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SNOWMELT AND SUBLIMATION: FIELD EXPERIMENTS AND MODELLING IN THE HIGH ATLAS MOUNTAINS OF MOROCCO

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ABSTRACT: Snow in the High Atlas Mountains is a major source for freshwater renewal and for water availability in the semi-arid lowlands of south-eastern Morocco. Snowfall- and snow-ablation monitoring and modelling is important for estimating potential water delivery from the mountain water towers to the forelands. This study is part of GLOWA-IMPETUS, an integrated management project dealing with scarce water resources in West Africa. The Ameskar study area is located to the south of the High Atlas Mountains, in their rain shadow. As a part of the M'Goun river basin within the upper Drâa valley, the study area is characterised by high radiation inputs, low atmospheric humidity and long periods with sub-zero temperatures. Its altitude ranges between 2000 m and 4000 m, with dominant north- and south-facing slopes. Snowfall occurs mainly from November to April but even summit regions can become repeatedly devoid of snow cover. Snow cover maps for the M'Goun basin (1240 km2) are derived from calculations of NDSI (Normalized Difference Snow Index) from MODIS satellite images and snow depth is monitored at four automatic weather stations between 2000–4000 m. Snowfall events are infrequent at lower altitudes. The presence of snow penitentes at altitudes above 3000 m indicates that snow sublimation is an important component of snow ablation. Snow ablation was modelled with the UEB Utah Energy Balance Model (Tarboton and Luce, 1996). This single layer, physically-based, point energy and mass balance model is driven by meteorological variables recorded at the automatic weather stations at Tounza (2960 m) and Tichki (3260 m). Data from snow pillows at Tounza and Tichki are used to validate the model's physical performance in terms of energy and water balances for a sequence of two snowfall events in the winter of 2003/4. First UEB modelling results show good overall performance and timing of snowmelt and sublimation compared to field investigations. Up to 44% of snow ablation is attributed to snow sublimation in typical winters with subzero temperatures and low atmospheric humidity at an altitude of 3000 m. At altitudes below 3000 m snowmelt generally dominates over sublimation. Unfortunately, the highest altitude zones suffer long periods with direct water loss into the atmosphere by sublimation in the course of which they cannot contribute to direct runoff or groundwater formation in the southern High Atlas Mountains.

KEYWORDS: sublimation, snow ablation modelling, energy balance model, High Atlas Mountains