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Hydrological regime of Sahelian small water bodies from combined Sentinel-2 MSI and Sentinel-3 SRAL data

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Sahelian small water bodies are critical resources that people use for multiple purposes: irrigation, fishing, bathing, drinking water, livestock watering. Better understanding their hydrological regimes and quantify water inflows and outflows is necessary to achieve better management of these water bodies. Thanks to satellite technological advances allowing regular monitoring in space and time, remote sensing techniques provide a major tool to do this. In this work we develop a remote sensing based method to quantify water fluxes in Sahelian small water bodies.

Water heights from Sentinel-3 SAR Radar Altimeter (SRAL) are combined with water areas estimated through MNDWI thresholding on Sentinel-2 Multispectral Instrument (MSI) images (using Google Earth Engine) to create a height-area curve for each studied lake. Dense water height time series are then obtained by pooling water height from both altimetry and optical data. Water height variations are compared to evaporative losses, estimated by the Penman–Monteith method with data from ECMWF ERA5, to analyse water fluxes during the dry season, when precipitation is null.

This method is applied on 37 lakes in the Central Sahel (Mali, Burkina Faso and Niger), whose areas range from 0.04 km^2 to 37.91 km^2, over the five year period 2016-2020. The five-year averaged dry-season difference between water height decrease and evaporation varies from –12.45 $mm.d^{-1}$ to 9.71 $mm.d^{-1}$. Lakes display three different regimes: a net water loss (i.e. water height decrease greater than evaporation), a net water supply, and a balanced behaviour (i.e. water losses correspond to evaporation).

Water supply is mainly observed in lakes in the the Inner Niger Delta and it is likely due to connections to the Niger River hydrographic network. The main flood in the Inner Niger Delta occurs indeed after the end of the rainy season. Water loss is mainly found in the centre of Burkina Faso and correspond to water withdrawal for small-scale irrigation. Interannual variability is related to changes in rainfall, in the length of the dry season, and in anthropogenic actions. Only 6 out of 37 lakes show a change in regime from positive to negative or vice versa within the study period. One of these lakes is a reservoir whose infrastructure was damaged by attacks during conflicts which caused leaks.

The remote sensing method developed allows to better understand the regime of small Sahelian water bodies and assessing water fluxes and anthropogenic water withdrawals. Oncoming SWOT

data will allow to apply this approach to a much larger number of water bodies in this region and more generally in semi-arid areas.