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Use of stable isotopes to calculate phreatic evaporation from irrigated cotton fields

Katrin Schneider (1), Martina Starke (1), Galina Stulina (2), Lutz Breuer (1), and Hans-Georg Frede (1)

(1) Justus-Liebig-Universität Gießen, Institute of Landscape Ecology and Resources Management, Giessen, Germany (katrin.schneider@umwelt.uni-giessen.de), (2) Interstate Commission for Water Coordination, Tashkent, Uzbekistan

Water scarcity in Central Asia is increasing, and water usage for agriculture, energy production or human consumption will foster conflicts. In particular, agriculture consumes a major part of the available water resources in Central Asia. To better understand and improve water use efficiency, information on the components of the water balance and their interaction are required.
This study focuses on analyzing phreatic evaporation by means of stable isotopes in Fergana Valley (Uzbekistan) as evaporative loss from groundwater can be an important parameter in the drainage basin of this region. Unadjusted irrigation management may cause high water losses through unproductive evaporation from groundwater. Soil samples were taken from irrigated cotton fields and from non-irrigated areas. The cotton sites were sampled before the first irrigation of the vegetation period. In addition, two of the cotton sites were sampled immediately after irrigation. The sites were selected with respect to different ground water levels and land use. On all sites, soil samples were taken from surface to groundwater level at steps of 0.1 m. The isotope profiles of extracted soil water between the different sites were compared. Phreatic evaporation can be calculated by fitting an exponential function to the experimental isotope profiles. In general, enrichment of heavy isotopes close to surface is apparent in all profiles, and no major differences between the isotope profiles of irrigated and non-irrigated sites could be found. Phreatic evaporation reaches up to approx. 0.6 m per year where groundwater level is smaller than 2.0 m from surface, and approx. 0.1 m where groundwater level is greater than 2.0 m from surface. It is interesting to note that isotope profiles are not completely destroyed after irrigation, i.e. enrichment in the upper horizon is still apparent. However, irrigation causes a displacement of the isotope signature with depth, indicating that equilibrium is reached after a short time under the given climate conditions. Results indicate that phreatic evaporation may contribute considerably to overall evaporation rates. However, the study took place at the beginning of the vegetation period, and hence a possible effect of plant growth which may alter the isotope profile was not captured.