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Hydrology and Earth System Sciences Discussions

Interactive comment on "Parameterization and quantification of recharge in crystalline fractured bedrocks in Galicia-Costa (NW Spain)" *by* J. R. Raposo et al.

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Interactive comment on "Parameterization and quantification of recharge in crystalline fractured bedrocks in Galicia-Costa (NW Spain)" by J. R. Raposo et al. Anonymous Referee #2 Received and published: 19 March 2012 The manuscript discusses an interesting topic, groundwater in granitic areas, which is often neglected in hydrological studies. The methodology, however, needs a more thorough explanation, especially the used models. As such, it is difficult for the readers to understand what those models actually do. The third dimension is also missing from the site descriptions: the reader would be interested to know to what depth the wheatering and fracturation of the crys-

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talline rocks has proceeded. Maybe groundwater recharge is in reality more interflow? References of this manuscript tend to be biased towards spanish publication. While this is ok for local data, more general topics should be based on literature available to and understandable for all readers. I would also recommend a literature review and comparison on groundwater recharge in granitic regions around the world. Brittany is mentioned but no data are presented. The language needs a thorough brush-up by a native speaker.

Reply to Anonymous Referee #2. We greatly appreciate your constructive and thoughtful comments that will definitely help to improve the manuscript. We will take into account all of them. In the following, we give a point-by-point reply to your comments:

RC: The methodology, however, needs a more thorough explanation, especially the used models. As such, it is difficult for the readers to understand what those models actually do. AC: As was explained to Referee #1, initially model description was not included since there is abundant bibliography (cited in the paper) that made a comprehensive explanation of the methodology applied, and repeat it again in this paper might seem reiterative. However we agree that the paper should be understandable as stand-alone. Therefore, section 3 “Hydrological Model” will be rewritten and additional information about the equations and parameters used by the model will be included in the revised manuscript.

RC: The third dimension is also missing from the site descriptions: the reader would be interested to know to what depth the wheatering and fracturation of the crystalline rocks has proceeded. AC: The weathering front in crystalline rocks is not continuous and the thickness of the regolith differs from place to place. Generally, in lowland areas, valleys and highly fractured areas the weathering depth varies from 5 to 20 m (Molinero et al. 1998, Wilson 1998); while in mountain and hilly areas the superficial weathering cover is very thin (< 3 m) (Samper et al. 2006). In lowlands in North Portugal, most granitic saprolite profiles exceed 10 m and some are more than 20 m deep (Sequeira Braga et al. 2002). Similarly, depth of fracturation of crystalline rocks varies significantly from

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site to site depending on tectonic history of the rock. In a granitic site, Molinero et al. (1998) limits the rock with a high density of fractures to a depth lower than 50 m. Geophysical surveys in a schistose site reported depths of fractured rock in a range between 30 and 100 m (Dafonte and Raposo 2009).

RC: Maybe groundwater recharge is in reality more interflow? AC: Different concepts are used to account for rapid subsurface responses (Sophocleous 2002); due to this fact, distinction among interflow and groundwater recharge is a controversial topic and may be difficult. Different models use different methodologies for quantifying interflow that may imply significant deviations in the estimations. Especially in consolidated rock areas, the results from some models are often affected by interflow leading to a significant overestimation of groundwater recharge (Bogena et al. 2005). In this study interflow quantification was also carried out (Table 2). According to model results, interflow is effectively the main component of water balance in most of the studied catchments. It may reach more than 40% of annual precipitation. However, only after water volume that flow horizontally in the vadose zone is subtracted in the water balance, the groundwater recharge is computed by the model. Methodology used by the model for interflow and groundwater recharge calculation will be explained and included in the model description (as was answered to the first comment).

RC: References of this manuscript tend to be biased towards spanish publication. While this is ok for local data, more general topics should be based on literature available to and understandable for all readers. I would also recommend a literature review and comparison on groundwater recharge in granitic regions around the world. Brittany is mentioned but no data are presented. AC: Effectively too much references in Spanish are included in this paper. This is due to most of bibliographic data used in this study were not published in international journals. Unfortunately, some technical reports must be cited as the only source of bibliographic data for local conditions. More references with groundwater recharge on crystalline rocks will be included, especially from Atlantic European regions were both geological and climatic conditions are sim-

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ilar, and recharge rates will be compared. Paragraph on page 1922 lines 22-27 will be rewritten as follow: “Besides in the neighboring North Portugal, aquifers with similar characteristics to Galician ones, developed on fractured crystalline bedrocks, are relatively frequent along the Atlantic Europe: in the Armorican and Central massifs of France, Scotland, Wales and Cornwall (UK), Ireland and Scandinavia, (Environment Agency, 2005; Wendland et al., 2008; Knutsson, 2008; Robins, 2009; Banks, 2010). These regions are generally characterized by high precipitation, temperate-cold climatic conditions and a traditional use of shallow groundwater. Recharge rate estimations in crystalline rocks areas in Brittany, Scotland, Wales and Channel Islands range between 15.4% and 40% of the precipitation (Robins and Misstear, 2000; McCartney and Houghton-Carr, 1998; Robins et al., 2002; Rouxel et al., 2011). Estimations in the Bohemian Massif are more than 20% of the mean annual precipitation (KrásnÃ¡, 2002). Crystalline rock aquifers are also exploited widely in tropical climes (Africa and India). There, however, the hydrogeological conditions are very different. The rocks are deeply weathered and rainfall recharge may be scarce. Granitic-gneissic complexes in southern India have a natural recharge rate of 3-15% of precipitation, partially because the adverse hydrometeorological factors (Sukhija et al., 1996; Massuel et al., 2007). Similarly, estimations of groundwater recharge of shallow aquifer on crystalline rocks in West Africa are 5-12% of precipitation (Martin and van de Giesen, 2005; Fouépé Takounjou et al., 2010).”

RC: The language needs a thorough brush-up by a native speaker. AC: An additional language review will be performed by a native speaker.

We will consider your contributions for improving the final manuscript and we hope that we have appropriately addressed your comments.

Kind regards, Juan Raposo, Jorge Molinero and Jorge Dafonte.

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