Author's Response to Referee #1 Comments

We would like to thank the reviewer for the constructive assessment, for generally finding our study interesting and well designed, and for the helpful comments for further improvement. We carefully considered and answered all comments below (comments quoted in *italic with gray background*, with the answers below each comment). Furthermore, for clarity and as found appropriate, we included initial versions of revised formulations, to indicate in which way we plan to improve the respective explanations in the revised manuscript.

Referee #1 (Specific comments and questions)

***1)** Equations 1 and 2: what, precisely, are the variables x and y? I would like to see a level of detail here corresponding to that provided for Equations 3 and 4. Also, latitude is used in Equations 1 and 2 before it is introduced in association with Equations 3 and 4.*

Thank you for noticing. We will correct this and make the formulations of these Equations consistent.

***2)** RO data retrievals: The key variable used in the study is geopotential height as a function of pressure (or pressure as a function of geopotential height). How is pressure retrieved? It is mentioned that the RO geopotential climatologies are available from 1000 hPa to 5 hPa. That covers atmospheric regions where the "dry" approximation is applicable as well as regions where it is certainly not applicable. Some explanations of how that is handled is needed.*

Thank you for asking. Briefly summarized, based on the atmospheric bending of the GNSS signals during the occultation sounding, it is possible to retrieve atmospheric refractivity profiles via an Abel transform. From these, air density and pressure profiles as a function of altitude, or geopotential height, can be accurately derived based on the refractivity equation, the equation of state, and the downward integration of the hydrostatic equation. Along the retrieval chain we derive the physical atmospheric parameters (e.g., physical pressure) using a moist-air retrieval described in detail in Li et al. (2019) . Roughly down to 700 hPa, but in practice significantly depending on the amount of water vapor, the physical information is dominantly dependent on information from RO measurements. This - of course - varies somewhat depending on the geographical latitude (dry polar troposphere versus moist tropical troposphere). Towards lower tropospheric altitudes, the moist information more strongly relies on background information.

We will add as additional reference for the moist-air retrieval:
Li, Y., Kirchengast, G., Scherllin-Pirscher, B., Schwaerz, M., Nielsen, J. K., Ho, S. P., & Yuan, Y. B. (2019). A new algorithm for the retrieval of atmospheric profiles from GNSS radio occultation data in moist air and comparison to 1DVar retrievals. *Remote Sensing*, *11*, 2729, https://doi.org/10.3390/rs11232729

Furthermore, we will add the following lines to Section 3.2, line 153 (initial formulation, may be refined):
"The WEGC OPSv5.6 retrieval system processes the atmospheric parameters as a function of altitude or geopotential height, based on the refractivity equation, the equation of state, and the downward integration of the hydrostatic equation. The physical atmospheric parameters (e.g., physical pressure)

are derived using a moist-air retrieval algorithm, which combines the individual profiles with background information by optimal estimation; see Li et al. (2019) for details."

3) *You mention that the monthly-mean RO data at the 2.5x2.5 degree grid points are computed by "Gaussian latitude-longitude weighting" within a radius of 600 km. What is the width of the Gaussian? Is it 600 km? Or is 600 km the distance from the grid point within which the profiles contributes to the grid point mean?*

Thank you – we will carefully check the description of the methodology and revise it accordingly. In general, the 600 km corresponds to the distance from the grid point within which the profiles contribute to the grid point mean. The profiles are weighted according to their longitudinal and latitudinal distance to the center with a gaussian function, with a standard deviation of 300 km (lon) and 150 km (lat).

We also intend to add in the description the following citation (in proper formatting, of course):
Ladstädter et al., OPAC-IROWG 2022 conference, Talk on gridding strategies, Seggau, Austria, September 8, 2022.

4) *You mention the need to further average to a 5x5 degree grid for the equatorial-balance calculation. Did you try other differencing techniques than forward finite-differences? It may be to simplistic, and other differencing schemes may be more suitable.*

Thank you for this thought. In the very first step of our analysis, we tested different differencing techniques (forward, central, backward) and found only minor impact on the final wind-components. However, we will take up your suggestion and perform further tests on the differencing techniques, and accordingly improve the relevant discussion in the methodology section.

5) *In Section 4, the analyses and discussions related to the RO data are focused on three atmospheric layers: 10 hPa, 50 hPa, and 200 hPa. However in Figures 5 and 6, RO data down to 1000 hPa is shown. Whether it makes sense to show RO data in the lower troposphere depends on how the RO data were retrieved. Depending on the answers to comment 2 above, you should consider not to show the full vertical span down to 1000 hPa.*

Since we are using a moist-air retrieval, we consider it, in principle, not a problem to show the results in Figure 5 down to 1000 hPa. Of course, in the troposphere the data become significantly influenced by background information (as briefly described in the answer to comment 2 above). To illustrate the vertical structure of the wind components, we still prefer to keep the range in these figures down to at least 800 hPa, i.e., throughout the free troposphere down to the boundary layer. However, we will make sure to better emphasize that the focus in our analysis is not on the lower to middle troposphere, but rather on the upper troposphere and lower stratosphere.

6) *Related to comment 5, there is a sentence in Section 4.3 which I don't know how to interpret (lines 259-260): "the larger influence of moisture leads to a higher need of background information in the RO retrieval chain, and as a consequence to an increase in the bias". Is this an indication that you use the "dry" solution all the way down to 1000 hPa?*

We are using a moist-air retrieval, see also answers to questions 2 and 5. We intend to rephrase the sentence in question along these lines (initial formulation, may be refined):

"… This feature clearly relates to the core region of high-quality RO data, which is in the upper troposphere and lower stratosphere. With decreasing altitude and therefore increasing moisture content, the retrieval of atmospheric parameters relies increasingly on background information (e.g., Li et al., 2019). The RO information dominates between about 8 km to 35 km in the tropics (e.g., Scherllin-Pirscher et al., 2011). "