Report of the Scientific Assessment Panel Response to Decision XXXVI/3: ***Emissions of HFC-23***

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Report is available at: https://ozone.unep.org/meetings/thirty-seventh-meeting-parties/pre-session-documents

Sources of information for the 2025 update

- **Decision XXXVI/3 requests an update to our understanding of the processes influencing the atmospheric abundance of HFC-23. This update was based on information emerging since publication of the SAP 2024 HFC-23 report, which includes:**
  - An extended global atmospheric measurement record by one year (through 2023)
  - New laboratory studies refining magnitudes of atmospheric production of HFC-23
  - The 2025 TEAP report in response to Decision XXXVI/3
  - Updated reporting of production, generation, and emissions of halocarbons including HFC-23

HFC-23 atmospheric abundance in the remote atmosphere

- **The global mean atmospheric abundance of HFC-23 continued to increase during 2023.**
- The measured global mean abundance in 2023 was 36.8 ± 0.9 ppt, which was 0.97 ± 0.04 ppt greater than the value measured in 2022.
- The increase from 2022 to 2023 was slightly less than the mean change observed from 2015 to 2023 of 1.10 ± 0.13 ppt yr^{-1}.
- Recall that HFC-23 has a lifetime of 228 yr and GWP_{100} of 14700.

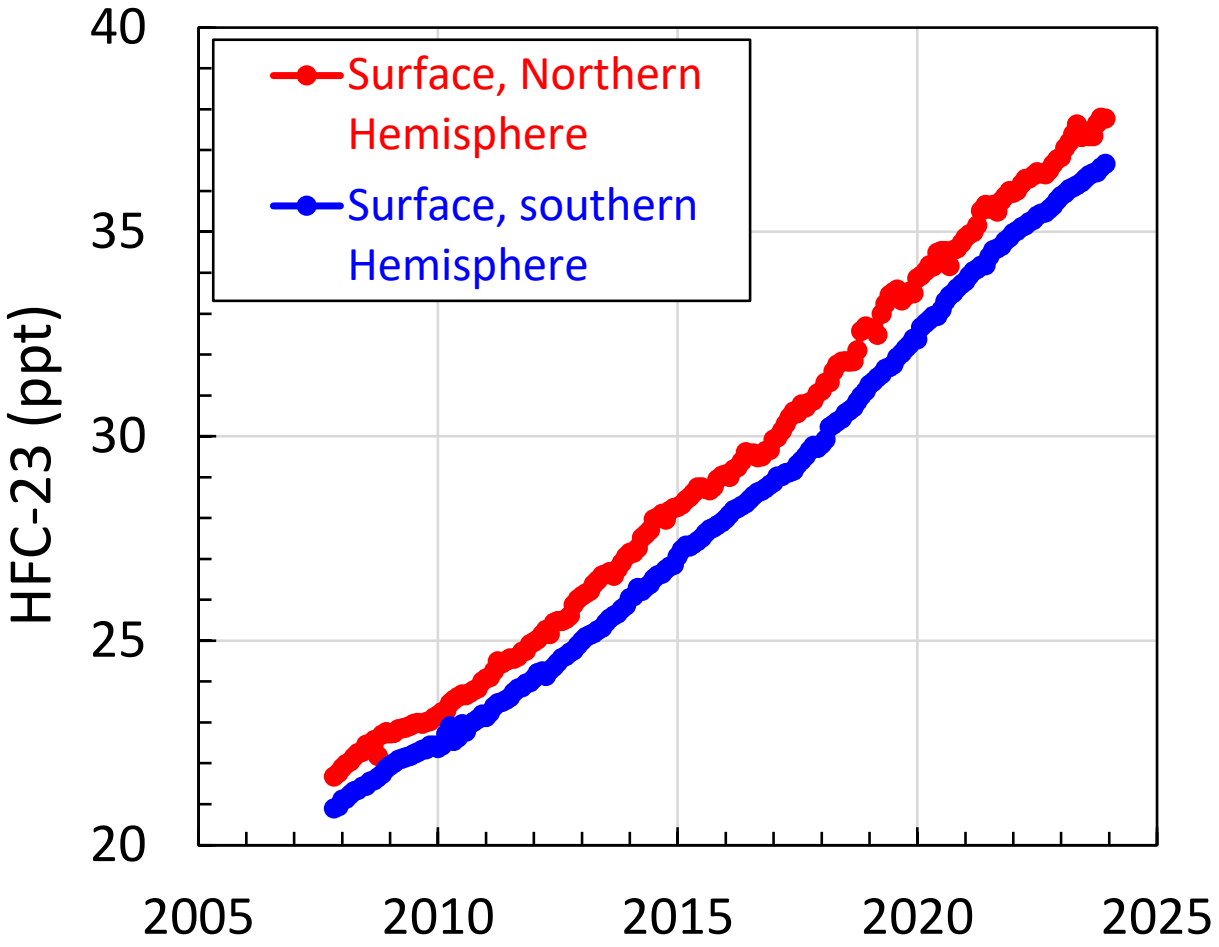

Figure 1

Source: data through 2023 from AGAGE, published in Adam et al., 2024

Global HFC-23 emissions derived from atmospheric measurements

- **Global HFC-23 emissions in 2023 derived from measured atmospheric abundances totaled 14.2 ± 0.7 kt yr^{-1} and were 2.7 ± 0.9 (16 ± 6%) lower than peak emissions derived for 2018-2019 of 16.9 ± 0.7 kt yr^{-1}.**

- **Emissions in 2023 were similar to emissions in 2022 (14.4 ± 0.6 kt yr^{-1}).** The small change in emissions from 2022 to 2023 contrasts with the larger annual decline from 2019 to 2022 that averaged 0.8 kt yr^{-1}.

- *Reported HCFC-22 production for all uses, which remains the largest known source of HFC-23 by-product, was 1.9% smaller in 2023 compared to 2022 (1175 kt in 2023)*

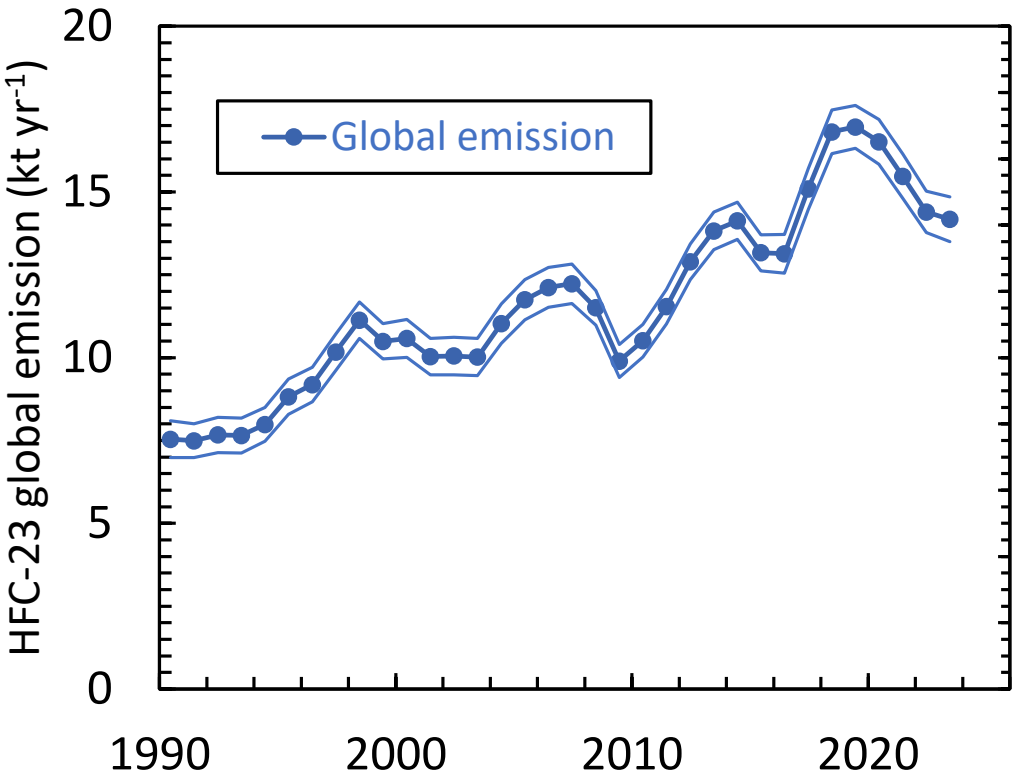

Figure 2

Global emissions: Comparing *atmosphere-derived* to *reporting-based* totals

- **In 2023, the difference (or gap) between atmosphere-derived and reporting-based global total emissions was 11.4 – 12.8 kt yr^{-1}, which was similar to the gap in 2022 (10.5 – 12.5 kt yr^{-1}).**
- The overall time-evolution of the gaps is unchanged from the 2024 report

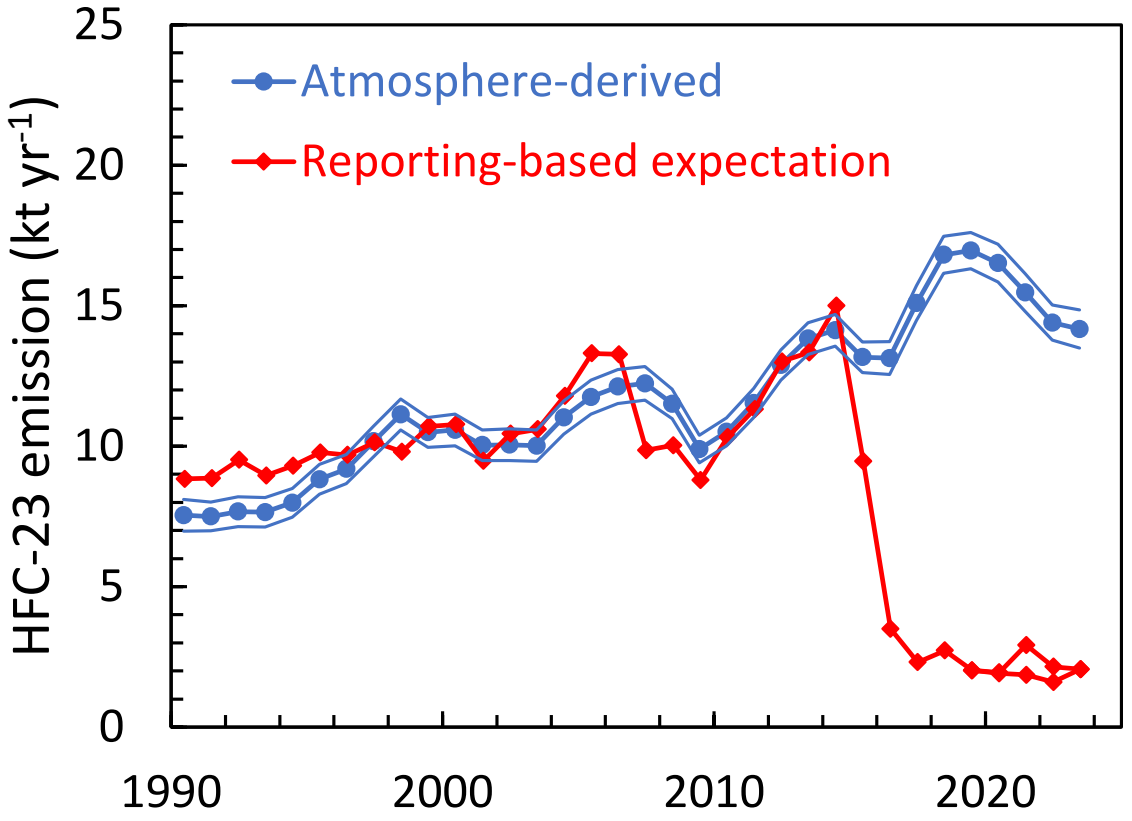

Figure 4

Do other known *industrial* sources explain the gap?

- **The gap is not reconciled by considering all known sources beyond HCFC-22 production.**
- **HFC-23 emissions from all known industrial sources and reported abatements sum to 1.6 – 3.7 kt yr^{-1} in recent years.** (dashed box in Figure; *from TEAP, 2025*)

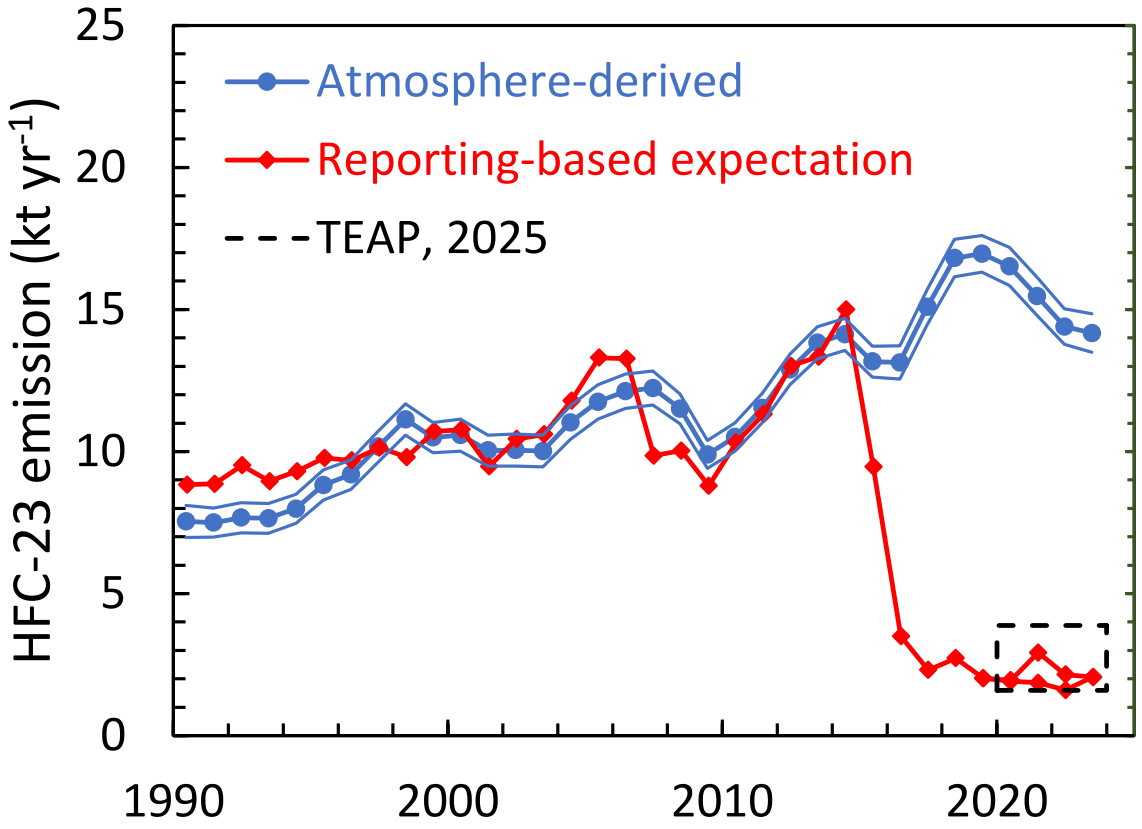

Figure 4

Estimating the HFC-23 source from *atmospheric photochemistry*

- **New scientific results confirm that HFC-23 is produced in oxidations reactions of some fluorinated gases present in the atmosphere.**
- **This HFC-23 source is estimated to be less that 0.22 kt yr^{-1}, in 2023.**
- This value is smaller than estimated in the previous SAP report from 2024 (less than 0.44 kt yr^{-1})
- The actual value could be substantially smaller.

Contributing gases that have been measured in the atmosphere:

HFC-143a	HFO-1234ze(E)
HFC-245fa	HFO-1336mzz(E)
HFC-365mfc	HCFO-1233zd(E)
HFC-236fa	

HCFC-133a

→ *Contributing gases have the chemical structure:*

CF_3CH_2 - R or
CF_3CH = R

The gap in global emissions and its change over time

- **The increasing emission gaps between 2015 and 2018 coincide with increases in reported abatement of HFC-23 from a limited number of A5 countries.**
- **After 2019, the emission gap decreased from a high of 15 kt yr^{-1} to 11 – 12.5 kt yr^{-1} in 2023; reported abatements from A5 and all countries increased after 2020 to a value of 23 kt yr^{-1} in 2023.**

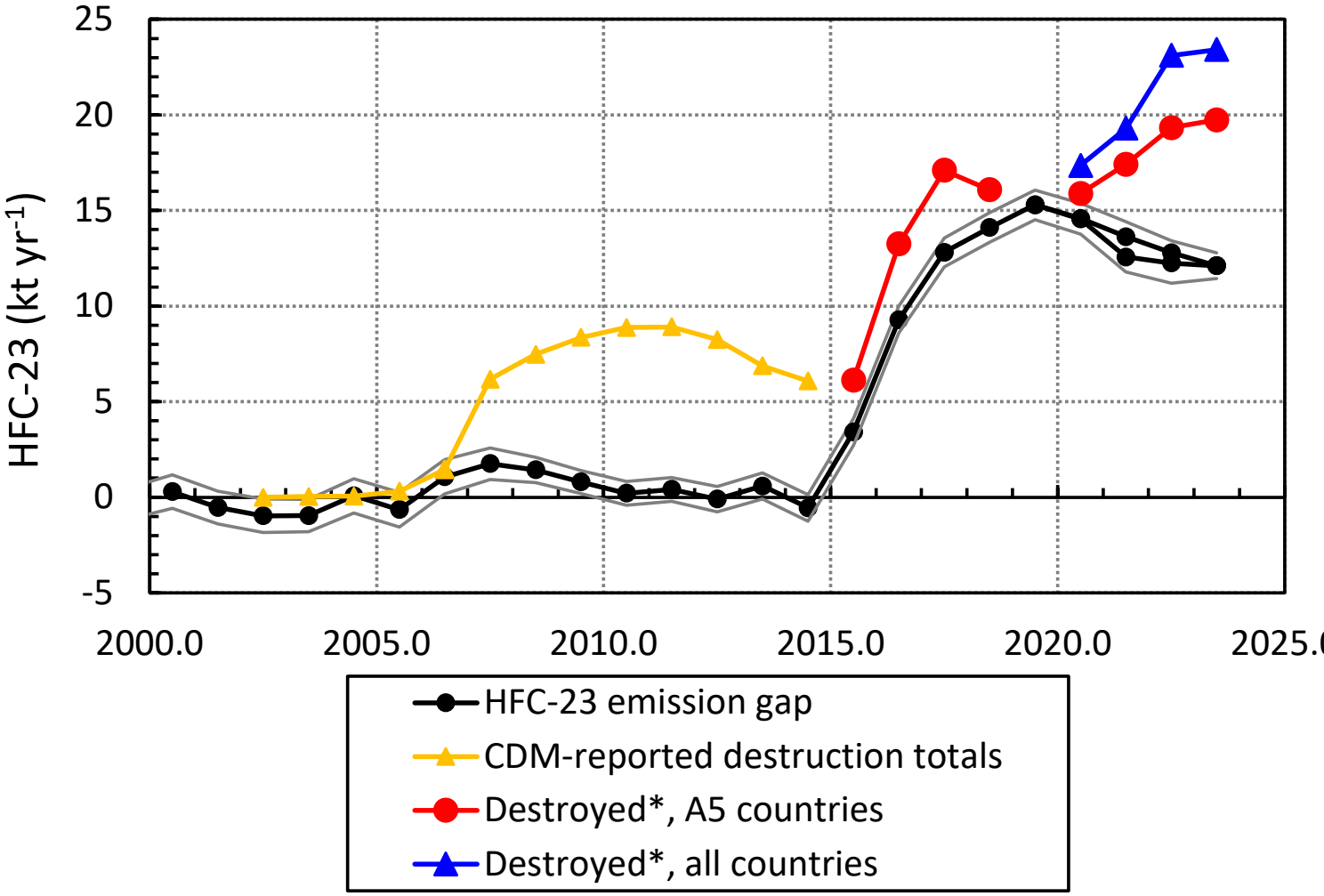

Figure 5

Note: "destroyed" refers to amounts captured, destroyed, used for feedstock*

Considering emissions relative to HCFC-22 production

- **The decrease in the emission gap after 2019 is concurrent with a declining ratio of emissions derived from global observations relative to reported total HCFC-22 production (E_{23}/P_{22}).**
- **The E_{23}/P_{22} ratio in 2023 of 1.1% is unchanged from 2022.**

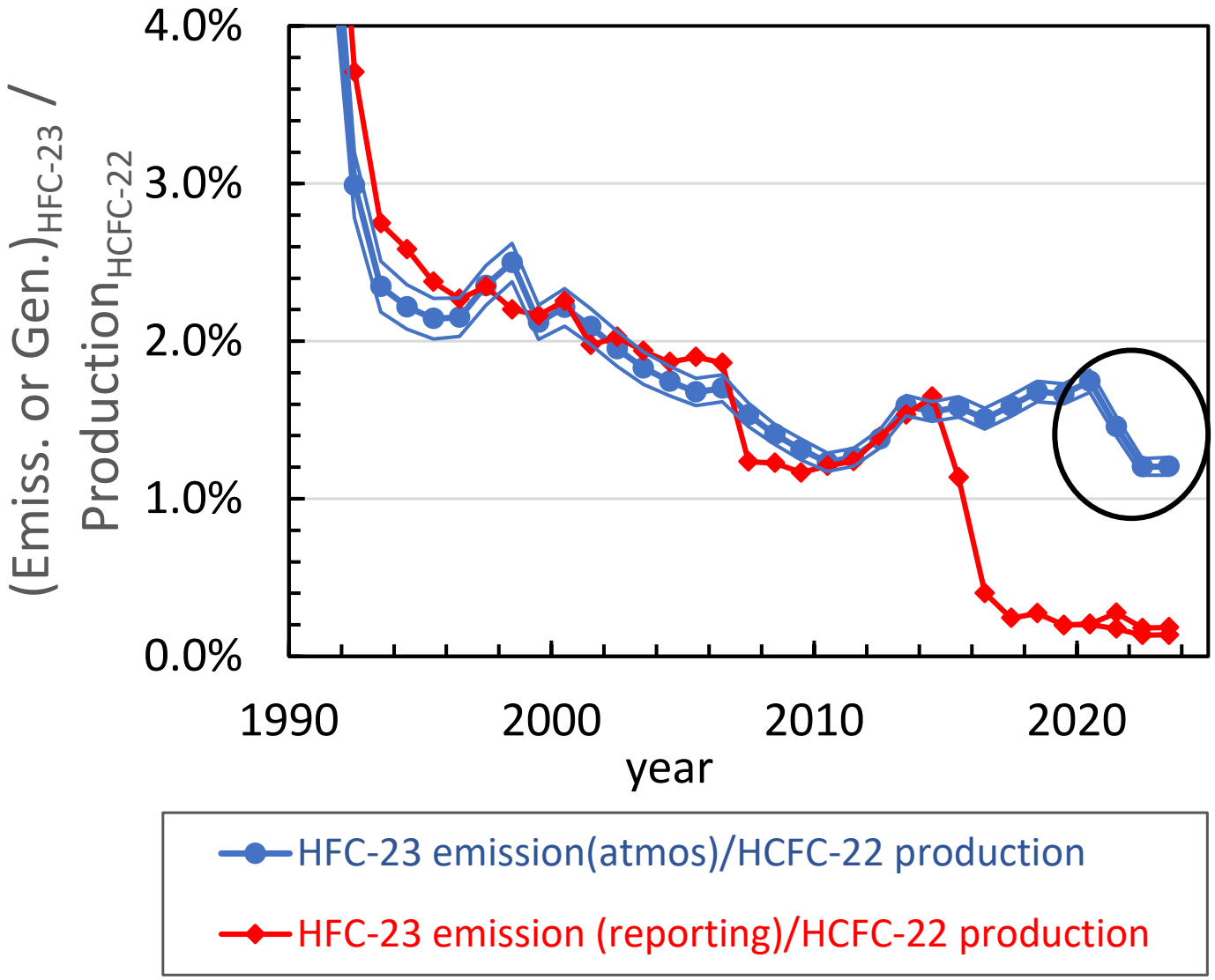

Figure 6

Updated regional emissions of HFC-23

- **Our understanding of regional contributions to global HFC-23 emissions remains incomplete.**
- **The sum of all available observationally-derived regional emission estimates accounted for only 6.1 ± 0.7 kt yr^{-1} of HFC-23 in 2023, or 43 ± 10 % of global emissions in that year.**
- **Regional emission of HFC-23:**

5.6 ± 0.7 kt	eastern China
0.23 ± 0.02 kt	Republic of Korea
0.15 ± 0.04 kt	north-western EU (Belgium, France, Germany, Luxembourg, Netherlands, UK)
0.10 ± 0.07 kt	western Japan
0.025 kt	Australia
0.01 ± 0.01 kt	Democratic People's Republic of Korea

- **These countries accounted for the majority (~93%) of HFC-23 generation in 2023;**
  - China accounted for 79% of total reported HFC-23 generation in 2023

Regional HFC-23 emissions from portions of China

- **Emissions from eastern China have been extended past 2019 based on measurements at the Gosan, Korea station.**
- **Eastern China emissions during 2020 – 2023 were smaller than the peak value derived for 2019 of 8.0 ± 0.4 to 9.5 ± 1 kt yr^{-1}.**
- **Emissions from eastern China in 2023 were 4.7 ± 0.7 kt greater than the 0.9 kt reported to the Ozone Secretariat for all of China in that year.**
- **This emission accounts for 40 ± 10% of the global emission gap in 2023.**

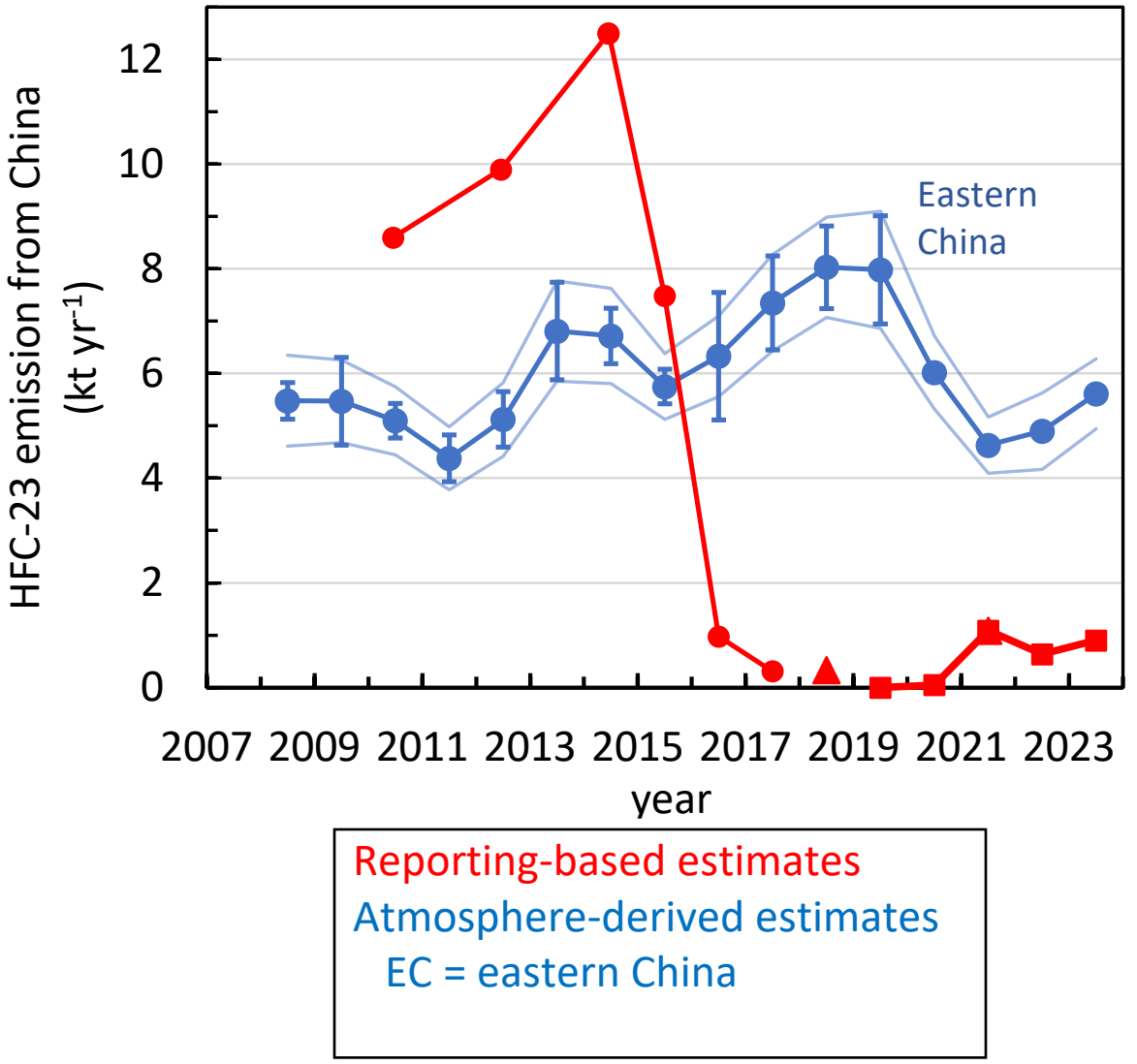

Figure 7

Regional HFC-23 emissions from portions of China (cont'd)

- **Emissions from eastern China have been extended past 2019 based on measurements at the Gosan, Korea station.**
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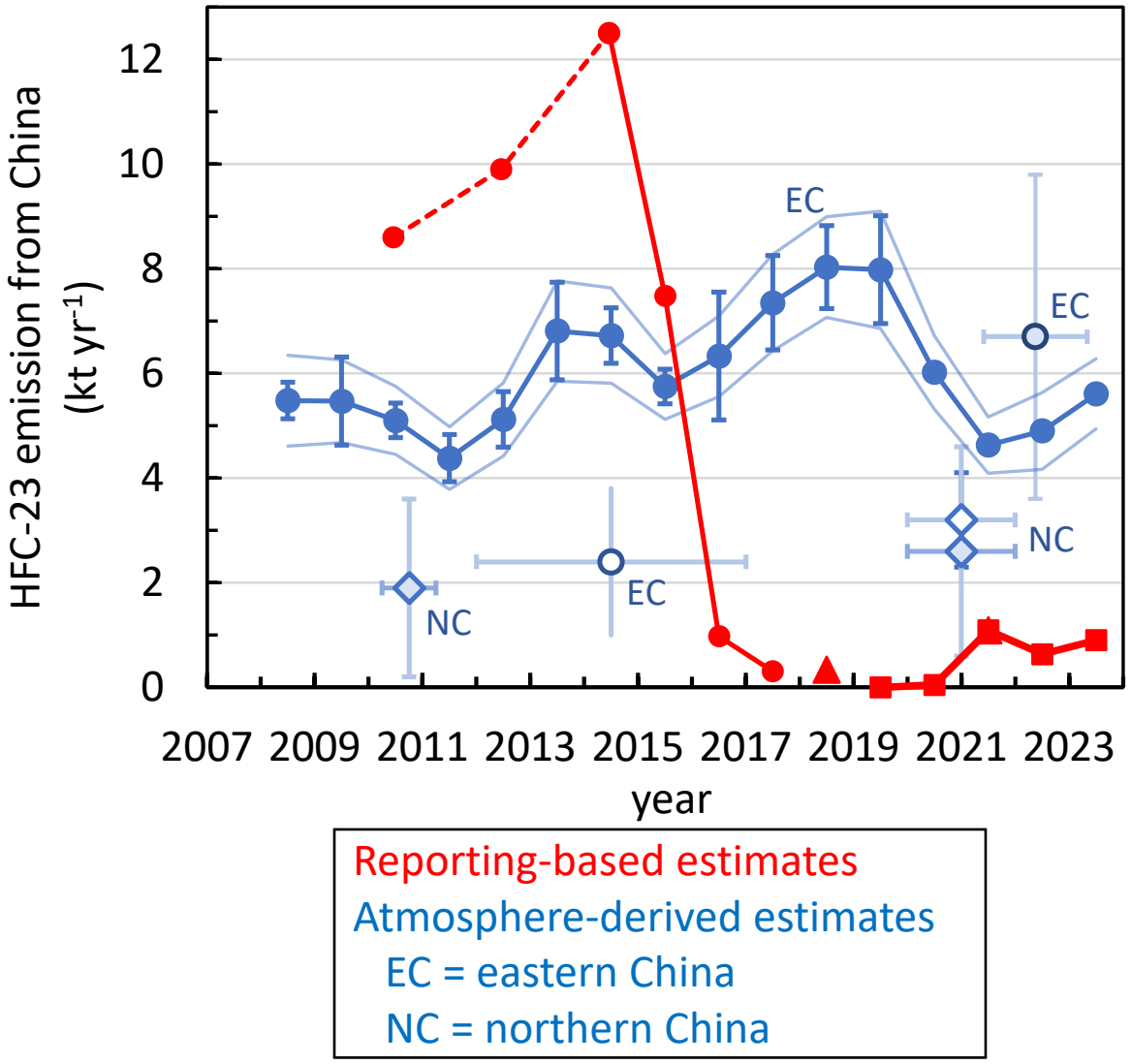

Figure 7

Regional HFC-23 emissions from other locations

- **Summed atmosphere-derived regional emissions from the other regions:**

  → *Australia, Belgium, Democratic People's Republic of Korea, France, Germany, Japan, Luxembourg, Netherlands, Republic of Korea, and the United Kingdom.*

- Summed emissions in recent years from the other countries totals 0.51 kt yr^{-1}, which is 0.4 kt yr^{-1} higher than their reporting.

- This emission accounts for **2.2 to 4.5 % of the recent global emission gap**.

Regional HFC-23 emissions from other locations

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- Summed emissions in recent years from the other countries totals 0.51 kt yr^{-1}, which is 0.4 kt yr^{-1} higher than their reporting.
- This emission accounts for **2.2 to 4.5 % of the recent global emission gap**.

- **Atmospherically derived HFC-23 emission estimates remain unavailable in the Kigali era (i.e., after 2019)** for the countries accounting for the remaining reported HFC-23 generation during 2023: Argentina, India, Mexico, the Russian Federation, and the United States of America (USA).

Summary

- **A substantial shortfall remains in our understanding of global emissions of HFC-23 derived from measurements in the remote atmosphere despite the new information provided in this Supplemental Report.**
- The gap between reported emissions and those inferred from atmospheric abundances is between 11.4 and 12.8 kt yr^{-1}
- The gap between emissions from all known sources estimated by TEAP (2025) and from atmospheric oxidation is between 9.6 and 13.3 kt yr^{-1}.

Summary (cont'd)

- The sum of all available observationally-derived regional emission estimates accounted for only 6.1 ± 0.7 kt yr^{-1} of HFC-23 in 2023, or 43 ± 10 % of global emissions in that year.
- **Eastern China accounted for 5.6 ± 0.7** kt of the available regional emission totals in 2023. These emissions were substantially larger than reported and account for 40 ± 10 % of the global gap.
- **Ten other countries accounted for the remaining 0.51 kt** of the regional emission totals. These emissions are substantially larger than reported and account for 2.2 to 4.5% of the global gap.
- **A regional-scale accounting of global emissions remains incomplete**, as atmospherically derived HFC-23 emission estimates remain unavailable after 2019 for the countries accounting for the remaining reported HFC-23 generation during 2023: Argentina, India, Mexico, the Russian Federation, and the USA.

Thank you for your attention

Global emissions: Comparing *atmosphere-derived* to *reporting-based* totals

- After 2014, a difference (or gap) emerged between estimated and reporting-based global emissions of HFC-23.
- The gap grew to reach a peak of 15 kt in 2019 and have decreased in the three years since 2019 to reach approximately 10.5 - 12.5 kt in 2022.

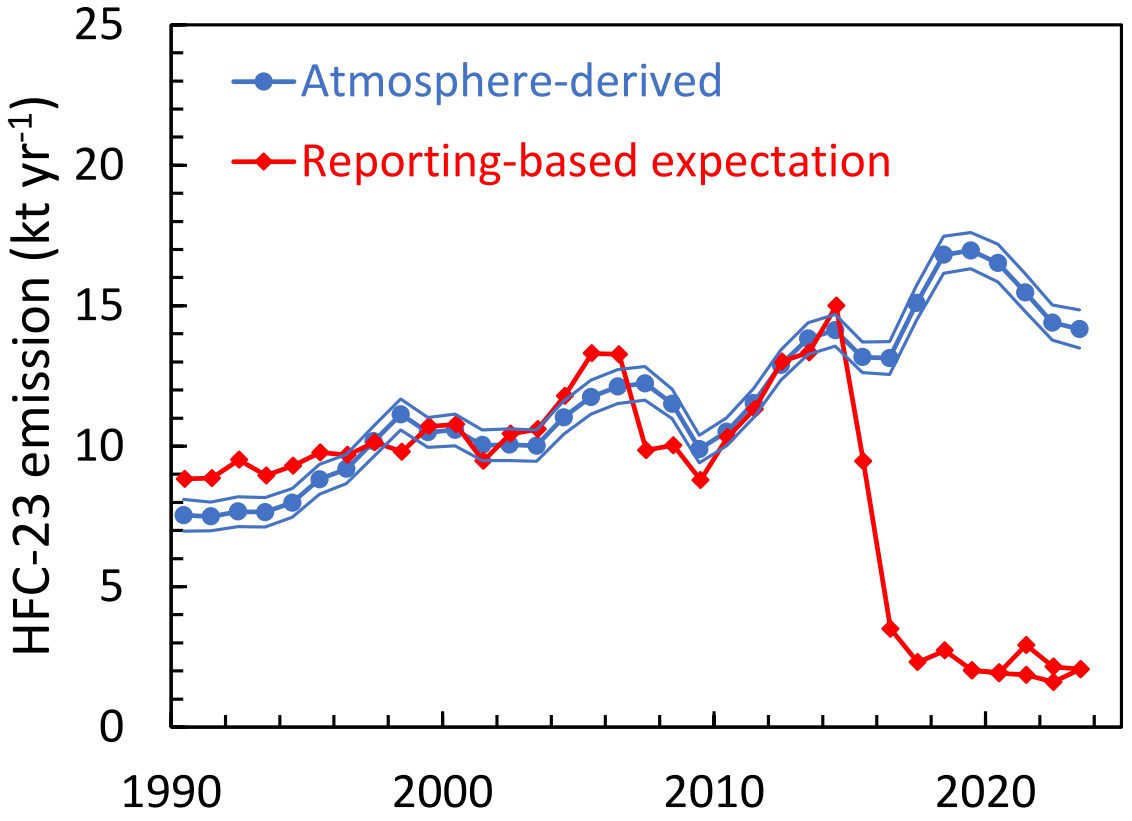

Figure 4