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Supplement of

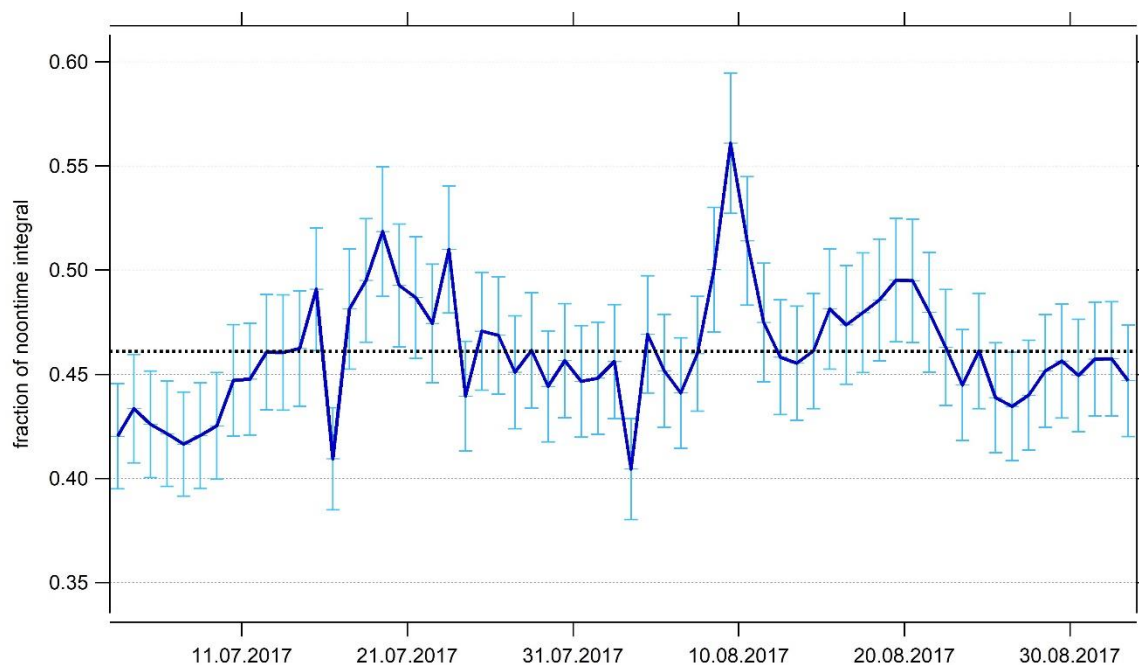
Net ozone production and its relationship to nitrogen oxides and volatile organic compounds in the marine boundary layer around the Arabian Peninsula

Ivan Tadic et al.

Correspondence to: Ivan Tadic (i.tadic@mpic.de)

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Figure S1 shows a day to day calculation of the correction factor to scale the fractional noontime integral to a diurnal value. An average \pm standard deviation of (46.1 ± 2.8) % of the diurnal integral within ± 2 h around noontime was estimated.



5 **Figure S1: Ratio of the noontime actinic flux (± 2 h around noon) with regard to the total actinic flux $j(\text{NO}_2)$ of that particular day. Dashed line represents the campaign average of (46.1 ± 2.8) %. The errors bars are represented by the relative uncertainty (6 %) of the campaign average.**

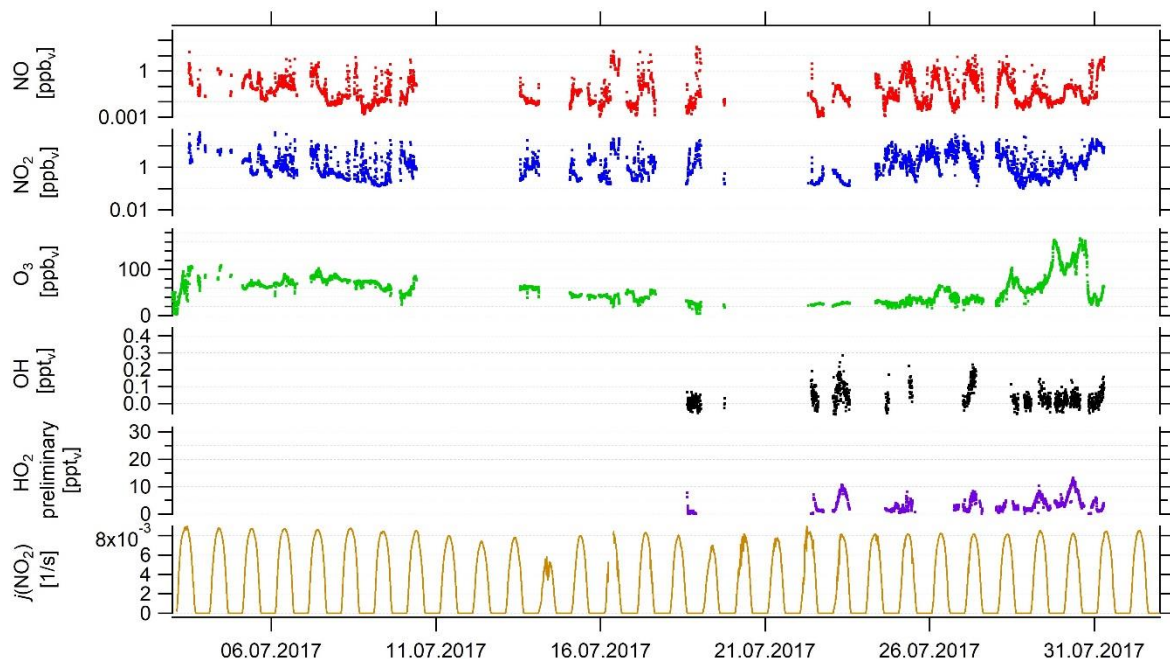


Figure S2: Timeline of NO, NO₂ (both CLD), O₃, OH, HO₂ preliminary (HO₂*) and $j(\text{NO}_2)$ data during the first leg. See Table ST2 for additional information on the ship cruise. Note that HO₂ data are preliminary.

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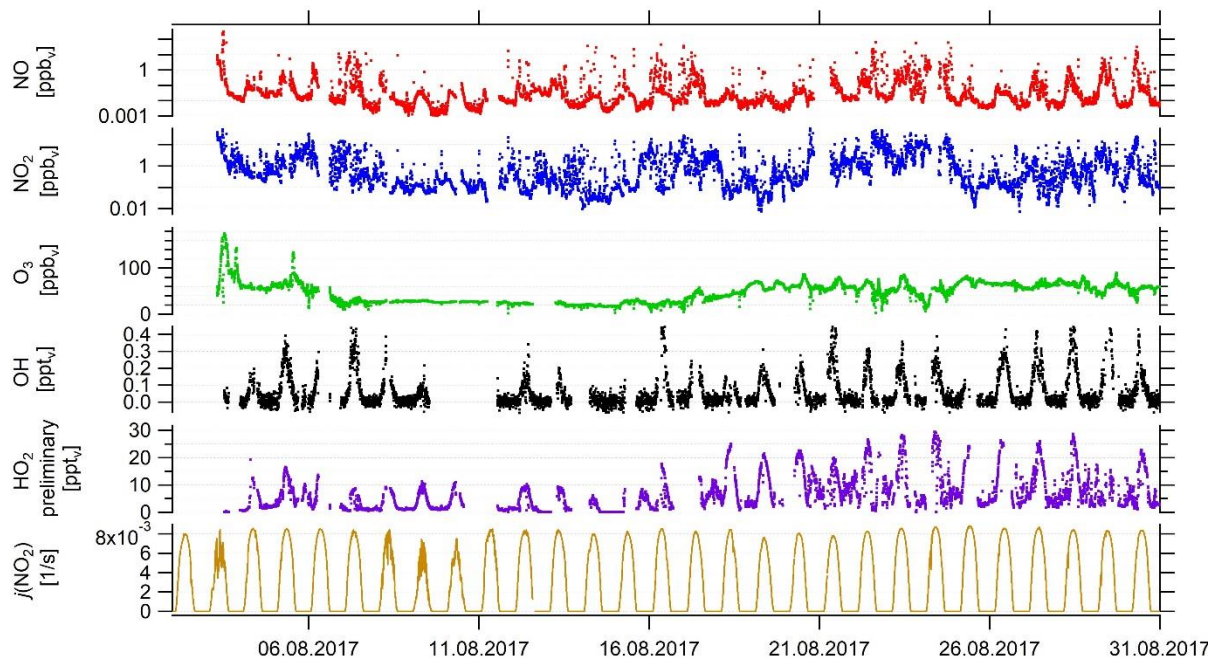
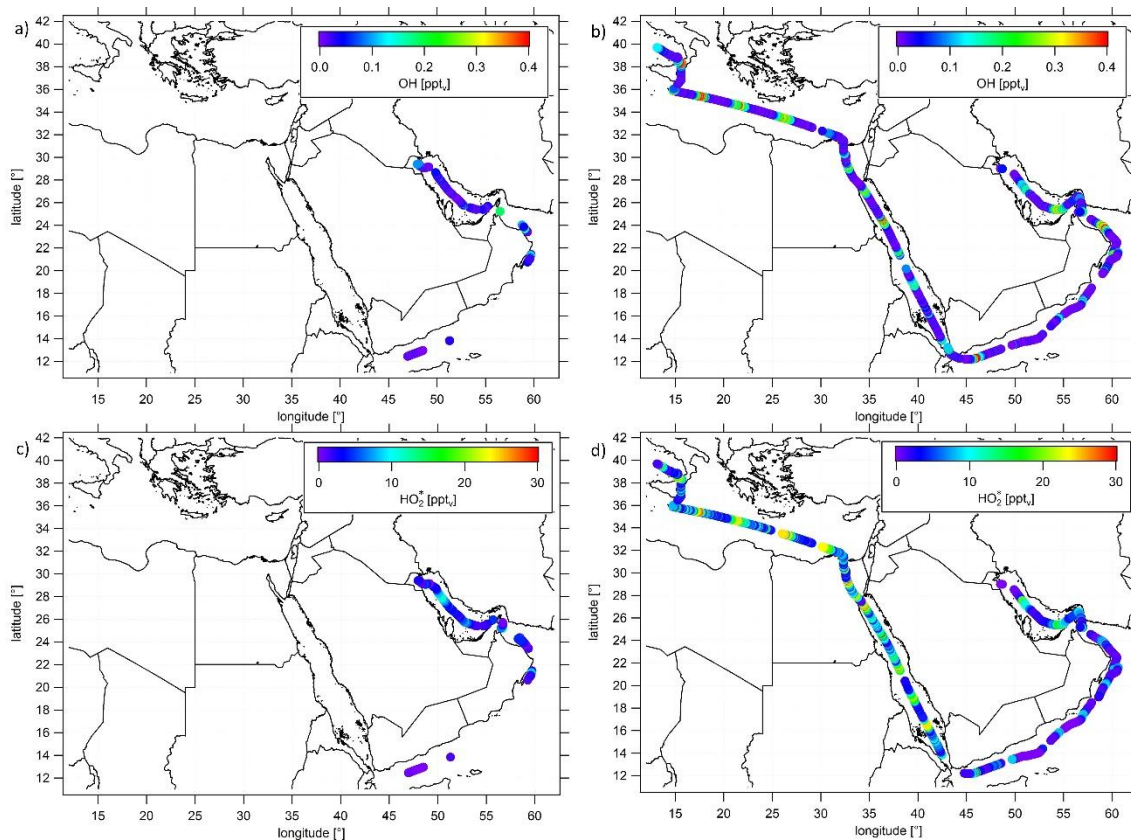
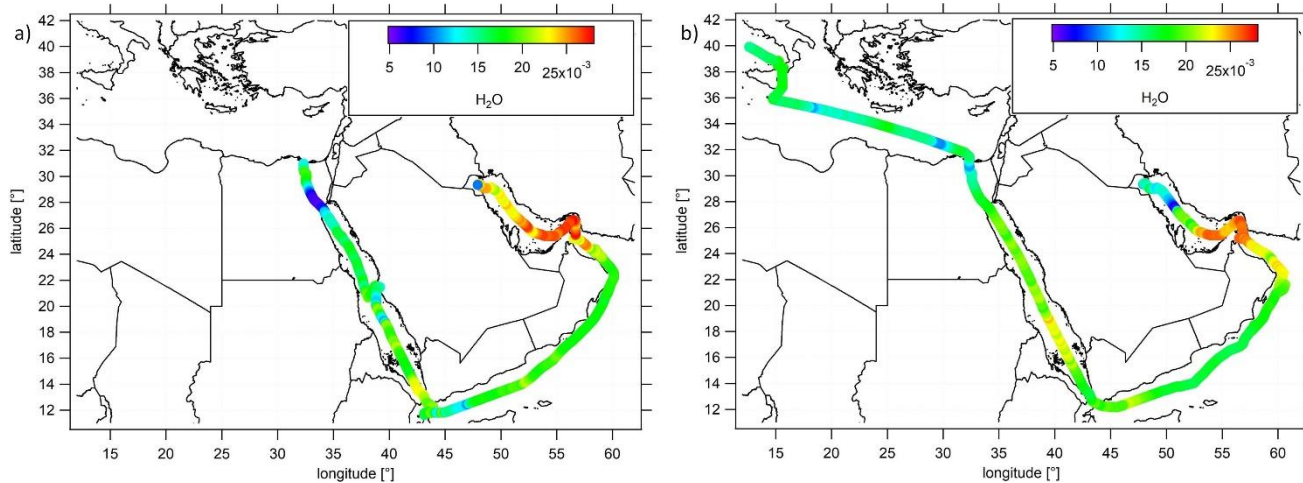


Figure S3: Timeline of NO, NO₂ (both CLD), O₃, OH, HO₂ preliminary (HO₂*) and $j(\text{NO}_2)$ data during the second leg. See Table ST2 for additional information on the ship cruise. Note that HO₂ data are preliminary.



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Figure S4: Ship cruises with color-scaled OH mixing ratios a) during the first and b) the second leg and color-scaled HO₂^{*} mixing ratios c) during the first and d) the second leg. Note that OH and HO₂^{*} data have been filtered for own stack contamination.



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Figure S5: Ship cruises with color-scaled absolute humidity a) during the first and b) the second leg.

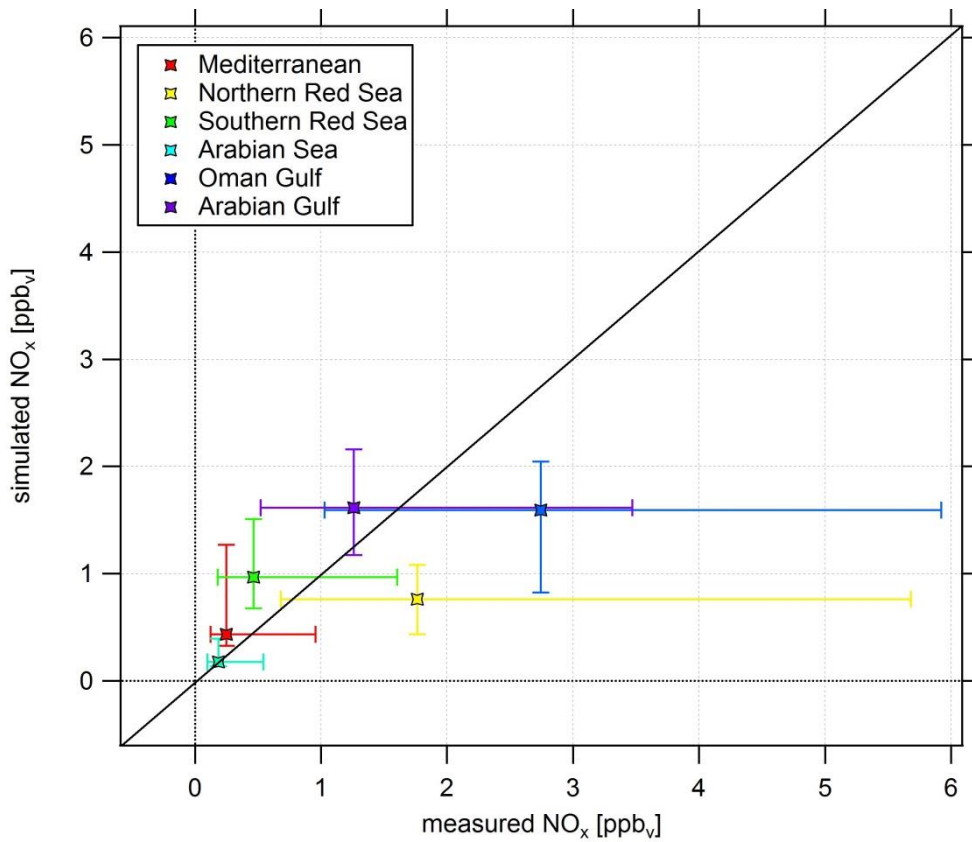
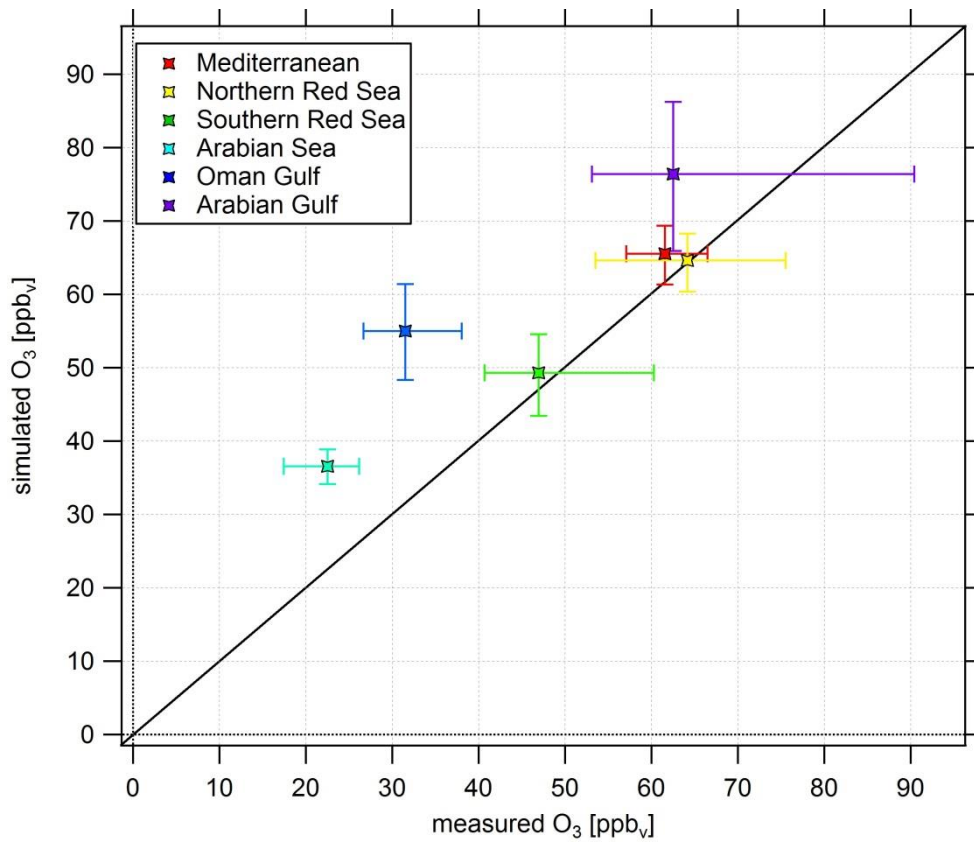
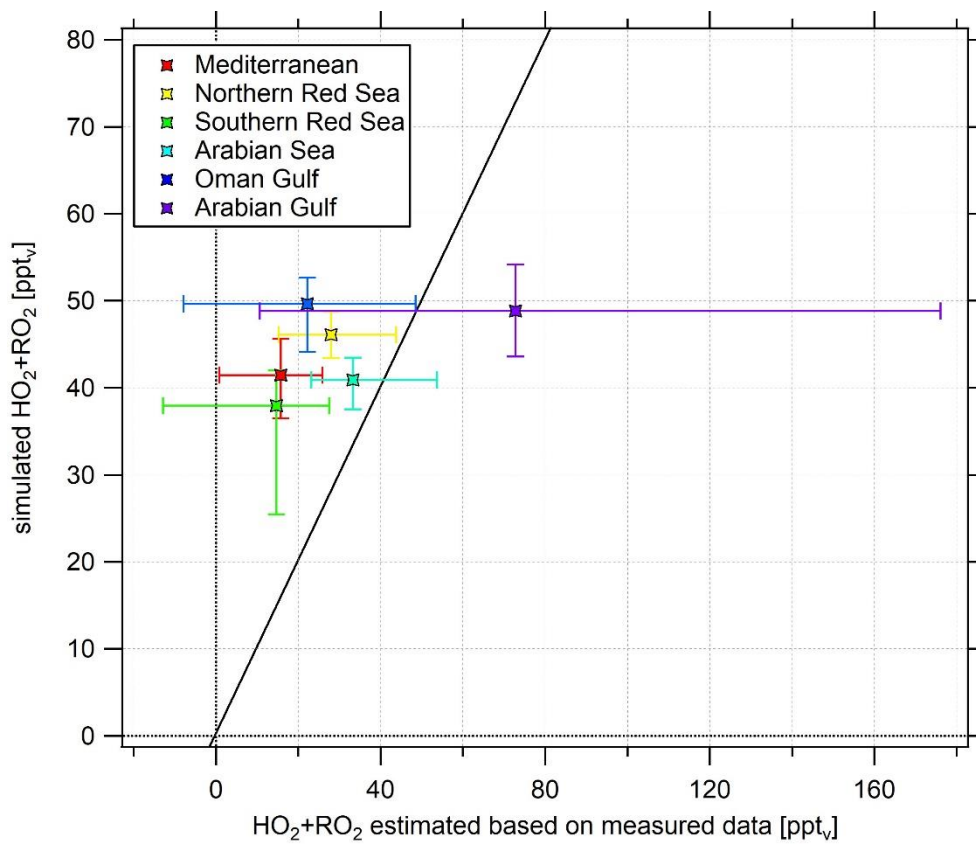


Figure S6: Scatterplot of simulated and measured regional NO_x median in ppbv. 1:1 line added for orientation. The error bars represent the 25-75-percentile variation.



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Figure S7: Scatterplot of simulated and measured regional O₃ median in ppb_v. 1:1 line added for orientation. The error bars represent the 25-75-percentile variation.



30 **Figure S8: Scatterplot of simulated regional ($\text{HO}_2 + \text{RO}_2$) median and regional ($\text{HO}_2 + \text{RO}_2$) median estimated based on measured tracer data in ppt_v . 1:1 line added for orientation. The error bars represent the 25-75-percentile variation.**

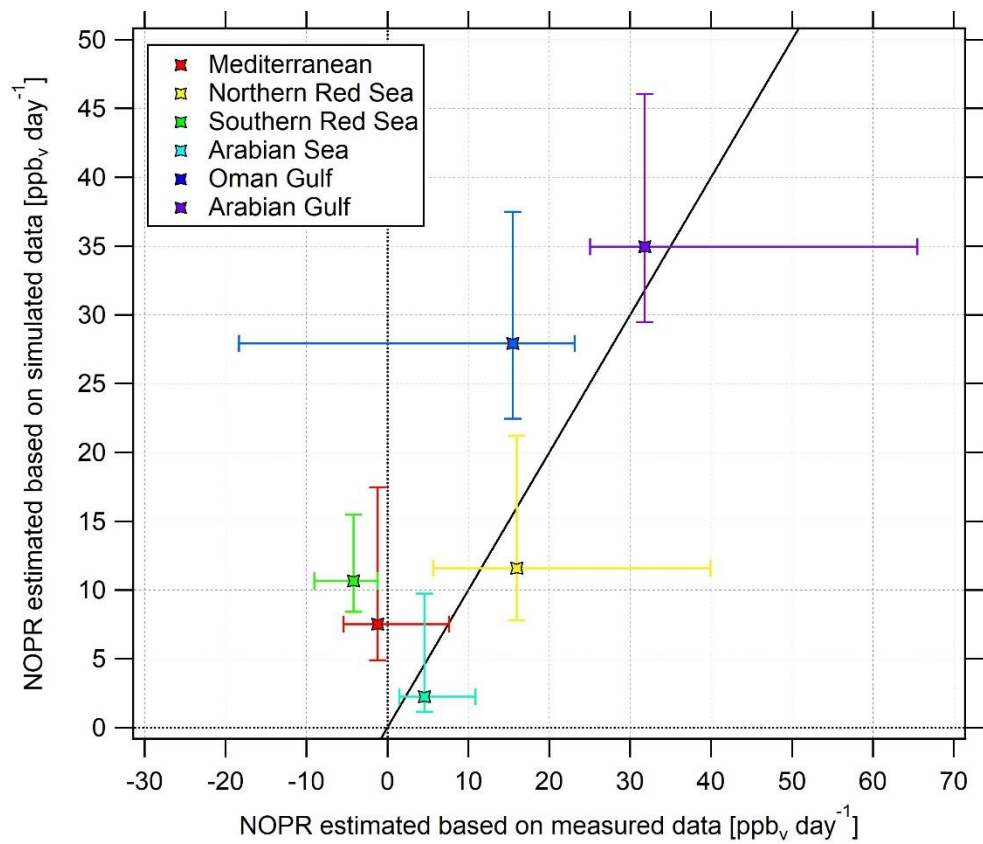


Figure S9: Scatterplot of median NOPR in ppb_v day⁻¹ estimated based on simulated and measured tracer data. 1:1 line added for orientation. The error bars represent the 25-75-percentile variation.

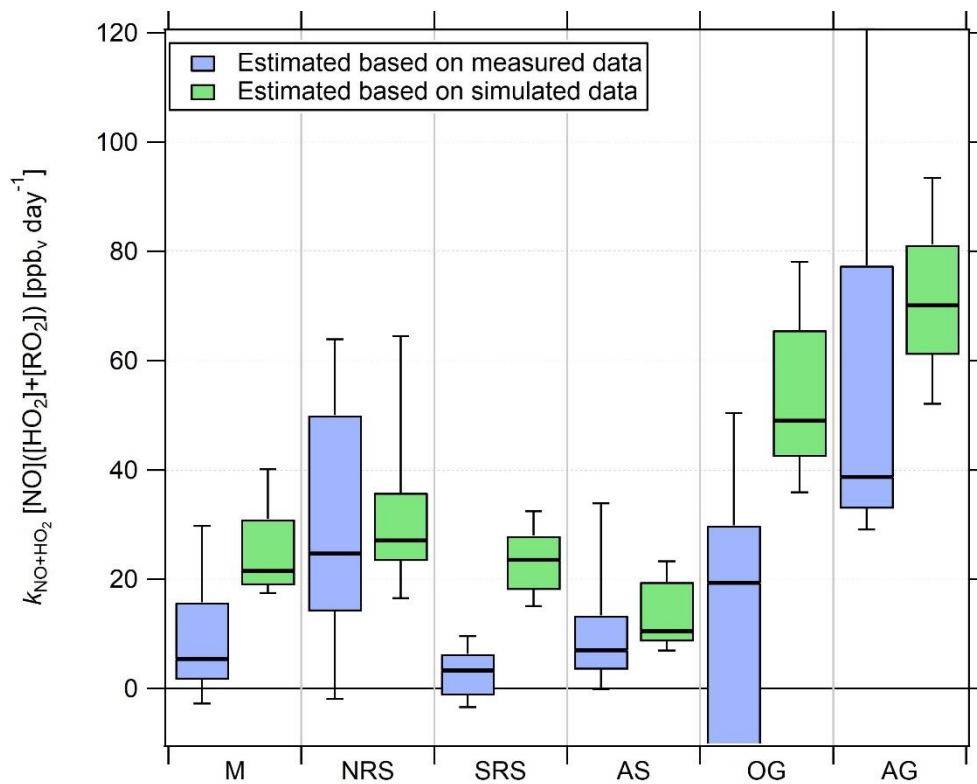
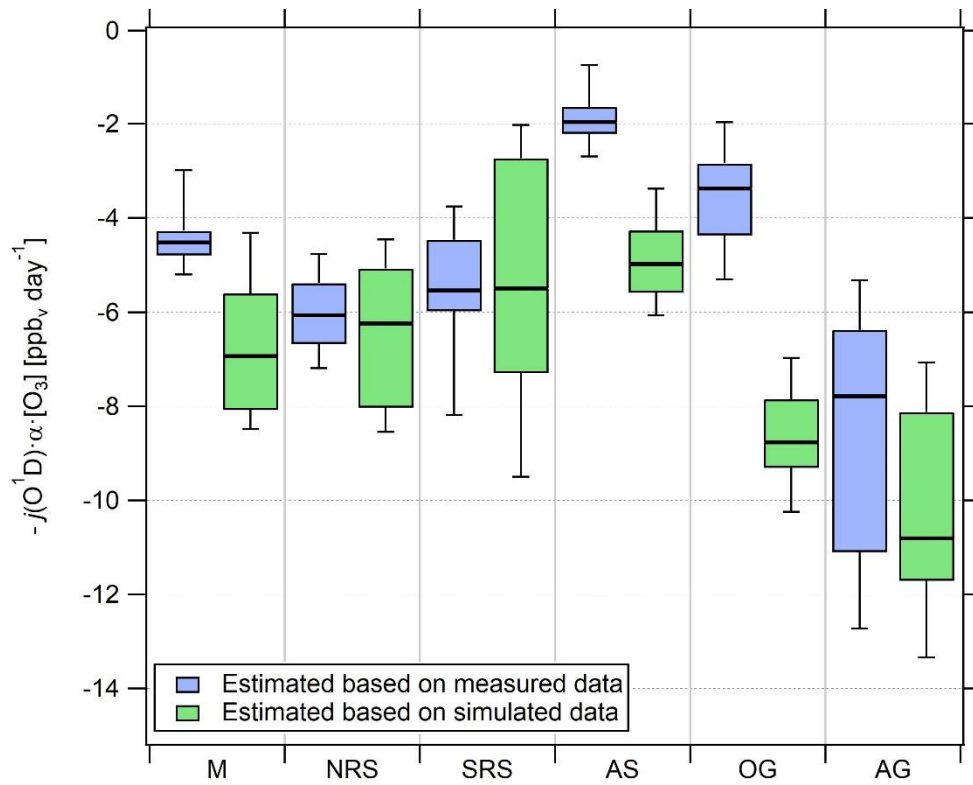


Figure S10: Comparison of the regional, absolute contribution of $k_{\text{NO}+\text{HO}_2}[\text{NO}][\text{HO}_2] + [\text{RO}_2]$ to NOPR in the six different regions investigated during AQABA. The horizontal black bar indicates the median value, the box the 25- and 75-percentiles and the whiskers the 10- and 90-percentiles.



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Figure S11: Comparison of the regional, absolute contribution of $-j(\text{O}^1\text{D}) \cdot \alpha \cdot [\text{O}_3]$ to NOPR in the six different regions investigated during AQABA. The horizontal black bar indicates the median value, the box the 25- and 75-percentiles and the whiskers the 10- and 90-percentiles.

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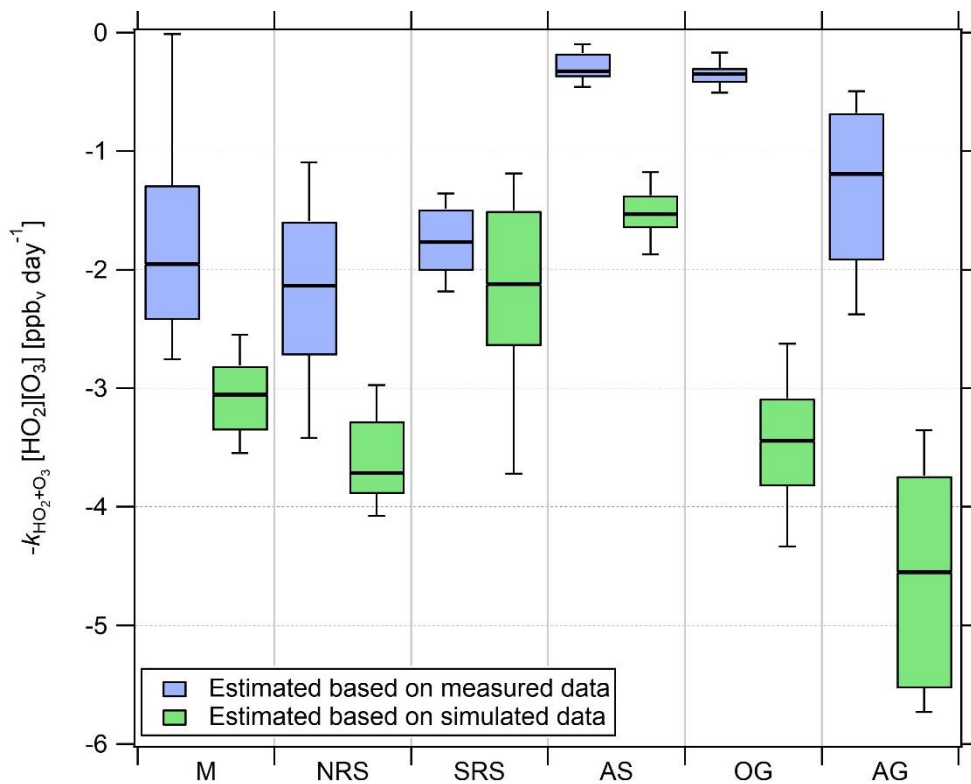
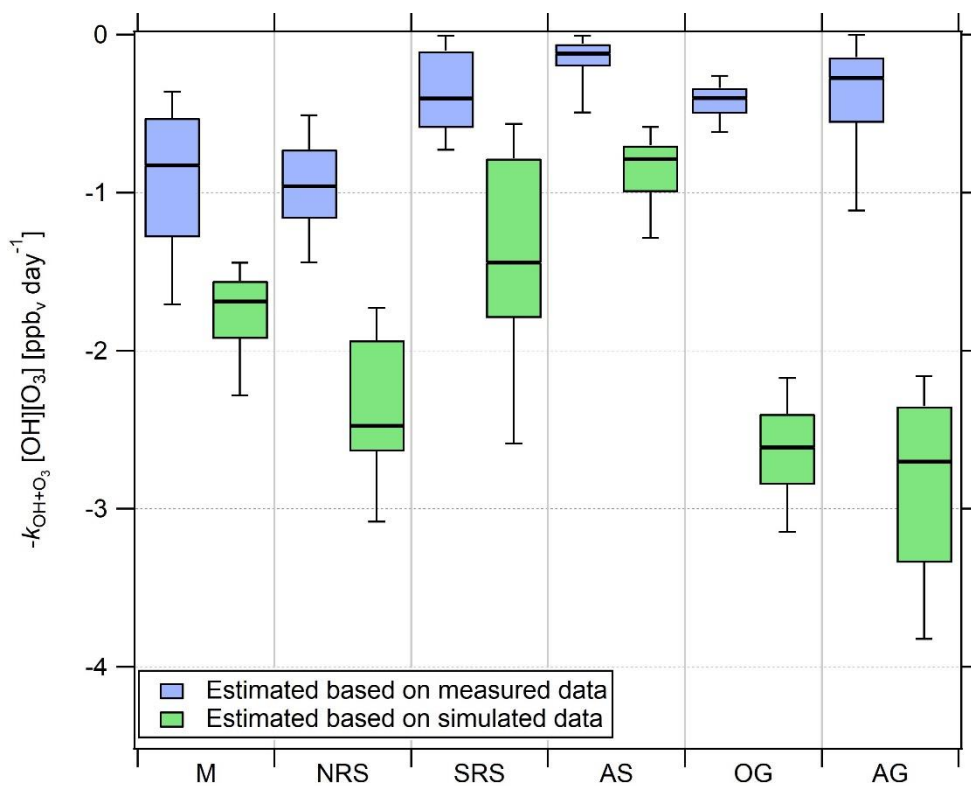


Figure S12: Comparison of the regional, absolute contribution of $-k_{\text{HO}_2+\text{O}_3}[\text{HO}_2][\text{O}_3]$ to NOPR in the six different regions investigated during AQABA. The horizontal black bar indicates the median value, the box the 25- and 75-percentiles and the whiskers the 10- and 90-percentiles.



55 **Figure S13:** Comparison of the regional, absolute contribution of $-k_{\text{OH}+\text{O}_3}[\text{OH}][\text{O}_3]$ to NOPR in the six different regions investigated during AQABA. The horizontal black bar indicates the median value, the box the 25- and 75-percentiles and the whiskers the 10- and 90-percentiles.

Table ST1: Range of latitudinal and longitudinal coordinates and dates during both legs of the different regions.

region (abbreviation)	latitudinal range	longitudinal range	Date (1 st leg)	Date (2 nd leg)
Mediterranean (M)	31.810° N- 39.923° N	12.620° E- 31.850° E	---	25.08.2017 – 31.08.2017
Northern Red Sea (NRS)	23.343° N- 30.986° N	32.305° E- 37.085° E	03.07.2017 – 08.07.2017	21.08.2017 – 24.08.2017
Southern Red Sea (SRS)	12.672° N- 22.494° N	37.411° E- 43.327° E	09.07.2017 – 16.07.2017	17.08.2017 – 20.08.2017
Arabian Sea (AS)	11.797° N- 22.782° N	44.035° E- 60.636° E	18.07.2017 – 24.07.2017	07.08.2017 – 16.08.2017
Oman Gulf (OG)	23.050° N- 25.622° N	56.492° E- 59.913° E	24.07.2017 – 27.07.2017	05.08.2017 – 07.08.2017
Arabian Gulf (AG)	25.396° N- 29.425° N	47.920° E- 56.772° E	27.07.2017 – 31.07.2017	03.08.2017 – 05.08.2017

60 Table ST2: Overview of the time spent in the particular regions during AQABA. Red color indicates periods with KI at anchor that are not included in the data analysis. Data measured during bunkering at Fujairah City (06 August, 07:00-15:00 UTC) were also not included in the analysis.

Date	Region	Date	Region
03.07.2017	Northern Red Sea	02.08.2017	Kuwait port
04.07.2017	Northern Red Sea	03.08.2017	Kuwait port/Arabian Gulf
05.07.2017	Northern Red Sea	04.08.2017	Arabian Gulf
06.07.2017	Northern Red Sea	05.08.2017	Arabian Gulf/Oman Gulf
07.07.2017	Northern Red Sea	06.08.2017	Oman Gulf
08.07.2017	Northern Red Sea	07.08.2017	Oman Gulf/Arabian Sea
09.07.2017	Southern Red Sea	08.08.2017	Arabian Sea
10.07.2017	Southern Red Sea	09.08.2017	Arabian Sea
11.07.2017	Southern Red Sea/Jeddah port	10.08.2017	Arabian Sea
12.07.2017	Jeddah port	11.08.2017	Arabian Sea
13.07.2017	Jeddah port/Southern Red Sea	12.08.2017	Arabian Sea
14.07.2017	Southern Red Sea	13.08.2017	Arabian Sea
15.07.2017	Southern Red Sea	14.08.2017	Arabian Sea
16.07.2017	Southern Red Sea	15.08.2017	Arabian Sea
17.07.2017	Djibouti port	16.08.2017	Arabian Sea
18.07.2017	Arabian Sea	17.08.2017	Southern Red Sea
19.07.2017	Arabian Sea	18.08.2017	Southern Red Sea
20.07.2017	Arabian Sea	19.08.2017	Southern Red Sea
21.07.2017	Arabian Sea	20.08.2017	Southern Red Sea
22.07.2017	Arabian Sea	21.08.2017	Northern Red Sea
23.07.2017	Arabian Sea	22.08.2017	Northern Red Sea
24.07.2017	Arabian Sea/Oman Gulf	23.08.2017	Northern Red Sea
25.07.2017	Oman Gulf	24.08.2017	Northern Red Sea
26.07.2017	Oman Gulf	25.08.2017	Mediterranean
27.07.2017	Oman Gulf/Arabian Gulf	26.08.2017	Mediterranean
28.07.2017	Arabian Gulf	27.08.2017	Mediterranean
29.07.2017	Arabian Gulf	28.08.2017	Mediterranean
30.07.2017	Arabian Gulf	29.08.2017	Mediterranean
31.07.2017	Arabian Gulf/Kuwait port	30.08.2017	Mediterranean
01.08.2017	Kuwait port	31.08.2017	Mediterranean

Table ST3: Overview of measured NO_x (upper table) and measured O₃ (lower table) spatial volume mixing ratio average, standard deviation, 1st quantile, median, 3rd quantile (all in ppb_v) and number of considered data points.

NO _x (upper), O ₃ (lower)	Mediterranea n	Northern Red Sea	Southern Red Sea	Arabian Sea	Oman Gulf	Arabian Gulf
data points	1767	1694	1755	2656	1056	1539
average	1.24	4.69	1.62	0.95	4.16	3.65
stdev	3.34	7.9	3.7	3.15	4.33	9.24
1 st quantile	0.12	0.68	0.18	0.10	1.03	0.52
median	0.25	1.76	0.46	0.19	2.74	1.26
3 rd quantile	0.96	5.68	1.6	0.54	5.92	3.47
data points	2010	2717	2307	4130	1249	1809
average	61.56	63.39	50.35	21.53	34.04	73.99
stdev	8.25	18.45	12.96	6.8	11.27	35.68
1 st quantile	57.05	53.51	40.68	17.45	26.66	53.08
median	61.54	64.16	46.93	22.52	31.5	62.5
3 rd quantile	66.48	75.51	60.28	26.19	38.03	90.42

65 **Table ST4: Overview of simulated NO_x (upper table) and simulated O₃ (lower table) spatial volume mixing ratio average, standard deviation, 1st quantile, median, 3rd quantile (all in ppb_v) and number of considered data points.**

NO _x (upper), O ₃ (lower)	Mediterranea n	Northern Red Sea	Southern Red Sea	Arabian Sea	Oman Gulf	Arabian Gulf
data points	2012	2719	2310	4464	1253	1810
average	0.84	1.27	1.13	0.31	1.88	1.91
stdev	0.75	1.97	0.62	0.29	1.47	1.37
1 st quantile	0.33	0.43	0.67	0.14	0.82	1.17
median	0.43	0.76	0.97	0.18	1.59	1.61
3 rd quantile	1.27	1.08	1.51	0.39	2.05	2.16
data points	2012	2719	2310	4464	1253	1810
average	65.15	64.76	49.5	36.91	55	76.85
stdev	4.99	7.7	7.21	3.87	9.94	12.8
1 st quantile	61.35	60.34	43.47	34.12	48.37	65.88
median	65.53	64.6	49.33	36.54	55.01	76.39
3 rd quantile	69.33	68.25	54.58	38.85	61.42	86.22

Table ST5: Overview of noontime (HO₂+RO₂) spatial volume mixing ratio average, standard deviation, 1st quantile, median, 3rd quantile (all in ppt.) estimated based on measured tracer data. Number of considered data points added in the first line.

HO ₂ +RO ₂	Mediterranean	Northern Red Sea	Southern Red Sea	Arabian Sea	Oman Gulf	Arabian Gulf
data points	288	126	190	338	166	242
average	13	27	7	64	23	94
stdev	24	20	34	83	42	113
1 st quantile	1	15	-13	23	-8	11
median	16	28	15	33	22	73
3 rd quantile	26	44	27	54	49	176

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Table ST6: Overview of simulated noontime (HO₂+RO₂) spatial volume mixing ratio average, standard deviation, 1st quantile, median, 3rd quantile (all in ppt.). Number of considered data points added in the first line.

HO ₂ +RO ₂	Mediterranean	Northern Red Sea	Southern Red Sea	Arabian Sea	Oman Gulf	Arabian Gulf
data points	336	192	192	720	203	293
average	41	46	36	40	48	49
stdev	5	4	11	5	6	7
1 st quantile	36	43	25	38	44	44
median	41	46	38	41	50	49
3 rd quantile	46	49	42	43	53	54

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Table ST7: Overview of NOPR average, standard deviation, 1st quantile, median, 3rd quantile (all in ppbv day⁻¹) estimated based on measured tracer data. Number of considered data points added in the first line.

NOPR	Mediterranean	Northern Red Sea	Southern Red Sea	Arabian Sea	Oman Gulf	Arabian Gulf
data points	148	114	89	187	84	111
average	-3	16	-5	-67	-105	-24
stdev	43	39	12	576	362	449
1 st quantile	-5	6	-9	1	-18	25
median	-1	16	-4	5	16	32
3 rd quantile	8	40	-1	11	23	65

Table ST8: Overview of NOPR average, standard deviation, 1st quantile, median, 3rd quantile (all in ppbv day⁻¹) estimated based on simulated tracer data. Number of considered data points added in the first line.

NOPR	Northern		Southern			
	Mediterranean	Red Sea	Red Sea	Arabian Sea	Oman Gulf	Arabian Gulf
data points	336	192	192	720	203	293
average	11	16	12	5	30	38
stdev	8	12	6	6	11	10
1 st quantile	5	8	8	1	22	30
median	8	12	11	2	28	35
3 rd quantile	17	21	15	10	37	46

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Table ST9: Overview of measured HCHO/NO₂-ratio average, standard deviation, 1st quantile, median, 3rd quantile and number of considered data points.

Ratio	Mediterranea	Northern Red	Southern Red	Arabian Sea	Oman Gulf	Arabian Gulf
	n	Sea	Sea			
data points	203	79	48	252	108	122
average	5.4	1.5	8.5	11.1	2.7	9
stdev	4.7	0.7	6.5	8.9	2.1	6.4
1 st quantile	1.3	0.8	4.4	2.3	1	2.5
median	5	1.4	7.7	9.4	2.2	9.3
3 rd quantile	7.4	2.1	9.8	16.1	3.6	12.7

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Table ST10: List of included peroxy radicals (with less than four carbon atoms) for the reaction with NO as recommended by Sander et al. (2019).

Species
HO ₂
CH ₃ O ₂
C ₂ H ₅ O ₂
C ₂ H ₅ CO ₃
CH ₃ CO ₃
C3DIALO2 (C ₃ H ₃ O ₄)
CH ₃ CHOHO ₂
CH ₃ COCH ₂ O ₂
CH ₃ COCO ₃
CHOCOCH ₂ O ₂
CO ₂ H ₃ CO ₃
HCOCH ₂ CO ₃
HCOCH ₂ O ₂
HCOCO ₃
HCOCOHCO ₃
HOC ₂ H ₄ CO ₃
HOCH ₂ CH ₂ O ₂
HOCH ₂ CO ₃
HOCH ₂ COCH ₂ O ₂
HOCH ₂ O ₂
CH ₃ CHO ₂ CH ₂ OH
IC3H7O2 (isopropylperoxy radical)
NC3H7O2 (propylperoxy radical)
NCCH ₂ O ₂
NO ₃ CH ₂ CO ₃
CH ₃ CHO ₂ CH ₂ ONO ₂