About inertia of measurement devices

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

$$d_t u = -k\left(u - f\right)\left|u - f\right|^b,\ k, b = const, k > 0. \qquad (1)$$

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 $\left\{u_j\right\}_{j=1}^n$ as a result of aerological measurements at time moments $\left\{t_j\right\}_{j=1}^n$, 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: $\lim_{t\to\infty} k(t) = K_\infty(T)$.

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 model (1) and use the system

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

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

where A is a constant. Compact finite-difference scheme are useful for approximation of the differential connections (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.

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