

Indirect Assessment of Sedimentation in Hydropower Dams Using MODIS Remote Sensing Images

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Abstract: In this study, we used Moderate Resolution Imaging Spectroradiometer (MODIS) satellite images to quantify the sedimentation processes in a cascade of six hydropower dams along a 700-km transect in the Paranapanema River in Brazil. Turbidity field measurement acquired over 10 years were used to calibrate a turbidity retrieval algorithm based on MODIS surface reflectance products. An independent field dataset was used to validate the remote sensing estimates showing fine accuracy (RMSE of 9.5 NTU, $r = 0.75$, $N = 138$). By processing 13 years of MODIS images since 2000, we showed that satellite data can provide robust turbidity monitoring over the entire transect and can identify extreme sediment discharge events occurring on daily to annual scales. We retrieved the decrease in the water turbidity as a function of distance within each reservoir that is related to sedimentation processes. The remote sensing-retrieved turbidity decrease within the reservoirs ranged from 2 to 62% making possible to infer the reservoir type and operation (storage versus run-of-river reservoirs). The reduction in turbidity assessed from space presented a good relationship with conventional sediment trapping efficiency calculations, demonstrating the potential use of this technology for monitoring the intensity of sedimentation processes within reservoirs and at large scale.

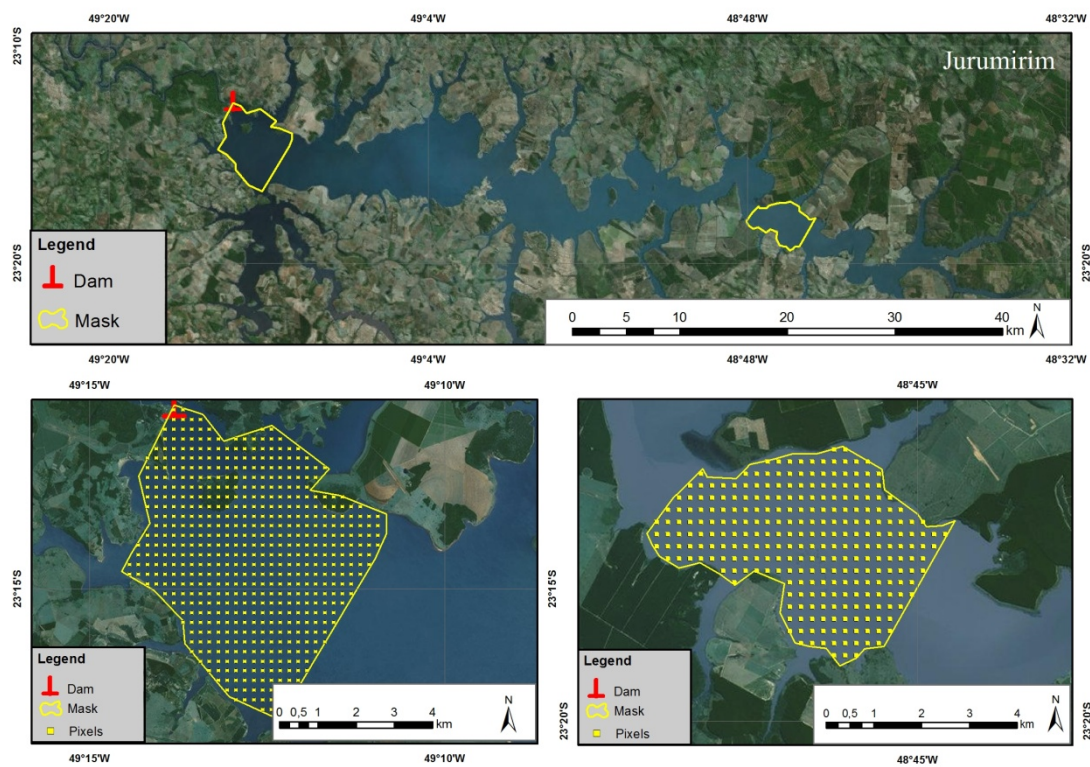


Figure S1. Above: MODIS virtual station locations showing the two masks representing the most upstream and downstream areas considered for the Jurumirim reservoir. The distance between two virtual stations is of 50 km. Below: location of the MODIS 250-m pixel centers (yellow points) within each mask. MOD3R retrieval procedure used in this study eliminates automatically mixed pixels based on their spectra values at red and near-infrared channels.

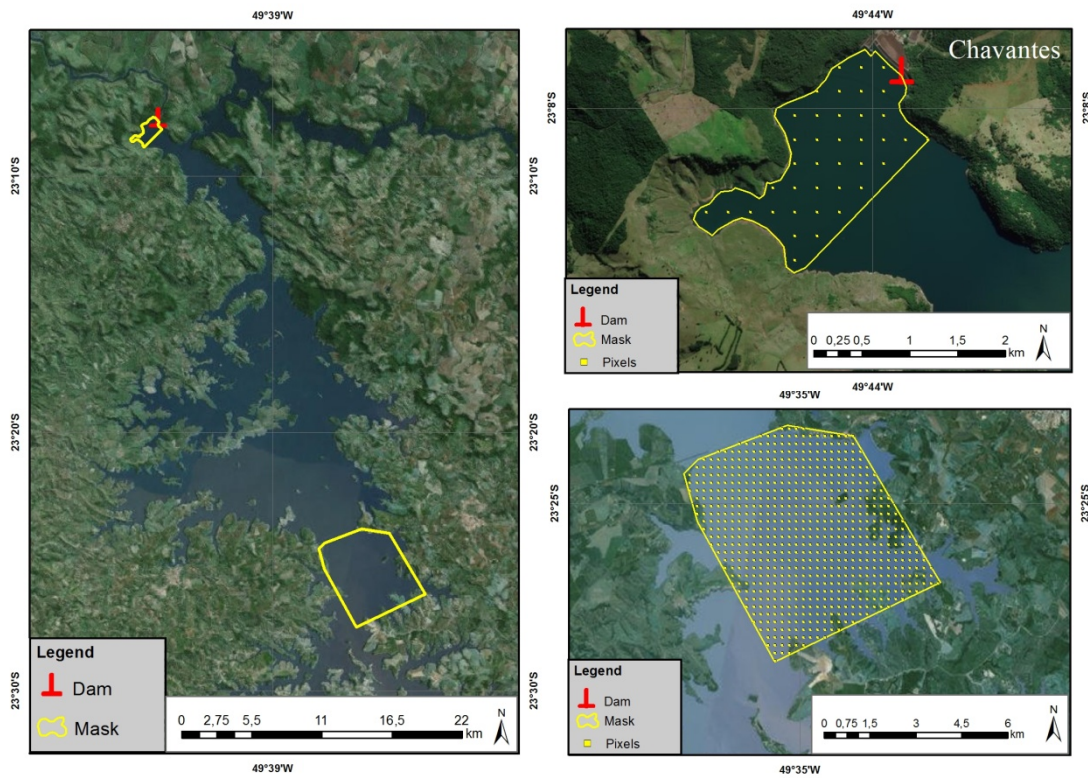


Figure S2. Above: MODIS virtual station locations showing the two masks representing the most upstream and downstream areas considered for the Chavantes reservoir. The distance between two virtual stations is of 33 km. Below: location of the MODIS 250-m pixel centers (yellow points) within each mask. MOD3R retrieval procedure used in this study eliminates automatically mixed pixels based on their spectra values at red and near-infrared channel.

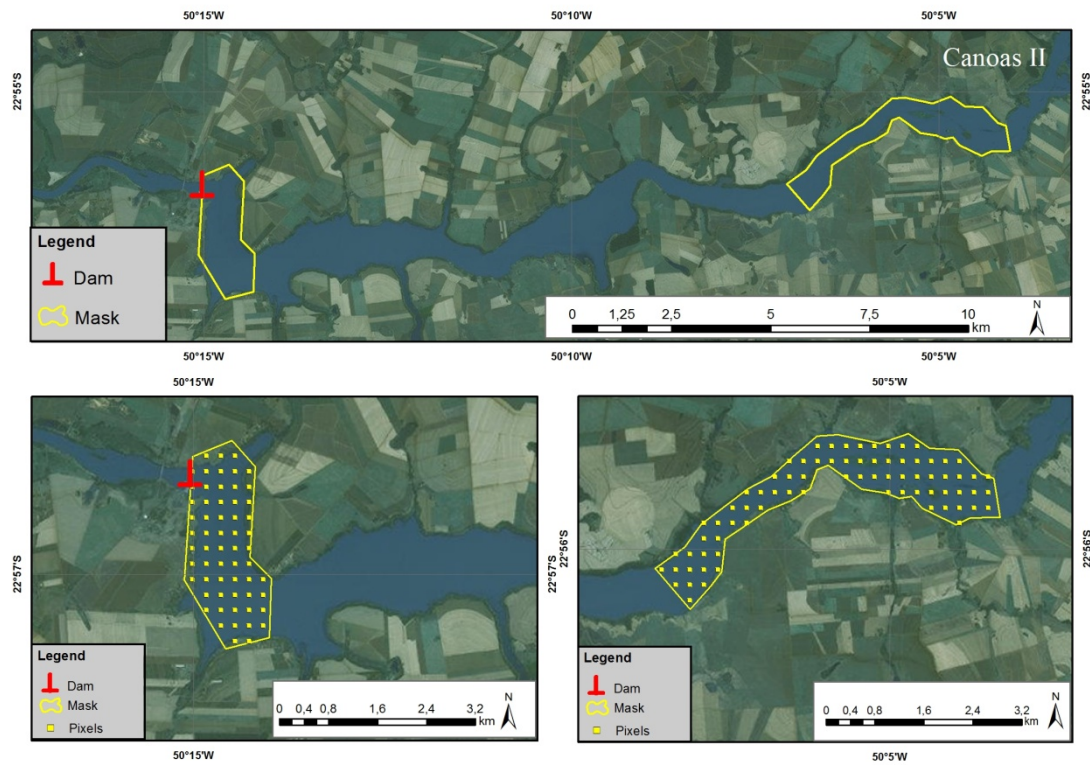


Figure S3. Above: MODIS virtual station locations showing the two masks representing the most upstream and downstream areas considered for the Canoas II reservoir. The distance between two virtual stations is of 13 km. Below: location of the MODIS 250-m pixel centers (yellow points) within each mask. MOD3R retrieval procedure used in this study eliminates automatically mixed pixels based on their spectra values at red and near-infrared channels.

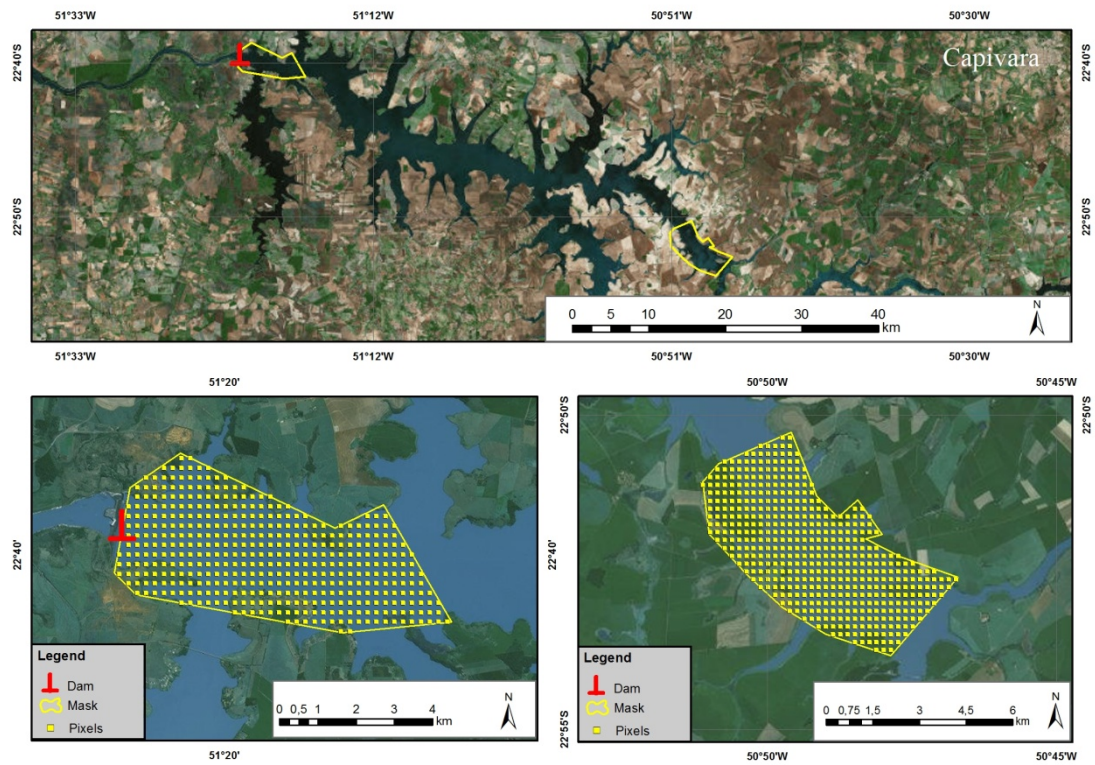


Figure S4. Above: MODIS virtual station locations showing the two masks representing the most upstream and downstream areas considered for the Capivara reservoir. The distance between two virtual stations is of 50 km. Below: location of the MODIS 250-m pixel centers (yellow points) within each mask. MOD3R retrieval procedure used in this study eliminates automatically mixed pixels based on their spectra values at red and near-infrared channels.

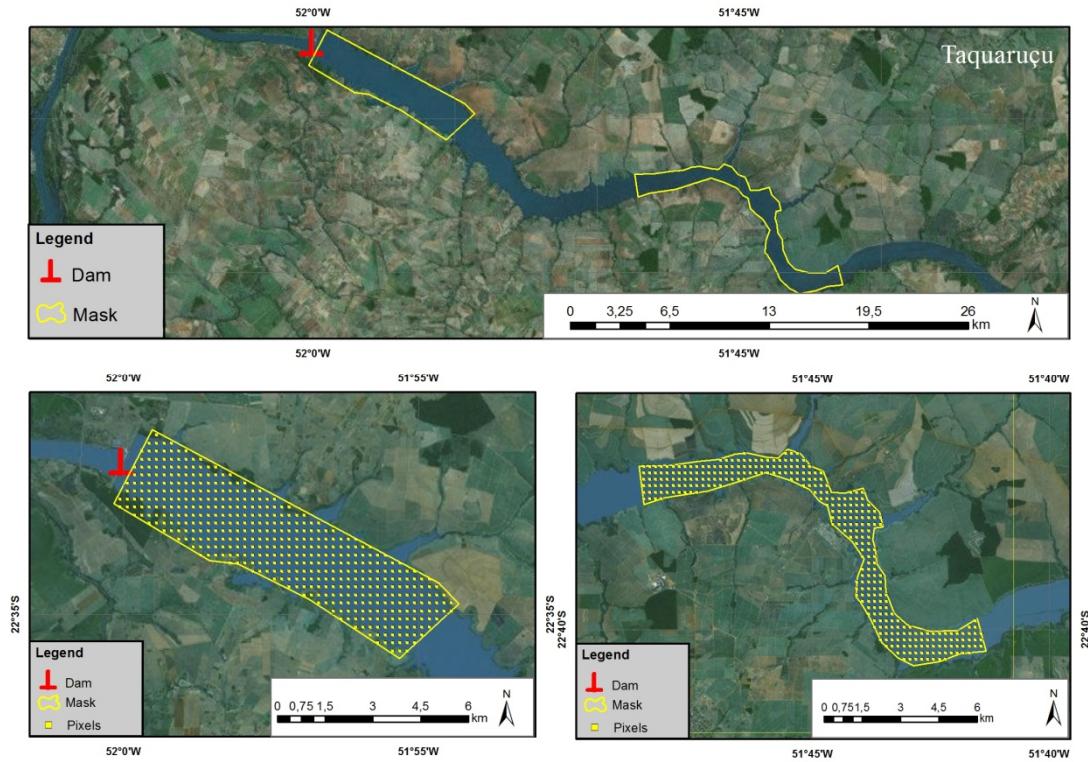


Figure S5. Above: MODIS virtual station locations showing the two masks representing the most upstream and downstream areas considered for the Taquaruçu reservoir. The distance between two virtual stations is of 12 km. Below: location of the MODIS 250-m pixel centers (yellow points) within each mask. MOD3R retrieval procedure used in this study eliminates automatically mixed pixels based on their spectra values at red and near-infrared channels.

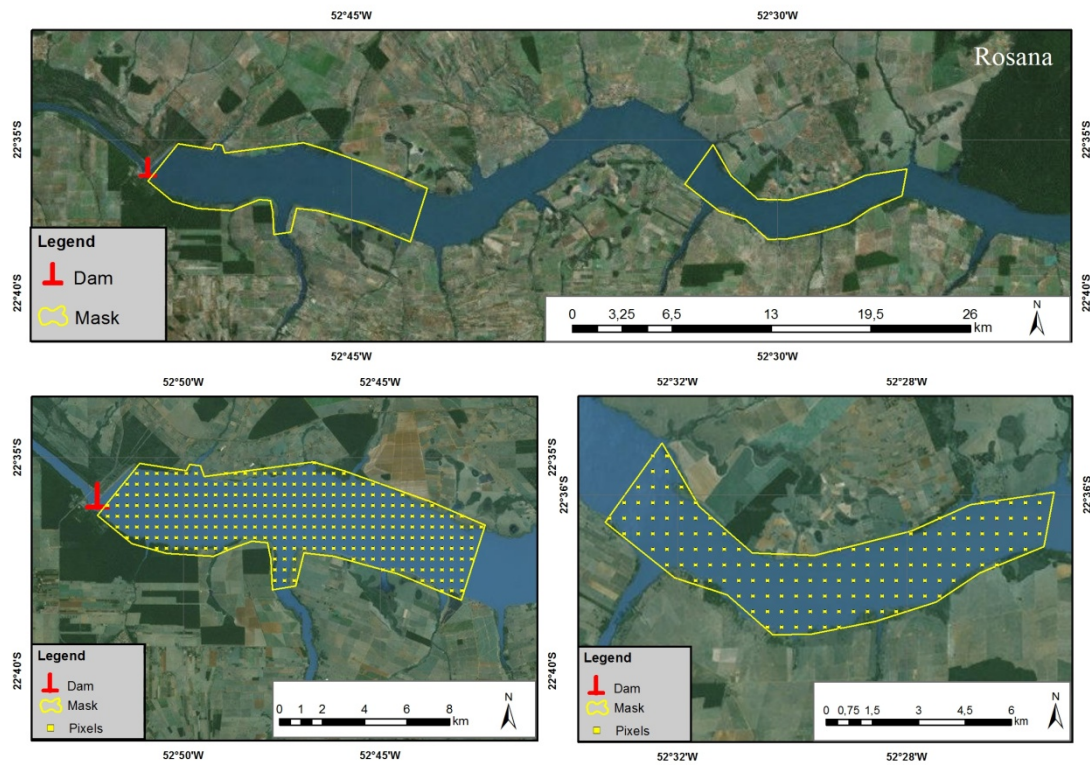


Figure S6. Above: MODIS virtual station locations showing the two masks representing the most upstream and downstream areas considered for the Rosana reservoir. The distance between two virtual stations is of 20 km. Below: location of the MODIS 250-m pixel centers (yellow points) within each mask. MOD3R retrieval procedure used in this study eliminates automatically mixed pixels based on their spectra values at red and near-infrared channels.

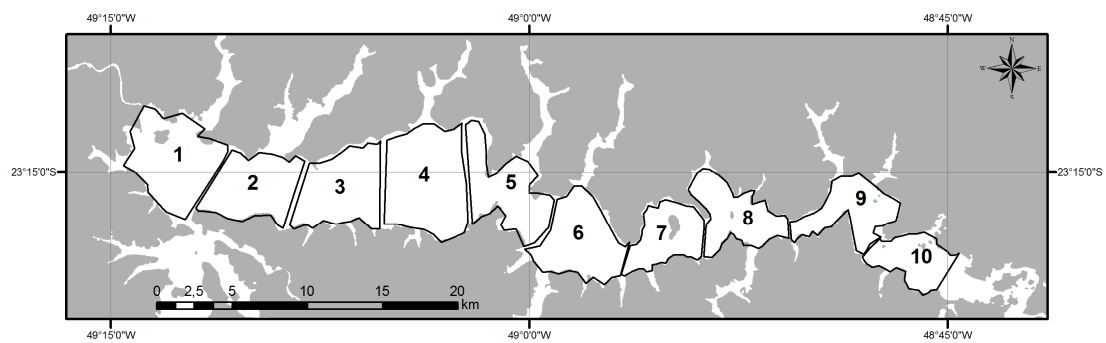


Figure S7. Virtual stations created along reservoir I (Jurumirim Reservoir), which were used to process the MODIS 8-day composite image time serie.

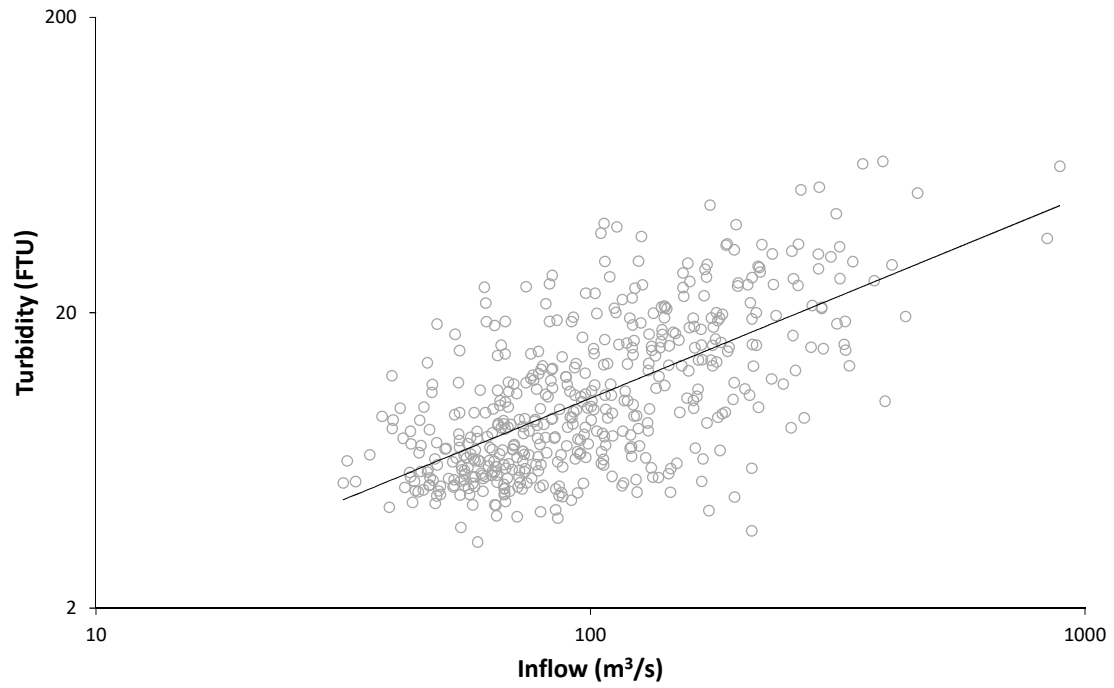


Figure S8. Variations in the river discharge and remote sensing-retrieved turbidity in the tail zone of reservoir #1 from 2000 to 2011.

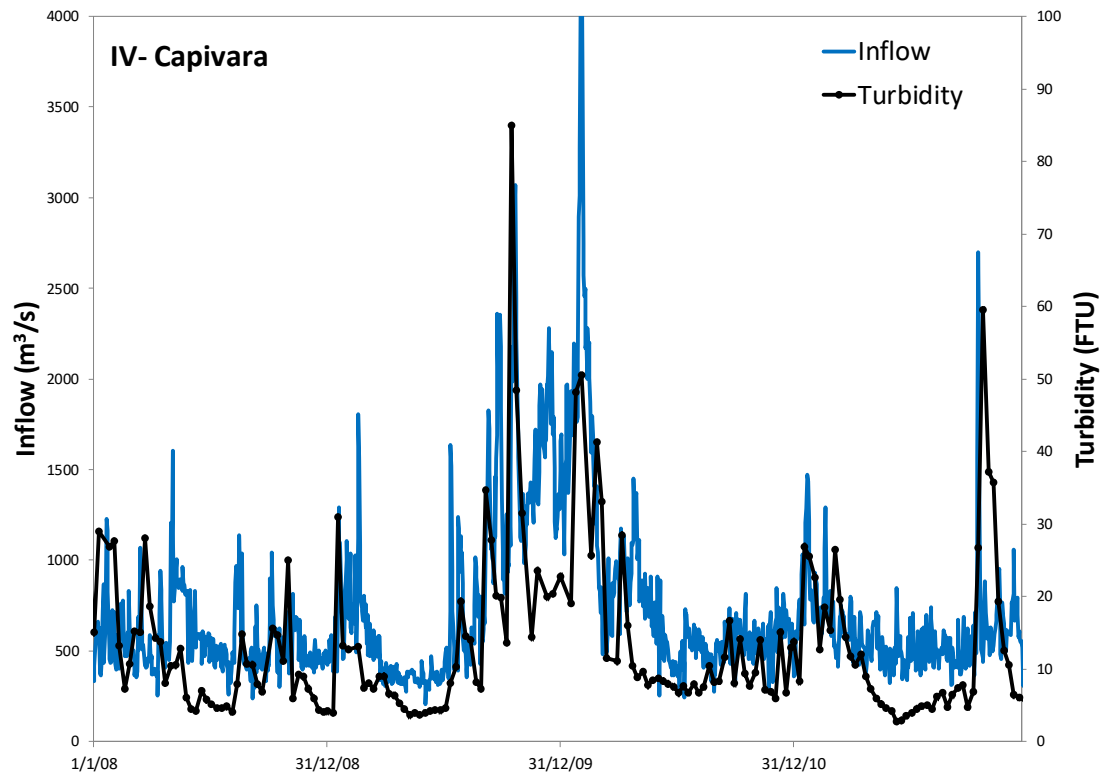


Figure S9. Variation in the river inflow and satellite-derived turbidity for the Capivara Reserv

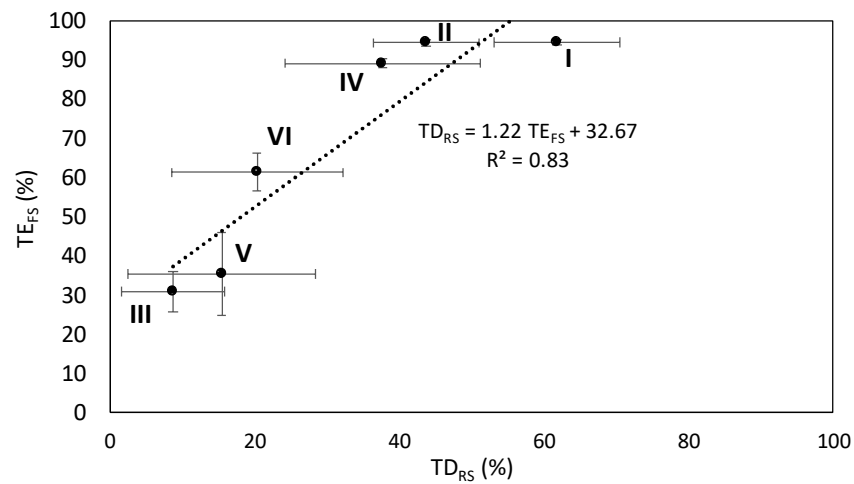


Figure S10. Comparison between the sediment trapping efficiency TE_{FS} assessed using equation (1) and the remote sensing-retrieved turbidity decrease TD_{RS} , calculated using Equation (2), for the 6 reservoirs studied and for the period of observation. The error bars stand for the standard deviation of all years from 2001 to 2012.