# An evaluation of spaciously averaged hydro meteorological characteristic errors

Sergey Koshkin, Lyudmila Tovmach and Yuri Tovmach
The State Hydrological Institute, 23 Second Line, St. Petersburg, 199053 the Russian Federation
Tel. +7-812-323-11-67, Fax +7-812-323-10-28, E-mail tovmachyv@mail.ru

## Abstract

The following model is used for evaluating water consumption: Q=f(H), where Q is water consumption and H is water level. This dependency is of only an approximate nature. In this work, a mathematical model that allows to more precisely specify the Q=f(H)B dependency is used. It is based on the mathematical apparatus used when averaging meteorological fields. That resulted in the creation of a program allowing to model the dependency of water consumption on the precision of measuring the speed of water flow.

## The initial conditions used for the construction of the mathematical model

In order to evaluate the errors of hydro-meteorological characteristics, averaged across an area, the field model of some or other characteristic is built. Models are constructed on the bases of various assumptions. Most often, the model of a uniform and isotropic field is built.

Uniformity means that the average values and their dispersions do not depend on sighting points and are equal at different sighting points. Isotropy means that the co-relational and structural functions of various sighting points depend only on distances between them. However, most hydro-meteorological fields are neither uniform nor isotropic which means that the evaluations of the errors of hydro-meteorological characteristics obtained through this approach are not reliable. The following model is used for evaluating water consumption: Q=f(H), Q being water consumption and H being water level. This dependency is approximate. A more precise evaluation of water consumption is obtained with the use of hydrometric propeller meters measuring the speed of water flow at various depths and variously removed from the bank line. This is to say that a field of speed measurements at various sighting points is built. The error of the measurement of water consumption will depend on the error of measurement at each sighting point. The coordinates of sighting points are also somewhat erroneous.

The error of the measurements of the speed of water flow meets the conditions of uniformity and isotropy. This is why we may evaluate the measurement error of the whole field of the measured value. On the other hand, while we know the speeds of water flow at the neighboring sighting points, we may adjust the speed figures for a given sighting point, remaining within the maximum permissible error values.

## Model description

The water level (H) may be found out with great precision. The precision of calculating water consumption (Q) is important. It is only natural to assume that the speed of water flow in the river, at a given point in time, depends only on the x and y coordinates in the river section. Let us say that we have measured the speed of water flow and it equals $V_0$(x, y). Speed, $V$, as a function depending on the section coordinates is smooth. That is, we assume that speed $V_1$ at the next sighting point whose coordinates are $x_1$ and $y_1$ approximately equals

$$V_1 = V_0 + a \cdot \rho + b \cdot \rho^2$$

where $p$ is the distance between the sighting points and $a$ and $b$ are coefficients. Using three adjacent sighting points, we get the following equations set:

$$\begin{cases} V_1 = V_0 + a \cdot \rho + b \cdot \rho^2 \\ V_2 = V_0 + a \cdot \rho + b \cdot \rho^2 \\ V_3 = V_0 + a \cdot \rho + b \cdot \rho^2 \end{cases}$$

Let us solve this equations set (1) for unknown $V_0$. The obtained speed figure will differ from the measured one. So we now adjust the speed figures measured at a given sighting point, remaining within the maximum permissible error values for the given type of propeller meter. Now, we proceed to the next sighting point.

This approach was verified with the use of a program that was purposely written to model and check it out. The input parameters included the profile of the river section, water level and the coordinates of sighting points. A randomizer was used to noise-pollute the measurements. After that the data are adjusted as described above. As a result, the river section is broken into a net of irregular hexagons in the center whereof the water flow speed was set. The distribution of speeds within the hexagon is considered as equal to $V=V_0+a\rho+b\rho^2$. After that, the program calculates the following integral:

$$Q=\iint_S V dxdy,$$

that determines water consumption at a given water level (H).

Changing the water level and coming up with a varying field of speeds, we get the dependency:

$$Q=f(H).$$

The obtained empirical functional dependency is approximated as

$$Q=\sum_{i=0}^{N} a_i H^i .$$

While the progress of the flood is being watched, the following dependency is built to analyze the water level:

$$H=\sum_{i}^{N} b_i Q^i$$

## The results

As the result of the numeric modeling of the method suggested in this work, we get

- the possibility of finding more precise error values while measuring water consumption;
- an algorithm of adjusting the results of water consumption measurements.