# Discharge characteristics for gauging stations

**Abstract**
Discharge data series of usually more than 5 years are available for around 550 gauging stations. On this basis, the most important discharge characteristics of mean, high and low flows are graphically displayed for each station by individual calendar year and – where available – as a mean value for the WMO standard periods as well as the period 1981–2010. This text explains the structure and contents of the graphics. Application examples demonstrate the wide range of uses of this map topic.

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## 1 Introduction

Observations of discharge are fundamentally relevant to hydrological questions in research and practice. Their scope of application is wide and ranges from hydrological and geographical studies to flood assessment and sustainable water management. Different methods and procedures are used in each, whether simple descriptive analyses or more or less complex statistical or deterministic modelling. In all of these cases, it is very important to have a broad overview of discharge characteristics in order to understand the general hydrological conditions, on the one hand, and to validate the results of studies and modelling, on the other. This is precisely where the present map topic comes in: for discharge gauging stations of the Federal Office for the Environment (FOEN, referred to as "Confederation" in the map legend) and of those cantons that made their data available to the Hydrological Atlas, the most important discharge characteristics for low, mean, and high flows are displayed for calendar years and selected periods. This information is complemented with graphics on the discharge regime, discharge in selected years, and selected flow duration curves, enabling a comprehensive view of the discharge characteristics of individual catchments.

## 2 Data and methods

In autumn 2019, both the FOEN and all cantons were asked to provide their discharge data to the Hydrological Atlas on behalf of the present topic. In Table 1, the cantons or respective offices that provided discharge data are marked with a ✓. The data exist in various formats, usually as daily means, occasionally as 10-minute values, and sometimes as validated or non-validated raw data. The different data formats were converted into a standardised format with mean daily flows. In most cases, the information delivered also contained data on monthly maximum flows, which were also standardised. In the case of stations for which no monthly maximum flows were delivered, these values were derived from the 10-minute values or raw data (if available). In the course of standardisation, negative discharge values – i.e. obvious measurement errors – were removed from the data series. As no further validation was performed, however, measurement errors cannot be ruled out.

The present map topic graphically illustrates the following discharge aspects for each gauging station: mean annual discharge (MQ), flow regime, flow duration curve, the lowest arithmetic mean discharge of 7 consecutive days within a year (NM7Q), and the annual peak discharge values ($HQ_a$). Like the other characteristics, the NM7Q refers to the calendar year and not, as in HADES Plate 5.11 [1], to the so-called low-flow year from 1 May to 30 April. In addition to annual values, the graphics also display mean values for MQ, NM7Q, and $HQ_a$ – if available – according to the WMO standard normal periods 1901–1930, 1931–1960, 1961–1990, as well as the current standard normal period 1981–2010 [2]. The flow regime and flow duration curve refer to both the entire measurement series and the specified periods. Discharge characteristics are only shown if the number of missing values does not exceed the allowable maximum defined for each characteristic. For example, the mean annual discharge is only indicated if less than 20% of the daily mean values are missing per calendar year.

## 3 Results

The map shows a total of 565 stations: 205 federal (FOEN) and 361 cantonal ones. The median data series length of the federal stations, at 56 years, is significantly higher than that of the cantonal stations, at 18 years (Figure 1). This means that only very few cantonal gauging stations cover multiple standard normal periods. For every gauging station, six graphics are available that characterise the discharge conditions in their full breadth. Four of them are shown in Figure 2. If the flow regime or the flow duration curve derive from data series of fewer than 5 years, they are plotted as dotted lines. If 5 to 15 years are available, the line is dashed, and if more than 15 years are available, a solid line is shown.

Drawing from all of the stations, the discharge characteristics enable fundamental insights into Switzerland's runoff conditions, as the following two examples illustrate: In Figure 3, the long-term mean specific discharge of northern Alpine catchments – i.e. the discharge standardised over the catchment area – is compared to the mean elevation of the catchments. Aside from a few outliers, the graphic shows an average increase in specific discharge of almost 2 l/(s km$^2$)

**Table 1.** Sources of data and information included in metadata on hydrometric stations. Discharge measurement series are available from agencies are marked with a ✓ (current as of spring 2020).

| Station code | Agency/Source of data and information | |
|---|---|---|
| CH- | Bundesamt für Umwelt BAFU, Abteilung Hydrologie | ✓ |
| CHAG- | Kanton Aarau, Departement Bau, Verkehr und Umwelt, Abteilung Landschaft und Gewässer | ✓ |
| CHAR- | Kanton Appenzell Ausserrhoden, Departement Bau und Volkswirtschaft, Tiefbauamt | ✗ |
| CHBE- | Kanton Bern, Bau- und Verkehrsdirektion, Amt für Wasser und Abfall | ✓ |
| CHBL- | Kanton Basel-Landschaft, Tiefbauamt bzw. Amt für Umweltschutz und Energie | ✓ |
| CHFR- | Staat Freiburg, Amt für Umwelt AfU | ✓ |
| CHGE- | République et Canton de Genève, Direction générale de l'eau | ✓ |
| CHGL- | Kanton Glarus, Departement Bau und Umwelt | ✓ |
| CHGR- | Kanton Graubünden, Amt für Natur und Umwelt | ✓ |
| CHLU- | Kanton Luzern, Bau-, Umwelt- und Wirtschaftsdepartement, Umwelt und Energie | ✓ |
| CHNE- | République et Canton de Neuchâtel, Département du développement territorial et de l'environnement | ✓ |
| CHSG- | Kanton St. Gallen, Amt für Wasser und Energie | ✓ |
| CHSH- | Kanton Schaffhausen, Baudepartement, Tiefbau | ✓ |
| CHSO- | Kanton Solothurn, Bau- und Justizdepartement, Amt für Umwelt | ✓ |
| CHTG- | Kanton Thurgau, Departement für Bau und Umwelt, Amt für Umwelt | ✓ |
| CHTI- | Repubblica e Cantone Ticino, Ufficio dei corsi d'acqua | ✓ |
| CHVD- | Canton de Vaud, Direction générale de l'environnement | ✓ |
| CHVS- | Canton du Valais, Service des forêts, des cours d'eau et du paysage | ✗ |
| CHZG- | Kanton Zug, Baudirektion, Amt für Umweltschutz | ✓ |
| CHZH- | Kanton Zürich, Baudirektion, Amt für Abfall, Wasser, Energie und Luft | ✓ |

for every 100 m increase in elevation. Alpine catchments (mean elevation $\geq$ 1550 m a.s.l.) display specific discharge amounts of 40 l/(s km$^2$) or more, while the smallest specific discharges observed are under 10 l/(s km$^2$).

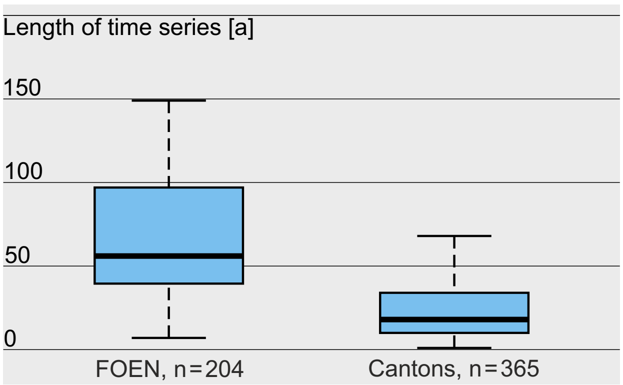


**Figure 1.** Length of the national and cantonal time series

Figure 4 shows the fundamental regional differences in terms of floods. It illustrates the distribution of mean annual floods across gauging stations differentiated by location (northern side of the Alps, southern side of the Alps) and mean catchment elevation. Two aspects are especially worthy of note:

1. The specific mean annual floods are generally higher on the southern side of the Alps than on the northern side. This difference is particularly evident in the elevation zone < 1000 m, where the median value on the southern side of the Alps is more than two times that of the northern side. The strong disposition of southern alpine catchments towards rapid surface runoff processes is related to high precipitation amounts (humid Mediterranean air masses), steep terrain, and relatively impermeable crystalline bedrock.

2. On the northern side of the Alps, the highest specific mean annual floods typically occur in the alpine foothills (elevation zone 1000–1550 m), caused by heavy precipitation (in thunderstorm zone), the topography, and often relatively impermeable rock (molasse).

## 4 Application examples

First of all, we should mention the interactive features that make this map topic especially accessible. Filter functions enable users to select gauging stations that fulfil specific criteria. Besides the measurement period, additional selection criteria can be chosen under "Apply additional filters". For example, users can select alpine catchments with a mean elevation of 1550 m above sea level (cf. [3]).
Clicking on a station on the map opens up a pop-up window with three selection options:

1. Display of the corresponding catchment, whose geometry can be downloaded as a shapefile.

2. Graphical illustration of the station's discharge characteristics.

3. A direct link to the FOEN website or that of the relevant canton. From there, users can obtain

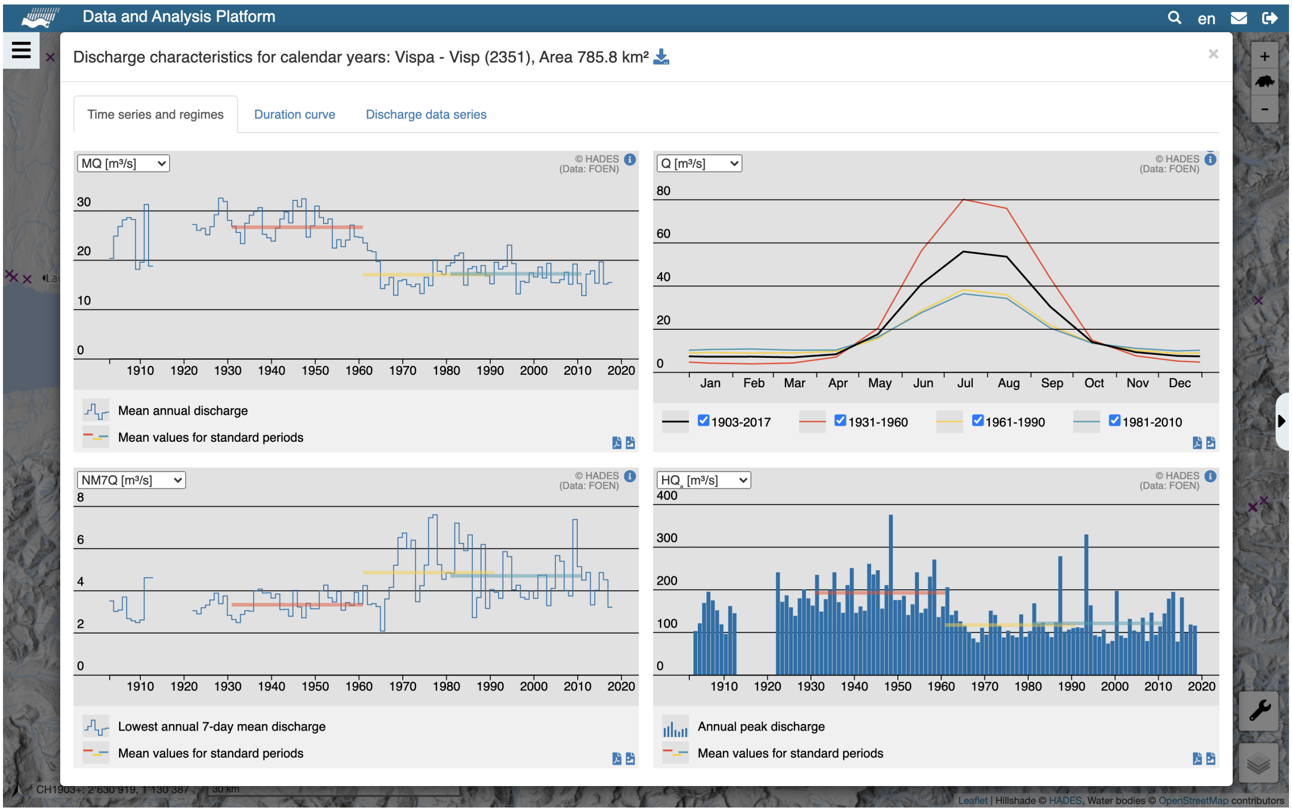


**Figure 2.** Discharge characteristics of the Vispa–Visp

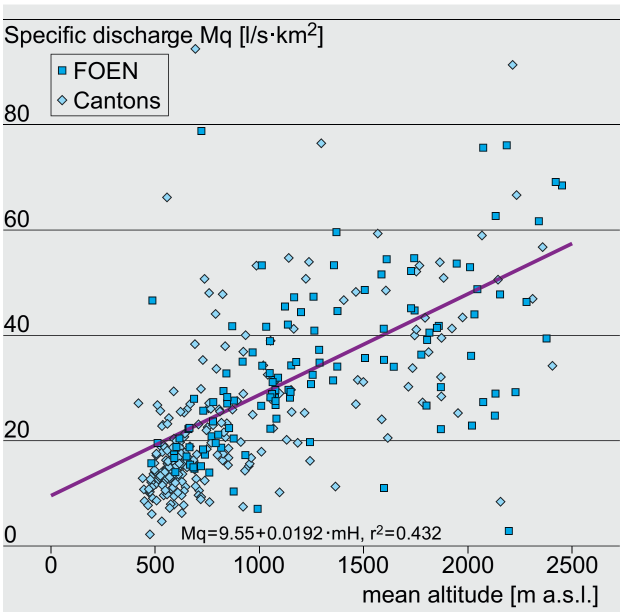


**Figure 3.** Mean specific discharge compared with mean elevation of catchments on the northern side of the Alps (Rhine catchment). MQ is derived from the entire available time series.

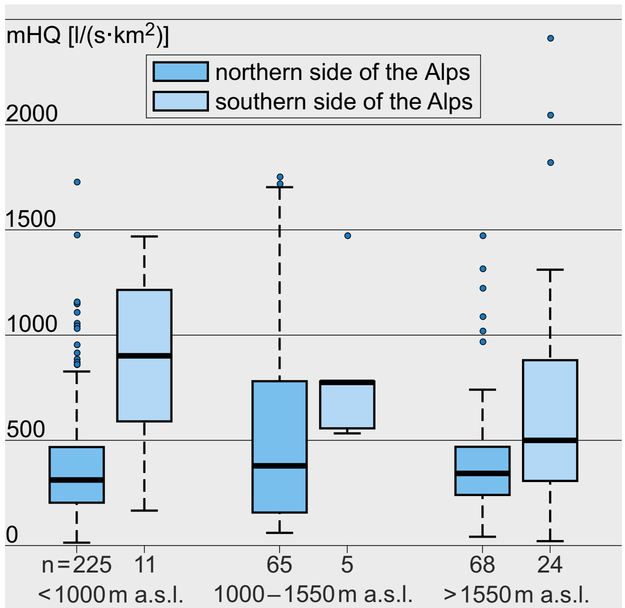


**Figure 4.** Mean 1-year flood mHQ for catchments on the northern side of the Alps (Rhine catchment) and on the southern side (Ticino, Adda, Adige), derived from the entire available time series

more information on the station, and often the latest measurement values.

Next, selecting "Discharge characteristics" displays the default tab "Time series and regimes" with corresponding graphics. Here, we focus on the graphic showing mean annual discharge (MQ): the dimension of the ordinates – discharge [$m^3$/s], specific discharge [l/(s $km^2$)], and depth of discharge [mm/a] – can be adjusted as desired. The "mouse-over function" enables numerical indication of mean annual discharges. Additionally, the timeline section displayed can be enlarged or reduced as needed by scrolling. Using the symbols at the lower right, the graphic can also be exported as SVG or PNG files.
The tab "Flow duration curve" displays the flow duration curves for the available periods. The abscissa values can be shown in days or %. With the "mouse-over function", users can display the discharge value $Q_{347}$, for example – that is, the discharge amount that is reached or exceeded on 347 days per year (95% of the days).
The graphic under the tab "Discharge data series" also enables a variety of applications. Individual years can be selected and put into context by comparing their mean daily discharge with the statistical values of the entire measurement series. Additional information can be obtained by means of direct graphical comparison of the hydrographs of two selected years, for example the flood years of 1999 and 2005. When available, a table with numerical values for the corresponding year can be downloaded via a link.
Let us now take a look at Figure 2 from an application perspective: The Vispa–Visp gauging station features an exceptionally long measurement series. From the 1960s on, the influence of hydropower use on discharge conditions is evident in an archetypical manner, characterised by reduced mean discharges (MQ) due to flow diversion into the Lac de Dix (see [4]), an altered discharge regime displaying increased winter discharge and reduced summer discharge due to electricity generation in the catchment (Mattmark power plants), and decreased flood peaks, although the large floods in 1987, 1993, and 2000 still remain clearly visible. The increase in NM7Q after 1960 corresponds with the production of electricity in winter, which significantly increases the small discharge values that naturally occur in winter. The influence of hydropower use is also evident in the flow duration curve in terms of a strong decrease in large flows and an increase in small flows, as well as in the annual hydrographs (tab "Discharge data series") that show a weekly rhythm determined by electricity production.
This brief application example points to the wide array of application possibilities of this map topic.

## 5 Versions

**Table 2.** Versions

| Version | Description |
|---|---|
| v1.0 (2020) | Discharge characteristics based on the data order in autumn 2019. |

## References


[1] Helbling, A., Kan, C. and Marti, P. (1992). Low Flow – Minimum Mean Discharge over Several Days. In: *Hydrological Atlas of Switzerland*. Ed. by Federal Office for the Environment FOEN. Vol. 1. Plate 5.11. https://hydrologicalatlas.ch/products/printed-issue/rivers-and-lakes/plate-5-11. Bern: Federal Office of Topography swisstopo.

[2] Begert, M., Frei, C. and Abbt, M. (2013). *Einführung der Normperiode 1981-2010*. Fachbericht MeteoSchweiz 245. https://www.meteoschweiz.admin.ch/home/service-und-publikationen/publikationen.subpage.html/de/data/publications/2013/9/einfuehrung-der-normperiode-1981-2010-.html.

[3] Weingartner, R. and Aschwanden, H. (1992). Discharge Regime – the Basis for the Estimation of Average Flows. In: *Hydrological Atlas of Switzerland*. Ed. by Federal Office for the Environment FOEN. Vol. 1. Plate 5.2. https://hydrologicalatlas.ch/products/printed-issue/rivers-and-lakes/plate-5-2. Bern: Federal Office of Topography swisstopo.

[4] Margot, A., Sigg, R., Schädler, B. and Weingartner, R. (1992). Influence on Rivers by Water Power Stations (≥300kW) and the Lake Control. In: *Hydrological Atlas of Switzerland*. Ed. by Federal Office for the Environment FOEN. Vol. 1. Plate 5.3. https://hydrologicalatlas.ch/products/printed-issue/rivers-and-lakes/plate-5-3. Bern: Federal Office of Topography swisstopo.