Hydrological dynamics in the Lower Ouémé watershed (Benin, West Africa) from in-situ and satellite data

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Located in Southern Benin, West Africa, the Lower Ouémé watershed is a vast floodplain comprising two major rivers, the Sô and Ouémé, and the Nokoué lagoon, which connects to the Atlantic Ocean via the Cotonou Channel. This region is both a socio-economic hub and highly vulnerable to flooding driven by the West African monsoon between September and October. Using Sentinel-1A SAR data, we identified flood-prone areas along the Sô river and estimated flooded surfaces from 2015 to 2023. Our analysis reveals that the flood extent fluctuates widely, ranging from 20 km² during the dry season to a peak of 160 km² during extreme events. September is identified as the peak flooding month, with an average inundated area of 55 km², though temporary flooding can exceed 120 km². By integrating CHIRPS satellite cumulative rainfall data from January to September with flood detection records, we identified a critical cumulative rainfall threshold of 1070 mm, beyond which flooding expands rapidly. Additionally, altimetric data (Sentinel-3 & 6) highlights the hydrological connectivity between rivers, wetlands, and the floodplain. An upward trend of 6 km²/year in flood extent over the study period underscores increasing flood risks in the region.

In-situ measurements, including water level (pressure sensors) and discharge (ADCP), further reveal the complexity of the hydrological regime within the river bed. During dry season, when river discharge is weak, tidal signal penetrates from the ocean and propagates into the rivers through the lagoon, influencing river flux (up to 80 m³/s variation at the southernmost station). During wet season, heavy rainfall dominates, establishing a marked discharge seasonality (increases of more than 1000 m³/s in the rainiest years) and dampening tidal effects. If the Sô and Ouémé rivers function as independent watersheds in the dry season, during the wet season, rising water levels generate overflows with the Ouémé river feeding the Sô river via four identified channels. Indeed, above a 450 m³/s threshold in the Ouémé, water flows from the Ouémé to the Sô, reversing their contributions to the lagoon. This pattern is confirmed by satellite flood detection.

Additionally, overflowing water feeds wetlands, which subsequently recharge the lagoon through runoff, though significant water loss occurs due to hydroclimatic factors. This study highlights the interplay between tidal, fluvial, and pluvial processes in shaping flood dynamics, underscoring the value of remote sensing for flood monitoring.

Keywords: floodplain, hydrology, remote sensing, in-situ, West Africa