ID48- TIDAL PROPAGATION AND FREQUENCY RESPONSES IN THE GUADALQUIVIR ESTUARY

IRENE NADAL ARIZO[1], JESÚS GARCÍA LAFUENTE[1], SIMONE SAMMARTINO[1], JAVIER DELGADO CABELLO[1] AND PABLO MUÑOZ LÓPEZ[1]

1 Physical Oceanography Group, University of Malaga.

Abstract
The Guadalquivir River is dominated by the tidal flows coming from the Gulf of Cadiz, being the semidiurnal oscillation the most relevant in the area. Tidal constituents in the estuary are especially sensitive to variations in frequency due to tidal friction and resonance balance, and fluctuate with other harmonic components. In this study both sensitive analyses have been covered, providing an assessment of the frictional interactions between tidal constituents.

Keywords
Guadalquivir Estuary, tidal resonance, tidal amplitude, semidiurnal constituents.

THE GUADALQUIVIR ESTUARY
The Guadalquivir Estuary opens into the Gulf of Cadiz (SW, Spain), where tidal oscillations are semidiurnal with a tidal range between 2 and 3.5 meters. Tide in the estuary is imported from the ocean and, as a consequence, the fluctuations of the water column thickness along the river are mostly determined by the tidal amplitudes, being the atmospheric components (wind and pressure) and anthropogenic-controlled discharges the following phenomena in importance. Within the estuary, energy is dissipated by friction. The bottom stress (higher friction), acts drawing out tidal propagation, causing lower incoming velocities into the river. Reports in literature show a considerable balance between the convergence of the channel, friction effect in the estuary and tidal reflection in Alcalá del Río dam, located ~100 km upstream [1].

TIDAL REGIME IN THE AREA
Tidal behaviour in the estuary is addressed according the same procedure as in oceanic studies, by means of the harmonic analysis. Among the astronomic constituents, the most important are semidiurnal, primarily M2 (main lunar constituent), which accounts for the major part of the explained variance in the estuary, and secondarily S2 (main solar constituent) and N2 (lunar elliptic). Diurnal constituents, K1 (lunar declination) or O1 (main lunar diurnal), may also be identified in the estuary, but they are an order of magnitude less than the mesotidal flow.

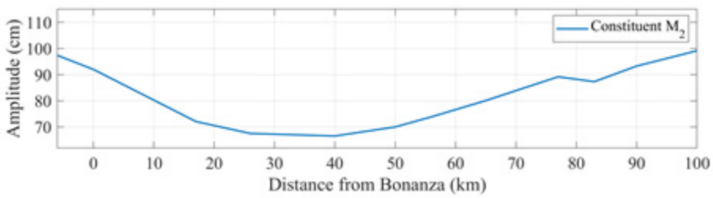

Fig 1. Profile of M2 amplitude (cm) along the Guadalquivir Estuary.

Focusing on the semidiurnal components, their amplitude profiles tend to be characterized by a notorious V-shape pattern along the whole estuary, which is particularly noticeable in the case of M2, achieving maximum amplitudes of around 1m in the mouth and head of the estuary, and minimum values of around 0.7m in the middle portion of the estuary (Figure 1). There is agreement in the literature that points at friction as the main process for the M2 amplitude damping in the middle estuary [2]. Another cause to this effect can be ascribed to the M2 behaviour as a stationary wave with resonant behaviour [3]. Considering both effects jointly, the frictional bottom layer would tend to balance the tidal amplification due to a likely resonance, thus preventing the channel from being purely resonant.

DEFINITION OF NUMERICAL EXPERIMENTS
Tidal resonance occurs when tidal frequency (ω_F) matches the natural oscillation frequency (ω_0) of a semi-enclosed body of water. To investigate the resonant frequency ω_0, a set of experiments that use a fictitious tidal constituent of predetermined frequency (which changes from an experiment to the other) and the same amplitude has been run, and the response at the estuary's head has been analysed. On the other hand, with the purpose of providing an explanation to some peculiar spatially-dependent features of tidal oscillation in the estuary, a simulation forced by M2 and S2 uniquely has been run. A second simulation that switched off M2 constituent was then run and the spatial patterns of S2 in both simulations have been compared in order to assess the frictional interactions between tidal constituents. A three-dimensional (3D) model (DELFT3D) has been used as the numerical tool.

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