Supplement of

Air quality trends and regimes in South Korea inferred from 2015−2023 surface and satellite observations

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S1. HCHO and CHOCHO columns and loss frequencies obtained by aircraft observations

We use the DC-8 aircraft in-situ observations conducted below 8 km over the SMA (37–37.8° N, 126.4–127.5° E) during KORUS-AQ to obtain aircraft-observed column measurements and loss frequencies. HCHO and CHOCHO mixing ratios were measured using the University of Colorado CAMS instrument (Richter et al., 2015) and Gwangju Institute of Science and Technology CAESAR instrument (Min et al., 2016), respectively. OH was measured using the Penn State ATHOS instrument (Faloona et al., 2004) and photolysis frequencies were measured by the NCAR CAFS instrument (Shetter and Müller, 1999).

We first compute mean vertical profiles of HCHO and CHOCHO mixing ratios within 0–8 km at 1 km (Δz) vertical resolution. We convert them into number densities (n_i in molecules cm^{-3}) at each altitude (i) using observed pressure and temperature, then integrate within the column to obtain $\mathrm{VCD} = \sum_i n_i \Delta z_i$ in molecules cm^{-2}. Loss frequencies of HCHO and CHOCHO against OH oxidation and photolysis (two channels for HCHO, three channels for CHOCHO) are defined as follows:

$$\mathrm{L_{HCHO}} = \mathrm{k_{HCHO+OH}}[\mathrm{OH}] + j_{HCHO(1)} + j_{HCHO(2)}\,, \quad \text{(Eq. S1)}$$

$$\mathrm{L_{CHOCHO}} = \mathrm{k_{CHOCHO+OH}}[\mathrm{OH}] + j_{CHOCHO(1)} + j_{CHOCHO(2)} + j_{CHOCHO(3)}\,, \quad \text{(Eq. S2)}$$

where $\mathrm{k_{HCHO+OH}} = 5.5 \times 10^{-12} e^{125/T}$, $\mathrm{k_{CHOCHO+OH}} = 3.1 \times 10^{-12} e^{340/T}$, T is temperature, and j indicates photolysis frequencies. We compute mean vertical profiles of $\mathrm{L_{HCHO}}$ and $\mathrm{L_{CHOCHO}}$ within 0–8 km at 1 km vertical resolution and integrate within the column to obtain $\mathrm{L} = \frac{\sum_i \mathrm{L}_i n_i}{\sum_i n_i}$, where L_i is the mean loss frequency at altitude i. Values at each time of day and the number of aircraft observations used are presented in Table S1.

Table S1. HCHO and CHOCHO columns and loss frequencies from aircraft observations.

Local time (LT)	7−9	9−11	11−13	13−15	15−17
VCD_{HCHO} [a]	1.32 (695) [c]	1.60 (89)	1.59 (472)	1.86 (366)	2.33 (223)
VCD_{CHOCHO} [b]	0.53 (469)	0.88 (75)	0.94 (344)	0.92 (272)	0.95 (346)
L_{HCHO} (hr^{-1})	0.29 (755)	0.41 (92)	0.44 (519)	0.40 (383)	0.35 (485)
L_{CHOCHO} (hr^{-1})	0.48 (755)	0.65 (92)	0.65 (519)	0.57 (383)	0.52 (485)

[a] Units are in 10^{16} molecules cm^{-2}.
[b] Units are in 10^{15} molecules cm^{-2}.
[c] Number of aircraft observations used are indicated in parentheses.

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