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Enhanced quantitative rainfall estimation using dual-channel TV-SAT microwave links: Progress and Experimentation

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Opportunistic remote sensing with TV-satellite microwave links (SML) in the Ku-band offers a promising approach for rainfall estimation by leveraging signal attenuation as an indicator of rainfall intensity. However, a key challenge remains: differentiating rain-induced attenuation from atmospheric induced noise.
In this study, we use SML to evaluate their ability to retrieve rainfall rates, by taking into account the emission of the atmospheric background noise. This method exploits signal variation of two distinct frequency channels coming from the same satellite - one with full-band satellite transmission, and the other without any signal emitted on the band. In this latter case, the receiver behaves like a radiometer, capable of measuring atmospheric radiation. To implement this approach, we establish a baseline for each channel (i.e., its signal level in dry conditions), which is automatically determined using a deep learning binary classification model. Additionally, we apply corrections for wet antenna, which significantly impacts light rainfall estimates, as well as for attenuation effects in the melting layer.
We apply this dual-channel measurement approach at Cadarache, France, where seven Ku-band sensors are co-located with six rain gauges. This setup allows for detailed validation of rainfall. Preliminary results indicate strong consistency between the rain gauge and the Ku-band sensors with dual channel method applied. The corrections for wet antenna and the melting layer effectively mitigate their respective biases, though further investigation is needed to refine their parameterization. The dual-channel algorithm produces highly consistent and unbiased results across the rainfall intensity range, significantly improving accuracy. In contrast, the standard method underestimates heavy rainfall by ignoring atmospheric radiation effects.
In addition, we will present the experiment that we have recently set up on the SIRTA platform observation in Palaiseau, France, to further refine our understanding of the factors influencing rainfall estimation with satellite microwave links. Three Ku-band sensors have been installed close to several disdrometers, rain gauges, the 95 GHz BASTA cloud radar, and, above all, the 9.4 GHz ROXI rain radar aimed in the same direction as the sensors. The objective is to better quantify uncertainties in our measurements, particularly related to melting layer height and thickness, drop size distribution, and vertical and horizontal heterogeneity of rain. These experiments will help improve error correction strategies and enhance the reliability of precipitation retrieval from TV-SAT links.

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