MkIV Balloon VMR Trends

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Retrieved MkIV profiles from 23 flights 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 is then interpolated to the desired N_2O value to yield a Gas vmr value.

It does this four times, with a weighting function that peaks at four different N_2O levels: 100, 150, 200, and 250 ppb of N2O. 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 $1/\text{Gas\_eror}^2$ least-squares weighting.

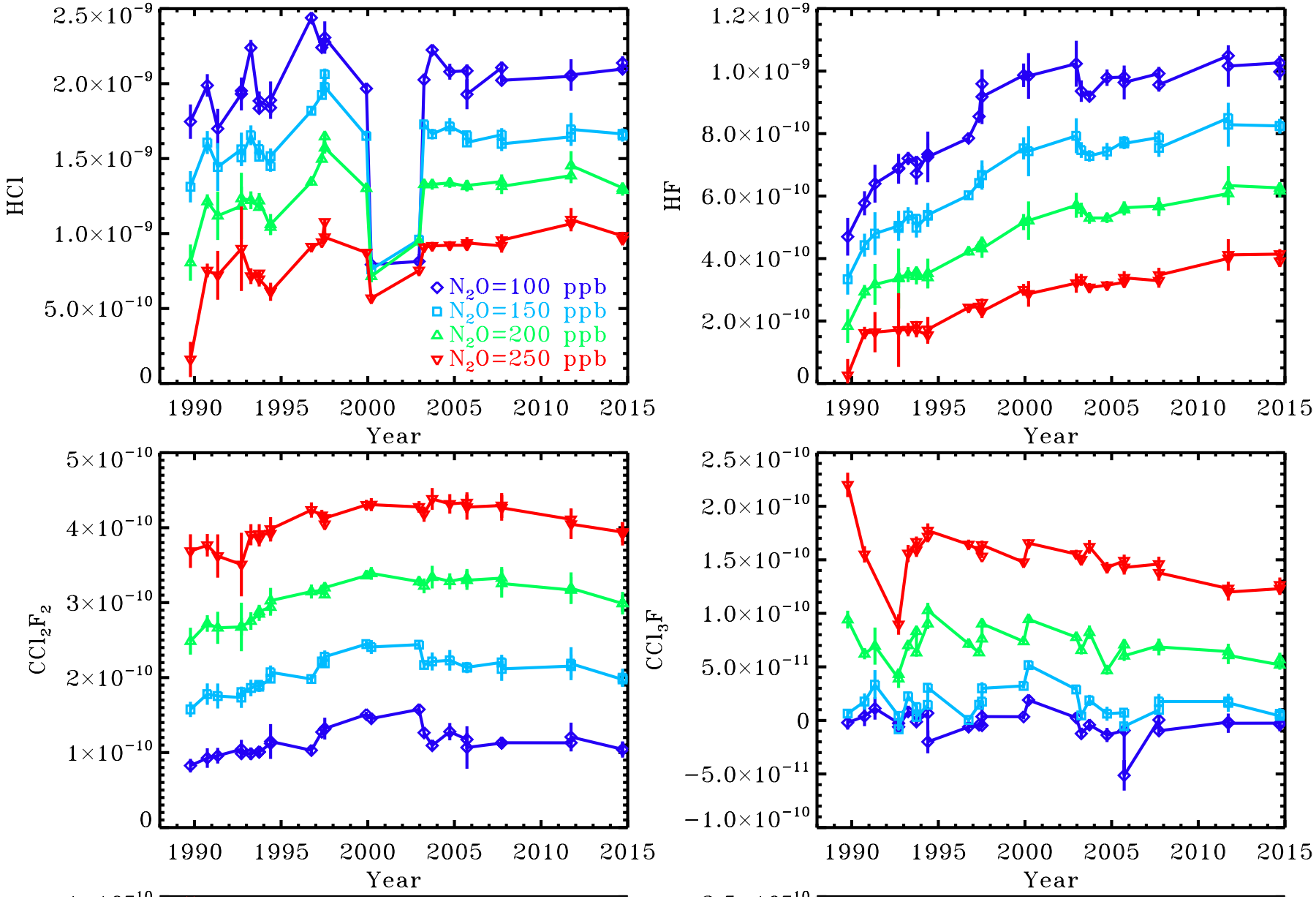
Notes

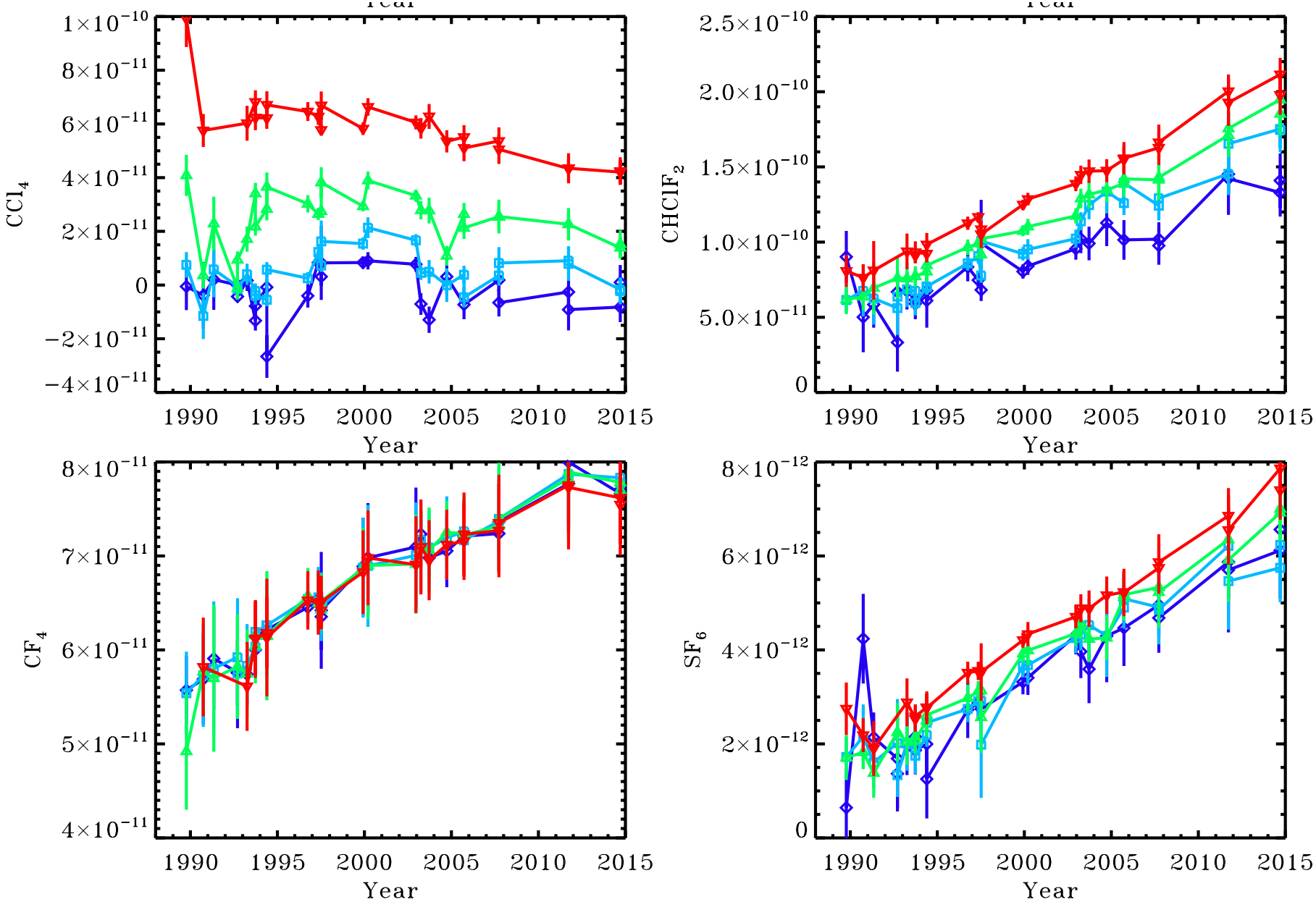
Balloon flights between 1997 and early 2003 were all from high latitude, following two launches from Fairbanks Alaska in May 1997 and 4 launches from Esrange, Sweden. The 1997 flights were out of the vortex. The Esrange flights (1999, 2000, 2002, 2003) were all inside the winter polar vortex, but the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

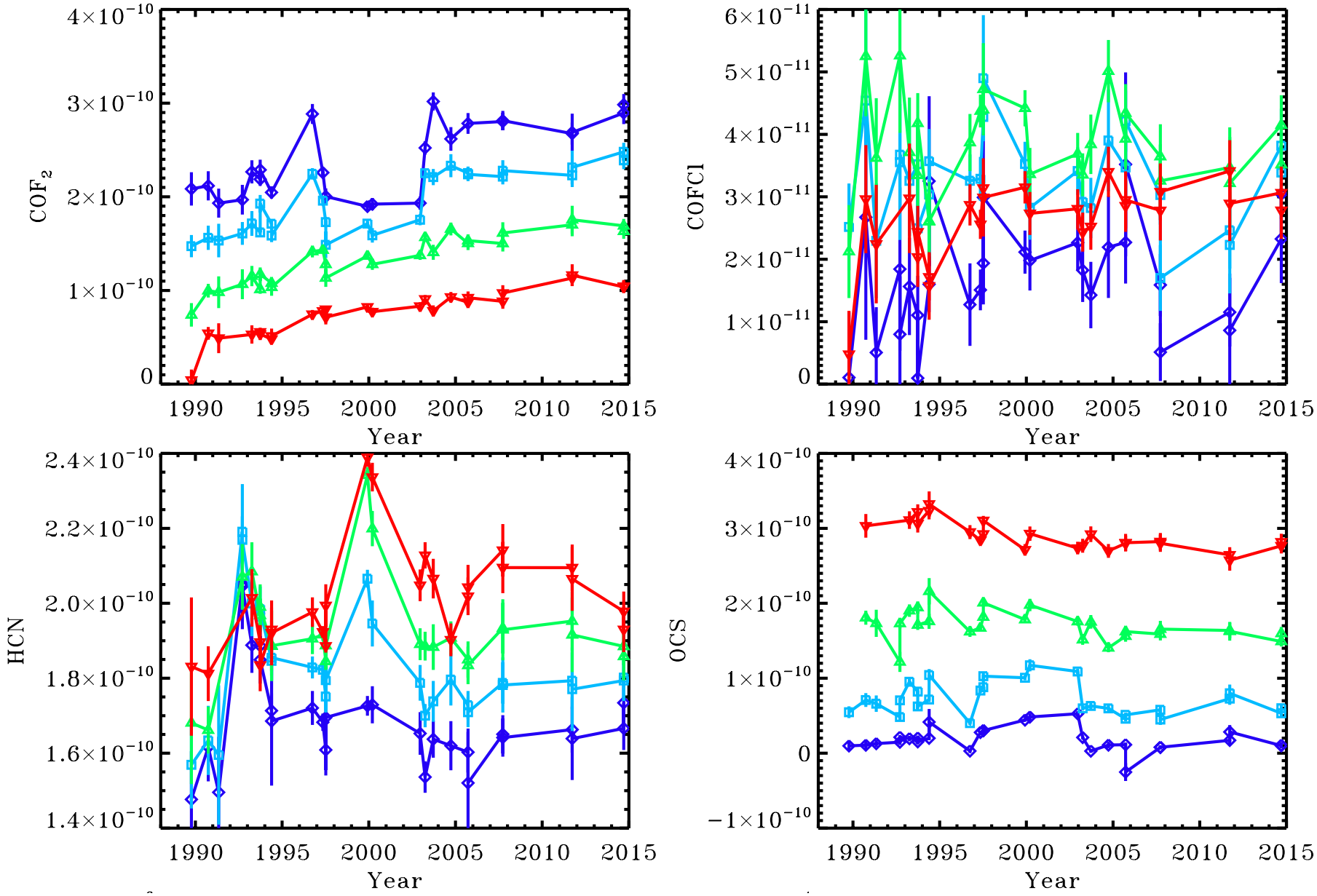
The Sep 1992 flight had so much aerosol remaining from the Jne 1991 Pinatubo eruption that the limb path became opaque below 22 km, which meant that the 250 ppm N_2O isopleth was never encountered on this flight. So no red point.

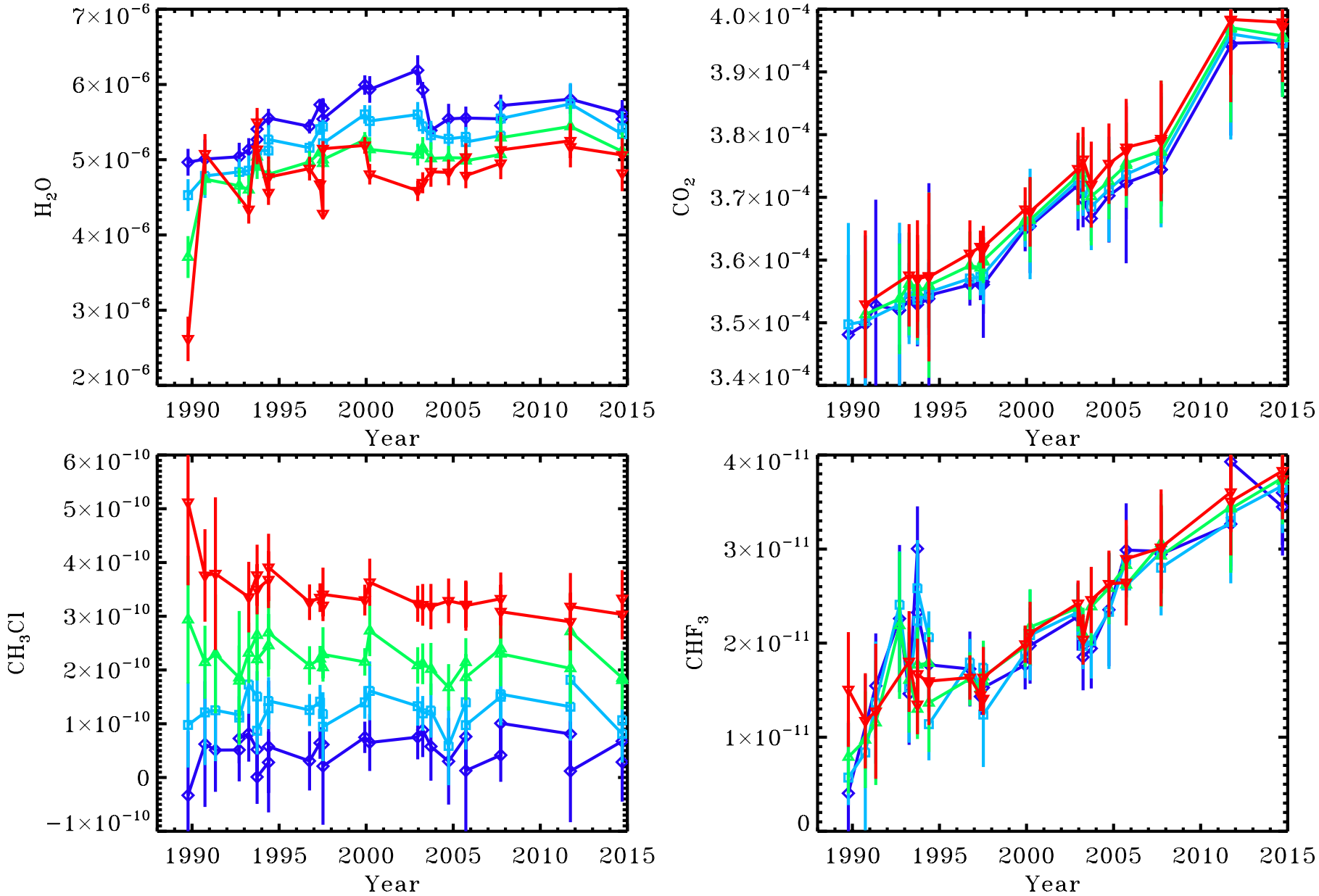
The last two plots show N_2 trends and N_2O trends. The latter show values that are exactly at the reference N_2O values without any trend, representing a self-consistency check of the method. The N_2 trend is essentially zero. The N_2 data are noisy because there are only half a dozen usable N_2 lines and these are weak being quadrupole transitions.

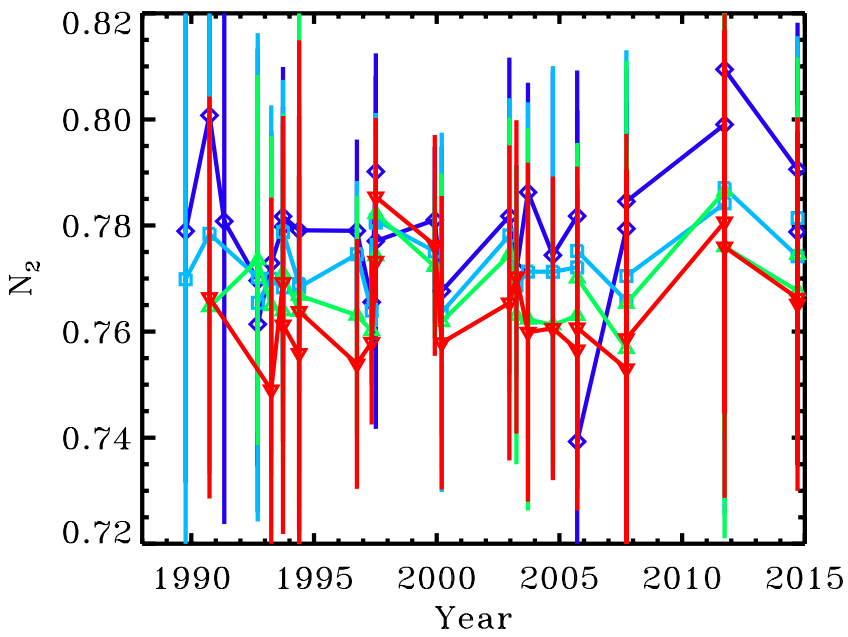
Of course, N_2O has been increasing steadily from 308 ppb in 1989 to 328 in 2014, so the apparent trends seen in the gases all all relative to the 0.25%/year trend in N_2O.

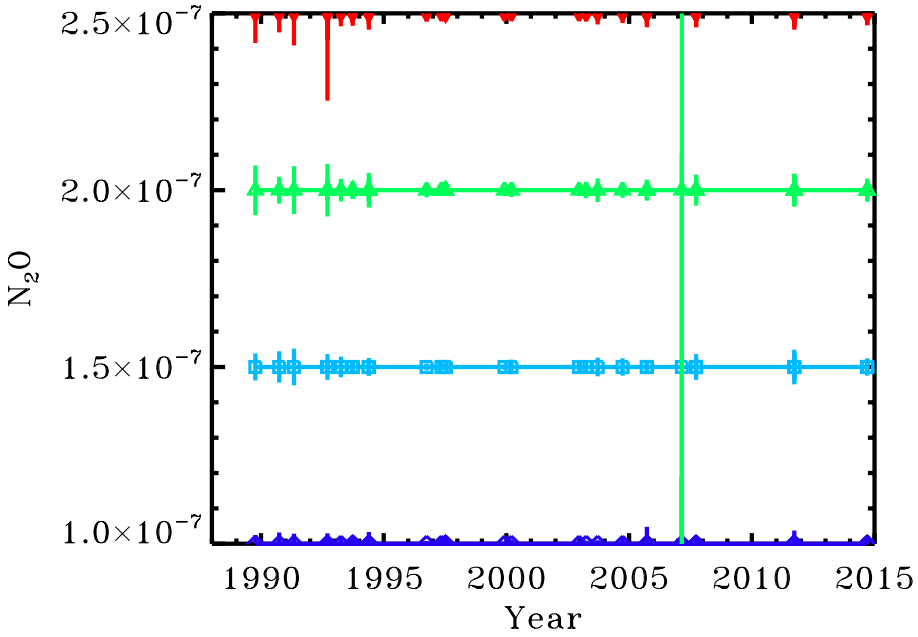

HCl
HF
CCl_2F_2
CCl_3F
Year
N_2O=100 ppb
N_2O=150 ppb
N_2O=200 ppb
N_2O=250 ppb


CCl4
1×10−10
8×10−11
6×10−11
4×10−11
2×10−11
0
−2×10−11
−4×10−11
1990
1995
2000
2005
2010
2015
Year
CHClF2
2.5×10−10
2.0×10−10
1.5×10−10
1.0×10−10
5.0×10−11
0
1990
1995
2000
2005
2010
2015
Year
CF4
8×10−11
7×10−11
6×10−11
5×10−11
4×10−11
1990
1995
2000
2005
2010
2015
Year
SF6
8×10−12
6×10−12
4×10−12
2×10−12
0
1990
1995
2000
2005
2010
2015
Year


COF2
4×10−10
3×10−10
2×10−10
1×10−10
0
1990
1995
2000
2005
2010
2015
Year
COFCl
6×10−11
5×10−11
4×10−11
3×10−11
2×10−11
1×10−11
0
1990
1995
2000
2005
2010
2015
Year
HCN
2.4×10−10
2.2×10−10
2.0×10−10
1.8×10−10
1.6×10−10
1.4×10−10
1990
1995
2000
2005
2010
2015
Year
OCS
4×10−10
3×10−10
2×10−10
1×10−10
0
−1×10−10
1990
1995
2000
2005
2010
2015
Year


H_2O
7×10^{-6}
6×10^{-6}
5×10^{-6}
4×10^{-6}
3×10^{-6}
2×10^{-6}
1990 1995 2000 2005 2010 2015
Year
CO_2
4.0×10^{-4}
3.9×10^{-4}
3.8×10^{-4}
3.7×10^{-4}
3.6×10^{-4}
3.5×10^{-4}
3.4×10^{-4}
1990 1995 2000 2005 2010 2015
Year
CH_3Cl
6×10^{-10}
5×10^{-10}
4×10^{-10}
3×10^{-10}
2×10^{-10}
1×10^{-10}
0
-1×10^{-10}
1990 1995 2000 2005 2010 2015
Year
CHF_3
4×10^{-11}
3×10^{-11}
2×10^{-11}
1×10^{-11}
0
1990 1995 2000 2005 2010 2015
Year


0.82
0.80
0.78
0.76
0.74
0.72
N_2
1990
1995
2000
2005
2010
2015
Year


2.5×10^{-7}
2.0×10^{-7}
1.5×10^{-7}
1.0×10^{-7}
N_2O
1990
1995
2000
2005
2010
2015
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.

The next step is to account for the known 6% increase in N_2O from 1989 (308 ppb) to 2014 (328 ppb).