Answers to Referee n°1

The referee's comments are repeated below in black italics and our answers are given in blue.Reviewer 1 - Specific Comments XX are abbreviated as RW1-SC-XX.

Reviewer 1 General comments

In this paper the characteristics of GPS tropospheric estimates (ZWD and gradients) and post-fit phase residuals during the wet season of the WAM have been investigate using two different GPS approaches (regional network of GPS stations, observations in PPP mode). MCSs passages are analysed based on a case study from the AMMA period in 2006 and on a statistical approach. The aims of the investigation are clearly given. The paper is clearly structured and well written and the added value of GPS information concerning MCS analysis is quite obvious. I recommend publication of the paper - some minor recommended changes are given below.

We thank the referee for his positive appreciation, valuable comments and constructive suggestions that, we think, contributed to improve the manuscript. We are pleased to answer to all his comments.

RW1-SC-01: interpretation of tropospheric gradients

Specific comments Section 2.3.1: I am not very familiar with the two parameters tropospheric gradients and post-fit phase residuals. E.g. a gradient normally is defined by dy/dx (unit1/unit2). However, here gradients are given in mm (e.g. Figure 4). I.e. the "gradients" are more related to spatial (north-south, east-west) inhomogeneities rather than real gradients. Therefore, I would recommend to add some more information how to interpret the "gradient" data (can any information be given over which horizontal distance the values occur?).

Reply to the RW1-SC-01

To answer your comment about the units in short: the gradient parameters are in units of m because they model the effect of horizontal gradients of the refractive index on the total optical path delay along the ray between the satellite and the receiver. Path delay is in units of m. For more details about for formulation and physics see Chen and Herring, 1997.

➔ We added the following sentences and references in the Introduction where the readers not familiar with the concepts of tropospheric delay gradients can find the definition, equations, and physical background.

Page 3 lines 1-5: "Both software implement tropospheric delay models which include also gradient parameters. Gradient parameters allow to represent the effect of first order azimuthal asymmetry in the atmospheric refractive index (MacMillan, 1995; MacMillan and Ma, 1997; Chen and Herring, 1997). The spatial scale over which the GPS measurements are sensitive to atmospheric refractivity gradients is about 50 km."

RW1-SC-02: more information about post-fit phase residuals

Concerning post-fit phase residuals: some more information what it really means and how to interpret the values would help readers which are not that familiar with this kind of GPS data analysis.

Reply to the RW1-SC-02

The post-fit phase residuals are the residuals (observed minus computed phase) from the least-squares fit when the estimated parameters are used in the model (« post-fit »). This is very standard with all fitting methods, see e.g. https://en.wikipedia.org/wiki/Least_squares_adjustment

➔ We added a GPS-related reference at the end of the first sentence on section 2.3.2 page 6 line 21:

Kouba, J.: A guide to using International GPS Service (IGS) products. IGS Central Bureau, Pasadena (available at http://igscb.jpl.nasa.gov/igscb/resource/pubs/GuidetoUsingIGSProducts.pdf), 2003.

RW1-SC-03: "ZWD should show a better correlation with the near-surface absolute humidity than relative humidity does "

Page 13, line 9: I wonder why you discuss ZWD together with relative humidity and not with absolute or specific humidity. As in most cases, i.e. in the WAM region, too, the IWV should be mainly determined by the humidity in the boundary-layer (this is e.g. obvious from specific humidity profiles, Schwendike et al., 2010). Thus, ZWD should show a better correlation with the near-surface absolute humidity than relative humidity does. Schwendike, J.; Kalthoff, N.; Kohler, M., 2010: The impact of mesoscale convective systems on the surface and boundary-layer structure in West Africa: Case-studies from the AMMA campaign 2006. doi:10.1002/qj.599 .

Reply to the RW1-SC-03

We fully agree with the reviewer that specific humidity is more directly linked to ZWD. Note that the aim of Table 3 is more broadly to compare results at sites located in distinct climates just before the arrival of the cold pools, not so much to analyse correlations with surface air humidity. In fact, we used relative humidity following Lothon et al. (2011), as the arrival of the cold pool is also quite well captured with relative humidity (e.g. their Fig. 5 or our Figs. 7 and 11).

RW1-SC-04 : "ground clutter"

Figure 6 and 10 include ground clutter. Could ground clutter be removed so that backscatter from rain remains.

Reply to RW1-SC-04

You are right, a signature of clutter can be seen in the images, but we don't have the full radar data at hand, so we can't remove these features. On the other hand, it is quite clear from the successive plots that the features are stationary and cannot be confounded with the MCS. So, we think it is not necessary to change these figures.

RW1-SC-05: Technical corrections

Technical corrections There are several typos etc. a few (not all) are listed below Page 1, line 14: should be '... the case of an MCS' Page 4, line 37: should be "... Whose parameter is ten times .." Page 7, PTU200 data and figure 7 and page 8 lines 14-20: as the PTU200 data are not really discussed, I would recommend to remove them from the diagram. The good agreement between ARM and PTU200 data could be mentioned in one sentence (when used in sect. 4). Page 7, line 29: it would be sufficient to give wind speed with one digit "5.8 m/s" instead of "5.81 m/s" as done before. Page 8, line 2: 3:33 UTC until 6:41 UTC would be 188 minutes. Where does 182 minutes come from? Page 8,

line 5: the start of the convective phase is given by 3:33 UTC. Here you give 3:32 UTC. Shouldn't the times be the same? Page 8, line 36: do you really mean 37 min? from line 3 and 4 it should be 41 min (29 min +12 min). Page 9, line 10: should read ".... to reach a maximum of " Page 10, line: should read " .... make it easy to ...." -, line 13: delete "to" after UTC. Page 11, line 9: delete "at" ".... Cold pools during ...." Figure 7: I would even here show the accumulated precip (instead of showing three times the same precip data in 7b,c,d) because it is discussed in the text on page 8.

Reply to RW1-SC-05

- ➔ *Page 1, line 14: should be '... the case of an MCS'* / **done**
- ➔ *Page 4, line 37: should be "... Whose parameter is ten times .."* / **done**

- ➔ PTU200 data are removed from Figure 7 p37 & Figure 11 p42 and the text has been modified accordingly section 3.1 p7 line 21. To meet recommendations of the two reviewers, The last paragraph of section 3.1 page 8 line 17-25 becomes:

"There is really added value of having the high sampling data from ARM-MF to capture details of the internal dynamics of the MCS. However, such data are only available at Niamey (Niger) for 2006 only. The data retrieved from the PTU200 sensor are in good agreement with data from ARM-MF but the 15-min sampling is not sufficient to detect that the surface temperature drops in two consecutive stages or the sudden and brief drop in relative humidity (not shown). Moreover, because of GPS stations were aimed at providing IWV data, the wind has not been recorded. The best way to identify the CPCT with only PTU200 data at the other AMMA GPS stations is thus to detect significant drops in surface temperature over a period between 30 minutes to 1 hour followed by strong rainfall (see section 4)."

- ➔ *Page 7, line 29: wind speed with one digit "5.8 m/s" instead of "5.81 m/s"* / **done**
- ➔ *Page 8, line 2: 3:33 UTC until 6:41 UTC would be 188 minutes. Where does 182 minutes come from?* You are right, logically, the sum should have matched but 6:41 UTC is the last time where rainfall more and more scattered is observed. The difference of 6 minutes corresponds to a period with no rainfall between 3:33 UTC and 6:41 UTC. ->For a better comprehension, the sentence becomes: "From 03:33 UTC until 06:41 UTC, the MCS events characterized by a two-phase rainfall pattern produces successively by its convective and stratiform parts."

- ➔ Page 8, line 5: the start of the convective phase is given by 3:33 UTC. Here you give 3:32 UTC. Shouldn't the times be the same? /You are right. The correction is made now.