We would like to thank Björn-Martin Sinnhuber for his corrections and recommendations. Additions to the text are highlighted in blue and text that has been removed from the original text is highlighted in red. The reviewer comments are included in bold.

**General comments:**
**1) artificial tracer: The argument that mixing does not change the correlation between ozone and the artificial tracer (p4, l4) is only true if the correlation exhibits the same slopes inside and outside the polar vortex. If not, than mixing across the vortex edge can influence the correlation. On p7, l30 it is stated that this method provides a mixing correction. This is not immediately clear. As this is a critical point, I suggest to show the correlations inside and outside of the vortex.**

Mixing of outside polar vortex air affects the correlation of the artificial tracer as air outside the polar vortex does not follow the same correlation. We have included the following statement at the end of the paragraph to clarify this:

"While it reduces the error from mixing of air near the vortex edge, this method, however, does not account for mixing of extra-polar vortex air into the vortex. The artificial tracer, established from observations inside the polar vortex does not follow the same linear correlation outside the polar vortex (Jin et al., 2006)."

**2) Uncertainty of passive subtraction with ATLAS (p11, l8): Estimating the uncertainty by comparing ATLAS and ACE-FTS for January will almost certainly underestimate the true uncertainty, as the model was initialized in early January and run only for a relatively short period  uncertainties in model transport will accumulate until March, not captured here. While it is difficult to come up with a better uncertainty estimate, this needs to be at least acknowledged and discussed.**

We have included the following sentence in Sect. 3.4.1 to point out this issue:

"Note that the uncertainty estimated here is a lower bound on the actual uncertainty since it does not consider the accumulated uncertainties in model transport since the initialization in January (e.g. caused by deficiencies in ERA Interim)."

**Specific comments and technical corrections:**

**P3, l13: Polar Night Jet Oscillation Event: I suggest either to give more information or drop the reference to the Polar Night Jet Oscillation Event. What is this and why is this relevant?**

A discussion of the Polar Night Jet Oscillation is probably too specific in the context of this paper. We have changed the sentence to:

"In January 2012, very strong polar vortex disturbance occurred ~~, likely due to a Arctic Polar-Night Jet Oscillation Event (Berhard et al., 2012; Chandran et al., 2013; Hitchcock et al., 2013)~~ (Berhard et al., 2012; Chandran et al., 2013) ."

**P4, l13: estimate differences between model and observations: The meaning of this sentence is not fully clear and should be rephrased accordingly.**

This sentence has been removed as it was not relevant.

**P4, l20: ...and the passive subtraction method using only modelled ozone: If the meaning here is ...and compare this to the modelled chemical ozone loss better say so.**

The sentence has been changed accordingly to:

"Chemical ozone depletion for each spring is estimated using the tracer-tracer correlation method, the artificial tracer approach, the average vortex profile descent technique, the modelled passive ozone subtraction method using a Lagrangian and an Eulerian transport model, and ~~the passive subtraction method using only modelled ozone~~modelled chemical ozone loss using SLIMCAT (Chipperfield et al., 2006)."

**P7,l11: high altitudes: upper stratosphere and mesosphere?**

We have changed this sentence accordingly to:

"The tracer-tracer correlation method also neglects descent of ozone or the tracer from high altitudes ~~that invalidates the use of~~ (upper stratosphere and mesosphere) above 550 K that is not included in our calculation of the early vortex reference function."

**P13, l11: uncertainty 10-20%: absolute or 10-20% of the ozone loss?**

To clarify, we have changed the sentence to:

"The estimated uncertainties of the ozone loss profile are ~0.2-0.6 ppmv, or approximately ~10-20 % of the estimated ozone loss, and the results from all tracers agree within the uncertainties ..."

**P13, l13: that further confirmed the tracer/tracer correlation method to be inaccurate for estimating Arctic ozone loss: This is a strong**

**statement. Do you really want to say tracer/tracer methods are inaccurate for ozone loss estimates?**

Numerous studies (including the references cited here; e.g., Michelsen et al., 1998 a, b, 2000; Plumb et al., 2000, 2003; Plumb, 2007) have shown both theoretically and observationally that trace correlation methods are inaccurate. However, we have softened the language and rephrased the last two sentences of this paragraph:

"This indicates the ~~failure~~ shortcomings of the tracer-tracer correlation method, even ~~though~~ in cases where only inner core vortex measurements were used for estimating the ozone loss. These results are ~~in agreement with the discussions of the tracer-tracer correlation method in~~ consistent with previous studies (e.g., Michelsen et al., 1998 a, b, 2000; Plumb et al., 2000, 2003; Plumb, 2007) that ~~further confirmed the~~ have shown tracer-tracer ~~correlation method to be inaccurate~~ correlations are not expected to be accurate for estimating Arctic ozone loss. However, in this study, though the profile loss estimates are different for different tracers, the partial column losses (maximum and mean) are not significantly different and agree within the estimated uncertainties. "

**P14, l24: does this apply specifically to ACE-FTS retrievals of OCS and CCl3F ? If so it would be good to mention explicitly.**

We have changed the sentence accordingly to:

'However, using OCS or $CCl_3F$ as a tracer, at least for the ACE-FTS v3.5 dataset, seems to result in larger uncertainties and has the disadvantage that there are not as many profiles available as there are for the rest of the tracers."

**P16, l6: The results of the artificial tracer technique should be uninfluenced by mixing: Again, it needs to be demonstrated that this is also true for mixing across the vortex edge.**

We have changed the paragraph to:

"Discrepancies are apparent between the measurement only methods and the passive subtraction ~~methods~~ using CTMs in 2010, especially for the computed mean partial column loss. Each time the vortex splits and the two parts reunite, extra-vortex air is mixed. In 2010 the polar vortex was very disturbed, therefore, ~~for 2010, the~~ methods that do not account for the mixing of extra-vortex air (the tracer-tracer ~~and~~ method, the profile descent techniques and the artificial tracer technique) are not reliable for that year since an isolated vortex is essential for these methods~~that do not account for the mixing of extra-vortex air. The results of the artificial tracer technique should be uninfluenced by mixing. The~~. The loss estimates in 2010 using the ~~artificial tracer technique~~ measurement only techniques do not agree with the passive subtraction ~~methods. It is worth noting~~

that the passive subtraction methods compute similar losses from year to year, including using CTMs. Generally, we see the largest differences between the passive subtraction method using CTMs and methods that use measurements only for years with strong turbulence and relatively small ozone loss (see Table 1). For example in 2010, when the vortex was much disturbed. The the passive subtraction methods using CTMs are nearly twice as high for the maximum ozone loss and more than three times as high for the mean ozone loss than the methods that use measurements only. This could either be due to mixing processes unaccounted for in the methods using measurements only or the passive subtraction methods using CTMs differences and model results in some years may compute some ozone loss even in the absence of chemistryvariabilities by overestimating passive ozone."

**P16, l9: The passive subtraction methods may smooth out the year-to-year differences and model results in some years may compute some ozone loss even in the absence of ClOx chemistry: Why?? The meaning and basis for this statement is unclear.**

We have changed the paragraph where this comment has been addressed, see comment above (p.16, l. 6).

**P16, l22: ozone loss has also been estimated using only the SLIMCAT ozone and passive ozone (SLIMCAT only): Again, I believe this is better expressed as modeled ozone loss.**

We have changed the sentence accordingly:

"The ozone loss has also been estimated using only the SLIMCAT ozone and passive ozone modelled ozone ("SLIMCAT only")."

**P18, l33: passive subtraction methods using either ATLAS or SLIMCAT seem to have smaller computed uncertainties: As remarked above, I suspect that for these methods the uncertainties here are systematically underestimated.**

The sentence has been changed to:

"While similar ozone losses were computed for all methods in years with an isolated polar vortex, the passive subtraction methods using either ATLAS or SLIMCAT seem to have smaller computed uncertainties. Note that the uncertainty estimated here is a lower bound on the actual uncertainty since it does not consider the accumulated uncertainties in model transport until March."

**P19, l4: and might smooth out the year-to-year variability: again, any idea why the year-to-year variability may be smoothed out?**

The sentence has been changed to:

"For example in 2010, ~~when the vortex was much disturbed. The~~ the passive subtraction methods ~~may smooth out the year-to-year differences and model results in some years may compute some ozone loss even in the absence of chemistry~~using CTMs are nearly twice as high for the maximum ozone loss and more than three times as high for the mean ozone loss than the methods that use measurements only. This could either be due to mixing processes unaccounted for in the methods using measurements only or the passive subtraction methods using CTMs may overestimate passive ozone. "

**P19, l11: For years with little to no ClOx activation the artificial tracer correlation technique might be the most reliable because it considers mixing and seems to compute a reasonably small ozone loss: This statement is problematic for two reasons: (a) one may argue that possible mixing across the vortex edge is better represented by the passive subtraction method that takes into account tracer gradients across the vortex edge at least in first order, and (b) the relatively good agreement between the passive subtraction method and modeled ozone loss (SLIMCAT only) for this year (2010) indicates that according to our understanding of the processes involved there was potential for substantial chemical loss.**

We have changed this paragraph to:

" ~~Based on this study, for years with significant activation either~~ For years with an unstable polar vortex we recommend using the passive subtraction ~~or the artificial tracer technique are best suited. For years with little to no activation~~ technique, since the artificial tracer ~~correlation technique might be the most reliable because it considers mixing and seems to compute a reasonably small ozone loss~~ technique does not account for mixing of extra-polar vortex air. We did not find any significant difference between an Eulerian or a Lagrangian model and found that both types of CTMs seem to compute the Arctic ozone loss equally well."