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Monitoring the spatial and temporal dynamics of annual floods in the Niger Inner Delta using MODIS satellite imagery

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The Niger Inner Delta is a vast three million hectare wetland in Mali, whose annual flood supports the livelihoods of over one million herders, fishermen and farmers. Large projects on the Niger River upstream may however alter the extent and dynamics of the flood in the future. Due to the scale (about 50 000 km^2) and the very flat topography of this hydrological system, there is very scarce ground data to characterise the flood and its spatial and temporal dynamics remain poorly understood. Since the flood is mainly caused by precipitation in the upper catchment, the flood peak in the delta occurs a few weeks after the rainy season, when cloud cover does not limit the use of optical remote sensing data.

An original automated method was developed to study the progress of the flooding using normalised band ratio indices on 8-day MODIS (Moderate Resolution Imaging Spectroradiometer) 500m-satellite images. The Modified Normalised Difference Water Index (MNDWI) was shown to be the most suitable for detecting flooded areas out of six commonly used band ratio indices. Its combination with the Normalised Difference Moisture Index (NDMI) aids the distinction between flooded and humid vegetation, especially in the drier months when the flood recedes. Three 30m Landsat images covering different phases of the flood, on which K-means clustering and analysis of spectral profiles enabled the identification of flooded pixels, were used to calibrate the threshold values of both indices. A programme using a specific composite MNDWI-NDMI index, with constant thresholds and a topographically relevant grid of the river and its floodplain was developed in ENVI IDL© to automatically provide the percentage of flooded pixels per grid cell for each image. The method was validated by computing correlations between water depth measurements from gauging stations in the delta and the flooded surface area for the corresponding grid cell calculated from the MODIS images. Estimates of the total surface area flooded are also coherent with previous values found in the literature. MODIS images provide adequate spatial resolution and sufficient temporal resolution to monitor the flood from September through to February. The beginning of the flood in August could not be monitored, due to the presence of clouds.

This method was developed on images from the period 2001-2010. It provides a dynamic assessment of the total area flooded, as well as information on the timing and duration of the flood per area. This knowledge may assist farmers and stakeholders in planning their agricultural activities, notably flood recession cropping. Its results may also be used to develop and calibrate a hydraulic model of the flooding of the Inner Delta, as well as a finer estimate of the water balance of the area, notably evapotranspiration values and contributions to downstream flows. Residual uncertainties, due to difficulties in distinguishing between flooded and humid vegetation especially as the flood recedes, could be reduced with additional ground truth data.