서울시 오존 농도 시계열 예측

2022711778 윤태호

구분	예보등급					
예측농도	좋음	보통	민감군	나쁨	매우나쁨	위험
	0~0.04	0.041~0.080	0.081~0.12	0.121~0.300	0.301~0.5	0.501

출처: 웨더뉴스

TABLE OF CONTENTS

DATA

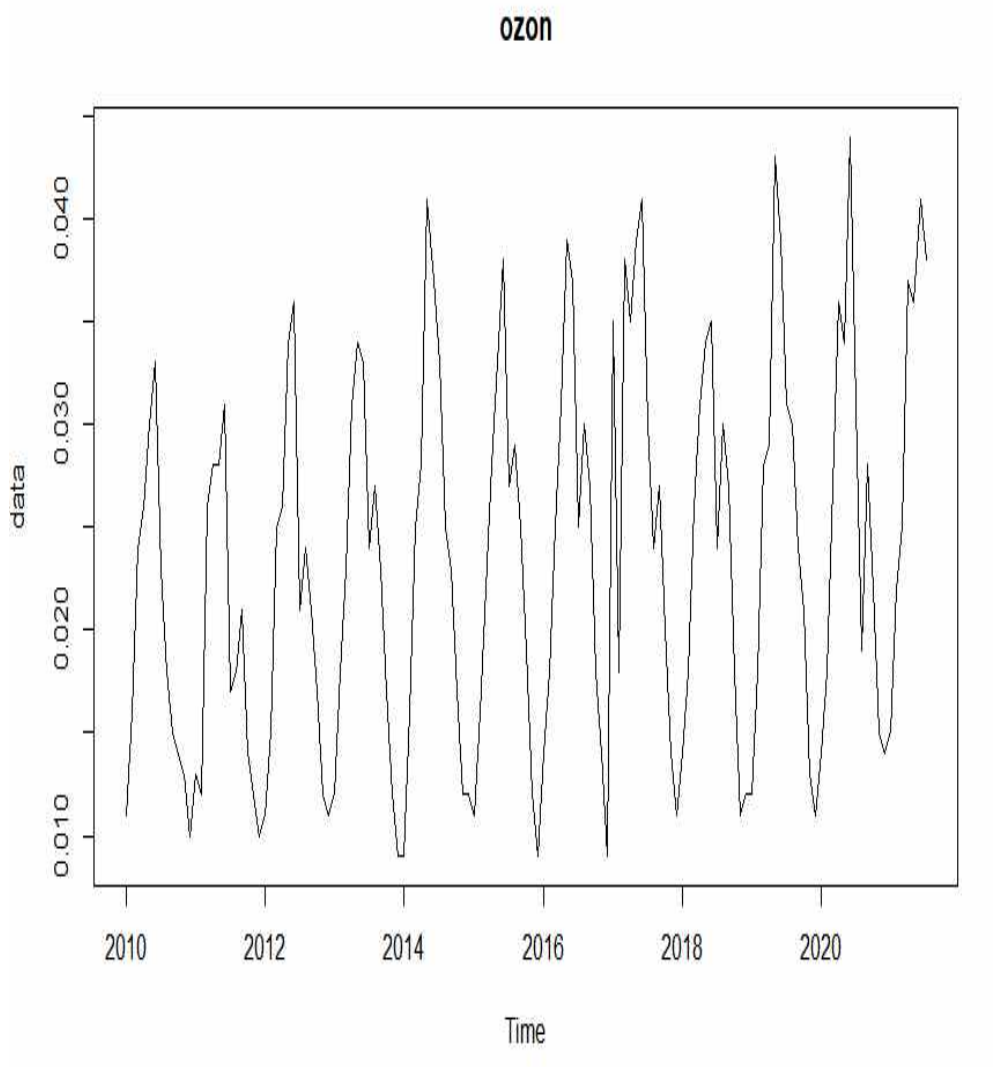
TIME:2000.01
~ 2021.07
COUNT:139
단위: ppm

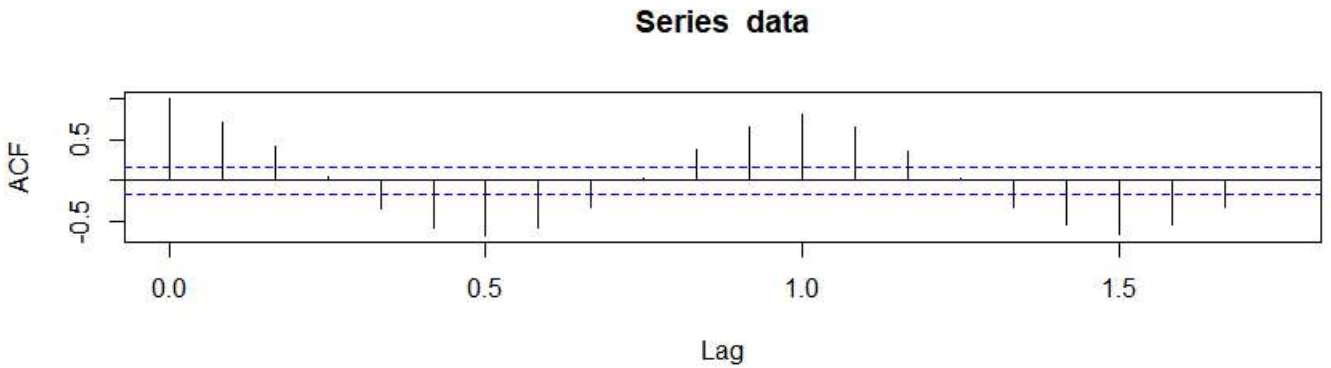
MAX:0.044
MIN: 0.009
1ST QU:0.015
MEDIAN:0.024
3RD QU:0.03

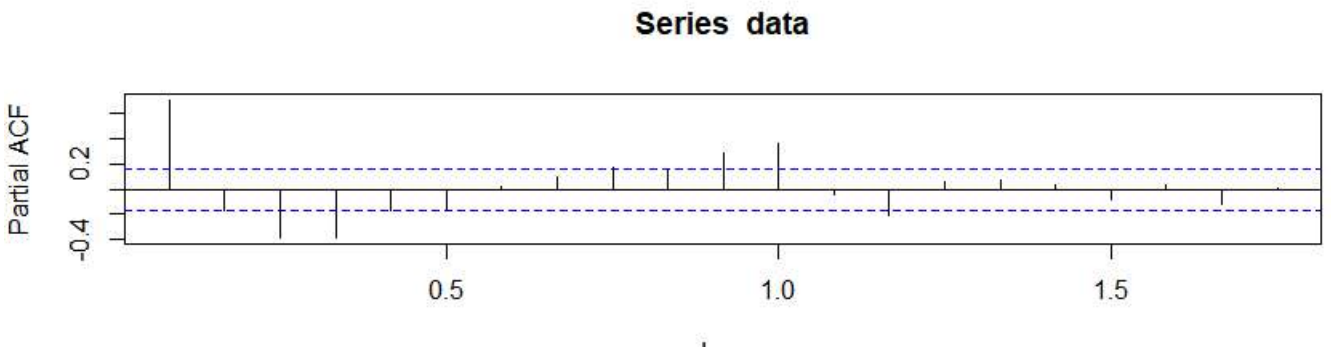
구분	예보등급					
예측농도	좋음	보통	민감군	나쁨	매우나쁨	위험
	0~0.04	0.041~0.080	0.081~0.12	0.121~0.300	0.301~0.5	0.501

SOURCE: 환경부

DATA PLOT(서울)


ozon
data
0.010
0.020
0.030
0.040
2010
2012
2014
2016
2018
2020
Time

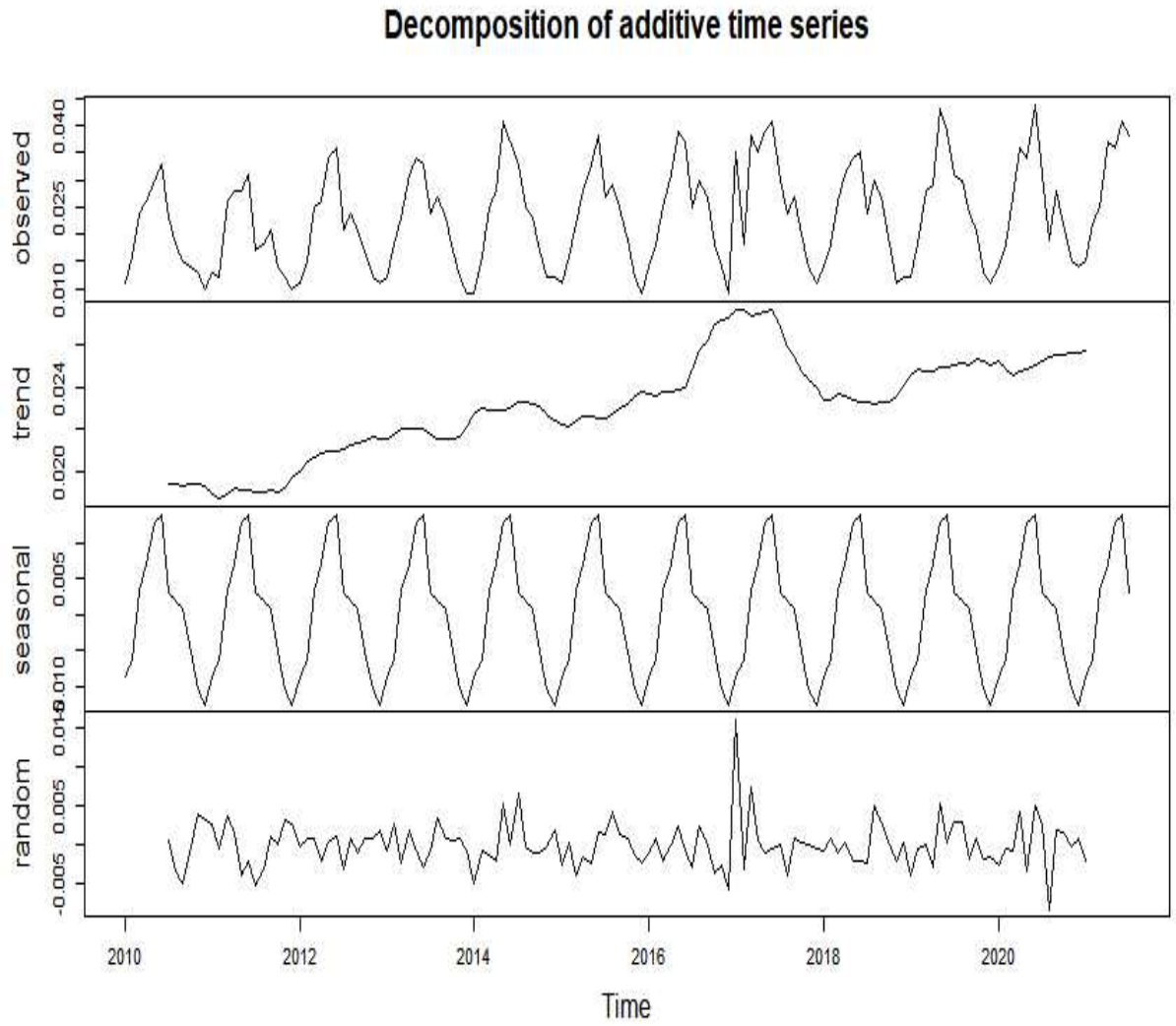

Series data
ACF
0.5
-0.5
0.0
0.5
1.0
1.5
Lag


Series data
Partial ACF
0.2
-0.4
0.5
1.0
1.5

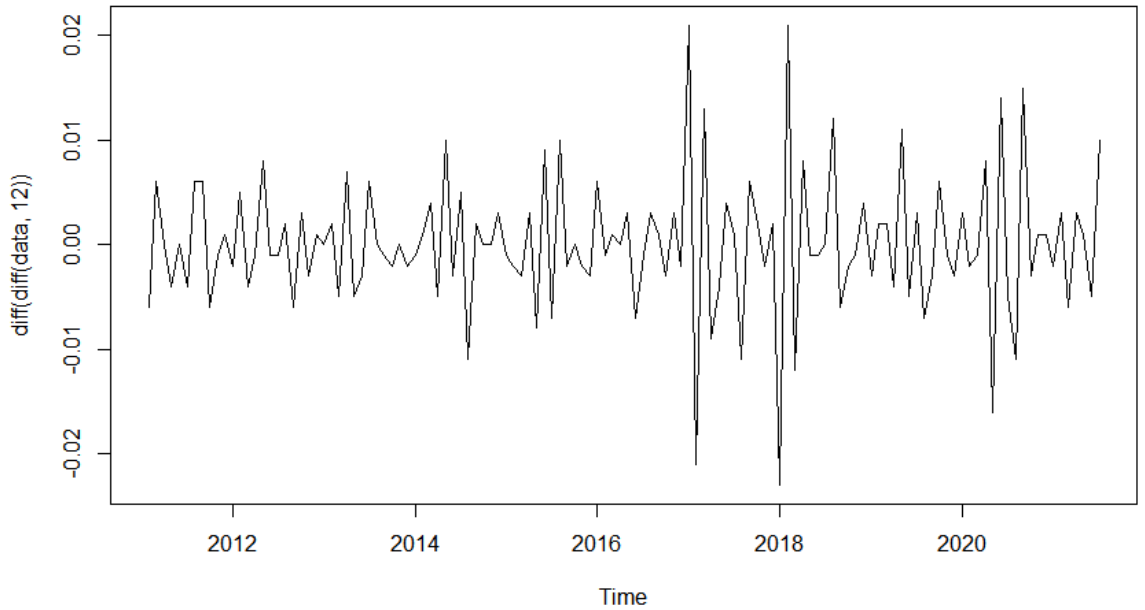
DATA DECOMPOSITION

- TREND
- SEASONALITY

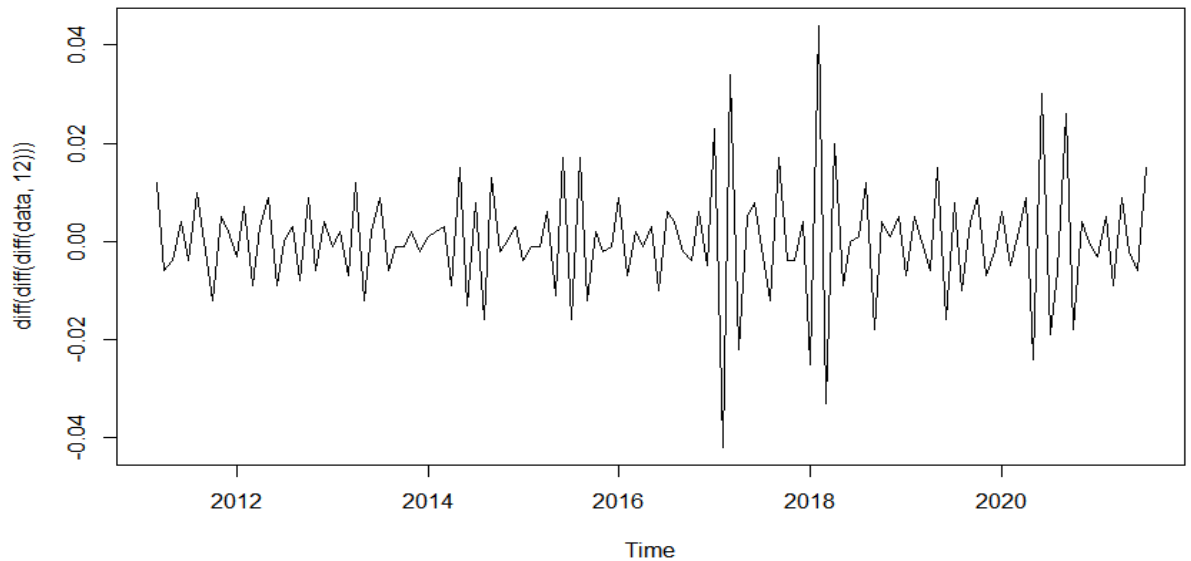
차분 & 계절 차분



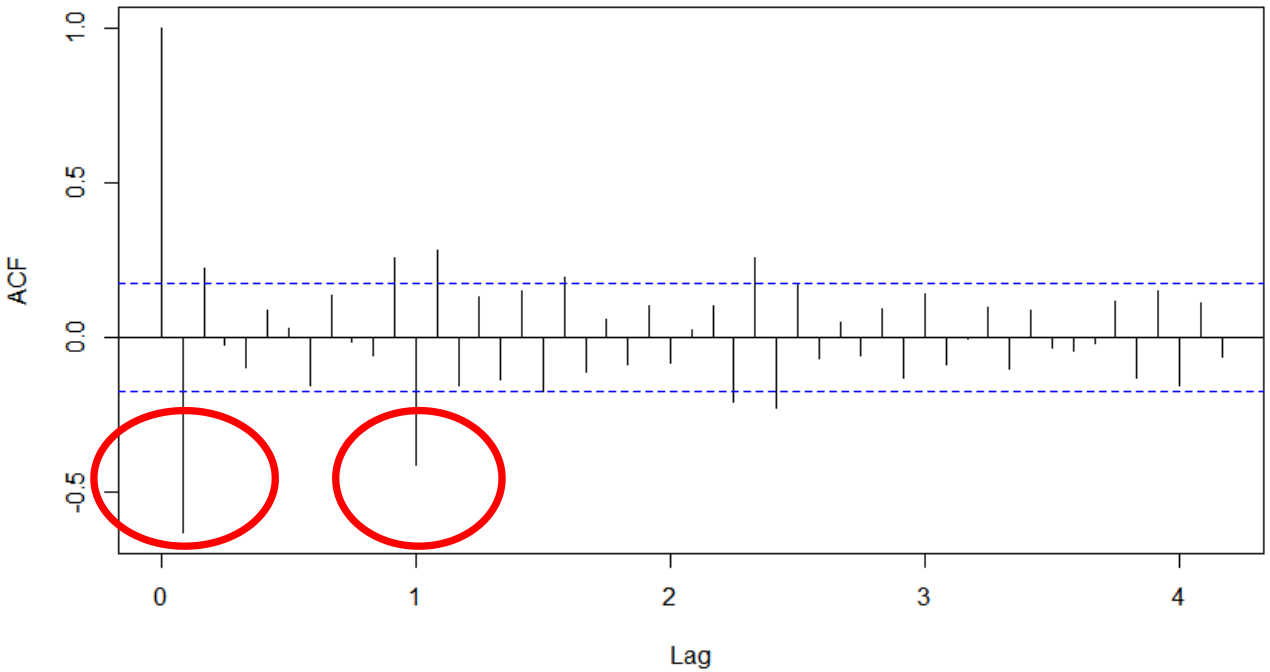
(계절차분 후)1번 차분

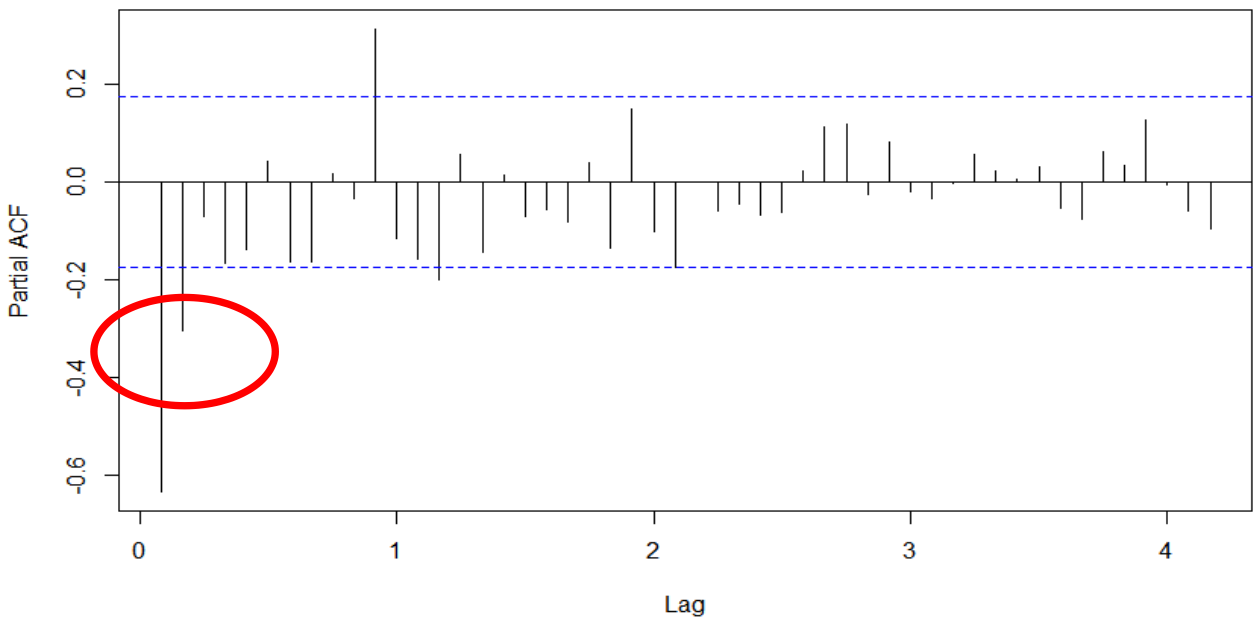


(계절차분 후)2번 차분



큰 차이 없어서 1번차분 선택





ARIMA(2,1,0)(0,1,1)

ARIMA(1,1,0)(1,1,0)

ARIMA(0,1,0)(1,1,1)

ARIMA(0,1,1)(2,1,1)

ARIMA(0,0,0)(0,1,1)

ARIMA(0,0,0)(2,1,0)

MODEL SELECTION

잔차 검정(p-value)

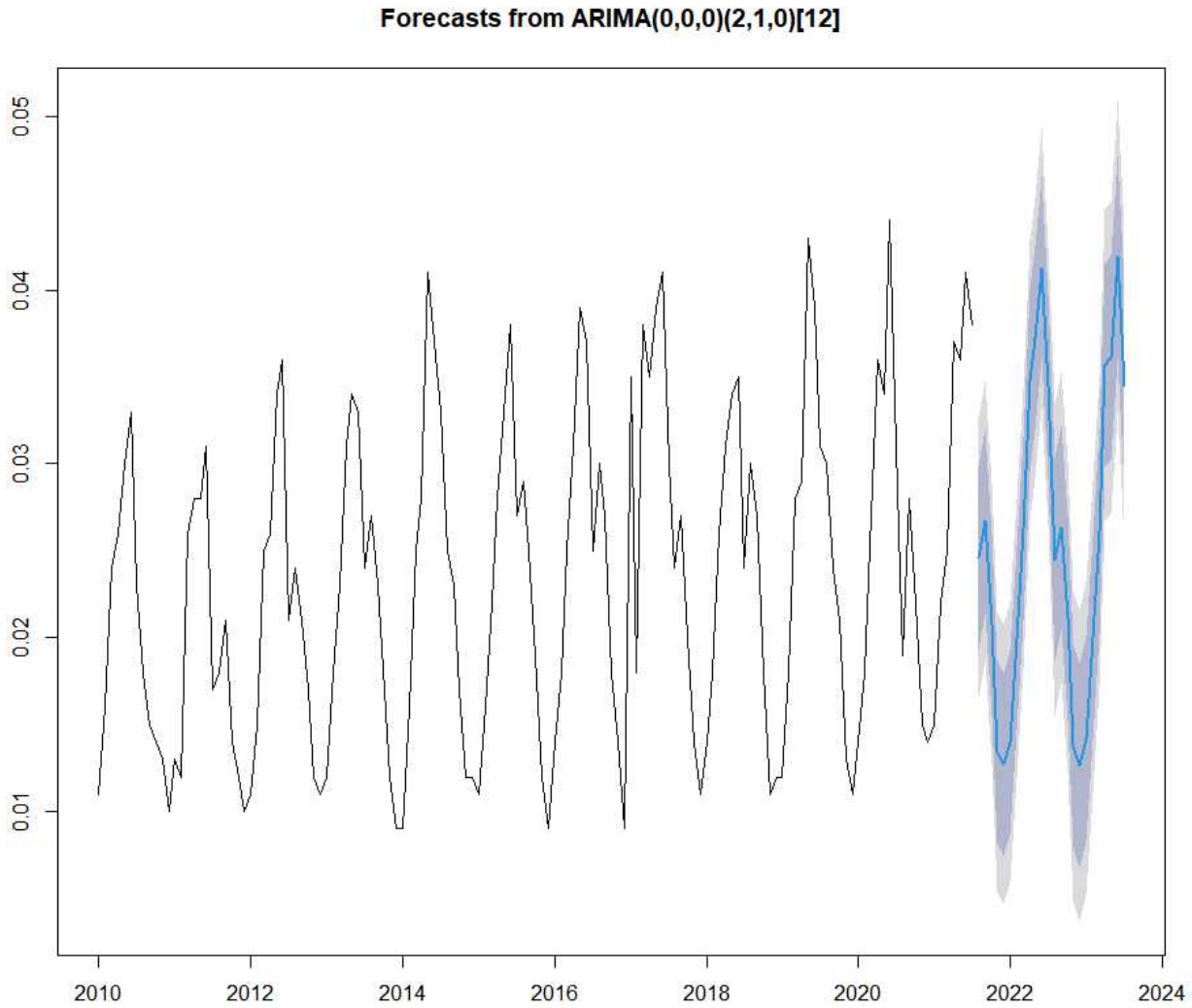
	ARIMA(2,1,0)(0,1,1)	ARIMA(1,1,0)(1,1,0)	ARIMA(0,1,0)(1,1,1)	ARIMA(1,1,1)(0,1,0)	ARIMA(0,0,0)(1,1,0)	ARIMA(0,0,0)(2,1,0)
Ljung-Box Q	0.8539	0.0494	0	0.0044	0.0989	0.3474
McLeod-Li Q	1	0.6517	7e-04	0.0105	0.1838	0.7857
Turning points T	0.0069	0.2802	0.0103	0.2802	0.9462	0.7872
Diff signs S	0.5582	0.3798	0.1432	0.0404	0.0192	0.0192
Rank P	0.877	0.439	0.4742	0.6217	0.8713	0.682

INFORMATION CRITERIA

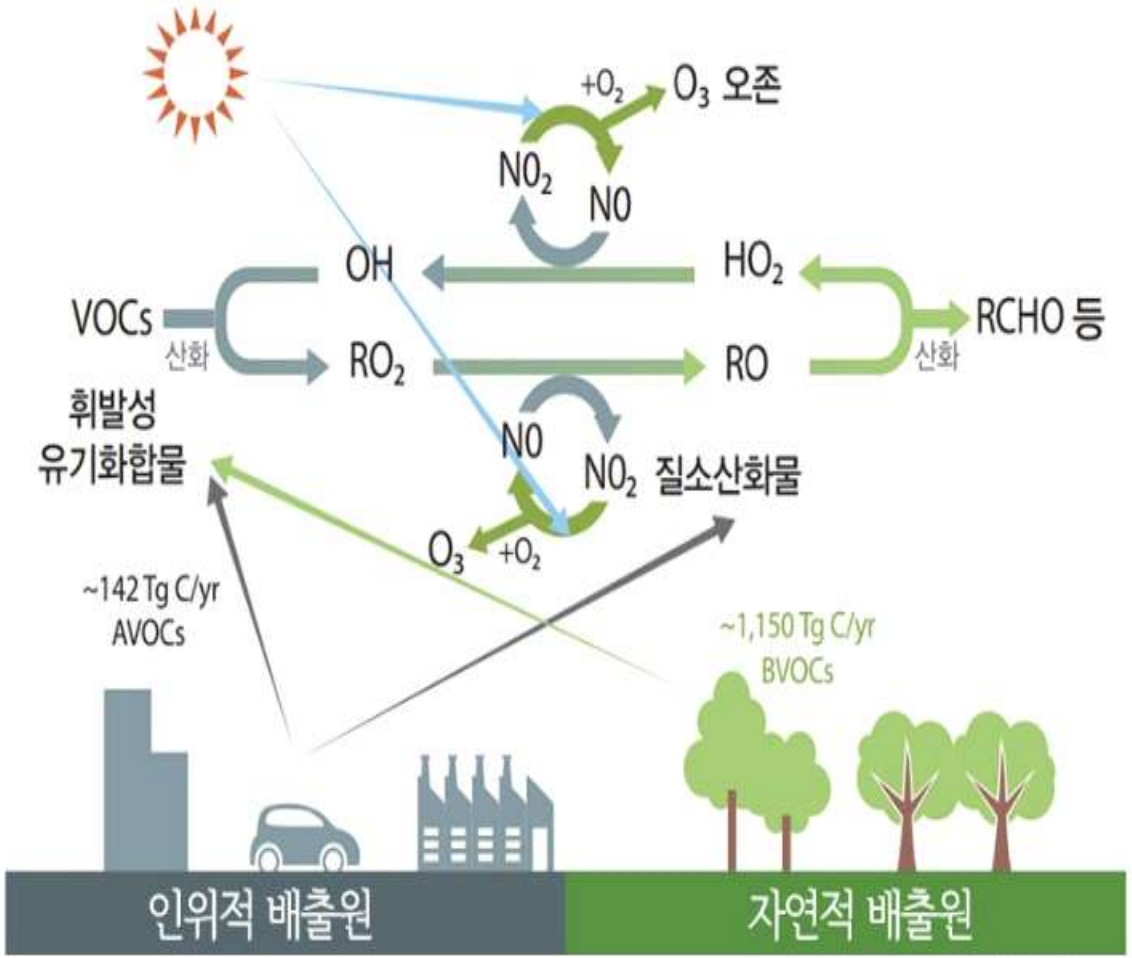
	ARIMA(2,1,0)(0,1,1)	ARIMA(1,1,0)(1,1,0)	ARIMA(0,1,0)(1,1,1)	ARIMA(1,1,1)(0,1,1)	ARIMA(0,0,0)(1,1,0)	ARIMA(0,0,0)(2,1,0)
RMSE	0.00349181	0.004322327	0.004430695	0.004445668	0.004071558	0.003925299
MAE	0.002410227	0.002882814	0.002927182	0.003002925	0.002700955	0.002566955
MAPE	-2.763059	13.37884	12.91164	13.47914	11.777263	11.07753
AIC	-1025.64	-992.95	-960.37	--987.84	-1019.99	-1025.64
BIC	-1014.297	-984.4431	-951.8654	-979.3326	-1014.304	-1017.107

FORECASTING(ARIMA(0,0,0)(2,1,0))

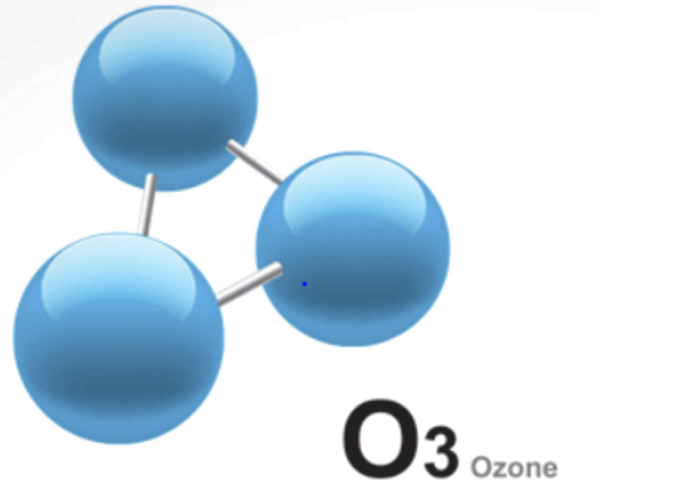
	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Aug 2021	0.02459908	0.019336317	0.02986184	0.016550379	0.03264778
Sep 2021	0.02671372	0.021450955	0.03197648	0.018665017	0.03476242
Oct 2021	0.02074124	0.015478481	0.02600401	0.012692543	0.02878995
Nov 2021	0.01348215	0.008219390	0.01874492	0.005433451	0.02153086
Dec 2021	0.01272289	0.007460131	0.01798566	0.004674192	0.02077160
Jan 2022	0.01399116	0.008728397	0.01925392	0.005942459	0.02203986
Feb 2022	0.01996397	0.014701207	0.02522673	0.011915269	0.02801267
Mar 2022	0.02626793	0.021005167	0.03153069	0.018219229	0.03431663
Apr 2022	0.03474158	0.029478817	0.04000434	0.026692878	0.04279028
May 2022	0.03723123	0.031968466	0.04249399	0.029182528	0.04527993
Jun 2022	0.04127744	0.036014678	0.04654021	0.033228740	0.04932614
Jul 2022	0.03443695	0.029174185	0.03969971	0.026388247	0.04248565
Aug 2022	0.02449818	0.018635282	0.03036109	0.015531649	0.03346472
Sep 2022	0.02636878	0.020505879	0.03223168	0.017402246	0.03533532
Oct 2022	0.02113204	0.015269142	0.02699495	0.012165509	0.03009858
Nov 2022	0.01375492	0.007892014	0.01961782	0.004788381	0.02272145
Dec 2022	0.01262320	0.006760300	0.01848610	0.003656667	0.02158974
Jan 2023	0.01425475	0.008391849	0.02011765	0.005288216	0.02322129
Feb 2023	0.02000066	0.014137758	0.02586356	0.011034125	0.02896720
Mar 2023	0.02612238	0.020259475	0.03198528	0.017155842	0.03508891
Apr 2023	0.03564122	0.029778314	0.04150412	0.026674681	0.04460775
May 2023	0.03610469	0.030241791	0.04196759	0.027138158	0.04507123



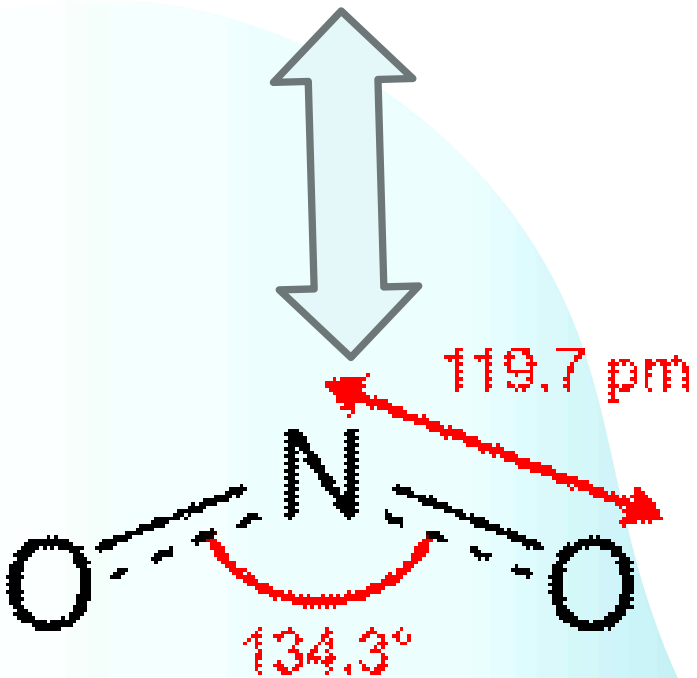
NO2



이미지 출처ⓒ환경부



O3 Ozone



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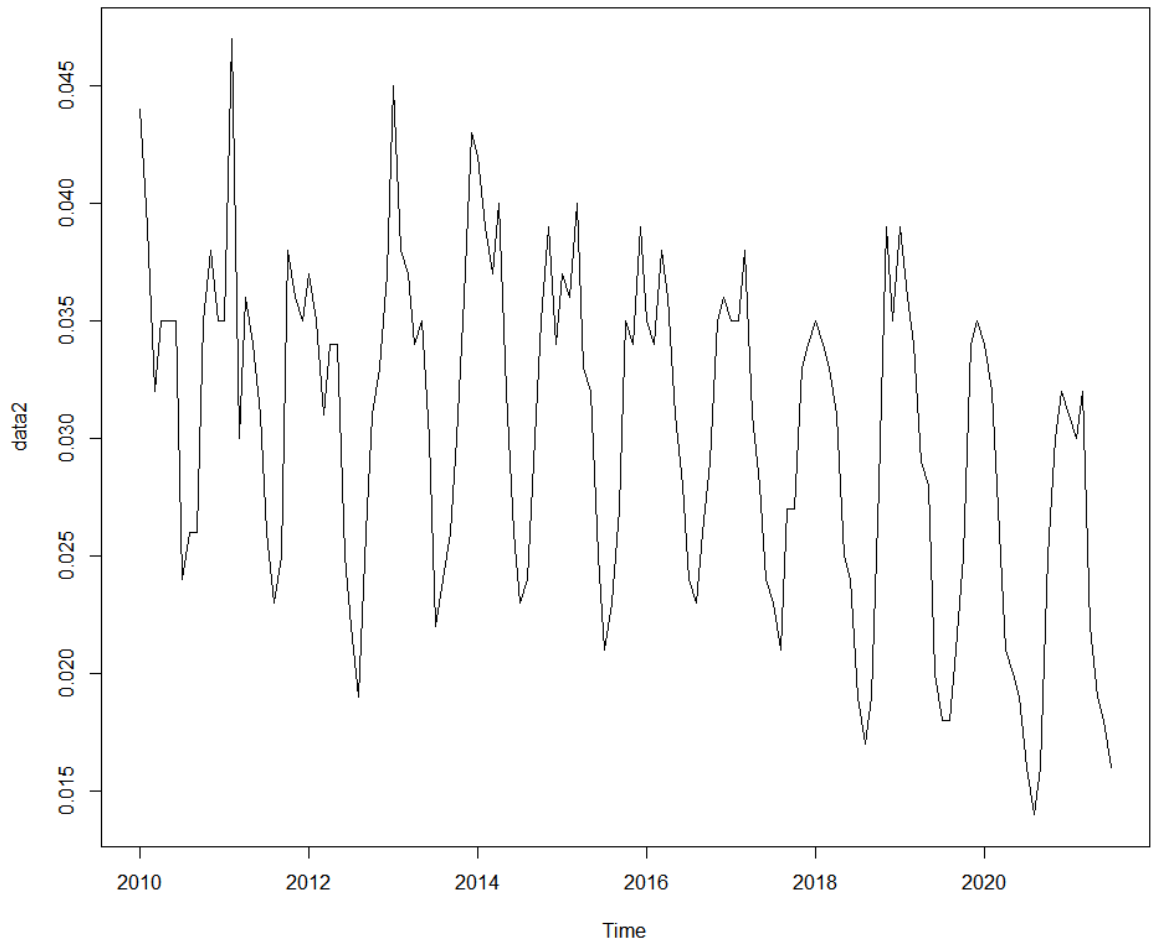
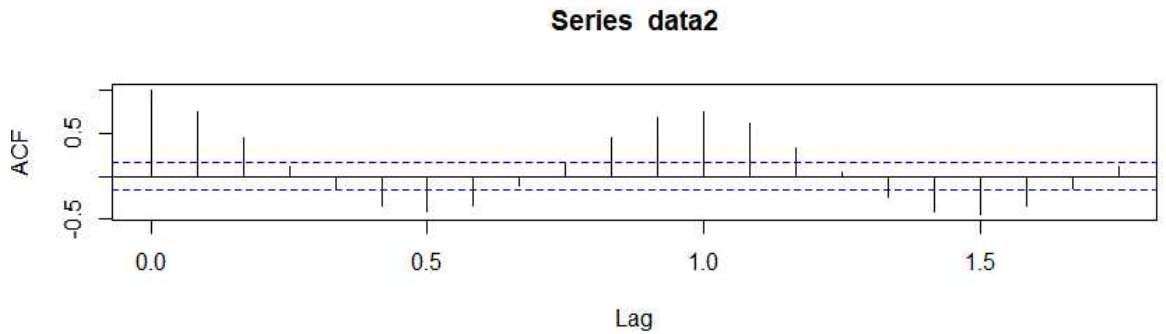
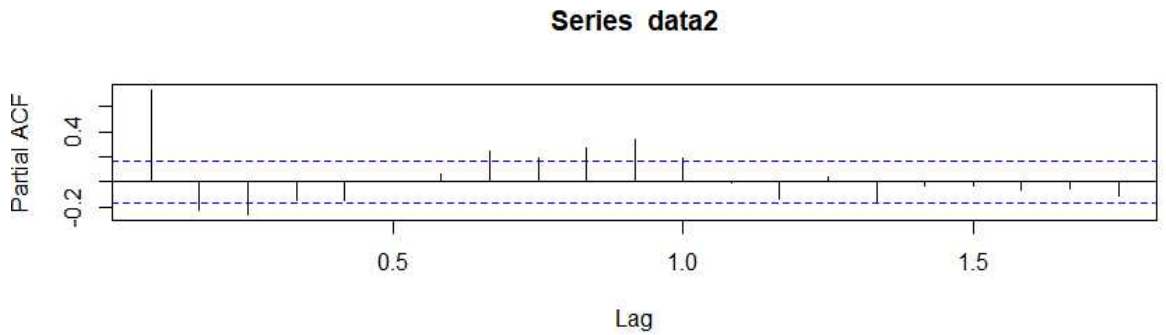


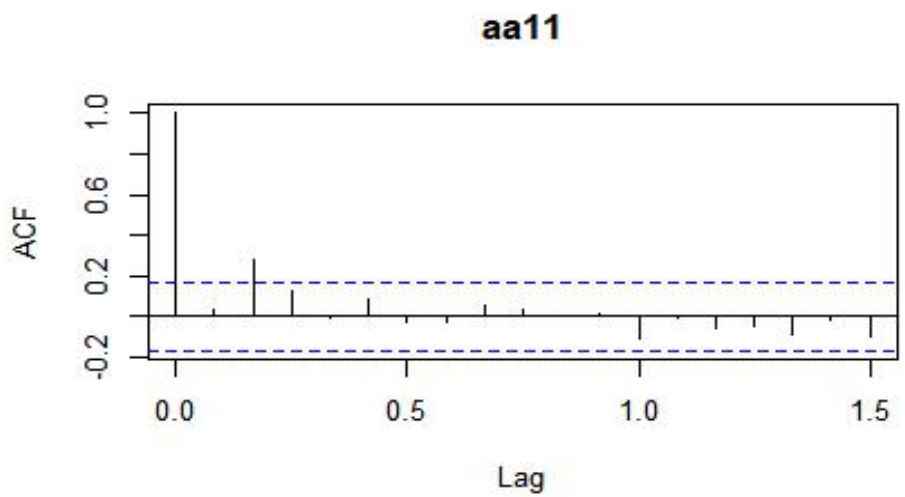


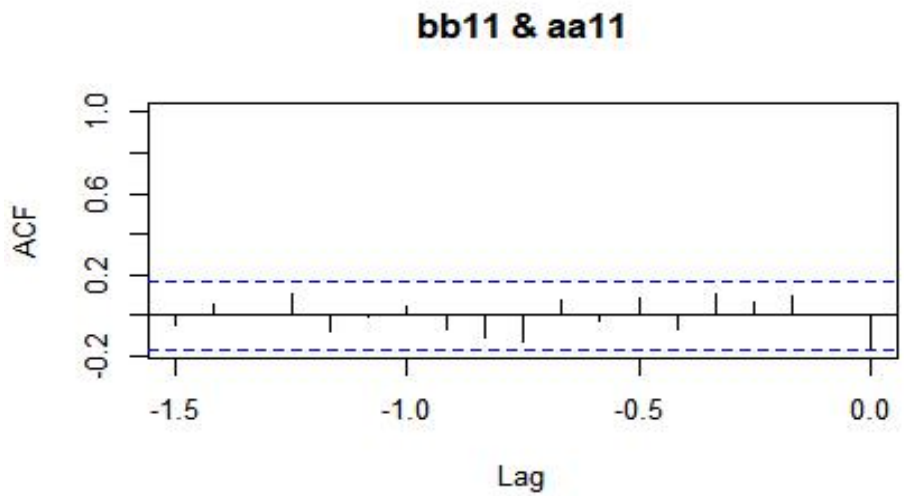



```
Series: data2
ARIMA(1,0,1)(0,1,1)[12] with drift

Coefficients:
          ar1      ma1     sma1   drift
      0.9309  -0.8010  -0.6100  -1e-04
s.e.  0.0745   0.1162   0.0896   1e-04

sigma^2 = 9.613e-06:  log likelihood = 552.71
AIC=-1095.43   AICc=-1094.93   BIC=-1081.21
```

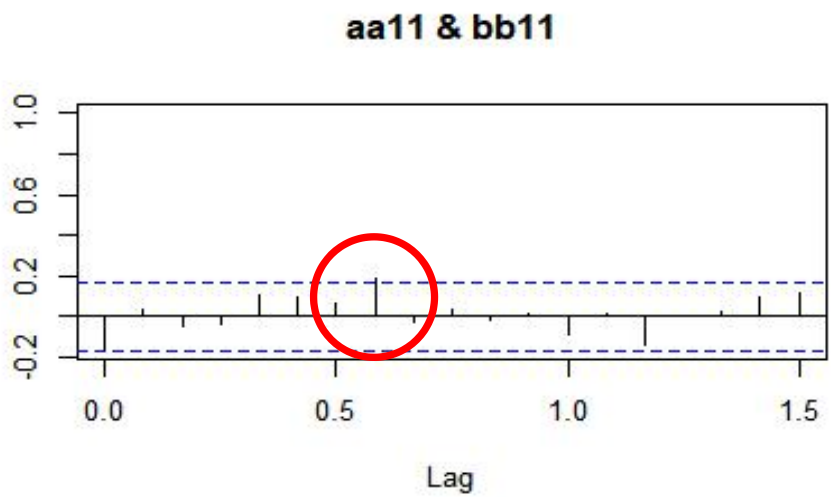
NO2

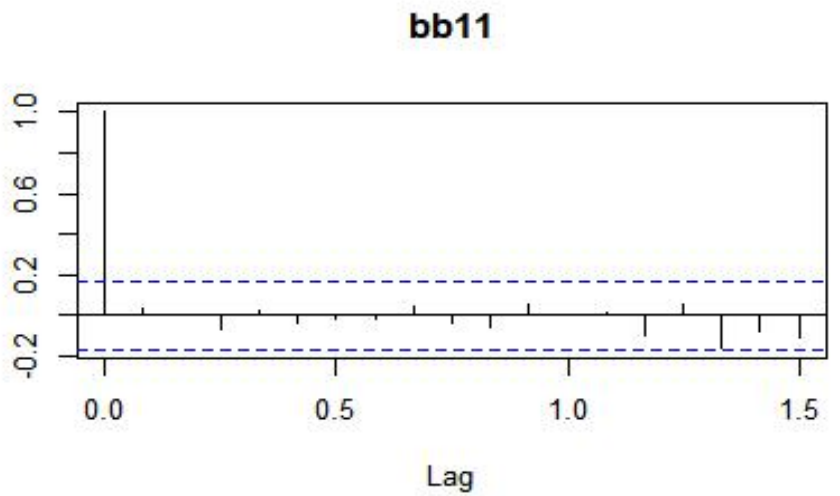
SARIMA(0,0,0)(2,1,0)





SARIMA(1,0,1)(0,1,1)





ADF.TEST

1번 차분후 검정

```
        Augmented Dickey-Fuller Test

data:  ozon
Dickey-Fuller = -11.6, Lag order = 0, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(ozon, k = 0) : p-value smaller than printed p-value
```

```
        Augmented Dickey-Fuller Test

data:  no2
Dickey-Fuller = -10.526, Lag order = 0, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(no2, k = 0) : p-value smaller than printed p-value
```

VAR(8)모형

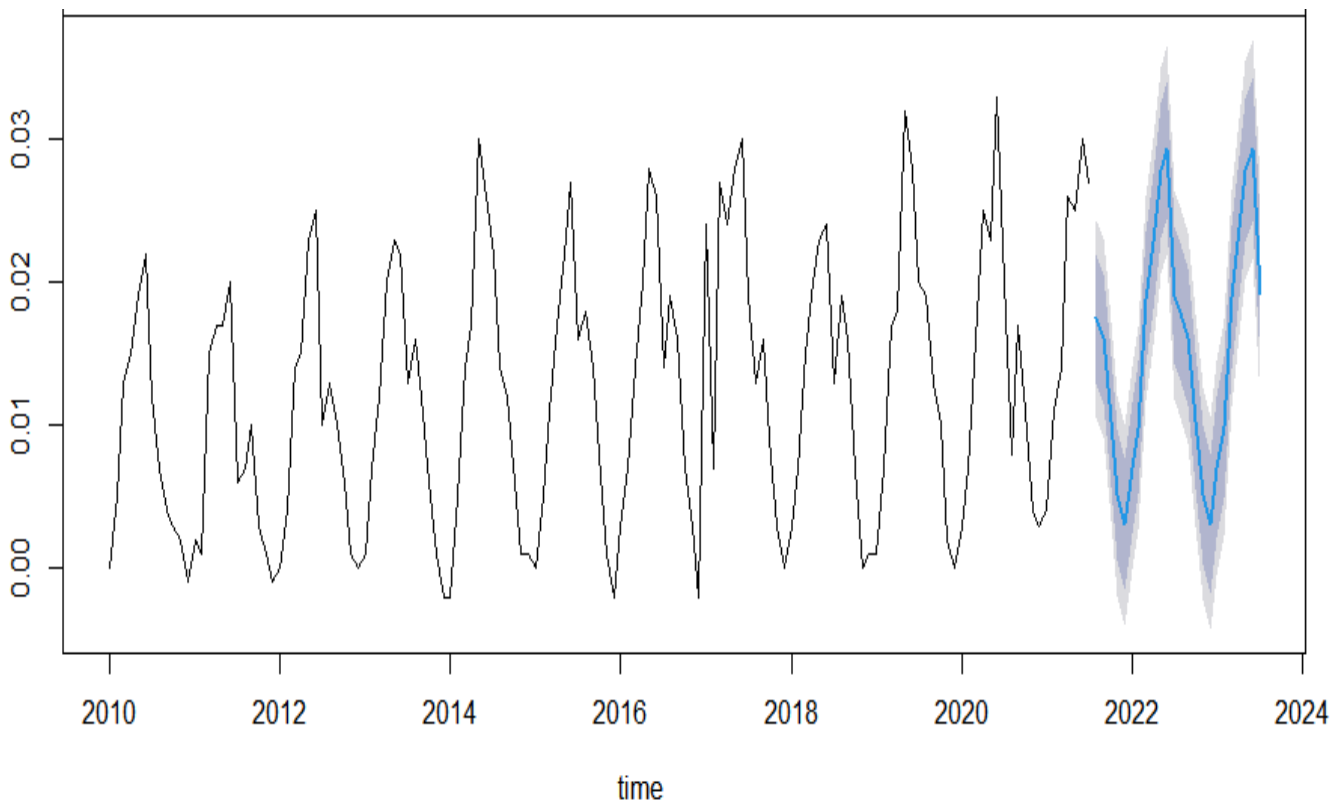
```
> VARselect(set,lag.max=10,type='const')
$selection
AIC(n)  HQ(n)  SC(n) FPE(n)
    10      8      8     10
```

```
Estimated coefficients for equation ozon:
=========================================
Call:
ozon = ozon.l1 + no2.l1 + ozon.l2 + no2.l2 + ozon.l3 + no2.l3 + ozon.l4 + no2.l4 + ozon.l5 + no2.l5 + ozon.l6 + no2.l6 + ozo
n.l7 + no2.l7 + ozon.l8 + no2.l8 + const

     ozon.l1       no2.l1      ozon.l2       no2.l2      ozon.l3       no2.l3      ozon.l4       no2.l4
-0.8190598328 -0.0317211380 -0.5608199794 -0.0735423608 -0.3854174273 -0.0871300246 -0.2990041220  0.3676391134
     ozon.l5       no2.l5      ozon.l6       no2.l6      ozon.l7       no2.l7      ozon.l8       no2.l8
-0.2070856097  0.6652812038 -0.3526087188  0.6367448843 -0.3115239837  0.7888435298 -0.1790676066  0.3825976402
       const
 0.0004573635
```

	Estimate	Std. Error	t value	Pr(>|t|)	
ozon.l1	-0.8190598	0.0886793	-9.236	1.79e-15	***
no2.l1	-0.0317211	0.1214290	-0.261	0.79439	
ozon.l2	-0.5608200	0.0965206	-5.810	5.85e-08	***
no2.l2	-0.0735424	0.1376594	-0.534	0.59423	
ozon.l3	-0.3854174	0.0898494	-4.290	3.79e-05	***
no2.l3	-0.0871300	0.1466426	-0.594	0.55359	
ozon.l4	-0.2990041	0.0935175	-3.197	0.00180	**
no2.l4	0.3676391	0.1466427	2.507	0.01360	*
ozon.l5	-0.2070856	0.1013731	-2.043	0.04340	*
no2.l5	0.6652812	0.1397045	4.762	5.73e-06	***
ozon.l6	-0.3526087	0.1062286	-3.319	0.00122	**
no2.l6	0.6367449	0.1326727	4.799	4.91e-06	***
ozon.l7	-0.3115240	0.1022638	-3.046	0.00288	**
no2.l7	0.7888435	0.1273833	6.193	9.82e-09	***
ozon.l8	-0.1790676	0.0849458	-2.108	0.03724	*
no2.l8	0.3825976	0.1243519	3.077	0.00263	**
const	0.0004574	0.0003745	1.221	0.22449	

FORECASTING(VAR(8))

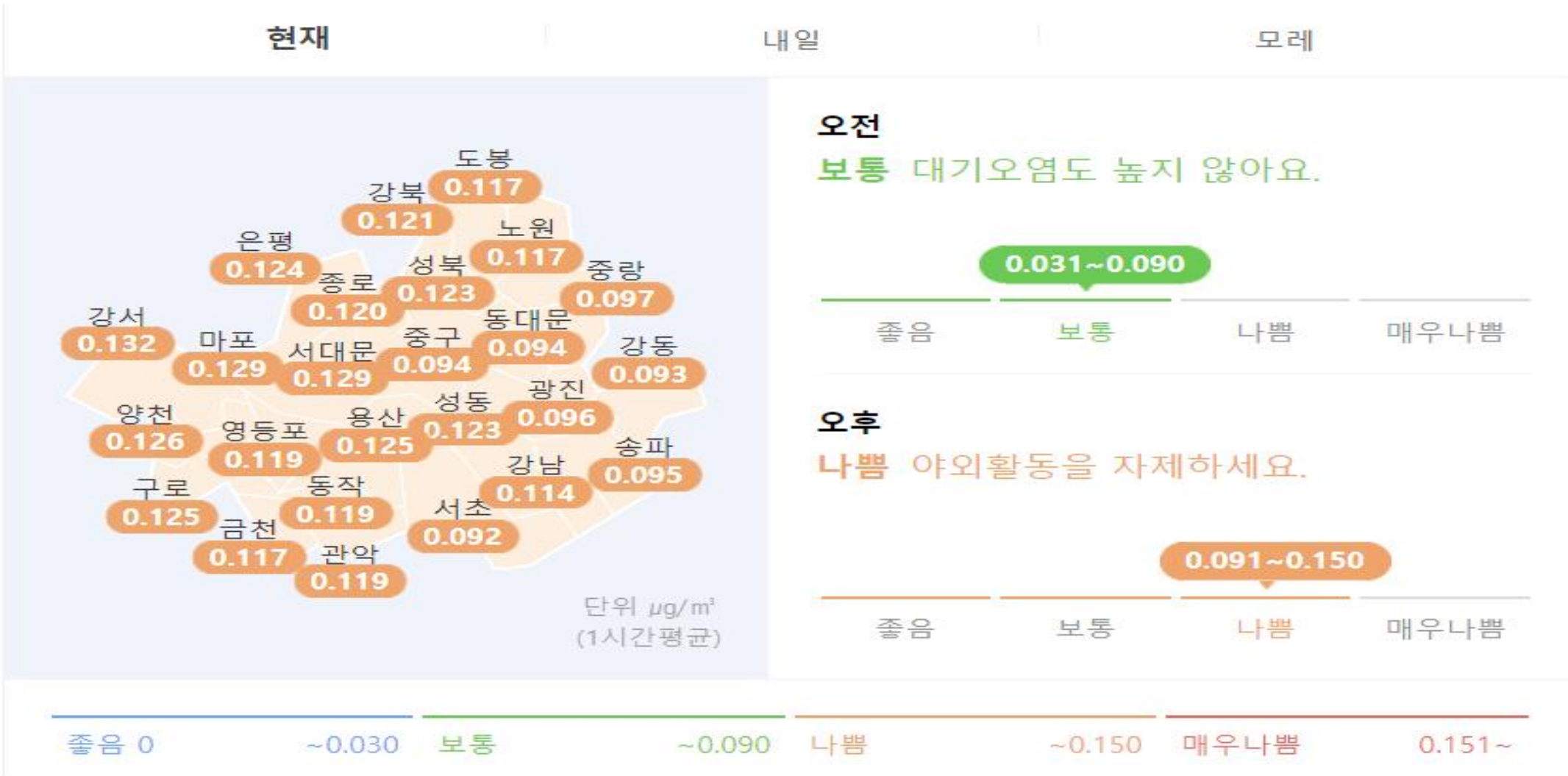
	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Aug 2021	-8.922010e-03	-0.014330958	-0.003513062	-0.017194283	-0.0006497381
Sep 2021	-5.484847e-03	-0.012472206	0.001502513	-0.016171091	0.0052013972
Oct 2021	-3.960327e-03	-0.010974988	0.003054334	-0.014688325	0.0067676706
Nov 2021	-4.455605e-03	-0.011470596	0.002559387	-0.015184109	0.0062728988
Dec 2021	-8.144405e-04	-0.008085665	0.006456784	-0.011934818	0.0103059375
Jan 2022	4.357491e-03	-0.002932416	0.011647398	-0.006791460	0.0155064420
Feb 2022	3.831437e-03	-0.003621193	0.011284067	-0.007566377	0.0152292512
Mar 2022	6.452812e-03	-0.001028847	0.013934471	-0.004989398	0.0178950220
Apr 2022	5.668206e-03	-0.002003165	0.013339576	-0.006064143	0.0174005544
May 2022	3.656065e-03	-0.004074784	0.011386913	-0.008167248	0.0154793768
Jun 2022	1.535759e-03	-0.006206446	0.009277965	-0.010304922	0.0133764408
Jul 2022	-2.997121e-03	-0.010810395	0.004816153	-0.014946493	0.0089522503
Aug 2022	-6.138126e-03	-0.014007594	0.001731342	-0.018173438	0.0058971866
Sep 2022	-5.857357e-03	-0.013727402	0.002012688	-0.017893552	0.0061788386
Oct 2022	-5.179593e-03	-0.013054312	0.002695127	-0.017222937	0.0068637522
Nov 2022	-3.624216e-03	-0.011542768	0.004294335	-0.015734595	0.0084861629
Dec 2022	5.901016e-05	-0.007901148	0.008019168	-0.012115001	0.0122330211
Jan 2023	2.931173e-03	-0.005036163	0.010898510	-0.009253816	0.0151161630
Feb 2023	5.057840e-03	-0.002924187	0.013039867	-0.007149617	0.0172652965
Mar 2023	6.155221e-03	-0.001841037	0.014151479	-0.006074000	0.0183844424
Apr 2023	5.274395e-03	-0.002758132	0.013306922	-0.007010295	0.0175590850



정리

	SARIMA(0,0,0)(2,1,0)	VAR(8)
MAX & MIN(미래 2년치 평균)	6월: 0.041481705 12월: 0.012673045	6월: 0.029302249 12월: 0.00308323
예보 등급	6월: 보통 12월: 좋음	6월: 좋음 12월: 좋음
MAX증가폭 MAX감소폭	3월~4월 7월~8월	2월~3월 6월~7월
MSPE for 1-step ahead prediction covariance maxtrix of residuals:	sigma^2 estimated as 1.686e-05:	Covariance matrix of residuals: no2 ozon no2 1.037e-05 -9.116e-07 ozon -9.116e-07 1.781e-05

정리


현재
내일
모레
도봉
0.117
강북
0.121
노원
0.117
은평
0.124
성북
0.123
중랑
0.097
종로
0.120
강서
0.132
동대문
0.094
마포
0.129
중구
0.094
강동
0.093
서대문
0.129
광진
0.096
양천
0.126
성동
0.123
용산
0.125
영등포
0.119
송파
0.095
강남
0.114
구로
0.125
동작
0.119
서초
0.092
금천
0.117
관악
0.119
단위 μg/m³
(1시간평균)
오전
보통 대기오염도 높지 않아요.
0.031~0.090
좋음
보통
나쁨
매우나쁨
오후
나쁨 야외활동을 자제하세요.
0.091~0.150
좋음
보통
나쁨
매우나쁨
좋음 0
~0.030
보통
~0.090
나쁨
~0.150
매우나쁨
0.151~

출처: 케이웨더

THANK YOU!