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KTT workshop for Hydropower

Impacts of climate change on reservoir sedimentation in the periglacial environment

Supported by:

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Reservoir sedimentation

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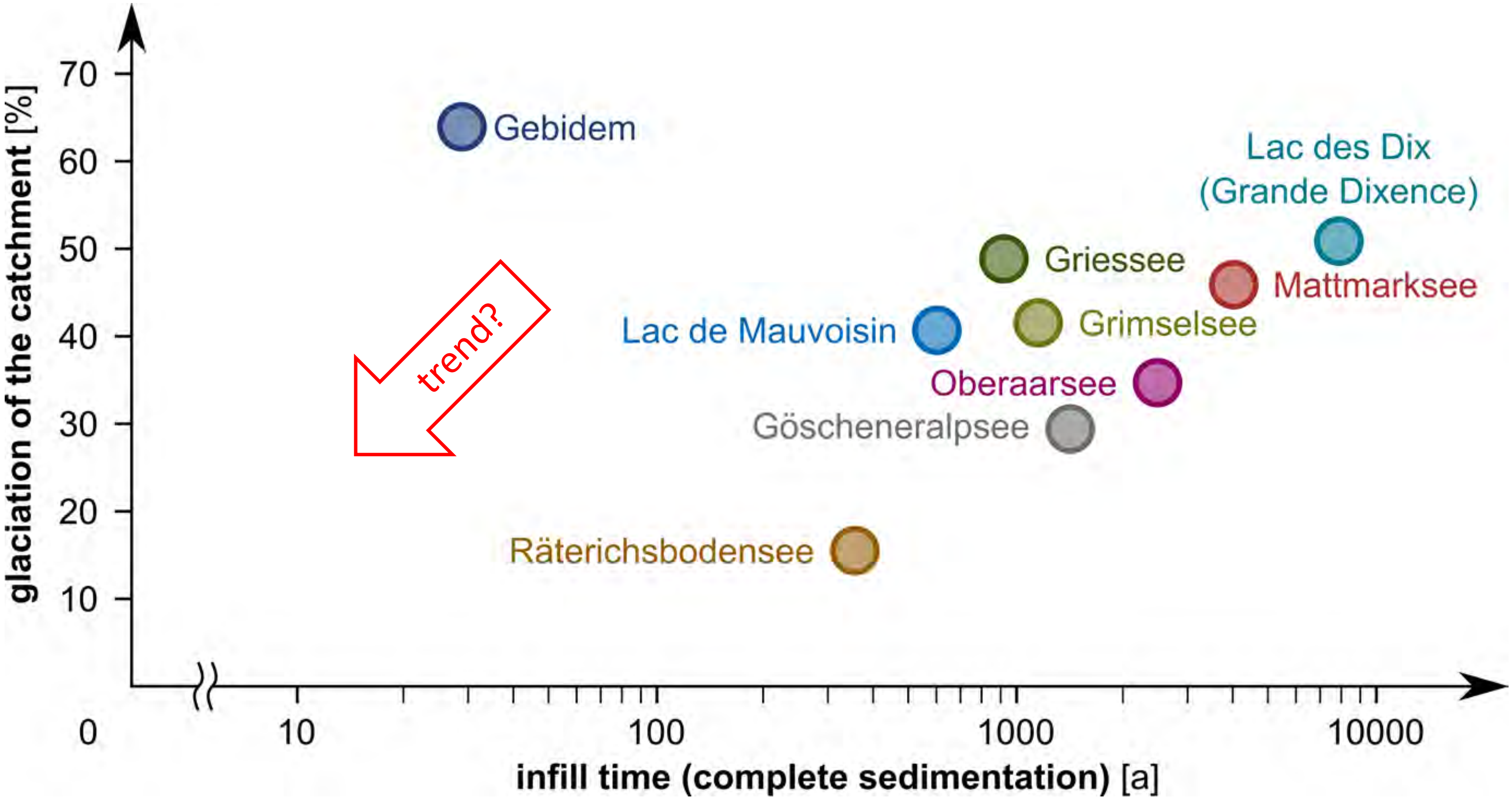

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data from: Schleiss et al. (1996), Beyer-Portner (1998), Anselmetti et al. (2007), Meile et al. (2014), Ehrbar et al. (2017)

Drivers and processes

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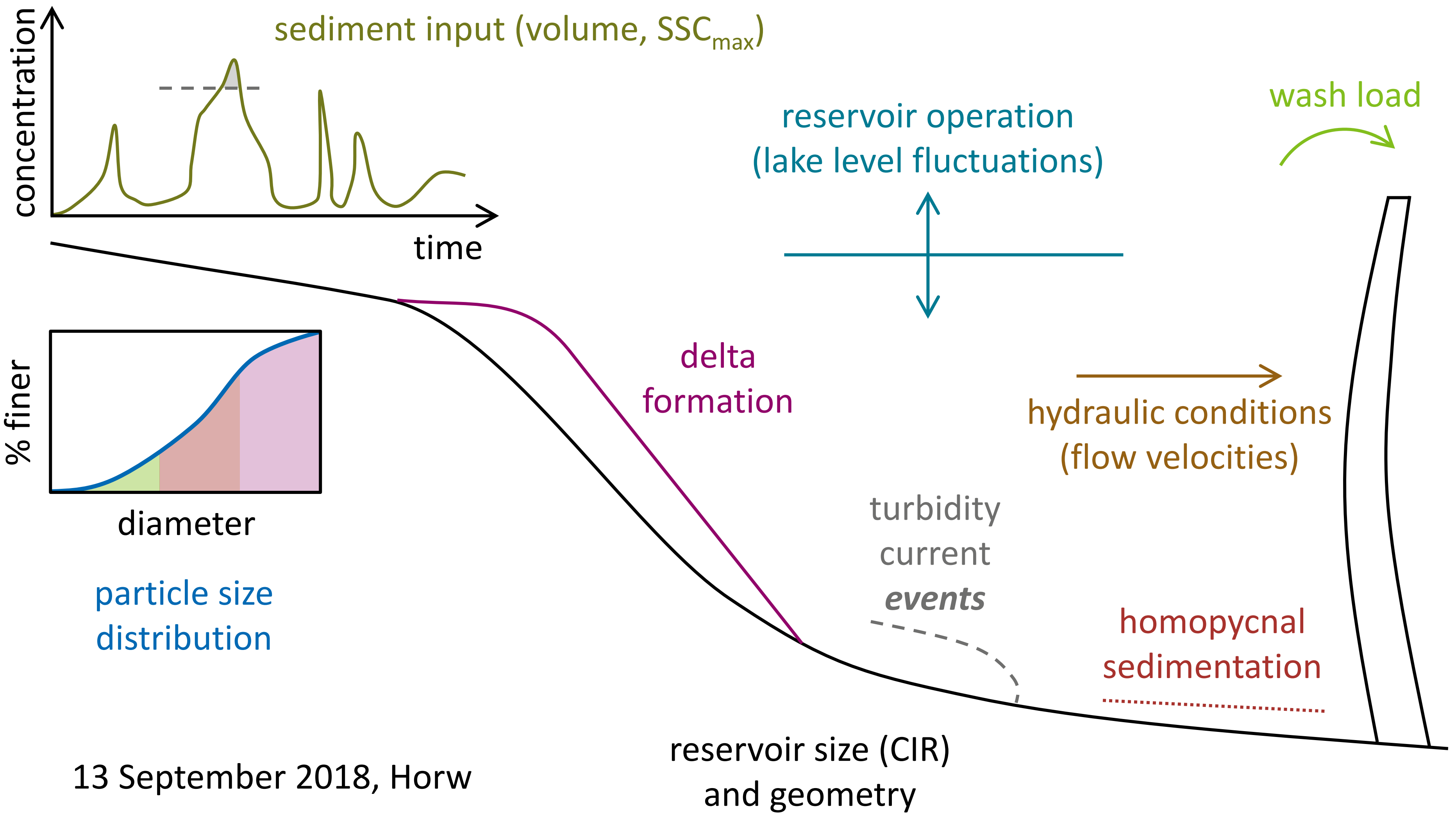

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Case study Gebidem

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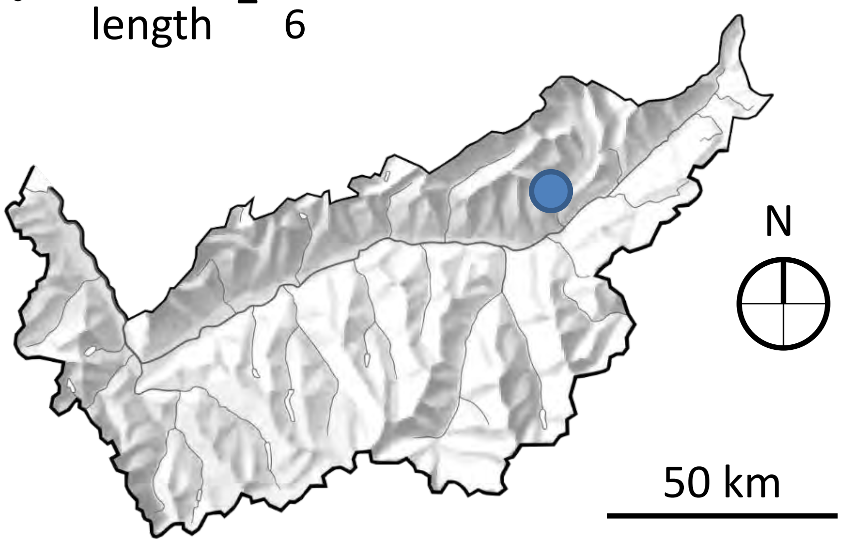
- capacity-inflow ratio (CIR) = 0.02
- infill time = 20–30 years
- $\frac{\text{width}}{\text{length}} = \frac{1}{6}$



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Numerical 1D model

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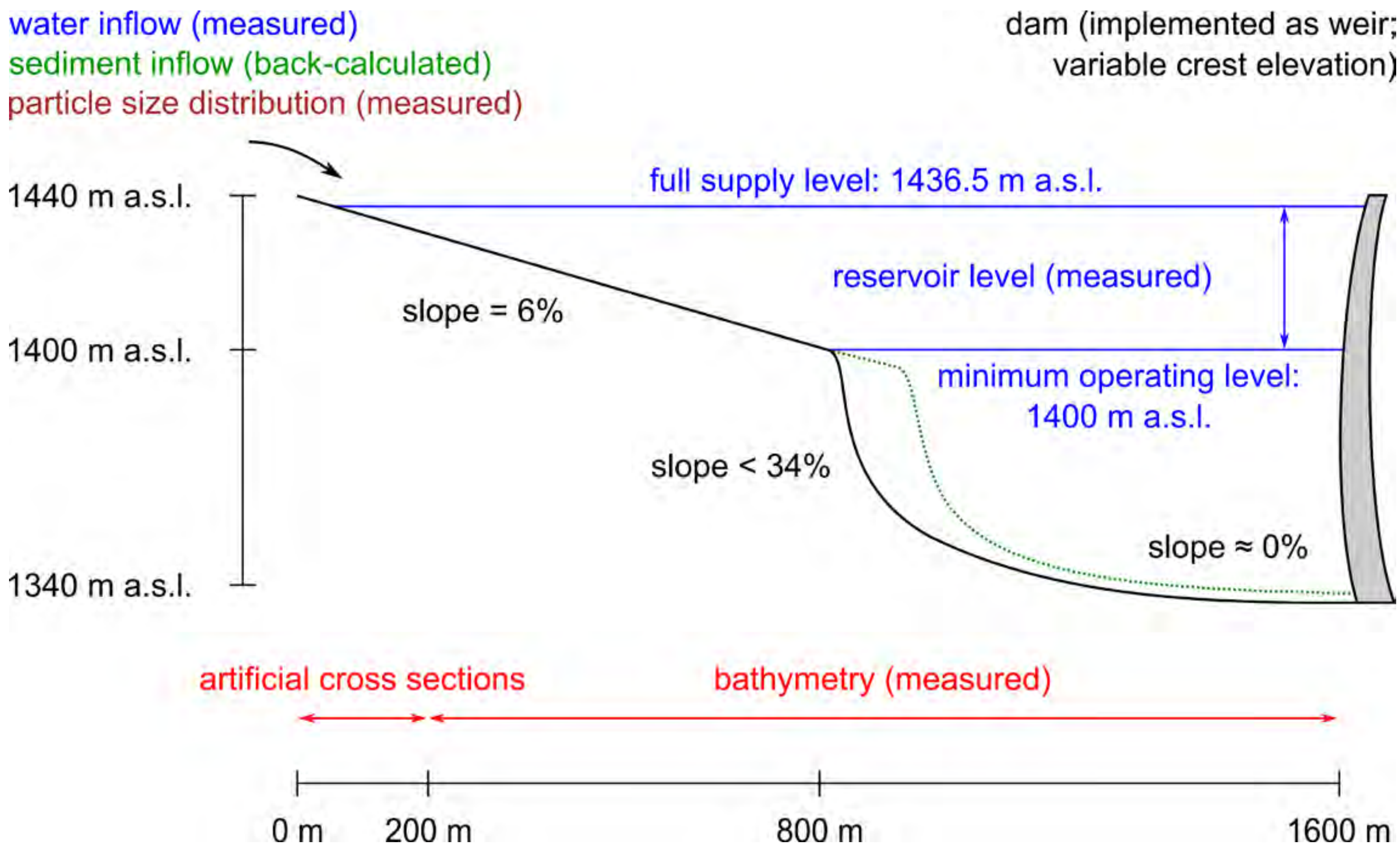

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Bathymetry measurements

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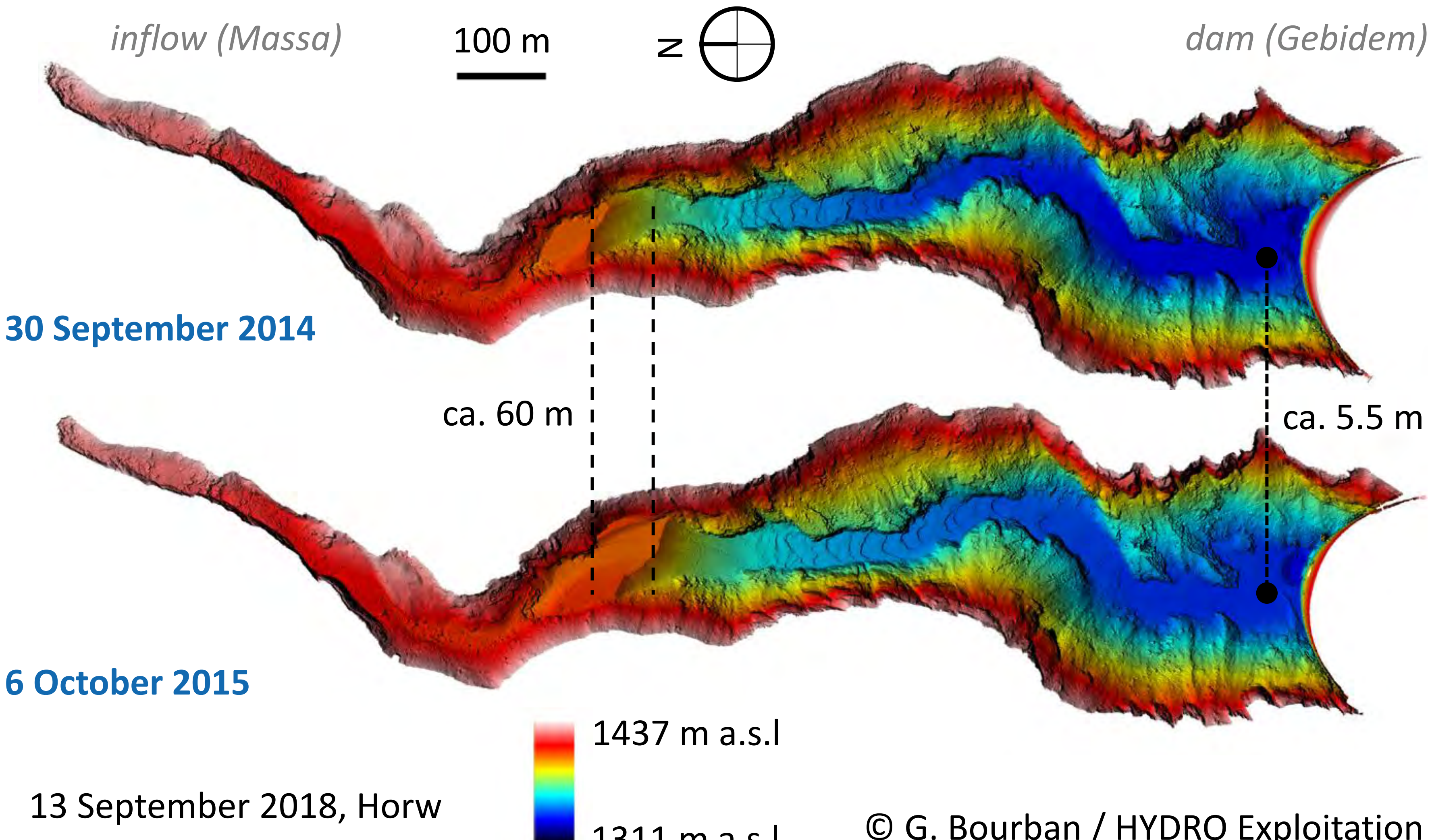

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Boundary conditions 2015

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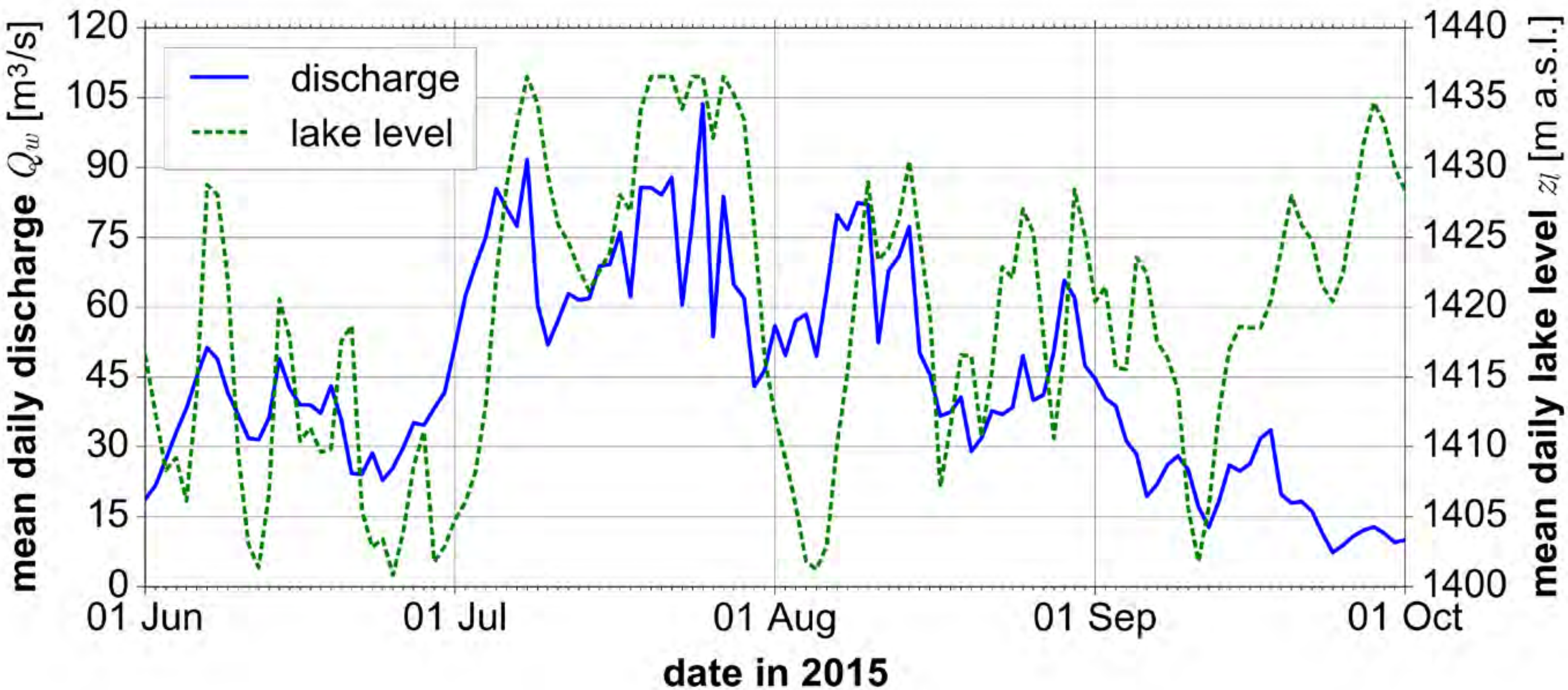

Results calibration 2015

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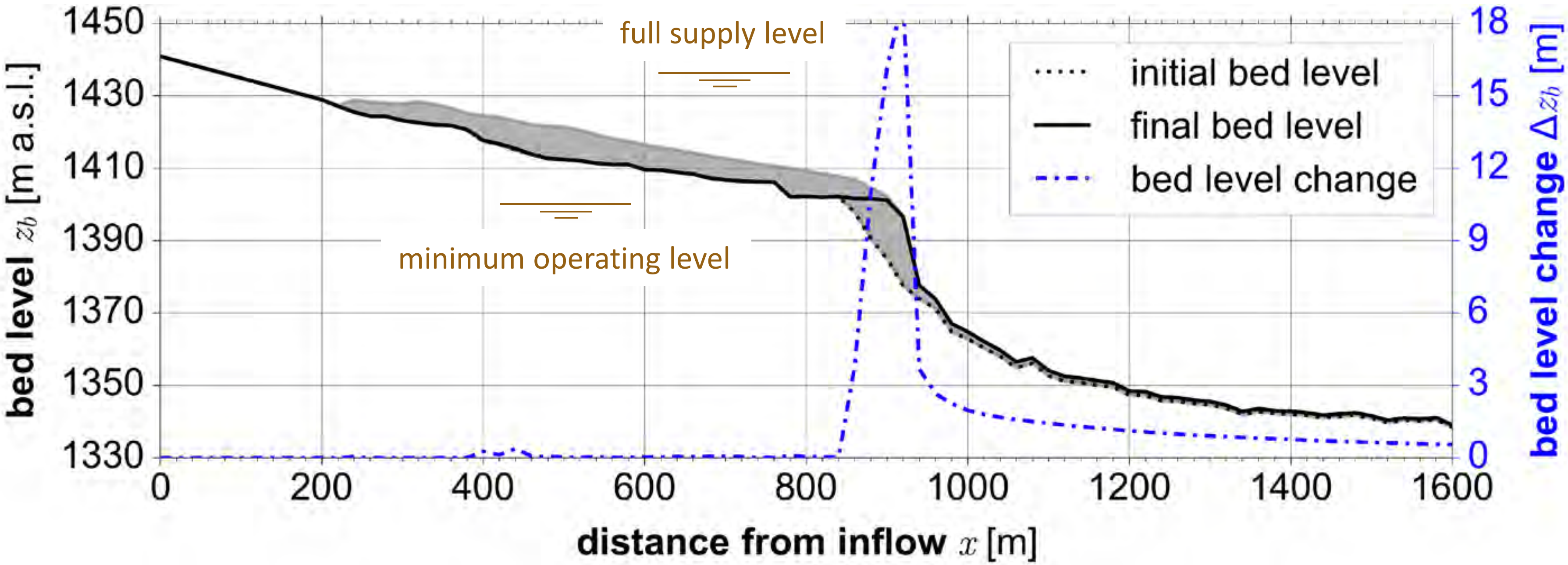

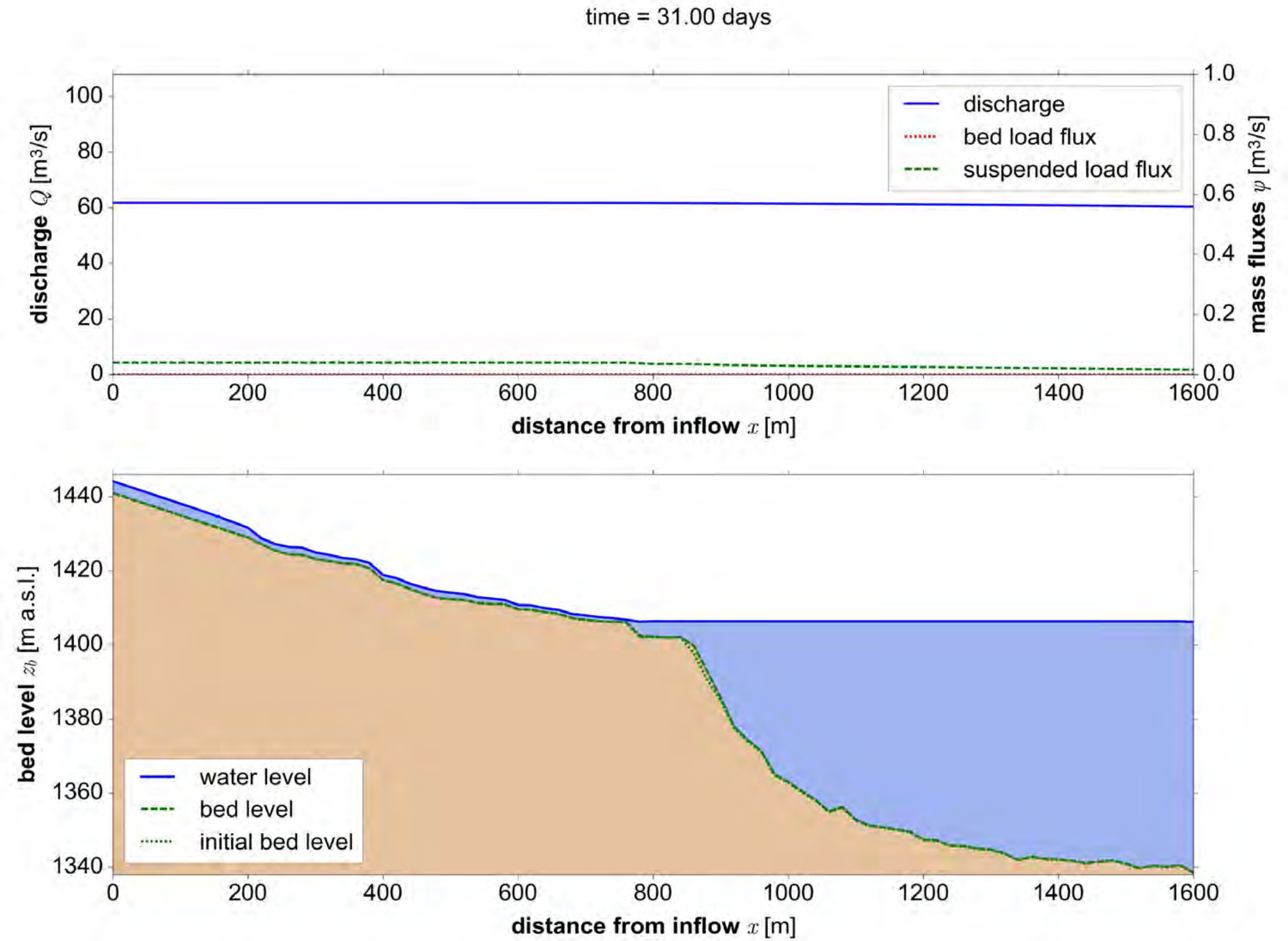
time = 31.00 days
discharge
bed load flux
suspended load flux
discharge Q [m³/s]
mass fluxes ψ [m³/s]
distance from inflow x [m]
water level
bed level
initial bed level
bed level z_b [m a.s.l.]
distance from inflow x [m]

Results calibration 2015

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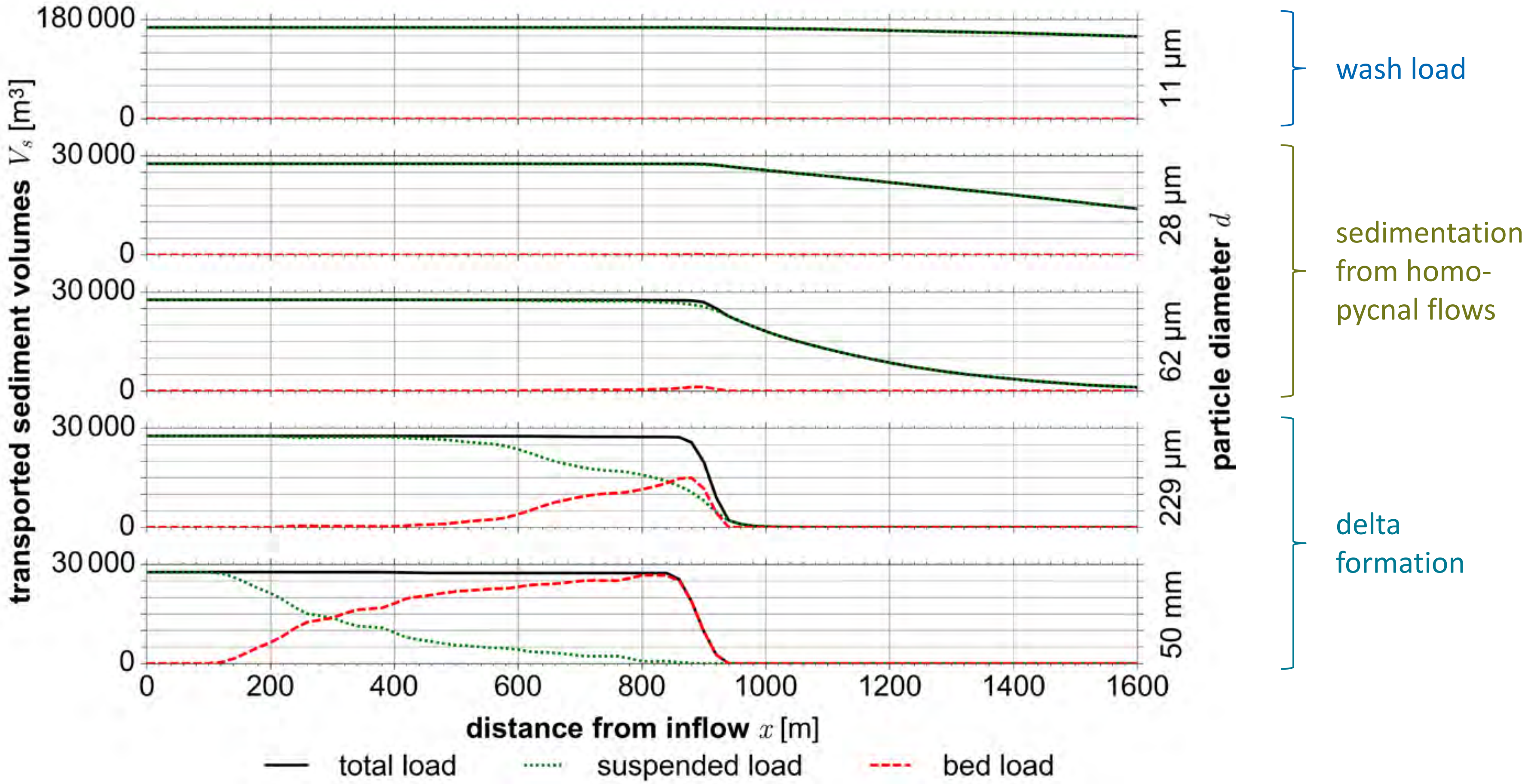

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Sensitivity of PSD

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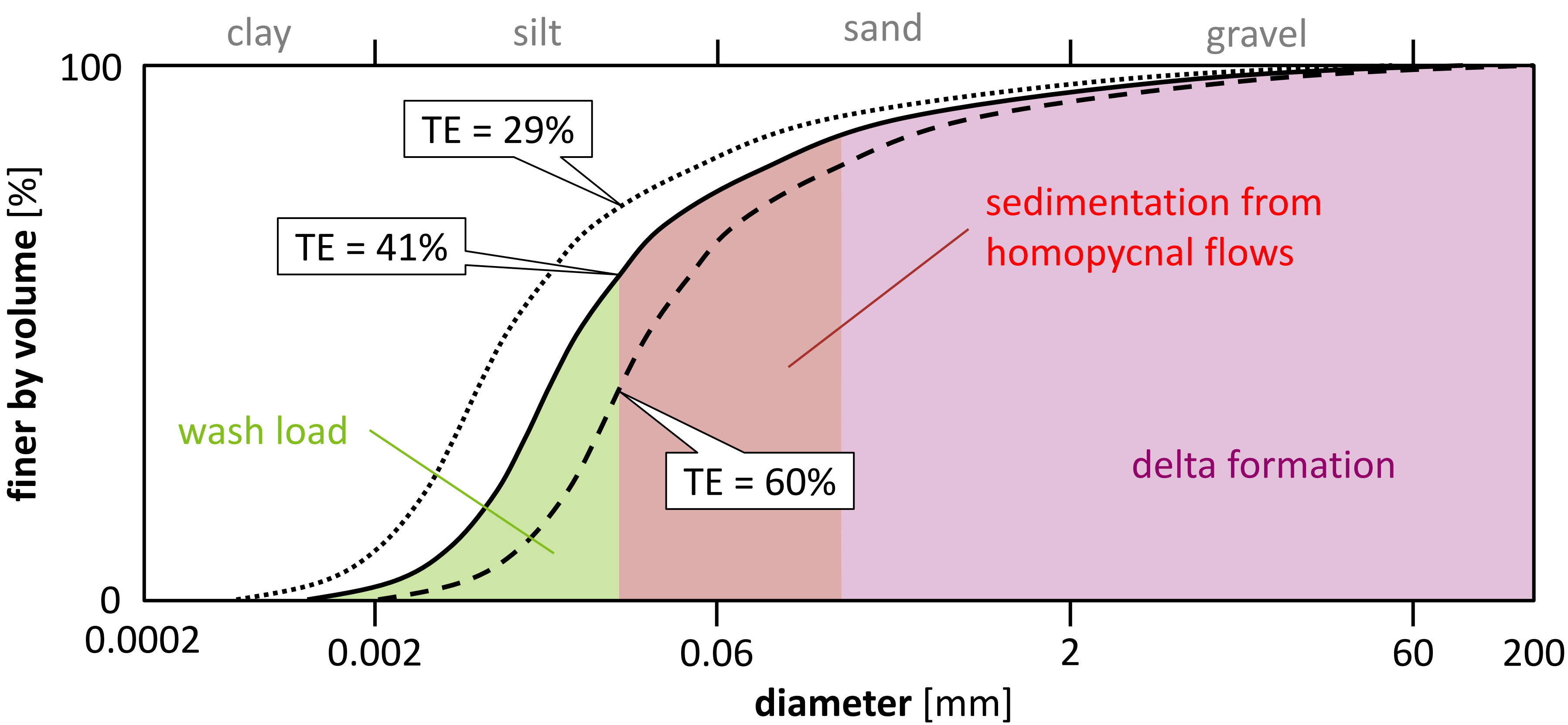

Sensitivity of sediment input

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- Müller & Förstner (1968): $SSC = a \cdot Q^b$ → here: a = 0.001; b = 1.8
- Gurnell et al. (1996): $V_S = \dfrac{V_W^{1.167}}{\rho_S \cdot 10^{1.462}}$
- Costa et al. (2018): $SSC = a_1 ER^{b_1} + a_2 IM^{b_2} + a_3\, SM^{b_3} + a_4\, HP^{b_4}$

SSC	susp. sediment concentration [kg/m^3]
Q	discharge [m^3/s]
a, b	calibration coefficients [–]
V_W	annual runoff volume [m^3]
V_S	annual sediment input [m^3]
ER	mean daily erosive rainfall [mm/d]
IM	mean daily ice melt [mm/d]
SM	mean daily snow melt [mm/d]
HP	daily release of water from virtual hydropower reservoir

Climate change and SSC

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year	2015	2040 («peak water»)
annual runoff volume		
• measured (BAFU, LH 2161)	536 hm^3 [100%]	
• SRES-A1B (Farinotti et al. 2012)		675 hm^3 [126%]
annual suspended sediment input		
• Gurnell et al. (1996)	0.20 hm^3 [100%]	0.26 hm^3 [130%]
• Müller & Förstner (1968)	0.28 hm^3 [100%]	0.54 hm^3 [193%] *

* applying the calibrated SSC-Q relationship to the upscaled (x 1.26) hydrograph of 2015

Conclusions

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future particle size distribution (PSD):
- connectivity: proglacial lakes as natural “desanders”?
- availability/accessibility: magnitudes of pro-/subglacial erosion?

future suspended sediment concentrations (SSC):
- relationship between SSC and Q: approach for changing climate?
- frequency of turbidity currents: peak SSC, peak input volume?

future reservoir operation (hydraulic conditions inside reservoir):
- drawdowns: more partial flushings because of additional water?
- fluctuations: more intense due to grid stabilisation operations?

Questions?

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