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Hydrology and Earth System Sciences Discussions

Interactive comment on "The hydrological response of baseflow in fractured mountain areas" *by* A. Millares et al.

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We acknowledge the review of anonymous referee #1. We have improved the paragraph structure as suggested, and we have included references to the suggestions into the text (please find attached the modified text as well as figure 6). We detected some mistakes related to the editing process which have changed the original structure of some paragraphs. These mistakes have already been solved: 1) The configuration of the paragraphs corresponding to page 3364 which were originally in punctuation format; 2) headlines of Table 1 and Table 2 have been rewritten as they included captions of Fig. 1 and Fig. 2.

Regarding to the general observations, we agree with the decision of the editors to in-

clude this paper in the IP3 special issue "Cold region hydrology", though we of course respect the final choice. The effects related with the snowmelt processes in the study site and their annual and interannual variability are determinant in the local groundwater recharge, as previously shown by other authors (Castillo et al., 1999; Castillo and Fideli, 2002; Herrero, 2009), and make it possible to maintain a significant water flow in the river and streams during summer, even in dry years. Such role can also be found in other areas throughout the world, with high altitudes and alpine climate despite their latitude location (Etna mountain in Italy; Pyrenees and Cantabric mountains in northern Spain; Atlas mountains in Morocco; Teide mountain in the Canary Islands and other volcanic systems. . .). In all these regions, recharge sources vary in both time and space and interact to produce a joint baseflow response throughout the year.

Specific comments:

Page 3363, lines 20-25. We did not mean that faster recession is due to more fractured material, though it could have been more clearly stated to avoid confusion. What we really argued is that downward concatenation of recession fragment coming exclusively from groundwater storage, are greatly related to faster responses from the subterranean system. Reasons for these different responses can vary as described by different studies (e.g., Sklash and Farvolen, 1979; Ward 1984; Beven, 1989). In the study area, two main patterns of fracture structure can be found (Castillo et al., 1999), some of them originated by the alteration of the surface layers, which produce a less inertial flow and which therefore could explain this fast response detected in the flow analysis.

In page 3362, line 18, where the empirical relationship N=[0.83·A]ˆ0.2 (Linsley et al., 1958) is exposed, N is the number of days between the storm crest and the end of runoff (see attached file page 5, lines 138-140, in the revised text).

Page 3368, lines 5-10, we have included references to Table 1 and Fig. 6 as it helps to better understand the paragraph (see attached file page 8, line 230, in the revised text).

Page 3370, line 6. As we described in pages 3366-3367 (Study area), the geologic features are the same in the three sub-basins studied. Although several authors link the main indices affecting the recession with geological features and the climate, some others (Mwakalila et al., 2001) remark the influence of the topographic and geomorphologic configuration in the baseflow patterns (this explanation has been incorporated into the reviewed version; see file attached, page 10, lines 284-290). As Fig. 8 shows, the differences between Lanjarón and Cádiar-Trevelez sub-basins can be seen from different geomorphologic indices such as the Gravelius index or the drainage density, related to surface morphology and relative dimensions. In this sense, we have added the definition of Gravelius index, as $Ic=0.28 \cdot P/\sqrt{S}$, where P and S are the perimeter (km) and catchment area (km2), respectively (see file attached, page 10, lines 289-290, in the revised text).

Page 3371, line 5. We fully agree with the reviewer questioning the basin as a simple bucket. In fact, the correction attempted to further identify recession events in terms of the surface processes that could interfere with the flow recession monitoring, but it may be not clear in the text. The correction made consisted of analysing the study period by the hydrological modelling of the basin, which quantified snowmelt, infiltration, evaporation from the soil, and identified which intervals corresponded to recessions events (see file attached, pages 4-5, lines 123-140, in the revised text). This is important as a previous selection of recession, since the recession analysis is based on the hypothesis of storage-discharge relationship in the groundwater system, and parameterizing such response from mixed recession patterns could induce over or underestimation of the storage coefficients commonly used as shown by different authors as Wittenberg and Sivapalan (1999). (see file attached, page 11, lines 317-319).

Page 3371, line 25. Differences in the available data refer to the discharge records showed in Fig. 4, with different periods of records available for each gauge station. Fig. 5 shows daily rainfall, snowmelt and evapotranspiration values for the 1969-2004

period, from the hydrological modelling of the watersheds used in this study to separate the baseflow recessions in the gauge station records.

Finally, the Figure 6 has been changed (see file attached) and the captions extended to explain the slower and faster recessions (see file attached, page 19, line 452).

References

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Please also note the Supplement to this comment.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 3359, 2009.