Nat. Hazards Earth Syst. Sci. Discuss.,
doi:10.5194/nhess-2015-326-AC2, 2016
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Natural Hazards and Earth System Sciences
Discussions
Open Access

Interactive comment on “3D-hydrodynamic modelling of flood impacts on a building and indoor flooding processes” *by* B. Gems et al.

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Received and published: 7 April 2016

The present authors’ comment, referring to the discussion paper titled “3D-hydrodynamic modelling of flood impacts on a building and indoor flooding processes”, is aimed at the comment of anonymous referee #2, published on 4 April 2016.

The authors of the manuscript would like to thank the reviewer for the valuable comment, which will lead to an improvement of the manuscript during further revision process. A couple of issues are briefly mentioned, they are commented by the authors as follows:

(1) The tested local structural protection measures are abstract

Building scenario (c) covers a set of structural protection measures which are intended

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Discussion paper

to prevent the fluid from entering the building, at least to a certain point in time during the considered flood event. Though considering the typical design of object protection measures (see therefore also Hofer (2014)), the set of structural measures was basically chosen arbitrarily. Since the primary focus of our investigation was to evaluate the possibilities and limits of the chosen modelling approach for flood prone buildings on a typical floodplain, working with fictitious scenarios, is, from the author's point of view, a reasonable procedure. The robustness of the modelling approach allows for an ex ante effectiveness test of envisaged structural mitigation options. To summarize, our basic aim was to show the full applicability of the modelling approach also with small scale and local structural changes within the built environment.

(2) The computational modelling results described in the manuscript pages 11 and 12 are difficult to read

The authors agree with this reviewer comment. The computational modelling results on pages 11 and 12 may be difficult to read due to the complexity of the building structure. We chose, for completeness to consider every single wall element. Moreover, the general arrangement of the figures at the end of the manuscript (the text on the pages 11 and 12 refers to the figures 9, 10 and 11) does not support the reader in keeping track of the entire result spectrum.

We will, within the revision process, slightly shorten this description of the modelling results and eventually provide a table which summarizes most relevant numbers mentioned in the text with better clarity and conciseness.

(3) The benefit of steady-state modelling is at least questionable

The authors fully agree with the referee in this context – steady-state modelling means an essential simplification compared to typically unsteady conditions during a flood event in a torrent catchment. Steady-state modelling scenarios have to be carefully interpreted within flood risk management in general, but they are still sporadically applied in practice. With respect to the conditions in the case study area and at the Rio

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Vallarsa this is even more true due to the following aspect: The design flood event is characterized by a comparatively short duration and a rather small discharge volume. A rather long duration of steady state modelling would lead to a significant overestimation of the fluid volume entering the building. This aspect is discussed in section 3.2 of the manuscript. However, if focusing on the efficiency of the local structural protection measures and thereby the location and time of initial flooding of the building, a steady-state scenario simulation also provides valuable information for the planner (Hofer, 2014). Due to this fact, the authors decided to provide a short section within the discussion of the modelling results to point out the relevance of unsteady modelling approach.

By again referring to the work of Hofer (2014), the informative value of the steady-state simulations will be more clearly pointed out during further revision process.

(4) Need for an adequate model calibration (validation)

and

(5) The aspect of transferring results of the case study analysis to other regions and / or buildings is not sufficiently discussed

This issues are also mentioned by anonymous referee #1 and the authors comment on that accordingly: To our knowledge previously occurred past events (at the Rio Vallarsa) did not cause relevant damages in the case study area and on the building selected for computational modelling purposes. As stated in section 2.2 of the manuscript, a flood event occurred in November 2012 and it is assumed from the Department of Hydraulic Engineering (Autonomous Province of Bolzano) that the designed stream channel can cope with discharges in the range 30-40 m^3/s before overbank flooding occurs. The data and information from the 2012-event led to an adaptation of the HQ100- and HQ300-discharge design hydrographs and this was also considered in the present work (section 2.2), which is primarily meant to analyse an extreme design flood (HQ300) (section 2.3, first paragraph). With the available information, the

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computational model was best possibly calibrated by adjusting the surface roughness parameters in the stream channel. As stated in section 2.3 (first paragraph) of the manuscript and already discussed in the work of Hofer (2014), discharges higher than 30 m^3/s exceed the channel capacity in the model which fits well with the available information and expert assessment. In summary, the roughness coefficients are well calibrated in the stream channel and – since any observation data is not available – we chose roughness coefficients values for the floodplain and the building structure according to values commonly cited in literature.

Since the aspect of model calibration is also mentioned in the comment of anonymous referee #1, the sections 2.2 and 2.3 of the manuscript are more detailed and clearly formulated within the further revision process.

The authors fully agree with the reviewer's note that consequences and benefits for planning new buildings, potentially resulting from the case study analysis at the Rio Vallarsa torrent, and also potential transfer of results to other regions / objects are not clearly stated in the conclusions. With regard to the computed impacts and wetting durations on the considered building, it seems not reasonable to transfer computed specific impact loads under design flood conditions to any further objects. The modelling results showed that the computed impacts and the flooding inside the building are significantly influenced by the design flood characteristics (hydrology and, if relevant, sediment transport processes), the capacity of the torrent channel and also by the topography of the adjacent floodplain. The general knowledge of a reasonable application of three-dimensional models for simulation of indoor flooding processes and, further, its computational limits represent the actual added value and novelty of the present case study analysis.

Within the further revision process this aspect is pointed out in more detail.

(6) No damage assessment and within this context the question concerning the benefit of a 3D- compared to a 2D- numerical modelling approach

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In the context of the proposed physics-based modelling approach proposed by Mazzorana et al. (2014) the presented work firstly focuses very much in detail on the hydraulic modelling aspect and, thereby, on the possibilities of simulating indoor flooding processes. Damage modelling, as it was done by Mazzorana et al. (2014) in a case study with intense bed-load transport and a 2D-numerical modelling approach, was chosen not to be accomplished in a first step. Compared to this case study and with regard to the modelling results under clear-water conditions at the Rio Vallarsa, it could be probably assumed that the computed impacting forces at the Rio Vallarsa will not endanger the stability of the building. They affect the usability of the building, damage inventory and endanger human life. However, damage assessment represents an interesting issue and could be an issue of further research (see therefore also section 4 of the manuscript).

The benefit of a 3D-numerical modelling approach is quite simply to adequately simulate flooding processes around and inside a building. Conventional 2D-numerical models are based on the Saint-Venant-equations and they provide depth-averaged flow parameters. Complex structures, as the building considered in our work, cannot be adequately considered in a 2D-numerical model. They are conventionally considered by a non-permeable building envelope in 2D-numerical models.

(7) Influence of different materials and structures in the building on modelling results

As the terrain and as well the building structure represent rigid elements in the numerical simulation (immobile obstacles within the flow field), any material parameters concerning the statics and stability of the building have no importance in the model. There is one parameter, surface roughness ks, that characterises the surface properties of the obstacles and thus influence hydrodynamic modelling. Figure 5 in the manuscript contains a list of the applied roughness parameters, differentiated according to the surface properties of the obstacles in the computational domain. As also mentioned in issue (4), the parameters are the results of model calibration and / or represent values commonly cited in literature. Different structures in the building and, more general, different approaches of hydraulic permeability of the building do have an influence on hydrodynamic modelling on the adjacent flood plain and also on the forces and wetting durations impacting the building. To analyse this is one of the main issues of the present manuscript. From the author's point of view, this was substantially analysed by simulating and comparing three building scenarios with different hydraulic permeability.

(8) Choice of case study area and building and the definition of the mesh grid size of the numerical simulation

Executing hydrodynamic modelling (no bed-load transport) as a first step towards the proposed physics-based modelling approach proposed by Mazzorana et al. (2014), the case study area the floodplain at the Rio Vallarsa in Laives (South Tyrol) seems well-suited for further analyses mainly due to the following reasons (they are comprehensively discussed in the sections 2.1 and 2.2 of the manuscript): - General risk of flooding of the case study area in the current state situation during flood events with peaks > 30 m^3/s (appr. HQ10) in the Rio Vallarsa; the considered building is thereby directly exposed to the hazard process and does not feature any structural protection measures against indoor flooding processes. - Non-relevance of bed-load transport due to the existence of a retention basin at the upstream boundary of the case study area. - Rather small spatial extent of the rigid torrent channel on the local floodplain in order to perform complex numerical simulation with still manageable computation times. - Availability of data for numerical modelling (topography, building characteristics, hydrology, etc.) and observation data.

Concerning the mesh grid resolution of the numerical model, comprehensive tests have been accomplished by Hofer (2014). This is stated in section 2.4 of the manuscript. The chosen grid resolution (0.167 m x 0.167 m x 0.167 m) leads to sufficiently adequate modelling results and exhibits still challenging computation times (see therefore section 3.3). A further refinement of the computational mesh does not noticeably change the modelling results.

(9) Manuscript language and style

It is found that an English prove reading is necessary before final publication. This issue is also mentioned by anonymous referee #1. Accordingly, the manuscript is again carefully checked within the further revision process.

References:

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2015-326, 2016.