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Uncertainty estimation and reconstruction of historical streamflow records

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Long historical series of streamflow are a precious source of information in the context of hydrological studies, such as research of trends or breaks due to climate variability or anthropogenic influences. For this kind of studies, it could be very important to go back as far as possible in the past, in order to highlight information content of historical observations. During our research we concentrate on the Durance watershed (14000 km^2) in order to understand last century (1900-2010) hydrological variability due to climate changes and/or anthropogenic influences. This watershed, situated in the Alps, is characterized by variable hydrological processes (from snowy to Mediterranean regimes) and a wide range of anthropogenic influences (hydropower generation, irrigation, industries, drinking water, etc.). We are convinced that this research is necessary before any climate and hydrological projection.

Documentary researches lead in collaboration with a historian allowed to find about ten long streamflow series from the beginnings of the 20th century on the Durance watershed. The analysis of theses series is necessary to better understand the natural hydrological behavior of the watershed, before the development of most of the anthropogenic influences. If the usefulness of such long streamflow series is obvious, they have some limitations, one of them being their heterogeneity, which can have many origins: shift of the gauging station, changes in the anthropogenic influences, or evolution in the methods used to build the series. Before their interpretation in terms of climate or land use changes, uncertainty estimation of historical streamflow records is therefore very important to assess data quality and homogeneity over time. This paper focuses on the estimation of the historical streamflow records uncertainty due to the evolution of their construction methods.

Since the beginnings of the 20th century, we have listed three main methods of construction of daily streamflow series: (1) daily punctual measurements of water height at the gauging station; (2) automatic graphical record of water height and manual sampling of the limnigraphs; (3) automatic numerical record of the height at an hourly timestep, conversion to streamflow and calculation of the daily streamflow by mean of the 24 hourly values (current method). By simulating and comparing the two fist methods with the current one on a panel of gauging stations, we show that the impact of the elaboration method of the streamflow series can be important. What we firstly consider as continuous long series is in fact a juxtaposition of several series which characteristics can be really different.

The first method can bias up to 20% the value of daily streamflow compared to a daily mean streamflow, depending on the measurement time and the season. The uncertainty strongly depends on the watershed hydrological regime and the dominant streamflow processes occurring (snowmelt influence or runoff). The most important impacts of this method are observed on mountainous watersheds due to the daily streamflow cycle induced by snowmelt. To a lesser extent, this method can also biais the interannual mean. A correction technique for this type of series is proposed. The second method seems to have a lower impact (around 2%) on the final result, but the bias can still be important (up to 15%) for some watersheds and some streamflow ranges.