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Interactive comment on "Comparison of GNSS integrated water vapor and NWM reanalysis data over Central and South America" *by* Laura Isabel Fernández et al.

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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 [m2 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 IWVGNSS 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 the reviewer: Answers to Anonymous Referee # 1:

Application of the correction This comment was considered and the integral correction strategy was applied to the whole set of data. Effectively, as you affirmed, the correction applied to the stations formerly classified as “small” is slight but still it is an improvement.

Definition of the correction The correction was defined independently of the integral definition of IWV. Both negative and positive results are included in equation (7) because the sign is given by the difference between atmospheric pressure values (PGNSS - PNWM). For a sake of clarity some paragraph were also included and a better explanation of the example (now Figure 3) is also given.

Computation of the correction According to the recommendations received by both reviewers, the structure and presentation of the work has changed. We have placed in the methodology section: the calculation of the GNSS geopotential from the geodetic coordinates of the station, the comparison of the mean values of both models with respect to the mean values IWVGNSS, as well as the quantification of the geopotential differences and a brief summary of the method for calculating the correction. The details of the calculation of the correction are presented in the following section and finally the results section only presents results after having applied the correction. Thus, the

way we compute and applied the proposed correction was clarified in the main text. Moreover, the suggestion of this reviewer was taken into consideration and the numerical integration procedure was tested for the whole set of stations. In the new Table 3 the mean values of the difference IWV from ERA Interim and the same IWV from a numerical integration of over q at each grid point is shown. The integral is computed from 1 hPa till the static geopotential height at each grid point and we used data given at 37 pressure levels from ERA Interim. Each of the 4 columns correspond to the 4 grid-point around the GNSS station. The averages and standard deviations were computed over the period 2007-2013. In addition, we have also calculated the alternative suggested by this reviewer: We have computed the integral over q from 1 hPa till the geopotential corresponding to GNSS at the 4 grid points surrounding the GNSS station. Then the value at the GNSS site was calculated using a bi-linear interpolation. However, given that the results proved to be very similar to our procedure (both the mean values and their dispersions), we have decided to omit them in favour of the extension of the work and given that this strategy does not add up different results. Note that this strategy differs from the integral performed at grid points from 1 hPa to the static geopotential of each point. These results were incorporated as before mentioned in Table 3.

Temporal interpolation: A paragraph was included to explain how the different time intervals of the datasets were handled.

Specific comments:

1. L. 22-23 abstract The discussion was included in the main part of the manuscript

2. P. 2 L. 22 Corrected. A new sentence was added

3. P. 3 L 21-22 and P. 4 section 2.1 Following your advise we just explain the main characteristics of the data set and removed the incomplete presentation, we also refer the reader to the work from Bianchi et al, 2016a for further technical details.

5. P. 6 eq. 5 The application of equation 5 is clarified in the text. This is the necessary

formula to estimate the atmospheric pressure p at zGNSS as well as at the geopotential of the each grid point around the GNSS site. These geopotentials (GNSS and the 4 grid points) are not necessarily coincident (generally they are not) with the geopotential correspondent to the 37 given pressure levels. As a matter of fact temperature (T) and pressure (p) data at each level are necessary to compute the p unknown at each geopotencial by using eq. 5. The unknown temperature at these geopotentials is estimated by assuming the rate 0.006499 °K/m. Thus, the unknown temperature is given by the numerator of Eq. 5.

6. P. 7 L 22 Yes, "interannual" averages refer to the mean value over the complete period 2007-2013. The sentence was clarified and this terminology avoided.

7. Section 4.1 Following your suggestion the tables were reworked and also graphics were added to enrich the comparison. Thank you.

8. P. 8 L. 8 The expression "model failure" was eliminated. The section was rewritten.

9. P. 8, L 9 This part was removed. The classification in: small, critical and large was dismissed.

10. P 9 L. 29 (and eq. 5) The methodology section was rewritten and it includes the explanation of Δz. On the other hand the meaning of δz, within equation 5, was clarified.

11. P. 10. L. 3 We emphasise this point with more discussion and a new figure

12. P 18 The figure was removed

Technical corrections

1. P1 L. 22 The abstract was rewritten.

2. P. 2 L. 3 Corrected

3. P.4 L.9 removed from the main text

4. Section 2.1.1 should probably be section 2.2 Corrected

5. to 8. These parts were eliminated from the main text

9. P. 21 former Fig 4 This figure was eliminated since its purpose was to show the behavior of the stations classified as small for not applying there the correction.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2019-20/angeo-2019-20-AC1-supplement.zip

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