Reply to Anonymous Referee #2

Referee #2

The authors would like to thank Reviewer 2 for his careful reading of the manuscript and for his constructive comments. We tried to reorganize the structure and improve the content as recommended. A detailed point by point reply (in blue) is provided hereafter.

The structure of the paper is confusing. I think it would be best to start with a comprehensive discussion of the IASI measurements and the CO retrievals, including the significance of the averaging kernels, and how an in situ profile needs to be transformed for proper comparison to the satellite retrieval. A discussion of the sensitivity of the retrieval to surface emissivity, etc., would be appropriate here. This could be followed by a discussion of the aircraft measurements, and their extension into the stratosphere with the ACE retrievals. Then the results of the validation comparisons could be shown. Finally the examples of long range transport could be shown, though I'm not sure it really fits with the paper.

The former structure was initially chosen to highlight the usefulness of IASI satellite observations in the framework of the POLARCAT campaign. This is why this manuscript is submitted in POLARCAT special issue. We changed the organization in order to follow the recommendations of both reviewers. The abstract and conclusion sections were reorganized accordingly. We now start with the IASI retrievals, and the manuscript is organized as follows: after an overview of the IASI CO retrievals over the Arctic (section 2), the general context of the 2008 polar campaigns and details about the CO measurements used for the validation are given in section 3. Section 4 describes the collocation criteria issue and the methodology adopted to validate IASI CO. Both a quantitative comparison and a statistical evaluation of the quality of the IASI CO retrievals in spring and summer 2008 are provided. Section 5 discusses further some of the interesting cases in terms of the spatial distribution of the observed plumes. Conclusions are presented in section 6.

Section 5.1: I think it should be emphasized that the transformation of the in situ profile with the averaging kernel and the a priori profile is required to take into account the sensitivity of the retrieval to the true profile. Frequently the transformation is referred to as 'smoothing' which I think is misleading, as the process is far more than that. Also, the colocation criteria are very stringent; I think they could be expanded significantly without harming the results.

- For better understanding, we changed the sentence "For a proper comparison of satellite data with in-situ measurements, the AK information for each observation needs to be taken into account (Rodgers and Connor, 2003)." to "For a proper comparison of satellite data with *in situ* measurements, the transformation of the *in situ* profile with the averaging kernel and the *a priori* profile is required in order to take into account the sensitivity of the retrieval to the true profile (Rodgers and Connor, 2003)."

- concerning to the collocation criteria we put this section earlier and we presented it in section 4.1 at the same time as methodology of validation (section 4.2).
And we added these sentences:
"In order to compare satellite observations and aircraft measurements, an important first step is to check the place and time coincidence. Different coincidence criteria around the flight position were tested (from ±0.2°, ±1h to ±0.5°, ±2h) and here, comparisons were conducted using a stringent collocation criterion, i.e. a box of 0.2°×0.2° and time of ±1 h. When the criteria were relaxed it appeared that IASI CO signatures were less visible and results from the comparisons were not improved."

Fig. 8a: How are you able to transform the in situ profile that only goes up to 6 km? Are the averaging kernels just truncated at that altitude? This does not make sense to me, and I think is misleading as a proper way to perform validation.

The objective of this Fig8 (now Fig. 6) is to show the difficulty to compare an *in situ* profile with a "complete" satellite profile. An ideal profile should extent from the surface to the top the atmosphere but this is not available from aircraft.
Thus the purpose of Fig8a was to demonstrate that a convolution with the lower part of the AK is not correct. That is why we explain later that we need complementary data to complete this profile and of course to use all the AK matrix. To extend this profile we used a profile generated from a climatology from ACE-FTS measurements. This climatology can complete the *in situ* profile from the upper troposphere to the top of the atmosphere.

We added to the sentence about the ACE-FTS climatology (in bold hereafter) in new section "4.2 Methodology":
"Since most co-located [±0.2°; ±1 h] aircraft profiles were limited in altitude (compared to the full satellite profile), **and in order to use the full AK matrix**, the *in situ* profiles were extended using CO profiles retrieved from the ACE-FTS instrument in the upper troposphere and above as described in the next section."

And in new section "4.4. Results: comparison of selected representative profiles":
"It can be seen that when combined with the ACE-FTS climatology **(and so applying the full AK matrix)**, the smoothed *in situ* profile is closer to the retrieved values from IASI."

Section 5.3.1: I don't understand why there is such a large difference at the surface between transformed in situ and IASI retrieval. If the IASI retrieval has little sensitivity at the surface, the comparison at the surface should be a priori to a priori. However, the averaging kernel for the surface is generally the largest (Figs 8 & 9), so I guess that explains the difference. Perhaps this could be explained in the paper.

It is a very interesting remark. We described in this paper the limited vertical sensitivity. And we said that IASI sometimes does not have a good sensitivity close to surface.

As can be seen from the example plotted in former Fig9c, the AK is sometimes close to zero at the surface. But looking at the values, we notice that values are very low and not equal to zero and the contributions of other levels are substantial.
For example, the first line of the AK matrix, representing the sensitivity at the first level of the retrieval, is 0.0010 in the first level but reaches 0.1850 at level 8 (at 7.5 km). Thus, taking into account all contributions with the AK, the value of the "smoothed" profile at the surface is ~167 ppbv and not 96.5 ppbv as the *a priori*.

Fig 10 & 13: I think it would be more informative to plot the mean of the differences between IASI and in situ, rather than the means of each measurement. Presumably the measurements for each aircraft cover a large range of conditions that are getting lost in these bulk averages.

Agreed, we have added the RD and RSD on these plots as supplementary information.