CropM

Understanding and Modelling Impacts of Climate Change on Crop Production

F Ewert, R Rötter
Work Package leaders and CropM partners
(Katharina Brüser)

FACCE MACSUR Workshop for policy makers
6 May 2015, Brussels

CropM - key ambitions (MACSUR 1):

To develop:

- a shared **comprehensive information system** on the impacts of climate change on **European crop production and food security**
- first shared **pan-continental assessments and tools**
  - **(Full) range** of important crops and **important** crop rotations
  - **Improved** management and analysis of data
  - **Model improvement** (stresses and factors not yet accounted for)
  - **Advanced** scaling methods
  - **Advanced** link to farm and sector models
  - **Comprehensive** uncertainty assessment and reporting
- To train **integrative** crop modeler

CropM - key ambitions (MACSUR 1):

To develop:

- a shared **comprehensive information system** on the impacts of climate change on **European crop production and food security**
- first shared **pan-continental assessments and tools**
  - **(Full) range** of important crops and **important** crop rotations
  - **Improved** management and analysis of data
  - **Model improvement** (stresses and factors not yet accounted for)
  - **Advanced** scaling methods
  - **Advanced** link to farm and sector models
  - **Comprehensive** uncertainty assessment and reporting
- To train **integrative** crop modeler

Progress on modelling more crops and crop rotations

- Modelling vine (model inter-comparison study)
- Modelling of crop rotations
- Modelling oil seed rape
- …

Field trial in Göttingen, Germany. (c) Mark Winter

More Crops and Crop Rotations

- Modelling of crop rotations

Continuous crop rotation modelling can improve simulation results compared to year-to-year models

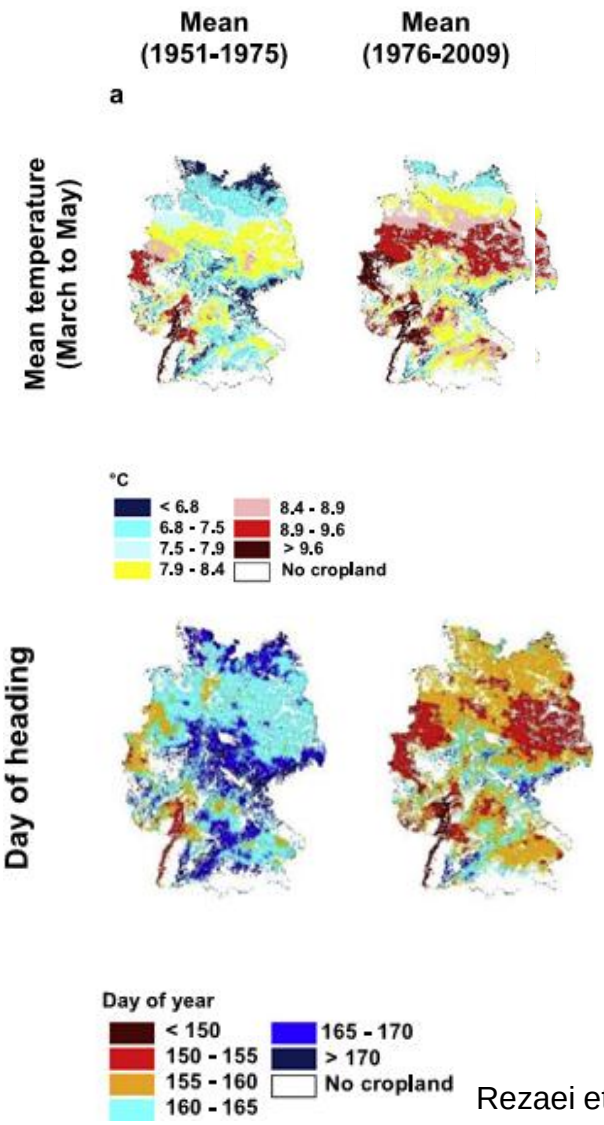
Kollas et al., in review

Data … for better understanding and modelling climate change impact

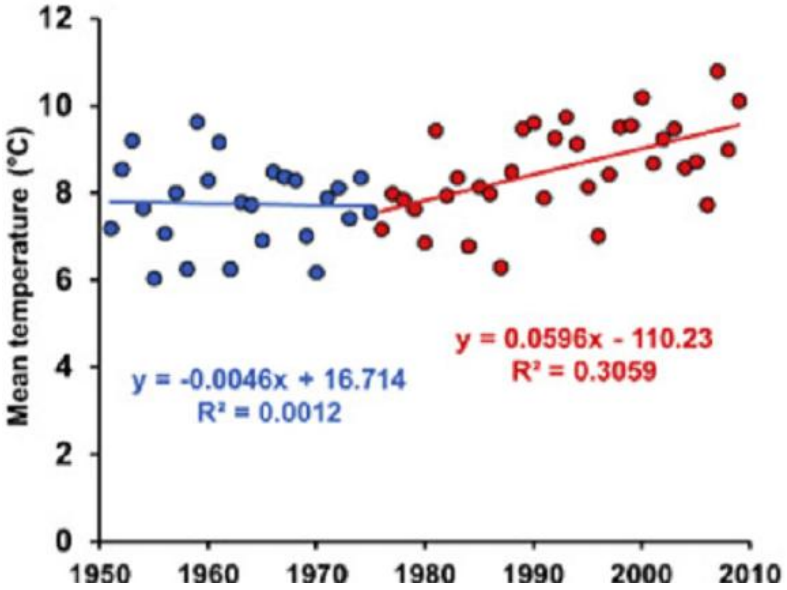
- Evaluation of data quality (platinum, gold, silver)
- Quantify data gaps for modelling
- Empirical analysis of crop responses to past climate variability and change
- Observed adaptation options and their efficacy
- Effect of extreme events (past analysis and projections)
- Climate change scenarios
- Concept for data management, data journal
- …

Data … for better understanding and modelling climate change impact

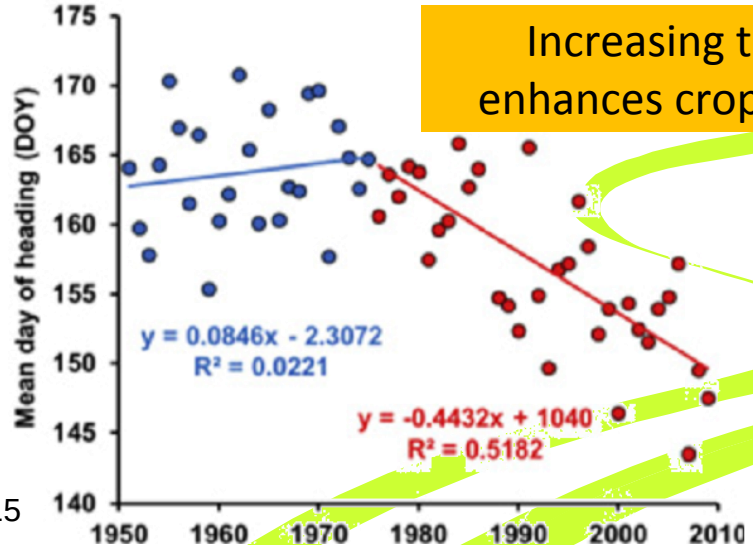
- Effect of temperature increase and extreme events (heat)



Rezaei et al., 2015



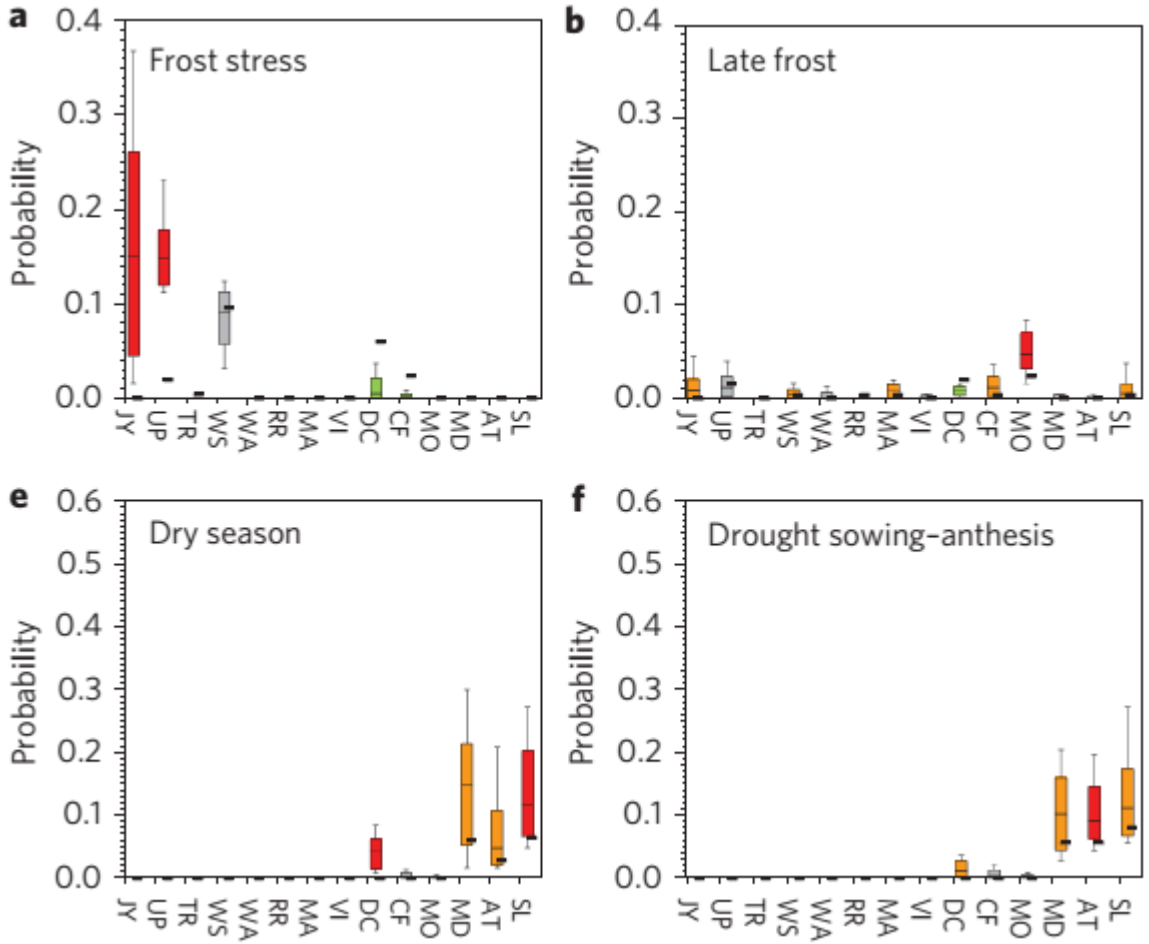
Example: Wheat (Germany)

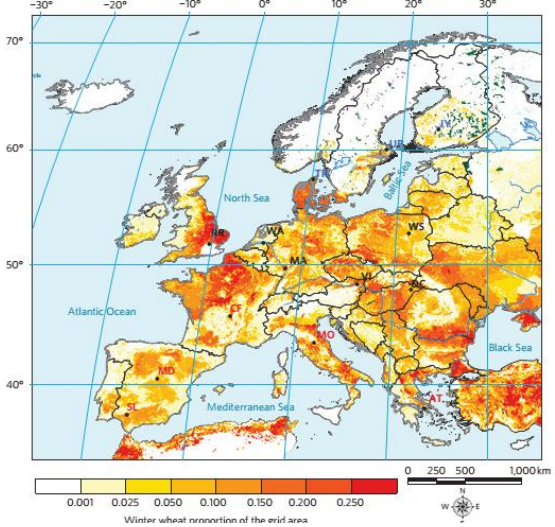


Increasing temperature enhances crop development

Data (analysis, quality, management, ...)

- Effect of extreme events (multiple events)



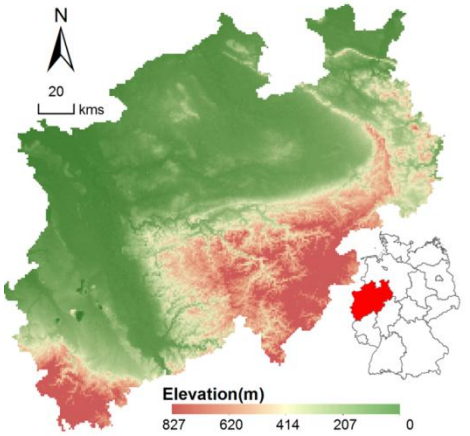


Probability of stress depends on type of stress and region

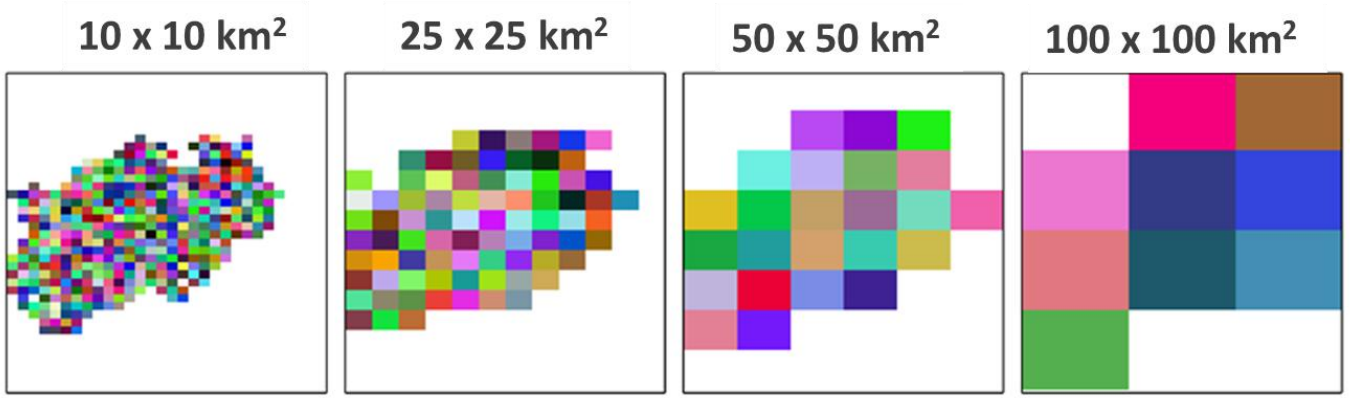
Trnka et al., 2014

Scaling … for large area model application

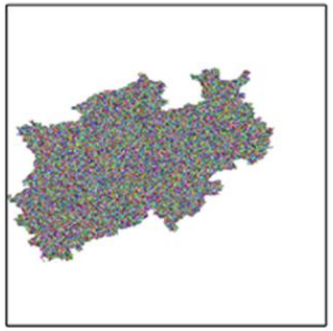
- Evaluation of scaling methods
- Linking of models



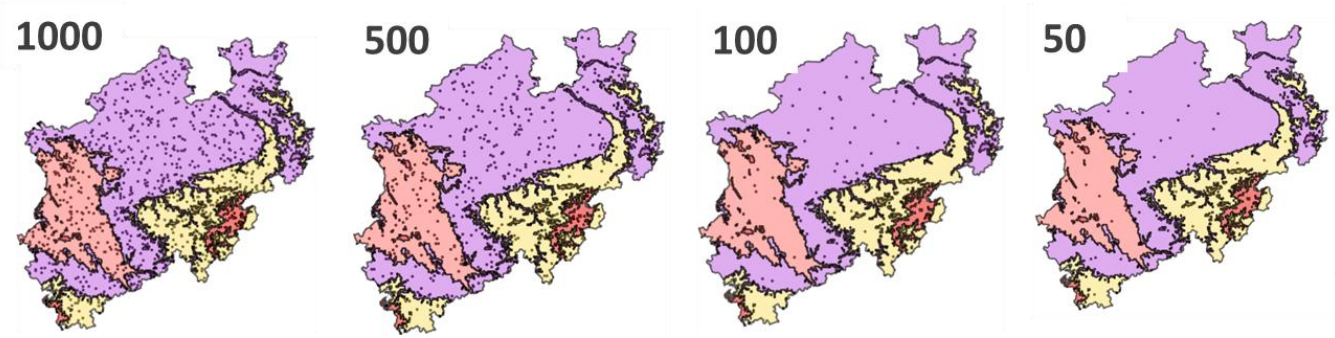
b) Changing size of grid cells



a) High resolution data



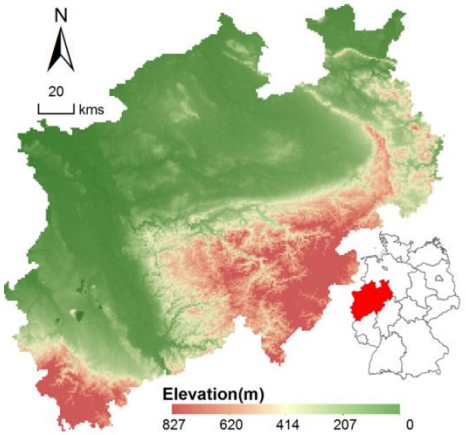
c) Changing size of sampling points

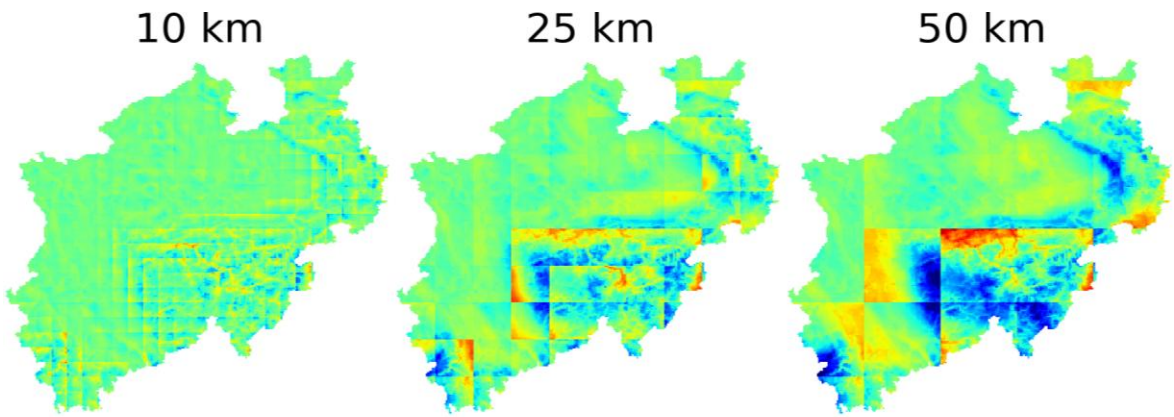


Ewert et al. (2015)

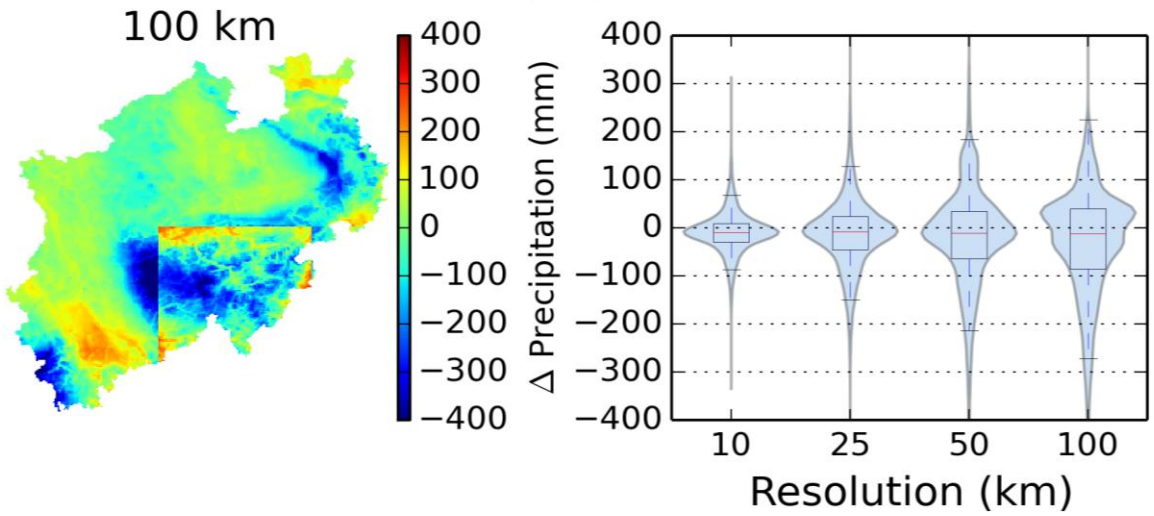
Scaling … for large area model application

- Evaluation of scaling methods





$$\Delta P = P_{10,\,25,50,100\ km} - P_{1\ km}$$



Example:
Wheat and maize
(NRW, Germany)

Loss of spatial variability with increasing aggregation

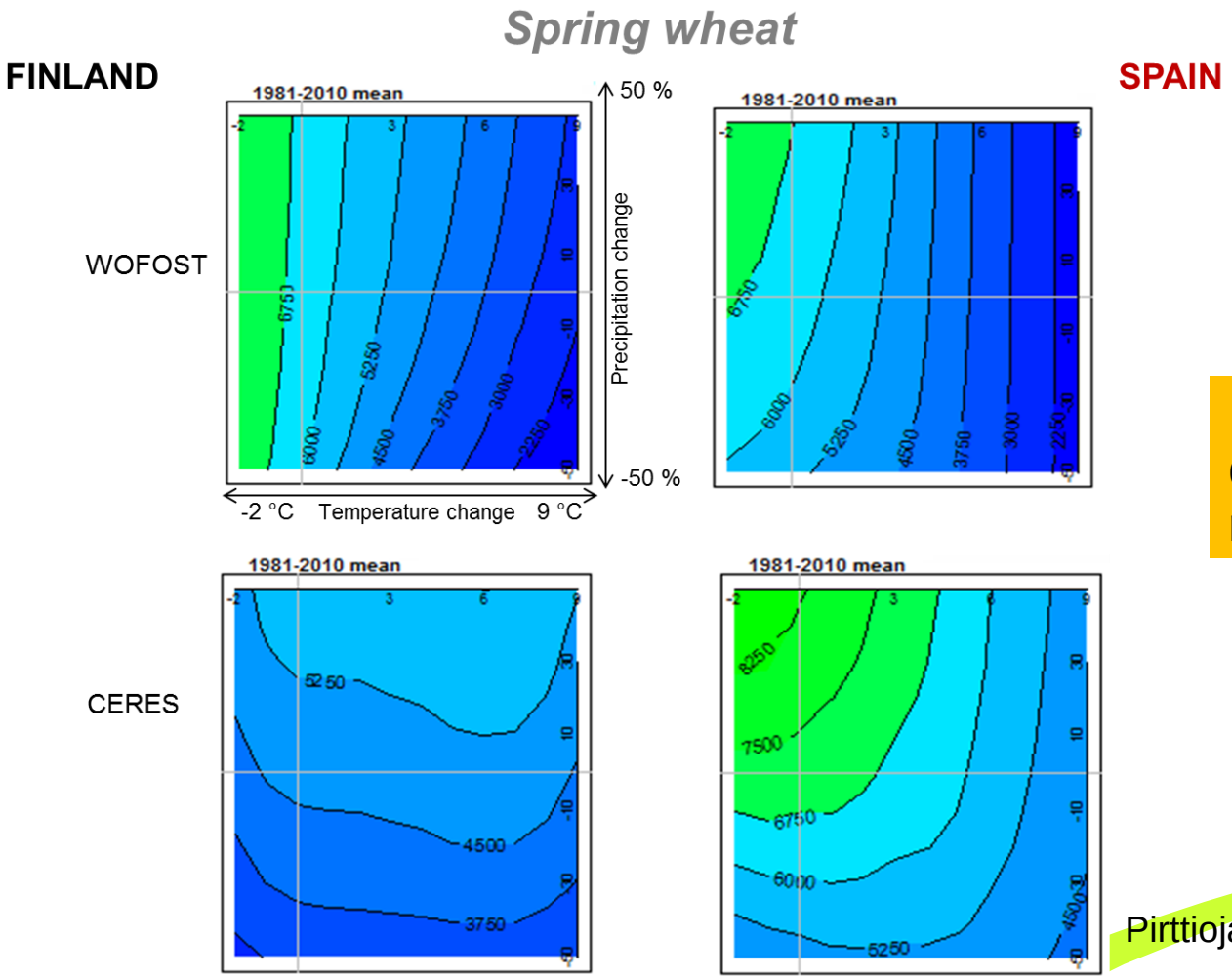
Zhao et al. (accepted)

Uncertainty

- Methodology & protocols for uncertainty analysis
- Methodology for standardized model evaluation
- Local-scale climate scenarios & uncertainties in climate projections
- Basic methodology for probabilistic assessment of CC impacts using impact response surfaces
- Methodology for probabilistic evaluation of alternative adaptation options

Uncertainty

- Basic methodology for **probabilistic assessment** of CC impacts using impact response surfaces (IRS1)



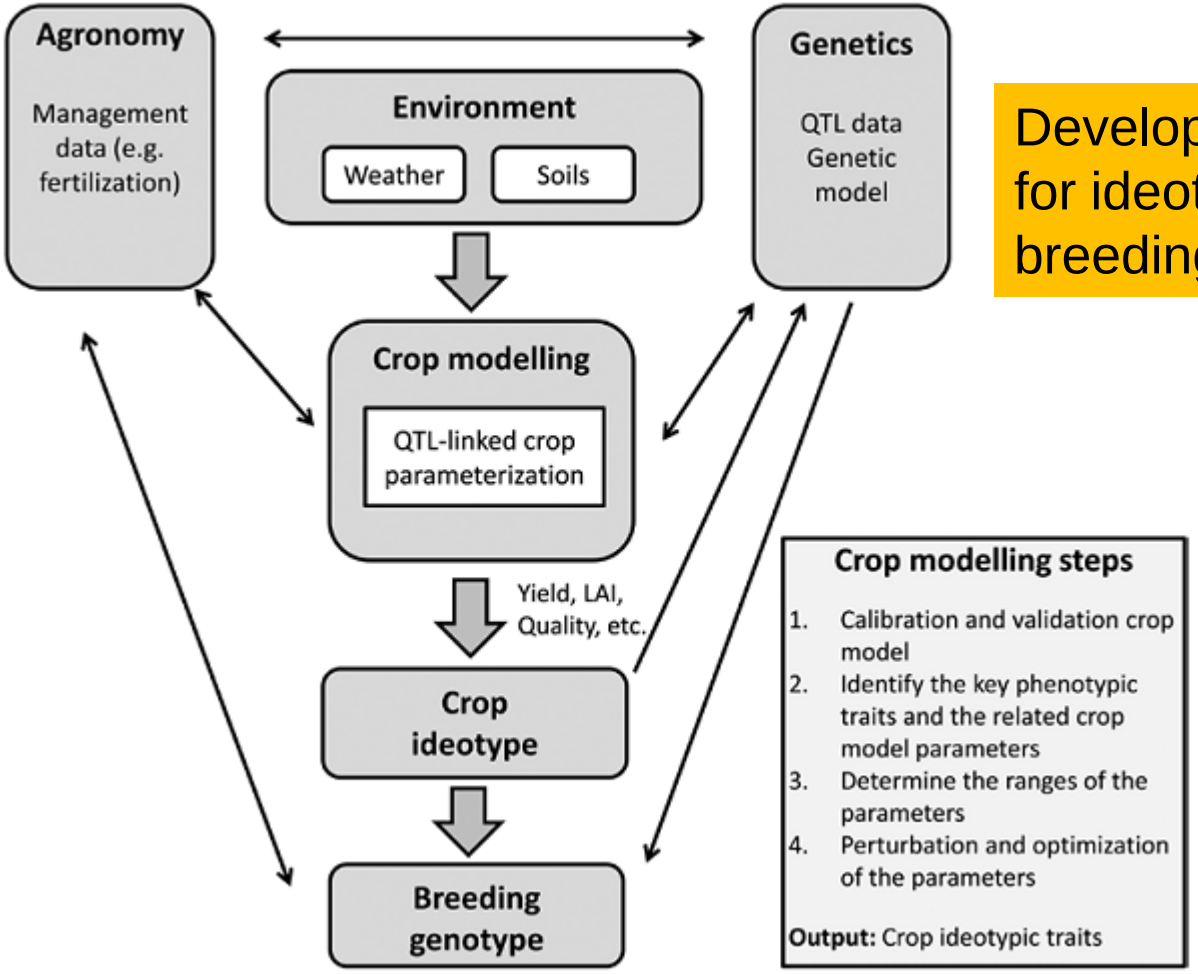
Example: Wheat (Finland, Spain) 2 models

Impact response surface depends on model and region

Pirttioja et al. (accepted)

Uncertainty

- Methodology for evaluation of alternative **adaptation** options through improved, climate robust crops



Develop crop modelling for ideotyping to support breeding

Rötter et al. (2015)

Implications for policy makers...

- Simulation of climate variability and change impacts

=> Past impacts…

Example: Wheat, maize (Europe), SIMPLACE, 1982-2006

Zhao et al. (in review)

Implications for policy makers...

- Simulation of climate variability and change impacts

=> Future impacts

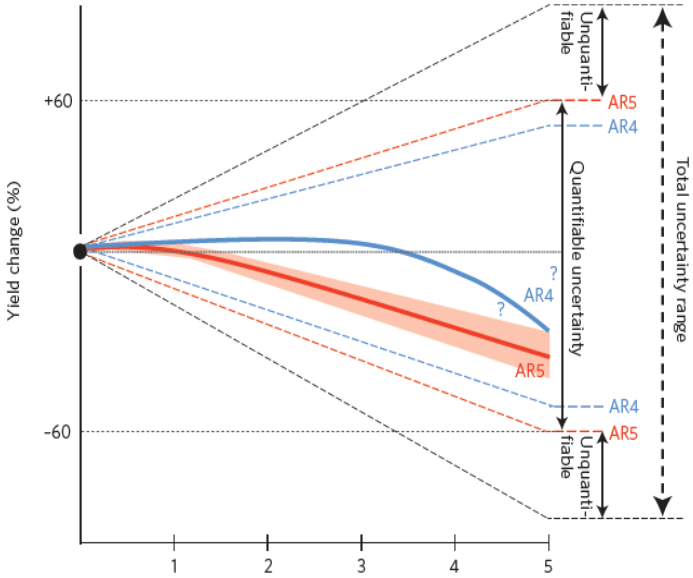
Example: Average European wide change in net irrigation requirement for different crops under three climate change scenarios

Requirement for irrigation increases depending on crop and region. **How to adapt?**

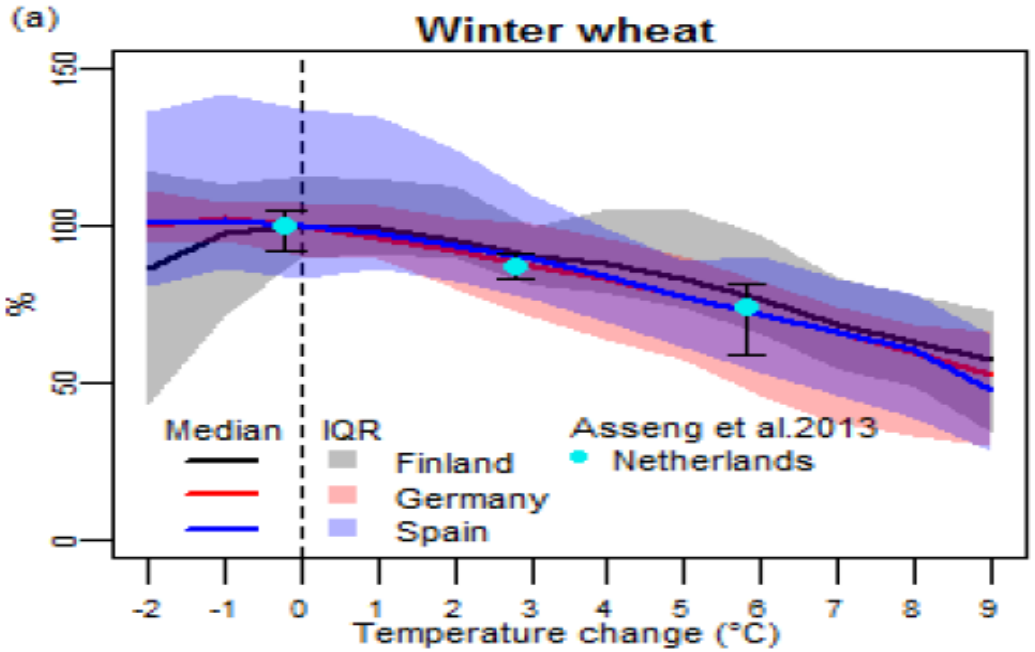
Zhao et al. (in review)

Implications for policy makers...

MACSUR review and updates of IPCC AR5, WGII chapter 7 on food security and food production systems (*here: Climate sensitivity of crop models beyond - thus far- quantifiable uncertainty range)*



Review of Porter et al 2014, Chapter 7, IPCC, WGII. *Source:* Rötter (2014): Robust uncertainty



Ensemble median response (26 models; solid) and IQR (coloured) of dry matter winter wheat yield relative to the baseline (1981-2010) 3 sites with changes in T and baseline Precip. Source: Pirttioja et al., Climate Research, accepted.

Outlook – Main aims MACSUR 2

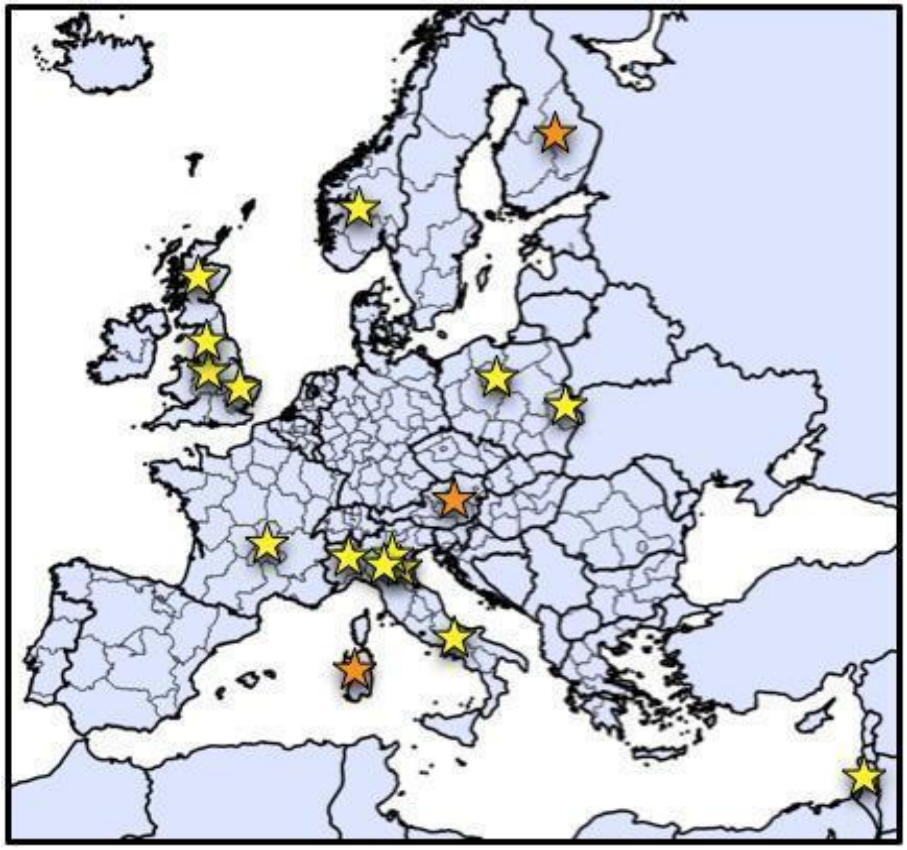
- Improve crop model to better capture **extremes**
- Complement knowledge from crop models with **empirical crop-weather** analysis
- Consider **management variables** in simulations
- Full range of methods for analysing **uncertainty** in climate impact assessments
- Evaluate potential **adaptation** options

❖ Contributing to cross-cutting issues and case studies.

❖ Further the links with other modelling activities

❖ Link local to European and global responses

Application, pilot and case studies



Finland: Northern Savo
Austria: Mostviertel
Italy: Oristano, Sardinia

Focus: 2020, 2030, 2050

Integration of models; participation of stakeholders; global economic and climate scenarios (SSPs, RCPs)

International Crop Modelling Symposium

"Crop Modelling for Agriculture and Food Security under Global Change"

15-17 March 2016, Berlin, Germany

(Co-Chairs: F Ewert, K Boote, R Rötter, P Thorburn)

(Local host: ZALF, C Nendel)

General Programme:

I. Improvement of crop models and modelling approaches
II. Linking crop models and genetics
III. Crop modelling for risk/impact assessment related to global change and food security
IV. Related other modelling activities (grassland, pest disease, FSMP, …)

MACSUR

AgMIP The Agricultural Model Intercomparison and Improvement Project

zalf

Thank you for your attention

Ewert F., van Bussel, L.G.J., Zhao, G., Hoffmann, H., Gaiser, T. … et al. (2015) Uncertainties in Scaling-up Crop Models for Large-area Climate-change Impact Assessments. In C. Rosenzweig and D. Hillel, editors. Handbook of Climate Change and Agroecosystems (in Press).

Eyshi Rezaei, E., S. Siebert, F. Ewert, 2015. Intensity of heat stress in winter wheat—phenology compensates for the adverse effect of global warming. Environmental Research Letters 10, 024012. DOI:10.1088/1748-9326/10/2/024012.

Kollas, C.… et al.(2015) Crop rotation modelling - a European model intercomparison. In review

Pirtioja, N et al (2015) A crop model ensemble analysis of temperature and precipitation effects on wheat yield across a European transect using impact response surfaces. Climate Research. (accepted)

Rötter, R., F. Tao, J. G. Höhn and T. Palosuo (2015) Use of crop simulation modelling to aid ideotype design of future cereal cultivars. Journal of Experimental Botany. doi:10.1093/jxb/erv098

Rötter, R. P. (2014). Agricultural Impacts: Robust uncertainty. *Nature Climate Change, 4*(4), 251-252. doi: 10.1038/nclimate2181

Trnka, M., Rötter, R. P., Ruiz-Ramos, M., Kersebaum, K. C., Olesen, J. E., Žalud, Z., & Semenov, M. A. (2014). Adverse weather conditions for European wheat production will become more frequent with climate change. *Nature Climate Change, 4*, 637–643. doi: 10.1038/nclimate2242

Zhao, G. …. et al (2015) The implication of irrigation in climate change impact assessment: a European wide study (in Review)

Zhao, G. …. et al (2015) Effect of weather data aggregation on regional crop simulation for different crops, production conditions and response variables. (accepted)