Perspectives and limits for modelling climate change impacts on pests and diseases:

Fusarium in wheat

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Too many factors to predict a problem ?

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Too many factors to predict a problem ?

- It’s easy to make a model
- Disease = a*temp
- But more difficult to predict reality

Modeling as a guiding principle for risk assessment

- risk perception is often based on emotion and intuition rather than on reason, rationality and knowledge
- In risk management, quantification and modelling is helpful to support policy making and to develop adaptive strategies.
- behaviour of complex systems can only be predicted by modelling approaches

Modelling constraints

- Models are a simplification of the real world.
- Choosing the right parameters
- How to handle complexity and uncertainty?

Who are the stakeholders for model output?

- Farmers
  - Seasonal Disease management: application of fungicides
  - Adaptation of cropping strategies
- Food and Feed industry
  - Buying and destination of batches with different qualities for processing
  - Monitoring and inspection (where / when)
- Quarantine and food safety authorities
  - Risk based inspection, regionally based
- Breeding industry and policy makers
  - Adaptation to future conditions (security and safety)

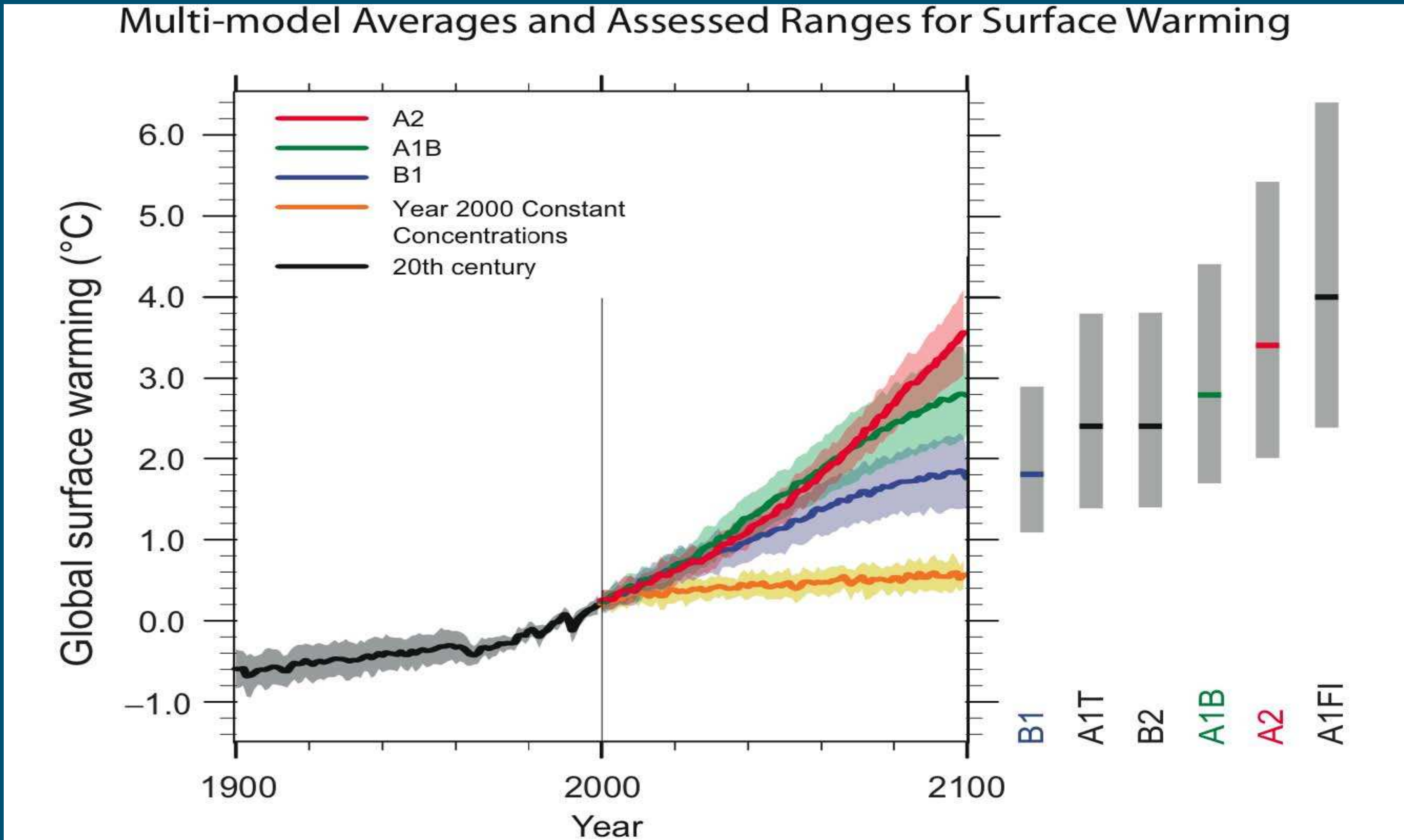
What to predict?

- Climate change and future weather
- Response of crops, pests and diseases
- Distribution
- Phenology
- Dynamics and epidemiology
- Crop-disease interactions
- Antagonists
- Genetic shifts (adaptation)

Steps in climate pest/disease modeling

- Choose climatic scenarios and time frames
- Downscale regional average climate to local weather
- Predict crop and disease/pest distribution based on climatic envelopes and other constraints
- Model crop growth and phenology in spatial context
- Model potential pest/disease development using climatic effects on life history traits (growth, development, reproduction, survival, infestation, dispersal)
- Link pest and disease models to crops and antagonist

Variability Climatic projections from IPCC



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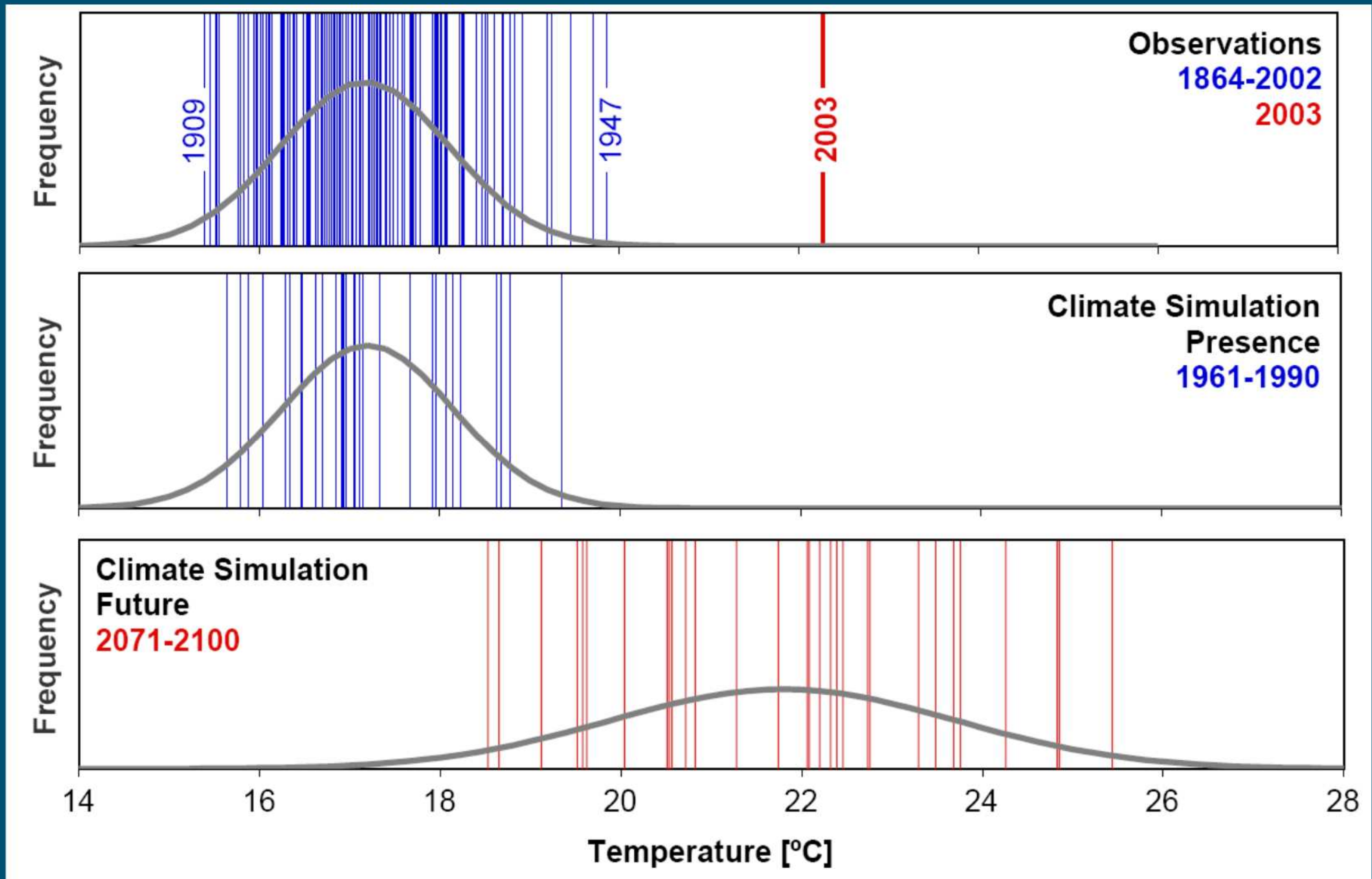
IPCC WG-I (2007)

Observed and projected temperature in Central Europe



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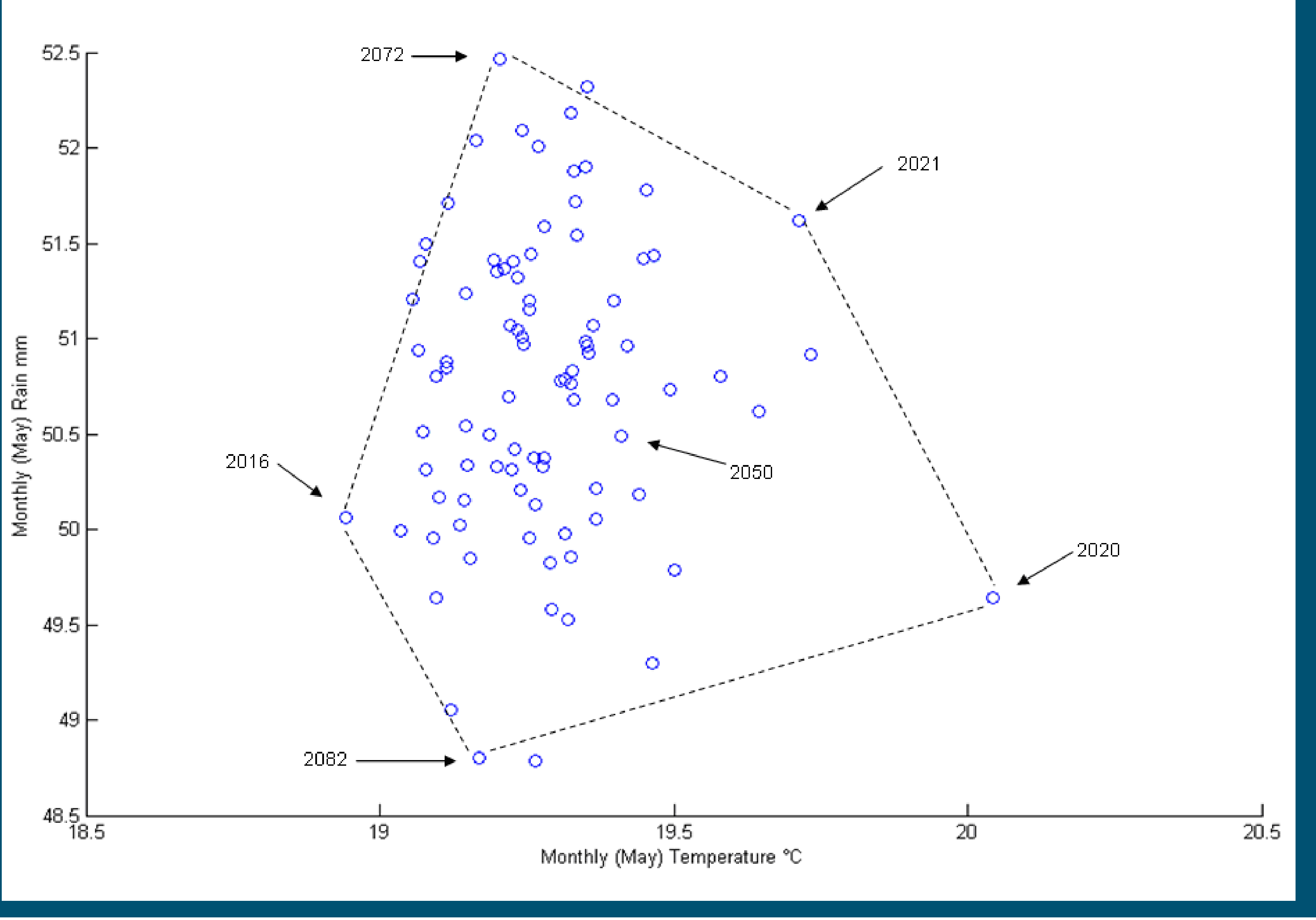
Schär et al. (2004)

Downscaling climate to weather

- Pests and disease respond to local weather on a daily or hourly time scale
- Weather generators are needed to make multiple runs for each time frame
- The spatial scale can be crucial for variation

Generated weather variabililty (EFSA 2011)



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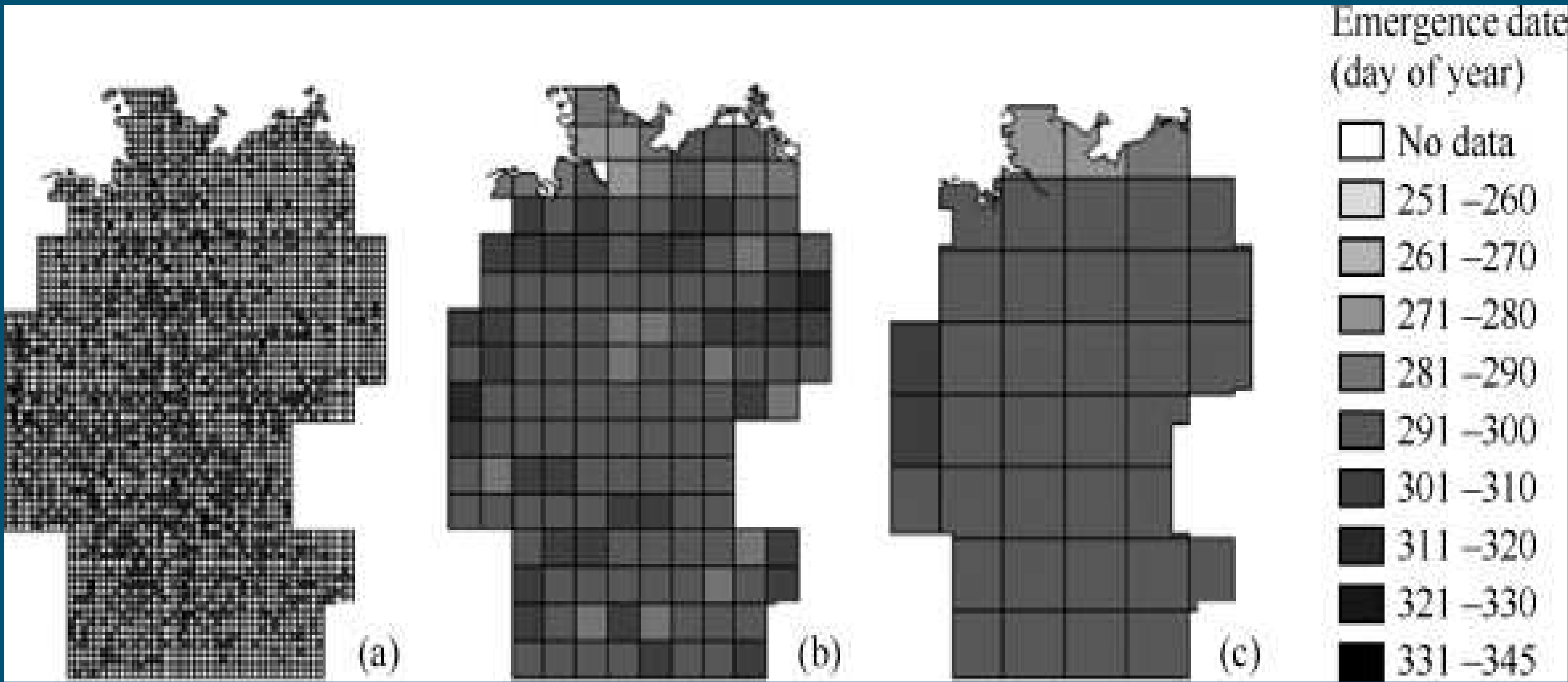
Effect of scaling on variability

(van Bussel 2010)

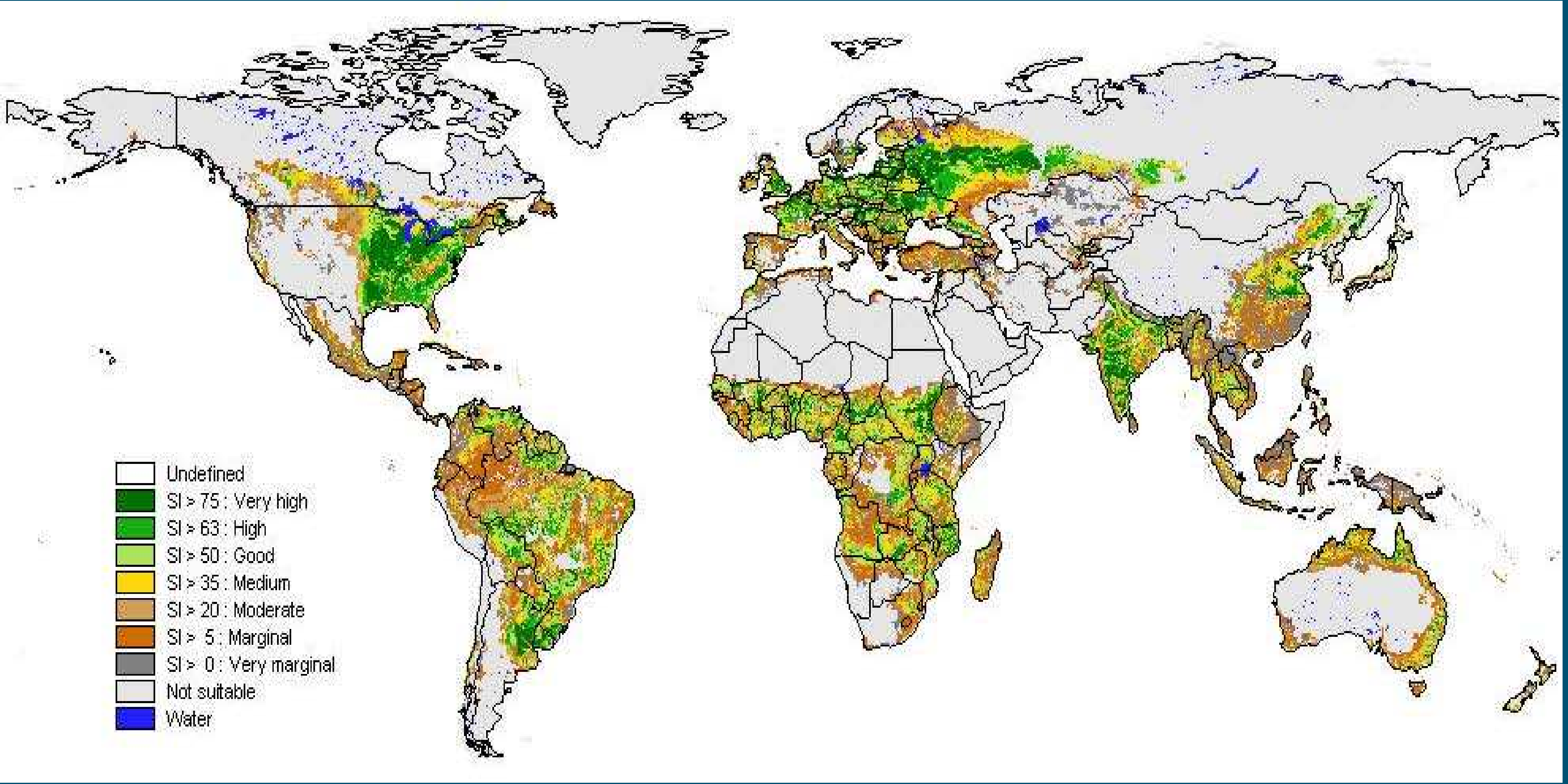


Shifts in crop, pest and disease distributions

- Crops will shift northwards
- Disease distribution is determined by:
  - climatic constraints
  - invasive capacity
  - range shifts in relation to climate and crops
  - alternative host plants
  - Vector distribution

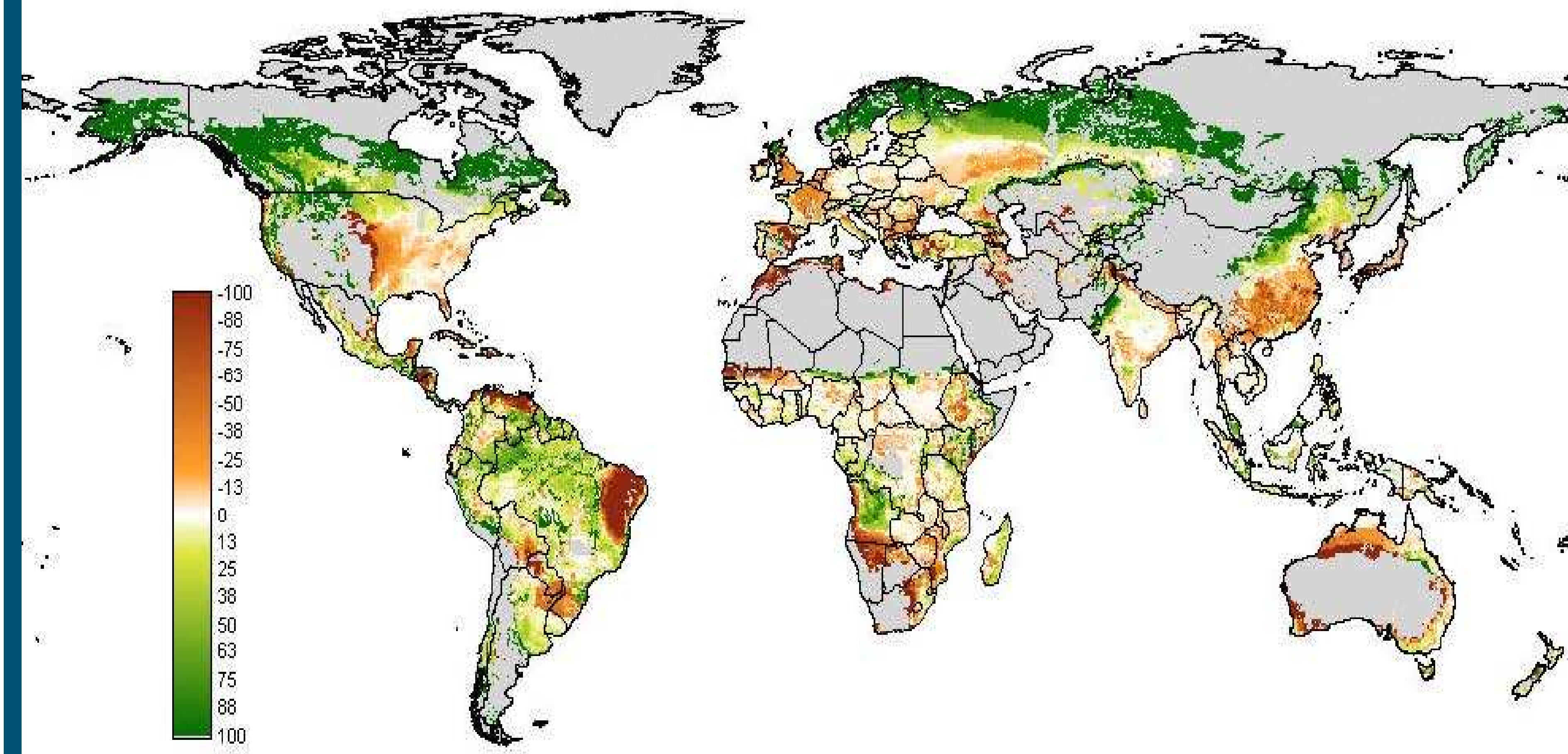
Climate and crop distribution

Suitability for rainfed grain production 1961-90



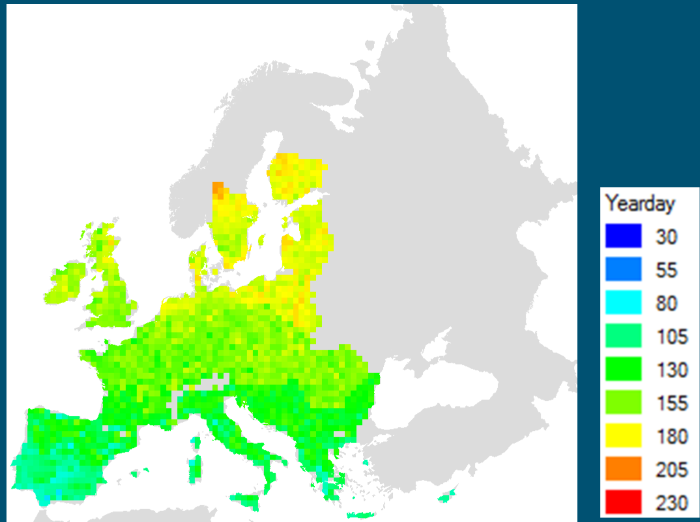
Climate and crop distribution

Change in suitability for rainfed grain 2080

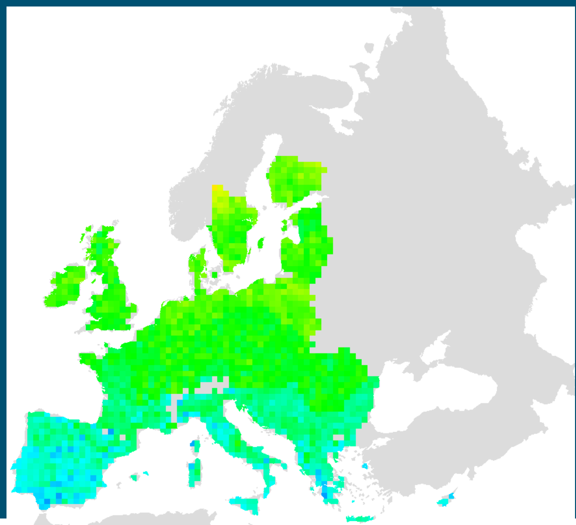


Shifts in phenology: flowering of wheat

2000



2050



A case study: the EMTOX project

- Aims: Integrating models for climate, crops and diseases to predict effects of climate change on Fusarium mycotoxins.
- Project Output: GIS based maps for Europe with estimated occurrence of emerging toxins in 2050 compared to 2000
- Funding: Safefoodera
- Consortium: Norway, Sweden, Denmark, The Netherlands and Cyprus climatologists, crop modelers, fytopathologists and mycotoxin experts

The simple approach

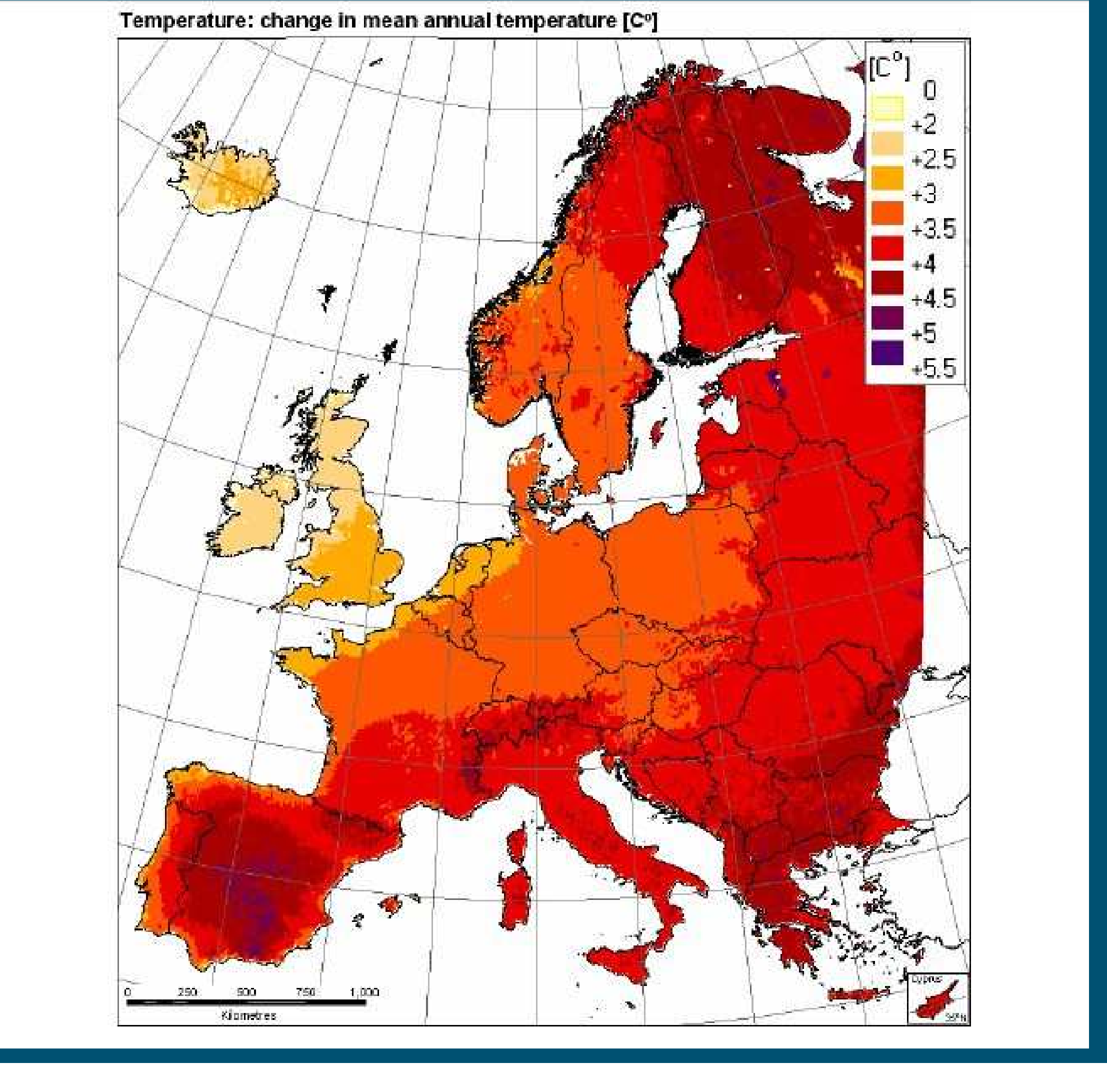
- Fusarium infections during the flowering period is the major factor for epidemics
- Toxins are related to Fusarium infection levels

- Flowering can be predicted based on TSUMS
- Fusarium / mycotoxin level can be predicted by:
  - temperature and moisture around flowering
    the preceding crop
  - crop resistance.
- Climate effects can be predicted by linking weather, crop phenology and Fusarium infection

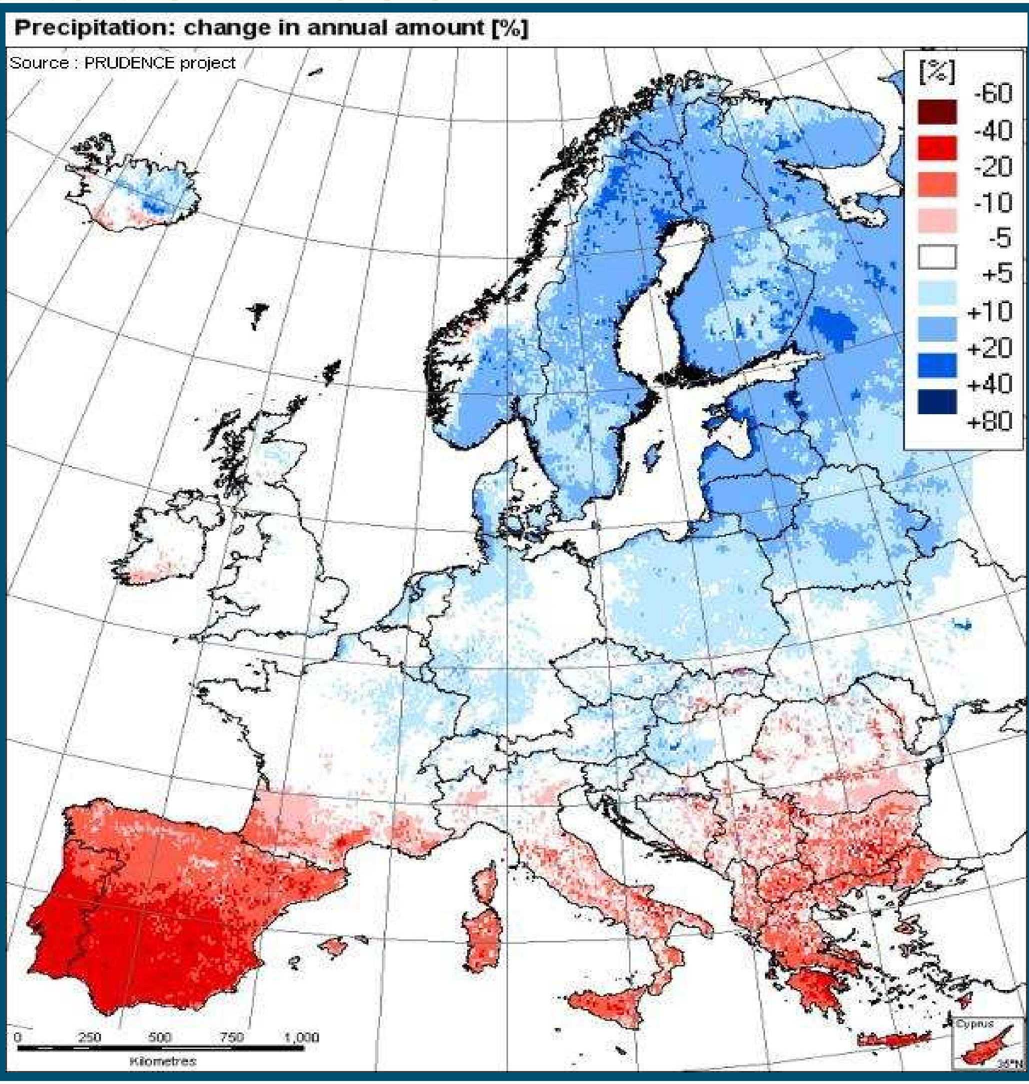
What do we need

- A map with wheat distribution in Europe
- A map with temperature and rainfall in 2050
- A temperature sum model for wheat flowering
- A generic forecasting model for Fusarium infection and/or mycotoxin level

Climate projections, temperature 2050



Precipitation 2050



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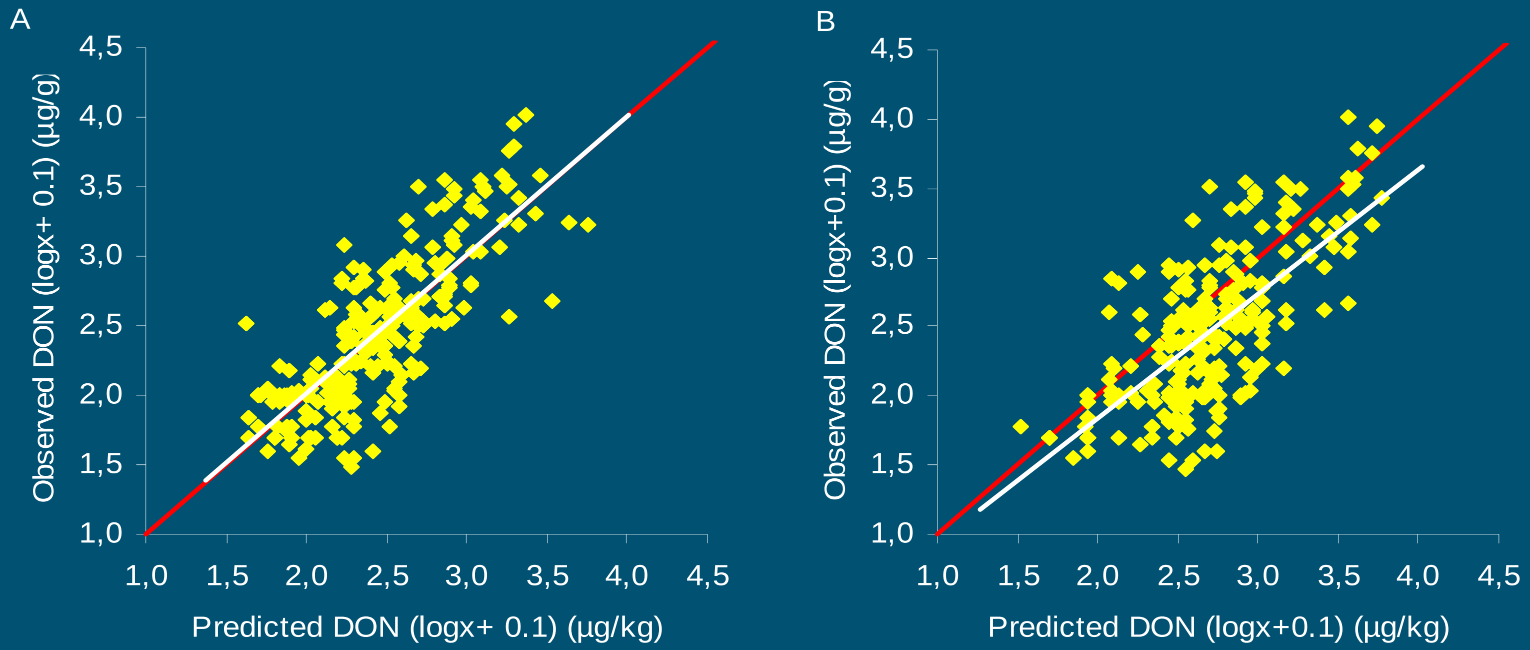
Mycotoxin models



Predicted vs observed DON values for models that include, crop resistance, temperature and rainfall around flowering and untill harvest

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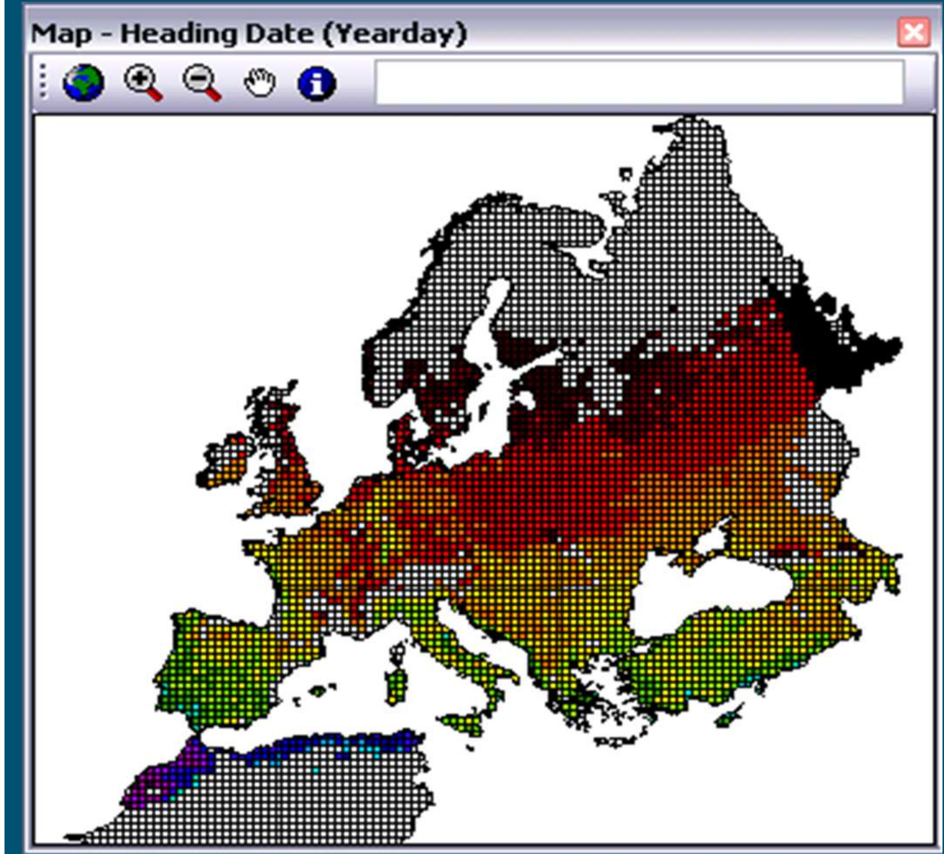
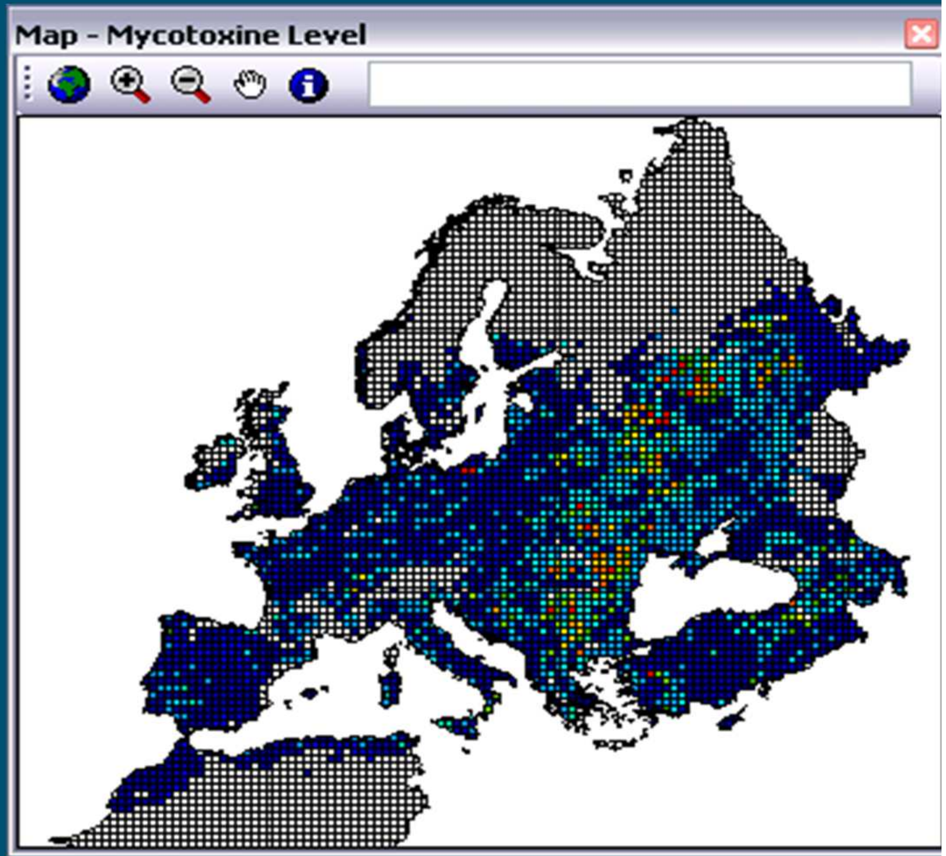
Weather predicts flowering and disease levels

Start of the flowering period

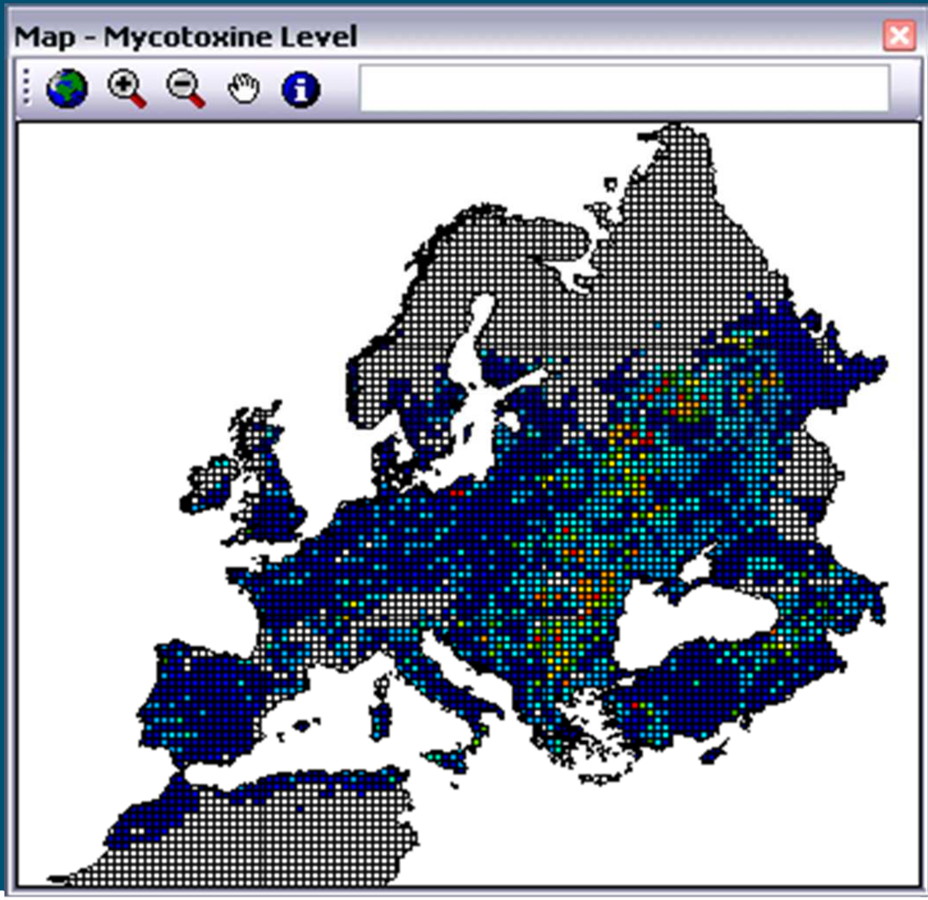


Predicted Fusarium mycotoxins

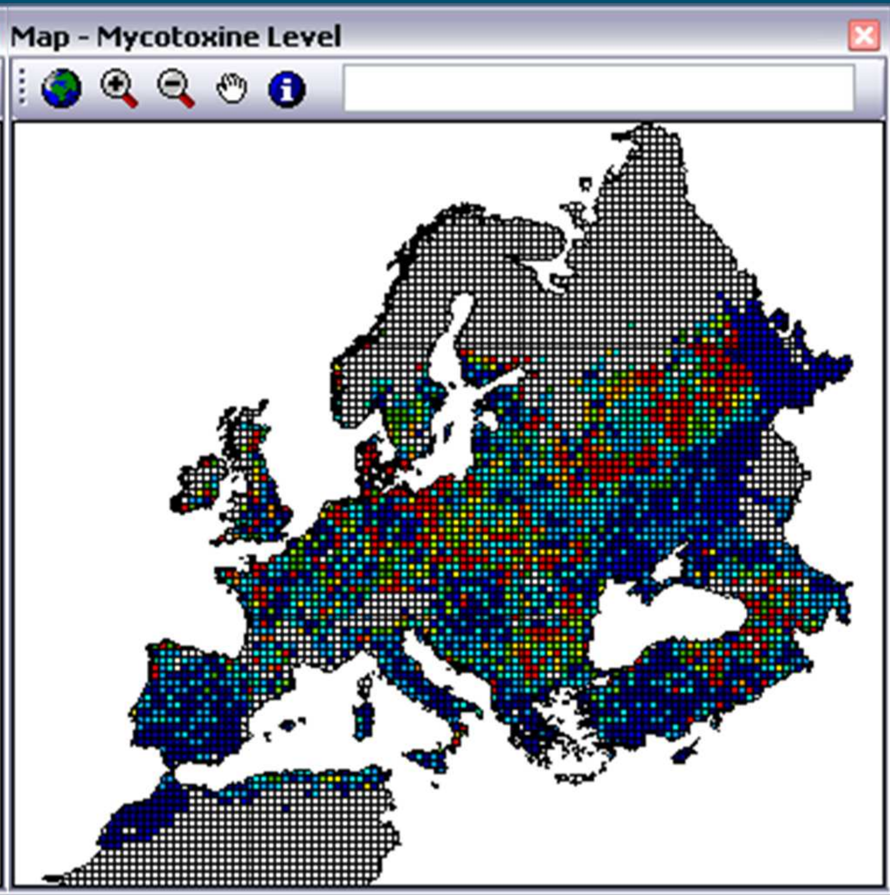


Mycotoxins in wheat in 2050 scenario

Situation 2007



Situation 2050



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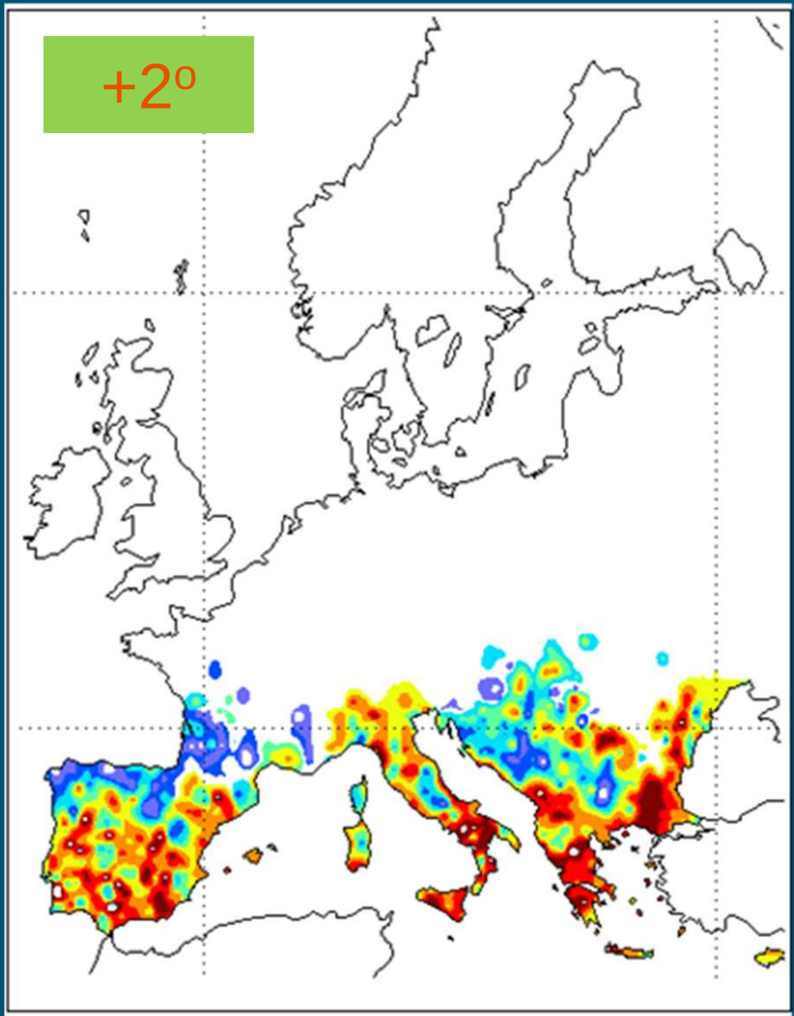
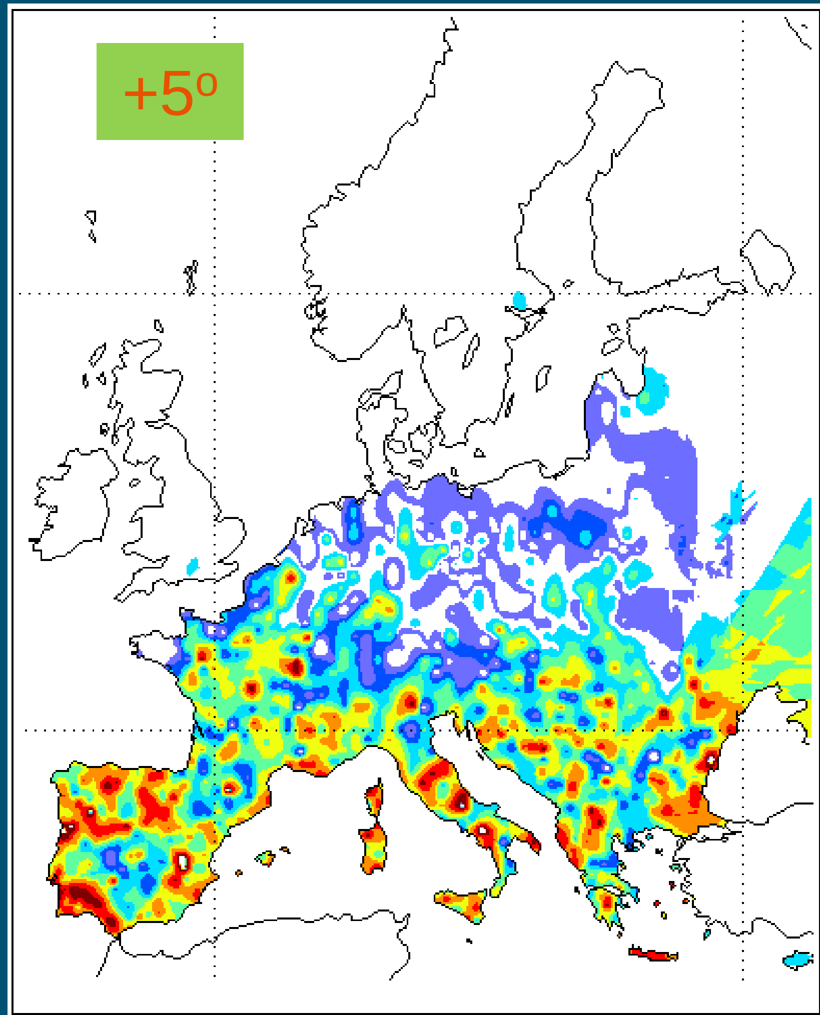
Mycotoxins in Mais in +2^o and +5^0 scenario's





What makes modeling complex ?

- climatic uncertainty
- shifting crop areas, crop responses
- shift in cultivars
- the accuracy of flowering dates
- future seeding dates and harvest dates?
- mycotoxin model uncertainty
- from climate to weather
- downscaling and spatial variability
- Fusarium: shifts, species, pathotypes, toxins

What happens with the wheat crops

- More winter wheat in Northern Europe
- Earlier sowing in many regions
- Does the area increase due to demand (food, feed, fuel?)
- Other varieties will be chosen regionally
- New varieties will be bred: what does it mean?


I THOUGHT I WAS INTERESTED IN UNCERTAINTY BUT NOW I'M NOT SO SURE
TOSHIO

How to improve modeling (1)

Climate and Weather

- Include temporal variability
  - multiple runs with generated weather data over a decade
- Include spatial variability at the right scale
  - quantify local variation and use this as input

Crops and cultivars.

- Use smart systems to predict cultivar phenology characteristics per region
  - climatic envelope approach for seeding, flowering, harvest

How to improve modeling (2)

Fusarium epidemiology and toxin formation

- Improve and develop better Fusarium and toxin models
  - use better extensive data, improve sampling
  - include large scale epidemiology (region effects)
  - generic mechanistic models in stead of empirical models?
- Accept variability
  - use Monte Carlo simulation or fuzzy numbers to evaluate variation
  - use scenario and compartment modeling to generate output variability

Recommendations for modellers

- cooperate in multidisciplinary teams
- focus improvements on the weakest points

- communicate robust conclusions but
- do not neglect variability and evaluate effects
- accept uncertainty and communicate it

How to use model outputs for adaptation

- Indentify the most sensitive parameters that can be used to adapt disease management
- Be prepared for worst case scenario's
- Make cropping systems resilient to extreme and variable unpredictable situations.
- Diversify crop production and crop protection to be more resilient
- Make systems more robust in stead of optimized for current situations.
- Cooperate with stakeholders when innovating

Thanks for your attention

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