HAFS Moving Nest and Physics Development, Tests & Evaluations at AOML

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COLLABORATORS:

A. MEHRA AND HURRICANE PROJECT TEAM (NCEP/EMC)

L. HARRIS AND WEATHER & CLIMATE DYNAMICS DIVISION (GFDL)

HAFS/HFIP Activities at AOML

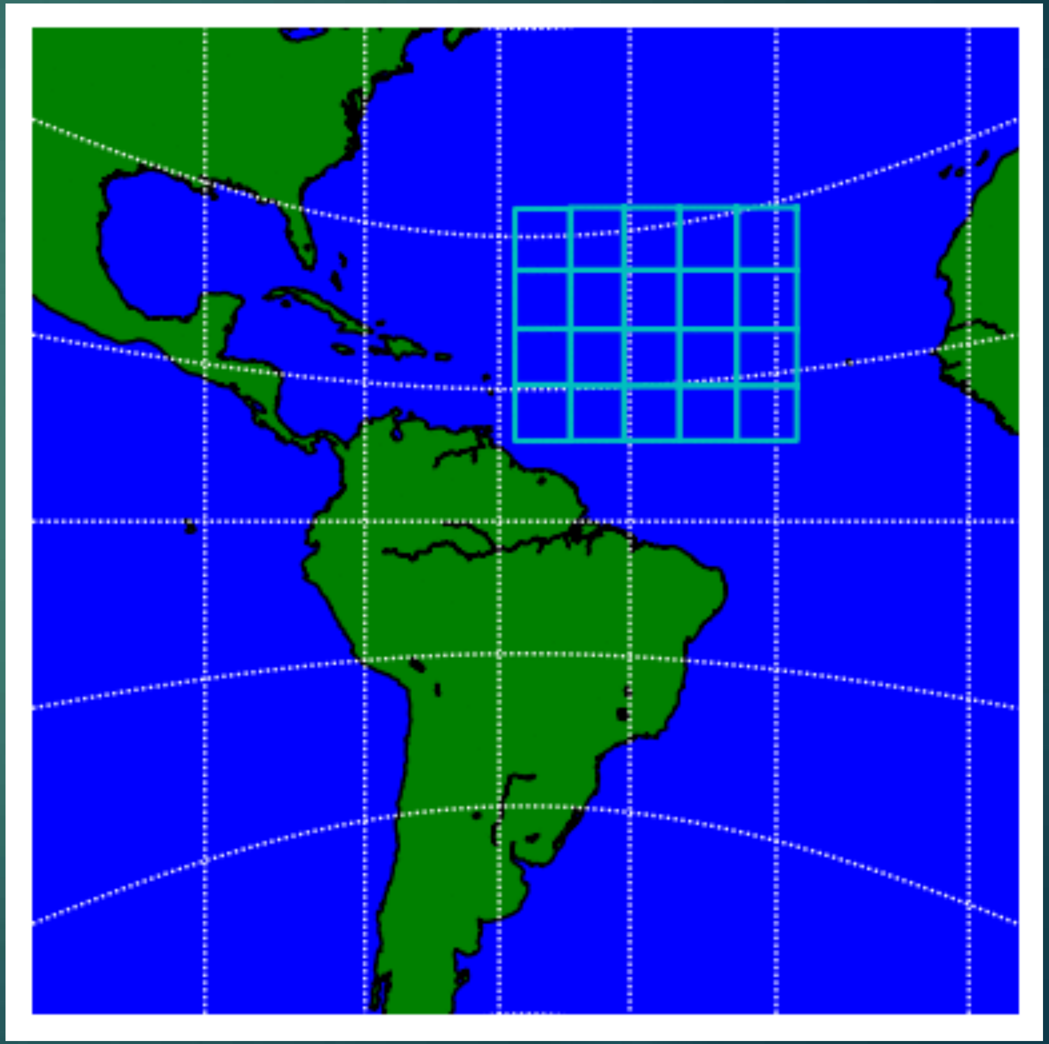
- Moving nest (IFAA 1A-4a, A. Mehra & S. Gopalakrishnan)
  - Model infrastructure changes
  - Moving nest testing with the infrastructure
  - **Workflow for multiple nests**
  - Moving nest in dynamic core
  - Nest tracking algorithm
  - Idealized TC
  - Configuration without physics for moving nest
  - Moving nest implementation with physics
  - Workflow for moving nest
- HAFS physics development and evaluation (IFAA 3A-1/HFIP, F. Marks)
  - Physics scheme evaluation in HAFS-B v0.1
  - Evaluate PBL scheme including K_m, TKE, and mixing length
  - Real-time global-nested HAFS-B and HWRF-B reservations
  - **HRD GPLOT transition to HFIP demo experiments**
  - **Prepare for real-time global-nested HAFS-B and HWRF-B demo**
  - **Semi real-time global multiple nests HAFS-B HFIP demo**
  - HAFS-B & HWRF-B real-time T & E
  - Continuing development of research and forecast products
- HPC resource issues
  - UFS-HAFS code transitioned and tested on Orion
  - **HWRF-B code transitioned and tested on Orion**
  - Data availability issue on Orion
- Publications and presentations related to HAFS &HWRF-B (not updated yet)
  - Publications
  - Presentations

Completed
Recently completed
Ongoing

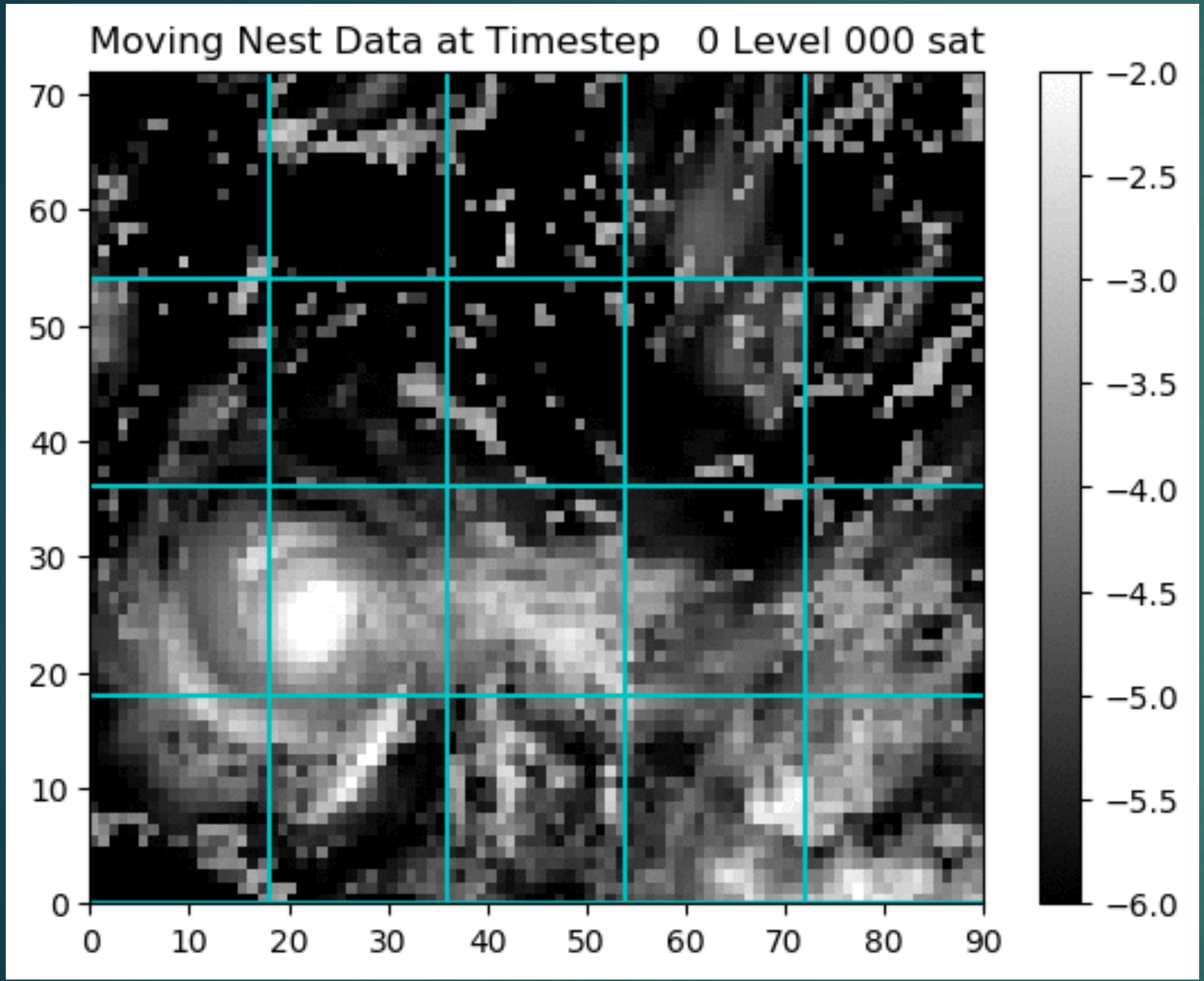
Moving Nest Code Implementation

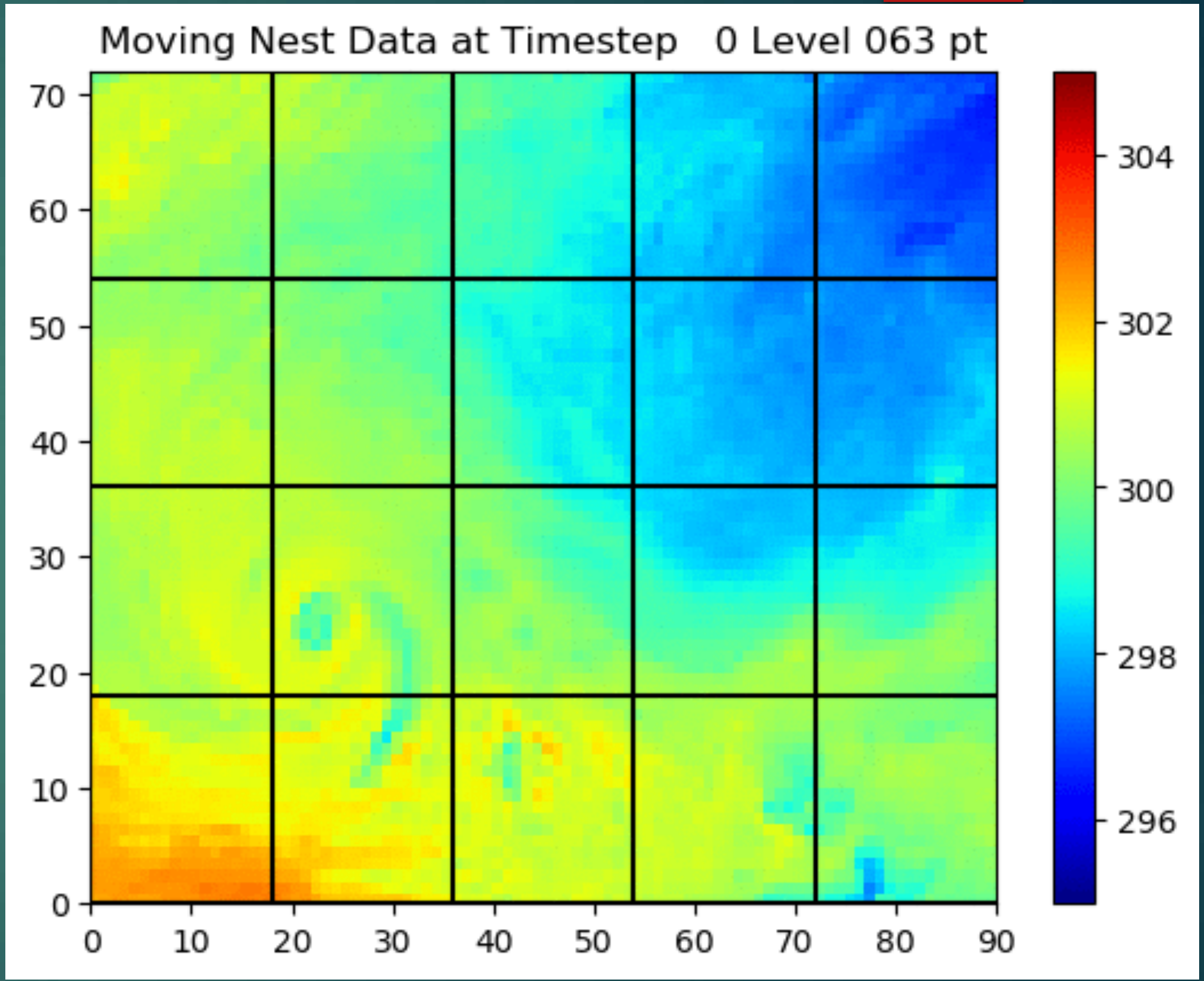
- Moving Nest Code Running in Dycore
- Moving metadata, A-grid variables
- Not yet running dynamics/physics

- C96 Model Resolution
- 3X Refinement Ratio
- 4X5 Processors for Nest
- 16 Processors for each cube face
- Hurricane Irma case from 2017



Moving Nest Code Implementation





- Column condensed water
- Simulated satellite

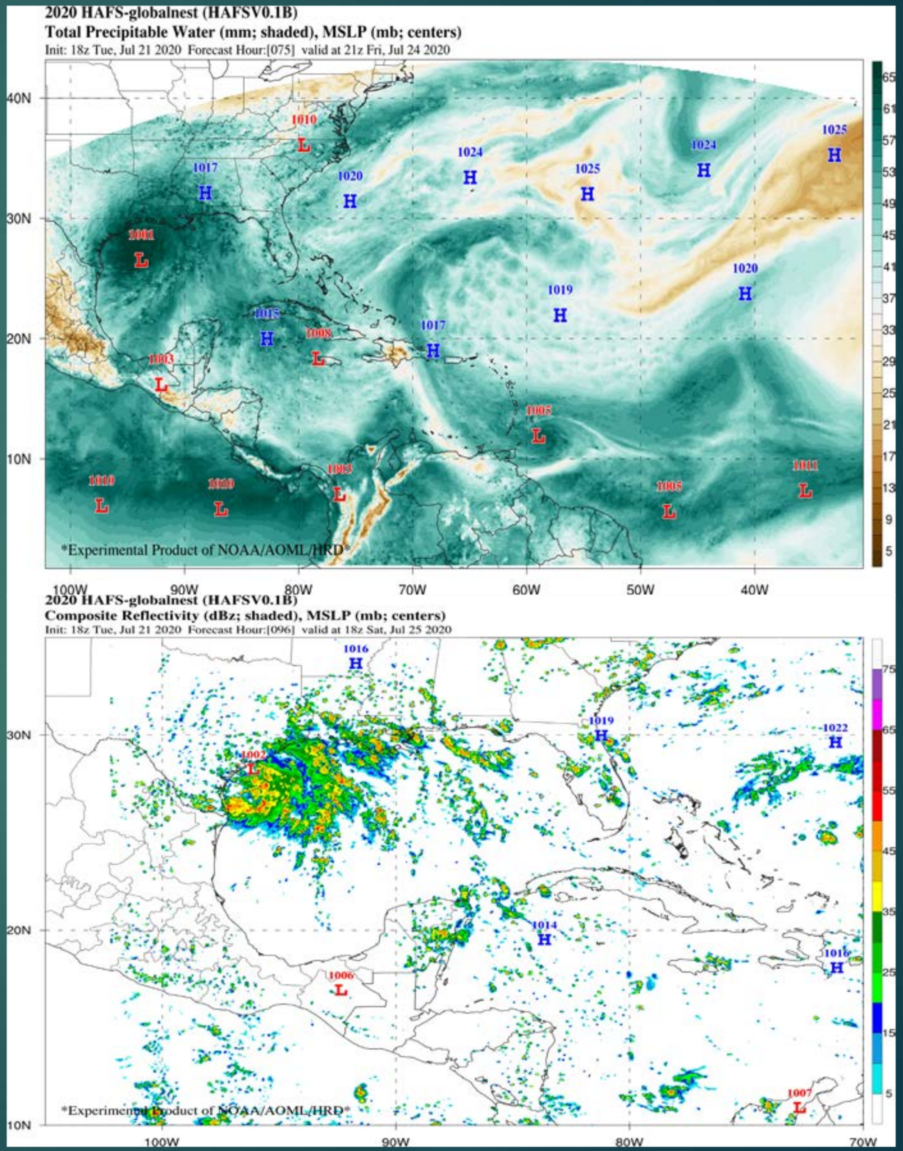
- Lowest model level temperature
- Continuous field

Moving Nest Code Implementation

mn_metadata_move_nest()
Move nest definition metadata
mn_var_fill_intern_nest_halos()
Populate halo data on internal nest edges
No interpolation needed; only communication between processors
mn_metadata_recalc()
Recompute lat/lon grids, indices, etc. to account for nest motion
mn_var_shift_data()
Shift the contents of prognostic/diagnostic variables
Interpolate from coarse grid along leading edge of nest
Shift data inside nest
mn_var_dump_to_netcdf()
Output variable data to netCDF file for diagnostics
Will not run in operational setting

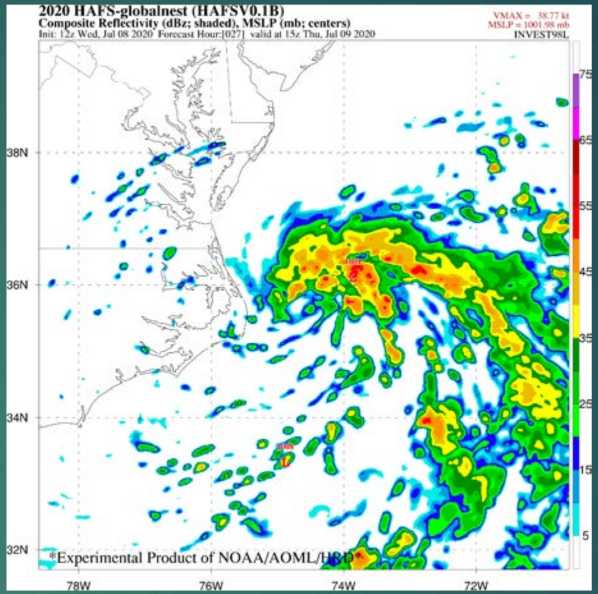
HAFS-B Real-Time Experiments

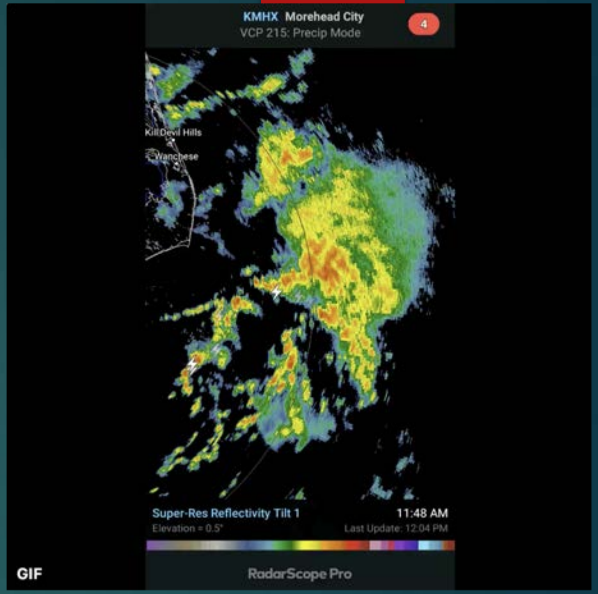
- HAFSV-B (global-nested HAFS) running in real-time on Jet
- 168h forecasts 00 UTC, 06 UTC, 12 UTC (18 UTC on Hera)
- Key Upgrades over 2019 version
  - Modified EDMF-TKE PBL physics
  - L75 vertical levels
  - Global and nested output, tracks available
  - Graphics created in-line in the workflow
- Output graphics available at
  https://storm.aoml.noaa.gov/basin/?projectName=BASIN
- Tracks available at
  ftp://ftp.aoml.noaa.gov/hrd/pub/data/HAFS/2020/

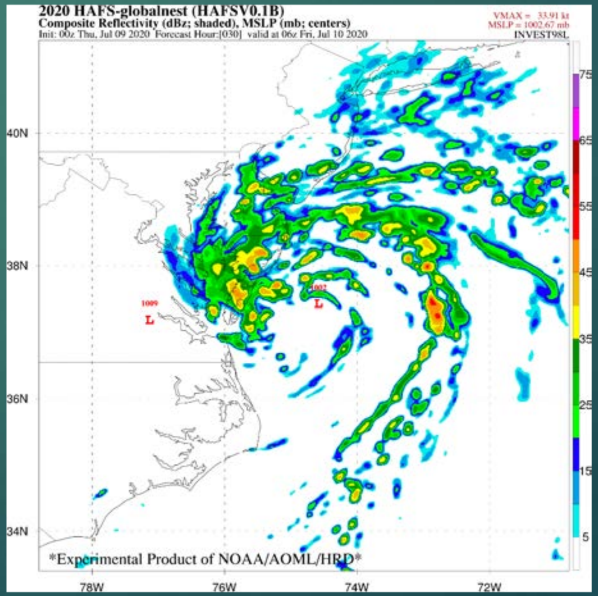


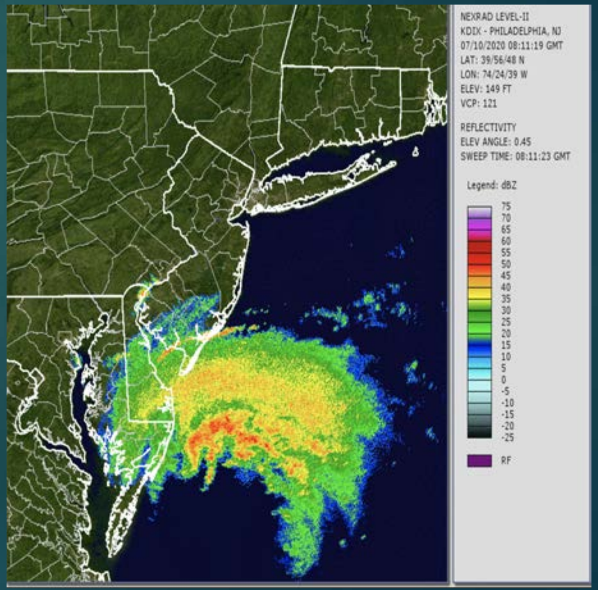
Tropical Storm Fay

- Fay provided an early chance to test HAFSV-B
- Short-term convective evolution was well-predicted
- Asymmetric due to shear but with a small core forming over the Gulf Stream



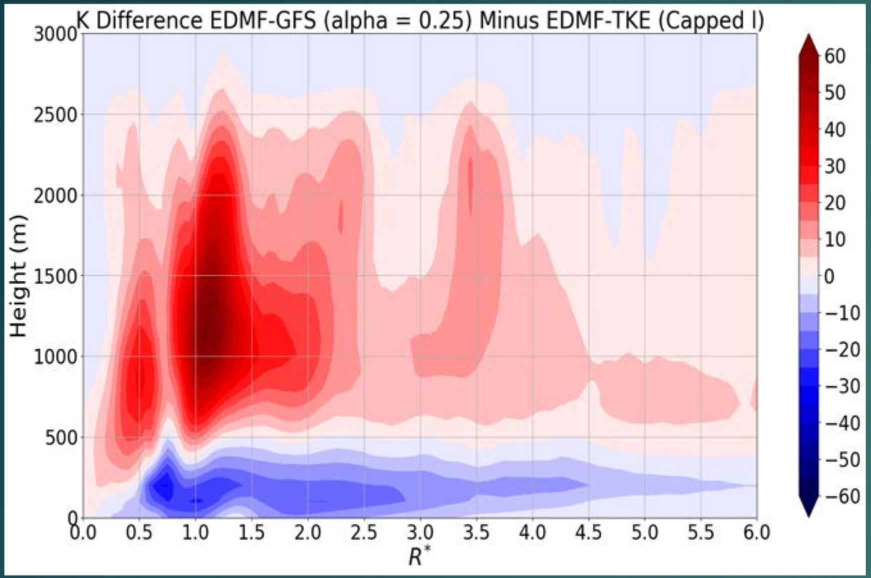




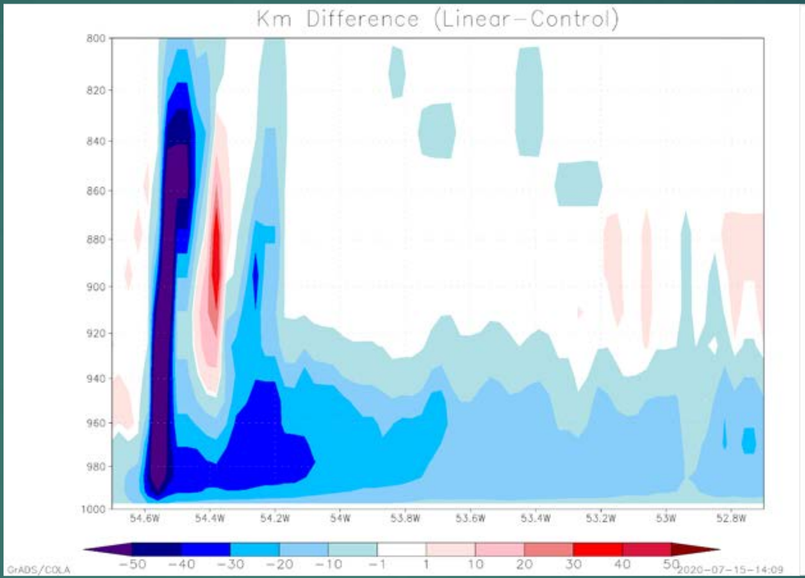


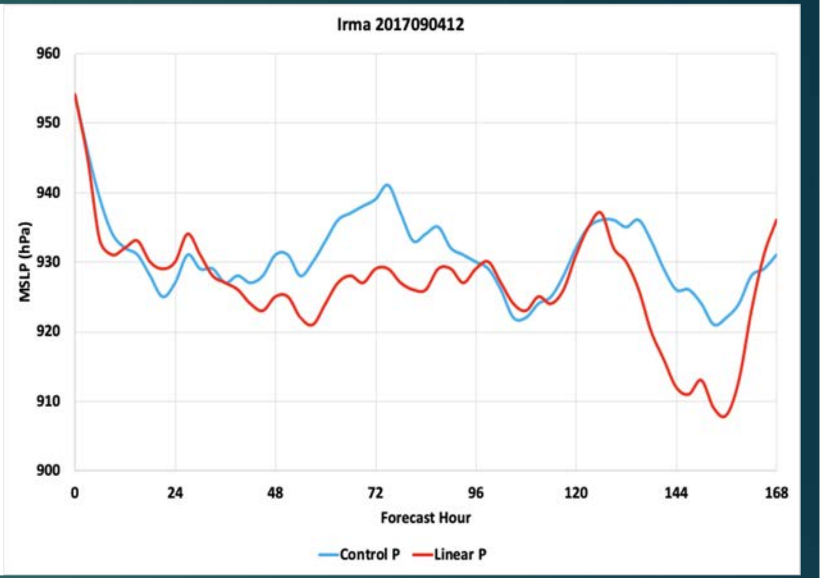
HAFS Physics Development

MEDMF-GFS vs. MEDMF-TKE



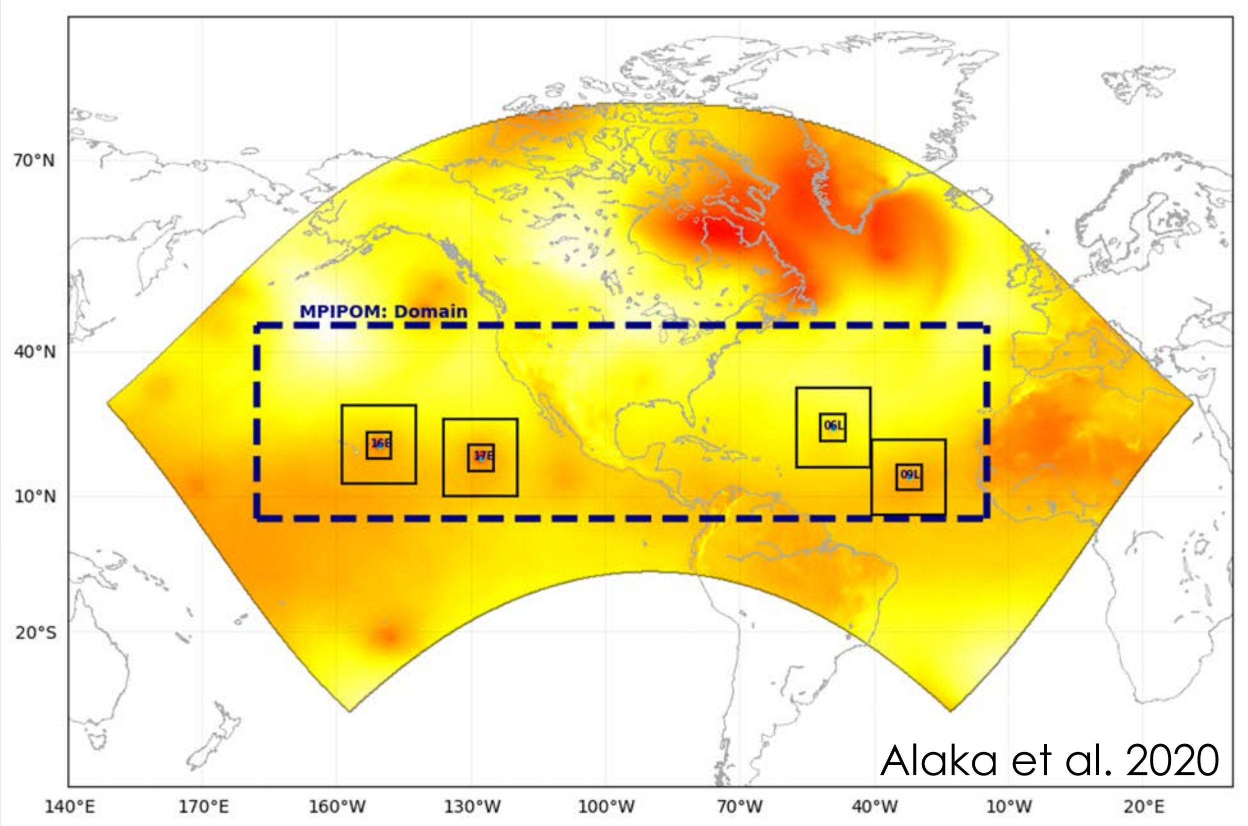
Two Different Settings of MEDMF-TKE





- Previous work showed convergence of physics schemes, similar K at 500 m
- Some differences in height, however
- We are able to get similar results from different configurations of EDMF-TKE
- Exploring new ways to realistically adjust and modify PBL physics based on observations, theory, LES simulations (collaborators: P. Zhu and X. Chen)

Basin-scale HWRF (HWRF-B)

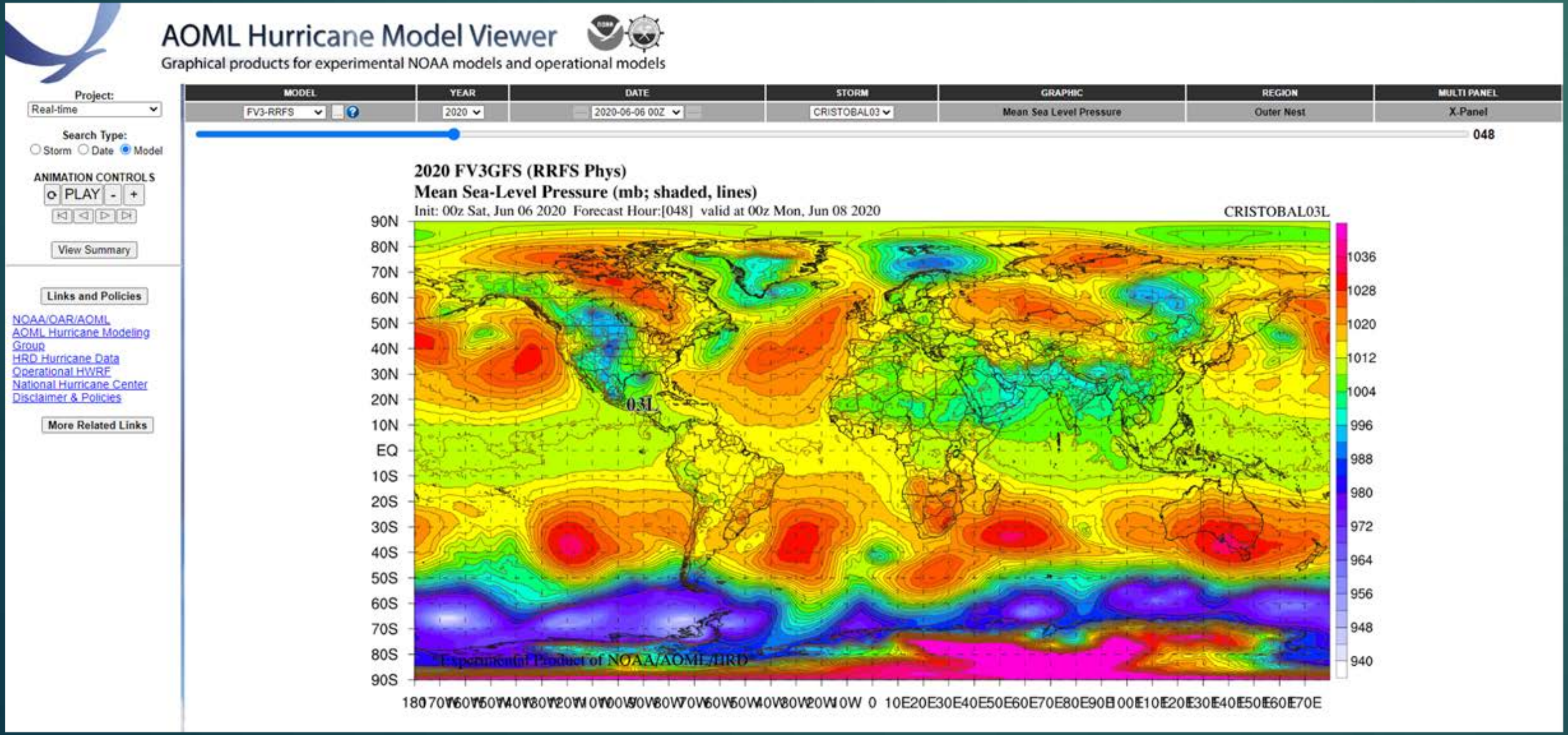


- **Only differences:** large D01 & multiple nests
- Self-cycled DA for multiple storms (new!)
- HB20: 3 storms, 11 sub-reservations
- Important baseline for HAFS

Configuration Options	HWRF-B	HWRF
Domain	13.5 km: 194.0° x 84.2° 4.5 km: 16.5° x 16.5° 1.5 km: 5.5° x 5.5°	13.5 km: 77.2° x 77.2° 4.5 km: 17.7° x 17.7° 1.5 km: 5.9° x 5.9°
Model Top	10 hPa	10 hPa
Vertical Levels	75	75
Vortex Init.	At 4.5/1.5 km	At 4.5/1.5 km
Data Assimilation	Hybrid & TDR-based EnKF	Hybrid & TDR-based EnKF
Ocean Coupling	13.5/4.5 km: YES (POM) 1.5 km: Downscaled	13.5/4.5 km: YES (POM) 1.5 km: Downscaled
Multi-Storm	**YES (up to 5)**	**NO**
PHYSICS SCHEMES		
Microphysics	Ferrier-Aligo	Ferrier-Aligo
Radiation (LW,SW)	RRTMG	RRTMG
Surface Layer	HWRF (GFDL-based)	HWRF (GFDL-based)
PBL	GFS Hybrid-EDMF	GFS Hybrid-EDMF
Convection	Scale-Aware SAS	Scale-Aware SAS
Land Surface	Noah LSM	Noah LSM

Graphical Production (GPLOT)

- Rocoto "graphics" task added to HAFS workflow (thanks Bin!)
- GPLOT graphical production is available for any HFIP RT experiment as a workflow task or standalone.
- Show graphics on the AOML Hurricane Model Viewer
  - Side-by-side comparisons with operational models (GFS, ECMWF, HWRF)
  - Proof of concept: **GSL's FV3GFS w/ RRFS Physics**



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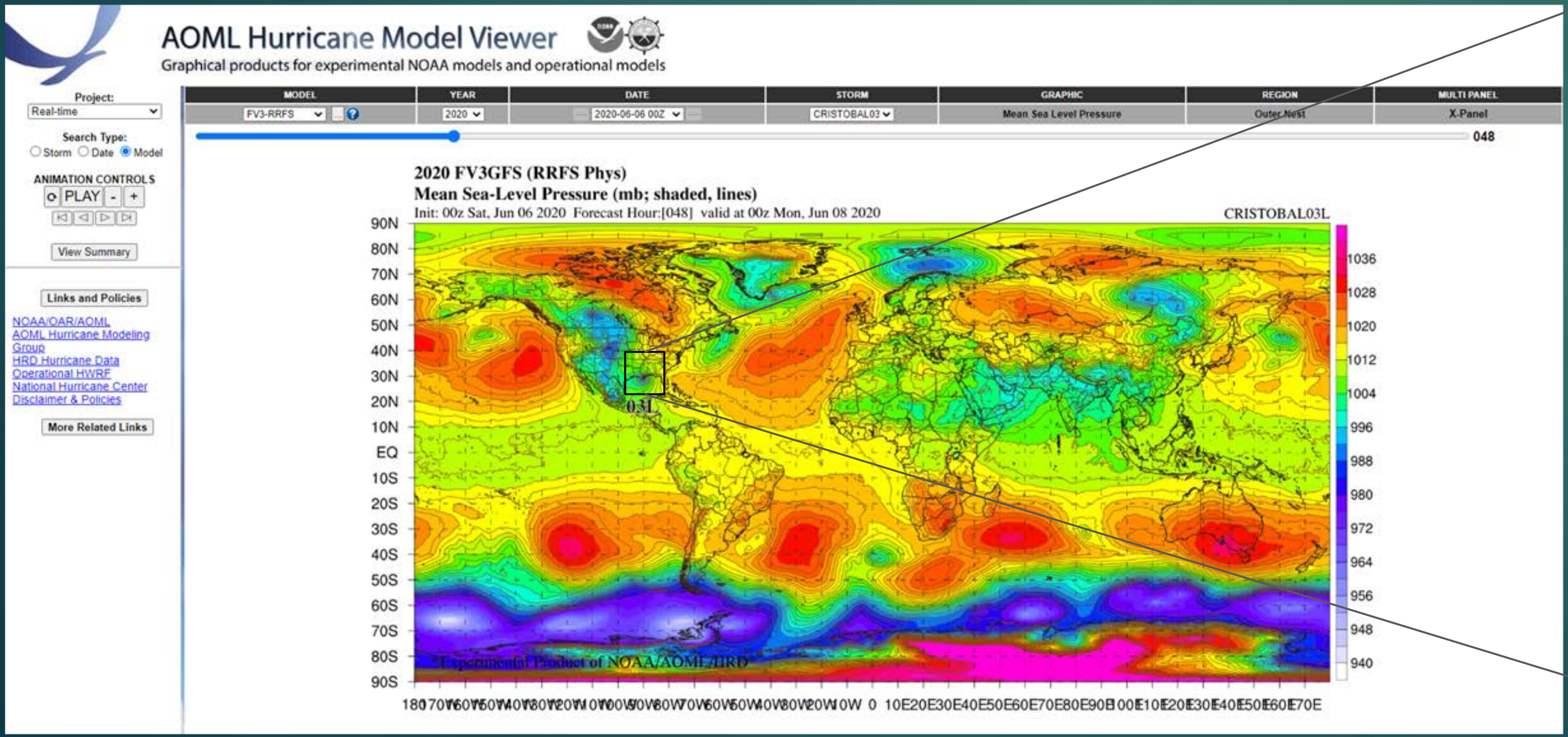

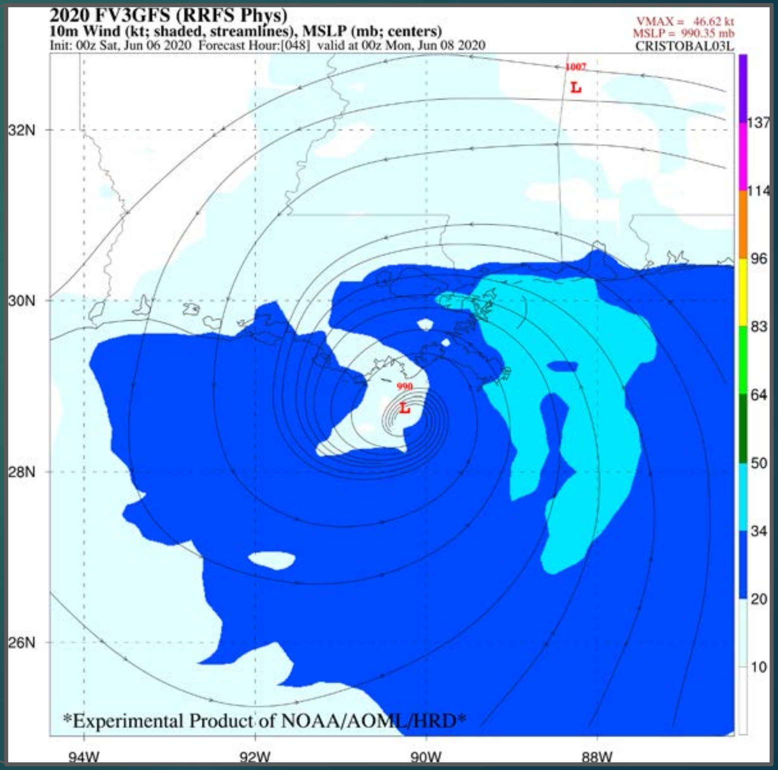

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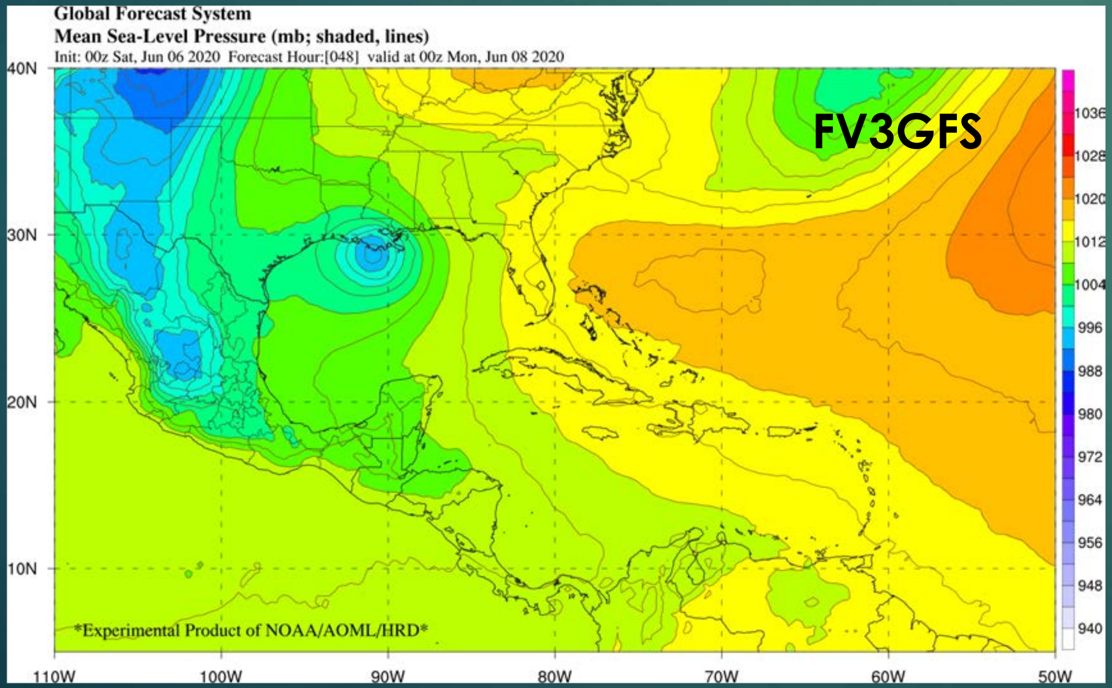

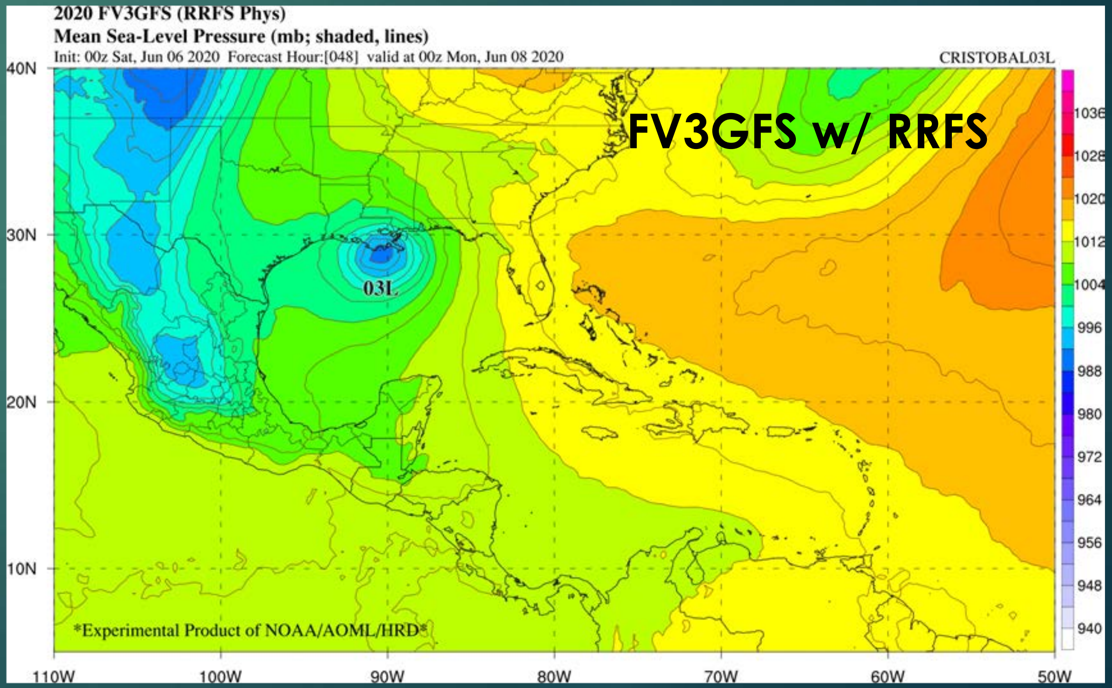

Publications and Presentations

- **Recent Publications (HAFS, HWRF-B, and HFIP related partial list)**
  - Gopalakrishnan, S., Hazelton, A. T., and J. A. Zhang, 2020: A generalized framework for hurricane boundary layer parameterization scheme based on observations, *Geo. Res. Let.*, in review.
  - Liu, Q., X. Zhang, M. Tong, Z. Zhang, B. Liu, W. Wang, L. Zhu, B. Zhang, X. Xu, S. Trahan, L. Bernardet, A. Mehra, V. Tallapragada, 2020: Vortex Initialization in the NCEP Operational Hurricane Models. *Atmosphere*, in review.
  - Leighton, H., R. Black, X. Zhang, F. D. Marks, Jr., S. G. Gopalakrishnan, 2020: Ice Particle Size Distributions from Composites of Microphysics Observations Collected in Tropical Cyclones, *Geo. Res. Let.*, Accepted.
  - Dong, J., B. Liu, Z. Zhang, W. Wang, A. Mehra, A. Hazelton, H. Winterbottom, L. Zhu, K. Wu, C. Zhang, V. Tallapragada, X. Zhang, S. G. Gopalakrishnan, F. D. Marks, Jr., 2020: The Evaluation of Real-time Hurricane Analysis and Forecast System (HAFS) Stand-Alone Regional (SAR) model performance in 2019 Atlantic Hurricane Season, *Atmosphere*, published.
  - Ko, M.-C, F. D. Marks, Jr., G. J. Alaka, and S. G. Gopalakrishnan, 2020: Evaluation of Hurricane Harvey (2017) Rainfall in Determinstic and Probablistic HWRF Forecasts, *Atmosphere*, published.
  - *Hazelton, A. T.*, and coauthors, 2020: Atlantic Hurricane Forecasts From the Global-Nested Hurricane Analysis and Forecast System (HAFS): Composite statistics and key events. *Wea. Forecasting,* in revision.
  - Harris, L., L. Zhou, S.-J. Lin, J.-H. Chen, X. Chen, K. Gao, M. Morin, S. Rees, Y. Sun, M. Tong, B. Xiang, M. Bender, R. Benson, K.-Y. Cheng, S. Clark, O. Elbert, A. Hazelton, J. Huff, Z. Liang, T. Marchok, H. Shin, and W. Stern, 2020: GFDL SHiELD: A Unified System for Weather-to-Seasonal Prediction, *J. Adv. Model. Earth Syst.*, in review.
  - Hazelton, A. T., Alaka, G., S. Gopalakrishnan, and L. Cowan, 2020: Analysis of the Early Intensification of Hurricane Dorian Using an Ensemble of the Hurricane Analysis and Forecast System (HAFS), *Atmosphere*, in preparation.
  - Chen, X., J. A. Zhang, and F. D. Marks, 2019: A thermodynamic pathway leading to rapid intensification of tropical cyclones in shear. Geophys. Res. Lett., 46, 9241-9251. doi: https://doi.org/10.1029/2019GL083667.
  - Zhang, J. A., and R. F. Rogers, 2019: Effects of parameterized boundary layer structure on hurricane rapid intensification in shear. Mon. Wea. Rev., 147, 853-871.

Completed Recently progressed Ongoing