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Estimating Surface Melt on the Larsen Ice Shelf Using a Deep Neural Network: Opportunities and Challenges

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Presently, surface melt over Antarctica is estimated using climate modeling or remote sensing. However, accurately estimating surface melt remains challenging. Both climate modeling and remote sensing have limitations, particularly in the most crucial areas with intense surface melt. The motivation of our study is to investigate the opportunities and challenges in improving the accuracy of surface melt estimation using a deep neural network. The trained deep neural network uses meteorological observations from automatic weather stations (AWS) and surface albedo observations from satellite imagery to improve surface melt simulations from the regional atmospheric climate model version 2.3p2 (RACMO2). Based on observations from three AWS at the Larsen B and C Ice Shelves, cross-validation shows a high accuracy (root mean square error = 0.898 mm.w.e.d^{-1}, mean absolute error = 0.429 mm.w.e.d^{-1}, and coefficient of determination = 0.958). The deep neural network also outperforms conventional machine learning models (e.g., random forest regression, XGBoost) and a shallow neural network. To compute surface melt for the entire Larsen Ice Shelf, the deep neural network is applied to RACMO2 simulations. The resulting, corrected surface melt shows a better correlation with the AWS observations in AWS 14 and 17, but not in AWS 18. Also, the spatial pattern of the surface melt is improved compared to the original RACMO2 simulation. A possible explanation for the mismatch at AWS 18 is its complex geophysical setting. Even though our study shows an opportunity to improve surface melt simulations using a deep neural network, further study is needed to refine the method, especially for complicated, heterogeneous terrain.