Modeling irrigation demand under increasing drought extremes

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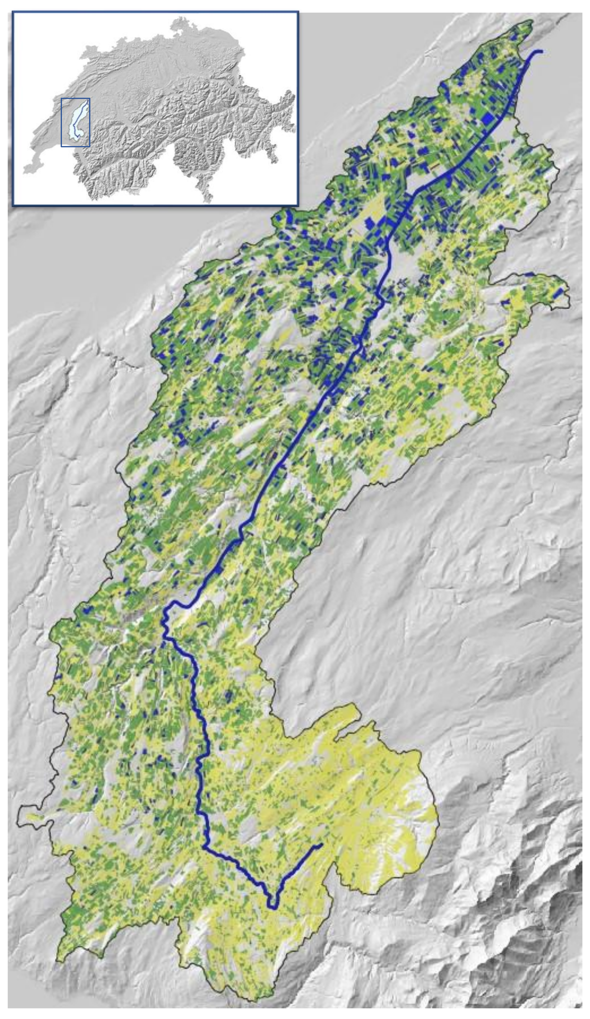
1 Introduction

Droughts are the leading cause for yield losses worldwide, and their intensity and durations are increasing with climate change (Bodner et al. 2015). Rising temperatures and changing precipitation patterns will **increase the need for irrigation** in the future, while decreasing summer **low flows reduce water availability** when most needed (Allani et al. 2020). Because of resulting water use conflicts and summer irrigation bans, approaches are needed to reduce irrigation demand in the first place. Well-targeted **crop and soil management** could increase water use efficiency and thus reduce the reliance on irrigation.

3 Study area

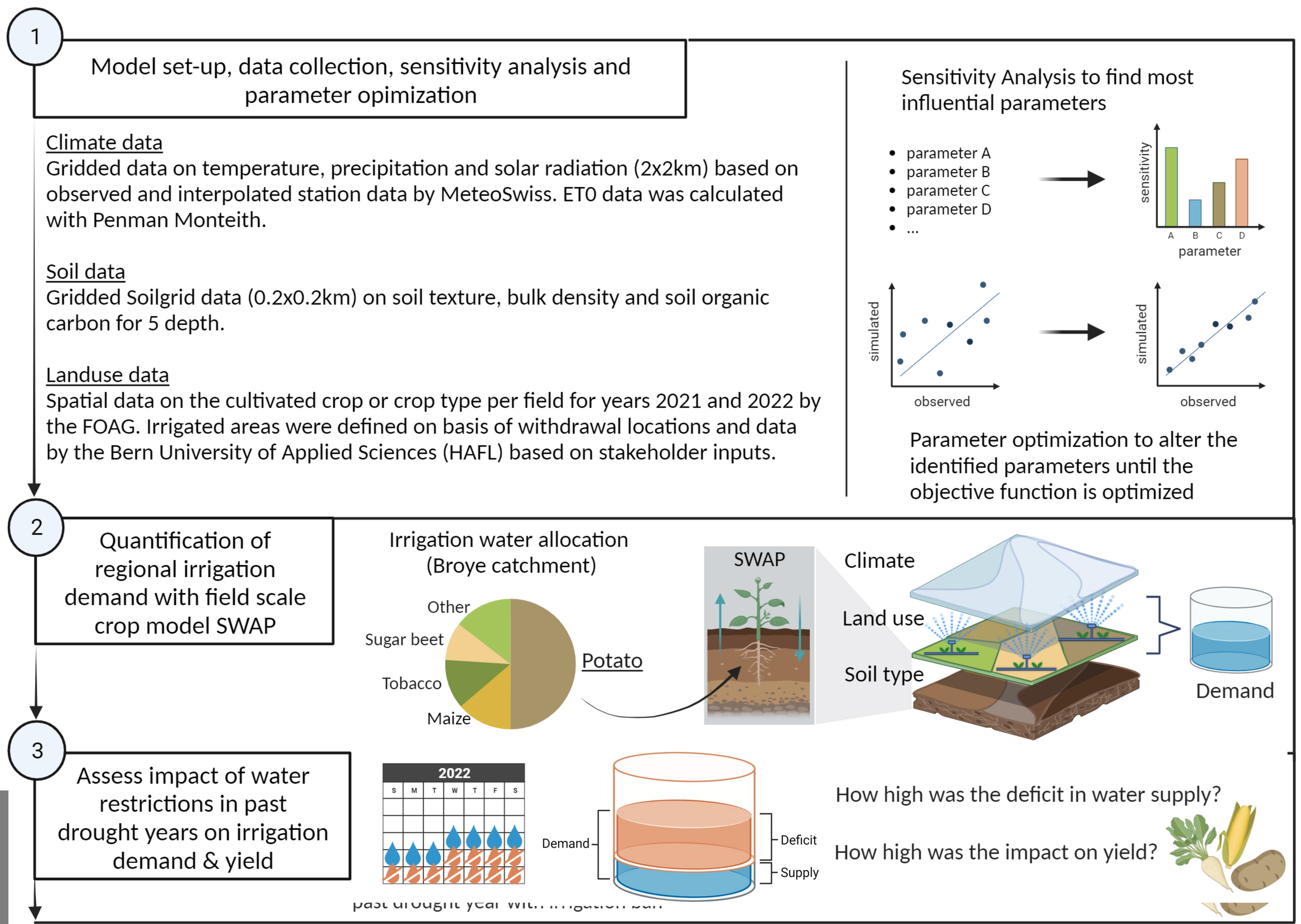
The mid-sized (630km²), prealpine Broye catchment is dominated by agricultural land use. The region is often **affected by summer irrigation bans**, which affect crop yield and quality (Zarrineh et al. 2018; FOEN 2019). Irrigated crops in blue, non-irrigated in green, meadows in yellow (BLW 2021). In this first study we decided to focus on potato, as they take up 50% of the irrigation water in this specific catchment.



2 Research gaps, aims and questions

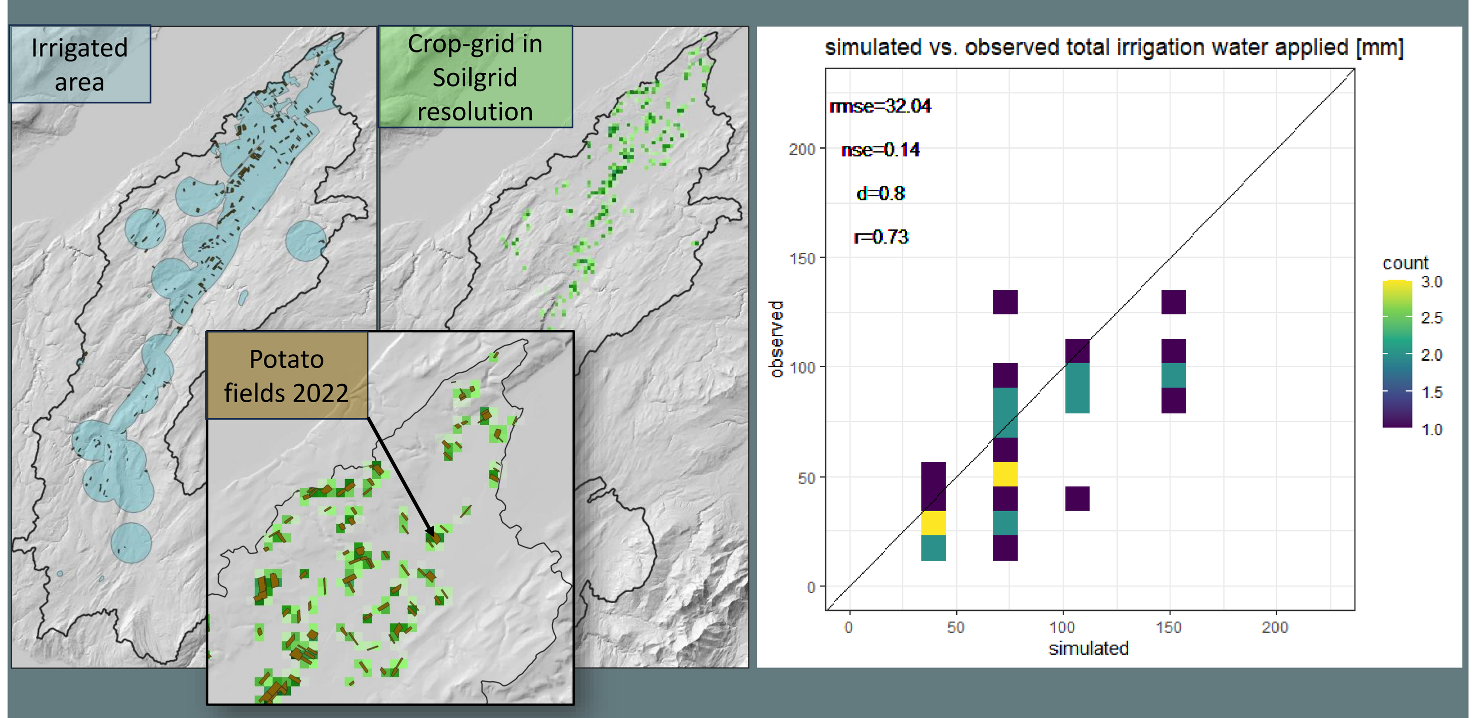
On the Swiss scale there is a **lack of data** on both, irrigation demands and irrigation water consumption. In the face of increasing demands and decreasing availability, the need for this data becomes more urgent. This study aims to bridge that gap by providing an approach to regionally **quantify irrigation demands and their response to irrigation bans**. We want to fulfill this aim by the means of a case study in the prealpine region.

4.1 Workflow

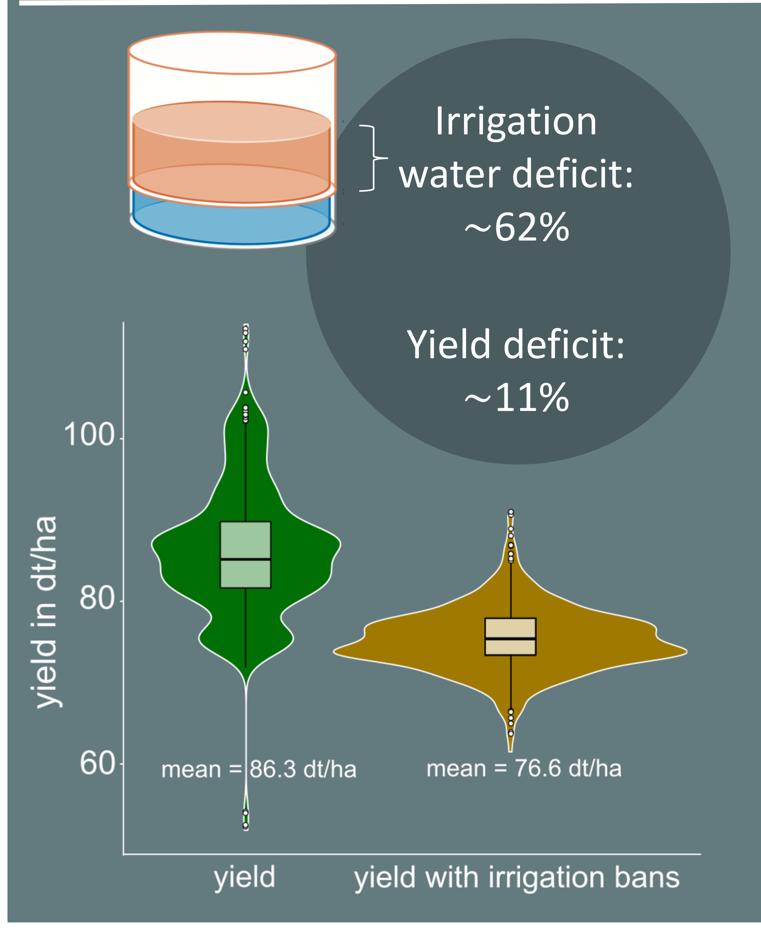


4.2 Regional application

We have combined locations of authorized mobile pumping stations with expert knowledge of the possible range of water transportation (area that can be irrigated shown in blue). Spatial land-use data (here potato fields) was converted to a grid based on the Soilgrid files. Each cell's potato field coverage fraction was determined (darker cells = greater coverage). SWAP was executed for each cell, with relevant soil and climate data extracted for input compilation. We scaled the simulated yield and irrigation values to match the area and summed them for the catchment. As the calibration process is ongoing, we **temporarily employed the default crop** file. For reference, we received observed irrigation amounts, yield, phenology and soil texture data for several irrigated potato fields within the catchment for 2018-2021 by the HAFL. The fit of the simulated versus the observed reference data on irrigation amounts (per season) is displayed below. The evaluation **metrics suggest a good fit**. We ran the model first with no restriction on irrigation, in the second run, we have narrowed the time span based on actual temporary bans for the Broye and tributaries in 2022.



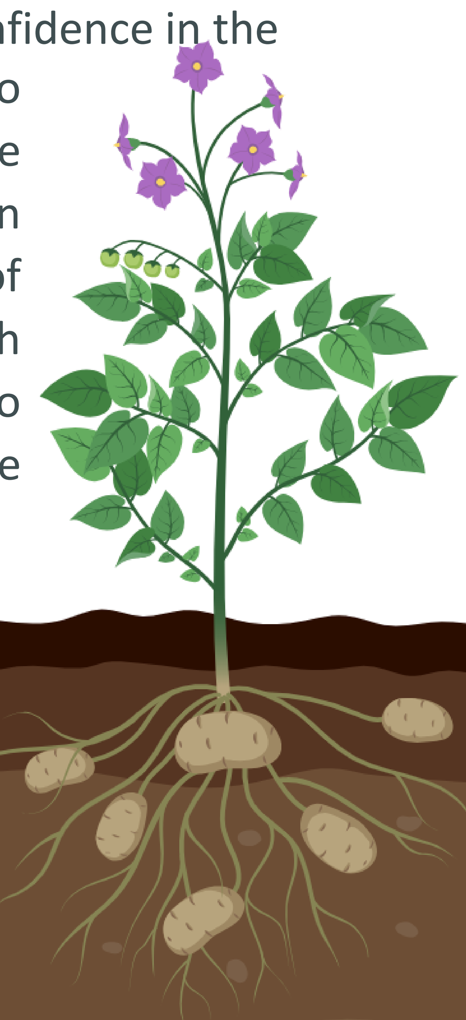
5 Preliminary results (uncalibrated crop file)



We applied the model to all potentially irrigated areas where potato was cultivated in 2021/2022 and assessed the irrigation demand. For 2021, a rather cool and wet year, the irrigation demand was only 5605 m^3. Without considering irrigation bans, the demand for rather hot and dry 2022 is 524756 m^3. Considering the irrigation bans, the amount of water that could be supplied was only 197975 m^3, 38% of the total demand. **The 62% deficit in irrigation water supply led to a reduction in yield by 11% on average**. We can assume this to be a conservative estimation, since drought stress mainly impacts the potato quality, leading to a probably much **higher reduction in marketable yields.**

6 Outlook

The preliminary results suggest, that **the irrigation bans have a considerable impact on the deficit in water supply** and may reduce yields by (at least) 12%. Since the reference data can already be reproduced relatively well with standard parameters, we have confidence in the results. To further reduce the uncertainties, the parameters are subjected to optimization. After having established the baseline irrigation demand, we now plan on **representing several soil and crop management measures** in the model in order to evaluate their reduction potential. There is a lack of understanding regarding the large-scale implementation of such management measures on catchment hydrology. Because of that we also plan to couple our field-scale agro-hydrological model SWAP with the mesoscale hydrological model mHM in future works.



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