Isotope-age-dating of alpine spring water and global change: Evidence from temperature, chemistry and tritium data

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Global air-temperature changes over the last 150 years and in particular during the last 30 – 40 years are well documented world-wide. In alpine areas in Europe the increase in air-temperature is even higher in the range of 2° C. Very few studies exist about groundwater temperature changes due to global warming. The increase or decrease in temperature at the point of discharge depends besides the air temperature at the time of infiltration on the amount of precipitation, the local meteorological conditions, the mean residence time, the land use, and the natural and anthropogenic heat flow during the passage underground.

Nearly no papers exist about the water quality changes due to global change impacts and Mean Residence Times (MRT). This is very difficult to evaluate due to missing long-term quality measurements and strong impacts by anthropogenic activities and land use changes. To avoid the complication by anthropogenic land use changes and activities the authors investigated the online discharge, temperature, and electric conductivity measurements as well as quarterly hydrochemical and isotope analyses of 40 Alpine springs from a monitoring network all over the Austrian Alps (approx. 60,000 km²). All the selected springs have a recharge area with no or minimal anthropogenic impacts during the last 30 – 40 years. About 235,000 on-line measurements and 11,000 chemical analyses were evaluated for trends and compared to daily measurements at meteorological and surface water stations close to the recharge areas of the springs. To show the connection to the paleoclimatology changes of existing δ¹⁸O measurements on precipitation and spring water was evaluated as well indicating altitudes of recharge areas in range of 500 – 2400m.

Forty springs with a minimum record of 16 years have been selected for trend analysis over a period of 20 years (1993 – 2013). 28 (74%) of the selected spring show a significant mean increase in water temperature of 0.34 °C in the range of 0.06 to 1.03 °C. This increase is half of the air- and water temperature increase in meteorological stations and surface waters close to the recharge areas of the investigated springs. The electric conductivity linearly increased in 21 (55%) of the investigated springs at about 4%. The discharge stayed the same in most springs. In 23 (72%) springs the content of dissolved oxygen decreased over these 20 years at about 9% percent.

The reasons of the changes in water-temperature, dissolved load and the oxygen content as well as the impact of different Mean Residence Times (MRT) will be discussed and interpreted.