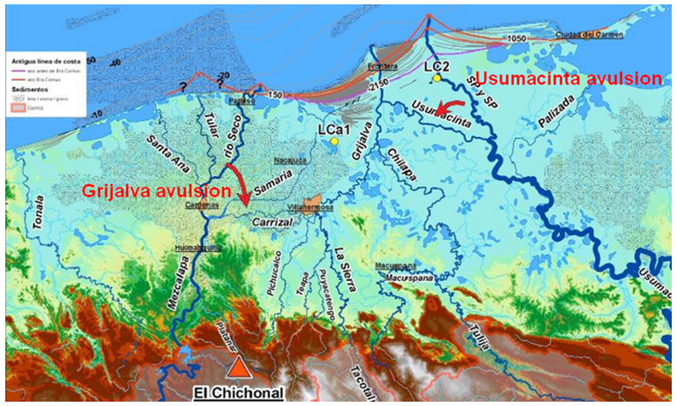
Modelling bifurcations in the Tabasco coastal plain, Mexico

I. R. Lokhorst[1], C. A. M. Nooren, M. G. Kleinhans, W. Z. Hoek
i.r.lokhorst@uu.nl[1], Utrecht University, Dept. of Physical Geography, Utrecht, Netherlands

Universiteit Utrecht
Faculty of Geosciences
Research group
River and delta morphodynamics

Field site:

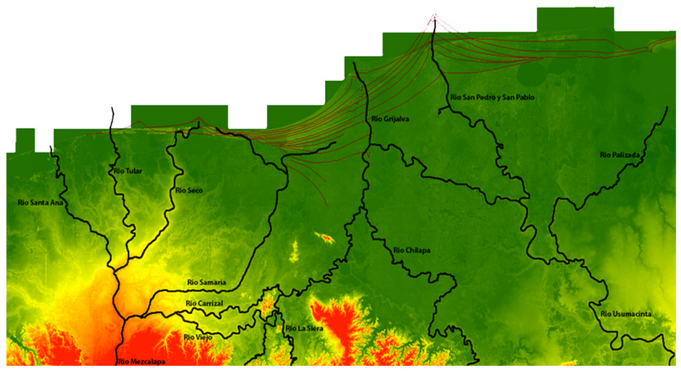
- The Tabasco coastal plain contains several beachridge dominated deltas and two major rivers, the Grijalva and Usumacinta
- Sedimentological research points to multiple avulsions during the late Holocene
- Currently instable bifurcations threaten the city of Villahermosa
- The Grijalva (or Mezcalapa) river had a much higher avulsion frequency
-The sediment load of the Grijalva river is relatively high due to the large input of easily eroded and transported volcaniclastic sediments from El Chichonal volcano



Overview of the positioning of the El Chichonal volcano and the two avulsions of interest

Questions:

- Which river created the currently active Grijalva delta?
- What drove the recent avulsions of the Grijalva and Usumacinta?
- What causes the higher avulsion frequency of the Grijalva?
- Does the El Chichonal volcono affect the Grijalva (or Mezcalapa's) behavior?
- The Grijalva's sediment has shown to be fining downstream, does this signicantly affect the river's behavior?



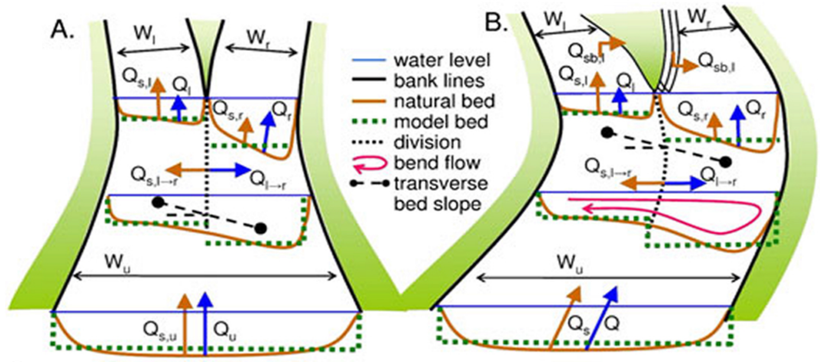
Digital elevation model of the area. The western river system (Grijalva) has experienced much more avulsions over its history

Aims:

- To find out why the Grijalva and Usumacinta avulsed in its recent history
- To determine the cause for the Grijalva's higher avulsion frequency

Methods:

- 1D bifurcation modelling, the model includes:
  - Transverse bedslope effects
  - Hellical flow
  - Adjustable channel widths based on hydraulic geometry

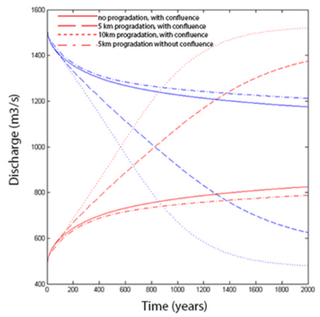


Scenarios:

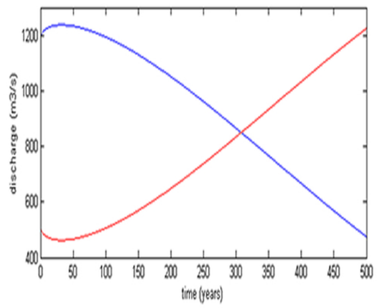
Usumacinta:
- 0 km, 5 km and 10 km delta progradation
- 2000 m^3/s discharge and 3700 m^3/s (flood)
- 0.1 cm/y and 0.5 cm/y tectonics
- 0.5 mm/y sealevel rise
- With and without confluence with the Grijalva
- 0.5 mm and 0.1 mm D_{50} grainsize
- 300 m and 400 m upstream width

Grijalva
- 0 km, and 2 km delta progradation
- 700 m^3/s discharge and 1700 m^3/s (flood)
- 5 mm/y sealevel rise
- With 0, 1, or 3 concluences
- Tectonics up to 1 cm/y in either both or one of the brances

Results: Cause of avulsion



The Usumacinta river shows that it avulses after 5 km delta progradation. A confluence with the Grijalva river strongly decreases the time involved in the avulsion process.



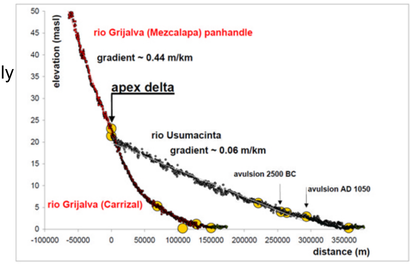
The Grijalva river did not avulse unless significant tectonics were applied in the new branch only. The figure above experienced 1 cm/y subsidence. This is an unlikely setting and thus uncertainty about the cause remains.

Results: Avulsion frequency

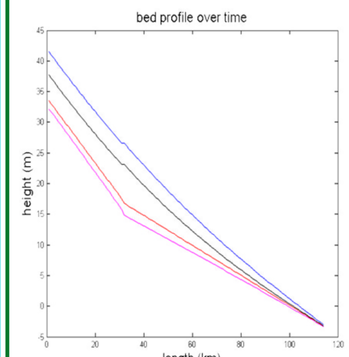
- Schematization of the river slopes
- Red: initial slope
- Black: slope after 100 years
- Blue: slope after 200 years
- Pink: slope after 100 years with suddenly fining grainsize on the profile knick

- Grijalva river starts aggrading quickly
- Usumacinta river barely aggrades

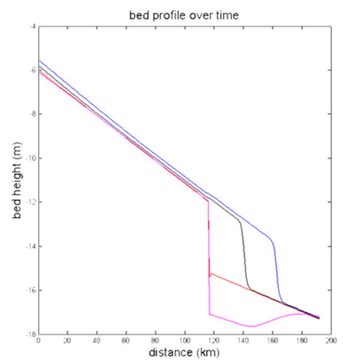
- Suddenly fining grainsize counteracts accumulation



measured river slopes



Modelled Grijalva river



Modelled Usumacinta river

Discussion:

- Influence of sea level rise is very minor, because the rivers are able to easily compensate with aggradation of the channel bed
- Tectonics has shown to be a major factor in many avulsions but is of minor influence in these scenarios.
- The Usumacinta has shown to be strongly affected by small changes in gradient
- The presence of a confluence strongly affects the system, just as was found in for example the Columbia river.
- The El Chichon volcano might have a significant influence on the behavior of the Grijalva river, but this was not investigated

Conclusions:

- The Usumacinta avulsed due to its own delta progradation
- The confluence with the Grijalva accelerates the avulsion process
- Higher avulsion frequency of the Grijalva likely to be caused by its stronger decrease in gradient
- Gradient might be caused by sudden decrease in grainsize
- Reason for the Grijalva's avulsion still unclear

Acknowledgements:
Thanks to H. Middelkoop, K.D. Smits and B post for their help with the data acquisition in Mexico
This study is a contribution to the NWO-ALW project: 'Five millennia of sea-level, palaeostorm, and Maya land use variability reconstructed from the world's largest beach ridge plain'