Measuring and modeling subglacial sediment transport in the Swiss Alps

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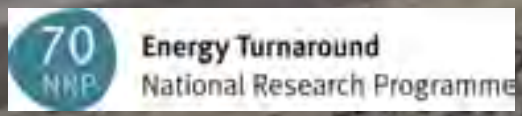


glacier sediment

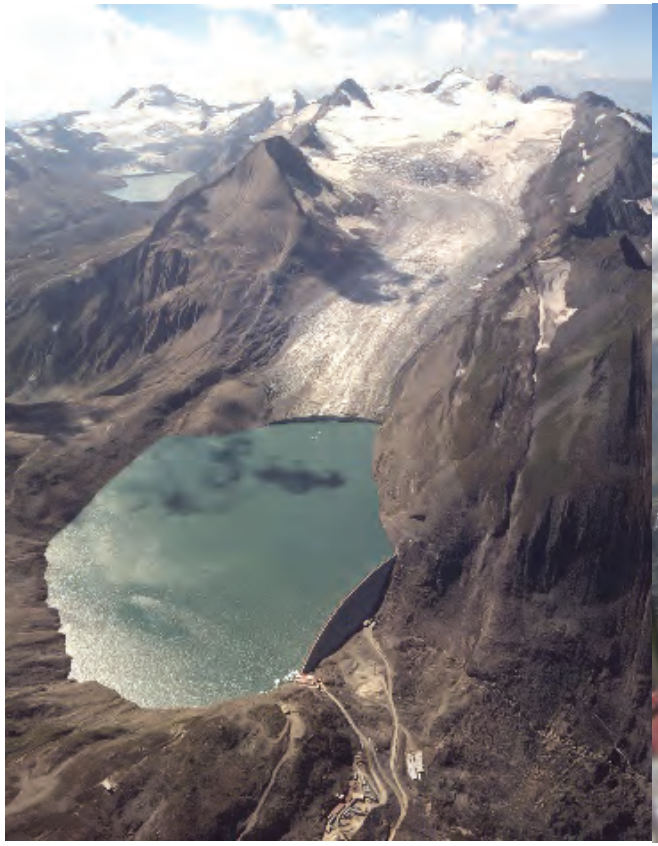
Griesgletscher

sediment sources

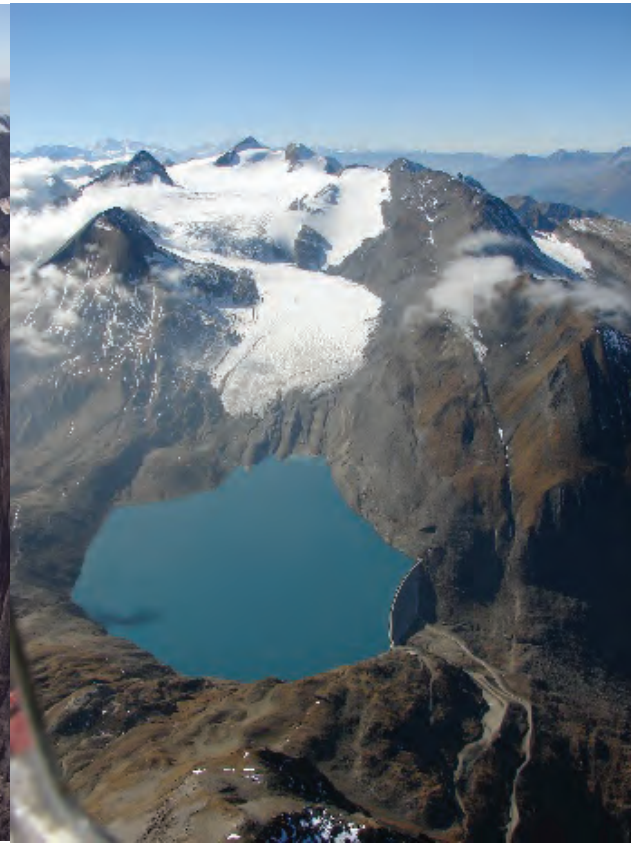
from **around** the glacier

from **below** the glacier

proglacial areas



1973

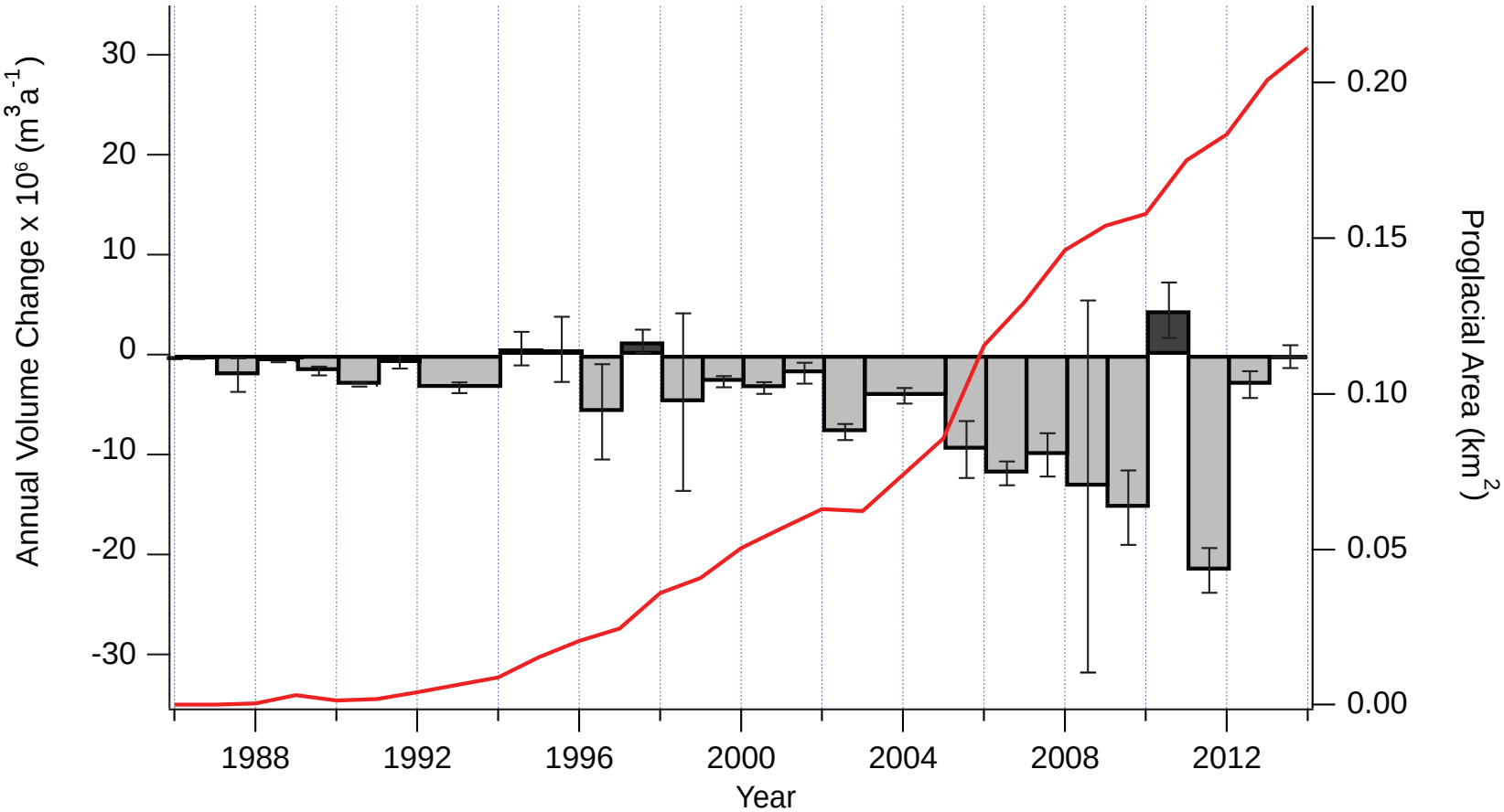


2010

photos from SwissTopo and G. Kappenberger

digital surface models created from annual aerial photographs

proglacial erosion



Increase in recent volume loss from Griesgletscher's proglacial area determined from photogrammetrically derived DEM subtraction.

subglacial sediment: how important?

Timespan	**% Vol. Subglacial**	**ΔH PGA**	**ΔH Subglacial**
		cm a^{-1}	cm a^{-1}
1976(86) - 2014	72 %	-5.96	-0.10

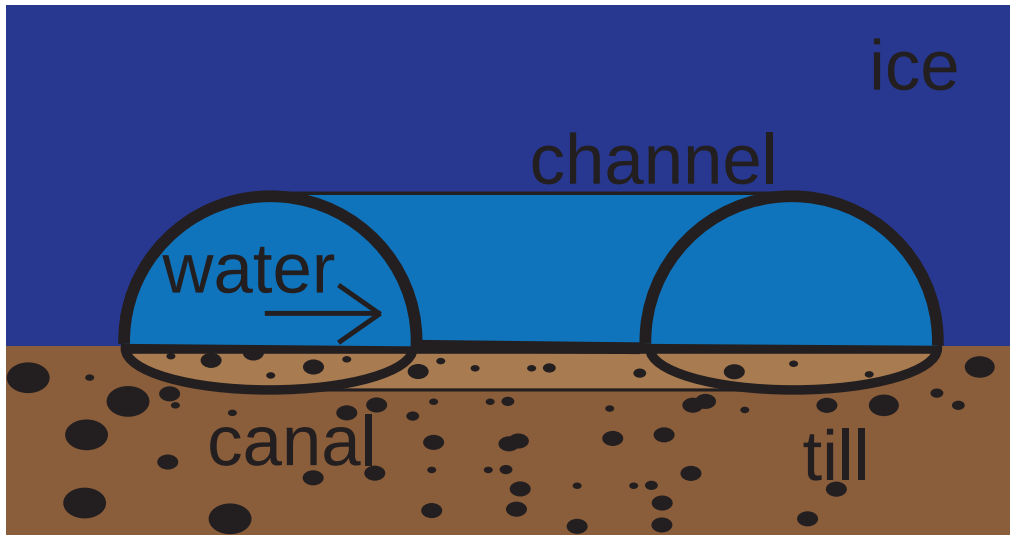
photo G. Kappenberger

More recent comparisons suggest that the amounts of subglacial sediment increased in recent years.

subglacial sediment: how important?

- proglacial areas could stabilize relatively quickly.
- our data suggests that more sediment originates subglacially than proglacially.

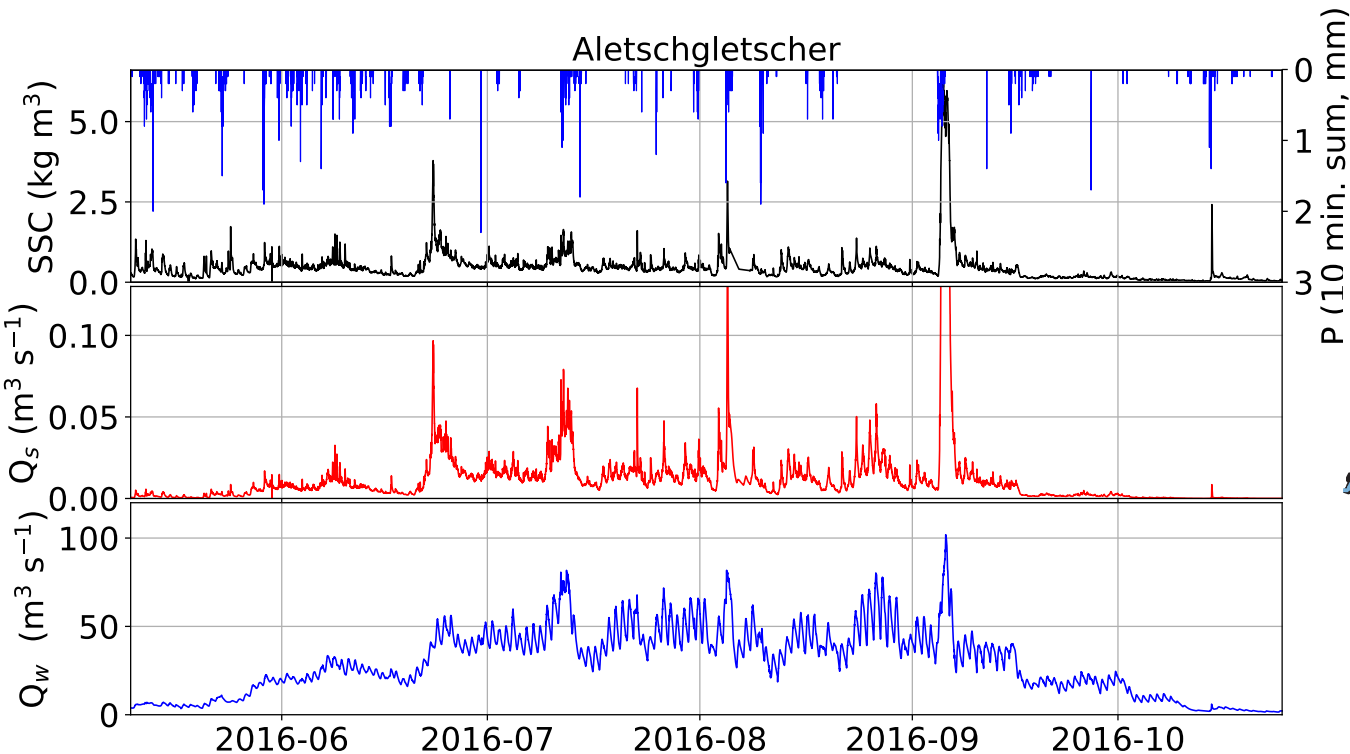
(Delaney et al., 2018)



so to understand alpine sediment dynamics, we must understand **subglacial sediment transport** as well!

subglacial sediment: sediment and water

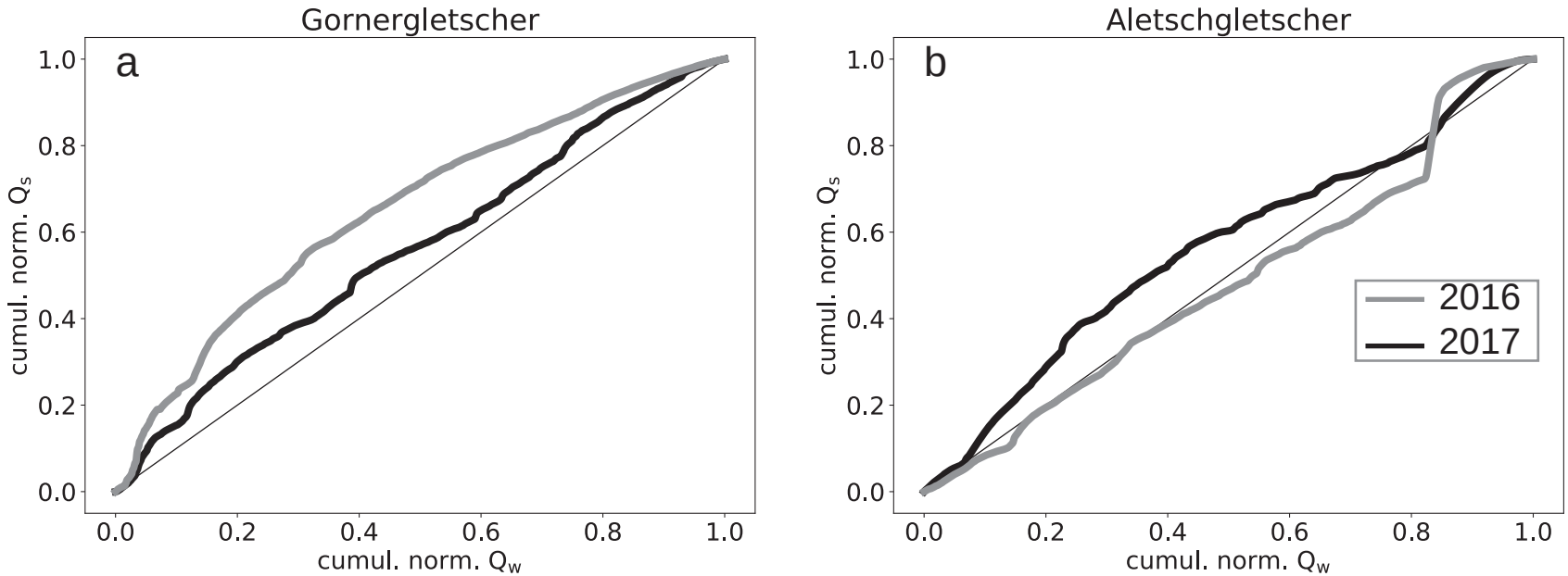
sediment data from Gorner and Aletsch glaciers over 2016 and 2017



but the relationship is not always very strong. . .

(Delaney et al., *in revision*)

subglacial sediment: sediment availability



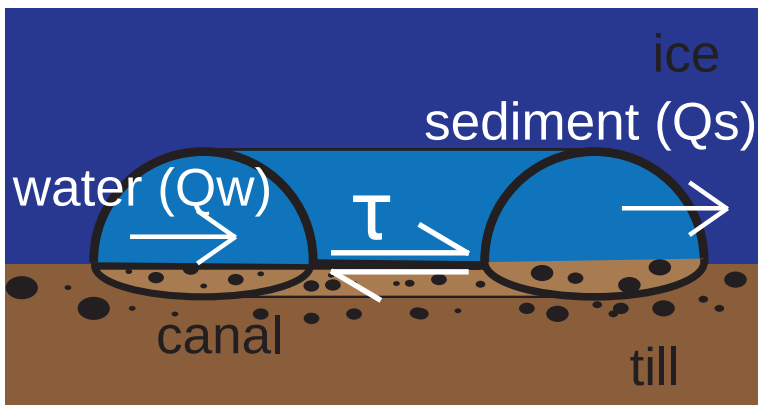
so subglacial sediment availability must be considered.
(Delaney et al., *in revision*)

modeling: framework

sediment discharge $= f$(sediment availability, shear-stress)

shear-stress $= f$(hydraulics)

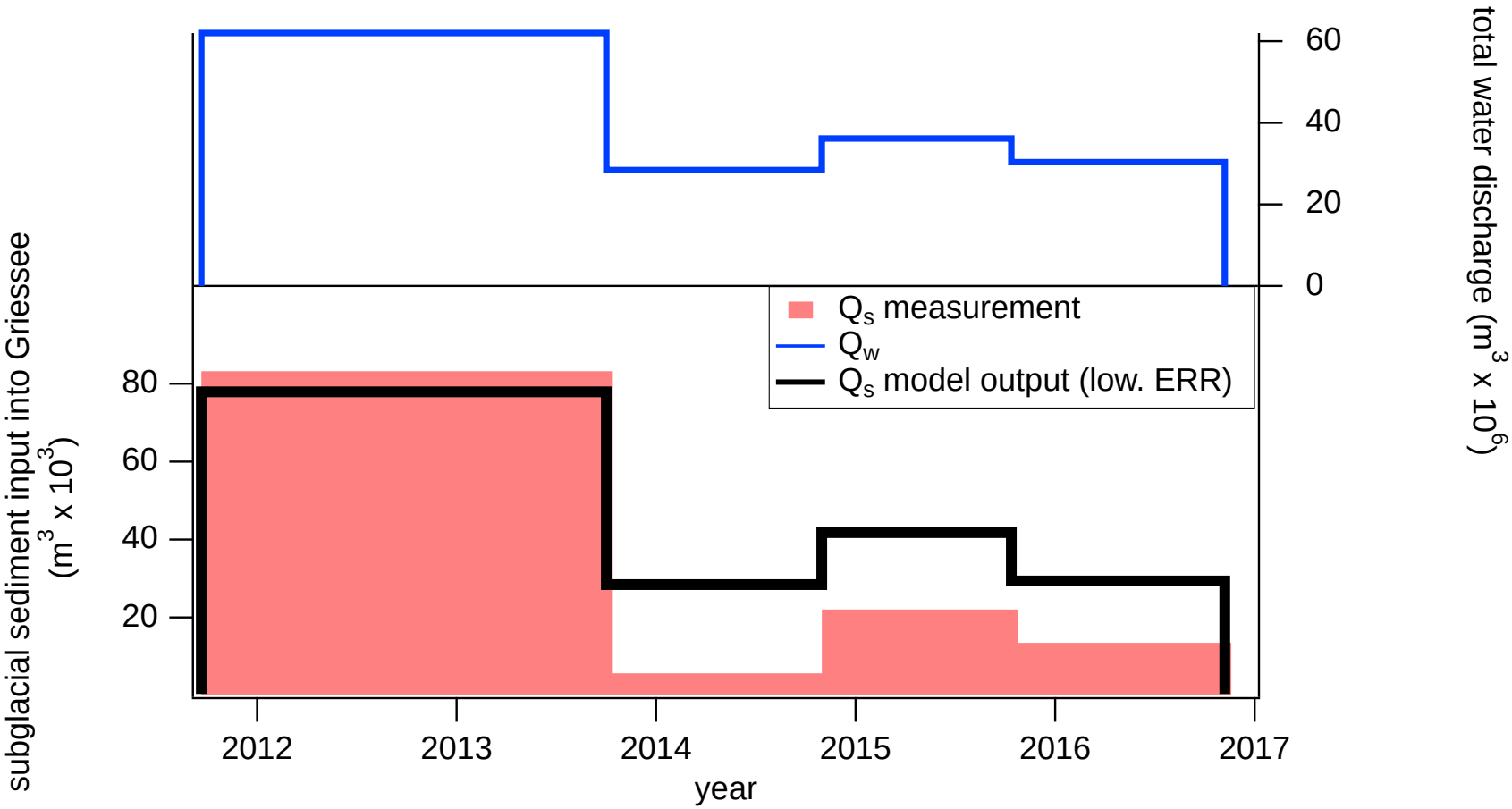
so several models must be implemented:



1. a hydraulics model (Darcy-Weissbach)
2. a sediment transport model (Engelund-Hansen, 1967)
3. a till layer model (sliding relationship)

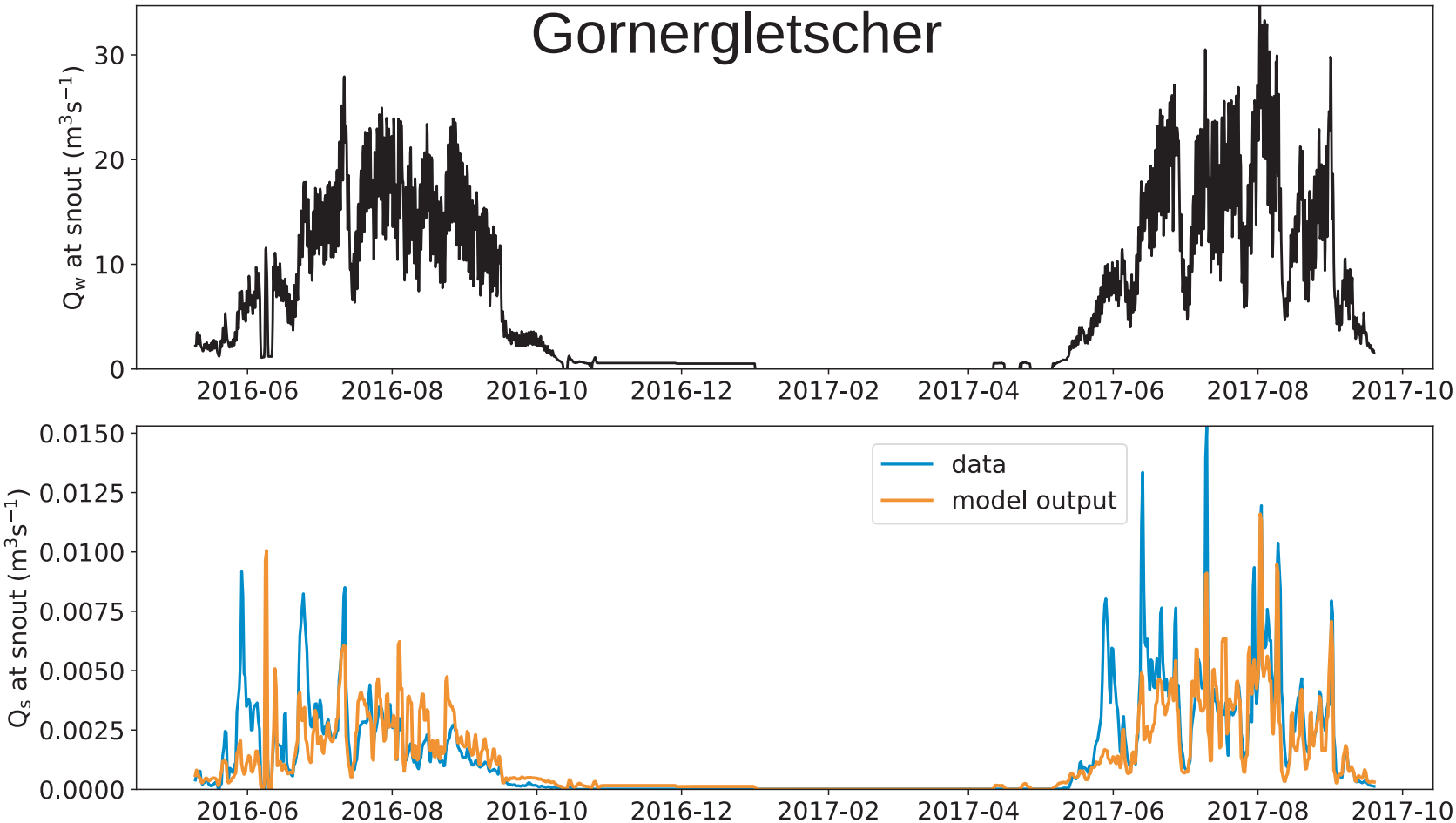
model performance: multi-year time spans

Griesgletscher 2011-2016



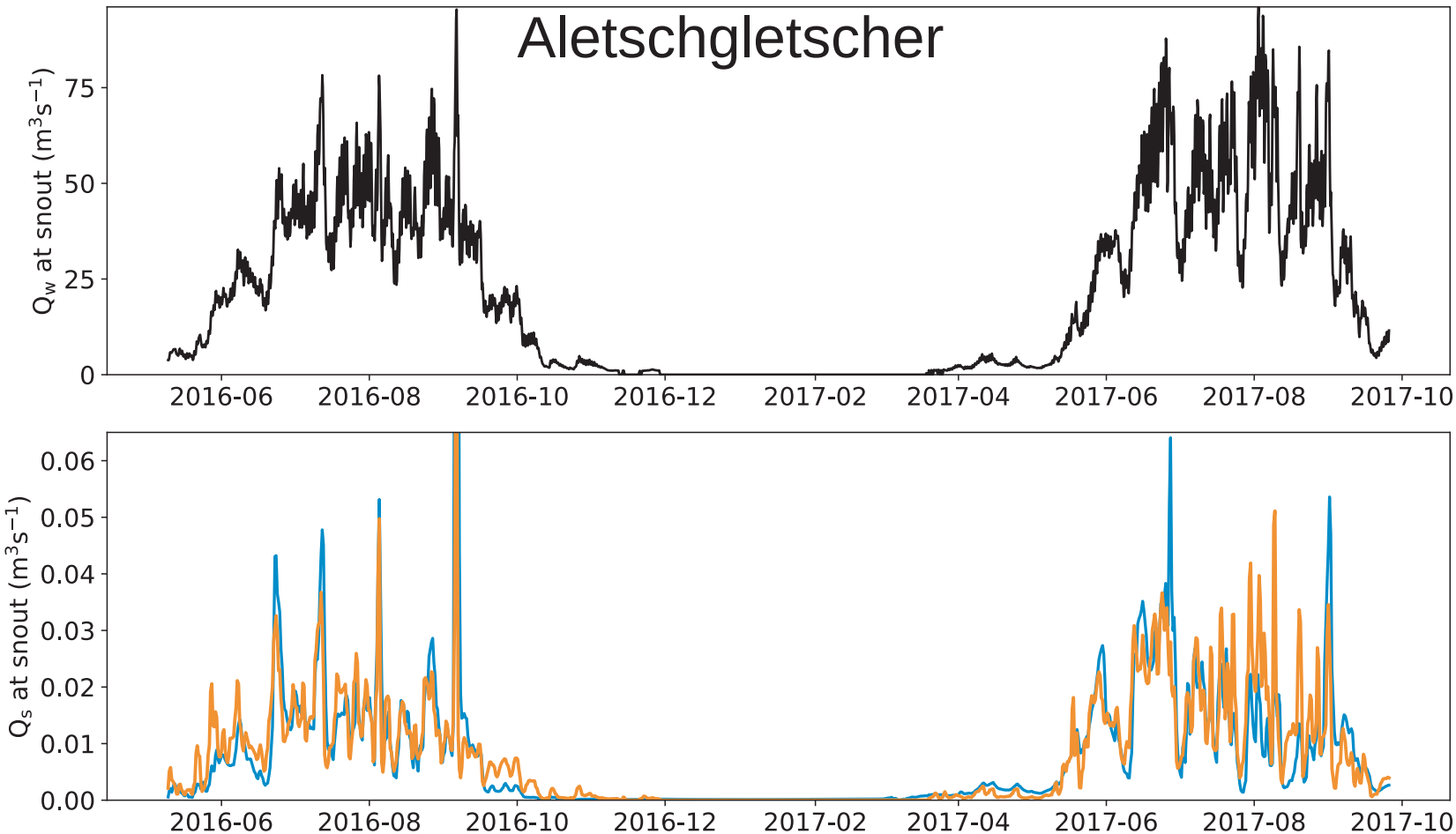
- interannual variations are captured...
- but there are some difficulties with extreme years
  - demonstrating limitations of sediment availability scheme

model performance: seasonal time spans (Gorner)



- Nash-Sutcliffe: 0.70
- captures total sediment discharge within 15%

model performance: seasonal time spans (Aletsch)



- Nash-Sutcliffe: 0.54
- captures total sediment discharge within 15%

final thoughts

- smaller amounts of sediment come from **proglacial areas** compared to **subglacial sources** . . .
  - . . . *but* erosion rates in **proglacial areas** are greater
- a subglacial sediment transport can be **modelled** with reasonable ability

. . . now these **observations** and **models** needs to better assess how **sediment dynamics** will evolve in a changing climate.