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

Dynamics and Nesting Working Group

Presented by

Vijay Tallapragada, NCEP/EMC

Presented at Coordination Meeting for UFS SIP

May 14-16, 2019; College Park, MD

Dynamics and Nesting WG *Membership*

Last Name	First Name	Org
Tallapragada	**Vijay****	**NCEP/EMC**
Harris	**Lucas****	**GFDL**
Gopalakrishnan	**Sundararaman****	**AOML/HRD**
Jablonowski	**Christiane****	**U. of Michigan**
Lin	Shian-Jiann ("SJ")%	GFDL
Reinecki	Alex	NRL Monterey
Wang	Ning	ESRL/GSD
Black	**Tom@**	**NCEP/EMC**
~~Trahan~~	~~Samuel~~	~~NCEP/EMC~~
Jovic	Dusan	NCEP/EMC
Michalakes	John	UCAR (NRL)
Bender	Morris	GFDL

Last Name	First Name	Org
Wicker	Lou	NSSL
Sun	Shan	ESRL/GSD
Govett	Mark	ESRL/GSD
Putnam	Bill	NASA/GMAO
Goldhaber	Steve	NCAR/CGD/CESM
Zhang	**Xuejin**	**AOML/HRD**
Ramstrom	**William**	**AOML/HRD**
Hazelton	**Andrew**	**AOML/HRD**
DeLuca	Cecelia	NESII/ NEMS
Mehra	**Avichal@**	**NCEP/EMC**
Juang	**Henry@**	**NCEP/EMC**
Viereck	Rodney	NCEP/SWPC
Yudin	**Valery@**	**CIRES/CSU**
Doyle	Jim	NRL Monterey

- *Co-Chairs ***
- *Core WG Members @*

Dynamics and Nesting WG Project Milestone Accomplishments

- **SIP project accomplishments to date:**
- **FV3 Dynamics:**
  - FV3GFS V1.0 (GFSv15.1) is on target for Q3FY19 (June 12, 2019); FV3GEFS (GEFSv12) planned for Q4FY20
  - FV3+MOM6+CICE5+WW3 Coupled System Development is in progress
  - FV3 dynamic core integrated into CESM; shared with NASA/GSFC/GMAO
- **Stand-Alone Regional FV3 (Project 4.1):**
  - Successful setup of a functional FV3-SAR along with FV3 parent with 3km Nest.
  - 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
  - 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)

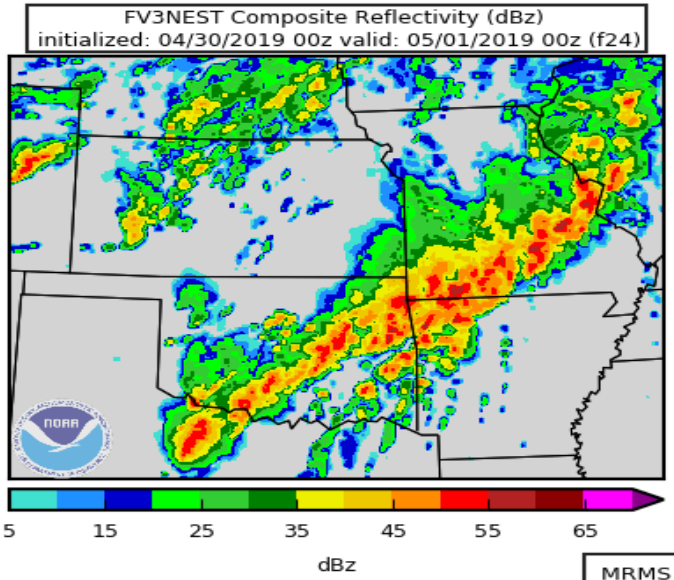
Current Status:

- 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/ and FV3SAR w/NAM Nests is at www.emc.ncep.noaa.gov/mmb/mmbpll/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).

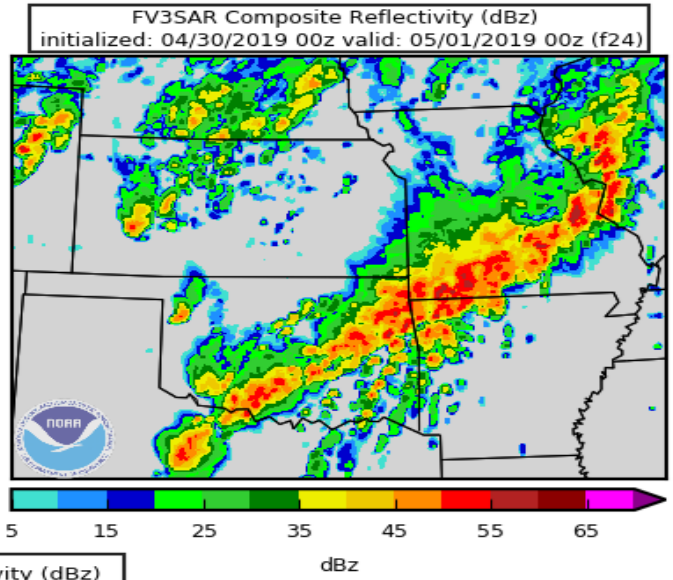
Risks/Issues:

- 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)

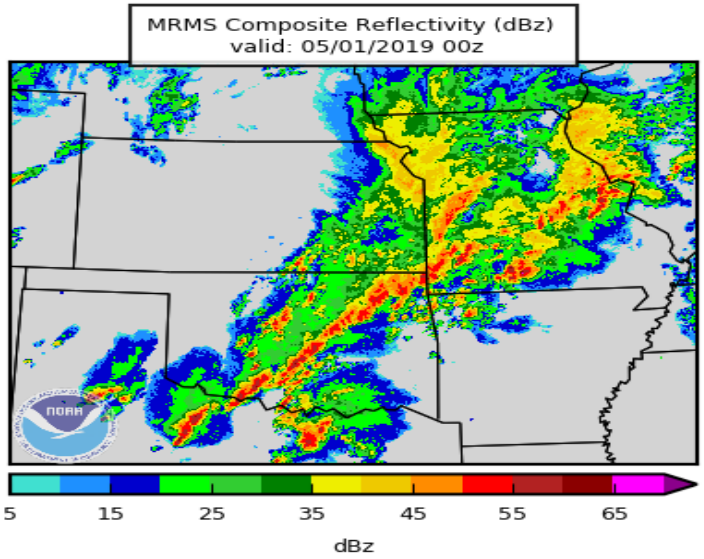


24 Hr Fcsts



Nest

Regional

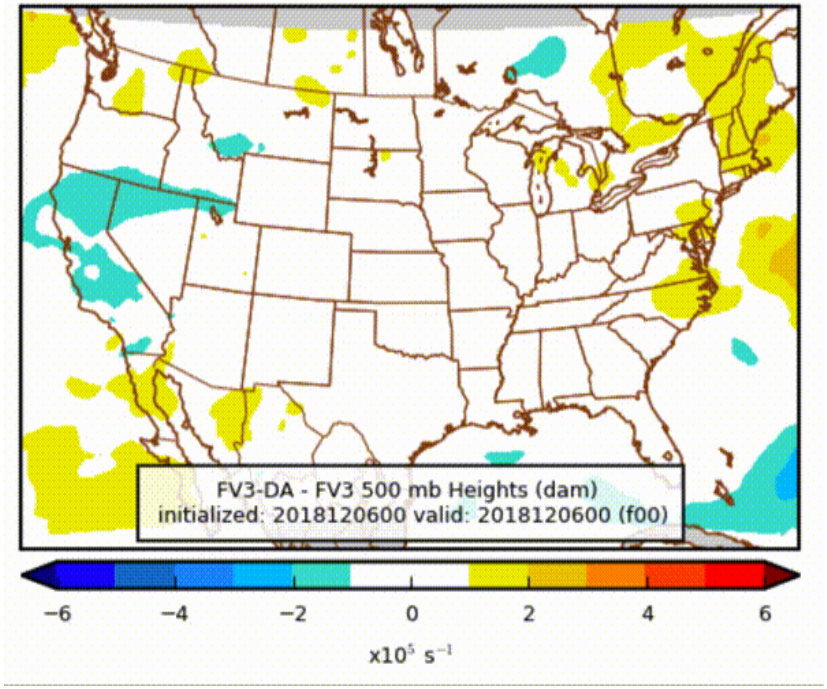


Composite Reflectivity

1 May 2019 0000 UTC

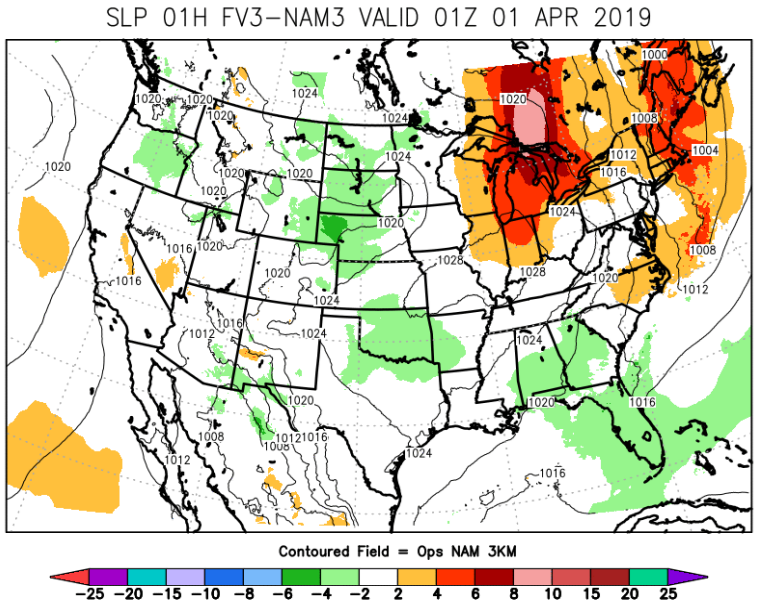
FV3 Real-Time CAM Testing (Project 4.1)

FV3SAR DA Runs and model noise - 500 hPa Hgts



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

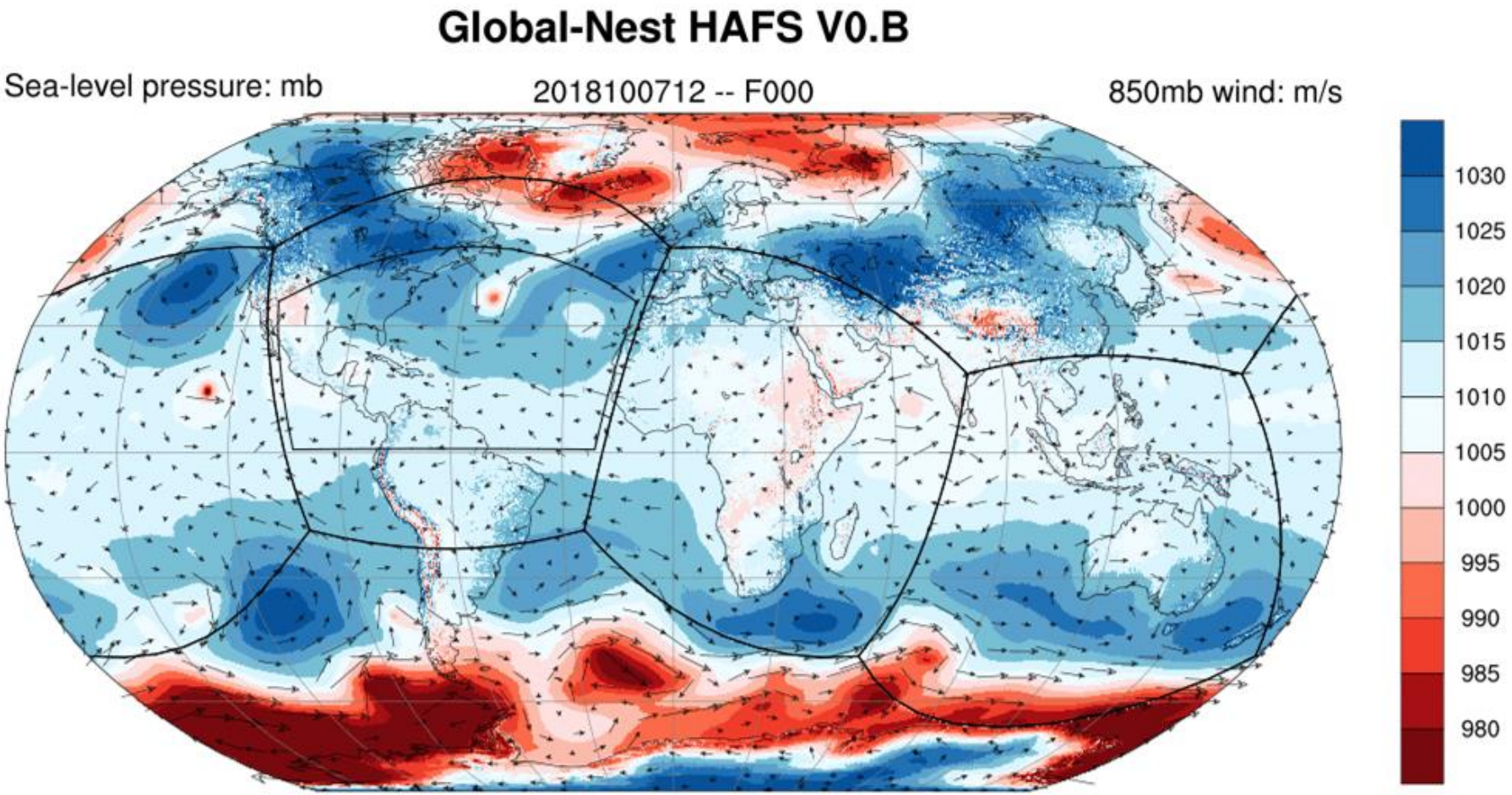
FV3SAR – NAM NEST DA Runs – F01 SLP



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



Hurricane Moving Nest (Project 4.2)
Multiple Static Nests

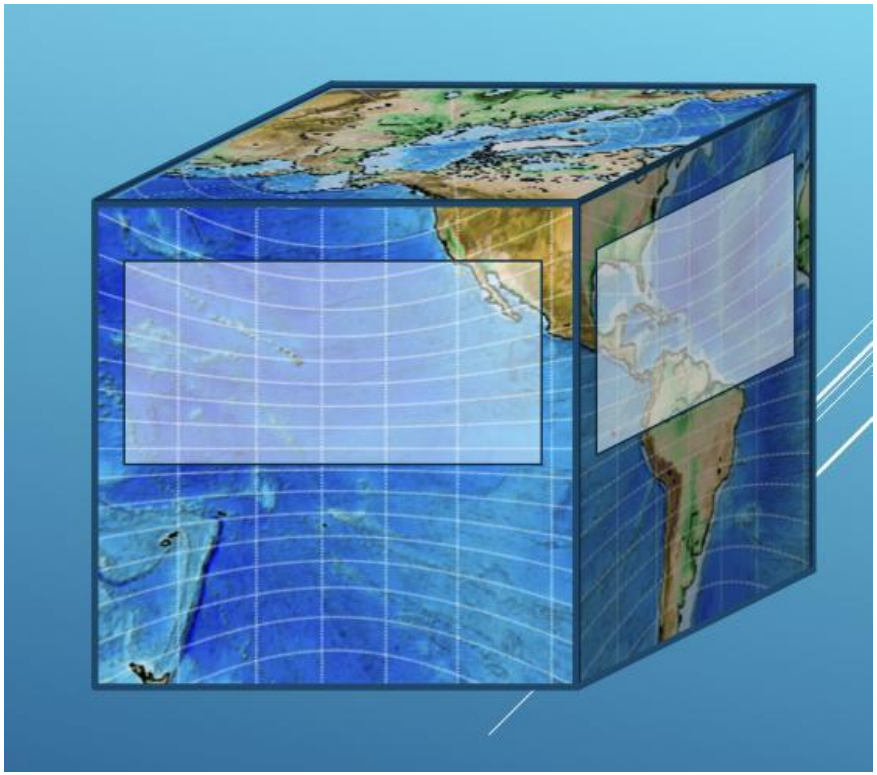
Extend from One to Many Nests (non-overlapping, one per tile):

- 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

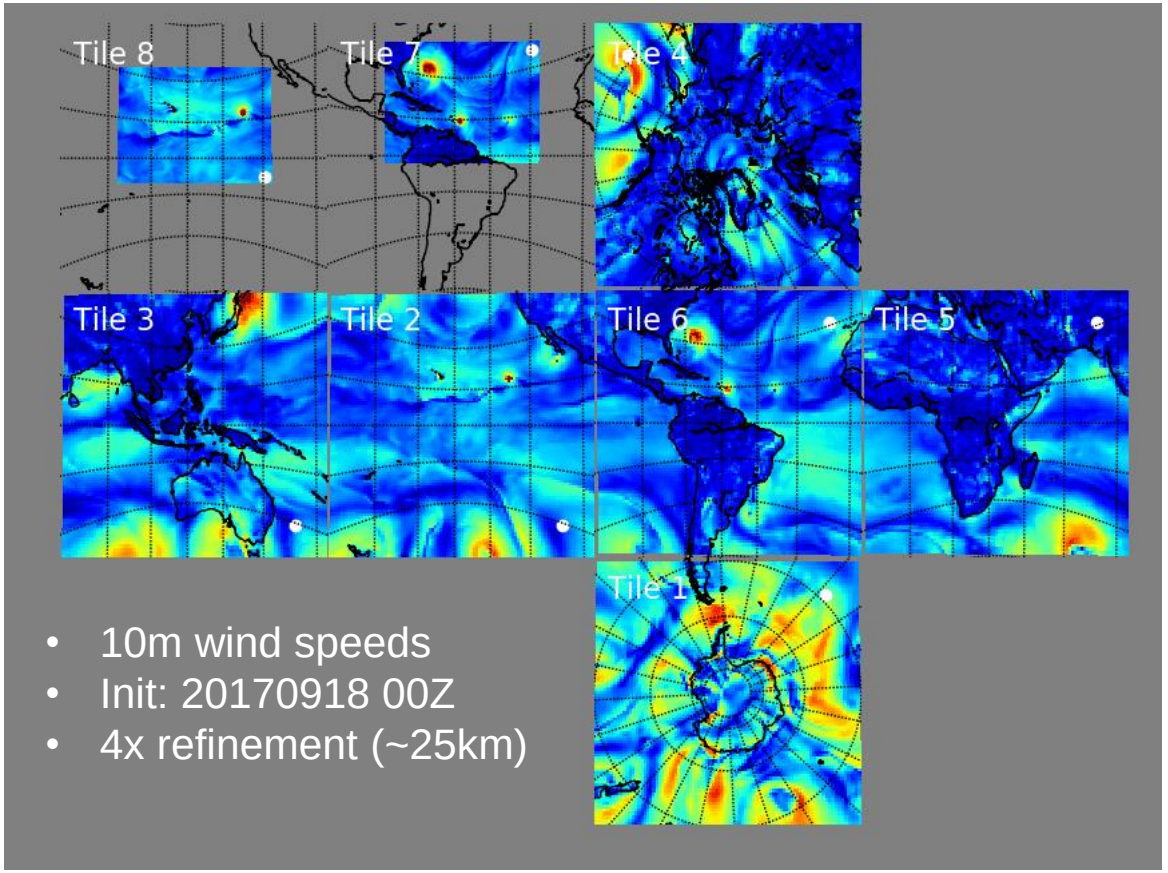
- Stable runs to 96 hours
- Scalable performance
- 24 (12) cores global (nest)
- 1 nest:36 cores: 1:29
- 2 nests:48 cores: 1:32
- Validation underway
- Original single nest results identical
- Multiple nests alter forecast in expected ways

Issues: Terrain smoothing

  - Disable full_zs_filter
  - Different results for terrain height depending on number of cores

- Debugging options causing numerical inconsistencies

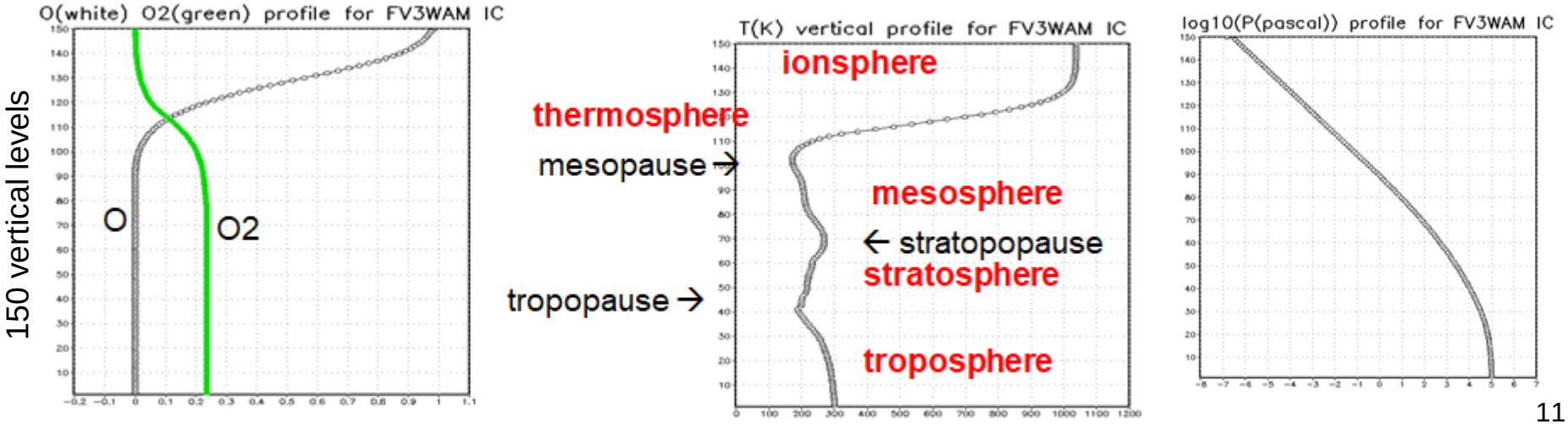
Maria, Jose (NATL) and Otis (EPAC)



Deep Atmosphere Dynamics (Project 4.3)

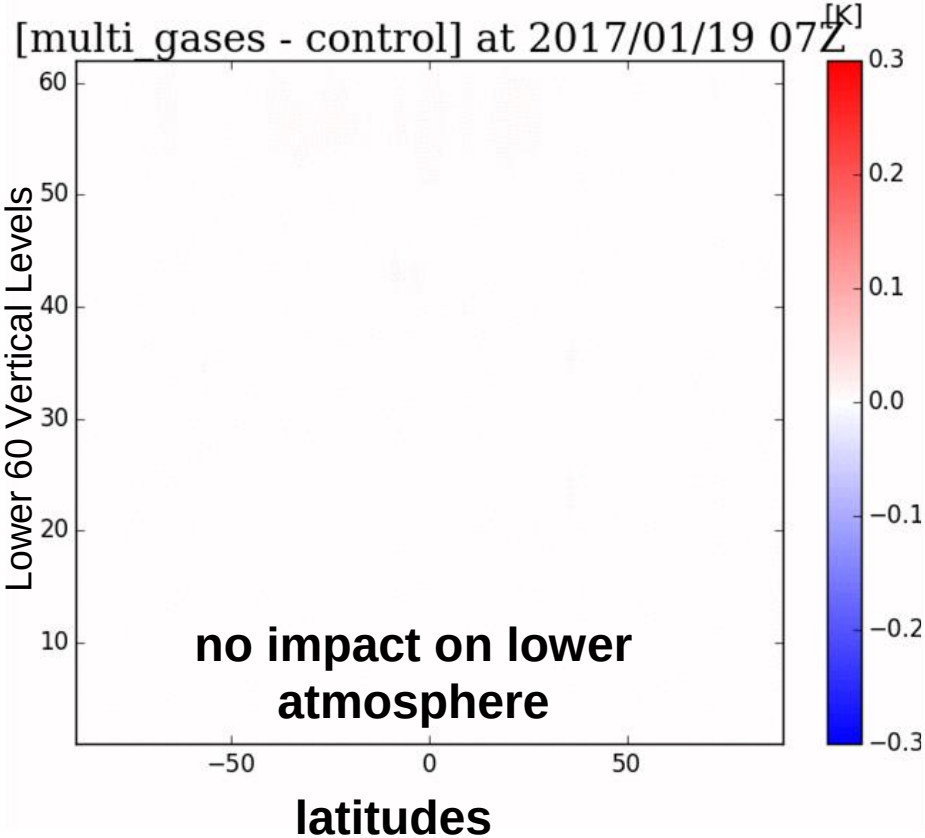
- Significant progress in developing the Deep Atmosphere Dynamics for FV3-WAM
- FV3 top layer has extended to 600km (1.E-7 pascal) with gas distributions of O, O2, and others.
- Accurate implementation of Multi_Gases for thermodynamics and coupled with physics
- Implementing WAM physics with physics 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)

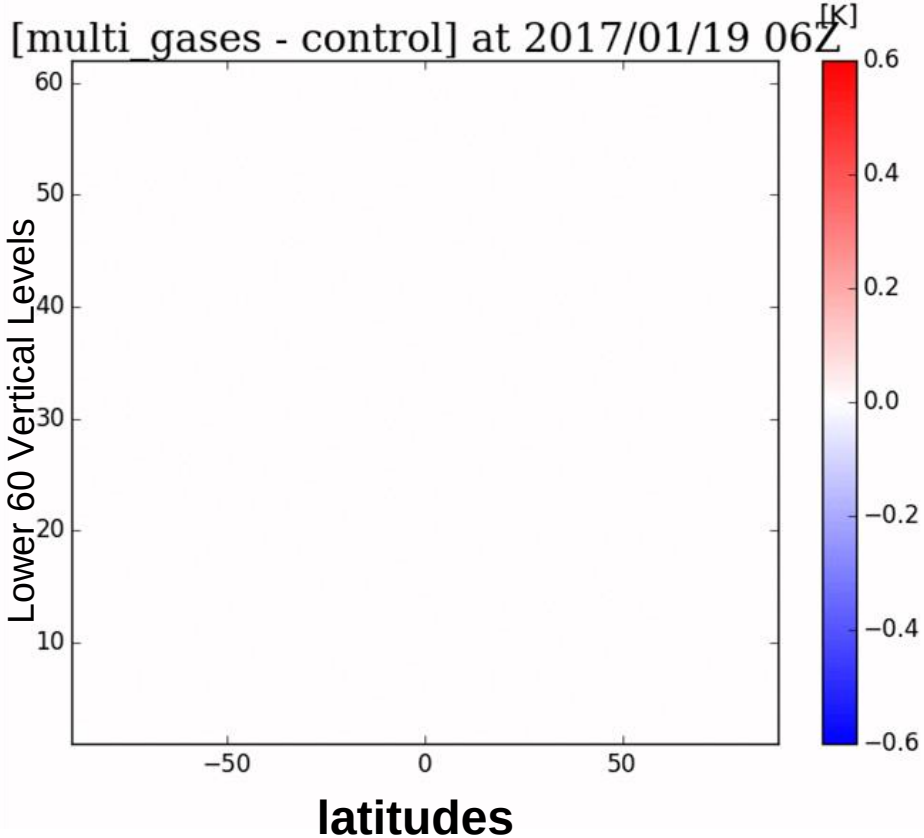
FV3WAM Initial Condition at lat=0 and lon=180; cold start with standard T, P, O, and O2 other fields, wind, and q are gradually decreasing to zero at top. Top pressure is about 1.E-7 Pa, close to 500~600 km
In plots below, Y-axis are model layer number from 1 to 150, X-axis is partition of dry gas in 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

Deep Atmosphere Dynamics (Project 4.3)

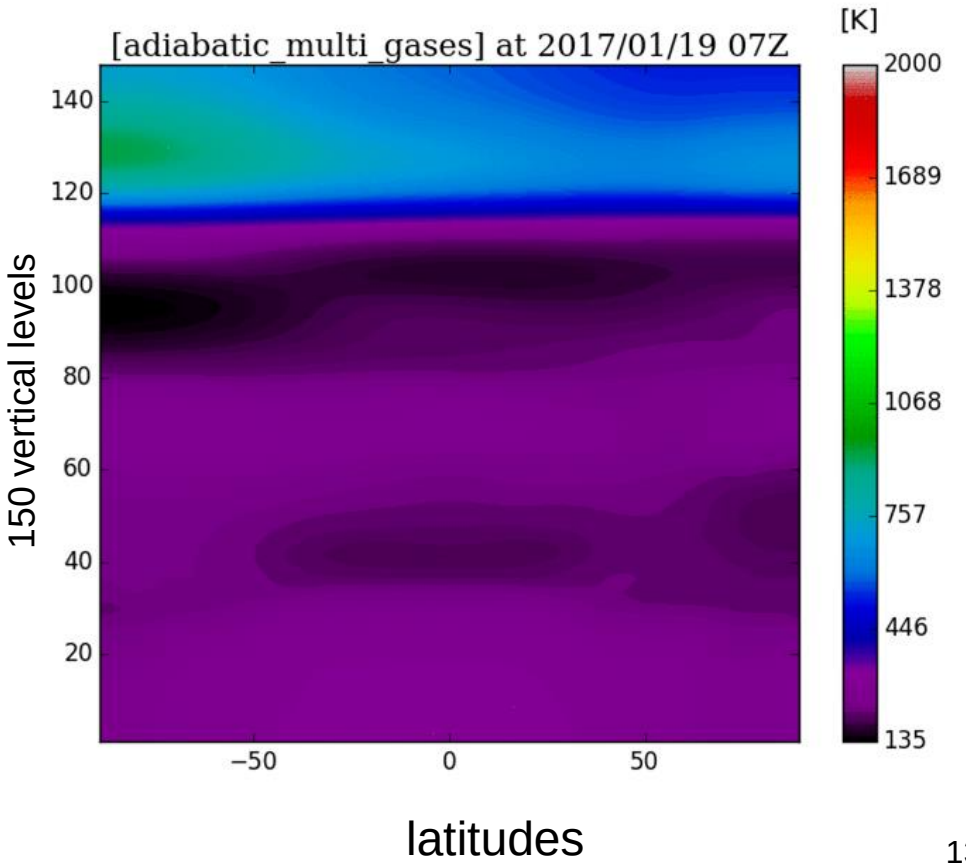
FV3GFS (L64)

	R	Cp
O3	173.225	820.239
All other dry gases	286.05	1004.60
Water vapor	461.50	1846.00

FV3-WAM (L150)

	R	Cp
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

Still some issues with upper boundary conditions



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?)