

# About inertia of measurement devices

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A usual model for measuring device readings is based on the following differential relation:

$$d_t u = -k(u - f)|u - f|^b, \quad k, b = \text{const}, k > 0. \quad (1)$$

Here  $u(t)$  is the measuring device reading, and  $f(t)$  is the true value of the measured parameter,  $t$  is the time, and  $k$  is the parameter characterizing the device inertia. The simplest version is:  $b=0$ .

We obtain some data  $\{u_j\}_{j=1}^n$  as a result of aerological measurements at time moments  $\{t_j\}_{j=1}^n$ , and use a finite-difference scheme to approximate (1) and evaluate the true signal  $f(t)$ . A compact difference scheme (see

e.g. [1]) provides high approximation order and can help us to avoid a significant amplification of high frequencies in the evaluation of  $f(t)$ .

The inertia parameter  $k$  is not constant and depends, e.g. on temperature, see [2]. We can evaluate it (e.g. for a humidity-measuring device) in laboratory experiments under constant temperature:

$$\lim_{t \rightarrow \infty} k(t) = K_{\infty}(T).$$

However, the inertia of a real device cannot change immediately with a change of temperature  $T=T(t)$ . It can be essential when variations of temperature  $T$  with height are strong (e.g. when the device is located on a radiosonde).

In this case we should modify the model (1) and use the system

$$d_t u = -k(t) \cdot (u - f) \Rightarrow f = u + k^{-1}(t) \cdot d_t u,$$

$$d_t k = A \cdot [K_{\infty}(T(t)) - k] \Rightarrow k(t) = K_{\infty}(T(0)) + \int_0^t K_{\infty}(T(s)) e^{A(s-t)} ds ,$$

where  $A$  is a constant. Compact finite-difference schemes are useful for approximation of the differential equations (see e.g. [1]).

We assume that the temperature  $T(t)$  is known. Beforehand we evaluate the constant  $A$  in additional laboratory experiments.

We recommend to use the algorithm for BUFR data assimilation.

1. V.A.Gordin. Differential and Finite-Difference Equations. What Are Phenomena That They Described, And How They Are Solved. “Publisher House of Higher School of Economics”, Moscow, 2016 (In Russian).

2. L.M.Miloshevich. Correction of Vaisala RS92 Radiosonde Humidity Measurements. 2011. [http://milo-scientific.com/prof/corr\\_method.php](http://milo-scientific.com/prof/corr_method.php)