We appreciate the comments from the reviewer and have taken the suggestions into account. In the following we respond to the remarks point by point. Our responses are in italics. Line numbers refer to the revision with changes marked. Changes in the manuscript have been marked in the following way: deleted text in red, new text in blue.

Anonymous Referee #2

(Received and published: 13 July 2018)

SUMMARY

This paper extends other recent studies of lunar tide effects in noctilucent cloud (NLC) observations by using the long data record (21 years) of lidar measurements collected at the ALOMAR observatory in Norway. The lidar measurements supplement other satellite data sets because all local times are sampled, which improves the ability to separate solar and lunar tidal signatures. These data have been used successfully in many other studies of NLC behavior.

This paper is well-written, and the results are generally reasonable. Some suggestions and comments related to specific items are provided below.

SPECIFIC COMMENTS

1. p. 3, line 11: Please give 1-2 references for examples of the application of the superposed epoch analysis method.

We have referenced the first application of this method by Chree, 1912: page 3, line 20.

2. p. 3, line 15: Extending the harmonic fit analysis to a 4th order term (period = 6 hours) requires high data quality to ensure that small noise fluctuations do not alias into apparent real behavior. Given the small magnitudes that are reported for this term in Table 1, is there any to demonstrate statistically that using it is valid?

6 hour periods are frequently found in lidar observation, e.g. Fricke-Begemann and Höffner [2005], which is the main reason for including the 4th order term in our work. We find the data quality of the solar time series sufficient for this (correlation coefficients between fit and data are close to 1, see Table 1), and use this term for the lunar time series for homogeneity. As you see we have not scientifically interpreted the 6-hour results. On the other hand it appears useful to show the result for 2 reasons. At first it demonstrates that these short periods are (mostly) of small magnitude and do barely contribute to the overall tidal variations. At second it is important to include them for the simulations of the mutual residual impact between solar and lunar tidal oscillations (reliability of tidal parameters). See also point 6 below.

3. p. 4, lines 16-21: The magnitude of the data reduction with the use of a "core" season is not that much different than the reduction when a long-term brightness limit is imposed (35% vs. 48%). It seems more likely that the brightness threshold eliminates some faint clouds that have a greater relative response to the weak lunar signal, whereas the use of a core season may actually improve the opportunity to identify this signal because faint clouds have better background conditions in which to form. If the

authors agree with this premise, I suggest adding it to the discussion.

The long-term brightness limit (BETAmax > 4) removes all faint clouds (1 < BETAmax < 4) which results into completely separated data sets. We also investigated these 2 data sets and found lunar tidal signatures in both of them. Also, the seasonal dependence of faint clouds occurrence is smaller compared to that of brighter clouds, cf. Schmidt et al. [2018] (Fig. 3), which is caused by the seasonal variation of temperature and water vapor. This suggests that faint clouds are not primarily responsible for lunar tidal signatures in the overall NLC population.
We did a small text adjustment: page 4, lines 27-28.

4. p. 5, lines 7-8: Fiedler et al. [2011] show significant interannual variation in amplitude and phase of solar tidal components in NLC properties measured at ALOMAR over 14 years. If similar variations are present in lunar tidal behavior, does that cause a problem for the application of the superposed epoch analysis method, which combines data taken during many separate years?

Such variations would certainly impact the results extracted from this method. We have tried to investigate this topic by splitting the data set (first and last half of the time series). However, despite our large database covering 21 years it seems to be still too small for such investigations.

5. p. 5, lines 21-22: Note that von Savigny et al. [2017] and Hoffman et al. [2018] only present a semi-diurnal variation (as a single fit). So you should be careful in evaluating the agreement (or difference) between amplitudes and phases derived from those analyses vs. the 4-term results presented here. I would not expect complete agreement even if the same data set was examined because of the extra terms present in the 4-term fit.

In principle we agree, but comparing fits and original data at Fig. 2 in von Savigny et al. [2017] suggest barely other periods than a semi-diurnal variation. So, comparing their 12-hour components with ours should be appropriate. See also next point.

6. p. 6, lines 12-14: Some of the terms in the lunar tidal results are barely larger than their 1-sigma uncertainty (e.g. 6-hour period for OF, 12-hour and 8-hour period for Bmax). Since the original lunar signal is fairly weak, are you sure that all of these terms are really significant? Have you looked at fit results using only 2 or 3 terms?

Yes, indeed we calculated all fit results not only for the 4-term version but also for only 2 terms (24- and 12-hour periods) in order to check the influence of the additional terms. It turned out that the fit algorithm is fairly robust, the amplitudes and phases resulting from both fit versions are close to each other. For example, for the 12-hour component of Bmax the deviations between including/omitting 8-hour and 6-hour periods are: 1.7% for amplitude value, 1.0% for amplitude error, 8.7% for phase value, 3.9% for phase error.
We added this information to the text: page 5, lines 18-22.

7. p. 7, lines 28-30: What is the meaning of a negative vertical wavelength? Is this related to the sign of the phase term?

Yes, the phase is decreasing with increasing altitude.

8. p. 8, lines 30-32: Would you expect that a nadir-viewing instrument (such as SBUV), that integrates the NLC signal vertically, would see something like a linear sum of the frequency values at each altitude? Or would it see a weighted sum because the larger (brighter) ice particles are present at lower altitudes?

Good question …, we would expect that such instrument would see a weighted sum because the vertical integration of the scattered light should be dominated by the brighter ice particles. Compared to the lidar, the SBUV signal has a weaker dependence on particle size (r^3 versus r^6) which should result in a weaker weighting. Additionally the anti-correlation between number density and size of the particles might further weakening the weighting.

TYPOGRAPHICAL ERRORS AND GRAMMATICAL SUGGESTIONS
p. 1, line 21: "waver" should be "water".
p. 2, line 2: "Prominent influence have diurnal and semidiurnal components" could be changed to "Diurnal and semidiurnal components have a prominent influence".
p. 2, line 6: "in atmosphere" should be "in the atmosphere".
p. 2, line 18: "overhead" could be changed to "above".
p. 2, line 31: "begin of" should be "the beginning of".

All done.

p. 3, line 1: "a subset of 3100 hours" could be changed to "with a subset of 3100 hours that".

Already changed due to comments by the other reviewer.

p. 4, line 19: "restricts to" could be changed to "restricts the sampling to".
p. 4, line 28: "observed 1997" should be "observed in 1997".
p. 5, line 27: "Limp" should be "Limb".
p. 6, line 8: "make aware" could be changed to "make the reader aware".
p. 6, line 28: "results into" could be changed to "results in".

All done.

p. 6, line 34: "only be small impacted" could be changed to "have only a small impact".

We leave it like it is.

p. 9, line 21: "vertical" should be "vertically".

Already changed due to comments by the other reviewer.

p. 9, line 22: “hinting for” could be changed to “suggesting”.

Done.

References:

Fricke-Begemann, C., and J. Höffner (2005), Temperature tides and waves near the mesopause from lidar observations at two latitudes, J. Geophys. Res., 110, D19103, doi:10.1029/2005JD005770.

Schmidt, F., Baumgarten, G., Berger, U., Fiedler, J., Lübken, F.-J. (2018), Local time dependence of polar mesospheric clouds: a model study, Atmos. Chem. Phys.,18, 8893–8908, doi:10.5194/acp-18-8893-2018.