Supplement of "Updated photolysis rates in the EMEP MSC-W chemical transport model using Cloud-*J* v7.3e"

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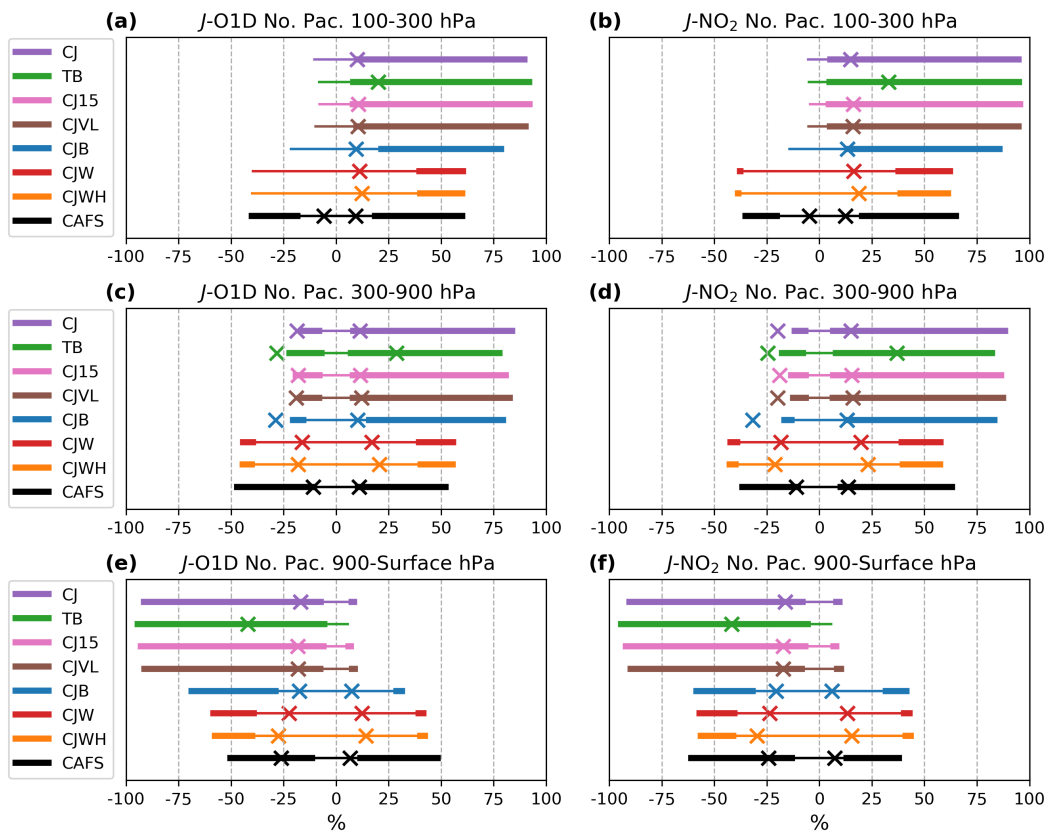
Figure S1. Frequency of occurrence and magnitude of the J-O(^{1}D) (a-c) and J-NO$_2$ (d-f) change due to clouds for the below-cloud, in-cloud, and above-cloud tropospheric regions over the Tropical Pacific basin. The interpretation of the line segments and marker locations is explained in the main body of the text.
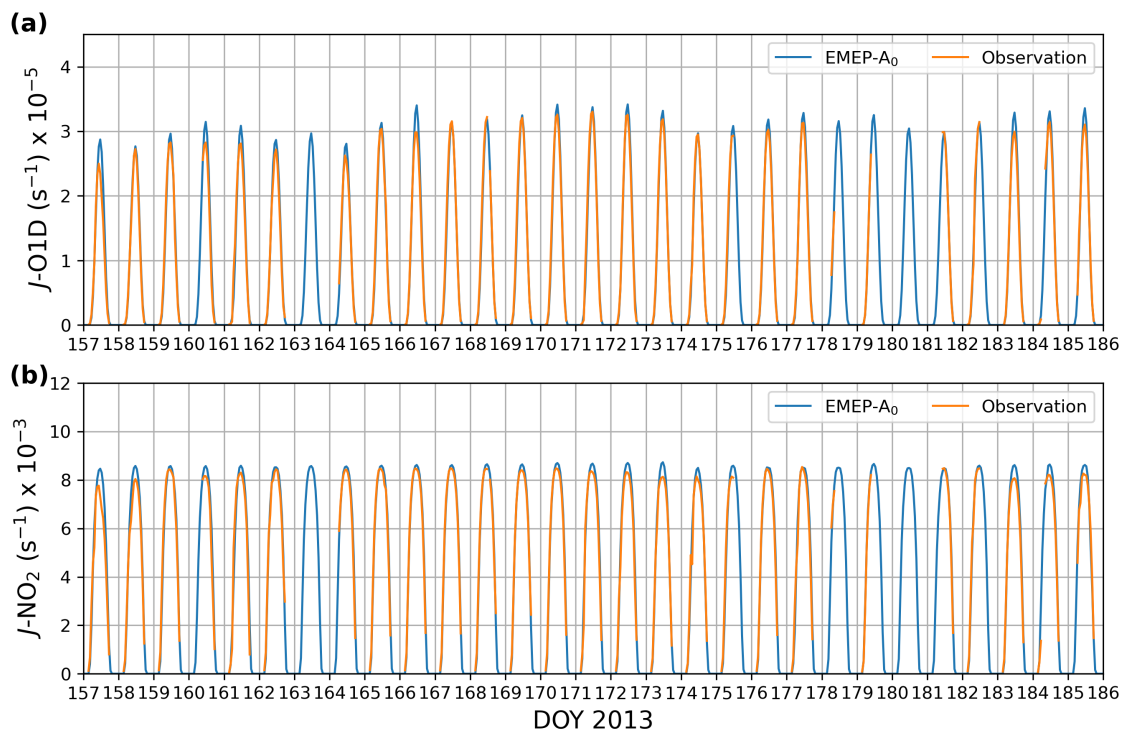
Figure S2. Hourly mean J-O1D **(a)** and J-NO$_2$ **(b)** photolysis rates observed at the Lampedusa site and simulated by the EMEP-A$_0$ model configuration between DOY 157 and 186 for the year 2013. The EMEP-A$_0$ simulation includes only the contribution from the downward surface actinic flux. Note that time periods where observational data are not available are left as blank.
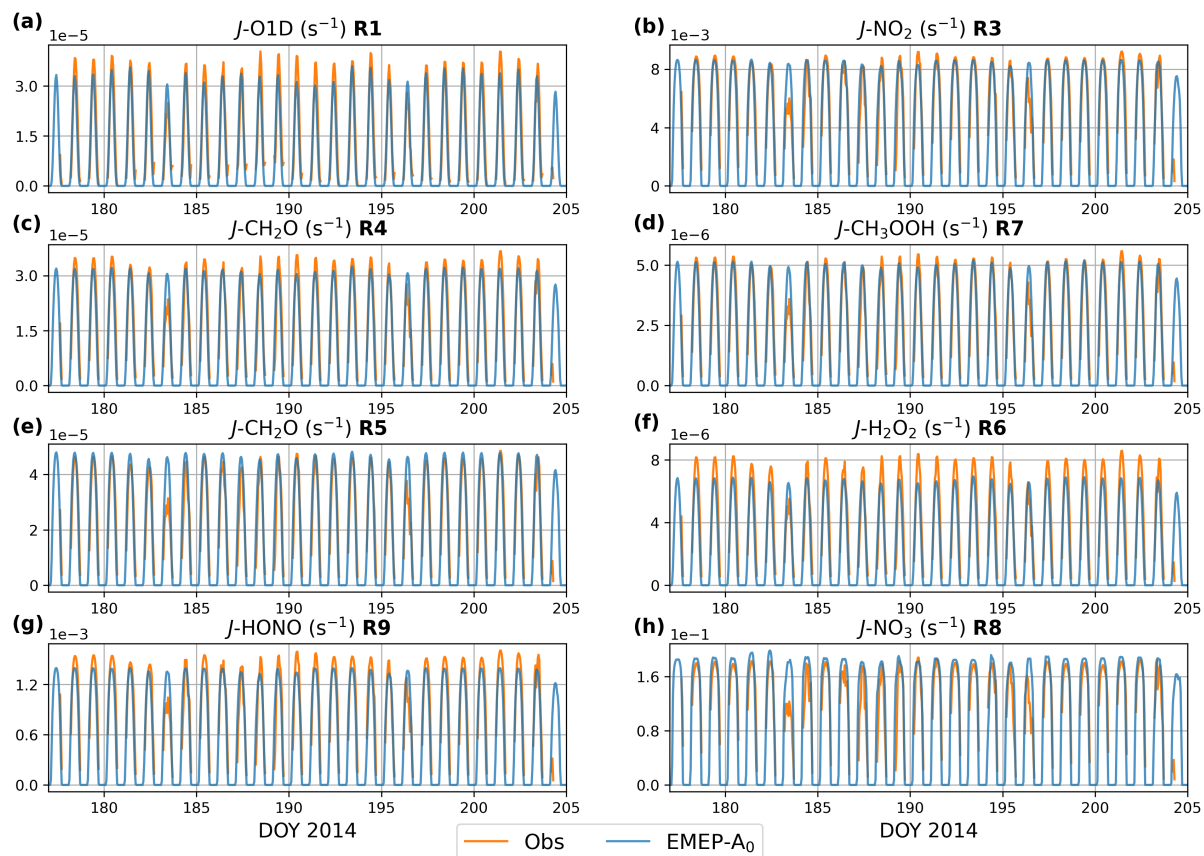
Figure S3. Hourly mean photolysis rates for eight photolysis reactions measured during the CYPHEX 2014 campaign (orange), and simulated by EMEP-A_0 (blue). Plot titles refer to the reactions listed in Table 1 of the main text.
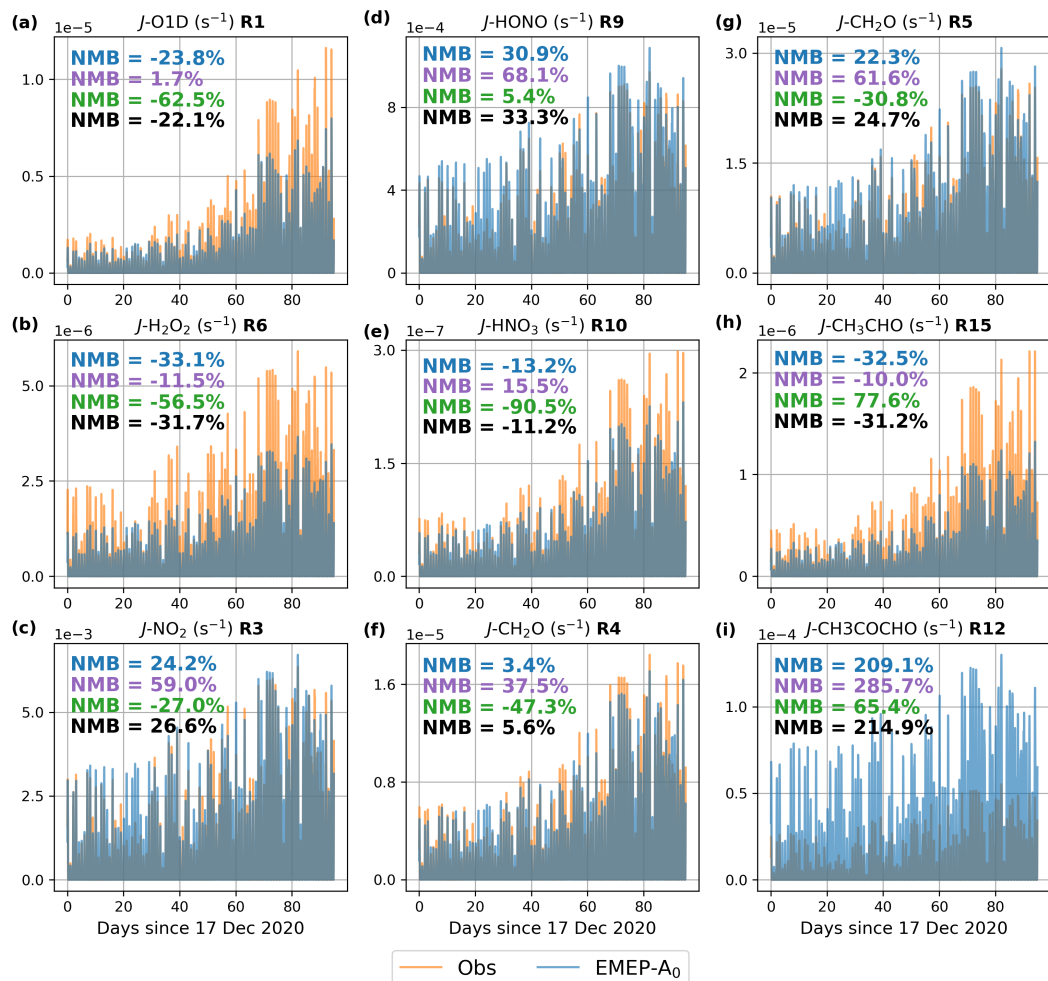
Figure S4. Hourly mean photolysis rates measured at the Chilbolton site (orange) and simulated by the EMEP-A_0 (blue) model in days since the 17th of December 2020. Plot titles refer to the reactions listed in Table 1 of the main text. The normalized mean bias (NMB,%) between model and observation for the EMEP-CJ (blue), EMEP-TB (green), EMEP-CJ (purple), and EMEP-A_0HR (black) models are also shown in each of the panels.
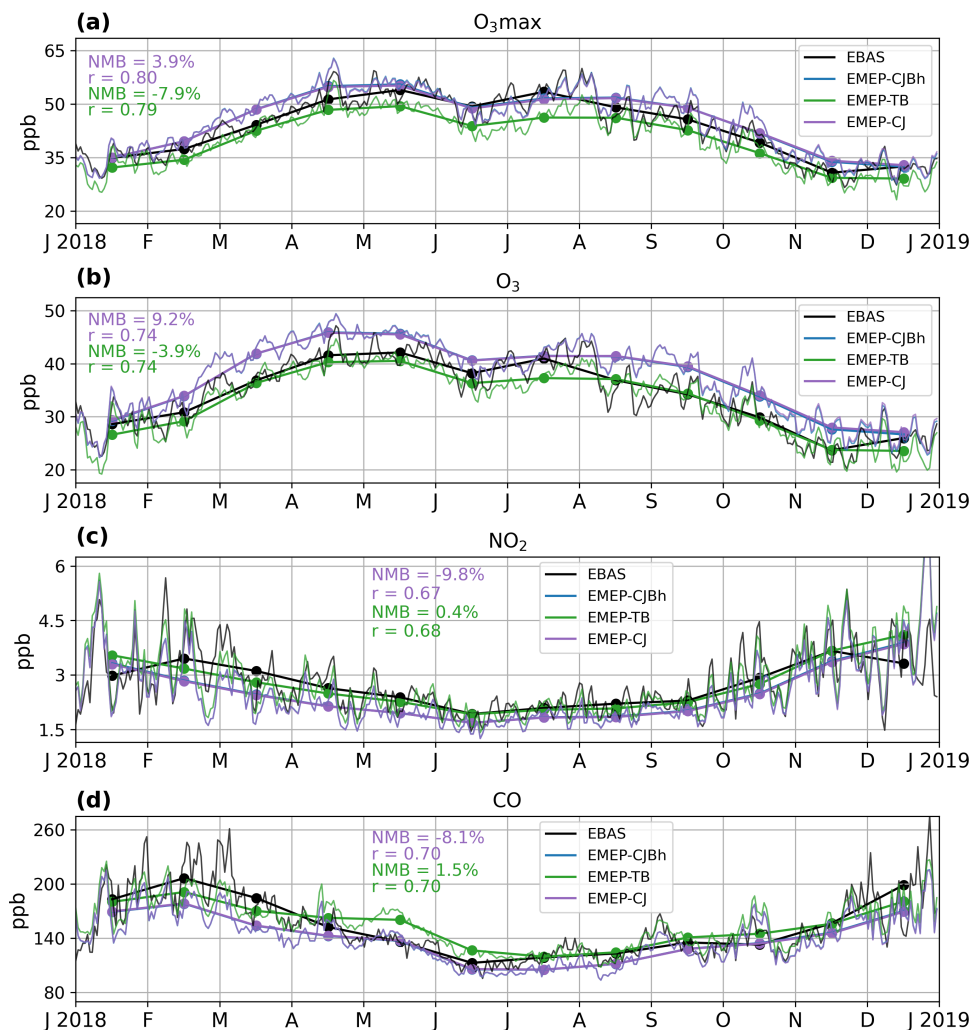
Figure S5. Time-series of O$_3$max, O$_3$, NO$_2$, and CO surface concentrations simulated by EMEP-CJ (purple), EMEP-TB (green), and EMEP-CJBh (orange) and observations from the EBAS database in Europe (black). The thick lines follow the monthly mean values, whereas the light coloured lines follow daily 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.

Table S1. 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_3max	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)