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From: Bob Maxson
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Subject: Update on GFS Version 15.1 Model Implementation
Effective May 6, 2019

Effective May 6, 2019, NWS is lifting the pause on implementation of GFS Version 15 with the FV3 dynamical core after making modifications to the model to address user feedback and renaming it Version 15.1.

NWS will conduct a planned 30-day technical test which is the last step in our implementation process. The final decision to implement the upgrade will depend on successful completion of this final technical test. Additional details to announce the start of the 30-day technical test will be made through a subsequent Service Change Notice.

Upon GFS V15.1 operational implementation, GFS V14 model output (the current operational version of the GFS) will remain available through September 30, 2019, on the NCEP Model Analyses and Guidance (MAG) Evaluation Website and NOAA National Operational Model Archive and Distribution System (NOMADS) Para-NOMADS Website.

BACKGROUND

On May 17, 2018, the NCEP Environmental Modeling Center (EMC) announced the beginning of the evaluation period for version 15.1 of the Global Forecast System (GFS).
https://www.emc.ncep.noaa.gov/gmb/STATS_vsdb/doc/GFSv15/Eval_Letter.docx

This upgrade replaces the spectral core with the Finite Volume-Sphere (FV3) core as well as the following model upgrades:
- Replacing the Zhao-Carr microphysical scheme with the more sophisticated GFDL scheme.
- Updating parameterization of ozone photochemistry with additional production and loss terms
- Introducing a new parameterization of middle atmospheric water vapor photochemistry

- Revising the bare soil evaporation scheme

Three years of fully cycled data assimilation retrospective model simulations (May 2015 through May 2018) were completed, and a real-time parallel simulation with fully-cycled data assimilation was launched on April 1, 2018. The validation and verification of the results are summarized at: https://www.emc.ncep.noaa.gov/users/meg/fv3gfs/

In October 2018, the NCEP Office of the Director (OD) approved proceeding with plans to implement FV3-based GFS V15 in the winter of 2019. See the OD briefing here: https://www.emc.ncep.noaa.gov/gmb/STATS_vsdb/doc/GFSv15/OD_Brief_20181001.pptx

In the summer of 2018, during the evaluation phase, two bugs were identified and addressed:
1. Snow was not adequately melting under warm conditions. A change to model parameters associated with communicating snow amounts to the land surface was introduced in July 2018 to address this.
2. The calculation of the solar zenith angle was incorrect. A fix was introduced in September 2018.

During the fall of 2018, EMC identified excessively cold temperature increments in the data assimilation system in polar regions. This was the result of an incorrect parameter associated with supersaturation over ice.

As the real-time parallel run and model evaluation by the community entered the winter of 2018, it became clear the change made to the snow accounting (Item 1 above) inadvertently caused excessive accumulating snow in marginally cold environments in mid-latitude storms, The fix to the solar zenith angle (Item 2 above) inadvertently exacerbated an existing cold bias at lower levels in the atmosphere. The increased cold bias in the lower atmosphere compounded the excessive accumulated snow issue noted above in Item 1.

On February 26, 2019, NWS paused the implementation plans for GFS V15. See scn19-12 below: https://www.weather.gov/media/notification/scn19-12gfsv15.pdf

EMC began exploring corrective actions to alleviate the excessive snow and cold bias that resulted in the following:
1. EMC changed the way snow amounts were calculated and communicated to the land surface model, basing it on the fraction of frozen precipitation falling on the ground rather than basing it on the total precipitation in cold conditions.
2. EMC refined the interaction of radiation with cloud particles, allowing for each type of hydrometeor (convective rain, stratiform rain, snow, graupel, and ice) to assume its own physical characteristics as calculated by the Geophysical Fluid Dynamics Laboratory (GFDL) microphysics scheme (like particle

radius) and interact accordingly with the radiation scheme.
3. EMC updated the supersaturation parameter over ice in the data assimilation system.

All three of these modifications were introduced into a new model configuration with fully cycled data assimilation. This simulates the full prediction system starting from mid-December 2018; it is now running in real time. In addition, a portion of the last hurricane season (from August 26, 2018, through October 31, 2018) was also simulated in a fully-cycled data assimilation configuration with these three modifications.

The results are promising and give NWS confidence to proceed. The three new modifications are significantly mitigating the cold bias and excessive snow in GFS V15.1, especially in the shorter lead times (0-96 hrs), while retaining the benefits of the new FV3 dynamical core documented in the brief to the NCEP Director in October 2018. These benefits include:
- (Significantly) Improved 500-hPa anomaly correlation (NH and SH)
- Intense tropical cyclone deepening in GFSv14 not observed in GFSv15
- GFS V15.1 tropical cyclone track forecasts improved (within 5 days)
- Warm season diurnal cycle of precipitation improved
- Multiple tropical cyclone centers generated by GFS V14 not seen in GFS V15.1 forecasts or analyses
- General improvement in HWRF runs
- New simulated composite reflectivity output is a nice addition
- Some indication that GFS V15.1 can generate modest surface cold pools from significant convection
- Improved ozone and water vapor physics and products
- Improved precipitation ETS score (hit/miss/false alarm)

Several individual case studies illustrate the model still exhibits a cold bias and may produce excessive snow in the medium range. Nonetheless, the aforementioned significant model improvements over GFS V14 are compelling and we are exiting the implementation pause outlined in Service Change Notice (SCN) 19-12. EMC will continue to explore ways to address these issues.

Additional material relevant to the performance of the new model configuration is documented here:
https://www.emc.ncep.noaa.gov/gmb/STATS_vsdb/doc/GFSv15/Decisional_Brief_for_NCEP_OD.pptx

The experiment that includes the three modifications and other results from our recent explorations were incorporated into the real-time parallel experiment that started on April 19, 2019. Details on the availability of data from this experiment are documented here:
https://www.emc.ncep.noaa.gov/gmb/STATS_vsdb/doc/GFSv15/parallels.pptx

For questions regarding products from GFS Version 15.1, please

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