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

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Didier Josselin

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May 31  
June 1  
June 2  
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 Ayrat\*, Jean-Marc Domergue\*, Nadine Grard\*, Anne Johannet\*\*,  
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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 ( $\approx 1700$  m)



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

Delaire, 2021



Site of la Baume

# From flash floods to low streams



*Réalisation : Didier Josselin, 2021*

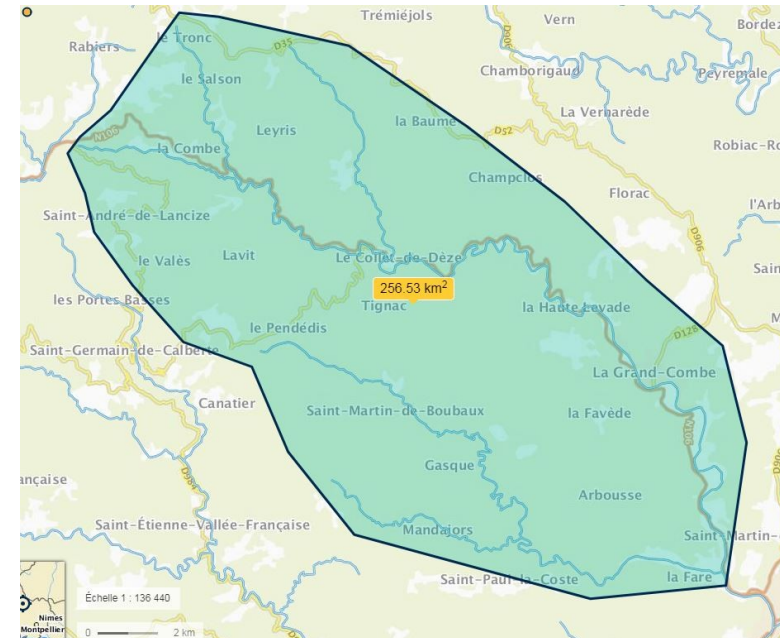
Landslide in 2020 at St-André de Valborgne (Southern France)

*Réalisation : Mathilde Delaire, 2021*

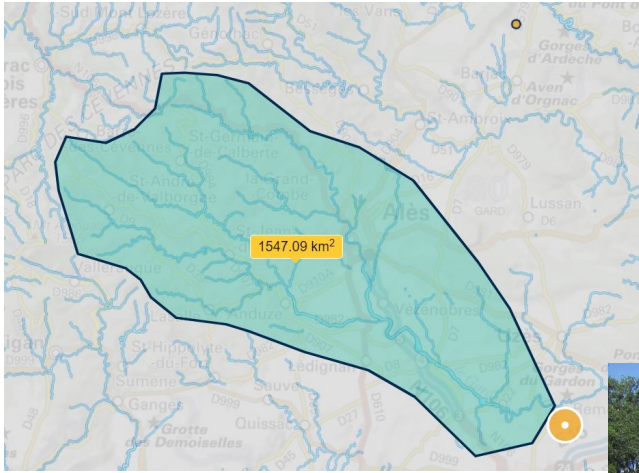
# The site of Blaquière



*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

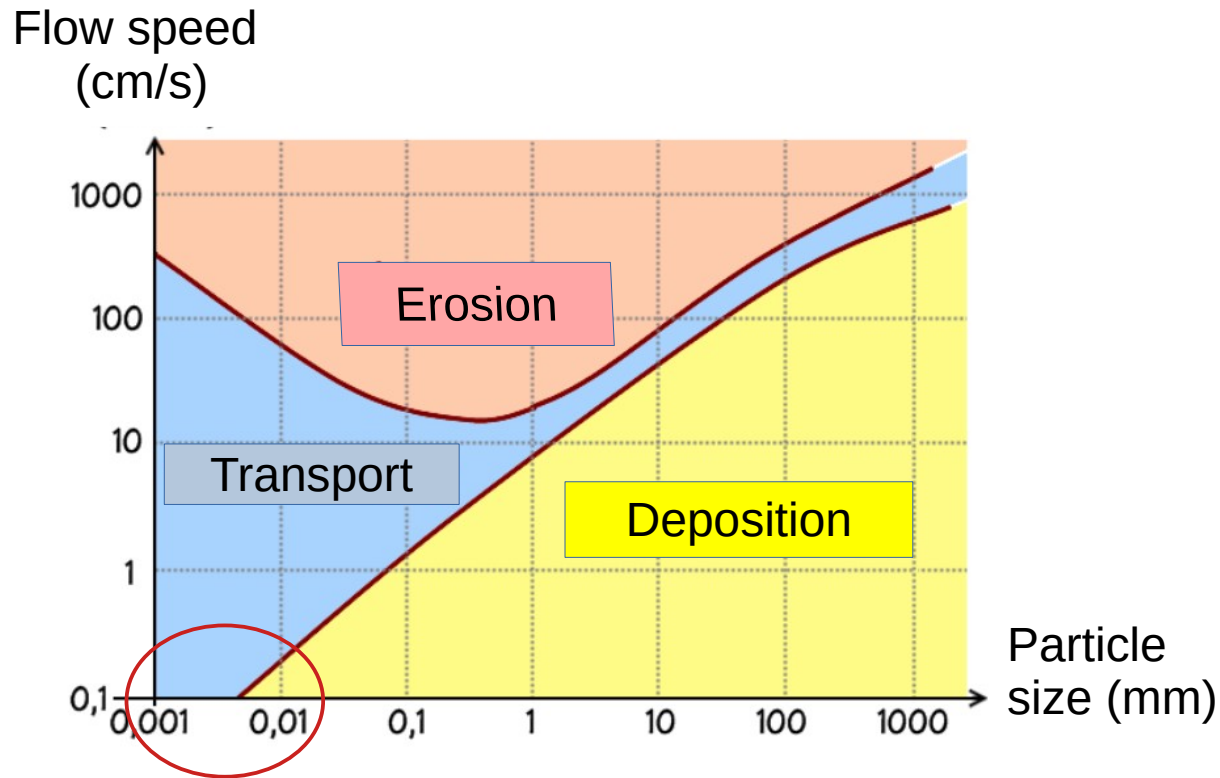
- Type of material
- Gauging
- Rate curve
- Estimation on the two sites

# 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*

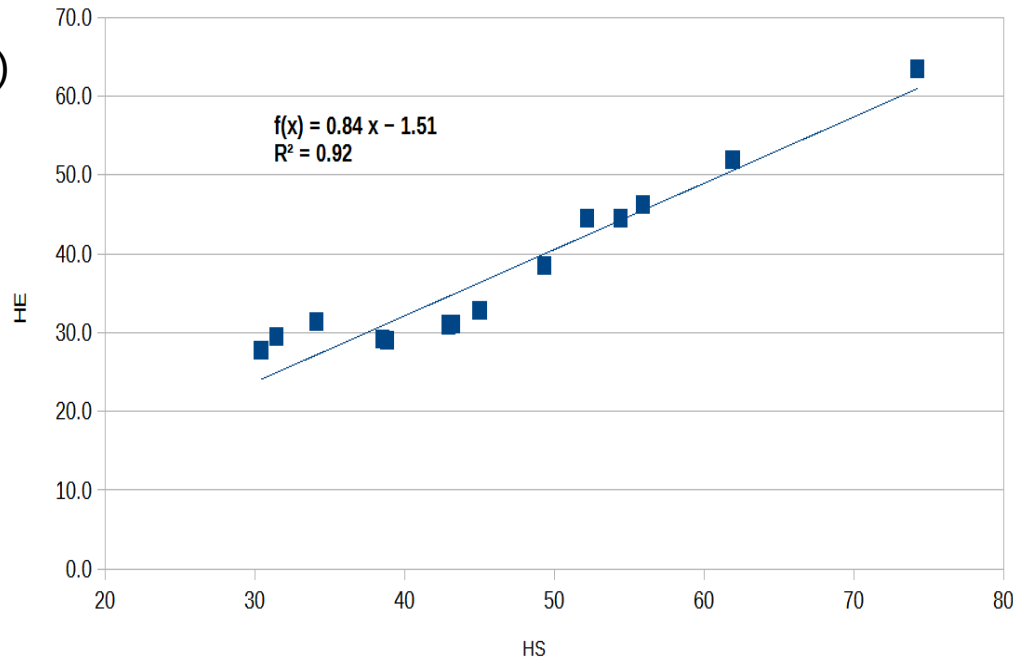
*Bernoulli's theorem*

Depends on the site

# Relation between real observed water levels and those estimated by sensors

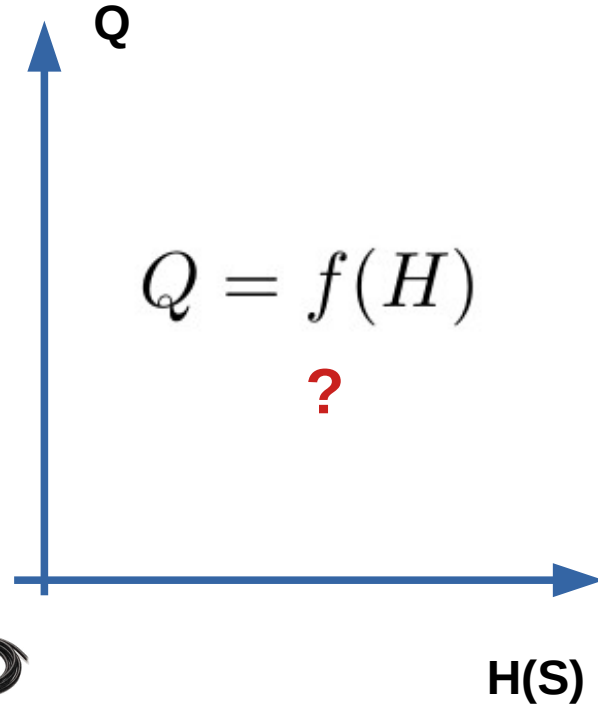
Water height read on the scale (HE)

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

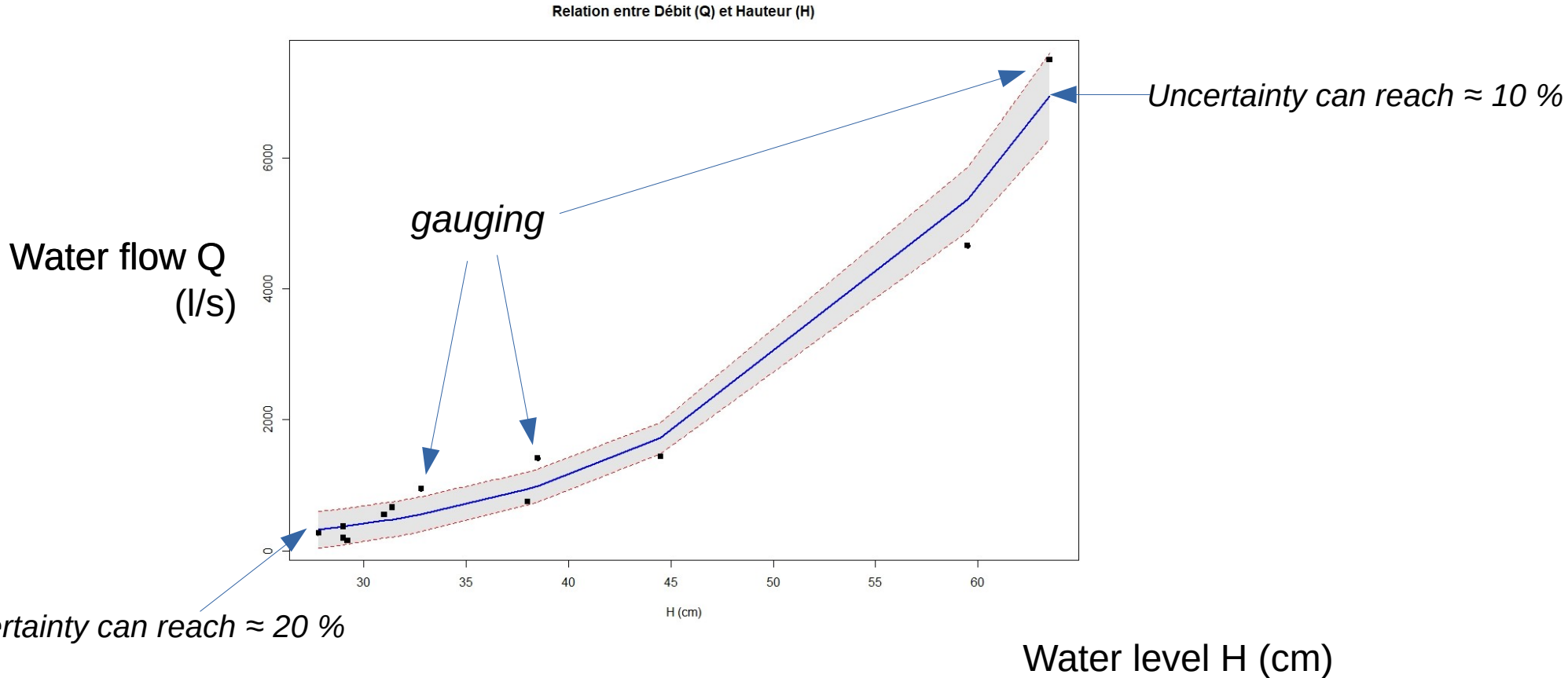
Observed value

Predicted value

**Prediction: “individual-centered”**

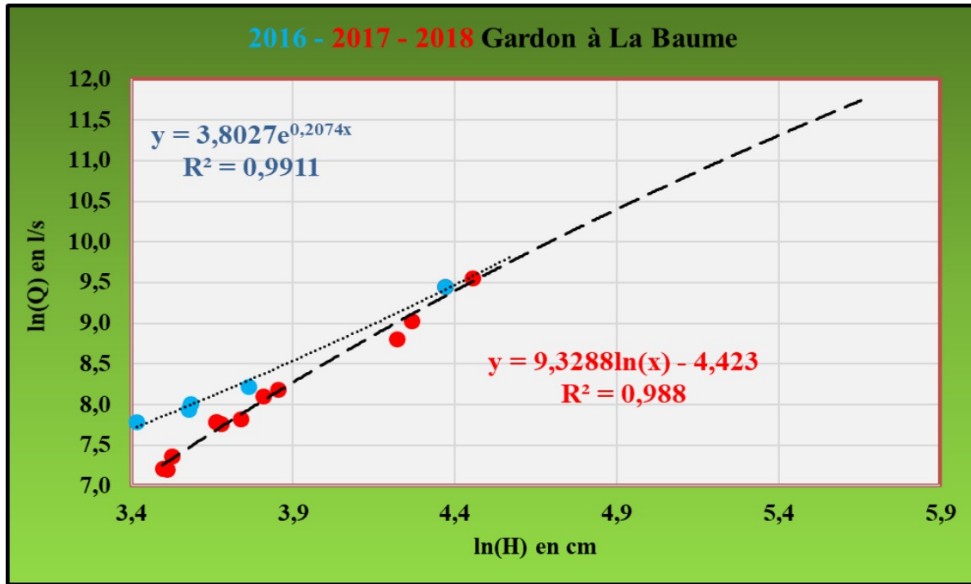
$$s(x) = \sigma(x) \cdot \sqrt{1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2}} = \sqrt{MSE \left[ 1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum_{i=1}^n (x_i - \bar{x})^2} \right]}$$

# Rating curves in Blaquière with confidence intervals of 5 %

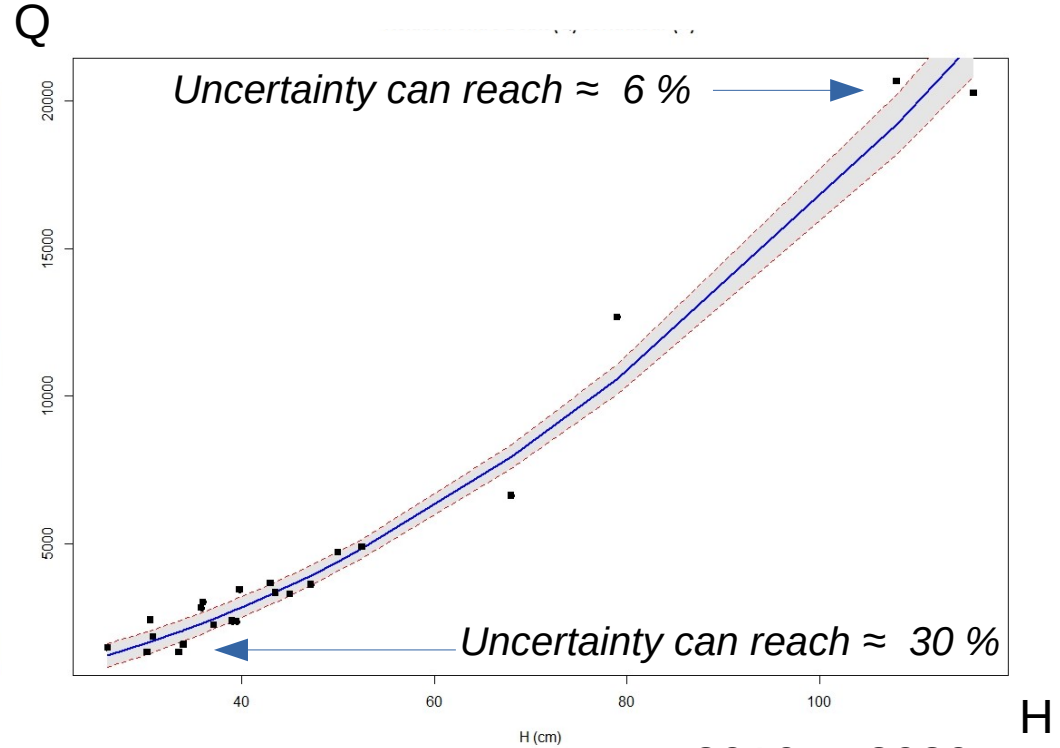


# Rating curves in the Baume with confidence intervals of 5 %

Possible « derating » process ?



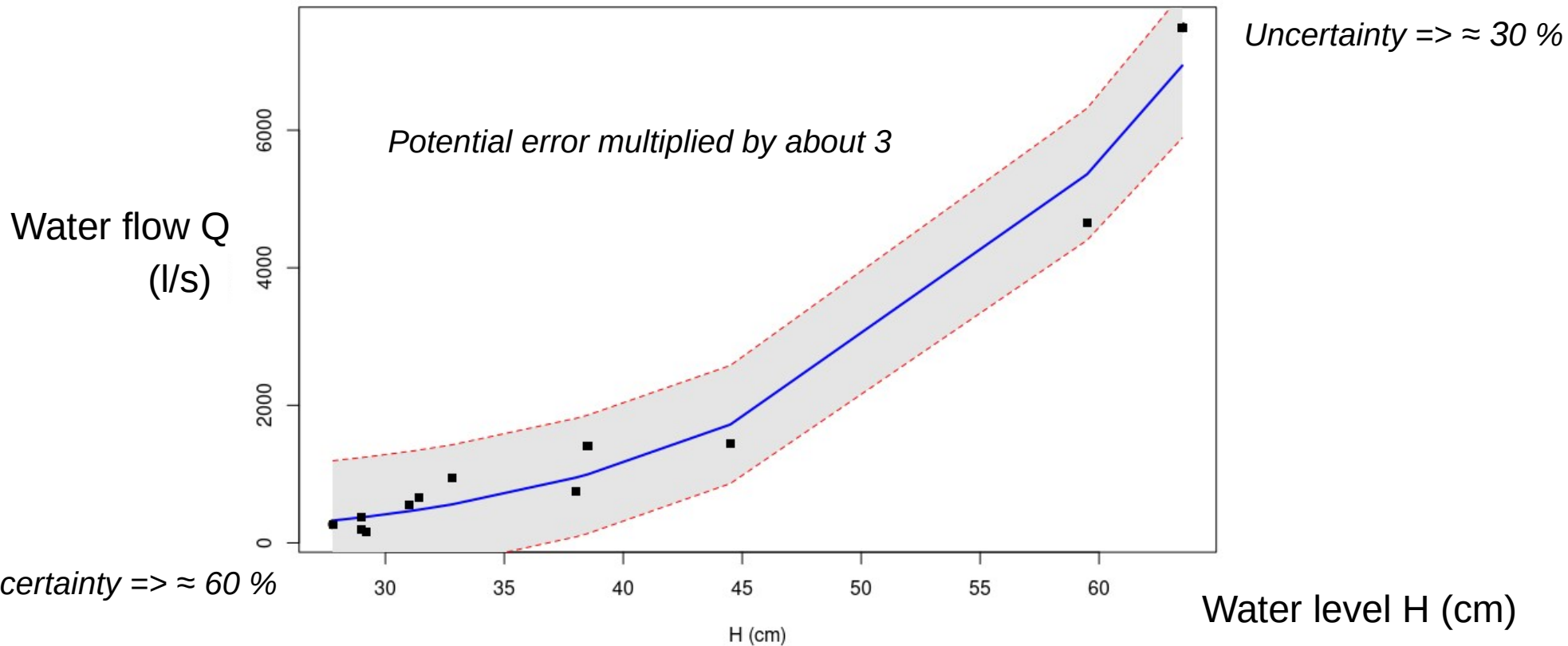
2016 to 2018 (log x log)  
(Martin et al., 2019)



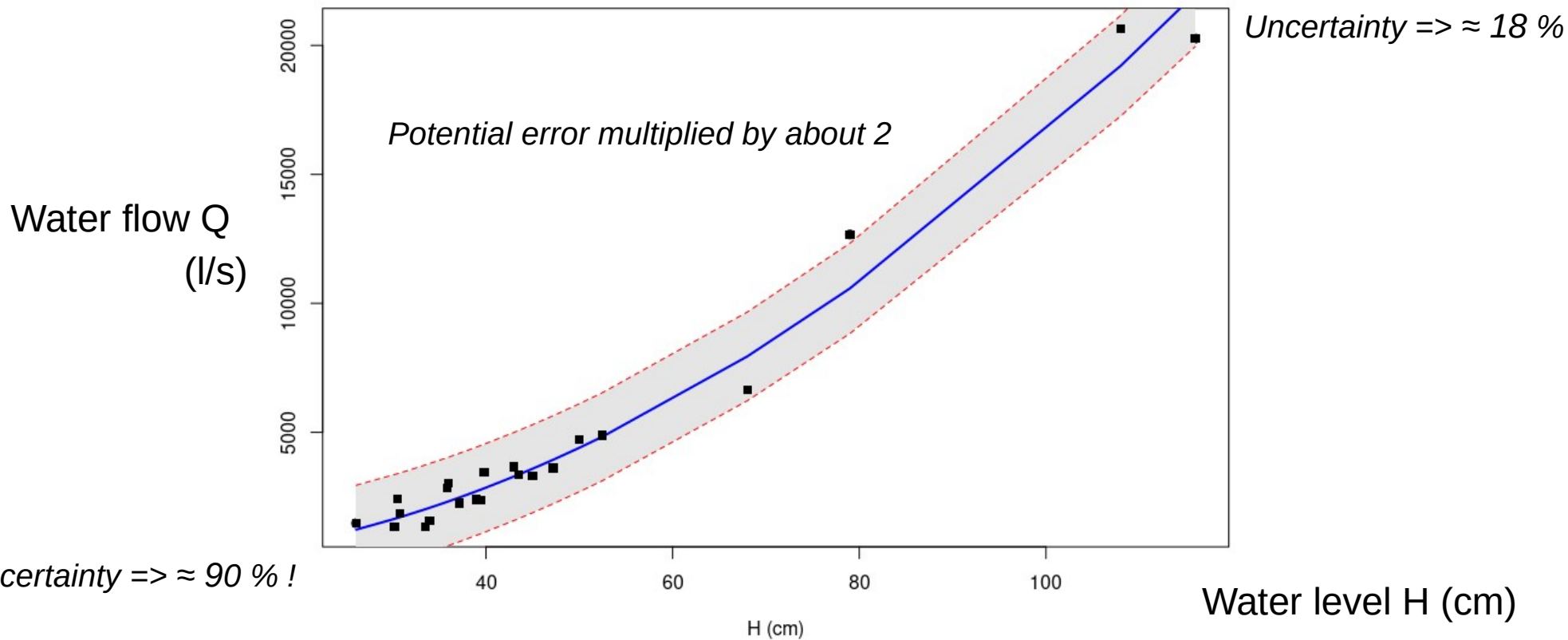
(Domergue et al., 2021) 2016 to 2020



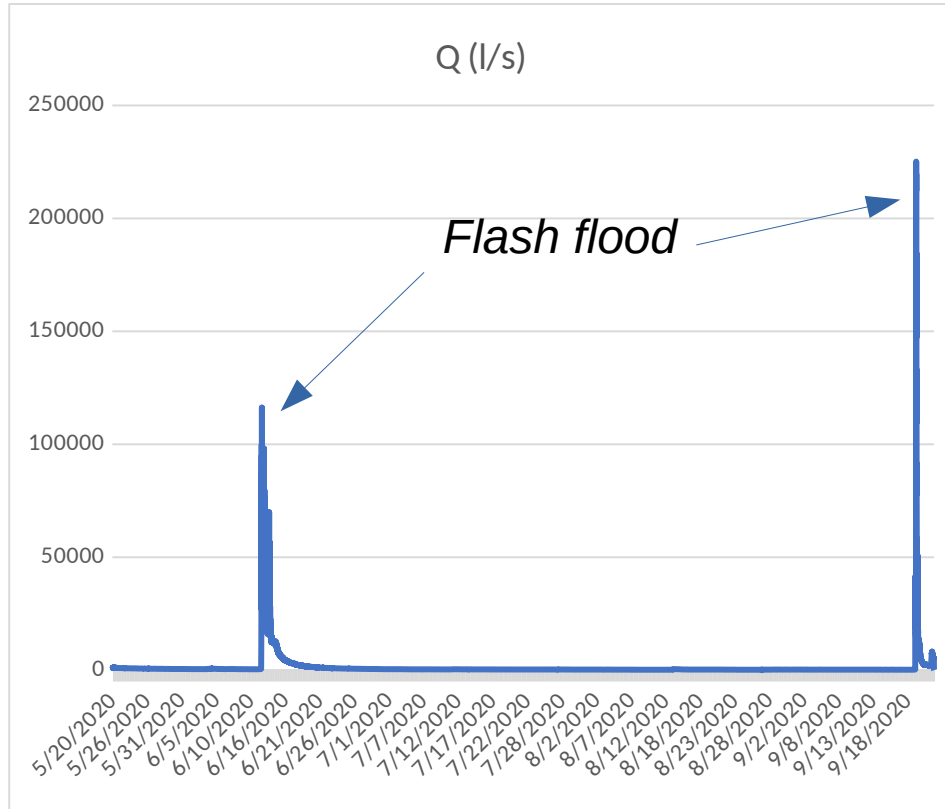
# Rating curves in Blaquière with prediction intervals of 5 %



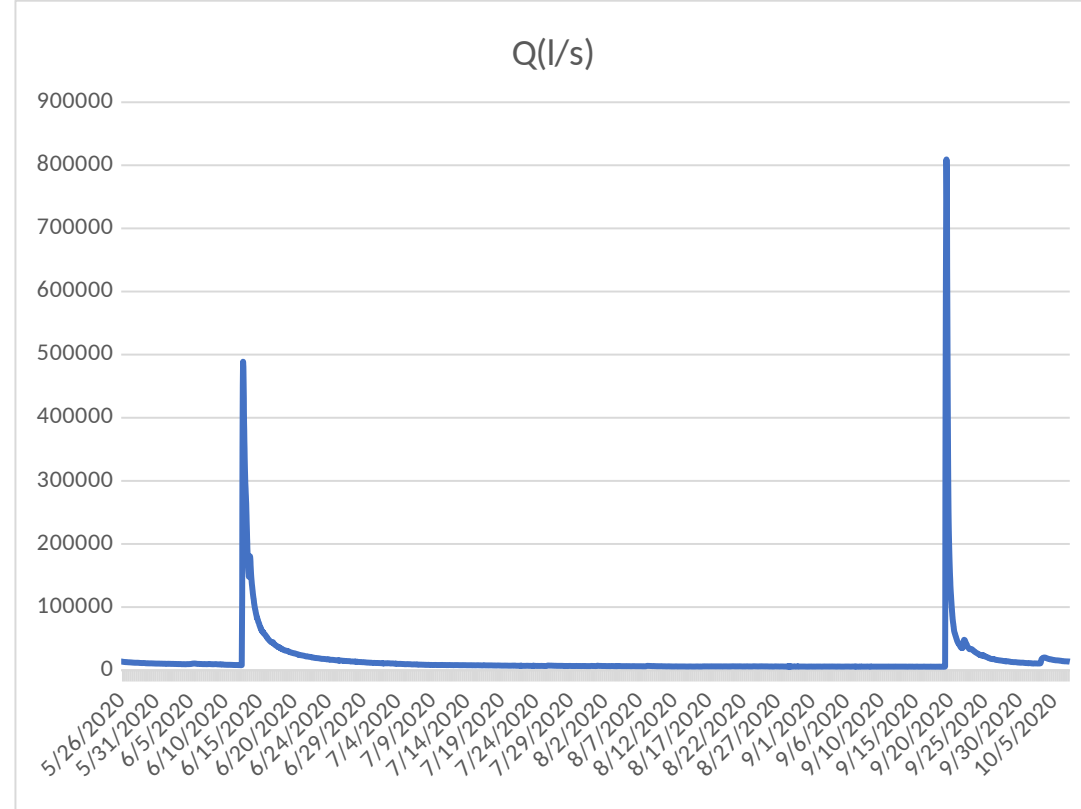
# Rating curves in the Baume with prediction intervals of 5 %



# 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

# Climat change & water

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Thank you for your attention