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Convolution integral vs. finite difference for the inverse problem of detection of a contamination source in rivers

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ABSTRACT

The identification of the source of a contamination in a river, either accidental or intentional, is of extreme interest for both the technical and scientific communities. To this aim, the recent development of innovative wireless sensors, coupled with computational tools capable of analyzing big data almost in real-time, offers novel opportunities to develop early warning systems for the protection of surface waters. In the present paper, a novel approach is discussed, in which the unknown location and magnitude of pollution are looked through the solution of an inverse problem, based on the experimental detection of a contamination pattern and on a suitable mathematical model of the governing system. Provided that the geometry, the hydraulic parameters and the boundary conditions are sufficiently simple, the equations describing the conservation of contaminant mass can be solved formally. On the other hand, for more general conditions there is no alternative to the numerical solution. Benefits and drawback of these two alternatives are analyzed in the present paper for a hypothetical case study concerning the Volturno river reach, close to the city of Caserta in Southern Italy, schematized as a one-dimensional (1-D) steady uniform flow. Namely, the response to the contamination pattern is computed by both the exact solution based on the convolution of the pulse response and the finite difference Crank–Nicolson discretization of the governing equations. The comparison between the two approaches, provides interesting results in terms of effectiveness, computational complexity (central processing unit time) and model limitations, which may be of valuable help in the implementation of an identification network based on smart sensors.

Keywords: Smart sensor network; Surface water; Sensors; Contamination; Water protection

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