Evaluation of the performance of agrometeorological indicators in lead times of weather forecasts as well as climate scenarios

Sabina Thaler[1,2*], Josef Eitzinger[1], Gerhard Kubu[1], Ahmad Manschadi[3], Marlene Palka[3], Stefan Schneider[4]

[(1)]Institute of Meteorology and Climatology, University of Natural Resources and Life Sciences, Vienna, Austria; [(2)]CzechGlobe-Global Change Research Institute CAS, Brno, Czech Republic; [(3)] Institute of Agronomy, University of Natural Resources and Life Sciences, Vienna, Austria; [(4)] Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Vienna, Austria

*E-mail: Sabina.Thaler@boku.ac.at, Tel.: +43/1/47654-81420

1. Objective of this study

With the help of the GIS (Geographical Information System)-based simulation tool ARIS, various agro-climatic indicators can be calculated for the Austrian agricultural area on a 1 km grid scale. These indicators can be used to monitor or predict the impact of adverse weather conditions on crops. Within this study, different abiotic and biotic risk indicators were estimated for main crops and grassland, including a quantitative and qualitative assessments of the occurrence and severity of weather-related impacts. Weather forecast data and climate scenarios were used as ARIS input to perform a statistical evaluation of the simulated indicators and to assess the suitability of the ARIS system for farm based decision-making.

2. Material and methods

INPUT

INCA: daily data

Forecasts: 10-days and 7-months global forecasts, downscaled to 1km, 16 ensemble members; data from 2018 until now

ÖKS15 projections: 13 Austrian climate change projections, RCP 4.5 and RCP 8.5; 1981-2010 vs. 2036-2065

MODEL

ARIS

(**A**gricultural **R**isk **I**nformation **S**ystem)

GIS-based high spatial and temporal scale modelling system

OUTPUT

Abiotic and biotic risks

for different main crops and grassland

32 locations in Austria (Fig 1) were selected for the evaluation of the seasonal forecast

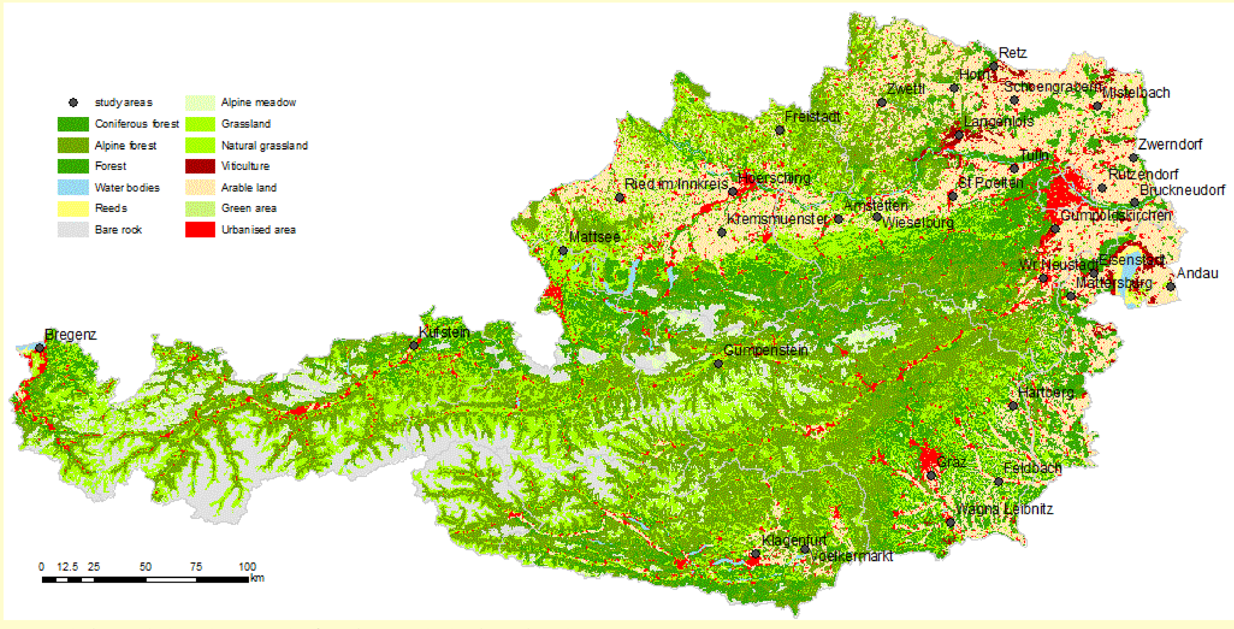

Fig 1. Selected sites in Austria for the statistical evaluations

INDICATORS

- Drought intensity
- Water stress
- Heat stress
- Intensive water deficit
- Peronospora
- Late frost (apple)
- Huglin index
- Potential yield reduction
- Hibernation damage risk
- Frost stress
- Winter severity
- selected pest algorithms…

3. Selected results (Huglin Index, Yield Reduction, Heat Stress and Intensive Drought)

3.1 Input: Seasonal weather forecast

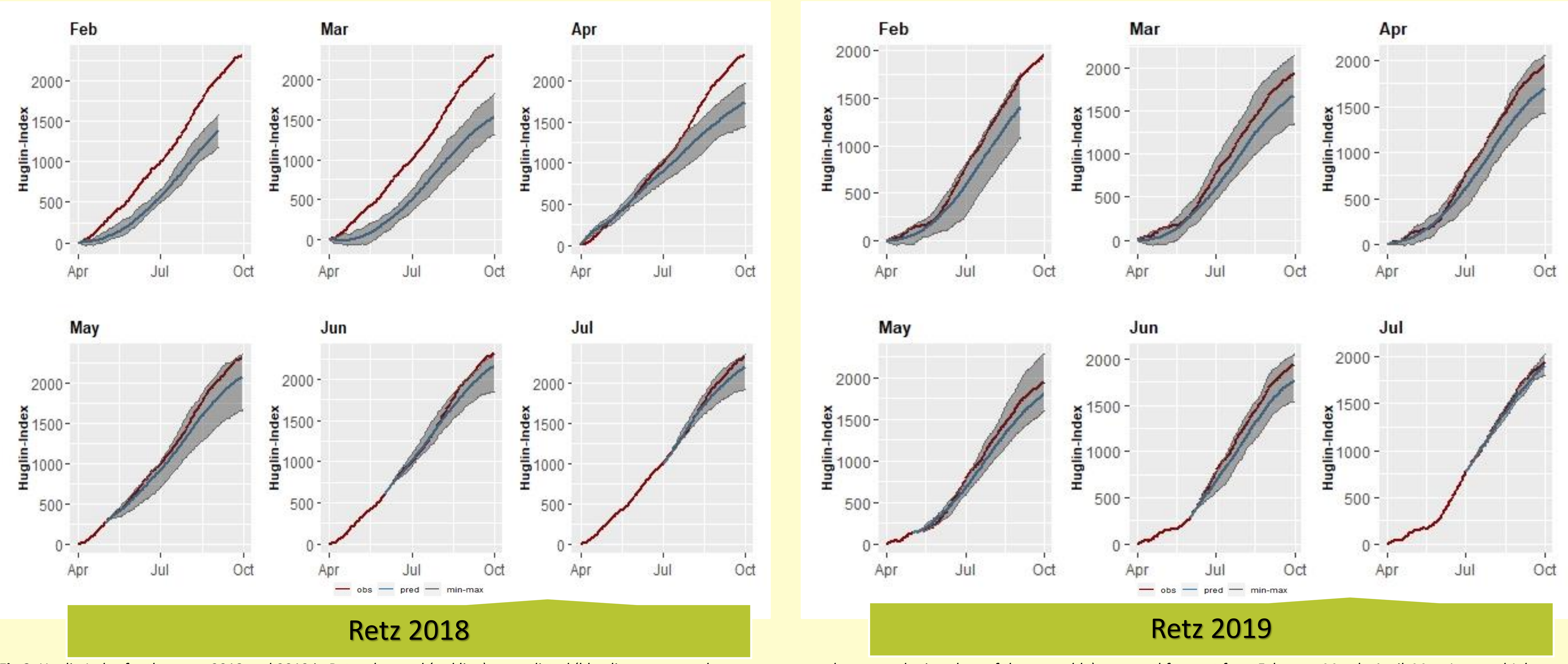

Fig 2. Huglin Index for the years 2018 and 2019 in Retz: observed (red line) vs predicted (blue line = mean value, grey areas marks max and min values of the ensemble); seasonal forecast from February, March, April, May, June and July

HUGLIN INDEX

The bioclimatic heat index calculates the temperature sum (T_{max} and T_{mean}) above the temperature threshold of 10°C for vineyards during the growing period from the beginning of April to the end of September. Fig 2 shows observed (red line) and predicted (blue line = mean value, grey area = max and min values of the ensemble) **Huglin Index** simulations for the years 2018 and 2019 in Retz. Seasonal forecasts starting from February to July, respectively, are displayed. In 2018, the Huglin Index was underestimated by the forecasts starting in February, March and April. The approximations with the observed values fit well from May onwards. In 2019, deviations were smaller compared to the previous year; again, simulated values become more accurate from May onwards.

YIELD REDUCTION

Based on drought and heat stress indicators, **Yield Reduction** index is presented for different sites and crops for the years 2020 and 2021 (Fig 3). Opposed to the Huglin Index, precipitation is also taken into account together with temperature for calculating yield reduction index. The results indicate that depending on the crop, region and time, variations in weather input data have different effects on yield reduction. For example, Hoersching shows good maize results in both years, while in Hartberg deviations are large, especially in 2021. For winter wheat, Rutzendorf showed smaller deviations of the simulated yield reduction from observations in 2020, while simulations for Kufstein were more accurate in 2021. In 2020, Andau and Voelkermarkt displayed minor deviations of the simulations for spring barley yield reduction, which considerably increased in 2021 however.

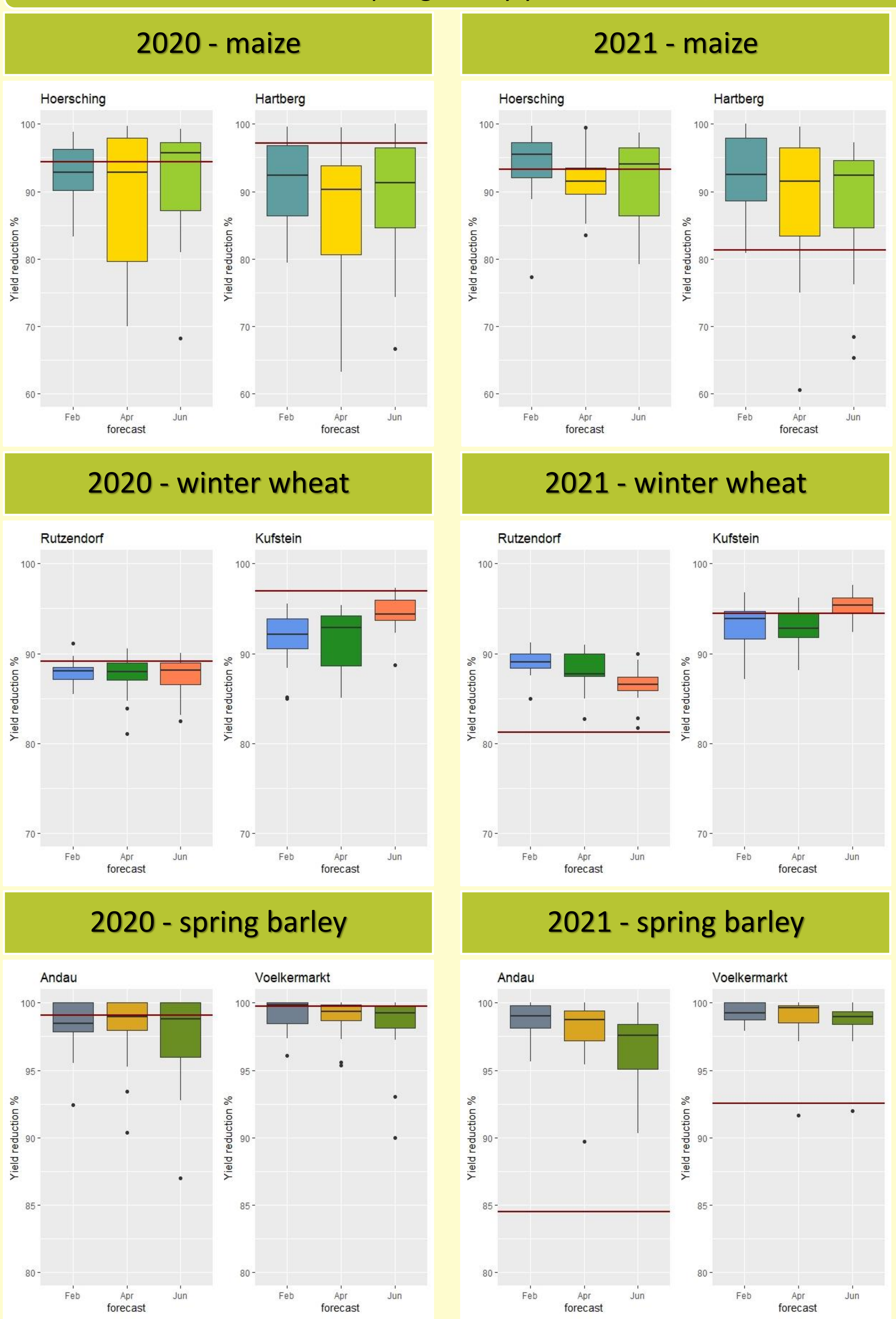

Fig 3. Yield reduction for the years 2020 and 2021 in Hoersching and Hartberg (maize), Rutzendorf and Kufstein (winter wheat), Andau and Voelkermarkt (spring barley): observed (red line), predicted (boxplots) from the ensemble forecasts February, April and June

3.2 Input: ÖKS 15 projections

HEAT STRESS

The agro-climatic **Heat Stress** index is defined as the number of days with T_{max}>=35°C and ET_a/ET_o<0.5. This index was simulated for winter wheat in the region of north-eastern Austria for IPSL_WRF, RCP 8.5 (Fig 4). A significant increase in days with heat stress is expected for the midterm future.

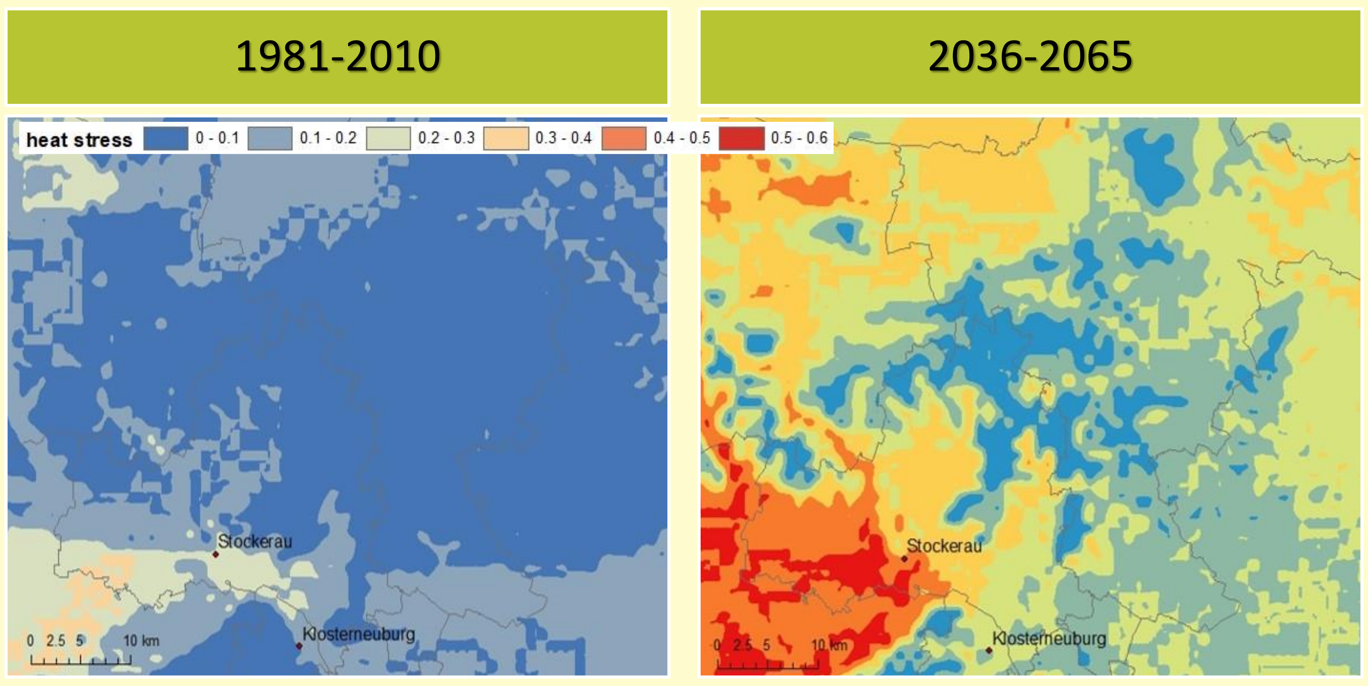

Fig 4. Number of Heat Stress Days in NE Austria 1981-2010 (left) and 2036-2065 (right) simulated with the IPSL_WRF projection, RCP 8.5

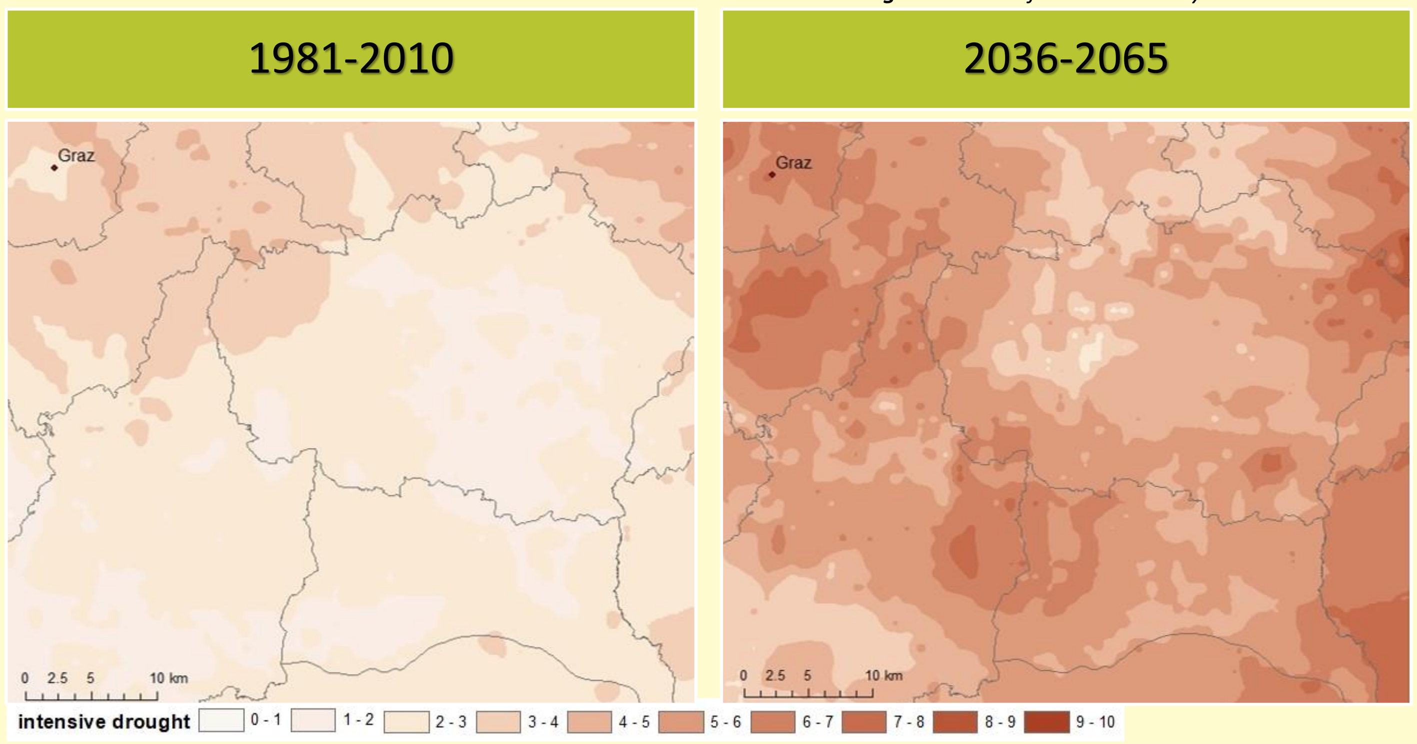

Fig 5. Number of Intensive Drought Days in SE Austria 1981-2010 (left) and 2036-2065 (right) simulated with the EC-Earth_RACMO projection, RCP 8.5

INTENSIVE DROUGHT

Fig 5 shows an example of the agro-climatic **Intensive Drought** index for winter wheat and its spatial distribution in south-eastern Austria with EC-Earth_RACMO, RCP 8.5: 1981-2010 and 2036-2065. The index calculates the number of days with intensive drought (ET_a/ET_o<0.3 for 5 days uninterrupted) from sowing to maturity. Simulations show that the number of these days can increase to up to 10 days in the selected region in the midterm future.

4. Conclusions

With this study, we were able to show the performance, sensitivity, and uncertainty of different agro-meteorological indicators for selected Austrian cropping sites using seasonal weather forecasts of different ranges as input for the ARIS. To determine potential impacts and ecological effects of long-term changes in growing conditions, these indicators were also calculated with selected Austrian ÖKS15 climate projections and the two emission scenarios RCP 4.5 and RCP 8.5 for the period 2036-2065 covering Austrian agricultural regions. A number of indicators with limited uncertainty will be tested further for farm decision-making applications.

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