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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparison of Global Observations and Trends of Total Precipitable Water Derived from Microwave Radiometers and COSMIC Radio Occultation from 2006 to 2013" *by* Shu-peng Ho et al.

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Reviewer#1 comments

Manuscript #: acp-2017-525 Manuscript title: Comparison of Global Observations and Trends of Total Precipitable Water Derived from Microwave Radiometers and COSMIC Radio Occultation from 2006 to 2013

Brief Summary of the Manuscript:

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Discussion paper

This manuscript compares TPW estimates from the COSMIC radio occultation mission against estimates from SSM/I, SSMIS, radiometers, and WindSat over clear sky and cloudy conditions. The authors report a very good agreement between COSMIC and all other TWP data sets and trends. They also claim that the estimated differences between MW radiometers and COSMIC are mainly due to biases in the MW retrieval uncertainty under cloudy and precipitating conditions. This analysis is in my opinion a novel approach to establishing radio occultations as a new remote sensing climate instrument by cross-comparing the COSMIC results with independent data sets. The manuscript is very well written, coherent, and the results are presented nicely within the context of the investigation. My recommendation for this manuscript is publication after minor revisions, as described below.

=> We thank the reviewer for his or her thoughtful comments and have incorporated the suggested changes in the revised manuscript.

Major Comments:

1) Page 7; Line 147: What is the cut-off value of the liquid water column? Given that this value establishes an upper limit in the estimation of the TPW in the RSS products, could this introduce a bias in the COSMIC vs RSS comparisons at high TPW values? I think this must be explicitly discussed in the manuscript.

=> As shown in the valid data range reported by RSS (see http://www.remss.com/missions/ssmi/) the cut off values of the liquid water column are from -0.05 to 2.45 mm (plus the offset value -0.05 mm). => As demonstrated in Fig. 5d, the number of samples for RSS total cloud water (liquid water column) for those MW-COSMIC pairs peaks at around 0.01 mm ($\sim$2600) then decreases to fewer than 10 at 0.4 mm. The sample number for RSS total cloud water value equal to or larger than the cut-off value (2.40 mm) is therefore less than 10, which will not introduce any significant biases in the RSS MW-COSMIC comparison.

2) Page 11; Line 236: The authors assume an 80% relative humidity below 0.1 km.

What is the sensitivity of the COSMIC TPW estimation the relative humidity assumption? How does that affect the conclusions of this investigation?

=> We added the following in Section 2.3: The COSMIC TPW estimates are not very sensitive to the assumption of 80% relative humidity below 0.1 km (Step i above). The assumption of 80%+/-10% (i.e., 90% and 70%) relative humidity below 0.1 km introduces an uncertainty of about -/+0.03 mm uncertainty in the WV – COSMIC comparisons for all conditions. As shown in Section 4, this uncertainty is small compared to the observed differences between the RO and MW estimates.

3) Lines 289–291, Lines 309–310, Lines 414-423: The authors conclude that the primary source of the estimated biases between COSMIC and the rest of the data sets is the MW retrieval uncertainty. Because the largest biases are found under cloudy precipitating conditions, I think that the authors should also acknowledge that errors due to: a) cut-off liquid water and b) the 80% RH assumption below 0.1 km, could also contribute to the reported differences. Could there be a combined effect as well?

=> As stated in our responses to major comment 1), the RSS pre-defined cut off value for liquid water will not affect the conclusion from this study. => As stated in our responses to major comment 2), the 80% RH assumption below 0.1 km does not affect the conclusions from this study. => Since there is a very small number of RSS total cloud water values equal or larger than the cut-off value (2.40 mm), there is no combined effect for these two uncertainties that will affect the conclusion from this study.

4) Page 16; Line 357: It should read: "...with F15, F16, F17, and WindSat under..."

=> Done

Minor Comments:

a) Line 57: Grammatically the sentence is fine, but the noun "increases" reads rather awkward. Perhaps, consider replacing it with the word "enhancements"?

=> "increases" is replaced by "enhancements"

b) Line 69: It should read: “reanalyses”.

=> All of the “reanalysis” are replaced by “reanalyses”.

c) Line 92: Place a comma after the word “Recently”.

ïč£ Done

d) Line 116: Delete the word “and”

=> Done

e) Line 161: It should read: “... (RR, in mm/hr), respectively, in 2007.”

=> Done

f) Line 161: It should read: “temperature variations over the Intertropical Convergence Zone (ITCZ) (Fig. 1b), which...”

=> Done

g) Lines 181-182: It should read: “where P is the pressure in hPa, T is the temperature in K, Pw is the water vapor pressure in hPa, Wwater is the liquid water content in grams per cubic meter (g m-3)... ”

=> Done

h) Line 208: Place a comma after the word “troposphere”.

=> Done

i) Lines 216-218: I think that this statement is a bit bold. Perhaps, mention that the “...retrieved water vapor profiles are weekly dependent on the first guess” and provide a more appropriate reference that demonstrates that?

=> In Line 226, “the retrieved water vapor profiles are insensitive to the first guess water vapor profiles” is replaced with “the retrieved water vapor profiles are weakly dependent on the first guess water vapor profiles (Neiman et al. 2008)”. Neiman et al.

(2008) is a good reference for this statement.

j) Line 244: Check “Wick2008”. Is it written properly?

=> In Line 125 of the original manuscript (141-142 of revised manuscript), we defined Wick et al.(2008) as “Wick2008” the first time the reference is given, so “Wick2008” is ok.

k) Line 264: Spell out December.

=> Done

l) Lines 264-266: Delete this sentence. It appears twice in Lines 259-260.

=> Done

m) Line 268: It should read: “Figures 2a-d...”

=> Done

n) Line 275: Explain briefly how the “rad-cal” beacon biases the F15 data.

=> One sentence is added in Line 285, “On 14 August 2006, a radar calibration beacon (RAD-CAL) was activated on F15. This radar interfered with the SSM/I, primarily the 22V channel, which is a key channel for water vapor retrievals. Although a correction method derived by Hilburn and Wentz (2008) and Hilburn (2009) was applied, the 22 V channel is not being full corrected (Wentz, 2012). As a result, there are still errors in the water vapor retrievals.” Âă

=> Two papers are added in to references:

Hilburn, K. A. and F. J. Wentz, 2008: Mitigating the Impact of RADCAL Beacon Contamination on F15 SSM/I Ocean Retrievals. Geophysical Research Letters, 35. L18806, doi:10.1029/2008GL034914.Âă

Hilburn, K. A., 2009: Including Temperature Effects in the F15 RADCAL Correction. RSS Technical Report 051209, Remote Sensing Systems, Santa Rosa, CA,

http://www.remss.com/papers/RSS_TR051209_RADCAL.pdf.

o) Line 300: It should read: “Figures 4a-d depict the...”

=> Done

p) Line 318: It should read: “Figure 5b indicates that...”

=> Done. And all “Fig.” replaced with “Figure” in the paper

q) Line 321: Delete “Fig. 5d” => Done

r) Line 323: It should read: “Figure 5e shows that...”

=> Done

s) Lines 338, 342: Spell out December.

=> Done

t) Line 353: It should read: “Figure 8 depicts the...”

=> Done

u) Line 366: It should read: “Figure 9 shows the...”

=> Done

v) Line 382: It should read: “Figure 10 shows...”

=> Done

w) Line 383: What about the F15 data?

=> The reason we did not include F15 data in Figure 10 is mentioned in the last para on page 17 of the revised manuscript: “The reason for larger standard deviations of the MW minus RO differences for F15 (Tables 2 and 3 and Fig. 8a) is very likely because the F15 data after August 2006 were corrupted by the “rad-cal” beacon that was turned on at this time.” Also on this page “RSS does not recommend using these

measurements for studies of long-term change. Thus, we consider the F15 data less reliable during the period of our study."

x) Line 385: It should read: "...and west of Australia, south..."

=> Done

y) Lines 399–400: It should read: "Because RO data have low sensitivity to clouds..."

=> Done

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