Geophysical Research Abstracts
Vol. 12, EGU2010-904, 2010
EGU General Assembly 2010


# Numerical study of the morphological evolution of the Guadiana estuary in response to the projected sea level rise and sediment supply reductions

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A behaviour-oriented numerical model study was carried out to predict the long-term morphological evolution of the Guadiana estuary and the associated intertidal zone in response to the sea-level rise and reduction of sediment supply during the 21st century. Long-term sediment deposition was simulated using the Estuarine Sedimentation Model (ESM), in which the following three factors have been taken into account: 1) changes in the rate of sea-level rise; 2) elevation-dependent accommodation space available for the deposition of sediment; and 3) inundation-dependent vertical accretion rate of sediment. Upper bound values of three IPCC, 2007 sea-level rise scenarios were considered for this study: 1) Global sustainability scenario (B1-38 cm), 2) Balanced use of fossil fuel under globalized economy scenario (A1B-48 cm), and 3) Intensive use of fossil fuel under globalized economy scenario (A1FI-59 cm). Three sediment deposition scenarios (Maximum, average and minimum) were derived using the analysis of Holocene sediment accumulation in the Guadiana estuary during the postglacial sea-level rise, since ca 13 000 cal yr BP. The Maximum sedimentation scenario represents the characteristic behaviour of the Guadiana estuary during the Holocene, (i.e. estuary was in pace with sea-level rise). The minimum scenario is for the constant sedimentation rate observed since ca. 7000 cal BP while the average scenario is the average of maximum and minimum scenarios. An additional sedimentation scenario (human intervention) was derived to represent the sediment supply reduction due to the construction of dams upstream.

Our results show that the potential sedimentation above the present mean sea level may attain only 37% of the total sedimentation potential in the intertidal zone. This may increase up to 50, 53 and 57% when an additional accommodation space is created in response to the projected sea-level rise of 38, 48 and 59 cm, respectively. The morphological evolution of the Guadiana estuary shows distinct behaviour for four sedimentation scenarios defined for each sea-level rise scenario, at the end of 21st century. For three sea-level rise scenarios and minimum sedimentation conditions, a net increase of effective water depth could be expected throughout the estuary. Furthermore, under the same conditions, high energy zone of the estuary (described as a deep sand bypassing channel) would show a significant lateral expansion. But the average and maximum sedimentation scenarios will enhance the meandering of the sand bypassing channel for A1FI sea-level rise scenario. Increased meandering of the main estuarine channel may be expected when the sediment supply is maintained at preanthropic levels.

In reduced sediment supply conditions, the Guadiana estuary and associated intertidal zone would submerge completely in response to the projected sea-level rise, resulting in disappearance of the salt marshes, in particularly of the Spanish margin. The sediment deposition under the maximum sedimentation scenario result in reduction of the effective water depth compared to the present water depth of the main channel. The expected average deposition heights along the central axis are 0.5, 0.8, and 1.2 m for B1, A1B and A1FI sea-level rise projections, respectively. Under the maximum sedimentation scenario, the increased accommodation space in the estuary due to sea-level rise would be offset by the sediment deposition maintaining the whole system stable. It is clear that the present sediment discharge is insufficient to maintain such stable effective depth within the lower estuary. Despite the uncertainties inherent to the modelled scenarios involving the estimated impacts due to simplifications, the presented predictions of the morphological evolution give a broader view of the expected impacts caused by the sediment starvation.