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Atmospheric Measurement Techniques Discussions

Interactive comment on "Limited angle tomography of mesoscale gravity waves by the infrared limb-sounder GLORIA" *by* Isabell Krisch et al.

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Dear Dr. Hart,

Thank you very much for these very helpful comments!

We included a better explanation of the measurement geometry to make it easier for the reader to follow the study. Also instrument effects are discussed in more detail. Further, we clarified that the paper is mainly based on synthetic data and only one Chapter uses real measurements.

Please find detailed answers on all your comments below.

Sincerely, Isabell Krisch

P2L23: You have described the FAT imaging volume as a cylinder, which is to be expected given the circular flight pattern described previously. You then go on to describe the LAT imaging region as simply a '3-D volume.' I suggest this imaging region, its shape, and dimensions require more of an explanation. In the conclusion (P17L11), you refer to the FAT volume is 'cubic.' Is this a contradiction?

A more detailed explanation of the volume reconstructed with LAT has been added to Section 2.2, as it would require too much space in the introduction (P2L23). Figure 2a has been changed to improve the understanding of the volume recovered with LAT. The term cubic in the conclusion has been replaced by "cylindrical" to avoid confusion.

The LAT flightpath geometry should be described in more detail. Specifically, the vertical curvature of the flight path is never discussed. Did this cause inconsistencies in image resolution as the altitude between GWs and GLORIA varied? Were edge effects or 'smearing' a problem as the altitude increased?

A more detailed explanation of the volume reconstructed with LAT has been added to Section 2.2. Figure 2a has been changed to improve the understanding of the volume recovered with LAT. The flight altitude has been kept constant during the whole study. This information is added to the text. This is also mostly the case during real aircraft measurements of gravity waves. Thus, smearing effects due to altitude changes do not play a role here.

You describe a 200-km horizontal extent perpendicular to the flight path (P2L25). The resolution of overhead multi-angle images typically degrades moving towards the edge of the images (away from the nadir). Was this effect compensated for in any of your preprocessing steps?

For the GLORIA retrieval presented in this paper, a region of interest of 48 x 128 pixels is used, albeit the optical system is designed for a region of interest of 128 x 128 pixels. In this configuration, the imaging quality is at, or close to, the diffraction limit for every pixel used and the edge effects are thus not a dominant error source in the retrieval process. The co-addition of pixels further reduces the relative impact of edge effects and the spectral errors are mostly corrected during level 1 processing (Friedl-Vallon et al., 2014; Kleinert et al., 2014). Furthermore, every single pixel has a point spread function (PSF) which is about 1.9 arcmin wide. As the tangent points for lower altitudes are further away from the airplane, the projected vertical PSF measured in meters is wider for lower tangent altitudes. This effect is taken into account in the radiative-transfer and instrument model of the retrieval (Ungermann et al., 2015).

The initialization of tomography algorithms can have a profound effect on the resulting reconstructions and I believe your initialization (P6L27) needs to be described in far more detail. This climatological field ac should be discussed further. How was it developed? How do you know it is accurate?

The retrieval setup was described in more detail. Especially the construction of the Covariance matrices was given in more detail. A detailed description of the used climatology and its accuracy is discussed in the given reference Remedios et al. (2007). The influence of the climatology on the result of the sensitivity study is negligible, because we are not interested in absolute temperature values but the perturbations. That is also one of the reasons, why the climatology is directly subtracted from the retrieval result before the analysis. Thus a detailed discussion of the climatology would exceed the scope of this paper.

It doesn't appear you have done any synthetic testing of your tomography algorithm. In this process, artificial projection (brightness) data are produced from a known synthetic structure and are then used to produce a 3D reconstruction. This result is compared with the original synthetic object to determine the accuracy of the algorithm. This approach can also be used to identify issues such

as edge effects or biasing which results from the initialization model. Could you comment on this or perhaps include some sample synthetic results?

The main point of this paper is to test the tomographic algorithm with synthetic data. To clarify this, the terminology has been changed and the before called "true" structures have been renamed to "synthetic". The authors hope that this helps to distinguish synthetic retrieval tests (Sections 3.1 & 3.2) from tests with real measurements (Section 3.3). The effects, which are introduced by the retrieval algorithm are discussed in section 3.2 extensively and include for example the "V-shape".

P7L21: You state the horizontal resolution along the flightpath is 30 km. Is this the image resolution? This isn't consistent with a field of view spanning only 100-200 km.

The horizontal field-of view of the detector is around 7km, which is mentioned in Section 2.2. The 100-200km are not a resolution but a coverage which is gained by overlapping forward and rearward looking measurements. We improved the description of the measurement geometry in Section 2.2 to avoid this confusion.

You might consider quantifying the spatial agreement between the resulting images in Figure 11 (i.e., (b) and (e), (c) and (f)). Common metrics include the structural similarity index measurement (SSIM) or the Pearson correlation coefficient (PCC).

The following has been included in the text: A more quantitative comparison of the similarities of both retrievals can be given by the Pearson correlation coefficient. Including only areas which are covered by tangent points gives a Pearson correlation coefficient of 0.91. Expanding this area to places with measurement content larger than 0.8 (includes areas crossed by a LOS before or after the tangent point) still leads to a Pearson correlation coefficient of 0.75. Thus, as expected the two retrievals are highly correlated.

P7L21: Why did you decide to use values 'larger than half the maximum'?

The resolution describes which area around a measurement point which influence its value. However, this influence can in theory reach till infinity. Atmospheric values closer to a measurement point in general have higher influence than values far away. One way to determine the influence of the atmosphere around the measurement point is to look at the averaging kernel matrix. Points with AVK smaller than the fwhm have lower impact and can therefore be neglected. This method is already used in 1-D and 2-D nadir and limb sounding (Rodgers, 2000; von Clarmann et al., 2009). In this paper we just extended this method to 3-D.

I am a little confused by your statement in the caption of Figure 2. You state the line-of-sight measurements assume a parabolic shape due to the cartesian coordinate system. Are you implying they are straight on a curved surface and then warped when plotted using straight axes?

Yes, we are implying that the originally straight lines are wrapped, when using straight axes in x, y and z. This has been clarified in the text.

P10L4: In discussing tomographic retrieval of gravity waves from atmospheric data, you have only cited one study. However, there have been multiple studies on this topic, using data from satellites such as ODIN and AIM. I suggest expanding these references.

Additional citations were added.

You need to be clearer about the differences between the rows in Figure 3. (a) and (c) show true waves which are nearly identical. Why are the retrieved waves so different?

Figure 3 shows only one wave, but multiple cross sections through the 3-D volume. The first row shows horizontal cross sections, rows 2 and 3 vertical cross sections along 0°N and 0°E, respectively. This has been clarified in the caption.

P19L9: What kind of artifacts are you referring to? Can you describe them?

The retrieval creates v-shaped phase fronts. This is added to the manuscript.

It is unclear what 'lz' and 'lh' refer to in Figure 9.

'lz' and 'lh' stand for the vertical and horizontal wavelengths of the waves, respectively. This has been clarified in the caption.

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