Hydrological Data

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Plan

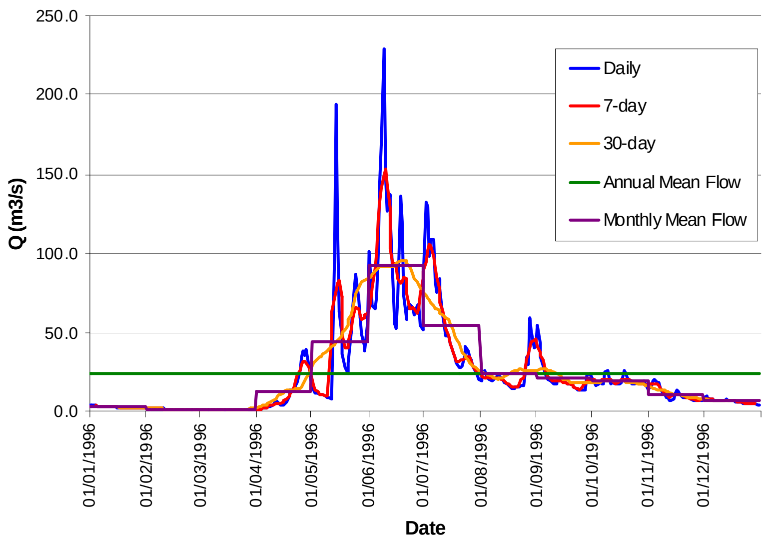
1. Types of hydrological data
2. Streamflow data
3. Uncertainties in data
4. Data quality control
5. Infilling missing data

Types of hydrological data

"Hydrological data encompasses all data commonly used by hydrologists" **(Kohler, 1958)**

Types of hydrological data

- **Time series data**



Types of hydrological data

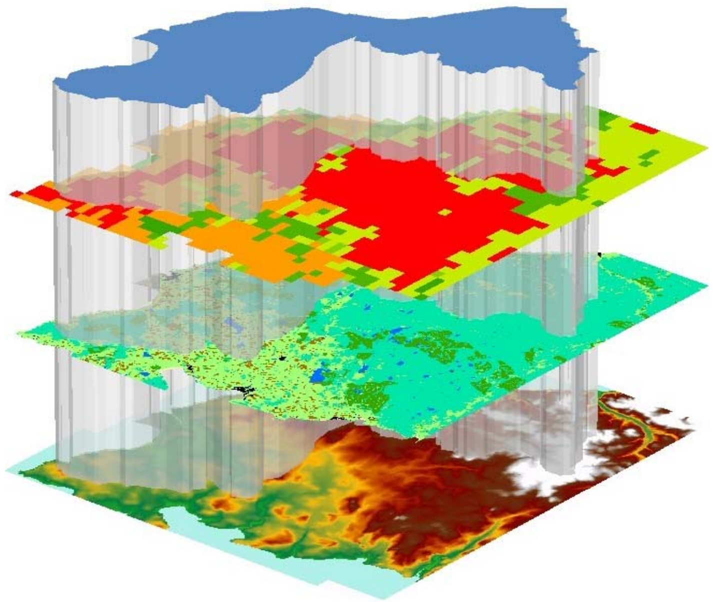
- **Thematic data**

"… information that can be used to describe the features and attributes of a certain entity"

"… that entity would typically be a catchment or a region, or area, of interest"

Types of hydrological data

- **Thematic data**



Catchment boundary

Rainfall (grid)

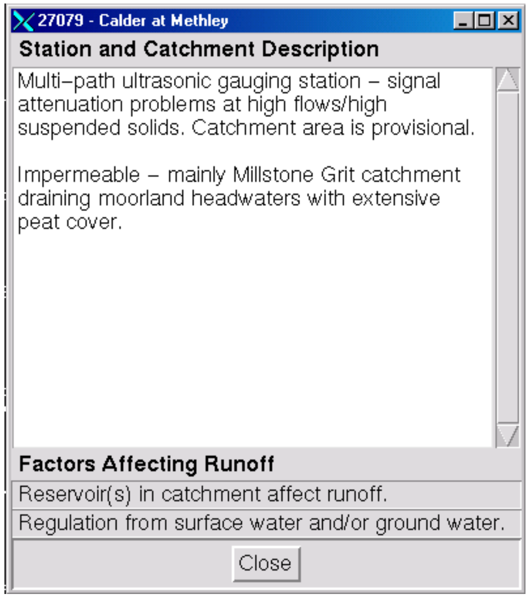
Land cover

DEM

Types of hydrological data

- **Metadata**

"…information, or data, on data"



Streamflow measurement

"Streamflow is the combined result of all climatological and geographical factors that operate in a drainage basin" (Herschy, 1985)

"…the only phase of the hydrological cycle in which the water is confined in well-defined channels which permit accurate measurements to be made" (Herschy, 1995)

Gauging Station types

Velocity-Area (open channels)

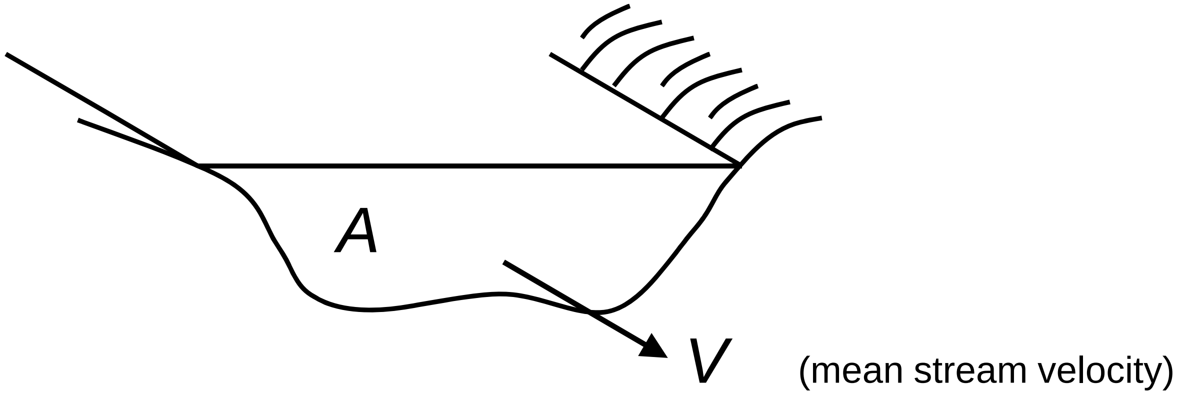
Weirs and Flumes

Ultrasonic

Electromagnetic

Streamflow measurement

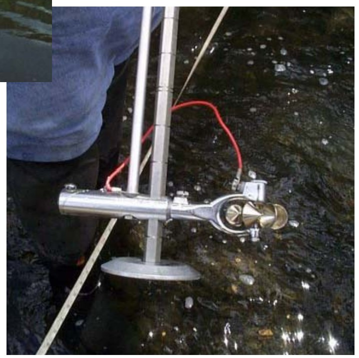
Velocity-Area method

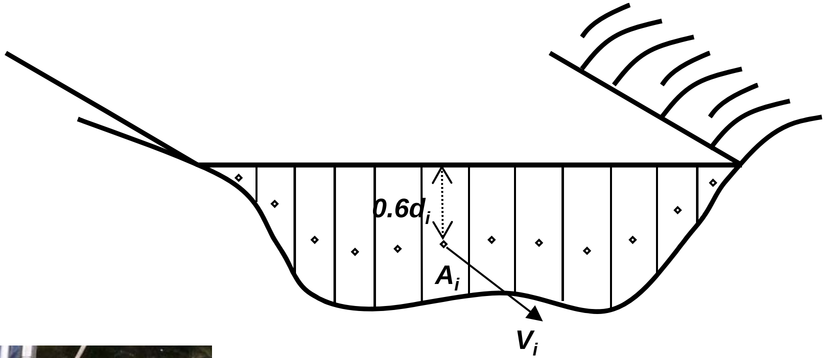


$$Q\ (m^3/s) = V\ (m/s) \times A\ (m^2)$$

Streamflow measurement

Velocity-Area method

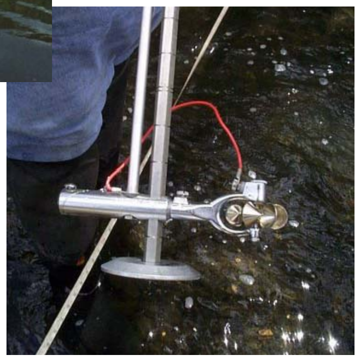


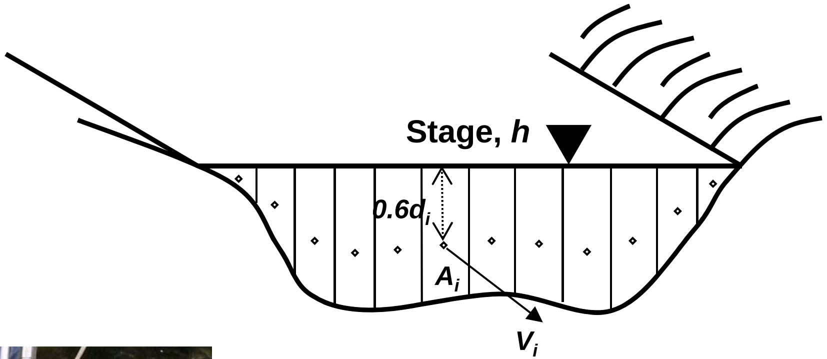


$$Q = \sum V_i A_i$$

Streamflow measurement

Velocity-Area method



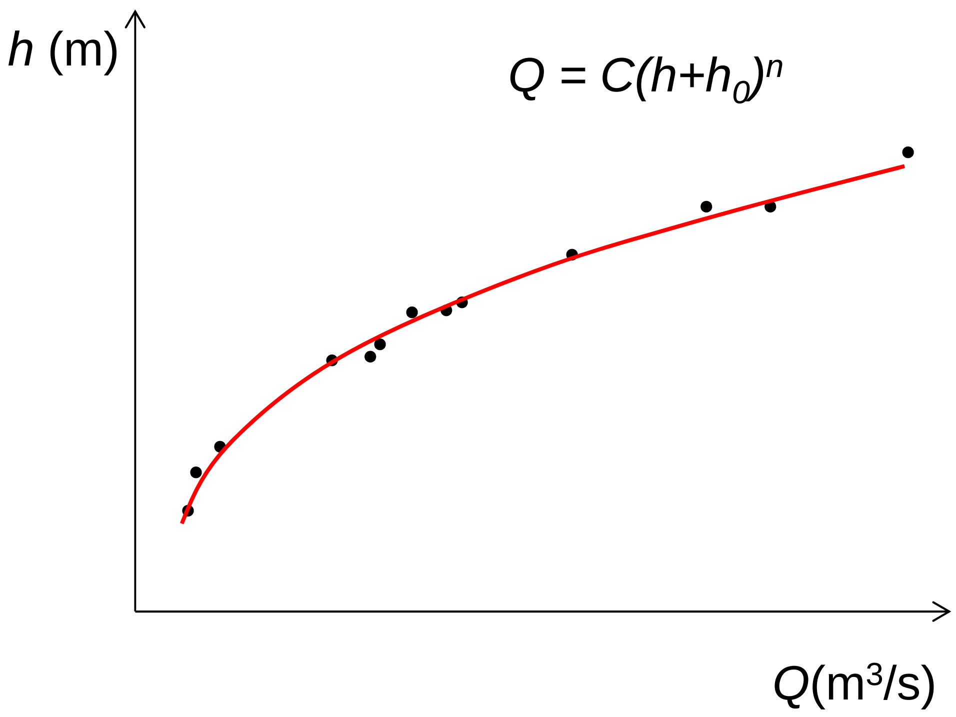


$$Q = \sum V_i A_i \quad = f\ (h)$$

Streamflow measurement

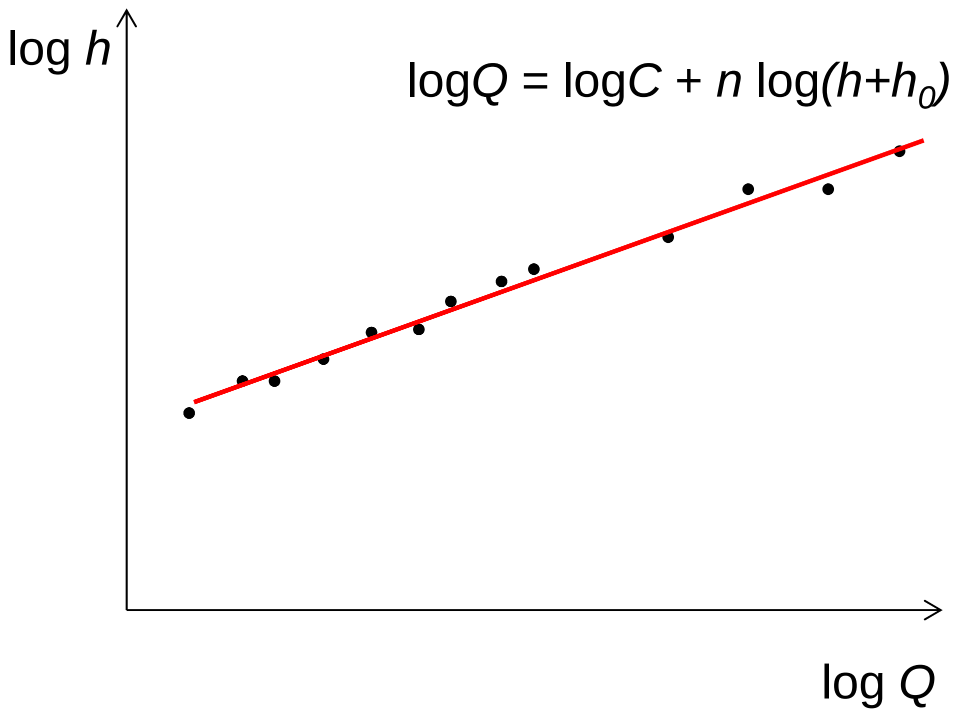
Velocity-Area method

Stage-Discharge relationship



Velocity-Area method

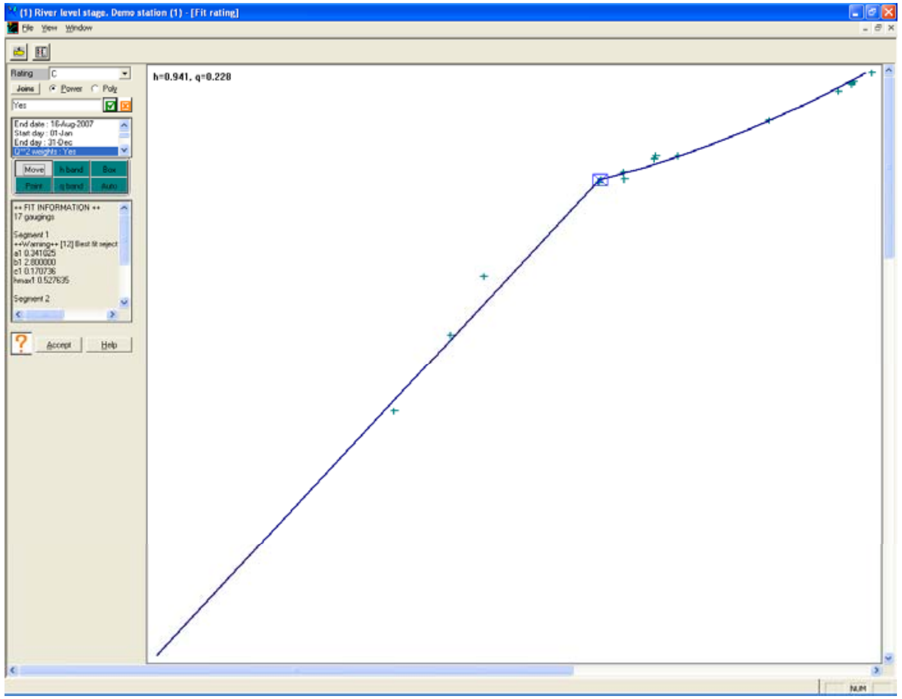
Stage-Discharge relationship



Streamflow measurement

Velocity-Area method

Stage-Discharge relationship



Streamflow measurement

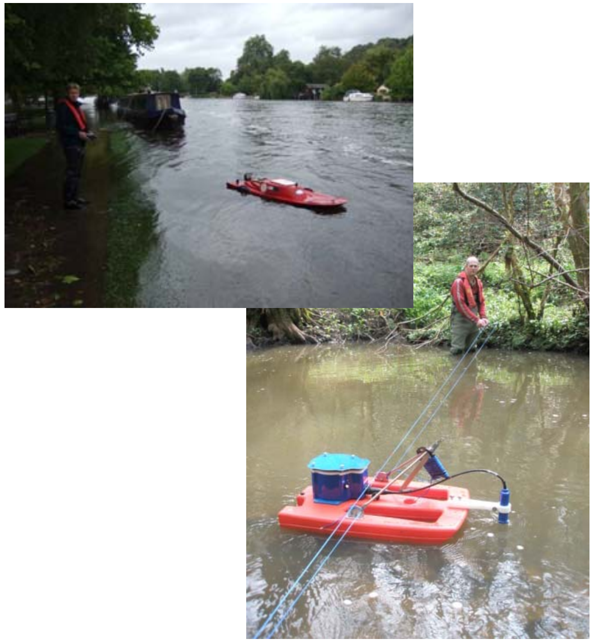
Velocity-Area method

Spot gauging methods

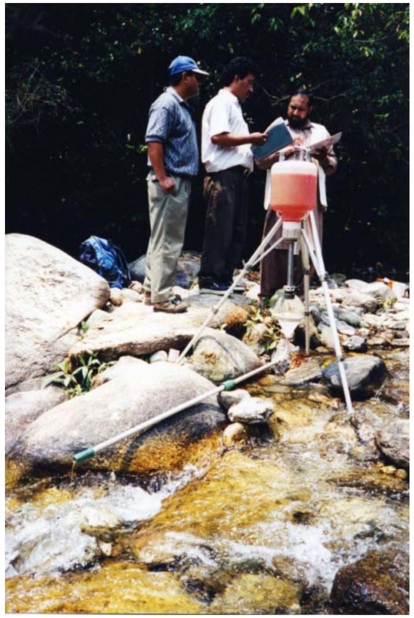
Current meters

ADCP

(Acoustic Doppler Current Profiler)



Dilution gauging



Streamflow measurement

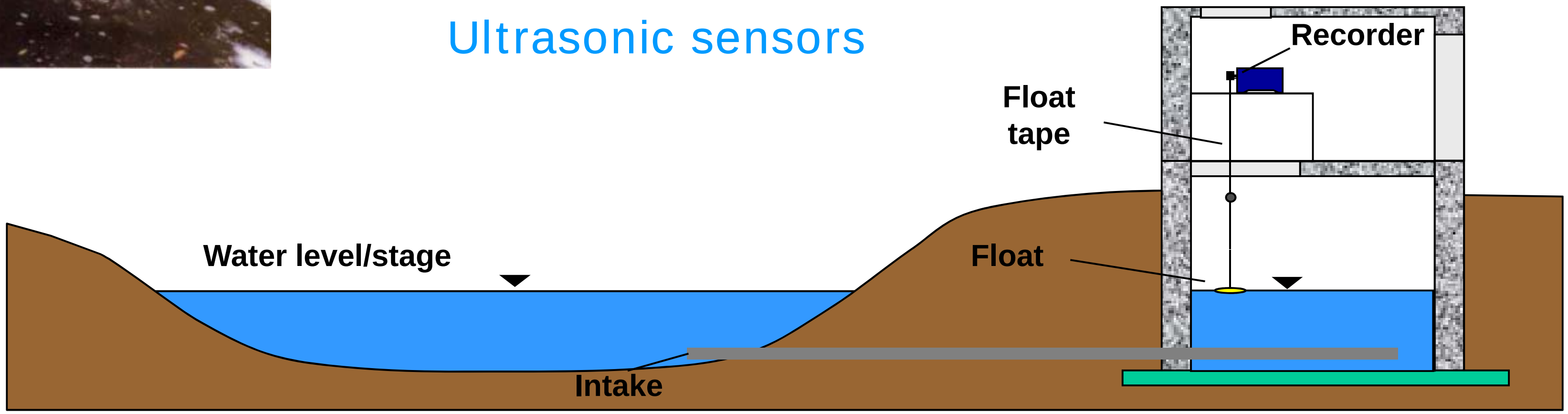
Measurement of stage

Staff gauge (manual)

Float-tape gauge

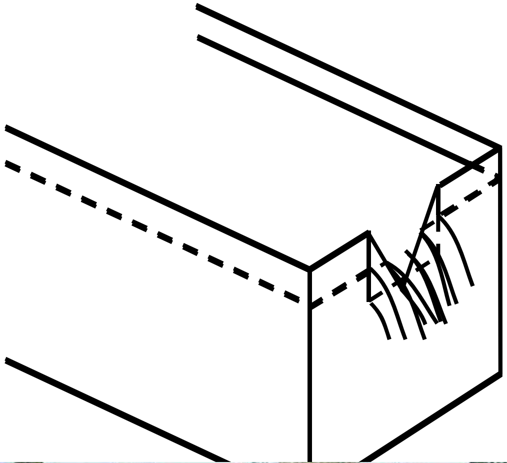
Pressure transducers

Ultrasonic sensors



Streamflow measurement

Weirs and Flumes



Thin plate weirs

rectangular notch

V-notch

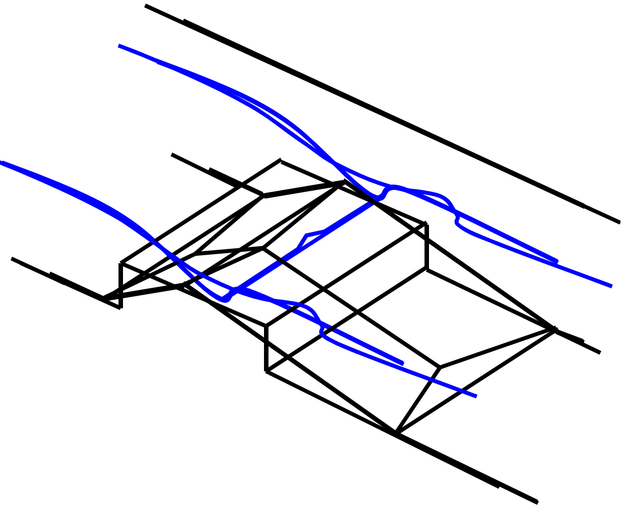
compound

Broad crested weirs

triangular profile (Crump) weir

flat V weir

gular broad crested weir



Flumes

rectangular

trapezoidal

U-shaped

Weirs and Flumes

Structures

Suitable for small rivers

Pre-calibrated under laboratory conditions

Relationship between *Q* & *h* proven empirically, based on physical principles

Less sensitive to downstream conditions, channel roughness and backwater influences

Streamflow measurement

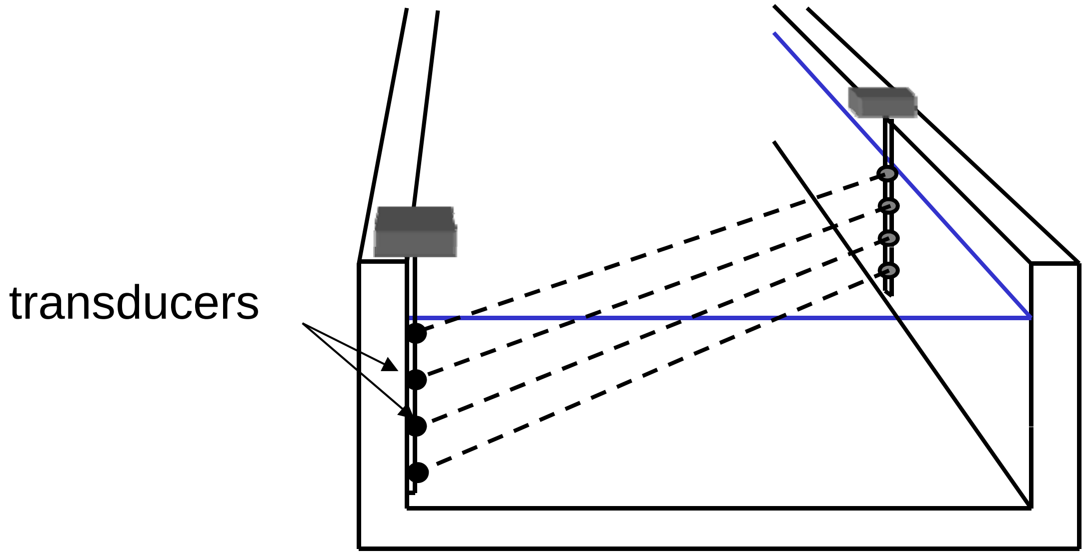
Weirs and Flumes

But … weed growth, accretion of silt/sediment behind weir, or algal growth on weir crest can affect observations

Streamflow measurement

Ultrasonic method

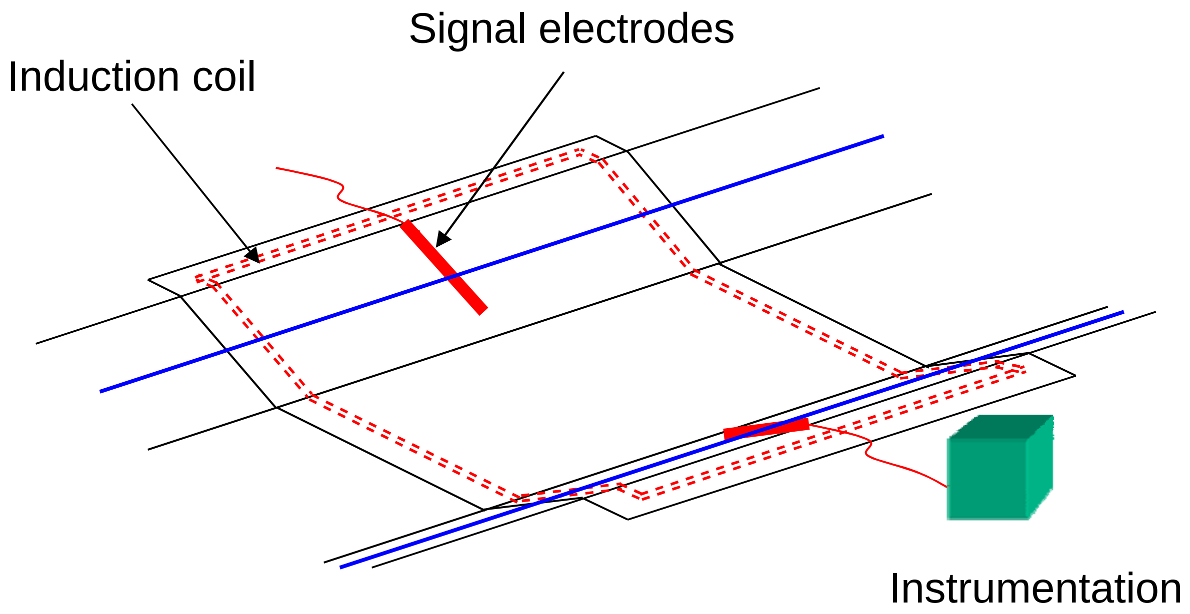
Continuous measurement of stream velocity by recording difference in ultrasonic pulses sent obliquely across river in different directions



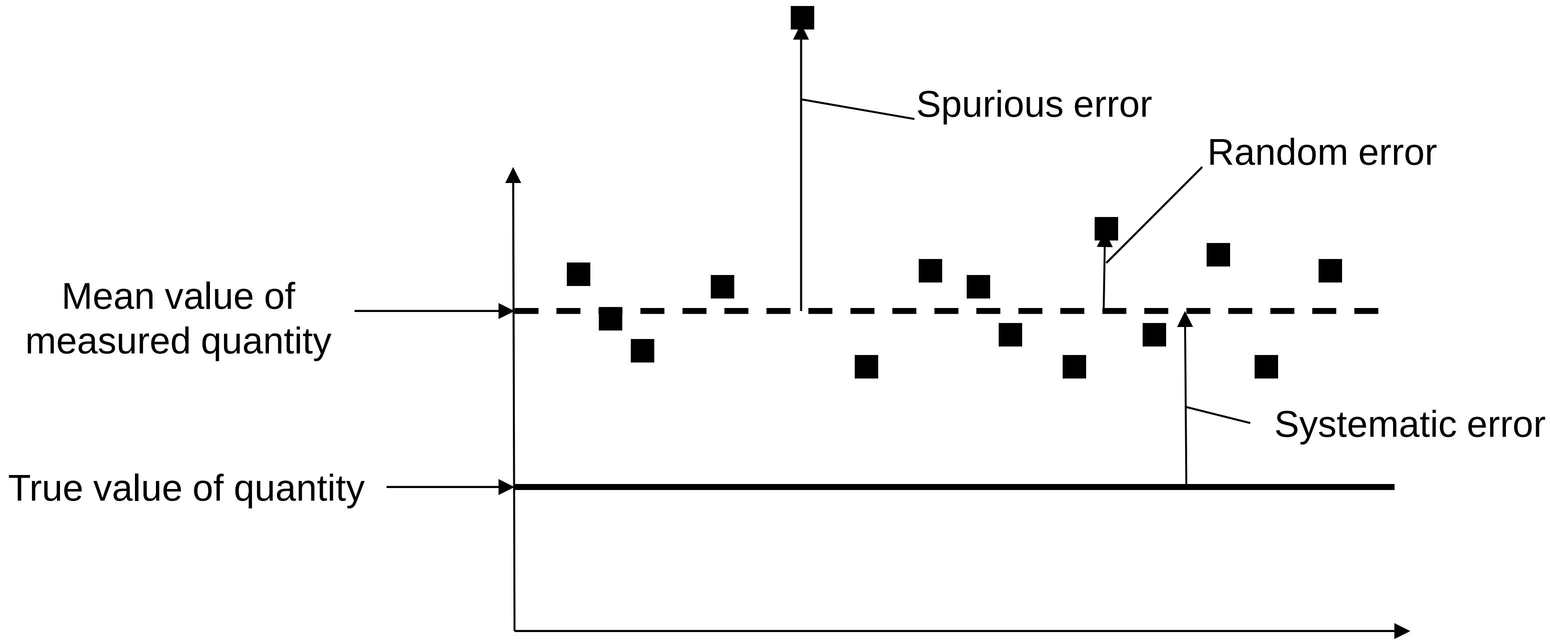
Streamflow measurement

Electromagnetic method

Measurement of induced electromotive force as water flows through a magnetic field



Types of error



Uncertainties in data

Sources of error?

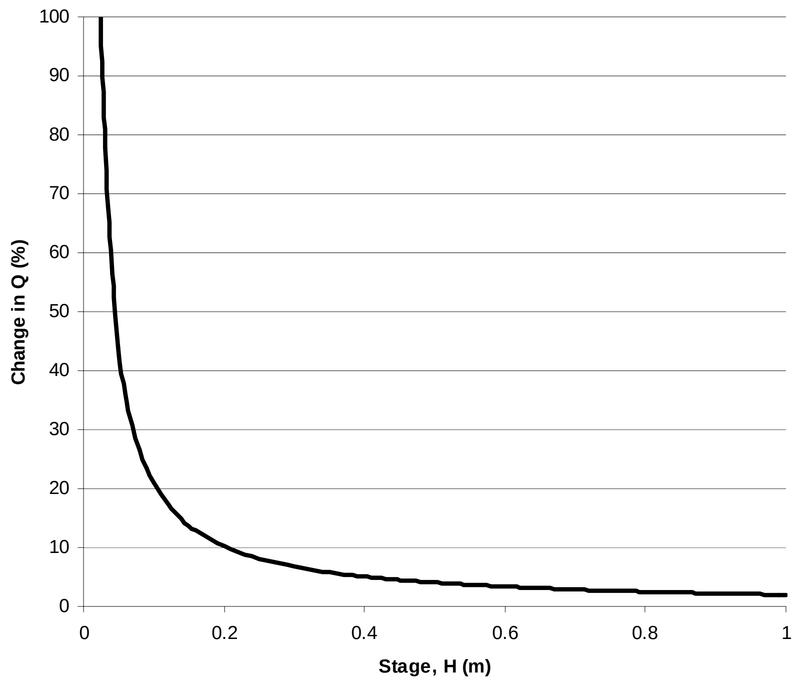
- **Measurement of stage**
- **Hydraulic conditions**

  approach/tail-water conditions; roughness
- **Number of verticals used in current metering**
- **Stage-discharge relation**
- **Coefficient of Discharge for weirs or flumes**
- **Operation and maintenance of station**

  debris; weeds; ice; siltation; algal growth

Uncertainties in data

Sensitivity at low flows



Change (%) in Q for a 10mm increase in stage, H

(rating curve $Q = 30H^2$)

Reducing error: operational measures

- Regular instrument & station maintenance, good practice (e.g. ISO748, ISO1100)
- Record changes in instrumentation; standardise instrumentation as much as possible
- Document changes that affect the rating curve (e.g. shifting bed/control)
- Revise/update rating curve after floods/spates
- Obtain spot-gaugings at extremes (high and low flows)
- Record details of factors that affect the record (e.g. changes to site conditions; upstream activities/influences)

Hydrological Data

Plan

1. Types of hydrological data ✓
2. Streamflow data ✓
3. Uncertainties in data ✓
4. Data quality control
5. Infilling missing data

Data quality control

QA / QC measures

• **Check continuity with previous batch of data**
(is there a step change between batches?)

•**Check difference between consecutive stage/flow values**
(is the rate of change realistic?)

• **Check for discontinuities (step-changes)**

• **Check for non-stationarity (trends)**

• **Compare catchment average annual runoff and rainfall**

• **Use validation plots (eye-balling)**

• **Correct erroneous data**

• **Infill missing data**

QA/QC measures: validation plots

- **Hydrograph analysis**

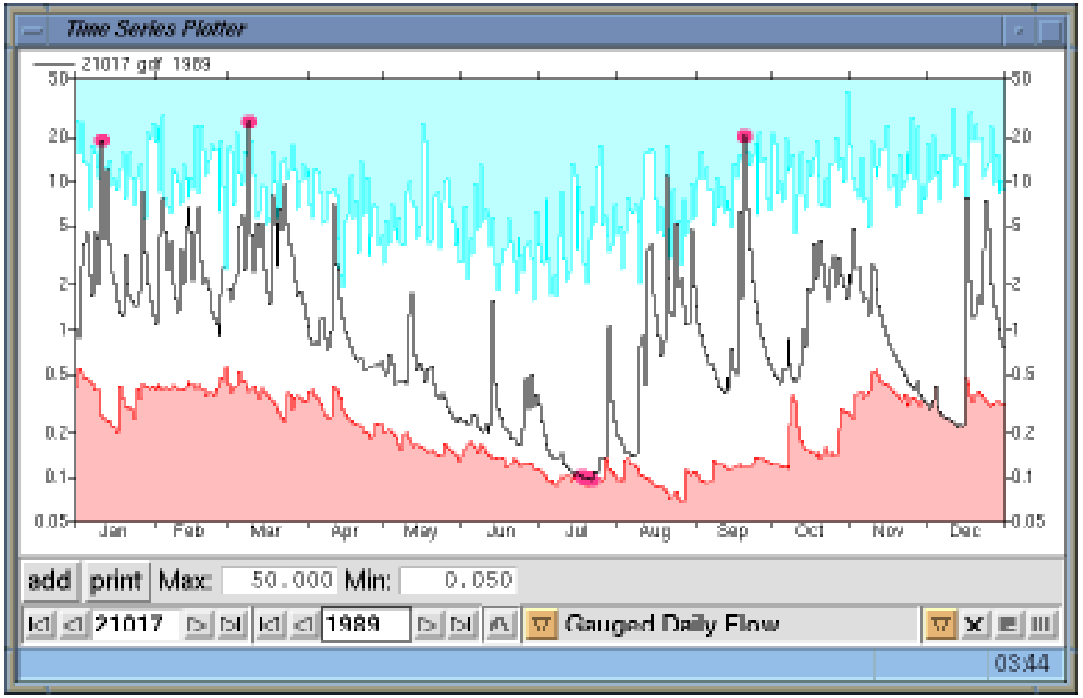
  Daily mean flows versus long-term daily extremes

  Time-series comparison plots

- **Double mass curves**

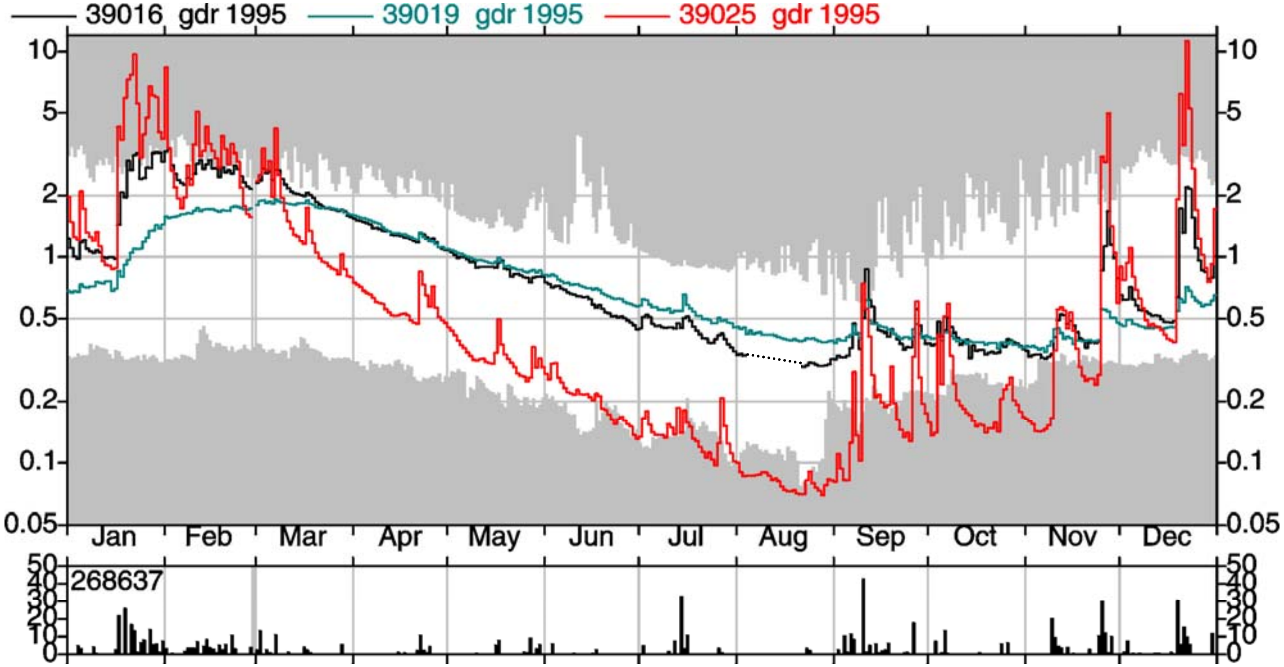
Data quality control

- **Daily mean flows versus long-term daily extremes**



Data quality control

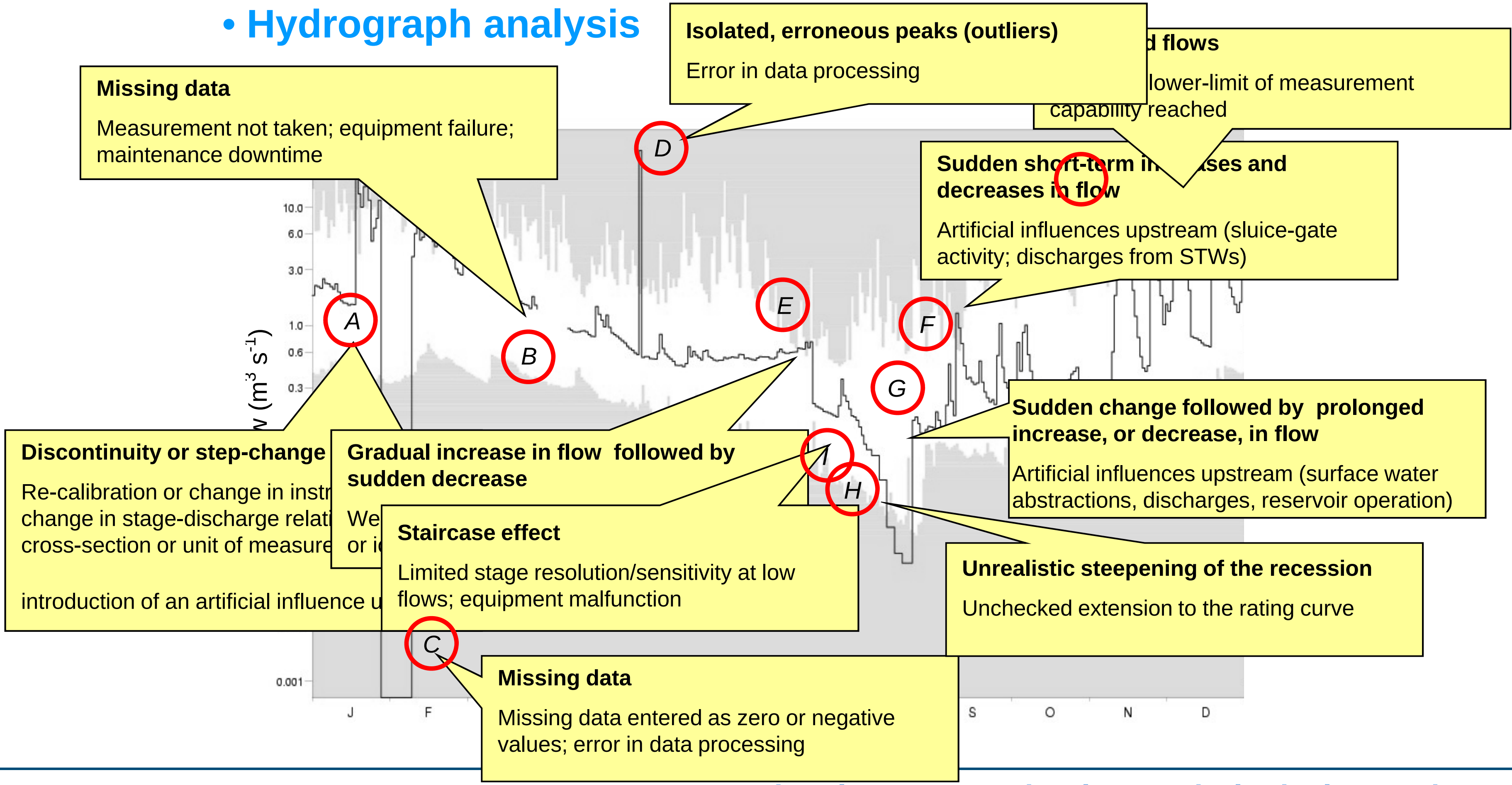
- **Time-series comparison plots**



Hydrographs from adjacent (analogue) catchments and a hyetograph from a nearby rain gauge

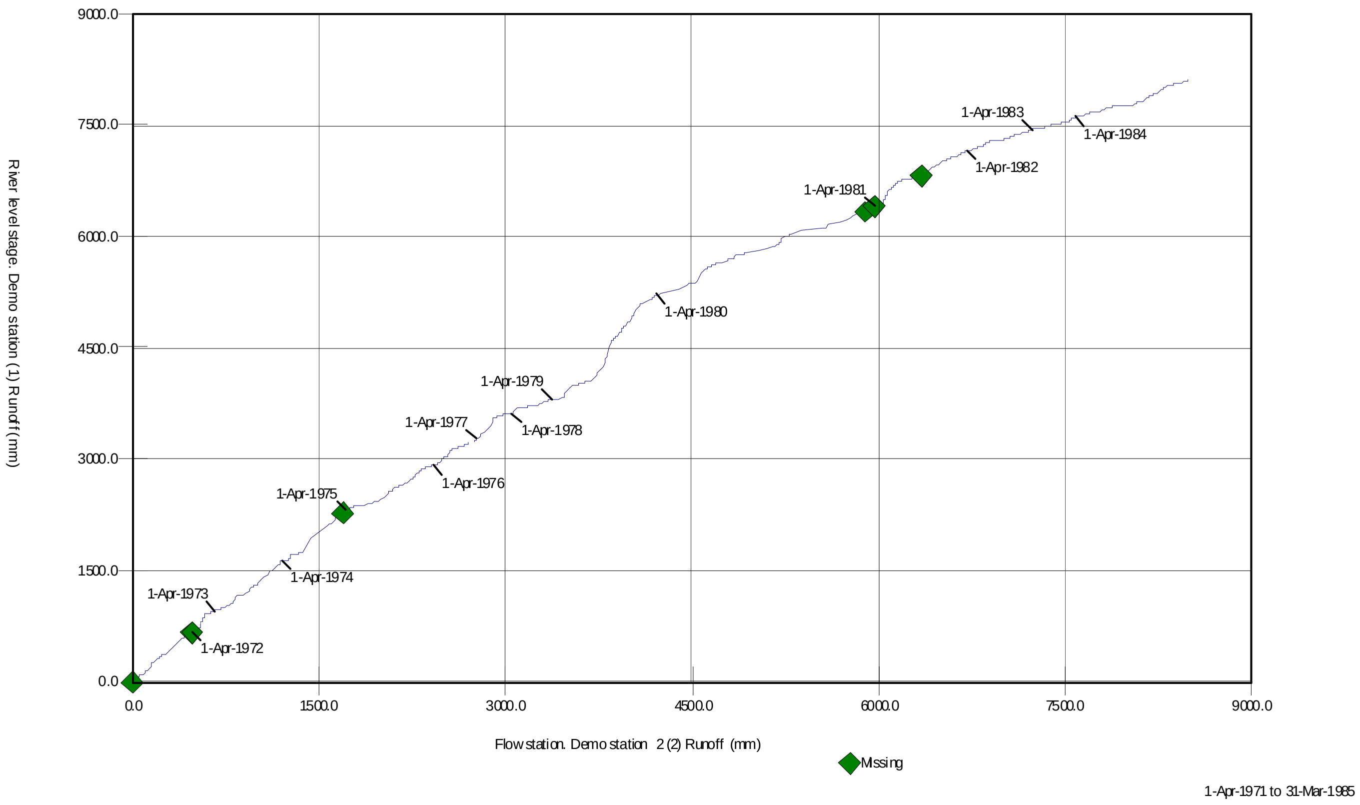
Data quality control

- **Hydrograph analysis**



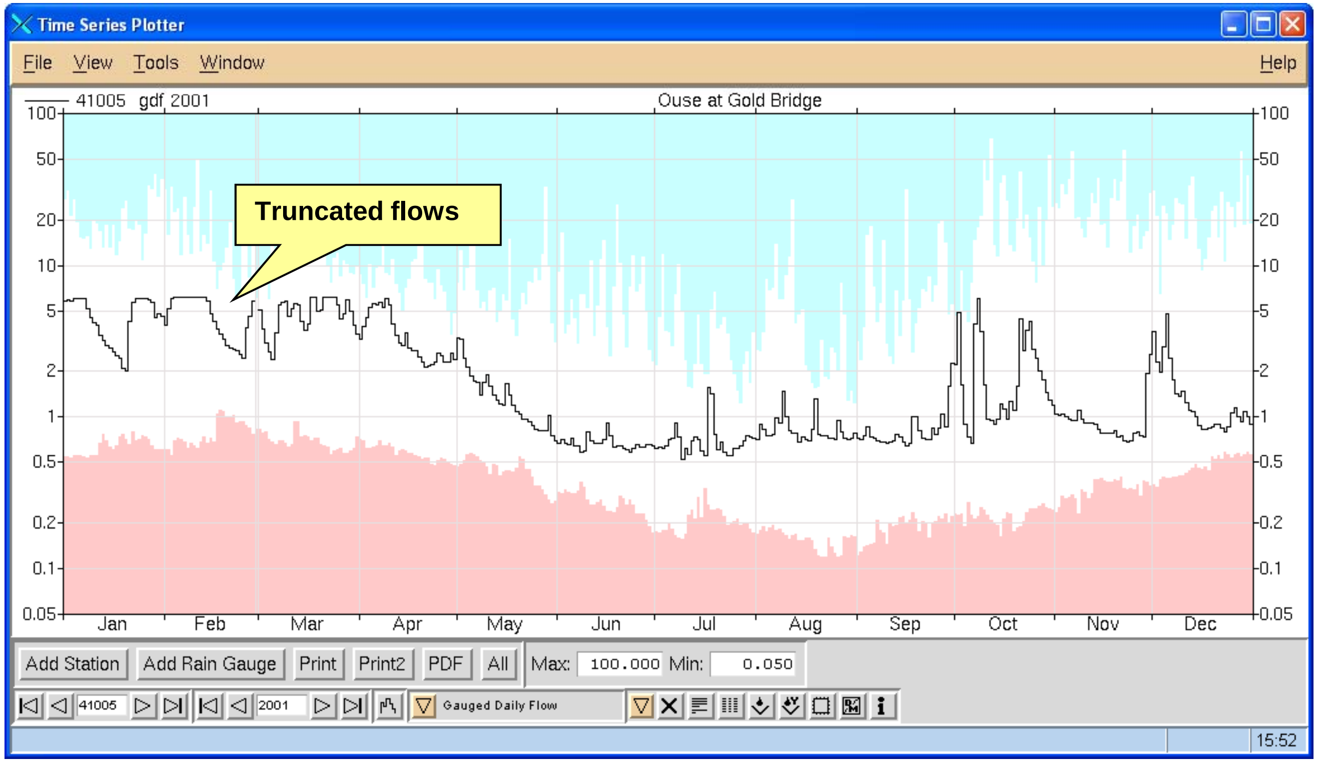
Data quality control

- **Double mass curves**



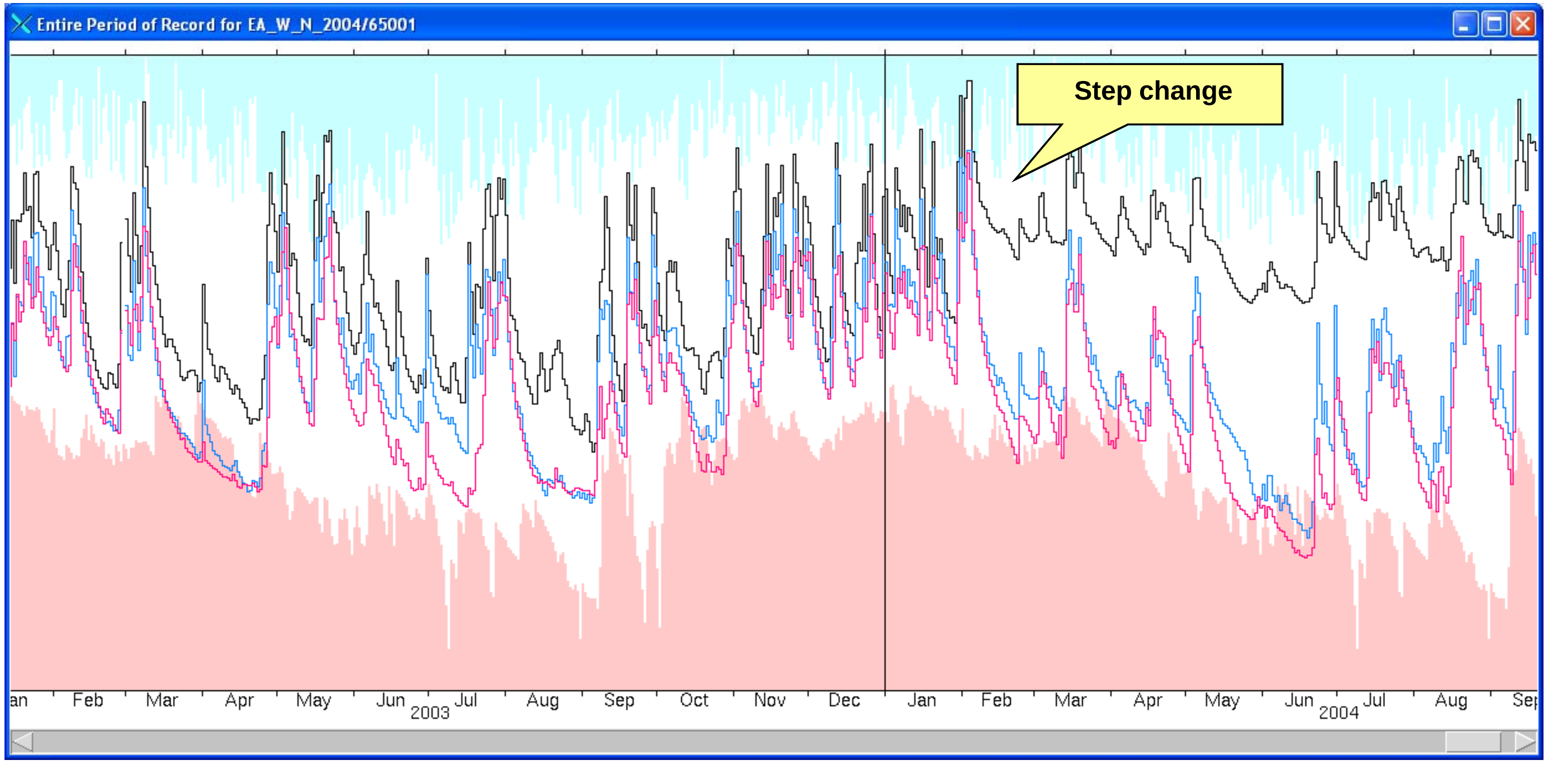
Data quality control

- **Examples of problem data (#1)…**



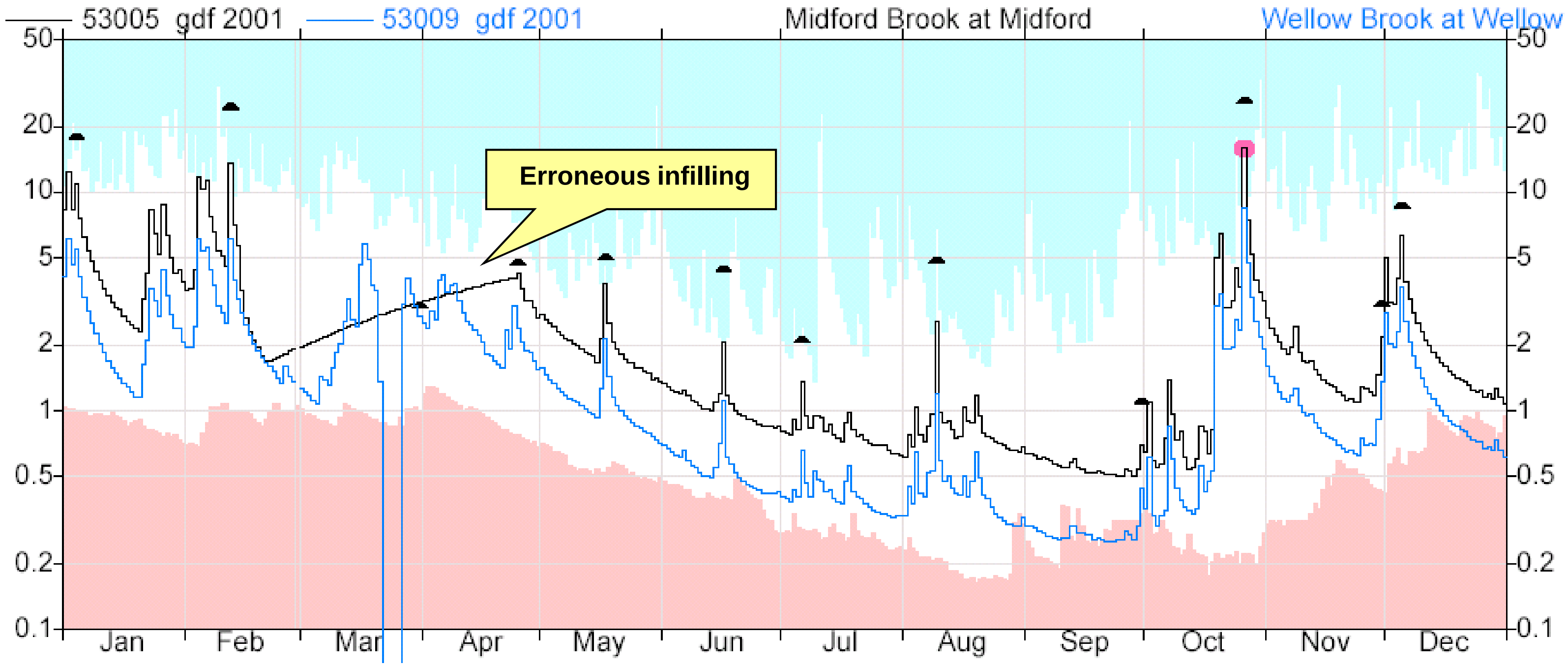
Data quality control

- **Examples of problem data (#2)…**



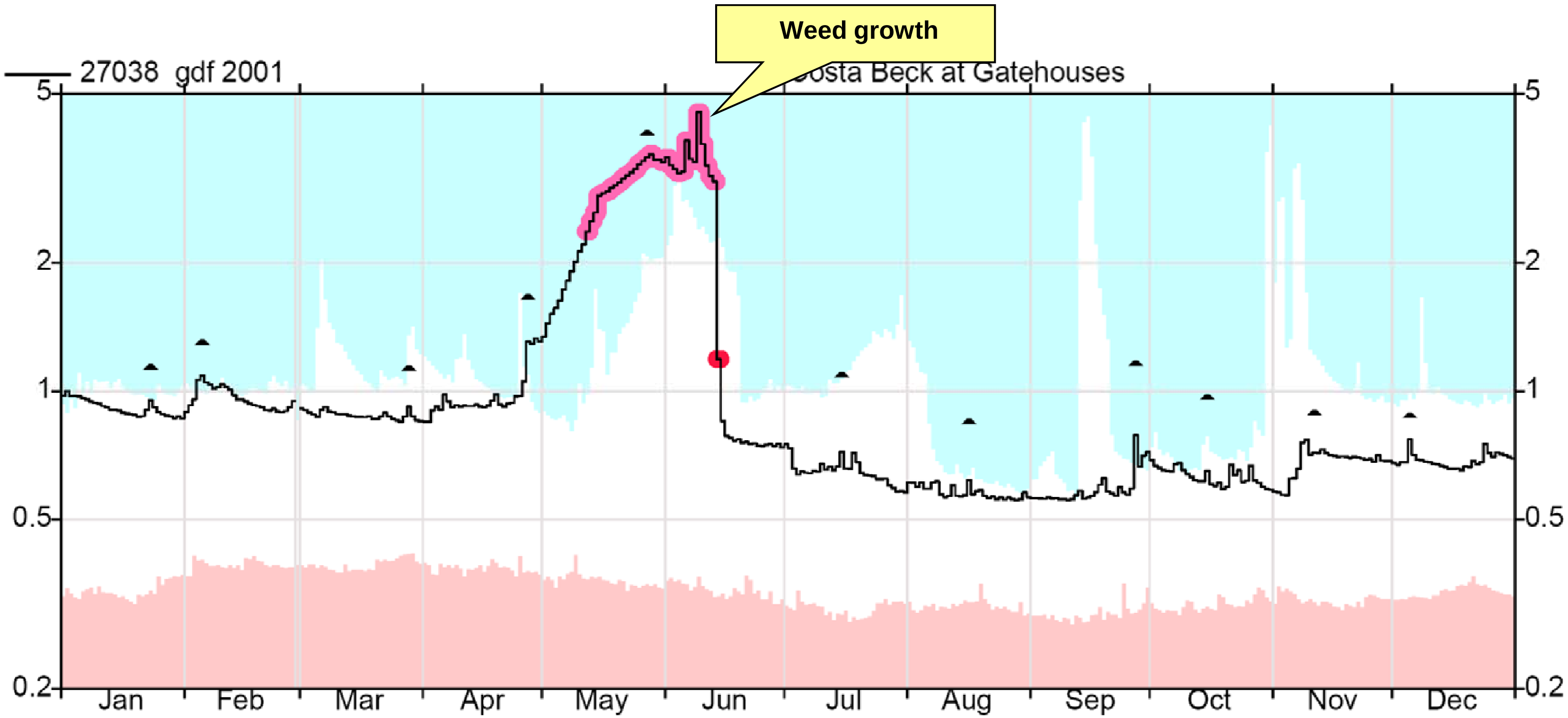
Data quality control

- **Examples of problem data (#3)…**



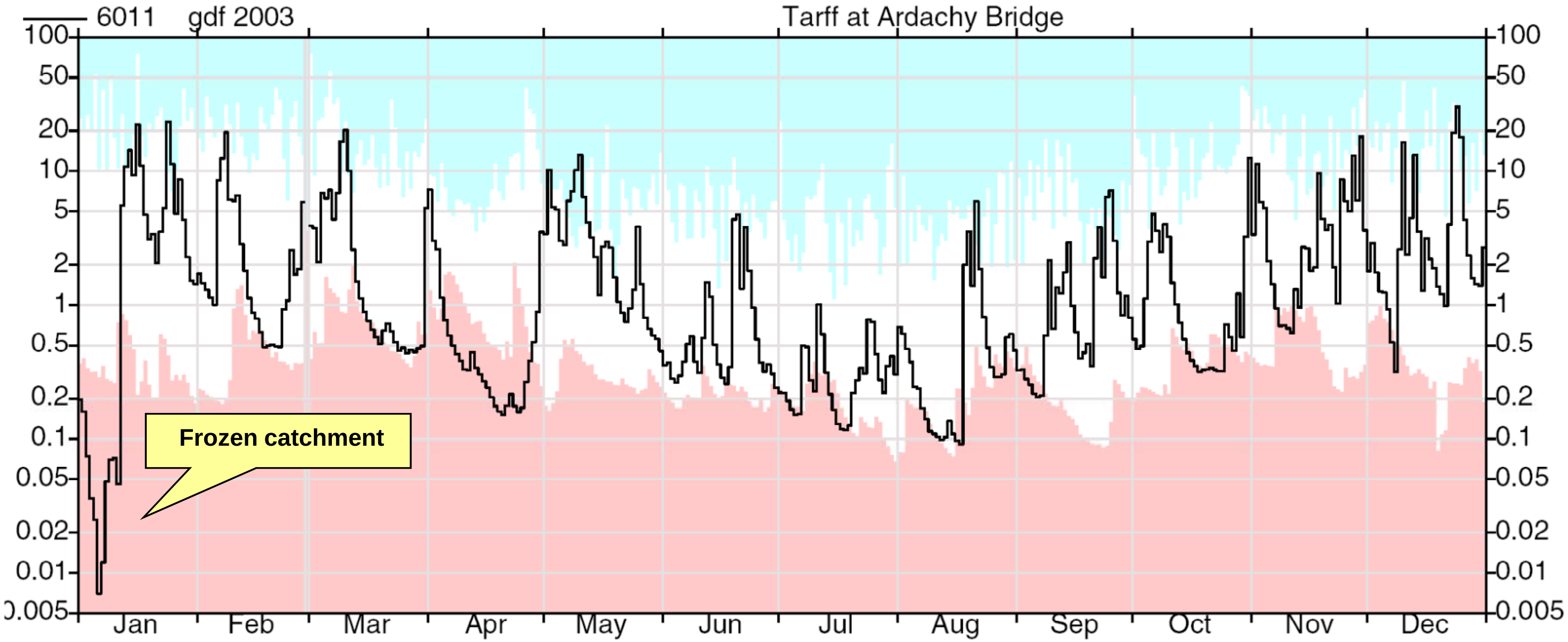
Data quality control

- **Examples of problem data (#4)…**



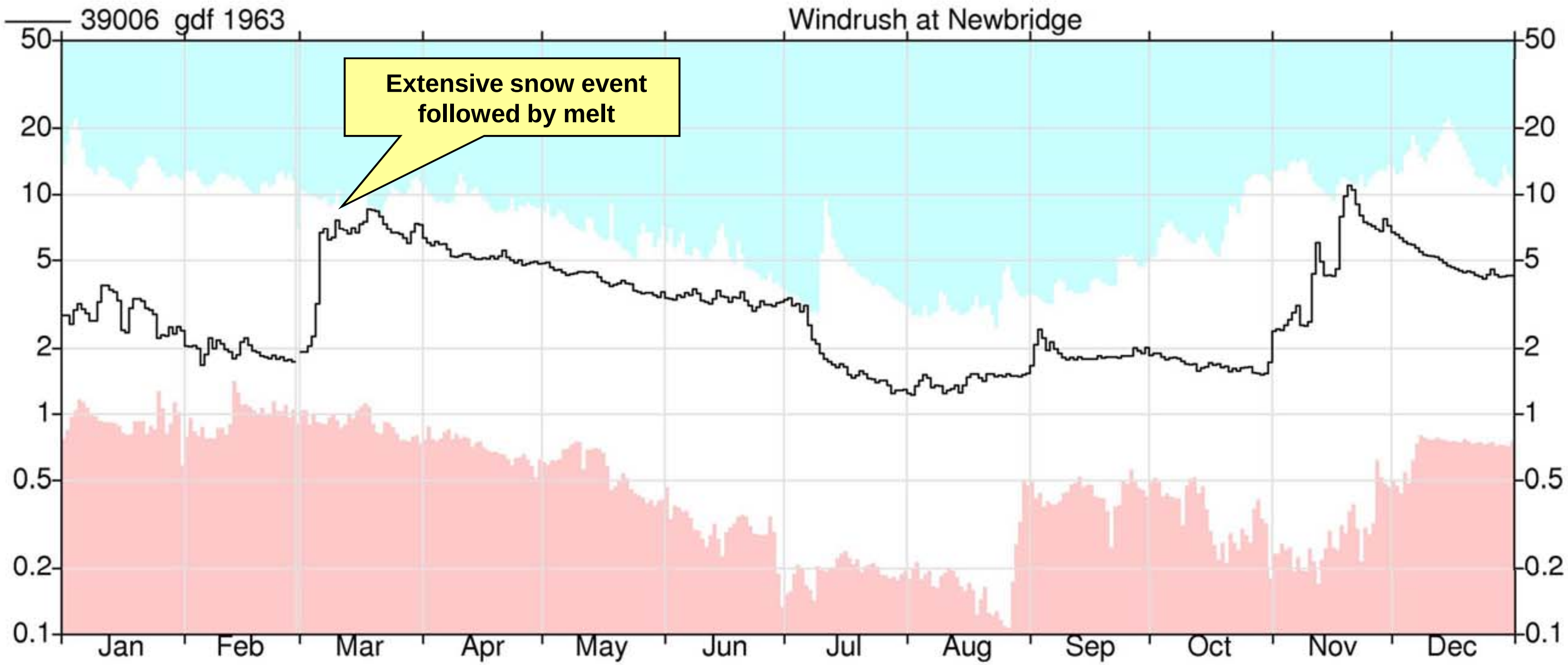
Data quality control

- **Examples of problem data (#5)…**



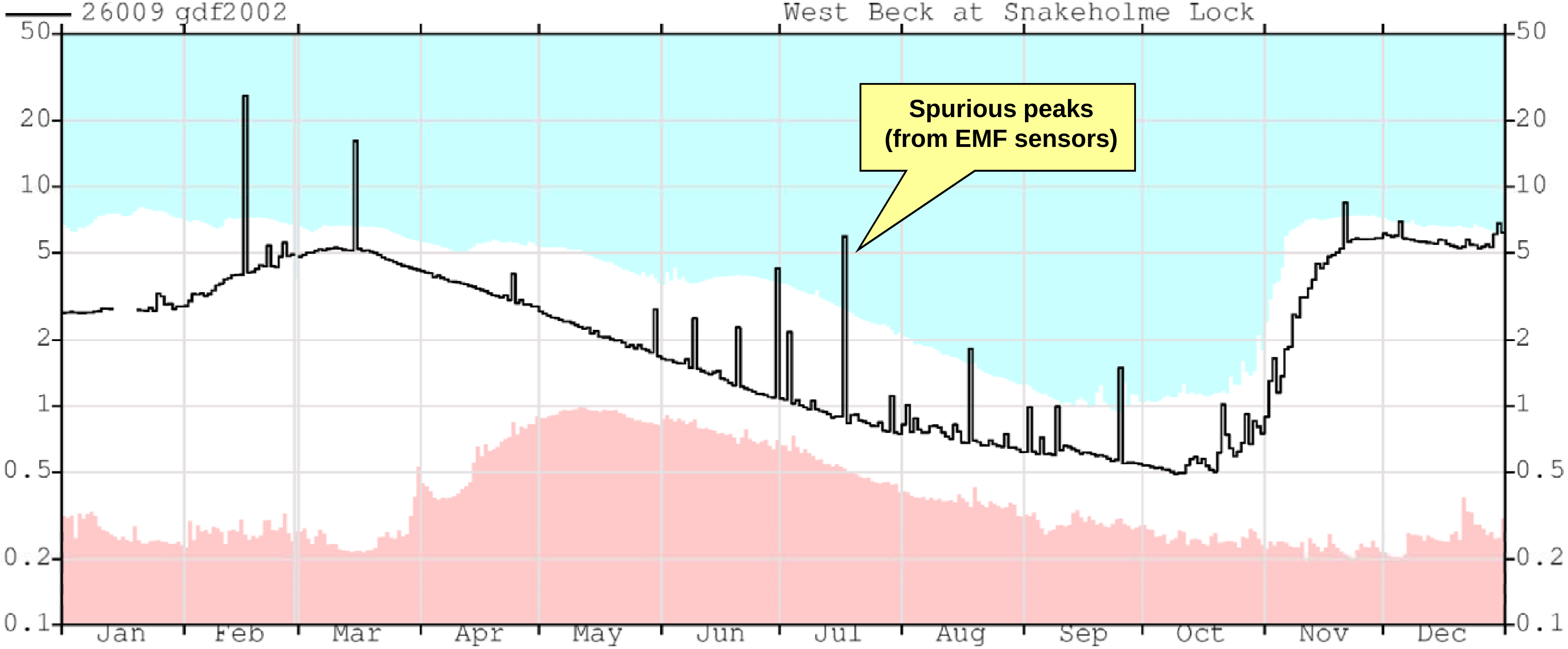
Data quality control

- **Examples of problem data (#6)…**



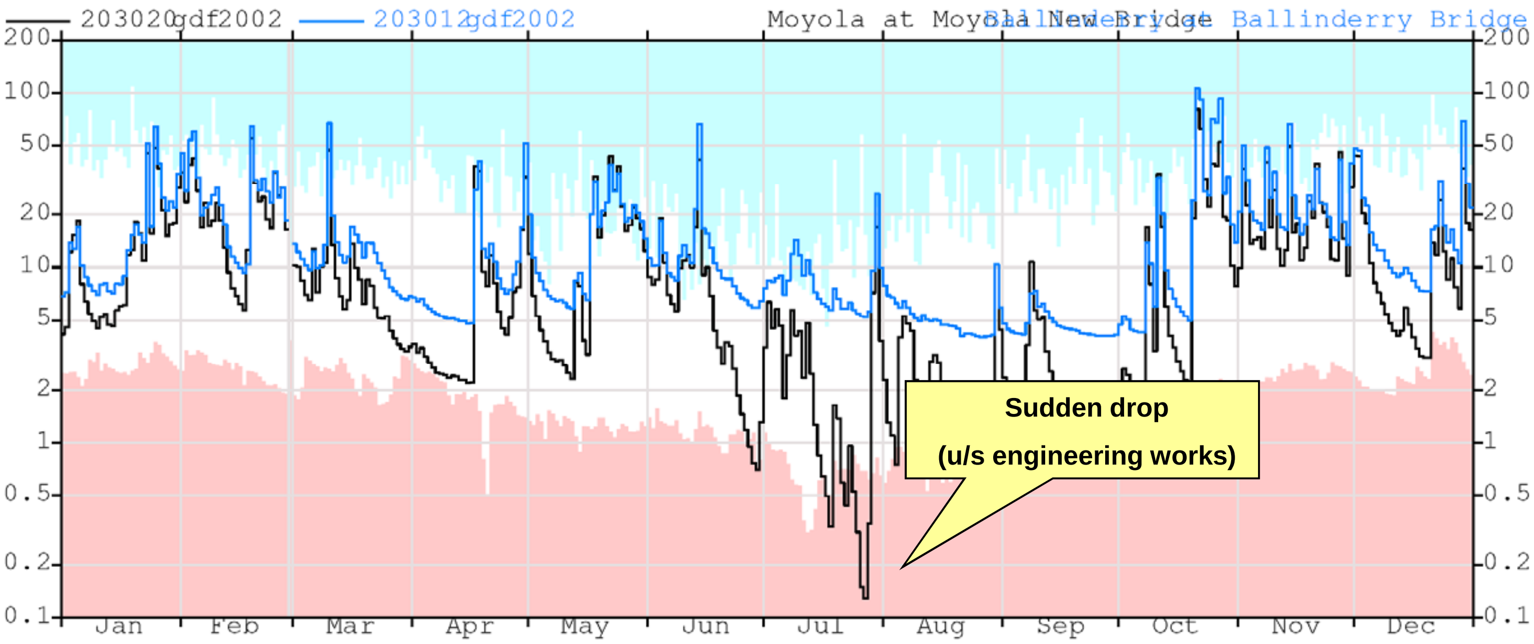
Data quality control

- **Examples of problem data (#7)…**



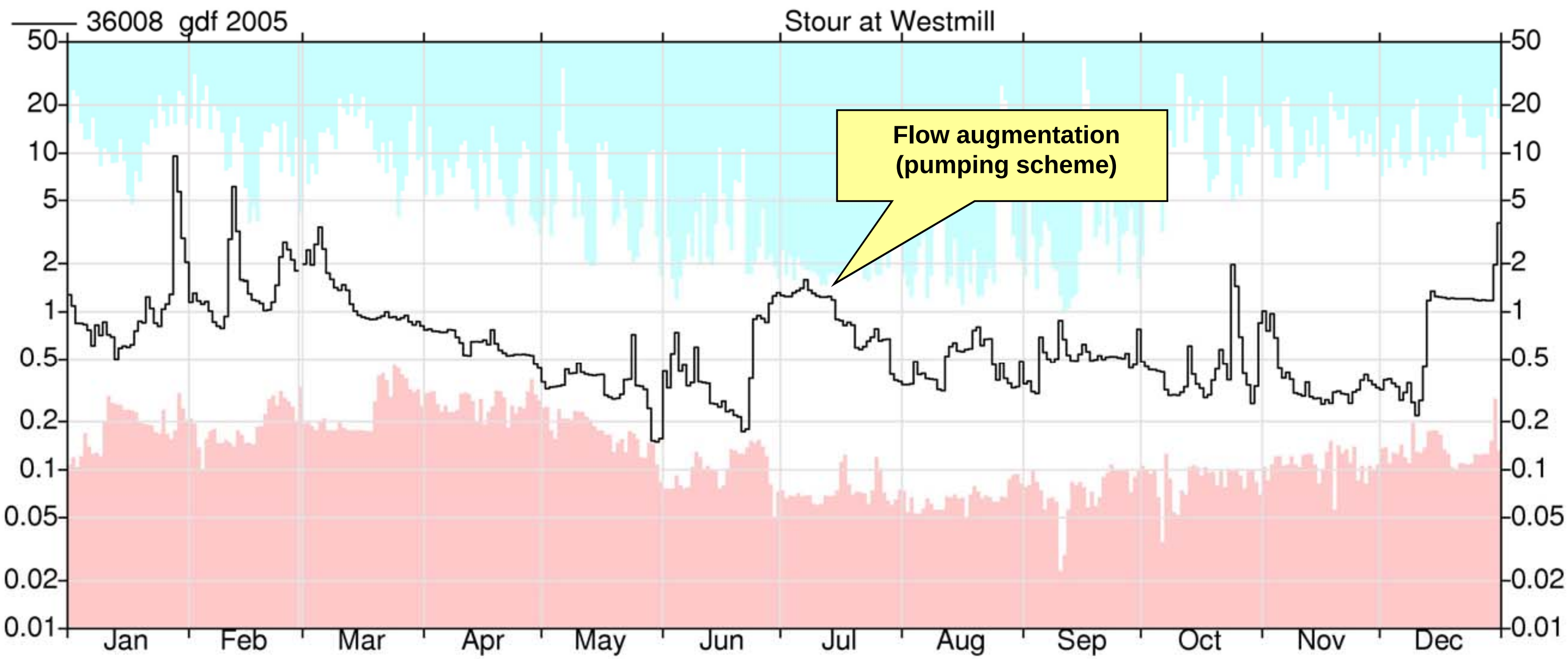
Data quality control

- **Examples of problem data (#8)…**



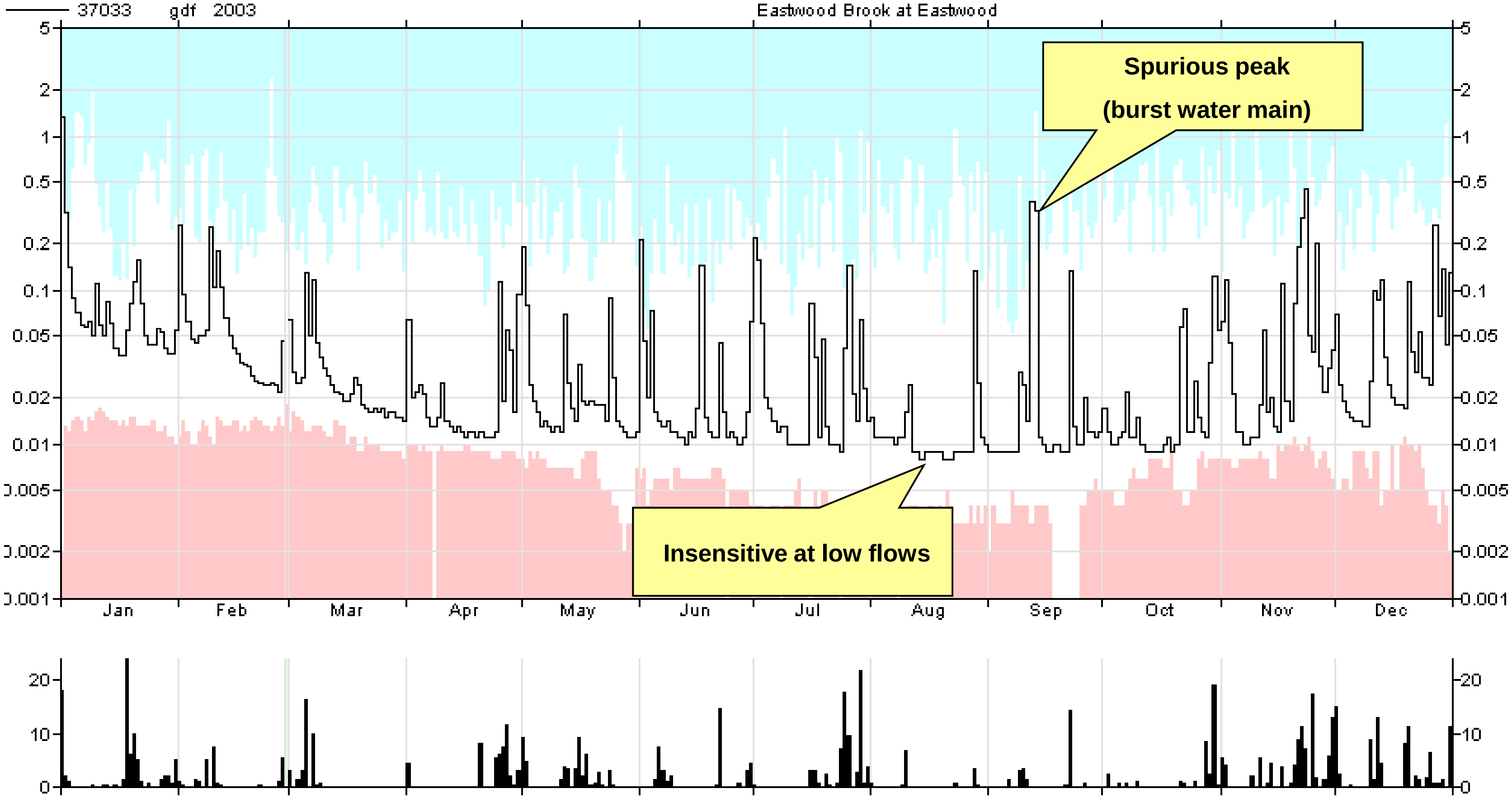
Data quality control

- **Examples of problem data (#9)…**



Data quality control

- **Examples of problem data (#10)…**



Data quality control

Tests to detect ***step change***

- Median change point test (Pettit's test for change)
- Wicoxon-Mann-Witney test
- Cumulative deviation test
- Worsley likelihood ratio test

Tests for ***trend***

- Spearmans's Rho
- Mann Kendall
- Linear regression

Ref: Kundzewicz, Z.W. and Robson, A. (Editors), 2000. Detecting trend and other changes in hydrological data, WCDMP-45, WMO/TD-No.113. World Meteorological Organization - World Climate Data and Monitoring Programme, Geneva, Switzerland, 157 pp.

Infilling data

"Missing data are a particular problem for low flow analyses because they tend to cluster in the extreme flow ranges" (Marsh, 2002)

"Even a small proportion of missing data can greatly reduce the ability to derive meaningful statistics… whilst it may not always be possible to derive realistic flows for longer, "problem" sequences, inclusion of auditable and flagged estimates is often preferable to leaving gaps in the record." (WMO/UNESCO 2008)

Infilling data

Methods

- **Interpolation methods**

  Inference ("by-eye"); linear, polynomial or spline interpolation

- **Station analogy methods**

  Scaling; equi-percentile

- **Rainfall-runoff models**

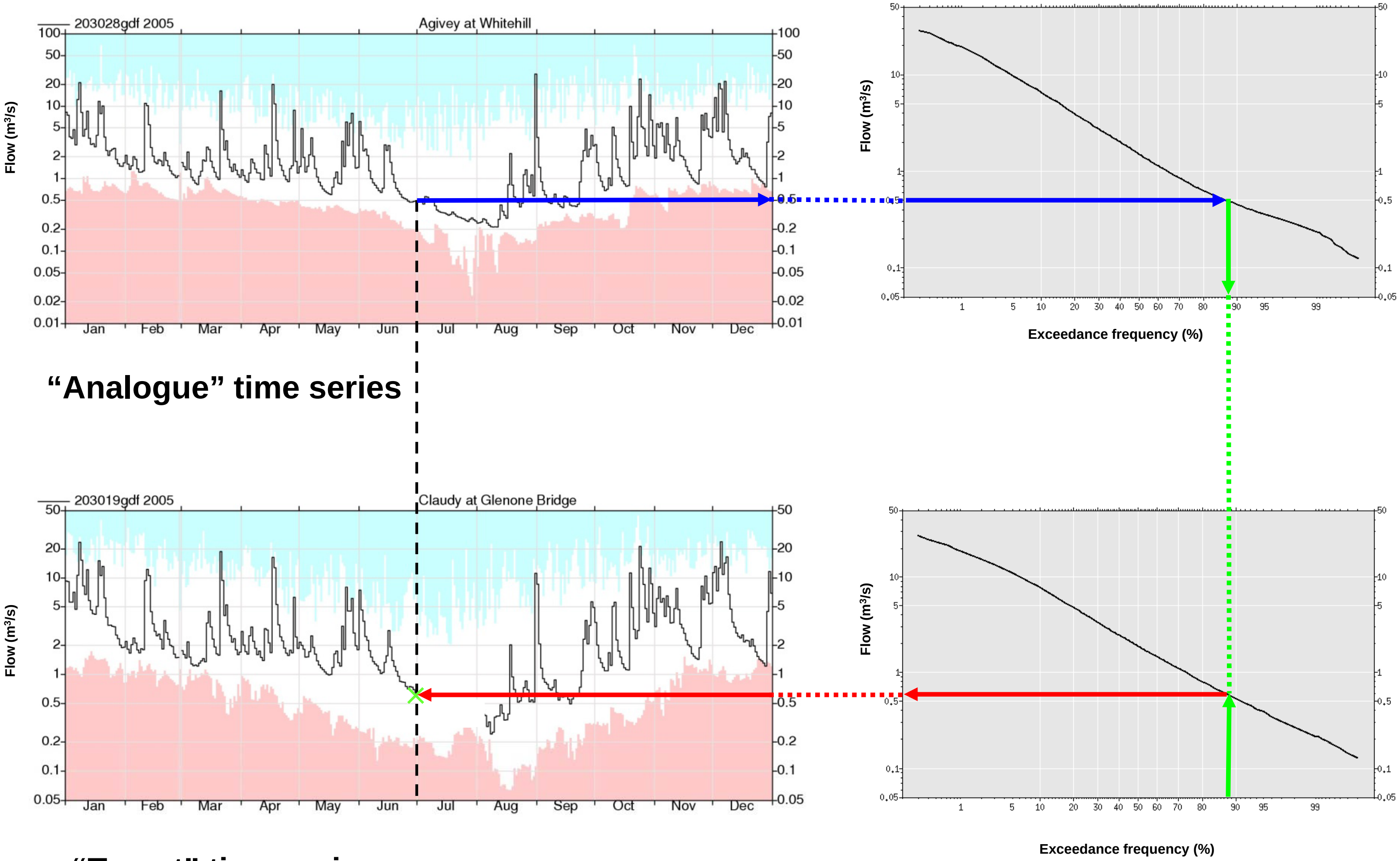
  Lumped (black-box); semi-distributed; distributed

Infilling data

Method selection

- nature of the site and characteristics of the catchment
- degree of data fluctuation at the site;
- size of the gap (the number of missing data values);
- length of the existing data record;
- hydrological conditions at the site when the gap occurred (was flow rising, falling or peaking at the time?)
- availability of supporting metadata
- software tools available
- knowledge of the person correcting the data

Equi-percentile approach

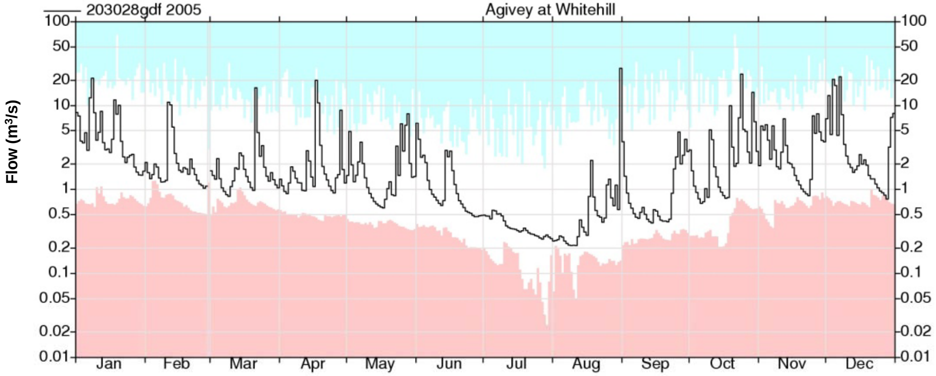


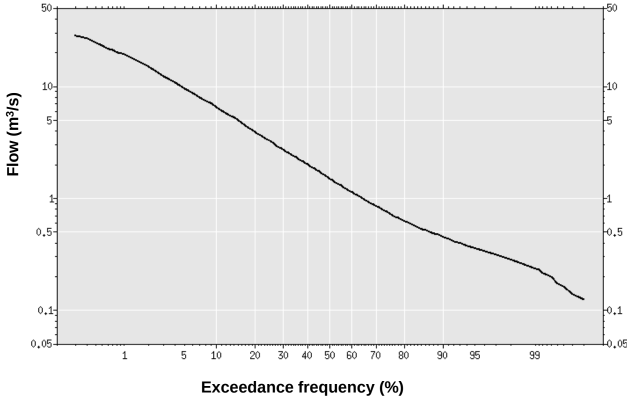
“Analogue” time series

“Target” time series

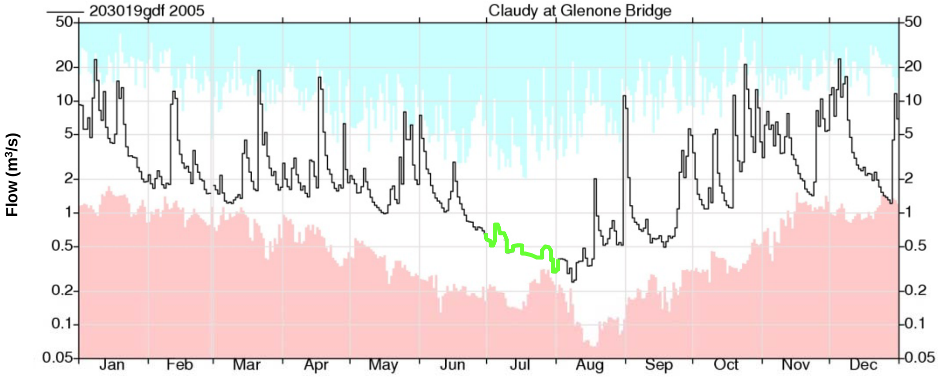
Period-of-record FDCs

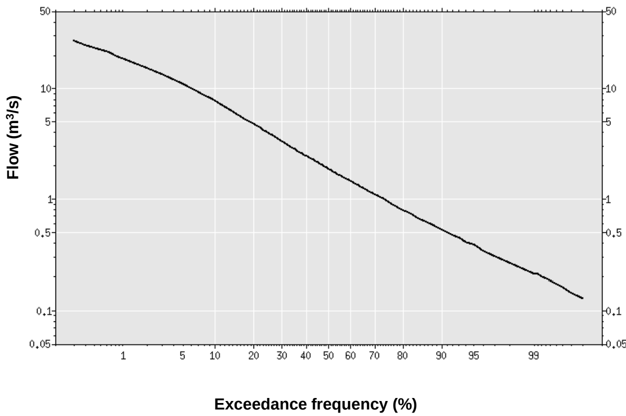
Equi-percentile approach





“Analogue” time series





“Target” time series

Period-of-record FDCs

Infilling data

Selection of analogue stations

- **proximity of catchments**
- **climatologically similar**
- **physiographically similar**

  (area, elevation range, orientation, soil and hydrogeology, land-cover)
- **similarity of hydrological response**

  (recession behaviour, base flow index)
- **absence of significant artificial influences**

  (river regulation, sewage or industrial effluent, intakes for irrigation etc).

Conclusion

"Careful examination, or validation, of data is essential before they are applied in analysis. All too often, hydrologists assume the data they have are "good" and proceed with analysis without rigorously checking the quality, which results in erroneous conclusions being drawn from "bad" data. The axiom, "garbage in – garbage out", is as true in a hydrological analysis context as it is in any other." (Rees, 2008)

Recommended reading

Herschy, R.W.,1995. Streamflow Measurement. Second Edition. Chapman & Hall, London, pp524. ISBN 0 419 19490

Gunston, H., 1998. Field Hydrology in Tropical Countries - A practical introduction. Intermediate Technology Publications, London, pp. 108. ISBN 1 85339 427 0

Kundzewicz, Z.W. and Robson, A. (Editors), 2000. Detecting trend and other changes in hydrological data, WCDMP-45, WMO/TD-No.113. World Meteorological Organization - World Climate Data and Monitoring Programme, Geneva, Switzerland, 157 pp.

World Meteorological Organization, 1980. Manual on Stream Gauging. WMO Report No. 13, Pub. No. 519World Meteorological Organization, 1994. Guide to Hydrological Practices. 5th Edition. WMO Report No. 168