

## ***Interactive comment on “Humidity sensor failure: a problem that should not be neglected by the numerical weather prediction community” by Y. Liu and N. Tang***

**Y. Liu and N. Tang**

liuyan@cma.gov.cn

Received and published: 17 September 2014

We are grateful for the reviewer' valuable comments and suggestions, which help us to improve the quality of our paper. In this paper, we present the survey of relative humidity observations dry biases in the low- and mid-troposphere. We hope that the scientists notice the problem of the sensor failure and use these erroneous data carefully. Following are our replies:

1)The authors should make a clear distinction between known error sources in radiosoundings, e.g. radiation dry bias or time-lag, which can in be corrected for, and

C2723

malfuction of the humidity sensor which is the topic of this study. The introduction should be more balanced, currently it discusses in length these known errors and only at the end of the introduction it becomes clear what the purpose/goal of the paper is. A: Thank you for your good suggestion. We have modified the introduction, tried to make a clear distinction between known error sources and malfunction of the humidity sensor, and balance these two part contents.

2) The authors have done a good job in identifying the correlation between atmospheric conditions and the failure of the humidity sensor, however a real explanation for the cause of the effect is missing. Sudden transitions from high to low humidity are not limited to the sub-tropics. Is there a difference between nighttime or daytime soundings when it comes to the occurrence of the humidity sensor malfunction? Did the authors check that the effect is not caused by the manufacturer's processing software? For example, for the RS92 and for the GRAW DFM-09 raw measurement data are stored as well (provided these data are still available at the station that performed the sounding). A: We have not known the real reason why the relative humidity observation significantly changes within a short time yet. The explanations are our guesses, including the relationship with the sensor performance and stratiform clouds. We just infer that the dramatic changes of relative humidity occur after the radiosonde goes through the stratiform clouds instead of convective clouds in Section 5.2. We guess it might be related to the inertia. When the radiosonde leaves cloud, namely it is from the very wet to very dry environment, the humidity observation value might have been reducing due to the inertia effect, even less than the response range of sensor(failure). Therefore, it might be cut off by the software with the missing value. Although sudden transitions from high to low humidity are not limited to the sub-tropics, in our study we find that they mainly occur in the sub-tropics, maybe it is related to the criteria we used. There is no difference between daytime and nighttime, whose results are presented in the table (in supplement). We do not checked if the phenomenon is caused by the processing software.

C2724

3) I would encourage the authors to include in the summary clear recommendations for the community regarding quality assurance of radiosounding data, so that in the future faulty data can be flagged before ending up in the radiosounding archives. A: Thank you for your suggestion. We have added this content in the summary part.

Detail comments: 1.p6626 l25-26: This sentence needs be rephrased. I assume you want to say something of the following effect: in the tropopause region the humidity sensor is not able to record rapid changes or steep gradients in the ambient humidity, which is mainly due to sensor time lag at low temperatures. Please be aware that among different radiosonde manufacturers there is wide range of humidity sensor performance. For example, The RS92 performs quite well up to the tropopause, whereas other radiosonde types become essentially insensitive to changes in the humidity profile at ambient temperatures below -40C as the result of time lag effects. The sentence should reflect this nuance, in its current form the sentence is too much of a sweeping statement. A: We have modified this sentence.

2. p6627 l3: at this point it is prudent to refer to the official WMO reports on the Mauritius (2005) and Yangjiang (2010) intercomparison campaigns. (WMO Technical Documents 1303 and 1580). A: Thank you for reminder. We have modified the references.

3.p6627 l5: these large errors mainly occur in the upper troposphere. A: You are right. We did not study these errors. We studied the error in the low troposphere. We have mentioned it in the introduction.

4. p6627 l6: bad -> limited A: We have corrected.

5. p6627 l7-8: low humidity conditions and the occurrence of sensor icing seems a contradiction to me. An important error source, radiation dry bias, is missing here. Sensor aging and contamination are more the result of radiosonde handling/storage than being attributable to the conditions in the upper troposphere. A: Thank you for providing the knowledge. We have modified this section.

C2725

6.p6627 l10: please replace hygrometer by humidity sensor, updated -> improved  
p6627 l18: deep -> thick, p6627 l19: RHs -> RH A: We have corrected.

7. p6627 l29: Tang et al 2013 is not listed in the bibliography, I assume this should be Tang2014, please check for this in other places in the manuscript as well. A: You are right. We have corrected. The reference of Tang (2013) is actually the thesis of Mr. Tang, and the reference of Tang (2014) is the paper based on his thesis.

8. p6628 l3: stratiformis -> stratiform A: We have corrected it.

9. p6628 l19: please provide a reference for the GTS (a weblink will do) A: we have provided a weblink explaining what is GTS, [http://gems.ecmwf.int/documents/workdescription/2\\_6\\_1\\_WMO\\_s\\_real\\_time\\_Global](http://gems.ecmwf.int/documents/workdescription/2_6_1_WMO_s_real_time_Global)

10.p6628 l21: data -> profiles A: we have corrected it.

11.p6628 l25: please rephrase. It should be clear that with the "new issue of humidity observation" you mean the above mentioned (temporary) failure of the humidity sensor. A: we have updated it.

12.p6629 l1: Please define RO. I know it is mentioned at the end of Sect 1, but it would be good to mention it again at this point. A: We have corrected it.

13.p6629 l3: Please provide model name and reference. A: Dee D.P., Uppala S.M., and Simmons et al., The ERA-Interim reanalysis: configuration and performance of the data assimilation system, Quarterly Journal of the Royal Meteorological Society,137,553-597,2011

14. p6629 l10-end of section: this extensive and detailed information should be moved to an appendix. A: It only includes two things: parameterization and coordinator transformation in this section; the content is not so much. Therefore, we think it will be better for keeping them here.

15. For temperature please use T instead of t. Please be consistent in the use of the

C2726

multiplication symbol x (e.g. Eq. 5) Please provide references for equations 1,2,4,5. For Eq 4 and 5 [Hofmann-Wellenhof, B., and H. Moritz (2006), Physical Geodesy, 2nd ed., 403 pp., Springer Verlag, Berlin, Germany.] might be useful. A: We have corrected them. But we cannot find the book of Physical Geodesy in our library, so we do not know what equation is.

16. p6630 l24: maximus -> maximum, p6631 l26:maximus -> maximum A: We have corrected them.

17. p6632 l7: please specify the altitude range in which the RO data can be used/is valid. A: We have mentioned it in paper. It is from surface to 100hpa.

18. p6632 l24: To my knowledge the Graw G sensor does not exist. Their currently available radiosondes are DFM-06 and DFM-09 please specify which type you refer to. A: We do not know if Graw G is the sensor name or not, because all the sensor names presented in the paper are indexed from the head file of radiosonde report of GTS.

19. p6633 l7: Please use radiosonde type instead of manufacturer. Presumably you mean the RS92, or are data from the RS80 and RS90 also used in this study? A: We have corrected them.

20. p6633 l10: quite few -> please provide a quantitative number, e.g. 3.5% as given in Table 2. A: We have provided a quantitative number

21. p6633 l10: capability -> quality, p6633 l15: evolvment -> evolution A: We have corrected them.

22.p6633 l16: please provide a reference. A: Rossow, W.B., and Schiffer, R.A., 1999: Advances in Understanding Clouds from ISCCP. Bull. Amer. Meteor. Soc., 80, 2261-2288.

23. p6634 l4: which sensor are you referring to here? A: It is referred to the US sippican sensor.

C2727

24. p3364 l12-16: I am not sure whether these sentences contribute to the discussion. A: We want to explain why sudden transitions from high to low humidity happen in the sub-tropics.

References In Bian2011: check spelling of Vömel and Lu A: We have corrected.

Tables Table 1: Define the latitude bands in the caption. Mention Dec 2008 - Nov 2009 in the caption, use only DJF, MAM, JJA, SON in the season column. A: We have corrected.

Table 2: Please provide statistics for more radiosonde types, perhaps for all 6 radiosonde types that are shown in Fig 7. The three listed radiosonde types account for approximately 50% of the soundings used in this study. A: We have supplemented the statistics of other radiosonde types in Table 2.

Figures Figure 2: The legend of the colorbar could do with less numbers. I don't think it is necessary to show 5 values between 23 and 53. It is not clear to me what at what frequency soundings are performed at the sites shown on the map. Presumably there is quite some variation in sounding frequency among the sites, this could skew the results as only absolute numbers are shown in the plot. How does the plot look like if you show the fraction of failure affected soundings instead of absolute numbers? Caption: hollow -> open A: The number of failure humidity observation is difference from station to station. In order to highlight the distribution in subtropics, we use more numbers. Following are the plot using the fraction of failure affected soundings instead of absolute numbers for a year and four seasons.

Figure 5: Can you provide separate plots for daytime and nighttime observations? A: The difference between daytime and nighttime is not obvious. We have provided a table in above, so we do not provide the separate plots.

Figure 6: Provide the station names. The last sentence of the caption: it has already been mentioned what the red and blue curves represent. A: 72797 is Quilliyute station

C2728

of USA; 58203 is Fuyang station of China. We have deleted the last sentence.

Figure 7: Please print the radiosonde type in the plots. Please provide station names and geographic coordinates Please abbreviate 12:00:00 to 12:00. I don't think it is necessary to mention the nationality of the radiosonde manufacturers, e.g. Vaisala RS92 would be sufficient. Graw radiosonde G should be DFM-06 or DFM-09. A: We have printed the radiosonde type in the plots, provide provide station names and geographic coordinates in the title, and modified the expression of time.

Figure 8: No need to mention the nationality of the radiosonde manufacturers. There are a lot of "unknown types" soundings over Siberia. As these soundings seem not to suffer from humidity sensor failure, as shown in Fig 2., it would be interesting to know which radiosonde is used in that region. A: We get the sensor type information from the file head of radiosonde report of GTS. If the file does not provide this information, we define them as unknown type. It is well known that the performance of Russian radiosonde sensor is not good, and the performance of Vaisala RS92 is good. However, the phenomenon of humidity sudden transition over Siberia is less, and the percentage of Vaisala RS92 reaches 3.53%. Therefore, we guess that the performance of sensor is not the only reason causing sensor fail, it also shall be related to the atmospheric condition, especially the cloud type.

Figure 9: Please add "according to satellite cloud climatology" to the caption. What quantity/unit does the color bar represent? A: We have added "according to satellite cloud climatology" to the caption. The unit of cloud amount is 1 in the color bar.

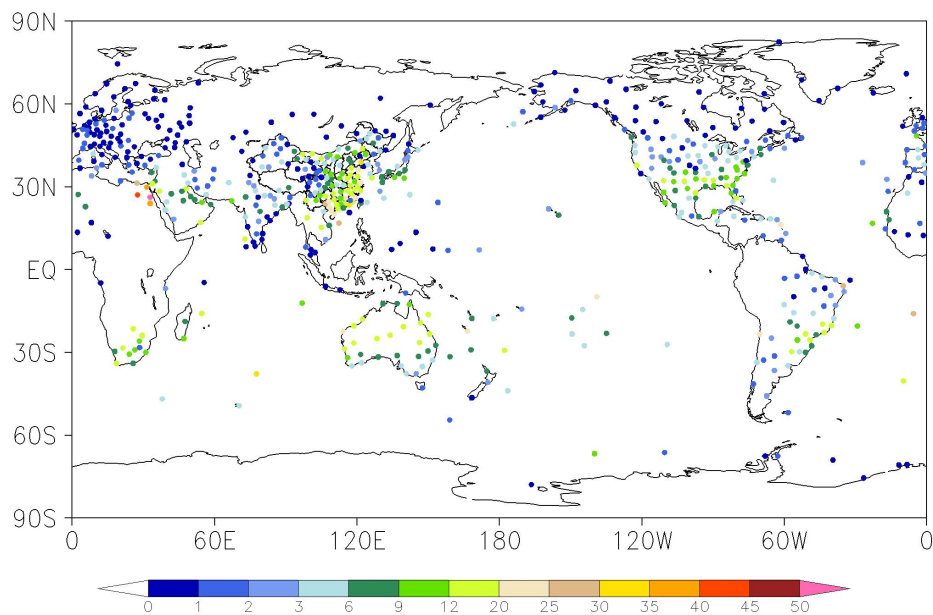
Finally, we wil also give our revision based on two reviewers as a supplement.

Please also note the supplement to this comment:

<http://www.atmos-meas-tech-discuss.net/7/C2723/2014/amtd-7-C2723-2014-supplement.zip>

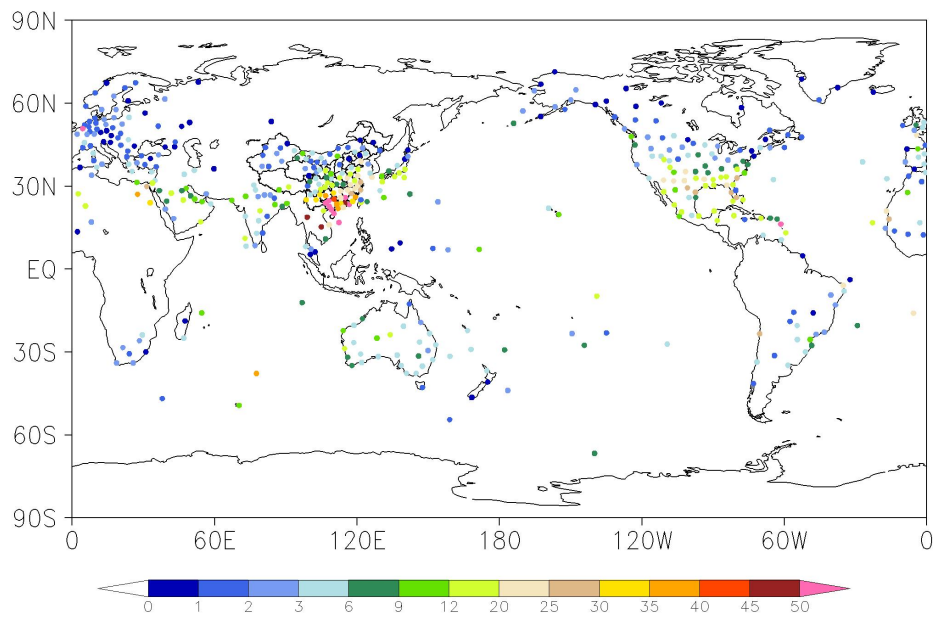
Interactive comment on Atmos. Meas. Tech. Discuss., 7, 6625, 2014.

C2729



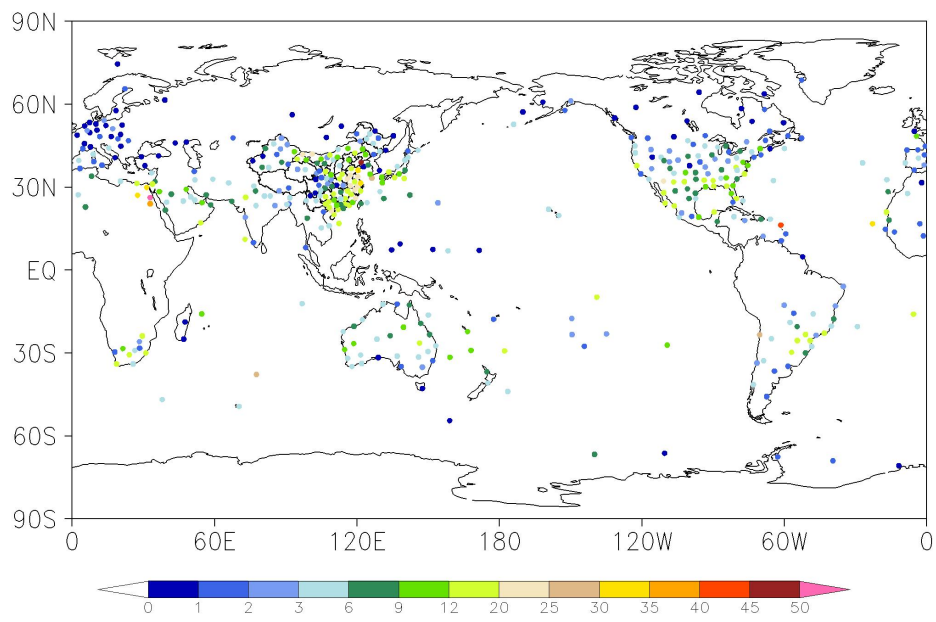
**Fig. 1.** The fraction of failure affected soundings from December 2008 to November 2009, Unit:%

C2730



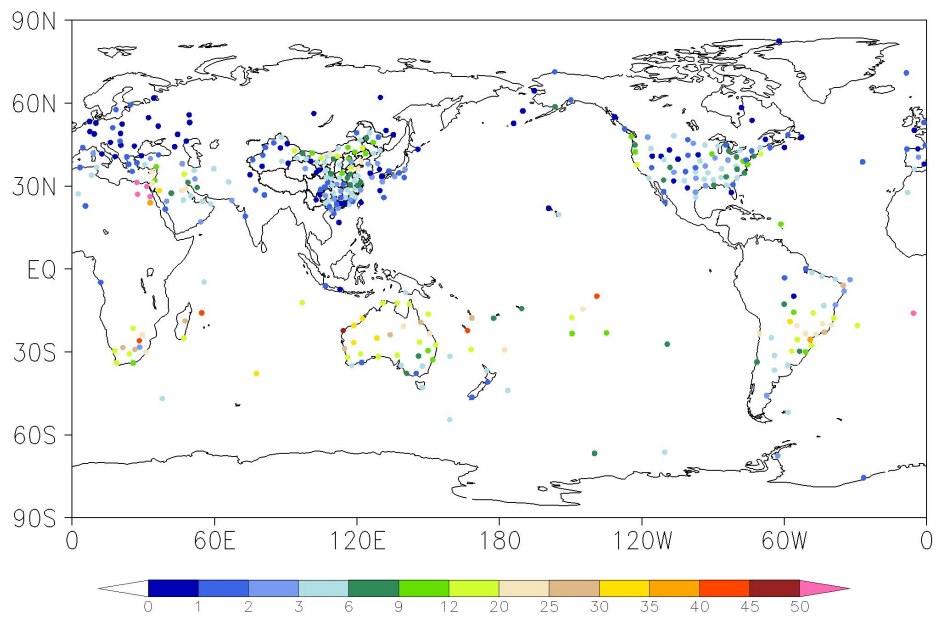
**Fig. 2.** The fraction of failure affected soundings from December 2008 to February 2009, Unit: %

C2731



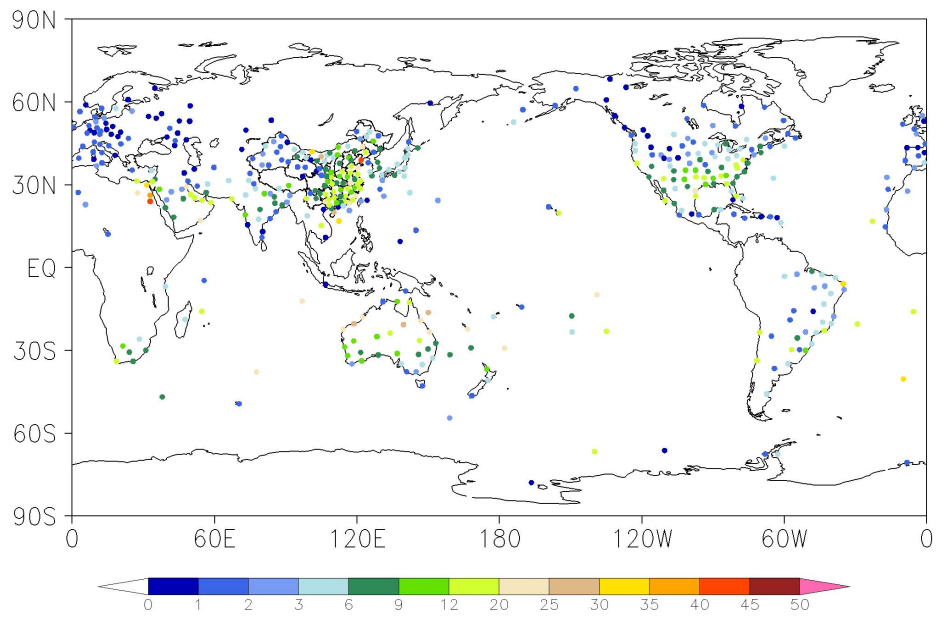
**Fig. 3.** The fraction of failure affected soundings from March 2009 to May 2009, Unit: %

C2732



**Fig. 4.** The fraction of failure affected soundings from June 2009 to August 2009, Unit: %

C2733



**Fig. 5.** The fraction of failure affected soundings from September 2009 to November 2009, Unit: %

C2734