Nested-EAGLE: A Data Driven, Global Weather Model with High Resolution over the Contiguous US

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Goal

Develop a global medium range weather prediction model that:

- captures synoptic scale dynamics
- represents precipitation at scale useful for decision makers
- produces forecasts at a low computational expense

Data

- Train on GFS & HRRR "Analysis" (fhr=0) for all variables, except precipitation, which uses 0-6h forecast accumulations
- Implement nested or "stretched" grid approach, following Met Norway [1]: cut out CONUS portion from GFS, stick in HRRR
- Conservatively regrid archived GFS: 1/4°→1° and HRRR: 3km→15km
- Use full archives available on NCAR RDA and AWS:
  - Training: Feb 2015-Jan 2023
  - Validation: Feb 2023-Jan 2024
  - Testing Feb 2024-Jan 2025
- Use `ufs2arco` [2] for all data processing

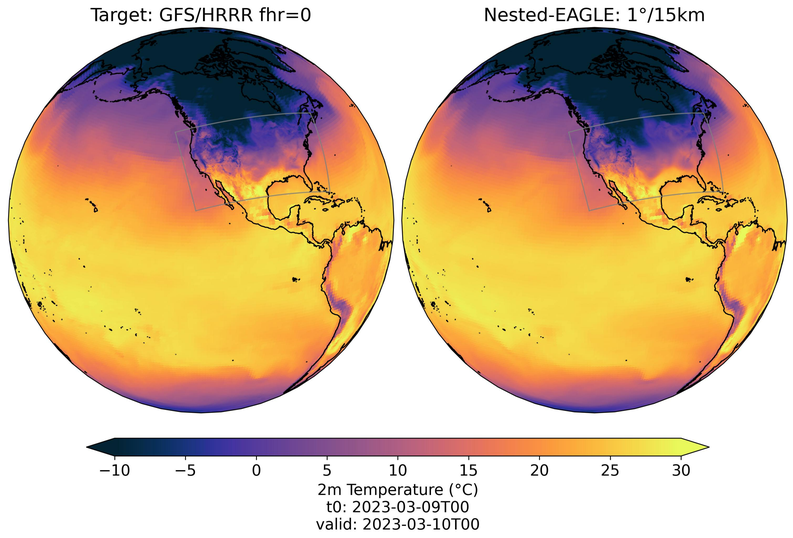
Design Choices that Mattered

- Moving from "GraphCast Style" multimesh [3] to single, high resolution mesh with shifted window processor removed GFS/HRRR boundary artifacts
- Reducing CONUS loss weight 50%→10% improved skill significantly

References

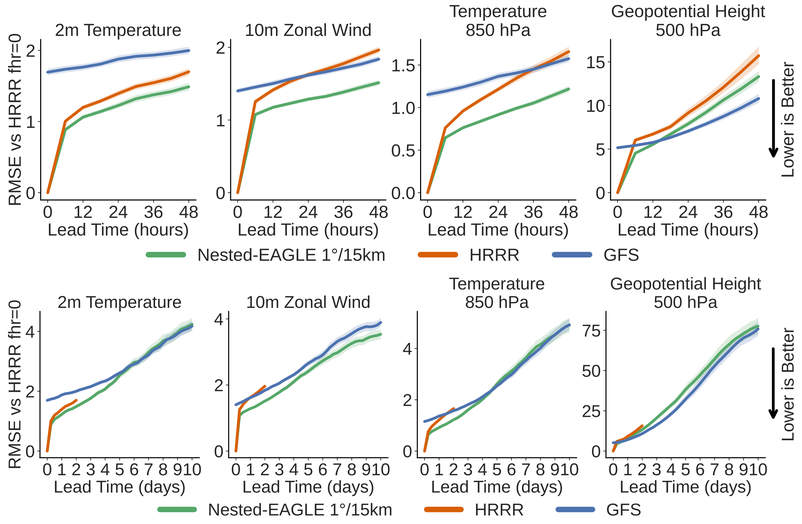
[1] Nipen et al., (2024). doi: 10.48550/arXiv.2409.02891
[2] `ufs2arco` Documentation. `ufs2arco.readthedocs.io`
[3] Lam et al., (2023). doi: 10.1126/science.adi2336
[4] AORC Dataset. `registry.opendata.aws/noaa-nws-aorc`

Prognostic Skill Over CONUS



Evaluation against HRRR Forecast Hour 0 (fhr=0):

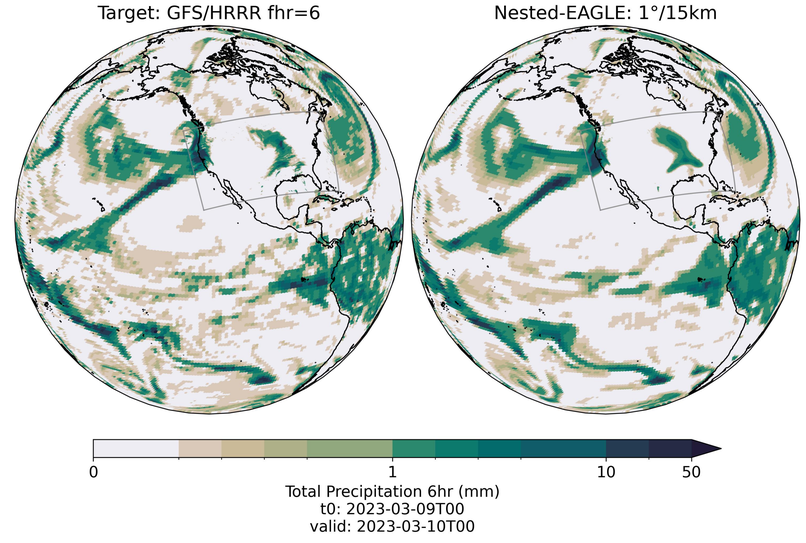
- 158 forecasts initialized throughout validation period
- all datasets conservatively regridded to 15km
- plots show median Root Mean Squared Error (RMSE), shading indicates 95% confidence interval



Main Results

- Lower RMSE than HRRR vs HRRR fhr=0 for all prognostic variables analyzed
- At 10 days, RMSE is competitive with GFS
- At 6h lead, monthly mean precipitation matches HRRR, but longer lead times have larger bias
- Lower FSS values at higher thresholds highlights blurring in the model, owing to MSE loss in deterministic model training

Precipitation Skill Over CONUS

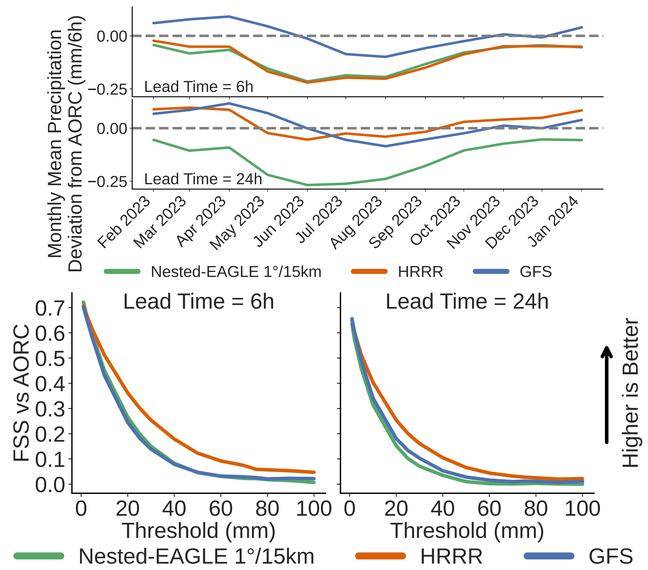


Evaluation against NOAA's Analysis of Record for Calibration (AORC) Dataset [4]:

- ∼1450 forecasts initialized during validation period
- compare 6h accumulations from each model at lead times: 6h, 12h, 24h, and 48h
- all datasets conservatively regridded to 15km

Here we show:

- monthly mean precipitation, relative to AORC
- Fractions Skill Score (FSS), using a ∼33km radius



Next Steps

- Scale to 0.25° global and 6km CONUS resolution
- Train with CRPS loss for ensemble uncertainty estimation and better feature representation
- Incorporate observations into evaluation and training