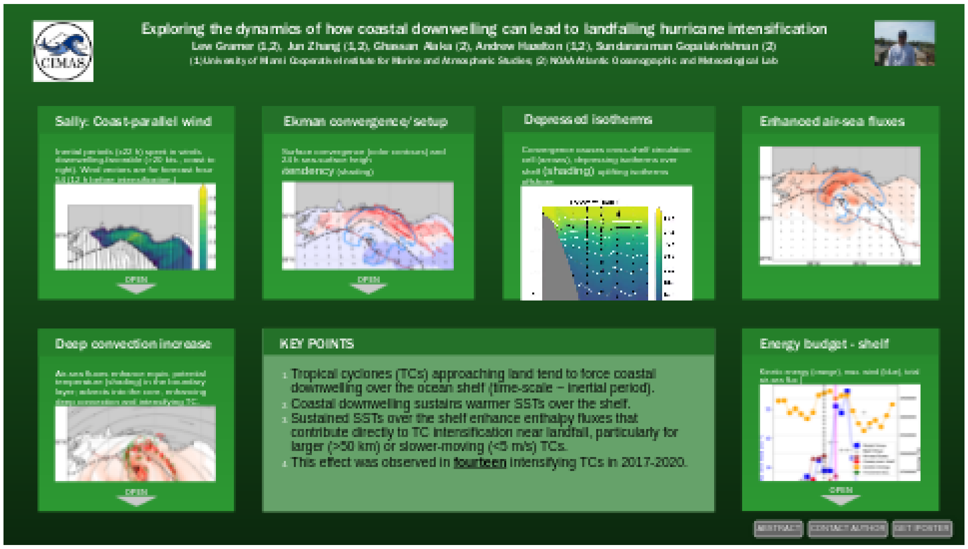
Exploring the dynamics of how coastal downwelling can lead to landfalling hurricane intensification



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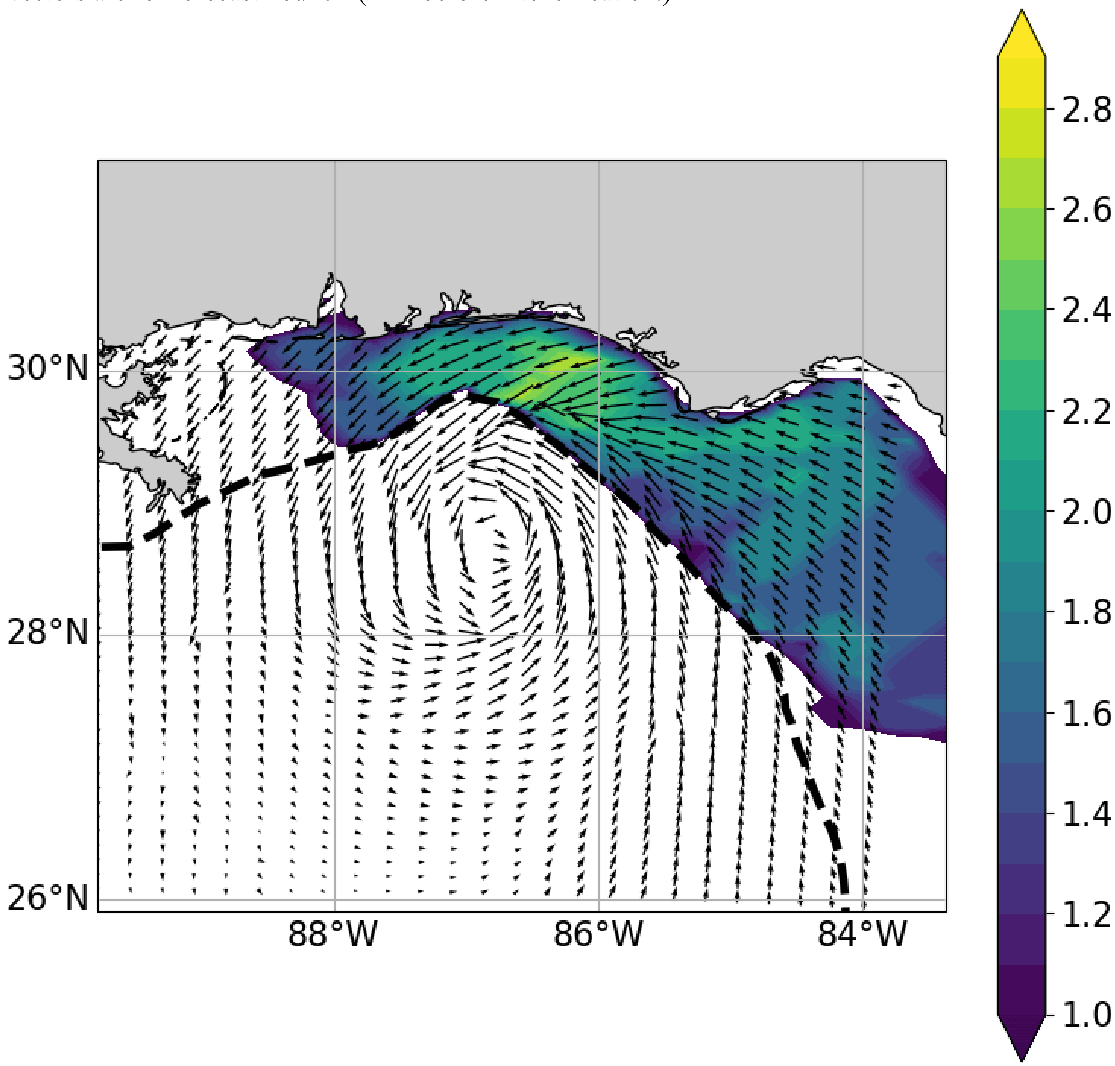
PRESENTED AT:

SALLY: COAST-PARALLEL WIND

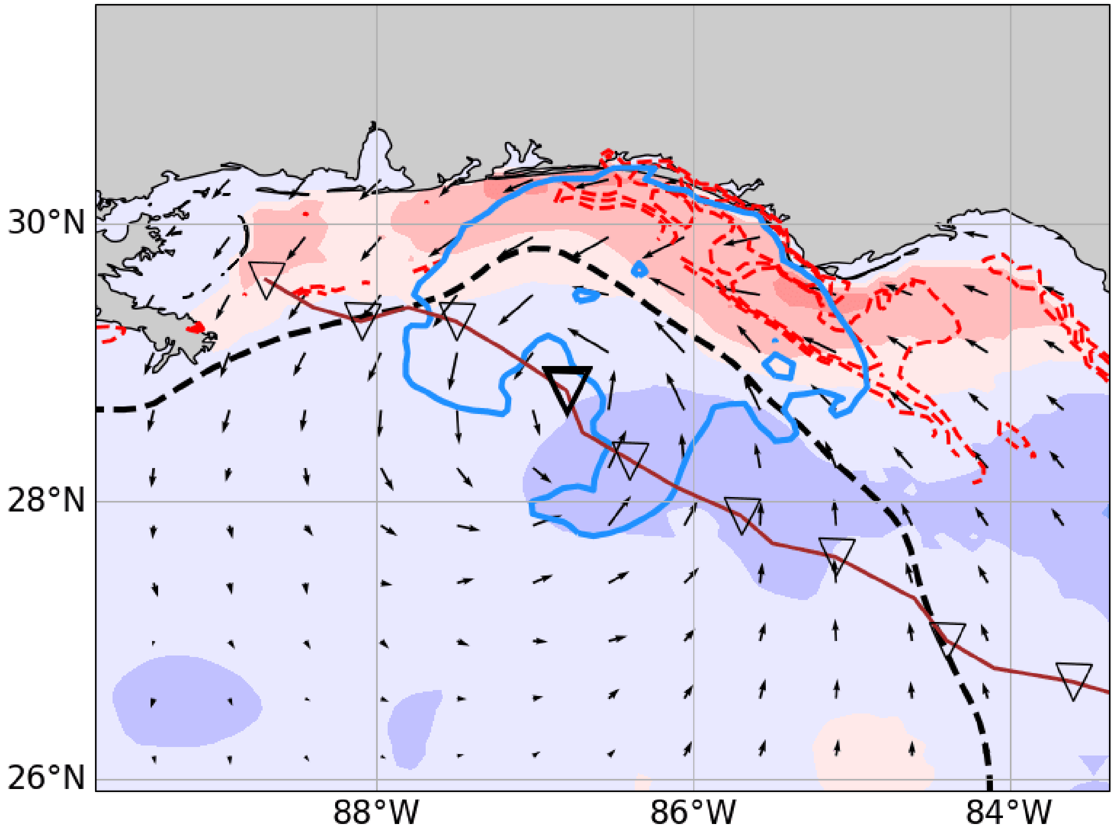
Inertial periods (x22 h) spent in winds downwelling-favorable (>20 kts., coast to right). Wind vectors are for forecast hour 54 (12 h before intensification.)



Wind vectors and downwelling-favorable wind magnitude (orange shade) during the entire forecast.
[VIDEO] https://res.cloudinary.com/amuze-interactive/image/upload/f_auto,q_auto/v1639102498/agu-fm2021/0e-39-ef-e4-56-a3-bb-49-ce-e1-59-5f-5b-62-d3-90/image/sally_2020091206_l10-anim_kfjp8e.mp4

EKMAN CONVERGENCE/SETUP

Surface convergence (color contours) and 24 h sea-surface heigh ttendency (shading)



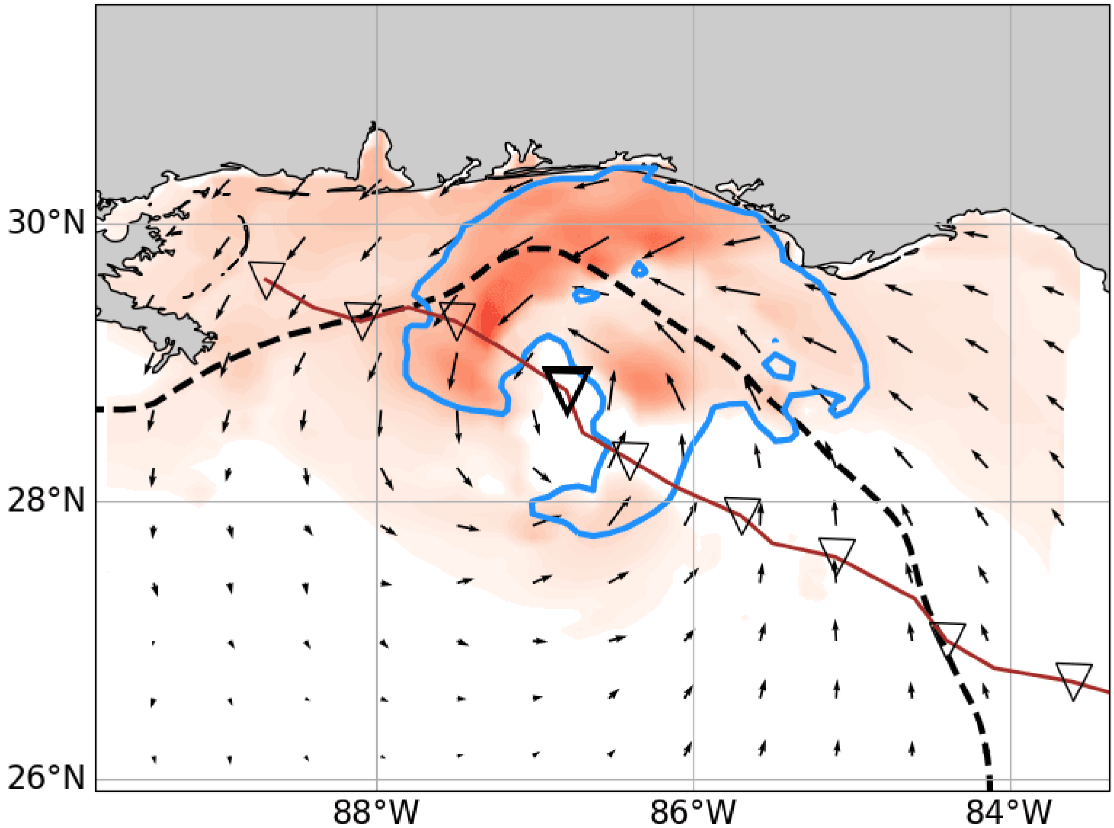
DEPRESSED ISOTHERMS

Convergence causes cross-shelf circulation cell (arrows), depressing isotherms over shelf (shading) uplifting isotherms offshore

[VIDEO] https://res.cloudinary.com/amuze-interactive/image/upload/f_auto,q_auto/v1638934519/agu-fm2021/0e-39-ef-e4-56-a3-bb-49-ce-e1-59-5f-5b-62-d3-90/image/pom-downwelling-nineteen-19l-section-t-vw-2020091206-anim_adlshe.mp4

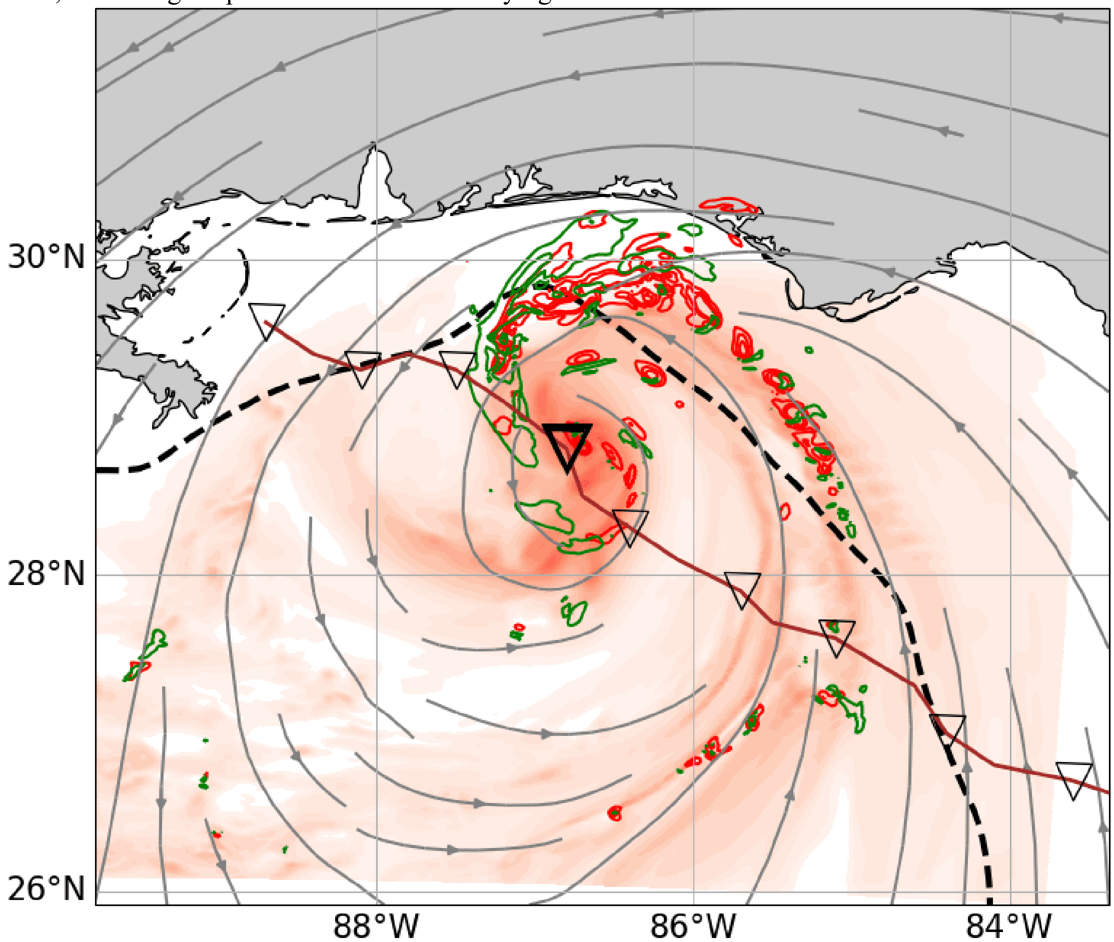
ENHANCED AIR-SEA FLUXES

Air-sea contrasts related to warm SSTs on the shelf enhanced enthalpy fluxes



DEEP CONVECTION INCREASE

Air-sea fluxes enhance equiv. potential temperature (shading) in the boundary layer; advects into the core, enhancing deep convection and intensifying TC.

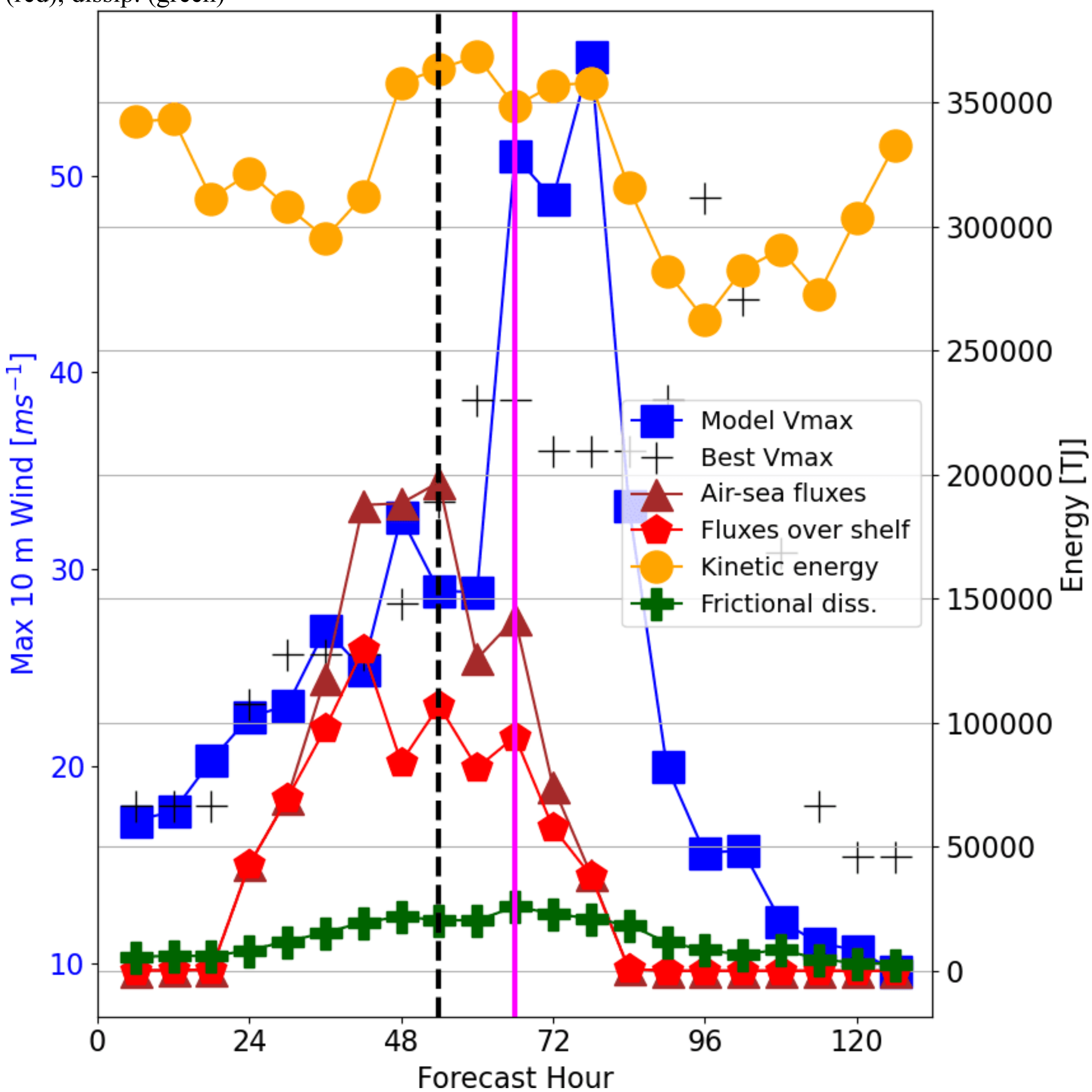


KEY POINTS

1. Tropical cyclones (TCs) approaching land tend to force coastal downwelling over the ocean shelf (time-scale ~ inertial period).
2. Coastal downwelling sustains warmer SSTs over the shelf.
3. Sustained SSTs over the shelf enhance enthalpy fluxes that contribute directly to TC intensification near landfall, particularly for larger (>50 km) or slower-moving (<5 m/s) TCs.
4. This effect was observed in **fourteen** intensifying TCs in 2017-2021.

ENERGY BUDGET - SHELF

Kinetic energy (orange), max. wind speed (blue), total air-sea flux (brown), SHELF air-sea flux (red), dissip. (green)



Shelf air-sea flux dominated the energy balance of TC Sally (2020 AL19) for 18 h before intensification (magenta line)

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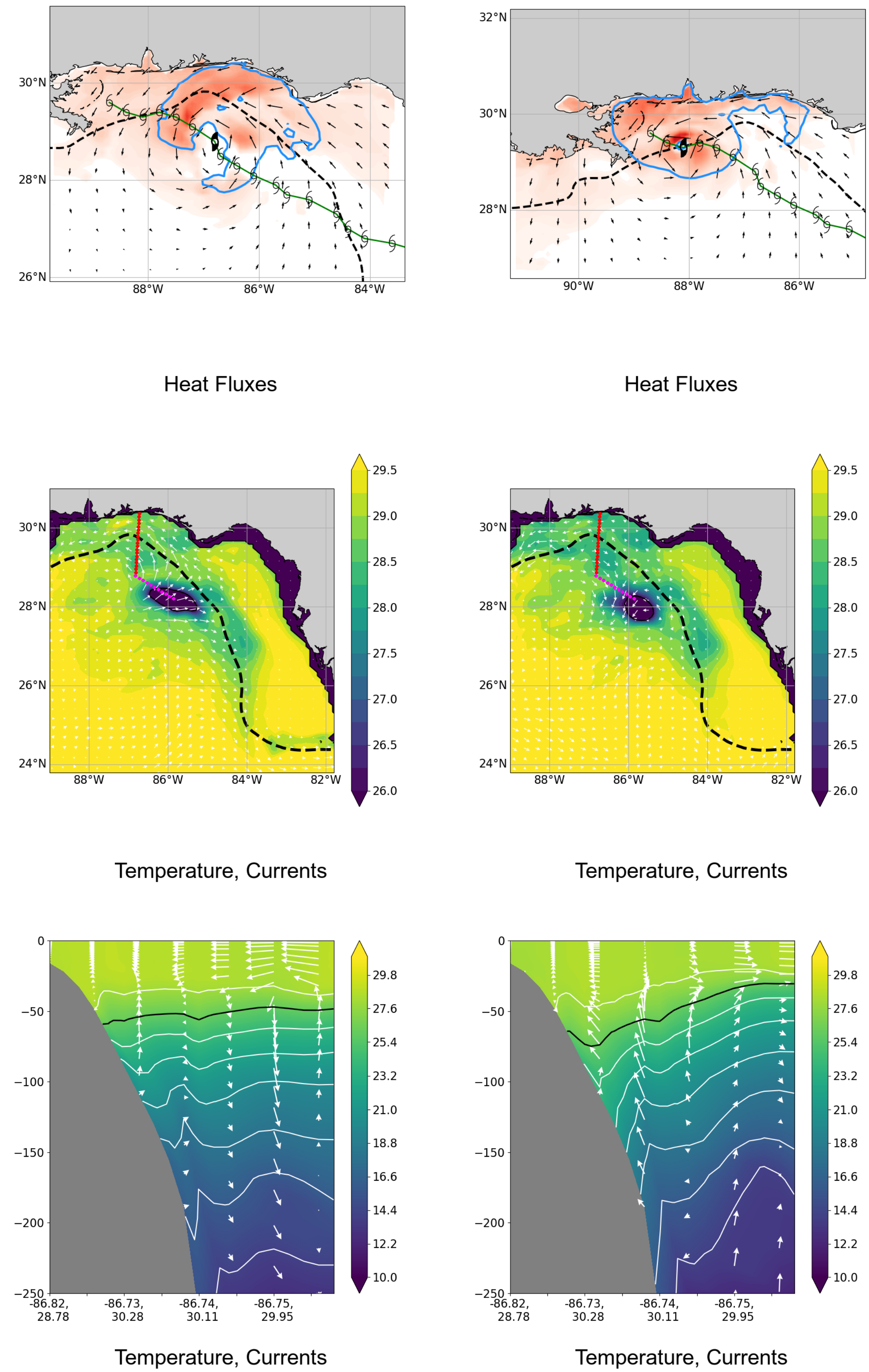
ABSTRACT

Our prior analysis of a coupled tropical cyclone (TC) air-sea model (HWRF-B) revealed three cases in the 2020 Atlantic hurricane season where coastal downwelling - developing ahead of a TC - contributed to the intensification of each TC as it approached landfall. Coastal downwelling is a specific oceanographic mechanism: we briefly consider other mechanisms potentially contributing to this "shelf effect", including coastal trapped waves and near-surface advection. We then present preliminary results from a further analysis of HWRF-B forecasts from the 2017-2020 Atlantic and east Pacific hurricane seasons, evaluating the prevalence of the shelf effect for TCs interacting with continental and insular coasts in these two ocean basins. We explore mechanisms linking shelf SST sustenance with inner core convective development and storm intensification, using both a detailed energy budget and Lagrangian tracking experiments within the boundary layers of case study storms. Finally, we briefly discuss the implications these findings hold for evaluating new coupled TC forecast

modeling systems currently being developed as a part of the Hurricane Forecast Improvement Program (HFIP).



(https://agu.confex.com/data/abstract/agu/fm21/3/1/Paper_966413_abstract_901798_0.png)

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