

Estimating daily flow duration curves from monthly streamflow data

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Abstract

The paper describes two techniques by which to establish 1-day (1d) flow duration curves at an ungauged site where only a simulated or calculated monthly flow time series is available. Both methods employ the straightforward relationships between daily and monthly flow characteristics. These relationships are first established on the basis of observed streamflow data and then used to convert synthetic monthly flow data into 1d flow duration curves. The paper suggests the conversion equations and describes step-by-step calculation procedures which may be applied to generate 1d flow duration curves at quaternary catchment level of spatial resolution.

Abbreviations

FDC	Flow duration curve
MAR	Mean annual runoff
MAP	Mean annual precipitation
MAE	Mean annual evaporation
Q95	Discharge exceeded 95% of the time
T_0	% of the time with zero flow conditions in a river
SE	Standard error
R^2	Coefficient of determination
HYMAS	HYdrological Modelling Application System
1 d	1-day
1 m	1-month

Introduction

Monthly streamflow volume time series data have been traditionally used in South Africa for management and development of water resources. These data are available as:

- Observed records cumulated with a monthly time step
- Monthly inflow volumes to major dams calculated by the water balance method
- simulated time-series from system analysis and basin study reports commissioned by the Department of Water Affairs and Forestry.

After the update of the nation-wide study on the surface water resources of South Africa (Midgley et al., 1994) synthetic monthly data are also available for 1 946 small and normally ungauged incremental drainage subdivisions ('quaternary catchments') throughout the entire country. The average area of quaternary catchments is 650 km² but it varies from 80 to 100 km² in humid regions to 2 000 km² in arid regions. It may be concluded that monthly streamflow data are available at the level of spatial resolution which would satisfy most of the large and medium water projects. However, an increased attention to environmental con-

siderations in water resources management on one hand, and development of small water supply schemes (e.g. in rural areas) on the other, has led to the growing demand for analyses based on daily streamflow data.

Characterisation of daily flow regimes in South Africa (and almost any other country) from observed data is possible only at a limited number of sites. At the same time, even the existing observed daily flow records are not always suitable for direct use since they

- often contain large gaps due to missing data;
- may be non-stationary because of the time variant land-use effects or water abstraction pattern;
- may be available only for a very short observation period;
- are rarely coincident in time with the time series from other sites within a basin and may therefore represent different sequences of dry and wet years.

Generating a time series of daily flows by deterministic rainfall-runoff models is a commonly used but rather expensive and time consuming approach. On the other hand, given a wide availability of monthly streamflow data in the country, a cost-effective methodology may be developed which allows daily streamflow characteristics to be derived from synthetic monthly flow records.

Ideally, the outcome of such method should be the continuous synthetic streamflow time series of daily discharges for all quaternary catchments for some standard period (e.g. similar to that of the synthetic monthly time series - 70 years, from 1920 to 1990). At the same time, for many practical purposes a FDC is a valid substitute for a complete time series. FDC is a relationship between any given discharge value and the percentage of time that this discharge is equaled or exceeded. It gives a summary of the flow variability at a site and represents perhaps the most informative method of displaying the complete range of river discharges from low flows to flood events. FDC is frequently used in water quality calculations, design of run-of-river abstraction schemes, estimation of required environmental flows etc. It is logical in this context to investigate the possibilities of deriving FDCs representing daily flow regimes from synthetic (or calculated) monthly flow time series. Once this task is completed, the techniques for the conversion of established curves into a complete daily flow time series may also be suggested.

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