Geophysical Research Abstracts
Vol. 19, EGU2017-1240, 2017
EGU General Assembly 2017

Multifractal analysis of different hydrological products of X-band radar

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Rainfall is widely considered as the hydrological process that triggers all the others. Its accurate measurements are crucial especially when they are used afterwards for the hydrological modeling of urban and peri-urban catchments for decision-making. Rainfall is a complex process and is scale dependent in space and time. Hence a high spatial and temporal resolution of the data is more appropriate for urban modeling. Therefore, a great interest of high-resolution measurements of precipitation in space and time is manifested.

Radar technologies have not stopped evolving since their first appearance about the mid-twentieth. Indeed, the turning point work by Marshall-Palmer (1948) has established the $Z - R$ power-law relation that has been widely used, with major scientific efforts being devoted to find "the best choice" of the two associated parameters. Nowadays X-band radars, being provided with dual-polarization and Doppler means, offer more accurate data of higher resolution. The fact that drops are oblate induces a differential phase shift between the two polarizations. The quantity most commonly used for the rainfall rate computation is actually the specific differential phase shift, which is the gradient of the differential phase shift along the radial beam direction. It is even stronger correlated to the rain rate R than reflectivity Z. Hence the rain rate can be computed with a different power-law relation, which again depends on only two parameters. Furthermore, an attenuation correction is needed to adjust the loss of radar energy due to the absorption and scattering as it passes through the atmosphere. Due to natural variations of reflectivity with altitude, vertical profile of reflectivity should be corrected as well. There are some other typical radar data filtering procedures, all resulting in various hydrological products.

In this work, we use the Universal Multifractal framework to analyze and to inter-compare different products of X-band radar operated by Ecole des Ponts ParisTech. Several rainfall events selected during the recent period (2015 - 2016) were studied over two different embedded grids (64kmx64km and 32kmx32km, with a resolution of 250 m) covering the test site, using a variety of hydrological products. Obtained results demonstrate that some of these products are much more compatible with the scaling ideas. Indeed, the choice of data filters and/or data conversion procedures with the associated parameters does affect the scaling behavior. In turn, the scaling principals help to revisit and furthermore to optimize the radar technologies, including the choice of the associated parameters.