Scale-related artefacts on precipitation measurement: why they impact satellite rainfall estimation

Sebastien Verrier*[1,2], Cécile Mallet[3], and Laurent Barthès[4]

[1]Université Versailles St Quentin/LATMOS (UVSQ/LATMOS/CNRS) – Université de Versailles-Saint Quentin en Yvelines – 11 bvd d'Alembert 78280 Guyancourt France, France

[2]LOCEAN/UPMC/IPSL (LOCEAN/UPMC/IPSL) – LOCEAN – 4 place Jussieu 75252 Paris, France

[3]Univ. Versailles St Quentin/LATMOS (UVSQ/LATMOS) – Université de Versailles-Saint Quentin en Yvelines – 11 bvd d'Alembert 78280 Guyancourt France, France

[4]Univ. Versailles St Quentin (UVSQ/LATMOS) – Université de Versailles-Saint Quentin en Yvelines – 11 bvd d'Alembert 78280 Guyancourt France, France

Abstract

Ground validation of satellite rainfall products relies on extensive comparisons with ground based data collected by rain gauges or weather radars. However, such comparisons are impacted by problems of representativeness due to the different resolutions involved (_˜ 10 cm for a rain gauge, _˜ 1 km for a ground-based weather radar, _˜ 10 km for space-borne sensors). Such problems of representativeness are especially crucial for rainfall due to its extreme variability over a wide range of scales. However, representativeness errors may be investigated with the help of statistical approaches related with the "multifractal" formalism, which is very convenient for describing the multiscale properties of rainfall. In this study, we show mathematically that due to the (now well-established) scaling properties of rainfall, a direct consequence may be derived for Marshall-Palmer Z= aRˆb relationships used in radar meteorology to estimate precipitation intensities (R) from reflectivities (Z). In particular, the prefactor "a" in such laws should increase as a 0.1 power-law of the scale. The latter prediction was validated empirically based on the study of reflectivity factors and rain rates computed at various resolutions from disdrometer DSD measurements.

In practice these properties mean that extrapolating a correctly calibrated Z-R law to another scale may lead to systematic errors that increase in a power-law way with the scale factor. In the case of satellite vs ground based radar data comparison, the relative error could be of the order of 10-20% in terms of rain intensities, but things may be much worse in the case of satellite vs raingauge data comparsion due to a larger scale factor.

The latter kind of errors are not specific to Z-R laws but should occur whenever the highly heterogeneous rainfall variable is related nonlinearly to a remotely-sensed observable. Equations resulting from the scaling theory of rainfall may provide useful information for correcting such errors. Another possibility would be to favor other relationships that are expectedly more stable across scales (R-Kdp for polarimetric radar, attenuation-rain rate for microwave links, ...). Finally, the potential of statistical downscaling techniques inspired from the theoretical framework is also described. Such techniques enable "resolution augmentation" of (satellite) observations into higher-resolution, statistically realistic realizations that could be easier to compare with observed pointwise (e.g. gauge) measurements.

*Speaker