Geophysical Research Abstracts
Vol. 16, EGU2014-6954-1, 2014
EGU General Assembly 2014

Glacier retreat since the Little Ice Age in the eastern Nyainqêntanglha Range, southeastern Tibet

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The remote eastern Nyainqêntanglha Range in southeastern Tibet is situated in a transition zone between warm-wet subtropical and cold-dry plateau climate conditions. In this high mountain environment, intense summer monsoon rainfalls support numerous temperate glaciers despite the latitude of ∼29° to ∼31°N. Due to the outstanding importance of the monsoonal airmasses for the water cycle of the whole region, it is a key area to study climate and subsequent glacier change in High Asia. Here, we present the results of a study in which 1964 glaciers were mapped by remote sensing from a Landsat ETM+ scene and subsequently parameterized by DEM supported measurements. Geomorphological evidence, such as glacier trimlines and latero-frontal moraines, was used to delineate the Little Ice Age (LIA) maximum glacier advance terminus positions. Statistical analysis of glacier length change revealed an average retreat of ∼40 % and a trend towards stronger retreat for smaller glaciers. Calculated ELAs show a southeast-northwest gradient ranging from 4,400 to 5,600 m a.s.l. and an average ELA rise of ∼98 m since the LIA. Due to the large amount of measurements the ELA distribution reveals topographic effects down to the catchment scale, i.e. orographic rainfall and leeward shielding. This gives numerous hints on the relief-climate-glacier interactions and allows a simplified reconstruction of the flow patterns of the monsoonal air masses. Contrasting to the expectations for subtropical settings, glaciers on south facing slopes have not retreated strongest and ELAs on south facing slopes did not rise furthest. Instead, highly heterogeneous spatial patterns emerge that show a strong imprint of both, topography and monsoonal dynamics. Our results indicate that the monsoonal temperate glaciers' high sensitivity to climate change is driven by two double forcings due to the coincidence of accumulation and ablation phases. First, monsoon intensity directly controls the amount of precipitation and additionally influences temperature through cloud cover. Second, many glaciers in the study area have steep upper accumulation areas. In these settings, temperature rise rapidly reduces the size of the accumulation areas. Additionally, the larger portion of precipitation that is falling as rain instead of snow results in increased melting through lowered albedos and the effects of liquid water in the glacier system.