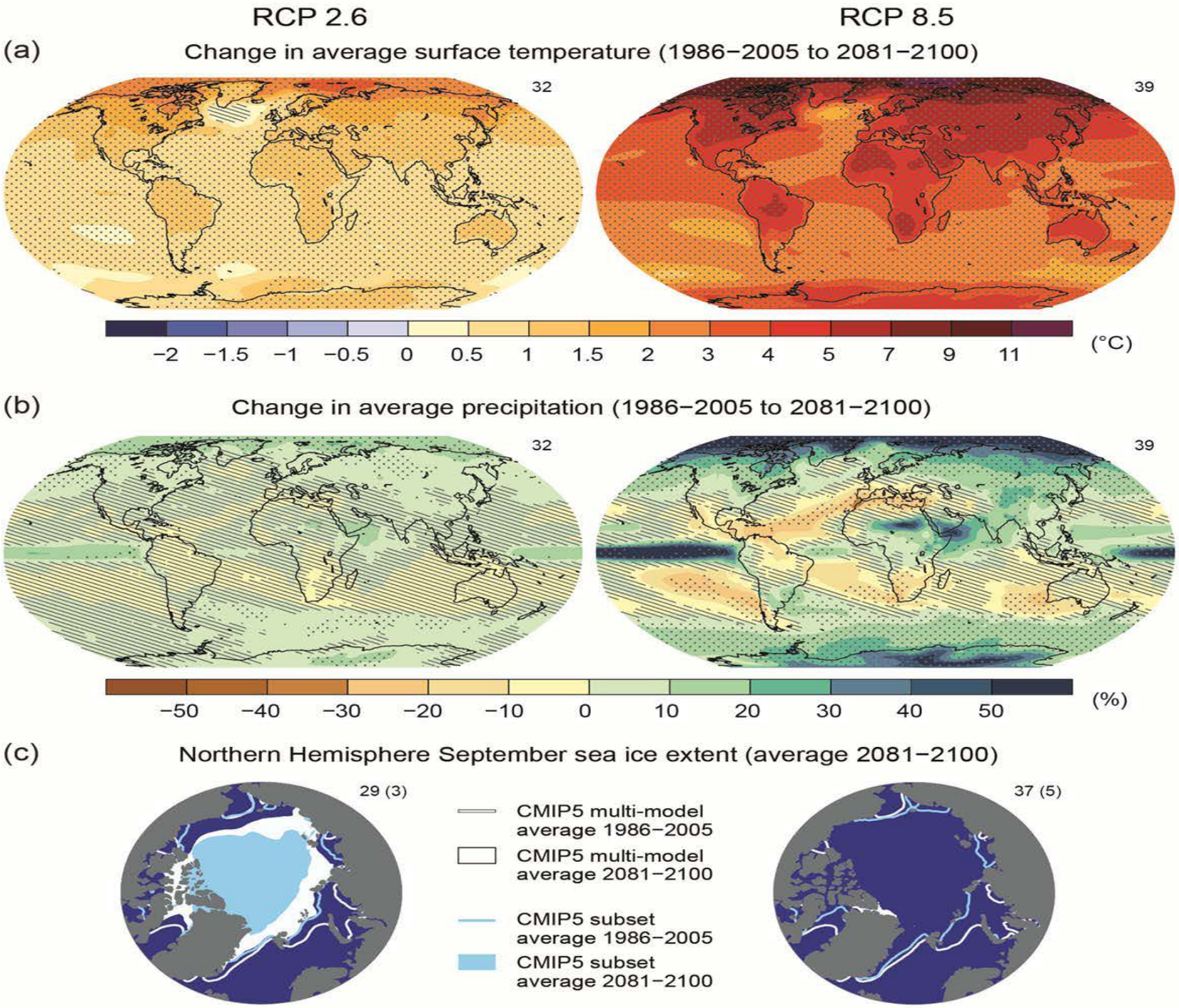
Climate change and agriculture

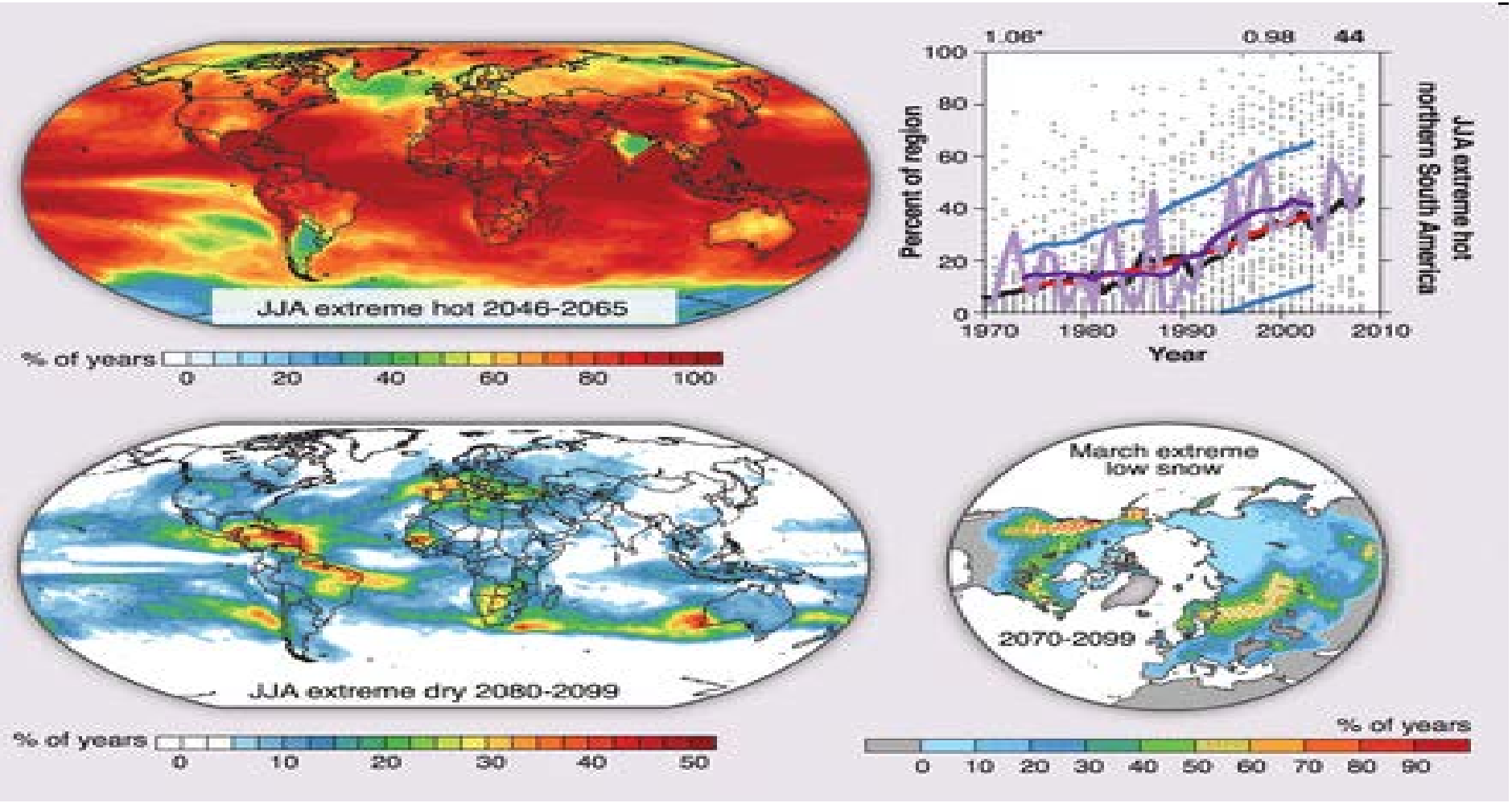
Bernard Seguin

INRA Avignon (France)

IPCC 2013

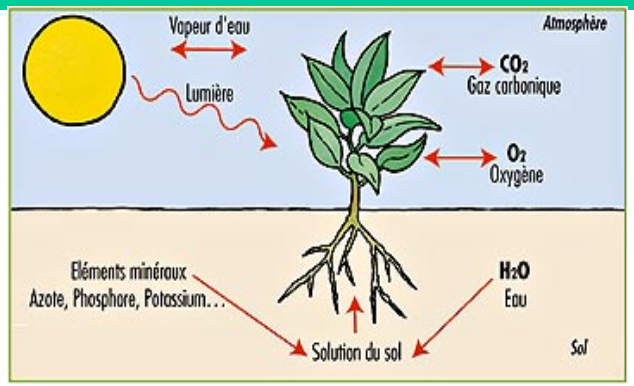

RCP 2.6
RCP 8.5
(a)
Change in average surface temperature (1986–2005 to 2081–2100)
32
39
−2 −1.5 −1 −0.5 0 0.5 1 1.5 2 3 4 5 7 9 11
(°C)
(b)
Change in average precipitation (1986–2005 to 2081–2100)
32
39
−50 −40 −30 −20 −10 0 10 20 30 40 50
(%)
(c)
Northern Hemisphere September sea ice extent (average 2081–2100)
29 (3)
37 (5)
CMIP5 multi-model average 1986–2005
CMIP5 multi-model average 2081–2100
CMIP5 subset average 1986–2005
CMIP5 subset average 2081–2100

The increase of extremes



Diffenbaugh et Field 2013

Impacts on plant production



CO2

? Rsolar

Tair

PET

? rainfall

PRODUCTION

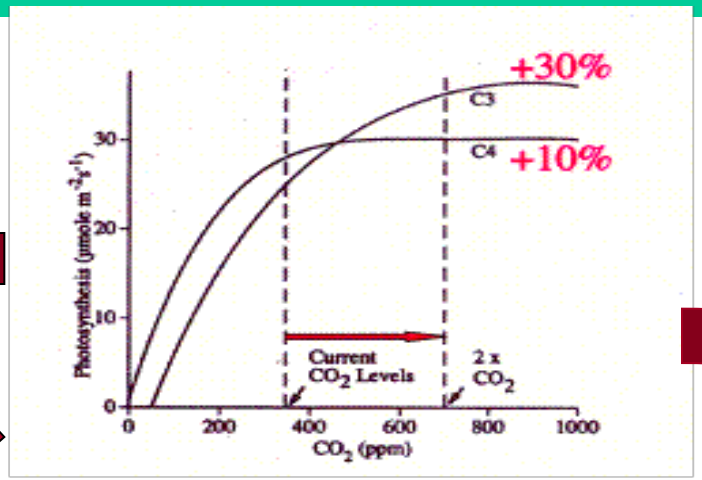
photosynthesis

cycle

Water balance
Nitrogen

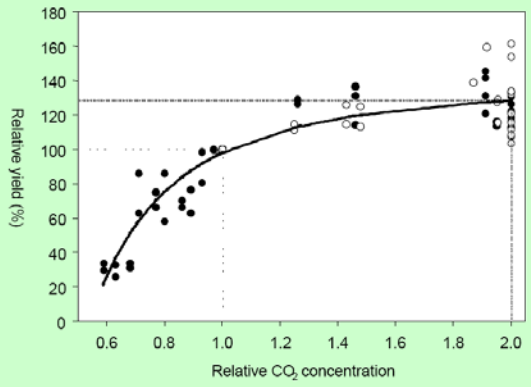
?

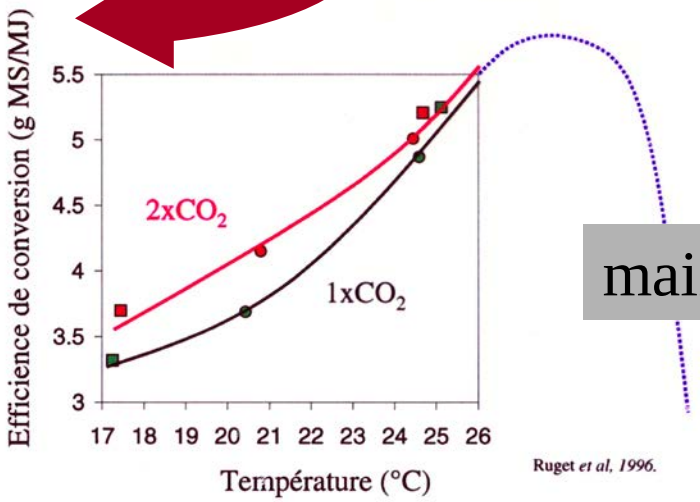
CO_2 and photosynthesis



Wheat yields with increasing CO_2 concentration

Danish Inst Agric Sciences





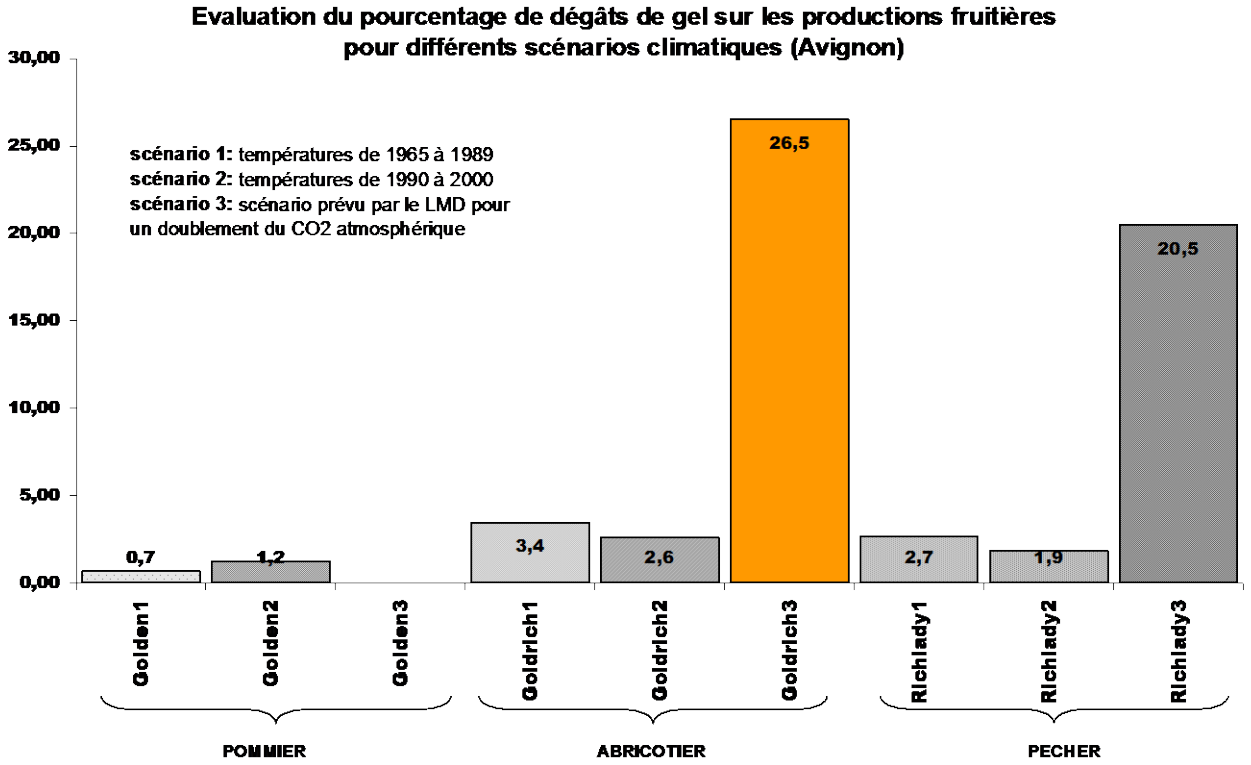
Ruget *et al, 1996.*

maize

INRA

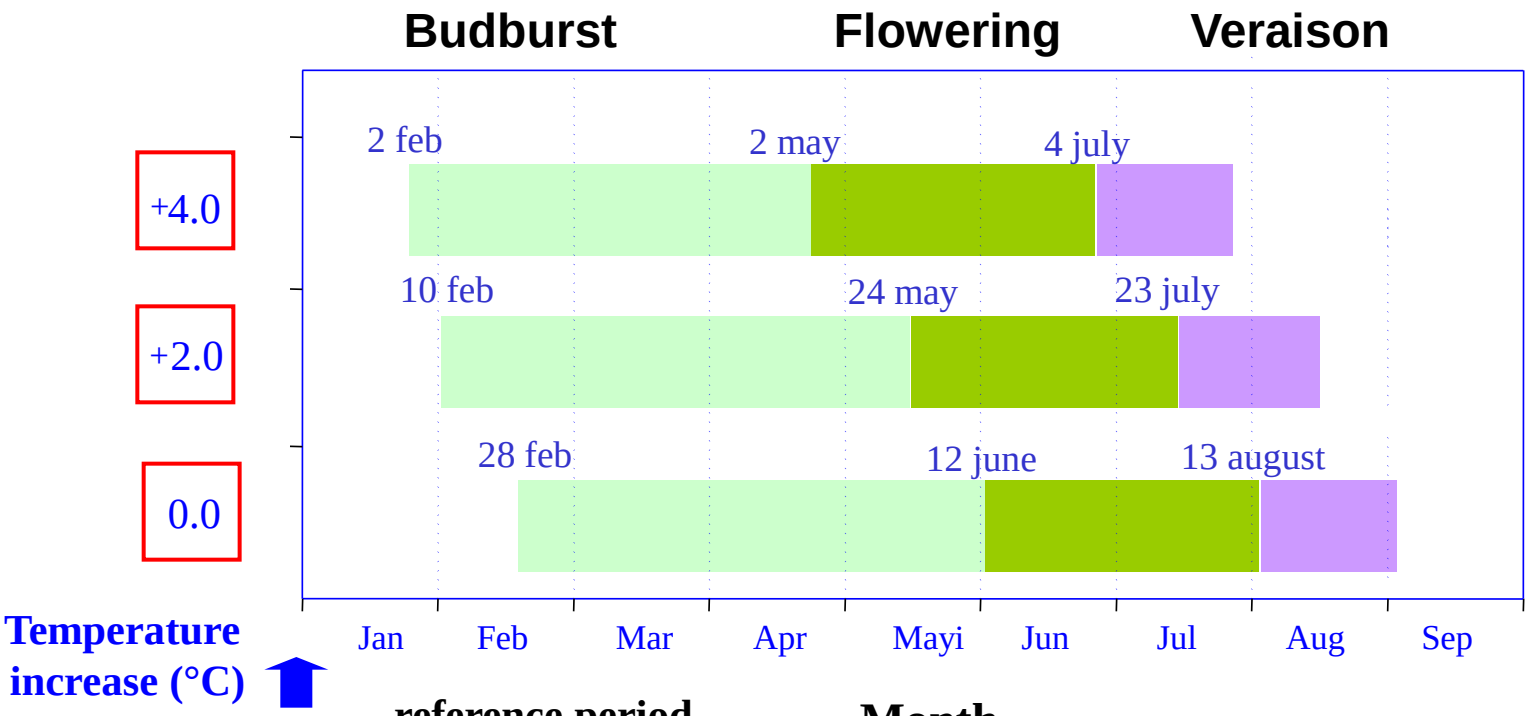
Phenology and fruit trees

problem of mild winters (dormancy break),
advance in phenology (flowering → frost risk/bad fruit setting)



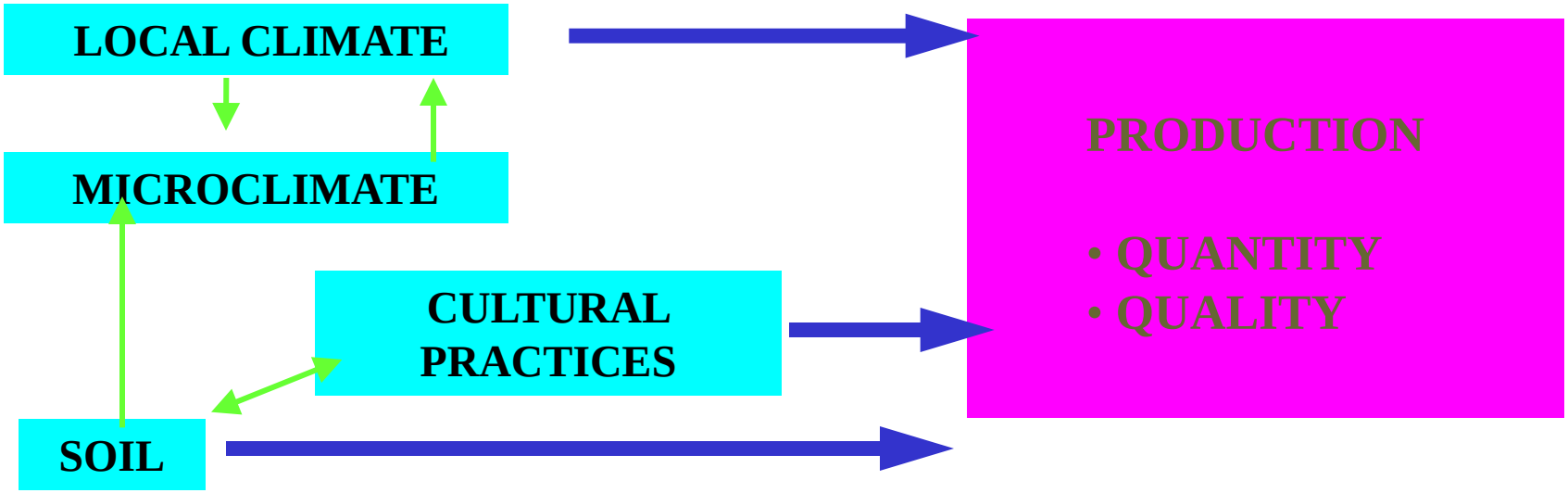
TOWARDS SHIFTS IN PHENOLOGY

An advance of ripening period towards the summer hottest period



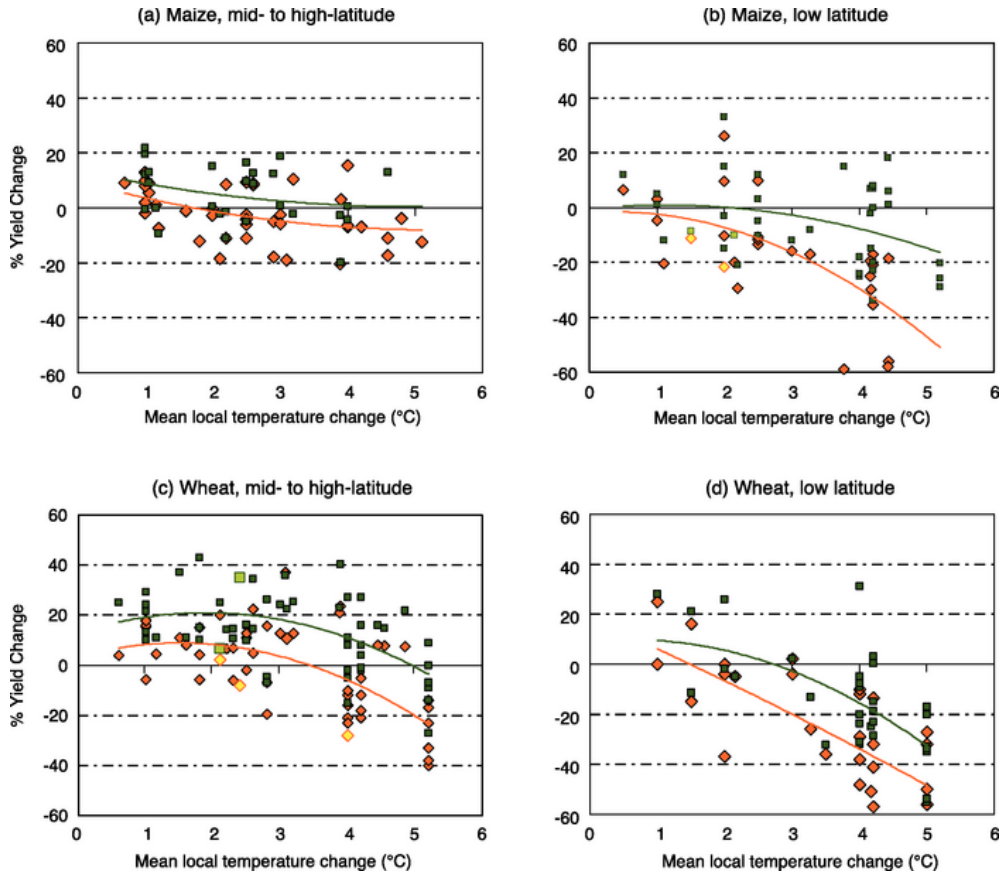
Lebon (2002)

More inputs with crop models



- **Integration of knowledge**
  Light microclimate, water budget, energy balance
- **Taking account of interactions**
  « climate x soil x cultural practices »
- **integration of quality criteria (sugar, acidity, biochemical components)**

Impacts on annual crops (IPCC 2007, WG II, ch5)



Which impact for livestock? (IPCC 2007)

» Pastures and forage:

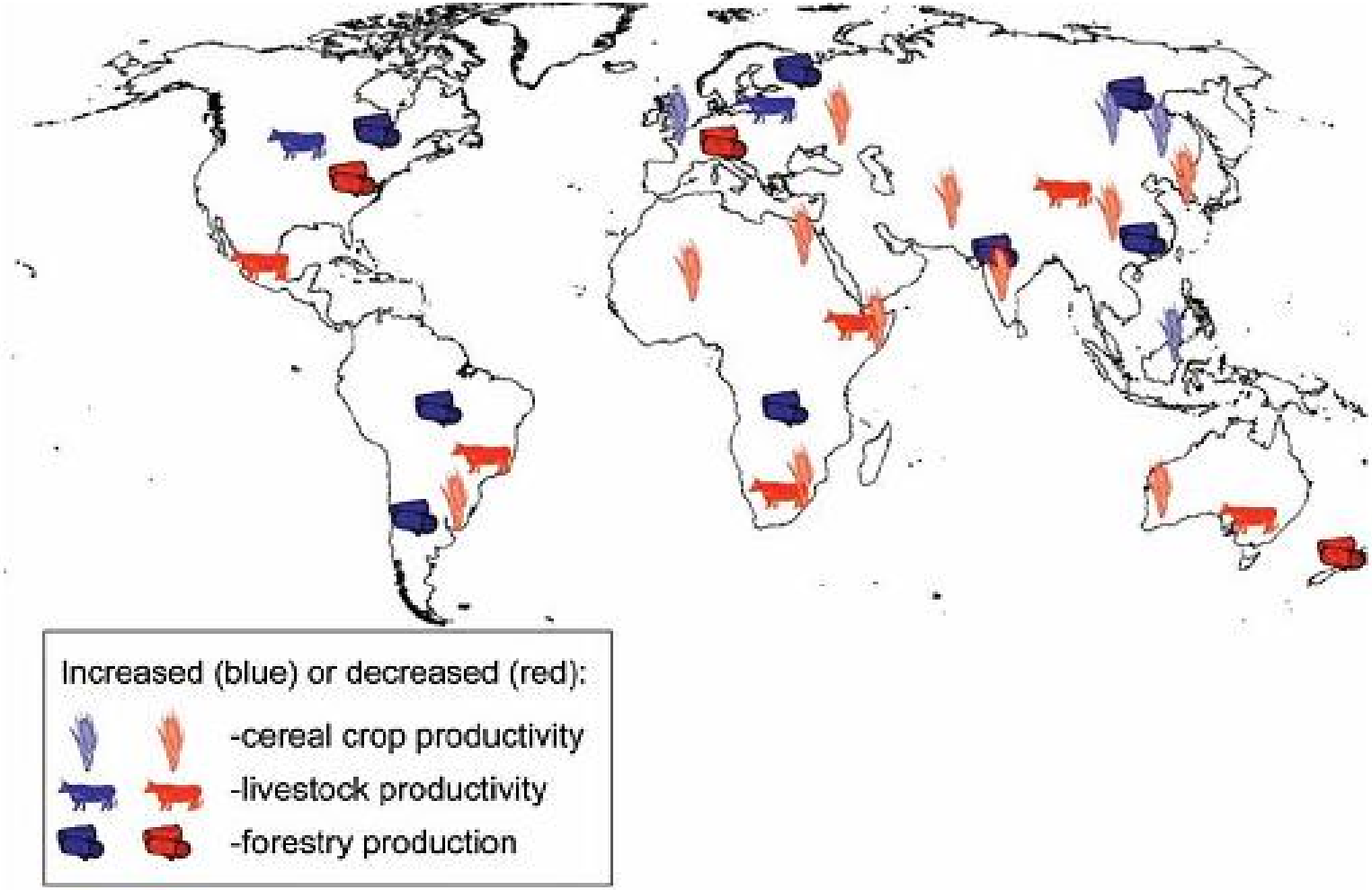
- production to increase in humid temperate grasslands (up to 2°C) and to decrease in arid and semi-arid regions
- plant community structure to be modified
- changes in forage quality and grazing behaviour are confirmed

• Animals

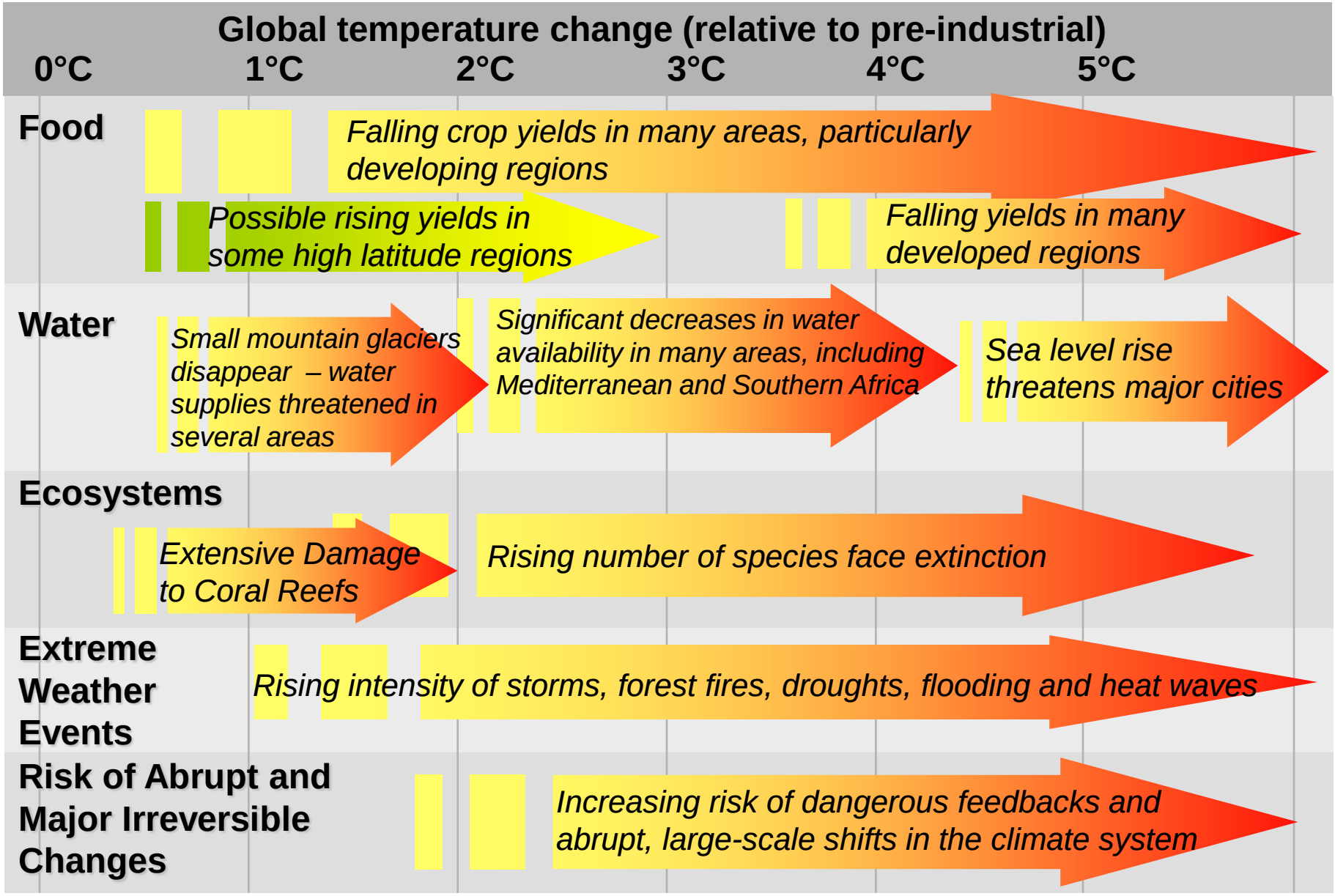
- thermal stress reduces productivity
- affects conception rates
- increases water requirements
- climate variability and droughts may lead to livestock loss

Few studies for tropical grasslands and rangelands

The global impact (IPCC AR4)



Projected impacts of climate change



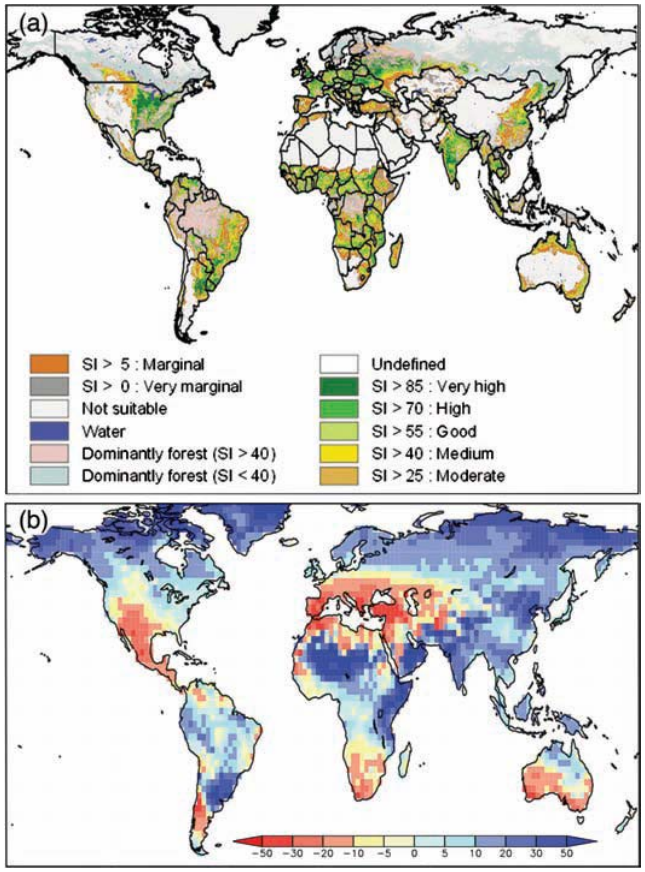
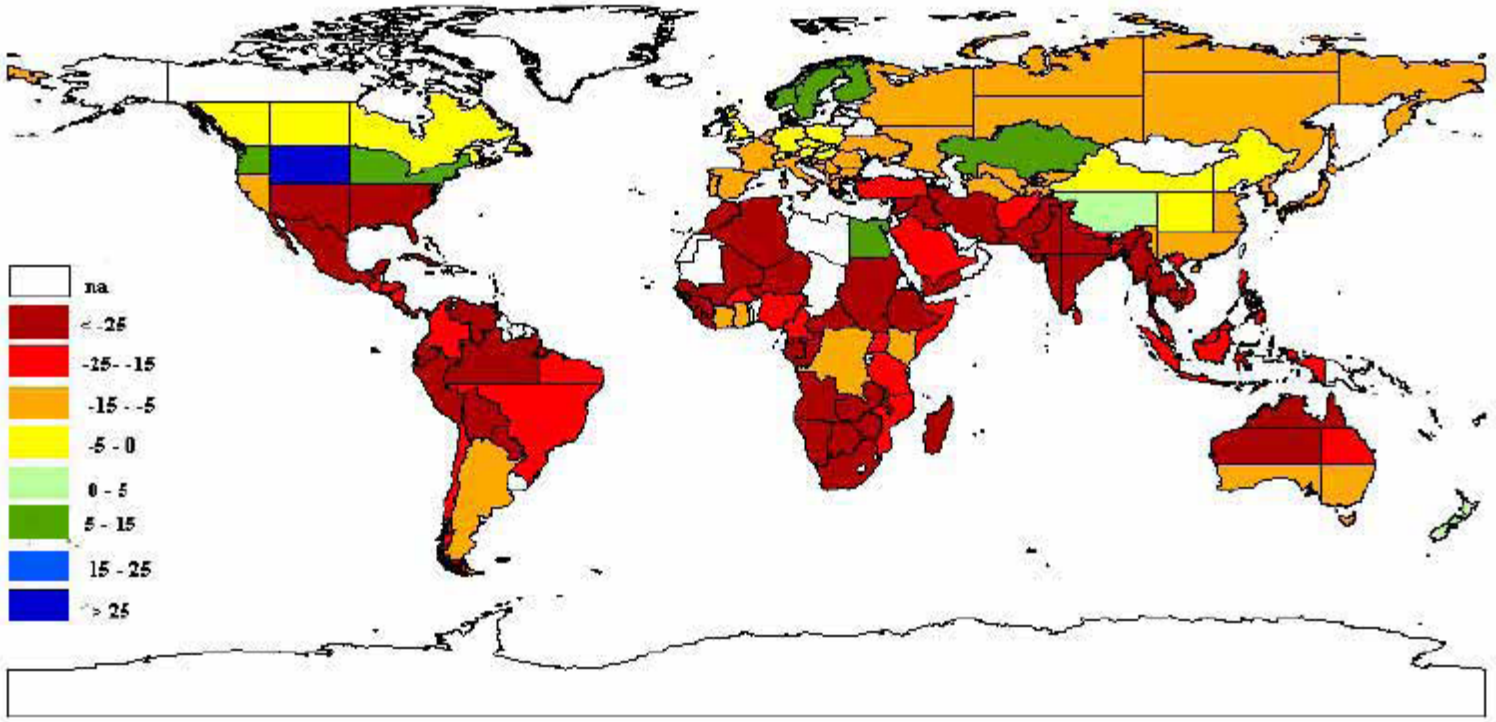


Figure 5.1. *(a) Current suitability for rain-fed crops (excluding forest ecosystems) (after Fischer et al., 2002b). SI = suitability index; (b)Ensemble mean percentage change of annual mean runoff between present (1981 to 2000) and 2100 (Nohara et al., 2006). From IPCC AR4*

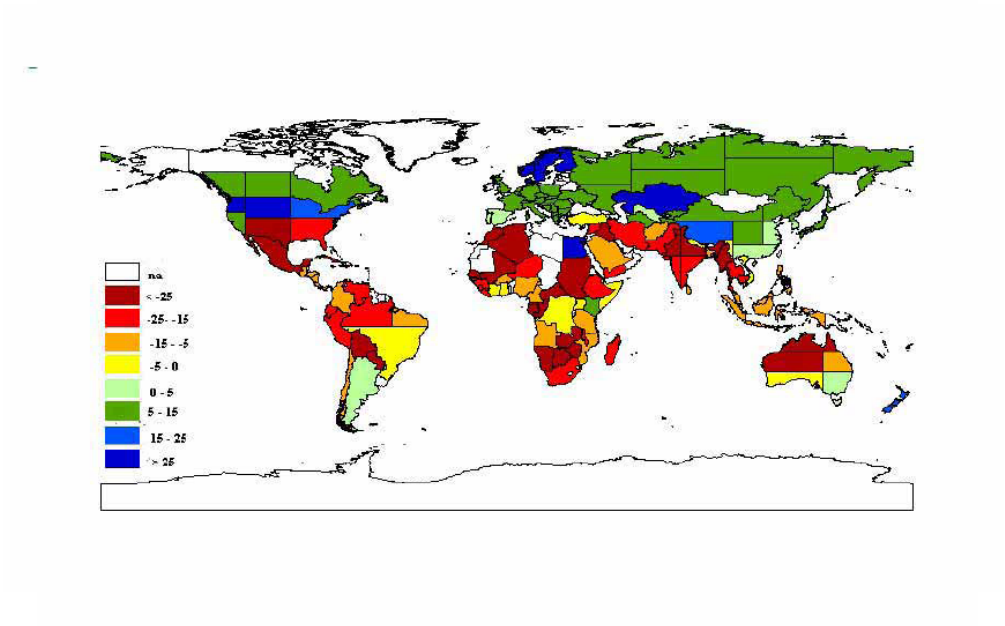
Impact on Agricultural Productivity without Carbon Fertilization (percent)



Cline 2007

The accentuation of N/S contrast

Impact on Agricultural Productivity with Carbon Fertilization (percent)



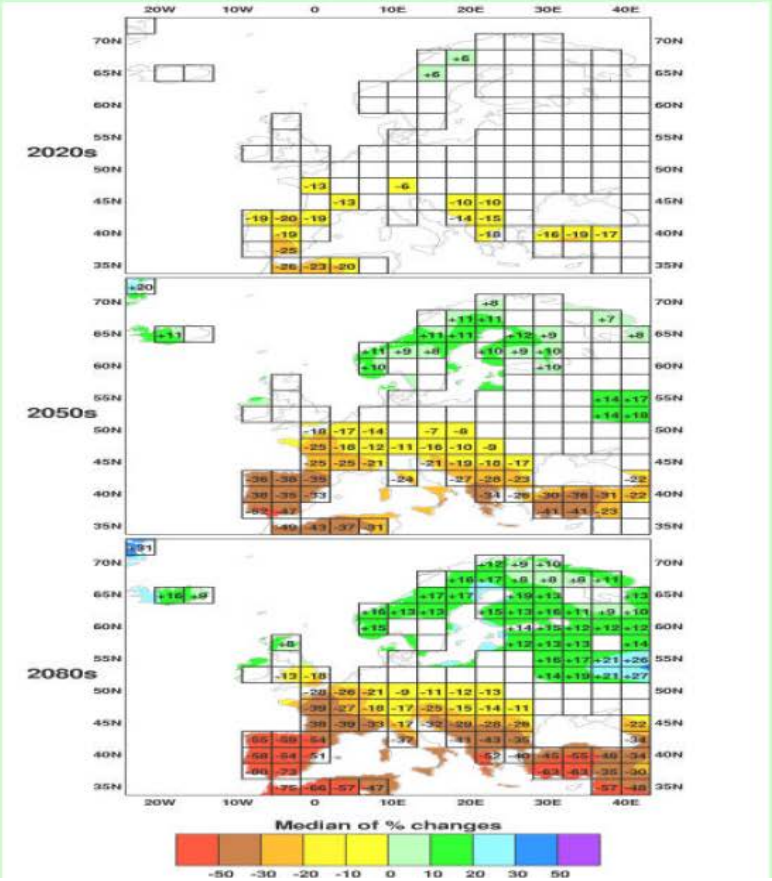
Cline 2007

Summer Precipitation

(only significant changes shown)

Acacia project

A2

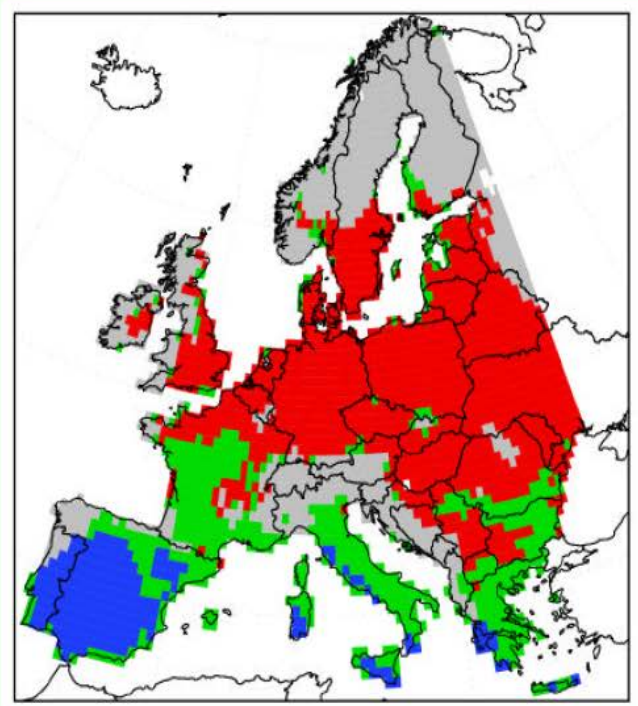


Parry 2005

PRUDENCE

Changes in wheat yield, 2080

(amount of agreement between 9 regional models, A2)

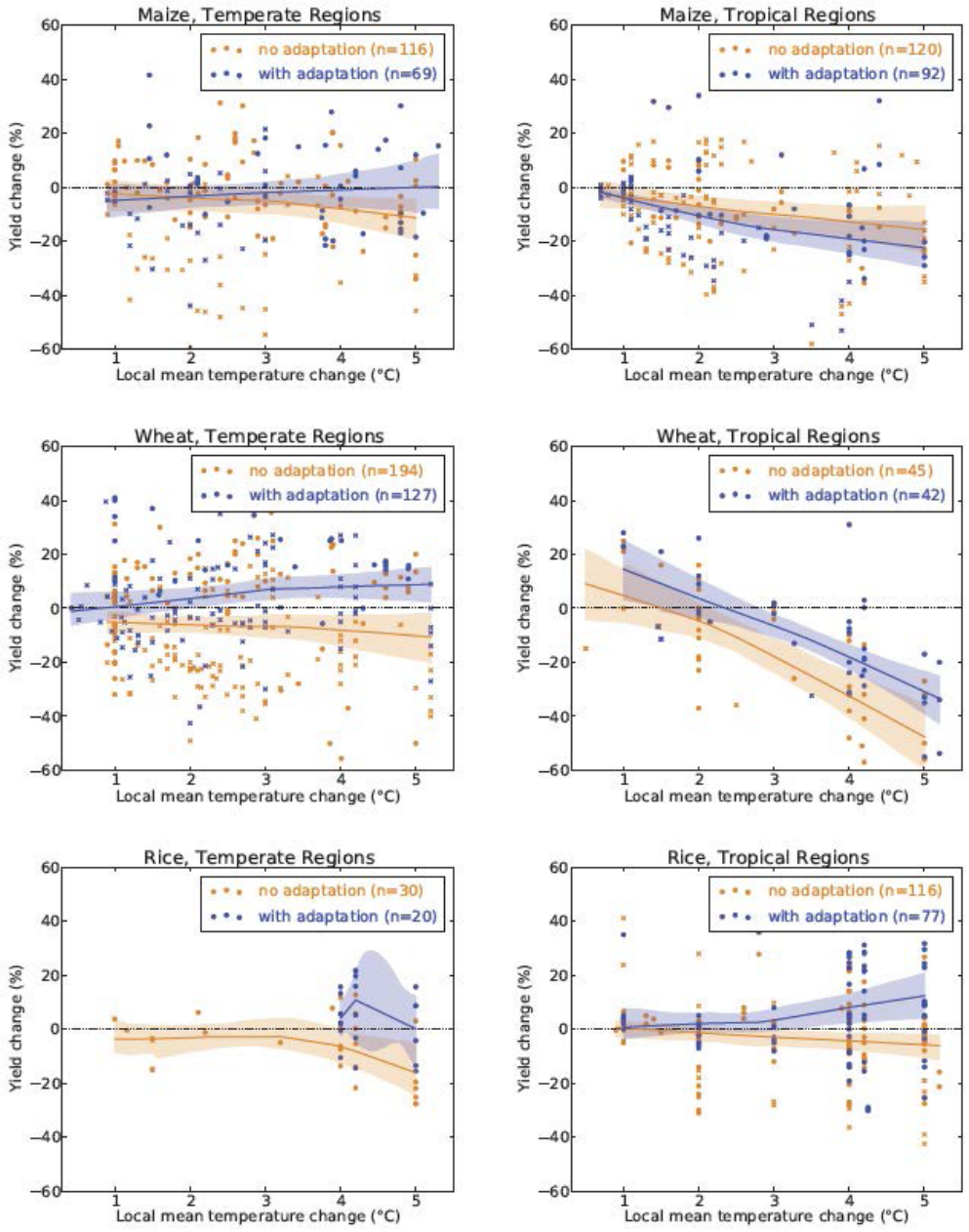


Reduced yield in all models

Increased yield in all models

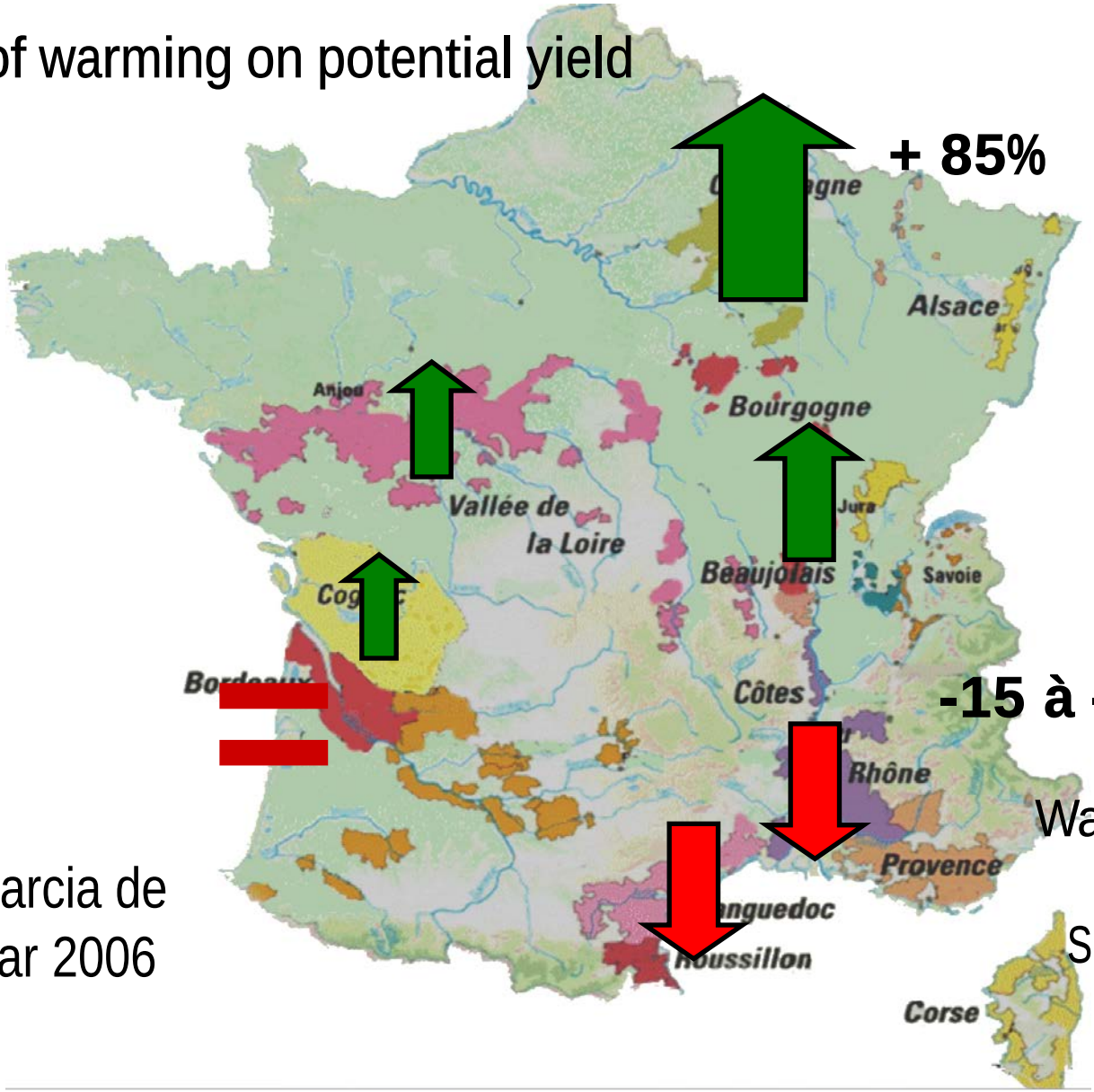
Models do not agree

Parry (2005)



IPCC 2014
WG II, ch 7)

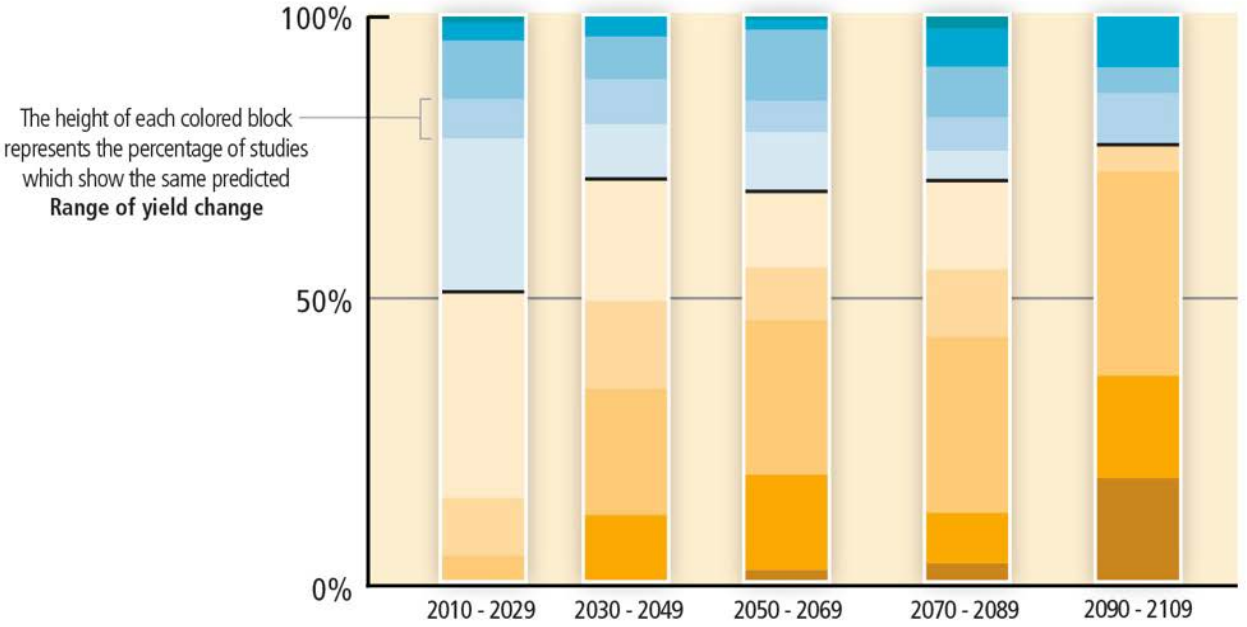
Effect of warming on potential yield

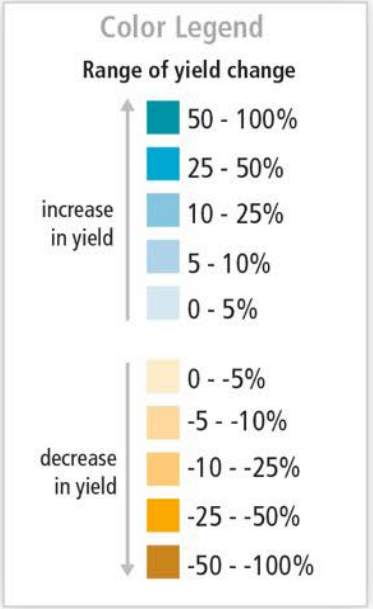


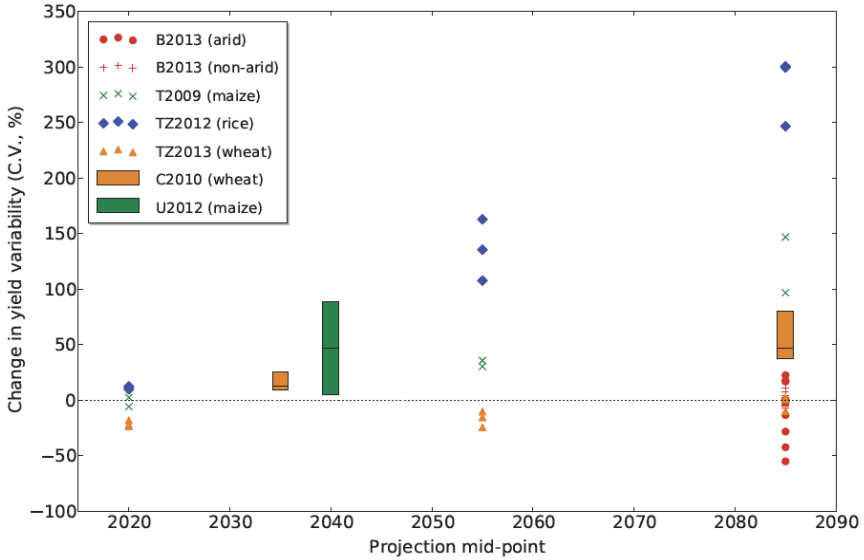
PhD Garcia de Cortazar 2006

Water and heat tress
Shortening of cycle

Intensité dépend du type du sol

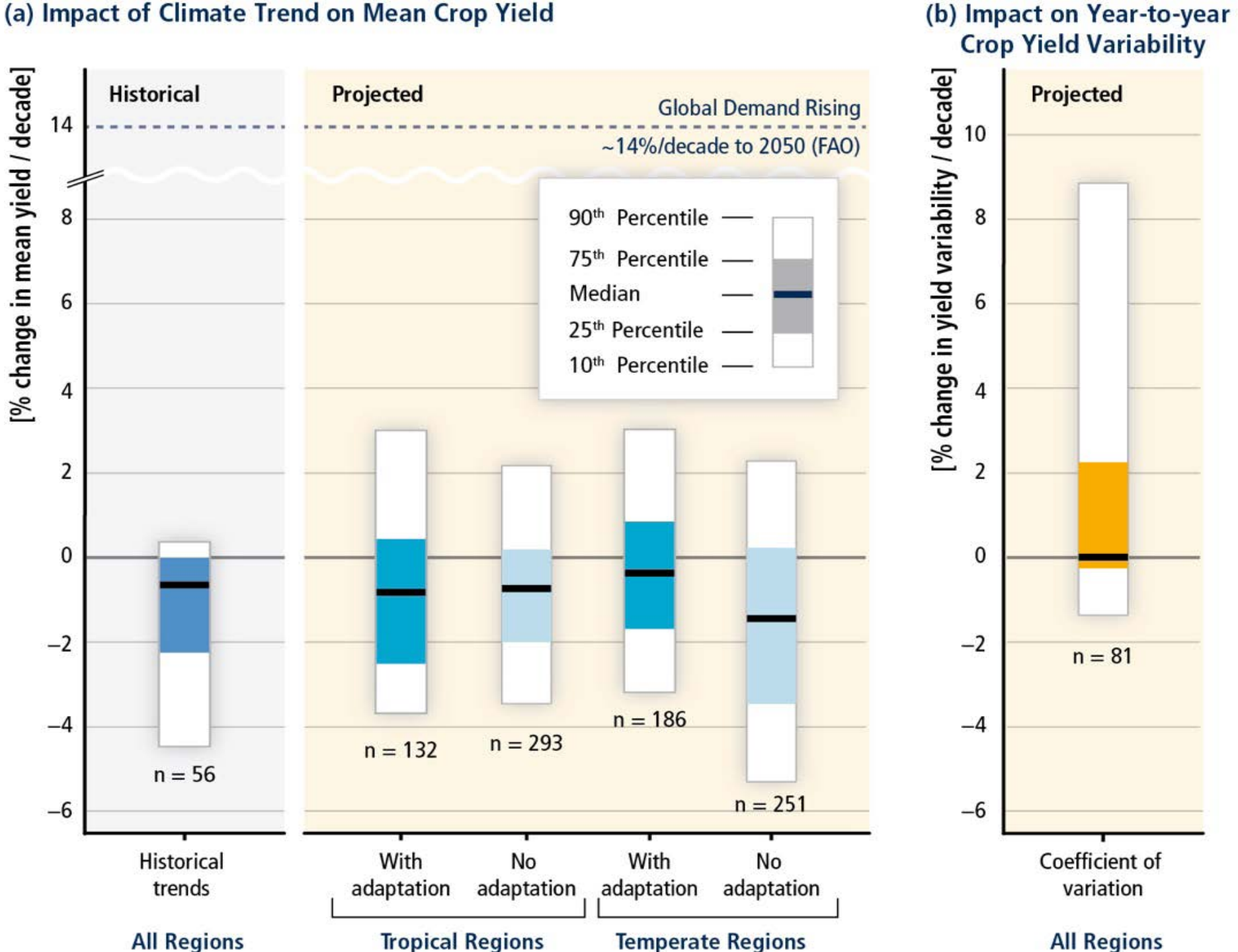






IPCC 2014, ch7

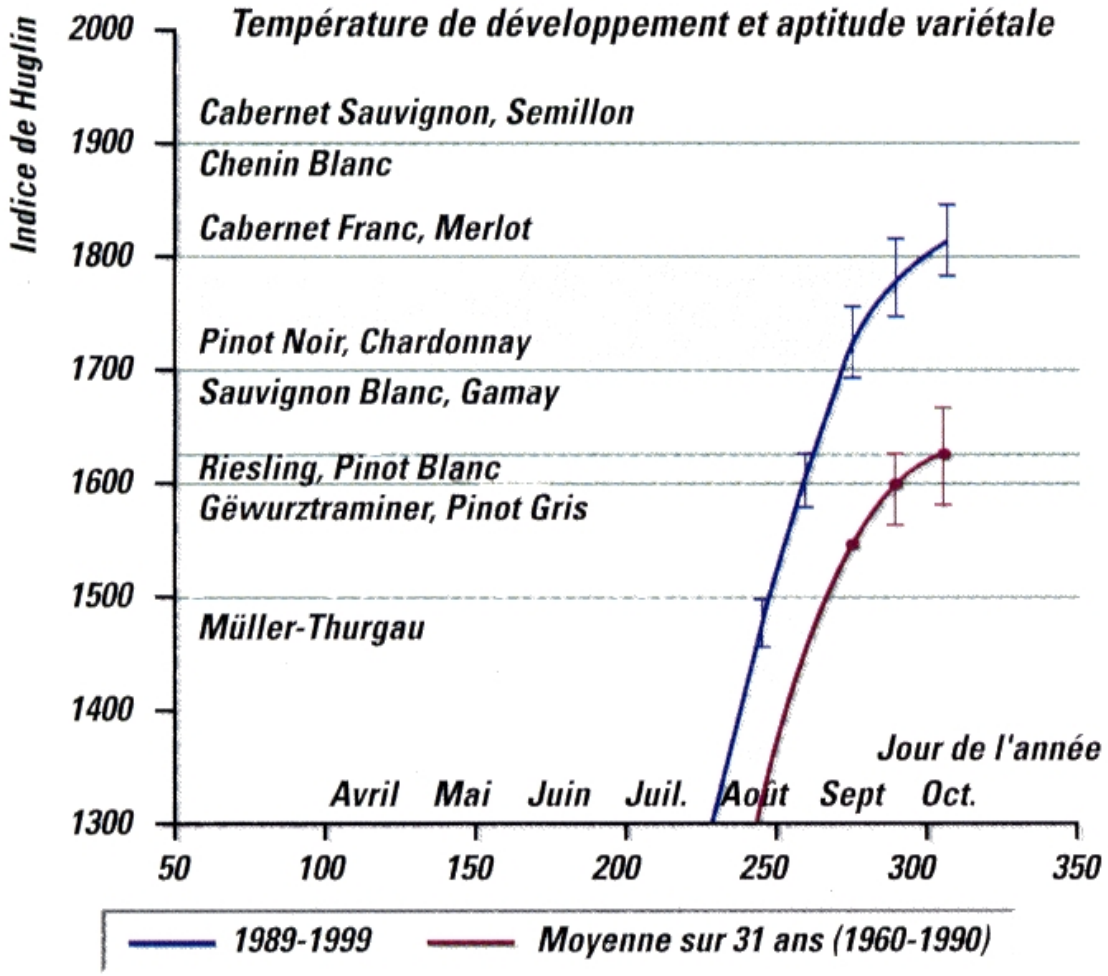
from


(a) Impact of Climate Trend on Mean Crop Yield
(b) Impact on Year-to-year Crop Yield Variability
[% change in mean yield / decade]
[% change in yield variability / decade]
Historical
Projected
Global Demand Rising
~14%/decade to 2050 (FAO)
90th Percentile
75th Percentile
Median
25th Percentile
10th Percentile
14
8
6
4
2
0
–2
–4
–6
10
n = 56
n = 132
n = 293
n = 186
n = 251
n = 81
Historical trends
With adaptation
No adaptation
With adaptation
No adaptation
Coefficient of variation
All Regions
Tropical Regions
Temperate Regions
All Regions

Local adaptation for cropping systems

- - genetic material (precocity, cycle duration, thermal optimum, chilling requirements, frost sensitivity ..)
- - adjustment of cultural practices : sowing dates, fertilization/irrigation,...
- - coping with pests and diseases

TRENDS IN POTENTIALITIES FOR VARIETIES IN GERMANY (Geisenheim)



Source : Schultz, 2000

Adaptation by geographical displacement

- + 1° ~ 200 km towards the North (in France) or 150m in altitude

- up to now, few evidences of recent evolution

- but need to consider future displacements in production zones (change in potentialities, new crops)..

- what about the economical context ?

- and the ‘ terroirs’ (they cannot be delocalized !) ?

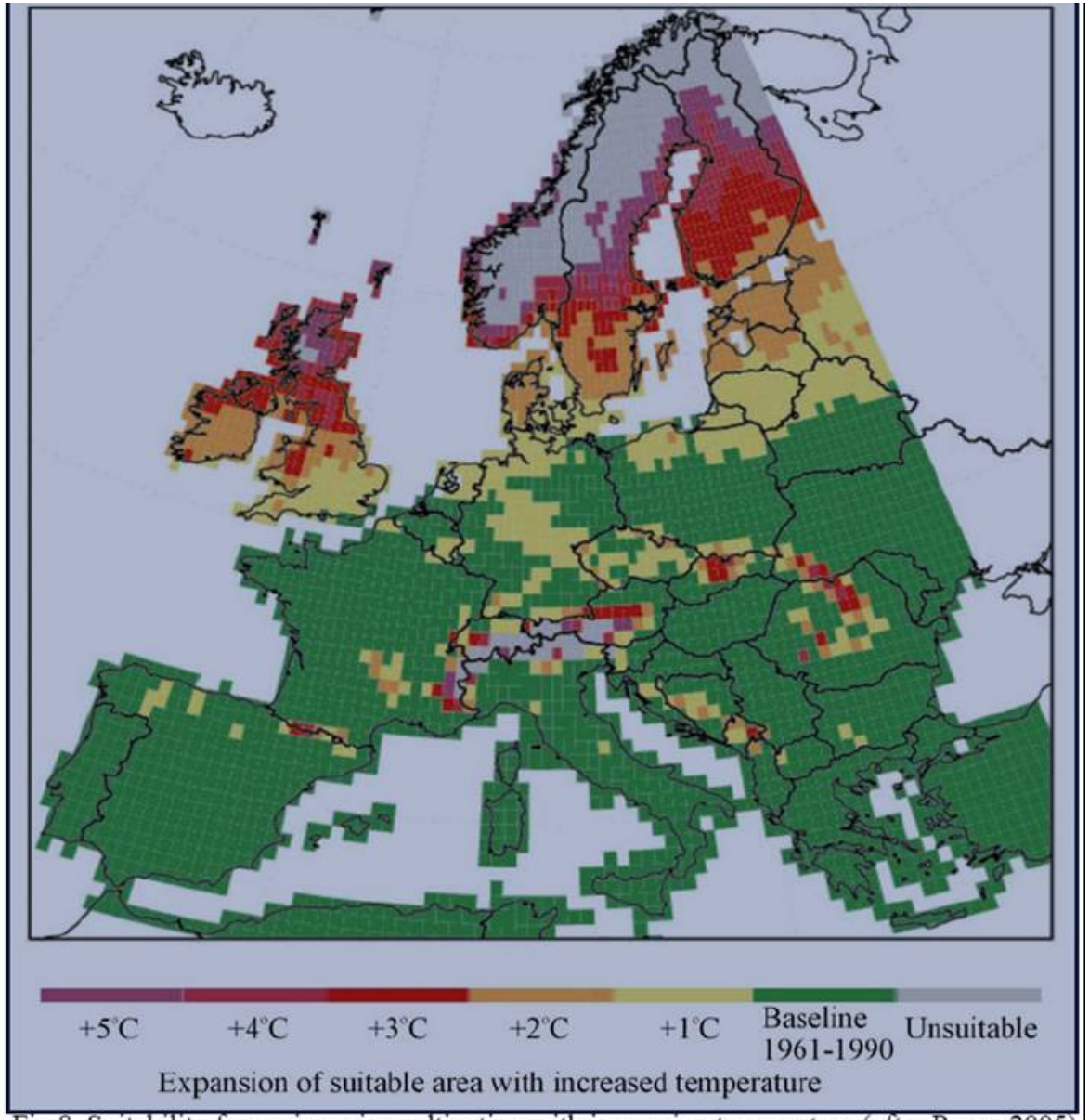
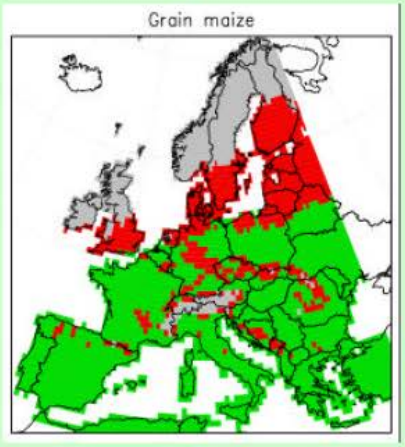
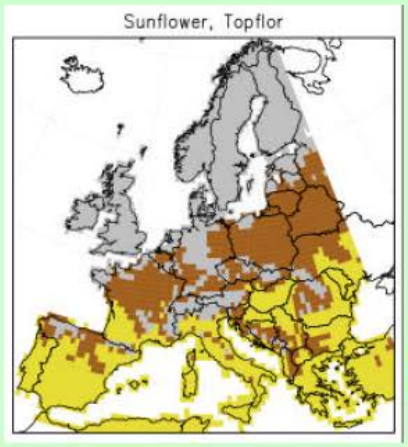


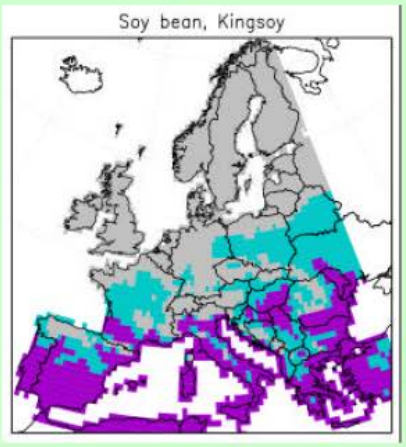
Fig.8. Suitability for grain maize cultivation with increasing temperature (after Parry, 2005)

SYKE

Suitability for grain maize, sunflower and soya, 2050s



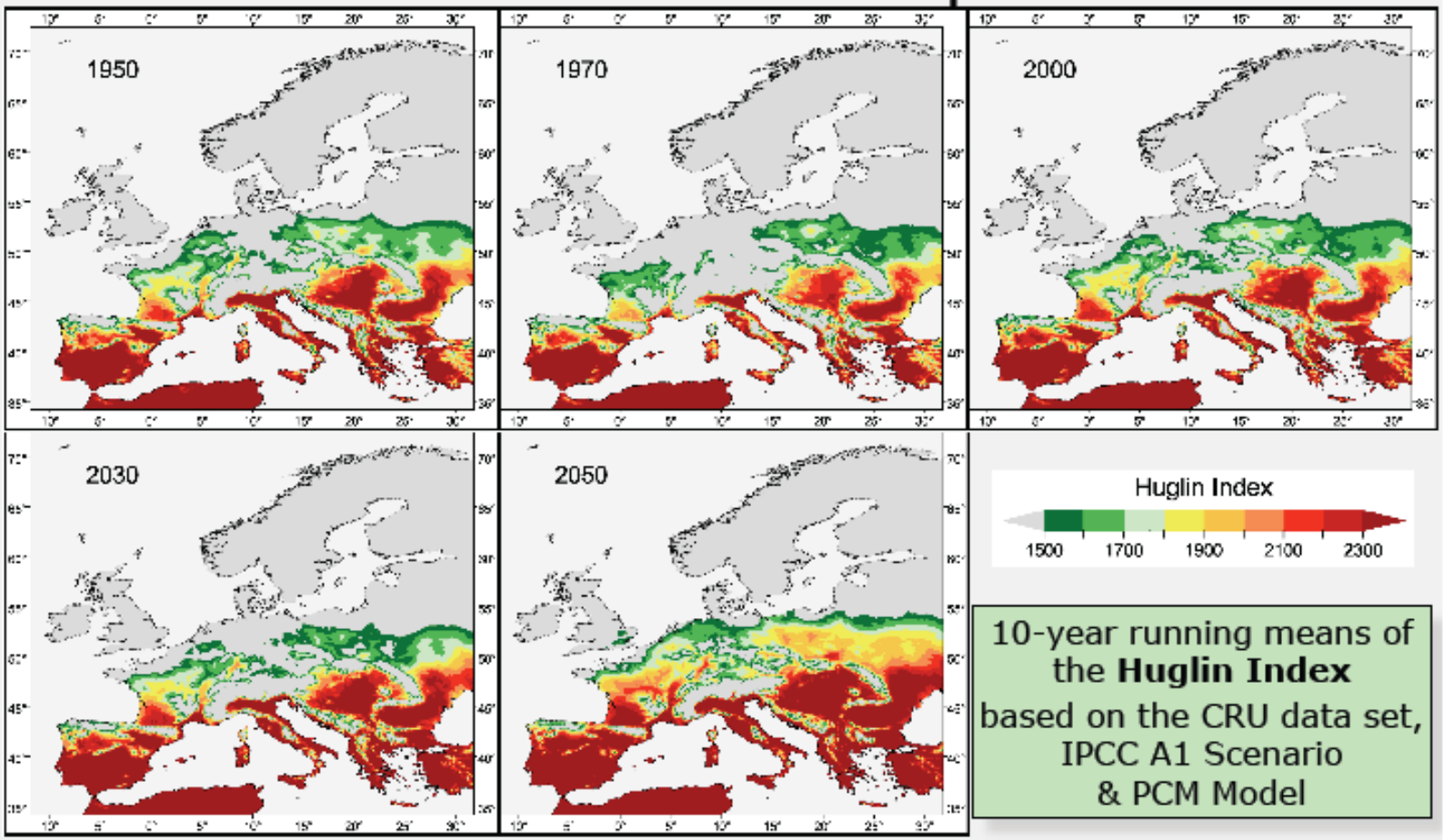




red/brown/blue: suitability extension
green/yellow/purple: Baseline 1961-90

Parry 2005

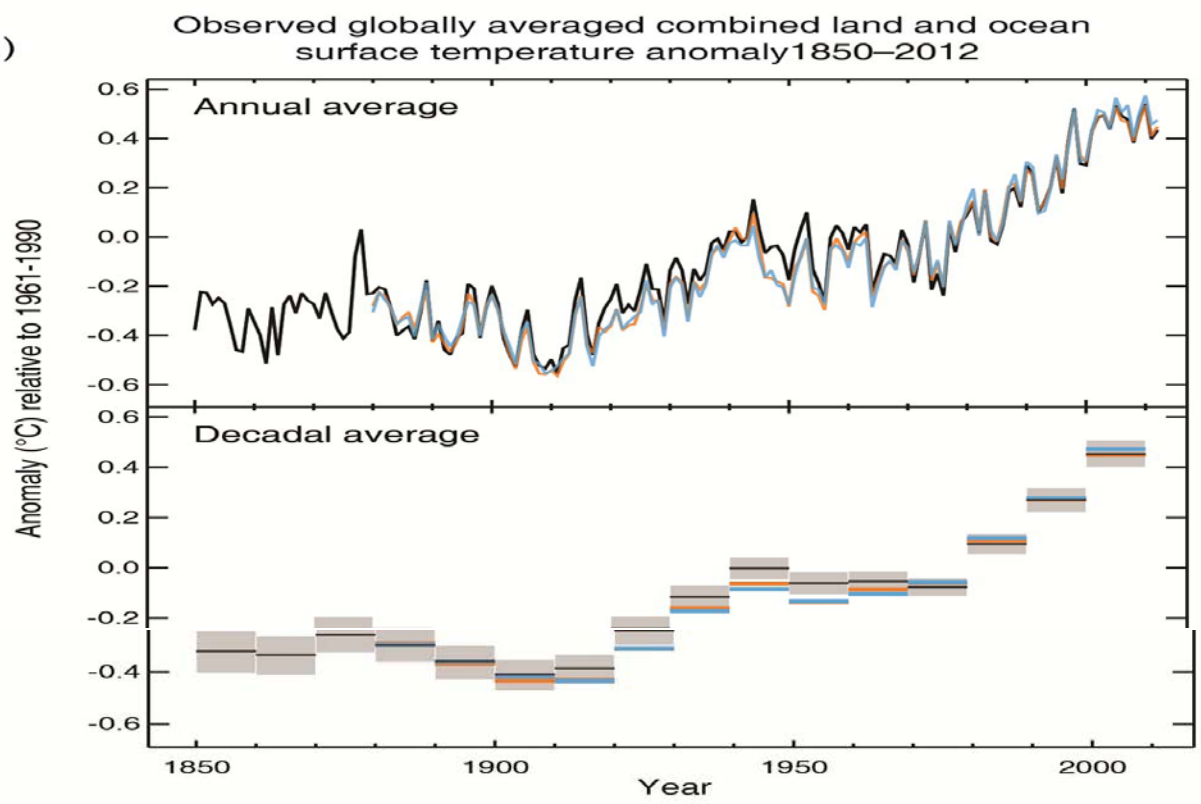
Climate Change Impact Assessment for Viticulture in Europe

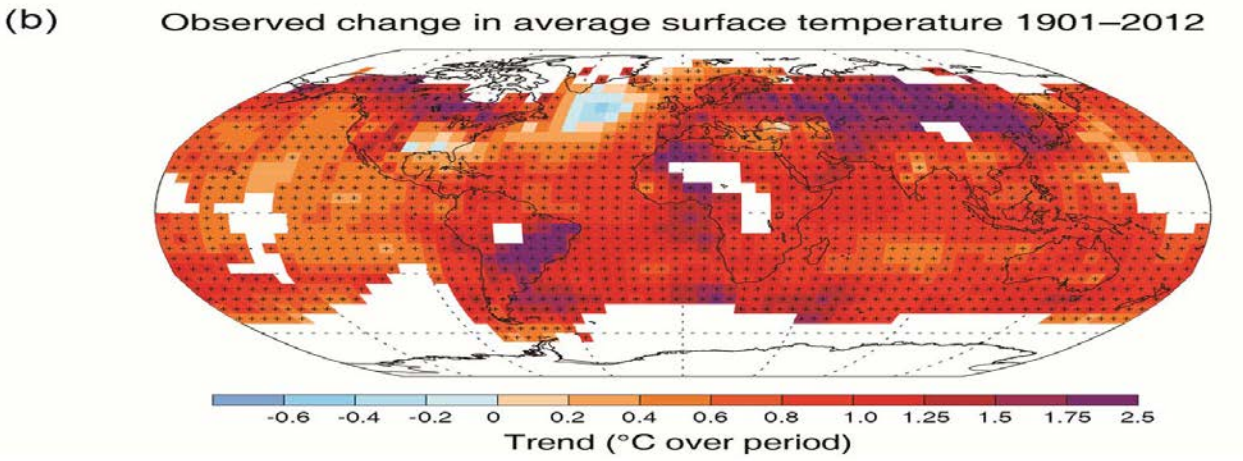


10-year running means of the **Huglin Index** based on the CRU data set, IPCC A1 Scenario & PCM Model

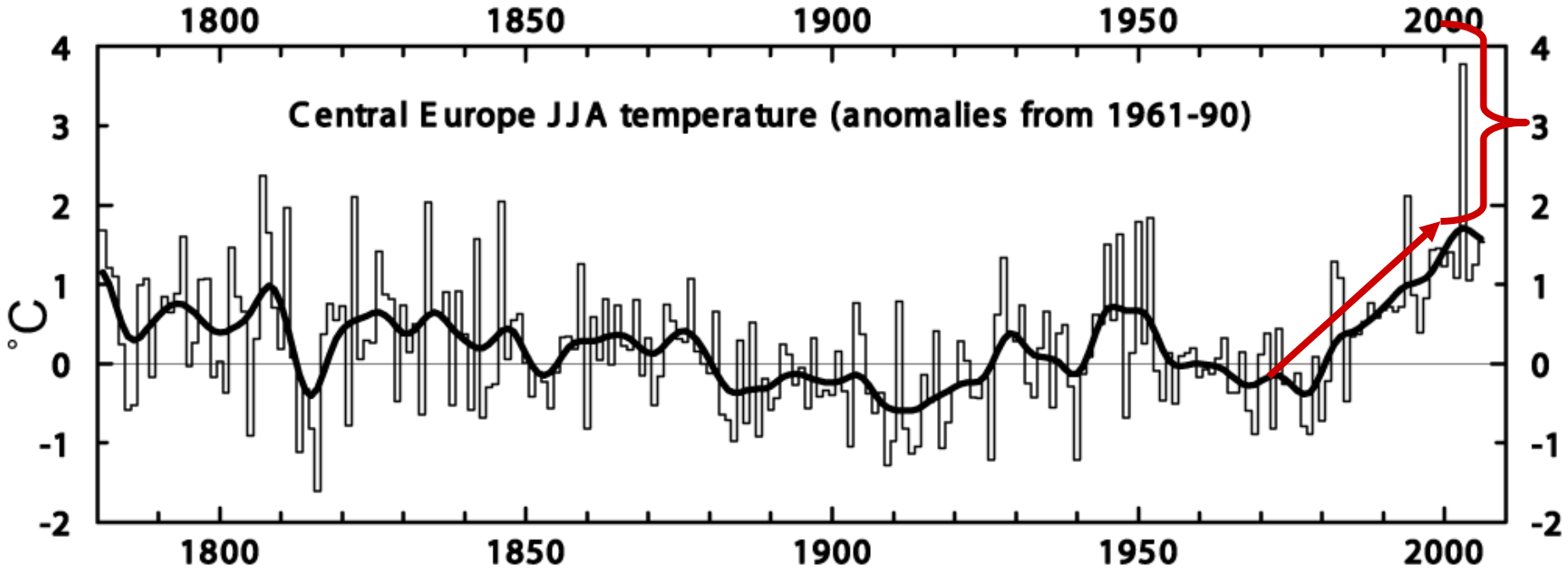
Stock, PIK

IPCC 2013


(a)
Observed globally averaged combined land and ocean surface temperature anomaly1850–2012
Annual average
Decadal average
Anomaly (°C) relative to 1961-1990
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1850
1900
1950
2000
Year


(b)
Observed change in average surface temperature 1901–2012
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1.0
1.25
1.5
1.75
2.5
Trend (°C over period)

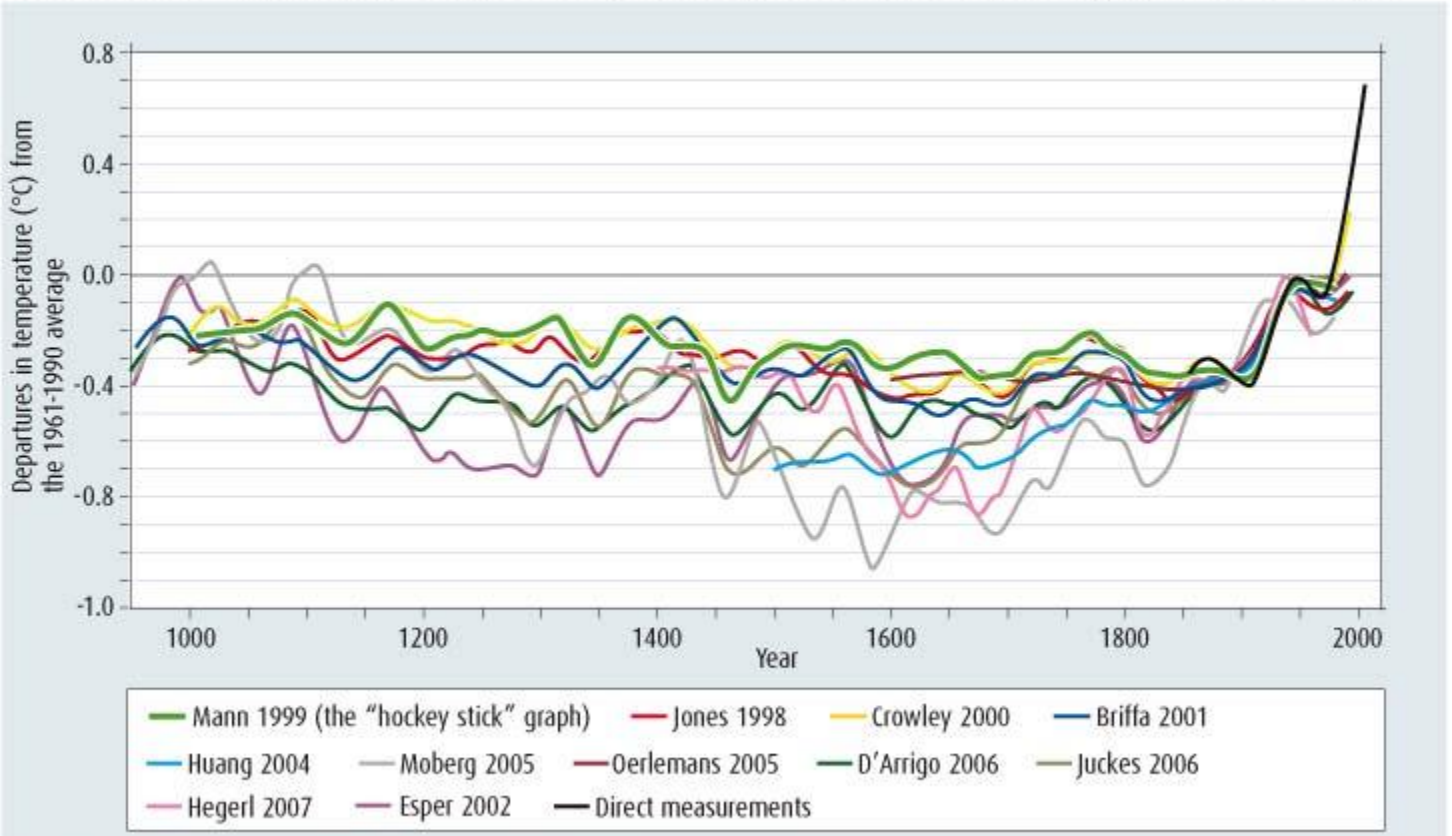
Heat waves are increasing: an example



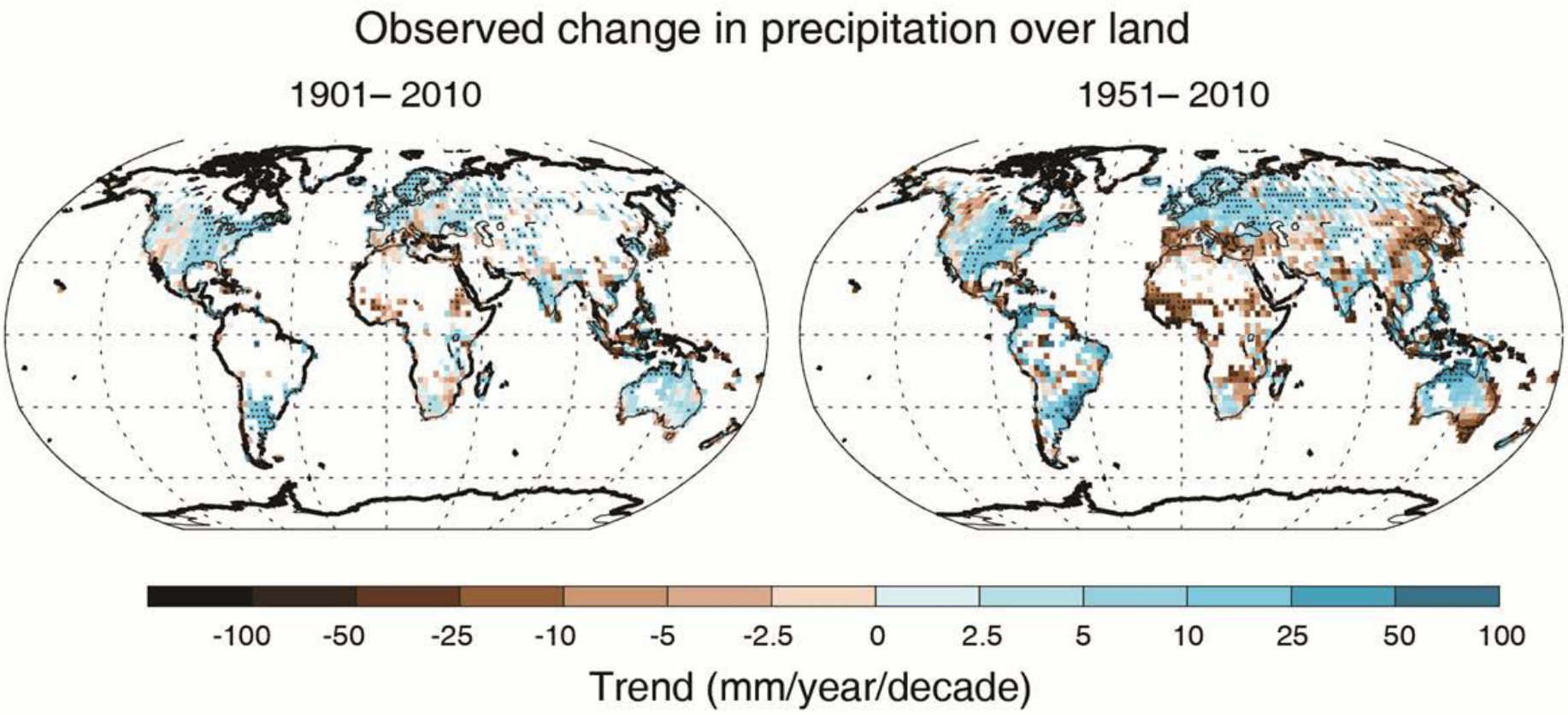
Extreme Heat Wave
Summer 2003
Europe

TEMPERATURE OVER THE PAST 1000 YEARS

Reconstructions of northern hemisphere temperature vary but all suggest it is warmer now than at any time in the past 1000 years

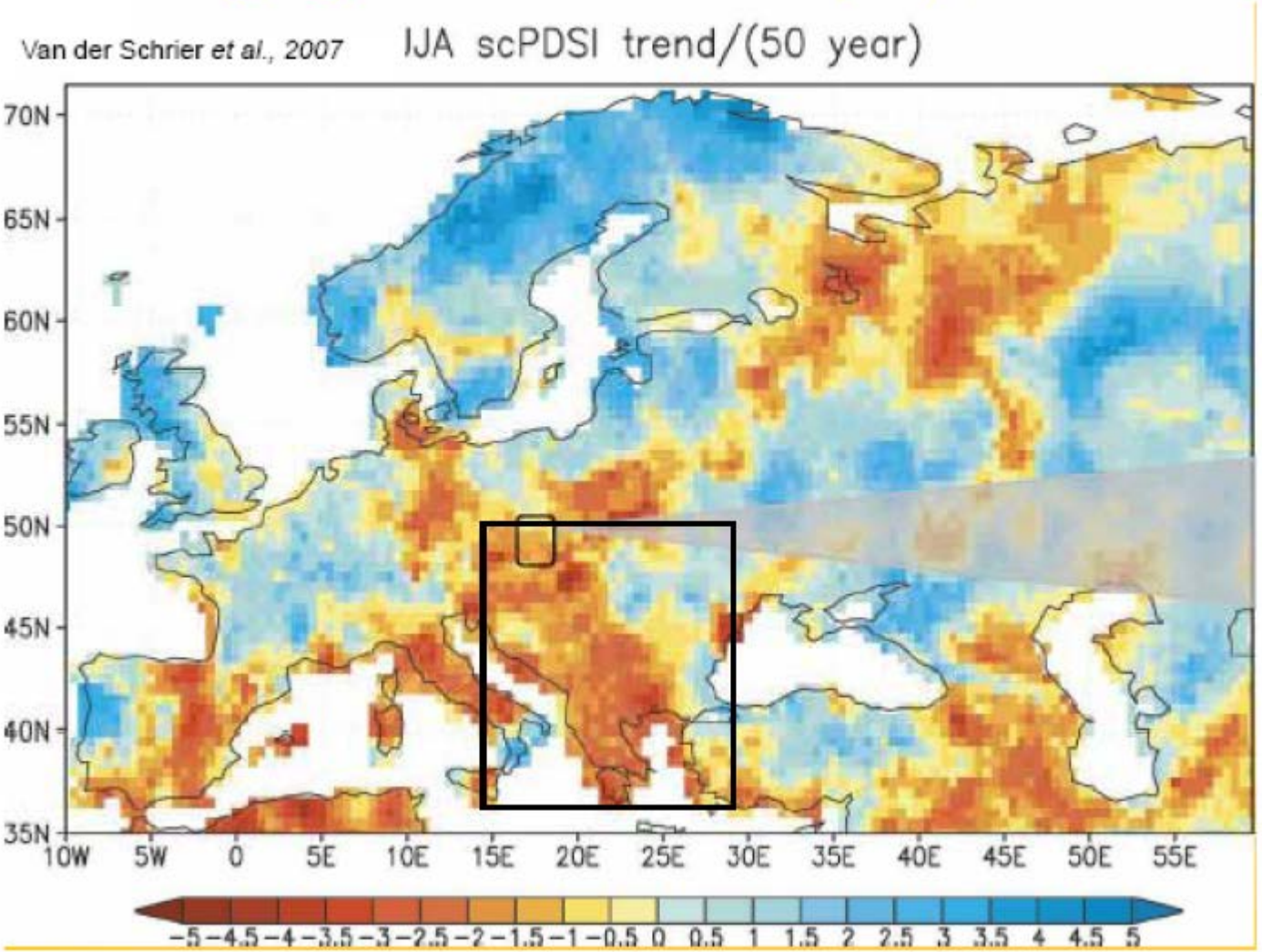


Compiled for *New Scientist* by Rob Wilson of the University of Edinburgh, UK


Observed change in precipitation over land
1901– 2010
1951– 2010
-100
-50
-25
-10
-5
-2.5
0
2.5
5
10
25
50
100
Trend (mm/year/decade)

IPCC 2013

Past drying trends over Europe (1950-2000)



History of food prices (IPCC 2014, ch 7)

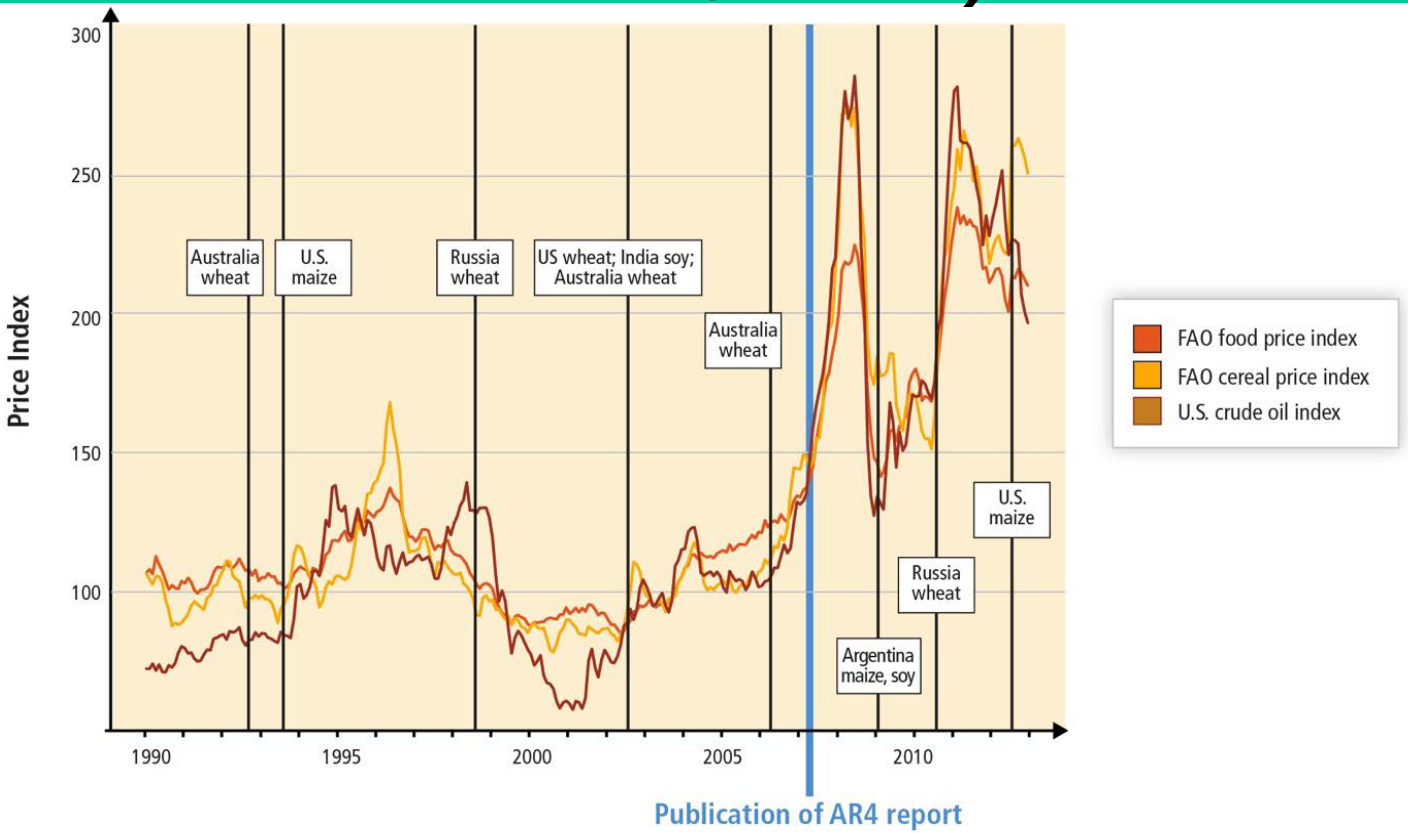
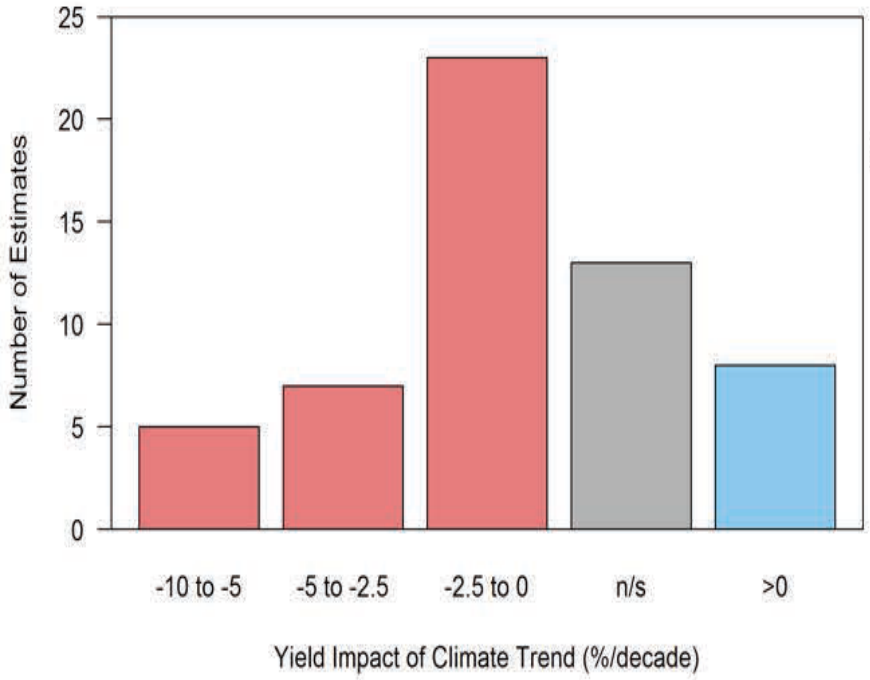


Figure 7-3: Since the AR4 report, international food prices have reversed historical downward trend. Plot shows history of FAO food and cereal price index (composite measures of food prices), with vertical lines indicating events when a top 5 producer of a crop had yields 25% below trend line (indicative of a seasonal climate extreme).



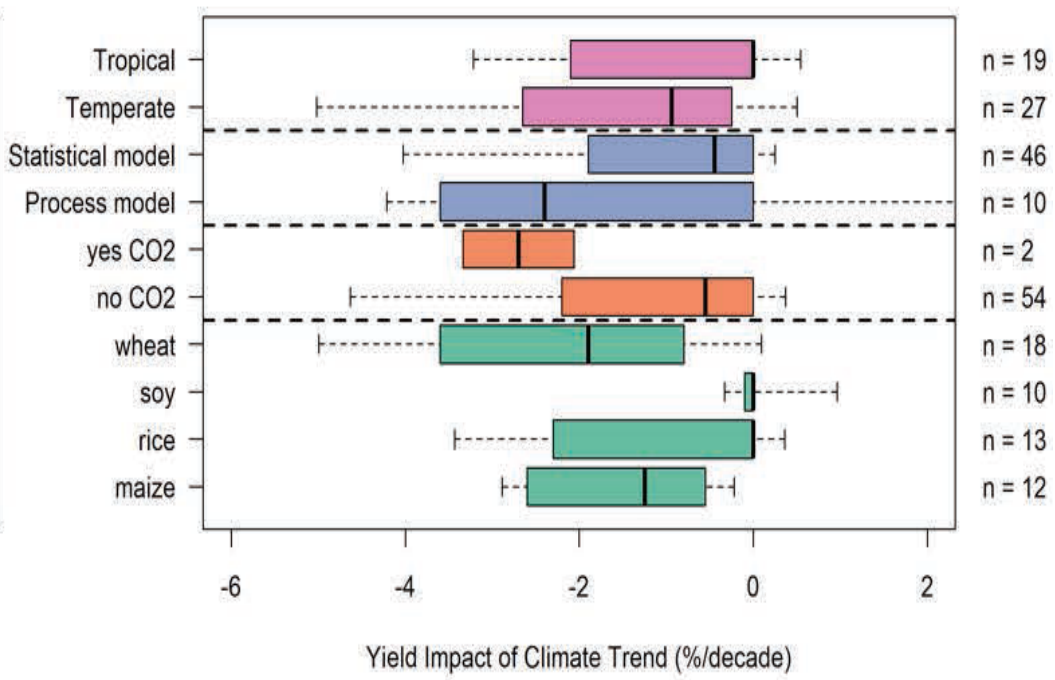
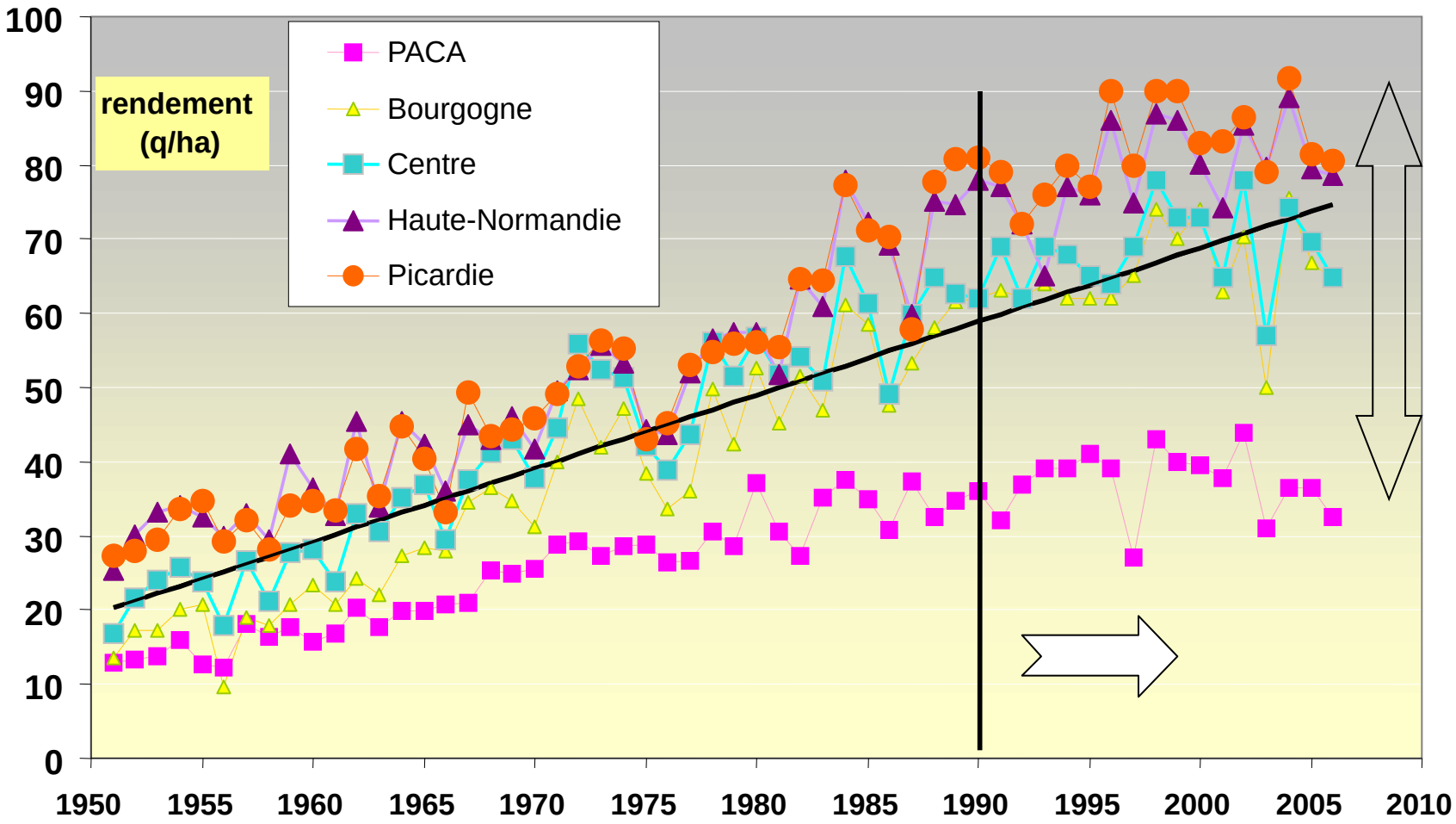


Figure 7-2: Summary of estimates of the impact of recent climate trends on yields for four major crops. Studies were taken from the peer-reviewed literature and used different methods (i.e., physiological process-based crop models or statistical models), spatial scales (stations, provinces, countries, or global), and time periods (median length of 29 years). Some included effects of positive CO2 trends (7.3.2.1.2) but most did not. (a) shows number of estimates with different level of impact (% yield per decade), (b) shows boxplot of estimates separated by temperate vs.tropical regions, modelling approach (process-based vs. statistical), whether CO2 effects were included, and crop.

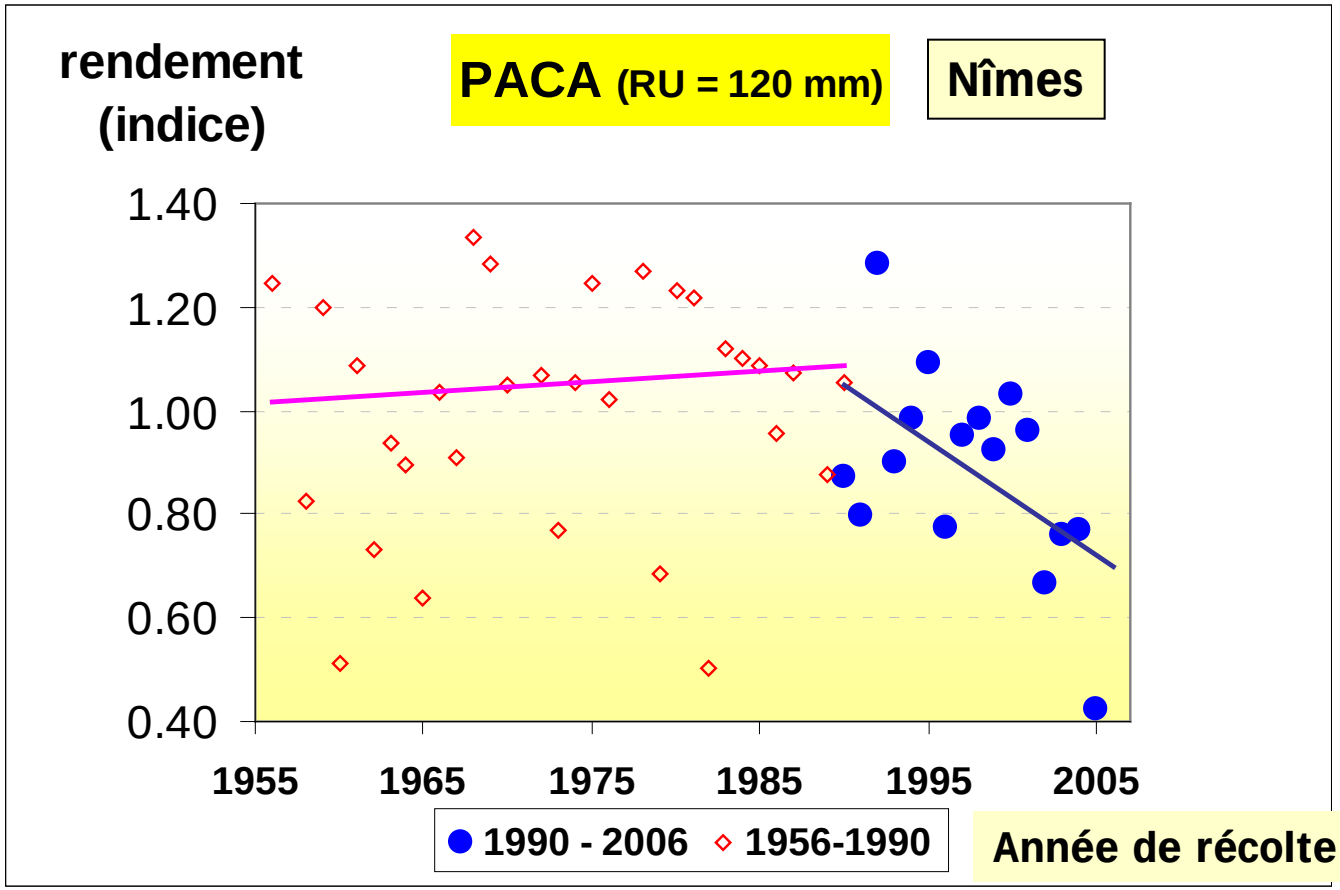
From IPCC 2014

Wheat yields in France

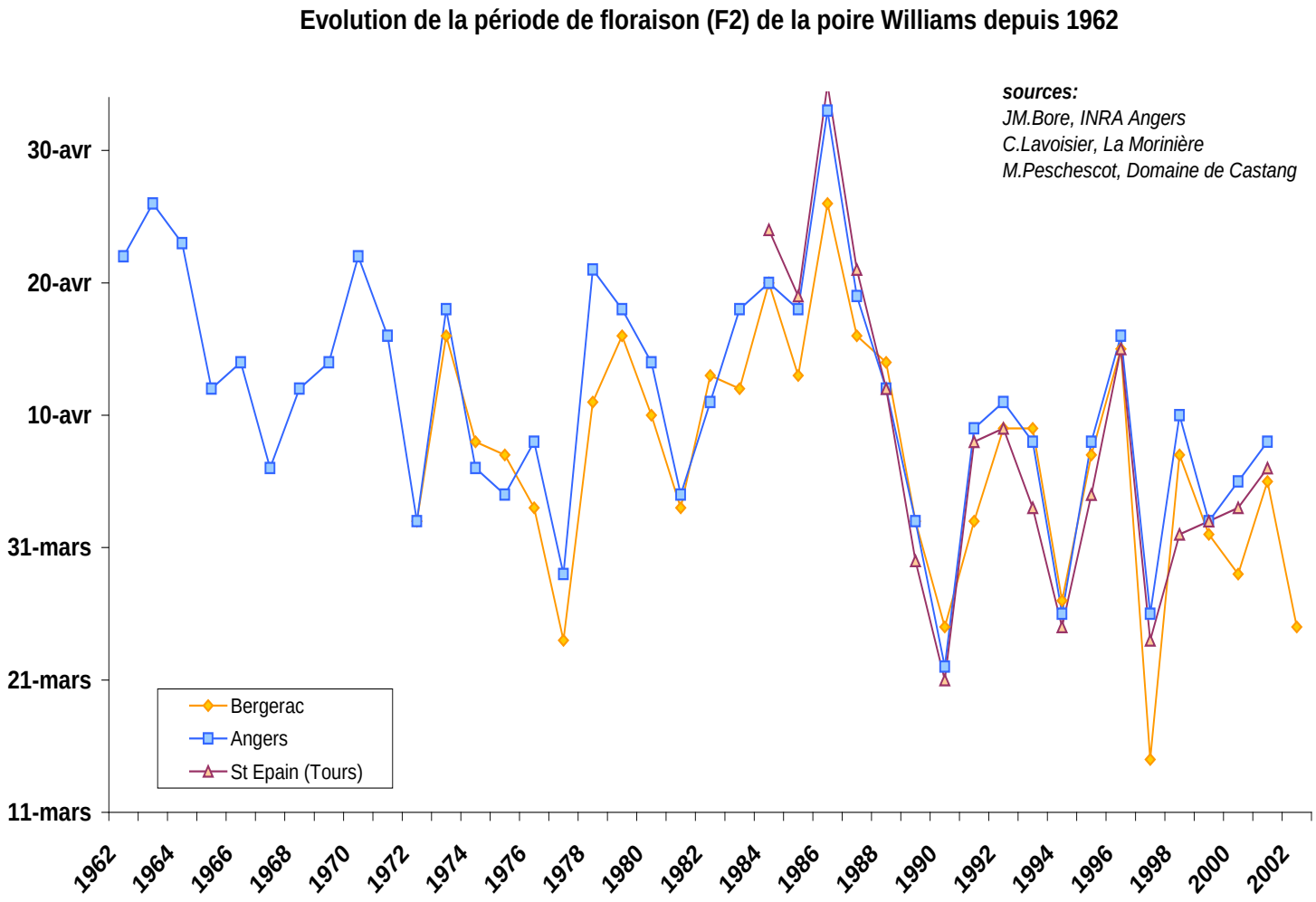


Explication de la variabilité par 2 conditions climatiques : sécheresse et Fortes T°C

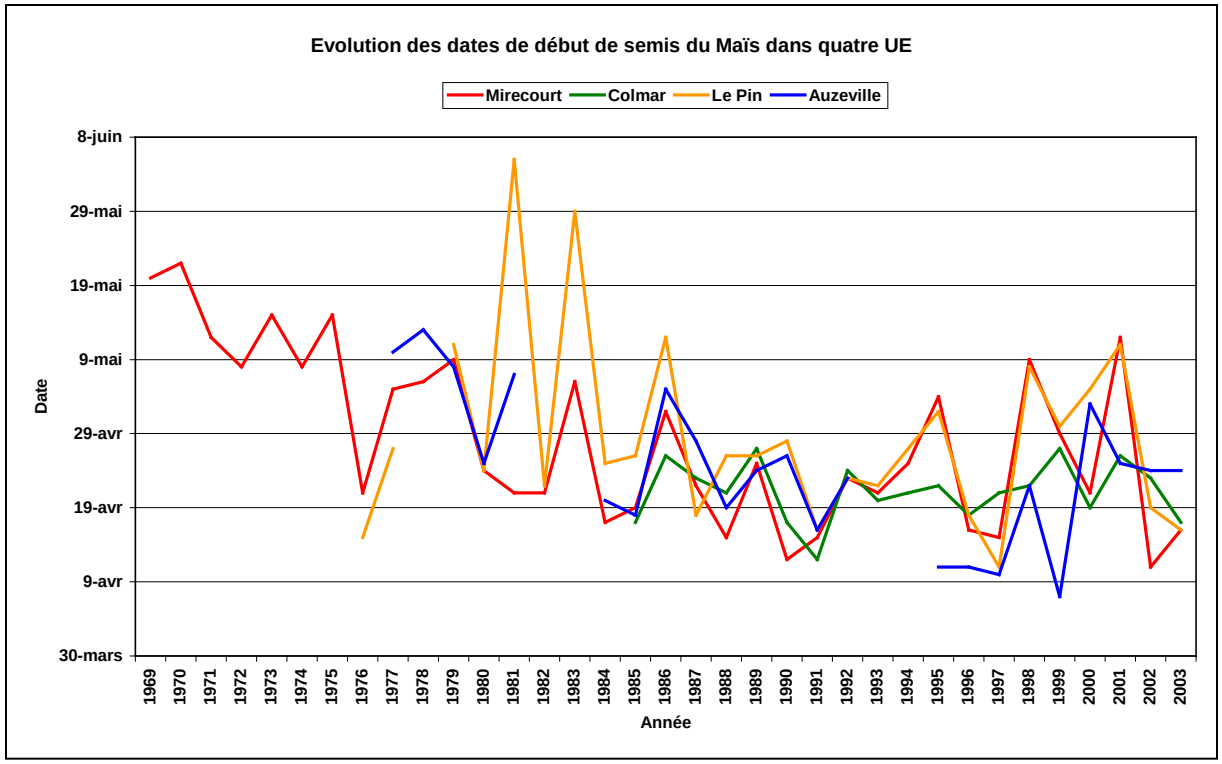
The effect of climate?



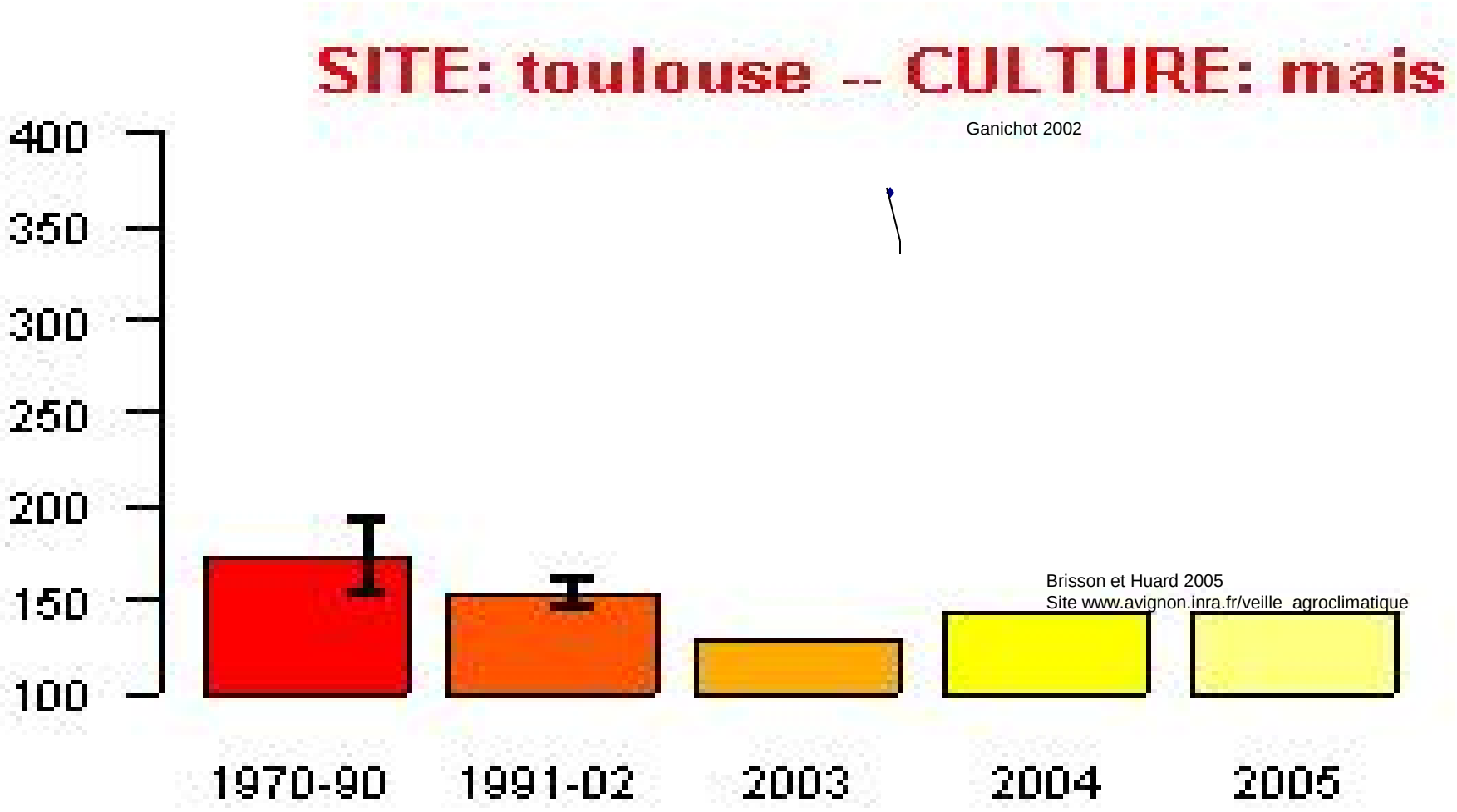
Phenology: flowering of fruit trees



Cultural practices: sowing dates for maize

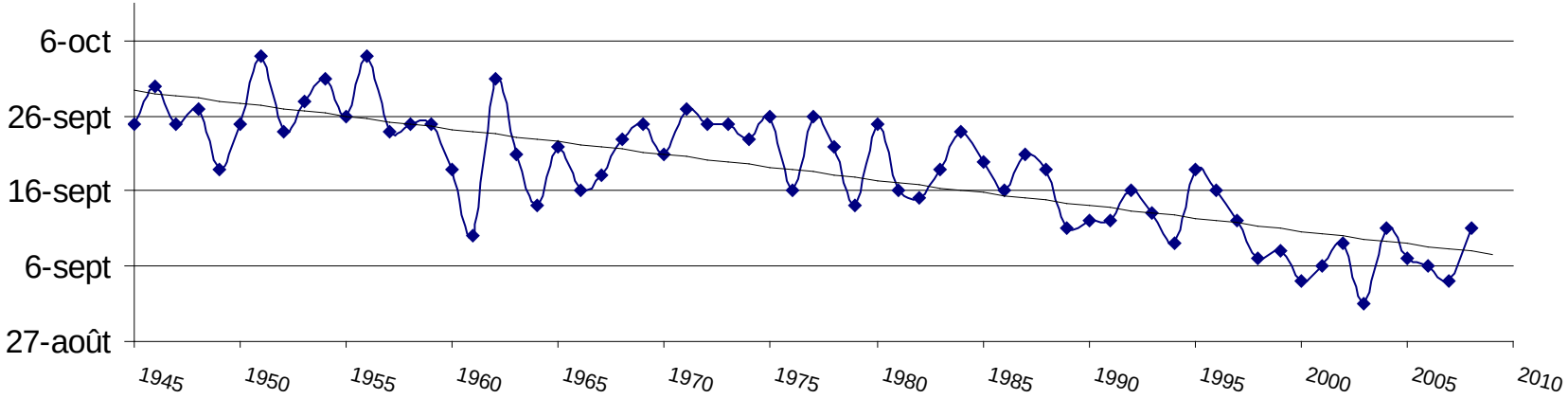


Reduction of cycle duration



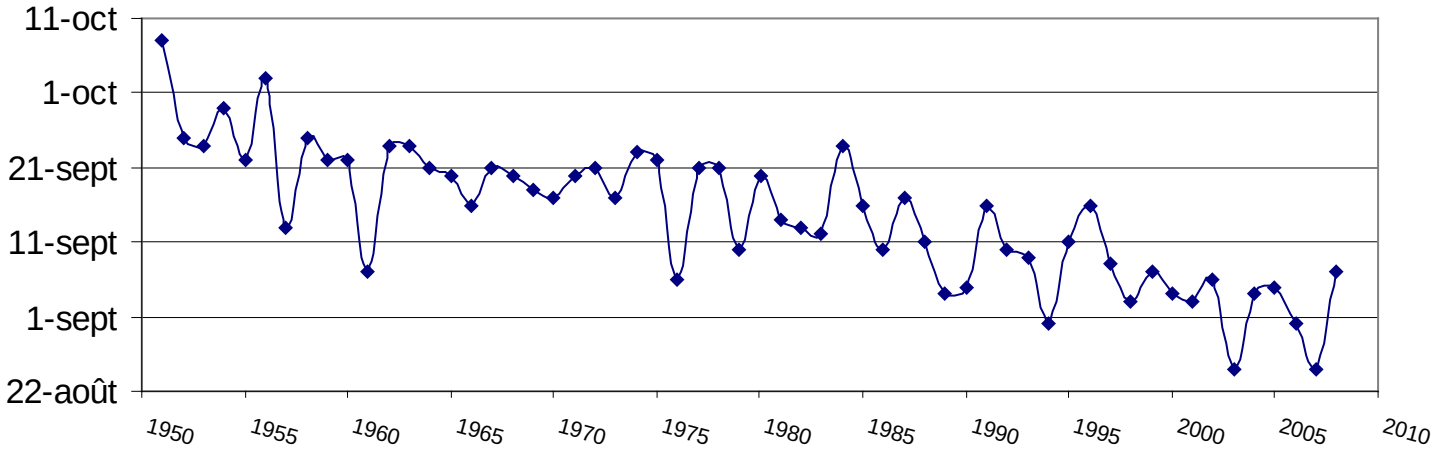
DATE DE DEBUT DES VENDANGES A CHATEAUNEUF DU PAPE depuis 1945

Source : Service technique Inter Rhône



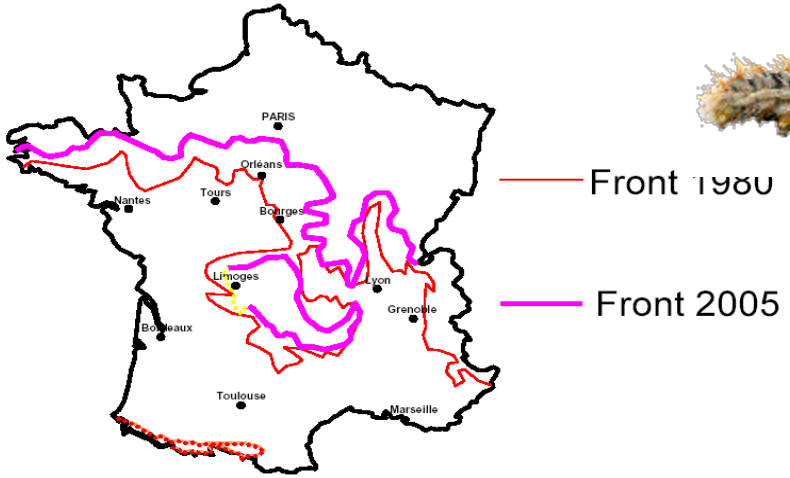
EVOLUTION DE LA DATE DU DEBUT DES VENDANGES A TAVEL DEPUIS 1951

Source : Service technique Inter Rhône



The processionary pine moth

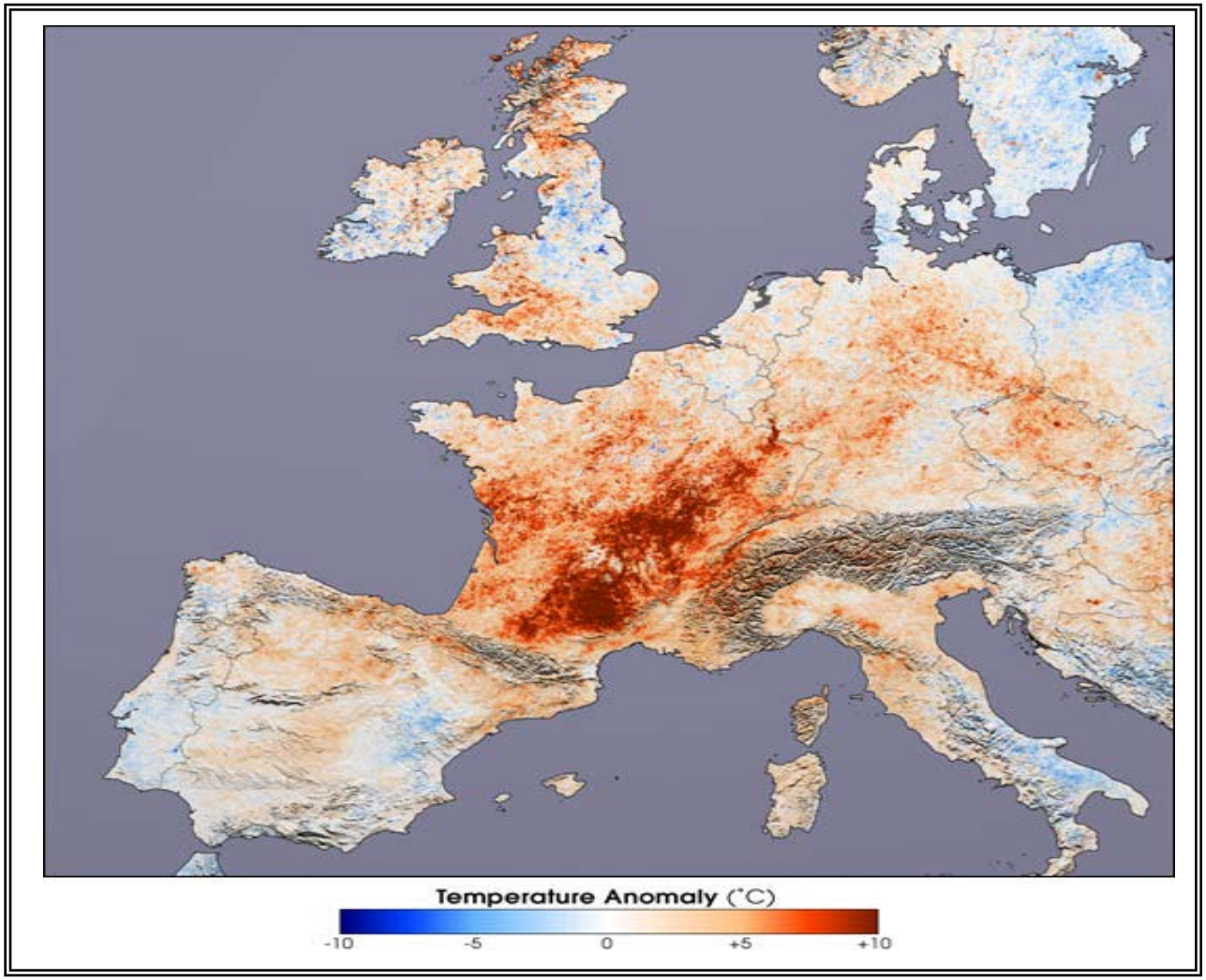
... Noticeable evolution



The 2003 heatwave

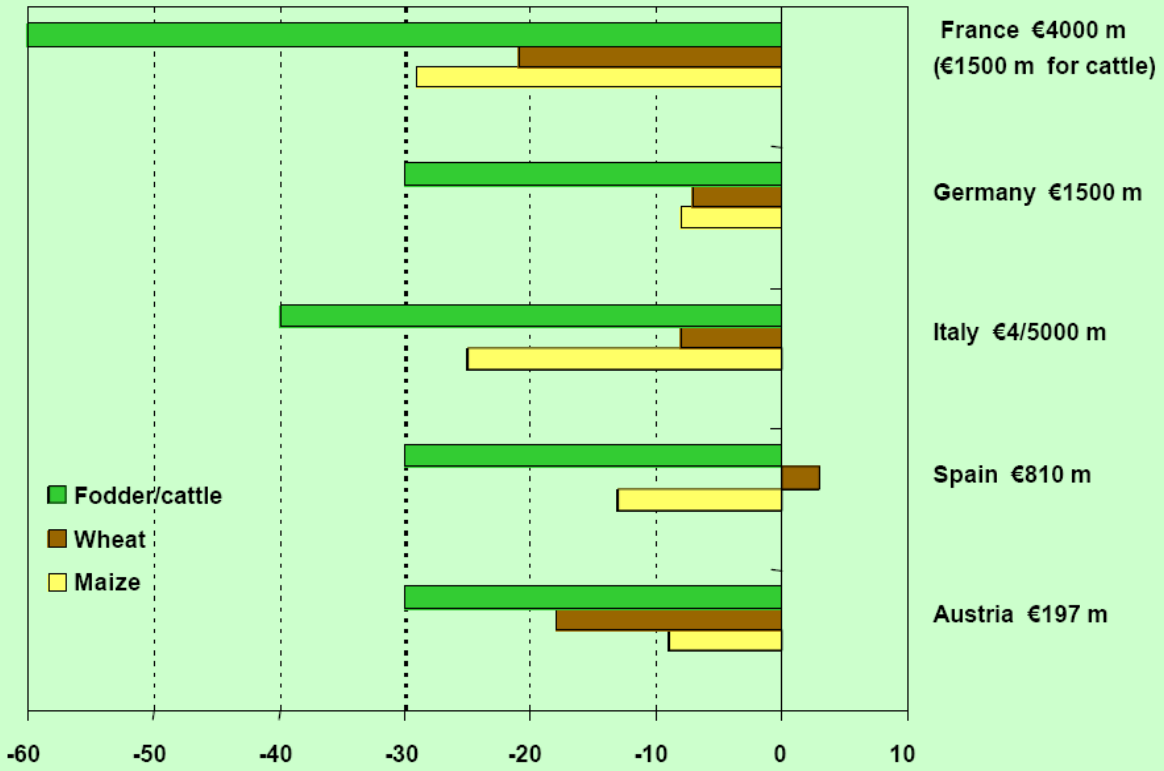
July 2003/
July2002

MODIS data



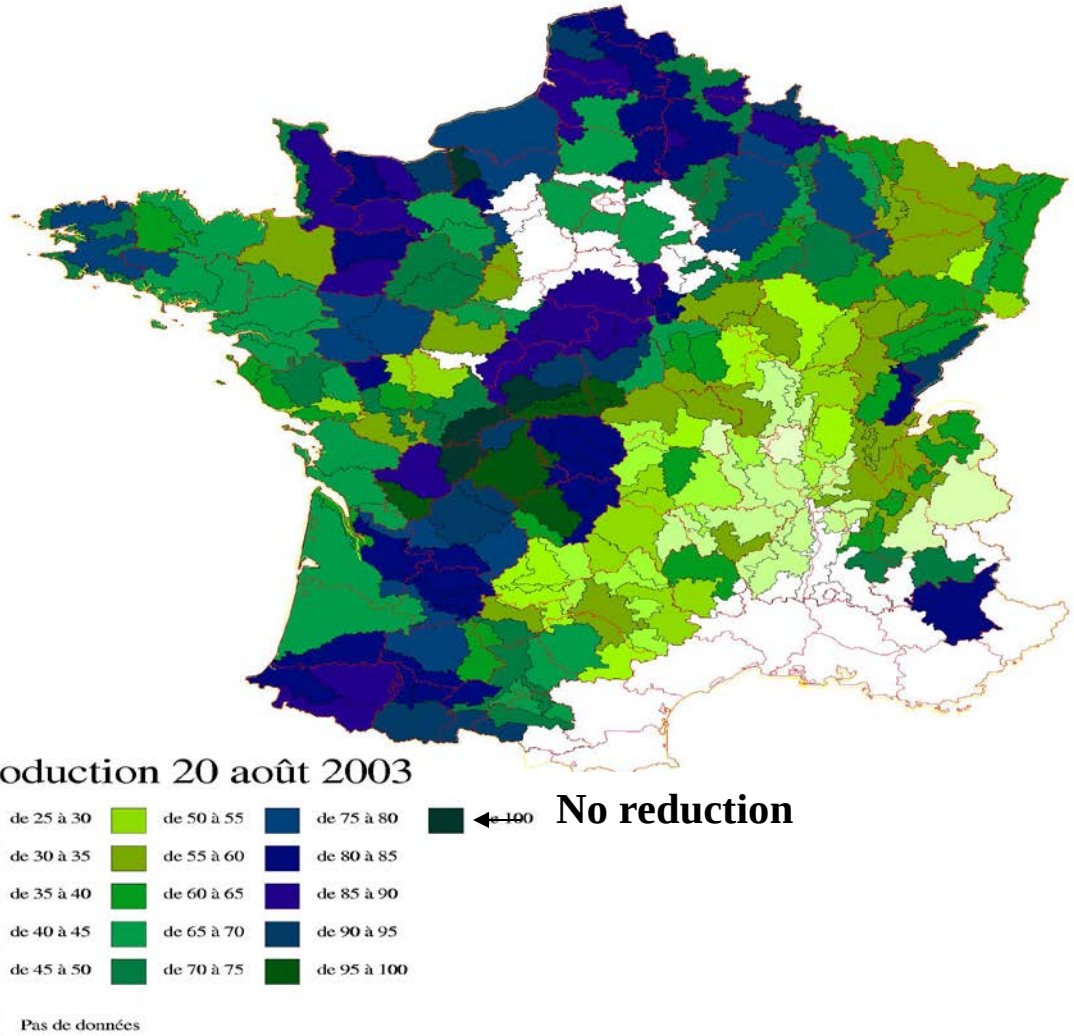
COPA

Effects of 2003 summer heat wave on EU agriculture



Parry 2005

Reduction in pasture cumulative production related to the previous 15 yr mean-value

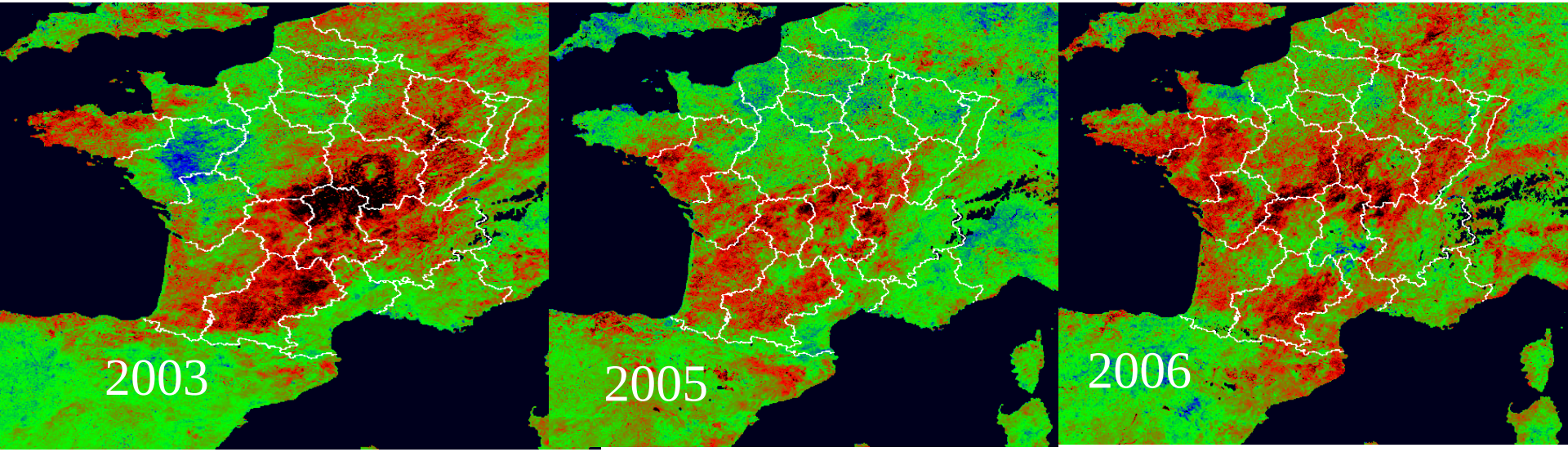


-25-30 %

No reduction

Institut National de la Recherche Agronomique

Recent droughts in France (2003, 2005,2006)

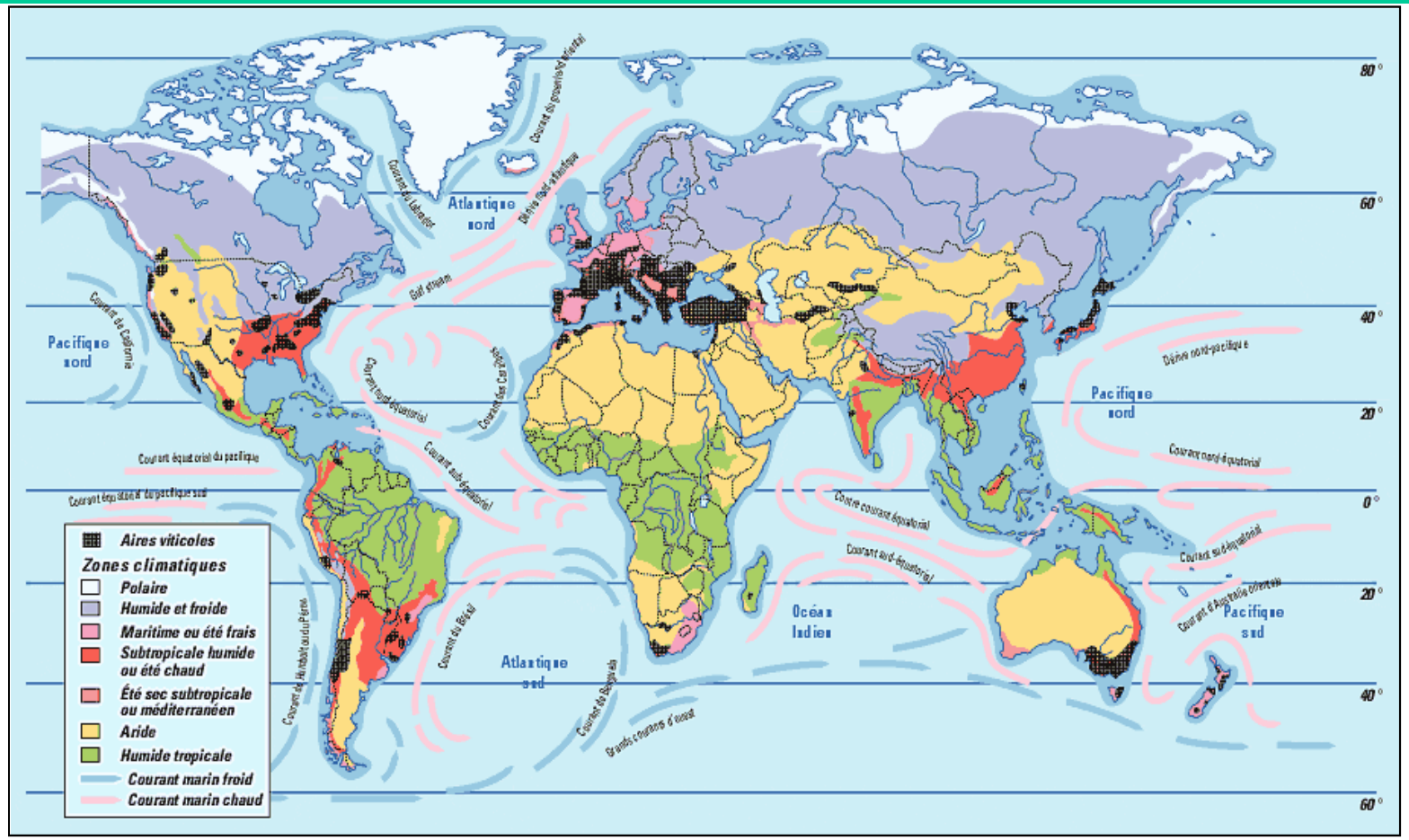


NDVI / mean 2002-2004 for the 1st of august

VEGETATION/Spot5

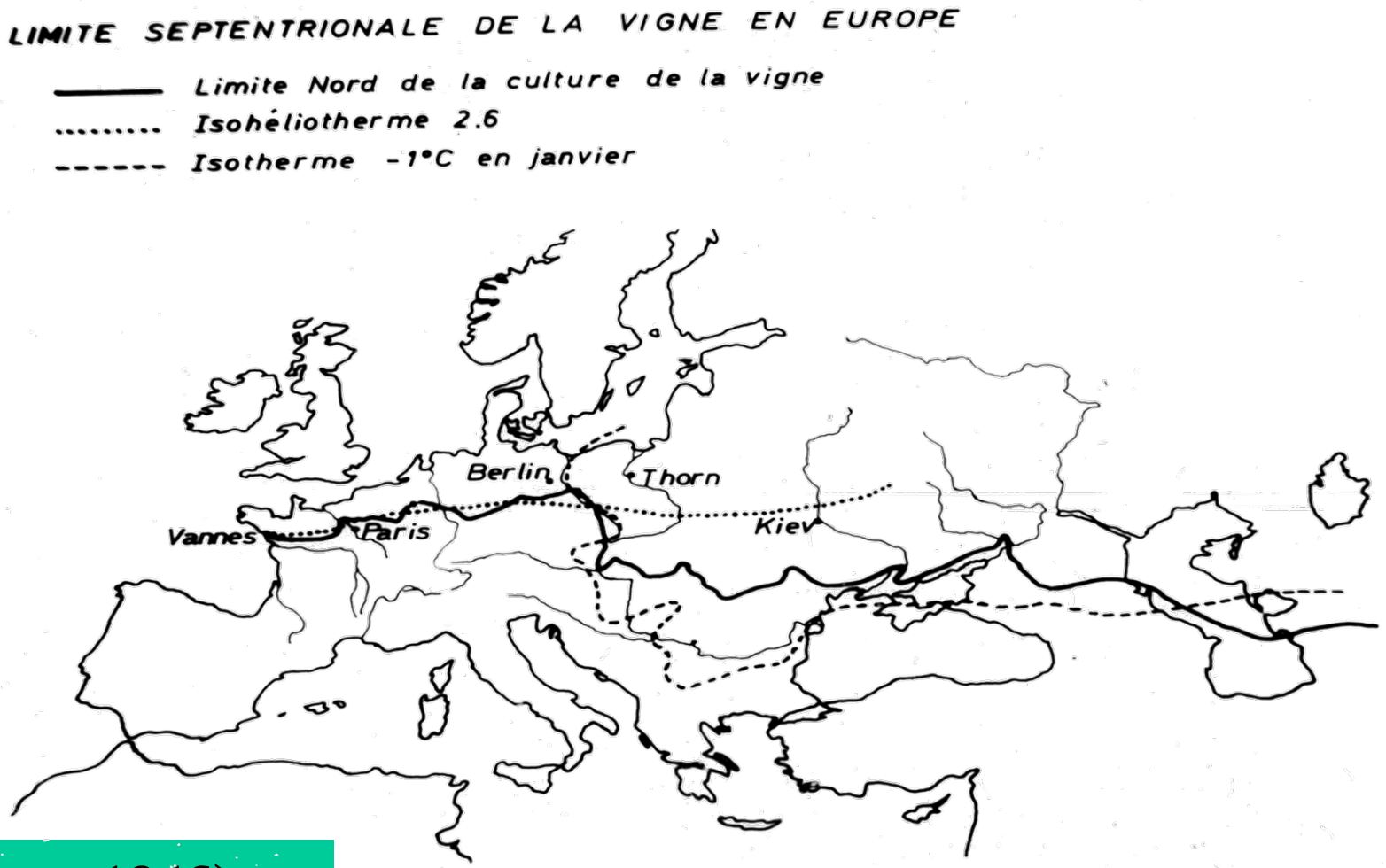
cnes

Vine cultivation is closely related to climate on a global scale



Revue des œnologues, n°96, juillet 2000

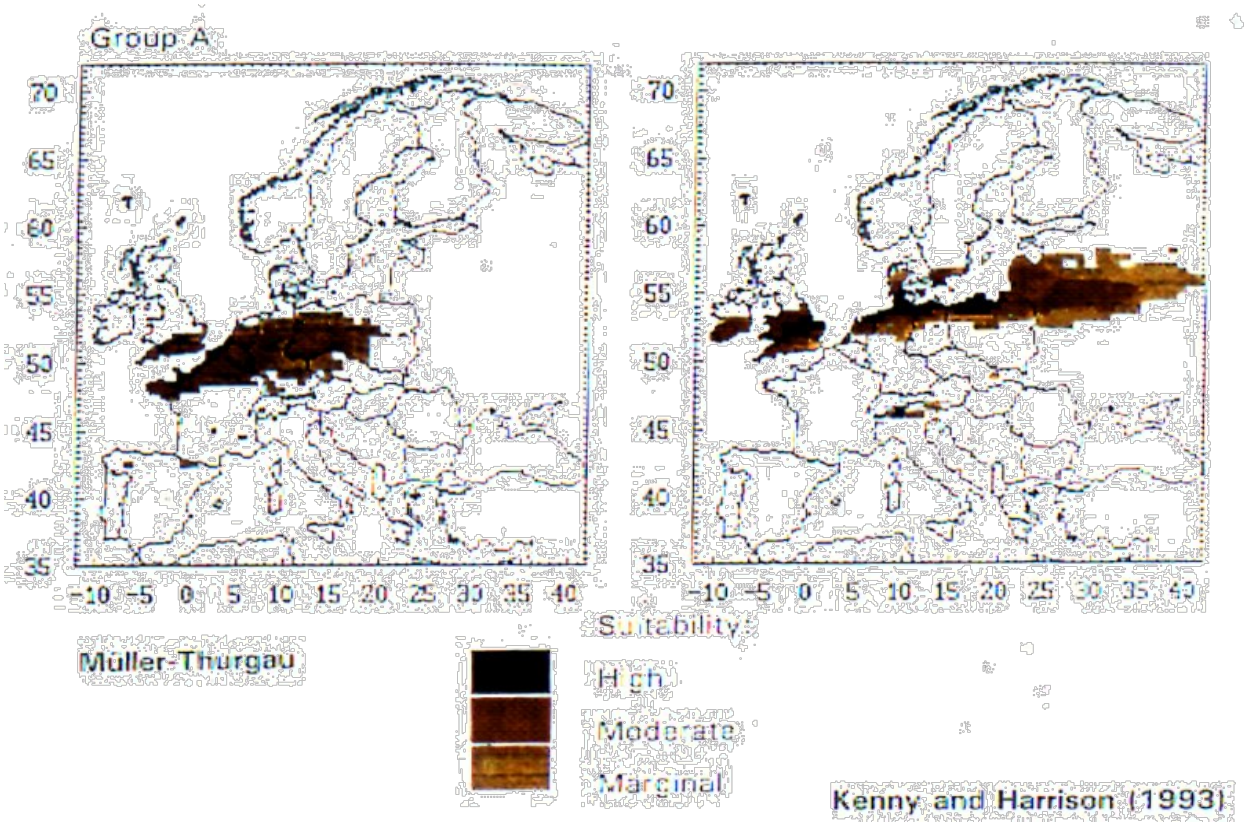
Its northern limits in Europe



(Branas 1946)

Vine will be very sensitive to climate change

- **in the geographical extent of potential cultivation**



CLimate Change Adaptability of WINE

FOCUS 43/2002 & other NEWS

IPCC TAR WG 2

Grapevine:

- suitable area expands northwards into central and northern England and eastwards into parts of eastern Poland, Romania, Belorussia and the Ukraine.
- Increasing yield in southern England and Brandenburg

CBS News

Britain: Great New Wine Region?

- *A Change In Climate Could Make It Happen*

„Tell a Frenchman that you're growing wine in England, and he thinks it's a bit of a joke."
Ian Berwick,
Bruisyard Vineyards

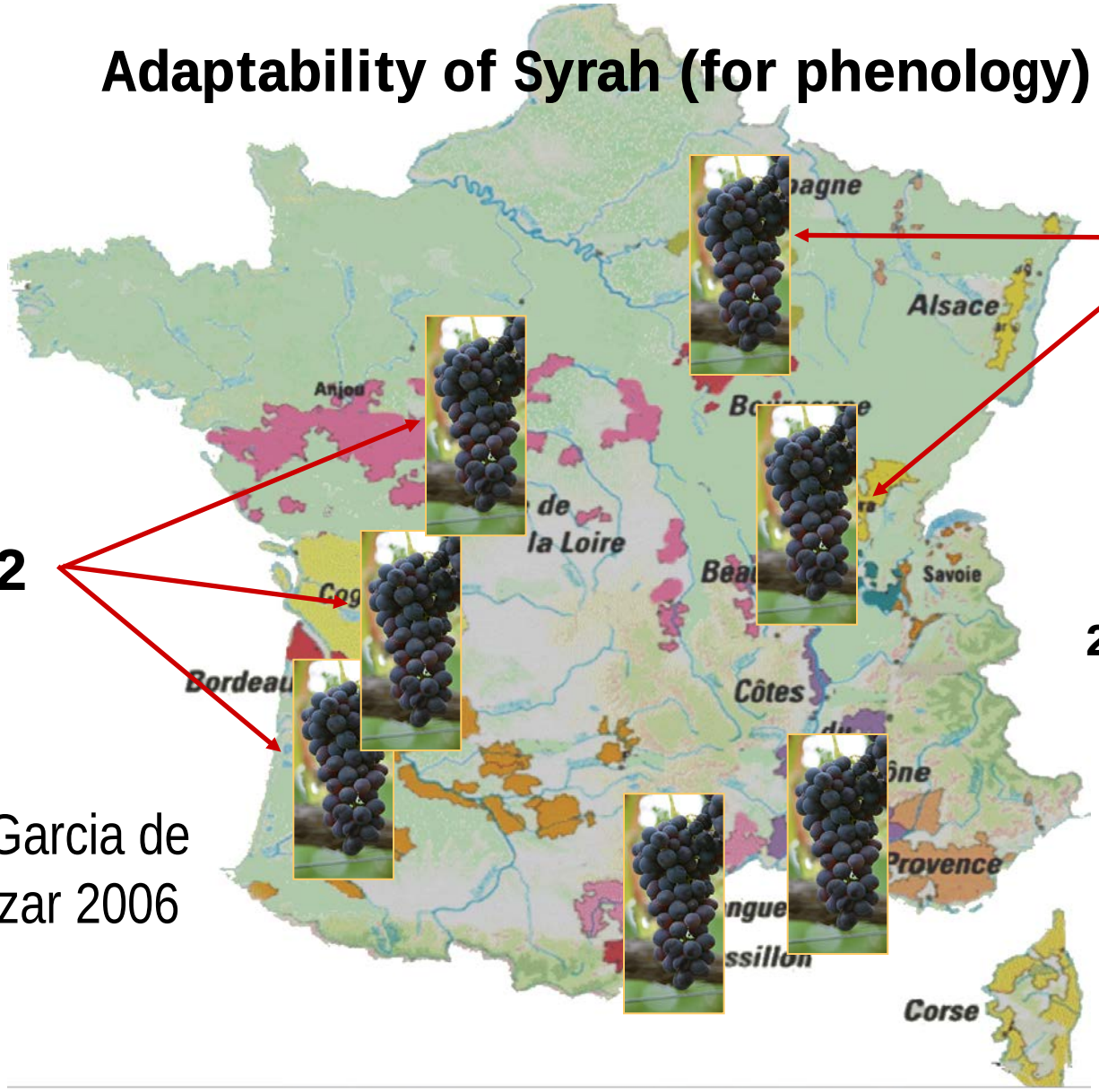
SAXMUNDHAM, England, April 06,2000

Vinologische Globalisierung

Stimmt das Szenario der Klimaforscher, könnten Reben in den nächsten **30 oder 40 Jahren** in ganz Norddeutschland gedeihen. Im mittleren Europa würden südliche Spezialitäten wie Merlot oder Syrah Standard werden.

Main producing regions in FRANCE

Adaptability of Syrah (for phenology)

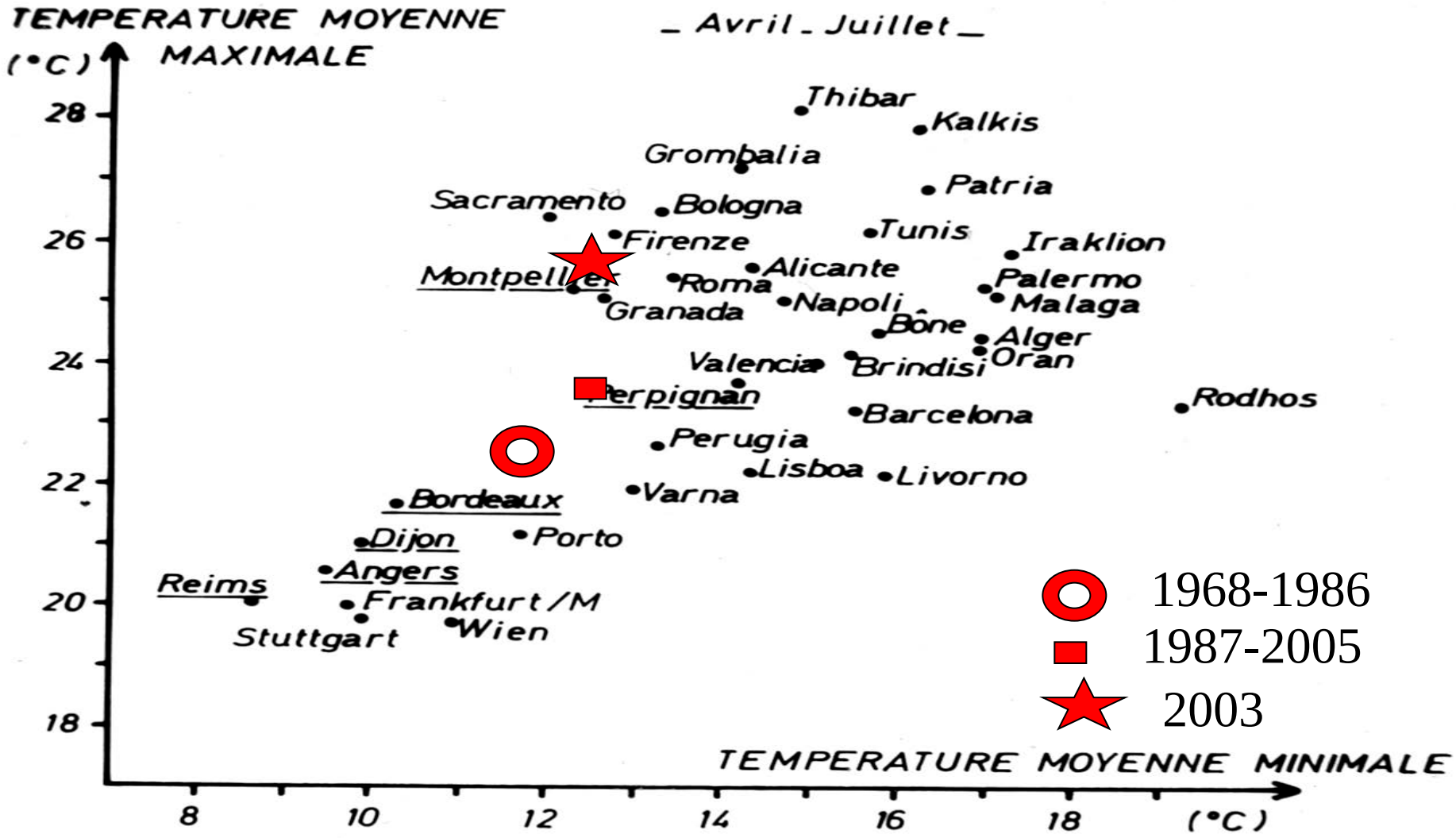


harvest
219.1 gr sugar/l

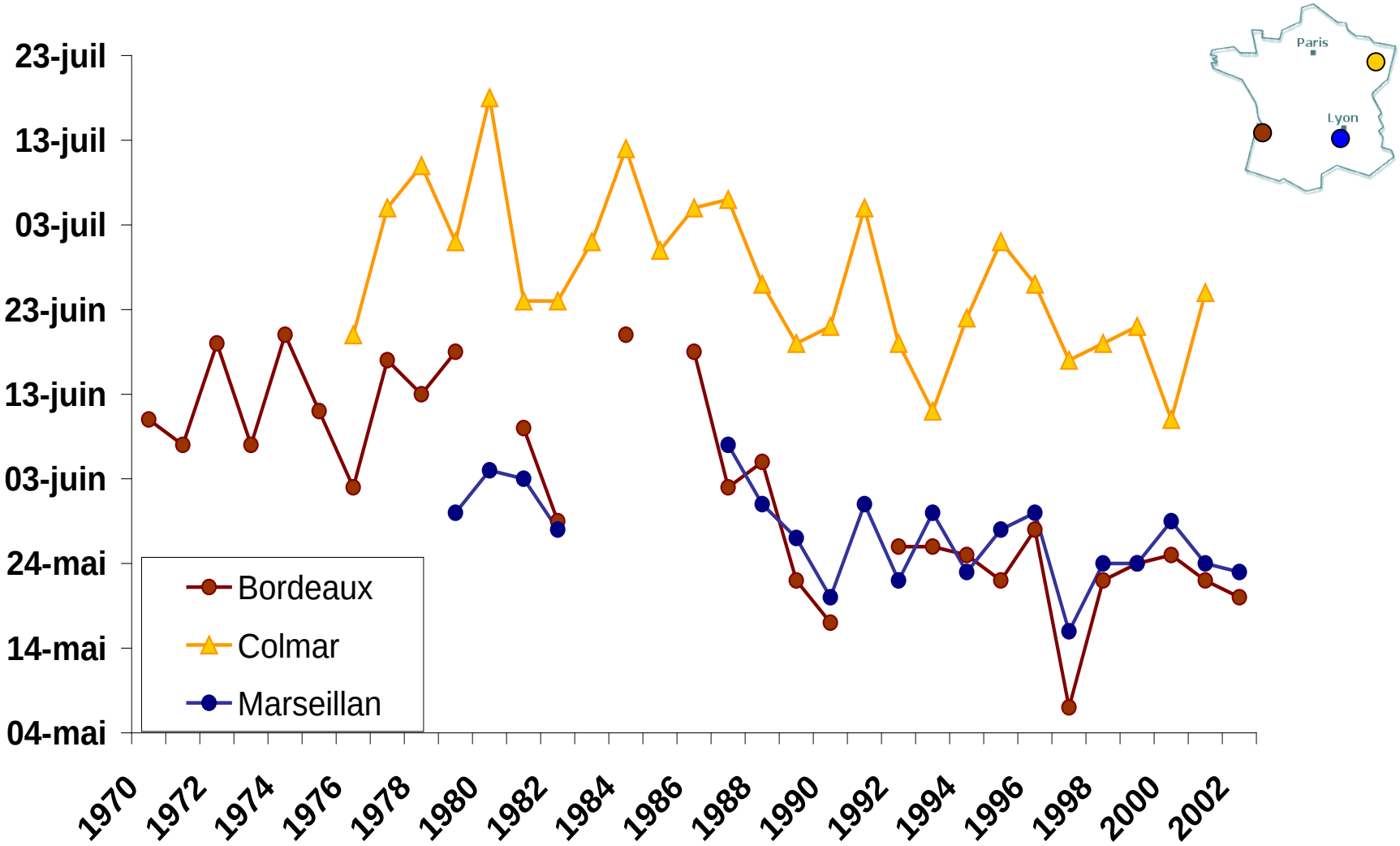
Before end of September

PhD Garcia de Cortazar 2006

The recent changes



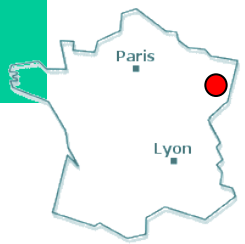
Observed trends in phenology



Flowering of Chasselas

Observed trends in harvest date

Alsace



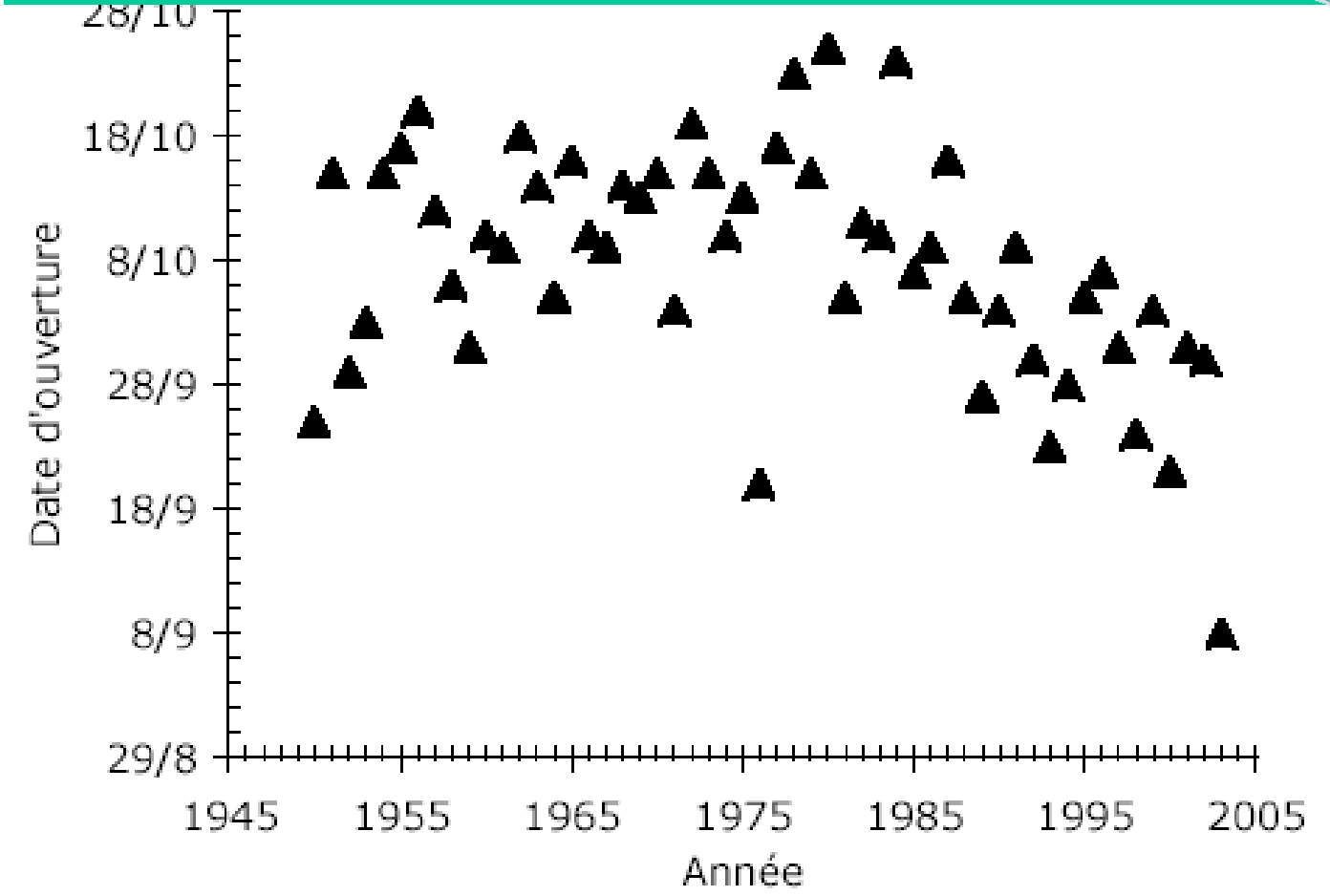
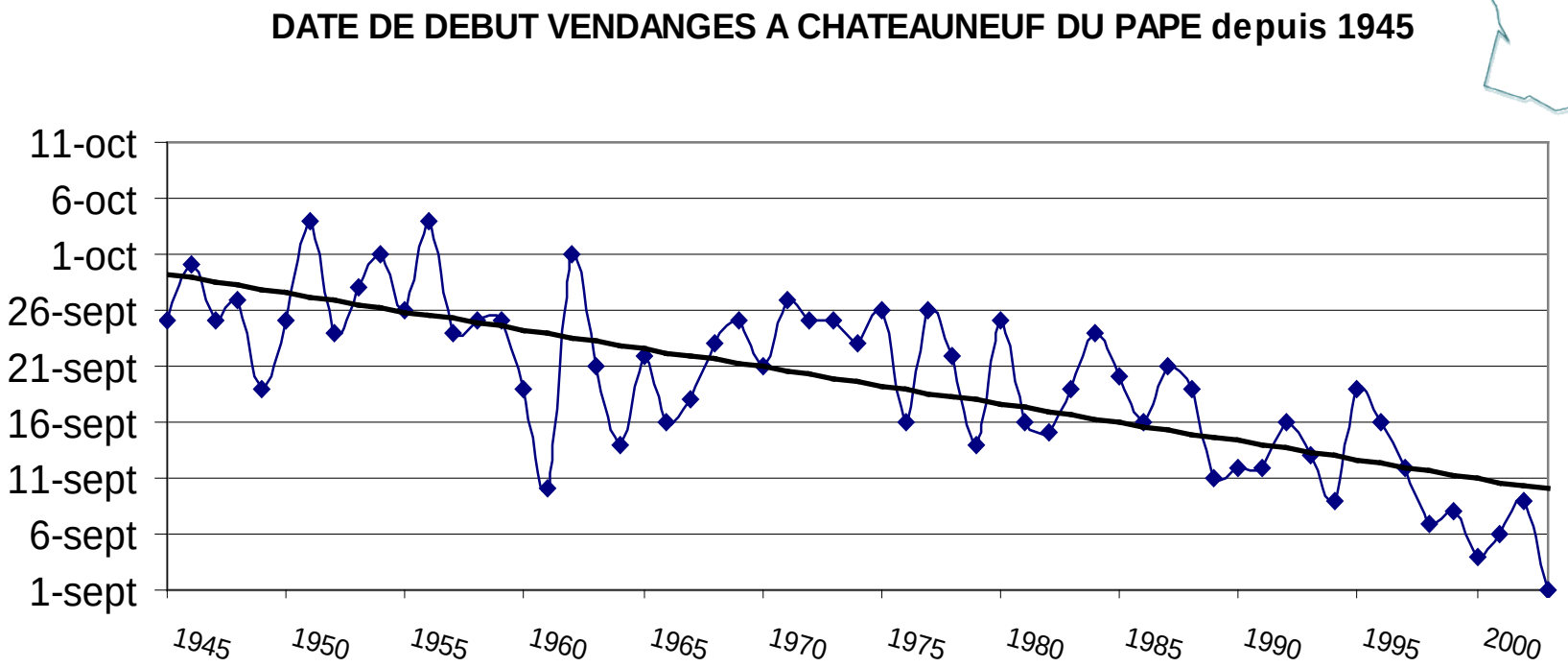


Figure 5 : Date d'ouverture des vendanges en Alsace. Source ITV Alsace.

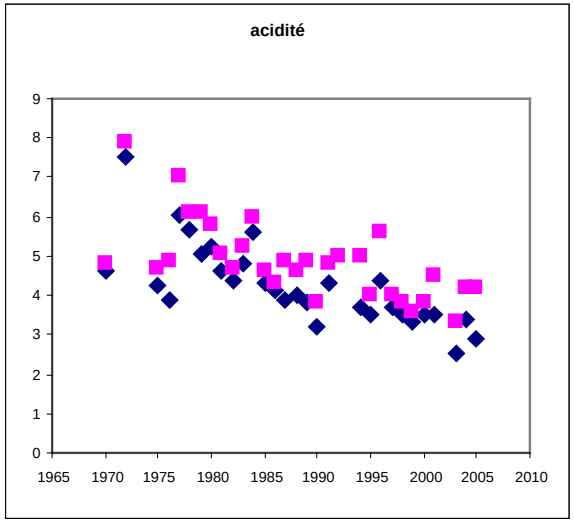
Duchêne, 2004

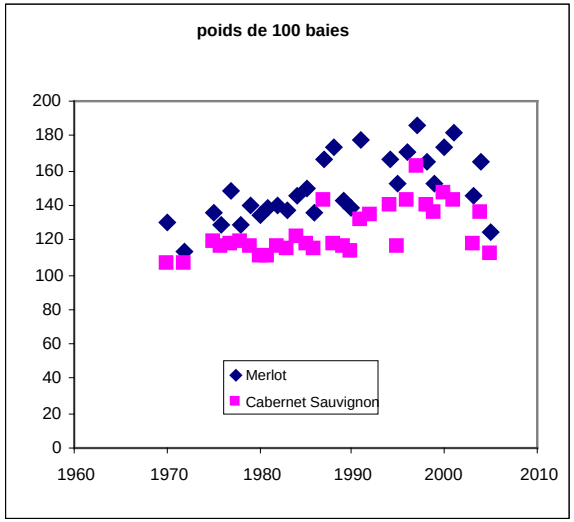
Observed trends in harvest date Côtes-du-Rhône

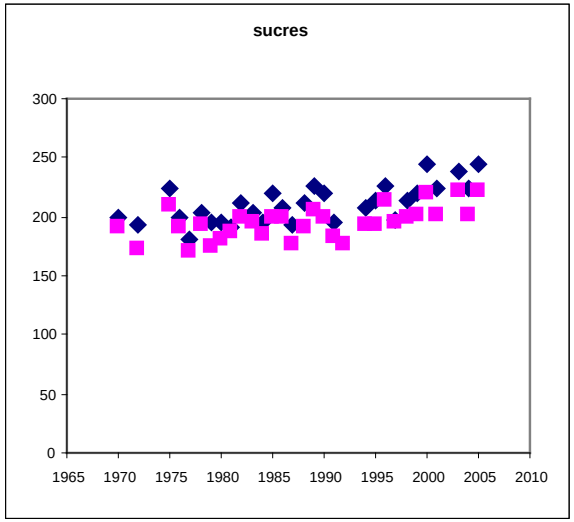


Ganichot, 2002

Sugar content is increasing , and acidity is decreasing

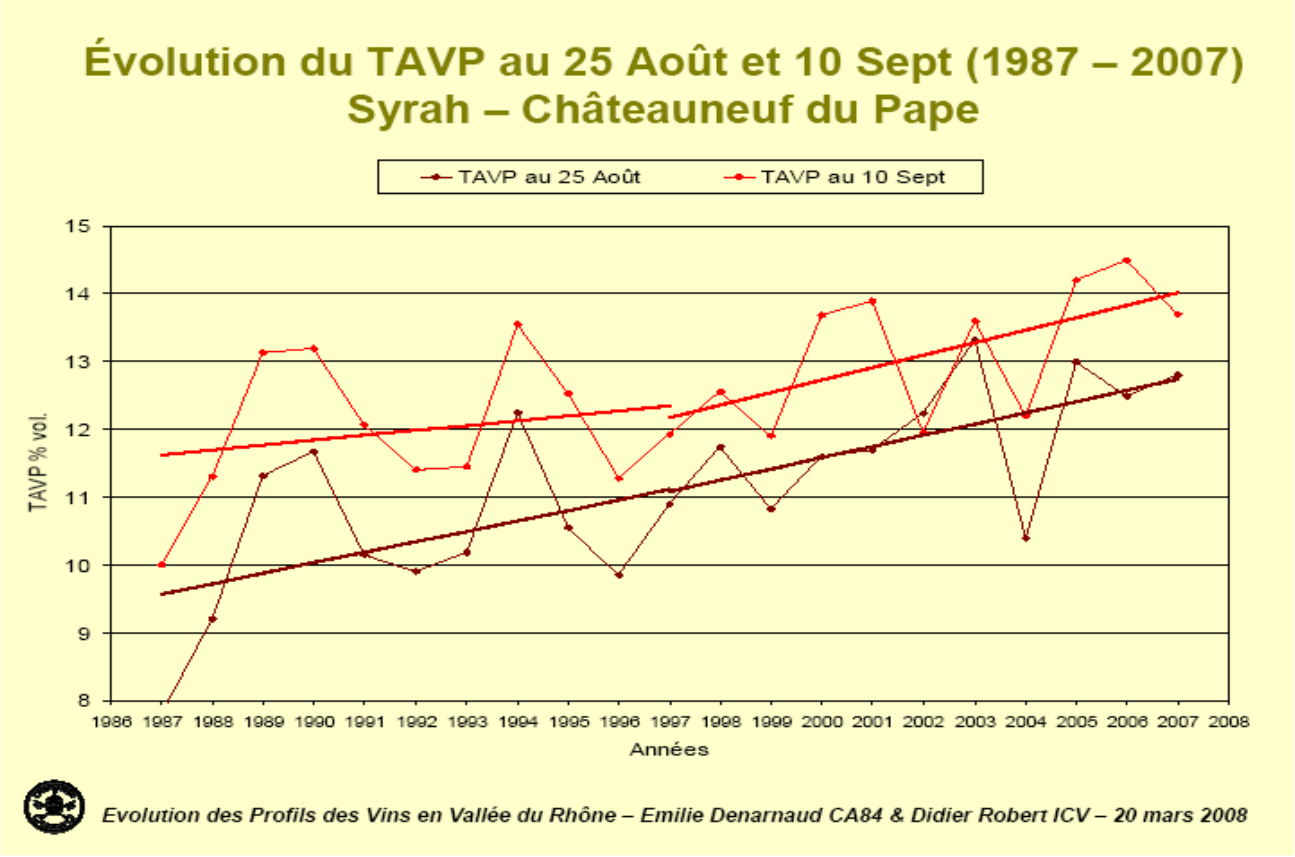






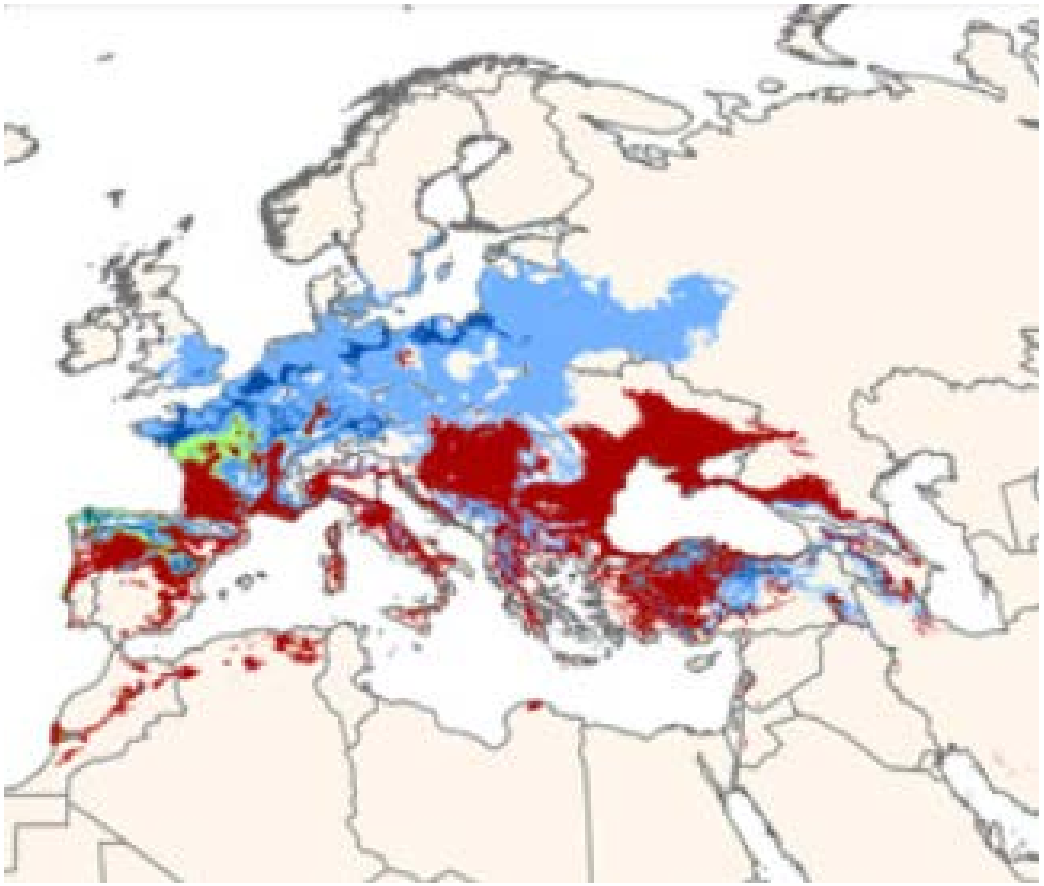
Bordeaux

A strong increase in alcoohol content



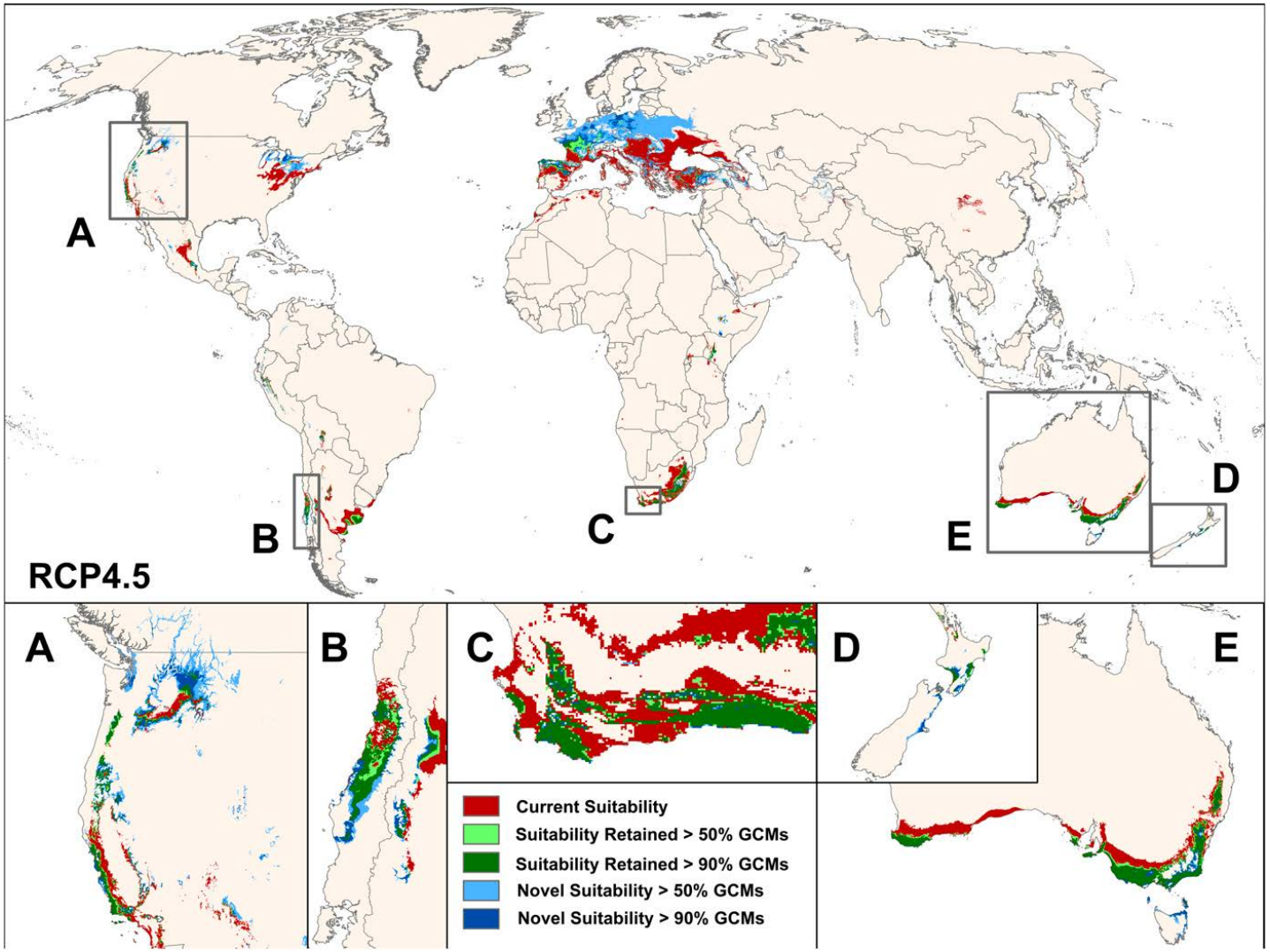
Côtes-du-Rhône

Questions about the potential ‘niche’ approach



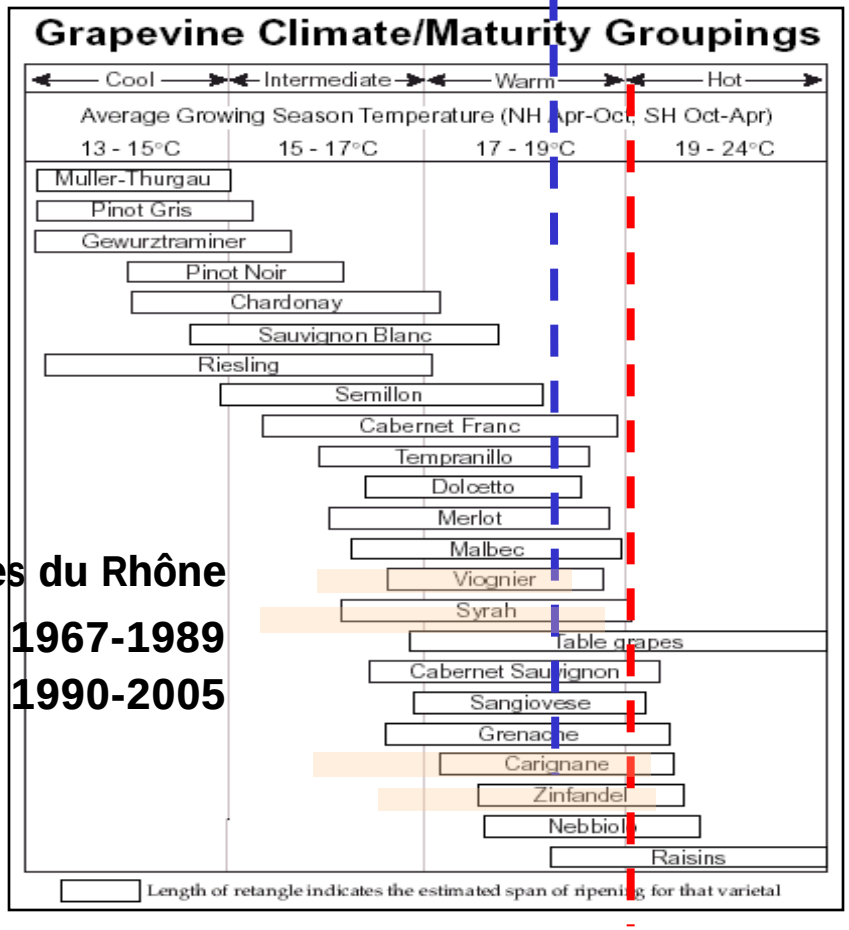
Hannah et al (2013)

Which future for vine production?



Hannah et al (2013)

A possible range for adaptation



Source: Jones, 2002, 2004, 2005

Summary and conclusions

- Vine cultivation is closely related to climate on a global scale
- Wine production is also closely related to climate on a local scale (terroir)
- So that vine could be considered *a priori* as one of the most sensitive to climate change by the simple use of basic climatic indices
- with possible extensions in new areas (England, Denmark, etc..)
- but also the projection of significant changes to the traditional adaptation of cultivars to local soil and climate within the long-experienced terroirs (in Europe, and especially France)

A true threat or an irresponsible joke ?