



## Short Communication

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DOI 10.2312/PIK.2018.002

# When climate projections return: Unusual insights for German rivers from a climate impact study for Beijings Guanting region

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## From Potsdam into Beijings Guanting Region

The possible characteristics of regional climate change and how this will affect the water balance of the German capital Berlin and its surrounding basins drained by the eastern German rivers Havel, Spree and Elbe have been of interest since the first days of the Potsdam Institute for Climate Impact Research (PIK) (Gerstengarbe et al. 2003; Wechsung et al. 2005).



Fig. 1: Location of the Guanting basin (solid boundary line around Datong) within the Hai River basin (dashed boundary line, Fig. 2.3 from Wechsung et al. 2017)

The scenario techniques and modeling systems that were developed together with other German research institutions for a number of studies on this area were also taken to China in 2010 and have since then been applied to the Guanting region north-west of Beijing as part of a German-Chinese research initiative. The scientific investigations were jointly supported by the Chinese and German national ministries of research.

The Guanting reservoir initially built to protect Beijing from major floods is known nationwide in China as the first project of this order, and was begun immediately after the foundation of the People's Republic. The region upstream of the reservoir contains within an area of 43,000 km<sup>2</sup> two well-known cities: Zhangjiakou, the main host of the 2022 Olympic Winter games and Danton, the 'Capital city of Chinese Coal' (Fig. 1).

PIK collaborated with German partners from earlier studies at home and with several Chinese research institutions. Thereby, we were able to continue a long research tradition in the region, stretching from the work of the German geographer Ferdinand von Richthofen to joint activities in recent years supported by the Federal State of Brandenburg, with its promotion of Brandenburg's small and medium enterprises to improve the water quality of the Yongding inflow to Beijing as one of the latest milestones. The final outcome of the recent scenario and modeling work has now been published by the scientific publishing house Schweizerbart under the title 'Sustainable water and agricultural land use in the Guanting basin under limited water resources' (Wechsung et al. 2017).

### Insights from China for Germany

As in similar applications, PIK models formerly developed and tested for German conditions had to undergo serious validation procedures before they could be applied abroad, often with advances that made them also more suitable at home. This happened also on this occasion for some of the models used. In one case the researches were confronted with a new, rather rarely publicly reported situation, whose coverage might be of general interest and which will therefore be more extensively described in the following.

The statistical climate model STARS, which was used before in several studies for Brandenburg and Germany (Gerstengarbe et al. 2013; 2015) turned out to be only of limited use. The basic assumption of the model is the usability of the interannual climate variability, i.e. the year by year changes in the relationship between temperature and other climate variables, for the projection of the complete long-term climate change from a prescribed temperature increase. It was shown that this assumption was not untenable.

When a complementary precipitation trend is to be determined for an expected longtime warming in a region, it would necessarily follow from that basic assumption for many regions in the boreal climate zone that the precipitation rather decreases during summer and rather increases during winter. This is a consequence of the fact that warmer summers usually have more sunshine and less rain, while warmer winters are more likely overcast and linked to higher precipitation in those regions (Wechsung & Wechsung 2015; 2016). Indeed, the STARS model can generate climate records coming from its first

principle that illustrate such a change. However, it does not contain a reasoning that supports a long-term projection of climate change into this direction. Thus, it can not to be considered a climate model. The theoretical analysis that was carried out during the Guanting project has now been published in relevant scientific climate journals (Wechsung & Wechsung 2015; 2016).

Inspired by these insights drawn within a project focusing on China, the above-mentioned studies carried out earlier for the East German rivers Elbe, Spree and Havel were repeated using latest ensemble simulations that were compiled at PIK (Warszawski et al. 2014). As the result, we concluded that previous studies about regional precipitation and discharge changes due to climate change based on STARS had to be considerably corrected. The future precipitation levels for eastern Germany might remain fairly stable, rather than decreasing at the extent earlier projected by STARS. In particular the decrease in summer precipitation is restricted to a shorter time period and might be less pronounced than formerly suggested (see also Hübener et al. 2017). These recent state-of-the-art projections could have been by chance also similar to the previous ones (following the logic of ‘ex falso quodlibet’ – from falsehood anything follows), although for a different reasons. However, this was not the case.

As a follow-up consequence of the recent projections of precipitation, the rivers' minimum discharge might still further decrease in many parts of the Elbe basin, which drains a large share of eastern Germany, but not to the extreme level formerly thought. The main factors for such a decrease would be warmer winters with less snow storage in the low mountain ranges and the generally higher rates of evapotranspiration due to the temperature increase expected (Roers & Wechsung 2015; Roers et al. 2016).

Regardless of the new classification of the STARS scenarios, earlier hydrological studies based on STARS still supply meaningful information about the consequences of extreme droughts and possible adaptation measures (Wechsung et al. 2005; 2013).

For our scenario region in China, the implications of the new methodological insights were even more relevant than for the Elbe region, which also motivated this in-depth analysis. In discussions with the ‘Haihe-River Commission’ - the water management body responsible for the region and thus a major stakeholder - it was repeatedly emphasized that the first STARS results would indicate a decreasing flood risk. The decreasing flood risk results from the decrease in heavy rain events in particular during spring and summer that is generated by STARS following its first principle.

The lately published inter-comparison study REKLIES-DE about currently available climate simulations for Germany illustrates the consequences of STARS first principle in a retrospective also for its home country (Hübener et al. 2017, p.22): “In comparison between the periods 2071-2100 and 1971-2000 increases the precipitation above the 95. and 99. Percentiles in all simulations except in those by the model STARS.” In Figure 2 we present the graphics related to this quote and give further information.

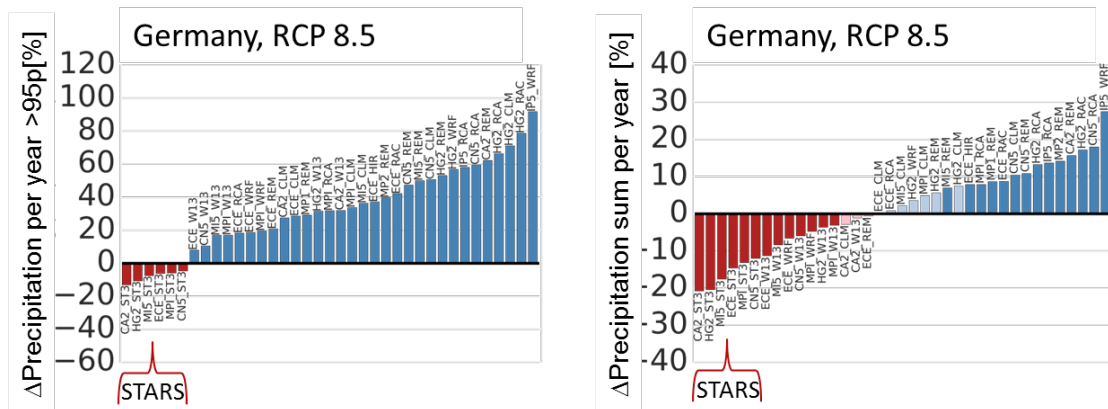


Fig. 2: Intercomparison of simulation results of different combinations of global (front part of column labels) and regional climate models (back part of column labels) with results of the model STARS (here labeled with ST3) for the scenario RCP 8.5. The figures present the changes between the periods 2071-2100 and 1971-2000 for the sum of extremely high daily precipitation events above the 95. percentile within a year (left) and changes in the precipitation sum (right) (compare Hübener et al. 2017, Fig. 5.4, pg. 22; Fig. 8.5, pg. 37, graphics taken from [https://swift.dkrz.de/v1/dkrz\\_a88e3fa5289d4987b4d3b1530c9feb13/ReKliEs-De/Internet-ReKliEs-De/startseite.html#Einzelbilder](https://swift.dkrz.de/v1/dkrz_a88e3fa5289d4987b4d3b1530c9feb13/ReKliEs-De/Internet-ReKliEs-De/startseite.html#Einzelbilder), 22.1.2018)

This again could allow a reduction of the flood protection function of the reservoirs, which would release additional resources for the irrigation of agricultural areas during periods of drought in case of the Guanting region.

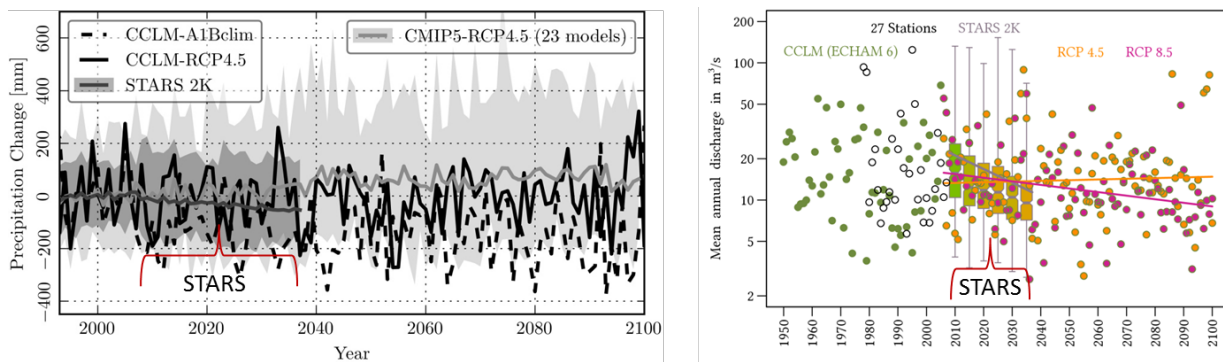


Fig. 3: Simulated tendencies in precipitation (left; Menz 2017, Fig. 3.7 p. 78) and discharge (right; Conradt, Fig. 4.13 p.99) for the Guanting region. The simulations with STARS were carried out for the period 2013 to 2037 postulating a temperature increase of 2°C between the reference period 1978-2007 and the pentad 2033-2037. In addition, the tendencies of simulations for precipitation and discharge are presented, that are based on runs of the dynamical regional climate model CCLM for different global driving forces by the climate model ECHAM 6 (precipitation, left and discharge, right) and are taken from simulations of 23 global climate models (left) about the precipitation up to the end of this century.

However, complementary simulations carried out additionally using a wide spectrum of global climate models point in a different direction (Fig. 3). Thus, the precipitation extremes would rather increase (Fig. 3 left, light gray background mountain) and subsequently the current flood risk would at least remain (Fig. 3 right, upper boundary of the point cloud), but not decrease (Menz 2017; Conradt 2017).

These results have been recently confirmed by a global analysis by PIK researches about the effect of a state-of-the-art bundle of climate change scenarios until 2035 to 2044 on flood risks and adaptation requirements (Willner et al. 2018). Within their analysis, the authors show a spatially consistent increasing adaptation demand for soaring flood risk in the Haihe basin around Beijing, including the Guanting region (ibid, Fig. 3).

The regional consequences of the record rainfall in the summers of 2011 and 2012 for Beijing and its surroundings illustrate again the relevance of a wrongly taken decision towards less flood protection founded on the expertise of a German-Chinese research collaboration.

Nevertheless, water shortage will remain a serious problem for the Guanting region. This was shown also by an extensive analysis using a wide spectrum of climate models (Fig. 3 right, lower boundary of the cloud of points). Beside their methodological restrictions STARS simulations (Fig. 3 right, figure center) could be still used to explore the regional vulnerability of the water-related economic sectors to warmer and dryer summers. Thus, it was done so also in a responsible way.

The regional water availability per capita is currently among the lowest of the world, which has led to intensive use of groundwater resources. The analyses of the Guanting project have shown that the resulting sinking of the groundwater table will further continue and will be amplified by climate change unless drastic measures are taken in agriculture, by local industries and by the municipalities beside the one currently discussed for future land and water use. The problems are even strengthened by the continued decline of the water quality of surface waters which will increase the demand for the relatively clean ground water. Sustainable water use is still a challenging task for the region. However, the boundary conditions, requirements and possibilities are better known now than before.

German geographers and environmental scientists may support this process of keeping their tradition of research in China alive and take valuable lessons about their research approaches and models back home at the same time.

These new insights result not only from the expanded test area for the research approaches and models, but also from the different situation of conflicts encountered by German researchers.

In our case, decreased flood protection as consequence of the STARS projections was never a seriously considered adaptation response for Germany. The originally projected drastic decrease of the low water levels in German river basins was only discussed in relation to the affected water users such as power stations and freight shipping. The impact simulations for these sectors revealed plausible vulnerabilities. The resulting need for adaptation already provided motivation for the participating stakeholders to question the sound basis of the scenario model. It was mostly left to the model developers to respond to these challenges. The stronger nexus between questions of flood protection and low water replenishment in the Guanting region required a more rigorous questioning of the used modeling approach within STARS, which went beyond the inner circle of the model developers. This challenge would not have existed without the dramatic situation of conflict between the regional interest in either less or more filled reservoirs to foster either flood or drought protection, which we found in the Guanting region. Looking back, the change in perspectives can be considered as one major benefit of the

temporary relocation of the research focus from Germany to China for the better scientific foundation of climate projections also for Germany.

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