TED4STL: Trend-Error Decomposition for Self-Supervised Time Series Learning

Technical Report

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Abstract

Self-Supervised Learning (SSL) has become a powerful paradigm in Artificial Intelligence, enabling the training of machine learning models using unlabeled data. However, in time series forecasting, SSL models are generally less effective than supervised models due to the complexity of temporal patterns, including trends, seasonality, and noise. To address this, we experiment with a data-centric approach that decomposes time series into two additive components. We investigate whether a straightforward trend-error decomposition improves the performance of SSL models. We introduce TED4STL (Trend-Error Decomposition for Self-supervised Time-series Learning), a pipeline that applies time series decomposition to SSL architectures. We adapt TED4STL to four SSL forecasting models evaluated on ten datasets. The experiments demonstrate that time series decomposition significantly improves the accuracy of SSL models in forecasting tasks, narrowing the gap with state-of-the-art supervised models. In short-term prediction, it enables SSL models to perform in general better than supervised ones.

Keywords

Self-Supervised Learning, Time Series Forecasting, Time Series Decomposition, Data-Centric AI, Data Preprocessing

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1 Experimental Evaluation

The following sections present supplementary results in the form of tables, offering additional insights that complement and enrich the main findings.

Settings. The experiments have been performed on a Workstation with an NVIDIA L40S GPU with 48 GB of VRAM, 256 GB of RAM, and a dual AMD EPYC 9254 24-Core Processor. According to the literature in the field, the predictions are computed via direct multi-step forecasting [1]. Moreover, we used the hyperparameters defined for each model as indicated in the original papers. The only exception was the moving average, whose kernel size we determined through a grid search, exploring the values $\{9, 25, 64, 96, 128, 224\}$ on the validation set.

Datasets. We conducted experiments on ten widely used in literature real-world datasets in the field of time series forecasting (see Table 1 for a quantitative description):

ETT (Electricity Transformer Temperature)[1]: It consists of two hourly sampled datasets (ETTh1/ETTh2) and two 15-minute-sampled datasets (ETTm1/ETTm2) of electricity transformer temperatures, containing features such as oil temperature and load.

Exchange[2]: It collects daily exchange rates of 8 countries from 1990 to 2016.

WTH[3]: The dataset contains hourly observations of 12 climate-related variables, including temperature, humidity, wind speed, and solar radiation, across nearly 1,600 locations in the United States.

Electricity[4]: The dataset consists of hourly electricity consumption data from 321 residential and industrial clients from 2012 to 2014.

Traffic[5]: It describes 48 months of hourly road occupancy rates, gathered between 2015 and 2016 by 862 sensors from the California Department of Transportation in the San Francisco Bay area.

Weather[6]: It includes 21 indicators of weather, such as air temperature, and humidity.

ILI (Influenza-like Illness)[7]: It contains weekly reports from the Centers for Disease Control (CDC) in the U.S., tracking the number of patients with influenza-like illness (ILI) from 1997 to 2022.

Supervised Forecasting Baselines. We selected PatchTST [2] and DLinear [3] as supervised forecasting models. PatchTST is a state-of-the-art transformer-based model; DLinear achieves competitive accuracy through moving average decomposition and a linear layer.

Table 1 shows a quantitative description of the datasets regarding the number of signals, series, timestamps and granularity.

Supervised Forecasting Baselines. We selected PatchTST [2] and DLinear [3] as supervised forecasting models. PatchTST is a SOTA transformer-based model; DLinear achieves competitive accuracy through moving average decomposition and a single linear layer.

[1] https://github.com/zhouhaoyi/ETDataset
[2] https://github.com/laiguokun/multivariate-time-series-data
[3] https://drive.google.com/drive/folders/1ohGYWWohJlOlb2gsGTeEq3Wii2egnEPR
[4] https://archive.ics.uci.edu/ml/datasets/ElectricityLoadDiagrams20112014
[5] http://pems.dot.ca.gov/
[6] https://www.bgc-jena.mpg.de/wetter/
[7] https://gis.cdc.gov/grasp/fluview/fluportaldashboard.html

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Table 1: The datasets used in the experiments.

Datasets	Signals	Series	Timestamps		Gran.
			Train	Val & Test	
ETTh1 & ETTh2	7	1	8640	2880	1hour
ETTm1 & ETTm2	7	1	34560	11520	15min
Exchange	8	1	4552	1518	1day
Electricity	1	321	15782	5261	1hour
Traffic	862	1	17544	10526	1hour
Weather	21	1	31617	10539	10min
ILI	7	1	579	193	1week
WTH	12	1	21038	7013	1hour

1.1 Forecasting Evaluation

The effectiveness of our decomposition pipeline is evaluated using Mean Squared Error (MSE) and Mean Absolute Error (MAE), defined as MSE $= \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2$ and MAE $= \frac{1}{N}\sum_{i=1}^{N}|y_i - \hat{y}_i|$, where y and $\hat{y}$ denote the true and predicted values, respectively. The experiment measures the forecasting error of SSL models with and without TED4STL across five prediction lengths, which vary by dataset and are chosen according to the literature for SSL forecasting models.

List of Tables. . The following list provides an overview of the tables included in this document.

1.2 Ablation Study

To understand the contribution of the time series decomposition, we run the selected SSL models again using the embeddings generated by the trend and the error components of the decomposition pipeline alone. In this case, we selected the same kernel size (25 timestamps) for the moving average in all experiments. The findings do not change considering different kernel sizes.

List of Tables. . The following list provides an overview of the tables included in this document.

References

[1] Chevillon, G.: Direct multi-step estimation and forecasting. Journal of Economic Surveys **21**(4), 746–785 (2007). https://doi.org/https://doi.org/10.1111/j.1467-6419.2007.00518.x, https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-6419.2007.00518.x

[2] Nie, Y., Nguyen, N.H., Sinthong, P., Kalagnanam, J.: A time series is worth 64 words: Long-term forecasting with transformers. In: ICLR. OpenReview.net (2023)

[3] Zeng, A., Chen, M., Zhang, L., Xu, Q.: Are transformers effective for time series forecasting? In: AAAI. pp. 11121–11128. AAAI Press (2023)

Table 2: Effectiveness of the SSL (with and without our decomposition pipeline) and Supervised Forecasting Models measured with the MSE. In bold the best result per model. Underlined the best result per dataset and prediction length L.

D	L	Ts2Vec		SimTS		CoST		MAE		PatchTST	DLinear
		TED4STL	Orig.	TED4STL	Orig.	TED4STL	Orig.	TED4STL	Orig.		
ETTh1	24	**0.333**	0.549	**0.231**	0.374	**0.298**	0.383	**0.867**	1.484	0.327	0.320
	48	**0.375**	0.598	**0.284**	0.424	**0.403**	0.434	**1.150**	1.544	0.351	0.343
	168	**0.498**	0.758	**0.497**	0.644	**0.589**	0.633	**1.144**	1.320	0.406	0.399
	336	**0.771**	0.899	**0.796**	0.844	0.903	**0.792**	**1.165**	1.289	0.431	0.447
	720	1.090	**1.060**	1.069	**1.014**	1.027	**0.904**	**1.160**	1.370	0.449	0.504
ETTh2	24	**0.150**	0.389	**0.118**	0.346	**0.188**	0.453	**1.892**	2.994	0.170	0.167
	48	**0.267**	0.562	**0.178**	0.586	**0.329**	0.699	**1.947**	2.820	0.219	0.221
	168	**1.217**	1.845	**1.221**	1.661	**1.281**	1.538	**2.400**	3.141	0.324	0.375
	336	**1.736**	2.291	**1.554**	1.932	**1.481**	1.743	**2.631**	2.741	0.331	0.463
	720	**2.143**	2.717	**1.812**	2.148	**1.716**	1.955	**2.698**	3.302	0.379	0.733
ETTm1	24	**0.131**	0.391	**0.078**	0.240	**0.117**	0.246	**0.227**	2.028	0.195	0.213
	48	**0.227**	0.498	**0.123**	0.319	**0.181**	0.330	**0.332**	1.840	0.261	0.272
	96	**0.330**	0.564	**0.211**	0.369	**0.275**	0.377	**0.453**	1.692	0.292	0.301
	288	**0.457**	0.633	**0.373**	0.464	**0.437**	0.471	**0.784**	1.683	0.356	0.365
	672	**0.640**	0.731	**0.555**	0.617	**0.617**	0.622	**1.121**	1.706	0.408	0.423
ETTm2	24	**0.079**	0.155	**0.056**	0.113	**0.076**	0.134	**0.313**	2.576	0.095	0.098
	48	**0.112**	0.219	**0.070**	0.168	**0.101**	0.196	**0.461**	2.499	0.125	0.129
	96	**0.172**	0.325	**0.106**	0.272	**0.155**	0.305	**0.643**	2.600	0.165	0.172
	288	**0.600**	0.690	**0.606**	0.713	**0.639**	0.754	**1.188**	2.685	0.261	0.293
	672	2.011	**1.831**	**1.519**	1.658	1.866	**1.589**	2.922	**2.955**	0.356	0.419
exchange	24	**0.058**	0.099	**0.039**	0.086	**0.059**	0.133	**2.257**	2.029	0.028	0.025
	48	**0.104**	0.184	**0.059**	0.192	**0.117**	0.250	2.452	**2.223**	0.047	0.042
	96	**0.267**	0.390	**0.161**	0.439	**0.334**	0.505	2.452	**2.227**	0.093	0.089
	288	1.455	**1.352**	**1.258**	1.312	**1.272**	1.278	2.776	**2.250**	0.307	0.274
	672	**2.290**	3.501	2.405	**1.889**	2.204	**1.942**	3.247	**2.305**	0.824	0.766
WTH	24	**0.223**	0.310	**0.204**	0.294	**0.203**	0.299	**0.252**	1.612	0.322	0.352
	48	**0.251**	0.377	**0.236**	0.356	**0.236**	0.360	**0.286**	1.719	0.398	0.419
	168	**0.384**	0.499	**0.353**	0.465	**0.351**	0.465	**0.541**	1.462	0.509	0.513
	336	**0.464**	0.535	**0.441**	0.500	**0.437**	0.498	**0.593**	1.529	0.556	0.552
	720	**0.515**	0.571	**0.504**	0.537	**0.501**	0.533	**0.573**	1.503	0.629	0.618
electricity	24	**0.207**	0.285	**0.090**	0.139	0.149	**0.135**	**0.978**	1.143	0.095	0.110
	48	**0.224**	0.307	**0.106**	0.154	0.169	**0.152**	**0.972**	1.136	0.110	0.125
	168	**0.262**	0.331	**0.139**	0.176	0.199	**0.175**	**0.979**	1.130	0.144	0.150
	336	**0.288**	0.348	**0.170**	0.195	0.219	**0.195**	**0.983**	1.124	0.166	0.169
	720	**0.321**	0.375	**0.213**	0.233	0.254	**0.231**	**0.971**	1.106	0.209	0.204
weather	24	**0.124**	0.316	**0.071**	0.241	**0.114**	0.258	**0.408**	2.015	0.091	0.106
	48	**0.176**	0.808	**0.113**	0.526	**0.160**	0.496	**0.553**	2.000	0.117	0.139
	96	**0.223**	1.297	**0.123**	0.957	**0.186**	0.787	**0.928**	2.053	0.152	0.174
	288	**0.879**	1.608	**1.108**	1.296	1.085	**1.082**	**1.280**	1.919	0.234	0.249
	672	**1.727**	2.424	1.849	**1.749**	1.808	**1.535**	**1.502**	1.785	0.315	0.322
traffic	24	**0.818**	0.914	**0.731**	0.756	0.787	**0.721**	**0.875**	1.816	0.320	0.373
	48	**0.848**	0.958	**0.765**	0.793	0.816	**0.745**	**0.900**	1.752	0.342	0.395
	96	**0.890**	1.017	**0.783**	0.809	0.833	**0.755**	**0.915**	1.796	0.367	0.413
	288	**0.906**	1.036	**0.798**	0.815	0.840	**0.764**	**0.972**	1.604	0.395	0.435
	672	**0.920**	1.073	0.814	0.827	0.856	**0.777**	**1.006**	1.692	0.427	0.462
ili	24	**2.903**	3.625	**1.975**	2.640	**2.389**	2.872	**8.299**	8.860	1.301	2.280
	36	**3.493**	3.821	**2.139**	2.905	**1.978**	3.155	**7.565**	9.049	1.658	2.235
	48	**4.015**	4.058	**2.547**	3.183	**2.363**	3.439	**7.387**	8.757	1.657	2.298
	60	**4.002**	4.319	**3.335**	3.572	**2.487**	3.831	**7.564**	9.195	1.436	2.573

Table 3: Effectiveness of the SSL (with and without our decomposition pipeline) and Supervised Forecasting Models measured with the MAE. In bold the best result per model. Underlined the best result per dataset and prediction length L.

D	L	Ts2Vec		SimTS		CoST		MAE		PatchTST	DLinear
		TED4STL	Orig.	TED4STL	Orig.	TED4STL	Orig.	TED4STL	Orig.		
ETTh1	24	**0.392**	0.509	**0.335**	0.418	**0.381**	0.427	**0.681**	0.958	0.372	0.364
	48	**0.424**	0.543	**0.368**	0.452	**0.439**	0.463	**0.842**	0.997	0.385	0.377
	168	**0.484**	0.638	**0.491**	0.581	**0.548**	0.578	**0.829**	0.913	0.416	0.410
	336	**0.632**	0.713	**0.646**	0.690	**0.711**	0.670	**0.844**	0.895	0.435	0.448
	720	**0.790**	0.795	**0.786**	**0.786**	0.789	0.748	**0.836**	0.934	0.466	0.515
ETTh2	24	**0.284**	0.459	**0.254**	0.441	**0.327**	0.507	**1.115**	1.339	0.265	0.263
	48	**0.387**	0.572	**0.319**	0.586	**0.428**	0.640	**1.105**	1.311	0.299	0.302
	168	**0.832**	1.060	**0.763**	1.002	**0.854**	0.983	**1.213**	1.406	0.369	0.412
	336	**1.057**	1.210	**0.978**	1.098	**0.962**	1.050	**1.271**	1.317	0.380	0.473
	720	**1.236**	1.396	**1.080**	1.185	**1.042**	1.089	**1.242**	1.436	0.422	0.606
ETTm1	24	**0.258**	0.407	**0.197**	0.322	**0.240**	0.329	**0.343**	1.106	0.275	0.287
	48	**0.330**	0.472	**0.244**	0.377	**0.295**	0.386	**0.413**	1.074	0.321	0.326
	96	**0.388**	0.518	**0.321**	0.413	**0.361**	0.419	**0.490**	1.002	0.343	0.345
	288	**0.470**	0.569	**0.425**	0.480	**0.465**	0.485	**0.655**	1.000	0.387	0.386
	672	**0.579**	0.628	**0.535**	0.572	0.575	**0.574**	**0.819**	1.041	0.417	0.422
ETTm2	24	**0.201**	0.273	**0.172**	0.234	**0.201**	0.259	**0.434**	1.160	0.193	0.198
	48	**0.241**	0.332	**0.191**	0.295	**0.234**	0.320	**0.531**	1.201	0.224	0.229
	96	**0.298**	0.409	**0.242**	0.383	**0.292**	0.405	**0.634**	1.261	0.255	0.265
	288	**0.582**	0.629	**0.574**	0.645	**0.592**	0.661	**0.886**	1.287	0.319	0.361
	672	1.072	**1.030**	**0.949**	0.999	1.035	**0.982**	1.380	**1.346**	0.378	0.434
exchange	24	**0.179**	0.235	**0.152**	0.214	**0.184**	0.277	**1.170**	1.151	0.116	0.110
	48	**0.245**	0.319	**0.187**	0.319	**0.256**	0.383	1.193	**1.187**	0.151	0.142
	96	**0.380**	0.463	**0.300**	0.491	**0.435**	0.548	1.226	**1.190**	0.213	0.216
	288	0.967	**0.887**	**0.894**	0.914	**0.903**	0.883	1.305	**1.193**	0.402	0.398
	672	**1.158**	1.362	1.231	**1.100**	1.168	**1.075**	1.399	**1.171**	0.676	0.673
WTH	24	**0.290**	0.365	**0.278**	0.356	**0.282**	0.361	**0.332**	1.151	0.361	0.385
	48	**0.323**	0.419	**0.311**	0.408	**0.318**	0.412	**0.361**	1.187	0.422	0.438
	168	**0.432**	0.509	**0.412**	0.492	**0.417**	0.492	**0.545**	1.190	0.506	0.510
	336	**0.488**	0.535	**0.476**	0.518	**0.475**	0.518	**0.580**	1.193	0.534	0.537
	720	**0.528**	0.559	**0.520**	0.544	**0.519**	0.542	**0.568**	1.171	0.576	0.580
electricity	24	**0.310**	0.373	**0.208**	0.243	0.265	**0.241**	**0.799**	0.873	0.191	0.209
	48	**0.337**	0.389	**0.223**	0.258	0.283	**0.257**	**0.798**	0.869	0.206	0.224
	168	**0.366**	0.407	**0.251**	0.276	0.307	**0.275**	**0.799**	0.866	0.237	0.247
	336	**0.385**	0.420	**0.278**	0.296	0.326	**0.296**	**0.801**	0.865	0.262	0.268
	720	**0.401**	0.439	**0.316**	0.329	0.354	**0.328**	**0.802**	0.860	0.298	0.300
weather	24	**0.236**	0.349	**0.155**	0.306	**0.212**	0.337	**0.480**	1.048	0.121	0.156
	48	**0.285**	0.584	**0.209**	0.484	**0.259**	0.488	**0.561**	1.075	0.158	0.197
	96	**0.336**	0.788	**0.220**	0.695	**0.292**	0.642	**0.771**	1.114	0.199	0.233
	288	**0.670**	0.939	**0.711**	0.859	**0.727**	0.794	**0.907**	1.102	0.272	0.304
	672	**0.999**	1.220	1.066	**1.033**	1.027	**0.977**	**0.993**	1.057	0.331	0.362
traffic	24	**0.473**	0.541	0.438	**0.431**	0.470	**0.423**	**0.490**	0.923	0.231	0.271
	48	**0.490**	0.556	0.453	**0.451**	0.482	**0.437**	**0.506**	0.899	0.240	0.279
	96	**0.508**	0.564	**0.465**	0.475	0.484	**0.438**	**0.504**	0.913	0.250	0.287
	288	**0.509**	0.571	**0.463**	0.472	0.482	**0.434**	**0.521**	0.837	0.263	0.297
	672	**0.511**	0.600	**0.464**	0.474	0.487	**0.435**	**0.532**	0.868	0.284	0.314
ili	24	**1.102**	1.209	**0.904**	1.048	**0.998**	1.077	**2.101**	2.160	0.734	1.061
	36	**1.249**	1.272	**0.958**	1.075	**0.969**	1.122	**1.960**	2.163	0.898	1.059
	48	1.333	**1.324**	**1.016**	1.124	**1.014**	1.178	**1.924**	2.125	0.879	1.079
	60	**1.316**	1.374	**1.150**	1.204	**1.024**	1.261	**1.941**	2.175	0.790	1.157

Table 4: Percentage improvements in terms of MSE and MAE referred to Table 3 and Table 2

(a) MSE percentage Improvements

	MSE				Avg
	TS2Vec	SimTS	CoST	MaskAE	
ETTh1	20.59%	**12.81%**	-2.34%	**21.71%**	13.20%
ETTh2	**29.36%**	**26.83%**	**21.80%**	**22.87%**	25.22%
ETTm1	**36.64%**	**33.32%**	**20.53%**	**67.40%**	39.47%
ETTm2	**7.65%**	**19.34%**	**4.70%**	**58.51%**	22.55%
Exch.	**24.48%**	-0.07%	**2.97%**	-19.47%	1.98%
WTH	**19.92%**	**19.25%**	**19.83%**	**71.32%**	32.58%
Electr.	**20.91%**	**20.08%**	-11.49%	**13.41%**	10.73%
Weath.	**51.51%**	**31.56%**	**19.36%**	**52.20%**	38.66%
Traff.	**12.33%**	**2.76%**	-9.85%	**46.10%**	12.83%
Ili	**8.91%**	**18.74%**	**30.68%**	**14.07%**	18.10%
Avg	23.23%	18.46%	9.62%	34.81%	21.53%

(b) MAE percentage Improvements

	MAE				Avg
	TS2Vec	SimTS	CoST	MaskAE	
ETTh1	**14.90%**	**10.26%**	**0.62%**	**14.14%**	9.98%
ETTh2	**19.18%**	**21.30%**	**15.35%**	**12.68%**	17.13%
ETTm1	**21.99%**	**20.49%**	**11.67%**	**47.91%**	25.52%
ETTm2	**10.37%**	**16.76%**	**10.40%**	**38.24%**	18.94%
Exch.	**10.33%**	**9.02%**	**6.96%**	-6.80%	4.88%
WTH	**13.62%**	**13.86%**	**13.46%**	**59.51%**	25.11%
Electr.	**11.29%**	**9.04%**	-9.77%	**7.71%**	4.57%
Weath.	**34.92%**	**30.11%**	**22.25%**	**31.23%**	29.63%
Traff.	**12.08%**	**0.92%**	-10.99%	**42.50%**	11.13%
Ili	**3.47%**	**9.50%**	**13.65%**	**8.08%**	8.67%
Avg	15.22%	14.13%	7.36%	25.52%	15.56%

Table 5: TS2Vec with different kernel size

D	L	ks=9		ks=25		ks=64		ks=96		ks=128		ks=224		Orig.	
		MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE
ETTh1	24	0.463	0.463	0.402	0.347	**0.392**	**0.333**	0.405	0.351	0.406	0.355	0.417	0.378	0.509	0.549
	48	0.511	0.539	0.466	0.453	0.427	0.392	0.424	0.375	**0.420**	**0.374**	0.428	0.394	0.543	0.598
	168	0.621	0.727	0.591	0.666	0.567	0.630	0.535	0.575	0.519	0.556	**0.484**	**0.498**	0.638	0.758
	336	0.707	0.887	0.697	0.862	0.685	0.844	0.677	0.832	0.667	0.821	**0.632**	**0.771**	0.713	0.899
	720	0.791	**1.026**	0.793	1.040	**0.790**	1.054	0.790	1.060	0.789	1.068	0.790	1.090	0.795	1.060
ETTh2	24	0.393	0.304	0.324	0.212	**0.284**	**0.150**	0.303	0.170	0.305	0.179	0.385	0.288	0.459	0.389
	48	0.562	0.584	0.476	0.424	0.406	0.303	0.392	0.271	**0.387**	**0.267**	0.417	0.314	0.572	0.562
	168	0.975	1.618	0.994	1.659	0.970	1.603	0.921	1.431	0.920	1.386	**0.832**	**1.217**	1.060	1.845
	336	1.128	2.055	1.144	2.074	1.150	2.094	1.106	1.933	1.118	1.940	**1.057**	**1.736**	1.210	2.291
	720	1.262	2.354	1.288	2.383	1.299	2.390	1.272	2.293	1.274	2.280	**1.236**	**2.143**	1.396	2.717
ETTm1	24	0.375	0.358	0.296	0.207	**0.258**	**0.131**	0.313	0.208	0.320	0.212	0.334	0.256	0.407	0.391
	48	0.465	0.496	0.395	0.364	0.335	0.253	0.333	0.237	**0.330**	**0.227**	0.368	0.305	0.472	0.498
	96	0.502	0.536	0.450	0.446	0.414	0.381	0.407	0.360	**0.388**	0.330	0.389	**0.326**	0.518	0.564
	288	0.566	0.634	0.532	0.574	0.509	0.528	0.505	0.513	0.487	0.487	**0.470**	**0.457**	0.569	0.633
	672	0.637	0.754	0.613	0.710	0.590	0.662	0.595	0.665	0.579	0.640	**0.565**	**0.615**	0.628	0.731
ETTm2	24	0.251	0.139	0.213	0.097	**0.201**	**0.079**	0.225	0.100	0.228	0.102	0.229	0.104	0.273	0.155
	48	0.319	0.217	0.274	0.160	0.245	0.121	**0.240**	0.113	0.241	**0.112**	0.260	0.128	0.332	0.219
	96	0.403	0.342	0.359	0.273	0.328	0.220	0.318	0.198	**0.298**	**0.172**	0.309	**0.172**	0.409	0.325
	288	0.639	0.736	0.610	0.668	0.589	0.640	0.580	0.613	**0.563**	**0.583**	0.582	0.600	0.629	0.690
	672	**1.012**	**1.749**	1.021	1.794	1.035	1.855	1.043	1.897	1.038	1.877	1.072	2.011	1.030	1.831
Exch.	24	0.213	0.082	0.208	0.077	**0.179**	**0.058**	0.192	0.070	0.209	0.076	0.184	0.067	0.235	0.099
	48	0.332	0.177	0.316	0.172	0.267	0.125	0.248	0.117	0.245	0.104	**0.229**	**0.093**	0.319	0.184
	96	0.525	0.438	0.522	0.429	0.472	0.406	0.462	0.398	0.440	0.347	**0.380**	**0.267**	0.463	0.390
	288	0.967	1.455	0.966	1.448	0.954	**1.374**	**0.941**	1.422	0.942	1.446	0.951	1.461	0.887	1.352
	672	1.158	2.290	**1.093**	**1.970**	1.187	2.385	1.233	2.698	1.268	2.876	1.297	2.920	1.362	3.501
WTH	24	0.333	0.273	0.307	0.242	**0.290**	**0.223**	0.305	0.236	0.319	0.250	0.342	0.278	0.365	0.310
	48	0.396	0.346	0.376	0.322	0.337	0.272	**0.323**	**0.251**	0.331	0.260	0.369	0.305	0.419	0.377
	168	0.492	0.471	0.482	0.459	0.465	0.435	0.452	0.414	0.444	0.405	**0.432**	**0.384**	0.509	0.499
	336	0.519	0.507	0.514	0.500	0.504	0.486	0.498	0.475	0.495	0.473	**0.488**	**0.464**	0.535	0.535
	720	0.543	0.543	0.541	0.538	0.536	0.531	0.533	0.525	0.532	0.523	**0.528**	**0.515**	0.559	0.571
Electr.	24	0.310	0.207	**0.317**	**0.202**	0.322	0.203	0.335	0.223	0.336	0.226	0.353	0.251	0.373	0.285
	48	0.332	0.234	0.342	0.236	**0.337**	**0.224**	0.342	0.228	0.340	0.227	0.357	0.252	0.389	0.307
	168	0.362	0.270	0.374	0.280	0.372	0.275	0.375	0.278	0.367	0.267	**0.366**	**0.262**	0.407	0.331
	336	0.378	0.290	0.391	0.302	0.389	0.298	0.393	0.302	0.386	0.292	**0.385**	**0.288**	0.420	0.348
	720	**0.401**	**0.321**	0.413	0.333	0.411	0.331	0.416	0.336	**0.410**	0.327	0.410	0.325	0.439	0.375
Weath.	24	0.393	0.391	0.311	0.260	**0.236**	**0.124**	0.291	0.177	0.251	0.140	0.253	0.138	0.349	0.316
	48	0.679	1.090	0.566	0.795	0.345	0.287	0.285	0.176	**0.284**	**0.166**	0.297	0.180	0.584	0.808
	96	0.930	1.817	0.843	1.521	0.618	0.844	0.500	0.545	0.400	0.338	**0.336**	**0.223**	0.788	1.297
	288	1.056	2.073	0.992	1.845	0.856	1.400	0.776	1.169	0.723	1.022	**0.670**	**0.879**	0.939	1.608
	672	1.337	3.016	1.280	2.774	1.172	2.338	1.108	2.103	1.056	1.921	**0.999**	**1.727**	1.220	2.424
Traff.	24	0.572	0.963	0.554	0.893	0.507	0.841	0.498	0.847	**0.473**	0.818	0.480	**0.813**	0.541	0.914
	48	0.583	0.994	0.532	0.916	0.516	0.881	0.515	0.884	**0.490**	**0.848**	0.499	**0.848**	0.556	0.958
	96	0.598	1.043	0.551	0.967	0.532	0.926	0.533	0.932	**0.508**	0.890	0.510	**0.879**	0.564	1.017
	288	0.605	1.072	0.556	0.988	0.533	0.940	0.533	0.945	**0.509**	0.906	0.509	**0.891**	0.571	1.036
	672	0.611	1.092	0.570	1.012	0.534	0.953	0.534	0.955	**0.511**	0.920	0.512	**0.907**	0.600	1.073
Ili	24	1.999	8.380	1.102	2.903	1.419	3.555	**1.049**	**2.350**	1.093	2.767	1.190	3.552	1.209	3.625
	36	1.672	6.235	1.249	3.493	1.336	3.662	1.113	**2.856**	**1.090**	2.874	1.176	3.478	1.272	3.821
	48	1.548	5.446	1.333	4.015	1.497	4.551	1.213	3.421	**1.172**	**3.333**	1.256	3.873	1.324	4.058
	60	1.467	5.029	1.316	4.002	1.425	4.302	1.221	3.543	**1.192**	**3.511**	1.264	3.959	1.374	4.319
	Sum	33.887	63.061	30.850	49.302	30.020	47.893	28.600	43.071	28.093	42.518	28.273	44.282	32.730	54.442
	Avg	0.692	1.287	0.630	1.006	0.613	0.977	0.584	0.879	0.573	0.868	0.577	0.904	0.668	1.111

Table 6: SimTS with different kernel size

D	L	ks=9		ks=25		ks=64		ks=96		ks=128		ks=224		Orig.	
		MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE
ETTh1	24	0.392	0.339	0.352	0.274	**0.335**	**0.231**	0.344	0.250	0.351	0.265	0.362	0.288	0.418	0.374
	48	0.438	0.404	0.417	0.373	0.388	0.319	**0.368**	**0.284**	0.371	0.293	0.378	0.310	0.452	0.424
	168	0.578	0.636	0.565	0.615	0.544	0.585	0.533	0.571	0.518	0.546	**0.491**	**0.497**	0.581	0.644
	336	0.688	0.838	0.681	0.827	0.669	0.806	**0.661**	**0.795**	0.662	0.816	0.646	0.796	0.690	0.844
	720	0.784	1.013	0.781	1.004	0.778	1.002	**0.776**	**1.001**	0.775	1.001	0.786	1.069	0.786	1.014
ETTh2	24	0.415	0.320	0.353	0.243	**0.254**	**0.118**	0.259	0.122	0.277	0.140	0.302	0.174	0.441	0.346
	48	0.565	0.556	0.526	0.498	0.411	0.328	0.339	0.210	**0.319**	**0.178**	0.342	0.219	0.586	0.586
	168	0.993	1.648	0.985	1.626	0.959	1.544	0.931	1.457	0.899	1.358	**0.763**	**1.221**	1.002	1.661
	336	1.090	1.923	1.087	1.912	1.072	1.863	1.055	1.809	1.035	1.743	**0.978**	**1.554**	1.098	1.932
	720	1.171	2.127	1.168	2.115	1.160	2.078	1.149	2.037	1.136	1.992	**1.080**	**1.812**	1.185	2.148
ETTm1	24	0.295	0.209	0.238	0.138	**0.197**	**0.078**	0.219	0.100	0.241	0.121	0.281	0.168	0.322	0.240
	48	0.366	0.308	0.334	0.265	0.269	0.167	**0.244**	**0.123**	0.255	0.134	0.302	0.190	0.377	0.319
	96	0.409	0.368	0.391	0.344	0.358	0.292	0.336	0.254	**0.321**	**0.225**	**0.321**	**0.211**	0.413	0.369
	288	0.478	0.463	0.470	0.452	0.454	0.425	0.446	0.410	0.438	0.397	**0.425**	**0.373**	0.480	0.464
	672	0.570	0.616	0.566	0.610	0.556	0.592	0.552	0.585	0.547	0.577	**0.535**	**0.555**	0.572	0.617
ETTm2	24	0.219	0.100	0.195	0.078	**0.172**	**0.056**	0.176	0.060	0.179	0.064	0.201	0.081	0.234	0.113
	48	0.285	0.158	0.265	0.139	0.222	0.096	0.201	0.077	**0.191**	**0.070**	0.212	0.086	0.295	0.168
	96	0.376	0.265	0.363	0.249	0.327	0.206	0.302	0.176	0.274	0.145	**0.242**	**0.106**	0.383	0.272
	288	0.640	0.705	0.634	0.695	0.618	0.671	0.606	0.652	0.610	0.672	**0.574**	**0.606**	0.645	0.713
	672	0.994	1.658	0.992	1.651	0.984	1.627	0.977	1.606	0.970	1.585	**0.949**	**1.519**	0.999	1.658
Exch.	24	0.203	0.078	0.177	0.062	0.152	0.039	0.156	0.043	**0.150**	**0.038**	0.176	0.052	0.214	0.086
	48	0.313	0.186	0.296	0.169	0.243	0.119	0.201	0.074	**0.187**	**0.059**	0.212	0.078	0.319	0.192
	96	0.486	0.432	0.475	0.417	0.442	0.368	0.410	0.333	0.380	0.282	**0.300**	**0.161**	0.491	0.439
	288	0.909	1.302	0.907	1.298	0.900	1.283	0.897	1.276	**0.894**	1.269	**0.894**	**1.258**	0.914	1.312
	672	**1.094**	**1.872**	**1.094**	1.873	1.099	1.893	1.106	1.920	1.117	1.957	1.231	2.405	1.100	1.889
WTH	24	0.335	0.267	0.301	0.229	**0.278**	**0.204**	0.293	0.221	0.306	0.235	0.329	0.260	0.356	0.294
	48	0.394	0.339	0.370	0.309	0.326	0.255	**0.311**	**0.236**	0.314	0.241	0.346	0.276	0.408	0.356
	168	0.487	0.461	0.479	0.451	0.460	0.425	0.447	0.407	0.436	0.391	**0.412**	**0.353**	0.492	0.465
	336	0.515	0.497	0.511	0.492	0.501	0.478	0.495	0.469	0.489	0.461	**0.476**	**0.441**	0.518	0.500
	720	0.540	0.532	0.538	0.530	0.534	0.524	0.530	0.519	0.527	0.515	**0.520**	**0.504**	0.544	0.537
Electr.	24	0.231	0.130	0.210	0.103	**0.208**	**0.090**	0.217	0.101	0.222	0.108	0.231	0.120	0.243	0.139
	48	0.254	0.151	0.240	0.135	0.228	0.114	**0.223**	**0.106**	0.227	0.110	0.236	0.121	0.258	0.154
	168	0.279	0.178	0.273	0.172	0.268	0.163	0.264	0.157	0.259	0.151	**0.251**	**0.139**	0.276	0.176
	336	0.300	0.198	0.296	0.194	0.293	0.189	0.289	0.184	0.286	0.180	**0.278**	**0.170**	0.296	0.195
	720	0.332	0.235	0.329	0.231	0.327	0.227	0.324	0.224	0.321	0.221	**0.316**	**0.213**	0.329	0.233
Weath.	24	0.291	0.213	0.232	0.141	**0.155**	**0.071**	0.160	0.075	0.169	0.084	0.175	0.094	0.306	0.241
	48	0.489	0.538	0.436	0.444	0.287	0.212	0.209	0.113	**0.182**	**0.093**	0.192	0.104	0.484	0.526
	96	0.719	1.046	0.691	0.998	0.573	0.757	0.464	0.528	0.362	0.333	**0.220**	**0.123**	0.695	0.957
	288	1.013	1.773	1.032	1.910	0.967	1.750	0.895	1.548	0.834	1.379	**0.711**	**1.108**	0.859	1.296
	672	1.227	2.430	1.221	2.417	1.186	2.305	1.139	2.114	1.107	1.979	1.066	1.849	**1.033**	**1.749**
Traff.	24	0.440	0.745	**0.438**	**0.731**	0.445	0.732	0.448	0.737	0.447	0.742	0.443	0.748	0.431	0.756
	48	0.457	0.780	**0.453**	0.765	0.459	**0.764**	0.462	0.764	0.462	0.766	0.456	0.768	0.451	0.793
	96	0.469	0.802	**0.464**	0.790	0.470	0.796	0.472	0.797	0.469	0.793	0.465	**0.783**	0.475	0.809
	288	0.469	0.813	0.464	0.803	0.467	0.806	0.468	0.806	0.467	0.804	**0.463**	**0.798**	0.472	0.815
	672	0.471	0.826	0.467	0.817	0.468	0.819	0.469	0.819	0.467	0.818	**0.464**	**0.814**	0.474	0.827
Ili	24	1.007	2.471	0.904	1.975	**0.912**	**1.862**	0.955	2.116	0.988	2.296	0.994	2.488	1.048	2.640
	36	1.049	2.803	0.981	2.422	**0.958**	**2.139**	0.978	2.235	1.012	2.407	1.018	2.620	1.075	2.905
	48	1.106	3.124	1.055	2.809	**1.016**	2.547	1.040	**2.546**	1.054	2.618	1.058	2.825	1.124	3.183
	60	1.189	3.542	1.150	3.335	**1.096**	2.969	1.121	2.982	1.118	**2.952**	1.124	3.149	1.204	3.572
	Sum	28.809	43.414	27.847	41.130	26.438	37.983	25.913	37.028	25.621	36.603	25.224	36.651	28.848	42.939
	Avg	0.588	0.886	0.568	0.839	0.540	0.775	0.529	0.756	0.523	0.747	0.515	0.748	0.589	0.876

Table 7: CoST with different kernel size

D	L	ks=9		ks=25		ks=64		ks=96		ks=128		ks=224		Orig.	
		MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE
ETTh1	24	0.416	0.366	0.440	0.416	**0.381**	**0.298**	0.425	0.400	0.433	0.400	0.451	0.438	0.427	0.383
	48	0.457	0.426	0.484	0.485	**0.433**	**0.386**	0.437	0.411	0.439	0.403	0.455	0.439	0.463	0.434
	168	0.585	0.648	0.609	0.694	0.591	0.660	0.578	0.644	0.576	0.638	**0.548**	**0.589**	0.578	0.633
	336	0.691	0.850	0.712	0.890	0.701	0.871	0.698	0.869	0.708	0.893	0.711	0.903	**0.670**	**0.792**
	720	0.789	1.027	0.822	1.109	0.813	1.092	0.818	1.106	0.820	1.116	0.828	1.160	**0.748**	**0.904**
ETTh2	24	0.441	0.350	0.395	0.284	0.327	0.188	**0.319**	**0.184**	0.341	0.210	0.416	0.300	0.507	0.453
	48	0.593	0.610	0.562	0.556	0.476	0.411	0.428	0.329	**0.423**	0.315	0.432	**0.314**	0.640	0.699
	168	1.004	1.638	0.997	1.611	0.965	1.514	0.946	1.460	0.919	1.439	**0.854**	**1.281**	0.983	1.538
	336	1.070	1.856	1.071	1.863	1.057	1.827	1.045	1.789	1.032	1.741	**0.962**	**1.481**	1.050	1.743
	720	1.139	2.055	1.136	2.041	1.117	1.980	1.104	1.937	1.093	1.885	**1.042**	**1.716**	1.089	1.955
ETTm1	24	0.305	0.217	0.269	0.165	**0.240**	**0.117**	0.379	0.326	0.300	0.185	0.364	0.287	0.329	0.246
	48	0.375	0.316	0.354	0.287	0.304	0.202	0.386	0.336	**0.295**	**0.181**	0.366	0.288	0.386	0.330
	96	0.416	0.373	0.408	0.362	0.390	0.331	0.441	0.425	**0.361**	0.279	**0.361**	**0.275**	0.419	0.377
	288	0.485	0.471	0.483	0.467	0.483	0.465	0.514	0.530	0.475	0.451	**0.465**	**0.437**	0.485	0.471
	672	0.576	0.625	0.577	0.626	0.585	0.634	0.603	0.671	0.583	0.628	0.575	**0.617**	**0.574**	0.622
ETTm2	24	0.237	0.114	0.221	0.097	**0.201**	**0.076**	0.217	0.090	0.220	0.093	0.248	0.123	0.259	0.134
	48	0.301	0.177	0.287	0.160	0.258	0.125	0.247	0.111	**0.234**	**0.101**	0.250	0.121	0.320	0.196
	96	0.390	0.287	0.380	0.275	0.353	0.238	0.334	0.211	0.313	0.185	**0.292**	**0.155**	0.405	0.305
	288	0.653	0.750	0.646	0.735	0.633	0.715	0.625	0.700	0.611	0.670	**0.592**	**0.639**	0.661	0.754
	672	1.067	1.937	1.067	1.947	1.068	1.950	1.066	1.948	1.058	1.928	1.035	1.866	**0.982**	**1.589**
Exch.	24	0.261	0.118	0.243	0.105	0.199	0.070	0.184	0.059	**0.181**	**0.056**	0.244	0.098	0.277	0.133
	48	0.378	0.248	0.361	0.230	0.317	0.182	0.283	0.146	**0.256**	**0.117**	0.292	0.140	0.383	0.250
	96	0.556	0.518	0.546	0.506	0.517	0.465	0.502	0.438	0.476	0.399	**0.435**	**0.334**	0.548	0.505
	288	0.923	1.340	0.923	1.339	0.919	1.327	0.902	1.289	0.902	1.283	0.903	**1.272**	**0.883**	1.278
	672	1.098	1.969	1.099	1.972	1.103	1.987	1.123	2.064	1.132	2.089	1.168	2.204	**1.075**	**1.942**
WTH	24	0.337	0.271	0.304	0.231	**0.282**	**0.203**	0.313	0.234	0.344	0.263	0.386	0.308	0.361	0.299
	48	0.397	0.343	0.374	0.314	0.324	0.248	**0.318**	**0.236**	0.342	0.261	0.385	0.306	0.412	0.360
	168	0.488	0.460	0.481	0.451	0.461	0.425	0.450	0.407	0.440	0.391	**0.417**	**0.351**	0.492	0.465
	336	0.514	0.494	0.510	0.489	0.501	0.475	0.495	0.467	0.490	0.459	**0.475**	**0.437**	0.518	0.498
	720	0.539	0.530	0.537	0.528	0.532	0.521	0.529	0.516	0.526	0.513	**0.519**	**0.501**	0.542	0.533
Electr.	24	0.265	0.149	0.387	0.271	0.308	0.181	0.465	0.371	0.376	0.264	0.435	0.342	**0.241**	**0.135**
	48	0.283	0.169	0.405	0.298	0.321	0.198	0.464	0.369	0.370	0.250	0.431	0.331	**0.257**	**0.152**
	168	0.307	0.199	0.425	0.332	0.356	0.247	0.489	0.418	0.394	0.291	0.437	0.341	**0.275**	**0.175**
	336	0.326	0.219	0.438	0.351	0.373	0.271	0.500	0.439	0.415	0.321	0.455	0.372	**0.296**	**0.195**
	720	0.354	0.254	0.459	0.383	0.398	0.305	0.517	0.469	0.436	0.354	0.477	0.408	**0.328**	**0.231**
Weath.	24	0.310	0.226	0.272	0.179	**0.212**	**0.114**	0.220	0.118	0.285	0.171	0.284	0.176	0.337	0.258
	48	0.472	0.484	0.434	0.424	0.313	0.239	**0.259**	**0.160**	0.293	0.181	**0.293**	0.187	0.488	0.496
	96	0.655	0.841	0.632	0.800	0.541	0.631	0.464	0.485	0.428	0.403	**0.292**	**0.186**	0.642	0.787
	288	0.916	1.477	0.905	1.448	0.857	1.333	0.830	1.285	0.806	1.257	0.727	1.085	**0.794**	**1.082**
	672	1.199	2.327	1.191	2.299	1.152	2.182	1.121	2.092	1.076	1.944	1.027	1.808	**0.977**	**1.535**
Traff.	24	0.470	0.787	0.631	1.036	0.551	0.905	0.700	1.172	0.604	0.994	0.670	1.163	**0.423**	**0.721**
	48	0.482	0.816	0.621	1.046	0.548	0.925	0.719	1.221	0.608	1.007	0.666	1.154	**0.437**	**0.745**
	96	0.484	0.833	0.632	1.082	0.549	0.951	0.716	1.258	0.617	1.050	0.671	1.159	**0.438**	**0.755**
	288	0.482	0.840	0.634	1.094	0.555	0.969	0.719	1.280	0.609	1.071	0.674	1.196	**0.434**	**0.764**
	672	0.487	0.856	0.658	1.138	0.570	0.999	0.731	1.311	0.623	1.118	0.678	1.225	**0.435**	**0.777**
Ili	24	1.058	2.811	0.998	2.389	**0.997**	**1.991**	0.988	2.146	1.032	2.392	1.034	2.528	1.077	2.872
	36	1.111	3.127	1.075	2.860	**0.969**	**1.978**	0.997	2.178	1.013	2.316	1.014	2.568	1.122	3.155
	48	1.165	3.413	1.136	3.188	1.014	2.363	1.036	2.389	**1.003**	**2.331**	1.010	2.657	1.178	3.439
	60	1.247	3.814	1.208	3.545	1.098	2.871	1.096	2.827	**1.024**	**2.487**	1.042	2.883	1.261	3.831
	Sum	29.549	45.023	30.441	45.394	28.210	39.631	29.739	42.316	28.331	39.774	28.788	41.148	28.903	42.926
	Avg	0.603	0.919	0.621	0.926	0.576	0.809	0.607	0.864	0.578	0.812	0.588	0.840	0.590	0.876

Table 8: MaskAE with different kernel size

D	L	ks=9		ks=25		ks=64		ks=96		ks=128		ks=224		Orig.	
		MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE
ETTh1	24	0.821	1.136	0.783	1.047	0.711	0.921	0.689	0.898	0.681	0.867	**0.678**	**0.864**	0.958	1.484
	48	**0.839**	1.162	0.851	1.166	0.841	1.152	0.842	**1.150**	0.840	1.151	0.840	1.160	0.997	1.544
	168	0.827	1.147	0.825	**1.144**	0.831	1.147	0.829	**1.144**	**0.826**	**1.144**	0.828	1.151	0.913	1.320
	336	0.838	**1.158**	0.844	1.165	**0.836**	1.160	0.846	1.167	0.847	1.168	0.850	1.172	0.895	1.289
	720	0.836	1.160	0.836	**1.158**	**0.835**	1.159	0.836	1.160	0.837	1.163	0.837	1.165	0.934	1.370
ETTh2	24	1.286	2.617	1.245	2.385	1.125	1.908	1.222	2.170	1.115	1.892	**1.095**	**1.885**	1.339	2.994
	48	1.233	2.422	1.152	2.091	1.105	1.947	1.128	2.132	1.118	2.137	**1.019**	**1.787**	1.311	2.820
	168	1.236	2.491	1.265	2.598	1.303	2.745	1.257	2.550	**1.213**	**2.400**	1.222	2.418	1.406	3.141
	336	1.334	2.715	1.402	2.932	1.370	2.900	1.369	2.927	1.351	2.925	**1.271**	**2.631**	1.317	2.741
	720	1.303	2.895	1.290	2.875	1.296	2.876	1.274	2.781	1.269	2.770	**1.242**	**2.698**	1.436	3.302
ETTm1	24	0.498	0.497	0.468	0.424	**0.343**	**0.227**	0.374	0.277	0.392	0.317	0.409	0.345	1.106	2.028
	48	0.680	0.902	0.563	0.650	0.451	0.406	0.422	0.346	**0.413**	**0.332**	0.420	0.357	1.074	1.840
	96	0.666	0.886	0.631	0.779	0.595	0.668	0.597	0.696	0.552	0.586	**0.490**	**0.453**	1.002	1.692
	288	0.764	1.032	0.738	0.971	0.781	1.029	0.719	0.896	0.709	0.903	**0.655**	**0.784**	1.000	1.683
	672	0.760	1.039	0.769	1.073	0.819	1.121	0.788	1.046	0.845	1.151	**0.740**	**1.003**	1.041	1.706
ETTm2	24	0.575	0.530	0.494	0.388	0.517	0.424	**0.434**	**0.313**	0.455	0.347	0.507	0.426	1.160	2.576
	48	0.844	1.048	0.801	1.025	0.643	0.629	0.532	0.439	0.531	0.461	**0.531**	**0.435**	1.201	2.499
	96	0.841	1.127	0.862	1.140	0.849	1.060	0.724	0.785	0.748	0.847	**0.634**	**0.643**	1.261	2.600
	288	0.898	1.216	0.869	1.157	**0.886**	1.188	0.912	1.241	1.060	1.642	0.954	1.316	1.287	2.685
	672	1.221	2.388	1.258	2.484	**1.182**	**2.181**	1.196	2.280	1.380	2.922	1.480	3.276	1.346	2.955
Exch.	24	1.170	2.257	1.174	2.273	1.268	2.513	1.306	2.656	1.327	2.742	1.367	2.903	**1.151**	**2.029**
	48	1.193	2.452	1.189	2.445	1.219	2.432	1.296	2.667	1.302	2.683	1.348	2.886	**1.187**	**2.223**
	96	1.226	2.448	1.226	2.452	1.270	2.555	1.306	2.692	1.345	2.849	1.396	3.079	**1.190**	**2.227**
	288	1.305	2.776	1.298	2.743	1.285	2.685	1.316	2.802	1.330	2.860	1.324	2.771	**1.193**	**2.250**
	672	1.391	3.229	1.382	3.185	1.362	3.084	1.399	3.247	1.440	3.431	1.496	3.698	**1.171**	**2.305**
WTH	24	0.389	0.322	0.355	0.277	**0.332**	**0.252**	0.355	0.278	0.369	0.293	0.376	0.305	1.151	1.612
	48	0.451	0.408	0.425	0.364	0.373	0.300	**0.361**	**0.286**	0.369	0.296	0.415	0.352	1.187	1.719
	168	0.573	0.587	0.584	0.604	0.575	0.590	0.579	0.595	0.566	0.589	**0.545**	**0.541**	1.190	1.462
	336	0.580	0.593	0.574	0.587	0.584	0.599	0.579	0.592	**0.572**	**0.586**	0.578	0.587	1.193	1.529
	720	**0.561**	**0.559**	0.562	0.560	**0.561**	0.560	0.568	0.573	0.563	0.565	0.567	0.567	1.171	1.503
Electr.	24	0.801	0.987	0.802	0.981	0.803	0.987	0.804	0.988	0.803	0.986	**0.799**	**0.978**	0.873	1.143
	48	0.797	0.974	**0.797**	0.978	0.799	0.975	0.798	**0.972**	0.800	0.973	0.801	0.981	0.869	1.136
	168	0.802	0.993	**0.799**	0.979	0.803	0.989	0.802	**0.977**	0.804	0.992	0.801	0.984	0.866	1.130
	336	0.800	0.976	**0.798**	**0.973**	0.801	0.983	0.802	0.983	0.802	0.986	0.800	0.978	0.865	1.124
	720	0.804	0.976	**0.802**	**0.971**	0.804	0.978	0.806	0.974	0.804	0.976	0.803	0.977	0.860	1.106
Weath.	24	0.687	0.833	0.630	0.695	0.480	0.408	0.496	0.432	**0.430**	**0.343**	0.704	0.914	1.048	2.015
	48	0.706	0.839	0.664	0.779	0.601	0.607	0.561	**0.553**	0.552	0.566	**0.547**	0.554	1.075	2.000
	96	0.969	1.629	1.028	1.788	0.869	1.248	0.776	0.982	0.833	1.113	**0.771**	**0.928**	1.114	2.053
	288	0.939	1.375	1.008	1.564	0.954	1.430	0.982	1.510	0.990	1.544	**0.907**	**1.280**	1.102	1.919
	672	0.995	1.517	**0.993**	**1.502**	1.119	1.897	1.185	2.111	1.091	1.813	1.119	1.919	1.057	1.785
Traff.	24	**0.490**	**0.875**	0.788	1.429	0.549	0.983	0.818	1.498	0.576	1.034	0.631	1.142	0.923	1.816
	48	**0.506**	**0.900**	0.810	1.481	0.573	1.031	0.644	1.136	0.588	1.052	0.588	1.065	0.899	1.752
	96	**0.504**	**0.915**	0.816	1.503	0.796	1.462	0.817	1.507	0.591	1.083	0.753	1.382	0.913	1.796
	288	**0.521**	**0.972**	0.822	1.522	0.819	1.524	0.832	1.553	0.560	1.042	0.593	1.095	0.837	1.604
	672	**0.532**	**1.006**	0.819	1.533	0.579	1.067	0.835	1.576	0.655	1.223	0.827	1.575	0.868	1.692
Ili	24	1.989	7.856	2.097	8.458	**1.928**	**7.314**	2.101	8.299	2.223	9.321	2.276	9.847	2.160	8.860
	36	1.990	7.861	2.109	8.724	**1.960**	**7.565**	2.122	8.814	2.009	8.078	2.170	9.333	2.163	9.049
	48	2.000	7.917	2.085	8.461	**1.924**	**7.387**	1.992	7.702	2.155	8.819	2.164	8.998	2.125	8.757
	60	1.964	7.725	2.045	8.211	**1.941**	**7.564**	2.039	8.120	2.066	8.279	2.068	8.338	2.175	9.195
	Sum	29.549	45.023	30.441	45.394	28.210	39.631	29.739	42.316	28.331	39.774	28.788	41.148	28.903	42.926
	Avg	0.603	0.919	0.621	0.926	0.576	0.809	0.607	0.864	0.578	0.812	0.588	0.840	0.590	0.876

Table 9: Short-term forecasting for prediction length from 6 to 22 timestamps.

		TS2Vec				SimTS				CoST				MaskAE				PatchTST		DLinear	
		TED4STL		Orig.		TED4STL		Orig.		TED4STL		Orig.		TED4STL		Orig.					
D	L	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE
ETTh1	6	0.329	0.231	0.445	0.436	**0.243**	**0.118**	0.341	0.259	0.387	0.332	0.355	0.272	0.658	0.831	1.087	1.743	0.327	0.255	0.313	0.242
	8	0.328	0.227	0.462	0.462	**0.245**	**0.119**	0.363	0.292	0.388	0.331	0.376	0.305	0.681	0.834	1.075	1.786	0.344	0.282	0.333	0.271
	10	0.331	0.230	0.475	0.483	**0.253**	**0.127**	0.382	0.318	0.389	0.330	0.389	0.326	0.632	0.752	0.976	1.537	0.353	0.297	0.342	0.286
	12	0.341	0.244	0.489	0.507	**0.267**	**0.142**	0.391	0.332	0.393	0.333	0.400	0.343	0.663	0.786	1.004	1.576	0.359	0.307	0.349	0.297
	14	0.352	0.264	0.498	0.523	**0.286**	**0.170**	0.398	0.343	0.401	0.346	0.408	0.355	0.744	0.964	0.986	1.562	0.364	0.315	0.354	0.305
	16	0.361	0.282	0.500	0.529	**0.304**	**0.198**	0.404	0.353	0.413	0.367	0.414	0.364	0.628	0.764	0.998	1.584	0.367	0.319	0.357	0.310
	18	0.373	0.301	0.501	0.530	**0.320**	**0.224**	0.409	0.361	0.423	0.386	0.418	0.370	0.727	0.965	1.016	1.654	0.369	0.322	0.359	0.314
	20	0.384	0.319	0.504	0.535	**0.333**	**0.245**	0.413	0.366	0.432	0.403	0.422	0.375	0.735	0.945	1.018	1.586	0.371	0.326	0.362	0.317
	22	0.393	0.333	0.506	0.536	**0.344**	**0.262**	0.416	0.371	0.440	0.416	0.425	0.379	0.824	1.148	1.010	1.590	0.372	0.327	0.363	0.318
ETTh2	6	0.218	0.097	0.316	0.195	**0.197**	**0.072**	0.293	0.166	0.260	0.124	0.337	0.205	1.139	1.953	1.311	2.811	0.211	0.106	0.209	0.105
	8	0.221	0.099	0.341	0.222	**0.202**	**0.076**	0.317	0.189	0.271	0.135	0.363	0.237	0.985	1.502	1.285	2.782	0.221	0.116	0.219	0.114
	10	0.226	0.102	0.362	0.247	**0.217**	**0.088**	0.337	0.211	0.284	0.146	0.387	0.268	0.964	1.426	1.323	2.914	0.230	0.125	0.228	0.123
	12	**0.234**	**0.109**	0.385	0.277	0.239	0.110	0.355	0.232	0.298	0.160	0.408	0.295	0.989	1.460	1.228	2.489	0.238	0.133	0.235	0.131
	14	**0.245**	**0.121**	0.401	0.299	0.257	0.129	0.372	0.254	0.317	0.182	0.427	0.324	0.998	1.517	1.264	2.650	0.244	0.141	0.244	0.140
	16	**0.257**	**0.134**	0.415	0.319	0.279	0.154	0.388	0.275	0.338	0.209	0.446	0.353	1.144	2.062	1.238	2.410	0.249	0.147	**0.249**	0.146
	18	0.271	**0.150**	0.429	0.340	0.301	0.180	0.404	0.296	0.356	0.232	0.463	0.380	1.080	1.717	1.296	2.784	**0.255**	0.154	**0.255**	**0.153**
	20	0.284	0.164	0.443	0.363	0.317	0.197	0.418	0.317	0.376	0.262	0.478	0.405	1.307	2.661	1.333	2.963	**0.258**	0.160	0.260	**0.159**
	22	0.300	0.183	0.461	0.390	0.336	0.221	0.429	0.329	0.396	0.292	0.494	0.430	1.117	1.910	1.311	2.836	**0.262**	0.165	0.263	**0.164**
ETTm1	6	0.170	0.061	0.250	0.145	**0.141**	**0.042**	0.204	0.098	0.170	0.059	0.211	0.101	0.258	0.137	1.172	2.189	0.177	0.079	0.185	0.089
	8	0.177	0.066	0.283	0.184	**0.144**	**0.043**	0.224	0.119	0.173	0.060	0.231	0.121	0.258	0.140	1.095	1.992	0.193	0.095	0.202	0.106
	10	0.189	0.075	0.314	0.227	**0.148**	**0.046**	0.243	0.139	0.179	0.064	0.249	0.141	0.243	0.119	1.126	2.114	0.207	0.108	0.217	0.123
	12	0.204	0.089	0.342	0.269	**0.157**	**0.052**	0.258	0.157	0.188	0.071	0.264	0.159	0.274	0.156	1.101	2.080	0.218	0.122	0.230	0.138
	14	0.220	0.108	0.367	0.308	**0.169**	**0.063**	0.272	0.174	0.200	0.082	0.278	0.176	0.295	0.189	1.059	1.902	0.231	0.137	0.242	0.153
	16	0.237	0.128	0.387	0.342	**0.183**	**0.076**	0.285	0.189	0.213	0.096	0.291	0.192	0.332	0.223	1.079	1.930	0.241	0.149	0.252	0.167
	18	0.253	0.148	0.406	0.373	**0.197**	**0.090**	0.296	0.204	0.226	0.111	0.302	0.208	0.367	0.272	1.118	2.104	0.251	0.162	0.266	0.183
	20	0.268	0.168	0.421	0.400	**0.211**	**0.106**	0.306	0.217	0.239	0.126	0.312	0.221	0.380	0.301	1.075	1.955	0.260	0.178	0.274	0.193
	22	0.282	0.188	0.434	0.424	**0.225**	**0.123**	0.315	0.230	0.251	0.142	0.321	0.234	0.407	0.351	1.056	1.838	0.269	0.185	0.277	0.202
ETTm2	6	0.146	0.044	0.219	0.103	**0.130**	**0.034**	0.162	0.060	0.162	0.051	0.191	0.075	0.364	0.213	1.142	2.389	0.140	0.055	0.142	0.056
	8	0.151	0.046	0.235	0.118	**0.136**	**0.037**	0.173	0.068	0.165	0.053	0.201	0.082	0.498	0.393	1.084	2.272	0.150	0.062	0.153	0.063
	10	0.157	0.050	0.248	0.130	**0.143**	**0.041**	0.183	0.075	0.171	0.056	0.210	0.090	0.467	0.344	1.154	2.563	0.158	0.067	0.160	0.069
	12	0.166	0.057	0.260	0.142	**0.150**	**0.044**	0.192	0.081	0.178	0.061	0.219	0.097	0.437	0.299	1.142	2.438	0.164	0.072	0.168	0.074
	14	0.175	0.064	0.270	0.152	**0.157**	**0.049**	0.200	0.087	0.186	0.067	0.227	0.104	0.512	0.399	1.149	2.427	0.171	0.078	0.174	0.079
	16	0.185	0.073	0.279	0.162	**0.165**	**0.055**	0.208	0.093	0.194	0.073	0.234	0.110	0.367	0.235	1.096	2.262	0.175	0.081	0.178	0.083
	18	0.193	0.080	0.287	0.170	**0.173**	**0.061**	0.215	0.098	0.201	0.079	0.240	0.116	0.447	0.338	1.212	2.661	0.179	0.085	0.184	0.087
	20	0.199	0.086	0.295	0.178	**0.181**	**0.067**	0.222	0.103	0.209	0.085	0.247	0.122	0.480	0.362	1.213	2.722	0.185	0.088	0.190	0.091
	22	0.206	0.091	0.302	0.186	**0.187**	**0.072**	0.228	0.108	0.217	0.092	0.254	0.128	0.452	0.347	1.120	2.351	0.189	0.092	**0.192**	**0.095**
Exch.	6	0.125	0.029	0.159	0.045	0.109	0.021	0.112	0.023	0.153	0.041	0.177	0.054	1.197	2.572	1.149	2.011	0.075	0.012	**0.059**	**0.009**
	8	0.131	0.032	0.172	0.054	0.115	0.024	0.125	0.029	0.162	0.046	0.190	0.063	1.140	2.379	1.137	1.993	0.080	0.014	**0.066**	**0.010**
	10	0.137	0.034	0.179	0.058	0.122	0.027	0.138	0.035	0.173	0.052	0.204	0.072	1.155	2.304	1.122	2.043	0.095	0.015	**0.074**	**0.013**
	12	0.149	0.039	0.184	0.061	0.120	0.026	0.149	0.041	0.184	0.059	0.215	0.081	1.215	2.509	1.113	1.926	0.091	0.018	**0.083**	**0.016**
	14	0.156	0.043	0.196	0.070	0.128	0.031	0.161	0.048	0.196	0.068	0.227	0.090	1.157	2.324	1.131	2.141	0.095	0.019	**0.083**	**0.016**
	16	0.164	0.048	0.201	0.073	0.137	0.036	0.172	0.056	0.207	0.076	0.237	0.098	1.198	2.343	1.130	2.006	0.099	0.021	**0.088**	**0.018**
	18	0.173	0.054	0.212	0.081	0.147	0.042	0.182	0.062	0.218	0.084	0.245	0.105	1.157	2.485	1.184	2.206	0.104	0.023	**0.093**	**0.019**
	20	0.192	0.064	0.222	0.090	0.158	0.049	0.193	0.070	0.228	0.092	0.255	0.113	1.245	2.622	1.163	2.106	0.108	0.025	0.099	**0.021**
	22	0.201	0.071	0.224	0.092	0.166	0.054	0.203	0.078	0.240	0.102	0.266	0.124	1.178	2.437	1.153	2.071	0.112	0.026	0.103	**0.023**
WTH	6	0.231	0.170	0.283	0.230	**0.223**	**0.151**	0.279	0.222	0.242	0.168	0.287	0.227	0.273	0.191	1.046	1.828	0.270	0.232	0.298	0.259
	8	0.236	0.173	0.299	0.244	**0.227**	**0.154**	0.294	0.235	0.243	0.168	0.302	0.240	0.259	0.173	1.041	1.792	0.288	0.248	0.315	0.276
	10	0.242	0.177	0.312	0.257	**0.233**	**0.158**	0.307	0.246	0.245	0.169	0.313	0.250	0.273	0.185	1.054	1.839	0.301	0.261	0.329	0.291
	12	0.250	0.183	0.322	0.267	**0.242**	**0.165**	0.317	0.256	0.250	0.172	0.323	0.259	0.295	0.209	1.119	2.031	0.314	0.273	0.341	0.303
	14	0.260	0.193	0.332	0.276	**0.253**	**0.177**	0.326	0.264	0.260	0.182	0.331	0.267	0.301	0.216	1.109	1.989	0.324	0.283	0.350	0.313
	16	0.270	0.203	0.339	0.284	**0.264**	**0.189**	0.333	0.271	0.270	0.193	0.338	0.275	0.314	0.232	1.024	1.730	0.333	0.292	0.359	0.323
	18	0.280	0.214	0.347	0.291	**0.275**	**0.201**	0.339	0.277	0.279	0.204	0.345	0.281	0.329	0.251	1.096	1.957	0.341	0.300	0.366	0.331
	20	0.290	0.224	0.353	0.299	**0.285**	**0.211**	0.345	0.283	0.289	0.214	0.351	0.287	0.333	0.256	1.119	2.037	0.348	0.308	0.373	0.338
	22	0.299	0.234	0.359	0.305	**0.294**	**0.221**	0.351	0.289	0.297	0.224	0.356	0.293	0.342	0.264	1.017	1.702	0.354	0.315	0.379	0.346
Electr.	6	0.320	0.196	0.391	0.302	**0.166**	**0.058**	0.383	0.293	0.398	0.281	0.220	0.108	0.801	0.995	0.882	1.170	**0.166**	0.070	0.186	0.085
	8	0.305	0.180	0.384	0.292	**0.168**	**0.060**	0.387	0.301	0.396	0.278	0.226	0.115	0.759	0.909	0.887	1.176	0.172	0.075	0.192	0.091
	10	0.305	0.179	0.388	0.299	**0.170**	**0.061**	0.390	0.307	0.393	0.273	0.231	0.120	0.796	0.969	0.886	1.177	0.177	0.079	0.197	0.096
	12	0.310	0.184	0.398	0.312	**0.174**	**0.064**	0.393	0.312	0.391	0.269	0.233	0.124	0.794	0.968	0.886	1.176	0.180	0.083	0.200	0.099
	14	0.316	0.191	0.402	0.318	**0.182**	**0.072**	0.397	0.319	0.388	0.266	0.236	0.127	0.792	0.972	0.881	1.160	0.183	0.086	0.203	0.102
	16	0.314	0.191	0.393	0.307	0.190	**0.080**	0.398	0.321	0.392	0.271	0.238	0.130	0.802	0.981	0.875	1.154	**0.187**	0.089	0.205	0.104
	18	0.318	0.197	0.390	0.304	0.196	**0.086**	0.398	0.321	0.391	0.269	0.239	0.132	0.803	0.970	0.880	1.158	**0.186**	0.089	0.206	0.106
	20	0.321	0.202	0.387	0.299	0.202	0.093	0.396	0.320	0.395	0.276	0.240	0.133	0.798	0.976	0.878	1.153	**0.188**	**0.091**	0.207	0.107
	22	0.322	0.206	0.382	0.296	0.207	0.100	0.395	0.319	0.402	0.286	0.241	0.134	0.799	0.978	0.871	1.136	**0.189**	**0.093**	0.208	0.108
Weath.	6	0.145	0.070	0.201	0.116	0.126	**0.049**	0.154	0.080	0.166	0.071	0.198	0.103	0.418	0.314	0.981	1.876	0.103	0.071	0.096	0.062
	8	0.155	0.077	0.211	0.127	0.132	**0.053**	0.169	0.093	0.170	0.073	0.212	0.117	0.415	0.311	1.037	2.011	0.086	0.064	0.104	0.069
	10	0.169	0.086	0.226	0.146	0.140	**0.058**	0.185	0.107	0.179	0.079	0.228	0.132	0.431	0.355	0.906	1.675	**0.088**	0.067	0.113	0.075
	12	0.187	0.100	0.236	0.156	0.150	**0.064**	0.203	0.123	0.190	0.088	0.244	0.149	0.514	0.452	0.997	1.890	**0.094**	0.072	0.120	0.080
	14	0.206	0.117	0.253	0.179	0.162	**0.074**	0.220	0.141	0.203	0.099	0.260	0.166	0.432	0.341	1.005	1.901	**0.101**	0.076	0.127	0.085
	16	0.227	0.139	0.272	0.204	0.174	0.084	0.238	0.160	0.213	0.110	0.275	0.183	0.489	0.456	1.044	1.950	**0.103**	**0.079**	0.133	0.089
	18	0.250	0.167	0.292	0.233	0.188	0.097	0.256	0.179	0.227	0.124	0.291	0.200	0.515	0.461	0.990	1.772	**0.108**	**0.082**	0.139	0.094
	20	0.274	0.201	0.313	0.265	0.202	0.110	0.273	0.199	0.239	0.138	0.307	0.220	0.654	0.771	0.955	1.716	**0.116**	**0.086**	0.144	0.098
	22	0.285	0.220	0.327	0.284	0.217	0.125	0.290	0.219	0.256	0.156	0.322	0.239	0.593	0.600	1.026	1.885	**0.117**	**0.088**	0.149	0.101
Traff.	6	0.518	0.803	0.536	0.902	0.428	0.691	0.417	0.726	0.581	0.920	0.411	0.698	0.575	1.043	0.890	1.665	**0.214**	**0.283**	0.259	0.343
	8	0.522	0.811	0.544	0.925	0.428	0.697	0.423	0.738	0.585	0.925	0.415	0.704	0.590	1.018	1.006	2.023	**0.224**	**0.299**	0.262	0.352
	10	0.524	0.816	0.542	0.927	0.426	0.699	0.426	0.744	0.594	0.933	0.416	0.707	0.624	1.107	0.966	1.899	**0.224**	**0.302**	0.267	0.358
	12	0.530	0.825	0.543	0.930	0.428	0.705	0.428	0.748	0.599	0.936	0.419	0.711	0.620	1.094	0.948	1.888	**0.229**	**0.309**	0.266	0.362
	14	0.537	0.838	0.555	0.951	0.431	0.711	0.430	0.751	0.597	0.942	0.421	0.715	0.570	0.999	0.962	1.911	**0.228**	**0.310**	0.269	0.365
	16	0.541	0.850	0.565	0.967	0.434	0.716	0.432	0.754	0.597	0.951	0.423	0.718	0.672	1.245	0.960	1.880	**0.230**	**0.314**	0.270	0.368
	18	0.546	0.862	0.568	0.971	0.437	0.722	0.432	0.755	0.597	0.957	0.423	0.720	0.603	1.108	0.914	1.806	**0.231**	**0.317**	0.268	0.369
	20	0.550	0.874	0.568	0.971	0.439	0.727	0.433	0.757	0.596	0.960	0.424	0.721	0.612	1.100	0.980	1.980	**0.231**	**0.318**	0.269	0.370
	22	0.552	0.883	0.566	0.966	0.439	0.730	0.433	0.757	0.596	0.963	0.423	0.721	0.731	1.341	0.980	1.973	**0.235**	**0.322**	0.273	0.372
Ili	6	0.630	0.856	0.811	2.096	0.556	0.708	0.766	1.417	0.718	1.069	0.819	1.584	1.663	5.351	1.831	6.774	**0.528**	**0.693**	0.674	1.041
	8	0.695	1.086	0.955	2.732	**0.575**	**0.734**	0.843	1.693	0.739	1.128	0.883	1.878	1.750	5.582	1.789	6.622	0.686	1.144	0.768	1.316
	10	0.787	1.405	1.045	3.075	**0.602**	**0.783**	0.902	1.921	0.760	1.195	0.927	2.088	1.596	5.113	1.869	7.190	0.768	1.378	0.850	1.577
	12	0.980	2.420	1.003	2.822	**0.644**	**0.892**	0.944	2.090	0.795	1.328	0.960	2.248	1.905	6.382	1.908	7.491	0.752	1.376	0.956	1.859
	14	1.165	3.737	1.056	2.997	**0.699**	**1.065**	0.971	2.210	0.835	1.497	0.986	2.376	1.795	5.944	1.906	6.991	0.811	1.634	0.949	1.914
	16	1.203	3.865	1.097	3.137	**0.760**	**1.301**	0.991	2.306	0.873	1.682	1.008	2.487	1.898	7.011	2.010	8.112	0.803	1.707	0.931	1.933
	18	1.054	2.804	1.125	3.249	**0.800**	**1.469**	1.007	2.391	0.904	1.837	1.028	2.591	1.858	6.591	1.927	7.252	0.918	2.091	0.931	1.933
	20	1.104	3.033	1.147	3.346	**0.848**	1.700	1.023	2.478	0.929	1.958	1.047	2.692	2.001	7.443	2.039	8.040	0.855	**1.673**	1.023	2.197
	22	1.150	3.218	1.168	3.434	0.878	1.844	1.037	2.562	0.951	2.068	1.064	2.787	2.028	7.844	2.127	8.850	**0.764**	**1.351**	1.012	2.157

Table 10: Ablation for the 1st pipeline application with kernel size of 25 timestamps - bold: best results, underlined: second best results.

(a) MSE ablation

D	L	Ts2Vec TED4STL	Ts2Vec Trend	Ts2Vec Err	Ts2Vec Orig.	SimTS TED4STL	SimTS Trend	SimTS Err	SimTS Orig.
ETTh1	24	**0.342**	0.515	1.081	0.549	**0.274**	0.418	0.952	0.374
	48	**0.440**	0.574	1.118	0.598	**0.373**	0.486	0.970	0.424
	168	**0.668**	0.728	1.146	0.758	**0.615**	0.696	1.007	0.644
	336	**0.863**	0.898	1.119	0.899	**0.827**	0.892	1.015	0.844
	720	**1.044**	1.098	1.046	1.060	1.004	1.083	**0.947**	1.014
ETTh2	24	**0.202**	0.206	3.489	0.389	**0.243**	0.278	3.530	0.346
	48	**0.412**	0.407	3.476	0.562	**0.498**	0.529	3.523	0.586
	168	**1.655**	1.742	3.508	1.845	**1.626**	1.635	3.534	1.661
	336	**2.079**	2.213	3.471	2.291	**1.912**	1.918	3.506	1.932
	720	**2.389**	2.471	3.503	2.717	**2.115**	2.134	3.574	2.148
ETTm1	24	**0.200**	0.308	1.110	0.391	**0.138**	0.147	1.063	0.240
	48	**0.352**	0.479	1.120	0.498	**0.265**	0.270	1.072	0.319
	96	**0.441**	0.567	1.123	0.564	**0.344**	0.347	1.068	0.369
	288	**0.570**	0.654	1.121	0.633	**0.452**	0.456	1.069	0.464
	672	**0.700**	0.763	1.113	0.731	**0.610**	0.616	1.087	0.617
ETTm2	24	**0.097**	0.105	3.433	0.155	**0.078**	0.079	3.499	0.113
	48	**0.162**	0.181	3.431	0.219	**0.139**	0.141	3.501	0.168
	96	**0.287**	0.312	3.429	0.325	**0.249**	0.250	3.502	0.272
	288	**0.681**	0.673	3.434	0.690	**0.695**	0.703	3.498	0.713
	672	**1.796**	1.984	3.443	1.831	**1.651**	1.647	3.498	1.658
Exch.	24	**0.076**	0.072	5.092	0.099	**0.062**	0.067	5.0905	0.086
	48	**0.171**	0.159	5.093	0.184	**0.169**	0.172	5.0882	0.192
	96	0.429	0.442	5.069	**0.390**	**0.417**	0.421	5.0648	0.439
	288	1.449	1.321	5.025	**1.352**	**1.298**	1.309	5.0447	1.312
	672	**1.970**	2.149	5.174	3.501	**1.873**	1.897	5.1729	1.889
WTH	24	**0.241**	0.262	0.701	0.310	0.229	**0.219**	0.751	0.294
	48	**0.320**	0.334	0.712	0.377	0.309	**0.305**	0.761	0.356
	168	**0.458**	0.477	0.742	0.499	0.451	**0.449**	0.774	0.465
	336	**0.500**	0.511	0.747	0.535	0.492	**0.490**	0.774	0.500
	720	**0.536**	0.543	0.746	0.571	**0.530**	**0.530**	0.771	0.537
Electr.	24	**0.202**	0.387	0.454	0.285	**0.103**	0.486	0.423	0.139
	48	**0.237**	0.419	0.463	0.307	**0.135**	0.508	0.430	0.154
	168	**0.281**	0.456	0.472	0.331	**0.172**	0.523	0.427	0.176
	336	**0.302**	0.474	0.473	0.348	**0.194**	0.532	0.421	0.195
	720	**0.334**	0.498	0.474	0.375	**0.231**	0.530	0.414	0.233
Weath.	24	0.259	**0.196**	4.368	0.316	0.141	**0.128**	4.129	0.241
	48	0.792	**0.588**	4.355	0.808	0.444	**0.421**	4.139	0.526
	96	1.518	**1.043**	4.422	1.297	0.998	**0.920**	4.108	0.957
	288	1.842	1.628	4.368	**1.608**	1.910	**1.292**	4.076	1.296
	672	2.772	2.532	4.557	**2.424**	2.417	**1.752**	4.115	1.749
Traff.	24	0.883	1.052	**0.870**	0.914	**0.731**	1.328	0.754	0.756
	48	**0.920**	1.069	0.915	0.958	**0.765**	1.337	0.784	0.793
	96	**0.969**	1.080	0.974	1.017	**0.790**	1.347	0.802	0.809
	288	0.994	1.091	**0.990**	1.036	**0.803**	1.365	0.809	0.815
	672	1.009	1.107	**1.001**	1.073	**0.817**	1.420	0.821	0.827
Ili	24	**2.919**	8.167	4.816	3.625	**1.975**	2.048	5.118	2.640
	36	**3.506**	4.207	5.033	3.821	2.422	**2.394**	5.246	2.905
	48	**4.027**	4.317	5.302	4.058	2.809	**2.712**	5.439	3.183
	60	**4.016**	4.248	5.471	4.319	3.335	**3.089**	5.617	3.572

(b) MAE ablation

D	L	Ts2Vec TED4STL	Ts2Vec Trend	Ts2Vec Err	Ts2Vec Orig.	SimTS TED4STL	SimTS Trend	SimTS Err	SimTS Orig.
ETTh1	24	**0.400**	0.477	0.810	0.509	**0.352**	0.439	0.794	0.418
	48	**0.461**	0.512	0.820	0.543	**0.417**	0.481	0.798	0.452
	168	**0.593**	0.605	0.828	0.638	**0.565**	0.608	0.804	0.581
	336	**0.698**	0.701	0.821	0.713	**0.681**	0.715	0.800	0.690
	720	**0.794**	0.799	0.783	0.795	0.781	0.818	**0.762**	0.786
ETTh2	24	**0.316**	0.326	1.440	0.459	**0.353**	0.382	1.445	0.441
	48	**0.469**	0.469	1.435	0.572	**0.526**	0.547	1.444	0.586
	168	**0.994**	1.009	1.441	1.060	**0.985**	0.993	1.449	1.002
	336	**1.148**	1.180	1.432	1.210	**1.087**	1.095	1.444	1.098
	720	**1.293**	1.299	1.445	1.396	**1.168**	1.183	1.465	1.185
ETTm1	24	**0.289**	0.363	0.831	0.407	**0.238**	0.248	0.819	0.322
	48	**0.389**	0.465	0.833	0.472	**0.334**	0.340	0.819	0.377
	96	**0.448**	0.529	0.832	0.518	**0.391**	0.396	0.817	0.413
	288	**0.532**	0.579	0.828	0.569	**0.470**	0.475	0.815	0.480
	672	**0.611**	0.639	0.820	0.628	**0.566**	0.571	0.818	0.572
ETTm2	24	**0.213**	0.227	1.426	0.273	0.195	**0.194**	1.432	0.234
	48	**0.277**	0.300	1.425	0.332	**0.265**	0.267	1.432	0.295
	96	**0.372**	0.396	1.425	0.409	**0.363**	0.365	1.433	0.383
	288	**0.617**	0.620	1.425	0.629	**0.634**	0.638	1.433	0.645
	672	**1.020**	1.077	1.427	1.030	**0.992**	0.996	1.435	0.999
Exch.	24	**0.206**	0.200	1.834	0.235	**0.177**	0.184	1.8334	0.214
	48	**0.314**	0.303	1.833	0.319	**0.296**	0.298	1.8339	0.319
	96	0.522	0.497	1.831	**0.463**	**0.475**	0.478	1.8279	0.491
	288	0.967	0.880	1.818	**0.887**	**0.907**	0.911	1.819	0.914
	672	**1.094**	1.104	1.855	1.362	**1.094**	1.102	1.8546	1.100
WTH	24	**0.306**	0.329	0.643	0.365	0.301	**0.292**	0.670	0.356
	48	**0.374**	0.391	0.650	0.419	0.370	**0.365**	0.674	0.408
	168	**0.481**	0.496	0.665	0.509	**0.479**	**0.479**	0.680	0.492
	336	**0.513**	0.523	0.667	0.535	0.511	**0.510**	0.679	0.518
	720	**0.539**	0.547	0.668	0.559	**0.538**	**0.538**	0.678	0.544
Electr.	24	**0.317**	0.472	0.488	0.373	**0.210**	0.524	0.463	0.243
	48	**0.343**	0.488	0.494	0.389	**0.240**	0.535	0.466	0.258
	168	**0.375**	0.508	0.499	0.407	**0.273**	0.544	0.465	0.276
	336	**0.392**	0.518	0.501	0.420	**0.296**	0.549	0.462	**0.296**
	720	**0.414**	0.530	0.504	0.439	**0.329**	0.549	0.458	**0.329**
Weath.	24	0.310	**0.271**	1.659	0.349	0.232	**0.212**	1.642	0.306
	48	0.565	**0.487**	1.646	0.584	0.436	**0.414**	1.644	0.484
	96	0.842	**0.709**	1.661	0.788	0.691	**0.665**	1.635	0.695
	288	0.991	0.955	1.652	**0.939**	1.032	**0.854**	1.628	0.859
	672	1.279	1.246	1.690	**1.220**	1.221	**1.032**	1.639	1.033
Traff.	24	0.550	0.589	**0.523**	0.541	0.438	0.740	0.449	**0.431**
	48	**0.530**	0.586	0.539	0.556	0.453	0.738	0.461	**0.451**
	96	**0.550**	0.585	0.559	0.564	**0.464**	0.742	0.466	0.475
	288	0.564	0.589	**0.562**	0.571	**0.464**	0.746	0.464	0.472
	672	0.568	0.594	**0.566**	0.600	**0.467**	0.778	0.466	0.474
Ili	24	**1.104**	2.015	1.579	1.209	**0.904**	0.934	1.632	1.048
	36	**1.251**	1.356	1.594	1.272	**0.981**	0.984	1.635	1.075
	48	**1.335**	1.371	1.627	1.324	1.055	**1.040**	1.660	1.124
	60	**1.318**	1.369	1.650	1.374	1.150	**1.115**	1.690	1.204

Table 11: Ablation for the 2st pipeline application with kernel size of 25 timestamps - bold: best results, underlined: second best results.

(a) MSE ablation

D	L	CoST				MaskAE			
		TED4STL	Trend	Err	Orig.	TED4STL	Trend	Err	Orig.
ETTh1	24	0.392	0.427	0.414	**0.383**	**1.047**	1.245	1.281	1.484
	48	0.466	0.491	0.489	**0.434**	**1.166**	1.237	1.243	1.544
	168	0.668	0.677	0.676	**0.633**	**1.144**	1.245	1.266	1.320
	336	0.854	0.853	0.829	**0.792**	**1.165**	1.293	1.296	1.289
	720	1.029	1.041	0.996	**0.904**	**1.158**	1.385	1.271	1.370
ETTh2	24	0.320	0.319	**0.312**	0.453	**2.385**	2.418	3.292	2.994
	48	0.606	0.605	**0.585**	0.699	**2.091**	2.372	3.262	2.820
	168	1.701	1.701	1.638	**1.538**	**2.598**	2.636	3.364	3.141
	336	1.935	1.935	1.883	**1.743**	2.932	**2.356**	3.395	2.741
	720	2.098	2.098	2.081	**1.955**	**2.875**	2.705	3.432	3.302
ETTm1	24	**0.154**	0.157	0.156	0.246	**0.424**	0.249	1.249	2.028
	48	**0.277**	0.280	0.279	0.330	**0.650**	0.521	1.272	1.840
	96	**0.353**	0.354	0.354	0.377	**0.779**	0.673	1.275	1.692
	288	**0.463**	0.463	0.464	0.471	**0.971**	0.978	1.257	1.683
	672	0.622	0.623	**0.620**	0.622	**1.073**	1.229	1.259	1.706
ETTm2	24	**0.099**	**0.099**	**0.099**	0.134	**0.388**	0.176	3.335	2.576
	48	**0.163**	**0.163**	0.164	0.196	**1.025**	0.691	3.026	2.499
	96	**0.274**	**0.274**	**0.274**	0.305	**1.140**	1.344	3.346	2.600
	288	0.737	0.736	**0.731**	0.754	**1.157**	1.418	3.232	2.685
	672	1.663	1.663	1.683	**1.589**	**2.484**	2.844	3.192	2.955
Exch.	24	**0.111**	**0.111**	0.129	0.133	2.273	2.215	4.096	**2.029**
	48	**0.226**	**0.226**	0.254	0.250	2.445	2.363	4.146	**2.223**
	96	**0.489**	**0.489**	0.512	0.505	2.452	2.425	4.155	**2.227**
	288	1.315	1.315	1.349	**1.278**	2.743	2.419	4.268	**2.250**
	672	2.020	2.020	2.015	**1.942**	3.185	3.065	4.138	**2.305**
WTH	24	0.232	0.233	**0.228**	0.299	**0.277**	0.264	0.462	1.612
	48	**0.315**	0.316	**0.314**	0.360	**0.364**	0.366	0.581	1.719
	168	**0.452**	**0.452**	**0.452**	0.465	**0.604**	0.639	0.564	1.462
	336	0.491	0.491	**0.490**	0.498	**0.587**	0.619	0.594	1.529
	720	**0.530**	**0.530**	0.530	0.533	**0.560**	0.582	0.549	1.503
Electr.	24	0.296	0.296	0.253	**0.135**	**0.981**	0.994	0.985	1.143
	48	0.320	0.319	0.277	**0.152**	**0.978**	0.982	0.988	1.136
	168	0.355	0.355	0.314	**0.175**	**0.979**	0.989	0.996	1.130
	336	0.378	0.375	0.334	**0.195**	**0.973**	0.993	0.989	1.124
	720	0.407	0.404	0.367	**0.231**	**0.971**	0.990	0.991	1.106
Weath.	24	**0.176**	**0.176**	0.175	0.258	0.695	**0.200**	1.942	2.015
	48	**0.432**	**0.432**	0.447	0.496	0.779	**0.577**	1.977	2.000
	96	0.827	0.827	0.860	**0.787**	1.788	**1.364**	1.536	2.053
	288	1.437	1.437	1.740	**1.082**	1.564	**1.120**	1.451	1.919
	672	2.134	2.134	2.505	**1.535**	1.502	1.262	**1.175**	1.785
Traff.	24	0.910	0.966	0.924	**0.721**	1.429	**1.209**	1.293	1.816
	48	0.938	0.989	0.958	**0.745**	1.481	**1.083**	1.210	1.752
	96	0.967	1.018	0.992	**0.755**	1.503	**1.324**	1.385	1.796
	288	0.986	1.043	1.008	**0.764**	1.522	1.548	**1.235**	1.604
	672	0.990	1.068	1.044	**0.777**	1.533	1.524	**1.481**	1.692
Ili	24	**2.166**	2.190	2.263	2.872	**8.345**	9.406	7.626	8.860
	36	**2.608**	2.673	2.735	3.155	**8.902**	9.451	8.432	9.049
	48	**2.984**	3.047	3.090	3.439	**8.353**	10.546	8.191	8.757
	60	**3.356**	3.380	3.478	3.831	**8.254**	9.399	8.252	9.195

(b) MAE ablation

D	L	CoST				MaskAE			
		TED4STL	Trend	Err	Orig.	TED4STL	Trend	Err	Orig.
ETTh1	24	**0.426**	0.447	0.441	0.427	**0.783**	0.852	0.877	0.958
	48	0.475	0.491	0.489	**0.463**	**0.851**	0.894	0.862	0.997
	168	0.599	0.605	0.607	**0.578**	**0.825**	0.897	0.872	0.913
	336	0.700	0.700	0.694	**0.670**	**0.844**	0.915	0.882	0.895
	720	0.797	0.803	0.786	**0.748**	**0.836**	0.974	0.869	0.934
ETTh2	24	**0.414**	0.415	0.415	0.507	**1.245**	1.285	1.369	1.339
	48	0.582	0.582	**0.577**	0.640	**1.152**	1.271	1.373	1.311
	168	1.028	1.028	0.998	**0.983**	**1.265**	1.322	1.391	1.406
	336	1.116	1.116	1.087	**1.050**	1.402	**1.210**	1.398	1.317
	720	1.173	1.173	1.147	**1.089**	**1.290**	1.291	1.406	1.436
ETTm1	24	**0.258**	0.263	0.262	0.329	**0.468**	0.347	0.848	1.106
	48	**0.346**	0.350	0.349	0.386	**0.563**	0.507	0.862	1.074
	96	**0.401**	0.403	0.403	0.419	**0.631**	0.601	0.868	1.002
	288	**0.480**	0.480	0.481	0.485	**0.738**	0.748	0.868	1.000
	672	0.575	0.576	0.576	**0.574**	**0.769**	0.880	0.864	1.041
ETTm2	24	**0.225**	**0.225**	0.225	0.259	**0.494**	0.317	1.386	1.160
	48	**0.290**	**0.290**	0.292	0.320	**0.801**	0.657	1.322	1.201
	96	**0.380**	**0.380**	0.382	0.405	**0.862**	0.968	1.401	1.261
	288	**0.647**	**0.647**	**0.647**	0.661	**0.869**	1.005	1.366	1.287
	672	1.003	1.003	1.010	**0.982**	**1.258**	1.362	1.352	1.346
Exch.	24	**0.252**	**0.252**	0.271	0.277	1.174	1.149	1.606	**1.151**
	48	**0.362**	**0.362**	0.385	0.383	1.189	1.169	1.607	**1.187**
	96	**0.541**	**0.541**	0.554	0.548	1.226	1.184	1.616	**1.190**
	288	0.903	0.903	0.919	**0.883**	1.298	1.205	1.648	**1.193**
	672	1.104	1.104	1.098	**1.075**	1.382	1.344	1.610	**1.171**
WTH	24	0.305	0.306	**0.303**	0.361	**0.355**	0.334	0.492	1.151
	48	**0.375**	0.376	**0.375**	0.412	**0.425**	0.419	0.571	1.187
	168	**0.482**	**0.482**	**0.482**	0.492	**0.584**	0.605	0.559	1.190
	336	**0.512**	**0.512**	**0.512**	0.518	**0.574**	0.597	0.571	1.193
	720	**0.539**	**0.539**	**0.539**	0.542	**0.562**	0.574	0.552	1.171
Electr.	24	0.409	0.409	0.370	**0.241**	**0.802**	0.810	0.803	0.873
	48	0.423	0.423	0.387	**0.257**	**0.797**	0.806	0.805	0.869
	168	0.444	0.444	0.411	**0.275**	**0.799**	0.810	0.810	0.866
	336	0.459	0.457	0.425	**0.296**	**0.798**	0.812	0.810	0.865
	720	0.476	0.475	0.446	**0.328**	**0.802**	0.808	0.809	0.860
Weath.	24	**0.273**	**0.273**	0.275	0.337	0.630	**0.287**	1.066	1.048
	48	**0.442**	**0.442**	0.452	0.488	0.664	**0.546**	1.138	1.075
	96	0.645	0.645	0.658	**0.642**	1.028	**0.863**	0.992	1.114
	288	0.895	0.895	0.989	**0.794**	1.008	**0.806**	0.965	1.102
	672	1.145	1.145	1.248	**0.977**	0.993	0.896	**0.862**	1.057
Traff.	24	0.559	0.595	0.566	**0.423**	0.788	**0.649**	0.693	0.923
	48	0.567	0.599	0.577	**0.437**	0.810	**0.585**	0.658	0.899
	96	0.574	0.604	0.589	**0.438**	0.816	**0.711**	0.738	0.913
	288	0.577	0.610	0.590	**0.434**	0.822	0.816	**0.656**	0.837
	672	0.577	0.622	0.606	**0.435**	0.819	0.796	**0.778**	0.868
Ili	24	**0.961**	0.974	0.978	1.077	**2.082**	2.193	1.989	2.160
	36	**1.030**	1.048	1.057	1.122	**2.128**	2.201	2.069	2.163
	48	**1.094**	1.110	1.123	1.178	**2.069**	2.404	2.050	2.125
	60	**1.169**	1.179	1.202	1.261	**2.053**	2.217	2.050	2.175