China National Report

for the 12th WMO/UNEP Ozone Research Managers Meeting

1. OBSERVATIONAL ACTIVITIES

1.1 Column measurements of ozone and other gases/variables relevant to ozone loss

China Meteorological Administration (CMA) started operation of ozone and UV monitoring since the 1980s. There are four ground-based ozone and UV observing stations running by CMA in China's mainland. Taiwan province and Hong Kong SAR of China also measured the ozone and UV on the ground. Chinese ground-based ozone and UV monitoring stations are listed in Table 1.

Table 1. Ground-based stations for measurements of Ozone and UV

Type of observation	Station	Org.	Instrument	Period
Total ozone	Waliguan	CMA	Brewer	1991-
Total ozone	Longfengshan	CMA	Brewer	1993-
Total ozone	Lin'an	CMA	Brewer	1993-
Total ozone/ UV	Hongkong	HK	Brewer	1993-
Total ozone/ UV	Taipei	Taipei	Dobson Brewer	1965- 1985-
Total ozone/ UV	ChengKung	Taipei	Brewer	1991-
UV	Shangdianzi	CMA	KIPP & ZONE	/

Since 2018, domestic satellites such as Atmospheric Environment Monitoring Satellite (DQ), Gaofen5 Satellite (GF5-02), and Hyperspectral Observation Satellite have further increased the frequency of remote sensing observations of atmospheric environment, improved revisiting and global coverage capabilities, and significantly enhanced China's quantitative remote sensing service capabilities in multiple fields such as ecological environment, meteorology, and agriculture, which are of great significance for promoting ecological and environmental protection.

The EMI payload onboard China's satellite GF5-02 was used to retrieve vertical column density of ozone, formaldehyde, and nitrogen dioxide, with a spatial resolution of 10km×10km. The instruments play an important role in atmospheric environment monitoring in key national regions such as the Beijing-Tianjin-Hebei Region and Fenwei Plain.

1.2 Profile measurements of ozone and other gases/variables relevant to ozone loss

The hyperspectral ultraviolet ozone monitoring suite (OMS) carried on FY-3F satellite observes the total amount of ozone column and ozone profile. In addition, the hyperspectral infrared atmospheric sounder (HIRAS) carried on FY-3D, FY-3E, and FY-3F satellites, as well as the geostationary interferometric infrared sounder (GIIRS) carried on FY-4B satellite, also have the ability to detect ozone profiles.

1.3 Measurements of substances controlled under the Montreal Protocol

1.3.1 Measurements of ODS and HFCs in the atmosphere

The Shangdianzi Station, managed by CMA, has been conducting online monitoring of halogenated GHGs in the atmosphere since 2006. Subsequently, starting in 2010, a network of 7 atmospheric background stations, namely Mount Waliguan in Qinghai Province, Lin'an in Zhejiang Province, Longfengshan in Heilongjiang Province, Shangdianzi in Beijing, Jinsha in Hubei Province, Akdara in Xinjiang Province, and Shangri-La in Yunnan Province, have been gradually carrying out canister sampling-laboratory analysis observations.

Since 2018, China National Environmental Monitoring Centre (CNEMC) has been conducting atmospheric monitoring research on ozone depleting substances (ODS). The first station to carry out high-frequency measurements was Changdao Station in Shandong Province, which began pilot monitoring in January 2022; the second station was the Wuyishan Station in Fujian Province, which began pilot monitoring in October 2023.

Table 2. Locations of monitoring sites for ODS and HFCs

Monitoring site	Latitude (°N)	Longitude (°E)	Altitude (m)	Year	Sampling frequency	Species	Organization
Changdao	38.19	120.74	231.8	Jan 2022 –	In-situ/2h	CFCs/HCFCs/ HFCs/Halons/ Solvents	CNEMC
Wuyishan	27.59	117.72	1164	Oct 2023 –	In-situ/2h	CFCs/HCFCs/ HFCs/Halons/ Solvents	CNEMC
Shangdianzi	40.65	117.11	373	Oct 2006 -	In-situ/2h	CFCs/HCFCs/ HFCs/Halons/ Solvents	CMA

1.3.2 Testing of ODS and HFCs in Industrial products

Since 2019, the Ministry of Ecology and Environment (MEE) has constructed 9 testing laboratories for industrial products, organized testing of ODS and HFCs in industrial products, and issued six testing method standards for ODS and HFCs in

industrial products (Table 3).

Table 3. Six testing method standards for ODS and HFCs

Standard NO.	Tested object	Substances	Testing method
HJ 1057-2019	Pre-blended polyols	HCFC-22, CFC-11 and HCFC-141b	Headspace/gas chromatography-mass spectrometry
HJ 1058-2019	Rigid polyurethane foam and pre-blended polyols	CFC-12, HCFC-22, CFC-11 and HCFC-141b	Portable headspace/gas chromatography-mass spectrometry
HJ 1194-2021	Liquid refrigerants	CFC-11 and HCFC-123	Headspace/gas chromatography-mass spectrometry
HJ 1195-2021	Gaseous refrigerants	HFC-23, HFC-32, HFC-125, HFC-143a, CFC-12, HCFC-22, HFC-134a, HFC-152a, HCFC-124 and HCFC-142b	Gas chromatography-mass spectrometry
HJ 1196-2021	Industrial solvents	HCFC-141b, CFC-113, TCA and CTC	Gas chromatography-mass spectrometry
HJ 1197-2021	Industrial products	substances controlled under the Montreal Protocol	/

1.4 Calibration activities

At present, the monitoring conducted by the stations in Table 2 is calibrated by standards at ambient air levels which could be traced to calibrations scales developed by Advanced Global Atmospheric Gases Experiment (AGAGE).

Air compressor for preparation of working standard gases as well as special treated stainless steel high pressure canister were developed and applied in supporting the high precision ODS and HFCs measurements.

Primary standard gases of 15 ODS and HFCs with concentrations ranging from 10 ppb to 1 ppm were developed by the National Institute of Metrology (NIM) of China.

2. RESULTS FROM OBSERVATIONS AND ANALYSIS

Topdown $CHCl_3$ emissions grew from 78 (72−83) Gg/yr in 2011 to a maximum of 193 (178−204) Gg/yr in 2017, followed by a decrease to 147 (138−154) Gg/yr in 2018, after which emissions remained relatively constant through 2020(An et al., 2023).

Long-term measurements of SO_2F_2 were conducted at 10 stations of CMA. The estimated total SO_2F_2 emissions of China was 0.49 ± 0.49 Gg/yr during 2011 to 2016 and 0.32 ± 0.32 Gg/yr during 2017 to 2019, and China's per capita SO_2F_2 emissions were lower than global averages during 2011-2019 (Yu et al., 2022).

Long-term in-situ measurements of CH_3CCl_3 conducted at the Shangdianzi Station in northern China and the 7 canister sampling stations show both mixing ratios and enhancements of CH_3CCl_3 have decreased by one or two orders of magnitude when comparing the results from previous studies in the early 2000s with the results in 2017. Emissions of CH_3CCl_3 in China, which were estimated by a tracer-ratio method, have decreased from 1.6 kt/yr in 2007 to 0.3 kt/yr in 2013 (Yu et al. 2020).

Magnitudes and changes of four major HCFCs emissions in China during 2011–2017 were studied based on atmospheric observation and inverse modelling. The emissions of all four HCFCs reached peaks before 2015. The results agreed well with the reported bottom-up inventories (Fang et al., 2019).

3. THEORY, MODELLING, AND OTHER OZONE RELATED RESEARCH

The CMA has conducted research on tropospheric ozone, precursors of photochemical pollution, and the relationship between meteorology and pollution.

4. DISSEMINATION OF RESULTS

Since 2002, the CMA has been conducting ultraviolet forecast. The national standard "Forecasting method for ultraviolet index" was released in September 2018. According to the national standard algorithm, an objective forecasting model for ground ultraviolet radiation intensity was constructed, which includes meteorological elements such as solar altitude, altitude, cloud cover, aerosols, precipitation, etc. The ultraviolet radiation intensity has been divided into five levels. The CMA has released ultraviolet intensity forecasts for 34 cities, including 31 provincial capitals, Hong Kong, Macau, and Taipei, through the Weather China website. Since 2022, the development of a UV WeChat mini program has enabled nationwide UV forecast based on users' location. The mini program has landed on the National Government Service Platform and provided services to over 50 million active users.

5. PROJECTS, COLLABORATION, TWINNING, AND CAPACITY BUILDING

Based on the national key R&D program founded by the Ministry of Science and Technology of the People's Republic of China (MST) (2019YFC0214500), a higher precision commercial ODS analyzer "Tianji ODS5-Pro" has been developed, a primary standard gas with a concentration range of 10 ppb-1 ppm has been developed, and research on emission inventory and effectiveness evaluation method

has been carried out.

A new national key R&D project was founded by MST named “high sensitivity continuous analyzer for ozone depleting substances” (2023YFF0714600) in 2023. The project, which runs from December 2023 to November 2026, aims at developing a high precision ODS analyzer with a detection limit at a concentration level of 10 ppq, capable of monitoring 55 substances; as well as a high frequency ODS analyzer with time resolution at 5s using TOF-MS technique for the measurement near sources.

The MEE has carried out capacity building, built continuous automatic monitoring capacity for ODS and HFCs in the atmosphere at two background stations in Changdao and Wuyishan, and built enforcement testing capacity for ODS in products at nine laboratories.

6. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE 11th OZONE RESEARCH MANAGERS MEETING

In response to the key research needs recommendations arising from the 11th ORM, China has carried out the following work in recent years.

a. The MST has founded scientific research programs to carry out a higher precision commercial instrument and monitoring methods for ODS and HFCs in the atmosphere, the development of primary standard substances, top-down inversion model research, and bottom-up inventory research.

b. Build multiple scientific atmospheric background stations, including Changdao station, to monitor ODS and HFCs in the atmosphere and gradually participate in global monitoring and assessment.

c. Carry out enforcement testing of ODS and HFCs in Industrial products and continue to enhance supervision of ODS and HFCs enterprises.

7. FUTURE PLANS

Primary standard gases for more ODS and HFCs will be studied and developed, and comparisons with international standards developed by NOAA and AGAGE are planned.

A study of FLEXPART transport model will be conducted, which will allow better estimation of emissions of ODS and HFCs.

8. NEEDS AND RECOMMENDATIONS

At present, the monitoring of ODS and HFCs is still in the research stage. Monitoring methods, quality control methods, and quantity traceability need to be continuously explored and improved in the future work. Data review work still needs some time to process.

It is recommended that international cooperation in the field of satellite ozone remote sensing be continued and encouraged, including new technique improvement,

retrieval algorithm theories, in-orbit calibration, data validation and evaluation, which will be helpful for establishing long-term, consistent and high quality ozone datasets.

References

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