Geophysical Research Abstracts
Vol. 14, EGU2012-3931-1, 2012
EGU General Assembly 2012

Glacier and climate change in Pakistan and Afghanistan

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Climate change predictions and water resource related issuesin Afghanistan and Pakistan have led to the need for detailed assessments and understanding of glacier fluctuations, and the determination of the dominant controlling factors governing glacier sensitivity to climate change. Consequently, we studied glacier fluctuations and the role of topography in an attempt to understand glacier fluctuations.Specifically we used ASTER imagery, Landsat ETM data, and an SRTM digital elevation model, together with Google Earth™ high-resolution imagery to examine terminus fluctuations, ice velocity variations, and local- and meso-scale topographic parameters that are related to irradiance variations, ablation, and glacial geomorphology.Multispectral satellite imagery were utilized to estimate advance and retreat rates, along with glacier profile velocities. Geomorphometric analysis was utilized to generateglacier altitude profiles of hypsometry, slope, curvature, and topographic shielding. Our results reveal that glacier response to climate change is highly variable in Pakistan, as many glaciers are advancing as well as retreating, while others exhibit a stationary terminus. It is important to note that advances in the Karakoram do not appear to be restricted to glaciers at high elevations, suggesting climate forcing. Glaciers in the Hindu Raj and Hindu Kush are retreating, with fewer glaciers advancing, indicating the possibility of a spatial trend from West to East in Pakistan. There is a dramatic diminution of Hindu Kush ice in Afghanistan. In the Karakoram, many new surging glaciers have been identified with flow velocities ranging from 200-1000 m/yr. Non- surging glaciers also exhibit relative high velocities there. Spatial patternsof relief appear to be associated with glacier debris cover, as snow/ice avalanchescontribute debris and ice mass. In addition, patterns of topographic shielding are highly variable, revealing variations in the diffuse-skylight irradiance component. Altitudinal slope and azimuth variations alsodictate significant variations in the direct-irradiance component. Consequently, glaciers within the same region receive very different amounts of surface irradiance, causing ablation variation that accounts for highly variable terminus fluctuations. Furthermore, altitudinal variations in glacier surface and topographic conditions can potentially be used to characterize glaciers and their dynamics, in terms of climate sensitivity and geomorphological influence. Collectively, our results suggest climate forcing in the Karakoram, and topographic control of glacier fluctuations.