

Implementation of the NCEP GFS NEMS

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The National Centers for Environmental Prediction (NCEP) is upgrading the Global Forecast System in July 2017. The upgrade reformulates the GFS in the NOAA Environmental Modeling System (NEMS) superstructure and infrastructure and introduces modifications to the land surface and convection parameterizations, a new treatment of sea surface temperature and changes to data assimilation. Details on the changes and evaluation of the changes can be found at:

<http://www.emc.ncep.noaa.gov/gmb/noor/GFS2017/GFS2017.htm>

The physics changes include upgraded land parameterizations, higher resolution land surface climatologies, and new surface albedo data that improve surface upward radiation, near-surface fields and reduce patchiness, introduction of a stability parameter constraint that prevents the land-atmosphere system from fully decoupling and greatly reduces excessive cooling of 2m temperatures during sunset (00Z), changes to cumulus convection parameterization that improve summertime precipitation forecasts and a 50% reduction in Rayleigh damping in the upper stratosphere above 2 hPa that improves stratospheric fields. Near-Surface Sea Temperature (NSST) describes oceanic vertical temperature structure near surface due to the diurnal warming and sub-layer cooling physics processes and improves SST, data assimilation and tropical weather forecasts. Data assimilation is improved by additional data (some GPS data, AMVs, and some radiances), minor bug fixes mostly related to cloud water and preparation for future satellites (JPSS, GOES-16, COSMIC-2).

This upgraded system was tested for 749 days over three summers and two winters of forecasts and evaluated in coordination with other NCEP centers and National Weather Service regional headquarters and forecast offices. Maps of several months of real time operational and upgraded forecasts were available to operational forecasters for evaluation, and selected case studies recommended by forecasters were conducted.

Objective verification against observations and the model's own analyses showed small changes in the troposphere and improvements in the stratosphere. The new GFS has stronger, more realistic winds. Analysis increments are reduced outside the tropics. Fits to radiosondes and aircraft observations are improved overall.

Precipitation forecasts over the continental US showed a reduction in the excessive drizzle seen in the GFS, increased bias for light to medium amounts, and significant improvements in skill for thresholds of 0.2 to 15 mm/day over forecast lengths of 0-24 to 72-96 hrs. Precipitation patterns averaged over several weeks showed improvements; the Aviation Weather Center and Weather Prediction Center noted improvements in tropical convection. NEMS forecasts better maintained convection over the western tropical Pacific.

In the GFS NEMS biases in 2 meter temperatures and dew points against observations were reduced more than increased over the United States, root-mean-square errors in 2 m dew points improved at all time of days, rms error in 2 m temperatures improved at 00UTC (reflecting reduced excessive cold bias at sunset)

but were worse at 12UTC. 10 m winds were improved over the eastern United States but were worse over the western US.

In the numerous case studies examined, the GFS NEMS outperformed the operational GFS overall.

Over the three years tropical storms in the GFS NEMS showed short-term track forecast degradation in the Atlantic (48-72 hr) by about 9-10% and in the East Pacific (24-48 hr) by about 4-5%. The degradation in the Atlantic was due to poorer forecasts of three storms in 2016; the errors in these three storms did not appear systematic. East Pacific track forecasts improved beyond 48 hrs, genesis forecasts were significantly improved both in Atlantic and East Pacific and the lead time for Atlantic genesis forecasts gained by almost a day.

This is the last implementation with the current GFS; future implementations will be with the new FV3 dynamic core.

This implementation followed the new implementation procedure developed the previous year with a considerably longer official evaluation period and more active engagement with and participation of the other NCEP centers and NWS regional headquarters and forecast offices.