Geophysical Research Abstracts
Vol. 14, EGU2012-8168, 2012
EGU General Assembly 2012

Precipitation patterns in the Karakoram range (Northern Pakistan) from observations and model simulations

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In this study, we discuss the pattern, distribution and variability of precipitation in the Karakoram mountain range and in the Upper Indus Basin in Northern Pakistan. We analyse recent in-situ measurements provided by two Automatic Weather Stations (AWS) placed at high elevation near the Baltoro glacier, providing a general characterization of the meteorological conditions in this area. The AWS provide data of standard meteorological parameters and precipitation, but the time series of the measured variables are quite short (from 2004-2005) and discontinuous, especially for precipitation. The analysis of rainfall in the Karakoram is then complemented using satellite estimates (TRMM data), and data from other archives based on in-situ rain gauges (Aphrodite, CRU, and GPCC data sets) and a combination of satellite and rain gauge data (GPCP archive), supplied on regular spatial grids and different temporal resolutions (from 3-hour to daily and monthly data). All observational data sets show that in the Karakoram, precipitation has a strong winter signal, associated with the arrival of "western weather patterns" originating from the Mediterranean and the Middle East. Owing to this circulation, the Karakoram range receives its water input in winter and the monsoon-controlled dynamics plays a minor role, at variance with the situation encountered in the eastern stretches of the Himalayas. We further consider precipitation data from a state-of-the-art Earth System Model, the European Consortium model EC-Earth. We evaluate model skill in reproducing the observed seasonality in the Karakoram, we assess the role of broad scale meteorology influencing precipitation in the Upper Indus Basin, and we analyse precipitation seasonality, variability and trends in this region under different climate change scenarios.