



Supplement of

Implementation and evaluation of updated photolysis rates in the EMEP MSC-W chemistry-transport model using Cloud-*J* v7.3e

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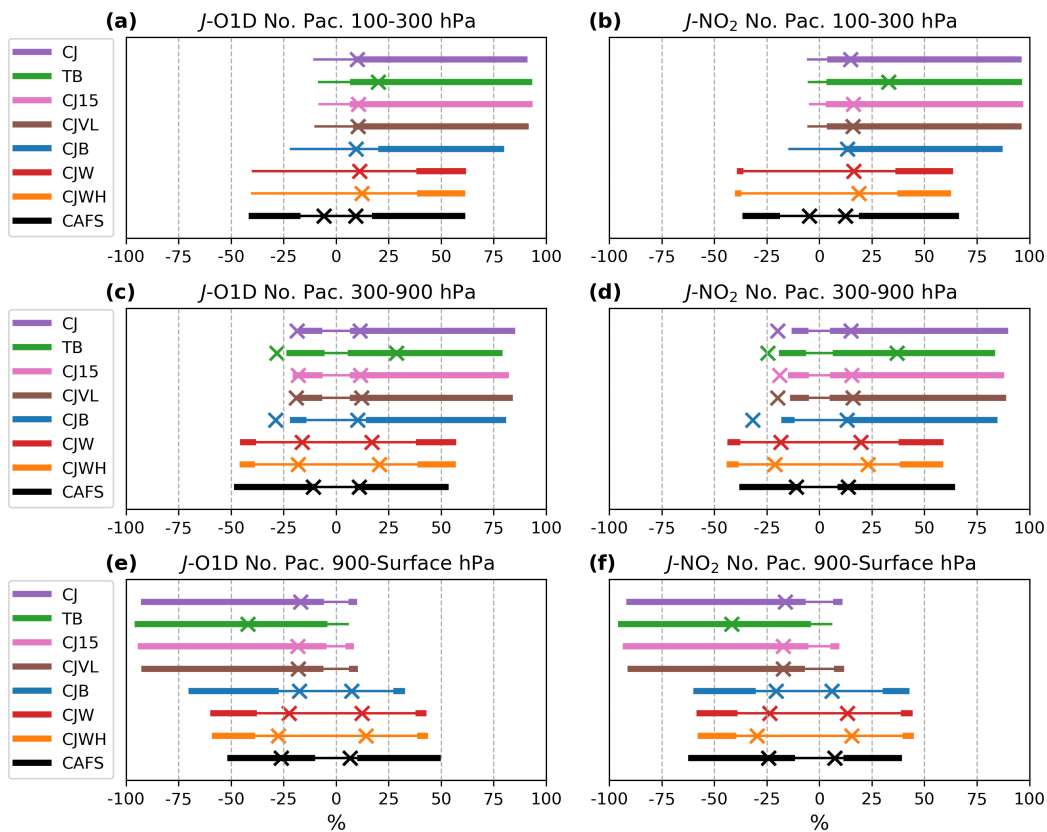


Figure S1. Frequency of occurrence and magnitude of the J -O(¹D) (a-c) and J -NO₂ (d-f) change due to clouds for the below-cloud, in-cloud, and above-cloud tropospheric regions over the Tropical Pacific basin. The interpretation of the line segments and marker locations is explained in the main body of the text.

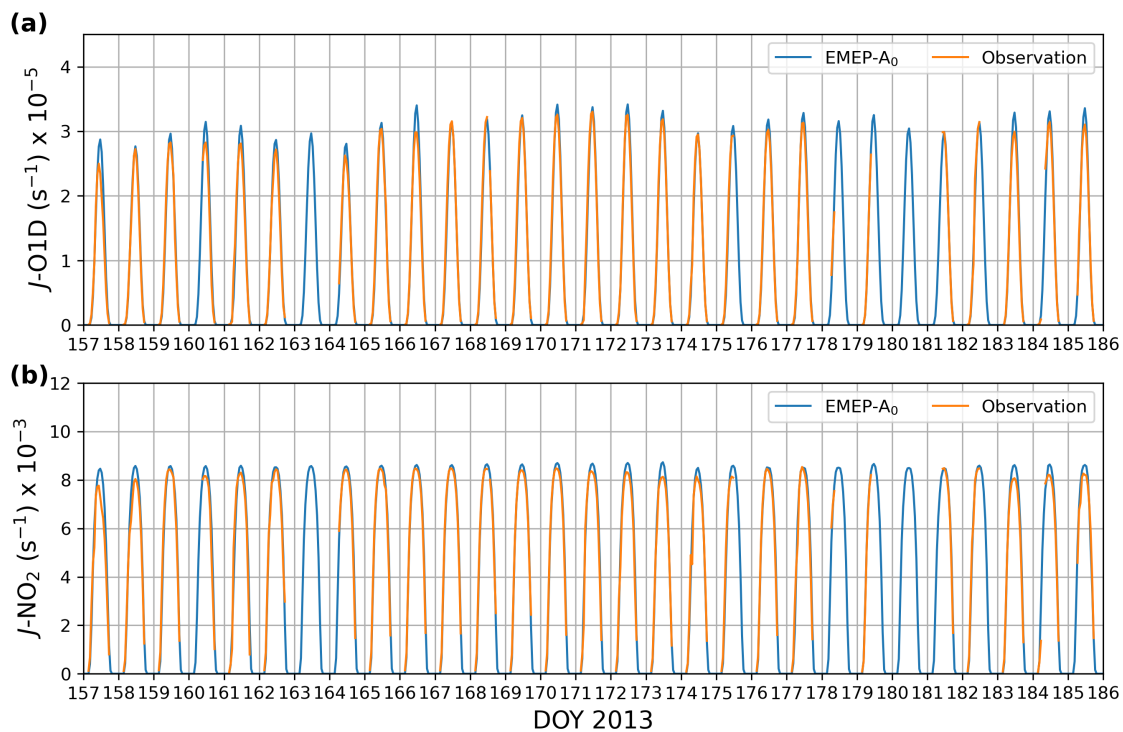


Figure S2. Hourly mean J -O1D (a) and J -NO₂ (b) photolysis rates observed at the Lampedusa site and simulated by the EMEP-A₀ model configuration between DOY 157 and 186 for the year 2013. The EMEP-A₀ simulation includes only the contribution from the downward surface actinic flux. Note that time periods where observational data are not available are left as blank.

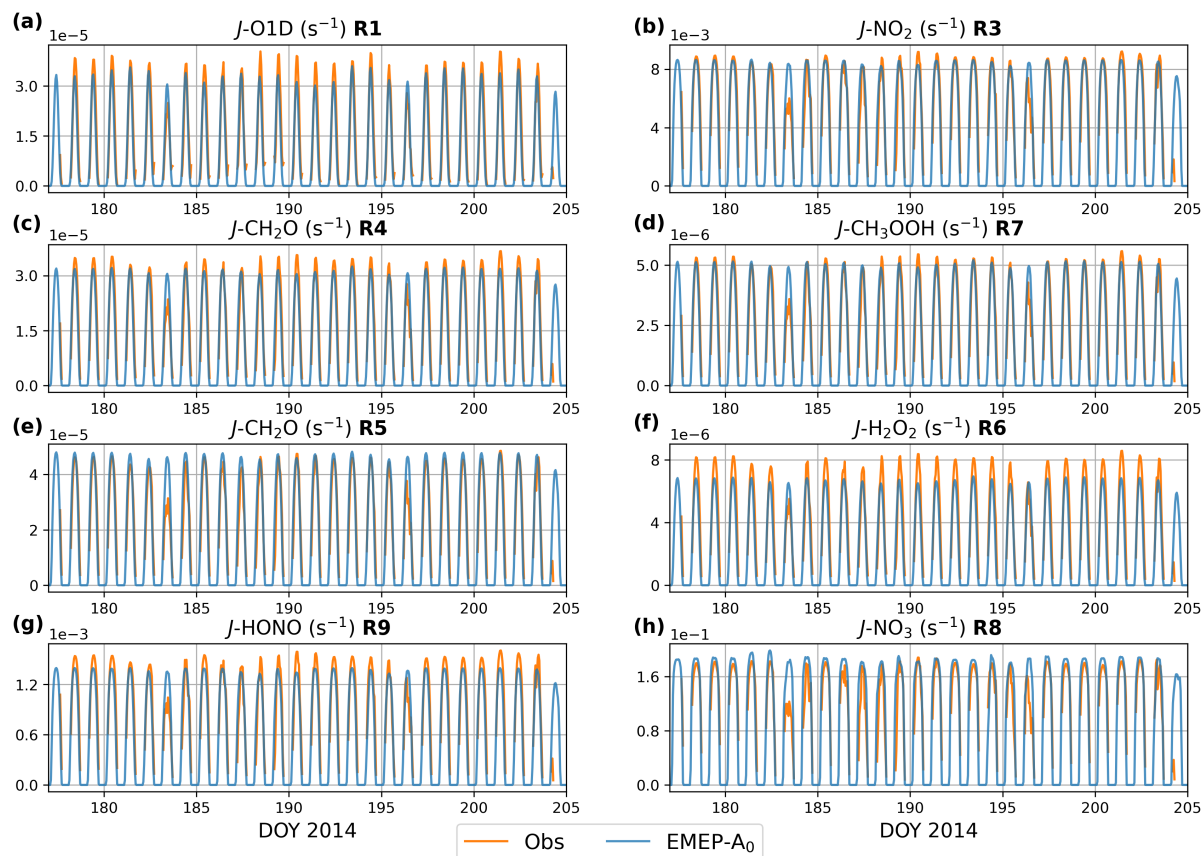


Figure S3. Hourly mean photolysis rates for eight photolysis reactions measured during the CYPHEX 2014 campaign (orange), and simulated by EMEP-A₀ (blue). Plot titles refer to the reactions listed in Table 1 of the main text.

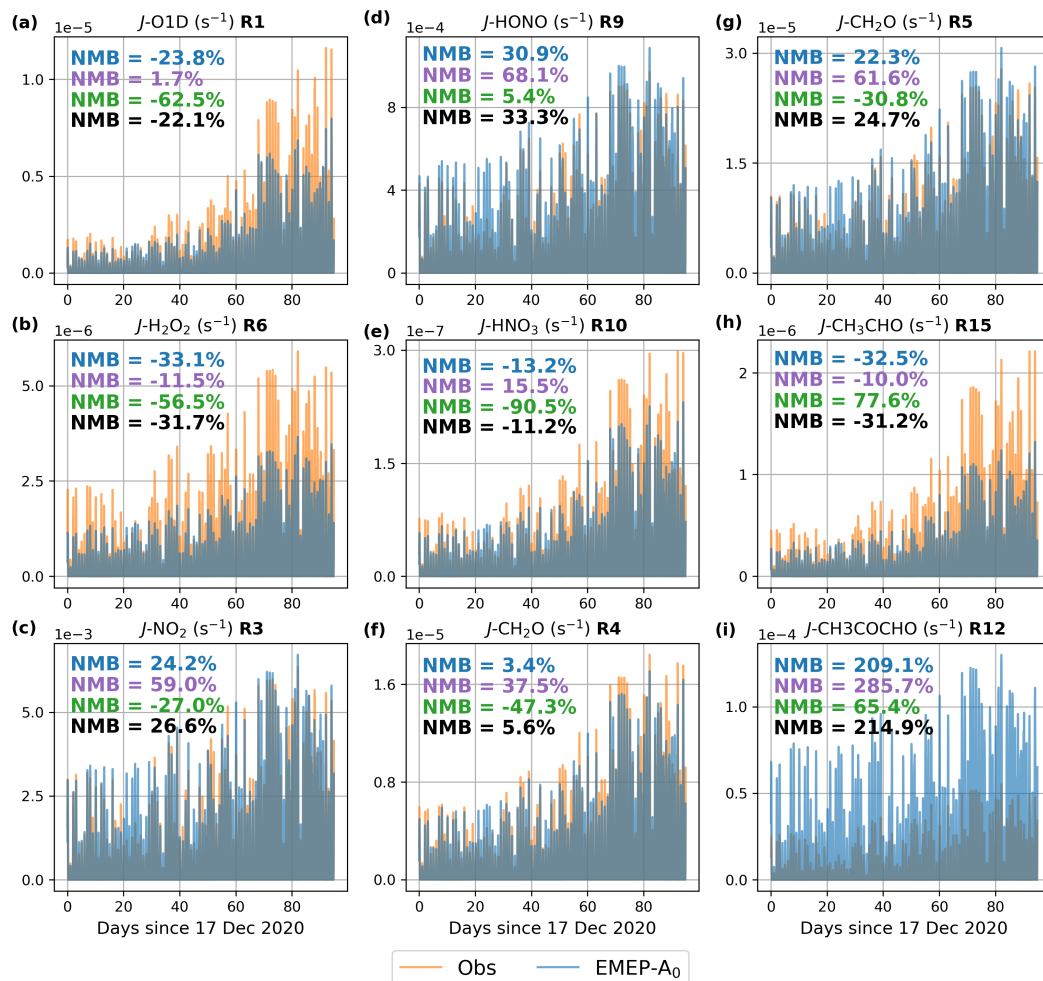


Figure S4. Hourly mean photolysis rates measured at the Chilbolton site (orange) and simulated by the EMEP-A₀ (blue) model in days since the 17th of December 2020. Plot titles refer to the reactions listed in Table 1 of the main text. The normalized mean bias (NMB,%) between model and observation for the EMEP-CJ (blue), EMEP-TB (green), EMEP-CJ (purple), and EMEP-A₀HR (black) models are also shown in each of the panels.

Table S1. Annual mean mass-weighted tropospheric hydroxyl concentrations (10^6 molecules cm^{-3}) following the results shown in Figure 10 of the main text. For the Naik *et al.* (2016) results, the standard deviation around the 17-model mean is also included.

		90°S-30°S	30°S-EQ	EQ-30°N	30°N-90°N
500-250 hPa	EMEP-CJ	0.45	1.36	1.40	0.58
	EMEP-TB	0.35	1.00	1.12	0.48
	Naik 2016	0.52±0.17	1.22±0.31	1.35±0.31	0.76±0.17
	Spivakovsky	0.64	1.43	1.36	0.64
750-500 hPa	EMEP-CJ	0.65	2.16	2.26	0.89
	EMEP-TB	0.62	1.96	2.14	0.90
	Naik 2016	0.57±0.15	1.50±0.25	1.71±0.27	0.91±0.17
	Spivakovsky	0.72	2.00	1.99	0.88
P_s -750 hPa	EMEP-CJ	0.67	2.20	2.39	1.09
	EMEP-TB	0.41	1.56	1.60	0.76
	Naik 2016	0.58±0.13	1.53±0.29	1.85±0.36	1.02±0.20
	Spivakovsky	0.47	1.44	1.52	0.76

Table S2. NMB (%) and correlation coefficients for EMEP-CJ and EMEP-CJBh (brackets) against surface observations from the EBAS database in Europe. Statistics are based on daily values, and are shown for the four seasons as well as for the yearly average.

Species [ppb]	Statistic	DJF	MAM	JJA	SON	Yearly
O ₃ max	NMB	2.4 (1.9)	6.0 (6.4)	0.0 (0.5)	7.9 (7.6)	3.9 (4.0)
	r	0.58 (0.58)	0.62 (0.62)	0.79 (0.80)	0.80 (0.80)	0.80 (0.80)
O ₃	NMB	5.3 (4.6)	10.4 (10.5)	6.6 (6.6)	15.0 (14.3)	9.2 (9.0)
	r	0.64 (0.64)	0.54 (0.54)	0.73 (0.73)	0.72 (0.72)	0.74 (0.74)
NO ₂	NMB	3.5 (4.3)	-19.6 (-19.4)	-14.4 (-14.1)	-11.8 (-11.1)	-9.8 (-9.3)
	r	0.63 (0.63)	0.68 (0.68)	0.62 (0.62)	0.72 (0.72)	0.67 (0.67)
CO	NMB	-9.5 (-9.5)	-8.8 (-9.0)	-9.4 (-9.5)	-4.7 (-4.4)	-8.1 (-8.2)
	r	0.64 (0.64)	0.67 (0.67)	0.72 (0.72)	0.72 (0.72)	0.70 (0.70)

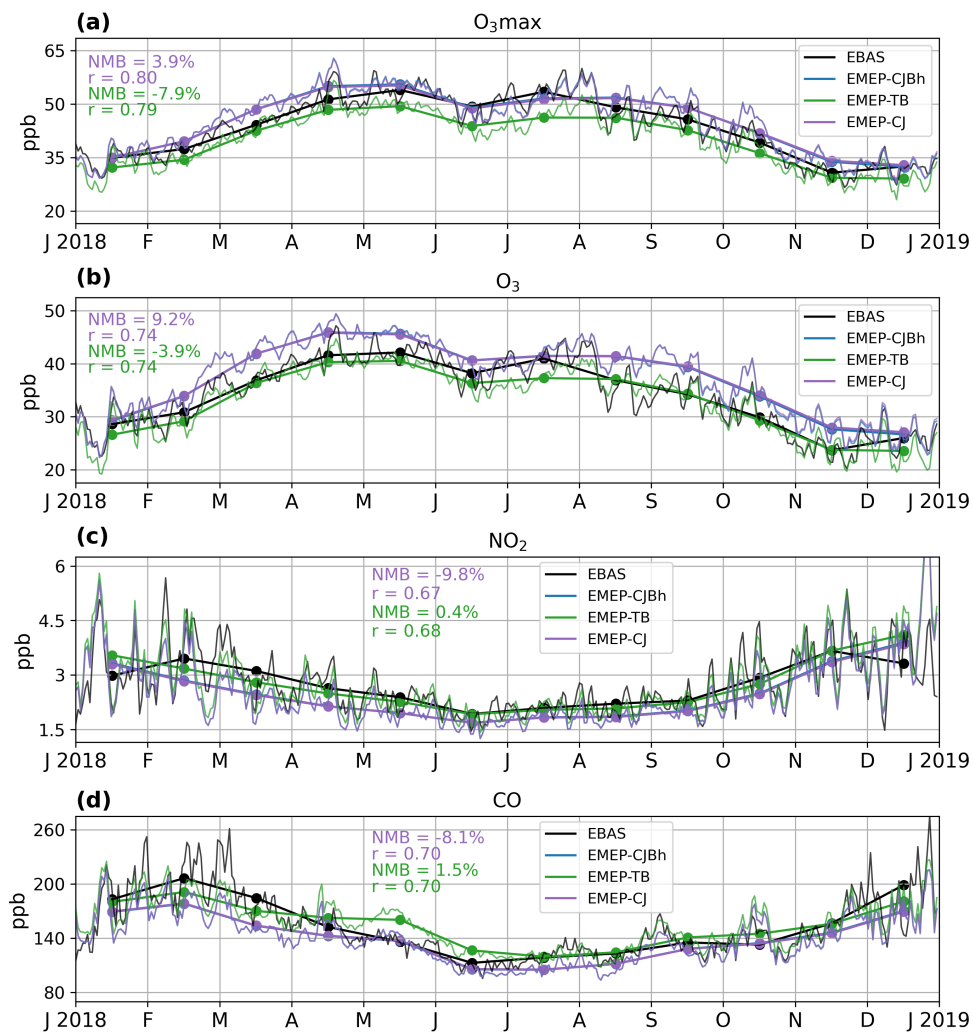


Figure S5. Time-series of O₃max, O₃, NO₂, and CO surface concentrations simulated by EMEP-CJ (purple), EMEP-TB (green), and EMEP-CJBh (orange) and observations from the EBAS database in Europe (black). The thick lines follow the monthly mean values, whereas the light coloured lines follow daily mean values. Yearly mean NMB and correlation coefficients between model and observation are shown in each of the panels for EMEP-CJ and EMEP-TB. Note that the EMEP-CJ and EMEP-CJBh curves nearly perfectly overlap.