Unified Global and Regional Weather Prediction at Medium- and Short-Range Timescales

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Geophysical Fluid Dynamics Laboratory Review

October 29-31, 2019

Development Path of SHiELD

System for **Hi**gh-resolution prediction on **E**arth-to-**L**ocal **D**omain

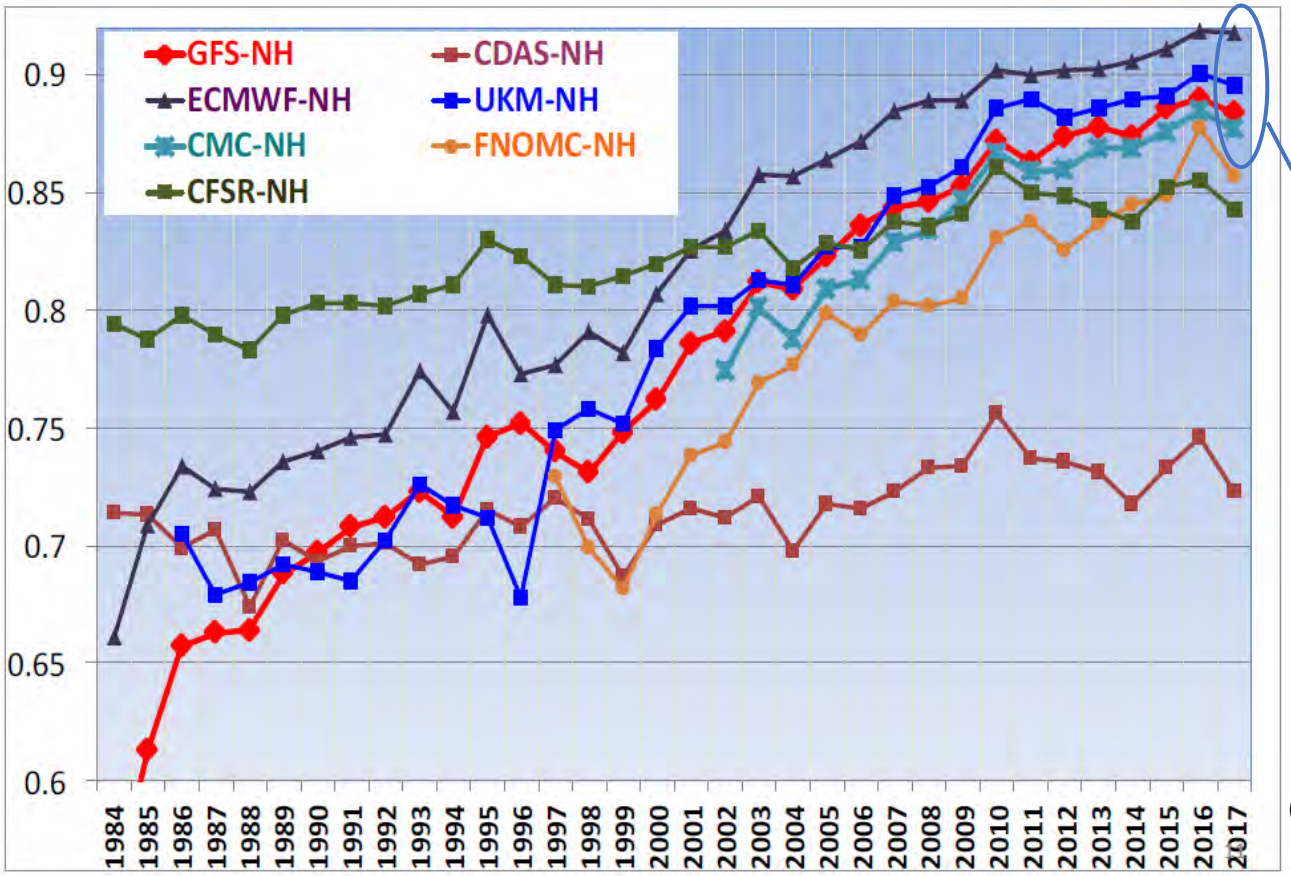
Version	NGGPS Phase II submission	fvGFS_v2016	fvGFS_v2018	SHiELD_v2019
Time of code release/ online real-time forecasts	**March 2016**	**August 2016**	**June 2018**	**July 2019**
Features/Updates:	• FV3 dycore • NOAH land model • 2015 GFS Physics	• **Zhao-Carr MP → GFDL MP** • Major bug fixes: energy conservation, surface cycle, surface albedo, surface emission	• Vertical levels: 63 → 91 • SAS→ Scale-aware SAS • YSU PBL • Inline GFDL MP • Mixed Layer Ocean Model • Higher land resolution • PD tracer advection	• Bug fixes: radiation, YSU • Updates: cloud-radiation interaction, GFDL MP, ocean surface roughness

Global **SHiELD** at **13 km** resolution: **weather and hurricane forecasts**

Two-way nested **C-SHiELD** at **3 km** resolution: **severe weather forecasts**

Weather Forecast at Global Scale

- **The prediction skill of 500-hPa geopotential height** -- the most important metric to measure the capability of a system to provide short and medium-range forecasts



Year of 2017

Model	ACC
GFS	0.887
CMC	0.881
UKMO	0.898
ECMWF	0.918

Historical Performance of Global NWP Models

Provided by Fanglin Yang, NCEP/EMC

(https://www.emc.ncep.noaa.gov/gmb/STATS_vsdb/longterm/)

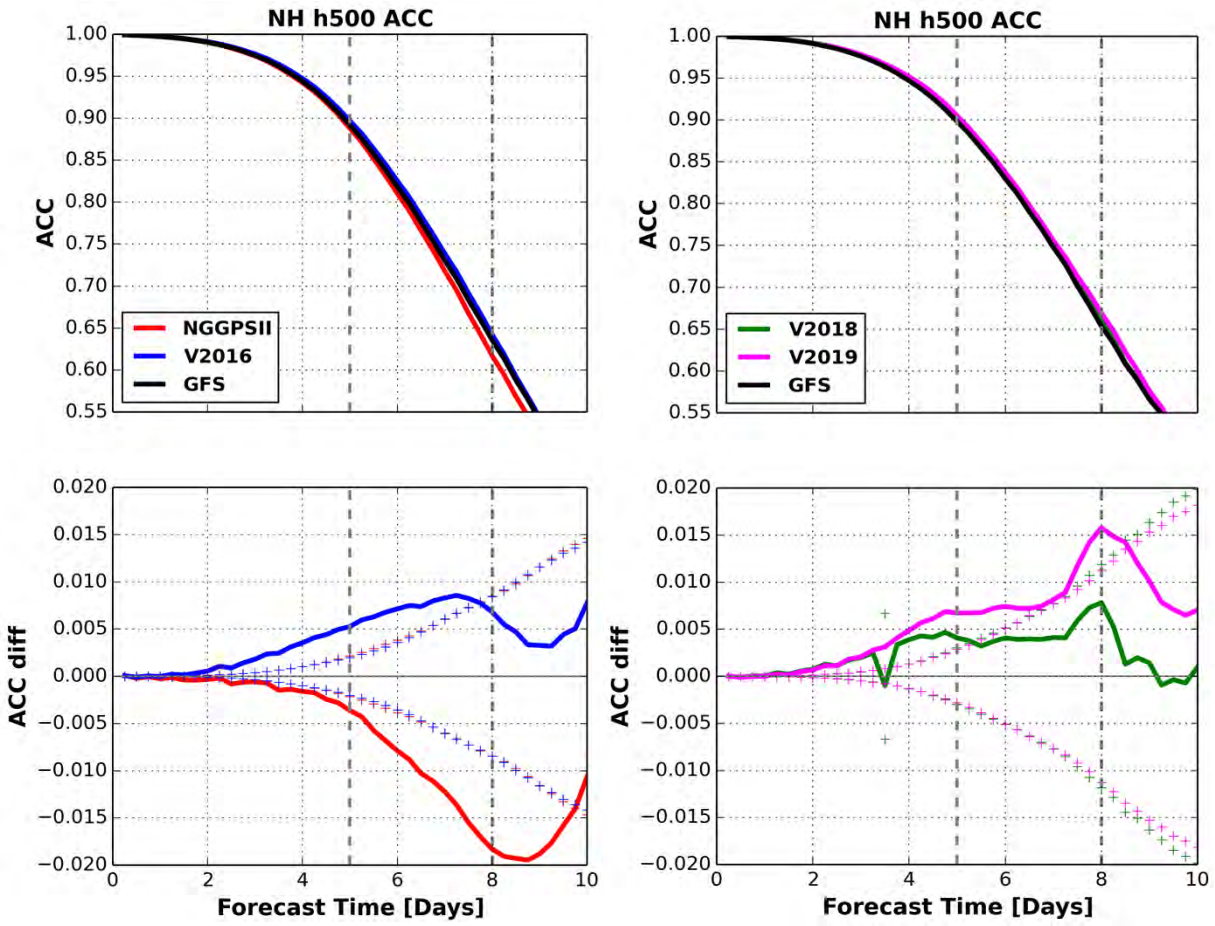
Improvements of H500 ACC in GFDL SHiELD

NCEP/GFS v14
Legacy operational forecasts

NGGPS Phase II submission
- FV3 dycore
- NOAH land model
- 2015 GFS Physics

Without optimizations

Impacts of updated physics



fvGFS_v2016
- Zhao-Carr MP → GFDL MP

fvGFS_v2018
- YSU PBL
- Inline GFDL MP
- Mixed Layer Ocean Model

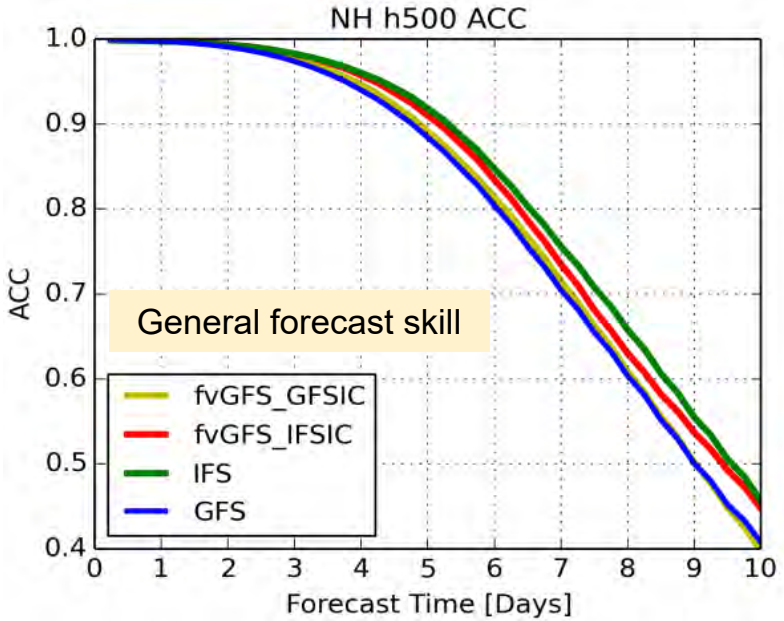
SHiELD_v2019
- Cloud-radiation Interaction
- Other bug fixes

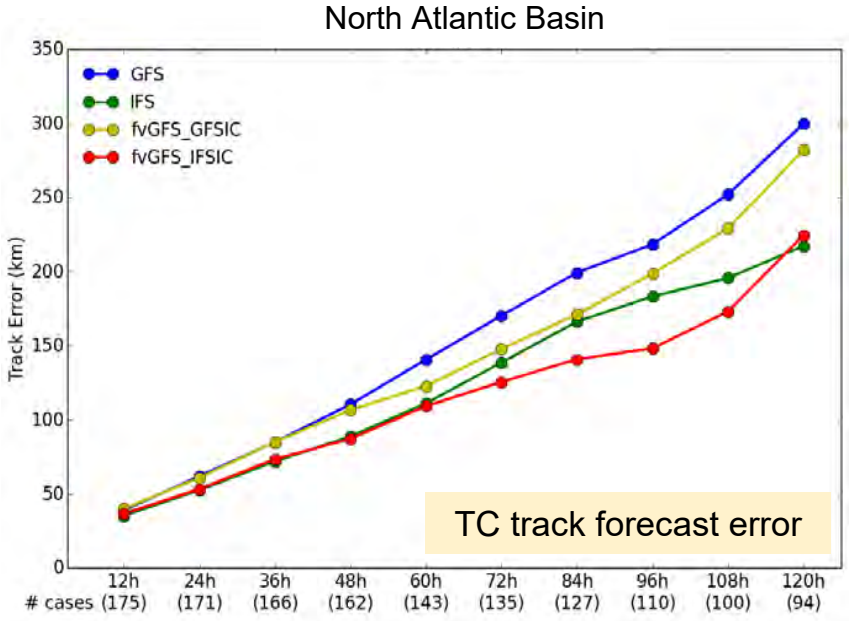
Tropical Cyclone Forecasts in SHiELD

Impacts of Using Different Initial Conditions

Model	NCEP/GFS v14	GFDL fvGFS_v2018	ECMWF/IFS (CY41R2)
Initial Condition	NCEP/GFS v14	NCEP/GFS v14 fvGFS_GFSIC ECMWF/IFS (CY41R2) fvGFS_IFSIC	ECMWF/IFS (CY41R2)

Based on 2017 NH hurricane season; Aug-Oct 2017

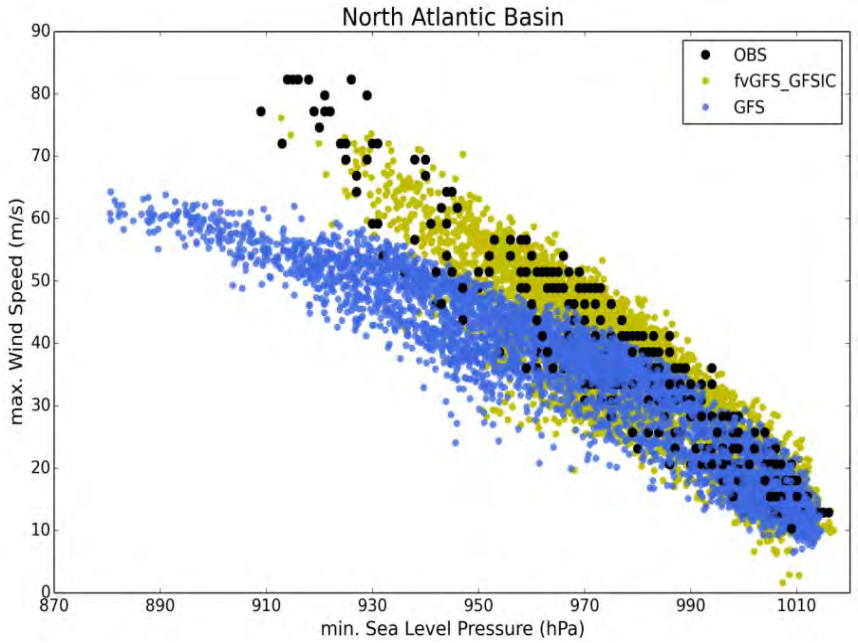


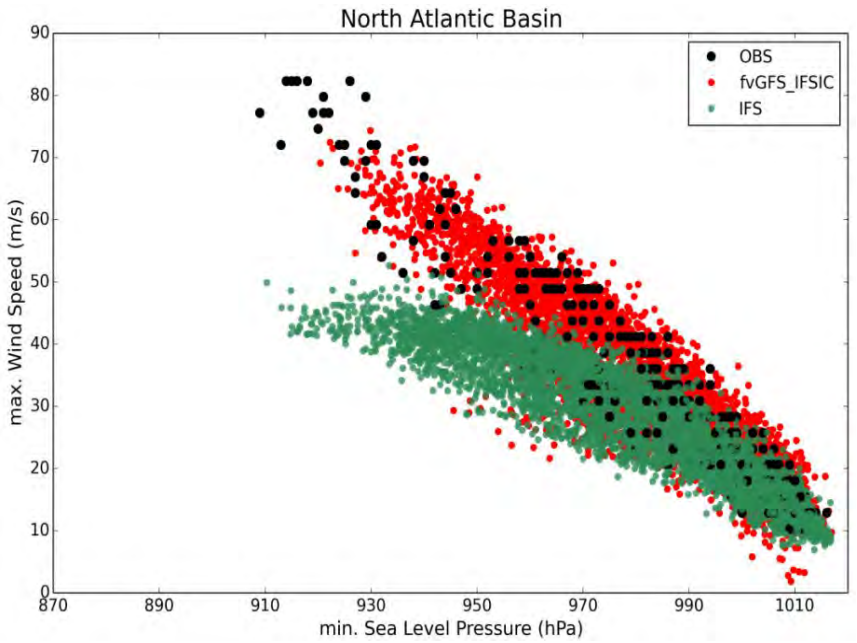


Chen et al. 2019, GRL

Impacts of Using Different Initial Conditions

- Intensity forecasts: Do the ICs or the model itself play a bigger role?



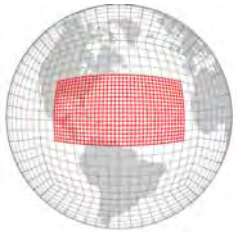


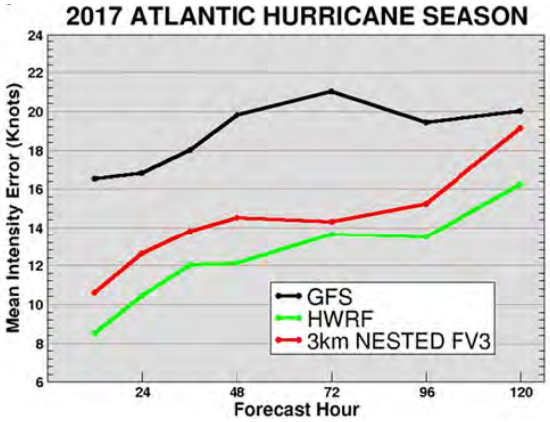
The improvement of TC intensity forecasts and P-W relationship with fvGFS is primarily due to the capabilities of the model itself and not the ICs.

Chen et al. 2019, GRL

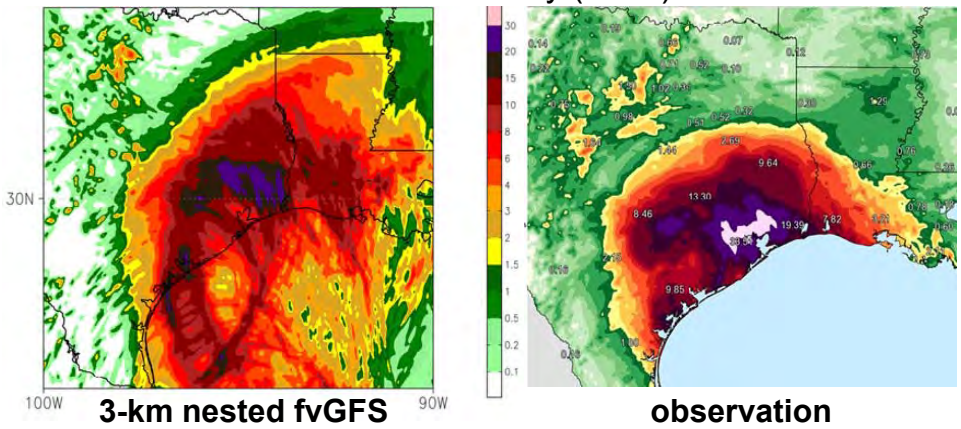
Forecasts with Variable Resolution SHiELD

- Improved TC intensity and structure (nested grid)





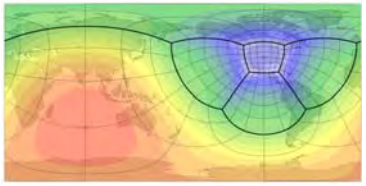
4-day total accumulated precipitation
Hurricane Harvey (2017)



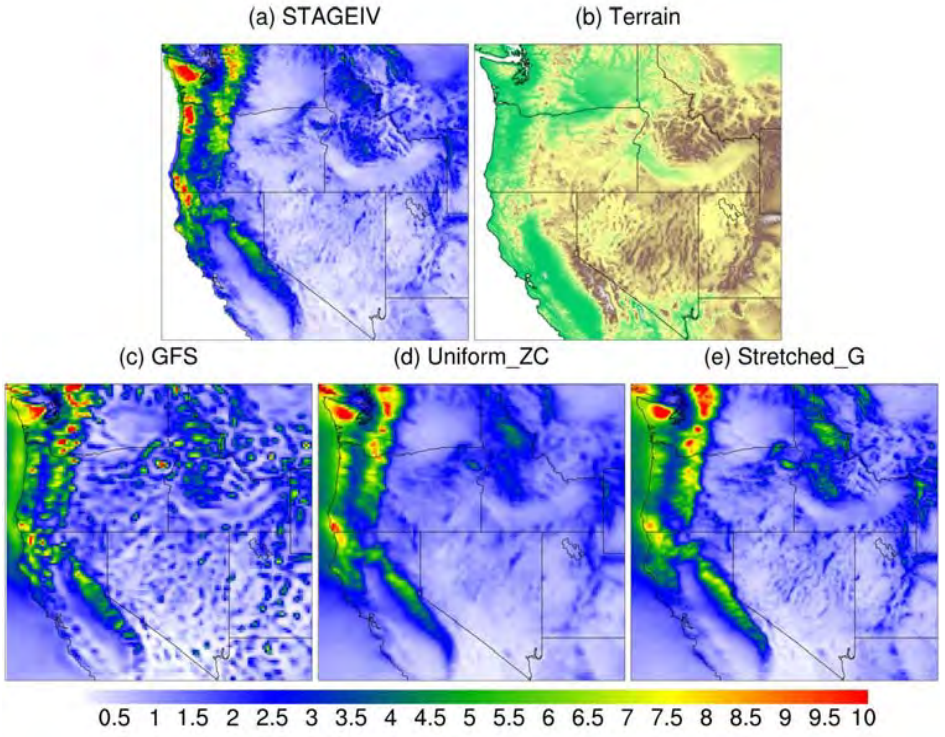
3-km nested fvGFS **observation**

Hazelton et al. 2018, WAF

- Improved terrain induced precipitation (stretched grid)

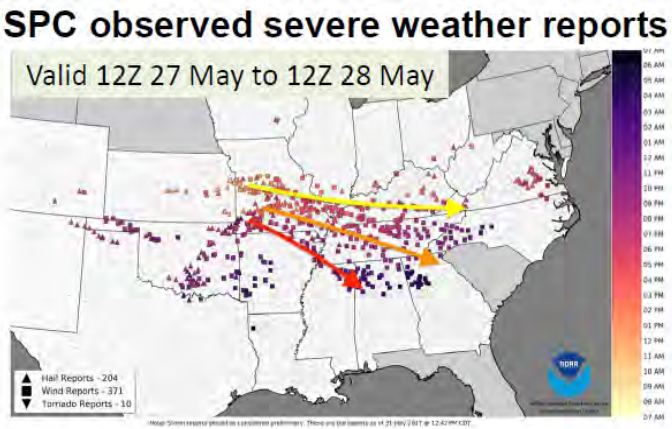


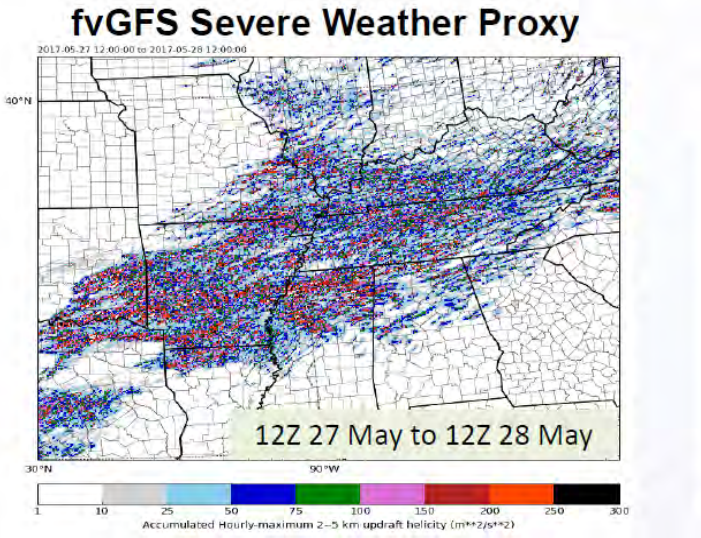
Zhou et al. 2019, BAMS



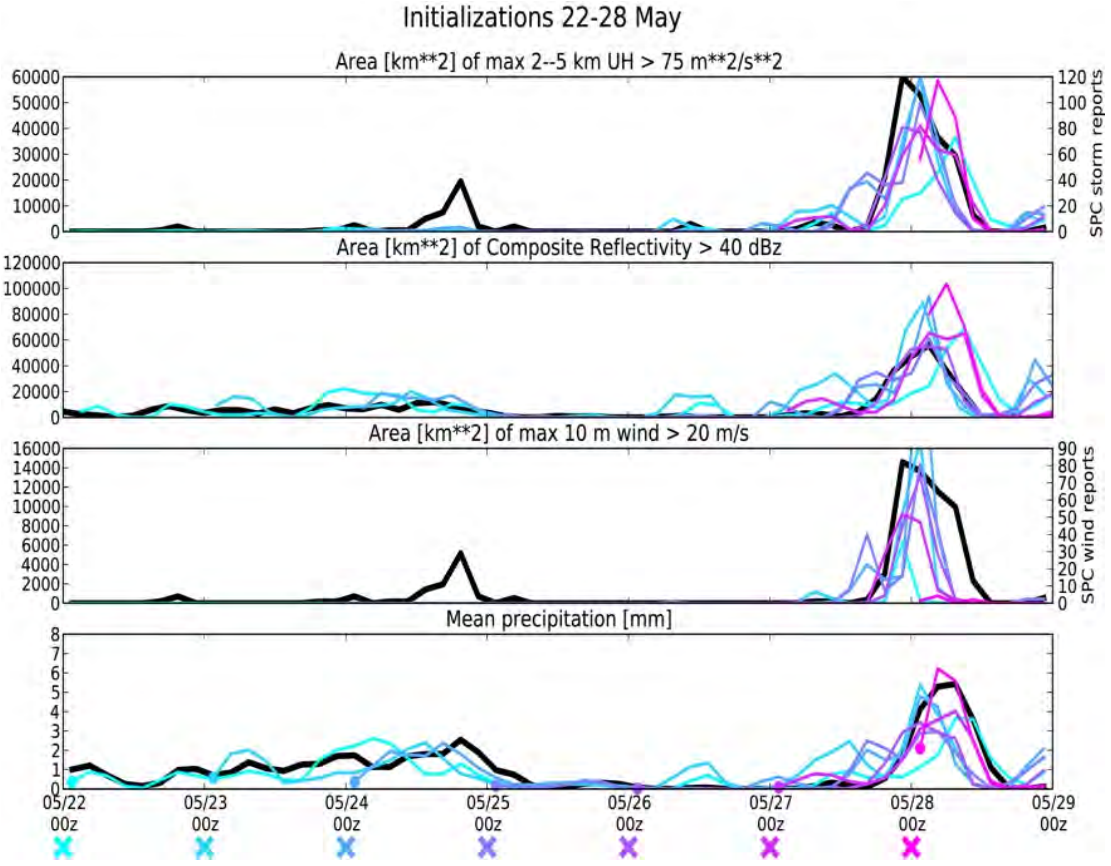
Convective Scale Prediction

- Severe weather event forecasts



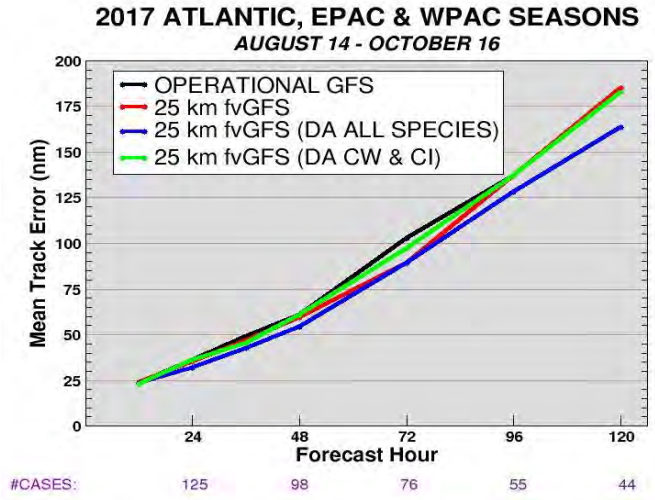


Multiple derechos predicted 5-6 days in advance



Future Plans & Challenges

- Increasing model resolution to 6.5km or higher with corresponding dynamical core and physics developments.
- Development of atmospheric data assimilation for model initialization and verification



Provided by Mingjing Tong

- Keep contributing model developments into the broader community, e.g., EMC

GFDL contribution:
Cold bias correction in the GFS V15

Provided by Linjiong Zhou (March 2019)