

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

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Notes...I want to acknowledge members of our staff for assistance with graphics – photos etc.

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

Inland Flooding

- While storm surge is always a potential threat, more people have died from inland flooding in the last 30 years.
- Intense rainfall is not directly related to the wind speed of tropical cyclones.
- In fact, some of the greatest rainfall amounts occur from weaker storms that drift slowly or stall over an area.

Excerpt from ...Hurricane Flooding: A Deadly Inland Danger

- *Notes...This we may all know! Excerpt from Hurricane Flooding: A Deadly Inland Danger.*

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

- More than 60% of our Nation's population live in coastal states from Maine to Texas, Hawaii, and Puerto Rico.
- Hurricane Floyd (1999) brought intense rains and record flooding to the Eastern U.S.
- Tropical Storm Alberto (1994) drifted over the Southeast United States and produced torrential rainfall... More than 21 inches of rain.
- So, the next time you hear hurricane -- think inland flooding!

Excerpt from ...Hurricane Flooding: A Deadly Inland Danger

- *Notes... This is what we not know. Not mentioned here is Tropical Storm Allison which had rainfall totals for up to 40 inches.*

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

What if it is not a Hurricane or a Tropical
Storm **BUT** a Tropical Wave ...
precursors to Hurricanes?

- *Notes...What if all you have is the signature – the beginning – a tropical wave that may or may not develop into a Tropical Storm or a Hurricane? Should we still be thinking severe inland flooding?*

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

Pre-Cursor to Tropical Storm Kyle ...
September 20-23, 2008.

Notes... This is what can happen even before the Hurricane/Tropical Storm is formed. We know it can cause severe flooding but what do we look for?

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- La Cordillera Central of PR ... up to 4,390 feet
- The range crosses the island from west to east
- It ends in a fork with two lower ranges which includes the Cuchillas de Panduras (1,700 feet) which runs between the towns of [Yabucoa](#) and [Patillas](#)



Notes... Why did this occur? Let's start with a brief intro to Puerto Rico. There is a chain of mountains running across Central Puerto Rico – aligned from west to east... ending with the Cuchillas de Panduras (in the SE) with peaks of up to 1700 feet.

Cuchillas de Panduras which runs between the towns of Yabucoa and Patillas



Notes...Notice the horseshoe shape of the Yabucoa area ... plains with mountains on three sides. Patillas is to the west.

Southeast Puerto Rico Yabucoa Pluvial Valley



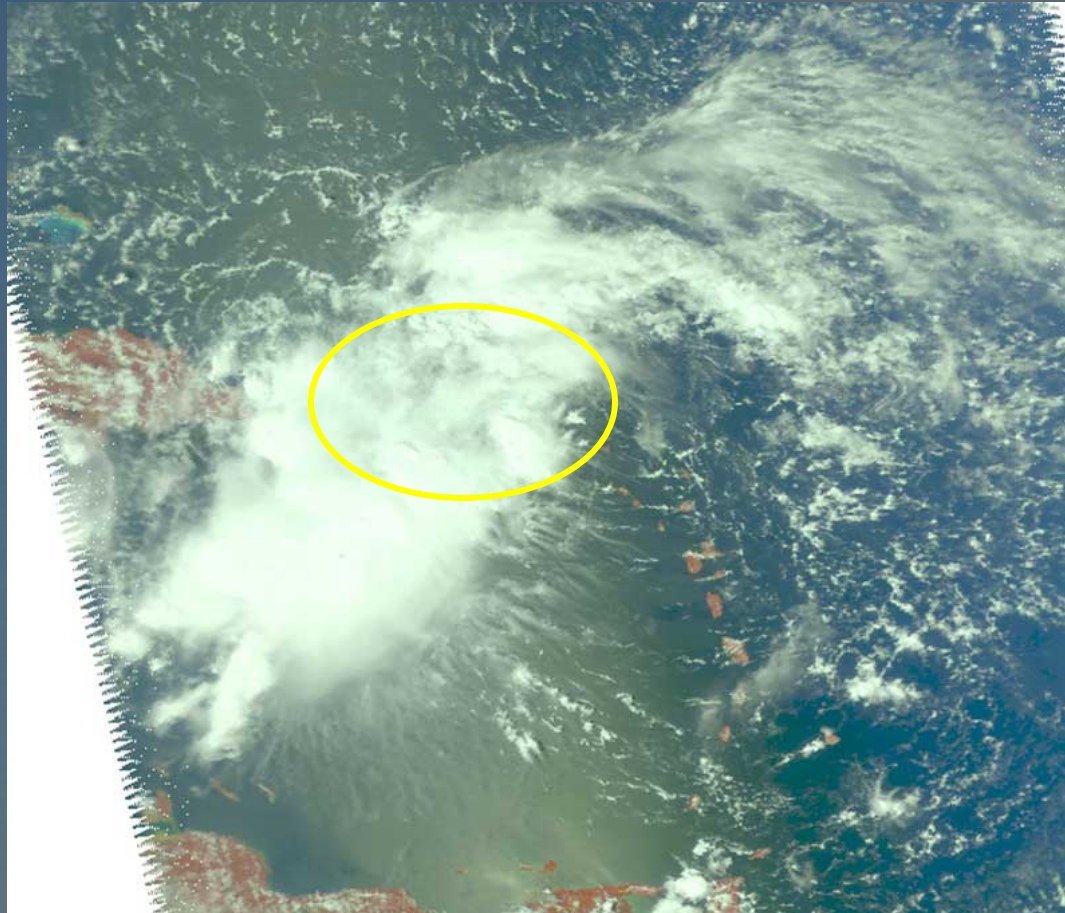
Cuchillas de Panduras ... 1,700 feet

**Flash Flooding in
hills!**

Yabucoa Valley

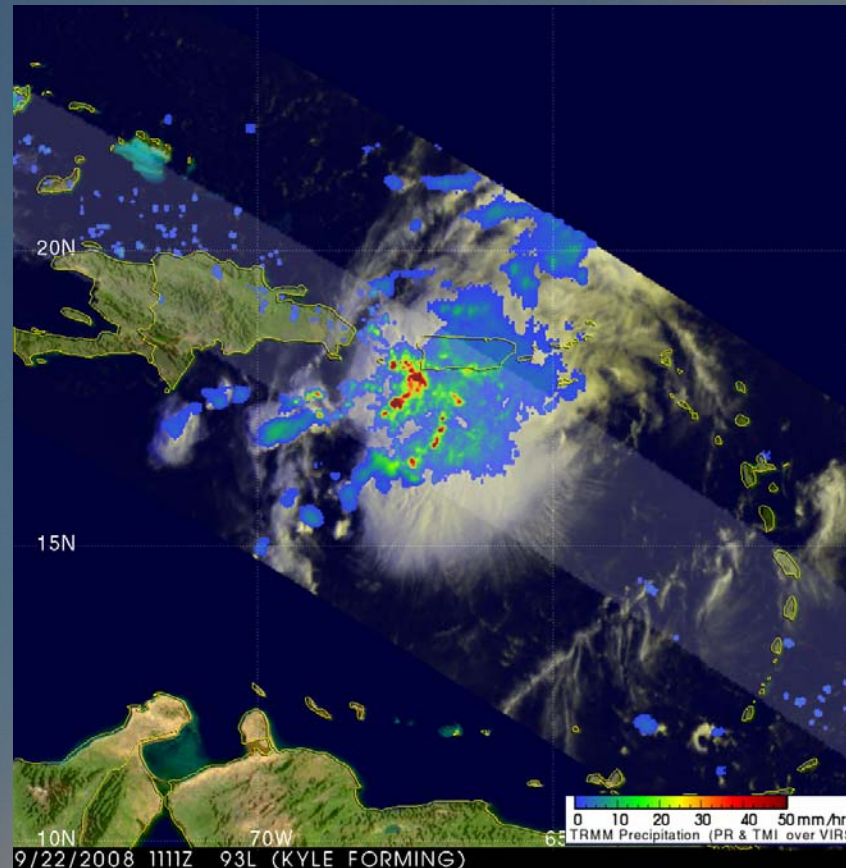
Notes...Flash Flooding in the hills ... areal flooding in the valley!

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico



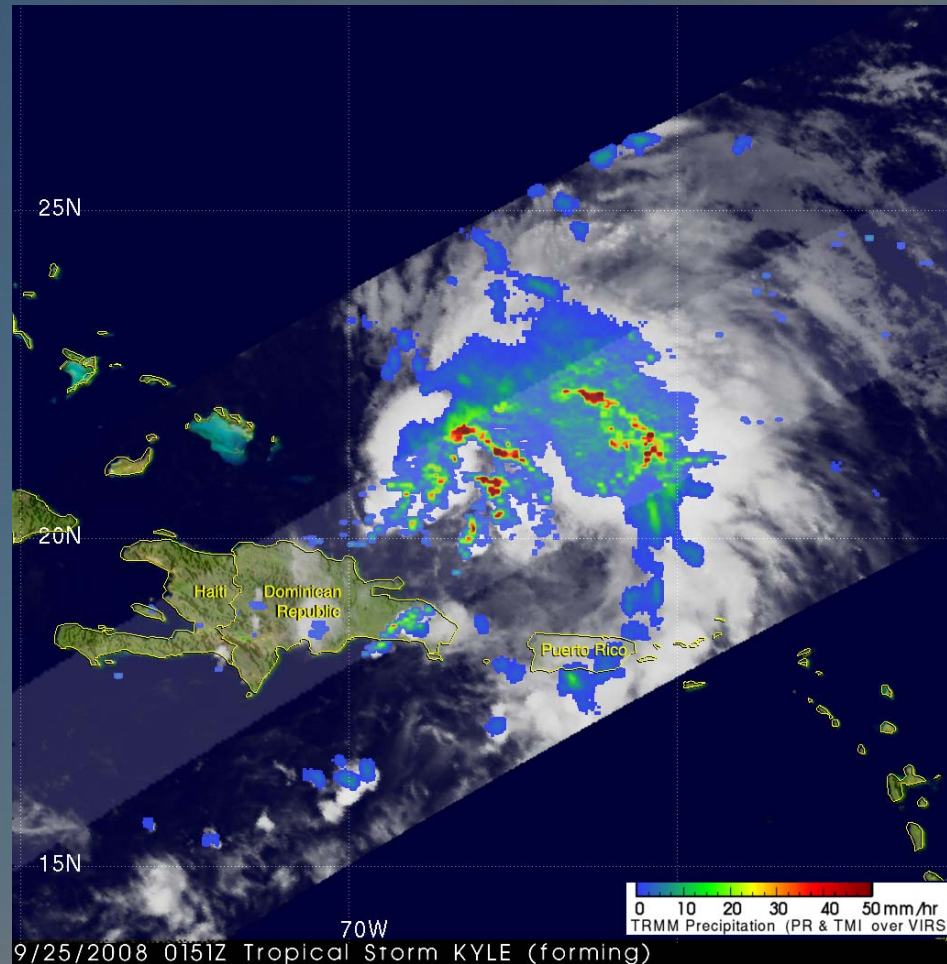
Notes...This is the tropical wave that is trying to develop into Tropical Storm Kyle in September of 2008. Puerto Rico is buried under the clouds. You can see the Dominican Republic to the west.

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Notes...This is early Monday morning ... 9/22/08 – the heaviest of the rainfall is already over for SE PR as the precursor of Kyle treks on to the north. Kyle has not yet been formed but the damage has been done for SE PR.

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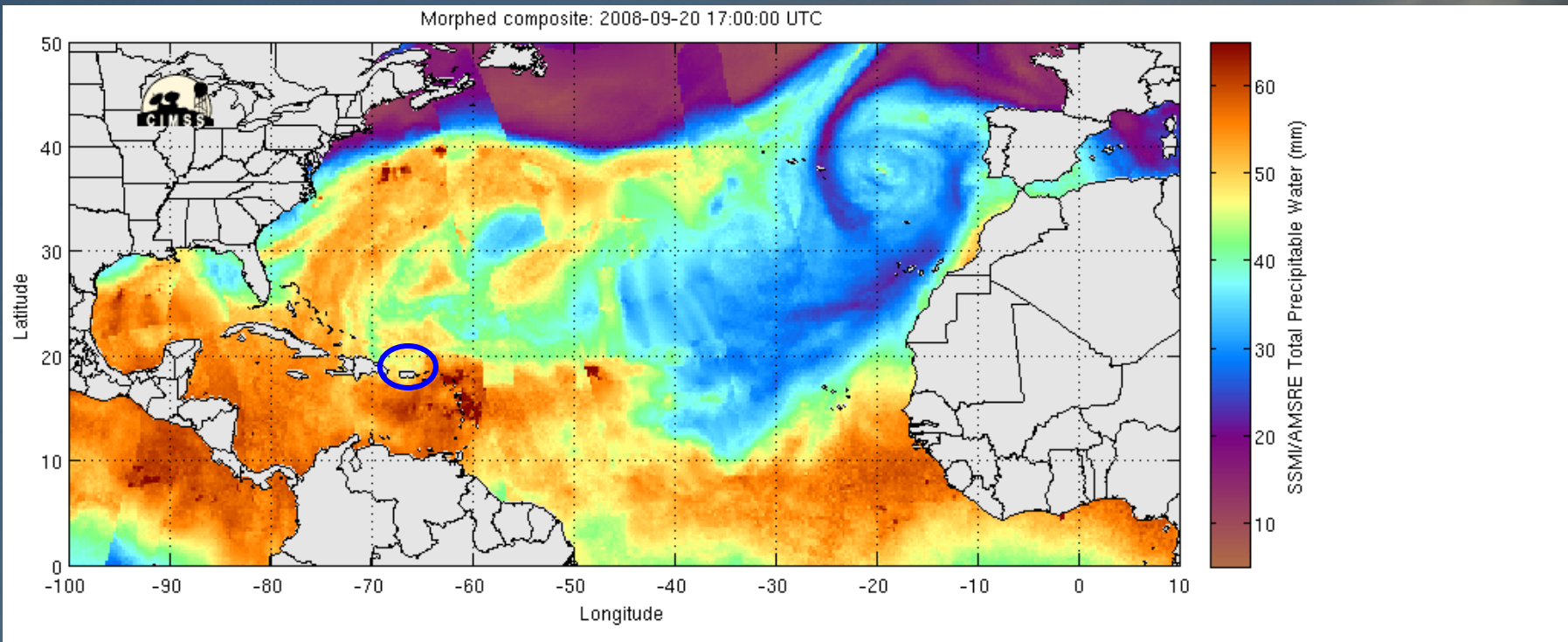
Notes...Finally, it is beginning to look like a Tropical Storm but the damage has already done to Southern PR. Catastrophic Flooding already ending in Southern PR. Approximately 630 People evacuated ... 4 people dead ... agriculture damaged – 5 to 15 inches of rain elsewhere across the island and no Kyle yet! On Thursday at 5pm NHC named the storm TS Kyle.

A blue sky with a faint rainbow and clouds. The rainbow is visible in the center-left, and there are some white clouds at the bottom. The text is overlaid on this background.

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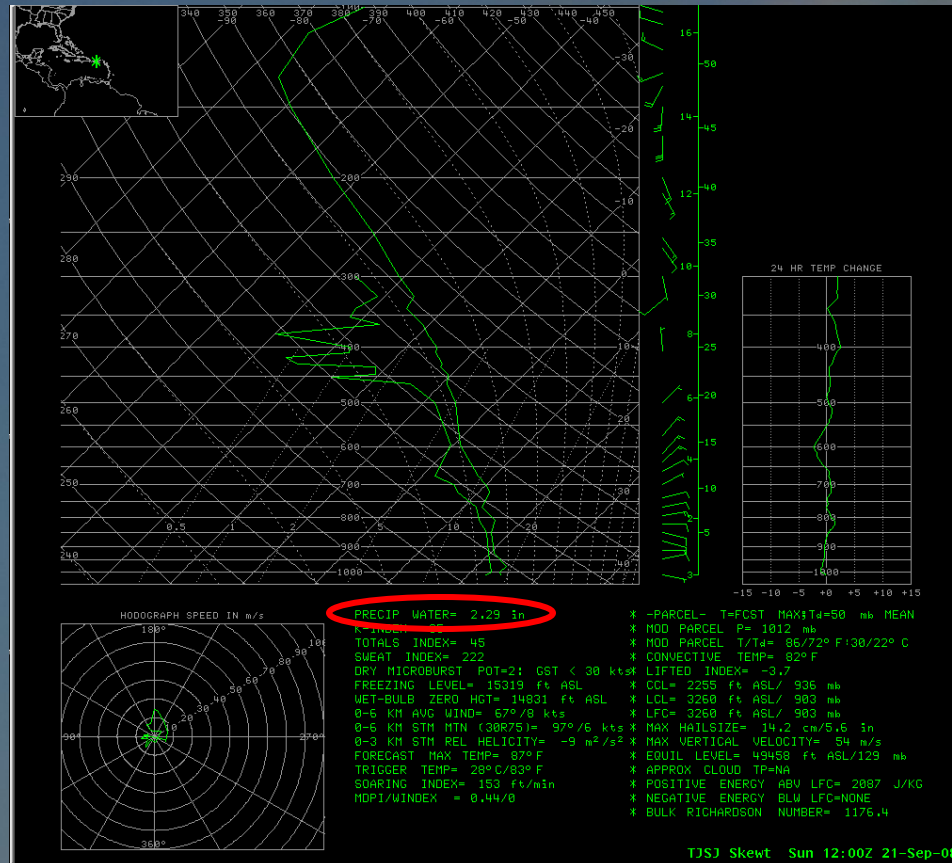
What happened before?

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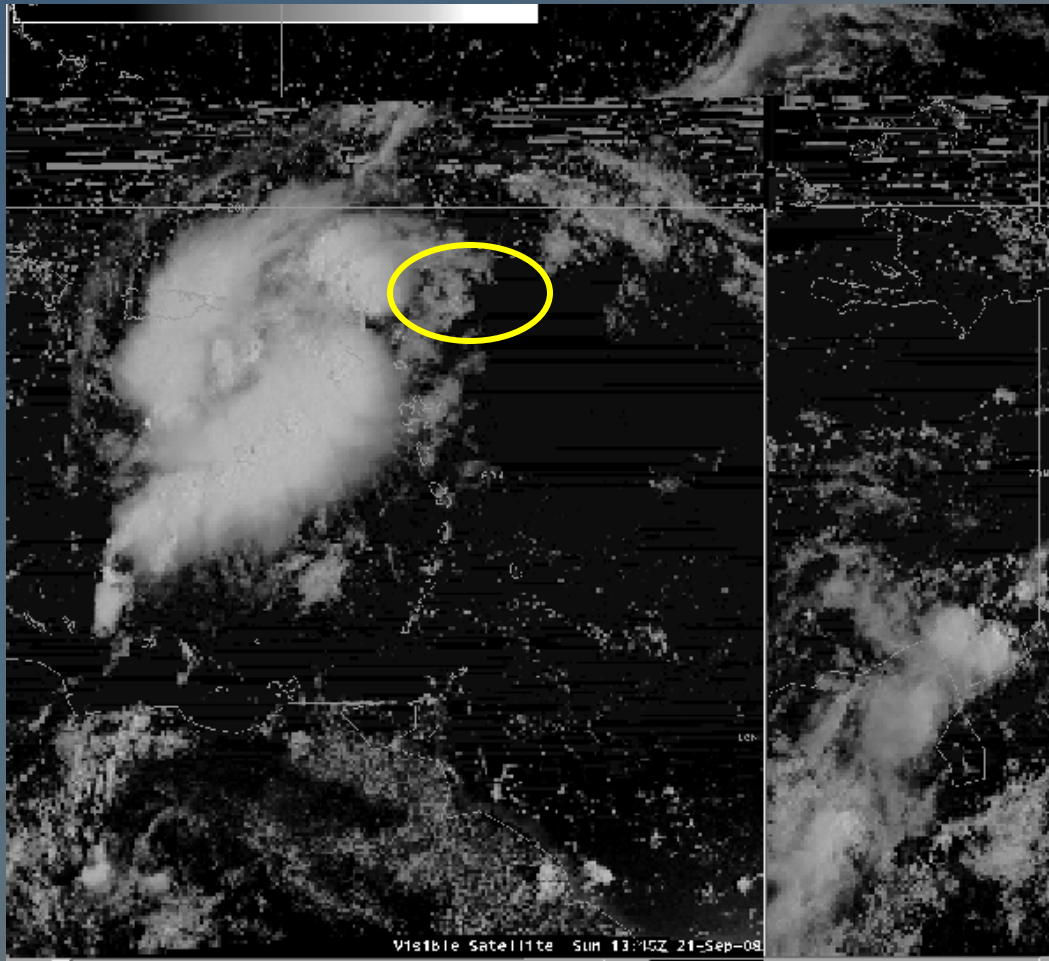
Notes...Precipitable water – 50 to 60 mm equivalent to between 2 and 2 ½ inches along the south coast. When running the loop, you can visibly see an increase of precipitable water along the south coast of PR . The loop if from the 20th to the 23rd ... you see the values are almost constant.

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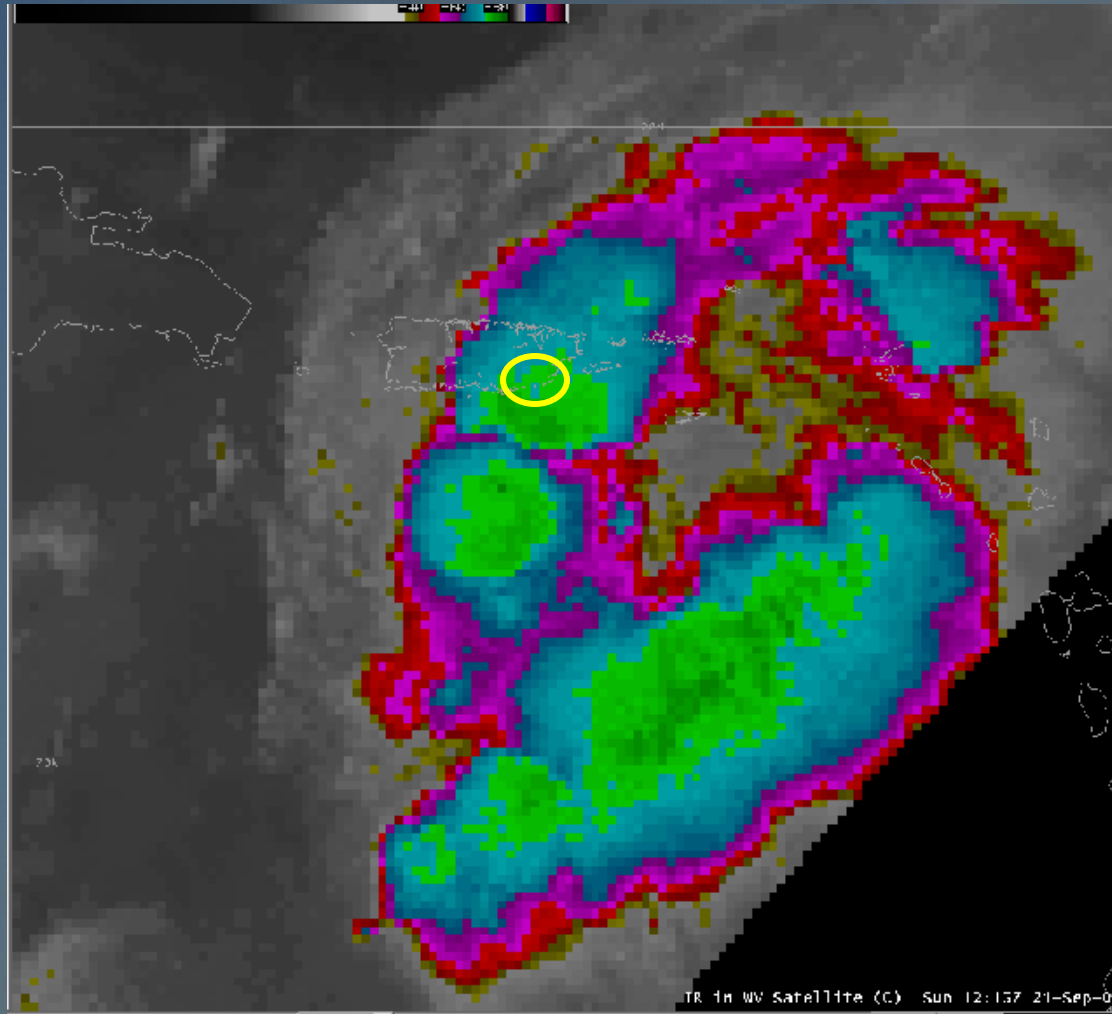
Notes...Let's look at the sounding for San Juan 12z on Sunday 21st - San Juan is located along the northern coast of the island but a good representative of moisture in this case ... may even be a bit drier than the south coast in this case.

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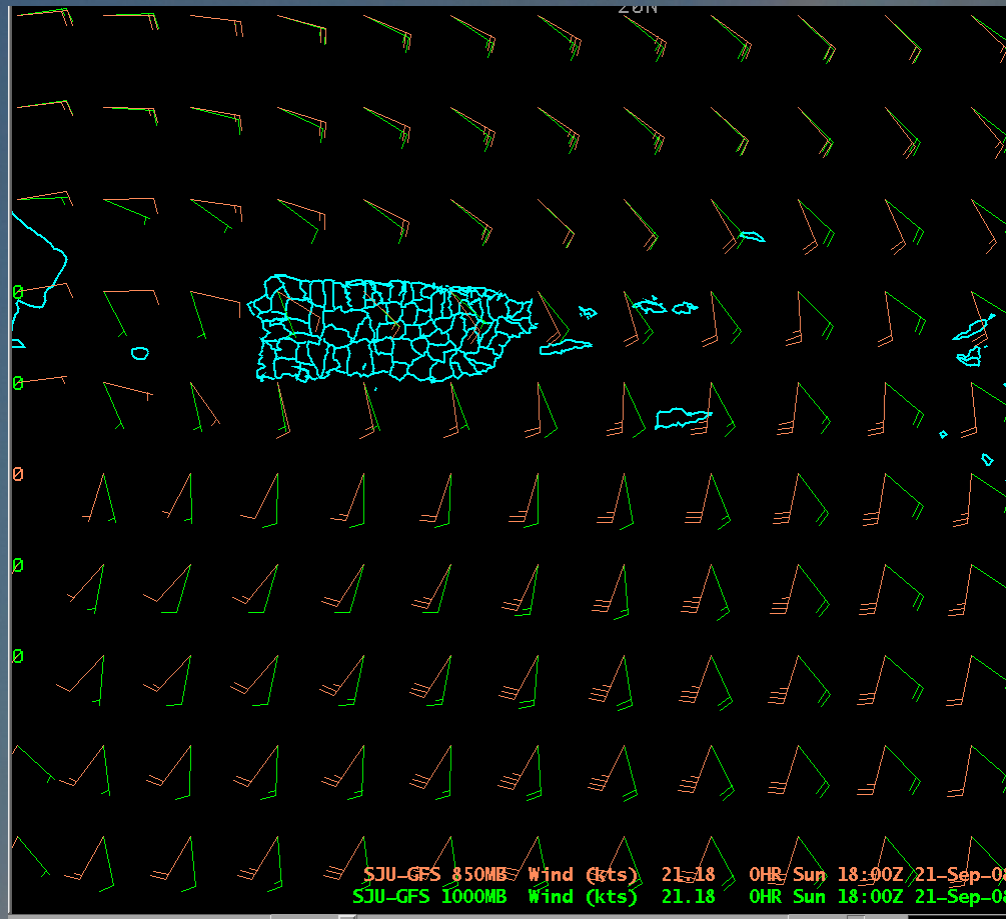
Notes... As we zoom in to the island – Also Sept 21st ...visible satellite shows the training of rainfall throughout the region ... concentrated across our area of focus.

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico



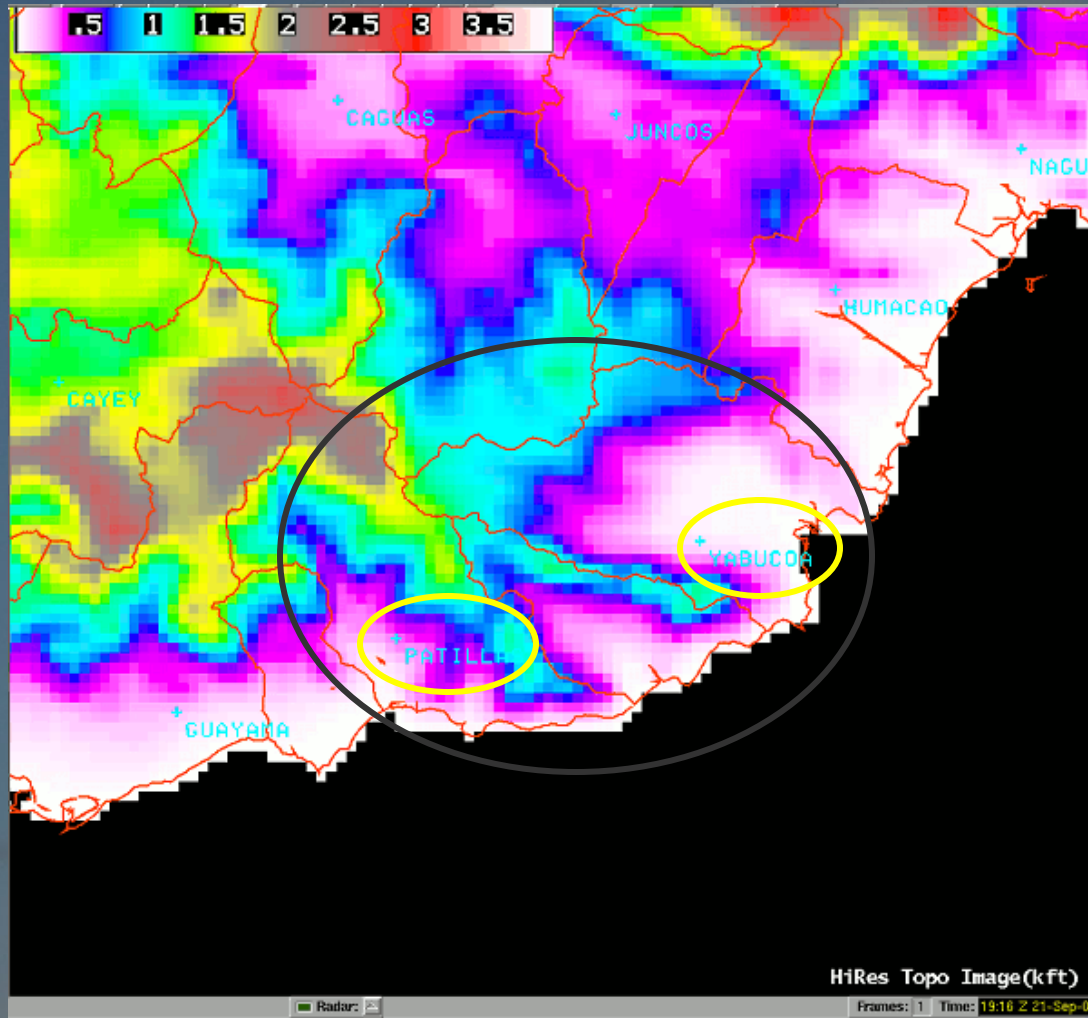
Notes...IRWVsat loop – water vapor loop for a few hours on Sept. 21st ... notice the south side of the island...with the maximum along the southeast coastline ... Yabucoa, Maunabo and Patillas.

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico



Notes...Flow varied from the southeast to the southwest for 3 days. The day with the highest 1 day total ... flow from the southeast at the surface and the south at 850mb.

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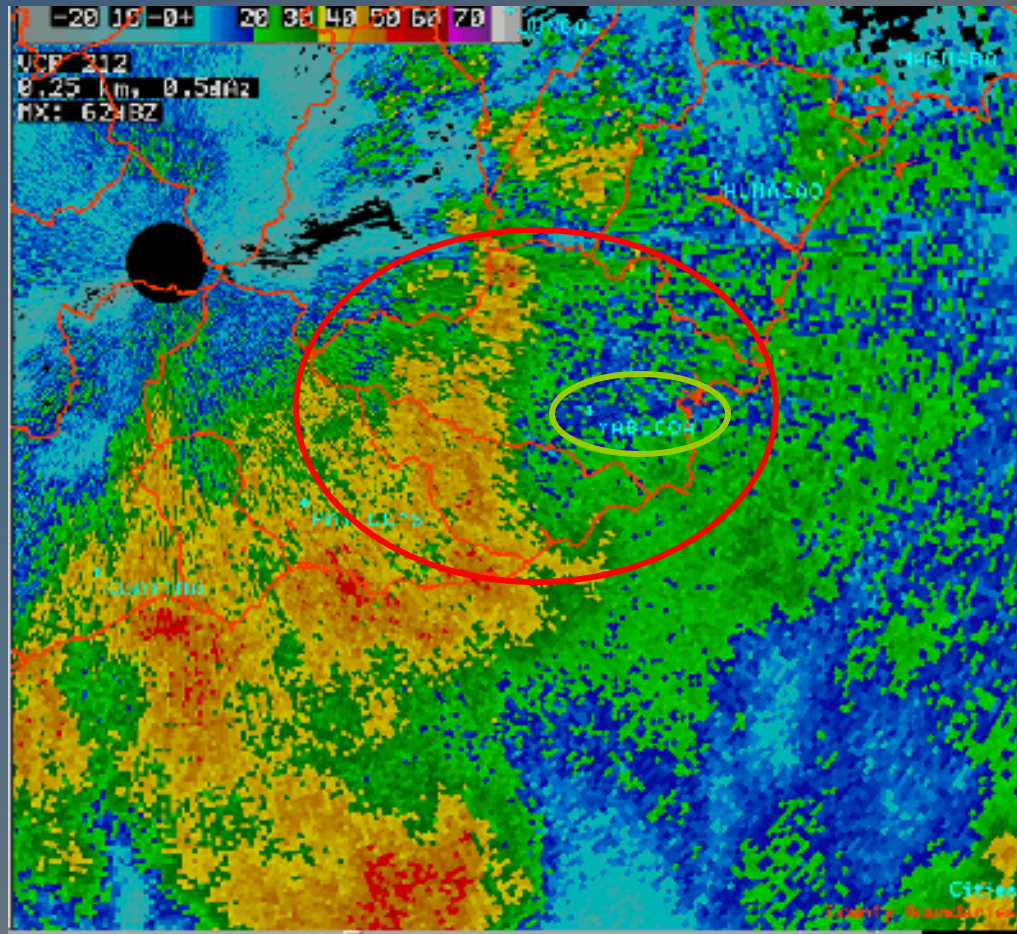
Notes...Southeast to southwest flow – “bad news” for Yabucoa and Patillas. Notice the protruding “blades” - Cuchillas de Panduras.

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico ... wind flow interacting with mtns



Notes... Wind flow from the southeast thru southwest into the “horseshoe” ... rapidly ascending the mountainside ... rapidly developing high intensity rainfall ... rapid runoff back towards the plains and the ocean. This is the setup for the severe flooding that occurred as all these ingredients were available. Moisture – instability – lift in a geographical horseshoe designed basin with mountains on three sides.

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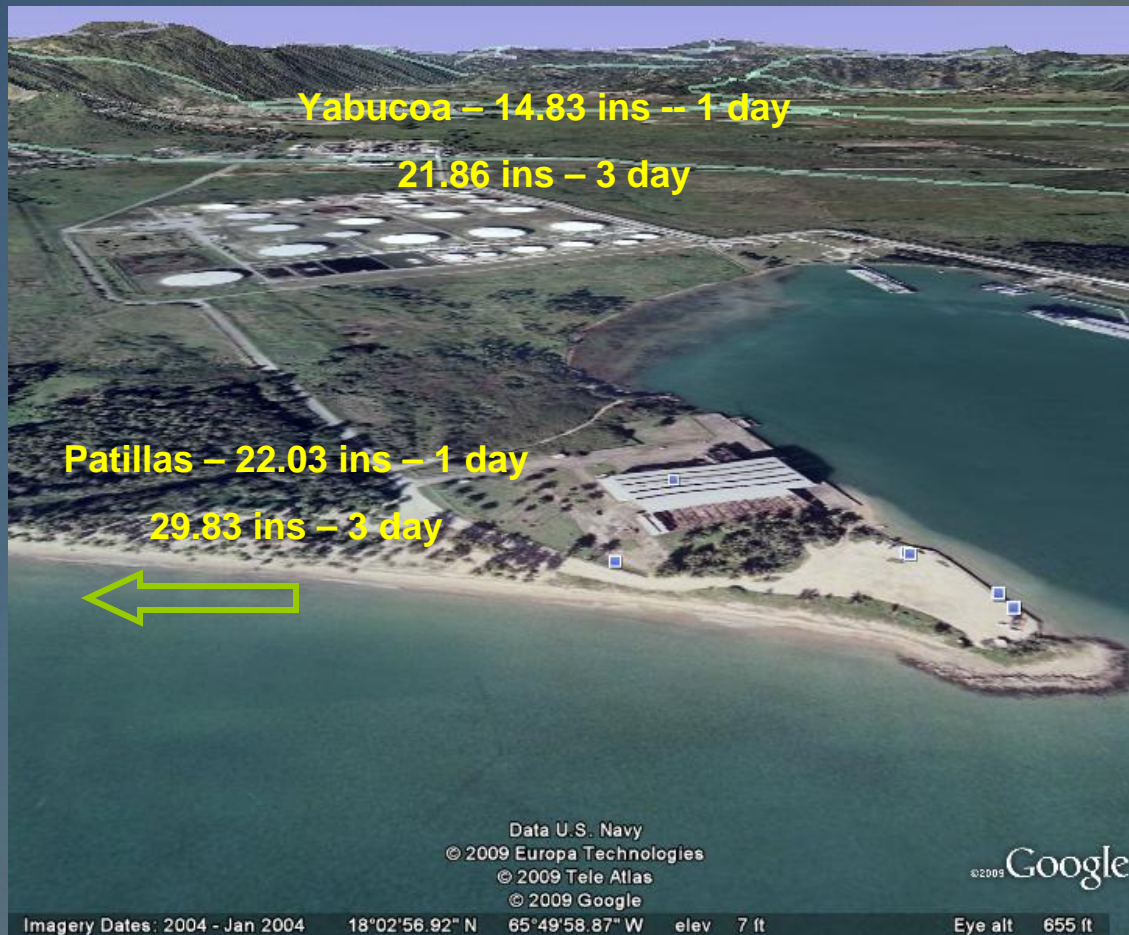
**Notes... What did the 88D show? Heaviest rainfall along the mountain range!!
Developing and training with runoff flowing down the hills into the plains and
back into the ocean**

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

- High Precipitable Water ... Tropical Wave
- Southeast thru Southwest flow into horseshoe shaped basin
- Rapidly ascending slopes from sea level to 1,700 feet

Notes...Pattern Recognition. Factors to look for.

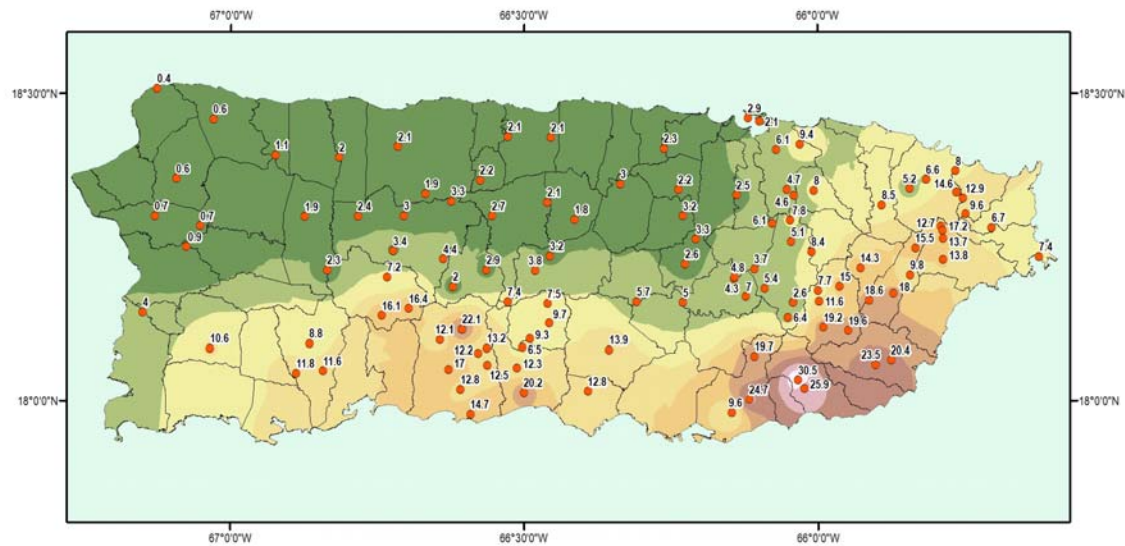
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***Notes...What was the result? Patillas exceeded the 500 yr 24 hour rainfall totals.
Yabucoa exceeded the 25 yr 24 hour rainfall totals.***

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Precipitation totals September 20-23, 2008, Puerto Rico



Explanation

<ul style="list-style-type: none"> ● USGS Station value is Precipitation in inches 	<ul style="list-style-type: none"> 10.5 - 13.7 13.8 - 17.1 17.2 - 20.4 20.5 - 23.8 23.9 - 27.1 27.2 - 30.5
<p>Precipitation (in)</p> <ul style="list-style-type: none"> 0.4 - 3.7 3.8 - 7 7.1 - 10.4 	



Preliminary data
subject to revision

Notes... Map of event totals from the USGS PR

Pre-Kyle Severe Flooding Rainfall Gage Reports

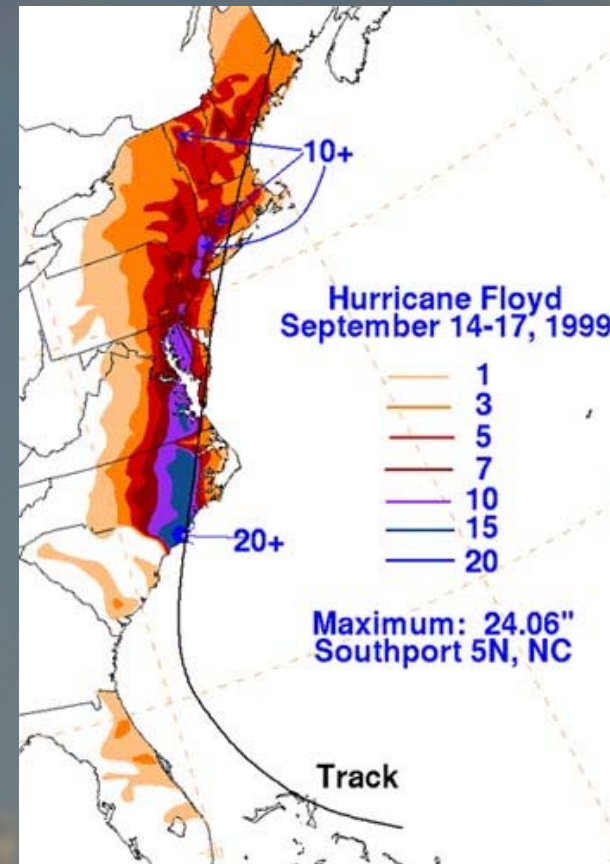
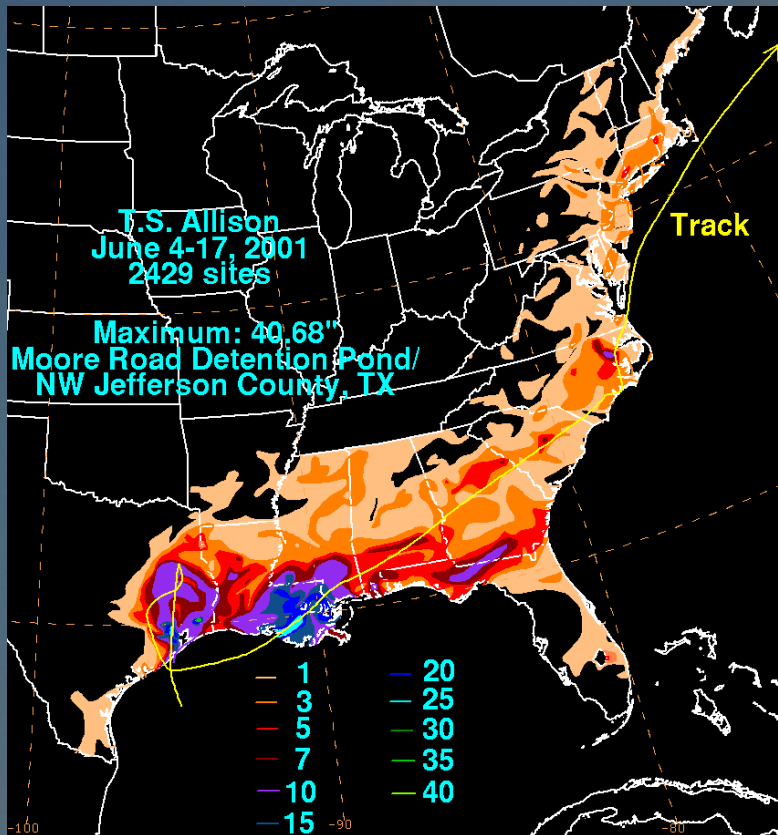
- THIS IS THE RAINFALL ACCUMULATIONS ENDING AT
- 12Z (8 AM) EACH MORNING FOR THE FOLLOWING DAYS

DATE	21	22	23	TOTAL

PATP4 RIO GRANDE DE PATILLAS NR PATILLAS	3.48	22.03	4.32	29.83
PAXP4 CANAL DE PATILLAS ABV GUAYAMA	2.48	17.10	4.40	23.98
YBUP4 RIO GUAYANES NR YABUCOA	3.95	14.83	3.08	21.86
PASP4 LAGO PATILLAS NR PATILLAS	2.90	18.76	M	21.66
PCEP4 RIO CERRILLOS NR PONCE	0.01	10.81	9.70	20.52
GUYP4 GUAYAMA 2 E	M	20.00	M	20.0
GCRP4 RIO GUAYANES @ CENTRAL ROIG	3.87	12.13	2.76	18.76
SLLP4 RIO LOIZA @ QUEBRADA ARENAS	0.49	13.85	4.27	18.61
CARP4 LAGO CARITE @ NR CAYEY	1.94	10.70	5.55	18.19
VAMP4 BO. MONTONES LAS PIEDRAS	0.65	12.19	5.16	18.0
CRRP4 CABO ROJO	0.55	16.00	1.27	17.82
DEXP4 FT ALLEN RSERVE CENTER JUANA DIAZ	0.00	11.73	5.82	17.55

Notes... Totals from gages along the south coast – 3 day totals. Patillas exceeded weekly total record of 27.13 inches in October 1985.

Pre-Kyle Severe Flooding ... similar to Allison and Floyd ... almost 30 inches of rain in 3 days



Notes... These weekly records were similar to the amounts seen during Floyd and Allison – days of rain because systems were so slow moving. Puerto Rico's totals 20 – 30 inches in three days.

Pre-Kyle Severe Flooding Across Southern Puerto Rico

photo acknowledgements - [El Nuevo Dia](#), [El Vocero](#), [Primera Hora](#), [Univision](#)



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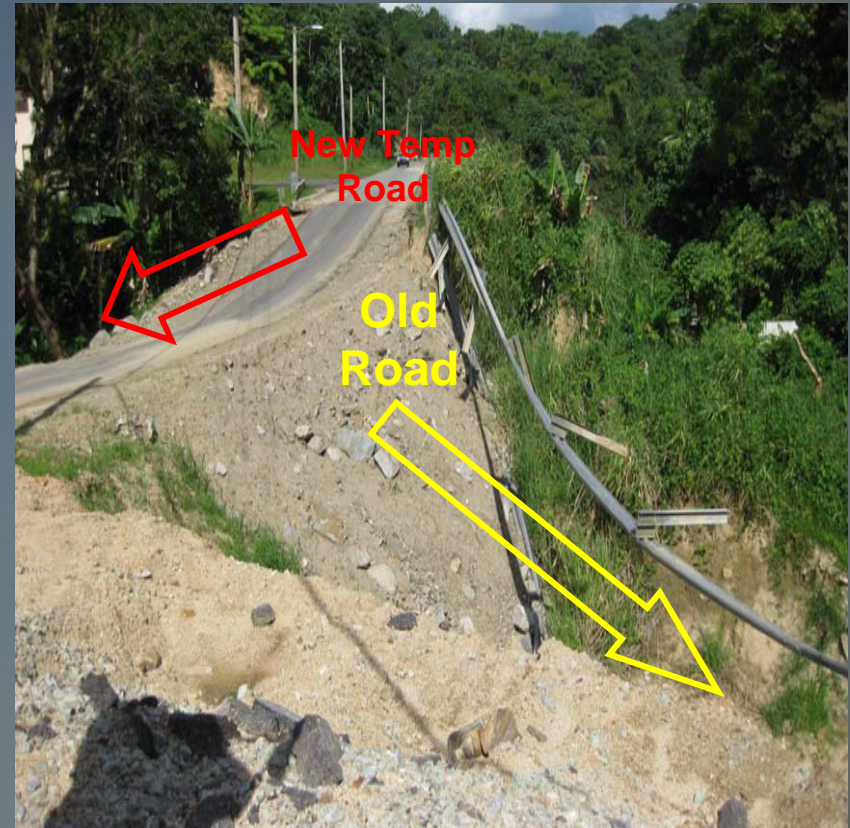


Pre-Kyle Severe Flooding Across Southeastern Puerto Rico ... the bridge is gone



**Notes...Almost every bridge in Maunabo and Yabucoa was damaged (source EMs of Yabucoa and Maunabo).
This crevice/bridge (photo on left) served as a dam (trees, rock and debris) and then eventually with a loud bang - as described by residents – technically a dam break which took the bridge with it.**

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Notes...Many temporary roads had to be built within 3 weeks to re-connect the communities that were cut off from remainder of island.

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Notes... Road closures and detours everywhere.



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Operational Key Lessons ...Factors

Pre-Kyle Severe Flooding Across Southeastern Puerto Rico

- Tropical moisture – Slow Moving Hurricane, Tropical Storm, Tropical Wave
- Wind Flow in conjunction with Topography / Geography of local area
- Slope of region – gentle slope to mountains or dramatic slope (flash flooding)

Notes... We have tropical waves moving through all the time ... what was different with this one? The wind flow and duration ... into the southern slopes! The key to catastrophic events along the south coast of PR! Flash Flooding and then areal flooding.

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Notes...Rivers were flooding and swollen and the crops were damaged/destroyed.

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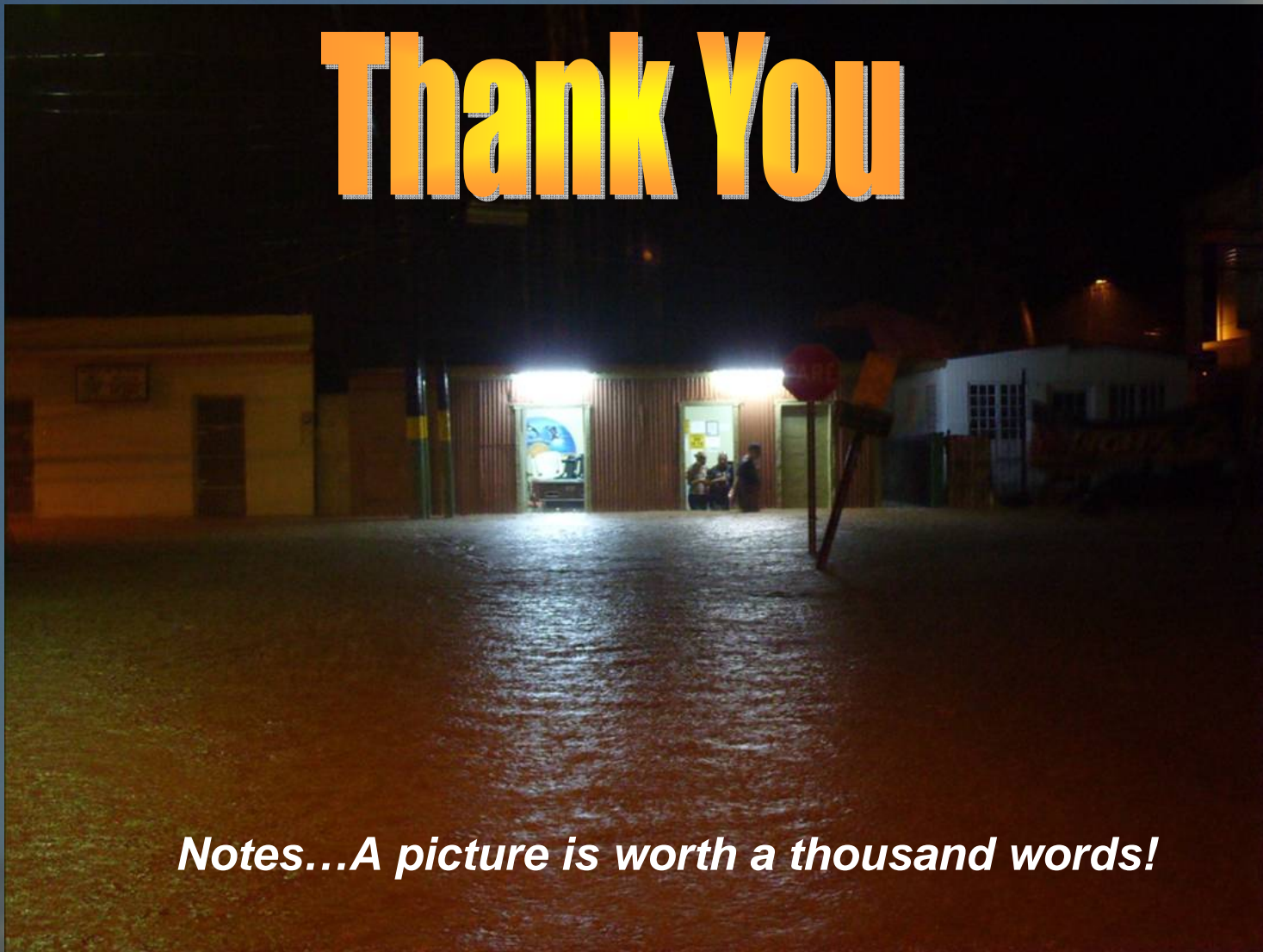


Notes...All we can do is study and prepare so that we will continue to recognize this pattern when it comes around again. Prepare and put out the warnings with as much lead time as possible to help Emergency Managers and ultimately the public.

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Thank You



Notes...A picture is worth a thousand words!