Geophysical Research Abstracts
Vol. 15, EGU2013-11389, 2013
EGU General Assembly 2013

Air temperature distribution over a debris covered glacier in the Nepalese Himalayas

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Air temperature is a key control in the exchange of energy fluxes at the glacier-atmosphere interface and also the main input variable in many of the melt models (both energy balance or temperature-index type of models) currently used to predict glacier melt across a variety of scales. The commonly used approach to derive distributed temperature inputs is extrapolation from point measurements, often located outside the glacier surface, with a lapse rate that is assumed to be constant in time and uniform in space.

Previous work for debris free glaciers has shown that lapse rates depend on several factors such as katabatic wind, humidity and the presence of clouds and that they vary in space and time. A dominant control however seems to be the presence of katabatic wind. For debris covered glaciers, the driving forces of air temperature are likely to be different but little is known because of the scarcity of field observations. Few preliminary studies have suggested that there is a strong coupling between surface and 2 m air temperature, while strong katabatic wind does not develop on debris covered tongues. In this study, we examine the variability in air temperature and lapse rates, as well as its atmospheric controls under different meteorological settings for the debris covered Lirung Glacier in the Nepalese Himalayas. We use a recently collected data set of air and surface temperature at a network of locations on the glacier tongue during the pre-monsoon season and the entire monsoon season of 2012. Additionally an AWS was installed on the glacier allowing the collection of meteorological observations.

We investigate differences in air temperature during different climatic conditions (monsoon vs. dry period, upvalley vs. downvalley wind, cloudy vs. clear-sky, etc.). We identify the main controls on temperature and discuss how appropriate the application of a temperature lapse rate is over a debris covered glacier by investigating the correlation between temperature and elevation for different conditions and temporal scales. There are clear differences between the monsoon and the dry period both in the magnitude of lapse rates and type of controls which should be taken into account for melt modelling under debris. We also assess the relationship of air and surface temperature. Lapse rates exist on the glacier during night time, but loose strength during day time, when the surface heats up and the coupling between air and surface temperature becomes strong. Spatial variations in surface temperature however cannot be explained by elevation, and we show that surface topography is important. We summarize possible applications of the new findings.