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Ponds' water balance and runoff of endorheic watersheds in the Sahel

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The Sahel has been characterized by a severe rainfall deficit since the mid-twentieth century, with extreme droughts in the early seventies and again in the early eighties. These droughts have strongly impacted ecosystems, water availability, fodder resources, and populations living in these areas. However, an increase of surface runoff has been observed during the same period, such as higher "summer discharge" of Sahelian's rivers generating local floods, and a general increase in pond's surface in pastoral areas of central and northern Sahel. This behavior, less rain but more surface runoff is generally referred to as the "Sahelian paradox".

Various hypotheses have been put forward to explain this paradoxical situation. The leading role of increase in cropped areas, often cited for cultivated Sahel, does not hold for pastoral areas in central and northern Sahel. Processes such as degradation of vegetation subsequent to the most severe drought events, soils erosion and runoff concentration on shallow soils, which generate most of the water ending up in ponds, seem to play an important role. This still needs to be fully understood and quantified.

Our study focuses on a model-based approach to better understand the hydrological changes that affected the Agoufou watershed (Gourma, Mali), typical of the central, non-cultivated Sahel.
Like most of the Sahelian basins, the Agoufou watershed is ungauged. Therefore we used indirect data to provide the information required to validate a rainfall-runoff model approach.

The pond volume was calculated by combining in-situ water level measurements with pond's surface estimations derived by remote sensing. Using the pond's water balance equation, the variations of pond volume combined to estimates of open water bodies' evaporation and infiltration determined an estimation for the runoff supplying the pond. This estimation highlights a spectacular runoff increase over the last sixty years on the Agoufou watershed.

The runoff proxy derived for the Agoufou pond is used to evaluate results from the KINEROS2 model (KINematic runoff and EROSion). This model is specifically designed to simulate surface runoff in semi-arid watersheds. It describes the processes of runoff, infiltration and erosion by taking into account land cover and soil characteristics.
We show that rain intensity, soil hydrological properties (hydraulic conductivity and Manning's roughness coefficient), contributing source area areas and land use-land cover were the major factors to take into account to correctly simulate runoff over the present period (2006-2010). This will help to simulate the past evolution of the Agoufou watershed and better understand the key mechanisms of the Sahelian paradox in non-cultivated Sahel.

Finally, we will discuss the application of the SWOT and Sentinel-2 future satellites, which will provide water level and pond's surface, to obtain large-scale estimates of water balance in ungauged Sahelian basins.