Geophysical Research Abstracts
Vol. 20, EGU2018-384, 2018
EGU General Assembly 2018

An analysis of catchment-scale, high elevation meteorology in the Khumbu region of the Nepal Himalayas, 2009-2012

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High altitude meteorology plays a crucial role in determining glacier viability, yet in situ observations are lacking, particularly for the Himalaya. This research presents meteorological data from five weather stations, with elevations ranging from 2,680 to 5,600 metres, in the glaciated Khumbu catchment of the Nepal Himalayas, for the period 2009-2012. There is high spatial variability in temperature, largely associated with elevation. The onset and decay of the monsoon is evident at all stations. It is characterised by increased and less variable temperatures, humidity levels ($\geq$90%) and precipitation, with drizzle being the most common precipitation type. The study of monsoon activity is essential as glaciers are reliant on monsoonal precipitation for accumulation in this region. There is decreased diurnal variability in wind speeds, and wind directions are consistently southerly relative to the pre and post monsoon periods. Valley orientation largely dictates the dominant wind direction, and south/north orientation of the Khumbu valley aids the signal of the southerly monsoon wind for most stations. There was evidence of a persistent katabatic wind from the debris-covered Changri Nup glacier, and the associated clean ice fall at the Kala Patthar station at 5,600 metres elevation. Such specific small-scale processes, such as katabatic winds or drainage flows in valleys, significantly influence local temperatures and winds. This emphasises the need for inclusion of small-scale processes in climate downscaling and glacier modelling. Temperature showed a changing sub-diurnal cycle with season, with a dampened cycle during the monsoon. This raises the question as to whether climate downscaling needs to include a specific process to account for seasonal and diurnal patterns in meteorological variables such as temperature. This study provides an insight into the meteorology of a high elevation, glaciated catchment and revealed how catchment-scale topography and atmospheric circulations strongly influence temperature, precipitation and winds. It also emphasises the importance of using local meteorological data for glacier modelling, both for validation and downscaling of climate models, and for use in glacier mass balance studies.