Environnement et Changement climatique Canada | Environment and Climate Change Canada

Canada

Verifications of NWP AI-based models against observations in altitude

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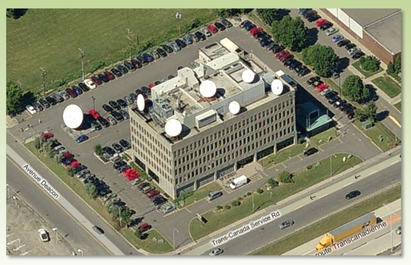


With the emergence of reliable AI-based models weather forecasts in the last two years, it has become important to assess the reliability of these new models with our in-house verification methods.

Since October 2023, we locally installed **GraphCast** and **FourCastNet** and initialize them with GDPS (Canada's global deterministic forecasting system) analyses and compare them with operational forecasts.

This poster presents an evaluation of the forecasts against observations in altitude. We show that AI-based models are very competitive except for high altitudes where the degradation is important.

AI-based NWP models

- **GraphCast**:
  - Developed by Google Deepmind published in December 2022
  - Based on graph neural networks
- **FourCastNet**:
  - Developed by Nvidia published in June 2023
  - Based on spherical fourier neural operators
- We use the Python package **ai-models** from ECMWF which offers a unified interface to run different AI models (reads GRIB files)

Autoregressive MODELS

GraphCast and FourCastNet have been trained both on 40 years of ERA5 reanalysis

FourCastNet: from data at T, it tries to predict the fields at T+6h

GraphCast is using T-6h and T to predict T+6h

Both models are autoregressive:

It reads its own 6h forecast to predict the next time step 6h later.

FourCastNet:

T0h -> T6h -> T12h -> T18h -> T24h -> … -> T240h

GraphCast:

(T-6h, T0h) -> T6h
(T0h, T6h) -> T12h
(T6h, T12h) -> T18h
(T12h,T18h) -> T24h
… -> T240h

Completed Activities

Running NWP AI-based models on current HPC facility:

GraphCast (Google)
13 vertical pressure levels
37 vertical pressure levels

FourCastNet V2 (NVIDIA)
13 vertical pressure levels

Each model is initialized with:

IFS ECMWF analyses (13 levels only)
ERA5 ECMWF analyses (13 and 37 levels)
GDPS CCMEP analyses (13 and 37 levels)

We run twice a day in real time
on-going collaboration with operational forecasters for the evaluation

In hindcast mode, for longer periods of evaluation
October 2021 to September2022

More details on model configurations

Both **GraphCast** and **FourCastNet** use the same 13 pressure levels:
1000, 925, 850, 700, 600, 500, 400, 300, 250, 200, 150, 100, 50
FourCastNet: TT, GZ, UU, VV, HR
GraphCast: TT, GZ, UU, VV, HU, WW

at the surface:
Both models: PN, TT at 2m, UU and VV at 10m
FourCastNet: P0, UU and VV at 100m, IH (Total column vertically-integrated water vapour)
GraphCast: MG (land-sea mask), GZ, PR (6 hours accumulation)

GraphCast 37 levels adds 24 levels which are:
975,950,900,875,825,800,775,750,650,550,450,350,225,175,125, 70,30,20,10,7,5,3,2,1

Computer efficiency

The operational GDPS takes ~55 minutes on 6264 cpus
Resolution of 15 km and 80 vertical levels
Generates hourly output from 0 to 240 hours
Total: 500 GB in FSTD

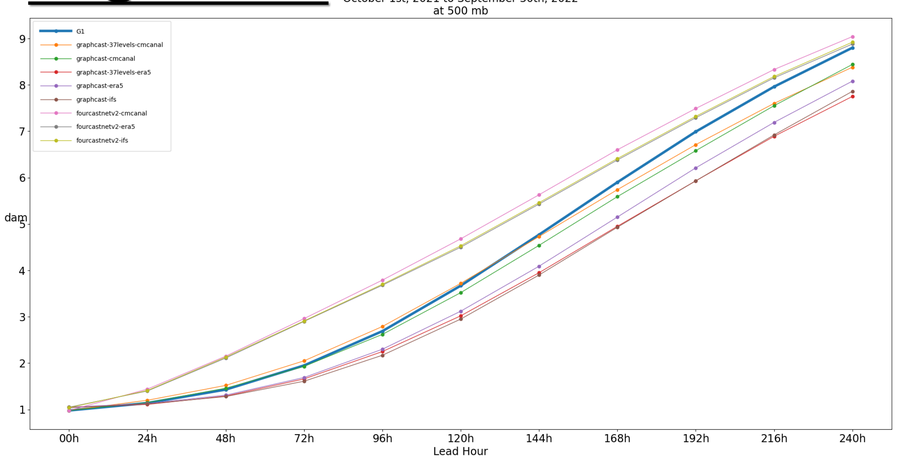
FourCastNet
Resolution of 25 km and 13 vertical levels
Takes 20 minutes on 1 cpu (10 GB of memory)
Generates outputs each 6 hours
Total: 5.7 GB in GRIB and 6.9 GB in FSTD

GraphCast
Resolution of 25 km and 13 vertical levels
takes 16 minutes on 1 cpu (100 GB of memory)
Generates outputs each 6 hours
Total: 6.4 GB in GRIB and then 8.4 GB in FSTD
Resolution of 25 km and 37 vertical levels
takes 20 minutes on 1 cpu (200 GB of memory)
Generates outputs each 6 hours
Total: 18 GB in GRIB and then 24 GB in FSTD

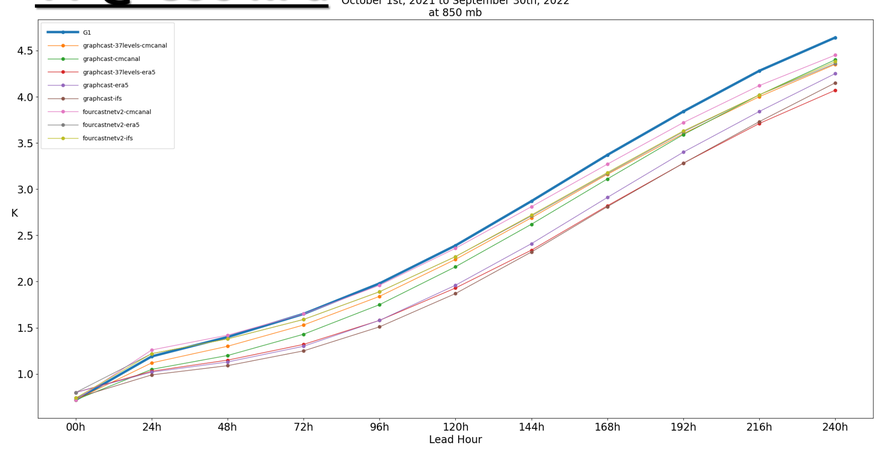
Verifications against radiosondes

From October 1st, 2021 to September 30th, 2022

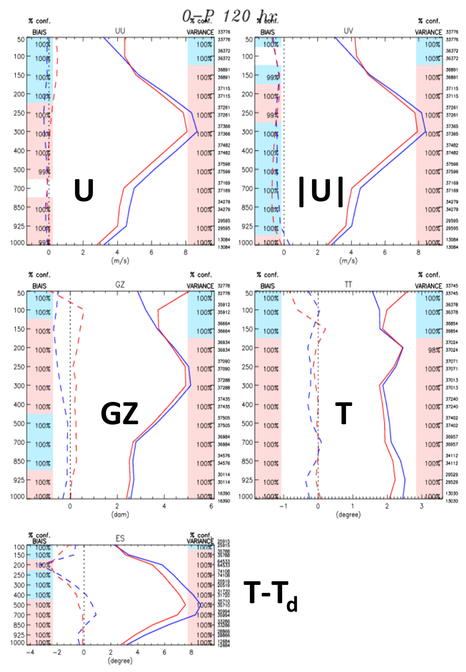
GZ @ 500 hPa



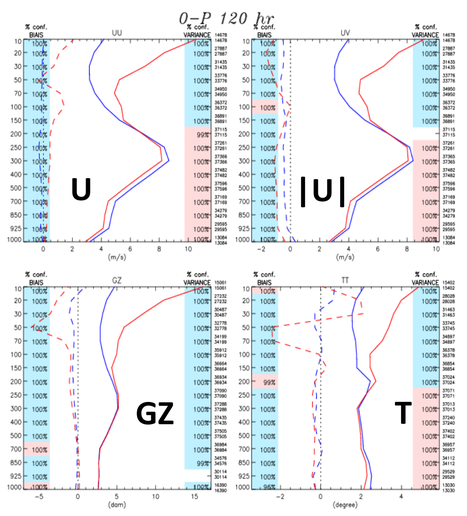
TT @ 850 hPa



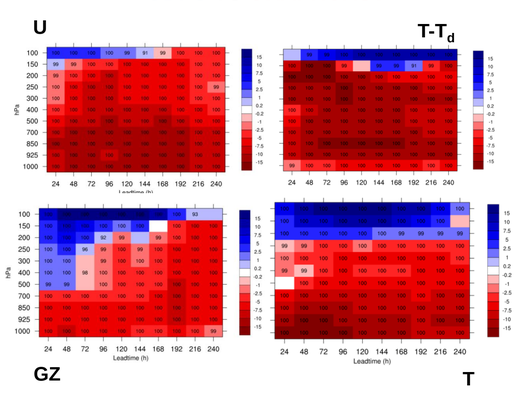
GDPS vs GraphCast 13 levels configuration



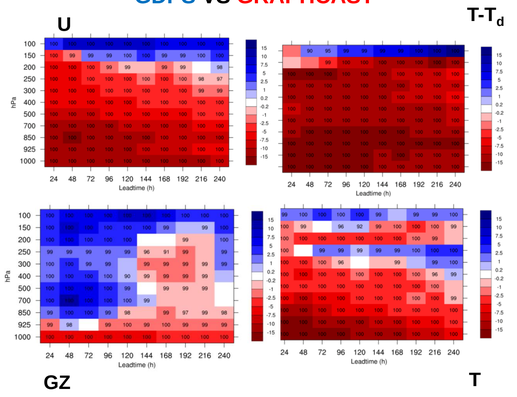
GDPS vs GraphCast 37 levels configuration



WINTER DJF 2022 GDPS VS GRAPHCAST



WINTER JJA 2022 GDPS VS GRAPHCAST



Further work

- Filter forecasts to represent them at the same resolution
- Surface observations
- Against analyses
- Forecasters verifications
- Case studies

- Generate real time forecasts
- Website to show AI-based forecasts

- Spectral Nudging to merge GraphCast and GEM forecasts during the integration itself

- Fine-tune GraphCast with CMC analyses