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Evaluation of snow cover and snow depth on the Qinghai-Tibetan Plateau derived from passive microwave remote sensing

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Snow cover on the Qinghai-Tibetan plateau (QTP) plays a significant role in the global climate system and is an important water resource for rivers in the high elevation region of Asia. At present, passive microwave (PM) remote sensing data are the only efficient way to monitor temporal and spatial variations in snow depth at large scale. However, existing snow depth products show the largest uncertainties across the QTP. In this study, MODIS fractional snow cover product, in situ observations, and airborne observation data are synthesized to evaluate the accuracy of snow cover and snow depth derived from PM remote sensing data and to analyze the possible causes of uncertainties. The results show that the accuracy of snow cover extents varies spatially and depends on the fraction of snow cover. Based on the assumption that grids with MODIS snow cover fraction > 10 % are regarded as snow cover, the overall accuracy in snow cover is 66.7 %, overestimation error is 56.1 %, underestimation error is 21.1 %, commission error is 27.6 % and omission error is 47.4 %.. The commission and overestimation errors of snow cover primarily occur in the northwest and southeast areas with low ground temperature. Omission error primarily occurs in cold desert areas with shallow snow, and underestimation error mainly occurs in glacier and lake areas. Comparison between snow depths measured in field experiments, measured at meteorological stations and estimated across the QTP shows that agreement between observation and retrieval improves with an increasing number of observation points in a PM grid. The misclassification and errors between observed and retrieved snow depth are associated with the relatively coarse resolution of PM remote sensing, ground temperature, snow characteristics and topography. To accurately understand the variation in snow depth across the QTP, new algorithms should be developed to retrieve snow depth with higher spatial resolution and should consider the variation in brightness temperatures at different frequencies emitted from ground with changing ground features.