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The use of isotope measurements for the separation of discharge components at a karst spring during hydrological events

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The catchment area of the Wasseralmquelle (802 m.a.s.l.) is situated in the NE part of the Schneealpe karst massif some 100 km SW of Vienna, in the northern "Kalkalpen". Calculations from long-term isotope records from the Wasseralmquelle showed that reservoir water of this karst system has a mean residence time of about 26 years, while the short-term component has a transit time of 1,2 months (including retention time in the snow cover) (Maloszewski et al., 2002). For these calculations, the karstic reservoir is approximated by two different parallel flow systems, which provide water from the surface to the karstic springs. The first flow system, with a high storage capacity, consists mainly of mobile water in the fissures and quasi-immobile water in the porous matrix. The water enters this system through the whole surface of the catchment area and is collected into the drainage channels connected with the karstic springs. The drainage channels separately create a second flow system with a high velocity and small groundwater volume (very short mean transit time of water). This system is connected with sinkholes, which introduce precipitation water directly into this system. As a result, in the karstic springs there is a mixture of two water components: (1) flowing from the surface through fissured/porous medium to the drainage channels and then to the springs; and (2) flowing directly from the sinkholes through the drainage channels to the springs. The conceptual model of the water flow in the karstic catchment area of the Wasseralmquelle is shown in Fig. 1. This special form of the model for the Wasseralmquelle system includes also some infiltration of water from the channel system into the fissured-porous aquifer, since low precipitation depths (< 20 mm) do not lead to any increase of the discharge at the spring (Steinkellner 1997). In this case all precipitation water is infiltrating into the fissured-porous matrix.

Here we present some preliminary results of the Wasseralmquelle study in spring and summer 2005. Snow-melting periods with daily variations in discharge and heavy rainfalls in summer were selected for event investigations (Wieselthaler, 2006). Sampling with time resolution of one or two hours was provided at the Wasseralmquelle. Snow samples and rain samples, respectively, were collected for the determination of the input data.

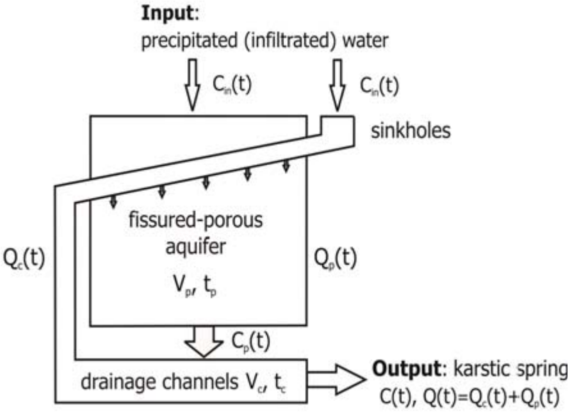

Figure 1. Conceptual model of water flow in the karstic system of the "Wasseralmquelle" (spring), modified after Maloszewski et al. (2002).

An example for the snow-melting investigations is shown in Fig. 2. Air temperature maxima, causing snow melting on the plateau of Schneealpe during the day, lead to an increase in discharge at the spring and a decrease in electrical conductivity (EC) in spring water, with a delay of approximately 16 hours (daily variations). The graph of the δ^{18}O-values develops similarly like the graph of electrical conductivity and indicates times of higher melting-water content in the discharge. At the end of the sampling period, air temperature drops, melting-water content decreases and therefore δ^{18}O-values and electrical conductivity are rising again.

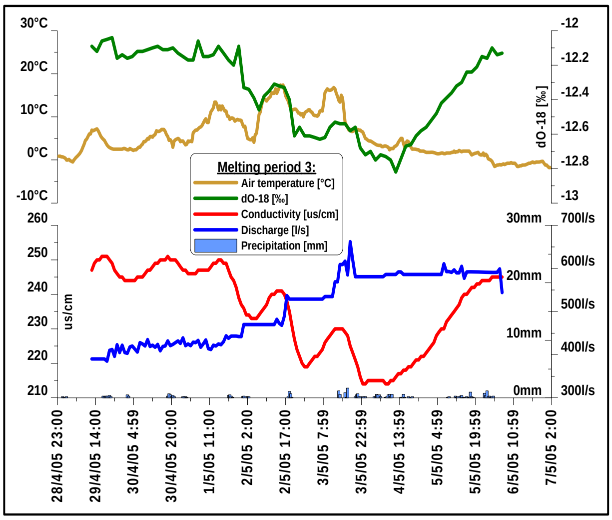

Figure 2. Example for the course of discharge, electrical conductivity and δ^{18}O in springwater of the Wasseralmquelle, air temperature and amount of precipitation on the plateau of the karst massif during a typical snow-melting period with daily variations (28.04.05 – 07.05.05) (Wieselthaler, 2006).

The investigations of rain events in summer - when we can expect the most significant ^{18}O signals – give information about the direct precipitation/discharge relation. An example for such an investigation is shown in Fig. 3 and Fig. 4. Heavy rainfalls during July 7 and 8 lead to an increase of the discharge from 300 l/s up to 800 l/s (Fig. 3). ^{18}O-content and EC changes at the same time show that event water contributes from the beginning to the increase of the discharge. The separation of discharge components yielded a content of up to 50 % of event water in the discharge of the Wasseralmquelle during the discharge peak (Fig. 4). After the discharge peak the amount of base flow remains increased. The karst-water level in the matrix is obviously raised by infiltrated event water and this leads to a larger base flow component. The results of the separation calculation indicate that about 8 % of the total precipitation water from the drainage area had passed the spring three days after the precipitation event.

Conclusions

The discharge of the Wasseralmquelle during hydrological events shows a clear two-component case. Allthough the baseflow water has a mean residence time of 26 years (calculated from ^{3}H records), event water (precipitation, snow melting) appears in the spring after a few hours with the first increase of the discharge. Most of the additional discharge at the beginning consists of event water. This water reaches the spring through “quick” channels in the karst system.

Regarding isotope ratios, EC and temperature, the spring waters from the different outlets in the spring galleries show the same origin. This is evidence for a bigger, well mixed karst reservoir, at least in the vicinity of the spring and during base flow conditions.

In the case of the Wasseralmquelle it turns out that EC of the springwater is probably not a suitable parameter for the separation of short-term discharge components. The electrical conductivity of the infiltrating precipitation water increases relatively quickly in the karstic system.

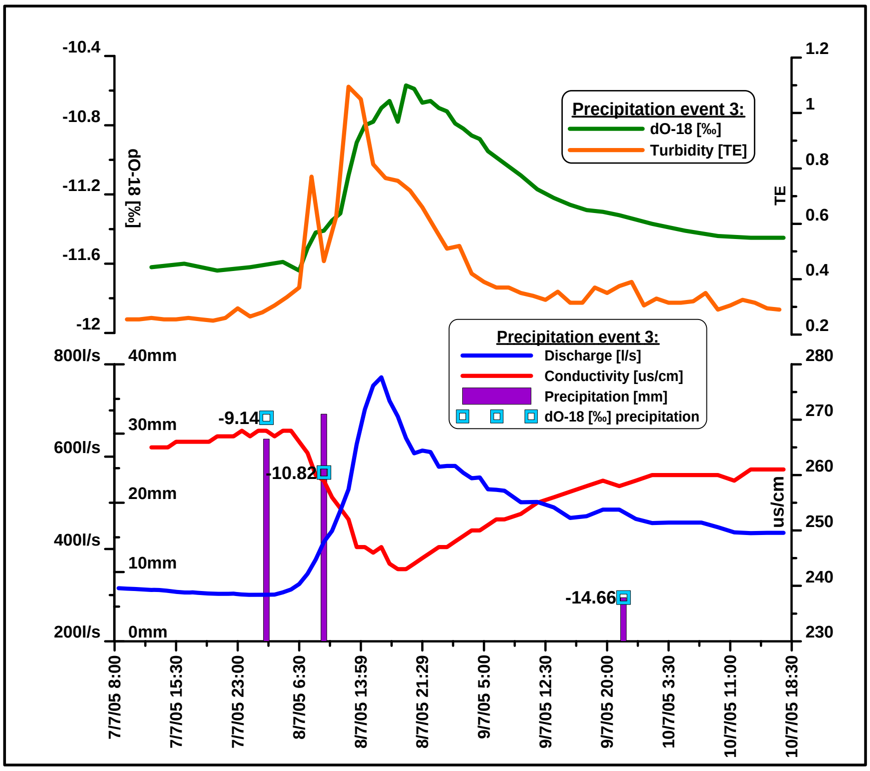

Figure 3. Example for the course of discharge, electrical conductivity, turbidity and δ^{18}O variations in springwater of the Wasseralmquelle during a strong precipitation event, amount of precipitation and δ^{18}O-values of the rainwater samples from the plateau of the karst massif (07.07.05 – 10.07.05).

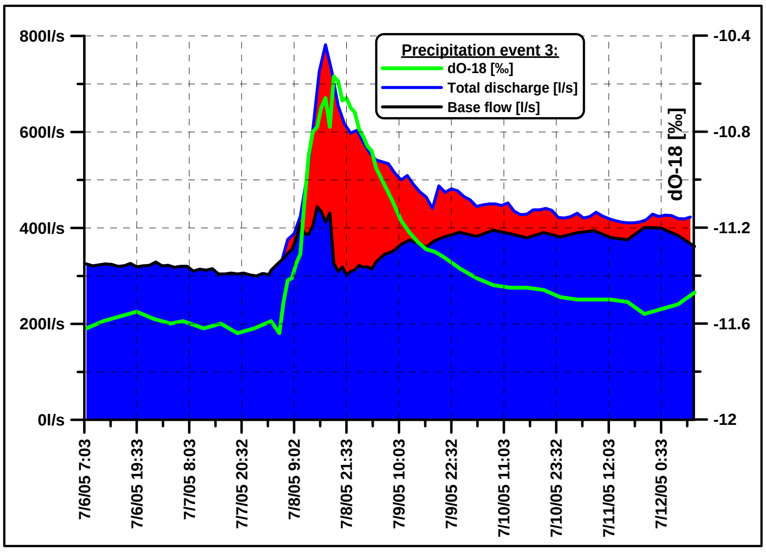

Figure 4. Separation of discharge components for precipitation event 3 (see Fig.3).

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