Recent Trends of HFC-23 from Ground-based FTIR at Rikubetsu, Tsukuba, and Syowa Station

*Masanori Takeda[1,2], Hideaki Nakajima[2,1], Isao Murata[1], Tomoo Nagahama[3], Isamu Morino[2]

1. Graduate School of Environmental Studies, Tohoku University, 2. Center for Global Environmental Research, National Institute for Environmental Studies, 3. Institute for Space-Earth Environmental Research, Nagoya University

Production and consumption of chlorofluorocarbons (CFCs) which are powerful ozone-depleting substances (ODSs) have successfully been phased out by 2010 under the Montreal Protocol on substances that deplete the ozone layer and their global atmospheric concentration have satisfactorily been decreasing till the present. Following the regulation schedule under the Montreal Protocol, production and consumption of hydrochlorofluorocarbons (HCFCs), which are the temporal replacements of CFCs but weak ODSs, should also be frozen by 2020 and 2030 in developed and developing countries, respectively. Hydrofluorocarbons (HFCs), the second generation alternatives of CFCs, are not ODSs but having high global warming potential (GWP). Due to their possible contribution to global climate change, manufacture and consumption of HFCs were adopted as abatement targets in the Kigali Amendment to the Montreal Protocol in 2016, and their regulation has started in developed countries in 2019. However, uses of HCFCs and HFCs would be continuing for a while. Trifluoromethane (CHF_3, HFC-23), with the highest GWP in HFCs (100-year GWP: 12,690) and a very long atmospheric lifetime of 228 years (WMO, 2019), is an unavoidable by-product during the production of chlorodifluoromethane ($CHClF_2$, HCFC-22) and is generally vented as an unwanted gas into the atmosphere. The atmospheric global annual mean mole fraction of HFC-23 had increased from almost zero in early 1960 to 28.9 ppt in 2016, corresponding to radiative forcing of 5.2 mW m^{-2}. Therefore, monitoring of the atmospheric concentration of HFC-23 is significant for understanding its impact on global climate change.

Ground-based Fourier Transform Infrared spectrometer (FTIR) has a capability to monitor multiple gas species simultaneously. We have enabled the retrieval of total column abundances of HFC-23 from FTIR spectra observed at Rikubetsu (43.5ºN, 143.8ºE), Tsukuba (36.1ºN, 140.1ºE) and Antarctic Syowa Station (69.0ºS, 39.6ºE) with the SFIT4 version 0.9.4.4 retrieval code based on the optimal estimate method (Rodgers, 2000).

The timeseries of the FTIR-retrieved HFC-23 column-averaged volume mixing ratios ($X_{HFC\text{-}23}$) for each station is shown in Figure 1, along with the flask-samples and in-situ measurements of the Advanced Global Atmospheric Gases Experiment (AGAGE). The mole fractions of FTIR measurements at Rikubetsu are mostly larger than other dataset of the AGAGE, while the FTIR measurements at Syowa Station are in agree with the in-situ measurements at Cape Grim (40.68ºS, 144.69ºE) by the AGAGE. Since Rikubetsu is located relatively close to China, which is the highest source of HFC-23, these indicates that the FTIR measurements have a potential to detect long-range transport of HFC-23 from China, not only to observe the background values. From the result of the error analysis of the HFC-23 retrieval, the retrieval error of HFC-23 total column mostly comes from the systematic error, the uncertainties of the absorption line parameters, and the random error is only about 10% which is dominantly caused by measurement noise.

In this presentation, firstly we describe the detail of our HFC-23 retrieval strategy. Secondly, we indicate the recent trends of HFC-23 estimated from the ground-based FTIR at Rikubetsu, Syowa Station, and Tsukuba. Finally, we would discuss in regard with the difference between the trends which are derived from FTIR measurements and the AGAGE measurement data.

References

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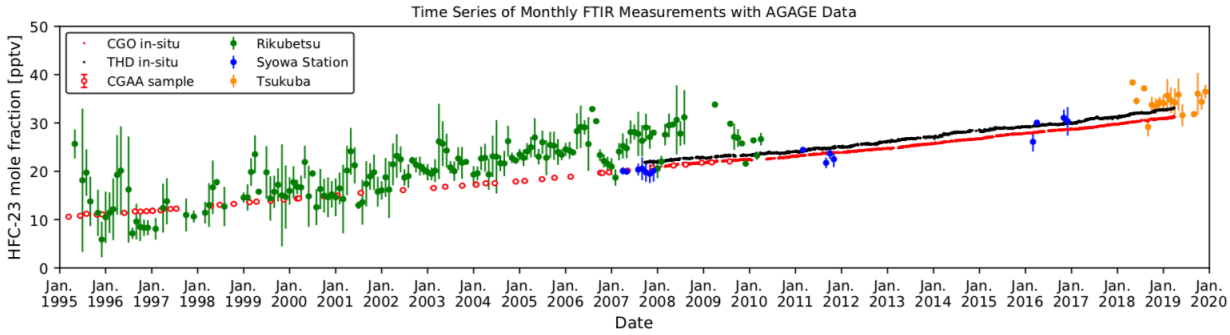

Figure 1. The timeseries of the monthly FTIR-retrieved $X_{HFC\text{-}23}$ at Rikubetsu (green), Syowa Station (blue), and Tsukuba (orange) with the standard deviations, along with the AGAGE in-situ measurements at Trinidad Head (41.05ºN, 124.15ºW; black) and Cape Grim (40.68ºS, 144.69ºE; red). Also, Cape Grim Air Archive data (red circles) is plotted here.

