

The modal flow: Focus on a rarely used value in hydrology

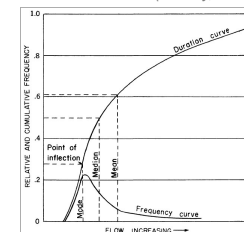
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STATE OF THE ART

The modal flow i.e. the flow that occurs most often is rarely used in hydrology and only a few authors have used or mentioned this value. In 1928, Meyer (in Searcy, 1959) considers the modal flow as an appropriate "normal" flow. In 1968, Hall also refers to the "modal flow" and shows that in southwest England (Devon, UK) this value is very close to the 70% exceedance value on the flow duration curve. In 1974, Hollis describes the Brook River characteristics with several values derived from the flow duration curve, in particular the median, the quartiles and the modal value. In 1991, Bullock et al. present a low flows estimation method for ungauged basins and the modal flow is one of the indicators they use in this study.

However, the method used to estimate the modal flow is never clearly describe by these authors. They only mention a break in the flow duration curve near the modal value (Fig.1). We have tested and compared 3 methods (Lang et al., 2016).

Fig. 1: Modal flow identified on the flow duration curve (Searcy, 1959)



METHODS FOR MODAL FLOW ESTIMATION

HISTOGRAM

The mode is the middle of the modal class (interval within which values appear most often, Fig. 2).

Fig. 2: Histogram of daily streamflows (Moselle at Hauconcourt, 1990-2009)

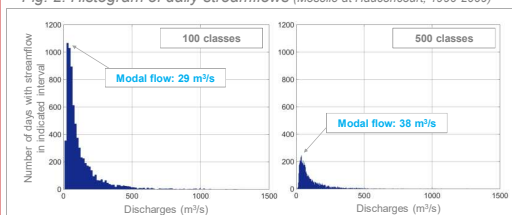
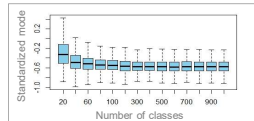


Fig. 3: Variation of the modal value depending on the number of classes

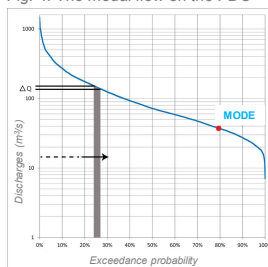
The mode depends on the number of classes (Fig. 3).



FLOW DURATION CURVE

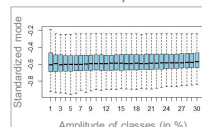
The portion of the curve with the lowest slope represent the modal value.

Fig. 4: The modal flow on the FDC



The lowest difference between the highest flow and the lowest flow (ΔQ) gives the mode (Fig. 4).

Fig. 5: Variation of the modal value depending on class amplitude

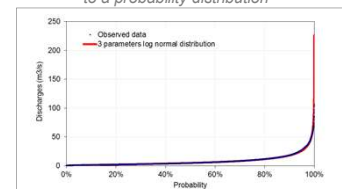


The amplitude on which the slope is computed must be chosen but the influence of this amplitude on the modal value is low (Fig. 5).

PROBABILITY DISTRIBUTION

Daily streamflow data are fitted to a probability distribution to estimate the mode (Fig. 6).

Fig. 6: Daily streamflow data fitted to a probability distribution



This method raises the issue of the choice of distribution.

MODAL FLOWS COMPARED TO LOW FLOW INDICES

Modal flows were calculated for 320 french gauging stations based on the flow duration curve method. The modal flows plot close to the Q80% (Fig. 7) and may be considered as the entrance in low flows (Fig. 8).

Fig. 7: The modal flow on the FDC

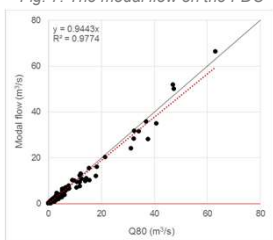
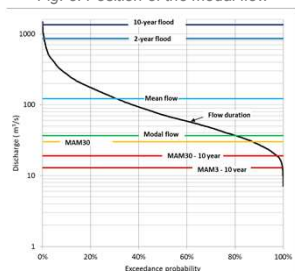
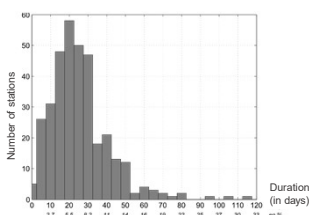
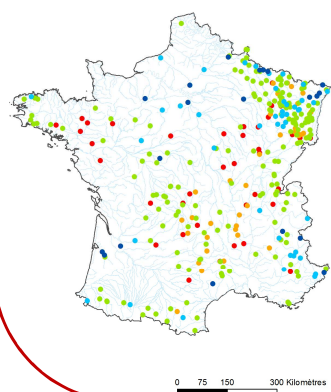


Fig. 8: Position of the modal flow



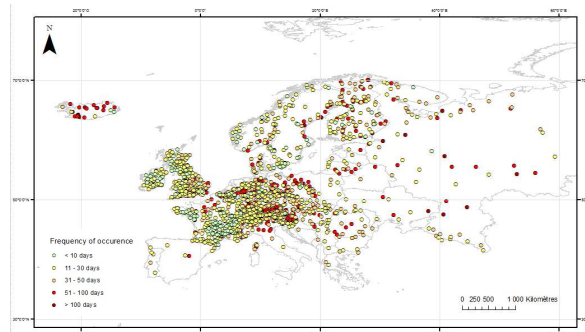
FREQUENCY OF OCCURRENCE OF THE MODAL FLOW



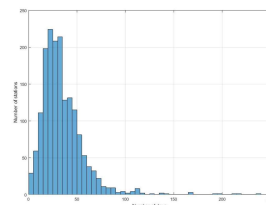
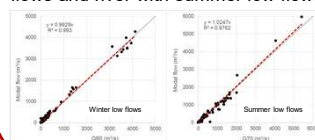
Frequency of occurrence of the modal flow

- < 10 days
- 10 - 15 days
- 15 - 35 days
- 35 - 50 days
- > 50 days

MODAL FLOWS FOR THE GRDC DATASET



On the GRDC dataset the modal flows plot close to the Q70 and Q80% respectively for river with winter low flows and river with summer low flows.



CONCLUSION

The modal flow is close to Q80% of the flow duration curve. This value was interpreted by Smakhtin (2001) as a condition at which a river starts getting water exclusively from a deep subsurface storage. The modal flow may give interesting information about catchments behaviors.

However for certain rivers the modal flow does not have any significance or representativity (bi-modal distribution, regulated rivers, etc.).