Atmos. Chem. Phys. Discuss., 13, C6046–C6051, 2013
www.atmos-chem-phys-discuss.net/13/C6046/2013/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Gravity wave influence on NLC: experimental results from ALOMAR, 69° N" *by* H. Wilms et al.

Anonymous Referee #1

Received and published: 22 August 2013

General Comment

The paper by Wilms et al. investigates the influence of gravity waves on the occurrence of NLC over ALOMAR. The data span the years 1999–2011, a relatively long period. One main improvement is that both NLC and gravity waves are observed in the same volume.

The analysis is very detailed and confirms previous findings that there is no strong correlation between gravity wave potential energy and NLC occurrences over ALOMAR considering the whole data set. For one subset of 12h in the year 2008, however, good correlation is found.

There are two minor concern:

(1) When discussing influences on the occurrence rate of NLC, the main focus is on gravity waves and their variations. There are however also other factors that are important for the formation of NLC. Only tides are mentioned. However also background temperature and planetary waves could play an important role. Their possible effects should also be mentioned.

(2) Tides and mesoscale gravity waves cannot be clearly distinguished in the data. Of course, an improvement of the analysis is therefore very difficult. Nevertheless, tides could bias the results. This should at least be mentioned!

The paper is well written and contains valuable and new information that is of interest for the readership of ACP. The paper is therefore recommended for publication in ACP after addressing my minor comments and the specific and technical comments, as detailed below.

Specific Comments

1. p.20050, ll.18–23: The strong seasonal cycle of temperature in the mesopause region provides the low temperatures needed for NLC to form and is therefore the main driver for the onset of the NLC season during summer. This is never mentioned in the whole introduction (only decadal variations, tides and gravity waves)! Please include this information!

2. p.20051, l.9: It should be mentioned that also planetary waves can strongly influence the distribution of NLC. For example, Dalin et al., JASTP, 2008, Merkel et al., JGR, 2008 and Merkel et al., JASTP, 2009.

ACPD
13, C6046–C6051, 2013

3. p.20052, l.4: Preusse et al., 2009 is mainly a theoretical study. There is also more direct indication from observations that non-vertical propagation of gravity waves could be important (Ern et al., JGR, 2011, 2013). This effect seems to be strongest in summer and could have influence on NLC. This should also be mentioned!

4. p.20056, l.4: What is the "gravity wave range"? Is this the range of wave periods 3–15 hours? Please add this information!

5. pp.20055/6 and Fig.1: The "averaged global wavelet spectrum" contains strong peaks due to tides: diurnal, semidiurnal and a weak peak of the terdiurnal tide. The semidiurnal tide is the by far strongest peak in this spectrum.

   Also the "reference variances" that are assumed to be caused by gravity waves contain the tidal peaks and are therefore biased in these wave bands. In addition, temporal fluctuations in these wave bands could be caused by tides rather than mesoscale gravity waves. This should at least be mentioned!

6. p.20056, l.14: Because there are fewer high kinetic energy events, it should be clear that there are fewer NLC observations during these events. Considering the relative occurrence rates in Figs.2 and 3, however, there is only little dependence on kinetic energy.

   The statement there would be "less" NLC during high kinetic energy events is therefore somewhat misleading.

7. p.20057, Fig.3: It should be mentioned that tides could bias the distribution of the 11h spectral band (semidiurnal tide). Possibly also the 7h and 9h spectral bands are affected by the terdiurnal tide, but certainly to much less extent. Overall, the effect of tides does not seem to alter the distributions much.

8. p.20057, l.16: Is the "summer season mean" an average over JJA? Is this also representative for the "NLC season"?

ACPD
13, C6046–C6051, 2013

9. pp.20058/9: In Fig.5 the dependence of η on the wave periods is discussed. Again, it should be mentioned that tides could influence the values at longer wave periods. However, there does not seem to be a strong effect.

10. pp.20058ff, Figs.5, 7–9: The parameter η is only shown for wave periods up to 12h. Please provide also values for longer periods, if possible.

    For longer wave periods the correlation between gravity waves and NLC should be strongest.

11. pp.20058/9, discussion of Fig.5:
    What was the average background temperature during the NLC events in the different years? I would expect that the background temperature has a strong effect on the correlation between NLC occurrence and wave activity. Maybe during the strong wave events in 2008 the background temperature was closer to the NLC temperature threshold. Perhaps this could explain the differences between the different years.

12. p.20059, l.19: "...increased gravity wave activity" is somewhat misleading, better: "...the longer duration of gravity wave activity at high kinetic energies"

13. p.20060, l.18: "in the long term limit" is misleading, better: "for $\beta_{\text{max}} = 4 \times 10^{-10}$ m^{-1}sr^{-1}"

14. p.20060, Fig.9: Could the reduction of η around 8h be an effect of the terdiurnal tide?
    If so: could there be a similar effect of the semidiurnal tide at periods 11h and 12h?

15. p.20061, ll.14/15: Possible effects of horizontal advection should be mentioned (see Gerding et al., 2007).

ACPD
13, C6046–C6051, 2013

It may not always be true that by common volume observations the same waves that are responsible for NLC formation are probed. Also horizontal advection of ice clouds could play a certain role. As stated by Rapp et al., 2002 the particle growth takes several hours. Assuming a background wind of 40 m/s, the particles could be horizontally advected by 150 km within one hour.
The same waves are therefore only observed if the horizontal scale of the waves exceeds a few hundred km.

16. p.20062, l.29: Could this also be enhanced activity of the terdiurnal tide?

17. p.20063, ll.27ff: There are several more findings by Chandran et al. (2010, 2012) that should be mentioned here:
In Chandran et al. (2010) roughly an anti-correlation between gravity waves and NLC is found. They also find a correlation between temperature and gravity waves. They state that breaking gravity waves could produce local heating, and the enhanced temperatures could reduce NLC.
In Chandran et al. (2012) it is indicated that enhanced long period gravity waves could lead to a short term increase of NLC brightness, but in the long term enhanced gravity waves would in all cases lead to NLC reduction.

Technical Comments

1. p.20052, l.5 extend → extent
2. p.20055, l.23: calculated → calculate
3. p.20056, l.4: increases → increase
4. p.20057, l.10: ... we conclude that at ALOMAR ...

ACPD
13, C6046–C6051, 2013

5. p.20057, l.15: in → into
6. p.20058, l.4: ... total orange framed area,...
7. p.20061, l.5: instead from → instead of
8. p.20061, l.18: mesopause → mesopause region
9. p.20073, Fig.4: ... fraction of the orange shaded area with respect to the orange framed area.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 20049, 2013.