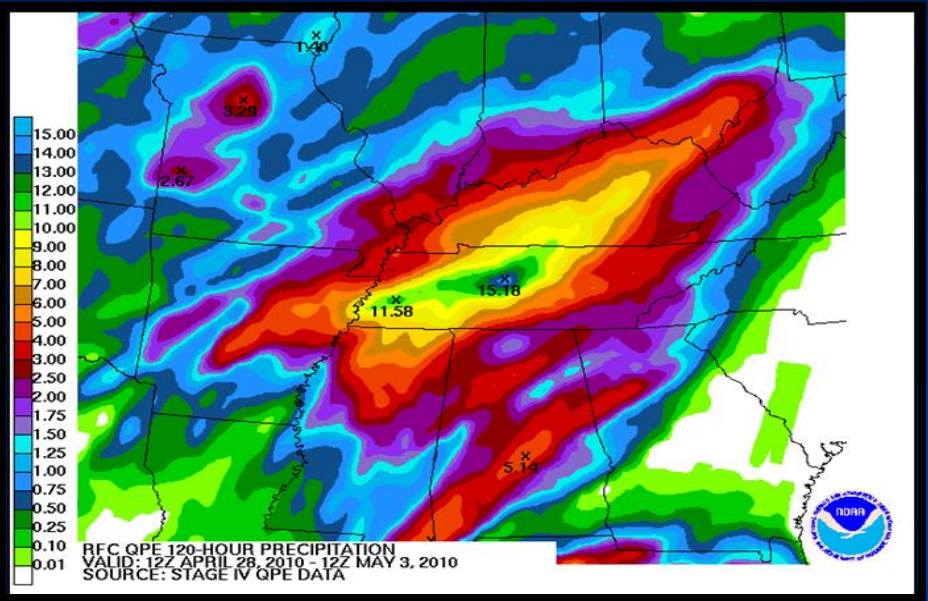
What is the MetWatch Desk?

- NCEP was asked to provide a product similar to SPC Mesoscale Convective Discussions (MCD) by NWS Central Region focusing on heavy rainfall
  - SPC and NESDIS/SAB supported this initiative
- Support for product during strategic planning process
    - Better positions WPC to support the NWS's Weather-Ready Nation initiative

WPC created the Mesoscale Precipitation Discussion (MPD) which is designed to enhance NWS flash flood warning services by providing enhanced situational awareness of potential flash flood events.

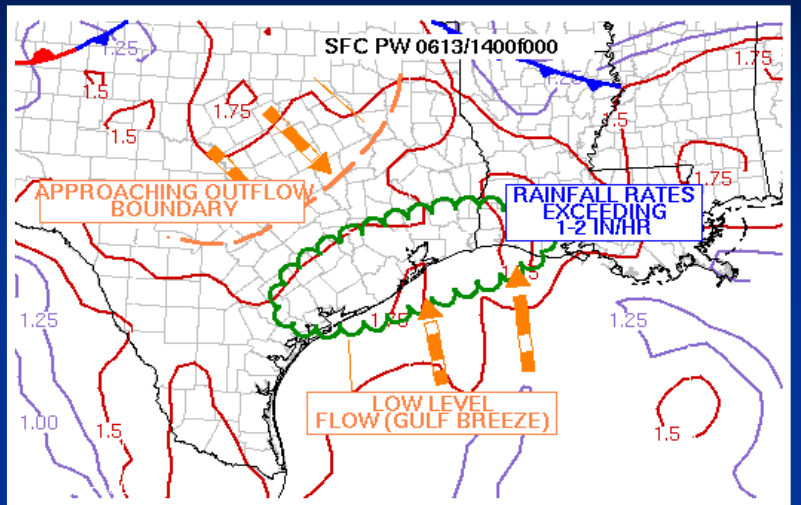
MetWatch Motivation

Can we anticipate an event like this in the short-range time period? Or provide value as an event is ongoing?



MetWatch Background

- WPC prototyped the MetWatch desk in 2012.
- Desk went operational on April 9th, 2013.
- 441 MPDs issued for the 2014 season.
- ***453 MPDs issued as of August 18 – on pace for ~680 in 2015.***



HPC MPD #0032

MESOSCALE PRECIPITATION DISCUSSION 0032
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
1216 PM EDT WED JUN 13 2012

AREAS AFFECTED...SOUTHEAST TEXAS...SOUTHWST LOUISIANA

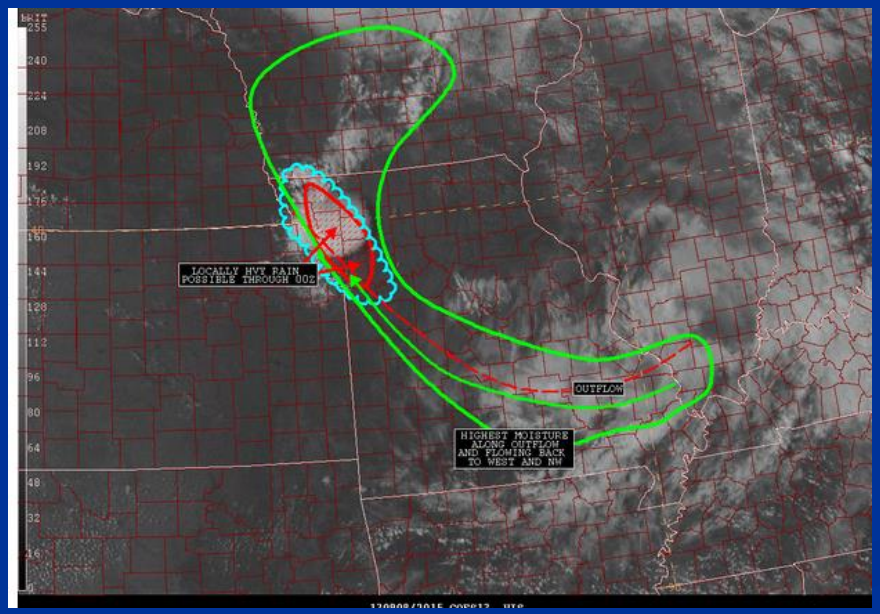
CONCERNING...HEAVY RAINFALL...FLASH FLOODING POSSIBLE

VALID 131600Z - 132000Z

...SLOW MOVING CONVECTION WITH POTENTIALLY EXCESSIVE RAINFALL AMOUNTS ACROSS COASTAL AREAS IN SOUTHEAST TEXAS AND WESTERN LOUISIANA...

COMPOSITE RADAR LOOPS SHOW REGENERATING CONVECTIVE CLUSTERS ALONG THE GULF BREEZE BOUNDARY ACROSS COASTAL PORTIONS OF SOUTHEAST TEXAS...EAST OF VICTORIA...AND SOUTHWEST LOUISIANA. THESE CELLS ARE AIDED BY THE STRENGTHENING DIURNAL DESTABILIZATION...WITH THE LATEST SPC MESOANALYSIS INDICATING SURFACE-BASED CAPES BETWEEEN 3,000-4,000 J/KG...COINCIDENT WITH THE RICH...DEEP MOIST ENVIRONMENT WITH SURFACE DEWPOINTS IN THE MID 70S...K INDICES IN THE MID TO UPPER 30S...AND PWATS BETWEEN 1.75 AND 2.00 PER THE LATEST GPS AND 12Z UPPER AIR ANALYSIS

NESDIS SPENES




```
000
TXUS20 KNES 082042
SPENES
ZCZC NFDSPENES ALL
SPENES
MOZ000-KSZ000-
.
SATELLITE PRECIPITATION ESTIMATES..DATE/TIME 09/08/13 2041Z
SATELLITE ANALYSIS BRANCH/NESDIS---NPPU---TEL.301-683-1404
LATEST DATA USED: GOES-13 2030Z  KUSSELSON
.
LOCATION...NW MISSOURI...EXT NE KANSAS...
.
ATTN WFOS...EAX...
ATTN RFCS...MBRFC...
.
EVENT...SLOW MOVING CELL ON END OF LAST NIGHT'S CONVECTIVE OUTFLOW
AFFECTING MOSTLY BUCHANAN...ANDREW AND HOLT COUNTY IN MISSOURI...
.
SATELLITE ANALYSIS AND TRENDS...DEEP MOISTURE FORCED WEST AND NW ALONG
OUTFLOW INTO NW MISSOURI NEAR THE KANSAS BORDER AND HAS RESULTED IN
CONVECTIVE DEVELOPMENT NEAR THE NEBRASKA-KS-MO BORDER AREA THAT IS NOW
DRIFTING SOUTHEAST ALONG SOME VERY HIGH PWAT MOISTURE CLOSE TO 2"..
RIGHT IN THE MIDDLE OF THE 85H THETA-E MAX...SO MOVEMENT WILL BE SLOW.
ONLY AN INSTANCE OF AN OVERSHOOTING CLOUD TOP BUT STILL COULD BE RESULTING
IN 1-1.5" IN A 30 MINUTE OR SO TIME PERIOD ACROSS HOLT AND ANDREW INTO
BUCHANAN COUNTY WITH A BIT MORE ACTIVITY REDEVELOPING T THE NORTH AND
NW FOR SOME ISOLATED TRAINING.
.
AN ANNOTATED SATELLITE GRAPHIC SHOWING THE HEAVY PRECIPITATION
THREAT AREA SHOULD BE AVAILABLE ON THE INTERNET ADDRESS LISTED
BELOW IN APPROXIMATELY 10-15 MINUTES.
.
SHORT TERM OUTLOOK VALID 2030-2330Z...MEDIUM CONFIDENCE FACTOR
IN SHORT TERM OUTLOOK...CELLS KEEP FIRING NORTH AND NW OF ORIGINAL
OVERSHOOTING CLOUD TOPS AND BASIC DRIFT WAS EAST AND SE...SO NOT EXPECTING
MUCH OF THE NEW DEVELOPMENT TO GIVE AS MUCH AS THE ORIGINAL CONVECTION
OVER THE SAME AREA...BUT WILL STILL HAVE TO KEEP AN EYE ON TRAINING AS
BOUNDARY ONLY SLOWLY MOVING EAST...AREAS TO WATCH NODAWAY TO ANDREW TO
BUCHANAN INTO PLATTE AND MAYBE SHIFTING INTO CLINTON AND DEKALB COUNTY
DURING THE MIDDLE OF THE PERIOD.
.
....NESDIS IS A MEMBER OF NWSCHAT (NESDISSATELLITEPRECIP)....
....NESDIS IS A MEMBER OF 12 PLANET....
.
FOR QUESTIONS AND COMMENTS CONCERNING THE SATELLITE
PRECIPITATION MESSAGES AND GRAPHICS PLEASE EMAIL
SSDPrecip@noaa.gov
.
FOR PRECIP MESSAGES AND GRAPHICS ON THE WEB:
http://www.ssd.noaa.gov/PS/PCPN/
```

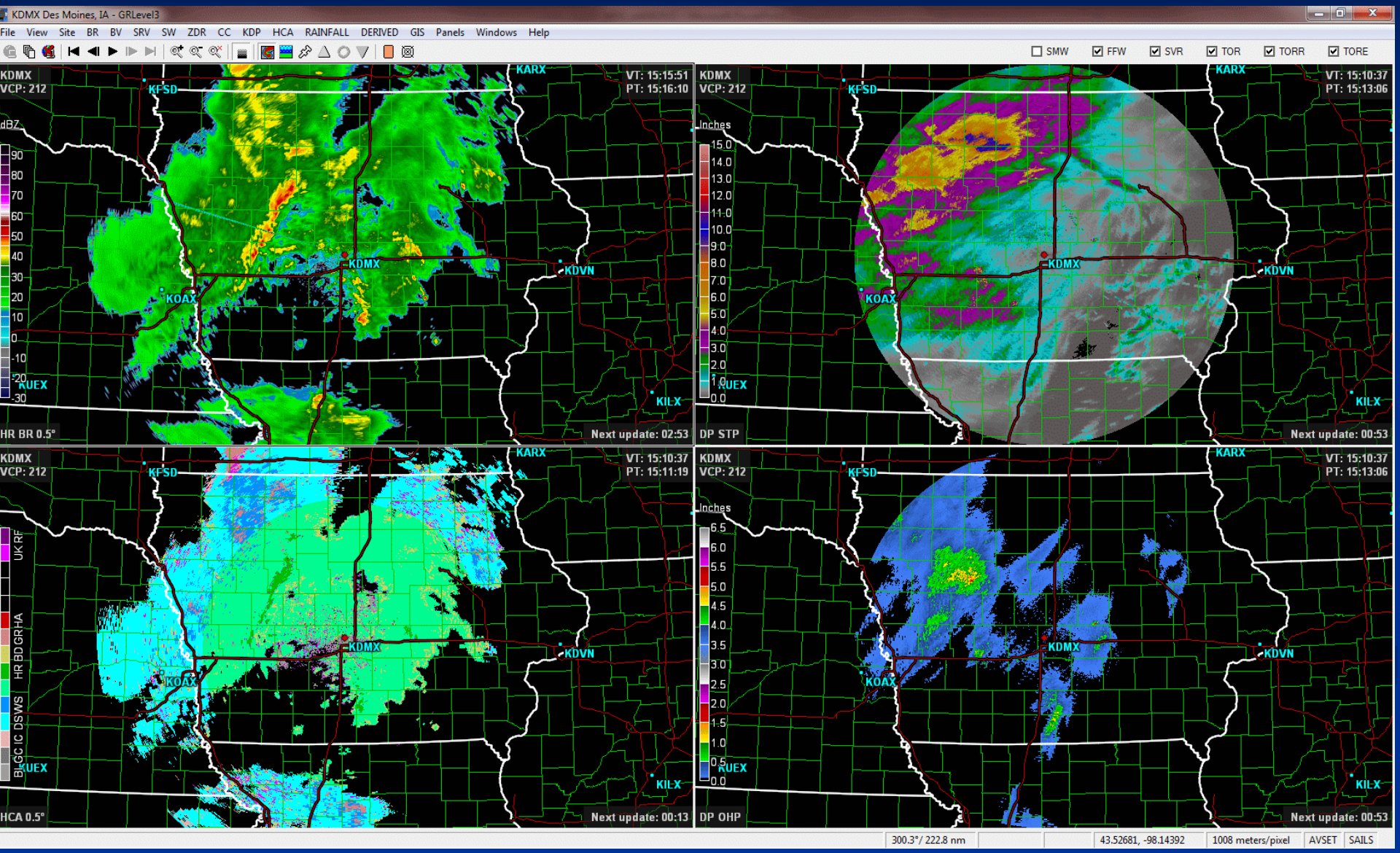
Role of GOES-R Proxy Products

- Given the challenge of short-range flash flood forecasting, forecasters are looking for new satellite products and tools that can provide value to the mission.
- GOES-R proxy products have been proven to help the WPC forecaster in NOWCASTing flash flood events across the nation, and with varying degrees of convective organization.
- WPC forecasters find the evolution of GOES-R product algorithms as being a key to providing value, which should help out after the planned October 2016 launch of the GOES-R satellite

Models utilized for MetWatch

- GFS
- NAM
- ECMWF
- Canadian (Regional)
- ARW
- NSSL ARW
- NAM CONEST
- WRF4NSSL
- SPCWRF
- RAP
- HRRR
- Storm Scale Ensemble of Opportunity (SSEO)
- NMM
- GFDL
- Hurricane WRF
- JMA

GR-Level 3 Analyst

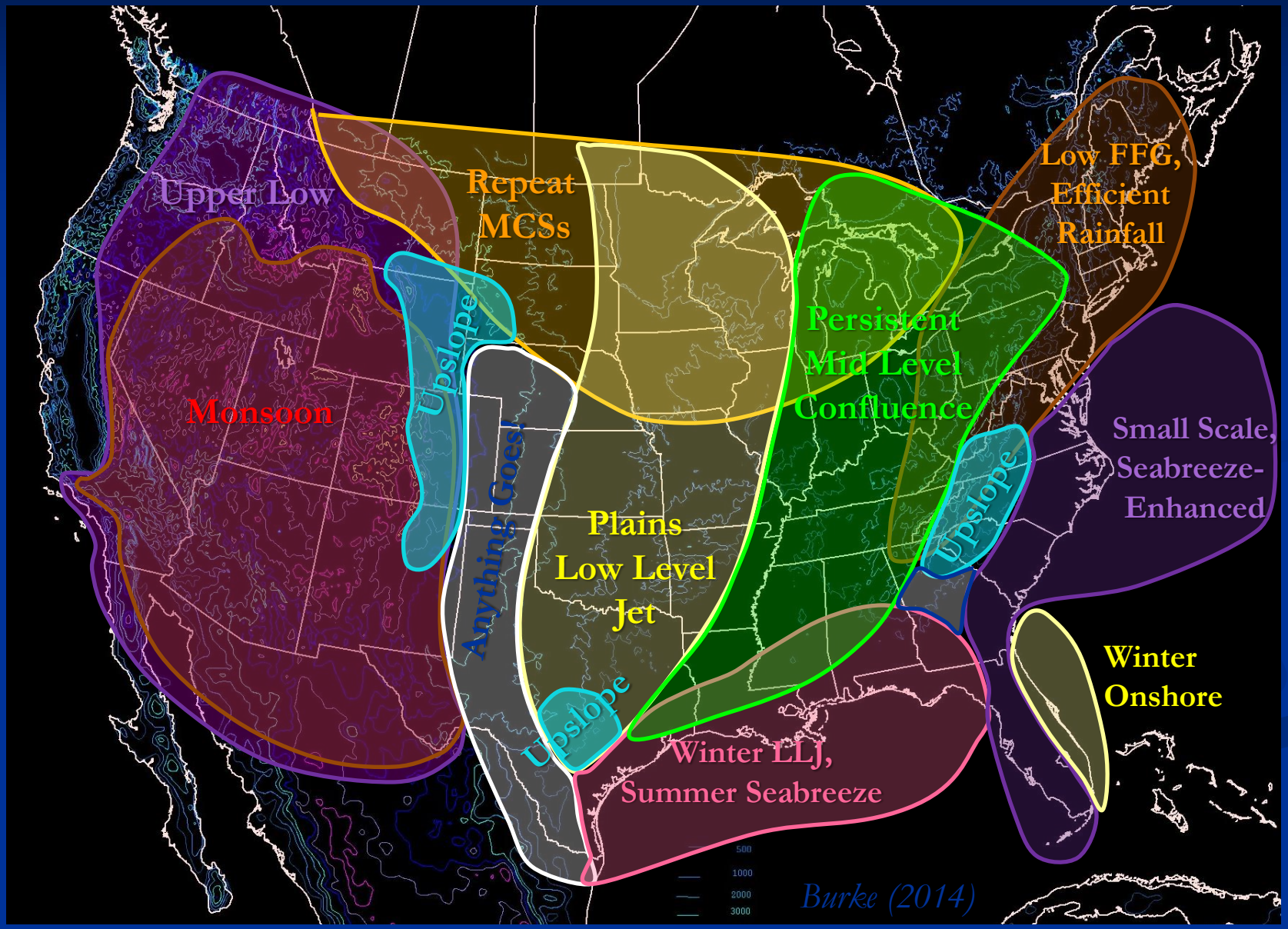


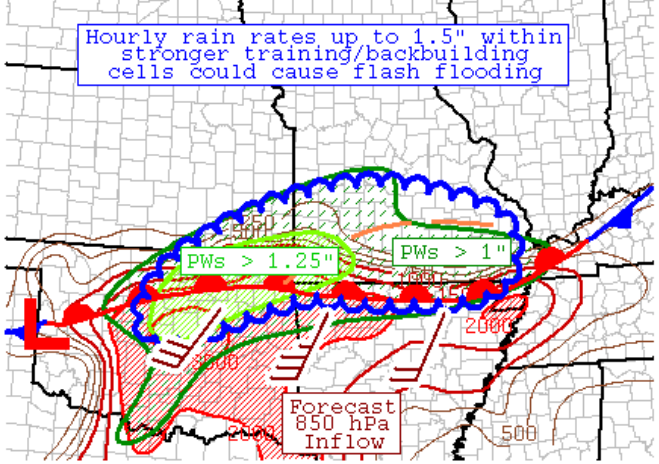
Factors we keep in mind for MPDs

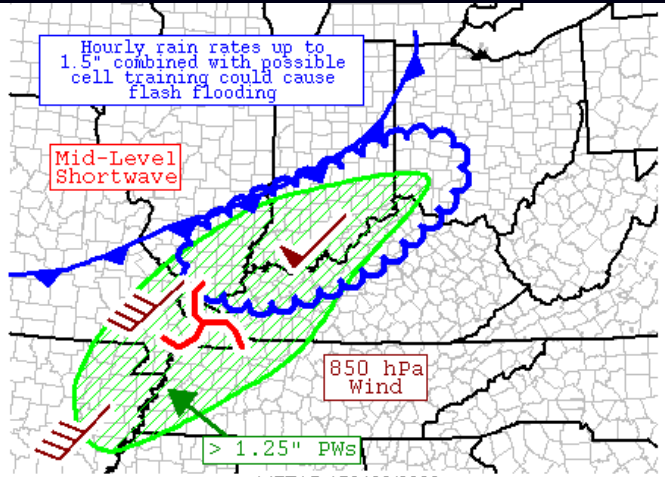
- Location of population centers / areas of soil saturation / Flash Flood Guidance values
- CAPE normally > 800 J/kg and < 3000 J/kg within 150 nm upstream (less for moist sounding profiles, more for drier profiles) with broad cloud base inflow >= 25 kts. Less inflow necessary with higher CAPE
- The appropriate propagation vectors
- PWs >= 1.50" (adjusted for elevation)
- Hourly rain rates ~104% of PW
- Surface boundaries present
- Support from the mesoscale QPF guidance

Flash Flood Causes – Composite Chart

Considers only convective events (nothing west of Cascades/Sierras)
Does not address tropical systems

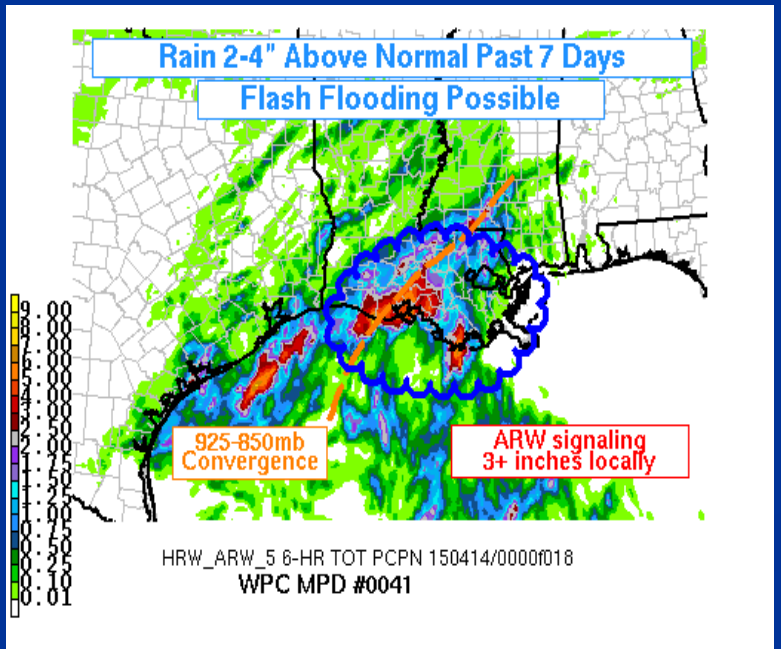


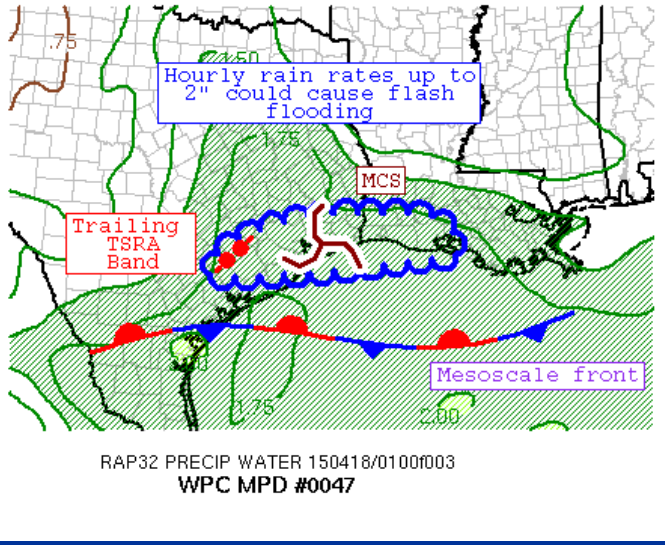




In AWIPS2: FFGMPD

http://www.wpc.ncep.noaa.gov/metwatch/metwatch_mpd.php

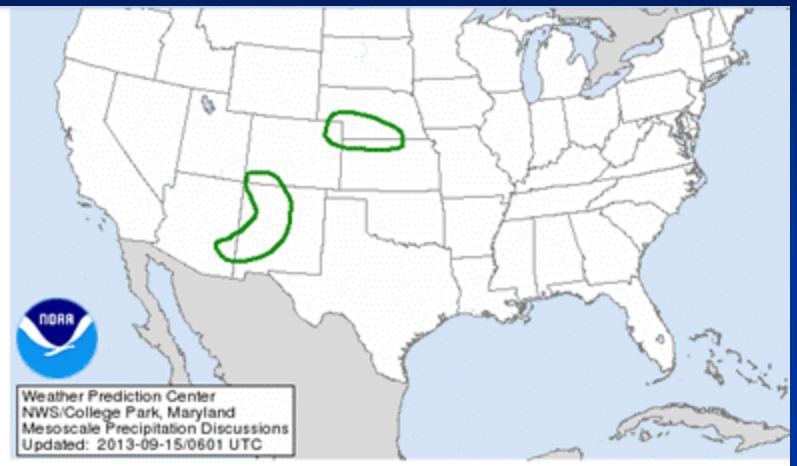




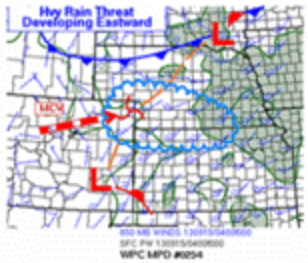
Coordination with WFOs

- Messages can be sent as a “heads up” to the field, or to get input from potentially impacted WFOs in perceived borderline situations
- Broadly within the overall chat to numerous WFOs
- Individually via private chat to WFOs
- hpc_Metwatch ID in 1-2 Planet
- Can use NWS Chat if impacted WFOs not in 1-2 Planet

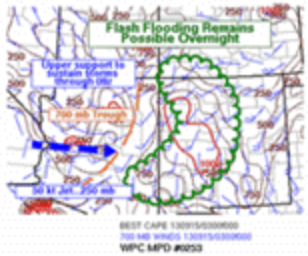
MPD Summary webpage



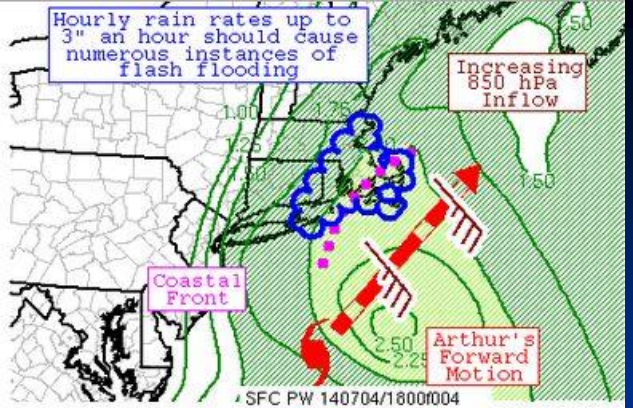
Clicking on the U.S. map will take you to the MPD and associated graphic



MPD #0254
Issued: 15/0544 UTC
Until: 15/1044 UTC
Concerning: **HEAVY RAINFALL...FLASH FLOODING POSSIBLE**



MPD #0253
Issued: 15/0432 UTC
Until: 15/0832 UTC
Concerning: **HEAVY RAINFALL...FLASH FLOODING POSSIBLE**



SFC PW 140704/1800f004

WPC MPD #0177

MESOSCALE PRECIPITATION DISCUSSION 0177
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
337 PM EDT FRI JUL 04 2014

AREAS AFFECTED...EASTERN LONG ISLAND AND SOUTHEAST NEW ENGLAND

CONCERNING...HEAVY RAINFALL...FLASH FLOODING LIKELY

VALID 041936Z - 050036Z

SUMMARY...THUNDERSTORMS WITH INCREASING RAINFALL RATES ARE EXPECTED ACROSS EASTERN LONG ISLAND AND SOUTHEAST NEW ENGLAND, WITH 3" AN HOUR RATES POSSIBLE. CONSIDERING THE RAINFALL RECEIVED SO FAR TODAY, NUMEROUS INSTANCES OF FLASH FLOODING ARE EXPECTED.

DISCUSSION...HURRICANE ARTHUR CONTINUES MOVING NORTHEAST TOWARDS THE REGION. WHILE A SYNOPTIC SCALE FRONTAL BOUNDARY LIES TO ITS WEST AND NORTH, A COASTAL FRONT IS FOCUSING THUNDERSTORM ACTIVITY WITH RAINFALL RATES OF 1" AN HOUR. PRECIPITABLE WATER VALUES NEAR 2" CONTINUE ACROSS THE REGION, AND RECENT RADAR IMAGERY SHOWS BANDS OF THUNDERSTORMS WITH INCREASING RAINFALL RATES JUST OFFSHORE LONG ISLAND AND SOUTHERN NEW ENGLAND.

THE 12Z ARW INDICATES THAT CAPES SHOULD RISE ABOVE 1000 J/KG AS THE RAP GUIDANCE INDICATES THAT 850 HPA INFLOW RAMPS UP OVER THE NEXT SEVERAL HOURS TO GALE-FORCE. THE CRITERIA FOR THE WET MULTI-CELL ENVIRONMENT SHOULD BE REACHED AROUND 21Z. THE SYNOPTIC SCALE FRONT IS EXPECTED TO PHASE WITH THE COASTAL FRONT OVER THE NEXT SEVERAL HOURS, WHICH SHOULD INCREASE SURFACE CONVERGENCE. RAINFALL RATES SHOULD APPROACH 3" AN HOUR IN STRONGER STORMS. THE CURRENT MESOSCALE GUIDANCE APPEARS TOO LIGHT WITH PRECIPITATION TOTALS IN THIS REGION, ALL THINGS CONSIDERED. LOCAL AMOUNTS OF 3-5" LOCALLY DURING THIS PERIOD SHOULD CAUSE NUMEROUS INSTANCES OF FLASH FLOODING.

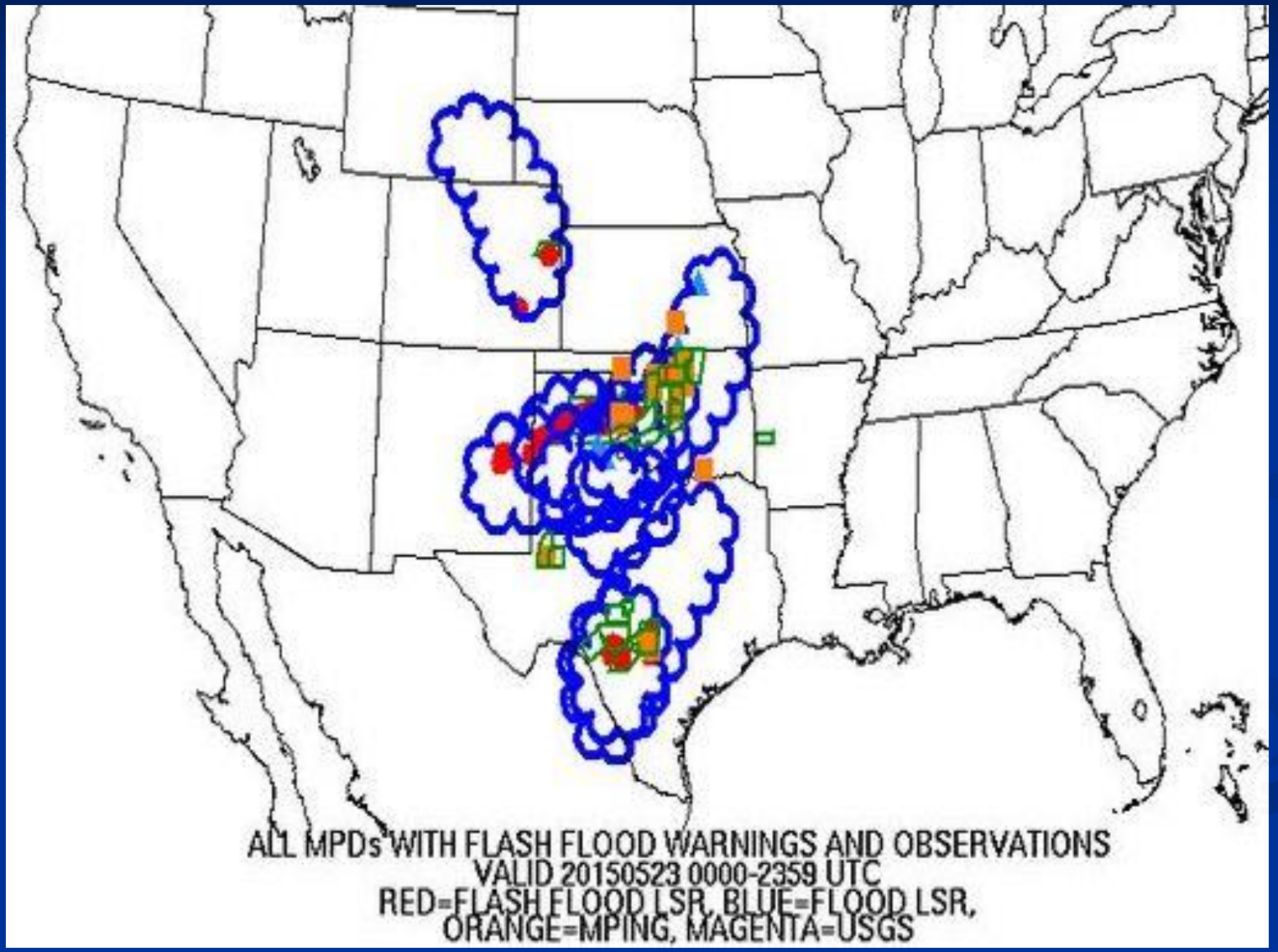
ROTH

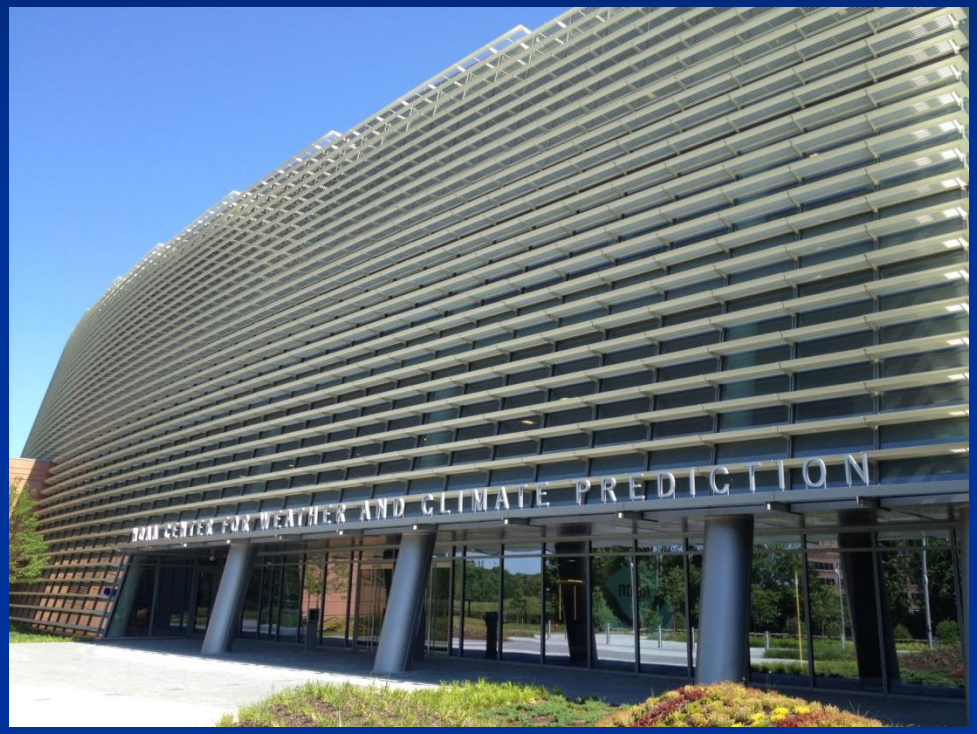
ATTN...WFO...BOX...OKX...

ATTN...RFC...NERFC...

LAT...LON 42177016 41876986 41556993 41547010 41607019 41487053
41437044 41357038 41337016 41407003 41336990 41196994
41197028 41297055 41257086 41417112 41347137 41107157
40867225 41067240 41897172 42087112 42787075 42707053

Subjective Verification





Thank You!

David Roth
e-mail:
David.Roth@noaa.gov
phone: (301)-683-1530

"Where America's Climate, Weather, Ocean, and Space Weather Services Begin"