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Spatial downscaling method of glacier surface albedo based on deep learning

Fuming Xie[1,2], Shiyin Liu[1,2], Yu Zhu[1,2], Yongpeng Gao[1,2], Kunpeng Wu[1,2], and Miaomiao Qi[1,2]
[1]Institute of International Rivers and Eco-Security, Yunnan University, Kunming, China
[2]Yunnan Key Laboratory of International Rivers and Transboundary Eco-Security, Yunnan University, Kunming, China

Heat exchange in glacier region is strongly affected by the interaction between solar radiation and glacial surface, and albedo is an important index to quantitatively describe energy balance in this interaction process. Under the background of global warming, the observation and modeling of albedo are of great significance in the aspects including identification of snow and ice darkening or pollution, reconstruction of glacier mass balance and inversion of supraglacial debris expansion. However, insufficient observations, coupled with low spatial resolution of satellite derived products (250-1000m), make it difficult to analyze spatial changes at the glacier scale. A convolution neural network (CNN) contains one or more of the convolution layer, in which inputs are neighborhoods of pixels, resulting in a network that is not fully-connected, has great potential to the image segmentation but is also suited to identifying spatial patterns. Therefore, in this study, a CNN model—U-NET was trained to improve the spatial resolution of albedo products. In the U-NET, we took the shortwave black-sky albedo derived from moderate resolution imaging spectroradiometer (MODIS) boarded on Terra/Aqua satellite with a spatial resolution of 500m as response variable, and raw spectral information, band ratios, and color-to-grayscale conversion from Landsat 8 optical satellite imagery and the topographical components derived from SRTM DEM products as feature variables. The predicted albedo has been validated using observations form radiometer mounted on an automatic weather station at Yazgil glacier in Hunza valley, Karakoram. The results show that the accuracy of U-NET predicted albedo (RMSE = 0.071) is similar to that of MODIS albedo (RMSE = 0.074), which proved that U-NET has great application potential. The high spatial resolution albedo estimated by the model enhances its use in the analysis of spatial changes at the glacier scale, especially for small glaciers, but the optimization of its temporal resolution needs to be further studied.