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# Establishing a Collaborative Effort to Assess The Contribution to High Asian Runoff from Ice and Snow (CHARIS)

Richard Armstrong (1), Andrew Barrett (1), Mary Jo Brodzik (1), Florence Fetterer (1), Ulyana Horodyskyj (1), Siri Jodha Khalsa (1), Adina Racoviteanu (2), Al Rasmussen (3), Bruce Raup (1), Mark Williams (4), and Alana Wilson (4)

(1) University of Colorado, CIRES/NSIDC, Boulder, United States (rlax@nsidc.org, 303 492 1828), (2) LGGE, Saint Martin d'Hères, France, (3) University of Washington, Seattle, Washington, United States, (4) INSTAAR, University of Colorado, Boulder, United States

The improved understanding of the regional water resources of High Asia is a cross-boundary exercise and in order to achieve this goal, University of Colorado scientists are working directly with researchers at institutions in nine different nations where these ice and snow resources are located across High Asia (Bhutan, Nepal, India, Pakistan, Afghanistan, Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan). These countries contain the headwaters of the Brahmaputra, Ganges, Indus, Syr Darya and Amu Darya rivers. This collaboration includes both joint research and capacity building that will enhance the scientific understanding of the regional hydrology through augmented field programs and technical training. The fundamental objective of this collaborative study is to develop a thorough and systematic assessment of the separate contributions from seasonal snow melt and from glacier ice melt to the water resources originating across the Himalaya, Karakoram, Hindu Kush, Pamir and Tien Shan mountain ranges. While it is generally accepted that the melt from glacier ice and seasonal snow is a significant component of High Asian water resources, the actual water volume available from these two individual sources remains uncertain.

To accomplish project objectives, a suite of satellite remote sensing, reanalysis and ground based data are applied as input to specific snow and ice melt models. Gridded maps of snow and glacier area/elevation are used as input to temperature-index melt models to estimate runoff from snow covered grid cells, based on cell area and melt depth. Glacier melt is estimated in the same way, once snow has disappeared from glacierized grid cells. The melt models are driven by daily mean temperature from reanalysis data. We are comparing the melt volume time series generated from temperature-index models with measured river discharge volumes and comparing the regional scale results with local sub-basin studies based on energy balance modeling approaches. We are also evaluating the accuracy of the melt model results using isotopic and geochemical tracers to identify and quantify the sources of water (ice melt, snow melt, rainfall and ground water) flowing into selected rivers representing the major hydro-climates of the study area. With our Asian partners, we are assessing the performance of the various melt models. Examples of the various tasks and methodologies to achieve the overall project goals are summarized and preliminary results are presented for the Upper Indus Basin for the period 2000-2012.