Upgrade NCEP Global Forecast Systems (GFS) to v15 in Spring 2019

The United States National Centers for Environmental Prediction (NCEP) will upgrade its Global Forecast Systems from version v14 to v15 in Spring 2019. The scientific and technical enhancements include the following:

NOAA/NWS selected the Geophysical Fluid Dynamics Laboratory (GFDL) finite- volume cubed-sphere (FV3) dynamical core as the Weather Service's Next Generation Global Prediction System (NGGPS). The current operational GFS, which has a spectral dynamical core, will be replaced by the proposed GFS with FV3 dynamical core and improved physics parameterizations.

The proposed GFS version maintains a horizontal resolution of 13 km, and has 64 levels in the vertical extending up to 0.2 hPa. It uses the same physics package as the current operational GFS except for: (a) the replacement of Zhao-Carr microphysics with the more advanced GFDL microphysics, (b) an updated parameterization of ozone photochemistry with additional production and loss terms, (c) a newly introduced parameterization of middle atmospheric water vapor photochemistry, (d) a revised bare soil evaporation scheme, e) a modified convection scheme to reduce excessive cloud top cooling.

The data assimilation system will be updated to:

- Add Infrared Atmospheric Sounding Interferometer (IASI) moisture channels
- Add Advanced Technology Microwave Sounder (ATMS) all-sky radiances
- Add NOAA-20 CrIS and ATMS data
- Add Megha-Tropiques SAPHIR data
- Add Advanced Scatterometer (ASCAT) data from MetOp-B
- upgrade the use of Cross-Track Infrared Sounder (CrIS) radiances
- Upgrade specific humidity perturbation and statistics physics tendency perturbation with new parameter settings in ensemble forecast. Statistical kinetic energy backscattering perturbation is excluded
- Exclude digital filter and storm relocation
- Increase horizontal resolution of the ensemble part of the hybrid data assimilation from 35 km to 25 km

- Update the Near Sea Surface Temperature scheme to 1) apply Sea Surface Temperature climatology tendency to the foundation temperature and, b) reduce background error correlation length from 450~800 km down to 100 km.

Major changes in model forecast output, post-processed fields and downstream products are as follows:

- The current operational GFS v14 is run at a coarser horizontal resolution after 240 hours of forecast, while GFS v15 will run at a uniform high resolution through the entire forecast length up to 384 hours. As a result, the delivery of all GFS products after 240 hours of forecast will be delayed. The last product at forecast hour 384 will be delayed by up to 35 minutes.

- Numerous variables at additional pressure levels or above ground levels will be included in the products.

    - Cloud hydrometers(ICMR, RWMR, SNMR, GRLE) at 22 isobaric levels which are predicted by the advanced microphysics scheme.
    - Cloud hydrometers(ICMR, RWMR, SNMR, GRLE, CLWMR) at model lowest hybrid level which are predicted by the advanced microphysics scheme.
    - Precipitation product(APCP, ACPCP) with continuous accumulation. The traditional precipitation product with 6-hour bucket is also provided.
    - Instantaneous precipitation types (CRAIN, CSNOW, CICEP, CFRZR).
    - Instantaneous precipitation rate (PRATE) and instantaneous convective precipitation rate (CPRAT).
    - Composite Radar reflectivity(REFC) derived using new cloud hydrometers predicted by new advanced microphysics scheme.
    - Total cloud fraction(TCDC) at 22 isobaric levels.
    - Ozone (O3MR) at 0.4, 15, 40, 50, 500, 700, 850, 1000 hPa.
    - Absolute Vorticity (ABSV), temperature (TMP), height (HGT) at 0.4, 15, 40 hPa.
    - Winds (UGRD, VGRD) at additional 4 levels above the ground (20, 30, 40, 50 m).
    - Vertical velocity (DZDT) at 21 isobaric levels. The height, pressure, and vertical velocity (DZDT) will be non-hydrostatic computed in model instead of being derived hydrostatically in the Unified Post Processor (UPP). Hydrostatic vertical velocity (VVEL) computed

in the UPP using hydrostatic equation is also provided in this implementation but will be discontinued in next GFS upgrade.

- A new cyclone tracker file (avnop.t??z.cyclone.trackatcfunix) will be added. It contains three parameters for depicting cyclone phases based on Hart (2003), where parameter B for cyclone thermal symmetry and parameters -Vt(lower) and -Vt(upper) for cyclone thermal winds. The existing cyclone tracker file avn.t??z.cyclone.trackatcfunix will still be included. It provides the basic hurricane track information such as location and intensity.

EMC has conducted 3-years of retrospective experiments, including the real-time parallel, covering the past three and half years for a comprehensive evaluation of the Q2FY19 GFS implementation. It shows overall improved forecast skills, especially for 500-hPa height anomaly correlations, precipitation diurnal cycle and ETS score over the CONUS, surface 2m temperature, stratospheric ozone and water vapor, and hurricane intensity overall all basins.

Evaluation of both the real-time and retrospective parallels can be found at:
http://www.emc.ncep.noaa.gov/users/Alicia.Bentley/fv3gfs
Which includes relevant links to various evaluation and verification web sites.