Response to Anonymous Referee #2

Referee comments: https://doi.org/10.5194/egusphere-2025-3745-RC2

Manuscript: Reiter, A., Danzer, J., and Steiner, A. K.: The potential of GNSS radio occultation data for the analysis of the tropical width: a comparison with reanalyses, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-3745, 2025.

This paper describes the use of GNSS-RO data to study several indirect metrics of the tropical width. This includes the use of tropopause temperature (which has been done using RO before) and locations of the subtropical and eddy driven jets based on the newly derived winds fields obtained from the RO geopotential height data. The authors show that the RO results generally compared well with the reanalyses, although some systematic (especially zonally varying) differences were noted. The authors argued that the RO data period (2006 – 2020) was currently too small to detect the tropical width trends, with 35 years needed based on the reanalyses.

This is a well-written paper with interesting results on an important topic. I recommend its publication after the following comments are addressed.

Thank you very much for your positive and encouraging assessment, for generally finding our study well-written and your recommendation to be published after minor revision. We carefully considered and answered all comments below (comments are quoted in *italic with gray background*, with the responding answers below each comment). Line numbers refer to the original manuscript.

Comments:

#1: In Sec 2.1, the authors should provide some description on the accuracy of the RO data used in the analysis, especially the wind retrieval which is a fairly new product that's not known by most readers

We are grateful for this comment, adding information on the accuracy of the RO dataset is very important to highlight the underlying data quality of our research objective. Therefore, two sentences were added to provide some insights into the accuracy of the RO temperature and RO wind record.

L93: "RO data have their highest precision and accuracy in the upper troposphere-lower stratosphere region, with uncertainty estimates of less than 0.7 K for individual temperature profiles from 8 km to 30 km and an accuracy of about 0.1 K (Scherllin-Pirscher et al., 2021). RO climate data records are therefore well suited for reliable trend analyses including benchmark quality temperature and geopotential height fields with a structural uncertainty of temperature trends of less than 0.05 to 0.1 K per decade for global to latitudinal means and a structural uncertainty of geopotential height trends of less than 4 m per decade within the RO core region (Steiner et al., 2013, 2020a)***."***

"As to the quality of the wind fields, values are within ±2 ms-1 (Danzer et al., 2024; Nimac et al., 2025) and thus fulfil the WMO-OSCAR standard for horizontal wind information (see WMO-OSCAR, 2025, https://space.oscar.wmo.int/variables/view/wind_horizontal, last access: 23 October 2025)."

#2: It would be interesting to include the tropical width trends from the RO data in Fig 5. How does that compare with the reanalyses for the same 15 years? How does that compare with previously published results if applicable (e.g, from Ao and Hajj 2012 , Davis and Birner 2013)

Thank you very much for your thought. However, the purpose of the figure is not to show trend estimates of the different data products, but rather to understand the needed time window for a reliable trend estimate. We emphasize, for example, in line 347, that we do not consider the currently studied RO record (14 years) long enough for trend studies of the tropical width.

For your convenience we include here the respective paragraph:

L347: "While we see great potential in RO records for the study of tropical atmospheric features, we also acknowledge their constraints. RO data has been successfully applied in climate studies, for instance, to investigate atmospheric temperature trends (e.g., Ladstädter et al., 2023; Steiner et al., 2020b) and tropopause trends (Ladstädter et al., 2025; Meng et al., 2021) over recent decades. However, for trend studies of the tropical width, which exhibits large variability, the record length is not yet considered long enough using regionally resolved RO data since 2006."

#3: Since the authors have 2D gridded dataset, can we say something about the regional trends? Is it possible that some regions show greater trends detectable over shorter periods?

We consider these questions as a very interesting topic. While currently the RO record is too short for trend detection of zonal mean metrics, trends might arise also on shorter time periods when studying changes for individual regions. Nevertheless, we have to emphasize that trends were not the purpose of the underlying study. The purpose (for now) was to demonstrate the potential that lies within RO data to capture tropical width metrics. In the future, the Wegener Center will release a new data set with an extended record period of 22 years (2002-2024). We intend to conduct a follow-up study on this specific topic with the extended data. Furthermore, we added a sentence on this subsequent research interest:

L353: "A revenue of subsequent work will be to focus on regional trends, which may manifest over shorter timescales due to a more pronounced climate signal in certain geographic areas (e.g., Manney and Hegglin, 2018; Martin et al., 2020)."

#4: What can we say/do with the different (indirect) metrics giving different trends?

Although these metrics (i.e., tropopause break, eddy driven jet, subtropical jet) have been bundled together in the term “tropical width metrics” the features they describe and how these are changing aren’t necessarily correlated. This has been shown by recent literature as outlined in the introduction of the manuscript (lines 54-60). Thus, also the physical message behind these different metrics does not necessarily coincide. While all metrics represent important features of the tropical atmosphere, with influence on the weather and climate of the subtropics, their specific impacts are more complex.

But we agree, we need to emphasize this more strongly in the manuscript and hence, added sentences in the introduction and method section.

L58: “All metrics represent important features of the tropical atmosphere, with individual influences on regional weather and climate patterns. Under climate change, shifts in these tropical width features can therefor lead to different changes in these subtropical patterns.”

L112: “These metrics describe different features of the atmosphere at the tropical edge, a detailed description is given below:”

#5: Figure 4: some metrics show large zonal variation and systematic differences between RO and reanalyses over certain regions. Could you comment on implications on using the metric for monitoring tropical width changes, generally, or with RO?

Thank you for this interesting question. We discussed the differences in the regional location of the metrics in chapter (3.2), we summarize here: With respect to the TPB the results align well between RO and reanalyses. Also, the STJ shows good results – all differences are minor with the exception of 180°W and 60°W in the northern hemisphere. Here it seems that the jet is shifted westward for RO. As for the EDJ, while in the southern hemisphere the metric seems to capture the location of the EDJ for RO in range of the one for reanalyses, in the northern hemisphere there are some notable differences. We assume that the systematic difference stems from the selection of the level. We conclude from our results that the temperature-based metrics can be used for monitoring purposes, consistent with ERA5 and JRA-3Q (MERRA-2 showed deviations over some regions). However, the wind-based metrics, specifically the EDJ in the northern hemisphere, needs to be viewed a little more carefully.

To express these differences and their relevance on the topic climate monitoring more clearly, we added some sentences in the results section 3.2:

L257: “Some exceptions occur over the NH, specifically for the EDJ metric there are some notable systematic differences over certain regions, which result most likely from the level selection of 850 hPa for reanalyses and 700 hPa for RO data (see also initial

validation in Fig. 1). Also, for the STJ in the NH, there are some longitudes at roughly 175 °W and 60 °W, where differences between the RO dataset and reanalyses occur."

We further extended and adapted a paragraph in the discussion as following:

L339: "We have proven the general applicability of RO data to locate jet streams, however, currently, the EDJ metric shows large systematic differences over some regions in the NH between RO and the reanalyses – this limits its utility for climate monitoring. Furthermore, other methods to define the jets exist (Keel et al., 2024; Liu et al., 2021), which were not tested in the process. Hence, a detailed investigation of further jet metrics using RO observations presents an interesting direction for future research to gain more insight into the jet response to climate change."

#6: Abstract: "The tropics are expanding poleward as a result of anthropogenic climate change." I think it's more accurate to say that "Many studies have shown that the tropics are expanding…"

Thank you for pointing this out. Since this comment coincides with a comment from the other reviewer, we combine here the answer and rephrased the first sentence in the following way:

L7: "The tropical width is changing, with a poleward expansion being linked to anthropogenic climate change."

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