Development of Modeling Requirements for Global Forecast Systems Based on Users' Needs Identified from User Feedback - Part II: Case Evaluation, Survey Analysis, and Draft Requirements

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NOAA's Subseasonal and Seasonal Applications Workshop, College Park, MD, September 4-6, 2024

Introductory presentation at the workshop: Development of Modeling Requirements for Global Forecast Systems Based on Users' Needs identified from User Feedback - Part I: Background and Introduction (YJ Kim et al.)

A. Case Evaluation

- Cases for **systematic biases of the GFS/GEFS** were solicited from the field in early 2023.
- The Environmental Modeling Center (EMC)'s **Model Evaluation Group (MEG)** has been conducting **GFS/GEFS evaluations** ongoing for several years.
- A **Met Watch** was performed by AFS11 in **2023** to identify **cases showing biases in the GFS/GEFS**.
- Based on combination of these efforts, **49 cases were evaluated and 15 themes** (categories) or subcategories were identified as potential systematic biases within the models.

Theme Examples

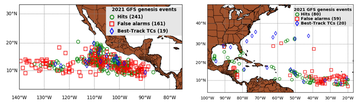

Fig. 1: 2021 Seasonal Genesis Statistics Summary

In both the eastern north Pacific and Atlantic basins, there has been an observed GFS bias toward excessive tropical cyclone genesis false alarms (**Fig. 1**).

In mid-July 2023, the **GEFS and also GFS had a consistent warm bias** in forecasts for a significant heatwave in the southwestern United States, including the central valley of California (**Fig. 2**). While the most significant errors occurred with a lead time of about 4 days, **this issue was present to within 24 hours**.

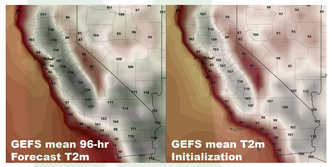

Fig. 2: GEFS mean 2-meter temperature forecast vs initialization. Figure courtesy of pivotalweather.com

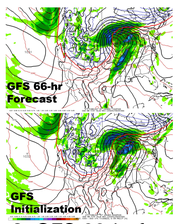

Fig. 3: GFS 66-hr forecast vs 00-hr analysis.

GFS/GEFS have a **tendency to overamplify Cold Season troughs**. Over several days leading up to April 5, 2023, the **GFS forecast was consistently too strong, too deep, and too negatively tilted** compared to observations for a major storm impacting the northern Plains (**Fig. 3**). **Similar errors were seen in the GEFS forecast** in addition to the deterministic GFS.

GFS/GEFS tend to **underestimate precipitation totals during training convection events**. On April 12-13, 2023, training storms produced record breaking rainfall of 25.91" in Fort Lauderdale, resulting in major flooding (**Fig. 4**).

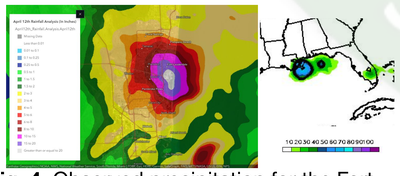

Fig. 4: Observed precipitation for the Fort Lauderdale, Florida metro area (left). GEFS probability of 24-hour precipitation > 1" (right).

B. Survey Analysis

- A survey was **conducted during January-February 2024**. It yielded 161 total responses, 113 from within NOAA and 48 from outside NOAA (plus additional entries from CPC).
- **Meteorologists/Forecasters were the main NOAA respondents**, with a significant response from SOOs/DOHs and hydrologists as well. SR, CR, ER, and NCEP had the highest response rates.
- **Private sector (private) participants were the highest non-NOAA respondents at 45%**, with the remainder being evenly distributed between academia, media, and retirees.
- **CPC forecasters** cited a **high priority need for a greater number of ensemble members**, preferably initialized from one cycle per day vs being spread over multiple cycles. They also mentioned the need for a **full reforecast dataset, ideally matching the real-time configuration**, released 3 months prior to realtime forecast implementation (following NMME agreement). **Reforecast data for at least 1991-2020, but more data is better, and 1981-2020**

Selected Noteworthy Responses

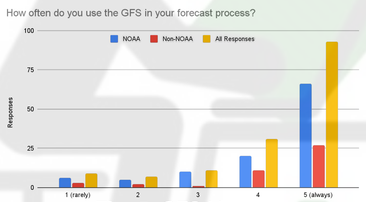

Fig. 5: GFS Usage

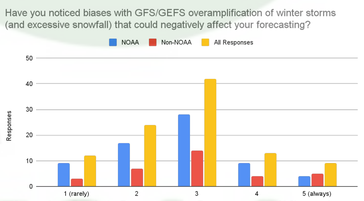

Fig. 6: Cold Season Overamplification

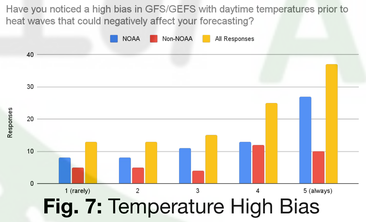

Fig. 7: Temperature High Bias

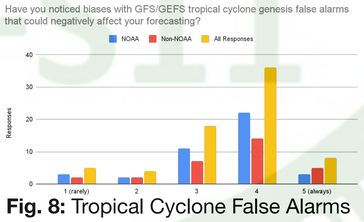

Fig. 8: Tropical Cyclone False Alarms

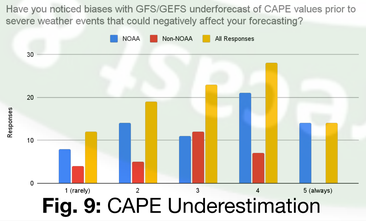

Fig. 9: CAPE Underestimation

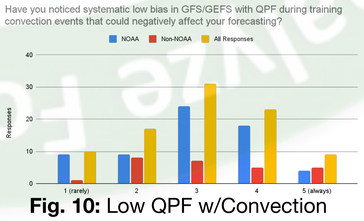

Fig. 10: Low QPF w/Convection

C. S2S Related Draft Requirements

- **Tropical Cyclones**
  - Reduce right of track bias
  - Reduce TC genesis false alarms
- **Winter Storms**
  - Forecast low track improvement
  - Reduce over-amplification of winter storms
- **Instability**
  - Improve the underforecast of CAPE
  - Reduce boundary layer overmixing
- **Wind**
  - Reduce low bias of wind speeds during high wind events
  - Provide direct model output 10 m wind gust data
- **QPF**
  - Reduce low bias of QPF during training convection events, Reduce high bias of QPF during large scale (particularly Winter) events
- **SFS-Specific**
  - Output for Dewpoint, Snowfall (in addition to snow water equivalent), 200-hPa Velocity Potential, Period Max Winds
  - Climatology/reforecast period to cover 1991-2020, preferably back to 1981
  - Reforecast configuration to match that of real-time forecast configuration
  - Reforecast ensemble size as close real-time forecast ensemble size as possible (at least >=10 members).
- **Other**
  - Lengthen GEFS extension to cover upcoming month
  - High-resolution week 3-4 model data for Hawaii, USAPI
  - Variables that capture smoke and particulate matter

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- **Desired Error Thresholds and Time Frames**

Forecast Element	Desired Error Threshold	Time Frame
TC Track	50 mi	2-3 days
TC Genesis False Alarms	0-25%	120 hours
TC Genesis Missed Events	0-25%	120 hours
Winter Storm Tracks	25-75 mi	48 hours
Winter Storm Intensity	5-10 hPa	48 hours
CAPE	500 J/Kg	48 hours
Heat Waves	4° F	2-3 days

Forecast Element	Desired Error Threshold	Time Frame
Extreme Cold Events	4-5° F	48 hours
Radiation Cooling Events	4° F	24-48 hours
Dew Point	4° F	48 hours
Wind Speed	5-10 mph	48 hours
Training Convection	0.75-1.00"	24-48 hours
Synoptic Scale (Winter)	0.25-0.50"	48 hours
Wave Heights	4'	24-48 hours