

Response to Referee #1

General response

We sincerely thank the referee for the careful reading of our manuscript and for the constructive comments. The comments helped us improve both the methodological rigor and the clarity of the presentation. In the revised manuscript, we (i) distinguished grid-cell occupancy from area-weighted surface coverage, (ii) recalculated the principal coverage statistics, (iii) redesigned the relevant figures, (iv) clarified the temporal representativeness of the analysis, (v) removed the ERA5-based retrieval evaluation, and (vi) expanded the discussion of regional data gaps. Our point-by-point responses below identify the exact sections, figures, tables, equations, additions, and deletions involved.

Major comment 1

Comment: Are lat/lon bin boxes the best choice for this analysis when the area size of the boxes has extreme variation on a global scale? Consider whether it might be better to use boxes of equivalent area coverage for some of the calculations. If this is not possible, please consider if there are any options for presentation/display or calculation that can help compensate for the different spatial coverage of the binning boxes with latitude.

Response: We agree that assigning equal weight to all latitude–longitude grid cells can overrepresent high-latitude regions because their physical areas decrease with latitude. We therefore retained the regular latitude–longitude grid for reproducibility and direct comparison among missions, but replaced the principal unweighted coverage results with area-weighted surface coverage. The revised manuscript now explicitly distinguishes grid-cell occupancy (the fraction of grid cells containing at least one event) from area-weighted surface coverage (the fraction of the Earth's gridded surface area represented by occupied cells).

The recalculation changes the reported magnitudes but not the principal mission ranking or the conclusion concerning multi-mission complementarity. For example, the 12-mission seven-day area-weighted coverage is 92.08%, 99.71%, and 99.995% at 0.5°, 1°, and 2°, respectively, and the mean joint 6 h coverage at 2° is 76.79%. The complete mission-by-mission and time-window values are provided in Table 2 and the corresponding figures.

Changes made in the revised manuscript:

- Section 3.1 (Coverage metrics and statistical methods): added four equations defining grid-cell occupancy, area-weighted surface coverage, the physical area of each spherical

latitude–longitude grid cell, and the area-weighted blank fraction (revised Eqs. 1–4). The later equations were renumbered accordingly.

- Abstract; Sections 3.5, 4.2, 4.4, and 6; Table 2; and Figures 5 and 9: replaced the principal unweighted coverage values with the recalculated area-weighted results and revised the associated interpretation.
- Sections 3.3 and 4.2, and the captions of Figures 3 and 7: replaced the potentially misleading term ‘event density’ with ‘event counts per grid cell’ and explicitly stated that these panels show raw counts rather than counts normalized by physical grid-cell area.
- Figures 2, 3, 6, 7, and 11: replotted the global distributions using the Mollweide equal-area projection so that the displayed map area is proportional to surface area.
- Section 4.4: retained the conclusion that the joint 12-mission configuration substantially increases short-window coverage, while revising all absolute and relative gains using the area-weighted calculation.

Minor comment 1

Comment: [Can you make any statement about whether the one-week period is indicative of longer periods?](#)

Response: Thank you for this important comment. The one-week period used in this study should be regarded as a short-term observational sample rather than as being fully representative of longer-term or seasonal conditions. As stated at the end of Sect. 3.5, the four 6 h windows describe the selected day and do not establish that the results are independent of the UTC window. In addition, the final paragraph of Sect. 6 explicitly notes that the seven-day and one-day analyses provide only short-term snapshots of mission sampling characteristics and that longer-term and seasonally stratified analyses are required to assess temporal representativeness. Therefore, the orbital sampling patterns identified in this study may provide a useful indication of the relative characteristics of the missions during the selected period, but the numerical coverage values should not be interpreted as annual or seasonal averages.

Minor comment 2

Comment: [ERA reanalysis was used to evaluate observation errors, but some of these observations may have been assimilated.](#)

Response:

We thank the reviewer for raising this important concern. We agree that ERA5 is not a fully independent reference because GNSS-RO observations from some missions may have been assimilated into the reanalysis. Moreover, differences in the geographical and latitudinal sampling of the missions complicate a direct global comparison of their departures from ERA5.

In response to this comment and to related concerns raised by another anonymous referee regarding the interpretability of the inter-mission comparison, we have reconsidered the scope of the manuscript. We have removed former Sect. 5 in its entirety, including the ERA5-based bending-angle and refractivity comparisons, Fig. 12, and Eqs. (6)–(13). We also removed the description of the ERA5 dataset from Sect. 2.2 and revised the abstract, introduction, and conclusions to eliminate statements concerning inter-mission retrieval accuracy. The revised manuscript now focuses more clearly on the spatiotemporal sampling characteristics, coverage, and complementarity of the GNSS-RO missions. We believe that these revisions address the reviewer's concern and avoid presenting the ERA5 comparison as an independent assessment of retrieval accuracy.

Minor comment 3

Comment: Figure 9 uses wedges whose perceived magnitude is influenced by area.

Response:

We agree that the original radial/wedge representation visually encoded the values by area and could exaggerate differences. Figure 9 has therefore been replaced by a three-panel linear comparison plot. The panels correspond to the 0.5°, 1°, and 2° grids; the four rows in each panel represent the four UTC windows; gray points show the individual missions; the blue point marks the best individual mission (Yunyao-1); and the orange diamond marks the 12-mission joint coverage. A horizontal segment reports the joint-coverage gain in percentage points. Because all values are read from a linear horizontal axis, the visual magnitude is now directly proportional to the reported percentage.

Changes made in the revised manuscript:

- Figure 9: deleted the original wedge diagram and inserted the new three-panel linear comparison plot.
- Figure 9 caption: added an explicit explanation of the gray mission points, the best-mission marker, the 12-mission joint marker, and the percentage-point gain.
- Section 4.4 and Table 2: updated the surrounding text and numerical summary to match the redesigned figure and the area-weighted calculations.

Minor comment 4

Comment: [Consider using an equal-area projection for the maps.](#)

Response:

Thank you for this helpful suggestion. We agree. We selected the Mollweide projection, which, like Gall–Peters, is an equal-area projection but provides a compact global view that is well suited to the present distributions. We emphasize that the projection addresses visual area distortion, whereas the area-weighted formulas in Section 3.1 address the quantitative weighting of grid cells; both changes were made.

Changes made in the revised manuscript:

- Figures 2, 3, 6, 7, and 11: replaced the previous global map projection with the Mollweide equal-area projection.
- Relevant figure captions: revised the map descriptions to match the new projection and retained the stated latitude–longitude grid resolution.
- Section 3.1: added physical grid-cell-area weighting so that the numerical coverage statistics do not depend on the visual projection alone.

Minor comment 5

Comment: [The paper by D. L. Wu \(2024\) is relevant to the observational gap over Russia and Ukraine.](#)

Response:

Thank you for this relevant reference. We added it to the discussion while keeping the causal interpretation appropriately cautious. The revised text explains that Wu (2024) identified interference signatures using normalized RO signal-to-noise ratio at deeply occulted tangent heights ($\text{HSL} < -140 \text{ km}$) and reported affected regions extending across the Mediterranean, Eastern Europe, and the Middle East toward Russia. We also clarify that this evidence does not directly demonstrate a reduction in the number of retrieved atmospheric profiles in our dataset; quality control, data transmission, and data-access restrictions remain plausible contributing factors.

Changes made in the revised manuscript:

- Section 3.2, in the paragraph discussing the localized Russia–Ukraine gap: added the Wu (2024) evidence, its diagnostic basis, and its geographical context.

- Section 3.2: added a caution that the cited interference study does not by itself prove profile-count loss in the present dataset, and retained alternative explanations.
- Reference list: added Wu, D. L.: 'GNSS Signal Jamming as Observed From Radio Occultation', IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 17, <https://doi.org/10.1109/JSTARS.2024.3385738>, 2024

Technical corrections

Technical correction 1: Mathematical formatting

Comment: Line 180: $n_i(r)$ should be in math style.

Response:

Corrected. The symbol $n_i(r)$ and the other variables introduced with the coverage metrics are now consistently formatted as mathematical notation.

Changes made in the revised manuscript:

- Section 3.1: standardized the mathematical formatting of $n_i(r)$, N_r , A_i , and related variables in the text and equations.

Technical correction 2: Lower limit in the former Equation 10

Comment: Equation 10: is this r_a or r_t ?

Response:

Thank you for identifying this ambiguity. The intended lower limit was r_t . However, the former Equation 10 belonged to the ERA5-based retrieval-evaluation section, which has now been removed in response to Minor comment 2. Therefore, the ambiguous equation no longer appears in the revised manuscript.

Changes made in the revised manuscript:

- Deleted the former Equation 10 together with the entire former Section 5 and renumbered the remaining equations.