The authors fully appreciate comments and suggestions given by the Anonymous Referee #1, which will contribute towards an improvement of the final paper. We note that the Anonymous Referee #1 appears to have based his questions largely on the original version of the paper, submitted to the NHESS Journal in July 2014, rather than the current version under discussion. Since the original review, the authors have incorporated various comments and suggestions from another reviewer (Anonymous Referee #2) which is reflected in the improved version of the article that was put to the current Public Discusion on the Journal's web site.

Response to introductory comments by the reviewer

In the final version of the paper several additional papers were added to point to recent significant contributions in the improvement of the SPH method to simulate or interpret the mudflow or debris flow propagation (eg. Laigle and Coussot, 1997; Pastor et al., 2009b; Haddad et al., 2010; Blanc et al., 2011; Calvo et al., 2014, etc.).
This SPH study examines principal features of the mudflow processes downstream of the Grohovo landslide. The simuation provides as assessment of the runout distance, quantities of the deposited materials and the velocity of mudflow progression which are qualitatively compared to the limited recorded consequences of the actual event which occurred in the past within the studied area. This study also illustrates a powerful link of the SPH modelling environment with the GID post processor, for the visual presentation of simulation results. Comparison with alternative simulation frameworks (e.g. FLO-2D model) was not considered at this stage.

As stated, the original submission was improved upon, and in the current version of the paper (open for Public Discusion) all registered historical data (about the intensity of precipitation, run-out of mudflow propagation etc.) that have been found in old historical documents (Croatian State Archive in Rijeka, JU 49 - Box 13, JU 51 - Box 45) were added (see page 6813, lines 4-12). The significant geological explorations and measurements at the Grohovo landslide only started at the end of the 20th century. For this reason, we used data from Table 1 as the only hitherto relevant geotechnical data for the purpose of creating the numerical model.

Furthermore, the current version referes to several major landslides that preceded or exacerbated the newly formed landslide and mudflow propagation in 1908 near the Grohovo village (see page 6813, lines 13-30 and page 6814, lines 1-3). Further reference was given to papers by Vivoda et al. (2012) and Žic et al. (2014) which include lists of all relevant landslide phenomena observed around the Grohovo village.

Finally, we intend to add the following references, in order to point to the most recent advances in SPH modelling of the debris flow:

2. Cascini, L., Cuomo, S., Pastor, M., Sorbino, G., Piciullo, L.: SPH run-out modelling of channelised landslides of the flow type. Geomorphology, 214, 502-513, 2014.
3. Cuomo, S., Pastor, M., Cascini, L., Castorino, G.C.: Interplay of rheology and entrainment in debris avalanches: A numerical study. Canadian Geotechnical Journal, 51 (11), 1318-1330, 2014.

Point-by-point replies to the reviewer's specific comments follow.

Comment/Question 1 - In Abstract, the main conclusions about the application of the SPH model for the case for a mudflow from the Grohovo Landslide should be presented. The first part of the Abstract is rather an introduction that should be part of the main text body and should therefore as a part of Abstract be shortened.

Reply 1 – As suggested, in the Abstract two sentences *„In recent decades, modeling of the propagation stage has been largely performed within the framework of continuum mechanics, and a number of new and sophisticated computational models have been developed. Most of the available approaches treat the heterogeneous and multiphase moving mass as a single-phase continuum.“* will be moved to the Introduction part of the article. The following text will be added at the end of the Abstract: *Within the SPH simulation the Newtonian rheological model in the turbulent flow regime and the Bingham rheological model were adoped and a comparison was made of the application of the Egashira and Hungr erosion law.*“.

Comment/Question 2 - In Section 4 you talk about the Croatian-Japanese project – be more specific about the monitoring system instead of quoting the project (this may go to the Acknowledgments).

Reply 2 – The text on page 6826, lines 3-7 *„The necessary measurement and research equipment, systems and equipment for meteorological and hydrological observations were provided by the Japanese Government as part of the Croatian–Japanese bilateral scientific research project "Risk identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia*".“ will be reformulated by the following text:
„Installation of the monitoring equipments on the Grohovo Landslide (part of Croatian–Japanese bilateral scientific research project "Risk identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia") started in May 2011. The necessary measurement and research equipment, systems and equipment for meteorological, hydrological and geotechnical observations include: meteorological stations and meteorological radar, Mini Diver instruments for measuring water and groundwater levels, as well as instruments for geodetic and geotechnical monitoring. Geodetic monitoring includes geodetic surveys with a robotic total station (measuring 25 geodetic benchmarks (prisms) and GPS master unit with 9 GPS receivers (rovers)), while geotechnical monitoring includes vertical inclinometers, long and short-span wire extensometers, pore pressure gauges, and weather station. A more detailed description of the the monitoring system is given in Arbanas et al. (2014).
The above cited reference will be added to the list of references:
Arbanas, Ž., Sassa, K., Nagai, O., Jagodnik, V., Vivoda, M., Dugonjić Jovančević, S., Peranić, J., Ljutić, K.: A landslide monitoring and early warning system using integration of GPS, TPS and conventional geotechnical monitoring methods, Landslide Science for a Safer Geoenvironment, Volume 2: Methods of Landslide Studies / Sassa, K., Canuti, P., Yin, Y. (eds.), Switzerland, Springer International Publishing, 631-636, 2014.

Comment/Question 3 - The SPH model was validated for the 1908 event? What reconstruction of this event were available nowadays, please specify: delineation of the event, run-out zone, depths, velocity, density? How good is the validation fitting of the SPH model to the 1908 event? On Page 13, line 13, you say that the values of the parameters that were found to best fit the reconstructed event from 1908 are this and that (turbulence coefficient value of 200-500 m/s^2 and friction angle of approx. 27 degrees).

Reply 3 – The reconstruction of the mudflow propagation from 1908, was described in historical documents (Croatian State Archive in Rijeka, JU 49 – Box 13, JU 51 – Box 45) as one of catastrophic events. The intention of the paper was to explore this event in more detail and demonstrate potential consequences of such a scenario happening again on the same area. There are no papers or studies that describe in detail the features of the 1908 event, only limited historical evidence and statements are available (some features of the mudflow event from 1908 are shown at the beginning of the Introduction section). From historical writings there is evidence that the mudflow stopped in the region of the watercourse between the Pašac village and former Žakalj village. Based on these findings the probable extent of the mudflow in 1908 was determined (see page 6832, lines 18-24). Also, in historical records it is stated that the occurrence of mudflow from 1908 was extremely rapid and occurred within a very short period of time. Unfortunately, there are no recorded data or estimates about the velocity and maximum thicknesses of the deposited mudflow material. Some old black and white photos to some extent were used for estimating the thickness of mudfllow on some places within the Rječina River channel. The description of validation and verification on the SPH model is given in the Conclusion section (page 6832, lines 9-24).
Several numerical simulations were conducted to describe the mudflow propagation based on the Bingham rheological model (SIMULATION 1) in which the turbulence coefficient was varied in the range of 200-1000 ms^{-2}, while the angle of internal friction is taken on the basis of laboratory tests of soil samples taken in the area of the Grohovo landslide. By varying the values of the turbulence coefficient of 200-500 ms^{-2} numerical simulations in SPH model no significant change was noted in terms of the mudflow reach, velocity and height of a mudflow. The value of the turbulence coefficient 1000 ms^{-2} leads to significant changes of the velocity and depth of mudflow. Some of simulations results did not provide a credible view of the mudflow propagation, as described in historical writings.

Comment/Question 4 - On Page 12, line 22 you say that long-term rainfall events and the consequent ground water level rises have been the primary triggering factors for landslide occurrences in the Rječina River Valley in the past. Are there have been any observations for these event so that you may draw such conclusions? You have not presented any evidence and/or field data for selected past (mudflow) events to support these conclusions.

Reply 4 – In the current version we clearly state that the mudflow propagation from 1908 appears to have been preceded the heavy rainfall, which we estimated with a value of 220 mm over a period of 7 hours (page 6813, lines 4-6). From historical documents no suggestion is ever made that the triggering of a mudflow event initiated seismic or anthropogenic activities. Also no significant seismic or anthropogenic activity was registered or recorded in the period few years before 1908.
Publications by Vivoda et al. (2012) and Žic et al. (2014) provide descriptions of the most significant landslide and flash-flood phenomena in the Rječina River Valley. In these papers, which are based on historical data and evidentiary materials, it is stated that numerous landslides in history (from the end of 19th century to the present) in the area of the Rječina River basin were apparently initiated by prolonged rainy periods, with different rainfall intensity. For some major catastrophic landslide occurrences on the same area, the estimated values of rainfall over a given period of time are stated. Two above mentioned references will be added to the current text (page 6826, 14-16):
„Long-term rainfall events and the consequent ground water level rising have been the primary triggering factors for landslide occurrences in the Rječina River Valley in the past (Vivoda et al., 2012; Žic et al., 2014).“

Comment/Question 5 - You have used different grid sizes (2x2, 5x5, and 10x10 m). Your discussion is not supported by literature on the influence of numerical grid size on the numerical results for mudflows or debris flows. You should add more in-depth discussion with regard to the grid size.

Reply 5 – For the current version of the paper (Public Discusion) further analysis of the mudflow propagation was conducted on examples of equidistant mesh with size 2x2, 5x5, and 10x10 m (Table 2, page 6840). The analysis of the influence of the space discretization was carried out on the example of the mudflow propagation in which the Egashira erosion law was applied. The values of the runout distance of mudflow and the maximum mudflow wave velocity were compared, as well as the total volume and total affected area of mudflow propagation.
We also added some concluding remarks (compared to the initial version of the article) in section 7 "Discussion" which are related to the accuracy of creating a digital elevation model, as well as the importance of better terrain surface discretization in order to provided a more realistic display of the mudflow propagation. In the sentence on page 6830, line 9 the authors will add references (Delinger and Iverson, 2004; Cuomo et al., 2013):
„*However, the irregular topography of natural slopes considerably affects the motion of propagating materials, and the accurate DEMs are paramount for realistic simulations and assessments (Delinger i Iverson, 2004; Cuomo et al., 2013)*.
The above cited references will be added to the list of references:
1. Denlinger R.P and Iverson R.M.: Granular avalanches across irregular three-dimensional terrain: 1. Theory and computation. Journal of Geophysics Research, 109, 1-14, 2004.
2. Cuomo, S., Pastor, M., Vitale, S., Cascini, L.: Improvement of irregular DTM for SPH modelling of flow-like landslides. XII International Conference on Computational Plasticity. Fundamentals and Applications, COMPLAS XII, Oñate, E., Owen, D.R.J., Peric, D. and Suárez, B. (Eds), 3-5 September 2013, Barcelona, Spain, 10 pp., 2013.
The authors note that the caption of Table 2 referes to the term "debris flow". This term will be replaced by the term "mudflow" in the final version of the paper.

Technical corrections:

Comment 6 - Page 1, line 19 – please, add years of these past mudflow events downstream of the Grohovo Landslide.

Reply 6 – Authors will reformulate the sentence on the page 6812, line 14 in the following form:
„*In this study, the main characteristics of mudflow processes that have emerged in the past (1908) in the area downstream of the Grohovo landslide are examined, and the more relevant parameters and attributes describing the mudflow are presented.*"

Comment 7 - Page 6, line 3 – why you use the expression The natural groundwater flow rate and then speak of cm/s, you should use the expression velocity instead and specify if apparent velocity is given or you had measured hydraulic conductivity in the field?

Reply 7 – Authors will reformulate the sentence on the page 6818, line 21 in the following form:
„*The natural groundwater flow velocity ranges from 0.2–4 cms^{-1}, and the hydraulic gradient varies from 0.03 to 0.06 (Biondić, 2000).*"

Comment 8 - Page 6, line 9 – the wording egresses means?

Reply 8 – Egress = means „the action of going out". However we will rephrase the sentence on page 6818, line 27 to read as follows: *„A spring with a capacity of 30 Ls^{-1} was also observed at the foot of the coarse-grained slope deposits after periods of intense precipitation."*

Comment 9 - Page 11, lines 27 & 28 – you are talking about the propagation mudflow generated in the past, please, be more specific whether you talk the 1908 case or some others as well – not very detailed data are given about these historic cases.

Reply 9 – Authors will reformulate the sentence on page 6825, line 17 in the following form: *„As stated earlier, the objective of the simulation is to gain a clearer picture of the mudflow which occured in 1908 in the area downstream of the Grohovo landslide and its propagation to the urban part of Rijeka.*". In the final version of the paper that has been put on a Public Discusion, the authors added all the data collected from old historical documents related to the event of mudflow from 1908. See also Reply 4.

Comment 10 - Page 13, line 30 & 32: .... – omit non-significant digits; the results are much too precise (e.g. the overall run-out distance is 1743.41 m, but the grid is 10 x 10 m).

Reply 10 – In the current version the above suggestion was already realised (see page 6827, line 23; page 6828, line 12). The authors have also appropriately rounded the values of other outputs of physical quantities obtained from the SPH simulation in section 5 (5 Analyses and results).

Comment 11 - Figs 7 & 9 – what is shown by colours? Mudflow depths? Height soil?

Reply 11 – The Figure 7 (i.e. Figure 9 in the current version of the paper that has been put on a Public Discusion) shows a change in erosion activity along the Rječina River due to the mudflow propagation. Authors will replace the legends on Figure 9 with legends that shows the changes of height of mudflow along the propagation route. The figure 9 will therefore appear in accordance with Figures 10, 11 and 12.