LARGE MACHINE LEARNING MODELS FOR WEATHER FORECASTING
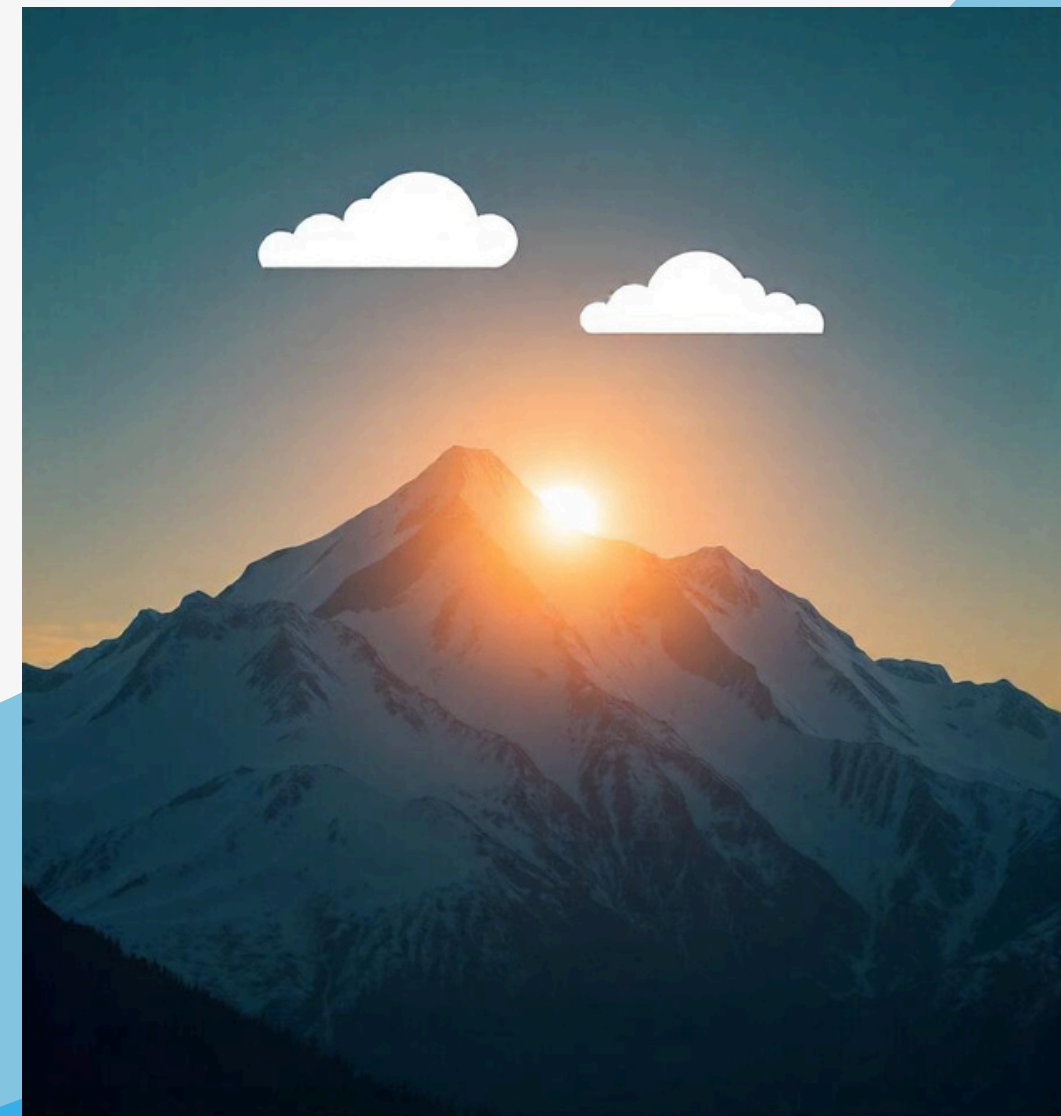
CHALLENGES AND OPPORTUNITIES AHEAD

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LLMs, BUT FOR WEATHER?

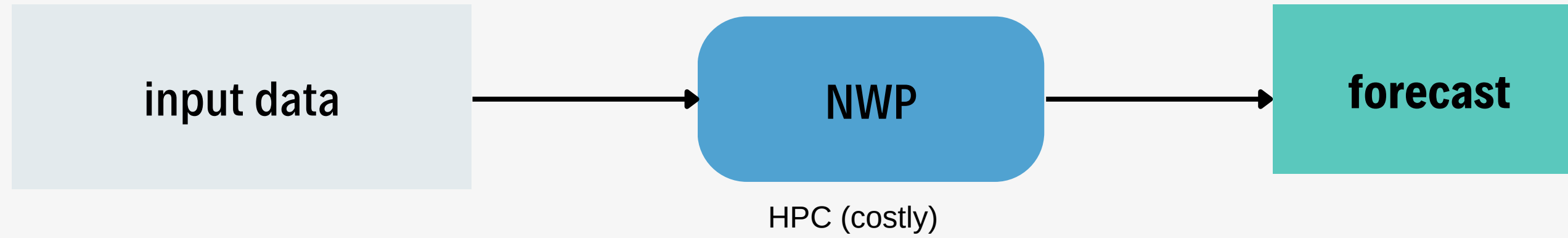**Machine learning weather models**

AI-based weather models

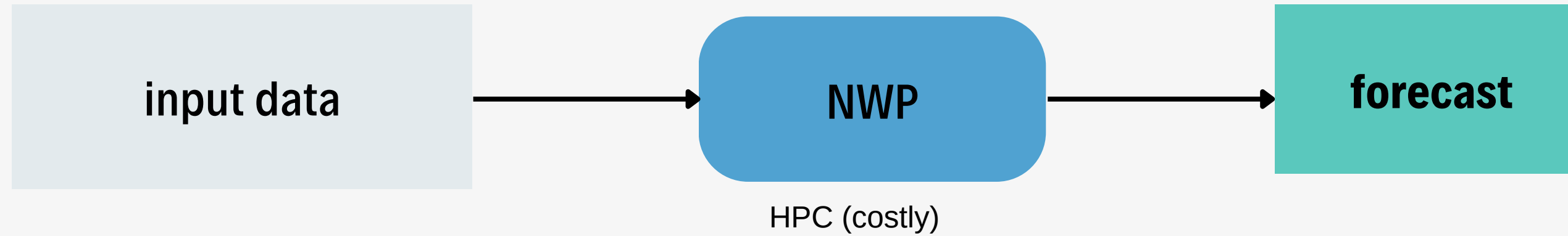**Data-driven models**

Model is built directly from data

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NWP MODEL VS. ML MODEL

NWP model application

NWP MODEL VS. ML MODEL

NWP model application

input data → NWP → **forecast**

HPC (costly)

ML model training

History of:
- input data
- expected output

→ **ML model training** → **trained model**

GPU (costly)
one-off

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NWP MODEL VS. ML MODEL

NWP model application

| input data | → | **NWP** | → | **forecast** |

HPC (costly)

ML model training

History of:
- input data
- expected output

→ **ML model training** → trained model

GPU (costly)
one-off!
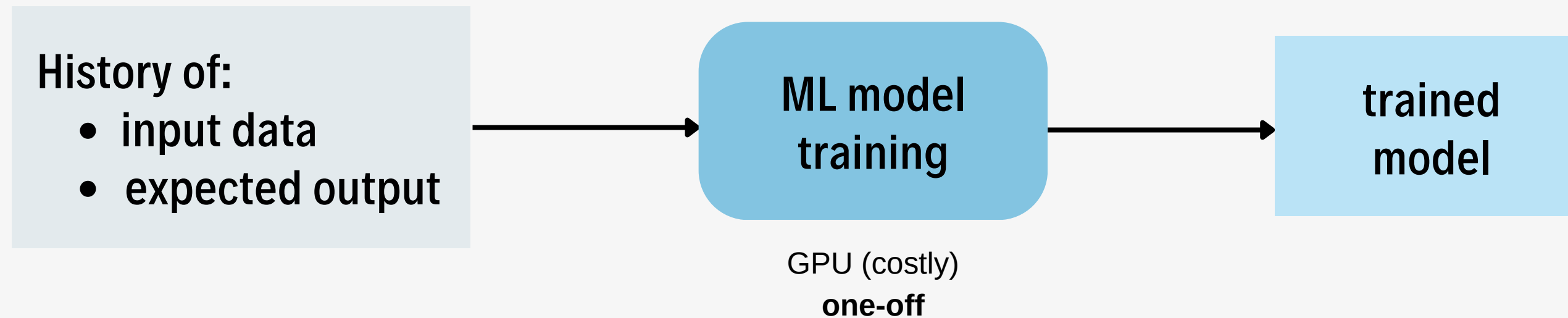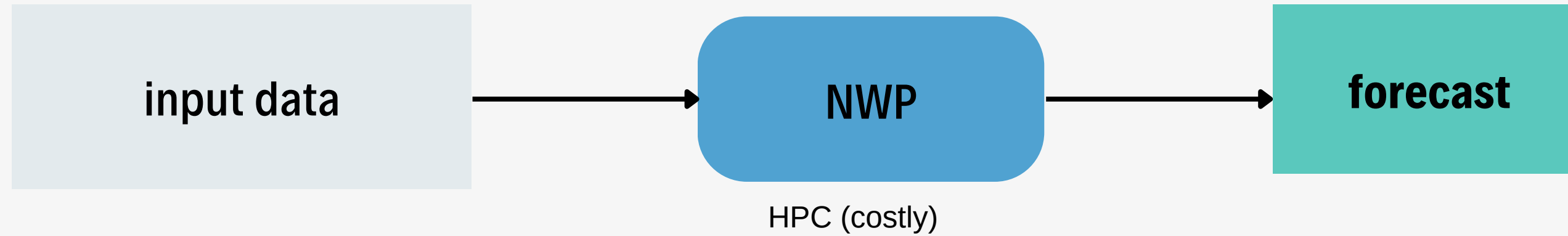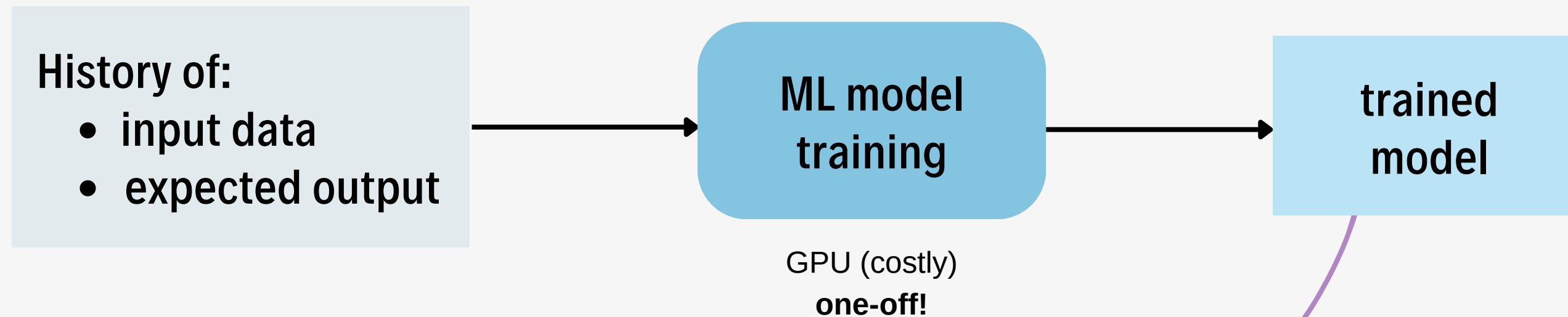
ML model application

| input data | → | trained model | → | **forecast** |

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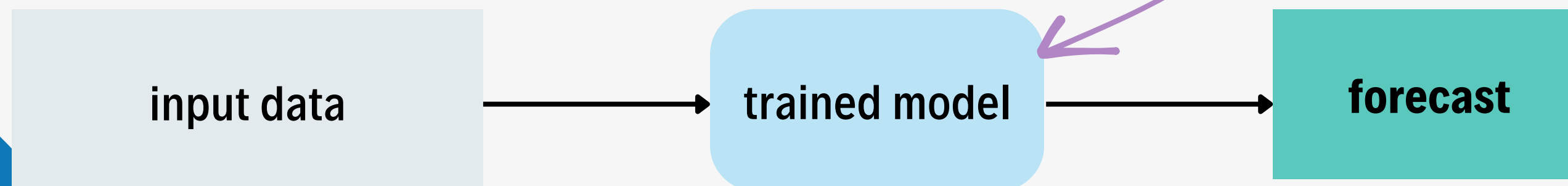
ML   NWP

ML	NWP
Training phase + application phase	No training phase
Training is costly, application is easy	Application is costly
Works best on GPU architectures	Works on CPU-based HPC
No configuration flexibility	Multiple configuration options
Limited output	Rich output
Difficult to build	Well established

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ML WEATHER MODELS

AIFS (ECMWF)

GraphCast (Google)

MetNet (Google)

ClimaX (Microsoft)

FourCastNet (Nvidia)

CorrDiff (Nvidia)

PanguWeather (Huawei)

AtmoRep (ECMWF/JSC/CERN)

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ADVANTAGES AND OPPORTUNITIES
OF APPLYING TRAINED ML MODELS

✓ Forecast can be obtained **within minutes** of the processing time

✓ We get forecasts easier and at **little cost** - no HPC needed

✓ **More people** can experiment with the models

✓ We can run **large ensembles** at a fraction of the cost

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LIMITATIONS

A machine learning model
is only **as good as the data**
it learns from

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POSSIBLE RESEARCH DIRECTIONS

▶ **Regional models** based on downscaled data

▶ Closer **interdisciplinary work** between meteorologists and ML engineers

▶ NWP to **improve the resolution** of the training data

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WHAT WILL THE WEATHER BE LIKE?

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