

Reviewer Comment 1

Thank you for your review. The original text is maintained in black, whereas our responses are marked in red. Any changes to the revised manuscript are also indicated in red text.

The manuscript provides impact assessment of massive GNSS-RO observation on UKMO's NWP system. The first half of the manuscript discusses the cause and solution of the forecast score degradation due to the introduction of large volumes of data, while the latter half presents how forecast score changes with the increasing number of observations. Observing System Experiments (OSEs) show that simply increasing the number of observations degrades forecast scores especially at troposphere. Sensitivity experiments employing 1D-Var show that observations at lower stratosphere induce change in the troposphere. OSEs with modulated refractivity observation operator coefficients, which aims to reduce the observation- background biases, show improved performance as the number of assimilated observations increase.

The manuscript provides comprehensive analysis on the impact of massive GNSS-RO observation on NWP system which also gives insight into essential role of GNSS-RO observation. The manuscript is definitely very dense and rich in information based on numerous OSE results. I think the content of the manuscript is very variable to the community and suggest publication after some revisions that might help to clarify the following points:

1. It seems that Figure 6 and its description/discussions are not consistent. Please provide more explanation on the figure and how you interpretate it.

Unfortunately, the wrong graphic was included in Figure 6 (it was a duplicate of Figure 7a). This error has been corrected in the latest manuscript.

2. While Figure 22 to 25 shows RMSE rises as observation number increases, section 4.3 states that RMSE decreases as observation number increases. It is confusing and I suggest that taking consistency between the explanations and the figure. Also please add explanations on "change in the RMSE scorecard".

As with the "overall" figure that is printed at the top of each scorecard, the values plotted in Figures 22 to 25 are positively-oriented (a reduction in the RMSE gives a positive overall figure). We accept that this is not clearly explained in the manuscript, so we have changed the presentation to be negatively-oriented, so that we are plotting the percentage reduction in RMSE. The figures have been changed and we feel this makes a lot more sense within the text.

3. In section 2.4 (line 178), it is stated that "change in tropospheric geopotential heights are likely due to a systematic reduction in the atmospheric pressure", whereas section 2.2 (line 130) states that "An adjustment to the atmospheric state below the observation will alter the modelled height of the observation". Since these sentences both explain same thing, ensuring consistency among these sentences will make it easy for the reader to follow the argument

The final sentences have been reworded to refer back to the hydrostatic tail which was introduced in the earlier argument:

The above results indicate that the reduction in the short-range geopotential height forecasts when assimilating the additional GNSS-RO observations is likely due to a systematic reduction in the atmospheric pressure. This is caused by observations in the upper troposphere and above, due to the hydrostatic tail present in the forward operator (Eyre, 1994; Bauer et al., 2014).

Other suggestions:

1. line 40: CGMS is not a sub-body of WMO.

Apologies, this has now been corrected to:

The Coordination Group for Meteorological Satellites (CGMS) provides recommendations on the number of observations that should be made each day by the various observation platforms. Whilst the CGMS is not able to mandate the number of observations to be made, it does provide guidance to national meteorological centres and world meteorological organisation (WMO) members on the number of observations that should be made.

2. line 105. Figure 1 does not provide information about bias change. It is beneficial to present figure on bias change for the reader to follow the argument.

We have brought forward the discussion of the forecast biases (promoting Figure 6 to be Figure 2). The discussion of biases is now split between Section 2.1 (where the initial experiments are discussed) and Section 2.2 (which applies a bias correction to the observations).

3. line133: Looking again at 2 => Looking again at **Figure.2**

Thank you, fixed.

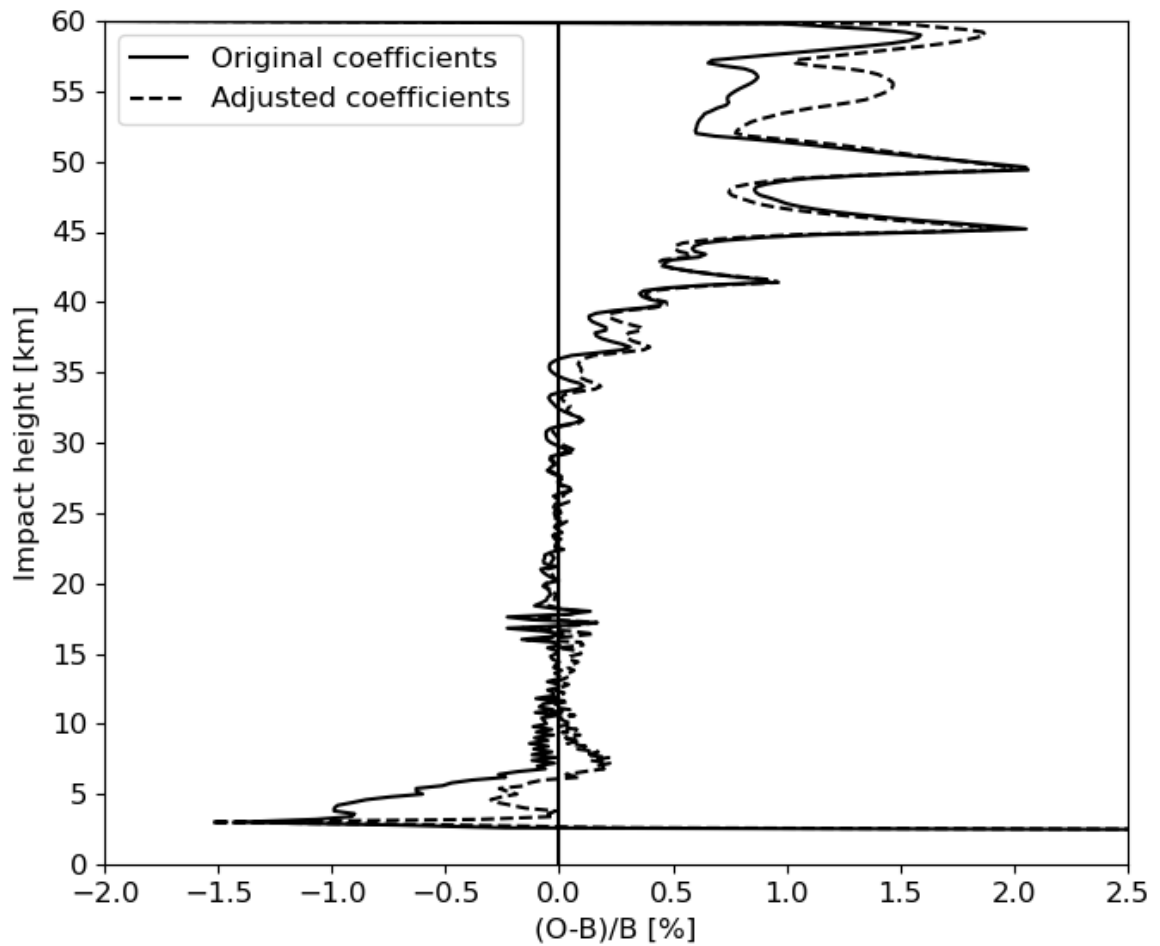
4. line 134: Add citation for “golden region”.

We have added a reference to Anthes et al., 2025 which explains the term.

5. Section 2.4 : It would be beneficial for the reader to present figure how O-B statistics changes by modulating forward operator coefficient.

We have produced the figure below which gives the effect of changing the coefficients in the observation operator. Unfortunately, this is only from one month of the ROMEX statistics, due to limitations on the files that we have available. Given the already long nature of the paper, we suggest not including this. Instead we have added a section of text describing these results.

BA Global O-B statistics for all satellites provided by multiple centres



References

Anthes, R., Sjöberg, J., Starr, J., and Zeng, Z.: Evaluation of biases and uncertainties in ROMEX radio occultation observations, *Atmospheric Measurement Techniques*, 18, 6997–7019, doi: [10.5194/amt-18-6997-2025](https://doi.org/10.5194/amt-18-6997-2025), 2025.