Using numerical models to constrain the evolution of the Ebro Delta

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1. Introduction

The Ebro Delta, Spain, with its distinctive plan-view shape, has experienced significant morphologic changes over the last two millennia (Canicio and Ibanez, 1999). While some of these changes might be caused by autogenic mechanisms, such as avulsions or wave reworking, others may be attributable to anthropogenic activities in the drainage basin.

In this study, we have used a plan-view shoreline model to quantitatively constrain the historical evolution of the delta. Land-use changes have had significant effects on deltaic areas around the world (Giosan et al., 2012). By looking at changes in the Ebro's fluvial history, we can potentially backtrack human influences on sediment supply and predict future responses.

2. Method

We study the evolution of Ebro delta morphology using an exploratory, process-based one-contour-line model (for a full description see Ashton et al. (2006). In short, the plan-view coastal zone is discretized in the plan view. A highly simplified fluvial domain is represented by the deposition of bed load sediment at a shoreline location determined by predefined river trajectory. Wave-sustained littoral transport, a function of wave energy flux and approach angle, carries the sediment alongshore, and divergence in the alongshore sediment flux evolves the shoreline. River avulsion is implemented by forcing the channel in a new direction after it reached a specific length.

We use this model with present-day wave climate and plan-view morphology to infer historical conditions in the Ebro drainage basin.

3. Results

Experiments are performed for various sediment supply rates and avulsion criteria. Two findings in particular are interesting: (i) the existence of the two spits on the north and south side of the delta (see Fig. 1) places constraints on plan-view morphology of the delta lobe at the time of avulsion. In turn, such a plan-view shape results from a select range of necessary fluvial conditions. For instance, a smaller sediment load would have resulted in a reworking style characterized by a simple reorientation of the shoreline, without the creation of a zero-flux point necessary for spit formation (Nienhuis et al., 2012).

In addition (ii), the curvature of the tip of a spit is directly related to the littoral transport updrift (Ashton et al., 2007). This places some interesting additional constraints on the retreat rate of abandoned lobes. High curvature is indicative of rapid lengthening of the spit. We have looked at the formation and orientation of the El Fangar and the La Banya spit (Fig. 1) in their respective wave climate.

These two mechanisms, combined with a simple mass-balance approach, enable us to constrain the rate and timing of lobe growth and retreat.

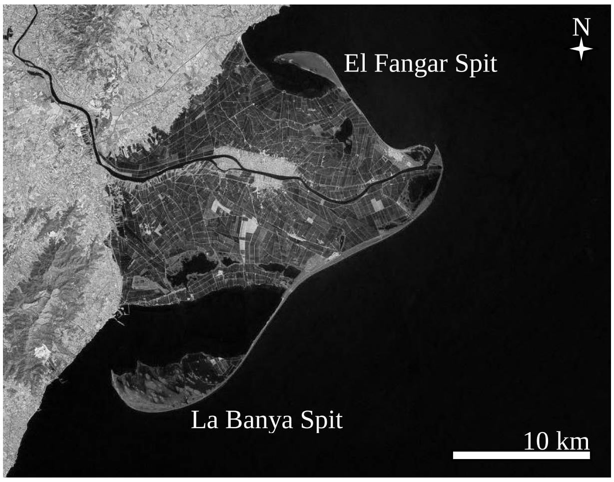

Figure 1: The Ebro Delta. © NASA

4. Conclusions

The Ebro morphology is the result of several natural processes shaped by anthropogenic activities. Exploratory modeling of subsequent lobe reworking enables reconstruction of historical fluvial sediment supply rates. This has allowed us to quantify effects of historical land-use changes and to predict future responses.

References

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