Retrieval of HFC-23 from FTIR observations at Syowa Station, Rikubetsu and Tsukuba

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The Montreal Protocol on Substances that Deplete the Ozone Layer has successfully been regulated production and consumption of chlorofluorocarbons (CFCs) 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 expanding up to the present. Especially, 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 their emissions into atmosphere have been increasing relevant to production of HCFC-22. Observations of these gases are possible not only by in-situ gas-chromatogram/mass-spectroscopy systems, but also by infrared spectroscopic measurements. Ground-based Fourier Transform Infrared spectrometer (FTIR) has a capability to monitor multiple gas species simultaneously. In this study, we retrieved total column abundances and vertical profiles of HFC-23 from ground-based FTIR observations with the SFIT4 version 0.9.4.4 based on the optimal estimate method (Rodgers, 2000).
We operated atmospheric solar absorption measurements using ground-based FTIR instrument at Antarctic Syowa Station (69.0ºS, 39.6ºE) in 2007, 2011 and 2016. 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 a.s.l. were taken by the daily temperature and pressure profiles from NCEP (National Centers for Environmental Prediction) Reanalysis-1 dataset. Meteorological information above 40 km a.s.l. were adopted from the monthly climatological profiles from the COSPAR International Reference Atmosphere (CIRA-86) dataset. The HFC-23 a priori profile was taken fromthe 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 the 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, 40 years (1980-2020) mean profiles of the monthly profiles provided from WACCM (Whole Atmosphere Community Climate Model) version 6 were used as a priori profiles. Figure 1 shows the timeseries of the FTIR-retrieved total columns of HFC-23. According to the error analysis, mean systematic and random errors on the HFC-23 retrievals were ~40% and ~10% to retrieved HFC-23 total column, respectively. The FTIR observation is practicable to estimate the 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 (43.46ºN, 143.77ºE) and Tsukuba (36.05ºN, 140.12ºE) in Japan in the same way as the retrieval strategy at Syowa Station. In the presentation, we will discuss on the differences of HFC-23 trends among these three FTIR sites, along with the trends of HCFC-22 from FTIR observations.

References

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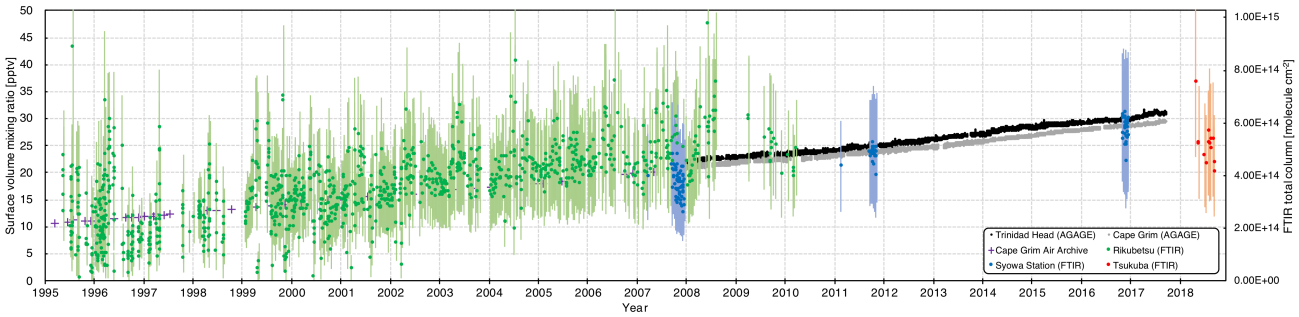

Figure 1. The timeseries of the FTIR-retrieved total columns of HFC-23 at Rikubetsu (green), Syowa Station (blue) and Tsukuba (red) with the retrieval uncertainties, along with ground-based in-situ measurements at Trinidad Head (41.05°N, 124.15°W; black) and Cape Grim (40.68°S, 144.69°E; grey). Also, Cape Grim Air Archive data (purple) is plotted during the period of 1995 to 2007.

