

## DYNAMICS OF SS IN THE GUADALQUIVIR ESTUARY: MONITORING NETWORK AND DATABASE MANAGEMENT

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**Abstract.** *The description of the climatic agents that control and define the Guadalquivir River estuary dynamics is made from a dataset made up of experimental measurements from the study site together with external sources. The complete database comprises wave, wind, atmospheric pressure, meteorological and astronomic tide, water inflow, turbidity, salinity, and other relevant parameters in water quality. Such information has been derived from data monitoring in (1) maritime stations in front of the river mouth at different water depth, (2) fluvial stations along the main channel of the river and different tributaries to the estuary, and finally (3) different stations located along the contributing area to the estuary. Data sources are varied (ICMAN, Puertos del Estado, Junta de Andalucía, etc.) and at least monthly updating is made, with many variables weekly updated to monitor sudden increases in suspended sediment concentrations. The final result is a continuous quasi-real time monitoring of forcing agents in the estuary together with the state variables relevant for different processes. Global management of the database is made through PROGE, a Matlab program with a visual interface, where the information from each monitoring point is gathered in a structure, providing not only a quick and easy access and visualization of the data, but also a precise and complete information of the monitoring process, and post-processing analysis.*

### 1 INTRODUCTION

Estuaries form and area is constantly altered by the erosion and deposition of sediment along their extent, and strongly affected by the variations in the sea level at different time scales. Their wide range of forms is the result of the complex interaction between riverine and marine processes. Estuaries are continually evolving, changing their shape, adapting to changes in river flow and weather pattern, changing the phase and amplitude of the input signals, with effects on salinity, temperature, suspended sediments (SS) and nutrients distribution in water in time and space<sup>[1]</sup>. In estuaries, sediment dynamics is a complex process where tidal cycles, density currents, freshwater inflows and mixing atmospheric agents, among others, interact determining deposition and erosion patterns and suspended sediment concentration distribution and evolution. Suspended sediments in seawater tend to flocculate, diverting from their behaviour in the fluvial reaches upstream.

Suspended sediment concentration in water may greatly influence other state variables such as dissolved oxygen, turbidity, temperature, density... and thus poses a big threat for the ecological state of waters. Most of the estuaries along the developed countries coastline are strongly modified by dam regulation upstream and socioeconomical uses of the estuary area, such as agriculture and aquaculture, and tourism. An integrated management not only of water resource but also of soil use in their contributing area is a necessary approach to restore and preserve the diversity of life and nutrient fluxes in our estuaries. The Guadalquivir River Estuary in Southern Spain is a good example of such demanding situation, with a great reduction of freshwater input due to the great regulation system upstream along the river, periodic dredge labors to maintain navigation upstream to Seville Port, and aquaculture systems and big rice crop areas downstream which require low suspended sediment concentration and moderate levels of salinity in water, respectively.

But to model rigorously SS dynamics in such an estuary requires to couple riverine and marine hydrodynamics together with a proper biogeochemical analysis to evaluate its current state and trend, and to simulate future states under different management strategies and/or subject to sea level rise and climate variability trends. A big amount of data from the system must be processed to include all relevant processes in the analysis and to feed and calibrate the final models<sup>[2]</sup>.

This work presents a data management tool, PROGES, under Matlab programming language, developed for the monitoring system of the Guadalquivir Estuary in the framework of the Project *Method Proposal for the Diagnosis and Prognosis of Human Actions Consequences on the Guadalquivir Estuary*, financed by the Port Authority of Seville and coordinated by the ICMAN, Institute of Marine Science of Andalusia (Cádiz).

## 2 STUDY SITE AND MONITORING SYSTEM DESCRIPTION

The Guadalquivir River estuary receives inflows from a 57400 km<sup>2</sup> basin which spreads along Cádiz, Huelva, Sevilla, Córdoba and Jaén. The low reach of the river travels across a wide alluvial plain, from Palma del Río (Córdoba) to the mouth; freshwater discharges to the estuary mainly come from the Alcalá del Río dam, upstream Sevilla, which can be thus considered as the estuary head, and tidal influence is significant up to 15 km upstream Sevilla. Downstream, Doñana National Park constitutes one of the greatest coastal wetland in Europe. Figure 1 shows the Guadalquivir Estuary location together with its contributing basin.

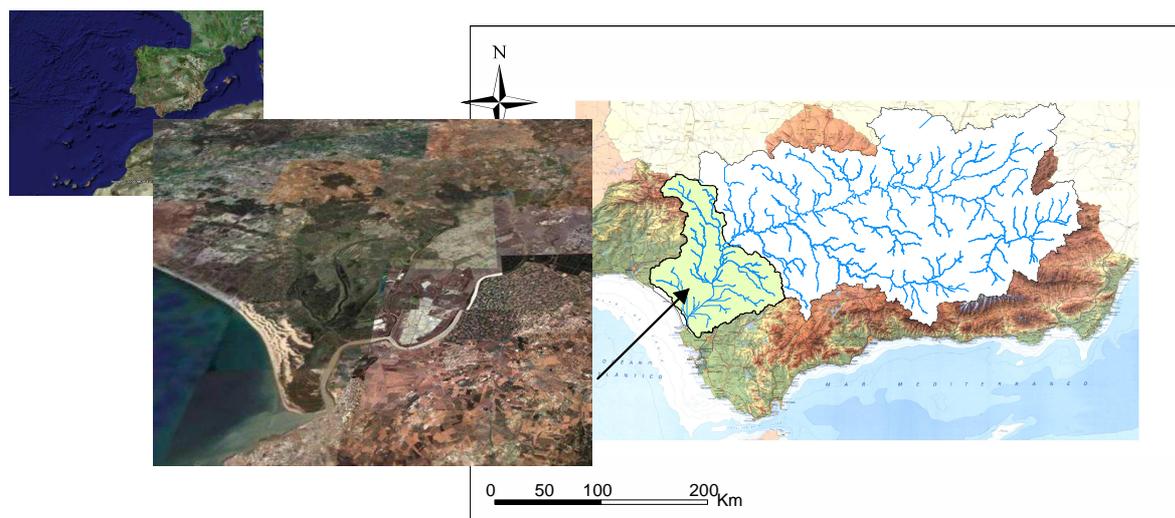


Figure 1. The Guadalquivir estuary location and contributing basin.

The monitoring network and data necessary for the estuary analysis and modeling comprises several sources and databases<sup>[3] [4]</sup>:

- Meteorological data from the automatic station network of the Junta de Andalucía.
- Tidal gauges network from different sources.
- WANA data in the outer platform, from the AEMET
- Water quality data from the Water Policy periodic campaigns along the estuary
- Water quality data from the Guadalquivir Water Administration (ICA network)
- Water discharges from the Alcalá del Río dam, and other contributing rivers to the estuary
- CTD monitoring network along the main channel in the estuary, implemented by the ICMAN, with continuous register of temperature, salinity, turbidity, velocity, among other variables, including also meteorological variables at the monitoring point.
- AWAC and ACDP monitoring points in the outer platform implemented by the Dynamic of Environmental Fluxes Group.
- Specific field campaigns during the Project.

Due to the characteristics of every dataset: frequency, time series extent, datasource, format, a huge amount of work deals with data validation, filtering, preprocessing, and format conversion. After one year of data collecting and analysis, the need for a management tool was patent, together with the need of up-to-date continuous actualization of the whole database from every responsible team in the research group, to trace sudden episodes of suspended sediment increases that periodically create alarm among the estuary economic users, such as rice farmers and aquaculture enterprises.

## 3 PROGE, THE DATA MANAGEMENT TOOL FOR THE GUADALQUIVIR ESTUARY

A Matlab program for data analysis and visualization was developed on the basis of the structured complete database created in the Project. The database is weekly updated, which involves a first screening of each new data set, filtering and filling of time series, and sometimes, changes in format for analysis requirements. In PROGE, each dataset is filed as a structure, which contains numeric and text information comprising information about the location and identification

of the data source point, information about the instrumentation involved in the register, information about the original data and the preprocessing analysis, and the time series. PROGE is currently run under a Spanish version.

The main core of PROGE allows a simultaneous visualization of several variables data from different periods or some analysis made from a given data set. The program includes an interface for users, which guides in an easy manner through the selection process and later analysis. The following figures show some examples of PROGE displays.

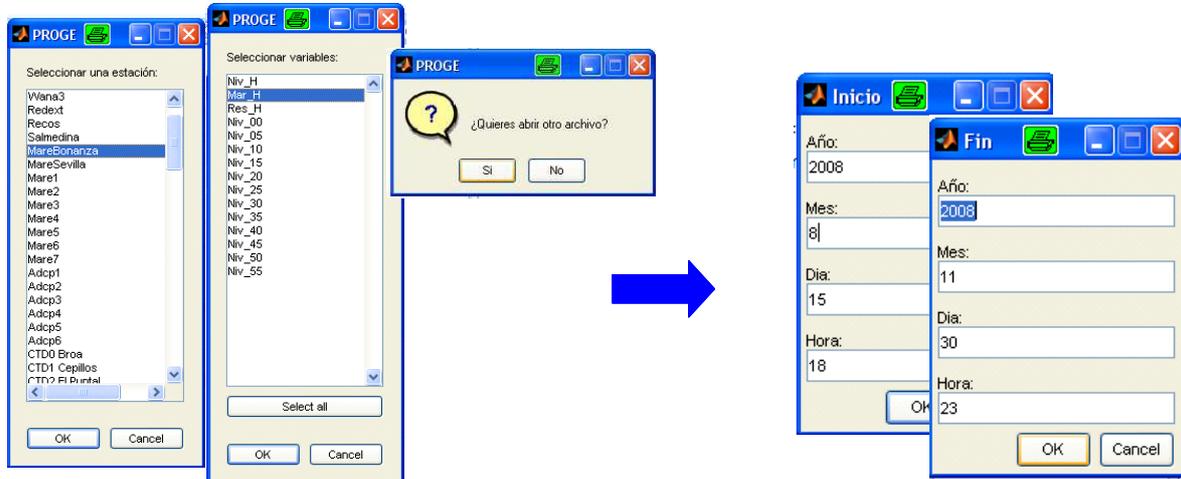


Figure 1. PROGE displays for data source and variable selection and period of visualization.

The final figures provided by PROGE can be filed in different format in order to be later imported by document processing additional tools.

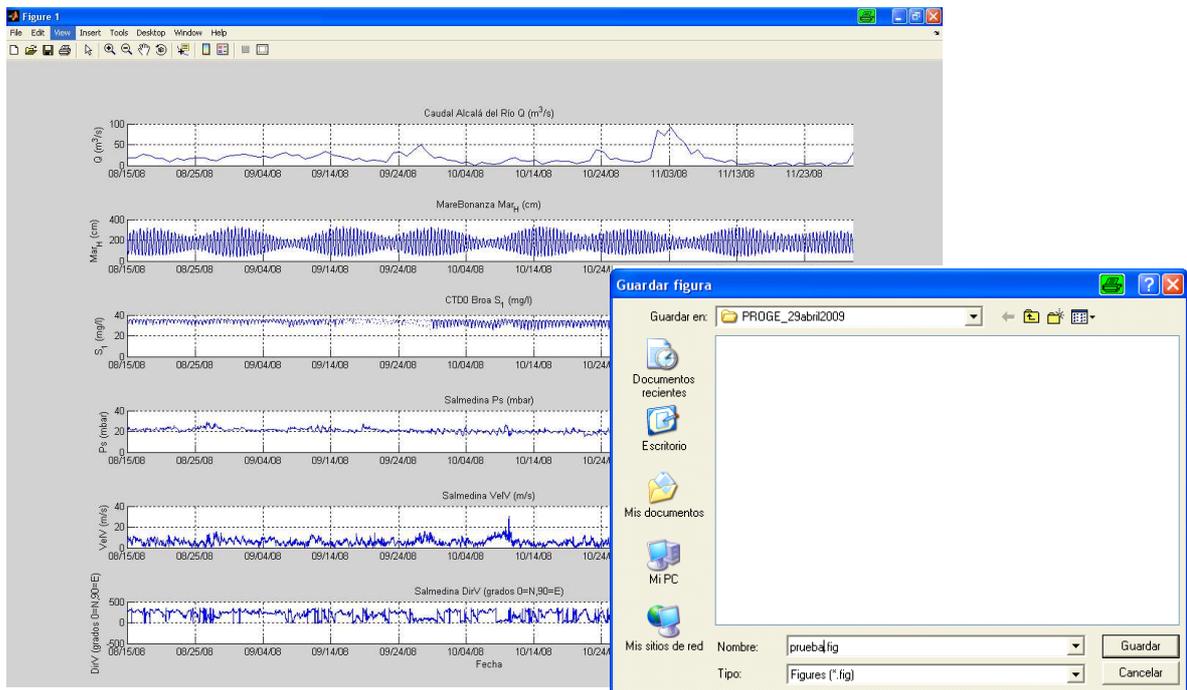


Figure 2. An example of PROGE figures and Save menu.

Usual analysis made up from certain groups of datasets are being included in PROGE utilities, such as the identification of extreme values periods for different event definition. Figure 3 shows an example, consisting of extreme values analysis of wave data (significant wave height, peak values period and average direction), together with the extreme events identification and visualization from the previous analysis.

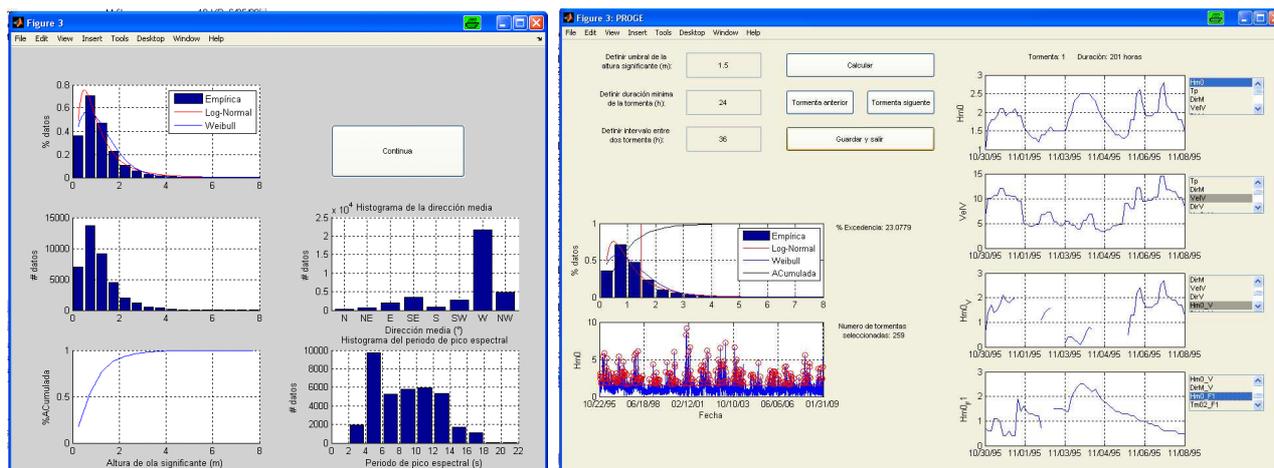


Figure 3. Wave data extreme values analysis and extreme event identification in PROGE.

#### 4 CONCLUSIONS

The complex and multiscale processes that interact in an estuary requires integrated monitoring of a wide variety of environmental variables from different sources. The Guadalquivir River estuary is currently being modeled and the huge amount of datasets arising from the Project work together with external sources has been efficiently structured in a database and the management data tool, PROGE, developed on Matlab, provides the whole research group with a validated data information and a strong, easy-to-handle, tool to visualize and further process such data. The database and management tool will be accessible from internet sources with different access users in the future, for further studies on the area, under the maintenance of the research group.

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