LONG TIME SERIES OF LANDSAT IMAGES TO RECONSTRUCT RIVER SURFACE TEMPERATURE AND TURBIDITY REGIMES OF GUADALQUIVIR ESTUARY

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ABSTRACT

Guadalquivir is one of the longest rivers in the Iberian Peninsula and so, it provides all the services needed by the whole Andalusian region (Southern Spain). More than 2000 yrs of use has attributed to the river a major cultural and socioeconomic role. In the last century, the river has undergone the most dramatic transformations and consequently its ecological and hydrological functioning has been seriously affected. Extensive cut-offs, dredging and channeling largely modified the final stretch of the river [1]. Nowadays, fisheries, rice paddles, waterway traffic, irrigated crops, fish farms, among the most demanding uses are the main pressures over the Guadalquivir Estuary. Such disturbances come from the continuous demand of fresh water to retain tidal influence through regulatory dams and periodical labor to keep ship canal depth. Recently, a deeper dredge has been proposed to increase ship size and number entering the Seville harbor.

Under this framework, a consortium of scientific institutions has started an integrative research project to understand the hydrological and ecological status of the Guadalquivir Estuary and evaluate the effects of the various pressures on its natural functioning and services. The Remote Sensing and GIS laboratory of Doñana Biological Station participates in the project with the aim to reconstruct the last 35 years regime of turbidity and river surface temperature (RST), both parameters revealing the estuarine response to natural and human-driven dynamics. Based on a long time series of Landsat images (TM and ETM+), we have developed accurate methods to systematically map RST and turbidity gradients across the last 100 km stretch of the River, i.e. the Estuary.

In this paper we present the results of applying an empirical model for river turbidity mapping and a physical model to map RST by the use of the optical and thermal bands of TM and ETM + sensors aboard of Landsat satellites. Both models were validated with ground-truth data and are used to reconstruct the recent historical dynamics of the Guadalquivir Estuary.

Both models are implemented over a time series of more than 300 Landsat scenes (path 202, row 34) geometrical and radiommetricaly corrected. The time series processing consist of co-registration of every scene to a single geometrically corrected ETM+ panchromatic scene (RMS < 15m) and radiommetric correction with the use of a

Lambertian simple dark object model [2]. Finally, radiommetric normalization was carried out by defining pseudo-invariant areas [3][4].

For turbidity mapping we apply a Generalized Additive Model to extract the best predictor of measured Nephelometric Turbidity Units (NTU) and Suspended Sediments Concentration (SSC). Thus, band 3 (0.63 - 0.69 µm) was identified as the most contributive band explaining 75% of deviance in comparison to NTU and SSC *in situ* measurements [5]. Figure 1 shows the turbidity map at the mouth of Guadalquivir River estimated for the 21st Jannuary 2004 and the spatial profile of NTU values along the estuary.

To estimate RST we apply Cristobal et al. (2005) model using thermal band 6 (10.40 - 12.50 µm) of Landsat TM and ETM+ together with MODIS water vapor product (MOD05), a constant emissivity value for water, and air temperature at the time of Landsat scene acquisition. The first step converts digital numbers of band 6 to radiances using the calibration coefficients of TM and ETM+. The calculation uses the radiative transfer model to estimate RST.

A network of probes and gauges were installed in 2008 along the estuary to record river flow measurements, together with temperature, salinity, and turbidity. This valuable information was used to validate the RST mapping for every single scene. RMS was therefore estimated around 1.5 ºC.

Once produced, turbidity and RST maps were analyzed to identify episodic events affecting estuarine dynamics as well as to detect trends through Man-Kendall time series test in order to evaluate the effects of human pressures on the natural dynamics of the river.

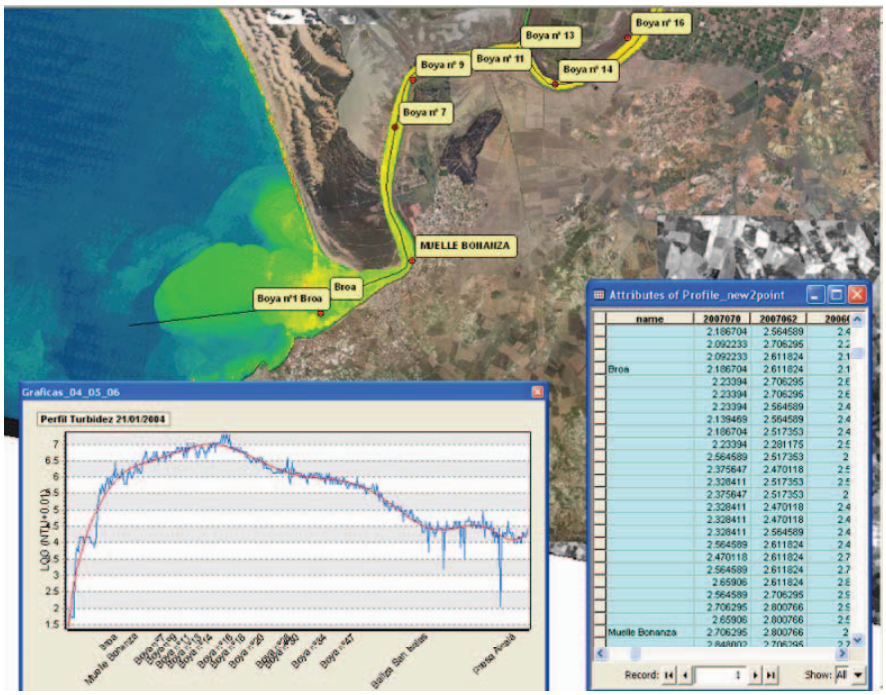

Figure 1. Turbidity map of 21st Jannuary 2004 at the mouth of the Guadalquivir River and spatial profile showing the turbidity gradient.

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