Assessing climatological precipitation gradients derived using spaceborne radars in mountainous regions

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Spaceborne radar data acquired over the last two decades have enhanced the fine-scale mapping of locally concentrated rainfall in mountainous regions. Compared with the conventional images obtained using other modes of measurement, the geographic association in such data is striking. However, terrain-related retrieval uncertainties remain in the geographically-induced precipitation profile estimates. A 0.01° resolving rainfall climatology from long-term PR data has sharpened signals contaminated by mainlobe clutter as a spatially-fixed feature over specific slope areas. On the other hand, depending on the angle and region, sidelobe clutter contamination in the DPR product appears at a certain level. These interferences are negligible when describing the gross features of rainfall maps but non-negligible when detecting subtle characteristics at high altitudes. This study examines the fine-scale concentration of precipitation, impact of such suspicious echoes, and consistency in the data of the precipitation profiles between incidence angles to specify the artificial bias resulting from different clutter depths. The particular focus of the study is the regional bias related to the masking of ground clutter interferences of TRMM PR and GPM DPR. As such, the aim of this study is to obtain a better understanding of the detection ability of local precipitation characteristics in complex terrains. The results presented herein are based on TRMM PR version 7 and GPM DPR KuPR 05A, but these will be sequentially updated to the latest products.

The number of 4-year DPR precipitation samples exceeds that of the 16-year PR in areas at the 0 °C isotherm height lower than 2 km. Data accumulation increasingly allows for the extraction of climatological gradients in high terrain. The clutter depth from the surface is approximately 1,000 and 2,000 m at the near-nadir and swath edge, respectively. Along the Himalayan range, the clutter interference levels are increased by 750–1,000 m. The vertical precipitation profiles below 2,000 m exhibit both downward increasing and decreasing rainfall rate, as indicated by the attached figure; however, increasing patterns prevail for significant rainfall in most areas. The near-nadir observation indicates that convective rain profiles have rainfall rate peaks near the clutter-free bottom level (1–1.5 km above the surface) over areas at the low 0 °C level. Consequently, the correction that uses a referential database based on the near-nadir statistics increases the surface rainfall estimates, particularly over high mountain ranges and areas wherein shallow storms are dominant. For example, it was found that DPR precipitation climatology at 53°S is underestimated by 13% owing to the clutter-removal filter. The attached figure indicates that the correction could increase more than 20% of surface rainfall in mountainous regions. The contrast of the correction effect between land and oceans is weaker for DPR than PR. The vertical gradient of the rainfall rate between 2 and 2.5 km is a major factor in determining the low-level profile. The regional differences in the profile correction become indistinct when the vertical gradient information is removed. The “storm top height” information of the PR product includes significant uncertainty for deep storms because of the contamination owing to random noises; hence, the vertical gradient plays a key role in determining the significant downward increasing profiles. A comparison of the per-angle profiles indicates that orographic rainfall derived from spaceborne radars should be increased to reduce retrieval inconsistency.
Keywords: spaceborne radar, retrieval uncertainty, incidence angle dependency, orographic rainfall

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