Extralonger: Toward a Unified Perspective of Spatial-Temporal Factors for Extra-Long-Term Traffic Forecasting

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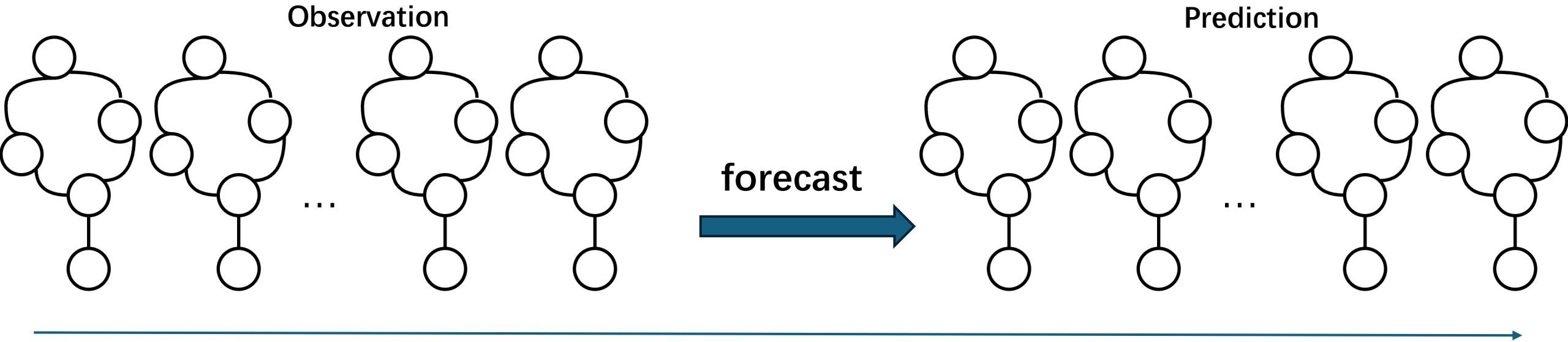
What is Traffic Forecasting?



N sensors, T observed time steps, and T' predicted time steps

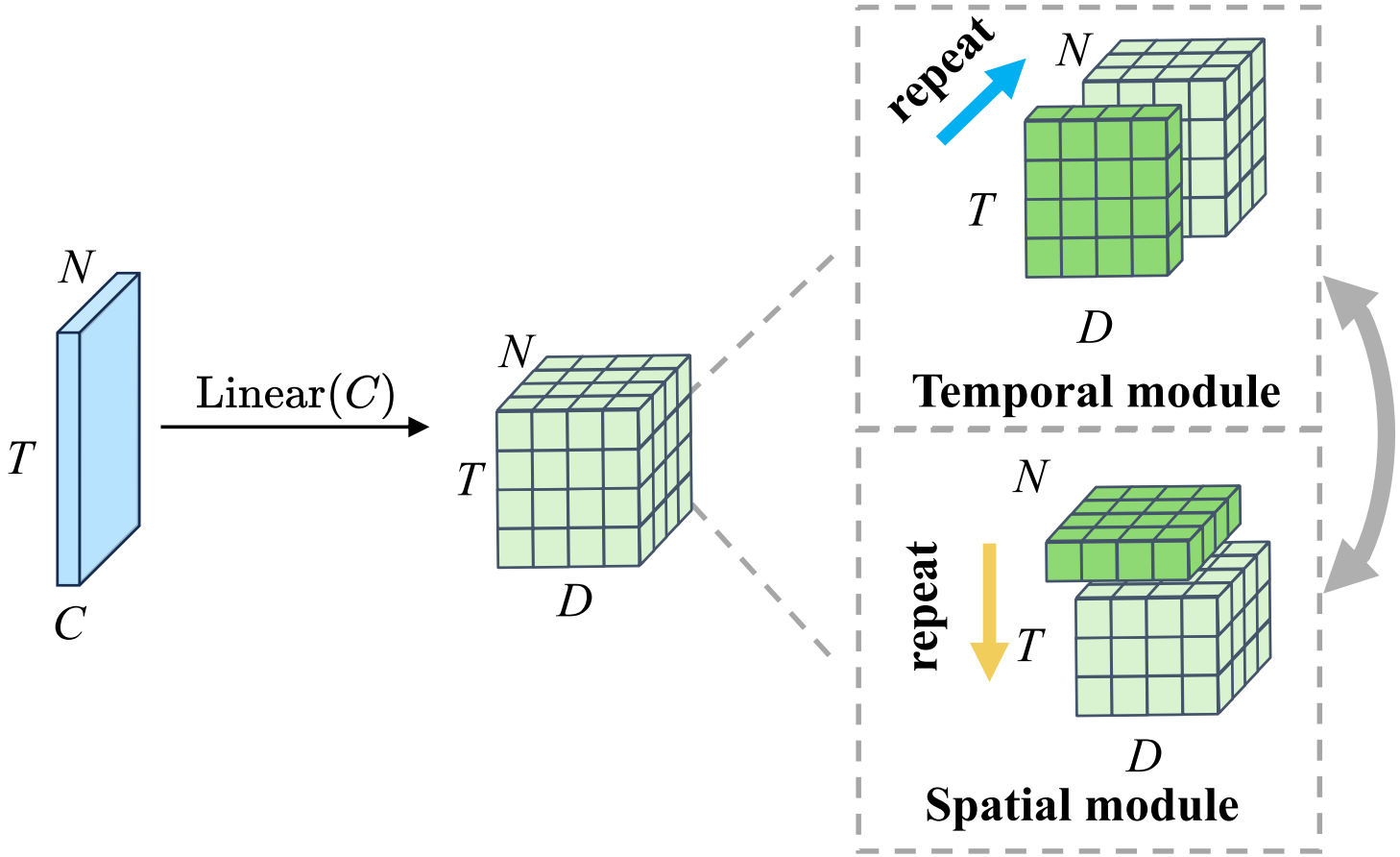
$$\mathbf{X} = [\mathbf{x}_0, \mathbf{x}_1, \ldots, \mathbf{x}_{T-1}] \xrightarrow{\mathbb{F}(\cdot|\Theta)} \hat{\mathbf{Y}} = [\hat{\mathbf{x}}_T, \hat{\mathbf{x}}_{T+1}, \ldots, \hat{\mathbf{x}}_{T+T'-1}]$$

Target: Extend Horizon to Extra Long Term

- Short term: 12-12
- Long term: 24-24 36-36 48-48
- **Extra long term**: 144-144, 288-288, ..., 288-2016

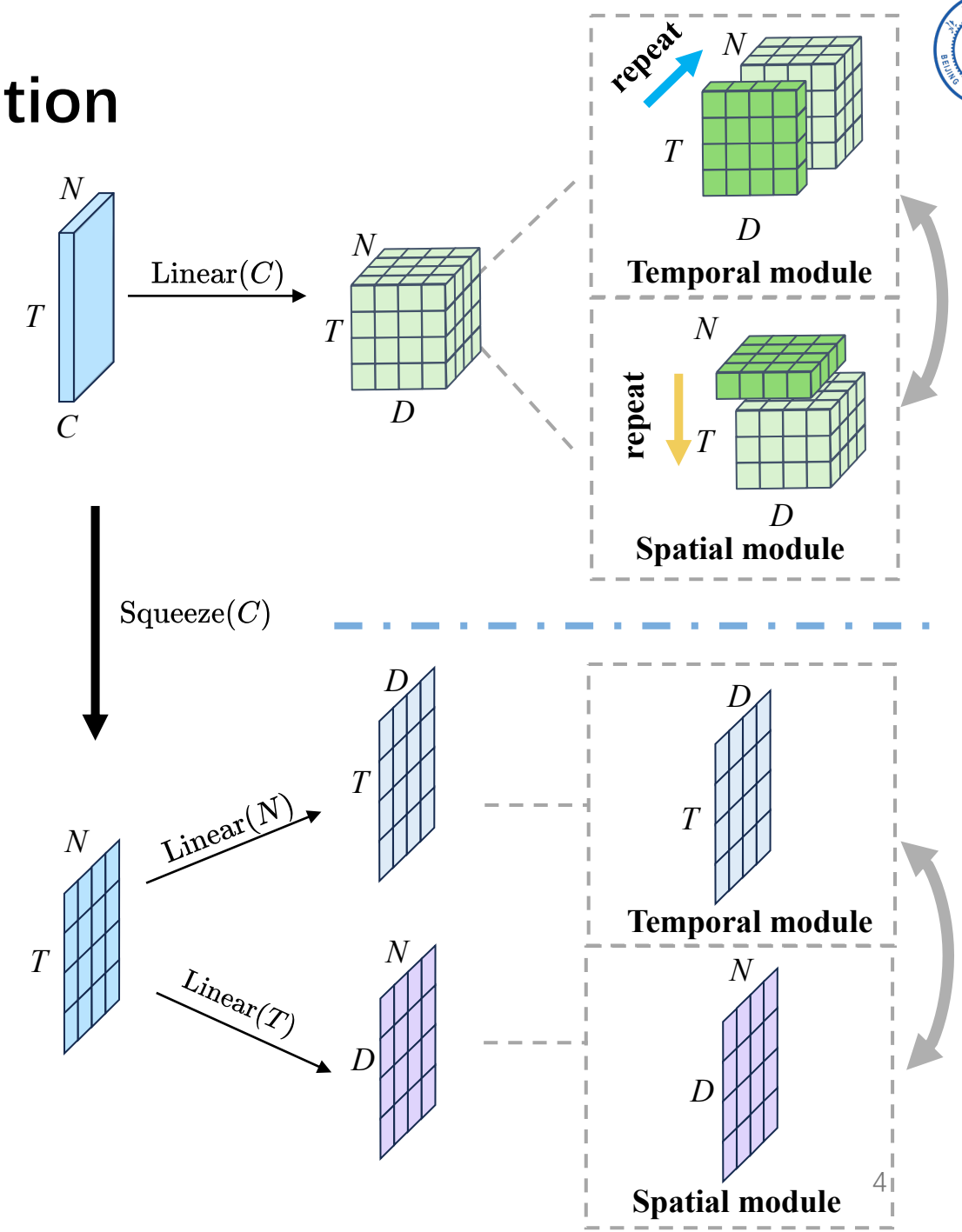
Challenge: high time and space complexity

- Feature set: $T \times N$
- Process temporal and spatial dimensions separately
- Iteration on the other dimension

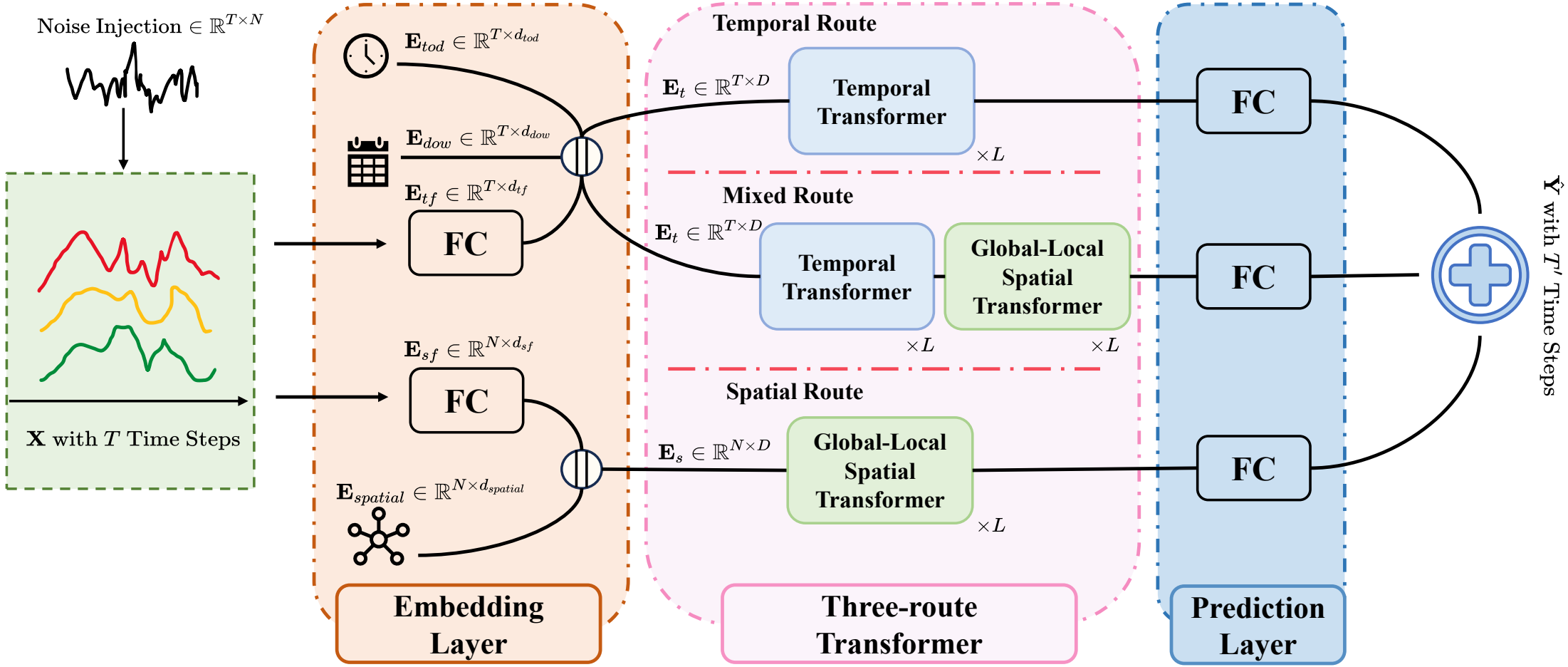


Unified Spatial-Temporal Representation

- Only focus on one feature, such as traffic flow, speed or road occupancy
- Squeeze the channel dimension C
- Process along temporal and spatial dimension to acquire the intertwined patterns



Extralonger



Experiment

- 11 settings of varying time steps on three benchmark datasets
- Gain the best performance in all settings

Dataset	Mehtod	24 Time Steps			36 Time Steps			48 Time Steps		
		RMSE	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*
PEMS04	HA	81.57	56.47	45.49	106.58	76.01	68.84	127.28	93.37	94.62
	VAR	41.09	27.19	21.42	45.44	30.48	24.51	49.46	33.5	27.28
	DCRNN	42.86	28.70	21.23	51.40	33.78	27.10	57.85	38.26	33.73
	GWNet	35.52	22.79	16.04	38.17	24.71	17.67	40.60	26.42	18.99
	GMAN	38.10	21.67	17.78	52.86	22.12	16.43	47.85	23.35	17.98
	AGCRN	34.44	21.63	14.65	38.19	24.15	16.33	38.26	24.18	16.31
	DMSTGCN	32.09	20.32	14.13	34.86	22.47	15.86	35.05	22.50	16.56
	SSTBAN	32.82	20.17	14.43	34.15	20.82	14.83	35.51	21.66	15.90
	Extralonger	**31.89**	**19.60**	**13.60**	**32.96**	**20.31**	**14.12**	**34.01**	**20.97**	**14.42**
PEMS08	HA	69.72	48.3	32.09	92.72	65.99	46.64	111.85	81.51	61.29
	VAR	44.47	28.31	19.53	48.96	31.7	22.56	52.14	34.51	25.28
	DCRNN	33.34	22.60	15.46	39.37	25.82	18.53	45.64	30.47	25.10
	GWNet	29.47	19.07	12.25	33.54	21.76	13.68	34.20	22.60	14.16
	GMAN	34.29	17.38	15.66	35.89	17.21	16.33	48.54	18.70	16.81
	AGCRN	28.05	17.45	11.25	30.96	19.39	12.73	31.11	19.46	12.88
	DMSTGCN	26.55	16.75	11.44	28.50	18.15	12.64	28.94	18.34	12.93
	SSTBAN	26.32	15.97	12.29	28.30	16.84	12.20	28.82	**16.94**	12.47
	Extralonger	**26.29**	**15.86**	**10.40**	**27.64**	**16.57**	**11.34**	**28.77**	17.14	**11.54**

Experiment

- 11 settings of varying time steps on three benchmark datasets
- Gain the best performance in all settings

Dataset	TS	HA			VAR			**Extralonger**		
		RMSE	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*
PEMS04	144	177.11	144.67	220.60	77.22	53.63	64.87	**39.33**	**23.66**	**16.04**
	288	128.50	103.95	166.55	50.43	34.98	34.22	**40.46**	**24.18**	**16.70**
	576	129.35	104.44	166.73	52.90	36.99	35.55	**42.15**	**26.08**	**19.32**
	864	129.65	104.56	167.80	54.55	38.32	37.43	**42.98**	**26.60**	**19.36**
	1152	129.78	104.56	169.59	55.99	39.50	39.12	**42.98**	**26.88**	**19.33**
	1440	129.91	104.66	169.81	56.64	40.05	39.40	**42.30**	**26.62**	**19.24**
	1728	130.00	104.77	169.29	57.01	40.40	39.69	**43.33**	**27.09**	**19.63**
	2016	130.37	105.09	167.48	56.21	39.64	39.23	**43.26**	**27.52**	**20.21**
PEMS08	144	153.98	123.81	114.18	89.00	61.09	46.52	**32.17**	**18.84**	**12.85**
	288	112.80	89.66	87.33	56.07	38.51	26.06	**32.76**	**19.38**	**13.05**
	576	113.80	90.29	87.28	63.16	43.37	28.59	**37.73**	**22.06**	**14.23**
	864	114.36	90.47	87.09	65.07	45.25	30.91	**38.57**	**22.57**	**15.04**
	1152	114.66	90.52	87.67	66.06	45.91	32.42	**40.45**	**23.50**	**16.03**
	1440	114.97	90.80	88.71	67.96	47.03	32.69	**41.44**	**23.78**	**17.90**
	1728	115.39	91.33	89.66	67.36	46.53	32.34	**40.85**	**23.68**	**18.42**
	2016	115.43	91.54	90.01	65.45	44.95	31.37	**41.38**	**23.69**	**19.18**

Experiment

- 11 settings of varying time steps on three benchmark datasets
- Gain the best performance in all settings

Table 6: Performance comparison on long-term traffic speed forecasting in Seattle Loop.

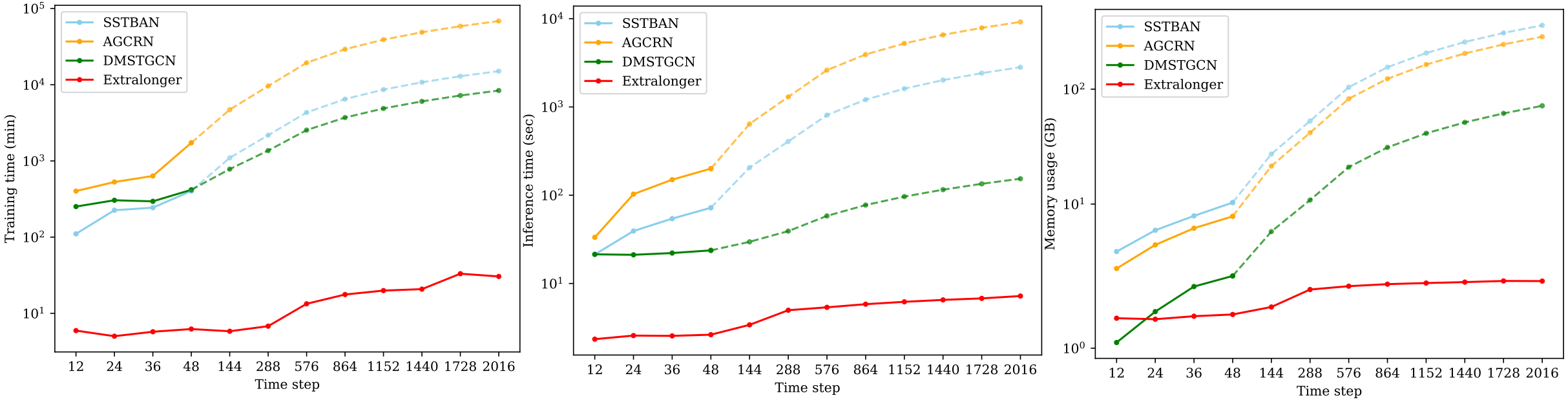
Time step	24			36			48		
Method	*RMSE*	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*
HA	11.86	8.07	26.57	12.37	8.47	27.76	12.31	8.49	27.82
VAR	9.56	6.21	19.94	9.96	6.44	21.28	10.28	6.69	22.24
DCRNN	7.97	4.37	14.04	8.38	4.60	14.41	8.63	4.73	14.91
GWNet	7.84	4.28	14.06	8.18	4.60	15.12	8.35	4.67	15.04
GMAN	7.84	4.13	12.88	8.10	4.23	12.95	8.09	4.26	13.26
AGCRN	7.83	4.27	13.53	8.31	4.66	14.76	8.60	4.82	15.62
DMSTGCN	7.59	4.08	13.51	7.98	4.31	14.31	8.20	4.49	14.86
SSTBAN	7.72	4.05	12.69	7.83	4.11	12.44	7.88	4.12	12.25
Extralonger	**7.43**	**4.04**	**12.48**	**7.51**	**4.05**	**11.96**	**7.68**	**4.11**	**12.04**

Table 7: Performance comparison on extra-long-term traffic speed forecasting in Seattle Loop.

Method	HA			VAR			**Extralonger**		
Time step	*RMSE*	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*	*RMSE*	*MAE*	*MAPE*
144	11.95	8.30	27.48	11.17	7.33	24.75	**8.07**	**4.33**	**12.64**
288	12.05	8.33	28.04	11.09	7.31	24.14	**8.20**	**4.44**	**14.03**
576	11.95	8.14	27.88	11.30	7.43	24.83	**8.15**	**4.59**	**14.46**
864	11.90	8.16	27.57	11.42	7.49	25.33	**8.07**	**4.50**	**13.63**
1152	11.87	8.02	27.43	11.53	7.54	25.77	**8.00**	**4.39**	**12.94**
1440	11.85	7.94	27.23	11.59	7.58	26.01	**7.69**	**4.15**	**12.36**
1728	11.83	7.88	26.96	11.70	7.65	26.49	**7.66**	**4.11**	**12.00**
2016	11.79	7.85	26.71	11.76	7.71	26.78	**7.57**	**4.02**	**11.63**

Resource Consumption

- 24.13% memory, 2.87% training time, and 6.47% inference time compared with SSTBAN, the second best method



logarithm of the value in Y-axis

Thanks~

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