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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "Sulfur hexafluoride ($SF_6$) emissions in East Asia determined by inverse modeling" *by* X. Fang et al.

**X. Fang et al.**

fangxuekun@gmail.com

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We thank the reviewer for his/her comments. However, we find it disappointing that the reviewer could not be more specific in his/her criticism, for example, the very last sentence of the review: "Because I could not believe in the results presented in the paper, no detail comments are provided". Thus we find it very difficult to respond to this review in which no clear arguments were presented. Still, we try to respond to those points that were raised.

1) Regarding the footprints:

The colour scales are non-linear but not logarithmic. This scale was chosen because the emission sensitivity drops-off quickly with distance from the station, which is a well-



known feature of atmospheric transport. However, although the emission sensitivity is weaker the further from the station, it still provides a constraint on the emissions. The area covered by the footprint increases with distance from the station, so that low values do not mean that they are not important, especially not in areas of high emissions. Furthermore, this constraint becomes stronger with longer averaging times, thus as the reviewer hints towards, the errors on the optimized fluxes become smaller with longer averaging times. Lastly, many other published studies have also used non-linear scales for presenting this type of information e.g. (Rigby et al., 2011; Keller et al., 2012). Indeed, western and southwestern China are not well covered by the emission sensitivity footprint, but these regions are only sparsely populated and emissions there are expected to be very small. However, North Korea, South Korea, Japan, the Taiwan region and most parts of China are well covered by the emission sensitivities of these three stations (Fig 1) and it is on these regions that this study focuses.

2) Regarding the temporal and spatial resolution of inversions in this study:

As for the temporal resolution, we did not make any inversions at monthly resolution as was suggested by the reviewer. We did make some inversions at seasonal (3-monthly) resolution, which is shown in our "Sensitivity Test" Section. However, these inversions were run at lower resolution (1500 boxes only, while ca. 2500 observations were available) and only regionally aggregated total emissions are reported for these inversions. For the final national a posteriori emissions for each country, we only report inversion results using a whole year of data rather than monthly or seasonal data. As for the spatial resolution, considering that we have circa 10000 observations for each year, we consider the inversion resolution used in our study to be appropriate. Indeed, Stohl et al. (2010) used data from the same three stations as we have used for HFC-23 inversions with a relatively similar resolution. They could show that individual HCFC-22 factory locations could be identified (these factories are the main source of HFC-23) with this set-up, although no information about the location of these factories was used in the a priori emissions. This clearly demonstrates that the retrieved

emission patterns, while probably noisy, contain relevant information. We, therefore, do not agree with the reviewer's suggests that "such minute details are not expected in a journal publication". Again, similar maps have been shown by other authors as well, e.g. Keller et al. (2012), Rigby et al. (2011) and Thompson et al. (2011). Actually, the somewhat higher resolution used in this study is an improvement compared to previous studies regarding the problematical attribution of emissions to different countries, especially along the borders, e.g., the border between South Korea and North Korea. We did not report emissions trend in individual grid cells but report emissions in a certain large regions or country domains (Table 2). Trends in these regions can be seen after multiple-year inversions.

3) Regarding the uncertainty of national a posteriori emissions:

In this study, uncertainties (indicated by $\pm$ values) are derived from the overall relative uncertainties as obtained in the Sensitivity Test Section. We consider these uncertainty estimates as more realistic than the smaller uncertainties obtained from error propagation in a single reference inversion. Many studies do not or not only report the aggregated uncertainty but report the uncertainty from various sensitivity tests, e.g., (Rigby et al., 2011) and (Keller et al., 2012). In our study, the error bars are greater than 100% only for Mongolia and North Korea. This is not very surprising because emissions in these countries are very small and, for Mongolia, the distance to the measurement stations is large. For other countries, the error bars (or uncertainties) are quite reasonable (17% for China, 26% for South Korea and 17% for Japan). We think the way we present our results will not cause "confusion among most of the readers, particularly the new comers to this field" but rather the opposite. Stripping away most of the information and presenting only the final results, as suggested by the reviewer, would lead to confusion and would mean that our research could not be exactly reproduced by others.

4) Regarding the inland measurement network:



Yes, we agree that more data input into the inversion could improve our results, as is always the case. SF6 data from within China does exist and we have tried to get access to these data, but these data were unfortunately not shared with us and are – to our knowledge – not available to anybody else than the data producers. Fortunately, Gosan and Hateruma are downwind of China and air masses carrying information about SF6 emissions in China reach these two stations frequently enough for us to retrieve valid emission information. For the purpose of inverse modeling, stations downwind of major emission centers and not influenced by local sources can in fact sometimes be more useful than stations that are strongly influenced by very local emissions on the scale of which the transport errors may be large (see Stohl et al. (2009) for a detailed discussion of this). However, this does not suggest that monitoring in regions like China, Europe or the U.S.A. should not be continued. Data from these regions would also provide valuable information.

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