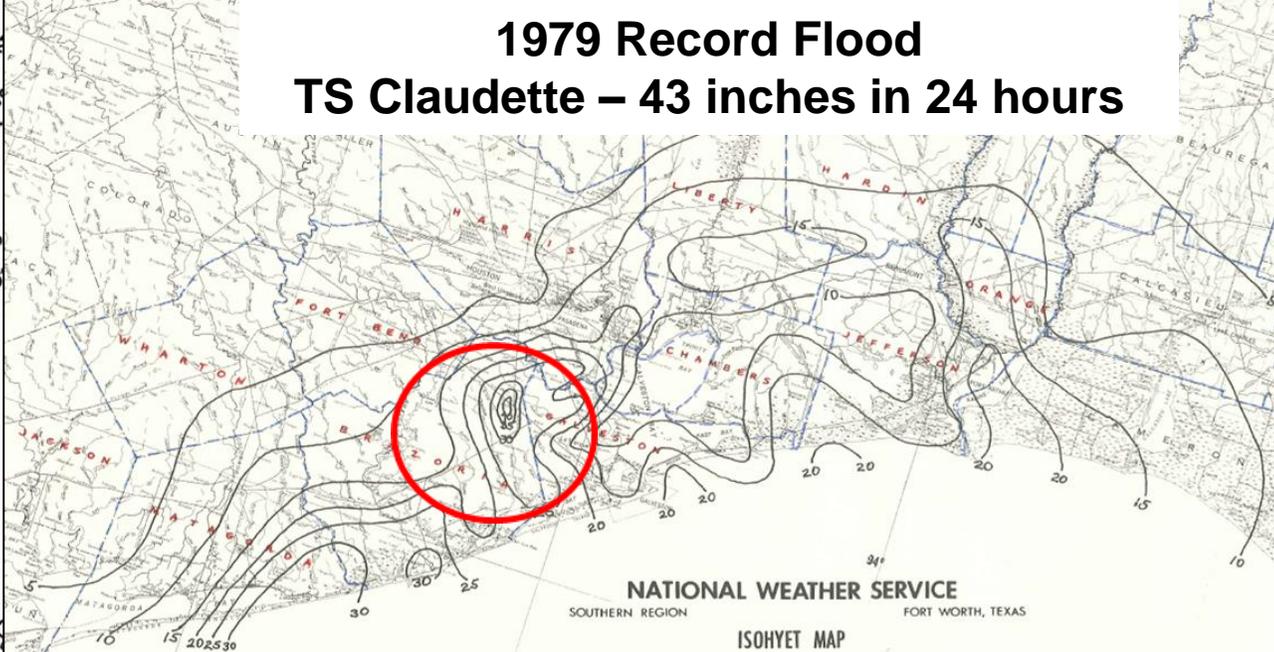
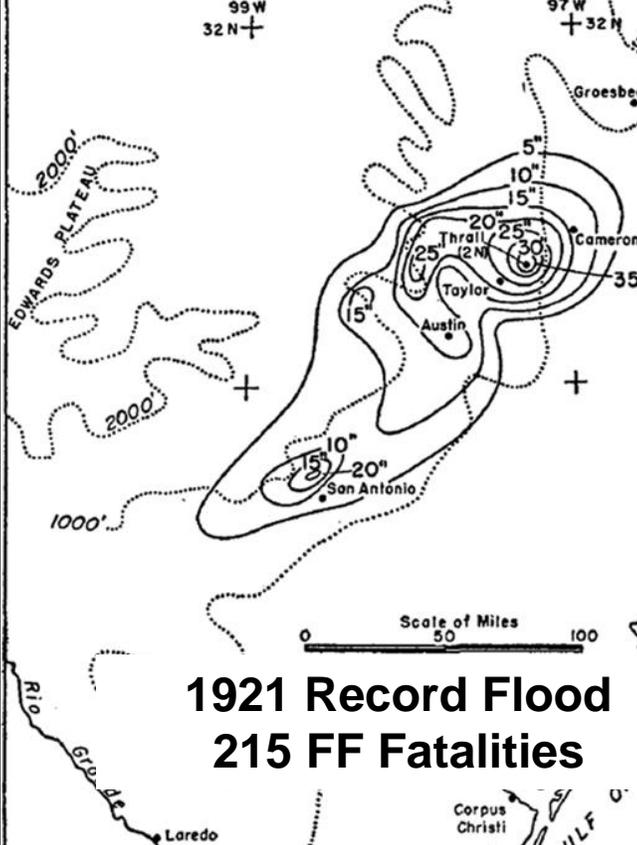


Flooding Rain Impact Recognition and Messaging

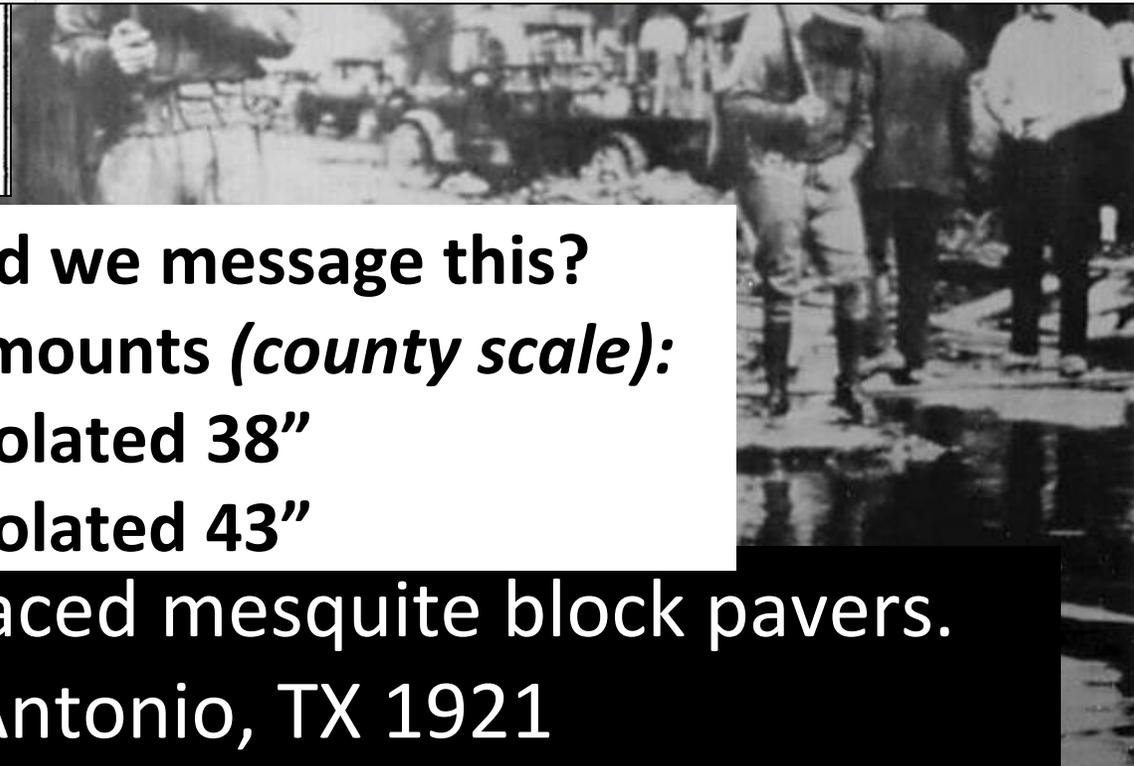


Acknowledgements: John Metz, Frank Alsheimer

1979 Record Flood TS Claudette – 43 inches in 24 hours



1921 Record Flood 215 FF Fatalities

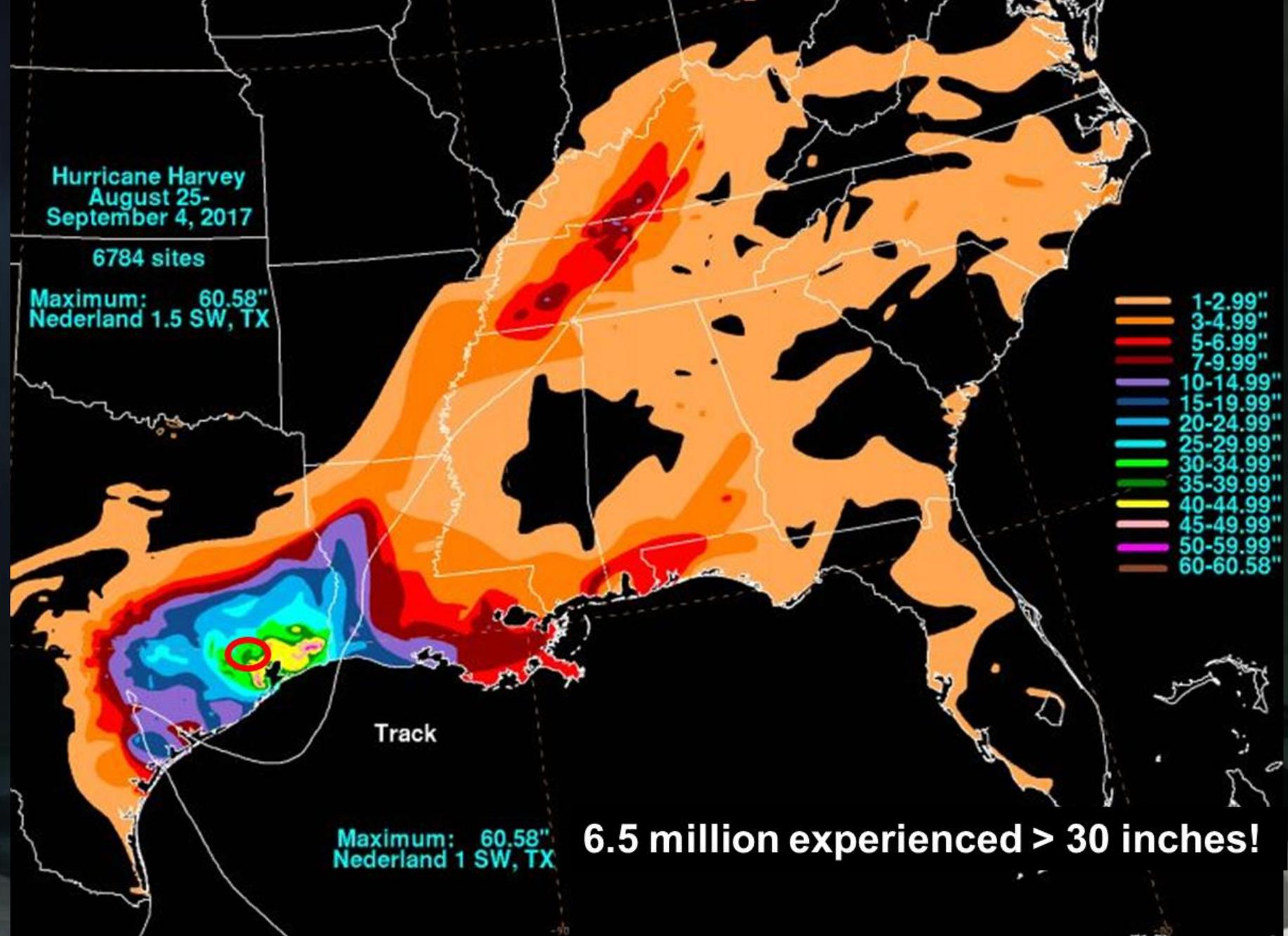


How would we message this?
Rainfall Amounts (*county scale*):
5 to 25" isolated 38"
5 to 30" isolated 43"

Soldiers on displaced mesquite block pavers.
San Antonio, TX 1921



Harvey was unprecedented with not only the max amounts, but also concerning the size of the extreme rainfall footprint.



Observed rainfall totals (inches) in association with Harvey and its remnants. Figure courtesy David Roth (WPC).

In just Harris county...

1,000,000,000,000 gal.

3200 astrodomes

15 days



**Texans like to count
in astrodomes**



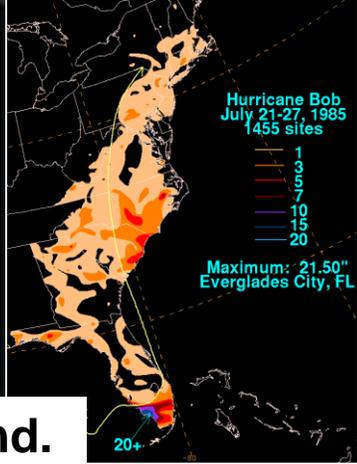
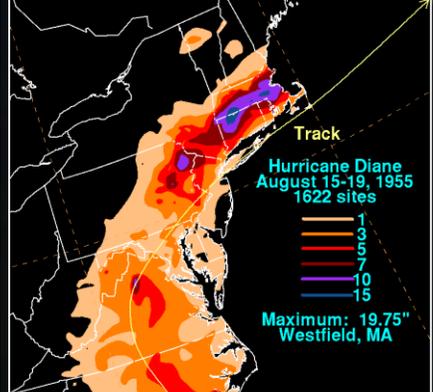
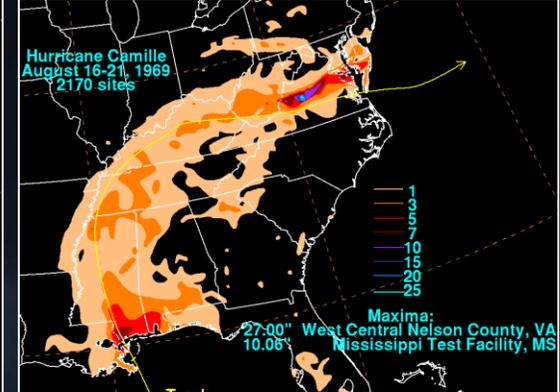
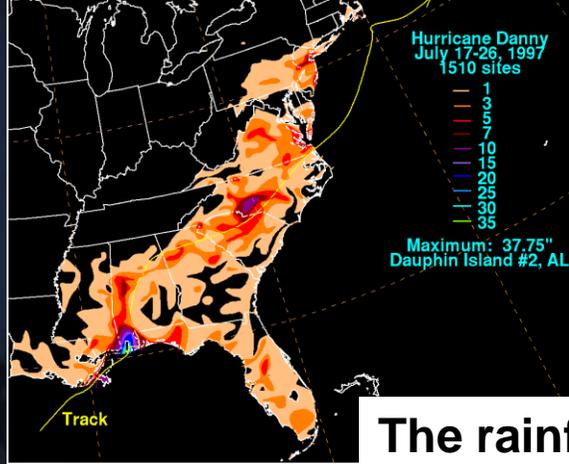
And... we love the Astros



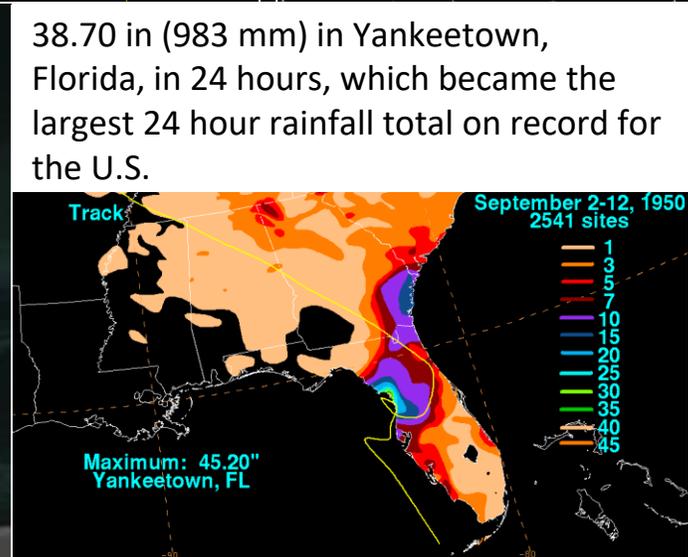
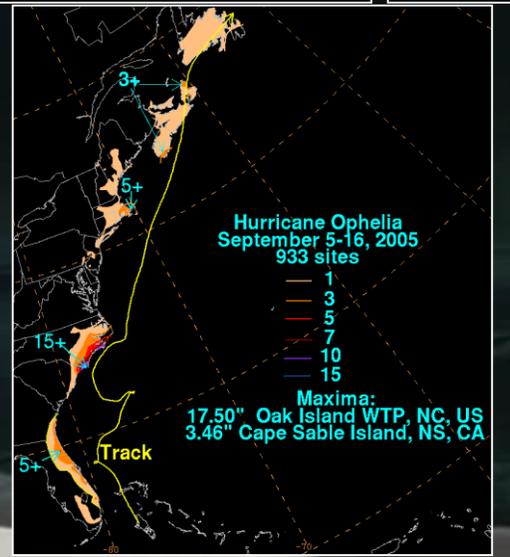
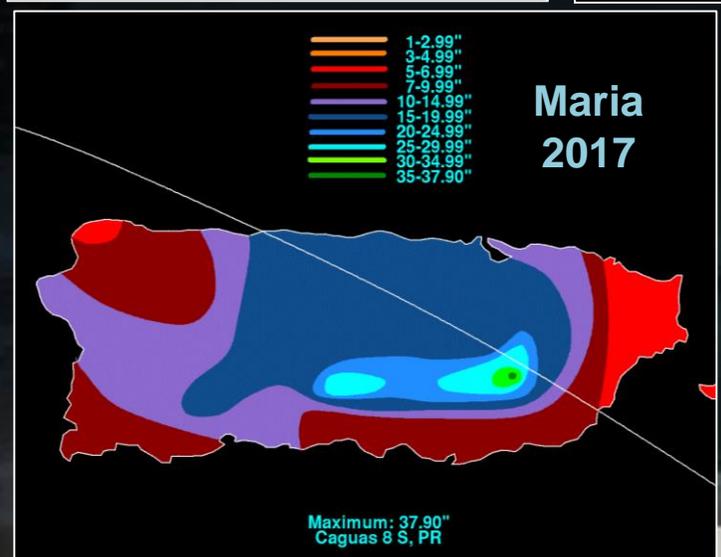
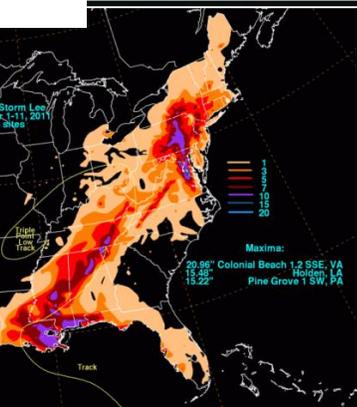
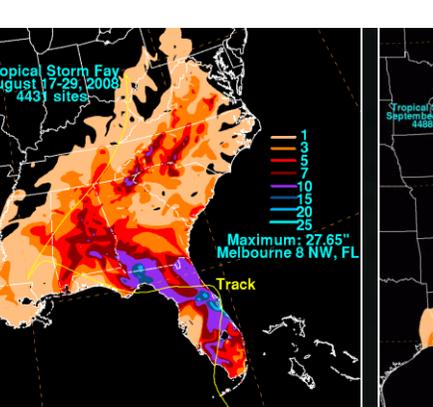
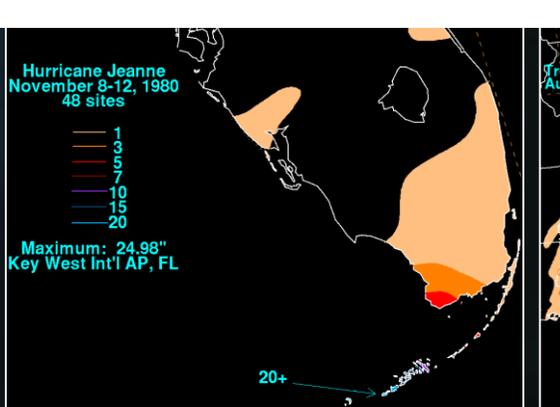
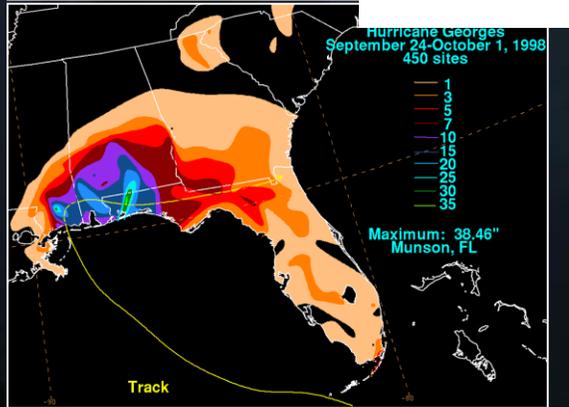
(REUTERS/Richard Carson)



Harris County



The rainfall footprint can be very large and well inland.

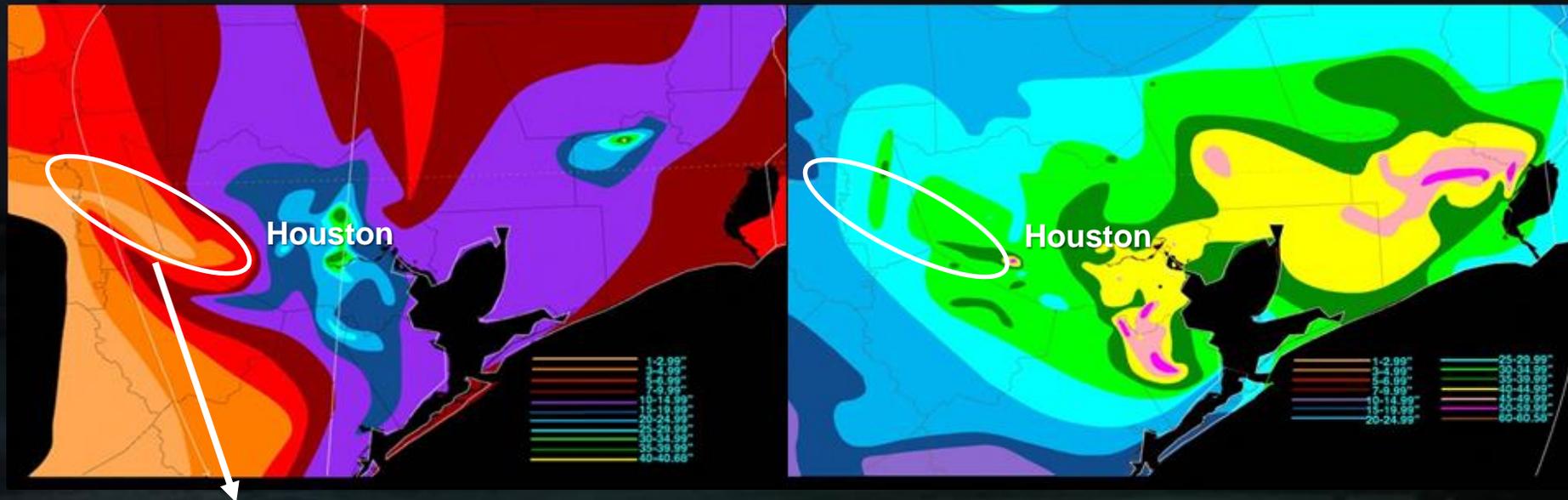


38.70 in (983 mm) in Yankeetown, Florida, in 24 hours, which became the largest 24 hour rainfall total on record for the U.S.



Danger of directly comparing storms to highlight a threat

Allison (2001) vs. Harvey (2017) Total Rainfall



This area received less than 6 inches during Allison and 25-40 inches during Harvey

Sat August 26th 4 AM > Tue August 29th 4 PM (84 HRS)

Average Speed of Movement = 2.7 KTS

Advisory:	Speed (KTS)	
24	5	
25	2	
26	0	
27	1	
28	1	Houston Metro Flood
29	2	
30	2	
31	3	
32	3	
33	4	
34	3	
35	3	
36	3	
37	4	
38	5	



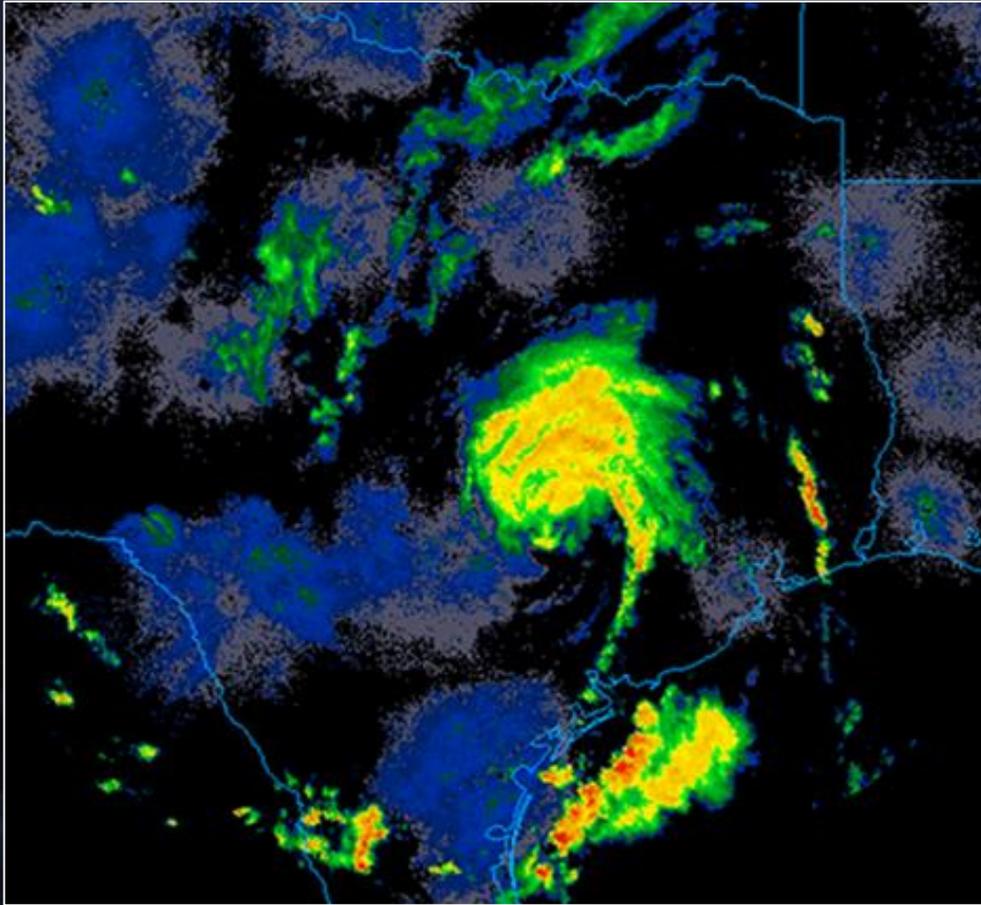
When I get asked, “How much rain are we going to get or how bad will it flood?” I often feel like...

“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”

Donald Rumsfeld



What are our Knowns/Unknowns?



- **(Known-Known)** The tropical cyclone will bring heavy rainfall.
- **(Known-Unknown)** Where are the bands going to setup, and who will get the most rain?
- **(Unknown-Unknown)** Some impacts? (maybe a flood driven hazmat event)

TS Bill June 2015



An Unknown Unknown?

Already swamped with historic flooding and 20 webinars/conf. calls a day
18 spot forecasts for the Arkema Plant explosions in Crosby, TX



How do we effectively communicate our *Knowns and Unknowns*?



Tim Heller
@HellerWeather



Following

#HGXIWT concludes with a round table discussion with all members of the Integrated Warning a Team.

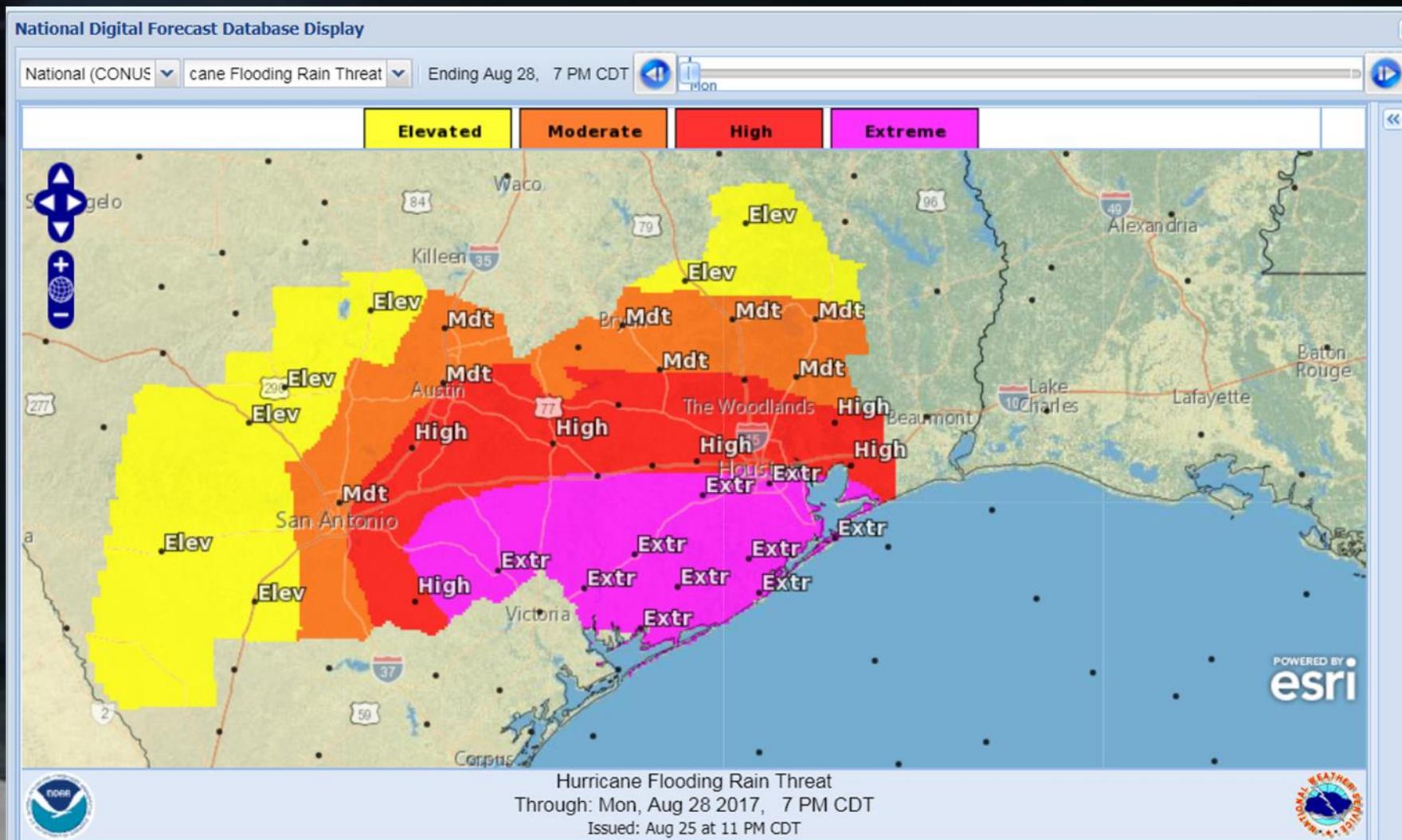


- Through a 2-way communication process that is ongoing (pre-season, just prior to the event, and during the event).
- Through recurring Integrated Warning Team Workshops (IWTWs), drill participation, partner meetings/interactions.
- By utilizing all of the tools that we have at our disposal, and learning which is most effective tool to a decision maker at the proper time.



Harvey at Landfall Flooding Rain Threat

Weather Forecast
Offices issue
Hurricane
Threat and Impact
graphics
For the 4 major
threats:
Tornadoes, Storm
Surge, Wind, and
Flooding Rain



An incredible pre-landfall Harvey rainfall forecast.

The maximum was displaced to the southwest, which followed the global models' placement.

Notice how large the 15-30 inch area is.

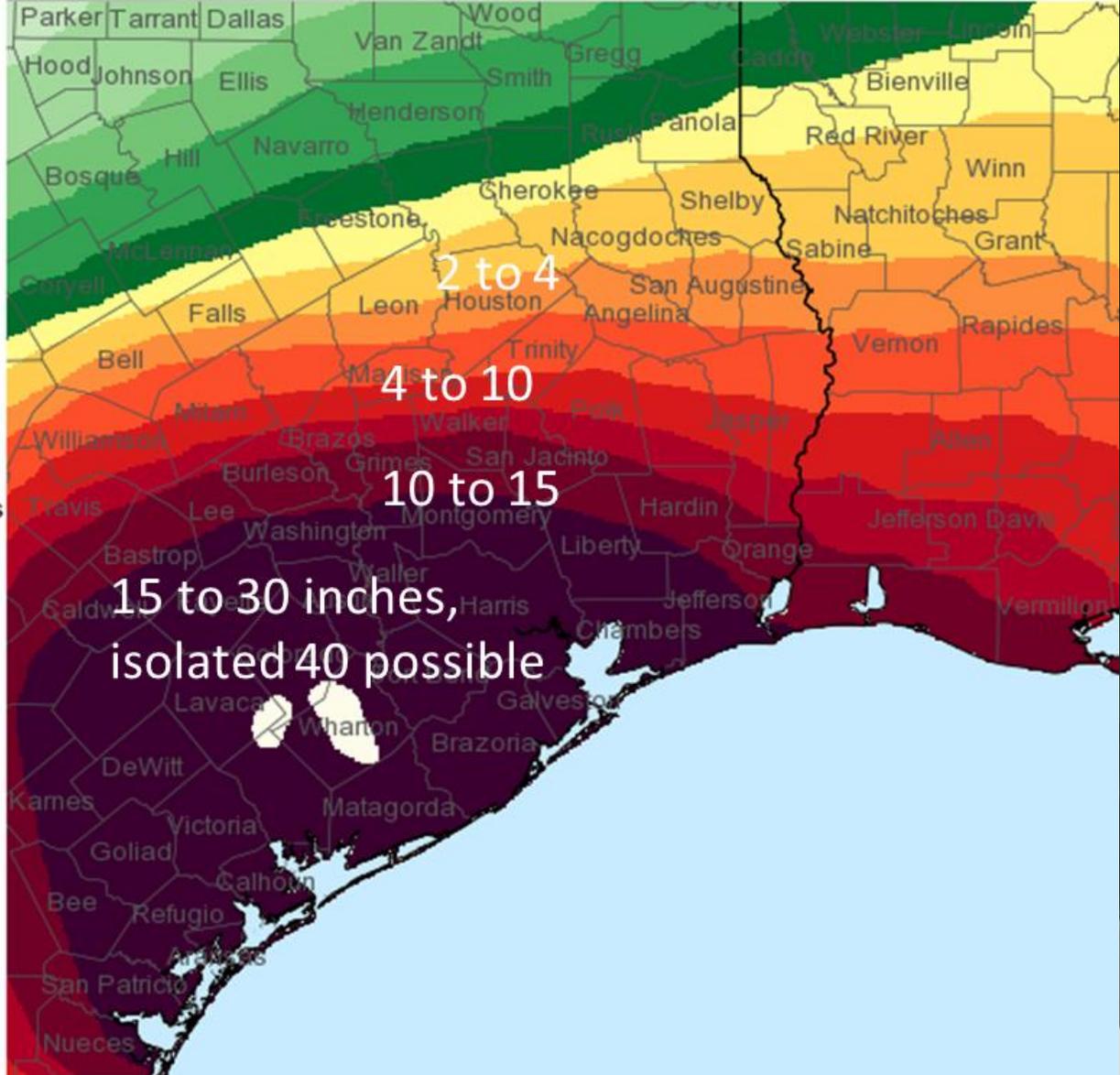
The ?'s I kept getting were: "When will the worst rainfall occur?, Will my house flood?, How many structures will flood with this forecast?, Should we evacuate?"

5 Day Forecast

Forecast Precipitation



Valid Ending Wednesday August 30th, 2017 at 7 PM CDT



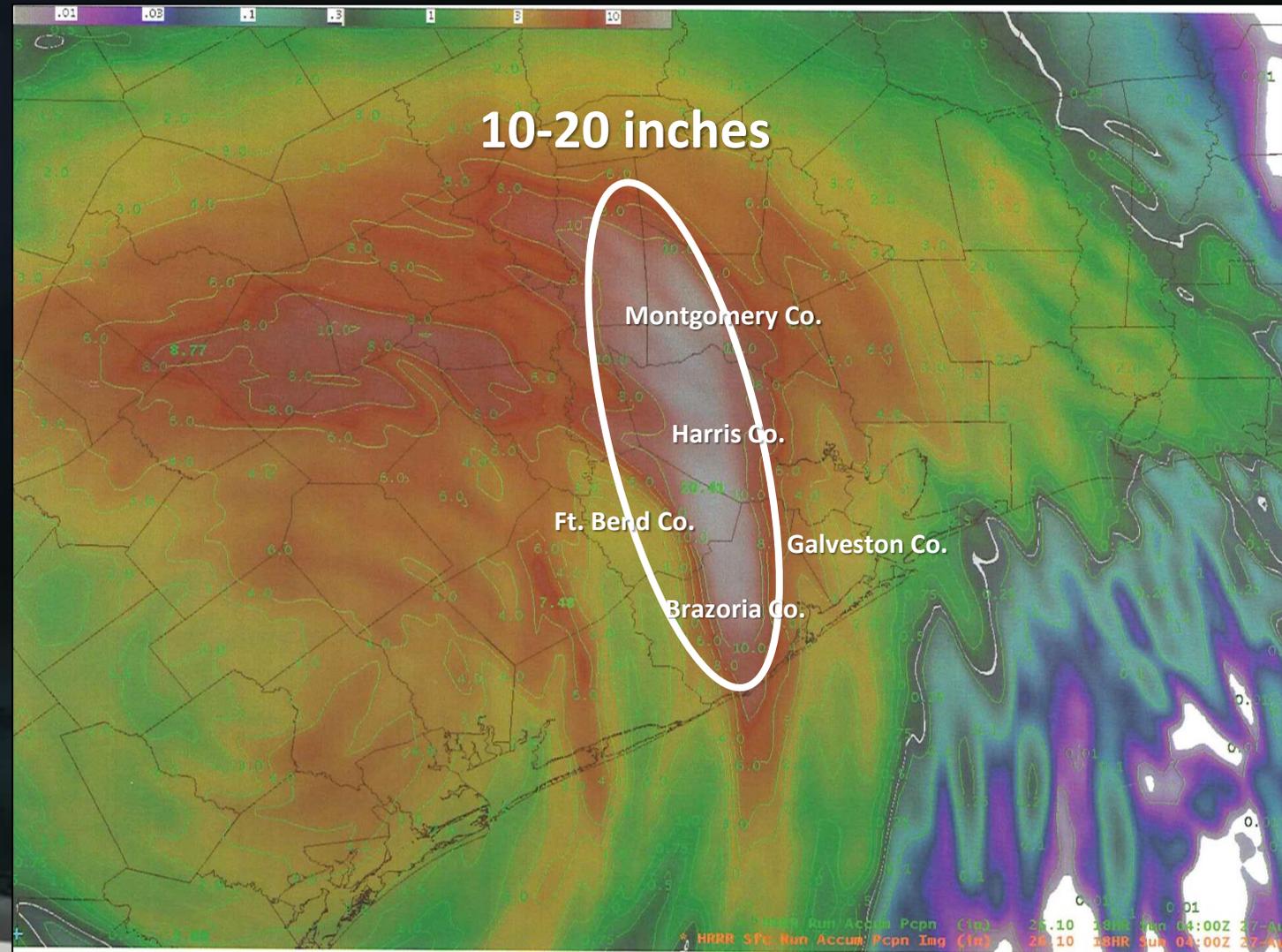
Graphic Created
August 25th, 2017
8:46 PM CDT

Harvey - Saturday Night - The Main Event

Aided the decision to order additional high water vehicles for Galveston county

Need inundation to provide impact details if ever considering a targeted evacuation

Model: High Resolution Rapid Refresh
(Saturday - 5 AM CDT -> 11 PM CDT)



When do we issue a Flash Flood Emergency?

- A. Multiple swift water rescue teams have been deployed for exceptional flooding.
- B. Total failure of a high hazard dam with potential for catastrophic impact.
- C. Emergency manager communicates that people are in a life threatening situation.
- D. All of the above.

Flash Flood Emergency – Dam Failure

 **NWS San Juan** @NWSSanJuan · 1h
Replying to @NWSSanJuan
This is an EXTREMELY DANGEROUS SITUATION. Busses are currently evacuating people from the area as quickly as they can #prwx
14 375 155

 **NWS San Juan** @NWSSanJuan · 1h
Replying to @NWSSanJuan
At 210 PM, dam operators reported the Guajataca Dam is failing causing flash flooding downstream on the Rio Guajataca. #PRWX
10 279 71

 **NWS San Juan** @NWSSanJuan · 1h
215PM FLASH FLOOD EMERGENCY for A Dam Failure in Isabela Municipality y Quebradillas Municipality in Puerto Rico... #prwx



Operators of the Guajataca Dam said it failed at 2:10 p.m. ET, prompting the NWS to issue a flash flood emergency warning for Isabela and Quebradillas municipalities, home to some 70,000 people, the agency said in tweets that went unseen by many in the blacked-out coastal area.



(Hector Santos Guia, Whitney Leaming/The Washington Post)

Harvey: Our 4th Flash Flood Emergency Event since May 2015



NWS Houston
@NWSHouston



EMERGENCY MANAGEMENT HAS REQUESTED: IF HIGHEST FLOOR OF YOUR HOME BECOMES DANGEROUS...GET ON THE ROOF. #houwx #glswx #txwx #Harvey

Go To The Roof!

Tweet Impressions:
1,831,082

As water rises in the home, an electrocution threat can develop.

Emergency management officials did not want people to become trapped in their attics. Also, they can not see that they need to be rescued in the attic.



CIVIL EMERGENCY MESSAGE

National Weather Service Houston/Galveston

000
WOUS44 KHGX 271110
CEMHGX
TXC039-167-201-271715-

BULLETIN - EAS ACTIVATION REQUESTED
CIVIL EMERGENCY MESSAGE
EMERGENCY MANAGEMENT IN CITY OF HOUSTON... GALVESTON COUNTY...
AND BRAZORIA COUNTY
RELAYED BY NATIONAL WEATHER SERVICE HOUSTON/GALVESTON TX
610 AM CDT SUN AUG 27 2017

THE FOLLOWING MESSAGE IS TRANSMITTED AT THE REQUEST OF THE
EMERGENCY MANAGEMENT IN THE CITY OF HOUSTON... GALVESTON
COUNTY... AND BRAZORIA COUNTY.

EMERGENCY MANAGEMENT OFFICIALS HAVE REQUESTED THAT PEOPLE ESCAPING
FLOOD WATERS AS A LAST RESORT DO NOT STAY IN THE ATTIC. IF HIGHEST
FLOOR OF YOUR HOME BECOMES DANGEROUS...GET ON THE ROOF. CALL 911
FOR HELP AND STAY ON THE LINE UNTIL ANSWERED.

\$\$



@NWSHouston
weather.gov/houston

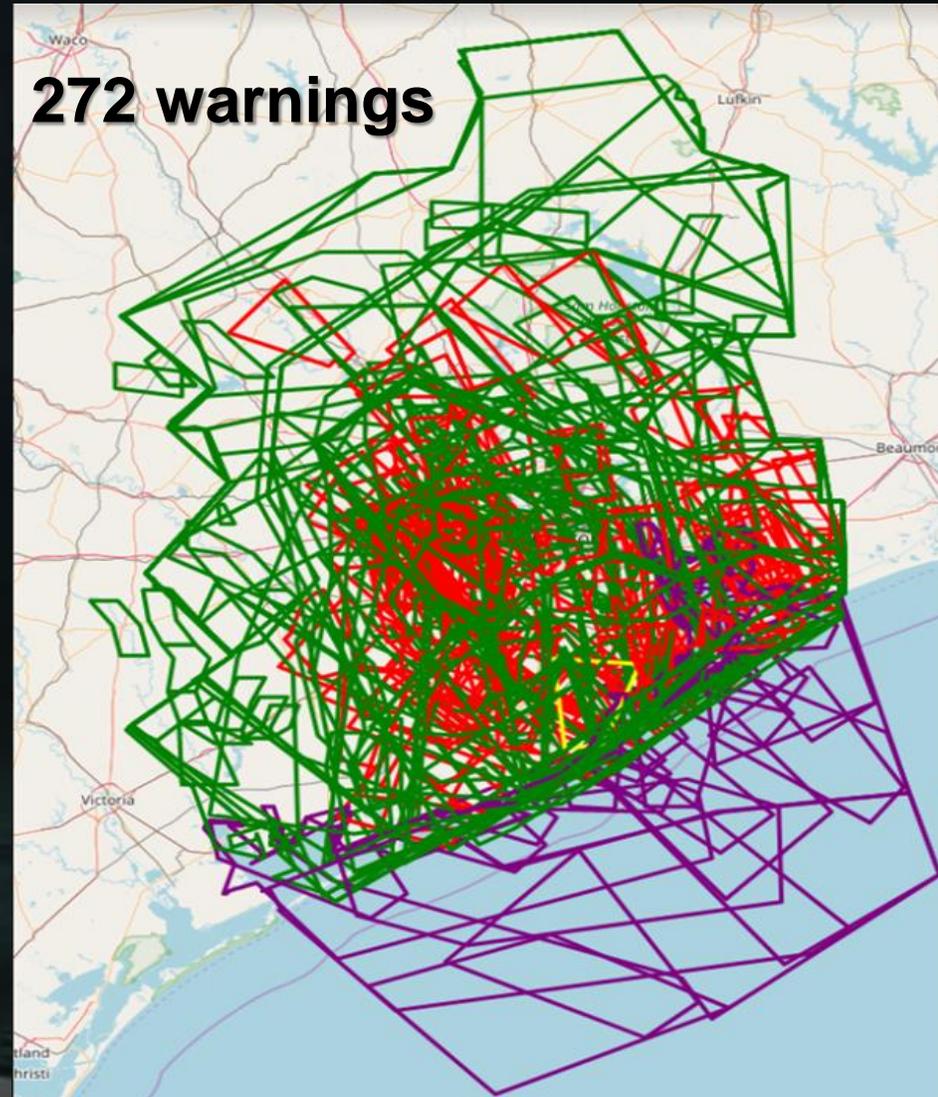


Harvey: The Epitome of Overlapping Tornado and Flash Flood Warnings/Threats

Tornado Warning calls to action and Civil Emergency messaging were sending conflicting messages in the flash flood emergency areas:

“Seek shelter now”

“Get on your roof”



Communicating the Threat

NWSChat critical for information exchange

03:31
UTC =
10:31
PM CDT

May 2015

Rockets playing
the Warriors in
Houston

Officials
recommended
fans stay in
their seats at
the end of the
game.

03:31 <HCFCD-Jeff Lindner> HGX: any consideration for FF emergency wording.

Have several watersheds nearing bankfull

03:32 <nws-joshua.lichter> Jeff- Yes. We have been discussing.

03:34 <HoustonOEM Michael Walter> Talked with safety folks at Toyota Center - They're holding people in their seats until the storms clear.

03:40 <media-steve.ayers> Torrential rainfall now HWY 6 N @ Huffmiester

03:41 <nwsbot> Local Storm Report by NWS HGX: Houston [Harris Co, TX] trained spotter reports FLASH FLOOD at 10:28 PM CDT -- flash flooding in and around the houston area. multiple water rescues. creeks and bayou coming out of banks.

Link: <https://nwschat.weather.gov/lsr/#HGX/201505260328/201505260328>

03:43 <nws-joshua.lichter> Looking at FFW emergency for southwest Harris into northern Fort Bend. This area has taken the brunt of it and still more rain coming.

03:43 <nwsbot> HGX issues Flood Warning for the Brickhouse Gully at Costa Rica Street [TX] till May 26, 4:41 AM CDT

Link: <https://nwschat.weather.gov/vtec/#2015-O-NEW-KHGX-FL-W-0072>

03:44 <HCFCD-Jeff Lindner> Halls Bayou 3 ft from bankfull

03:46 <ham-david.a.fanelli> Report from spotter in Mission Bend of water up to curbs

03:47 <nwshgx-melissa.huffman> Flash Flood Emergency coming shortly for SW Harris, Northern Ft. Bend

03:48 <nwshgx-melissa.huffman> This will include Spring Branch, Sugar Land, Stafford, Mission Bend

03:50 <HCFCD-Jeff Lindner> Nearing 7 inches on Buffalo

03:52 <nwsbot> HGX issues Flash Flood Warning for Fort Bend, Harris [TX] till May 26, 12:45 AM CDT



S.C. didn't get Joaquin, but experienced record flooding.

Social media post using the terms **historic**, **catastrophic** flash flooding.



Harvey – The Impacts and a Devastating Threat



Devastating Flood Threat: Harvey (Excessive Rainfall Outlook)

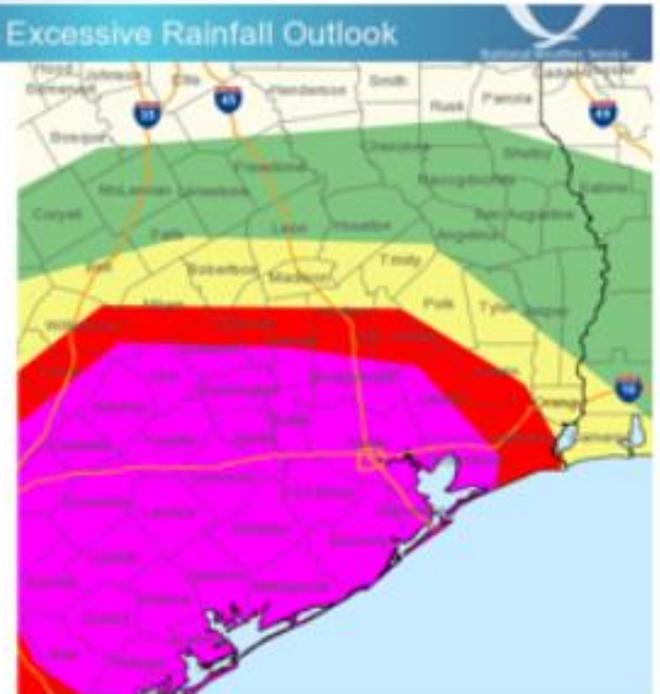
National Weather Service Houston/Galveston

- A slow track over the area will mean **periods of heavy rain** from today into **at least Wednesday**.
- Impacts: **Widespread flooding** with numerous road closures as rainfall amounts grow through the weekend. Major bayou and river flooding is expected. Some structure flooding is likely.

Day One Excessive Rainfall Outlook

Legend:
Marginal
Slight
Moderate
High

Today



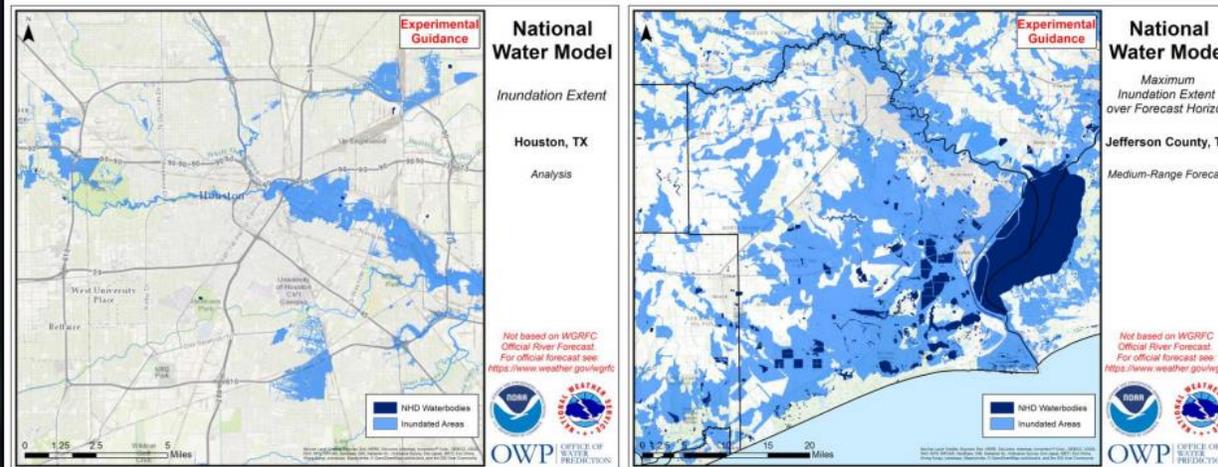
Graphic Created:
August 26th, 2017
6:45 AM CDT

Future Flooding Decision Support

High resolution convection allowing models driving high resolution inundation forecasts

Better pre-positioning of resources
Better identification of life-threatening risk areas
in extreme rainfall cases

Example of NWM-Based Experimental Flood Inundation Maps



Maps support emergency management efforts to stage supplies in non-flooded areas and to target relief efforts

F. Salas, NWC

