A new report summarizes how climate change is affecting the water cycle in Germany

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Climate change not only involves rising temperatures – it also causes changes in the hydrological balance. Precipitation, evaporation and groundwater formation will follow a new rhythm in future. The consequences of these changes for water levels, ecosystems and sectors

that depend on water, like agriculture, are presented in a new report by researchers from the Climate Service Center Germany (GERICS). The authors include Stefan Hagemann from the Max Planck Institute for Meteorology in Hamburg.

People still have very vivid memories of the record-breaking summer of 2003: During a heat wave in the first half of August, temperatures in some locations in Germany exceeded 40 degrees Celsius, and many people suffered from the effects of the extreme heat. Because little rain had fallen over the course of the year, the water levels in rivers and reservoirs fell in late summer, drastically in some cases. Shipping had to be halted on some sections of the rivers Elbe and Danube. Nuclear power plants reduced their output because they had insufficient cooling water available to them. Plants withered in the fields and the risk of forest fires increased.

According to the authors of the GERICS study, Der Einfluss des Klimawandels auf die terrestrischen Wassersysteme in Deutschland ("The influence of climate change on terrestrial water systems in Germany"), which was published in February 2017, global warming will pave the way for similar periods of drought in the future. The study summarizes the findings of 29 individual studies carried out between 2009 and 2013 on the impacts of climate change on the hydrological balance in Germany. The six authors stress that they are not in a position to provide detailed forecasts on how the flow rates and water levels in individual rivers will develop. However, some trends and their consequences can already be identified.

For example, observations show that precipitation in Germany has increased by 11 percent since 1881 – and according to the forecasts, this trend is set to continue. It now rains considerably more in winter almost everywhere in Germany; in some cases, precipitation volumes have increased by as much as 30 percent in the cold season. In contrast,

summers in many Federal States have become dryer.

Longer periods of low precipitation

The water levels in the major rivers will change as a result of this development, the authors report. Previously, the water level in most flowing water bodies was highest in spring when the snow melts and lowest in summer or autumn. The authors assume that, overall, the periods with low water levels will increase in duration until the end of the century. This has impacts on inland navigation, for example. Hagemann and his colleagues expect that the navigability of the Elbe River in summer will deteriorate from the year 2050, particularly in the Federal States of Saxony, Saxony-Anhalt and Thuringia. "Low water will arrive earlier, last longer and fall below the usual levels," says the report. In contrast, the researchers were unable to identify any trend for the Rhine, and the Danube water level will probably reach its lowest point in late summer rather than autumn – due to the earlier snowmelt.

The falling water levels in summer also affect the energy supply, which requires large volumes of river water for cooling. If there is not enough cooling water available, production at nuclear power plants must first be reduced and then entirely halted. Another problem: Water temperatures in German rivers are also rising due to climate change, on average up to two degrees by 2100 and this also creates a difficulty for cooling in nuclear power plants. Because high water temperatures and low water levels will arise more often than before, the power station output will fall during summer months in the 40 years to come, write the GERICS researchers.

Agriculture will also have to adapt to more frequent, longer and more intensive periods of drought in summer. In North Rhine-Westphalia, for example, the number of days on which fields have to be irrigated, will double from 30 to 60 by the year 2100. According to the report, the

flood risk will also increase – among other reasons because less precipitation will fall in the mountains in the form of snow. Hence, the rainwater that falls at low altitudes is transported away by the rivers and does not remain standing until spring. It is difficult, however, to produce more detailed forecasts for floods as their frequency depends not only the climate but also on many other factors, for example land use and reservoirs.

Ecological community in bogs, marshes and lakes under stress

Hagemann and the other authors predict that freshwater ecosystems will come under particular pressure. "The ecological balance of terrestrial water systems has already been dramatically altered by human activity," states the report. Changes in land use, population growth and environmental pollution pose a threat to the communities of organisms that live in bogs, marshes, lakes and rivers. Further stress factors will be added to these through climate change: falling groundwater levels cause lakes and small streams to dry out and higher water temperatures exacerbate existing problems arising from the overuse of fertilisers and promote algal bloom. Non-native species may also proliferate more than before. It is very difficult to estimate the precise scale of the consequences as ecosystems often react unpredictably to environmental changes.

Climate change also affects the groundwater, from which most of the drinking water is extracted. However, the German population will not face water shortages in the future. According to the study, water supplies throughout the country will be sufficient. Nonetheless, the report notes that temporary bottlenecks could arise in the water supply in some regions, for example Brandenburg or eastern Bavaria. Moreover, groundwater levels will fluctuate more strongly in future – on the one

hand, because some of the precipitation has moved from summer to winter and, on the other hand, because more groundwater will have to be extracted during periods of drought in the summer for irrigation. At the same time, the researchers predict a fall in the demand for water due to population decline. More efficient household appliances and the increased use of rainwater also result in lower drinking-water consumption. In any case, the authors recommend that water suppliers consider the consequences of climate change to ensure, for example, that peaks in demand on hot days or during periods of drought can be covered.

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