Geophysical Research Abstracts
Vol. 12, EGU2010-8425, 2010
EGU General Assembly 2010

Multifractal analysis of long term records of karst watershed discharges

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Karstic aquifers constitute a freshwater resource still under exploited in the world. Despite the importance of karst aquifer as a freshwater source for most Mediterranean countries for example, their complex behavior makes their exploitation much less easier than classic porous or even fissured aquifers. The mechanisms that generate water production and circulation need to be further precised. In classical porous aquifers, water both flows and is stored in the pores or in the fissures. Because of the carbonates dissolution, karstic aquifers structure makes the water flows in large drains connected to annex systems that constitute large water reserves.
The existence of both rapid infiltration via boreholes and infiltration via epikarstic soil combined to diphasic flow in the unsatured zone and complex hydraulic connections in the saturated zone lead to a nonlinear response reflecting the large diversity of pathways connecting surface with spring.Therefore, karstic aquifers appear naturally as unconventional aquifers with micro- and macro-hydraulic elements.
This extreme variability over a wide range of scales naturally suggests applying multifractal concepts based on scale invariance. In this contribution, based on a 10-years high temporal resolution runoff database over two French karstic watersheds (Aliou and Baget) with around 80000 consecutive data, we identify and characterize this multifractal properties of these two karstic watersheds and compare them to multifractal parameters already determined in surface hydrology.
Besides the apparent heterogeneity of karstic systems, the aquifer response exhibits scale invariance behaviour over one or two large range of scales from flood scales (up to 1 day) to annual behaviour. The existence of a scale break in Aliou runoff time series can be explained by the high degree of karstification of this system that lead to a drain-concentrated behaviour for processes inferior to 1 day.
In order to quantify the degree of multifractality of the system, the slopes of the M(l,q) function of the moment q are estimated leading to an empirical estimation of the K(q) function, leading to an estimation of the alpha and C1 multifractal parameters. The multifractal parameters determined for karst watersheds appear as slightly different from results from Tessier et al. (1996), Pandey et al. (1998) and Zhou et al. (2007). Therefore, karstic aquifers appear as original hydrological systems that exhibit significant differences with non-karstified watersheds. More precisely, it also shows that the multifractal karstic basin response is rather fast and somehow similar to small basin response. We finally propose some possible connections with the spatial organization of the karsts.