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Interactive comment

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

Anonymous Referee #2

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SABER temperature profiles are used as input to a calculation of gravity wave parameters, including the vertical and horizontal wavenumbers, the intrinsic frequency, and the horizontal velocity perturbations associated with each wave component in the decomposed wave spectrum. The goal is to estimate the vertical shears associated with the wave spectrum over the extended time periods and greater geographical extent provided by the satellite data.

The presentation of the material and methodology is clear, the discussion of past work is useful and very complete, and the figures represent the results well. Nonetheless, there are several major questions related to the validity of the analysis.

The shears obtained from the SABER data are calculated and are not directly measured. A broader global climatology, including the seasonal variations, is valuable

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to the community and represents a worthwhile goal. There are a number of critical assumptions required, however, for the calculations to be valid and meaningful. Those assumptions are especially likely to break down in the altitude range around the mesopause, which is where the largest shears occur that are a focus of the analysis. The assumptions are not adequately addressed in the paper, and the effect of those assumptions are therefore also not addressed. The recommendation is to return the manuscript to the authors for revisions.

Specific comments are as follows:

Tides are in some sense global-scale gravity waves constrained by spherical boundary conditions, but they clearly do not conform to the simple linearized polarization relations given in equations (2) and (3). The authors introduce some filtering to reduce or eliminate larger-scale modes, but it is not clear that the tidal modes, especially the higher order modes, are eliminated prior to extracting the gravity wave spectral components. This is especially important since the altitude range where the large shears occur near the mesopause is also an altitude range where a number of tidal modes have large amplitudes, perhaps not coincidentally.

A further concern is that the region of large shears near the mesopause is also a region of large winds that represents a height range with critical levels for a large fraction of the gravity wave spectrum, especially since the background winds rotate with height through that altitude range, so there are critical levels for a broad range of propagation directions. It appears questionable to apply the linearized polarization relations in regions with critical levels where the vertical wavelength is changing rapidly with height and the dynamics are almost certainly nonlinear. The validity of the analysis in those regions is not discussed.

The large shear region is also a region where many gravity waves break, producing turbulence and, in some cases, secondary waves, as discussed in at least one of the references cited in the manuscript. The critical levels mentioned in the previous com-

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ment can produce breaking, but breaking waves can also be a result of the amplitude growth with height, which by itself leads to amplitudes large enough to produce such effects at heights near the mesopause.

If we assume a localized source in the lower atmosphere that produces a spectrum of waves, then the lowest-frequency gravity waves propagate at a lower elevation angle while the higher-frequency waves propagate at angles closer to vertical. A vertical profile extending from the ground to the lower thermosphere is therefore unlikely to have the contents from a single set of monochromatic waves contributing at all heights. As an example, several studies have been published in the past with special cases in which waves have been traced from the troposphere to the thermosphere when there has been an especially strong source, such as a strong line of thunderstorms, but those waves become displaced horizontally as they propagate vertically so that a vertical sample would only intercept the wave packet in a small part of the complete altitude range. In the general case the altitude profile measured by the satellite will likely have contributions from an extended range of geographically-distributed sources and therefore also different phasing dominating the vertical wavelength contribution in each part of the altitude range. If so, it is not clear that an individual wavelength contribution extracted via a DFT represents the wave structure accurately and applying the polarization relations as if that particular component represents a single monochromatic wave seems questionable.

Finally, since only the along-track direction is sampled, the horizontal wavelength will be overestimated for any waves propagating in an off-track direction. The resulting underestimate of the horizontal wavenumber artificially increases the value of omega prime (equation 12) and leads to an overestimate of the vertical shear (equations 8 and 9). Given that, it seems possible that the apparent seasonal variations and latitudinal variations in the derived shears are a reflection of seasonal and latitudinal changes in preferred wave propagation directions rather than actual changes in the magnitudes of the shears.

A minor comment is that the title of the paper, which uses the terms "gravity wave induced shears", suggests an effect in which waves are accelerating the flow to produce the shears, i.e., inducing a shear by momentum deposition for example, but that is not what the manuscript describes since the analysis focuses only on the superposition of shears that are naturally a part of the wave spectrum without any mean-flow acceleration.

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