
Modeling and Forecasting Climate Variables– Temperature, Groundwater Level, and Rainfall in Bangladesh: A machine learning approach.

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01

Background Study

Background Study

- Climate Change and Its Impact on Bangladesh
- Climatic Variables – Temperature and Rainfall
- Importance of Climate Modeling and Forecasting
- Introduction to Machine Learning for Forecasting
- Relevance of the Study for Bangladesh

02

Objectives

Objectives

- **Construct predictive models**
- **Benchmark model performance**
- **Evaluate model adaptability**
- **Deliver actionable insights**

03

Literature Reviews

Literature Reviews

References	Title	Outcomes
Shahid, S., Wang, X. J., Harun, S. B., Shamsudin, S. B., & Ismail, T. (2017)	Climate variability and changes in the major cities of Bangladesh: observations, possible impacts and adaptation	Highlights significant climate shifts in major cities and suggests adaptation strategies.
S Ali, B. C. Ghosh, A. G. Osmani, E. Hossain, C. Fogarassy	Farmers' Climate Change Adaptation Strategies for Reducing the Risk of Rice Production: Evidence from Rajshahi District in Bangladesh	Examines climate change effects on crop yield and evaluates effective local adaptation practices.
Shamsuddin Shahid (2012)	Rainfall variability and changes in Bangladesh during the last fifty years	Details significant rainfall variability and trends, impacting agricultural and water management planning.
M.A. Al Mamun, M.R. Sarker, M.A.R. Sarkar, S.K. Roy, S.A.I. Nihad, A.M. McKenzie, M.I. Hossain, M.S. Kabir.	Identification of influential weather parameters and seasonal drought prediction in Bangladesh using machine learning algorithm	Accurately predicts seasonal droughts in Bangladesh using advanced machine learning algorithms for enhanced climate resilience.

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Data Collection and Processing

Source of Data

Data Sources:

- Bangladesh Agricultural Research Council(BARC)
- Time period: 1970 – 2022 (years)

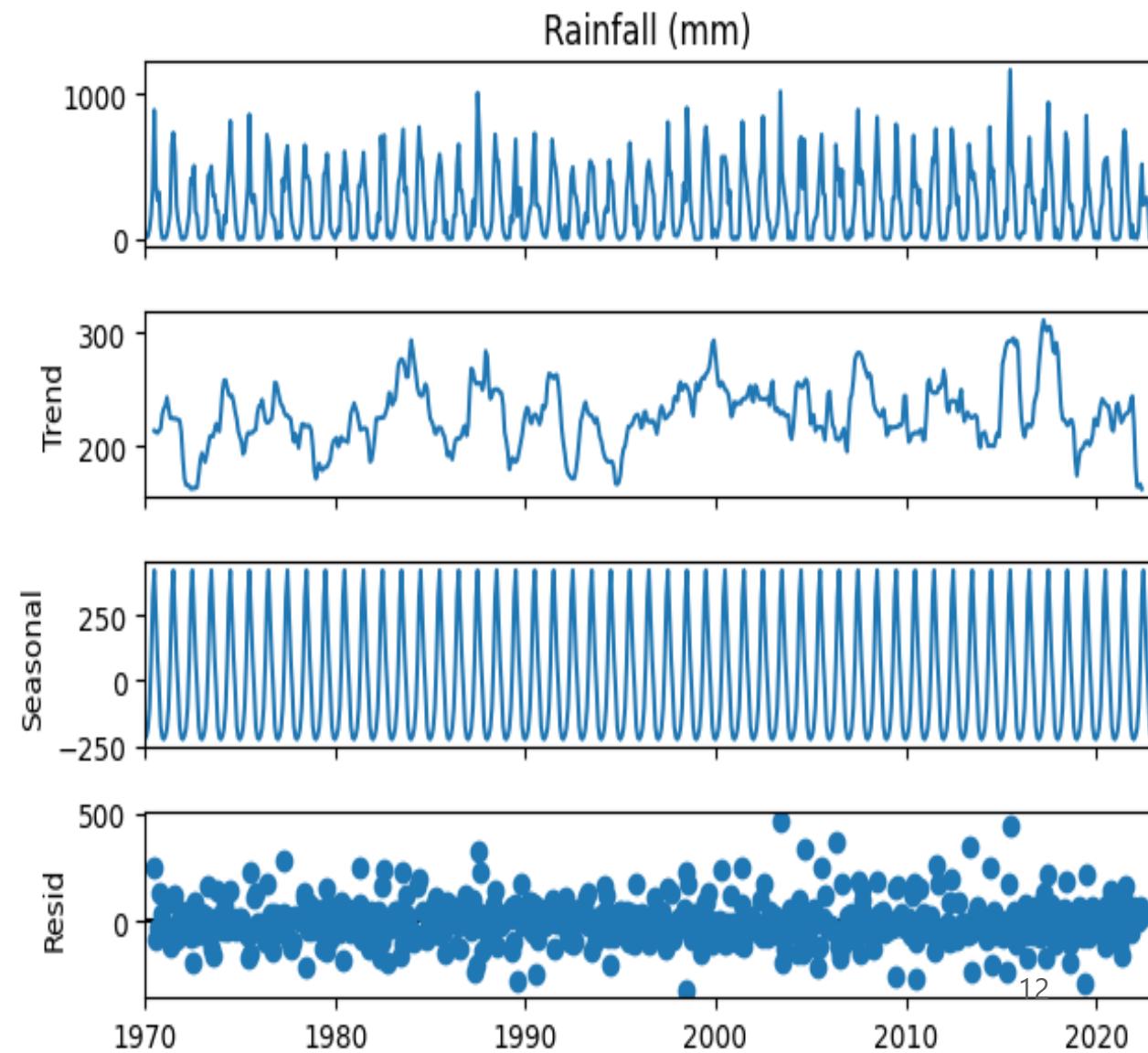
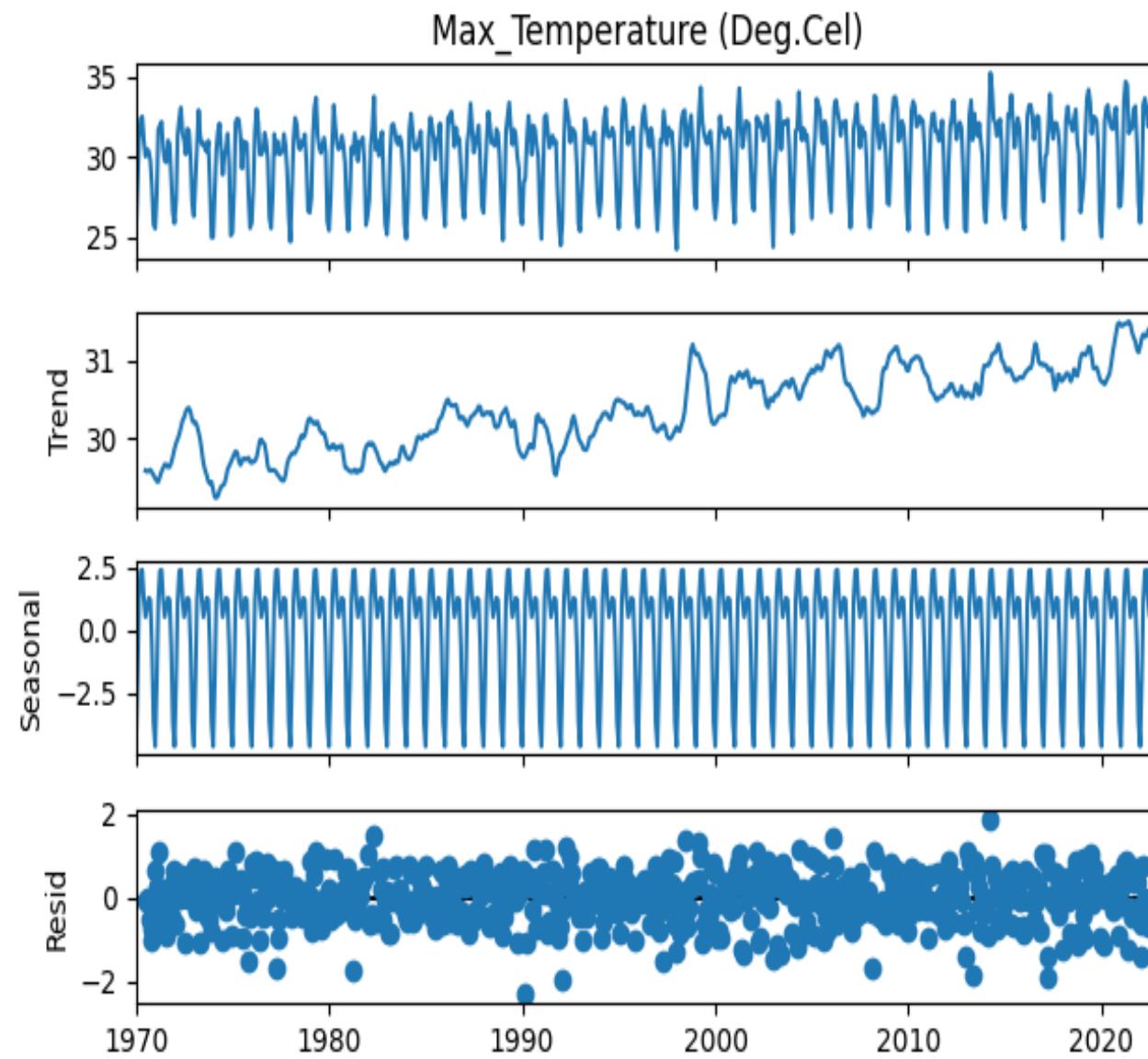
Variables:

- Temperature, and Rainfall

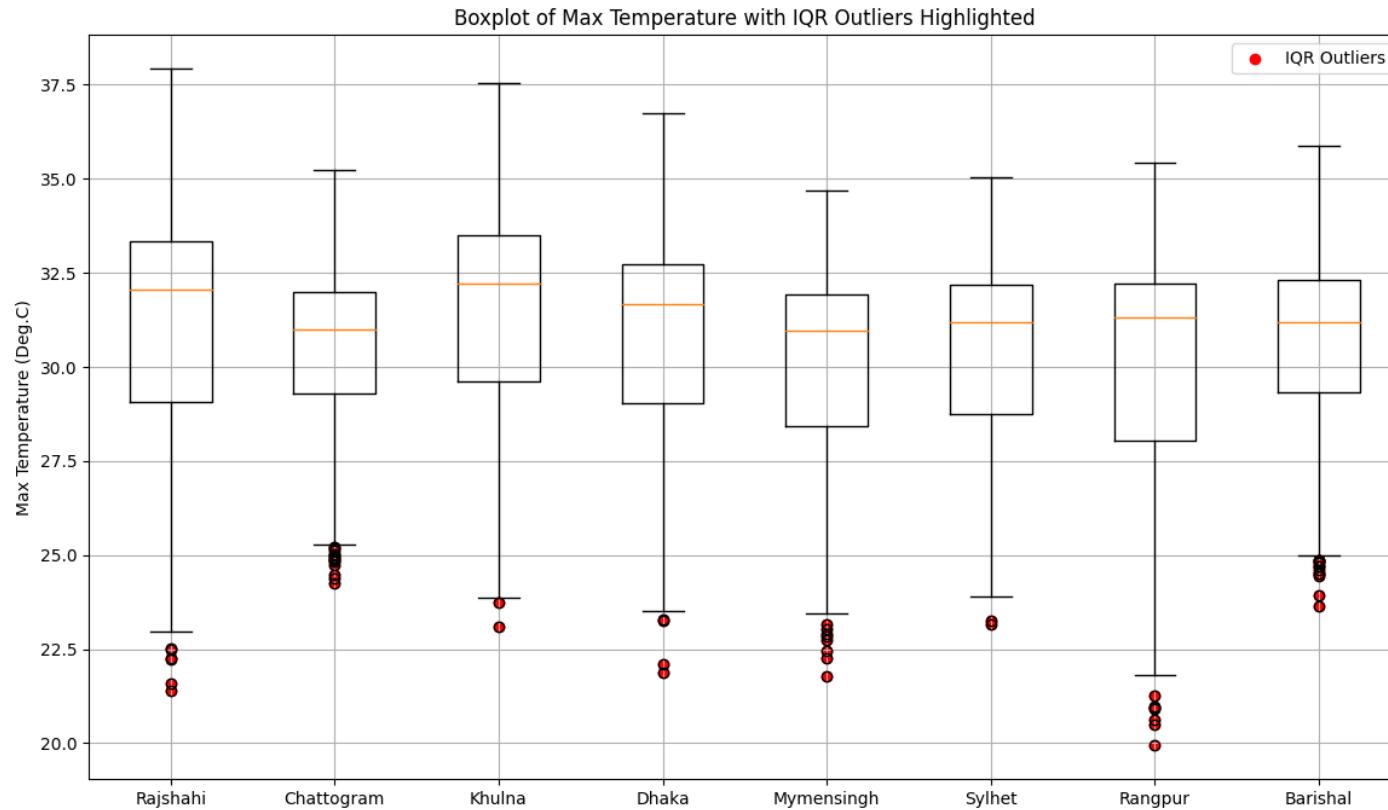
Data Processing

- Time Series
- Basic Statistic on Data
- Outlier [Boxplot]
- Normality [Jerque Bera]
- Stationarity [ADF]

Time Series with Linear Trend

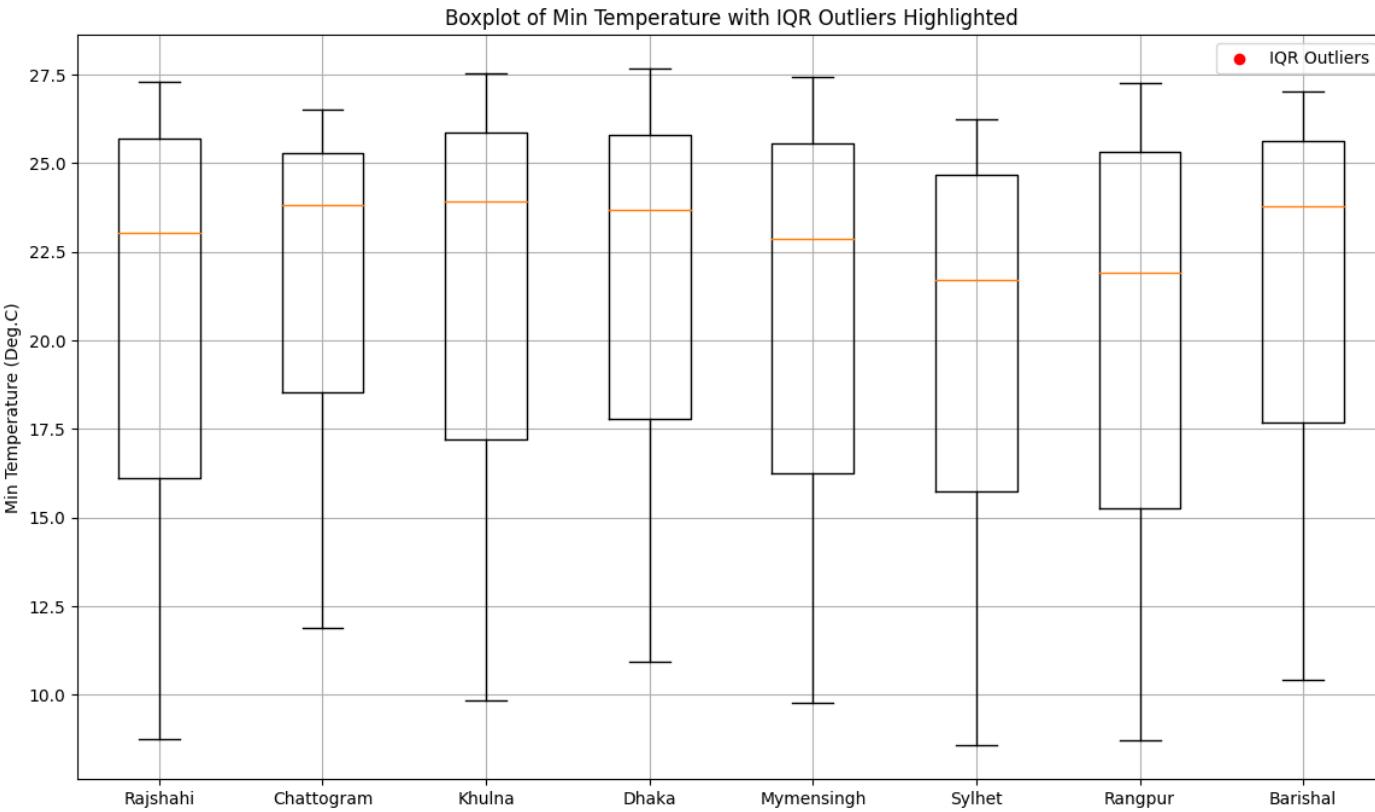


Outlier [BoxPlot]



Max_Temperature of all Division

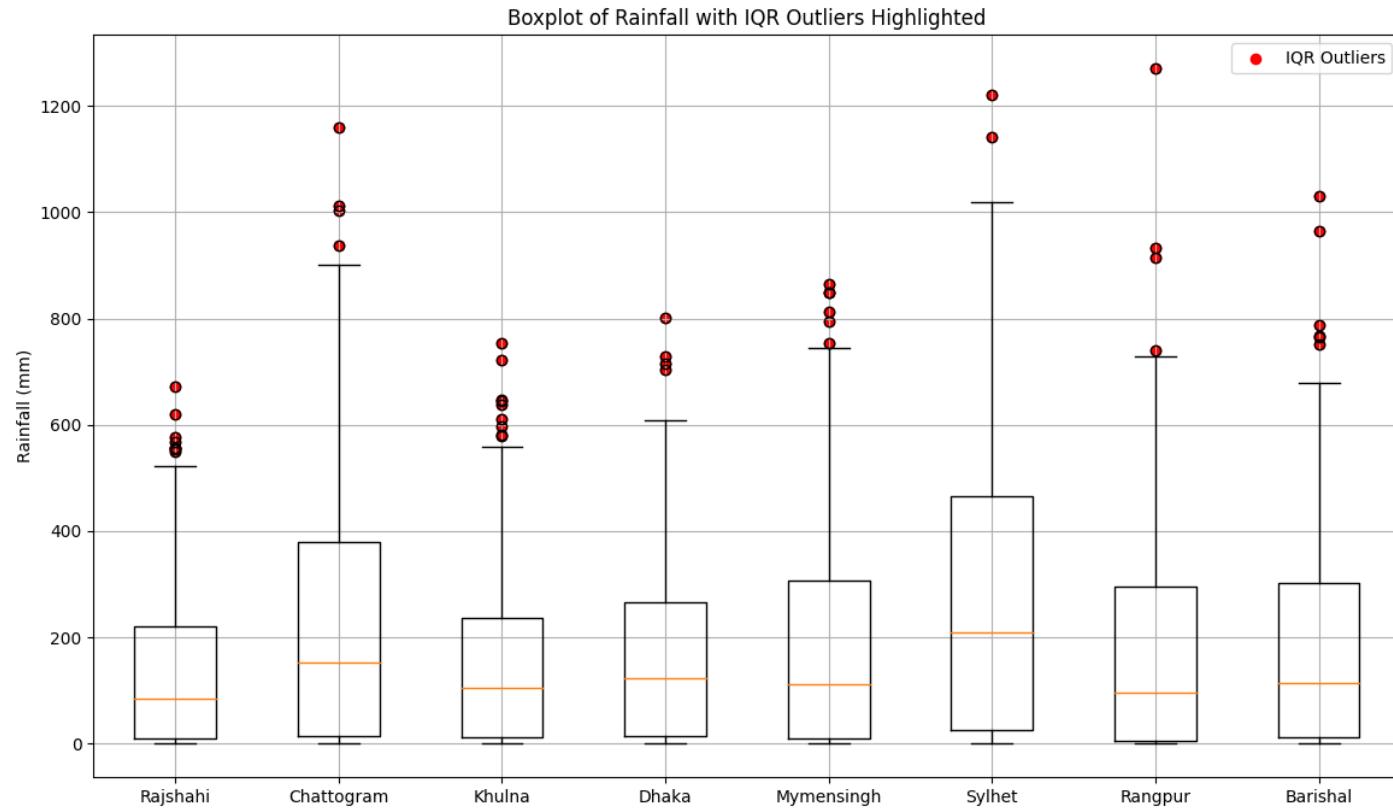
Outlier [BoxPlot]



Min_Temperature of all Division

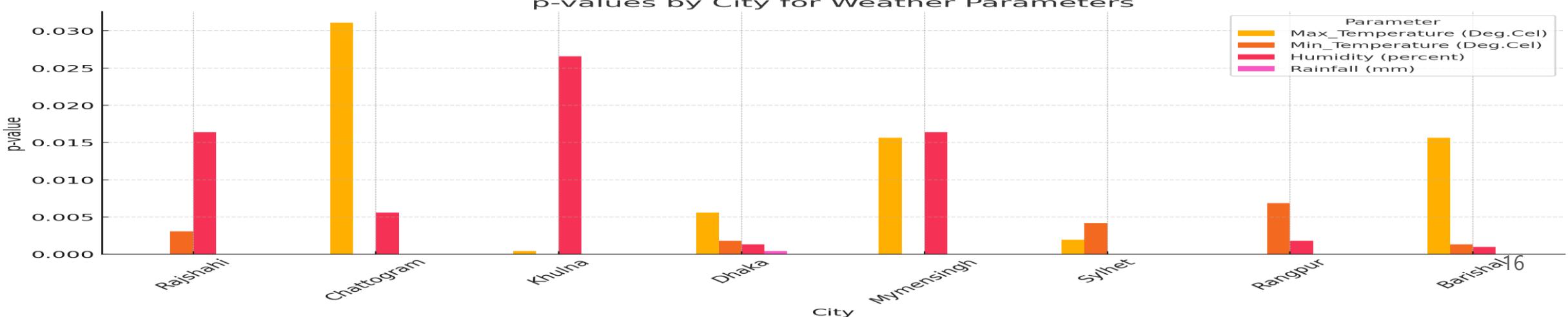
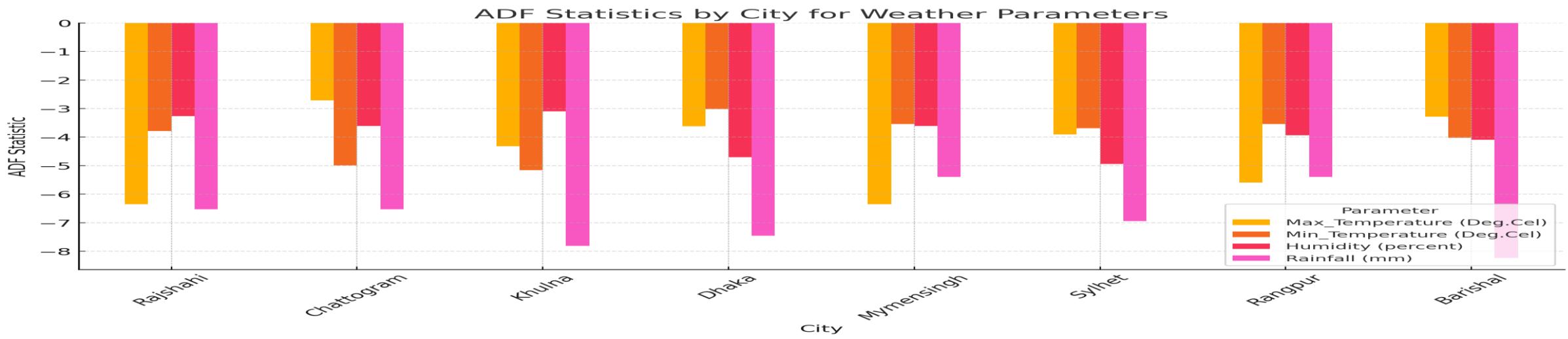
Outlier [BoxPlot]

Rainfall of all Division



Stationary

Augmented Dickey-Fuller (ADF) Test Result



05

Methodology

Methodology

Models/ Algorithms:

- ARIMA, SARIMA, LSTM, GARCH, EGARCH

Workflow:

- Time series decomposition
- Validation strategies (train-test split, cross-validation)
- Model fitting
- Forecasting

06

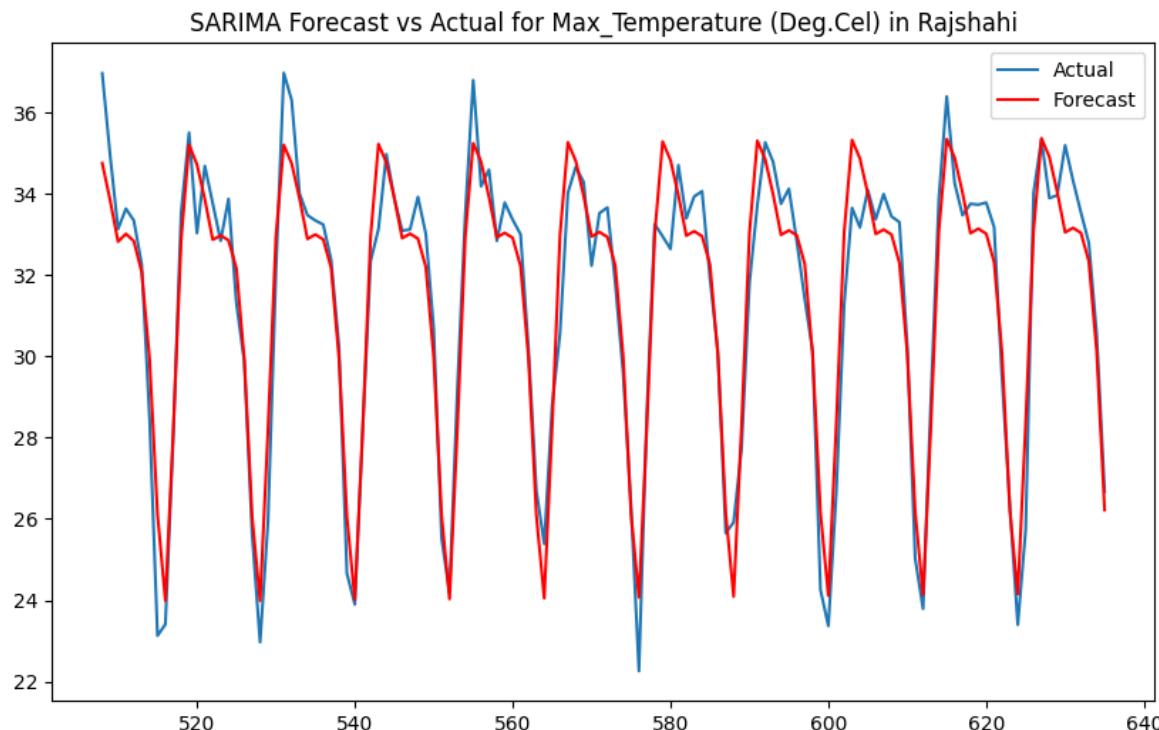
Models

Models

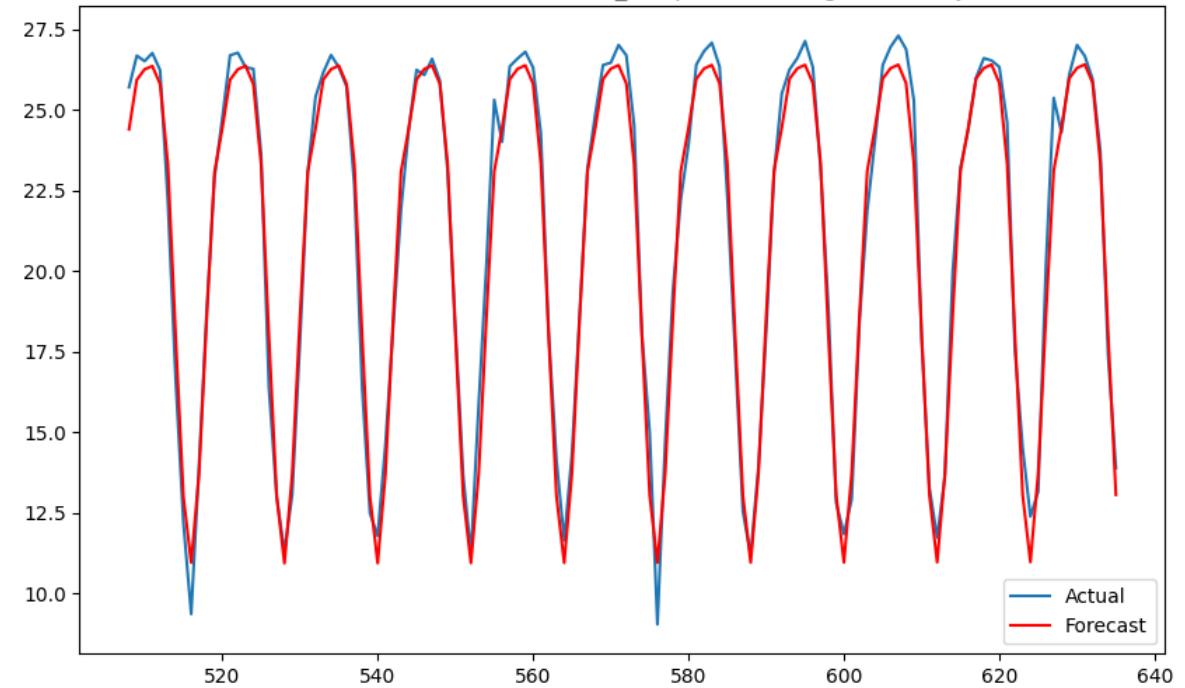
Temperature

Temperature Forecast vs Actual for SARIMA

Actual Forecast

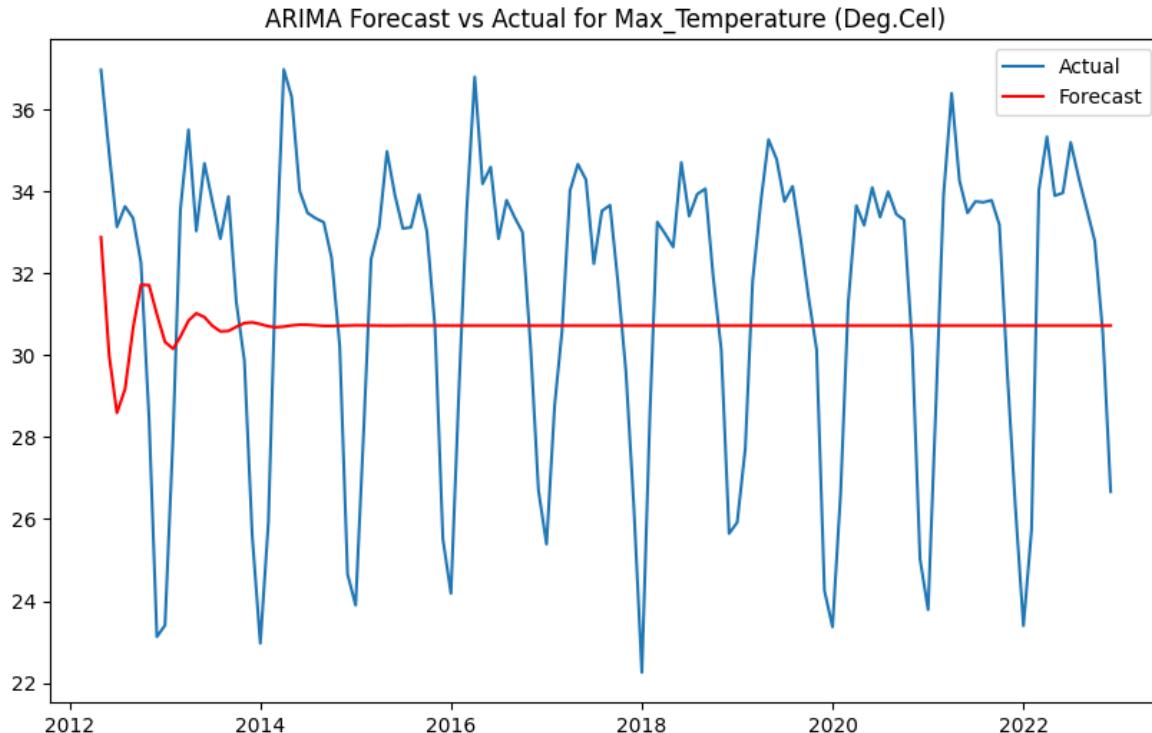


SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Rajshahi

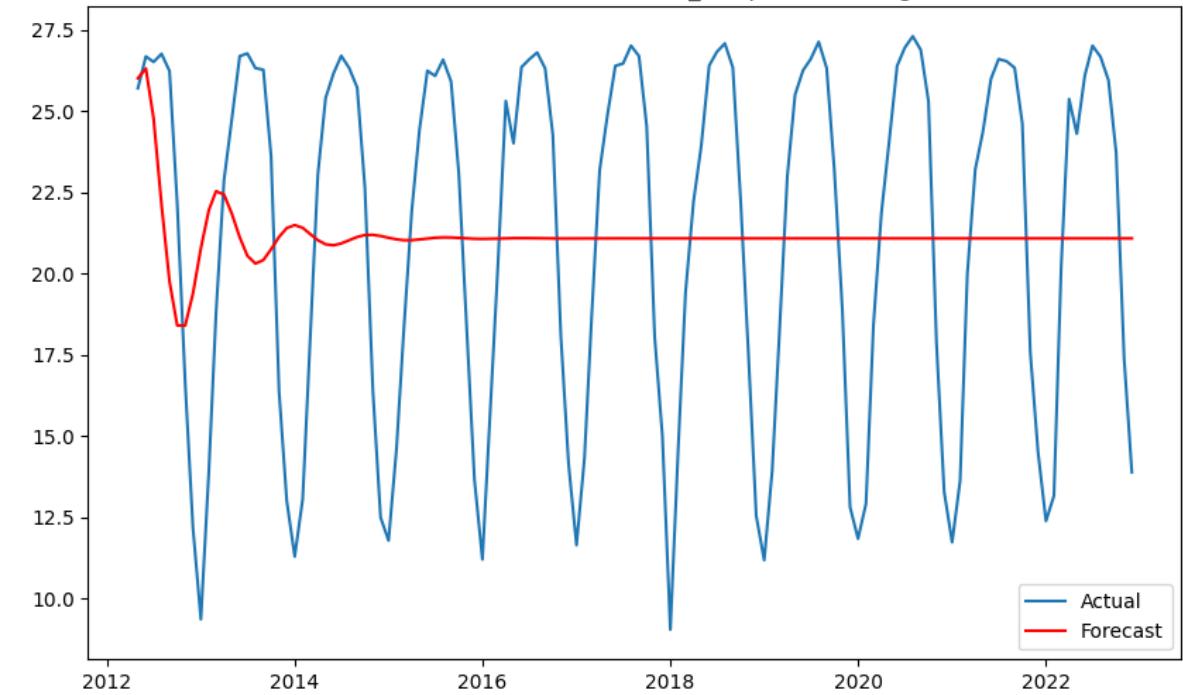


Temperature Forecast vs Actual for ARIMA

ARIMA Forecast vs Actual for Max_Temperature (Deg.Cel)

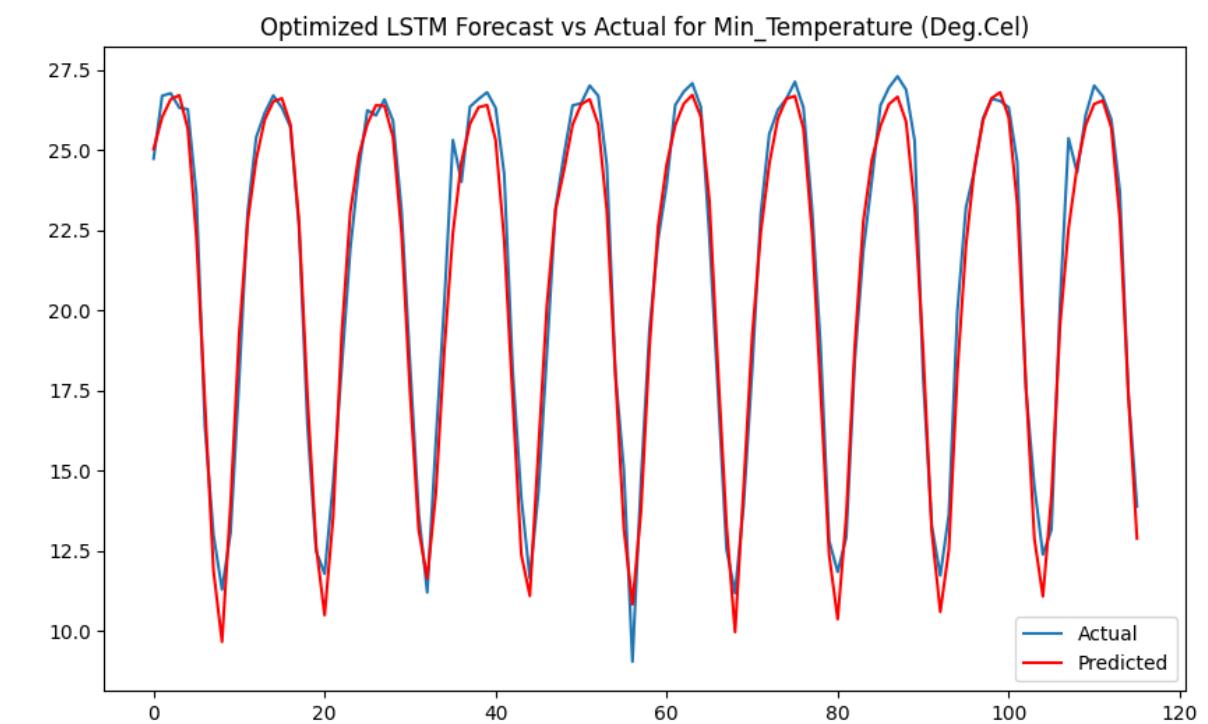
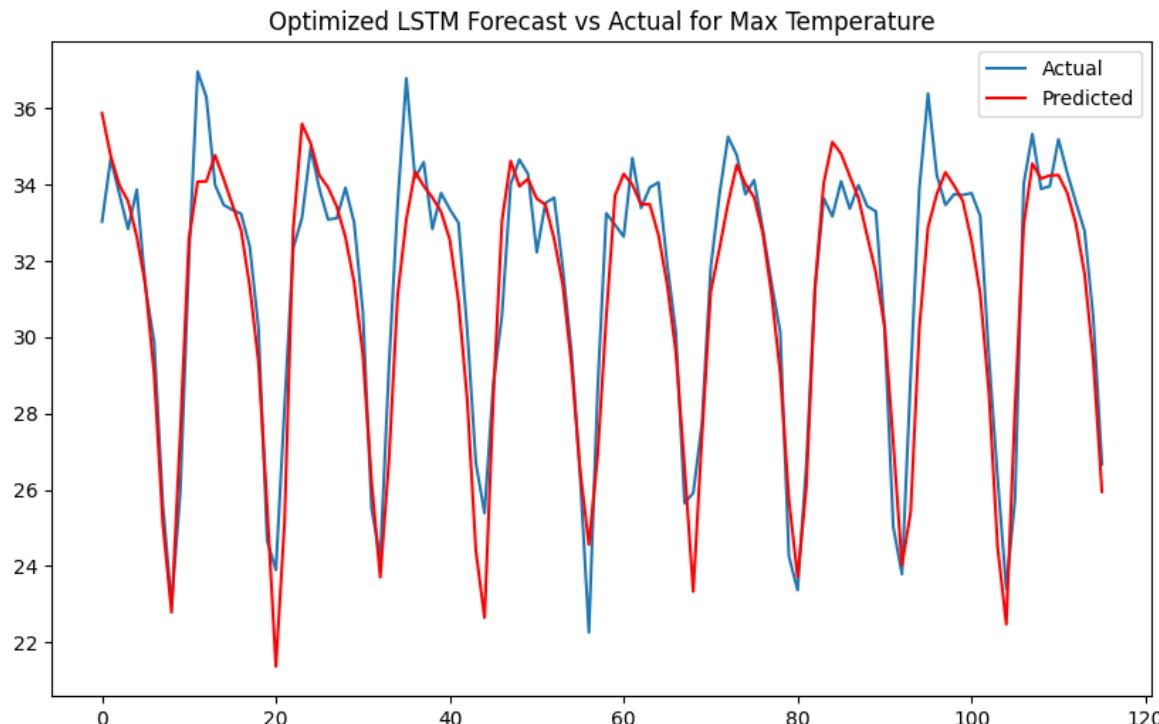


ARIMA Forecast vs Actual for Min_Temperature (Deg.Cel)



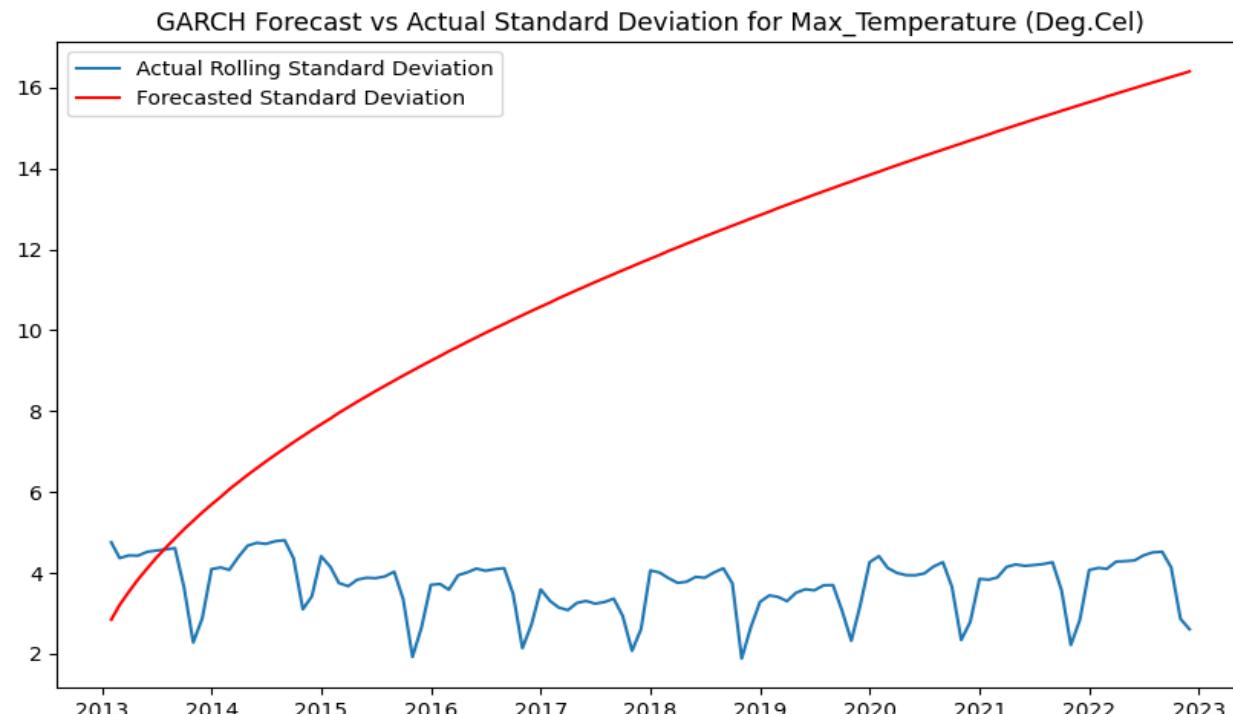
Temperature Forecast vs Actual for LSTM

Actual Predicted

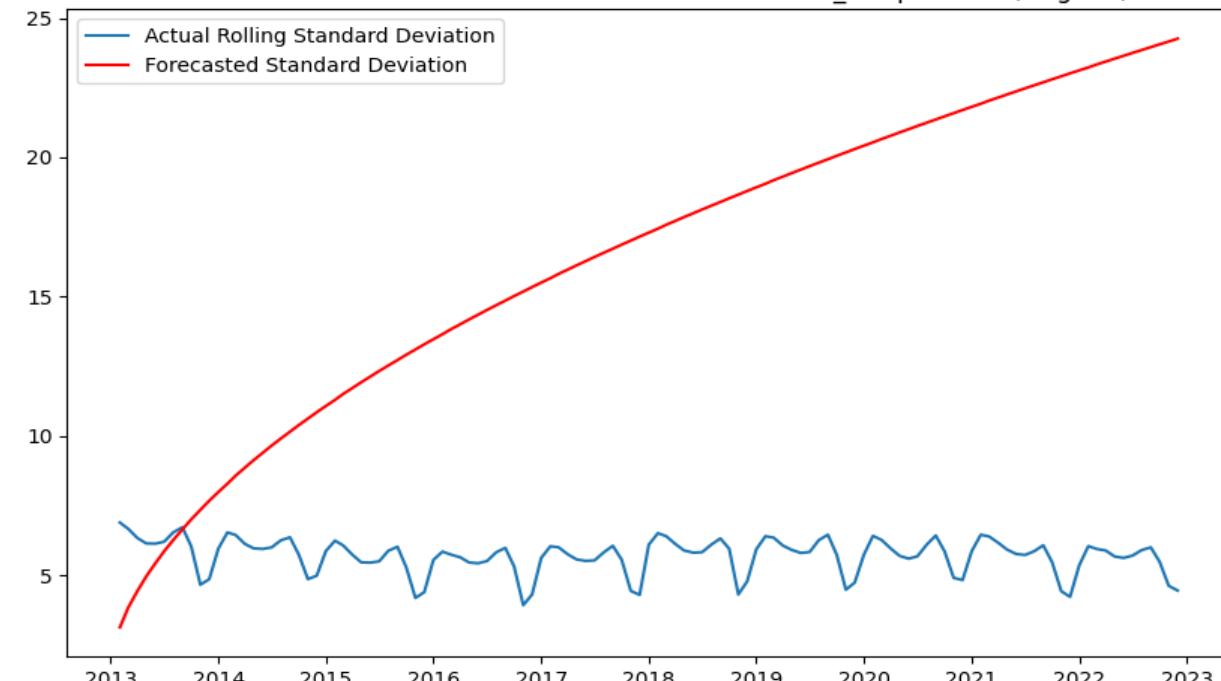


Temperature Forecast vs Actual for GARCH

Actual Rolling Standard Deviation

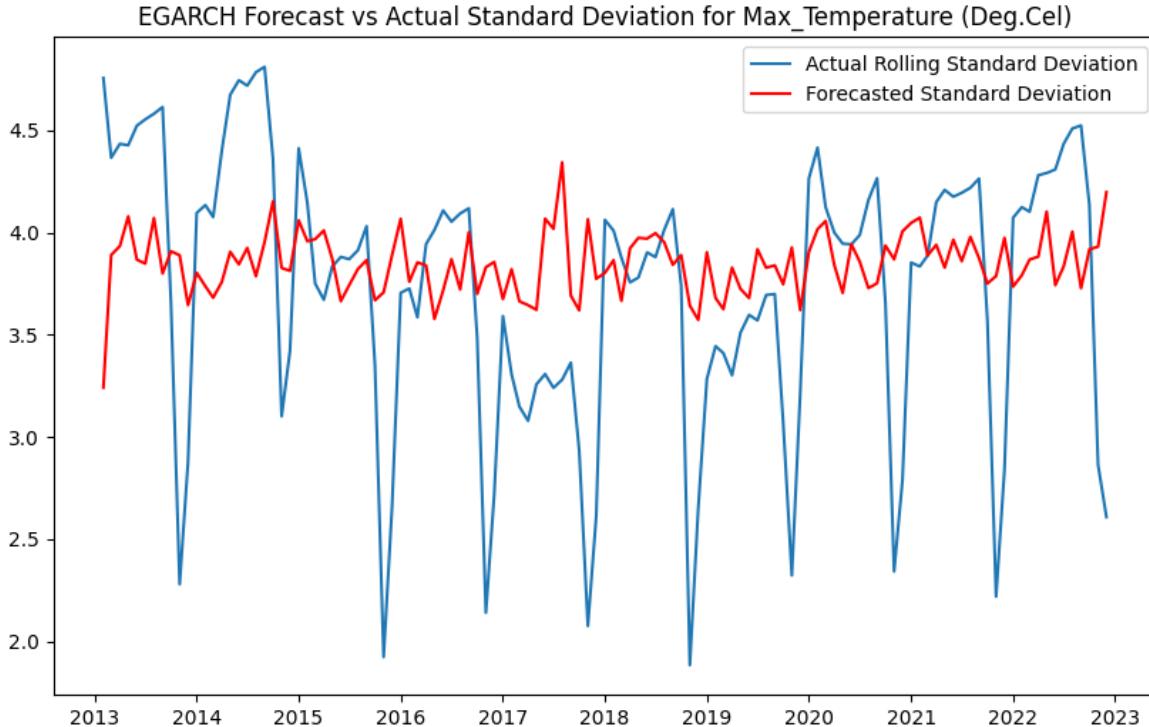


Actual Rolling Standard Deviation

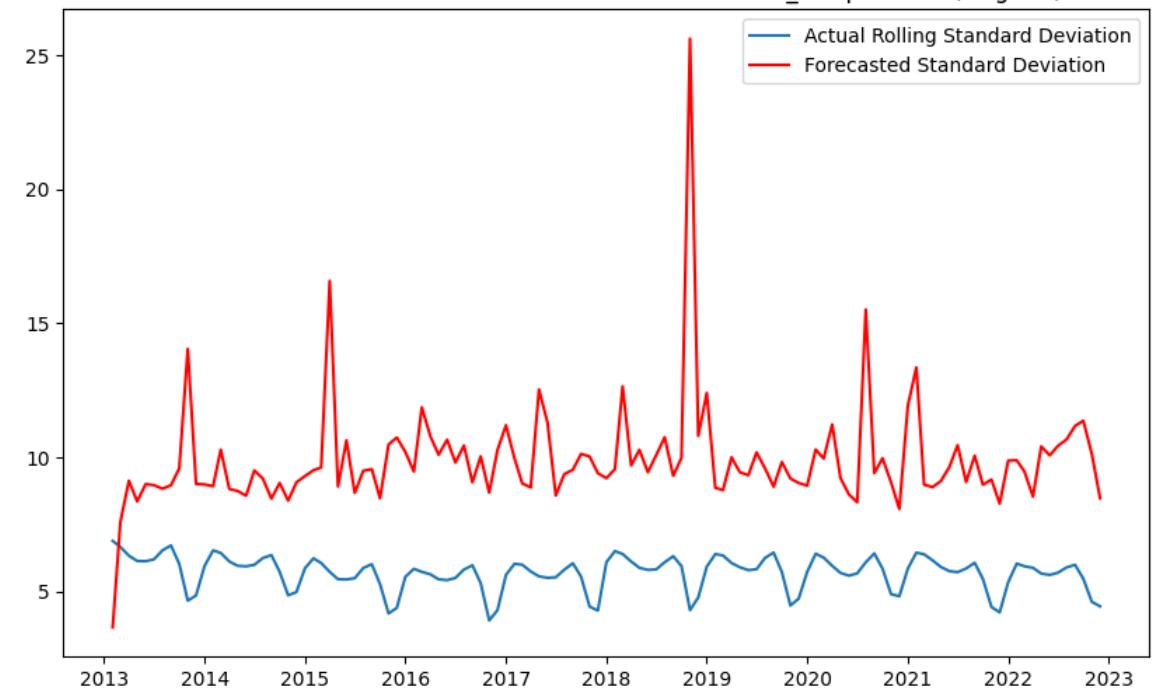


Temperature Forecast vs Actual for EGARCH

EGARCH Forecast vs Actual Standard Deviation for Max_Temperature (Deg.Cel)



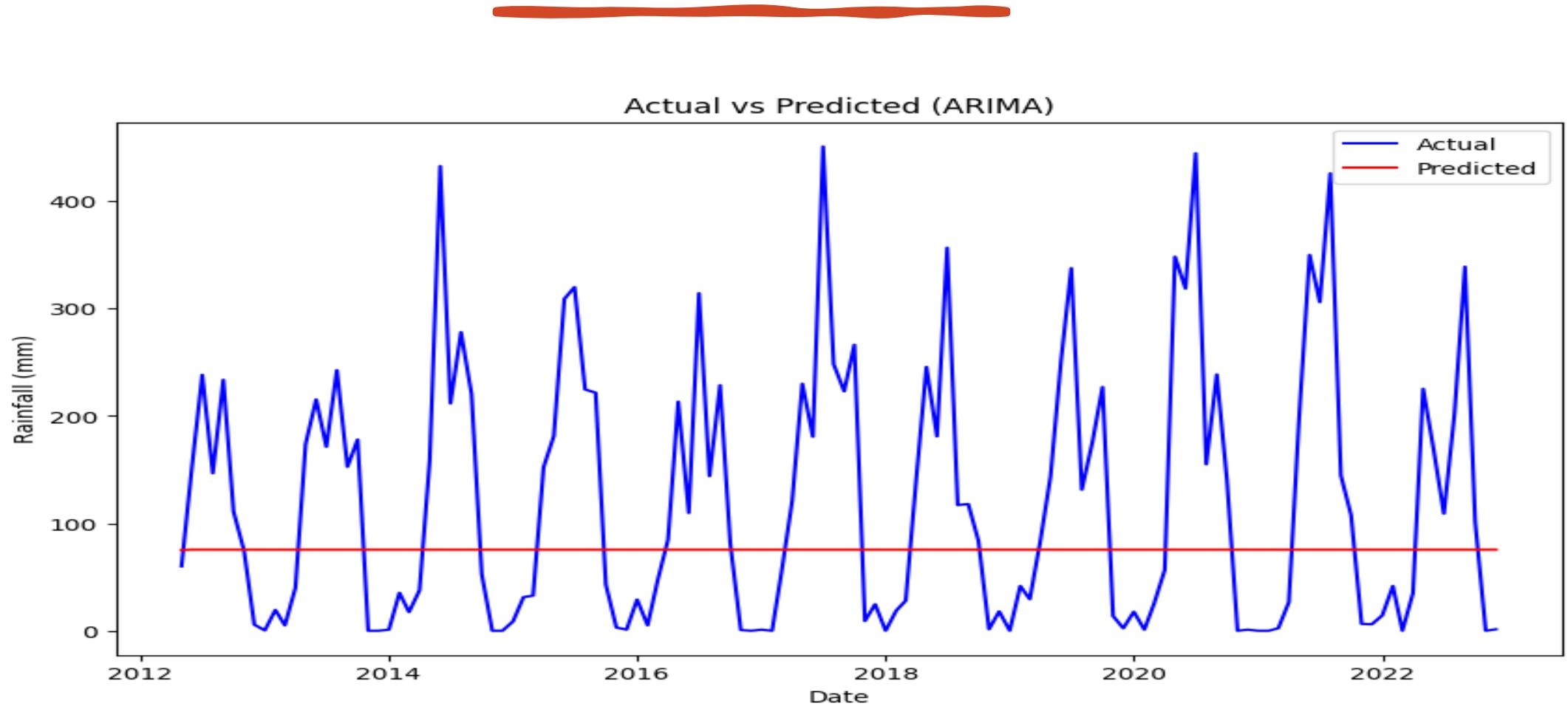
EGARCH Forecast vs Actual Standard Deviation for Min_Temperature (Deg.Cel)



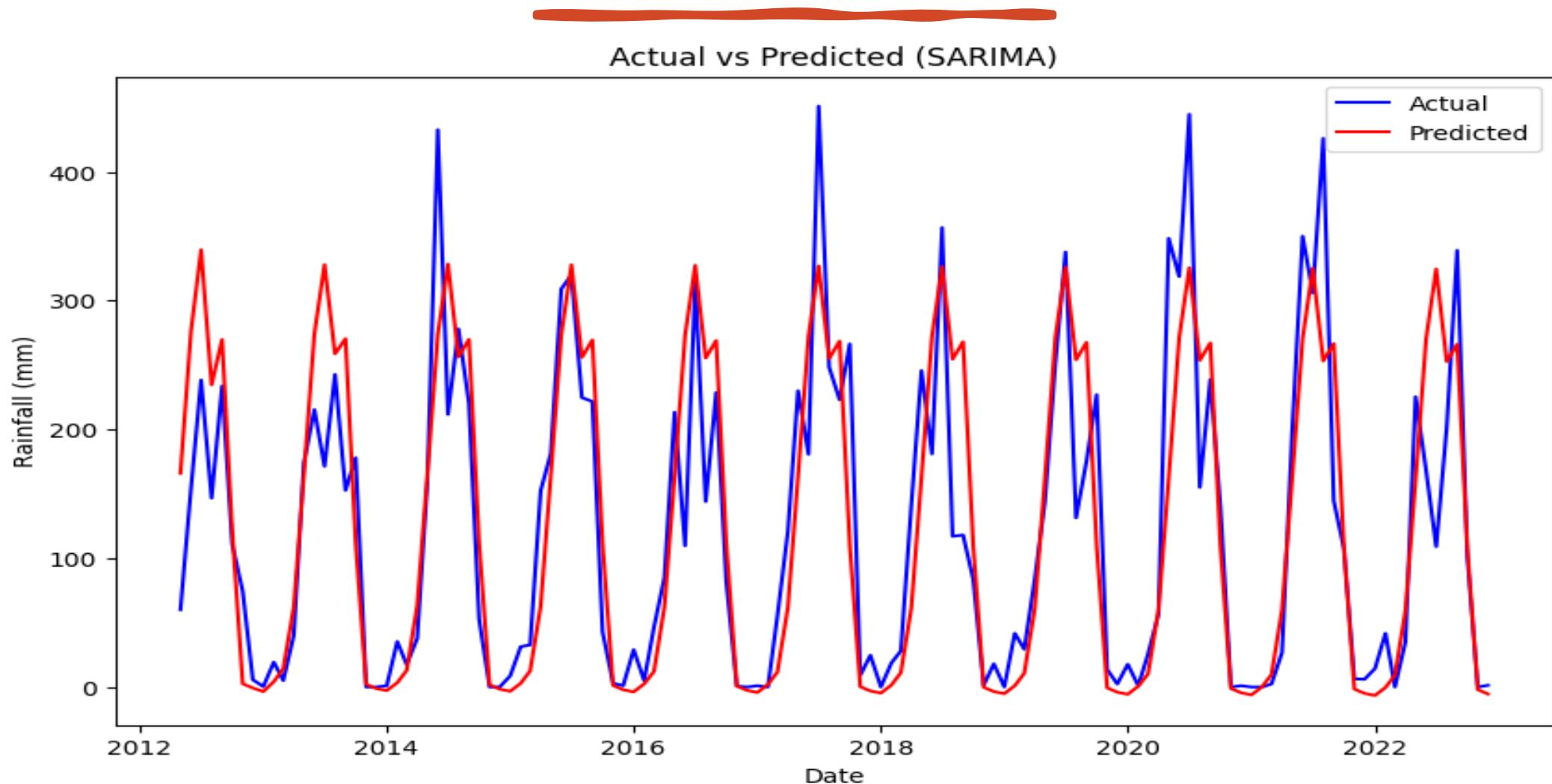
Models

Rainfall

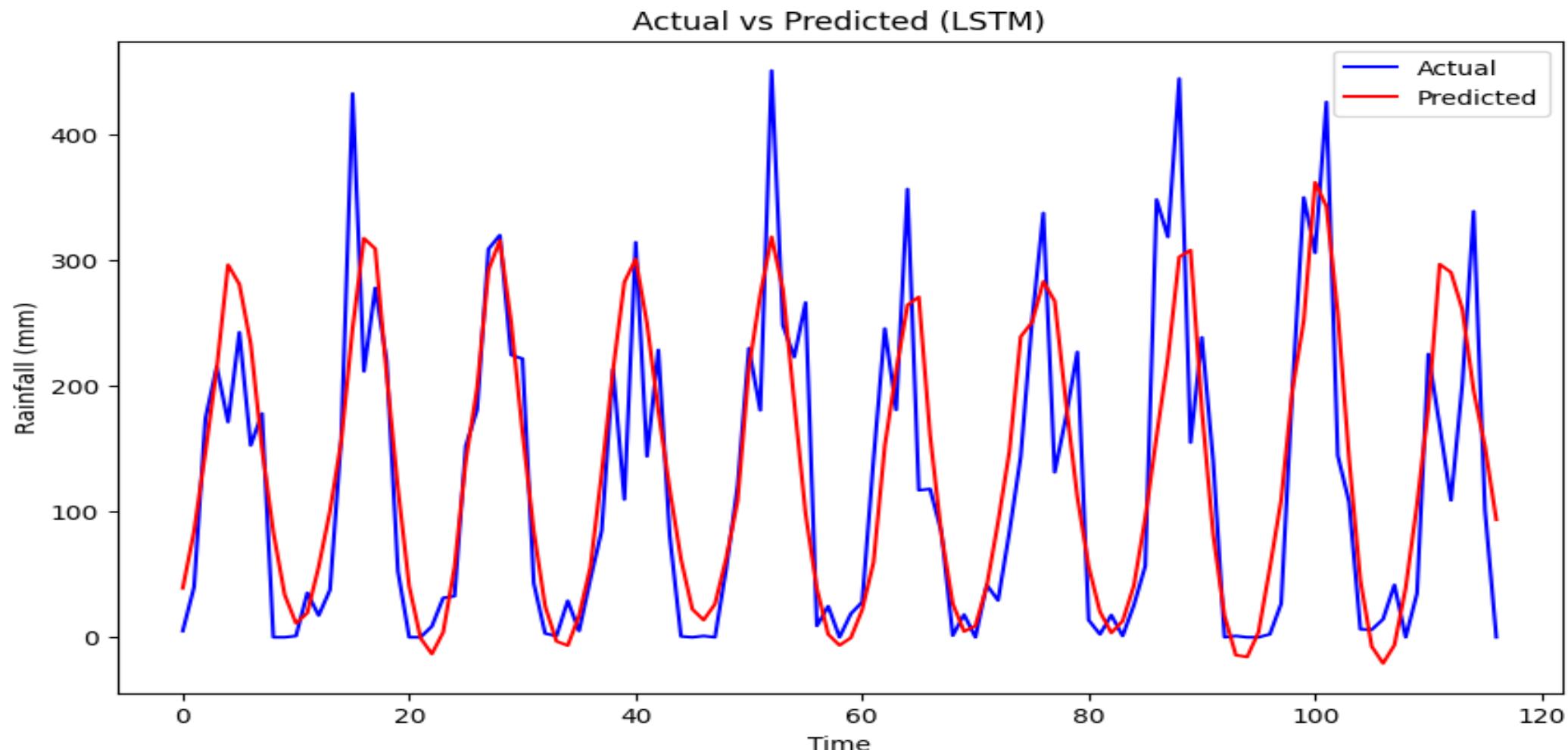
Rainfall Forecast vs Actual for ARIMA



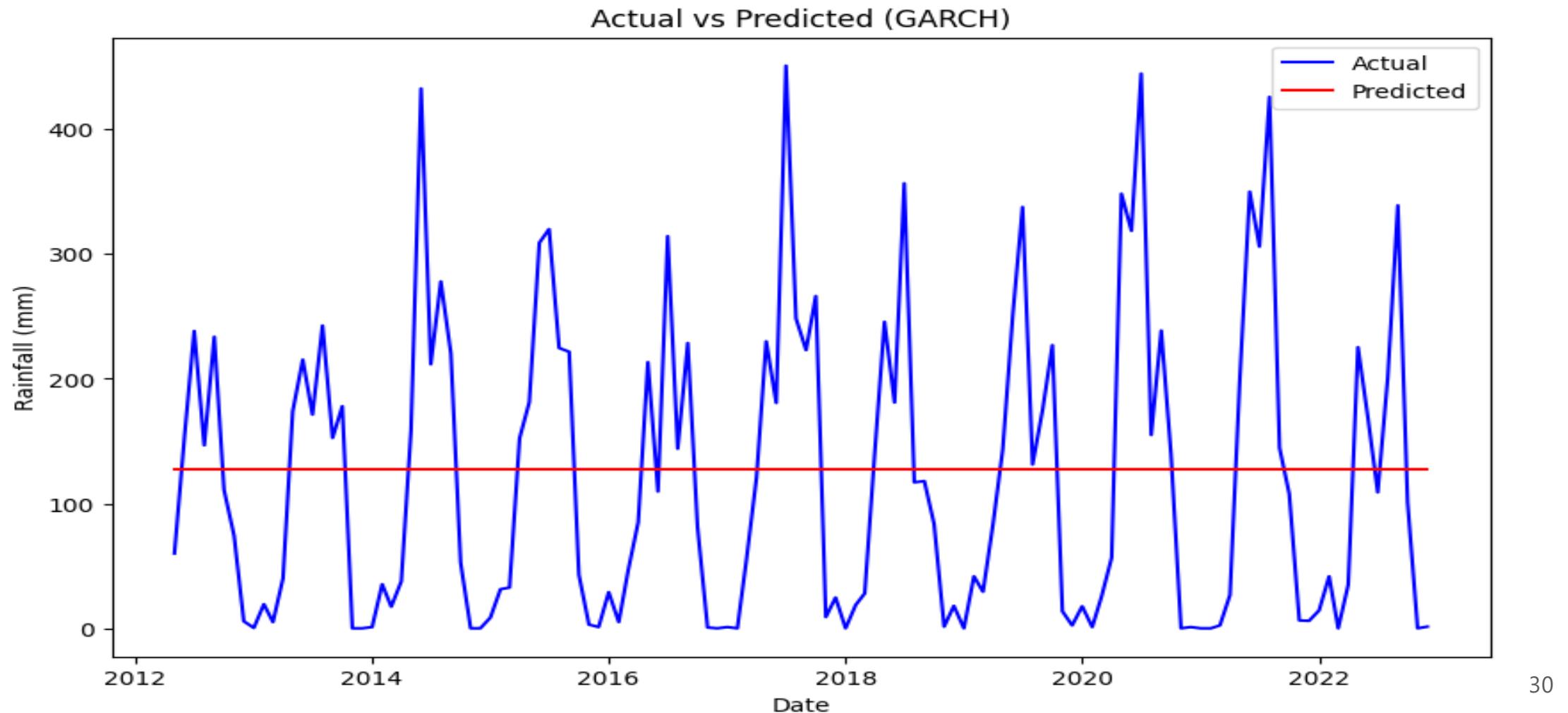
Rainfall Forecast vs Actual for SARIMA



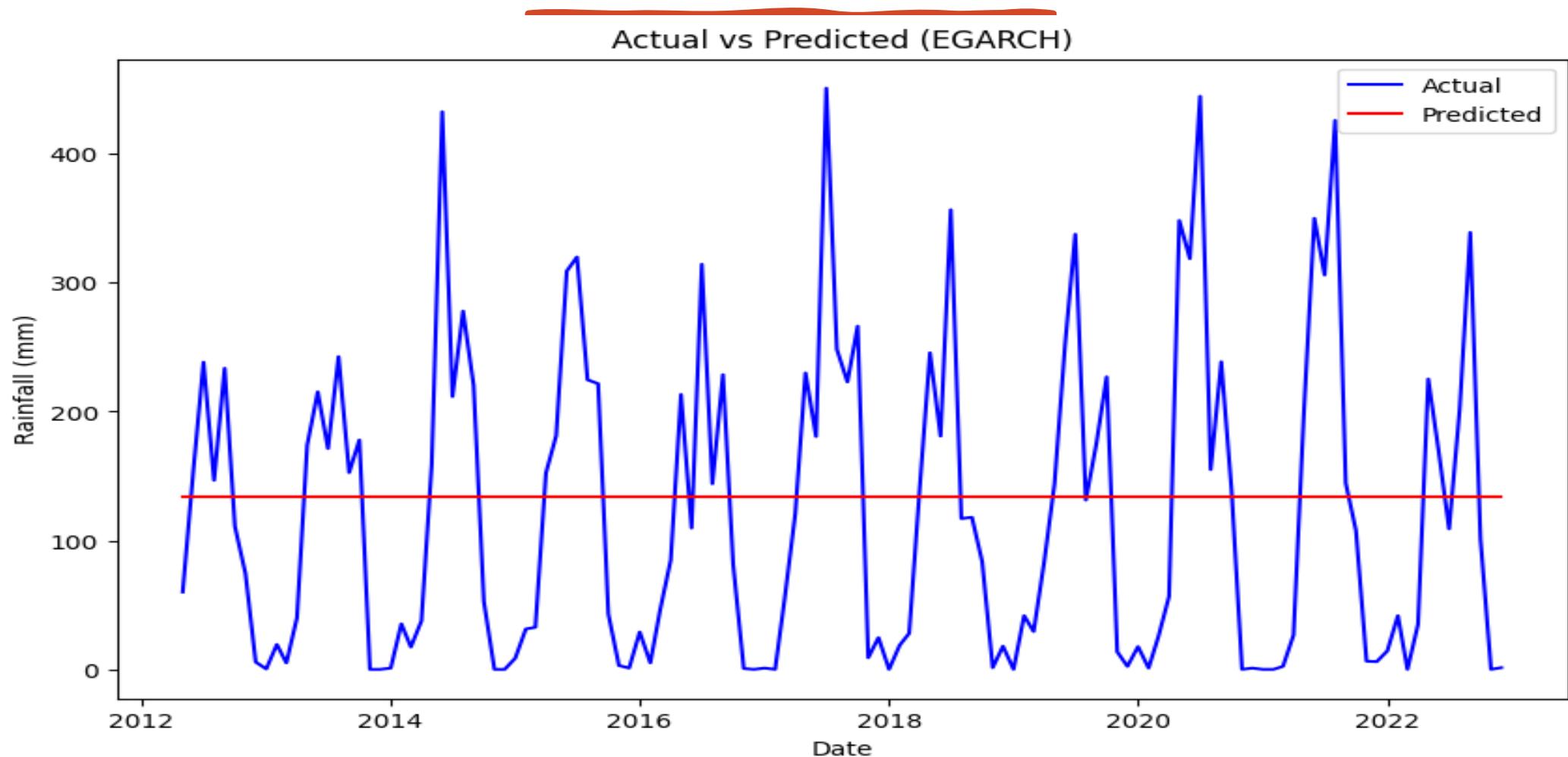
Rainfall Forecast vs Actual for LSTM



Rainfall Forecast vs Actual for GARCH



Rainfall Forecast vs Actual for EGARCH



07

Results & Comparison of Models

SARIMA

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rajshahi	Max_Temperature	1.08604849	1.179501323	0.894292644	0.912071865	1441.242281	1462.26507
Rajshahi	Min_Temperature	0.823671962	0.678435501	0.628513554	0.977907400	1219.280361	1240.30315
Rajshahi	Humidity(percent)	3.233643927	10.45645305	2.556970532	0.716690517	2623.09955	2644.122339
Rajshahi	Rainfall (mm)	66.47601804	4419.060975	46.43008005	0.820515882	5908.628192	5929.650981

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Chattogram	Max_Temperatur	0.77050731	0.59368158	0.61107094	0.8985976	1020.658007	1041.680796
Chattogram	Min_Temperatur	0.81340541	0.66162954	0.634705541	0.9641872	1037.796197	1058.818986
Chattogram	Humidity	2.3101814	5.3369661	1.72003173	0.7914203	2171.062788	2192.085577
Chattogram	Rainfall (mm)	115.52024	13345.096	77.5153083	0.8410695	6145.049072	6166.07186

SARIMA – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Khulna	Max_Temp	0.936398633	0.87684294	0.76717619	0.91671263	1279.0303	1300.0612
Khulna	Min_Temp	0.826757951	0.68352377	0.62863705	0.97493932	1285.1224	1306.1433
Khulna	Humidity	2.15851545	4.6593943	1.6868734	0.82783935	2358.558	2379.6089
Khulna	Rainfall (mm)	81.1527185	6585.7453	55.010974	0.80175812	5897.1809	5918.2058
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Dhaka	Max_Temp	0.950473717	0.9034288	0.797977473	0.909655267	1345.96896	1366.991184
Dhaka	Min_Temp	0.749042349	0.56104045	0.559437928	0.975310696	1229.155829	1250.178618
Dhaka	Humidity	3.57476904	12.77897558	2.885881999	0.725819924	2427.906696	2448.929485
Dhaka	Rainfall (mm)	91.7646421	8420.750294	63.87646419	0.781937019	5909.766816	5930.789605
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Mymensingh	Max_Temp	1.04373973	1.08939292	0.84782568	0.87306211	1386.3933	1407.4142
Mymensingh	Min_Temp	0.835538074	0.698123717	0.66958605	0.97306425	1211.7364	1232.7553
Mymensingh	Humidity	2.37024236	5.61804317	1.82577791	0.66734777	2499.6764	2520.6982
Mymensingh	Rainfall (mm)	97.8319145	9571.09281	65.8703037	0.75225482	6347.65	6368.5699

SARIMA – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Sylhet	Max_Temperature (Deg.Cel)	0.98609724	0.9723877667	0.7668530873	0.8612474618	1377.162851	1398.18564
Sylhet	Min_Temperature (Deg.Cel)	0.7229279617	0.5226248378	0.5245910653	0.9783806386	1253.960172	1274.982961
Sylhet	Humidity (percent)	3.34754996	11.20609074	2.683616091	0.658480409	2375.944653	2396.967442
Sylhet	Rainfall (mm)	133.8833405	17924.74887	90.0998577	0.8200010715	6380.061256	6401.084045
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rangpur	Max_Temperature (Deg.Cel)	1.170893519	1.370991633	0.9553027323	0.8843291469	1424.713206	1445.735995
Rangpur	Min_Temperature (Deg.Cel)	0.7219641499	0.5212322337	0.5757904079	0.9829574704	1100.844368	1121.867156
Rangpur	Humidity (percent)	4.553762195	20.73675013	3.791353223	0.2455356242	2564.150408	2585.173197
Rangpur	Rainfall (mm)	119.3751646	14250.42992	76.70751451	0.7451338795	6153.429691	6174.45248
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Barishal	Max_Temperature (Deg.Cel)	0.844940416	0.7139243065	0.6868752816	0.9003933005	1150.02105	1171.043839
Barishal	Min_Temperature (Deg.Cel)	0.8854278089	0.7839824047	0.6416268678	0.9699086207	1239.08308	1260.105869
Barishal	Humidity (percent)	2.285613519	5.224029159	1.805946139	0.7600690133	2208.605693	2229.628482
Barishal	Rainfall (mm)	104.2216718	10862.15687	65.96524188	0.7550842869	6202.633218	6223.656006

ARIMA – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rajshahi	Max_Temperature	5.009599078	25.09608292	3.596841198	-0.8708344854	2320.966846	2333.652379
Rajshahi	Min_Temperature	9.011242353	81.20248874	7.073115904	-1.644280916	2373.653935	2386.339468
Rajshahi	Humidity (percent)	8.969764654	80.45667795	8.078738552	-1.179911265	3263.323431	3276.008964
Rajshahi	Rainfall (mm)	120.1063386	14425.53256	103.1434231	-0.01027644646	6268.425536	6281.111069

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Chattogram	Max_Temperature	2.931495887	8.593668135	2.019974559	-0.468329627	1942.991768	1955.677301
Chattogram	Min_Temperature	4.630731869	21.44367764	3.535314529	-0.1632479344	2172.929927	2185.61546
Chattogram	Humidity (percent)	5.863009997	34.37488622	4.475697152	-0.3433000545	2774.137885	2786.823418
Chattogram	Rainfall (mm)	251.7009776	63353.38211	201.8597904	-0.001185494606	6744.772562	6757.458095

ARIMA – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Khulna	Max_Temperature (Deg.Cel)	4.796327855	23.00476089	3.698591556	-1.185120875	2201.266882	2213.952415
Khulna	Min_Temperature (Deg.Cel)	6.309546668	39.81037915	4.441585662	-0.4596288326	2377.770293	2390.455826
Khulna	Humidity (percent)	6.405697087	41.03295517	5.555109526	-0.5159054536	2955.507942	2968.193475
Khulna	Rainfall (mm)	157.9739758	24955.77703	115.8581436	-0.2438640157	6356.13986	6368.825393
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Dhaka	Max_Temperature (Deg.Cel)	3.827689343	14.65120571	2.532423526	-0.4652413038	2219.434358	2232.119891
Dhaka	Min_Temperature (Deg.Cel)	5.222267801	27.27208098	3.970226172	-0.1998304374	2333.56318	2346.248713
Dhaka	Humidity (percent)	7.440327796	55.35847771	6.367234186	-0.1877477045	3121.043951	3133.729484
Dhaka	Rainfall (mm)	162.2117341	26312.64669	138.5853822	-0.1188668444	6447.025726	6459.71126
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Mymensingh	Max_Temperature (Deg.Cel)	2.96033271	8.763569756	2.282434003	-0.02114599475	2178.485674	2191.171207
Mymensingh	Min_Temperature (Deg.Cel)	6.067410164	36.8134661	4.559989233	-0.420075941	2293.469773	2306.155306
Mymensingh	Humidity (percent)	4.11904968	16.96657026	3.346193462	-0.004515625119	3078.26134	3090.946873
Mymensingh	Rainfall (mm)	176.6286966	31197.69648	156.7735699	-0.003582306608	6628.051257	6640.73679

ARIMA – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Sylhet	Max_Temperature (Deg.Cel)	2.672126357	7.140259267	2.281784823	-0.01886215654	2135.957739	2148.643272
Sylhet	Min_Temperature (Deg.Cel)	4.919376799	24.20026809	4.364914788	-0.001089699687	2298.847276	2311.532809
Sylhet	Humidity (percent)	5.869077307	34.44606844	4.90699031	-0.04978689551	3033.516986	3046.202519
Sylhet	Rainfall (mm)	316.5635772	100212.4984	272.6345186	-0.4535847839	6865.620567	6878.3061
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rangpur	Max_Temperature (Deg.Cel)	3.958943626	15.67323463	2.658501102	-0.3223541106	2267.196645	2279.882178
Rangpur	Min_Temperature (Deg.Cel)	10.15552193	103.1346257	8.46205235	-2.372153138	2202.968364	2215.653897
Rangpur	Humidity (percent)	8.868886028	78.65713938	8.019608884	-1.861779652	3235.420223	3248.105756
Rangpur	Rainfall (mm)	191.8062427	36789.63474	144.2992096	-0.07103947894	6649.243955	6661.929488
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Barishal	Max_Temperature (Deg.Cel)	3.458600081	11.96191452	2.455540207	-0.6689259839	2070.884497	2083.57003
Barishal	Min_Temperature (Deg.Cel)	5.338893511	28.50378392	4.255890377	-0.09405283482	2371.366242	2384.051775
Barishal	Humidity (percent)	5.021199613	25.21244555	4.40245151	-0.1579657682	2743.330002	2756.015535
Barishal	Rainfall (mm)	178.2760694	31782.35691	154.756215	-0.009213402618	6625.907895	6638.593428

GARCH – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rajshahi	Max_Temperature (Deg.Cel)	3.787741025	14.34698207	2.804417287	-0.06952263848	2543.970557	2560.892483
Rajshahi	Min_Temperature (Deg.Cel)	6.78059871	45.97651887	4.912300508	-0.4971811001	3048.503056	3065.424982
Rajshahi	Humidity (percent)	6.187403801	38.2839658	4.753326985	-0.03727434971	3542.755187	3559.677112
Rajshahi	Rainfall (mm)	119.7572429	14341.79722	102.5638556	-0.004412133011	6508.905891	6525.827817
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Chattogram	Max_Temperature (Deg.Cel)	2.435555958	5.931932826	1.867620668	-0.01354073438	2171.556388	2188.478313
Chattogram	Min_Temperature (Deg.Cel)	4.974258908	24.74325169	3.525161905	-0.3422388125	2722.262234	2739.18416
Chattogram	Humidity (percent)	5.182173463	26.8549218	4.144218891	-0.04943526741	3156.712216	3173.634141
Chattogram	Rainfall (mm)	277.3910917	76945.81775	202.658387	-0.2159893291	6953.668541	6970.590467

GARCH – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Khulna	Max_Temperature (Deg.Cel)	3.309054817	10.94984378	2.495730948	-0.04007741409	2464.261554	2481.18348
Khulna	Min_Temperature (Deg.Cel)	6.428305679	41.3231139	4.470233517	-0.5150925409	2930.897673	2947.819599
Khulna	Humidity (percent)	5.232780999	27.38199699	4.300146563	-0.01158979156	3360.592785	3377.51471
Khulna	Rainfall (mm)	141.6477232	20064.0775	116.5271147	-0.00004836449994	6516.366919	6533.288845
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Dhaka	Max_Temperature (Deg.Cel)	3.1975675	10.22443792	2.446208486	-0.02252804592	2399.173547	2416.095473
Dhaka	Min_Temperature (Deg.Cel)	5.379469156	28.9386884	3.981494176	-0.2731525396	2913.637063	2930.558988
Dhaka	Humidity (percent)	7.236102341	52.36117709	5.589335463	-0.1234389106	3460.320071	3477.241997
Dhaka	Rainfall (mm)	153.5693313	23583.53951	126.475641	-0.002819698538	6604.713734	6621.63566
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Mymensingh	Max_Temperature (Deg.Cel)	3.122192186	9.748084049	2.192139327	-0.1358632681	2263.456537	2280.378463
Mymensingh	Min_Temperature (Deg.Cel)	5.569469686	31.01899258	4.37768105	-0.1965546779	2996.0115	3012.933426
Mymensingh	Humidity (percent)	4.143097668	17.16525829	3.26359375	-0.01627906472	3356.016488	3372.938414
Mymensingh	Rainfall (mm)	176.4421461	31131.83091	154.5650764	-0.001463511658	6834.242887	6851.164813 ⁴⁰

GARCH – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Sylhet	Max_Temperature (Deg.Cel)	2.67212914	7.140274142	2.0820222	-0.0188642791	2234.636101	2251.558027
Sylhet	Min_Temperature (Deg.Cel)	5.355067417	28.67674704	4.226737344	-0.1862676879	2984.472263	3001.394189
Sylhet	Humidity (percent)	6.296643828	39.6477235	4.483613314	-0.208313821	3297.120854	3314.04278
Sylhet	Rainfall (mm)	263.0681298	69204.84092	226.8892848	-0.003817940256	7080.436089	7097.358015
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rangpur	Max_Temperature (Deg.Cel)	3.728264775	13.89995824	2.577349863	-0.1727424072	2422.298458	2439.220384
Rangpur	Min_Temperature (Deg.Cel)	5.924781012	35.10303004	4.768192465	-0.1477502549	3100.541233	3117.463159
Rangpur	Humidity (percent)	5.989825314	35.87800729	4.268102886	-0.305348148	3373.286494	3390.208419
Rangpur	Rainfall (mm)	229.8141698	52814.55264	153.9234986	-0.5375654403	6699.076864	6715.998789
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Barishal	Max_Temperature (Deg.Cel)	2.686473244	7.21713849	2.091665305	-0.006934962892	2255.877733	2272.799659
Barishal	Min_Temperature (Deg.Cel)	6.038392257	36.46218105	4.244748092	-0.3995177853	2887.109619	2904.031545
Barishal	Humidity (percent)	4.853056159	23.55215408	3.77819227	-0.08171133735	3105.457131	3122.379056
Barishal	Rainfall (mm)	177.4807138	31499.40379	152.6131656	-0.0002285410041	6770.259036	6787.180962

EGARCH – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rajshahi	Max_Temperature (Deg.Cel)	3.724982885	13.87549749	2.862171607	-0.034374938	2402.590948	2423.743355
Rajshahi	Min_Temperature (Deg.Cel)	6.745796783	45.50577424	4.899020381	-0.4818517542	2901.478633	2922.63104
Rajshahi	Humidity (percent)	6.377683516	40.67484703	4.700312338	-0.1020534217	3491.309073	3512.46148
Rajshahi	Rainfall (mm)	133.779816	17897.03917	101.9171078	-0.2533996273	6346.449564	6367.601972
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Chattogram	Max_Temperature (Deg.Cel)	2.425818218	5.884594027	1.891356058	-0.005452341927	2060.273916	2081.426324
Chattogram	Min_Temperature (Deg.Cel)	5.304978093	28.14279257	3.594086822	-0.5266525579	2567.852756	2589.005163
Chattogram	Humidity (percent)	5.85415902	34.27117783	4.472968184	-0.3392473432	3114.587052	3135.73946
Chattogram	Rainfall (mm)	286.0305445	81813.4724	205.1441992	-0.2929137972	6832.96081	6854.113217

EGARCH – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Khulna	Max_Temperature (Deg.Cel)	3.300379155	10.89250257	2.505023799	-0.03463082487	2356.966194	2378.118601
Khulna	Min_Temperature (Deg.Cel)	6.25097123	39.07464132	4.415713484	-0.4326533511	2746.049968	2767.202375
Khulna	Humidity (percent)	5.275782073	27.83387649	4.280781782	-0.02828385106	3350.360497	3371.512904
Khulna	Rainfall (mm)	158.6843835	25180.73357	116.1143897	-0.2550764634	6367.336123	6388.48853
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Dhaka	Max_Temperature (Deg.Cel)	3.173572543	10.07156268	2.509472398	-0.007239263	2270.478248	2291.630655
Dhaka	Min_Temperature (Deg.Cel)	5.696188328	32.44656147	4.064849882	-0.4274808023	2793.357236	2814.509643
Dhaka	Humidity (percent)	8.161981154	66.61793635	6.001465362	-0.4293258099	3415.199508	3436.351916
Dhaka	Rainfall (mm)	166.089045	27585.57087	124.7632783	-0.1729941494	6511.67597	6532.828377
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Mymensingh	Max_Temperature (Deg.Cel)	3.041867244	9.252956328	2.218431389	-0.07817014731	2136.827159	2157.979566
Mymensingh	Min_Temperature (Deg.Cel)	5.125127061	26.26692739	4.660510195	-0.0132442168	3082.775493	3103.927901
Mymensingh	Humidity (percent)	4.385294758	19.23081011	3.351661769	-0.1385712578	3318.524031	3339.676438
Mymensingh	Rainfall (mm)	192.7633241	37157.69912	150.3329165	-0.1953065	6723.635372	6744.787779

EGARCH – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Sylhet	Max_Temperature (Deg.Cel)	2.650223257	7.02368331	2.13468158	-0.002227630118	2137.440857	2158.593264
Sylhet	Min_Temperature (Deg.Cel)	5.876222914	34.52999574	4.403212613	-0.428398352	2877.941495	2899.093902
Sylhet	Humidity (percent)	6.525339218	42.58005191	4.594376649	-0.2976801864	3211.729757	3232.882164
Sylhet	Rainfall (mm)	298.1183582	88874.55548	235.2406005	-0.2891276395	7014.324061	7035.476468
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Rangpur	Max_Temperature (Deg.Cel)	3.62735071	13.15767317	2.578202698	-0.1101156598	2314.045392	2335.197799
Rangpur	Min_Temperature (Deg.Cel)	5.587694065	31.22232496	5.097172001	-0.02086433536	3172.126144	3193.278552
Rangpur	Humidity (percent)	5.924894868	35.1043792	4.214189343	-0.2772012673	3291.964453	3313.11686
Rangpur	Rainfall (mm)	212.7245083	45251.71645	149.2604057	-0.3173921173	6581.802325	6602.954733
Division	Variable	RMSE	MSE	MAE	R2	AIC	BIC
Barishal	Max_Temperature (Deg.Cel)	2.682454263	7.195560875	2.105473637	-0.003924454539	2156.352413	2177.50482
Barishal	Min_Temperature (Deg.Cel)	6.205718238	38.51093885	4.289374096	-0.4781546877	2728.268381	2749.420788
Barishal	Humidity (percent)	5.442879646	29.62493884	4.047470896	-0.3606242598	3064.512045	3085.664452
Barishal	Rainfall (mm)	194.1496332	37694.08006	148.1140466	-0.1969335976	6651.540234	6672.692642 ⁴⁴

LSTM – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2
Rajshahi	Max_Temperature (Deg.Cel)	1.516393261	2.299448522	1.148529424	0.8206828707
Rajshahi	Min_Temperature (Deg.Cel)	1.319625633	1.74141181	0.9546683071	0.9421482491
Rajshahi	Humidity (percent)	3.572443163	12.76235015	2.818541089	0.6266890219
Rajshahi	Rainfall (mm)	73.11295359	5345.503983	52.97441078	0.6423262546
Division	Variable	RMSE	MSE	MAE	R2
Chattogram	Max_Temperature (Deg.Cel)	1.245123065	1.550331447	1.011657066	0.7288350997
Chattogram	Min_Temperature (Deg.Cel)	1.198336837	1.436011176	1.011623322	0.9199651112
Chattogram	Humidity (percent)	2.607668585	6.799935451	2.043024818	0.7242722088
Chattogram	Rainfall (mm)	143.5048129	20593.63132	97.46323514	0.6748838491

LSTM – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2
Khulna	Max_Temperature (Deg.Cel)	1.43866922	2.069769126	1.031711507	0.7952832737
Khulna	Min_Temperature (Deg.Cel)	1.52299009	2.319498814	1.255797797	0.9131012074
Khulna	Humidity (percent)	2.880771788	8.298846096	2.296657457	0.679860039
Khulna	Rainfall (mm)	89.02340053	7925.165842	62.68695719	0.6165295637
Division	Variable	RMSE	MSE	MAE	R2
Dhaka	Max_Temperature (Deg.Cel)	1.638338893	2.684154327	1.35955963	0.7222928689
Dhaka	Min_Temperature (Deg.Cel)	1.544676615	2.386025845	1.28441767	0.8927234091
Dhaka	Humidity (percent)	3.824754492	14.62874692	3.05081946	0.6775071162
Dhaka	Rainfall (mm)	97.42131027	9490.911694	74.01995256	0.6181021783
Division	Variable	RMSE	MSE	MAE	R2
Mymensingh	Max_Temperature (Deg.Cel)	1.422409808	2.023249661	1.148872586	0.7571911098
Mymensingh	Min_Temperature (Deg.Cel)	1.278985141	1.635802992	0.9421876608	0.9360268148
Mymensingh	Humidity (percent)	2.79761174	7.826631448	2.261014378	0.5045643512
Mymensingh	Rainfall (mm)	112.5099565	12658.49031	85.03221886	0.6078960826

LSTM – RMSE, MSE, MAE, R2, AIC and BIC value

Division	Variable	RMSE	MSE	MAE	R2
Sylhet	Max_Temperature (Deg.Cel)	1.404555395	1.972775858	1.15127708	0.7085877111
Sylhet	Min_Temperature (Deg.Cel)	1.444885188	2.087693205	1.127952806	0.9121776173
Sylhet	Humidity (percent)	3.367530349	11.34026065	2.760842304	0.6285810806
Sylhet	Rainfall (mm)	159.2775401	25369.33478	109.3360241	0.6332061877
Division	Variable	RMSE	MSE	MAE	R2
Rangpur	Max_Temperature (Deg.Cel)	1.820107423	3.312791032	1.407704825	0.7139359083
Rangpur	Min_Temperature (Deg.Cel)	1.291031397	1.666762068	1.080941918	0.9446149157
Rangpur	Humidity (percent)	4.354106251	18.95824125	3.577562656	0.2728257977
Rangpur	Rainfall (mm)	149.9207812	22476.24062	110.0228886	0.3623537329
Division	Variable	RMSE	MSE	MAE	R2
Barishal	Max_Temperature (Deg.Cel)	1.533616555	2.351979737	1.247011122	0.6639305384
Barishal	Min_Temperature (Deg.Cel)	1.564074213	2.446328144	1.30541545	0.9044756084
Barishal	Humidity (percent)	2.52698698	6.385663197	1.940390762	0.7001976638
Barishal	Rainfall (mm)	114.4468654	13098.08499	81.91208075	0.602769297

08

Key Model

SARIMA

AR(p): Autoregressive component of order p

MA(q): Moving average component of order q

I(d): Integrated component of order d

Seasonal AR(P): Seasonal autoregressive component of order P

MA(Q): Seasonal moving average component of order Q

Seasonal I(D): Seasonal integrated component of order D

s: Seasonal period

SARIMA(p, d, q)(P, D, Q, s)

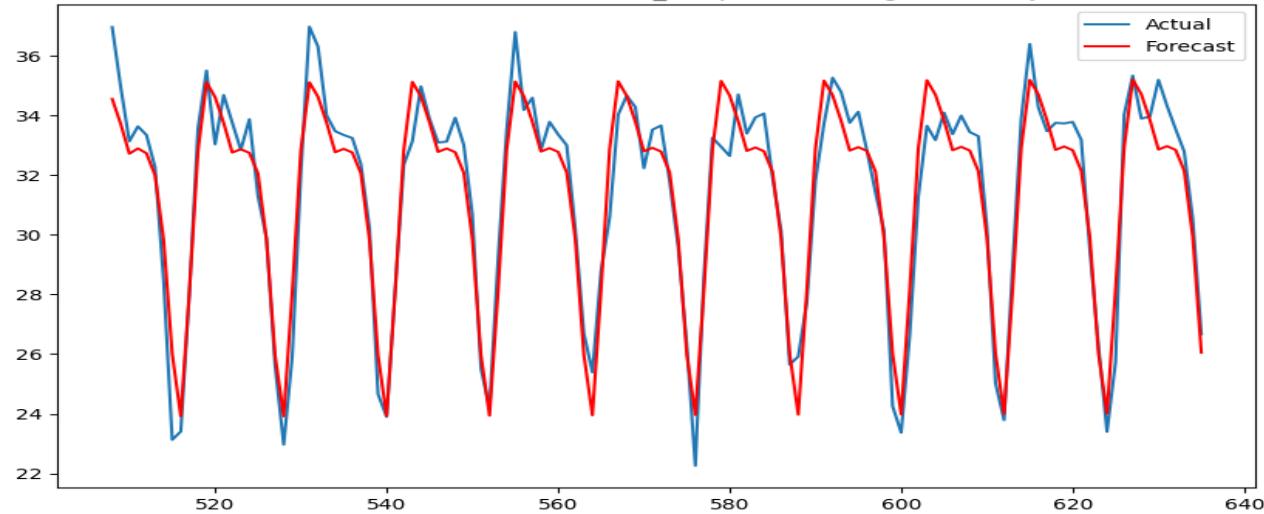
SARIMA

Temperature

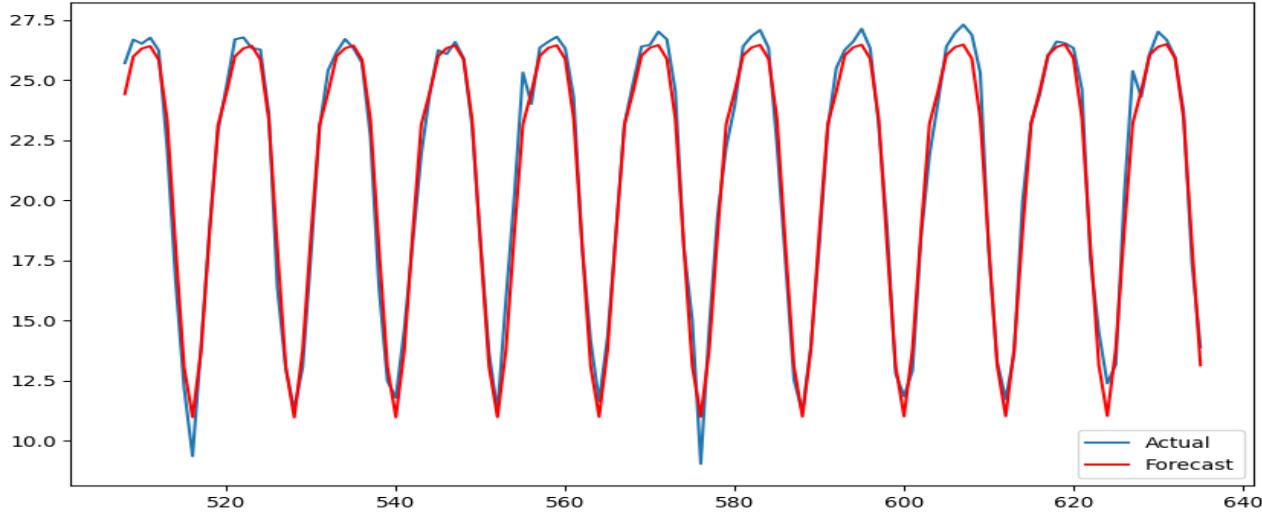
SARIMA(p, d, q)(P, D, Q, s) : (1, 1, 1)(1, 1, 1, 12)

SARIMA

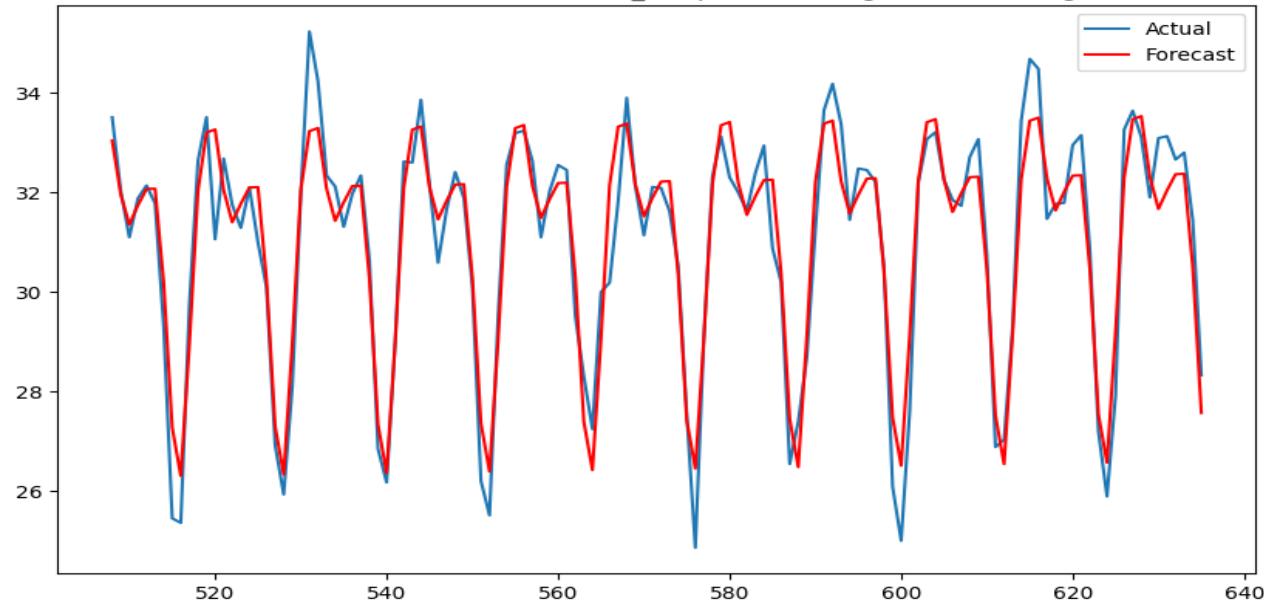
SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Rajshahi



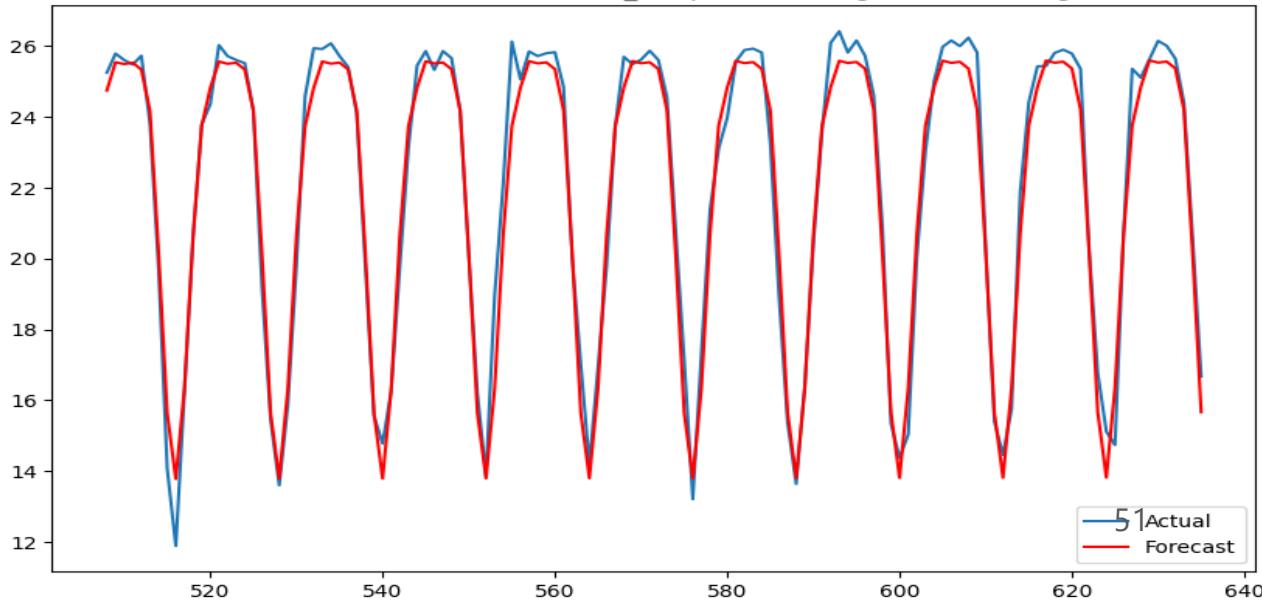
SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Rajshahi



SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Chattogram

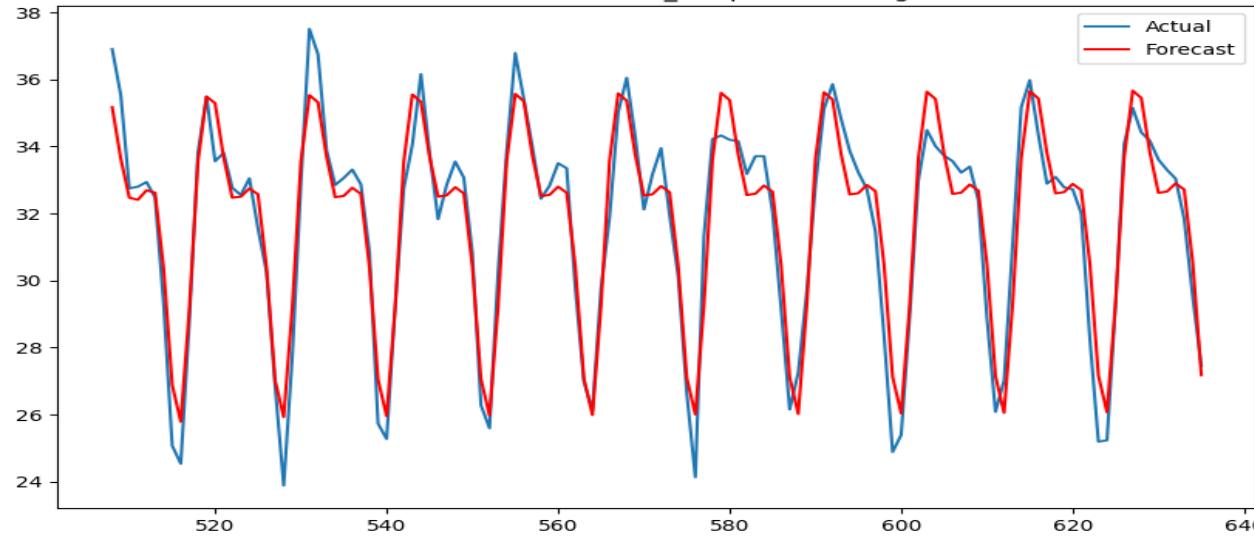


SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Chattogram

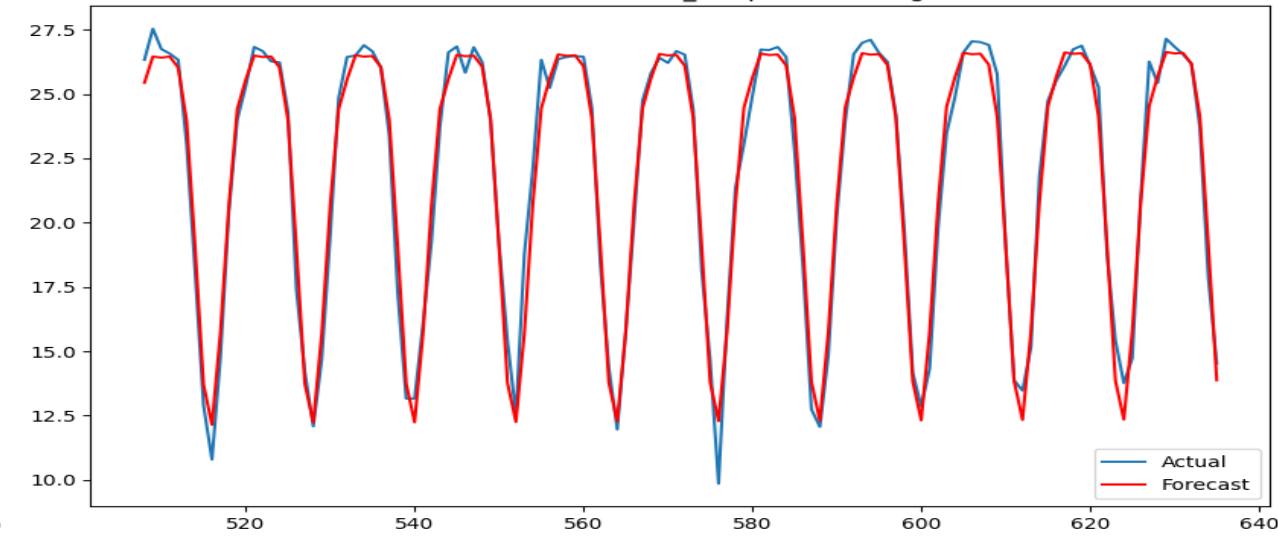


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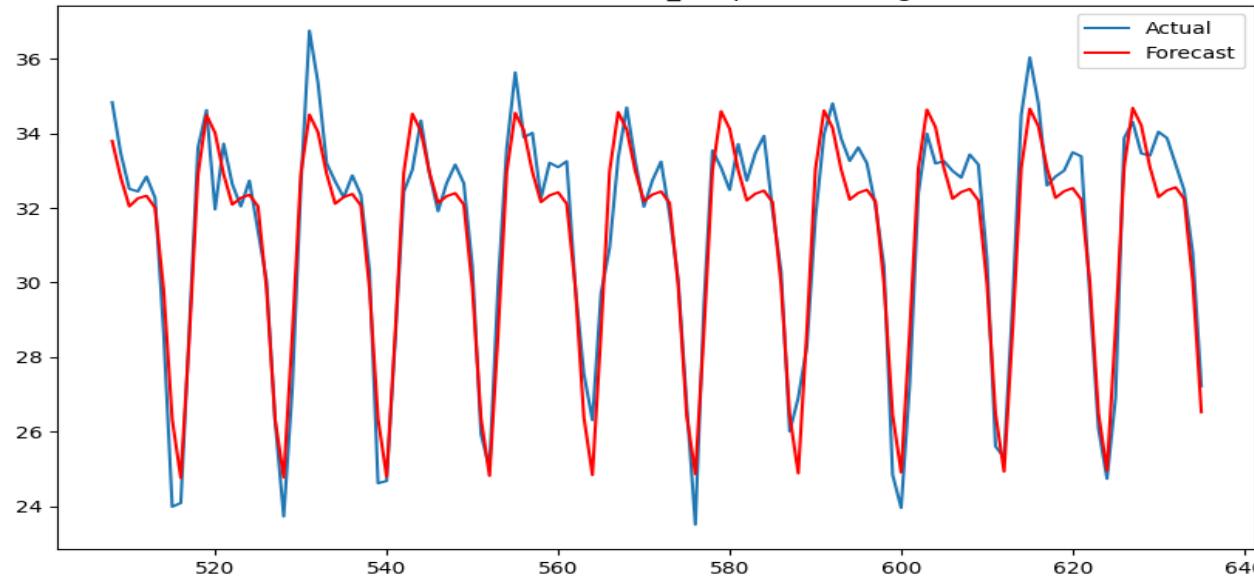
SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Khulna



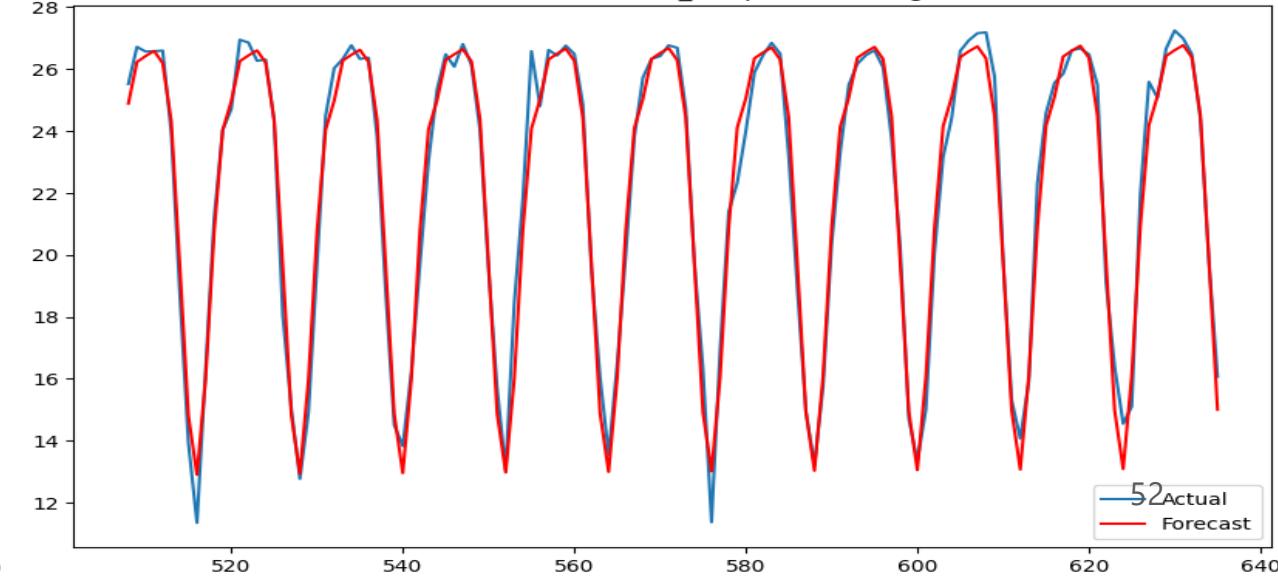
SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Khulna



SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Dhaka

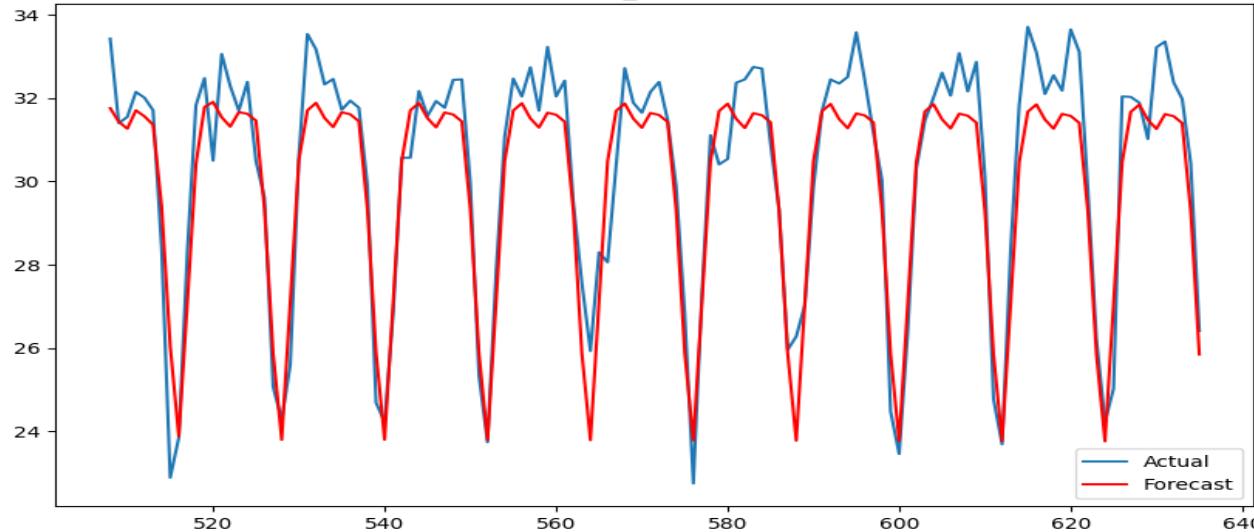


SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Dhaka

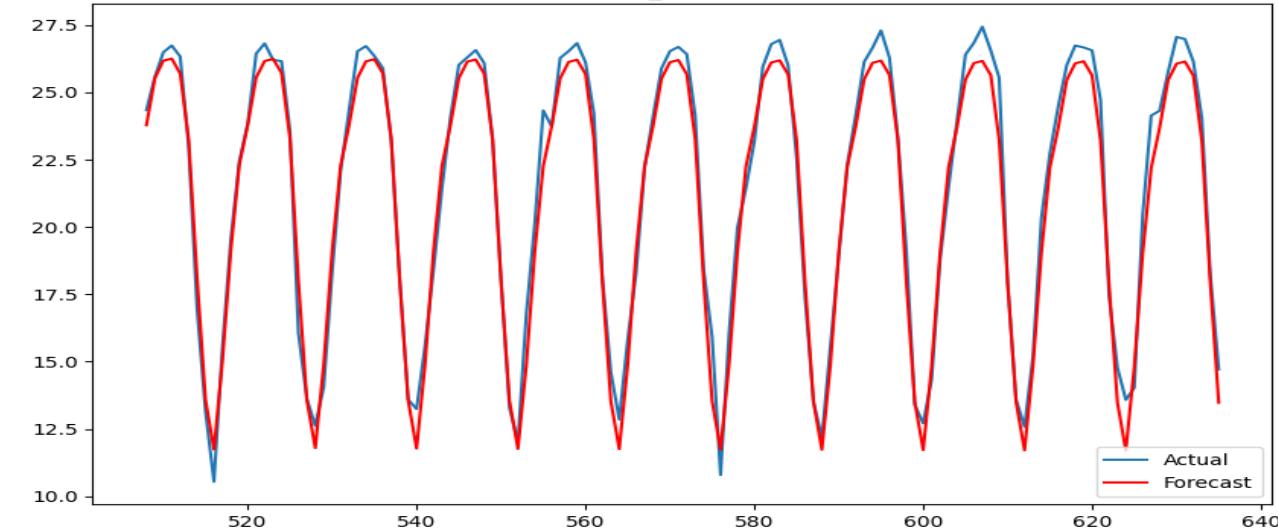


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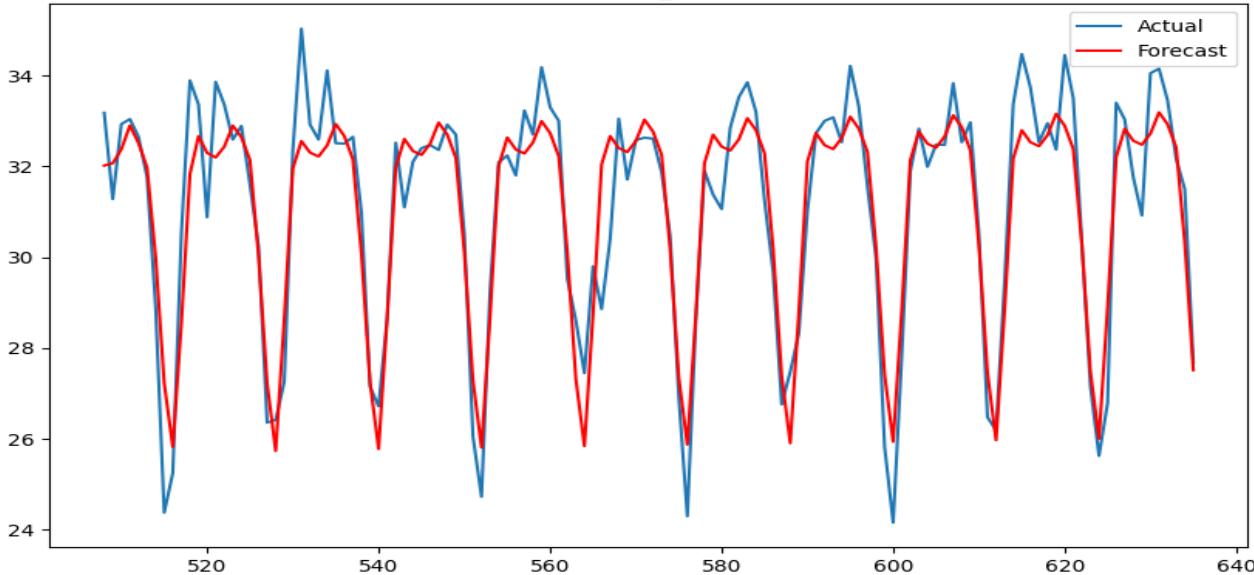
SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Mymensingh



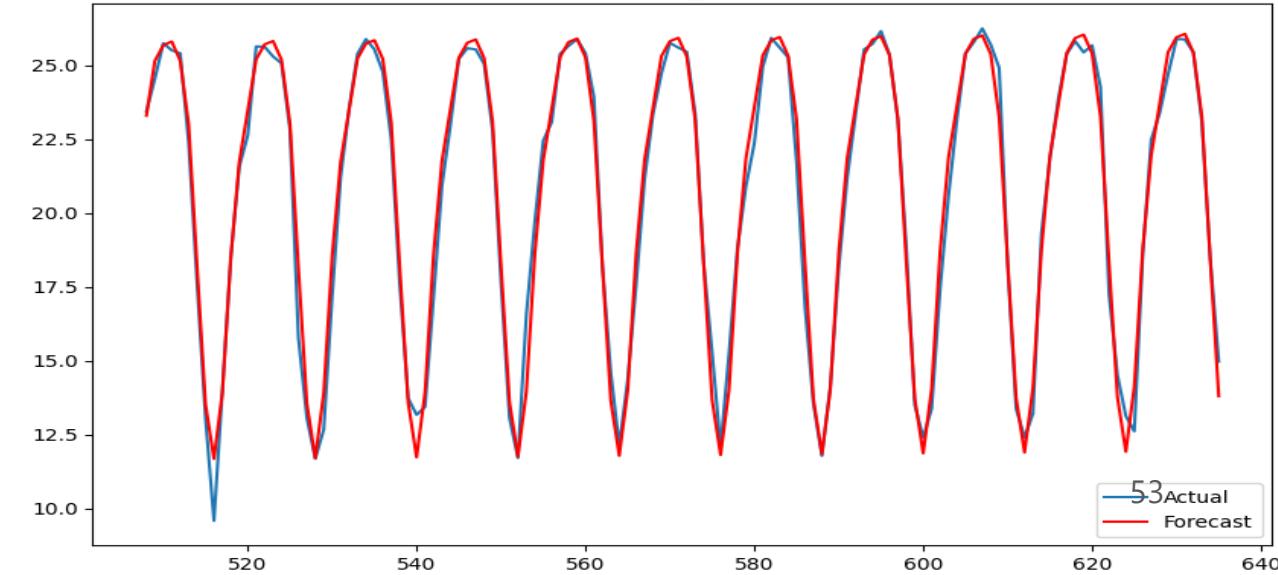
SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Mymensingh



SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Sylhet

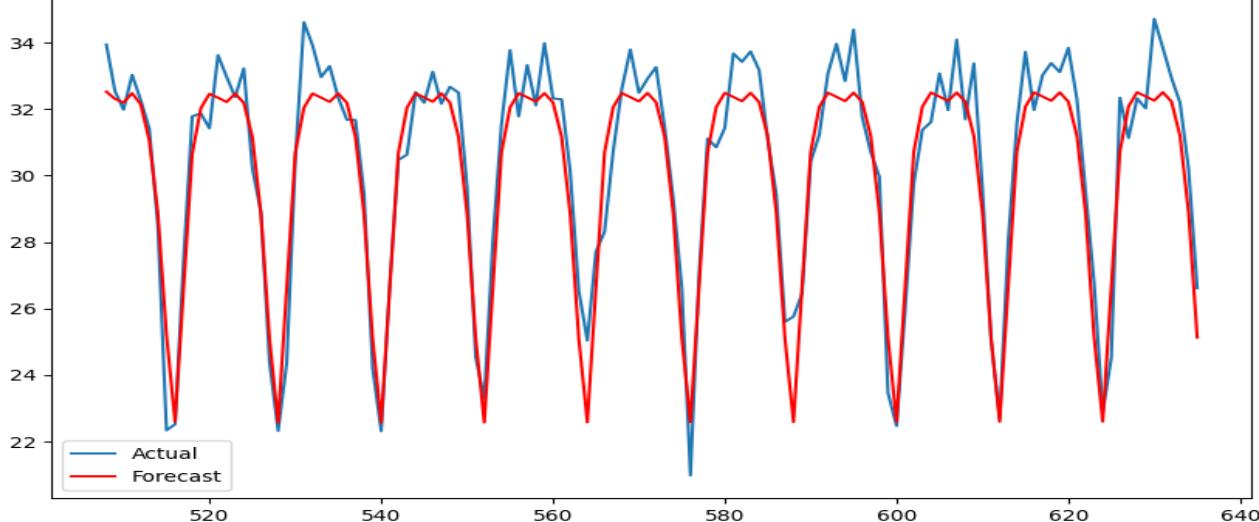


SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Sylhet

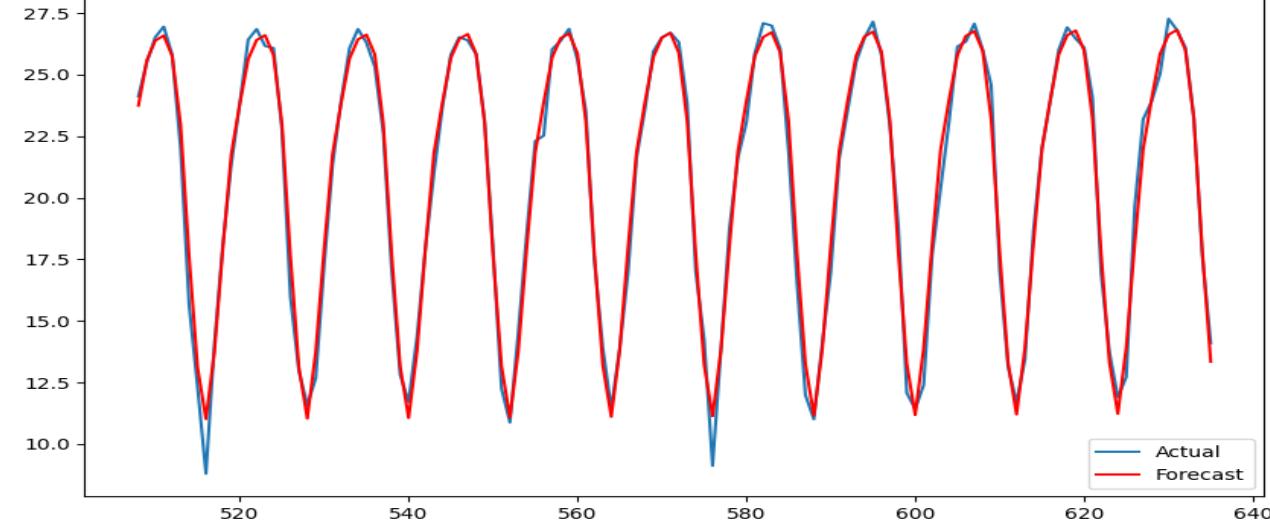


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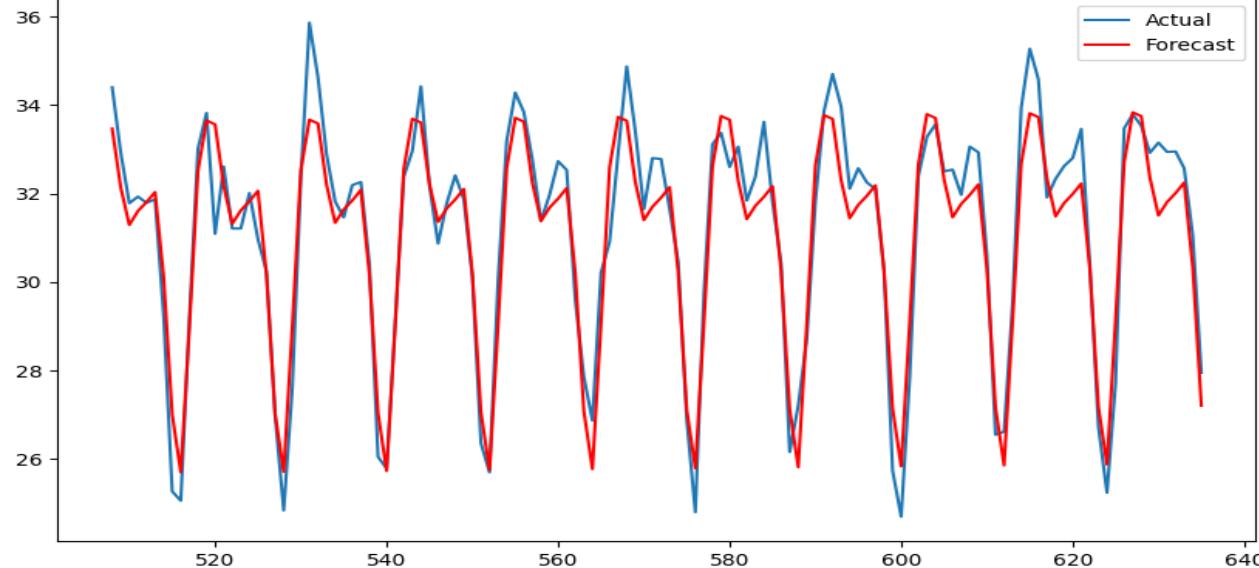
SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Rangpur



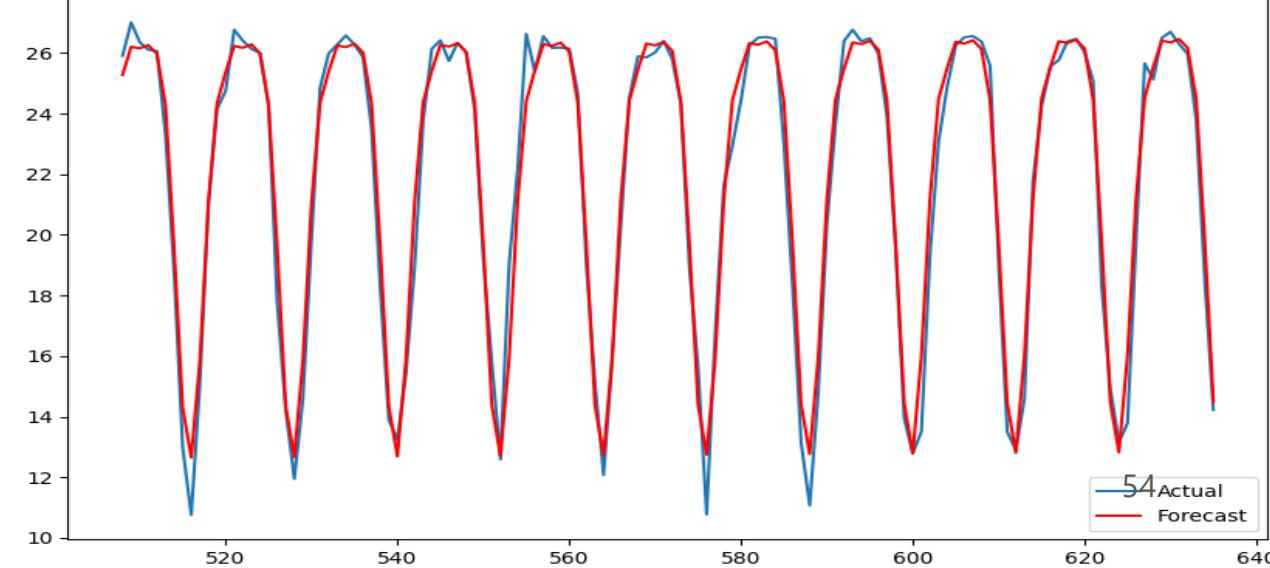
SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Rangpur



SARIMA Forecast vs Actual for Max_Temperature (Deg.Cel) in Barishal



SARIMA Forecast vs Actual for Min_Temperature (Deg.Cel) in Barishal

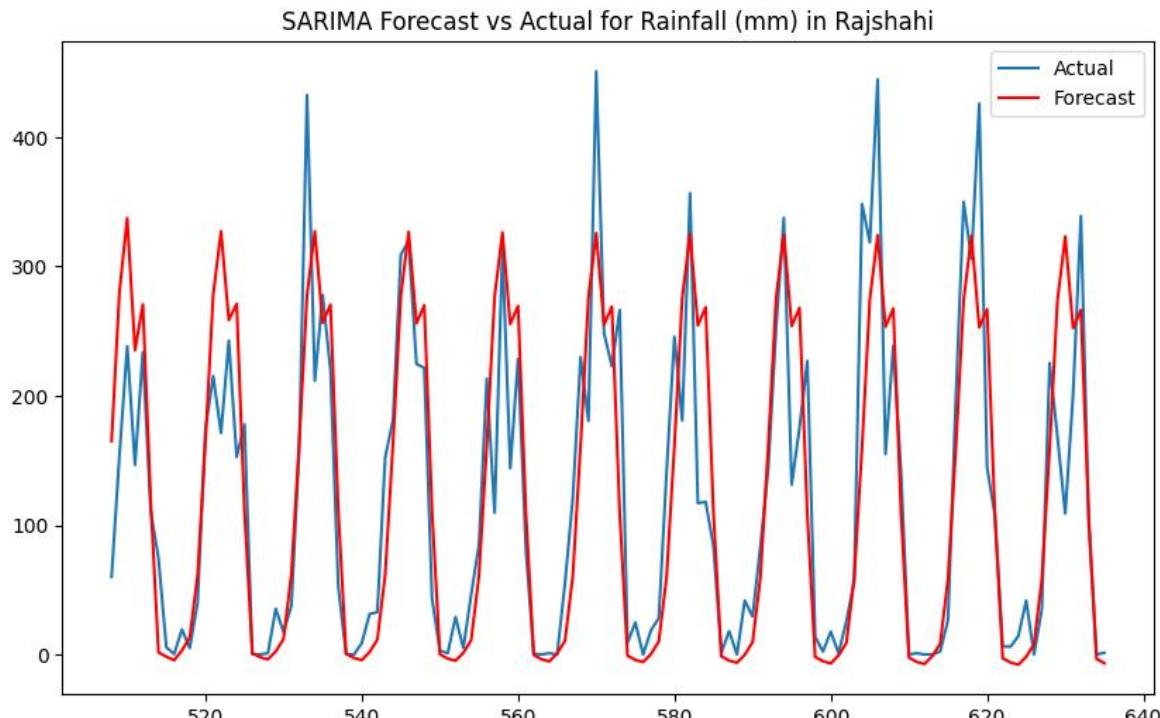


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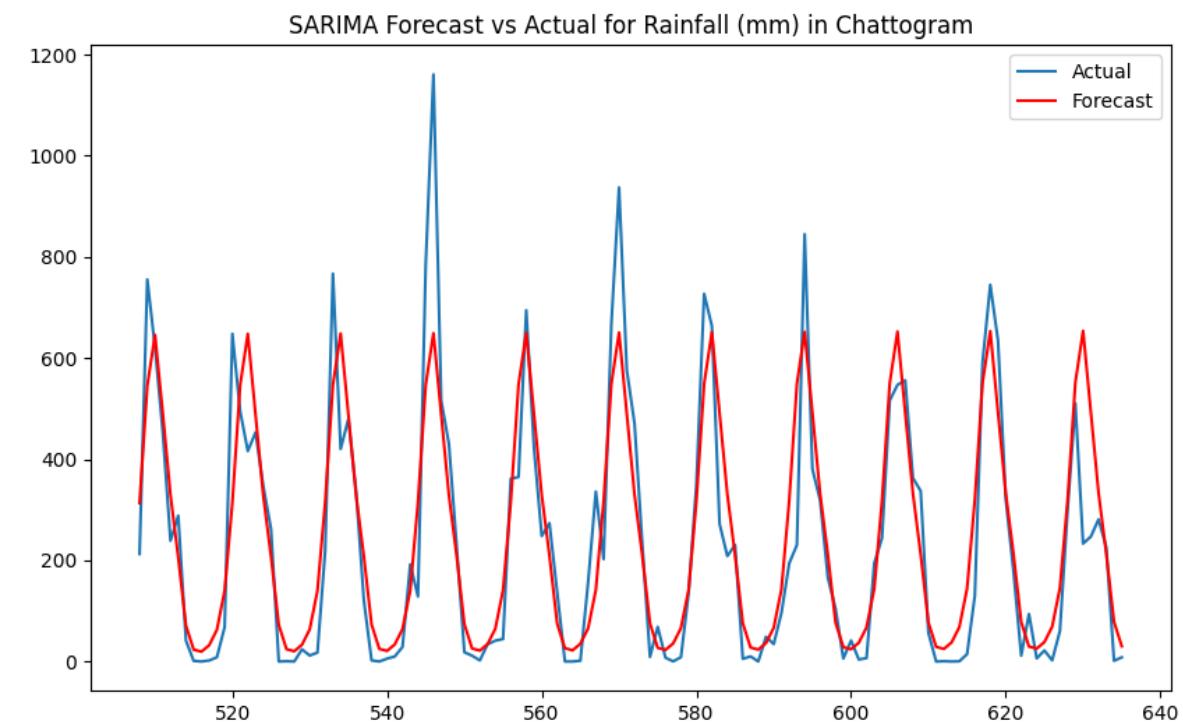
Rainfall

SARIMA

SARIMA(p, d, q)(P, D, Q, s) : (0, 1, 1)(1, 1, 1, 12)

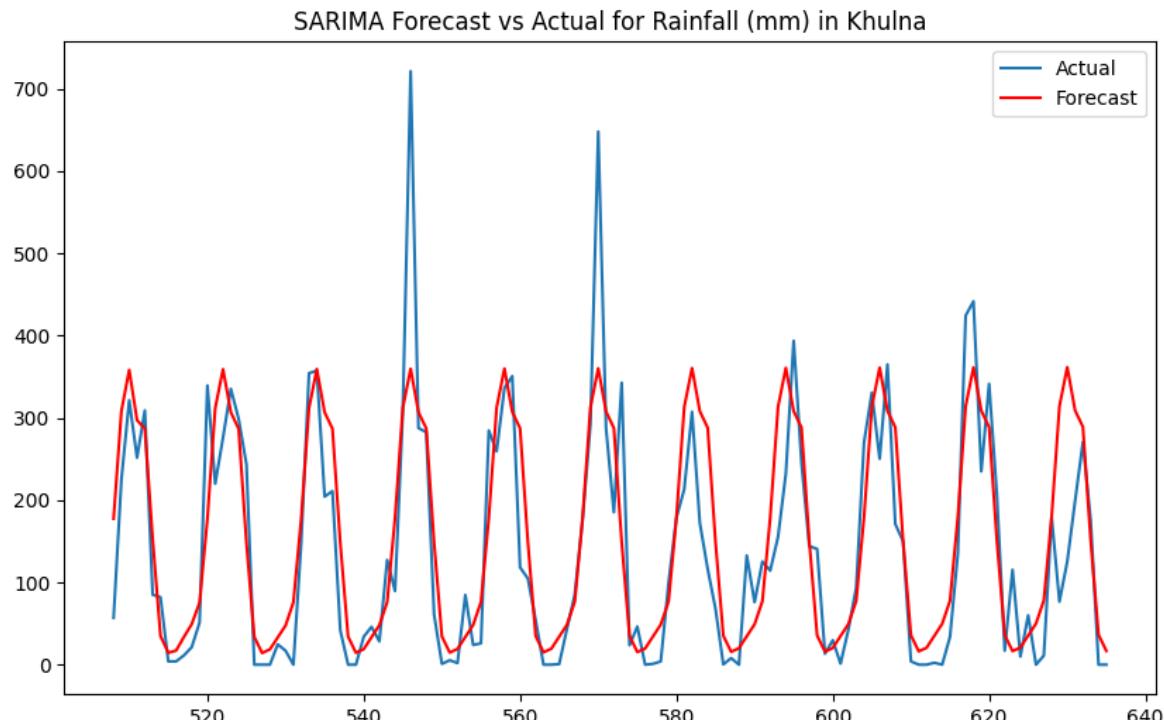


SARIMA(p, d, q)(P, D, Q, s) : (1, 1, 1)(1, 1, 1, 12)

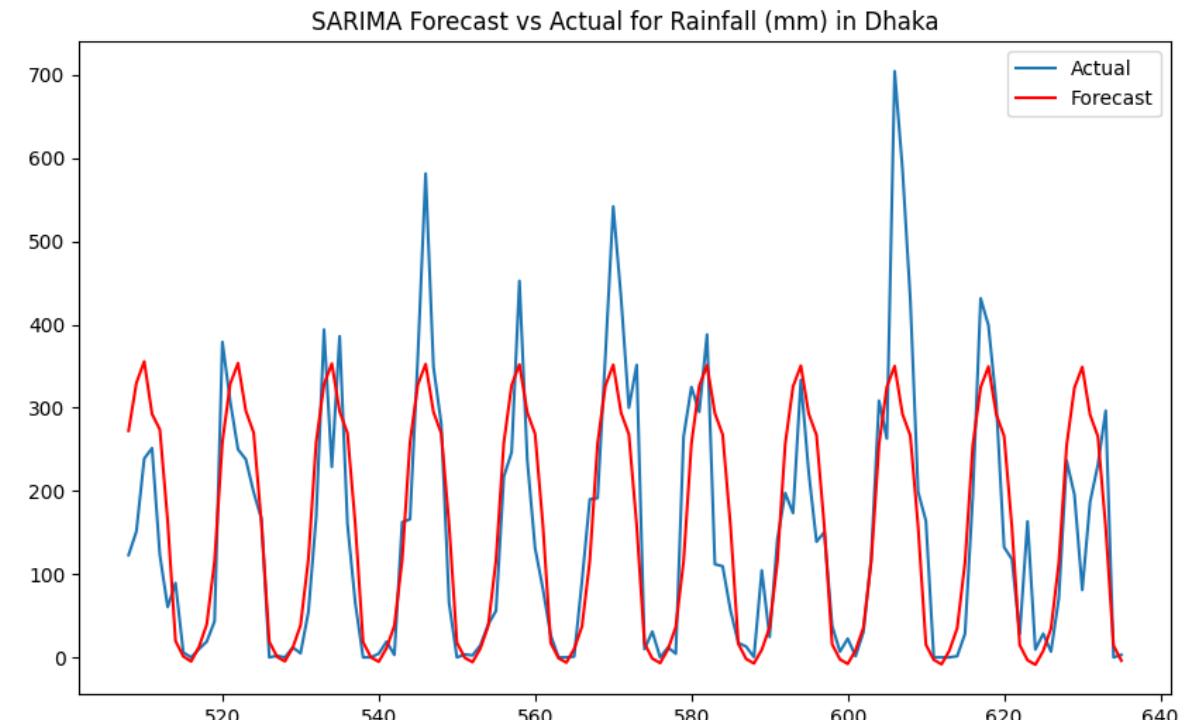


SARIMA

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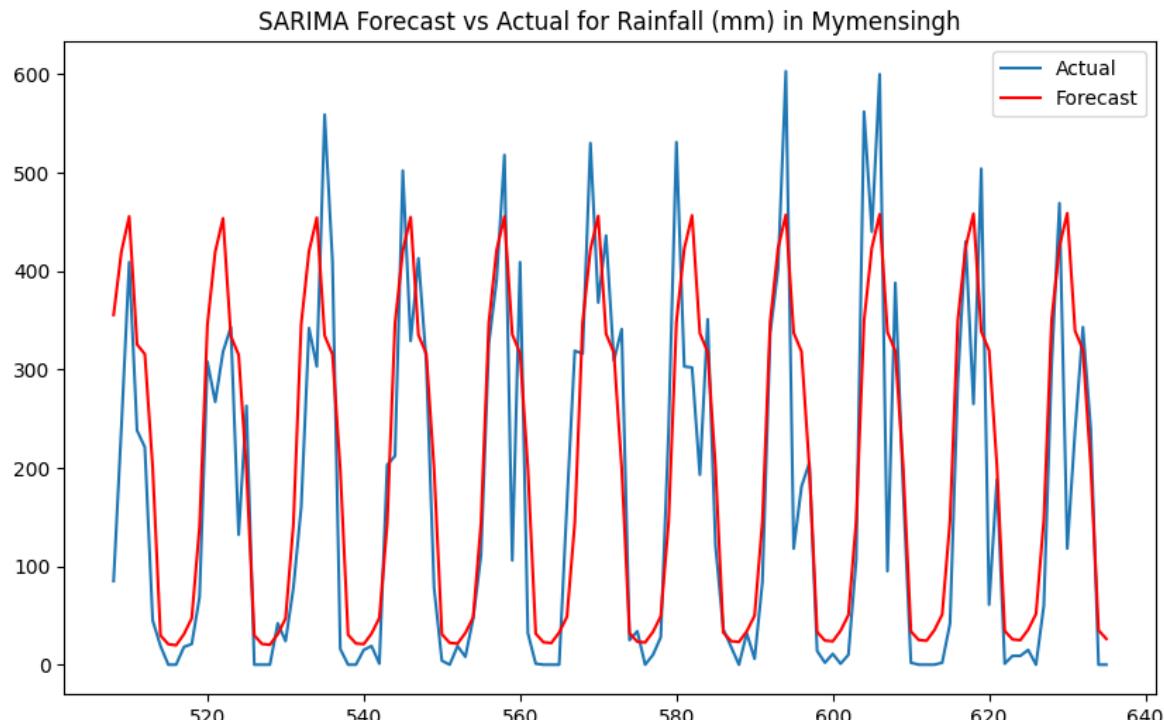


SARIMA(p, d, q)(P, D, Q, s) : (0, 1, 1)(1, 0, 1, 12)

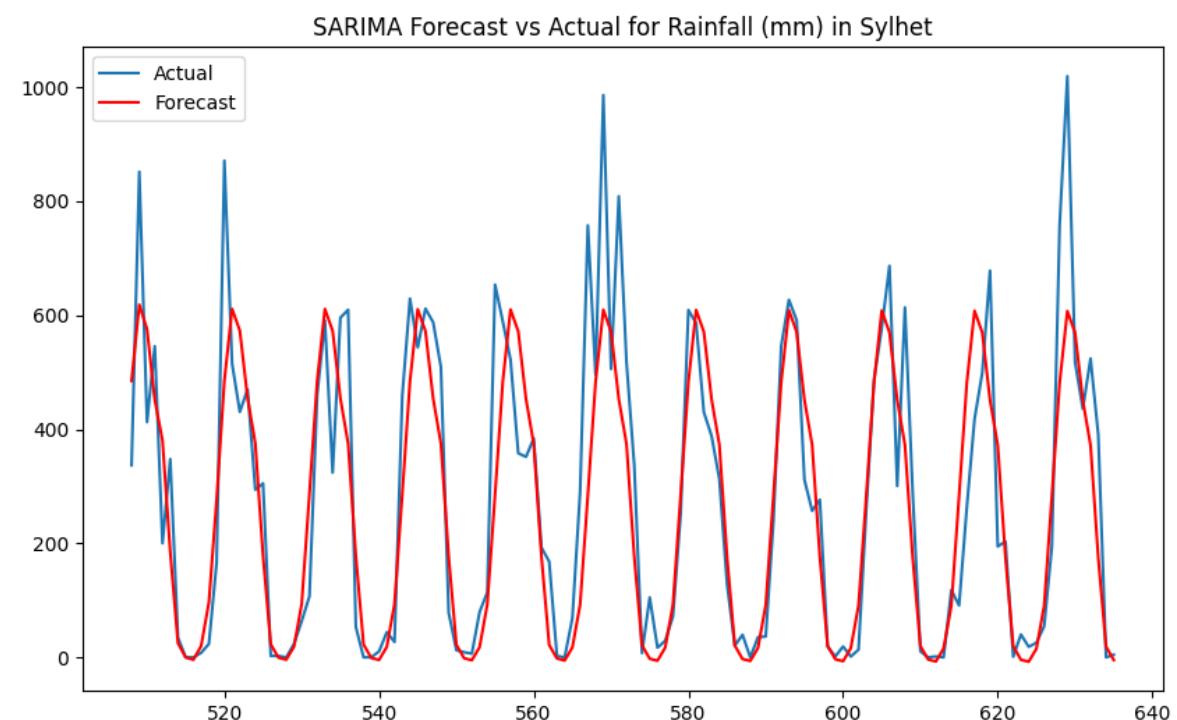


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SARIMA(p, d, q)(P, D, Q, s) : (1, 0, 1)(0, 1, 1, 12)

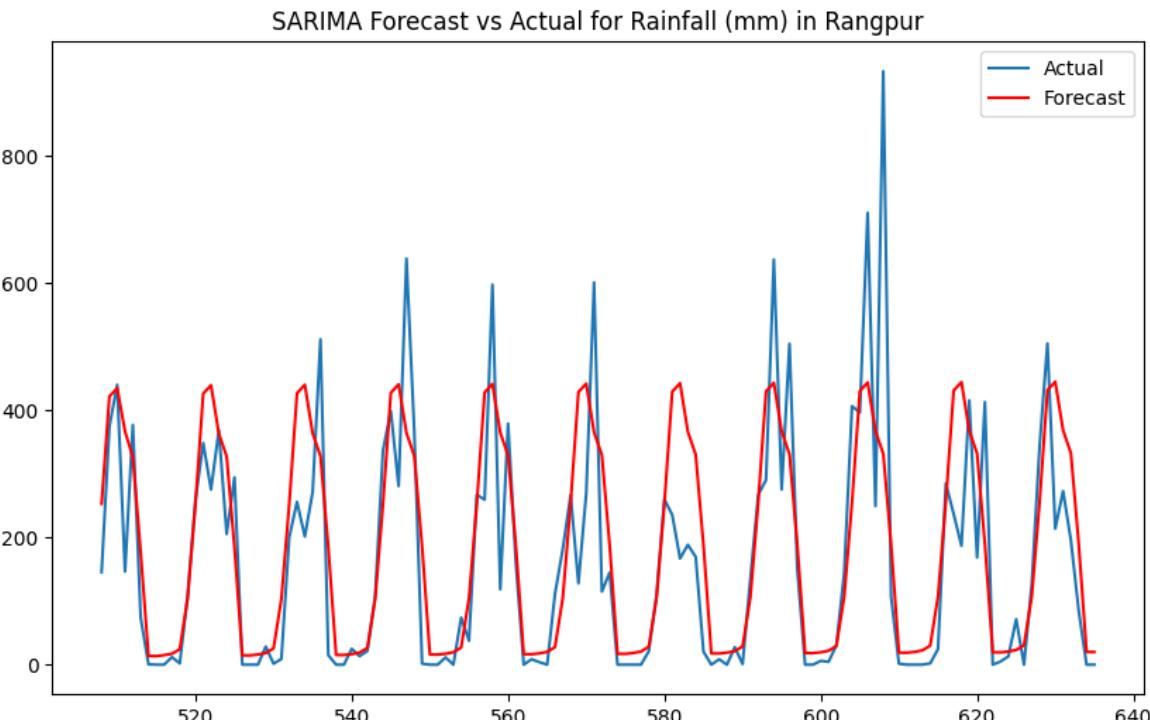


SARIMA(p, d, q)(P, D, Q, s) : (0, 1, 1)(1, 1, 1, 12)

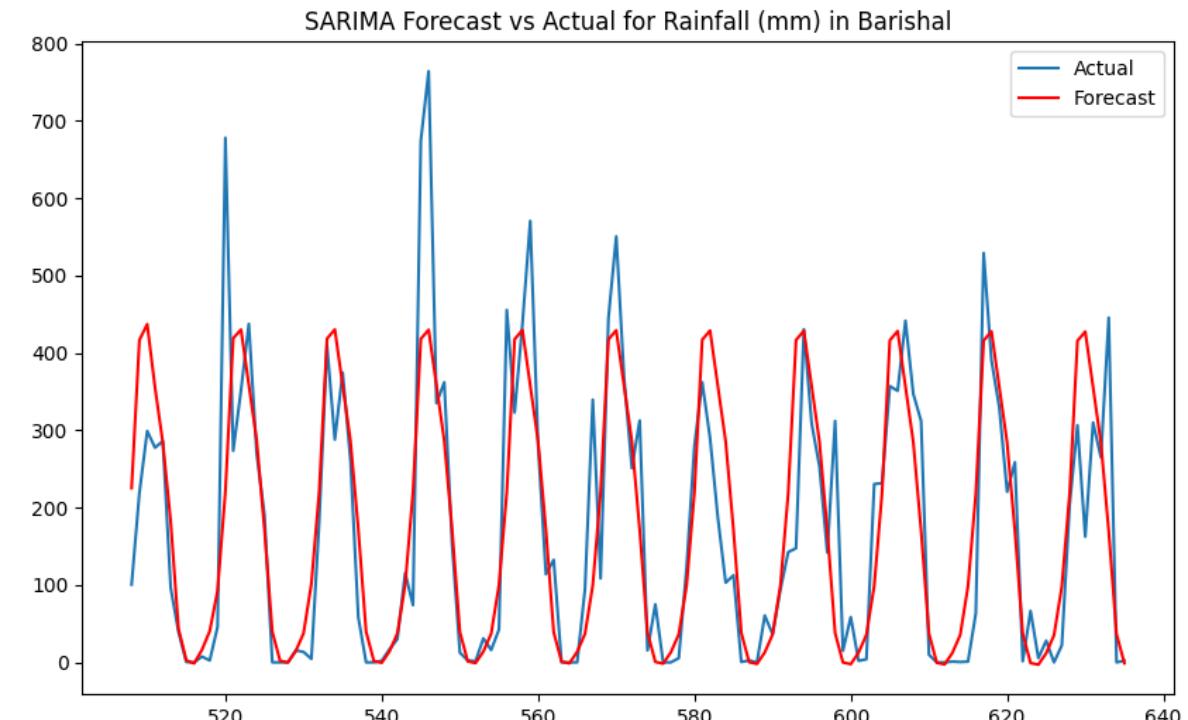


SARIMA

SARIMA(p, d, q)(P, D, Q, s) : (1, 0, 1)(1, 1, 1, 12)



SARIMA(p, d, q)(P, D, Q, s) : (0, 0, 0)(1, 0, 1, 12)



09

Future Work

Future Work

- Seasonal and Long-Term Forecasting
- Development of a Publicly Accessible Forecasting System
- Incorporating More Climatic Variables
- Extreme Weather Event Prediction

10

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