

Plate 2.1² Precipitation-Measuring Networks

Introduction

Precipitation is an environmental factor of major ecological and economic importance. Precipitation data in different temporal and spatial resolutions are used for hydrological models, in the management of water resources and for drawing up hydro-engineering projects, as well as in relation to planning issues [1]. In hydrological applications, in many cases precipitation measurements at individual points cannot be used directly, since questions regarding the systematic measuring error (plate 2.3), extrapolation of individual point measurements to a larger area (plates 2.2, 2.5, 2.6 and 2.7) and expected extreme values (plates 2.4² and 2.5) have to be solved first. Many measuring stations also record snow depths and determine the water equivalent of the snow cover in addition to measuring precipitation (plates 3.1², 3.2, 3.3 and 3.4).

The development of measuring networks

The systematic recording of precipitation began in Switzerland in 1863 on the initiative of the Swiss Academy of Natural Sciences. Of the eighty or so weather stations in operation at the time, only half had a precipitation gauge initially. At the time the measuring network was not dense enough to measure the marked spatial variation in precipitation adequately [14], which is why certain cantons in eastern Switzerland created their own network of stations beginning in the 1870s.

In 1881, the year it was founded, the Swiss Meteorological Institute – today the Federal Office of Meteorology and Climatology (MeteoSwiss) – took over both the weather stations and the cantonal rain-measuring stations. By 1900 these two networks comprised some 350 stations, just under a third being weather stations, which represented a mean density of 1 station per 120 km² (cf. 2005: 1 station per 95 km²). The density varied considerably from one region to another, however.

After 1900 the two measuring networks were developed as follows:

- rain-measuring stations: 247 stations in 1900, 306 in 1930, 327 in 1963, 344 in 1989 and 342 in 2005;
- climatic stations: 98 stations in 1900, 112 in 1930, 129 in 1960, 63 in 1989 and 25 in 2005.

From the 1950s on, the climatic stations were divided into climatological and synoptic stations. On the map, both types of stations are indicated by the same name (“Konventionelle Klimastationen”) using the same symbol. Between 1960 and 2005, the number of climatic stations fell dramatically owing to the fact that, after 1978, the synoptic stations and some of the climatological stations were integrated into the automatic measuring network (ANETZ). A few climatic stations continued to operate as rain-measuring stations within the precipitation measuring network (NIME).

In addition to the automatic measuring network, the automatic supplementary network (ENET) was developed and became operational in the early 1990s. The stations in this network are primarily intended for measuring snow and wind; a few of them also measure precipitation.

A detailed knowledge of precipitation conditions in the Alps in particular is necessary for planning hydro-electric power stations in the high Alps. For this reason in 1914 the totalisator measuring network was instigated, which was originally intended solely to serve the needs of hydro-electric power stations. Apart from the power stations, MeteoSwiss in particular is responsible for operating measuring stations.

An overview of the measuring networks

The automatic weather stations are equipped with Joss-Tognini tipping bucket rain gauges. Like other climatic parameters, precipitation is measured at 10-minute intervals. It is also possible to obtain information about the intensity of the precipitation. Since 2005, both the automatic climatic stations (ANETZ/ENET) and the climatological stations have been integrated into the new

automatic SwissMetNet. Care has been taken to ensure that both the locations and the equipment are maintained as far as possible.

Climatic parameters are measured three times a day (7.30 a.m., 1.30 p.m. and 7.30 p.m. CET) at the climatological stations. Until 1971 precipitation was measured once a day; it is now measured in the morning and in the evening. Pluviographs were or still are in operation at certain synoptic and climatological stations.

At the rain-measuring stations precipitation is measured once a day (7.30 a.m. CET). Since 1900 most rain-measuring and weather stations have been using a Hellmann rain gauge with a 200 cm² receiving surface.

The Mouglin collector with a wind shield is the standard measuring instrument used in the totalisator measuring network. The 200 cm² collector is installed at about 3 to 4 m from the ground (cf. Hellmann rain gauge: 1.5 to 2 m from the ground). Around one third of the 138 totalisators in operation in 2005 were located above 2500 m. MeteoSwiss publishes figures for total annual precipitation based on two measurements per year at the most [5,10]. From a hydrological point of view, however, the number of stations and the frequency of the measurements are not sufficient to provide a proper picture of precipitation in higher Alpine regions [1,9].

Thanks to the radar stations at La Dôle, Albis and Monte Lema, which have been operating in their present form since 1993, precipitation events can be observed in spatial and temporal terms [1]. They are not shown on the map.

The data provided by the MeteoSwiss network have been published in various forms [6,7,10,11]. All data that are available in digital form are stored in a database. Data series for longer periods have been summarised in various publications [2,4,12,13].

Other stations that are not part of the MeteoSwiss network are maintained by cantonal authorities, institutes and private organisations. Most of these stations are equipped with pluviographs or tipping bucket rain gauges. The number of such stations has increased dramatically over recent years in particular, with the result that today a remarkable area is covered by precipitation gauges; this is particularly true for the lower areas on the northern side of the Alps. The tables show where such data can be obtained.

Processing measurement data

Processing the data obtained from MeteoSwiss includes in particular checking the data, determining so-called norms, and homogenising long-term climate measurement series. In the case of precipitation and other climatic parameters, norms (means 1961–1990) are available for the WMO's standard period of 1961–1990 from all the climatic and precipitation measuring stations operated at that time by MeteoSwiss [3]. For measurement series that are shorter than the standard 1961–1990 period, wherever possible mean values have been converted (reduced) to norm values in order to permit spatial comparisons.

Moreover, a long and homogeneous time series dating from 1864 is available for describing and studying climatic developments in each climatic region of Switzerland (fig. 2).

Extreme value analysis was carried out for measurement series from stations that are listed with an additional number allotted by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL; see plate 2.4²). The results have been published by [8,15].

Mapping measurement networks

On the map the precipitation measuring stations have been categorised according to the network to which they belong, the date on which measurements began and the duration and topicality of the measurements. The map shows the situation at the end of 2005.

Regarding the duration of measurement, it should be noted that with measurement series of over 25 years mean values can be analysed, and with measurement series of over 100 years the analysis of time series and extreme values can produce significant results, on condition that the

series is homogenous. The indications on the map refer only to the latest, continuous measurement series. The “+” symbol indicates that data are also available for that station from one or more earlier measuring periods of at least 25 years (see list of stations).

The cantonal and private stations were selected according to the same criteria as the MeteoSwiss stations; availability of data was also taken into account. Since this cannot always be guaranteed, a large number of privately run stations, at sewage treatment works or cantonal or local works depots for example, were excluded. This also applies to stations with special measuring arrangements.

The MeteoSwiss stations can be identified by their code numbers, which have been assigned according to the hydrographic principle. The numbers of the cantonal stations are made up of the abbreviation for that canton and the official code number used within the canton. If a station had no such number it was assigned one to be used solely for locating it on the map and in the table. The privately operated stations have a “P” before the number.

History of the measuring stations

The list of stations shows for which periods precipitation data are available, the frequency of the measurements and whether they are analogue or digital. A history of the stations and the availability of data were compiled primarily from the information in the databases run by MeteoSwiss. When doubts arose, the publications [8,15], the Annals or the archives of MeteoSwiss [7,10] were consulted. Using this method we succeeded in obtaining annual information about the stations. Minor relocations were not taken into account, and the frequent relocation of stations to towns has not been dealt with in detail. Information regarding privately operated and cantonal stations was obtained by making enquiries.

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