

Concentration changes of atmospheric F-gases and analysis of their potential sources at Zhongshan Station, Antarctica, 2021

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Supplement material

Table S1. Basic properties of the measured F-gases.

Categories	Species	Total lifetime (year) ^a	ODP ^a	100-year GWP ^a
HFCs	HFC-134a	14	0	1470
	HFC-23	228	0	14700
	HFC-125	31	0	3820
	HFC-143a	52	0	5900
	HFC-32	5.3	0	749
	HFC-152a	1.5	0	153
	HFC-227ea	38.9	0	3580
	HFC-236fa	242	0	9120
Other F-gases	PFC-116	10000	0	9200
	CF ₄	50000	0	6500
	NF ₃	550	0	17000

^a: The total lifetime, ODP, and 100-year GWP are from the Scientific Assessment of Ozone Depletion: 2022

Table S2. Sampling record at Zhongshan Station.

No.	ID	Sampling Date	Local Time (UTC+5)	Temperature (°C)	Humidity (%)	Wind Direction (°)	Wind Speed (m/s)	Meteorological Conditions
01	C-S-00090677	2021/1/15	10:00	0.5	55	100	14.6	cloudy
02	C-S-00091876	2021/1/22	9:50	-2.6	51	74	4.2	sunny
03	C-S-00099991	2021/2/5	10:32	-1.6	50	NE	4.7	less cloudy
04	C-S-00099992	2021/2/19	10:30	-2.9	55	ENE	4.5	cloudy
05	C-S-00091771	2021/3/5	10:30	-1.3	51	E	6.9	cloudy
06	C-S-00090633	2021/3/19	11:30	-10.3	39	ESE	5.0	sunny
07	C-S-00099993	2021/4/2	10:39	-7.5	44	E	9.0	cloudy
08	C-S-00091740	2021/4/17	9:36	-18.1	38	ESE	11.5	sunny
09	C-S-00033333	2021/4/30	10:29	-19.7	57	ESE	6.6	cloudy
10	C-S-00091742	2021/5/15	10:29	-10.6	89	ESE	2.6	light snow
11	C-S-00099994	2021/5/28	10:32	-25.2	72	ESE	7.0	sunny
12	C-S-00001234	2021/6/11	10:40	-15.0	72	E	5.3	light Snow
13	C-S-00091868	2021/6/25	10:32	-15.9	69	ESE	15.0	blowing snow
14	C-S-00099995	2021/7/9	10:34	-7.7	66	ESE	12.3	blowing snow
15	C-S-00099996	2021/7/23	10:28	-20.5	45	E	6.8	cloudy
16	C-S-00099997	2021/8/6	10:36	-27.1	67	123	1.9	cloudy
17	C-S-00091782	2021/8/20	10:40	-8.7	60	106	12.9	cloudy
18	C-S-00090704	2021/9/3	10:37	-12.3	89	79	8.5	light snow
19	C-S-00090650	2021/9/17	10:36	-8.8	54	114	12.2	cloudy
20	C-S-00091833	2021/10/1	9:35	-7.4	90	96	6.7	light snow
21	C-S-00099998	2021/10/15	10:40	-9.3	61	98	2.9	cloudy
22	C-S-00099999	2021/10/29	10:28	-11.5	66	71	10.9	cloudy
23	C-S-00091774	2021/11/12	10:24	-4.0	54	44	3.5	cloudy
24	C-S-00091796	2021/11/26	10:33	-5.9	51	86	2.1	sunny
25	C-S-00090688	2021/12/3	10:20	2.3	46	119	3.2	cloudy
26	C-S-00090001	2021/12/10	10:30	1.9	58	68	2.8	sunny

Table S3 Accuracy, limit of detection and quantitative method for each compound by ODS5-pro system.

Compound	Limit of Detection(ppt)	Accuracy(%)	Precision(%)	Quantify
HFC-134a	0.16	0.48	0.65	A
HFC-23	0.08	0.50	0.63	A
HFC-125	0.21	0.61	0.72	A
HFC-143a	0.18	0.84	1.10	A
HFC-32	0.59	0.55	0.72	A
HFC-152a	0.91	1.07	1.36	H
HFC-236fa	0.08	2.02	2.42	H
HFC-227ea	0.11	4.62	5.85	H

PFC-116	0.08	2.00	2.63	A
CF ₄	0.23	0.70	0.84	A
NF ₃	0.7	1.36	1.86	H

Limit of Detection of 11 F-gases are measured at background mole fraction level by ODS5-pro system, ppt.

The quantitative method of the mole fraction for each compound by mass spectrometry. “A” means using the peak area for calculation, “H” means using the peak height for calculation. Limit of detection from Yi et al., 2023.

Table S4. F-gases concentration(ppt) carried by different trajectory clusters in 2021 at four Antarctic stations.

Site	ZOS			TRL			SPO			PSA		
Cluster	1	2	3	1	2	3	1	2	3	1	2	3
HFC-134a	112.74	112.8	113.69	111.98	111.33	112.11	113.02	112.3	112.69	86.66	86.7	86.8
HFC-23	35.16	35.38	35.27	34.05	33.98	34.2						
HFC-125	34.32	34.39	34.67	34.58	34.21	34.68	32.89	32.6	33.09	32.69	32.48	32.82
HFC-143a	26.45	26.53	26.75	26.73	26.45	26.61	25.65	25.44	25.84	25.34	25.24	25.41
HFC-32	24.37	24.4	24.83	24.16	23.77	24.21	21.02	20.92	21.53	21.02	20.41	20.46
HFC-152a	4.78	4.81	4.85	4.82	4.72	4.8	5.02	4.93	5.04	4.86	4.83	4.87
HFC-227ea	1.87	1.88	1.88	1.87	1.86	1.88	1.78	1.78	1.79	1.75	1.74	1.74
HFC-236fa	0.22	0.23	0.23	0.21	0.21	0.21	0.36	0.34	0.39	0.2	0.2	0.2
PFC-116	5.27	5.32	5.2				5	4.98	4.99	4.96	4.87	4.86
CF ₄	86.66	86.7	86.8	86.34	86.27	86.39	86.42	86.3	86.39	86.3	86.15	86.22
NF ₃	2.56	2.53	2.62				2.25	2.25	2.27	2.32	2.28	2.29

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Figure S1. Pictures of collecting ambient air sample using a sampler and canister at Swan Ridge, Zhongshan Station.

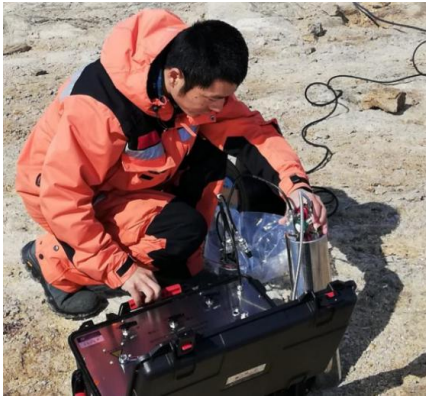
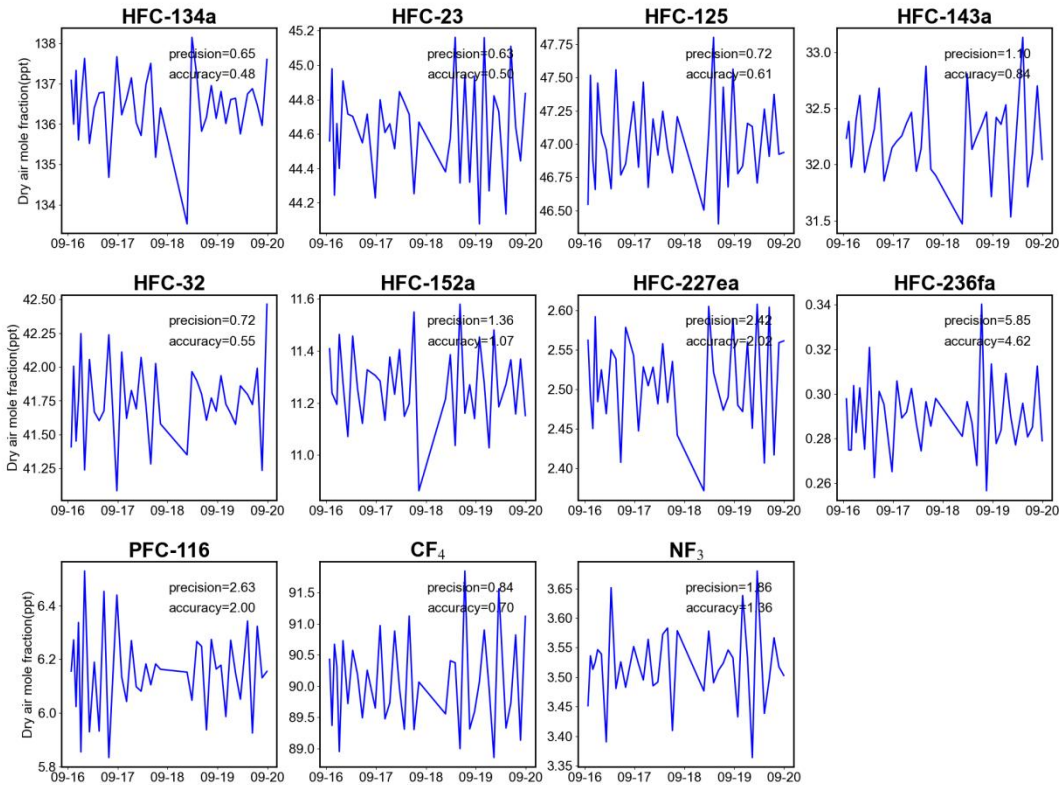


Figure S2. The precision and accuracy when ODS5-pro system measuring standard gas.



Relative standard deviation (%) represent precision and mean relative error(%) represents accuracy.

Figure S3. The scaled residuals from positive matrix factorization (PMF) model.

