Model calculations with downscaled climate change scenarios

First results

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Outline

- Introduction
- Development of downscaled climate change scenario
- Effects on precipitation distributions
- SWAP calculations of consequences for maize irrigation
- Calculations of yield effects on winter wheat
- Conclusions

Used climate change scenario

Basic scenario from MPI Hamburg (scenario ECHAM 4)

Assumptions and general trend

- moderate CO_2 emissions (A1B scenario, IPCC, 2001)
- increase of average temperature by 1.4 K from 2001 to 2055

Spatial and temporal downscaling (from Gerstengabe et al. 2003)

To use the scenarios of GCMs for agroecological or operational models the calculated trends of the GCMs have to be downscaled.

Method:

- A statistical method was used to proceed historical observations of meteorological time series with a special cluster analysis developed by Gerstengabe et al. (1999)
- Example for station Magdeburg (latitude 52.12 degrees)

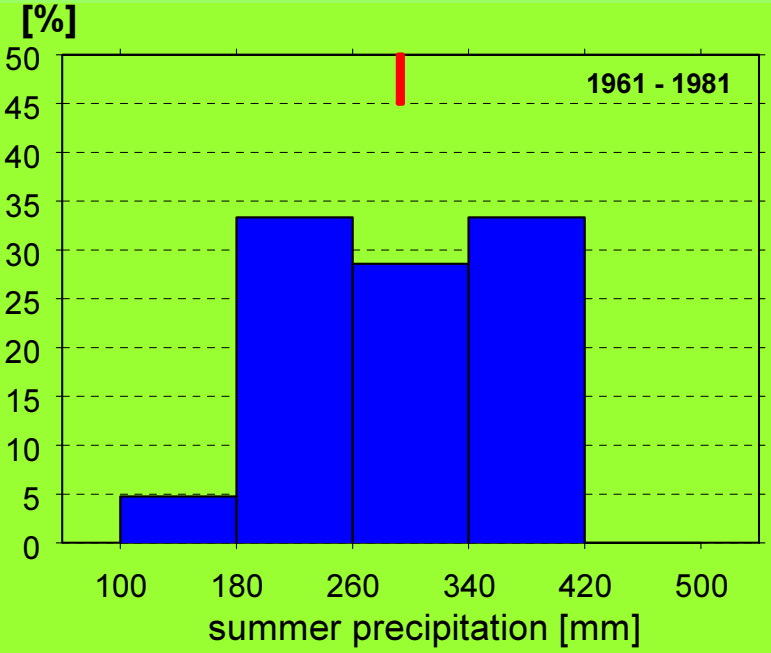
- Simulation models used:

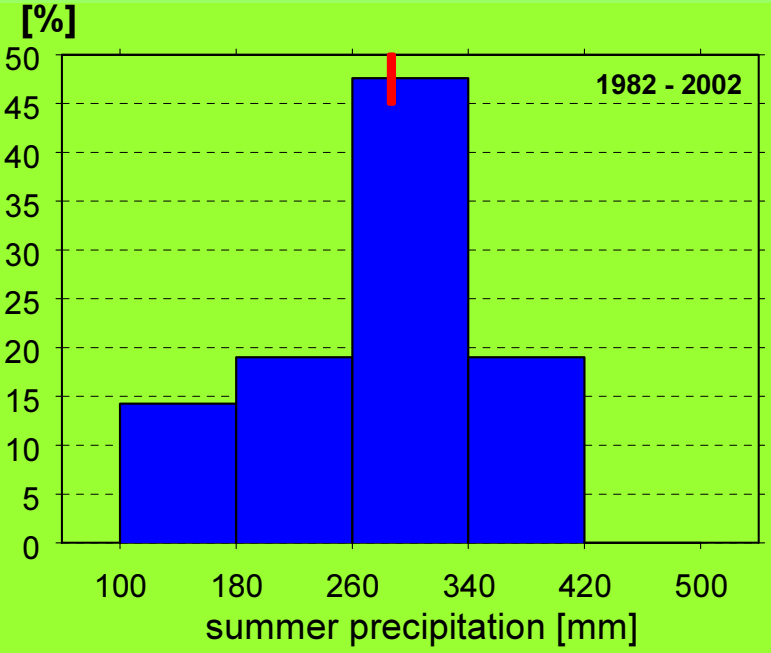
SWAP (Irrigation maize)

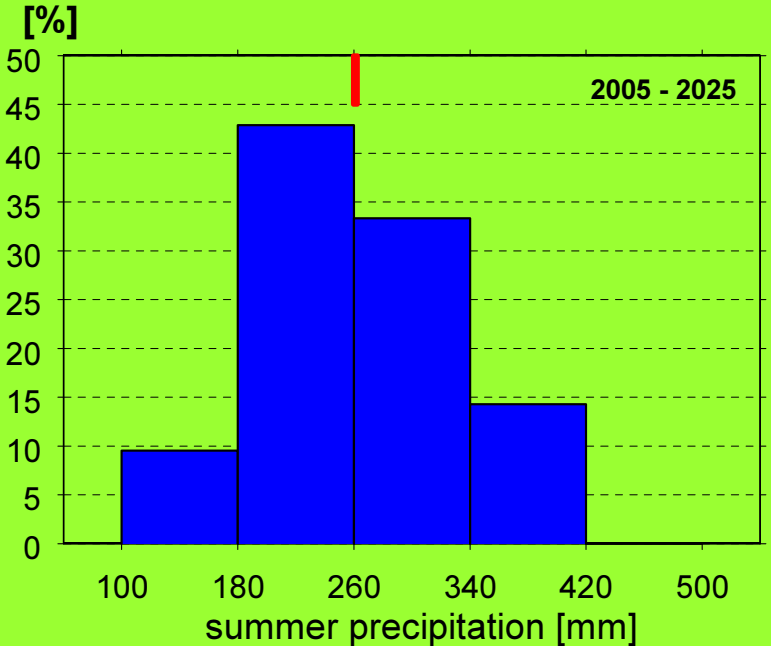
HERMES (yields of winter wheat)

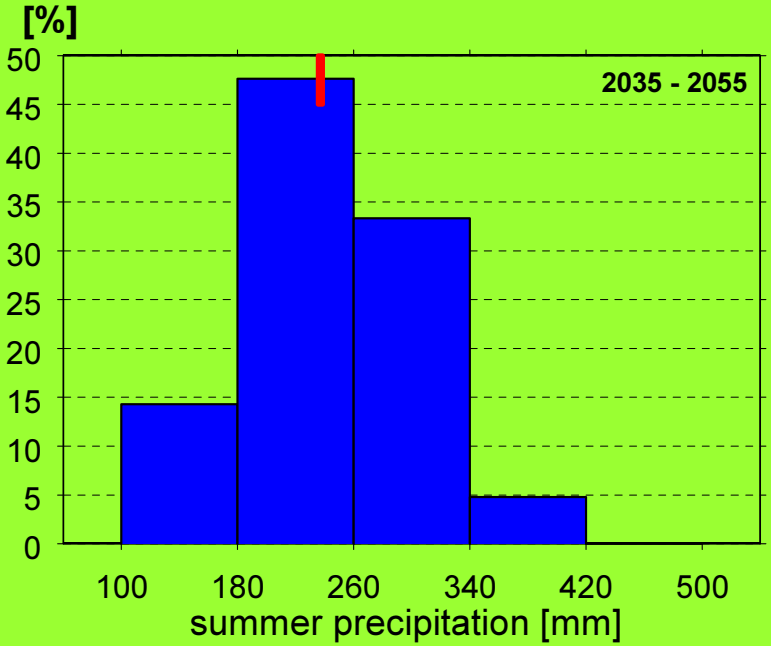
Frequency distribution and 20 years averages of summer precipitation at Magdeburg

(observations 1961 – 2002, climate change scenario 2005 – 2055 downscaled from GCM model output)



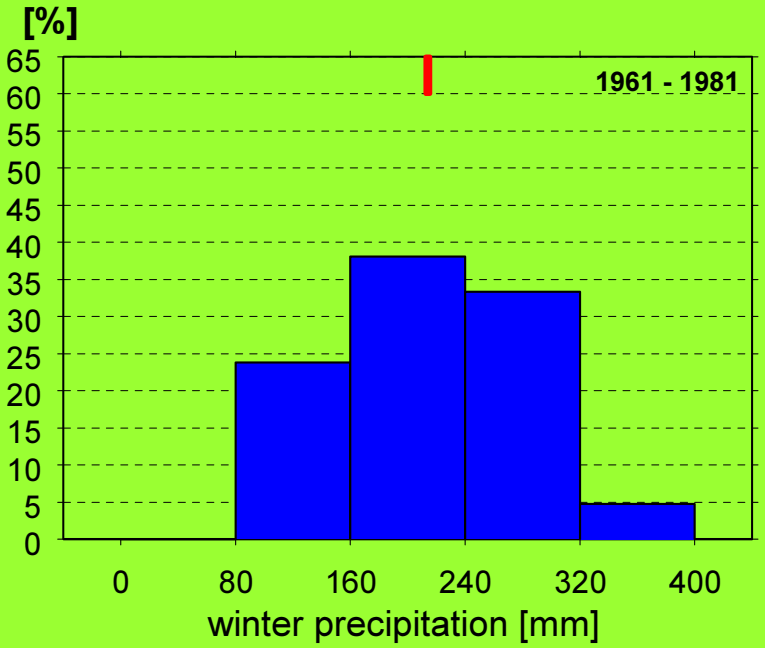


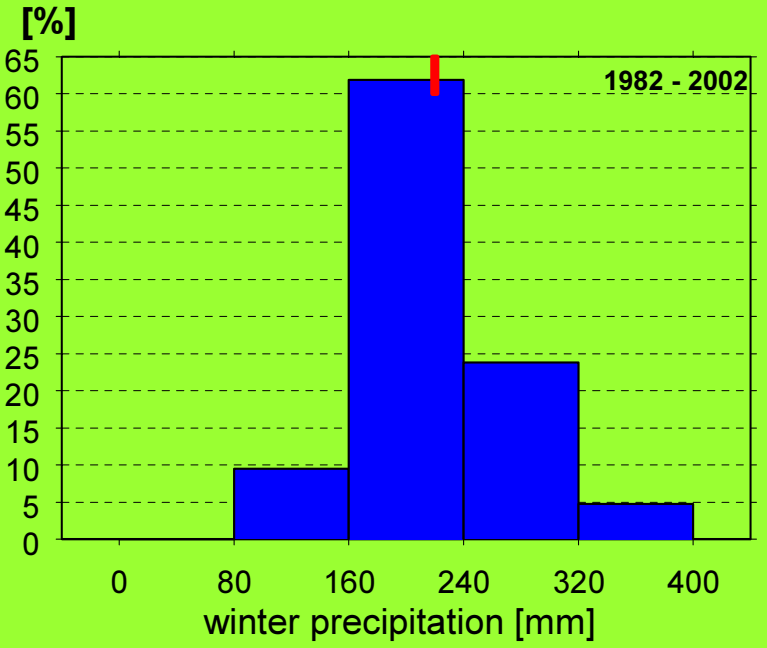


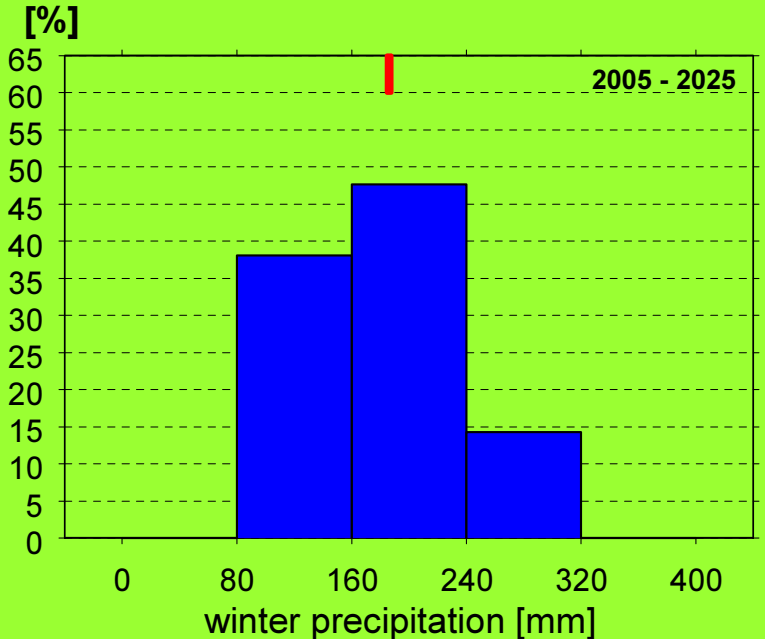


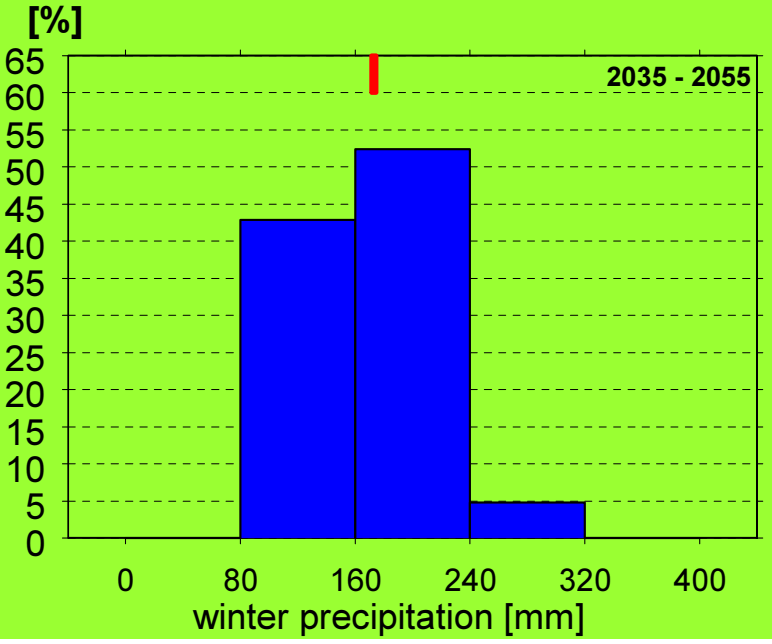
Frequency distribution and 20 years averages of winter precipitation at Magdeburg

(observations 1961 – 2002, climate change scenario 2005 – 2055 downscaled from GCM model output)



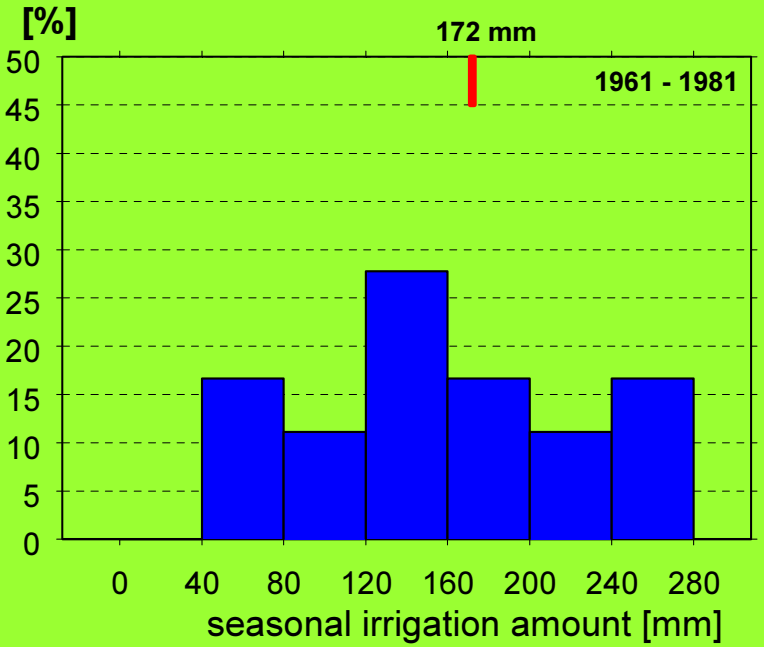


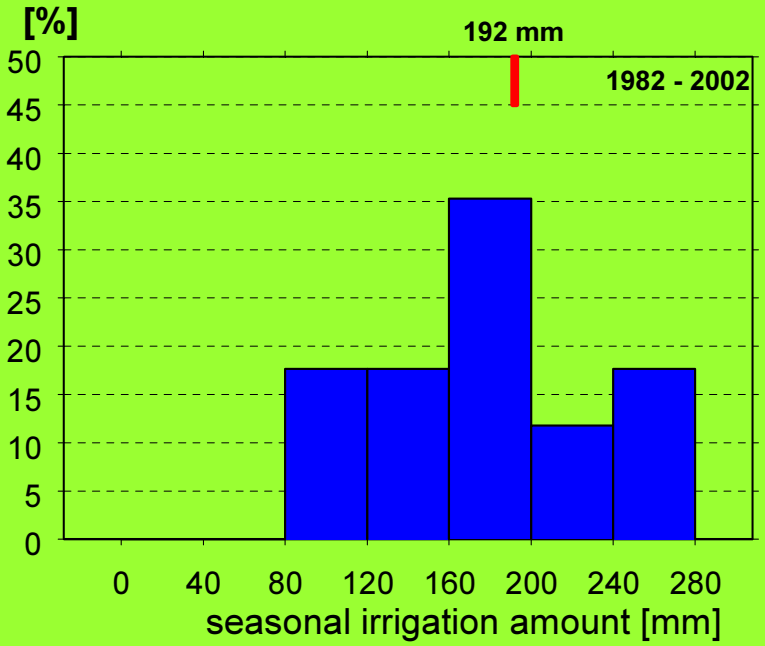


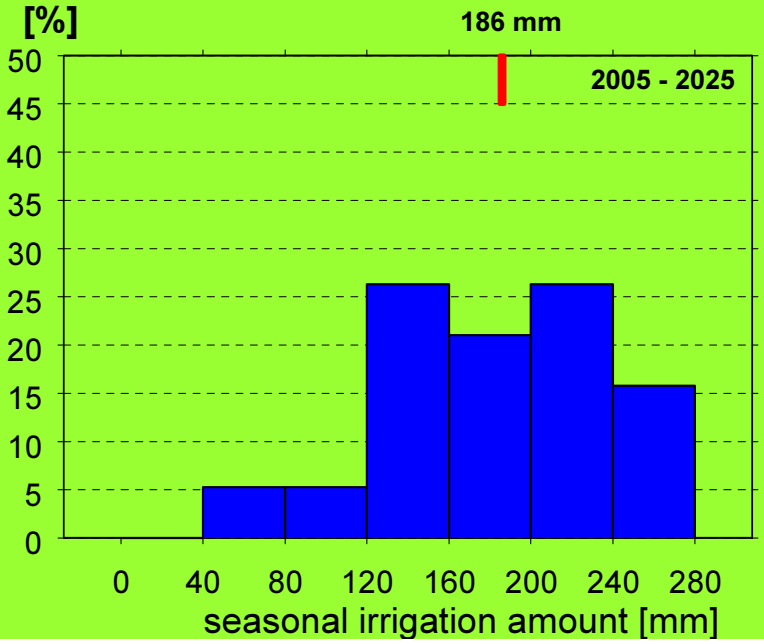


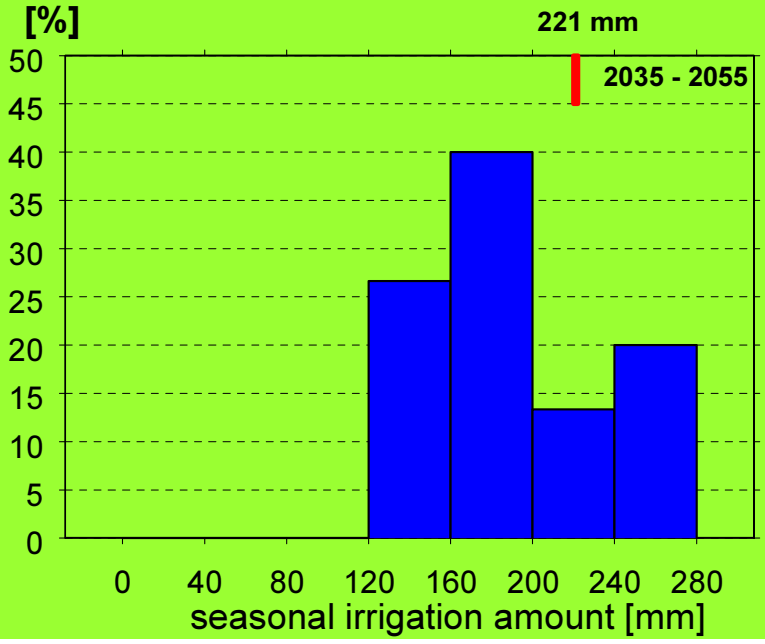
Frequency distribution and 20 years averages of calculated irrigation demand for maize

(observations 1961 – 2002, climate change scenario 2005 – 2055, irrigation requirements calculated with SWAP)



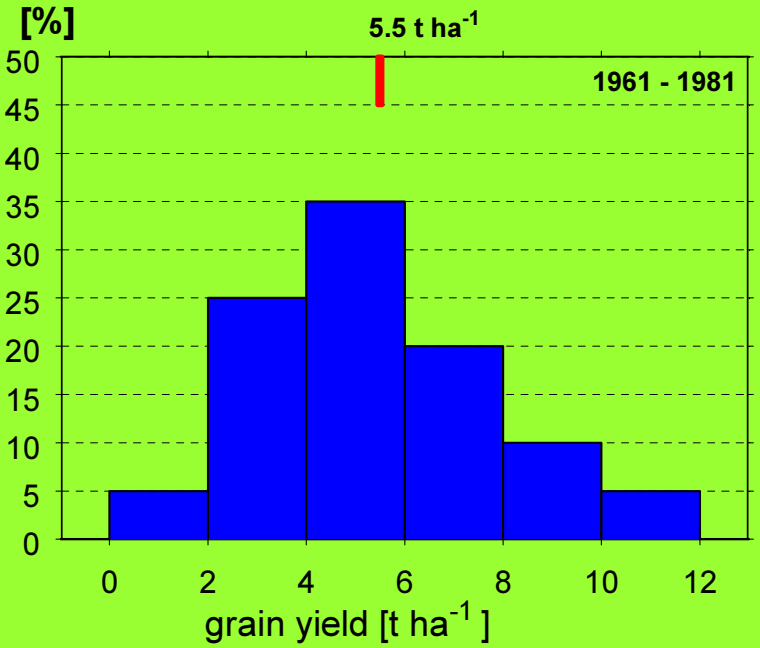


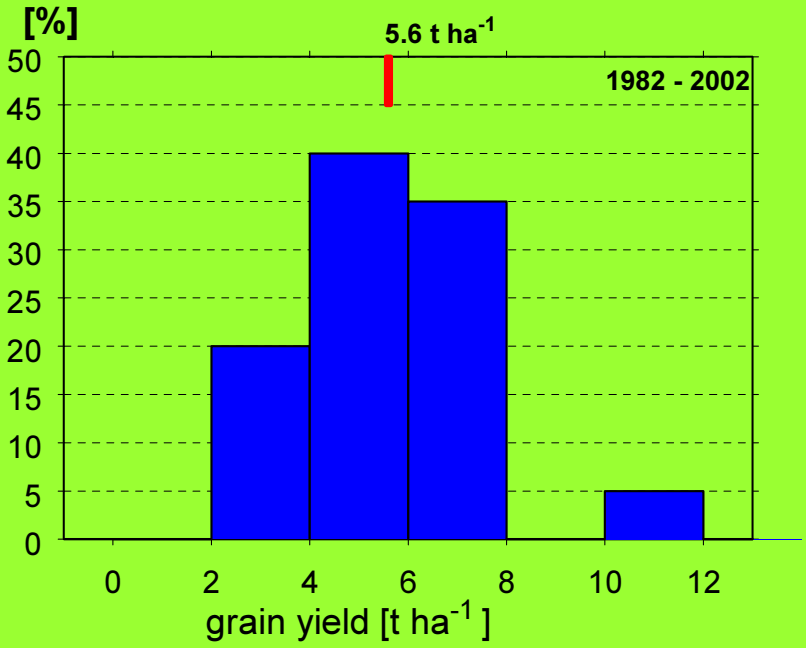


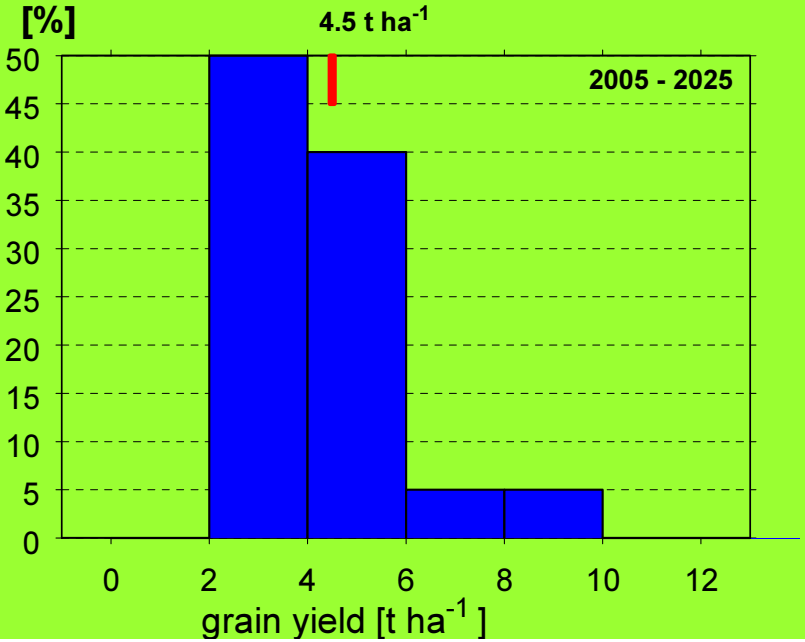


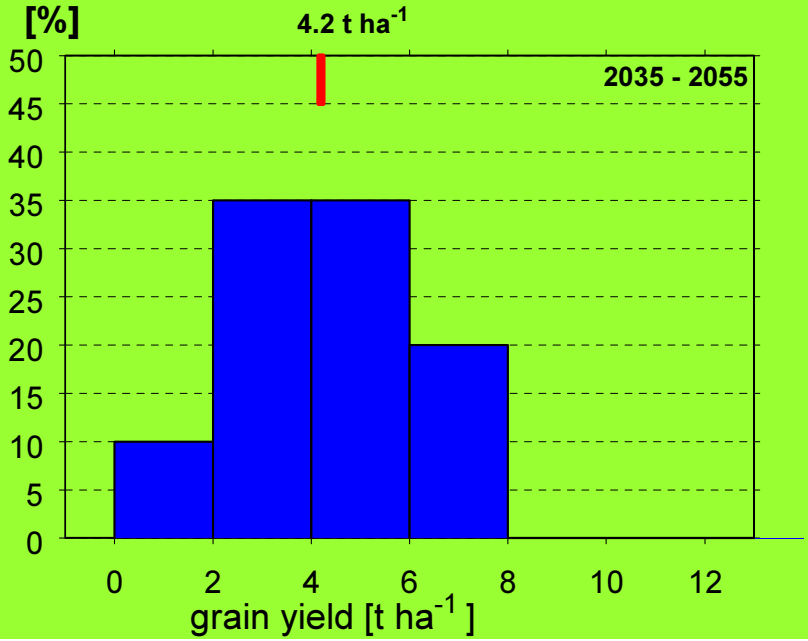
Frequency distribution and 20 years averages of calculated winter wheat yields

(observations 1961 – 2002, climate change scenario 2005 – 2055, crop yields calculated with HERMES)









Conclusions

- Spatial and temporal resolution of GCM trend calculations for climate change can be improved by statistically based downscaling methods linking the trends to historical weather data time series.
- Simulated time series can be used as input for agro-ecosystem models to estimate consequences for agricultural production.
- Calculations of a climate change scenario for Magdeburg/Germany show that precipitation is expected to decrease especially during the growing season.
- Simulations with the SWAP model indicate an increase of irrigation requirements for maize of about 50mm per year.
- Calculations with the HERMES model predict anaverage reduction of grain yield for winter wheat of 24% (without irrigation) between 1961 and 2055.
- Higher water use efficiency especially for C3 crops caused by higher CO_2 concentrations have to be considered in the future to estimate the effects of climate change on agricultural production.

7 steps are required

•Estimation of averages, interannual variability and ranking of a reference variable

•Random generation of a simulated time serie of annual averages considering the statistical properties of the observations and their ranks

•Implementation of the trend

•Estimation of anomalies between daily value and annual average for each year of the observed time serie

•Random allocation of anomalies considering the rank of the year to daily values

•Testing and correction of the statistical characteristics of the simulated time serie

• Linking the reference variable to other varables using the same parameters within the clusters