Direct satellite measurements of the radiative forcing of long-lived halogenated gases

S. Whitburn [1,2], L. Clarisse [1], H. De Longueville [3], P.-F. Coheur [1], C. Clerbaux [1,4], A. Delcloo [2].

[1] ***Université libre de Bruxelles (ULB), Spectroscopy, Quantum Chemistry and Atmospheric Remote Sensing (SQUARES)***
Avenue Franklin D. Roosevelt 50, 1050 Bruxelles, Belgique.
EMail: simon.whitburn@ulb.ac.be

[2] ***Royal Meteorological Institute of Belgium (RMIB), Atmospheric Composition, Measurements and Modelling (ACM^2)***
Avenue Circulaire 3, 1180 Bruxelles, Belgique

(3) ***University of Bristol, School of Chemistry***
University of Bristol, Cantock's Close, Bristol (BS8 1TS)

(4) ***LATMOS/IPSL, Sorbonne Université, CNRS***
4 Place Jussieu, 75005 Paris, France

ABSTRACT

Long-lived halogenated compounds are potent greenhouse gases. Following the Montreal Protocol, many of these substances have seen their concentrations evolving rapidly in the atmosphere. Until now, their Instantaneous Radiative Efficiencies (IREs) - a crucial parameter when assessing the impact of a driver on the Earth's climate - were evaluated from radiative transfer model calculations.

Here, we derive the clear-sky IREs at the top-of-the-atmosphere (TOA) of a series of halogenated gases based directly on the long-term changes in the Earth's spectrally resolved Outgoing Longwave Radiation (SR-OLR). The latter is derived from 15 years of measurements of IASI. These changes in the SR-OLR contain the spectral signature of the absorbing species whose concentrations are evolving globally in the atmosphere. To calculate the IREs, a Jacobian is fitted to the trend signature of each of the identified halogenated species and integrated. The result is then divided by the known change in concentration over the considered period (2008-2022). The great advantage of this method is that no computationally expensive radiative transfer model calculations or assumptions on the atmospheric state are required.

In total, we derive clear-sky IRE at TOA for five long-lived halogenated species: CFC-11, CFC-12, SF6, HCFC-22 and HFC-134a. For each of them, a detailed uncertainty budget is also estimated, ranging from about 12% for CFC-11 to 38% for HFC-134a. The comparison with the different IREs values reported in the literature shows a very good agreement for all species, with relative differences below 20%.

With the increasing period covered by IASI and the future launch of IASI-NG, the IASI-derived IREs are expected to become more accurate over time as the spectral signature associated to their change in concentration should become more marked in the spectrum. In addition, new signatures related to other halogenated compounds should appear more clearly (e.g. CF_4, CCl_4) allowing to retrieve their IRE.