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Long-term trends and emissions of seven perfluorocarbon compounds in the Southern and Northern Hemispheres

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Major sources for perfluorocarbons (PFCs) include the electronics industry and aluminium production, and to a lesser extent substitutes for chlorofluorocarbons and hydrochlorofluorocarbons. PFCs do not destroy ozone. However, they are greenhouse gases with Global Warming Potentials that are several thousand times stronger than carbon dioxide on a 100-year time horizon. The lack of any significant sinks for PFCs means that they have long atmospheric lifetimes of several thousands of years.

To date, there have been no reports that indicate detectable atmospheric abundances for the longer-chained PFCs ($>C_4$) before the 1960s. However, their global mixing ratios have been increasing since then, which is highly likely due to industrial activities. Even though the F-Gas Regulation signed by the European Union in the Paris Agreement severely limits their usage in Europe, this is not the case yet in other parts of the world, such as East and South-East Asia. Despite their relatively low abundances, the strong radiative forcing of PFCs and their lack of a significant atmospheric removal mechanism renders the investigation of their continuing emissions highly relevant for predictions regarding climate change.

Here we report an update on the atmospheric abundances of the following PFCs: cyclic-octafluorobutane (c-C_4F_8), n-decafluorobutane (n-C_4F_{10}), n-dodecafluoropentane (n-C_5F_{12}), n-tetradecafluorohexane (n-C_6F_{14}), and n-hexadecafluoroheptane (n-C_7F_{16}). Additionally, we report the first data set on the atmospheric abundances of cyclic-decafluoroheptane (c-C_5F_{10}) and the i-tetradecafluorohexane (i-C_6F_{14}) isomer from 1978 until the present. The existence and significance of PFC isomers has not been much reported before, due to the analytical problems of separating them.

We present PFC measurements from air samples collected at Cape Grim, Australia, representing remote atmospheric abundances in the Southern Hemisphere. While recent increases in the abundances of most of these PFCs are lower than in the 1990s, we continue to see a significant increasing trend in the last seven years, ranging from 5% to 20% compared to respective 2010 abundances. However, the sources remain poorly constrained, as emissions have been largely unaccounted for.

The Cape Grim data will be contrasted to measurements on samples collected between 2013-2017 at distinctively different sites in the Northern Hemisphere: Tacolneston (United Kingdom) and two sites in Taiwan. Observed abundances are much more variable for Taiwan, suggesting that these sites may be in close proximity to significant PFC sources. Additional modelling work will shed light on the recent variability in annual global emissions.