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Centralized Rainfall Estimation via Opportunistic Use of Satellite Communication Networks

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An extensive knowledge of the precipitation structure is critical to the scientific understanding of the Earth's hydrological cycle. Conventionally, observations from meteorological radars operating at low frequencies such as S-, C-, and X-bands are used for reliably estimating rainfall. While many developed regions of the world are largely covered by national weather radar networks, the size and cost of such deployments restricts the density of individual radar units to perform rainfall retrievals at high spatio-temporal resolutions. Further, significant portions of global weather remain unexamined because of lack of ground radar networks in many countries.
In this work, we present a centralized method for probing rainfall via opportunistic use of satellite communication network. The advantage is availability millions of satellite ground terminals throughout the world at a higher density than radars operated by national weather services. Our key idea is to use the signalling data generated in satellite communication networks to estimate the rainfall. In a typical broadband satellite network, to maintain a certain level of quality of service for users, gateway stations continuously monitor the links between satellite and satellite ground terminals. Carrier-to-Noise ratio (C/N) parameter denotes quality of the received signal and the link condition. Satellite ground terminals measure this parameter and send it back to the gateway station (enabled by bidirectional links).
The satellite links in our study operate at Ka-band at which the signal attenuates strongly as it propagates through the rain medium. At Ka-band, there is a linear relationship between the rain rate R and the specific attenuation A which, in turn, is directly related to C/N. We exploit this correlation between the two quantities in our retrieval algorithms for stratiform rain.
Compared to prior research on rainfall estimation, our approach has several novel features and interesting research challenges. It yields estimates at higher spatial resolution than conventional meteorological radars and rain gauges. We demonstrate this by comparing our results with the observations from the rain gauges and German weather service Deutscher Wetterdienst (DWD) radars. Secondly, our Ka-band rain rates are obtained through a passive non-radar link. It is, therefore, not as accurate as the recent work on millimetre wavelength weather radars but is instructive for its easy availability at many locations around the world. Also, the communication satellites far outnumber the spaceborne weather radars such as NASA Tropical Rainfall Measurement Mission (TRMM) and Global Precipitation Measurement (GPM). Finally, our use of appropriate signal processing and machine learning techniques enables us to estimate the rainfall from C/N measurements to a considerable accuracy. The idea opens up a novel avenue for the use of satellite signalling data for environmental monitoring as well as an interesting research field on combining machine learning with model based processing.