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The Contribution to High Asia Runoff from Ice and Snow (CHARIS): Understanding the source of cryospheric contributions to the water balance

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The Contribution to High Asia Runoff from Ice and Snow (CHARIS) project systematically assesses the role of glaciers and seasonal snow in the freshwater resources in five major river basins: the Ganges, Brahmaputra, Indus, Amu Darya and Syr Darya. Our automated partitioning method generates daily maps of snow over ice (SOI), snow over land (SOL), exposed glacier ice (EGI), and debris covered glacier ice (DGI) using 500 m MODIS-derived products. Maps are calibrated and validated with Landsat 8 classification maps (30 m resolution) using a semi-automated procedure based on spectral and topographic information. These daily land cover maps are inputs to a calibrated temperature-index model and an uncalibrated energy balance model (ParBal) used to estimate the different sources of meltwater. Water chemistry and isotope data provide an independent comparison of model results and offer additional insight into groundwater's role.

Model results indicate a sharp geographic contrast in the role of snow and ice to runoff and show the runoff composition transition from meltwater to liquid precipitation along elevational gradients. Meltwater dominates dry season flow sources in the arid Amu Darya, Syr Darya, and Indus basins where SOL contributes 66% to 68% annually, whereas in the high-elevation easterly monsoon affected Brahmaputra, SOL contributes 55% annually. Rain controls the monsoon influenced Ganges runoff contributing 63% of annual flows. SOI and EGI's annual contribution vary from 5% to 10% across the basins. This work improves our understanding of the current hydrologic regime through the use of remote sensing data and algorithms for snow and ice to guide realistic estimates of the future availability and vulnerability of water resources in High Asia.