Graph-based Neural Weather Prediction for Limited Area Modeling

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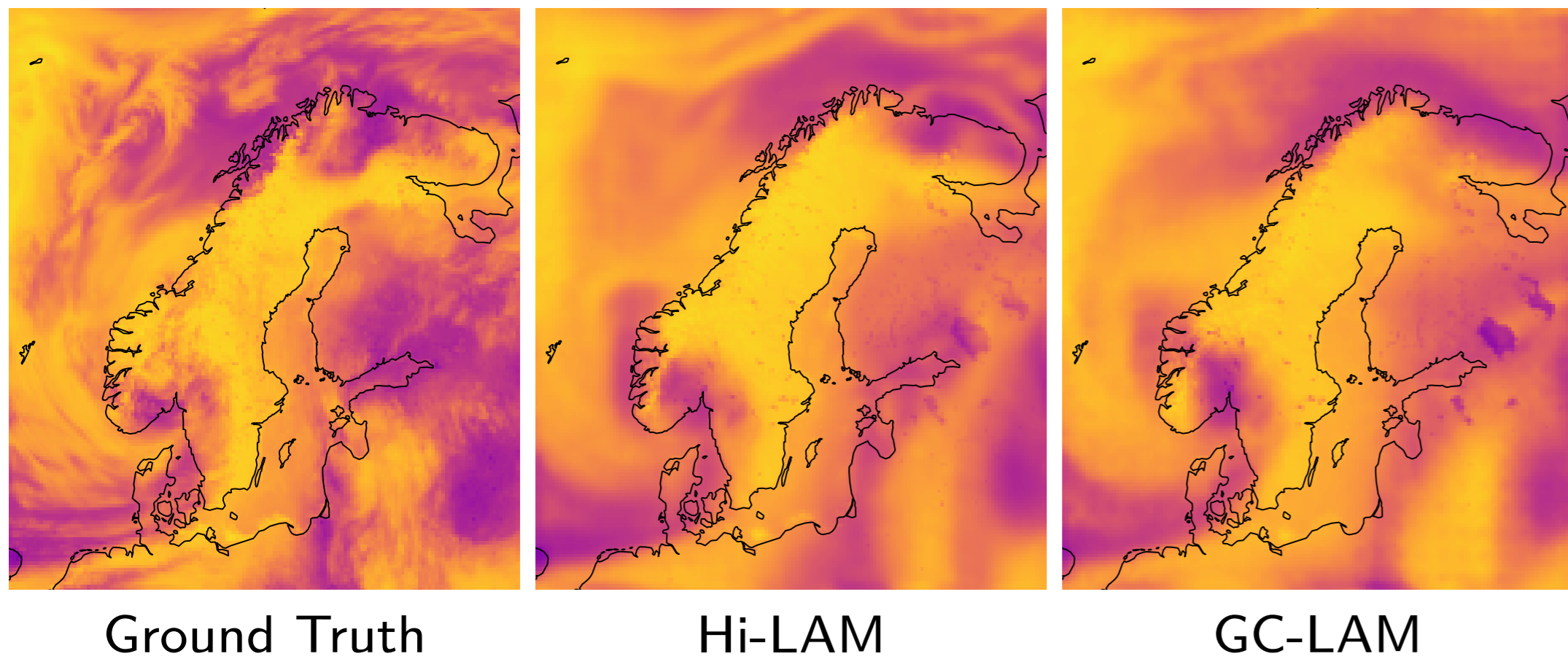
Figure: Forecasts of solar radiation (`nlwrs`) at 57 h lead time

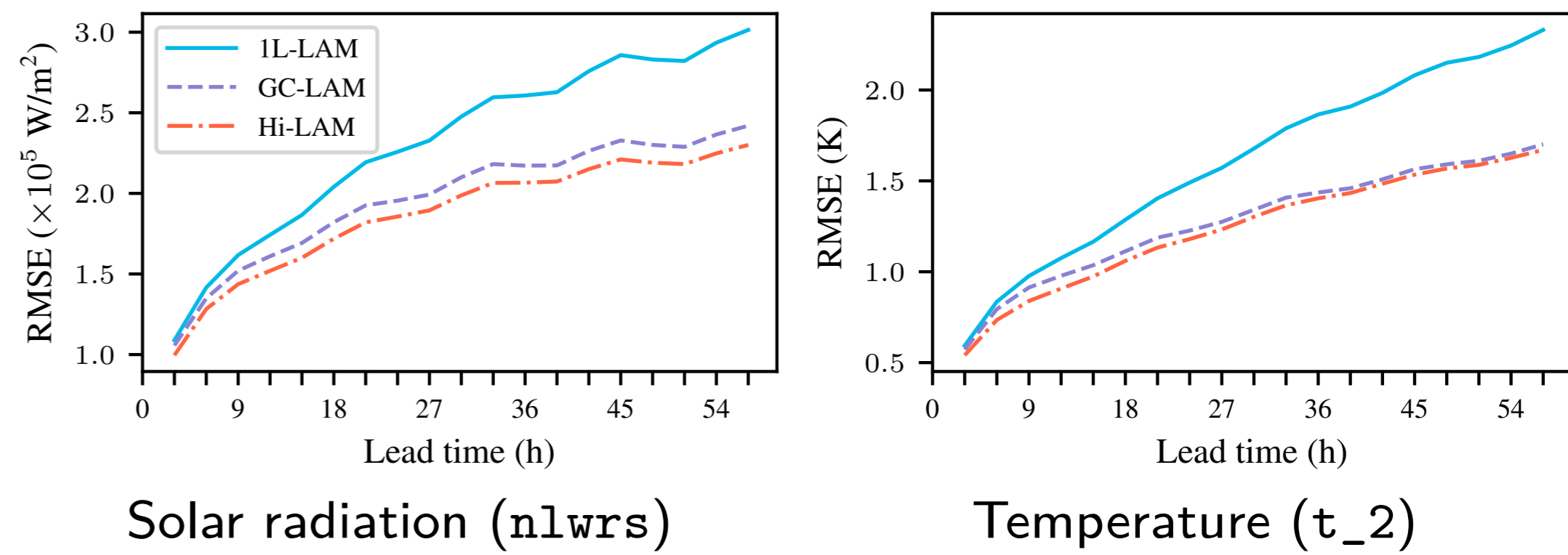

Solar radiation (`nlwrs`)   Temperature (`t_2`)

**Figure:** RMSE at different lead times

Machine Learning for Weather Forecasting

The latest Neural Weather Prediction (NeurWP) models are as accurate as traditional Numerical Weather Prediction (NWP) systems, but require far less resources.

	Traditional NWP	**NeurWP**
Time to produce forecast	Hours	Seconds
Computational resources	Large cluster	Single GPU

Problem formulation: Given initial condition X^0 predict a trajectory $X^1, \ldots, X^T$ of following weather states.

- Learn single time step dynamics model $\hat{f}$
- Roll out forecast auto-regressively
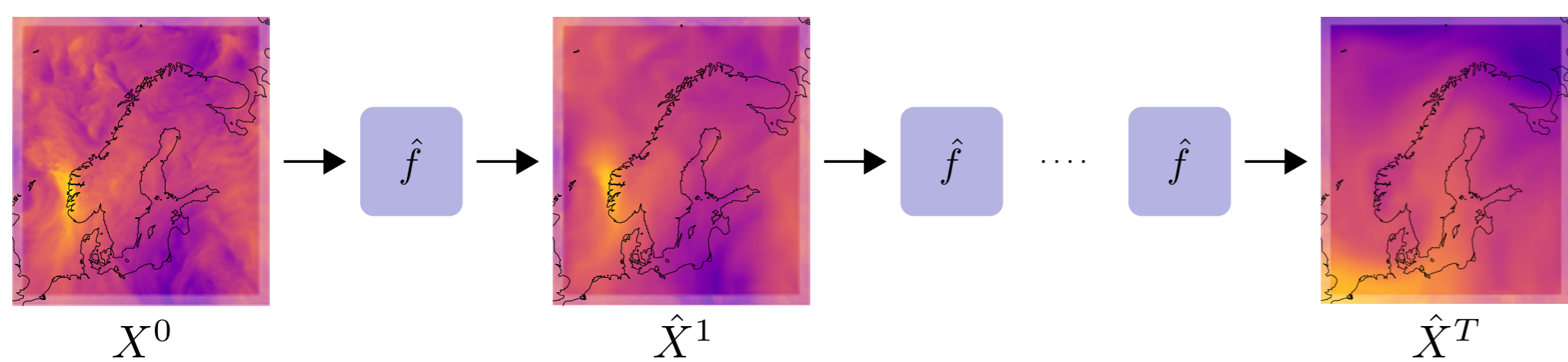
Existing models focus on global weather forecasting.
Our work: Adapt graph-based neural weather prediction for Limited Area Models (LAMs)!

Climate Impact

- Enabling large-scale ensemble forecasting, important for extreme weather prediction
- Providing fast and accurate forecasts for renewable energy production
- Reducing the energy required to produce forecasts

Dataset: MEPS forecasts

- 6 000 forecasts from the MetCoOp Ensemble Prediction System (MEPS)
- Data in 238×268 grid, covering Nordic area
- 17 atmospheric variables: Temperature, wind, pressure, water vapor, solar radiation, humidity, geopotential

Neural Limited Area Models

Graph-based NeurWP [1, 2]

- Construct *mesh graph* covering forecasting area
- Utilize Graph Neural Networks (GNNs) to
  - *Encode* gridded observations to mesh
  - *Process* latent representation on mesh
  - *Decode* to grid, producing one time step prediction
- **GC-LAM**: adaptation of GraphCast [2] to LAM
- **Hi-LAM**: Extended model with hierarchical mesh graph

GC-LAM

Hi-LAM

Encode   Process   Decode
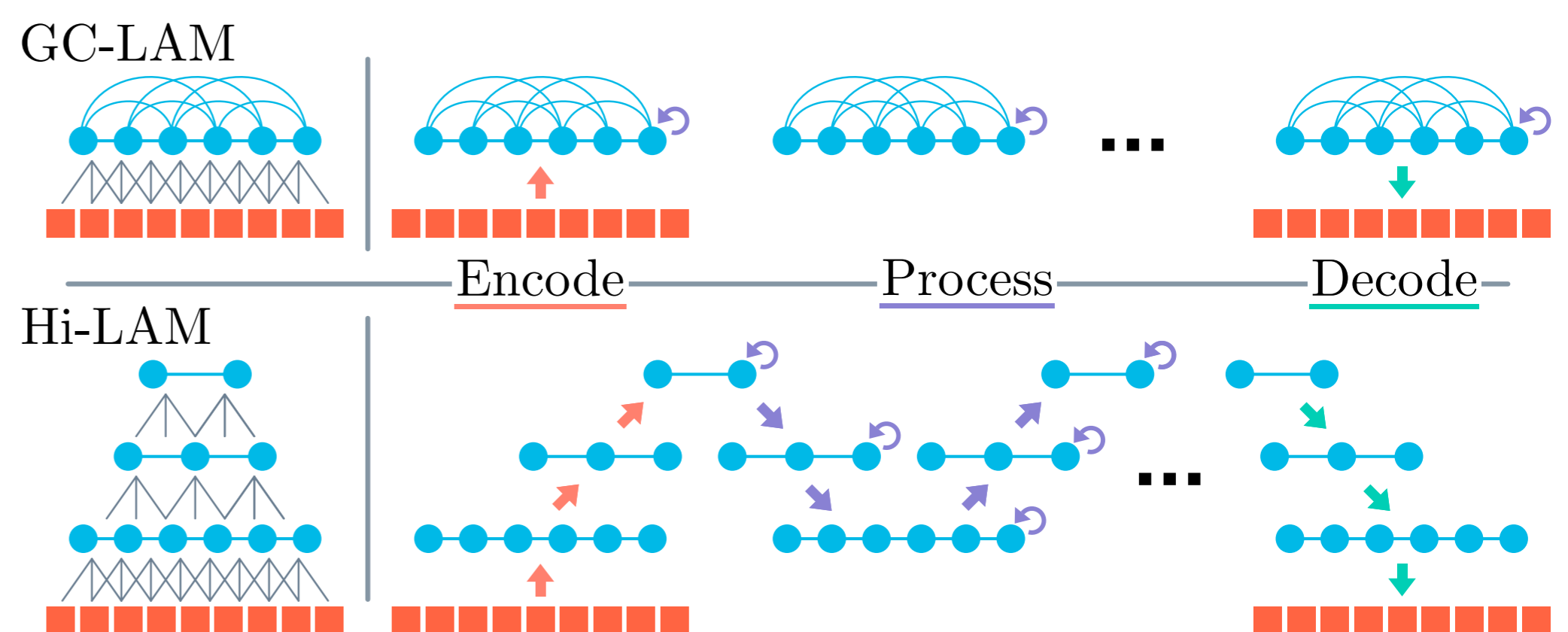
Adapting to LAM setting

- *LAM mesh graph*: Regular quadrilateral mesh
- *Area boundary*: Forcing along boundary from existing forecast
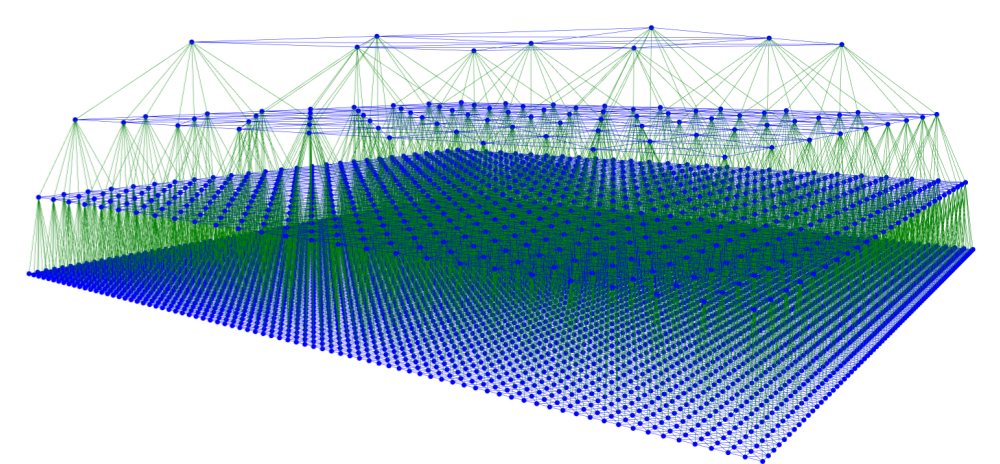
Contact and Links

Webpage   Paper   Code

We are attending virtually, please ask questions through the submission webpage or later at `joel.oskarsson@liu.se`.

References

[1] R. Keisler. Forecasting global weather with graph neural networks. *arXiv preprint arXiv:2202.07575*, 2022.
[2] R. Lam et al. Learning skillful medium-range global weather forecasting. *Science*, 2023.

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Tackling Climate Change with Machine Learning
Workshop at NeurIPS 2023