Climate elasticity of streamflow revisited – an elasticity index based on long-term hydrometeorological records

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Abstract

We present a new method to derive the empirical (i.e., data-based) elasticity of streamflow to precipitation and potential evaporation. This method, which uses long-term hydrometeorological records, is tested on a set of 519 French catchments.

We compare a total of five different ways to compute elasticity: the reference method first proposed by Sankarasubramanian et al. (2001) and four alternatives differing in the type of regression model chosen (OLS or GLS, univariate or bivariate). We show that the bivariate GLS and OLS regressions provide the most robust solution, because they account for the co-variation of precipitation and potential evaporation anomalies. We also compare empirical elasticity estimates with theoretical estimates derived analytically from the Turc-Mezentsev formula.

Empirical elasticity offers a powerful means to test the extrapolation capacity of those hydrological models that are to be used to predict the impact of climatic changes.

1. Introduction

1.1 About hydrological elasticity

In a context of growing uncertainty on water resources due to climate change, simple tools able to provide robust estimates of this impact are essential to support policy and planning decisions. Streamflow elasticity is one such tool: it describes the sensitivity of the changes in streamflow related to changes in a climate variable (Schaake and Liu, 1989). $\varepsilon_{Q/X}$, the elasticity of streamflow Q to a climate variable X is defined by the following equation:

$$\Delta Q / \overline{Q} = \varepsilon_{Q/X} \Delta X / \overline{X} \quad \textbf{Eq. 1}$$

where $\overline{Q}$ and $\overline{X}$ are the long-term average value of streamflow and the climatic variable, respectively, and the operator Δ indicates the difference between the dated and the average value. $\varepsilon_{Q/X}$ is nondimensional [% / %], because it is a ratio between two relative (and thus already nondimensional) quantities. One can also define elasticity as the ratio between two absolute quantities and, provided both quantities are expressed in the same unit (for example, $mm.yr^{-1}$ for streamflow, precipitation or potential evaporation), it would still be a nondimensional ratio [$mm.yr^{-1}$ / $mm.yr^{-1}$]. We will name this absolute elasticity $e_{Q/X}$, defined as:

$$\Delta Q = e_{Q/X} \Delta X \quad \textbf{Eq. 2}$$

Table 1 summarizes the notations used in this paper.

1.2 Past studies on elasticity in hydrology

- **Theoretical (model-based) studies**

Most of the studies on elasticity are *theoretical*, in the sense that they are based on flows simulated by a hydrological model fed with different inputs. There are many examples of such theoretical studies. Nemec and Schaake (1982) used the Sacramento model, Vogel et al. (1999) used the linear regression coefficients of annual streamflow models, Sankarasubramanian et al. (2001) used the abcd model, Niemann and Eltahir (2005) used a purpose-built model and Chiew (2006) used the SIMHYD and AWBM models. The most widely used model in elasticity studies is the long-term water balance formula first proposed by Turc & Mezentsev (Mezentsev, 1955; Turc, 1954) (see section 3.2). This formula (sometimes improperly confused with Budyko's formula) was used in elasticity studies by Dooge (1992), Arora (2002), Sankarasubramanian et al. (2001), Yang et al. (2008), Potter and Zhang (2009), Yang and Yang (2011), Donohue et al. (2011) and Yang et al. (2014), among others.

- **Empirical (data-based) studies**

Only a few of the published elasticity studies are *empirical*. By *empirical*, we mean that they use measured data (for different sub-periods) to evaluate the climate elasticity of streamflow. To our knowledge, *Sankarasubramanian et al.* (2001) were

the first to publish a method based on the median of annual flow anomalies to compute elasticity, later used by Chiew (2006). Potter et al. (2010) analyzed concomitant reductions of precipitation and streamflow in the Murray-Darling basin over three major historic droughts, and Potter et al. (2011) suggested computing elasticity as a multiple linear regression linking annual transformed streamflow values to annual precipitation and temperature anomalies.

- **Difference between theoretical (model-based) and empirical (data-based) elasticity assessments**

To clarify the differences existing between theoretical and empirical elasticity computing approaches, we have listed the key characteristics of both methods in Table 2. The most important problem stems from the co-variation of potential evaporation (or temperature) and precipitation: Fu et al. (2007a) mentioned this issue and proposed to transform the "single parameter precipitation elasticity of streamflow index" into a "two parameter climate elasticity index" which would be function of both precipitation and temperature, in order to account for both effects simultaneously. Recently, Chiew et al. (2013) underline that "because of the inverse correlation between rainfall and temperature, any effect from the residual temperature on streamflow is much less apparent than the direct effect of (the much more variable) rainfall." Note that the use of model simulations to compute streamflow elasticity circumvents this problem.

However, there remains what we consider to be a major disadvantage: since all hydrological models are a simplification of reality, using them to predict changes requires some type of initial validation on empirical (observed) data. Indeed, we have recently compared (see Fig. 9a in Coron et al., 2014) the ability of three models of increasing complexity to reproduce the variations in water balance equilibrium over 10-year-long periods and shown that all three models tested had a tendency to underestimate observed changes.

In this paper, we will focus on identifying the most robust approach to compute empirical elasticity. Then we will compare the results obtained by this method with the theoretical elasticity of the Turc-Mezentsev water balance formula. This comparison will only aim at illustrating the difference between the two approaches, since there is no reason to consider one or the other as the "true" reference.

1.3 Scope of the paper

In this paper, we test four alternative approaches to compute the empirical streamflow elasticity, which we compare over a large catchment set to the approach first suggested by Sankarasubramanian et al. (2001). In section 2, we present the data set of 519 French catchments on which this study is based. Section 3 gives a short overview on the possible graphical representations of catchment elasticity and the methods used to quantify empirical elasticity. Section 4 presents a preliminary selection of the formulas, focusing on the distinction between univariate and bivariate methods. Then section 5 presents a regional analysis of streamflow elasticity to precipitation and potential evaporation over France. Last, the conclusion identifies a few perspectives for further work.

2. Catchment dataset

Figure 1 presents the 519 catchments analyzed for these studies.

Long series of continuous daily streamflow and precipitation were available over the 1976–2006 period. The data set encompasses a variety of climatic conditions (oceanic, Mediterranean, continental, mountainous). Precipitation data was provided by Météo France as a gridded product, based on a countrywide interpolation of rain gage data (SAFRAN product, see Le Moigne (2002)). As far as potential evaporation data is concerned, we used the Penman-Shuttleworth equation (Shuttleworth, 1993) because Donohue et al. (2010) suggested that it was the most appropriate form of *atmospheric evaporation demand* when considering a changing climate.

To illustrate the issues raised this paper, we will use the catchment of the River Brèze at Meyrueis. This 36-km² catchment located in the south of France has a good quality stream-gaging station and a long observation series.

3. A review of methods to assess streamflow elasticity

3.1 Graphical assessment of elasticity

Nemec and Schaake (1982) introduced the classical sensitivity plots showing the changes in streamflow (or in some streamflow-based characteristics) as a function of percent change in precipitation (Figure 2). Their approach consisted in assessing

streamflow elasticity over the whole modeling period by gradually changing the model inputs individually. If the hydrological model behavior is free from thresholds or strong hysteresis effects, this method produces a set of parallel curves such as those shown in Figure 2.

Wolock and McCabe (1999) used a similar graph (Figure 3), but replaced the percent changes with the absolute changes (plotting $e_{Q/X}$ instead of $\varepsilon_{Q/X}$): in this paper, we will follow their example, but replace the model-based results with observations.

The graphs used herein describe *empirical elasticity*: they are based on hydrological data only and require a sub-sampling of long-term records, i.e., distinguishing a number of sub-periods. Therefore, a point is apparent for each of these sub-periods. Figure 4 presents an example in which ΔQ is plotted as a function of either ΔP or ΔE_P.

To represent the co-variations of ΔQ with both ΔP or ΔE_P simultaneously, we need either a three-dimensional graph or a graph based on isolines (see Fu et al., 2007b). Figure 4 c presents an example using a color code. This graph is particularly useful because the values of ΔP and ΔE_P are often correlated (Chiew et al., 2013), which may make the two-dimensional representations misleading.

The graphical representation of empirical elasticity shown in Figure 4 allows looking at data without formulating an arbitrary modeling choice. The only convention lies in the duration of the sub-periods. Here, we chose a duration of 10 years in order to obtain contrasted yet representative periods. Figure 5 illustrates the changes induced by a change in this duration. It is reassuring to see that similar trends are observed for a wide range of period lengths. The relationship between the different variables does not remain absolutely identical, however, and there is clearly a trade-off between a longer duration, which ensures that the relationships are close to their long-term value, and a lower number of points, which reduces the confidence in the trend displayed by the plot.

3.2 Reference method for theoretical elasticity assessment: the Turc-Mezentsev formula

Most of previous studies used a model-based definition of elasticity, and several of them used the Turc-Mezentsev formula (Mezentsev, 1955; Turc, 1954). The

interested reader can refer to *Lebecherel et al.* (2013) for an historical review on this formula, which is given by:

$$Q = \Psi(P, E_P) = P - \frac{P}{\left(1 + \left(\frac{P}{E_P}\right)^n\right)^{\frac{1}{n}}} = P - \left(P^{-n} + E_P^{-n}\right)^{\frac{-1}{n}} \quad \textbf{Eq. 3}$$

with Q – long-term mean average flow (mm/yr), P – long-term mean average precipitation (mm/yr), E_P – long-term mean average potential evaporation (mm/yr). n is the only free parameter of the formula. Here, we followed *Le Moine et al.* (2007) and used a fixed value n=2.5.

Partial derivatives of the Turc-Mezentsev formula are easily computed, they are given in Eq. 4 and Eq. 5. They allow computing the theoretical value of the precipitation and potential evaporation elasticity directly for each catchment.

$$\frac{\partial Q}{\partial E_P} = \Psi'_P(P, E_P) = -\left(1 + \left(\frac{E_P}{P}\right)^n\right)^{-\frac{n+1}{n}} \quad \textbf{Eq. 4}$$

$$\frac{\partial Q}{\partial P} = \Psi'_{E_P}(P, E_P) = 1 - \left(1 + \left(\frac{P}{E_P}\right)^n\right)^{-\frac{n+1}{n}} \quad \textbf{Eq. 5}$$

3.3 Alternative methods for empirical streamflow elasticity assessment

We will now focus on data-based methods assessing empirical elasticity. Long-term series of streamflow and catchment climate are required. Before introducing the methods compared in this paper, let us introduce the notation $\Delta X_i^{(M)} = X_i^{(M)} - X^{(LT)}$ denoting the departure (anomaly) of a variable X computed over a period of M years starting from year i versus the long-term average $X^{(LT)}$ computed over the entire period.

Five methods will be compared in this paper, all listed in Table 3.

- **Nonparametric method**

This method computes an annual time-series of relative streamflow anomalies (i.e., differences with the long-term mean) and then uses the median of these values as an elasticity estimator:

$$\begin{cases} e^{(M)}{}_{Q/P} = median\left(\dfrac{\Delta Q_i^{(M)}}{\Delta P_i^{(M)}}\right) \\ e^{(M)}{}_{Q/E_P} = median\left(\dfrac{\Delta Q_i^{(M)}}{\Delta E_{P_i}{}^{(M)}}\right) \end{cases} \qquad \textbf{Eq. 6}$$

This method is similar to the one advocated by *Sankarasubramanian et al.* (2001) except that they used it to compute the relative rather than the absolute elasticity (see Table 1). In addition, *Sankarasubramanian et al.* (2001) applied the method to yearly data only, whereas we used sub-periods ranging from 1 to 25 years in this study.

- **Regression methods quantifying precipitation and potential evaporation elasticities (OLS or GLS estimates) *independently***

These methods compute elasticity as either an ordinary least-square (OLS) or generalized least-square (GLS) solution (Johnston, 1972) of the regression models detailed in Table 4. See Appendix 1 for a quick description of the method used to perform the GLS regression.

- **Methods quantifying precipitation and potential evaporation elasticities (OLS or GLS estimates) *simultaneously***

These methods (OLS or GLS) quantify precipitation and potential evaporation elasticities *simultaneously* by looking for the GLS solution of a regression model with the same statistical assumptions as above (see Table 5).

The strength of the bivariate method obviously lies in the fact that it accounts for the cross-correlation of ΔP and ΔE_P values. The method used for inferring the parameter values and their significance was identical to the method described above.

Note that for the sake of consistency with the GLS models, the uncertainty in the OLS parameters was assessed with the bootstrap approach (Efron and Tibshirani, 1994).

4. Selection of the best method to compute empirical streamflow elasticity

4.1 Assessing the capacity of the five methods to compute the empirical elasticity of a synthetic data set

As a first step to compare the merits of the different regression models presented in the previous section, the elasticity estimation was conducted with synthetic streamflow data generated from the Turc-Mezentsev formula, where the parameter n was set at 2.5 (Le Moine et al., 2007) and input data from the 519 catchments described in section 2. The advantage of using synthetic flow here is that we know the exact (i.e., analytical) solution for elasticity, and this will help identify the drawbacks of some of the methods compared.

For this test, the observed streamflow anomalies $\Delta Q_i^{(M)}$ were replaced by the estimates $\Delta\tilde{Q}_i^{(M)} = \Psi\left(P_i^{(M)}, E_{P_i}^{(M)}\right) - \Psi\left(P^{(LT)}, E_P^{(LT)}\right)$ where Ψ is given in Equation 3. The empirical elasticity values were subsequently compared with the exact values $\Psi'_P\left(P^{(LT)}, E_P^{(LT)}\right)$ and $\Psi'_{E_P}\left(P^{(LT)}, E_P^{(LT)}\right)$ given in Equations 4 and 5, respectively. The performance of each regression model was judged according to the absolute bias B and root mean square error (RMSE) R:

$$B_X^{(M)} = \left|\sum_{k=1}^{N}\left[e_{Q_i/X_i}^{(M)} - \Psi'_x\left(P_i^{(LT)}, E_{Pi}^{(LT)}\right)\right]\right| \quad \textbf{Eq. 7}$$

$$R_X^{(M)} = \sqrt{\sum_{i=1}^{N}\left[e_{Q_i/X_i}^{(M)} - \Psi'_x\left(P_i^{(LT)}, E_{P^i}^{(LT)}\right)\right]^2} \quad \textbf{Eq. 8}$$

where X is the climate variable (P or E_P), $e_{Q_i/X_i}^{(M)}$ is the corresponding empirical elasticity value computed for catchment i using sub-periods of M years, and N=519 is the number of catchments.

The performance of the five alternative methods is presented in Figure 6, which shows the absolute bias and the root mean square error on the elasticity for precipitation and potential evaporation, respectively.

The four plots in Figure 6 clearly indicate the superiority of the two bivariate models (OLS-2 and GLS-2) over the three univariate models (NP, OLS-1 and GLS-1), with bias and RMSE on both types of elasticity that are lower by several orders of magnitude. This first result suggests that the estimation of empirical elasticity is

greatly improved when conducted simultaneously on rainfall and potential evaporation.

Figure 6 also shows that the duration of the sub-periods can slightly affect the performance of the regression model. The largest impact can be seen in the bias on the elasticity to potential evaporation (Figure 6.a) where the optimal duration of 20 years provides a better performance compared to the other durations. The 20-year duration seems to be the best choice for both types of elasticity, for all regression models, and both bias and RMSE.

This study based on synthetic data shows the clear superiority of the methods based on bivariate regressions (OLS2 and GLS2): the Non-Parametric method (NP) and the univariate regressions (OLS1 and GLS1) are clearly unable to compute streamflow elasticity robustly. Because the NP method is the reference method (suggested by (Sankarasubramanian et al., 2001)), Figure 7(a,c) compares the empirical elasticity values given by the NP method and the GLS2 method: the differences are very large. On the other hand, Figure 7(b,d) shows that there is little difference between the estimates given by OLS2 and GLS2. However, for statistical reasons (presented in Appendix 2) we consider that the GLS method should be preferred.

Having decided on the best method to compute empirical elasticity, we can now compare model elasticities with the GLS estimates based on measured streamflow.

4.2 Coherence of data-based and model-based elasticity estimates

We now wish to compare the *empirical* elasticity computed with the GLS2 method (the recommended one) with the *theoretical* elasticity derived analytically from the Turc-Mezentsev formula (see Eq. 3). While in the previous test we used synthetic data, we now use the actual (measured) streamflow. This means that contrary to the preceding test, we do not have any “reference”: since neither the data-based nor the model-based elasticity can be considered “true,” we can only assess the coherence between the two computations.

The scatterplots illustrated in Figure 8 compare the elasticity values obtained by the multivariate regression (GLS2) method and the model-based approach: we can see that the link between the two measurements on a catchment-by-catchment basis is extremely weak for precipitation… and even more for potential evaporation.

The fact that empirical and theoretical elasticities differ is in itself noteworthy and would require further analysis. At this point, we cannot draw any further conclusion from this comparison: as widely used as it is, the Turc-Mezentsev relationship remains a theoretical model and cannot be considered superior to the data-based elasticity assessment.

5. Results: Regional elasticity analysis over France

Henceforth, we only consider the empirical elasticity estimates given by the GLS2 method. Figure 9 illustrates the results: each of the 519 gauging stations of the data set are shown, but the points for which the elasticity coefficient is not significantly different from zero are indicated with a cross only. For the other points, the color code gives the elasticity value.

From the maps, it is difficult to identify physical reasons for the spatial variations in elasticity values. The Massif central highlands seem to show a slightly higher occurrence of high-intensity elasticities, both to P and E_P, and the Paris Basin lowlands a slightly lower occurrence. This tendency could perhaps be related to the absence/presence of large groundwater aquifers, but more detailed comparative studies are needed to draw a firm conclusion.

A few outliers appear, which is common when using a large data set: one catchment shows a negative elasticity to precipitation and five catchments show a positive elasticity to potential evaporation. We checked each of the plots individually and verified that this was in fact due to a very limited span of streamflow anomaly ΔQ, which made the regression rather meaningless.

To conclude this countrywide analysis of elasticity, we tested a possible relation between catchment size and elasticity values. Figure 10 speaks for itself: over the range of catchment areas covered by this study, no trend could be identified with catchment area.

6. Conclusion

6.1 Synthesis

In this paper, we identified an improved method to assess the empirical elasticity of streamflow to precipitation and potential evaporation. This method (GLS2), which uses long-term hydrometeorological records, was tested on a set of 519 French catchments.

We started with a synthetic data set and compared this improved method with the reference nonparametric method and with several univariate and bivariate alternatives: we obtained results with a much lower bias and RMSE, this difference being clearly due to the fact that the improved method was able to account for the covariation of precipitation and potential evaporation anomalies.

We then compared the improved empirical elasticity estimate with the theoretical estimates derived analytically from the Turc-Mezentsev formula. Empirical and theoretical estimates weakly correlated: the link between the two measurements on a catchment-by-catchment basis is weak for precipitation, and very weak for potential evaporation.

6.2 Limits and perspectives

As a simple method characterizing the sensitivity of streamflow to climatic changes, the identification of empirical elasticity seems promising. Indeed, the empirical elasticity assessment advocated in this paper can provide an estimate of the impact of climate change on hydrology that is *almost* model-free (except for the assumption of linearity, of course) and allows digging into *past* observations to predict the impact of *future* changes. Another perspective can also be seen for studies involving hydrological models for climate change assessment: empirical elasticity could provide a very useful benchmark against which to test the predictions of complex hydrological models (see e.g. how the extrapolation capacity of several hydrological models was assessed in Coron et al. (2014)).

Naturally, the elasticity assessment has its limits: there is no guarantee for its ability to extrapolate to the most extreme climatic changes (i.e., to changes that are far from those observed over historical records). The formula chosen to compute potential evaporation is also a concern. In this paper, we used the Penman-Shutlleworth

equation (Shuttleworth, 1993). We also repeated this study with the Oudin et al. (2005) formula (a formula widely used in France), and the Penman-Monteith equation (Allen et al., 1998), which did not yield significant differences. This result was expected because the catchments considered here are energy-limited with few cases where actual evaporation reaches its potential value. However, for other climates (i.e., drier environments), additional work would be required to further test the sensitivity of streamflow elasticity to the potential evaporation formula.

7. Acknowledgements

The authors would like to acknowledge Météo-France for making the SAFRAN meteorological archive available for this study, and SCHAPI-Banque Hydro for the hydrometrical series. They would also like to acknowledge the reviews of Alberto Viglione, Francis Chiew, Tim McVicar and an anonymous reviewer, which contributed to improve this paper.

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Appendix 1 – GLS regression

The parameters of the GLS regression were inferred by maximizing the log-likelihood function associated with this model:

$$L\left(\left\{\Delta Q_i^{(M)}\right\},\left\{\Delta X_i^{(M)}\right\} \mid e_{Q/X}^{(M)},\sigma,\alpha\right) = -\frac{k}{2}\log(2\pi) - k\log(\sigma) - \frac{1}{2}\log(1-\alpha^2) - \frac{1}{2\sigma^2}\left(\left(1-\alpha^2\right)\omega_1{}^2 + \sum_{i=2}^{k}\left(\omega_i - \alpha\omega_{i-1}\right)^2\right) \quad \textbf{Eq. 9}$$

where k is the number of sub-periods. The optimization was performed with the Nelder-Mead algorithm (Nelder and Mead, 1965) using the ordinary least-square solution (OLS) as a starting point (i.e., the solution of the same regression model with $\alpha = 0$). The validity of the model assumptions was checked (see Appendix 2) by computing the Shapiro-Wilks test (with an expected *p*-value greater than 0.05) and Durbin-Watson statistic (with an expected value greater than 1) from the series of innovations $\hat{\delta}_i$:

$$\hat{\delta}_i = \hat{\omega}_i - \alpha\hat{\omega}_{i-1} \text{ if } i > 1 \text{ and } \hat{\delta}_1 = \hat{\omega}_1 \quad \textbf{Eq. 10}$$

$$\hat{\omega}_i = \Delta Q_i^{(M)} - e_{Q/X}^{(M)}\Delta X_i^{(M)} \quad \textbf{Eq. 11}$$

Unlike the OLS solution, the distribution of the elasticity values obtained with this approach does not have a closed form. As a result, the significance of the regression's coefficients was assessed with a bootstrap approach as follows:

a. The GLS model was fit with the maximum likelihood approach first. This allowed computing the series of innovations δ_i.

b. The innovations $\{\delta_i\}_{i=2,..,n}$ were resampled with replacement to form a new series of bootstrapped innovations $\{\delta^*{}_i\}_{i=2,..,n}$. The first innovation δ_1^* of this series was set to ω_1.

c. The bootstrapped innovations were used to generate a new series of bootstrapped observations $\Delta Q_i^{(M)*} = e_{Q/X}^{(M)}\Delta X_i + \sum_{i=1}^{n}\delta_i^*\alpha^i$.

d. Finally the GLS model was fit with the maximum likelihood approach using the bootstrapped observations leading to new values of the GLS parameters.

Steps (c) and (d) were repeated 1000 times and the 2.5% and 97.5% percentiles of the GLS parameters were derived from the empirical distribution formed with the

1000 parameter samples. A parameter was considered as significantly different from zero if both the 2.5% and 97.5% percentiles were either strictly positive or negative.

Appendix 2 - Validity of statistical assumptions underlying the regression models

This section reviews the validity of the statistical assumptions underlying the OLS2 and GLS2 regression models described in section 3.3.

- Figure 11.a shows that the GLS2 model has the highest proportion of catchments where the normality assumption cannot be rejected based on the Shapiro-Wilks test. However, the difference with the other models remains limited, with this proportion varying from 41.2% for OLS2 with 10-year sub-periods to 69.5% for GLS2 with 20-year sub-periods. Overall, a significant proportion of catchments still fail the test, whatever regression model is considered, which suggests that additional assumptions could be explored for the distribution of the innovations.
- Figure 11.b reveals that a high level of autocorrelation is present in the innovations of the OLS2 model with 7.5% (with 10-year sub-periods) and 23.9% (with 20-year sub-periods) of the catchments reaching a satisfactory Durbin-Watson statistic value only. This was an expected result. Logically, this proportion is much higher for the GLS2 models, reaching 92.7% for 10-year sub-periods and 91.9% for 20-year sub-periods. Here also, a small proportion of the catchments fails the test, even with regression models taking autocorrelation into account. This result suggests that the regression model could be extended to include a higher-order autoregressive component.

Overall, the results illustrated in Figure 11 indicate that the GLS2 model is the most satisfactory regression model from a statistical point of view. The difference introduced by the length of the averaging period (10 or 20 years) is very limited.

Appendix 3 – Main characteristics of the catchment dataset

Note: all long-term values have been computed over the 1986-2006 time period

Catchment code	e_{Q/E_p}	$e_{Q/P}$	Altitude of the outlet (m a.s.l.)	Area (km²)	X outlet (DD)	Y outlet (DD)	Long-term precip. P (mm/yr)	Long-term potential evap. E (mm/yr)	Long-term streamflow Q (mm/yr)	River Name
A1050310	-0.74	0.58	282	238	7.2439	47.6252	983	666	312	L' Ill à Altkirch
A1080330	-0.58	0.54	242	668	7.3058	47.7172	962	671	298	L' Ill à Didenheim
A1152010	-0.42	0.48	256	288	7.2481	47.6710	964	672	316	La Largue à Illfurth
A2023030	-0.58	0.54	432	44	7.1103	48.0515	1563	587	994	La Petite Fecht à Stosswihr
A2073010	-0.38	0.86	303	31	7.3016	48.1995	1390	633	362	Le Strengbach à Ribeauvillé
A2122010	0.05	0.68	326	118	7.2140	48.1563	1344	618	654	La Weiss à Kaysersberg [Fréland-Gare]
A2332110	-0.52	0.69	262	107	7.2921	48.2701	1372	627	518	La Lièpvrette à Lièpvre
A2512010	-1.25	0.91	221	42	7.4221	48.3862	1261	618	585	L' Andlau à Andlau
A2612010	-0.60	0.71	161	57	7.5111	48.4517	1036	659	290	L' Ehn à Niedernai
A2732010	-1.31	1.08	267	224	7.2751	48.5051	1302	604	825	La Bruche à Russ [Wisches]
A2842010	0.04	1.01	169	167	7.4892	48.5725	821	675	269	La Mossig à Soultz-les-Bains
A3151010	-0.22	0.66	146	280	7.7299	48.8258	813	682	277	La Moder à Schweighouse-sur-Moder [amont]
A3301010	-0.37	0.52	144	622	7.7418	48.8225	845	676	272	La Moder à Schweighouse-sur-Moder [aval]
A3422010	-0.57	0.45	196	184	7.3331	48.7287	1089	652	369	La Zorn à Saverne [Schinderthal]
A3472010	0.23	0.80	147	684	7.6335	48.7499	849	677	286	La Zorn à Waltenheim-sur-Zorn
A3712010	-0.84	0.41	176	192	7.7575	48.9587	902	665	283	La Sauer à Goersdorf [Liebfrauenthal]
A3832010	-0.59	0.78	124	204	8.0483	48.9037	833	687	251	Le Seltzbach à Niederroedern
A3902010	-0.64	0.38	173	275	7.9019	49.0422	909	662	280	La Lauter à Wissembourg [Weiler]
A4050620	-0.98	1.73	439	152	6.6861	47.9096	1650	600	1402	La Moselle à Rupt-sur-Moselle
A4142010	-0.58	1.11	407	184	6.7133	47.9959	1687	577	1460	La Moselotte à Vagney [Zainvillers]
A4173010	-0.61	0.98	455	65	6.6899	48.0526	1665	594	1205	La Cleurie à Cleurie
A4200630	-0.71	0.99	372	627	6.6103	48.0655	1651	598	1207	La Moselle à Saint-Nabord [Noirgueux]
A4250640	-0.88	0.90	325	1218	6.4529	48.1656	1553	609	983	La Moselle à Épinal
A5261010	-0.72	0.74	265	383	6.1373	48.3050	1016	649	381	Le Madon à Mirecourt
A5431010	-0.31	0.77	225	948	6.1317	48.5446	945	654	364	Le Madon à Pulligny
A5730610	-0.38	0.88	200	3346	5.8976	48.6698	1171	641	609	La Moselle à Toul
A6051020	-0.51	0.59	339	371	6.9561	48.2847	1588	611	667	La Meurthe à Saint-Dié
A6151030	-0.70	0.51	282	727	6.8447	48.4025	1558	623	614	La Meurthe à Raon-l'Étape
A6571110	-0.18	0.81	220	560	6.4868	48.5948	970	657	384	La Vezouze à Lunéville
A6731220	-0.45	0.75	234	498	6.5243	48.4872	1166	655	366	La Mortagne à Gerbéviller
A6761010	-0.52	0.96	211	2294	6.3839	48.5632	1207	646	482	La Meurthe à Damelevières
A6953010	-0.18	1.32	198	85	6.1982	48.7467	825	675	283	L' Amézule à Lay-Saint-Christophe
A7010610	-0.54	0.90	184	6835	6.1237	48.7896	1124	649	529	La Moselle à Custines
A7122010	-0.16	0.73	187	228	6.0434	48.8659	829	672	204	L' Esch à Jezainville
A7642010	-0.41	0.41	200	150	6.5060	48.8173	882	671	259	La Petite Seille à Château-Salins
A7821010	-0.22	0.71	180	928	6.2278	48.8880	842	674	267	La Seille à Nomeny
A7881010	-0.16	0.67	164	1274	6.1877	49.1007	825	674	246	La Seille à Metz
A8431010	0.06	1.17	167	1241	6.0715	49.2564	882	657	304	L' Orne à Rosselange
A9942010	-0.39	0.72	191	1150	6.5397	49.3012	835	659	279	La Nied à Bouzonville
B0220010	-0.18	0.65	300	368	5.6139	48.2406	960	658	365	La Meuse à Goncourt
B1092010	-1.02	0.40	291	401	5.7104	48.3171	1002	644	346	Le Mouzon à Circourt-sur-Mouzon [Villars]

B2220010	-0.46	0.75	216	2543	**5.5310**	**48.8709**	**978**	**649**	**384**	La Meuse à Saint-Mihiel
B3150020	-0.59	0.84	162	3915	**5.1780**	**49.4939**	**975**	**650**	**397**	La Meuse à Stenay
B4631010	-0.26	0.74	159	1978	**5.1592**	**49.6292**	**929**	**642**	**412**	La Chiers à Carignan
B5322010	0.00	0.77	153	125	**4.7142**	**49.7277**	**1021**	**635**	**584**	La Vence à la Francheville
D0206010	0.06	0.79	133	115	**3.9971**	**50.2613**	**906**	**635**	**397**	La Solre à Ferrière-la-Grande
E1766010	-0.15	0.26	37	88	**3.5325**	**50.3304**	**769**	**649**	**220**	La Rhonelle à Aulnoy-lez-Valenciennes
E1827020	-0.31	0.99	15	241	**3.6376**	**50.4379**	**770**	**649**	**267**	L' Hogneau à Thivencelle
E3346010	-0.35	0.45	26	132	**3.1820**	**50.5783**	**762**	**665**	**218**	La Marque à Bouvines
E3511210	-1.45	0.81	83	87	**2.1734**	**50.5219**	**1068**	**623**	**409**	La Lys à Lugy
E4035710	0.12	0.79	19	392	**2.2448**	**50.7085**	**1026**	**620**	**461**	L' Aa à Wizernes
E5300210	-0.90	0.73	26	103	**1.7677**	**50.6812**	**1054**	**632**	**574**	La Liane à Wirwignes
E5400310	-0.08	0.44	6	917	**1.8308**	**50.4483**	**1002**	**629**	**435**	La Canche à Brimeux
E5406510	-0.08	0.55	24	345	**2.0378**	**50.3799**	**997**	**627**	**428**	La Ternoise à Hesdin
E5505720	0.06	0.36	12	792	**1.9177**	**50.3050**	**904**	**634**	**332**	L' Authie à Dompierre-sur-Authie
E6470910	0.08	0.34	4	5643	**1.8793**	**50.0625**	**744**	**649**	**205**	La Somme à Abbeville [Epagne-Epagnette]
G1003010	-0.58	0.69	15	255	**1.3381**	**50.0001**	**963**	**635**	**337**	L' Yères à Touffreville-sur-Eu
H0100010	-0.57	0.67	249	373	**4.5700**	**47.7649**	**949**	**669**	**384**	La Seine à Nod-sur-Seine
H0100020	-1.07	0.87	180	686	**4.4806**	**47.9960**	**919**	**678**	**486**	La Seine à Plaines-Saint-Lange
H0400010	-0.24	0.66	149	2340	**4.3767**	**48.1166**	**906**	**678**	**340**	La Seine à Bar-sur-Seine
H0400020	-0.13	0.60	139	2392	**4.3107**	**48.1474**	**904**	**678**	**208**	La Seine à Courtenot
H0503010	-0.09	0.64	109	249	**4.1097**	**48.2459**	**795**	**690**	**184**	L' Hozain à Buchères [Courgerennes]
H1051020	-0.29	0.66	185	690	**4.7959**	**48.1454**	**948**	**668**	**336**	L' Aube [partielle] à Longchamp-sur-Aujon [Outre Aube]
H1333010	1.62	1.87	137	22	**4.7353**	**48.3788**	**877**	**685**	**1447**	La Laine à Soulaines-Dhuys
H1513210	-0.38	0.72	86	171	**4.0628**	**48.5380**	**713**	**687**	**131**	La Barbuise à Pouan-les-Vallées
H1603010	-0.21	0.46	78	366	**3.9053**	**48.6139**	**730**	**680**	**133**	La Superbe à Saint-Saturnin
H1932020	0.04	0.43	63	281	**3.2347**	**48.4878**	**749**	**684**	**187**	La Voulzie à Jutigny
H2062010	-0.61	0.29	161	264	**3.4936**	**47.4144**	**891**	**702**	**238**	Le Beuvron à Ouagne [Champmoreau]
H2073110	-1.00	0.40	170	87	**3.4078**	**47.4305**	**912**	**696**	**318**	Le Sauzay à Corvol-l'Orgueilleux
H2083110	-0.32	0.52	150	192	**3.5090**	**47.5096**	**824**	**693**	**244**	La Druyes à Surgy
H2322010	-0.49	0.47	312	267	**4.2917**	**47.4181**	**949**	**676**	**262**	Le Serein à Bierre-lès-Semur
H2342010	-0.35	0.51	129	1116	**3.8002**	**47.8176**	**873**	**691**	**224**	Le Serein à Chablis
H2412010	-0.20	0.58	205	478	**4.2627**	**47.6075**	**902**	**678**	**217**	L' Armançon à Quincy-le-Vicomte
H2513110	-0.43	0.75	88	133	**3.3552**	**47.9392**	**752**	**711**	**187**	Le Tholon à Champvallon
H3102010	-0.39	0.49	187	152	**3.2926**	**47.7329**	**825**	**686**	**192**	L' Ouanne à Toucy
H3122010	-0.46	0.46	133	559	**3.0908**	**47.8855**	**814**	**691**	**195**	L' Ouanne à Charny
H3201010	-0.38	0.64	78	2302	**2.7322**	**48.0356**	**747**	**701**	**156**	Le Loing à Châlette-sur-Loing
H3613010	-0.14	0.22	86	162	**2.8603**	**48.2455**	**742**	**703**	**92**	Le Lunain à Paley
H3623010	-0.15	0.23	105	104	**3.0234**	**48.2564**	**778**	**701**	**107**	L' Orvanne à Blennes
H4022020	-0.20	0.19	56	851	**2.3475**	**48.4643**	**660**	**705**	**135**	L' Essonne à Guigneville-sur-Essonne [La Mothe]
H4223110	-0.16	0.43	80	152	**2.0333**	**48.5700**	**675**	**683**	**134**	La Remarde à Saint-Cyr-sous-Dourdan
H4243010	-0.18	0.55	54	231	**2.2335**	**48.7006**	**675**	**682**	**187**	L' Yvette à Villebon-sur-Yvette
H5062010	-0.14	0.76	206	618	**5.1655**	**48.3440**	**1027**	**659**	**486**	Le Rognon à Doulaincourt-Saucourt
H5142610	-0.39	0.79	170	114	**5.0558**	**48.8836**	**1072**	**653**	**438**	La Chée à Villotte-devant-Louppy [Villote devant Loupy]
H5172010	-0.23	0.78	95	2109	**4.6271**	**48.7460**	**1033**	**657**	**411**	La Saulx à Vitry-en-Perthois
H5732010	-0.06	0.84	62	769	**3.0131**	**48.8174**	**763**	**678**	**232**	Le Grand Morin à Pommeuse
H6102010	-0.63	0.73	222	283	**5.2090**	**48.9645**	**1089**	**646**	**413**	L' Aire à Beausite [Amblaincourt]

H6122010	-0.56	0.97	154	629	**5.0342**	**49.2275**	**1055**	**649**	**464**	L' Aire à Varennes-en-Argonne
H6162010	-0.40	0.92	117	957	**4.9036**	**49.3338**	**1032**	**651**	**445**	L' Aire à Chevières
H6201010	-0.44	0.78	100	2242	**4.7827**	**49.3075**	**954**	**660**	**341**	L' Aisne à Mouron
H6221010	-0.48	0.84	77	2888	**4.5377**	**49.4920**	**942**	**659**	**342**	L' Aisne à Givry
H6313020	-0.19	0.27	59	810	**4.0238**	**49.3835**	**755**	**668**	**161**	La Suippe à Orainville
H6423010	-0.05	0.58	58	300	**3.6736**	**49.3061**	**712**	**663**	**166**	L' Ardres à Fismes
H6531011	-0.23	0.57	33	7810	**2.9521**	**49.4108**	**832**	**664**	**287**	L' Aisne à Trosly-Breuil [Hérant]
H7021010	-0.09	0.59	160	320	**4.0709**	**49.9227**	**1034**	**623**	**547**	L' Oise à Hirson
H7033010	-0.95	0.90	140	256	**4.0199**	**49.8956**	**990**	**634**	**463**	Le Thon à Origny-en-Thiérache
H7041010	-0.27	0.85	101	860	**3.7003**	**49.8996**	**987**	**633**	**467**	L' Oise à Monceau-sur-Oise
H7061010	-0.35	0.80	70	1193	**3.4821**	**49.8399**	**949**	**635**	**330**	L' Oise à Origny-Sainte-Benoite
H7162010	-0.17	0.85	51	1637	**3.4843**	**49.6926**	**848**	**654**	**291**	La Serre à Pont à Bucy
H7401010	-0.21	0.57	35	4320	**2.9939**	**49.5597**	**843**	**652**	**256**	L' Oise à Sempigny
H7423710	-0.24	0.36	33	280	**2.8464**	**49.4418**	**696**	**663**	**140**	L' Aronde à Clairoix
H7611012	-0.14	0.60	26	13484	**2.6211**	**49.3105**	**824**	**661**	**264**	L' Oise à Pont-Sainte-Maxence [Sarron]
H7713010	-0.52	0.31	89	214	**1.9986**	**49.5287**	**843**	**633**	**238**	Le Petit Thérain à Saint-Omer-en-Chaussée
H7742010	-0.82	0.68	61	755	**2.0998**	**49.4220**	**843**	**639**	**238**	Le Thérain à Beauvais
H7742020	-0.25	0.42	33	1210	**2.3779**	**49.2623**	**799**	**647**	**223**	Le Thérain à Maysel
H7833520	0.05	0.09	32	58	**2.3997**	**49.1365**	**707**	**690**	**120**	L' Ysieux à Viarmes [Giez]
H7853010	-0.23	0.22	37	102	**2.1710**	**49.1266**	**713**	**671**	**167**	Le Sausseron à Nesles-la-Vallée
H8012010	-0.66	0.63	87	247	**1.7288**	**49.4728**	**971**	**636**	**248**	L' Epte à Gournay-en-Bray
H8043310	0.02	-0.01	40	99	**1.6901**	**49.1510**	**732**	**664**	**149**	L' Aubette de Magny à Ambleville
H8212010	-0.45	0.53	53	377	**1.3833**	**49.4454**	**973**	**636**	**338**	L' Andelle à Vascoeuil
H9202010	0.15	0.44	119	477	**1.1049**	**48.7617**	**738**	**666**	**175**	L' Avre à Acon
H9222010	0.12	0.35	78	872	**1.3467**	**48.7748**	**701**	**666**	**133**	L' Avre à Muzy
H9331010	0.08	0.28	24	4561	**1.2087**	**49.1151**	**661**	**674**	**128**	L' Eure à Cailly-sur-Eure
H9402030	-0.15	0.26	47	1029	**1.1507**	**49.0804**	**690**	**666**	**115**	L' Iton à Normanville
H9501010	-0.13	0.11	13	5891	**1.1775**	**49.2244**	**667**	**672**	**134**	L' Eure à Louviers
I0113010	-0.17	0.51	166	82	**0.4851**	**48.9452**	**819**	**642**	**248**	Le Guiel à Montreuil-l'Argillé
I0122010	-0.20	0.47	127	251	**0.5684**	**49.0237**	**819**	**641**	**272**	La Charentonne à Ferrières-Saint-Hilaire
I1203010	-0.38	0.46	32	173	**0.2855**	**49.2978**	**813**	**659**	**323**	La Calonne aux Authieux-sur-Calonne
I2001010	-0.41	0.57	90	88	**0.0745**	**48.8149**	**747**	**663**	**156**	La Dives à Saint-Lambert-sur-Dive
I2021010	-0.37	0.37	53	283	**-0.0778**	**48.8982**	**732**	**663**	**164**	La Dives à Beaumais
I2213610	-0.07	0.52	6	57	**-0.0688**	**49.2346**	**772**	**666**	**251**	L' Ancre à Cricqueville-en-Auge
I3131010	-0.23	0.64	106	1019	**-0.3029**	**48.7927**	**821**	**659**	**232**	L' Orne à Rabodanges
I4032010	-0.76	0.63	8	256	**-0.5305**	**49.2910**	**877**	**662**	**293**	La Seulles à Tierceville
I5053010	1.15	0.24	76	116	**-0.8883**	**48.9474**	**941**	**643**	**421**	La Souleuvre à Carville
I7222020	0.47	1.62	18	141	**-1.4438**	**49.0363**	**1032**	**659**	**542**	La Soulles à Saint-Pierre-de-Coutances
I7913610	-0.27	0.70	9	73	**-1.5317**	**48.7843**	**1014**	**669**	**398**	Le Thar à Jullouville
J0014010	-1.09	0.44	111	65	**-1.1988**	**48.3744**	**878**	**675**	**312**	Le Nançon à Lécousse [Pont aux Anes]
J0144010	-0.76	0.54	58	82	**-1.4364**	**48.4292**	**870**	**680**	**290**	La Loysance à Saint-Ouen-la-Rouërie
J0323010	-0.42	0.39	19	62	**-1.6874**	**48.5271**	**775**	**678**	**213**	Le Guyoult à Epiniac
J1103010	-0.82	0.61	32	103	**-2.3337**	**48.4024**	**867**	**672**	**235**	L' Arguenon à Jugon-les-Lacs
J1114010	-0.54	0.22	41	113	**-2.2478**	**48.3644**	**775**	**679**	**199**	La Rosette à Mégrit
J1313010	-0.77	0.72	40	244	**-2.5686**	**48.4848**	**772**	**674**	**175**	Le Gouessant à Andel
J1513010	-0.87	0.81	103	135	**-2.8332**	**48.4474**	**1055**	**653**	**371**	Le Gouët à Saint-Julien

J1813010	-0.68	0.57	17	342	-3.0672	48.7054	908	668	241	Le Leff à Quemper-Guézennec
J2233010	-0.74	0.62	94	265	-3.3982	48.5465	1088	644	562	Le Léguer à Belle-Isle-en-Terre
J2603010	-0.48	0.54	26	44	-3.7997	48.5660	1168	660	523	Le Jarlot à Plougonven
J2605410	-0.56	0.51	27	42	-3.7971	48.5671	1136	655	445	Le Tromorgant à Plougonven
J2723010	-0.66	0.74	13	142	-3.9242	48.5847	1175	660	641	La Penze à Taulé [Penhoat]
J3024010	-0.12	0.76	33	45	-4.0762	48.6163	966	663	489	Le Guillec à Trézilidé
J3205710	-0.13	0.91	39	24	-4.3618	48.5310	1098	673	596	L' Aber Wrac'h au Drennec
J3213020	-0.56	0.81	47	27	-4.4058	48.5240	1102	673	574	L' Aber-Benoit à Plabennec [Loc Maria]
J3323020	-0.36	0.66	20	95	-4.6805	48.4556	1058	673	468	L' Aber Ildut à Brélès [Keringar]
J3601810	-2.25	1.21	97	117	-3.6678	48.3889	1246	648	589	L' Aulne à Scrignac [Le Goask]
J3713010	-0.82	0.65	91	258	-3.5100	48.3211	1099	660	531	L' Hyères à Trébrivan [Pont Neuf]
J3834010	-0.11	0.77	26	140	-4.0610	48.2599	1289	663	765	La Douffine à Saint-Ségal [Kerbriant]
J4214510	-0.88	0.62	128	7	-3.9866	48.1025	1217	669	706	Le Langelin à Briec [Pont D 72]
J4224010	-0.52	0.64	22	108	-4.0146	47.9891	1191	682	665	Le Jet à Ergué-Gabéric
J4313010	-0.25	0.95	20	181	-4.1470	48.0269	1205	679	638	Le Steir à Guengat [Ty Planche]
J4514010	-0.39	0.66	20	21	-3.8745	47.8838	1101	699	498	Le Moros à Concarneau [Pont D 22]
J4614010	-0.72	0.65	36	72	-3.7512	47.9075	1230	680	680	Le Ster Goz à Bannalec [Pont Meya]
J4742010	-0.33	0.74	23	576	-3.4691	47.9038	1192	666	548	L' Éllé à Arzano [Pont Ty Nadan]
J4803010	-1.29	1.14	100	102	-3.6705	47.9883	1295	662	720	L' Isole à Scaër [Stang Boudilin]
J4902010	-0.06	0.90	7	832	-3.5429	47.8677	1203	668	564	La Laïta à Quimperlé [ancienne]
J5102210	-0.54	0.54	24	299	-3.4197	47.9054	1194	674	534	Le Scorff à Plouay [Pont Kerlo]
J5613010	-0.53	0.52	44	316	-2.9741	47.9013	941	687	338	L' Evel à Guénin
J5704810	-0.73	0.50	46	46	-3.2011	47.9051	1146	687	568	Le Coët-Organ à Quistinic [Kerdec]
J6213010	-0.51	1.05	25	182	-2.9895	47.7221	1021	698	473	Le Loch à Brech
J7083110	-0.40	0.62	44	152	-1.4982	48.1832	838	693	227	Le Chevré à la Bouëxière [Le Drugeon]
J7483010	-0.32	0.75	17	809	-1.7225	48.0199	748	710	185	La Seiche à Bruz [Carcé]
J7633010	-0.24	0.89	24	406	-1.6299	47.8601	779	709	231	Le Semnon à Bain-de-Bretagne [Rochereuil]
J7824010	-0.26	0.76	15	112	-1.6910	47.7130	780	712	202	L' Aron à Grand-Fougeray [La Bernardais]
J7973010	-0.20	0.90	27	40	-1.9791	47.7766	773	716	237	Le Canut Sud à Saint-Just [La rivière Colombel]
J8002310	-1.58	1.12	178	29	-2.9654	48.3216	1105	649	404	L' Oust à Saint-Martin-des-Prés [La Ville Rouault]
J8363110	-0.44	0.79	35	301	-2.3687	47.9948	807	682	236	L' Yvel à Loyat [Pont D 129]
J8433010	-0.49	0.72	49	135	-2.7029	47.8259	993	691	408	La Claie à Saint-Jean-Brévelay
J8602410	-0.38	0.57	69	28	-2.1435	47.9829	856	664	262	L' Aff à Paimpont [Pont du Secret]
J8632410	-0.37	0.68	14	343	-2.0744	47.8297	815	686	245	L' Aff à Quelneuc [La rivière]
J8813010	-0.42	0.90	26	161	-2.4321	47.7174	1009	698	439	L' Arz à Molac [Le Qinquizio]
J9300610	-0.10	0.54	1	10148	-2.1255	47.5801	819	701	231	La Vilaine à Rieux
K0010010	0.42	1.48	1116	60	4.1475	44.7704	1369	558	1374	La Loire à Usclades-et-Rieutord [Rieutord]
K0403010	-0.07	1.02	936	138	4.3015	45.0575	1097	579	699	Le Lignon du Velay au Chambon-sur-Lignon
K0454010	-0.19	0.79	596	217	4.2141	45.2146	941	612	454	La Dunières à Sainte-Sigolène [Vaubarlet]
K0523010	-1.02	0.38	706	347	3.9380	45.3071	1114	585	378	L' Ance du Nord à Saint-Julien-d'Ance [Laprat]
K0567520	-0.48	0.86	653	129	4.2494	45.3148	951	619	454	La Semène à Saint-Didier-en-Velay [Le Crouzet]
K0567530	-0.07	0.36	811	58	4.3649	45.3002	1001	606	461	La Semène à Jonzieux
K0624510	-0.28	0.56	432	105	4.1870	45.4706	953	654	246	Le Bonson à Saint-Marcellin-en-Forez [Le Bled]
K0663310	-0.84	1.07	583	61	4.5258	45.6283	888	677	318	La Coise à Larajasse [Le Nézel]
K0673310	-0.15	1.05	436	181	4.3750	45.6087	883	683	268	La Coise à Saint-Médard-en-Forez [Moulin Brûlé]

K0724510	-0.53	0.65	342	13	**4.2294**	**45.7759**	**768**	**717**	**204**	Le Chanasson à Civens [La rivière]
K0733220	-1.58	0.63	817	60	**3.8672**	**45.6968**	**1124**	**561**	**857**	Le Lignon de Chalmazel à Chalmazel [Chevelières]
K0773220	-1.15	0.74	333	662	**4.1649**	**45.7311**	**923**	**654**	**347**	Le Lignon de Chalmazel à Poncins [2]
K0813020	-1.84	1.58	378	197	**4.0022**	**45.8317**	**987**	**635**	**445**	L' Aix à Saint-Germain-Laval
K0974010	-0.38	0.84	364	86	**4.1866**	**45.9548**	**896**	**698**	**290**	Le Gand à Neaux
K0983010	-0.47	0.84	293	435	**4.1190**	**45.9802**	**932**	**699**	**363**	Le Rhins à Saint-Cyr-de-Favières [Pont Mordon]
K1084010	-1.58	0.71	357	23	**3.8847**	**46.1375**	**840**	**686**	**400**	La Teyssonne à Changy [La Noaillerie]
K1173210	5.89	2.39	241	593	**4.0495**	**46.3583**	**911**	**702**	**278**	L' Arconce à Montceaux-l'Étoile
K1284810	-0.63	0.78	318	135	**4.1977**	**47.0039**	**1211**	**657**	**690**	La Selle à la Celle-en-Morvan [Polroy]
K1321810	-1.25	0.49	268	1792	**4.1924**	**46.8510**	**998**	**679**	**368**	L' Arroux à Étang-sur-Arroux [Pont du Tacot]
K1503010	-1.69	0.47	361	157	**3.6812**	**46.1266**	**1113**	**642**	**458**	La Besbre à Châtel-Montagne
K1524010	-0.99	0.69	314	121	**3.6880**	**46.1940**	**999**	**686**	**436**	Le Barbenan au Breuil
K1724210	-1.05	0.80	212	114	**3.7638**	**46.9112**	**1109**	**689**	**481**	La Dragne à Vandenesse
K1753110	-0.91	0.25	200	333	**3.6794**	**46.8447**	**978**	**691**	**398**	L' Alène à Cercy-la-Tour [Coueron]
K1914510	-0.62	0.63	196	115	**3.3367**	**46.9625**	**928**	**689**	**326**	L' Ixeure à la Fermeté
K1954010	-0.68	0.64	207	226	**3.2529**	**47.1341**	**941**	**686**	**312**	La Nièvre d'Arzembouy à Poiseux [Poisson]
K2064010	-0.86	1.28	910	66	**3.8584**	**44.7298**	**938**	**562**	**661**	Le Langouyrou à Langogne
K2123010	-0.66	0.89	1124	125	**3.6993**	**44.6725**	**959**	**550**	**366**	Le Chapeauroux à Châteauneuf-de-Randon [Hermet]
K2233020	-0.35	1.37	634	231	**3.6368**	**44.9674**	**867**	**568**	**349**	L' Ance du Sud à Monistrol-d'Allier [Pouzas]
K2514010	-0.08	1.13	768	156	**3.0065**	**45.1340**	**1223**	**563**	**542**	L' Allanche à Joursac [Pont du Vernet]
K2523010	-0.06	0.93	710	322	**3.0271**	**45.1591**	**1191**	**560**	**601**	L' Alagnon à Joursac [Le Vialard]
K2834010	-0.38	0.83	836	71	**3.6289**	**45.4470**	**1091**	**579**	**475**	La Dolore à Saint-Bonnet-le-Chastel [Moulin Neuf]
K2871910	-1.12	0.56	412	795	**3.6102**	**45.6893**	**1059**	**607**	**389**	La Dore à Saint-Gervais-sous-Meymont [Maison du Parc / Giroux-Dore]
K2884010	-2.87	0.74	403	73	**3.5938**	**45.7020**	**1103**	**611**	**641**	La Faye à Olliergues [Giroux-Faye]
K2944010	-1.66	0.65	335	72	**3.5665**	**45.7455**	**1043**	**633**	**526**	Le Couzon à Courpière [Le Salet]
K3206010	-3.04	-0.31	784	8	**2.8933**	**45.7608**	**1145**	**609**	**957**	La source-de-chez-Pierre à Ceyssat
K3222010	-0.70	0.68	666	360	**2.8490**	**45.8330**	**1128**	**609**	**513**	La Sioule à Pontgibaud
K3264010	-0.57	0.70	538	111	**2.6741**	**45.8705**	**936**	**650**	**259**	La Saunade à Pontaumur
K3292020	-0.74	0.65	502	1300	**2.7961**	**45.9735**	**1001**	**634**	**389**	La Sioule à Saint-Priest-des-Champs [Fades-Besserve]
K4094010	-0.50	0.41	153	478	**2.9986**	**47.3553**	**846**	**697**	**207**	Le Nohain à Saint-Martin-sur-Nohain [Villiers]
K4443010	-0.30	0.59	79	165	**1.6631**	**47.7609**	**738**	**718**	**94**	L' Ardoux à Lailly-en-Val
K4873110	-0.01	0.56	82	263	**0.8973**	**47.5669**	**674**	**709**	**156**	La Brenne à Villedômer [Bas-Villaumay]
K5090910	-0.21	0.69	321	526	**2.5491**	**46.1767**	**901**	**673**	**350**	Le Cher à Chambonchard
K5183010	-0.41	0.54	329	861	**2.4455**	**46.1841**	**959**	**680**	**306**	La Tardes à Évaux-les-Bains
K6334010	-0.54	0.01	180	79	**2.4362**	**47.4912**	**866**	**699**	**215**	La Nère à Aubigny-sur-Nère
K6402510	-0.80	0.06	102	1240	**2.0332**	**47.4234**	**829**	**702**	**229**	La Sauldre à Salbris
K6492510	-0.85	0.30	73	2297	**1.5355**	**47.2870**	**780**	**710**	**187**	La Sauldre à Selles-sur-Cher
K7312610	-0.90	0.65	82	1707	**1.1265**	**47.0171**	**796**	**726**	**227**	L' Indre à Saint-Cyran-du-Jambot
K7414010	-0.47	0.60	99	109	**1.2412**	**47.1361**	**729**	**724**	**177**	La Tourmente à Villeloin-Coulangé [Coulangé]
K7424010	-0.30	0.51	97	78	**1.2112**	**47.1826**	**725**	**722**	**151**	L' Olivet à Beaumont-Village [1]
K7514010	-0.20	0.69	66	128	**0.8187**	**47.2474**	**670**	**732**	**138**	L' Échandon à Saint-Branchs
L0010610	-1.15	0.68	749	64	**2.0067**	**45.7014**	**1397**	**611**	**845**	La Vienne à Peyrelevade [Servières]
L0010620	-1.43	0.68	740	77	**1.9952**	**45.6996**	**1391**	**611**	**771**	La Vienne à Peyrelevade [La Rigole du Diable]
L0093010	-0.27	0.96	301	188	**1.5538**	**45.7666**	**1200**	**702**	**624**	La Combade à Masléon
L0314010	-0.95	0.71	313	131	**1.5782**	**45.9557**	**1145**	**703**	**603**	La Vige à Saint-Martin-Sainte-Catherine

L0563010	-0.77	0.72	218	605	**1.2404**	**45.7568**	**1113**	**723**	**398**	La Briance à Condat-sur-Vienne [Chambon Veyrinas]
L0624010	-0.45	0.76	230	153	**1.1308**	**45.7719**	**1075**	**729**	**345**	L' Aixette à Aixe-sur-Vienne
L0813010	-0.59	0.76	214	298	**0.9150**	**45.9133**	**1051**	**730**	**404**	La Glane à Saint-Junien [Le Dérot]
L4033010	-0.53	0.84	448	190	**2.1768**	**45.9321**	**1121**	**651**	**414**	La Rozeille à Moutier-Rozeille [Aubusson]
L4220710	-0.67	0.60	215	1235	**1.6789**	**46.3783**	**1062**	**679**	**381**	La Creuse à Fresselines
L4321710	-0.62	0.49	272	561	**1.9950**	**46.3572**	**916**	**695**	**282**	La Petite Creuse à Genouillac
L4411710	-0.59	0.57	218	853	**1.6892**	**46.3856**	**917**	**701**	**296**	La Petite Creuse à Fresselines [Puy Rageaud]
L4530710	-0.73	0.54	187	2427	**1.6129**	**46.4544**	**993**	**692**	**335**	La Creuse à Éguzon-Chantôme
L4653010	-0.63	0.60	124	438	**1.6271**	**46.6659**	**834**	**727**	**212**	La Bouzanne à Velles [Forges]
L5034010	-1.37	0.52	324	129	**1.4948**	**46.0964**	**1100**	**710**	**413**	L' Ardour à Folles [Forgefer]
L5101810	-0.64	0.59	297	568	**1.4337**	**46.1139**	**1034**	**705**	**432**	La Gartempe à Folles [Bessines]
L5134010	-0.57	1.00	200	175	**1.1418**	**46.1508**	**970**	**719**	**348**	La Semme à Droux
L5223020	-0.44	0.75	178	286	**1.0205**	**46.1342**	**1058**	**726**	**387**	Le Vincou à Bellac [2]
L5323010	-0.39	0.65	171	232	**0.9982**	**46.2518**	**951**	**737**	**292**	La Brame à Oradour-Saint-Genest
L5623010	-0.72	1.01	183	188	**1.2582**	**46.3553**	**956**	**723**	**305**	La Benaize à Jouac
L6202030	-0.56	0.48	58	886	**0.8178**	**46.9073**	**766**	**742**	**142**	La Claise au Grand-Pressigny [Étableau 2]
M0050620	-0.08	0.71	124	909	**-0.0231**	**48.3867**	**798**	**677**	**232**	La Sarthe à Saint-Céneri-le-Gérei [Moulin du Désert]
M0250610	-0.13	0.73	48	2713	**0.2064**	**48.0898**	**791**	**690**	**238**	La Sarthe à Neuville-sur-Sarthe [Montreuil]
M0361510	-0.15	0.43	102	833	**0.8133**	**48.3187**	**775**	**674**	**236**	L' Huisne à Nogent-le-Rotrou [Pont de bois]
M0500610	0.03	0.55	38	5452	**0.1439**	**47.9132**	**769**	**694**	**210**	La Sarthe à Spay [amont]
M0680610	-0.16	0.64	21	7523	**-0.3842**	**47.7986**	**761**	**702**	**204**	La Sarthe à Saint-Denis-d'Anjou [Beffes]
M1034020	0.05	0.71	126	267	**1.3479**	**48.2084**	**703**	**680**	**166**	L' Ozanne à Trizay-lès-Bonneval [Prémoteux]
M1041610	-0.11	0.89	118	1080	**1.4175**	**48.1514**	**665**	**683**	**101**	Le Loir à Saint-Maur-sur-le-Loir
M1214010	-0.13	0.33	121	87	**0.8492**	**48.0538**	**718**	**695**	**182**	Le Couëtron à Souday [Glatigny]
M3253110	-0.79	0.97	94	185	**-0.6269**	**48.2696**	**851**	**681**	**318**	L' Aron à Moulay
M3313010	-1.12	0.69	115	121	**-0.9454**	**48.2972**	**892**	**672**	**322**	L' Ernée à Ernée
M3323010	-0.66	0.76	67	376	**-0.7785**	**48.1676**	**880**	**680**	**327**	L' Ernée à Andouillé [Les Vaugeois]
M3340910	-0.25	0.88	45	2908	**-0.7399**	**48.0130**	**884**	**671**	**324**	La Mayenne à l' Huisserie [Bonne]
M3423010	-0.24	0.78	50	404	**-0.7062**	**48.0336**	**803**	**703**	**246**	La Jouanne à Forcé
M3504010	-0.55	0.83	51	234	**-0.7826**	**47.9875**	**827**	**695**	**247**	Le Vicoin à Nuillé-sur-Vicoin
M3600910	-0.26	0.96	27	3935	**-0.6992**	**47.8187**	**859**	**680**	**296**	La Mayenne à Château-Gontier
M3630910	-0.08	0.87	20	4166	**-0.6858**	**47.6787**	**852**	**682**	**306**	La Mayenne à Chambellay
M3774010	-0.60	0.76	43	77	**-0.9857**	**47.7839**	**751**	**709**	**212**	Le Chéran à la Boissière
M5102010	-0.23	0.87	46	259	**-0.3745**	**47.1931**	**694**	**740**	**129**	Le Layon à Saint-Georges-sur-Layon
M5222010	-0.26	0.79	20	927	**-0.6323**	**47.3164**	**680**	**741**	**136**	Le Layon à Saint-Lambert-du-Lattay [Pont de Bézigon]
M6014010	-0.14	0.78	70	38	**-0.9626**	**47.1778**	**750**	**734**	**241**	Le Beuvron à Andrezé [Tuvache]
M6333020	-0.32	0.67	6	463	**-1.4809**	**47.4635**	**768**	**725**	**190**	L' Erdre à Nort-sur-Erdre [Moulin de Vault]
M7112410	-0.54	0.63	50	872	**-1.1147**	**47.0184**	**916**	**725**	**327**	La Sèvre Nantaise à Tiffauges [La Moulinette]
M7453010	-0.67	0.60	19	595	**-1.3701**	**47.0555**	**877**	**737**	**273**	La Maine à Remouillé
M8205020	-0.02	1.11	6	139	**-1.5331**	**47.1222**	**820**	**745**	**290**	L' Ognon aux Sorinières [Villeneuve]
N0113010	0.29	0.89	28	33	**-1.7028**	**46.8876**	**824**	**745**	**312**	Le Falleron à Falleron
N3001610	-0.30	0.69	65	131	**-0.9509**	**46.7504**	**943**	**732**	**353**	Le Grand Lay à Saint-Prouant [Monsireigne]
N3024010	-0.52	0.52	42	121	**-0.9708**	**46.6697**	**911**	**739**	**302**	Le Louing à Chantonnay [St-Philbert du Pont Charrault]
O0015310	1.36	1.32	558	36	**0.7480**	**42.8668**	**1359**	**568**	**1154**	Le Maudan à Fos
O0105110	-2.23	-0.18	2154	5	**0.1183**	**42.8197**	**1641**	**387**	**1339**	La Neste de Cap de Long à Aragnouet [Les Edelweiss]

O0126210	-1.31	0.90	1070	67	**0.3000**	**42.7918**	**1585**	**461**	**952**	La Neste de Rioumajou à Tramezaïgues [Maison Blanche]
O0362510	-0.82	0.62	472	385	**1.2137**	**42.9087**	**1530**	**614**	**1263**	Le Salat à Soueix-Rogalle [Kercabanac]
O0384010	-1.10	0.52	501	170	**1.2322**	**42.8990**	**1448**	**656**	**1067**	L' Arac à Soulan [Freychet]
O0502520	-1.18	0.61	386	1159	**1.1411**	**42.9914**	**1411**	**655**	**903**	Le Salat à Saint-Lizier [Saint Girons]
O0525010	0.02	1.16	441	14	**1.0504**	**43.0003**	**1054**	**742**	**958**	La Gouarège à Cazavet [Aliou]
O0592510	-0.45	0.72	270	1579	**0.9745**	**43.1548**	**1287**	**684**	**784**	Le Salat à Roquefort-sur-Garonne
O0744030	-0.84	0.86	290	220	**1.3599**	**43.0826**	**1070**	**754**	**531**	L' Arize au Mas-d'Azil
O1115010	-0.79	0.93	1239	24	**1.4161**	**42.7094**	**1530**	**496**	**1653**	L' Artigue à Auzat [Cibelle]
O1432930	-0.71	0.39	521	134	**1.9263**	**42.8931**	**1222**	**657**	**444**	L' Hers à Bélesta [source de Fontestorbes]
O1442910	-0.81	0.73	417	191	**1.9356**	**42.9543**	**1147**	**687**	**615**	L' Hers Vif au Peyrat
O1484310	-1.10	1.01	507	68	**1.8514**	**42.9404**	**1145**	**684**	**795**	La Touyre à Lavelanet [2]
O1494330	-1.03	0.96	387	95	**1.9121**	**42.9892**	**1086**	**709**	**638**	La Touyre à Léran
O1584610	-0.44	0.69	306	136	**1.7733**	**43.0434**	**959**	**775**	**351**	Le Douctouyre à Vira [Engraviès]
O1634010	-0.35	0.65	239	197	**1.7497**	**43.2014**	**761**	**816**	**179**	La Vixiège à Belpech
O2344010	-0.50	0.71	122	524	**1.4339**	**43.7528**	**758**	**822**	**120**	Le Girou à Cépet
O2725010	-0.17	0.61	191	36	**0.7293**	**43.4974**	**723**	**799**	**165**	La Lauze à Sémézies-Cachan [Faget-Abbatial]
O3006710	-0.59	0.83	1026	10	**3.7890**	**44.3403**	**1634**	**564**	**1457**	La Goudech à Saint-Maurice-de-Ventalon [La Cépède]
O3011010	-0.43	0.73	927	65	**3.7545**	**44.3615**	**1660**	**564**	**1552**	Le Tarn au Pont-de-Montvert [Fontchalettes]
O3035210	1.48	0.88	611	26	**3.6127**	**44.3560**	**1231**	**627**	**633**	Le Briançon aux Bondons [Cocures]
O3064010	-0.51	1.68	554	132	**3.5980**	**44.3148**	**962**	**641**	**835**	Le Tarnon à Florac
O3084320	1.00	1.13	556	126	**3.6030**	**44.3157**	**1500**	**651**	**863**	La Mimente à Florac
O3165010	-0.59	1.64	708	34	**3.4375**	**44.1790**	**1006**	**603**	**855**	La Brèze à Meyrueis
O3194010	0.34	1.45	704	98	**3.4263**	**44.1809**	**1019**	**608**	**630**	La Jonte à Meyrueis [aval]
O3364010	-0.74	0.77	446	428	**3.2895**	**44.0724**	**1208**	**667**	**505**	La Dourbie à Nant [Pont de Gardies]
O3401010	-0.27	0.98	355	2143	**3.0740**	**44.0921**	**1139**	**656**	**675**	Le Tarn à Millau [2]
O3424010	-1.23	0.49	343	169	**2.9865**	**44.0801**	**1017**	**728**	**427**	Le Cernon à Saint-Georges-de-Luzençon [aval]
O3454310	0.02	0.45	340	112	**2.9217**	**44.0813**	**977**	**686**	**398**	La Muze à Montjaux [Saint-Hippolyte]
O4194310	-0.23	0.40	357	207	**2.4172**	**43.6828**	**1174**	**710**	**645**	Le Gijou à Vabre [Rocalé]
O4704030	-0.61	0.63	427	71	**2.4410**	**43.8221**	**1160**	**722**	**569**	Le Dadou à Paulinet [Saint-Jean-de-Jeanne]
O5042510	-0.95	0.34	578	300	**2.8460**	**44.3991**	**1048**	**684**	**315**	L' Aveyron à Palmas [Pont de Manson]
O5055010	-0.56	0.47	584	108	**2.8712**	**44.4152**	**1103**	**696**	**279**	Le Serre à Coussergues [Resuenhe]
O5092520	-1.22	0.46	533	584	**2.6213**	**44.3622**	**1046**	**695**	**309**	L' Aveyron à Onet-le-Château [Rodez]
O5192520	-0.80	0.51	276	1060	**2.0548**	**44.3478**	**1019**	**710**	**344**	L' Aveyron à Villefranche-de-Rouergue [Recoules]
O5224010	-0.29	0.74	276	208	**2.0497**	**44.3568**	**958**	**748**	**357**	L' Alzou à Villefranche-de-Rouergue [barrage Cabal]
O5284310	-0.94	0.59	317	104	**2.0442**	**44.2093**	**953**	**744**	**329**	La Serène à Saint-André-de-Najac [Canabral]
O5292510	-0.75	0.56	163	1604	**1.9733**	**44.1515**	**990**	**726**	**314**	L' Aveyron à Laguépie [1]
O5312910	-0.24	0.94	730	139	**2.8013**	**44.3085**	**1009**	**666**	**522**	Le Viaur à Arques
O5344010	-0.11	0.84	814	57	**2.8130**	**44.2104**	**1019**	**659**	**534**	Le Vioulou à Salles-Curan [Trébons-Bas]
O5424010	-1.13	0.42	352	161	**2.4067**	**44.1431**	**999**	**708**	**362**	Le Céor à Centrès [Estrebaldie]
O5464310	-1.23	0.43	363	176	**2.4353**	**44.1080**	**980**	**723**	**339**	Le Giffou à Saint-Just-sur-Viaur [La Fabrèguerie]
O5534010	-0.80	0.95	245	223	**2.1981**	**44.1637**	**972**	**732**	**364**	Le Lézert à Saint-Julien-du-Puy [Port de la Besse]
O5685010	-0.43	0.35	139	181	**1.7483**	**44.1721**	**908**	**779**	**191**	La Bonnette à Saint-Antonin-Noble-Val
O5754020	-0.53	0.60	125	310	**1.6726**	**44.0242**	**827**	**800**	**189**	La Vère à Bruniquel [La Gauterie]
O6125010	-0.08	0.90	143	62	**1.1903**	**44.3340**	**825**	**796**	**264**	La Petite Barguelonne à Montcuq
O6134010	-0.30	0.75	74	453	**0.9963**	**44.1691**	**798**	**803**	**182**	La Barguelonne à Valence [Fourquet]

O6793310	-0.16	0.58	58	834	**0.2463**	**44.0754**	**816**	**811**	**160**	La Gélise à Mézin [Courbian]
O6804630	-0.43	0.87	245	9	**0.3240**	**43.3989**	**872**	**783**	**281**	L' Osse à Castex [Mielan]
O7011510	-0.85	0.90	813	187	**3.5964**	**44.5262**	**1104**	**564**	**602**	Le Lot à Sainte-Hélène
O7015810	-0.57	-0.64	981	33	**3.6181**	**44.5412**	**960**	**546**	**448**	L' Esclancide à Pelouse [Les Salces]
O7041510	-1.22	0.71	667	468	**3.4233**	**44.4813**	**1099**	**589**	**477**	Le Lot à Balsièges [Bramonas]
O7085010	-0.56	-0.52	663	83	**3.3114**	**44.5507**	**1013**	**607**	**314**	Le Coulagnet à Marvejols
O7101510	-0.94	0.64	525	1158	**3.1979**	**44.4428**	**1030**	**606**	**362**	Le Lot à Banassac [La Mothe]
O7131510	-0.70	0.54	388	1633	**2.8670**	**44.5033**	**1045**	**621**	**420**	Le Lot à Lassouts [Castelnau]
O7145220	0.62	0.91	439	53	**2.8484**	**44.5322**	**1316**	**607**	**1005**	La Boralde de Saint-Chély à Castelnau-de-Mandailles
O7234010	-0.46	0.81	948	117	**3.3215**	**44.7664**	**1044**	**590**	**450**	La Rimeize à Rimeize
O7245010	-0.08	0.83	947	65	**3.2954**	**44.7919**	**1006**	**599**	**374**	Le Chapouillet à Rimeize [Chassignoles]
O7265010	-0.60	0.67	921	78	**3.3609**	**44.7778**	**929**	**568**	**384**	La Limagnole à Fontans [Saint-Alban]
O7444010	-0.78	1.13	924	286	**3.0850**	**44.8268**	**1051**	**570**	**787**	Le Bès à Saint-Juéry
O7502510	-0.43	0.70	704	1795	**3.0736**	**44.9231**	**937**	**589**	**412**	La Truyère à Neuvéglise [Grandval]
O7635010	-1.08	0.87	645	109	**2.6843**	**44.8270**	**1601**	**606**	**935**	La Bromme à Brommat
O7874010	-1.22	0.33	236	545	**2.4009**	**44.5873**	**1063**	**742**	**376**	Le Dourdou à Conques
O8113510	-0.11	0.59	183	681	**1.9843**	**44.5886**	**1200**	**732**	**567**	Le Célé à Figeac [Merlançon]
O8133520	-0.62	1.20	142	1246	**1.6793**	**44.5197**	**1107**	**751**	**446**	Le Célé à Orniac [Les Amis du Célé]
O8255010	-0.92	0.80	103	119	**1.2320**	**44.5108**	**914**	**779**	**328**	Le Vert à Labastide-du-Vert [Les Campagnes]
O8394310	-0.64	0.45	87	220	**0.9460**	**44.5363**	**892**	**781**	**159**	La Lémance à Cuzorn
O9196210	-0.07	0.42	53	10	**-0.0747**	**44.5240**	**804**	**805**	**114**	La Cadanne à Pondaurat
P0010010	-2.40	0.65	786	89	**2.6892**	**45.6042**	**1313**	**551**	**1253**	La Dordogne à Saint-Sauves-d'Auvergne
P0115010	-0.30	0.89	905	21	**2.6964**	**45.5286**	**1451**	**537**	**1501**	La Burande à la Tour-d'Auvergne
P0115020	-0.50	0.94	569	85	**2.5416**	**45.5425**	**1382**	**583**	**1038**	La Burande [ou ru de Burons] à Singles
P0212510	-0.84	0.68	954	40	**2.8297**	**45.4084**	**1602**	**552**	**1317**	La Rhue à Égliseneuve-d'Entraigues
P0364010	-0.63	0.95	709	169	**2.7512**	**45.3341**	**1302**	**559**	**765**	La Santoire à Condat [Roche-Pointue]
P0885010	-1.74	0.61	377	117	**2.3877**	**45.2970**	**1385**	**610**	**910**	Le Mars à Bassignac [Vendes]
P0924010	-0.96	0.64	631	79	**2.2395**	**45.4913**	**1286**	**639**	**708**	La Triouzoune à Saint-Angel
P1114010	-0.48	0.61	566	81	**2.1513**	**45.4687**	**1312**	**634**	**785**	La Luzège à Maussac [Pont de Maussac]
P1154010	-1.11	0.83	452	250	**2.1286**	**45.3823**	**1351**	**649**	**765**	La Luzège à Lamazière-Basse [Pont de Bouyges]
P1502510	-0.52	1.02	419	455	**2.1932**	**45.0820**	**1409**	**644**	**942**	La Maronne à Pleaux [Enchanet]
P1772910	-1.07	0.72	559	349	**2.3506**	**44.8815**	**1622**	**607**	**976**	La Cère à Sansac-de-Marmiesse
P2114010	-2.05	0.67	131	63	**1.7245**	**44.9886**	**1245**	**731**	**468**	La Sourdoire à la Chapelle-aux-Saints
P2184310	-0.68	0.67	114	191	**1.6679**	**44.9469**	**1069**	**768**	**340**	La Tourmente à Saint-Denis-lès-Martel
P2484010	-0.48	0.41	77	573	**1.1709**	**44.7899**	**916**	**780**	**166**	Le Céou à Saint-Cybranet
P3001010	-1.48	0.74	773	42	**2.0072**	**45.6285**	**1403**	**611**	**1041**	La Vézère à Saint-Merd-les-Oussines [Maisonnial]
P3021010	-0.99	0.95	675	138	**1.9227**	**45.6030**	**1389**	**623**	**929**	La Vézère à Bugeat
P3234010	-1.57	0.56	153	104	**1.4150**	**45.3067**	**1176**	**726**	**487**	La Loyre à Voutezac [Pont de l'Aumonerie]
P3245010	-1.03	0.47	123	52	**1.3965**	**45.2706**	**1086**	**748**	**396**	Le Mayne à Saint-Cyr-la-Roche
P3352510	-0.86	0.37	478	164	**1.8900**	**45.3771**	**1423**	**641**	**1047**	La Corrèze à Corrèze [Pont de Neupont]
P3502510	-1.06	0.72	224	354	**1.7799**	**45.2750**	**1379**	**668**	**887**	La Corrèze à Tulle [Pont des soldats]
P3614010	-0.47	0.67	546	42	**1.9387**	**45.3422**	**1418**	**670**	**891**	La Montane à Eyrein [Pont du Geai]
P3922510	-0.42	0.81	103	954	**1.5013**	**45.1626**	**1296**	**702**	**655**	La Corrèze à Brive-la-Gaillarde [Le Prieur]
P4015010	-1.38	0.75	133	58	**1.4680**	**45.0948**	**1076**	**765**	**461**	La Couze à Chasteaux [Le Soulier]
P4271010	-0.56	0.66	56	3657	**0.9584**	**44.9034**	**1157**	**729**	**496**	La Vézère à Campagne
P5404010	-0.27	0.65	36	74	**0.3665**	**44.8882**	**885**	**800**	**217**	L' Eyraud à la Force [Bitarel]

P6081510	-0.85	0.75	137	448	**0.9492**	**45.3766**	**1102**	**738**	**399**	L' Isle à Corgnac-sur-l'Isle
P6134010	-0.54	0.56	154	197	**1.0674**	**45.3438**	**1104**	**741**	**451**	La Loue à Saint-Médard-d'Excideuil
P7001510	-0.80	0.78	91	1859	**0.8046**	**45.2028**	**1061**	**749**	**408**	L' Isle à Bassilac [Charrieras]
P7181510	0.26	0.49	36	3342	**0.2473**	**45.0291**	**992**	**766**	**388**	L' Isle à Saint-Laurent-des-Hommes [Bénévent]
P7261510	-0.59	0.50	7	3757	**-0.1254**	**45.0214**	**974**	**769**	**297**	L' Isle à Abzac
P8012510	-0.98	1.04	160	140	**0.7524**	**45.5152**	**1100**	**733**	**478**	La Dronne à Saint-Pardoux-la-Rivière [Le Manet]
P8215010	-0.59	0.45	113	40	**0.4667**	**45.4478**	**969**	**764**	**230**	La Belle à Mareuil
P8312520	-0.66	1.12	37	1912	**0.1515**	**45.2387**	**955**	**767**	**316**	La Dronne à Bonnes
Q0115710	-1.15	1.52	505	32	**0.1030**	**43.0898**	**1360**	**710**	**883**	L' Oussouet à Trébons
Q0214010	-1.81	0.91	337	78	**0.0223**	**43.1753**	**1247**	**765**	**486**	L' Échez à Louey
Q0280030	-1.75	0.90	167	876	**0.0290**	**43.4982**	**1161**	**713**	**469**	L' Adour à Estirac
Q0664010	-0.28	0.38	141	207	**0.1244**	**43.5550**	**875**	**797**	**240**	Le Bouès à Juillac
Q1094010	-0.27	1.24	92	426	**-0.2346**	**43.6469**	**1030**	**805**	**332**	Le Larcis à Lannux
Q1100010	-0.35	0.91	80	2921	**-0.2619**	**43.7038**	**1038**	**772**	**373**	L' Adour à Aire-sur-l'Adour [2]
Q2593310	-0.64	1.07	26	2478	**-0.6595**	**43.9076**	**909**	**813**	**231**	La Midouze à Campagne
Q3120010	-0.33	0.83	6	7707	**-1.0001**	**43.7331**	**1000**	**799**	**339**	L' Adour à Saint-Vincent-de-Paul
Q3464010	-0.90	0.96	6	1144	**-1.0427**	**43.6769**	**1110**	**823**	**424**	Le Luy à Saint-Pandelon
Q7322510	-3.30	0.85	123	498	**-0.8747**	**43.2466**	**1766**	**717**	**1383**	Le Saison à Mauléon-Licharre
Q8032510	-0.75	0.77	43	246	**-1.0286**	**43.3337**	**1521**	**791**	**602**	La Bidouze à Aïcirits-Camou-Suhast [Saint-Palais]
Q8345910	-0.33	0.75	37	17	**-1.3096**	**43.4109**	**1380**	**825**	**863**	Le Mendialçu à Hasparren
Q9164610	-1.89	1.09	149	157	**-1.3370**	**43.1842**	**1742**	**731**	**1228**	La Nive des Aldudes à Saint-Étienne-de-Baïgorry
R1132510	-1.23	1.34	217	139	**0.6898**	**45.7267**	**1059**	**730**	**448**	La Tardoire à Maisonnais-sur-Tardoire
R1264001	-0.25	0.42	106	293	**0.4729**	**45.6072**	**1049**	**754**	**406**	Le Bandiat à Feuillade
S2224610	-0.42	0.59	41	113	**-0.7528**	**44.4107**	**1023**	**796**	**260**	Le Grand Arriou à Moustey [Biganon]
S2235610	-0.29	0.40	35	42	**-0.7734**	**44.4650**	**927**	**797**	**183**	Le Bouron à Belin-Béliet [Moulin du Moine]
S2242510	-0.52	0.70	14	1678	**-0.8711**	**44.5477**	**1017**	**796**	**292**	L' Eyre à Salles
S4214010	-1.13	0.34	21	77	**-1.2240**	**43.7808**	**1177**	**809**	**407**	Le Magescq à Magescq
S5144010	-1.90	1.37	31	142	**-1.5491**	**43.3215**	**1467**	**801**	**968**	La Nivelle à Saint-Pée-sur-Nivelle
U0104010	-0.92	0.86	306	64	**6.3025**	**48.0817**	**1185**	**646**	**619**	Le Coney à Xertigny
U0444310	-0.72	1.41	243	225	**6.2717**	**47.8855**	**1316**	**643**	**796**	La Semouse à Saint-Loup-sur-Semouse
U0474010	-0.57	0.79	209	1028	**6.0760**	**47.7488**	**1337**	**659**	**668**	La Lanterne à Fleurey-lès-Faverney
U0610010	-0.48	0.96	195	3761	**5.8257**	**47.5765**	**1105**	**667**	**492**	La Saône à Ray-sur-Saône
U0635010	-0.18	0.64	200	146	**5.7957**	**47.6062**	**981**	**674**	**365**	La Gourgeonne à Tincey-et-Pontrebeau
U0724010	-0.92	0.93	200	385	**5.6470**	**47.5700**	**968**	**675**	**373**	Le Salon à Denèvre
U0924010	-0.48	0.89	232	397	**5.4068**	**47.5784**	**965**	**666**	**325**	La Vingeanne à Saint-Maurice-sur-Vingeanne
U0924020	-0.55	0.89	198	609	**5.3672**	**47.4219**	**935**	**678**	**314**	La Vingeanne à Oisilly
U1004010	-1.64	0.42	388	71	**6.6680**	**47.8030**	**1894**	**610**	**1348**	L' Ognon à Servance [Fourguenons]
U1025010	-0.89	0.43	445	32	**6.7302**	**47.7314**	**2078**	**602**	**1640**	Le Rahin à Plancher-Bas
U1054010	-0.38	0.60	229	1259	**6.1813**	**47.4158**	**1299**	**672**	**583**	L' Ognon à Beaumotte-Aubertans
U1074010	-0.64	0.64	200	1755	**5.8260**	**47.2974**	**1247**	**682**	**489**	L' Ognon à Chevigney-sur-l'Ognon
U1084010	-0.34	0.68	186	2071	**5.5452**	**47.2929**	**1222**	**687**	**518**	L' Ognon à Pesmes
U1109010	-0.52	0.91	291	56	**5.1902**	**47.5840**	**958**	**665**	**344**	La Venelle à Selongey
U1204010	-0.60	0.87	273	230	**5.1248**	**47.5540**	**958**	**666**	**379**	La Tille à Crécey-sur-Tille
U1224010	-0.28	0.66	223	845	**5.1896**	**47.3734**	**936**	**672**	**272**	La Tille à Arceau [Arcelot]
U1224020	-0.44	0.50	202	882	**5.2177**	**47.2808**	**931**	**674**	**241**	La Tille à Cessey-sur-Tille

U1235020	-0.66	0.94	194	271	**5.2207**	**47.2385**	**829**	**703**	**305**	La Norges à Genlis
U1420010	-0.39	0.79	173	11693	**5.1509**	**47.0674**	**1031**	**683**	**420**	La Saône à Pagny-la-Ville [Lechatelet]
U2002010	-0.46	0.70	938	33	**6.1907**	**46.7012**	**1749**	**537**	**1662**	Le Doubs à Mouthe
U2012010	-0.24	0.50	855	170	**6.2798**	**46.7730**	**1722**	**539**	**822**	Le Doubs à Labergement-Sainte-Marie
U2022010	-0.27	0.45	824	382	**6.3566**	**46.9063**	**1701**	**546**	**639**	Le Doubs à la Cluse-et-Mijoux [Pontarlier amont]
U2122010	-0.51	0.68	506	1159	**6.9505**	**47.2714**	**1648**	**554**	**789**	Le Doubs à Goumois
U2142010	-0.44	0.67	414	1306	**7.0258**	**47.3441**	**1619**	**560**	**817**	Le Doubs à Glère [Courclavon]
U2215020	-0.62	0.77	394	590	**6.7945**	**47.3055**	**1512**	**598**	**737**	Le Dessoubre à Saint-Hippolyte
U2222010	0.02	0.84	334	2236	**6.7859**	**47.4401**	**1550**	**580**	**740**	Le Doubs à Mathay
U2305210	-1.28	1.10	474	9	**6.9498**	**47.7382**	**1297**	**660**	**1035**	Le Saint-Nicolas à Rougemont-le-Château
U2345020	-1.07	0.20	468	30	**6.8285**	**47.7411**	**2155**	**606**	**1554**	La Savoureuse à Giromagny
U2345030	-0.87	0.49	358	144	**6.8587**	**47.6408**	**1850**	**642**	**930**	La Savoureuse à Belfort
U2356610	0.00	0.21	323	43	**6.7524**	**47.5008**	**1138**	**678**	**430**	Le Rupt à Dung
U2425260	-0.20	0.16	275	541	**6.3732**	**47.3381**	**1360**	**659**	**425**	Le Cusancin à Baume-les-Dames
U2512010	-0.13	0.87	241	4658	**6.0312**	**47.2397**	**1394**	**625**	**703**	Le Doubs à Besançon
U2542010	-0.49	0.78	201	5169	**5.5627**	**47.1223**	**1373**	**633**	**667**	Le Doubs à Rochefort-sur-Nenon
U2604030	-0.69	1.84	359	291	**6.2268**	**47.0567**	**1560**	**591**	**2310**	La Loue à Vuillafans
U2615820	-0.28	0.53	437	210	**6.0123**	**46.9656**	**1574**	**601**	**776**	Le Lison [source] à Nans-sous-Sainte-Anne
U2615830	0.08	0.50	325	284	**5.9576**	**47.0313**	**1533**	**613**	**816**	Le Lison à Myon
U2616410	-0.10	0.42	629	15	**6.0213**	**46.9617**	**1541**	**600**	**1029**	Le Verneau à Nans-sous-Sainte-Anne
U2624010	-0.28	1.10	275	1068	**5.9569**	**47.1394**	**1474**	**629**	**1383**	La Loue à Chenecey-Buillon
U2634010	-0.28	0.98	236	1264	**5.8148**	**47.0438**	**1460**	**636**	**1287**	La Loue à Champagne-sur-Loue
U2722010	-0.32	0.81	180	7346	**5.3510**	**46.9227**	**1360**	**643**	**760**	Le Doubs à Neublans-Abergement
U3205210	-1.26	0.70	368	31	**4.5583**	**46.2757**	**1034**	**683**	**517**	La Grosne à Trades [Les Chambosses]
U3214010	-1.65	0.57	243	334	**4.6494**	**46.4044**	**957**	**693**	**365**	La Grosne à Jalogny [Cluny]
U3225010	0.87	0.78	214	271	**4.5647**	**46.5582**	**901**	**703**	**226**	La Guye à Sigy-le-Châtel [Corcelles]
U3424010	-0.26	0.36	176	938	**5.2586**	**46.6740**	**1226**	**711**	**469**	La Seille à Saint-Usuge
U4014010	-0.10	0.49	240	84	**5.2900**	**46.1717**	**1023**	**729**	**199**	La Reyssouze à Montagnat
U4204010	-0.53	0.65	255	41	**5.1978**	**46.1173**	**1010**	**733**	**281**	La Veyle à Lent
U4235010	-0.77	0.71	215	93	**4.9994**	**46.1636**	**1007**	**736**	**242**	Le Renon à Neuville-les-Dames
U4505010	-0.92	0.61	310	55	**4.5858**	**46.1564**	**1032**	**694**	**444**	L' Ardières à Beaujeu
U4624010	-0.77	0.62	211	337	**4.6439**	**45.8744**	**975**	**708**	**357**	L' Azergues à Châtillon
V0144010	0.03	0.98	606	332	**6.5521**	**46.1136**	**1937**	**487**	**1827**	Le Giffre à Taninges [Pressy]
V0205010	-3.49	0.20	458	28	**6.4565**	**46.0649**	**1892**	**531**	**729**	Le Bronze à Bonneville [Thuet]
V0245610	-0.32	0.32	436	47	**6.0669**	**46.1397**	**1240**	**636**	**421**	L' Aire à Saint-Julien-en-Genevois [Thairy]
V0325010	-2.93	0.70	707	171	**6.6210**	**46.2651**	**1979**	**500**	**1348**	La Dranse de Morzine à Seytroux [Pont de Couvaloup]
V1015010	-0.88	0.36	851	76	**5.9221**	**46.2831**	**1930**	**535**	**878**	La Valserine à Lélex [Niaizet]
V1015030	-1.63	0.69	579	110	**5.8648**	**46.2200**	**1890**	**544**	**1214**	La Valserine à Chézery-Forens [Chézery]
V1015810	-1.32	1.13	401	182	**5.8006**	**46.1500**	**1712**	**589**	**1562**	La Semine à Châtillon-en-Michaille [Coz]
V1214010	-7.26	0.89	528	224	**6.2070**	**45.9053**	**1835**	**549**	**1336**	Le Fier à Dingy-Saint-Clair
V1235210	-7.92	0.38	469	25	**6.2242**	**45.7831**	**1745**	**586**	**1187**	L' Ire à Doussard
V1235610	-3.62	0.24	456	93	**6.2322**	**45.7873**	**1674**	**610**	**907**	L' Eau Morte à Doussard
V1237410	-1.61	0.31	465	30	**6.1634**	**45.8347**	**1436**	**618**	**712**	Le Laudon à Saint-Jorioz
V1264010	-2.70	0.93	316	1286	**5.9204**	**45.9013**	**1583**	**609**	**960**	Le Fier à Vallières
V1414010	-0.26	0.20	382	158	**5.6728**	**45.8819**	**1699**	**594**	**252**	Le Seran à Belmont-Luthézieu [Bavosière]
V1425010	-3.11	2.23	249	41	**5.6866**	**45.8761**	**1539**	**644**	**2365**	Le Groin à Artemare [Cerveyrieu]

V1504010	-1.53	0.55	433	94	**5.7362**	**45.3856**	**1880**	**565**	**1559**	Le Guiers Mort à Saint-Laurent-du-Pont
V1774010	-0.14	0.68	204	696	**5.1589**	**45.7150**	**1037**	**744**	**339**	La Bourbre à Tignieu-Jameyzieu
V2024010	-1.28	0.60	793	101	**6.0281**	**46.6400**	**1903**	**538**	**1045**	La Saine à Foncine-le-Bas
V2035010	-0.33	0.19	819	95	**5.9645**	**46.6069**	**1904**	**564**	**290**	La Lemme à Fort-du-Plasne [Pont-de-Lemme]
V2202010	-0.83	0.82	458	734	**5.7669**	**46.6859**	**1752**	**582**	**1135**	L' Ain à Marigny [Chalain]
V2206010	-0.43	0.79	499	51	**5.7750**	**46.6479**	**1778**	**607**	**1012**	Le Hérisson à Doucier
V2414010	-2.25	0.83	442	203	**5.8684**	**46.4163**	**1972**	**544**	**1372**	La Bienne à Saint-Claude [Chenavier]
V2444020	-0.36	0.94	323	593	**5.7062**	**46.3627**	**1902**	**566**	**1568**	La Bienne à Jeurre
V2814020	-0.31	0.37	272	331	**5.3904**	**46.1123**	**1469**	**679**	**353**	Le Suran à Neuville-sur-Ain [La Planche]
V2924010	-0.33	0.64	293	210	**5.4393**	**45.9480**	**1668**	**606**	**915**	L' Albarine à Saint-Rambert-en-Bugey
V2934010	0.01	0.43	242	290	**5.3326**	**45.9545**	**1634**	**622**	**692**	L' Albarine à Saint-Denis-en-Bugey [Pont Saint Denis]
V4144010	-0.20	0.64	309	454	**4.5393**	**44.8748**	**1331**	**639**	**607**	L' Eyrieux à Beauvène [Pont de Chervil]
V4214010	-0.66	0.63	542	189	**5.4440**	**44.6191**	**1108**	**621**	**373**	La Drôme à Luc-en-Diois
V4225010	-1.70	0.76	564	227	**5.4910**	**44.6933**	**1356**	**568**	**560**	Le Bez à Châtillon-en-Diois
V4275010	-0.97	0.56	329	101	**5.1456**	**44.7747**	**1193**	**652**	**291**	La Gervanne à Beaufort-sur-Gervanne
V4414010	-0.43	0.62	276	192	**5.0159**	**44.6249**	**1028**	**695**	**303**	Le Roubion à Soyans
V5045810	-1.20	1.26	638	63	**3.9499**	**44.5755**	**1851**	**597**	**1267**	Le Borne à Saint-Laurent-les-Bains [Pont de Nicoulaud]
V6035010	0.42	0.65	338	157	**5.2141**	**44.2150**	**1000**	**675**	**247**	Le Toulourenc à Malaucène [Veaux]
V6052010	-0.94	0.71	194	587	**5.0690**	**44.2403**	**936**	**717**	**344**	L' Ouvèze à Vaison-la-Romaine
V7124010	0.27	1.28	148	244	**3.9682**	**44.0797**	**1499**	**755**	**724**	Le Gardon de Mialet à Générargues [Roucan]
W0000010	-1.37	0.32	1851	46	**6.9878**	**45.4476**	**1050**	**260**	**1189**	L' Isère à Val-d'Isère
W0224010	1.06	1.01	652	333	**6.5847**	**45.4493**	**1289**	**368**	**1296**	Le Doron de Bozel à la Perrière [Vignotan]
W2222010	0.50	1.17	750	984	**5.9104**	**44.8174**	**1302**	**466**	**1026**	Le Drac à Corps [Le Sautet]
W2335210	-0.23	0.85	948	70	**5.8668**	**44.9493**	**1592**	**483**	**1061**	La Roizonne à la Valette [La Rochette]
W2405010	0.54	0.88	885	51	**5.7822**	**44.9142**	**1420**	**559**	**436**	La Jonche à la Mure
W2714010	-0.04	0.66	1088	223	**6.1837**	**45.0387**	**1280**	**325**	**1048**	La Romanche à Mizoën [Chambon amont]
W3315010	-0.72	0.23	962	74	**5.5313**	**45.1126**	**1446**	**569**	**248**	Le Meaudret à Méaudre
W3335210	-1.49	0.59	707	37	**5.4452**	**45.0043**	**1408**	**564**	**471**	L' Adouin à Saint-Martin-en-Vercors [Tourtre]
X0010010	0.98	1.44	1363	206	**6.6791**	**44.9240**	**1176**	**383**	**739**	La Durance à Val-des-Prés [Les Alberts]
X0100010	-1.39	0.83	1190	548	**6.6255**	**44.8865**	**1115**	**381**	**729**	La Durance à Briançon [aval]
X0310010	-1.88	0.60	784	2283	**6.4878**	**44.5522**	**1038**	**405**	**678**	La Durance à Embrun [La Clapière]
X0434010	1.46	1.03	1136	542	**6.6525**	**44.3837**	**1001**	**382**	**555**	L' Ubaye à Barcelonnette [Abattoir]
X0454010	1.26	1.27	806	943	**6.4011**	**44.4501**	**997**	**409**	**661**	L' Ubaye au Lauzet-Ubaye [Roche Rousse]
X0500010	-1.03	0.93	756	3580	**6.2809**	**44.4752**	**1026**	**421**	**667**	La Durance à Espinasses [Serre-Ponçon]
X1034020	-0.14	1.14	674	731	**5.7144**	**44.4428**	**1135**	**581**	**587**	Le Buech à Serres [Les Chambons]
X1225010	-0.01	0.85	829	165	**6.2754**	**44.2170**	**916**	**539**	**504**	Le Bes à la Javie [Esclangon-Péroure]
X2114010	0.97	0.94	943	138	**6.5020**	**43.9961**	**1080**	**538**	**535**	L' Issole à Saint-André-les-Alpes [Mourefrey]
Y0115410	-1.50	0.96	101	16	**2.9862**	**42.5255**	**856**	**861**	**550**	La Massane à Argelès-sur-Mer [Mas d'en Tourens]
Y0255020	-0.14	0.65	197	49	**2.6983**	**42.4946**	**939**	**817**	**228**	L' Ample à Reynès [Le Vila]
Y0325010	0.38	0.78	160	32	**2.7330**	**42.5986**	**780**	**846**	**199**	La Canterrane à Terrats [Moulin d'en Canterrane]
Y0624020	-0.31	0.02	246	218	**2.4977**	**42.8022**	**984**	**738**	**408**	L' Agly à Saint-Paul-de-Fenouillet [Clue de la Fou]
Y1225010	0.25	0.07	346	66	**2.3992**	**43.0601**	**901**	**775**	**277**	Le Lauquet à Greffeil
Y1325010	-0.10	0.46	128	142	**2.0908**	**43.2764**	**719**	**853**	**117**	Le Treboul à Villepinte
Y1415020	-0.09	0.33	94	242	**2.4314**	**43.2326**	**1043**	**762**	**343**	L' Orbiel à Bouilhonnac [Villedubert]
Y1416210	-0.67	0.84	109	85	**2.4375**	**43.2532**	**1013**	**769**	**296**	La Clamoux à Malves-en-Minervois

Y2015010	0.63	1.21	198	155	**3.6582**	**44.0003**	**1483**	**739**	**949**	L' Arre au Vigan [La Terrisse]
Y2102010	-0.73	0.87	139	916	**3.7346**	**43.9157**	**1389**	**748**	**615**	L' Hérault à Laroque
Y2214010	-0.37	1.06	160	181	**3.3234**	**43.7287**	**1296**	**750**	**771**	La Lergue à Lodève
Y3204010	0.49	1.25	40	116	**3.8718**	**43.6513**	**910**	**862**	**602**	Le Lez à Montferrier-sur-Lez [Lavalette]
Y4002010	-0.32	0.46	252	50	**5.7272**	**43.4876**	**780**	**819**	**96**	L' Arc à Pourrières
Y4022010	-0.06	0.56	174	297	**5.5143**	**43.5013**	**706**	**818**	**112**	L' Arc à Meyreuil [Pont de Bayeux]
Y4214010	-0.46	0.19	96	205	**5.1746**	**43.6286**	**637**	**824**	**82**	La Touloubre à la Barben [La Savonnière]
Y4604020	0.52	0.55	81	184	**6.0369**	**43.1941**	**892**	**828**	**175**	Le Gapeau à Solliès-Pont
Y4624010	-0.03	0.83	12	536	**6.1482**	**43.1488**	**873**	**857**	**182**	Le Gapeau à Hyères [Sainte-Eulalie]
Y5005210	0.47	0.40	254	146	**5.9514**	**43.4965**	**812**	**834**	**110**	Le Cauron à Bras [Pont de l'Avocade]
Y5032010	-0.74	0.64	183	505	**6.0247**	**43.5022**	**765**	**821**	**168**	L' Argens à Châteauvert
Y5105010	3.33	1.35	181	203	**6.1764**	**43.4420**	**830**	**849**	**277**	Le Caramy à Vins-sur-Caramy [Les Marcounious]
Y5106610	1.22	0.86	189	228	**6.2258**	**43.4420**	**851**	**852**	**159**	L' Issole à Cabasse [Pont des Fées]
Y5202010	-0.73	0.72	42	1651	**6.4742**	**43.4445**	**811**	**839**	**185**	L' Argens aux Arcs
Y5215020	-0.34	0.92	46	229	**6.4534**	**43.3949**	**852**	**879**	**258**	L' Aille à Vidauban [Le Baou]
Y5235010	-0.58	0.78	151	194	**6.4812**	**43.5063**	**892**	**767**	**181**	La Nartuby à Trans-en-Provence
Y5235030	-0.13	0.61	235	149	**6.4232**	**43.5778**	**896**	**741**	**182**	La Nartuby à Châteaudouble [Rebouillon]
Y5312010	-0.95	0.69	8	2514	**6.6452**	**43.4513**	**822**	**841**	**191**	L' Argens à Roquebrune-sur-Argens
Y5505410	-3.86	0.72	7	48	**6.8496**	**43.4429**	**825**	**877**	**239**	Le Grenouiller à Saint-Raphaël [Agay]
Y5615010	-0.11	0.94	133	206	**7.0088**	**43.6981**	**1112**	**709**	**488**	Le Loup à Tourrettes-sur-Loup [Les Vallettes]
Y5615020	-0.06	0.79	192	153	**6.9921**	**43.7213**	**1130**	**690**	**412**	Le Loup à Gourdon [Loup amont]
Y6432010	-0.60	0.96	188	1829	**7.1905**	**43.9081**	**1144**	**563**	**576**	Le Var à Malaussène [La Mescla]
Y6434010	0.19	1.04	140	443	**7.1590**	**43.8446**	**1042**	**706**	**425**	L' Estéron au Broc [La Clave]
Y6624010	-0.16	1.31	280	453	**7.5204**	**43.9316**	**1127**	**596**	**770**	La Roya à Breil-sur-Roya

494 **Table 1. Summary of the elasticity notations used in this paper (*X* being precipitation *P* or**
495 **potential evaporation E_P)**

Notation	Definition	Formula
$\varepsilon_{Q/X}$	*Relative streamflow elasticity* – *percent* change of streamflow *Q* by *percent* change of climate variable *X*	$\frac{\Delta Q}{\overline{Q}} = \varepsilon_{Q/X} \frac{\Delta X}{\overline{X}}$
$e_{Q/X}$	*Absolute streamflow elasticity* – *mm* change of streamflow *Q* by *mm* change of climate variable *X*	$\Delta Q = e_{Q/X} . \Delta X$

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498 **Table 2. Comparison of the theoretical and empirical elasticity assessment methods**

	Theoretical (model-based) elasticity assessment	**Empirical (data-based) elasticity assessment**
Co-variations of different climatic variables	The modeling approach distinguishes between the impact of different climatic variables (by keeping part of the forcing constant while modifying the other part).	Problem: the changes in observed climatic variables can be correlated (e.g., ΔP negatively correlated with ΔT when the driest years are also the warmest), which makes it more difficult to attribute streamflow changes to one or the other variable
Data requirements	No need for long concomitant series of observed streamflow and climatic variables (only what is needed for model calibration)	Long concomitant series of observed streamflow and climatic variables are required
Extrapolation capacity	Extrapolates to extreme climatic changes (i.e., to changes that have not been observed over historical records)	Can only deal with the changes that have been observed in the available historical record.

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502 **Table 3. Regression models used to assess empirical elasticity**

Notation	Definition	Inputs	Number of parameters
NP	Nonparametric regression	$\Delta P_i^{(M)}$ or $\Delta E_{P_i}^{(M)}$	0
OLS1	Ordinary least squares using a single climate input	$\Delta P_i^{(M)}$ or $\Delta E_{P_i}^{(M)}$	1
OLS2	Ordinary least squares using two climate inputs	$\Delta P_i^{(M)}$ and $\Delta E_{P_i}^{(M)}$	2
GLS1	Generalized least squares using a single climate input	$\Delta P_i^{(M)}$ or $\Delta E_{P_i}^{(M)}$	3
GLS2	Generalized least squares using two climate inputs	$\Delta P_i^{(M)}$ and $\Delta E_{P_i}^{(M)}$	4

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505 **Table 4. Univariate regression models for empirical elasticity assessment**

$\Delta Q_i^{(M)} = e^{(M)}_{Q/X} . \Delta X_i^{(M)} + \omega_i$ **Eq. 12**	
OLS	$\omega_i \sim N(0, \sigma)$
GLS	$\begin{cases} \omega_i = \alpha \omega_{i-1} + \delta_i \\ \delta_i \sim N(0, \sigma) \\ \omega_i \sim N(0, \sigma\sqrt{1-\alpha^2}) \end{cases}$

$\Delta Q_i^{(M)}$: streamflow anomaly over *M* years, considered as the explained variable

$\Delta X_i^{(M)}$: rainfall or potential evaporation anomaly for the same sub-period, considered as the explanatory variable

$e^{(M)}_{Q/X}$: streamflow elasticity (equal to the regression slope)

ω_i : regression residual

α : parameter of the first-order autoregressive process (AR1)

δ_i : innovation of the autoregressive process

σ : standard deviation

M: number of years over which the long-term streamflow, precipitation and evaporation average is computed

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508 **Table 5. Bivariate regression models for empirical elasticity assessment**

$\Delta Q_i^{(M)} = e_{Q/P}^{(M)}.\Delta P_i^{(M)} + e_{Q/E_P}^{(M)}.\Delta E_{P_i}^{(M)} + \omega_i$ **Eq. 13**	
OLS	$\omega_i \sim N(0,\sigma)$
GLS	$\begin{cases} \omega_i = \alpha\omega_{i-1} + \delta_i \\ \delta_i \sim N(0,\sigma) \\ \omega_i \sim N(0,\sigma\sqrt{1-\alpha^2}) \end{cases}$

$\Delta Q_i^{(M)}$: streamflow anomaly over *M* years, considered as the explained variable

$\Delta X_i^{(M)}$: rainfall or potential evaporation anomaly for the same sub-period, considered as the explanatory variable

$e_{Q/X}^{(M)}$: streamflow elasticity (equal to the regression slope)

ω_i : regression residual

α : parameter of the first-order autoregressive process (AR1)

δ_i : innovation of the autoregressive process

σ : standard deviation

M: number of years over which the long-term streamflow, precipitation and evaporation average is computed

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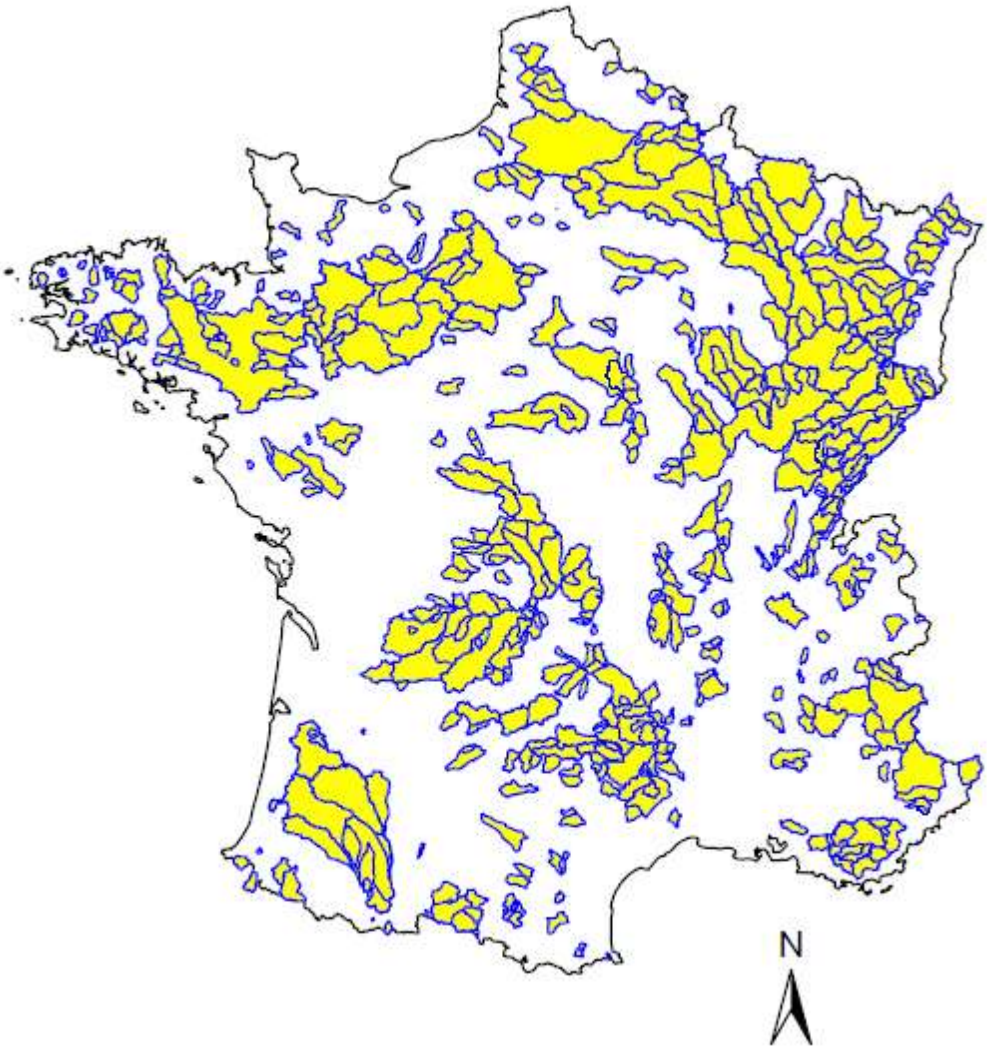


Figure 1. Location of the 519 French catchments analyzed in this study

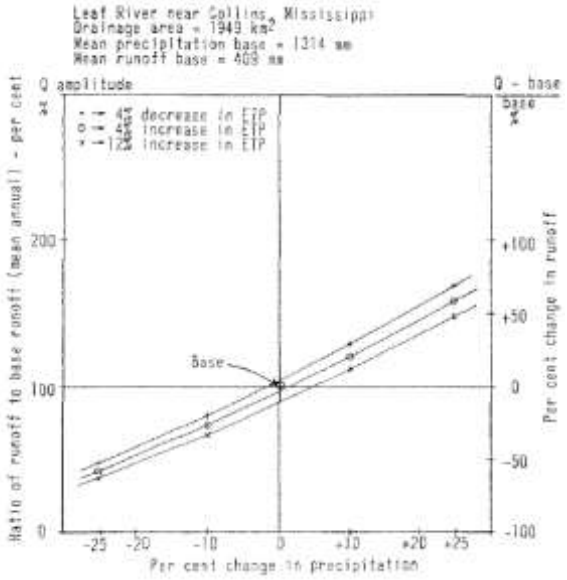
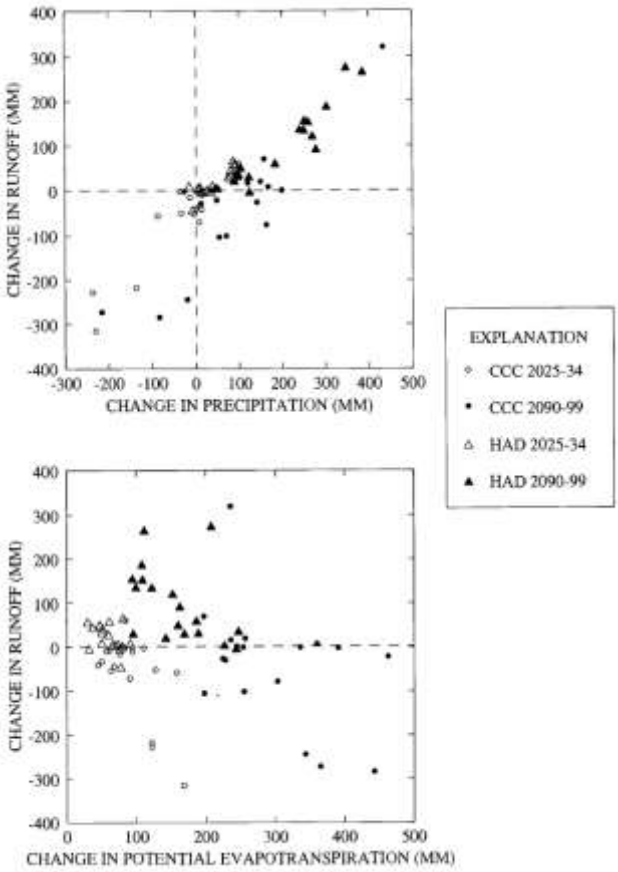


Figure 2. Yield change graph proposed by Nemec and Schaake (1982) to illustrate the hydrological elasticity analysis



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520 **Figure 3. Elasticity graphs proposed by Wolock and McCabe (1999)**

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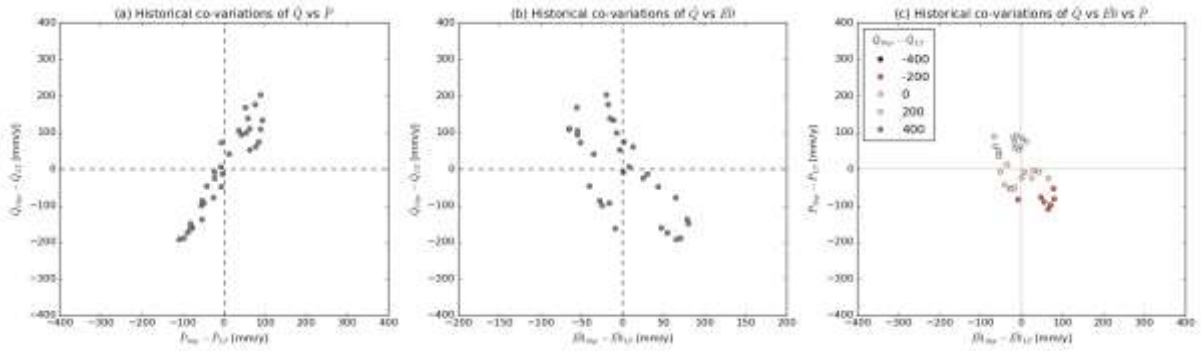
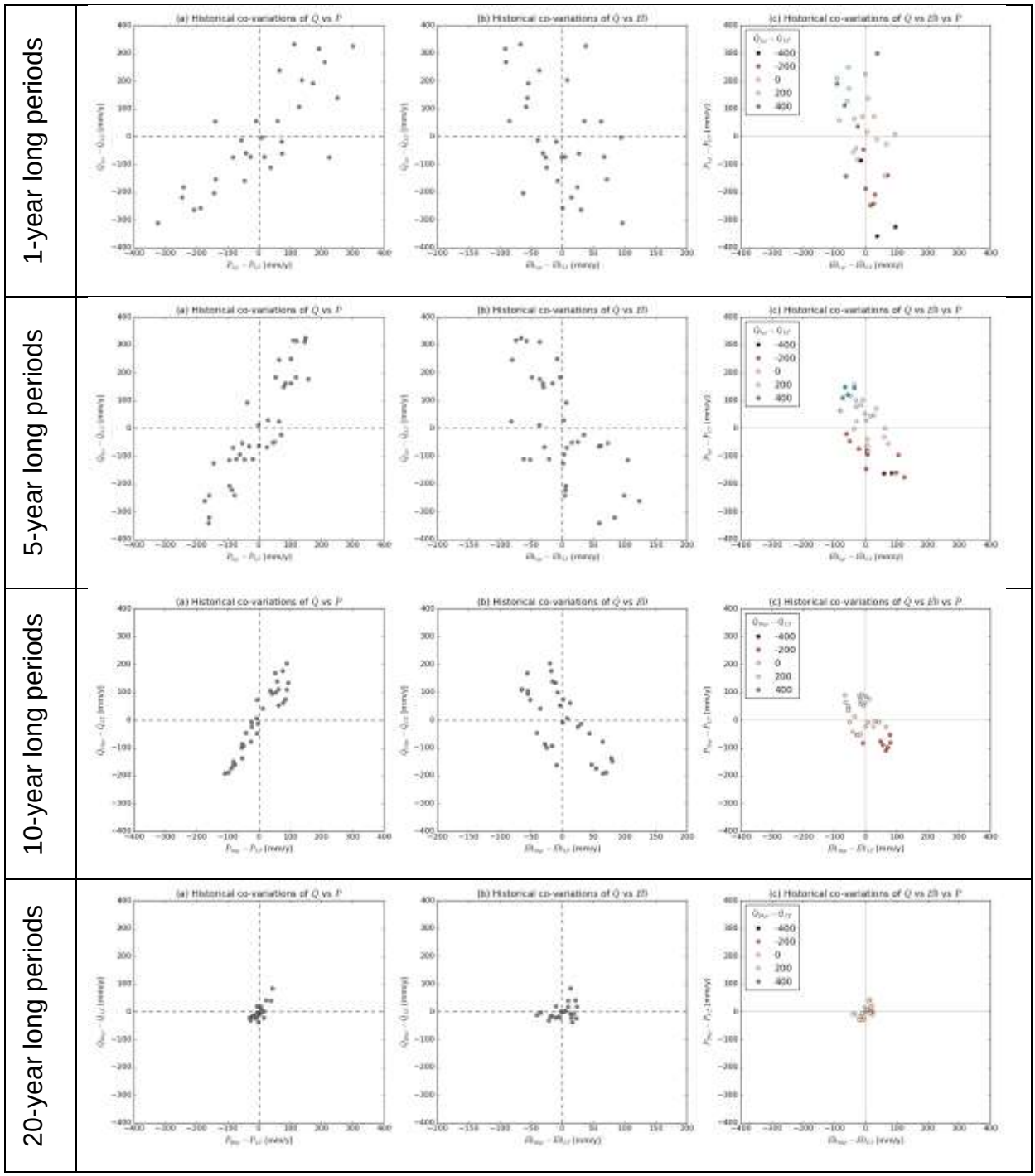


Figure 4. Streamflow elasticity graphs for an empirical (data-based) assessment for the Brèze catchment at Meyrueis (code: O3165010): (a) ΔQ vs ΔP, (b) ΔQ vs ΔE_P, (c) ΔQ (color-coded) vs ΔP and ΔE_P



527 **Figure 5. Impact of period length on the streamflow elasticity graphs for an empirical (data-**
528 **based) assessment. The graphs present from left to right ΔQ vs ΔP, ΔQ vs ΔE_p, ΔQ (in colors)**
529 **vs ΔP and ΔE_p. LT stands for Long Term (entire period).**
530

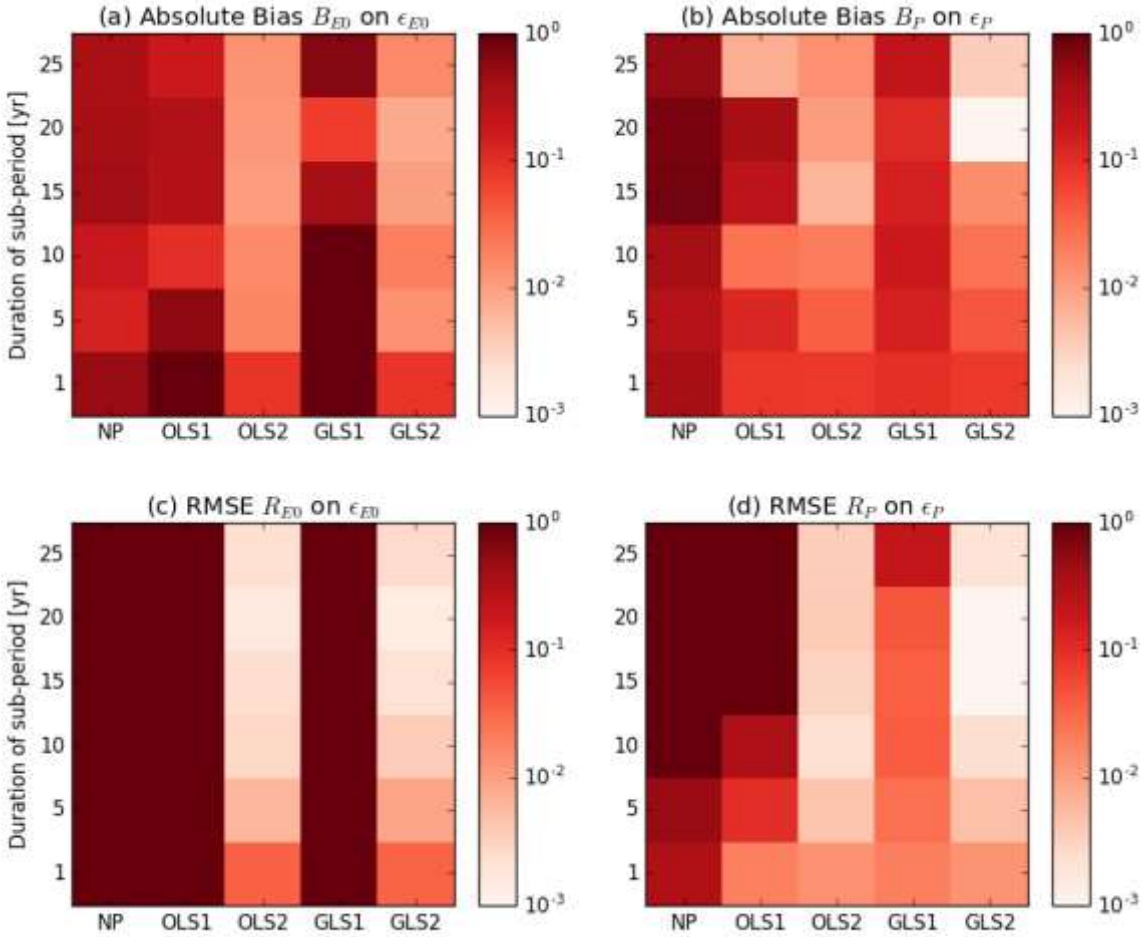
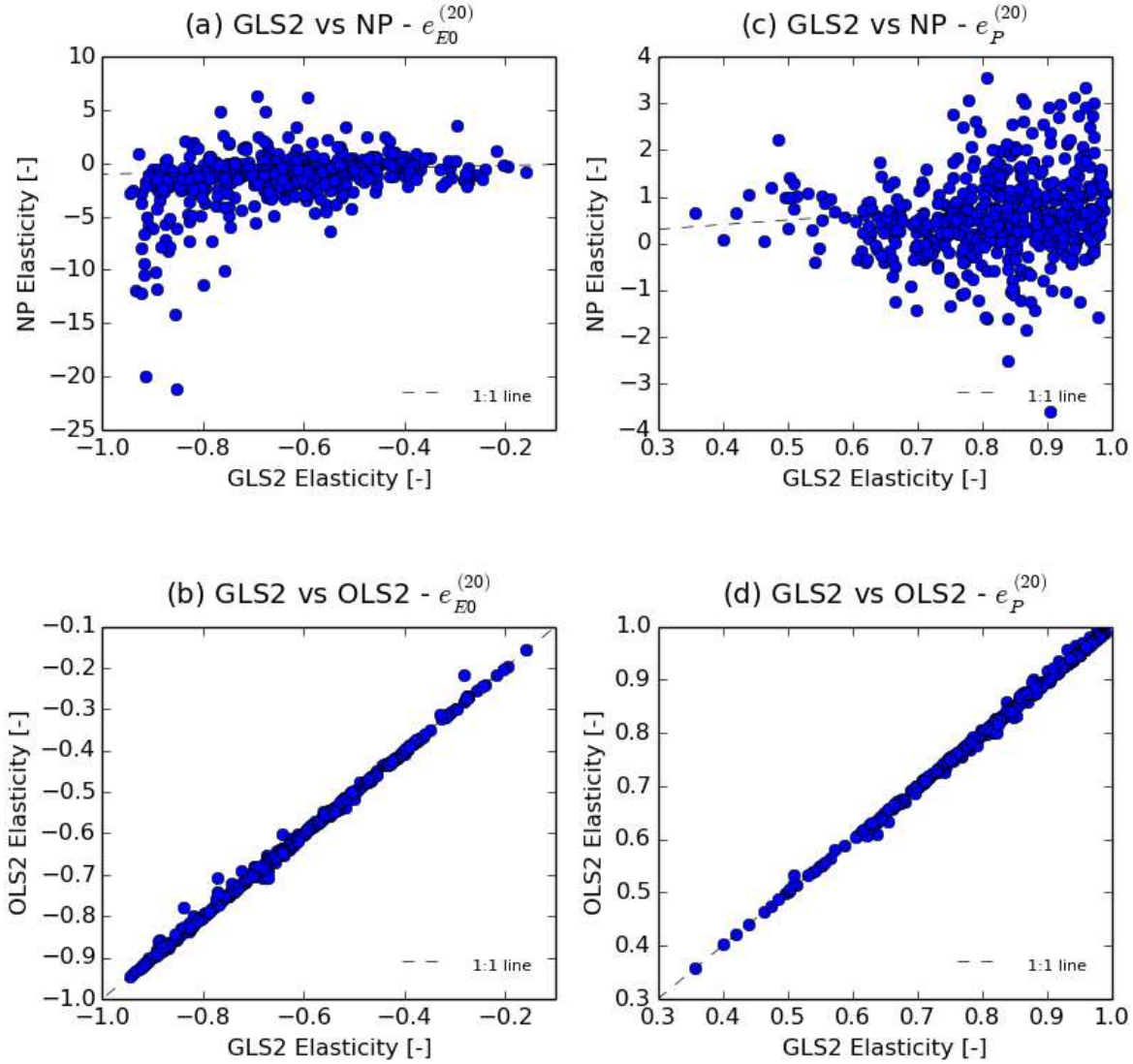


Figure 6: Performance of the five models proposed to compute empirical elasticity, tested on synthetic data generated with the Turc-Mezentsev model.



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537 **Figure 7: Comparison of elasticity estimates obtained with the GLS2, OLS2 and NP methods**
538 **using synthetic flow data and 20-year sub-periods.**

539

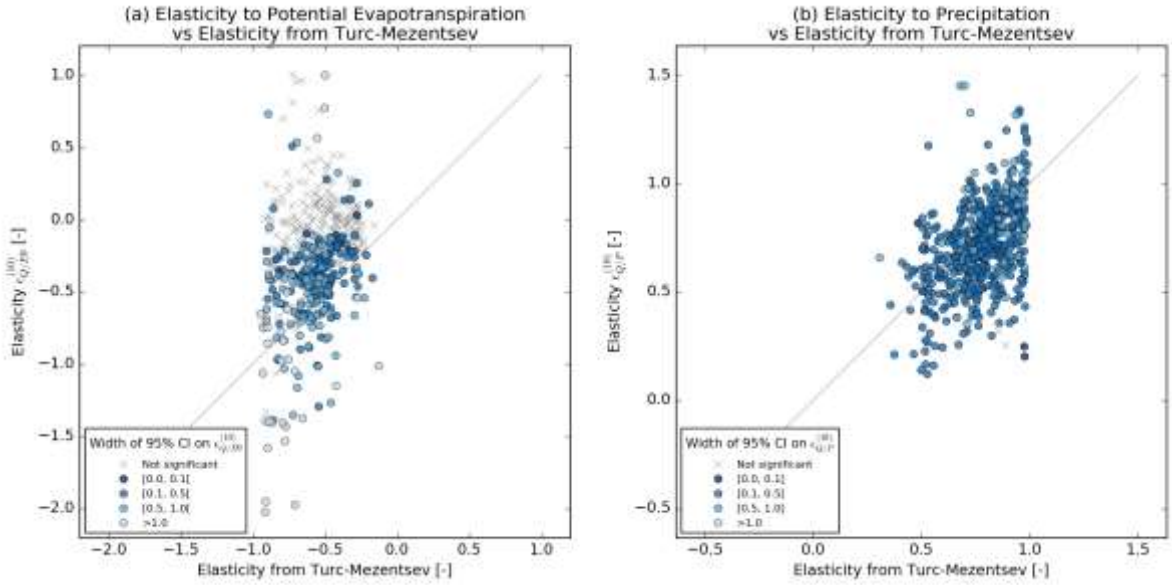

Figure 8. Comparison of the data-based and model-based elasticities; streamflow elasticity to potential evaporation (a) and precipitation (b). The points are coloured according to the width of the 95% bootstrap confidence intervals on the empirical elasticity estimate.

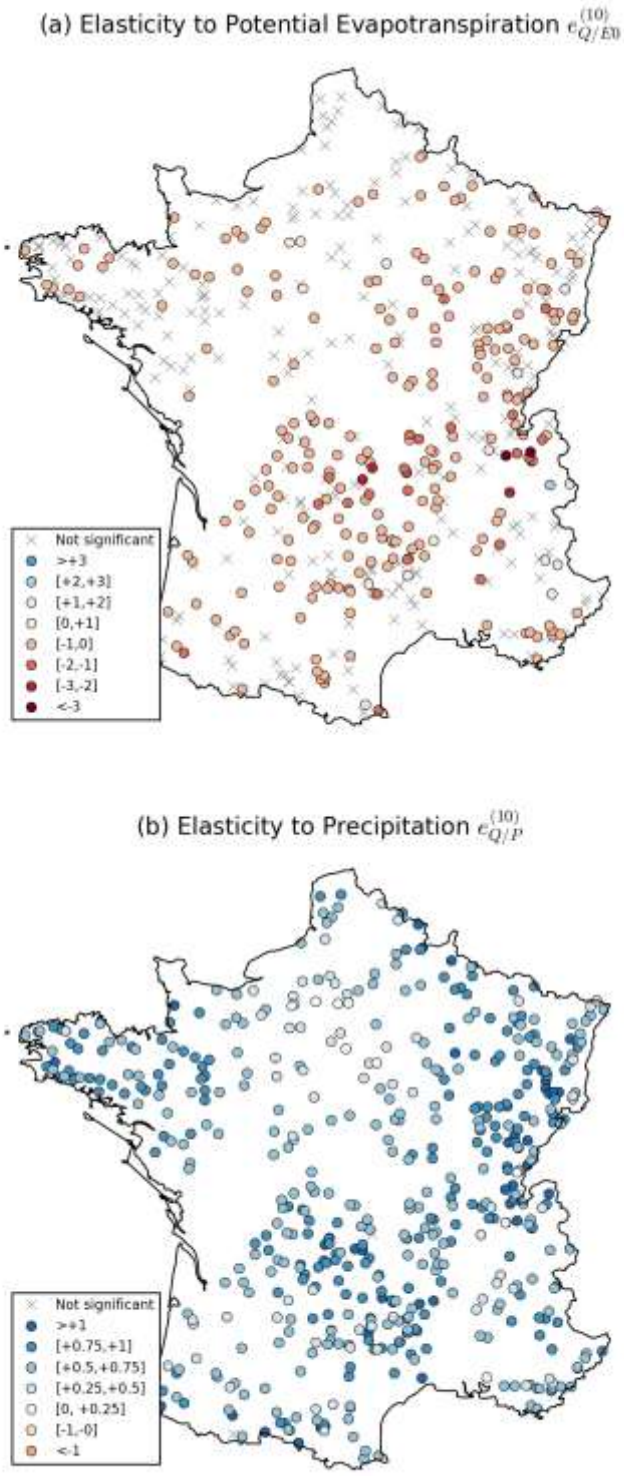

Figure 9. Regional analysis of (a) streamflow elasticity to precipitation and (b) streamflow elasticity to potential evaporation. Elasticity values were obtained by the GLS2 regression method using 20-year sub-periods. Each dot represents a catchment outlet, the color represents the elasticity value. Those catchments where the linear correlation was found to be nonsignificant are indicated with a cross.

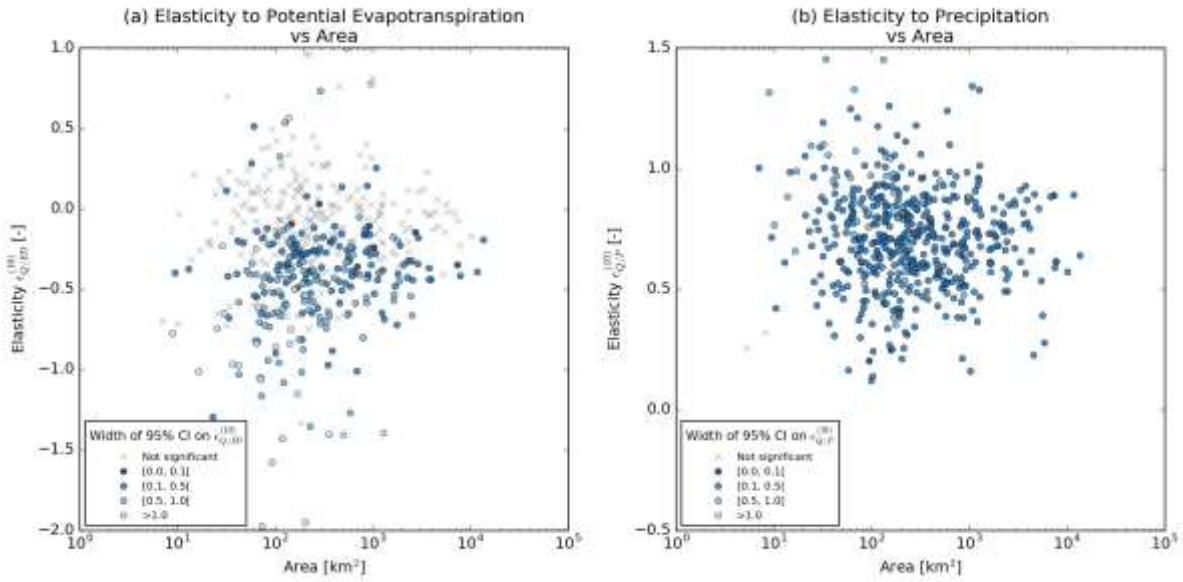

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Figure 10. Elasticity values vs catchment area: (a) streamflow elasticity to potential evaporation and (b) streamflow elasticity to precipitation. Elasticity values were obtained by the GLS2 regression method with sub-periods of 10 years. The points are coloured according to the width of the 95% bootstrap confidence intervals on the GLS2 elasticity estimate.

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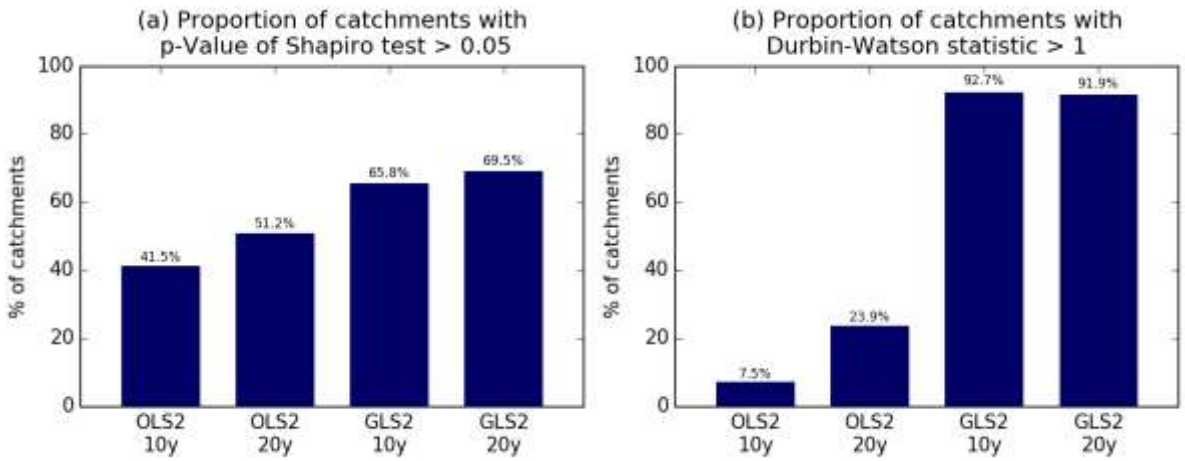

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555 **Figure 11. Proportion of catchments having a positive outcome for (a) the Shapiro-Wilks**
556 **normality test and (b) the Durbin-Watson test on autocorrelation of innovations**

557