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Atmospheric Measurement Techniques Discussions

Interactive comment on "Rainfall measurement from opportunistic use of earth-space link in Ku Band" *by* L. Barthès and C. Mallet

L. Barthès and C. Mallet

laurent.barthes@latmos.ipsl.fr

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Interactive comment on "Rainfall measurement from opportunistic use of earth-space link in Ku Band" by L. Barthès and C. Mallet Response to Anonymous Referee #2 Received and published: 7 May 2013

General comments âĂć Comment #1 : In my view, too much emphasis is put on the (low) cost of the microwave receiver. The authors do not provide specific numbers but I think it is fair to assume that the real cost (including maintenance and manpower) of such a system is higher than the one of state-of-the art rain gauge networks. Also, if you think about it, the microwave receivers are not necessarily easier to deploy than rain gauges, especially in remote locations and mountainous terrain. The Earth-space

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links however provide interesting and complementary information about precipitation at the path scale, from the ground surface up to the troposphere (and beyond) that are very valuable for the remote sensing community, especially for people working with ground-based or space borne radars. The price is an important argument but it should not be the major motivation in this study. The abstract and the Introduction should be revised in order to clarify this point.. The deployment of such network is not more expensive than a rain gauge network. Indeed, microwave equipment in the band 10-12 GHz are inexpensive because of its wide utilisation for public use. The mains advantages concerns the maintenance cost since rain gauges require constant surveillance. Therefore I would stress the fact that such setup can provide relatively inexpensive measurements in unpopulated areas where there would be otherwise no measurements at all. Some sentences were added/modified in the introduction (See text in red). A table comparing main features between weather radars, rain gauge networks and Ku device was added. âĂć The general Comments #2 and 3 are considered together âĂć General Comment #2 : In Section 2.2, the authors make an interesting point by mentioning that the 12 GHz frequency is not optimal and does not allow to accurately retrieve small rain rates. They suggest to focus on higher rain rates instead, which makes more sense from the theoretical point of view but also raises a lot of questions. Indeed, strong rain events are known to exhibit complex spatial and temporal structures (including intermittency, winds, strong temperature gradients and complex vertical evolution of the DSD) that are not accounted for in the retrieval method proposed in Sections 2 and 4. I think this issue merits some further discussion in Section 2.2 or in Section 6. âĂć General comment #3: The authors do not address the problem of mixed precipitation (e.g., hail or wet snow) nor do they develop on the importance of the melting layer in their application. I understand that this might be beyond the scope of the paper but why not mentioning it somewhere in the conclusions or the description of the method? The following sentences were added in section 6 : “As the parameter b of the k-R law is close to 1 the variability of the DSD along the link does not play an important role. Nevertheless some discrepancies on attenuation

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non-induced by rain may occur for example during heavy rain events that are known to exhibit complex spatial and temporal structures with strong temperature gradients and complex vertical humidity. Moreover in this study the presence of hail, wet snow or a melting layer is not taken into account. An attenuation of approximately 0.2-0.3 dB is expected in Ku band when melting layer is present, i.e. mainly during stratiform events. However if non precipitating clouds with melting layer are present just before a rain event the resulting attenuation (due to clouds and melting layer) is “embedded” in the reference level estimation and consequently do not lead to an important error on rain attenuation estimation. “

âĂć General comment #4 : In Section 4.2, one can point out that the accuracy of the retrieved rain rates strongly depends on the estimated geometric path length L and rain height hR. The rain height obviously depends on a lot of factors, such as the type of precipitation and the local atmospheric conditions. Yet there are very few details about how it is determined in practice. The authors could provide more details about this, rather than just citing an ITU report

For the moment, the geometric path length L is estimated from Eq. 12 in which rain height hR is needed. As it is said by the referee this latter is expected to vary in accordance to local atmospheric conditions. However in this study we used the value recommended by ITU P829 which provide en empirical formula (see below) based from the Yearly average 0° C isotherm height above mean sea level ho. In our case ho=3 km. HR=ho + 0.36 = 3.36 km. The text has been modified and the above formula added: “After identification of dry and rainy periods from received signal, the reference level is interpolated during rainy periods allowing the estimation of rain attenuation ARain(t). By using Eq. (12) to express the geometric path length L (ITU-R P 618) the specific attenuation is estimated. (12) Where hR is the rain height and ho the yearly average 0° C isotherm height above mean sea level. The latter is given by ITU-R P 539 recommendation and is equal to 3 km in our case. The parameter hS is the altitude of the ground station and ïĄś the elevation angle”

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Specific comments âĂć Specific comment 1: The authors could mention the studies of Kharadly n& Ross (Effect of Wet Antenna Attenuation on Propagation Data Statistics, IEEE TAP, 2001), Crane (Analysis of the Effects of Water on the ACTS Propagation Terminal Antenna, IEEE TAP, 2002), Overeem et al. (Country-wide rainfall maps from cellular communication networks, PNAS, 2013) and Schleiss et al. (Quantification and modeling of wet-antenna attenuation for commercial microwave links, IEEE GRSL 2013). A Wet Antenna can introduce an artificial attenuation, depending on antenna. To minimise this effect we have applied on the dish and the horn an superhydrophobic coating (avalaible in spray). This kind of coating is efficient even if it does not allow to suppress completely all the raindrops. For this reason we have no introduced an additional attenuation term. Three additional references and the following sentences were added in section 4.1: “Wet Antenna can introduce an artificial attenuation depending on antenna (Schleiss, 2013; Crane 2002; Leijnse et al., 2008). To minimize this, we have applied on the dish and horn an superhydrophobic coating. This kind of coating is efficient even if it does not allow suppressing completely all the raindrops. For this reason this term does not appear Eq. 8.”

âĂć Specific comment 2: Figure 5 clearly shows that there is a daily cycle in the baseline of the path-integrated attenuation. So why is the baseline interpolated linearly during the rainy periods? The base line is interpolated linearly for simplicity reasons. For short duration rain events this method is accurate enough. For longer rain events a more sophisticated method should be used instead. Actually we are working on a method based on Kalman filter but this work is in progress. âĂć Specific comment 3: The authors should cite the upcoming GPM (Global Precipitation Measurement Mission) by NASA, which will provide remotely sensed precipitation estimates that are not confined within the inter tropical regions (like TRMM). Yes we agree. The sentence concerning the inter-tropical regions has been removed. âĂć Specific comment 4: The authors should add an extra term for the wet-antenna attenuation in Equation (5). I know that this term is neglected in the proposed study but it nevertheless contributes to the total attenuation and should appear somewhere. See specific comment 1 âĂć

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Specific comment 5: Is there a rough estimate of the uncertainty affecting the emitted power pE in Equation (5)? The transmitted power should be constant in theory but I know that this is hardly ever the case. Usually Earth stations include an uplink power control unit allowing the transponders on board the satellites to re-emit the signals to the ground with a constant level. In practice, sudden level changes may occur but they are relatively rare and easy to identify âĂć Specific comment 6: path-average? path-averaged? path averaged? path-integrated? Corrected âĂć Specific comment 7: polarisation vs polarization? polarised vs polarized? Please use the English (and not the American) spelling for AMT papers. Same for kilometre vs kilometer and meter vs metre. Corrected âĂć Specific comment 8: Please do not use the expression "drought period" to denote a perfectly normal period without rain. A drought is an abnormally long dry period. Just write "dry period" or "dry spell". Corrected âĂć Specific comment 9: Please do not use the notation x to denote multiplication (e.g., Equations 1-2-3). Use a simple dot or a space.

âĂć Specific comment 10: The official abbreviation of minute is min and not mn.

Corrected

Note: The final version will be corrected by a native English speaker. All comments were taken into account. The corrected version is joined in the supplement section We would like to thank the referee to have accepted to review the paper. Sincerely Laurent Barthes, Cécile Mallet

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/6/C915/2013/amtd-6-C915-2013-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 6, 2113, 2013.