Geophysical Research Abstracts,
Vol. 11, EGU2009-1833-2, 2009
EGU General Assembly 2009

Long bed waves in tidal seas, a simple model

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The sandy bottom of shallow tidal seas often shows the presence of rhythmic topography being characterised by different length scales. Two types of bedforms are known to be inevitably linked to the presence of oscillating tidal currents. These are sand banks (length scale 5̃ km, crests almost aligned with the largest tidal currents) and sand waves (length scale5̃00 m, crests perpendicular to the current). Analysis of recent bathymetric surveys made in the North Sea has revealed other bed forms, which can be classified neither as sand waves nor as sand banks. These new bedforms have a wavelength of about 1.5 km, and crests which are either clockwise or counter-clockwise rotated with respect to the tidal current. The clockwise bedforms form an angle of about 35 degrees with respect to the major axis of the tidal current, while the counter-clockwise bedforms form an angle of about 60 degrees.

In this presentation a simple model is discussed to explain the appearance of the long bed waves. The model is based on the hypothesis that bottom features emerge as spontaneous instabilities driven by tide-topography interactions. The model consists of depth-averaged shallow water equations for the flow, supplemented with a bottom evolution equation (derived from conservation of sediment mass) and a formulation for bedload transport of sediment. The latter formulation involves a threshold value of the bottom stress below which no sediment moves. By performing a linear stability analysis it follows that, in accordance with previous studies, for strong rectilinear tidal currents the model predicts the formation of sand banks. However, if tidal currents are eccentric and maximum currents are slightly above the critical velocity for sediment erosion, the model shows the existence of other growing modes, with geometrical characteristics that are similar to those of the long bed waves observed in the field. A physical explanation of why these bottom features form will also be given.