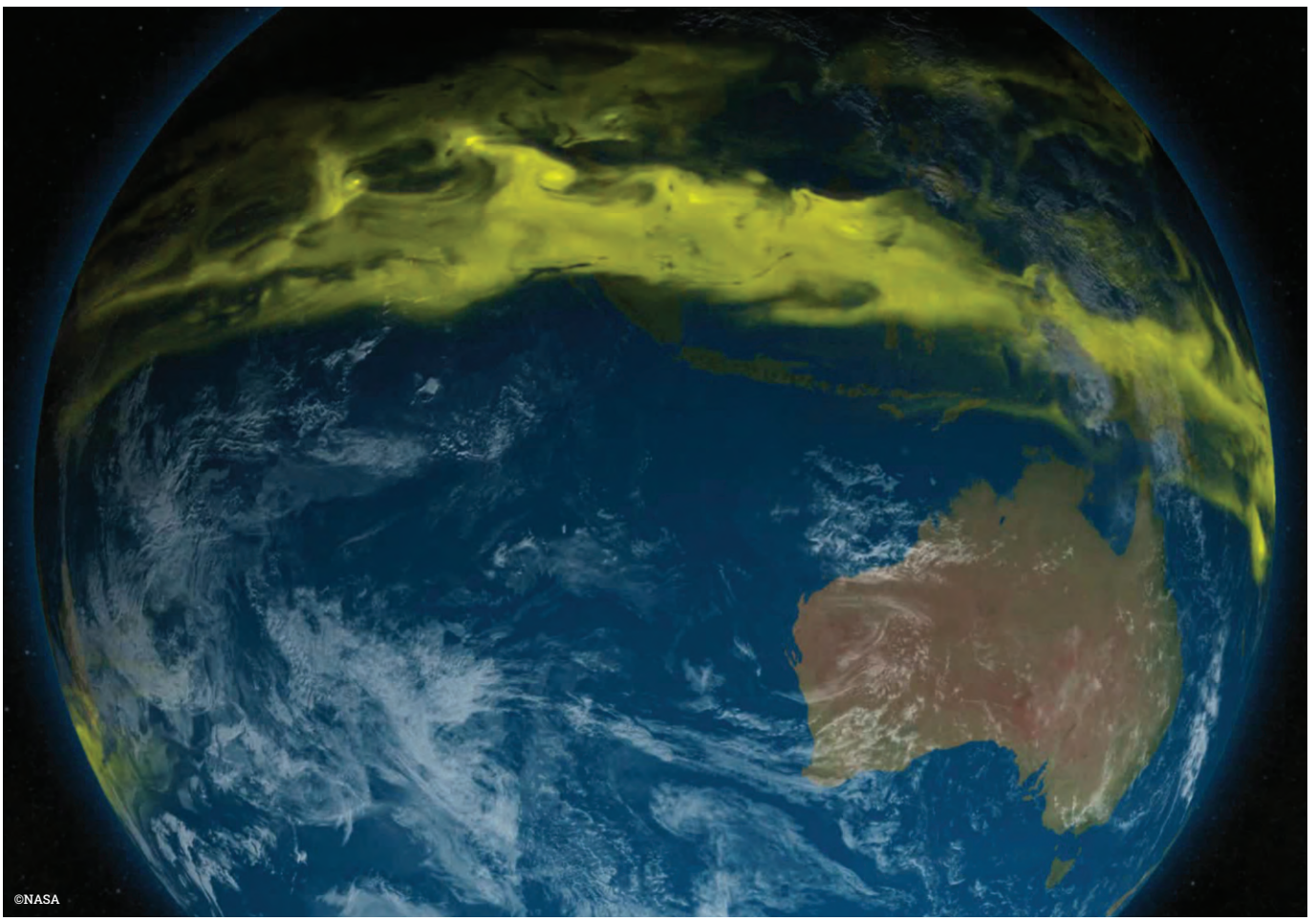
environmental investigation agency

Plugging the Gaps in the Ozone Treaty:

Addressing Fluorochemical Feedstock Emissions

Briefing to the UN Climate Change Conference (CoP28)

December 2023



The Dubai pathway on HFCs, adopted at MOP27 in 2015, mandated the Montreal Protocol Parties to negotiate an amendment on HFCs, which was agreed to at 6:54 am on 15th October 2016.

Background

Widely hailed as the world's most successful international environmental treaty, the Montreal Protocol has played a critical role in mitigating climate change for more than 35 years.

The successive phase-out of more than 99 per cent of the production of controlled Ozone Depleting Substances (ODS), which are also highly potent greenhouse gases (GHGs), has set the ozone layer on the path to recovery, protecting the world's biosphere from harmful ultraviolet (UV) radiation and avoiding significant global warming.[1]

Scientists have estimated that action under the Montreal Protocol will have avoided a total of 2.5°C warming by 2100, taking into account the damaging effect of UV radiation on the terrestrial biosphere's capacity as a carbon sink.[2] An additional almost half a degree of warming will be avoided with full implementation of the hydrofluorocarbon (HFC) phase-down under the Kigali Amendment, agreed in 2016.[3]

Despite this undeniable success, significant and unexpected ongoing emissions of phased-out ODS are being reported with increasing frequency by atmospheric scientists. According to EIA's analysis, recently published papers report almost half a billion tonnes of carbon dioxide equivalent emissions ($GtCO_2e$) per year that are linked to unregulated fluorochemical industrial processes.

The emissions raise serious questions about sustained compliance with the Montreal Protocol's controls and objectives and highlight important gaps and loopholes which need to be addressed in order to secure the recovery of the ozone layer and maximise the contribution of the Protocol to addressing the climate challenge.

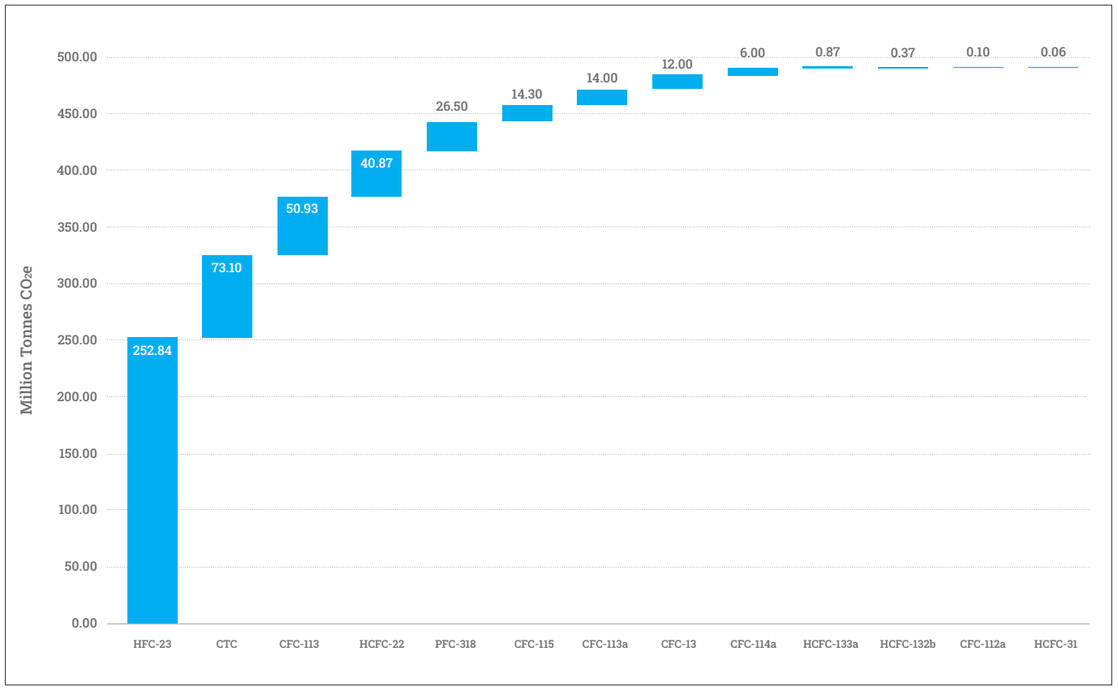
Continued and unexpected ODS emissions

Although the chlorofluorocarbon (CFC) phase-out is complete and the hydrochlorofluorocarbon (HCFC) phase-out well underway, annual emissions of these damaging GHGs are still significant.

According to the Scientific Assessment Panel of the Montreal Protocol, emissions of the major CFCs in 2020 were 0.73 $GtCO_2e$, while HCFC emissions were 0.78 $GtCO_2e$.[4] Some of these emissions result from continued legitimate use of HCFCs in equipment and products in developing countries (A5 Parties) which have until 2030 to phase out their consumption. Other emissions result from the leakage of chemicals in 'banks' of old products and equipment at end of life.

In 2018, scientists reported unexpected CFC-11 emissions of 67 ± 3 Gg/yr between 2014-16, an estimated 25 ± 13 per cent increase since 2012.[5] Atmospheric studies pointed to east Asia as the source and EIA investigations traced to the source to illegal production and use of CFC-11 in the polyurethane foam sector in China.[6] A nationwide enforcement effort in China quickly followed, resulting in a sharp decrease in emissions, but not before an estimated cumulative 120-440 Gg of CFC-11 were emitted (from 2012-19), equivalent to 0.77-2.82 $GtCO_2e$.[7]

Figure 1: *Scientific Findings on Emissions Linked to Fluorochemical Production* [8]



A review of recently published atmospheric observations reveals a much broader suite of ongoing fluorochemical greenhouse gas emissions that are unreported, unexplained and/or unexpected. While some part of these additional observed emissions could be related to illegal production and use of phased-out chemicals, their primary sources appear to be emissions of feedstocks, by-products and intermediates in fluorochemical production processes, which are not controlled by the Montreal Protocol. This includes the production of HFCs, as well as hydrofluoroolefins (HFOs), which are marketed as climate-friendly alternatives to HFCs.

EIA estimates that these avoidable fluorochemical GHG emissions from production processes are as high as 491.94 million tonnes CO_2e emissions per year (See Figure 1 and Table 1).

Table 1: *Scientific Findings on Emissions Linked to Fluorochemical Production*

Chemical	WMO 2022 GWP	Estimated Emissions (Gg/yr)	Estimated Emissions (Million Tonnes CO_2e/yr)	Observation Year(s)	Description of Emission Sources	Reference[8]
HFC-23	14,700	17.20	252.84	2019	Top-down estimate of global emissions. By-product emissions from production of HCFC-22, as well as from pyrolysis of HCFC-22 to produce TFE and HFP. Potential by-product emissions from production of HFC-32, HFC-125 and other controlled substances. Also includes emissions from banks of niche refrigerant and fire suppression uses.	WMO (2022)
CTC	2,150	34.00	73.10	2020	Top-down estimates of global CTC emissions are 44 ± 15 Gg/yr from 2016 and 2020. Once legacy emissions from landfills and contaminated soils (5-10Gg) are subtracted, total emissions from production and unexplained sources are 44 - 10 = 34Gg. Unexplained emissions are assumed to be from feedstock and chloromethane production or other unknown sources. CTC is a feedstock to various CFCs, HFCs, HFOs, & chloroform, which is used to make HCFC-22.	WMO (2022) (Update to Sherry *et al.*, 2018)
CFC-113	6,530	7.8	50.93	2014-2016	Top-down estimate of unexpected emissions excluding emissions from banks. CFC-113 is a common feedstock used to make HFC-134a, TFA, pesticides and chlorotrifluoroethylene (CTFE) which is a precursor used to make fluoropolymers.	Lickley *et al.* (2021)
HCFC-22	1,910	21.40	40.87	2019	Bottom-up estimate of emissions from feedstock production and use. Feedstock to TFE/HFP to produce PTFE and other fluoropolymers.	WMO (2022)
PFC-318	10,600	2.50	26.50	2020	Top-down estimate. By-product of hexafluoropropylene (HFP) production, which is used to make fluoropolymers including PTFE (aka Teflon)	WMO (2022)
CFC-115	9,630	n/a	14.30	2020	Top-down estimate of global emissions. No significant banks from end uses. By-product of HFC-125 production	Western *et al.* (2023)
CFC-113a	3,930	n/a	14.00	2020	Top-down estimate of global emissions. No significant banks from end uses. Feedstock/By-product in HFC-125, HFC-134a, HFO-1334mzz production; feedstock in production of TFA & pesticides	Western *et al.* (2023)
CFC-13	16,300	n/a	12.00	2020	Top-down estimate of global emissions. Unknown sources. Potential use as a feedstock for CFC-11, however emissions have not declined in recent years with CFC-11 emissions.	Western *et al.* (2023)
CFC-114a	7,410	n/a	6.00	2020	Top-down estimate of global emissions. No significant banks from end uses. Feedstock/intermediate in production of HFC-125 and HFC-134a	Western *et al.* (2023)
HCFC-133a	378	2.30	0.87	2016-2019	Top-down estimate of global emissions. No known dispersive end-uses or banks. Feedstock to produce HCFC-123, CFC-113a.	Vollmer *et al.* (2021)
HCFC-132b	332	1.10	0.37	2019	Top-down estimate of global emissions. No known dispersive end-uses or banks. Likely by-product of HFC production.	Vollmer *et al.* (2021)
CFC-112a	3,550	n/a	0.10	2020	Top-down estimate of global emissions. No significant banks from end uses. Unexplained, previous uses as a solvent and feedstock in fluorovinyl ether production	Western *et al.* (2023)
HCFC-31	85	0.71	0.06	2016-2019	Top-down estimate of global emissions. No known dispersive end-uses or banks. By-product of HFC production.	Vollmer *et al.* (2021)
Total			**491.94**			

Emissions from the fluorochemical production sector

When used as feedstocks, the chemical building blocks for manufacturing other chemicals, ODS and HFCs are exempt from Montreal Protocol controls, based on the assumption that emissions are negligible.[9]

As such, the control measures under the Montreal Protocol have phased out the production and consumption of ODS only for emissive end uses, such as refrigerants, aerosols and foams. Meanwhile, feedstock use of ODS has continued to increase, by 75 per cent between 2000-19.[10]

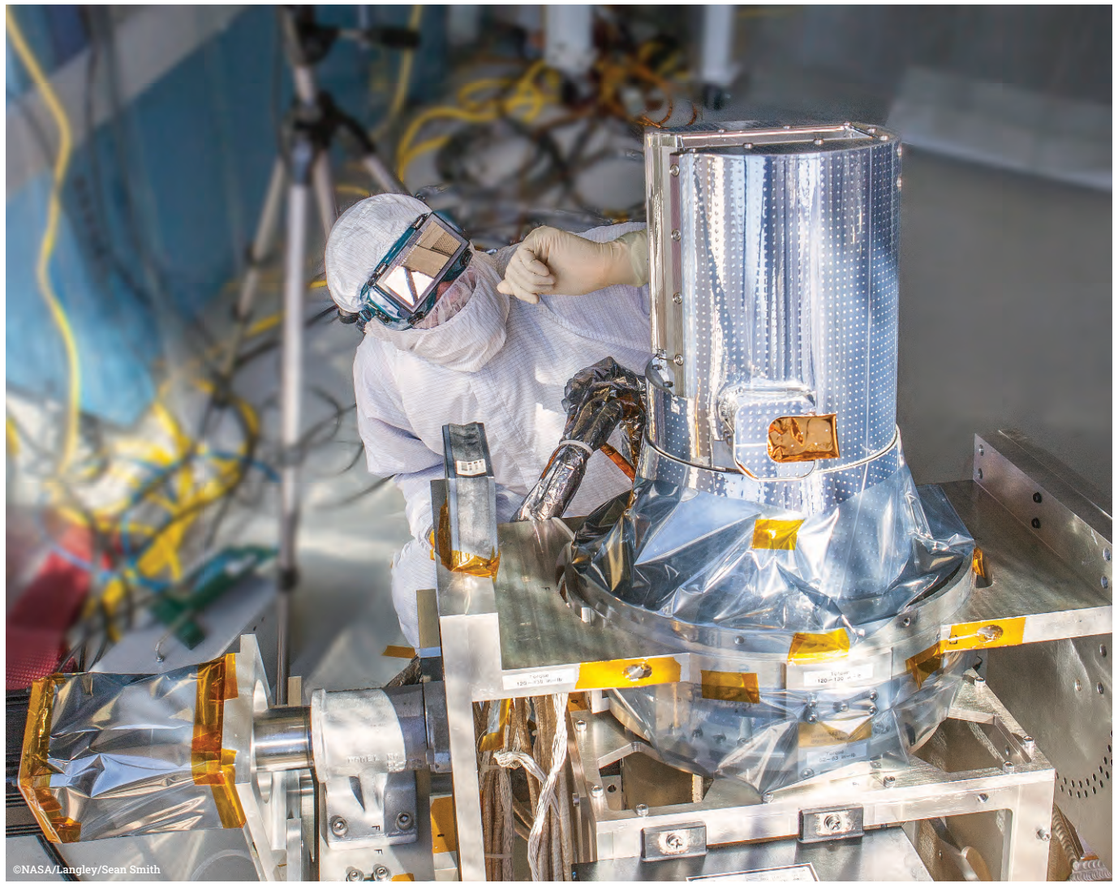
Global feedstock production is dominated by HCFC-22, representing 48 per cent of the total mass quantity of feedstocks produced.[11] In 2020, 97 per cent of the 713,536 tonnes that were produced as feedstock were used to produce tetrafluoroethylene (TFE) and hexafluoropropene (HFP), both of which are used in fluoropolymer production.[12] However, TFE/HFP production generates by-product emissions of perfluorocyclobutane or c-C4F8 (PFC-318), which has a GWP of 10,200. Emissions of PFC-318 are rising sharply, having more than doubled since the early 2000s, reaching 2,300 tonnes in 2020.[13]

HCFC-22 production is also directly associated with unwanted by-product emissions of HFC-23, a highly potent GHG with a GWP of 14,700. Despite numerous pledges from fluorochemical companies and producer countries to ensure the capture and destruction of HFC-23, and a requirement since 2020 to do so under the Kigali Amendment to the Montreal Protocol, emissions are as much as eight times greater than expected and predicted to increase as feedstock production of HCFC-22 continues to grow.[14]

A recent assessment by the Montreal Protocol's Technology and Economic Assessment Panel (TEAP) has identified 24 chemical pathways that are likely to result in "substantial emissions" (greater than 1,000 tonnes per year) of controlled substances, including CFCs, HCFCs and HFCs.[15] EIA investigators have also deployed portable infrared spectroscopic gas detectors to demonstrate emissions of a suite of CFCs, HFCs and HFOs at the fenceline of major fluorochemical production facilities in the US, some of which have not previously been reported by the companies involved.[16]

This, coupled with the scale of ongoing emissions of ODS, clearly warrants a comprehensive re-examination of fluorochemical production processes and tighter controls over emissions of feedstocks, intermediates, by-products and the products themselves.

Fluorochemical manufacturing of HFCs and HFOs is linked to significant feedstock and byproduct emissions



Testing of SAGEIII launched in 2017 to measure the Earth's ozone and other gases. Global atmospheric monitoring is critical to undertanding unexpected emissions of GHGs and ODS from fluorochemical production.

Conclusion

Despite the success of the Montreal Protocol in phasing out the production and consumption of ODS in key sectors, the job is far from done. Emissions from fluorochemical production processes have for too long avoided scrutiny or regulation. These emissions are significant, avoidable and represent an important cost-effective climate mitigation opportunity.

At the 35th Meeting of the Parties to the Montreal Protocol in October 2023, the Parties adopted a decision on feedstock uses which requests the Protocol's TEAP to provide an update on emissions from feedstock production, as by-products, and from feedstock use of controlled substances.[17] Additional decisions on emissions of HFC-23 and carbon tetrachloride were also adopted.[18]

This unprecedented attention to feedstock emissions and fluorochemical production is an important milestone which will generate new data and information to support a re-examination of the exemption for feedstocks uses from production and consumption controls.

It will be incumbent on the Parties to the Montreal Protocol to transform this information into mitigation during this critical decade for climate action.

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