The AIGFS, AIGEFS, and Hybrid GEFS (HGEFS) Applications
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Artificial Intelligence and Machine Learning (AI/ML) technology have advanced rapidly in recent years, transforming the field of numerical weather prediction with improved forecast skill and remarkable efficiency. In response, operational centers are beginning to integrate AI/ML models into their systems to provide transformative forecast products.

The **AIGFS** is NOAA's AI-based emulator of the Global Forecast System (GFS). It was created by fine-tuning Google DeepMind's GraphCast model with a combination of NOAA's GFS analyses and ERA5 and HRES from the European Centre for Medium-Range Weather Forecasts (ECMWF). The development involved creating novel training infrastructure, utilizing cloud computing, and employing various training configurations with NOAA's datasets.

Evaluations show that the AIGFS generally improves forecast skill compared to the operational GFS and maintains physically meaningful large-scale synoptic features. Notably, it exhibits significant improvement in tropical cyclone (TC) track forecasts in the North Atlantic and North Western Pacific basins at 5-6 day lead times, though TC intensity forecasts are somewhat degraded. More details can be found in NOAA Office Note 521 (https://doi.org/10.25923/xd3y-wy31, Tabas et al., 2025)

AIGFS v1.0 runs four times a day, producing 6-hourly forecasts for up to 16 days. It provides primary atmospheric and surface fields like temperature, wind, humidity, and precipitation in GRIB2 format. Most impressively, AIGFS is incredibly efficient. A single 16-day 0.25 degree resolution forecast requires about 0.3% of the computing resources of the 13 km operational GFS and is four times faster.

Building on this foundation, the **AIGEFS** is an AI-based emulator of the Global Ensemble Forecast System (GEFS). To account for forecast uncertainty, it uses the same perturbed initial conditions as the operational GEFS and incorporates model uncertainty by leveraging different model weights generated during the training process. This approach yields a 31-member AIGEFS that captures both initial condition and model uncertainty. Evaluations show its performance is comparable to the operational GEFS. For the AIGEFS, a single 16-day 0.25 degree resolution forecast requires about 9% of the computing resources of the same resolution operational GEFS.

Perhaps the most unique application is the **Hybrid-GEFS (HGEFS)**, which combines the 31 members of the operational NWP model GEFS with the 31 members of the AI-based model AIGEFS. This creates a 62-member grand ensemble that more effectively represents forecast uncertainty and results in a more useful product. To our knowledge, NOAA is the first operational center to pursue this innovative hybrid approach. The HGEFS consistently

outperforms both GEFS and AIGEFS across all major atmospheric fields, including key surface variables such as 2 meter temperature and 10 meter winds as well as upper atmospheric fields. This superior skill is verified by numerous metrics such as CRPSS, ensemble mean RMSE, anomaly correlation, and spread-error ratio. Furthermore, while HGEFS offers appreciable improvement in hurricane track prediction, its intensity forecasts are degraded compared to GEFS. More details on AIGEFS and HGEFS can be found in NOAA Office Note 522 (https://doi.org/10.25923/7kpr-5e68, Wang et al., 2025). A more comprehensive review of the verification will take place during an upcoming MEG meeting in a few weeks.

In this webinar we will introduce AIGFS, AIGEFS, and the HGEFS.