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 comment: we chose to compare the newly developed model with results using a constant nucleation rate, as the latter parameterisation makes no assumptions about the nucleation mechanism, is used in many modelling studies, and has, until now, not been shown to be too simple to correctly simulating PSC formation. Homogeneous nucleation on the other hand, has been shown in laboratory studies (e.g. Koop et al 1995, Koop et al. 1997,Knopf et al. 2002) to be far too slow to cause NAT nucleation under polar stratospheric conditions; therefore we found it unnecessary to consider it further here. However, we have added a table with values for the nucleation rate coefficients, which includes also the homogeneous nucleation rate coefficient.

1) P7991 L9: Two new parameterisations were added to the model for this work. One is the heterogeneous nucleation of NAT on foreign nuclei and the other is the heterogeneous nucleation of ice on foreign nuclei. Both of these new parameterisations are described in the section, even though details of the latter are given in the companion paper by Engel et al. We have changed the title of the section to "Extension to heterogeneous NAT nucleation and heterogeneous ice nucleation on foreign nuclei" to clarify this.
2) P7996 L20: Observations during the RECONCILE campaign showed that around 80% of the aerosol observed in the polar vortex contained non-volatile residuals (Von-Hobe et al 2013), while Murphy et al. 2007 report fractions of aerosol containing meteoritic material of between about 30% and 70%, depending on altitude above the tropopause (the data reported in Murphy et al. are however not polar vortex measurements). Curtius et al 2005 report around 70% of aerosol particles containing non-volatile residuals within the polar vortex. The fact that non-volatile residuals are found in the aerosol indicates that the meteoritic particles remain solid although, admittedly, there is also evidence that the residuals may contain materials other than meteoritic. As there is a large range in the fraction of aerosol containing meteoritic material, and there are no measurements available for the specific trajectories used in our modelling study, we decided on a fraction of 50%. This is however not a critical parameter in our NAT nucleation parameterisation. Other values could be used, and would produce the same results once the parameterisation is slightly re-tuned. As described in the paper, only a small fraction of the meteoritic material present can act as NAT nuclei, if the observations are to be reproduced, and this fraction is determined by the three parameters, alpha, gamma prime, and P_pre. We have added the following text to the section describing the model:

"Measurements reported by Curtius et al. (2005) show that during January to March 2003 approximately 67% of aerosol particles in the Arctic polar vortex contained non-volatile residuals, while outside the vortex the value was much lower at approximately 24%. Similar values (between 30% and 70% depending on altitude above the tropopause) are reported for meteoritic particles in aerosol by Murphy et al. 2007, for mid to low latitudes. During the RECONCILE campaign, values of up to 80% were found. The value used here, of 7.5 cm^{-3} aerosol particles containing foreign nuclei, corresponding to 50% of the total aerosol, was chosen as a conservative estimate. As discussed below, only a small fraction of these nuclei actually participate in the NAT nucleation, therefore only choosing a far lower percentage would have any effect on the results presented here."

3) Fig 5: The contour lines in Fig 5 show the temperatures with respect to T_NAT (from the ERA-Interim reanalysis) at the time of CALIOP observation. This information was missing from the figure caption and has now been added. The labels to the right of the colour bar indicate the PSC classification (as described in the text) assigned to each colour on the colour bar. We have now also added this information to the figure caption.

4) Fig 6. The temperature is relative to T_NAT. We have now added this information to the figure caption.

5) Pg 8003, L25: We have performed some further model runs, and attached a figure with the results to the end of this reply. The first column shows the model results for the orbit 21_03, as shown in Figure 7 (column 2) of our paper. The second column shows what happens if we reduce the trajectory temperatures by 1K. The third column shows the observed optical properties for this orbit, and the forth column shows the effect of increasing the liquid aerosol which does not contain foreign nuclei (FN), from 7.5/cm^3 to 14/cm^3 (the 7.5/cm^3 which do contain FN are kept the same as in our initial parameterisation). From this figure, it is apparent that both decreasing the temperature, and increasing the number of aerosol particles will increase the number of STS formed. Reducing the temperature by 1K over the whole trajectory produces a rather extreme change, the area of the PSC increases, STS is formed, and the inverse backscatter ratio decreases (bottom panel). On the other hand, increasing the number of aerosol particles increases the amount of STS, but has no effect on the range of backscatter ratio values. Therefore we believe that small deviations in trajectory temperature from the actual temperature (~0.5 – 1K, not necessarily over the whole length of the trajectory) are probably the main cause of the difference in both backscatter ratio and in STS abundance between observed and modelled values.
   We stated in the paper that the model over represents mix 2, and while this is indeed the case, it was perhaps a too harsh statement. Looking at the bottom rows of Figures 7 and 8 for example, one can see that the observations and the model results are very close to the (rather arbitrary) line representing the division between mix1 and mix2. Thus while the classification of the PSC is different in the observations and model results, the optical properties are actually very similar.

We have adjusted the discussion on page 8003/8004 and with respect to the overrepresentation of mix2 to reflect the points made above.

6) P8004, L7: We found that the value of gamma prime needs to be changed to 700 only if the model in which the parameterisation is being implemented is capable of simulating the small scale dynamics leading to temperature fluctuations. If this is not the case, 650 should be used for gamma prime, as the use of this lower value will mostly compensate for the lack of temperature fluctuations. We have added a table with the values, as suggested, and also added some text to section 3.4 clarifying when each value of gamma prime should be used. Previously, this was only discussed in the Conclusions.

7) P8006 L17: We have now changed this to “and thus, on average, NAT nucleates at higher temperatures ”

8) Fig 1: T_dew is now explained in the figure caption, and the figure has been modified and further text added to clarify that NAT is assumed to form from STS droplets containing foreign nuclei. Text has been added to the figure caption to indicate that the temperatures given in the schematic are approximate, based on typical polar stratospheric conditions.

9) Fig 3. These areas are now marked and explained.

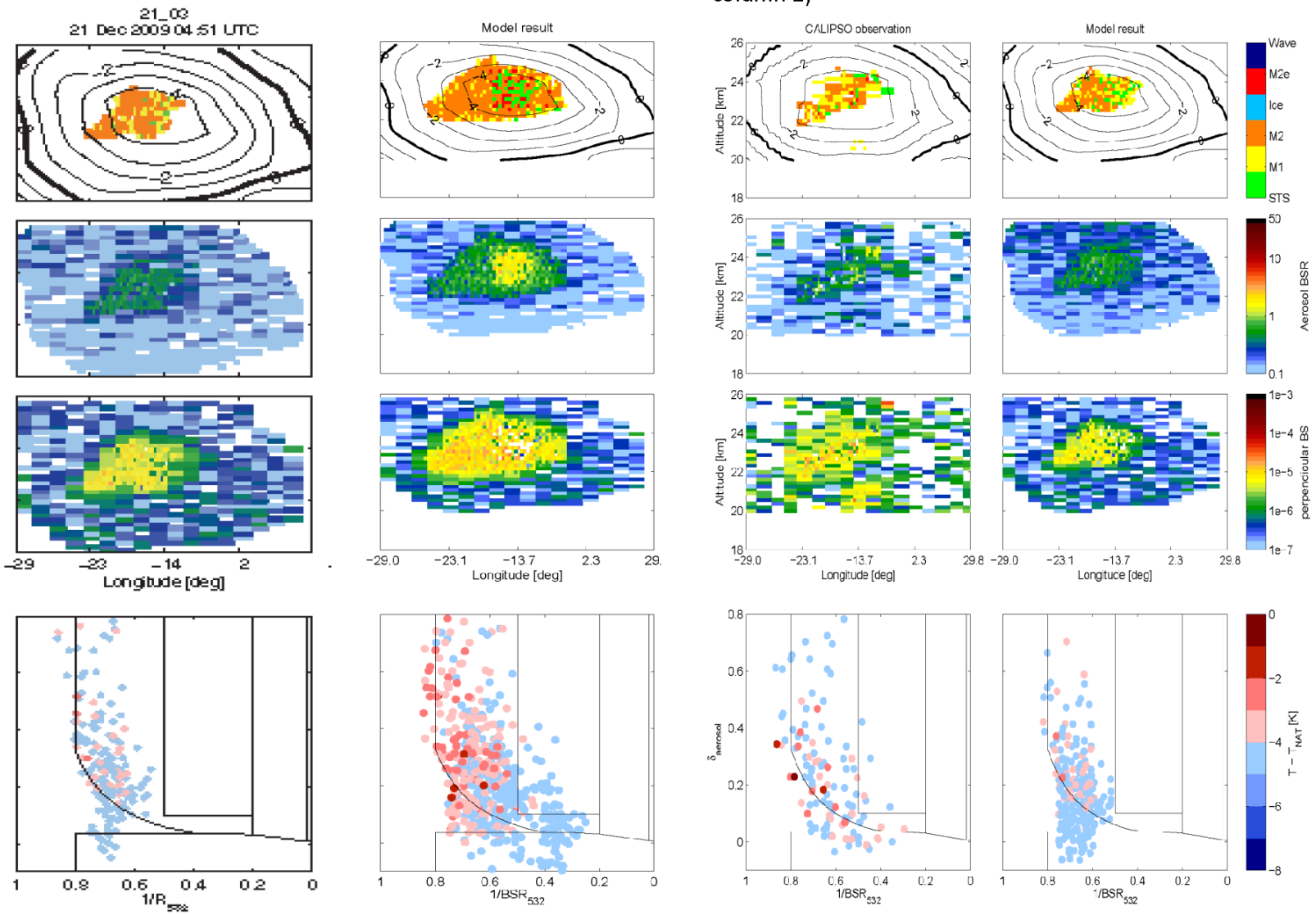
Results and observations for orbit 3, 21 Dec (c.f. Figure 8, column 2)

Our parameterisation from paper

Temperature reduction by 1K

Observed values (i.e. Fig 7 column 2)

STS 21/cm^3 7.5/cm^3 of which contain a solid nucleus.



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