

IMPACTS OF PRESENT AND FUTURE CLIMATE VARIABILITY ON AGRICULTURE AND FORESTRY IN THE TEMPERATE REGIONS: EUROPE

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International Workshop on
Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change
Ljubljana, Slovenia, 7-9 October 2002.

Main topics

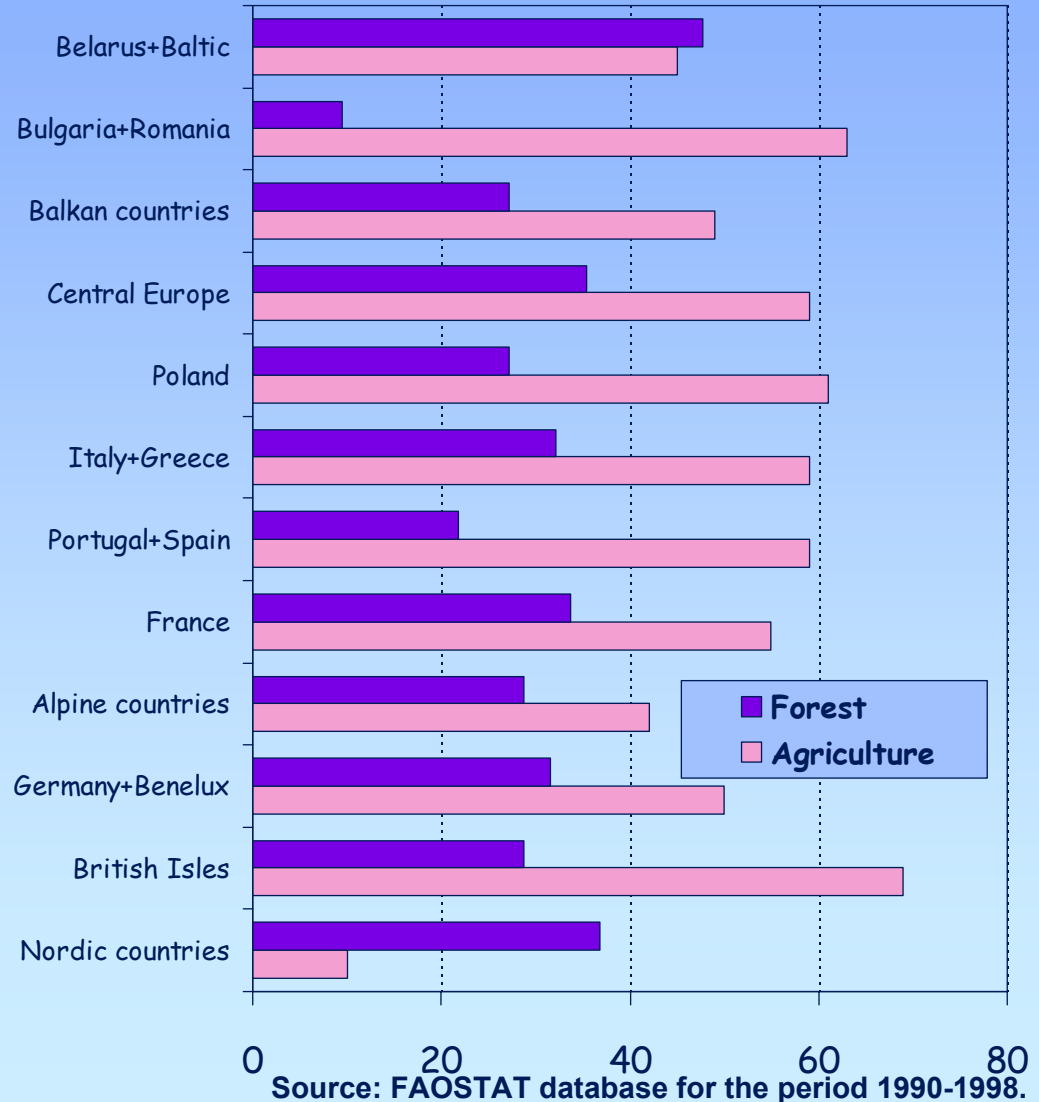
- Role in European countries
- Sensitivity to present climate
- Impact of climate change
- Vulnerable regions
- Adaptive strategies available
- Main future research strategies

AGRICULTURE - FORESTRY: Role in European countries

Land-use relevance

→ In the **European countries** agricultural and forest areas cover:

- **Agriculture:** 52% of land (ranging from 10% to 69%)
- **Forest:** 30% of land (ranging from 9% to 48%)

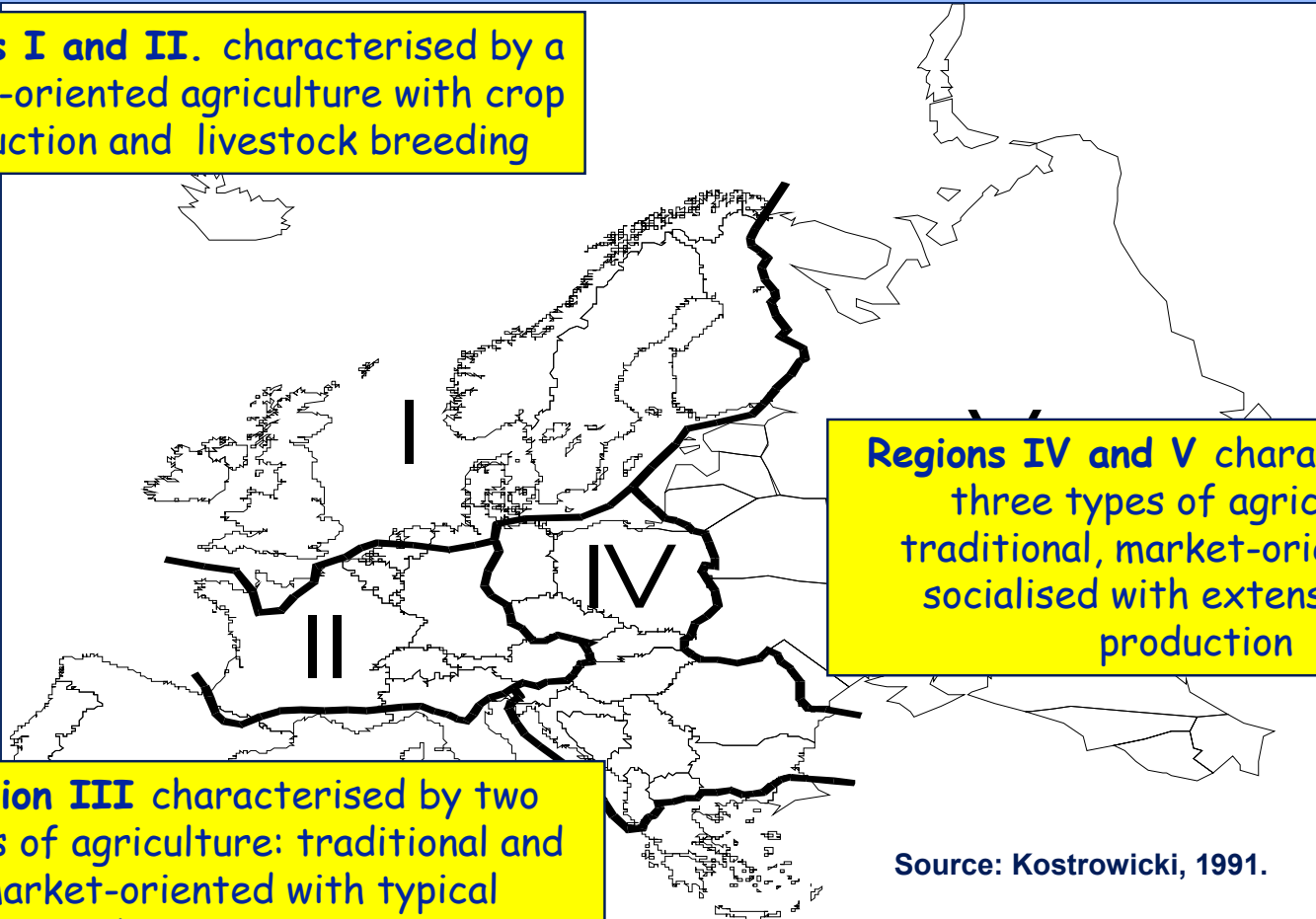


AGRICULTURE - Role in European countries

Agricultural Regions

Five major agricultural regions can be distinguished on the basis of **environmental and socio-economic factors**:

Regions I and II, characterised by a market-oriented agriculture with crop production and livestock breeding



Regions IV and V characterised by three types of agriculture: traditional, market-oriented and socialised with extensive crop production

Region III characterised by two types of agriculture: traditional and market-oriented with typical Mediterranean crops

Source: Kostrowicki, 1991.

FOREST - Role in European countries

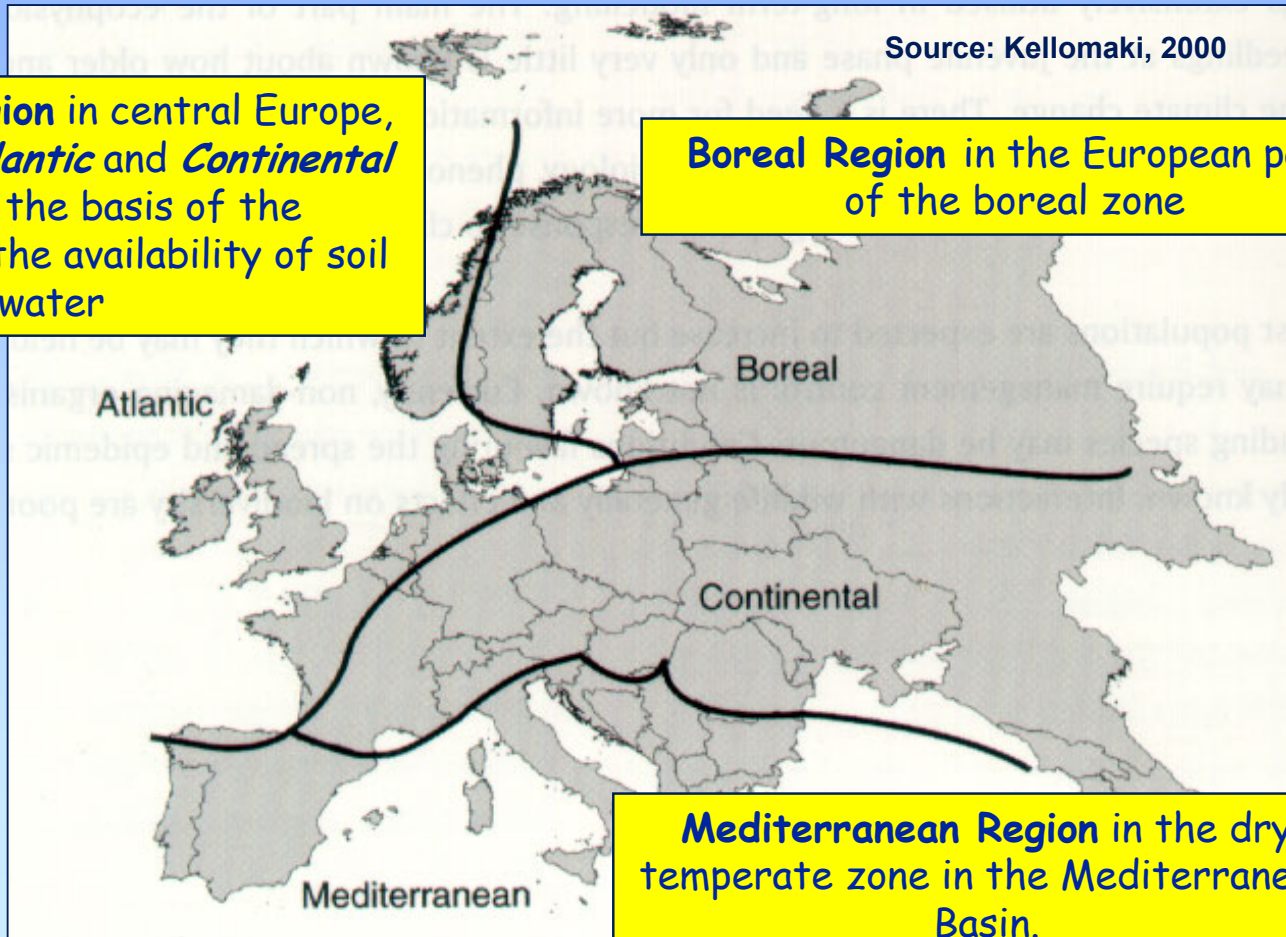
Forest Regions

Three major forest regions can be distinguished on the basis of **environmental factors**:

Temperate Region in central Europe, divided into *Atlantic* and *Continental* forests on the basis of the differences in the availability of soil water

Boreal Region in the European part of the boreal zone

Mediterranean Region in the dry temperate zone in the Mediterranean Basin.

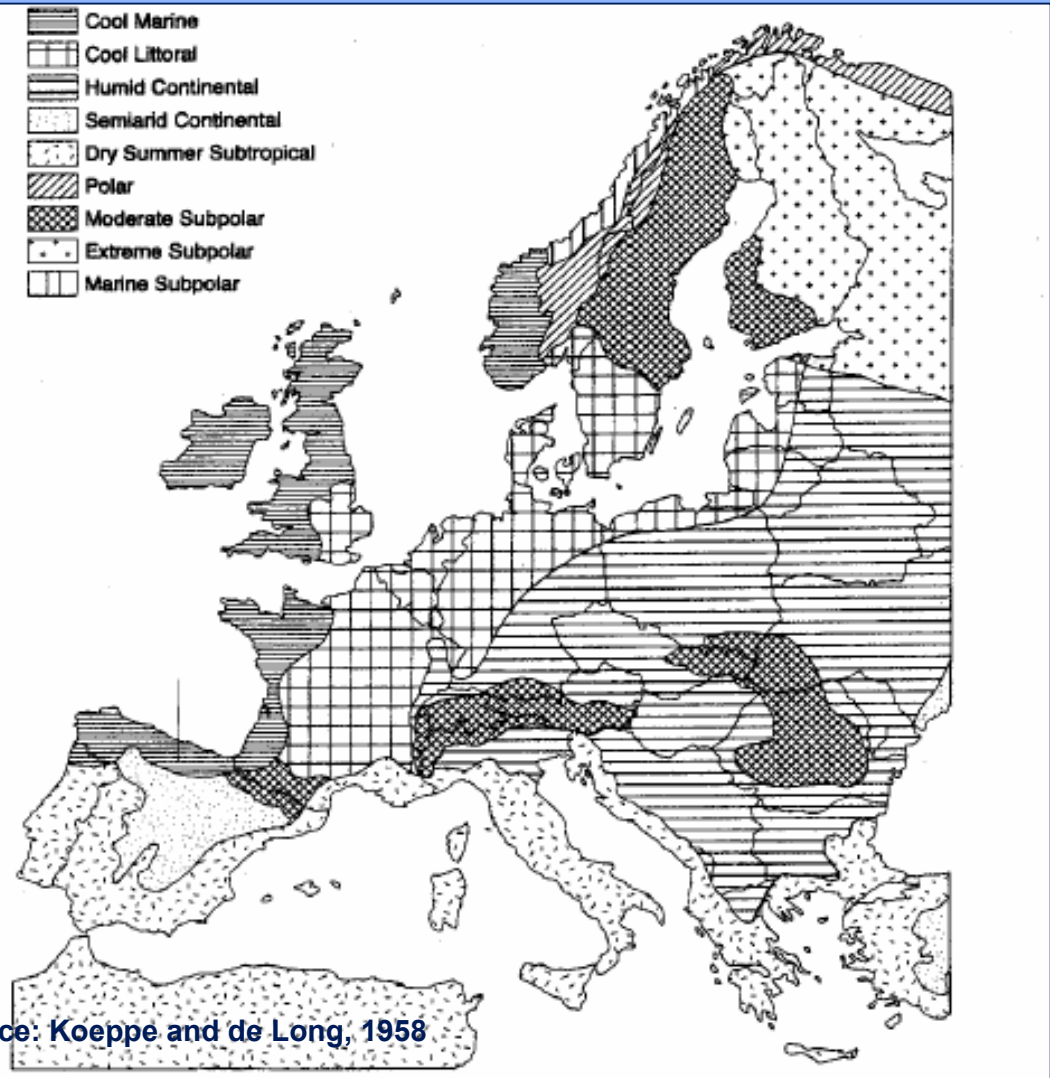


Climate - Climate classification for Europe

Climate of Europe

The **climate of Europe** shows large differences from west (maritime) to east (continental) and from north (Arctic) to south (Mediterranean).

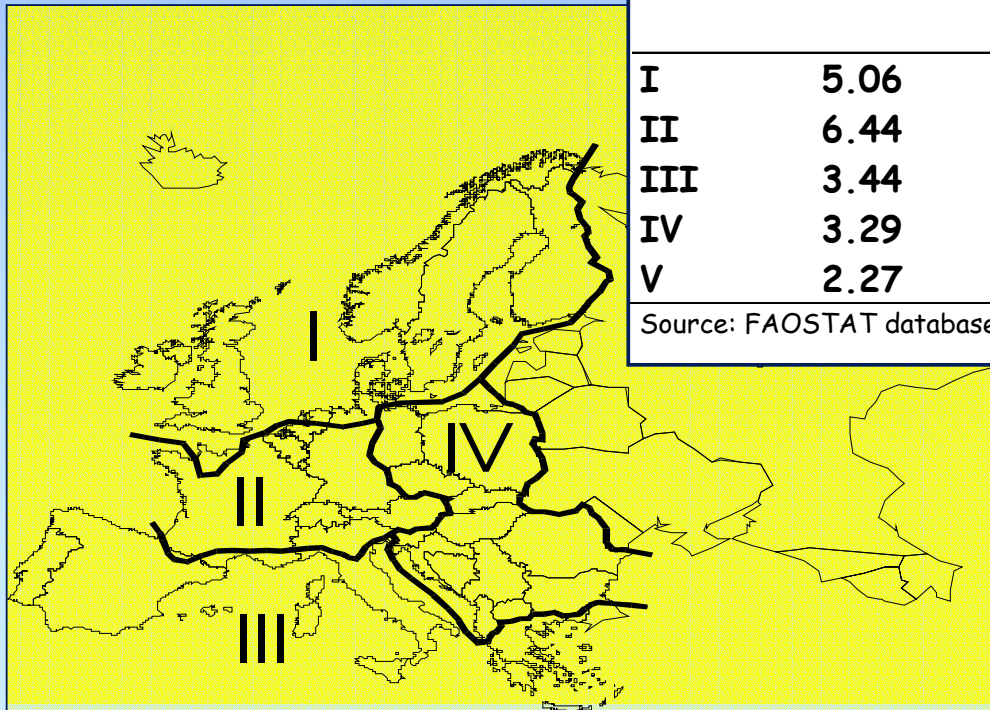
The *climatic conditions* are then modified by the spatial distribution of land, ocean, mountains which act on atmospheric circulation.



AGRICULTURE - Role in European countries

Yields variability across Europe

The different type of organisation and environment determine large **variability in yield** of crops across the European regions



Mean yield of different crop types (t/ha)

Regions	Cereals	Oil-crops	Root-tuber crops	Vegetables	Fruit crops
I	5.06	0.86	24.5	26.2	9.36
II	6.44	0.83	27.6	22.5	18.28
III	3.44	0.41	14.1	21.0	8.58
IV	3.29	0.53	17.7	18.1	6.07
V	2.27	0.34	20.3	15.9	3.69

Source: FAOSTAT database for the period 1980-2000.

FORESTRY - Role in European countries

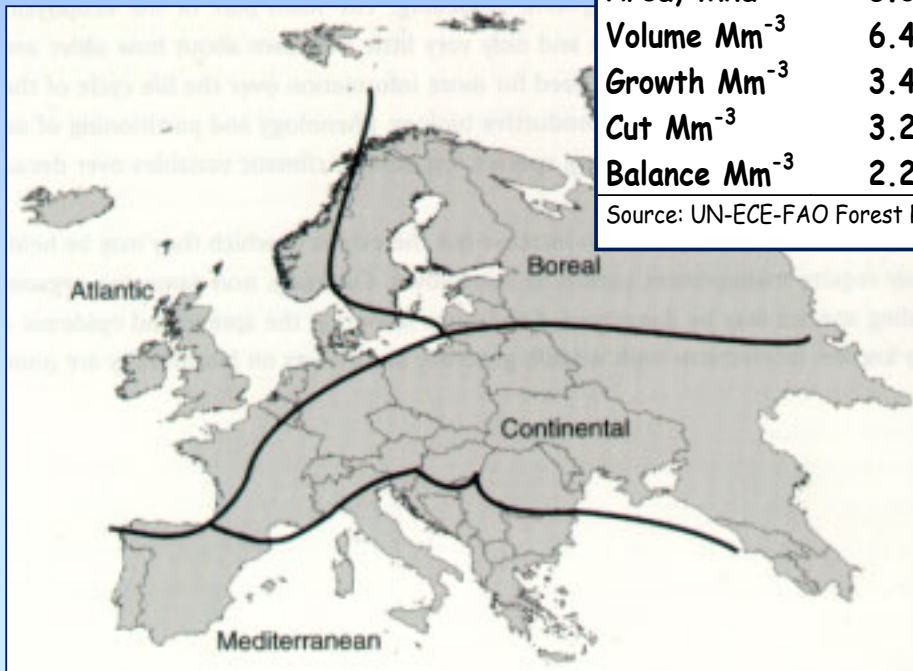
Forest parameters across Europe

The different type of tree species and environment determine large **variability in forest resources** across the European regions

Mean parameters for European Forest Region

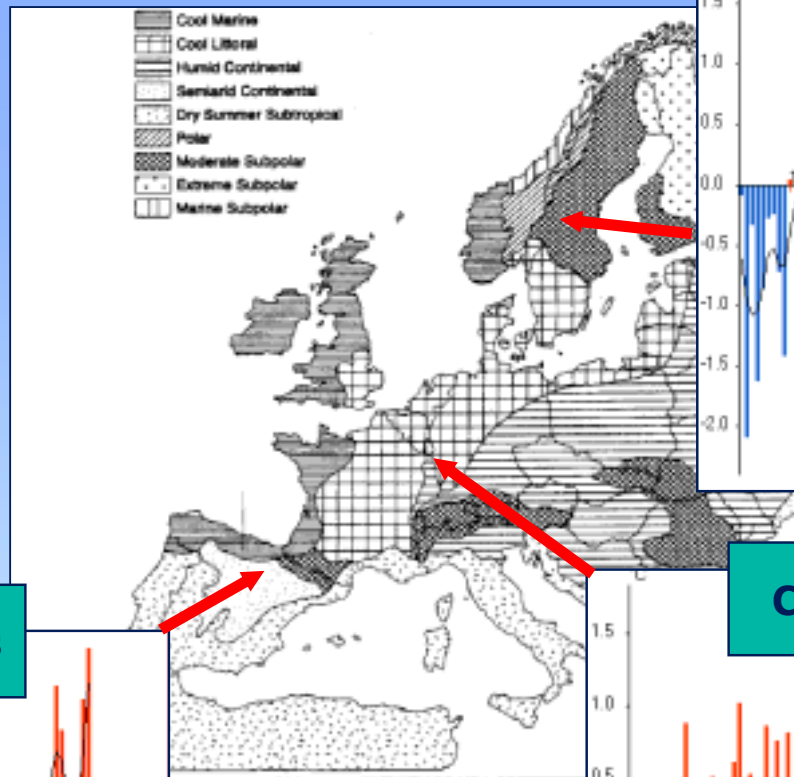
Parameters	Region			
	Boreal	Atlantic	Continental	Mediterranean
Area, Mha	5.06	0.86	24.5	26.2
Volume Mm ⁻³	6.44	0.83	27.6	22.5
Growth Mm ⁻³	3.44	0.41	14.1	21.0
Cut Mm ⁻³	3.29	0.53	17.7	18.1
Balance Mm ⁻³	2.27	0.34	20.3	15.9

Source: UN-ECE-FAO Forest Resource Assessment, 1992

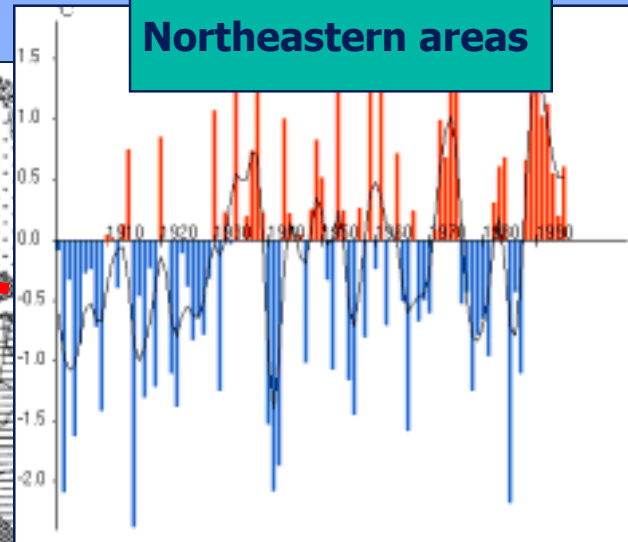


Climate - Observed trends in Europe

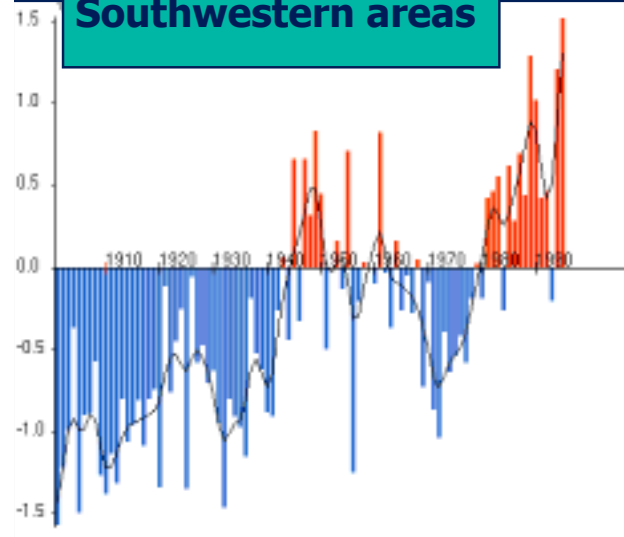
Mean Temperature



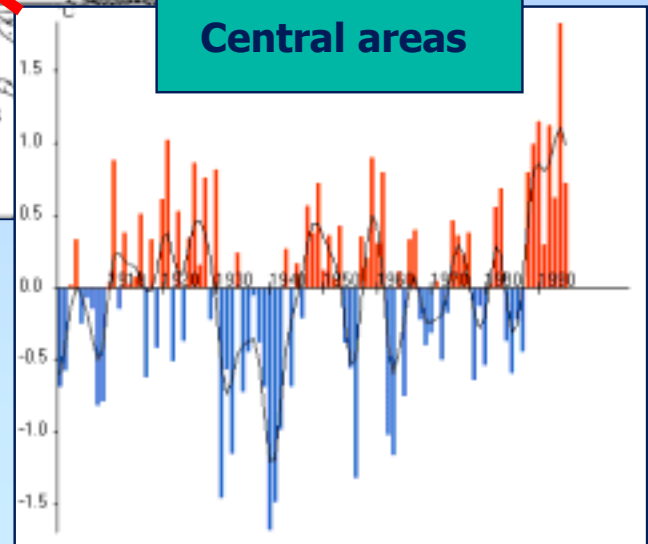
Northeastern areas



Southwestern areas



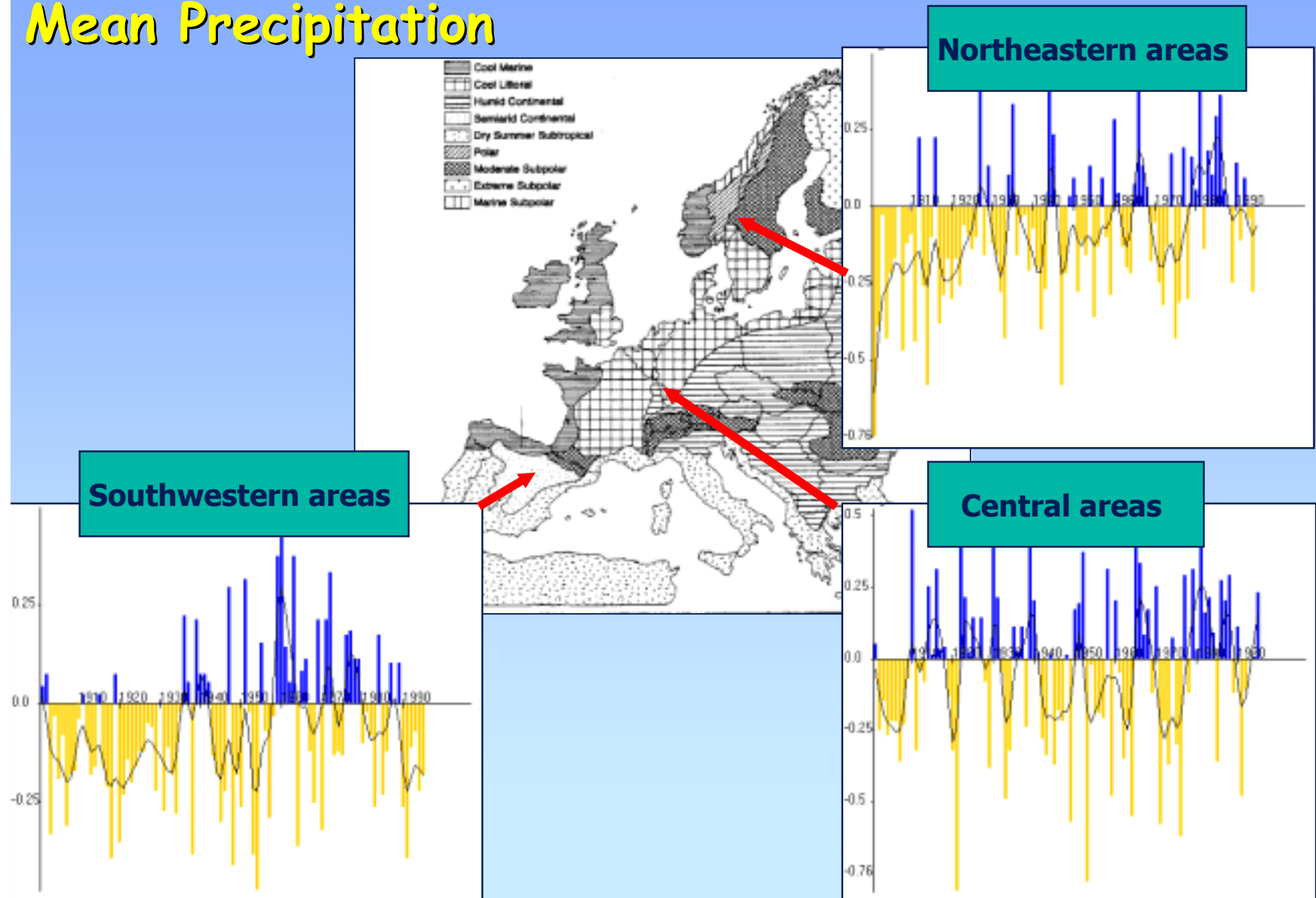
Central areas



Source: IPCC Data Distribution Centre

Climate - Observed trends for Europe

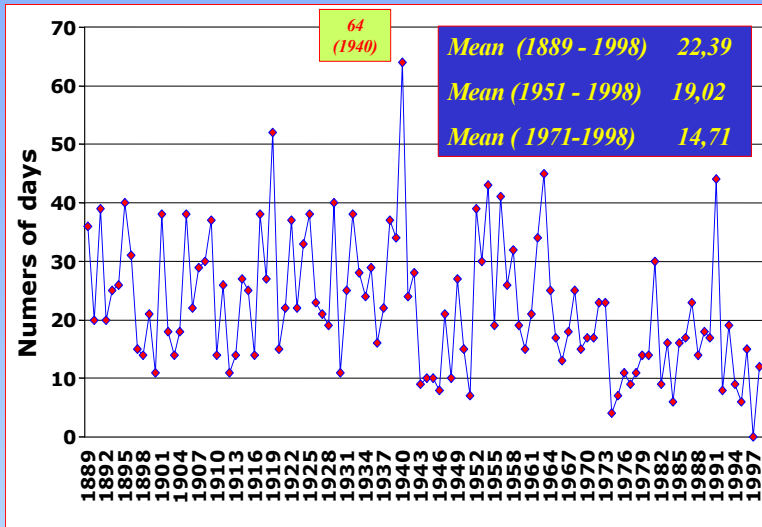
Mean Precipitation



Source: IPCC Data Distribution Centre

Climate - Observed trends for Europe

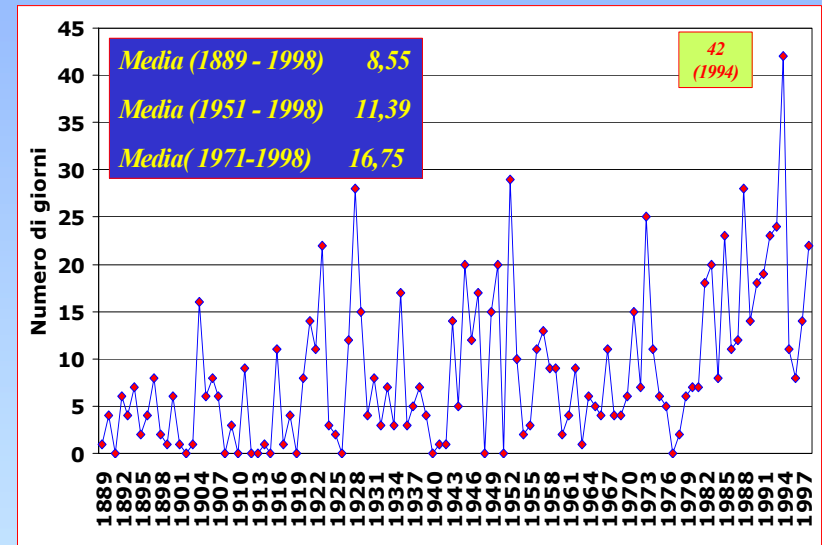
Frost days (T Min. < 0°C)



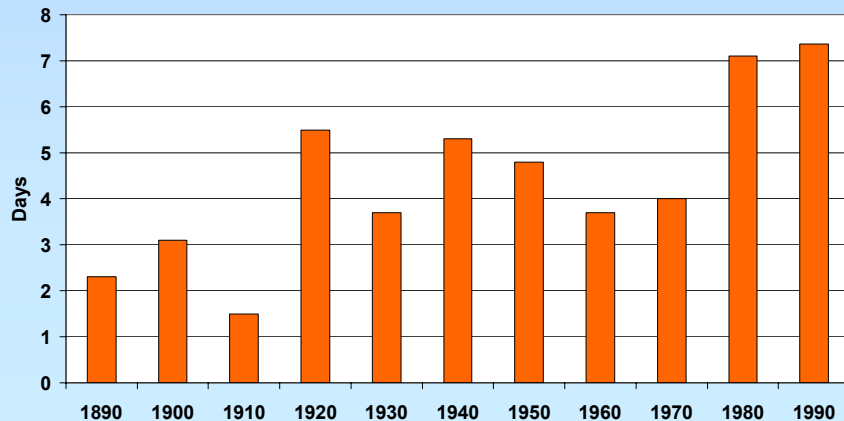
Temperature extremes (case study in Tuscany Italy)

Maracchi et al., 2001

N ° Days with T Max > 34°C

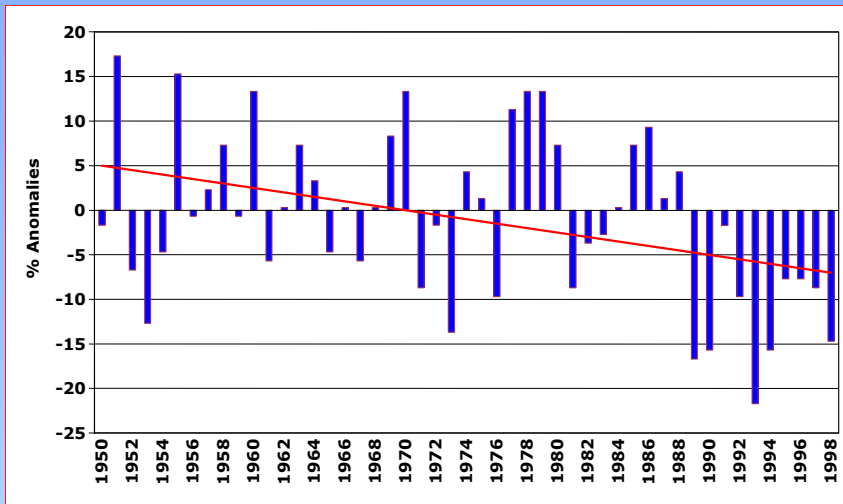


Decadal mean summer longest spell with Tmax > 34°C



Climate - Observed for Europe

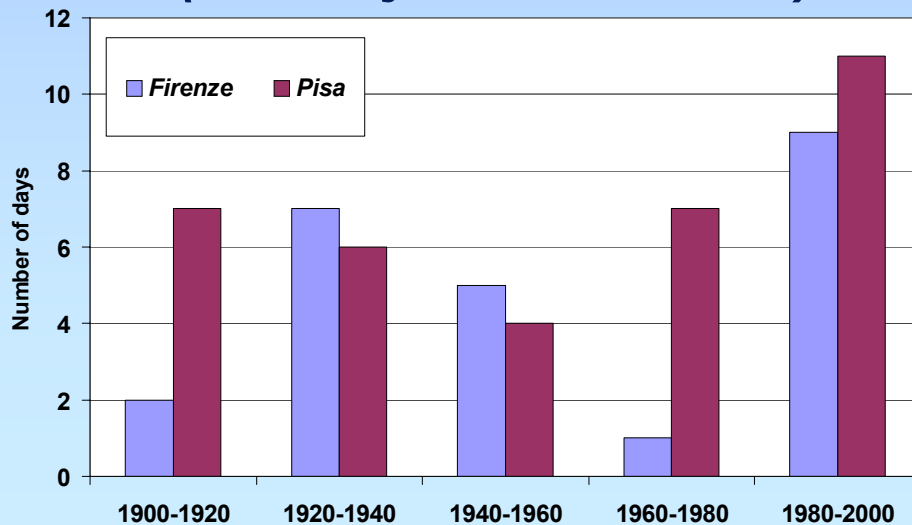
Winter rainy days



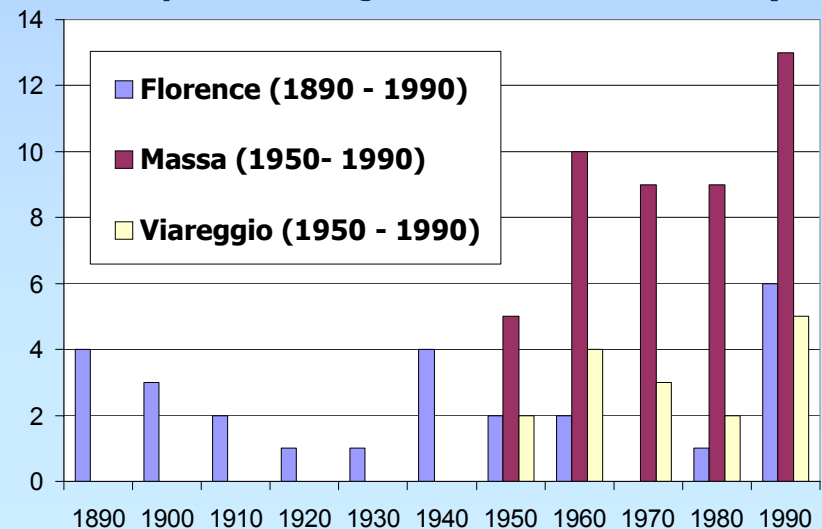
Precipitation extremes (case study in Tuscany Italy)

Maracchi et al., 2001

Rainfall in Autumn (with daily amount > 60 mm)



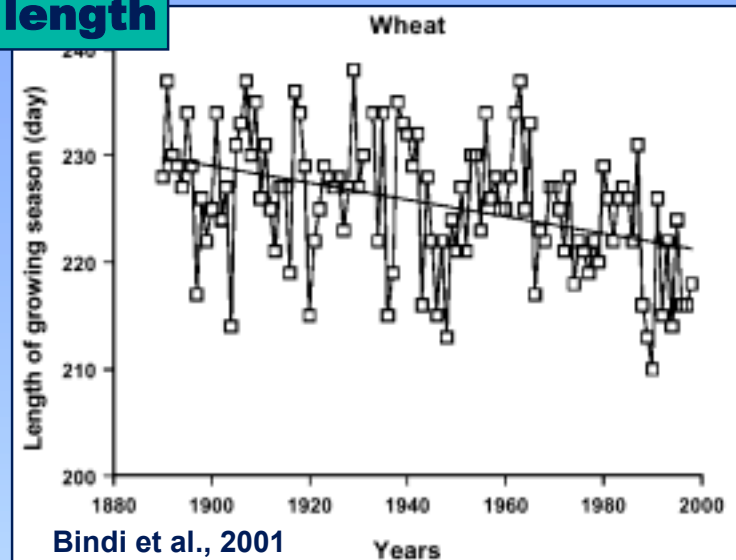
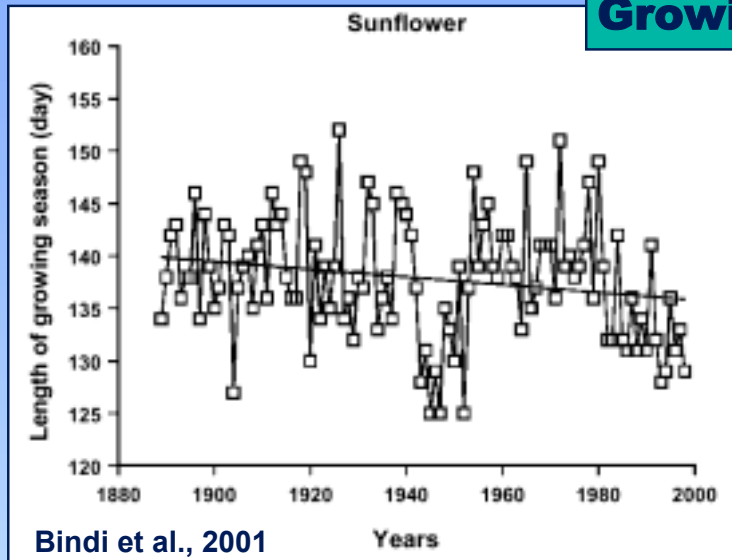
Number of rainfall in Spring (with daily amount > 40 mm)



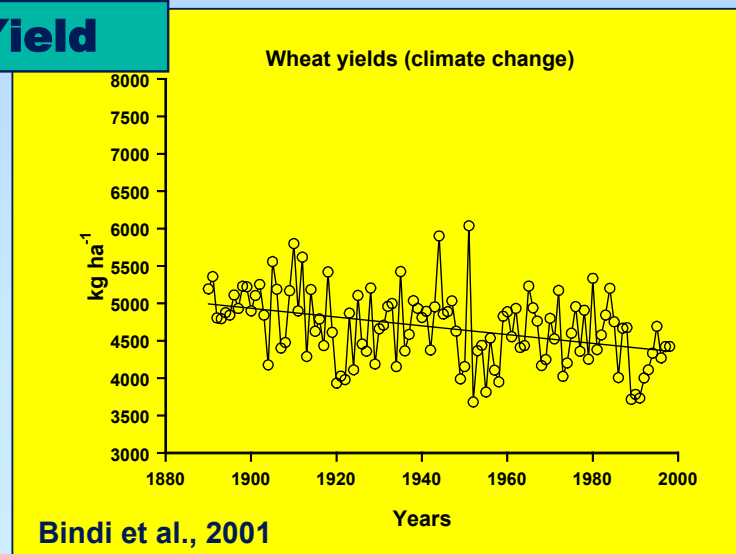
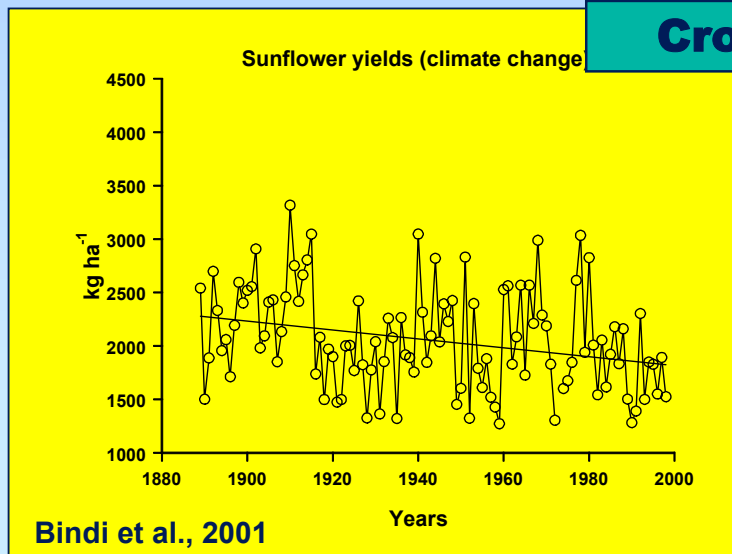
Climate - Effect of climate now

Agricultural crop development and yield

Growing length



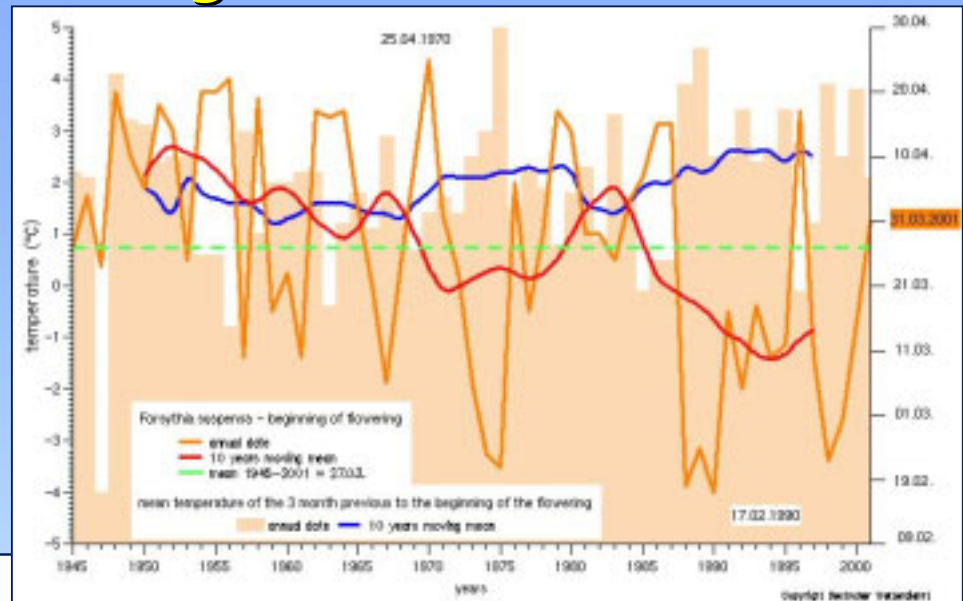
Crop Yield



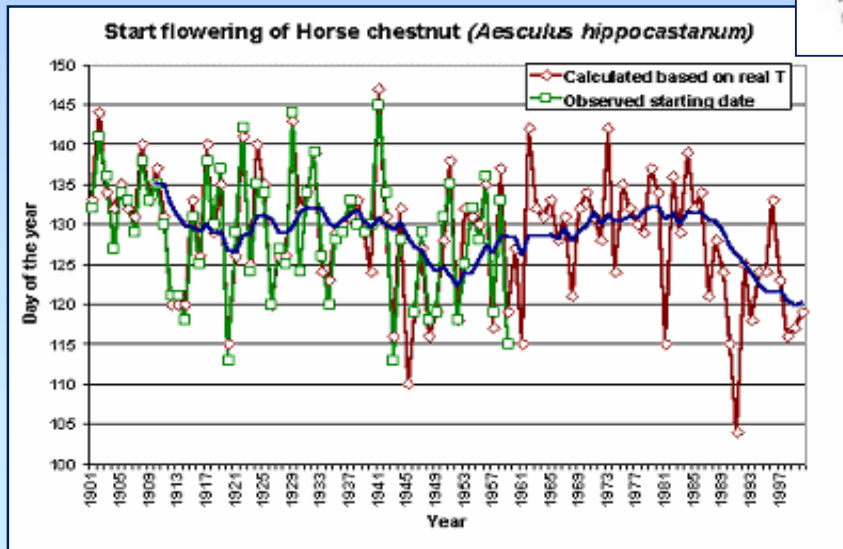
Climate - Effect of climate now

Natural and Forest vegetation

Early starting of
growing phases
(flowering)



Source: EPN European Phenology Network Bruns E.

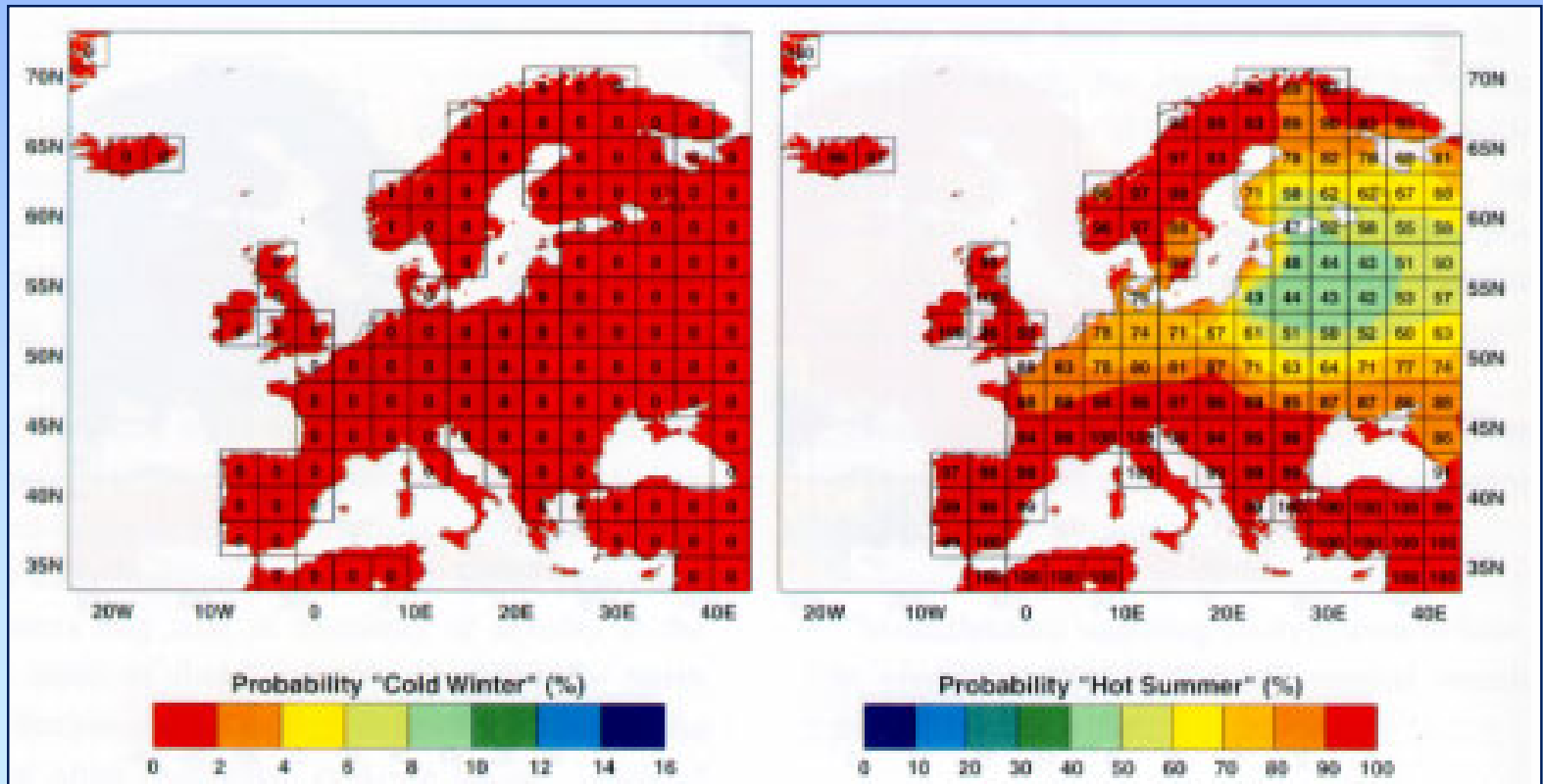


Source: EPN- European Phenology Network Van Vliet A. E.

Climate - Future scenarios

Temperature extremes

Climate change is expected to determine a general *reduction of "cold winter"* and a strong *increase in "hot summer"* especially over southern Europe.

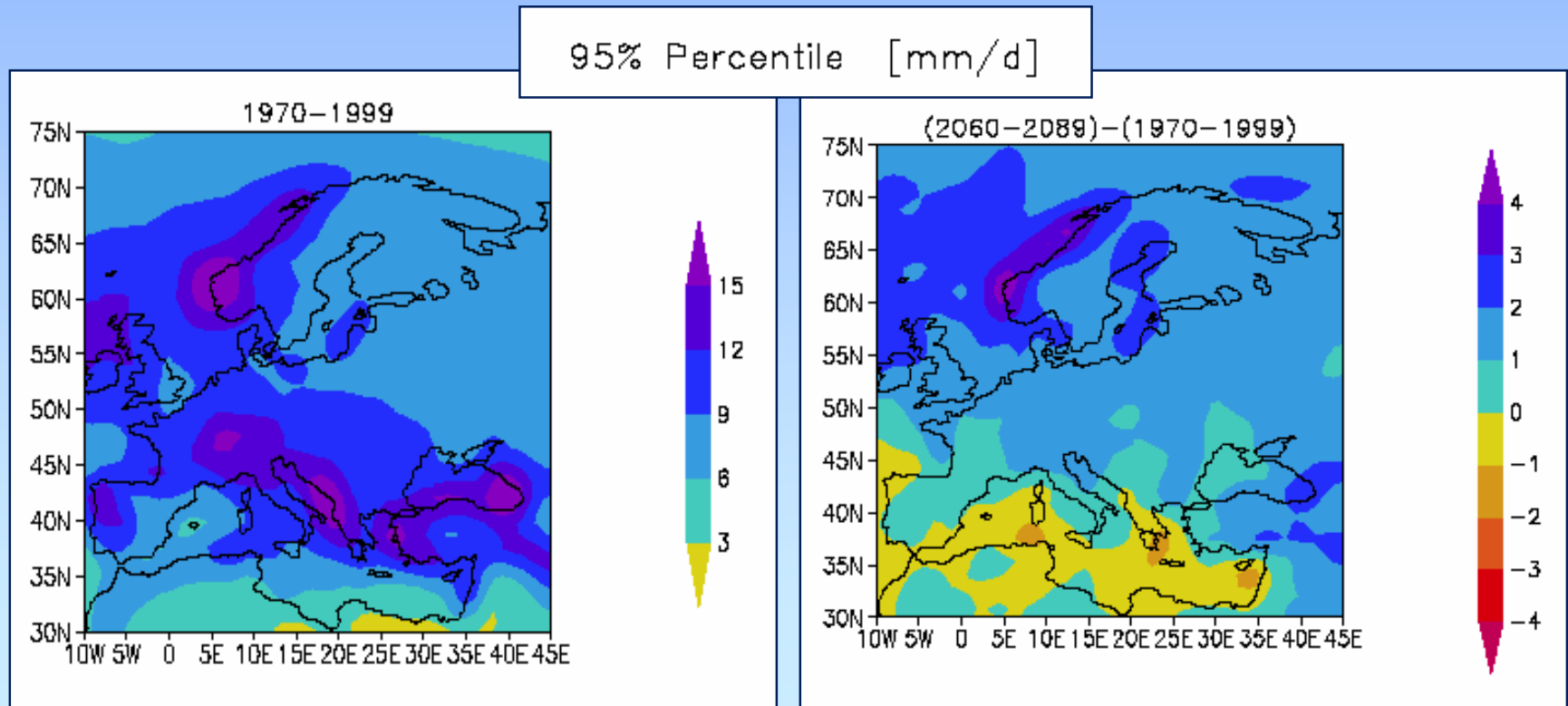


Source: Carter and Hulme, 2000

Climate - Future scenarios

Precipitation extremes

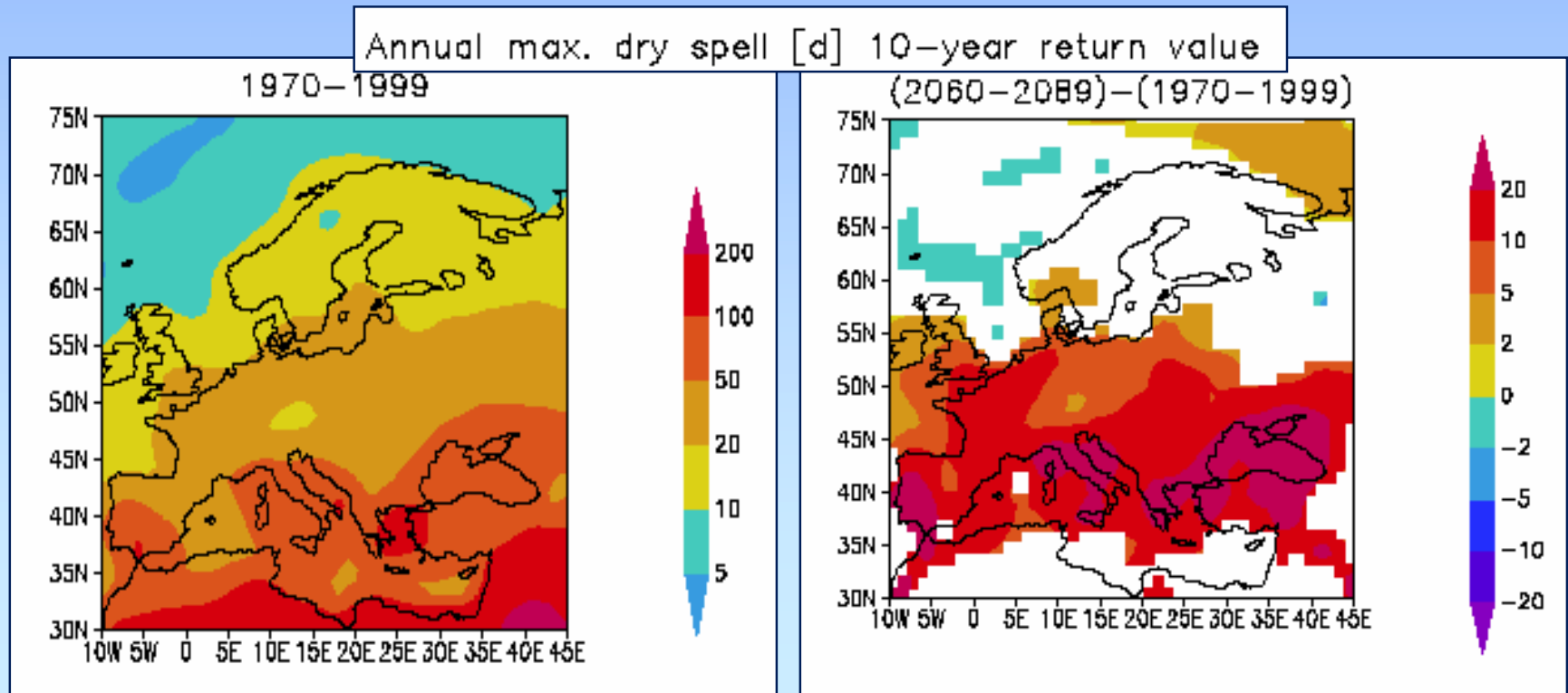
Climate change is expected to determine an *increase in the frequency and intensity of heavy precipitation* events in Europe also in those areas (southern Europe) where the total amount of precipitation is reduced



Climate - Future scenarios

Wet - Dry spells

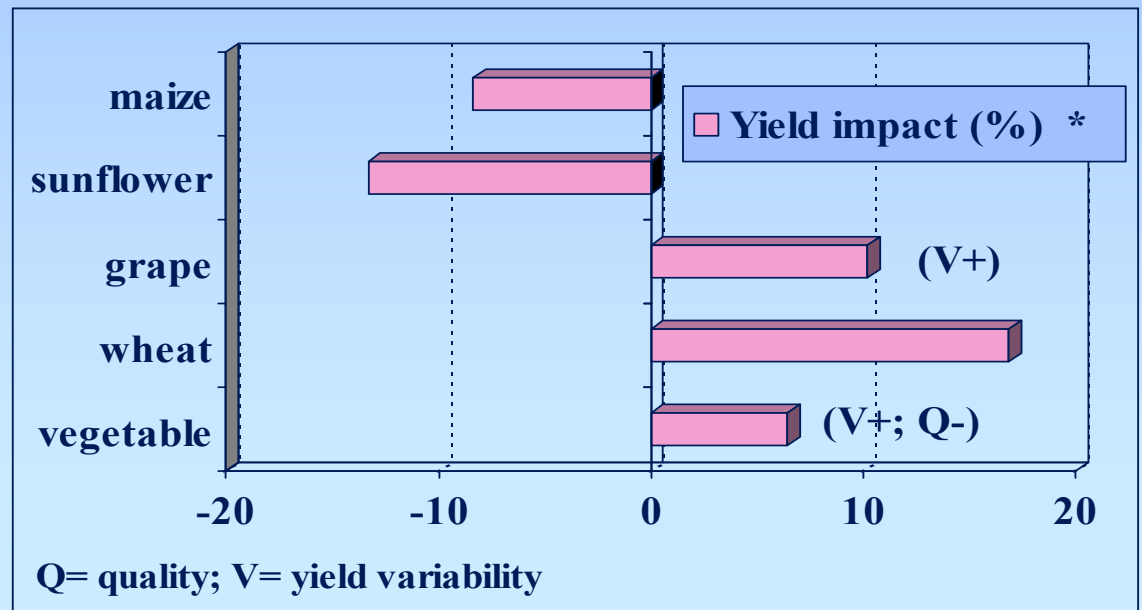
Climate change is expected to determine *a prolongation of extreme dry spells* on the entire continent except for northern Scandinavia and northern Russia, in particular in western and southern Europe.



AGRICULTURE - Production Response

Combined effect of climate change and enhanced CO₂ on crop production

- yields of C3 crops (vegetable, wheat and grapevine) generally increase
- yields of C4 crops and summer crops generally decrease
- Inter-annual variability of crop yields increase
- Yield quality may be affected



* UKTR model, decade 66-75, CO₂ 617; (Source: Harrison and Butterfield, 1995)

AGRICULTURE - Most sensitive/vulnerable regions

Vulnerable Regions

Northern and southern current marginal areas for production of traditional crops will be particularly sensitive to climate changes:

Northern areas

Benefits

- introduction of new crops
- higher crop production
- expansion of suitable areas for crop cultivation

Disadvantages

- increase in plant protection
- increase in risk of nutrient leaching
- acceleration of breakdown of soil organic matter

Southern areas

Benefits

- introduction of new crops

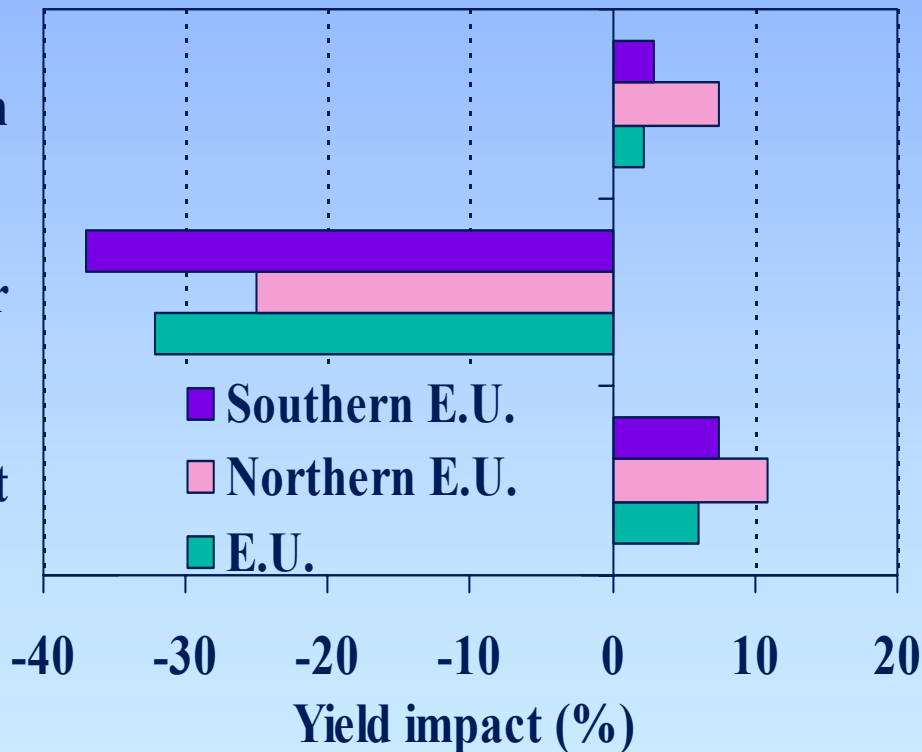
Disadvantages

- lower yield
- higher yield variability
- reduction of suitable areas for traditional crops

Onion

Sunflower

Wheat



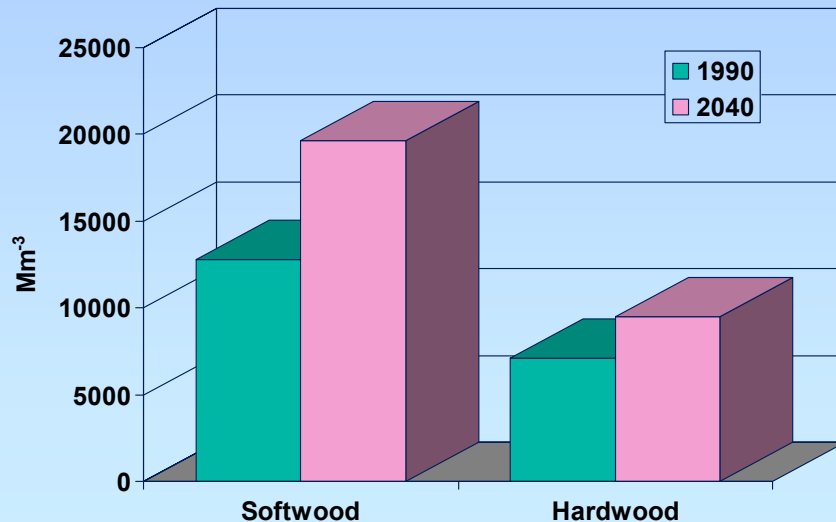
(Source: Harrison and Butterfield, 1995)

FOREST - Production Response

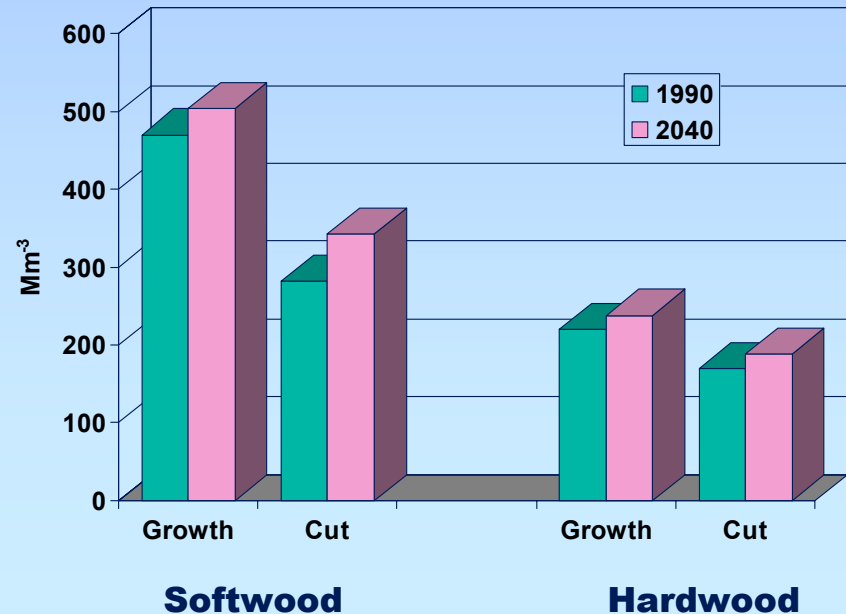
Combined effect of climate change and enhanced CO₂ on forest production

- Expansion of **forest border**
- Increase in **timber producing capacity**
- Higher risk of **wind and fire damage**
- Lower summer **soil water availability**
- Enhancement of **insects and fungi attack**

Tree volume of European forest areas



Tree growth and cutting of European forest areas



(Source: Pajuola, 1995)

AGRICULTURE - Main adaptive strategies

Adaptive strategies

The **agronomic strategies** intend to offset either partially or completely the loss of productivity caused by climate change :

- **Short-term adjustments**
- **Long-term adaptation**

Short-term adjustments

- **Management of cropping systems:**
 - *Changes in crop varieties* (varieties with different thermal requirements, varieties given less variable yields)
 - *Changes in agronomic practices* (sowing/planting dates)
 - *Changes in fertiliser and pesticide use*
 - *Adoption of new tools* for crop selection (climate seasonal forecast)
- **Conservation of soil moisture:**
 - The *introduction of moisture conserving tillage methods* (minimum tillage, conservation tillage, stubble mulching, etc.)
 - The *management of irrigation* (amount and efficiency)

AGRICULTURE - Main adaptive strategies

Long-term adaptation may overcome adversity caused by climate change through major structural system changes:

- ***Changes in land allocation*** to optimise or stabilise production.
- ***Development of "designer-cultivars"*** to adapt to climate change stresses (heat, water, pest and disease, etc.) much more rapidly than it possibly today
- ***Crop substitution*** to conserve soil moisture. (e.g. sorghum is more tolerant of hot and dry conditions than maize)
- ***Microclimate modification*** to improve water use efficiency in agriculture (e.g. windbreaks, inter-cropping, multi-cropping techniques)
- ***Changes in nutrient management*** to reflect the modified growth and yield of crops

Main future research strategies

AGRICULTURE:

- Produce **climate scenarios** including a wider range of climatic variables (e.g. isolated and extreme events such as hail and severe wind)
- Develop methods for **downscaling climate change scenarios** and **up-scaling impact and adaptation assessments**
- Perform studies on **cropping systems** more than on single crops
- Develop **seasonal weather forecasts** and methods for adapting such forecasts in farm management
- Explore in greater detail a range of **technological adjustments** (short and long term strategies) available in agriculture
- Develop **integrated assessment** using climatic and non-climatic conditions (economic, technological, environmental, etc)

FORESTRY:

- **Physiology and genetics studies** to resolve the problem of regeneration, growth, development and adaptation of key species in the short and long-term
- **Process-based models** of forest stand development in the long-term with particular reference to the effects of increased ambient CO₂
- Elucidation of **biology and potential pest and disease organisms** in relation to host physiology.
- Development of **monitoring techniques** to detect the effects of environmental change with emphasis on changes in productivity in existing forests.

Conclusions

- Current **differences in producing capacity** between northern and southern countries will increase under climate change
- **Inter-annual variability of plant production and abiotic and biotic damages (i.e. wind, fire, pest-disease damages)** will increase, especially in regions, such southern Europe, where agro-forest ecosystems are affected by water shortages and extreme weather events (e.g. Heat waves, wind speed, etc.)
- Negative impacts could be addressed supporting the development and introduction of **specific agricultural and forestry adaptive management measures** (e.g. Agronomic and water conservation practices, modification of microclimate, regular forest management, shorter rotations, etc.)
- **Future climate change strategies** will have to be focussed on the definition of climate change target that should be meet for avoiding or at least limiting negative effects for producing capacity