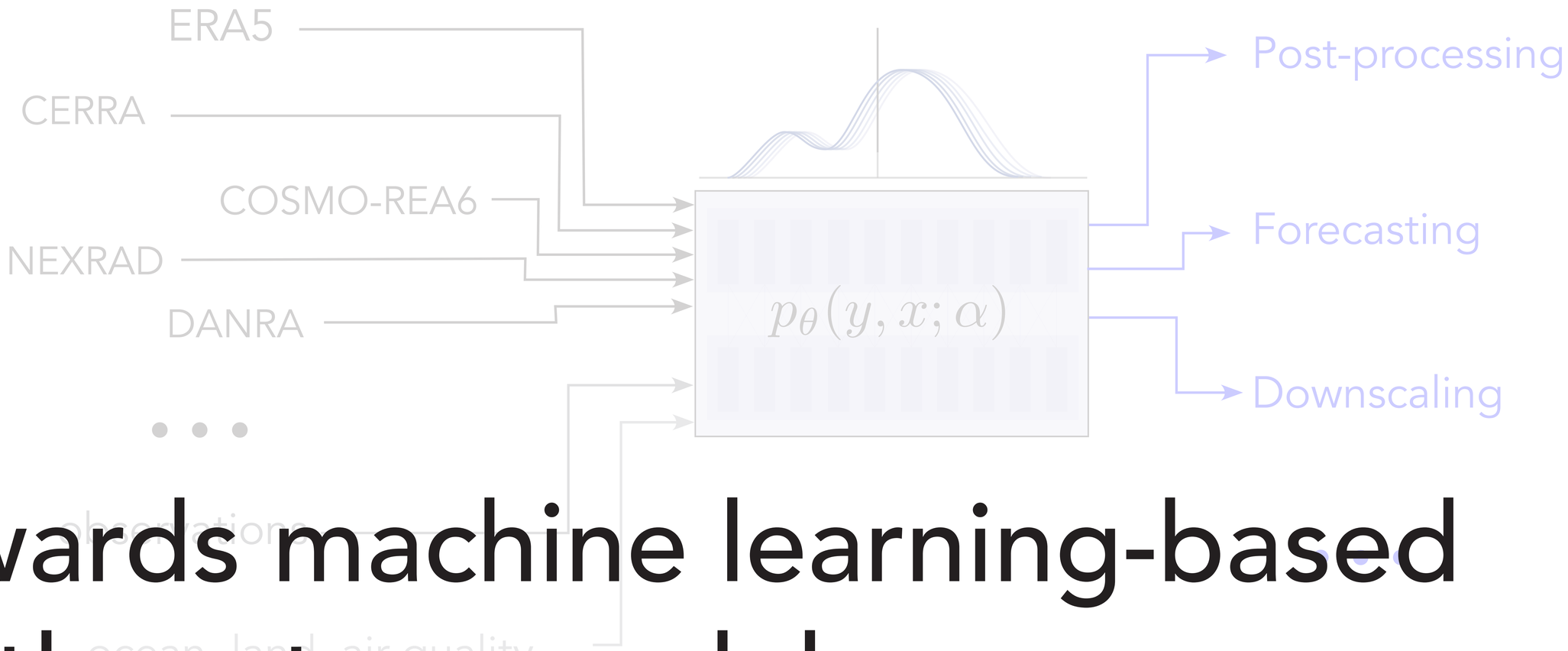

Towards machine learning-based Earth system models

Christian Lessig, European Centre for Medium-Range Weather Forecasts
christian.lessig@ecmwf.int

Machine learning-based Earth system models?

ERA5

Weather forecasting

Machine learning-based Earth system models?

ERA5

Weather forecasting

Post-processing

Climate projections

Scenario generation

• • •

Machine learning-based Earth system models?

ERA5

Weather forecasting

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CO_2 monitoring

• • •

Machine learning-based Earth system models?

ERA5

CERRA

COSMO-REA6

• • •

Weather forecasting

Post-processing

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CO_2 monitoring

• • •

Machine learning-based Earth system models?

ERA5

CERRA

COSMO-REA6

• • •

IFS

CMIP6

ICON

Weather forecasting

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Machine learning-based Earth system models?

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• • •

IFS

CMIP6

ICON

• • •

AMSU-A, METOP, ...

Landsat, ...

• • •

Weather forecasting

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Climate projections

Scenario generation

CO_2 monitoring

• • •

Machine learning-based Earth system models?

ERA5

CERRA

COSMO-REA6

• • •

IFS

CMIP6

ICON

• • •

AMSU-A, METOP, ...

Landsat, ...

• • •

Local GDP, tax revenue, ...

Weather forecasting

Post-processing

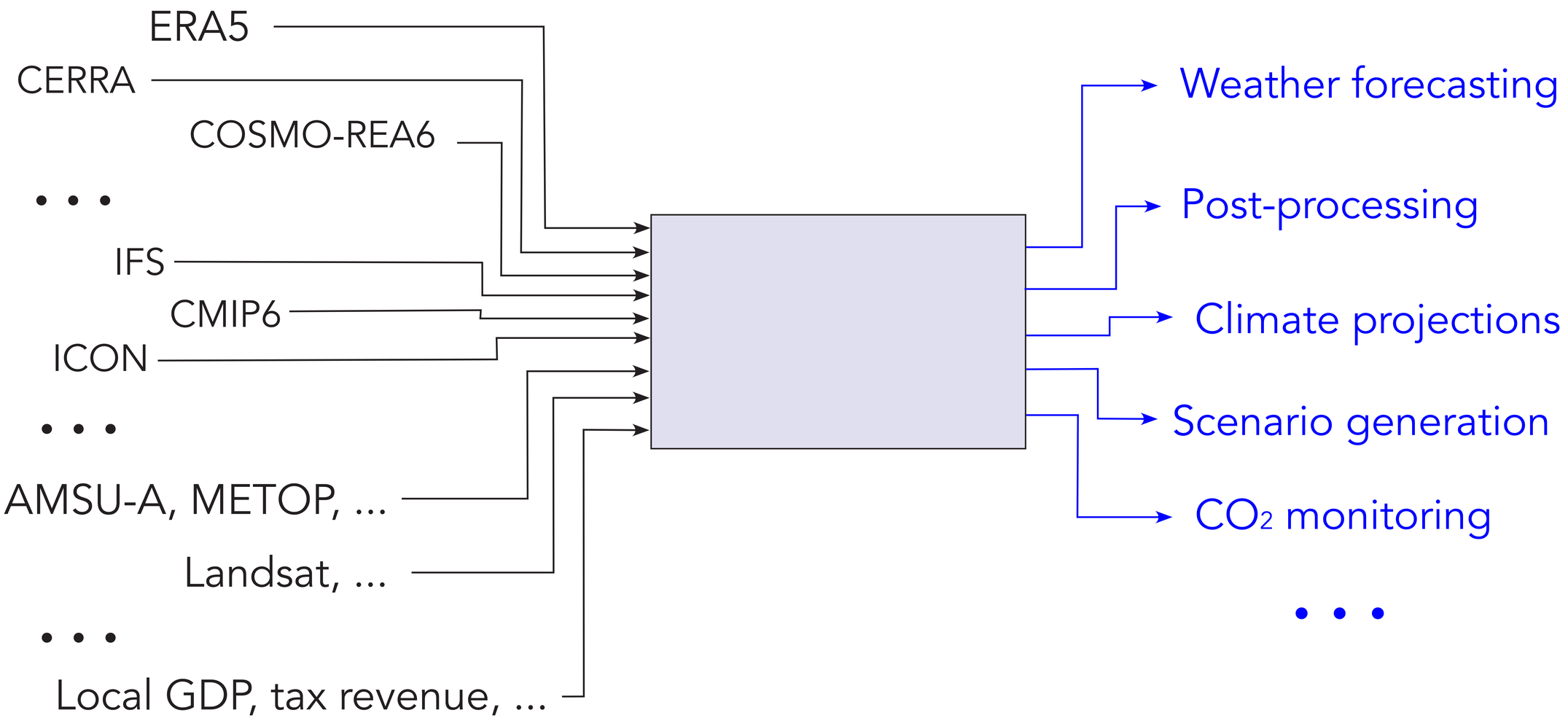
Climate projections

Scenario generation

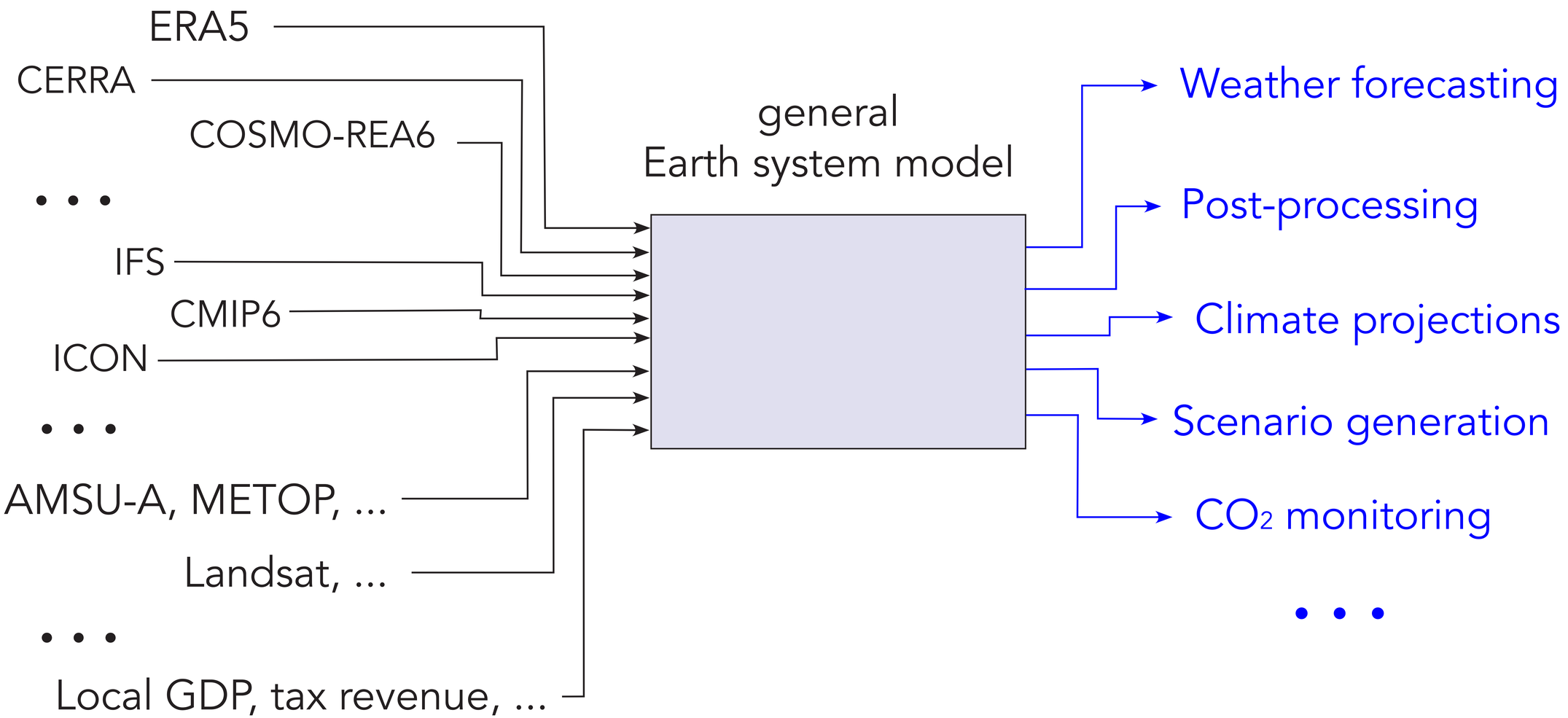
CO_2 monitoring

• • •

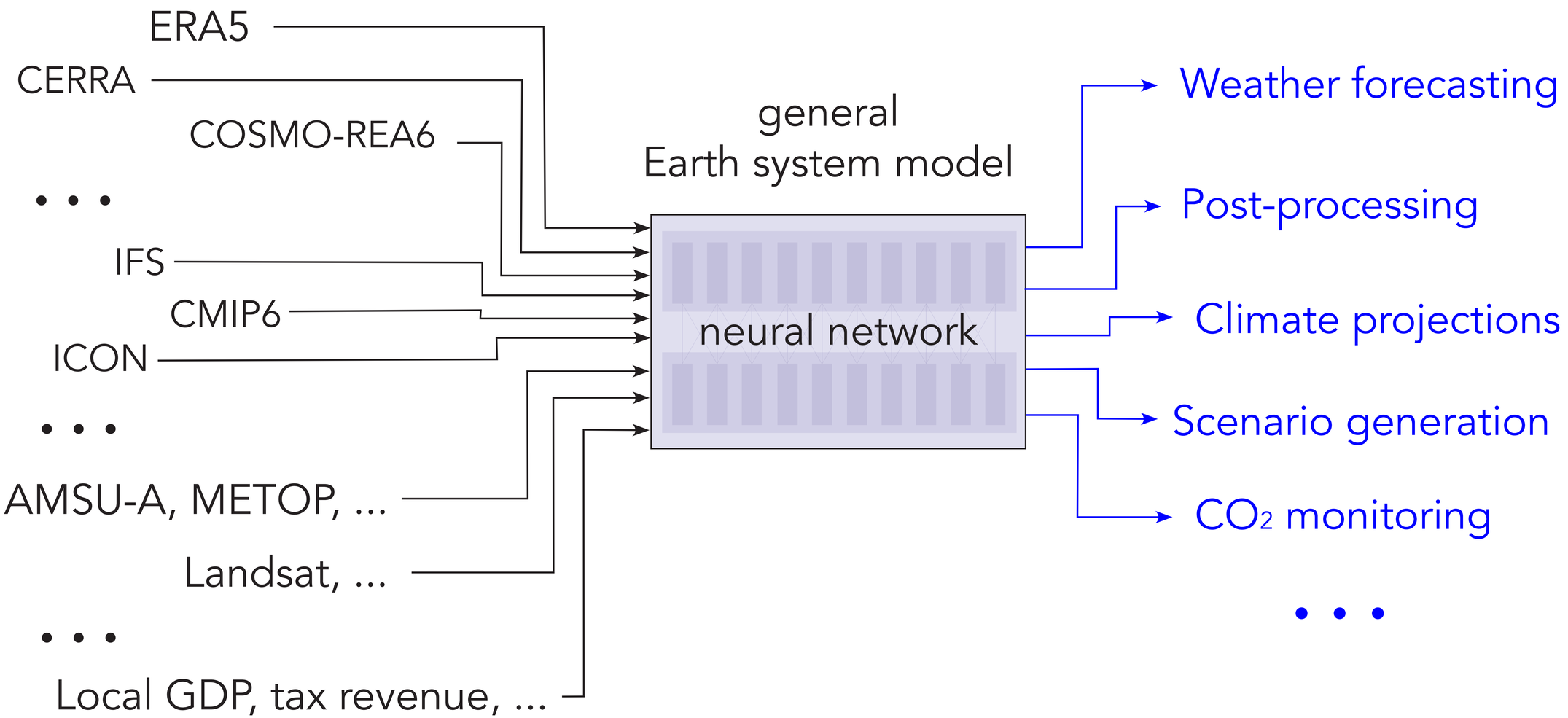
Machine learning-based Earth system models?



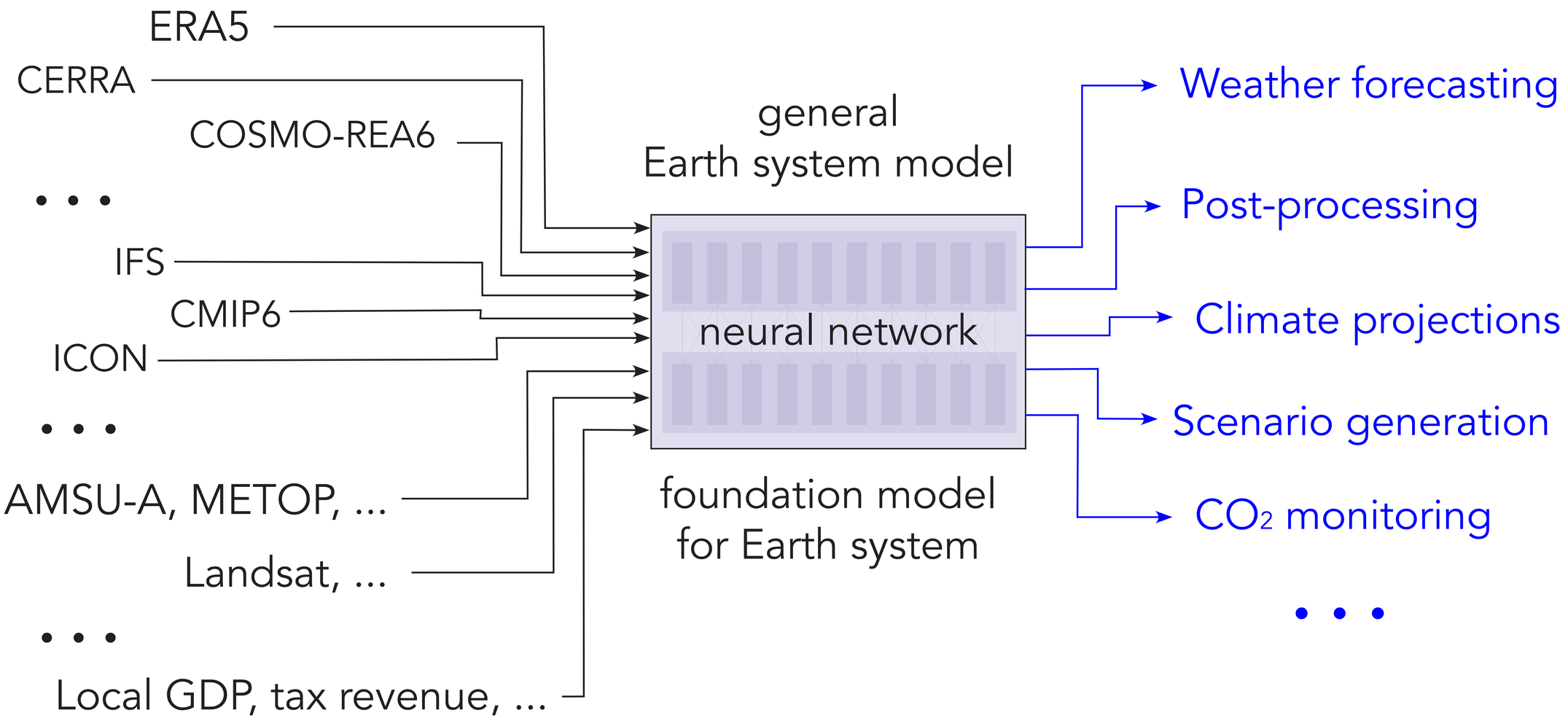
Machine learning-based Earth system models?



Machine learning-based Earth system models?

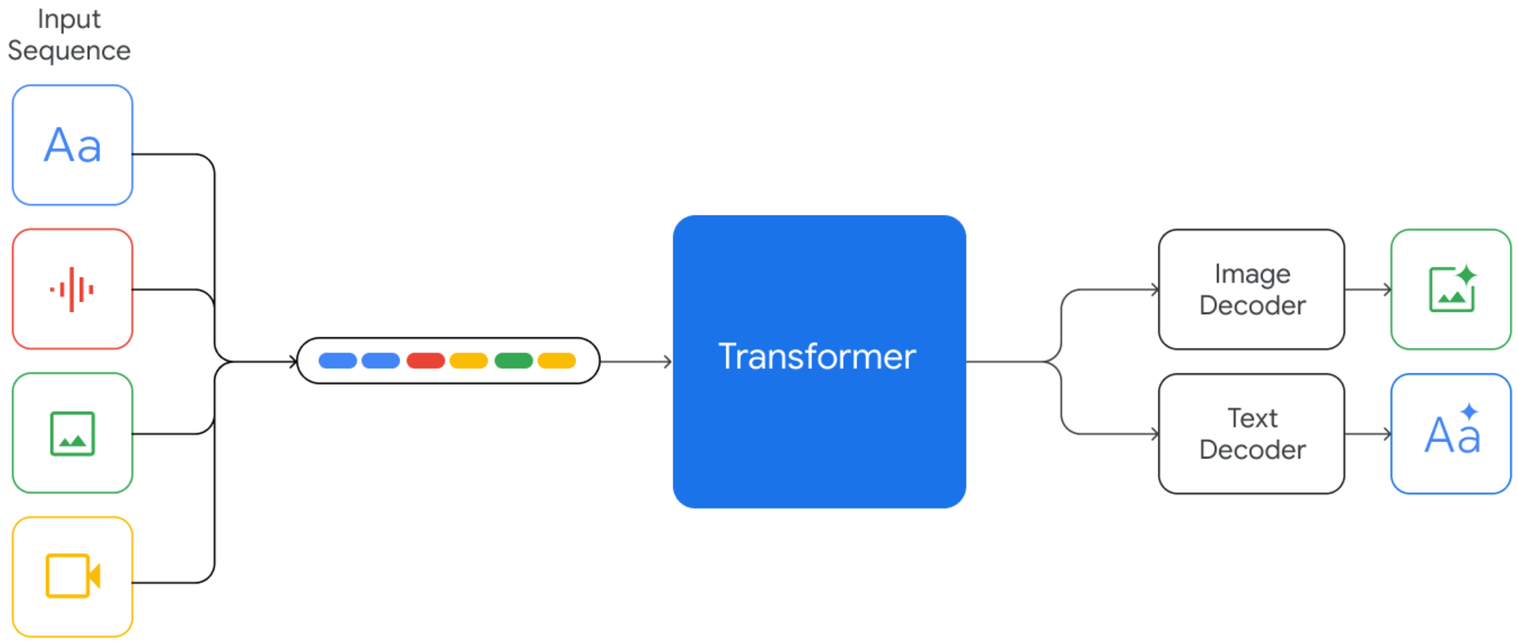


Machine learning-based Earth system models?



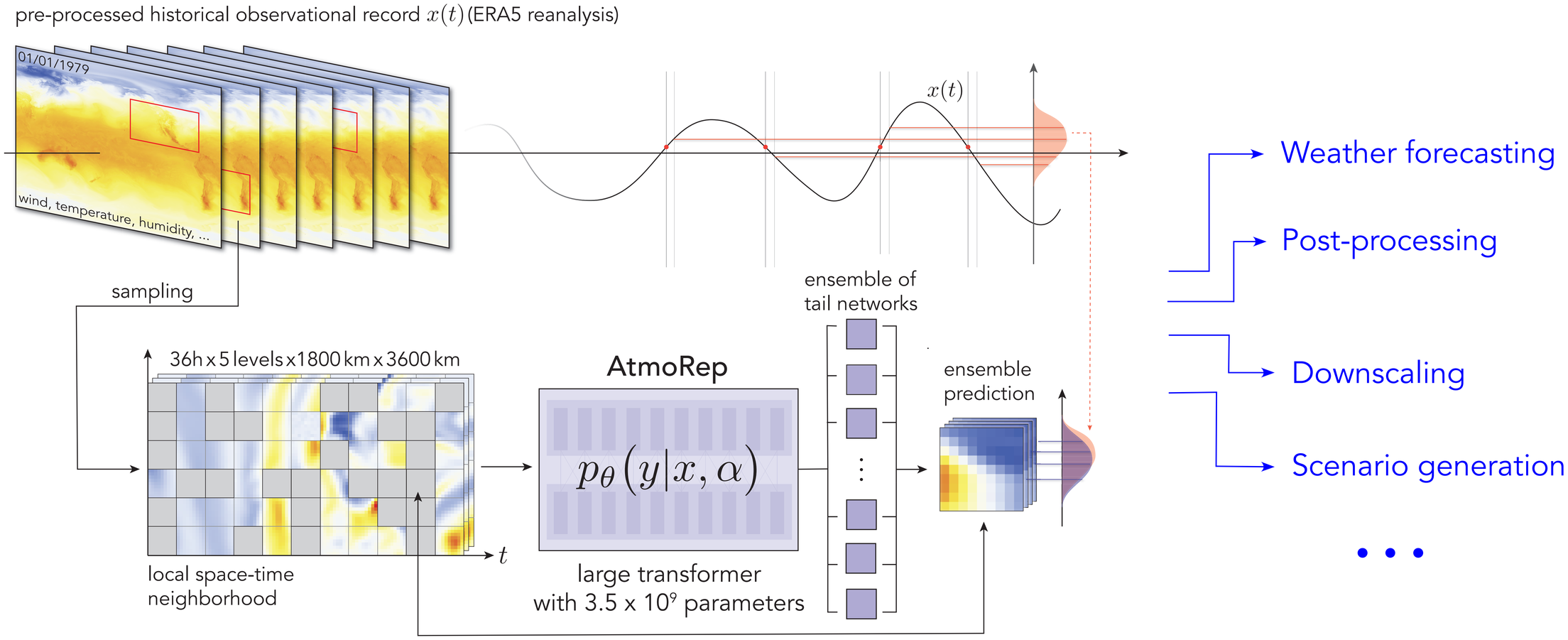
An example

- Google's Gemini model:[1]



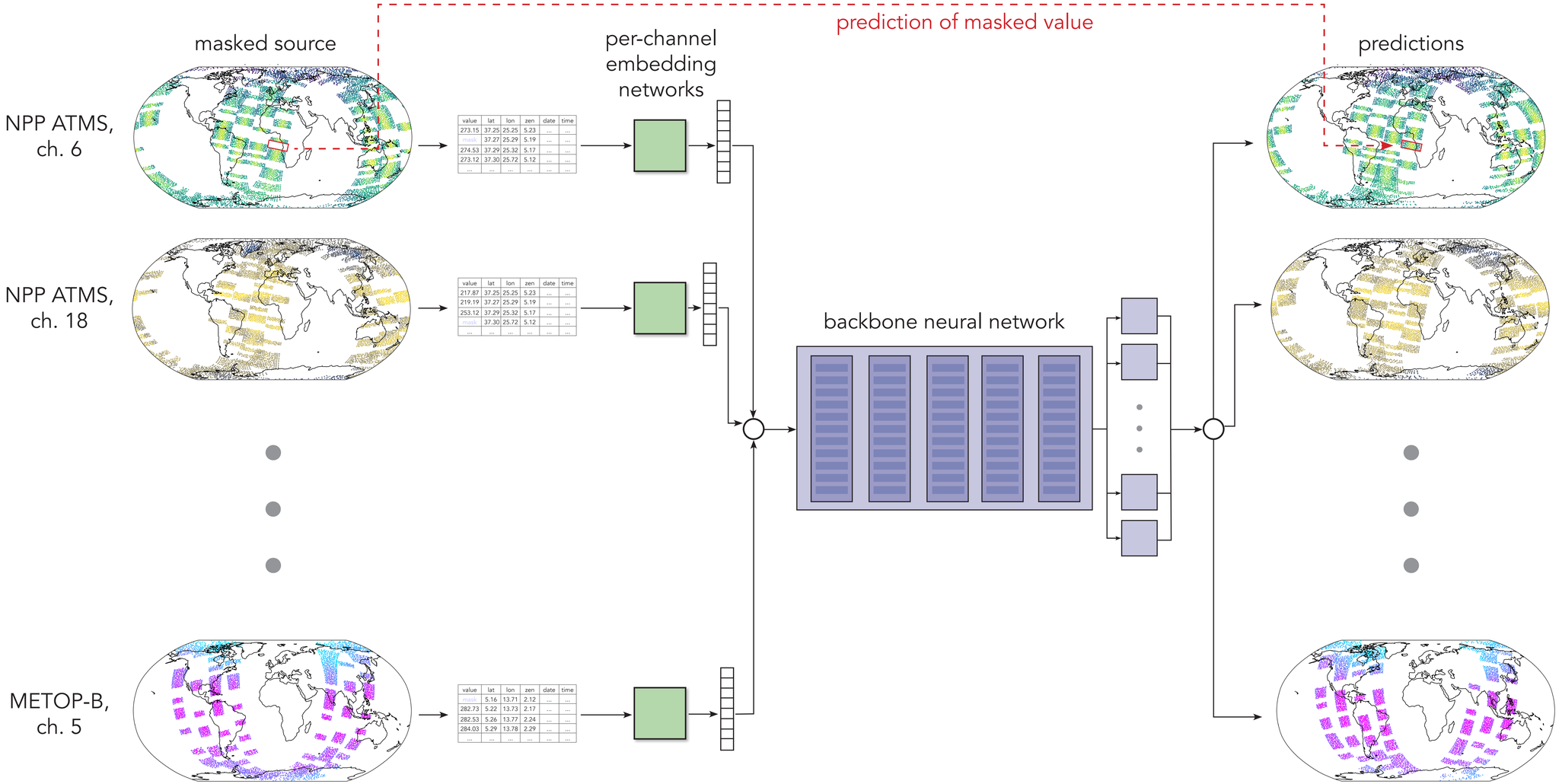
[1] Google Team. Gemini: A family of highly capable multimodal models, 2023.

First steps: AtmoRep



[2] C. Lessig, I. Luise, B. Gong, M. Langguth, S. Stadler, and M. Schultz. Atmorep: A stochastic model of atmosphere dynamics using large scale representation learning, 2023; https://arxiv.org/abs/2308.13280

First steps: Learning from observations



Summary

- Machine learning-based Earth system model is plausible
  - Extension of multimodal model (with many challenges)
- Integration of many different data streams in the network
  - Correlations between them learned from the data
  - Include Earth observations might allow to obtain models with better skill than conventional ones
- Would (also) allow for merged botton-up and top-down approaches for CO_2 monitoring