Characteristics and use of HIRDLS Version 4 CFC11 and CFC12 Data

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Abstract:

HIRDLS Version 4 data contains 2 new gaseous species, CFCs 11 and 12. They show the tropical upwelling characteristic of a long-lived tracer, although there are some artifacts in this version. Comparisons with ACE and MIPAS show generally good agreement. A trend over the 3+ years can be seen in F11, although not in F12, as expected. Seasonal variations are noted. Recommendations on use of the data will be presented.

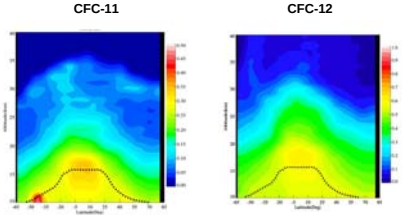

Figure 1: The above shows altitude-latitude cross-sections of current F11 and F12 from 18 May 2006

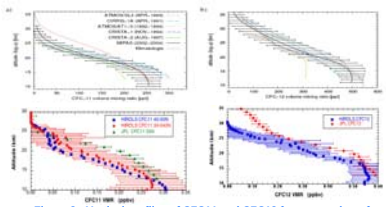

Figure 2: Vertical profiles of CFC11 and CFC12 from a number of satellite and balloon experiments (ATMOS, CIRRIS, CRISTA, MIPAS, JPL MK4) and from HIRDLS. Observations are all from northern hemisphere mid-latitudes.

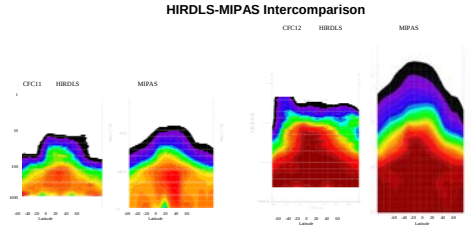

Figure 3: Altitude-latitude cross-sections of CFC11 and CFC12 as measured on the same day (2007d287) by HIRDLS and MIPAS.

Considerable improvements in the HIRDLS correction algorithm in the past year have lead to significant improved CFC products, see Figure 1. Improvements in the algorithm included vertical correction in the data retrieval location, open fractional area update, out of field contribution update, cloud detection using ozone retrieval and incorporation of GEOS 5.1.0 data in the line-of-sight correction. HIRDLS CFC measurements are generally useful between latitudes of 65 S to 82 N and within pressure ranges of 26.1 – 287.3 hPa (about 10 to 25 km) for CFC11 and 10.0 – 287.3 hPa (about 10 to 31 km) for CFC12. Average precision of the zonal mean for CFC11 and CFC12 is about 30% for the useful pressure region. Figures 2 and 3 show comparisons made with other global observations of CFC11 and CFC12. It should be noted that data outside of the useful range has been eliminated from the publicly released data.

The lifetimes of CFC11 and CFC12 in the atmosphere are relatively long (approximately 50 and 100 years respectively). Thus we may expect that the tropospheric amounts of the CFCs to be fairly uniform with the same magnitude as the surface value. Surface observations of CFCs have been made by NOAA [Elkins et al., 1994] for many years and show a slowly varying concentration with time. CFC11 surface values, from stations at latitudes from 71N to 90S, in 2006 ranged from 248 to 252 pptv; for CFC12, for the same stations and times, surface amounts were 530-540 pptv. As may be seen in Figures 4 and 5 to the right, the CFC amounts retrieved by HIRDLS are similar to those measured from the NOAA surface stations. There is a regularly observed excess of CFC11, of about 30%, in the upper tropical troposphere that cannot be explained at this time.

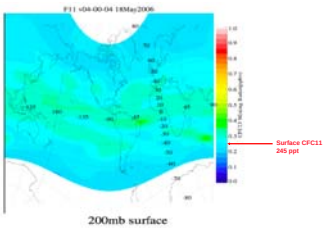

Figure 4: CFC-11 distribution at 200 mb looks fairly uniform with a value close to the expected value of the surface amount (about 245 pptv, average from NOAA monitoring network).

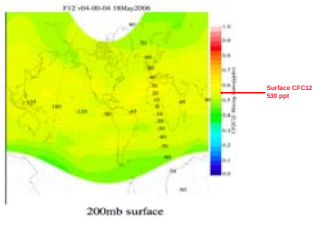

Figure 5: Similar situation of uniform field of CFC-12 at 200mb with a vlaue near the expected (from NOAA surface network) surface value of 530 pptv.

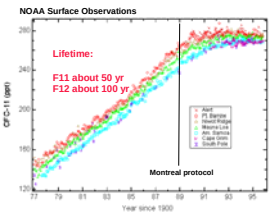

Figure 6: NOAA surface observations from 1977 to 1996. The sites here range from 90 S to 82.5 N.

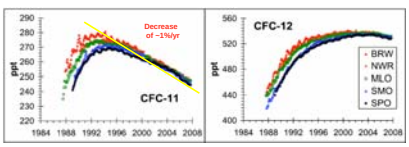

Figure 7: Current F11 surface amount about 245 ppt
Current Fl12 surface amount about 530 ppt

Surface concentration of CFCs began to level off when the provisions of the Montreal protocol began to take effect. The long lifetimes of CFC11 and CFC12 make for small spread in the surface values. Figures 6 and 7 to the left show the NOAA surface observations for CFC11 and CFC12 over time. CFC12 has recently leveled off. CFC11 has peaked and is now decreasing at about 1% per year at the surface. Is this trend seen by the HIRDLS observations?

The figures below indicate that this feature is indeed observed in the HIRDLS CFC data. Figure 8 is a zonal mean plot of three days in June from 2005 through 2007. (Note that this analysis used an older HIRDLS data version, v2.04.09, since it was the only version processed for three years at the time of this analysis. The analysis should be repeated for the current HIRDLS data version v2.04.19 [DISC version 004]). The data clearly shows a decreasing amount in CFC11 from year to year. Figure 9 shows the same results for other times of the year, here February and October were analyzed. These last two figures were for latitudes from 40N to 50N. What about other latitudes? Would the same decrease be observed? Figure 10 shows three days in June from 2005 through 2007 for 50N to 60N. The same pattern of annual decrease is seen.

From the NOAA observations, CFC12 should be constant over this time period. Is this observed by HIRDLS? Figure 11 shows the HIRDLS observations of CFC12 for June from 2005 through 2007. CFC12 does not show a decrease or increase for this time period as expected.

The previous figures were for the northern hemisphere. What about the southern hemisphere? Figures 12 and 13 show observations for June from 2005 through 2007 for the southern hemisphere. The situation in the southern hemisphere is not as clear, and maybe more interesting. This effect does not seem to be due to high clouds, as shown in Figure 14. More studies are warranted.

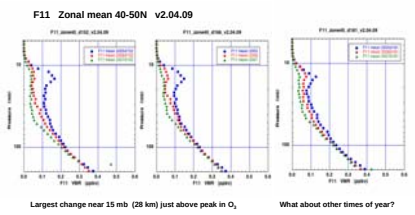

Figure 8: Seems to be a change from year to year with an ever decreasing amount in upper troposphere and lower stratosphere. Three days in June from 3 years.

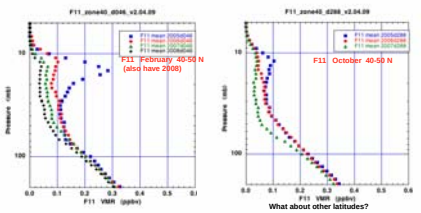

Figure 9: Same result for other times or year

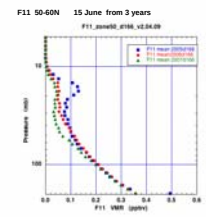

Figure 10: Three days in June; 3 years from 50-60N. Same result of annual decrease

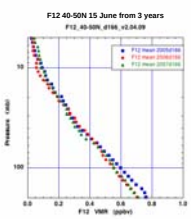

Figure 11: CFC-12 does not show a decrease (or increase) for these three years, as the surface observations would suggest

Conclusions

The current version of the HIRDLS data has produced notable improvements to the CFC and previously released products. Future work includes implementing further improvements to the correction algorithm to address variations in the radiance signal to improve the quality of the CFC products and completing validation of these products.

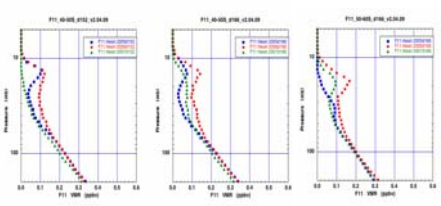

Figure 12: SH situation not so clear, maybe the most interesting. What about SH summer?

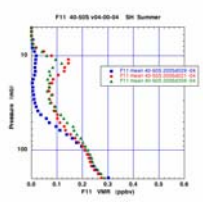

Figure 13: SH Summer

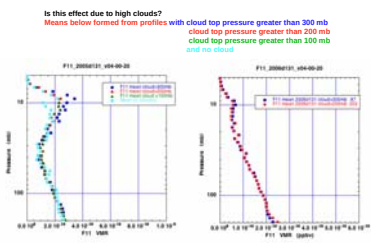

Figure 14: Effect does not appear to be due to high clouds