

Recommendations on Deep Learning Numerical Weather Prediction (DLNWP)

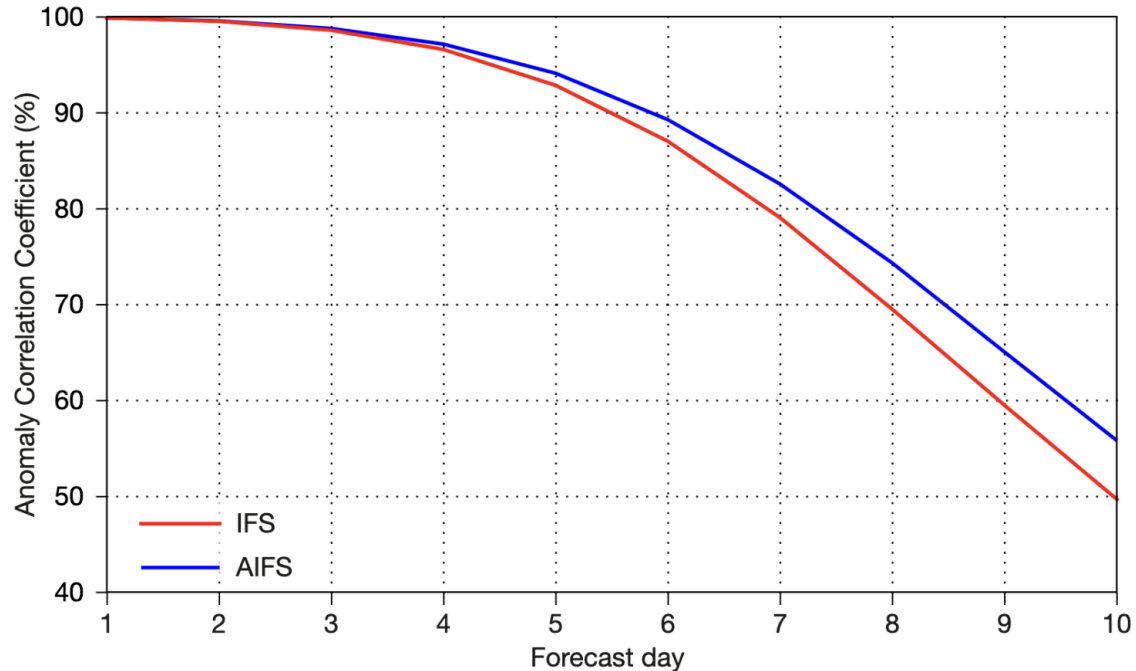
EISWG

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Introductory section

- NWP: the rising tide that lifts many NOAA products and services boats.
- NWP has a long history of small accumulations of improvements; about 1 day improvement / decade.
 - Based primarily on laws of physics, $F=ma$, $p = \rho RT$
 - Improvements come with large computational expense, large observing system investment, large staff investment, code complexity, and inherent simplifications (e.g., parameterizations).
- Deep learning is conceptually different.
 - Data driven, so far largely from reanalysis.
 - Model learns to step forward in time, which can be repeated to generate weather forecasts.
- Advantages (preliminary) include forecast computational expense, **accuracy**, code simplicity, **rapid improvements**.
- *Current* disadvantages include training expense, a simplified model state (e.g., no cloud hydrometeors), use of different GPU computational resource.
- NOAA is late to the game, with industry, ECMWF, and other met agencies rapidly building capacity. DLNWP is not much mentioned in various NOAA plans + PWR.
- As NOAA is looked to as primary provider of weather services to the nation, it's a major risk not to thoroughly explore DLNWP. And soon, given rate of others' progress.



AIFS forecast skill. We show the northern hemisphere Anomaly Correlation Coefficient (ACC) for geopotential height at 500 hPa of IFS forecasts (red, dashed) and AIFS forecasts (blue) for 2022. Higher values indicate better skill.

Reproduced from Lang et al., [ECMWF Newsletter, 178, Winter 2023-2024](#).

The IFS is the conventional NWP system of ECMWF, the AIFS is the deep-learning, artificial-intelligence version of the system.

Recommendations

1. **A substantial investment in new staff with DLNWP expertise.** We encourage NOAA to identify how many FTEs they believe are needed to establish a base DLNWP capacity; ID what skill set is necessary from those FTEs; and we recommend that NOAA briskly hire or retrain this core staff. [mentions 15 new at ECMWF, a smaller outfit].
2. **Living roadmap.** Recognize the potential revolutionary character of DLNWP and incorporate this into relevant strategic plans as well as more directed documents. This would include preparing a living roadmap document with key research questions, ID'ing necessary data sets, DLNWP focus areas, and a plan of action. Since DLNWP systems may have very different software architectures and pipelines, DLNWP scientists should not be unduly constrained by conventional NWP approaches.

Recommendations, continued

- 3. Data collation and reanalysis.** With ECMWF/Copernicus providing high-quality, lower-resolution multi-decadal global reanalyses, there is a particular **need for very high resolution, high-quality, unbiased reanalyses and data collections covering areas of US interest, including CONUS, hurricane basins, Alaska, and Hawaii**, designed to serve multiple use cases and made readily available to all developers across the enterprise.
- 4. Changes in computational resourcing.** Surges of GPU-based computations will be required for model training, but radically less computational resources may be needed for prediction. Re-thinking NOAA high-performance computational resourcing will be needed alongside the development of a DLNWP capacity and its evaluation. **NOAA should evaluate how much computational resources will be needed for initial DLNWP training and data set development to get it to a point of being able to more comprehensively evaluate DLNWP and estimate longer-term computational resourcing.** It should provide those resources to the DLNWP developers.

Recommendations, continued

- 5. Partnerships.** Collaboration is in the mutual interests of partners across the enterprise, given the cross-disciplinary and rapidly evolving nature of DLNWP and the natural synergies. NOAA should **identify barriers** to industry, academic, and pan-government collaborations and actively **eliminate them**. NOAA should **make all its DLNWP data readily available to others** through partnerships with cloud providers. **Pan-government collaborations are greatly encouraged** where they advance NOAA interests; **however, it's important for NOAA to proceed briskly** with DLNWP. Other federal agencies may be slower to pivot.
- 6. Management of DLNWP.** As NOAA DLNWP will be built from the ground up, there is an opportunity to improve upon past practices. We recommend that NOAA build and manage its DLNWP as a **coherent team**, working collaboratively in pursuit of the common goal, with the enthusiastic support of all affected line offices.