

## ***Interactive comment on “Atmospheric histories and emissions of chlorofluorocarbons CFC-13(CClF<sub>3</sub>), CFC-114 (C<sub>2</sub>Cl<sub>2</sub>F<sub>4</sub>), and CFC-115 (C<sub>2</sub>ClF<sub>5</sub>)” by Martin K. Vollmer et al.***

### **Anonymous Referee #1**

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This paper describes the atmospheric histories of CFC-13, CFC-114, and CFC-115; substances controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. The authors present atmospheric measurements and measurements of air archived in cylinders and firn, and use these to estimate historical emissions. They also investigate regional emissions using high-frequency measurements at a site in Korea.

The results are significant in that they represent the first comprehensive study of atmospheric CFC-13. The results also complement a recent study of CFC-114. The Vollmer et al study includes new information on possible sources of these gases, includ-

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ing emission as impurities in other gases used in refrigeration. This study provides constraints on current emissions of gases controlled under the Montreal Protocol, and recent (possibly unexpected) increases in emissions.

#### General Comments

This paper is comprehensive, well-written, and based on well-established methods. I do not have any objections to publication. The overall body of work and technical information available in the Supplement will be of interest to others in this field.

#### Specific Comments

Table 1: Why not include GWP from WMO 2014 (CFC-114, CFC-115)? Also, the lifetime of CFC-13 was reported as 640 yr in WMO 2006 and WMO 2011, but is not listed in Table 1.

Table 2: How do you define a “hot spot”? It looks like there could be “hot spot” emissions of CFC-114 also in 2013.

Pg. 8, Line 2: You use the term “primary calibration scale”. Consider using “interim calibration scale” instead since you refer to the “interim” scale on line 10.

Pg 9, Line 28: Add “(See Supplement)” after “Extrapolation of the AFEAS data, as in Daniel and Velders (2007)”

Pg. 9, Line 33: I don’t see emission scenarios from 1930-2100 in the 2006 Assessment Report. Do you mean atmospheric abundances from 1990-2040 (Fig 8-2) or 1955-2100 (Table 8-5)?

Pg 12. Line 11: What is meant by “regularization”? Do you simply mean “additional constraints”?

Pg 13, Line 14: Can you comment on the sensitivity of posterior emissions to the magnitude of the priors?

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Pg. 15, Line 33: “more unexpected” than what?

Pg. 17, Line 29: Suggest “projected by Velders and Daniel . . .” since 2016 emissions would have been a projection in 2014

Pg. 18, Line 10: Do you mean that a “change” in the latitudinal gradient has not been detected? There is clearly a gradient (N-S).

Pg 18, Line 19: Possibly re-phase. The use of “improvement/improved” in same sentence not entirely clear. Or refer to Supplement for model performance?

Figure 2: I’m not sure how the blue line (SPO) adds to the story, being based on only one sample from the SPO firm. Since this paper does not focus heavily on firm results, it might be better to keep the SPO sample “point”, but delete the “line”.

Figure 6: Hard to tell the difference between orange and red lines.

Figure S4: panels “b” and “c” look very similar. Perhaps draw a circle around green points in “c” to draw attention to what is different?

Pg S18, Line 11: Something still missing [Cathy to calculate this value]?

Pg. 17, Line 4: Seems like a sentence is needed here to clarify that CFC-13 emissions were not reported by Fraser et al, 2013 (if that is what you are saying). I suggest: “CFC-13 was previously found in the emissions from aluminum plants (Penkett et al., 1981; Harnisch, 1997), but was not reported by Fraser et al (2013) from a similar study.” And then follow with: “On re-analysis of the Fraser et al samples, we found enhancements over background levels of 45 ppt – 130 ppt in the various smelter samples. “

#### Technical Corrections

Pg 7, Line 17: Add comma between “measurements” and “samples”

Pg 14, Line 5: delete “again”

Pg 15, line 11: Suggest: “Its growth rate then slowed during the mid-2000s to near

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zero, with . . .”

Pg 16, Line 3: Suggest substitute “removal rates” for “removal fluxes”<sup>0</sup>

Pg. 18, Line 25: add “since 2010” after “steadily”

Pg. 19, Line 7: Suggest: “Large posterior emissions were detected for all analyzed years . . .”

Pg. 19, Line 13: I calculate a different number (0.63 kt) for the average Chinese emissions in the years 2013-2016 from values in Table 2 (0.68, 0.59, 0.78, 0.47).

Pg. 19, Line 13: Total Chinese emissions in 2012: (0.23±0.38 kt yr<sup>-1</sup>) does not match value shown in Table 2 for 2012.

Fig. 9 caption: change “derives from” to “was derived from”

Fig. S4: “Laube et al 2017” should be “Laube et al 2016” (two places in figure, caption is correct)

Pg. S16, Line 8: Suggest replacing “emissions are rather faster” with “emissions occur earlier in the life-cycle”

Pg. S17, Line 12: This sentence does not read well. “The very crude approach we have taken is still based on the above assumption of similarities to CFC-115 but are comparing production data, . . .”. Do you mean “ . . . but is based on a comparison of production data”?

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