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Atmospheric Measurement Techniques
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Interactive comment on "Advanced hodograph-based analysis technique to derive gravity waves parameters from Lidar observations" *by* Irina Strelnikova et al.

Anonymous Referee #1

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This paper presents an advanced analysis method for lidar wind and temperature data to derive gravity wave properties. The analysis method consists of 2D-FFT to define the background, a scaling of the amplitudes to remove the influence of growing amplitude with altitude/decreasing density, wavelet analysis in combination with a cosine fit to isolate monochromatic waves, and subsequent hodograph analysis to determine wave properties. The approach is demonstrated for a case study over Northern Norway.

The paper addresses the issue of deriving gravity wave properties from ground-based lidar measurements of wind and temperature in the middle atmosphere. Deriving gravity wave properties is an issue which affects all sorts of measurements from ground-based to spaceborne. Several analysis methods have been developed in the past. They all have their limitations and assumptions which affect the derived gravity waves properties. Development and adaption of gravity wave analysis methods for present types of measurements is an important task. Detailed descriptions of state of the art methods are required for reproducibility and comparability. Therefore, the paper is of interest to the gravity wave community. The presented case study nicely shows what kind of statistics the analysis can reveal with the advantage that it could be applied to even longer time series of lidar data. However, there are some issues the authors should address before final publication.

Major comments:

1) The current structure of the paper makes it hard to follow the story at some point. This is especially true for section 3 (theoretical introduction) which already presents one part of the analysis method, i.e. hodograph analysis. I suggest to include the content of current section 3 in the next section and place the details about hodograph analysis in the respective subsection.

2) Scaling seems to be an essential step of the analysis (section 4.2). Here, you can refer to Wright et al. 2017 who applied the scaling to satellite data. They used a reference altitude in the middle of their observations (41 km). Can you tell if the scaling altitude has an influence on your results? One may question if it's reasonable to scale amplitudes to surface values (z=0) for measurements starting above 25 km.

Wright, C. J., Hindley, N. P., Hoffmann, L., Alexander, M. J., and Mitchell, N. J.: Exploring gravity wave characteristics in 3-D using a novel S-transform technique: AIRS/Aqua measurements over the Southern Andes and Drake Passage, Atmos. Chem. Phys., 17, 8553-8575, https://doi.org/10.5194/acp-17-8553-2017, 2017.

3) I don't fully understand how the fitting process of the cosine functions works. Please, try to clarify. What is prescribed in the first guess? Where do the values come from? See comments P8, L3; P8, L27; P9, L15

Minor/detailed comments:

P1, L12-15: It doesn't seem necessary to give/repeat details about the (hodograph) technique here. ...We identified 4507 quasi monochromatic waves. In the vicinity of the polar night jet...

P2, L2: define small scale (horizontally, vertically)

P2, L7: high resolution numerical modelling is also a useful tool; please remove "only"

P2, L24: again, what is meant by "these small scale waves"

P3, L4: I don't think that geophysical meaningful results are enough to justify the capability of the method at this point. I suggest to simply go with "Finally in section 5, the capability of the method is demonstrated with continuous ALOMAR lidar data during a four day period in 2016.

P5, L3: comment shows up: "%begin equation"

P6, L7: This means your algorithm doesn't take into account stationary waves because they are assigned to the background. Should be mentioned here.

P6, L13: "...which might only be produced by gravity waves...": I don't think this is true and you already mentioned in your introduction that wave structures must be distinguished from e.g., turbulence. The fluctuations need to follow the GW-dispersion relation which is hard to prove in measurements as one usually lacks either vertical or horizontal information of the wave structure.

P6, L19: "...skip this step from the analysis.": this conclusion doesn't make sense to me. Don't you need fluctuations of u, v, T for all the analysis?

P7, Fig. 5: Did you apply zero-padding to the data? You should explain and include the cone of influence of the wavelet analysis. It limits the interpretation of signatures at the edges and the true vertical extent of packages with longer wavelength.

P8, L3: I cannot fully follow the description in this paragraph. You start with a first guess from the scalogram for z0 and vertical wavelength (are you automatically searching for the maxima?). Your fitting reveals intrinsic frequency and propagation direction + corrected z0 and vert. wavelength? The equations for T', u', v' depend not only on z0 and vertical wavelength. Which values are you using for the wave packet width and intrinsic frequency? Propagation direction is calculated afterwards using Eq. A4. Isn't the conclusion then that Eq. A4 is not well performing for intrinsic periods larger than 1h OR the whole fitting process including z0 and vertical wavelength brings some uncertainty?

P8, L12: "For low frequency GW, i.e. those with periods close to the Coriolis period ($2\pi/f$) the fluctuations reveal a circle." This does not agree with the fact that hodograph method/stokes analysis is especially used and appropriate for gravity waves with intrinsic frequencies close to the inertial frequency (<10f), i.e. showing an ellipse in the hodograph?

P8, L27: "Additionally we calculate a vertical wavelength by requiring the hodograph to close the full 360° cycle." How is this done? Why all the effort to correct the vertical wavelength in the previous step if you could use this value anyway?

P8, L1: Did you account for the influence of transverse-shear on the axial ratio of the ellipse? *correction given in: Vincent R.A., Allen S.J., Eckermann S.D. (1997) Gravity-Wave Parameters in the Lower Stratosphere. In: Hamilton K. (eds) Gravity Wave Processes. NATO ASI Series (Series I: Environmental Change), vol 50. Springer, Berlin, Heidelberg *effect was pointed out by Hines, C. 0., 1989: Tropopausal mountain waves over Arecibo: A case study, J. Atmos. Sci., 46, 476-488

P9, L15: "That is, the dominating frequency is used as a zero guess for the fitting of Eqs. 1 to derive exact values of z0 and λz.." Now, I am totally confused (see comment P8, L3)

P11, L1: I think you already have demonstrated how the method works with real data profiles. This section now shows “Finally, this algorithm for a single point in time is subsequently applied to all time points of the entire data set shown in Fig. 2, 3 and 4.” as you say at the end of the previous section. Maybe you can just shift this sentence to the beginning of this section.

P12, L1-8: I recommend to put this paragraph prior to the up/downward discussion of literature.

P12, L6: Any physical explanation for this finding? Enhanced vertical wavelength due to high wind speed?

P12, L10: No scaling of the amplitudes? To enhance the visibility at lower altitudes compared to higher altitudes, it may be useful scale amplitudes in Fig. 10.

P14, L14-15: But didn’t you mention earlier that the sensitivity of your analysis to the chosen background is small?

P14, L17: compare comment P6, L19

P14, L21: Wright et al 2017, see major comment 2

P15, L12: “additional robust algorithm to pick out wave packets automatically”. Isn’t this what your algorithm does already as implicated by “our algorithm resolves many more GWs than it can be inferred by manually applied hodograph technique”? Please clarify.

P15, L14: holographs should be hodographs

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