

**Manuscript angeo-2020-42 “Lower thermosphere – ionosphere (LTI) quantities:
Current status of measuring techniques and models” by Palmroth et al.**

Response to Reviewer #1

We thank the Reviewer for their very positive and constructive comments on our manuscript. Below we present how we intend to address them in a revision of the paper. The Reviewer’s comments are reproduced in bold font, and our responses are given in normal font.

Overall quality of the manuscript (general comments):

The manuscript “Lower thermosphere - ionosphere (LTI) quantities: Current status of measuring techniques and models” by Palmroth et al. is a well written review of the lower thermosphere and ionosphere, with the focus on the open questions with a lot of them cannot be addressed without high-quality in-situ measurements and describing the state of the art of measuring this region. The manuscript is motivated by the Daedalus mission. In my opinion the manuscript is a very valuable contribution to the literature of the LTI region and will most likely be used by many researchers.

Thank you very much for this very positive opening statement.

Addressing individual scientific questions/issues ("specific comments"):

Line 5: should the wind dynamo be mentioned?

This is a very good point, we will add a few sentences on the wind dynamo in the revision.

Line 8: does directly mean “in-situ” or without any elaborate assumptions?

Indeed, here we the intended meaning is “in situ”. We can replace “directly” by a more accurate phrase in the revised version of the manuscript to avoid any ambiguity.

Line 17: I think the mesosphere was originally termed “ignorosphere” since it is too low for satellites and too high for airplanes and weather balloons. So maybe change “this region” to the “LTI region”

The Reviewer is right, we will correct this in the revision and make sure we avoid using “ignorosphere” when referring to the LTI.

Line 44: “the motion of the atmosphere is driven by both solar irradiance and waves.” Do the authors mean thermal atmospheric tides caused by solar irradiance? Maybe reformulated so that it fits to the waves.

Indeed, thank you for this notion; both are of course driven by solar irradiance in the end. We will reformulate this sentence in the revision.

Line 85: There are other efforts of whole atmosphere models: WAM (), GAIA ().

Thank you for pointing to these models, they will be briefly introduced in the revision.

Figure 2: Is the depicted neutral wind the total horizontal wind? Similar for the ion drift-is this the ExB drift and is the one perpendicular to the magnetic field?

The neutral winds depicted in this figure correspond to those also shown in Fig. 1, i.e., neutral wind along the model pressure levels. Since the pressure levels are 3D surfaces, there is a small vertical pressure gradient, hence inducing a small component of vertical wind. However, overall the shown neutral wind magnitudes essentially represent horizontal winds.

Regarding ion drifts, they are indeed given by ExB. We are currently working on updating Figs 1 and 2 for the revised manuscript, to address the technical comments made by both Reviewers. Clarifications will be added to the figure descriptions in the revision.

Line 199: “total upward energy flux by resolved waves at 100 km” Does this refer to only 100km waves or also larger ones?

Here, 100 km refers to the altitude where the waves are considered, not their wavelengths. We will rephrase this sentence to remove the ambiguity and add a statement regarding the resolved wavelengths.

Line 201: “horizontal scales less than 200 km are poorly resolved” Shouldn’t waves be resolved with wavelengths approximately 4x the resolution? How does this fit to the 100km in line 199?

Once the ambiguity in the previous sentence is removed, this statement will no longer seemingly conflict with it.

Line 518: “resolution ranges from one orbit to several days” It is not clear to me what is meant here? Orbit averaged to several day averaged? Is this temporal resolution-one measurement pre orbit or every few days?

Thank you for this comment, which calls for a clarification. This technique intrinsically allows to infer changes in the neutral density based on the orbit tracking of a single object with a temporal resolution of the order of three days or longer (Doornbos et al., 2008). However, by combining orbit data from multiple tracked objects, it is possible to obtain information on neutral density changes at a resolution of 3 h (Storz et al., 2005). We will modify the original statement in the revised version of the manuscript.

Line 661: Maybe the Weimer (2005) empirical ion convection model based on DE-2 data could be mentioned.

Thank you for suggesting this addition, which we will gladly include in the revised manuscript.

Line 715: section 3.6 Magnetic fields: I may have missed it but the summary does not mention that the Swarm was able to derive currents without any assumption of current flow due the constellation with nearby satellites. I find this an important point since at the end of the section, the E-region is mentioned and this is the region where strong currents flow. So the interpretation of magnetic fields with respect to current flow without constellation is a challenge (e.g. see the modeling of Maute & Richmond 2017). Maute, A., Richmond, A.D. F-Region Dynamo Simulations at Low and Mid-Latitude. Space Sci. Rev 206, 471–493 (2017).

Thank you for the suggestion, we will make sure to include and discuss this point in the revision.

Line 757: “which are essential also for FACs” It is not quite clear to me what this means? That FAC flows along magnetic field lines?

Indeed, the sentence needs rephrasing. We will find a better formulation in the revision (for instance “along which FACs flow”) to improve clarity.

Line 773: “Above the E-layer, electrons and ions drift together and the ionospheric current vanishes.” I do not think the authors mean that there is no ionospheric current above the E-region as the sentence suggests. Could this be further explained?

This is an excellent point; the above statement is misleading and might suggest that F-region currents do not exist. We will correct this by reformulating in the revision.

Technical corrections at the very end ("technical corrections")

Line 125: Fig 2. Remind the usual -> reminds of the

Will be corrected.

Figure 1: I suggest to add the altitude or pressure range of the plots. Does it go from the surface to approximately 500km?

Great suggestion, we will update Fig. 1 and find a way to add altitude/pressure range information.

Figure 2: It would be easier to add approximate solar local times to the geographic locations of the profiles in the captions.

Thank you for this suggestion, we will add this information as well.

Line 146: reference frames with the neutral gas velocity -> of the neutral gas?

We meant here “other reference frames with non-zero neutral gas velocity U ”; we will therefore clarify by rephrasing this in the revision.

Line 212: “In this topic, the” Should this read “in this study/review”?

Actually, we should here rephrase into “The current key research question associated to this topic...” to convey our intended meaning.

Line 300: suggested: to the lower atmosphere

Indeed, we will add “the” in the revision.

Line 564: Should planetary waves be mentioned?

Yes, we will add them in the revised manuscript. Thank you for the suggestion.

Line 600: Any reason to use speed instead of velocity?

Thank you for this comment; we should actually rather use “velocity” throughout this section. This will be changed in the revision.

Line 648: metre-> meter

Line 449: analyser -> analyzer (at least that is the spelling UTD is using)

Indeed, although we are using British English throughout the manuscript, we agree that for instrument names we should follow their preferred spelling. These will be corrected in the revision.

Line 835: engineering grade magnetometer

We will implement as suggested in the revision.

Line 1083: “propagating tides” upward propagating? Tides can also propagate east-ward and westward. Not all tides reach the F-region.

Thank you for pointing this out; we will modify as suggested to avoid ambiguity.

On behalf of the co-authors,

Minna Palmroth