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Climate or industry? What changes Rhine water temperatures?

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The year 2018 showed the highest air temperature-average on record in Germany. With river temperatures exceeding 28°C, the 2018 summer's weather severely impacted industry and ecology. Power plants and industrial plants reduced their cooling water output to minimize the anthropogenic heating of rivers. We investigated which part of the river temperature can be attributed to a change in air temperature or climate and how significant the share of anthropogenic impact is.
An analysis of river water temperatures of four monitoring stations (Basel km 171, Worms km 443, Koblenz km 590, Cologne km 690) along the Rhine between 1980-2018 is presented. We calculate a catchment air temperature and linearly correlate this temperature, together with discharge data, with the river water temperature.
Within the time frame, the change of river water temperatures was significantly different along the Rhine stream course. The total warming rate for water temperature in Basel is 0.05°C per year, for Cologne it is 0.002°C. The decrease of electric power generation at the Rhine (between Basel and Cologne) is the key driver for the difference in warming rate between middle Rhine (Cologne) and upper Rhine (Basel). The shutdown of nuclear power plants in 2011 and the resulting decrease of anthropogenic heating compensated the impact of increasing air temperatures in the river catchment area. Additionally, we can identify business cycles and production rates of industries by the change in river water temperature.