

Interactive comment on “Validating HY-2A CMR Precipitable Water Vapor Using Ground-based and Shipborne GNSS Observations” by Zhilu Wu et al.

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Received and published: 24 June 2020

Dear reviewer,

Thank you for the constructive and encouraging comments regarding our manuscript. We have enclosed a carefully revised manuscript according to the comments and suggestions provided. We also provide an item-by-item response to all comments.

Yours Sincerely, Zhilu Wu

Response to Reviewer

The author needs to read the guidelines for acronyms. Where should you use them and where should you define them in manuscript is a basic background knowledge

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for scientific writing. Line 12, please provide the full name of acronym PWV. Line 14, I understand HY-2A is Haiyang-2A, but you need to add this to the end of Haiyang-2A for clarification. Line 18, what is RMS? Line 30, Acronyms MODIS, FY-2C? SSM/I, TMI?

Response: Thank you for the suggestion. We are so sorry about our mistake. We revised the manuscript accordingly: Line 12 is revised as “Ground-based Global Navigation Satellite Systems (GNSS) provide precise precipitable water vapor (PWV) with high temporal resolution”. Line 10 is revised as “The calibration microwave radiometer (CMR) onboard Haiyang-2A (HY-2A) satellite”. Line 15 is revised as “... using ground-based GNSS observations of 100 International GNSS Service (IGS) stations along ...”. Line 18 is revised as “Geographically, the root-mean-square (RMS) is 1.12 mm in the polar region ...”. Line 29 is revised as “satellite-borne infrared sensors (e.g. Moderate-resolution Imaging Spectroradiometer, Fengyun-2C) and microwave radiometers (Special Sensor Microwave/Image, Tropical Rainfall Measuring Mission’s (TRMM) Microwave Imager (TMI))”.

The result section is largely based on the separation of clean and contaminated pixels. But I don’t see a clear validation and explanation of how the author did this.

Response: Thanks a lot for your comments. Before the validation, the raw HY-2A PWV observations were processed with a outlier detection method, and coastal observation reconstruction was implemented. The reconstruction method of contaminated HY-2A PWV is described from line 150 to line 160, and the HY-2A CMR observations (DOY 123 and 128, 2014) in Southeast Asia were used as an example to illustrate the coastal PWV reconstruction (line 161 to 175).

The separation from 200km, 150km, until 50km is nice, but the data points are too little. Overall 600+ points is quite small for this kind of comparison. Since you already have the automatically methods for running this analysis, I would highly suggest to extend the running to at least one full year.

Response: Thanks a lot for your comments. We acknowledge the number of cross-

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points was limited in this study due to original GNSS observations. The limiting aspect of the study is the small number of points examined. And even fewer number of days which make the result not very much representative of general conditions. To better assess the HY-2A CMR bright temperature measurements and the PWV retrieving algorithms, more spatially distributed open-sea GNSS observations are needed, including those from various kinds of ships or buoys. Thank you so much for your advice again and we are planning to collect more GNSS observations (more than one year) to extend my research.

Line 15, coastline along China or India? Before you submit a paper, it is always a good practice to get a second opinion. You are familiar with all the acronyms and station set ups, but not the readers.

Response: Thank you for the suggestion. We revised the manuscript accordingly: "100 IGS stations along the global coastline "

Line 25, reference is needed here.

Response: Thanks a lot for your suggestion. We revised the manuscript accordingly: "Sea surface height measurement is mainly implemented by satellite altimetry, where the precise tropospheric delay is required to correct the atmosphere propagation error in the measured distance between satellite and sea surface (Obligis et al., 2011) "

Obligis E, Desportes C, Eymard L, et al. Tropospheric corrections for coastal altimetry[M]//Coastal altimetry. Springer, Berlin, Heidelberg, 2011: 147-176

Line 51, over the sea and over the land. Response: Thanks a lot for your comments. We revised the manuscript accordingly: "where it happens very often that one footprint covers partly over the sea and partly over the land "

Line 71, delete the first and. The full sentence from line 71-72 needs to be rewritten. Grammar mistake.

Response: Thank you so much for your advice again, we are truly sorry for the mistake.

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We revised the manuscript accordingly: "In this section, we introduced the processing strategy of ground-based and shipborne GNSS observations. The height correction for PWV of ground-based GNSS was also discussed. "

Line 74, ECMWF is a large dataset, what exactly did you based on here?

Response: Thank you so much for the comment. We revised the manuscript accordingly: "Then we presented the HY-2A CMR retrieval method and the reconstruction algorithm of coastal HY-2A CMR contaminated data based on European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim layer data"

Line 123-127, more detailed coefficients calculation used here is needed. If you are using any standard lookup table, the reference should be provided.

Response: Thank you for the suggestion. The data we used is level 2 product, which is from National Ocean Satellite Application Center (NSOAS), Ministry of Natural Resources (MNR) of China, and our paper is focus on the validation of level 2 product (PWV data). We revised accordingly: "These coefficients must be estimated using external PWV datasets, e.g., NWM, radiosonde profiles, or previous satellite altimetry missions. In our study we used the product from National Ocean Satellite Application Center (NSOAS), Ministry of Natural Resources (MNR) of China."

Line 139-141, you named all the potential problem, what is you solution? Just say be careful is not enough.

Response: Thank you for the suggestion. We find the potential problem of CMR PWV data, therefore, we propose a method to reconstruct the contamination CMR data after line 143: "...Therefore, a linear fitting of HY-2A CMR PWV could be used for quality control in principle. ..."

Line 158-159, what is clean points? On both side how? How did you get the clear points? Figure 2 Still what defines a clean point? Contaminated points? The better way is to first describe how the points are classified (more figures), then show a scatter

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plot of the PWV point's correction result. The current figure is very confusing.

Response: Thank you for the suggestion. The contaminated points are the CMR abnormal PWV data causing by the signal from land. The clean points are original HY-2A CMR PWV without contamination. We revised the manuscript accordingly: "In this study, the vertical integral of water vapor (VIWV) from ERA-Interim surface product was used, where the PWV differences between HY-2A CMR and ECMWF at crossover points should be small and stable. Those with extremely large values (differences over three times of the standard deviation value of the differences) were considered as contaminated points, and the remaining CMR data were taken as clean points."

Line 176-179, consider delete this paragraph, the sentences are useless and contain several grammar mistakes.

Response: Thank you for the suggestion. We deleted this paragraph.

Line 184, the word complicated will raise concerns. Please elaborate on the advantage and disadvantages of the processing algorithm or packages.

Response: Thank you for the comment. Before the validation, we need to pre-process raw CMR data. The CMR data flagged with "land" and "ice" were removed firstly, and then CMR data that the footprints within 100 km to GNSS sites were selected. The integral of water vapor (VIWV) from ERA-Interim surface product was used, and those with extremely large values (differences over three-time of the STD value of the differences) were considered as contaminated points. The pre-processing can help to find the coastal contaminated points and make preparation for the reconstruction, which make the validation result reliable.

Line 193, mislabeling Figure 3. Check the rest of figure labeling, most of them needs updates.

Response: Thank you for the suggestion. We revised the label of the Figure 3 and other figures in the manuscript.

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Line 203, how did you come up with the criteria of 200 km and 2 hours, any histograms to show the overlapping points so that these criteria can be trusted?

Response: Thank you for the comment. Research shows that successive zenith wet delay estimates are significantly correlated for up to 1.7 hours (El-Mowafy A et.al., 2011). And a troposphere delay resolution of 1 or 2 hours is usually used in GNSS processing (Snajdrova K et al., 2006; Geng J et al., 2012). Larger temporal resolution might miss the real signals, while too small temporal resolution might cause low robustness of the solution (especially for kinematic platforms). Wet delay is nearly proportional to the PWV. Therefore, we take 2 hours as the time criteria. There are only 49 crossovers when the distance criteria is 50 km, so we loose the distance criteria to 200 km to have more crossover points for comparison.

El-Mowafy A, Lo J. Prediction of troposphere wet delay [J]. *Journal of Applied Geodesy*, 2011, 5(3-4): 163-173. Geng J, Williams S D P, Teferle F N, et al. Detecting storm surge loading deformations around the southern North Sea using subdaily GPS[J]. *Geophysical Journal International*, 2012, 191(2): 569-578. Snajdrova K, Böhm J, Willis P, et al. Multi-technique comparison of tropospheric zenith delays derived during the CONT02 campaign [J]. *Journal of Geodesy*, 2006, 79(10-11): 613.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-503, 2020.

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