Uncertainty of streamflow data: a few concepts to show hydrometrical monsters!

Thibault Mathévet, Thibault.mathévet@edf.fr, Cécile Carré, Rémy Garçon, Christian Perret
EDF - DTG, 21 avenue de l'Europe, BP 41, 38040 Grenoble Cedex 9, France

Context:

Water resources management is a central concern for EDF, both in the fields of safety, regulation and energy production. To meet these needs, EDF manages an hydrometric network composed by more than 350 stations. Thus, ensuring the streamflow data quality has become a priority for EDF. EDF, like other hydrometric data producers, faces some gauging stations whose hydraulic control sections are moderately to poorly stable. To ensure the reliability of hydrological studies and streamflow predictions it has become necessary to assess streamflow uncertainty.

Streamflow uncertainty:

Up to now, continuous streamflow estimation is still a rather difficult task. In fact, continuous streamflow estimation depends on three different steps:

1) continuous water stage measurement;
2) river streamflow gauging for given water stages;
3) calibration of a rating curve.

Each step being characterised by its own uncertainties! Streamflow uncertainty depends on many parameters, such as gauging section sensitivity, hydraulic control of the gauging section, gauging practices, stage measurements, rating curve calibration, etc. However, the most important parameter is the stability of the gauging section and hydraulic control across time. Non-stationarity of flow conditions around the gauging section usually greatly modifies the water stage – discharge relationships, and greatly decreases streamflow data quality.

Another not negligible uncertainty comes from the rating curve which commonly concerns high streamflow (Q > T = 2 years, T = 5 years).

Hydrometry at EDF – DTG:

At EDF-DTG, hydrometrical practices are based on:

- a long experience of more than 50 years of measurements and more than 30,000 gaugings on hundreds of watersheds;
- gaugings based on exploration of the velocity field (current meter, doppler) or tracer dilution;
- a wide range of watershed types (size, hydrological regime, slopes, erosion, ...);
- a wide range of gauging section stationarity!

From gaugings to rating curve:

The water stage – streamflow relationship is usually approximated by the following hydraulic law:

\[ Q = a(H - H_0) \]

where \( a \) and \( H_0 \) are parameters to calibrate. Following a LN transformation, this relation, \( \ln(Q) = \alpha + \beta \ln(H - H_0) \), becomes easy to calibrate. However, in function of the typology of each gauging sections, it is necessary to calibrate this relation by water stage domains to better represent water stage – streamflow relationship.

Modeling streamflow uncertainty:

In the literature, studies on the estimation of streamflow uncertainty are seldom and usually based on ideal cases, far from the reality encountered on a wide hydrometrical network! Given our long experience in hydrometry, we believe that the most important source of streamflow uncertainty is the probable modification of the gauging section. The non-stationarity of the gauging sections usually comes from slopes and soils erosion in the watershed, which depend on the geological substratum. Unfortunately, the main part of our hydrometrical network is situated within young mountainous areas (Alps, Pyrenees) and Mediterranean area where erosion is still high.

Usually, models of streamflow uncertainty take into account:

- rating curve sensitivity:

\[ \sigma_{\text{QySensitivit}} = \frac{\sigma_y}{\sqrt{\sigma_{\text{QySensitivit}}}} \]

Where \( H \) : Water stage, \( Q_{\text{RT}} \) : streamflow, \( \epsilon_y \) : typical error on water stage measurement.

- rating curve uncertainty:

\[ \sigma_{\text{QyCertitude}} = \frac{\sigma_y}{\sqrt{\sigma_{\text{QyCertitude}}}} \]

Where \( \sigma_y \) : rating curve uncertainty, \( \epsilon_y \) : gaugings uncertainty, N : number of gaugings close to \( Q_{\text{RT}} \).

To our opinion, this simple model is limited to very stable (stationary) gauging stations. In fact, we believe that it is important to take into account the probable non-stationarity of the gauging station. To do so, we propose to give a weight \( (\omega_i) \) to each gauging in function of three concepts to modelise streamflow uncertainty:

1) wt : The information of gaugings \( (Q_i) \) decrease in the function of time and \( Q_{\text{RT}} \).

2) w2 : For a given streamflow value of the rating curve \( (Q_{\text{RT}}) \), the information of a gauging \( (Q_i) \), is a function of \( Q_i / Q_{\text{RT}} \).

3) w3 : If a flood event occurs, greater than a certain value (T > 5 years, T > 10 years), the information of gaugings \( (Q_i) \) decrease.

Finally, the definition of the rating curve uncertainty is the following:

\[ \sigma_{\text{QyCertitude}} = \frac{\sigma_y}{\sqrt{\sum_{i=1}^{N} \omega_i (Q_i/\overline{Q_{\text{RT}}})^a \sigma_i (Q_i/\overline{Q_{\text{RT}}})^b}} \]

Conclusions:

This model of streamflow uncertainty is currently under development. We wish to apply it on a wide sample of gauging stations, in order to (1) test and improve our model and (2) be able to better estimate typical streamflow uncertainties.