Existing capability and case studies of 3-D hydrodynamic modelling at MRC

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introduction

- The work presented is part of the WUP-FIN project under MRC (2001-2007)
- Aim: to present the 3D modelling tools, capabilities and needs of those + some case studies
- Content:
  - why to model?
  - how to model?
  - what can be modelled?
  - where to model?
  - and then what?

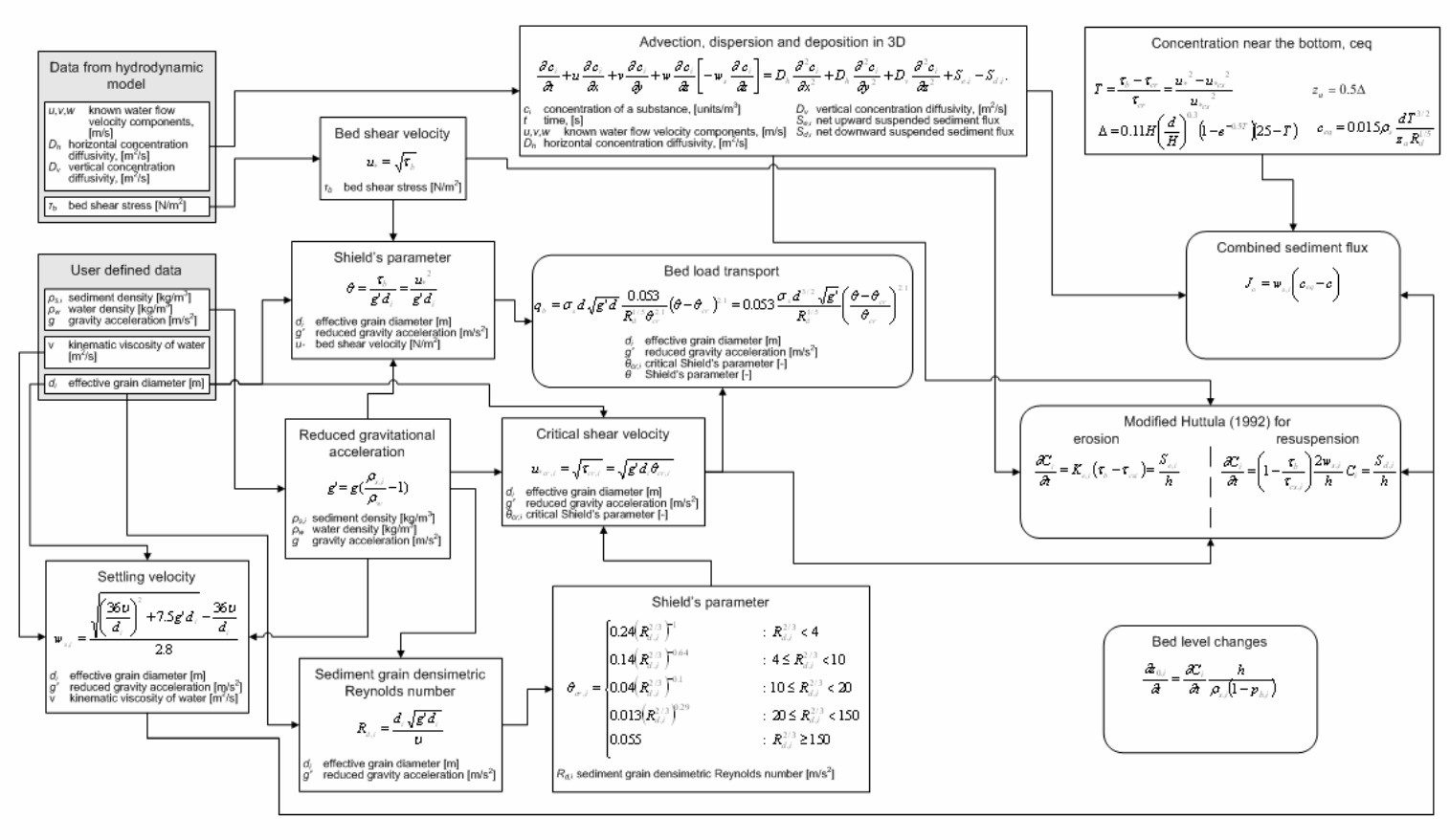
why to model?

- Modelling is one of the few tools to
  - understand the dynamics of complex ecosystems
  - assess the impacts of human activities on those ecosystems
  - demonstrate the results to the decision makers and encouraging public participation
- Modelling, however
  - is always simplification of reality
  - includes many assumptions and inaccuracies
  - can give false information if not done properly

how to model?

- EIA 3D model: Developed by EIA Ltd (www.eia.fi)
- Fully 3D model, applied to Mekong at various places (e.g. Tonle Sap, LMB floodplains, etc.)
- Input*:*
  - Digital Elevation Model (DEM): defines the grid
  - Landuse: defines the friction and some WQ parameters
  - Boundary conditions: flow, WL, SSC, WQ
  - Various computational parameters
- Output (field and point data) :
  - Flooding characteristics
  - 3D currents
  - SSC and sedimentation
  - other water quality parameters (salinity, DO, etc)

sediment module in EIA 3D



- able to model: - bed load
  - suspended load (cohesive and non-cohesive)

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modelling principles

The following principles of the sediment modelling in the Mekong have been used:

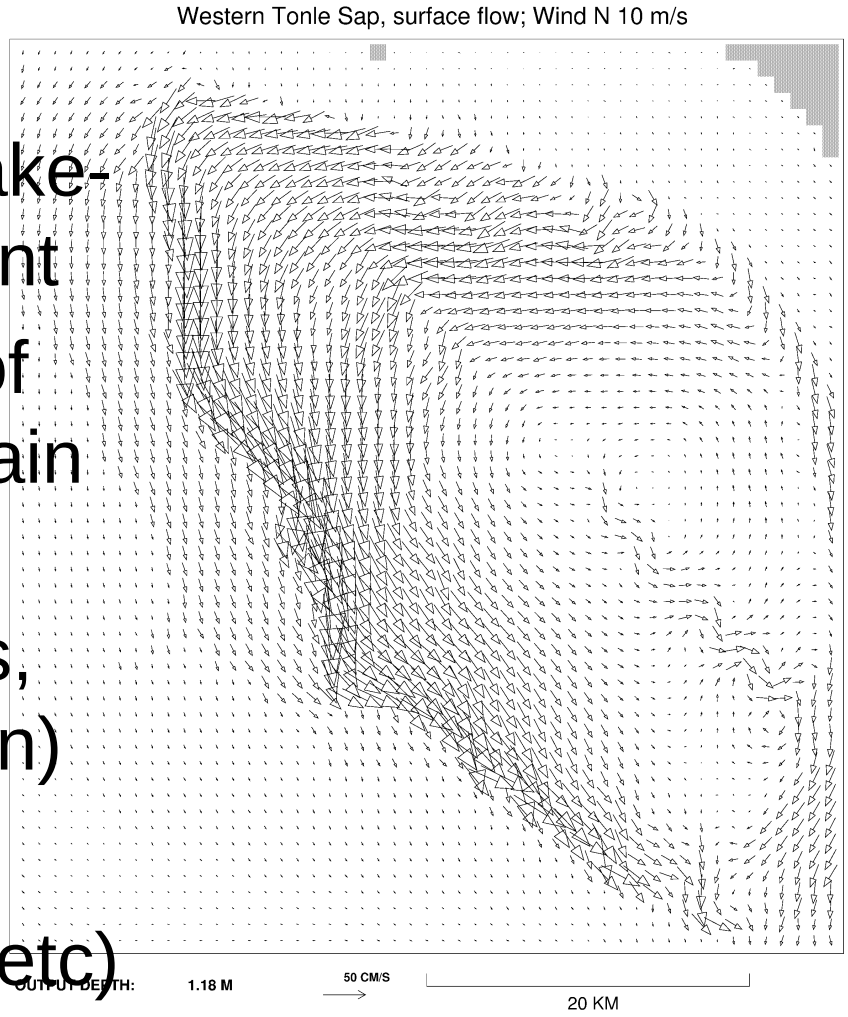
- The solution should be **universal** – it must enable modelling of floodplains, wetlands, reservoirs, lakes, rivers, channels, coastal areas which participate in the sediment processes
- The solution should be **practical** so that setting up the model is not too laborious and the computational costs for sediment modelling are not prohibitively expensive
- The solution should be also **flexible** so that model can be changed easily depending on the problem at hand

data from modelling point of view

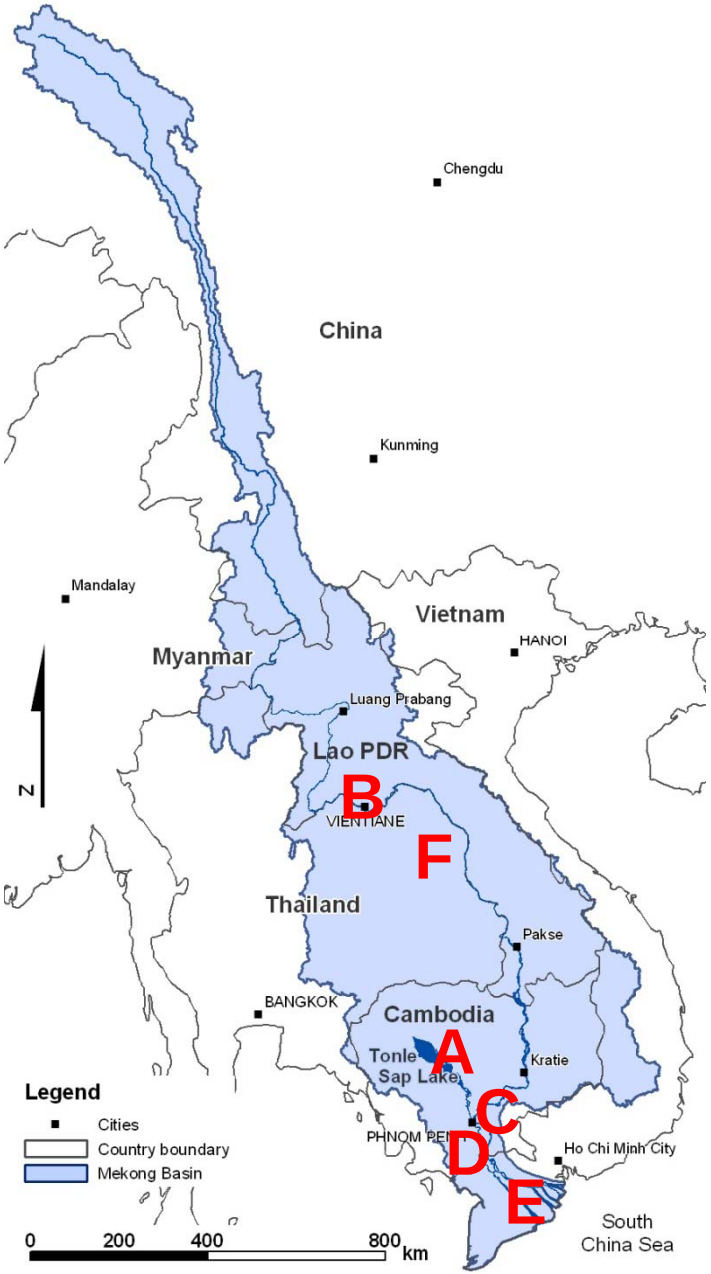
- suspended sediment
  - for input: depth integrated over the cross section (concentration and grain size distribution)
  - for validation: point data and satellite image
- bed load:
  - for input: bed material grain size and bed load at boundary
  - for validation: velocity and thickness
- sedimentation
  - sediment traps
  - coring for long term sedimentation

what can be modelled?

- flow and flood simulations in river-lake-floodplain environment
- sediment dynamics of the river-lake-floodplain system
- river reach (velocities, potential bank erosion)
- reservoir modelling
- others (WQ, oil spill, etc)



where to model?

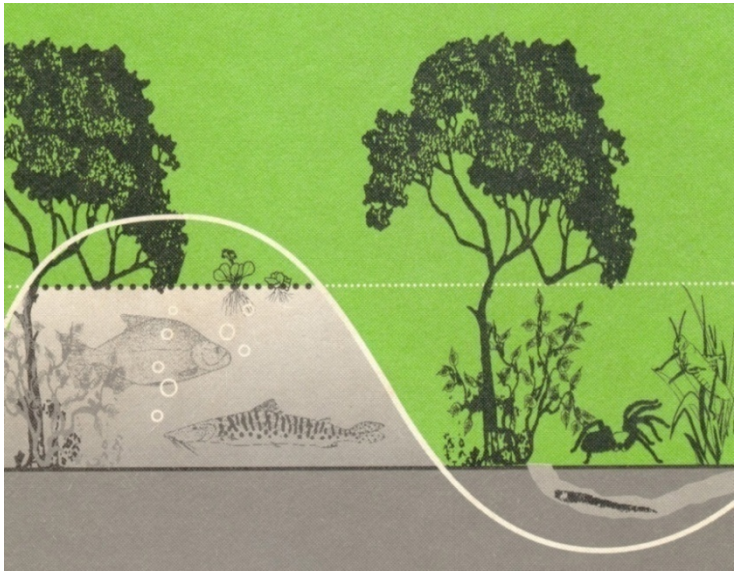


A. **Tonle Sap Lake and floodplains**: flood and sediment dynamics
B. **Vientiane – Nong Khai**; bank erosion and sediment dynamics
C. LMB floodplains: flood dynamics
D. Chaktomuk confluence
E. **Vietnam Delta**: various applications
F. Nam Songhkram floodplains: flood dynamics

Tonle Sap Lake

- Tonle Sap is one of the most important ecosystems in the Mekong
- intensive fisheries, and important breeding ground for many migratory fishes
- productivity driven by annual flood pulse
- complex river-lake-floodplain ecosystem with water level variation between 1-10 m

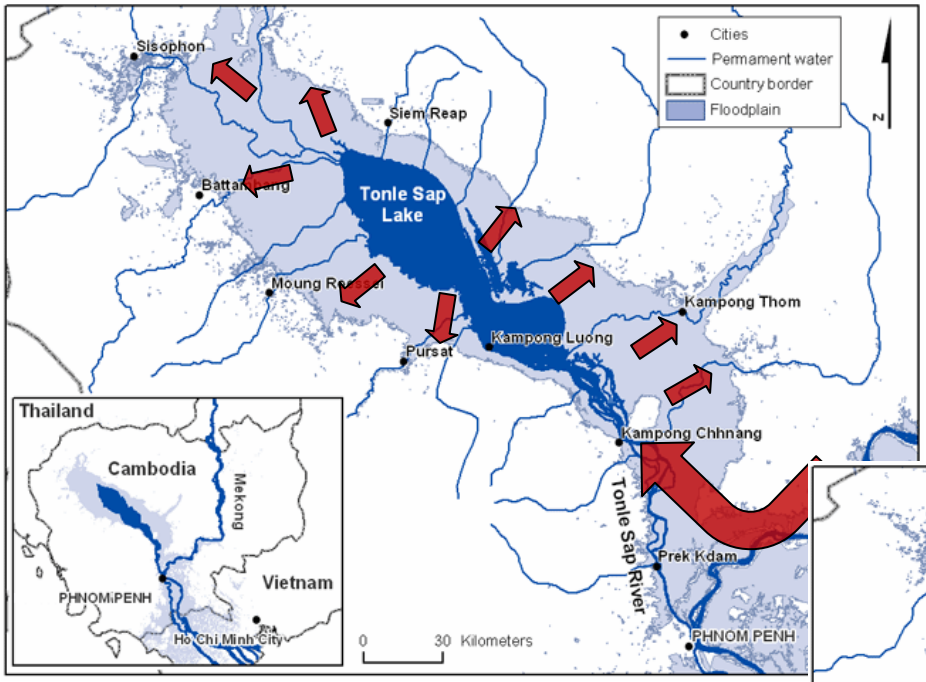
  → challenging for modelling



Junk (1997)

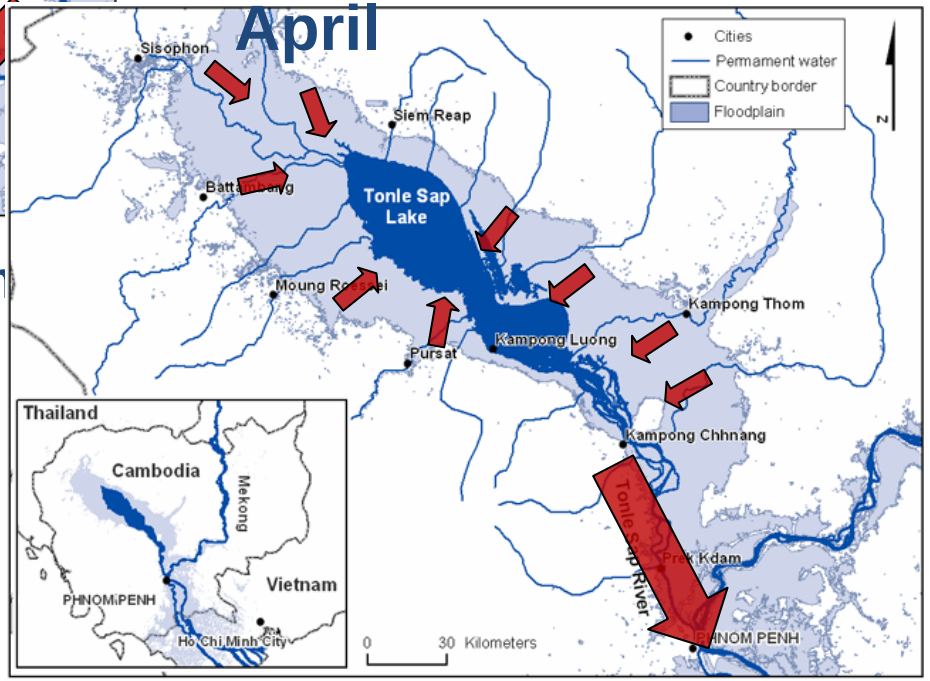
hydrology

Wet season: May-October



Water from Mekong mainstream to the Tonle Sap Lake

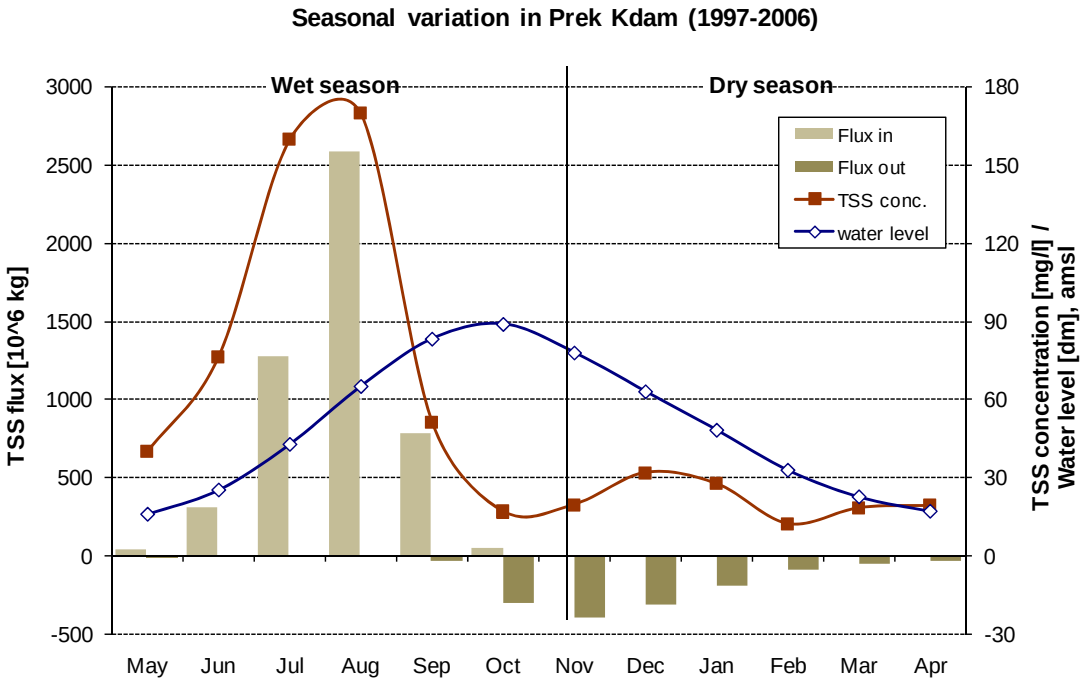
Dry season: November-April



Water from Tonle Sap Lake to the Mekong mainstream

mekong influence

- 55% of the annual inflow (73 km^3) from Mekong, 33% from tributaries
- 72% of the annual TSS flux (7.1 million tons) from Mekong
- 80% of sediment remains in Tonle Sap system



Kummu & al (2008)

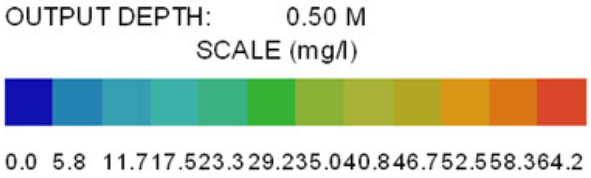
role of sediment

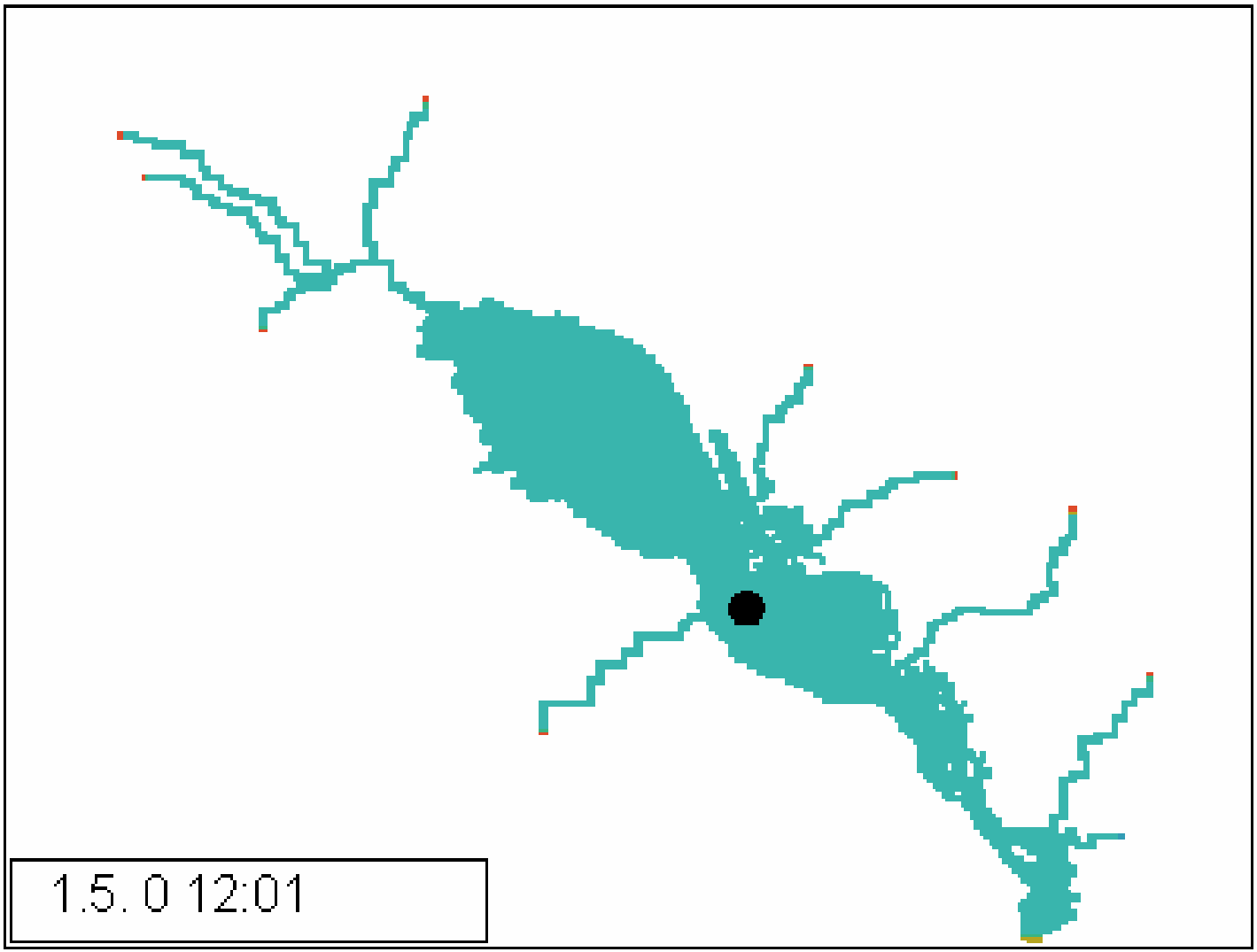
- sustain the geomorphology of the Tonle Sap estuary and river
- nutrient input

  →ecosystem productivity
- sustain the conditions for larvae and fish

  → e.g. buoyancy of fish larvae depends on the SSC

surface SSC


OUTPUT DEPTH: 0.50 M
SCALE (mg/l)
0.0 5.8 11.7 17.5 23.3 29.2 35.0 40.8 46.7 52.5 58.3 64.2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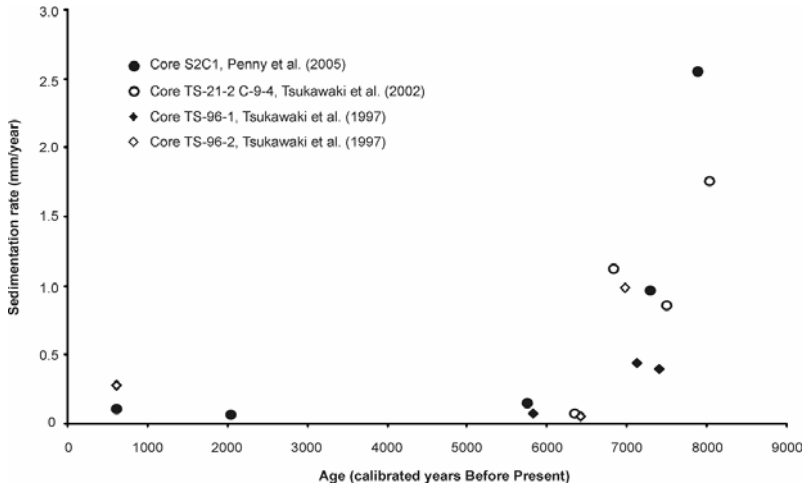
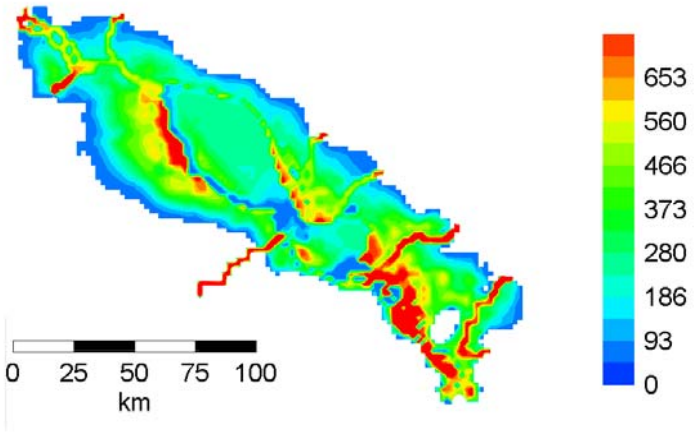
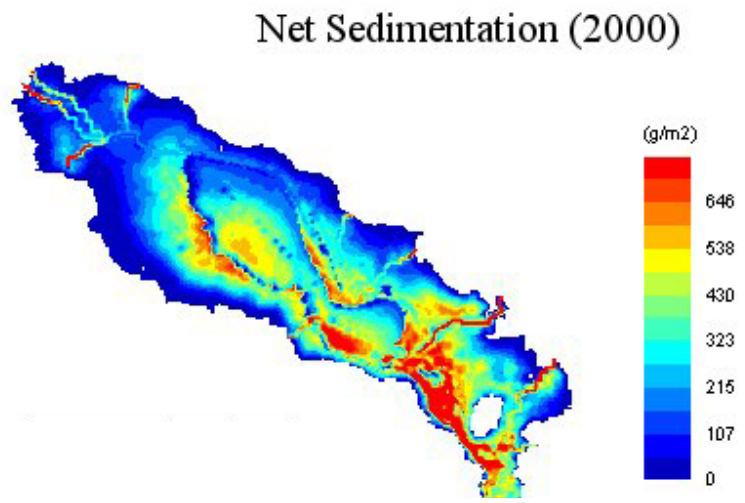
sedimentation

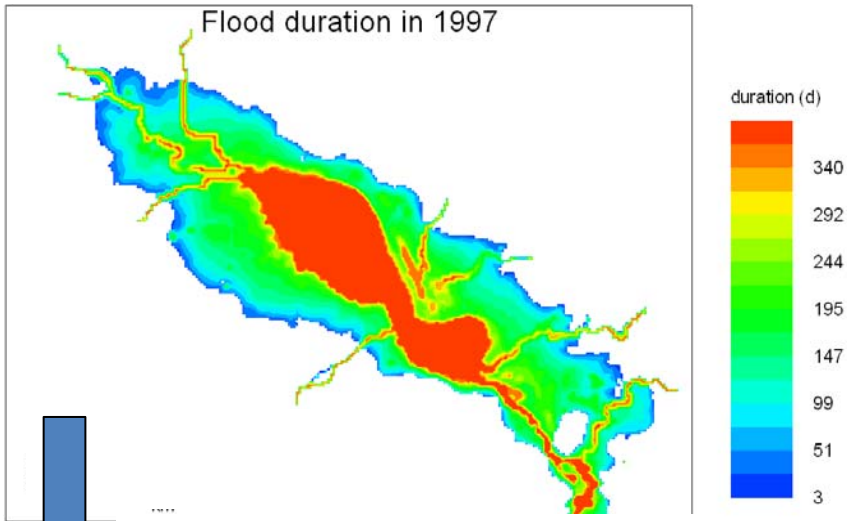
- Sediment is one of the key driving forces for the ecosystem productivity
- Tonle Sap is not filling up with the sediment, sedimentation rate: 0.1 mm/year in lake proper
- Deposition on floodplain levee





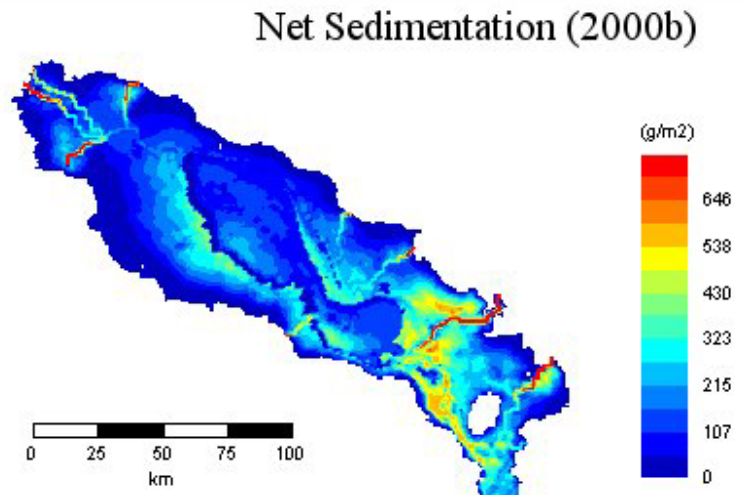
scenario runs

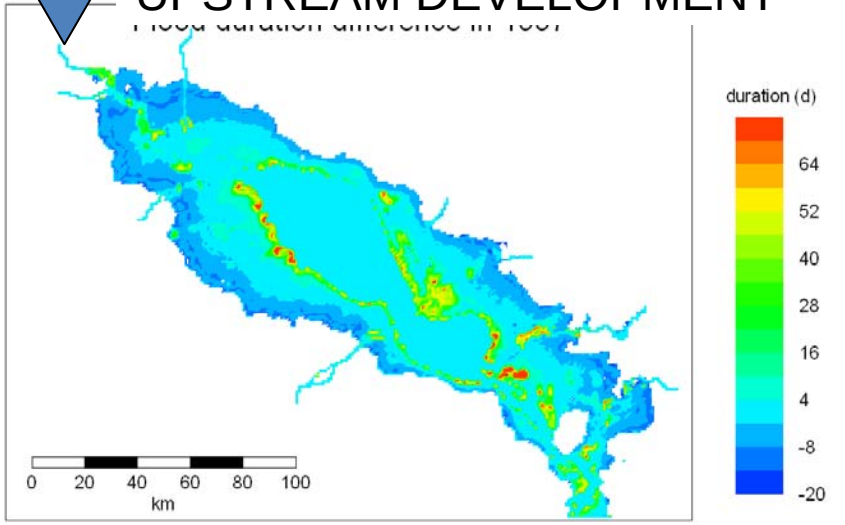




UPSTREAM TRAPPING SEDIMENTS

UPSTREAM DEVELOPMENT





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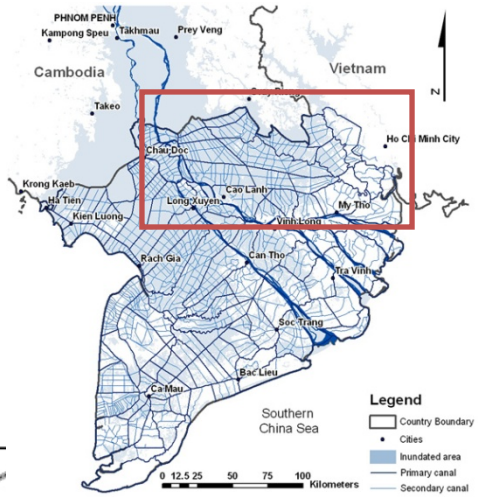
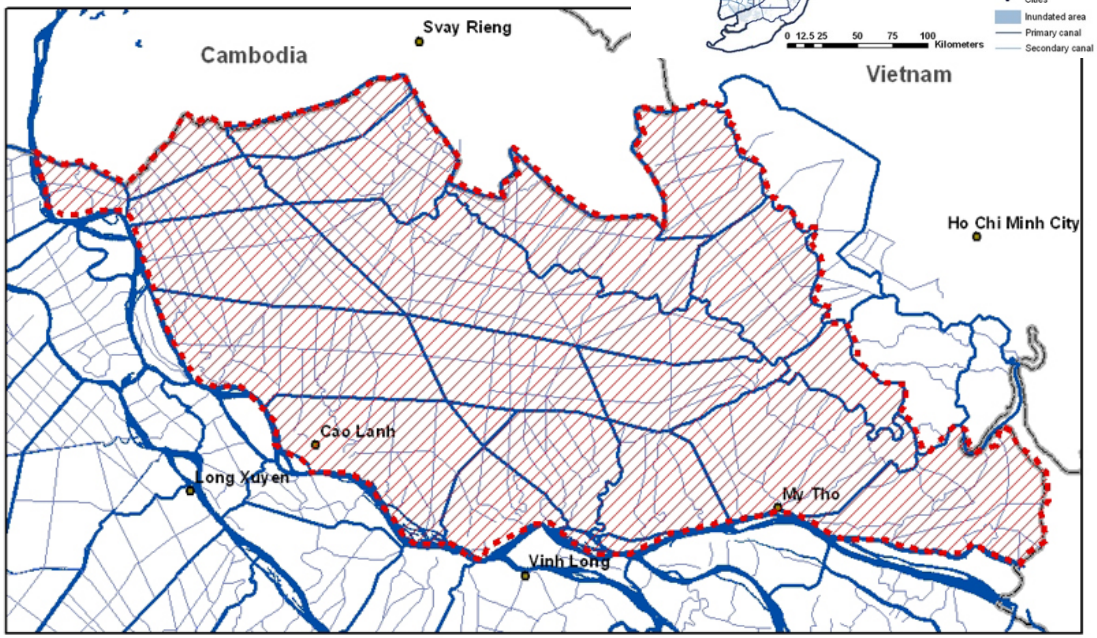
Plain of reeds, Vietnam Delta

- hybrid model EIA 1D/3D
- able to model
  - currents & flooding
  - sediments
  - salinity





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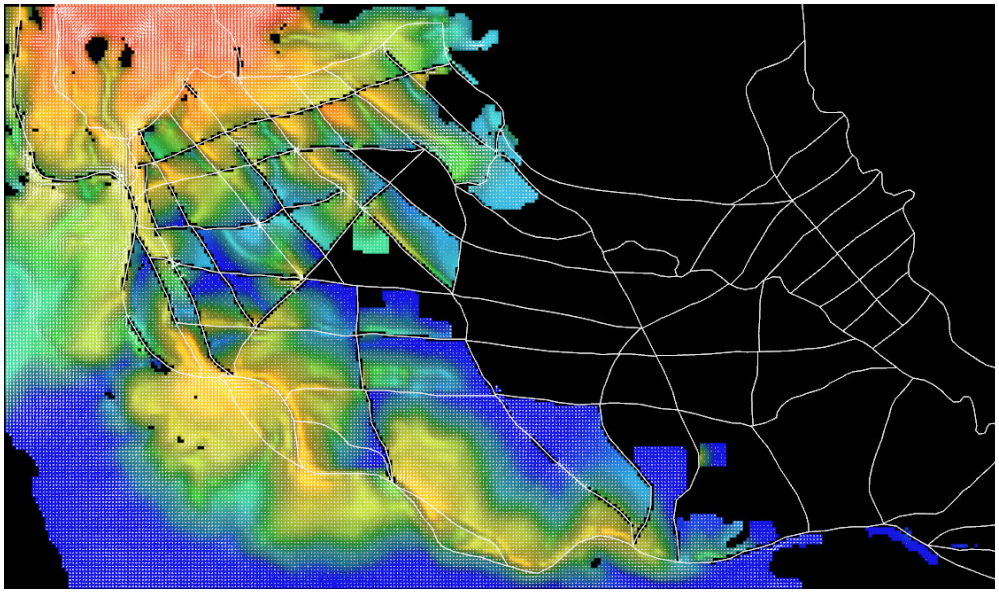
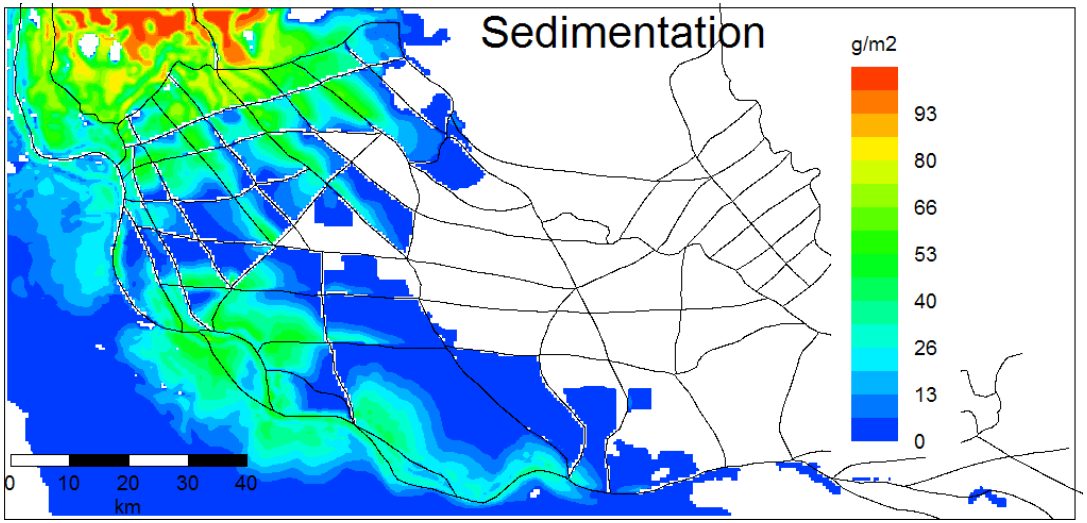
sediment modelling

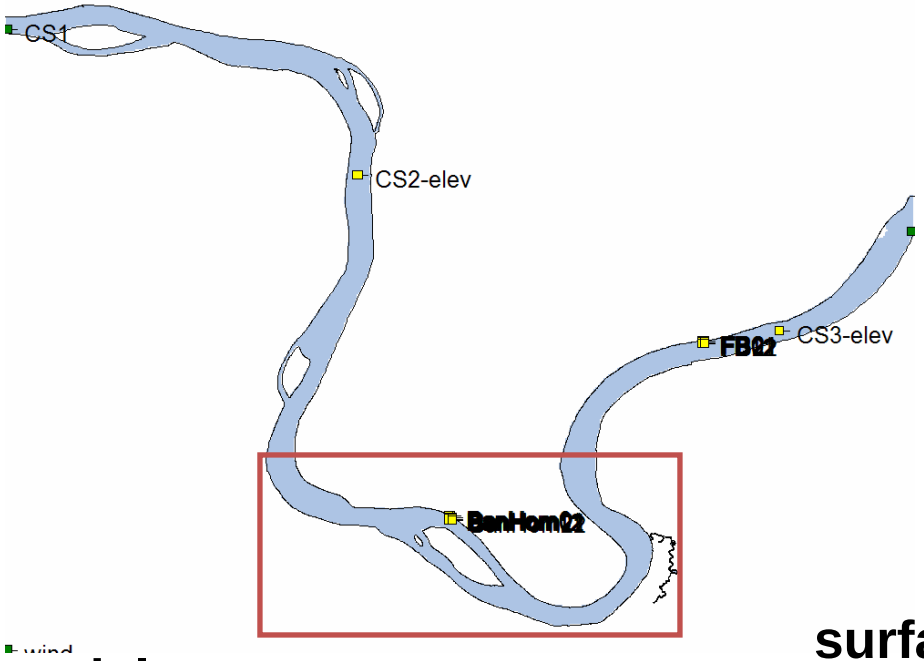


Suspended sediment concentration

sedimentation



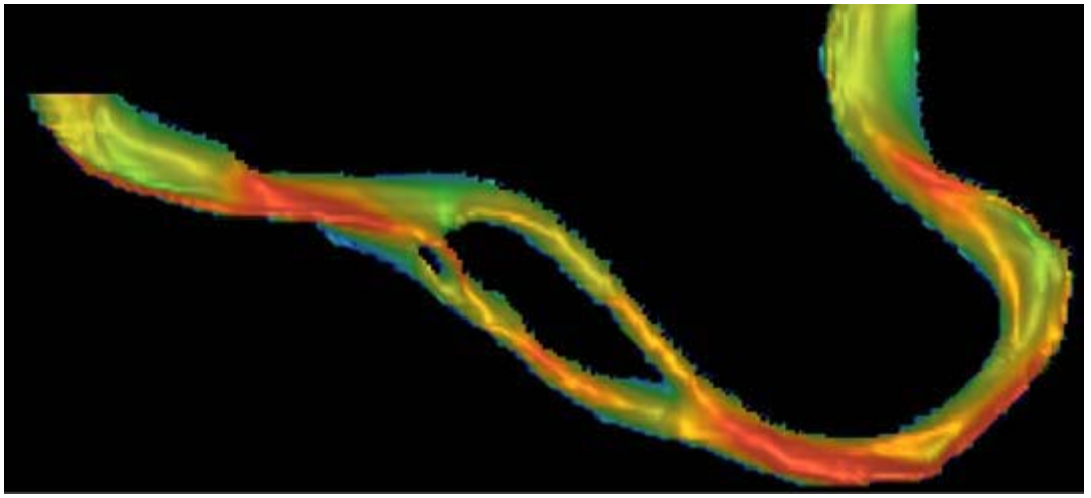
Vientiane – Nong Khai



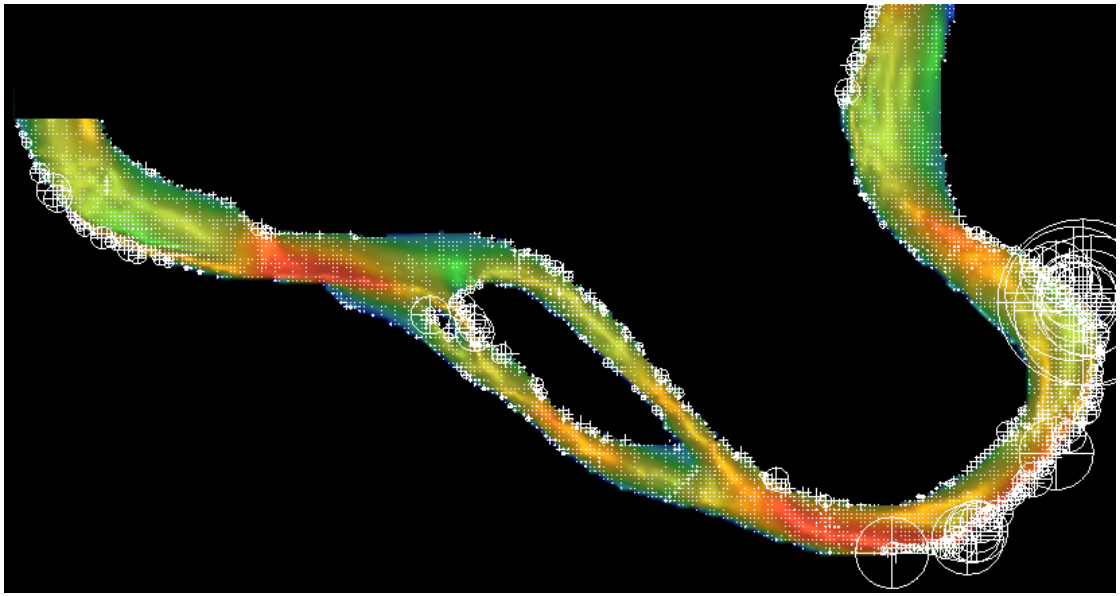
model area

- EIA 3D model
- Aim to simulate:
  - SSC
  - potential bank erosion

surface velocity (Q=12,000 m³/s)

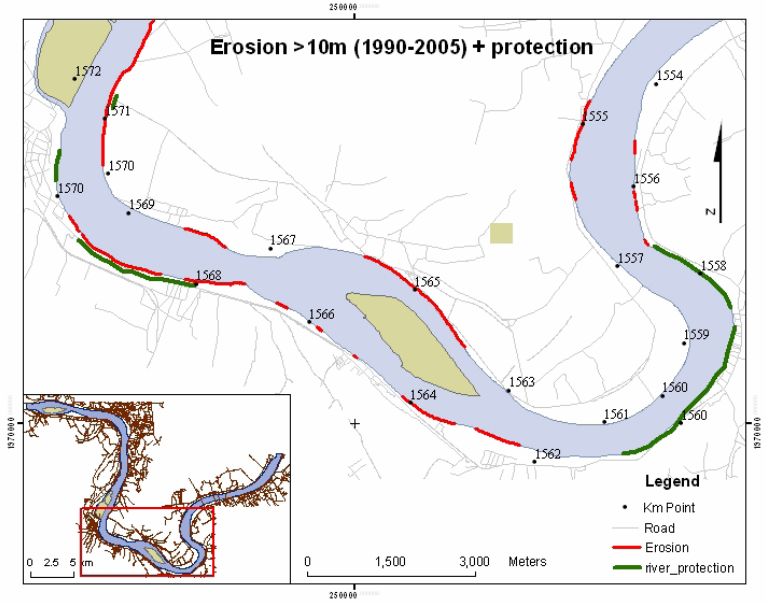


Vientiane – Nong Khai case study



Simulated horizontal (colours) and vertical velocities (crosses and circles)

observations



Kummu & al (2008)

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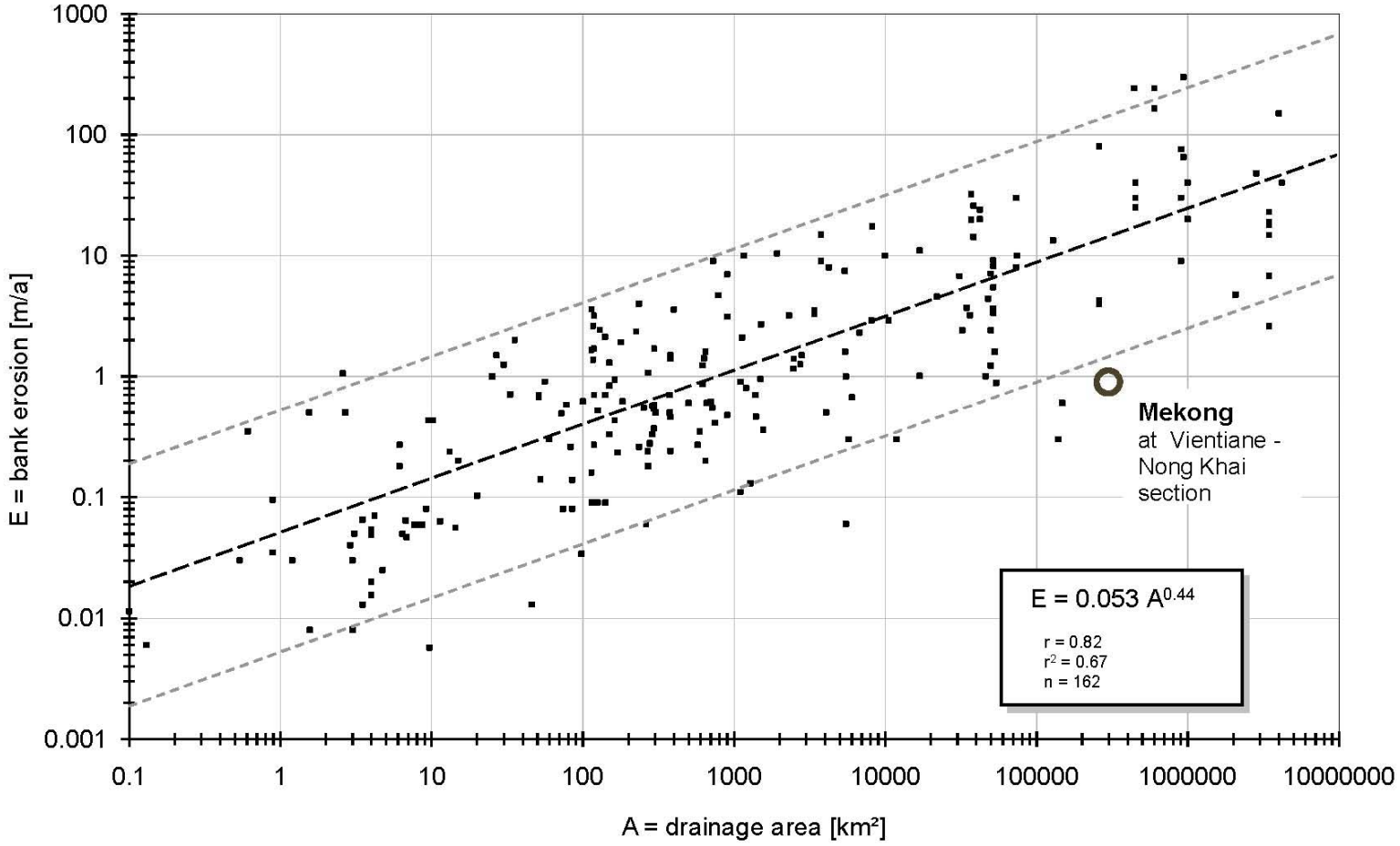
bank erosion in Mekong



Mekong data (Kummu & al, 2008)
Global data from (Van de Wiel, 2003, 2007)

and then what?

- urgent need for Cumulative Impact Assessment (inc hydrology, sediments, etc) of the foreseen development activities
- multiple impacts related to sediments need to be assessed
  - geomorphological (erosion, accretion)
  - productivity (nutrients bound to sediment)
  - larvae buoyancy
  - others?
- modelling only part of the assessment
- data issues – improved monitoring essential

Thank you for attention!

more information:

- www.eia.fi/wup-fin
- matti.kummu@iki.fi