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Climate change impact on precipitation extremes and associated infection risks from combined sewer overflows

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The climate-induced increase in precipitation extremes leads to more frequent combined sewer overflows (CSOs) from wastewater treatment plants into urban rivers, which are often used for recreation. This study simultaneously investigates the changes in precipitation extremes, CSO frequency and volume, the resulting fecal microbial loads to streams, and the human infection risks during recreational use.

Our model approach consists of four steps. First, a disaggregation model is used to increase the temporal resolution of the 22 climate scenarios used to cope with the dynamics of urban hydrological processes. Then, continuous simulations are performed using an urban hydrological model (SWMM) for the C20 period (1971-2000), the near-term future (2021-2050), and the long-term future (2071-2100). We simulated the microbial load of the combined sewer discharge with the fecal indicators *E. coli*, *C. perfringens*, a human-associated genetic fecal marker HF183/BacR287, and the pathogens *Giardia* and *Cryptosporidium spp.* To determine the dilution in the stream, rainfall-runoff modeling is performed using a conceptual semi-distributed hydrological model in the third step for the urban catchment towards the point of CSO discharge. In the final step, a quantitative microbial risk assessment (QMRA) is performed to quantify the potential human infection risks during recreational use.

A hypothetical urban drainage system serves as the study area, which was adapted to the local conditions of a subarea of the city of Vienna including a receiving river. For the precipitation extremes, average increases in precipitation of 13 % for the near future and 19 % for the long-term future are determined over the 22 climate scenarios and 5 rainfall stations considered (extreme event durations 5 min to 24 h, recurrence intervals 0.33 yrs to 10 yrs).

The increase in precipitation extremes results in a higher number of CSOs for both the near- and long-term future. The simulated discharge of the receiving river is often still unaffected by the rainfall event at the time of discharge due to the concentration-time of the catchment, resulting in no direct relationship between discharge and CSO. A realistic estimate of the microbial load discharges during extreme rainfall events is possible for the first time based on the simultaneous continuous hydrological and urban hydrological models in this study.

The resulting concentrations of *E. coli*, *C. perfringens*, HF183/BacR287, *Giardia,* and *Cryptosporidium spp.* in the receiving water as well as the potential infection risks are analyzed separately on a seasonal and annual basis. For both pathogens, infection risks in the distant future are found to increase in all seasons, with lower increases in the winter months (December-February) than in the rest of the year. The highest risk of infection is found in autumn (September-November).