Answers to the comments on "Comparison of GNSS integrated water vapor and NWM reanalysis data over Central and South America"

The authors would like to thank both anonymous reviewers for their contributions, which have enriched our work. We have taken all their comments and suggested corrections and we have completely changed the manuscript in the title and structure as well as in the organization and quantity of contents and results we had shown.

In brief we enumerate the most important modifications present in this new version of the manuscript:

a) the classification of the stations following the geopotential height difference (small, large and critical) was dismissed and the complete set of stations was analyzed as a whole. Thus, new tables, figures and plots were adequate to this.

b) Geopotential heights were changed by geopotentials [$m^2\ s^{-2}$] and the nomenclature was also changed: z lower case instead of z upper case.

c) Figure 1 was eliminated

d) New table 1 shows geopotential GNSS and the static geopotential values assigned by the models to each GNSS site. The geopotential for ERA Interim and geopotential for MERRA2 come from a bi-linear interpolation of the given static geopotential values at the 4 grid points surrounded the GNSS site.

e) A discussion about the behavior of the mean IWV from the reanalysis models with respect to the mean IWV_{GNSS} highlights overestimations and underestimations is incorporated. New plots are also incorporated to easily follow the discussion of the new findings.

f) A new Table 3 was included in order to demonstrate the robustness of our numerical integration method for reproducing IWV values at ERA Interim grid points around each GNSS site. For this calculation we used the q and t data (specific humidity and temperature) given at 37 atmospheric pressure levels. This q, t and p set is the same data used for the calculation of the integral correction.

g) Likewise, and following the suggestion, new figures were incorporated to improve the visualization of the results of the comparison between the models and GNSS, prior to the application of the integral correction.

h) The scheme of application of the correction for a given example was clarified in its caption and through new text incorporated in the main body of the manuscript.

i) The correction is presented with a new equation independently of the integral definition of the IWV. Moreover, the different possible signs for the correction are included in this new mathematical expression.

j) The previous classification by height differences (small, large, critical) is sketched out without mentioning it in the new presentation of the results. The residuals of the differences (IWV_{GNSS} -$IWV_{ERA\ Interim}$) before and after applying the integral correction are shown in a new figure. The new figure also shows the results for cases where the model geopotential is located above the GNSS geopotential (right column) and below the GNSS potential (left column).

k) Also following the suggestion, the title was changed since the region of South and Central America only refers to the GNSS sites available for this work and we do not perform any analysis of the IWV behavior in the region.

Following, the detailed answers to each of the reviewers:

Answers to Anonymous Referee # 2:

Reviewer #2 made all comments and corrections in the text. Because the main text has changed dramatically, we will answer here the questions that need further explanation since the grammatical errors disappeared when rewriting or eliminate those parts of the text.

Page 3: #5: vague statement.

The exact quantity of years was included in the text

Page 3: #6: in Geodesy, we usually designated H for geopotential height and Z for the third component of the Cartesian coordinate system

Yes, it is true but some authors also designate H for the orthometric height in order to distinguish it from h the ellipsoidal height. Therefore, we decided to adopt z (lower case) and express the differences in terms of geopotential (not geopotential height). In this way, we use the data from the models as they are provided (geopotential in m^2/s^2) and only the GNSS height has to be converted.

Page 3: #8-9 why 100 m and not 90 m, 110 or another value?

These comments were taken into account and the entire available dataset was studied without discrimination.

Page 4: *#1 to #4.*

The description of the geodetic processing was incomplete and resulted unclear. Because we used IWV from GNSS from a previously published study, we reformulate the section including just the reference of the source and the mean characteristics of the dataset.

Page 4: *#5*

A mention to the partial evaluation of MERRA2 was included.

Page 5: #1.to #11 ; Page 6: #5 to #7; Page 7: #4 to #6, #8

The sections *Methodology* and the subsection *Computation of the integral correction* were rewritten. For a sake of clarity, the different paragraphs were reordered and some other sentences added.

In this new text we took into account the items highlighted by the reviewer:

A clarification of how the geopotential GNSS was calculated from geodetic data,

An explanation about how the geopotential GNSS (z_{GNSS}) and the static geopotential data from the models at the 4 grid points (z^i_{NWM}) are related. We also explained how we computed p, t and q at z_{GNSS} and at z^i_{NWM} . Or in other words, an explanation of how the formulas were used.

We also described how the correction is calculated and how to take into account the sign of the correction.

We also highlighted which is the difference between Δz and δz.

Finally, A more detailed description of the example (see Figure 2) was included

Page 6: #1 and #2

The former discrimination in small, large and critical height differences was dismissed in this new manuscript.

Page 6: #3 and #4

Given that any structure smaller than the resolution of the model could not be evidenced and considering that many of the GNSS stations of the available dataset are in mountain areas, the model with the smallest grid was chosen. It is expected that stations located near or at mountainous regions will suffer great height changes in short distances. We assume that the model with the finest grid can better reflect this situation. Moreover, we better explained why we also took into account results from Zhu et al. (2014) to back up this decision.

Page 7: #7

The suggested reference was incorporated

Page 7: #9 to #11; Page 8: #7, Page 9: #1, Page 10: #1

The section Results was rewritten and now it incorporates the old section Application of the integral correction. Then, it includes only the results after the application of the integral correction.

On the other hand, the comparison between IWV_{GNSS} and IWV_{NWM} was moved to the section Methodology.

The title was changed.

Page 10: #2

The section discussion and conclusions was rewritten too. The agreement with the state-of-the-art literature was also highlighted.

About originality of the work: although the application of an altitude correction is not new, in fact it is commonly accepted and silently assumed, it is not widely studied. In other words, the statistical quantification of the differences between IWV from NWM and GNSS is not extensively known.

In this paper we offer an analysis of the differences that users of IWV data from NWM in South and Central America might encounter if they intend to use such data as a substitute for IWV_{GNSS} values.