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Monitoring suspended sediments and turbidity in Sahelian basins

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Suspended matter can carry viruses and bacteria that are pathogenic to humans and can foster their development. Therefore, turbidity can be considered a vector of microbiological contaminants, which cause diarrheal diseases, and it can be used as a proxy for fecal bacteria. Few studies have focused on water turbidity in rural Africa, where many cases of intestinal parasitic infections are due to the consumption of unsafe water from ponds, reservoirs, lakes and rivers. Diarrheal diseases are indeed the second cause of infant mortality in sub-Saharan Africa. Furthermore, in this region, environment survey is minimal or inexistent. Monitoring water turbidity therefore represents a challenge for health improvement.

Turbidity refers to the optical properties of water and it is well suited to monitoring by remote sensing. Because it varies in space and time and because the small water bodies ($< 250m^2$) are critical for Sahelian societies, monitoring turbidity requires the use of high temporal and spatial resolution sensors like Landsat 7 and 8, Sentinel-2 as well SPOT5-TAKE5 data.

Compared to many other regions of the world, the particularly high turbidity values found in tropical Africa challenges the use of remote sensing and questions the methods developed for less turbid waters. In addition, high aerosol loadings (mineral dust and biomass burning) may be detrimental to turbidity retrieval in this region because of inaccurate atmospheric corrections.

We propose a method to monitor water quality of Sahelian ponds, lakes and rivers using in-situ and remote sensing data, which is tested at different sites for which in-situ water turbidity and suspended sediments concentration (SSSC) measurements are acquired. Water sample are routinely collected at two sites within the AMMA-CATCH observatory part of the Réseau de Bassin Versants (RBV) French network: the Agoufou pond in northern Mali (starting September 2014), and the Niger River at Niamey in Niger (starting June 2015).

These data are used to evaluate different indexes to derive water turbidity from the reflectance in the visible and infrared bands of high resolution optical sensors (LANDSAT, SENTINEL2). The temporal evolution of the turbidity of ponds, lakes and rivers is well captured at the seasonal and interannual scales with the NIR reflectance.

The Agoufou pond displays a strong seasonal evolutions, and also the highest values of turbidity and SSSC (as high as 4200 mg/l).Turbidity increases from the first rains in June with a maximum observed in July and August and then declines from October onwards. The 2015 and 2016 dry seasons however differ markedly, with a secondary maximum of SSSC in February occurring in 2016, possibly caused by wind-driven sediments remobilization or cattle trampling.

The Niger River in Niamey displays a rapid increase in turbidity between mid-June and late August associated to the ‘red’ flood, with a maximum in late July-early August and then a sharp decline associated with the black flood. Overall, the high turbidity observed at these sites indicates clear risks for human health.

The methods developed here for the AMMA-CATCH, RBV sites will be applied to all inland waters in West Africa.