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

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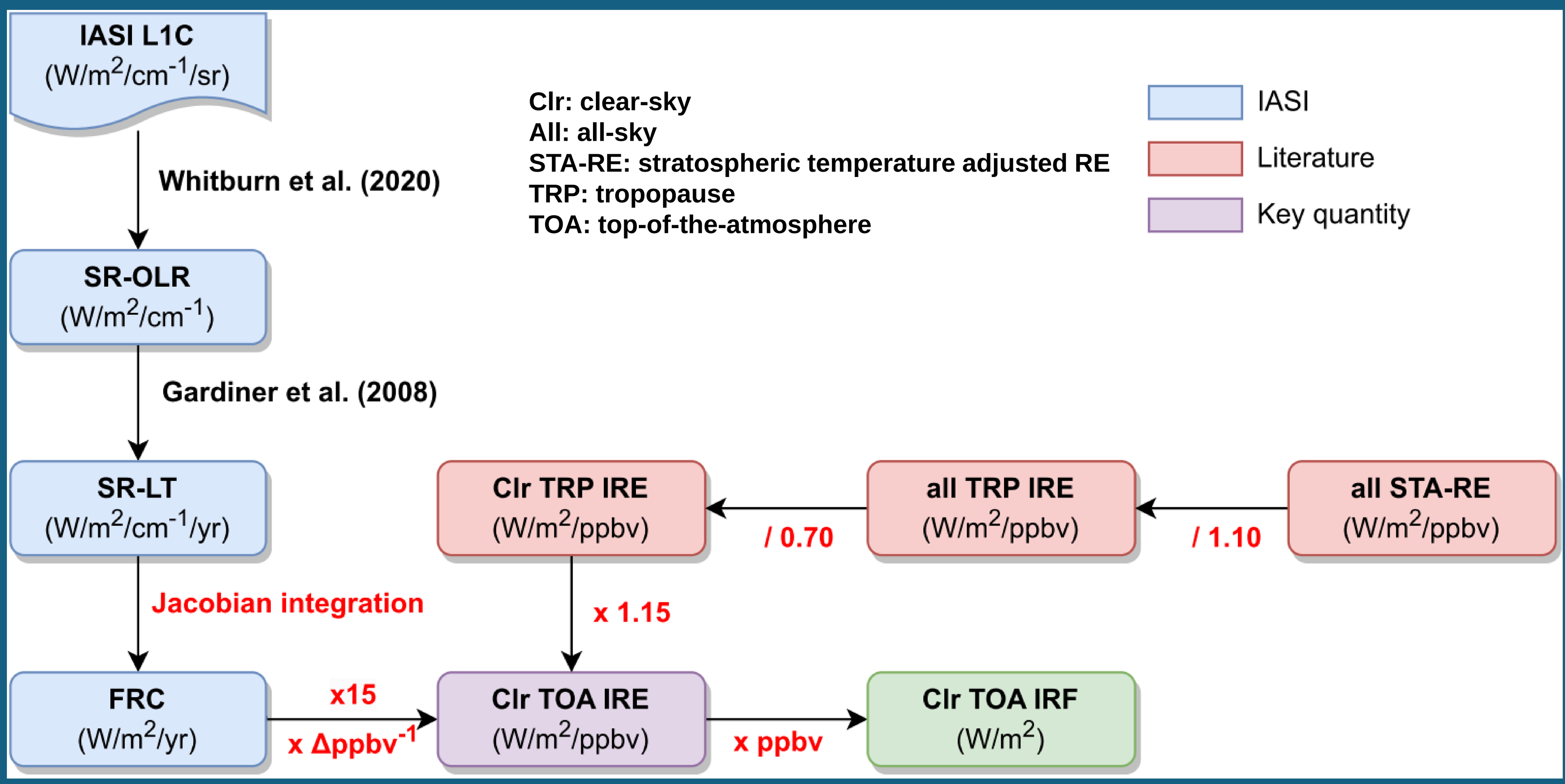
1- Introduction

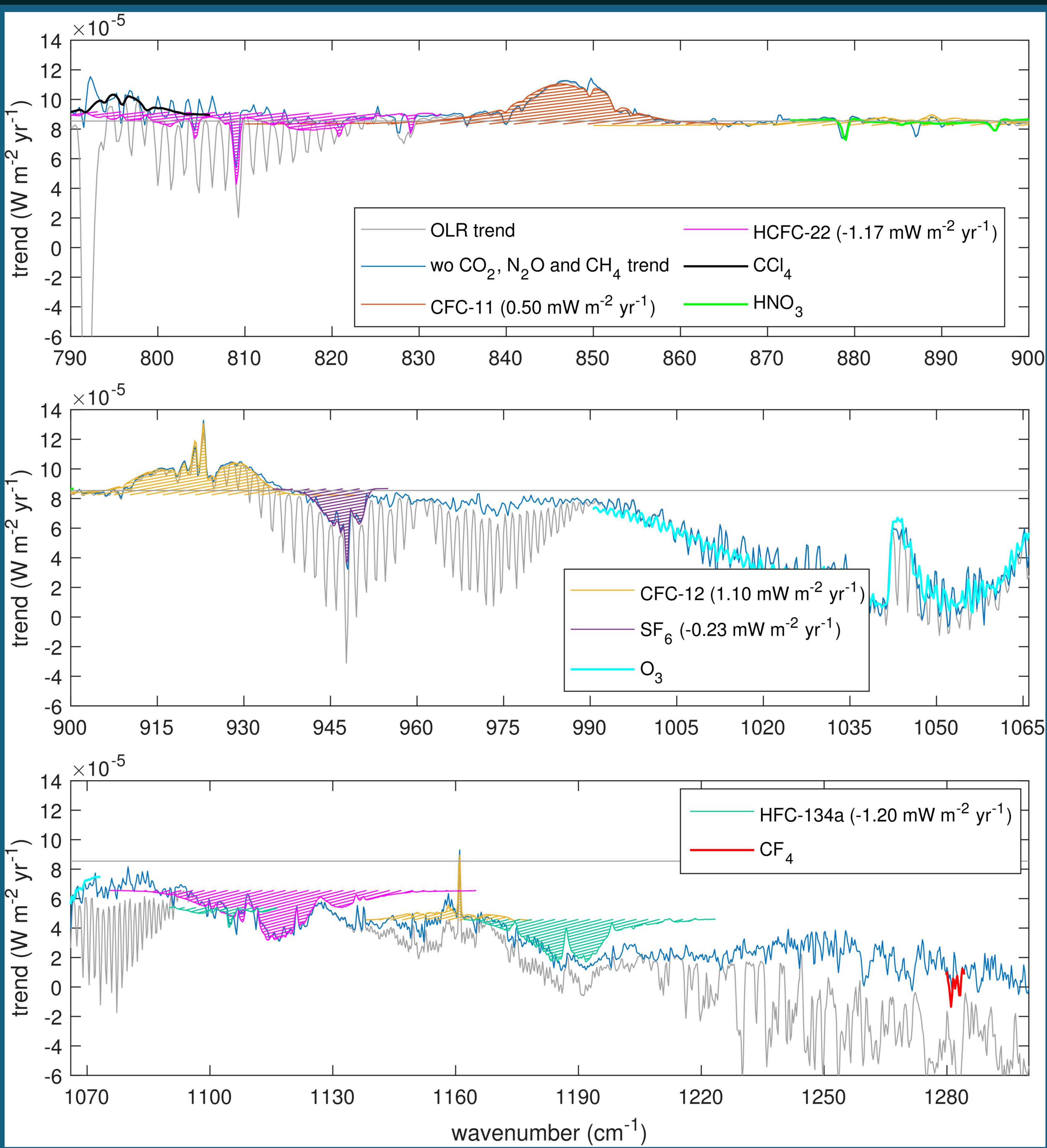
- Long-lived halogenated compounds such as CFC-12, PFC-14, HCFC-22 or SF_6 are potent greenhouse gases.
- Following the Montreal Protocol, many of these substances have seen their concentrations evolving rapidly in the atmosphere.
- Today, their Instantaneous Radiative Efficiency (IREs) are mostly evaluated from radiative transfer model calculations for a few idealized atmospheres.
- **Here, a measurement-based approach is proposed. Clear-sky IREs of a series of halogenated compounds are derived at the top-of-the-atmosphere (TOA) directly from the long-term changes in the Earth's spectrally resolved Outgoing Longwave Radiation (SR-OLR)[1,2].**
- Compared to other methods, **no computationally expensive radiative transfer model calculations or assumptions on the atmospheric state** are required.

2- Method



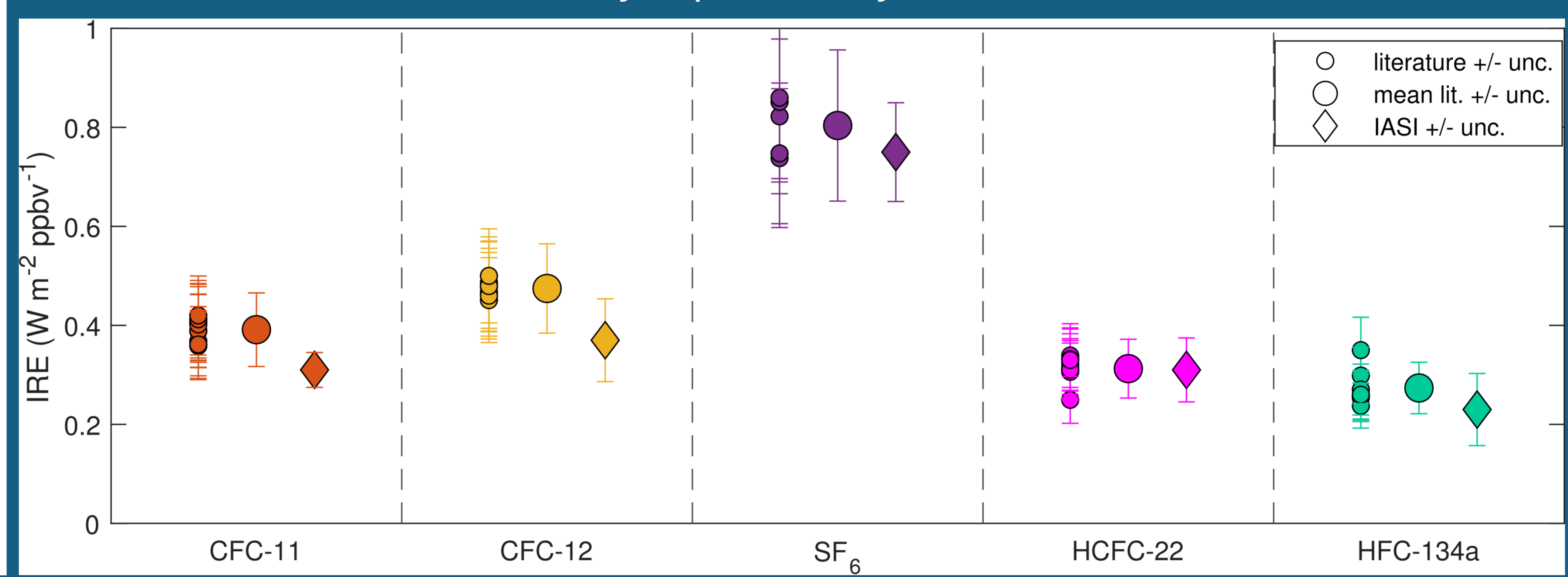
- 15 years (2008-2022) of clear-sky SR-OLR are derived from the IASI radiance measurements[1].
- For each IASI channel between 750 and 1400 cm^{-1}, **the global linear trends (LT) in the SR-OLR (in W m^{-2} yr^{-1})** are calculated[2].
- These LTs contain the spectral signature of the absorbing species whose concentration is evolving globally in the atmosphere.
- For each of the identified halogenated species, **the clear-sky IRE (W m^{-2} $ppbv^{-1}$) at TOA is derived in three steps**:
  1. The contribution of CO_2, N_2O and CH_4 are removed by fitting and subtracting their respective Jacobians to the original LT.
  2. The forcing rate of change (FRC, in W m^{-2} yr^{-1}) is calculated by fitting and integrating the Jacobian of the halogenated compounds to the residual LT.
  3. For the conversion to the IRE (W m^{-2} $ppbv^{-1}$), the FRC is multiplied by the period length (15 years) and divided by the change in concentration between 2008 and 2022.

3- Results



	CFC-11	CFC-12	SF_6	HCFC-22	HFC-134a
IRE (W m^{-2} $ppbv^{-1}$)	0.31 ± 0.03	0.37 ± 0.08	0.75 ± 0.10	0.31 ± 0.06	0.23 ± 0.07
IRF (W m^{-2})	0.067 ± 0.008	0.183 ± 0.041	0.008 ± 0.001	0.077 ± 0.016	0.030 ± 0.009

- **Total uncertainties on the IRE and IRF** derived from a full sensitivity analysis (methodology, construction of the Jacobians, slope of the LT, ...).
- Clear signature of 5 halogenated species: CFC-11, CFC-12, SF_6, HCFC-22 and HFC-134a.
- Total FRC<0 (-0.0150 W m^{-2} $15years^{-1}$) → decrease in CFC-11 and CFC-12 not compensating the increase in SF_6, HCFC-22 and HFC-134a concentrations.
- Over 65% of the present day IRF (W m^{-2}) is due to CFC-11 and CFC-12.
- SF_6: largest IRE (0.75 W m^{-2} $ppbv^{-1}$) but lowest IRF and FRC because of lowest atmospheric concentration.
- **Comparison with literature :**
  - Results from literature (e.g. 3,4,5,6) are converted from stratospheric-adjusted and all-sky RE to clear-sky IRE using average factors.
  - Very good correspondence for HCFC-22, HFC-134a and SF_6.
  - Reasonable correspondence for CFC-11 and CFC-12.
  - Differences can be mostly explained by the uncertainties on the IREs.



4- References and contact

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