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Evapotranspiration dynamics along elevational and disturbance gradients at Mt. Kilimanjaro

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Future climate characteristics of the Mt. Kilimanjaro region, Tanzania, will be governed by two superior processes: (i) global climate change and (ii) local land cover transformation. Whilst precipitation amounts remained stable throughout the last climate normals, recent studies revealed distinctly increasing air temperatures in the study region between 1973 and 2013, resulting in a gradual reduction of available moisture. In addition, climate predictions show rising temperatures over East Africa throughout the 21st century. Modifications of the local hydrological cycle resulting from land cover transformation will either favor or counteract the thus induced, increasing dryness. Considering that the local-scale climate is a key parameter for ecosystem processes and biodiversity, quantifying the driving components on the credit (precipitation, through-fall, fog) and debit side of the local-scale water balance is of outstanding (biogeo-)scientific importance.
In this context, a multidisciplinary German research unit investigates the interrelationship between climate, land use and biodiversity along the southern slopes of Mt. Kilimanjaro. A total of 65 climate stations have been installed to record rainfall and estimate potential evaporation across different land cover types ranging from savanna (880 m a.s.l.) to the upper mountain Helichrysum sites (4,550 m a.s.l.). The associated data is used for both the area-wide interpolation of meteorological parameters and as input for satellite-based retrievals of rainfall and evapotranspiration (ET).
We conducted an extensive field campaign employing a surface-layer scintillometer in order to gain insights into ET dynamics over different land cover types following elevational and disturbance gradients. Scintillometer measurements are available for study sites below (savanna, maize, grassland, coffee plantations) and above the forest belt (natural and disturbed ericaceous forest, Helichrysum), covering a period of 4-7 days each. Minor data gaps are introduced by particular environmental conditions (e.g. strong winds, fog) and external power failure, and a random forest-based approach has been successfully implemented to impute missing values.
Visual inspection revealed that ET rates on study sites below the forest belt (<2000 m a.s.l.) remarkably differed from corresponding measurements above the densely wooded areas (>3500 m a.s.l.) in magnitude and diurnal variation. Diurnal ET variation on the lower elevated research plots followed the course of the sun, with maximum values in the early afternoon and minimum values during sunrise and sunset. Maximum evapotranspirative net water loss occurred on the selected grassland sites, followed by maize, coffee, and minimum values on savanna. The study sites located above the forest belt, however, showed maximum ET rates coinciding with sunrise, whilst ET remained almost constantly low during the remaining hours of sunlight.
We tentatively suggest that tree density regulates net water loss on the lower elevated research plots, while water scarcity is of subordinate importance. As for the high-lying sites, maximum ET rates directly after sunrise indicate an immediate sublimation of ice accumulated in the soil during night and subsequently attenuated water loss as a result of limited water availability. However, further analysis steps need to be performed in order to draw more reliable conclusions on the observed ET patterns.