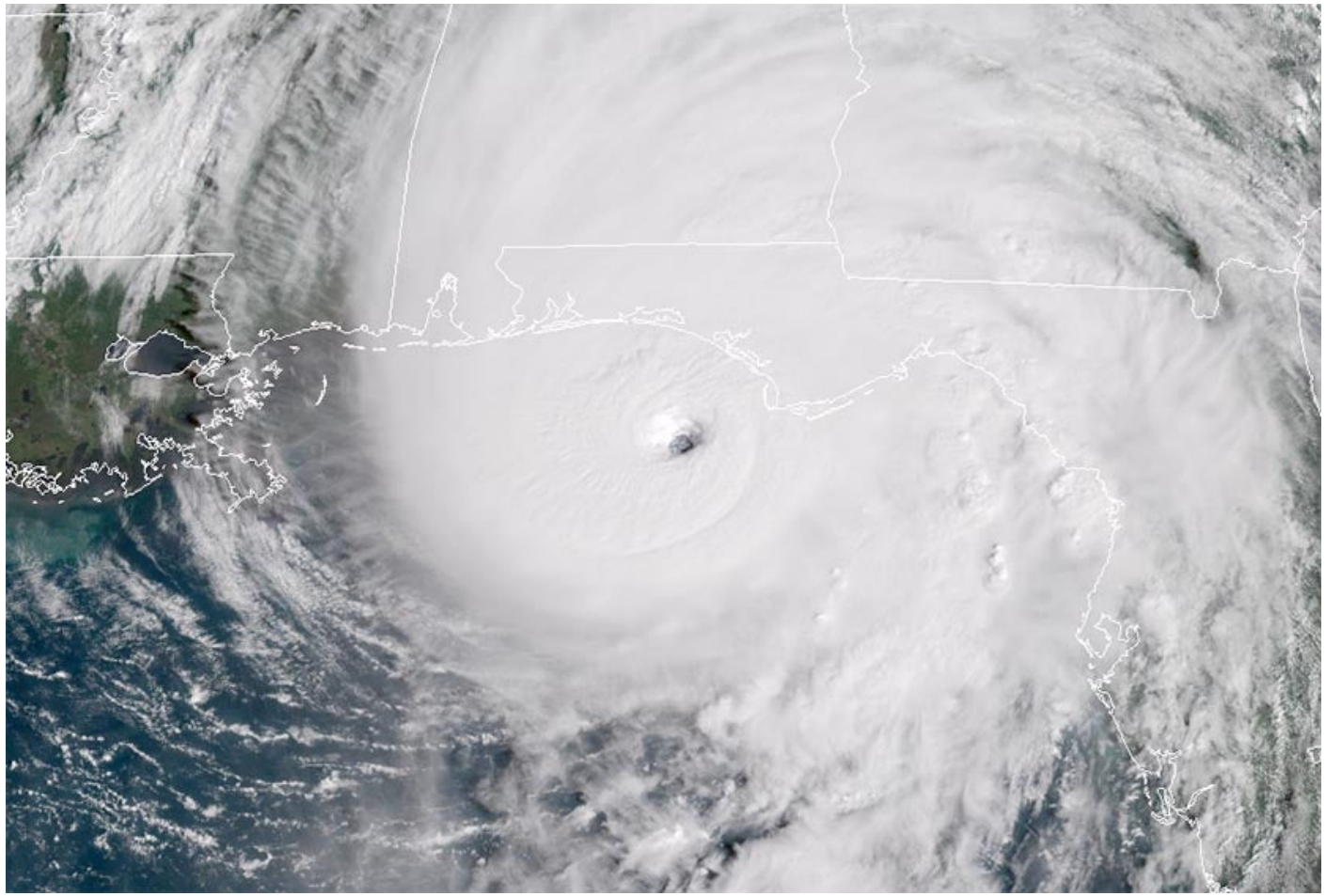
Changing US Hurricane Hazard



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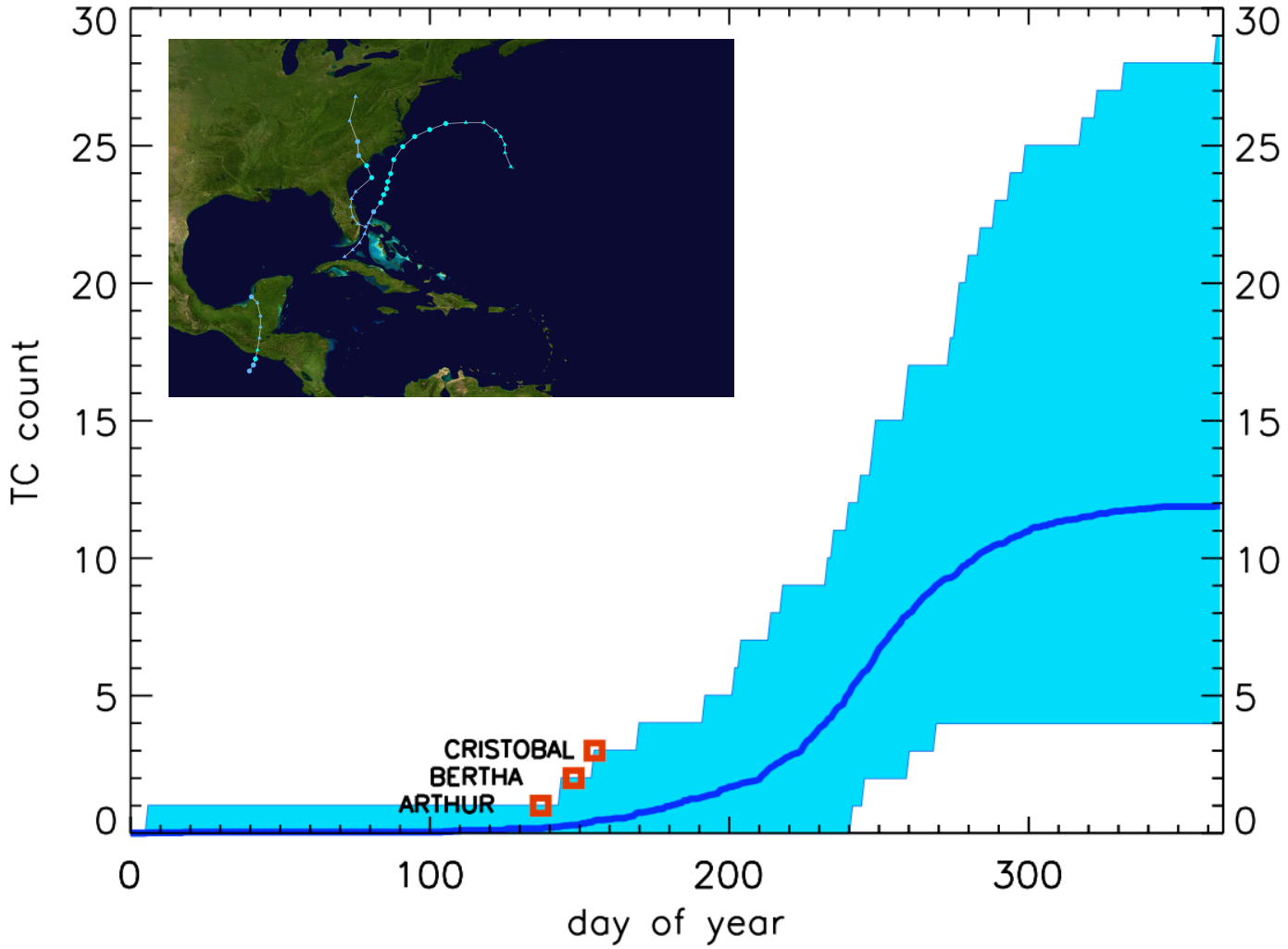
National Aeronautics and Space Administration
Goddard Institute for Space Studies

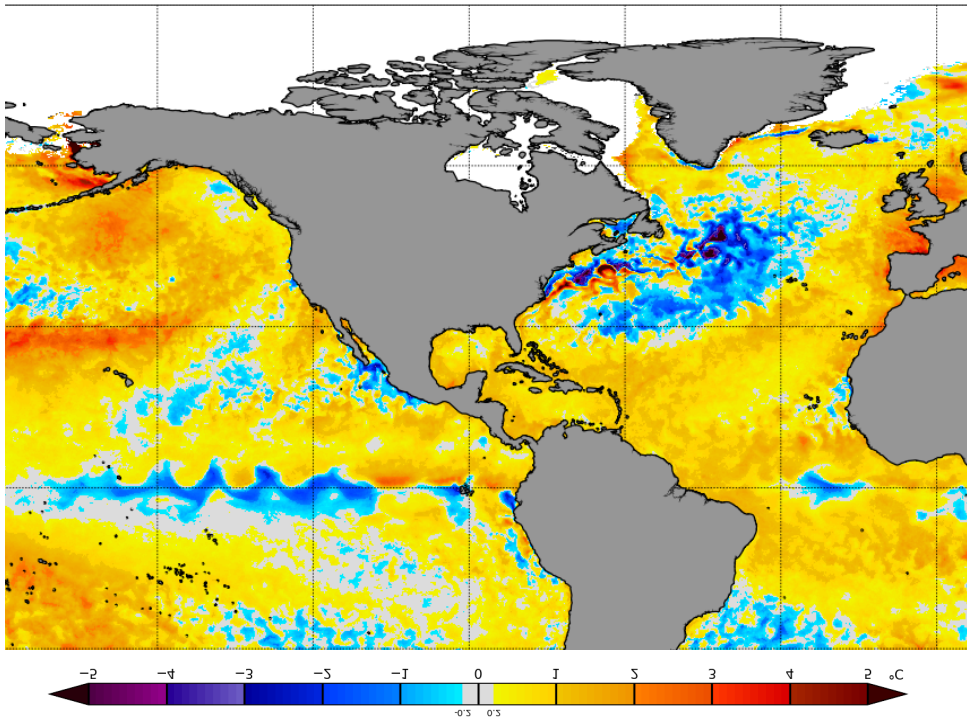
2020 Season

Warm tropical North Atlantic and no El Nino → Active Season

Three storms so far, well above average for date.



May 31 SST Anomalies



But seasonal forecasting imperfect. Little skill for regional landfall rates.

Hurricane-climate analysis is based on a long-term view and physical understanding, not just a few active seasons. Long-term climate impacts on hurricanes include …

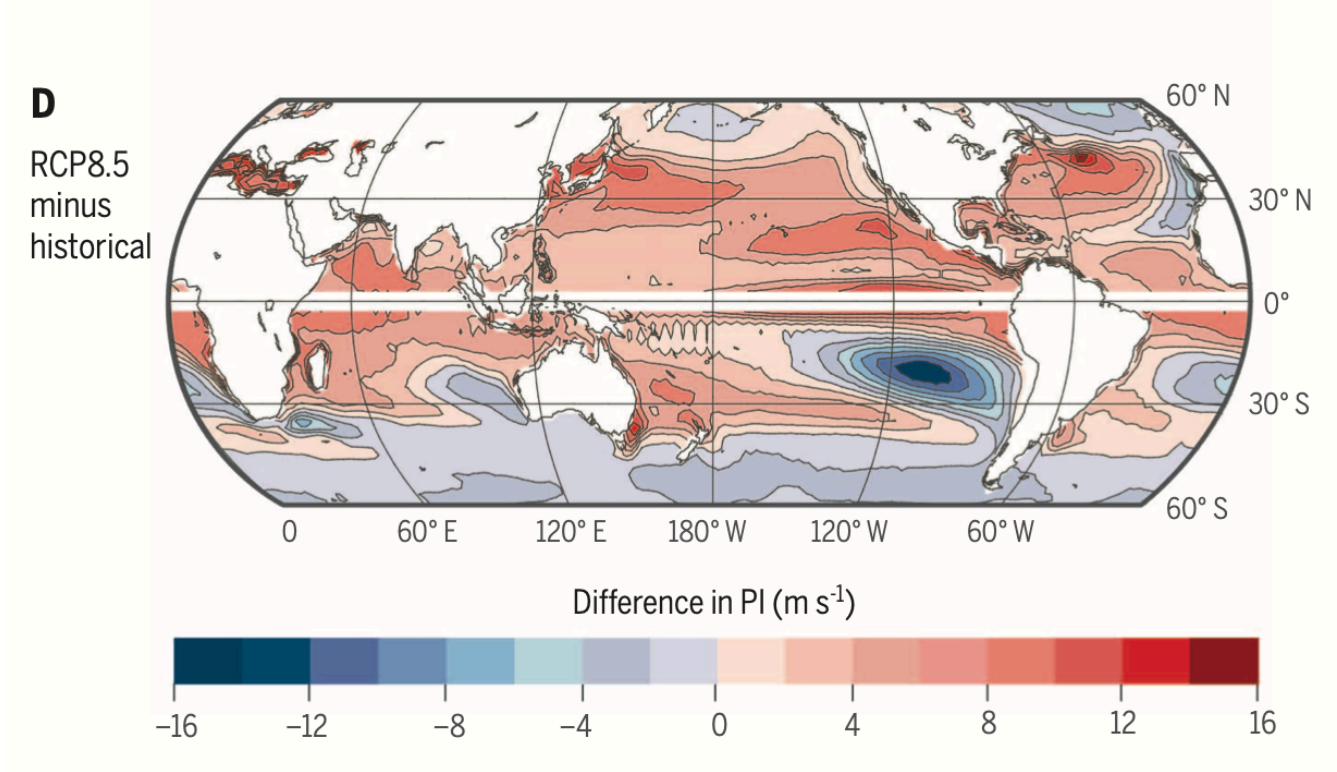
more certain

1. **More population and infrastructure in harm's way.**
2. **Greater storm surge from sea-level rise.**
3. **More intense rain events from warmer, moister air.**
4. **Increased intensity from warmer oceans.**
5. **Slower, stalling tracks due to changing atmospheric wind patterns.**
6. **Fewer overall tropical cyclones.**

less certain

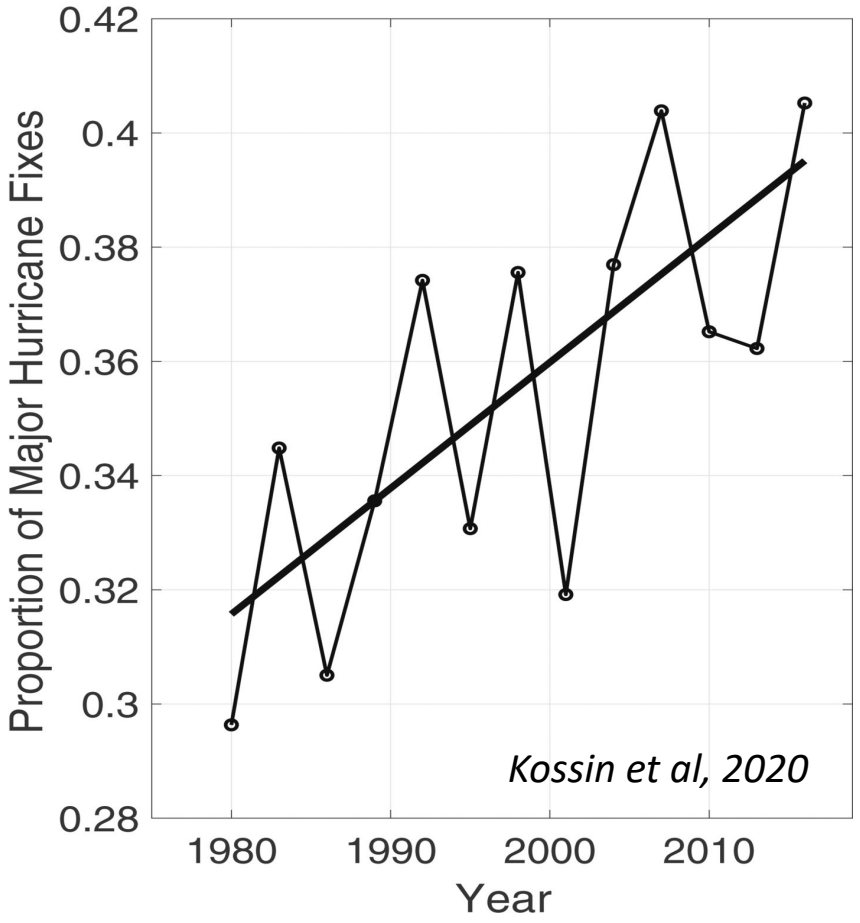
Intensity:

Warmer oceans and changing vertical profile of atmospheric moisture and temperature → increase hurricane intensity



Sobel et al, 2016

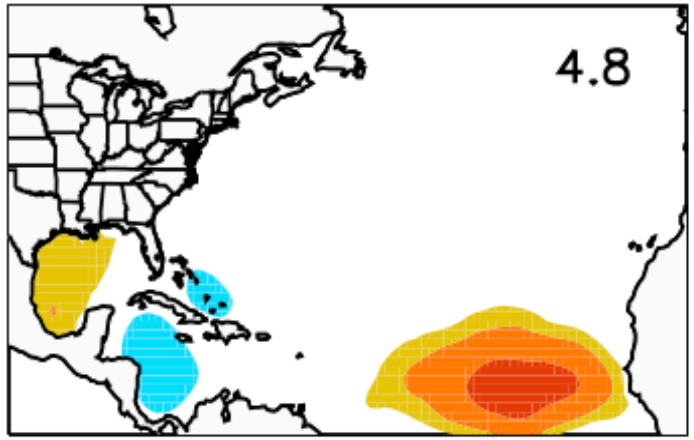
Projected increases in “potential intensity” (PI), the upper limit for hurricane intensity given environment. (Actual hurricane intensities distributed from weakest up to PI. Increased PI “stretches” the distribution.)

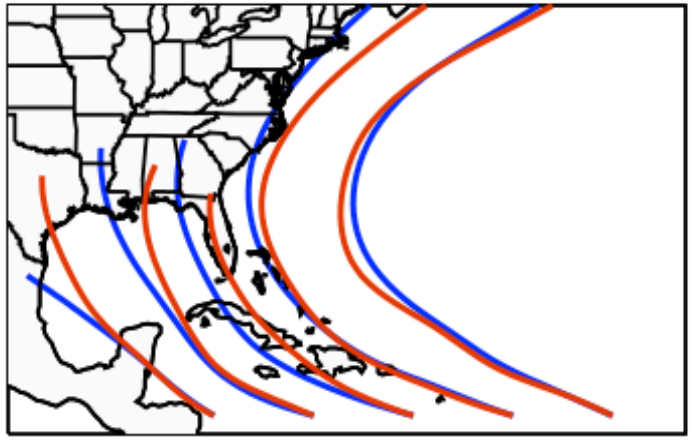


Positive trend in fraction of hurricanes reaching “major” status now visible in historical record.

Regional Hazard:

Other factors in addition to intensity:
Where storms form? How they propagate?



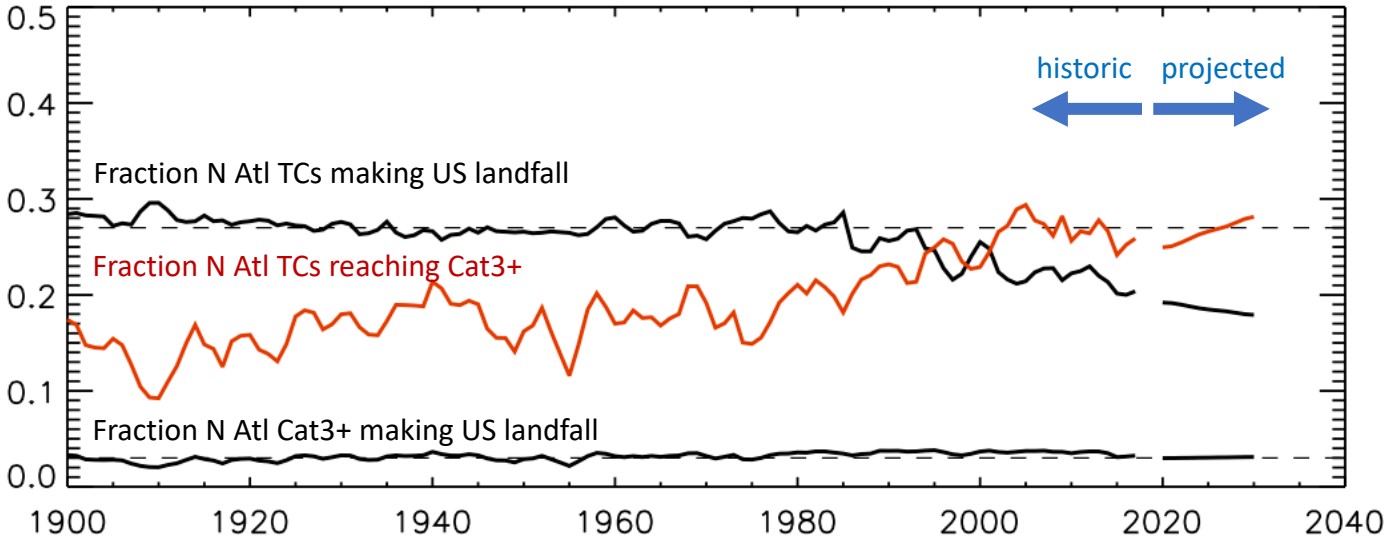


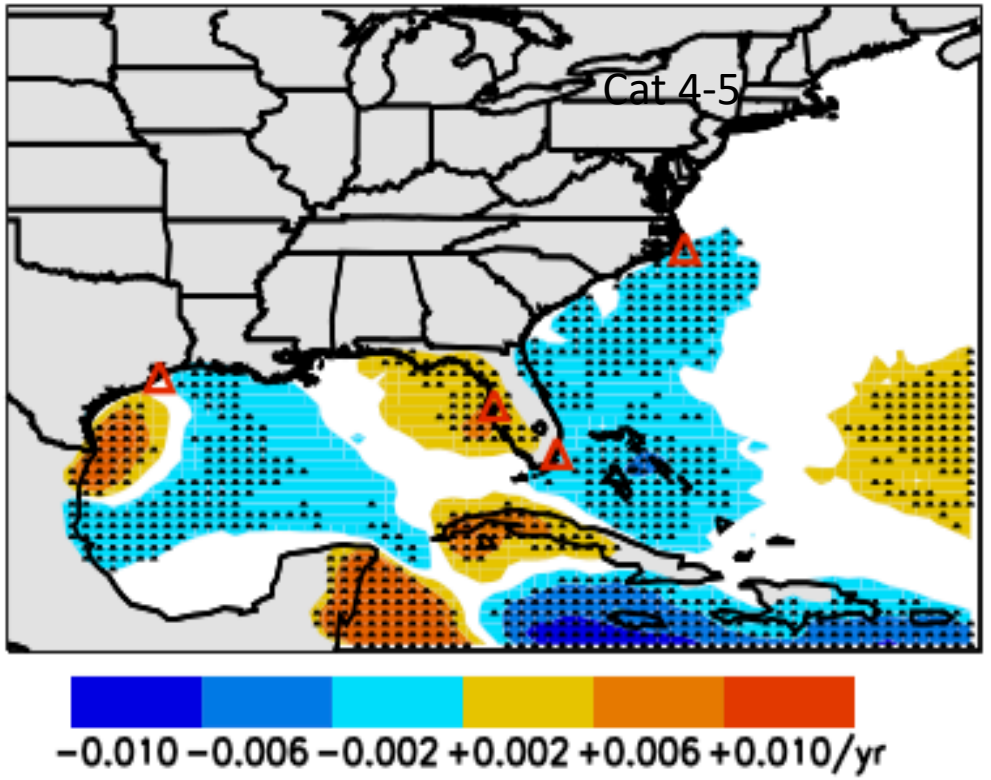
Results from statistical model driven by historical and projected ocean temperature.

Projected North Atlantic changes into 2030s:
- Eastward shift in formation region.
- Eastward shift in track.

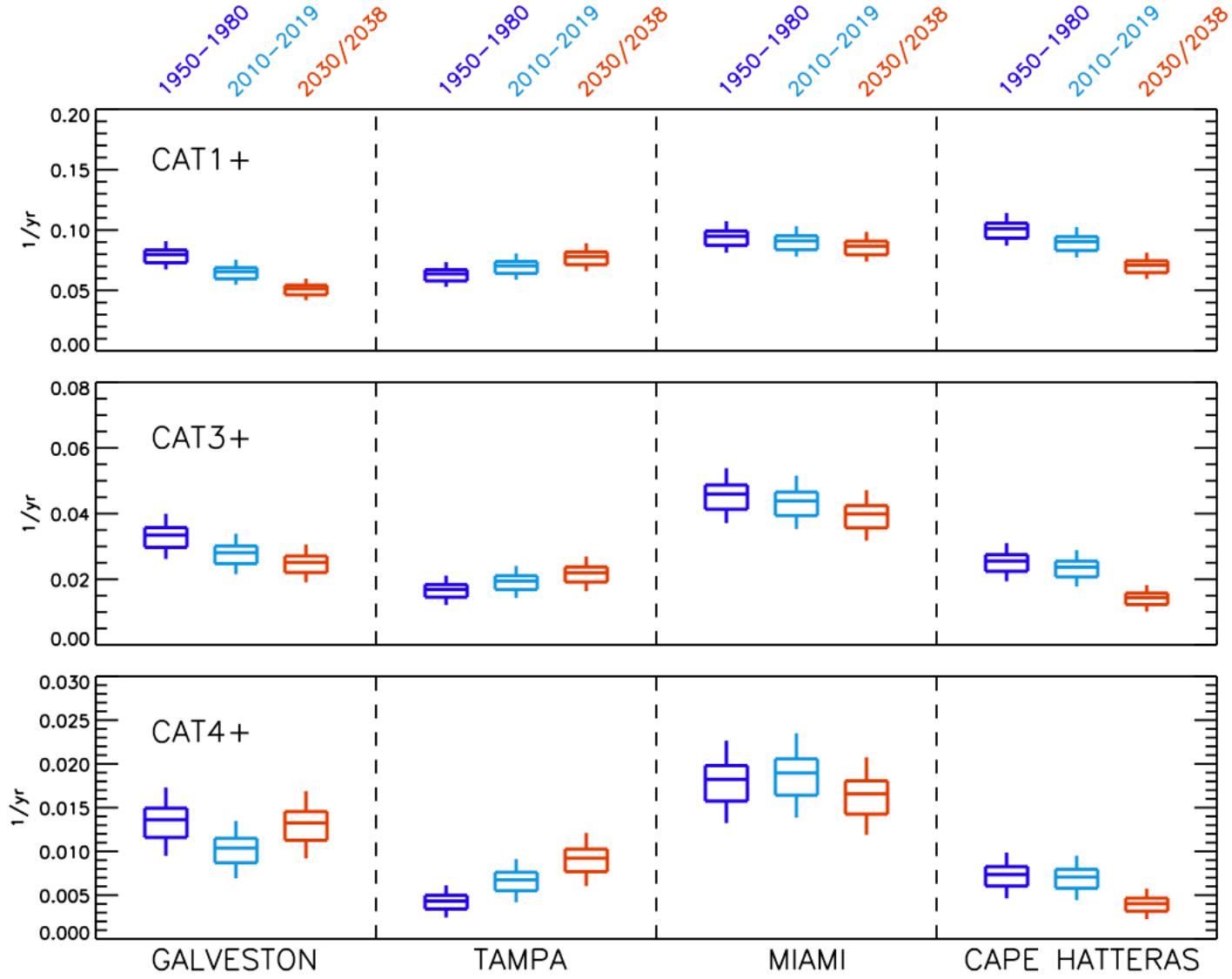
Complex signal for US coast:
- More storms but smaller fraction hit US.
- Increased landfall hazard some regions.
- Decreased landfall other places.

Hall et al, 2020



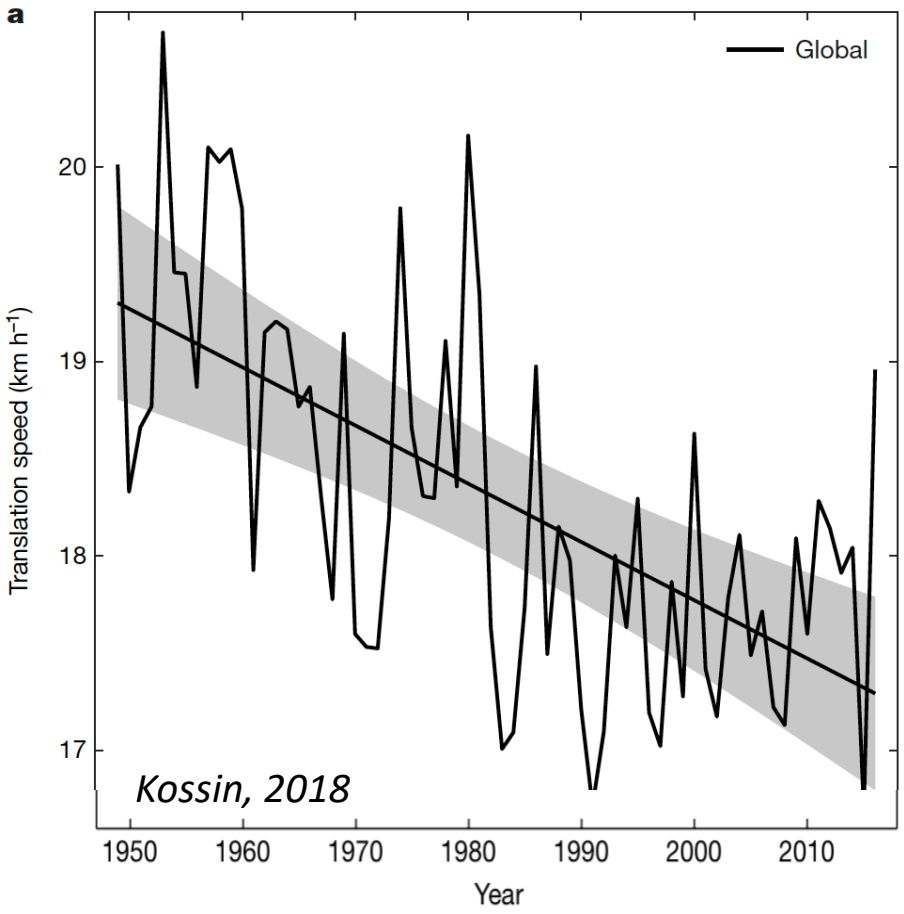


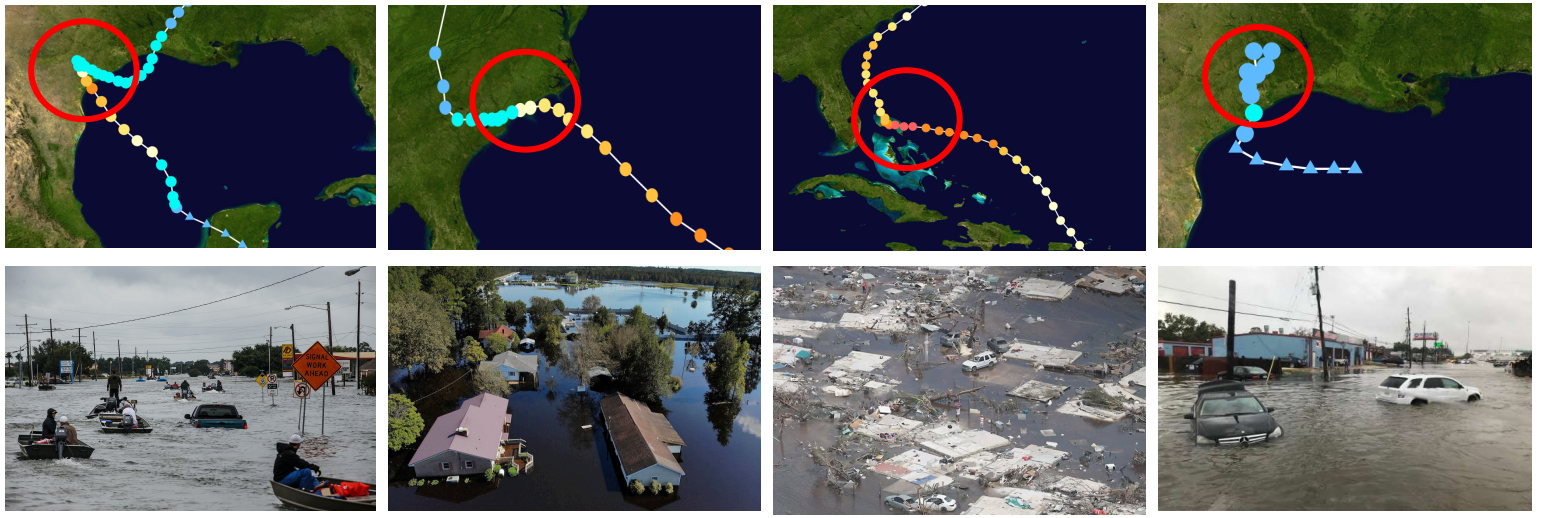
Summary of 2030s changes on four US locations



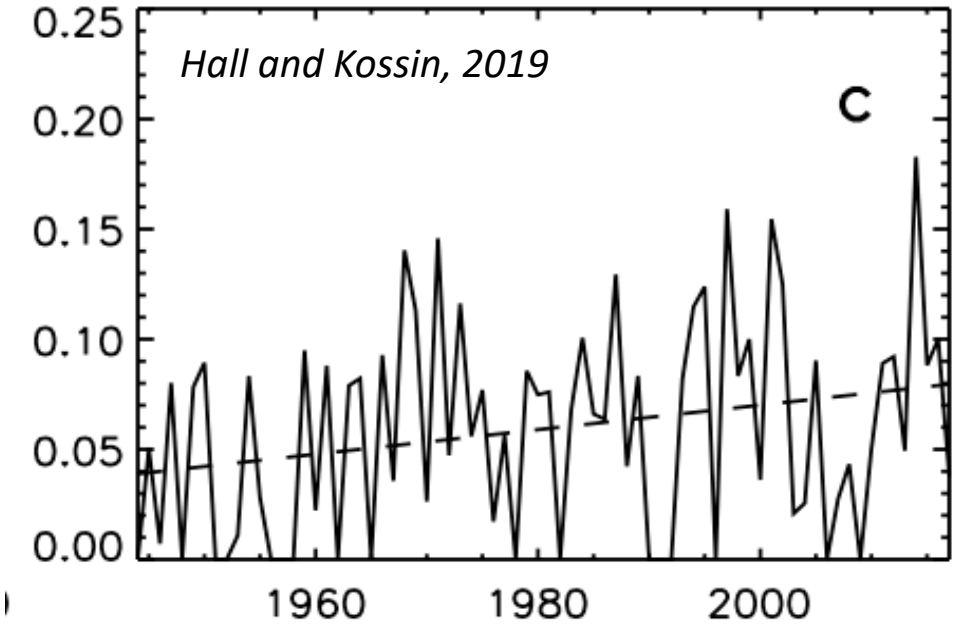
Hall et al., 2020

TC tracks are slowing and stalling more



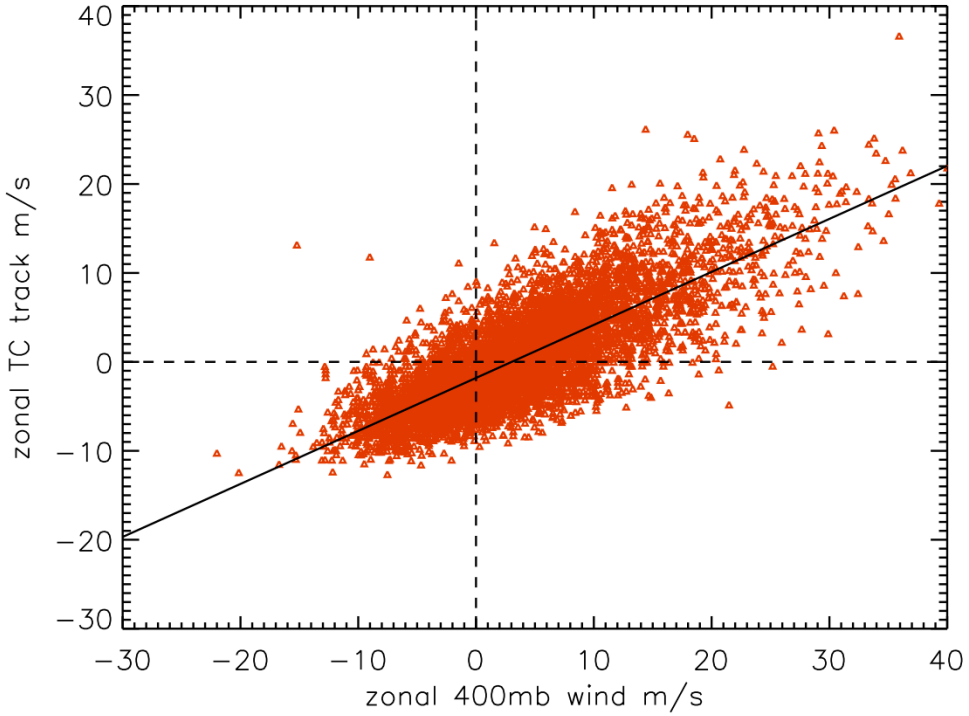


Harvey 2017 | Florence 2018 | Dorian 2019 | Imelda 2019



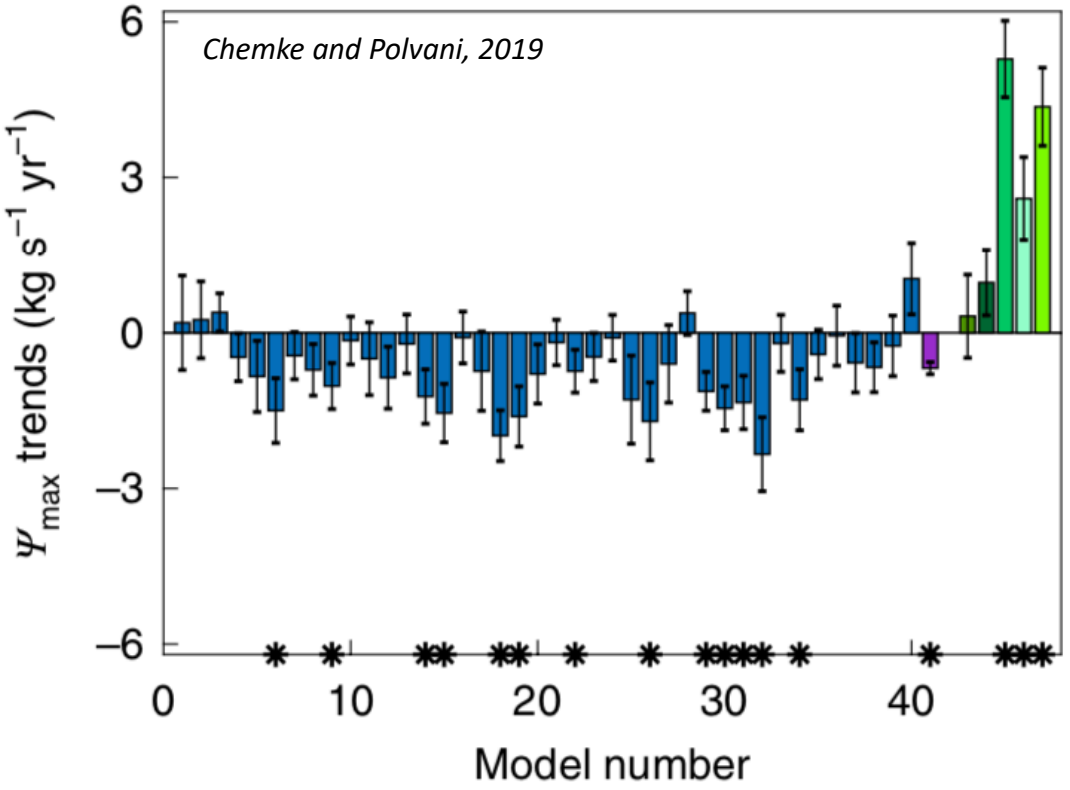
Annual fraction of TCs that pass through specified coastal 200km-radius regions that spend at least 48 hours in those regions.

Slowing-Stalling Mechanisms

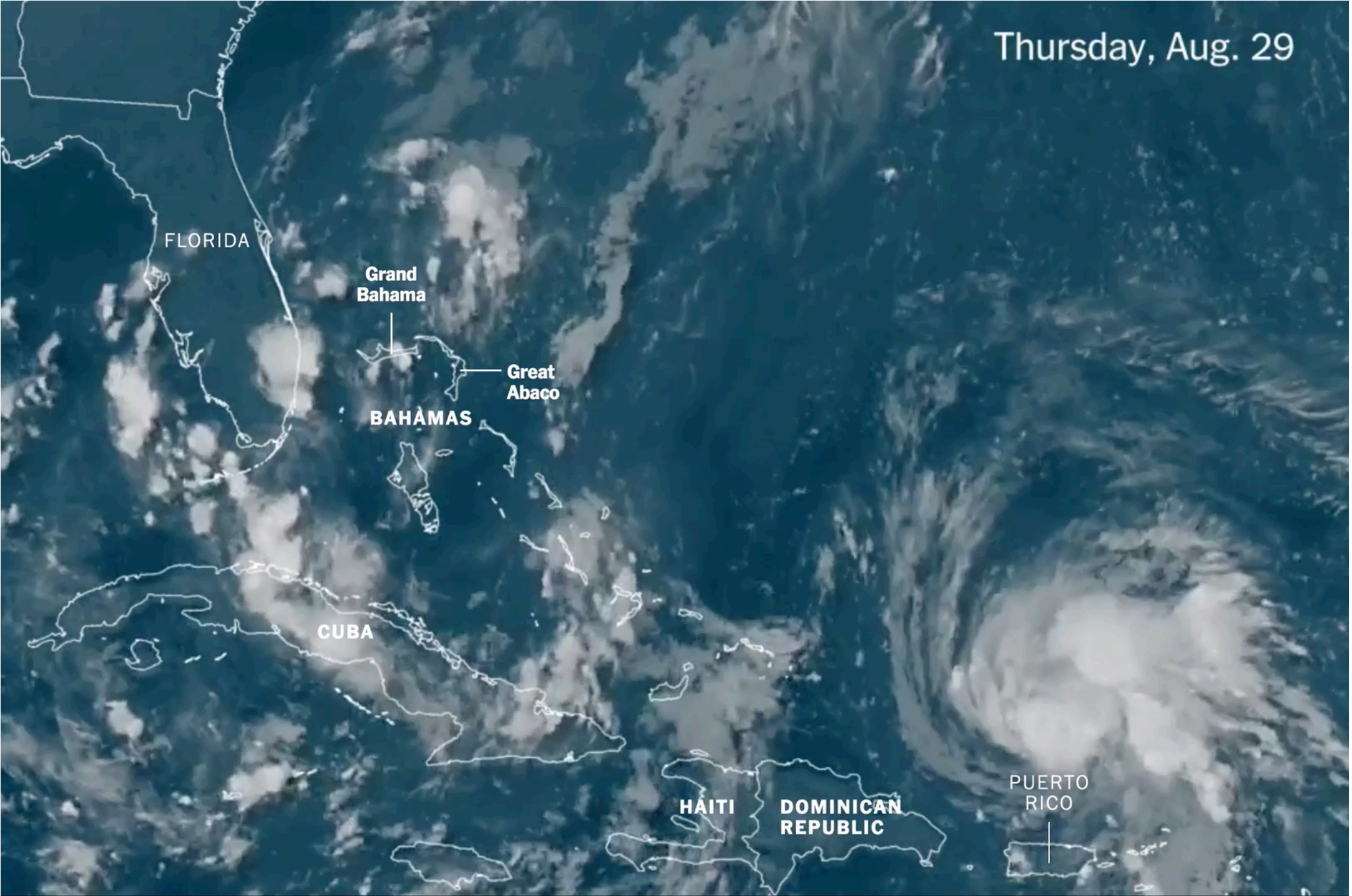


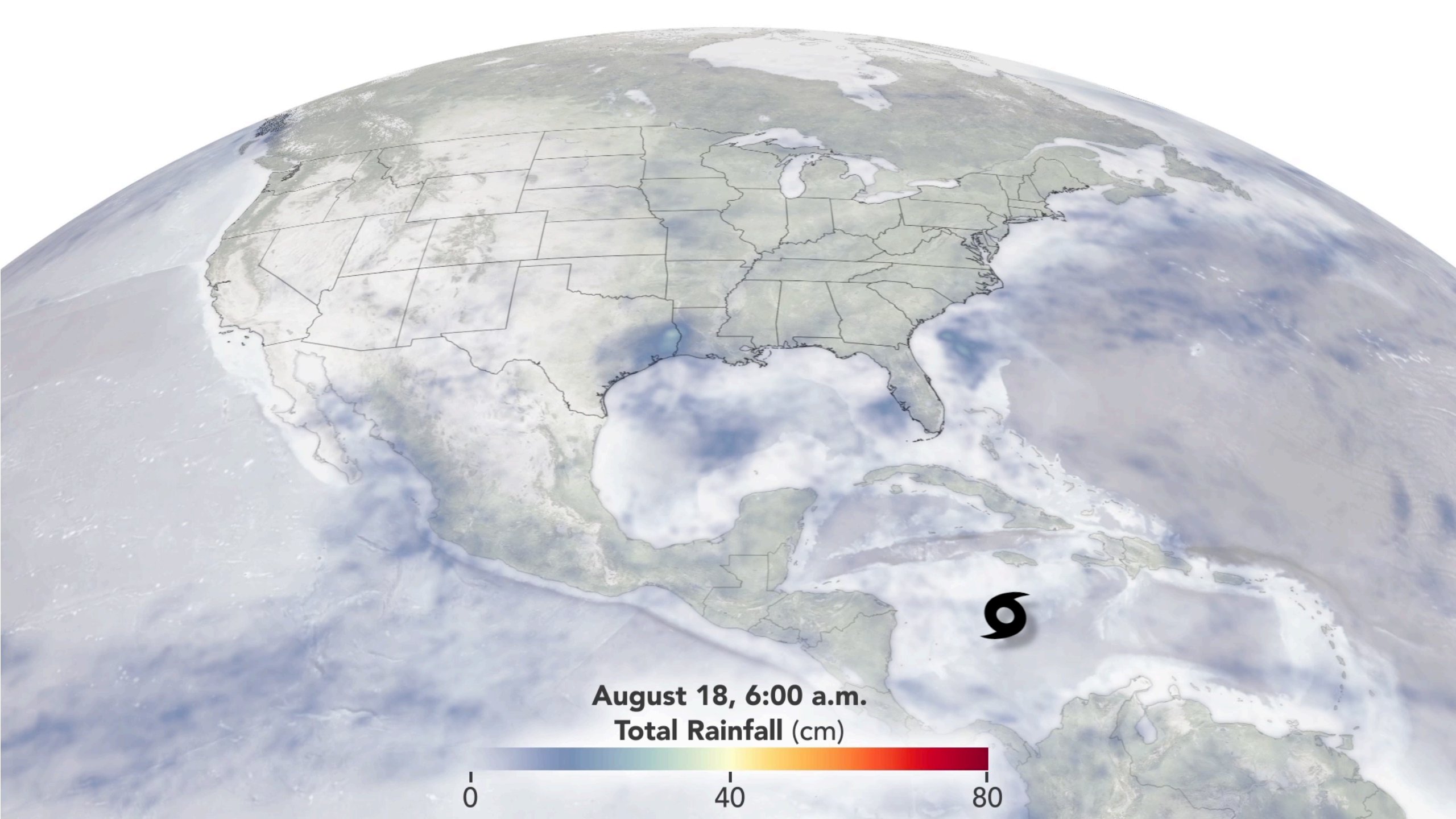
TCs approximately translate with large-scale mid-tropospheric flow. (Enough spatial averaging cancels symmetric TC winds, leaving just translating large-scale flow.)

Robust feature of climate models: slowdown of tropical circulation in warming climate. Details of the physical mechanisms still debated. Difficult signal to observe directly.

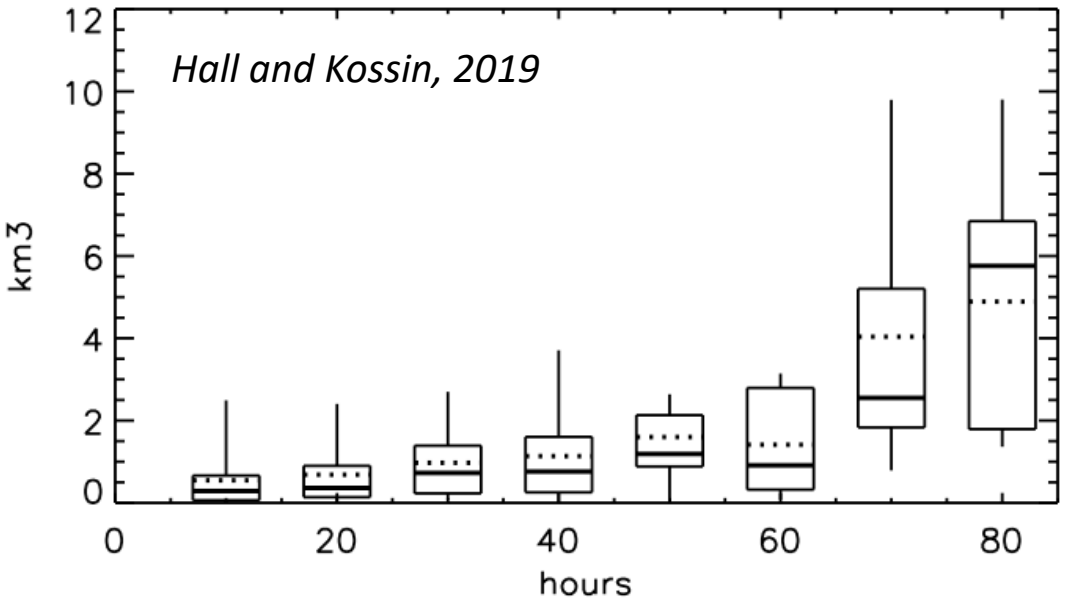


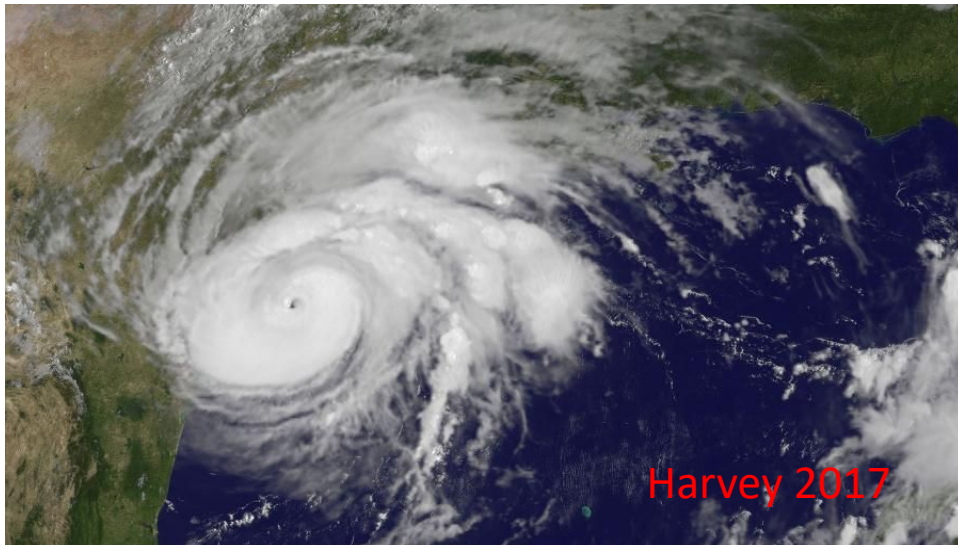
CMIP5 climate model trends in Hadley circulation strength over past 40 years (blue) and meteorological reanalysis (green). Independent precipitation observations indicate bias in reanalyses, not CMIP5 models (Chemke and Polvani, 2019).

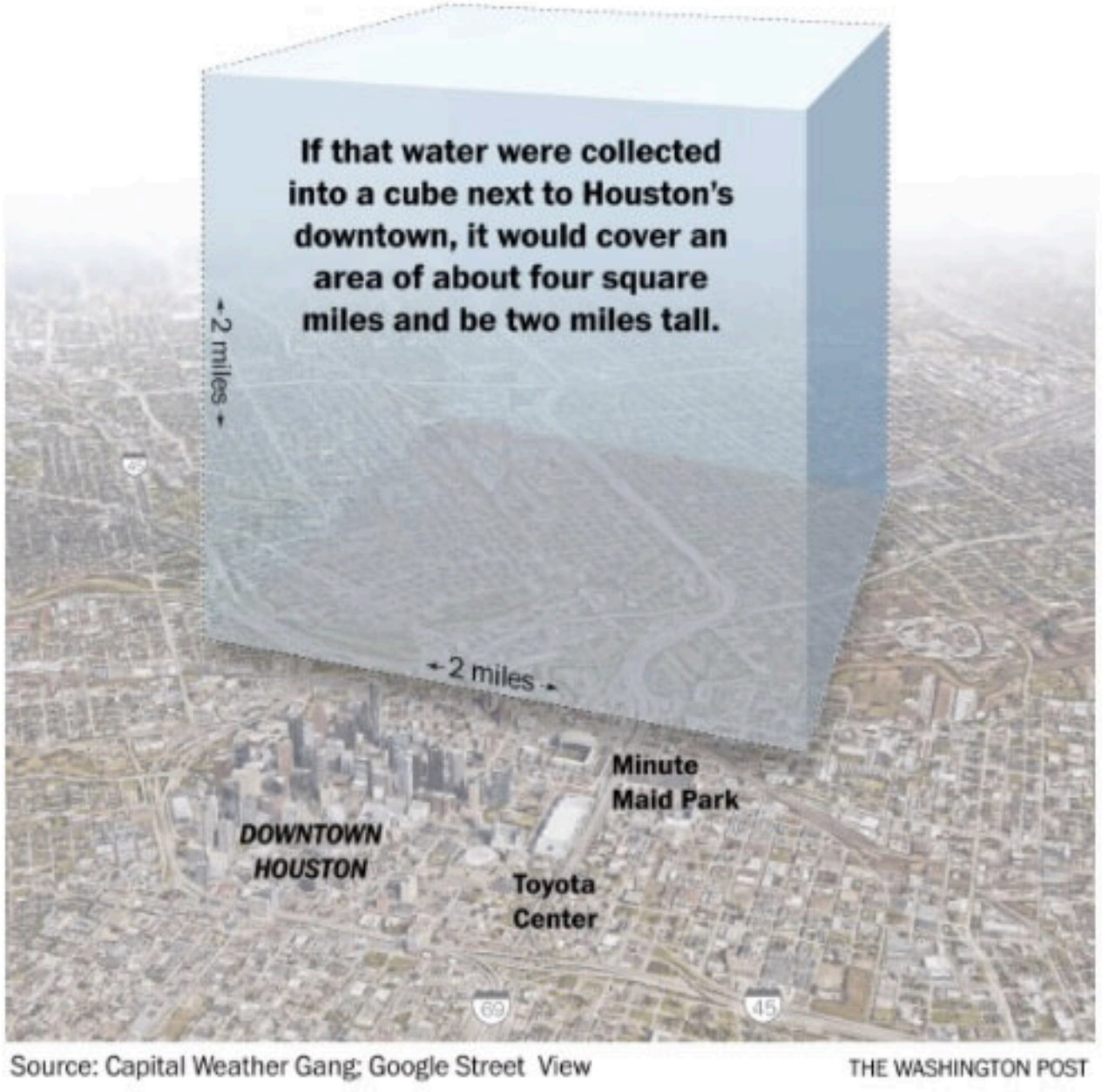

Thursday, Aug. 29
FLORIDA
Grand Bahama
Great Abaco
BAHAMAS
CUBA
HAITI
DOMINICAN REPUBLIC
PUERTO RICO


August 18, 6:00 a.m.
Total Rainfall (cm)
0
40
80

Longer stalls → more accumulated rain







Touched on just a few aspects of hurricane-hazard changes in a warming climate:

- Increased intensity
- Changes in hurricane tracks, more stalling and US regional variations in landfall.

Two aspects I didn't talk about are actually the most robust:

- Increased storm surge from sea-level rise.
- Increased population & infrastructure in harm's way.

Population & Infrastructure:

- Better forecasts & evacuation procedures (hopefully) and more resilient structures.
- But during a pandemic (or other simultaneous catastrophe)
  Where do people go? Are resources depleted?