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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Do gravity waves significantly impact PSC occurrence in the Antarctic?" *by* A. J. McDonald et al.

Anonymous Referee #4

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1. General Comments

This paper attempts to quantify the impact of gravity waves on PSC occurrence in the Antarctic through analyses of POAM III aerosol extinction and water vapor measurements and UKMO and CHAMP-GPS temperature data. The overall importance of gravity waves on PSC formation is still an open question and this topic should be of interest to ACP readers. The authors use a clustering algorithm to identify PSCs in the POAM III aerosol extinction data. Then, the observed POAM III PSC occurrence rates are compared with the frequency that UKMO temperatures drop below TNAT, a proxy for PSC occurrence. On average, the observed POAM III PSC occurrence rates are lower than would be predicted based on the UKMO temperature departures below TNAT; a result the authors claim would be expected based on a number of microphys-

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ical arguments. However, in certain years (e.g., 2002 and 2005) the observed POAM III PSC occurrence rates in early winter (June and July) actually exceed the expected PSC occurrence based on the temperature perturbations below TNAT. The authors then attempt to demonstrate that at least part of this discrepancy can be explained by gravity wave-induced temperature perturbations below TNAT that are not resolved by relatively low-resolution UKMO analyses, but actually are resolved by the higher resolution CHAMPS-GPS temperature data. The authors conclude that gravity waves can account for as much as 40 percent of TNAT threshold crossings in June, but only about 15 percent in other months. In other words, gravity waves can have a significant influence on PSC formation early in the season, but have a smaller impact later.

Although, in general, the idea to analyze PSC observations in combination with high resolution temperature data is a reasonable approach for quantifying gravity wave impacts, there are some fundamental issues with the overall analyses that need to be addressed before the paper can be considered for publication. First of all, the inherent latitude sampling bias of POAM III (measurement latitude slowly drifting from 65S to 90S from June to September) needs to be addressed early on in the paper and the results need to be interpreted in terms of this bias. Since POAM III doesn't sample the Antarctic Peninsula (so-called gravity wave 'hotspot') after early winter, how can you adequately assess the impact of gravity waves from over the Peninsula on PSC formation later in the season? Is it possible that your main conclusion is just an artifact of the POAM III sampling latitude bias? Results based on occultation datasets such as POAM III are strictly representative of their sampling latitudes and not of the polar region as a whole. A PSC dataset with more representative sampling such as MIPAS or CALIPSO would be much better suited for such a study. Secondly, doesn't observational filtering of the gravity waves resolved by the CHAMP-GPS instrument likely result in a general underestimation of the presence of gravity waves? Therefore, the number of gravity wave-induced temperature perturbations below TNAT is almost certainly being underestimated with the CHAMPS-GPS data. You should address these issues in more detail and discuss the potential impacts on your conclusions.

ACPD

9, S402–S406, 2009

With the sampling issues mentioned above, it is really difficult to study the seasonal variability of gravity wave impacts using the POAM III data. However, given the multi-year dataset, the year-to-year variability in gravity wave influences could be examined. For instance, you could focus on June and July (when POAM III sampled the latitudes of the Antarctic Peninsula) to see how gravity waves impacted PSC formation from year to year. Just a suggestion for future work.

Additional minor comments are listed below. Once all these comments are satisfactorily addressed, I would recommend publication in ACP.

2. Specific Comments

P3402, L12: you are being too general here- POAM III observations of PSCs are more abundant than expected from temperature thresholds in June in only 2-3 out of 8 years.

P3403, L18: you mention here that the PSC 1a enhanced is relevant to this study, but the only mention of it later is in a reference to an Arctic study. Either remove this sentence or include a discussion later of its relevance to this study.

P3404, L7: ice condensation point? Do you really mean ice frost point?

P3404, L17: this period was actually in 2003 not 2005. You should really spell out all acronyms the first time they are introduced, such as MIPAS.

P3406, L1-4: The Felton et al. study was based on data from the SOLVE campaigns which were Arctic missions. What's the relevance of this study to the Antarctic?

P3407, L18-19: Using POAM III data (with its inherent latitudinal sampling bias), the present study will also not be able to quantify the importance of gravity waves across the entire Antarctic!

P3408, L19-20: This would be a good place to insert a discussion of the POAM III sampling bias.

P3409, L4: I'm a bit confused here. You mention that your algorithm identifies both

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9, S402–S406, 2009

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Type 1a and 1b aerosols. In the next sentence you say that you don't differentiate between them. Then on the next page, you mention again a second algorithm for separating PSCs into Type 1a and 1b. You need to clarify this.

P3409, L15: 'none PSC' should be 'non-PSC'

P3410, L5-9: What about early in the Antarctic season, such as June. There aren't a lot of PSC observations then- does that impact your ability to identify meaningful clusters?

P3410, L10-14: Do all Type II ice clouds produce high Zmin events in the POAM III data?

P3410, L25: Since the true vertical resolution is 1.4 km, the data is really provided at a vertical 'spacing' of 200m, not at a vertical 'resolution' of 200m.

P3410, L26-38: What effect does the large measurement volume along the LOS have on resolving gravity waves?

P3412, L12: What exactly do you mean by 'strong correspondence'? From Fig. 3, I see a correlation between high PSC occurrence and cold temperatures, but I don't see any particularly strong correspondence in June and July- can you expand on this a bit more?

P3412, L22: It is really difficult to see the uncertainties in Figure 4.

P3414, L14-17: I believe that the Pitts et al.(2007) study attempted to account for denitrification and dehydration in their Tnat and Tsts calculations, but still found that Tnat overestimated the observed PSC occurrence significantly.

P3415, L13: Just curious why you didn't select an example from 2002 or 2005- years in which the observed PSC occurrence rates exceeded that predicted by Tnat?

P3415, L25: Lots of problems with Fig.6! The figure caption needs to be revised to reflect the correct line and symbol colors. Do the CHAMP temperature probability points represent monthly zonal values for the POAM III measurement latitudes? Are

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9, S402–S406, 2009

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there multiple red lines representing the three HNO3 mixing ratio values? I can only see one red line. The bottom panel of Fig.6 is confusing- can you please clarify what the blue line and green stars actually represent? I cant' see any error bars.

P3416, L1: This sentence is poorly worded. Do you mean that each PSC occurrence value in Fig. 6 is based on the average of up to 1820 POAM III measurements?

P3416, L2: What is this 'value' and why does it depend on the quality of the observations?

P3418, L9-11: The MIPAS study was based on data from 2003, not 2005.

P3418, L22: I don't understand what you are showing in Fig.9. Can you explain in more detail how you derived these data? How did you produce the multiple points per month?

P3419, L9-12: What is the relevance of this Type 1a-enhanced result for the Arctic to your study?

P3420, L1-2: With the POAM III sampling pattern, is it not likely that you are also underestimating the importance of gravity waves in August-October?

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 3401, 2009.