Meandering channel dynamics in highly cohesive sediment on an intertidal mud flat

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Research Questions
• How do meandering channels form and behave in a cohesive bed?
• How can the channel deepening and bend migration be predicted for these channels?

Main processes
• Channel initiation
  (Meandering) tidal channel (how?)
  Erosive step
  Mud erosion by flow
  Deepening
  Undercutting
  Bank failure
  Bend migration

Conclusions
• Vortices in sharp bends results in highly localized bank erosion;
• Sharp bends successfully parameterised in meander simulation model
• Successive erosive steps deepen the channel;
• Process well reproduced in laboratory flume and celerity well modelled

EROSIVE STEP MIGRATION

Field
• Deepening channels
• Cyclic and solitary steps
• Migration rate O(10^-6) m/s

Flume
• Steps easily recreated in flume
• Both cyclic as solitary steps
• Migration rate O(10^-6) m/s for natural sediment
• Migration rate O(10^-5) m/s for sand/mud mixture

Model
• Izumi-Parker stability analysis
• Calculated Migration rate O(10^-6) m/s
• Same order as measured values

• Above line - migration infinite upstream
• Below line - migration is limited
• Observations confirm prediction

SHARP MEANDER BENDS

Field
• 2 vortices per bend
• Flow impinges on outer bank
• Phase lag between erosion and curvature
• Small erosion rate
• Erosion by bank collapse

Flume
• 2 vortices in sharp bends results in highly localized bank erosion;
• Sharp bends successfully parameterised in meander simulation model
• Successive erosive steps deepen the channel;
• Process well reproduced in laboratory flume and celerity well modelled

Locations of erosion in pre-formed channels:
• 2 vortices
• Localised incision of channel
• Bank erosion where flow impinges
• Small erosion rate

Model
• Meander migration model of Ikeda et al. (1981) computes bend migration by:
  \( \dot{\xi} = \frac{E_t u_{\text{bank}}}{P_t} \)
  where \( u_{\text{bank}} \) is the excess flow velocity at the outer bank, which is related to the bend curvature.
• Parameterisation for sharp bends:
  1) Additional phase lag between curvature and bank flow velocity
  2) Critical flow velocity for bank erosion
• Modelled locations of bend erosion agree with observations
• Very slow process

References:

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