We would like to thank the reviewer for taking the time to read this manuscript, and for offering suggestions for improvements. Below, we provide a list of responses to the reviewer's points. The relevant citations for this response are listed at the end, in the references section.

General question:

This particular time period was chosen for the analysis, because we required a set of trajectories where we could be sure that there was no ice formed before the NAT, so that we could define the fitting parameters for the nucleation parameterisation. The temperatures had to be below TNAT for less than 80 hours, so that we could assume minimal mixing between the air parcels, and so that the model could be initialised above TNAT. It seems relatively rare that there is such a clear case where the temperatures are below TNAT for a relatively short time, but still remain above Tice, however we are not currently able to make a quantitative estimate on how frequently this occurs. When the new parameterisation is applied in models to study whole winters, it should of course be used in conjunction with a parameterisation of the usual NAT on ice nucleation mechanism, as we do in the part two paper. Additionally, the constraint of a short time below TNAT is only important when defining the parameterisation, once this has been done, the appropriate nucleation rates can be calculated regardless of how long the air parcel was below TNAT.

In the future, we hope to extend the analysis to other Arctic and Antarctic winters, which would also enable us to make a better estimate of how often NAT is likely to nucleate on non-ice surfaces. Due to the computational expense of calculating the necessary trajectories and performing the model runs for several winters and longer time periods than studied here, this will have to be performed as a separate project.

Pg 7985, ln 15 : We have constructed a histogram showing the distribution of the minimum temperature encountered along each trajectory, with respect to Tice. We have added this to the manuscript (now fig. 1), and adjusted the text as follows:

"In order to derive and test the new NAT nucleation parameterisation, the CALIOP observations made over the Arctic in December 2009 are used. During the second half of December 2009, stratospheric temperatures were slightly below TNAT and patchy areas of PSCs were detected on a daily basis. The vortex average temperatures were several degrees above T_Frost (Dornbrack et al., 2012), and additionally there were no observations of ice clouds during this period. In Fig 1, the minimum temperatures with respect to the frost point, along all trajectories used in the analysis here (as described in Sect. 2.3 and 3), are shown. Even the lowest temperatures along these trajectories are 2.5K above the frost point, while the peak of the distribution is at approximately 5K above the frost point. Considering that temperatures approximately 3K below the frost point are required to homogeneously nucleate ice, even accounting for small scale temperature fluctuations, the probability of undetected ice clouds having occurred is extremely low. This set of observations and model calculations therefore …."

Pg 7996, ln 6 We have now referenced several more PSC/wave studies here, however we merely stated that there has been a lot of interest in the effect of waves on PSCs, and provided some sample citations, as the vast majority of studies examining the effect of waves on PSC are related to ice formation and possibly subsequent effects on NAT clouds, both mechanisms which we deliberately avoid in this study by choosing a period where no ice can exist.

Pg 7998, ln 2: This was a trajectory taken from one of the orbits (24_04, starting at 5:22 UTC) presented in the paper. The nitric acid and water mixing ratios were taken from the MLS data, as described in section 2.3.1. This was not very well explained in the paper, so we have changed the text slightly to clarify this. We now point out that the trajectory was taken from the orbit 24_04, and that the MLS data provided the HNO_3 and H_2O values.

Pg 8000, ln 1: We ran a few of the other parameter sets for all of the orbits presented (including the top and bottom panels of the second column of fig. 5). We found that the chosen parameters are those that provide the best overall representation of all the orbits examined. Although the PSC area for the two panels mentioned above compares well with the observations, the abundance of Mix 2 is higher than for the chosen parameters, and in other orbits this problem is more pronounced (too large areas of NAT, too much Mix2 and Mix2-enh).

Pg8001, ln 1: Actually, in discussing this point in the manuscript we were probably a bit hard on the model. Comparing the lower row of Fig 7 and 8, (the scatter plots), one can see that the modelled and measured points are distributed in a fairly similar fashion in terms of inverse backscatter ratio. However, both modelled and measured points straddle the line separating Mix1 from Mix2. Therefore a small bias of the model towards the Mix2 area looks like a large overestimation of Mix2 when comparing the PSC classifications, despite the fact that the modelled optical properties are actually very similar to those observed. We added a little text to explain this in the conclusions:

"Further, it should be noted that although the classification Mix2 is slightly over represented in the model results, the inverse backscatter values derived from both the modelled and observed PSCs straddle the boundary between Mix1 and Mix2 and are actually very similar (e.g. bottom rows of Fig. 7 and Fig 8). Therefore, small shifts in inverse backscatter lead to different modelled and observed classifications of the PSC despite very similar optical properties."

Pg8002, ln 3: The start times for the orbits are listed on the figures. In using, for example, 21_03 to refer to the third orbit on the 21st of December, we were looking for a short way of referring to the orbits in the text.

Pg 8003, ln 15: The noise in the non-cloud areas is well accepted as an instrumental issue due to radiation. The cloud classification routines applied to the CALIOP data are also specifically adjusted to avoid interpreting it as cloud. Variations within cloud areas on the other hand may be from small scale perturbations, as discussed in the section on small scale temperature fluctuations.

Pg8006, ln 14: We have added more PSC wave references here too, although again, as they relate to mechanisms which we do not examine in our study, we do not discuss them in detail. The waves are presumably small wavelength gravity waves, we mention this now too.

Fig 3/7/8/9: Done as suggested.