Meteorological Scientific Days - Hungary

Budapest, November 24-25 2011

Trends and Future Challenges in Agrometeorology

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With special thanks to Federica Rossi (Italy) and Branka Lalic (Serbia) for providing some slides

Agrometeorology
plays an increasing important role
in agriculture and food production !

Why?
Global change
leads to
higher risks in agricultural production
and less resources for more people.

The top 100 questions of importance to the future of global agriculture

J. Pretty et al., Int. J. Agric. Sust. 8(4), 2010, 219–236

Agriculture unprecedented combination of drivers is **population growth**, dietary shifts, **energy and resource unsecurity**, **climate change** and variability.

The goal is no longer simply to maximize productivity, but to optimize across a far more complex landscape of production, rural development, environmental, social, economic outcomes.

Synergies and dialogue between policies, social, environmental, economic are fundamental to prioritize investments and research efforts.

Impacts of climate change on agriculture - World

- physiological effects on crops, pasture, forests and livestock (quantity, quality);
- changes in land, soil and water resources (quantity, quality);
- increased weed and pest challenges;
- shifts in spatial and temporal distribution of impacts;
- sea level rise, changes to ocean salinity;
- sea temperature rise causing fish to inhabit different ranges.

socio-economic impacts:

- decline in yields and production;
- reduced marginal GDP from agriculture;
- fluctuations in world market prices;
- changes in geographical distribution of trade regimes;
- increased number of people at risk of hunger and food insecurity;
- migration and civil unrest.

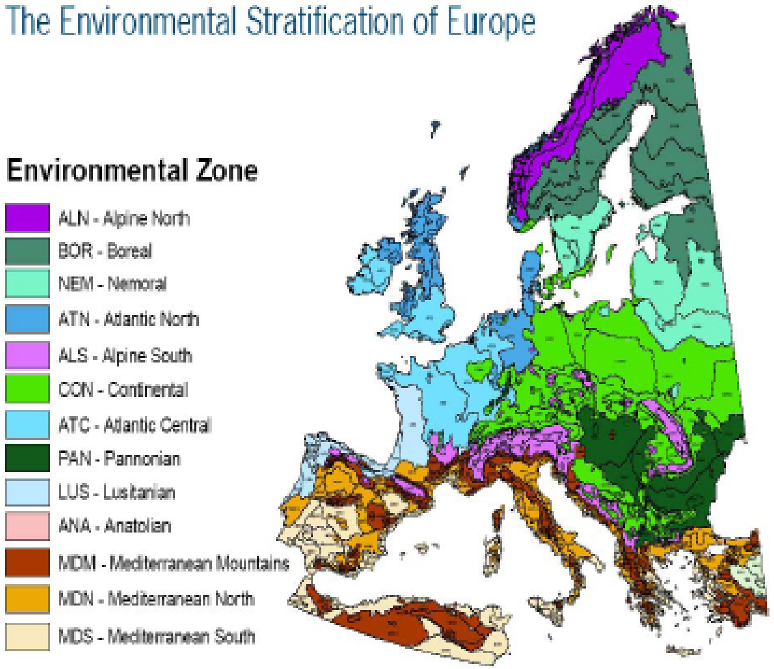
FAO, 2007

Climate change impacts

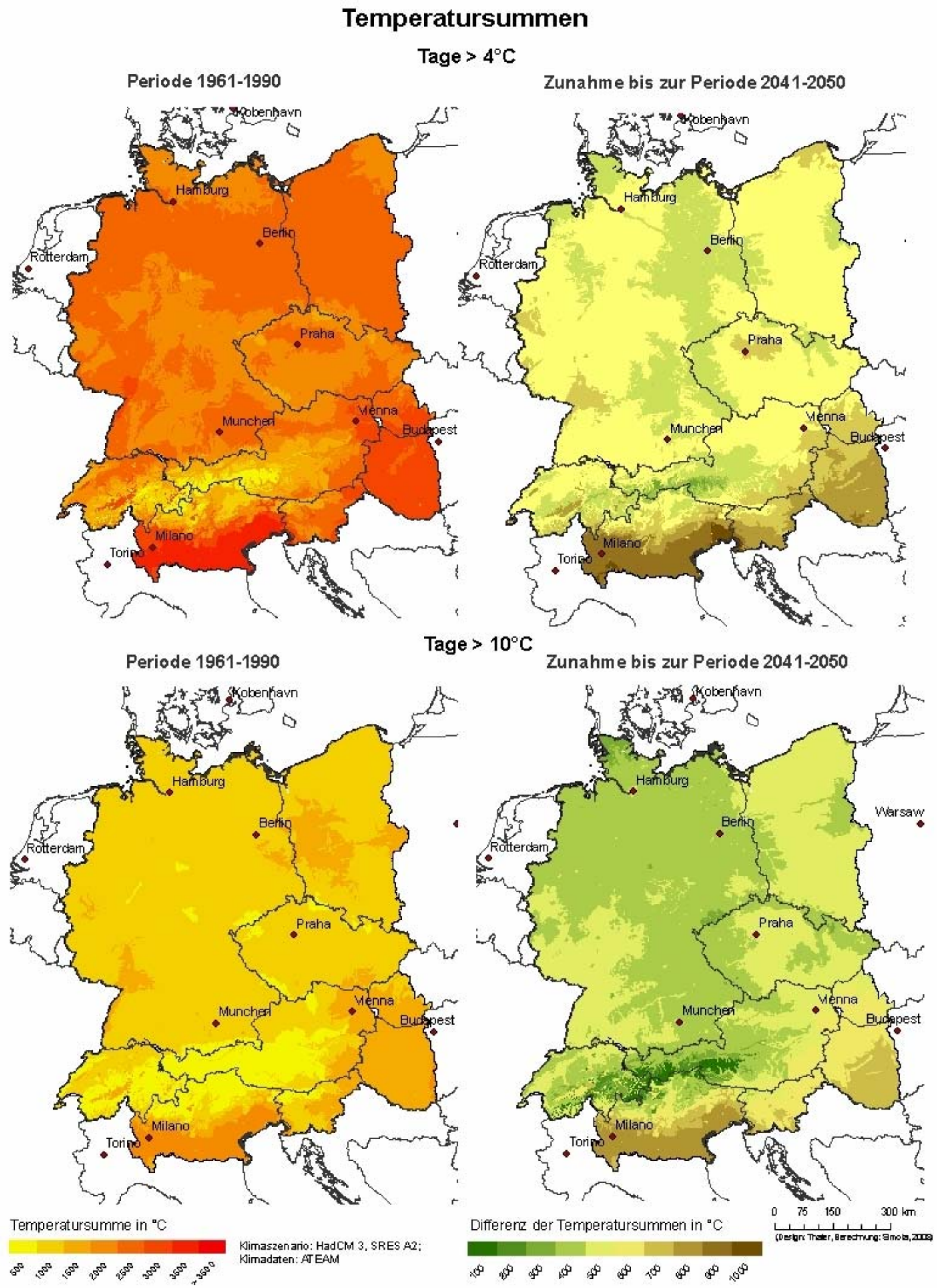
ATN (2)	w.wheat	s.barley	w.rape	Maize	Potato	sugar b.	Grassland	Apple	Grape
Duration of growing season	-0.5	0.0	-0.5	2.0	1.5	0.5	1.0	2.0	1.0
Overwintering damage	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.5	0.0
Frost damage	-0.5	0.0	-0.5	-1.0	-1.0	0.0	-0.5	-0.5	-0.5
Suitable harvest conditions	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Interannual variability	0.0	-1.0	-1.0	0.0	-1.0	-1.0	-1.0	-1.0	-1.0
Drought	-0.5	-0.5	-0.5	0.0	-0.5	-1.0	-0.5	-1.0	-0.5
Heat stress	-1.0	-0.5	-0.5	0.0	-0.5	-1.0	0.0	-0.5	0.0
Hail	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	0.0	-1.0	-1.0
Pest and diseases	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.0	-0.5	-1.5
Weeds	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Soil erosion	-0.5	-1.0	-0.5	-1.0	-1.0	-1.0	-0.5	0.0	-1.0
Nitrogen losses	-1	-1	-1	1	1	0.0	-0.5	0.0	-1.0

ATC (2)	w.wheat	s.barley	w.rape	Maize	Potato	sugar b.	Grassland	Apple	Grape
Duration of growing season	-1.5	-1.0	-1.5	0.0	1.0	0.0	1.5	0.0	-0.5
Overwintering damage	1.0		1.0				0.0	0.0	0.0
Frost damage	-1.0		-1.0				-1.0	-1.0	-1.0
Suitable harvest conditions	0.5	0.5	0.5	1.5	1.0	1.0	1.5	1.0	1.5
Interannual variability	0.0	-1.0	-1.0	0.0	-1.0	-1.0	-1.0	-1.0	-1.0
Drought	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.5	-1.0	-1.0
Heat stress	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.5	-1.0	-0.5
Hail	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	0.0	-1.0	-1.0
Pest and diseases	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.5	-1.5	-1.0
Weeds	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Soil erosion	-0.5	-1.0	-0.5	-1.0	-1.0	-1.0	0.0		
Nitrogen losses	-1	-1	-1	1	1	1.0	0.0		

CON (7)	w.wheat	s.barley	w.rape	Maize	Potato	sugar b.	Grassland	Apple	Grape
Duration of growing season	-0.3	-0.2	-0.3	-0.9	0.2	-0.5	0.5	0.8	0.4
Overwintering damage	-0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.9	0.6
Frost damage	0.3	0.6	0.1	-0.8	-0.8	-0.6	-0.5	0.5	0.2
Suitable harvest conditions	1.2	1.3	1.2	0.7	1.5	1.3	1.0	1.0	-0.3
Interannual variability	-0.7	-1.0	-1.0	-0.7	-1.2	-1.4	-1.2	-1.4	-1.6
Drought	-1.0	-1.5	-1.0	-1.5	-1.5	-1.7	-1.5	-1.3	-1.0
Heat stress	-1.0	-1.3	-0.7	-0.5	-1.3	-1.5	-1.3	-1.2	-0.7
Hail	-1.0	-1.0	-1.0	-1.0	-0.5	-0.5	0.0	-1.5	-1.5
Pest and diseases	-1.4	-1.4	-1.8	-1.6	-1.8	-1.8	-1.4	-1.3	-1.3
Weeds	-0.5	-0.5	-1.0	-0.5	-0.5	-1.0	-0.5	0.0	0.0
Soil erosion	-0.7	-1.0	-0.7	-1.4	-1.4	-1.3	-0.6	-1.2	-1.6
Nitrogen losses	-1	-0.6	-1	-0.5	0	-0.3	-0.7	-0.5	-1.0



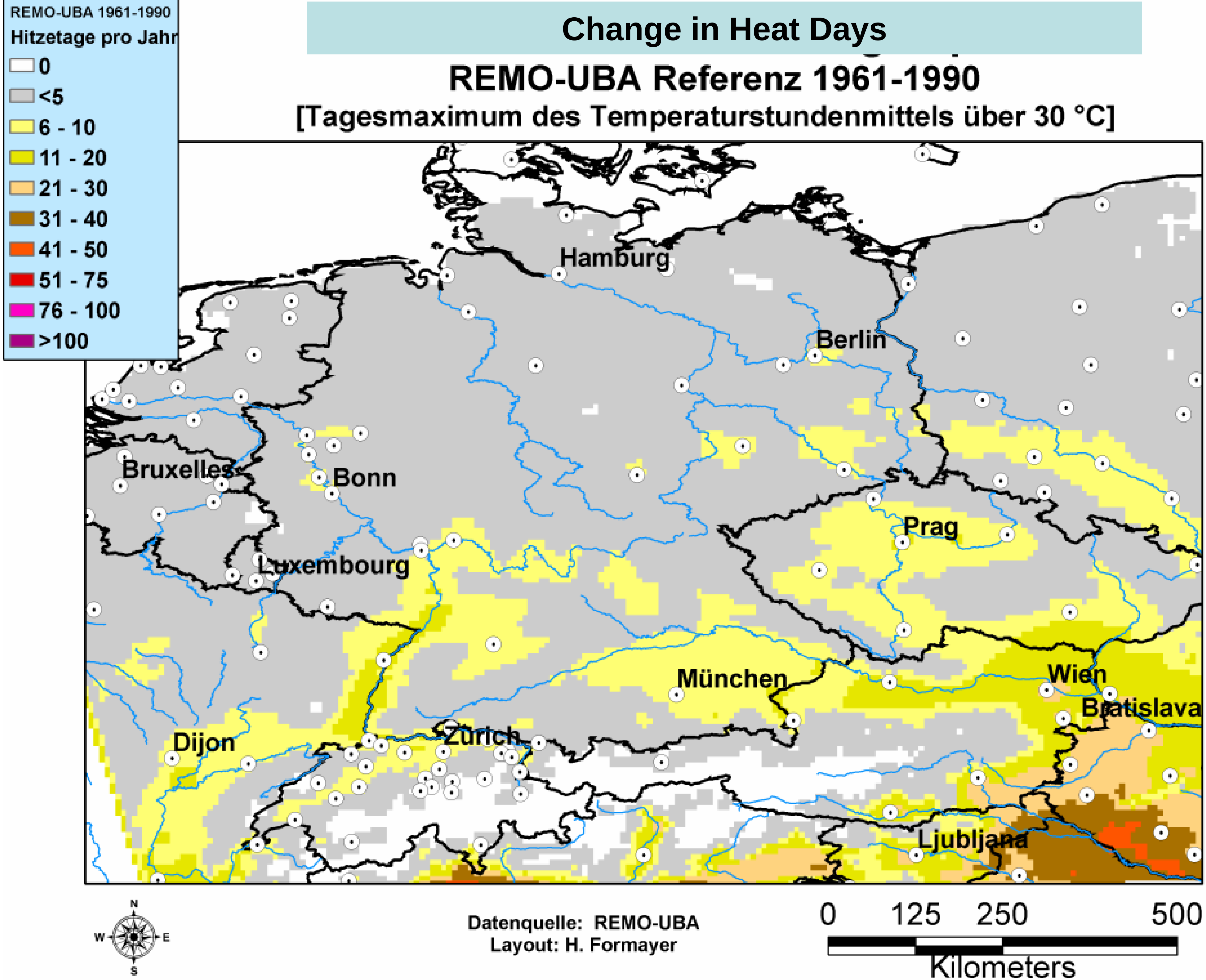
Olesen J.E., M. Trnka, K.C. Kersebaum, A.O. Skjelvag, B. Seguine, P. Peltonen-Sainio, F. Rossi, J. Kozyrah, F. Micale, 2011- Review- Impacts and adaptation of European crop production systems to climate change. Europ. J. Agronomy 34 96–112



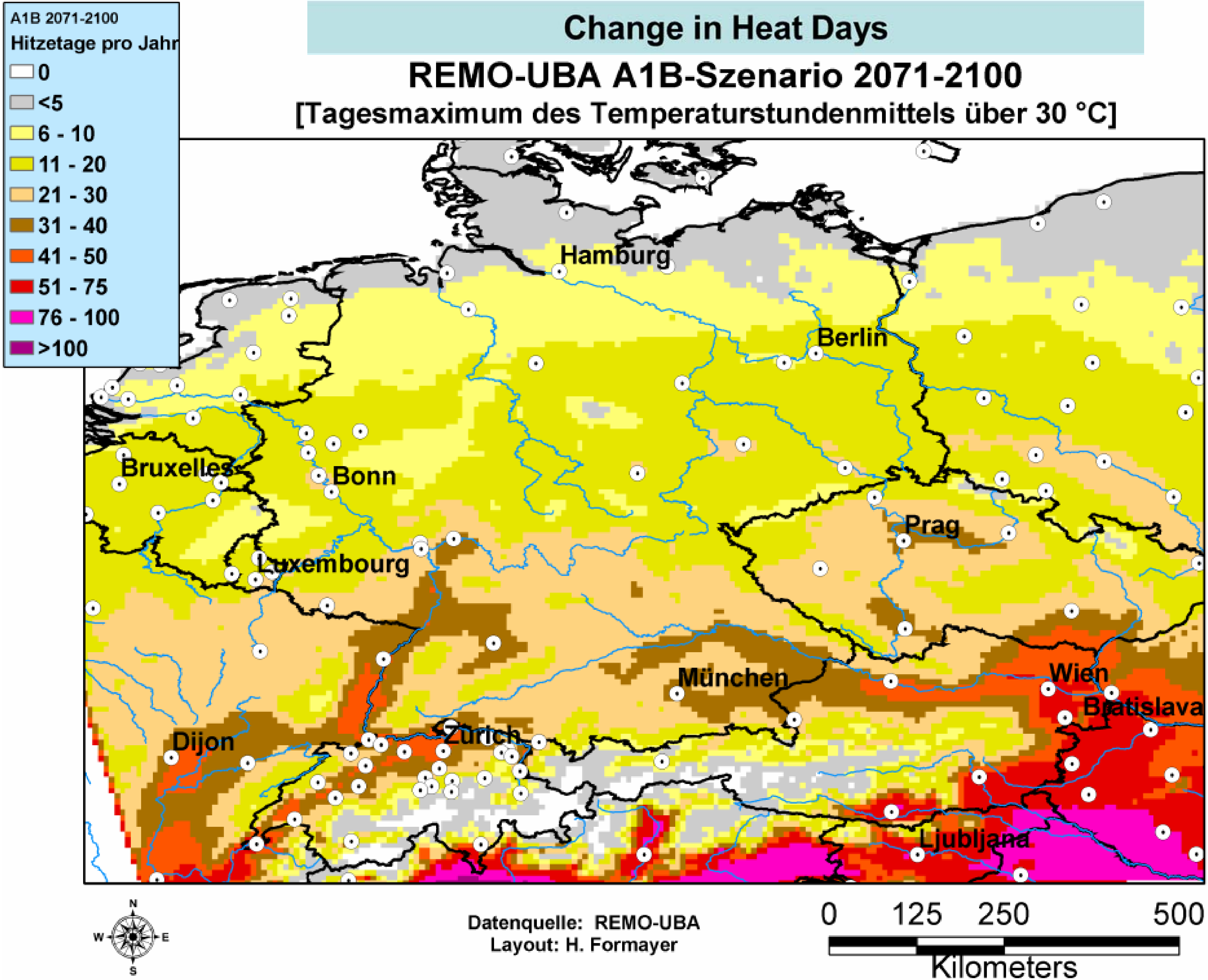
Increasing number of Growing Degree Days

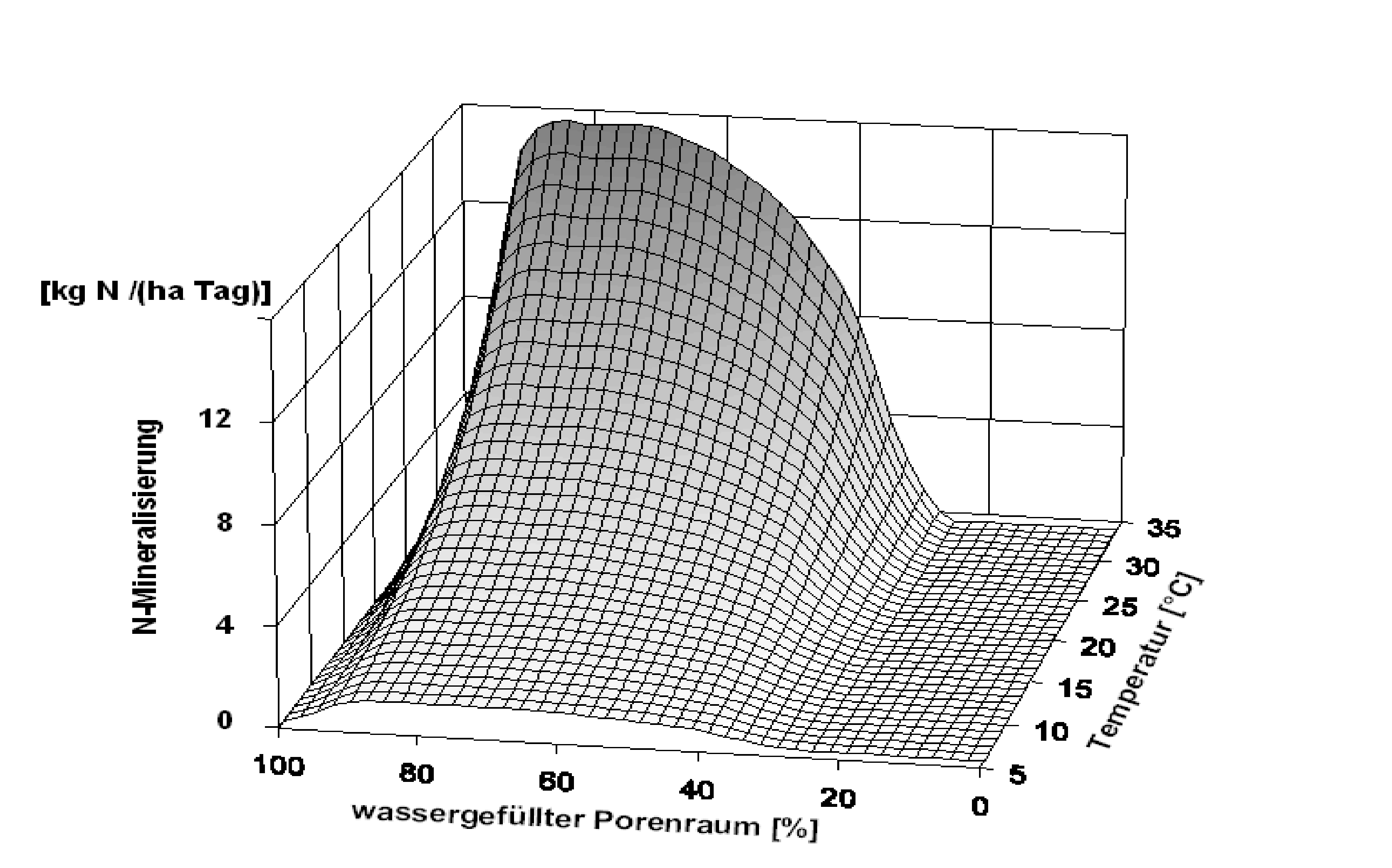
(Eitzinger et al., 2009)

Change in Heat Days



Change in Heat Days

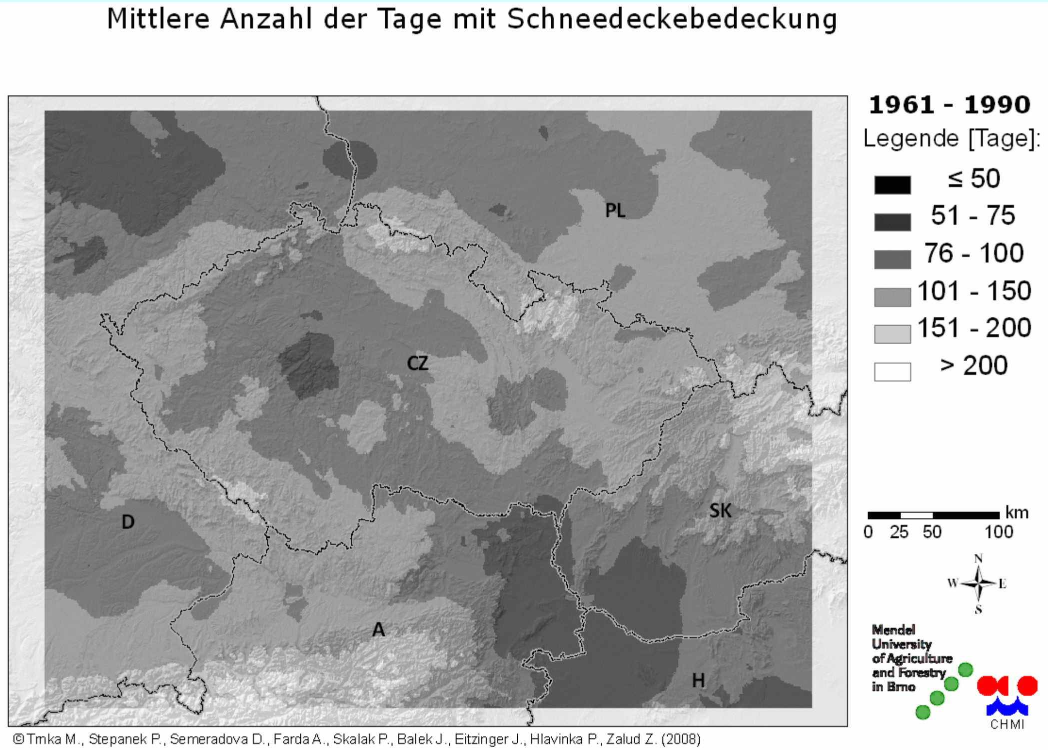


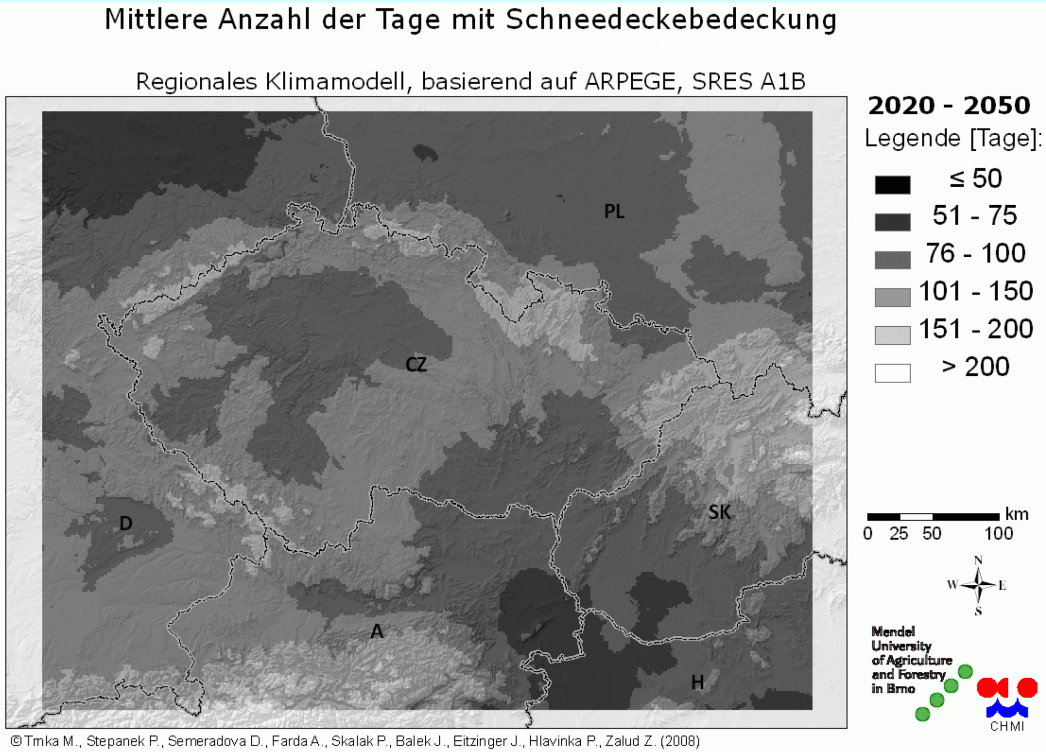


Soil temperature and wetness vs. soil N-mineralization

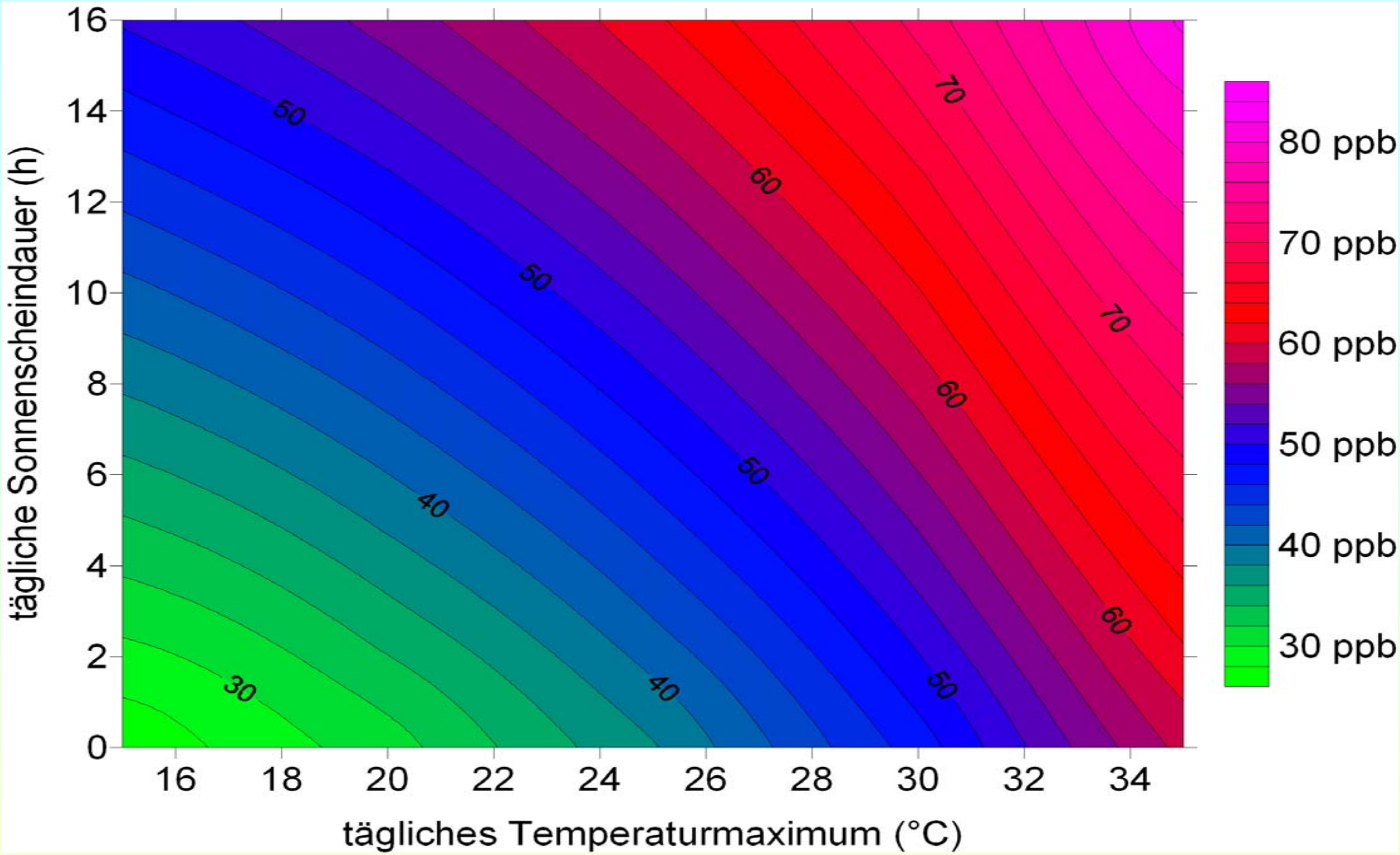
(Eitzinger et al., 2009)

Snow cover duration
Ca. -20 days till 2020/50





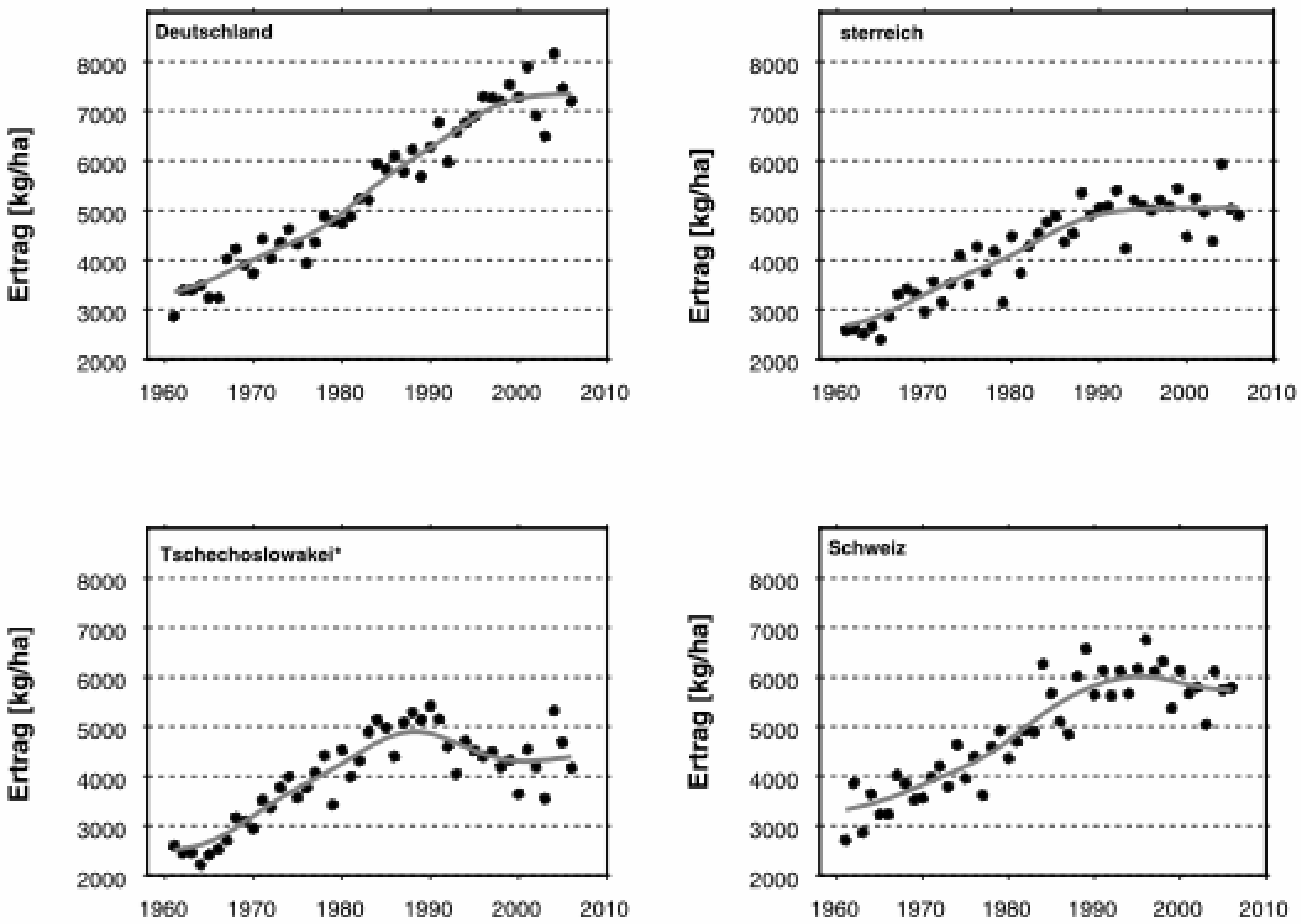
(Eitzinger et al., 2009)



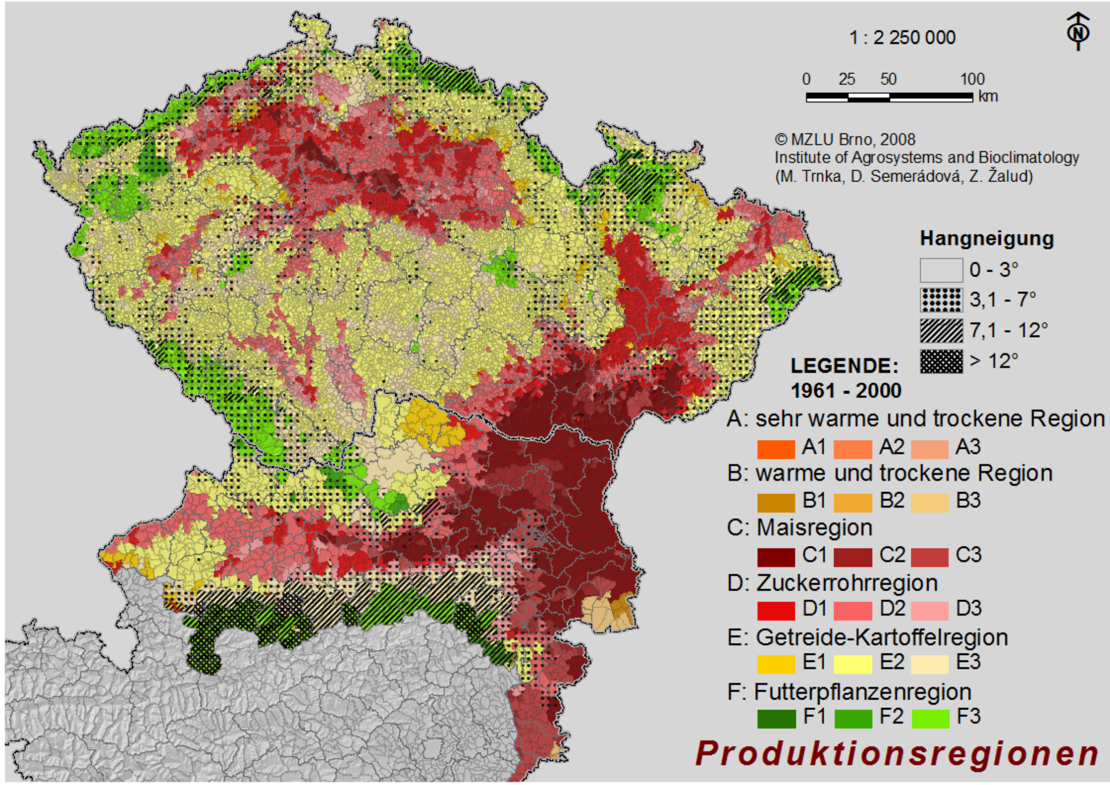
High temperatures influencing troposhperic ozone

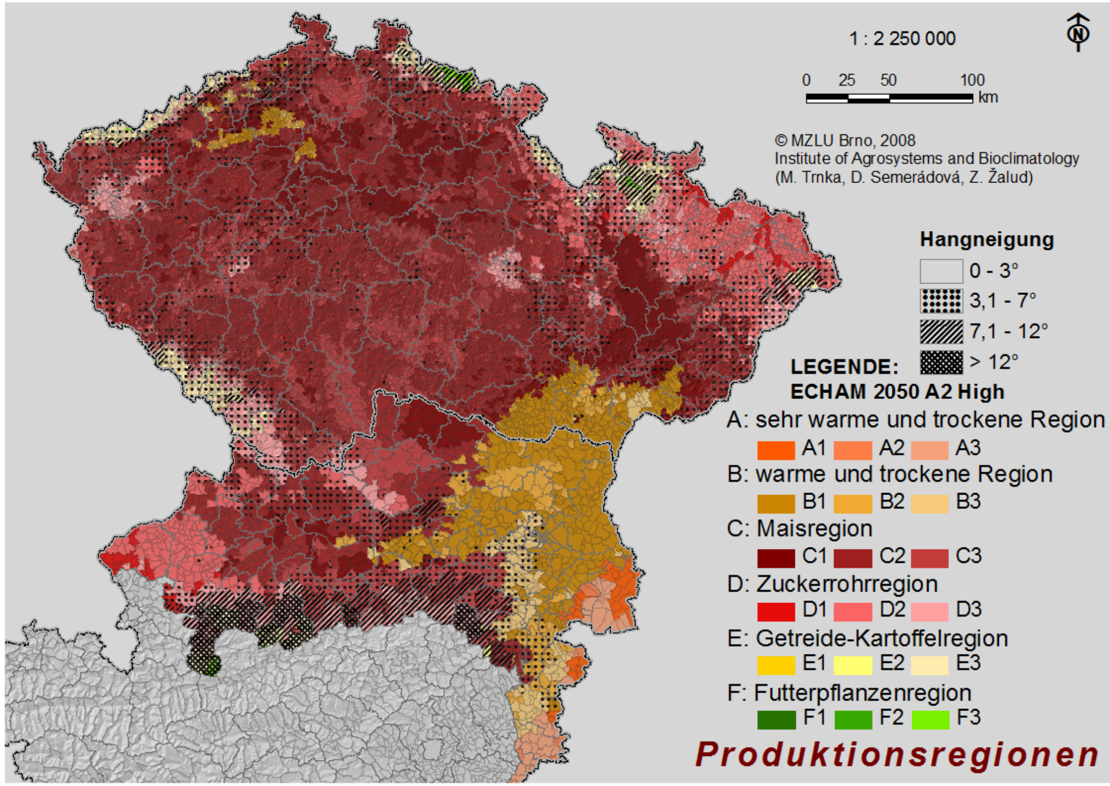
(Eitzinger et al., 2009)

National yield trends in Europe



(Eitzinger et al., 2009)





AGRICLIM-INDEX model

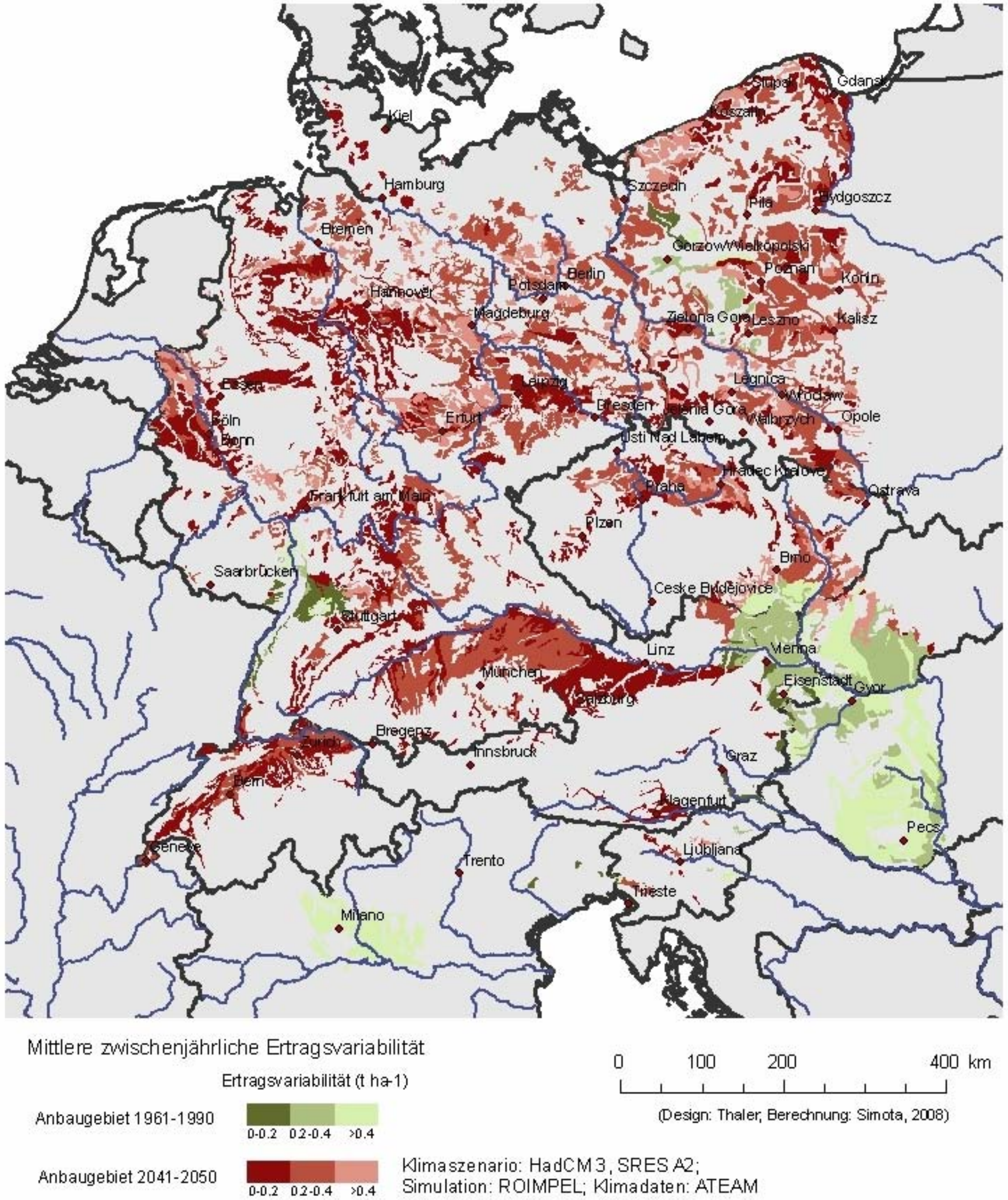
Change in agroecological production regions

Trnka et al., 2008

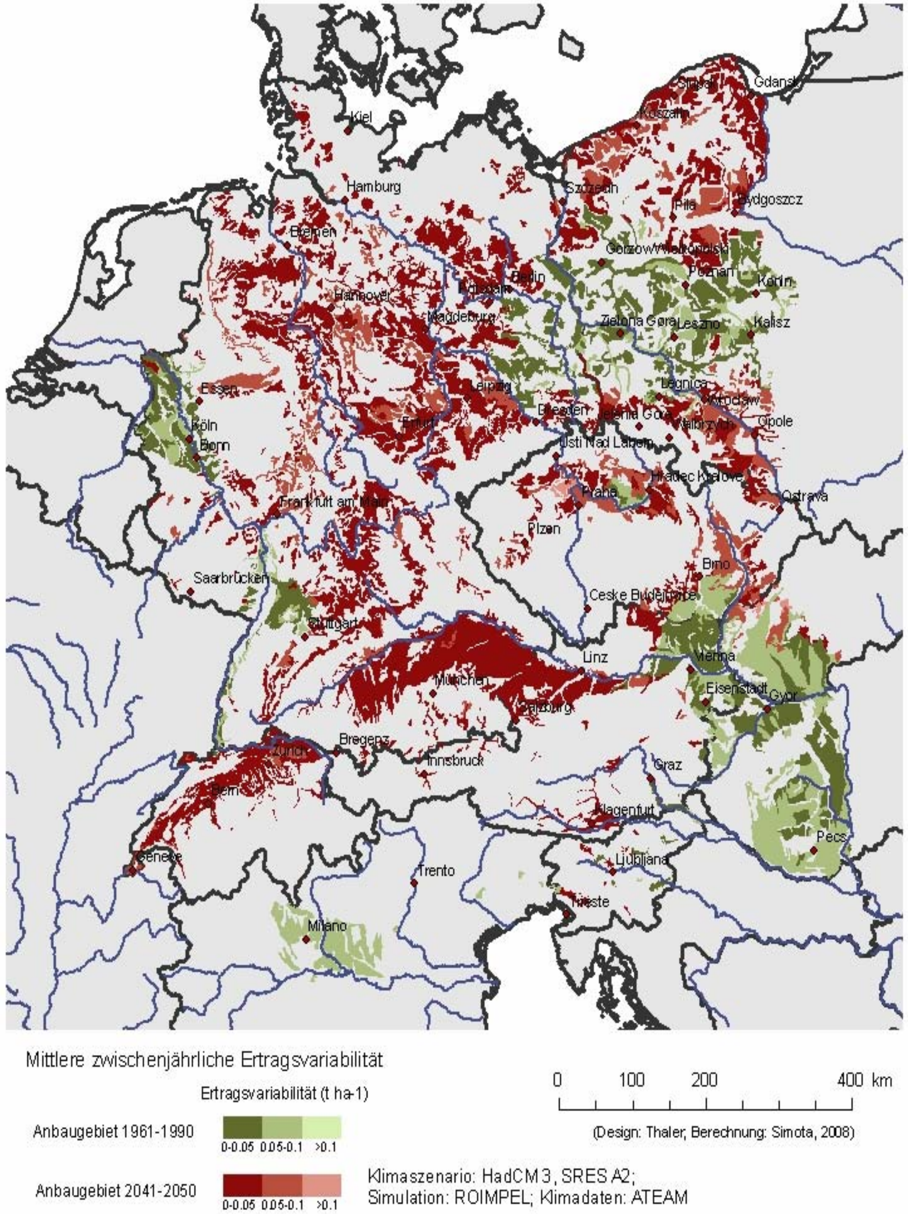
(Eitzinger et al., 2009)

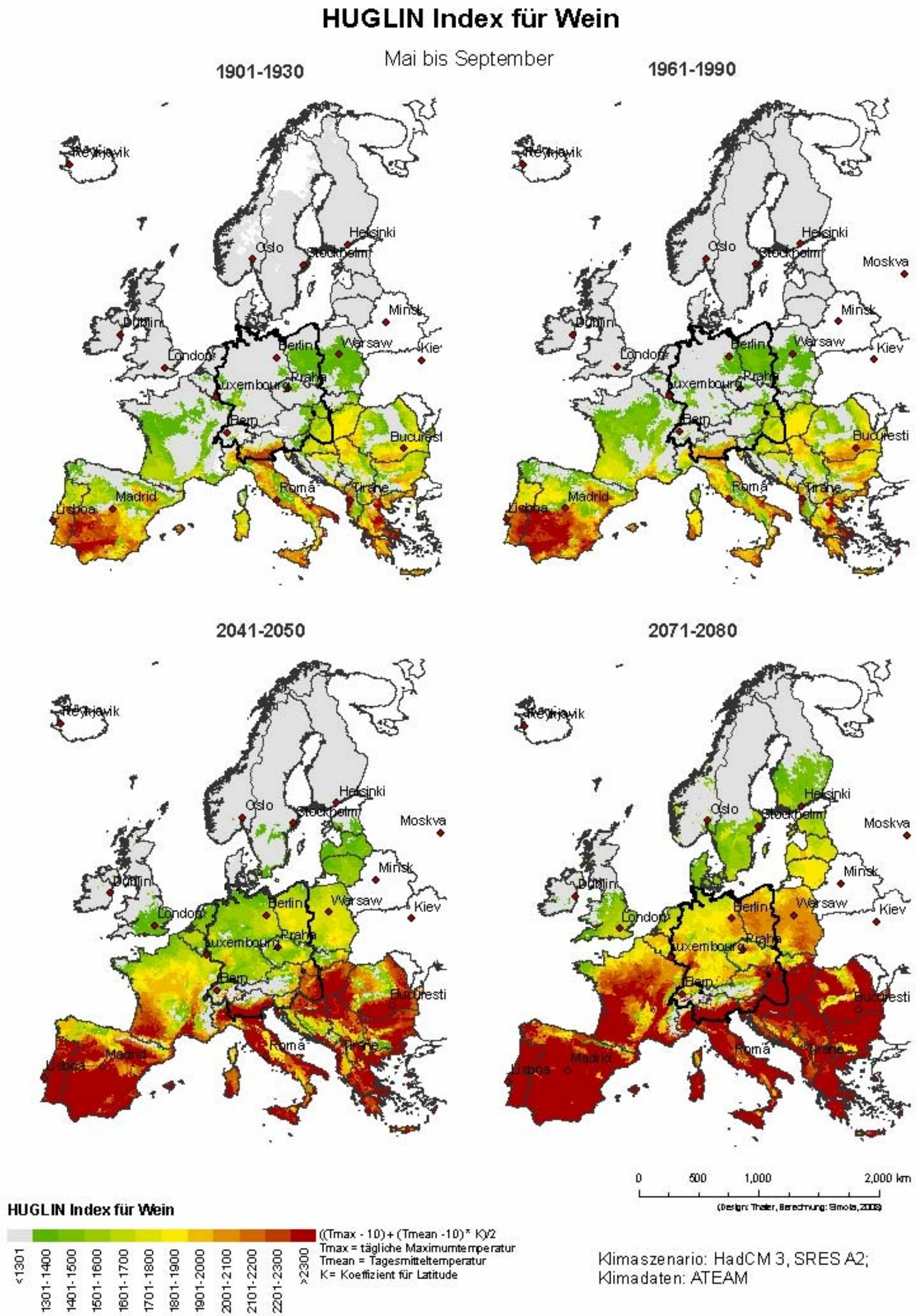
Körnermais

spätreifende Sorten



Sonnenblume

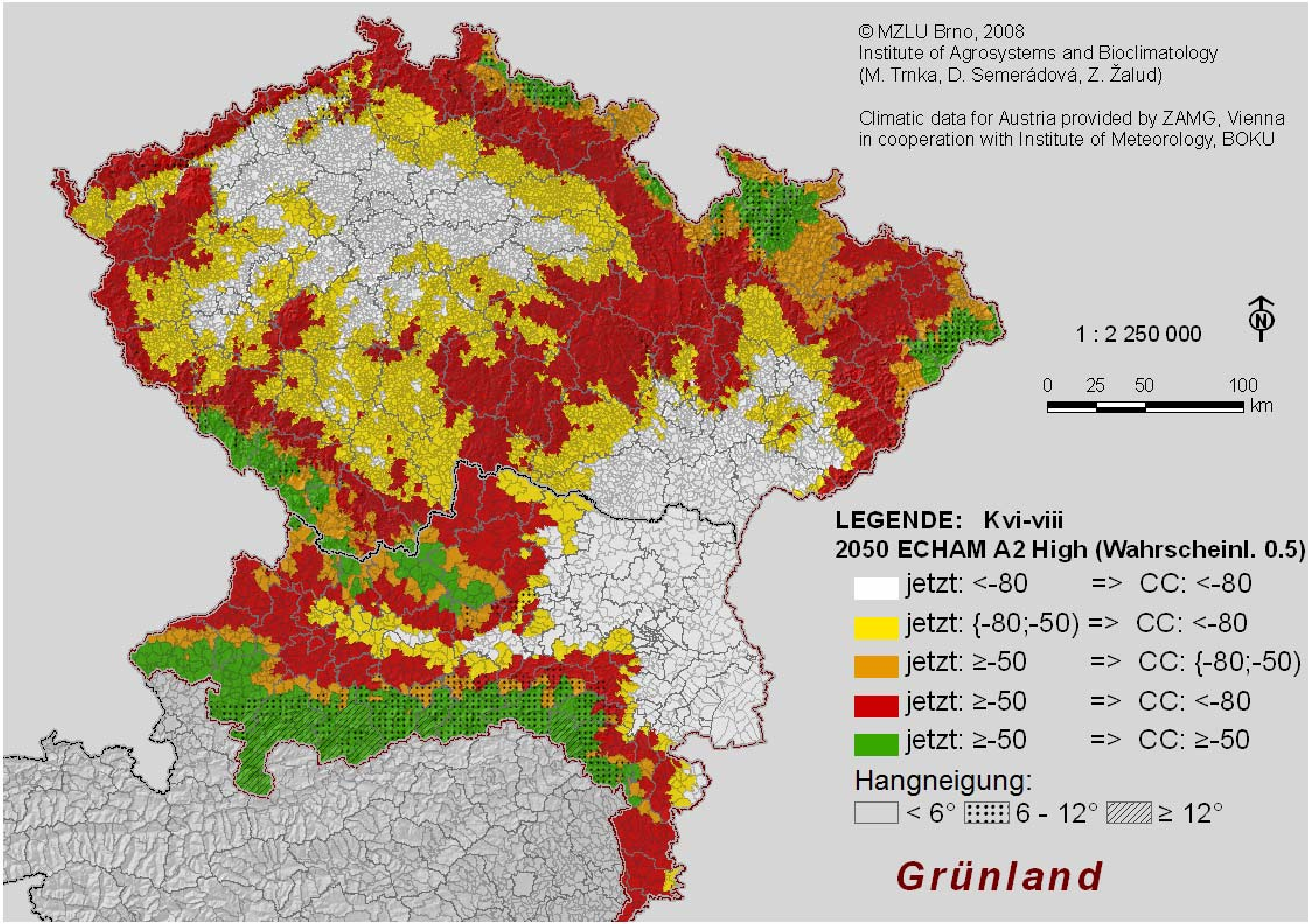




Climatic potential for wine production in Europe (Huglin Index)

(Eitzinger et al., 2009)

Change in grassland production potential

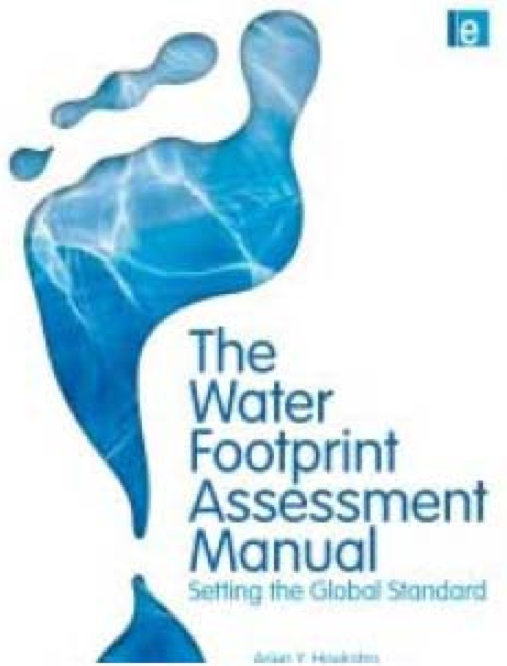


The top 100 questions of importance to the future of global agriculture

2600 Km3 globally withdrawn to irrigation: in some Countries 80% of water resources are diverted to agriculture (share variable), with increasing competition for urban and industrial usage. In some Country the importance is such that in absence great economic hardship would occur with potential for land abandonment.

Increasing demand (rising population, rising incomes, diet shifts to more water-intensive products) and uncertainties (climate).

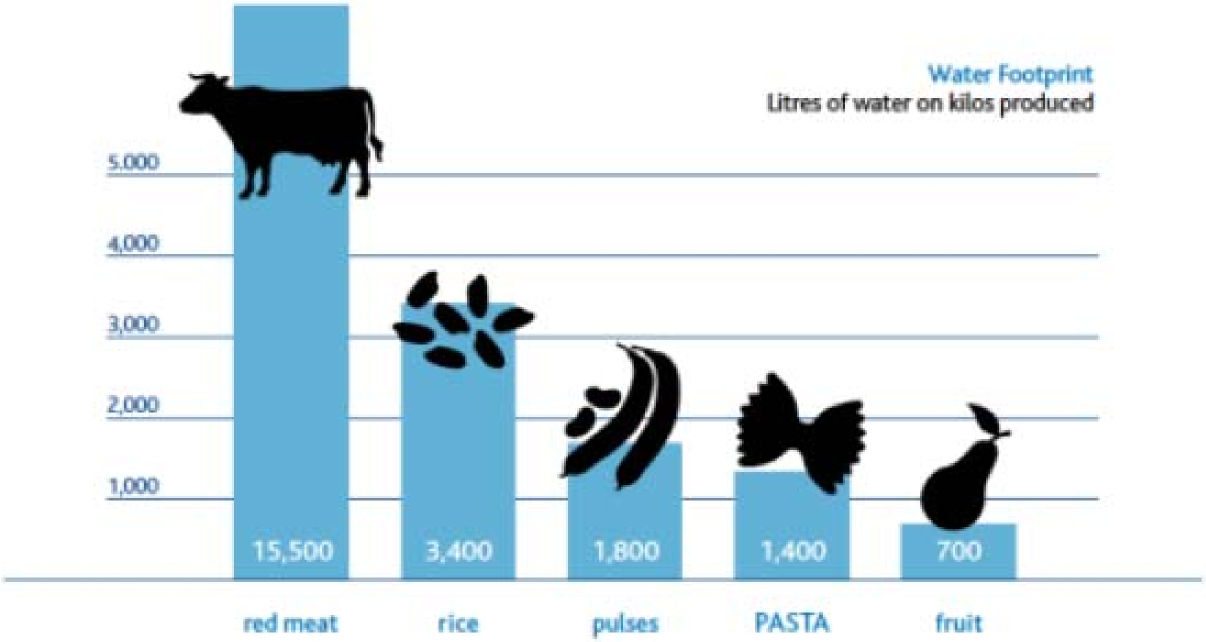
Interventions required across scales: field – communities - watershed, catchcements - river basins with focus to increase “green” and “blue” water productivity.
How to optimize the allocation (agriculture, environmental functions)?
What approaches to develop to increase water-use efficiency, and their cost-effectiveness?



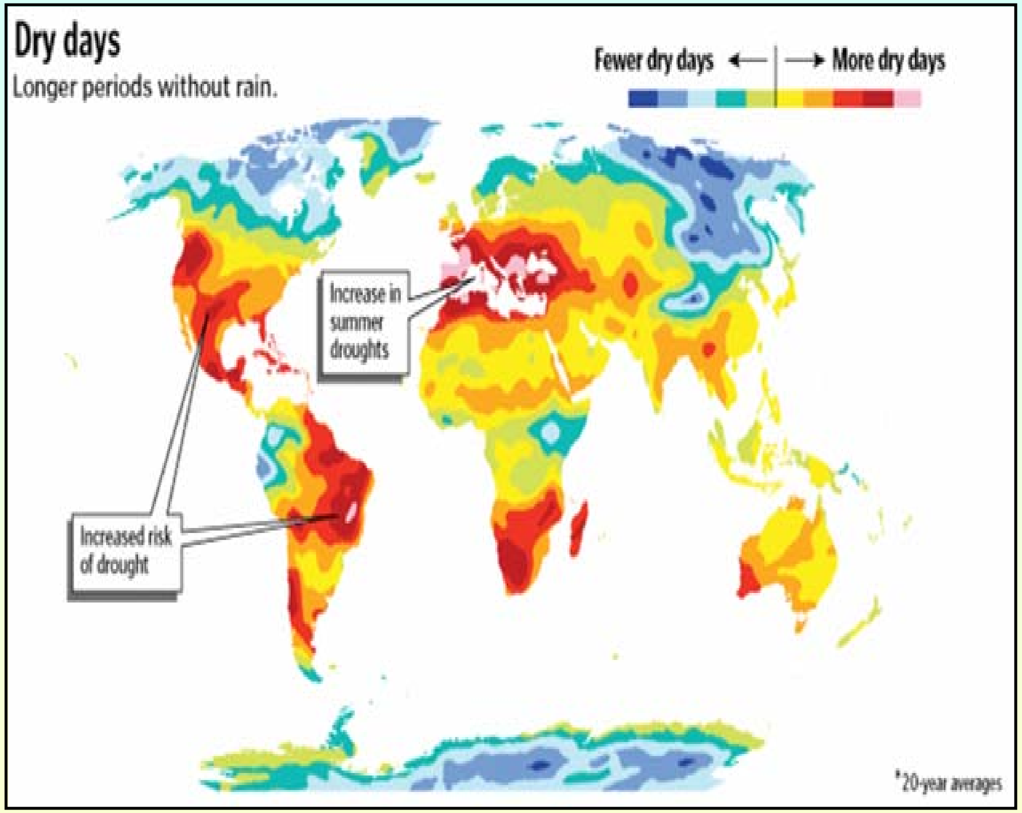
Water footprint (Mutti)

1 kg tomato: 156 l H2O

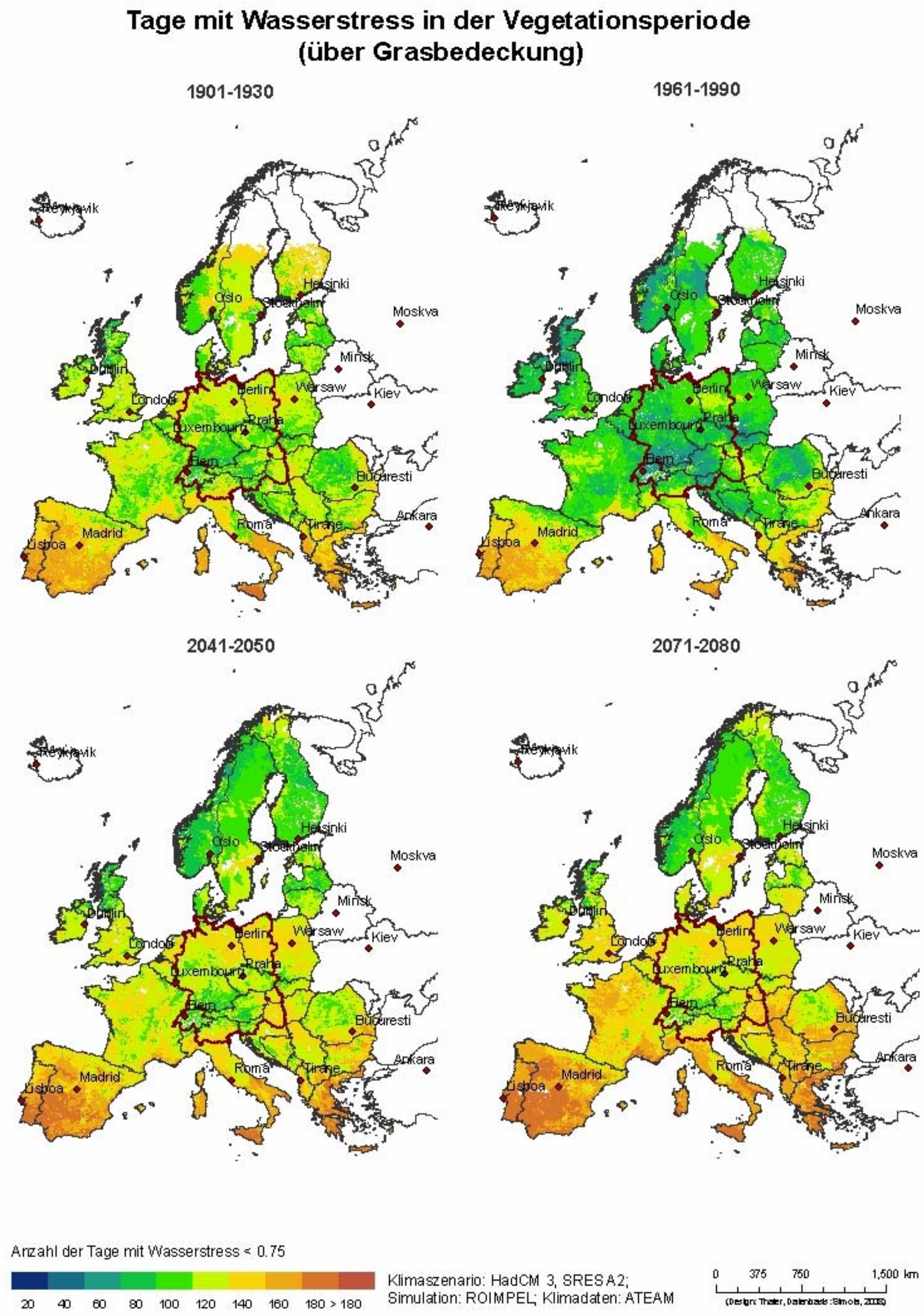
1 kg tomato souce: 557 l



Effect on rain days



- Increased drought risk
- Increased erosion risk
- Increased risk of within season drought
- Reduced growing season (too dry)
- Increased average temperatures

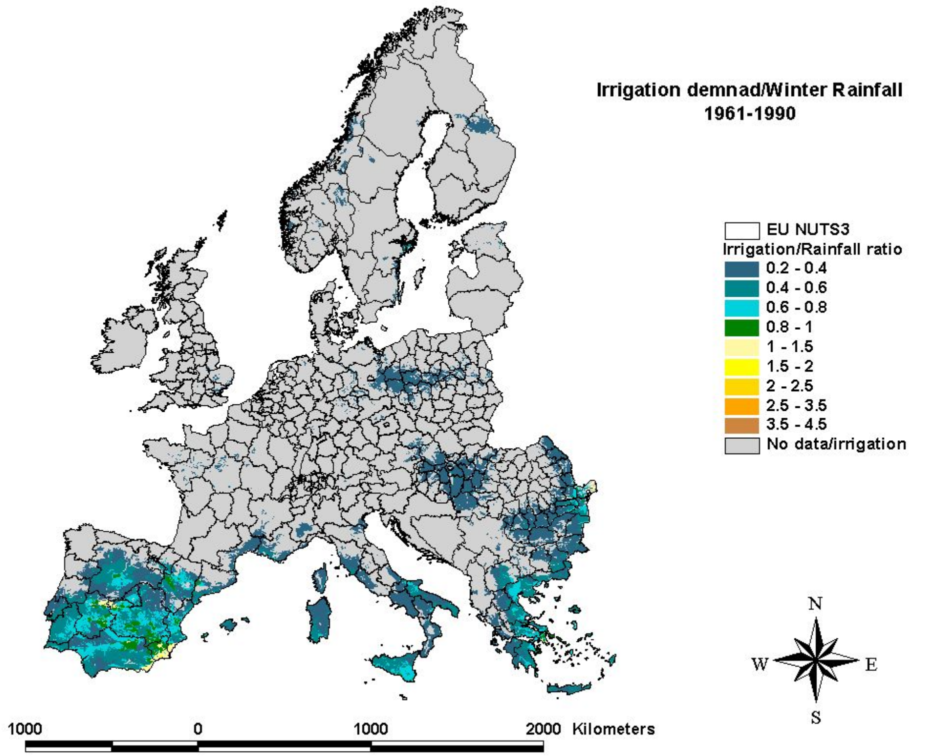


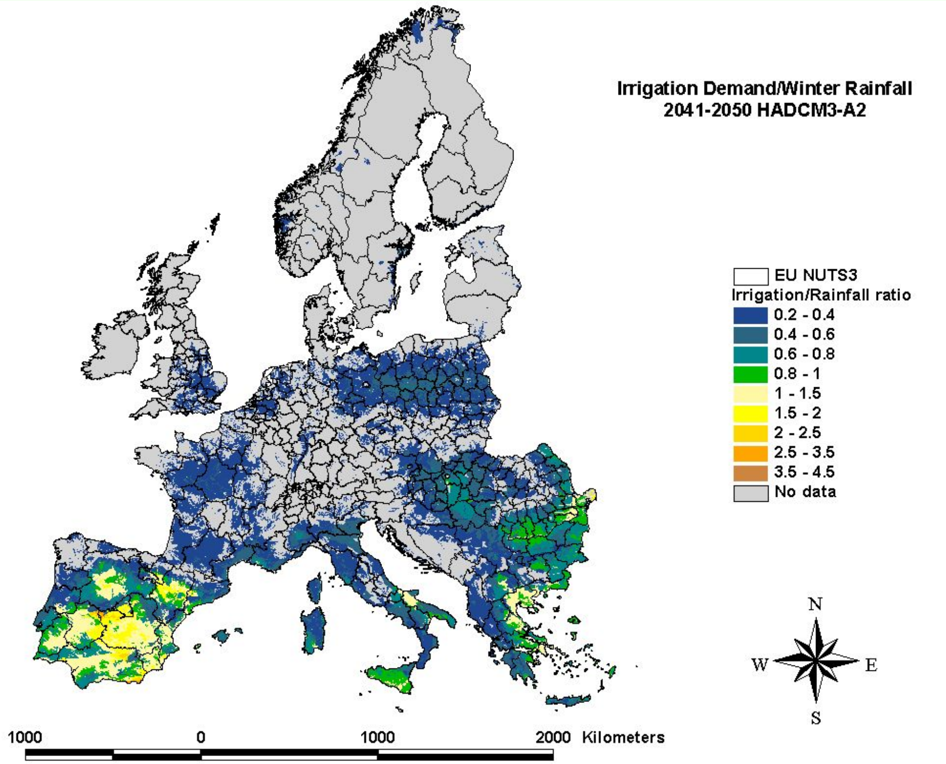
Change in days with crop water stress in summer (Mai-September)

Crop Model: ROIMPEL

Simota et al., 2008

Decreasing water availability for irrigation in Europe during winter period





Difference water demand vs. precipitation (Simota, 2009)

Water erosion

(Eitzinger et al., 2009)

Developement of pests depend on temperature (corn borer)

(Eitzinger et al., 2009)

Diseases: depend on humidity and temperature mainly

Dürrfleckenkrankheit (Alternaria) bei Kartoffel (Quelle: Glauninger)

(Eitzinger et al., 2009)

Weeds : Example Ambrosia

(Eitzinger et al., 2009)

The top 100 questions of importance to the future of global agriculture

Markets and consumption: food supply chain, food standards, LCA, energy, C footprint, environmental impact.

As energy prices rise, how can agriculture increase its efficiency and use fewer inputs to become economically sustainable and environmentally sensitive, yet still feed a growing population?

Agricultural development: networking, solidarity, reciprocity and exchange, farmer participation in technological development.

Farmers involvement enables novel technologies and practices to be learned directly, adopted and adapted. Agricultural, Weather, Climate, Water Sevices services are vital elements to address needs and provide support and critical advises.

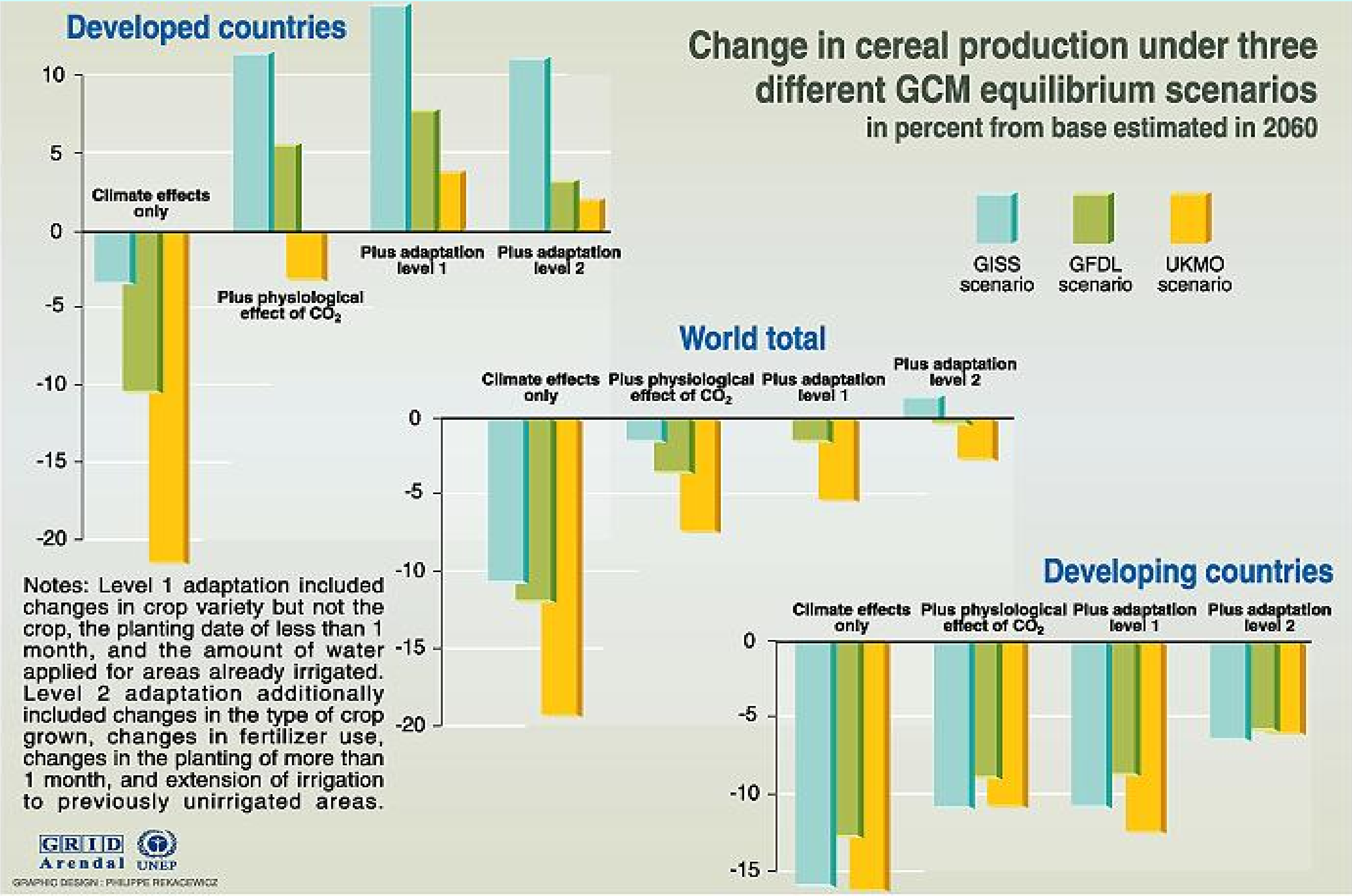
Main classes of adaptation (short and long term)

- seasonal changes and sowing dates;
- different variety or species;
- water supply and irrigation system;
- other inputs (fertilizer, tillage methods, grain drying, other field operations);
- new crop varieties;
- forest fire management, promotion of agroforestry, adaptive management with suitable species and silvicultural practices (FAO, 2005).

Accordingly, types of responses include (*ibid*., p. 770-771):

- reduction of food security risk;
- identifying present vulnerabilities;
- adjusting agricultural research priorities;
- protecting genetic resources and intellectual property rights;
- strengthening agricultural extension and communication systems;
- adjustment in commodity and trade policy;
- increased training and education;
- identification and promotion of (micro-) climatic benefits and environmental services of trees and forests (FAO, 2005).

FAO, 2007



Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Low input system solutions (dominating in developing countries)

- **Including knowledge on adapted traditional (indigenous) techniques or methods**
- **New low cost "high technology" (e.g. pumps, sensors, ...)**
- **Interactions with structural changes : Increase farm production flexibility (mixed farming, agroforestry, Increase of institutional support (micro insurances, ...)**

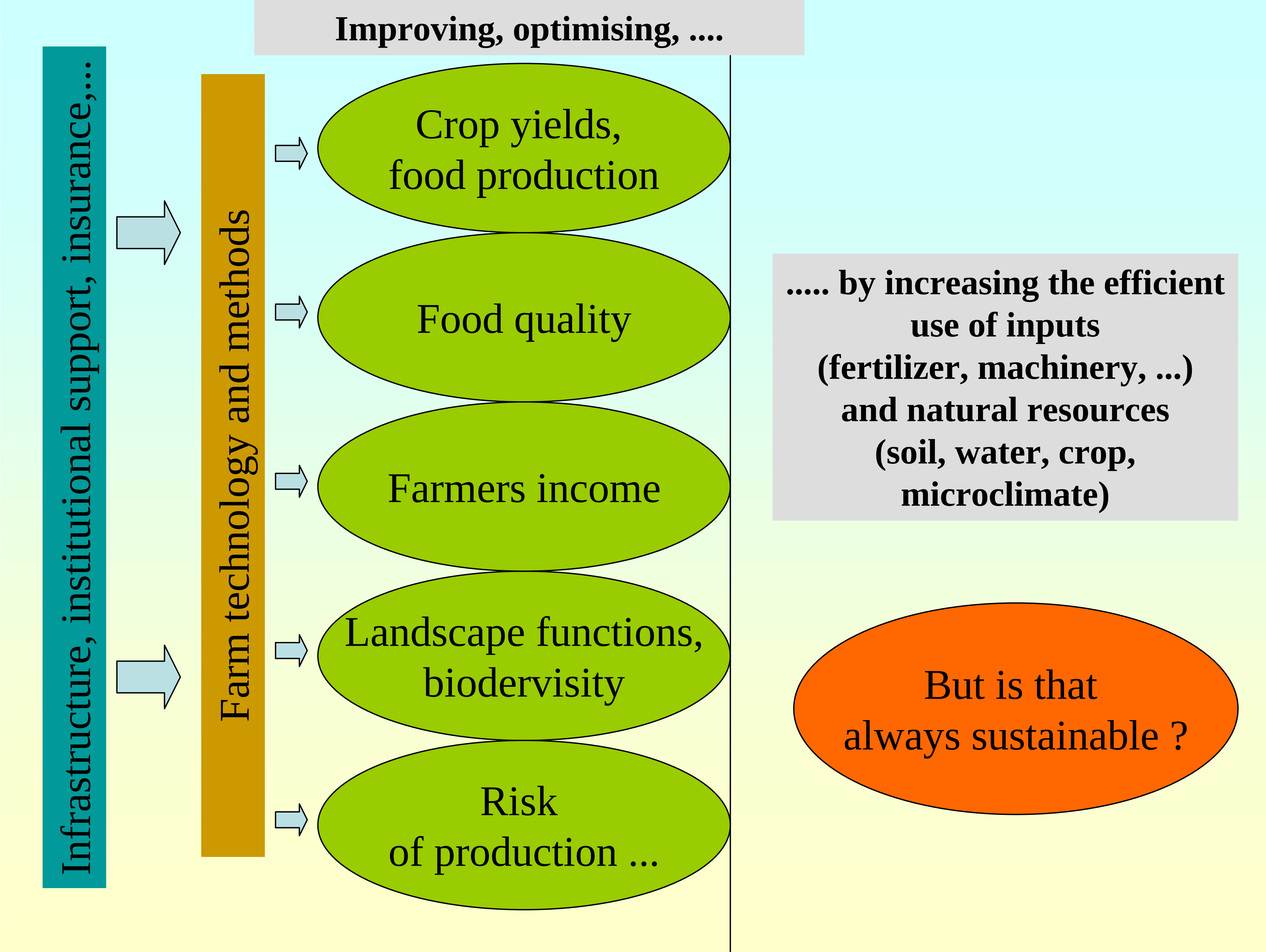
PHOTO 80
A woman fertilizing a crop field with great care and precision (Kenya)

A simple pump, powered by one person, can irrigate acres of land easily. These pumps, produced by Approtec, are inexpensive and efficient.

Expected adaptation levels

In the light of expected impacts, which are the best hypotesis of changes in management ?

	MDS	MDN	ALS	CON	BOR		ATC	ATN
Timing of field operations	1	2	1.5	1.4	3		1	0.9
Changed cultural practices	1	2	1.75	1.3	3		1	0.9
Changed fertilisation	1	1	1.75	1.5	2		1	1.5
Changed crop protection	2	2	1.25	1.7	3		1	1.4
Cultivars adapted to warmer and drier	1.5	0.5	2.5	2.2	2		1	1.0
Soil water saving technologies	3	2	1.5	2	1		1	0.5
Soil erosion and fertility protection	1	2	1.5	1.4	2		1	0.9
Monitoring drought, pests and diseases	3	3	2.5	2.2	3		1	1.0
Use of seasonal weather forecasts	3	3	2	1.75	3		2	
Crop insurance	0	0	1.75	1.9			1	
New (warm season) crops	2	2	2	2.2	2			3.0
Crop rotations for better water use	2	2	2.5	1.9	1			1.0
Crop rotations for better nutrient use	1	1	2.5	2.1	2			2.0
Expansion of irrigation systems	3	2	2	1.8	3			0.0
Improvement of irrigation systems	3	3	2	1.5	3			0.0
Regulation of water rights for irrigation	3	3	2	1.8				0.0
Microclimate modification	3	3		1.5				0.0
Landscape changes			1	1.6	1			2.0
Revised environmental regulations			2	2	3			2.0
Revised subsidy schemes	0	0	2	2	0			


Improving, optimising, ...
Infrastructure, institutional support, insurance,...
Farm technology and methods
Crop yields, food production
Food quality
Farmers income
Landscape functions, biodervisity
Risk of production ...
..... by increasing the efficient use of inputs (fertilizer, machinery, ...) and natural resources (soil, water, crop, microclimate)
But is that always sustainable ?

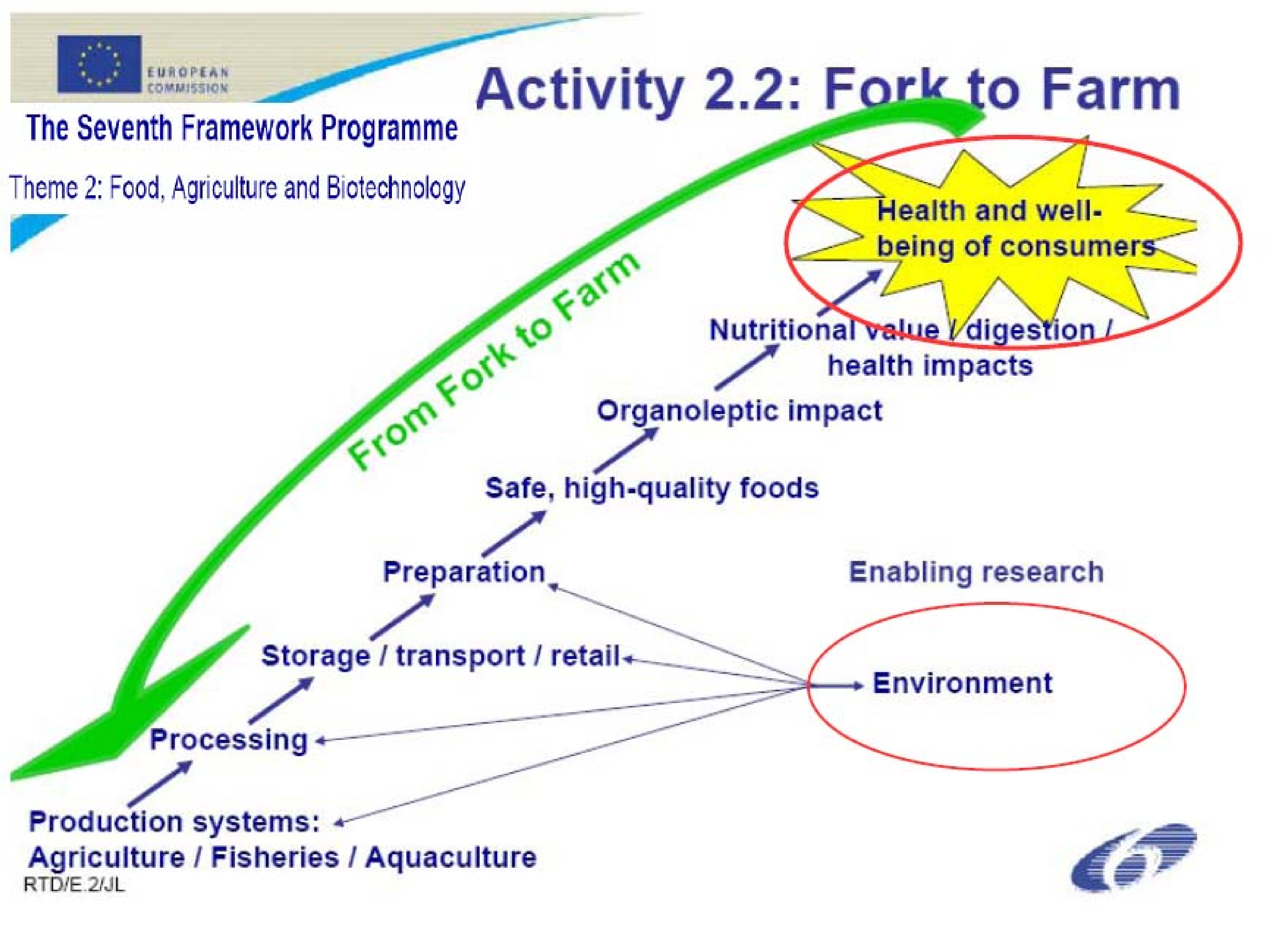
Challenges for operational agrometeorological application and future research

• Monitoring activities:
Real time and forecasts (drought, extreme weather etc.)

• Decision Support Systems:
Application and user oriented, economic, short and long term focus

• Climate Mapping:
High spatial resolution, considering climate change and crop specific aspects

• Improving and combining the tools:
Remote Sensing, GIS, agrometeorological , crop and irrigation models, measurement systems, data transfer and processing etc.

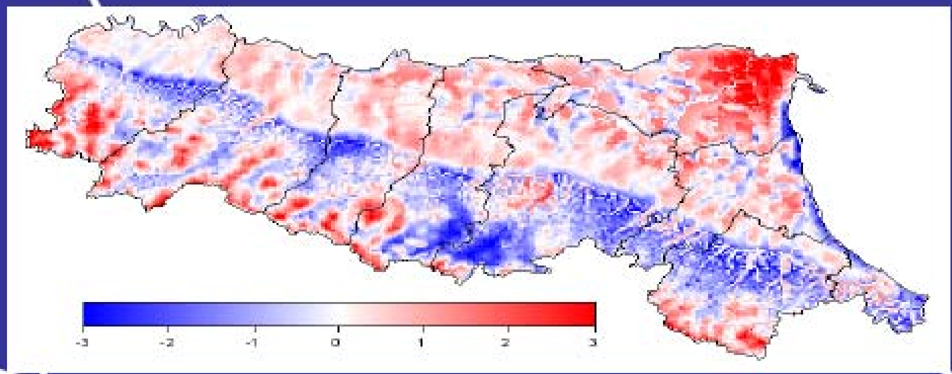

EUROPEAN COMMISSION
The Seventh Framework Programme
Theme 2: Food, Agriculture and Biotechnology
Activity 2.2: Fork to Farm
From Fork to Farm
Health and well-being of consumers
Nutritional value / digestion / health impacts
Organoleptic impact
Safe, high-quality foods
Preparation
Enabling research
Storage / transport / retail
Environment
Processing
Production systems: Agriculture / Fisheries / Aquaculture
RTD/E.2/JL

WHY DSS??

Awareness of the risk

Passive protection

Selection of low-risk sites !!!!



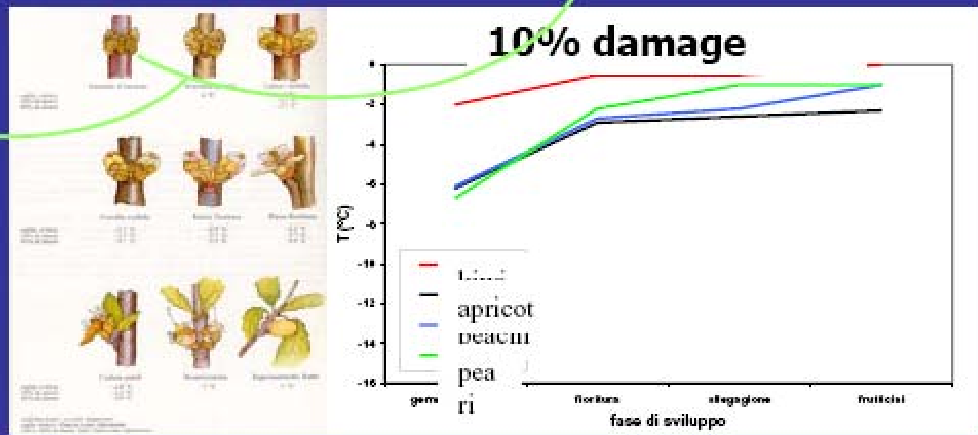
Crop selection

WHY FARMERS NEED PREVISIONS ?

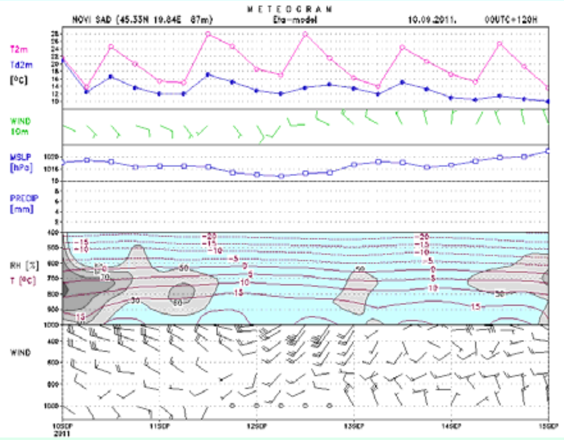
Awareness of the risk

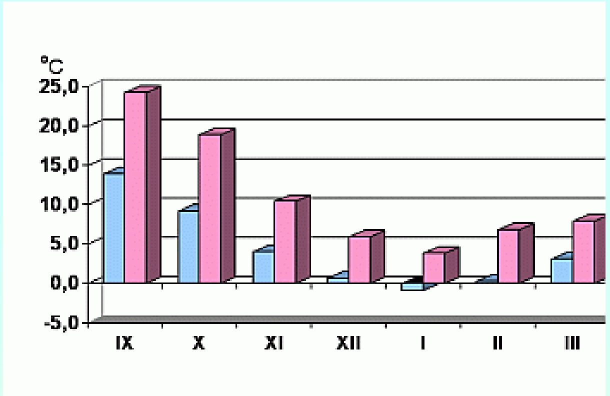
Active protection

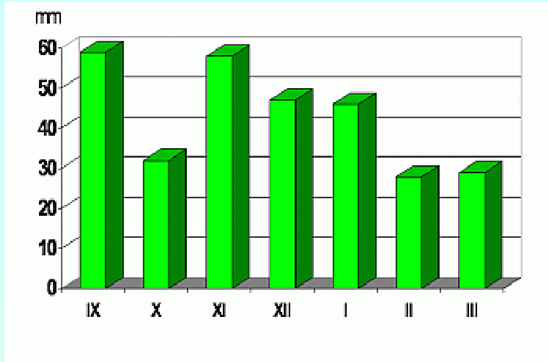
What a probability for a frost tonight? Can the thermal levels predicted compromize my crops at this stage ? Shall I activate my protection devices? What the ratio cost sustained/cost of the possible damage?

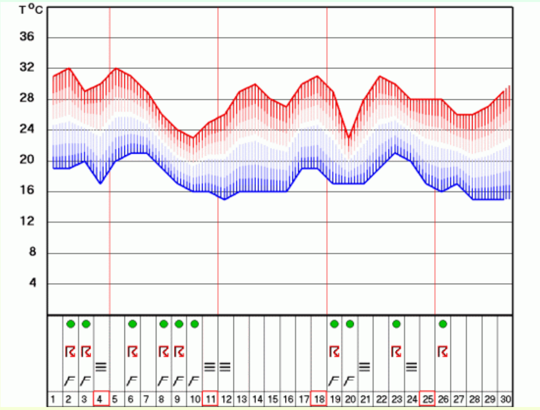


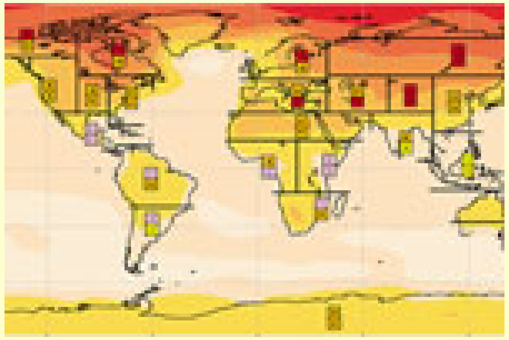
Source: Republic Hydrometeorological Service of Serbia











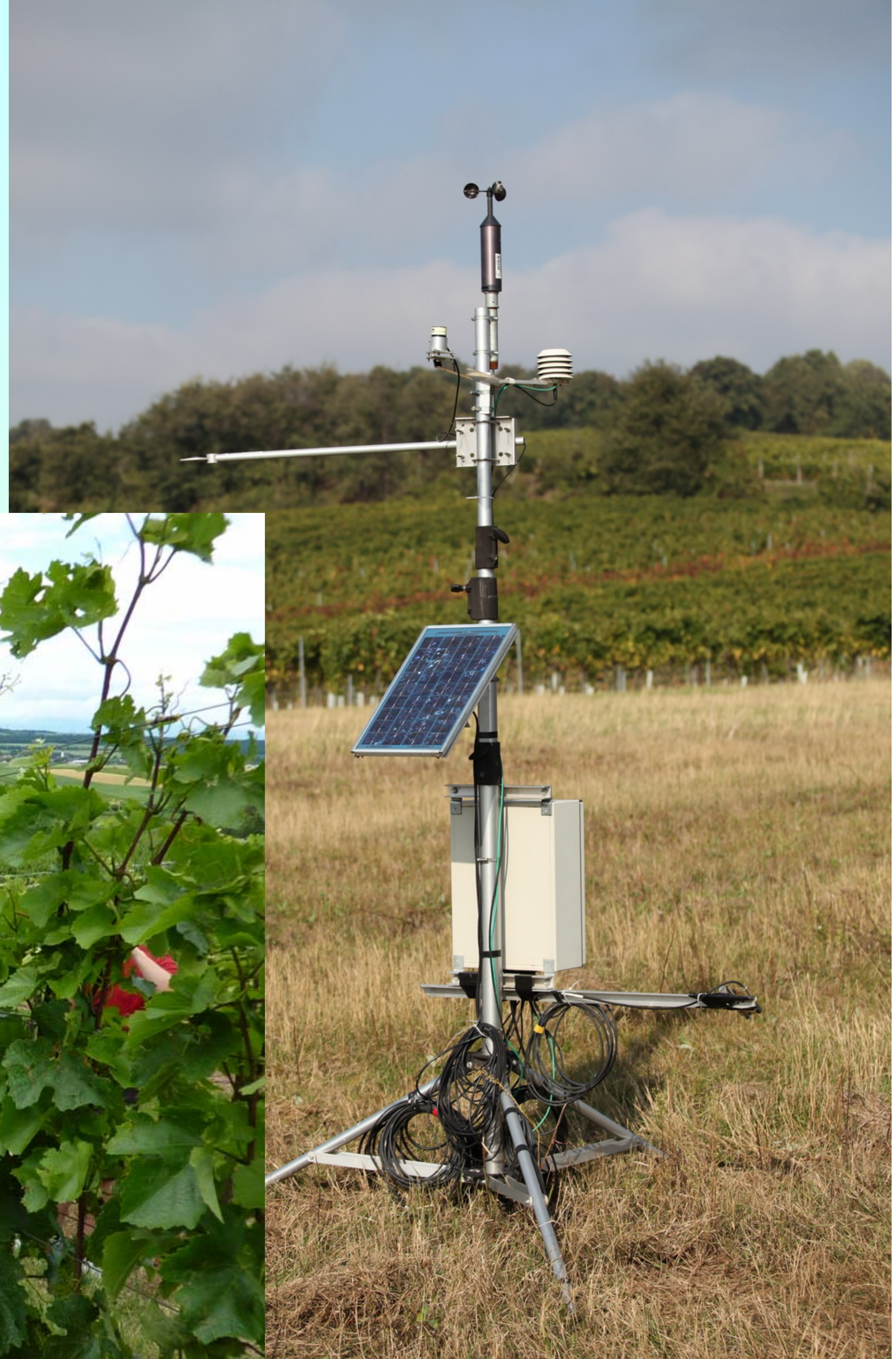
NWP products of interest in agrometeorology

- Short-range weather forecast (out to 5 days)
- Medium-range weather forecast (out to 15 days)
- Monthly forecast (10 to 30 days)
- Seasonal forecast (out to 7 months)
- Climate model simulations (decades)

Frost Advisory

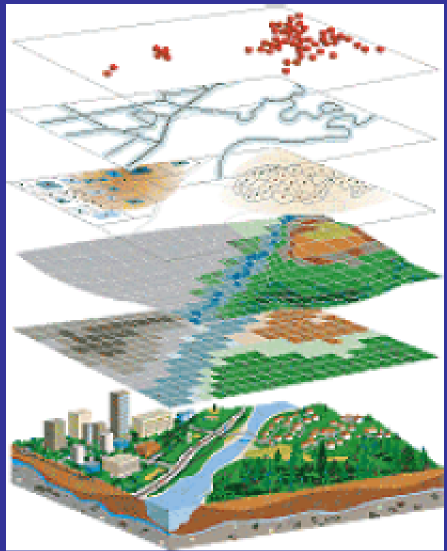
- Forecast of night temperatures depending on foreseen weather conditions and on temperature at sunset. At 10.00 and 01.00 forecasted temperatures and measured temperatures are checked.
- In case of temperatures below 0 °C, a SMS is sent to all registered users

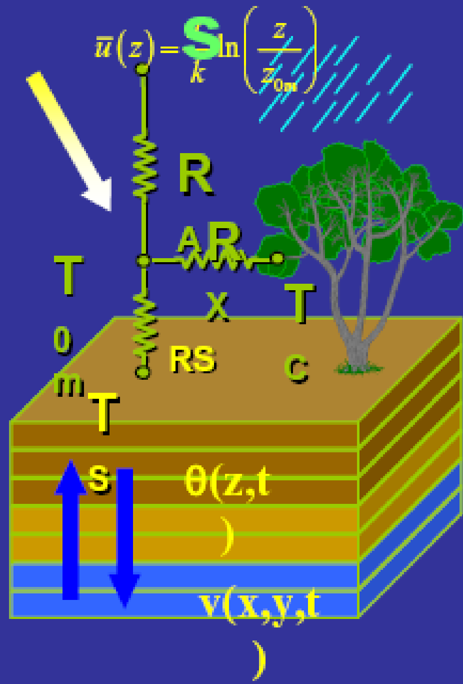
On site measurements are crucial for many agrometeorological applications (e.g. crop protection)



Meteorology-agrometeorology-earth observations

GIS + **Earth observation** + **model**



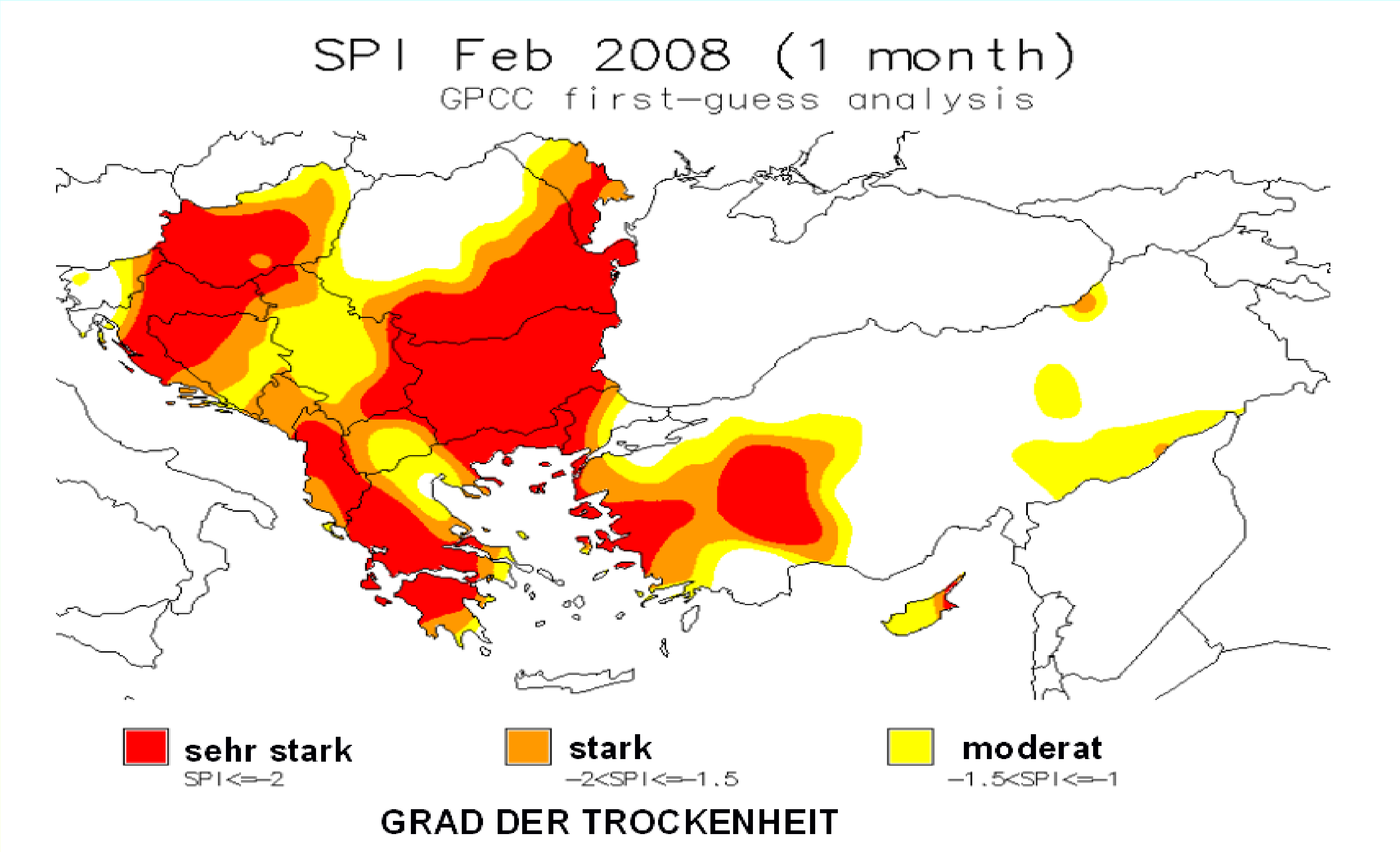


Support GAPs

To improve production (yield, quality)

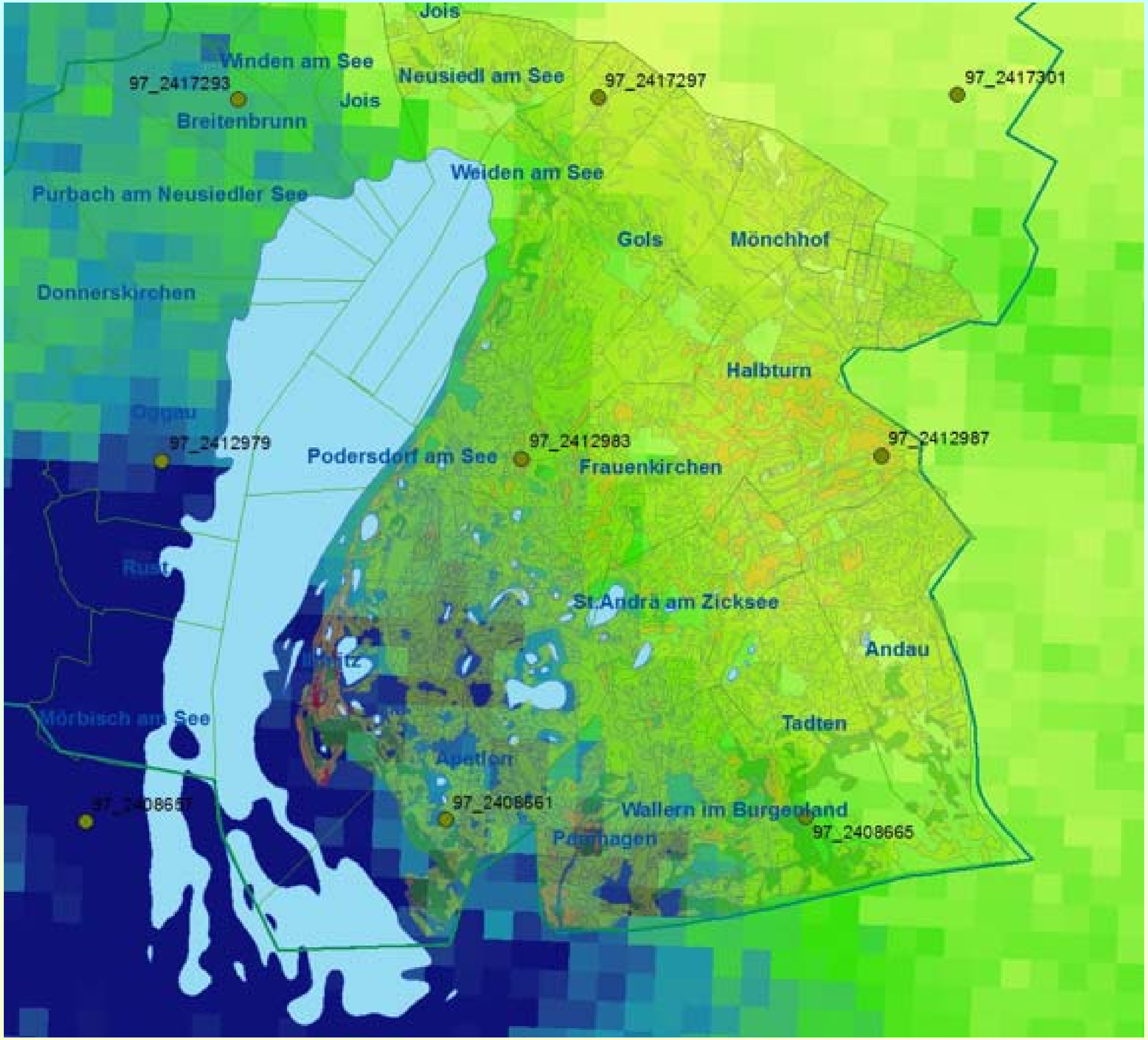
To reduce risks and impacts, to ensure stability and safety

To improve multifunctionality and agro-ecosystem services



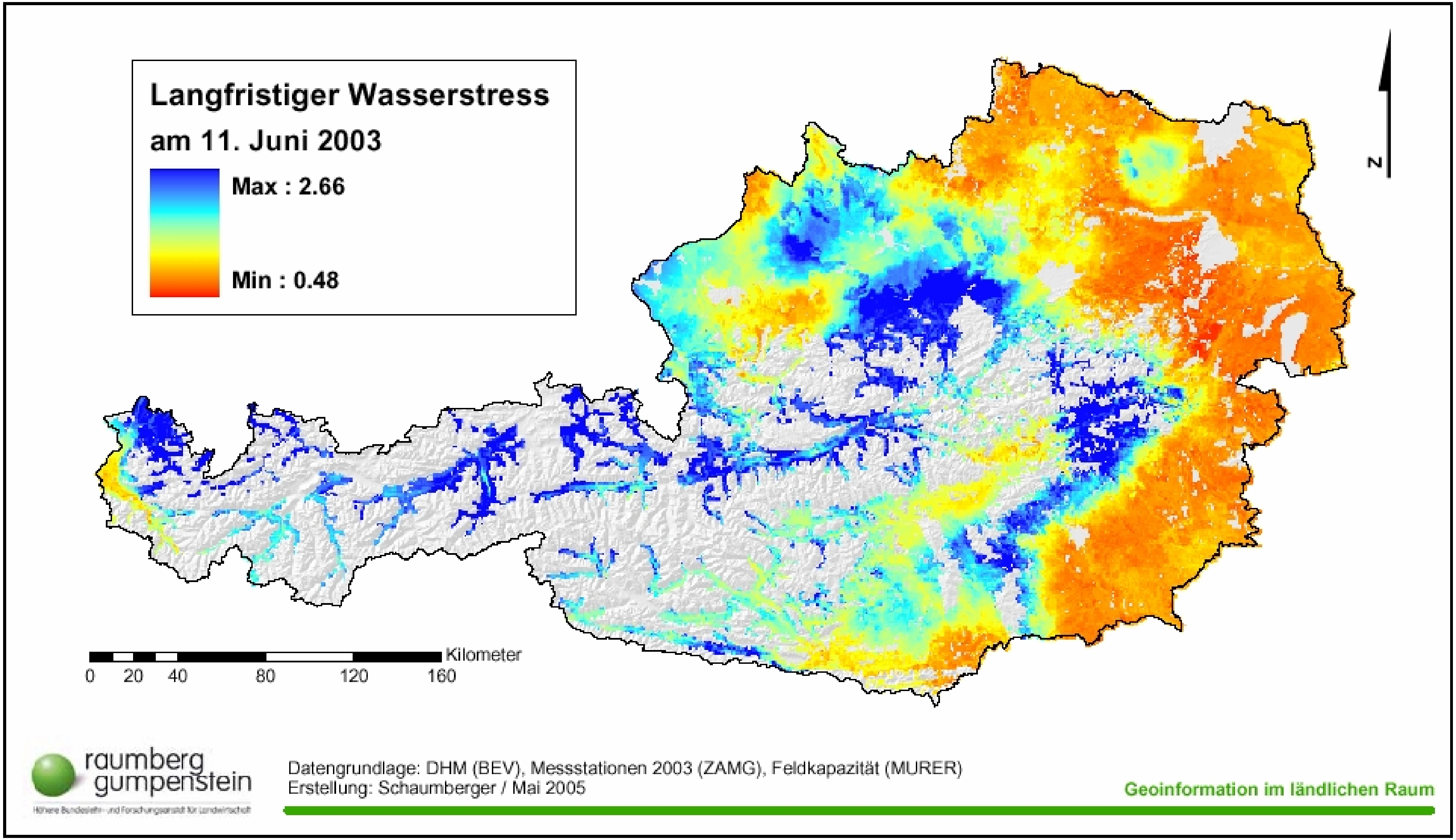
Drought monitoring

(Source: Susnik, Drought Management Center for South eastern Europe (DMCSEE); www.dmcsee.org)



Combination of spatial data bases: High resolution water balance

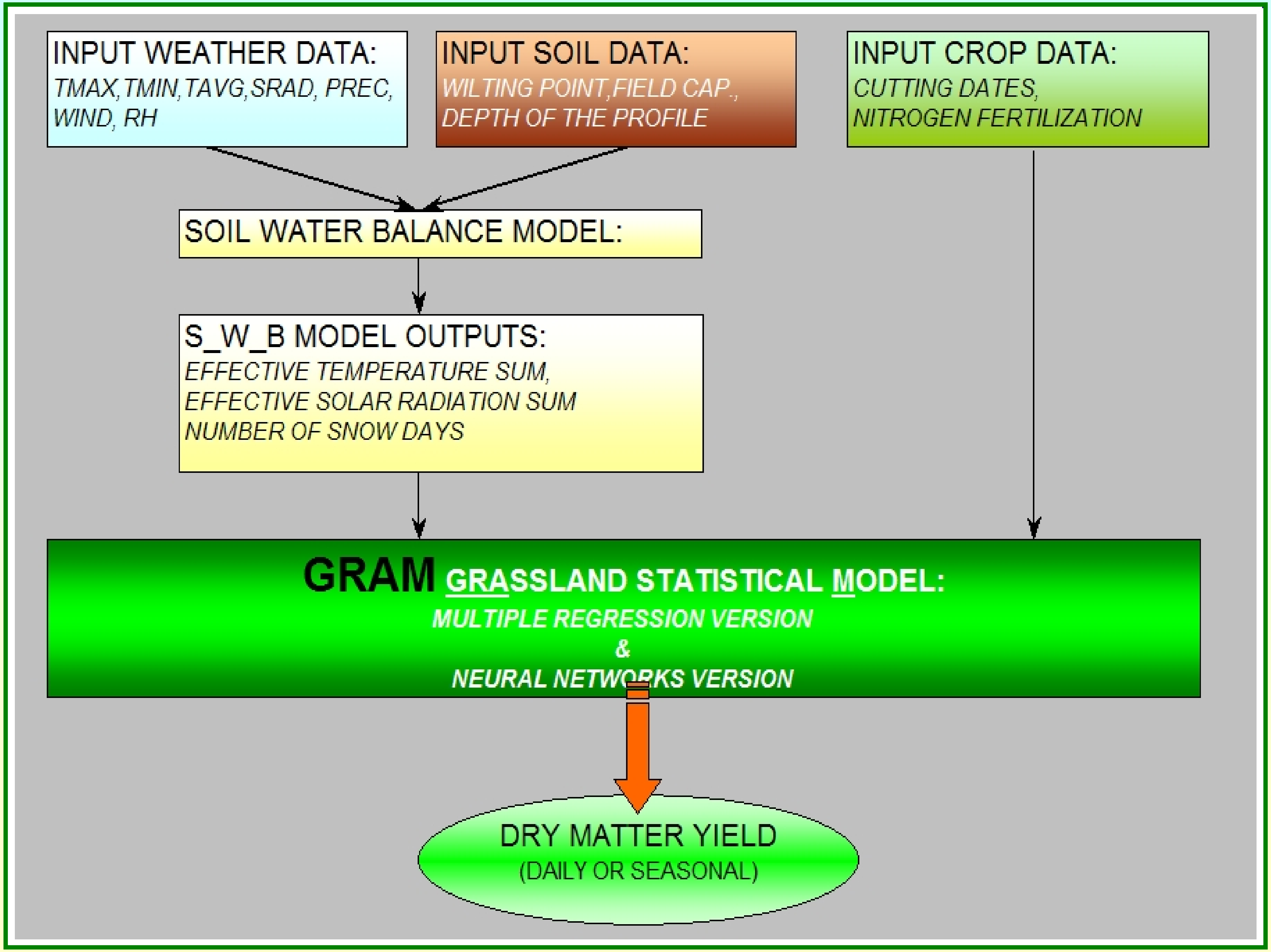
Example: Surface Soil Moisture ASCAT Scatterometer 500m
Vs. Soil map



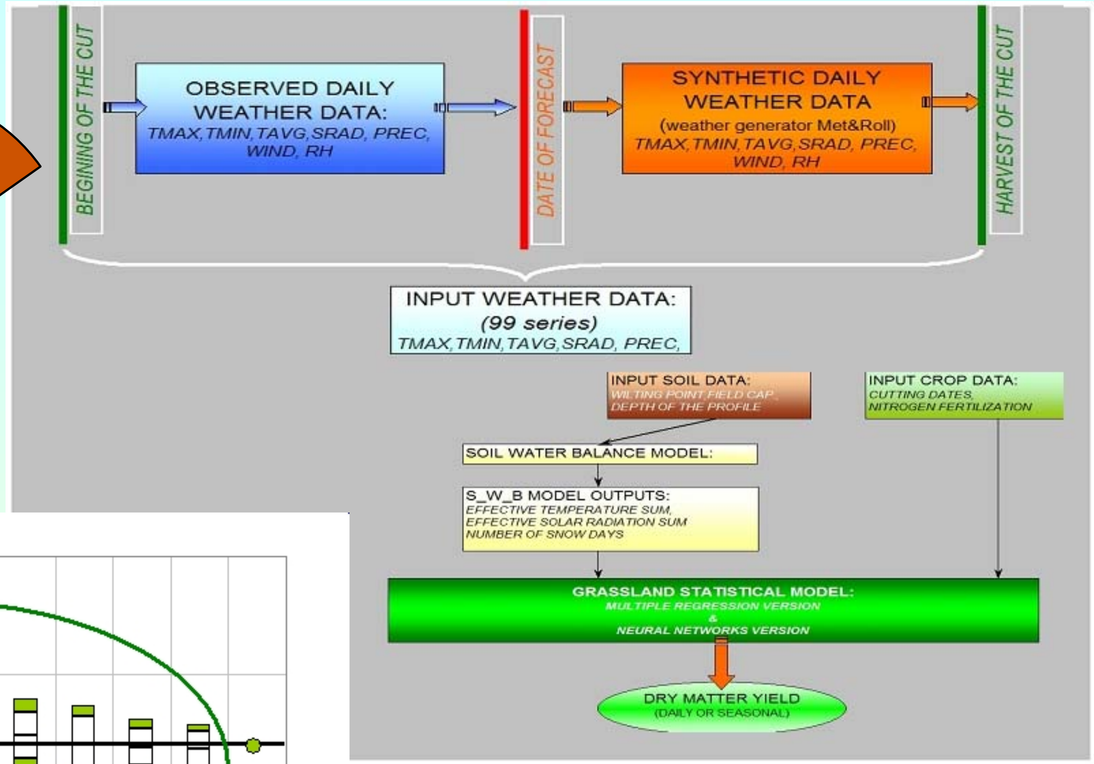
Spatial data into GIS based agrometeorolgical/crop models:
Long term water stress factor of grassland June 11 2003

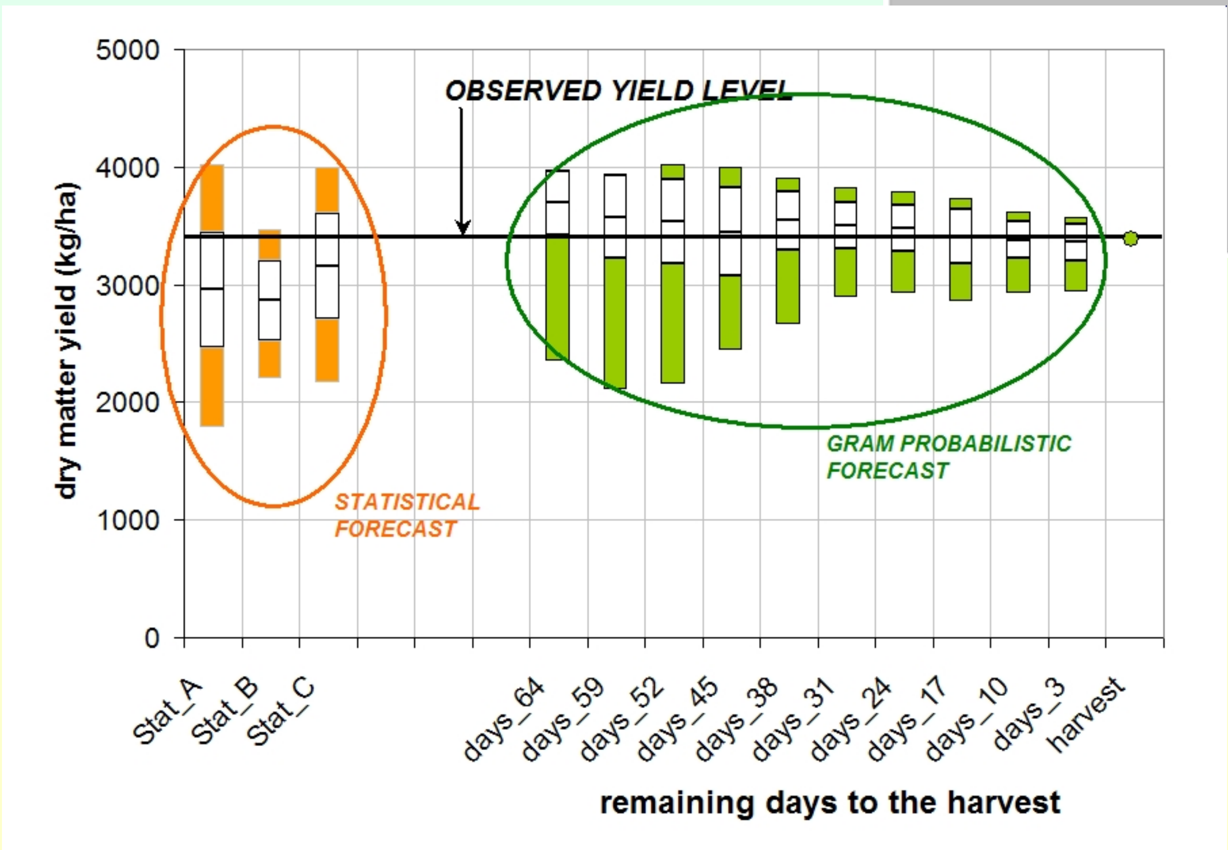
The grassland yield model concept

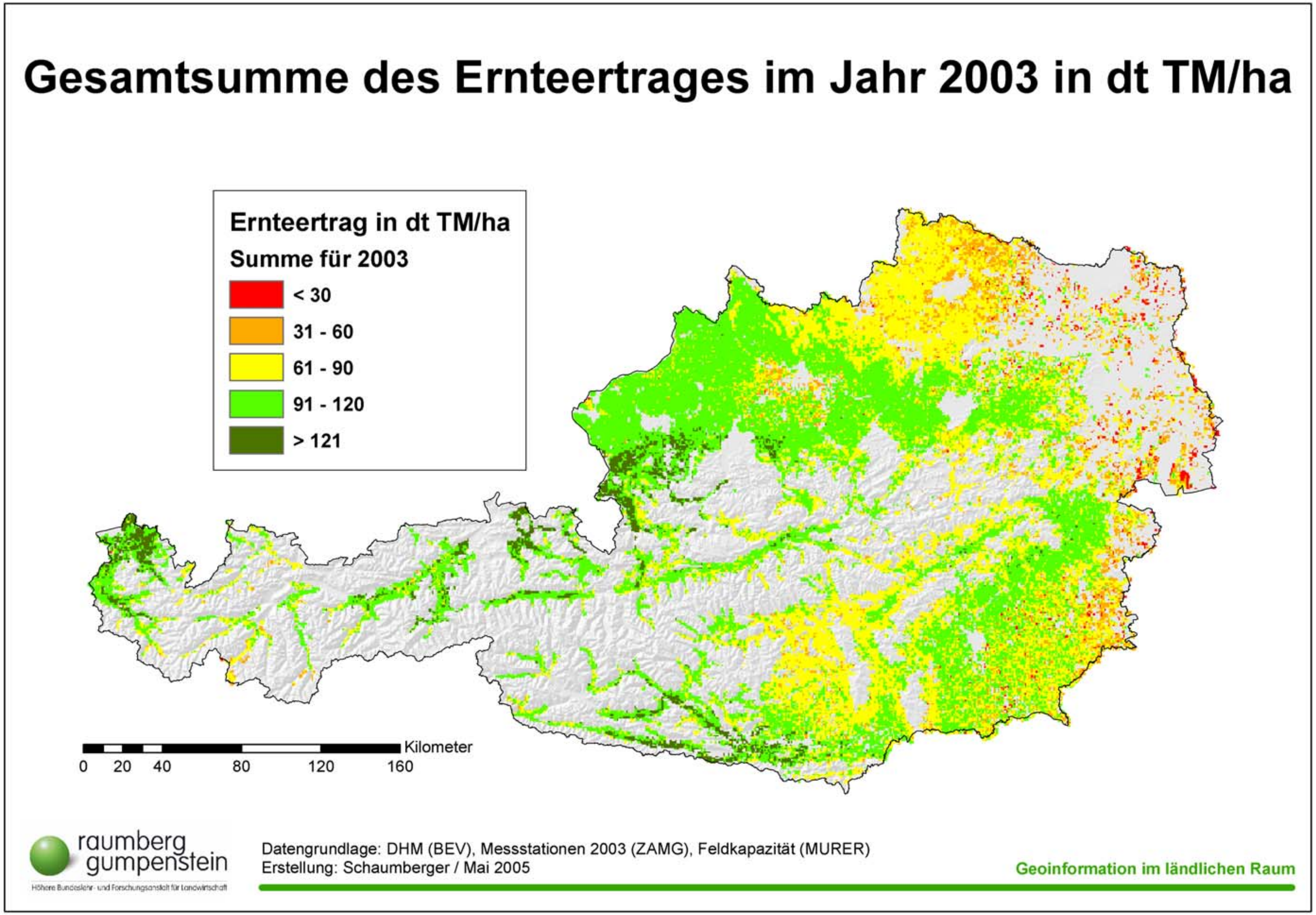
M. Trnka, J. Eitzinger



Outlook :Using GRAM for grassland yield forecasting



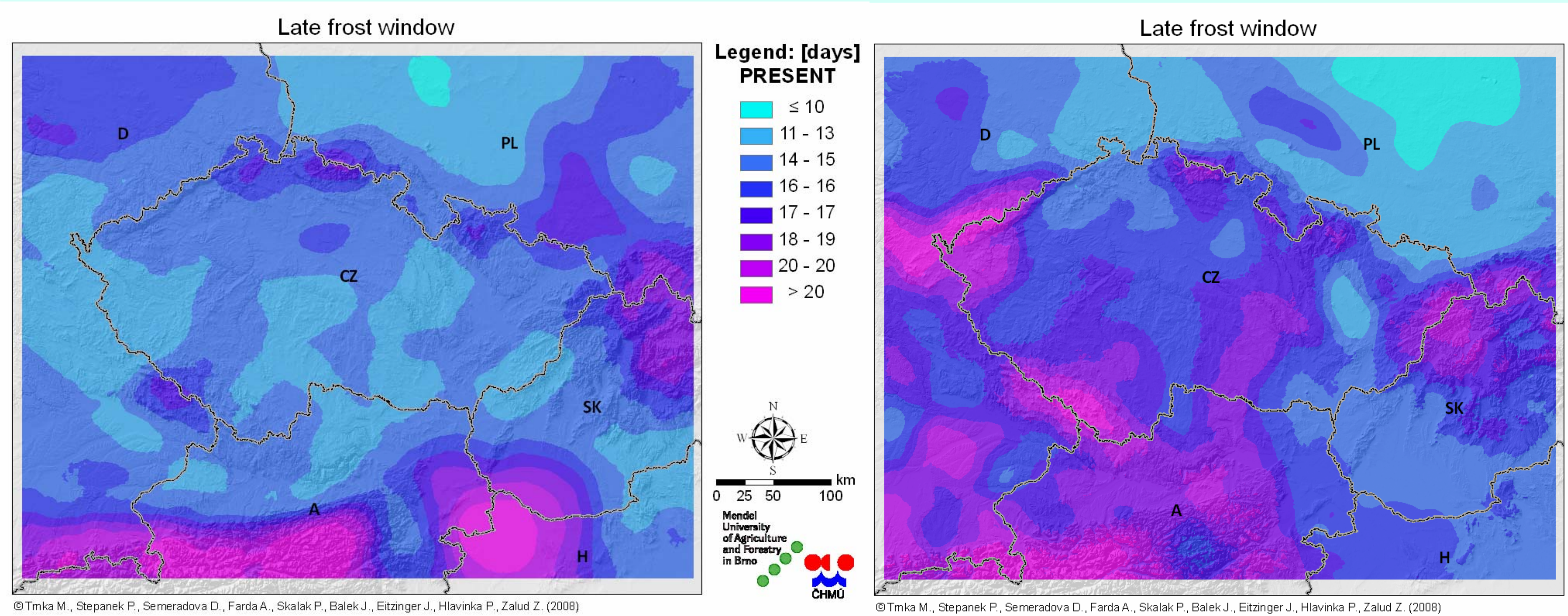




Simulated drought damage in Austrian grasslands (Source: Schaumberger)

Difference between date of the last frost with the return probability 2 and 20 years

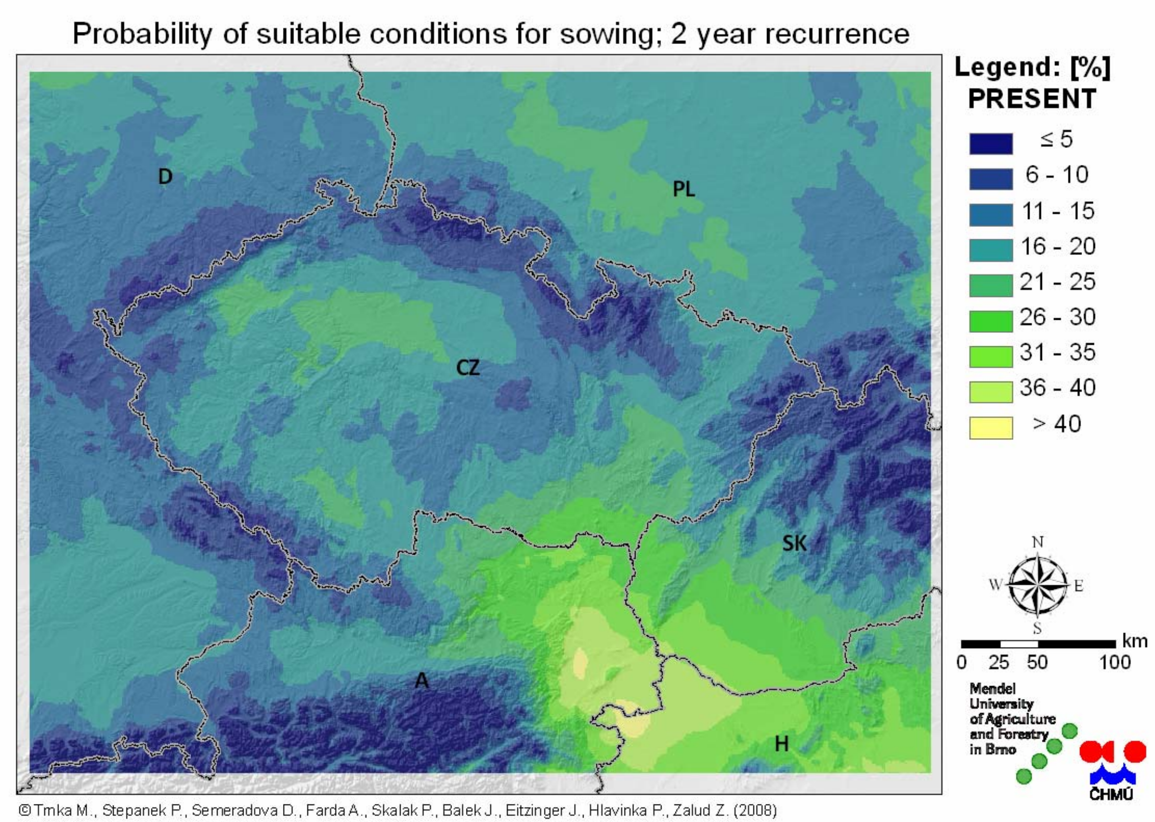
RCM - Frost risk (Agriclim)

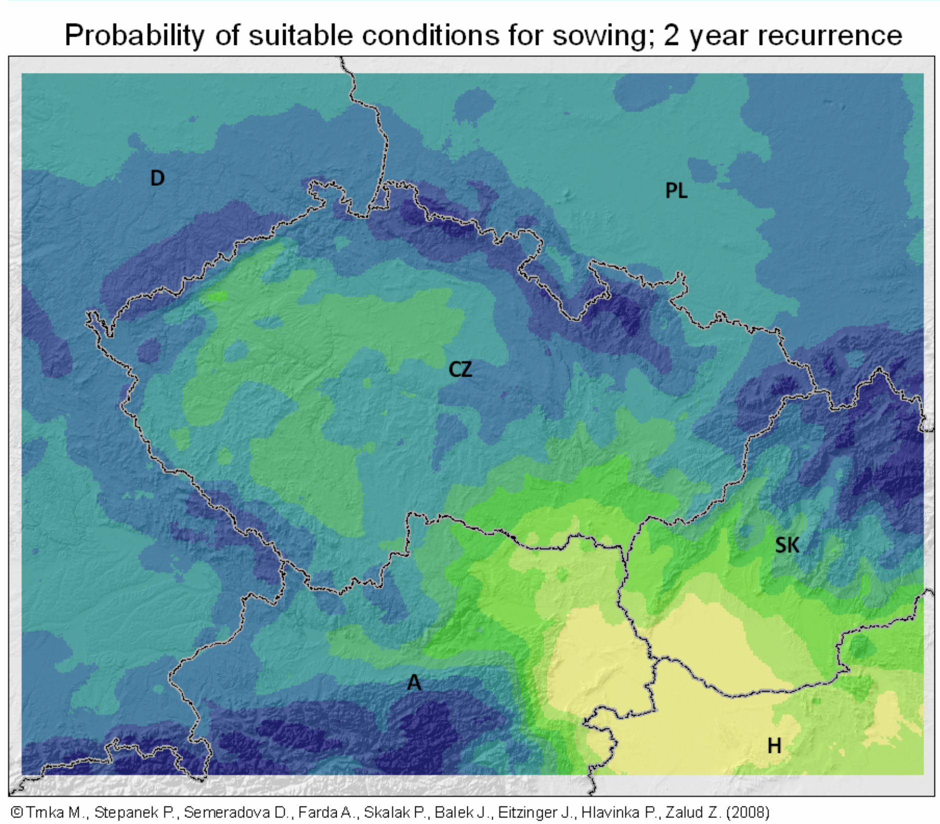


Median = 14 days
Min = 6 days
Max = 38 days

Median = 16 days
Min = 7 days
Max = 33 days

RCM - Sowing conditons (early spring)

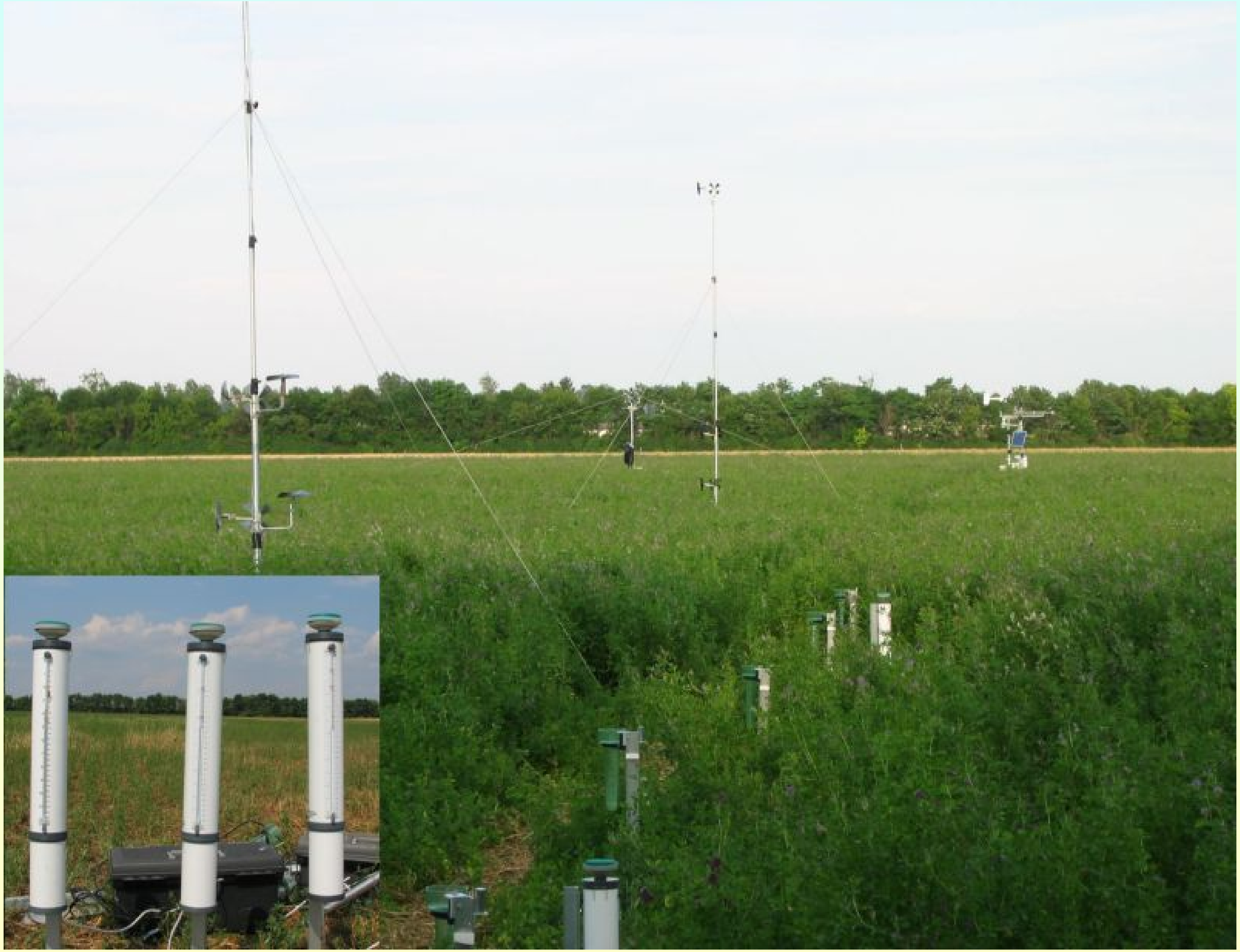




Median = 16%
Min = 0%
Max = 53%

Median = 16%
Min = 0%
Max = 60%

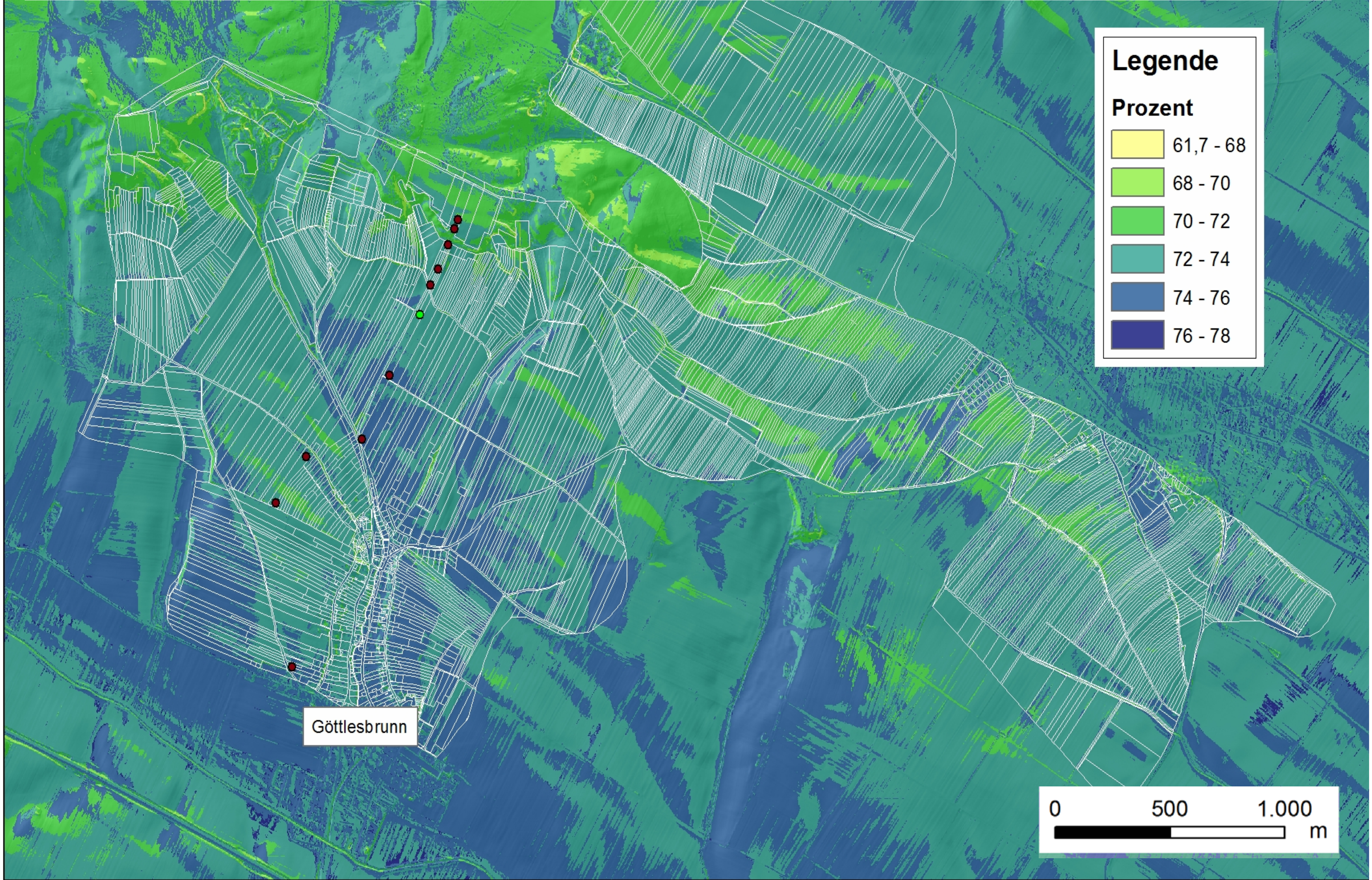
Importance of ground truth data: Transect measurements for high resolution spatial climate mapping



ETgages:

placed in 20m and 80 m distance from the hedgerow (lee side)

Wineyard conditions (climatic terroir): Daily air humidity in June at 0.5 m (mean 1990-2009)

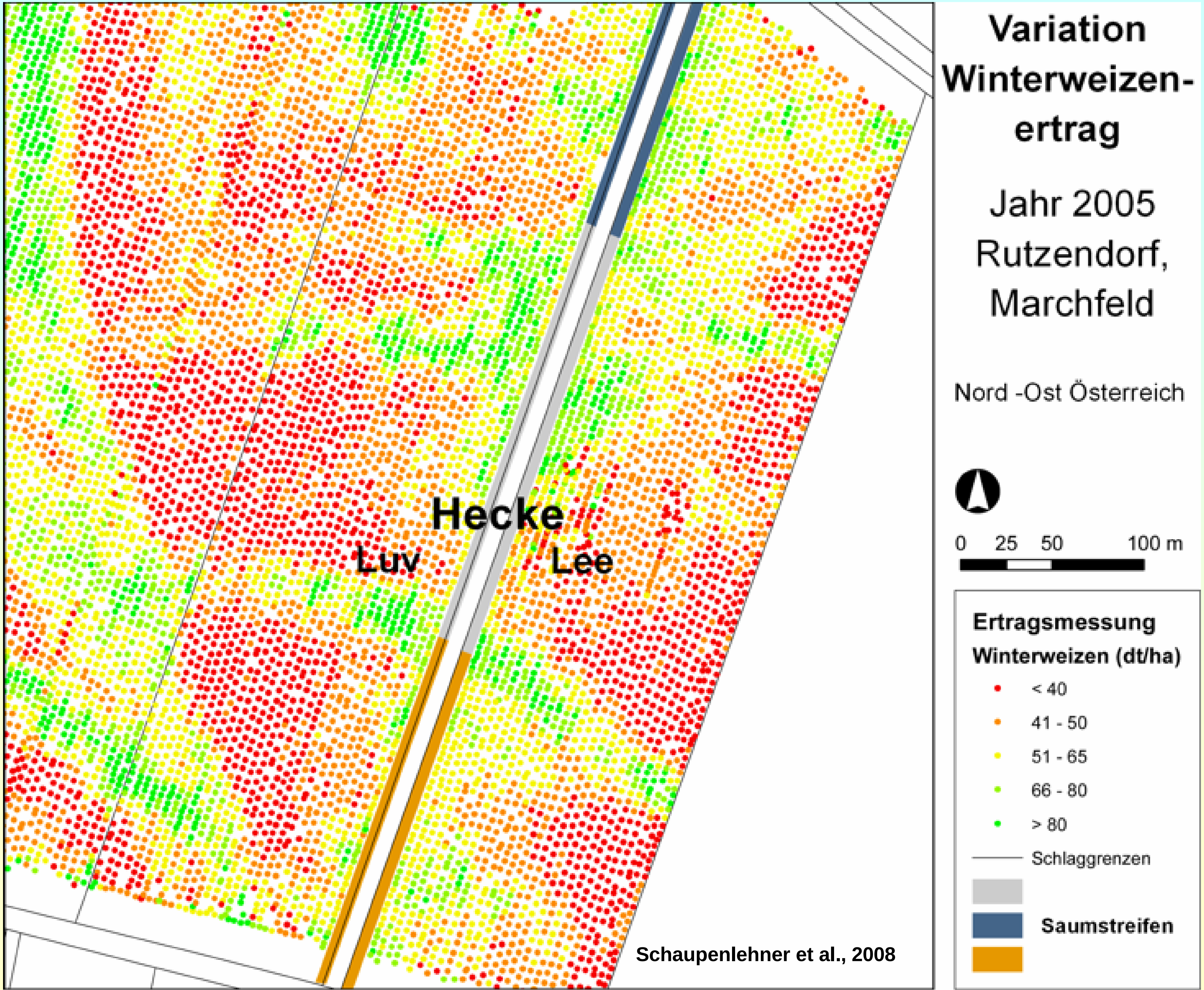


Remote Sensing Methods:

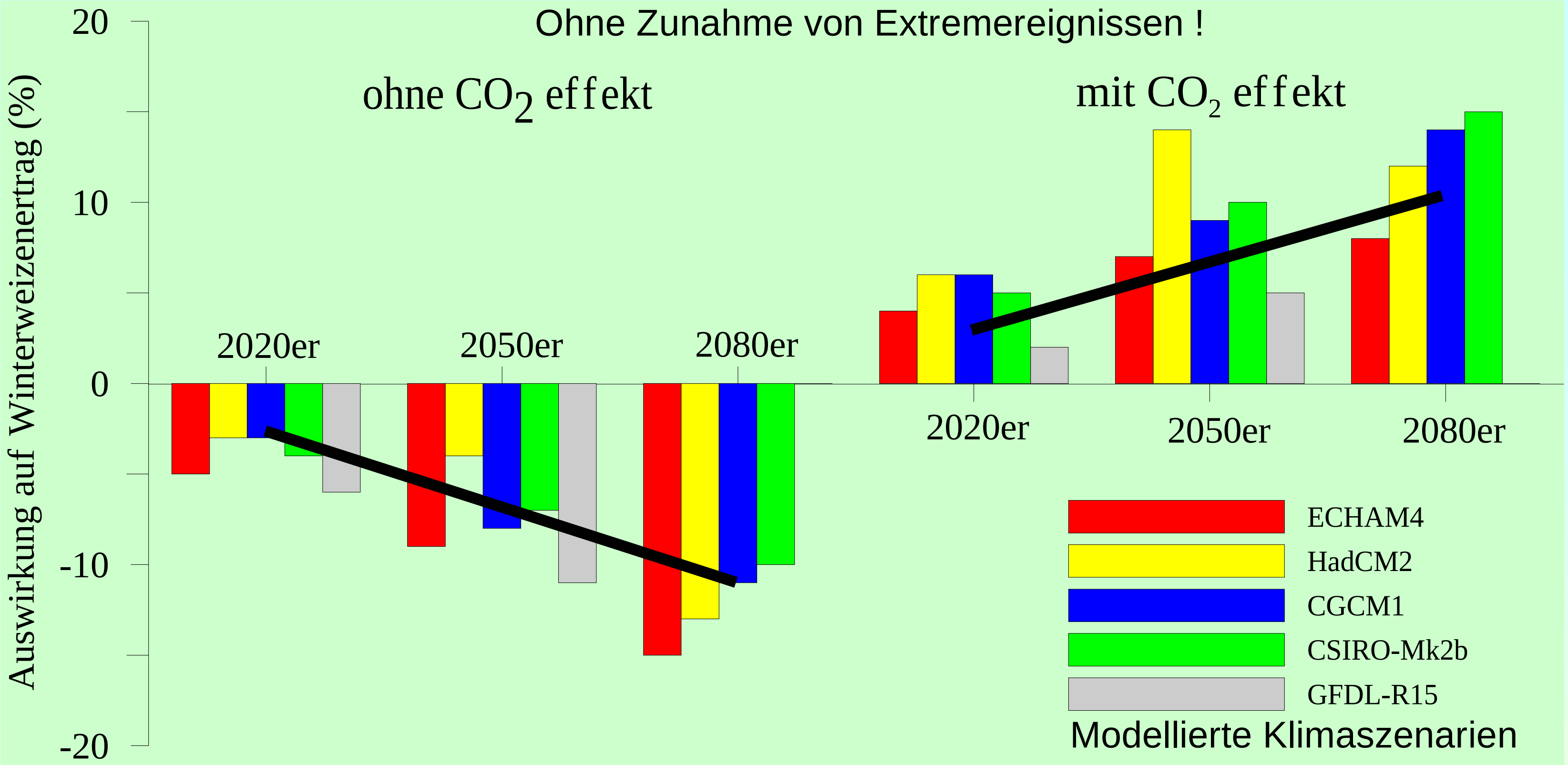
Improving knowledge on spatial variabilites of surface conditions

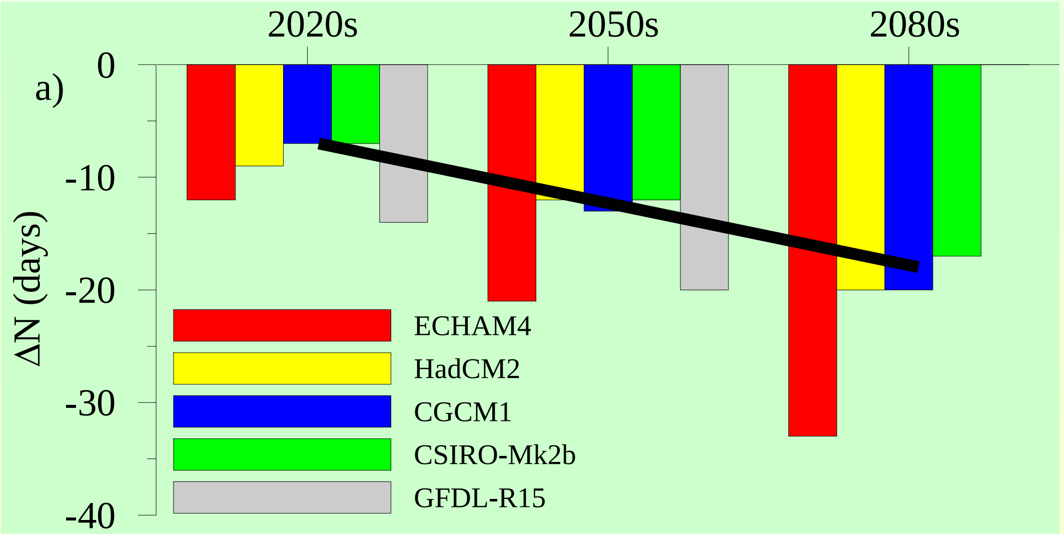
Below: Spatial soil varibilities (Hymap, Marchfeld)

Precision farming: Spatial yield distribution, winter wheat



Schaupenlehner et al., 2008



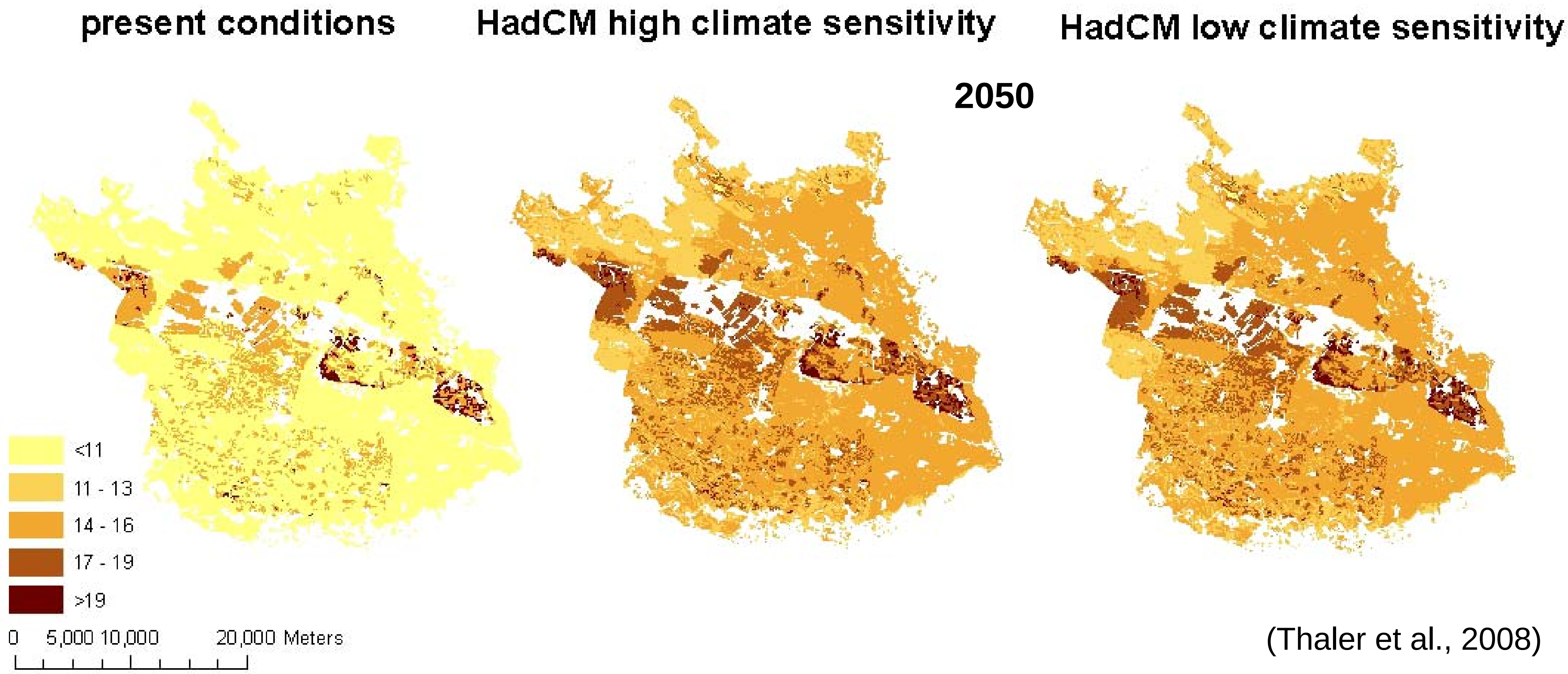


Crop model applications

Climate change impacts on winter wheat yields in Austria

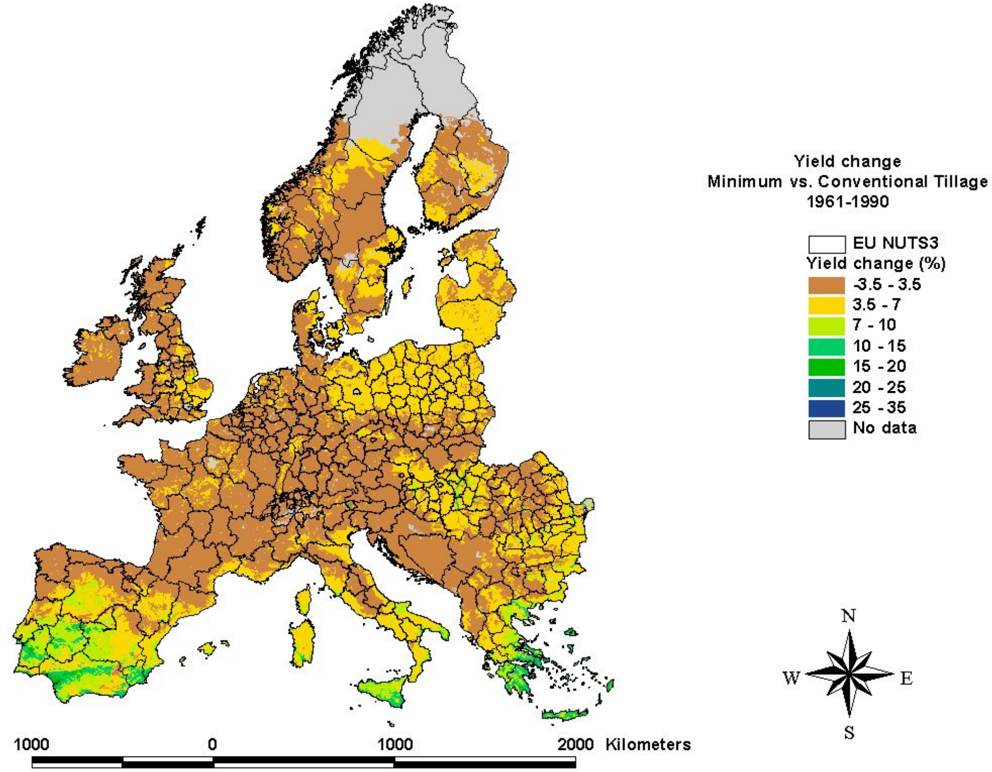
(Alexandrov and Eitzinger, 2001)

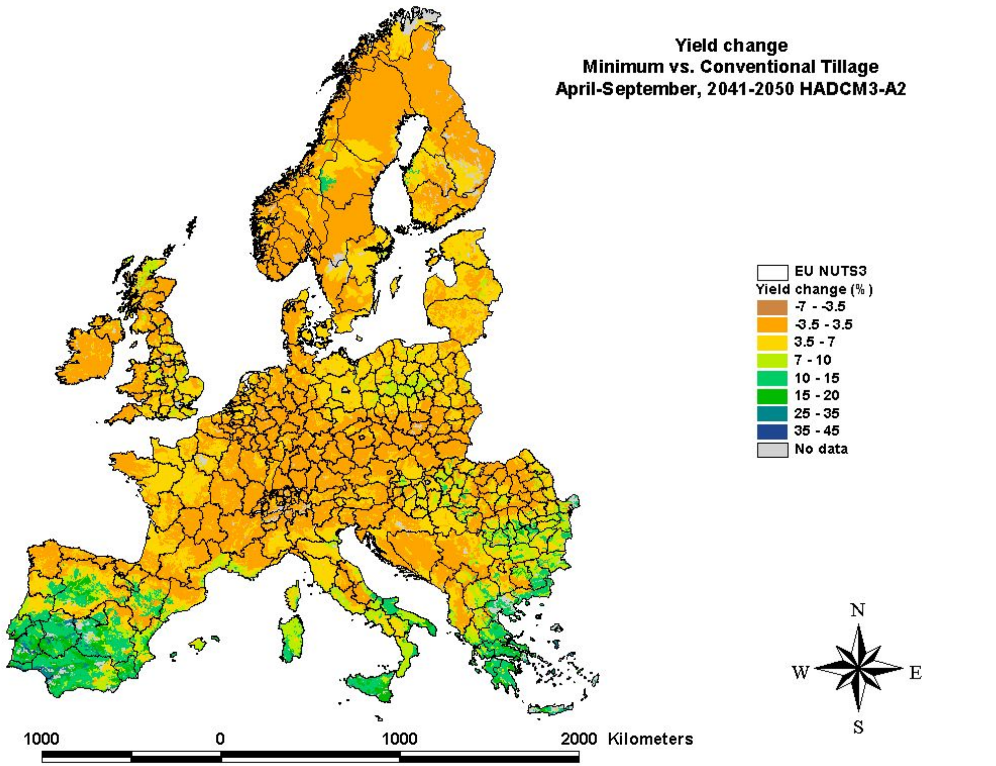
Increase of water stress
(simulated for spring barley - eastern Austria



(Thaler et al., 2008)

Spatial scale: 1:25000 digital soil map – 5 soil classes





Spring wheat yield change (%) between minimum and conventional tillage for baseline (1961-1990)
and climate change scenario (2041-2050 HADCM3-A2)
(Simota, 2009)

Potential deviations between crop models – simulated yield

MAIZE – Minimum Soil Cultivation

Site A - 2003

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-15.4	-10.5	-13.9	-15.8	-34.3	-32.2	-32	-37.6	-29.6
EPIC	-8.5	4	-2.7	-5.4	-45.9	-44.3	-45.1	-47	-43.5
WOFOST	-15.3	-6.9	-11.1	-23.5	-66.7	-62.2	-64.8	-72.8	-55.3
AQUACROP	-4.1	-3.7	-4.5	-5.6	-86.7	-86	-86.3	-86.8	-85.8
FASSET	-2	-2	-2	-5.1	-22.2	-22.2	-22.2	-24.4	-22.2
HERMES	2	2	2	1.3	-26.2	-26.2	-26.2	-39.6	-35.1
CROPSYST	-5.6	3.5	-1.7	-5.1	-11.1	-5.1	-8.6	-10.2	-7.4
mean	***-7***	***-1.9***	***-4.8***	***-8.5***	***-41.9***	***-39.7***	***-40.7***	***-45.5***	***-39.8***

Site A - 2004

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-24.9	-22.1	-23.9	-28.3	-25	-22.3	-23.7	-28.4	-19
EPIC	-6.2	4.6	-1.1	-2.1	-12.7	-3.1	-8.3	-9	-7.3
WOFOST	-10.5	-5.2	-8.3	-16.9	-16.1	-11.1	-14	-22.4	-6
AQUACROP	0.6	-1.9	-2.4	-2.8	-13.5	-11.8	-12.5	-13.3	-12.1
FASSET	-4.8	-4.8	-4.8	-7.8	-5.8	-5.8	-5.8	-9.2	-0.6
HERMES	3.9	3.9	3.9	-2.8	-3.7	-3.7	-3.7	-23.4	1.1
CROPSYST	-6.5	2.8	-1.2	-3.7	-15.5	-11.4	-13.6	-14.6	-13
mean	***-6.9***	***-3.2***	***-5.4***	***-9.2***	***-13.2***	***-9.9***	***-11.7***	***-17.2***	***-8.1***

Site B - 2003

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-3.5	-0.7	-2.9	-7.7	-54.3	-54.2	-54.8	-58.8	-50.9
EPIC	-8	-1.1	-4.6	-9.9	-66.9	-66.1	-66.5	-69.5	-63.2
WOFOST	-92.9	-8.1	-9.5	-13.6	-99.5	-99.3	-99.5	-99.9	-11.7
AQUACROP	-4	-6.3	-7.8	-10.1	-77.1	-76	-76.5	-77.2	-75.8
FASSET	-2.9	-2.9	-2.9	-4.6	-26.1	-26.1	-26.1	-25.3	-23.9
HERMES	-6.3	-6.3	-6.3	-8.1	-69.3	-69.3	-69.3	-69.2	-69.8
CROPSYST	-7.4	-0.6	-5.2	-7.1	-11.6	-7.3	-10.1	-10.2	-9.4
mean	***-17.8***	***-2.7***	***-4.5***	***-7.8***	***-59.3***	***-58.2***	***-58.8***	***-60***	***-44.9***

Site B - 2004

	T4	t2	Tt2	Tt4	T4P	t4P	Tt2P	Tt4P	P
DSSAT	-0.6	-0.6	-0.1	0	-15.8	-13	-14.4	-15.2	-14.2
EPIC	-6	1.6	-2.5	-6	-16.5	-10.8	-14.1	-17.6	-11.1
WOFOST	-18.8	-2.1	-2.7	-6.7	-22.1	-20.5	-20.7	-23.6	-4.8
AQUACROP	-0.7	0.2	-0.3	-0.9	-43	-40.8	-41.8	-40.5	-40
FASSET	-1.5	-1.5	-1.5	-1.1	-0.6	-0.6	-0.6	-0.4	1
HERMES	6.3	6.3	6.3	7.2	13.2	13.2	13.2	14.4	6.5
CROPSYST	-11.6	3.7	-4.4	-9	-27.8	-23.1	-25.8	-26.6	-24.9
mean	***-4.6***	***1.2***	***-0.6***	***-2.2***	***-10.7***	***-8.4***	***-9.5***	***-10.5***	***-7.5***


Thank you for your attention!