Hydrology and Earth System Sciences Discussions

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Comment on hess-2021-294

Nolwenn Lesparre (Referee)

Referee comment on "Gravity as a tool to improve the hydrologic mass budget in karstic areas" by Tommaso Pivetta et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-294-RC1, 2021

The paper "Gravity as a tool to improve the hydrologic mass budget in karstic areas" presents an original data set of continuous gravimetric measurements acquired above karstic caves during a flood event. The authors developed a 3D hydraulic model to be able to estimate the water level monitored in the karstic conduit as well as the gravity data set. From the model they infer the water volume flowing through the karstic network during the flood event. They show that the karstic cave above which they performed measurements is particularly suitable for applying such a methodology thanks to its location relatively close to the surface and its large dimension. But they also show from synthetic tests that other caves smaller or deeper could be monitored with continuous gravimetric measurements.

The data set is particularly interesting and the model conception to reproduce the data set is pertinent. The figures are clear, the references are appropriate, but the text could gain clarity. Also the originality of the experiment should be better empasized. Find below some comments, hoping they could help you improving such weaknesses.

Abstract: "We demonstrate how the inclusion of gravity observations improves water mass budget estimates"

☐ In the paper you show (Fig. 2) how the water volume estimated differs if computed from the gravity & hydraulic model with respect to the hydraulic only model. However you do not show how the hydraulic only model fits the data (at least the water level of Martelova). Is the fit of this data set degraded when you fit also the gravity measurements?

l. 34: To assess the structure of karst aquifers, different geophysical and hydrological techniques are used, each of them being applicable to a specific situation

☐ This sentence is very general and does not render the advantages and drawbacks of the

different methods that could be used to study karst structures. A short description of the classical methods with references to the main contributions (such as Chalikakis, K., Plagnes, V., Guerin, R., Valois, R., & Bosch, F. P. (2011). Contribution of geophysical methods to karst-system exploration: an overview. *Hydrogeology Journal*, *19*(6), 1169-1180.) should be added. This will help better highlitghting the interest of your work and its contribution to the previous researches on karst structure studies.

Paragraph from line 40: You should underline that the gravimetric temporal signal is directly sensitive to the water mass redistribution (no need of petrophysical relationships), which is very powerful when you want to interpret the variations of your signal. You could also develop the specificity of the gravimetry which is an integrative tool (versus water head which is very local), but that can still provide an information on the water content state integrated around the instrument. Discharge measurements is also integrative but it integrates information concerning the whole catchment.

You could add a paragraph on the state of the art concerning the karst hydrosystems modelling. Some of them require the geometry of the conduits, you could then develop the supply of such models compared to black boxes model that reproduce well hydrological data and do not need any geometrical information on karst networks structure.

Paragraph from line 47: this part does not render what you expect from gravimetry to validate your model that other data type would not provide

l.52: "numerical models" ☐ you could develop what kind of hydrological model you use.

l.54: "In July 2018, a continuously recording gravimeter was installed above the caves." ☐ you could specify the duration of the continuous gravimetric measurements

Fig. 1c, legend exterme ☐ extreme

l. 75: Slovene /Carso ☐ Slovene/Carso

l. 113: "The cross-section of the canyon is between 2,000 m2 and 12,000 m2." ☐ could you describe how you estimate it

l.124: "The long-term monitoring of groundwater" ☐ could you indicate since when are acquired the different data (temperature/pressure in the Škocjan Caves and in the KaÄ☐na Cave, the gauging station…)

l.141: "a gPhone gravimeter » -> could you provide the drift of your instrument and its precision

l.142: "was installed on the surface above Škocjan Caves in July 2018." ☐ add the duration of the dataset you analyse.

l. 170: Hydrologists might not be familiar with the term "admittance" ☐ provide a short definition

Fig. 4: Could you place on the plan views the location of the cross-sections?

Could you also locate on the plan views the two dolines located before the entrance of the cave system, where water is susceptible to accumulate?

l. 207 and Fig.3: specify what cpd means.

Paragraphs from l. 221 ☐ it is not clear if you adapted the model of Gabrovšek et al. (2018) or if you built a new one since you do not describe the physics behind the Gabrovšek et al. (2018) model. It is not clear neither if you use this previous model to define the parameter of the 3D model you built. You should better emphasize the need of a 3D model to compute the gravity signal. The model you built is particularly relevant to estimate the water mass budget and you had to build it to be able to fit the gravimetric data. To me the description of how this model functions should be integrated to the paper.

l. 244: "The final RMS difference between the observed and modelled data amounts to 8 m" ☐ The final RMS difference between the observed and modelled **water level** data amounts to 8 m

Fig. 2: Add on the c and d plots the estimate of the water level by the Gabrovšek et al. (2018) model

l. 350: "Detectability of water storage units in karst trough gravimetry" ☐ Detectability of water storage units in karst **through** gravimetry

l. 415: "that seem to cause" ☐ that seem**s** to cause

l. 422: "Apart from karst aquifers in carbonates, a similar approach can be extended to monitor cavities on gypsum and evaporates, which represent an hazard in many regions worldwide."

☐ Join this lonely sentence to the above paragraph

an hazard ☐ a hazard

Fig. A1 a ☐ both lines are not distinguishable since they overlap, it would be better understood if one of them ("ET model") would be represented by a dashed line. In the legend "ET model" corresponds indeed to the LTM model.

Fig. A1 b ☐ in the legend the term ET is not introduced neither in the manuscrpit text nor in the caption, do you mean LTM?

Fig. A1 c ☐ you would ease the readability if you place the c plot below the b one

Fig. A1 d ☐ the "ET" prediction could be represented by a dashed line, change ET to LTM or specify its meaning. Explain the meaning of the terms O1, P1, K1, M2, S2, M3 or relate them to the table A1

Fig. A1 e ☐ in the legend "No umberlla" ☐ No umbrella

Fig. B1: "DEM of of the Škocjan" ☐ DEM of of the Škocjan.

"SK1 position" it seems that you started a sentence but didn't finish it

l. 653: "By 'outside' we mean the water masses contained inside the blue dashed outline in Figure B2a" ☐ I don't see any blue dashed line or area on that plot, do you mean Fig. B1?