Enabling Hierarchical Testing in the Hurricane Analysis and Forecast System (HAFS)

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Motivation

- How can we use offline datasets to selectively disable feedbacks in coupled modeling systems like HAFS?
- How might disabling these feedbacks lead to scientific insights that would be difficult to obtain in the fully-coupled system?

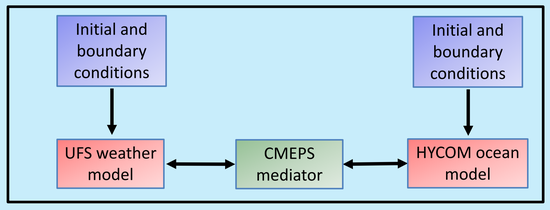
The Hurricane Analysis and Forecast System (HAFS)

- HAFS is a Unified Forecast System (UFS) application, with a planned transition into NOAA operations in 2023.
- Supports both regional and global-nested configurations (dx=3 km).

Figure courtesy Bin Liu

- The atmospheric model is the UFS weather model, coupled to the HYCOM ocean model using the Community Mediator for Earth Prediction Systems (CMEPS).

HAFS: UFSATM+HYCOM

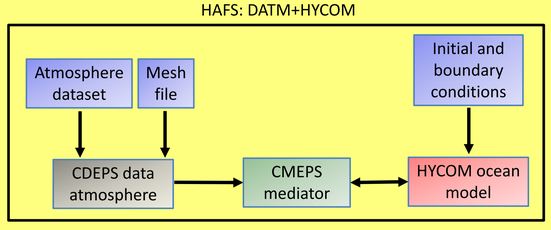


Community Data models for Earth Prediction Systems (CDEPS): Bringing Hierarchical Testing to HAFS

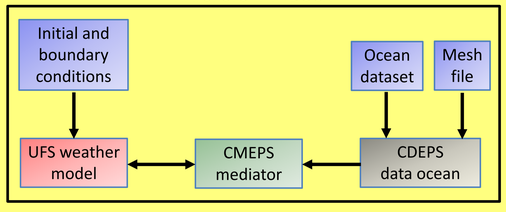
- CDEPS was developed by NCAR to allow researchers to selectively disable feedbacks in coupled modeling systems. CDEPS has been integrated into the HAFS workflow.

The diagram at right shows a HAFS forecast where the CDEPS data atmosphere is forcing the HYCOM ocean model. The example that follows uses a data atmosphere created from the ERA5 reanalysis (hourly, 0.25 degrees).

HAFS: DATM+HYCOM



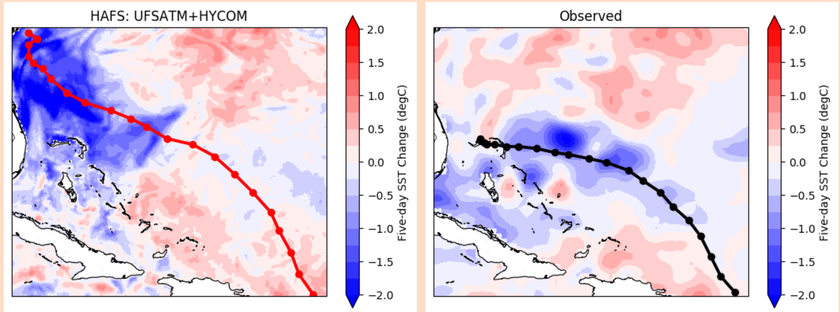
HAFS: UFSATM+DOCN



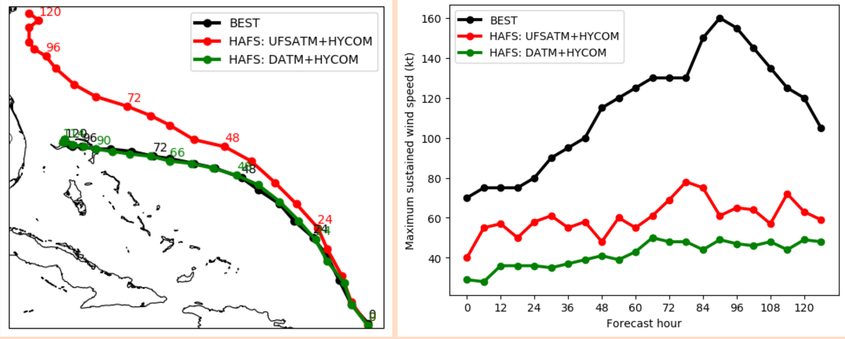
The diagram at left shows a HAFS forecast where the CDEPS data ocean is forcing the UFS weather model. The example that follows uses a data ocean created from the Optimally-Interpolated Sea-Surface Temperature (OISST) dataset (daily, 0.25 degrees).

Hurricane Dorian (2019): A use case for HAFS DATM+HYCOM

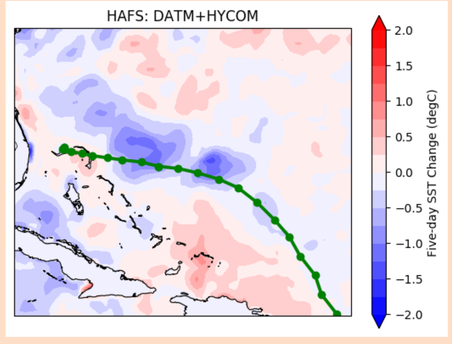
A researcher wants to use HAFS to study the upper-ocean response to Hurricane Dorian. But, the track forecast from this cycle is poor, leading to unrealistic forcing from the atmosphere.



Above: Since the track forecast is too far to the north and too fast, most SST cooling in HAFS (left) occurs to the northwest of the observed SST cooling (right).



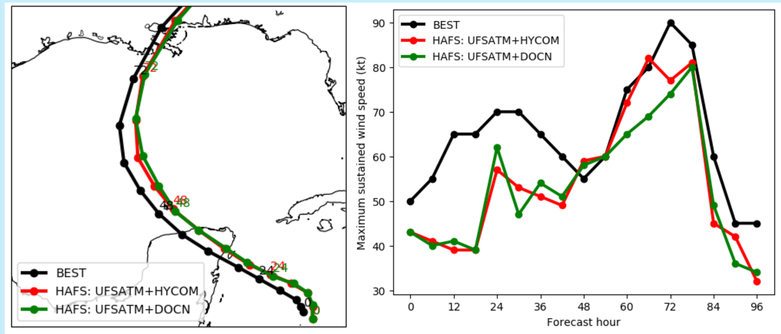
The researcher could try to find another cycle with a better forecast. But they could also use the CDEPS DATM to force the ocean with the ERA5 reanalysis, which will provide an accurate storm track (green line in left figure).



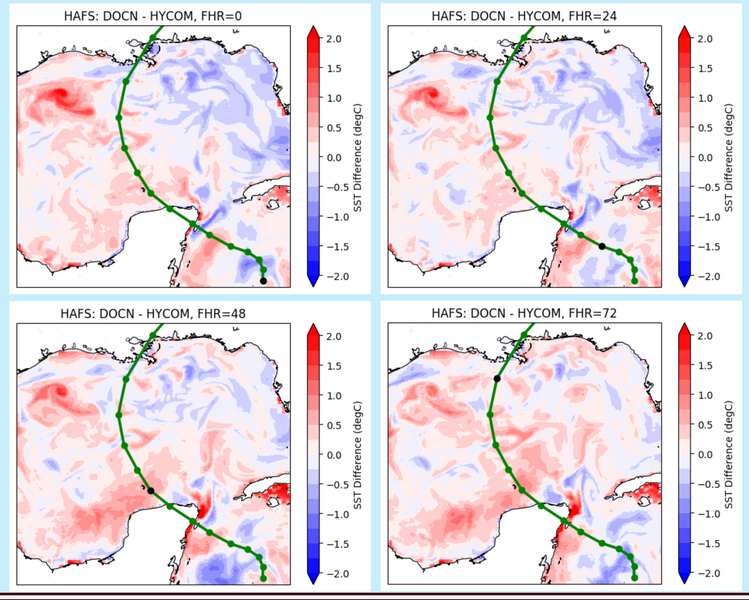
Even though the intensity in ERA5 is weaker than observed, HAFS: DATM+HYCOM still induces a much more realistic upper-ocean response to Hurricane Dorian due to the elimination of the track bias. The weaker-than-observed intensity in ERA5 is likely due to the coarse resolution (0.25 degrees) and the absence of some inner-core data from the analysis.

Hurricane Zeta (2020): A use case for HAFS UFSATM+DOCN

A researcher wonders whether the weak bias in the intensity forecast for Zeta should be attributed to errors in the atmosphere or the ocean state.



Despite the 0.5 °C warmer SST in HAFS: UFSATM+DOCN, Zeta does not intensify further, suggesting the atmosphere may be more important.



Summary

- CDEPS has been added to the UFS weather model and the HAFS workflow through collaborative work between NCAR, CIRES, and NOAA.
- CDEPS enables HAFS developers to perform hierarchical testing by allowing them to selectively disable feedbacks within the coupled ocean-atmosphere system.
- CDEPS can be used to eliminate the effect of poor track forecasts in HAFS and to narrow down the source of poor forecasts. Other uses are possible as well.

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