

Weather Prediction Center

Tropical Cyclone Services Heavy Rainfall Focus

Greg Carbin, Patrick Burke, Alex Lamers, and WPC Staff
NOAA/NWS Weather Prediction Center
College Park, Maryland

What Is This Talk About?

What is WPC?

Focus on Excessive Rainfall Prediction and Products

- Excessive Rainfall Outlook and High Risks
- Mesoscale Precipitation Discussions
- Probabilistic QPF

Coordinated Messaging for Tropical Rainfall

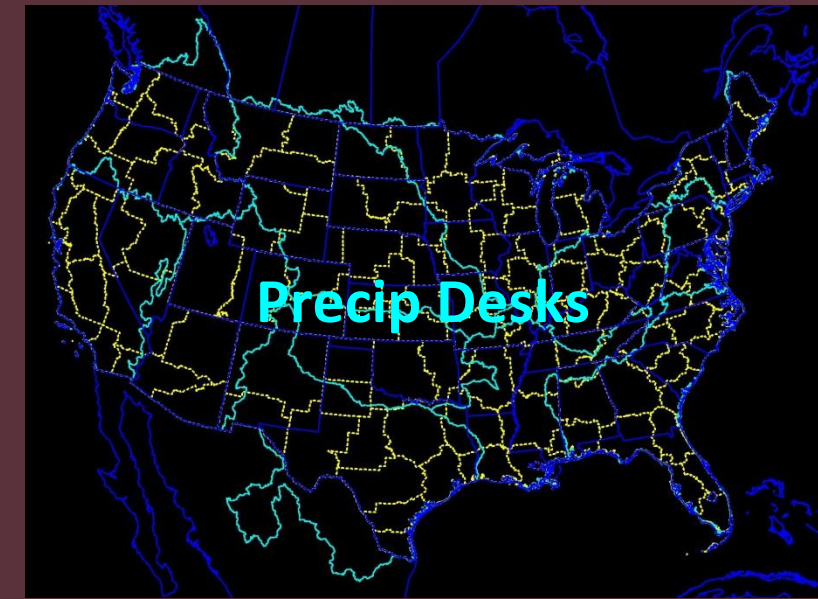
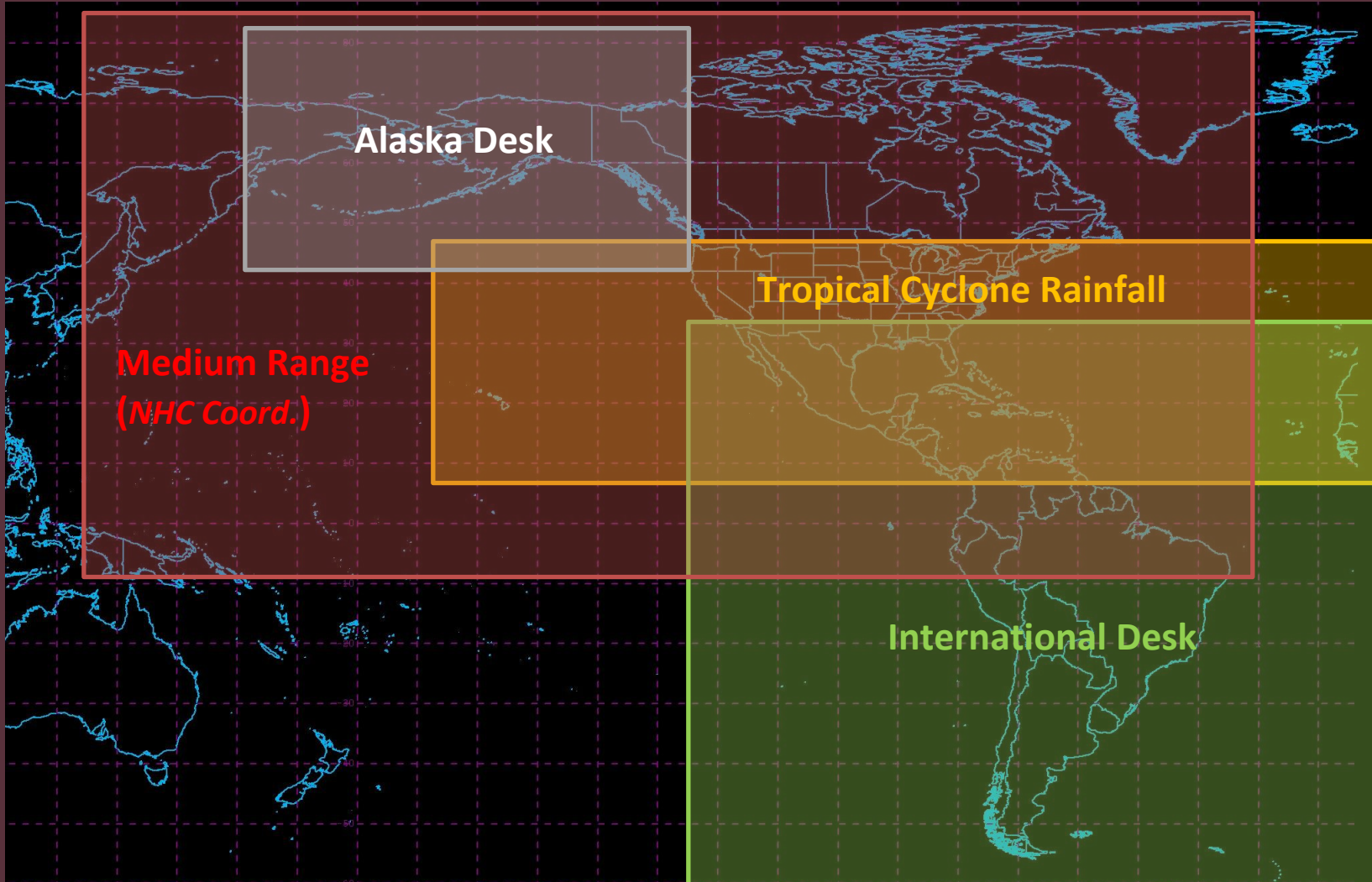
- How it worked in Harvey
- What's Planned in 2018

Evolving to a Fully Integrated Field Structure

- Partnerships with NHC, WFOs, RFCs



WPC: A Unique National Resource



WPC is with every WFO, RFC
Every Day and Night...
Experiencing it All!

WPC: A Unique National Resource

NOAA, NWS, NCEP Connections

A Stone's Throw Away:



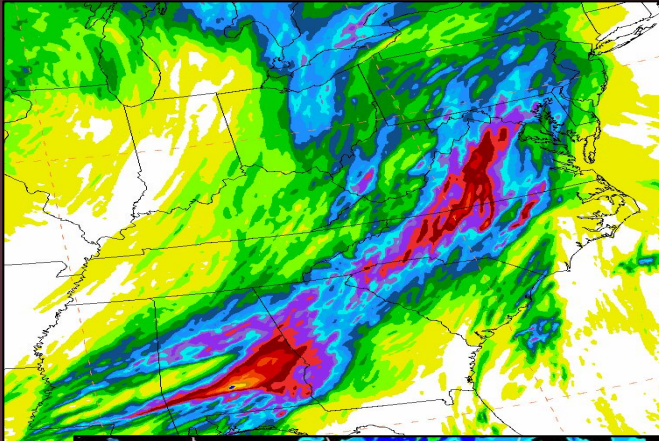
Satellite Liaison
NESDIS Precipitation Desk
Senior Duty Meteorologist
Environmental Modeling Center
Hydrometeorological Testbed / FFaIR
NOAA & NWS HQ
Increased connectedness with the Field
(Integrated Field Structure)



This decision to break directive and deliver an emphatic forecast message at three-day lead time was coordinated from College Park to Silver Spring to Houston, Texas, all within the span of about ten minutes which is absolutely remarkable. — Patrick Burke

WPC: A Unique National Resource

Numerical Modeling Expertise



NCEP: WRF-ARW, WRF-ARW2, NAM CONUS Nest, HREF, HRRR, SREF, GFS/GEFS, NBM (& parallel / beta versions evaluations)

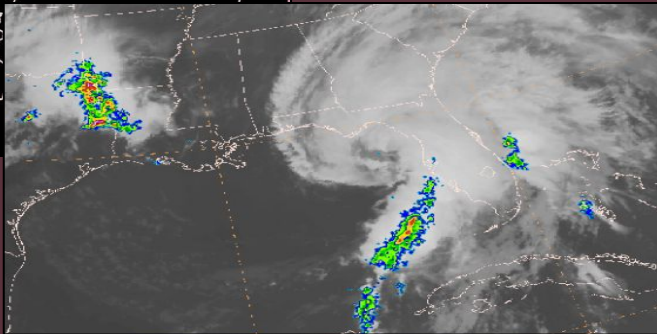
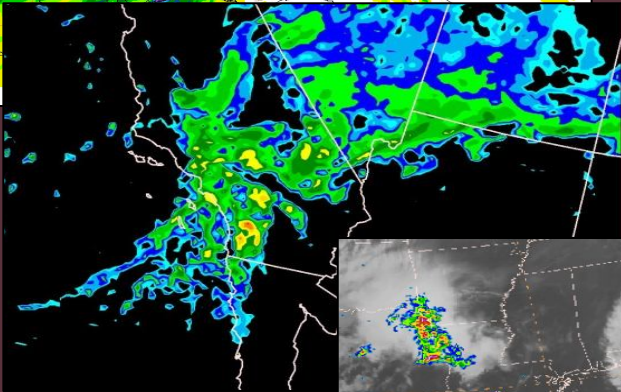
ECMWF: ECMWF ensemble and deterministic

CMC: GEM Regional, Canadian ensemble

ESRL: Experimental HRRR

NSSL: NSSL NEWS-e

WPC: In-house, skillful, NBM-like ensemble with longer history. Includes hi-res “flavors” using an adjusted mean and pseudo bias-corrections. (PQ/WPF)



National domain / frequent practice / trend analysis...

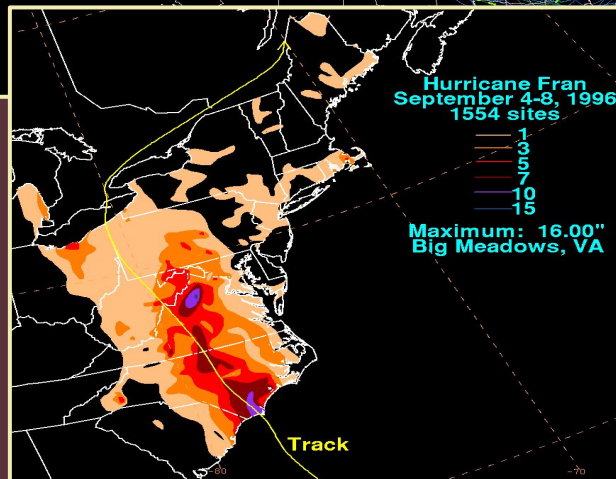
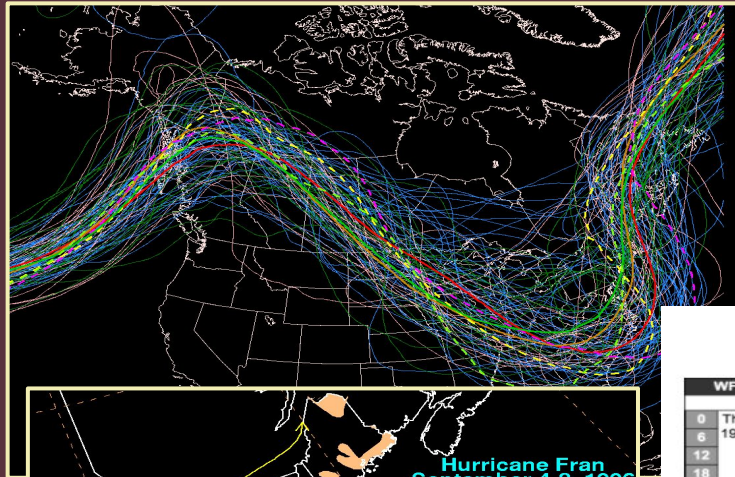
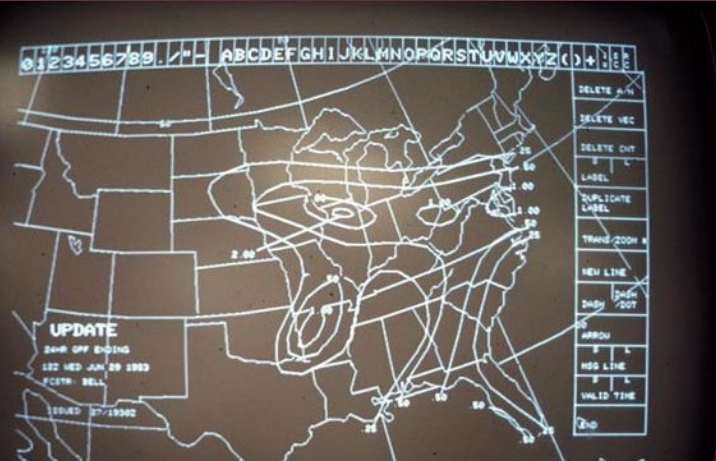
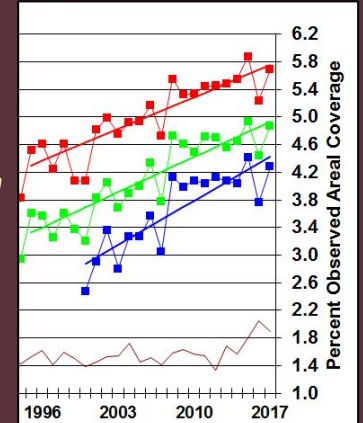
WPC forecasters are strongly calibrated to model strengths, weaknesses.

WPC: A Unique National Resource

Historical Context and Change

WPC has a nearly 60 year legacy of QPF
And over 30 years of Excessive Rainfall Outlooks

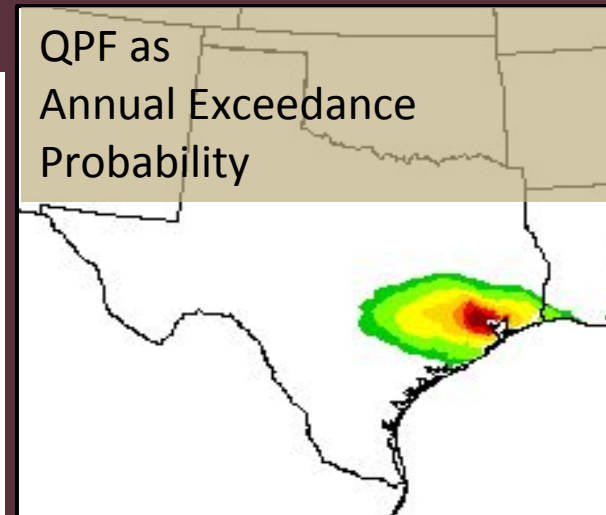
QPF Threat Scores (1")
Days 1, 2, and 3



ECMWF ESAT

WFO Western U.S. Table May 19, 2016 00Z Run

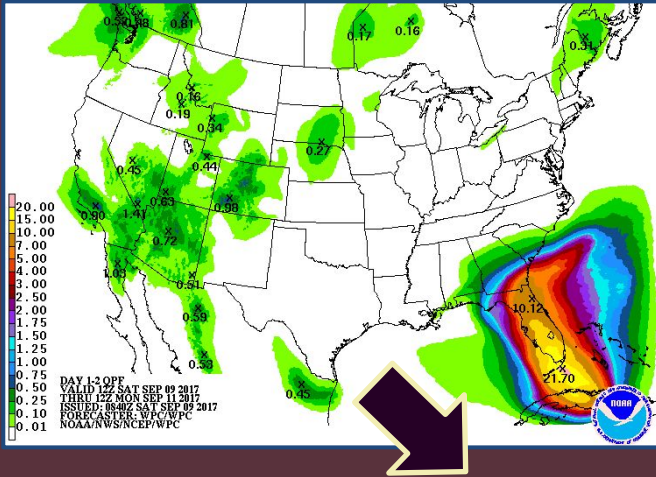
	Z	T	U	V	WSP	SLP	Q	PW	IVT	
0 Thu	00Z	10	MIN	99.5	0.5	99.5	99.5	2.5	99.5	90
6	06Z	10	0.5	99.5	MIN	MAX	2.5	99.5	10	97.5
12	12Z	10	0.5	99.5	MIN	MAX	2.5	99	MIN	99
18	18Z	10	MIN	MAX	MIN	MAX	2.5	0.5	0.5	99
24	00Z	2.5	MIN	MAX	0.5	MAX	0.5	0.5	1	99.5
30	06Z	1	MIN	MAX	99.5	MAX	1	99	99	99.5
36	12Z	0.5	MIN	MAX	99.5	MAX	MIN	1	10	99
42	18Z	0.5	MIN	99.5	MAX	MAX	0.5	0.5	2.5	99.5
48	00Z	0.5	MIN	99.5	MAX	99.5	0.5	MIN	97.5	99.5
54	06Z	0.5	MIN	MAX	MAX	99.5	1	99	99	99.5
60	12Z	2.5	0.5	99.5	MAX	99.5	2.5	1	97.5	97.5
66	18Z	2.5	MIN	99.5	MAX	99.5	97.5	99.5	10	99.5
72	00Z	2.5	2.5	99.5	MAX	99.5	99.5	MAX	99	99.5
78	06Z	99.5	2.5	99	MAX	99.5	99.5	99.5	97.5	99
84	12Z	2.5	10	MAX	99.5	MAX	99	1	10	97.5
90	18Z	2.5	1	99.5	99.5	99.5	99	0.5	10	90
96	00Z	1	10	99	97.5	97.5	2.5	10	10	AVG
102	06Z	1	10	99.5	90	97.5	2.5	97.5	10	AVG
108	12Z	1	10	97.5	10	97.5	2.5	10	2.5	90
114	18Z	2.5	1	99	90	99.5	2.5	1	10	90



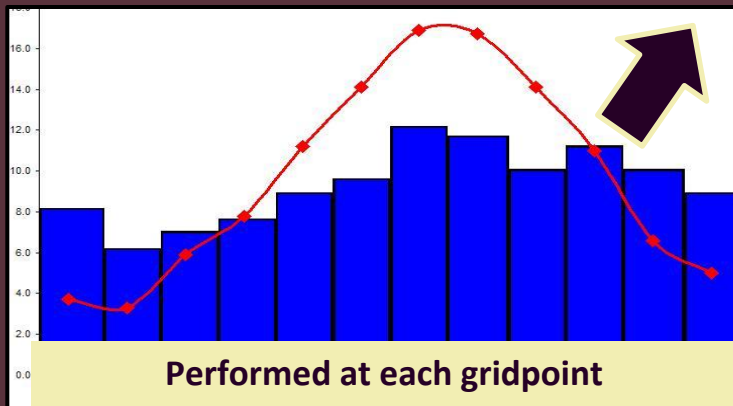
Extreme Rainfall Prediction

Processes and Products

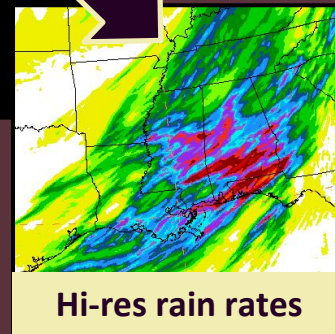
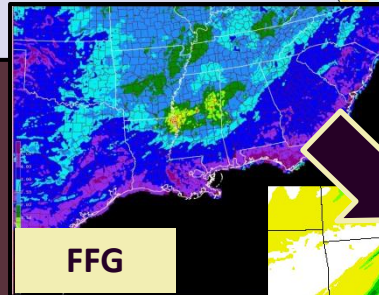
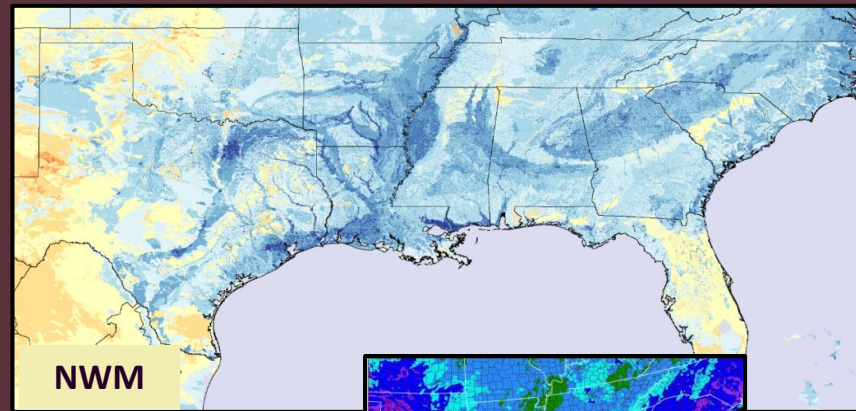
Forecaster expertise...



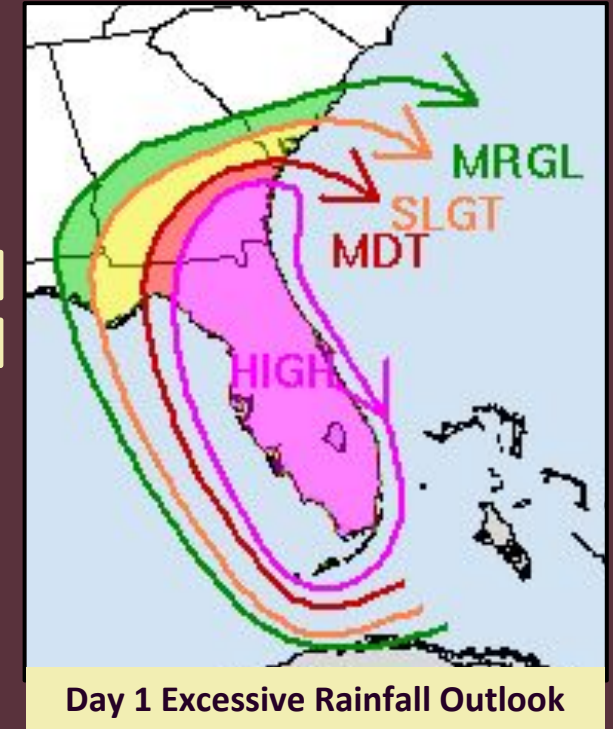
...combined with ensembles for a quantifiable, probabilistic approach...



...analyzed in context with a host of atmospheric and hydrologic datasets...



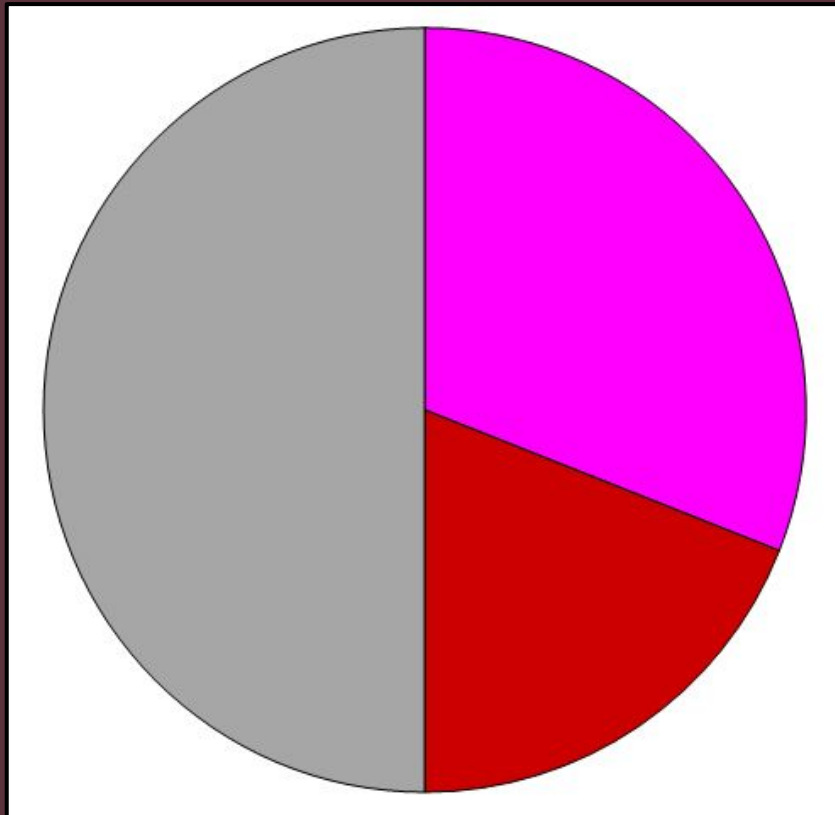
...result in probabilistically-based and verified extreme rainfall risk forecasts.



WPC High Risks are a BIG DEAL

From 2014 to 2017. Includes flood, flash flood, heavy rain, and debris flow LSRs.

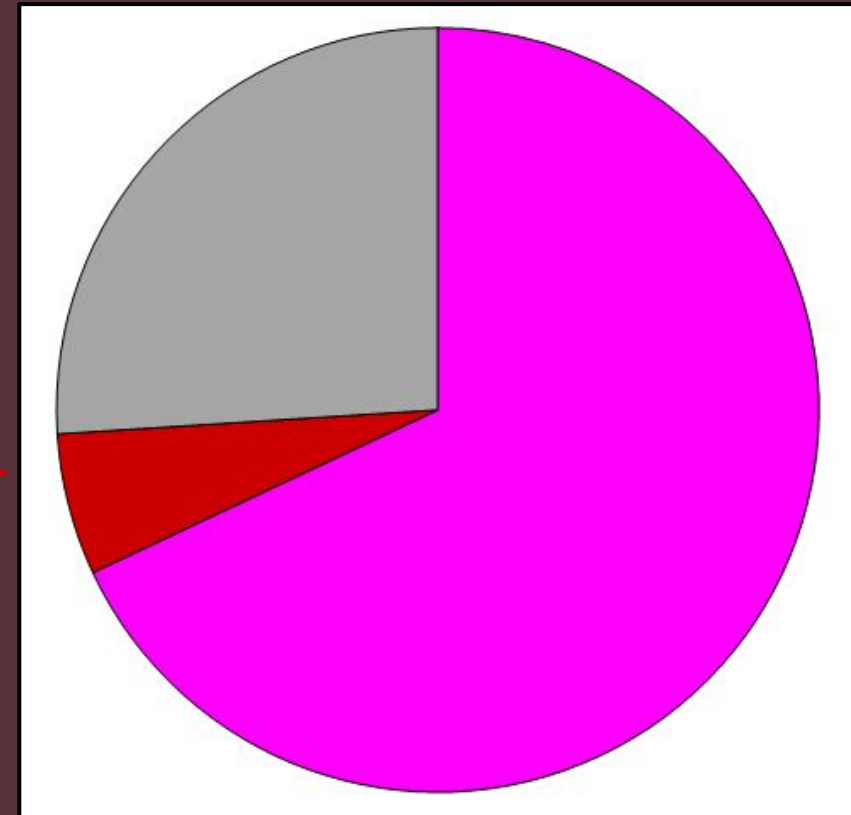
1/3 of ALL Flood-related **Fatalities**



HIGH
31%

MDT
19%

2/3 of ALL Flood-related **Damages**

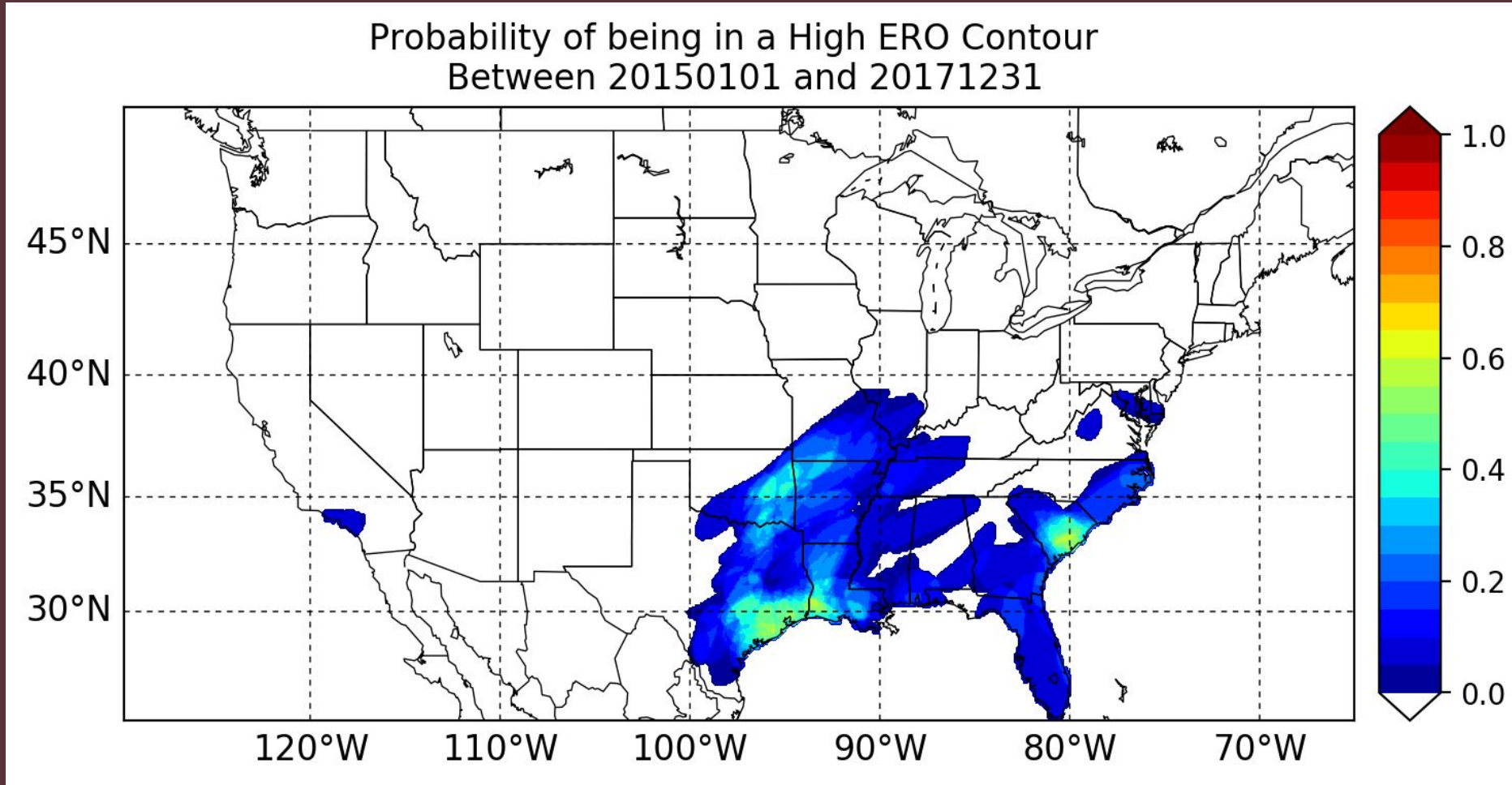


HIGH
68%

MDT
6%

Numbers become **2/5** and **9/10**, respectively, when including Hurricane Harvey

WPC High Risk Locations, 2015-2017



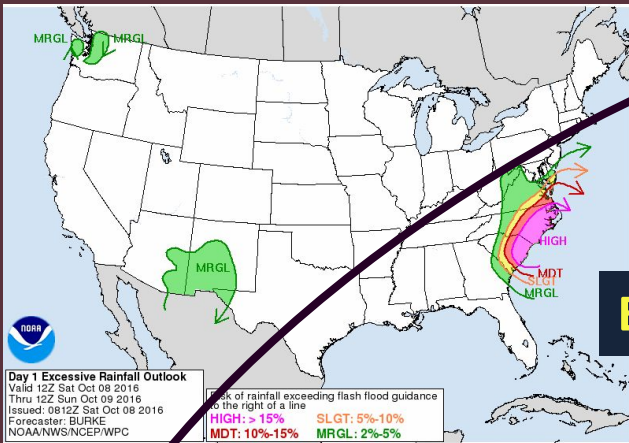
Inland flooding threat from tropical cyclones cannot be stressed enough!

Did you know? DOC has set a FY19 priority goal to improve the skill of extreme rainfall prediction at 3-day lead time.

Joaquin, Matthew, Cindy, Harvey, Irma

Messaging the Details

From sophisticated users to the general public, WPC leverages probabilistic information to craft messages



ERD

MESOSCALE PRECIPITATION DISCUSSION 0253
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
1233 AM EDT SUN SEP 15 2013

AREAS AFFECTED...FAR SE AZ...FAR SW CO...SW AND CNTRL NM

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

VALID 150432Z - 150832Z

SUMMARY...UPPER SUPPORT REMAINS EFFICIENT ENOUGH TO SUSTAIN CLUSTERS OF THUNDERSTORMS OVERNIGHT. SLOW MOVEMENT MAY RESULT IN 2 INCH RAINFALL IN SPOTS AND LOCAL FLASH FLOODING.

DISCUSSION...THUNDERSTORMS HAD SURVIVED ALREADY A FEW HOURS INTO THE NIGHT. RAOBS INDICATED THE SURFACE WOULD DECOUPLE RATHER EASILY...BUT GIVEN THE PERSISTENCE OF CONVECTION IN SW NM AND SW CO...AND NEW DEVELOPMENT NEAR ABQ AND ALSO OFF THE HIGHER ELEVATIONS OF SE AZ AT 04z...IT APPEARS THAT MID LEVEL MOISTURE...MODERATELY STEEP LAPSE RATES...AND SUBTLE UPPER FORCING COULD SUSTAIN THUNDERSTORMS ANOTHER FEW HOURS.

WEAK WARM ADVECTION WAS OBSERVED IN THE 700-600 MB LAYER...COINCIDENT WITH SOME OF THE MORE UNSTABLE PARCELS IN THE OBSERVED AND FORECAST SOUNDINGS...RAP AND NAM. THE SREF MEAN PREDICTS MAINTENANCE OF MUCAPE AT LEAST 500-750 J/KG THROUGH 09Z ACROSS THIS REGION...AS THE LOWER/MID LEVEL WARM ADVECTION AND WEAKLY DIFFLUENT UPPER LEVEL FLOW IS SUSTAINED AHEAD OF A 45-50 KT DET STREAK AT 250 MB.

SUSPECT DUAL POL ESTIMATES ARE UNDERESTIMATING THE CONVECTIVE LINE APPROACHING SOCCORRO NM...GIVEN THE DISTANCE FROM RADAR...AND PLACEMENT OF ALL THE BASE ELEVATION ECHOS...A RANGE BEYOND THE MELTING LAYER. LEGACY ESTIMATES SUGGEST RATES CLOSER TO 1.5-2 INCH PER HOUR IN ISOLATED SPOTS. WOULD NOT EXPECT ANYTHING MUCH HEAVIER THAN THIS WITH PW VALUES HAVING REMAINED BELOW 1 INCH OVER THIS REGION...BUT WITH FLASH FLOOD GUIDANCE VALUES VERY LOW...ESPECIALLY IN NM...FLASH FLOODING IS CERTAINLY A POSSIBILITY. ACTIVITY MAY PERSIST EVEN BEYOND 09Z...ESPECIALLY TOWARD SOUTHWEST CO WHERE UPPER LIFT IS CONCENTRATED. INTENSITY IS LIKELY TO DECREASE DIURNALLY...BUT THESE AREAS COULD SEE MULTIPLE ROUNDS OF MODERATE RAIN ADDING UP OVER

BURKE

ATTN: INFO...PUB...ABQ...EPZ...GJT...TMC...FGZ...PSR...
ATTN: RFC...ABRFC...CBRFC...CIRFC...WGRFC...

LAT...LON 37590695 36730590 35730544 33890581 32740723 32320906
32520994 33221044 33640960 34380859 34350788 36550873
37210888 37590857 37590695

MPD



Talking Points Coordinated and Amplified:

- NHC Key Messages
- Social Media

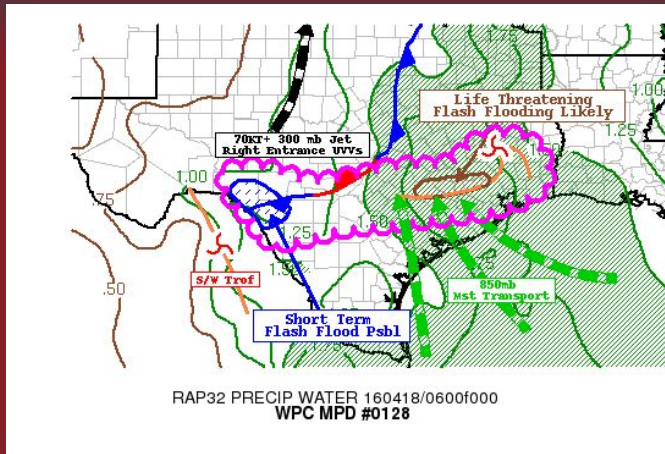
NOAA NWS Weather Prediction Center
August 27, 2017

ATTENTION: Local rainfall amounts of 50 inches would exceed any previous Texas rainfall record. The breadth and intensity of this rainfall are beyond anything experienced before. Catastrophic flooding is now underway and expected to continue for days.

Value added products for RFCs, WFOs and other meteorologically savvy users.

Mesoscale Precipitation Discussions

- These discussions and accompanying graphics provide short term, rapid updates on areas of greatest concern for flash flooding.
- WPC has issued MPDs since 2013.

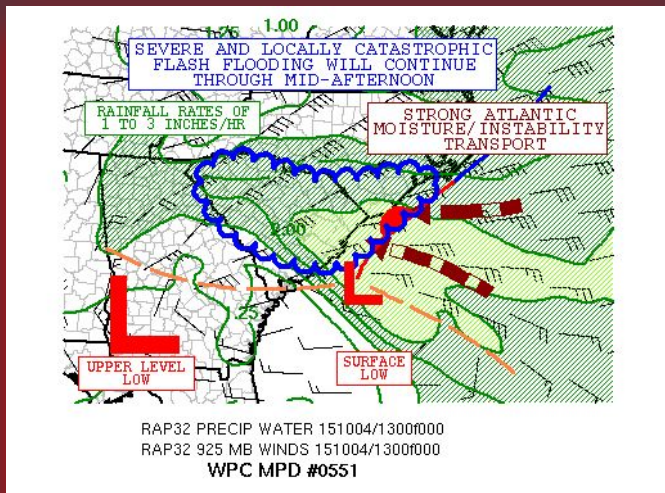


On High Risk Days ('15-'17)

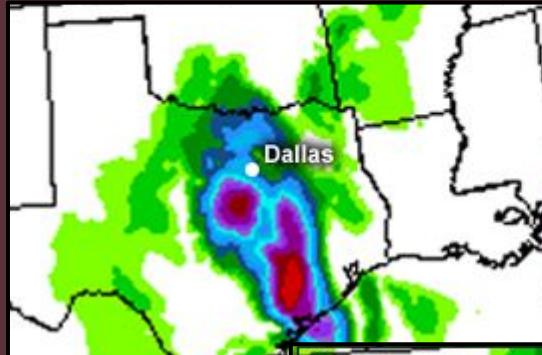
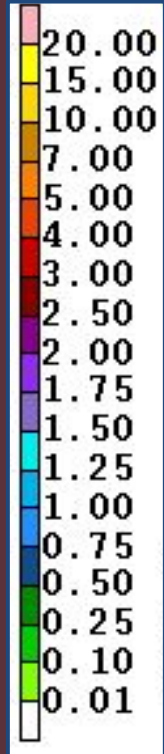
MPDs preceded fatality flooding events/reports by an average of **2 hours and 53 minutes**.

MPDs were in effect for **90 percent** of the flooding fatalities, with the remaining events just outside MPDs in areas of lingering flooding.

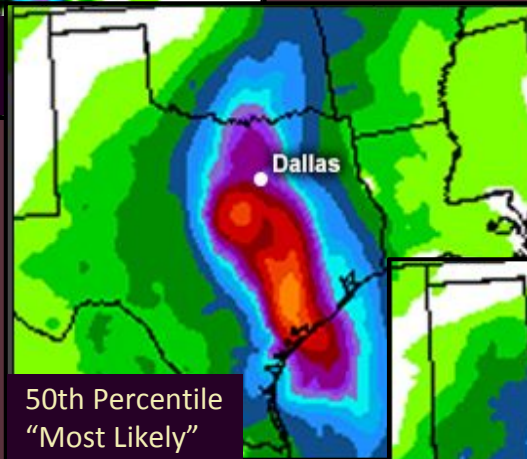
40 percent of the MPDs for fatality events had some sort of enhanced wording (e.g., "significant flooding expected").



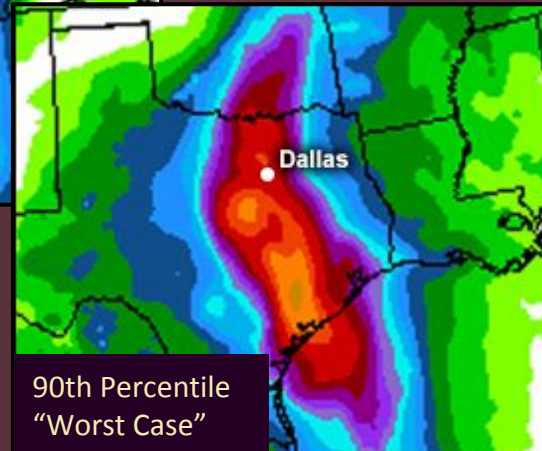
Probabilistic QPF (PQPF)



10th Percentile
"At least this much"



50th Percentile
"Most Likely"



90th Percentile
"Worst Case"

- Best used as a point-based tool
 - Storm unlikely to verify at given percentile across the board
- Tropical rainfall amounts tend to verify closer to worst case scenarios

Did you know?
5 WFOs will be leading a test to integrate PQPF into mainstream rainfall messaging

WPC's Role in the Tropical Program

- Collaborative track forecast - medium range
- Rainfall expertise - including rainfall hazard within NHC public advisories
- Assume responsibility for inland depressions outside of Florida
- Service backup for Atlantic basin - ATCF workstation
- *Collection of observed rainfall included in Storm Summary or Advisory products*

Need your help
on this one!



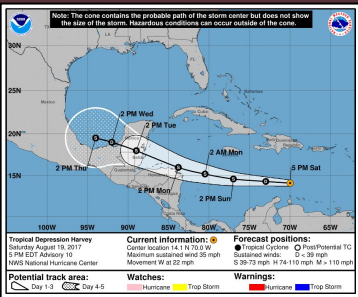
Another set of eyes on hemispheric scale meteorology and the unique ensemble-based datasets available to NCEP Centers

An Example of Success: Hurricane Harvey

Harvey Timeline

How NWS and WPC forecast services evolved as the event unfolded and the flooding became increasingly dire...

Harvey dissipates
Sat. Aug. 19



Medium Range Desk Highlights the Threat: 7-day QPF and discussion:

...multiple models now produce a heavy rain event in the vicinity of the Texas coast.

Mon 21

Tue

22

Wed

23

Thu

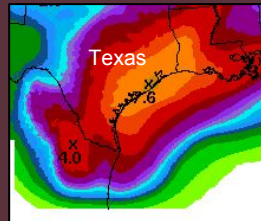
24

Fri

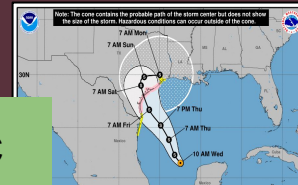
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Sat

26

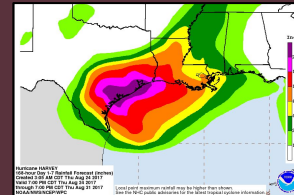


Harvey regenerates into tropical depression



WPC & SR-ROC initiate forecast collaboration calls

20" contour added to TC QPF graphic

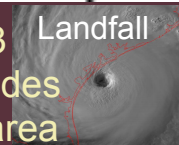


Key Message: Rainfall from Harvey may cause life-threatening flooding.

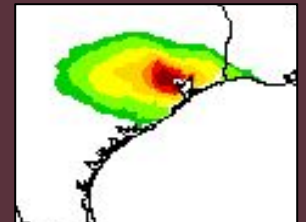
First-ever Day 3 "High" Risk includes Houston metro area



BEFORE landfall, 11 am EDT Collaborated 'Catastrophic' statement: RAINFALL OF THIS MAGNITUDE WILL CAUSE CATASTROPHIC AND LIFE THREATENING FLOODING.

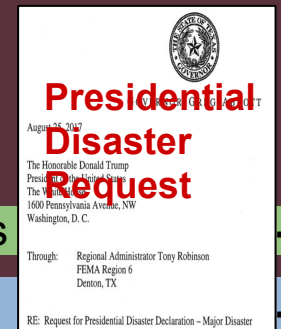


Day 1 QPF ARI potential 1% AEP for Houston area.



4x daily collaboration w/SR-ROC/WFOs

Extensive briefing with FEMA & partners



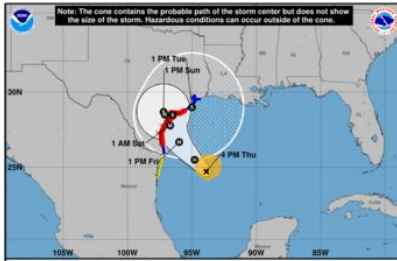
What to Expect for 2018

Coordinated Messaging and Content Delivery

Key Messages for Hurricane Harvey
Advisory 18: 4:00 PM CDT Thu Aug 24, 2017

- Harvey is expected to be a major hurricane at landfall, bringing life-threatening storm surge, rainfall, and wind hazards to portions of the Texas coast. Preparations to protect life and property should be completed by tonight, as tropical-storm-force winds will first arrive in the hurricane and storm surge warning areas on Friday.
- A Storm Surge Warning is in effect for much of the Texas coast. Life-threatening storm surge flooding could reach heights of 6 to 12 feet above ground level at the coast between the north entrance of the Padre Island National Seashore and Sargent. For a depiction of areas at risk, see the Storm Surge Watch/Warning Graphic at hurricanes.gov.
- Devastating and life-threatening flooding is expected across the middle and upper Texas coast from heavy rainfall of 15 to 25 inches, with isolated amounts as high as 35 inches, from Friday through next Wednesday. Please refer to products from your local National Weather Service office and the NOAA Weather Prediction Center for more information on the flooding hazard.
- The Potential Storm Surge Flooding Map is available on the NHC website. This product depicts a reasonable worst-case scenario - the amount of inundation that has a 10 percent chance of being exceeded at each individual location. This map best represents the flooding potential in those locations within the watch and warning areas.

For more information go to hurricanes.gov



Note: The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.


Hurricane Harvey
 Thursday August 24, 2017
 4 PM CDT Advisory 18
 NWS National Hurricane Center

Current information: x
 Center location 24.7 N 93.9 W
 Maximum sustained wind 85 mph
 Movement NNW at 10 mph

Forecast positions:
 Tropical Cyclone
 Sustained winds: 7 - 39 mph
 S 39.73 mph N 74.110 mph M x 110 mph

Potential track area: Watches: Tropical Storm, Hurricane, Major Hurricane
 Warnings: Tropical Storm, Hurricane, Major Hurricane

Tropical-Storm-Force Wind Speed Probabilities (Preliminary)
 For the 120 hours (5.0 days) from 1 PM CDT THU AUG 24 to 1 PM CDT TUE AUG 29



Probability of tropical-storm-force winds (1-minute average < 39 mph) from all tropical cyclones
 O indicates Hurricane Harvey center location at 1 PM CDT THU AUG 24, 2017 (Forecast Advisory #18)








Hurricane HARVEY Satellite | Buoy | Grids | Storm Archive

**...MAJOR HURRICANE HARVEY APPROACHING THE TEXAS COAST...
 HURRICANE AND TROPICAL STORM WARNINGS ISSUED FOR TEXAS**

11:00 PM EDT Tue Oct 4
 Location: 20.4°N 74.4°W
 Moving: N at 8 mph
 Min pressure: 950 mb
 Max sustained: 130 mph

Public Advisory #28 1100 PM EDT	Aviso Publico* not available	Forecast Advisory #28 0300 UTC	Forecast Discussion #27 500 PM EDT	Pronóstico Discusión* not available	Wind Speed Probabilities #28 0300 UTC
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NWS Local Statements 842 PM EDT **US Watch/Warning** 1100 PM EDT

 Wind Speed Probabilities	 Wind History	 Warnings/Cone Interactive Map	 Warnings/Cone Static Images	 Warnings and Surface Wind
 Storm Surge Inundation	 Prototype Storm Surge Watch/Warning			

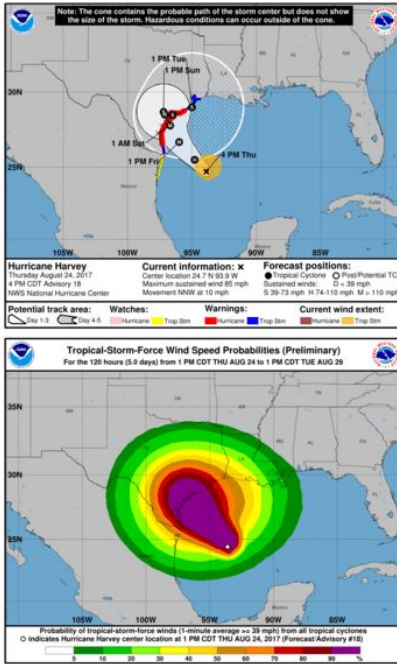
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NWS Local Statements 842 PM EDT	US Watch/Warning 1100 PM EDT					

Cross-center and cross-platform KEY MESSAGES are a best practice!

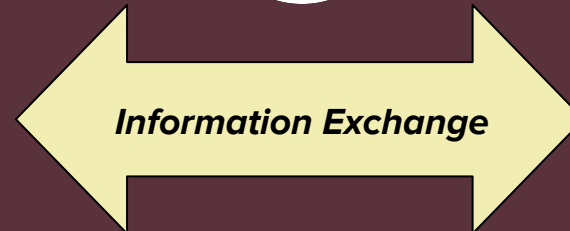
In Partnership with WFOs and RFCs

WFO/RFC



WPC

- WPC finds your input on local antecedent hydrologic conditions valuable. We may ask in some situations, but always feel free to reach out!
- Local experience and heuristics can be helpful to us as we consider ERO & MPD
- Any local tools that could potentially be useful?
 - Local or regional models, perhaps from univs
 - Precip monitoring sites and networks



Crucial to successful predictions and effective messaging!

- We are always available via chat or phone as a resource!
- Precip forecasting experience, developed over many years
- Detailed knowledge of model strengths and biases, particularly as it relates to overall QPF and rainfall rates
- Real-time monitoring of flash flood threats on Metwatch desk, with ability to drill down into localized high-impact events

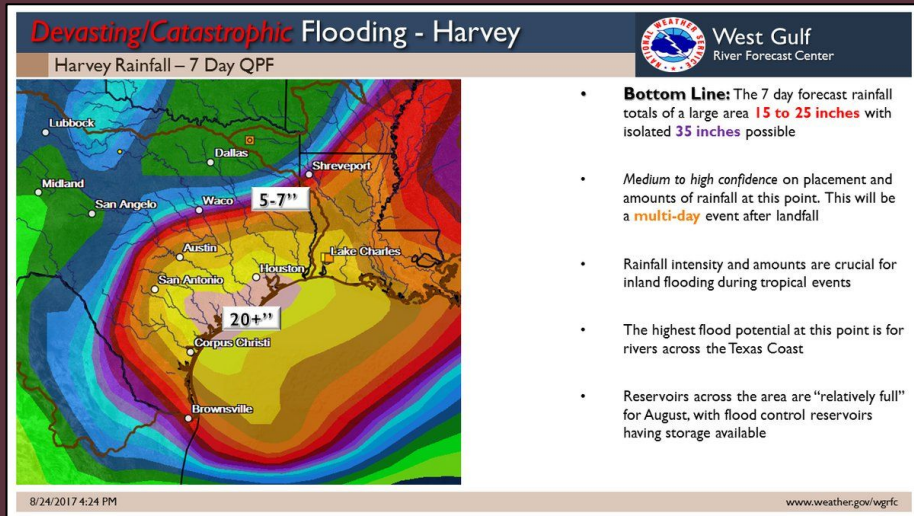
We all want to go from
THIS **TO THIS**



Coordinated Messaging Saves Lives



- Forecasters ramped up official forecasts through time, resulting in unprecedented forecasts for an unprecedented event.
- Used strong language (“catastrophic,” “beyond anything experienced before”) and did so consistently from the national to regional to local levels.
- Enterprise amplified the message.



What Was This Talk About?

Takeaways

WPC provides a wide range of forecast expertise with an emphasis on precipitation forecasting.

Extreme precipitation and inland flooding are not uncommon with TCs.

WPC and NHC are focused on coordinated messaging for tropical cyclone rainfall and inland flooding threats.

In partnership with the NWS field, these coordinated efforts can continue to save lives and move us closer to the concept of a *Weather-Ready Nation!*



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Thank you!