Atmos. Meas. Tech. Discuss., 8, C295–C299, 2015
www.atmos-meas-tech-discuss.net/8/C295/2015/

Atmospheric Measurement Techniques
Discussions

Interactive comment on "On the comparisons of tropical relative humidity in the lower and middle troposphere among COSMIC radio occultations, MERRA and ECMWF data sets" *by* P. Vergados et al.

P. Vergados et al.

panagiotis.vergados@jpl.nasa.gov

Received and published: 12 March 2015

Manuscript Number : amt–2014–361 Associate Editor : Dr. Ulrich Foelsche Manuscript Title : On the comparisons of tropical relative humidity in the lower and middle troposphere among COSMIC radio occultations, MERRA and ECMWF data sets

Dear Referee #1,

We would like to thank you for taking the time to review our manuscript. Your kind words

about our work are greatly appreciated, and your comments have now been addressed and implemented in the revised manuscript.

Please, also check the supplementary material, which contains the revised manuscript with "Track Changes" Enabled to follow the minor revisions we performed in response to the commends provided. ————————————————-

Comment #1: What kind of ECMWF temperature is used (forecast or analysis) in Eq. 1? Answer: ECMWF analysis. Please, see line 158.

Comment #2: Why is the temperature not used from the wetPrf? Answer: The temperature profile in the "wetPrf" files is the product of the 1-D variational assimilation. We wanted to use temperature profiles that are independent from 1D-var. Please, see lines 158–166.

Comment #3: Furthermore, why is the humidity not used from the wetPrf instead from Eq 1. Answer: Similar to Comment #2, the humidity profiles in the "wetPrf" files are products of the 1-D variational assimilation. We wanted to use humidity profiles that are as independent as possible from any a-priori humidity information. Please, see lines 158–166.

Comment #4: What is the specific advantage of using Eq.1 instead of the wetPrf humidity? Answer: The advantage is that the retrieved humidity is not constrained by any a-priori information, is independent of the humidity uncertainty of any a-priori profiles, as well as less dependent on the ECMWF humidity profiles. Additionally, because the temperature uncertainty is much smaller than the humidity uncertainty, given well-defined temperature profiles with documented errors, we can retrieve humidity profiles with well defined error characteristics even at higher altitudes than the 1-D var method. See lines 158–166.

Comment #5: How much are the GPS RO relative humidity results effected by deriving them from the ECMWF temperature? Answer: We have included section 3.3, which explicitly addresses this question. In particular, temperature errors of ±1.0 K introduce relative humidity errors of < 5% in the lower troposphere; <9% in the middle troposphere. These uncertainties are smaller than the documented differences between the GPS RO, ECMWF and MERRA data sets computed herein; and thus, our results are statistically significant. Above the 400 hPa pressure level, the relative humidity error increases non-linearly exceeding 30% at 300 hPa. However, this uncertainty magnitude is within the reported relative humidity errors from other space–based platforms (e.g., AIRS, which also exceeds 25% relative humidity errors [Gettleman et al., 2004] at 300 hPa, while systematically underestimate very wet and very dry conditions [Fetzer et al., 2008; Chou et al., 2009]). Due to this 30% relative humidity uncertainty, we explicitly state in the manuscript that the differences between the GPS RO data sets and the analyses are comparable to the retrieval errors are not considered statistically significant at 300 hPa and above. See lines 319–321.

Comment #6: Furthermore, ECMWF reanalysis assimilates GPS RO data since Nov 2006. I was wondering why the agreement between ECMWF RH and GPS RO RH is not closer; see e.g., Fig. 1 and Fig. 2? Answer: Briefly, there are numerous satellite products being assimilated by ECMWF, among which in the top of the list of assimilated products are the IR IARS and AIRS radiances, the relative humidity profiles from radiosondes (whenever available), and the GPS RO bending angle profiles. Different weight is applied to different data sets; and thus, the ECMWF relative humidity profiles contain contributions from multiple products (among which the GPS RO bending angle profiles). Also, we derive relative humidity using Eq. (1), which is a different technique than what ECMWF uses.

Comment #7: Can the authors explain again why they use a three-years average? Answer: Because we want to have a multi-year picture of the water vapor climatology. We could use a 1-year average, but we wanted to increase the statistical significance of our results. We could also use a 5-year average, but since we are focusing on climatological means at seasonal time scales we do not expect any significant change

on the results.

Comment #8: Furthermore, are there any natural effects (El Nino, La Nina), which affect the data in this period of time? Answer: The time series for the ENSO index from 1950 to present fluctuates within the (-3, 3) range. During summer, June–July–August (JJA), for all years considered (2007, 2008, and 2009), the ENSO indices were smaller than 0.4 (absolute value) and thus, we don't' expect the summer season to be strongly affected by ENSO signatures. During winter, December–January–February (DJF), we had a Weak El Nino (+0.7) and Moderate La Nina (-1.5 in 2007-2008 and -0.8 in 2008-2009). We have added relevant text in the conclusions section of the revised manuscript to explicitly state these facts. See lines: 361–367.

Comment #9: Are such effects might better captured by GPS RO than reanalysis model ERA-interim? Could natural variability have an impact on the results? Answer: Given that such natural variabilities affect the temperature field of the Earth's atmosphere, from the surface to stratospheric altitudes (if not higher) [Free and Seidel, 2009; Scherllin-Pirscher et al., 2012], the question comes down to which data set (GPS RO or ERA-interim reanalysis) better captures the Earth's thermal structure, both in terms of vertical profile and accuracy. That said, we could argue that GPS RO might better capture such natural variabilities than reanalysis model ERA-Interim. The natural variability is present in all data sets. However, given the weak El Nino and La Nina signatures in the time period considered in this study, there is no strong forcing in our data sets. In particular, numerous researchers (when studying the seasonal variability of relative humidity) did not consider the impact of ENSO signals on their results and conclusions. Here are a few references: Gettelman et al. [2006], Chuang et al. [2010], Fasullo and Trenberth [2012]. We have added relevant text in the revised manuscript. See lines: 367–374 and the associated references in lines: 476–478; 498–501; 515–517.

References: [1] Gettelman, A., W. D. Collins, E. J. Fetzer, A. Eldering, F. W. Irion, P. B. Duffy, and G. Bala (2006), Climatology of Upper-Tropospheric Relative Humidity

from the Atmospheric Infrared Sounder and Implications for Climate. J. Climate, 19, 6104–6121, doi: http://dx.doi.org/10.1175/JCLI3956.1 [2] Chuang, H., X. Huang, and K. Minschwaner (2010), Interannual variations of tropical upper tropospheric humidity and tropical rainyâĂŘregion SST: Comparisons between models, reanalyses, and observations, J. Geophys. Res., 115, D21125, doi:10.1029/2010JD014205 [3] Fasullo, J. T., and K. E. Trenberth (2012), A less cloudy future: the role of subtropical subsidence in climate sensitivity, Science, 388, pp. 792-794, doi:10.1126/science.1227465

Comment #10: p 522, line 14 and line 15: in the data sets description the data is described to be used from 2006 until 2009. In the plots later on, data is shown averaged over 2007 until 2009. Typo? Answer: Yes, the years considered are 2007, 2008, and 2009. We corrected it in the data description.

Comment #11: p 523, Eq. 1: there is no space/no arrow between refractivity and water vapor pressure Answer: Fixed.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/8/C295/2015/amtd-8-C295-2015-supplement.pdf

---

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 517, 2015.