Low flow for the River Thames at Reading is likely to continue

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July 2022 has been confirmed the driest July on record for southern England. The same month also saw a record-breaking heatwave with temperatures reaching 40°C for the first time. Precursors to the latest drought was a drier than average winter and spring 2022, the driest winter-spring sequence since the 1970s. Flows in the River Thames at Reading has been declining since spring 2022 and high evaporation from the exceptionally hot and dry summer has exacerbated this decline

How do we predict future river flows?
The Hydrological Outlook, published by the UK Centre for Ecology and Hydrology (UKCEH), publishes monthly updates and projections of the flow of a number of rivers across the UK. The service is based on a technique called the "Ensemble Streamflow Prediction" (ESP). This works by first asking "what would river flow for the next few months look like if we get a repeat of weather from a particular past year?" It then generates a set or 'ensemble' of predicted river flows based a large number of past years. From this, we can make a statistical estimate of what the river flow is likely to look like for the next few months.

What is the outlook for the Thames at Reading?
Unfortunately, the UKCEH's hydrological outlook does not include Thames at Reading. I therefore replicated their approach to look at how river flow near the Reading Hydro site might fare, from September 2022 to August 2023.

The hydrological model I've used to predict flow from weather data is the GR6J model, a model that is also used by water companies in the UK. For the ESP approach to be useful, we first need to confirm that this model is reliable.

Confirm that we have a reliable way to predict flow
To do this, we used the model to predict River Thames flow in the past from past rainfall and temperature, and then looked at how the predictions compare with the actual measured flow. Figure 1 suggests that the flow matches adequately with the measured flow data, available from 1992 onwards, particularly during periods of low river flow which we're interested in. We therefore have reasonable confidence in the model's predictions for the future.

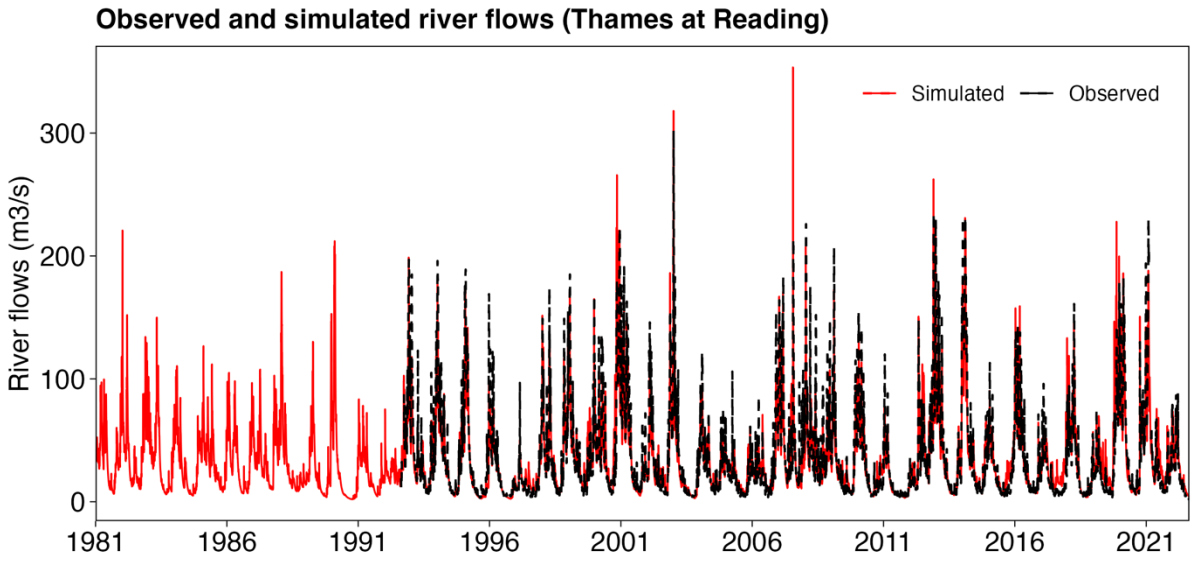


Figure 1

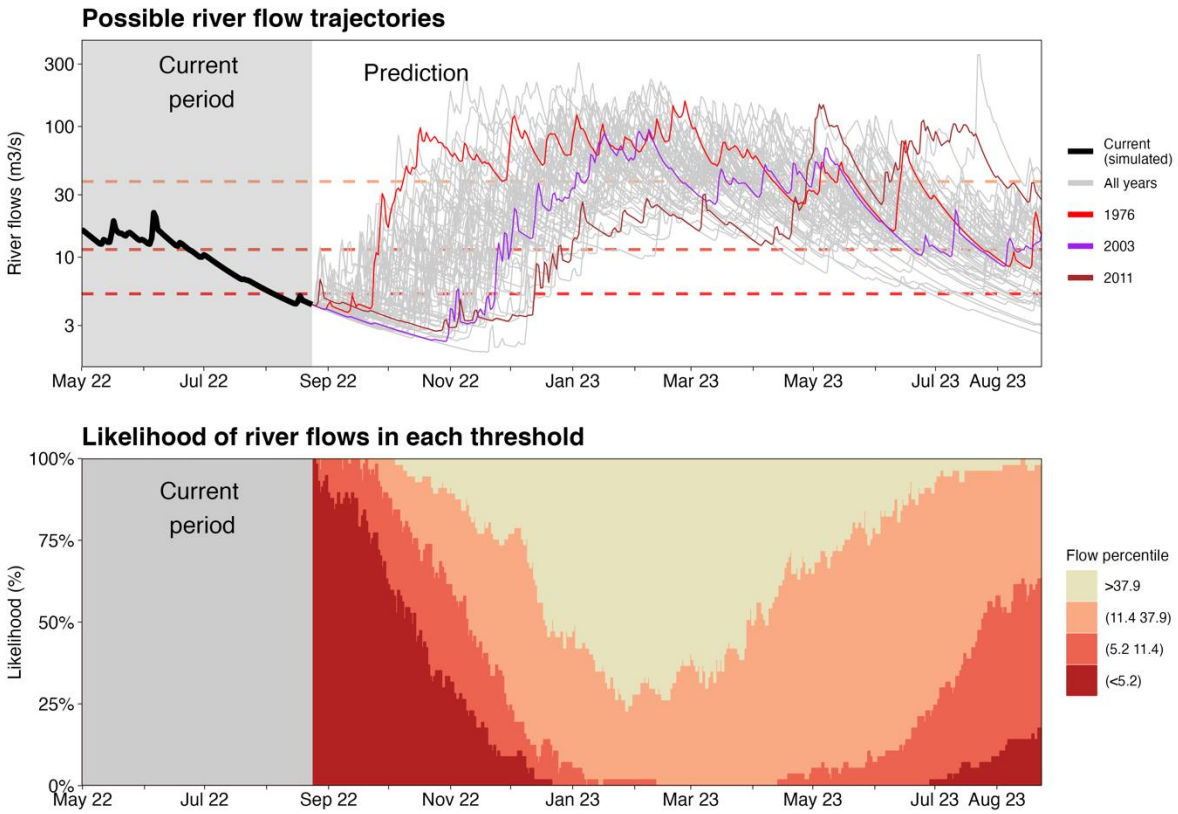
Make predictions for the coming year

We then take the rainfall and temperature of each individual year in the past, append it to the end of July 2022, and use the model to simulate how river flows could fare if we repeat the weather of that year. I have done this using the weather of the past 56 years (1965-2021) which means we get 56 plausible river flow trajectories for August 2022 to July 2023 as shown in grey in Figure 2. The variation in weather from year to year leads to a large variation in predicted river flow. I have highlighted what would happen if we have a repeat of particularly dry years (i.e. 1976, 2003 and 2011)

Assess what flow is likely over the coming months

It's useful to see the wide range of plausible flow rates, but how do we know what flow is **likely** on a given day? One approach might be to calculate the mean of 56 values for each day, and plot a single trajectory for the coming year. However, that would waste a lot of valuable information.

The approach I used is to calculate the percentage of simulations falling in defined 'bands' of flow rate. This gives the % probability that, based on past weather, the flow on a particular day next year will lie in this band, as shown in Figure 3. On each day, the likelihood of river flows below certain thresholds is calculated. Here, I've chosen thresholds relevant to Reading Hydro: a) 5.24 m/s, the hands-off flow below which we are not allowed to generate, b) 11.44 m/s, the minimum flow required for full generation and c) 37.9 m/s, the average flow of Thames at Reading.



Figures 2 & 3

Aggregating the results across the next 3 months, Figure 4 shows that the likelihood of flows remaining below 11.44 m/s remains high over the rest of summer and across early autumn. The prediction isn't very encouraging. It suggests that, without exceptionally high rainfall soon, there is a high likelihood that river flow will be below the level needed for the Reading Hydro turbines to re-start operation until at least October 2022.

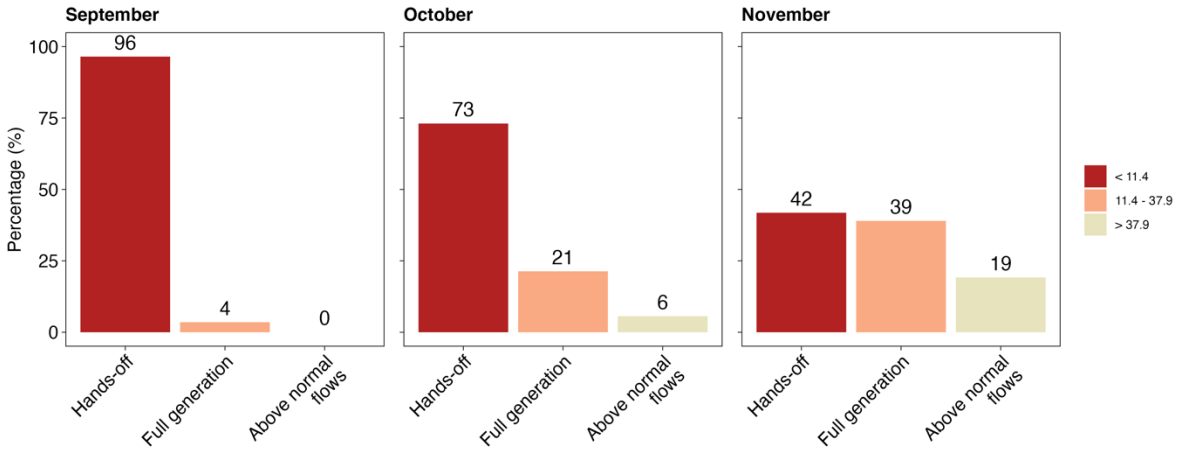


Figure 4

What weather is likely in the next few months?

Long-range forecasts indicate possible continued dry conditions over the next three months, and potentially into the next winter. This is still subject to change, and anything beyond three months is much more uncertain. As the analysis above is based purely on past weather data, it becomes less reliable beyond the near future. River flows are virtually certain to remain below the flows needed for full generation for the rest of the summer and early autumn. There could be short-duration, thunderstorms in the meantime like the ones we've seen recently but they do not significantly affect river flows and won't be enough to bring flows back to normal conditions.

Reading Hydro volunteer Wilson Chan is a PhD student at Reading University, carrying out research on the impacts of climate change on UK water resources. He's applied his data modelling expertise to predict likely flow in the River Thames over the next few months. In a future blog he'll update the data and also discuss the likely impact of climate change on the Thames flow. It's great to have Wilson's data modelling expertise to help us understand river flow better (even though the outlook is somewhat gloomy for the next few months....).