FV³-powered Global-to-Regional Modeling at GFDL and Beyond

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WHAT IS FV³? FV³ IS:

• **Fully finite volume!** Flux divergences + vertical Lagrangian + integrated PGF with excellent advection, nonhydrostatic option, and rigorous thermodynamics

But...

FV³ is just a dynamical core not a model itself

Needs physics, land model and ocean to be a complete model

• **Proven** effective at all scales. Maintains the large-scale circulation while accurately representing mesoscale and cloud-scale

• **Popular!** FV³ the global core of choice for NOAA and NASA; predecessor FV standard in CESM and GEOS-CHEM community models, with FV³ coming soon
TWO-WAY NESTING IN FV³

- **Simultaneous** coupled, consistent global and regional solution. **No waiting for a regional prediction!**
- Different grids permit different parameterizations and timesteps; **doesn’t need a “compromise” for high-resolution region**
- **Flexible!** Great possibilities for combining nesting and stretching.
NESTED-GRID HIRAM SUBSEASONAL FORECASTS

- HiRAM 4: FV$^3$ and AM2 physics + GFDL six-category microphysics and UW/GFDL double-plume convection

- Subseasonal forecasts: Chen & Lin (2012, 2013) seasonal frozen SST anomalies methodology

- 5-member perturbed-physics 30-d forecast ensemble from 1$^{st}$ of each month
Hiram Subseasonal Forecasts 2000-2015
North Atlantic Major Hurricanes

25 km Uniform

8 km Nested

TC Energy x 1e5 (knot^2)

obs; mean = 0.63
mod; mean = 0.26; cor = 0.5

obs; mean = 1.6
mod; mean = 0.72; cor = 0.49

obs; mean = 1.25
mod; mean = 1.17; cor = 0.64

obs; mean = 2.22
mod; mean = 1.88; cor = 0.71

Courtesy of Kun Gao
3-KM NESTED fvGFS

• fvGFS: FV³ coupled to GFS physics

• Prototype and proof-of-concept for next-generation GFS and unified global-to-regional forecast model

• Simple GFS microphysics replaced with GFDL six-category scheme

• CONUS nest to 3 km for severe storm forecasts

• Atlantic nest to 2km for hurricane forecasts
SEVERE CONVECTION IN \textit{fvGFS}

2013 MOORE OUTBREAK FORECAST INITIALIZED 00Z 18 MAY (72 HOUR LEAD)
TUNED SAS-SHALLOW AND PBL, NO DEEP CONVECTION
SEVERE CONVECTION IN fvGFS

2012 DERECHO FORECAST INITIALIZED 00Z
27 JUNE (72 HOUR LEAD)

TUNED SAS-SHALLOW AND PBL,
NO DEEP CONVECTION

fvGFS w2500, lowest-level winds, T
HURRICANE MATTHEW

INITIALIZED 5 OCT 2016
DEEP CONVECTION ON
TUNED SAS-SHALLOW AND PBL

Courtesy Andy Hazelton and Morris Bender
GLOBAL CONVECTION-RESOLVING FORECASTING

2009: NASA GEOS-5 at 3.5 km global resolution

2017: GFDL fvGFS at 3-km global resolution
45 mins/day with 18.5K processors

Courtesy S-J Lin and Shannon Rees
PLANS FOR GLOBAL-TO-REGIONAL MODELING

• fvGFS: Working towards real-time 3-km system for HWT Spring Experiment
  • Improvements to land model, microphysics, and forecast diagnostics
  • Longer term: considering Thompson MP, YSU PBL, UW/GFDL Convection, etc.

• HiRAM & AM4: Bring grid refinement into next GFDL model
  • Convection-permitting (and resolving?) seasonal and longer simulations

• NCEP & AOML FV³-powered models:
  • 3-km NAM physics
  • Moving nested grids for next-generation HWRF

• NASA: 1.5-km GEOS forecasts coming soon
  • 3-km, year-long global nature run planned
ADDITIONAL SLIDES
PLANS FOR CONVECTION-RESOLVING fvgfs APPLICATIONS

- Thompson, Ferrier, or M-G Microphysics (collaboration with OU-CAPS and EMC)
- YSU, EDMF, or M-Y-type PBL
- Higher-resolution land model inputs
- Two fvgfs variants for the 2017 HWT Spring Experiment:
  - GFDL: fvgfs with GFDL MP
  - OU-CAPS: fvgfs with Thompson MP
- FV^3-powered NAM and HWRF planned at EMC and AOML
- Convection-resolving and convection-permitting GFDL HiRAM/AM4 to continue

fvgfs is still improving! Stay tuned for further updates.

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TWO-WAY NESTING IN FV³

- Correct inflow/outflow BCs "baked-in" by FV³ upwinding fluxes
- Concurrent nesting permits both domains to be run simultaneously
- Two-way updating of winds, w, and temperature consistent with finite-volume discretization
- Trivial mass conservation by not updating the mass field
2015 HINDCAST SKILL IN NESTED fvGFS

CONUS Precipitation Fractions Skill Score
12 km neighborhood for nested,
40 km for uniform

fvGFS 13 km
fvGFS 3 km (no deep)
fvGFS 3 km (w/ deep)
GFS 13 km