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Estimating evapotranspiration from remote sensing: the case of Sahelian Africa

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Evapotranspiration (ET) is a key surface process in the Earth's water and energy cycles. In the cultivated Sahel, it was shown that, on average, over 80% of rainfall returns to the atmosphere by evapotranspiration from hillslope plots (Velluet et al., 2014). Despite its importance in the water balance and hence in the space-time variation of limited blue and green water resources, as well as in the atmosphere dynamics and ensuing climate, reliable mapping of actual evapotranspiration over time and space is definitely lacking in this region. Field instruments can only provide highly local, small-scale estimates. Given its spatial coverage and affordability, remote sensing in the optical domain may allow estimating ET over large areas, however suitable methods are still lacking. A new approach to this end, called "Evapotranspiration Assessment from SPAce" (EVASPA), has been recently proposed (Gallego-Elvira et al., 2013). One of its strengths is that it is designed for integrating several estimation algorithms in order to provide a range of uncertainty on estimated ET. Up to now it has been applied only to areas with more water available for evapotranspiration, such as the Mediterranean areas.

The objective of this study is to evaluate the potential of EVASPA for pluri-annual ET monitoring at a regional scale in the Sahel. Algorithms in EVASPA are based on so-called "contextual" methods. The objective of these methods is to identify a reliable relationship between surface temperature and surface albedo or a vegetation index in the area of interest. EVASPA is applied at a regional scale to South-West Niger using MODIS/TERRA and AQUA data acquired over the 2005-2008 period. ET estimates obtained with EVASPA are evaluated locally against simulations with a Soil-Vegetation-Atmosphere Transfer (SVAT) model, which has previously been validated against in-situ eddy-correlation flux measurements in a millet crop and a shrub savannah (Velluet et al., 2014). Direct application of EVASPA shows real limits, in particular with respect to poor reproduction of ET seasonality. EVASPA results were significantly improved by introducing new algorithms for determining relationships between surface temperature and albedo or vegetation indices that are more suitable for arid and semi-arid areas. The surface temperature data filtering procedure was also improved. Daily ET estimates obtained with this new version show good agreement with estimates from the SVAT model. This modification results in a significant improvement compared to the initial version: bias is reduced by $\sim$76% and RSME by $\sim$51%, while R^2 increases by $\sim$48%. Regional ET estimates provided by this modified EVASPA are also compared with six other freely available remote sensing ET products: MOD16 (Mu et al., 2011), GLEAM (Miralles et al., 2011), ALEXI (Anderson et al., 2011), WACMOS-GLEAM, WACMOS–PT and WACMOS-PM (Michel et al., 2016; Miralles et al., 2016). The modified EVASPA globally outperforms the other ET products, except for GLEAM and WACMOS-GLEAM, and offers the additional benefit of a finer spatial resolution. These results invite to evaluate the modified EVASPA in other reference sites of West Africa, and to apply it with finer spatial resolution ($\sim$100m) remote-sensing data.

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