



Model-based reconstruction and projections of soil moisture anomalies and crop losses in Poland

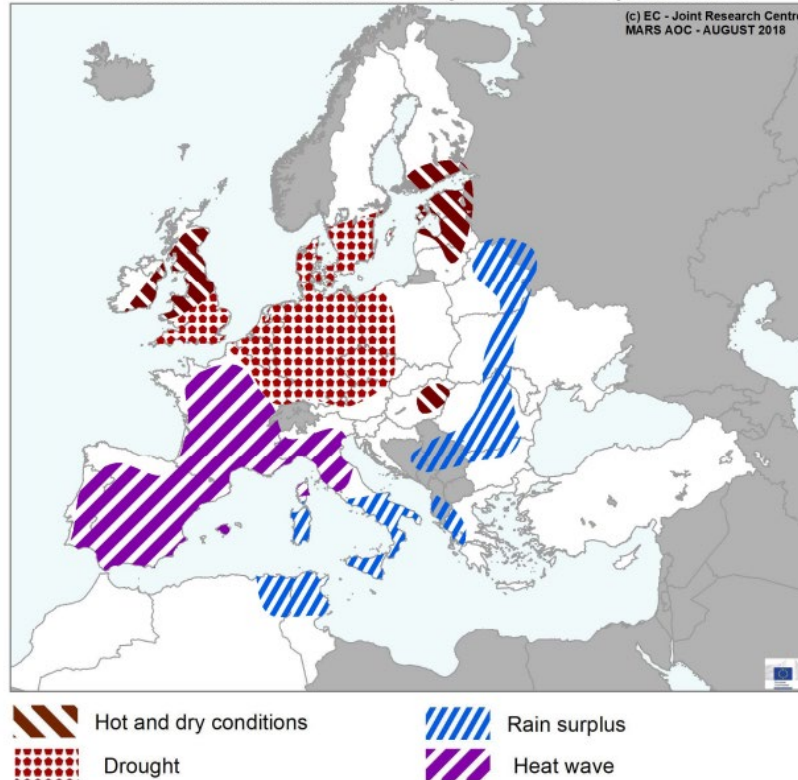
Mikołaj Piniewski¹, Paweł Marcinkowski¹, Joanna O'Keeffe¹, Mateusz Szcześniak¹, Anna Nieróbca², Jerzy Kozyra², Zbigniew W. Kundzewicz^{3,4}, Tomasz Okruszko¹

1. Warsaw University of Life Sciences (WULS)
2. Institute of Soil Science and Plant Cultivation (IUNG-PIB)
3. Potsdam Institute for Climate Impact Research (PIK)
4. Institute for Agricultural and Forest Environment, Polish Academy of Sciences (IAFE PAS)

Extreme weather events hit hard European farmers this year

AREAS OF CONCERN - EXTREME WEATHER EVENTS

Based on weather data from 1 July 2018 until 1 September 2018



JRC MARS Bulletin, August 2018

Weather-related crop losses

- Weather variability explains ~44% of wheat yield variability in 4 largest EU producers (PL included) (Ray et al., 2015)
- Many studies suggest that indices based on soil moisture are more powerful in explaining yield variability than those based solely on weather parameters
- Crop losses due to excessive soil moisture should not be ignored either (Rosenzweig et al., 2002)



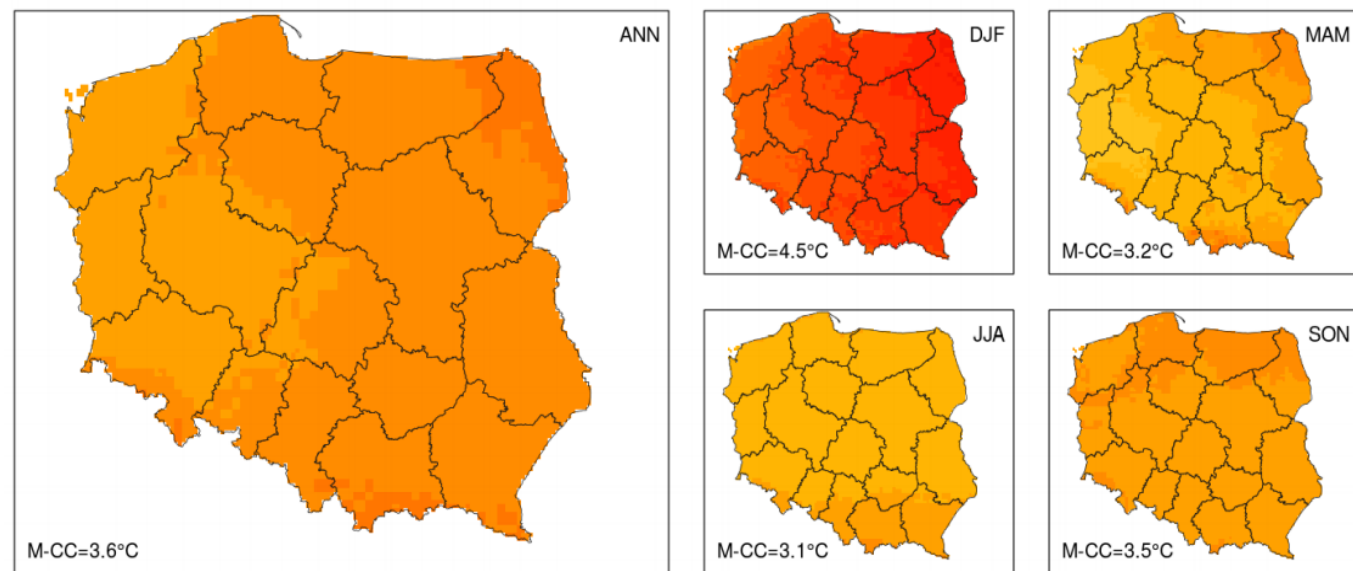
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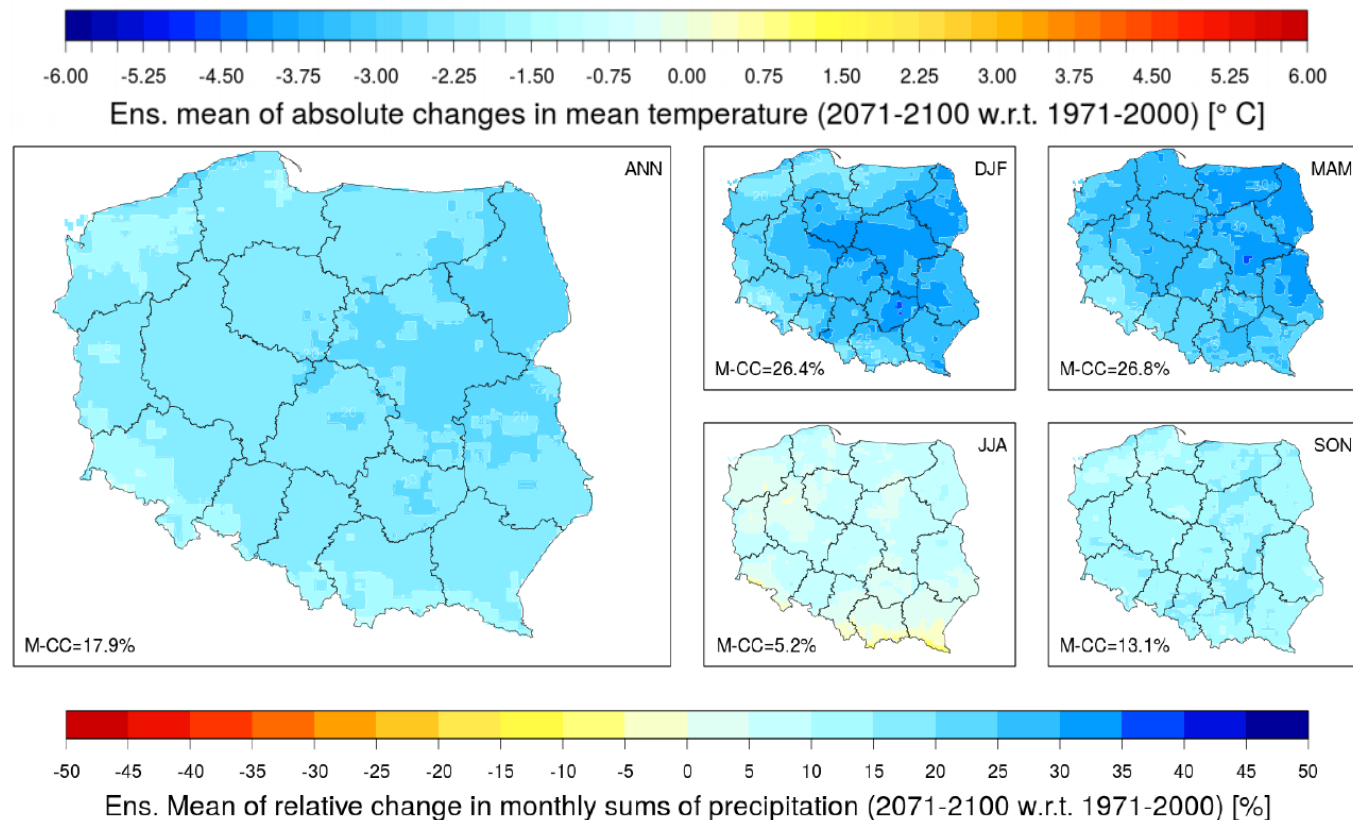
www.topagrar.pl

Poland: warmer and wetter?

Maps for RCP8.5 in the far future (2071-2100 vs. 1971-2000) based on 9 bias-corrected EURO-CORDEX RCMs



The direction of change in SM conditions are non-obvious for „warmer and wetter” futures

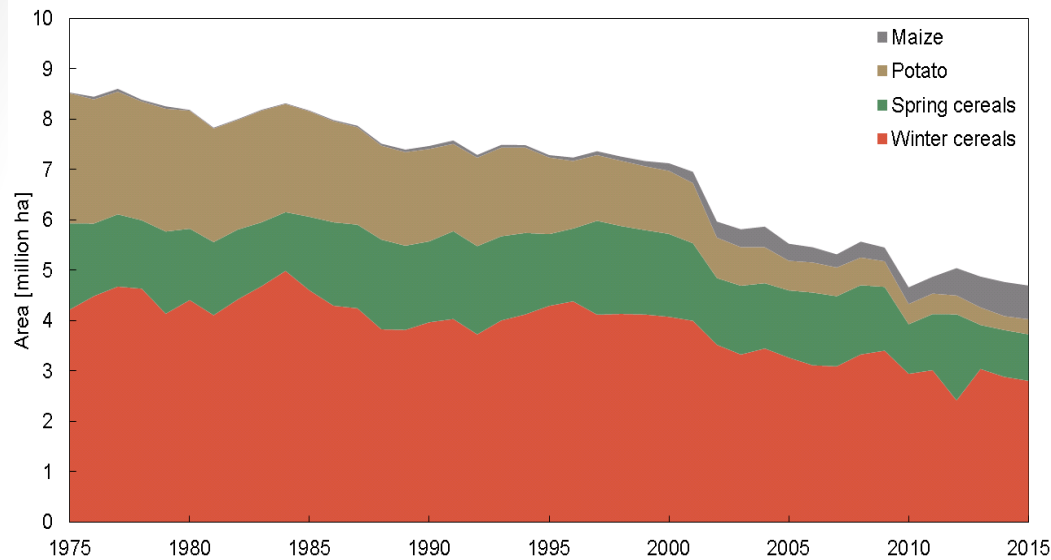


Objectives

- To simulate historical, multi-annual variability of soil moisture anomalies (deficits and excesses) that could lead to potential crop yield reductions in Poland
- To assess the effect of climate change on future extreme SM conditions, potentially affecting crop yields in Poland

Inter-annual variability of cultivated areas and yields

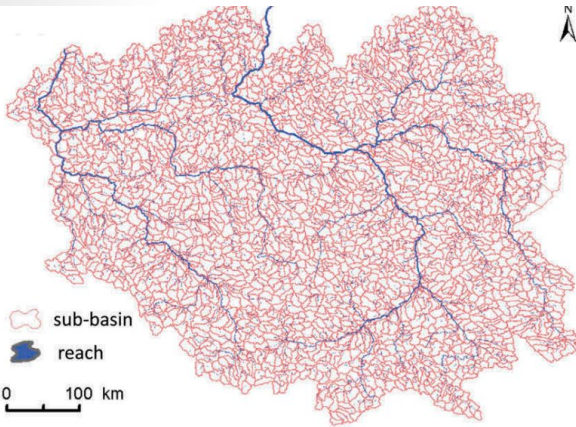
A. Cultivated area of selected crops in Poland



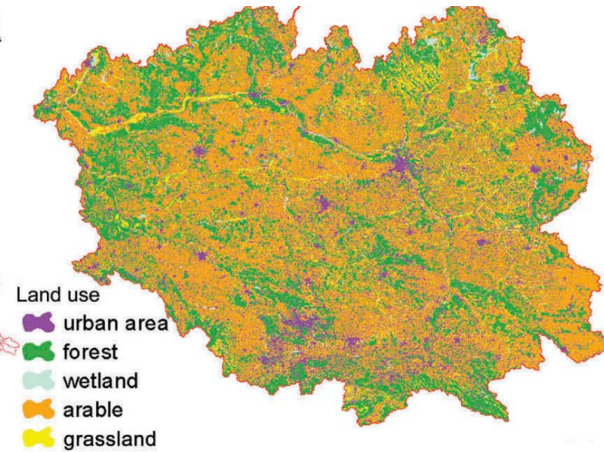
Decline due to giving up cultivation in small-sized farms, change of consumers' preferences, changing structure of animal feed

SWAT model of the Vistula and Odra basins

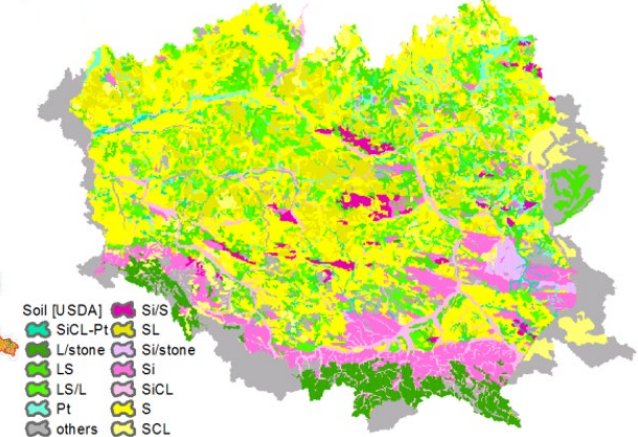
Subbasins



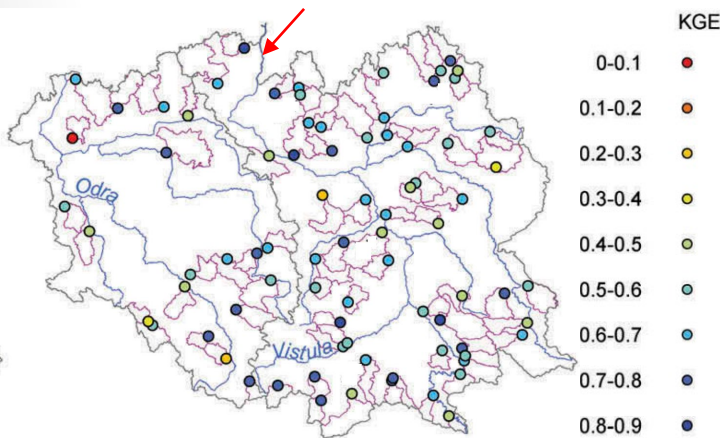
Land cover



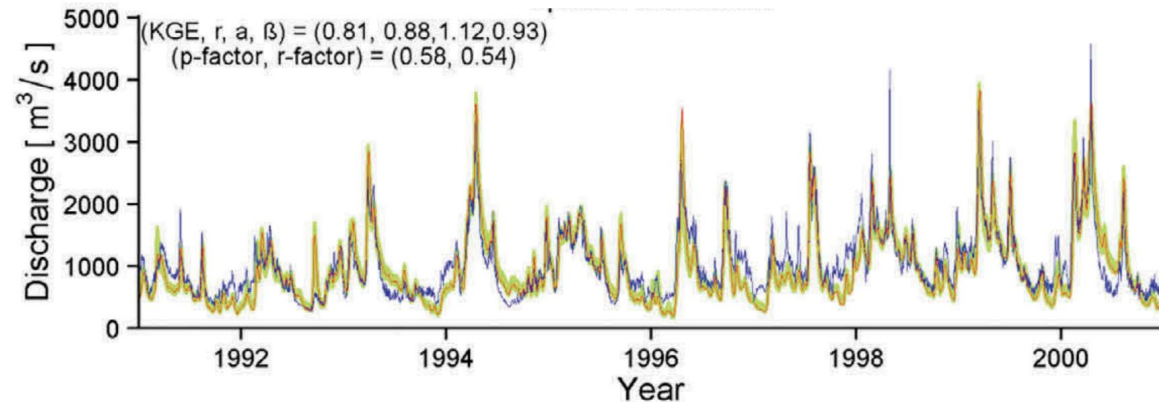
Soils



KGE validation period (2001-2010)

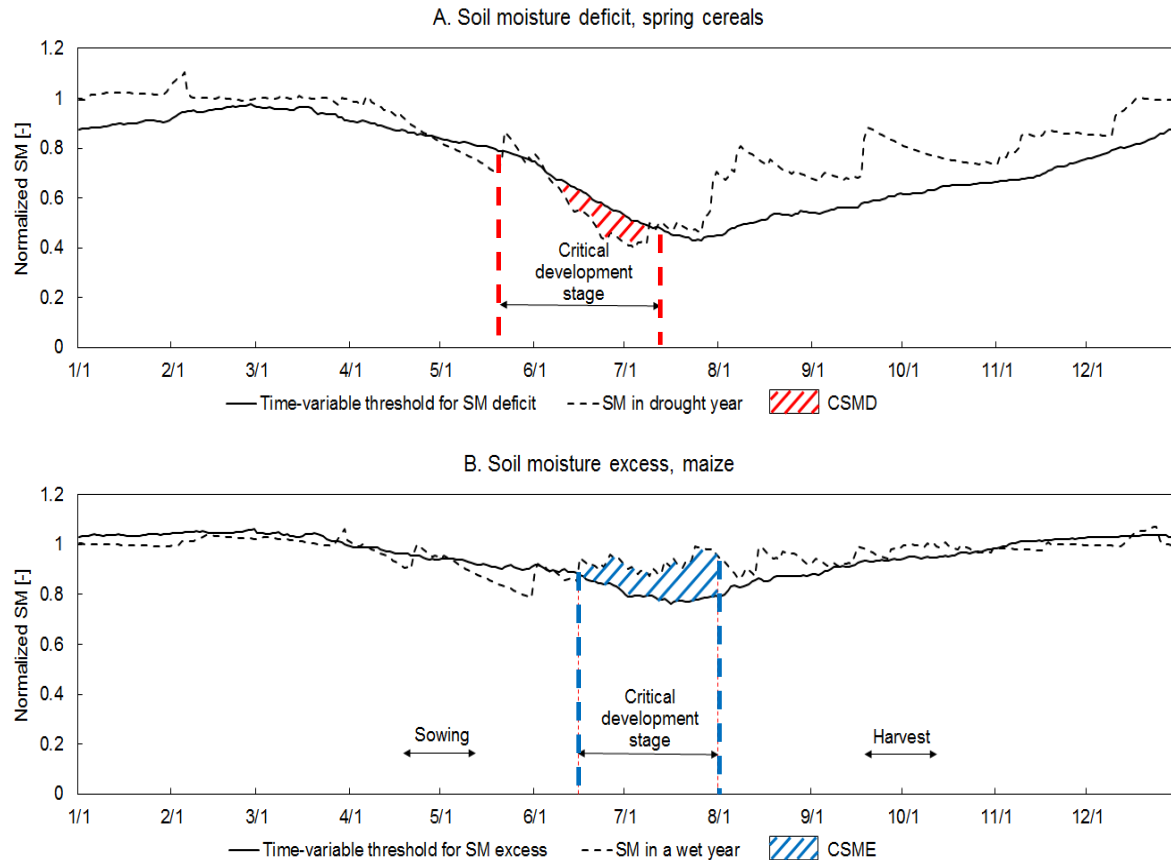


The Vistula - outlet



Schematic illustration of soil moisture-based cumulative deficit and excess indicators

- Indices measure the negative / positive anomalies of SM content from daily varying thresholds
- They accumulate values within the plant development periods with critical SM requirements
- The higher the values, the more extreme SM conditions during critical development stages, and hence, the more likely crop yield losses



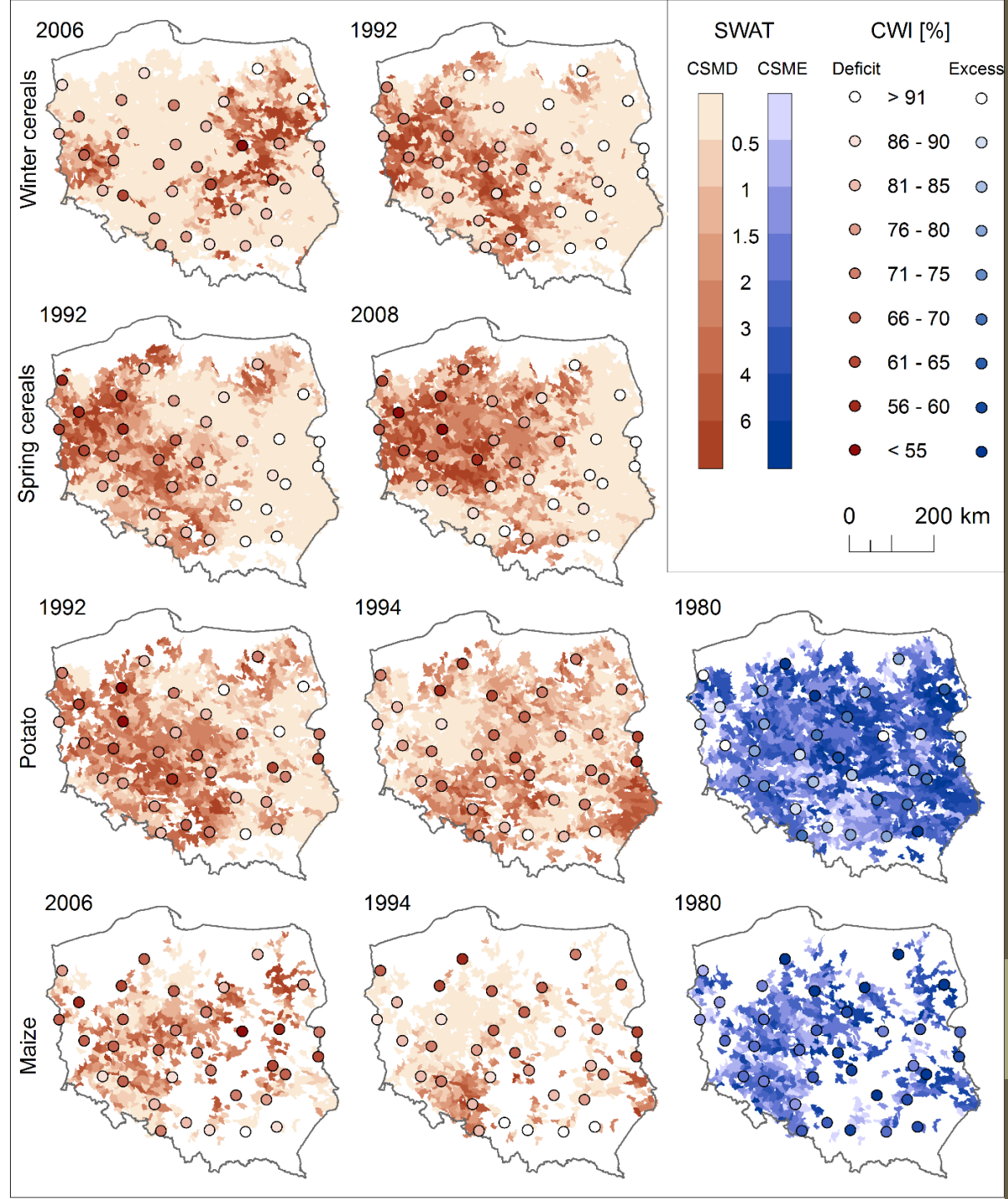
Critical plant development stages for soil moisture requirements

Crop	Sowing date	Harvest date	Critical stage	Description
Winter cereals	10 Sep – 5 Oct	10 Jul – 10 Aug	10 May – 5 Jul	Stem elongation – Milk stage
Spring cereals	20 Mar – 15 Apr	1 Aug – 30 Aug	20 May – 15 Jul	Stem elongation – Milk stage
Potato	10 Apr – 10 May	10 Sep – 10 Oct	15 Jun – 15 Aug	Tuber initiation – Tuber formation
Maize	20 Apr – 10 May	20 Sep – 10 Oct	15 Jun – 31 Jul	Boot stage – Milk stage

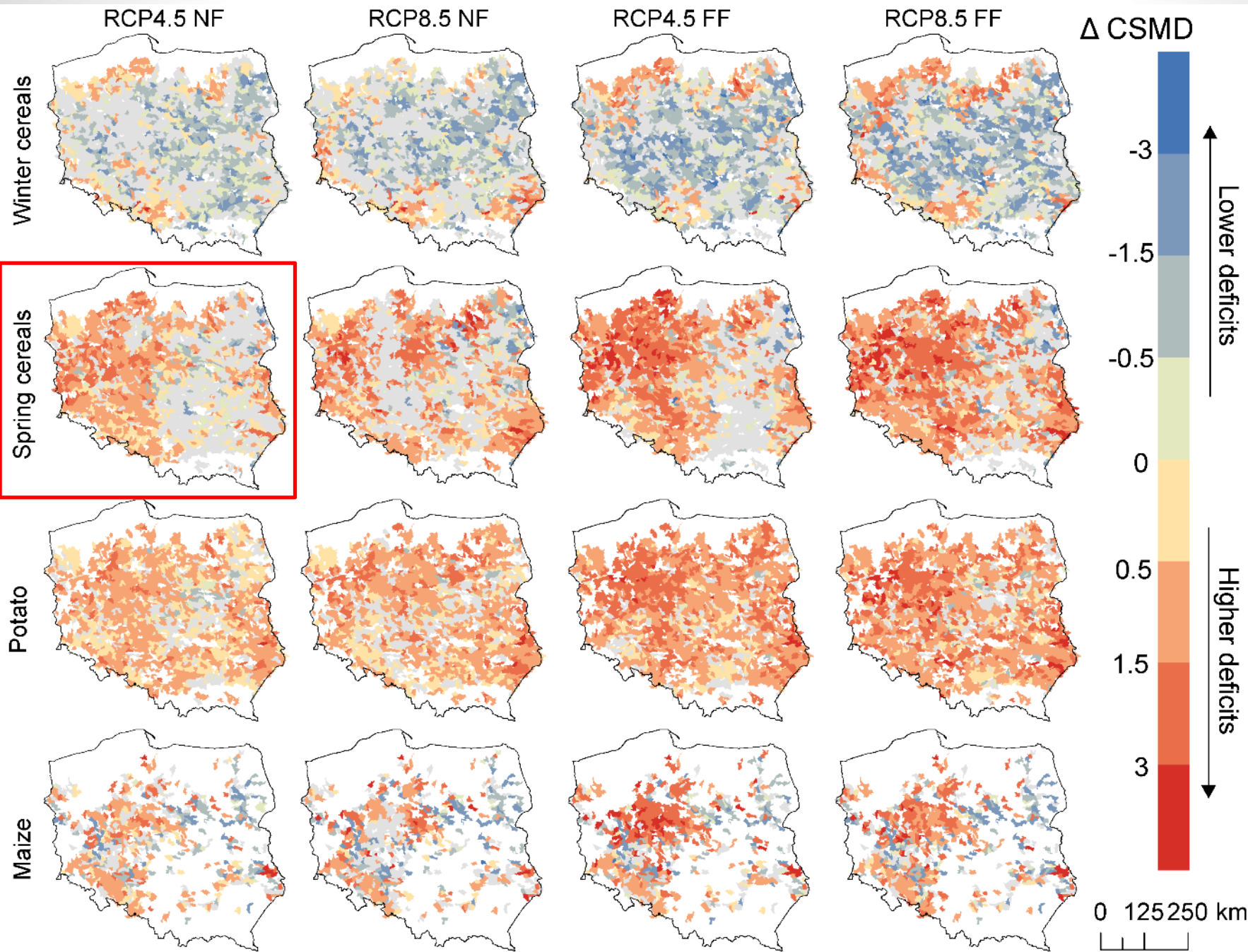
Sources: Nix and Fitzpatrick (1969); Hane and Pumphrey (1984); Farooq *et al.* (2014); Grzebisz (2011); McWilliams (2005)

Spatial evaluation of indices in years with SM extremes

- SWAT-based SM indices compared with station-based, empirical “crop-weather indices” (CWIs) indicating weather-related crop losses
- Fairly good spatial agreement for different years and crops



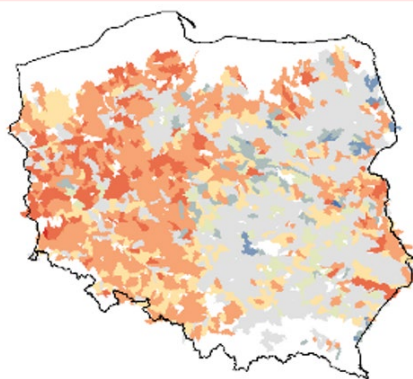
Climate change impact on soil moisture deficit indicator



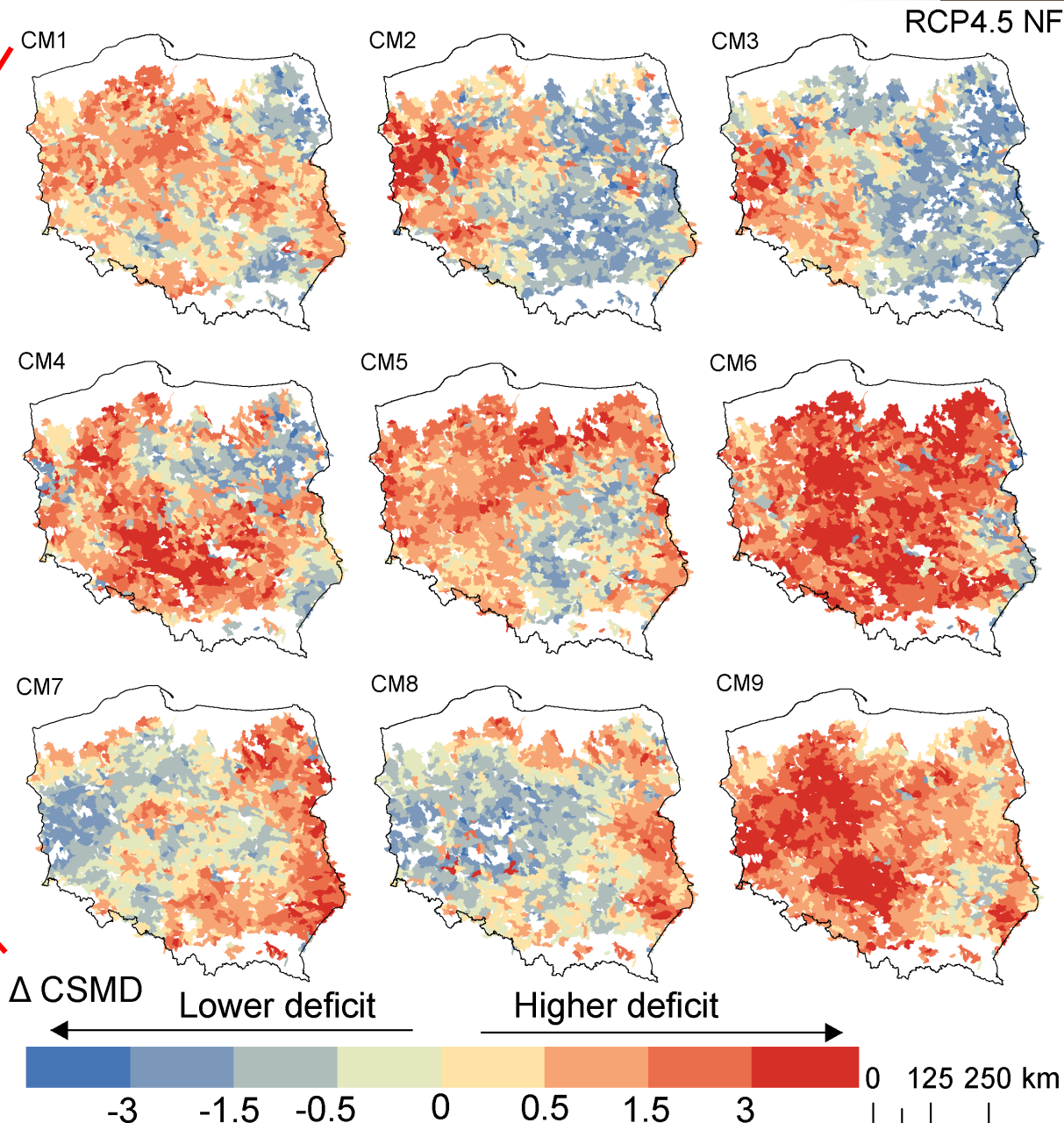
Uncertainty due to climate models

Example: spring cereals, near future (2021-2050, vs. 1971-2000), RCP4.5

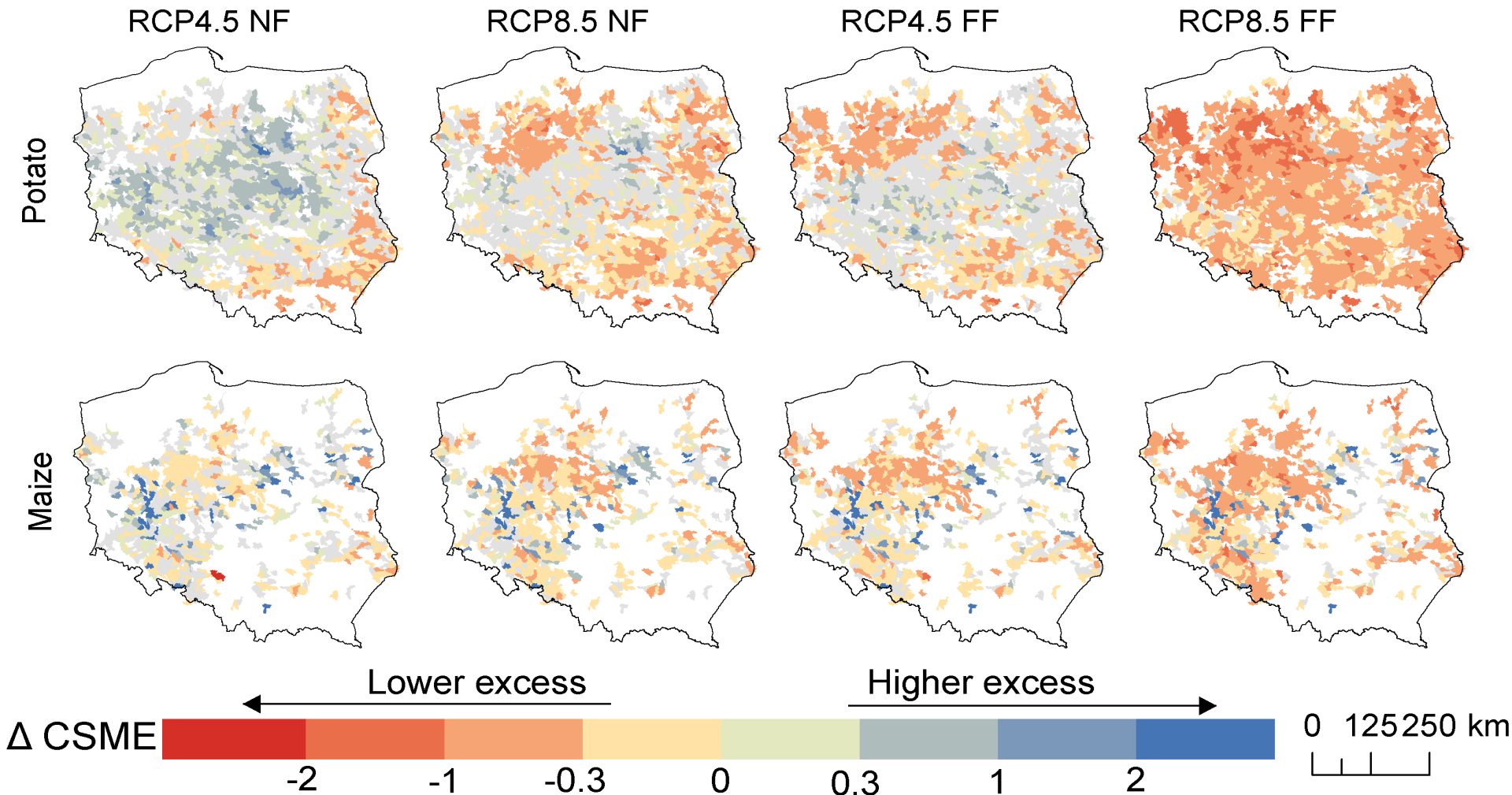
Spring cereals



- Ensemble median
- Grey overlay corresponds to areas for which the agreement on the direction of change is less than two thirds

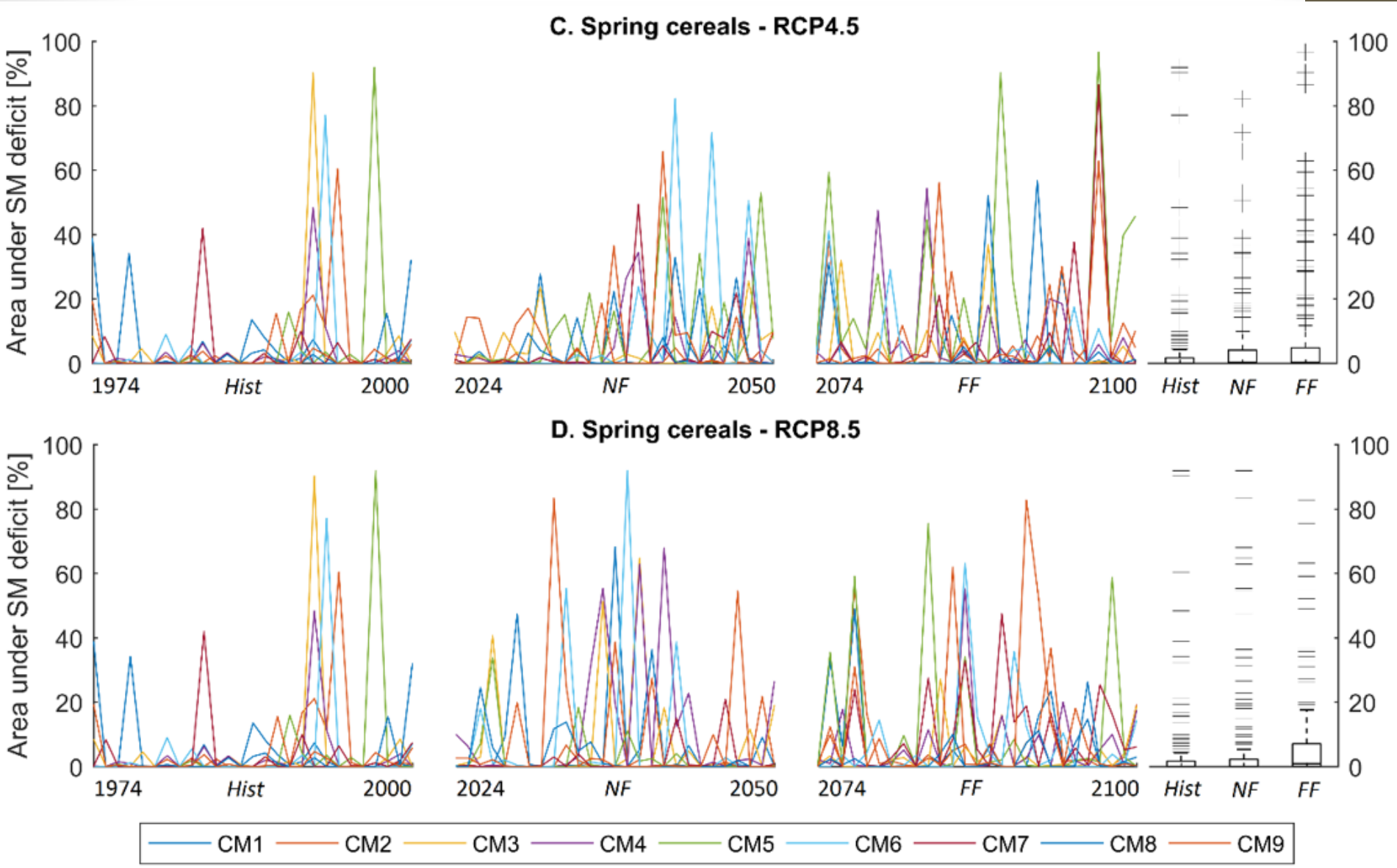


Projections of changes in SM excess



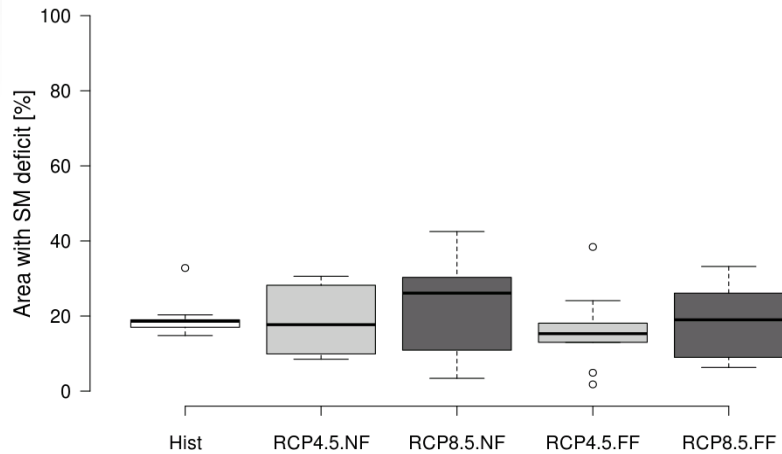
Projections of changes in the area under drought (spring cereals)

defined as the fraction of land occupied by spring cereals with *CSMD* above the threshold value of 3

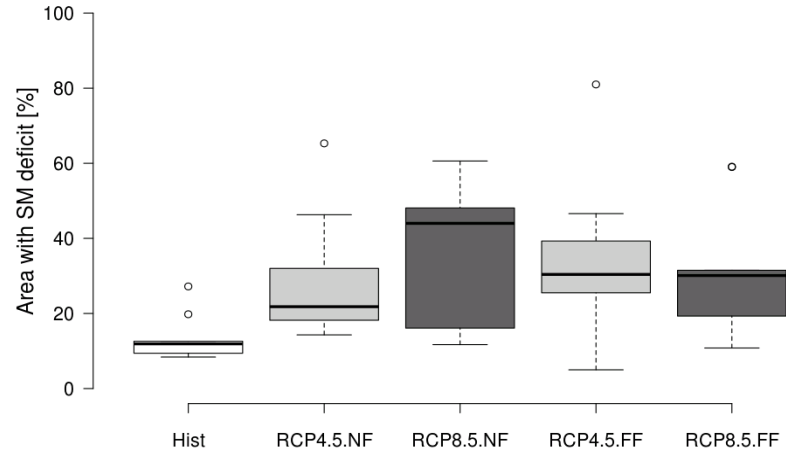


Projections of the area under severe SM drought defined as the 95th percentile of the multi-annual time series of fractions of land occupied by a given crop with *CSMD* above 3

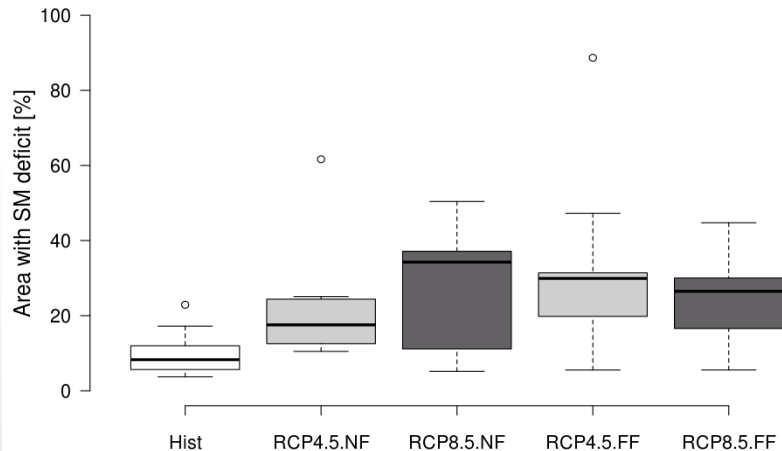
A. Winter cereals



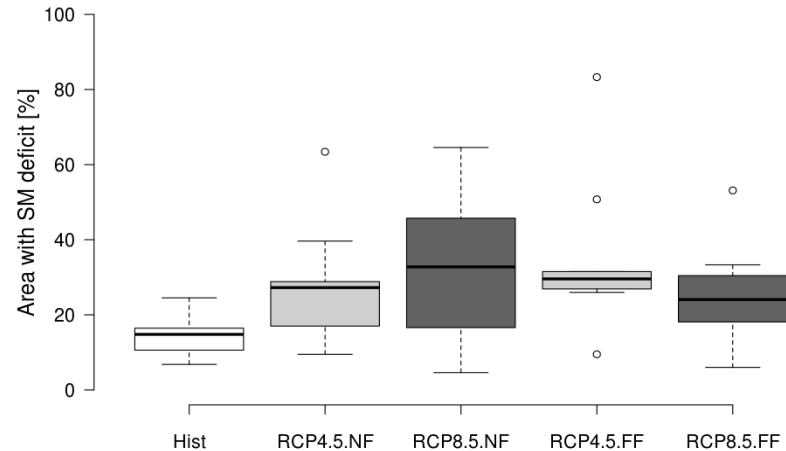
B. Spring cereals



C. Potato

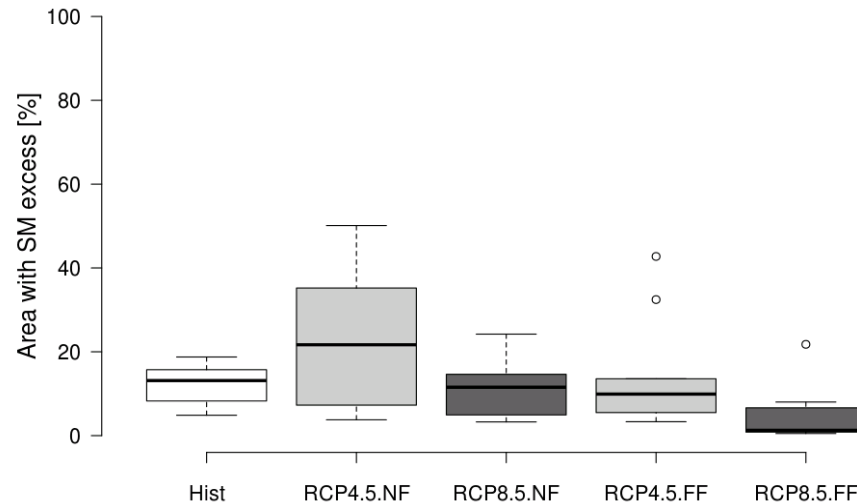


D. Maize

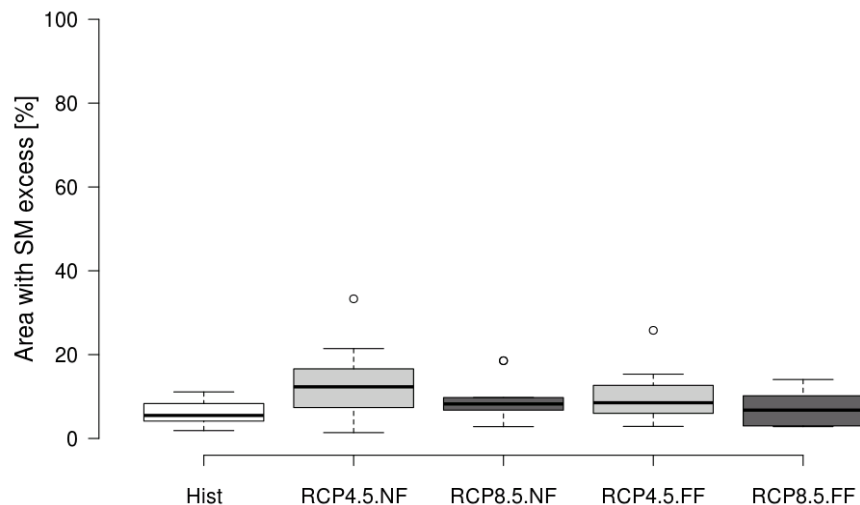


Projections of the area under severe SM excess defined as the 95th percentile of the multi-annual time series of fractions of land occupied by a given crop with *CSME* above 2

A. Potato



B. Maize



Summary

- Soil moisture droughts are the principal factor limiting crop yields in Poland
- SWAT was able to capture major soil moisture deficit and excess events leading to yield reductions in Poland
- Agricultural droughts may become more severe and affect larger area than in the reference period (spring cereals, potato and maize)
- Higher uncertainty regarding future soil moisture excess events
- Stronger impacts can be expected even in the near future (which is in agreement with trends we are observing right now)

References

- Piniewski, M., Marcinkowski, P., O'Keeffe, J., Szcześniak, M., Nieróbca, A., Kozyra, J., Kundzewicz, Z.W., Okruszko, T. 2018 Model-based reconstruction and projections of soil moisture anomalies and crop losses in Poland. *Agr. Forest Meteorol.* (under review).
- Mezghani, A., Dobler, A., Haugen, J.E., Benestad, R.E., Parding, K.M., Piniewski, M., Kardel, I., Kundzewicz, Z.W. 2017 *Earth Syst. Sci. Data*
- Piniewski, M., Szcześniak, M., Kardel, I., Berezowski, T., Okruszko, T., Srinivasan, R., , Vikhamar-Schuler, D., Kundzewicz, Z.W., 2017 Hydrological modelling of the Vistula and Odra river basins using SWAT. *Hydrol. Sci. J.* 62(8), 1266-1289.
- Piniewski, M., Szcześniak, M., Huang, S., Kundzewicz, Z.W. 2018 Projections of runoff in the Vistula and the Odra river basins with the help of the SWAT model. *Hydrol. Res.* 49 (2), 303-317.

Acknowledgements



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Thank you for your attention!



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