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Quantifying amount and distribution of rainfall based on the Dead Sea sediments geochemistry

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The Dead Sea ICDP Deep Drilling Project recovered a high temporal-resolution record of changes in the East Mediterranean-Levant hydroclimate over the past 220,000 years, reflected in the core's lithology and geochemistry. The greatest changes occur on glacial to interglacial time-scales, where during glacials lake levels were high and aragonite precipitated, and during interglacials, lake levels were low and halite precipitated. However, the lithology and geochemistry of the sediments record much higher frequency variations. Based on aragonite, gypsum and halite abundance along with the XRF (chemical) record, and calibrating these to the known lake level curve, we have generated a modeled lake level curve and estimates of the fresh water runoff with a time-scale resolution reaching decades. In addition to the significant changes in the amount and temporal variability of rainfall based on the lithology and major element chemistry, radiogenic isotopes (U, Pb, Sr) provide information on the spatial distribution of rainfall, which can be quantified by the budgets of these elements in the lake. The lithology around the lake varies, including carbonate rocks in the western and northern catchments and sandstone and crystalline rocks in the southern and eastern catchments, which affects the water sources flowing through each of these lithologies. $^{234}U/^{238}U$ ratios were found to be an excellent proxy for these water sources, where water from the east and southern catchment have low activity ratio of $\sim$1.1 and water from the northern and western catchment have an activity ratio of $\sim$1.6. These different water sources reflect the effects of Mediterranean storms vs. southern climate systems related to the tropics. The U budget of the Dead Sea today ($^{234}U/^{238}U \sim 1.45$) is consistent with the composition of water sources and their fluxes. The fraction and the amount of southern sources contributing to the total runoff over the past 220,000 years can be calculated using the U budget, the $^{234}U/^{238}U$ ratios through time (from authigenic minerals), and the total modeled runoff. Our results show that during glacials the total runoff was 1.2-to-3 times the present-day runoff, while during interglacials it was 20-to-100% of the present-day. The fraction of southern runoff varies most of the time between $\sim$10% in glacials and $\sim$20% in interglacials but can reach 50-90% during peak Northern Hemisphere summer insolation periods during interglacials.