MkIV Balloon VMR Trends

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VMR profiles of 40+ gases were retrieved from 25 MkIV flights (31 occultations). This file can be found in

https://mark4sun.jpl.nasa.gov/data/mkiv/m420191007__all_balloon.ames

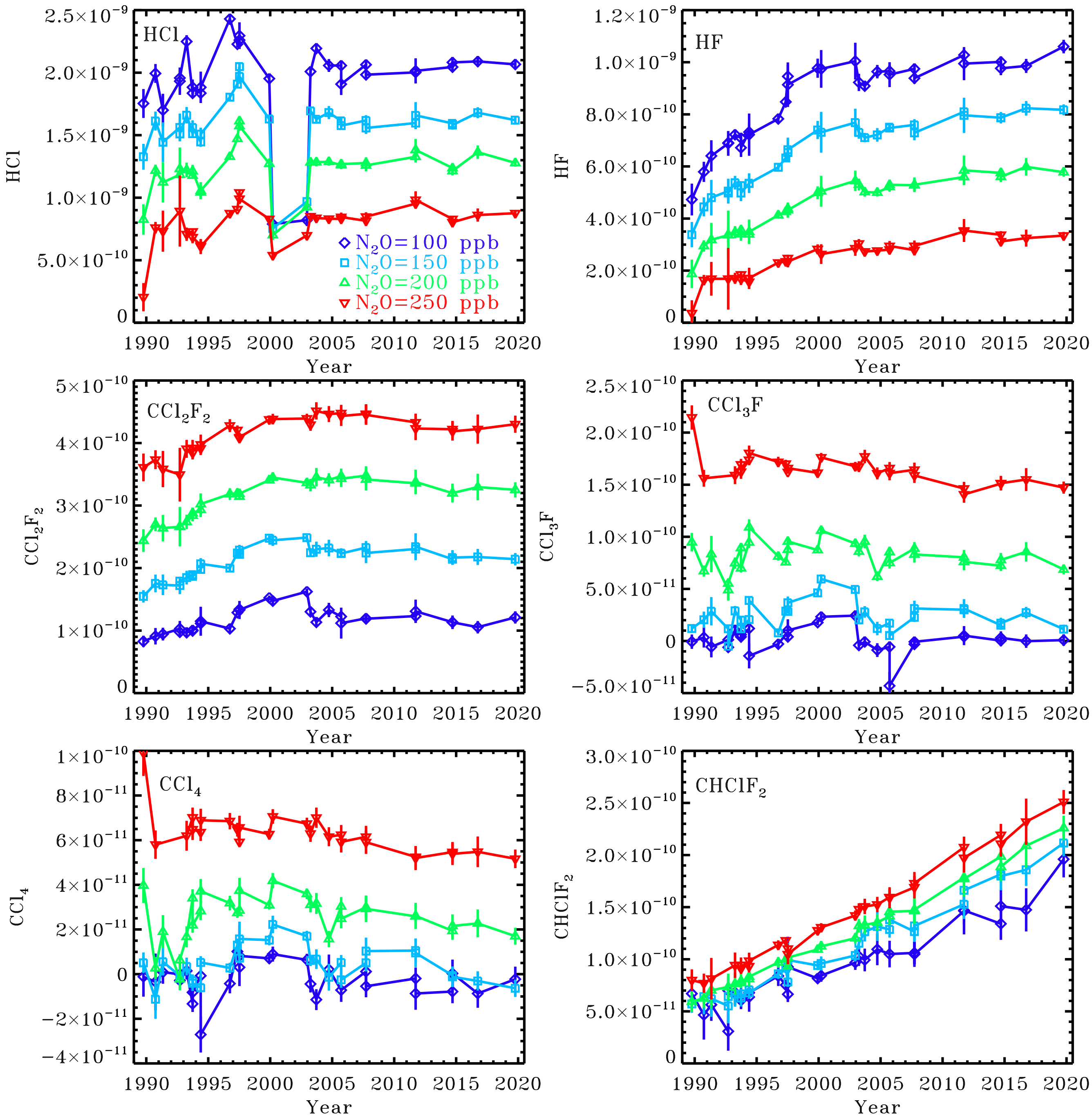
These profiles were analyzed by the program: vmr_n2o_trend.f which fits a straight line to the Gas-N_2O relationship for each retrieved profile. This straight line was then interpolated to the desired N_2O value to yield a gas vmr value.

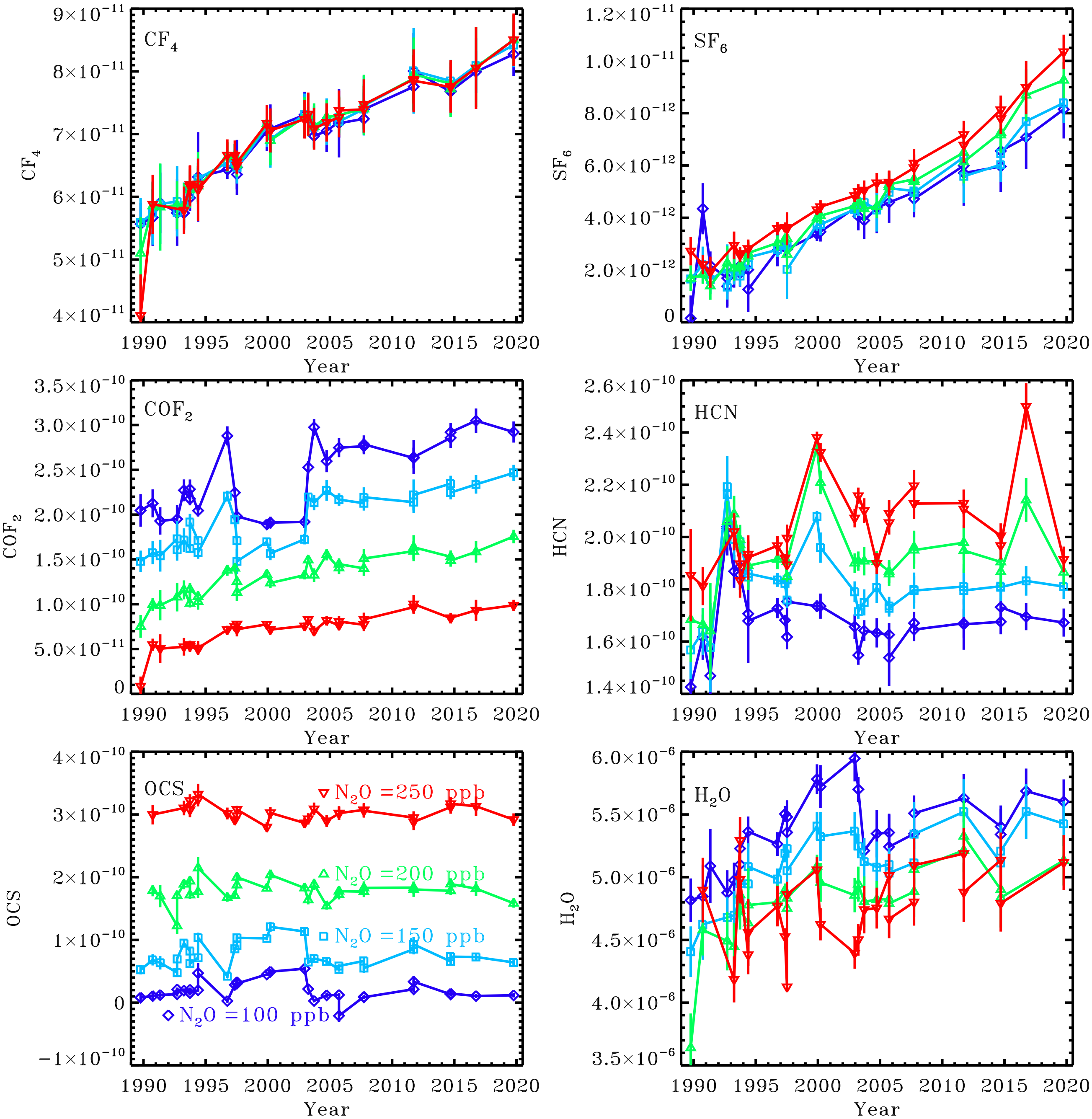
It did this four times, with a weighting function that peaks at four different N_2O levels: 100, 150, 200, and 250 ppb. In this way, if there is any curvature in the Gas-N_2O relationship, then the local gradient will be used to compute the intercept since the distant points will be strongly de-weighted. The weighting function is a Lorentzian of 50 ppb N_2O half-width, in conjunction with the usual 1/Gas_error^2 least-squares weighting.

Of course, N_2O has been increasing steadily from 308 ppb in 1989, to 328 ppb in 2014, and to 334 ppb in 2020. This 0.26%/year trend was removed from the MkIV N_2O, so that the trends in the other gases are true.

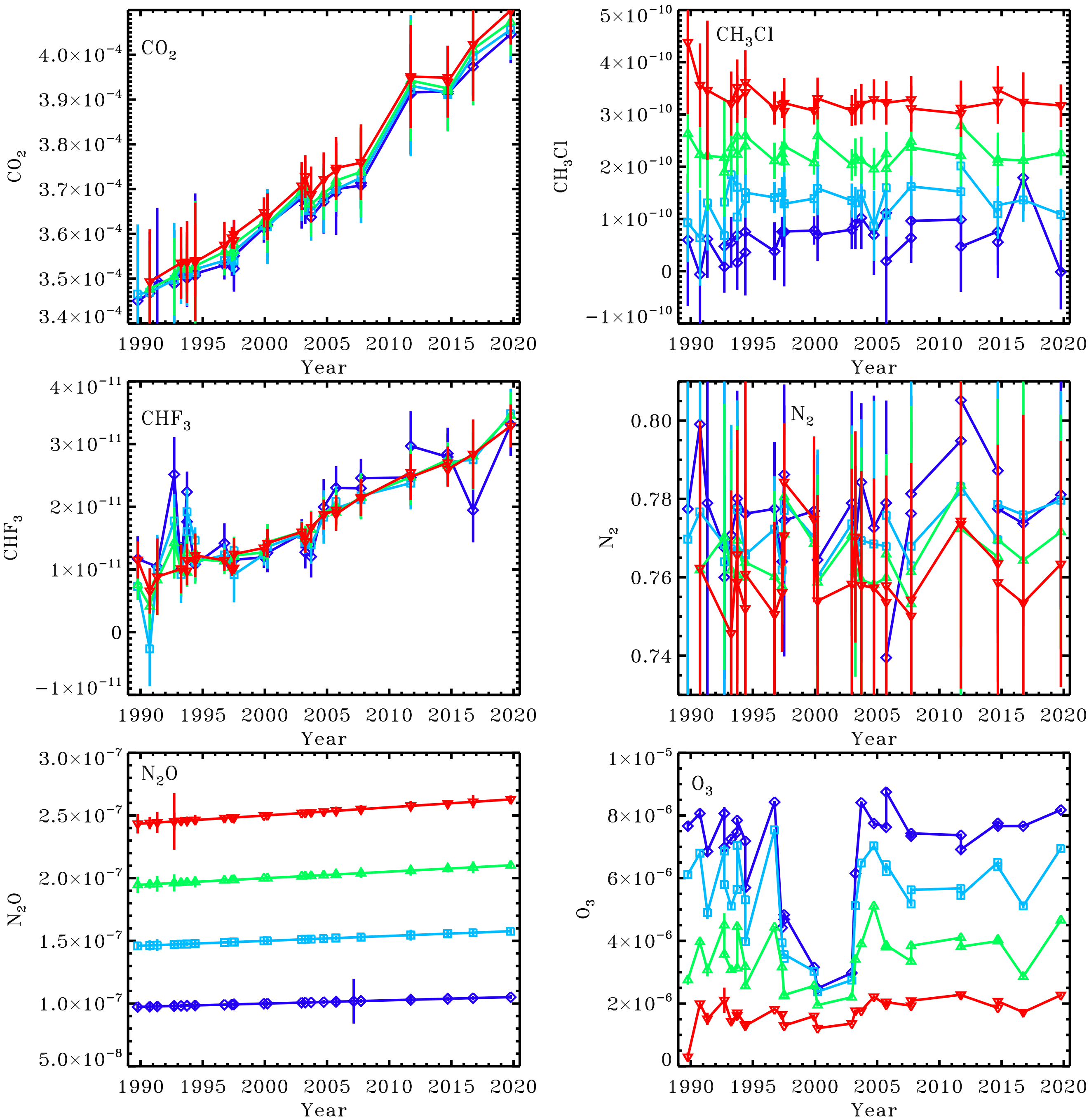
Balloon flights between 1997 and early 2003 were all from high latitude, following two launches from Fairbanks Alaska in May 1997 and 4 launches from Esrange, Sweden. The 1997 flights were out of the vortex. The Esrange flights (1999, 2000, 2002, 2003) were all inside the winter polar vortex, but the Dec 1999 flight occurred before any heterogenous chemistry.

The Sep 1992 flight had so much aerosol remaining from the Jne 1991 Pinatubo eruption that the limb path became opaque below 22 km, which meant that the 250 ppm N_2O isopleth was never encountered on this flight. So no red point.





CF4
SF6
COF2
HCN
OCS
H2O
Year
N2O =250 ppb
N2O =200 ppb
N2O =150 ppb
N2O =100 ppb


CO2
CH3Cl
CHF3
N2
N2O
O3
Year

Summary

Trend data have been extracted from MkIV balloon vmr profiles. The effects of dynamical variability have been largely removed by interpolating the retrieved gas vmrs to reference N_2O isopleths, allowing the underlying trend to be more clearly seen. This is especially important because of the large range of latitudes covered by the MkIV balloon flights from 33N to 69N. To account for the increasing amounts of atmospheric N_2O, the MkIV N_2O values were detrended by the equation

$$N2O^{\#} = N2O / (1 + 0.0026*(\text{Year}-2000))$$

The disadvantage of this approach is that it cannot be used to obtain the N_2O trend. The trend seen in the N_2O figure panel is that prescribed from the equation above. This panel is therefore simply a self-consistency check. Note that each N_2O vmr value crosses its labelled value in the year 2000.

The N_2 trend is essentially zero with values in the rang 0.75 to 0.80. The N_2 data are noisy because there are only half a dozen usable N_2 lines and these, being quadrupole transitions, are weak in the stratosphere.

This large reduction in O_3 seen in the flights from 1997 to 2003 is simply due to the higher latitude of these flights. Ozone is created in the tropics and its vmr decreases as it is carried poleward.