

Is measuring flow in streams such an easy thing to do?

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Why does one measure flow?

- Calculate a water balance in a watershed
 - e.g. Cumulative flow volume
- Evaluate maximum flow rate
 - e.g. Flood prediction
- Calculate nutrient loads
 - At the event, seasonal, annual basis
 - e.g. Nutrient balance at the reach, wetland scale
 - Detect % water quality improvement, nutrient retention, etc.
- Others...

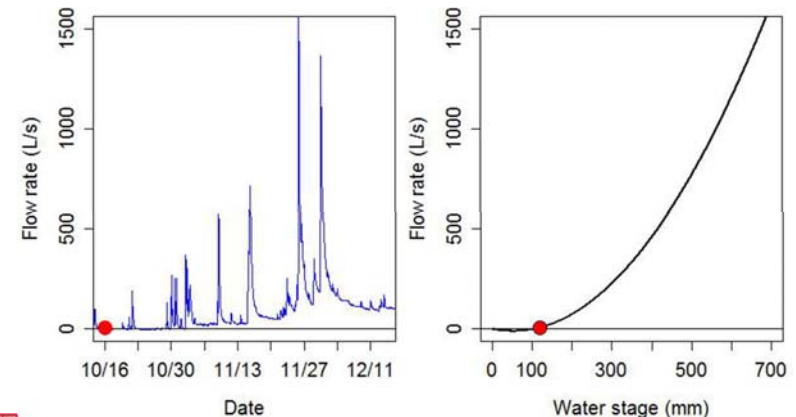
Is measuring flow easy to do?

- How many have done it?
- How many hydrologists?
- Yes, easy in principle!
 1. Hypothesis of unique stage discharge relationship
 2. Establish a rating curve
 3. Measure water stage on a near continuous basis

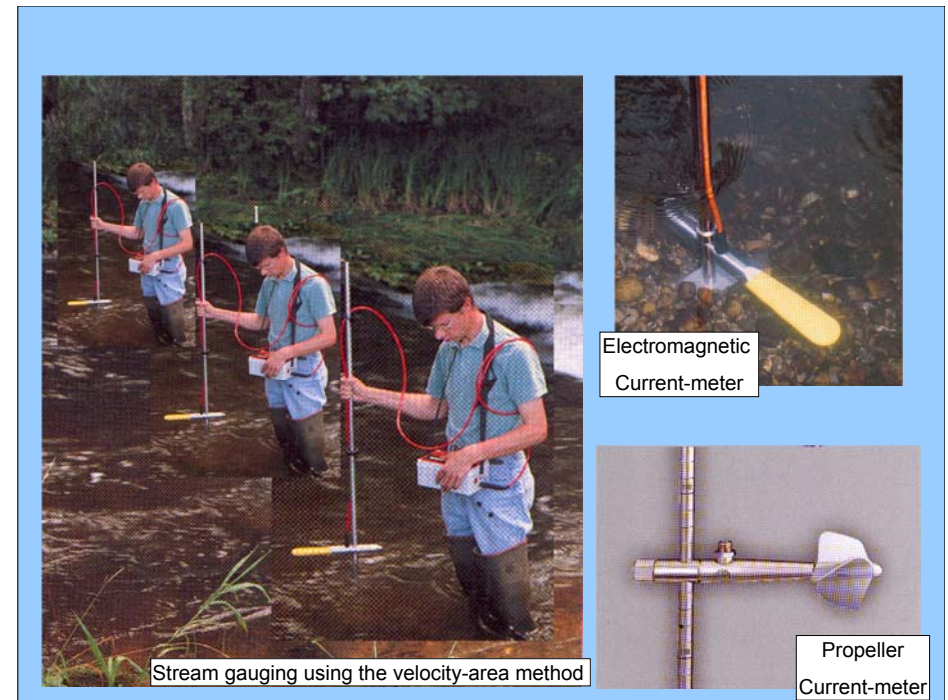
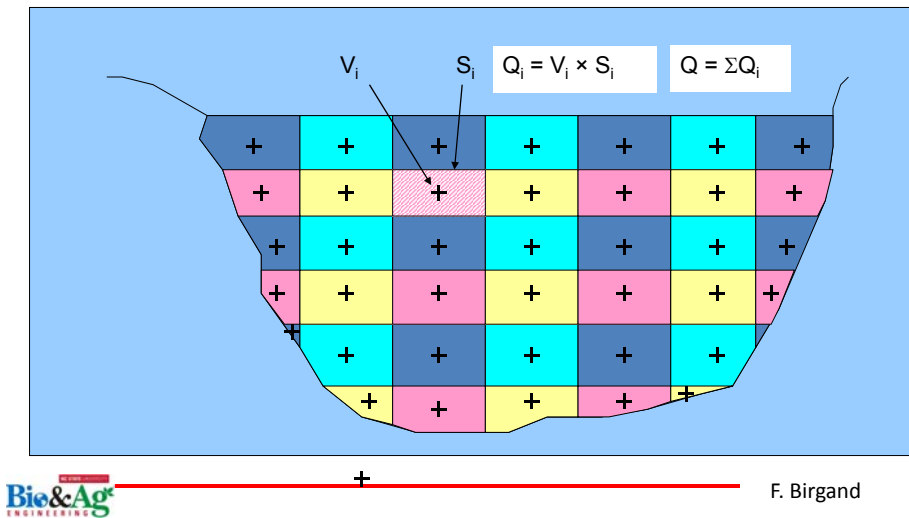


1. Hypothesis of unique stage discharge relationship

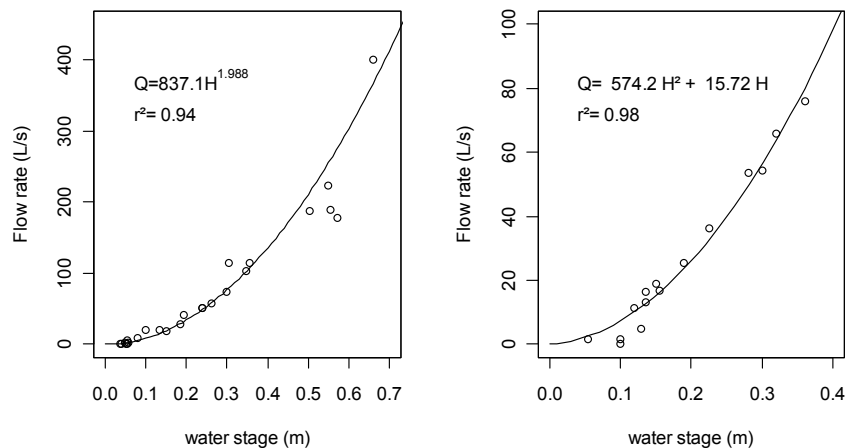
- Hydraulic laws tell us that, for the right conditions, there is a unique relationships between stage and discharge



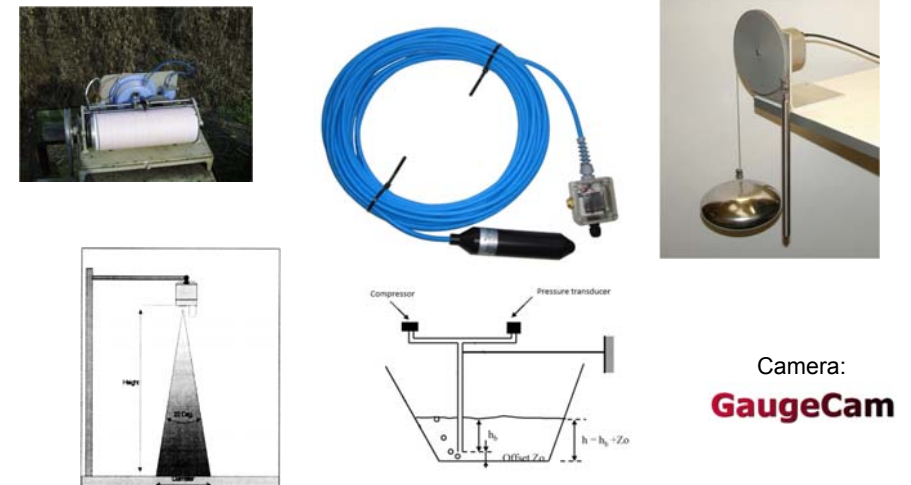
2. Establish a rating curve: e.g. Velocity area method



Examples of rating curves

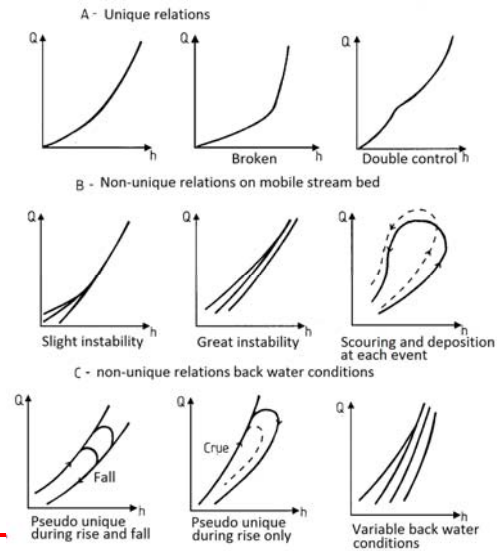


3. Measure stage on a continuous basis



Sources of uncertainties?

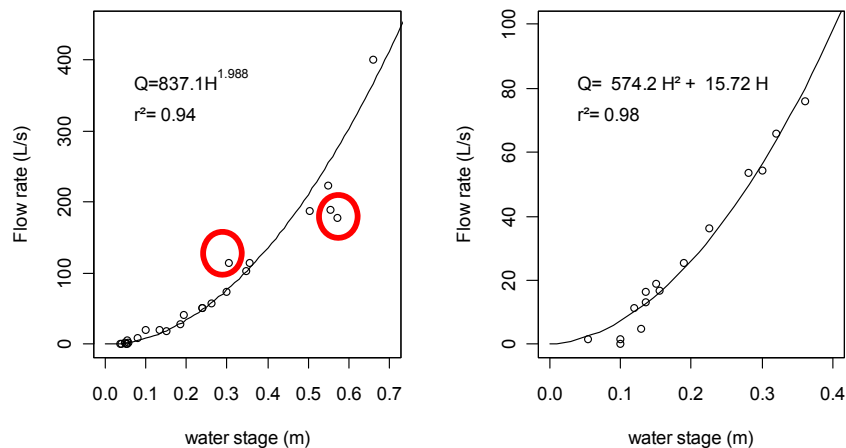
- 1. Unique stage-discharge relationship?



2. How good is a rating curve?

- Depends on the manual gauging
 - Uncertainties on velocity measurements
 - Uncertainties on wetted **cross section surface areas**
 - Uncertainties on stage measurements
- Depends on the **number of manual points**
- Depends on the representation of the **range of stage and discharge**

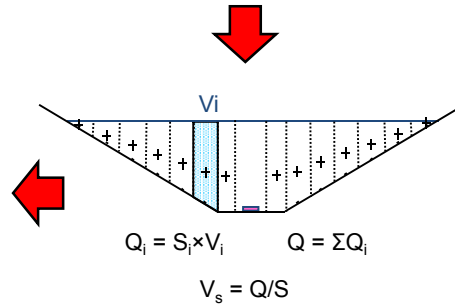
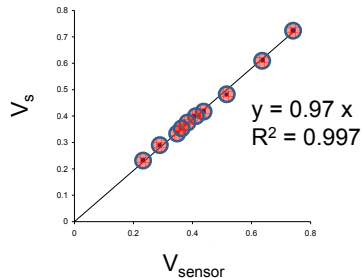
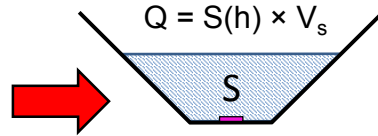
Good enough?



Objectives and method

- Objectives:
 - Estimate the level of uncertainties to be expected on flow measurements in low- and upland streams
- Method:
 - Use **reference** flow obtained from Doppler flow meters in trapezoidal wooden sections
 - **Simulate** random manual gauging (6 to 30 per year) and establish rating curves from simulations
 - Calculate and **compare the cumulative annual flow** volume to reference values

Reference data



Plymouth, NC

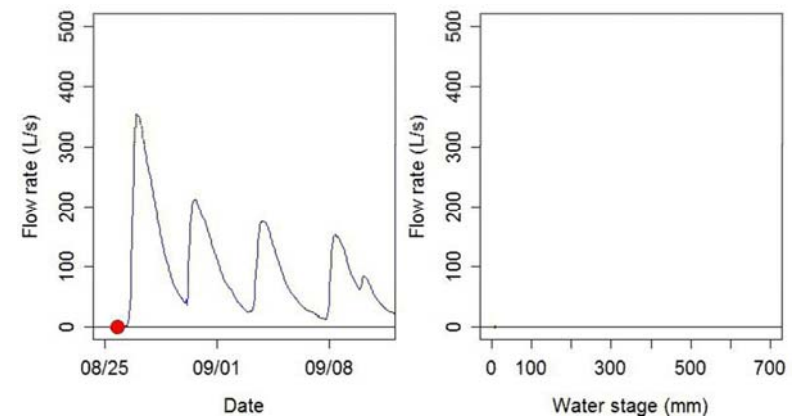
Lowland stream: 0.01% slope, up to 1 m³/s



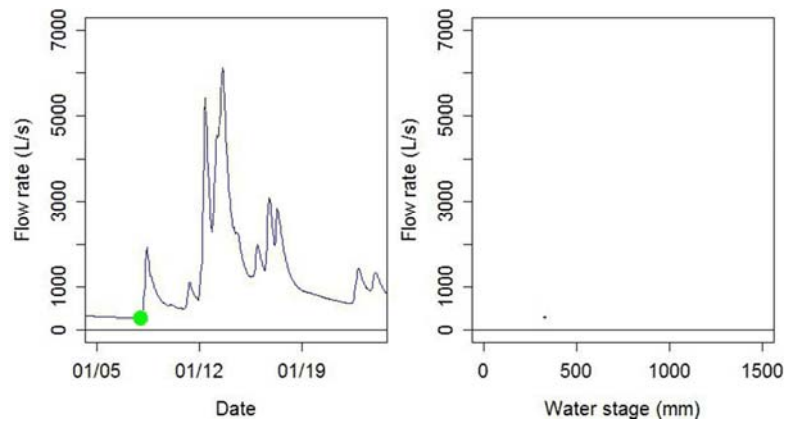
Nozay, France

Upland stream: 1% slope, up to 10 m³/s

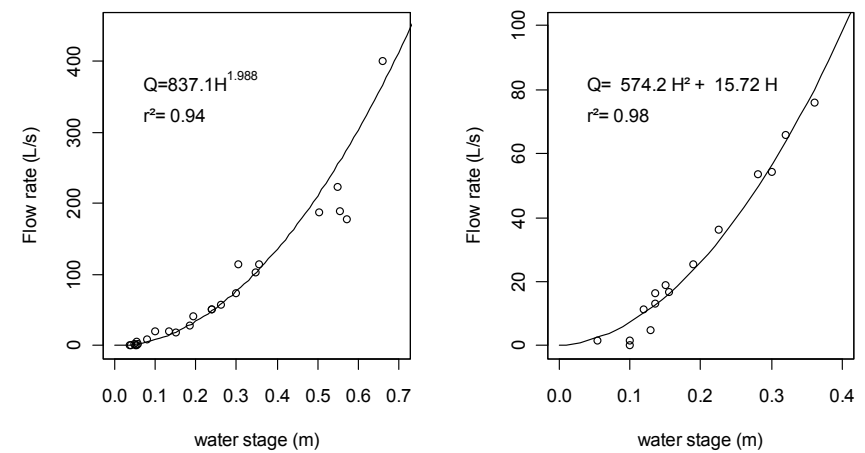
1. Unique Q=f(H)? Low gradient stream



1. Unique $Q=f(H)$? Upland stream



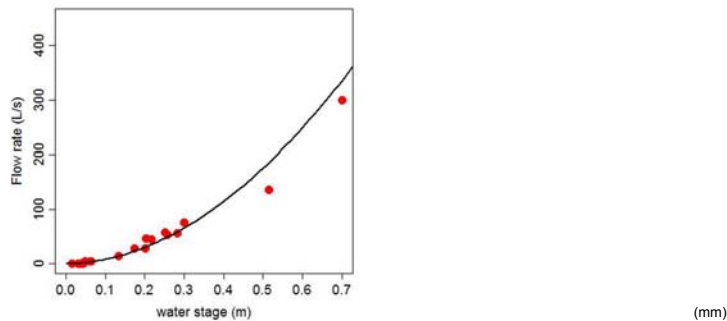
2. Establish Stage discharge relationship



2. Establish Stage discharge relationship (sssssss...)

Low gradient stream (slope = 0.01%)

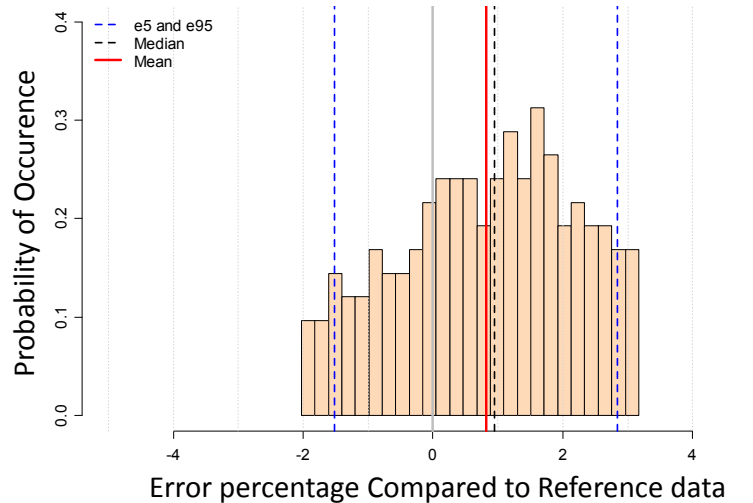
Upland stream (slope = 1%)



Consequences on cumulative flow volume

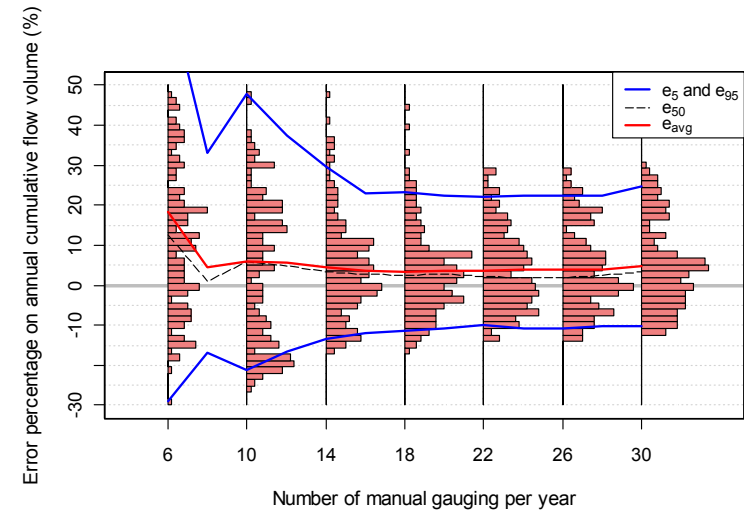
- Hydrographs obtained from 200 simulated rating curves
- Calculate the cumulative flow volume for each simulation
- Compare simulated volumes to reference one
- Create distribution of errors

Distribution of errors

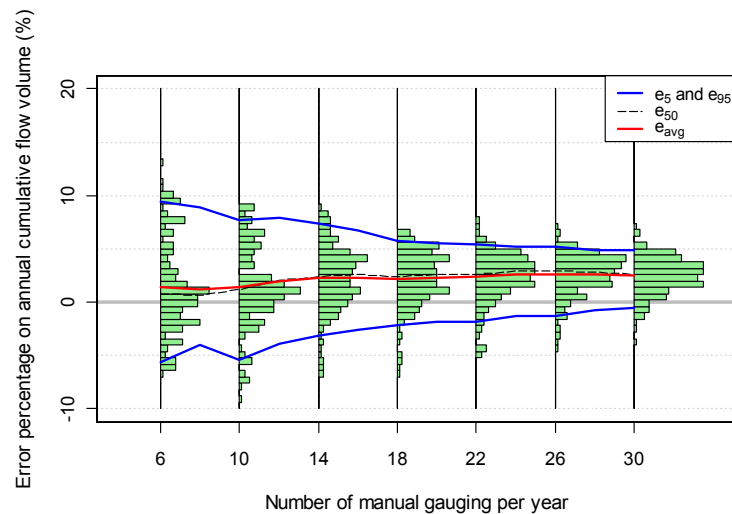


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Results on lowland stream



Results on upland stream



Conclusions

- Measurement uncertainties must be several times lower than the object to be measured
- Caution when using the Stage-discharge relationship method. Additional sources of uncertainties
- New technologies may help diminish uncertainties on flow
- Measuring flow easy? Technically yes, but practically not really!
- Flow: most important parameter to be known with precision



Thank you for your attention!

Questions?