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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Gravity Waves induced Wind Shears Derived from SABER Temperature Observations" *by* Xiao Liu et al.

Anonymous Referee #1

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The paper by Liu et al. provides climatologies of vertical wind shear. This can be obtained essentially from temperature amplitude multiplied by vertical wave number and is thus different from climatologies of GW amplitudes (without the m) and GW momentum flux which scales m*Tˆ2. Both m and T-amplitude can, in principle gained from vertical profiles obtained from satellites at good accuracy. Corrections are applied for the ratio of intrinsic frequency to Coriolis parameter. For these, however, quite a number of assumptions have to be made. These are either not explained at all or not very well in the paper. A further major point is that the scaling with m emphasizes the noise of the observations. That fact needs to be discussed. My recommendation is therefore to return to the authors for major revisions.

Major comments:

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1. All the problems in the theory part arise out of the fact that you apply the omega/f correction. My recommendation therefore is to present also the results for mid-frequency assumption (omega » f), for figure 4 in the main text, for figures 5-9 in the appendix. That would allow the reader to estimate for herself/himself whether the assumptions which need to be made (at least for current satellites) are important to the findings. Are they just amplifying the shears in an about uniform way or are they contributing to the shape of the distributions.

2. Rewrite the theory part and properly name the assumptions (see also detailed comments below). How does your picture change, if you assume that the different waves you superpose have different propagation directions? The following more in the line of suggestions, which may be beyond the scope of the paper: It would be nice to have a Monte Carlo simulation showing the effect of superposing waves of different omega/f and different propagation direction, but I admit that the result would again depend on some assumptions about the real distributions. You could also try to use simulated observations through the model (just sampling, no radiative transfer) to get some idea on the size of effects. Maybe it also would be worthwhile to assume first that one could infer propagation direction as well, as in principle such instruments could be build.

3. Discuss the influence of noise. In particular it is known that SABER temperature retrievals have a noise problem at the summer mesopause. That is stated on the SABER web-page and also discussed for GW analyses by Ern et al. 2018. The results for this particular region have to be treated with care. At least some discussion must be included in the paper.

4. The paper must be self explaining. Explain how you arrive at your vertical wavelengths and amplitudes. Anyway: You should not use FFT over the whole altitude regime. There is so much Doppler shift, critical level filtering and oblique propagation going on that the case where you observe the same gravity wave at all altitudes and furthermore with similar vertical wavelength is the absolute exception.

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5. In particular: how do you deal with tides? All tides must be removed before the analysis as they are global wave modes with wind amplitudes maximizing at a different latitude than temperature amplitudes.

6. Discussions: for GWMF I think it is a valid assumption that wind modulation causes most of the relevant waves to propagate opposite to the winds. You can find some of this expressed in AIRS results and also GW reolving global models. However, for shear I don't think that is further valid. Therefore I would include some of the discussion (very much shortened) in sec. 2.

Specific comments:

P2L4 It is now accepted ... A larger part of the shear and the winds is associated with tides. You need to mention them here. In particular sporadic E is primarily associated with tides (e.g. Arras et al., 2009, Arras et al. 2018).

P2L9 Please explain this equation: what is the motivation? Static stability of saturated mid frequency GW?

P2L34 "poorly known" Motivate. What are the limitations of the wind observations? Noise? Altitude resolution? Combination to vector winds?

P3 Equ 1: Under the assumption of conservative propoagation and no refraction. Reasonable for some waves in a limited altitude range, but must not be taken over the whole MA as is done below.

P3L20/L25 These polarization relations are for winds u parallel and v perpendicular to the wavevector of the GW. You can do the assumption, but must say so in the text.

P4 Equ. 6 and Equ. 7 These equations make the much stronger assumption that the wave vectors are all pointing in the same direction. While that seems a plausible assumption, if you look for the largest amplitudes (preferrential orientation against the mean wind), I don't see why this should be the case for wind shear. You shown in Equs 4 and 5 that shear is proportional to m as well as to the amplitude. Handwaving, these

two effects should largely cancel with regards to phase speed. Thus, you would not expect a direction preference.

P4 Equ. 8 and 9 then are not valid

P5 Equ 12 is fine, but is introduced in a way that makes belief that you could get the horizontal wavenumber from the satellite. Instead it is the one projected to the track. This will introduce overestimate of lambda_h, underestimate of k_h and thus underestimate of \hat{\omega}. You introduce some of these arguments below, but this must be more clearly ordered.

P5L8 No you can not! This is not the zonal and meridional component!

P5L15 And why should the wavevector point along the orbital track? That is as unlikely.

P5L25 There is no reason to believe that the waves at 20km have anything to do with the waves at 100km. Please explain your method. Phase differences should be gained from "local" phases determined for a limited altitude range

P8L6 can you please make these number codes plain text 01 July - 31 July which Year?

P8L15 This is a region problematic for retrievals due to very cold temperatures and low IR signals (cf. Remsberg, Ern). Some of what you see there may be real, but some is very likely due to increased noise. A discussion is needed.

P9L16 You mean the zonal mean of the individual shear profiles? Please be precise, as the zonal mean shear due to GWs should be zero. But then: what does the lidar provide? Average of abs.(shears) or shear of average?

P9L25 You do not discuss here the visibility filter, which also should reduce amplitudes

P12L17 And also on what you emphasize due to the scaling with m: shear (short vertical wavelength), amplitudes (mid lz) or GWMF (long lz).

P12L21 also Schmidt et al.

P13L11 SABER "sees" GWs with horizontal wavelengths > 200km, much the same as WACCM, though with somewhat reduced amplitude. I would check by mid-frequency approach, whether the scaling and profile distance is really of importance. In addition, as you said above, if there is an influence, it would be an overestimation.

Technical corrections:

P1L28 ... (or more precisely vertical wind shears) ...

P1L30 ... and from ground-based ...

P2L2 ... strong gravity wave (GW) activity.

P2L2 You probably want to refer to a generally knowledge on GWs rather than on evidence from the aformentioned papers for the sources: Most prominent sources of GWs are convection, orogrophy and jets and fronts in the troposphere as well as spontaneous adjustment and secondary wave generation in the stratosphere. Amplitudes and shears increase when the GWs propagate ...

P2L13 driving -> are the cause of

P2L17 reproduced the large wind shears seen in the observations.

P2L22 Observations ... were made by sounding ... for a very limited number of locations only and hence cannot ...

P2L24 still challenging

P3L4 of deriving shears from GW anylses of temperature observations.

P3L6 SABER luckily still measures: Temperature profiles measured by .... from 2002 to 2019 are used for this study providing an 18 year period.

P3L8 ... website based on Remsberg et al. (2008).

P3L10 omit () at this point

P4L3 In reality, usually spectrum of GWs is observed formed by superposition of several monochromatic GWs.

P5L7 and the amplitude and vertical wavenumber determined from the satellite observations for the individual monoc. GWs, we ...

P6L26 https://en.wikipedia.org/wiki/Flowchart Please use different wording here

P7L20 a factor 0.2 would be underestimation overestimated by 20% ?

P8L9 comment -> common

P9L15 slightly larger

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