



## Human-induced climate change has decreased wheat production in northern Kazakhstan

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Northern Kazakhstan is a major exporter of wheat, contributing to food security in Central Asia and beyond, but wheat yields fluctuate and low-producing years occur frequently. The most severe low-producing year in this century was in 2010, leading to severe consequences for the food security of wheat importing countries. To date, the extent to which human-induced climate change contributes to this is unclear.

In this session, we present the first attribution study for wheat production in northern Kazakhstan, which is at the same time one of the very first climate impact attribution studies for the agricultural sector in general. We quantify the impact of human-induced climate change on the average wheat production as well as economic revenues and on the likelihood of a low-production year like 2010. For this, we use bias-adjusted counterfactual and factual climate model data from two large ensembles of latest-generation climate models as input to a statistical subnational yield model. The climate data and the yield model were shown to be fit for purpose as the factual climate simulations represent the observations, the out-of-sample validation of the yield model performs reasonably well with a mean  $R^2$  of 0.54, and the results are robust under the performed sensitivity tests.

Our results show that human-induced climate change, and explicitly increases in daily-minimum temperatures and extreme heat, have had a critical impact on wheat production, decreasing yields between 2000 and 2019 by around 6.2 to 8.2% (uncertainty range of two climate models), increasing the likelihood of the 2010 low-production event by 2.1 to 3 times, and leading to economic losses of 119 to 158 million USD. The latest IPCC report assessed that climate change has today mixed positive and negative impacts on wheat production in Central Asia, but the

results are stated with low confidence as studies are sparse in this region. This climate impact attribution study addresses this gap, finding clear indications for a negative influence of climate change, especially via temperature increases, on wheat production in northern Kazakhstan.