Climate change and agriculture

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European Commission

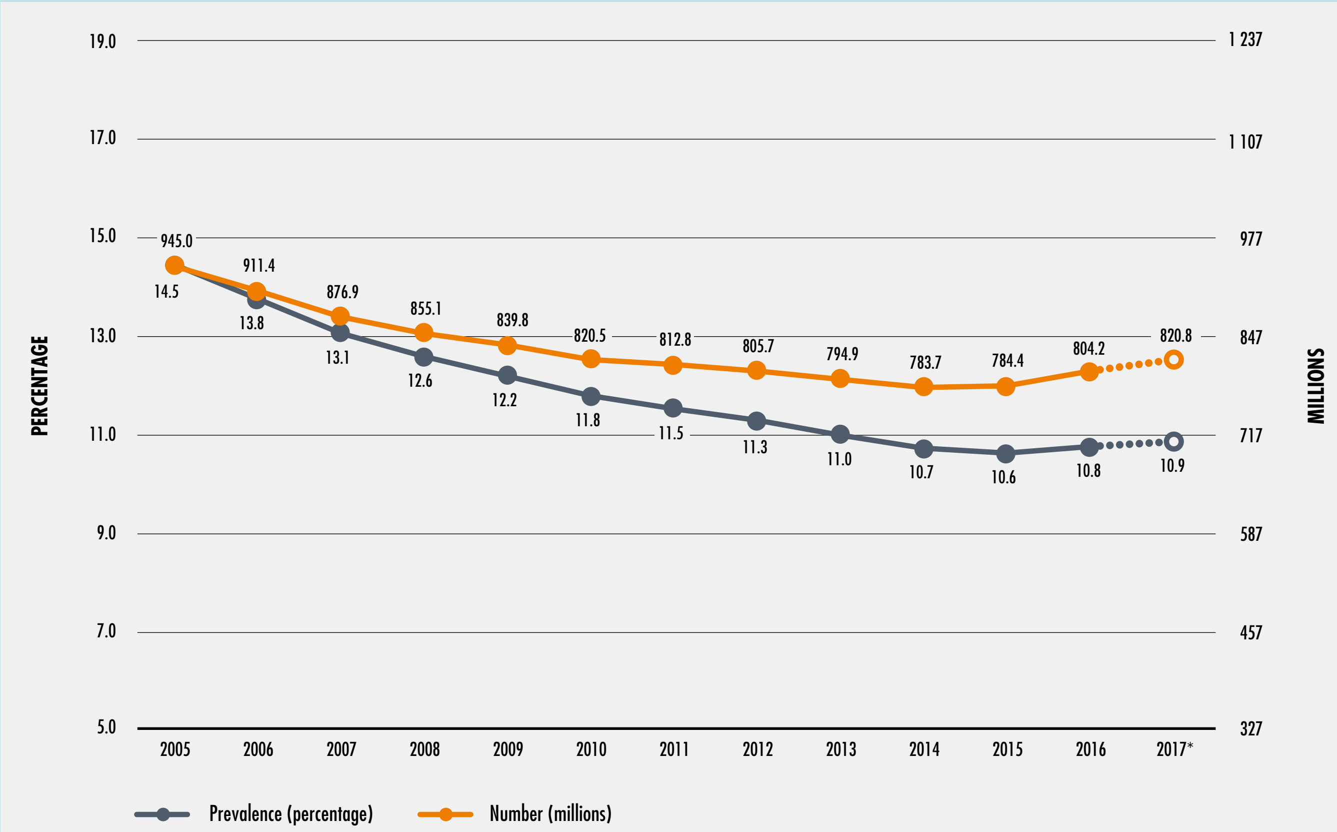
Introduction

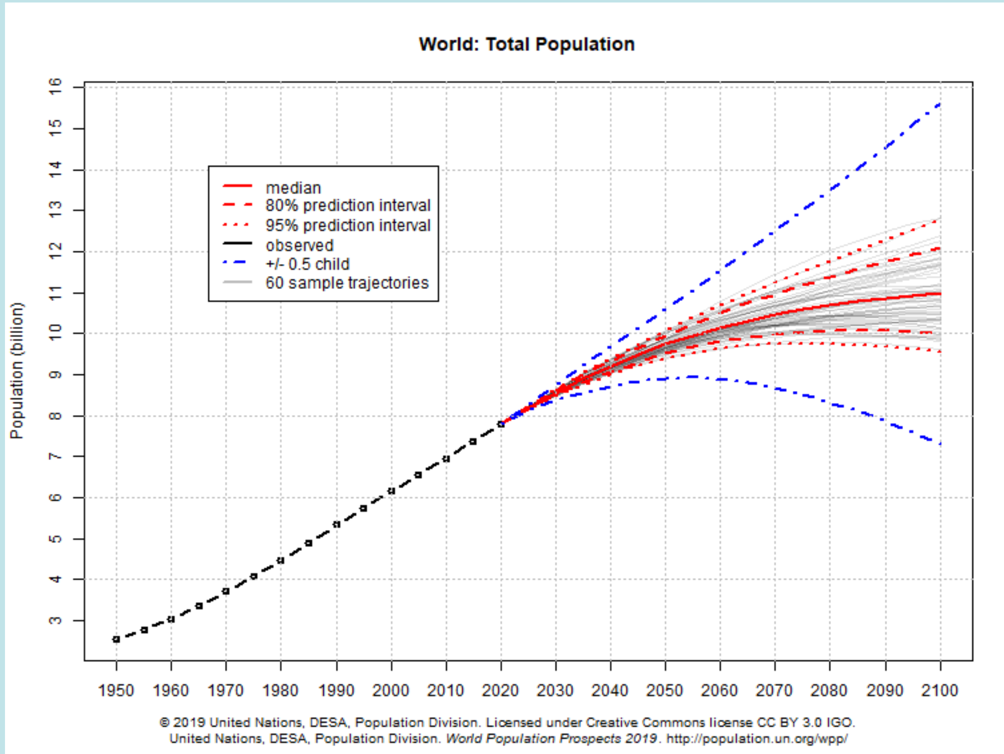
UN decade of action on nutrition 2016-2025

Source: WHO Department of Nutrition for Health and Development, 2018

Introduction

Undernourished people

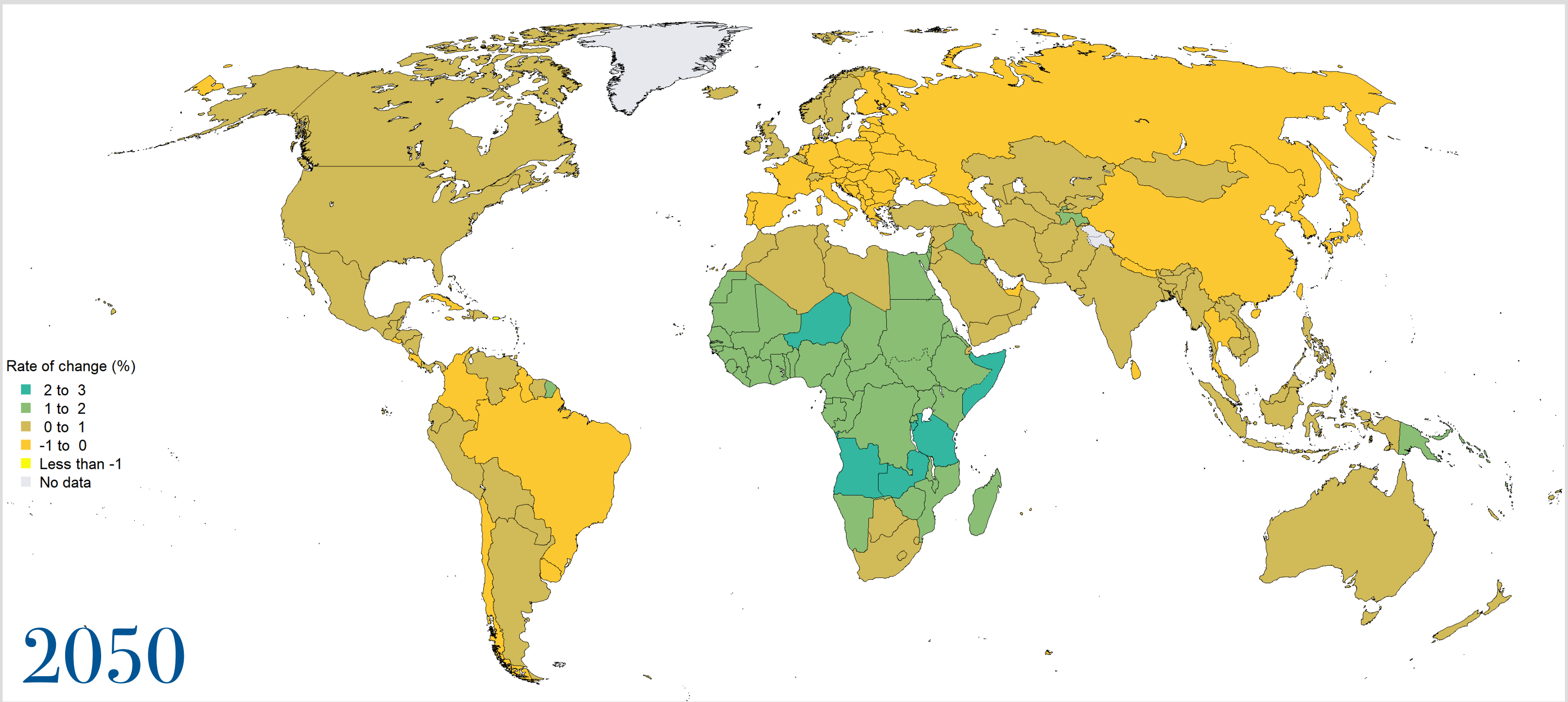


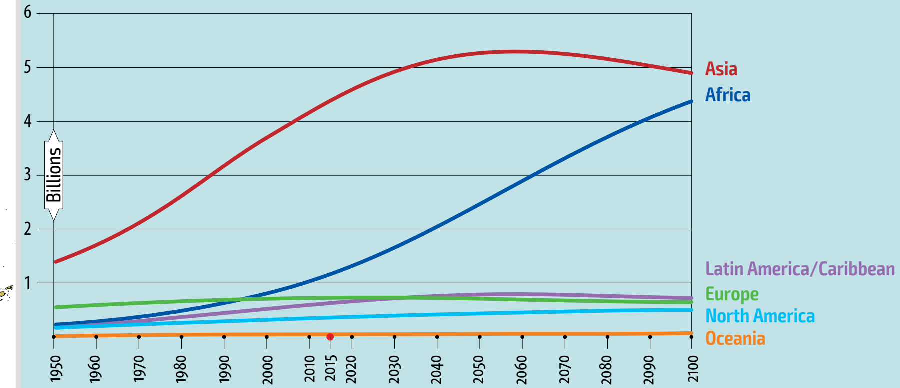


Source: FAO, SOFI 2018

Source: UN, 2019

Introduction





Annual rate of population change

Source: UN, 2019

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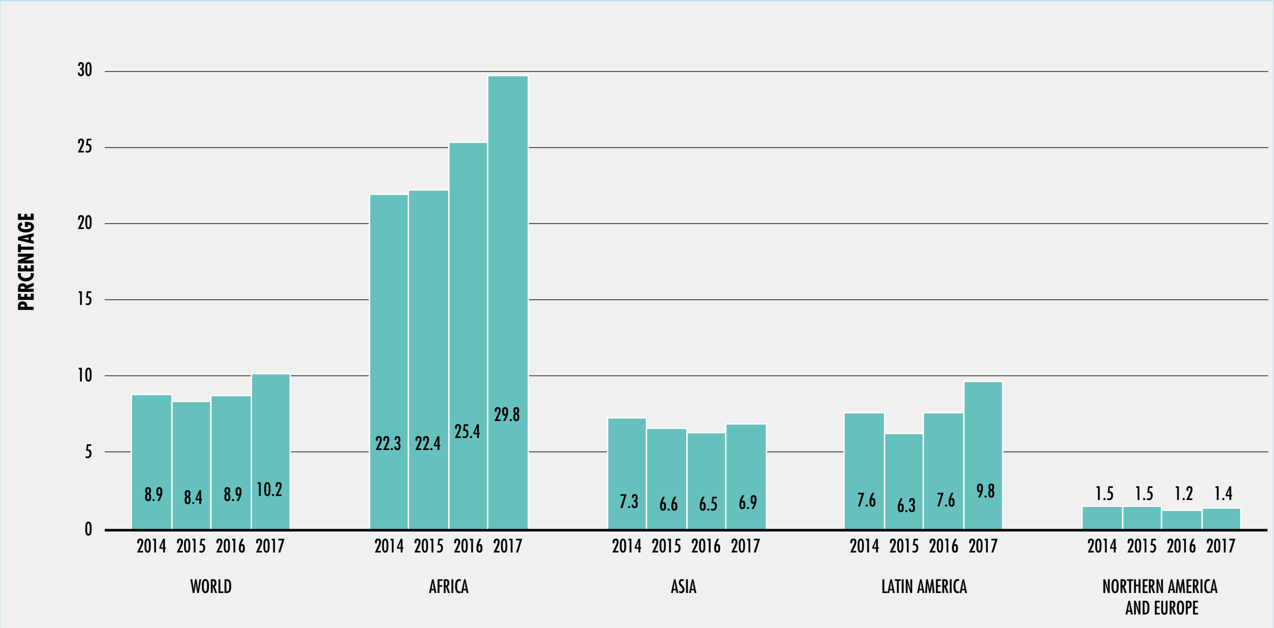
Introduction

Severe food insecurity



Source: FAO, SOFI 2018

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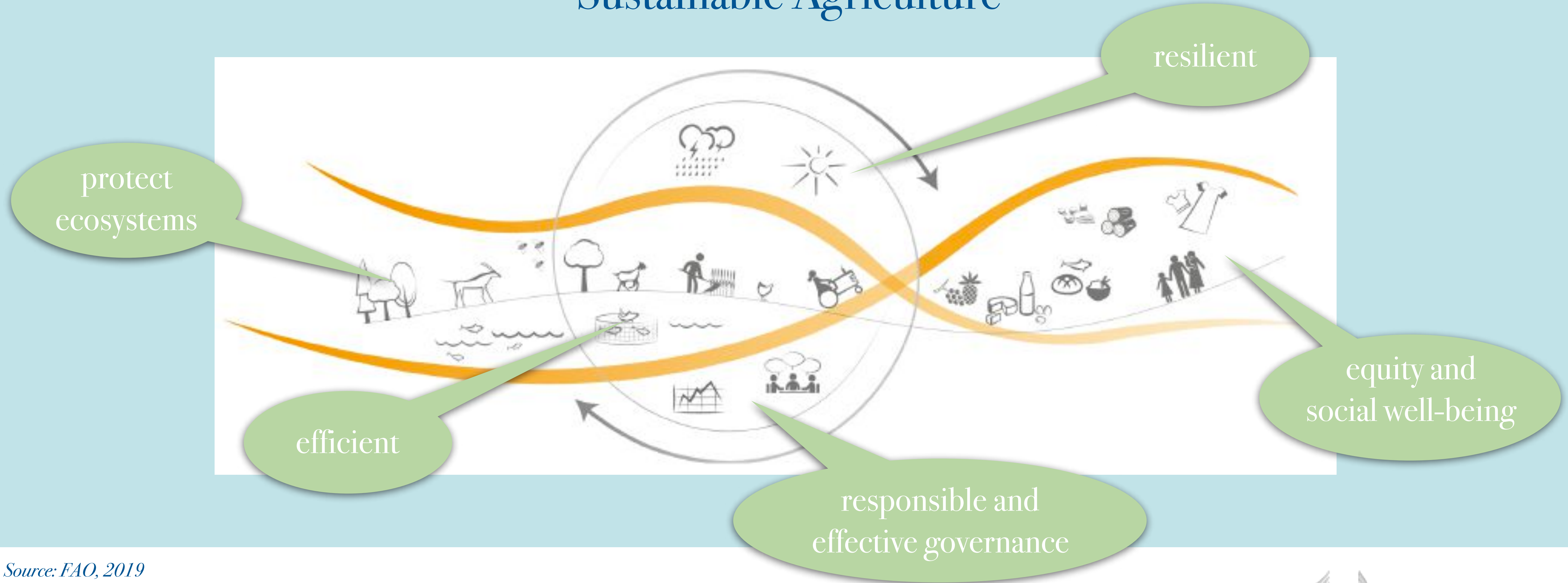
Source: FAO, 2019

Introduction

Sustainable Agriculture

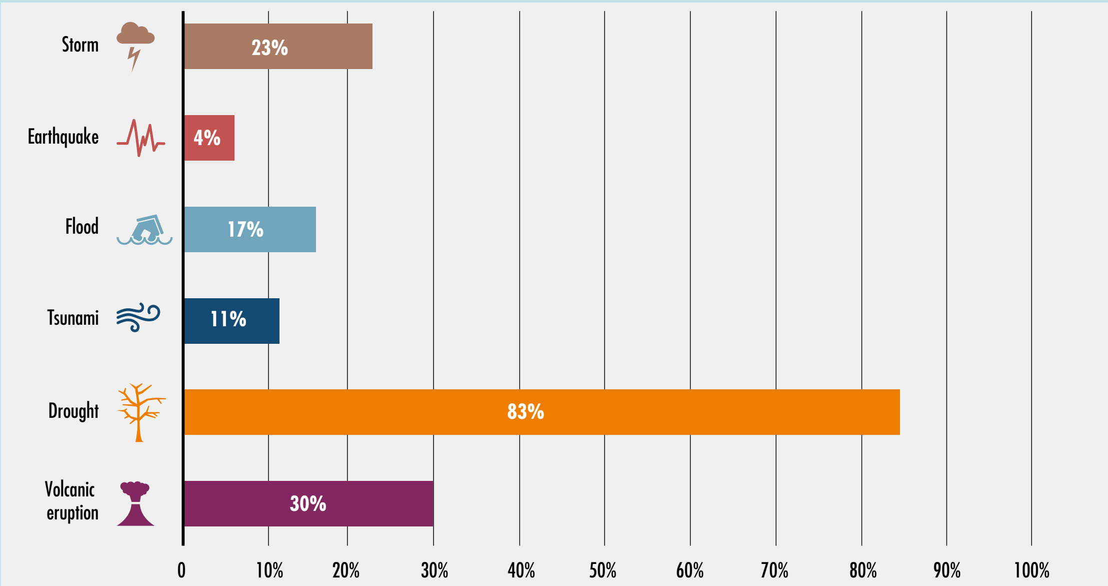


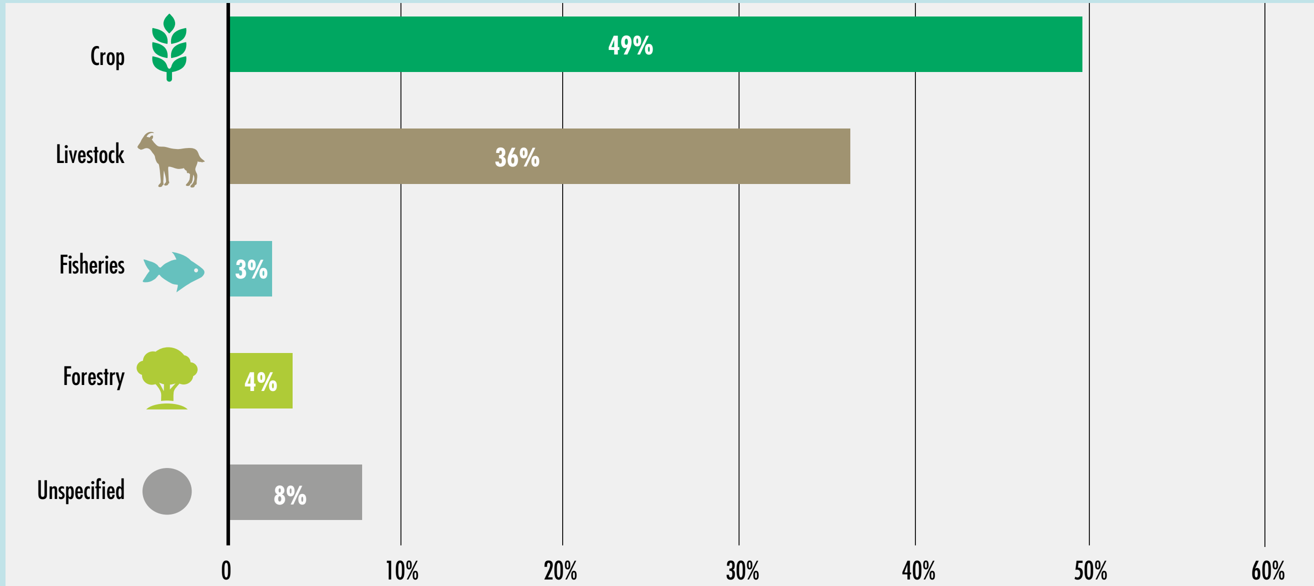
Source: FAO, 2019

Introduction

Damages and losses in agriculture

share of total damages/losses across all sectors

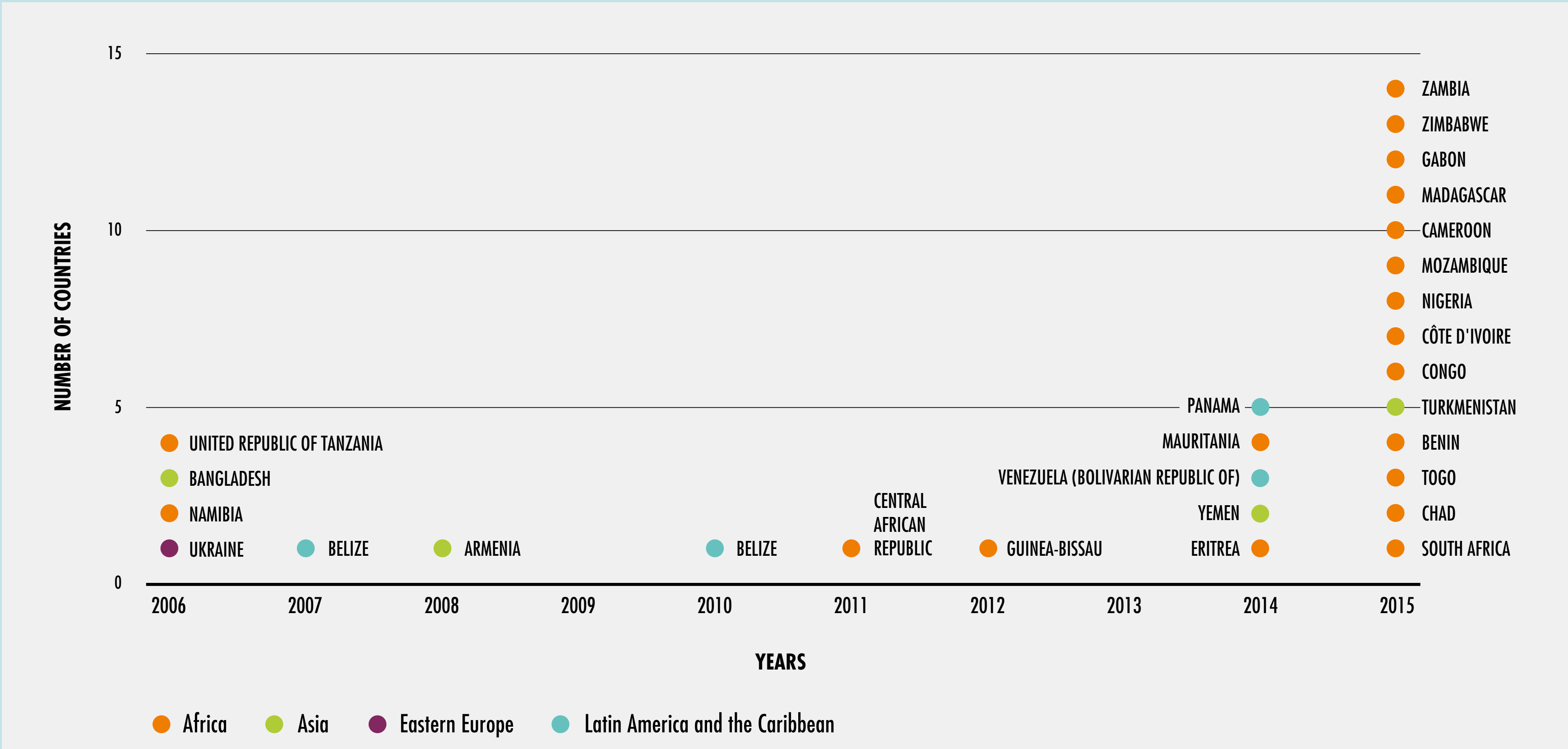




Source: FAO, SOFI 2018

Introduction

Drought and changes in the undernourished people



Source: FAO, SOFI 2018

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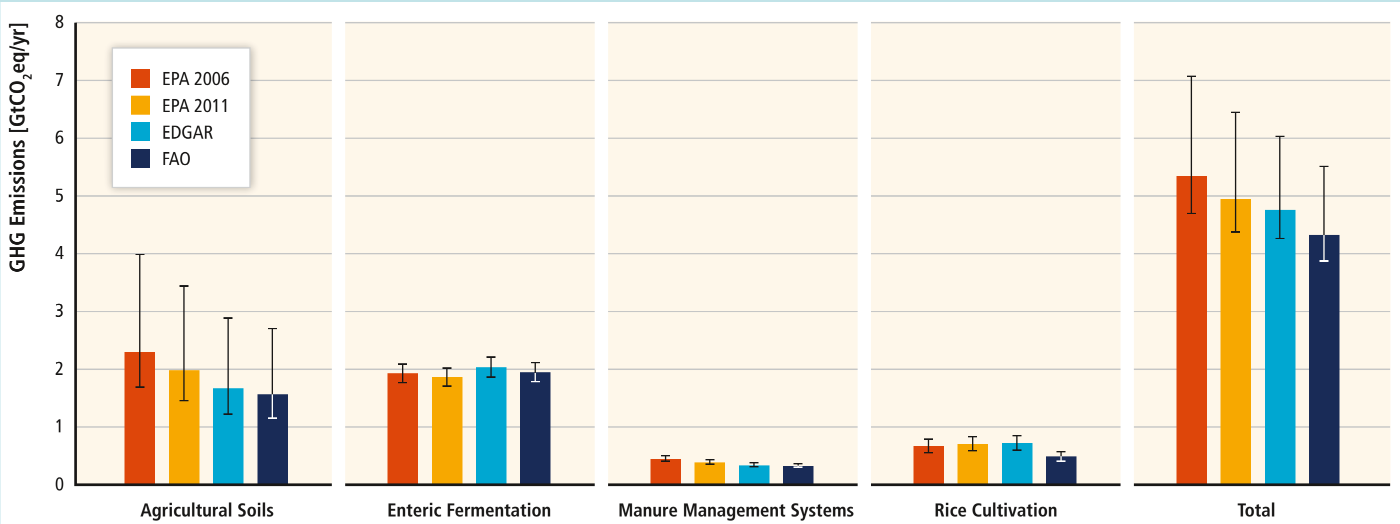
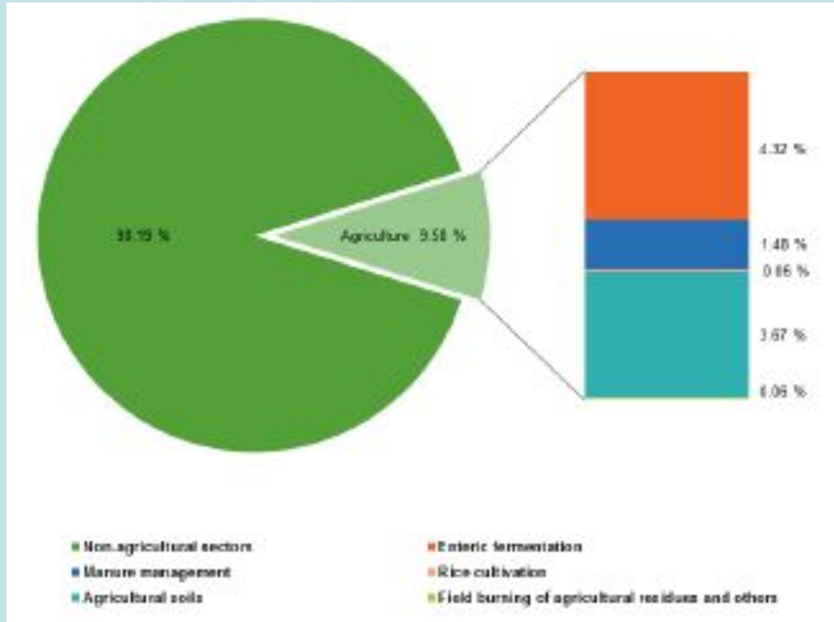
Introduction

13 CLIMATE ACTION

agriculture GHG emissions





EU28

Source: IPCC, 2014

Source: Eurostat, 2019

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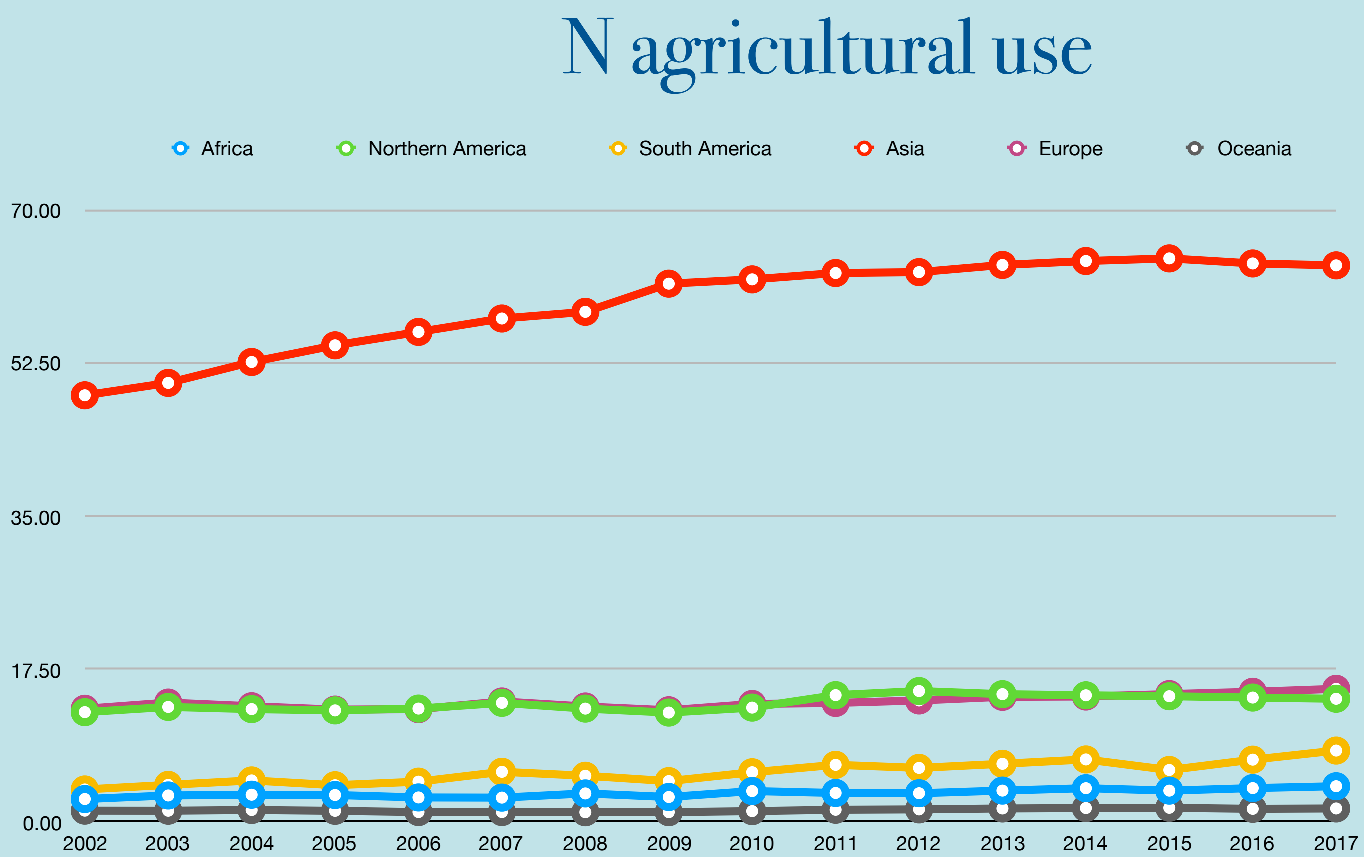
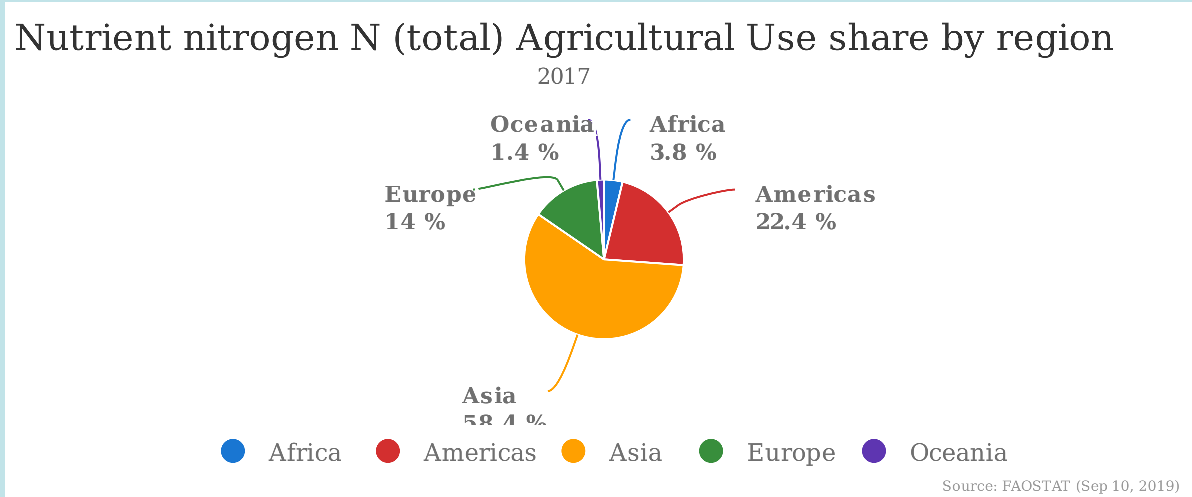
Introduction

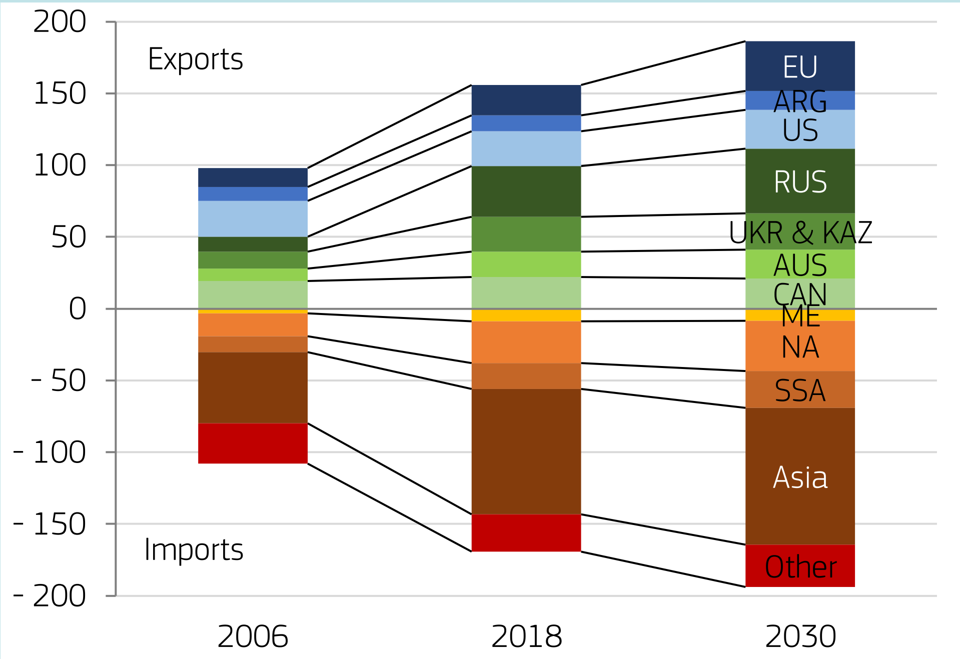




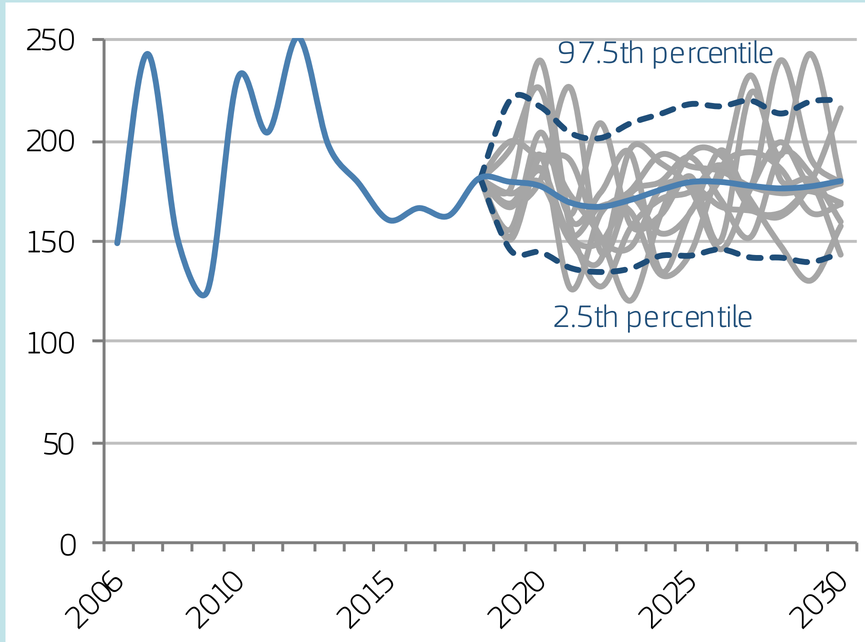
Data from FAOSTAT

Introduction

Wheat import/export



Wheat price in the EU



Source: EC-Agri, 2019

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Introduction

Past climate and agronomic data

Experiments

Statistical modelling

Crop growth models

Land models

Economic models

climate projections

climate predictions

climate observations

Impact assessments

Adaptation and mitigation strategies

Scientific knowledge and understanding

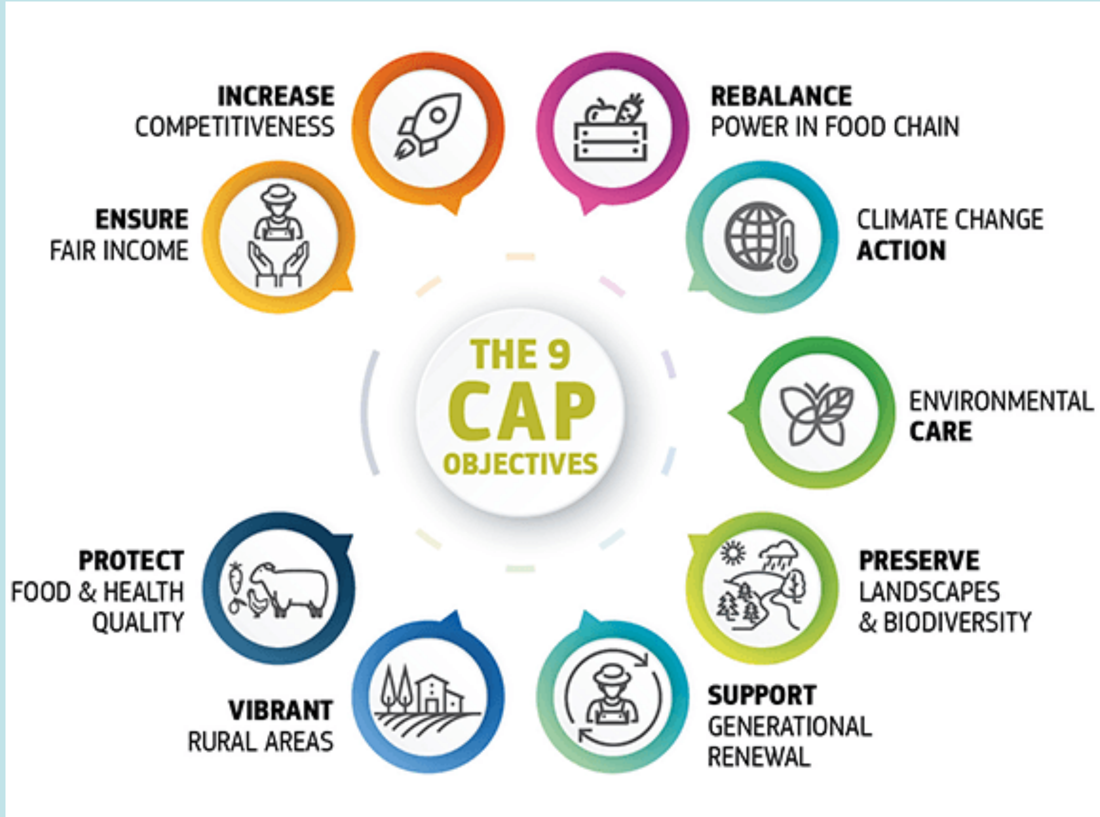
Introduction

Scientific knowledge and understanding

Policy Support

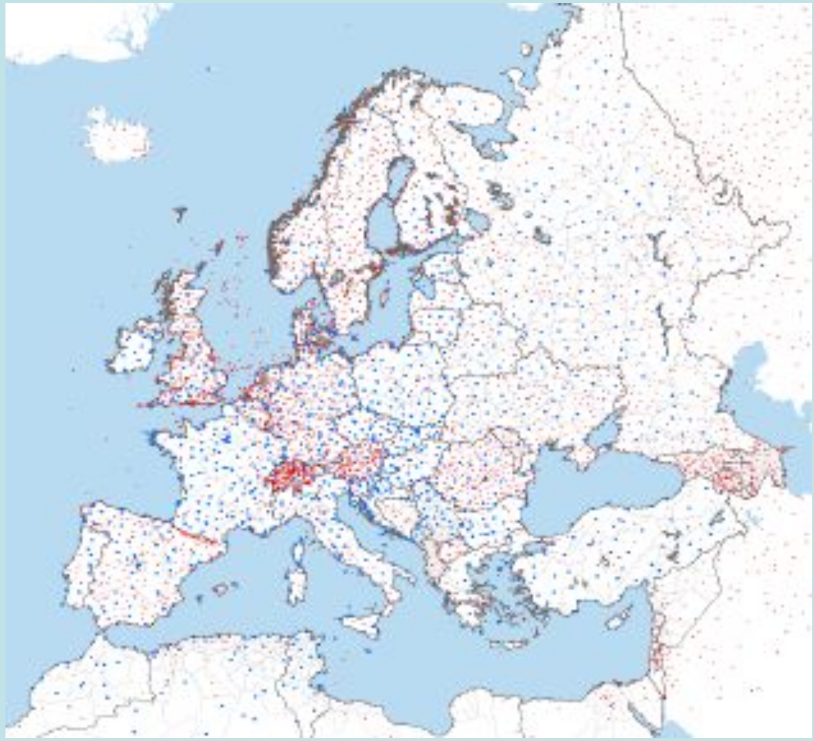
Support to farmers

Sustainable development



Climate data

Past and current climate: observations, reanalysis, etc.



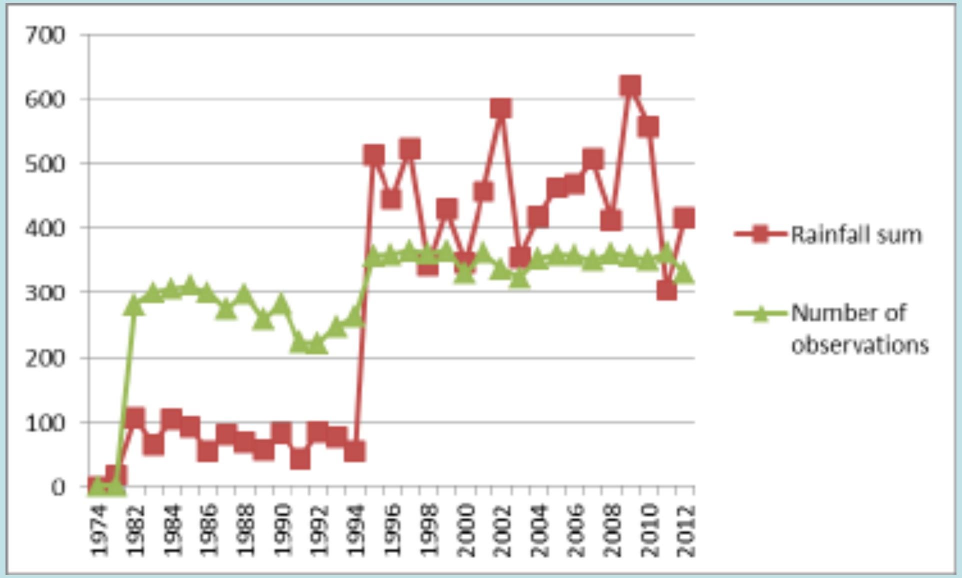
MarsMet: data from approx. 4000 stations

ERA5, AgMERRA, ERA5-Land, etc.

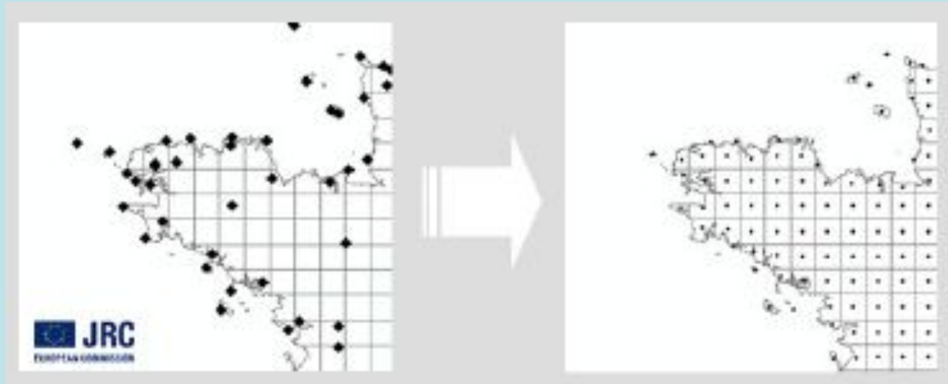
Satellite

Climate data

Inhomogeneity and quality checks



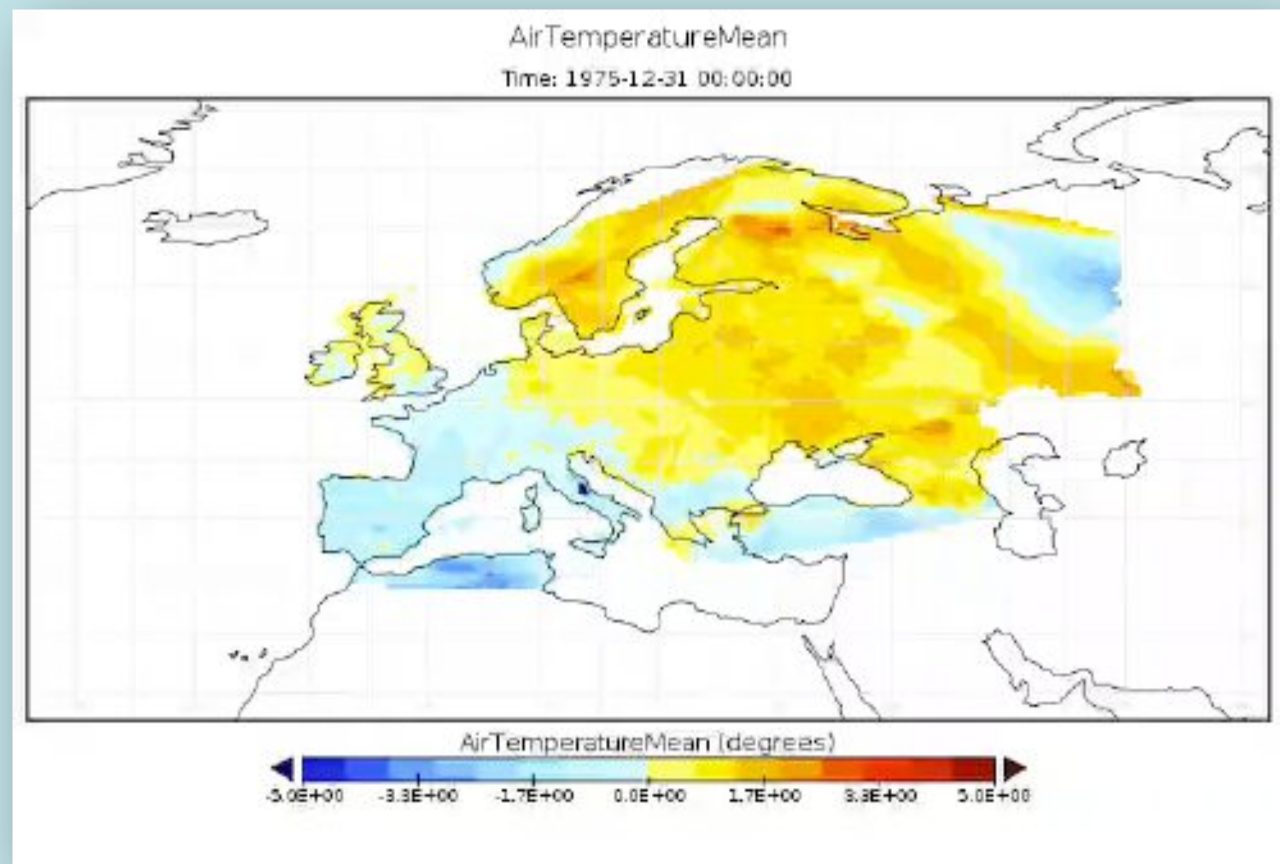
Interpolation methods



Complex spatio-temporal processes

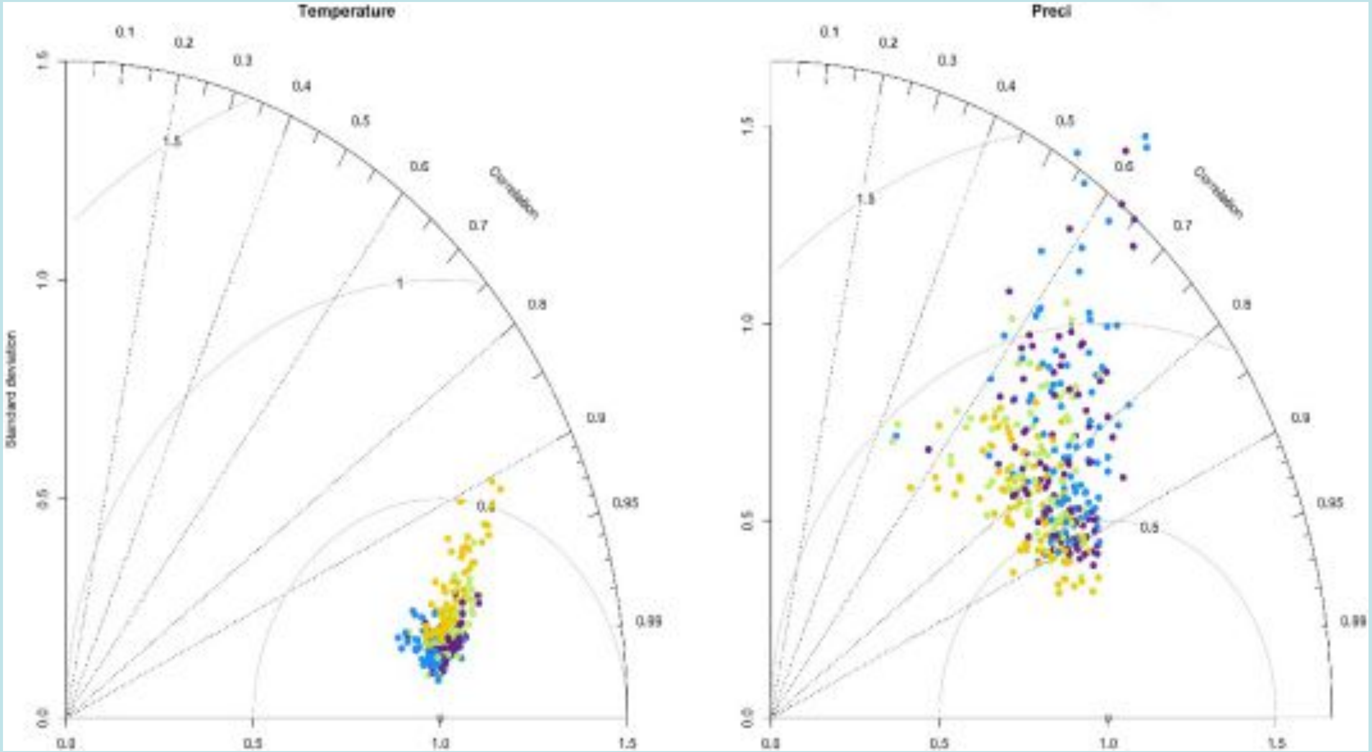
Climate data

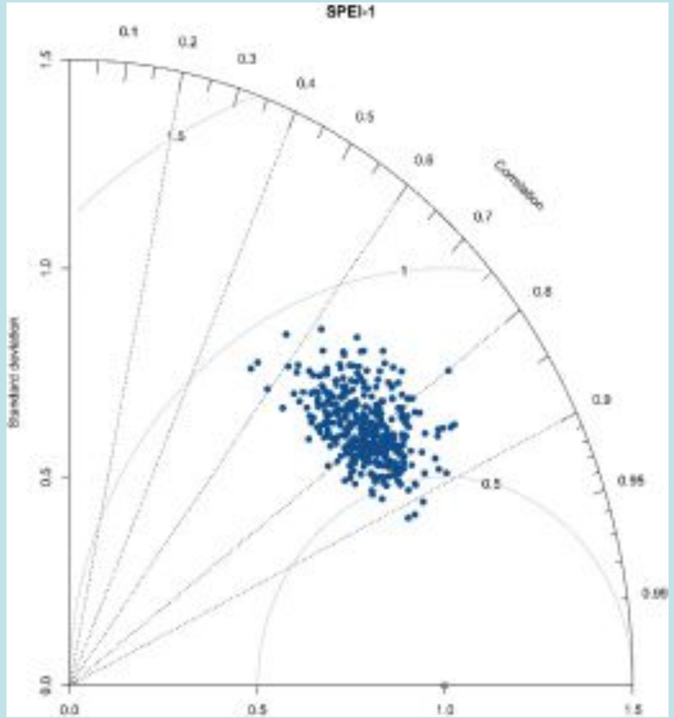
MARSMet since 1975



Climate data

Obs vs Reanalysis



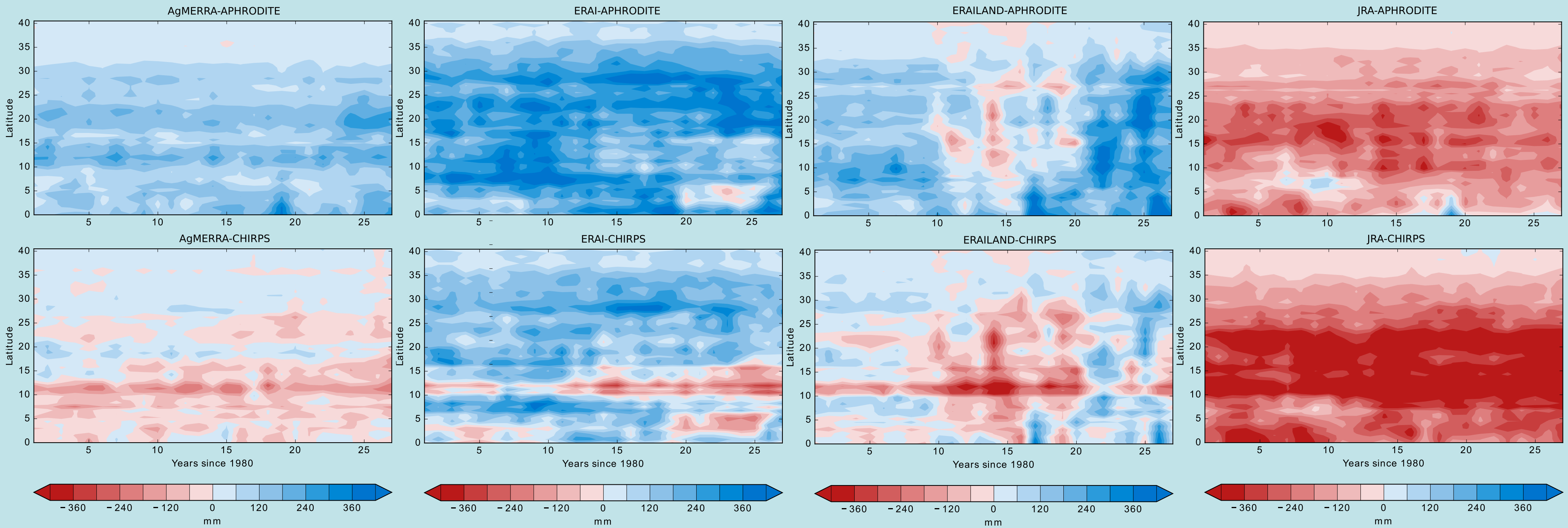


Blue, green, yellow and violet represent, respectively, winter, spring, summer and autumn

Source: Toreti et al., 2019

Climate data

Reanalysis vs Reanalysis vs Observations



Mean zonal summer precipitation in Monsoon Asia

Source: Ceglar et al., 2017

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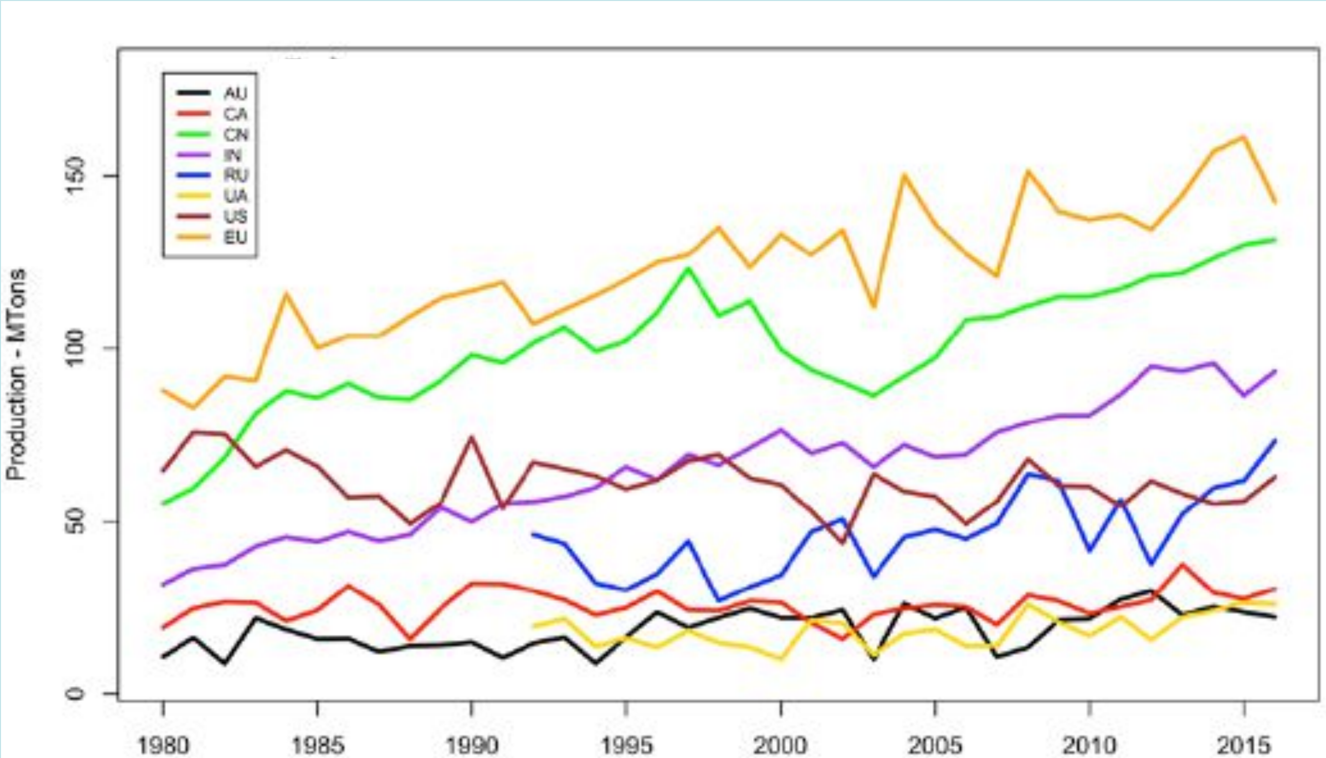
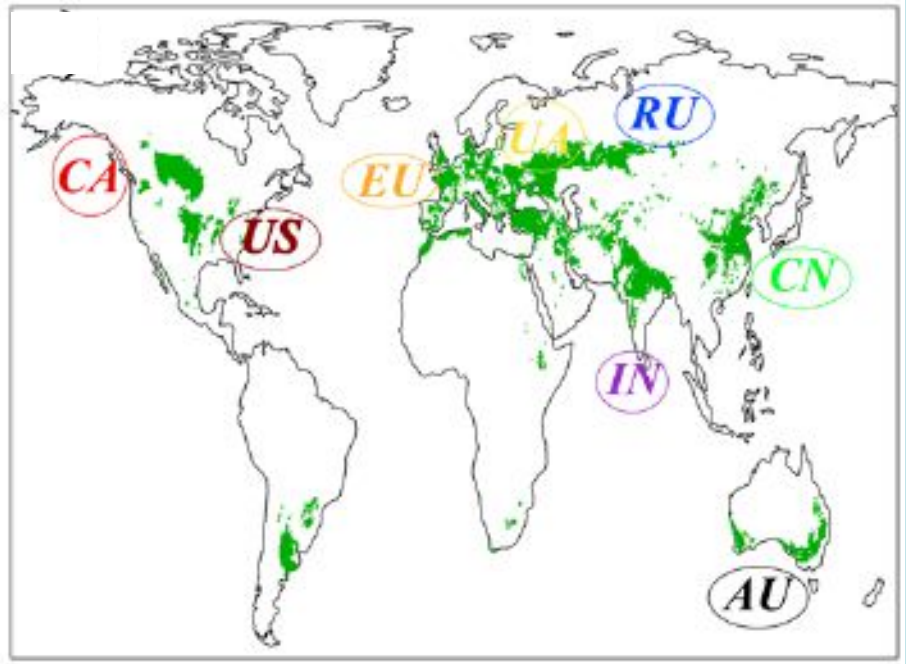
Agronomic data

Main wheat producing regions of the world

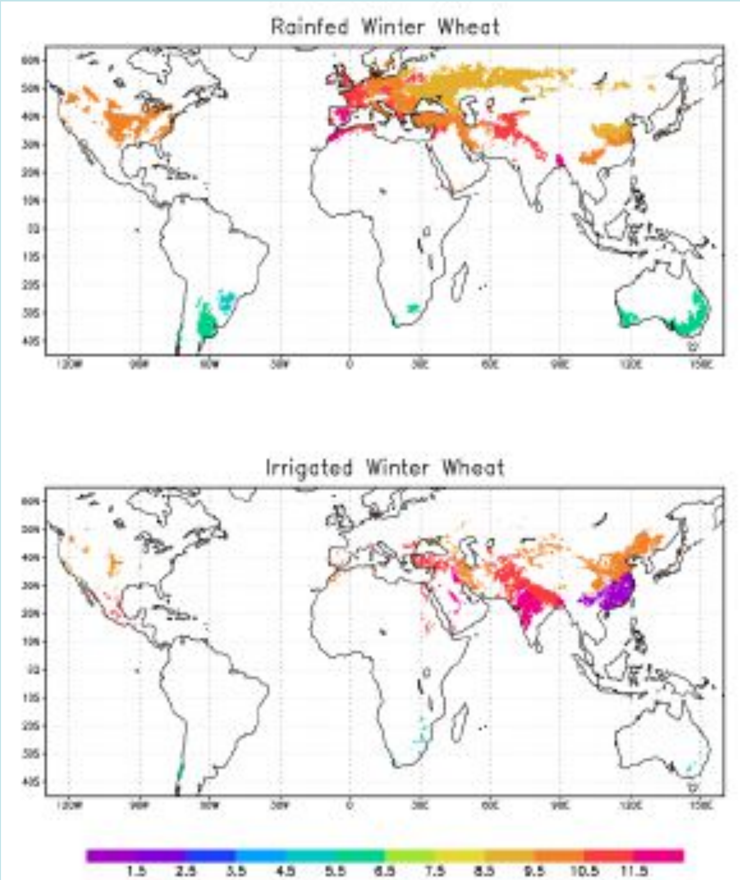


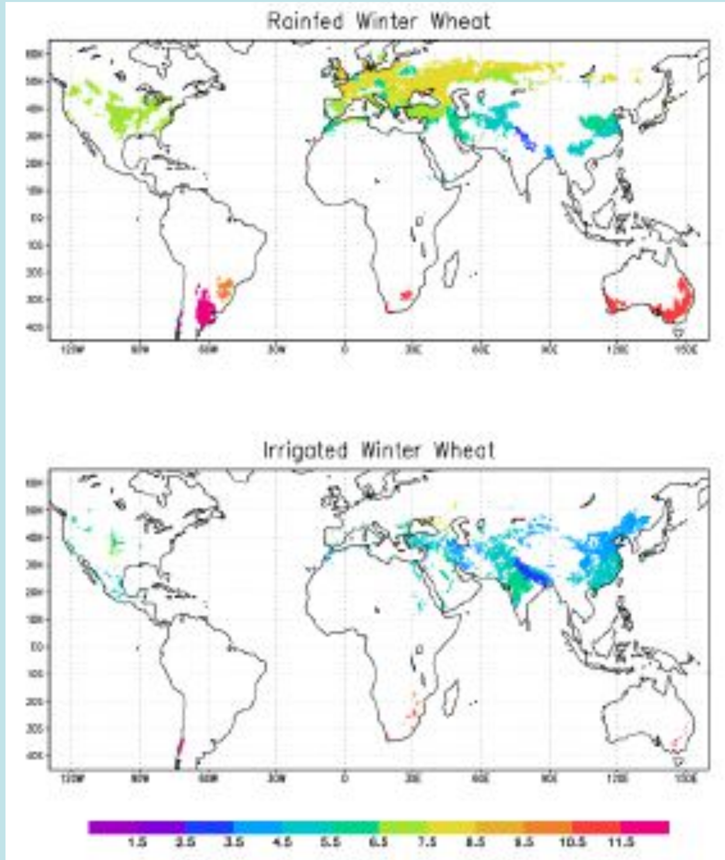


Source: Toreti et al., 2019

Agronomic data

Sowing and harvesting





Source: Zampieri et al., 2017

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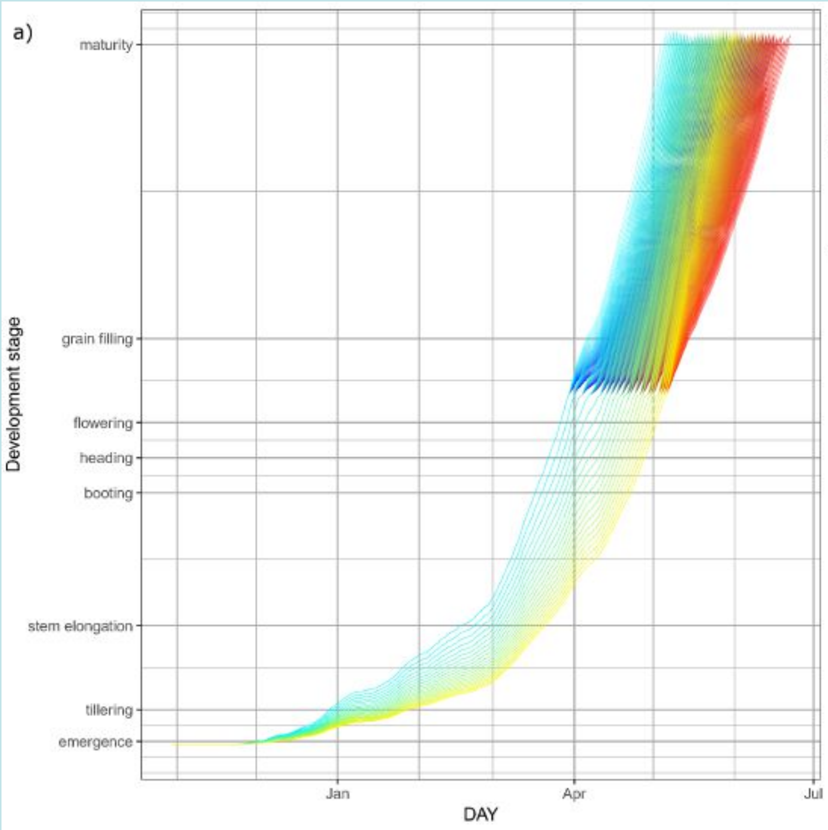
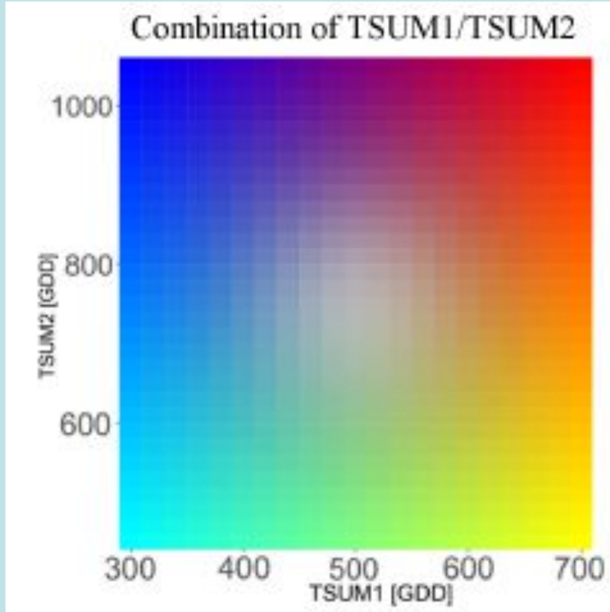
Agronomic data

More would be needed…

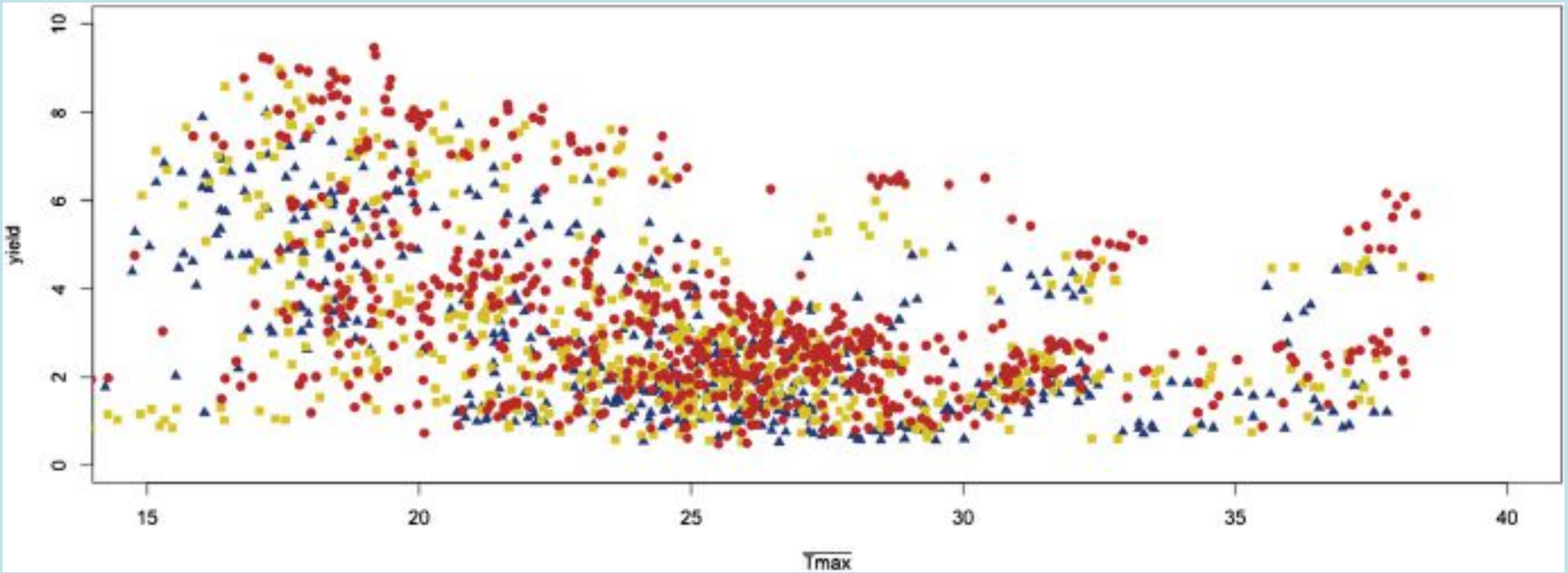




Source: Ceglar et al., in preparation

Agronomic data

wheat yields in different climatic regions of the world

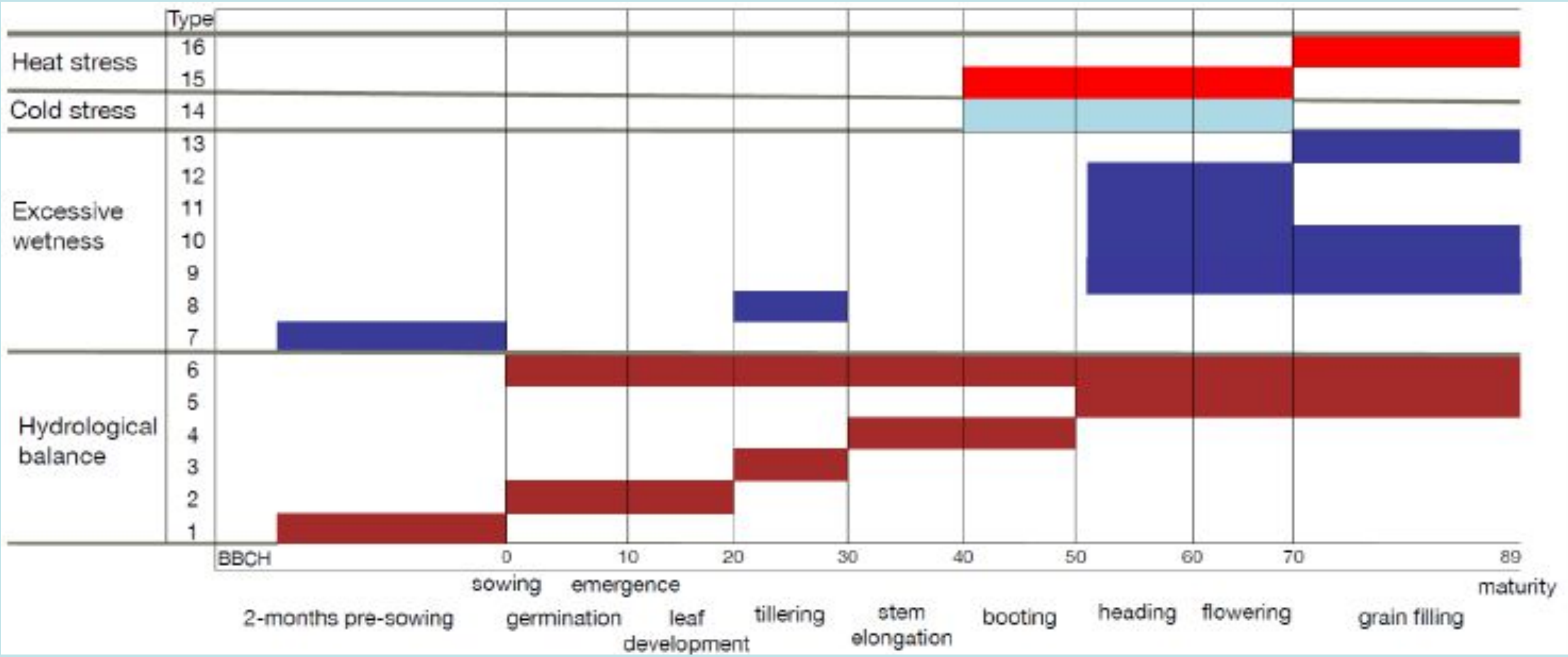


wheat yields as a function of average daily Tmax in grain filling in 3 time periods: 1980-9 (blue), 1990-9 (gold), 2000-9 (red)

Source: Toreti et al. 2019,

Agronomic data

characterising crop growth and key factors



Source: Ceglar et al., in preparation

Climate projections

high-res GCMs

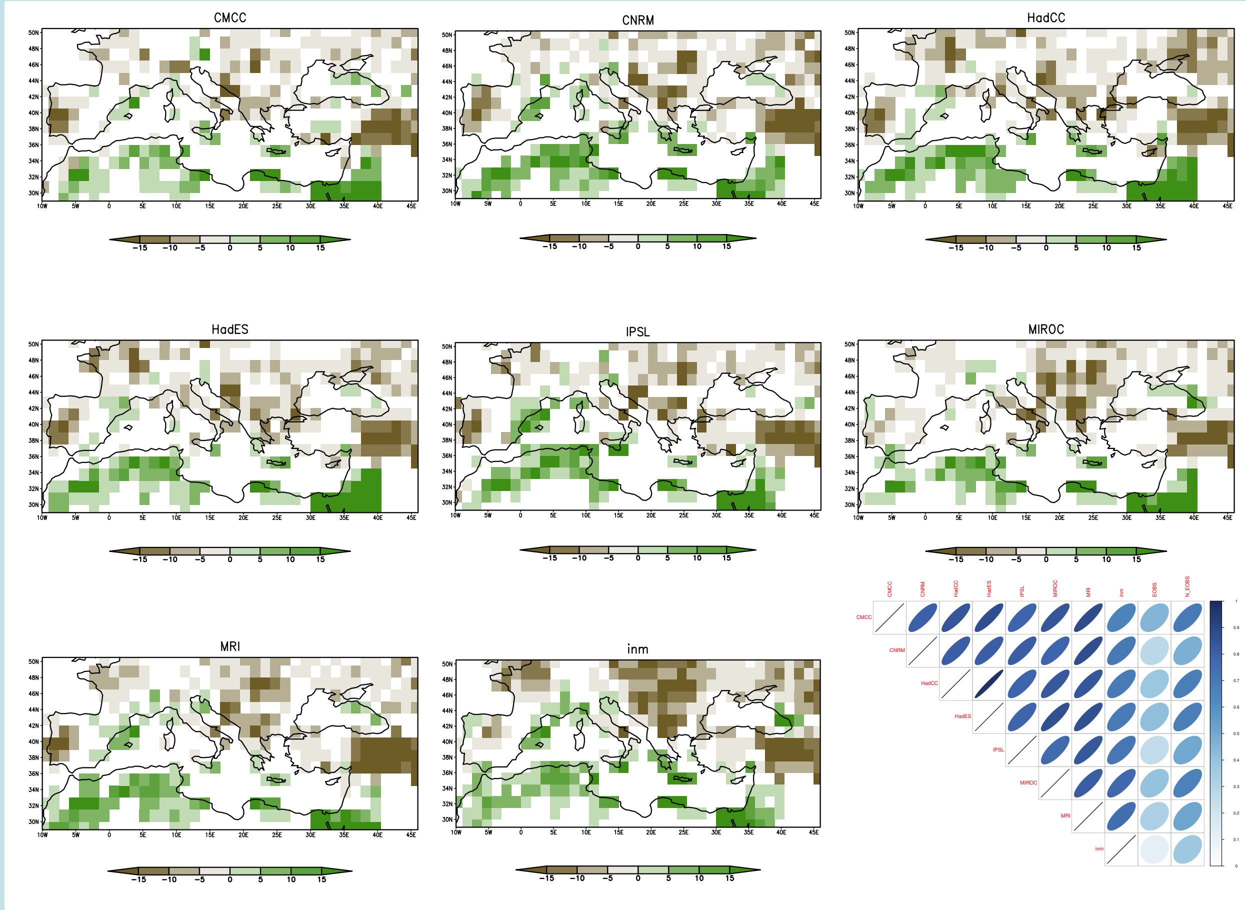
RCMs

downscaling

Models' evaluation → Bias Adjustment

Climate projections

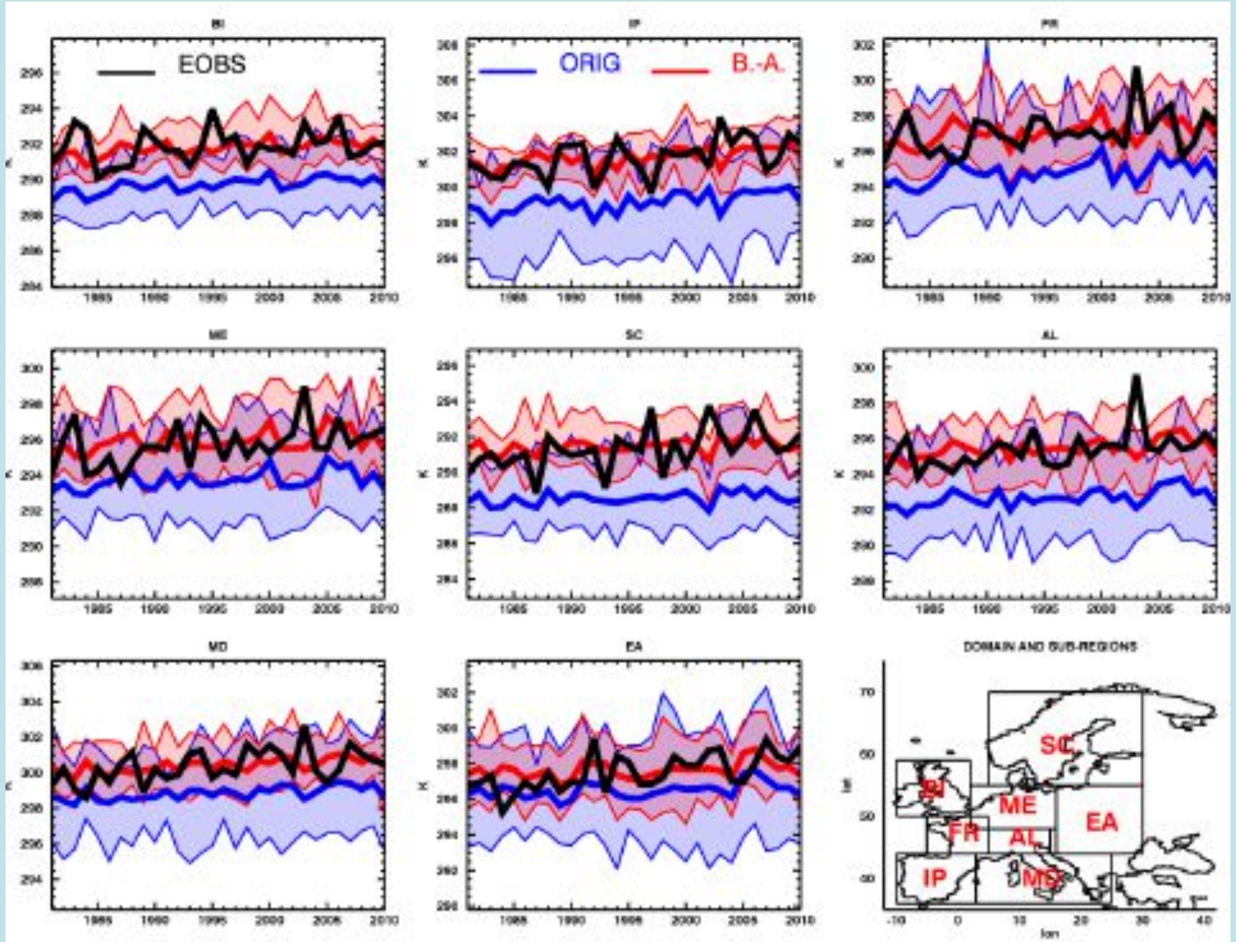
Evaluating climate models is not an easy task…means are usually not enough



Source: Toreti and Naveau, 2015

Climate projections

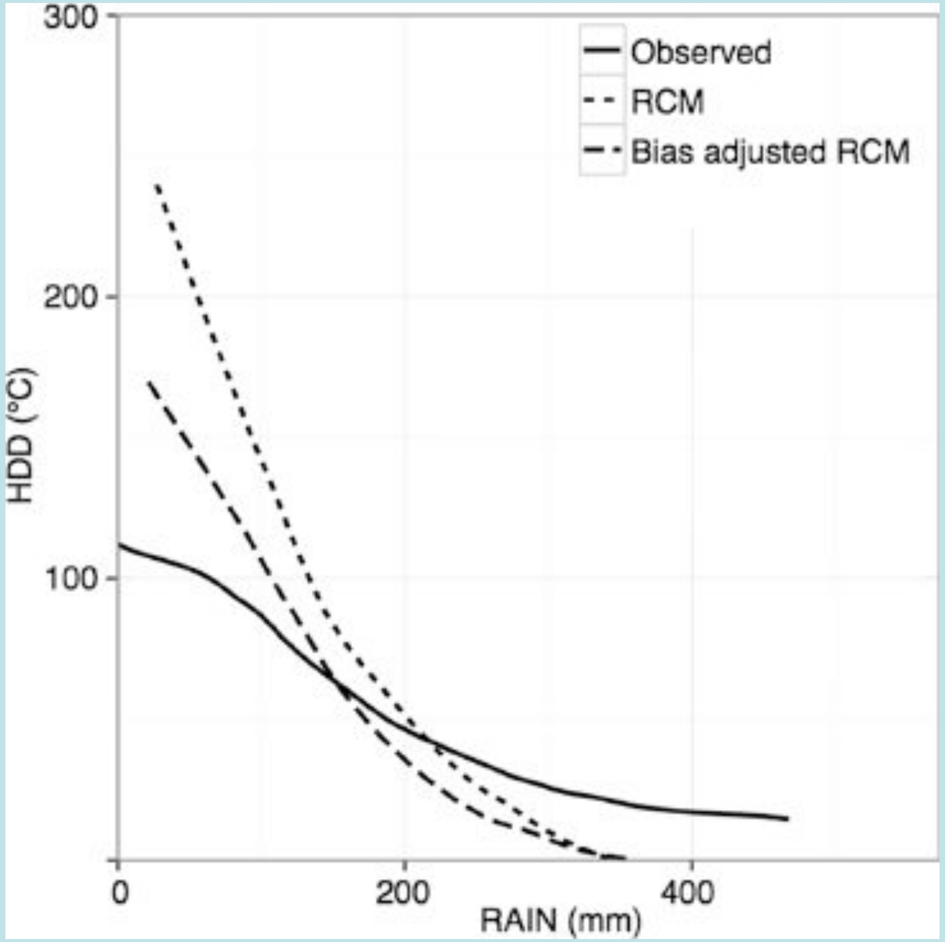
Bias Adjustment



Source: Dosio, 2016

Climate projections

Bias Adjustment is not an easy task…
especially when more variables are needed



Source: Toreti and Naveau, 2015

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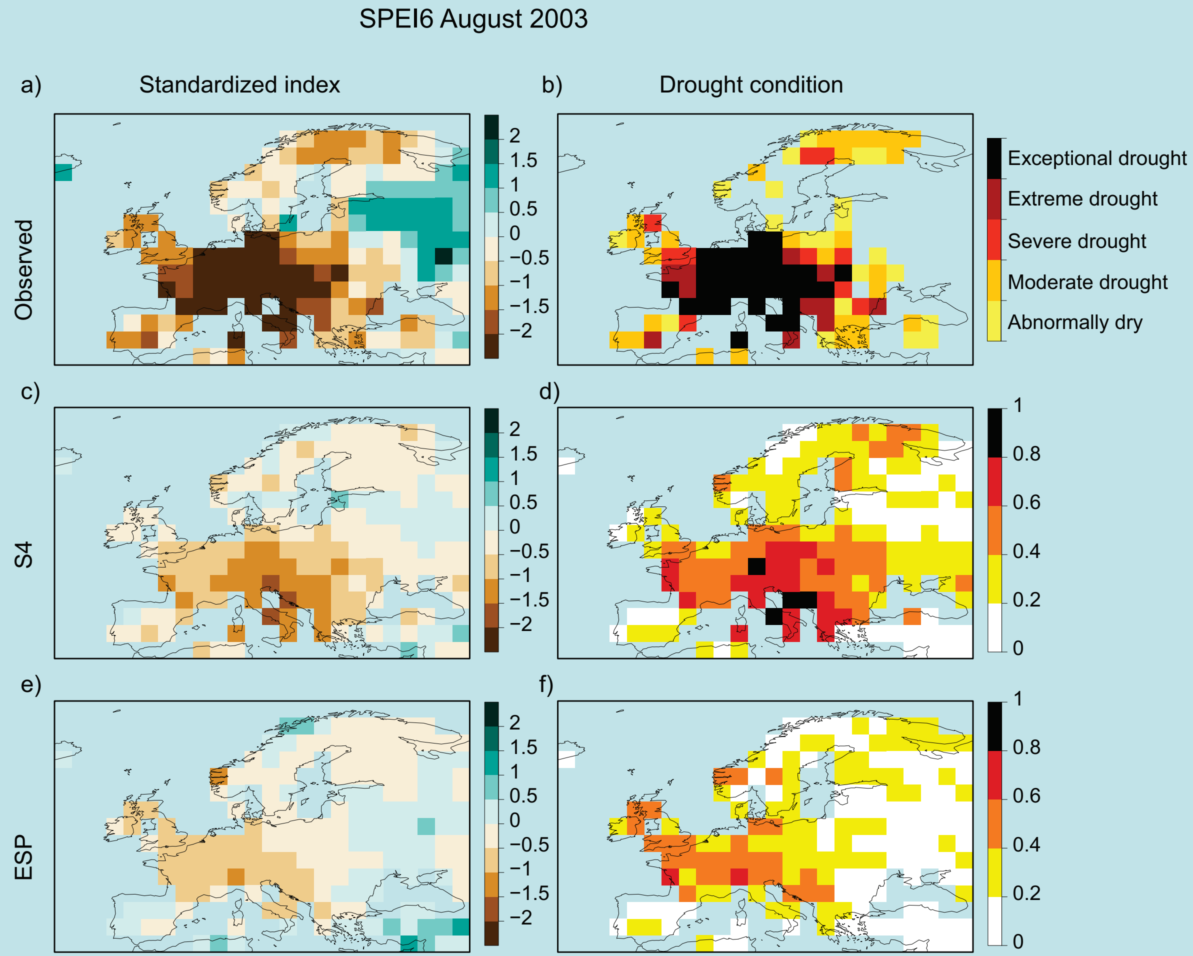
Climate predictions

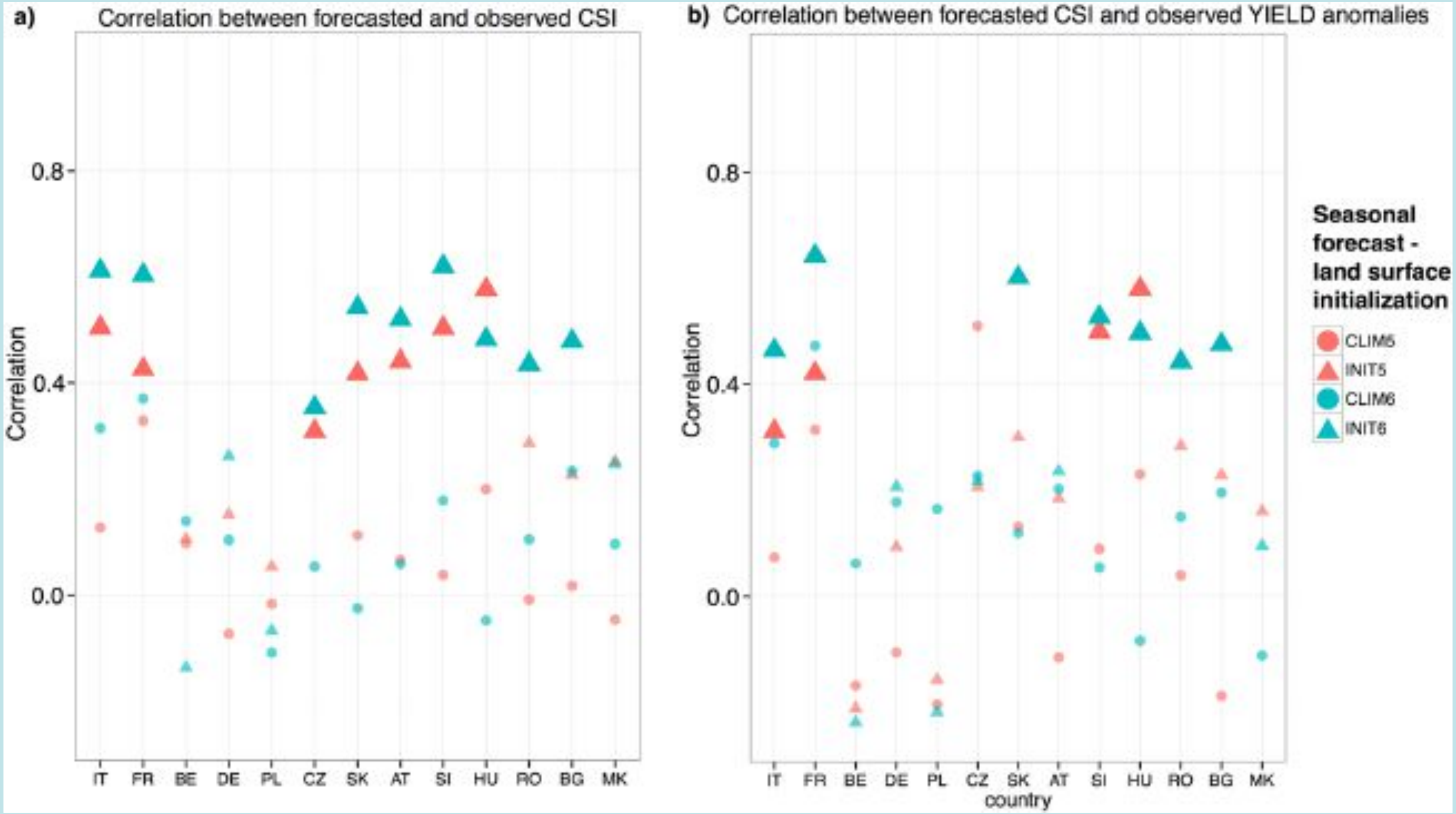
Seasonal and decadal predictions



Source: Turco et al., 2017

Climate predictions

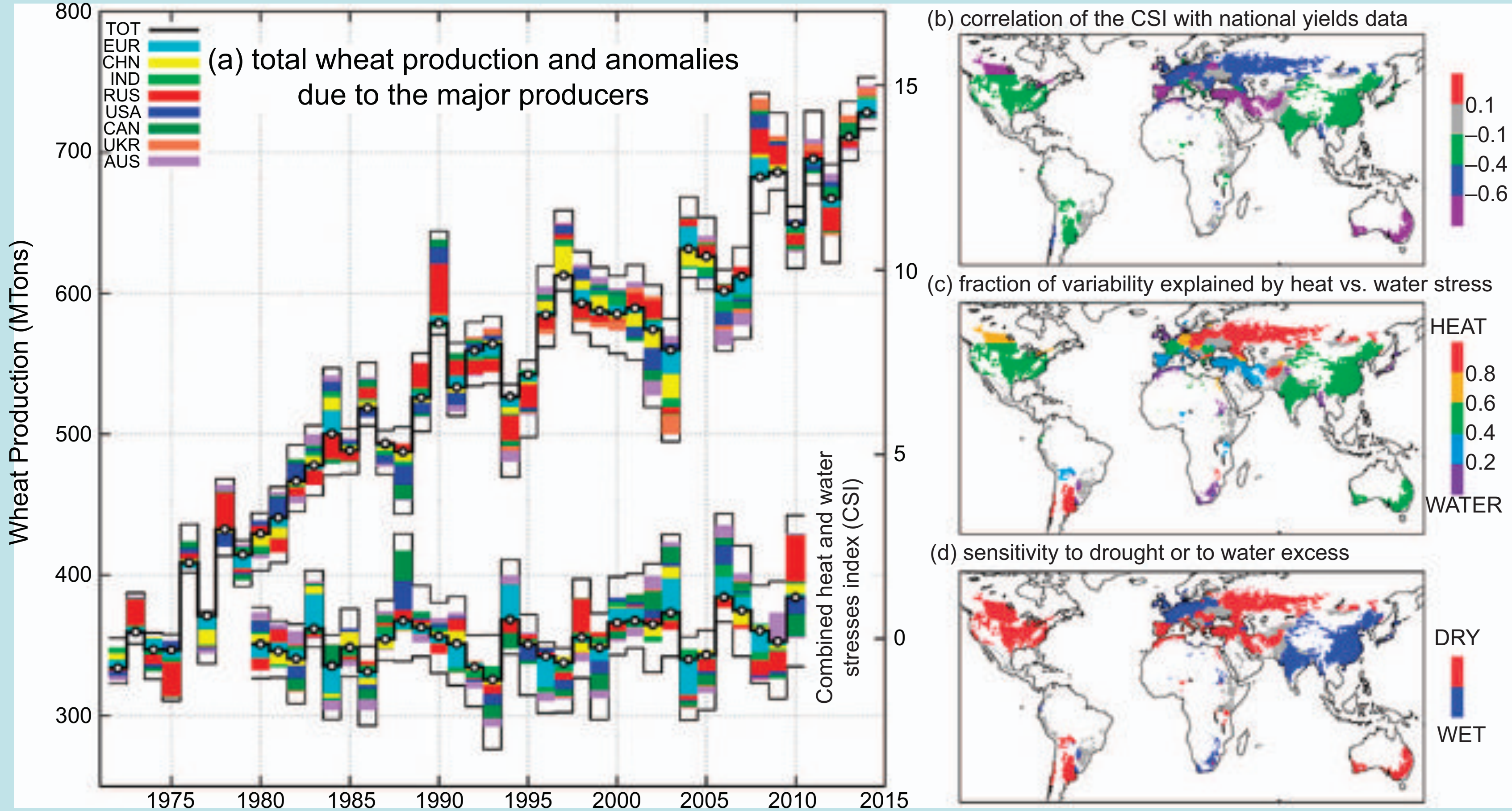
Seasonal predictions and soil moisture initialisation



Source: Ceglar et al., 2018

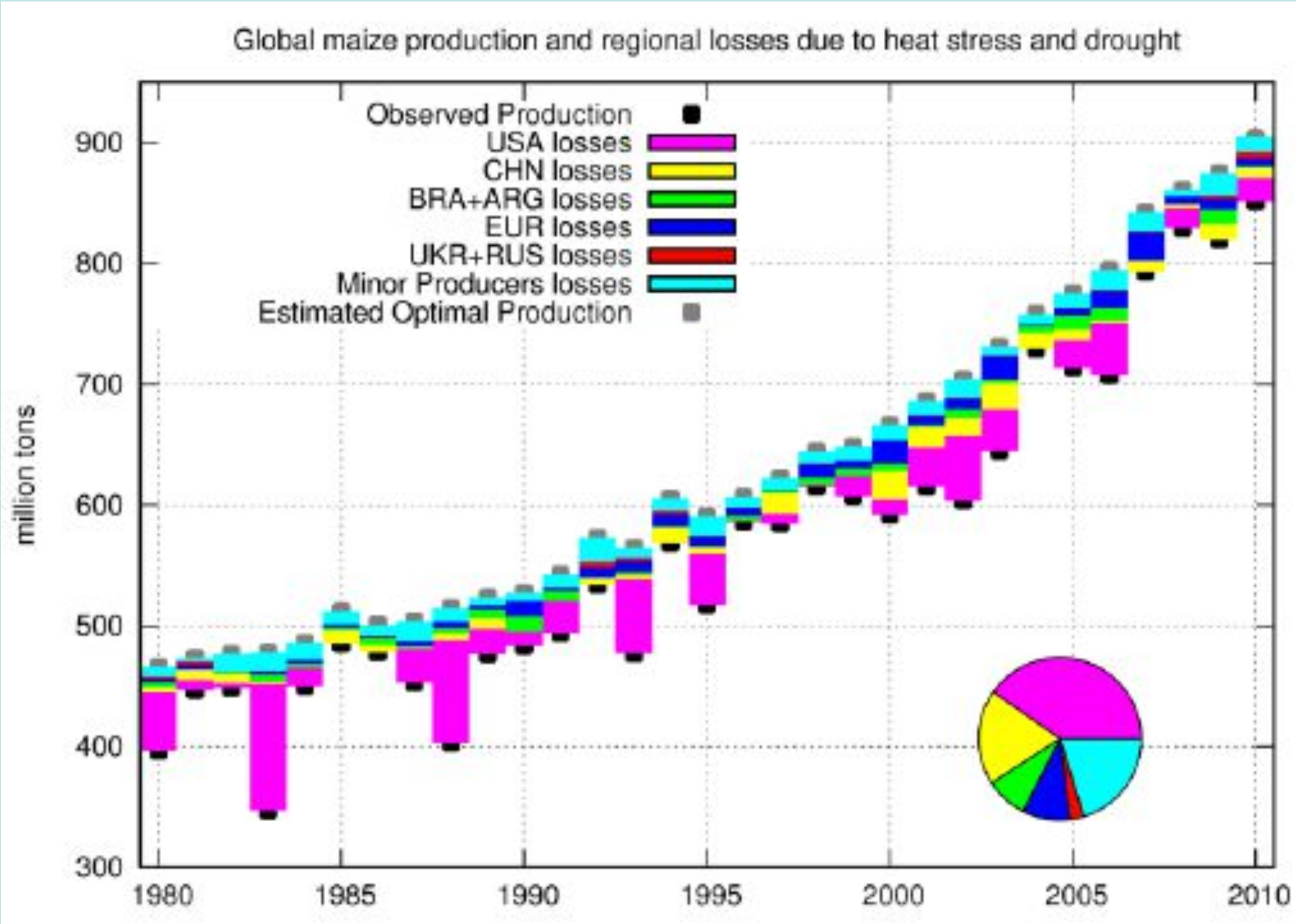
Statistical Modelling

Wheat and climate



Source: Zampieri et al., 2017

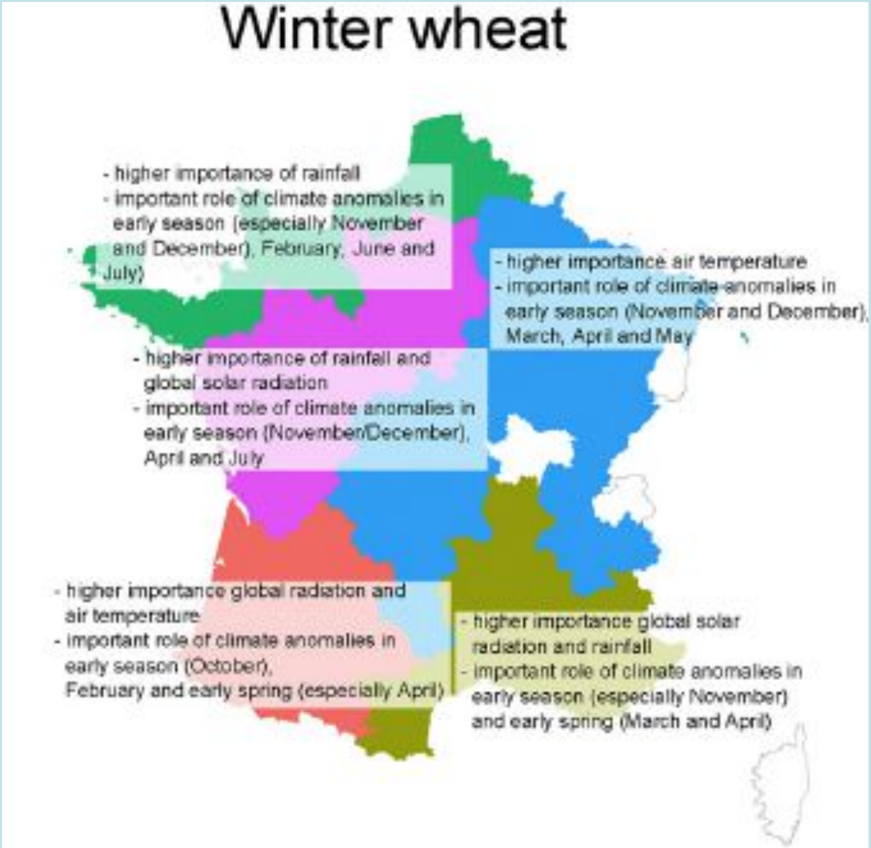
Statistical Modelling

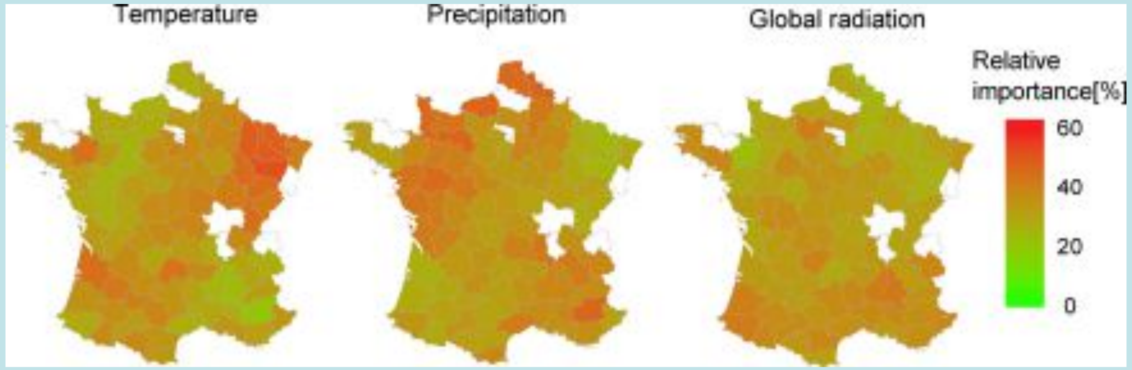


Maize and climate

Statistical Modelling

Wheat and Climate in France





Source: Ceglar et al., 2016

Crop growth models

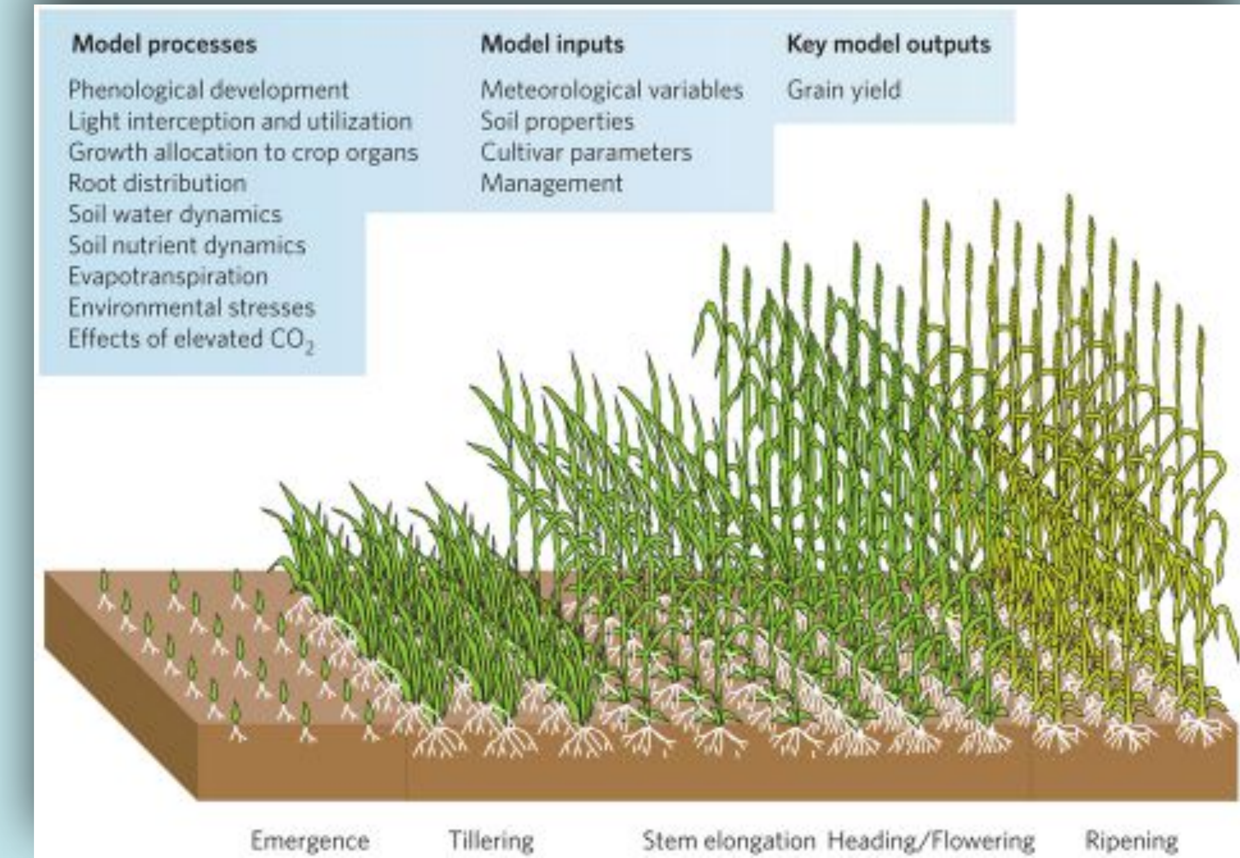
Soil and agronomic information

Daily Min and Max Temperatures

Relative Humidity

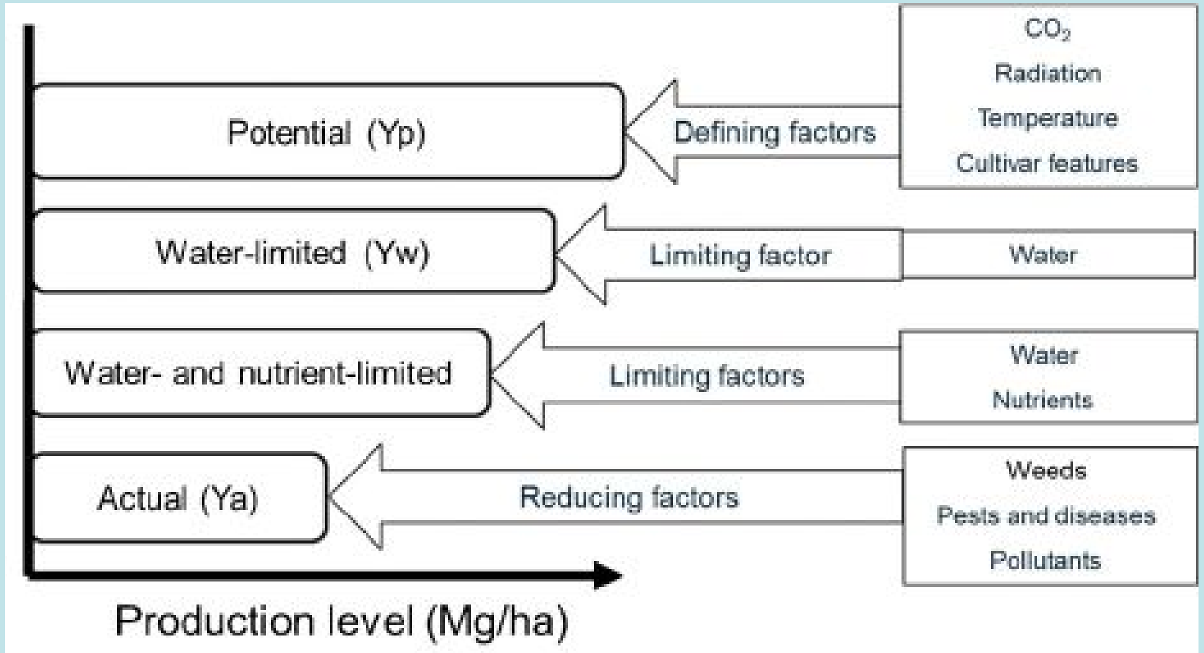
Global solar radiation

wind



Crop growth models

Requirements	Representation by major crop models
Ambient [CO_2] effect	All major crop models include [CO_2] effect but often in simplified form and based on old experimental data or not tested
Temperature	All major crop models represent temperature effects at different levels of detail, though often not tested
Heat stress	Specific heat stress impacts (e.g. floret mortality leaf senescence) not considered explicitly (except for a few of the major models) and not tested yet
Early/Late frost damage	Some models consider frost damage but are not tested
Tropospheric O_3 effect	Few of the major models explicitly includes O_3 stress (except, AFRCWHEAT2-O3, LINTULCC)
Drought stress and excess water	All crop models include effect of water and drought stress. Lack of oxygen in the root zone is only considered by a few models (HERMES, MONICA, Lintul, WOFOST)
Diffuse radiation	Only considered in a few crop models (CERES, SUCROS)
Effect of snow and hail	Rarely taken into account, exceptions are available
Lodging due to strong winds and rain	Detailed models for cereal lodging exist, but rarely integrated in crop models



Source: Ewert et al., 2015

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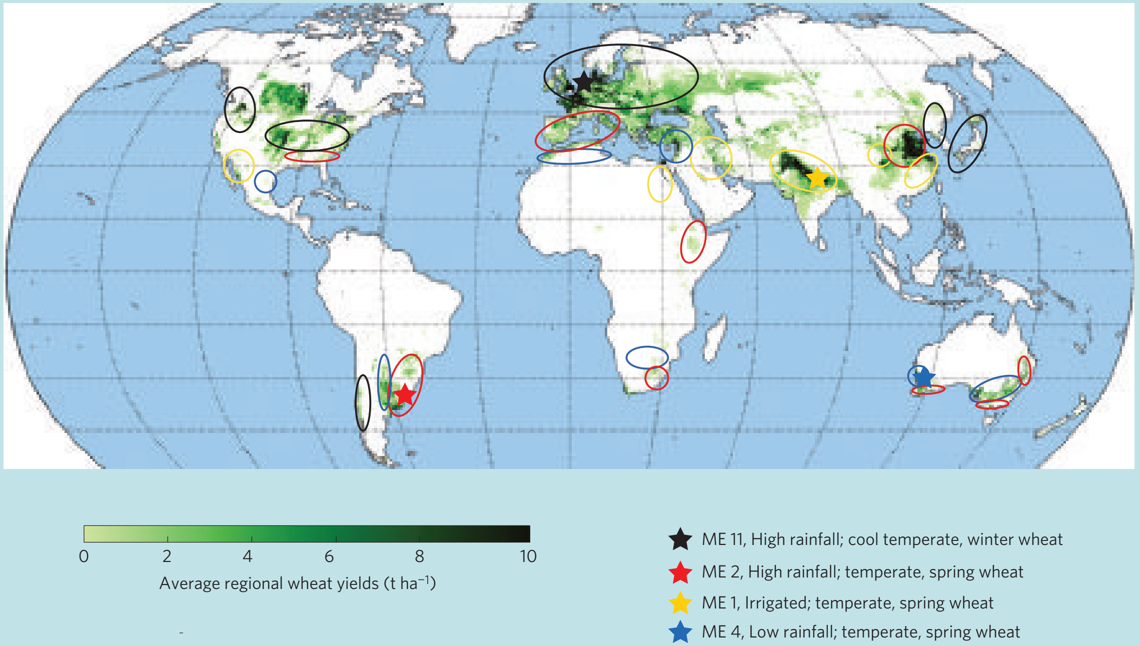
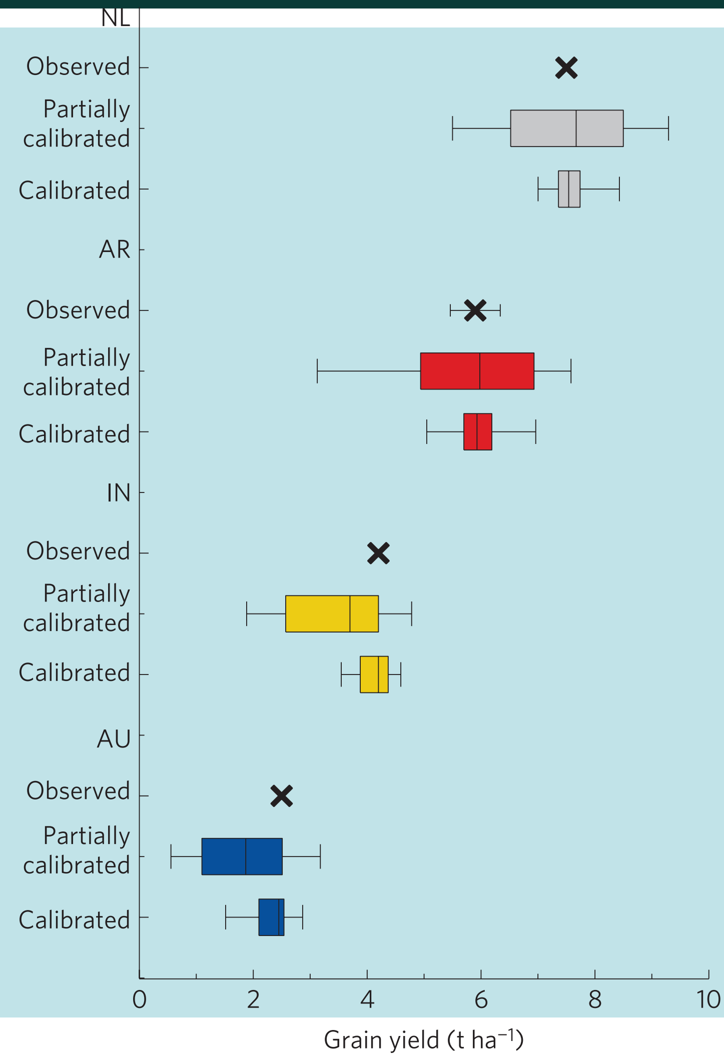
Crop growth models



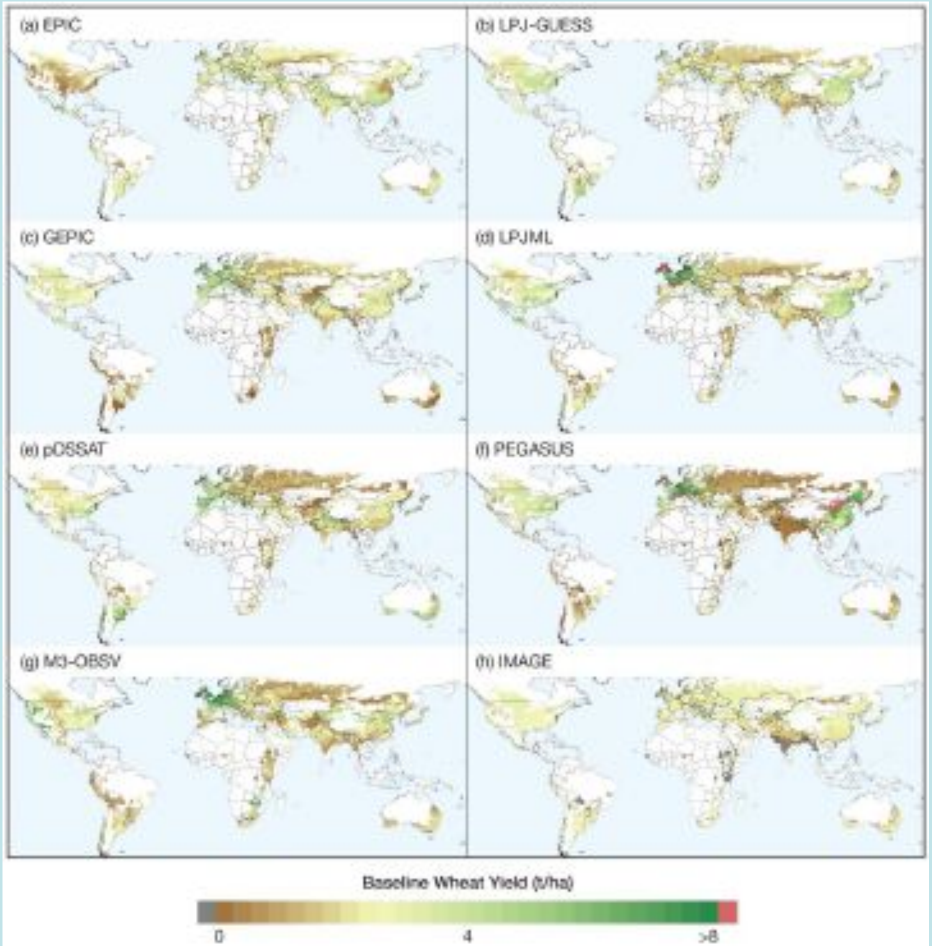


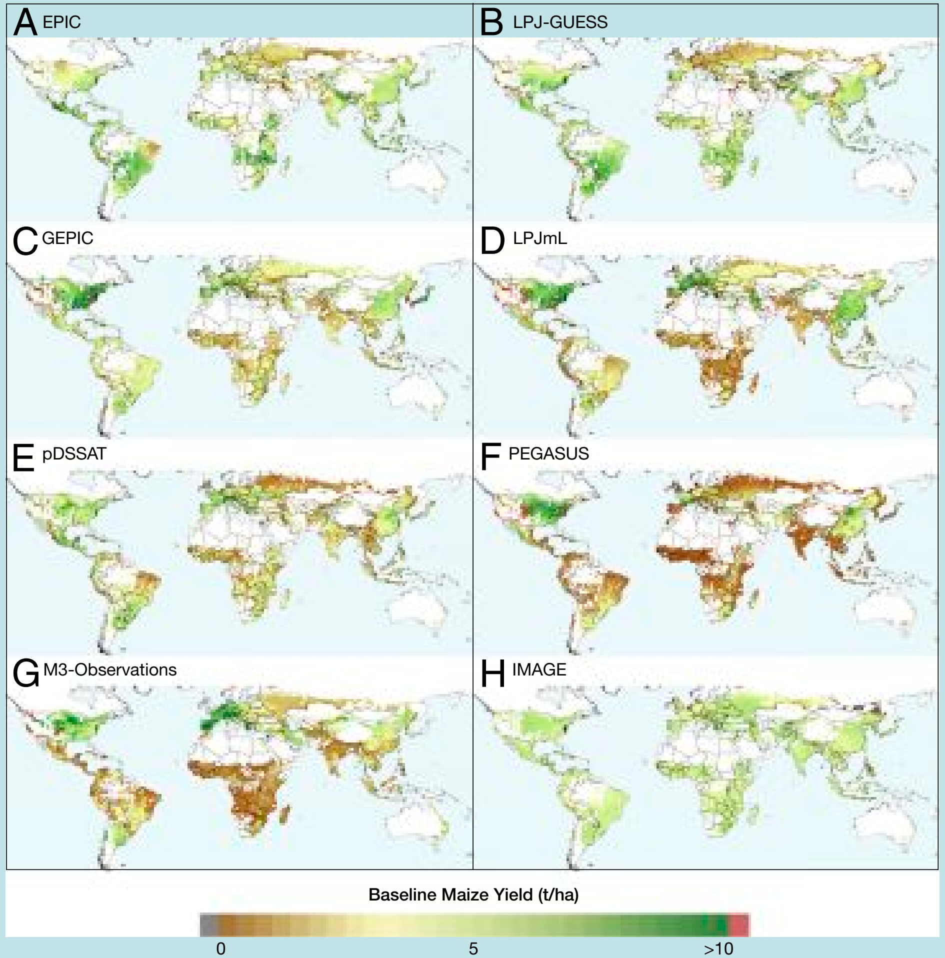
Wheat

Source: Asseng et al., 2013

Crop growth models

Wheat

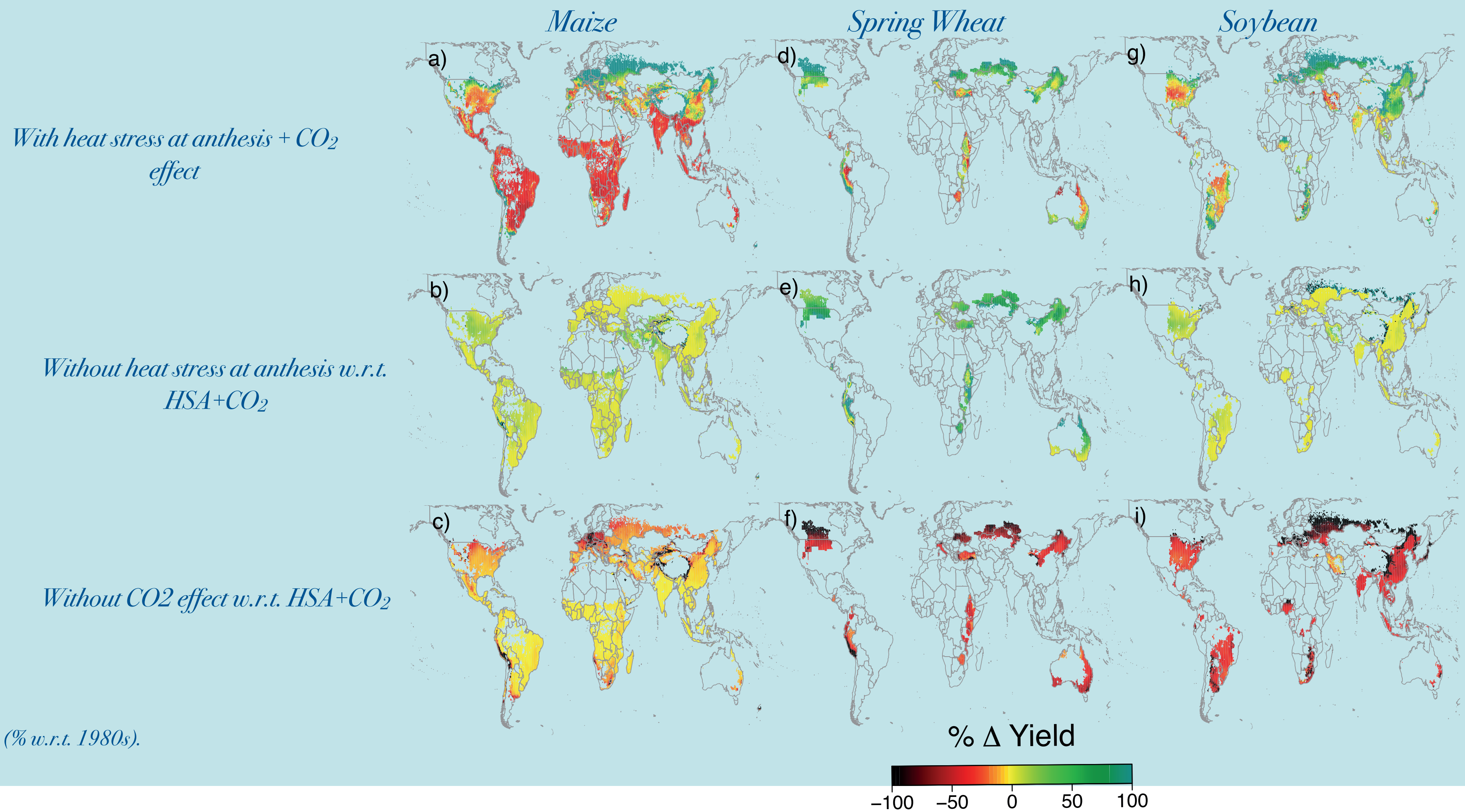




Maize

Source: Rosenzweig et al., 2014

Crop growth models

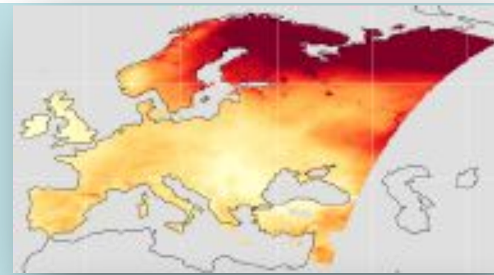


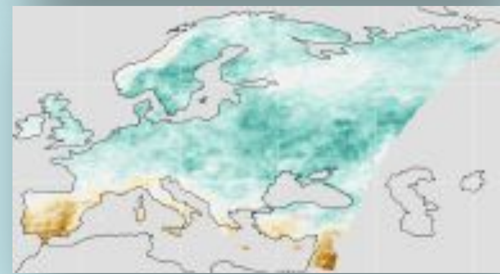
RCP8.5 2080s yield changes (% w.r.t. 1980s).

Source: Deryng et al., 2014

Crop growth models

GCMs → RCMs → BC



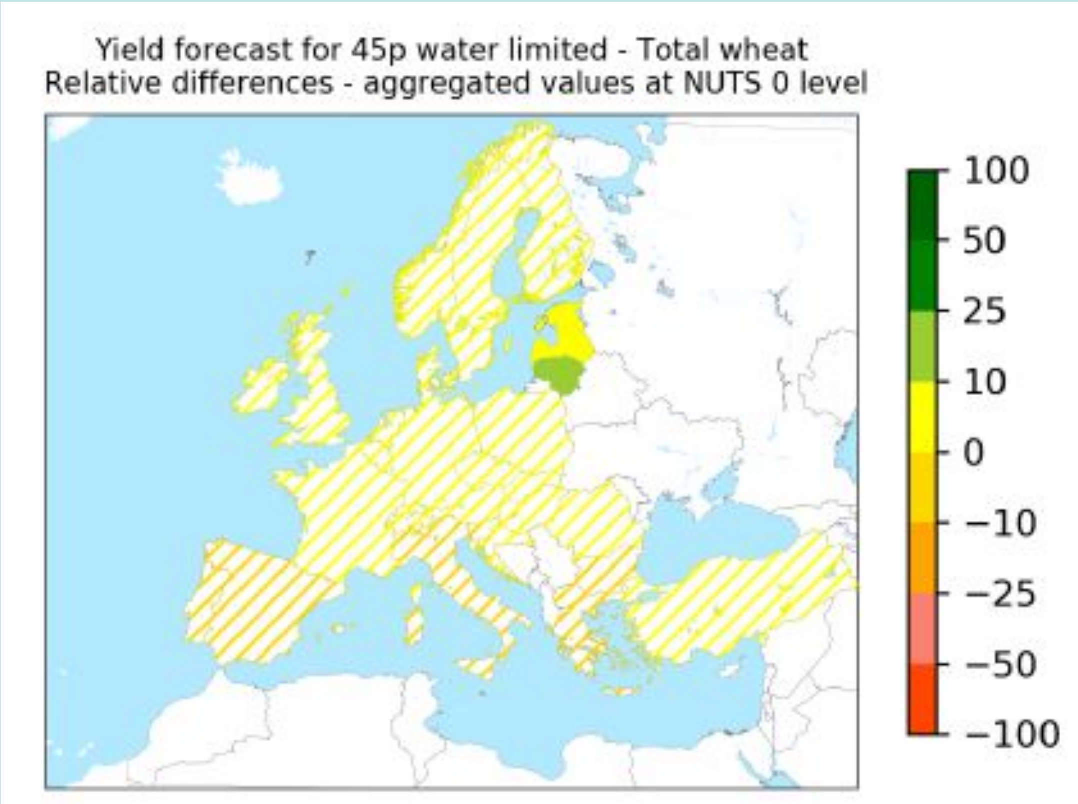


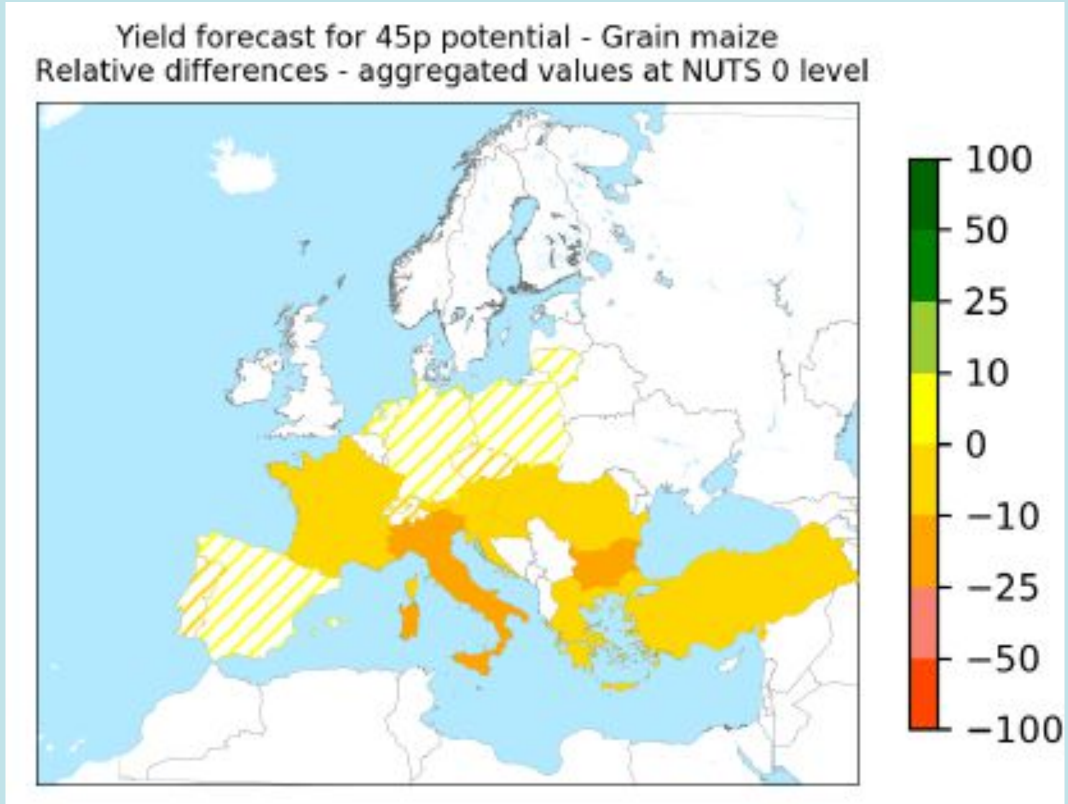
Assumptions

Crop Growth Model - Simple Parallelizable Extensible Model

Crop growth models

Projections 2021-2050





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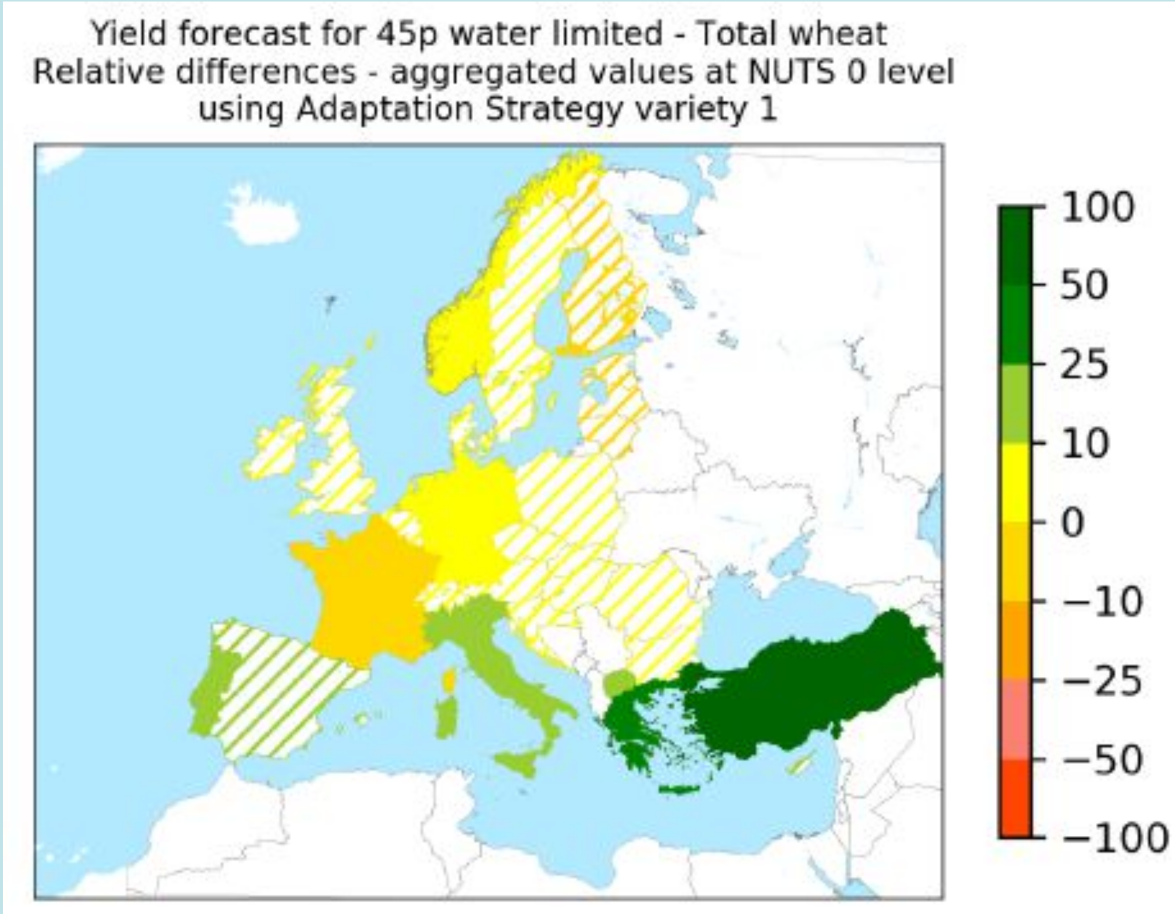
Adapting to climate change



Adapting to climate change

Engage users and co-design targeted sectorial climate services

MED-GOLD

Time scale	Decision type	Challenges	MED-GOLD climate service	Benefits
Mid-term (e.g., 6-13 months)	Agro-management	• Better planning of soil tillage, fertilization, crop protection treatment and weed management • Improve choice of variety and density at sowing • Higher accuracy with sowing and harvest setting	• Wheat phenological development • Temperature • Precipitation • Hydrological balance • Heavy rain during winter • Useful rain for fertiliser activation • Frost risk index • Heat stress index	• Minimize exposure to weather extremes • Cost reduction through optimal fertilization and agro-management planning • Maximize crop yield and quality • Optimize use of fertilizers
	Stock management	• Better contracts and price • Better planning of supply chain		• Better planning of supply chain, contracts and prices
Long-term (e.g., up to 30 years)	Long-term strategy	• Selection of future new cultivation areas • Choice of new varieties, breeding and genetic improvement activities • Monitoring of new pests, pathogens, weeds • Anticipation of purchase needs	• Projected yield changes • Projected risk of climate extremes (i.e., heat stress, drought in critical phenological phases…) • Projected risk of quality and nutritional issues • Feasible adaptation strategies	• Indicate suitable cultivation areas • Better estimation of production for market and food security • Improve regional policy planning and development, national adaptation strategies and EU policies (e.g. CAP) • Match adequate varieties to expected climate • Prepare for crop protection and prevention of invasive species • Better use of investments (e.g., machinery, irrigation)

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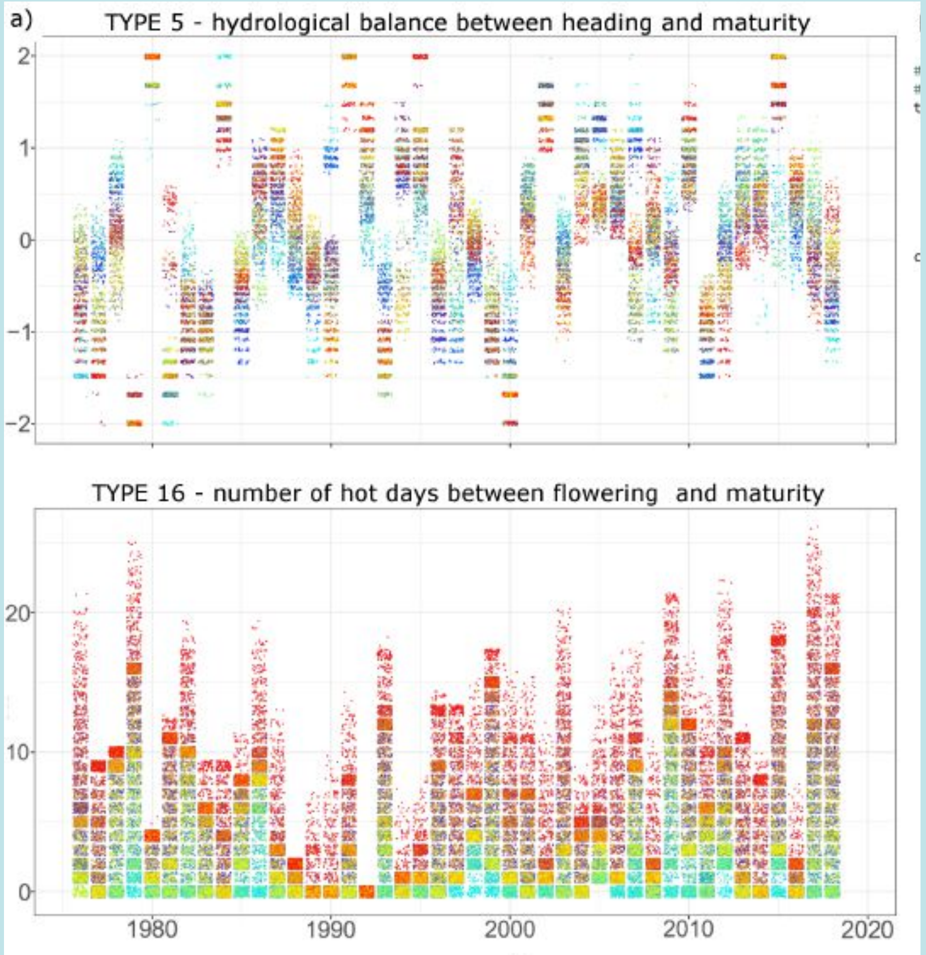
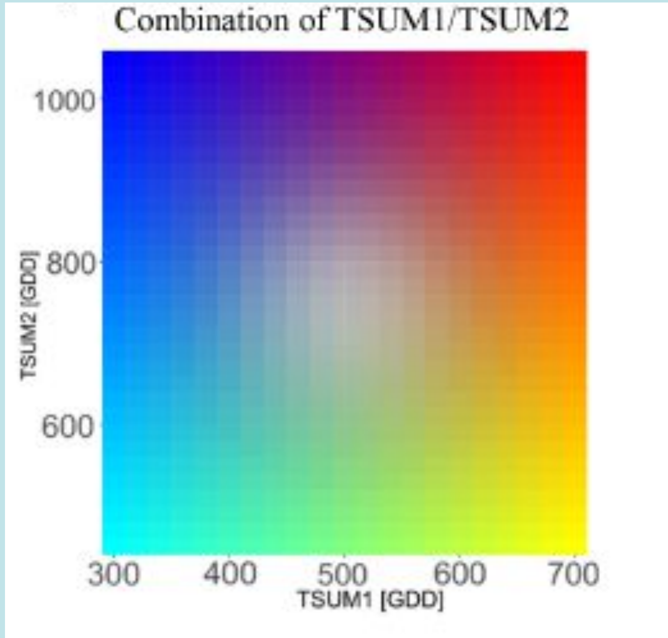
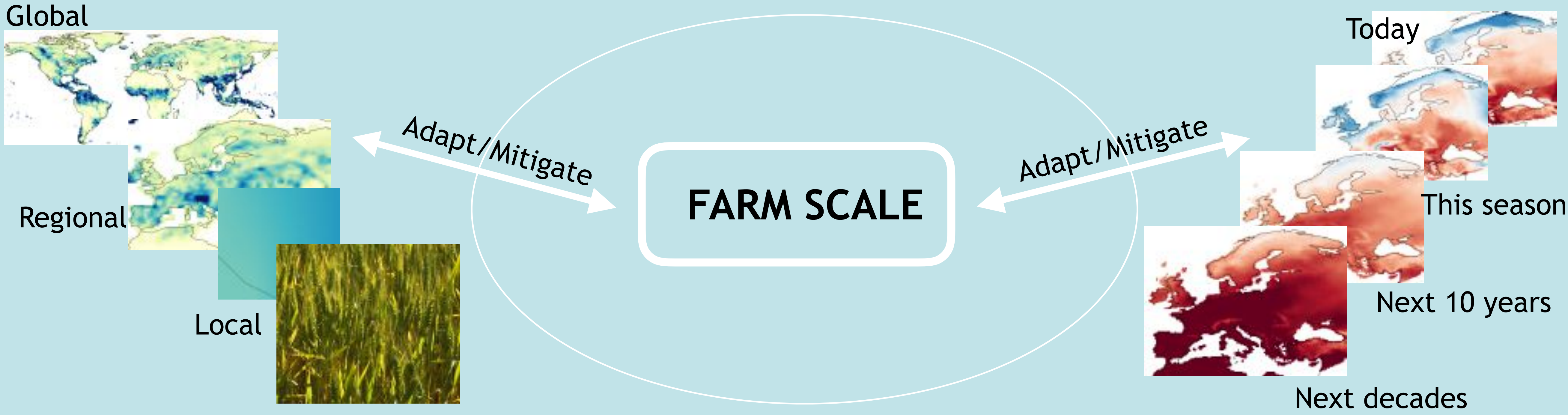
Adapting to climate change





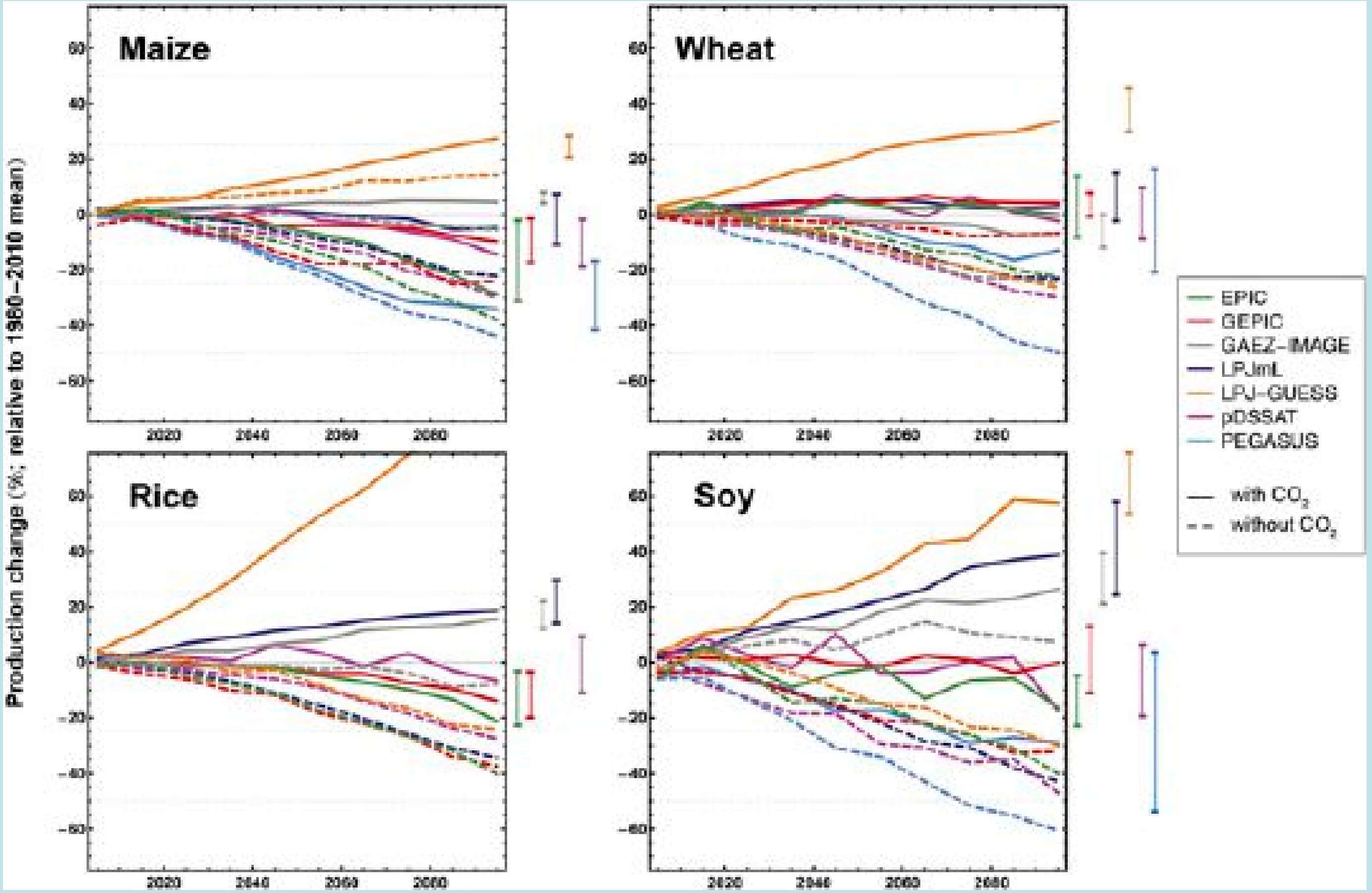
Source: Ceglar et al., in preparation

Adapting to climate change



Developing an integrated multi-scale system to allow for dynamic adaptation and mitigation as well as enhanced resilience

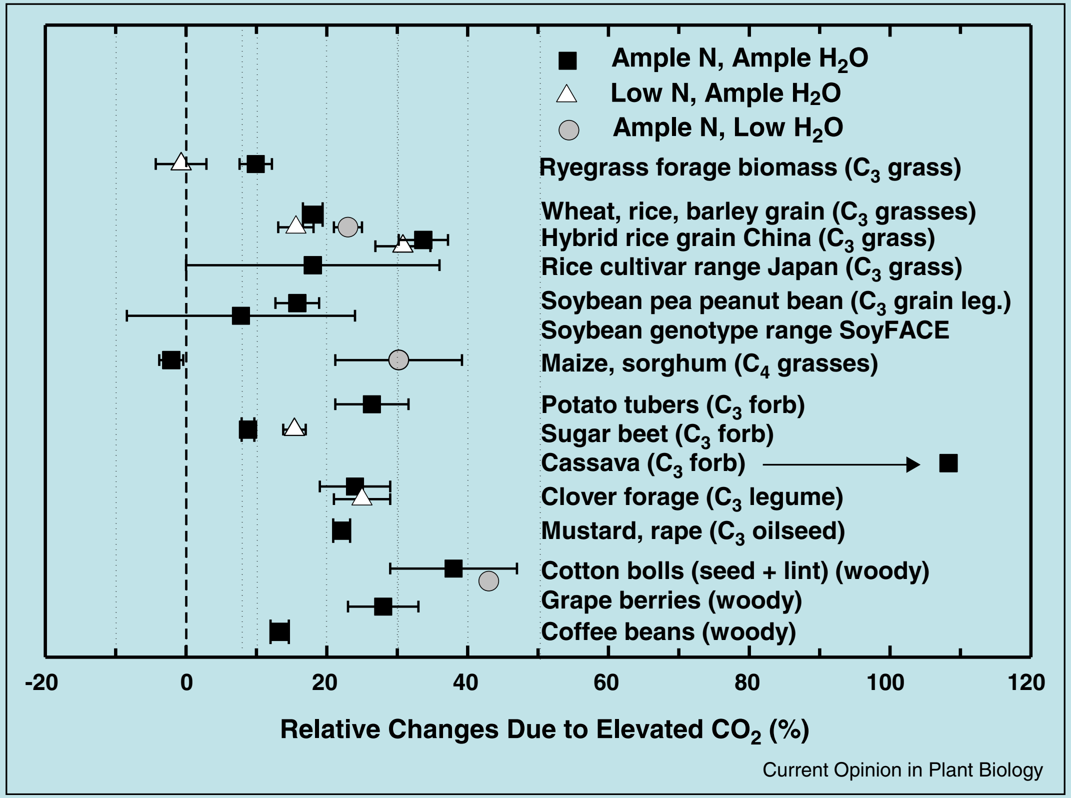
CO_2 effects



Source: Rosenzweig et al., 2014

CO_2 effects

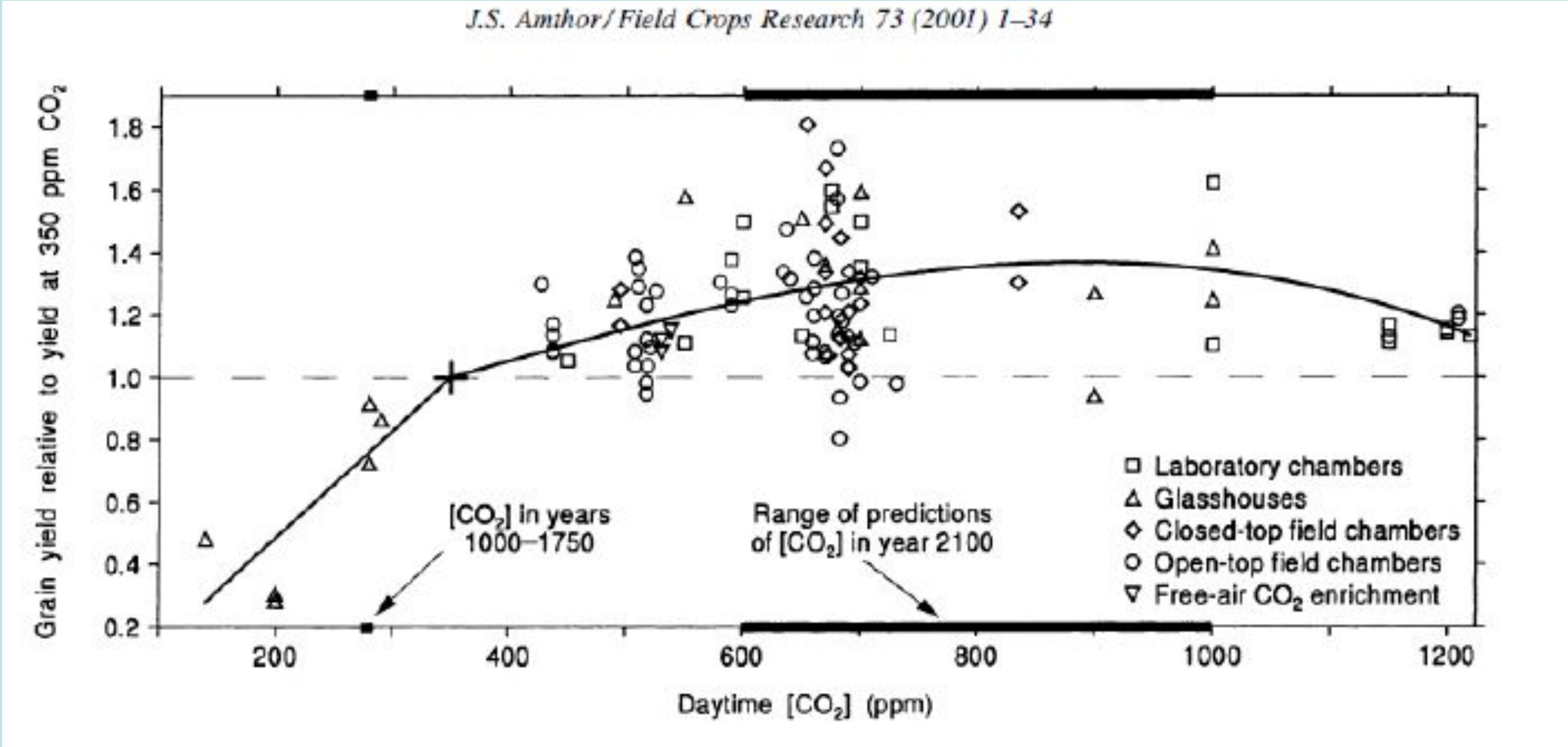
The effects depend on crop type, variety, nutrients and water availability, climate conditions, etc.



Source: Kimball 2016

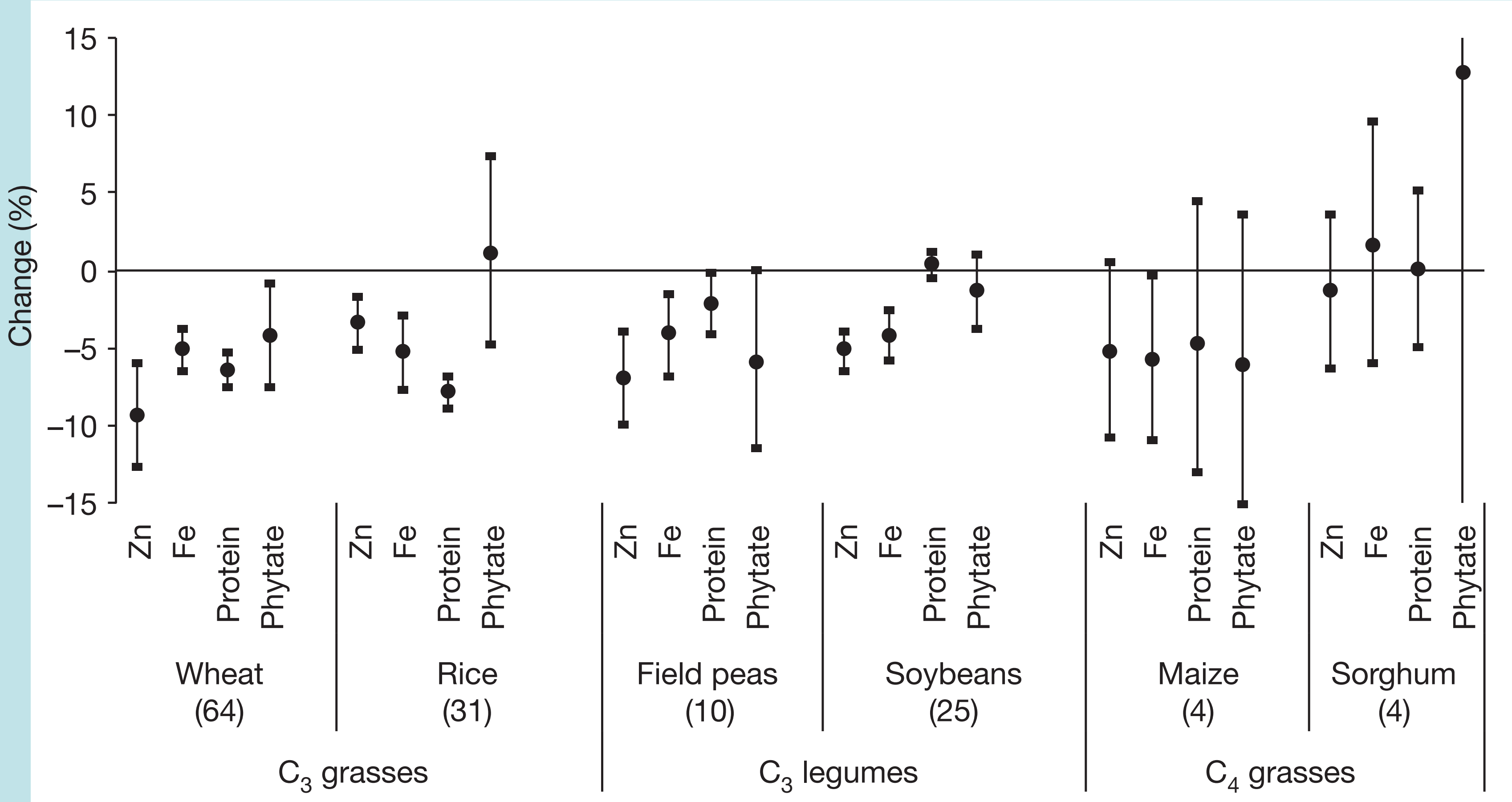
CO_2 effects

nonlinear response



CO_2 effects

Nutritional and quality issues



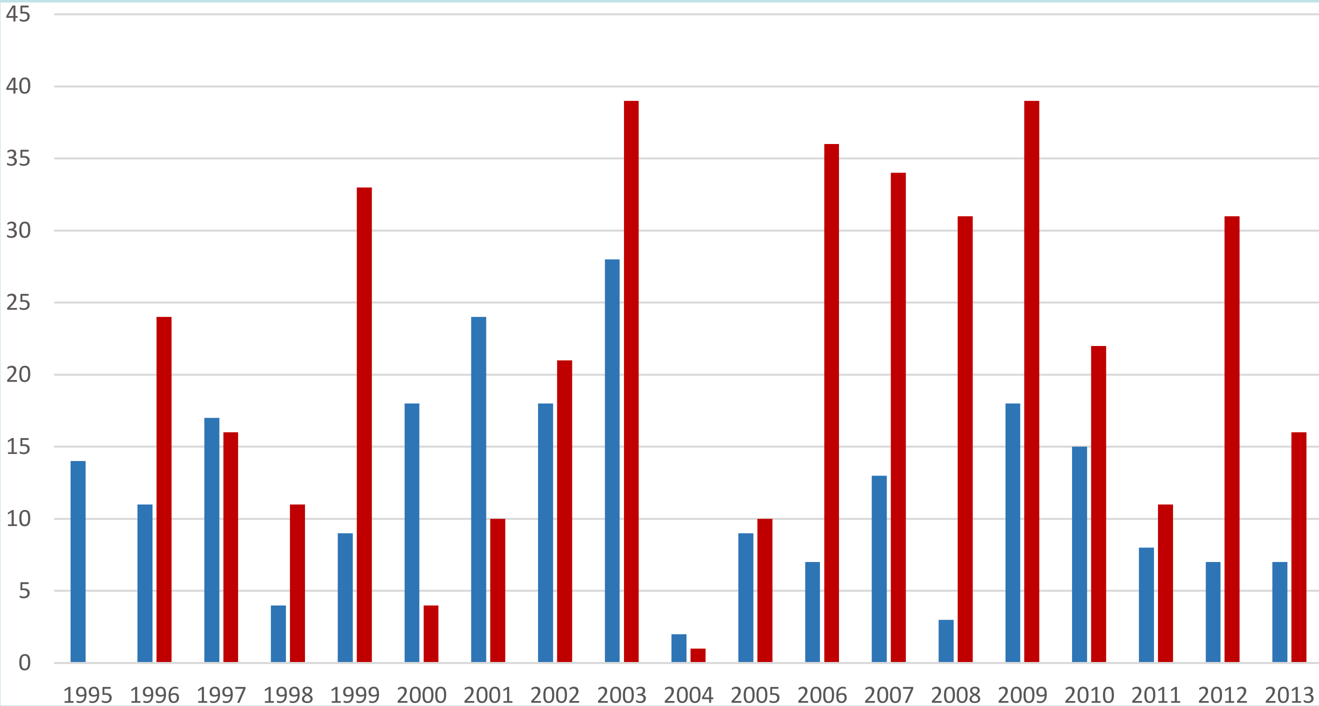
Source: Myers et al., 2014

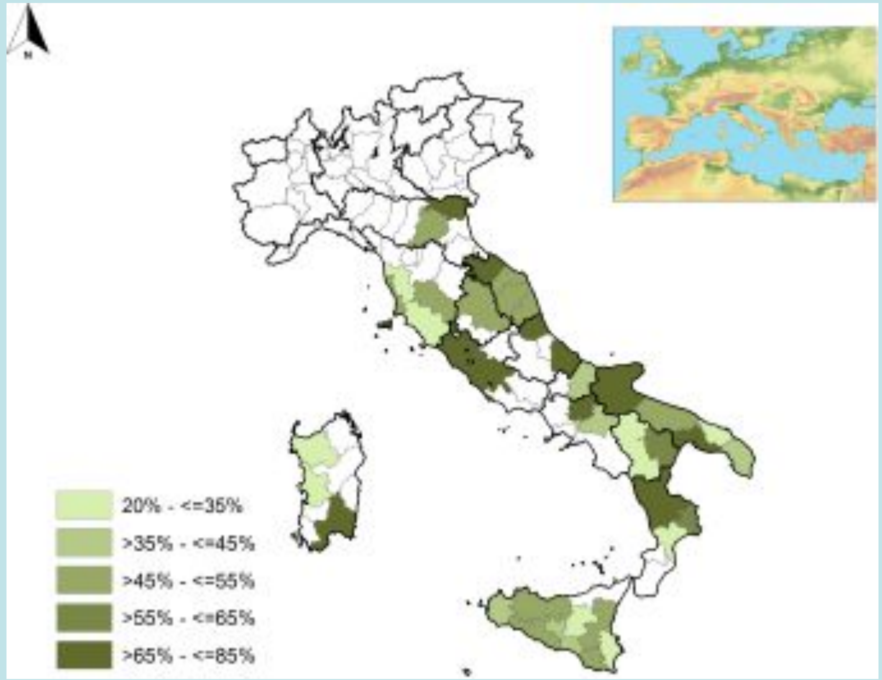
CO_2 effects

FACE experiments

Source:Gerald Moser

Climate extremes - concurrent events



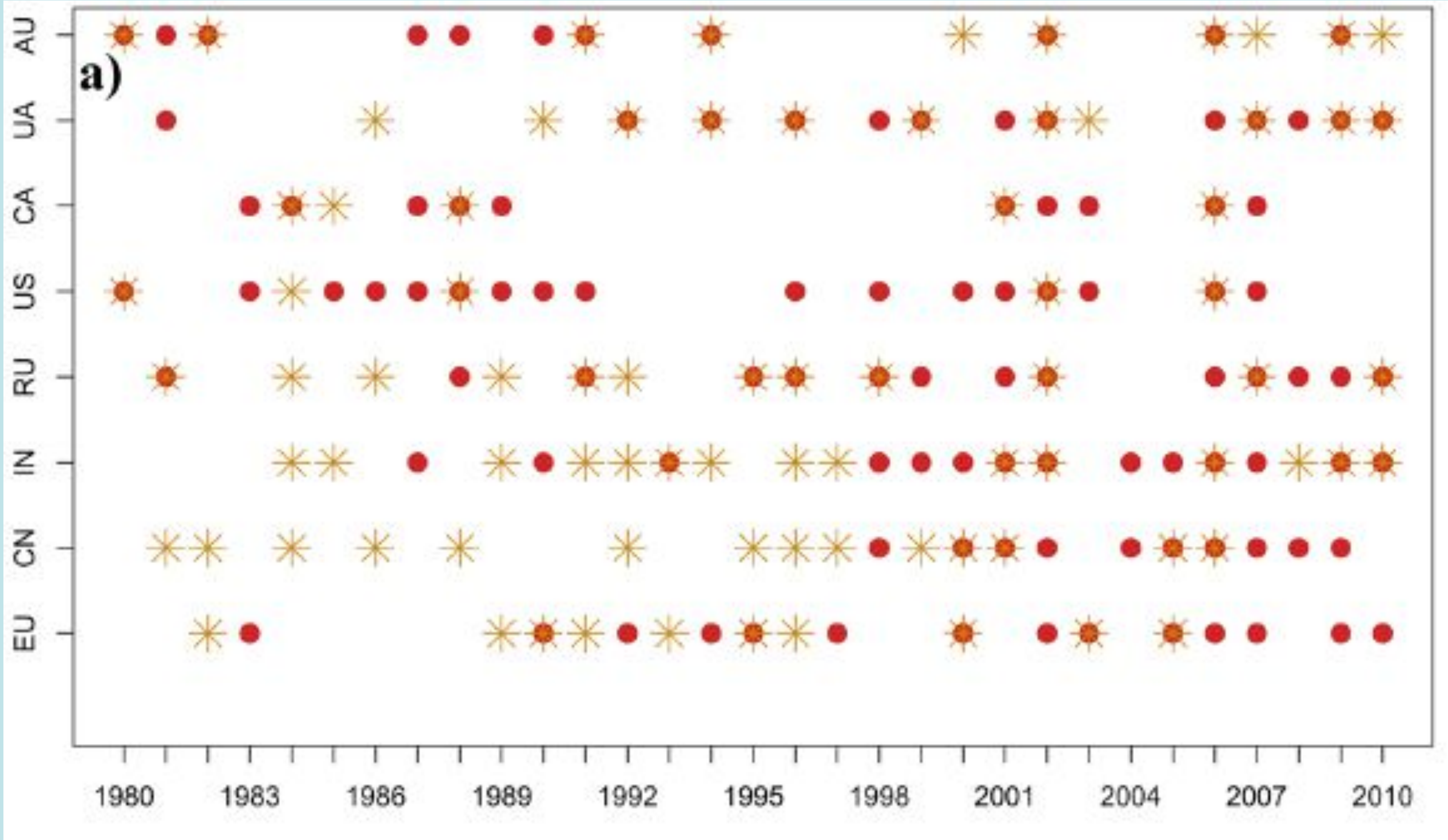


Early HW and durum wheat production

Source: Fontana et al. 2015

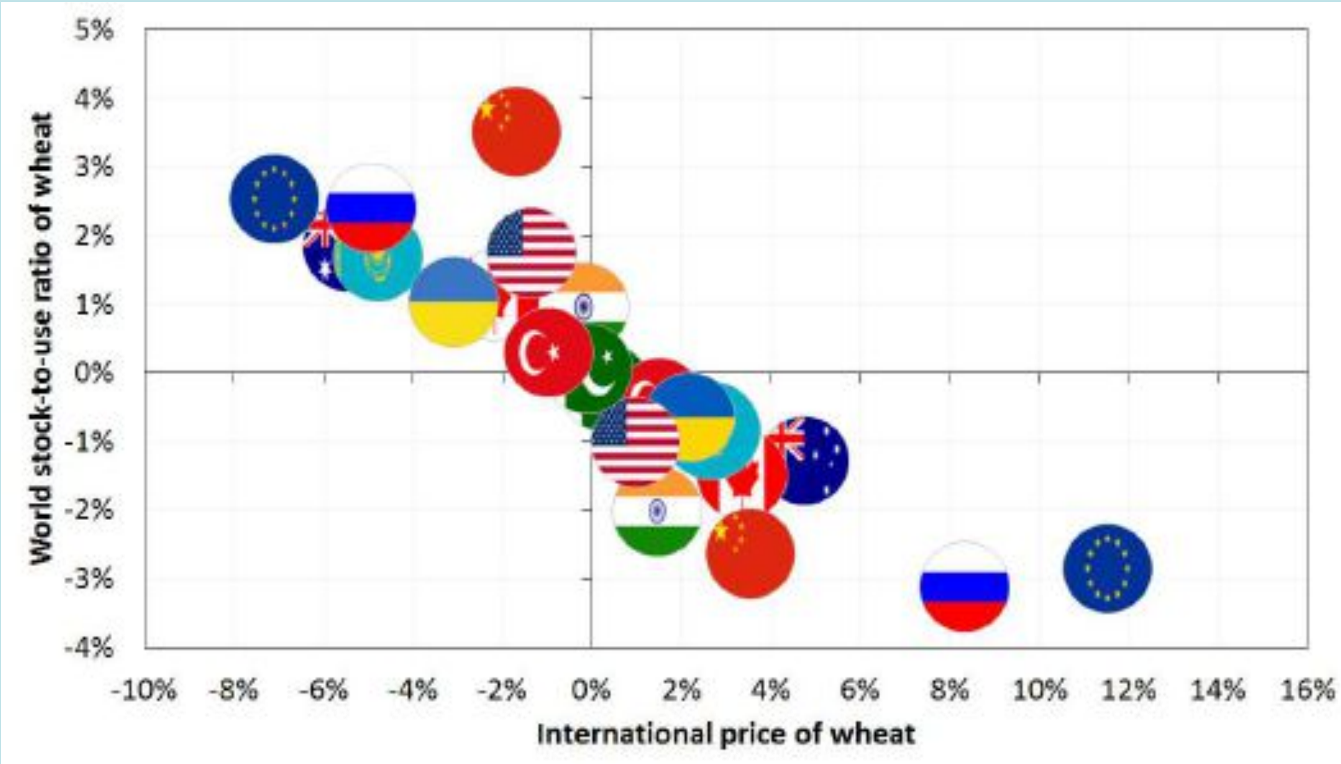
Climate extremes - concurrent events

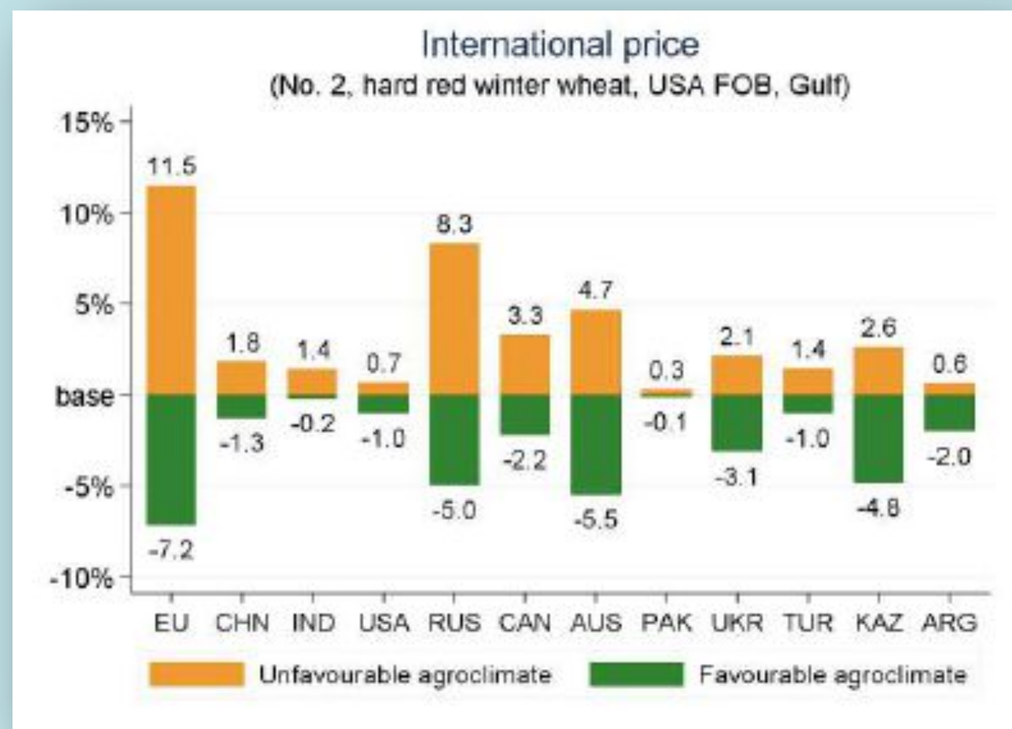
Large scale heat stress and drought events



Source: Toreti et al., 2019

Climate extremes - concurrent events





Source: Chatzopoulos et al., 2019

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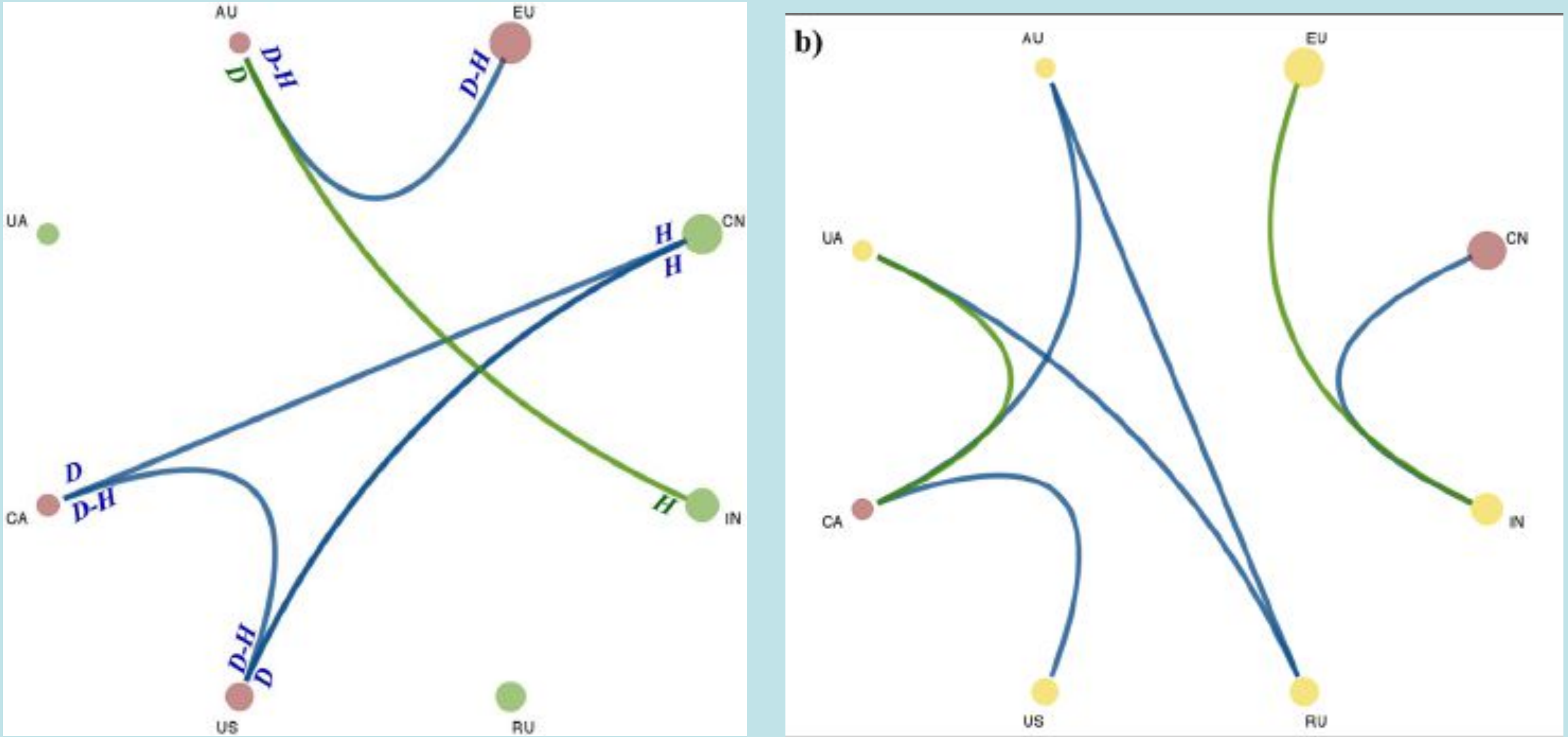
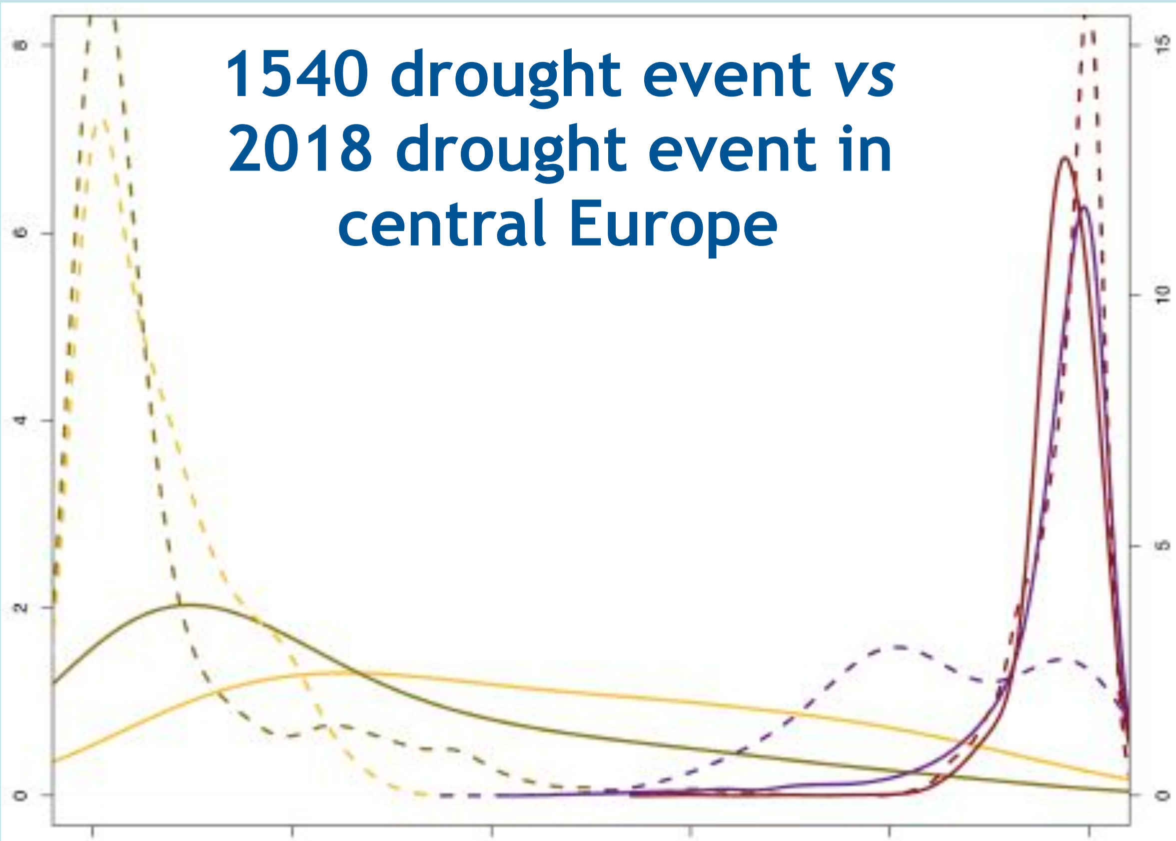
Climate extremes - concurrent events

concurrent events



Source: Toreti et al., 2019

Climate extremes - concurrent events



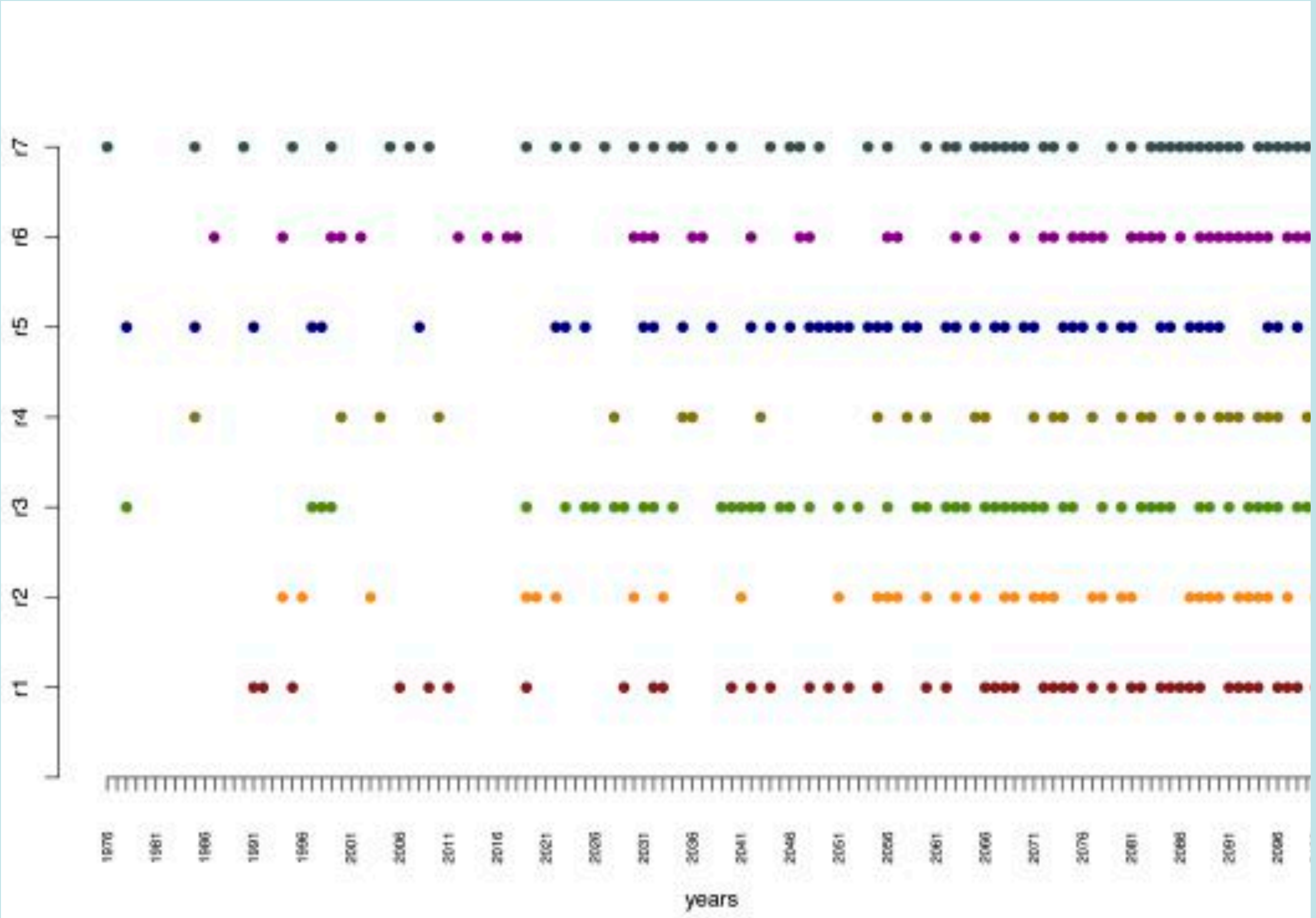
1500 CE

No concurrent spring/ summer climate anomalies in central Europe
similar to the ones in 2018

2017 CE

Source: Toreti et al., 2019

Climate extremes - concurrent events

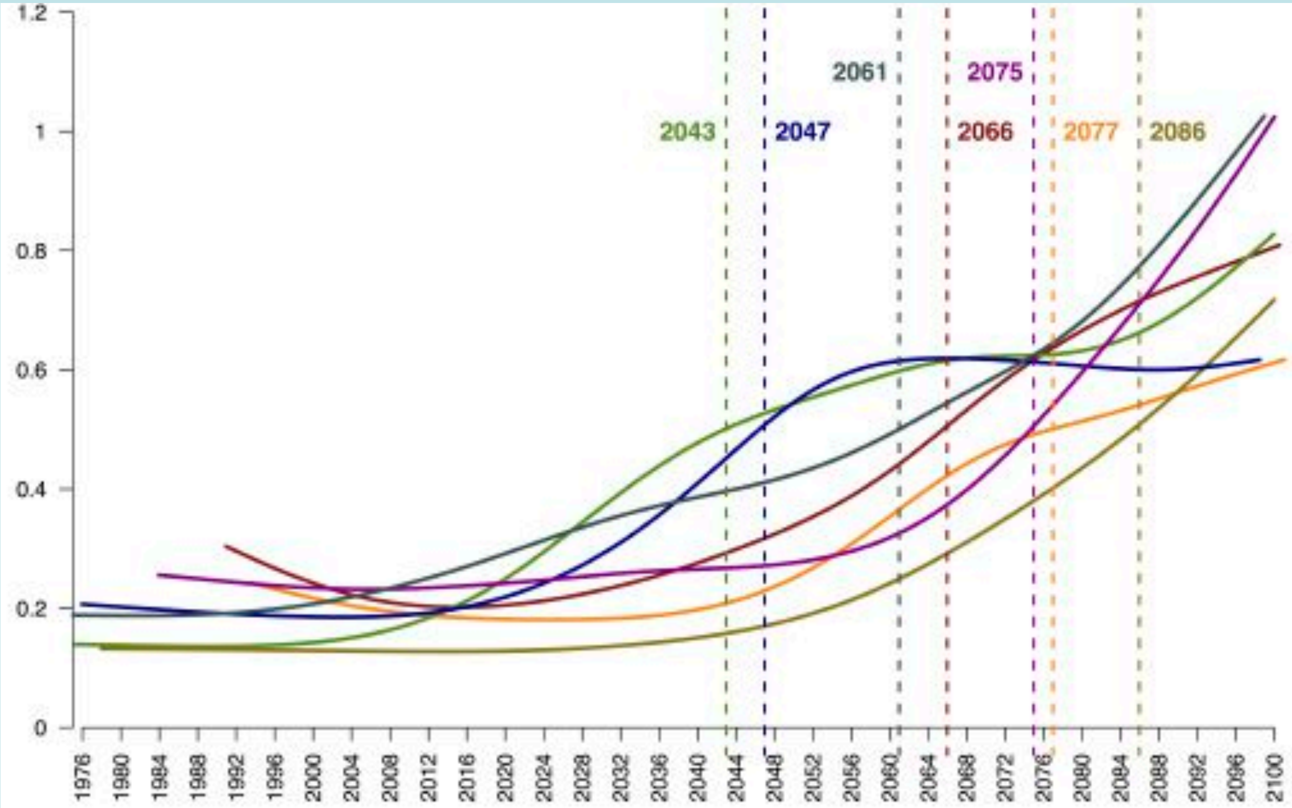


spatial *pdf* of SPEI-6

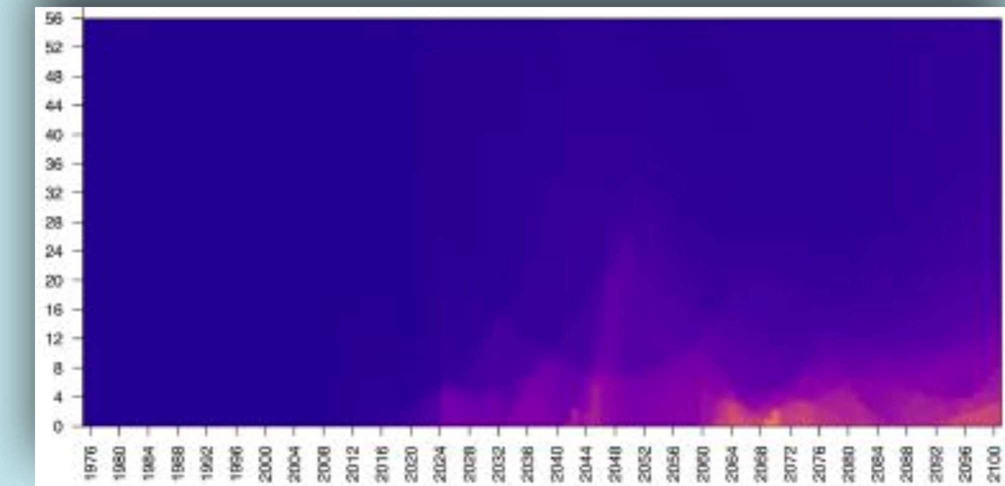
Projections of the **2018-like** drought events till 2100 under RCP8.5 in seven climate model runs (HELIX)

Source: Toreti et al., 2019

Climate extremes - concurrent events

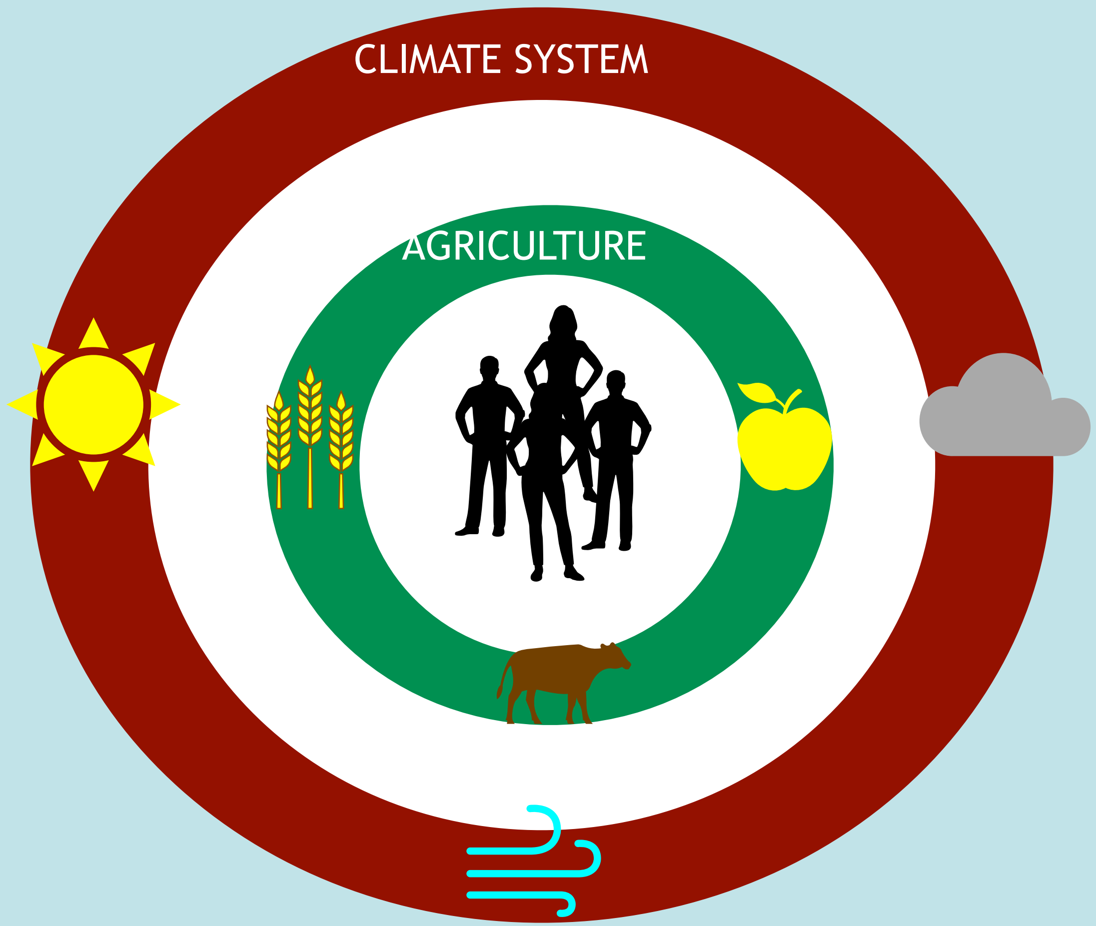


Estimated frequency of occurrence of the projected **2018-like** drought events



Source: Toreti et al., 2019

The missing component



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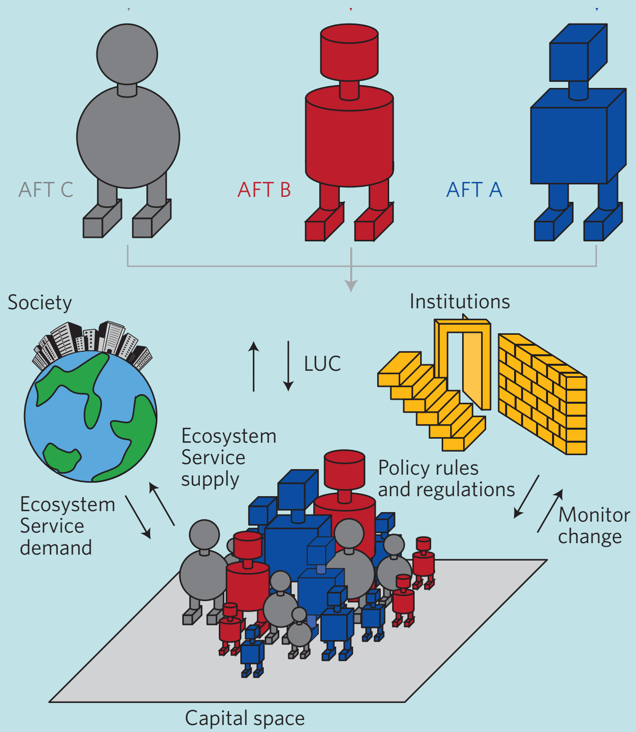
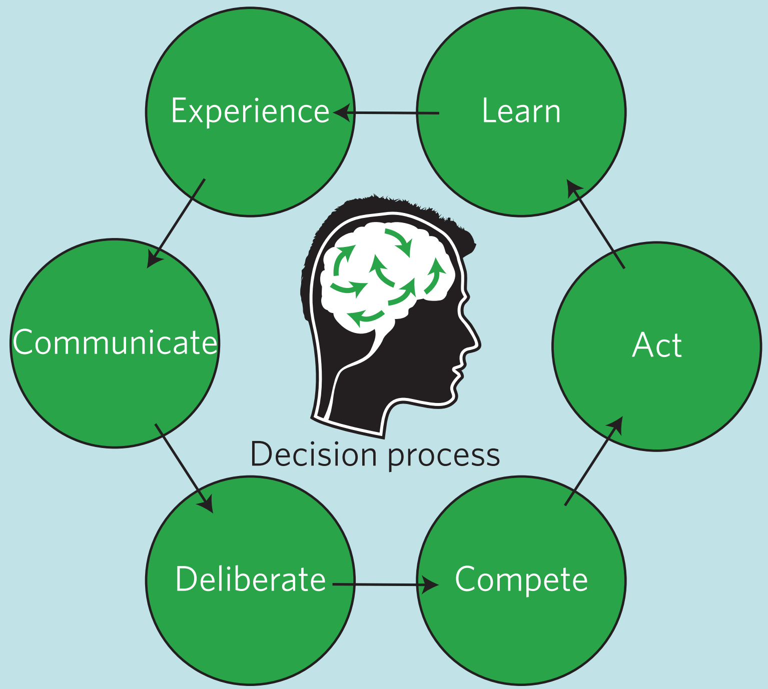
The missing component

Modelling human interaction with the agro-climatic system





Thanks

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