ai-models

Running data-driven NWP models

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ECMWF

Introduction

```
% module load ai-models
% ai-models panguweather
```

Introduction

```
2023-09-03 13:25:00,810 INFO Writing results to panguweather.grib.
2023-09-03 13:25:00,810 INFO Loading pressure fields from MARS
2023-09-03 13:25:02,350 INFO Loading surface fields from MARS
2023-09-03 13:25:02,476 INFO ONNXRuntime providers: ['CUDAExecutionProvider', 'CPUExecutionProvider']
2023-09-03 13:25:02,476 INFO Using device 'GPU'. The speed of inference depends greatly on the device.
2023-09-03 13:25:20,438 INFO Loading /usr/local/apps/ai-models/0.24/assets/panguweather/pangu_weather_24.onnx: 18 seconds.
2023-09-03 13:25:37,420 INFO Loading /usr/local/apps/ai-models/0.24/assets/panguweather/pangu_weather_6.onnx: 16 seconds.
2023-09-03 13:25:37,420 INFO Model initialisation: 36 seconds
2023-09-03 13:25:37,420 INFO Starting inference for 40 steps (240h).
2023-09-03 13:25:40,575 INFO Done 1 out of 40 in 3 seconds (6h), ETA: 2 minutes 6 seconds.
2023-09-03 13:25:42,718 INFO Done 2 out of 40 in 2 seconds (12h), ETA: 1 minute 43 seconds.
2023-09-03 13:25:44,851 INFO Done 3 out of 40 in 2 seconds (18h), ETA: 1 minute 34 seconds.
2023-09-03 13:25:47,196 INFO Done 4 out of 40 in 2 seconds (24h), ETA: 1 minute 30 seconds.

[...]

2023-09-03 13:27:05,223 INFO Done 38 out of 40 in 2 seconds (228h), ETA: 6 seconds.
2023-09-03 13:27:07,400 INFO Done 39 out of 40 in 2 seconds (234h), ETA: 4 seconds.
2023-09-03 13:27:09,587 INFO Done 40 out of 40 in 2 seconds (240h), ETA: 2 seconds.
2023-09-03 13:27:09,588 INFO Elapsed: 1 minute 32 seconds.
2023-09-03 13:27:09,588 INFO Average: 2 seconds per step.
```

```
ai-models --input mars -date ...
ai-models --input cds -date ...
ai-models --input file ...
```

https://github.com/ecmwf-lab/ai-models-panguweather/blob/main/utils/pangu-gfs-input.py

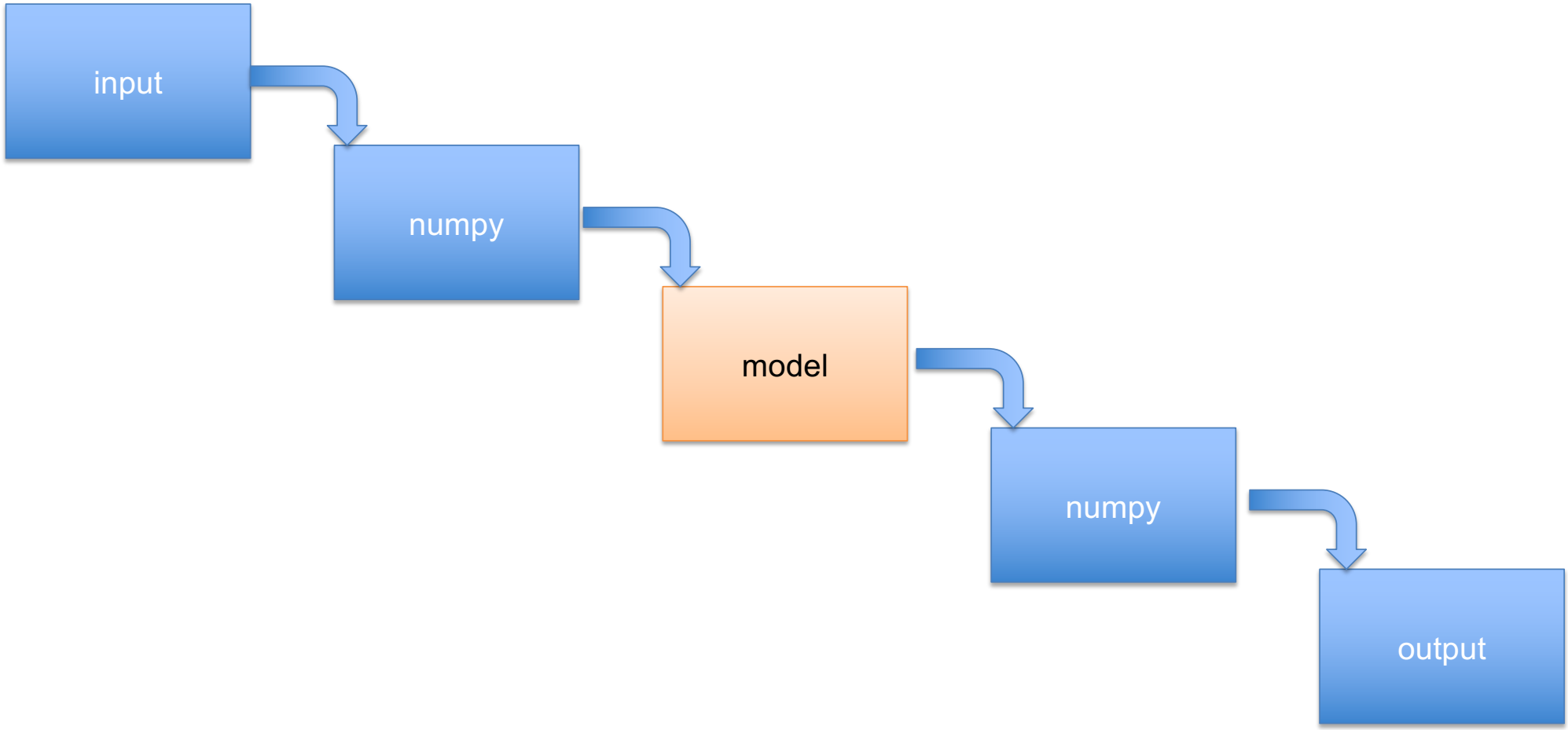
ai-models

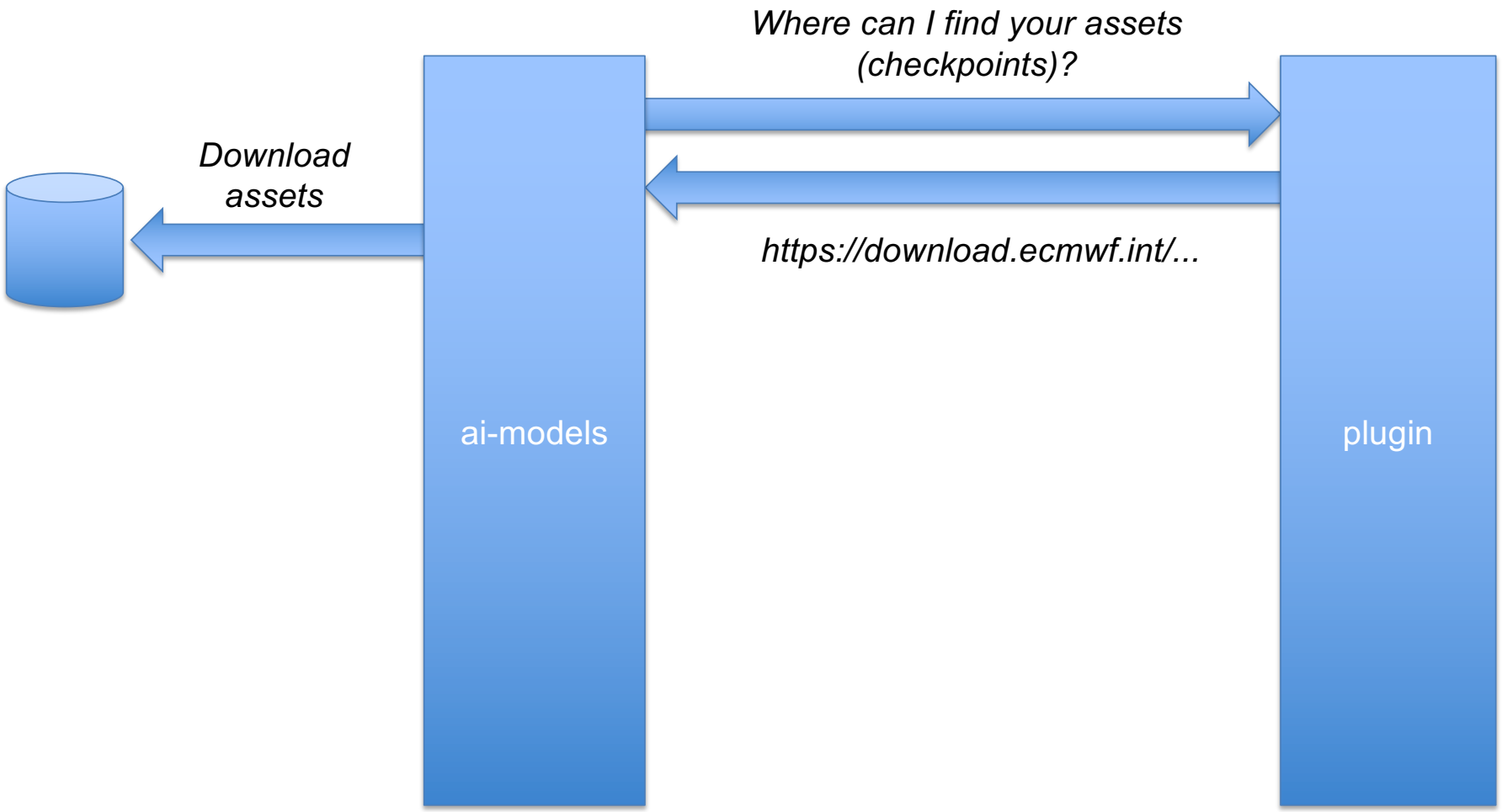
- ai-models is a command line tool
  - Designed for batch production
  - (not for notebooks)

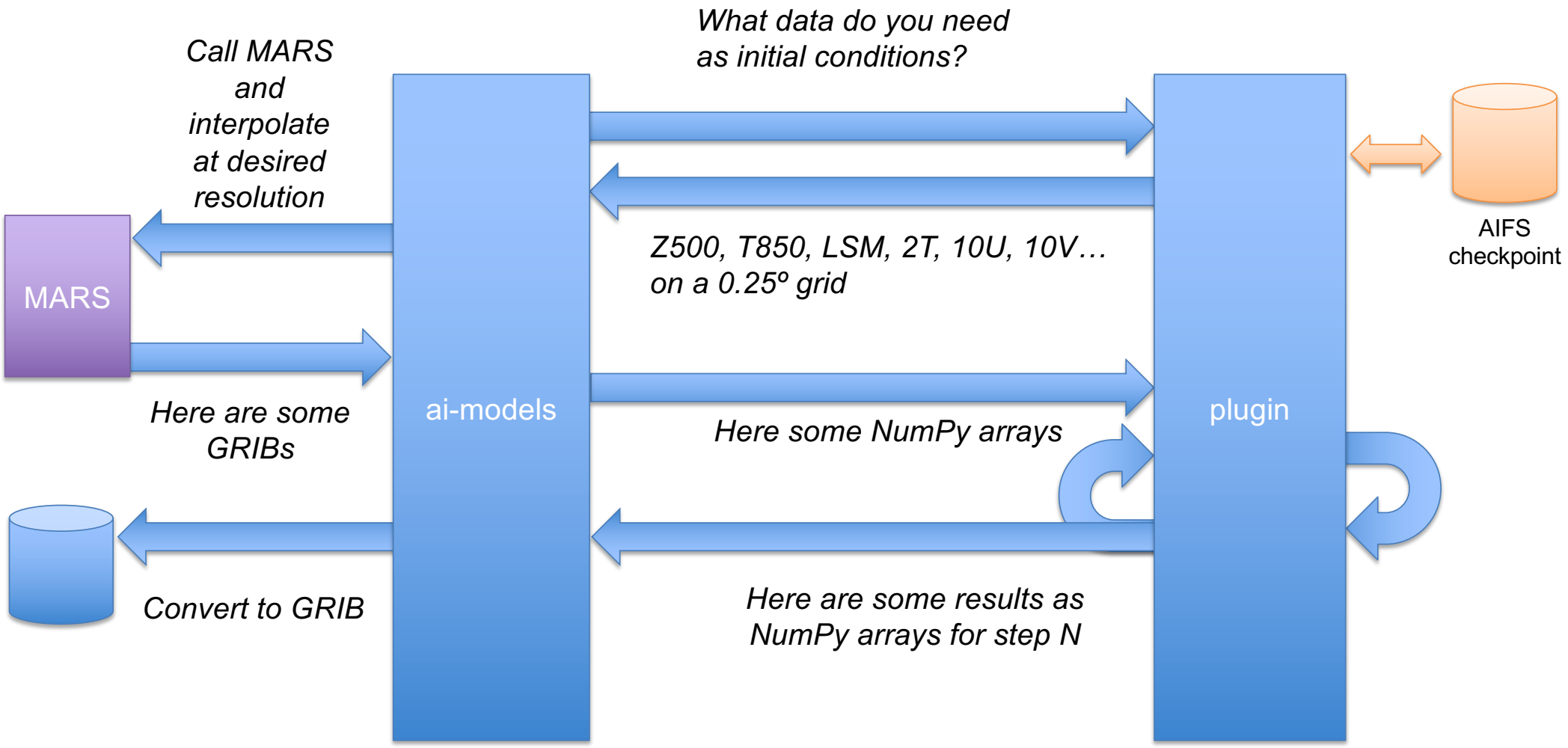
- Uses Python's plugin mechanism (entrypoints)
  - A plugin is a Python package that wraps a model
  - Each plugin can be installed separately
  - Solve issues of different development life cycles, ownership and licenses

- Plugins for:
  - Pangu-weather
  - Fourcastnet
  - FourcastnetV2-small
  - GraphCast
  - AIFS (ECMWF's upcoming model)

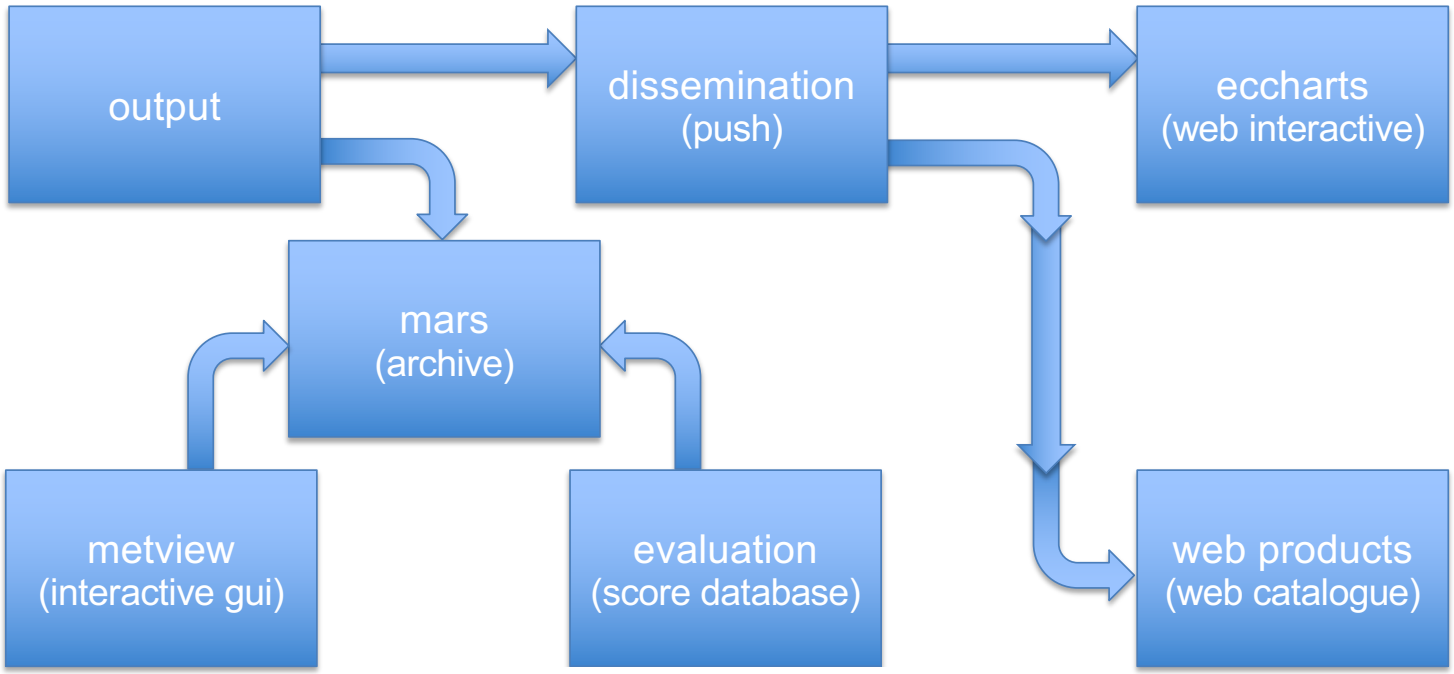
Data pipeline

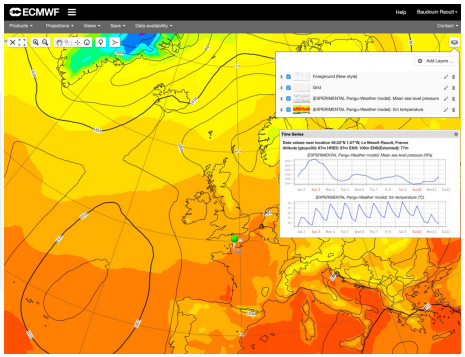


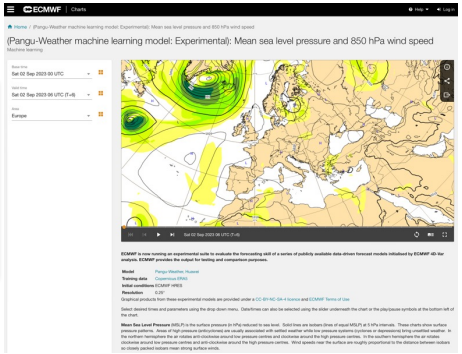

Where can I find your assets (checkpoints)?
Download assets
https://download.ecmwf.int/...
ai-models
plugin

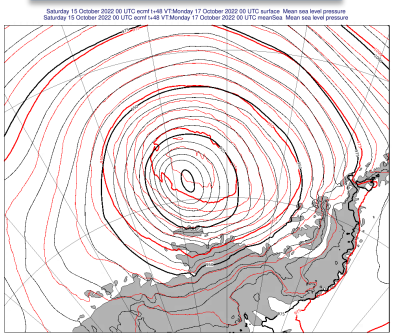

Call MARS and interpolate at desired resolution
What data do you need as initial conditions?
MARS
ai-models
plugin
AIFS checkpoint
Z500, T850, LSM, 2T, 10U, 10V… on a 0.25º grid
Here are some GRIBs
Here some NumPy arrays
Convert to GRIB
Here are some results as NumPy arrays for step N

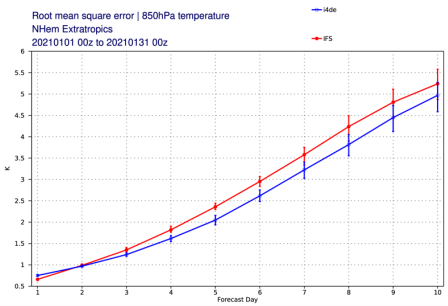
Output


output
dissemination
(push)
eccharts
(web interactive)
mars
(archive)
metview
(interactive gui)
evaluation
(score database)
web products
(web catalogue)




(Pangu-Weather machine learning model: Experimental): Mean sea level pressure and 850 hPa wind speed




Root mean square error | 850hPa temperature
NHem Extratropics
20210101 00z to 20210131 00z
i4de
IFS
K
Forecast Day

Issues

- Loading Python modules is slow
  - It may take up to 30s to load pytorch on Lustre which is 50% of the time to run the inference
- Loading weights is also time consuming
- So is writing the results to disk
- Version dependency hell
  - Python, cuda, cudnn, etc
  - pytorch wants nvidia-cudnn-cu11==8.5.0.96
  - jaxlib wants nvidia-cudnn-cu11==8.9.4.25
- Models may be trained on variables (from ERA5) not generated by HRES

prepml

- **prepml** is the companion tool to **ai-models**
- It allows to run inferences over many years
- Archive all outputs in the MARS archive in research mode
- It feeds ECMWF's scores database to that models can evaluated
- It allows user to run development code a well
- It can create ensembles using various combination of models, inputs, ...

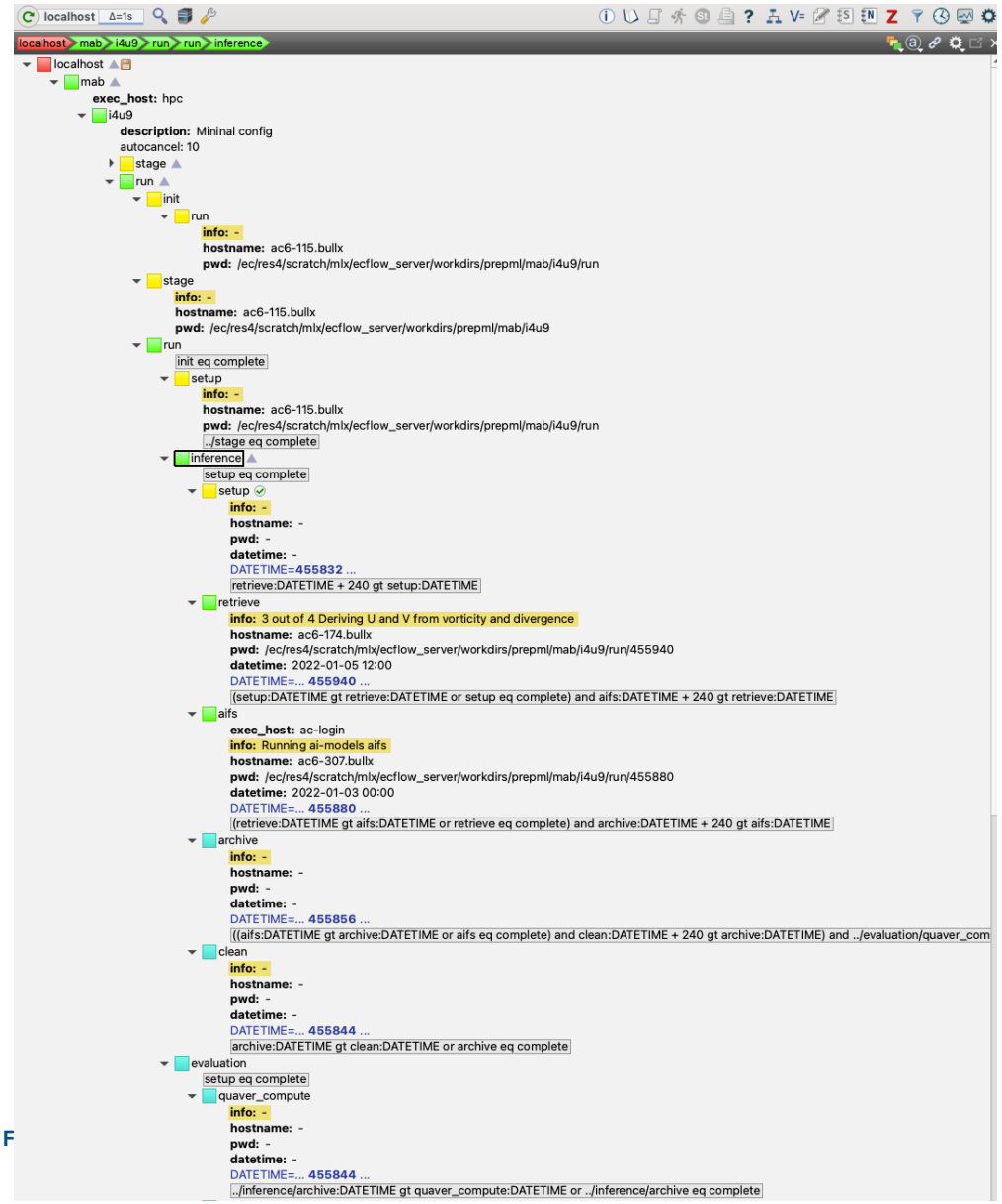
% prepml inference config.yaml

```yaml
description: Just a test

dates:
  start: 2022-01-01
  end: 2022-12-31

model:
  name: aifs
  checkpoint: /home/checkpoints/test.ckpt

runner:
  name: ai-models-dev
  conda:
    clone: /home/conda/env/dev
    pip:
    - git+ssh://git@github.com/ecmwf/aifs.git@dev
```



Ensembles

```yaml
description: ensemble with 4 models

dates:
  start: 2022-01-01
  end: 2022-03-31

ensemble:
  model:
    name:
      loop:
      - aifs
      - panguweather
      - graphcast
      - fourcastnetv2-small

output:
  number: "{member_number}"
  stream: enfo
  type: pf
```

```yaml
description: ensemble with 5 checkpoints

dates:
  start: 2023-06-01
  end: 2023-08-01

ensemble:
  model:
    checkpoint:
      loop:
        - genial_surf.ckpt
        - mat_model.ckpt
        - scarlet_elevator.ckpt
        - worthy_elevator.ckpt
        - zany_serenity.ckpt

output:
   number: "{member_number}"
   stream: enfo
   type: pf
```

Future

- Short term: More models!!!
- Medium term: keep track of provenance: code, checkpoints, initial condition...
- Medium term: understand bottlenecks (mostly I/O)
- Long term: how to run large ensembles and postprocess their output on the fly?

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Range

- [ ] Medium (15 days)
- [ ] Extended (42 days)
- [ ] Long (Months)

Type

- [ ] Forecasts
- [ ] Verification

Component

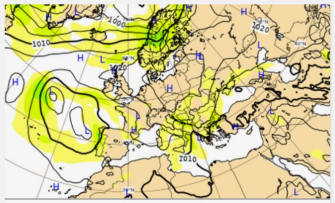
- [ ] Surface
- [ ] Atmosphere
- [ ] Next IFS version (cy48r1)

Product type

- [ ] High resolution forecast (HRES)
- [ ] Ensemble forecast (ENS)
- [ ] Combined (ENS + HRES)
- [ ] Extreme forecast index
- [ ] Point-based products
- [x] Experimental: Machine learning models
- [ ] Atmospheric composition

Parameters

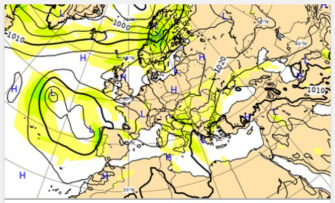
- [ ] Wind
- [ ] Mean sea level pressure



Latest forecast

(FourCastNet machine learning model: Experimental): Mean sea level pressure and 850 hPa wind speed

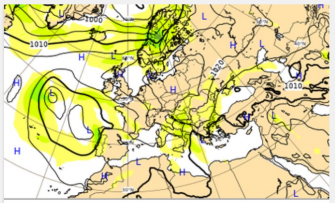
FourCastNet v2-small:a deep learning-based system developed by NVIDIA in collaboration with researchers (FourCastNet machine learning model: Experimental): Mean sea level pressure and 850 hPa wind speed initialised with E FourCastNet operates at 0.25° resolution.



Latest forecast

(GraphCast machine learning model: Experimental): Mean sea level pressure and 850 hPa wind speed

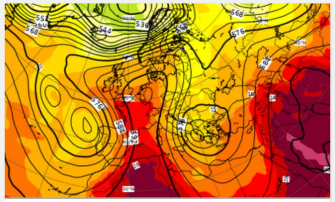
GraphCast (Google Deepmind): a deep learning-based system developed by Google Deepmind.It is initialised with ECMWF HRES analysis. GraphCast operates at 0.25° resolution.



Latest forecast

(Pangu-Weather machine learning model: Experimental): Mean sea level pressure and 850 hPa wind speed

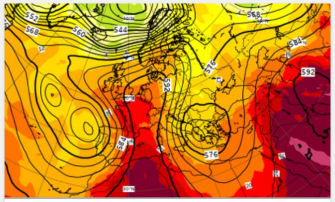
Pangu-Weather: a deep learning-based system developed by Huawei. It is initialised with ECMWF HRES analysis. Pangu-Weather operates at 0.25° resolution.



Latest forecast

(FourCastNet machine learning model: Experimental): 500 hPa geopotential height and 850 hPa temperature

FourCastNet v2-small:a deep learning-based system developed by NVIDIA in collaboration with researchers at several US universities.It is initialised with ECMWF HRES analysis. FourCastNet operates at 0.25° resolution.



Latest forecast

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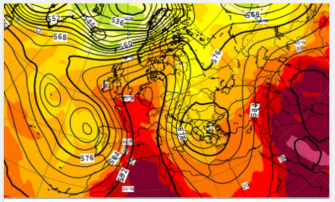

Latest forecast

(Pangu-Weather machine learning model: Experimental): 500 hPa geopotential height and 850 hPa temperature

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