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Inventorying and monitoring the recent behavior of Afghanistan's glaciers – debris-covered glaciers, supraglacial lakes, and the potential for catastrophic flooding (jökulhlaups)

B.F. Molnia

USGS, Earth Surface Processes, 926A National Center, Reston, VA 20192 USA, (bmolnia@usgs.gov, 703-648-6953)

The U.S. Geological Survey's nationwide investigation of the water resources of Afghanistan has one component focused on characterizing the behavior of the country's glaciers and their response to changing climate. A recent emphasis has been on determining the distribution and extent of debris-covered glaciers in order to understand the relationship between debris cover, supraglacial lakes, and the potential for catastrophic flooding (jökulhlaups). In glacier environments, catastrophic flooding (jökulhlaups) is usually caused by (1) drainage of ice-dammed lakes, (2) drainage of ice-marginal lakes, (3) release of water stored subglacially, englacially, or supraglacially, sometimes through surge-related processes, or (4) through melting of glaciers located around the summit craters of erupting volcanoes. All but the last are significant sources of flooding in Himalayan Mountain glacier environments.

A systematic examination of two data sets: (1) VNIR (visible and near-infrared) digital images collected between 2001 and 2004 by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on the Terra spacecraft, and (2) Landsat 7 Thematic Mapper (ETM+) digital images, was used to determine the distribution of glacier-related lakes. This examination of all of the glacier-covered areas of Afghanistan revealed relatively few ice-dammed and ice-marginal lakes. However, it determined that many valley glaciers have large concentrations of debris on their lower reaches, and that this debris hosts significant numbers of supraglacial lakes. Typically, supraglacial lakes develop on stagnant or slowly moving ice through thermokarst processes. Because of the ephemeral character of supraglacial water storage, these debris-covered glaciers present a high risk with respect to jökulhlaup generation. Some Afghan debris-covered glaciers support more than 30 supraglacial lakes.

Among the areas that support large numbers of debris-covered glaciers with supraglacial lakes are the central Wakhan Pamir; the western end of the Wakhan panhandle; and the retreating, debris-covered valley glaciers of the Panshir Valley region. In the Wakhan panhandle, more than 100 debris-covered glaciers were examined. In addition to supraglacial lakes, many displayed empty thermokarst pits, suggesting recent drainage. All of the glaciers analyzed are thinning and/or retreating. A significant amount of the meltwater produced by this thinning and/or retreat is temporarily stored in subglacial, englacial, and supraglacial environments. The results of this investigation suggest that in Afghanistan, supraglacial lakes that may pose a significant threat to outburst flooding and landslide generation