

Spectral Modulation Meets Multi-Scale Convolution for Effective Multivariate Time Series Forecasting

Supplementary File

I. INTRODUCTION

THIS is the supplementary file for the paper entitled “Spectral Modulation Meets Multi-Scale Convolution for Effective Multivariate Time Series Forecasting”. We have put the tables and figures of experimental results in Section IV.

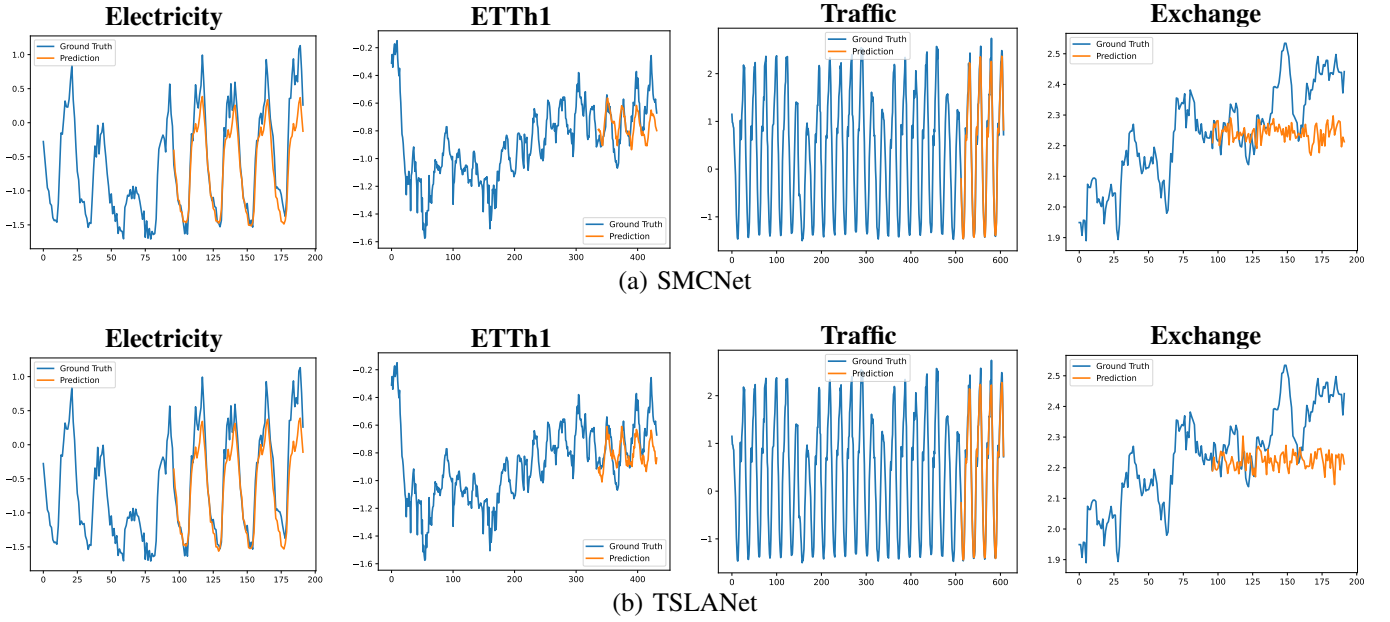


Fig. S1. Forecast comparison between SMCNet and TSLANet on four datasets. The blue line corresponds to the true values, while the red line denotes the predicted values.

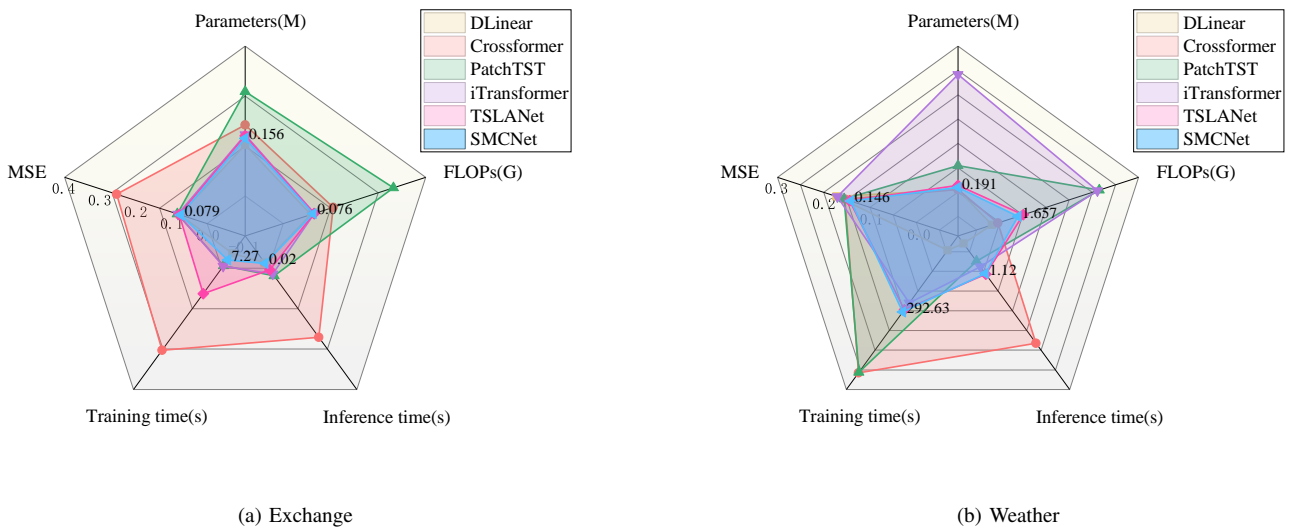


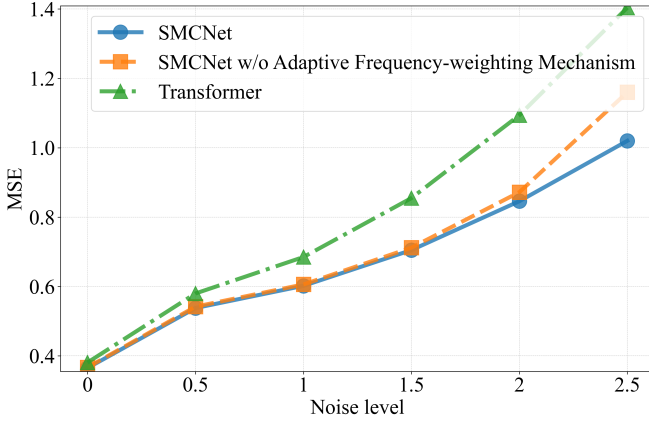
Fig. S2. Comparison of SMCNet and five baselines on MSE, Parameters, FLOPs, Inference time, and Training time.

TABLE S(I)
FULL RESULTS OF SMCNET AND BASELINES.

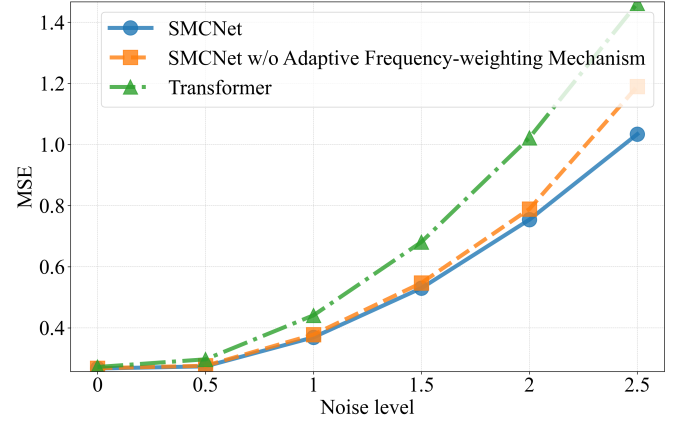
CNN-based Network										Transformer-based Network										MLP-based Network			
Methods	SMCNet		TSLANet		TimesNet		SCINet		iTransformer		PatchTST		Crossformer		FEDformer		Autoformer		RLinear		DLinear		
Metric	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	
ECL	96	0.137	0.225	0.136	0.229	0.168	0.272	0.247	0.345	0.148	0.240	0.138	0.230	0.219	0.314	0.193	0.308	0.201	0.317	0.201	0.281	0.140	0.237
	192	0.151	0.242	0.152	0.244	0.184	0.289	0.257	0.355	0.162	0.253	0.149	0.243	0.231	0.322	0.201	0.315	0.222	0.334	0.201	0.283	0.153	0.249
	336	0.165	0.260	0.168	0.262	0.198	0.300	0.269	0.369	0.178	0.269	0.169	0.262	0.246	0.337	0.214	0.329	0.231	0.338	0.215	0.298	0.169	0.267
	720	0.203	0.295	0.205	0.293	0.220	0.320	0.299	0.390	0.225	0.317	0.211	0.299	0.280	0.363	0.246	0.355	0.254	0.361	0.257	0.331	0.203	0.301
	Avg	0.164	0.255	0.165	0.257	0.193	0.295	0.268	0.365	0.178	0.270	0.167	0.259	0.244	0.334	0.214	0.327	0.227	0.338	0.219	0.298	0.166	0.264
ETTh1	96	0.365	0.391	0.370	0.394	0.384	0.402	0.654	0.599	0.386	0.405	0.382	0.401	0.423	0.448	0.376	0.419	0.449	0.459	0.386	0.395	0.375	0.399
	192	0.409	0.413	0.412	0.417	0.436	0.429	0.719	0.631	0.441	0.436	0.428	0.425	0.471	0.474	0.420	0.448	0.500	0.482	0.437	0.424	0.405	0.416
	336	0.398	0.417	0.399	0.416	0.491	0.469	0.778	0.659	0.487	0.458	0.451	0.436	0.570	0.546	0.459	0.465	0.521	0.496	0.479	0.446	0.439	0.443
	720	0.450	0.465	0.472	0.475	0.521	0.500	0.836	0.699	0.503	0.491	0.452	0.459	0.653	0.621	0.506	0.507	0.514	0.512	0.481	0.470	0.472	0.490
	Avg	0.405	0.421	0.413	0.426	0.458	0.450	0.747	0.647	0.454	0.448	0.428	0.430	0.529	0.522	0.440	0.460	0.496	0.487	0.446	0.434	0.423	0.437
ETTh2	96	0.267	0.330	0.280	0.341	0.340	0.374	0.707	0.621	0.297	0.349	0.285	0.340	0.745	0.584	0.358	0.397	0.346	0.388	0.288	0.338	0.289	0.353
	192	0.323	0.370	0.330	0.375	0.402	0.414	0.860	0.689	0.380	0.400	0.356	0.386	0.877	0.656	0.429	0.439	0.456	0.452	0.374	0.390	0.383	0.418
	336	0.308	0.367	0.317	0.374	0.452	0.452	1.000	0.744	0.428	0.432	0.350	0.395	1.043	0.731	0.496	0.487	0.482	0.486	0.415	0.426	0.448	0.465
	720	0.386	0.426	0.404	0.440	0.462	0.468	1.249	0.838	0.427	0.445	0.395	0.427	1.104	0.763	0.463	0.474	0.515	0.511	0.420	0.440	0.605	0.551
	Avg	0.321	0.373	0.333	0.383	0.414	0.427	0.954	0.723	0.383	0.407	0.347	0.387	0.942	0.684	0.437	0.449	0.450	0.459	0.374	0.399	0.431	0.447
ETTh1	96	0.288	0.338	0.289	0.349	0.338	0.375	0.418	0.438	0.334	0.368	0.291	0.340	0.404	0.426	0.379	0.419	0.505	0.475	0.355	0.376	0.299	0.343
	192	0.326	0.364	0.328	0.370	0.374	0.387	0.439	0.450	0.377	0.391	0.328	0.365	0.450	0.451	0.426	0.441	0.553	0.496	0.391	0.392	0.335	0.365
	336	0.358	0.381	0.355	0.389	0.410	0.411	0.490	0.485	0.426	0.420	0.365	0.389	0.532	0.515	0.445	0.459	0.621	0.537	0.424	0.415	0.369	0.386
	720	0.419	0.420	0.421	0.425	0.478	0.450	0.595	0.550	0.491	0.459	0.422	0.423	0.666	0.589	0.543	0.490	0.671	0.561	0.487	0.450	0.425	0.421
	Avg	0.347	0.375	0.348	0.383	0.400	0.406	0.486	0.481	0.407	0.410	0.352	0.379	0.513	0.495	0.448	0.452	0.588	0.517	0.414	0.408	0.357	0.379
ETTh2	96	0.164	0.254	0.169	0.259	0.187	0.267	0.286	0.377	0.180	0.264	0.169	0.254	0.287	0.366	0.203	0.287	0.255	0.339	0.182	0.265	0.167	0.260
	192	0.225	0.295	0.224	0.297	0.249	0.309	0.399	0.445	0.250	0.309	0.230	0.294	0.414	0.492	0.269	0.328	0.281	0.340	0.246	0.304	0.224	0.303
	336	0.279	0.332	0.275	0.329	0.321	0.351	0.637	0.591	0.311	0.348	0.280	0.329	0.597	0.542	0.325	0.366	0.339	0.372	0.307	0.342	0.281	0.342
	720	0.364	0.387	0.354	0.380	0.408	0.403	0.960	0.735	0.412	0.407	0.378	0.386	1.730	1.042	0.421	0.415	0.433	0.432	0.407	0.398	0.397	0.421
	Avg	0.258	0.317	0.256	0.316	0.291	0.333	0.571	0.537	0.288	0.332	0.264	0.316	0.757	0.611	0.305	0.349	0.327	0.371	0.286	0.327	0.267	0.332
Exchange	96	0.079	0.199	0.083	0.201	0.107	0.234	0.267	0.396	0.086	0.206	0.088	0.205	0.256	0.367	0.148	0.278	0.197	0.323	0.093	0.217	0.081	0.203
	192	0.172	0.294	0.177	0.299	0.226	0.344	0.351	0.459	0.177	0.299	0.176	0.299	0.470	0.509	0.271	0.315	0.300	0.369	0.184	0.307	0.157	0.293
	336	0.330	0.416	0.331	0.417	0.367	0.448	1.324	0.853	0.331	0.417	0.301	0.397	1.268	0.883	0.460	0.427	0.509	0.524	0.351	0.432	0.305	0.414
	720	0.884	0.737	0.888	0.739	0.964	0.746	1.058	0.797	0.847	0.691	0.901	0.714	1.767	1.068	1.195	0.695	1.447	0.941	0.886	0.714	0.643	0.601
	Avg	0.366	0.411	0.370	0.414	0.416	0.443	0.750	0.626	0.360	0.403	0.367	0.404	0.940	0.707	0.519	0.429	0.613	0.539	0.379	0.418	0.297	0.378
Traffic	96	0.357	0.248	0.372	0.261	0.593	0.321	0.788	0.499	0.395	0.268	0.401	0.267	0.522	0.290	0.587	0.366	0.613	0.388	0.649	0.389	0.410	0.282
	192	0.374	0.253	0.388	0.266	0.617	0.336	0.789	0.505	0.417	0.276	0.406	0.268	0.530	0.293	0.604	0.373	0.616	0.382	0.601	0.366	0.423	0.287
	336	0.384	0.259	0.394	0.269	0.629	0.336	0.797	0.508	0.433	0.283	0.421	0.277	0.558	0.305	0.621	0.383	0.622	0.337	0.609	0.369	0.436	0.296
	720	0.423	0.281	0.430	0.289	0.640	0.350	0.841	0.523	0.467	0.302	0.452	0.297	0.589	0.328	0.626	0.382	0.660	0.408	0.647	0.387	0.466	0.315
	Avg	0.384	0.260	0.396	0.271	0.620	0.336	0.804	0.509	0.428	0.282	0.420	0.277	0.550	0.304	0.610	0.376	0.628	0.379	0.627	0.378	0.434	0.295
Weather	96	0.146	0.195	0.148	0.197	0.172	0.220	0.221	0.306	0.174	0.214	0.160	0.204	0.158	0.230	0.217	0.296	0.266	0.336	0.192	0.232	0.176	0.237
	192	0.192	0.238	0.193	0.241	0.219	0.261	0.261	0.340	0.221	0.254	0.204	0.245	0.206	0.277	0.276	0.336	0.307	0.367	0.240	0.271	0.220	0.282
	336	0.244	0.279	0.245	0.282	0.280	0.306	0.309	0.378	0.278	0.296	0.257	0.285	0.272	0.335	0.339	0.380	0.359	0.395	0.292	0.307	0.265	0.319
	720	0.322	0.334	0.325	0.337	0.365	0.359	0.377	0.427	0.358	0.349	0.329	0.338	0.398	0.418	0.403	0.428	0.419	0.428	0.364	0.353	0.323	0.362
	Avg	0.226	0.261	0.228	0.264	0.259	0.287	0.292	0.363	0.258	0.278	0.238	0.268	0.259	0.315	0.309	0.360	0.338	0.382	0.272	0.291	0.246	0.300
Solar-Energy	96	0.195	0.230	0.198	0.236	0.250	0.292	0.237	0.344	0.203	0.237	0.234	0.286	0.310	0.331	0.242	0.342	0.884	0.711	0.322	0.339	0.290	0.378
	192	0.234	0.260	0.230	0.258	0.296	0.318	0.280	0.380	0.233	0.261	0.267	0.310	0.734	0.725	0.285	0.380	0.834	0.692	0.359	0.356	0.320	0.398
	336	0.246	0.268	0.248	0.270	0.319	0.330	0.304	0.389	0.248	0.273	0.290	0.315	0.750	0.735	0.282	0.376	0.941	0.723	0.397	0.369	0.353	0.415
	720	0.246	0.268	0.247	0.269	0.338	0.337	0.308	0.388	0.249	0.275	0.289	0.317	0.769	0.765	0.357	0.427	0.882	0.717	0.397	0.356	0.356	0.413
	Avg	0.230	0.256	0.230	0.258	0.3																	

TABLE S(II)
SMCNET PERFORMANCE ROBUSTNESS ACROSS FIVE RANDOM SEEDS.

Datasets	ETTh2		Exchange		Weather		Solar-Energy		PEMS08	
Horizon	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
96	0.267±0.001	0.330±0.001	0.079±0.001	0.199±0.000	0.146±0.001	0.195±0.001	0.195±0.000	0.230±0.002	0.072±0.000	0.173±0.001
192	0.323±0.002	0.370±0.001	0.172±0.001	0.294±0.001	0.192±0.001	0.238±0.001	0.234±0.002	0.260±0.003	0.096±0.001	0.195±0.000
336	0.308±0.001	0.367±0.001	0.330±0.002	0.416±0.002	0.244±0.001	0.279±0.001	0.246±0.001	0.268±0.001	0.139±0.001	0.228±0.001
720	0.386±0.002	0.426±0.001	0.884±0.001	0.737±0.001	0.322±0.001	0.334±0.001	0.246±0.001	0.268±0.001	0.202±0.000	0.248±0.002



(a) Noise Robustness Evaluation on ETTh1 Dataset



(b) Noise Robustness Evaluation on ETTh2 Dataset

Fig. S3. Effectiveness analysis of the adaptive frequency-weighting mechanism in noise attenuation.

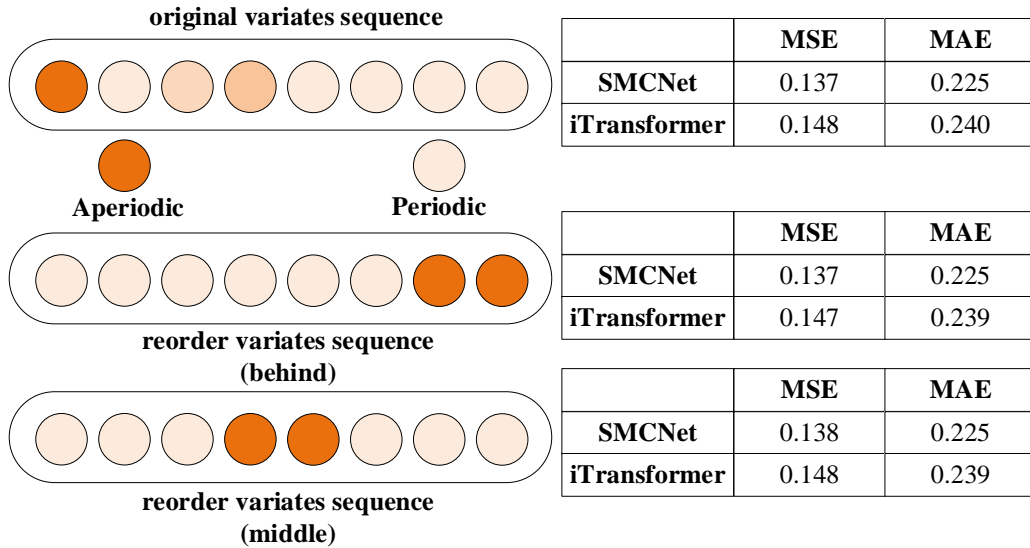


Fig. S4. The distributions of periodic and aperiodic variables in the ECL dataset were modified. The left panel visualizes these distributions, while the right panel illustrates the model's performance.

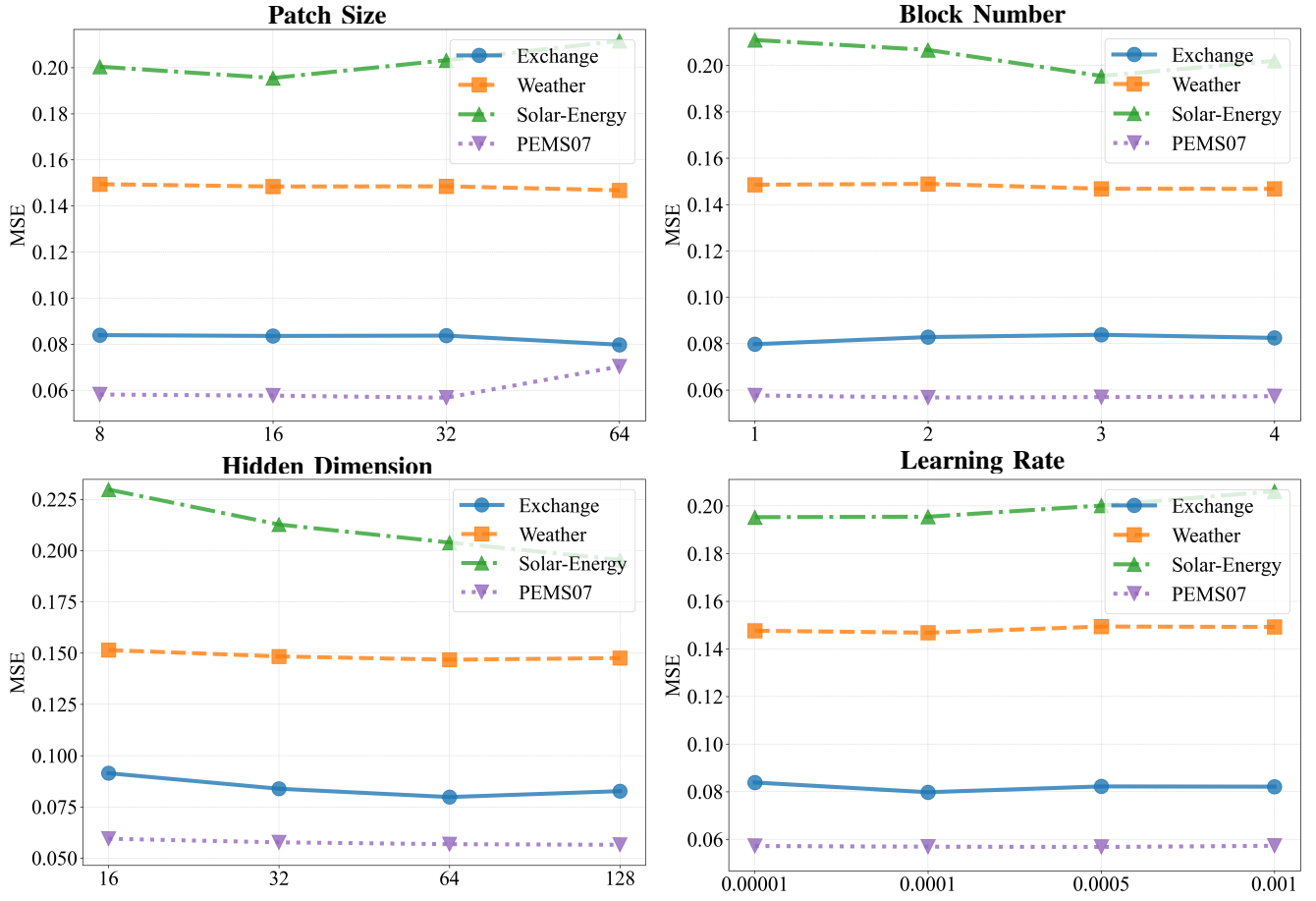


Fig. S5. Performance sensitivity analysis of SMCNet under four parameters: Patch Size, Number of Network Blocks, Hidden Dimension, and Learning Rate.