Ensemble learning for bias correction of satellite retrievals of orographic precipitation

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The performance of various composite satellite precipitation products is severely limited by their individual passive microwave (PMW)-based retrieval uncertainties because the PMW sensors have difficulties in resolving heavy rain and/or shallow orographic precipitation systems. Characterizing the error structure of PMW retrievals is crucial to improving precipitation mapping at different space-time scales. This paper introduces an ensemble learning framework to quantify the uncertainties associated with satellite precipitation products with an emphasis on orographic precipitation. In particular, a deep convolutional neural network (CNN) is developed as a baseline, which utilizes the ground-based Stage IV precipitation estimates as target labels in the training phase, to reduce biases involved in the precipitation product derived using the NOAA/Climate Prediction Center morphing technique (CMORPH). An ensemble strategy is incorporated to boost the performance of individually trained deep learning models. The products before and after bias correction are evaluated using independent precipitation events over the coastal mountain region in the western United States, and the impact of topography on satellite-based precipitation retrievals is quantified. The results show that the orographic gradients have a strong impact on precipitation retrievals in complex terrain regions. The accuracy of CMORPH is dramatically enhanced after applying the proposed ensemble learning-based bias correction technique, indicating the great potential of machine learning in satellite precipitation retrievals.