



Rainfall Estimation by Opportunistic Use of Communications Satellite Signals: Facts and Myths Revealed

G. Scognamiglio⁽¹⁾, A. Rucci⁽¹⁾, A. Vaccaro⁽¹⁾, G. Serafino⁽¹⁾, F. Sapienza⁽²⁾, F. Giannetti^{*(2)}, G. Bacci⁽²⁾,
V. Lottici⁽²⁾, E. Adirosi⁽³⁾, S. Angeloni⁽³⁾, L. Baldini⁽³⁾, S. Melani⁽⁴⁾, and A. Ortolani⁽⁴⁾

(1) MBI Srl, Pisa, Italy

(2) University of Pisa, Department of Information Engineering, Pisa, Italy (filippo.giannetti@unipi.it)

(3) Italian National Research Council, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Rome, Italy

(4) Italian National Research Council, Institute for the BioEconomy (CNR-IBE), Florence, Italy

Accurate weather forecasting on a very precise scale in time/space domains (i.e., *nowcasting*), is playing a dramatic role in many important aspects of everyday's life such as for public safety, business-oriented services, and personal services, just to mention a few. For instance, the availability of reliable real-time forecast for hazardous and extreme weather conditions, such as intense rain showers and thunderstorms, may effectively reduce the threat to life and property, thanks to timely emergency rescue operations. This branch of meteorology has been made possible by a combination of factors, including the availability of low-cost and low-consumption sensors. Quantitative precipitation estimation can in fact be obtained by several observing systems using different measurement principles that have different time/space resolutions, and accuracies [1].

In the last few decades, the opportunistic use of pre-existing microwave (MW) communication links has been investigated to retrieve precipitation estimates. The basic idea is to estimate rainfall intensity relying on the attenuation due to the presence of precipitation along the propagation path, which affects either terrestrial links (e.g., backhaul connections in cellular networks), or the downlink of direct-to-home (DTH) satellite broadcasting, at Ku-band (10-13 GHz). In particular, satellite-based opportunistic systems for rain monitoring [2], powered by dedicated algorithms [3], reveal very appealing due to: *i*) wide diffusion of already-installed DTH satellite receivers which could, in principle, act as rain sensing devices, prospectively allowing for a considerable geographical capillarity, at least in densely populated areas; *ii*) ease of installation of new terminals to obtain higher spatial density; *iii*) good performance in detecting start and end epochs of rain events; *iv*) availability of many sensing measurements per minute, which enable higher temporal resolution of the estimates; and *v*) availability of a large number of visible satellites in the geosynchronous earth orbit (GEO) arc.

However, despite the advantages listed above, in this contribution we aim at presenting some myths that need to be unrevealed. First, despite the availability of a large number of already installed DTH devices, in most cases real-time measurements can be neither accessed nor logged, unless resorting to additional equipment and/or integration. Then, low-cost MW equipment for DTH, which usually has a negligible impact on the performance of broadcast TV services, yields a too unreliable accuracy for precise rainfall estimation. For instance, low-cost low-noise block converters (LNBS) are electrically noisy and poorly thermally shielded, thus producing unstable measurements. Similarly, low-cost antenna reflectors show geometrical irregularities severely affecting the estimation accuracy. Definitely, the “pure” opportunistic paradigm, relying on the above features, reveals hardly feasible and the selection, or the design, of HW components requires more care and effort to obtain reasonable accuracy.

Acknowledgements: This work was supported by the H2020 SCORE project, G.A. 101003534, and by the Italian Ministry of Education and Research (MUR) in the framework of the FoReLab project (Departments of Excellence).

References

- [1] E. Adirosi, L. Facheris, F. Giannetti, S. Scarfone, G. Bacci, A. Mazza, A. Ortolani, , and L. Baldini, “Evaluation of rainfall estimation derived from commercial interactive DVB receivers using disdrometer, rain gauge, and weather radar,” *IEEE Trans. Geosci. Remote Sens.*, vol. 59, no. 11, pp. 8978–8991, Nov. 2021.
- [2] F. Giannetti and R. Reggiannini, “Opportunistic rain rate estimation from measurements of satellite downlink attenuation: A survey,” *Sensors*, 2021, vol. 21, no. 17, p. 5872, Aug. 2021.
- [3] F. Giannetti, M. Moretti, R. Reggiannini, and A. Vaccaro, “The NEFOCAST system for detection and estimation of rainfall fields by the opportunistic use of broadcast satellite signals,” *IEEE Aerosp. Electron. Syst. Mag.*, vol. 34, no. 6, pp. 16–27, Jun. 2019.