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Counterfactual hydrological pesticide transport modelling: Can we detect long-term in-stream pesticide trends due to mitigation?

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In many countries, agroecological schemes are implemented in order to reduce water quality impairment from agricultural pesticide use. However, demonstrating the success or failure of these schemes is challenging because other influencing factors can confound their effects. For instance, in-stream pesticide concentrations have been found to vary greatly due to the interannual variability in weather conditions (e.g., the timing, intensity, and duration of precipitation events) and pesticide application practices (e.g., the variability in timing and spatial application of differing pesticides that have different chemical properties).

Our current work aims to investigate the necessary conditions to detect significant trends in pesticide concentrations in the context of the Swiss National Action Plan (NAP), which aims to halve the pesticide risk from agricultural activities within Swiss river networks by 2027. We use a modelling approach to explore possibilities and limitations of the existing monitoring scheme for separating long-term effects of the NAP from interannual variability due to weather conditions. For that purpose, we use an existing model for simulating pesticide transport at the catchment scale. After calibration, we simulated 10 years of herbicide concentrations with and without (i.e., the counterfactual) an assumed 50% reduction of the pesticide applied and evaluated the resulting concentration levels.

Our results indicate that the interannual variability due to weather conditions can exceed even a 50% change in pesticide application. This implies that the concentration levels themselves are insufficient to demonstrate the effectiveness of the NAP within a reasonable time horizon of a decade. This is because the lowering of in-stream pesticide concentrations may be due to the timing and intensity of precipitation relative to the application of pesticides and not from the effectiveness of pesticide mitigation measures. Therefore, we explore ways to account for the weather effects on the pesticide concentration levels. Furthermore, we found that comparing the pesticide concentrations in years that have both above average precipitation during pesticide application periods and contain precipitation events that occur shortly after pesticide application can lead to more robust statements about the effectiveness of the mitigation measures. Preliminary double mass analyses of cumulative rainfall during the application period versus cumulative maximum concentrations suggest that significant trends can be identified with 11

years of data (6 years before NAP implementation and 5 years into it). We are currently exploring how sensitive our results are to pesticide properties, such as sorption and degradation half-lives.