GeoMAN: Multi-level Attention Networks for Geo-sensory Time Series Prediction

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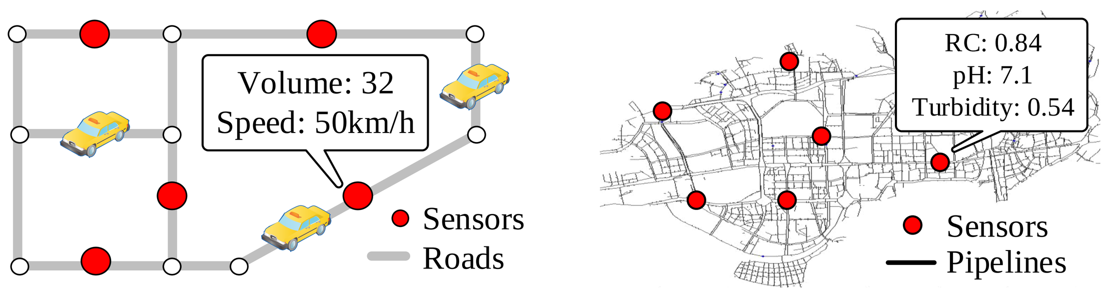
Codes & Data

Introduction

Geo-sensory time series

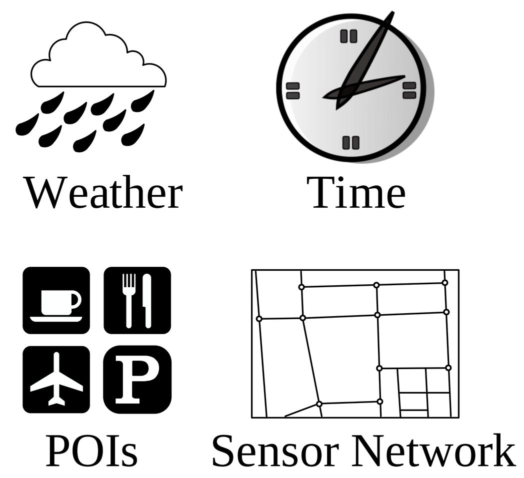
- Properties
  - Each sensor has a unique geospatial location
  - Reporting time series readings about different measurements
  - With geospatial correlation between their readings
- Examples

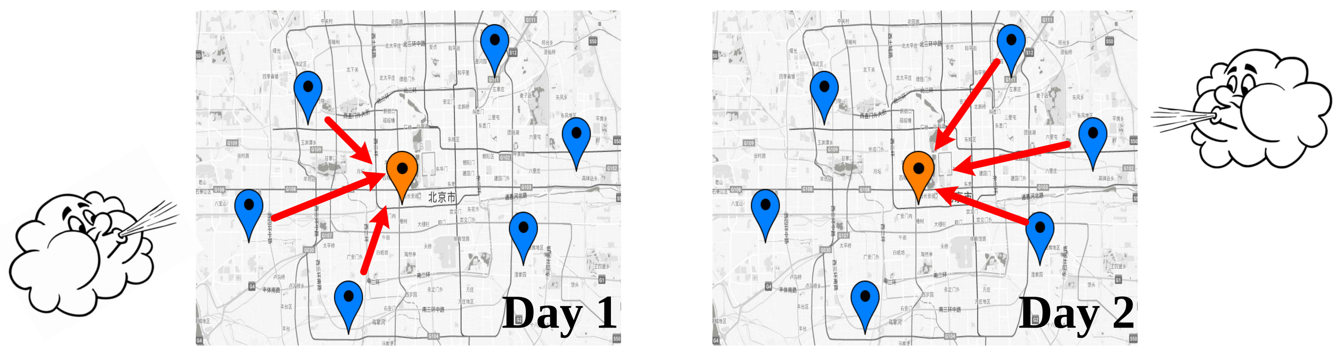


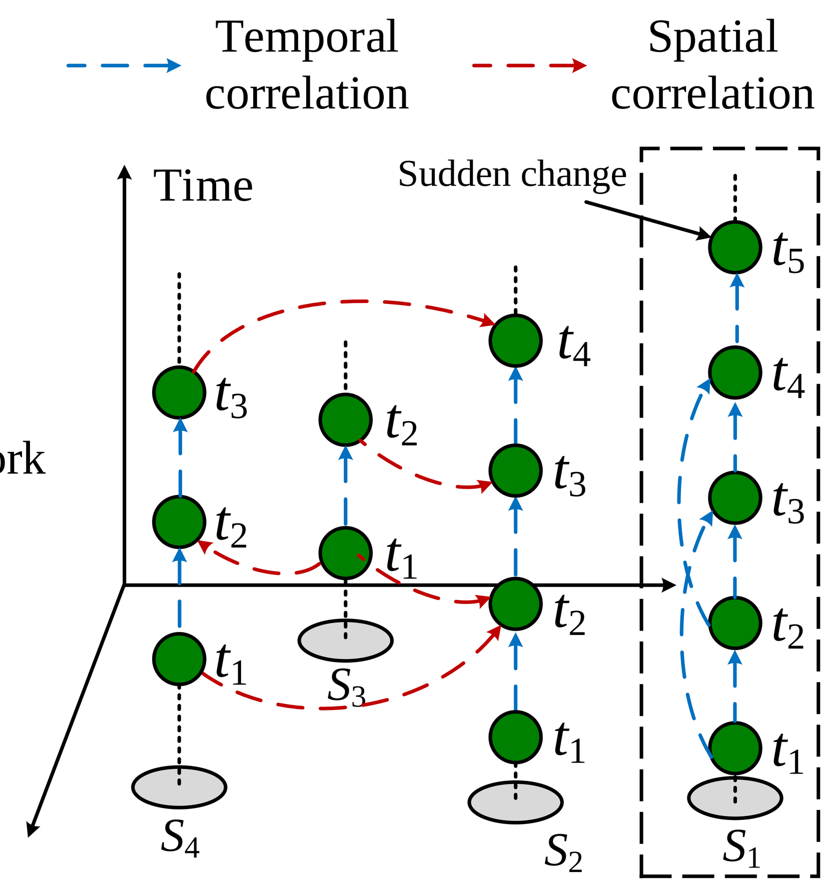
- Goal
  - Predict **target series** of a sensor over several future hours

Challenges

- Affected by many factors
  - Readings of previous time interval
  - Readings of nearby sensors
  - External factors
- Dynamic inter-sensor correlation
- Dynamic temporal correlation

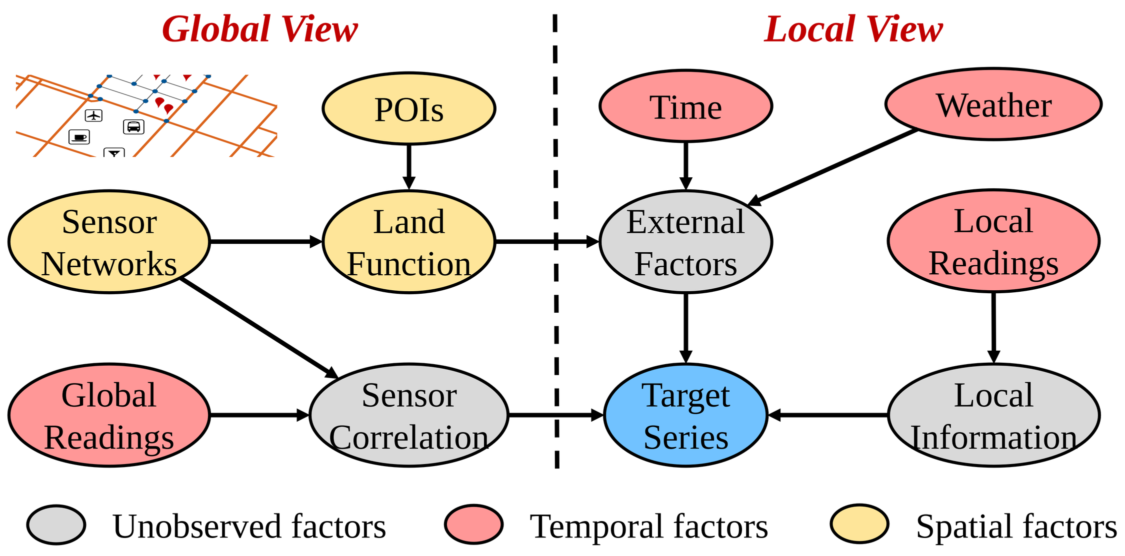






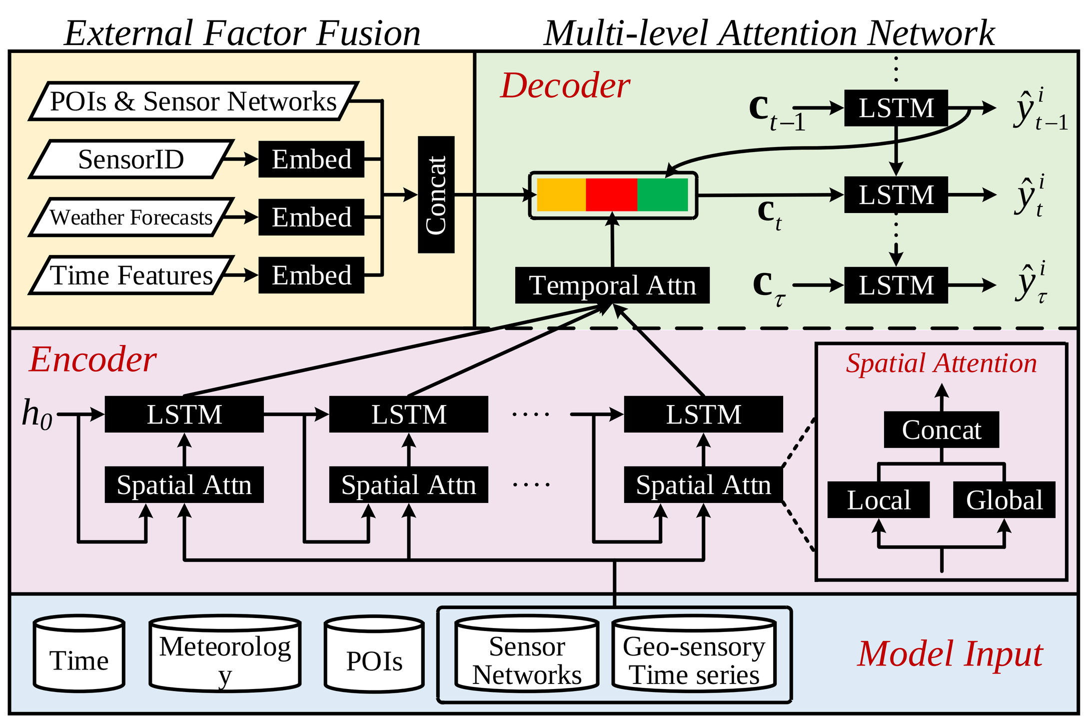
Methodology

Insight



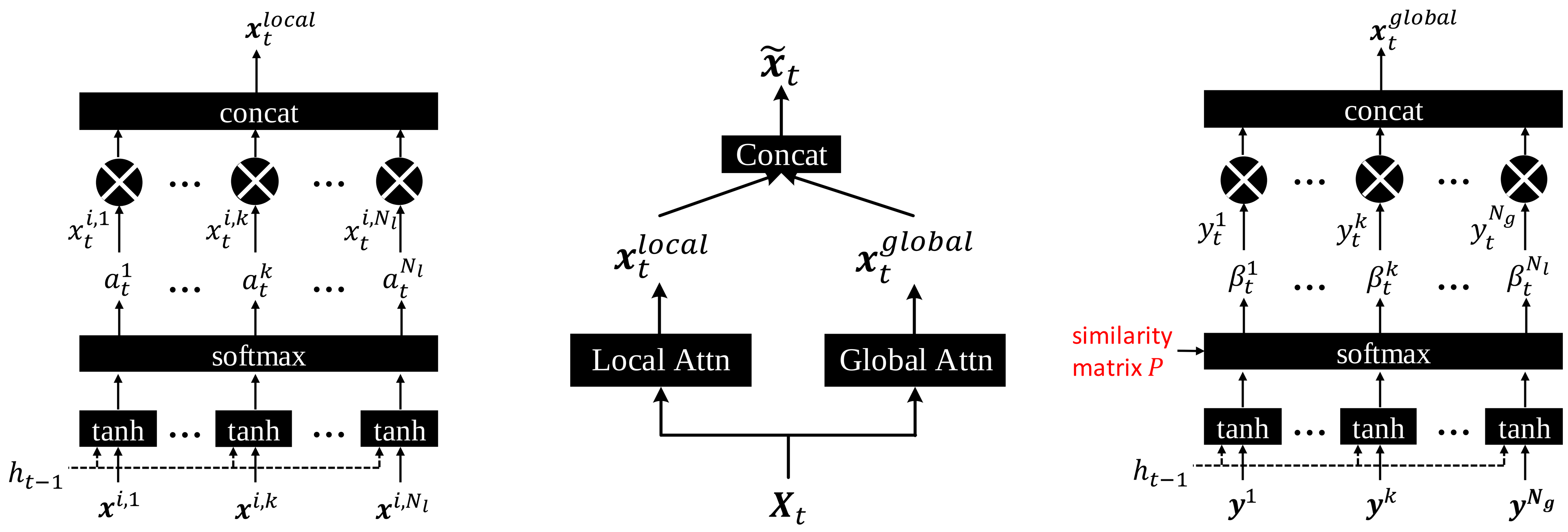
Framework

- Multi-level attention network
  - Spatial attention
  - Temporal attention
- External factors fusion module



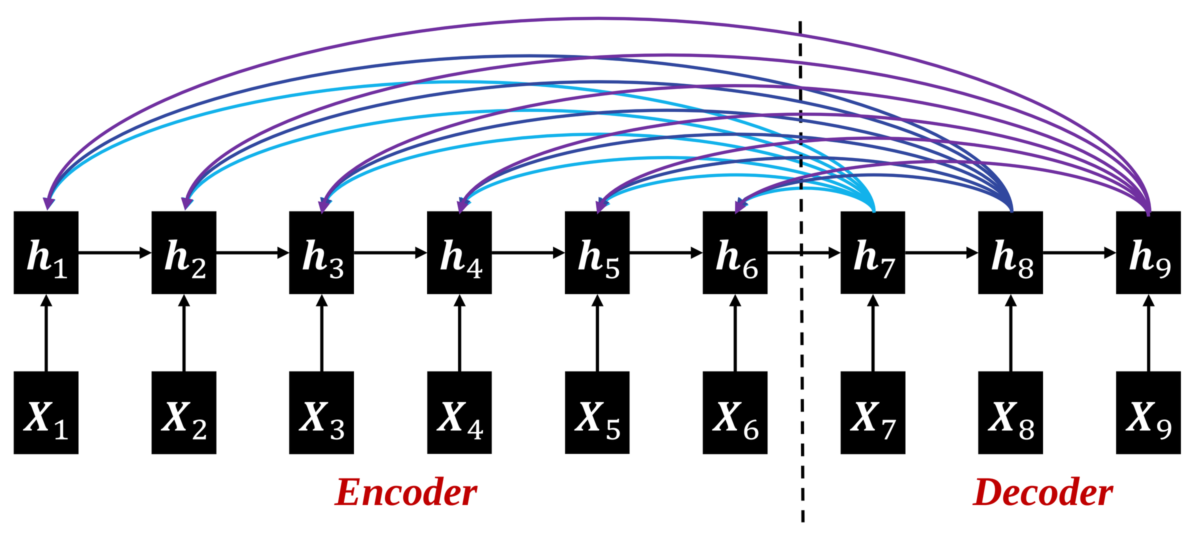
Spatial Attention

- Capture dynamic inter-sensor correlation
- Local: adaptively captures the correlation between target series and local features (other series)
- Global: adaptively select the relevant sensors to make predictions



Temporal Attention

- Select relevant historical time slots to make predictions



Model Training

- Encoder-decoder + Multi-level attention
- GeoMAN is smooth and differentiable
- Loss function: MSE

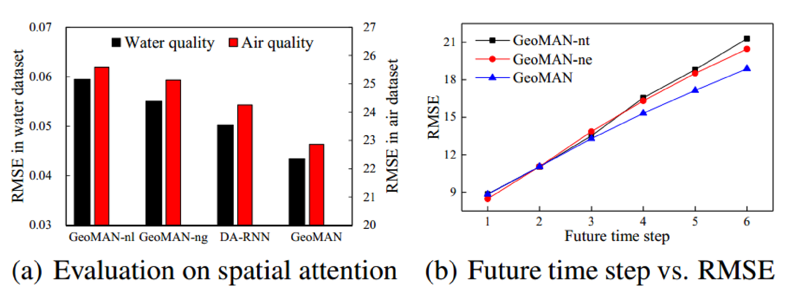
$$\mathcal{L}(\theta) = \left\| \hat{\mathbf{y}}^i - \mathbf{y}^i \right\|_2^2$$

- Optimizer: Adam

Results

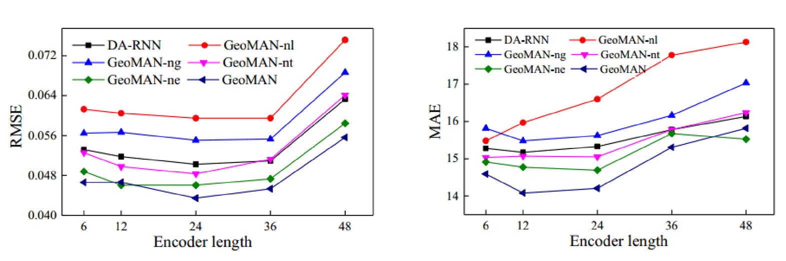
- Datasets: water quality dataset & air quality dataset

Method	Water Quality		Air Quality	
	RMSE	MAE	RMSE	MAE
ARIMA	8.61E-02	7.97E-02	31.07	20.58
VAR	5.02E-02	4.42E-02	24.60	16.17
GBRT	5.17E-02	3.30E-02	24.00	15.03
FFA	6.04E-02	4.10E-02	23.83	15.75
stMTMVL	6.07E-02	4.16E-02	29.72	19.26
stDNN	5.77E-02	3.99E-02	25.64	16.49
LSTM	6.89E-02	5.04E-02	24.62	16.70
Seq2seq	5.80E-02	4.03E-02	24.55	15.09
DA-RNN	5.02E-02	3.52E-02	24.25	15.17
GeoMAN	**4.34E-02**	**3.02E-02**	**22.86**	**14.08**



(a) Evaluation on spatial attention (b) Future time step vs. RMSE

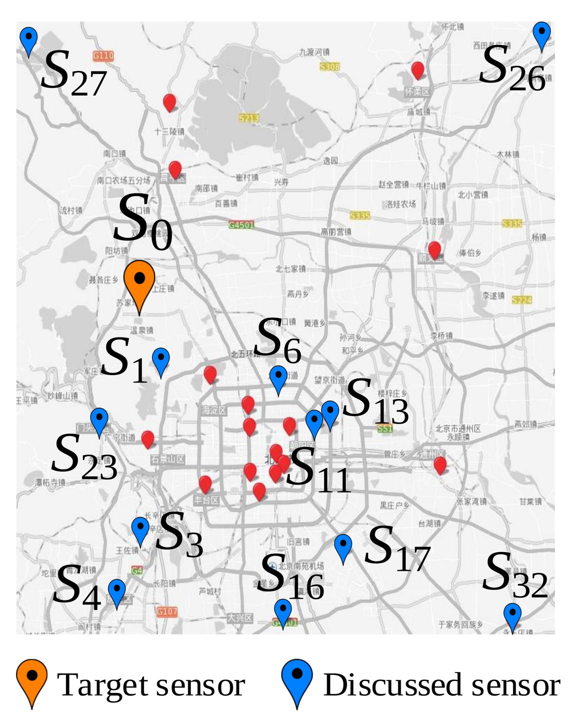
Figure 3: Performance comparison among different vairants.



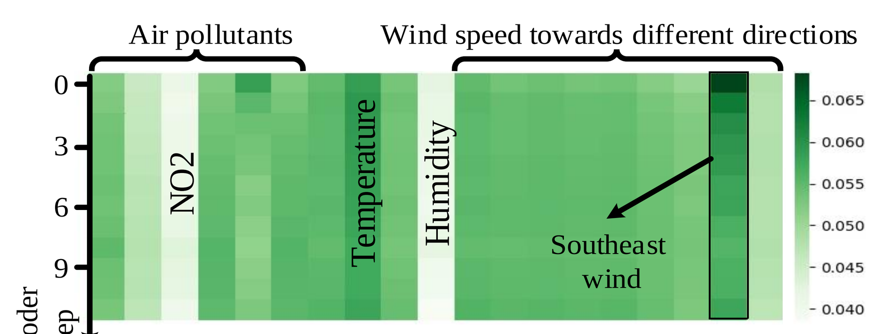
(a) Results on water quality. (b) Results on air quality.

Figure 4: Encoder length vs. metrics over the two datasets.

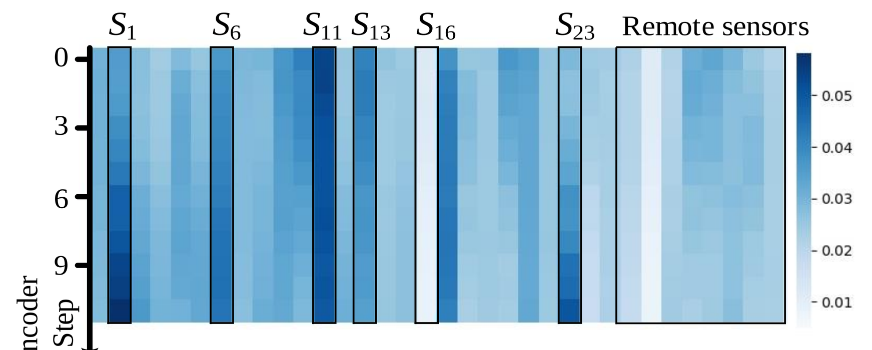
Visualization



(a) Air quality stations in Beijing



(b) Plot of local spatial attention weights



(c) Plot of global spatial attention weights