Positional Encoder Graph Neural Networks for Geographic Data

Konstantin Klemmer (Microsoft Research),
Nathan Safir (University of Georgia),
Daniel B. Neill (NYU)

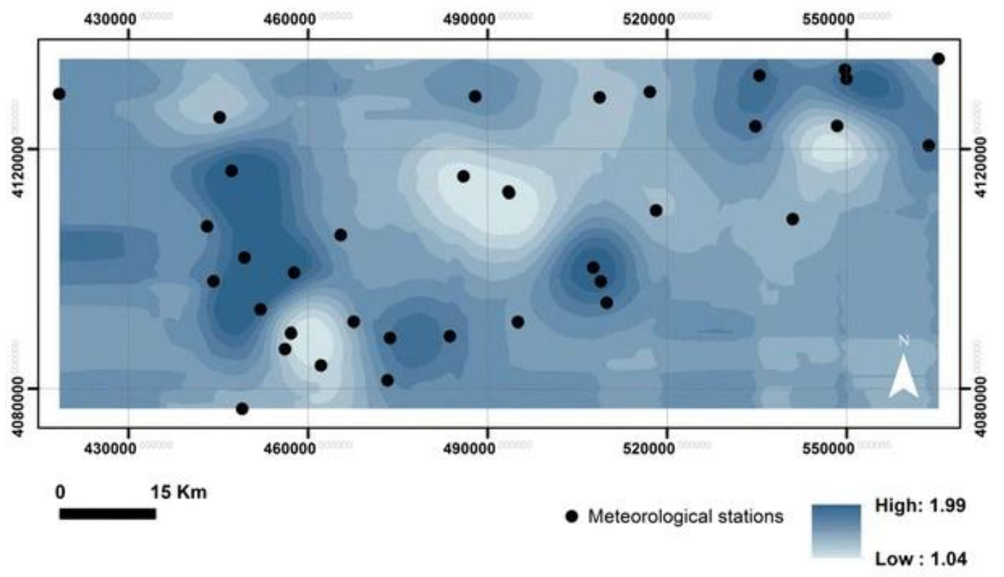
TCCML – NeurIPS'22
December 9, 2022

Motivation

Location data is central to many climate-relevant applications

Motivation

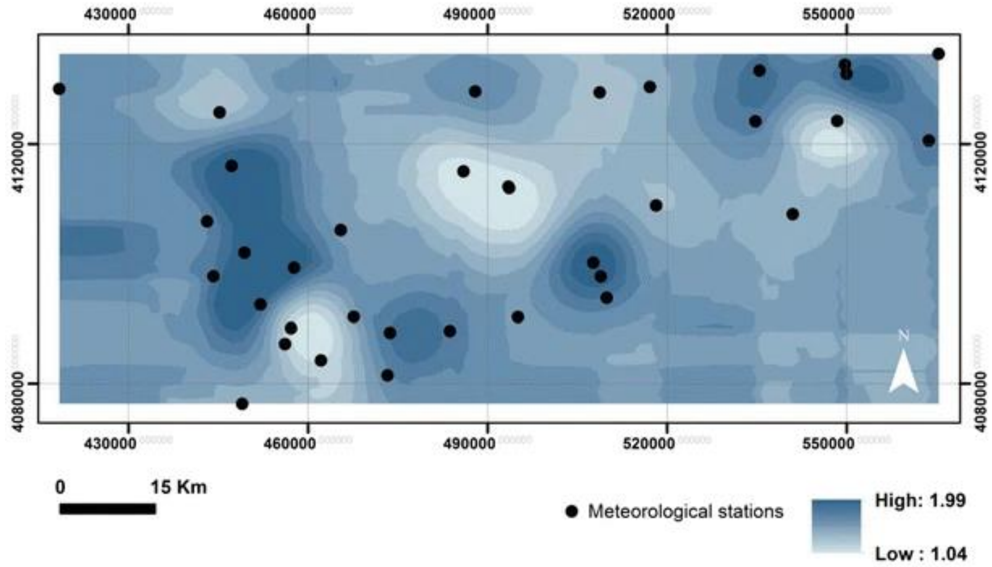
Location data is central to many climate-relevant applications



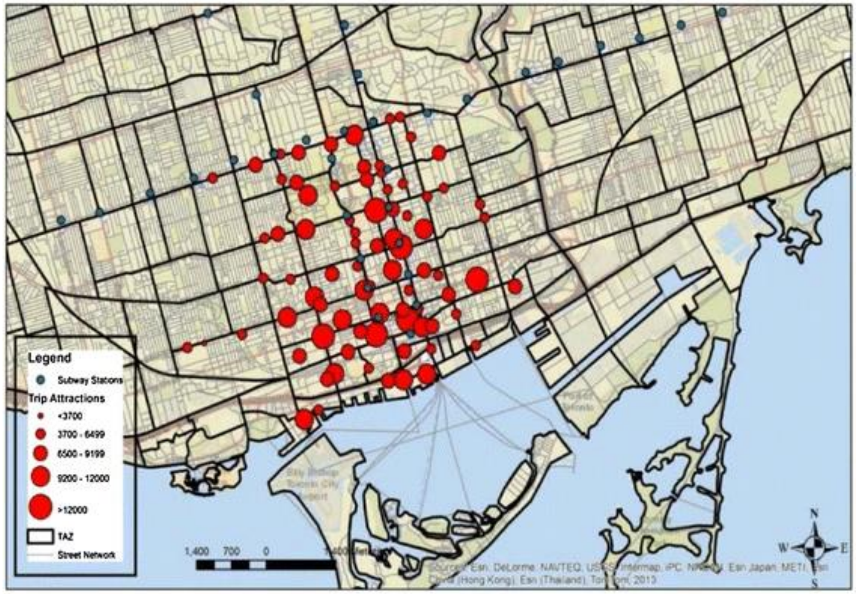
Spatial interpolation of precipitation from meteorological stations

Motivation

Location data is central to many climate-relevant applications



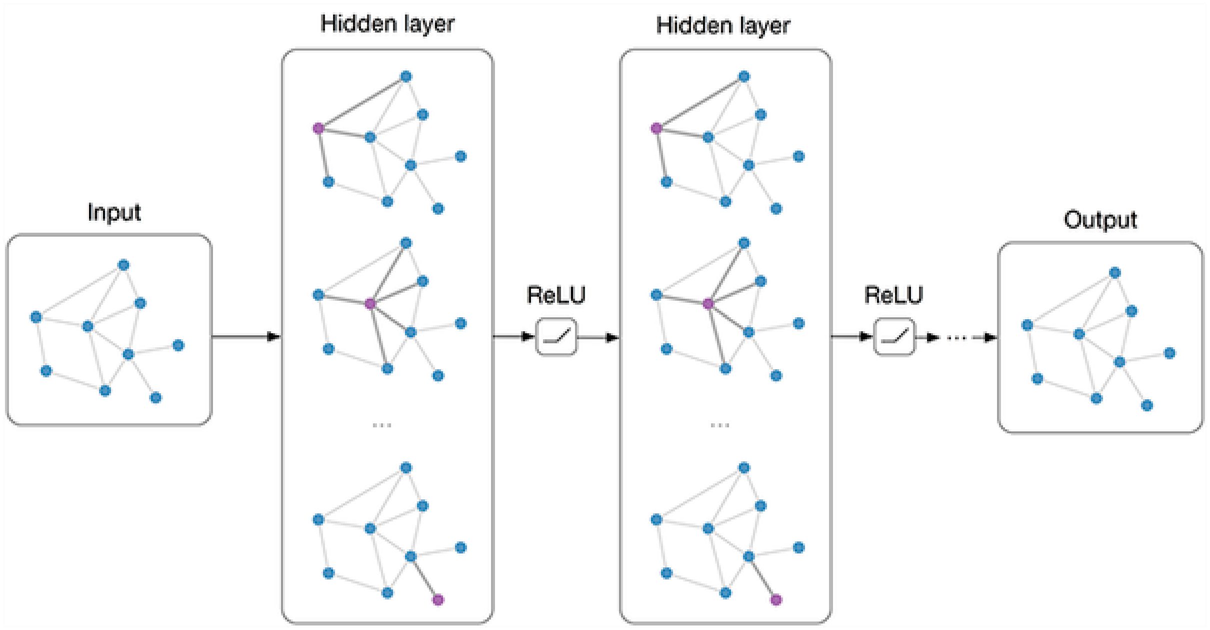
Spatial interpolation of precipitation from meteorological stations



Forecasting bike-sharing trip demand

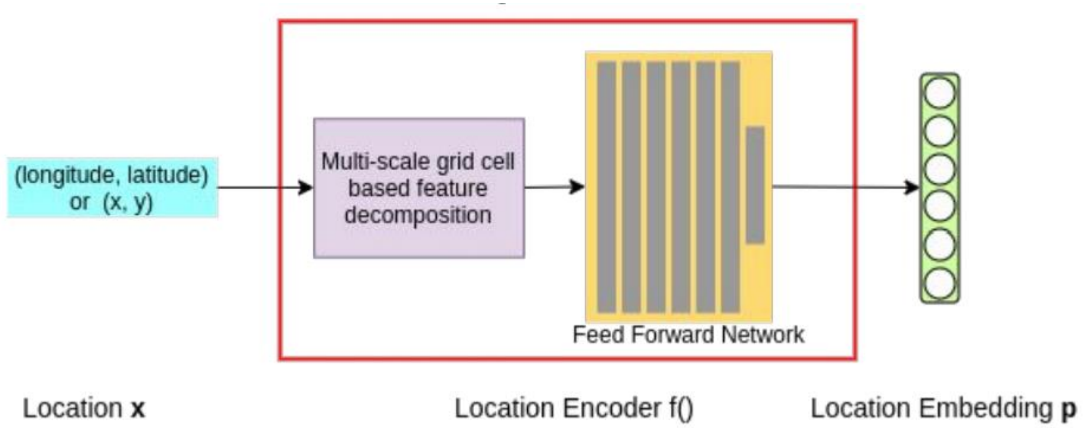
Motivation

Graph neural networks (GNNs) are a natural fit for location data: **spatial relationship** can be represented graphically, and they **scale well** to high-dimensional data.



Motivation

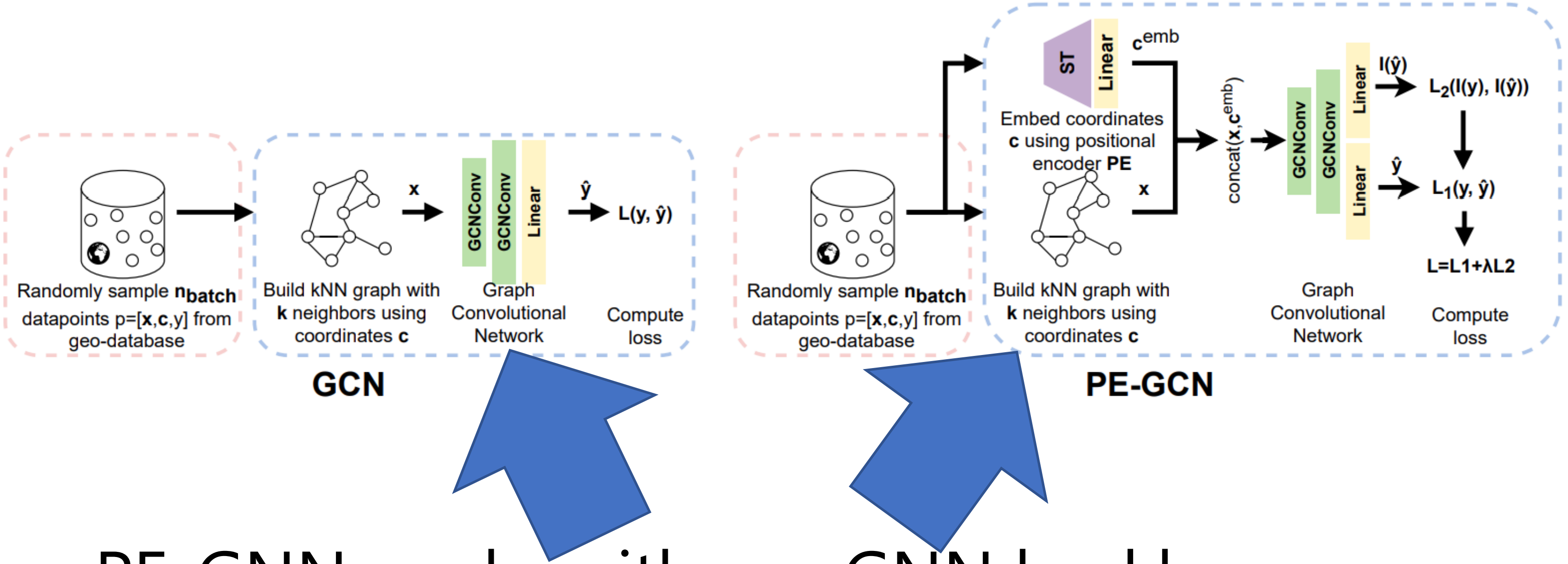
Recent advances in transformers and positional encoding allow for the learning of **meaningful latitude / longitude coordinate embeddings**



Mai, Gengchen, et al. "Multi-Scale Representation Learning for Spatial Feature Distributions using Grid Cells." *International Conference on Learning Representations*. 2020.

Method

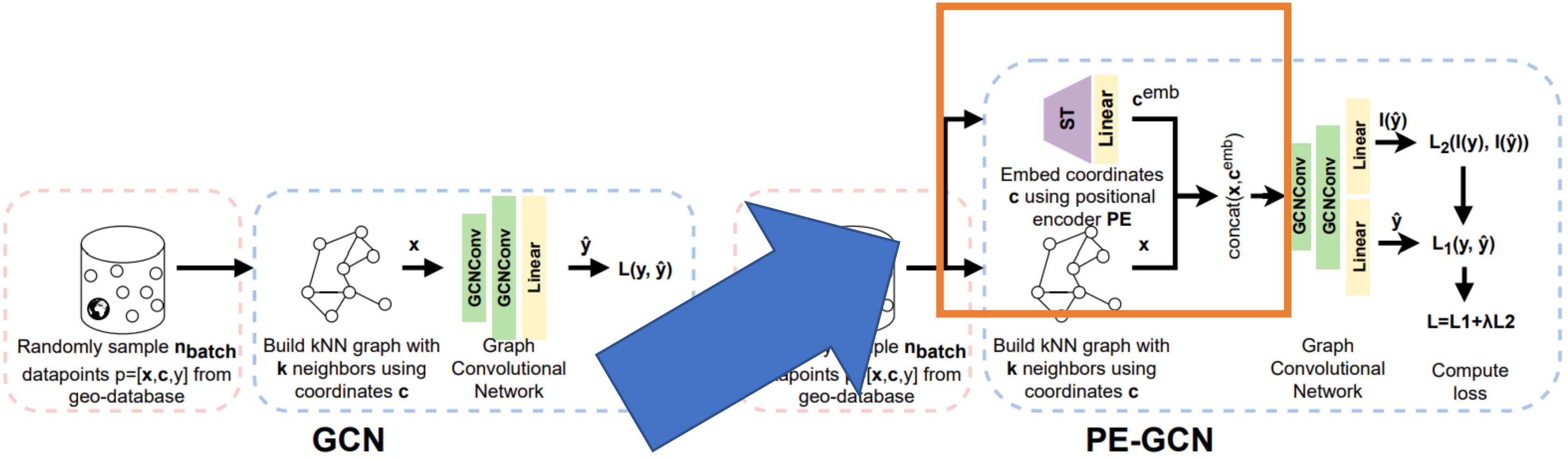
We combine GNNs with latitude / longitude positional encoders and introduce **PE-GNN**



PE-GNN works with any GNN backbone –
here a **Graph Convolutional Network (GCN)**

Method

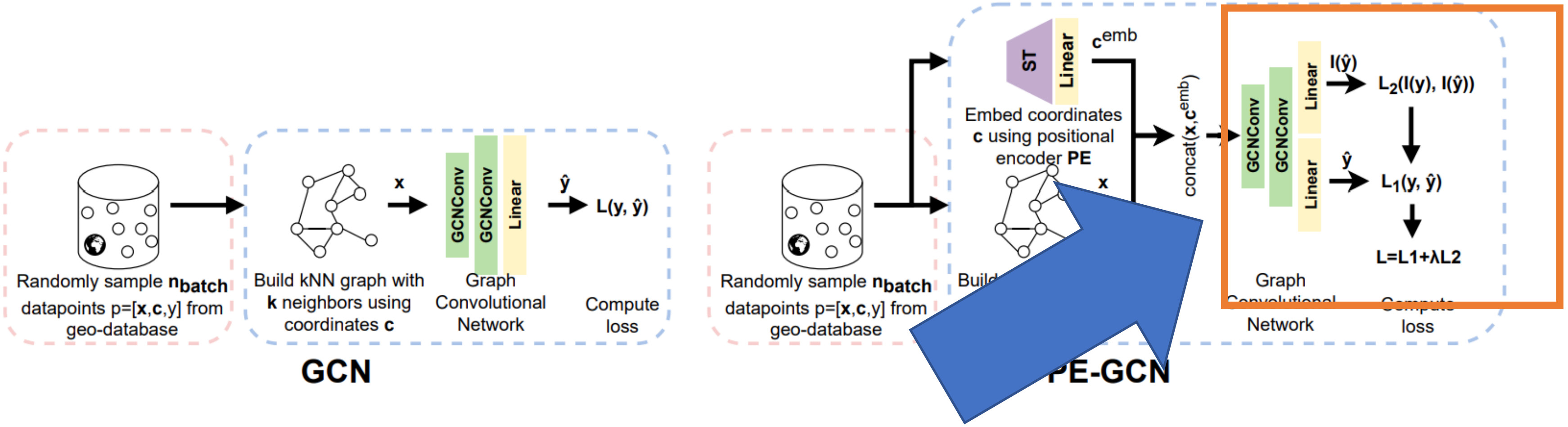
We combine GNNs with latitude / longitude positional encoders and introduce **PE-GNN**



- Coordinate embeddings are **concatenated with other node features**
- GNN and Positional encoder weights are **learned end-to-end** through the loss on the **downstream task**

Method

We combine GNNs with latitude / longitude positional encoders and introduce **PE-GNN**



- We reinforce the learning of spatial dependencies through **auxiliary prediction of spatial autocorrelation**

Klemmer, Konstantin, and Daniel B. Neill. "Auxiliary-task learning for geographic data with autoregressive embeddings." Proceedings of the 29th International Conference on Advances in Geographic Information Systems. 2021.

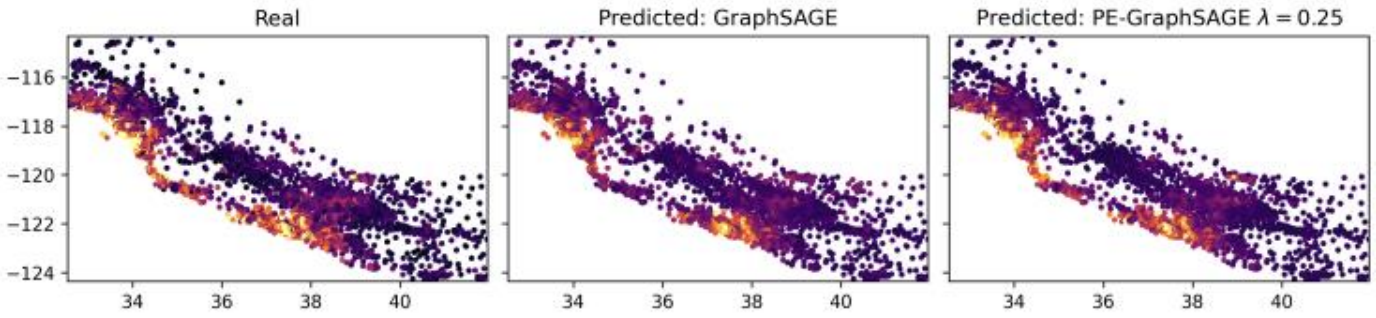
Results

We test PE-GNN on two **climate-relevant, real-world tasks**:

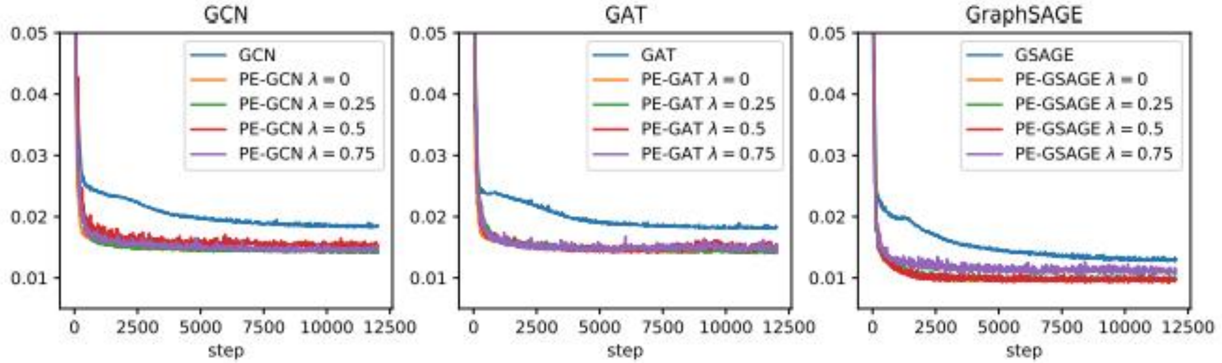
- **Spatial interpolation of elevation** for constructing digital elevation models (DEMs)
- **Mean temperature prediction** from location and precipitation data

Results

PE-GNN outperforms different existing GNN methods: GCN, GAT, GraphSAGE, KCN



(a) Real values and predictions using GraphSAGE and PE-GraphSAGE.



(b) Test error curves of GCN, GAT and GraphSAGE based models, measured by the MSE metric.

Thank you!

Questions or comments?
Reach out anytime. 🎉

kklemmer@microsoft.com

@kklmmr