HFC-23 column abundances retrieved from FTIR observations at Syowa Station, Rikubetsu and Tsukuba

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Depending on the Montreal Protocol on Substances that Deplete the Ozone Layer, production and consumption of chlorofluorocarbons (CFCs) have been regulated and global atmospheric CFCs concentration have kept decreasing. On the other hand, production and consumption of hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) as alternatives for CFCs are steady expanding, and emissions of these gases which are powerful greenhouse gases are rapidly increasing (Carpenter et al., 2014). HFC-23 (CHF_3) which has very high global warming potential (100yr-GWP: 12,400) is generated as unavoidable by-product of HCFC-22 ($CHClF_2$) production and has limited industrial uses. HFC-23 emission into atmosphere relevant to HCFC-22 production have increased, but the emission will be under control by the Kigali 2016 Amendment to the Montreal Protocol. In order to monitor continuously HFC-23 global emission, we need to establish the observation method of HFC-23 concentration using ground-based remote sensing instrument.

We operated atmospheric solar absorption measurements using ground-based Fourier transform infrared spectrometer (FTIR) at Antarctic Syowa Station (69.0ºS, 39.6ºE) in 2007, 2011 and 2016. In this study, we retrieved total column abundances and vertical profiles of HFC-23 from the FTIR observations with the SFIT4 version 0.9.4.4 based on the optimal estimate method (Rodgers, 2000). Then we performed the error analysis to estimate various uncertainties contained in retrieved HFC-23 abundances. We used two micro-windows (MWs) of 1138.5-1148.0 cm^{-1} (MW1) and 1154.0-1160.0 cm^{-1} (MW2) in this study. As the spectroscopic parameters of HFC-23, the pseudo line lists produced by G. C. Toon (NASA/JPL) were used. For other interfering species, the line parameters from HITRAN2008 were used. Temperature and pressure vertical information from surface to 40 km was taken by the daily temperature and pressure profiles from NCEP (National Centers for Environmental Prediction) Reanalysis-1 dataset. Meteorological information above 40 km were adopted from the monthly climatological profiles from the COSPAR International Reference Atmosphere (CIRA-86) dataset. The HFC-23 a priori profile was taken from the simulated profile by Naik et al. (2000) but that was scaled to make the concentration of the lowest level equal to 20 pptv which is approximate value of surface concentration in southern hemisphere in 2007. For H_2O and its isotopologues, the a priori profiles were taken from independent preliminarily profile retrievals for each observed spectra. For other interfering species, the 40 years (1980-2020) mean profiles of the monthly profiles provided from WACCM (Whole Atmosphere Community Climate Model) version 6 were used as the a priori profiles. According to the error analysis, mean systematic and random error on the HFC-23 retrievals were ~40% and ~10% to retrieved HFC-23 total column, respectively. The FTIR observation is practicable to estimate trend of atmospheric HFC-23 because the random uncertainty is relatively small.

In addition, we performed retrievals of HFC-23 from FTIR spectra at Rikubetsu (43.46°N, 143.77°E) and Tsukuba (36.05°N, 140.12°E) in Japan in the same way as the retrieval strategy at Syowa Station. In the presentation, we will discuss difference of HFC-23 trend between these three FTIR sites, along with trend of HCFC-22 linked to HFC-23 emission.

References

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