**Reviewer #2**

**Review of Nimac et al.: The added value and potential of long-term radio occultation data for climatological wind field monitoring", submitted to Atmospheric Measurement Techniques. – Author's Response to Reviewer #2**

The paper reports on a study of global wind-field monitoring from the middle troposphere to the middle stratosphere using the satellite-based Radio Occultation (RO) technique. The focus is on climate applications, hence monthly means and a rather coarse 2.5x2.5 degree latitude-longitude resolution. The latter is also a consequence of the limitations of the RO observing system.
Winds are derived from the gridded RO data by means of the geostrophic and gradient wind approximations. The idea is to use ERA5 reanalysis data as a reference in two ways: by computing wind fields from ERA5 using the same approximation as for RO, and by using the original ERA5 winds. In this way the approximation itself can be evaluated (ERA approximation vs original), RO data can be evaluated (RO vs ERA approximation), and the general ability of RO-derived wind fields to represent the real winds can be evaluated (RO vs ERA original). Key questions addressed are where and under what circumstances the approximation holds and RO can be expected to provide useful information on the wind.
Scientifically, the study presented is perhaps not a major leap forward, but it is a well-designed study, it fills a gap in the literature, it is well-written and easy to follow and it provides practically useful information. For anyone interested in generating atmospheric wind fields from RO data, or that is interested in the validity of the geostrophic and gradient wind approximations, this paper will provide highly valuable information.
The manuscript is well worth to be published. I mainly have one set of questions that I would like to see clarified. That relates to sampling and data retrievals. See the comments and questions below. I believe that addressing these questions and issues will improve the manuscript.

We are thankful to Reviewer #2 for the valuable comments regarding details on the data retrievals. We added more information about it in the manuscript.

**Comments and questions**

In Section 2.2, it is described how the monthly 2.5x2.5 degree grids are derived for the RO satellite data. For a calendar month, all RO profiles within 600 km from the center of a grid box are averaged with data weighted less with increasing distance from the center, following a Gaussian.
1) What is the width of the Gaussian?

We now explained this part better in the manuscript and added:
"*The monthly-mean fields are calculated based on the daily RO climatological fields, which are created by temporal and spatial weighting of RO atmospheric profiles. Temporal weighting is carried out within ±2 days, while spatial weighting is done within the constant radius of 600 km in order to maintain effective horizontal resolution. The profiles are weighted based on their distance from the center location of a bin with a bivariate (latitude–longitude) Gaussian function, which has a peak at the center of the bin and corresponding standard deviation of 150 km in latitudinal and 300 km in longitudinal direction, respectively. Details are given in the presentation by Ladstädter (2022).*" (L160)

2) Doesn't this mean that there are more data points per monthly mean at high latitudes compared to low latitudes, given the polar orbits of the satellites? Does this have any implications for the sampling errors of the monthly means?

Yes, however this is compensated for by larger variability in these regions (Scherllin-Pirscher et al., 2011).

3) Are the monthly means adjusted for sampling errors? It appears to be used in other studies using RO satellite data for climate studies.

Yes, the data we used are sampling-error corrected. We added this information in the manuscript (L166).

RO data retrievals: The key variable used in the study is the geopotential height of isobaric surfaces, i.e. geopotential height as a function of pressure. How is pressure retrieved? It is mentioned that "background information (re)analys data" is used in the retrieval. As an alternative, the pressure can be retrieved from the refractivity without such background information ("dry" retrieval).
4) Which data are used as background? If ECMWF reanalysis is used, does it have any consequences for the comparison between RO and ERA5?

The background data (short-range forecasts) from ECMWF-IFS/ERA5 are used in the regions, where dry variables differ much from the physical (actual) ones. This is the case in the moist lower troposphere where physical parameters are derived using the moist-air retrieval algorithm by combining individual profiles and background information (Li et al., 2019). In the UTLS region, the information is purely derived from the RO data. The variables dry density, pressure and temperature are estimated based on the refractivity equation, the downward integration of the hydrostatic equation and the equation of state.
We provide a clarification for the selection of ERA5 reanalysis as a reference dataset despite its "RO dependence" in the "Data and study method" section (L123).

5) Is the "dry" retrieval used in this study, e.g., at altitudes where humidity is small? If so, describe this.

Yes, we use the dry retrieval, as discussed in the previous comment.

In Section 2.1, it is briefly described that the geostrophic and gradient winds are computed from isobaric geopotential height data on a monthly 2.5x2.5 degree grid.
6) To avoid that sampling errors have an impact on the results, wouldn't it be an idea to extract ERA5 profiles co-located with the RO profiles and then compute the ERA5 wind fields from that sampled data set? Or is that the way it has been done? If not, could you comment on that, e.g., why sampling issues are not likely to change the conclusions of the study.

See answer earlier above; we use sampling-error corrected RO data and hence the sampling error is not likely to change the conclusions of the study (for details on sampling error estimation see, e.g., Scherllin-Pirscher et al., 2011, 2017).

You also mention that you apply a 5-point Gaussian filter to the geopotential fields before computing the geostrophic winds.
7) What is the reason for this additional smoothing? Do you apply this smoothing to both RO and ERA5, or only to RO?

The smoothing is applied only to the RO data due to a larger spatial variability (i.e., noise features) observed in the initially estimated winds based on the non-smoothed geopotential. As ERA5 is based on a numerical integration, which produces much smoother fields compared to the observation-based RO product, it was necessary to smooth RO geopotential field.

**Reference list (citations in this Response to Reviewer):**

Ladstädter, F.: Talk on gridding strategies, in: OPAC-IROWG 2022 conference, Seggau, Austria, Seggau Castle, 8–14 September 2022, https://static.uni-graz.at/fileadmin/veranstaltungen/opacirowg2022/programme/08.9.22/AM/Session_1/OPAC-IROWG-2022_Ladstaedter.pdf (last access: 27 September 2024), 2022.

Scherllin-Pirscher, B., Kirchengast, G., Steiner, A. K., Kuo, Y.-H., and Foelsche, U.: Quantifying uncertainty in climatological fields from GPS radio occultation: an empirical-analytical error model, Atmos. Meas. Tech., 4, 2019–2034, https://doi.org/10.5194/amt-4-2019-2011, 2011.

Scherllin-Pirscher, B., Steiner, A. K., Kirchengast, G., Schwärz, M., and Leroy, S. S.: The power of vertical

geolocation of atmospheric profiles from GNSS radio occultation, J. Geophys. Res. Atmos., 122, 1595–1616, https://doi.org/10.1002/2016JD025902, 2017.

Li, Y., Kirchengast, G., Scherllin-Pirscher, B., Schwaerz, M., Nielsen, J. K., Ho, S. P., and Yuan, Y. B.: A new algorithm for the retrieval of atmospheric profiles from GNSS radio occultation data in moist air and comparison to 1DVar retrievals, Remote Sens., 11(23), 2729, https://doi.org/10.3390/rs11232729, 2019.