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OCEAN MIXING DURING HURRICANE IDA (2021): THE IMPACT OF A FRESHWATER BARRIER LAYER

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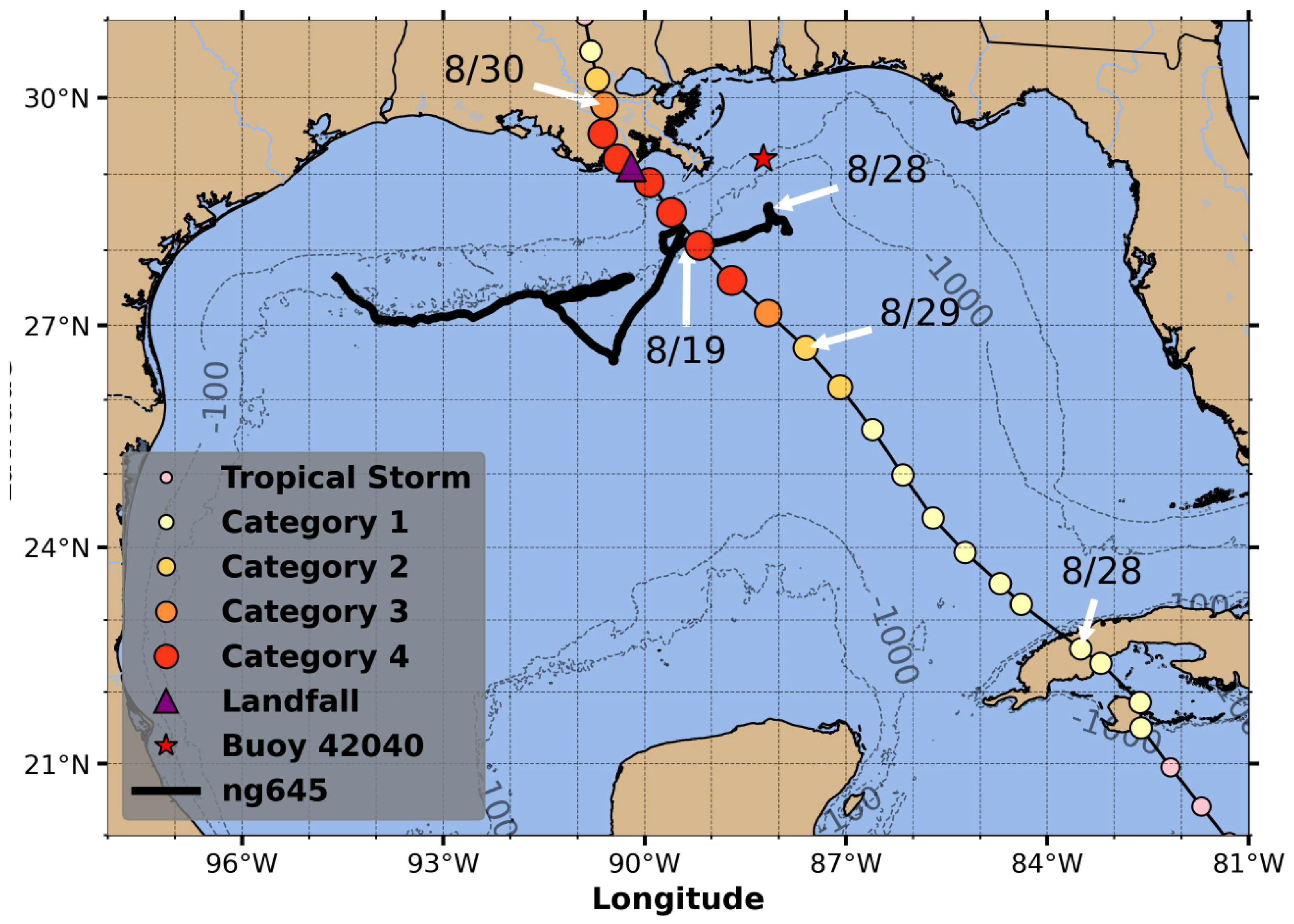
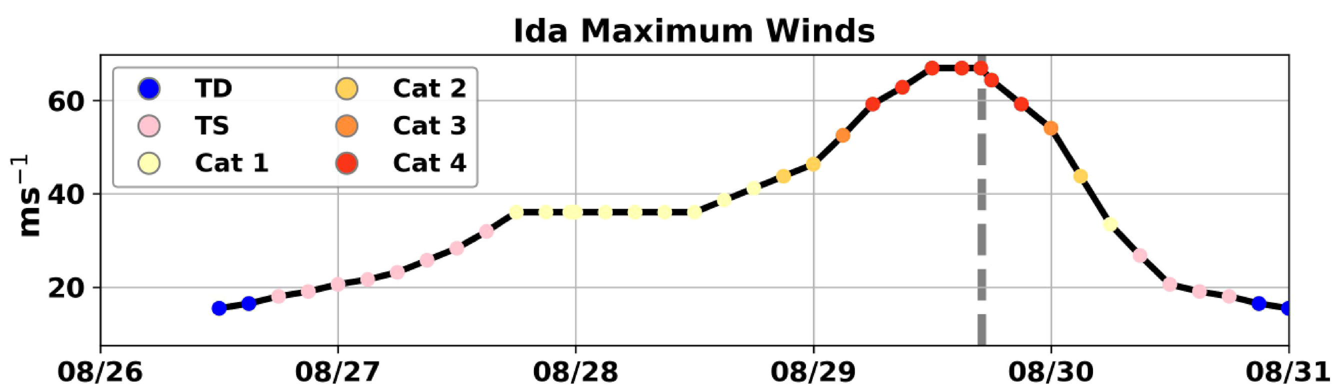
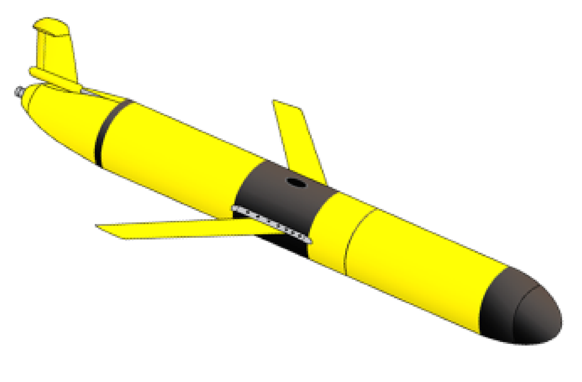
ABSTRACT

Tropical cyclones are one of the costliest and deadliest natural disasters globally, and impacts are currently expected to worsen with a changing climate. Hurricane Ida (2021) made landfall as a category 4 storm on the US gulf coast after intensifying over a Loop Current eddy and a freshwater barrier layer that extended from the coast to the open ocean waters off the continental shelf. An autonomous underwater glider sampled this ocean feature ahead of Ida. We use this data with 1-D shear driven mixed layer models to investigate the sensitivity of the upper ocean mixing to a barrier layer during Ida's intensification period. In our simulations that the freshwater barrier layer inhibited cooling by as much as 56% and resulted in increased enthalpy flux to the atmosphere by >20% as the storm made landfall. This highlights the utility of sustained observations to support coupled ocean and atmosphere hurricane forecasts.

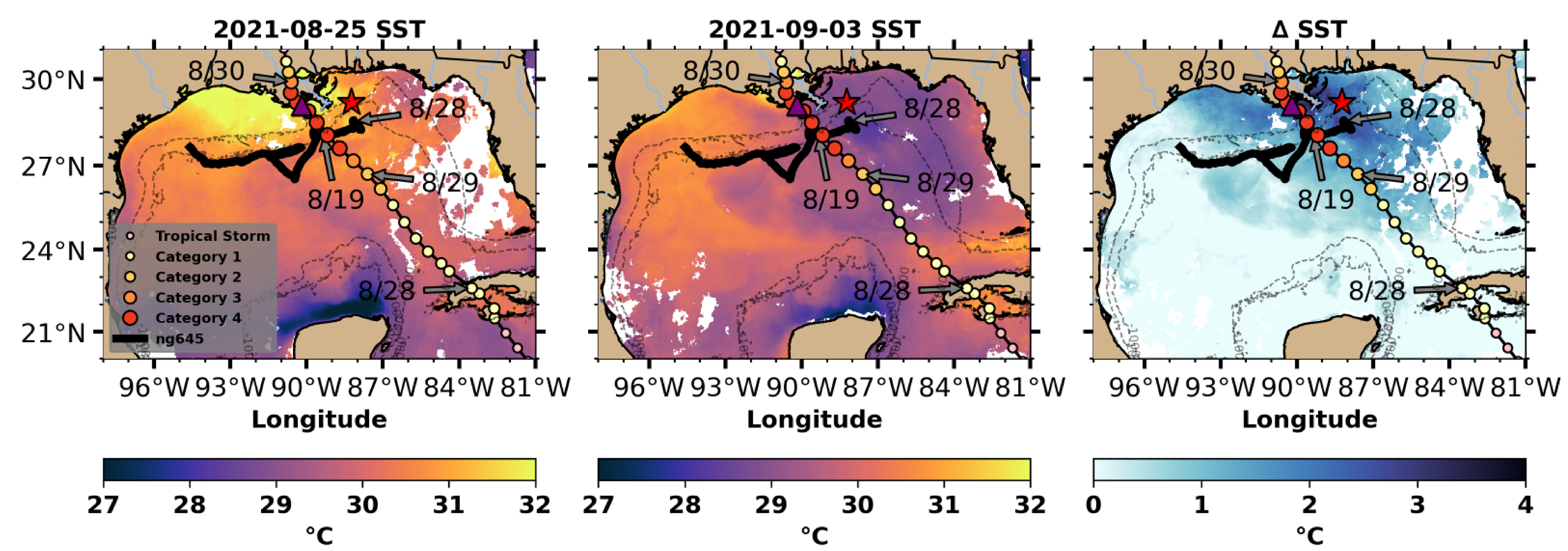






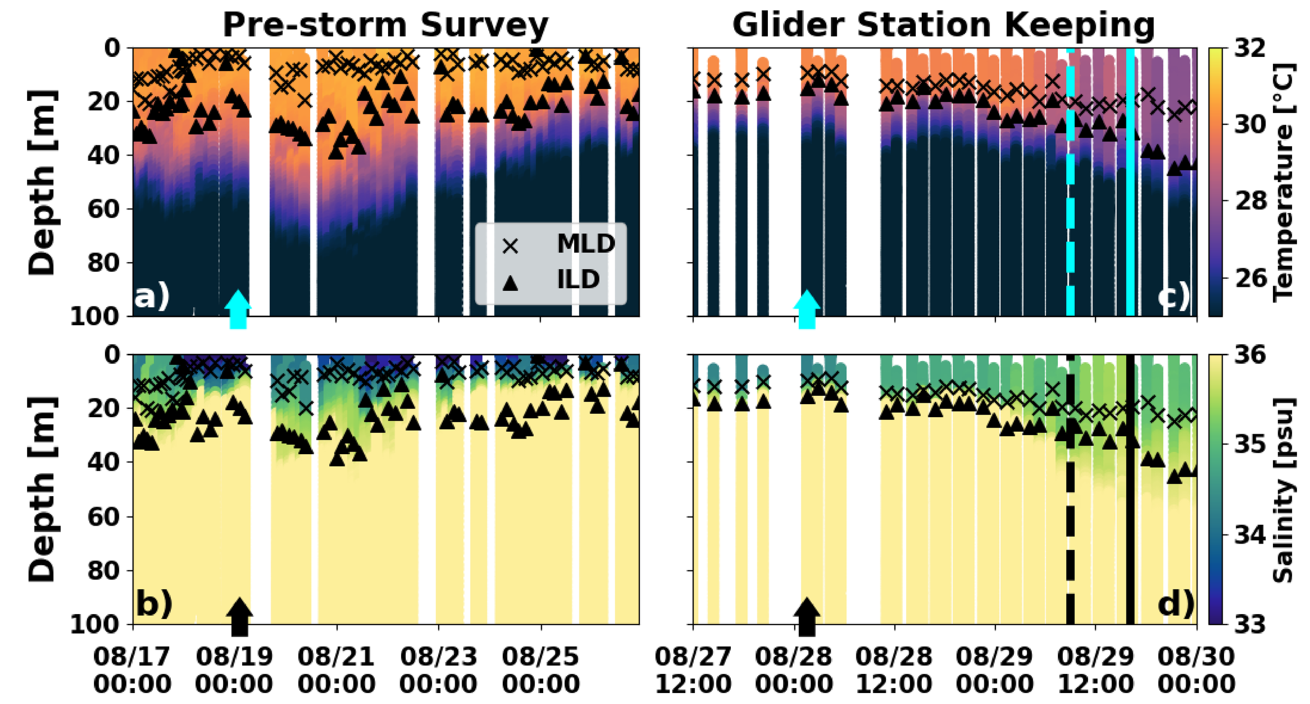
Hurricane Ida's NHC best track with colored circles denoting the storm's category .The black line indicates the NG645 glider track, with additional arrows indicating the glider position on 8/19 and 8/28 for reference to profiles used to initialize our PWP experiments. NDBC Buoy 42040 is represented by the red star. A time-series (bottom) of Ida's NHC best track maximum wind speed and intensity (colored circles) as well as the storms landfall time (dashed grey line).

Ocean Observations

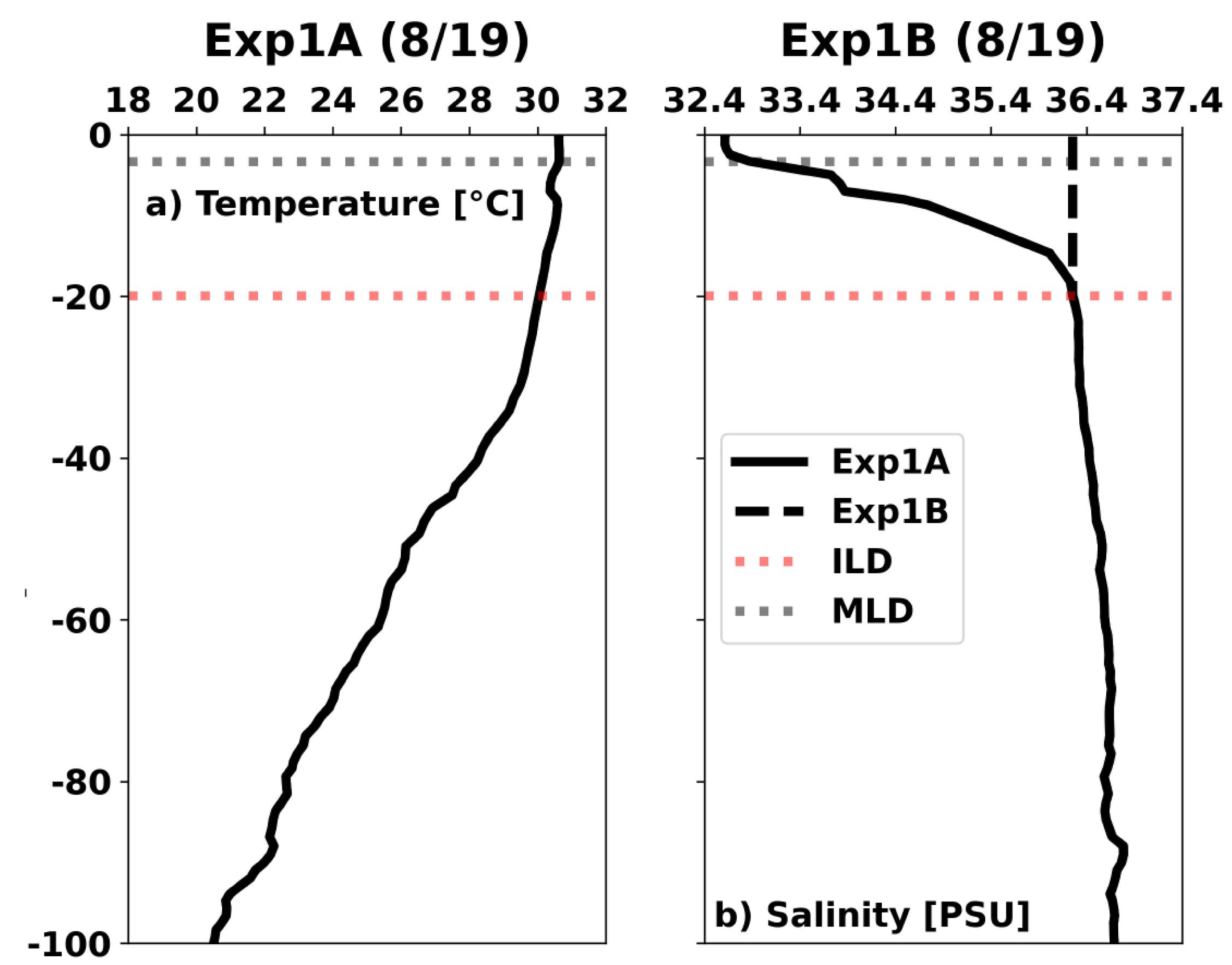


Maps of Sea Surface Temperature (SST) from GOES16 SST daily composite SST on 8/25 (left) and 9/3 (middle). The right panel is the difference (8/25 – 9/3) in SST with positive values indicating ocean cooling.

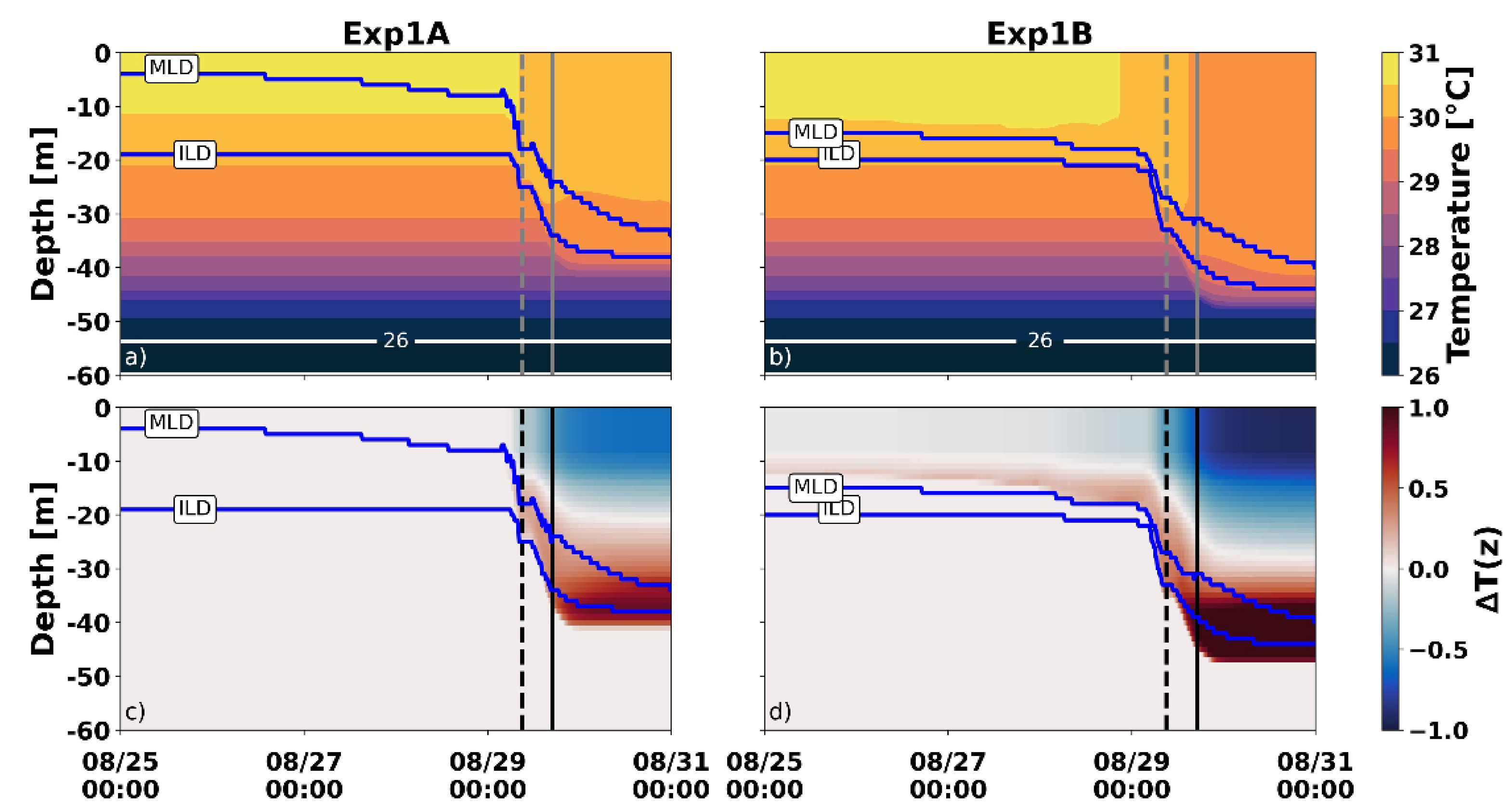
Ocean Observations



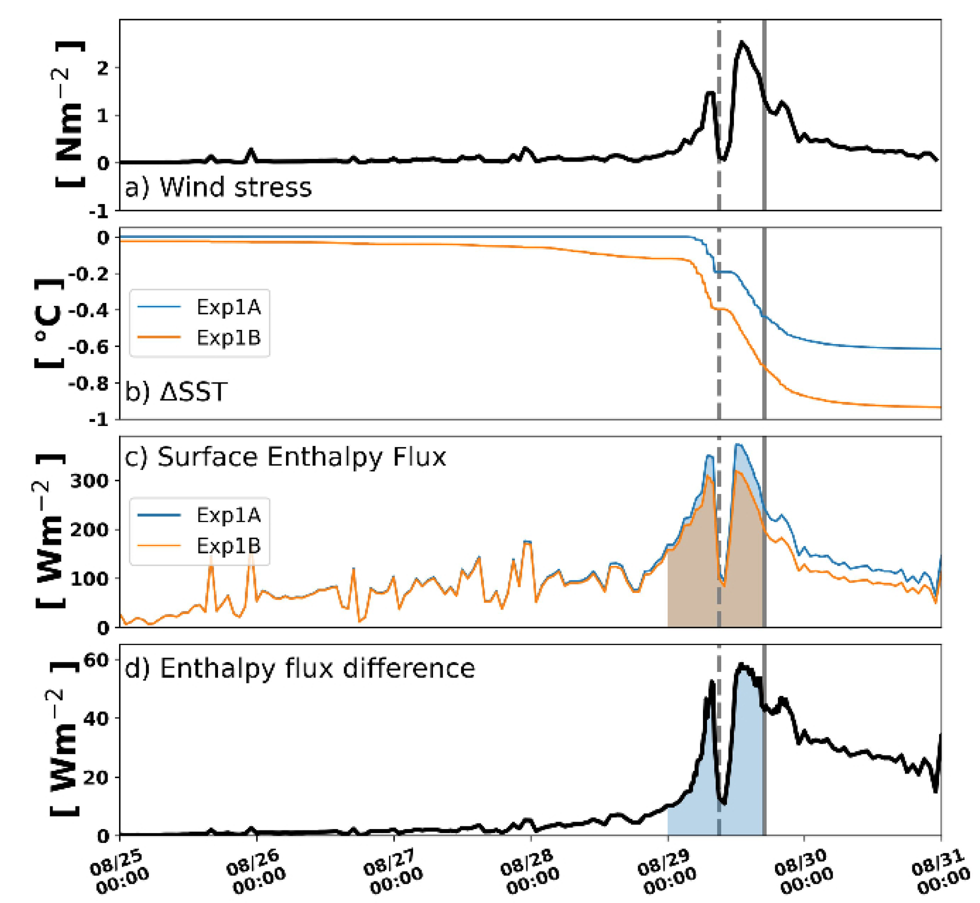
Glider NG645 cross-sections of temperature (a,c) and salinity (b,d) during the pre-storm survey (a,b) 8/17 to 8/27 and glider station keeping (c,d) 8/27 to 8/30 0900. MLD and ILD estimates are represented by x's and triangles, respectively in al panels.



1D Ocean Mixing Model Experiments



PWP model runs initialized using the 8/19 NG645 profile and simulated from 8/19 00:00 to 8/31 00:00. Exp1A (a,c) is inclusive of the barrier layer and depicts (a) temperature with the 26 C isotherm (white) and (c) contoured change in temperature since initialization. The MLD and ILD are labeled and contoured in blue. Panels (b,d) are similar but for Exp1B with the barrier layer removed. The vertical lines represent the times at which Hurricane Ida passed the glider (dashed line) and made landfall (solid line). We limit the beginning display period from 8/25 00:00 as limited ocean cooling occurred before that time.



Time-series plots from experiment 1 a) wind stress, b) ΔSST from both Exp1A (blue) and Exp1B (orange), c) surface enthalpy flux from both Exp1A (blue) and Exp1B (orange), and d) difference (Exp1A – Exp1B). The shading in c and d represents the period used to calculate the cumulative enthalpy flux. The vertical lines represent the times at which Hurricane Ida passed the glider (dashed line) and made landfall (solid line).

Key Findings

- Twin model experiments show the salinity barrier layer inhibited SST cooling by 53% ahead-of-eye passage and 38% by landfall.
- Removal of the barrier led to earlier, more rapid, and greater cooling, which resulted in reduced enthalpy flux to the atmosphere.
- This study highlights the need and capability of expanded ocean observing assets along the shelf-break of the GoM to identify freshwater barrier layers and improve intensity forecasts of landfalling hurricanes

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