CFD modelling approach for Dam break flow studies

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Rebuttal to T. Tucciarelli (Referee)

The authors thank the referee for his helpful suggestions. In the following we answer on the general and on the specific comments

R: *According to my opinion, the conclusions drawn by the authors have weak motivation. First of all, the condition of frictionless bed with zero slope is not realistic, specially for the SW models. Even if the friction terms are negligible with respect to the inertial terms immediately after the beginning of the break, their effect on the peak discharge and mainly on the water levels shortly after the dam section can be significant.*

A: We absolutely agree with the reviewer that the friction effects may induce errors in the simulations, but we also certainly cannot say "a priori" how these errors would compare with the differences between the SW and the VOF-NS approach. It is important to notice, also, that friction effects at the wall boundaries may be (and will be) included in the code, but the "good practice" in numerical methods suggests to perform model validation by step. The aim of the present test case is to highlight the differences between the two approaches and reference test cases, without friction effects. However, as the point raised by the referee is important, the fact that frictionless simulations are not realistic has been stressed in the revised version of the paper.

R: *Moreover, there is experimental evidence in literature that the SW approach provides a good match between the measured and the computed water heads; see for example the experiment of Fraccarollo and Toro (1995) or other benchmark solutions shown by Aricò et al. (2007). The unsteady state velocity measurement is more difficult, but it could also questioned the relevance of high accuracy in the computation of very high velocities, when the same fixed bed hypothesis is a rough approximation of reality, close to the dam and immediately after the break.*

A: From this observation, we understand that we may failed in communicating the aim of this paper and we modified the revised version of the paper accordingly. This paper does not aim to state that the SW approach isn't able to predict experimental results. Also in the present paper we highlight that the shallow water model is capable of reproducing the literature (numerical and experimental) solution with acceptable accuracy in all the provided numerical tests.

On the other hand, it is important to highlight that, with the advent of extremely more powerful resources, more detailed (i.e. three-dimensional) Computational Fluid Dynamics (CFD) may be successfully applied to these kind of problems with acceptable computational efforts. As now reported in the revised version of the paper, present 3D simulations have been carried out in a PC with processor AMD phenom Quadcore 2.33 GHertz and 3.2 Gigabyte of RAM memory. The SW model runs on Windows XP operative system, while the NS-VOF on Lynux Ubuntu 9.10 operative system. The simulation of the first test case, using a dimension of mesh-side of 1m, took 0.25 h and 2 h, for the 2D model and the 3D model, respectively.

Therefore, the aim of the present paper is to show how this 3D NS-VOF model behaves in simulating dam-break problems, where it differentiates from the SW and why. This validation phase can be (and should be in our opinion) done for simplified test cases, as done for any other numerical method. Then, being the model valid for this kind of analysis, it could be run in a multiprocessor linux clusters or a workstation (few thousand dollars of cost) and simulate hydraulic problems with a high level of detail taking into account both the geomorphologic characteristics of the studied site and the non-instantaneous dam-break.

The three-dimensional model may provide a complete and detailed information on the physical quantities in space and time, that in turn give information on the potential flood evolution especially in terms of water depth, free surface profile, flow velocity, wave front dynamics etc. also over complicated terrain profiles and frequent discontinuities. For the above reasons, we must disagree on the fact that the present simulations are irrelevant because of the presence of unrealistic approximations.

R: The same hypothesis of instantaneous dam break is a simplification of reality. How much 'instantaneous' must be the break in order to make relevant a 3D computation of the wave formation? This should be investigated, because I suspect that even a gradual variation of the breach of few seconds makes the results of the two models almost equivalent.

A: Again the instantaneous dam break is a simplification (as the absence of friction) and again this simplification may produce errors. We do not get the point why the fact that the break is instantaneous makes the 3D simulation relevant or not.

R: *According to the previous notes, I think that test case 1 should be changed with a more realistic one, where also laboratory data are available, if possible. If laboratory data are not available, the variation of the error according to same parameter (like the height-width ratio of the breach or the effective break time) could be interesting.*

A: The first test case has been chosen as widely simulated in literature with the SW approach with the aim of testing the model to simulate the front wave propagation over a dry bed, with particular attention to the 2D aspect of the flow motion. Analytical and experimental reference solutions for this test case are not available. According to reviewer's suggestion, the discussion of the first test case has been shortened in the revised version of the paper.

In order to improve the discussion and the comparison and following the suggestion of the reviewer, another relevant test case has been added in the revised version of the paper: the steady flow at a 90° open-channel junction. The test intend to document the description of the dam-break phenomenon in the case of a 90° bend. In this case numerical results are compared to experimental results available from Weber et al. (2001 J. Hydraul. Eng.).

R: *The original contribution of the researchers in the paper is also not fully clear to me. The authors say that the 2D SW model is an open source model and they provide more details on the 3D model. The space and time discretization is provided by the OpenFOAM platform? According to which numerical scheme? The k-epsilon turbulence model is just an option of the OpenFOAM platform or has been specifically coded by the authors? The same questions hold for the Volume of Fluid method.*

A: OpenFoam is an open source library (source files are in C++) for solving partial differential equations and it allows customizing numerical solvers for continuum mechanics with particular emphasis on fluid dynamics. Different solvers are available for the discretisation/integration and the user may choose from them or use his own. Pre-written solvers collection represents the state-of-the-art of numerical methods.

Differently from commercial softwares, the user defines his model, which is to say his system of PDEs to be solved, and translates it into the OpenFoam syntax. Then he chooses the discretisation schemes (temporal discretisation, gradient discretisation, divergence discretisation, laplacian discretisation and so on). In this scenario, the k-epsilon model is a part of the PDEs system.

Summarising, the contribution of the authors is to choose the mathematical model to solve the specific fluid dynamic problem, to write down the PDEs and to choose the specific numerical models to discretise them. The effective advantage of using an open source software as OpenFoam instead of a commercial software is related to the fact that the user is free to choose among various numerical schemes for convection and is not therefore restricted to those that are strongly stable or bounded, e.g. upwind differencing, or to a prescribed set. For each term (laplacian, divergence etc.) and for interpolations, time discretisations, pressure-velocity coupling different schemes are available and may be individually chosen. This means that the user must have the specific know-how to use it.

Even if, in principle, it could be possible to write down and link our coded numerical models, in this case we did not obviously code the models as pre-written solvers collection represents the state-of-the-art of numerical methods.

R: The comparison of different 2D SW model results, reported in section 3.1.2, I think is not of strong interest in the paper context.

A: The discussion of this test case has been significantly shortened.

R: Technical corrections…

A: All the technical corrections suggested by the reviewer have been done