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Quantification and analysis of deuterium and oxygen-18 isotope composition of precipitation at the southern foothills of Mt. Kilimanjaro (Tanzania)

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Tropical rainforest are important ecosystems for cycling water at local, regional and global scales. A number of studies have emphasized the increasing trend of extreme seasonal and inter-annual variability of precipitation and hydrology in the Kilimanjaro region. So far, only a limited number of observations have been available for water budget quantification.

For quantifying atmospheric water input at the southern foothills of Mt. Kilimanjaro, rainfall, fog and throughfall were measured for two years along an elevation and disturbance gradient ranging from 950 m a.s.l. to 3,880 m a.s.l.. Measurements were conducted at eight research plots, equipped with one accumulating rainfall bucket, one accumulating standard mesh fog collector and a sampling network of 29 accumulating throughfall buckets. The bimodal rainfall distribution is shaped by a "short" (October to December) and "long" (March to May) rainy season. Maximum annual rainfall is denoted in the midmontane zone between 2,200 m a.s.l. and 2,490 m a.s.l. (approximately 3,300 mm). In higher elevations precipitation amounts declines, reaching 55% of the maximum at 3,880 m a.s.l., while fog water deposition ranges from 2% of rainwater input in the lower montane forest (1,800 m a.s.l.) to 8% at 3,880 m a.s.l..

Stable isotope composition of volume-weighted samples from eight of the 29 throughfall accumulation buckets, the fog mesh grid and the rainfall accumulation gauge were measured in a weekly interval from November 2012 to November 2014 on each of the eight research plots. To get insights into the importance of local vs. remote water sources, two additional rainfall gauges were installed in eastern direction (Same, Mkomazi National Park, Tanga) to get isotope characteristics of the approaching rainfall systems. During one transition from dry to wet (December 2013) and wet to dry (April 2014) season, the sampling interval was increased to a sub-daily resolution to account for amount and elevation effects in the analysis. Variations in isotopic content were noted. The 24 month weekly dataset for the entire research area gives the following regression: $\delta 2H = 7.55\ \delta 18O + 15.41$, altering to $\delta 2H = 7.20\ \delta 18O + 12.76$ during the intensive campaign in December 2013 and to $\delta 2H = 7.31\ \delta 18O + 15.74$ during the second intensive campaign in April 2014. The isotopic composition between mean fog water deposition and mean rainfall samples shows variations along the elevation gradient with 7‰ δ18O and 34‰ δ2H for lower montane forest (1,800 m a.s.l.) and 18‰ δ18O and 32‰ δ2H in 3,800 m a.s.l..

Furthermore, deuterium & oxygen-18 isotope composition will be used to interpret the importance of local evaporation as a significant resource for fog and rainfall (recycling hypothesis) to analyse if local land-cover change will likely have a negative effect on the atmospheric water input. If fog and rainfall is primarily fed by remote water sources, local land-cover changes might enhance rainfall (convection hypothesis).