Strategic Implementation Plan (SIP) for a Community-based Unified Forecast System (UFS)

Dynamics and Nesting Working Group

Presented by
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Presented at Coordination Meeting for UFS SIP
May 14-16, 2019; College Park, MD
# Dynamics and Nesting WG

## Membership

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<td>Tallapragada</td>
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<td>Alex</td>
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<td>Wang</td>
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<td>Michalakes</td>
<td>John</td>
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<td>Valery@</td>
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<td>Doyle</td>
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- **Co-Chairs**
- Core WG Members @
Dynamics and Nesting WG
Project Milestone Accomplishments

• SIP project accomplishments to date:
  • FV3 Dynamics:
    o FV3GFS V1.0 (GFSv15.1) is on target for Q3FY19 (June 12, 2019); FV3GEFS (GEFSv12) planned for Q4FY20
    o FV3+MOM6+CICE5+WW3 Coupled System Development is in progress
    o FV3 dynamic core integrated into CESM; shared with NASA/GSFC/GMAO
  • Stand-Alone Regional FV3 (Project 4.1):
    o Successful setup of a functional FV3-SAR along with FV3 parent with 3km Nest.
    o Real-time experiments are run comparing regional forecasts and those of a nest on the parent cube at 3km resolution. Forecasts skills are very similar indicating that FV3 in regional mode is working properly while running in 40-50% less time than the global/nest setup when using the same resources
    o Refinements of the regional version of the model are ongoing
Dynamics and Nesting WG
Project Milestone Accomplishments

• Hurricane Moving Nests (Project 4.2):
  ○ Merge of separate EMC and HRD efforts for nesting within NGGPS/UFS
  ○ Two static nests in two different tiles capability was created by AOML, GFDL, and EMC based on EMC's FV3GFS-nest repository
  ○ Planned evaluation of real-time configuration for FV3GFS-nest and FV3SAR for hurricanes (EMC, AOML, GFDL)
  ○ Establishment of a well coordinated HAFS plan and ongoing efforts between six different groups

• DAD and WAM (Project 4.3):
  ○ Development of vertical extension of FV3GFS-127L to 80 km top lid for GFSv16
  ○ For DAD+WAM project in progress, FV3 has been extended vertical domain to cover WAM needs up to about 600 km top lid with 149L, and thermodynamics parts of DAD by multi-gases option has been implemented
FV3 Real-Time CAM Testing
(Project 4.1)

Current Status:

• Running daily forecasts of 3 regional configurations of the FV3 model w/GFDL MP and FV3GFS (GFS v15.1) IC/BC at EMC on WCOSS Dell:
  – (a) 3-km nest within the FV3GFS global domain compared to (b) 3-km stand-alone regional configuration; and (c) SAR with regional DA.

• A web page comparing the three runs is at [www.emc.ncep.noaa.gov/mmb/bblake/fv3/](http://www.emc.ncep.noaa.gov/mmb/bblake/fv3/) and FV3SAR w/NAM Nests is at [www.emc.ncep.noaa.gov/mmb/mmbpl/conushourly60/](http://www.emc.ncep.noaa.gov/mmb/mmbpl/conushourly60/)

• Two pairs of CLUE members with matching physics configurations (EMC FV3 and SAR FV3) are run for HWT2019 Spring Experiments where one member uses a global configuration of FV3 with a high-resolution nest over the CONUS, and the other member uses SAR FV3 with ICs/LBCs provided by the FV3GFS (GFS v15.1).

Risks/Issues:

• The imbalance between the regional domain interior and the boundary following the DA spinup cycle must be adequately addressed.

• Blending between the boundary and interior to be added.

• Construction of a standalone regional FV3 domain that can contain nests will involve some significant modifications and additions to both the pre-processing and to the model code, and the underlying framework(s) (FMS for construction and ESMF for coupling to external models).
FV3 Real-Time CAM Testing (Project 4.1)

Nest Regional Composite Reflectivity

24 Hr Fcsts

FV3NEST Composite Reflectivity (dBz)
initialized: 04/30/2019 00z valid: 05/01/2019 00z (f24)

FV3SAR Composite Reflectivity (dBz)
initialized: 04/30/2019 00z valid: 05/01/2019 00z (f24)

MRMS Composite Reflectivity (dBz)
valid: 05/01/2019 00z

Composite Reflectivity

1 May 2019 0000 UTC
FV3 Real-Time CAM Testing (Project 4.1)

FV3SAR DA Runs and model noise - 500 hPa Hgts

Hours 0 - 6 of the free forecast following the 6-hr DA spinup

FV3SAR – NAM NEST DA Runs – F01 SLP

Significant differences show up comparing FV3SAR with NAM Nest (both with DA)
Hurricane Moving Nest (Project 4.2)
Single 3km Nest on Global Parent

Proposed Real-Time Demo Configuration for HFIP during 2019 Summer

Global-Nest HAFS V0.B

Sea-level pressure: mb 2018100712 -- F000 850mb wind: m/s
Hurricane Moving Nest (Project 4.2)

Multiple Static Nests

Extend from One to Many Nests (non-overlapping, one per tile):

- Understand nesting code
- 1st stage toward multiple moving nests

Code Modifications:

- Grid and terrain generation step
- Interpolation of GFS initial conditions (chgres)
- FV3 dynamic core

FMS changes are being made by GFDL for moving nests and telescopic nests
Hurricane Moving Nest (Project 4.2)
Two Static Nests on Two Tiles

- Stable runs to 96 hours
- Scalable performance
- 24 (12) cores global (nest)
- 1 nest:36 cores: 1:29
- 2 nests:48 cores: 1:32
- Validation underway
- Original single nest results identical
- Multiple nests alter forecast in expected ways

**Issues:** Terrain smoothing
- Disable full_zs_filter
- Different results for terrain height depending on number of cores

- Debugging options causing numerical inconsistencies

**Maria, Jose (NATL) and Otis (EPAC)**

- 10m wind speeds
- Init: 20170918 00Z
- 4x refinement (~25km)
Deep Atmosphere Dynamics (Project 4.3)

- Significant progress in developing the Deep Atmosphere Dynamics for FV3-WAM
- FV3 top layer has extended to 600km (1.0E-7 pascal) with gas distributions of O, O2, and others.
- Accurate implementation of Multi_Gases for thermodynamics and coupled with physics
- Implementing WAM physics with physics coupling and evaluation/compare with GSM-WAM
- Working to have molecular diffusion to remove/reduce top layer Rayleigh damping for stability
- Shallow-atmosphere form for DAD is ready for DAD-FV3 (details in NCEP Office Note #488)

FV3WAM Initial Condition at lat=0 and lon=180; cold start with standard T, P, O, and O2 other fields, wind, and q are gradually decreasing to zero at top. Top pressure is about 1.0E-7 Pa, close to 500~600 km.

In plots below, Y-axis are model layer number from 1 to 150, X-axis is partition of dry gas in left panel, degree K in middle panel, and log10(pascal) in right panel.
Deep Atmosphere Dynamics (Project 4.3)

Accurate implementation of MULTI_GASES into FV3-WAM

- MULTI_GASES adiabatic configuration
- MULTI_GASES Full GFS Physics configuration

no impact on lower atmosphere

*lower 60 vertical levels*
Deep Atmosphere Dynamics (Project 4.3)

```latex
\begin{tabular}{|c|c|c|}
\hline
 & R & Cp \\
\hline
O3 & 173.225 & 820.239 \\
All other dry gases & 286.05 & 1004.60 \\
Water vapor & 461.50 & 1846.00 \\
\hline
\end{tabular}
```

```
Still some issues with upper boundary conditions

FV3-WAM (L150)
```

```latex
\begin{tabular}{|c|c|c|}
\hline
 & R & Cp \\
\hline
O & 519.674 & 1299.18 \\
O2 & 259.837 & 918.096 \\
O3 & 173.225 & 820.239 \\
All other dry gases & 295.389 & 1031.11 \\
Water vapor & 461.50 & 1846.00 \\
\hline
\end{tabular}
```

[adiabatic_multi_gases] at 2017/01/19 07Z
Dynamics and Nesting WG
Team Coordination and Dependencies

- **General D&N WG Team Coordination and Dependencies:**
  - Bi-Weekly calls with WG core group members; occasional meetings with other WGs

- **FV3 Dynamics**
  - Weekly meeting with GFDL and GMAO
  - Monthly meeting with CESM
  - **NEW:** Bi-weekly Dynamics Discussion Study Group at EMC (led by Henry Juang)

- **DAD and WAM**
  - Weekly FV3 DAD meetings led by EMC; 1 FTE funded by SWPC (to me moved to CU)

- **Stand-Alone Regional FV3:**
  - Dependency on FMS modifications by GFDL to develop static, telescopic, and moving nests in regional/global FV3
  - CCPP enabled high-resolution physics needed for testing

- **Moving Nests in FV3:**
  - Bi-weekly HAFS Development Meetings (HFIP)
  - Published HAFS user/developer guide materials
  - [HAFS Developer Guide; Quick Start for HAFS Developers; Quick Start for HAFS Users](#)
  - HSupp activities to gain momentum once funding in place and staff hired
  - Need dedicated HPC resources (MSU, Cloud?? Others?)