High-Resolution Weather Prediction with GraphCast and Implicit Neural Representations

CSED499I: Research Project I @ ML Lab

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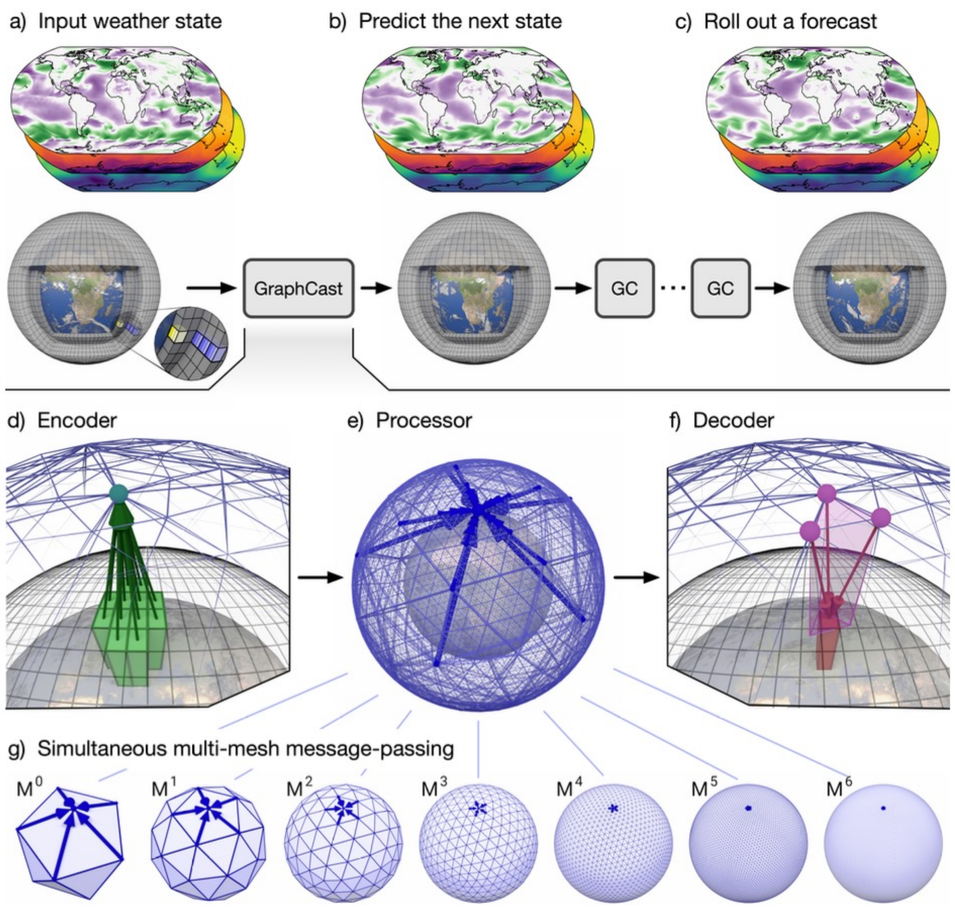
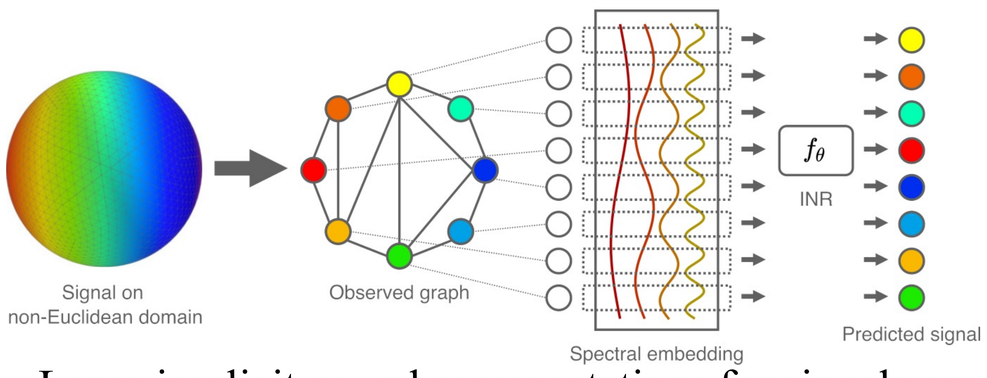
- Graphcast



- GNN-Based Weather Prediction System
- Multiple Resolutions from meshes M^0 to M^6
- M^6 (40,962 nodes) is the highest resolution avaliable

- Generalised Implicit Neural Representations (GINR)



- Learn implicit neural representations for signals on non-Euclidean domains
- Train a neural network which maps the sprectral embedding of the graph to corresponding signal values

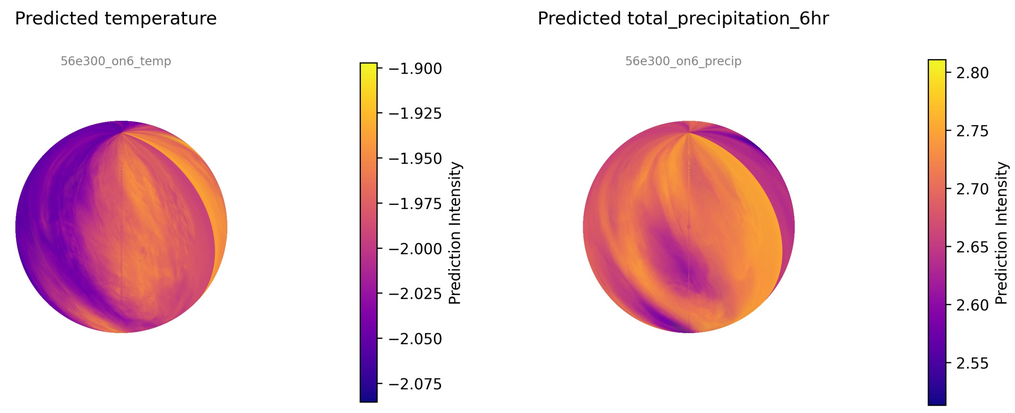
- **Research Topic**
  - Enhance high-resolution weather forecasting by training GINR to predict weather conditions on a finer Graphcast mesh, using input from a coarser mesh

- Original Dataset: ERA5
  - ECMWF atmospheric reanalysis of the global climate
    - resolution: 0.25°
    - number of time: 3
    - number of pressure levels: 37

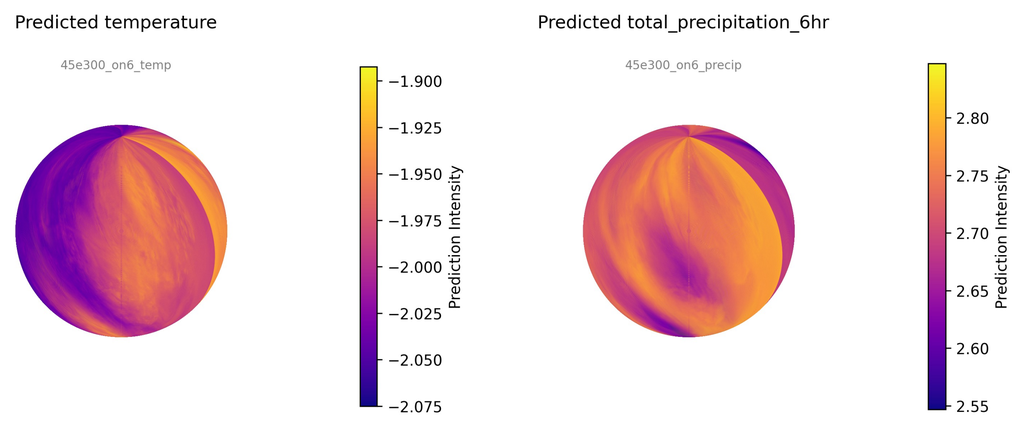
- Processed Dataset (using Graphcast)
  - Weather prediction by Graphcast on ERA5 dataset
    - Predictions on meshes M^4, M^5, M^6
  - Converted to GINR input (graph coordinates, spectral embeddings, and signals)

- **Training**
  - Each with 300/1k epochs, 0.001 learning rate, 8 layers
- Model ‘45e300/45e1k’
  Input: Prediction results on M^4,
  Output: Signals on M^5
- Model ‘56e300/56e1k’
  Input: Prediction results on M^5,
  Output: Signals on M^6
- Model ‘46e300/46e1k’
  Input: Prediction results on M^4,
  Output: Signals on M^6

- **Results**
  - Loss has converged to **~1e5** for all models
  - Model ‘56e300’ Train Results (on M^6):



  - Model ‘45e300’ Predictions on M^6:



  - MSE of Train Result & Prediction between target
    - epoch = 300
      - Train Result MSE = **107370.383**
      - Prediction MSE = **107358.695**
    - epoch = 1k
      - Train Result MSE = **111771.875**
      - Prediction MSE = **111715.977**

  → Prediction is as accurate as the trained result

- References

- Remi Lam *et al*., Learning skillful medium-range global weather forecasting. Science 382, 1416-1421 (2023). DOI: 10.1126/science.adi2336
- Daniele Grattarola, Pierre Vandergheynst, “Generalised Implicit Neural Representations”, *NeurIPS 2022*. arXiv:2205.15674

- Code, Details
  - github.com/jiwooh/CSED499I