Exploring the Relationship between Ocean Heat Content and Tropical Cyclone Precipitation within the Gulf of Mexico

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Poster #2421

Introduction

- High-category cyclones pose a threat because of intense wind speeds and precipitation
- Trenberth et al. (2018) **shows the large rainfall amount associated with Harvey is linked to the high ocean heat content** within the Gulf of Mexico (GoM)
- As global warming continues, there will be potential changes in these extreme weather systems from the accumulation of ocean heating (Figure 1)

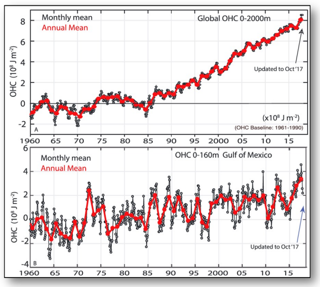


Fig 1. Ocean heat content anomalies globally and in the Gulf of Mexico from 1960-2018 (Trenberth et al. 2018)

- Trenberth et al. (2018) sought to examine this relationship, but only analyzed one hurricane in 2017: Hurricane Harvey (Figure 2)
- This research will focus on 12 tropical cyclones within the GoM and **evaluate the relationship between ocean heat content (OHC) and TC flood rains and intensity**

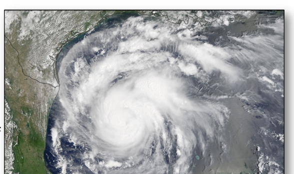


Fig 2. Depiction of Hurricane Harvey. Courtesy of NASA.

Data & Model

- Examine high resolution regional climate model simulation datasets as described in Fu et al. (2021)
- **Model and observation data on hurricane rainfall, OHC, and surface latent heat flux (LHF)/evaporation** which produces results on relationships among these three variables
- The Regional Community Earth System Model (R-CESM; Fu et al. 2021) was used to run simulations of the 12 cases (see Table 1) within GoM and compute OHC change (Figure 3)

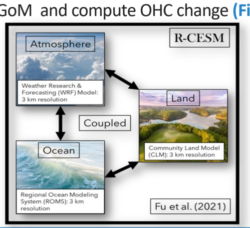


Fig 3. Three models that make up the R-CESM Model (Fu et al. 2021).

Computing OHC

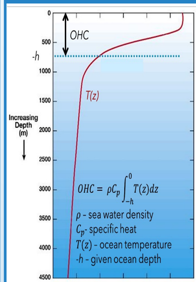


Fig. 4. Vertical profile of temperature as a function of depth in meters (From MarineBio).

- **OHC is computed by integrating temperature from the surface (0 meters) to the ocean floor (Figure 4)**
- Integrate OHC, rainfall and LHF over the entire Gulf of Mexico to drive the total OHC change, hurricane rain, and latent heat loss for each storm (Figure 5)

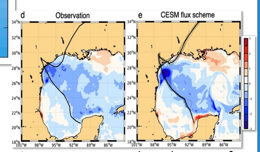


Fig. 5. Hurricane Harvey track and sea-surface temperature change (From Fu et al. 2021)

TC Simulations

- Two questions this research attempts to address are:
  - ***Is tropical cyclone rainfall directly related to ocean heat content changes? (As hypothesized in Trenberth et al. 2018)***
  - ***Is there a direct relationship between ocean heat content change and LHF/evaporation?***
- Compute the heat content before and after the storm and take the difference between the two to derive a hurricane-induced heat content change
- Use Accumulated Cyclone Energy (ACE) against OHC to arrange the 12 hurricanes (Figure 6)

Tropical Cyclones	Category
Opal (1995)	4
Earl (1998)	2
Bret (1999)	4
Lili (2002)	4
Claudette (2003)	1
Katrina (2005)	5
Rita (2005)	5
Dolly (2008)	1
Isaac (2012)	1
Hermine (2016)	1
Harvey (2017)	4
Michael (2018)	5

Table 1. List of sampled 12 TCs within the Gulf of Mexico (GoM) (Fu et al. 2021).

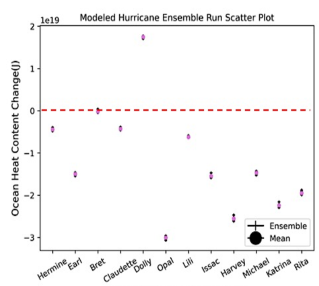
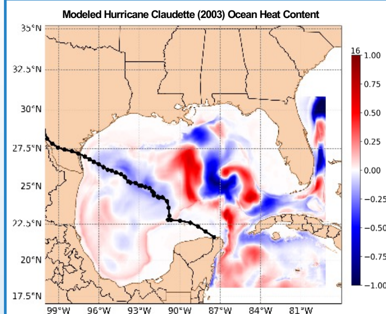


Fig. 6. Modeled hurricane ensemble run of OHC change based off increasing ACE.

Modeled TC Rainfall & OHC



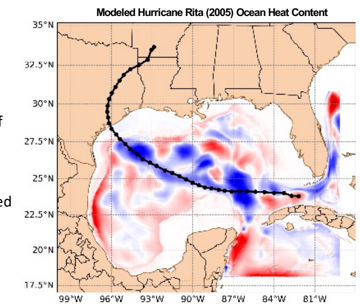
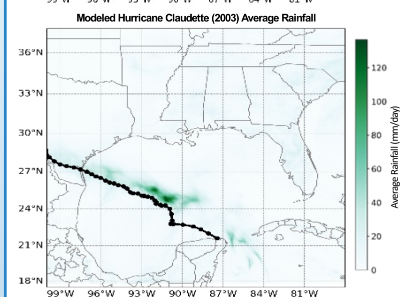


Fig. 7. Modeled OHC of Category 1 & 5 hurricanes. Light blue areas display negative OHC change, and light red areas displays positive OHC change.



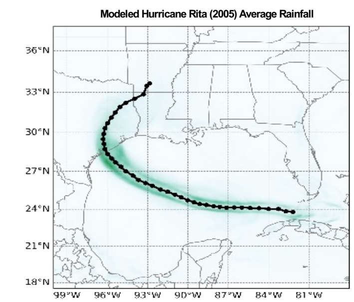


Fig. 8. Modeled accumulated rainfall for category 1 & 5 hurricanes.

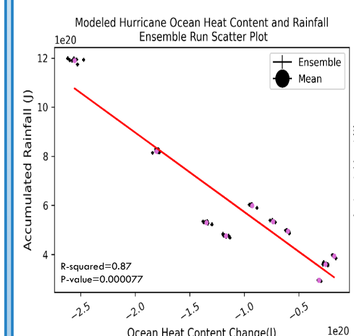


Fig. 9. Modeled accumulated rainfall against OHC change.

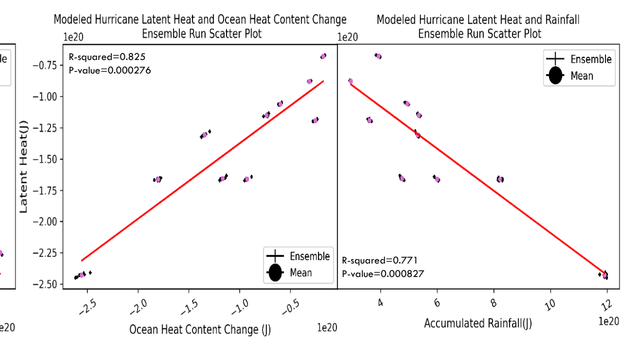


Fig. 10. Modeled hurricane latent heat and OHC change. Figure A displays latent heat against OHC change in J. Figure B displays latent heat against accumulated rain.

Discussion

- **Clear cooling (negative values) of OHC of each hurricane track (Figure 7)**
- Clear warming (positive values) of OHC away from hurricane tracks
- Heavy rainfall is developed along hurricane tracks
- **No trend for higher categorized hurricanes producing more rainfall (Figure 8)**
- **Noticeable and significant correlation between the two variables (Figure 9)**
- Energy required by the hurricane rainfall is significantly larger than provided by OHC changes (Figure 10)
- Energy induced by the OHC change is almost entirely released to the atmosphere
- **Latent heat associated with OHC is not the only energy source for rainfall (Figure 10)**
- Moisture heat flux convergence could be another source for rainfall

Scan ME for acknowledgements, references and more!