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May 31
June 1
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2022



3rd edition of the international symposium

Climat change & water

EXTREMES EVENTS

Water and environments

New Auditorium Thélème, Tours, France



Problem of hydrological metrology of low streams and impact on the estimation of water resources

Pierre-Alain Ayras*, Jean-Marc Domergue*, Nadine Grard*, Anne Johannet,
Didier Josselin***



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Outline

- Context of climate change and its effects on water “mood”
- Methods to assess water flow in low streams
- Methodological concerns and conclusion

Context of climate change and its effects on water moods

- Floods
- Drought
- Erosion
- Large rain gaps

Region of study



The Lozère Mount (≈ 1700 m)



Source :
[https://www.castagnere.com/pages/situatio
n.html](https://www.castagnere.com/pages/situatio
n.html),
consulté le 07/05/2021

Delaire, 2021

Site of la Baume

From flash floods to low streams



Réalisation : Didier Josselin, 2021

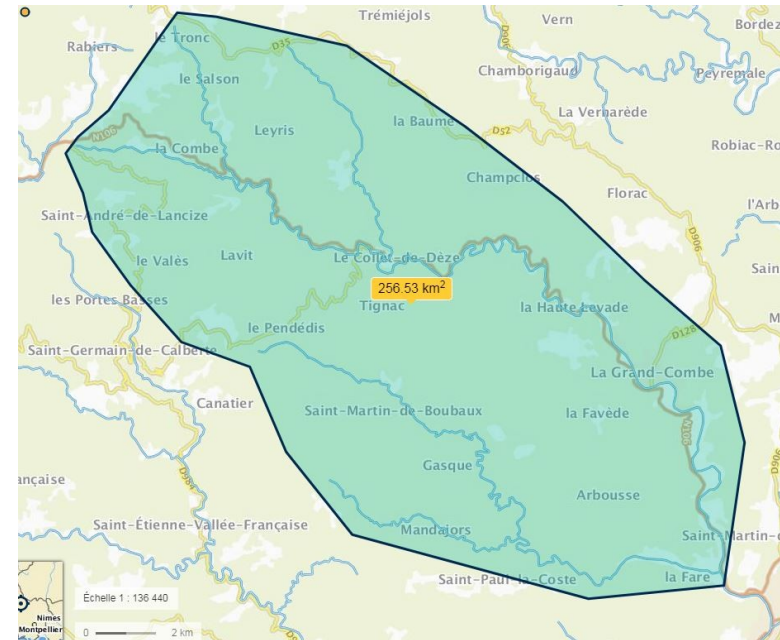
Landslide in 2020 at St-André de Valborgne (Southern France)

Réalisation : Mathilde Delaire, 2021

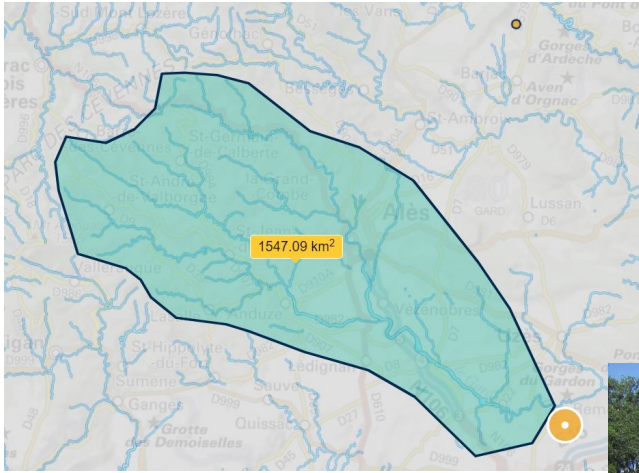
The site of Blaquière



Gauging with salt



The site of the Baume



Gauging with a velocimeter based on Doppler radar ultrasound



Methods to assess water flow in low streams

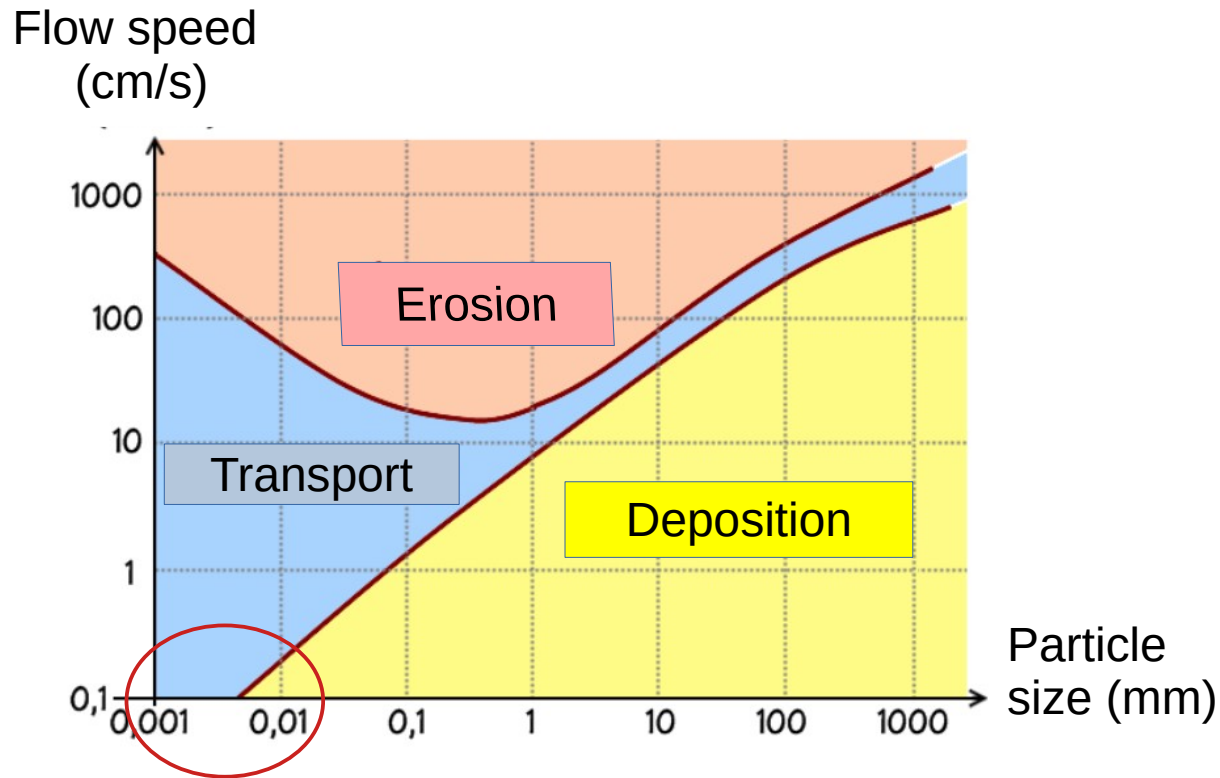
- Type of material
- Gauging
- Rate curve
- Estimation on the two sites

Few methods to estimate flow rate

- Based on *time* : e.g. water volume or floater displaced on a time period
- Based on *water chemistry* monitoring : e.g. **salt dilution**, conductivity
- Based on *water level and characteristics* : e.g. piezometric sensors (recording temperature, pressure, conductivity and water height)
- Based on *water speed, river bed* : e.g. « manual » velocimeter, **radar using Doppler ultrasound** to draw the river bed section shape

(Daum, 1994)

Relation between water flow and erosion



The Hjulström's curve (1950)

Water flow estimation (Q)

$$Q_{(m^3/s)} = \frac{M_{(m^3)}}{T_{(s)}} = S_{(m^2)} \cdot \frac{D_{(m)}}{T_{(s)}} = S_{(m^2)} \cdot V_{(m/s)} = H_{(m)} L_{(m)} \cdot V_{(m/s)}$$

mass → $M_{(m^3)}$
time → $T_{(s)}$
section → $S_{(m^2)}$
distance (length) → $D_{(m)}$
height → $H_{(m)}$
width → $L_{(m)}$
speed → $V_{(m/s)}$

$$E = Z + P + C = Z + \frac{p}{mg} + \frac{v^2}{2g}$$

relation (orange arrow from Q to E)
Variable (green circle around v^2)
Global constant (red circle around $\frac{p}{mg} + \frac{v^2}{2g}$)

With:

E the hydraulic load

Z the elevation

p the atmospheric pressure

m the fluid density

g Earth gravity constant

v the flow speed

Global constant

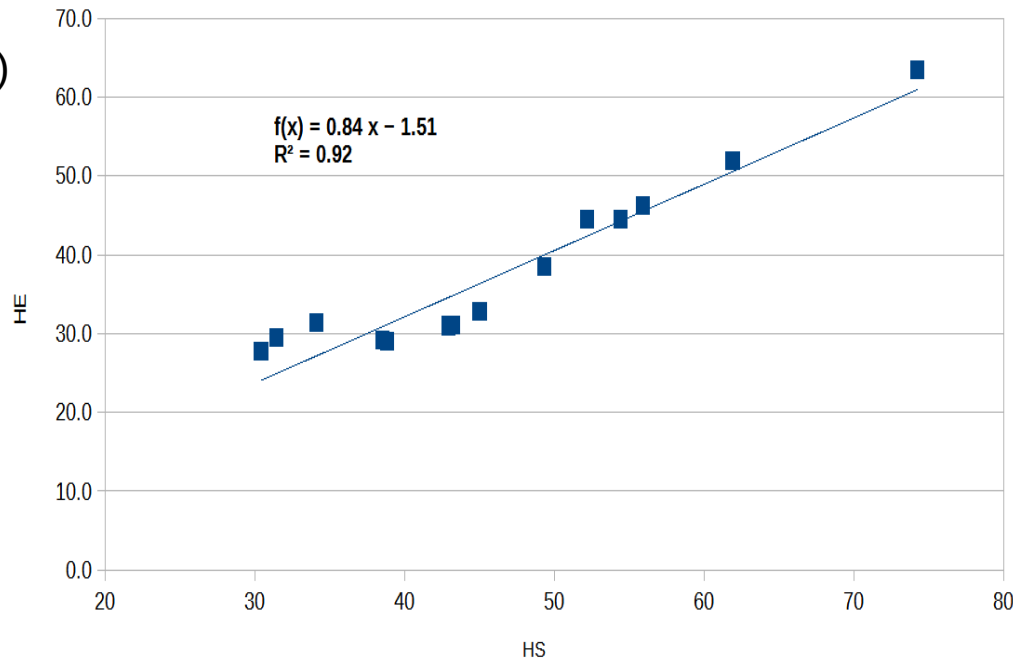
Bernoulli's theorem

Depends on the site

Relation between real observed water levels and those estimated by sensors

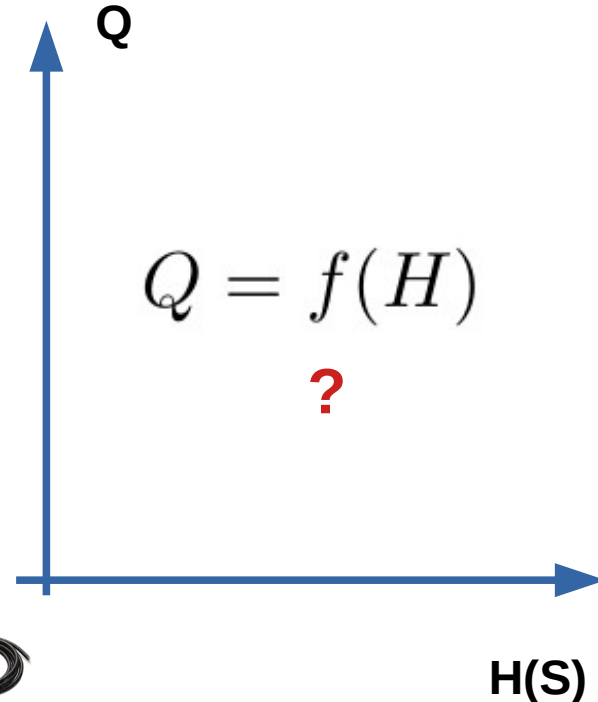
Water height read on the scale (HE)

From time to time



Water height measured by the level meter (HS)

Continuously



Confidence and prediction intervals

Confidence : “model-centered”

$$s(x) = \sigma(x) \cdot \sqrt{\frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}} = \sqrt{MSE \left[\frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2} \right]}$$

For $i=1$ to n gauging points

At any point x on the curve

Mean squared error : $MSE = \frac{1}{n} \sum_{i=1}^n (x_i - \hat{x}_i)^2$

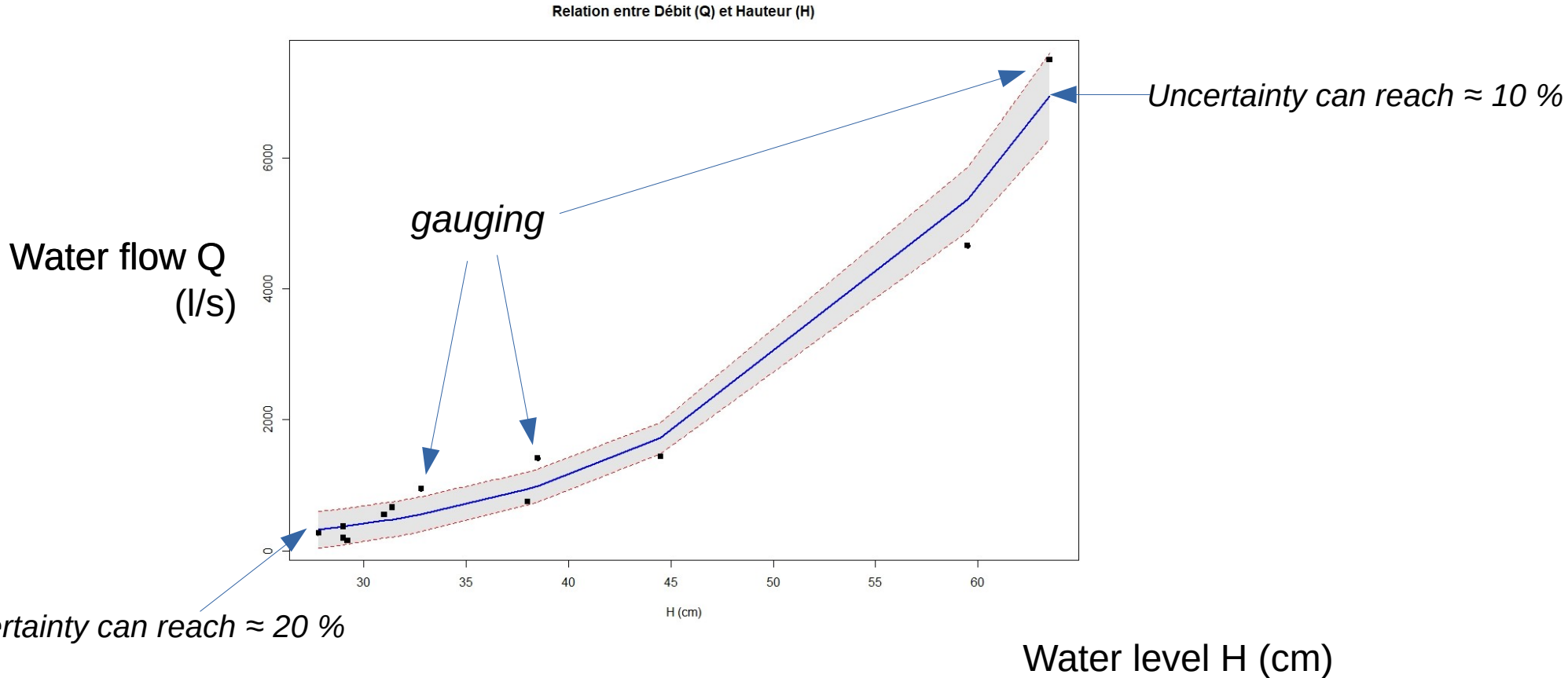
Observed value

Predicted value

Prediction: “individual-centered”

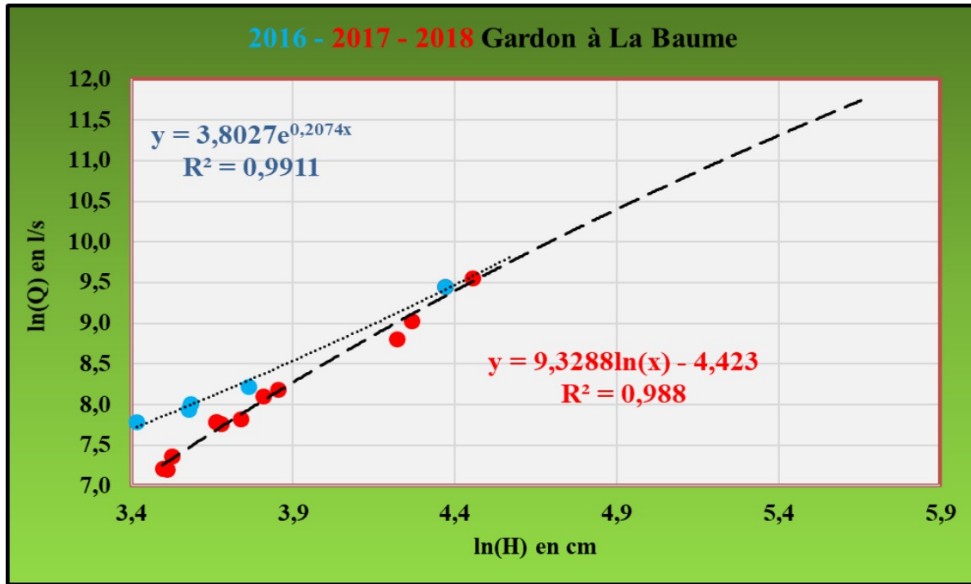
$$s(x) = \sigma(x) \cdot \sqrt{1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}} = \sqrt{MSE \left[1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2} \right]}$$

Rating curves in Blaquière with confidence intervals of 5 %

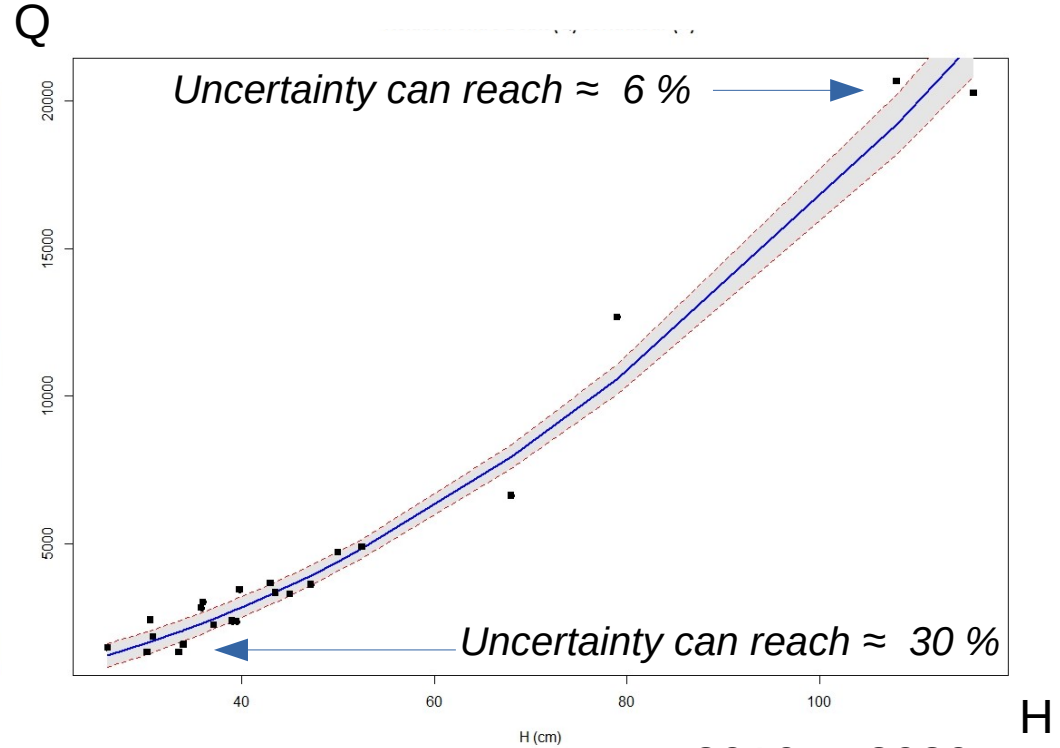


Rating curves in the Baume with confidence intervals of 5 %

Possible « derating » process ?

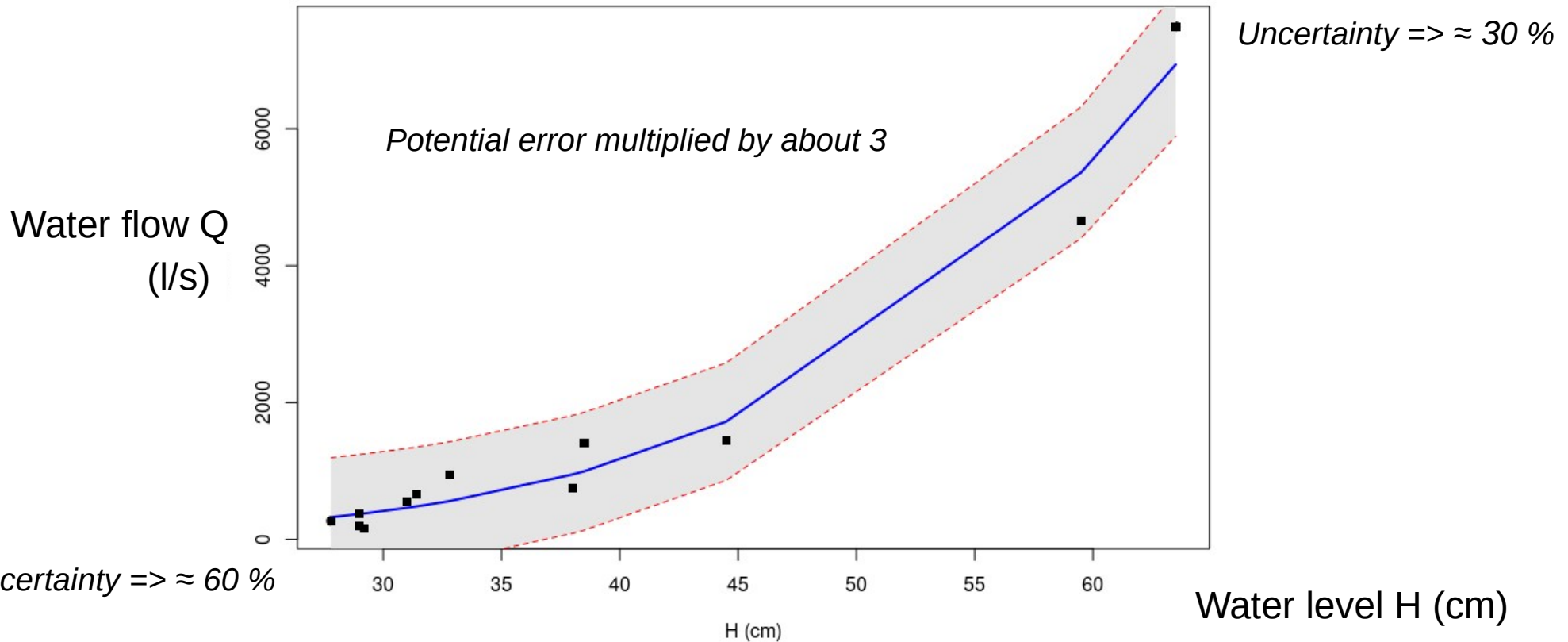


2016 to 2018 (log x log)
(Martin et al., 2019)

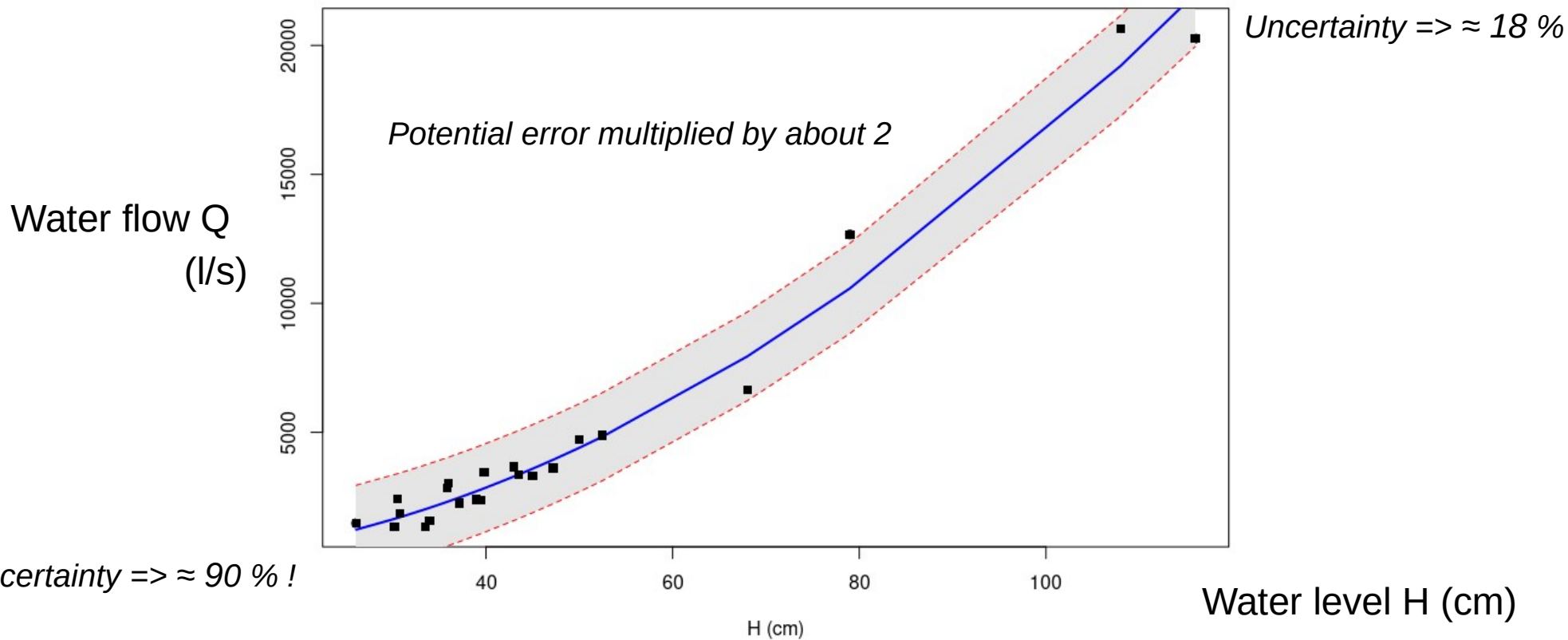


(Domergue et al., 2021) 2016 to 2020

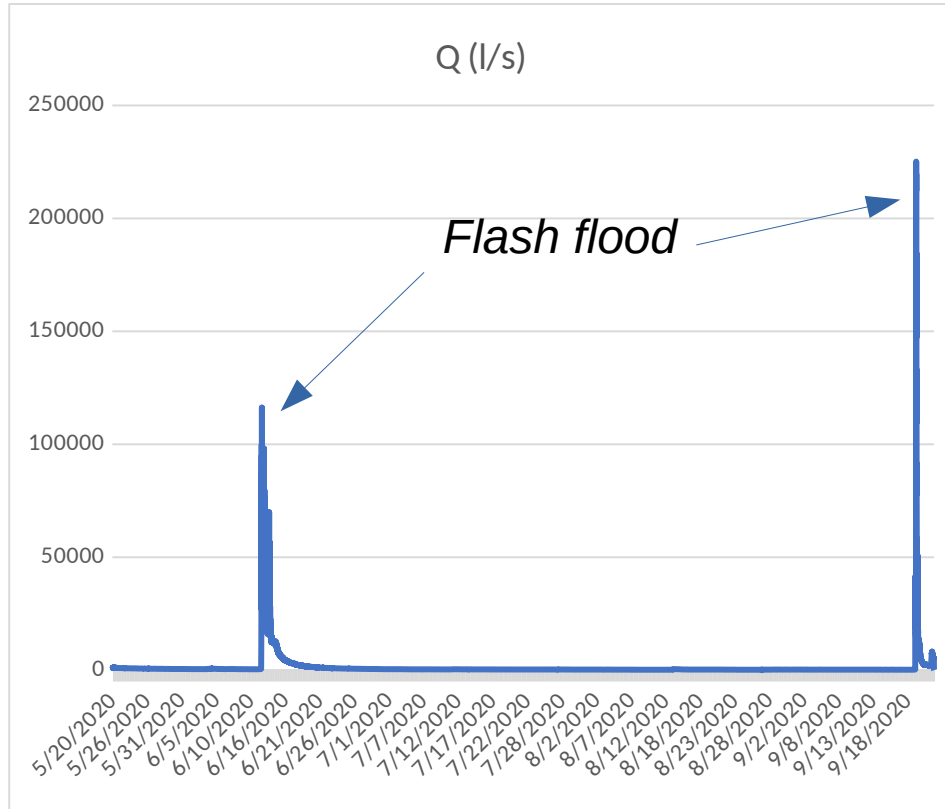
Rating curves in Blaquière with prediction intervals of 5 %



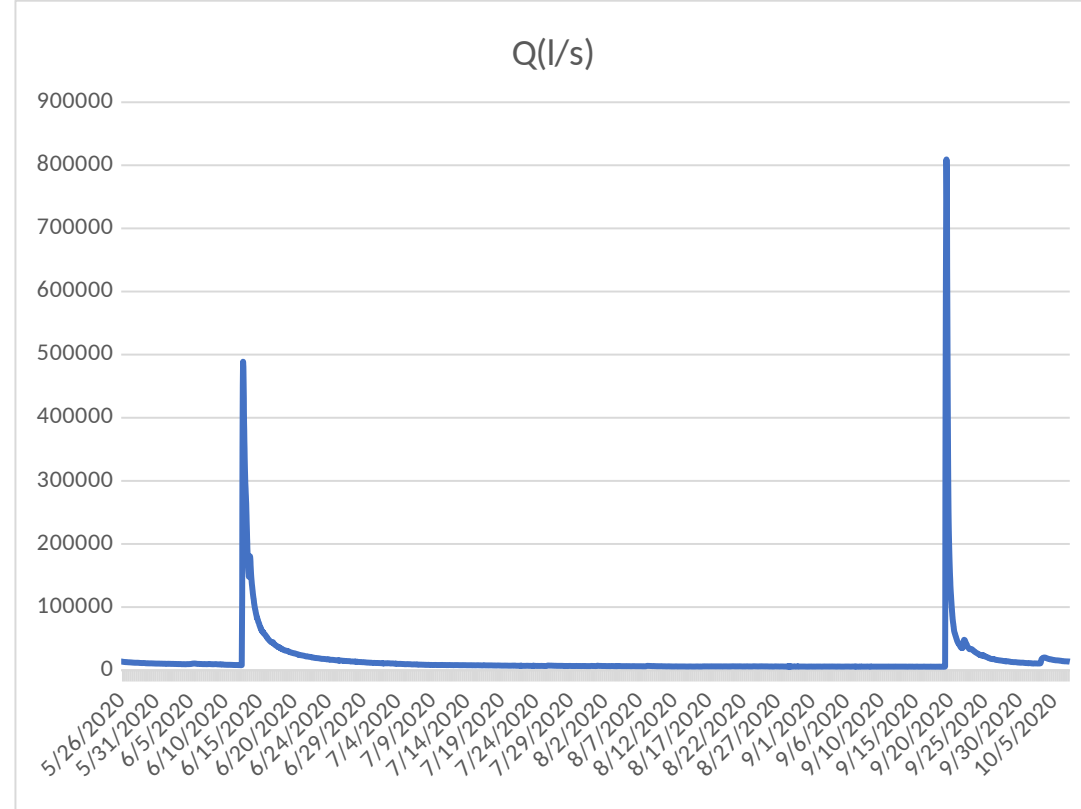
Rating curves in the Baume with prediction intervals of 5 %



Estimation of the water flows



Blaquière



La Baume

Discussion-conclusion

- In weak water flows, intervals (5 %) are very large: difficult to estimate them with current methods (even with many gauging points)
- For high water flows: rare measurements but lower error with lower impact on the estimation (and unknown water flows in extreme conditions)
- Within intermediate flows: usefulness of good coverage of gauging along the water height
- Globally: making relative the estimation quality by crossing information on potential error due to measurement uncertainty

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Thank you for your attention