

Table 1. Summary of the retrieval parameters used for O₃, CO, and HCHO. All micro-windows (MWs) are given cm⁻¹.

Gases	O ₃	CO	HCHO
Retrieval code	SFIT4 v 0.9.4.4	SFIT4 v 0.9.4.4	SFIT4 v 0.9.4.4
Spectroscopy	HITRAN2008	HITRAN2008	HITRAN2008
<i>P</i> , <i>T</i> , H ₂ O profiles	NCEP	NCEP	NCEP
A priori profiles for target/interfering gases except H ₂ O	WACCM	WACCM	WACCM
MW for profile retrievals	1000–1004.5	2057.7–2058 2069.56–2069.76 2157.5–2159.15	2763.42–2764.17 2765.65–2766.01 2778.15–2779.1 2780.65–2782.0
Retrieved interfering gases	H ₂ O, CO ₂ , C ₂ H ₄ , ⁶⁶⁸ O ₃ , ⁶⁸⁶ O ₃	O ₃ , N ₂ O, CO ₂ , OCS, H ₂ O	CH ₄ , O ₃ , N ₂ O, HDO
SNR for de-weighting	None	500	600
Regularization 	<i>S_a</i> Diagonal: 20 % No correlation	 Diagonal: 11 %–27 % No correlation	Diagonal: 10 % No correlation
ILS 	<i>S_ε</i> Real SNR LINEFIT145	Real SNR LINEFIT145	Real SNR LINEFIT145
Error analysis	Systematic error – smoothing error (smoothing) – errors from other parameters: background curvature (curvature), optical path difference (max_opd), field of view (omega), solar line strength (solstrnth), background slope (slope), solar line shift (solshft), phase (phase), solar zenith angle(sza), line temperature broadening (linetair_gas), line pressure broadening (linepair_gas), line intensity(lineint_gas)		
	Random error – interference errors: retrieval parameters (retrieval_parameters), interfering species (interfering_species) – Measurement error (measurement) – errors from other parameters: temperature (temperature), zero level (zshift)		

vided into four, three, and one independent layers, respectively (Fig. S3). The troposphere is well resolved by O₃, CO, and HCHO, where CO exhibits the best vertical resolution with more than two independent layers in the troposphere.

In this study, we have chosen the same upper limit (12 km) for the tropospheric columns for all gases (Table 2), which is about 3 km lower than the mean value of the tropopause (~ 15.1 km). In this way we ensured the accuracies for the tropospheric O₃, CO, and HCHO retrievals and minimized the influence of transport from the stratosphere, i.e., the so-called STE process (stratosphere–troposphere exchange).

3.3 Error analysis

The results of the error analysis presented here are based on the average of all measurements that fulfill the screen-

ing scheme, which is used to minimize the impacts of significant weather events or instrument problems (Supplement Sect. S2). In the troposphere, the dominant systematic error for O₃ and CO is the smoothing error, and for HCHO it is the line intensity error (Fig. S4). The dominant random error for O₃ and HCHO is the measurement error, and for CO it is the zero baseline level error (Fig. S5). Taking all error items into account, the summarized errors in O₃, CO, and HCHO for the 0–12 km tropospheric partial column and for the total column are listed in Table 3. The total errors in the tropospheric partial columns for O₃, CO, and HCHO have been evaluated to be 8.7 %, 6.8 %, and 10.2 %, respectively.