Time series trends of Landsat-based ET using automated calibration in METRIC and SEBAL: The Bekaa Valley, Lebanon

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The Bekaa Valley in Lebanon currently hosts the highest number of refugees per capita in the world. It is also the primary agricultural production area in the country. Groundwater levels in some regions of the valley have decreased by >15 m in the last five years. Water use estimates at the regional and the field scale for this valley are crucial for enhancing resilience and for managing competing sectorial water demands. In this research, we derive a novel time series of field-scale actual evapotranspiration for the Bekaa Valley using two one-source energy balance models for the period 1984–2017, utilizing local weather data and all available original Level 1 Landsat thermal imagery and Level 2 surface reflectance products. We compare a modified METRIC model with an automated hot and cold pixel identification procedure run in batch mode to pySEBAL, a new version of SEBAL, which also has its automated anchors pixel selection algorithm. Analysis of 1200 cloud-masked and gap-filled Landsat-derived ET products show that the two models give comparable water use estimates at the seasonal and annual time steps. We estimate an average annual ET of 652 ± 53 mm (or 800 mcm) over the heavily cultivated valley in the last 34 years (with high agreement between both METRIC and pySEBAL models). Most (64%) of the ET is consumed from blue water in the dry season of May–October. ET in the wet season of November–April consumes >70% of the precipitation in the Bekaa valley. Annual analysis shows no discernable trend in ET across the valley, but there is an increase in irrigated agriculture in the Orontes Basin in the last five years. METRIC yields 15% higher ET than pySEBAL for the non-agricultural lands in summer. A water balance analysis shows that groundwater storage in the Litani basin is decreasing at a rate of 330 ± 50 mm yr^{-1}. The outcome of this research also offers unique opportunities for estimating past and future trends of groundwater withdrawals. Results can provide insights into the sustainability of irrigated agriculture and the required international interventions in the water sector for enhancing the resilience of refugee and local communities.