

# Greenhouse gases thought dead

## Searching for traces in the atmosphere

*By Jan Schwenkenbecher*



**In the Taunus Mountains, atmospheric researcher Kieran Stanley is able to study the air of the whole world. His work exposes entire regions when they emit greenhouse gases in fact long outlawed.**

Once a week, Kieran Stanley, 32, gets into his car and winds his way up the snaking Hochtaunus Road, first past beech trees and then past spruce trees, until he finally reaches his destination 825 metres above sea level on Kleiner Feldberg: The Taunus Observatory of Goethe University. He has a good view from here. For one, Stanley can see half the Rhine-Main region at the foot of the Taunus. And for another, he can see how planet Earth is getting along.

For the latter, however, a couple of intermediate steps are necessary. That is why Stanley removes the samples from the instruments, checks the equipment and brings the collected material back to his workplace, the Institute for Atmospheric and Environmental Sciences of Goethe University on Riedberg Campus, 695 metres further down. He has been studying the planet's air here since May 2019, the same work he previously did at the University of Bristol,

where he is today still a visiting fellow. At the beginning of his research career, Stanley, who was born in the United Kingdom, was interested in peatlands, and his doctoral thesis centred on the carbon and nitrate cycle of wetlands. He has always had a very pronounced interest in the environment, he says, and, having completed his doctorate, he knew that he wanted to do something that involved analysing gas samples. That is how he arrived in Bristol, and greenhouse gases became his special field. Luckily for atmospheric research and possibly also for planet Earth, since at the beginning of 2020 he achieved rather a coup in this area: In a study with Stanley as first author and in collaboration with an international research team, he showed that somewhere in the world greater quantities of the greenhouse gas HFC-23, fluoroform, were being emitted than should actually be the case. The scientists' two main suspects: China and India.

### **Greater impact than CO<sub>2</sub>**

HFC-23 is a greenhouse gas and a very potent one at that. »If you look at a time period of 100 years, one ton of HFC-23 emissions corresponds to about 12,000 tons of CO<sub>2</sub>« explains Kieran Stanley. »This is because it's very long-lived. The

Kieran Stanley on the roof of  
Goethe University's Taunus  
Observatory on Kleiner Feldberg.



overall lifetime of this gas in the atmosphere is about 228 years.« What do we humans need it for? In fact, nothing at all. It is used here and there as a refrigerant, says Stanley, but there are in fact more efficient gases. HFC-23 is still found nevertheless. It is usually an unwanted by-product from the manufacture of another gas: HCFC-22, chlorodifluoromethane, also a refrigerant – one of the more efficient ones.

Although HFC-23 is a much more potent greenhouse gas than CO<sub>2</sub>, in absolute terms, its impact is probably less, simply because humans emit so much CO<sub>2</sub>. »These and other halogenated hydrocarbons play an important role nonetheless,« says Stanley. »And if it's the case that we can make a difference by not emitting these gases, then it somehow makes sense to me that we should endeavour to do just that.«

### Big profits with greenhouse gases

That is why Stanley and his former colleagues from Bristol had already been keeping an eye on HFC-23 for some time. »Many environmentalists and climate scientists see it as a kind of easy prey because you can prevent emissions really easily,« says Stanley. »In the production of HCFC-22, you can separate the two gases and remove or capture the HFC-23 through thermal oxidation so that it's no longer released into the atmosphere.« Indeed, global emissions have dropped over the past years and especially after 2005, when manufacturing companies were offered financial incentives for clean HCFC-22 production under the Clean Development Mechanism (CDM) established by the Kyoto Protocol.

As a consequence, the global community was able to significantly reduce HFC-23 emissions in a short space of time. »But then some manufacturing companies realised that money could be made from the mechanism,« says Stanley. In 2010, CDM Watch, a non-governmental organisation,

calculated that beneficiaries of the programme were receiving 65 to 75 times what it in fact cost to eliminate the gas. As a result, companies produced more and more HCFC-22 – more than was actually needed – in order in turn to save HFC-23, which otherwise would never have needed to be saved. »Emissions went up again, and in 2013/2014 the CDM for HFC-23 was stopped.«



### About Kieran Stanley

**Dr. Kieran Stanley**, born in 1987, studied physical geography and French at Keele University, and water science, policy and management at the University of Oxford, both in the United Kingdom. He wrote his doctoral thesis on peatland biogeochemistry at Queen Mary University of London. After some time as a postdoctoral researcher at the University of Bristol in the field of atmospheric chemistry, since 2019 he has been a researcher at the Institute for Atmospheric and Environmental Sciences of Goethe University.

[stanley@iau.uni-frankfurt.de](mailto:stanley@iau.uni-frankfurt.de)

### Apparent stop of HFC-23 production

In 2016, numerous countries agreed in the framework of the »Kigali Amendment« to gradually reduce and finally end the use of all HFC compounds with high greenhouse gas potential over the next few years. However, the two main emitters, China and India, have so far failed to ratify the agreement. Both countries had, however, already announced their own programmes shortly after the end of the CDM, which aimed to stop emissions by their factories within a very short space of time. In 2017, they declared that almost all HFC-23 emissions had ceased – China had reported to the World Bank that it had already correctly disposed of 45 per cent in 2015, then 93 per cent in 2016 and finally 98 per cent in 2017. The world was happy. And researchers anticipated that global emissions should have fallen by about 90 per cent between 2015 and 2017. But then Kieran Stanley double-checked.

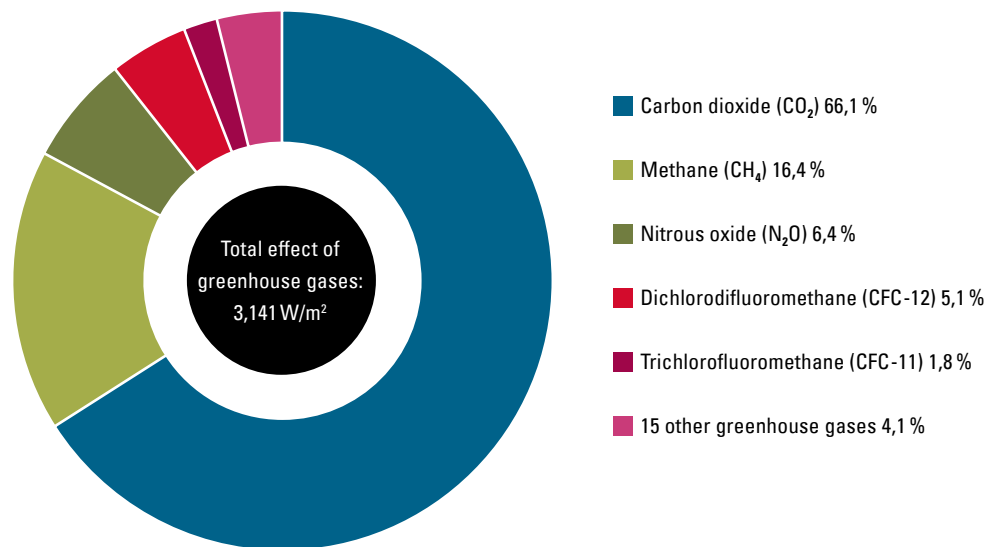
The thing is, how can you actually measure how many grams of a certain gas are floating about in the Earth's atmosphere? To do this, Stanley needed not just one measuring station but a whole network of stations – one like the Advanced Global Atmospheric Gases Experiment (AGAGE). The AGAGE network is an alliance of 15 measuring stations, scattered around the whole world from Ireland to Rwanda and South Korea to American Samoa. There is also a large number of associated centres, which

AGAGE: The Advanced Global Atmospheric Gases Experiment has been measuring the composition of the Earth's atmosphere since 1978. <https://agage.mit.edu>

### IN A NUTSHELL

- Reductions in the potent greenhouse gas HFC-23 have been reported worldwide. Yet it is still being emitted.
- With the help of measurement data from a global network, to which the Taunus Observatory of Goethe University also belongs, scientists were able to prove this.
- Studies that focus on specific regions should in future show where HFC-23 is being produced so that emissions can be stopped.

## Contribution to the greenhouse effect by carbon dioxide and long-lived greenhouse gases 2020



Source: German Environment Agency/NOAA Earth System Research Laboratory, the NOAA Annual Greenhouse Gas Index (AGGI) <https://www.esrl.noaa.gov/gmd/aggi/aggi.html>.

meanwhile also includes the Taunus Observatory of Goethe University. This is how Stanley and his colleagues were able to access the corresponding atmospheric data.

### Suspects: China and India

In order now to calculate differences in the distribution of the gas, they divided the atmosphere into twelve compartments: They partitioned the Earth's surface into four sectors and then distinguished between three levels of altitude. »In this way, we were able to spot any differences and examine, with some climatic, physical and chemical variables, when which emissions must have occurred and from which direction they stem from a global perspective – from the northern hemisphere or the southern hemisphere,« says Stanley. »In fact, there's always a north-south gradient. This is due to how the world's population is distributed, and we can identify global emissions on that basis.«

When Stanley and his colleagues then analysed the data, they saw that global HFC-23 emissions had not – as originally assumed – dropped by up to 90 per cent. They had not even dropped a little bit. Instead, in 2018 concentration had risen to a new all-time high. The researchers suspect that the emissions must be coming from China or India – even though they were unable to prove this directly with their method. »But when you think that in 2017 China and India were together responsible for about three quarters of global HCFC-22 produc-

tion, then they're very probably the source of these emissions,« says Stanley.

At the beginning of 2020, Stanley and his colleagues published the results of their study in the research journal *Nature Communications*. The media reported on it, but politics did not react – at least not publicly. That such research work in the field of climate mitigation and the non-adherence to climate protection measures can nonetheless lead to significant consequences is shown by a very similar case with another halogenated hydrocarbon that happened two years before.

### Search for climate culprits

In May 2018, a research team from the US-American National Oceanic and Atmospheric Administration (NOAA) discovered that emissions of a certain chemical compound were decreasing far more slowly than had actually been expected. The compound was CFC-11, trichlorofluoromethane, a greenhouse gas harmful to the ozone layer that belongs to the group of chlorofluorocarbons, better known by the abbreviation CFCs.

Once celebrated as miracle compounds, CFCs were used for numerous purposes in the 20th century: As coolants, for example in refrigerators, but also as propellants in spray cans, blowing agents in foams, and as detergents, solvents or extinguishing agents. Then, in the 1970s, there were first indications of the environmentally harmful effect of CFC compounds.



### The author

**Jan Schwenkenbecher**, born in 1989, is a science journalist resident in the Rhine-Main area. He studied psychology in Giessen and Mainz before training as a journalist at *Süddeutsche Zeitung*.

[jan.schwenkenbecher@posteo.de](mailto:jan.schwenkenbecher@posteo.de)



In May 1985, British researchers reported in the journal *Nature* that there was a pretty big hole in the ozone layer that surrounds the Earth and protects it from a large part of the UV rays emitted by the Sun. Two years later, in 1987, the world agreed in the framework of the Montreal Protocol first of all to use less CFC compounds and ultimately none. According to the agreement, there were to be no more manmade emissions of CFC-11 at all from 2010 onwards.

#### **Crime scene: Eastern China**

However, as the NOAA scientists revealed, somebody had apparently breached the agreement. The researchers had expected the results of their measurements to show that the CFC-11 content in the atmosphere had decreased continuously since the mid-1990s because emissions were supposed to drop more and more, and the remains of this long-lived gas would then dissipate over a couple of decades. They were indeed able to chart this as a declining line. However, at about the level of 2012, there was a kink in the line. From that point on, degradation of CFC-11 seemed to slow down. Apparently, somewhere in the world, the gas was being emitted again. Indeed, the NOAA researchers assumed that the gas was presumably entering the atmosphere from China. But they were unable to say for sure.

Then, in the summer of 2018, first of all the *New York Times* reported on several smaller

Chinese companies that its journalists had tracked down with independent investigators in the coastal province of Shandong. These companies were emitting CFC-11 because they were using it to foam plastics. The real evidence, however, surfaced in the spring of 2019, and the University of Bristol was involved here too. Led by Kieran Stanley's former research group, a large team of international scientists published an analysis which proved irrefutably that the global increase in CFC-11 emissions was coming from the eastern edge of China. According to reports in Chinese media, in the spring of 2020 the first factory manager was sentenced to ten months in prison.

Is this story currently repeating itself? His study has not led to any consequences so far, says Stanley. But he also says: »There are scientists from the AGAGE network who are working on a study that focuses on specific regions in order to assess whether the emissions really are coming from China and, if so, exactly where in China they are coming from.« ●

**Back in the lab:** Kieran Stanley connects the electropolished stainless steel flasks containing the air samples from the Taunus Observatory to the analysis system, with which he can identify around 50 halogenated hydrocarbons.