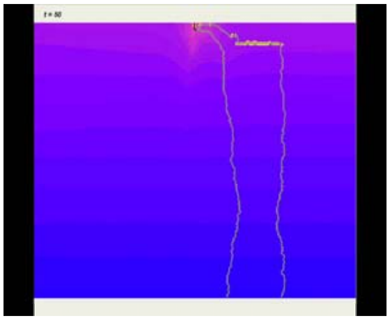
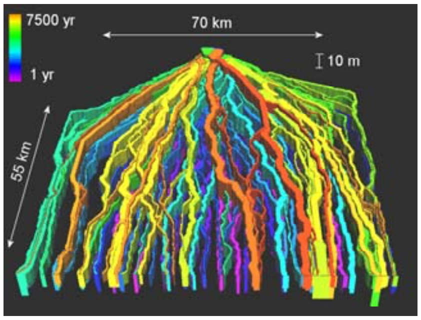
A 3D MODEL SIMULATING SEDIMENT TRANSPORT, EROSION AND DEPOSITION WITHIN A NETWORK OF CHANNEL BELTS AND AN ASSOCIATED FLOODPLAIN

Derek Karssenberg[1] & John Bridge[2]





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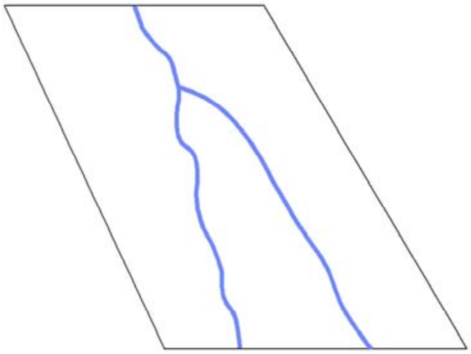
Content

- short introduction to the model
- model outputs standard run
- model components and sensitivity analysis
- conclusions

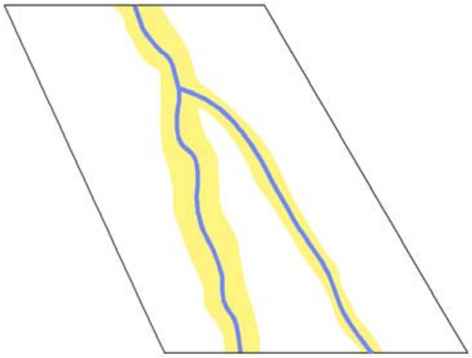
Channel network

- multiple channels
- erosion and deposition from sediment continuity equation
- bifurcations (incl. avulsions)



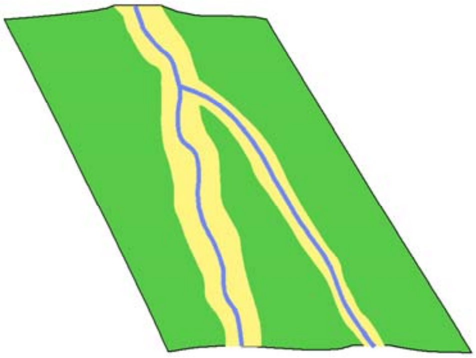
Channel belts

- width increases through time



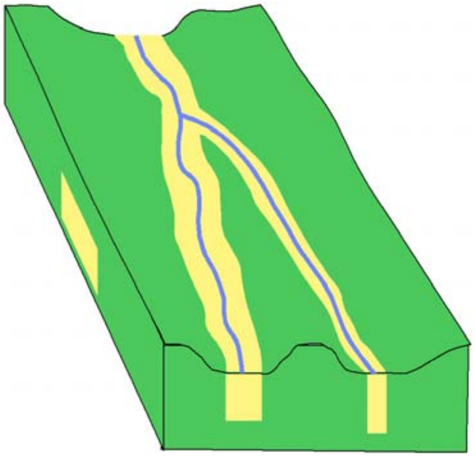
Overbank deposition

- function of deposition at nearest by channel belt
- decreases away from channel belts



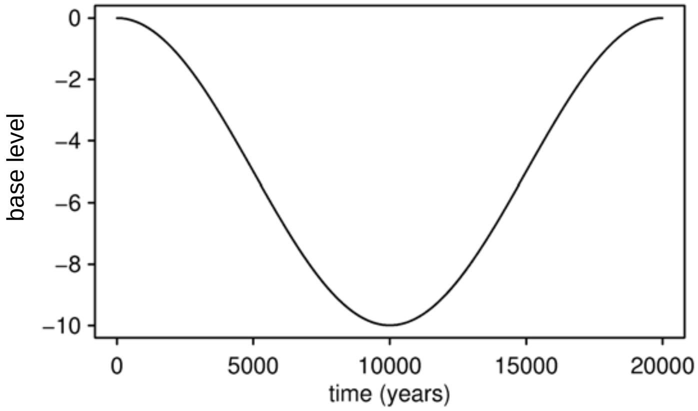
3D architecture

- compaction

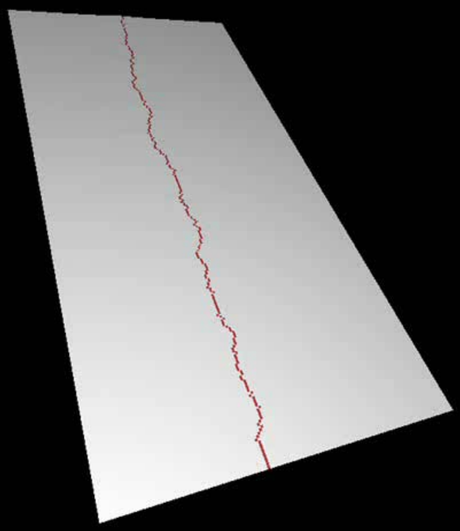


Standard run

- parameters and boundary conditions comparable to Rhine-Meuse
- cell size 200 m, modelling area 30 x 60 km
- external forcing: base level change

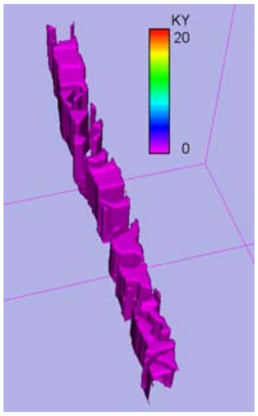


Standard run

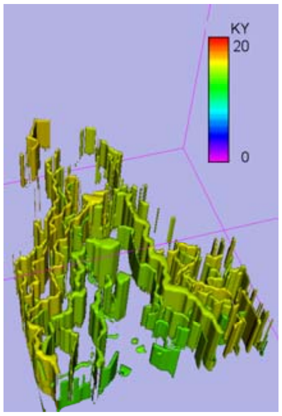


3D volumes

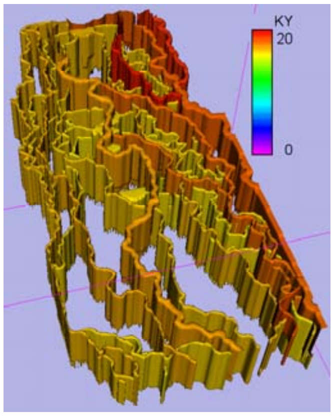
0-13 KY



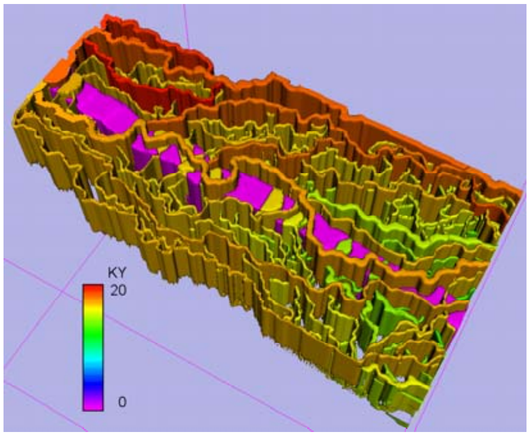
13-16.5 KY

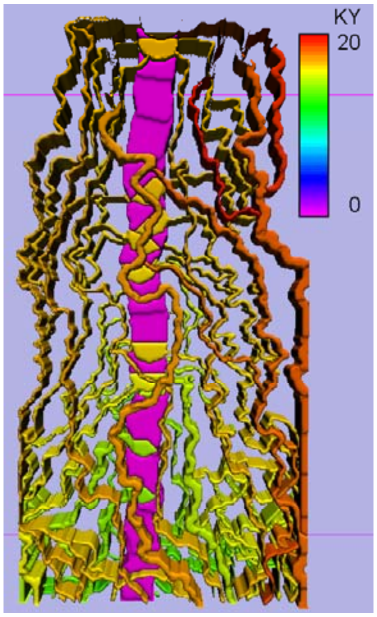


16.5-20 KY

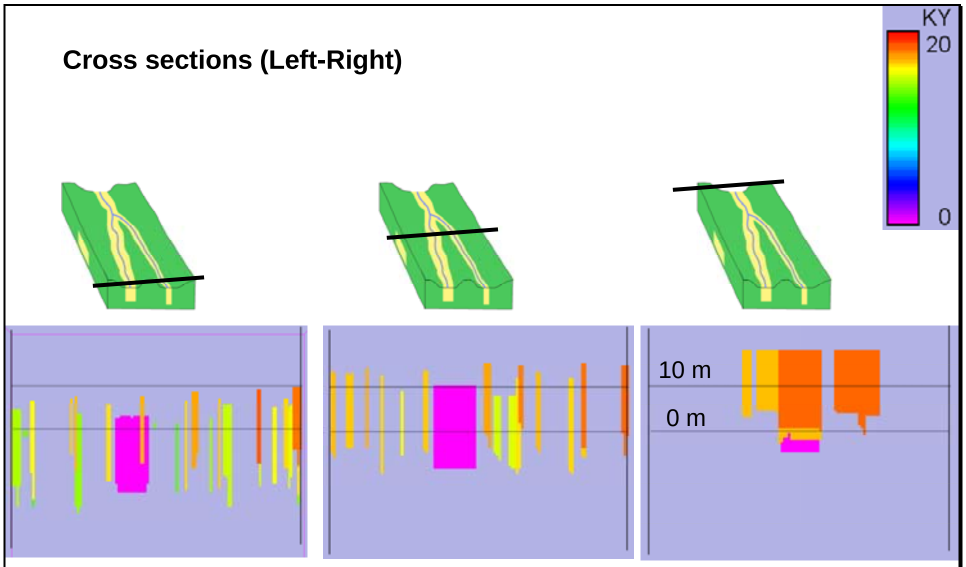


3D volumes

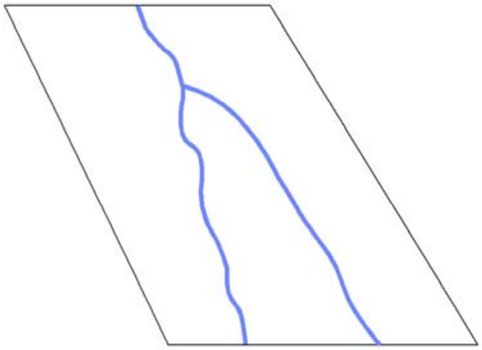




Cross sections (Left-Right)



Bifurcations



Probability *P*(*a*) of a new bifurcation (in a year, for each cell)

$$P(a) = P_s P_d$$

P_s	probability of a bifurcation as function of the superelevation -> function of ratio of downstream slope and slope perpendicular to the channel belt
P_d	probability of a yearly flood discharge leading to an avulsion, given a very high superelevation of the channel belt

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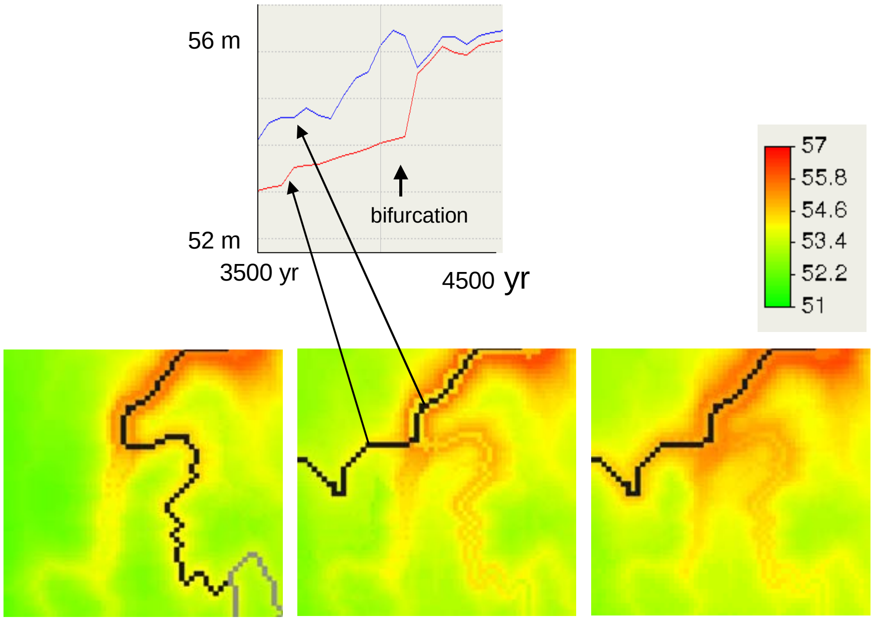
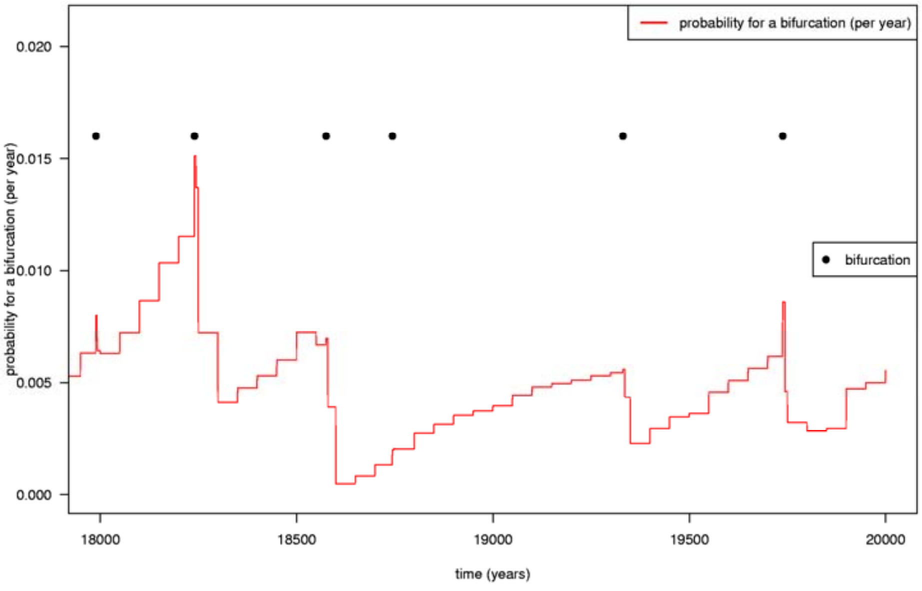
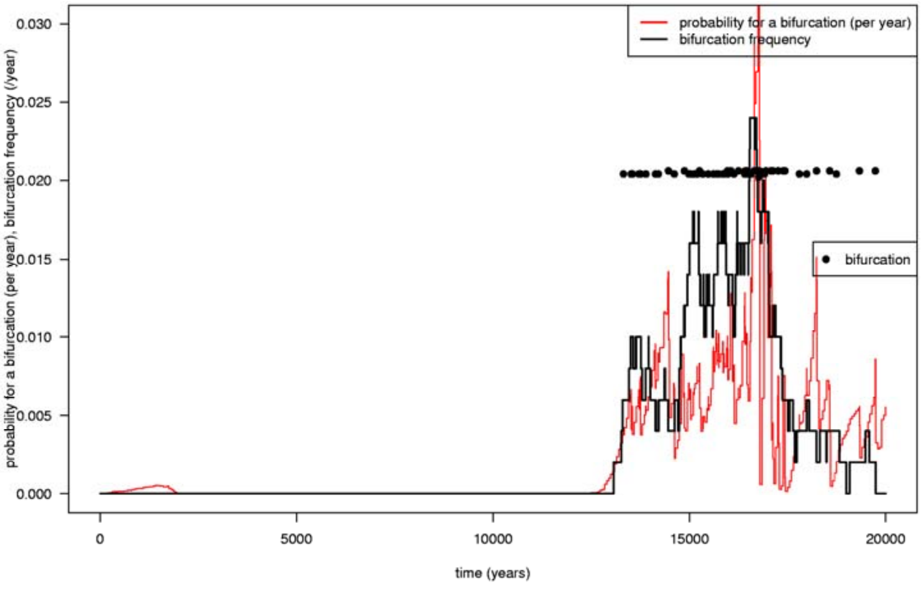
Aggradation and degradation at a bifurcation point



Strong decrease in bifurcation probability after a bifurcation



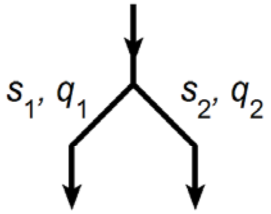
Bifurcation frequency, external and internal forcing



Water flow routing

- at a bifurcation, water discharge is distributed over the two distributaries according to

$$\frac{q_1}{q_2} = \frac{\sqrt{s_1}}{\sqrt{s_2}}$$



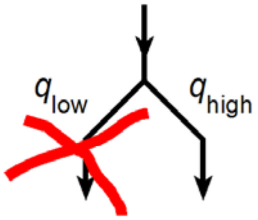
with,

q_1, q_2	water discharge (m^3/year) for the two distributaries
s_1, s_2	channel gradient of the two distributaries (directly downstream of the bifurcation)

Channel network evolution

- a channel disappears when

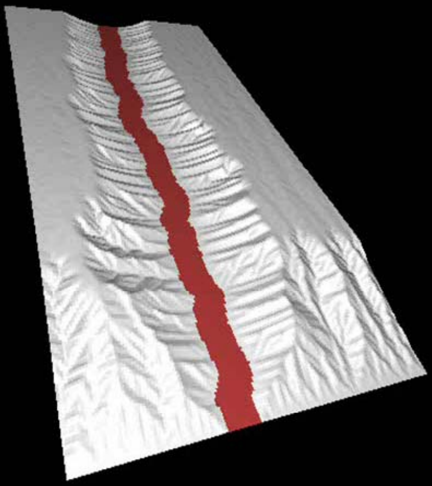
$$\frac{q_{low}}{q_{high}} \leq u_{crit}$$



with, at the bifurcation,

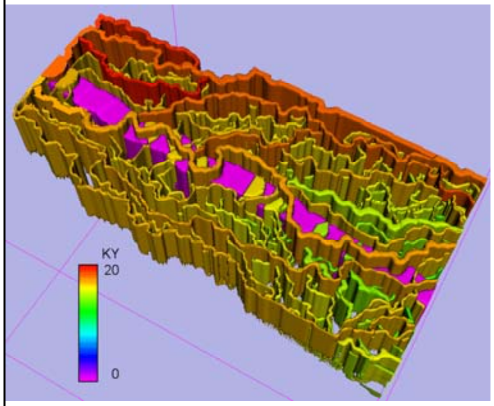
q_{low}	water discharge (m^3/year) of the channel with the lowest discharge
q_{high}	water discharge (m^3/year) of the channel with the highest discharge

Sensitivity to u_{crit}: $u_{crit} = 0.4$ (was 0.48)

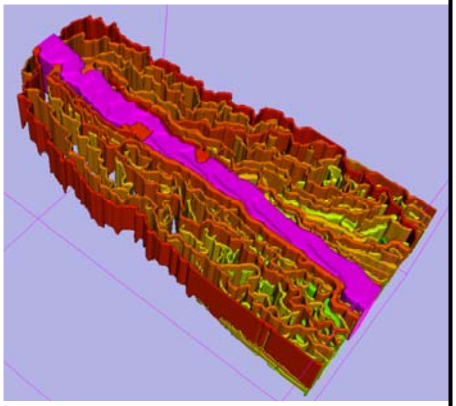


Sensitivity to u_{crit}

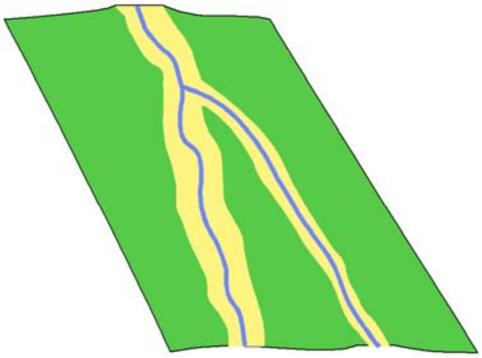
$u_{crit} = 0.4$



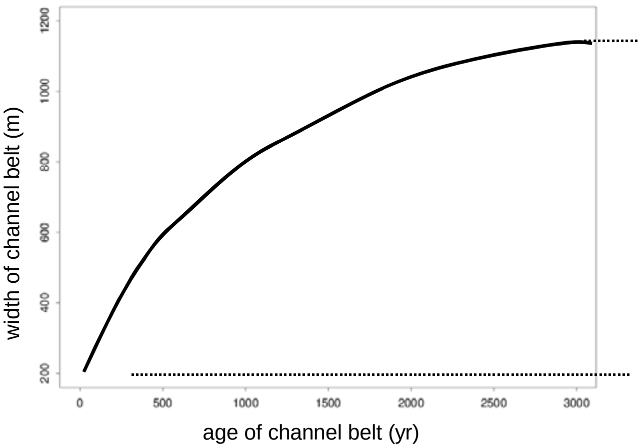
$u_{crit} = 0.48$



Overbank deposition



Increase in channel-belt width

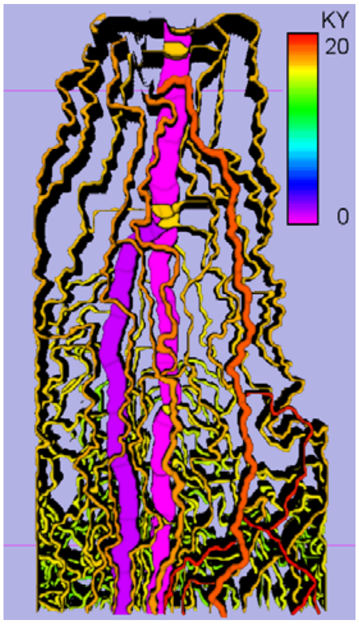


maximum width
of channel belt (m),
function of channel
width

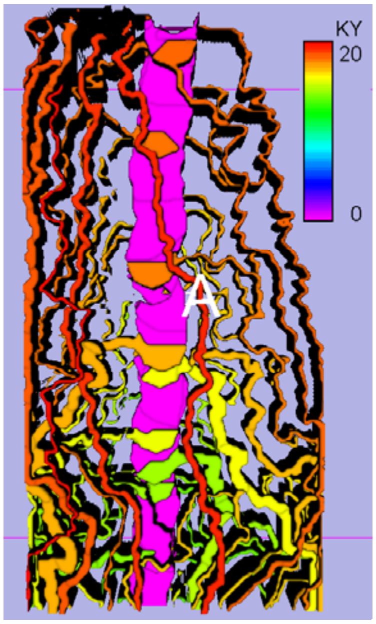
minimum width
of channel belt (m),
equals channel width

Bank erodibility parameter defines rate of increase in width

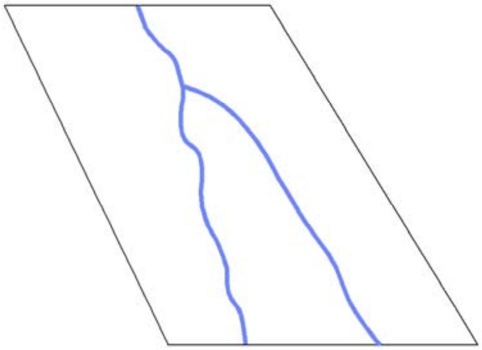
Low bank erodibility



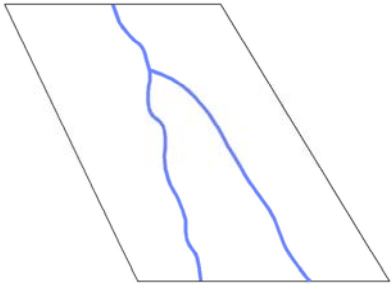
High bank erodibility



Sediment transport through the channels



Diffusion



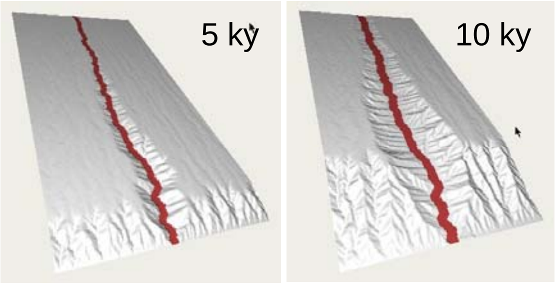
$$q_s = a q_w \frac{\partial h}{\partial x_c}$$

q_s	sediment transport (m^3/yr)
q_w	discharge (m^3/yr)
a	parameter
h	elevation of the bank of the channel (m)
x_c	distance along the channel

Changing the diffusion parameter and sediment input

standard run

diffusion x 5,
sediment input /5



Changing the diffusion parameter and sediment input

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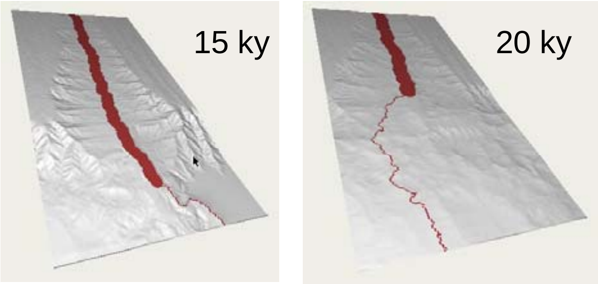
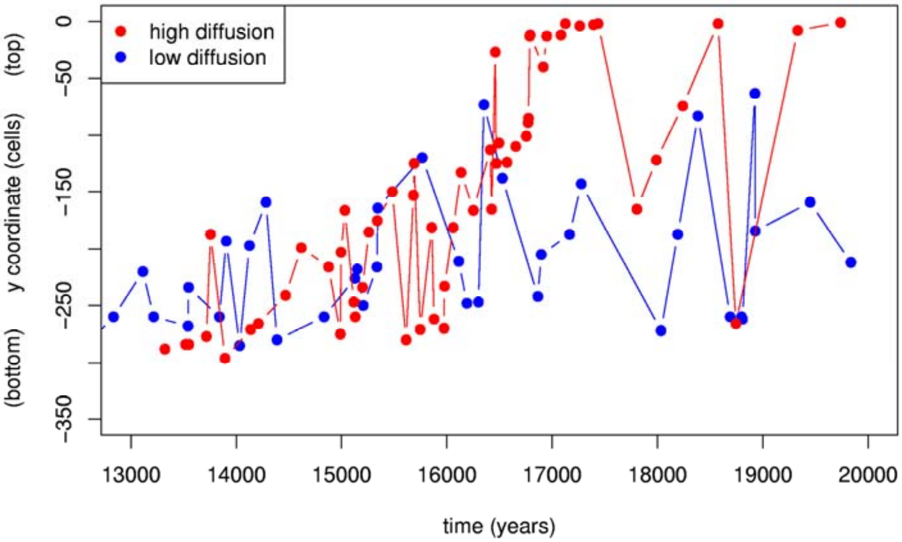
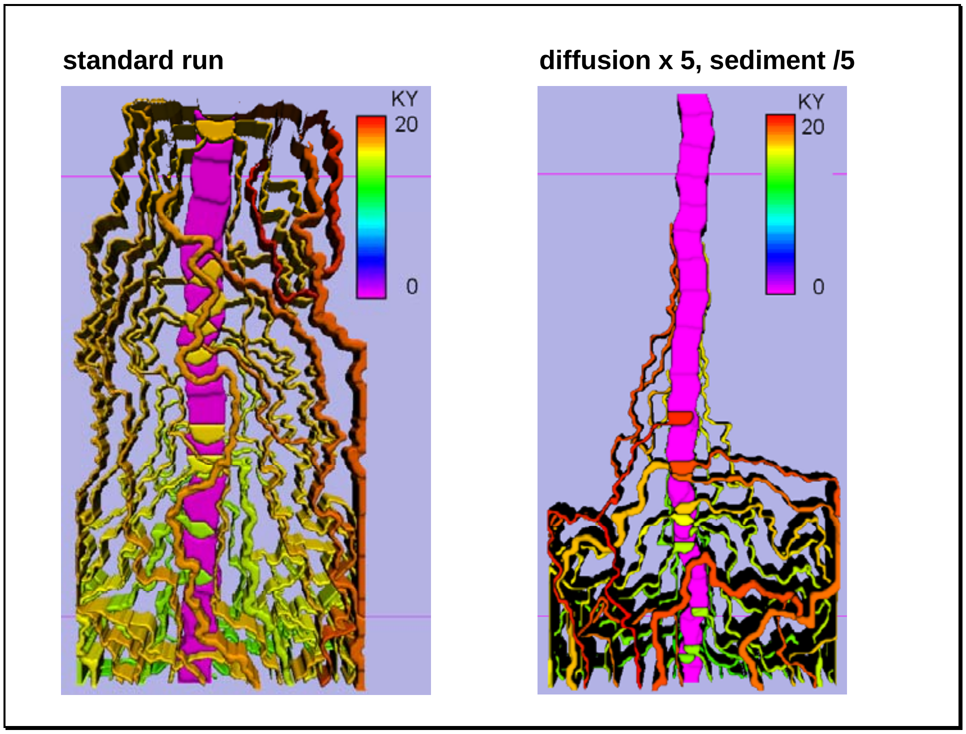


diffusion x 5,
sediment input /5

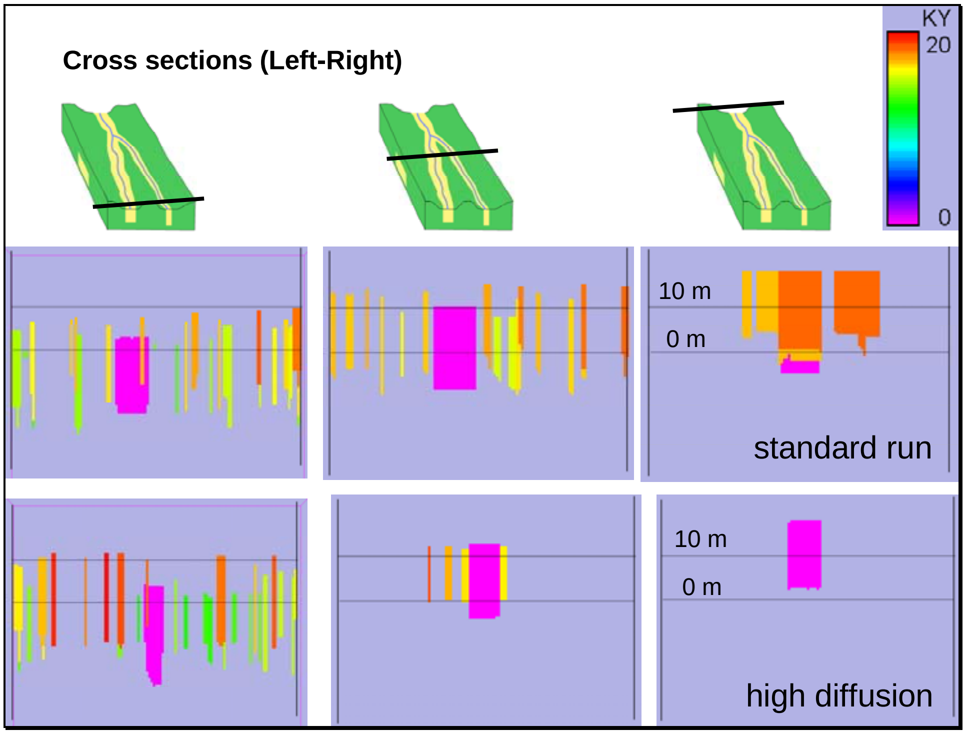
Effect on bifurcation location





standard run

diffusion x 5, sediment /5



Cross sections (Left-Right)

standard run

high diffusion