Published as a conference paper at ICLR 2024

TIMEMIXER: DECOMPOSABLE MULTISCALE MIXING FOR TIME SERIES FORECASTING

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Codes and pre-trained models are
open-sourced in OpenReview

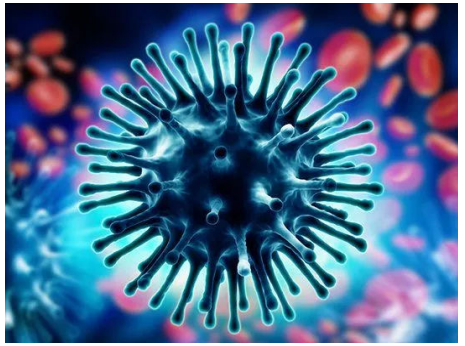
Time Series In Real World

Energy Consumption

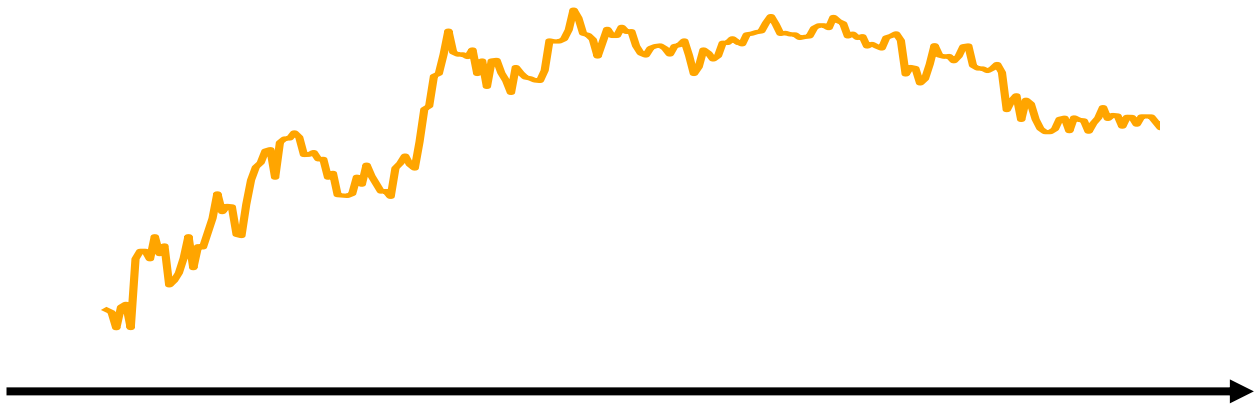
Traffic Flow

Economic Changes

Weather Variations



Disease Propagation



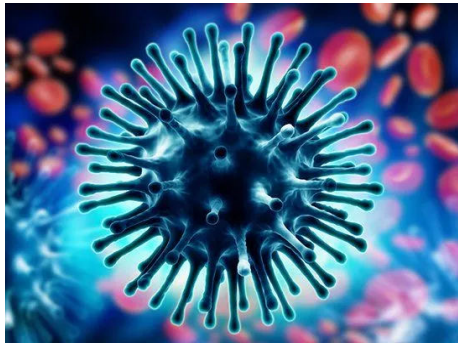
Time Series Forecasting

Energy Consumption

Traffic Flow

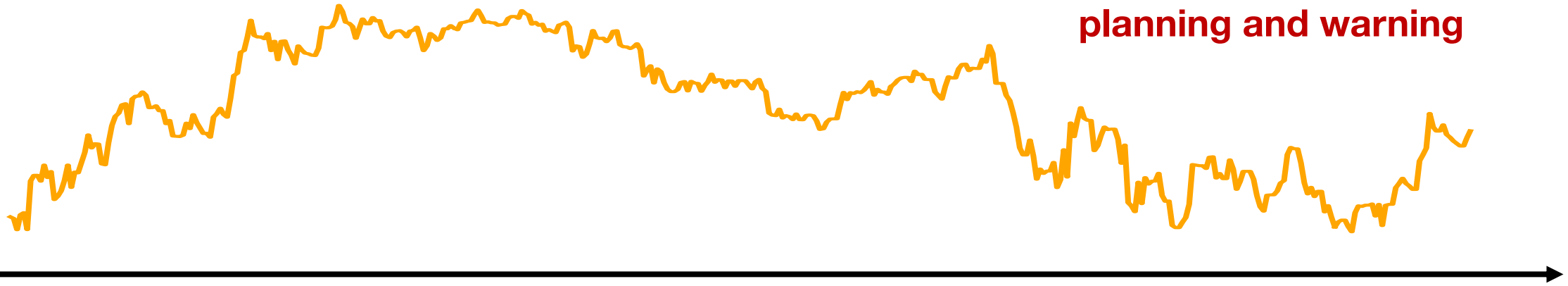
Economic Changes

Weather Variations



Disease Propagation

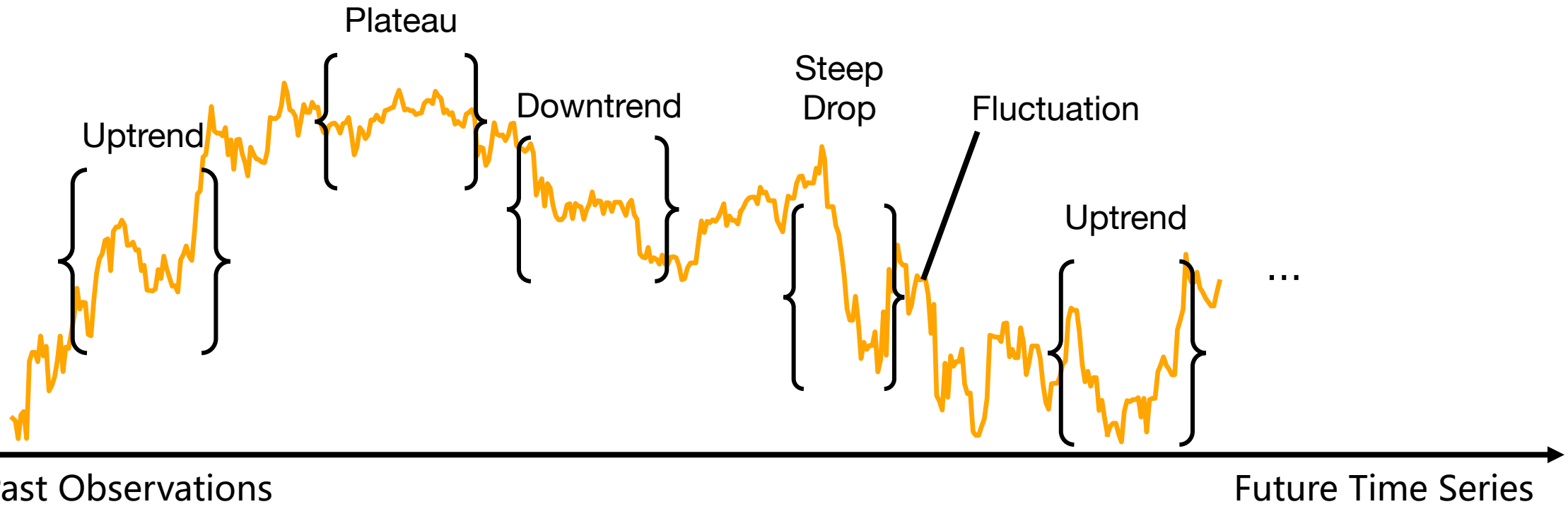
Predict the future for planning and warning



Intricate Temporal Variations

How to tackle intricate temporal variations?

- Decomposition: Autoformer (NeurIPS 2021)
- Multiperiodicity: TimesNet (ICLR 2023)

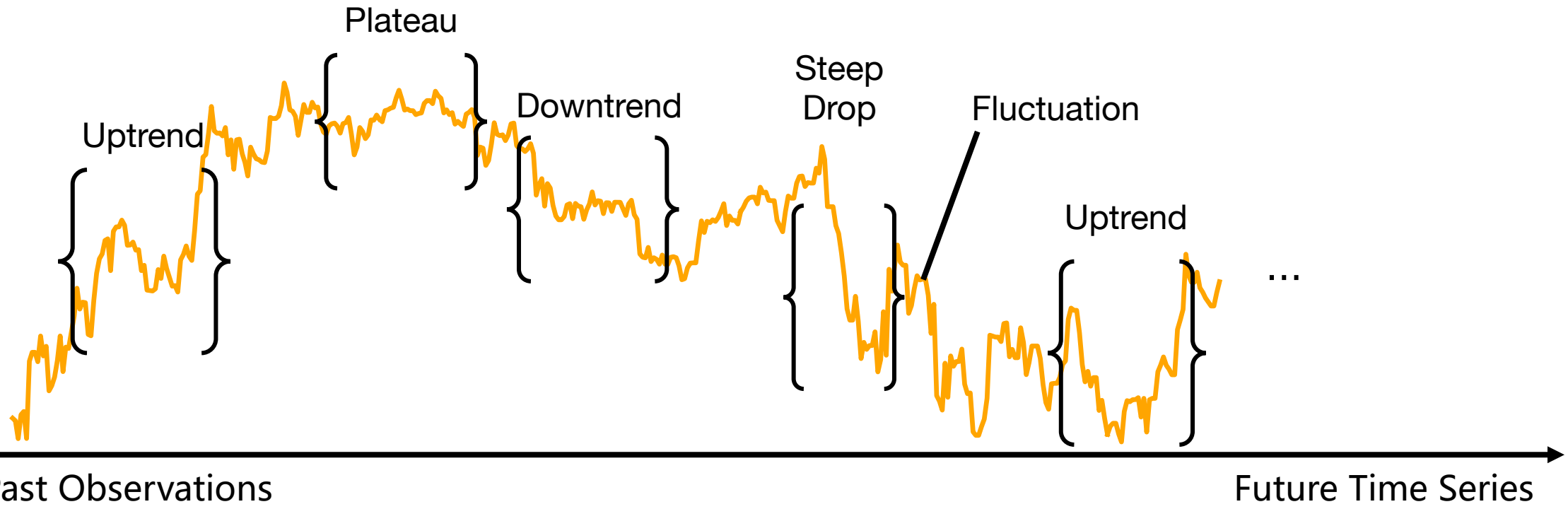


Intricate Temporal Variations

How to tackle intricate temporal variations?

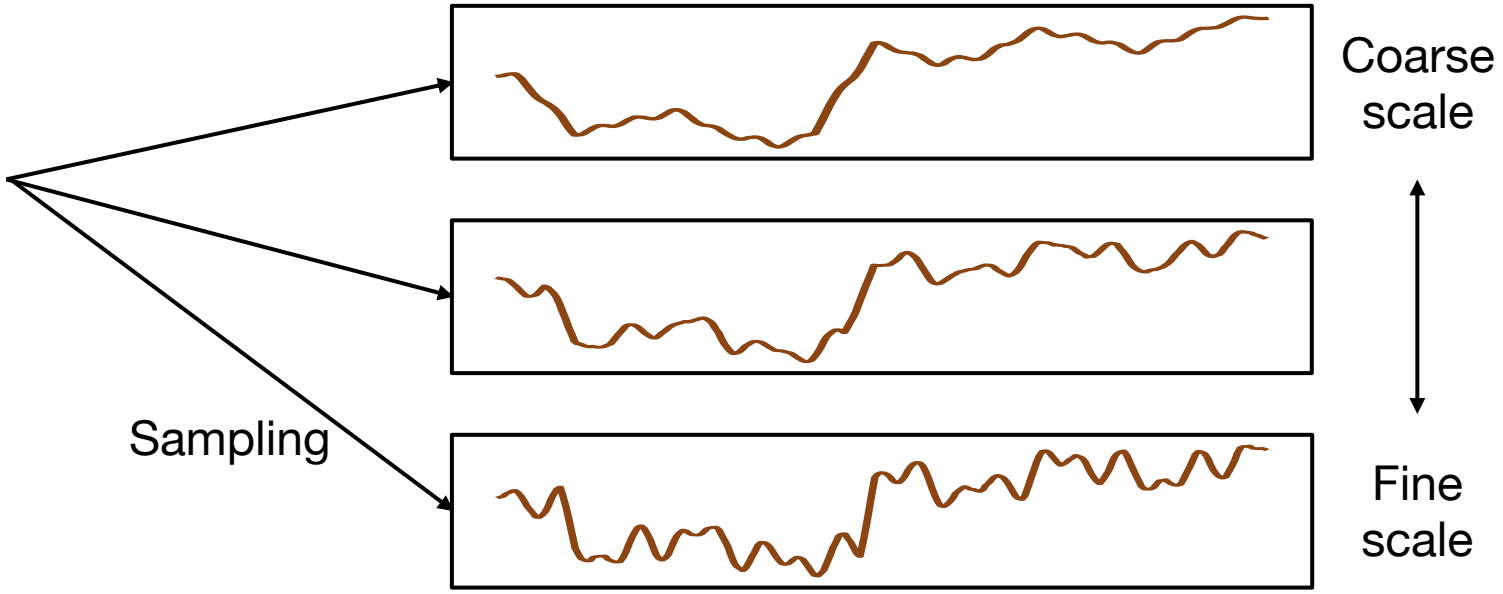
- Decomposition: Autoformer (NeurIPS 2021)
- Multiperiodicity: TimesNet (ICLR 2023)

⇨ **Multiscale Analysis (Our paper)**



Multiscale Property of Time Series

- ✓ Traffic: daily and weekly
- ✓ Weather: daily and yearly

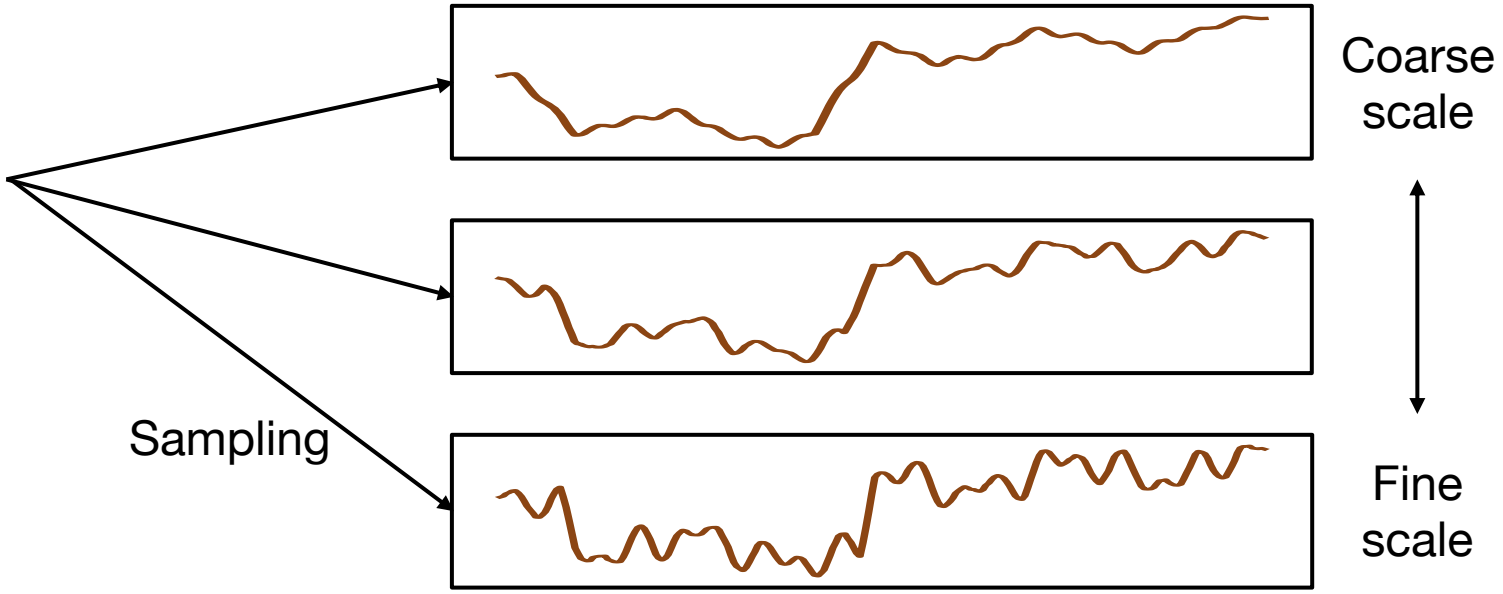


Fine Variations: microscopic information

Coarse Variations: macroscopic information

Multiscale Property of Time Series

- ✓ Traffic: daily and weekly
- ✓ Weather: daily and yearly



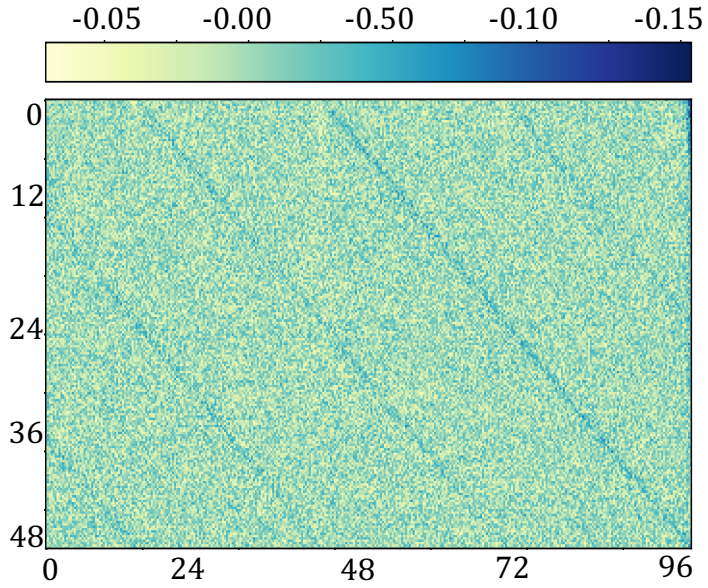
Fine Variations: microscopic information

Coarse Variations: macroscopic information

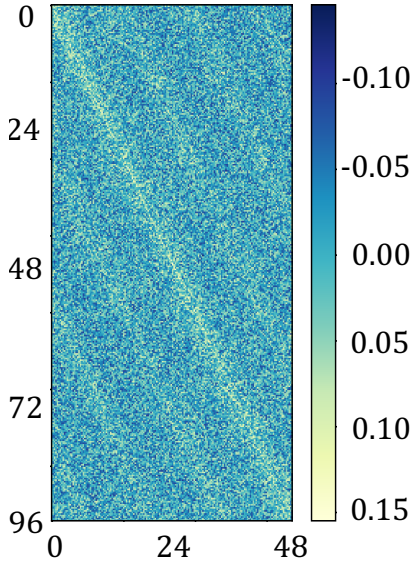
How to utilize these disentangled multiscale variations for forecasting?

Observation 1: History Extraction

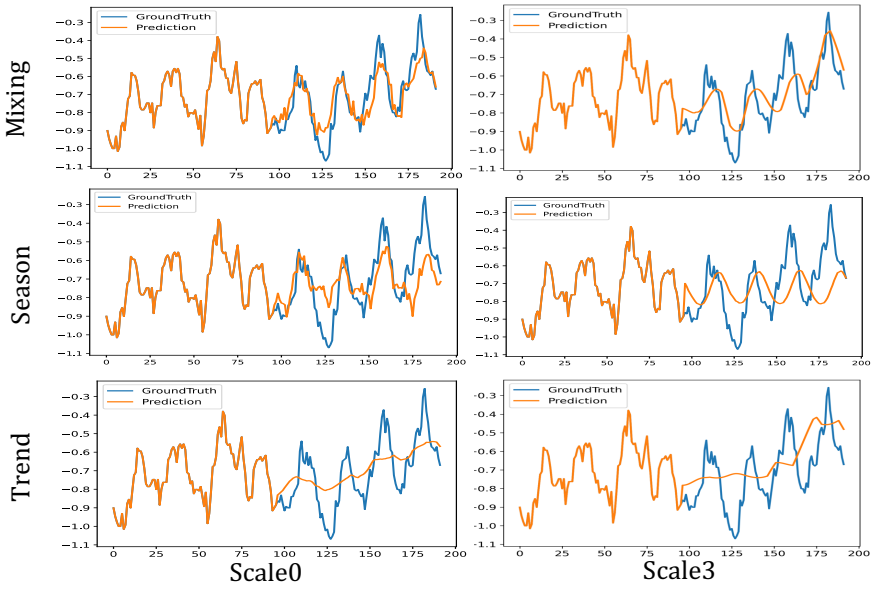
- **Seasonal and trend parts present different mixing properties.**
- **Fine-scale seasonal and coarse-scale trend are essential.**



(a) Seasonal Mixing Weights
(bottom-up: from 96 to 48)



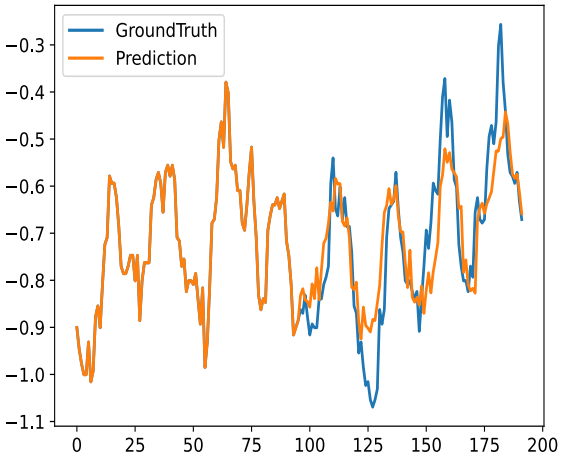
(b) Trend Mixing Weights
(top-down: from 48 to 96)



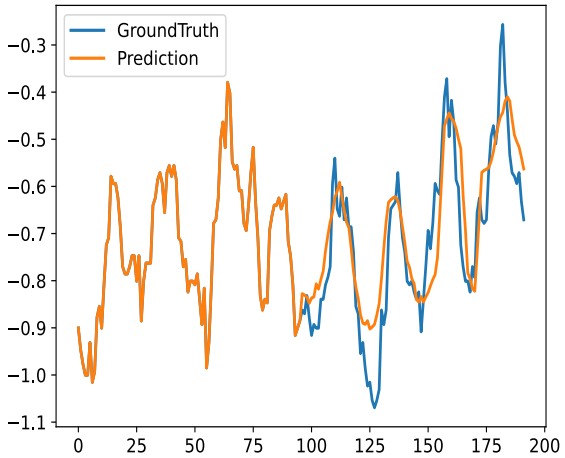
(c) Multiscale Season-trend Predictions
(input-96-predict-96)

Observation 2: Future Prediction

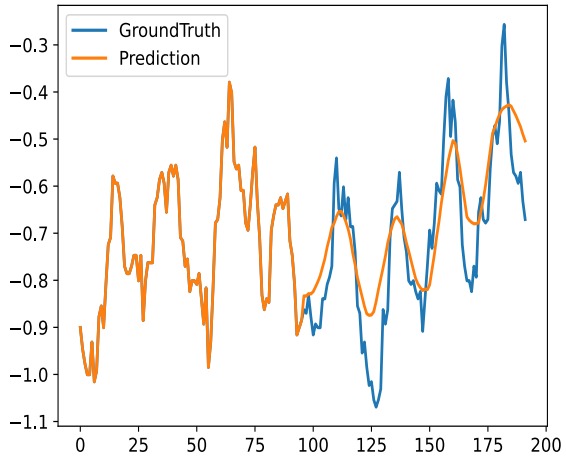
- **Future variation is jointly determined by multiscale past series.**
- **Different scale present complementary forecasting capabilities.**



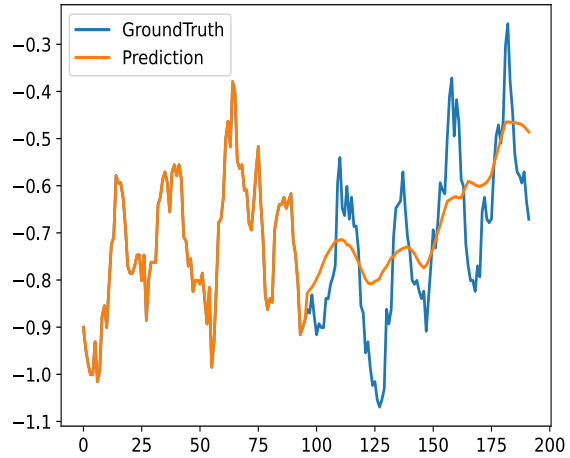
(b) Scale 0



(c) Scale 1

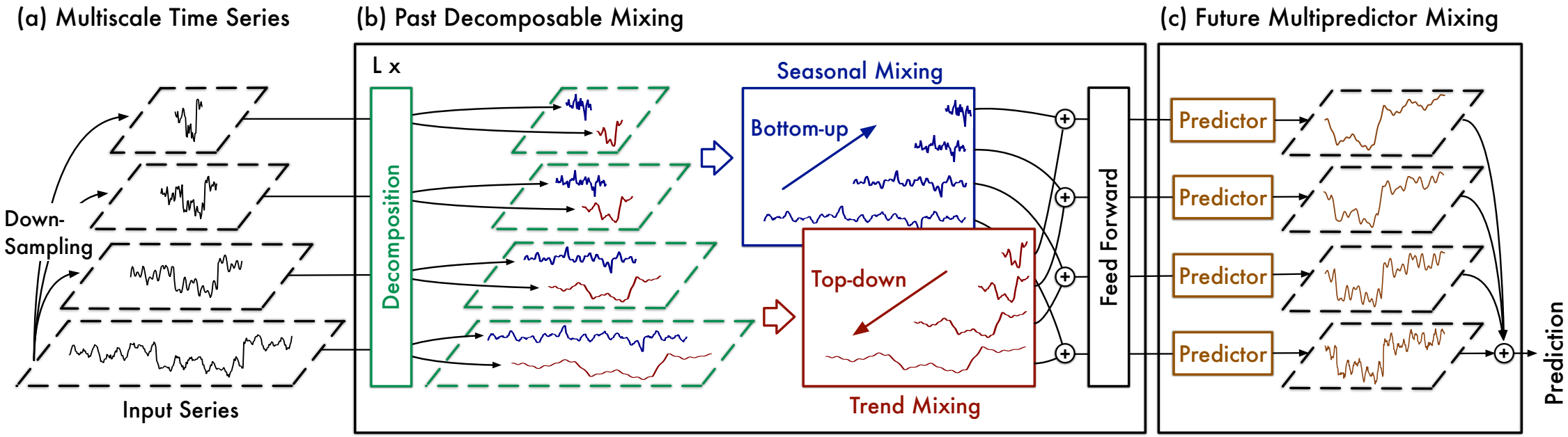


(d) Scale 2



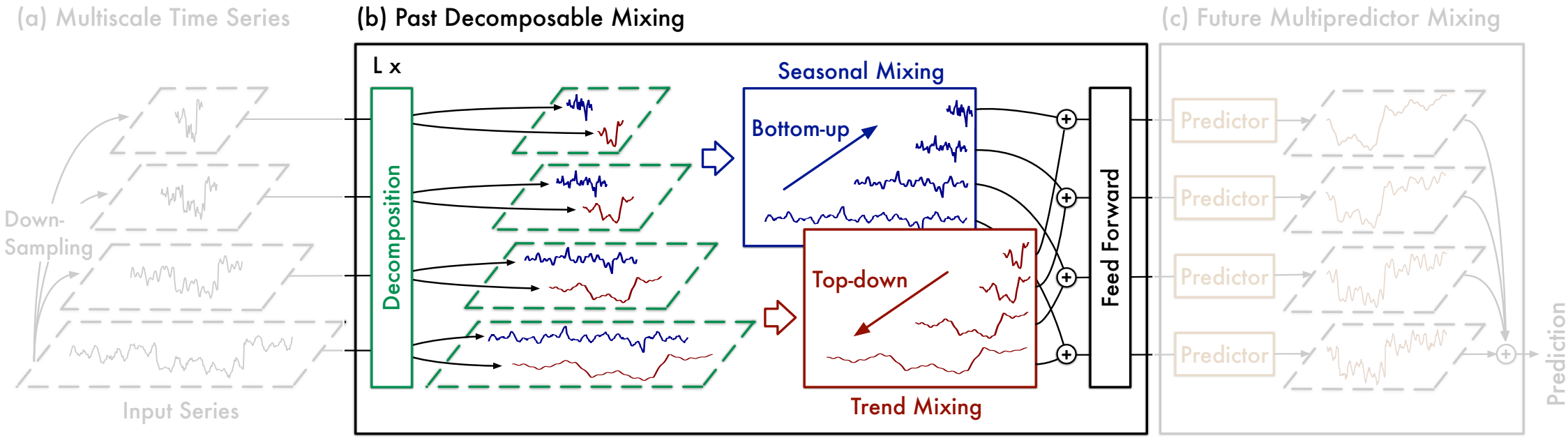
(e) Scale 3

Overall design of TimeMixer



- Past Decomposable Mixing for history extraction
- Future Multipredictor Mixing for future prediction

Past Decomposable Mixing



$$\mathbf{s}_m^l, \mathbf{t}_m^l = \text{SeriesDecomp}(\mathbf{x}_m^l), m \in \{0, \cdots, M\},$$

$$\mathcal{X}^l = \mathcal{X}^{l-1} + \text{FeedForward}\left(\text{S-Mix}\left(\{\mathbf{s}_m^l\}_{m=0}^M\right) + \text{T-Mix}\left(\{\mathbf{t}_m^l\}_{m=0}^M\right)\right)$$

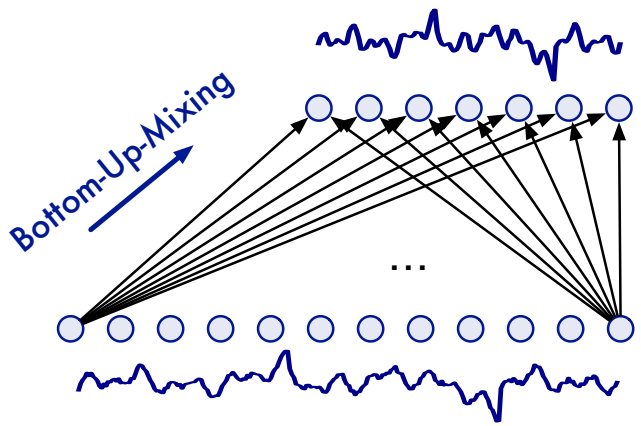
Past Decomposable Mixing

$$\mathbf{s}_m^l, \mathbf{t}_m^l = \text{SeriesDecomp}(\mathbf{x}_m^l), m \in \{0, \cdots, M\},$$

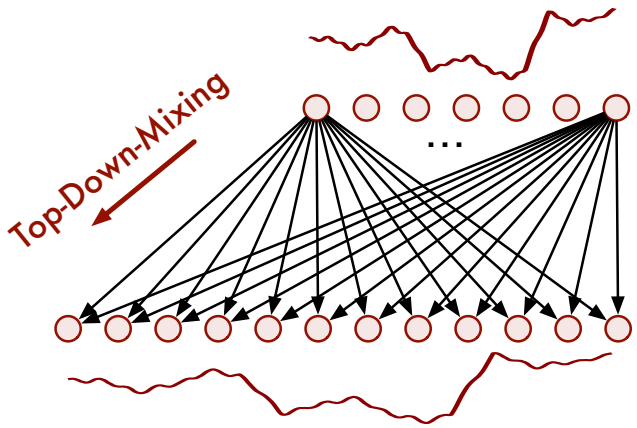
$$\mathcal{X}^l = \mathcal{X}^{l-1} + \text{FeedForward}\left(\text{S-Mix}\left(\{\mathbf{s}_m^l\}_{m=0}^M\right) + \text{T-Mix}\left(\{\mathbf{t}_m^l\}_{m=0}^M\right)\right)$$

for m: $1 \to M$ do: $\mathbf{s}_m^l = \mathbf{s}_m^l + \text{Bottom-Up-Mixing}(\mathbf{s}_{m-1}^l)$.

for m: $(M-1) \to 0$ do: $\mathbf{t}_m^l = \mathbf{t}_m^l + \text{Top-Down-Mixing}(\mathbf{t}_{m+1}^l)$

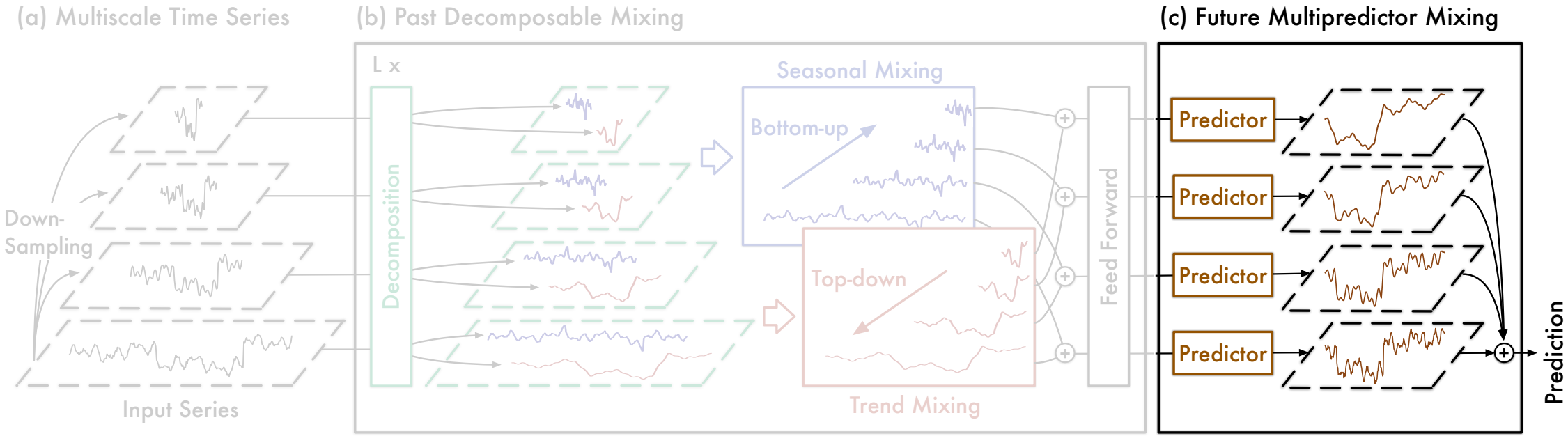


(a) Seasonal Mixing



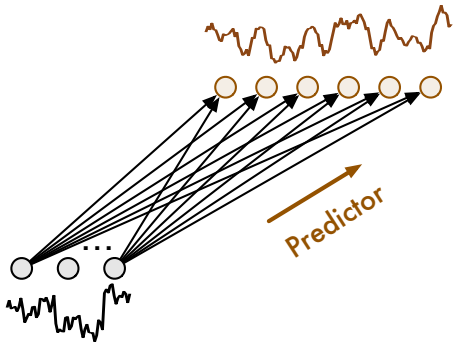
(b) Trend Mixing

Future Multipredictor Mixing



$$\widehat{\mathbf{x}}_m = \text{Predictor}_m(\mathbf{x}_m^L),\ m \in \{0, \cdots, M\},$$

$$\widehat{\mathbf{x}} = \sum_{m=0}^{M} \widehat{\mathbf{x}}_m$$



Experiment: Overall

Tasks	Dataset	Variate	Predict Length	Frequency	Forecastability	Information
Long-term forecasting	ETT (4 subsets)	7	96∼720	15 mins	0.46	Temperature
	Weather	21	96∼720	10 mins	0.75	Weather
	Solar-Energy	137	96∼720	10min	0.33	Electricity
	Electricity	321	96∼720	Hourly	0.77	Electricity
	Traffic	862	96∼720	Hourly	0.68	Transportation
Short-term forecasting	PEMS (4 subsets)	170∼883	12	5min	0.55	Traffic network
	M4 (6 subsets)	1	6∼48	Hourly∼Yearly	0.47	Database

- ✓ 8 well-established benchmarks, 15+ baselines
- ✓ **Two Experiment Settings**: Unified & searched hyperparameter

TimeMixer achieves consistent state-of-the-art in all benchmark and two settings

Long-term Forecasting

Unified Hyperparameter

TimeMixer > TimesNet > PatchTST

Models		**TimeMixer (Ours)**		PatchTST 2023		TimesNet 2023a		Crossformer 2023		MICN 2023		FiLM 2022a		DLinear 2023		FEDformer 2022b		Stationary 2022b		Autoformer 2021		Informer 2021	
Metric		MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
Weather	96	**0.163**	**0.209**	0.186	0.227	0.172	0.220	0.195	0.271	0.198	0.261	0.195	0.236	0.195	0.252	0.217	0.296	0.173	0.223	0.266	0.336	0.300	0.384
	192	**0.208**	**0.250**	0.234	0.265	0.219	0.261	0.209	0.277	0.239	0.299	0.239	0.271	0.237	0.295	0.276	0.336	0.245	0.285	0.307	0.367	0.598	0.544
	336	0.251	**0.287**	0.284	0.301	**0.246**	0.337	0.273	0.332	0.285	0.336	0.289	0.306	0.282	0.331	0.339	0.380	0.321	0.338	0.359	0.395	0.578	0.523
	720	**0.339**	**0.341**	0.356	0.349	0.365	0.359	0.379	0.401	0.351	0.388	0.361	0.351	0.345	0.382	0.403	0.428	0.414	0.410	0.419	0.428	1.059	0.741
	Avg	**0.240**	**0.271**	0.265	0.285	0.251	0.294	0.264	0.320	0.268	0.321	0.271	0.291	0.265	0.315	0.309	0.360	0.288	0.314	0.338	0.382	0.634	0.548
Solar-Energy	96	**0.189**	**0.259**	0.265	0.323	0.373	0.358	0.232	0.302	0.257	0.325	0.333	0.350	0.290	0.378	0.286	0.341	0.321	0.380	0.456	0.446	0.287	0.323
	192	**0.222**	**0.283**	0.288	0.332	0.397	0.376	0.371	0.410	0.278	0.354	0.371	0.372	0.320	0.398	0.291	0.337	0.346	0.369	0.588	0.561	0.297	0.341
	336	**0.231**	**0.292**	0.301	0.339	0.420	0.380	0.495	0.515	0.298	0.375	0.408	0.385	0.353	0.415	0.354	0.416	0.357	0.387	0.595	0.588	0.367	0.429
	720	**0.223**	**0.285**	0.295	0.336	0.420	0.381	0.526	0.542	0.299	0.379	0.406	0.377	0.357	0.413	0.380	0.437	0.375	0.424	0.733	0.633	0.374	0.431
	Avg	**0.216**	**0.280**	0.287	0.333	0.403	0.374	0.406	0.442	0.283	0.358	0.380	0.371	0.330	0.401	0.328	0.383	0.350	0.390	0.586	0.557	0.331	0.381
Electricity	96	**0.153**	**0.247**	0.190	0.296	0.168	0.272	0.219	0.314	0.180	0.293	0.198	0.274	0.210	0.302	0.193	0.308	0.169	0.273	0.201	0.317	0.274	0.368
	192	**0.166**	**0.256**	0.199	0.304	0.184	0.322	0.231	0.322	0.189	0.302	0.198	0.278	0.210	0.305	0.201	0.315	0.182	0.286	0.222	0.334	0.296	0.386
	336	**0.185**	**0.277**	0.217	0.319	0.198	0.300	0.246	0.337	0.198	0.312	0.217	0.300	0.223	0.319	0.214	0.329	0.200	0.304	0.231	0.443	0.300	0.394
	720	0.225	**0.310**	0.258	0.352	0.220	0.320	0.280	0.363	**0.217**	0.330	0.278	0.356	0.258	0.350	0.246	0.355	0.222	0.321	0.254	0.361	0.373	0.439
	Avg	**0.182**	**0.272**	0.216	0.318	0.193	0.304	0.244	0.334	0.196	0.309	0.223	0.302	0.225	0.319	0.214	0.327	0.193	0.296	0.227	0.338	0.311	0.397
Traffic	96	**0.462**	**0.285**	0.526	0.347	0.593	0.321	0.644	0.429	0.577	0.350	0.647	0.384	0.650	0.396	0.587	0.366	0.612	0.338	0.613	0.388	0.719	0.391
	192	**0.473**	**0.296**	0.522	0.332	0.617	0.336	0.665	0.431	0.589	0.356	0.600	0.361	0.598	0.370	0.604	0.373	0.613	0.340	0.616	0.382	0.696	0.379
	336	**0.498**	**0.296**	0.517	0.334	0.629	0.336	0.674	0.420	0.594	0.358	0.610	0.367	0.605	0.373	0.621	0.383	0.618	0.328	0.622	0.337	0.777	0.420
	720	**0.506**	**0.313**	0.552	0.352	0.640	0.350	0.683	0.424	0.613	0.361	0.691	0.425	0.645	0.394	0.626	0.382	0.653	0.355	0.660	0.408	0.864	0.472
	Avg	**0.484**	**0.297**	0.529	0.341	0.620	0.336	0.667	0.426	0.593	0.356	0.637	0.384	0.625	0.383	0.610	0.376	0.624	0.340	0.628	0.379	0.764	0.416
ETTh1	96	**0.375**	**0.400**	0.460	0.447	0.384	0.402	0.423	0.448	0.426	0.446	0.438	0.433	0.397	0.412	0.395	0.424	0.513	0.491	0.449	0.459	0.865	0.713
	192	**0.429**	**0.421**	0.512	0.477	0.436	0.429	0.471	0.474	0.454	0.464	0.493	0.466	0.446	0.441	0.469	0.470	0.534	0.504	0.500	0.482	1.008	0.792
	336	**0.484**	**0.458**	0.546	0.496	0.638	0.469	0.570	0.546	0.493	0.487	0.547	0.495	0.489	0.467	0.530	0.499	0.588	0.535	0.521	0.496	1.107	0.809
	720	**0.498**	**0.482**	0.544	0.517	0.521	0.500	0.653	0.621	0.526	0.526	0.586	0.538	0.513	0.510	0.598	0.544	0.643	0.616	0.514	0.512	1.181	0.865
	Avg	**0.447**	**0.440**	0.516	0.484	0.495	0.450	0.529	0.522	0.475	0.480	0.516	0.483	0.461	0.457	0.498	0.484	0.570	0.537	0.496	0.487	1.040	0.795
ETTh2	96	**0.289**	**0.341**	0.308	0.355	0.340	0.374	0.745	0.584	0.372	0.424	0.322	0.364	0.340	0.394	0.358	0.397	0.476	0.458	0.346	0.388	3.755	1.525
	192	**0.372**	**0.392**	0.393	0.405	0.402	0.414	0.877	0.656	0.492	0.492	0.404	0.414	0.482	0.479	0.429	0.439	0.512	0.493	0.456	0.452	5.602	1.931
	336	**0.386**	**0.414**	0.427	0.436	0.452	0.452	1.043	0.731	0.607	0.555	0.435	0.445	0.591	0.541	0.496	0.487	0.552	0.551	0.482	0.486	4.721	1.835
	720	**0.412**	**0.434**	0.436	0.450	0.462	0.468	1.104	0.763	0.824	0.655	0.447	0.458	0.839	0.661	0.463	0.474	0.562	0.560	0.515	0.511	3.647	1.625
	Avg	**0.364**	**0.395**	0.391	0.411	0.414	0.427	0.942	0.684	0.574	0.531	0.402	0.420	0.563	0.519	0.437	0.449	0.526	0.516	0.450	0.459	4.431	1.729
ETTm1	96	**0.320**	**0.357**	0.352	0.374	0.338	0.375	0.404	0.426	0.365	0.387	0.353	0.370	0.346	0.374	0.379	0.419	0.386	0.398	0.505	0.475	0.672	0.571
	192	**0.361**	**0.381**	0.390	0.393	0.374	0.387	0.450	0.451	0.403	0.408	0.389	0.387	0.382	0.391	0.426	0.441	0.459	0.444	0.553	0.496	0.795	0.669
	336	**0.390**	**0.404**	0.421	0.414	0.410	0.411	0.532	0.515	0.436	0.431	0.421	0.408	0.415	0.415	0.445	0.459	0.495	0.464	0.621	0.537	1.212	0.871
	720	**0.454**	**0.441**	0.462	0.449	0.478	0.450	0.666	0.589	0.489	0.462	0.481	**0.441**	0.473	0.451	0.543	0.490	0.585	0.516	0.671	0.561	1.166	0.823
	Avg	**0.381**	**0.395**	0.406	0.407	0.400	0.406	0.513	0.495	0.423	0.422	0.411	0.402	0.404	0.408	0.448	0.452	0.481	0.456	0.588	0.517	0.961	0.734
ETTm2	96	**0.175**	**0.258**	0.183	0.270	0.187	0.267	0.287	0.366	0.197	0.296	0.183	0.266	0.193	0.293	0.203	0.287	0.192	0.274	0.255	0.339	0.365	0.453
	192	**0.237**	**0.299**	0.255	0.314	0.249	0.309	0.414	0.492	0.284	0.361	0.248	0.305	0.284	0.361	0.269	0.328	0.280	0.339	0.281	0.340	0.533	0.563
	336	**0.298**	**0.340**	0.309	0.347	0.321	0.351	0.597	0.542	0.381	0.429	0.309	0.343	0.382	0.429	0.325	0.366	0.334	0.361	0.339	0.372	1.363	0.887
	720	**0.391**	**0.396**	0.412	0.404	0.408	0.403	1.730	1.042	0.549	0.522	0.410	0.400	0.558	0.525	0.421	0.415	0.417	0.413	0.433	0.432	3.379	1.338
	Avg	**0.275**	**0.323**	0.290	0.334	0.291	0.333	0.757	0.610	0.353	0.402	0.287	0.329	0.354	0.402	0.305	0.349	0.306	0.347	0.327	0.371	1.410	0.810

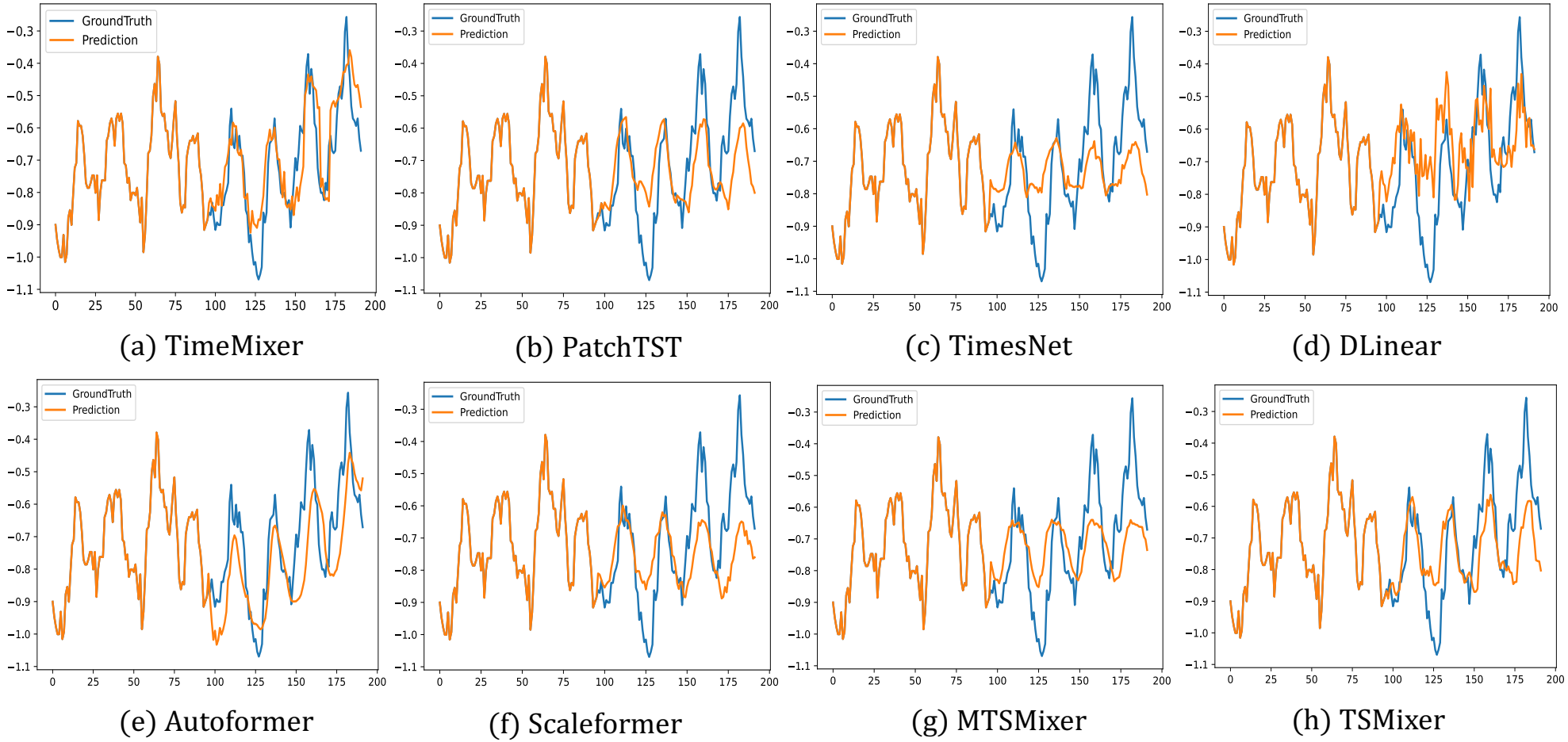
Searched Hyperparameter

TimeMixer > PatchTST > DLinear

Models		**TimeMixer (Ours)**		PatchTST 2023		TimesNet 2023a		Crossformer 2023		MICN 2023		FiLM 2022a		DLinear 2023		FEDformer 2022b		Stationary 2022b		Autoformer 2021		Informer 2021	
Metric		MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
Weather	96	**0.147**	**0.197**	0.149	0.198	0.172	0.220	0.232	0.302	0.161	0.229	0.199	0.262	0.176	0.237	0.217	0.296	0.173	0.223	0.266	0.336	0.300	0.384
	192	**0.189**	**0.239**	0.194	0.241	0.219	0.261	0.371	0.410	0.220	0.281	0.228	0.288	0.220	0.282	0.276	0.336	0.245	0.285	0.307	0.367	0.598	0.544
	336	**0.241**	**0.280**	0.306	0.282	0.246	0.337	0.495	0.515	0.278	0.331	0.267	0.323	0.265	0.319	0.339	0.380	0.321	0.338	0.359	0.395	0.578	0.523
	720	**0.310**	**0.330**	0.314	0.334	0.365	0.359	0.526	0.542	0.311	0.356	0.319	0.361	0.323	0.362	0.403	0.428	0.414	0.410	0.419	0.428	1.059	0.741
	Avg	**0.222**	**0.262**	0.241	0.264	0.251	0.294	0.406	0.442	0.242	0.299	0.253	0.309	0.246	0.300	0.309	0.360	0.288	0.314	0.338	0.382	0.634	0.548
Solar-Energy	96	**0.167**	**0.220**	0.224	0.278	0.219	0.314	0.181	0.240	0.188	0.252	0.320	0.339	0.289	0.377	0.201	0.304	0.321	0.380	0.456	0.446	0.200	0.247
	192	**0.187**	**0.249**	0.253	0.298	0.231	0.322	0.196	0.252	0.215	0.280	0.360	0.362	0.319	0.397	0.237	0.337	0.346	0.369	0.588	0.561	0.220	0.251
	336	**0.200**	0.258	0.273	0.306	0.246	0.337	0.216	**0.243**	0.222	0.267	0.398	0.375	0.352	0.415	0.254	0.362	0.357	0.387	0.595	0.588	0.260	0.287
	720	**0.215**	**0.250**	0.272	0.308	0.280	0.363	0.220	0.256	0.226	0.264	0.399	0.368	0.356	0.412	0.280	0.397	0.335	0.384	0.733	0.633	0.244	0.301
	Avg	**0.192**	**0.244**	0.256	0.298	0.244	0.334	0.204	0.248	0.213	0.266	0.369	0.361	0.329	0.400	0.243	0.350	0.340	0.380	0.593	0.557	0.231	0.272
Electricity	96	**0.129**	0.224	**0.129**	**0.222**	0.168	0.272	0.150	0.251	0.164	0.269	0.154	0.267	0.140	0.237	0.193	0.308	0.169	0.273	0.201	0.317	0.274	0.368
	192	**0.140**	**0.220**	0.147	0.240	0.184	0.322	0.161	0.260	0.177	0.285	0.164	0.258	0.153	0.249	0.201	0.315	0.182	0.286	0.222	0.334	0.296	0.386
	336	**0.161**	**0.255**	0.163	0.259	0.198	0.300	0.182	0.281	0.193	0.304	0.188	0.283	0.169	0.267	0.214	0.329	0.200	0.304	0.231	0.338	0.300	0.394
	720	**0.194**	**0.287**	0.197	0.290	0.220	0.320	0.251	0.339	0.212	0.321	0.236	0.332	0.203	0.301	0.246	0.355	0.222	0.321	0.254	0.361	0.373	0.439
	Avg	**0.156**	**0.246**	0.159	0.253	0.192	0.295	0.186	0.283	0.186	0.295	0.186	0.285	0.166	0.264	0.214	0.321	0.213	0.296	0.227	0.338	0.311	0.397
Traffic	96	**0.360**	**0.249**	**0.360**	**0.249**	0.593	0.321	0.514	0.267	0.519	0.309	0.416	0.294	0.410	0.282	0.587	0.366	0.612	0.338	0.613	0.388	0.719	0.391
	192	**0.375**	**0.250**	0.379	0.256	0.617	0.336	0.549	0.252	0.537	0.315	0.408	0.288	0.423	0.287	0.604	0.373	0.613	0.340	0.616	0.382	0.696	0.379
	336	**0.385**	0.270	0.392	**0.264**	0.629	0.336	0.530	0.300	0.534	0.313	0.425	0.298	0.436	0.296	0.621	0.383	0.618	0.328	0.622	0.337	0.777	0.420
	720	**0.430**	**0.281**	0.432	0.286	0.640	0.350	0.573	0.313	0.577	0.325	0.520	0.353	0.466	0.315	0.626	0.382	0.653	0.355	0.660	0.408	0.864	0.472
	Avg	**0.387**	**0.262**	0.391	0.264	0.620	0.336	0.542	0.283	0.541	0.315	0.442	0.308	0.434	0.295	0.609	0.376	0.624	0.340	0.628	0.379	0.764	0.415
ETTh1	96	**0.361**	**0.390**	0.370	0.400	0.384	0.402	0.418	0.438	0.421	0.431	0.422	0.432	0.375	0.399	0.376	0.419	0.513	0.491	0.449	0.459	0.865	0.713
	192	0.409	**0.414**	0.413	0.429	0.436	0.429	0.539	0.517	0.474	0.487	0.462	0.458	**0.405**	0.416	0.420	0.448	0.534	0.504	0.500	0.482	1.008	0.792
	336	0.430	**0.429**	**0.422**	0.440	0.638	0.469	0.709	0.638	0.569	0.551	0.501	0.483	0.439	0.443	0.459	0.465	0.588	0.535	0.521	0.496	1.107	0.809
	720	**0.445**	**0.460**	0.447	0.468	0.521	0.500	0.733	0.636	0.770	0.672	0.544	0.526	0.472	0.490	0.506	0.507	0.643	0.616	0.514	0.512	1.181	0.865
	Avg	**0.411**	**0.423**	0.413	0.434	0.458	0.450	0.600	0.557	0.558	0.535	0.482	0.475	0.423	0.437	0.440	0.460	0.57	0.536	0.496	0.487	1.040	0.795
ETTh2	96	**0.271**	**0.330**	0.274	0.337	0.340	0.374	0.425	0.463	0.299	0.364	0.323	0.370	0.289	0.353	0.346	0.388	0.476	0.458	0.358	0.397	3.755	1.525
	192	0.317	0.402	0.314	0.382	**0.231**	**0.322**	0.473	0.500	0.441	0.454	0.391	0.415	0.383	0.418	0.429	0.439	0.512	0.493	0.456	0.452	5.602	1.931
	336	0.332	0.396	**0.329**	**0.384**	0.452	0.452	0.581	0.562	0.654	0.567	0.415	0.440	0.448	0.465	0.496	0.487	0.552	0.551	0.482	0.486	4.721	1.835
	720	**0.342**	**0.408**	0.379	0.422	0.462	0.468	0.775	0.665	0.956	0.716	0.441	0.459	0.605	0.551	0.463	0.474	0.562	0.560	0.515	0.511	3.647	1.625
	Avg	**0.316**	0.384	0.324	**0.381**	0.371	0.404	0.564	0.548	0.588	0.525	0.393	0.421	0.431	0.447	0.433	0.447	0.526	0.516	0.453	0.462	4.431	1.729
ETTm1	96	**0.291**	**0.340**	0.293	0.346	0.338	0.375	0.361	0.403	0.316	0.362	0.302	0.345	0.299	0.343	0.379	0.419	0.386	0.398	0.505	0.475	0.672	0.571
	192	**0.327**	**0.365**	0.333	0.370	0.374	0.387	0.387	0.422	0.363	0.390	0.338	0.368	0.335	**0.365**	0.426	0.441	0.459	0.444	0.553	0.496	0.795	0.669
	336	**0.360**	**0.381**	0.369	0.392	0.410	0.411	0.605	0.572	0.408	0.426	0.373	0.388	0.369	0.386	0.445	0.459	0.495	0.464	0.621	0.537	1.212	0.871
	720	**0.415**	**0.417**	0.416	0.420	0.478	0.450	0.703	0.645	0.481	0.476	0.420	0.420	0.425	0.421	0.543	0.490	0.585	0.516	0.671	0.561	1.166	0.823
	Avg	**0.348**	**0.375**	0.353	0.382	0.353	0.382	0.514	0.510	0.392	0.413	0.358	0.38	0.357	0.379	0.448	0.452	0.481	0.456	0.588	0.517	0.961	0.733
ETTm2	96	**0.164**	**0.254**	0.166	0.256	0.187	0.267	0.275	0.358	0.179	0.275	0.165	0.256	0.167	0.260	0.203	0.287	0.192	0.274	0.255	0.339	0.365	0.453
	192	0.223	**0.295**	0.223	0.296	0.249	0.309	0.345	0.400	0.307	0.376	**0.222**	0.296	0.224	0.303	0.269	0.328	0.280	0.339	0.281	0.340	0.533	0.563
	336	0.279	0.330	**0.274**	**0.329**	0.321	0.351	0.657	0.528	0.325	0.388	0.277	0.333	0.281	0.342	0.325	0.366	0.334	0.361	0.339	0.372	1.363	0.887
	720	**0.359**	**0.383**	0.362	0.385	0.408	0.403	1.208	0.753	0.502	0.490	0.371	0.389	0.397	0.421	0.421	0.415	0.417	0.413	0.422	0.419	3.379	1.388
	Avg	**0.256**	**0.315**	**0.256**	0.317	0.291	0.333	0.621	0.510	0.328	0.382	0.259	0.319	0.267	0.332	0.304	0.349	0.306	0.347	0.324	0.368	1.410	0.823

See our paper for full results ☺

Long-term Forecasting

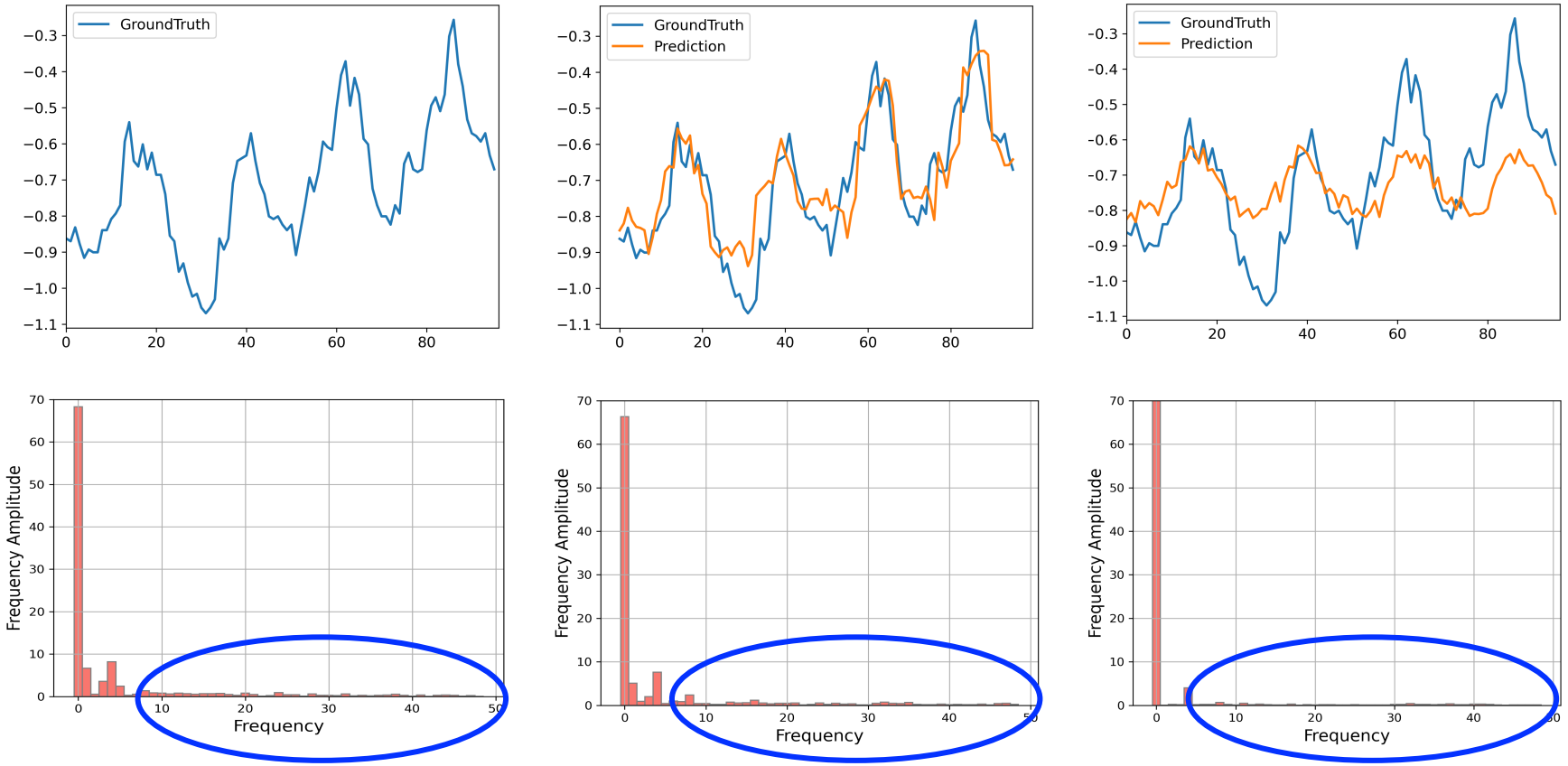


(a) TimeMixer (b) PatchTST (c) TimesNet (d) DLinear

(e) Autoformer (f) Scaleformer (g) MTSMixer (h) TSMixer

Input-96-Predict-96 in the ETTh1 dataset

Long-term Forecasting

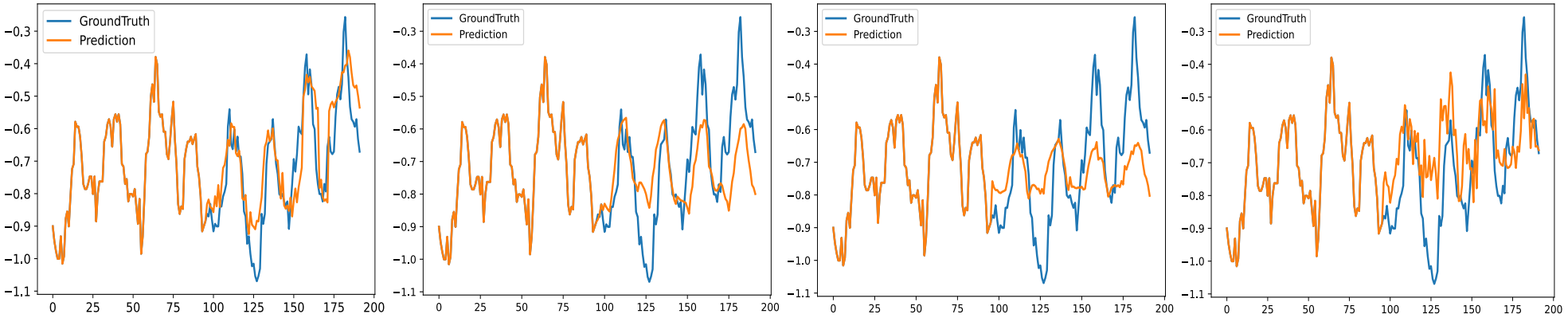


(a) Ground Truth spectrogram (b) TimeMixer spectrogram (c) PatchTST spectrogram

Input-96-Predict-96 in the ETTh1 dataset

TimeMixer excels at high-frequency part modeling

Long-term Forecasting



(a) TimeMixer (b) PatchTST (c) TimesNet (d) DLinear

(e) Autoformer (f) Scaleformer (g) MTSMixer (h) TSMixer

Input-96-Predict-96 in the Solar-Energy dataset

Short-term Forecasting: Multivariate data

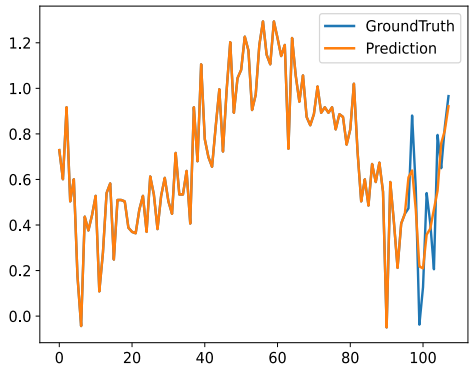
PEMS datasets

- Input-96-Predict-12 for the 5min-sampled traffic data
- The number of Variables is in the range of [170, 883]

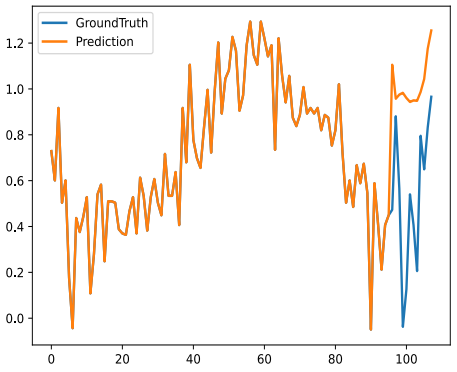
⇨ **Spatiotemporal Correlation Modeling**

Models		**TimeMixer (Ours)**	SCINet (2022a)	Crossformer (2023)	PatchTST (2023)	TimesNet (2023a)	MICN (2023)	FiLM (2022a)	DLinear (2023)	FEDformer (2022b)	Stationary (2022b)	Autoformer (2021)	Informer (2021)
PEMS03	MAE	**14.63**	15.97	15.64	18.95	16.41	15.71	21.36	19.70	19.00	17.64	18.08	19.19
	MAPE	**14.54**	15.89	15.74	17.29	15.17	15.67	18.35	18.35	18.57	17.56	18.75	19.58
	RMSE	**23.28**	25.20	25.56	30.15	26.72	24.55	35.07	32.35	30.05	28.37	27.82	32.70
PEMS04	MAE	**19.21**	20.35	20.38	24.86	21.63	21.62	26.74	24.62	26.51	22.34	25.00	22.05
	MAPE	**12.53**	12.84	12.84	16.65	13.15	13.53	16.46	16.12	16.76	14.85	16.70	14.88
	RMSE	**30.92**	32.31	32.41	40.46	34.90	34.39	42.86	39.51	41.81	35.47	38.02	36.20
PEMS07	MAE	**20.57**	22.79	22.54	27.87	25.12	22.28	28.76	28.65	27.92	26.02	26.92	27.26
	MAPE	**8.62**	9.41	9.38	12.69	10.60	9.57	11.21	12.15	12.29	11.75	11.83	11.63
	RMSE	**33.59**	35.61	35.49	42.56	40.71	35.40	45.85	45.02	42.29	42.34	40.60	45.81
PEMS08	MAE	**15.22**	17.38	17.56	20.35	19.01	17.76	22.11	20.26	20.56	19.29	20.47	20.96
	MAPE	**9.67**	10.80	10.92	13.15	11.83	10.76	12.81	12.09	12.41	12.21	12.27	13.20
	RMSE	**24.26**	27.34	27.21	31.04	30.65	27.26	35.13	32.38	32.97	38.62	31.52	30.61

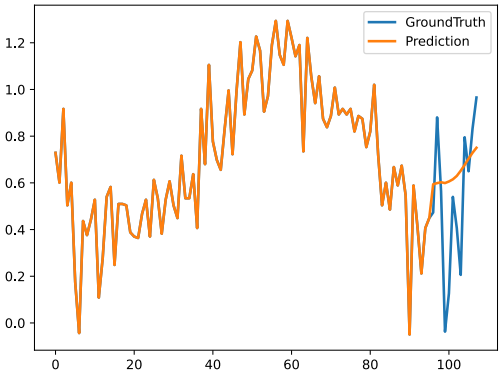
Short-term Forecasting: Multivariate data



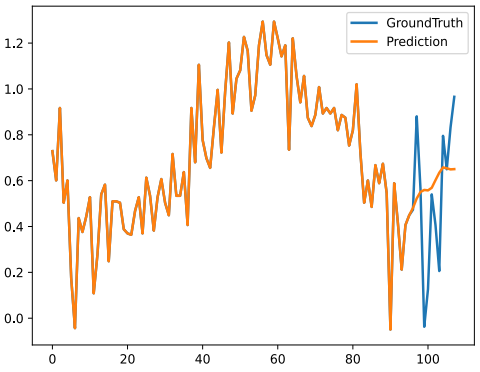
(a)TimeMixer



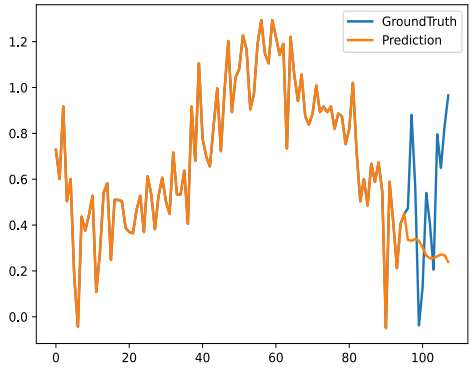
(b)SCINet



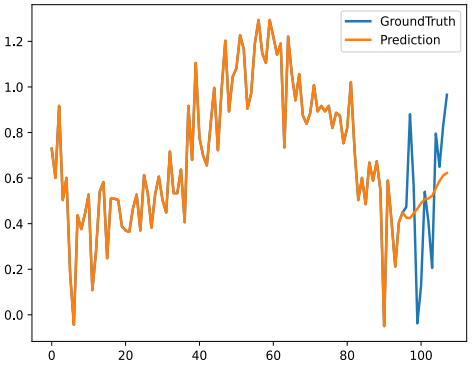
(c) TimesNet



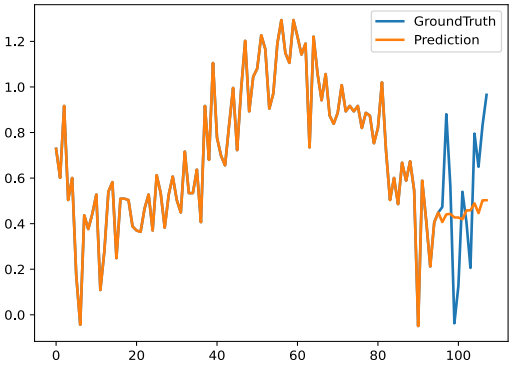
(d) Crossformer



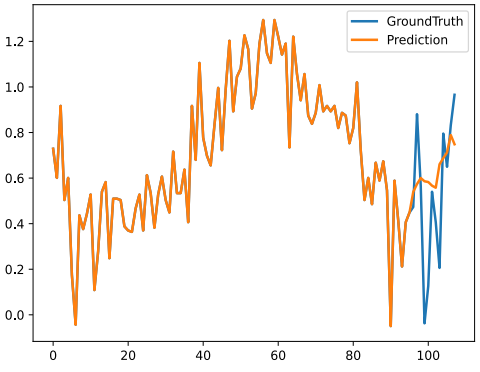
(e) Autoformer



(f) Scaleformer



(g) MTSMixer



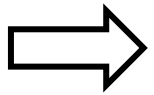
(h) TSMixer

Input-96-Predict-12 in the PEMS07 dataset

Short-term Forecasting: Univariate data

M4 datasets

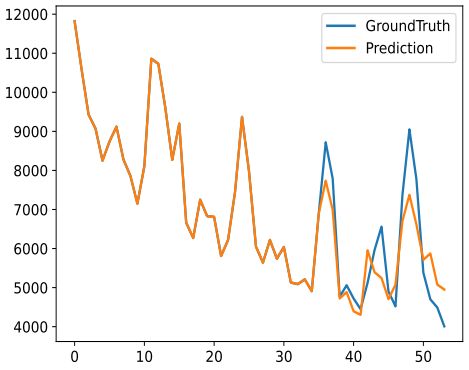
- Predict-[6,48] for multifrequency market data
- Diverse temporal variations: from hourly to yearly



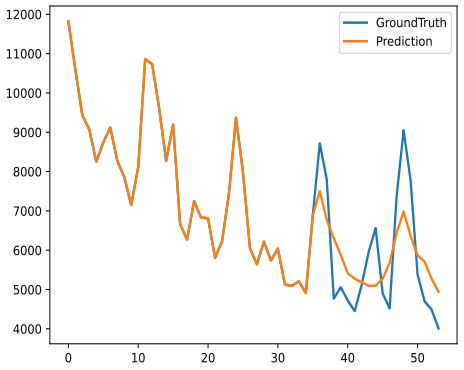
Diverse temporal variations

Models		**TimeMixer (Ours)**	TimesNet (2023a)	N-HiTS (2023)	N-BEATS* (2019)	SCINet (2022a)	PatchTST (2023)	MICN (2023)	FiLM (2022a)	LightTS (2022)	DLinear (2023)	FED. (2022b)	Stationary (2022b)	Auto. (2021)	Pyra. (2021)	In. (2021)
Yearly	SMAPE	**13.206**	13.387	13.418	13.436	18.605	16.463	25.022	17.431	14.247	16.965	13.728	13.717	13.974	15.530	14.727
	MASE	**2.916**	2.996	3.045	3.043	4.471	3.967	7.162	4.043	3.109	4.283	3.048	3.078	3.134	3.711	3.418
	OWA	**0.776**	0.786	0.793	0.794	1.132	1.003	1.667	1.042	0.827	1.058	0.803	0.807	0.822	0.942	0.881
Quarterly	SMAPE	**9.996**	10.100	10.202	10.124	14.871	10.644	15.214	12.925	11.364	12.145	10.792	10.958	11.338	15.449	11.360
	MASE	**1.166**	1.182	1.194	1.169	2.054	1.278	1.963	1.664	1.328	1.520	1.283	1.325	1.365	2.350	1.401
	OWA	**0.825**	0.890	0.899	0.886	1.424	0.949	1.407	1.193	1.000	1.106	0.958	0.981	1.012	1.558	1.027
Monthly	SMAPE	**12.605**	12.670	12.791	12.677	14.925	13.399	16.943	15.407	14.014	13.514	14.260	13.917	13.958	17.642	14.062
	MASE	**0.919**	0.933	0.969	0.937	1.131	1.031	1.442	1.298	1.053	1.037	1.102	1.097	1.103	1.913	1.141
	OWA	**0.869**	0.878	0.899	0.880	1.027	0.949	1.265	1.144	0.981	0.956	1.012	0.998	1.002	1.511	1.024
Others	SMAPE	**4.564**	4.891	5.061	4.925	16.655	6.558	41.985	7.134	15.880	6.709	4.954	6.302	5.485	24.786	24.460
	MASE	**3.115**	3.302	3.216	3.391	15.034	4.511	62.734	5.09	11.434	4.953	3.264	4.064	3.865	18.581	20.960
	OWA	**0.982**	1.035	1.040	1.053	4.123	1.401	14.313	1.553	3.474	1.487	1.036	1.304	1.187	5.538	5.879
Weighted Average	SMAPE	**11.723**	11.829	11.927	11.851	15.542	13.152	19.638	14.863	13.525	13.639	12.840	12.780	12.909	16.987	14.086
	MASE	**1.559**	1.585	1.613	1.559	2.816	1.945	5.947	2.207	2.111	2.095	1.701	1.756	1.771	3.265	2.718
	OWA	**0.840**	0.851	0.861	0.855	1.309	0.998	2.279	1.125	1.051	1.051	0.918	0.930	0.939	1.480	1.230

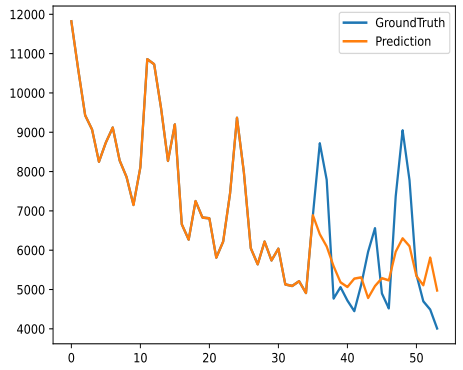
Short-term Forecasting: Univariate data



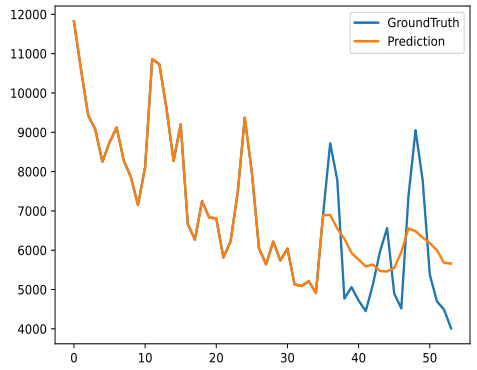
(a)TimeMixer



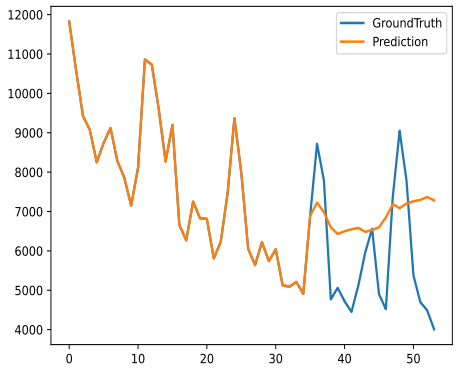
(b)SCINet



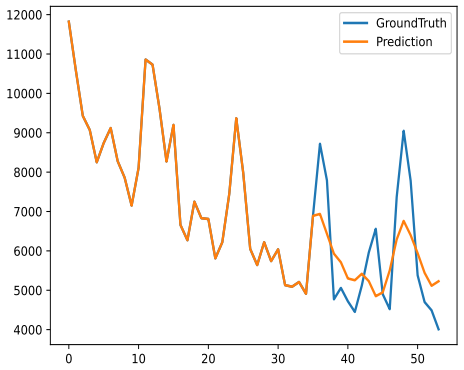
(c) TimesNet



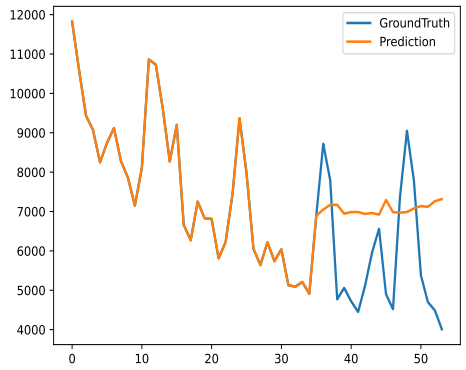
(d) PatchTST



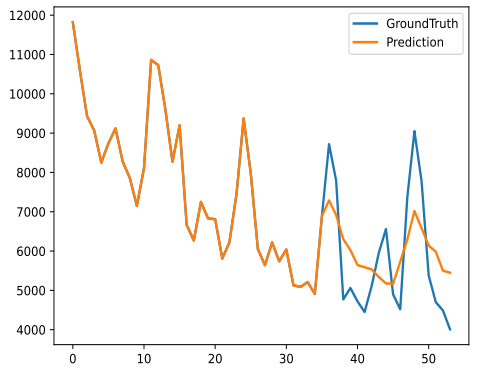
(e) Autoformer



(f) Scaleformer



(g) MTSMixer



(h) TSMixer

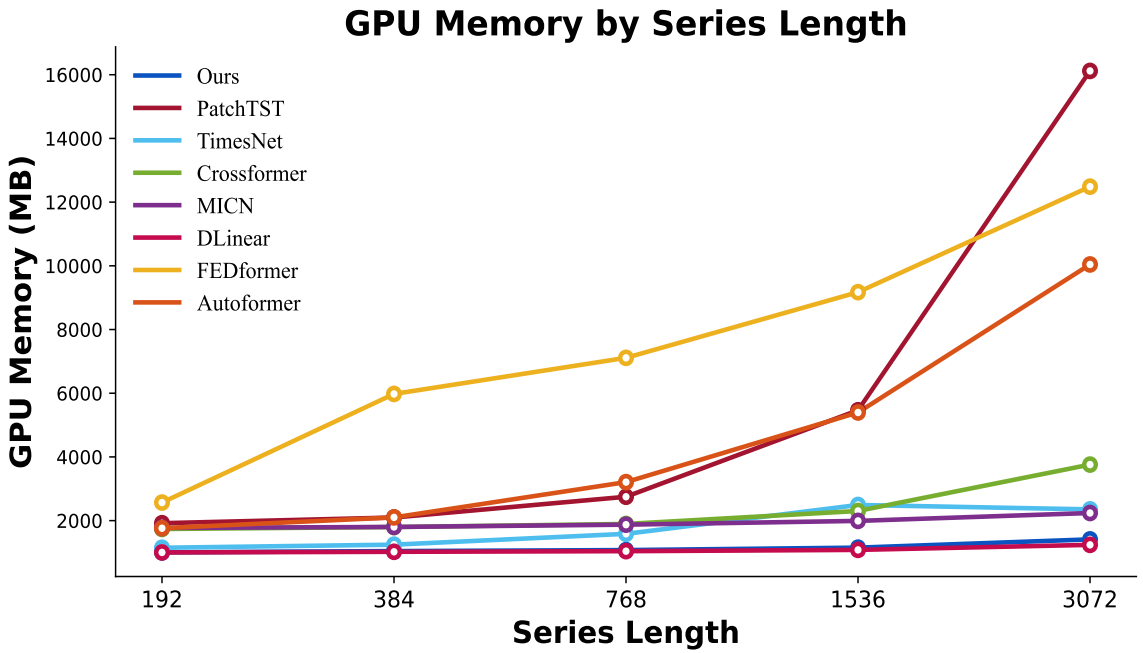
Input-96-Predict-12 in the M4 dataset

Ablation Studies

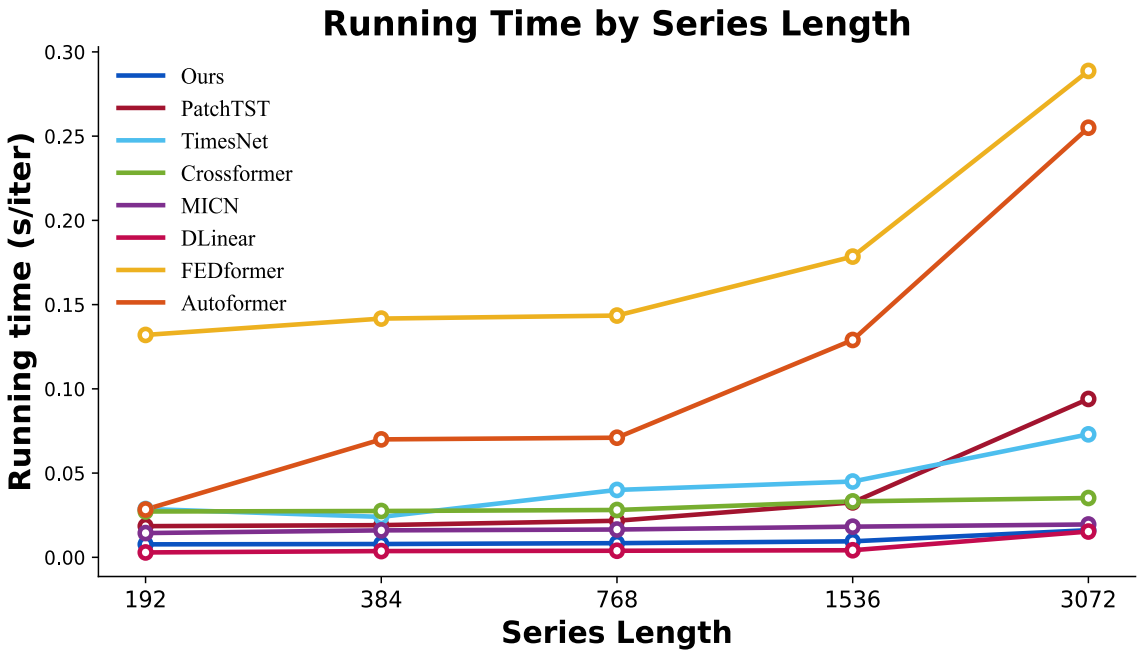
	Case	Decompose	Past mixing		Future mixing	M4			PEMS04			ETTm1	
			Seasonal	Trend	Multipredictor	SMAPE	MASE	OWA	MAE	MAPE	RMSE	MSE	MAE
Ours	①	✓	↗	↙	✓	**11.723**	**1.559**	**0.840**	**19.21**	**12.53**	**30.92**	**0.390**	**0.404**
	②	✓	↗	↙	×	12.503	1.634	0.925	21.67	13.45	34.89	0.402	0.415
	③	✓	×	↙	✓	13.051	1.676	0.962	24.49	16.28	38.79	0.411	0.427
	④	✓	↗	×	✓	12.911	1.655	0.941	22.91	15.02	37.04	0.405	0.414
	⑤	✓	↙	↙	✓	12.008	1.628	0.871	20.78	13.02	32.47	0.392	0.413
	⑥	✓	↗	↗	✓	11.978	1.626	0.859	21.09	13.78	33.11	0.396	0.415
	⑦	✓	↙	↗	✓	13.012	1.657	0.954	22.27	15.14	34.67	0.412	0.429
	⑧	×	↗		✓	11.975	1.617	0.851	21.51	13.47	34.81	0.395	0.408
	⑨	×	↙		✓	11.973	1.622	0.850	21.79	14.03	35.23	0.393	0.406
	⑩	×	×		✓	12.468	1.671	0.916	24.87	16.66	39.48	0.405	0.412

Every design in TimeMixer is effective.

Efficiency Comparison



(a) Memory Efficiency Analysis



(b) Running Time Efficiency Analysis

TimeMixer achieves favorable efficiency in comparing with Transformer-based models

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Thank You!

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Codes and pre-trained models are
open-sourced in OpenReview