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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Inclusion of mountain wave-induced cooling for the formation of PSCs over the Antarctic Peninsula in a chemistry–climate model" *by* A. Orr et al.

Anonymous Referee #3

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Inclusion of mountain wave-induced cooling for the formation of PSCs over the Antarctic Peninsula in a chemistry-climate model by Orr et al.

This study examines a method for including mountain wave cooling effects on Polar Stratospheric Clouds over the Antarctic Peninsula in a coarse-resolution model that does not resolve the mountain waves. The study includes comparison to a wave-resolving limited-area model and to wave-resolving satellite observations. This is a unique and generally well-executed study. The manuscript is also generally well written.

Major Concerns:

1. Changes in PSC area in the model are discussed throughout the manuscript in a quantitative manner. However, the decision to include only the cooling phase of the clouds renders these numbers a bit dubious. While there is clear justification for including only cooling effects in the chemistry calculation, this is not at all clear for the PSC area calculation where exposure to both the cooling and warming phases is likely to be important. This is explained in context in the comments below. The suggestion is to discuss these numbers more qualitatively due to the uncertainty associated with the assumptions in the method.

2. "Upstream influence" on PSCs is not mentioned until the summary section of the paper, yet it is apparent in Figure 11 that was presented much earlier. This upstream influence is never adequately explained in the paper. Both Figures 6 and 11 should be plotted without smoothing to make the coarse resolution of the result more clear. This coarse resolution may also influence any discussion of upstream influence, so this should be clarified prior to publication. Suggestions to alleviate this concern appear in context in the section below.

Detailed Comments:

Page 18292, (Also mentioned on 18288) line 6: "only mountain wave cooling being used" and line 28-29: "The effect of the parameterisation on PSCs is investigated by evaluating the 30 year average difference in PSC surface area density between the perturbation and control" Since parcels would alternately feel both the cooling and heating phases of the orographic wave, this approach needs better justification before showing PSC surface area density. The use for evaluating frequency of occurrence of cold T is fine, but here you look at PSC area. The time a parcel experiences the cooling phase will be half of the wave intrinsic (Lagrangian) period. This will be much shorter than the Eulerian period for stationary mountain waves. PSC particles may not grow very large in this time and might sublimate again in the neglected wave warm phase.

Hence the method may grossly overestimate PSC area.

18278, 18-21: “increased stratospheric cooling was passed to the PSC scheme of the chemistry–climate model, and caused a 30–50 % increase in PSC surface area density over the Antarctic Peninsula compared to a 30 year control simulation” Including only cooling makes these PSC area statistics a bit dubious. Suggest deleting these specific numbers from the abstract, and instead discussing this more qualitatively. The assumptions do not warrant such a quantitative statement.

18290: Fig 6b would illustrate the point better if plotted without smoothing of the field. This would more clearly show that this is a coarse resolution result. The smoothed field implies the result applies to higher resolution.

18293, 20 and Figure 11: Comment on the mechanism for upstream influence of mountain waves on the PSC area seen in Figure 11 is needed here. How that would come about is certainly not intuitively clear. Is this a model grid/coarse resolution effect? As also suggested for Figure 6, plotting the true coarse resolution result here without smoothing would be clearer and more representative, for example, it may help to understand the upstream influence on PSC area.

18294, 6-8: “This in turn is also a good rational for using the negative temperature anomalies only for the call to the chemistry scheme.” Yes, but you further examine geographic distributions of PSC frequency (e.g. Next page line 9), a quantity that would be greatly affected by processing of air parcels through both cold and warm phases.

18294, 9-11: “So for a grid-box averaged PSC coverage only additional incidents below the threshold temperature increase the coverage” Something is wrong with this sentence structure, and the meaning is completely cloudy as a result.

18294, 11-12: “Certainly for such an assumption to be true the sub-grid wave train should be slowly evolving horizontally compared to the model time step” This statement mixes space and time scales in a nonsensical way. A method to connect the wave

scale to the model time step is with the use of the Lagrangian wave frequency (intrinsic frequency). This can be computed easily from your wave-resolving model simulation for the purpose of this discussion.

18294, 29: “due to it representing” "It" here is ambiguous due to a run-on sentence. Suggest splitting this sentence in two.

18295, 23: “allow” Do you mean “permits”? The sentence is rather long, but the subject of this verb is apparently “state”, so use “permits” or “allows”, or rewrite the sentence for clarity.

18295, 20-21: “The simulation of PSC differences both upstream and downstream of the Antarctic Peninsula” This is the first mention of the upstream influence of the waves on PSCs. It should have been discussed when Figure 11 was introduced. How much of this upstream influence is simply due to the coarse resolution of topography? Perhaps all?

18296, 11-15: “However, future work will investigate replacing the quasi-equilibrium PSC scheme with the full microphysical scheme DLAPSE (Den-itrification by Lagrangian Particle Sedimentation), which uses a Lagrangian trajectory scheme and as such is able to transport PSC particles away from the region of formation” If this is done, representing both warm and cold phases of the gravity waves would become essential.

Figure panels are too small in Fig. 2 and 3, but perhaps this will be remedied when the publication appears in full-page format?

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 18277, 2014.