Geophysical Research Abstracts
Vol. 19, EGU2017-12002, 2017
EGU General Assembly 2017

An analysis of the long term hydrological dynamics of the Careser, a rapidly retreating Alpine glacier.

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Alpine glaciers are shrinking at a relentless pace, as an effect of the increasing temperature and the concomitant reduction of snowfall that the Alpine region experienced in the last 40 years. The impact of these changes is relevant, given the importance of the Alps from ecological and economical points of view. While the ubiquitous reduction of glaciers mass through the Alps has been reported in a number of studies, its effect on streamflow is less studied, mainly because much less data are available on streamflow emerging from glaciers. In the present work we analyze a long streamflow time series, recorded since the 70s, in the Careser creek emerging from the Careser Glacier, which mass has been monitored since 1920, first discontinuously and then continuously from 1967. Because of these long-term observations, the Careser has been classified as one of the reference glaciers by the World Glacier Monitoring Service, which provides balances data every two years. We performed a comprehensive analysis of multiscale variations of precipitation, temperature, water discharge and glacier mass. In addition we explored the correlations between streamflow and climatic drivers at monthly and subdaily scales. We observed significant changes in the timing of streamflow, with anticipated snow melting and a reduction of summer runoff, while at the annual scale the increase of ice-melting offsets runoff reduction caused by less winter precipitation falling as snow. In fact, in most years since the 1990 ice melts from beginning of May to October, thereby causing a dramatic reduction of the glacier volume. However, in the last years the significant reduction of the glacier surface, attenuated this tendency to increase the total annual runoff volume. At the sub-daily scale we observed a progressive increase of the difference between the maximum and minimum water discharge. Overall the hydrological regime changes significantly as an effect of the rise in temperature and the lower winter snowfall, which increased the importance of ice melting as source of streamflow with respect to snow melting, which was still the primary source of streamflow in the 70s.