# A APPENDIX

## A.1 EXPERIMENT DETAILS

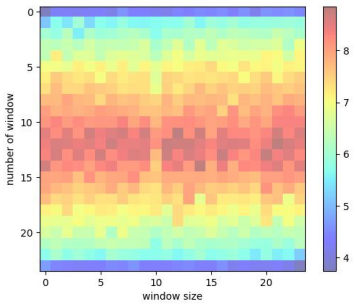
**Datasets characteristics** The dataset is characterised as follows in Appendix Table 7. We follow standard protocol ((Nie et al., 2023)) and split all datasets into training, validation and test set in chronological order by the ratio of 6:2:2 for the ETT dataset and 7:1:2 for the other datasets. Frequency indicates the sampling time difference between neighbouring time steps.

Table 7: Summary of experiment datasets.

| Datasets | ETTm1 | ETTm2 | ETTh1 | ETTh2 | weather | ILI | exchange | traffic | ECL |
|---|---|---|---|---|---|---|---|---|---|
| Channels | 7 | 7 | 7 | 7 | 21 | 7 | 7 | 862 | 321 |
| Lengths | 69680 | 69680 | 17420 | 17420 | 52696 | 966 | 7588 | 17544 | 26304 |
| Frequency | 15min | 15min | 1h | 1h | 10min | 7day | 1day | 1h | 1h |

**Decomposition Correlation Block** Convolutional networks can extract the local correlation between period-trend and oscillation terms based on the weights of the convolutional kernel. A higher weight means the relatively higher correlation. As shown in Appendix Figure 5, we visualise the heat map after the convolution kernel and can see that the model focuses more on the local periodicity of the intermediate window from 5 to 18 for the 2D tensor. In terms of periods, our model pays more attention to the previous 10-15 periods when forecasting.

Figure 5: The features after the Decomposition Correlation Block. In the figure, the rows represent periodic windows and the columns represent the number of windows.




**Two-Dimensional Period Decomposition** We take real data from ETTh1 for TDPD and get the period-trend and oscillation terms. As demonstrated in Appendix Figure 6, each column of the period-trend keeps essentially the same trend. In contrast, the oscillation term is characterised by disorganized distributions.

## A.2 FULL RESULTS

Due to the space limitation of the main text, we place the full results of all experiments in the following: multivariate long-input length forecasting in Appendix Table 8, multivariate short-input length forecasting in Appendix Table 9, univariate long-input length forecasting in Appendix Table 10.

## A.3 PREDICTION VISUALIZATION

As shown in Appendix Figure 7, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, we visualize the long-term univariate prediction results of WinNet from the test set of all eight datasets. Here, we predict {24, 36, 48, 60} steps on ILI dataset and {96, 192, 336, 720} steps on other datasets. It can be seen that the proposed model can achieve the best results.

Figure 6: Showcase of the TDPD.

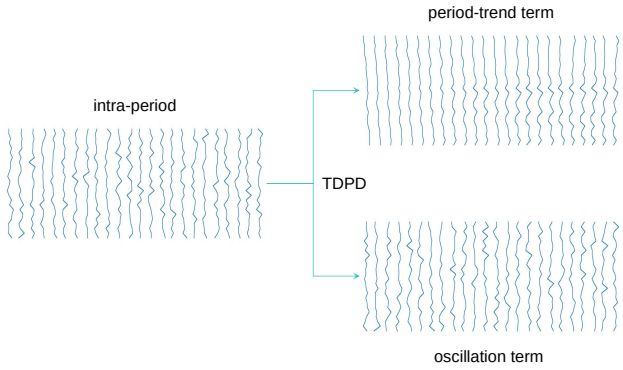
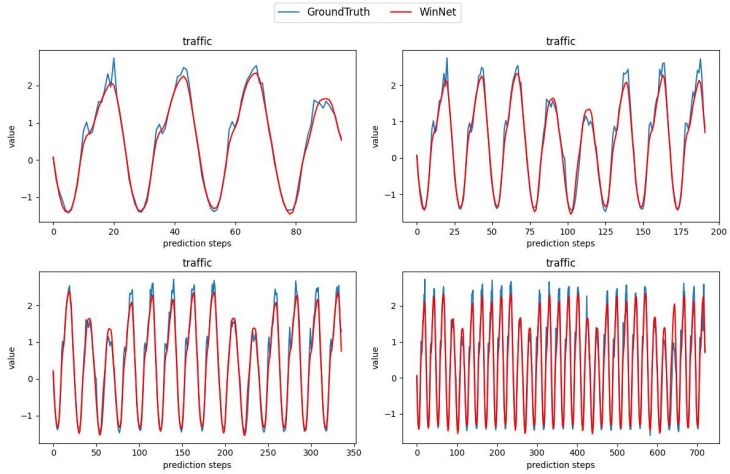



Figure 7: Visualization of prediction on traffic with the look-back window L=336.




### A.4 More ablation studies

**Window size** As shown in Appendix Figure 14, since the window size is approximated as a multiple of the multi-short periods, it can also have implications for experimental performance of the proposed model. For example, for a sequence with top-4 periods $\{4, 6, 8, 12\}$, we can take 24 as the window size, but it is equally possible to approximate the period of 8 as 9 and take 36 as the final window size. The top-4 periods for the datasets can be seen in Table 1. As demonstrated in Appendix Table 12, the proposed approach can achieve better performance for the periodic window of 24.

**CNN Kernel** The convolution kernel size determines the receptive field for extracting periodicity from the sequence. In this section, we consider the model performance with different kernel size to $\{3, 5, 7\}$, respectively, and the experimental results are shown in Appendix Table 13. It can be found that a larger convolution kernel causes lower prediction accuracy. The results can be attributed that after the proposed period decomposition, the period of the reshaped sequence is smaller and a larger kernel excessively extracts the temporal correlation from other periods to degrade the model performance. More ablation study results are available in Appendix Table 15.

Table 8: Full results for multivariate long-input length prediction. We compare extensive competitive models under different prediction lengths. The input sequence length is set to 104 for the ILI dataset and 512 for the others. Avg is the averaged result from all four prediction lengths. The 1st count indicates the numbers of best performance.

| Methods | | **WinNet (Ours)** | | PatchTST (2023) | | TimesNet* (2023) | | MICN* (2023) | | Crossformer (2023) | | DLinear (2023) | | FEDformer (2022) | | Autoformer (2021) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | **0.283** | **0.335** | 0.293 | 0.346 | 0.377 | 0.397 | 0.305 | 0.354 | 0.302 | 0.359 | 0.290 | 0.342 | 0.326 | 0.390 | 0.510 | 0.492 |
| | 192 | **0.324** | **0.360** | 0.333 | 0.370 | 0.389 | 0.401 | 0.362 | 0.399 | 0.341 | 0.387 | 0.332 | 0.369 | 0.365 | 0.415 | 0.514 | 0.495 |
| | 336 | **0.357** | **0.379** | 0.369 | 0.392 | 0.393 | 0.414 | 0.382 | 0.405 | 0.419 | 0.432 | 0.366 | 0.392 | 0.392 | 0.425 | 0.510 | 0.492 |
| | 720 | **0.416** | **0.411** | **0.416** | 0.420 | 0.470 | 0.458 | 0.441 | 0.441 | 0.637 | 0.577 | 0.420 | 0.424 | 0.446 | 0.458 | 0.527 | 0.493 |
| | Avg | **0.345** | **0.371** | 0.352 | 0.382 | 0.407 | 0.417 | 0.372 | 0.399 | 0.424 | 0.438 | 0.352 | 0.381 | 0.382 | 0.422 | 0.515 | 0.493 |
| ETTm2 | 96 | **0.160** | **0.251** | 0.166 | 0.256 | 0.201 | 0.280 | 0.189 | 0.287 | 0.305 | 0.361 | 0.167 | 0.260 | 0.180 | 0.271 | 0.205 | 0.293 |
| | 192 | **0.212** | **0.287** | 0.223 | 0.296 | 0.242 | 0.313 | 0.239 | 0.323 | 0.355 | 0.391 | 0.224 | 0.303 | 0.252 | 0.318 | 0.278 | 0.336 |
| | 336 | **0.261** | **0.322** | 0.274 | 0.329 | 0.310 | 0.356 | 0.348 | 0.385 | 0.420 | 0.431 | 0.281 | 0.342 | 0.324 | 0.364 | 0.343 | 0.379 |
| | 720 | **0.359** | **0.381** | 0.362 | 0.385 | 0.381 | 0.396 | 0.421 | 0.434 | 0.592 | 0.548 | 0.397 | 0.421 | 0.410 | 0.420 | 0.414 | 0.419 |
| | Avg | **0.248** | **0.310** | 0.256 | 0.316 | 0.283 | 0.336 | 0.299 | 0.357 | 0.418 | 0.432 | 0.267 | 0.331 | 0.291 | 0.343 | 0.310 | 0.356 |
| ETTh1 | 96 | **0.362** | **0.390** | 0.379 | 0.401 | 0.460 | 0.464 | 0.404 | 0.429 | 0.394 | 0.418 | 0.375 | 0.399 | 0.376 | 0.415 | 0.435 | 0.446 |
| | 192 | **0.394** | **0.410** | 0.413 | 0.429 | 0.458 | 0.462 | 0.511 | 0.506 | 0.423 | 0.436 | 0.412 | 0.420 | 0.423 | 0.446 | 0.456 | 0.457 |
| | 336 | **0.419** | **0.426** | 0.435 | 0.436 | 0.523 | 0.501 | 0.482 | 0.489 | 0.438 | 0.451 | 0.439 | 0.443 | 0.444 | 0.462 | 0.486 | 0.487 |
| | 720 | **0.436** | **0.453** | 0.446 | 0.464 | 0.502 | 0.497 | 0.697 | 0.631 | 0.508 | 0.514 | 0.472 | 0.490 | 0.469 | 0.492 | 0.515 | 0.517 |
| | Avg | **0.402** | **0.419** | 0.418 | 0.432 | 0.485 | 0.481 | 0.523 | 0.513 | 0.440 | 0.454 | 0.424 | 0.438 | 0.428 | 0.453 | 0.473 | 0.476 |
| ETTh2 | 96 | **0.267** | **0.332** | 0.274 | 0.337 | 0.338 | 0.397 | 0.290 | 0.356 | 0.395 | 0.417 | 0.289 | 0.353 | 0.332 | 0.374 | 0.332 | 0.368 |
| | 192 | **0.322** | **0.372** | 0.338 | 0.376 | 0.422 | 0.446 | 0.415 | 0.441 | 0.427 | 0.438 | 0.383 | 0.418 | 0.407 | 0.446 | 0.426 | 0.434 |
| | 336 | **0.351** | 0.401 | 0.363 | **0.397** | 0.431 | 0.460 | 0.627 | 0.573 | 0.449 | 0.459 | 0.448 | 0.465 | 0.400 | 0.447 | 0.477 | 0.479 |
| | 720 | **0.389** | 0.436 | 0.393 | **0.430** | 0.467 | 0.480 | 1.340 | 0.858 | 0.501 | 0.509 | 0.605 | 0.551 | 0.412 | 0.469 | 0.453 | 0.490 |
| | Avg | **0.332** | **0.385** | 0.342 | **0.385** | 0.414 | 0.445 | 0.668 | 0.557 | 0.443 | 0.455 | 0.431 | 0.446 | 0.387 | 0.434 | 0.422 | 0.442 |
| ILI | 24 | 1.985 | 0.905 | **1.522** | **0.814** | 2.500 | 1.055 | 2.559 | 1.099 | 3.383 | 1.249 | 2.215 | 1.081 | 2.624 | 1.095 | 2.906 | 1.182 |
| | 36 | 1.897 | 0.900 | **1.430** | **0.834** | 2.222 | 1.007 | 2.483 | 1.023 | 3.151 | 1.157 | 1.963 | 0.963 | 2.516 | 1.021 | 2.585 | 1.038 |
| | 48 | 1.868 | 0.910 | **1.673** | **0.854** | 2.304 | 1.043 | 2.371 | 1.007 | 3.386 | 1.186 | 2.130 | 1.024 | 2.505 | 1.041 | 3.024 | 1.145 |
| | 60 | 1.928 | 0.933 | **1.529** | **0.862** | 2.354 | 1.046 | 2.694 | 1.112 | 3.658 | 1.268 | 2.368 | 1.096 | 2.742 | 1.122 | 2.761 | 1.114 |
| | Avg | 1.919 | 0.912 | **1.538** | **0.841** | 2.345 | 1.037 | 2.526 | 1.060 | 3.394 | 1.215 | 2.169 | 1.041 | 2.596 | 1.069 | 2.819 | 1.119 |
| weather | 96 | **0.143** | **0.198** | 0.152 | 0.199 | 0.163 | 0.223 | 0.170 | 0.235 | 0.147 | 0.211 | 0.176 | 0.237 | 0.238 | 0.314 | 0.249 | 0.329 |
| | 192 | **0.188** | **0.240** | 0.197 | 0.243 | 0.218 | 0.266 | 0.214 | 0.277 | 0.194 | 0.261 | 0.192 | 0.246 | 0.275 | 0.329 | 0.325 | 0.370 |
| | 336 | **0.235** | **0.280** | 0.249 | 0.283 | 0.280 | 0.306 | 0.278 | 0.326 | 0.246 | 0.306 | 0.240 | 0.287 | 0.339 | 0.377 | 0.351 | 0.391 |
| | 720 | **0.310** | 0.336 | 0.320 | **0.335** | 0.349 | 0.356 | 0.318 | 0.363 | 0.322 | 0.363 | 0.316 | 0.352 | 0.389 | 0.409 | 0.415 | 0.426 |
| | Avg | **0.219** | **0.263** | 0.229 | 0.265 | 0.252 | 0.287 | 0.245 | 0.300 | 0.227 | 0.285 | 0.231 | 0.280 | 0.310 | 0.357 | 0.335 | 0.379 |
| traffic | 96 | 0.394 | 0.274 | **0.367** | **0.251** | 0.603 | 0.328 | 0.461 | 0.290 | 0.489 | 0.276 | 0.410 | 0.282 | 0.576 | 0.359 | 0.597 | 0.371 |
| | 192 | 0.407 | 0.279 | **0.385** | **0.259** | 0.610 | 0.329 | 0.482 | 0.302 | 0.503 | 0.281 | 0.423 | 0.287 | 0.610 | 0.380 | 0.607 | 0.382 |
| | 336 | 0.416 | 0.283 | **0.398** | **0.265** | 0.619 | 0.330 | 0.487 | 0.300 | 0.528 | 0.292 | 0.436 | 0.296 | 0.608 | 0.375 | 0.623 | 0.387 |
| | 720 | 0.453 | 0.305 | **0.434** | **0.287** | 0.632 | 0.352 | 0.527 | 0.310 | 0.593 | 0.326 | 0.466 | 0.315 | 0.621 | 0.375 | 0.639 | 0.395 |
| | Avg | 0.417 | 0.285 | **0.396** | **0.265** | 0.616 | 0.334 | 0.489 | 0.300 | 0.528 | 0.293 | 0.433 | 0.295 | 0.603 | 0.372 | 0.616 | 0.383 |
| ECL | 96 | **0.130** | 0.226 | **0.130** | **0.222** | 0.181 | 0.281 | 0.162 | 0.272 | 0.198 | 0.292 | 0.140 | 0.237 | 0.186 | 0.302 | 0.196 | 0.313 |
| | 192 | **0.147** | **0.240** | 0.148 | **0.240** | 0.193 | 0.293 | 0.176 | 0.285 | 0.266 | 0.330 | 0.153 | 0.249 | 0.197 | 0.311 | 0.211 | 0.324 |
| | 336 | **0.163** | **0.257** | 0.167 | 0.261 | 0.205 | 0.312 | 0.194 | 0.301 | 0.353 | 0.384 | 0.169 | 0.267 | 0.213 | 0.328 | 0.214 | 0.327 |
| | 720 | **0.198** | **0.290** | 0.202 | 0.291 | 0.222 | 0.320 | 0.222 | 0.327 | 0.400 | 0.416 | 0.203 | 0.301 | 0.233 | 0.344 | 0.236 | 0.342 |
| | Avg | **0.159** | **0.253** | 0.161 | **0.253** | 0.200 | 0.301 | 0.188 | 0.296 | 0.304 | 0.355 | 0.166 | 0.263 | 0.207 | 0.321 | 0.214 | 0.326 |
| 1st count | | **56** | | 29 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | |

$*$ We replace the input length L=512 in TimesNet and MICN for a fair comparison. Other experimental results are taken from the PatchTST and PETformer (Lin et al., 2023).

Table 9: All results for multivariate short-input length prediction. The input sequence length is set to 36 for the ILI dataset and 96 for the others. Avg is the averaged result from all four prediction lengths. The 1st count indicates the numbers of best performance.

| Methods | | **WinNet (Ours)** | | PatchTST* (2023) | | TimesNet (2023) | | MICN (2023) | | Crossformer* (2023) | | DLinear (2023) | | FEDformer (2022) | | Autoformer (2021) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | **0.316** | **0.356** | 0.320 | 0.359 | **0.316** | 0.362 | 0.338 | 0.375 | 0.355 | 0.391 | 0.345 | 0.372 | 0.379 | 0.419 | 0.505 | 0.475 |
| | 192 | 0.368 | 0.383 | 0.364 | 0.381 | **0.363** | 0.390 | 0.374 | 0.387 | 0.416 | 0.433 | 0.380 | 0.389 | 0.426 | 0.441 | 0.553 | 0.496 |
| | 336 | 0.398 | 0.402 | **0.391** | **0.401** | 0.408 | 0.426 | 0.410 | 0.411 | 0.486 | 0.479 | 0.413 | 0.413 | 0.445 | 0.459 | 0.621 | 0.537 |
| | 720 | **0.443** | **0.431** | 0.455 | 0.439 | 0.481 | 0.476 | 0.478 | 0.450 | 0.624 | 0.570 | 0.474 | 0.453 | 0.543 | 0.490 | 0.671 | 0.561 |
| | Avg | **0.381** | **0.385** | 0.382 | 0.395 | 0.392 | 0.413 | 0.400 | 0.405 | 0.470 | 0.468 | 0.403 | 0.406 | 0.448 | 0.452 | 0.587 | 0.517 |
| ETTm2 | 96 | **0.171** | **0.252** | 0.181 | 0.265 | 0.179 | 0.275 | 0.187 | 0.267 | 0.356 | 0.388 | 0.193 | 0.292 | 0.203 | 0.287 | 0.255 | 0.339 |
| | 192 | **0.240** | **0.300** | 0.247 | 0.307 | 0.307 | 0.376 | 0.249 | 0.309 | 0.422 | 0.440 | 0.284 | 0.362 | 0.269 | 0.328 | 0.281 | 0.340 |
| | 336 | **0.295** | **0.336** | 0.308 | 0.348 | 0.325 | 0.388 | 0.321 | 0.351 | 0.507 | 0.494 | 0.369 | 0.427 | 0.325 | 0.366 | 0.339 | 0.372 |
| | 720 | **0.399** | **0.395** | 0.406 | 0.401 | 0.502 | 0.490 | 0.408 | 0.403 | 0.598 | 0.552 | 0.554 | 0.522 | 0.421 | 0.415 | 0.433 | 0.432 |
| | Avg | **0.276** | **0.320** | 0.285 | 0.330 | 0.328 | 0.382 | 0.291 | 0.332 | 0.470 | 0.468 | 0.350 | 0.400 | 0.304 | 0.349 | 0.327 | 0.370 |
| ETTh1 | 96 | 0.379 | **0.388** | 0.392 | 0.408 | 0.421 | 0.431 | 0.389 | 0.412 | 0.409 | 0.432 | 0.386 | 0.400 | **0.376** | 0.419 | 0.449 | 0.459 |
| | 192 | 0.432 | **0.418** | 0.450 | 0.433 | 0.474 | 0.487 | 0.442 | 0.442 | 0.458 | 0.459 | 0.437 | 0.432 | **0.420** | 0.448 | 0.500 | 0.482 |
| | 336 | 0.474 | **0.439** | 0.518 | 0.477 | 0.569 | 0.551 | 0.491 | 0.469 | 0.509 | 0.492 | 0.481 | 0.459 | **0.459** | 0.465 | 0.521 | 0.496 |
| | 720 | **0.472** | **0.457** | 0.522 | 0.490 | 0.770 | 0.672 | 0.521 | 0.500 | 0.696 | 0.632 | 0.519 | 0.516 | 0.506 | 0.507 | 0.514 | 0.512 |
| | Avg | **0.439** | **0.425** | 0.470 | 0.452 | 0.558 | 0.535 | 0.460 | 0.455 | 0.518 | 0.503 | 0.455 | 0.451 | 0.440 | 0.459 | 0.496 | 0.487 |
| ETTh2 | 96 | **0.289** | **0.337** | 0.297 | 0.347 | 0.299 | 0.364 | 0.340 | 0.374 | 0.402 | 0.425 | 0.333 | 0.387 | 0.358 | 0.397 | 0.346 | 0.388 |
| | 192 | **0.375** | **0.391** | 0.390 | 0.403 | 0.441 | 0.454 | 0.402 | 0.414 | 0.452 | 0.456 | 0.477 | 0.476 | 0.429 | 0.439 | 0.456 | 0.452 |
| | 336 | **0.416** | **0.428** | 0.417 | 0.429 | 0.654 | 0.567 | 0.452 | 0.452 | 0.533 | 0.506 | 0.594 | 0.541 | 0.496 | 0.487 | 0.482 | 0.486 |
| | 720 | **0.423** | **0.445** | 0.432 | 0.448 | 0.956 | 0.716 | 0.462 | 0.468 | 0.577 | 0.557 | 0.831 | 0.657 | 0.463 | 0.474 | 0.515 | 0.511 |
| | Avg | **0.375** | **0.400** | 0.384 | 0.406 | 0.587 | 0.525 | 0.414 | 0.427 | 0.491 | 0.486 | 0.558 | 0.515 | 0.436 | 0.449 | 0.449 | 0.459 |
| ILI | 24 | 2.445 | 0.963 | **1.743** | **0.814** | 2.684 | 1.112 | 2.317 | 0.934 | 4.721 | 1.524 | 2.398 | 1.040 | 3.228 | 1.260 | 3.483 | 1.287 |
| | 36 | 2.465 | 1.008 | **1.579** | **0.804** | 2.667 | 1.068 | 1.972 | 0.920 | 4.148 | 1.379 | 2.646 | 1.088 | 2.679 | 1.080 | 3.103 | 1.148 |
| | 48 | 2.296 | 0.961 | **2.199** | **0.897** | 2.558 | 1.052 | 2.238 | 0.940 | 4.023 | 1.354 | 2.614 | 1.086 | 2.622 | 1.078 | 2.669 | 1.085 |
| | 60 | 2.348 | 0.977 | **1.813** | **0.868** | 2.747 | 1.110 | 2.027 | 0.928 | 4.114 | 1.369 | 2.804 | 1.146 | 2.857 | 1.157 | 2.770 | 1.125 |
| | Avg | 2.388 | 0.977 | **1.833** | **0.845** | 2.664 | 1.085 | 2.138 | 0.930 | 4.251 | 1.406 | 2.615 | 1.090 | 2.846 | 1.143 | 3.006 | 1.161 |
| exchange | 96 | **0.082** | **0.198** | **0.082** | **0.198** | 0.099 | 0.240 | 0.107 | 0.234 | 0.253 | 0.364 | 0.088 | 0.218 | 0.148 | 0.278 | 0.197 | 0.323 |
| | 192 | **0.173** | **0.294** | **0.173** | 0.295 | 0.198 | 0.354 | 0.226 | 0.344 | 0.482 | 0.517 | 0.176 | 0.315 | 0.271 | 0.380 | 0.300 | 0.369 |
| | 336 | 0.327 | **0.412** | 0.333 | 0.415 | **0.302** | 0.447 | 0.367 | 0.448 | 0.908 | 0.748 | 0.313 | 0.427 | 0.460 | 0.500 | 0.509 | 0.524 |
| | 720 | 0.911 | 0.722 | 0.880 | 0.700 | **0.738** | **0.662** | 0.964 | 0.746 | 1.414 | 0.975 | 0.839 | 0.695 | 1.195 | 0.841 | 1.447 | 0.941 |
| | Avg | 0.373 | 0.406 | 0.367 | **0.402** | **0.334** | 0.425 | 0.416 | 0.443 | 0.764 | 0.651 | 0.354 | 0.413 | 0.518 | 0.499 | 0.613 | 0.539 |
| weather | 96 | 0.164 | 0.223 | 0.177 | **0.218** | **0.161** | 0.229 | 0.172 | 0.220 | 0.162 | 0.231 | 0.196 | 0.255 | 0.217 | 0.296 | 0.266 | 0.336 |
| | 192 | 0.213 | 0.268 | 0.225 | **0.259** | 0.220 | 0.281 | 0.219 | 0.261 | **0.211** | 0.281 | 0.237 | 0.296 | 0.276 | 0.336 | 0.307 | 0.367 |
| | 336 | 0.271 | 0.313 | 0.275 | **0.296** | 0.278 | 0.331 | 0.280 | 0.306 | **0.270** | 0.328 | 0.283 | 0.335 | 0.339 | 0.380 | 0.359 | 0.395 |
| | 720 | 0.354 | 0.370 | 0.351 | **0.346** | **0.311** | 0.356 | 0.365 | 0.359 | 0.352 | 0.382 | 0.345 | 0.381 | 0.403 | 0.428 | 0.419 | 0.428 |
| | Avg | 0.250 | 0.293 | 0.257 | **0.279** | **0.242** | 0.299 | 0.259 | 0.286 | 0.248 | 0.305 | 0.265 | 0.316 | 0.308 | 0.360 | 0.337 | 0.381 |
| traffic | 96 | **0.421** | 0.344 | 0.540 | 0.357 | 0.519 | 0.309 | 0.593 | 0.321 | 0.512 | **0.288** | 0.650 | 0.396 | 0.587 | 0.366 | 0.613 | 0.388 |
| | 192 | **0.452** | 0.350 | 0.536 | 0.352 | 0.537 | 0.315 | 0.617 | 0.336 | 0.538 | **0.297** | 0.598 | 0.370 | 0.604 | 0.373 | 0.616 | 0.382 |
| | 336 | **0.475** | 0.362 | 0.547 | 0.355 | 0.534 | **0.313** | 0.629 | 0.336 | 0.569 | 0.315 | 0.605 | 0.373 | 0.621 | 0.383 | 0.622 | 0.337 |
| | 720 | **0.483** | 0.371 | 0.541 | 0.330 | 0.577 | **0.325** | 0.640 | 0.350 | 0.613 | 0.336 | 0.645 | 0.394 | 0.626 | 0.382 | 0.660 | 0.408 |
| | Avg | **0.457** | 0.356 | 0.541 | 0.348 | 0.541 | 0.315 | 0.619 | 0.335 | 0.558 | **0.309** | 0.624 | 0.383 | 0.609 | 0.376 | 0.627 | 0.378 |
| ECL | 96 | 0.167 | **0.259** | 0.208 | 0.297 | **0.164** | 0.269 | 0.168 | 0.272 | 0.224 | 0.310 | 0.197 | 0.282 | 0.193 | 0.308 | 0.201 | 0.317 |
| | 192 | **0.177** | **0.265** | 0.198 | 0.288 | **0.177** | 0.285 | 0.184 | 0.289 | 0.281 | 0.345 | 0.196 | 0.285 | 0.201 | 0.315 | 0.222 | 0.334 |
| | 336 | **0.193** | **0.282** | 0.200 | 0.285 | **0.193** | 0.304 | 0.198 | 0.300 | 0.351 | 0.394 | 0.209 | 0.301 | 0.214 | 0.329 | 0.231 | 0.338 |
| | 720 | 0.232 | **0.317** | 0.241 | 0.318 | **0.212** | 0.321 | 0.220 | 0.320 | 0.426 | 0.439 | 0.245 | 0.333 | 0.246 | 0.355 | 0.254 | 0.361 |
| | Avg | 0.192 | **0.280** | 0.211 | 0.297 | **0.186** | 0.294 | 0.192 | 0.295 | 0.320 | 0.372 | 0.211 | 0.300 | 0.213 | 0.326 | 0.227 | 0.337 |
| 1st count | | **50** | | 21 | | 16 | | 0 | | 5 | | 0 | | 3 | | 0 | |

∗ We replace the input length L=96 in PatchTST and Crossformer for a fair comparison. Other experimental results are taken from the TimesNet and MICN.

Table 10: All results for univariate long-input length prediction. The input sequence length is set to 104 for the ILI dataset and 336 for the others. Avg is the averaged result from all four prediction lengths. The 1st count indicates the numbers of the performance.

| Methods | | **WinNet (Ours)** | | PatchTST (2023) | | TimesNet* (2023) | | MICN* (2023) | | DLinear (2023) | | FEDformer (2022) | | Autoformer (2021) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | **0.025** | **0.120** | 0.026 | 0.121 | 0.028 | 0.126 | 0.027 | 0.123 | 0.028 | 0.123 | 0.033 | 0.140 | 0.056 | 0.183 |
| | 192 | **0.038** | **0.148** | 0.039 | 0.150 | 0.048 | 0.167 | 0.043 | 0.154 | 0.045 | 0.156 | 0.058 | 0.186 | 0.081 | 0.216 |
| | 336 | **0.051** | **0.171** | 0.053 | 0.173 | 0.060 | 0.188 | 0.052 | 0.173 | 0.061 | 0.182 | 0.084 | 0.231 | 0.076 | 0.218 |
| | 720 | **0.062** | **0.189** | 0.074 | 0.207 | 0.076 | 0.213 | 0.075 | 0.206 | 0.080 | 0.210 | 0.102 | 0.250 | 0.110 | 0.267 |
| | Avg | **0.044** | **0.157** | 0.048 | 0.162 | 0.053 | 0.173 | 0.049 | 0.164 | 0.053 | 0.167 | 0.069 | 0.201 | 0.080 | 0.221 |
| ETTm2 | 96 | **0.062** | **0.181** | 0.065 | 0.186 | 0.076 | 0.206 | 0.063 | 0.183 | 0.063 | **0.183** | 0.067 | 0.198 | 0.065 | 0.189 |
| | 192 | **0.090** | **0.224** | 0.094 | 0.231 | 0.107 | 0.251 | 0.091 | 0.225 | 0.092 | 0.227 | 0.102 | 0.245 | 0.118 | 0.256 |
| | 336 | **0.116** | **0.258** | 0.120 | 0.265 | 0.135 | 0.284 | 0.121 | 0.265 | 0.119 | 0.261 | 0.130 | 0.279 | 0.154 | 0.305 |
| | 720 | **0.168** | **0.318** | 0.171 | 0.322 | 0.210 | 0.362 | 0.172 | 0.317 | 0.175 | 0.320 | 0.178 | 0.325 | 0.182 | 0.335 |
| | Avg | **0.109** | **0.245** | 0.112 | 0.251 | 0.132 | 0.275 | 0.111 | 0.247 | 0.112 | 0.247 | 0.119 | 0.261 | 0.129 | 0.271 |
| ETTh1 | 96 | **0.052** | **0.176** | 0.055 | 0.179 | 0.062 | 0.195 | 0.059 | 0.190 | 0.056 | 0.180 | 0.079 | 0.215 | 0.071 | 0.206 |
| | 192 | **0.068** | **0.203** | 0.071 | 0.205 | 0.080 | 0.225 | 0.087 | 0.235 | 0.071 | 0.204 | 0.104 | 0.245 | 0.114 | 0.262 |
| | 336 | 0.080 | **0.225** | 0.081 | **0.225** | **0.075** | **0.215** | 0.089 | 0.237 | 0.098 | 0.244 | 0.119 | 0.270 | 0.107 | 0.258 |
| | 720 | **0.079** | **0.225** | 0.087 | 0.232 | **0.079** | **0.225** | 0.176 | 0.343 | 0.189 | 0.359 | 0.142 | 0.299 | 0.126 | 0.283 |
| | Avg | **0.069** | **0.207** | 0.073 | 0.210 | 0.074 | 0.215 | 0.102 | 0.251 | 0.103 | 0.246 | 0.111 | 0.257 | 0.104 | 0.252 |
| ETTh2 | 96 | **0.128** | 0.277 | 0.129 | 0.282 | 0.151 | 0.310 | 0.128 | 0.271 | 0.131 | 0.279 | **0.128** | **0.271** | 0.153 | 0.306 |
| | 192 | **0.168** | **0.324** | **0.168** | 0.328 | 0.179 | 0.337 | 0.175 | 0.328 | 0.176 | 0.329 | 0.185 | 0.330 | 0.204 | 0.351 |
| | 336 | 0.194 | 0.355 | **0.185** | **0.351** | 0.195 | 0.356 | 0.192 | 0.354 | 0.209 | 0.367 | 0.231 | 0.378 | 0.246 | 0.389 |
| | 720 | 0.222 | 0.380 | 0.224 | 0.383 | **0.195** | **0.363** | 0.268 | 0.418 | 0.276 | 0.426 | 0.278 | 0.420 | 0.268 | 0.409 |
| | Avg | 0.178 | **0.334** | **0.176** | 0.336 | 0.180 | 0.341 | 0.190 | 0.342 | 0.198 | 0.350 | 0.205 | 0.349 | 0.217 | 0.363 |
| weather | 96 | **0.0010** | **0.0237** | 0.0012 | 0.0256 | 0.0012 | 0.0257 | 0.0059 | 0.0645 | 0.0055 | 0.0617 | 0.0042 | 0.0533 | 0.0034 | 0.0467 |
| | 192 | **0.0012** | 0.0269 | 0.0013 | **0.0268** | 0.0013 | 0.0281 | 0.0063 | 0.0674 | 0.0061 | 0.0659 | 0.0067 | 0.0669 | 0.0039 | 0.0482 |
| | 336 | **0.0014** | 0.0284 | **0.0014** | **0.0283** | 0.0015 | 0.0298 | 0.0075 | 0.0748 | 0.0064 | 0.0678 | 0.0024 | 0.0394 | 0.0077 | 0.0633 |
| | 720 | **0.0019** | 0.0333 | **0.0019** | **0.0324** | 0.0020 | 0.0345 | 0.0059 | 0.0634 | 0.0068 | 0.0706 | 0.0038 | 0.0510 | 0.0103 | 0.0743 |
| | Avg | **0.0013** | **0.0280** | 0.0014 | 0.0282 | 0.0015 | 0.0295 | 0.0064 | 0.0675 | 0.0062 | 0.0665 | 0.0042 | 0.0526 | 0.0063 | 0.0581 |
| exchange | 96 | **0.098** | **0.232** | 0.162 | 0.314 | 0.156 | 0.293 | 0.150 | 0.328 | 0.111 | 0.262 | 0.369 | 0.475 | 0.418 | 0.516 |
| | 192 | **0.210** | **0.341** | 0.273 | 0.411 | 0.264 | 0.375 | 0.211 | 0.377 | 0.229 | 0.391 | 0.511 | 0.551 | 0.538 | 0.591 |
| | 336 | **0.412** | **0.480** | 0.479 | 0.538 | 0.501 | 0.536 | 0.440 | 0.524 | 0.427 | 0.514 | 0.713 | 0.635 | 0.978 | 0.760 |
| | 720 | 1.218 | 0.836 | **0.912** | **0.770** | 1.411 | 0.937 | 1.337 | 0.943 | 1.500 | 1.009 | 1.307 | 0.888 | 1.223 | 0.857 |
| | Avg | 0.484 | 0.472 | **0.456** | **0.508** | 0.583 | 0.535 | 0.534 | 0.543 | 0.566 | 0.544 | 0.725 | 0.637 | 0.789 | 0.681 |
| ECL | 96 | **0.202** | **0.314** | 0.247 | 0.348 | 0.227 | 0.338 | 0.244 | 0.355 | 0.208 | 0.321 | 0.396 | 0.471 | 0.482 | 0.519 |
| | 192 | 0.239 | **0.341** | 0.315 | 0.389 | 0.286 | 0.382 | 0.295 | 0.395 | **0.238** | 0.342 | 0.376 | 0.460 | 0.574 | 0.568 |
| | 336 | 0.276 | **0.369** | 0.490 | 0.494 | 0.326 | 0.401 | 0.333 | 0.428 | **0.273** | **0.369** | 0.522 | 0.543 | 0.587 | 0.581 |
| | 720 | 0.317 | 0.413 | 0.550 | 0.540 | **0.392** | **0.455** | 0.397 | 0.472 | **0.310** | **0.411** | 0.531 | 0.555 | 0.564 | 0.567 |
| | Avg | 0.258 | 0.359 | 0.400 | 0.442 | 0.307 | 0.394 | 0.317 | 0.412 | **0.257** | **0.360** | 0.456 | 0.507 | 0.551 | 0.558 |
| traffic | 96 | **0.126** | **0.207** | 0.134 | 0.211 | 0.144 | 0.232 | 0.150 | 0.249 | 0.139 | 0.230 | 0.250 | 0.355 | 0.280 | 0.388 |
| | 192 | **0.131** | **0.214** | 0.139 | 0.219 | 0.142 | 0.228 | 0.146 | 0.225 | 0.140 | 0.232 | 0.216 | 0.325 | 0.292 | 0.398 |
| | 336 | **0.129** | **0.217** | 0.138 | 0.221 | 0.139 | 0.229 | 0.152 | 0.239 | 0.142 | 0.236 | 0.331 | 0.428 | 0.241 | 0.354 |
| | 720 | **0.143** | **0.233** | 0.154 | 0.244 | 0.153 | 0.250 | 0.161 | 0.249 | 0.157 | 0.254 | 0.414 | 0.487 | 0.240 | 0.341 |
| | Avg | **0.132** | **0.217** | 0.141 | 0.223 | 0.144 | 0.234 | 0.152 | 0.240 | 0.144 | 0.238 | 0.302 | 0.398 | 0.263 | 0.370 |
| ILI | 24 | **0.619** | **0.557** | 0.845 | 0.651 | 0.698 | 0.661 | 2.356 | 1.209 | 0.742 | 0.661 | 1.024 | 0.880 | 0.928 | 0.834 |
| | 36 | 0.677 | **0.602** | 0.698 | 0.624 | 0.708 | 0.680 | 0.646 | 0.616 | **0.553** | 0.613 | 1.009 | 0.897 | 0.942 | 0.838 |
| | 48 | **0.683** | **0.633** | 0.806 | 0.711 | 0.792 | 0.740 | 0.955 | 0.859 | 0.700 | 0.706 | 1.014 | 0.886 | 1.032 | 0.881 |
| | 60 | **0.683** | **0.663** | 0.827 | 0.753 | 0.911 | 0.814 | 1.162 | 0.970 | 0.863 | 0.801 | 1.384 | 1.025 | 1.657 | 1.171 |
| | Avg | **0.665** | **0.613** | 0.794 | 0.684 | 0.777 | 0.723 | 1.279 | 0.913 | 0.714 | 0.695 | 1.107 | 0.922 | 1.139 | 0.931 |
| 1st count | | **67** | | 15 | | 8 | | 0 | | 9 | | 2 | | 0 | |

∗ We replace the input length L=336 in TimesNet and MICN for a fair comparison. Other experimental results are taken from the PatchTST.

Figure 8: Visualization of prediction on ETTm2 with the look-back window L=336.

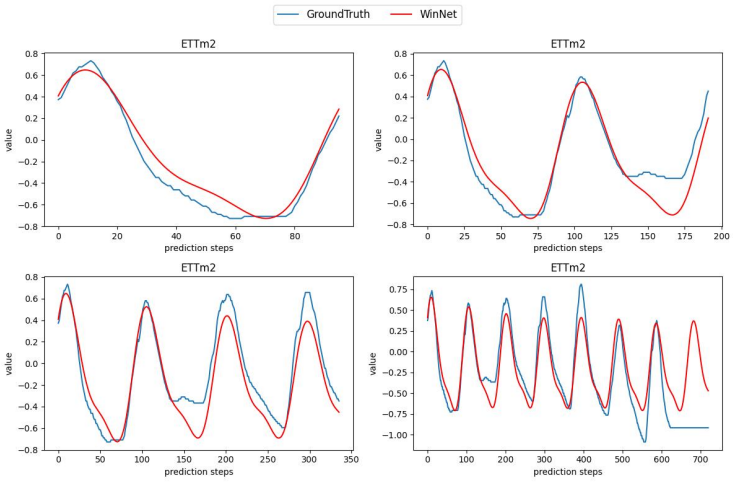



Figure 9: Visualization of prediction on ETTh1 with the look-back window L=336.

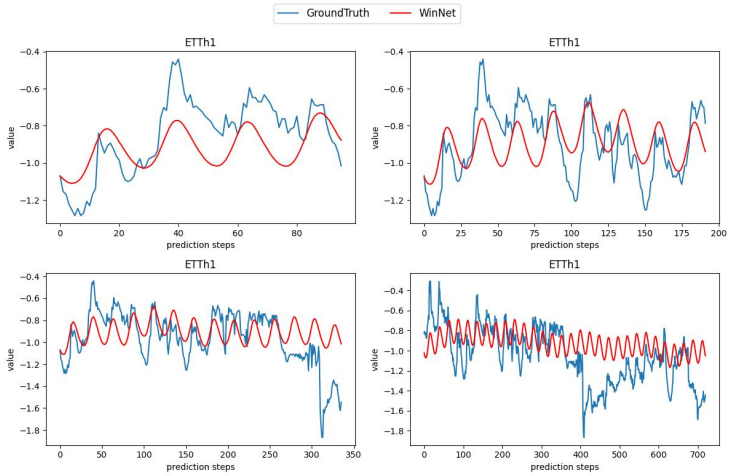



Figure 10: Visualization of prediction on ECL with the look-back window L=336.

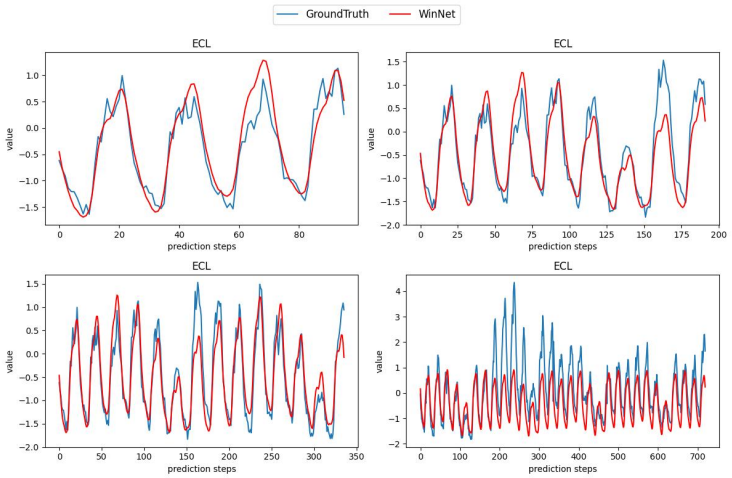


Figure 11: Visualization of prediction on ETTh2 with the look-back window L=336.

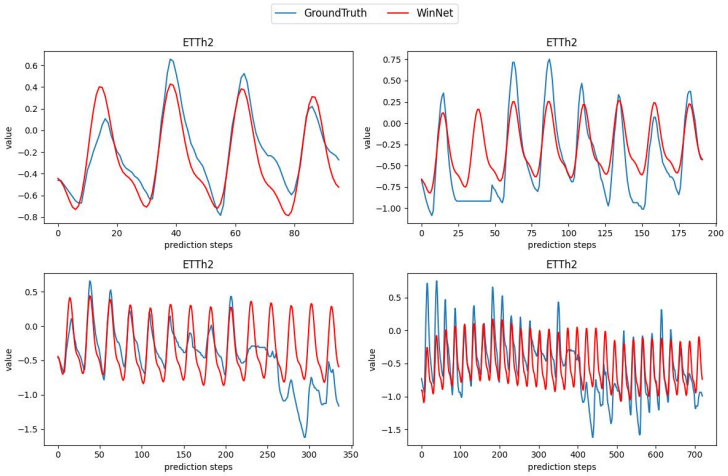



Figure 12: Visualization of prediction on ETTm1 with the look-back window L=336.

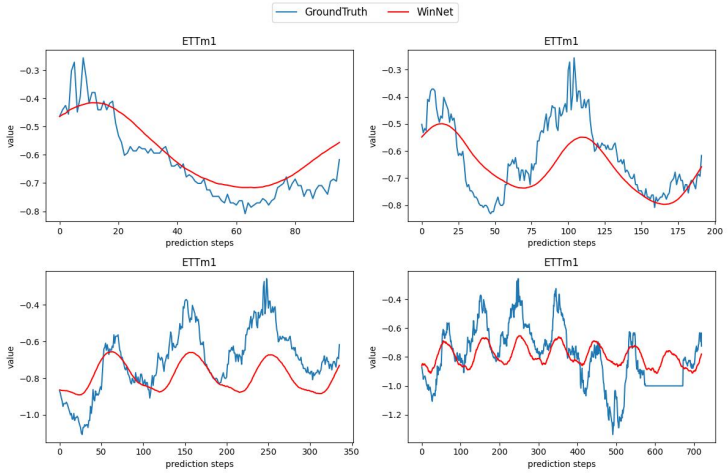



Figure 13: Visualization of prediction on ILI with the look-back window L=104.

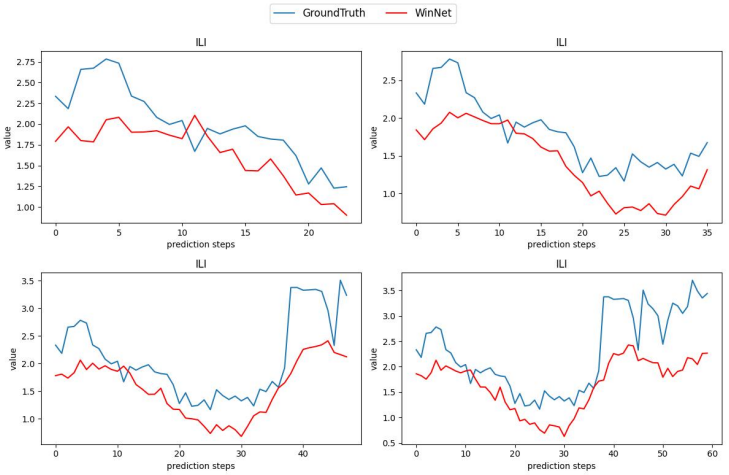


Table 11: Period frequencies obtained by FFT for each dataset before MLP. The 1st period represents the period with the highest number of occurrences, and so on. Period represents the specific value of periods and count represents the number of occurrences. It can be seen that most datasets have large periods, difficult to capture the periodicity through CNNs.

| topk periods | 1st period | | 2nd period | | 3rd period | | 4th period | |
|---|---|---|---|---|---|---|---|---|
| statistics | period | count | period | count | period | count | period | count |
| weather | 168 | 759 | 336 | 759 | 112 | 759 | 67 | 759 |
| ETTm1 | 112 | 711 | 84 | 711 | 336 | 711 | 168 | 711 |
| ECL | 168 | 374 | 336 | 294 | 84 | 235 | 112 | 234 |
| ETTm2 | 336 | 711 | 112 | 711 | 84 | 711 | 168 | 711 |
| ETTh1 | 24 | 171 | 336 | 171 | 12 | 171 | 168 | 171 |
| traffic | 24 | 246 | 12 | 246 | 8 | 246 | 168 | 246 |
| exchange | 336 | 101 | 168 | 101 | 112 | 101 | 84 | 101 |
| ETTh2 | 336 | 171 | 24 | 171 | 168 | 171 | 112 | 171 |

Figure 14: Period Window. The samples with same colour in each row represent time steps in a same period. A sequence can obtain its top-k period values by FFT. The 1st period indicates the most dominant period in the sequence, and so on. For example, the top-3 periods are $\{6, 4, 3\}$ and approximated multiples of these periods are selected as the size of the periodic window, i.e. 12.

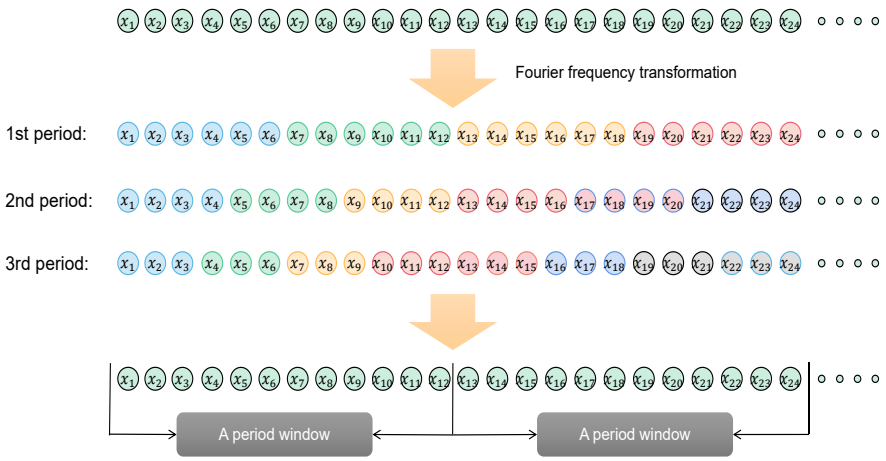


Table 12: Ablation study with different sizes of the periodic window.

| Methods | | WinNet | | | | | | TimesNet* | | DLinear | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18 | | 24 | | 32 | | | | | |
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | 0.282 | 0.336 | 0.283 | **0.335** | **0.279** | 0.334 | 0.377 | 0.397 | 0.290 | 0.342 |
| | 192 | **0.319** | **0.357** | 0.324 | 0.360 | 0.323 | 0.361 | 0.389 | 0.401 | 0.332 | 0.369 |
| | 336 | **0.354** | **0.379** | 0.357 | **0.379** | **0.354** | 0.382 | 0.393 | 0.414 | 0.366 | 0.392 |
| | 720 | 0.419 | 0.412 | 0.416 | **0.411** | **0.408** | 0.414 | 0.470 | 0.458 | 0.420 | 0.424 |
| ETTm2 | 96 | 0.163 | 0.252 | **0.160** | **0.251** | 0.162 | 0.251 | 0.201 | 0.280 | 0.167 | 0.260 |
| | 192 | 0.216 | 0.290 | **0.212** | **0.287** | 0.216 | 0.291 | 0.242 | 0.313 | 0.224 | 0.303 |
| | 336 | 0.271 | 0.325 | **0.261** | **0.322** | 0.268 | 0.323 | 0.310 | 0.356 | 0.281 | 0.342 |
| | 720 | 0.363 | 0.385 | **0.359** | **0.381** | 0.360 | 0.386 | 0.381 | 0.396 | 0.397 | 0.421 |
| ETTh1 | 96 | 0.367 | 0.392 | **0.362** | **0.390** | 0.374 | 0.397 | 0.460 | 0.464 | 0.375 | 0.399 |
| | 192 | 0.402 | 0.413 | **0.394** | **0.410** | 0.409 | 0.420 | 0.458 | 0.462 | 0.412 | 0.420 |
| | 336 | 0.426 | 0.428 | **0.419** | **0.426** | 0.427 | 0.430 | 0.523 | 0.501 | 0.439 | 0.443 |
| | 720 | 0.442 | 0.454 | 0.436 | 0.453 | **0.434** | **0.451** | 0.502 | 0.497 | 0.472 | 0.490 |
| ETTh2 | 96 | 0.271 | 0.333 | **0.267** | **0.332** | 0.275 | 0.337 | 0.338 | 0.397 | 0.289 | 0.353 |
| | 192 | 0.326 | 0.374 | **0.322** | **0.372** | 0.337 | 0.377 | 0.422 | 0.446 | 0.383 | 0.418 |
| | 336 | 0.356 | **0.400** | **0.351** | 0.401 | 0.368 | 0.414 | 0.431 | 0.460 | 0.448 | 0.465 |
| | 720 | 0.395 | 0.437 | **0.389** | **0.436** | 0.406 | 0.448 | 0.467 | 0.480 | 0.605 | 0.551 |
| weather | 96 | 0.151 | 0.207 | **0.143** | **0.198** | 0.146 | 0.202 | 0.163 | 0.223 | 0.176 | 0.237 |
| | 192 | 0.196 | 0.253 | **0.188** | **0.240** | 0.191 | 0.245 | 0.218 | 0.266 | 0.192 | 0.246 |
| | 336 | 0.245 | 0.288 | **0.235** | **0.280** | 0.239 | 0.289 | 0.280 | 0.306 | 0.240 | 0.287 |
| | 720 | 0.319 | 0.341 | **0.310** | **0.336** | 0.315 | 0.345 | 0.349 | 0.356 | 0.316 | 0.352 |
| ECL | 96 | 0.141 | 0.238 | **0.130** | **0.226** | 0.142 | 0.240 | 0.181 | 0.281 | 0.140 | 0.237 |
| | 192 | 0.155 | 0.251 | **0.147** | **0.240** | 0.157 | 0.253 | 0.193 | 0.293 | 0.153 | 0.249 |
| | 336 | 0.172 | 0.268 | **0.163** | **0.257** | 0.174 | 0.270 | 0.205 | 0.312 | 0.169 | 0.267 |
| | 720 | 0.211 | 0.300 | **0.198** | **0.290** | 0.212 | 0.301 | 0.222 | 0.320 | 0.203 | 0.301 |
| ILI | 24 | 1.987 | 0.906 | **1.985** | **0.905** | 2.031 | 0.934 | 2.500 | 1.055 | 2.215 | 1.081 |
| | 36 | 1.928 | 0.915 | 1.897 | **0.900** | **1.889** | 0.902 | 2.222 | 1.007 | 1.963 | 0.963 |
| | 48 | 1.904 | 0.919 | **1.868** | **0.910** | 1.902 | 0.922 | 2.304 | 1.043 | 2.130 | 1.024 |
| | 60 | 2.066 | 0.976 | **1.928** | **0.933** | 2.012 | 0.958 | 2.354 | 1.046 | 2.368 | 1.096 |

$*$ We replace the input length L=512 in TimesNet and MICN for a fair comparison.

Table 13: Prediction error (MSE & MAE) with different kernel size on 3 datasets: weather, ECL and traffic.

| Methods | | WinNet | | | | | | TimesNet* | | DLinear | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3x3 | | 5x5 | | 7x7 | | | | | |
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| weather | 96 | 0.143 | **0.198** | **0.141** | 0.239 | 0.150 | 0.203 | 0.163 | 0.223 | 0.176 | 0.237 |
| | 192 | **0.188** | **0.240** | 0.193 | 0.245 | 0.193 | 0.244 | 0.218 | 0.266 | 0.192 | 0.246 |
| | 336 | **0.235** | **0.280** | 0.243 | 0.285 | 0.244 | 0.287 | 0.280 | 0.306 | 0.240 | 0.287 |
| | 720 | **0.310** | **0.336** | 0.323 | 0.346 | 0.318 | 0.340 | 0.349 | 0.356 | 0.316 | 0.352 |
| ECL | 96 | **0.130** | **0.226** | 0.141 | 0.239 | 0.140 | 0.238 | 0.181 | 0.281 | 0.140 | 0.237 |
| | 192 | **0.147** | **0.240** | 0.161 | 0.258 | 0.161 | 0.258 | 0.193 | 0.293 | 0.153 | 0.249 |
| | 336 | **0.163** | **0.257** | 0.178 | 0.274 | 0.178 | 0.274 | 0.205 | 0.312 | 0.169 | 0.267 |
| | 720 | **0.198** | **0.290** | 0.212 | 0.301 | 0.216 | 0.306 | 0.222 | 0.320 | 0.203 | 0.301 |
| traffic | 96 | **0.394** | **0.274** | 0.414 | 0.287 | 0.415 | 0.289 | 0.603 | 0.328 | 0.410 | 0.282 |
| | 192 | **0.407** | **0.279** | 0.426 | 0.294 | 0.428 | 0.295 | 0.610 | 0.329 | 0.423 | 0.287 |
| | 336 | **0.416** | **0.283** | 0.436 | 0.295 | 0.439 | 0.297 | 0.619 | 0.330 | 0.436 | 0.296 |
| | 720 | **0.453** | **0.305** | 0.464 | 0.310 | 0.467 | 0.313 | 0.632 | 0.352 | 0.466 | 0.315 |

$*$ We replace the input length L=512 in TimesNet for a fair comparison.

Table 14: Ablation study the fusion mode of inter-period and intra-period on all datasets in WinNet. NF means the normal fusion, while DF means no transposition, direct fusion.

| Methods | | WinNet | | | | TimeNet* | | DLinear | |
|---|---|---|---|---|---|---|---|---|---|
| | | DF | | NF | | | | | |
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | **0.283** | **0.335** | 0.286 | 0.337 | 0.377 | 0.397 | 0.290 | 0.342 |
| | 192 | **0.324** | **0.360** | 0.326 | 0.360 | 0.389 | 0.401 | 0.332 | 0.369 |
| | 336 | **0.357** | **0.379** | 0.366 | 0.381 | 0.393 | 0.414 | 0.366 | 0.392 |
| | 720 | **0.416** | **0.411** | 0.421 | 0.414 | 0.470 | 0.458 | 0.420 | 0.424 |
| ETTm2 | 96 | **0.160** | **0.251** | 0.162 | 0.252 | 0.201 | 0.280 | 0.167 | 0.260 |
| | 192 | **0.212** | **0.287** | 0.217 | 0.290 | 0.242 | 0.313 | 0.224 | 0.303 |
| | 336 | **0.261** | **0.322** | 0.273 | 0.326 | 0.310 | 0.356 | 0.281 | 0.342 |
| | 720 | **0.359** | **0.381** | 0.363 | 0.384 | 0.381 | 0.396 | 0.397 | 0.421 |
| ETTh1 | 96 | **0.362** | **0.390** | 0.369 | 0.393 | 0.460 | 0.464 | 0.375 | 0.399 |
| | 192 | **0.394** | **0.410** | 0.409 | 0.419 | 0.458 | 0.462 | 0.412 | 0.420 |
| | 336 | **0.419** | **0.426** | 0.432 | 0.432 | 0.523 | 0.501 | 0.439 | 0.443 |
| | 720 | **0.436** | **0.453** | 0.438 | 0.456 | 0.502 | 0.497 | 0.472 | 0.490 |
| ETTh2 | 96 | **0.267** | **0.332** | 0.270 | 0.335 | 0.338 | 0.397 | 0.289 | 0.353 |
| | 192 | **0.322** | **0.372** | 0.330 | 0.376 | 0.422 | 0.446 | 0.383 | 0.418 |
| | 336 | **0.351** | **0.401** | 0.385 | 0.413 | 0.431 | 0.460 | 0.448 | 0.465 |
| | 720 | **0.389** | **0.436** | 0.424 | 0.464 | 0.467 | 0.480 | 0.605 | 0.551 |
| weather | 96 | **0.143** | **0.198** | 0.154 | 0.206 | 0.163 | 0.223 | 0.176 | 0.237 |
| | 192 | **0.188** | **0.240** | 0.193 | 0.246 | 0.218 | 0.266 | 0.192 | 0.246 |
| | 336 | **0.235** | **0.280** | 0.244 | 0.285 | 0.280 | 0.306 | 0.240 | 0.287 |
| | 720 | **0.310** | **0.336** | 0.321 | 0.342 | 0.349 | 0.356 | 0.316 | 0.352 |
| ECL | 96 | **0.130** | **0.226** | 0.141 | 0.239 | 0.181 | 0.281 | 0.140 | 0.237 |
| | 192 | **0.147** | **0.240** | 0.156 | 0.252 | 0.193 | 0.293 | 0.153 | 0.249 |
| | 336 | **0.163** | **0.257** | 0.173 | 0.269 | 0.205 | 0.312 | 0.169 | 0.267 |
| | 720 | **0.198** | **0.290** | 0.211 | 0.300 | 0.222 | 0.320 | 0.203 | 0.301 |
| traffic | 96 | **0.394** | **0.274** | 0.414 | 0.288 | 0.603 | 0.328 | 0.410 | 0.282 |
| | 192 | **0.407** | **0.279** | 0.427 | 0.294 | 0.610 | 0.329 | 0.423 | 0.287 |
| | 336 | **0.416** | **0.283** | 0.435 | 0.296 | 0.619 | 0.330 | 0.436 | 0.296 |
| | 720 | **0.453** | **0.305** | 0.465 | 0.312 | 0.632 | 0.352 | 0.466 | 0.315 |
| ILI | 96 | **1.985** | **0.905** | 2.003 | 0.923 | 2.500 | 1.055 | 2.215 | 1.081 |
| | 192 | **1.897** | **0.900** | 1.906 | 0.909 | 2.222 | 1.007 | 1.963 | 0.963 |
| | 336 | **1.868** | **0.910** | 1.925 | 0.930 | 2.304 | 1.043 | 2.130 | 1.024 |
| | 720 | **1.928** | **0.933** | 1.937 | 0.934 | 2.354 | 1.046 | 2.368 | 1.096 |

$*$ We replace the input length L=512 in TimesNet for a fair comparison.

Table 15: Prediction error (MSE & MAE) with different kernel sizes on 5 datasets: ETTm1, ETTm2, ETTh1, ETTh2 and ILI.

| Methods | | WinNet | | | | | | TimesNet* | | DLinear | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3x3 | | 5x5 | | 7x7 | | | | | |
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | **0.283** | **0.335** | 0.288 | 0.339 | 0.286 | 0.338 | 0.377 | 0.397 | 0.290 | 0.342 |
| | 192 | **0.324** | **0.360** | 0.335 | 0.368 | 0.329 | 0.364 | 0.389 | 0.401 | 0.332 | 0.369 |
| | 336 | **0.357** | **0.379** | 0.370 | 0.385 | 0.366 | 0.380 | 0.393 | 0.414 | 0.366 | 0.392 |
| | 720 | **0.416** | **0.411** | 0.423 | 0.414 | 0.422 | 0.413 | 0.470 | 0.458 | 0.420 | 0.424 |
| ETTm2 | 96 | **0.160** | **0.251** | 0.163 | 0.252 | 0.162 | 0.252 | 0.201 | 0.280 | 0.167 | 0.260 |
| | 192 | **0.212** | **0.287** | 0.216 | 0.289 | 0.217 | 0.290 | 0.242 | 0.313 | 0.224 | 0.303 |
| | 336 | **0.261** | 0.322 | 0.267 | **0.321** | 0.269 | 0.324 | 0.310 | 0.356 | 0.281 | 0.342 |
| | 720 | **0.359** | **0.381** | 0.361 | 0.382 | 0.375 | 0.387 | 0.381 | 0.396 | 0.397 | 0.421 |
| ETTh1 | 96 | **0.362** | **0.390** | 0.368 | 0.392 | 0.366 | 0.392 | 0.460 | 0.464 | 0.375 | 0.399 |
| | 192 | **0.394** | **0.410** | 0.410 | 0.420 | 0.425 | 0.434 | 0.458 | 0.462 | 0.412 | 0.420 |
| | 336 | **0.419** | **0.426** | 0.436 | 0.434 | 0.442 | 0.442 | 0.523 | 0.501 | 0.439 | 0.443 |
| | 720 | 0.436 | 0.453 | **0.435** | **0.453** | 0.436 | **0.453** | 0.502 | 0.497 | 0.472 | 0.490 |
| ETTh2 | 96 | **0.267** | **0.332** | 0.274 | 0.337 | 0.270 | 0.334 | 0.338 | 0.397 | 0.289 | 0.353 |
| | 192 | **0.322** | **0.372** | 0.337 | 0.378 | 0.360 | 0.399 | 0.422 | 0.446 | 0.383 | 0.418 |
| | 336 | **0.351** | **0.401** | 0.376 | 0.409 | 0.364 | 0.409 | 0.431 | 0.460 | 0.448 | 0.465 |
| | 720 | **0.389** | **0.436** | 0.502 | 0.532 | 0.418 | 0.458 | 0.467 | 0.480 | 0.605 | 0.551 |
| ILI | 24 | **1.985** | **0.905** | 2.034 | 0.923 | 1.966 | 0.900 | 2.500 | 1.055 | 2.215 | 1.081 |
| | 36 | **1.897** | **0.900** | 1.906 | 0.909 | 1.900 | 0.902 | 2.222 | 1.007 | 1.963 | 0.963 |
| | 48 | **1.868** | **0.910** | 1.925 | 0.930 | 1.906 | 0.922 | 2.304 | 1.043 | 2.130 | 1.024 |
| | 60 | **1.928** | **0.933** | 1.937 | 0.934 | 1.945 | 0.937 | 2.354 | 1.046 | 2.368 | 1.096 |

∗ We replace the input length L=512 in TimesNet for a fair comparison.

Table 16: Ablation study on all ETT datasets of the proposed modules including the I2PE, TDPD and DCB in WinNet. Four cases are included: (a) all the three modules are included in model (Final: I2PE+TDPD+DCB); (b) only the TDPD; (c) TDPD+DCB; (d) the original version with the common CNN and one-dimensional trend decomposition.

| Methods | | WinNet | | | | | | | | TimeNet* | | DLinear | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Final | | TDPD+DCB | | TDPD | | original | | | | | |
| Metric | | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE | MSE | MAE |
| ETTm1 | 96 | **0.283** | **0.335** | 0.288 | 0.341 | 0.289 | 0.341 | 0.292 | 0.352 | 0.377 | 0.397 | 0.290 | 0.342 |
| | 192 | **0.324** | **0.360** | 0.328 | 0.363 | 0.330 | 0.365 | 0.327 | 0.374 | 0.389 | 0.401 | 0.332 | 0.369 |
| | 336 | **0.357** | **0.379** | 0.362 | 0.385 | 0.363 | 0.384 | 0.357 | 0.391 | 0.393 | 0.414 | 0.366 | 0.392 |
| | 720 | 0.416 | **0.411** | **0.409** | 0.413 | 0.428 | 0.421 | **0.409** | 0.423 | 0.470 | 0.458 | 0.420 | 0.424 |
| ETTm2 | 96 | 0.160 | 0.251 | **0.159** | **0.247** | 0.161 | 0.249 | 0.359 | 0.390 | 0.201 | 0.280 | 0.167 | 0.260 |
| | 192 | **0.212** | **0.287** | 0.217 | 0.288 | 0.217 | 0.290 | 0.611 | 0.511 | 0.242 | 0.313 | 0.224 | 0.303 |
| | 336 | **0.261** | **0.322** | 0.270 | 0.326 | 0.268 | 0.324 | 0.855 | 0.613 | 0.310 | 0.356 | 0.281 | 0.342 |
| | 720 | 0.359 | 0.381 | **0.358** | **0.380** | 0.359 | 0.383 | 1.002 | 0.674 | 0.381 | 0.396 | 0.397 | 0.421 |
| ETTh1 | 96 | **0.362** | **0.390** | 0.363 | 0.393 | 0.377 | 0.404 | 0.379 | 0.415 | 0.460 | 0.464 | 0.375 | 0.399 |
| | 192 | **0.394** | **0.410** | 0.397 | 0.415 | 0.402 | 0.418 | 0.411 | 0.438 | 0.458 | 0.462 | 0.412 | 0.420 |
| | 336 | **0.419** | **0.426** | 0.422 | 0.431 | 0.448 | 0.450 | 0.440 | 0.461 | 0.523 | 0.501 | 0.439 | 0.443 |
| | 720 | **0.436** | **0.453** | 0.437 | 0.456 | 0.449 | 0.461 | 0.506 | 0.525 | 0.502 | 0.497 | 0.472 | 0.490 |
| ETTh2 | 96 | 0.267 | **0.332** | **0.264** | **0.332** | 0.269 | 0.333 | 0.842 | 0.622 | 0.338 | 0.397 | 0.289 | 0.353 |
| | 192 | 0.322 | **0.372** | **0.319** | **0.372** | 0.330 | 0.375 | 0.971 | 0.682 | 0.422 | 0.446 | 0.383 | 0.418 |
| | 336 | 0.351 | **0.401** | **0.349** | **0.401** | 0.382 | 0.416 | 1.098 | 0.728 | 0.431 | 0.460 | 0.448 | 0.465 |
| | 720 | **0.389** | **0.436** | 0.391 | 0.437 | 0.398 | 0.443 | 1.428 | 0.854 | 0.467 | 0.480 | 0.605 | 0.551 |

∗ We replace the input length L=512 in TimesNet for a fair comparison.

Table 17: Efficiency of our model on the ECL dataset vs other methods in multivariate prediction. We set the input length to 720 and the prediction length to 720. See relevant computational efficiency with thop, torchsummary and memory_allocated functions.

| Method | FLOPs | Parameter | Time | Memory |
|---|---|---|---|---|
| **WinNet** | **273M** | **836.8K** | 0.42s | **12MiB** |
| PatchTST | 51.1G | 18.18M | 0.17s | 85MiB |
| TimesNet | 1620.1G | 226.3M | 0.70s | 878MiB |
| MICN | 5.95G | 19.07M | 0.04s | 88MiB |
| Crossformer | 146.4G | 11.1M | 0.54s | 96MiB |
| DLinear | 333M | 1.04M | **0.01s** | 14MiB |
| FEDformer | 2.35G | 4.76M | 0.56s | 39MiB |
| Autoformer | 2.35G | 3.19M | 0.26s | 32MiB |
| Informer | 1.84G | 3.35M | 0.14s | 33MiB |
| Transformer | 2.17G | 2.95M | 0.03s | 31MiB |

Table 18: Efficiency of our model on the ETTm1 dataset vs. other methods in multivariate prediction. We set the input length to 720 and the prediction length to 720. See relevant computational efficiency with thop, torchsummary and memory_allocated functions.

| Method | FLOPs | Parameter | Time | Memory |
|---|---|---|---|---|
| **WinNet** | **5.96M** | **830.9K** | 28ms | **11MiB** |
| PatchTST | 309M | 8.69M | 26ms | 44MiB |
| TimesNet | 406.2G | 57.28M | 500ms | 239MiB |
| MICN | 5.33G | 18.75M | 25ms | 85MiB |
| Crossformer | 3.46G | 11.09M | 62ms | 57MiB |
| DLinear | 7.26M | 1.04M | **15ms** | 12MiB |
| FEDformer | 1.75G | 3.96M | 450ms | 24MiB |
| Autoformer | 1.75G | 2.39M | 270ms | 27MiB |
| Informer | 1.42G | 2.78M | 150ms | 29MiB |
| Transformer | 1.75G | 2.39M | 45ms | 27MiB |