The Hurricane Analysis and Forecast System: Development of the Next-Generation Model

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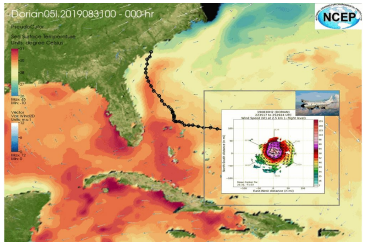
HFIP | HURRICANE FORECAST IMPROVEMENT PROGRAM

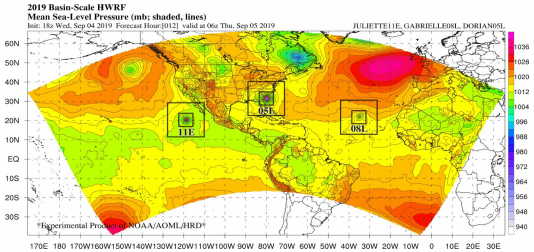
WEATHER PROGRAM OFFICE
National Oceanic and Atmospheric Administration

Creating Next-Generation Hurricane Models for NOAA

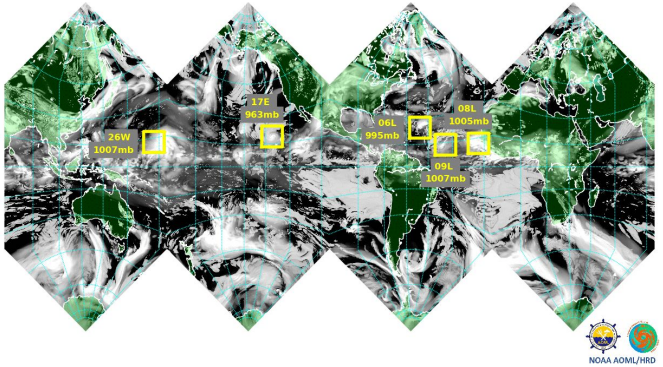
HWRF: Tracking One Storm at a Time



BASIN-HWRF: For Improved Land-storm Storm-storm



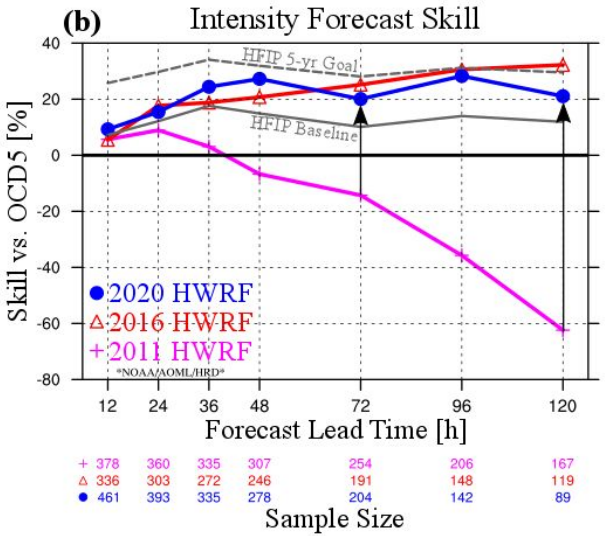
Moving Nests in Global FV3 to Track all Hurricanes



FV3- HAFS

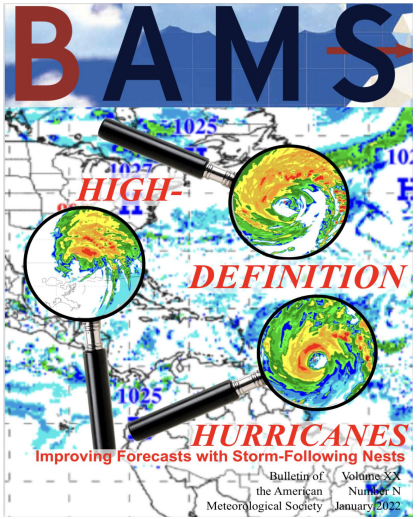
2012 — Sandy Supplemental & HFIP — 2019 — Disaster Supplemental & HFIP — 2023

Operations HWRF: Flag-Ship Model for TC predictions

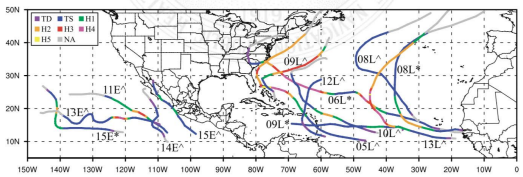


NOAA Capacity for Advancing Hurricane Prediction

Basin-Scale HWRF: A Bridge to Next-Generation

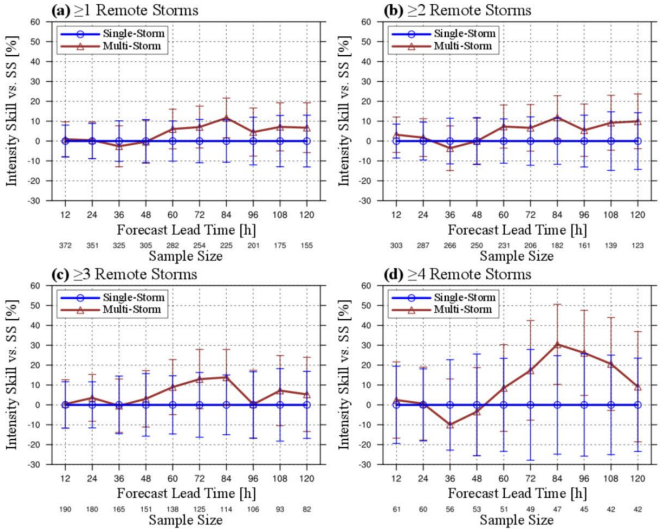


Tropical Cyclones 1000's of miles apart could influence each other via outflow region. Storm following nests offers a reliable NWP solution for capturing these interactions



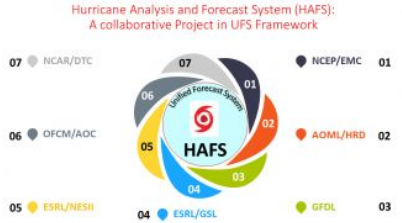
Name	Year	Basin	Storm ID	Group
Miriam	2018	Eastern North Pacific	15E	1
Florence	2018	North Atlantic	06L	1
Helene	2018	North Atlantic	08L	1
Isaac	2018	North Atlantic	09L	1
Dorian	2019	North Atlantic	05L	2
Juliette	2019	Eastern North Pacific	11E	2
Gabrielle	2019	North Atlantic	08L	2
Kiko	2019	Eastern North Pacific	13E	3
Humberto	2019	North Atlantic	09L	3
Mario	2019	Eastern North Pacific	14E	3
Lorena	2019	Eastern North Pacific	15E	3
Jerry	2019	North Atlantic	10L	3
Karen	2019	North Atlantic	12L	3
Lorenzo	2019	North Atlantic	13L	3

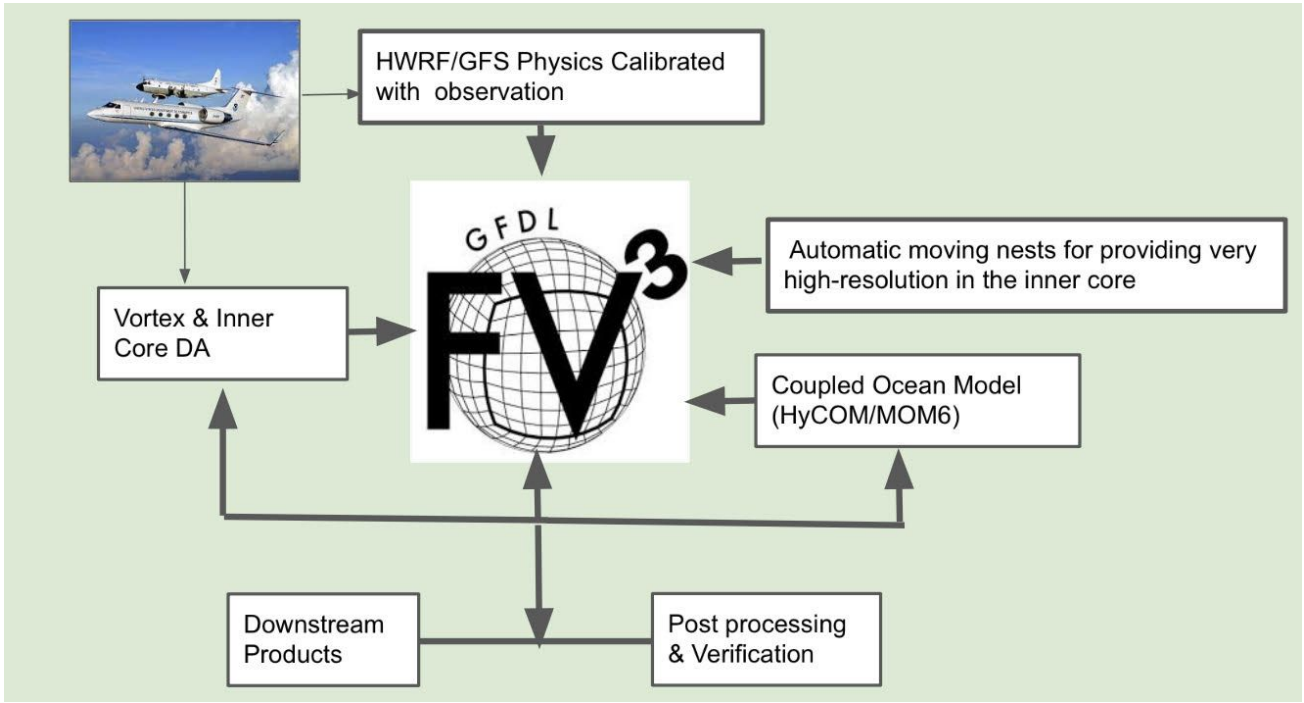
Intensity skills -vs- operational HWRF improves with number of moving nests in the domain. As much as 30% for 4 or more storms in the basin scale domain



G Alaka, X.Zhang and Gopal," High Defination Hurricanes: Improving Forecasts with Storm-Following Nests", BAMS, 2022

Our Vision: UFS- HAFS developments





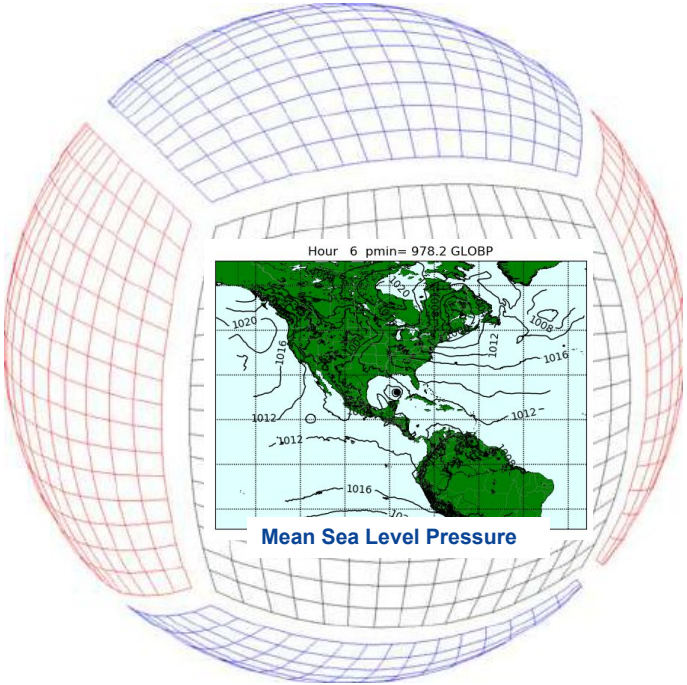
HAFS is a part of NOAA's Unified Forecast System (UFS) and is supported by Disaster Supplementals

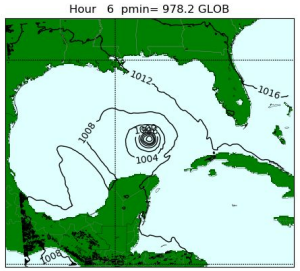
HAFS developments: Moving Nest in Global FV3

On February 3, 2021 by AOML Communications to Hurricane Research, Research Partnerships

AOML Hurricane Scientists Facilitate Leap in Hurricane Modeling and Prediction Systems

Hurricane scientists at NOAA's Atlantic Oceanographic and Meteorological Laboratory have created a new, advanced moving nest model within the Unified Forecast System, the bedrock of NOAA's weather prediction applications. AOML's Hurricane Modeling and Prediction Team developed the high resolution moving nest model for the FV3 dynamical core, laying the foundation for next generation advancements in hurricane forecasting.





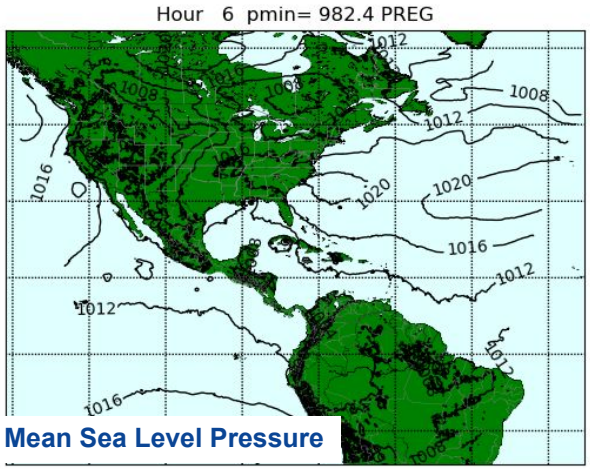
Case Description

- Hurricane Laura 2020
- C768 with 3X nest refinement
- 13km/4km resolution
- GFS initialization (cold start)
- Storm-following motion
- 96 hour forecast

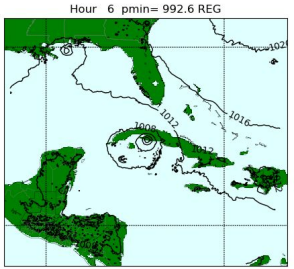
Developed under Disaster Supplemental 1A4 & 3A1

R2O: Regional Implementation of Moving Nest

Description	HAFS
Domain	Storm-centric with one moving nest, parent: ~86x86 degree, nest: ~19x19 degre
Resolution	Regional ESG, ~6/2 km, ~L81, ~2 hPa model top
DA/VI	Storm inner-core DA, cycling for NATL/EPAC TCs, VI
Ocean/Wave Coupling	Two-way HYCOM, one-way WW3 coupling for NHC AOR
Physics	HAFSv0.3A/GFS like CCPP physics suite
Computer Resources	~6,000 cores per storm x 7 storms = ~42,000 cores



Mean Sea Level Pressure



Case Description

- Hurricane Laura 2020
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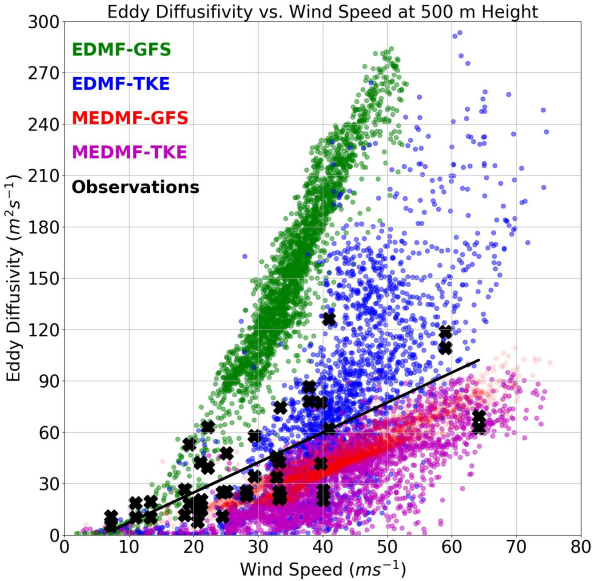
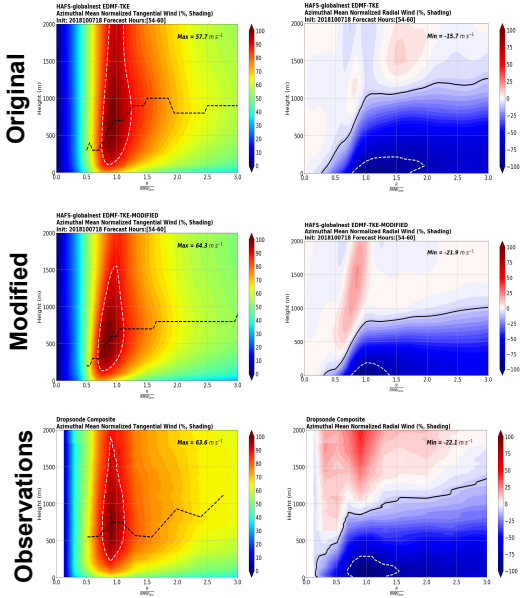
- HFIP Real-Time Experiments (HREX) will test multiple configurations of this model this summer before operational implementation
- Operational implementation subject to available HPC

Use of P3 Observations for Improving HAFS Physics



HAFS default PBL Physics too diffusive



Eddy diffusivity calibrated to observations leads to improved structure and RI predictions

- Hazelton, A., J.A. Zhang, and S.G. Gopalakrishnan. Comparison of the performance of the observation-based hybrid EDMF and EDMF-TKE PBL schemes in 2020 tropical cyclone forecasts from the Global-nested Hurricane Analysis and Forecast System. Weather and Forecasting,
- Gopalakrishnan, S., A. Hazelton, and J.A. Zhang. Improving hurricane boundary layer parameterization scheme based on observations. Earth and Space Science

Summary and Recommendations

- History of progress related to storm-following nested grid models for Hurricane Predictions developed in the HFIP era was provided.
- Tropical Cyclones 1000's of miles apart could influence each other via outflow region. Multiple Storm following nests, HWRF-B, offers a reliable NWP solution for capturing these interactions
- The Hurricane Analysis and Forecast System (HAFS) is NOAA's next-generation ocean coupled multi-scale numerical model, with the atmospheric model based on FV3 core.
- Under NOAA's Hurricane Supplemental Program (HSUP) the first-ever moving nest in the Global Forecast System within the UFS was created for the hurricane application. This system will be the basis of the HAFS.
- A regional version of the system, HAFS-V1.0, is expected to go into operation in 2023.
- The initial implementation will be similar to operational HWRF/HMON configurations
- It is highly recommended that future implementation plans beyond 2023 should focus on developments of storm following nests for any number of Tropical Cyclones in either basin-wide regional or global forecast system.