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*Supplement of*

# Advanced error diagnostics of the CMAQ and Chimere modelling systems within the AQMEII3 model evaluation framework

**Efisio Solazzo et al.**

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# SUPPLEMENTARY FIGURES

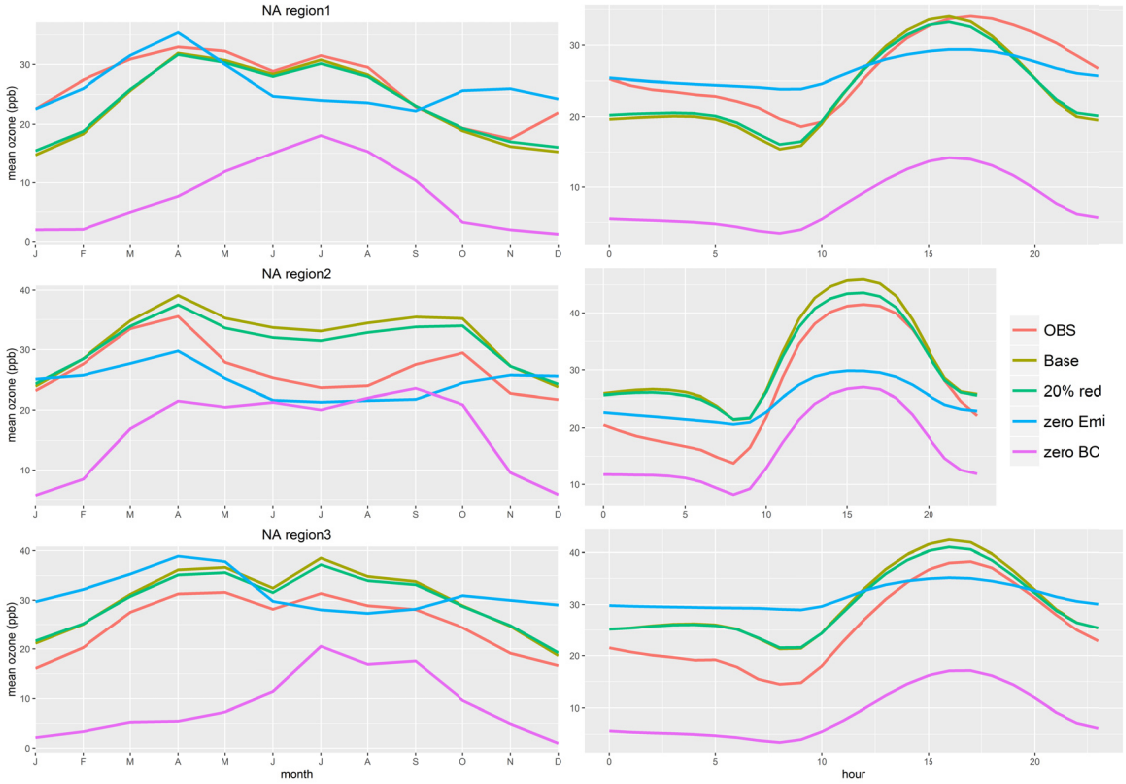



**FIGURE S1** Annual aggregated ozone time series for the North American sub-regions (Urban stations only). Average monthly and diurnal curves

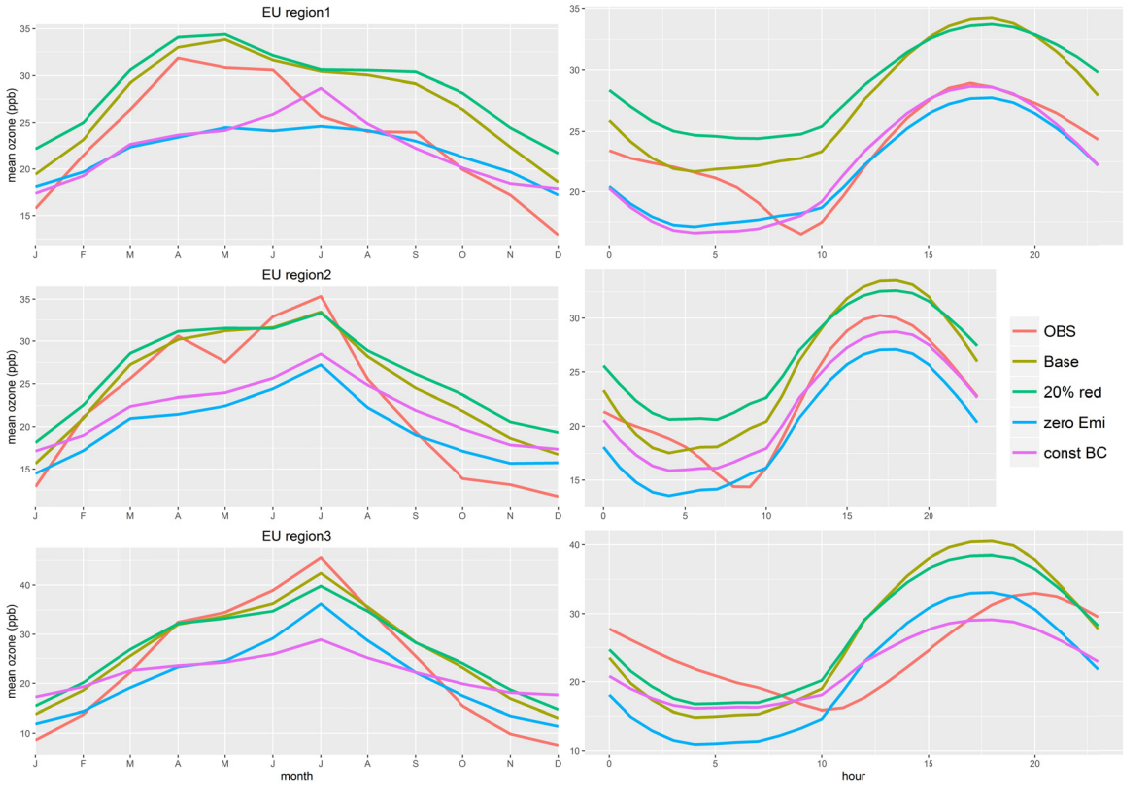



**FIGURE S2.** Annual aggregated ozone time series for the European sub-regions (urban stations only). Average monthly and diurnal curves

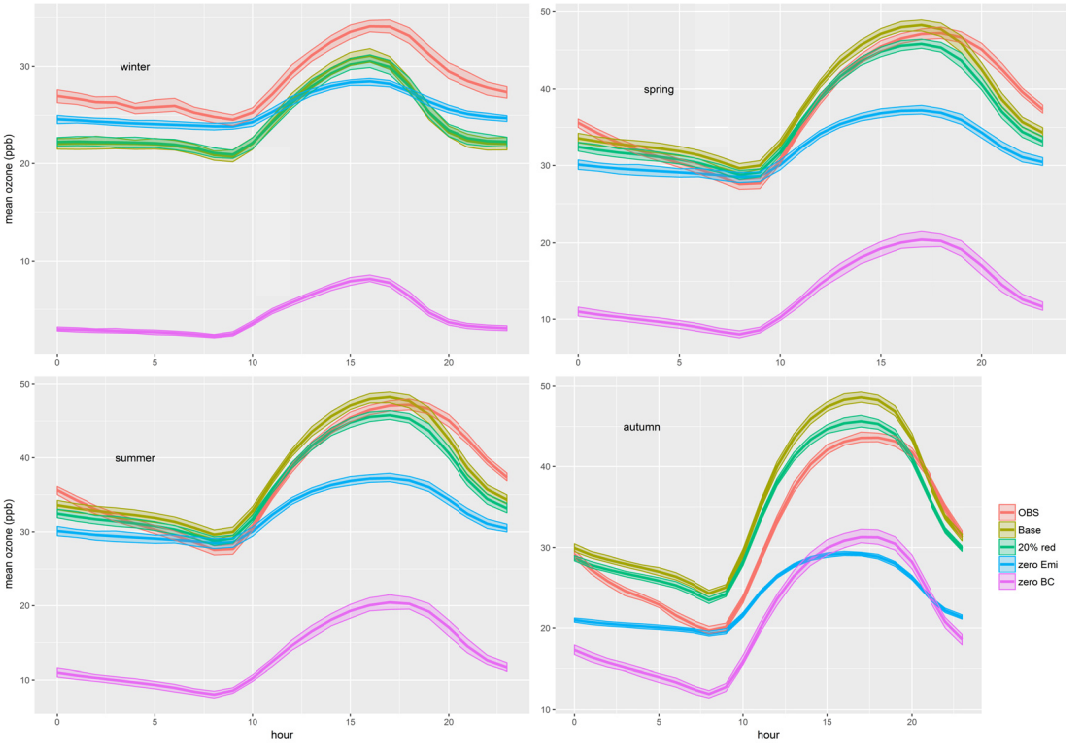



**FIGURE S3** Network average seasonal daily ozone profiles for North America. The confidence bands indicate the 95% confidence interval of the mean

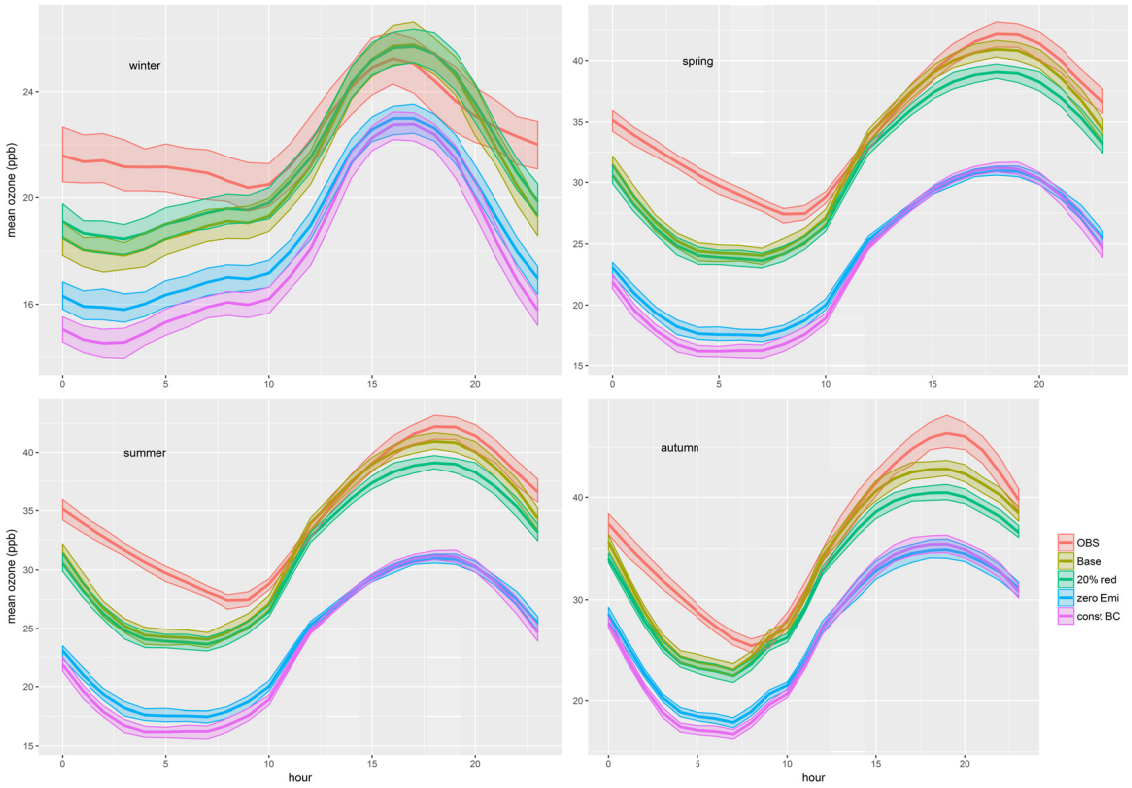
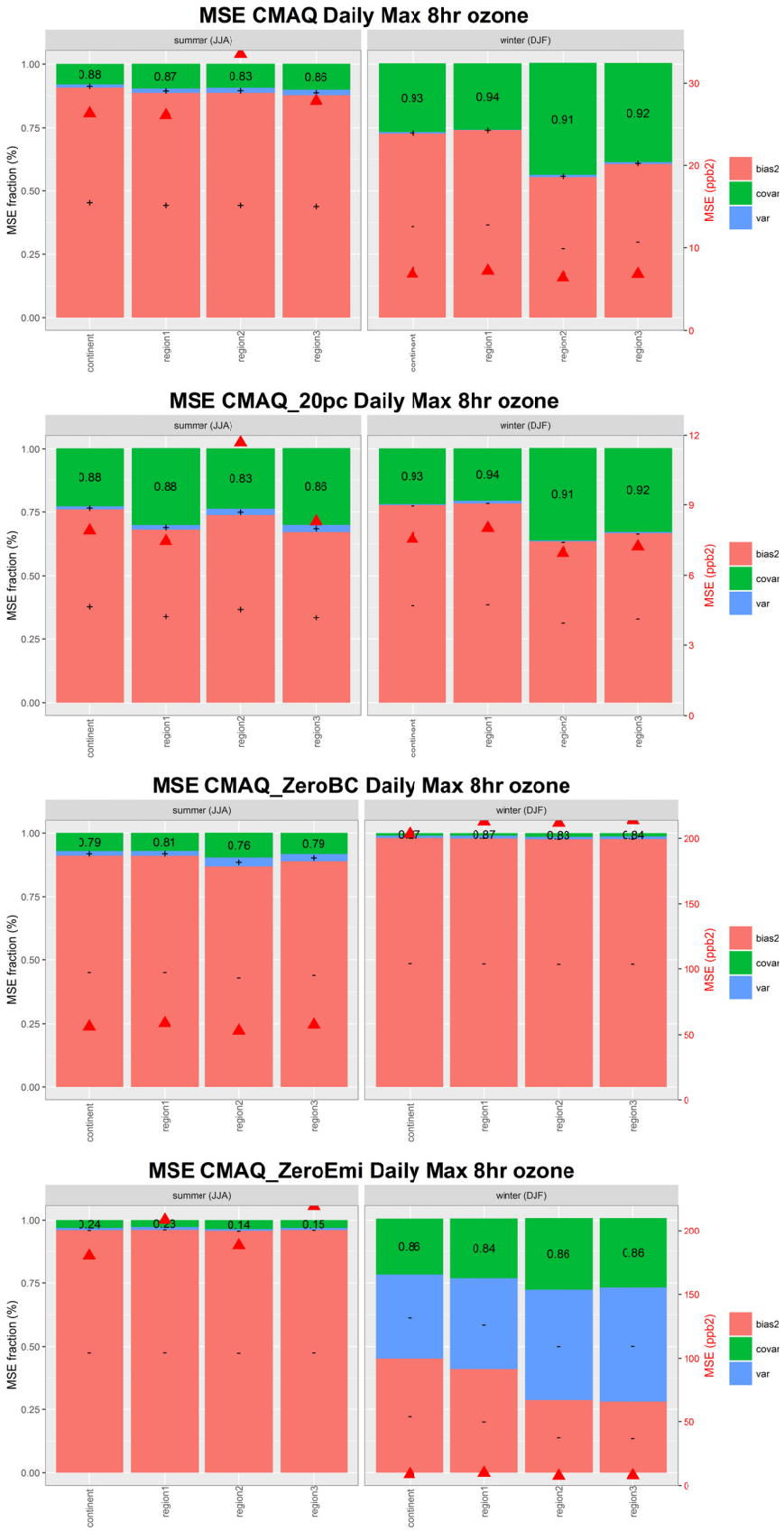
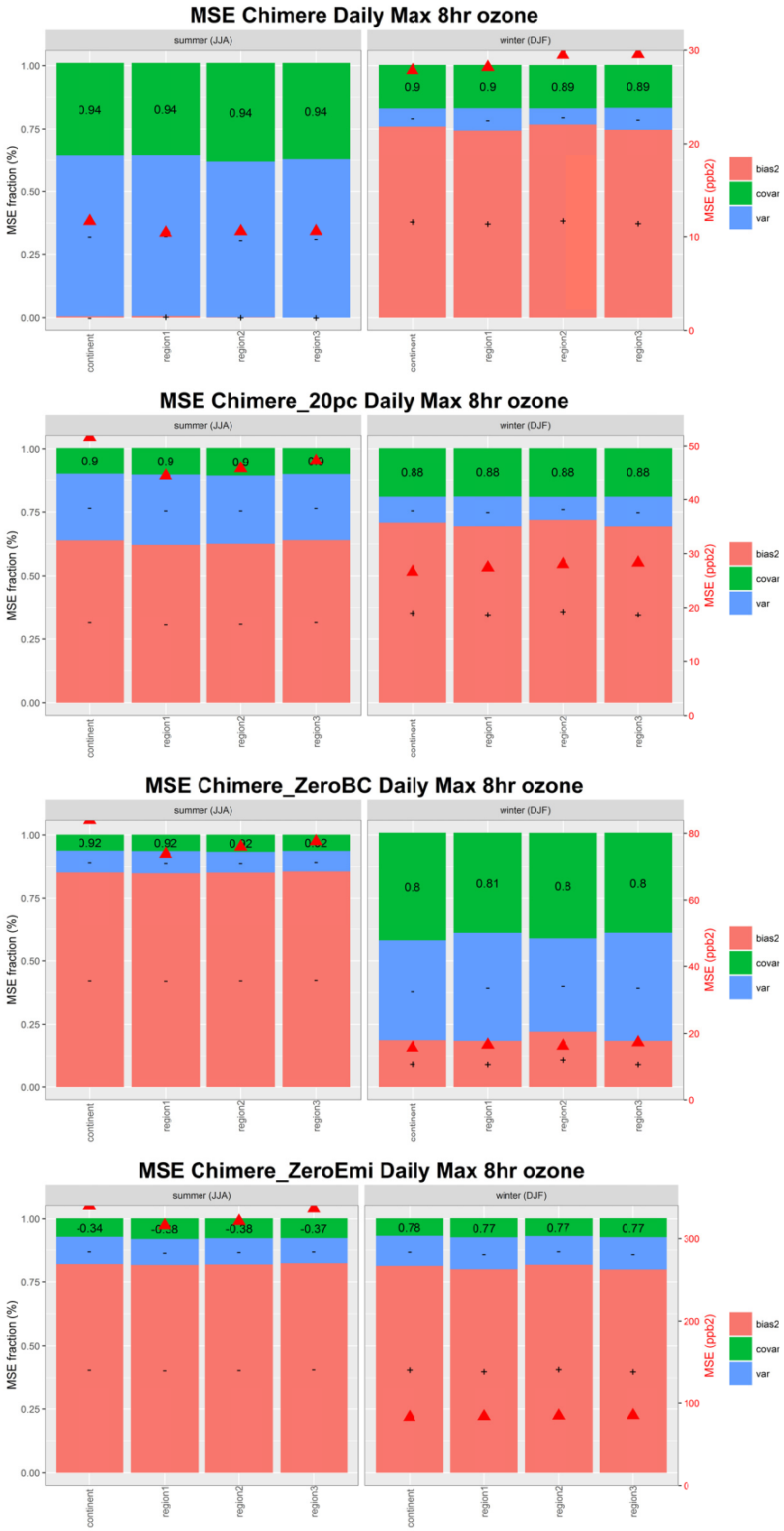


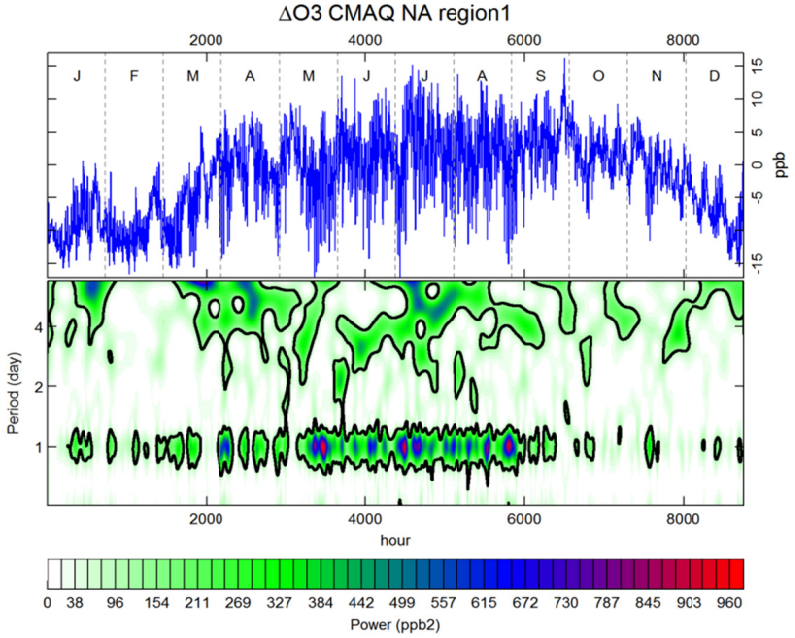

**FIGURE S4.** Network average seasonal daily ozone profiles for Europe. The confidence bands indicate the 95% confidence interval of the mean



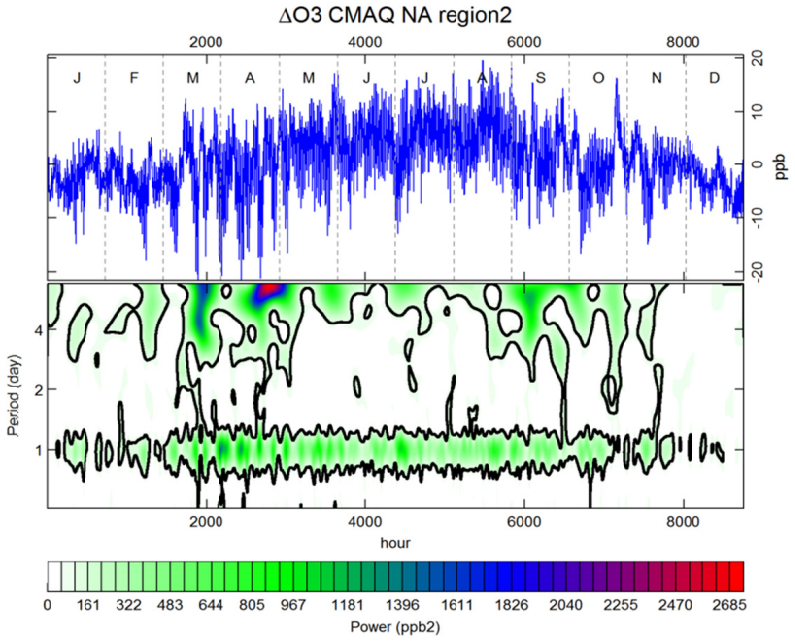

27 **FIGURE S5.** Same as Figure 6 to Figure 10 of the main text for the daily maximum 8-hour rolling average ozone



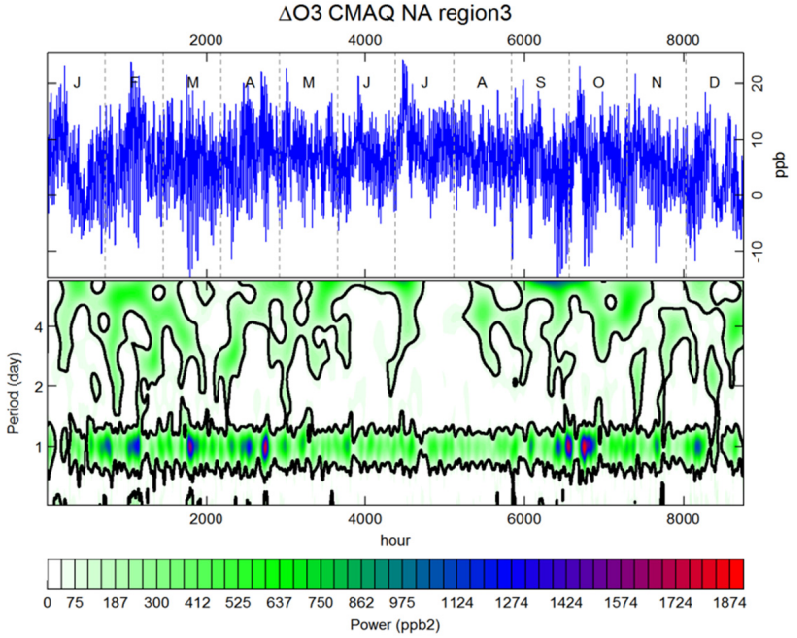

28 **FIGURE S6.** Same as Figure 11 to Figure 15 of the main text for the daily maximum 8-hour rolling average ozone


ΔO3 CMAQ NA region1
2000
4000
6000
8000
J
F
M
A
M
J
J
A
S
O
N
D
15
10
5
0
-5
-15
ppb
Period (day)
4
2
1
hour
0 38 96 154 211 269 327 384 442 499 557 615 672 730 787 845 903 960
Power (ppb2)

32


ΔO3 CMAQ NA region2
2000
4000
6000
8000
J
F
M
A
M
J
J
A
S
O
N
D
20
10
0
-10
-20
ppb
Period (day)
4
2
1
hour
0 161 322 483 644 805 967 1181 1396 1611 1826 2040 2255 2470 2685
Power (ppb2)

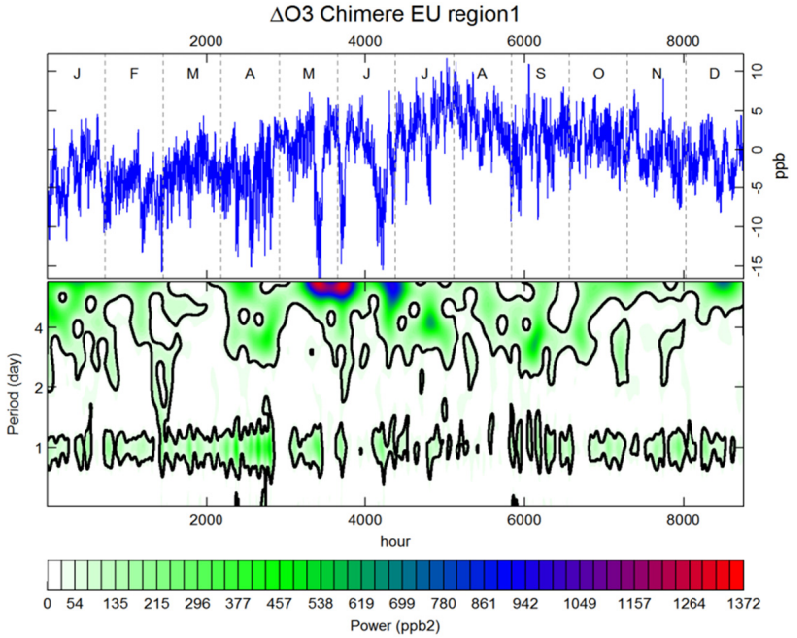
33




31

41 **FIGURE S7**. Annual time series of differences between CMAQ and observed $O_3$ ($\Delta O_3$, top panel) and Morlet
42 wavelet analysis of the periodogram of $\Delta O_3$ (lower panel) for the three NA subdomains, for periods between
43 0.5 and 6 days. Black contours lines identify the 95% confidence interval. The period (in days) is reported in the
44 vertical axis, while the quantiles of the power spectral density are measured in $ppb^2$.

36

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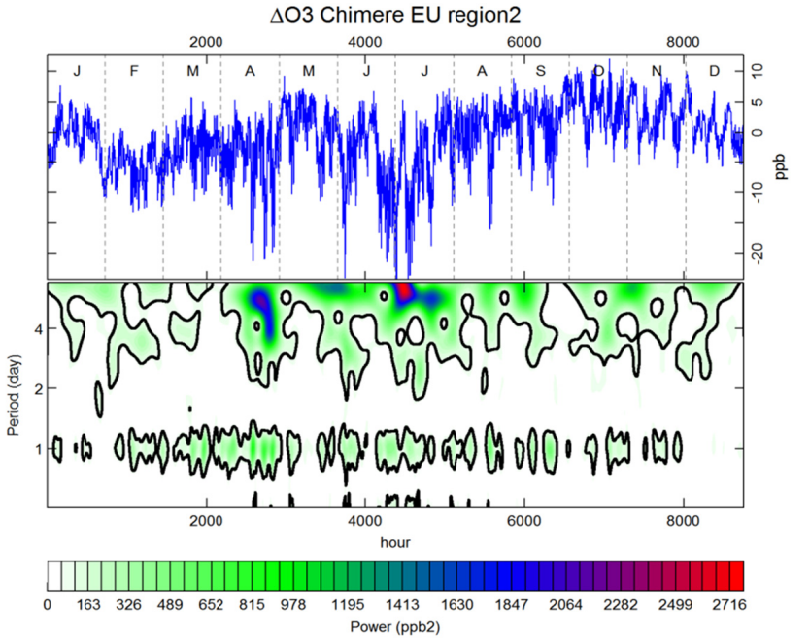


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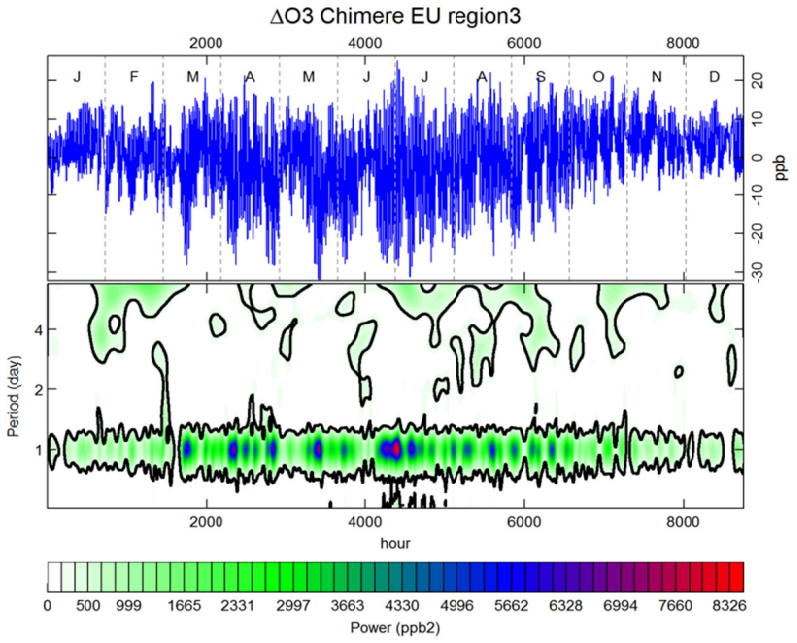
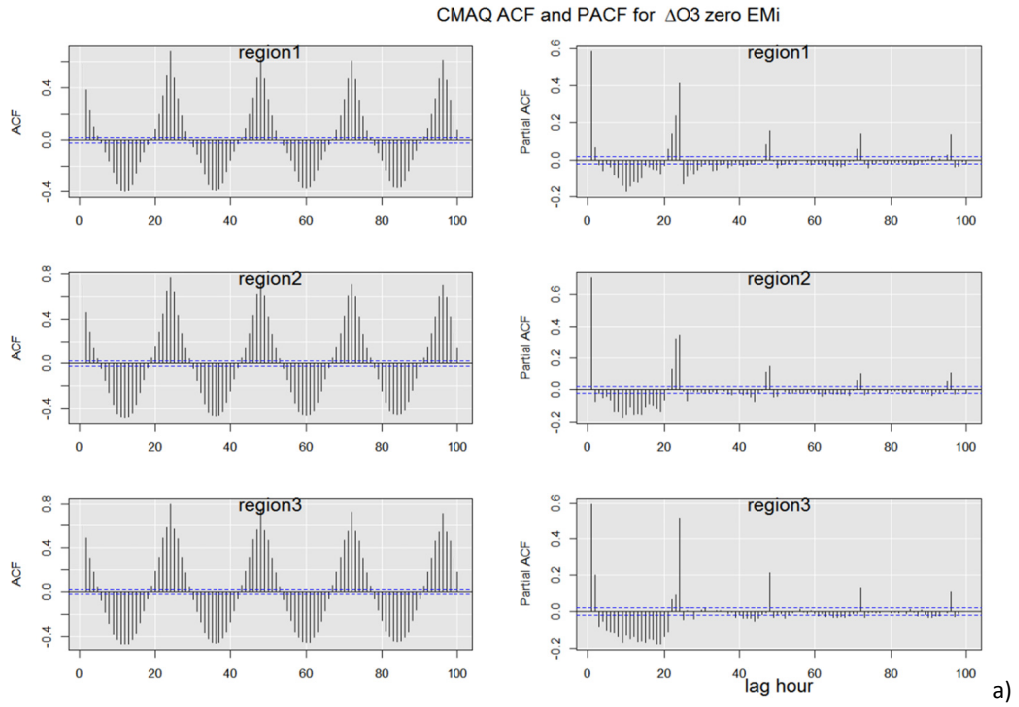
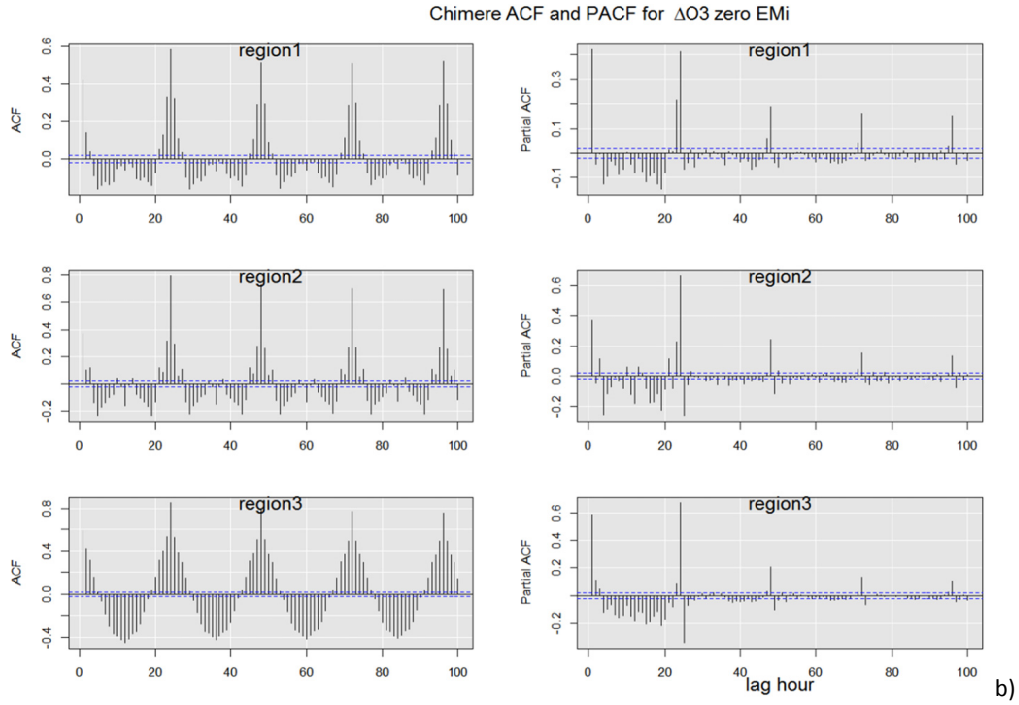



39

49 **FIGURE S8**. Annual time series of differences between Chimere and observed $O_3$ ($\Delta O_3$, top panel) and Morlet
50 wavelet analysis of the periodogram of $\Delta O_3$ (lower panel) for the three EU subdomains, for periods between
51 0.5 and 6 days. Black contours lines identify the 95% confidence interval. The period (in days) is reported in the
52 vertical axis, while the quantiles of the power spectral density are measured in $ppb^2$.

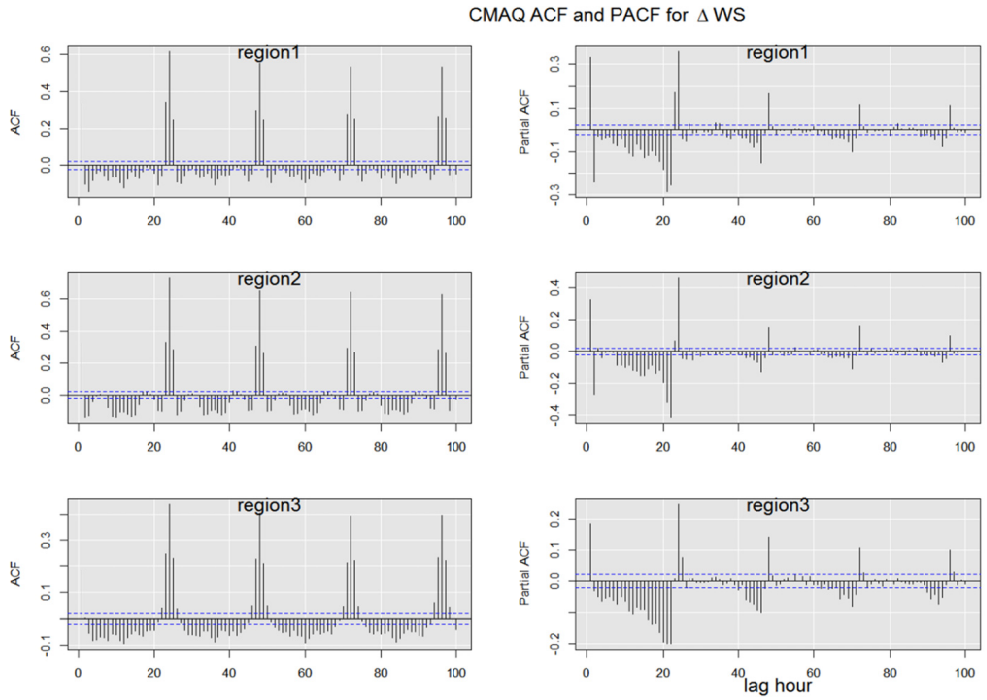



a)

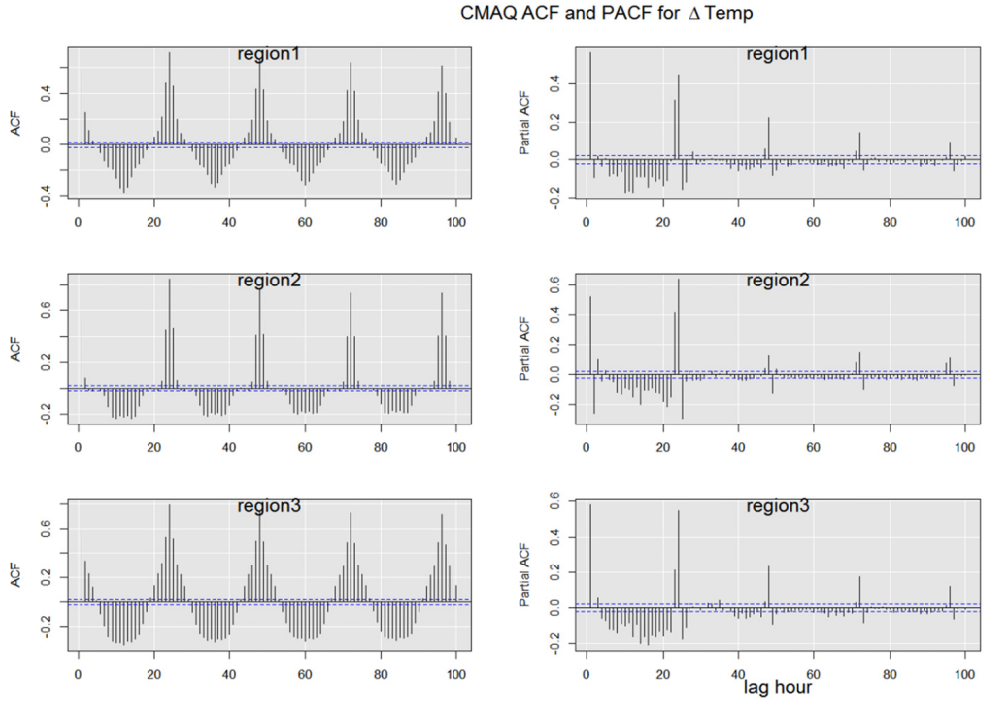



b)

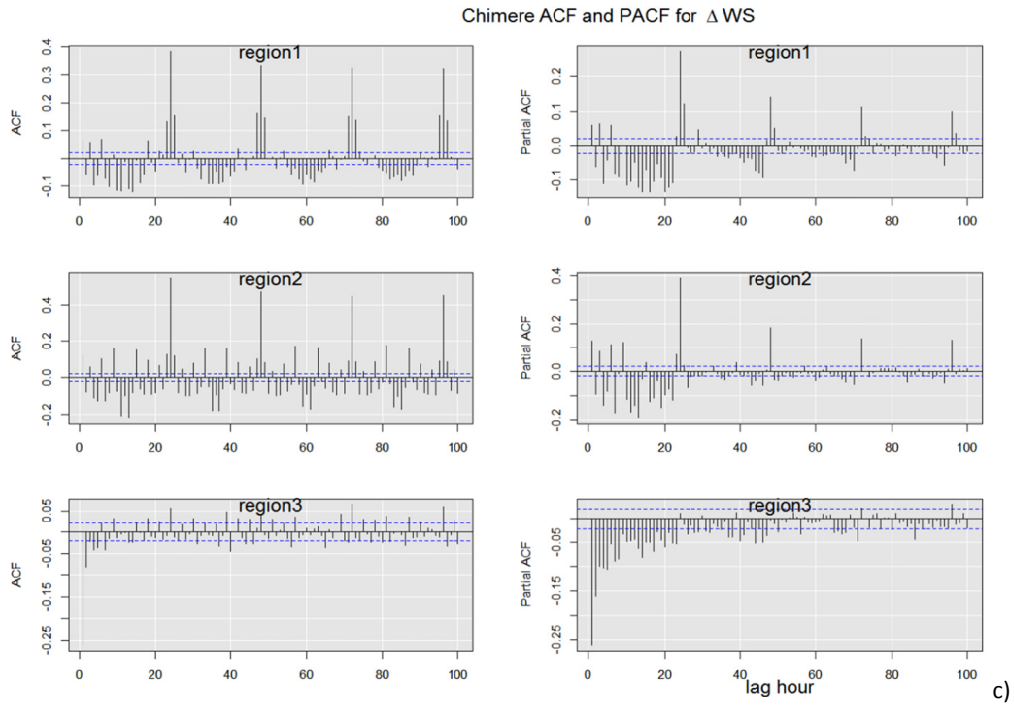
**FIGURE S9.** Autocorrelation (ACF) and partial autocorrelation (PACF) function for the differenced time series of residuals of ozone (mod-obs) for the 'zero Emi' scenario for a): CMAQ and b): Chimere.


CMAQ ACF and PACF for Δ WS
region1
region2
region3
ACF
Partial ACF
lag hour

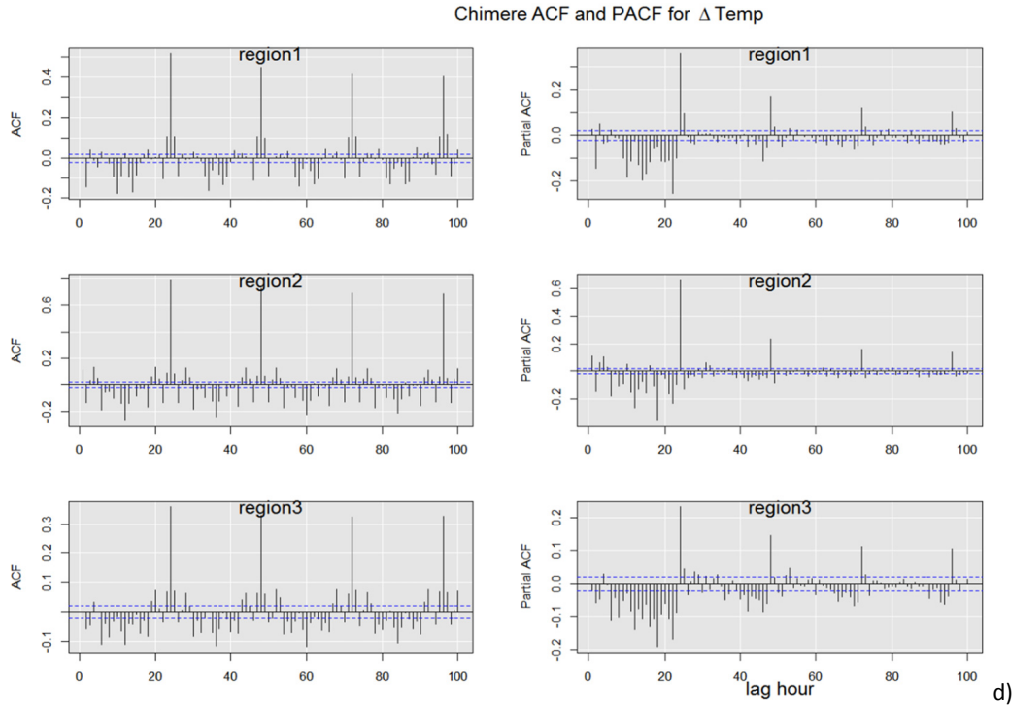
a)


CMAQ ACF and PACF for Δ Temp
region1
region2
region3
ACF
Partial ACF
lag hour

b)

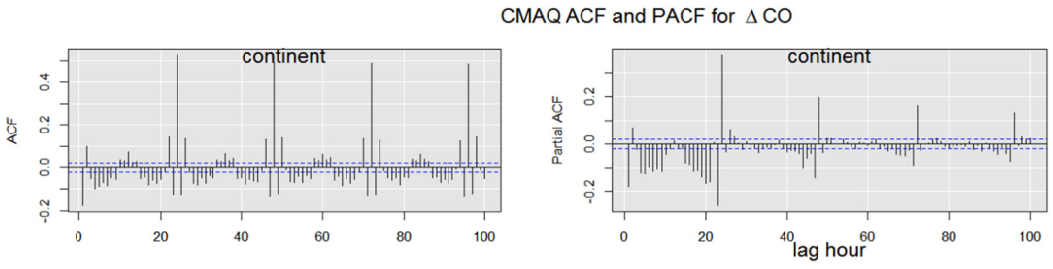



c)

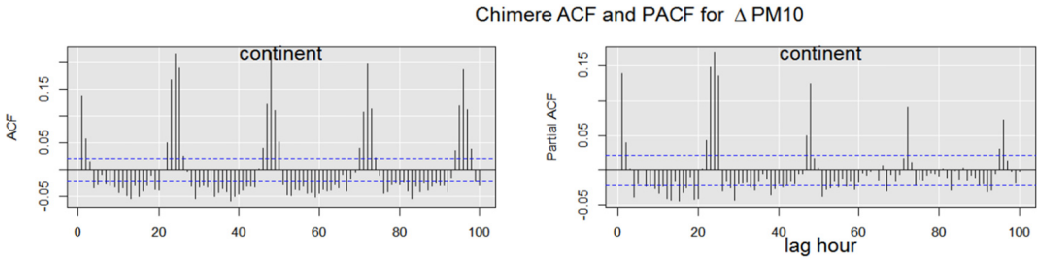



d)

**FIGURE S10.** Autocorrelation (ACF) and partial autocorrelation (PACF) function for *a)* the differenced time series of residuals of WS (mod-obs) (a: CMAQ, c: Chimere) and Temp (b: CMAQ, d: Chimere).

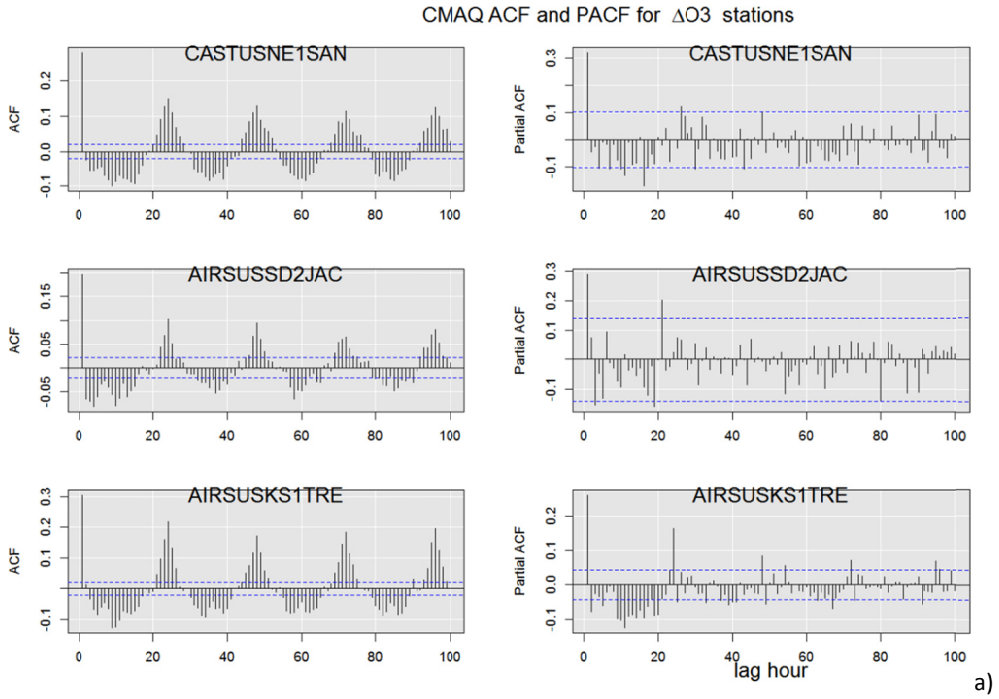



a)

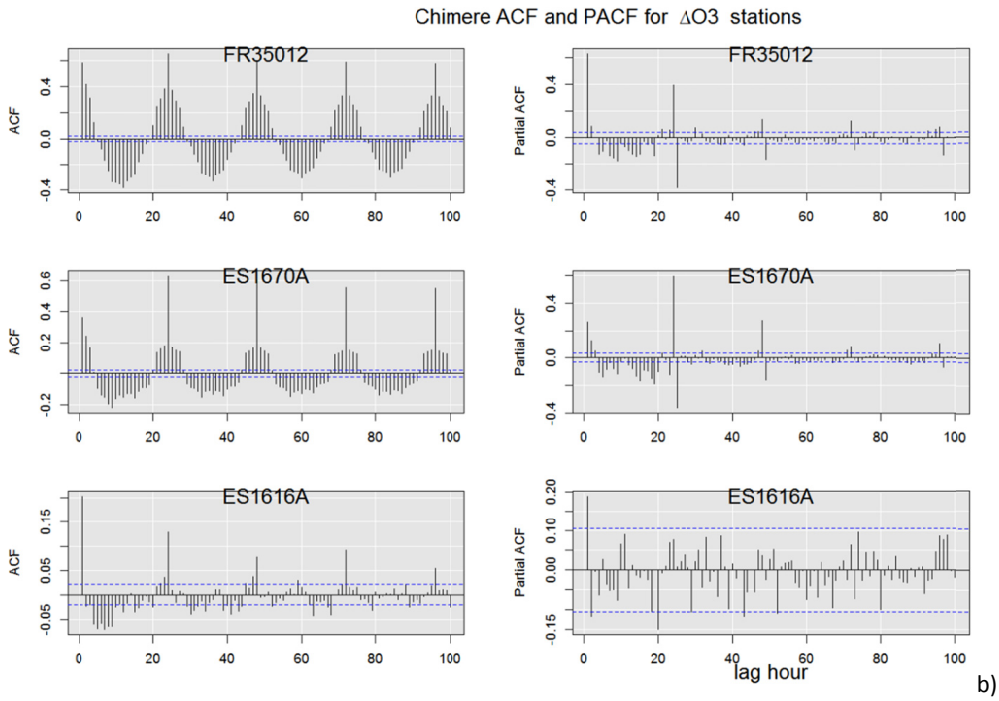



b)

**FIGURE S11** Autocorrelation (ACF) and partial autocorrelation (PACF) function for the differenced time series of residuals (mod-obs) of a) CO in NA and b) $PM_{10}$ in EU.




a)




b)

**FIGURE S12.** Autocorrelation (ACF) and partial autocorrelation (PACF) function for the differenced time series of residuals of ozone (mod-obs) for the 'zero Emi' scenario calculated at three stations where the cumulated isoprene concentration over the months of June-July-august is minimum (compatibly with the availability of and completeness of monitoring data). a) CMAQ and b) Chimere

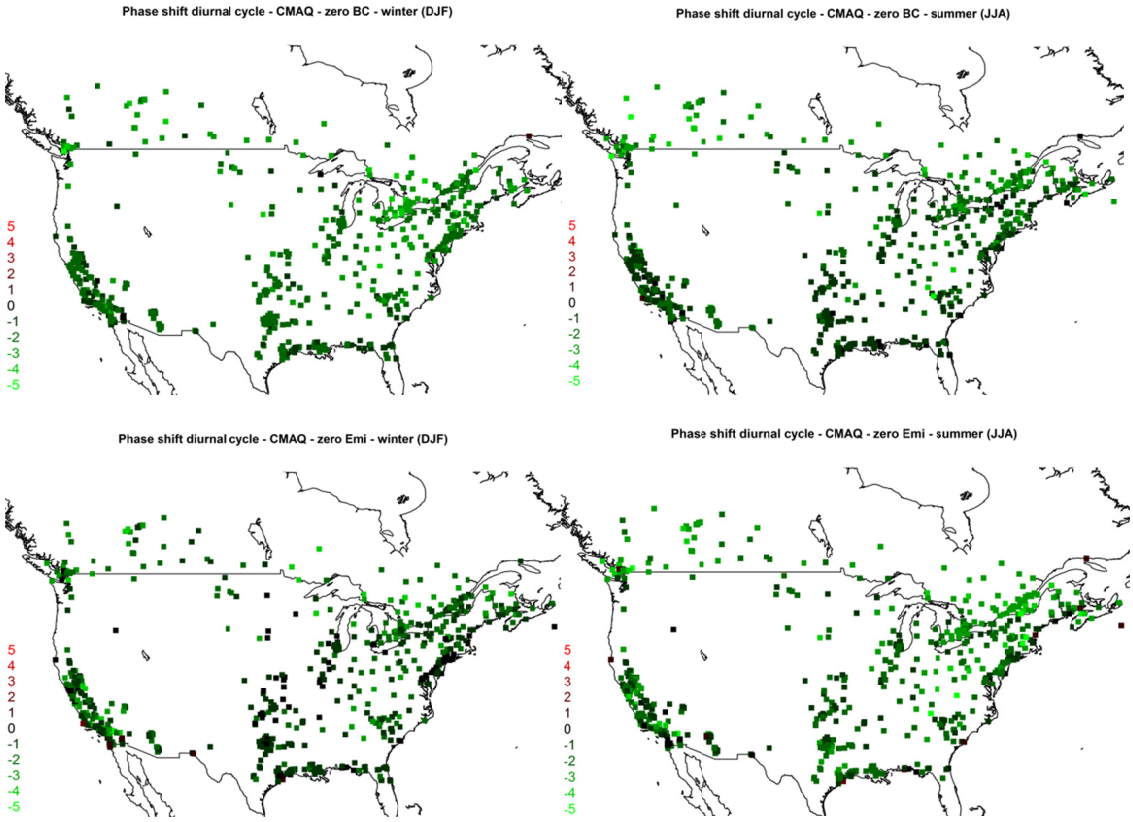



**FIGURE S13.** Phase shift of the diurnal cycle (in hour) for the network of receptors in NA (includes all stations types). A positive phase shift indicates that the model peak is 'late', vice-versa if the phase shift is negative, the model peak occurs earlier than the observed peak. Top panels 'Zero BC' case (winter and summer); lower panels: 'Zero EMI' case (winter and summer)

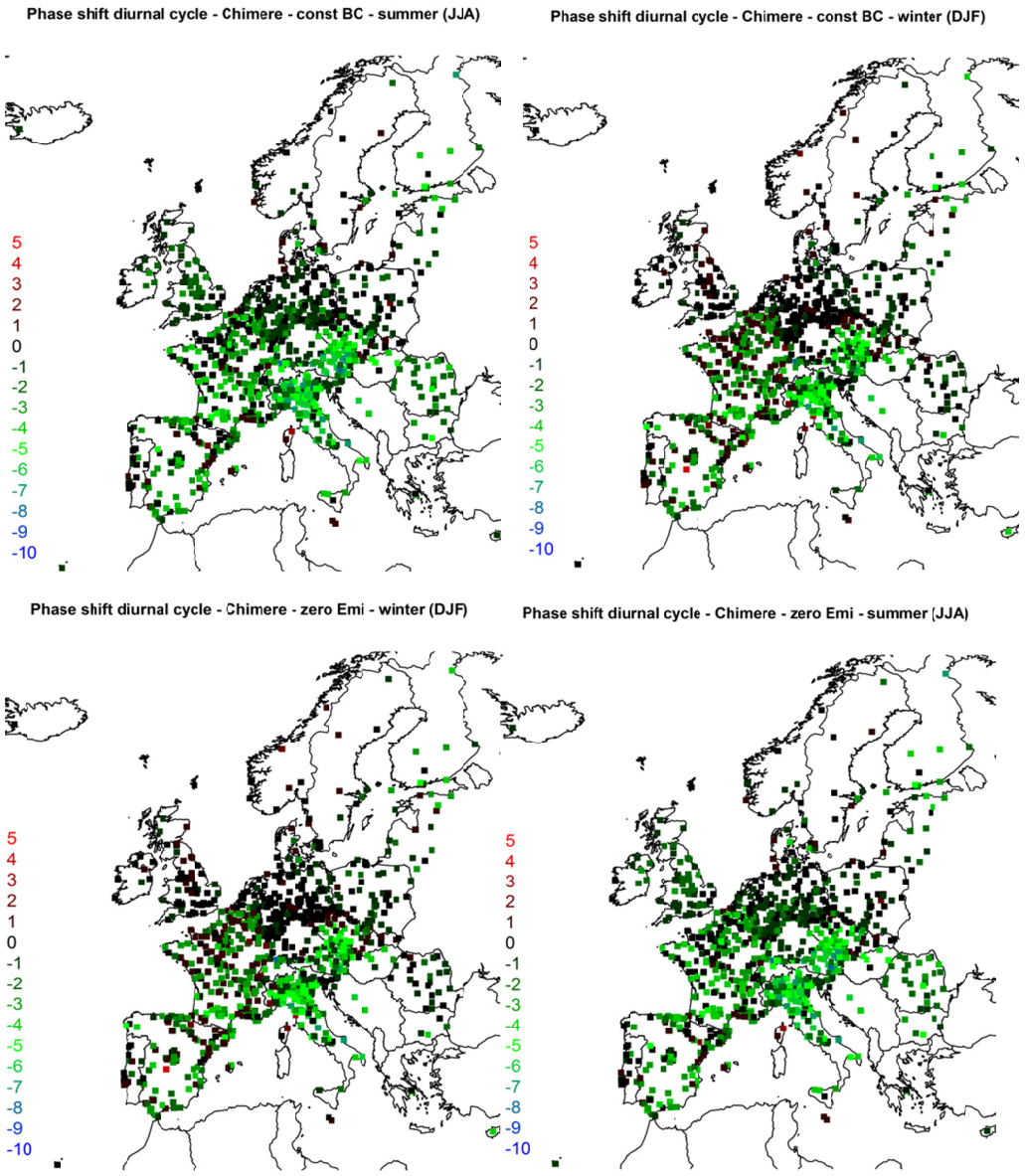
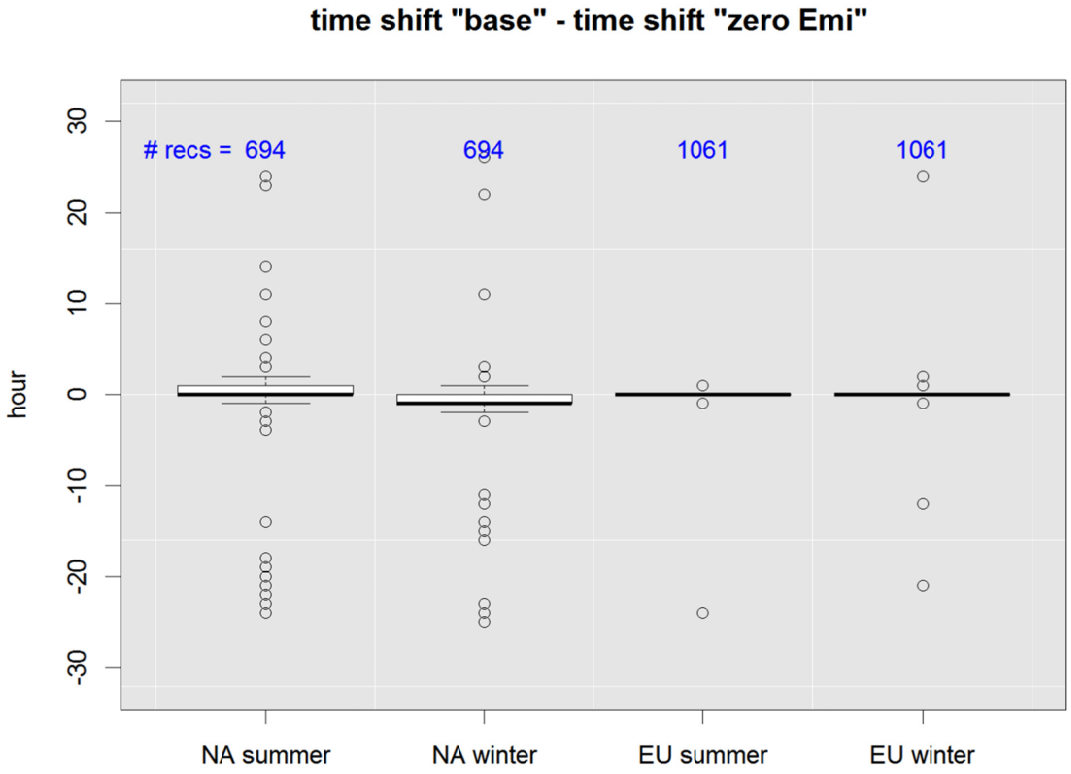



**Figure S14**. As in Figure S13 for Europe




85

89 **FIGURE S15.** Percentile distribution of the difference (in hour) at the receptors (the number of receptors is
90 reported at the top) between the time shift of the base and the 'zero Emi' case

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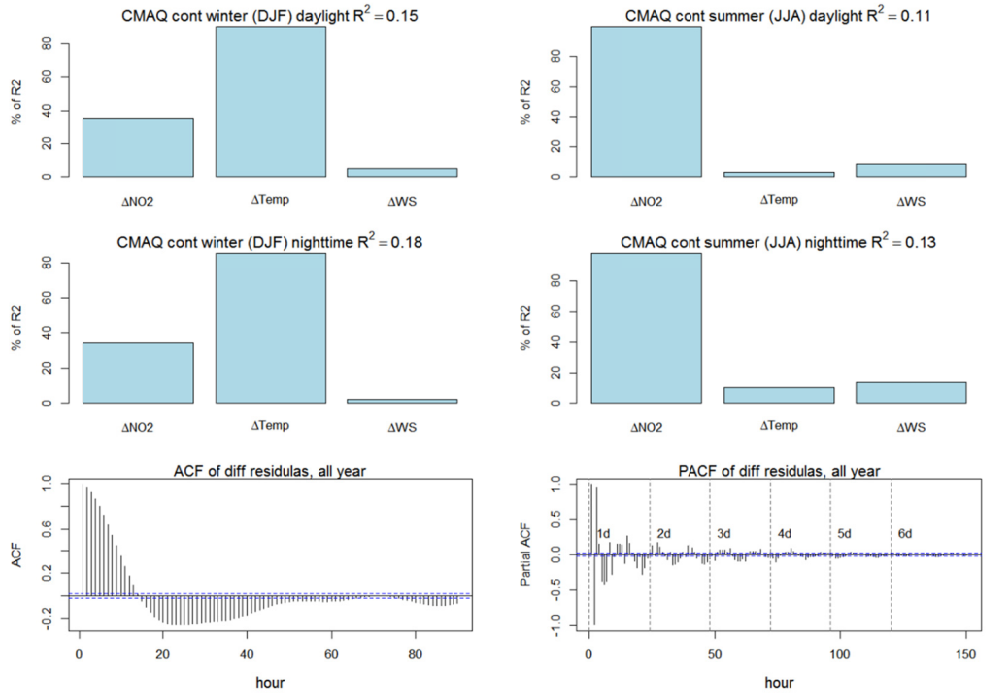


**FIGURE S16.** Percentage of variance explained by the regressors (the total $R^2$ for the regression is reported in the title of each panel) when the diurnal fluctuations are removed. The relative importance of each variable is assessed by using a bootstrap resampling. The plots at the bottom show the ACF and PACF of the yearly time series of residual of the fit, that is, of what is not captured by the linear regressions on the available variables. . The analysis encompasses 47 co-located stations (the NA stations for ozone, $NO_2$, WS, and Temp that fall in a radius of 1000 m and vertical displacement less than 250m).

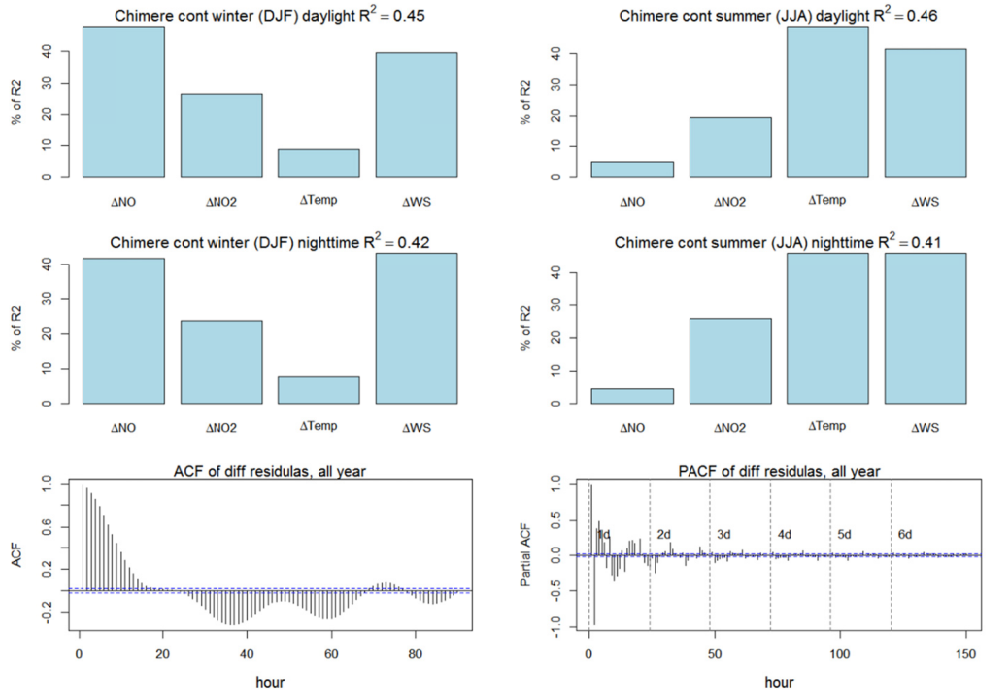


**FIGURE S17.** Same as FIGURE S16 for EU. The analysis encompasses 61 co-located stations (the EU stations for ozone, NO, $NO_2$, WS, and Temp that fall in a radius of 1000 m and vertical displacement less than 250m).