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A new project AFTER investigates the impacts of climate change in the Europe-Russia-Turkey region

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A new research project AFTER "Impacts of climate change and climate extremes on Agriculture and Forestry in the Europe-Russia-Turkey Region" started in 2018. It was designed to bridge the gap between supply and demand of state-of-the-art climate information to assess the impact of changing climate on agriculture and forestry.

The IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial level and related global greenhouse gas emission pathways "Global Warming of 1.5°C" provides clear scientific evidence that global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate (high confidence) [IPCC SR1.5°C, 2018].

Human-induced global warming has already caused multiple observed changes in the climate system [Hoegh-Guldberg et al., 2018]. The frequency and intensity of extreme weather events, in particular in the mid-latitudes, have been increasing [Coumou and Rahmstorf, 2012; Horton et al., 2016; Nature Editorials, 2017; Stagge et al., 2017; Sévellec and Drijfhout, 2018]. Belgium recorded its warmest summer in 2018 since the start of the measurement record [https://www.meteo.be/meteo/view/nl/39993011-Zomer%2B2018.html]". Northern Russia experienced an exceptionally warm summer with July up to 12°C warmer than normal [https://climate.copernicus.eu/surface-air-temperature-june-2018].

Both extreme weather events and less dramatic but potentially more serious long-term climate effects can impact on economic activity in the key economic sectors and services. One of the key economic sectors, agriculture, is highly vulnerable to climate change. Warmer climate may lead to robustly positive calorie yield change for a number of EU Member States [Balkovič et al., 2018], however, drought across the growing season may have a negative effect on the yield potential [Semenov and Shewry, 2011]. Crop damages were observed in Belgium after prolonged drought during the spring seasons of 2007, 2010, 2011 and 2015 [Gobin, 2018; Zamani et al., 2015].

The combined heat and drought stress of 2018 resulted in crop failure in many areas and concerns were omnipresent in the public press during summer 2018, e.g. the grain harvest of 2018 in Germany was forecast to be the lowest in 24 years

[https://www.dw.com/en/german-river-levels-fall-in-heat-drought-as-farmers-seek-help/a-45100169]; according the Latvian Ministry of Agriculture the provisional losses in 2018 due to the drought, heatwaves, and forest fires may total up to approximately 359 million euros [https://www.zm.gov.lv/presei/zemkopibas-ministrs-janis-duklavs-ar-igaunijas-lauku-attistibas-minist?id=9737].

A warmer climate also affects forest ecosystems, e.g. forest disturbance [Seidl et al., 2017]. Analysis of 478 most extreme wildfires between 2002 and 2013 showed the close link between disastrous fires, and extreme droughts, and heat waves [Bowman et al., 2017]. Extreme consequences from forest-peat fires in European Russia have resulted from the combination of climate change, land use and specific weather conditions within second half of the summer 2010 [Sirin et al. 2011].

In this context, a comprehensive, scientifically based assessment of the multiple risks of observed and future climate change for agriculture and forestry is required [Keenan et al., 2013, Samaniego et al., 2018]. Exciting advancements have been made in climate science and a vast

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amount of climate data have been produced over the last years to assess possible climate change and associated changes in the intensity, frequency and duration of weather/climate extremes [Taylor et al., 2012]. The European Roadmap on Climate Services [European Commission, 2015] highlighted, however, that there is an increasing demand in bridging the available climate information to users' needs. In addition, open exchange of information should be fostered to enhance the impact of research and to ensure a more efficient use of scientific developments.

AFTER goals and objectives

AFTER (https://www.projectafter.net) is funded by the "ERA.NET Plus with Russia" Programme (https://www.eranet-rus.eu) to foster research and innovation cooperation between the EU Member States, Turkey and Russia. It is a truly interdisciplinary project as it integrates the expertise of climate scientists and impact specialists together with stakeholders from the selected regions. Bringing different expertise into the project addresses the challenges on how to translate the best available climate data into tailored information that is useful for a wide range of stakeholders in the agriculture and forestry sectors. On the other hand, working with researchers from different countries, different disciplines and scientific traditions in one project provides additional expertise at national and local levels and helps avoid duplication of effort.

The main objective of AFTER is to study the impact of climate change and climate extremes on the selected regions with extensive agriculture and forestry across Europe, Russia and Turkey. The rationale behind this is as follows.

Although a number of spatially high-resolution experiments are already available for Europe and Turkey [e.g. EURO-CORDEX, or Med-CORDEX; Jacob et al., 2014; Giot et al., 2016], Russia is covered by fewer and mostly large-scale simulations. However, this region is crucial for understanding the correlations of climate change-induced temperature and precipitation extremes in the higher and middle latitudes. Due to the size and extension of the country, Russia presents a wide range of climate zones – from the Arctic in the north to deserts and subtropics in the south; from lowlands to the high mountains [Trewatha, 1954]. Ongoing climate change combined with human impacts is considered as the key risk for the vegetation cover, biodiversity of flora and fauna, ecosystems services [Sergienko and Konstantinov, 2016; Tchebakova et al., 2016; IPBES. 2018]. Climate driven changes in water and energy exchange could affect vegetation distribution, structure and production [Liu et al. 2015; Parfenova et al., (2017)]. Longer growing seasons and precipitation changes could make previously inappropriate lands suitable for agriculture [US National Intelligence Council, 2009].

In this context, a consistent set of climate projections for the entire region of Europe, Russia and Turkey is of particular importance. While Earth System Models (ESM) could provide the large-scale picture of the climate and interactions between different components of the Earth System, regional climate models (RCMs) with high spatial resolution are required when it comes to investigating adaptation strategies at local levels.

A newly designed experiment for the CORDEX Central Asia domain

AFTER will follow the protocol of the Coordinated Regional Downscaling Experiment (CORDEX) [Giorgi et al., 2009; Jones et al., 2011]; the CORDEX Central Asia domain is selected. It covers not only nearly the entire part of Russia east of the Urals, but also the regions in Eastern Europe and Turkey. Ozturk et al. (2017) investigated future climate changes in seasonal mean temperature and precipitation over this domain with the regional climate model RegCM4.3.5. The downscaling, however, was done for 50 km and for time slices only.

AFTER will go beyond this and will provide an added value for science-based climate information that is already available for the CORDEX Central Asia domain. Two regional climate models ALARO-0 (RMI) [De Troch et al., 2013] and REMO (HZG-GERICS) [Jacob, 2001] have been used. The coordinated model set-up, multi-model-multi-scenario experiments with high-spatial resolution up to 25 km and systematic model evaluations will enable an accurate estimation of local climate information along with their uncertainties. Furthermore, the investigation of differential climate impacts in the different vegetation and climate zones under global warming of 1.5, 2, and 3-degree worlds will contribute to the scientific basis of the Paris Agreement [UNFCCC, 2015].

These newly designed simulations will build the basis for investigating climate change impacts on forest ecosystems, crop yields, phenological processes of the crops and quality and quantity of the crop yields.

Changes in climate, carbon dioxide (CO_2) concentrations in the atmosphere and plants phenology could affect the growth of crops and forests. The Community Earth System Model (CESM) will be used to simulate and quantify biogeochemical and biogeophysical land processes to include phenology, hydrology, photosynthesis, carbon-nitrogen interactions and dynamic plant cover changes. Impact analysis under different climate scenarios will enable the formulation of adaptation and mitigation strategies for the agriculture and forestry sector.

Due to climate change $+2^{o}$C increase in land surface temperature per decade was prominent marked in Turkey (Tayanç et al., 2009). The sowing period, the start and end of the growing season and heading period of winter wheat have been offset in the Mediterranean and continental climate zones by a period of 2 to 4 weeks, respectively. This directly affects quality and quantity of winter wheat yield in Turkey. In this context, the start and end of the growing season for common wheat (*Triticum aestivum*), and the impacts of land surface temperature change on the phenological cycle will be investigated in the project.

Strengthening scientific cooperation

As it was mentioned before, AFTER combines the expertise of different research groups concerning regional climate modeling, extreme value analysis, modeling of crops and forestry and providing climate services. Collaboration among research groups with a close contact to stakeholders from different countries is of central importance to the project. The representatives of Germany, Belgium, Latvia, Russia and Turkey are involved in AFTER. Nevertheless, the AFTER community would be delighted to have the contribution of other countries, which are covered by the CORDEX Central Asia domain. We welcome members of the end-user communities as well as from the research and climate service providers, who are interested in generating and applying climate information in support of decision-making in the selected region.

We are convinced that open exchange of knowledge, expertise and data will improve synergies between research activities at international, national and local levels and facilitate the scientific engagement in the Europe-Russia-Turkey region.

More information about the project can be found at https://www.projectafter.net; you can stay updated on the latest development via our newsletter (after.newsletter@gmail.com).

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