Preface

Precipitation is one of the most important components of the hydrological and global energy cycles. Accurate quantification and prediction of precipitation on a global scale or even at a watershed level remains a challenging task to achieve. Nevertheless, recent advances in radio remote sensing techniques, both from space-borne and ground-based, have improved precipitation estimations and our understanding of microphysical and dynamical processes occurring in precipitating systems. This special issue consolidates the most recent scientific findings related to the above aspects with a prime focus on **Radio probing of precipitation**.

This special issue is organized into four research domains: probing of precipitation with ground-based weather radars, improvements in satellite precipitation estimates, fundamental scientific issues related to raindrop size distribution, accurate prediction of rainfall.

The papers in ground-based weather radar discuss several aspects of precipitation, from advanced techniques employing polarimetric concepts to data fusion techniques involving multiple instruments and to nowcasting of thunderstorms using Doppler weather radars (DWRs). The special issue starts with an overview of challenges and opportunities of using multiple remote sensing instruments to estimate precipitation [Multi-sensor Precipitation Estimation (MPE)]. It divides major challenges of rainfall estimation from radars into basic science issues and engineering problems and highlights how polarimetric radars address these issues. It introduces several data fusion concepts, which merge data from different radars and satellites. One such merging technique is employed in another study, where the data from a network of X-band radars and operational C-band radar are merged, to fill the signal extinction areas of X-band radar and to improve rainfall estimates. Other papers highlight the problems in accurate forecasting of thunderstorms and hailstones in an operational set up. The intricacies of operational forecasting, tools available and necessity to develop new tools for a better prediction of the above severe weather events are emphasized.

The fundamental scientific problems dealt with, in this special issue, focus on the variability of raindrop size distribution (DSD) and the impact of DSD variability on traditional Z-R relationships, polarimetric rain estimators and earth-space communication links. All the papers note the large and complex variability in DSD within the rain event and also between the seasons. This variability introduces large uncertainty in the estimation of rainfall using the traditional Z-R relationship. It is experimentally shown that the Z-R relationships adjusted to rain gauge derived rainfall produce better rainfall estimates than the disdrometer derived Z-R relationship. The sensitivity of the DSD variations on polarimetric precipitation estimators is studied using four years of DSD measurements and radar scattering theory for an X-band radar. It has been found that the relations employing R-(K_{DP}) and R-(Z, Z_{DR}) show weak dependency on DSD, however, the coefficients of the above relations are found to be distinctly different from those reported elsewhere. The impact of DSD variability on attenuation and depolarization of Ku-band signal is found to be large in different types of rain and in different seasons.

The papers in satellite remote sensing focus on the techniques to improve microwave satellite rainfall estimates. The first paper in this area attempts to improve the accuracy of surface reference technique (SRT) based on a new idea, which may improve the algorithms of the Global Precipitation Mission (GPM) and Tropical Rainfall Measuring Mission (TRMM). It uses TRMM precipitation radar (PR) data to show that dividing the data into classes (unsupervised clustering) reduces the standard deviation of surface backscatter, especially near nadir incidence. The other paper describes comparisons of two commonly used rain detection techniques (the Petty and Grody techniques) using a matched radar-passive microwave observation database over tropical oceans. It is found that both the techniques have difficulty in separating rain from no rain pixels, particularly at lower rain rates. They quantified misclassified rain/non-rainy pixels over the global tropics. The paper also reports that there is no regional preference indicating that this problem is universal.

The paper in modeling section addresses the role of land surface processes in Indian summer monsoon (ISM) using the Weather Research Forecasting (WRF) model which is setup to run in a climate mode. The simulated rainfall over Indian region has been shown to have a wet bias relative to TRMM rainfall and this bias is attributed to stronger low level monsoon flow. Model simulations also show encouraging results in simulating the intraseasonal rainfall variations, the monsoon onset and amplitude of the diurnal variation but not the phase angle.

The ten papers in the special issue, covering a wide range of topics, clearly brought out the current state of knowledge and future challenges remain in this rapidly growing field. We hope that these papers stimulate further research, which will lead to a better understanding of precipitation and technique(s) for its quantification. Lastly, the Guest Editors would like to express their sincere gratitude to authors and reviewers. This special issue would not have been possible without their continued and kind support.

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