Atmospheric dynamical core (FV3) and NOAA Next Generation Global Prediction System

Presented by

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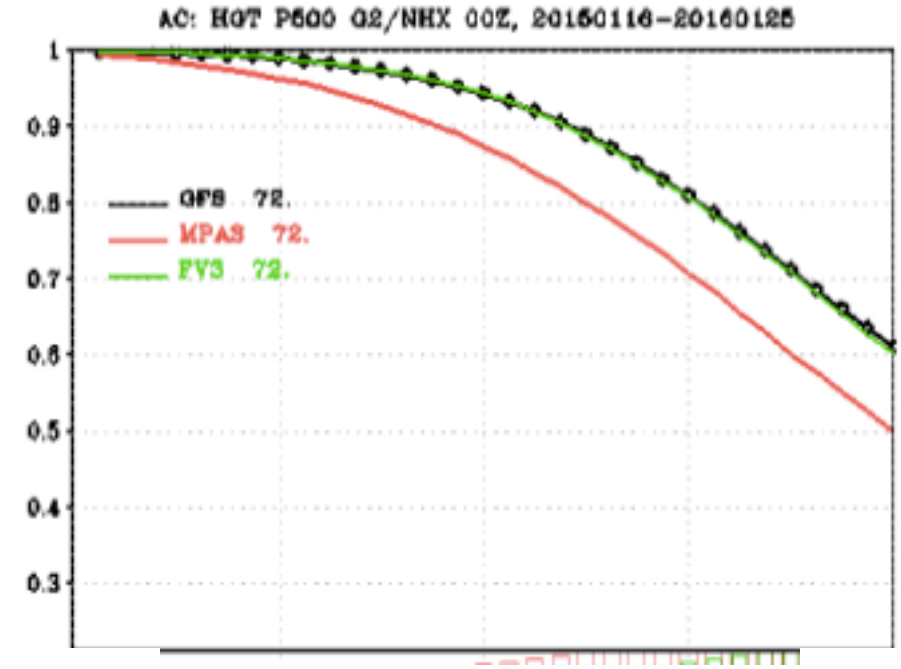
The Next Generation Global Prediction System (NGGPS)

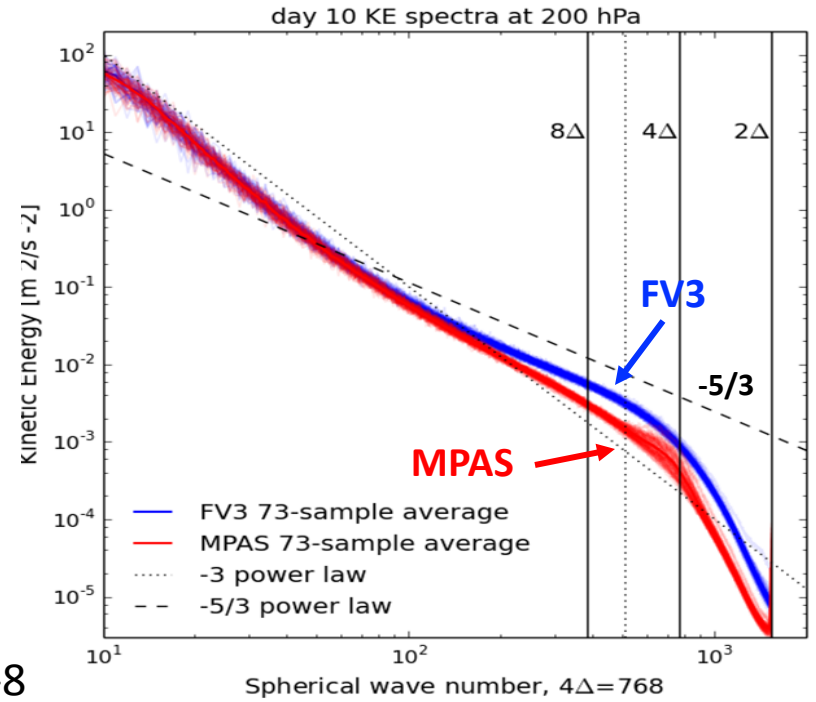
- The FV3 development started at NASA in early 90s and significantly improved and enhanced at GFDL
- NOAA in 2016 selected (via competition) GFDL Finite-Volume Dynamical Core on the Cubed-Sphere (FV3) as the foundation for building the nation's unified weather-climate prediction system for the next 10-20 years
- The New FV3 (nu-FV3) will be breaking the traditional boundary between "dynamics" and "physics"

Anomaly Correlation Coefficient (500-mb Height)



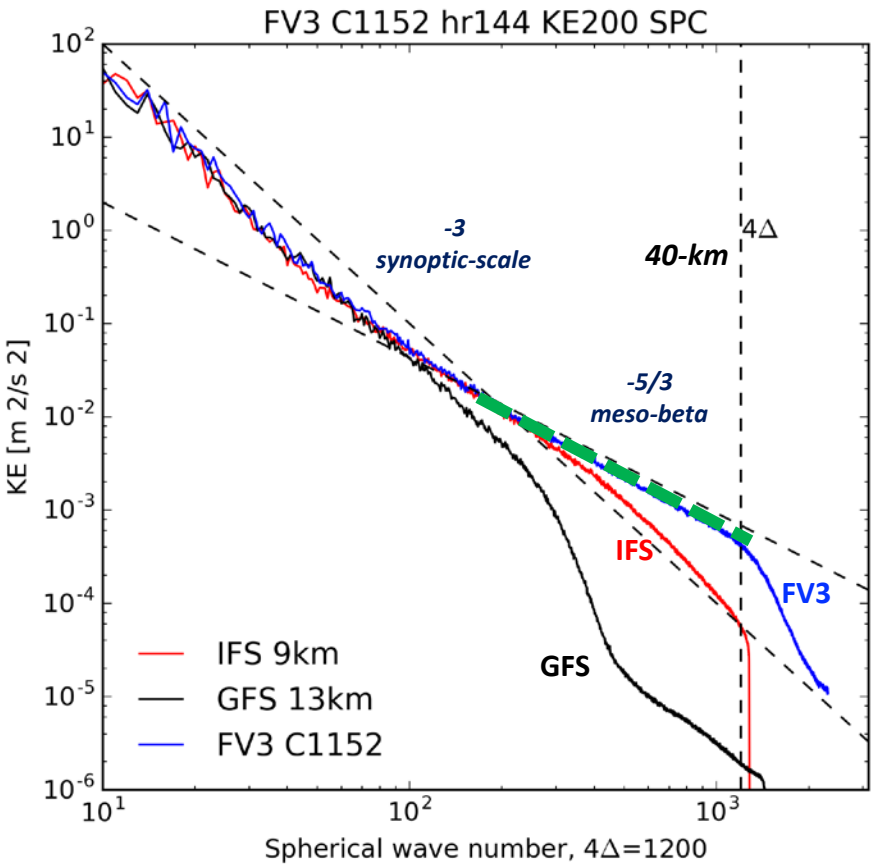
Day-0 Day-8

Kinetic Energy Spectra (200-mb)



Kinetic Energy Spectra are the *fingerprints* of the dynamics

(determined mostly by "total diffusion")



Total diffusion = implicit + explicit diffusion

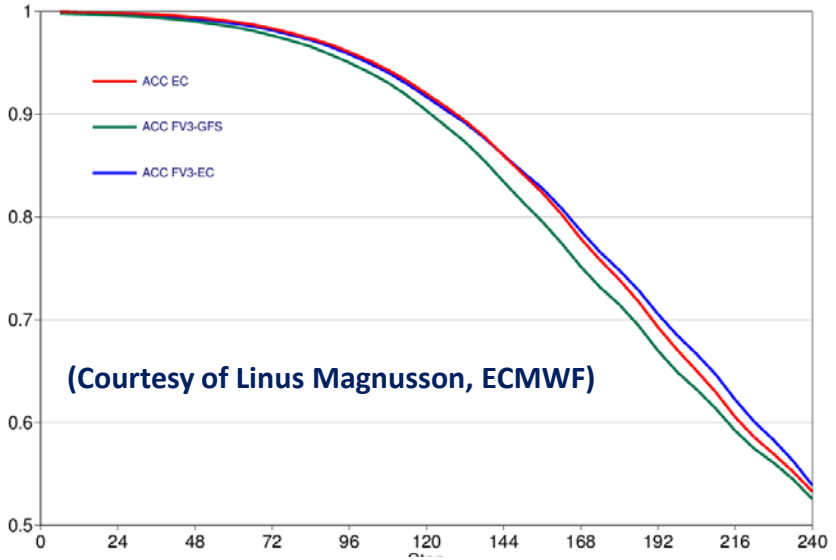
- FV3 at C1152 (9km, roughly the same as "Euro" IFS) resolves the "-5/3" meso-beta (20-200 km) spectrum
- The "Euro" IFS has much lower energy in the meso-scale; but it does follow "-3" spectrum (synoptic scale) well
- The GFS has the least amount of energy in the meso-scale (3 orders of magnitude smaller than FV3 and the theoretical value)

Higher ACC ☛ more accurate hurricane tracks

74 cases initialized with GFS IC

73 cases initialized with IFS IC

fvGFS with 2-Δx flux-limiter



Better than GFS

GFS as the baseline

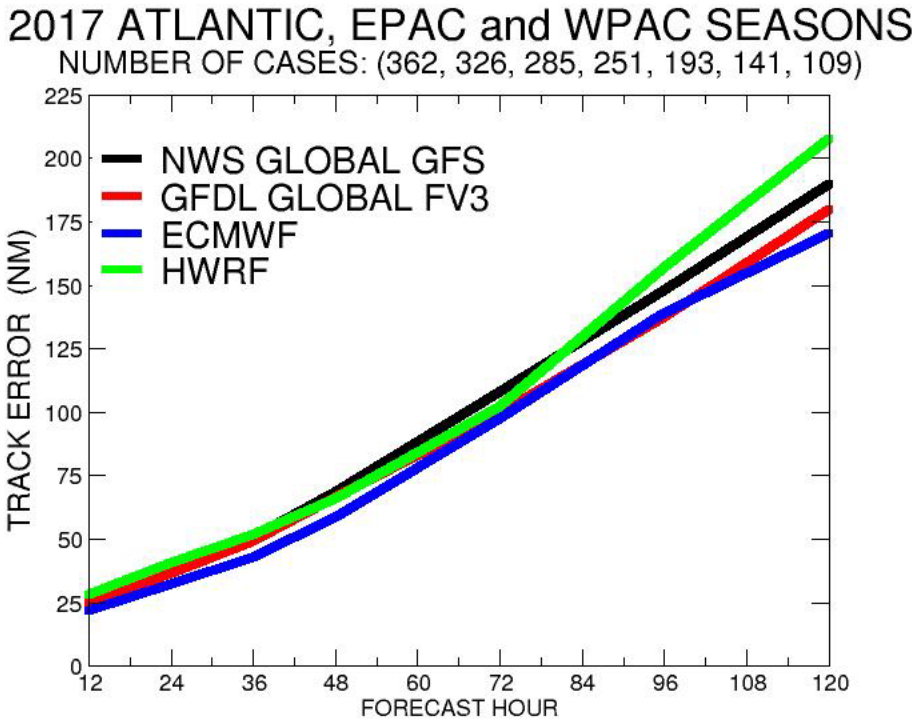
Worse than GFS

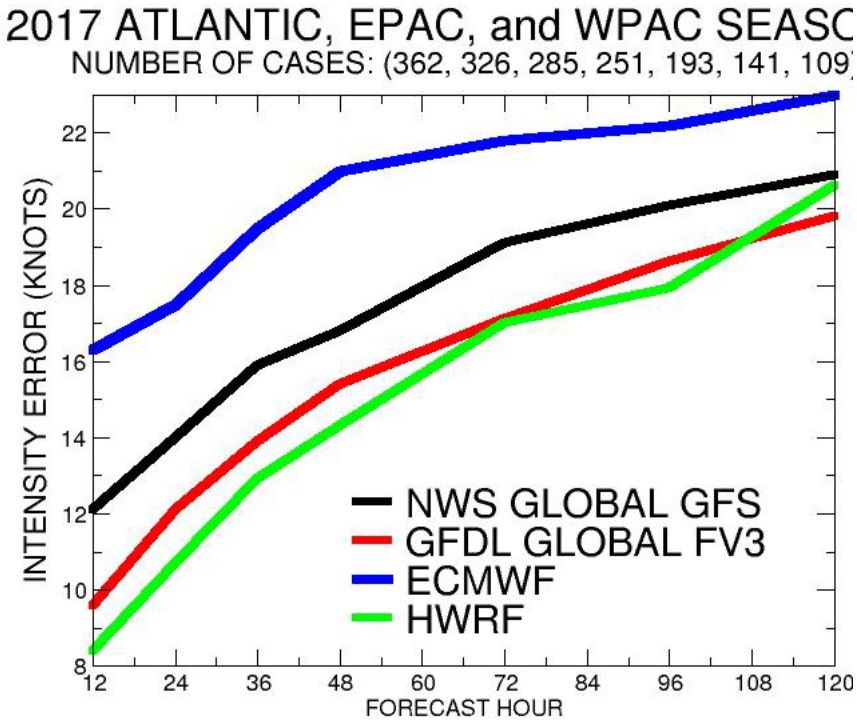
IFS FV3

- fvGFS (FV3 with GFDL MP) initialized with GFS IC caught up with the IFS after day-9
- fvGFS with same IC as IFS is comparable to IFS up to day-7 and outperforms IFS after that

Performance of fvGFS in real-time forecasts of global tropical cyclones during 2017 (up to Oct 23)

- For all basins, FV3 is comparable in “track errors” to the best operational model in the world (the “Euro” IFS)
- For all basins, FV3 is comparable in “intensity errors” to the best intensity model in the world (HWRF)

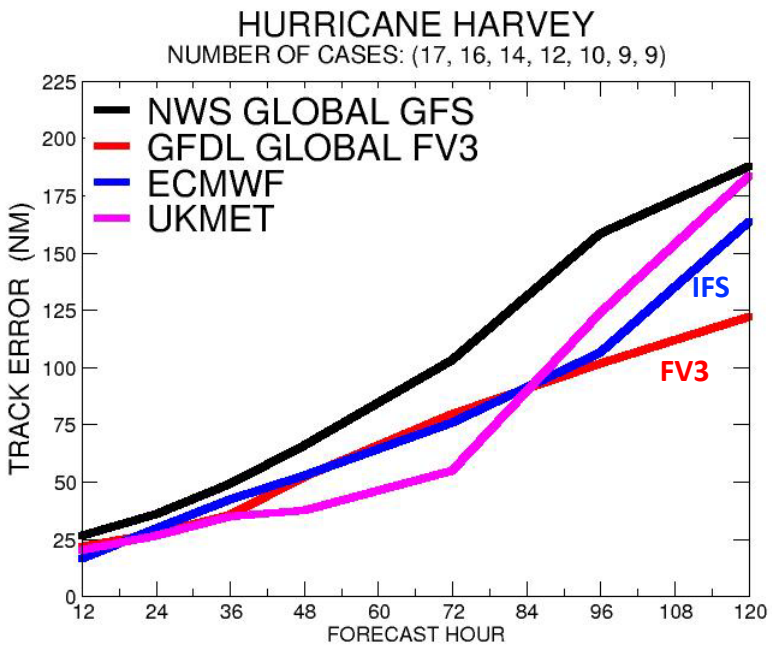




Performance of fvGFS in experimental real-time forecasts hurricanes Harvey & Irma

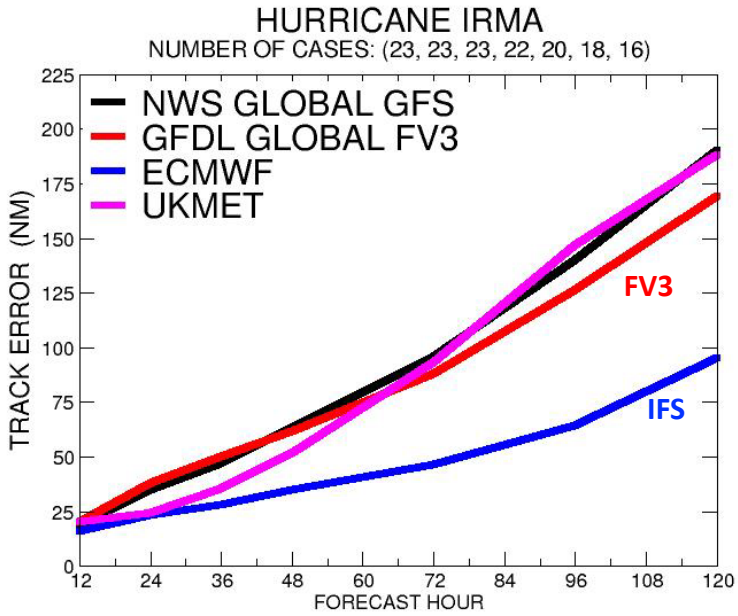
Comparisons of track errors with operational global models

Harvey



FV3 is the best for Harvey

Irma



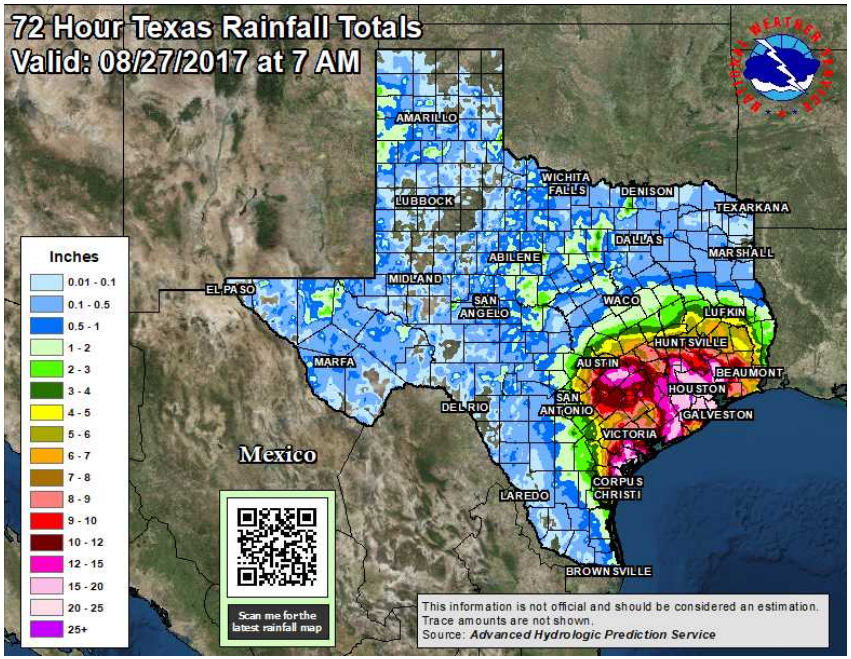
IFS is THE BEST for Irma

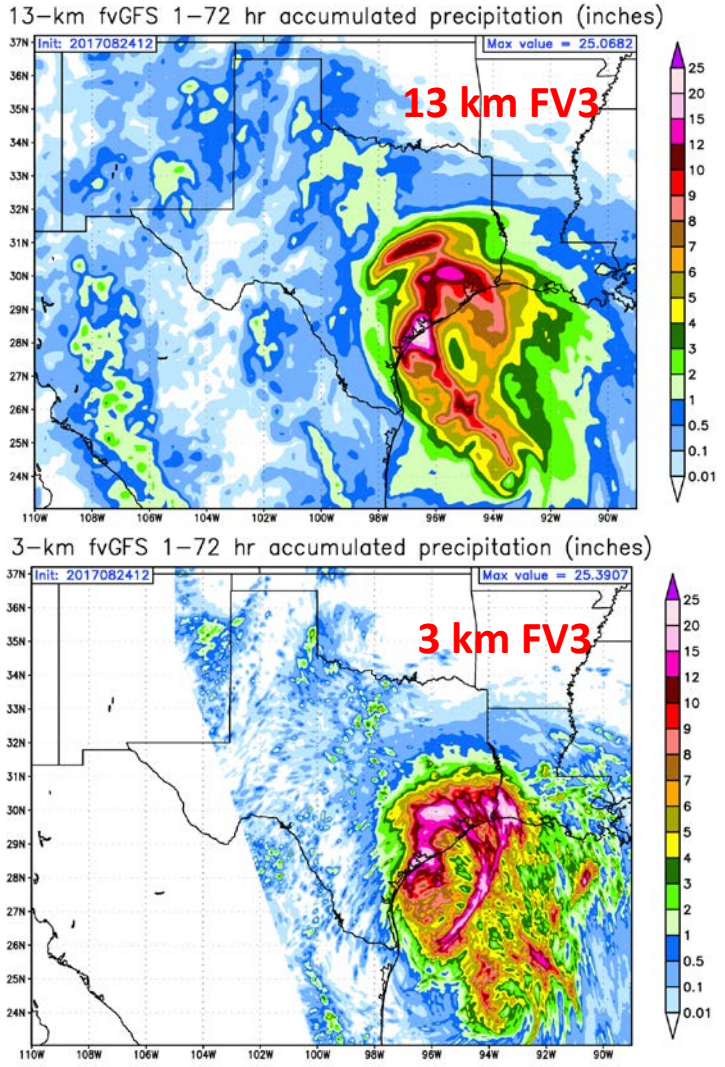
Hurricane Harvey: flooding produced the most damage

Precipitation Verifications in Inches

INIT: 2017082412

OBSERVED 72h PRECIPITATION TOTALS



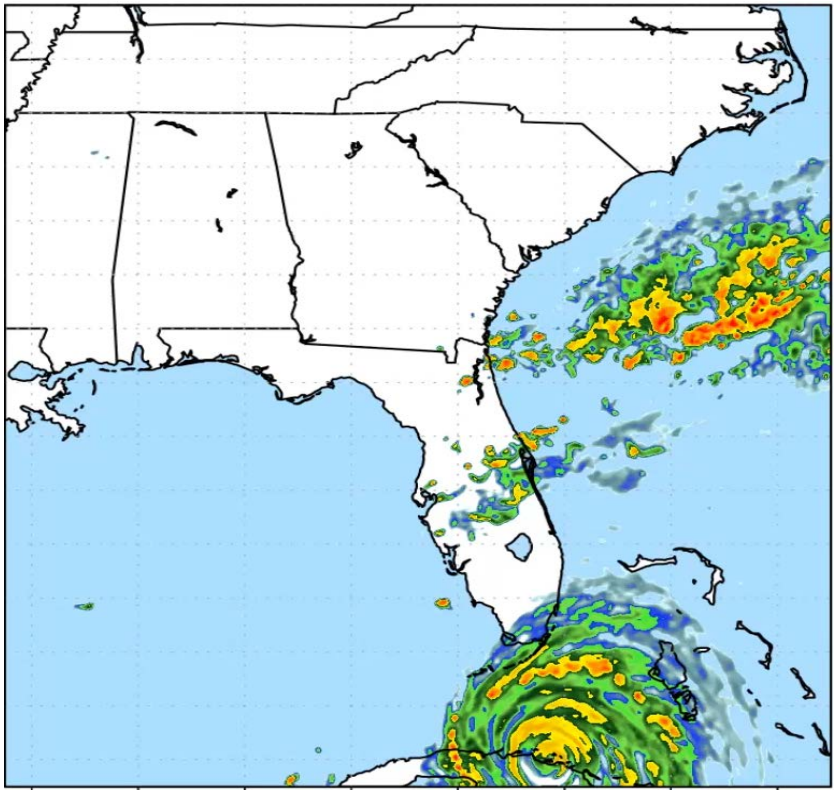


Hurricane Irma: 3-km fvGFS vs. Radar

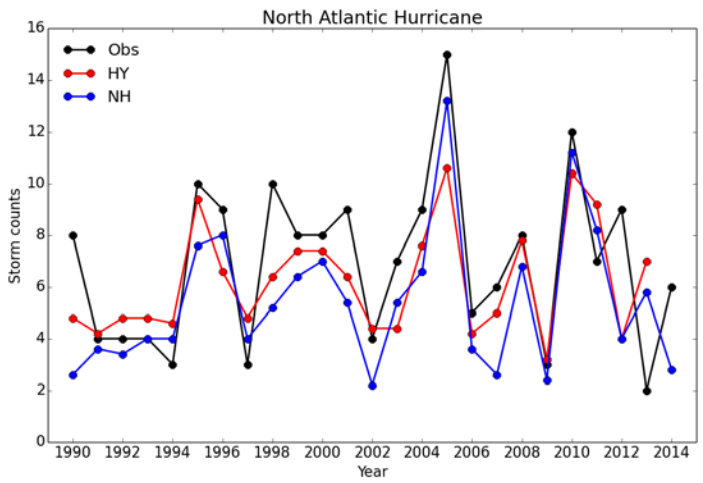
The Next Generation Hurricane Prediction System – a global model with regional resolution

Observed radar image (Brian McNoldy)

Nested FV3 forecast from 0906 (Andrew.Hazelton@GFDL)



Seasonal hurricane Prediction with GFDL HiRAM



***"The remarkable predictability of the inter-annual variability of Atlantic hurricane activity during the past decade"* (Chen and Lin 2011, GRL)"**

⇨ **model-observed correlation > 0.94**

Periods	HY	NH
2000-2010	0.94	0.96
1990-2014	0.72	0.76

The non-hydrostatic FV3-based HiRAM provided improvements over the hydrostatic (HY) HiRAM (Chen & Lin 2011)

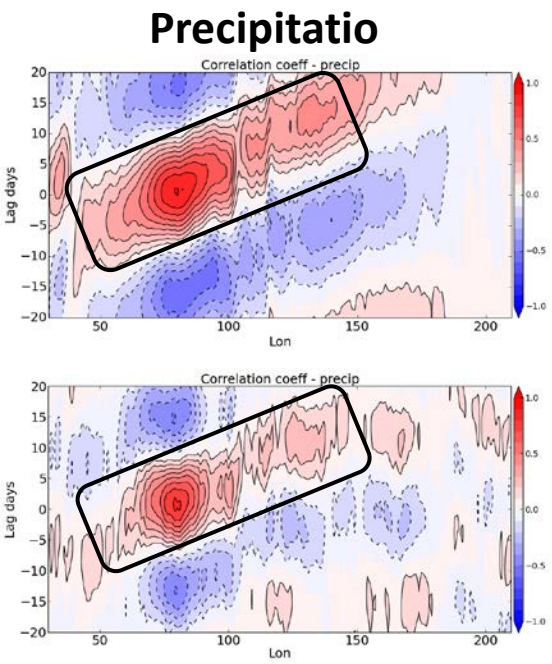
Seasonal hurricane predictions with GFDL HiRAM

Impact of MJO on Gulf of Mexico tropical cyclones

(Kun et al., submitted)

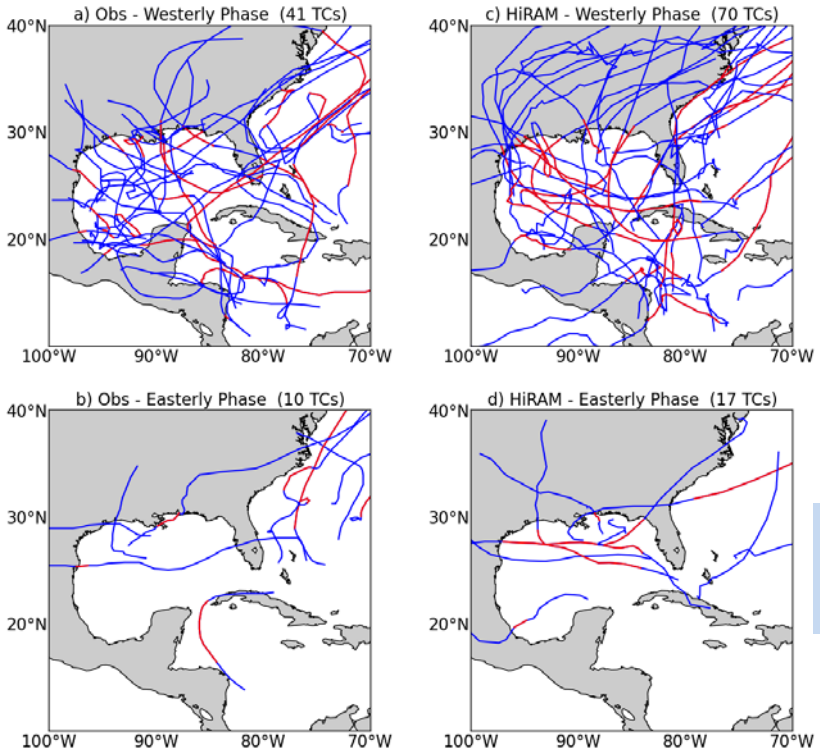
Obs

HiRAM



Observation

HiRAM



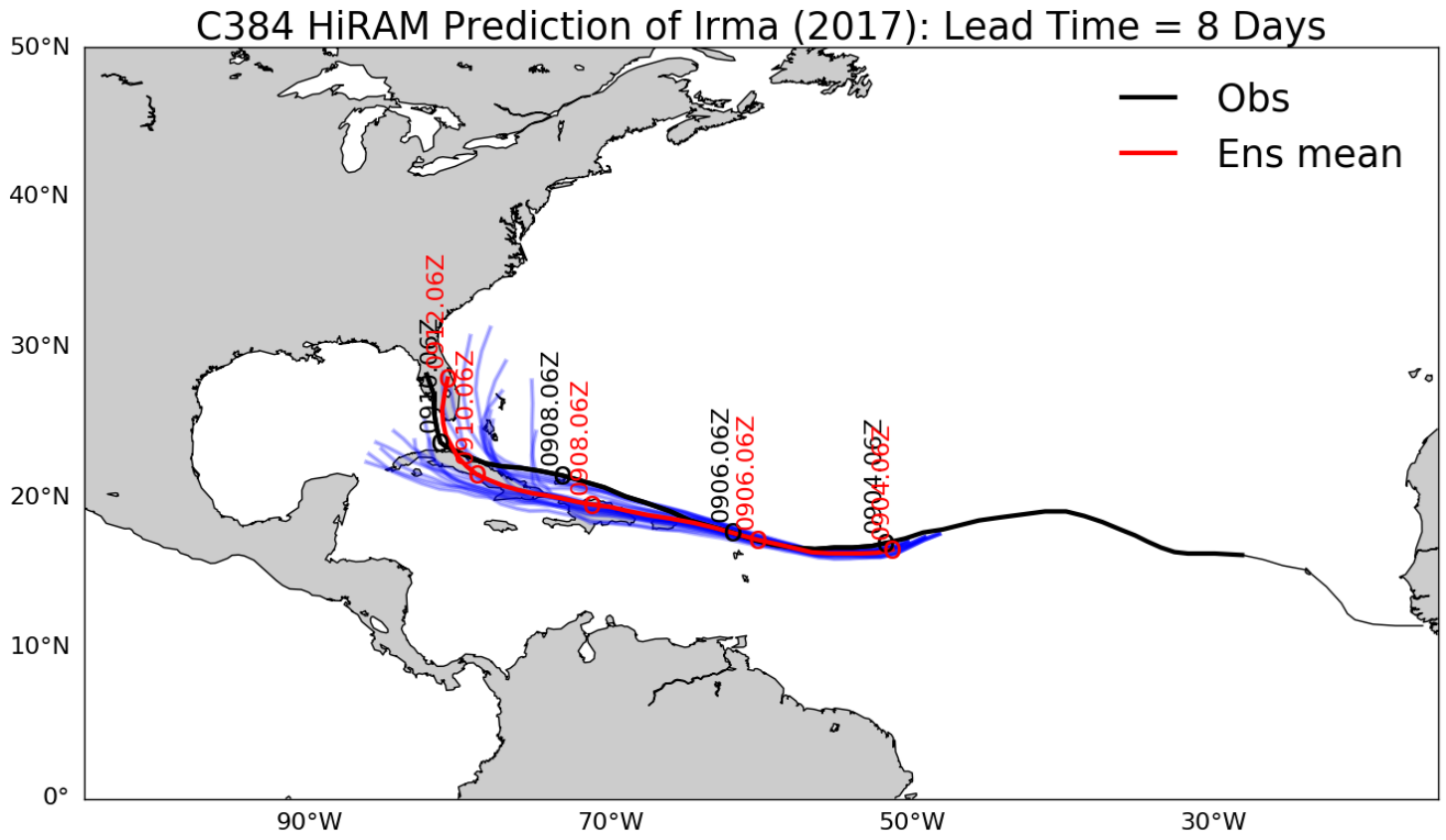
Convectively enhanced MJO Phase

Blue - Tropical Storms
Red - Hurricanes

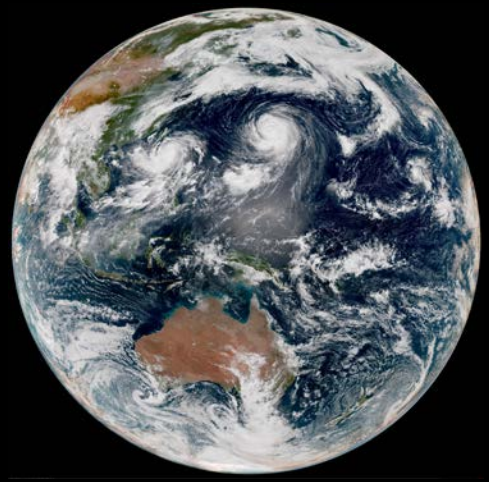
Convectively suppressed MJO Phase

Long-range prediction of Irma with GFDL HiRAM: 8 Day Lead

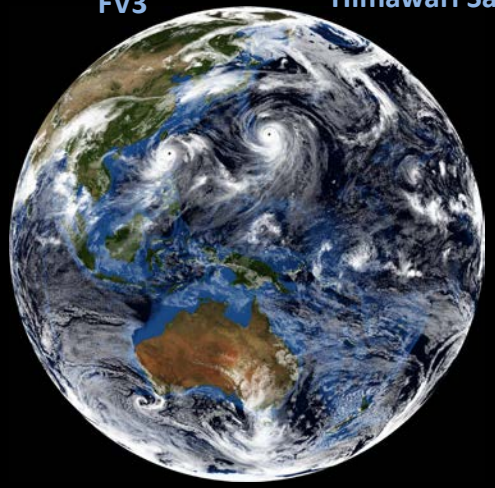
Physically based ensemble by time-lag and perturbed physics (Gao & Chen)



The next generation FV3 for long-range predictions: challenge and path forward



FV3 Himawari Satellite



The Challenge:

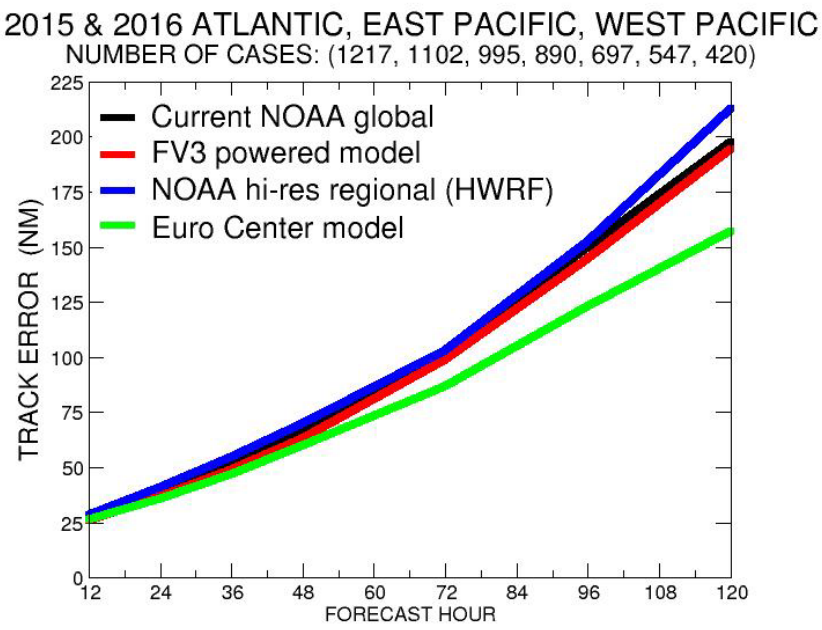
- Building a GFDL global-regional prediction system with resolution high enough to resolve hurricanes & thunderstorms (*via* 2-way nest, next talk) and efficient enough for ensemble seasonal predictions

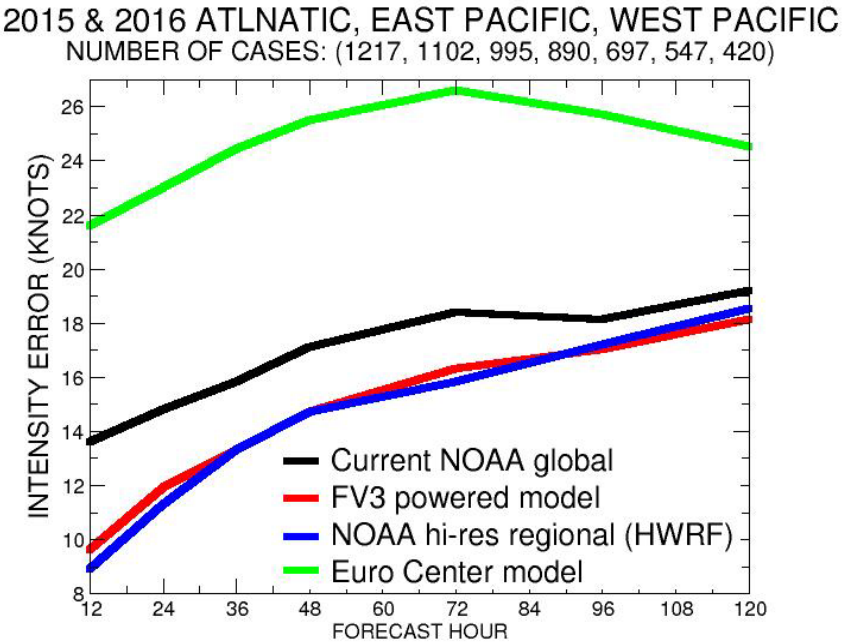
Path forward: the next generation "new" FV3

- Embedding Sub-Grid Orography (SGO) processes and cloud micro-physics (MP) within the FV3 – the next evolution of the "dynamical core"
  - Precise FV integration of SGO "mountain blocking" and SGO-forced "3D gravity waves" (via bottom BC in the non-hydrostatic solver of the ***nu-FV3***)
  - Explicit consideration of SGO within the cloud MP (e.g., precip from subgrid mountain lifting)

Performance of fvGFS in retrospective forecasts of all tropical cyclones during 2015-2016

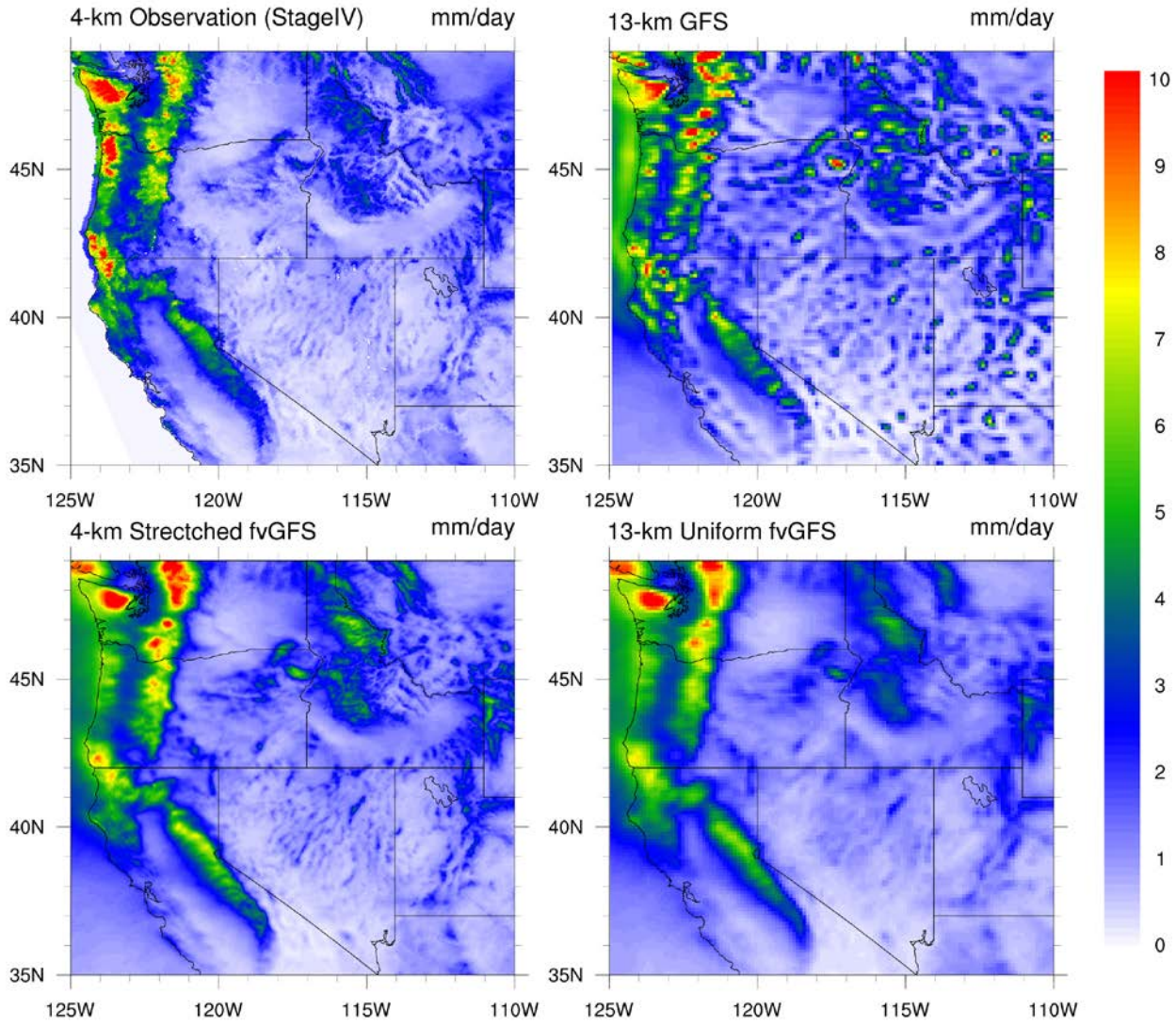
- **Track errors are slightly improved over operational GFS; IFS is THE best for track prediction**
- **Intensity skill is as good as the best intensity model in the world (HWRF); IFS is worst in intensity**





(analysed by Morris Bender)

An alternative approach to ultra-high resolution (convection permitting over CONUS)



CONUS precipitation (2015–2016, clock-wise, from upper left)

- **Observation**
- **13-km operational GFS**
- **13-km fvGFS**
- **4-40 km variable-resolution fvGFS**