Response to Reviews

On our paper acp-2009-695 "First climatology of Polar Mesospheric Clouds from GOMOS / ENVISAT stellar occultation instrument". We thank both reviewers for their attention to our paper. We greatly acknowledge their comments and suggestions. Below we present the detailed replies to each referee comment.

Review #1

Specific comments:

Bodil Karlsson

1) Page 25600, line 24 -25: The sentence that reads "They occur at latitudes greater than 55. . ." Consider adding the word "typically" before "occur" - the clouds are sometimes seen at lower latitudes.

Authors

This modification was taken into account in the revised manuscript.

Bodil Karlsson

2) Page 25601, line 7 – 8: Consider exchanging the word "attenuation" with "breaking" since the word attenuation can be a bit misleading: (the gravity waves break and deposit the momentum they carry onto the background flow, hence distorting the local (geostrophic) balance, which in turn lead to the meridional poleward flow in the summer mesosphere - and, by continuity, upwelling above the pole.)

Authors

The word "breaking" is indeed more suited. This was corrected in the revised version.

Bodil Karlsson

3) Page 25604, line 5 - 6: Are the photometers' signals integrated over the wavelength range 470 - 520 nm, and 650 - 700 nm, respectively?

Authors

Yes, this is correct. We clarified this in the revised version.

Bodil Karlsson

4) Page 25604, line 28 - 29: In the sentence that reads ". . . as will be described in the next section" – here it would be helpful to be more specific. Thus, I suggest adding "3.2" after the word "section".

Authors

This modification has been taken into account in the revised manuscript.

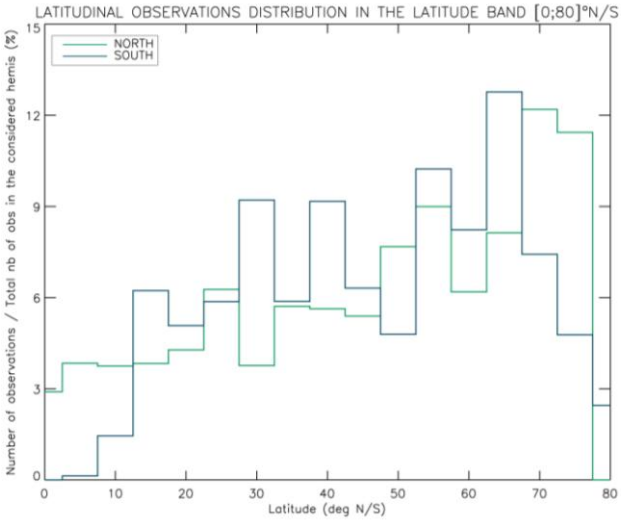
Bodil Karlsson

5) Page 25605, line 5 – 20: In this paragraph, the differences between the viewing conditions in the NH and SH are discussed. Are the number of observations at latitudes lower than 80° approximately the same for the two hemispheres? If not, is it possible to quantify the differences (e.g. percentage

differences in number of observations)? Is the latitudinal distribution of the observations roughly the same (except for pole-ward of 80°, as already explained in the text)?

Authors

The number of observations at latitude lower than 80° is not the same for the two hemispheres: there are even more data in the south and this difference is rather significant. During the PMC season, there are indeed 18% less observations in the NH than in the SH, and the latitudinal distribution is different. At latitudes higher than 55°, where the clouds are most likely to occur, the southern observations are 6% more numerous than in the North up to 70°, but they are 50% less numerous between 70° and 80°.



These precisions have been added in the revised version.

Bodil Karlsson

6) Page 25608, line 13-20: From my understanding, a 3rd degree polynomial is fitted to each and every profile (with or without clouds). Each fitted curve (the dashed lines, which are referred to as the modeled curves) is then compared to its corresponding 'original' profile (i.e. the one that it was fitted to) – is this correct? Or are all the profiles least-square fitted to one and the same modeled (cloud free) curve? It is not clear from the text that the polynomial fit is carried out on profiles containing clouds, but from Figure 4, it looks like this is the case. This could be clarified a bit further. Also, it is a bit unfortunate that the dashed lines in Figure 3 are not distinguishable – the first impression is that these curves are accidently missing or that the legend is wrong. It might help if the dashed lines are made thicker and the solid lines are made thinner. This is however not critical, since an explanation is given in the text. It would be helpful to indicate the wavelengths of the blue and the red curves in the figure caption (Figure 3 and 4).

Authors

Yes, you read right: the polynomial fit is carried out on each profile, with or without clouds. It is true that the wording was somewhat misleading. We clarified this a bit further in the revised manuscript.

Moreover Figure 3, and then Figure 4 also, has been modified. We thickened the dashed lines and changed their color in order to distinguish them. (However, the solid lines cannot be thinner; they are already made as thin as possible, as you can see in the caption. Their thickness is due to the intrinsic variability of the photometers measurements.)

The wavelengths corresponding to the blue and the red curves have been added in the figure title.

Bodil Karlsson

7) Page 25611, line 7 – 14 and Table 1: In the table it appears like the NH season 2005 started unusually late – on June 22 (day +1 relative to solstice). From figure 8 and further reading of the

paper, this late start seems to be connected to lack of data rather than a delayed onset of the NLC season. It would be good to point that out already here, in this paragraph.

Authors

This was clarified in the revised version, both in the text and in the table caption.

Bodil Karlsson

8) Page 25612, line 24: In the sentence that reads "Lübken et al. (2009) also found a significant decrease in the occurrence frequency in 2005. . ." - Is the 'also' in that sentence related to the NH season 2005 as observed by GOMOS (e.g. significantly smaller occurrence frequencies than the other NH seasons, as shown in Figure 6)? If it is, it might be worth pointing out the reduced amount of data for this season (see previous comment) once again.

Authors

Yes, the word "also" in that sentence is related to the NH season 2005 as observed by GOMOS. A similar year-to-year variability was observed by the LIMA model (see Lübken et al., 2009, Fig. 3). In the northern hemisphere, the second half of the month of July is always characterized by the highest PMC occurrence frequency, and, in 2005, GOMOS resumed its normal operation on July 18. As a result, we believe that the value obtained for the second half of July was not affected by the encountered instrumental problems, and therefore shows a significant decrease in the frequency, also observed by LIMA. This is why we do not believe that pointing out the reduced amount of data is useful in this paragraph.

Bodil Karlsson

9) Page 25612, line 25-27: As I understand it, the variation between 5% and 85% (and 10% - 50% in the SH) is related to the intra-seasonal changes in occurrence frequency, and not to the year-to-year variability – is this correct? This could be clarified, e.g. by removing "from year to year" on line 27 (or replace it with e.g. "within a season").

Authors

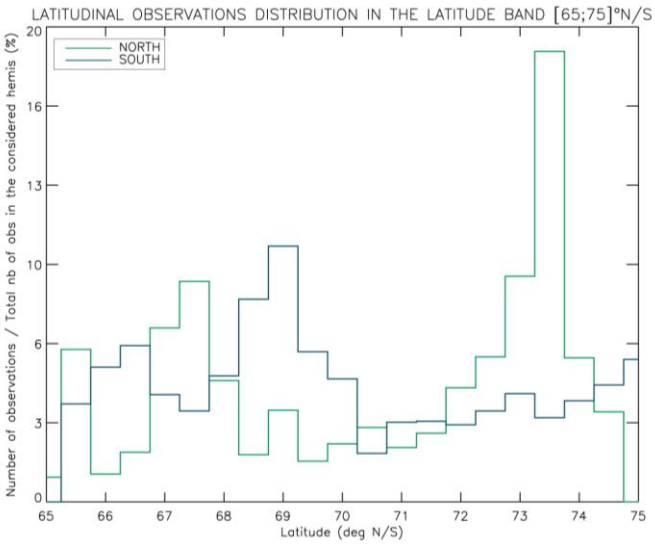
This is correct. We clarified this in the revised version.

Bodil Karlsson

10) Page 25613, line 1-5: How are the observations distributed between 65° and 75° N compared to 65° and 75° S (see previous comment 5)? Are there, for example, more observations at the higher latitudes in the NH than in the SH in this latitude band? If the observations are relatively evenly distributed in these latitude bands, or distributed in a similar manner, the comparisons between the hemispheres should be adequate.

Authors

The figure opposite represents the latitudinal distribution of GOMOS observations between 65° and 75°. As you can see, the observations are distributed rather unevenly: they are more numerous at higher latitudes in the North than in the South. This explains why we stay cautious about our conclusion on the interhemispheric comparison. Noctilucent clouds are more frequent in the NH than in the SH, but this difference is somewhat difficult to quantify precisely.



Bodil Karlsson

11) Page 25614, line 20: I suggest adding "(bottom)" after the word "second" for clarification.

Authors

We clarified this in the revised version.

Bodil Karlsson

12) Page 25615, line 5 – 9: Could you specify the range of scattering angles covered in the NH and in the SH, respectively? Also, I think the differences between the hemispheres will be reduced rather than amplified (line 8) by GOMOS viewing geometry: the SH clouds, which in general are considered to be dimmer and less abundant than the NH clouds, will 'benefit' from being viewed at smaller scattering angles – dimmer clouds may be detected in the forward regime, which might add to the frequency of occurrence. The same (but reversed) arguments apply for the NH: fewer clouds may be detected in the backward scattering regime.

Authors

Scattering angles range from 73° to 180° in the northern hemisphere, and from 40° to 151° in the southern hemisphere.

As a consequence, we did not suggest that the differences between hemispheres are amplified by GOMOS viewing geometry, but rather that, in case this effect would be accounted for, these differences would be even greater than those observed (hence the word "considering" line 8, see the 4th technical correction).

We clarified this in the revised version.

Bodil Karlsson

Note: SCIAMACHY is viewing the PMC in the forward scattering regime in the NH and in the backward scattering regime in the SH, so exactly opposite to what GOMOS observes – it might be fruitful to compare occurrence frequencies measured by the two data sets in the future; such a comparison could perhaps reveal possible biases in occurrence frequencies due to differences in scattering angles and, if there is a bias, could help to quantify it.

Authors

It could actually be very interesting to compare these two data sets. This is an excellent suggestion.

Technical corrections:

All technical corrections have been taken into account in the revised manuscript.

Review #2

Specific comments:

Reviewer #2

1) Page 25602, lines 22-23: recent results of [Murray et al., 2009; Zasetsky et al., 2009a, and Zasetsky et al, 2009b] specifically address the mesospheric ice nucleation mechanism and formation rates can be mentioned in this section.

Authors

It is actually worth mentioning these recent results in this section. These references have been added to the revised manuscript.

Reviewer #2

2) Page 25605, lines 1-3: please rewrite this sentence, possibly as: 'This, however, does not affect our results on PMC climatology as these clouds do not form in the winter mesosphere."

Authors

This sentence has been rewritten in the revised manuscript.

Reviewer #2

3) Page 25605, line 23: [Stevens et al., 2009] have published the detailed analysis of the diurnal variations in PMC properties at mid-latitudes. Perhaps this work should also be mentioned.

Authors

This reference has been added to the revised version.

Reviewer #2

4) Page 25606, line 13: "other sources" that contribute to the signal should be either described, or at least mentioned here.

Authors

Other sources that contribute to the signal are mentioned in the sentence immediately following: "The sensor indeed detects the solar light scattered at the limb by the molecules (Rayleigh scattering) or by particles." The contribution of atmospheric molecules is then described. And the contribution of particles, which actually corresponds to the case where a cloud is present, is described in detail in the following paragraph. This sentence is simply intended to emphasize the fact that the measured signal does not solely include the light of the star, although GOMOS is a stellar occultation instrument. This sentence was written to avoid any kind of confusion and to clearly explain the detection algorithm that we used.

Reviewer #2

5) Page 25608, line 4: does the solar zenith angle of 94° correspond to the daylight conditions? The sun is well below the horizon in this case. Please clarify.

Authors

Indeed, this needed to be clarified.

The considered solar zenith angle (SZA) is not measured at ground level, but corresponds to the SZA at the tangent point, averaged for each occultation between 50 and 100 km. The sun goes below the horizon when the SZA at ground level is equal to 90° (if we neglect the atmospheric refraction), but the upper layers of the atmosphere are still illuminated. At the PMC altitude, around 80 km, the sun sets when the solar zenith angle is around 99°.

In this study, we selected all cases with a SZA lower than 94° (and not 99°), because this provides the optimal conditions to our detection algorithm. The choice of this threshold value is based on a sensitivity analysis in which the detection algorithm was run for a representative data sample. For cases with an angle greater than 94°, mesospheric clouds are not sunlit enough to be detected by GOMOS. For a PMC illuminated with a 94° SZA, the lower altitude reached by the sunlight is about 55 km and the absorption along the line of sight becomes to be important.

We clarified this in the revised version.

Reviewer #2

6) Page 25613, lines 8-12: comparison of GOMOS PMC properties for these seasons with other instruments' results may help to identify and maybe even quantify the instrument effects.

Author

GOMOS actually encountered some technical problems, which affected measurements, but only during very well defined periods. The main ones occurred in 2003 and 2005 (see GOMOS monthly reports at: http://earth.esa.int/pcs/envisat/gomos/reports/monthly/ for precise dates of these periods, during which the instrument provided no data). We would like to clarify that these problems had no other effect than data loss during those periods, and therefore the results presented in this paper were calculated from data obtained under normal operating conditions. Moreover, as explained in response to the 8th Bodil Karlsson's comment, the reliability of the results presented in Fig.6 was not affected by these technical problems.

Maybe we were too conservative in our conclusion. We tried to clarify this point in the revised version.

Technical corrections:

The first four technical corrections have been taken into account in the revised manuscript.

Reviewer #2

Page 25606, lines 23-24: please rewrite this sentence. In its present form it reads as the scattering process is governed by the Mie theory.

Authors

That is exactly what we meant: the process that occurs is the Mie scattering. We have rewritten this sentence anyway, in order to clarify this point.

Reviewer #2

Figure 5: all labels near and inside the panels are too small to read. Maybe the landscape format will allow for more space for larger fonts.

Authors

Figure 5 has been more clearly stated (larger and thicker fonts, no more labels inside the panels, and fewer meridians and parallels). However we prefer to keep the portrait format which is, in our opinion, more appropriate to the column format of the final revised paper.