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Retrieval of Arctic sea ice freeboard from passive microwave data using deep neural network

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Changes in Arctic sea ice cover represent one of the most visible indicators of climate change. While changes in sea ice extent affect the albedo, changes in sea ice volume explain changes in the heat budget and the exchange of fresh water between ice and the ocean. Global climate simulations predict that Arctic sea ice will exhibit a more significant change in volume than extent. Satellite observations show a long-term negative trend in Arctic sea ice during all seasons, particularly in summer. Sea ice volume has been estimated by ICESat and CryoSat-2 satellites, and then NASA's second-generation spaceborne lidar mission, ICESat-2 has successfully been launched in 2018. Although these sensors can measure sea ice freeboard precisely, long revisit cycles and narrow swaths are problematic for monitoring of the freeboard in the entire of Arctic ocean effectively. Passive microwave sensors are widely used in retrieval of sea ice concentration. Because of the capability of high temporal resolution and wider swaths, these sensors enable to produce daily sea ice concentration maps over the entire Arctic ocean. Brightness temperatures from passive microwave sensors are often used to estimate sea ice freeboard for first-year ice, but it is difficult to associate with physical characteristics related to sea ice height of multi-year ice. In machine learning community, deep learning has gained attention and notable success in addressing more complicated decision making using multiple hidden layers. In this study, we propose a deep learning based Arctic sea ice freeboard retrieval algorithm incorporating the brightness temperature data from the AMSR2 passive microwave data and sea ice freeboard data from the ICESat-2. The proposed retrieval algorithm enables to estimate daily freeboard for both first- and multi-year ice over the entire Arctic ocean. The estimated freeboard values from the AMSR2 are then quantitatively and qualitatively compared with other sea ice freeboard or thickness products.