URSI AP-RASC, Sydney, Australia, 17-22 August 2025

Challenges of Quantitative Precipitation Estimation over Complex Terrain using Dual-Polarization Radar Observations

V.Chandrasekar* [(1)], EunYeol Kim[(1)], Sounak Biswas[(1)], Renzo Bechini[(1)], and Swaroop Sahoo[(2)]

(1) Colorado State University, Fort Collins, USA; e-mail: chandra@colostate.edu; eunyeol.kim@colostate.edu; sounak.biswas@colostate.edu; renzo.bechini@colostate.edu;
(2) Indian Institute of Technology Palakkad, Kerala, India; e-mail: swaroop@iitpkd.ac.in;

Dual-polarization radar systems have been widely used for precipitation monitoring, as it provides the capability to observe a wide range of spatial and temporal variability. Dual-polarization radar products provide detailed information on precipitation and are valuable for understanding the microphysical processes underlying precipitation. Quantitative precipitation estimation (QPE) from radar observations is useful for weather forecasting and preventing floods. Radar based QPE has been studied using a nonlinear Z-R equation. However, the Z-R equation struggles to capture the variability of precipitation and the differences across various environmental regions. Radar based QPE using deep learning techniques has emerged for accurately estimating precipitation. However, radar based QPE in complex terrain presents significant challenges. This paper examines the fundamental challenges of radar based QPE in the complex terrain of San Francisco Bay Area using deep learning techniques. Vertical profiles are constructed from X band radar observations and used to train a deep learning model. The X band radar systems collected the observation every 2 minutes. 15 minutes temporal resolution of rain gauge measurements within the radar coverage are used as a ground truth to train a deep learning model. The radar observations and rain gauge measurements are aligned both temporally and spatially. Two main challenges posed by complex terrain in San Francisco Bay Area are addressed in this paper. First, the radar beam can be obstructed by mountainous regions. The beam blockage causes inaccurate construction of the vertical profiles from radar observations. Second, the San Francisco Bay Area is influenced by atmospheric river, which result in contamination of the radar observations. These challenges provide inaccurate information to a deep learning model in complex terrain. This paper presents techniques to fill the gaps in vertical profiles and correct the contamination, ensuring a proper training of the deep learning model. The performance of radar based QPE using deep learning techniques is evaluated against current ongoing physics based method using various metrics.