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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Lagrangian simulation of ice particles and resulting dehydration in the polar winter stratosphere" *by* Ines Tritscher et al.

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We would like to thank the anonymous reviewer for reading this manuscript and offering suggestions for improvements. In the following, we respond to his/her comments.

## Minor comments

**p.11, l.13-14.** *The maximum of PSC occurrence seen by MIPAS at 15 km is explained by the possible contamination of PSC detection by cirrus clouds and/or aerosol remaining in the stratosphere after Sarychev eruption. I think the occurrence of cirrus clouds at this level during winter at high latitudes is too rare to introduce* *such a strong signal. Post-Sarychev sulfuric aerosol sounds more reasonable however I wonder if this aerosol could also bias the CALIOP PSC detection. I suggest that the authors clarify this point. A more general question on the subject: could the presence of volcanic aerosol in the polar vortex enhance the formation of PSC?*

To reply to this comment, mentioned in all three reviews, we further improved Figs. 2 and 6 of the manuscript. The ACPD version shows solely PSC clouds detected by CALIOP and simulated by CLaMS. However, the MIPAS data include cirrus clouds as well, even though they are often misclassified as NAT. Therefore, we now include cirrus data from the CALIOP data set. By doing this, it becomes evident that CALIOP observes cirrus clouds throughout the entire 2009/2010 season at altitudes below 15 km. CALIOP also observes some NAT mixtures at lower altitudes, but these are likely cirrus that have been misclassified. In reference to the comment on volcanic aerosol, MIPAS is highly sensitive to volcanic aerosol whereas CALIOP will consider volcanic aerosol as part of the "background". If the aerosol is widespread, it will not be included in the CALIOP PSC product since it just identifies outliers. Only if it is a localized plume, then it would be identified as PSC. In CLaMS, we do not simulate clouds other than PSCs. The origin of the large PSC area at low altitudes seen in the CLaMS PSC area panel can be explained by the altitude independent fixed detection threshold of 3.3 $\mu m^2\,cm^{-3}$ for STS droplets. At altitude levels around 12 km, the Junge layer becomes visible as well. To reduce the large "PSC area" in CLaMS at low altitudes, we introduced now a temperature threshold to this plot. Only data points with temperatures less than 200 K are considered. This temperature threshold reduces the maximum values slightly.

We explained this now in more detail in the paper as well.

To the last more general question: In our understanding, the presence of volcanic aerosol in the polar vortex would enhance PSC formation at least in





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the northern hemisphere. It would increase the number of heterogeneous nuclei and therefore increase the probability of NAT and/or ice nucleation. Of course, temperatures and the availability of water and nitric acid plays a role, too. In the southern hemisphere, where temperature are well below the frost point anyway, the additional presence of volcanic aerosol might not change the total number of PSCs. It might lead to an earlier occurrence of PSCs in the season. However, this question could be the focus of further, detailed research.

**p.13, l.10-11.** *If I understood correctly this sentence, it suggests that the overestimation of NAT occurrence by CLaMS with respect to CALIOP observations may be caused by denitrification (supposedly underestimated by simulation). However, this statement is at odds with what can be inferred from Fig. 10, where CLaMS produces even stronger denitrification than that derived from MLS observations.*

We realized that our explanation was too short. Therefore, we tried to make this point more clear.

"A comparison between MLS and CLaMS $HNO_3$ mixing ratios is acceptable but reveals differences. CLaMS $HNO_3$ gas phase mixing ratios around 500 K potential temperature are lower than the observations for the whole season. However, from August on, a layer of high $HNO_3$ values below 500 K points to the possibility that the redistribution of $HNO_3$ is not efficient enough in the simulation and needs to extend down to lower altitudes. This might explain the simulation of NAT particles in areas which are almost cloud free in the observations as seen in Fig. 7. Even though CLaMS gas phase mixing ratios of $HNO_3$ might be even lower than observed at that time, $HNO_3$ in the model could still be present in the particle phase and could not be redistributed correctly to lower altitudes."

**p.13, l.26-28.** *"The total magnitude of dehydration is slightly smaller in the simulations*





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Discussion paper

*than in the observations, which agrees with the impression that CLaMS simulations produce less ice than observed." I did not get the same impression. Instead, Fig. 6 rather shows that CLaMS produces at least as much ice PSC as observed by CALIOP or even more.*

After producing a new panel for Fig. 10, showing the quantitative deviations in stratospheric water vapor between MLS and CLaMS, we now agree with this comment. We therefore changed the text in the manuscript accordingly.

"Overall, over the entire season, CLaMS simulations somewhat underestimate ice occurrences on several occasions (e.g. Fig. 8, July and August). However, Fig. 6 gives the impression that the areal coverage of ice PSCs is at least as large as in the observations. [...] The temporal evolution of gas-phase water vapor and nitric acid as measured by MLS and simulated by CLaMS is presented in Fig. 10. [...] The difference between measurements and simulations are quantified in the right panels (Fig. 10). The minimum values of $H_2O$ match very well. The layer of rehydrated air around 350 K potential temperature is slightly less than in the observations meaning that $H_2O$ mixing ratios are smaller in the simulation than in the observations."

**Fig. 6.** *There seem to be different upper limits of the color scale in the upper-row plots. Do these plots really have a unique color scale?*

They do have the same color scale. Only the maximum value differs and is written as upper limit on top of the color scale. We repeated the hint "Please note that the color code is always identical except the maximum value of the top color bin." given at Fig. 2 also for Fig. 6.

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