Author response to Referee #1

We would like to thank referee #1 for the valuable comments. We have included the comments one by one, in bold text, along with our answers. Lines in the answers refer to the original manuscript. The blue colour indicates text added in the revised manuscript.

- **The analysis focused on cuts on zonal wavenumber, Savitzky-Golay filtering and S3D transforms. Other methods that are also applied to observational data in order to analyze gravity waves like Butterworth filters, wavelet transforms or modal decompositions were not mentioned.**

  It is a good suggestion to mention some examples of other methods. Referee #2 suggested mentioning S-transform. In the revised manuscript we introduce Butterworth and Savitzky-Golay filtering as two examples of scale separation, as well as wavelet transform (in the form of the S-transform) and S3D as two tools for wave analysis on 3D temperature observations. As far as we understand modal decomposition requires “full” model data and would not be applicable (or difficult) for satellite observations. In the updated manuscript we mention the two scale-separation methods and wave analysis tools in the introduction:

  L57: Based on this, both full temperatures and reference temperature residuals (T'_G) are sampled to the MATS observation geometry. A second set of temperature residuals (T'_L) is generated via local scale separation. The local scale separation in this study is made using a Savitzky-Golay filter (Savitzky and Golay, 1964). An alternative method could be to apply Butterworth filters (Butterworth,1930). Based on a comparison between these separation methods with 3D temperature data we expect the results to be similar (Krisch et al., 2020). Both T'_G and T'_L are then analyzed with respect to gravity waves and the results are compared. In this way, the local scale separation can be optimized and validated against the reference global scale separation. The residuals are analysed using a wave analysis tool. For 3D temperature observations, one alternative is to use the continuous wavelet transform in the form of the S-transform (Wright et al., 2017; Hindley et al., 2019). In this study, we use S3D (Lehmann et al., 2012), a computationally cheap method based on sinusoidal fits.

- **It may be interesting, if feasible, to discuss in more detail one specific wave event when the performance was especially bad, in order to get a feeling on what type of waves would not be well captured. For example the differences in the meridional component at 50 deg N are large, maybe due to a wave with short vertical wavelength?**

  We agree that some further analysis of why local disagreement between S3D and the reference occurs is beneficial for the article. In the revised manuscript we add a discussion to Sect. 4.1 (S3D performance on the MATS tomography grid) regarding the disagreement at 50 deg N:

  L249: As both the wind residuals and the temperature residuals are derived from the same global scale separation, the difference in GWMF arises mainly from the use of S3D on the temperature residuals (some of the difference can be attributed to the sampling difference between the orbit grid and the global model grid but investigations show that this effect is quite small). At 50N the meridional component of the zonal mean GWMF is overestimated by S3D. The specific region from which the discrepancy arises is the area of high GWMF in the northern Pacific, just south of Alaska, as seen in the map of Fig. 4. Due to the orbit sampling, this area has a large contribution to the zonal mean and if excluded the discrepancy disappears. To understand why the disagreement occurs we visually compared the residual field with the identified waves (not shown). The region in question is characterised by waves with large vertical wavelengths, short meridional wavelengths and large amplitudes, all contributing to large GWMF. The large vertical wavelengths appear to be overestimated by S3D, which in turn leads to an overestimation of the momentum flux. Naturally, it is easier to characterise waves that are smaller than the cuboid and it is not surprising that an area with these large vertical waves is challenging.

- **Is the used HIAMCM snapshot considered representative? In a sense that different snapshots are comparable in covered gravity wave events and variability, such that it does not seem necessary to evaluate different snapshots?**

  At the time of the study, we were considering performing tests on a larger set of HIAMCM data but this was abandoned as we could not obtain this dataset. As we only have one snapshot, it is indeed hard to know exactly how representative it is. However, as references and the parameters we derive using local scale separation are from the same snapshot, we are not critically dependent on this. We have added a short discussion regarding this in the conclusions of the revised manuscript:

  L345: This study was performed on a HIAMCM snapshot from 1st January 2016. For investigating if the method works, a global snapshot from an arbitrary day should be reasonable as it should include regions where analysis might be harder (for example in the vicinity of wave-breaking) and easier (well-defined wave structures). Nevertheless, for future studies, a larger dataset would be preferable.

- **307 missing closing bracket after (Fig.8a**

  This has been corrected in the updated manuscript.

References

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