Estimating evapotranspiration from seasonal wetlands in north-central Namibia based on satellite data fusion and VI-Ts method

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Estimation of evaportanspiration (ET) with highly spatio-temporal resolution is essential for various environmental applications such as plant dynamics monitoring, agricultural management, and assessment of human impact on local water environment. In such cases high spatial resolution (several tens to hundreds of meters) is required to describe heterogeneous land use or land cover (LULC) finely. However, existing researches for ET estimation by using land surface models or remote sensing have been mostly provided with insufficient spatial resolution (several tens to hundreds of kilometers). Thus we implemented ET estimation with highly spatio-temporal resolution based on three types of satellite images (AMSR series, MODIS, and Landsat ETM+) over a study site in north-central Namibia, where seasonal wetlands appear in rainy season.Our proposed method calculate ET from two ground source (one is surface water with vegetation, and the other is soil) separately, to appropriately describe the heterogeneous seasonal wetlands. It mainly consists of two phases: 1) satellite data fusion by using “database unmixing” (Mizuochi *et al.*, 2014) to obtain daily 30-m-resolution water maps, and 2) estimation of weekly ET with 30-m-resolution by VI-Ts method with MODIS short-wave radiation and land surface temperature (Ts) products. Although the VI-Ts method has been originally designed for a scatter plot between vegetation index (VI) and Ts to estimate air temperature and theoretical maximum soil temperature, we insteadly applied it between water index (MNDWI) and Ts. This application enabled us to evaluate ET from surface water and soil separately within sub-pixel scale (i.e. less than 30-m-resolution). Specific procedure of this phase is as follows: firstly, we calculated ET from soil based on the VI-Ts method and radiation and heat balance equation. Secondly, we calculated ET from surface water based on complementary relationship and Jarvis conductance model. Finally, we calculated total ET in each pixel as weighted-average of the soil ET and the surface water ET by water fraction (WF) of each pixel.We calculated spatio-temporal ET distribution in three test sites of north-central Namibia (each site has area of 5.3 km×5.3 km) from 2003 to 2013, and then compared it with both in-situ flux data and MODIS ET product (MOD16), which is retrieved by Penman-Monteith equation. Also, we calculated 1) available energy (Q), 2) evapotranspiration fraction (EF), 3) surface water ET contribution (WC) within total ET, and 4) WF, to investigate the features of ET in seasonal wetlands.The estimated ET is consistent with the in-situ flux data, and the variation of ET from dry- to rainy-season was described well. Comparison among Q, EF, WC and WF revealed that in seasonal wetlands most of Q was used as ET, and most ET came from surface water source. Achieved ET in high spatial resolution could well describe the heterogeneous seasonal wetlands, whose scale is several tens to several hundreds of meters and is not detectable by MOD16. However, comparing with MOD16, our proposed method tends to overestimate ET. This means the necessity of the improvement in algorithm and more careful validation.The provided method enables us to describe ET from highly heterogeneous land surface, and it is applicable to the other regional-scale research over the world. Our next work will focus on the assessment of impact of anthropogenic LULC change on ET of the seasonal wetland, by changing scenarios of parameters in VI-Ts and Jarvis conductance model.

Keywords: database unmixing, VI-Ts method, seasonal wetlands

