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Distinguishing ice from snow for melt modeling using daily observations from MODIS

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In high mountainous regions of the Earth during melt periods, both seasonal snow and glacier ice melt may contribute to surface water and ground water feeding streams. In these regions there are often few in-situ observations that can help distinguish between the two components of melt, particularly across large mountain ranges. Understanding the contribution of melt water from the seasonal snow and glacier ice sources informs us about the current state of the water cycle and how a changing climate may alter the water cycle. In this study, we analyze daily time series of MODIS data products to distinguish ice from snow as the seasonal snowpack recedes, revealing melt over glacier ice surfaces.

Broadband albedo increases as ice is exposed because of larger grain sizes and dust/debris on the glacier surface. To investigate the grain sizes we use estimates from the MODIS Snow Covered Area and Grain Size Model (MODSCAG) and MODIS Dust Radiative Forcing in Snow (MODDRFS) derived from MODIS surface reflectance (MOD09GA). MODSCAG uses the shape of the spectrum selected by a spectral mixture analysis model while MODDRFS uses the Normalized Difference Grain Size Index (NDGSI). Comparison of the grain sizes with grain sizes derived from the Airborne Visible/Infrared Imaging Spectrometer have demonstrated higher accuracy for the NDGSI approach. In addition to analysis of grain sizes, we use 2 standard albedo products from the MODIS, the Terra Daily Snow Cover algorithm (MOD10A1) that uses a narrow-to-broadband conversion scheme to create an integrated broadband albedo and Surface Reflectance BRDF/Albedo (MOD43) product that provides albedo in three broad bands. We focus on the Hunza River basin, in the Upper Indus located in Northern Pakistan. We use the annual minimum ice and snow from the MODICE Persistent Ice and Snow (MODICE) algorithm to identify glaciated regions for analysis. The methods (MODSCAG, MODDRFS, MOD10A1, MOD43) all show sensitivity to exposed glacier surfaces. Further work will use a time series of melt modeling in this region to determine the contributions from seasonal snow versus glacier ice melt.