Geophysical Research Abstracts
Vol. 18, EGU2016-13160, 2016
EGU General Assembly 2016

Snow and glaciers in the tropics: the importance of snowfall level and snow line altitude in the Peruvian Cordilleras

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The snow line altitude, defined as the line separating snow from ice or firn surfaces, is among the most important parameters in the glacier mass and energy balance of tropical glaciers, since it determines net shortwave radiation via surface albedo. Therefore, hydroglaciological models require estimations of the melting layer during precipitation events, as well as parameterisations of the transient snow line. Typically, the height of the melting layer is implemented by simple air temperature extrapolation techniques, using data from nearby meteorological stations and constant lapse rates. Nonetheless, in the Peruvian mountain ranges, stations at the height of glacier tongues (>5000 m asl.) are scarce and the extrapolation techniques must use data from distant and much lower elevated stations, which need prior careful validation. Thus, reliable snowfall level and snow line altitude estimates from multiple data sets are necessary.

Here, we assemble and analyse data from multiple sources (remote sensing, in-situ station data, reanalysis data) in order to assess their applicability in estimating both, the melting layer and snow line altitude. We especially focus on the potential of radar bright band data from TRMM and CloudSat satellite data for its use as a proxy for the snow/rain transition height.

As expected for tropical regions, the seasonal and regional variability in the snow line altitude is comparatively low. During the course of the dry season, Landsat satellite as well as webcam images show that the transient snow line is generally increasing, interrupted by light snowfall or graupel events with low precipitation amounts and fast decay rates. We show limitations and possibilities of different data sources as well as their applicability to validate temperature extrapolation methods.

Further on, we analyse the implications of the relatively low variability in seasonal snow line altitude on local glacier mass balance gradients. We show that the snow line altitude - ranging within only few hundreds of meters within one year - determines the observed high mass balance gradients. An increase in air temperature by for example 1°C during precipitation events may have even stronger impacts on glacier mass balances of tropical glacier than it would have on those of mid-latitude glaciers. This is an important reason for the high sensitivity of tropical glaciers on past and current climatic changes.