gembloux
faculté universitaire
des sciences agronomiques

Benelux Society of Horticultural Science

Climate change : challenges, risks and impacts on cropping systems

April 3, 2009 Gembloux Agricultural University, BE

Convener : Prof. Monique Bodson bodson.m@fsagx.ac.be

Program:

9.00 - 9.30 Registration

9.30 - 9.45 Introduction : Monique Bodson (FUSAGx)

Welcome address : Rob Bogers, BNL-SHS chairman

9.45 - 10.30 Luc Debontridder (KMI/IRM, Brussels)
Climate change myth or reality?

10.30 - 11.15 Paul Struik and H. Meinke (WUR,Wageningen)
Climate robust crop science : modelling climate change impacts across scales

11.15 - 11.30 coffee break

11.30 - 12.15 Marc Aubinet, B.Bodson, C. Moureaux, D. Dufranne, F. Vancutsem (FUSAGx, Gembloux)
Carbon balance of a pluriannual cropping system (4-year rotation) : impact of climate and cropping management

12.15 - 12.45 Martine Maes (ILVO, Merelbeke)
New and increased disease incidence in horticulture and green environment

12.45 - 14.00 Lunch break

14.00 - 14. 45 Michel De Proft (CRA, Gembloux) :
Climate change impact on crop pests

gembloux
faculté universitaire
des sciences agronomiques

Benelux Society of Horticultural Science

14.45 - 15.15	Laurent Pfister and Jean-François Hausman (Gabriel Lipmann Institute, Luxembourg) **Climate change, an imminent threat for trees**
15.15 – 15.45	Marie-France Destain and A. Piron (FUSAGx, Gembloux) **Detecting weeds by artificial vision in carrot crops: towards optimization of herbicide/pesticide use**
15.45 – 16.15	Kathy Steppe, Dirk J.W. De Pauw, Raoul Lemeur (Gent University) **Models as effective tools for optimizing irrigation**
16.15 – 16.30	General discussion
	A. Kunz and Michael M. Blanke (University of Bonn, Germany) Discrepancies in the data analysis and interpretation of climate change
16.30	Drink

SYMPOSIUM OF THE BENELUX SOCIETY OF HORTICULTURAL SCIENCE
BNL-SHS
Convener Prof. Monique Bodson Gembloux, Belgium April 3, 2009

"Climate change : challenges, risks and impacts on cropping systems"

ABSTRACTS

Carbon balance of a pluriannual cropping system (4-year rotation) : impact of climate and cropping management

Aubinet M.*, Bodson B.**, Moureaux C.*, Dufranne D.*, Van Cutsem F.**
Faculté Universitaire des Sciences Agronomiques de Gembloux
* Unité de Physique des Biosystèmes
** Unité de Phytotechnie des régions tempérées

Eddy covariance is a useful tool to measure carbon dioxide fluxes exchanged at the scale of an ecosystem. The technique, its advantages and the uncertainties inherent of the technique will be presented and discussed.

More specifically, measurements performed over a crop managed in a traditional way during a complete sugar beet/winter wheat/potato/winter wheat rotation cycle will be presented. Eddy covariance measurements, completed with soil respiration, leaf diffusion and biomass increment measurements, allowed computing the crop carbon balance and evaluate its variability according to cultivated species, climate and farmer interventions.

The climate impact was evaluated by comparing two similar winter wheat crops cultivated at the same site and with the same methods but under different climatic conditions, in 2005 and 2007. Result showed that the milder conditions in winter and early spring 2007 induced a larger Gross Primary Productivity (GPP) but, on the contrary, wetter late spring and summer induced on the same year lower harvest and Net Primary Productivity. This suggests that GPP is not a good harvest predictor. Mechanisms responsible for the difference in harvest were analysed.

The whole cycle budget showed that the rotation behaved as a sink of 1.59 kgC m^{-2} over the 4-year rotation. However, if exports are deducted from the budget, the crop became a small source of 0.22 (±0.14) kgC m^{-2}. This suggested that the crop soil carbon content decreased. This could be explained by the crop management, as neither farmyard manure nor slurry had been applied to the crop for more than 10 years and because cereal straw had been systematically exported for livestock.

This results being obtained in the frame of the Carboeurope network, they can be compared with those obtained at other European sites. Similarities and differences were discussed.

Contact : M. Aubinet, Unité de Physique des Biosystèmes, Faculté Universitaire des Sciences Agronomiques de Gembloux, 8 avenue de la Faculté, B-5030 Gembloux, aubinet.m@fsagx.ac.be.

SYMPOSIUM OF THE BENELUX SOCIETY OF HORTICULTURAL SCIENCE
BNL-SHS

Convener Prof. Monique Bodson Gembloux, Belgium April 3, 2009

Climate change : myth or reality

Luc Debontridder
Royal Meteorological Institute of Belgium (KMI/ IRM), Brussels
luc.debontridder@oma.be

Based on the long series of observations carried out at Brussels – Ukkel of different kinds of climatological parameters, significant changes in our climate have been detected in our temperatures during the last 20 years.
We will show in this presentation that not only human activities but also natural phenomena such as solar radiation, volcano eruptions do affect our climate in a significant way also.
The temperature rise in Belgium was very abrupt and recent. We will show that precipitation regimes and quantities in our country did not change in a significant way.
We will try to have a look at our future climate using the IPCC scientific report of February 2008, issued in Paris and at the same time have a look at the Regional climate models for Belgium based on the CCI-HYDR project of the RMI and the KULeuven.
The conclusion will be that our climate is warming but that the consequences of the warming seem to be less worrying for our country the for other parts of Europe.

Key Words: Climate change, human activities, natural phenomena, Climate models, IPCC, CCI-HYDR.

SYMPOSIUM OF THE BENELUX SOCIETY OF HORTICULTURAL SCIENCE
BNL-SHS
Convener Prof. Monique Bodson Gembloux, Belgium April 3, 2009

Climate change impact on crop pests

Michel De Proft
Centre wallon de Recherches agronomiques ; Département Phytopharmacie
Rue du Bordia 11 ; 5030 Gembloux ; deproft@cra.wallonie.be

Insect pests are cold-bloody organisms. Temperature increase can act upon the speed of their development, the diapausis and other regulation mechanisms, their reproduction, their movements in space, and their survival on winter.
For polyvoltin species, acceleration of biological cycles, added to extension of activity periods (earlier springs, longer autumns), will enhance the number of generations per year what could drive to populations inflation and increase of linked damages in crops, to staggering of damage periods or overlapping of generations -both factors complicating the protection schedules- and to enhanced probability of resistance to insecticides.

Climate change shall modify agronomic importance of pests. Some of them could profit from warmer springs and to wetter summers, announced by climatologists. It seems this is the case for *Sitodiplosis mosellana*, the wheat blossom midge. This pest is not yet very well known in our country because of its discretion (it is very small and flies only at nightfall), and also because its damage are rarely correctly identified. However, frequency of damages is growing and this could make worse because of climate change.

When it is spoken about climate warming, it is often imagined that geographic distribution areas of species will move toward North. Some observations seem to confirm that it can be so (pine processionary for instance), but on the other hand, distribution area of many insects is unchanged because it is not only limited by mean temperatures, but also by other elements including many ecological requirements.

From year to year, climate conditions in a region change, leading to modifications of the geographic distribution of pests and of their local agronomic impact. These changing fronts, these moves forwards followed by retreats, are always observed, due to the high mobility of many crop pests and to their ability to colonize or re-colonize quickly areas. So, it is expectable that, except some cases, climate change shall drive to more frequent incursions of pests from neighbouring areas, instead of their permanent naturalisation in new areas.
On the other hand, what is surely important for crop protection in our areas shall be the effect of winter warming on survival of organisms which have until now been destroyed by cold. A very spectacular example is this of aphids, whose parthenogenetical forms, surviving to winters several years consecutively, can produce huge populations and enhance virus propagation.

Forests are more threatened by climate change than agriculture because, for the majority tree species, populations are very closely adapted to the conditions of their site of origin, and could be affected by brutal changes. Tree pests like bark beetles are often weakness pests. A forest stressed by unfavourable climate conditions or by climate accidents (storms, droughts, hot waves) shall be more exposed to their damages.

Discrepancies in the analysis and interpretation of climate change data

A. Kunz and Michael M. Blanke, University of Bonn Germany

Email : mmblanke@uni-bonn.de

Weather and phenology data were analysed from 50 year records (1958-2007) at Campus Klein-Altendorf of the University of Bonn in the proximity to Holland and Belgium (190 km East of Gembloux). The weather data included air and soil temperature, precipitation and frost and the phenological data of the beginning and end of flowering, harvest, yield and leaf drop of 4 apple and pear varieties. While our data analysis compared the last 20 years with climate change (1988-2007) with the 30 previous years without climate change (1958-1987) and partially **confirms results of other authors such an earlier flowering, earlier harvest and earlier leaf drop**, it **contradicts** in the following

1) **increased threat of frost** (due to the combination of remaining April spring frosts and more advanced, more frost-sensitive flowering stages) in contrast to reported/forecast less frost (DWD, 2007)
2) a **shorter flowering period**, also after warm winters in contrast to reported longer flowering periods particular after warm winter with pollination problems (Legave, 2008);
3) a **longer fruit development** (due to more advanced flowering than harvest in contrast to reported shorter fruit development (Ruess, 2009), which requires a re-think of the T-stage harvest date prediction
4) **earlier leaf drop**, which contradicts/waives any issues of longer vegetation period at a time when the fruit trees have no leaves

Since the results seem to depend on the method of data analysis (long-term average versus regression), we analysed our and reported data to explore the potential reasons for the apparent discrepancies and showed at least two reasons:
a) linear regression lines through short term (e.g. 30 years) data sets
b) use of the temperature (>5°C) based vegetation period rather than a phenology based units; this could be more suitably called ‘phenological or pomological period’. The complete talk can be viewed also on this Benelux website and in the special climate change issue of Erwerbs-Obstbau 3/2009.
Blanke, M.M, and A. Kunz, 2009: Beschreibung des rezenten Klimawandels und sein Einfluß auf Kernobst am Standort Klein-Altendorf. Erwerbs-Obstbau (Springer Heidelberg) 51 (3), 00- 00 (in print)- special climate change edition

Climate change, an imminent threat for trees

Pfister, L. and Hausman, J.-F.

Centre de Recherche Public – Gabriel Lippmann
Department Environment and Agro-biotechnologies
41, rue du Brill
L-4422 Belvaux, Grand-Duchy of Luxembourg
pfister@lippmann.lu hausman@lippmann.lu

Climate fluctuations in the Grand-Duchy of Luxembourg are documented through temperature and rainfall measurements initiated during the first half of the 19th century. The analysis of these daily climatological data records has shown how climate conditions have gradually shifted from rather cold conditions to a substantial increase of temperature, close to 1°C since the 1950's (Drogue et al., 2005). The annual number of days with average negative temperatures has almost continually decreased over the past 150 years. Precipitation eventually also underwent quite substantial changes, even though it is more specifically affected by interseasonal redistributions of rainfall. Under the forcing of a very strong increase of westerly atmospheric circulation patterns during winter months throughout the second half of the 20th century, winter precipitation totals indeed strongly increased, while during summer months a slight decrease of rainfall totals was observed (Pfister et al., 2000 & 2005).

These redistributions in seasonal amplitudes of rainfall and temperature over the past few decades already had direct implications on the rainfall-runoff transformation processes within the river basins of the Grand-Duchy of Luxembourg. Especially maximum winter discharge values underwent significant increases, eventually contributing to some of the most severe floodings of the 20th century in the Alzette and Sure river alluvial plains. With the increase of westerly atmospheric circulation patterns during winter months, the spatial distribution of precipitation over the Grand-Duchy of Luxembourg is strongly influenced by topography, with rainfall totals being much higher in the North-West (approx. 1100 mm/year over the Ardennes massif and the Moselle cuestas) than in the East (approx. 750 mm/year in the Moselle valley). Trends in river discharge eventually also turned out to be strongly influenced by this high spatial variability in precipitation totals (Pfister et al., 2004).

Forests play a primordial role in the water cycle of our hydrological systems, intercepting up to 20% of total incoming precipitation at annual level (Gerrits et al., 2007). As for most processes involved in the hydrological cycle, interception is characterised by a tremendous spatial and temporal variability and thus contributes, together with other physiographic characteristics (topography, geology, etc.), to what has been defined as the 'uniqueness of place' by Beven (2000) and which causes our hydrosystems to have highly diversified combinations of first order controls on the water balance. As any other physiographic component of the hydrosystems, forests are subject to the spatio-temporal variations of climate conditions. Consequently, the water balance is potentially exposed to substantial modifications that are likely to profoundly modify tree species compositions inside our hydrosystems.

Currently, the question to be raised is: how will such changes interact with tree development and thus disturb plant-ecosystem equilibrium? This (negative) effect is usually referred to as plant stress. For plant scientists, stress also refers to a set of unfavorable conditions that alter the physiological status of plants. Indeed, farmers or gardeners have experienced for a long time that their crops or perennials are often able to adapt to different environmental changes, but that this flexibility is also limited. Obviously, their adaptability, also known as phenotypic plasticity, is an essential mechanism in the plants' life cycle, because their anchoring to the soil does not allow them to escape from adverse conditions (Renaut et al., 2009). Therefore, individual or combined stress conditions have been studied intensively by both plant physiologists and molecular biologists. The changes in climate conditions in Europe and North America are nowadays an issue of growing concern. The amazing amount of data produced by omics approaches, allows plant scientists to combine and integrate complementary approaches to obtain insights on gene functions and plants' ability to cope with multiple stress factors. Although the techniques are evolving very rapidly, the global molecular changes that will be observed will always remain part of the total scheme. The next challenging step towards the full understanding of plant stress responses will depend on our ability to link and interpret the amount of data that will emanate from research projects. In the end, it should never be forgotten that the final aim of this research is to understand how the plant cell reacts to the stressing agent to elaborate appropriate remedies to the problem.

References

Beven K.J., 2000: 'On uniqueness of place and process representations in hydrological modelling'. Hydrol. Earth Syst. Science 4, 203-212.

Drogue G., Hoffmann L., Pfister L., 2005: 'Les archives climatiques quantitatives de Luxembourg-ville: analyse primaire des longues séries chronologiques (1838-2003)'. Ferrantia, 43 : 21-55.

Gerrits A.M.J., Savenije H.H.G., Hoffmann L., Pfister L., 2007: 'New technique to measure forest floor interception - an application in a beech forest in Luxembourg', Hydrology and Earth System Sciences, 11: 695-701.

Pfister L., Drogue G., Poirier C., Hoffmann L., 2005: 'Spatial variability of trends in hydrological extremes induced by orographically enhanced rainfall events due to westerly atmospheric circulations'. Water Science and Technology, 51: 15-22.Beven, 2000

Pfister L., Drogue G., El Idrissi A., Iffly J.-F., Poirier C., Hoffmann L., 2004: 'Spatial variability of trends in the rainfall-runoff relationship: A mesoscale study in the Mosel basin'. Climatic Change, 66: 66-87.

Pfister L., Humbert J., Hoffmann L., 2000: 'Recent trends in rainfall-runoff characteristics in the Alzette river basin, Luxembourg'. Climatic Change, 45: 323-337.

Renaut J., Bohler S., Hausman J.F., Hoffmann L., Sergeant K.,Ashan N., Jolivet Y. Dizengremel P., 2009: 'The impact of atmospheric composition on plants: a case study of ozone and poplar'. Mass Spec. Rev. DOI 10.1002/mas.20202

SYMPOSIUM OF THE BENELUX SOCIETY OF HORTICULTURAL SCIENCE
BNL-SHS
Convener Prof. Monique Bodson Gembloux, Belgium April 3, 2009

Detecting weeds by artificial vision in carrot crops: towards optimization of herbicide/pesticide use

Piron A., Destain M.-F.,
Gembloux Agricultural University,
2 Passage des Déportés, 5030 Gembloux (Belgium)
piron.a@fsagx.ac.be; destain.mf@fsagx.ac.be

Several studies show that there is significant potential for the development of carbon offsets and greenhouse gas emission reductions as a result of the application of precision farming techniques (also called site-specific crop management techniques). Amongst these techniques, the reduction of pesticides use in agriculture and horticulture has to be favourably considered.

Within this scope, the paper concerns detection of weeds in vegetable crops by machine vision. This is the first step for a localized herbicide application. In-row weed detection in carrots is taken as an example, as particular difficulties arise from the slow germination of carrot seeds (leading to a strong competition for nutrients and sunlight in the early stages of growth) and the irregular and dense sowing pattern.

In machine vision, features such as colour and height can be used for discrimination between objects.

To evaluate the efficiency of colour discrimination, a multispectral device consisting of a black and white camera coupled with a rotating wheel holding 22 interference filters in the VIS-NIR domain was set up (Fig. 1, 2). Measurements were performed over a period of 19 days, starting 1 week after crop emergence and seven different weeds species were considered. The best combination of filters included three interference filters, respectively centred on 450, 550 and 700 nm. With this combination, the overall classification accuracy (CA) was 72%. When the classification results were reported on field images, a systematic misclassification of carrot cotyledons appears. Better results were obtained with a more advanced growth stage (Piron *et al.*, 2008).

To measure the height of weeds and crop, an active stereoscopy technique was developed. It is based on specific coded structured light taking into account the specificities of the small scale scene, e.g. occlusions between weeds, carrots leaves and ground. A height feature integrating the ground irregularities was computed. As the weeds and the crop grow at different speeds, this feature provided a means to differentiate weeds from carrots with an overall classification accuracy of 83% (Piron *et al.*, under review) (Fig. 3, 4).

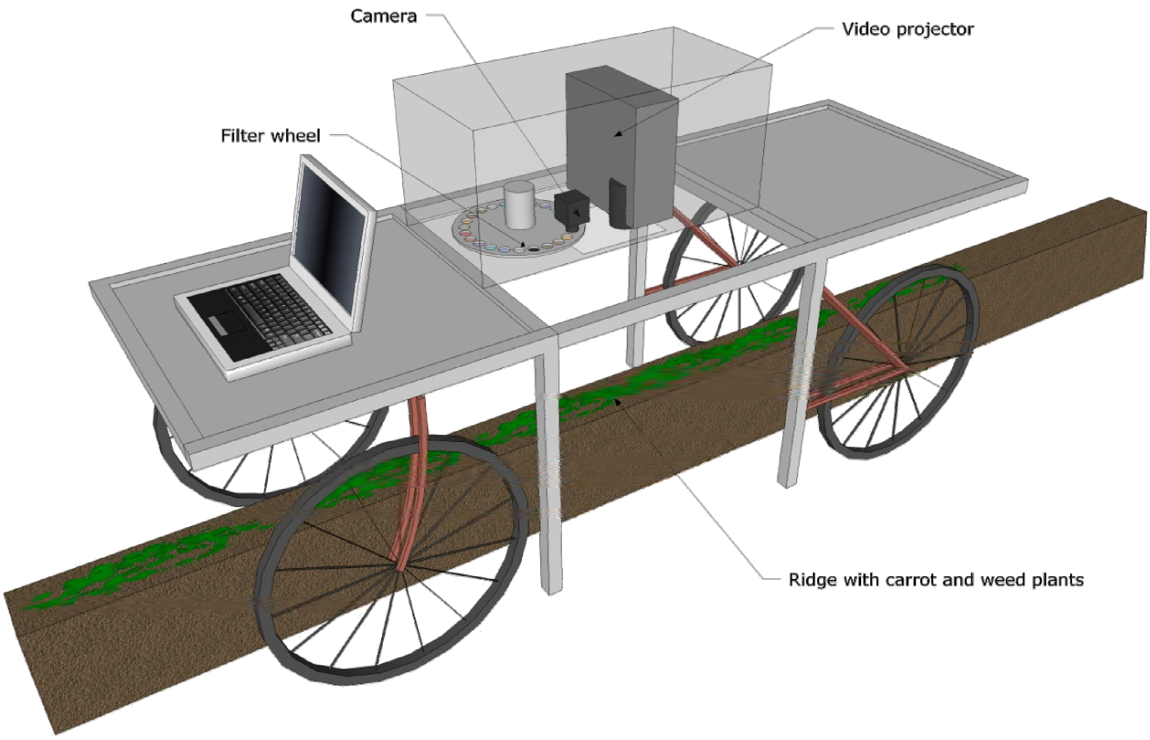


Fig. 1. Schematic view of the acquisition device (natural light shielding parts not represented).

Fig. 2. Multispectral image in simulated colors showing a creeping weed under carrot plants.

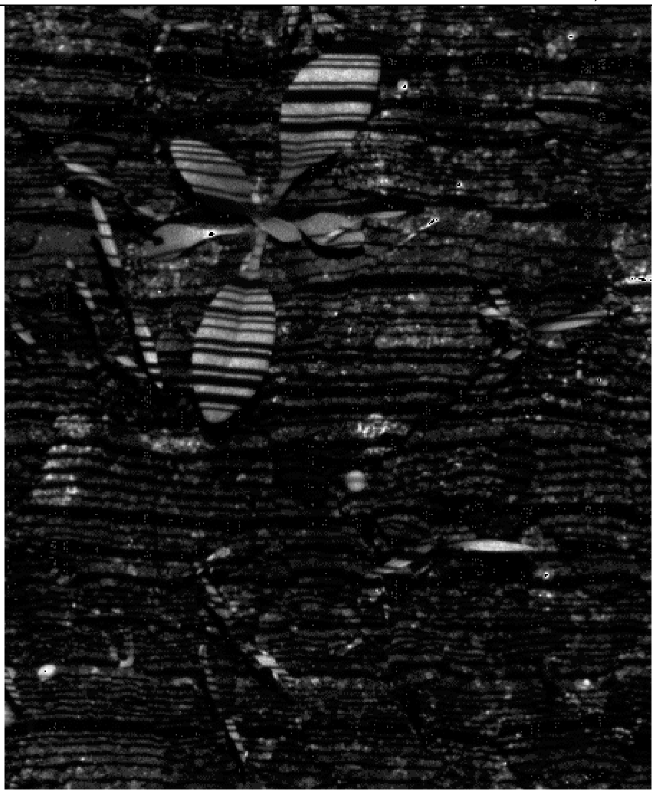


Fig. 3. Scene showing soil, a weed and carrot cotyledons with projected pattern (detail).

Fig. 4. Detail of stereoscopic depth images showing the high variability in ground flatness and multiple weed species. Lighter colors correspond to points closer to the camera.

Models as effective tools for optimizing irrigation

K. STEPPE[1*], D.J.W. DE PAUW[2] & R. LEMEUR[1]
[1]Department of Applied Ecology and Environmental Biology, Laboratory of Plant Ecology, Ghent University, Ghent, Belgium
[2]Department of Applied Mathematics, Biometrics and Process Control, KERMIT: Knowledge based systems, Ghent University, Ghent, Belgium

*corresponding author: phone: +32 (0)9 264 61 12; fax: +32 (0)9 224 44 10; email: kathy.steppe@UGent.be

The increasing worldwide shortages of freshwater and costs of irrigation have led to an emphasis on the development of improved, more accurate irrigation strategies in order to conserve water, minimize water wastage and to keep the associated costs down. In the past, sensors to continuously monitor the soil moisture or plant water status have been proposed as useful tools for irrigation scheduling. These approaches are limited in the sense that they only provide information on whether or not irrigation is needed, but they do not quantify how much irrigation should be applied.

As the quest for greater precision in the application of irrigation water continues, a new generation of irrigation strategies presents itself, whereby mathematical models are used in combination with plant and/or environmental measurements to provide information on “when” and “how much” irrigation should be applied. In scientific literature, interesting mechanistic models are available, but their practical application in irrigation scheduling has not been exploited so far due to implementation issues, model identifiability problems or temporal variability issues of some of the model parameters. However, today these issues related to mechanistic models should not longer constitute a problem due to progress made in mathematical modelling and computer technology. A thorough mathematical analysis of the model allows an intelligent way of dealing with the identifiability problems and new software can be used to solve the implementation issues and the problems related to possible temporal variability of the model parameters.

In this presentation we will demonstrate how a mechanistic water flow and storage model, which was originally developed to gain new scientific insight in the functioning of the stem diameter, was used as an effective tool for optimizing irrigation (Steppe et al. 2008). The proposed methodology combines the model with continuously measured sap flow rates and stem diameter variations in order to simulate the dynamic behaviour of the stem water potential which is, in practice, notoriously unreliable to measure with automated stem hygrometers. The simulated stem water potential is used to control the timing of the irrigation by continuous comparison with a certain threshold value. The amount of required irrigation water is derived from a time integration of the measured sap flow profile. A thorough mathematical analysis of the model showed that an initial (offline) model calibration based on measurements of sap flow, stem diameter variation and stem water potential is required to deal with the model identifiability problems. During irrigation control, however, only stem diameter variation and sap flow measurements are required for online simulation and model calibration. For the proposed system to be applicable in practice, new software called STACI (Software Tool for Automatic Control of Irrigation) was developed as well. This software allows for the optimal integration of the continuous measurements, the mathematical modelling and the real-time irrigation control. A test of the newly developed system in a small-scale setup showed that the newly proposed methodology is an effective tool to predict when and how much irrigation has to be supplied.

Reference:

Steppe K, De Pauw DJW, Lemeur R (2008) A step towards new irrigation scheduling strategies using plant-based measurements and mathematical modelling. *Irrigation Science* 26: 505-517.

Climate-robust crop science: modelling climate-change impacts across scales

Paul C. Struik & H. Meinke
Centre for Crop Systems Analysis, Plant Sciences Group, Wageningen University, P.O. Box 430, NL 6700 AK Wageningen, The Netherlands
E-mail: paul.struik@wur.nl

Agriculture, including crop and horticultural science, is in a state of flux, caught up in 'tensions of scale'. These tensions arise from the attempts to address 'top-down' issues such as climate change impacts with 'bottom-up' solutions such as biotechnology, including the bio-engineering of climate-robust genetic responses to environmental stresses. The rapidly changing global environment affects the management of farms, fields, crops and plants. However, as the resolution of spatial scale decreases, attribution of these global impacts is becoming increasingly difficult. Similarly, rapid biotechnological developments provide new insights and skills at the molecular, genome and cell levels, but with decreasing spatial resolution, environmental interactions increase, making it difficult to quantify the impact of biotechnology at crop, field, farm, regional or global levels. Attribution of cause and effect becomes increasingly intractable as the scale difference between the problem and the proposed technological solution increases. Correctly matching problems of societal importance, such as the climate change issue, with science-based solutions is a challenge for horticultural science. This challenge requires well-designed, quantitative modelling at all scales. We can only develop a climate-robust horticultural sector by developing modelling tools that help us to integrate knowledge across scales. We will show that simulation modelling helps to negotiate the scale-related tensions by integrating knowledge from a range of disciplinary domains across hierarchical levels and across temporal and spatial scales. We will also show that simulation modelling provides an effective means of helping decision makers at all scales to evaluate alternative options and of engaging all stakeholders in a process of innovation by design. To be most effective, modelling should be conducted in an open, transparent and participatory style that creates legitimacy for the approach and fosters global collaboration and communication.

Climate Change : myth or reality

Debontridder Luc
Attaché – Assistant, Scientist Disaster fund
Royal Meteorological Institute of Belgium
Operational services en services for users.

Introduction

- Climate changes are disturbing. Our lives could change drastically in the near future (heat waves, periods of drought, periods of excessive precipitations, …)
- What do we really know? What should we believe and what not?

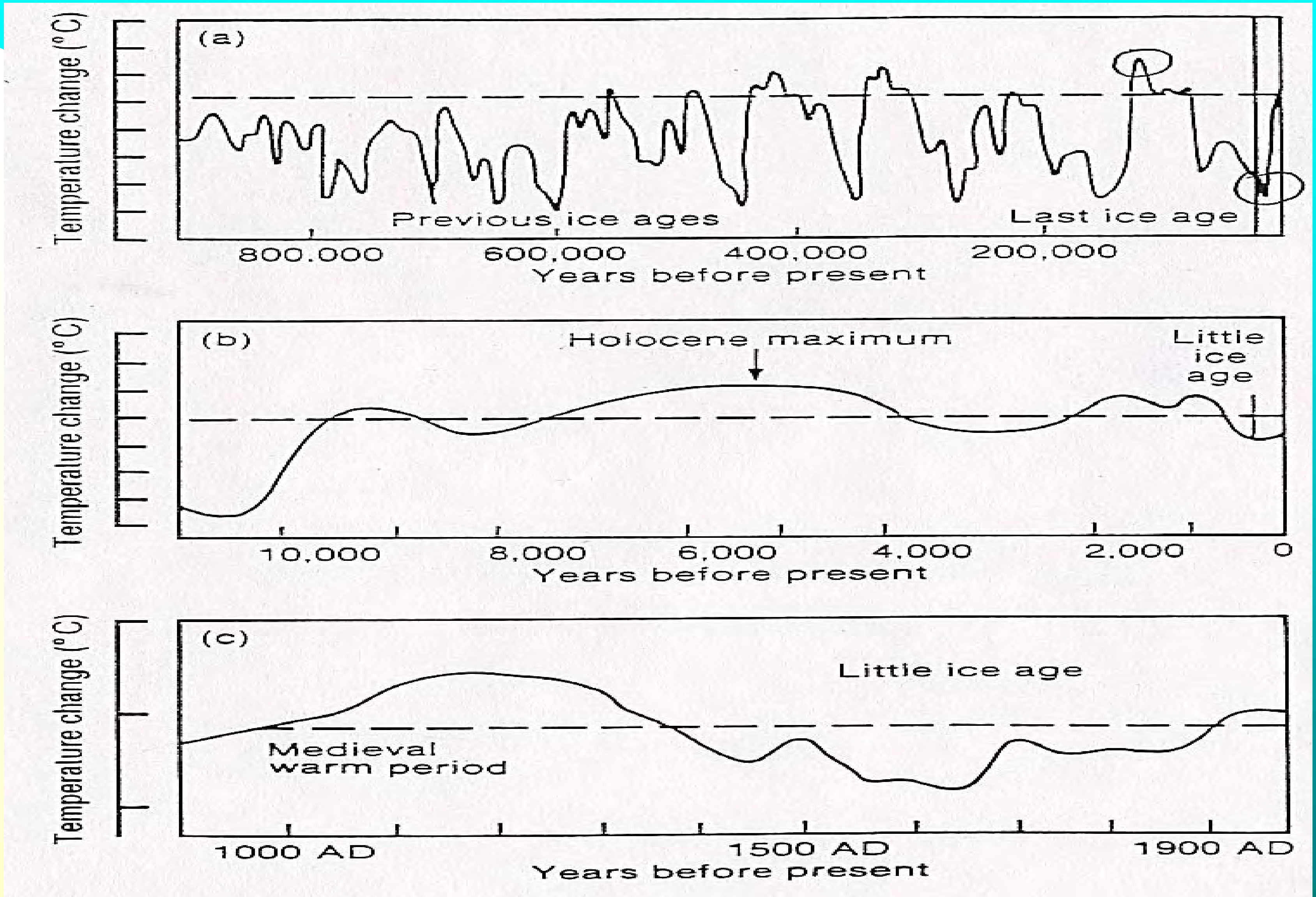
Main Questions

- What is ‘the climate’?
- What determines today's climate?
- How does the climate change?
- Why does the climate change?
- How will the climate change in the future?

What is ‘the climate’?

- The weather is unstable and fickle.
- But: during the winter it is colder than during the summer, in Spain it is sunnier etc.
- The climate can be described as the average weather at a certain place. What you can expect but also what can happen in extreme circumstances. (storms, snowfall, vacation guides, vegetation, height of dikes, hibernation periods of birds etc.

Climate reconstructions



What determines today's climate?

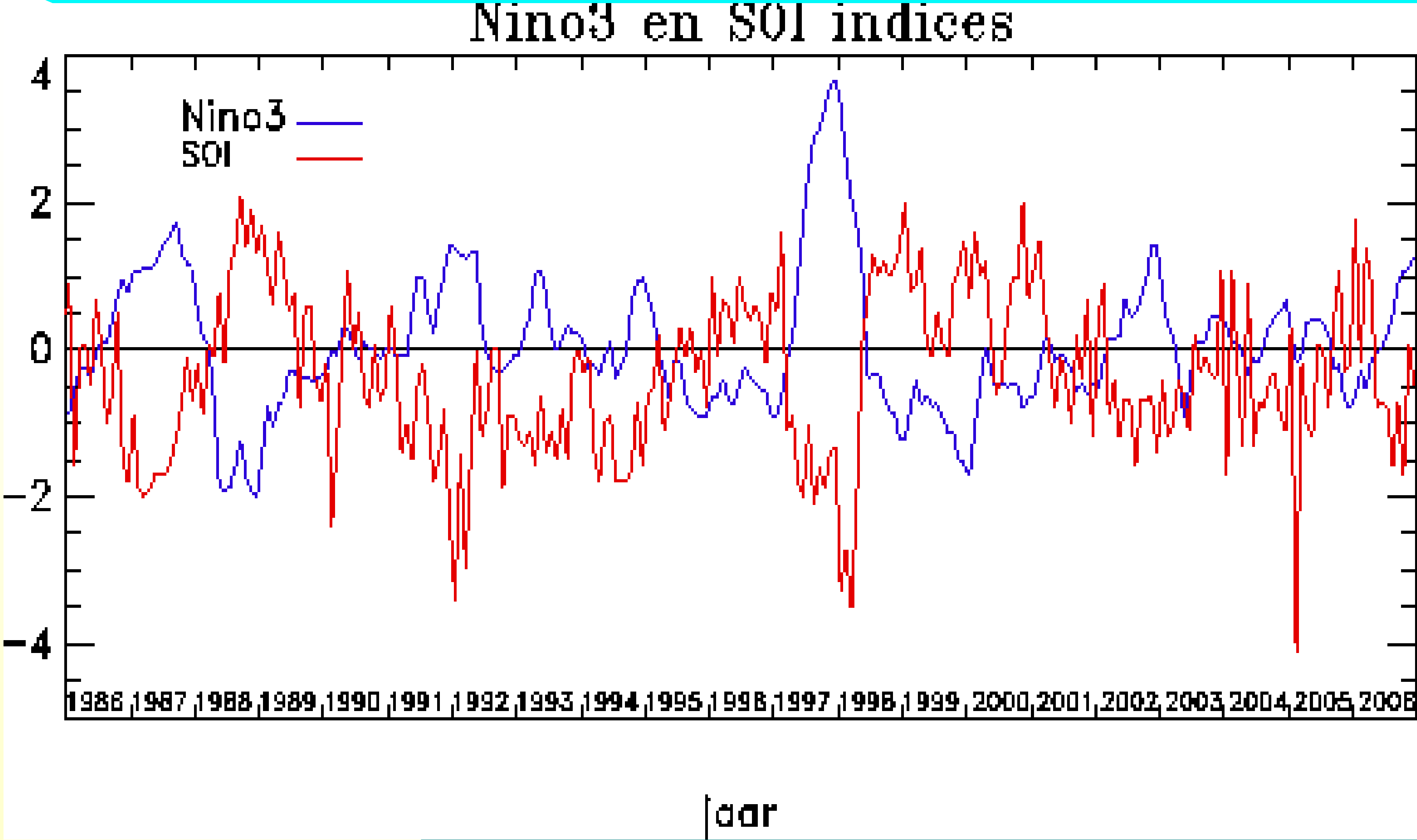
- The climate varies depending on the degree of latitude, the angle in which the solar rays reach the earth surface. The annual change of this angle, a consequence of the orbit of the earth around the sun, determines the seasons. But Rome is situated more north than New York and still the temperatures are a lot higher there...
- This is the result of the combined action of the oceans and the atmosphere. (The Gulf Stream, the mainly westerly air current on the Northern Hemisphere = milder climate).

- Some influences of the oceans on the climate occur alternately. An example of this are the trade winds in the Pacific Ocean that push the warm surface water along the equator to the west. This warm water is replaced by cold water from the depths. This is why a difference in temperature develops which leads to a difference in atmospheric pressure through which the trade winds become even stronger. This a full circle.
- Once every 3 to 7 years this phenomenon does occur and we get a phenomenon called El Niño. (the complete name is ENSO = El Niño Southern Oscillation)

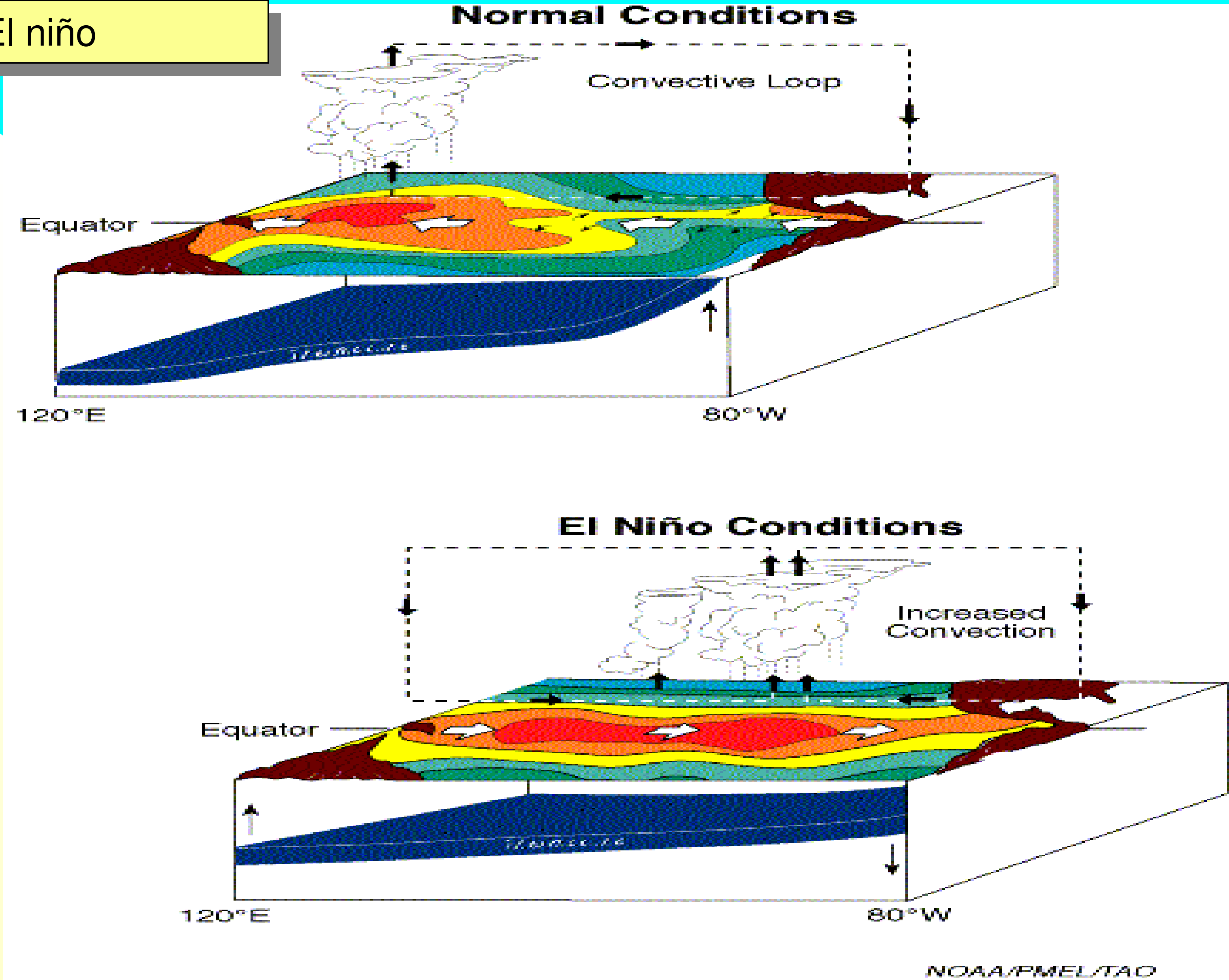
What is El Niño and what are the consequences?

El Niño is an irregular condition of the climate of the atmosphere and the ocean in the tropical Pacific that occurs every few years. With El Niño the seawater around the equator in the Eastern half of the Pacific is warmer than normal and there is a lower pressure difference between Tahiti (18S, 150W) and Darwin (12S, 131E). The other way around, with seawater that is colder than normal, is called La Niña.
Large parts of the earth experience the consequences of this condition. El Niño and La Niña are the main causes worldwide for the variability of the climate from year to year. On the other hand El Niño has no or very little influence on the Belgian weather.

El niño Southern Oscillation

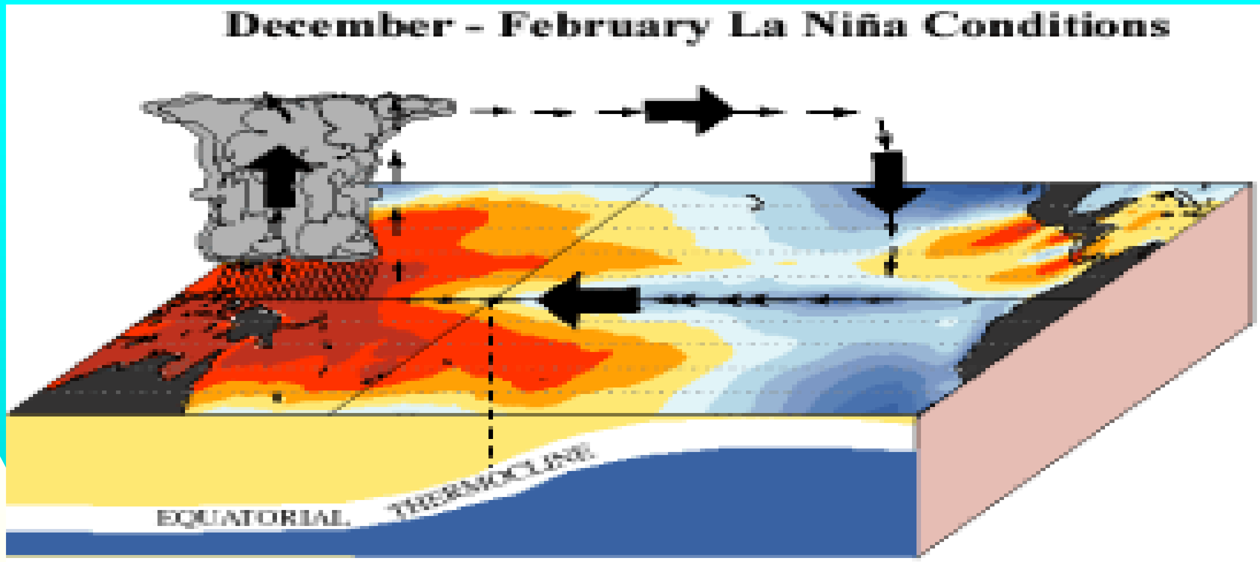


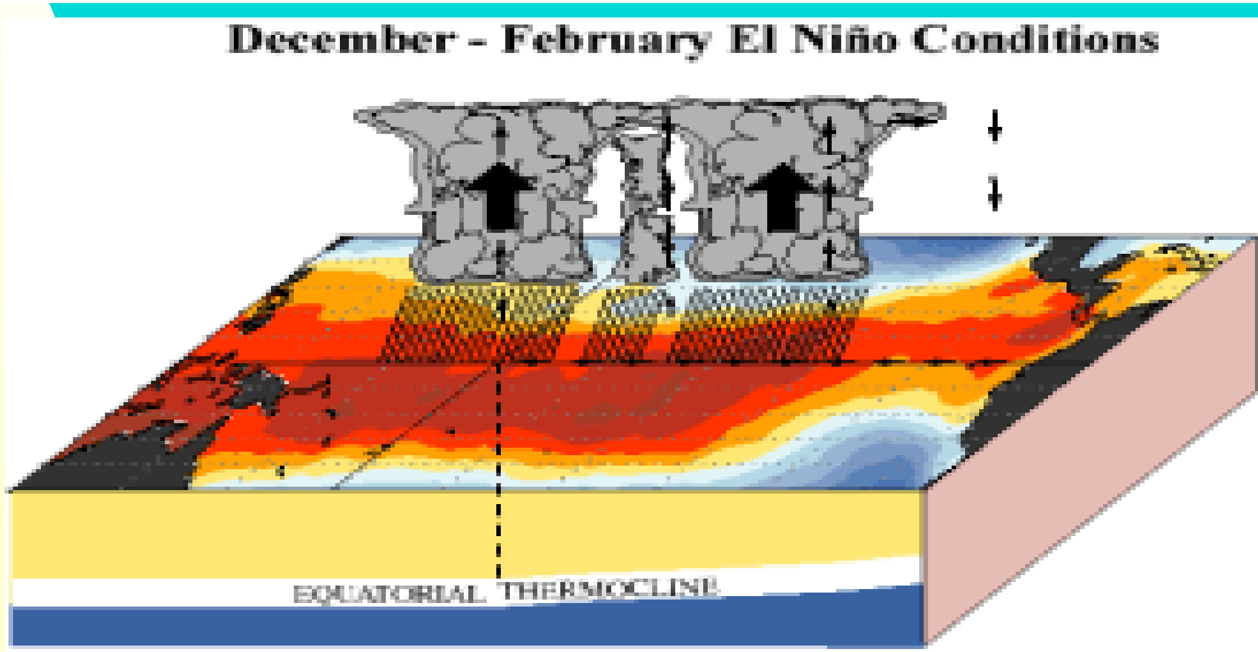
El niño


Normal Conditions
Convective Loop
Equator
Thermocline
120°E
80°W
El Niño Conditions
Increased Convection
Equator
Thermocline
120°E
80°W
NOAA/PMEL/TAO

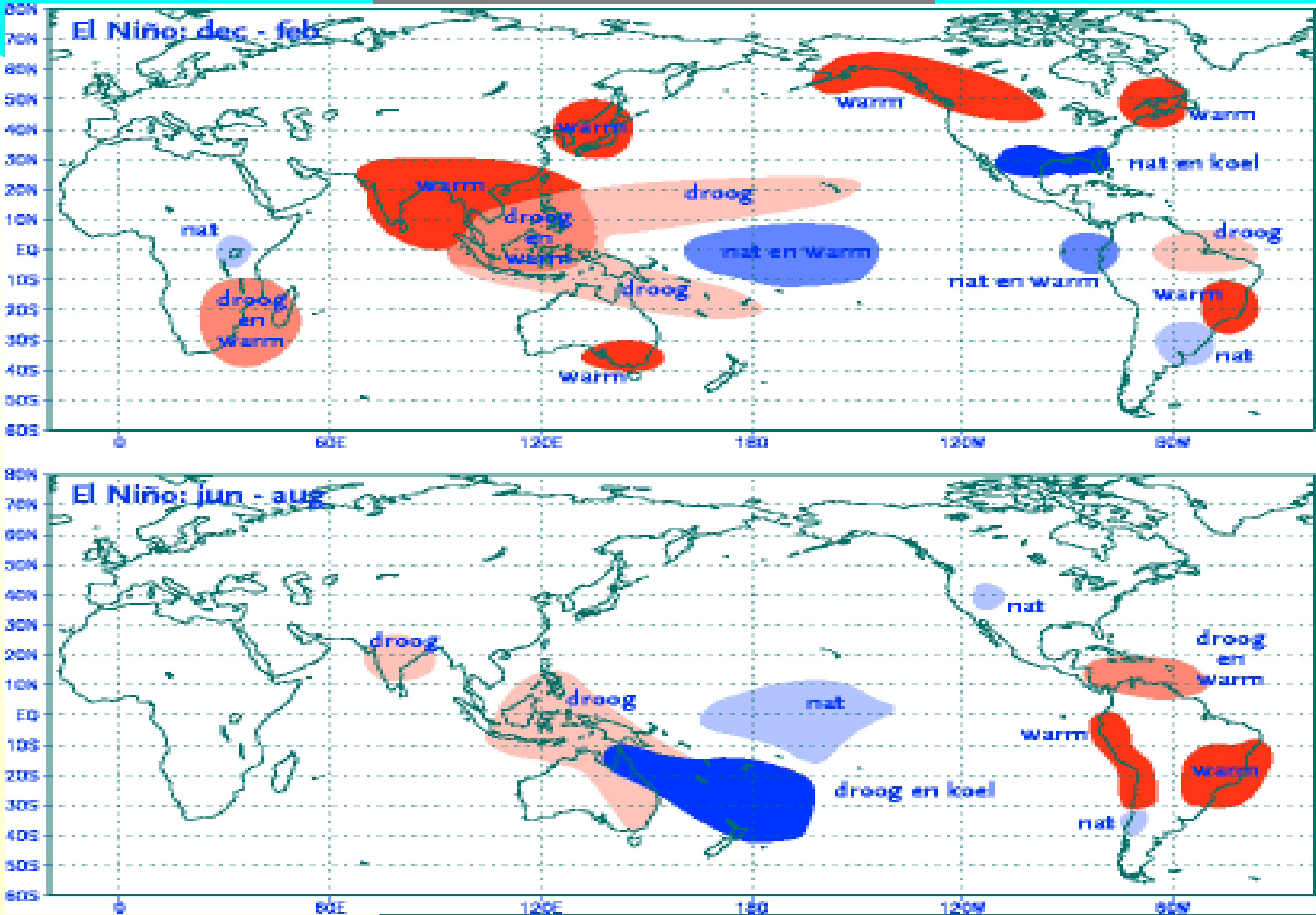
La Niña

El Niño

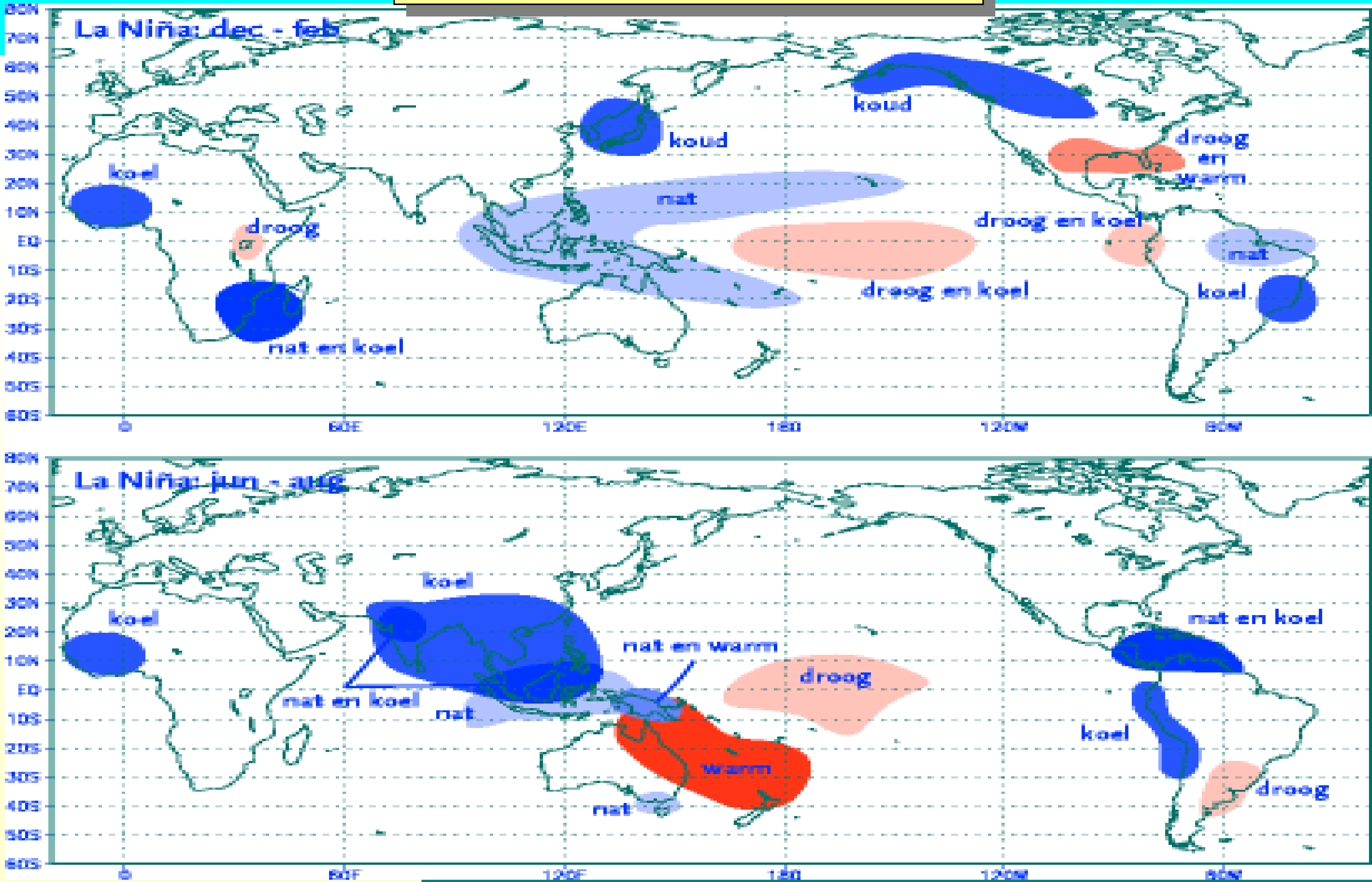




Consequences El Niño worldwide

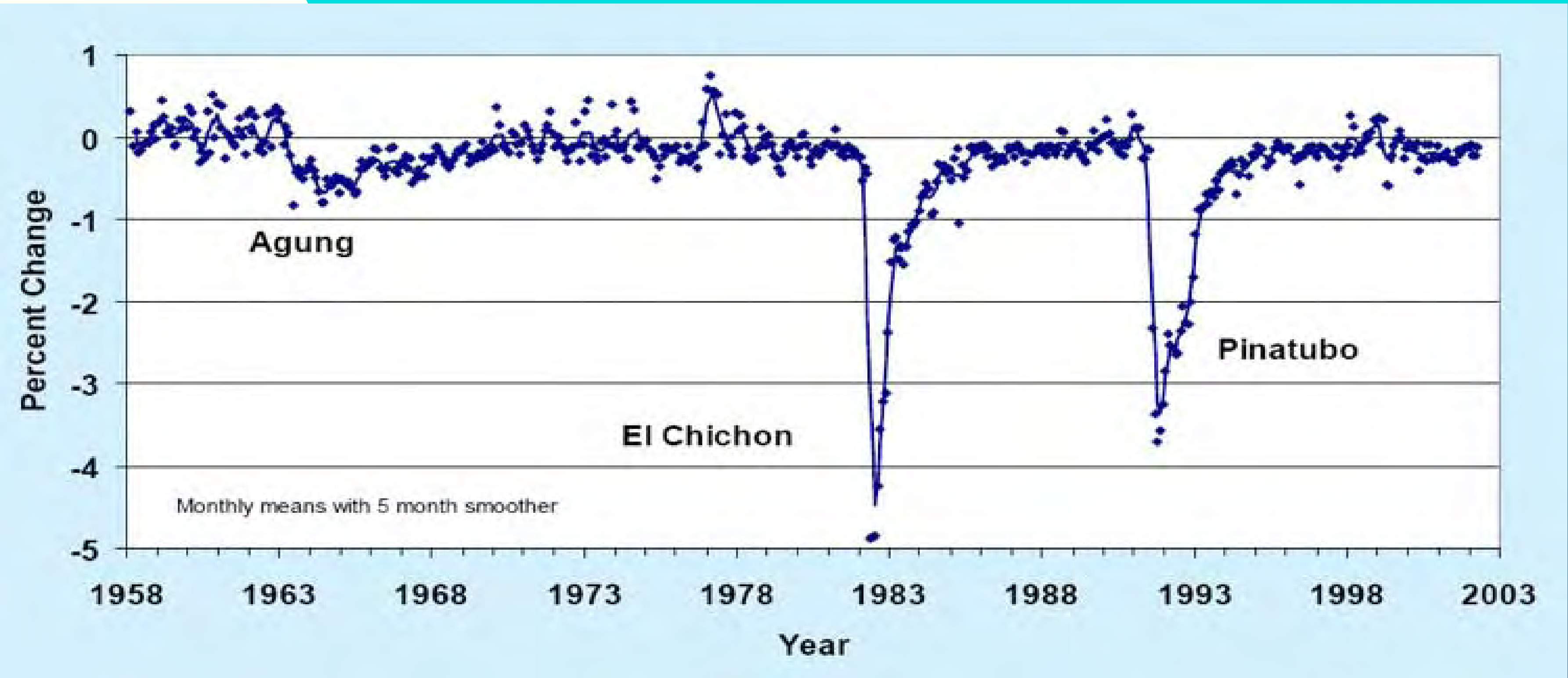


La niña : consequences worldwide

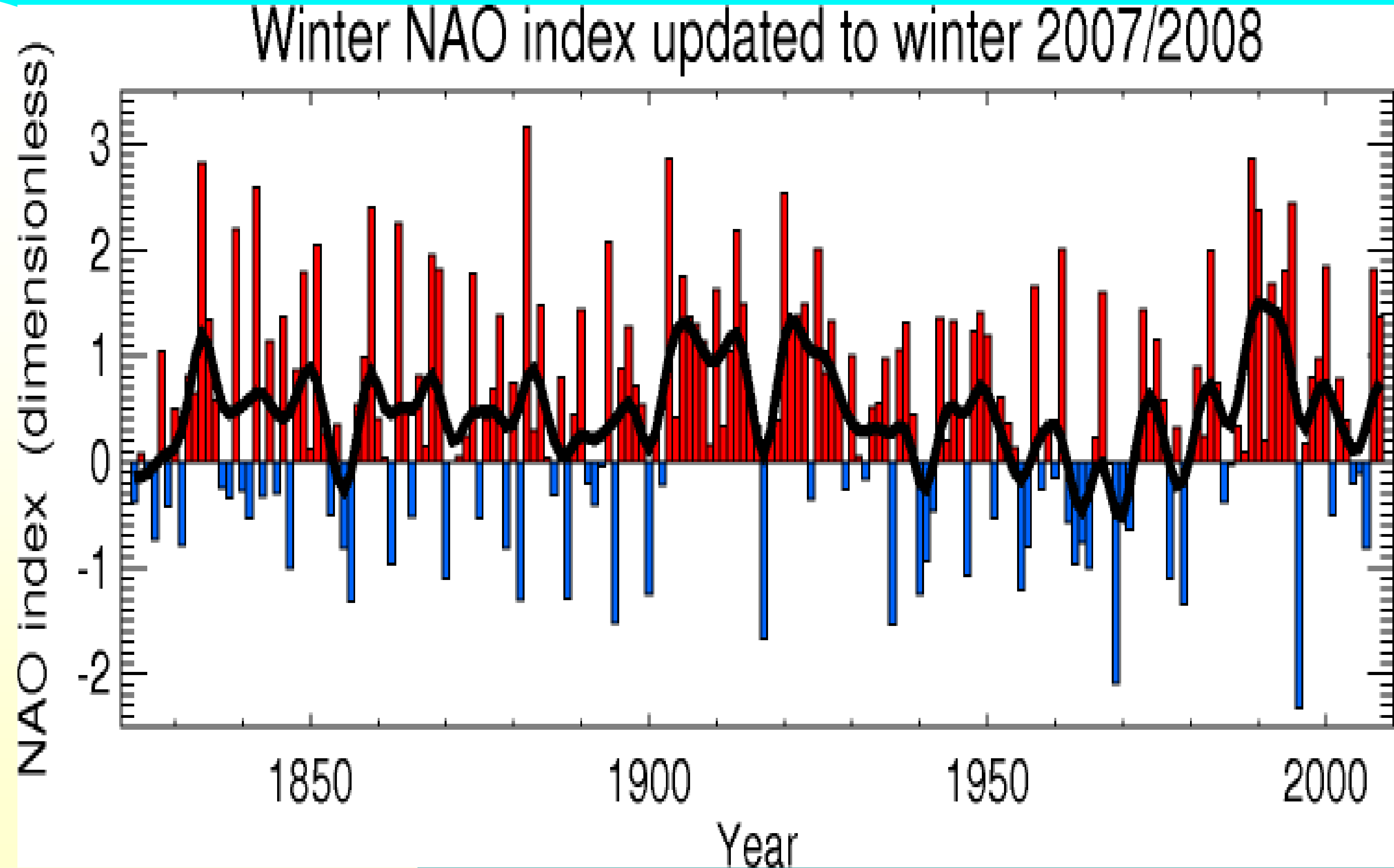


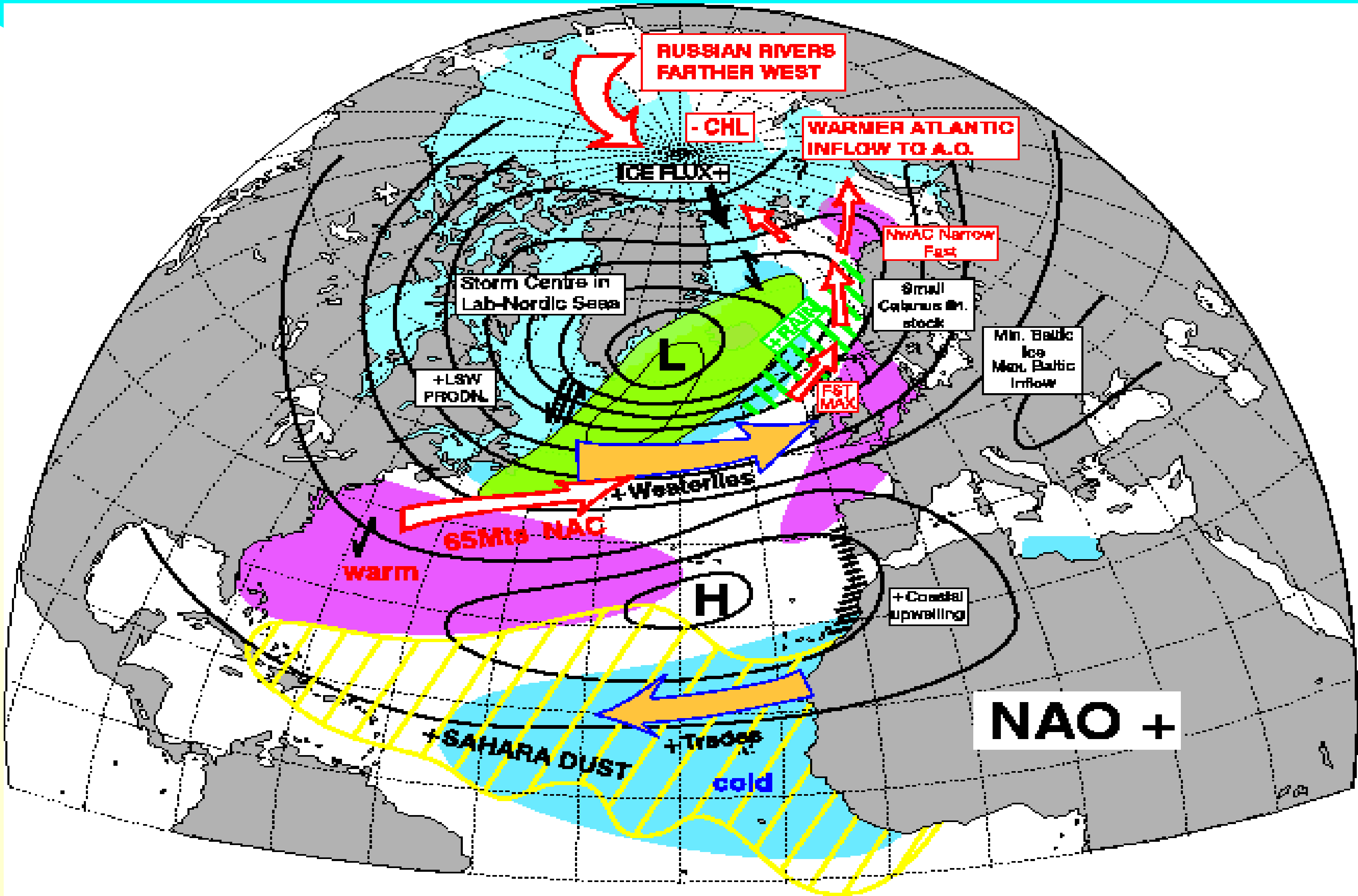
Volcanoes and climate

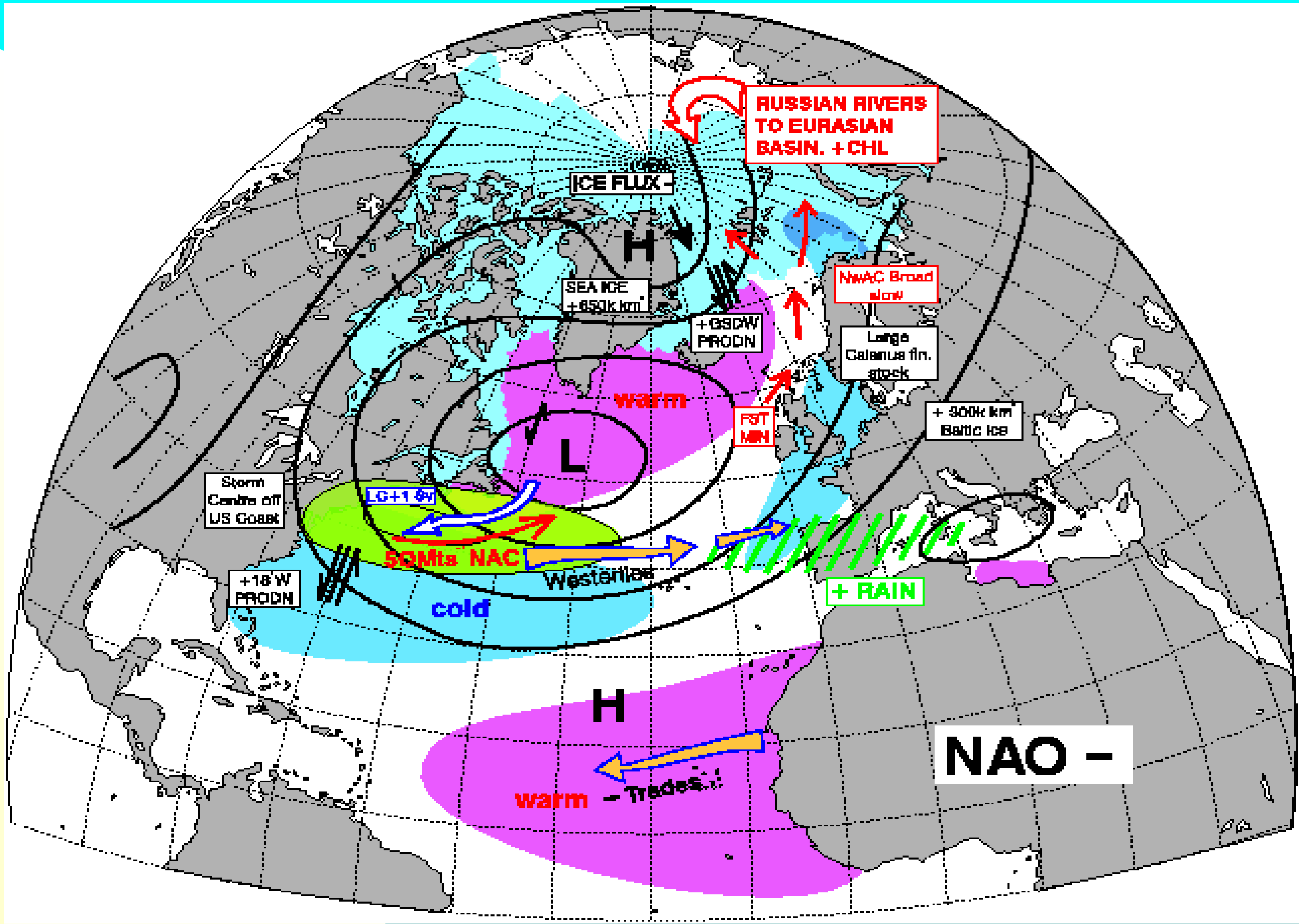
Volcanoes with important eruptions can send enormous clouds of fine dust and gasses to a great height into the atmosphere, sometimes higher than 15 kilometers. Such a cloud, that consists mainly of sulphuric acid and sulphuric compounds can remain a couple of years in the atmosphere and during that period it can be of influence on the weather and the climate in the whole world.



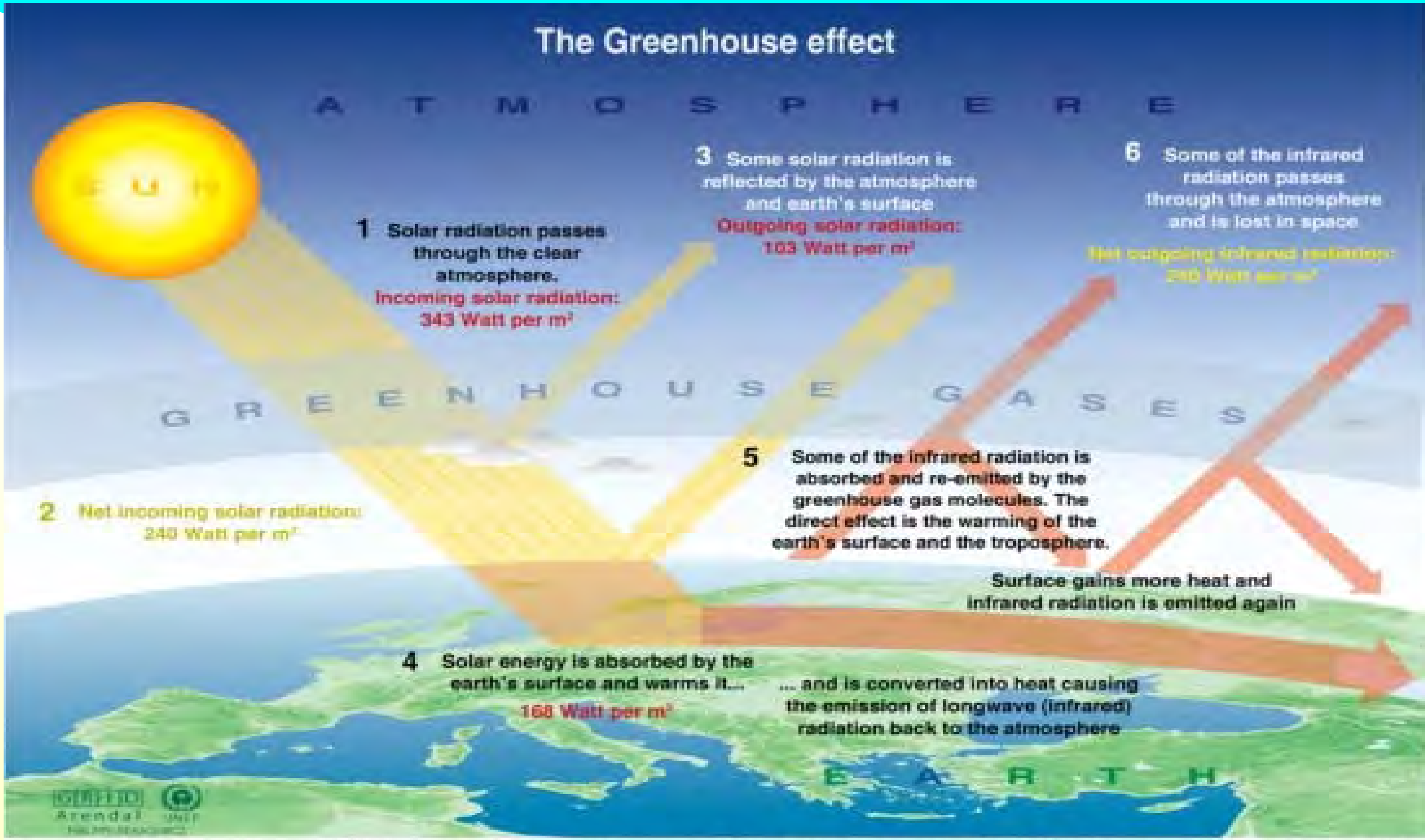
North Atlantic Oscillation : NAO




RUSSIAN RIVERS FARTHER WEST
- CHL
WARMER ATLANTIC INFLOW TO A.O.
ICE FLUX+
NwAC Narrow Fast
Small
stock
Min. Baltic Ice
Max. Baltic Inflow
Storm Centre in Lab-Nordic Seas
+LSW PRODN.
L
+RAIN
FST MAX
+Westerlies
65Mts NAC
warm
H
+Coastal upwelling
NAO +
+SAHARA DUST
+Trades
cold


RUSSIAN RIVERS TO EURASIAN BASIN. + CHL
ICE FLUX -
H
SEA ICE +650k km²
+GSDW PRODN
NwAC Broad slow
Large Calanus fin. stock
warm
FST MIN
+ 300k km² Baltic Ice
L
Storm Centre off US Coast
LC+1 Sv
50Mts NAC
Westerlies
+18 W PRODN
cold
+ RAIN
H
NAO –
warm
– Trades

The radiation balance of the Earth



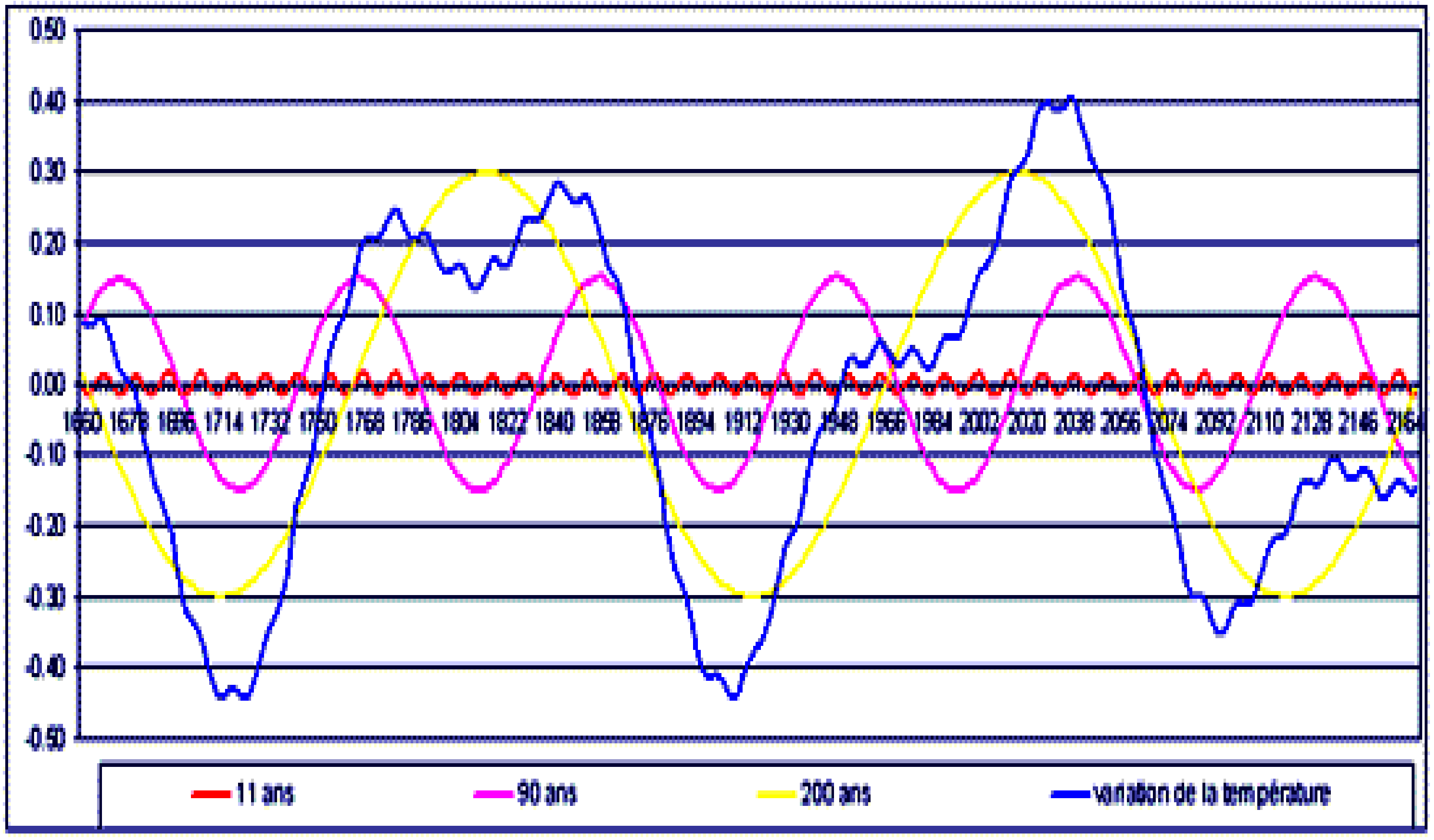
Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

Solar driven climate changes and fluctuations

The extent to which the variations in solar activity can influence the earth's climate is an important scientific theme and is up for discussion. The social importance is very big too because this discussion plays a part in determining the contribution of mankind to the observed climate changes.

Fluctuations in reconstructions of solar activity can give indications on the influence of variations in solar activity on the climate, even though the causal connection isn't always clear. Solar signals are often difficult to separate from other sources of climate changes like volcano eruptions, El Niño and long-term internal variability. The global solar radiation on the ground is the amount of solar energy that falls onto a horizontal surface. First of all this parameter depends on the amount of clouds (a high solar radiation means a little amount of clouds) and then on the transmission of the cloudless atmosphere, which in it's turn depends on parameters like the amount of vapour, the amount of ozone and the presence of aerosols in the atmosphere.

Variations in solar activity



11-year solar cycle

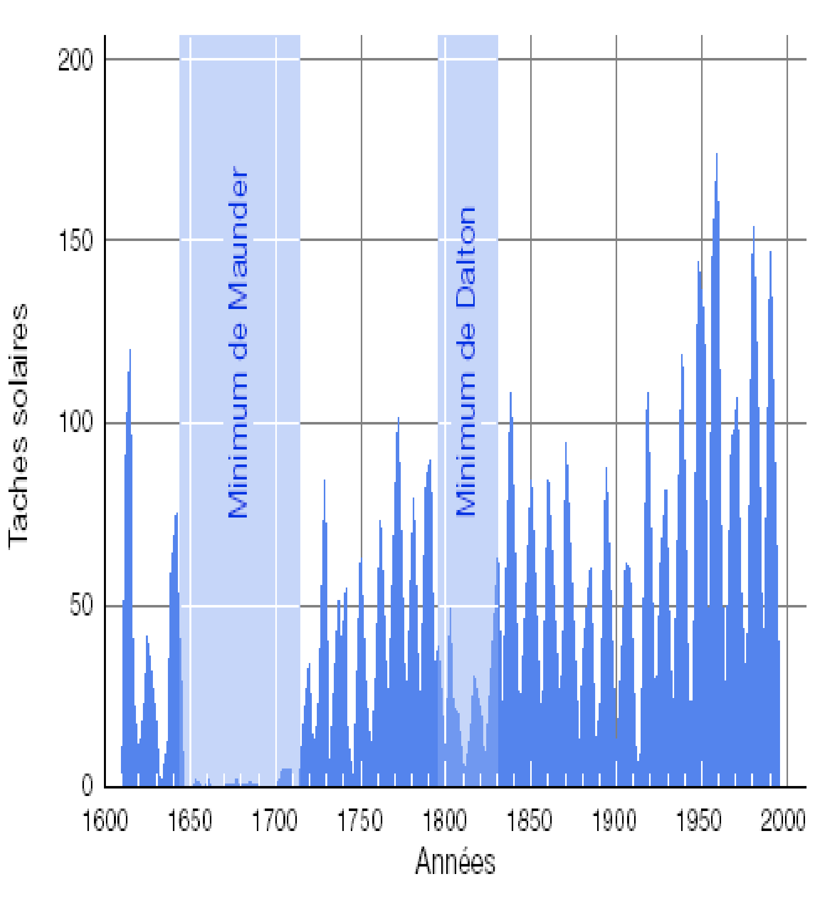


Fig. 2: Nombre de taches solaires observées depuis 1610 [4] représenté à partir des moyennes annuelles. Plus le soleil est actif, plus les taches formées à sa surface sont nombreuses. On observe en plus d'un cycle de 11 ans très net une tendance à l'augmentation de l'activité solaire depuis le début du XVIII° siècle.

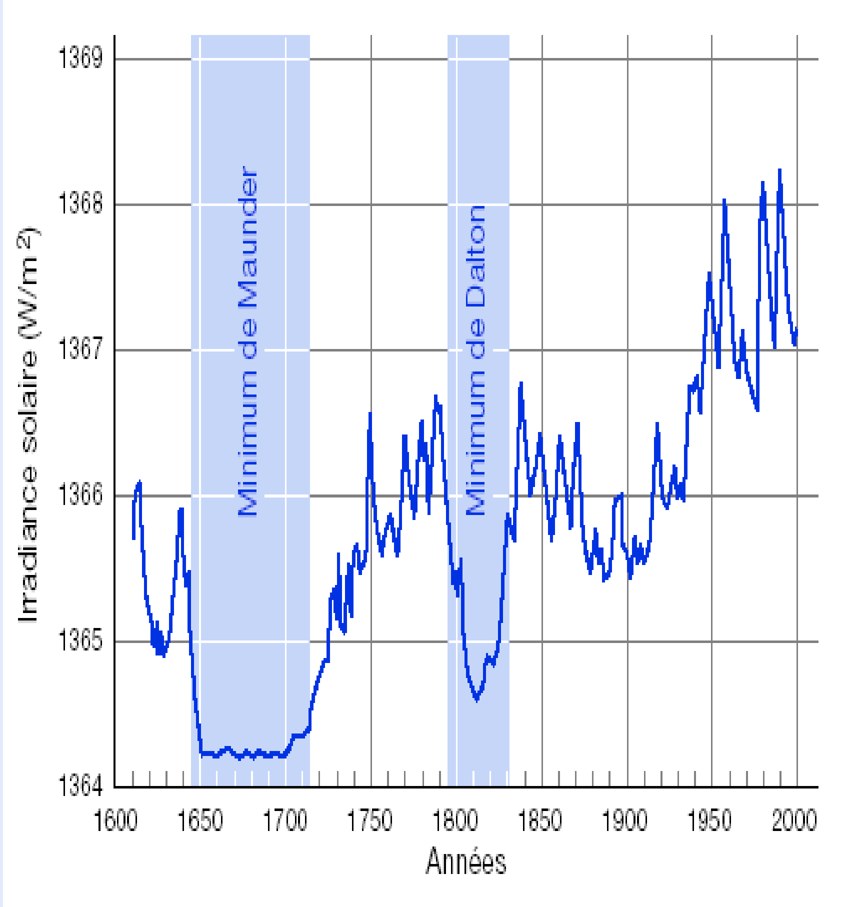


Fig. 3: Evolution de l'irradiance solaire retracée de 1610 à nos jours. La courbe a été obtenue à partir des protocoles d'observation des taches solaires et de l'étude d'étoiles similaires au soleil. D'après ces calculs, l'éclairement solaire a augmenté de 0,24% depuis le minimum de Maunder. D'après [2], modifié.

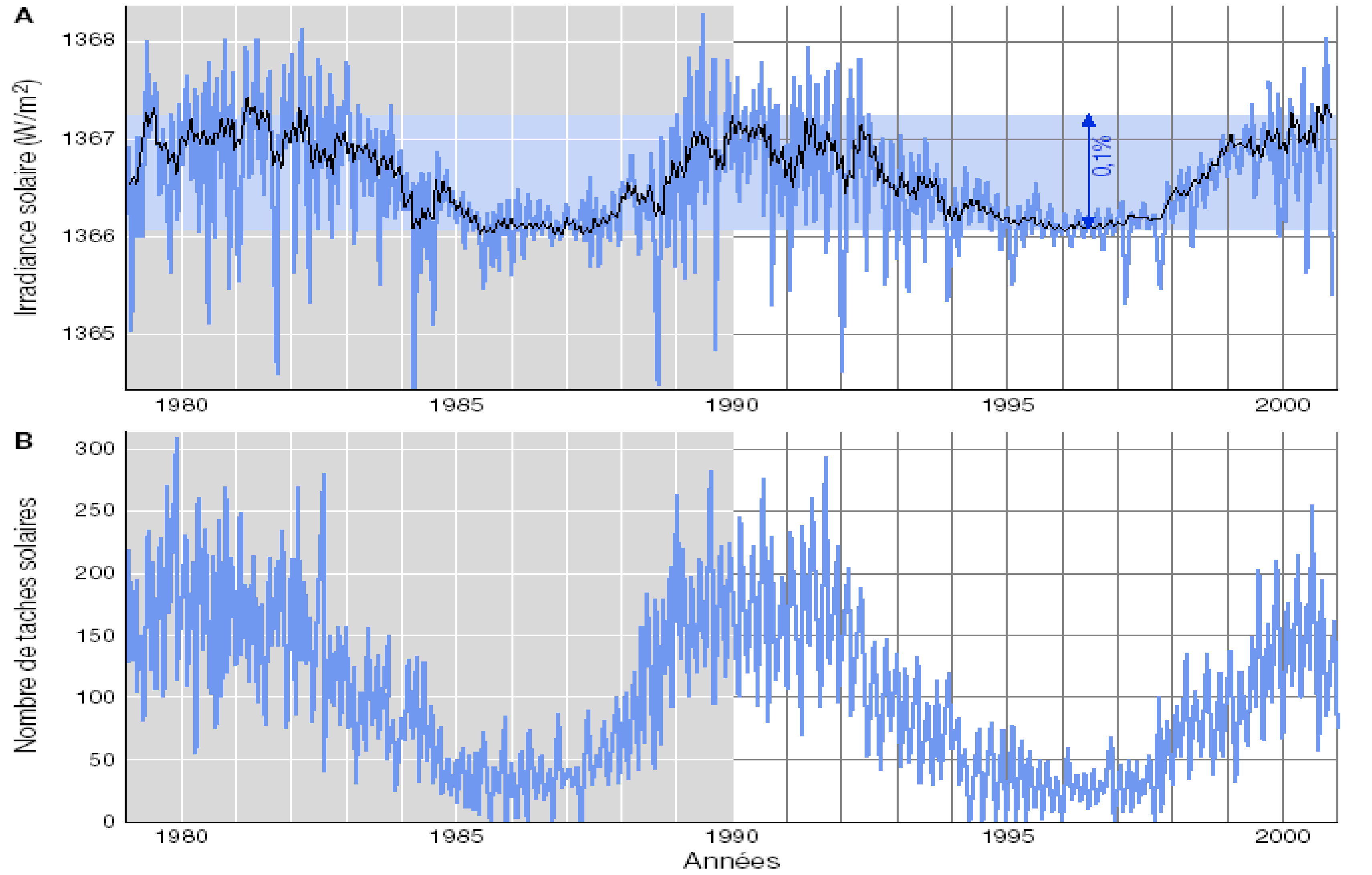
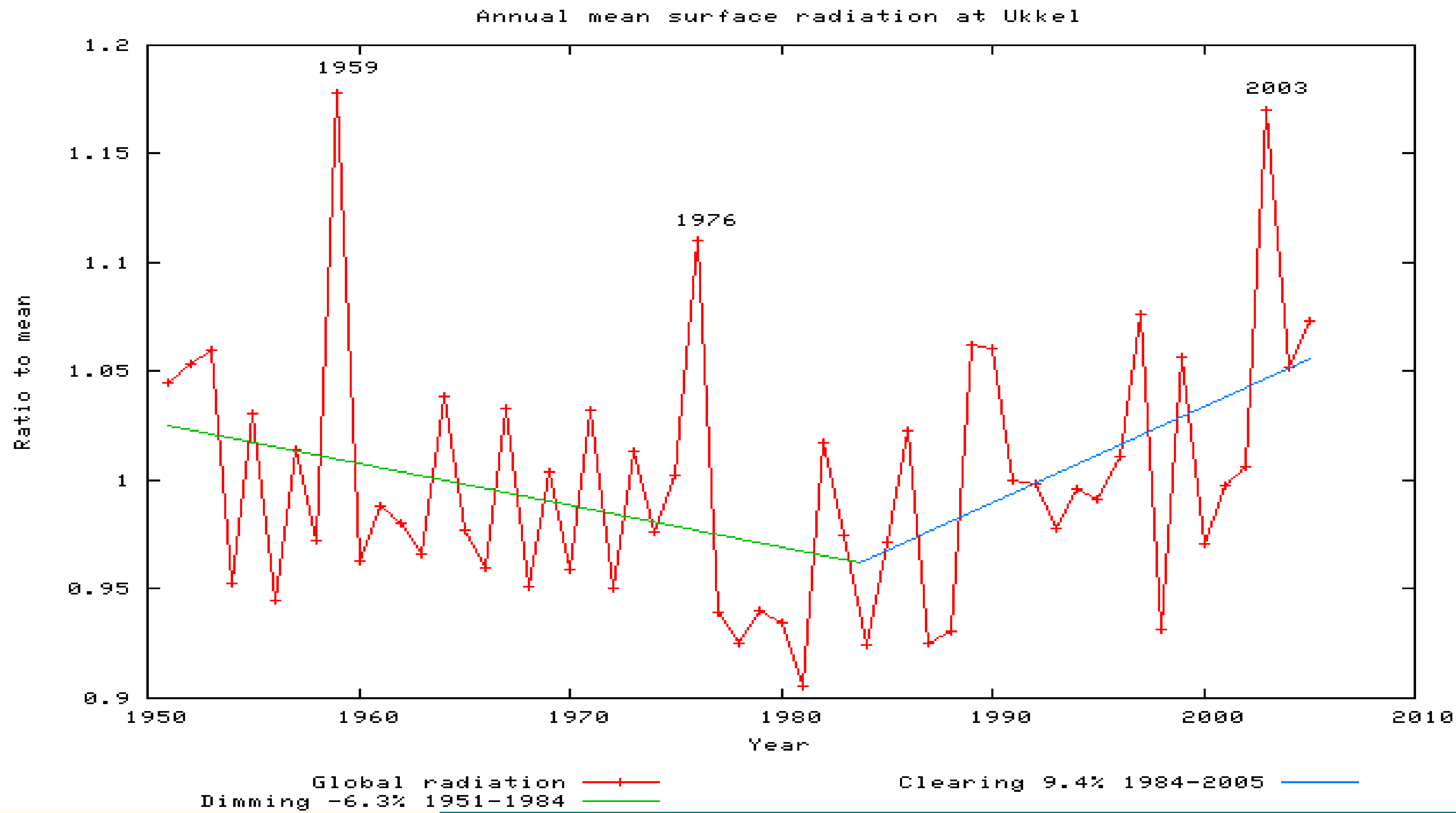


Fig. 1: Mesures d'irradiance solaire effectuées par satellite depuis 1978 (A) [1] et comparées au nombre de taches solaires observées pendant la même période (B) [4].

Monitoring solar radiation: Uccle



* The longest series of observations of the global solar radiation in Belgium is the one in Uccle, which started in 1951. The red curve in the chart shows the relative values of the annual average (relative compared to the average of the following period 1951-2005) of this global solar radiation.
The ‘well-known’ warm years of 1959, 1976 and 2003 stand out as years with an exceptional amount of solar radiation. The immediate warming of the earth’s surface by the high solar radiation can explain at least partly the high temperatures, as can also the possible advection of warm air from the predominant wind directions.

* In the period from 1951 till 1984 there is a decrease of the solar radiation of 6.3 % (green line in the figure). This corresponds to the 'global dimming' that was internationally determined. The most logical explanation is the increase of the aerosols because of the pollution of the atmosphere. The rise of the aerosols in the atmosphere decreases the solar radiation on the ground because of the so-called direct and indirect aerosol effects. The direct aerosol effect is a decrease of the transmission of the cloudless atmosphere because of the increase of polluting particles. Because of the indirect aerosol effect the water droplets in the clouds are formed easier, so that the clouds reflect more sunlight and less sunlight reaches the earth’s surface.

* In the period from 1984 till 2005 there is an increase in the solar radiation of 9.4 % (blue line in the figure). This corresponds to the recent global rise that was determined internationally by the BSRN (Baseline Surface Radiation Network). The end of the period of decrease of solar radiation in 1984 can possibly be explained by the measures taken against air pollution. This means the increase from 1984 is possibly partly due to the decrease of the amount of aerosols to low values, but the decrease of the amount of clouds possibly also plays a role. Whatever the reason is for the increase in solar radiation, since 1984 it contributes, at least in Belgium, to the rise in temperatures that is expected because of the rise in the amount of greenhouse gasses.

Aerosols

Aerosols = volatile particles between 0 and 3 km height.

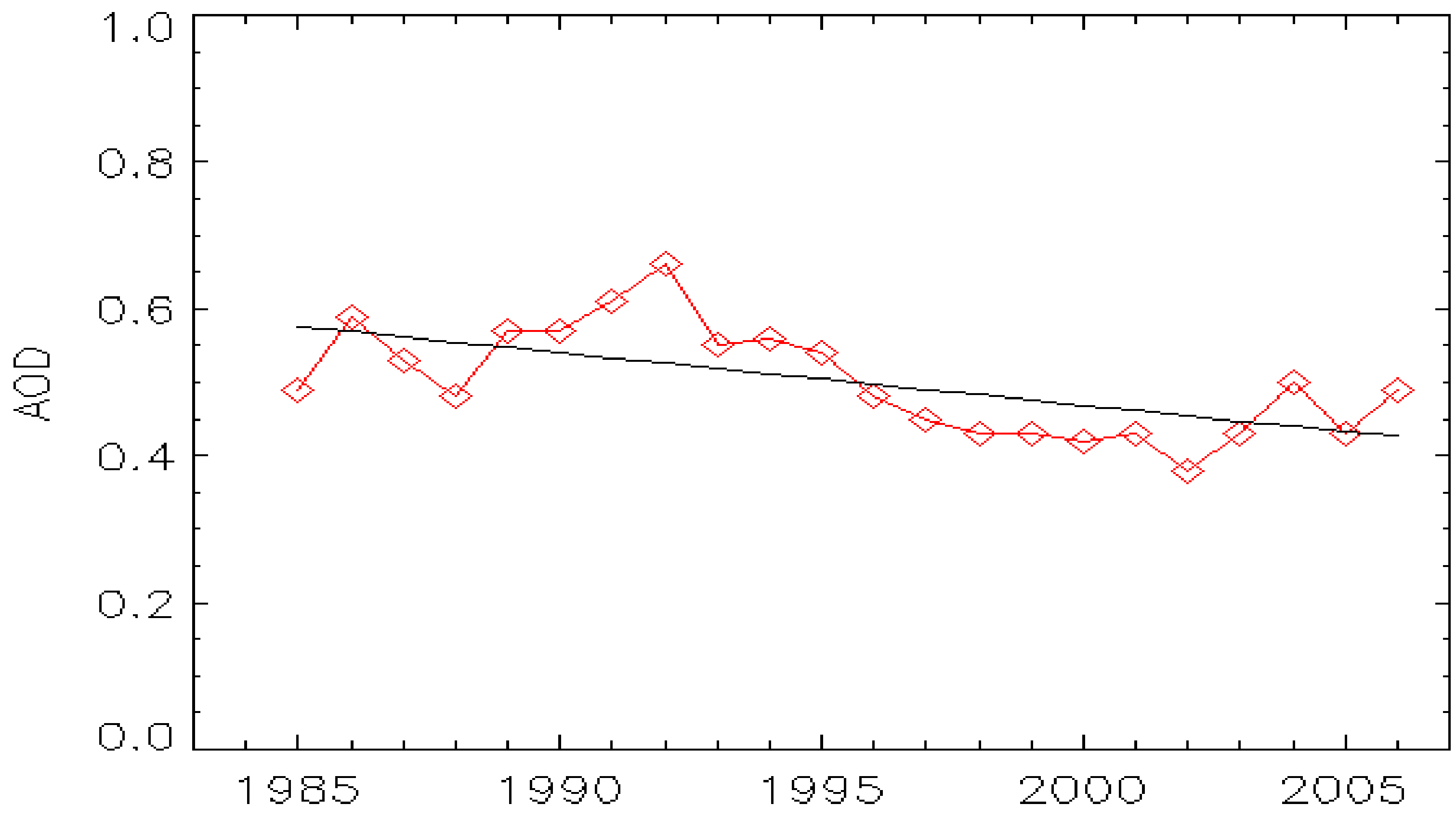
Optical thickness = measurable and this measure is an indication for the quantity

!!! Insecurities about their impact on the climate changes. That is why further studies are necessary (IPCC 2001).

The warming or cooling effect of the particles depend on their composition.

Direct influence on the UV solar radiation and indirect influence on the degree of cloudiness.

AEROSOLS



Aerosol Optical Thickness (AOD) since 1985 in Uccle

- For the remaining part the climate is determined by local conditions:
  - height and degree of cover
  - presence of a lake or river
  - colour of the earth’s surface (Albedo)
  - relief
  - urbanisation

The Earth sends back this energy as infra-red radiation.

A part of this earth radiation is absorbed by gasses in the atmosphere.

This last process is the so-called “greenhouse effect”.

Without this greenhouse effect, the Earth would be about 30° C colder because the warmth of the earth would be lost into space a lot faster.

Without this effect, the average temperature of the Earth would be —18°C, which means that Earth would be a dead planet.

The natural greenhouse effect increases the temperatures to approximately 15°C.

Mankind has always seemed able to reinforce the natural greenhouse effect with the large-scale emission of greenhouse gasses.

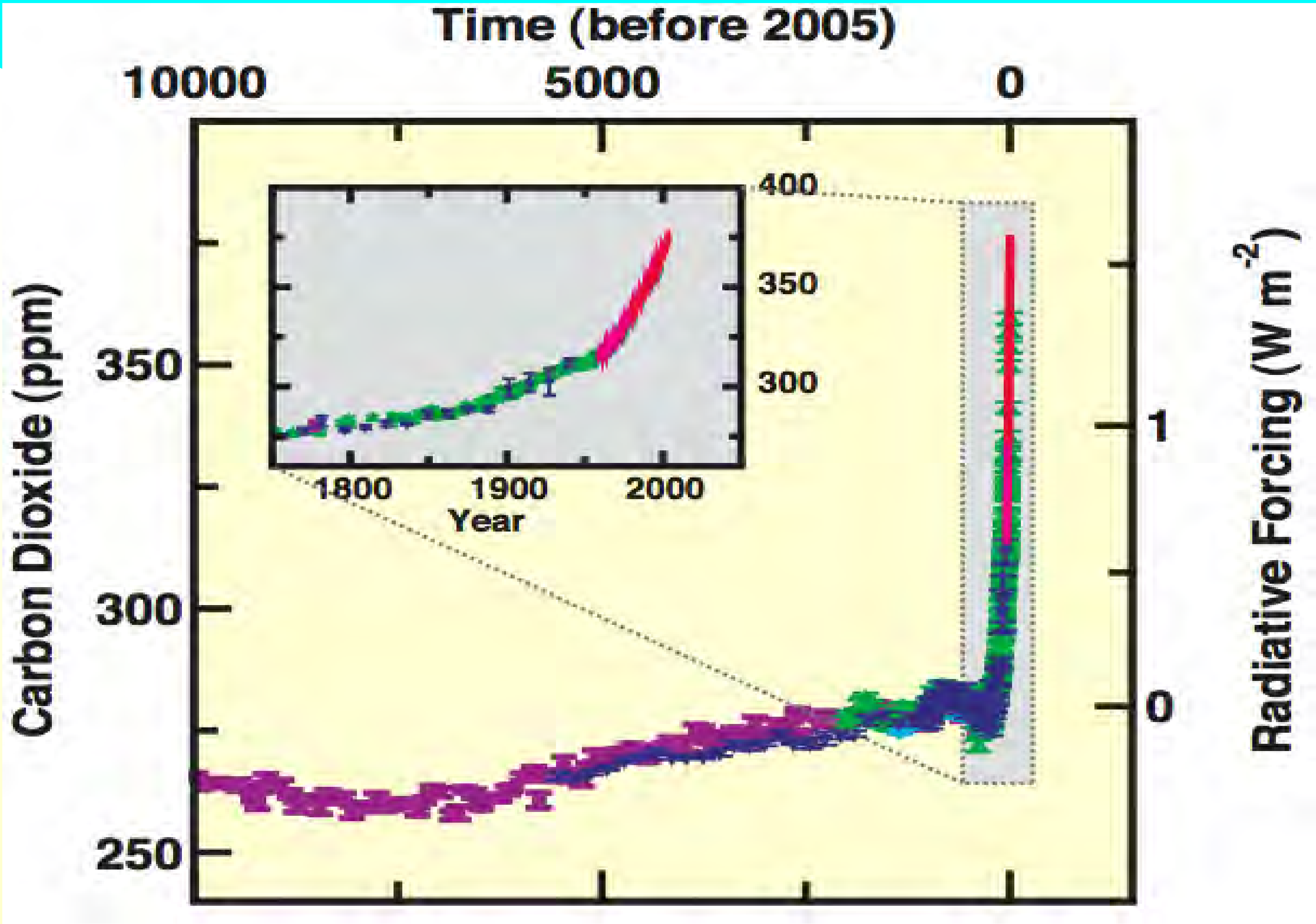
ANTHROPOGENIC CAUSES BECAUSE OF GREENHOUSE GASSES

GHG = GREENHOUSE GASSES

•The most important greenhouse gas is **water vapour**!!! = natural greenhouse gas

•Anthropogenic greenhouse gasses: natural and produced by human activity.

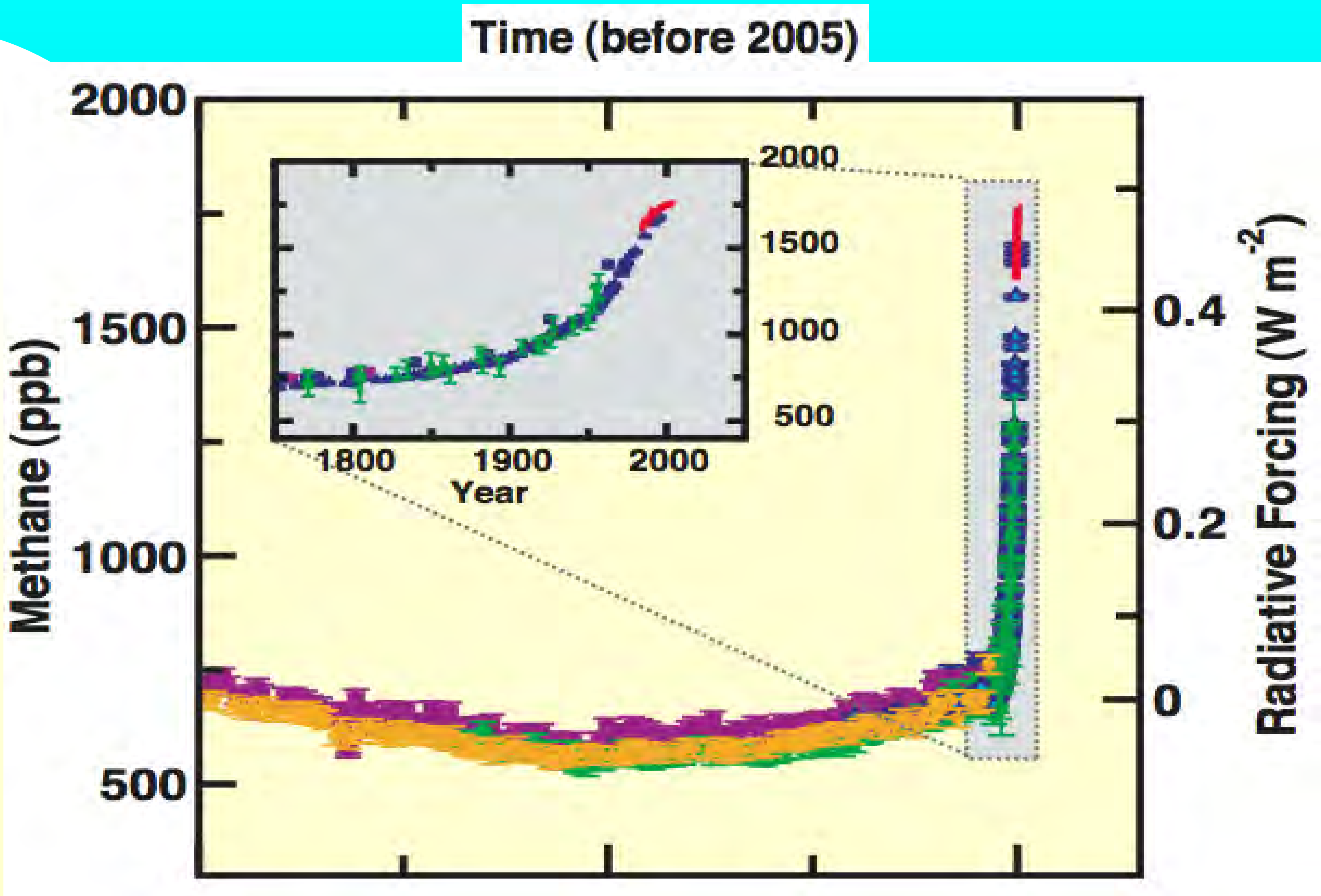
1) **Carbon dioxide : CO_2**; is a part op the biological cycle, is not poisonous and dissolves easily in water. The natural origin of this gas lies on the one hand in the burning of carbonaceous products (forest fires), volcanism and on the other hand in the biological cycle of respiration and rot. Man kind increases the emission of CO_2 every year through burning of fossil fuels, coal and petroleum but also through changes in the use of land (deforestation). The annual proportion of CO_2 gradually increases. The current concentration is at ± 379 ppmv (parts per million by volume, the amount of CO_2 molecules / 1 mln air molecules).


Time (before 2005)
10000
5000
0
Carbon Dioxide (ppm)
350
300
250
400
350
300
1800
1900
2000
Year
Radiative Forcing (W m-2)
1
0

- CO_2 = most important anthropogenic greenhouse gas.
- Current concentration is a lot higher than the natural pre-industrial values: 379 compared to 180 – 300 ppm³; highest value since 650.000 years.
- Life span: 50 - 200 years.
- Decomposition: photosynthesis and absorption by oceans.

2) **Methane CH_4 : (= swamp gas)** gets set free when organic substances rot in swamps, rice fields and cowsheds, via intestines of ruminants and also during certain production processes in factories. The rise manifests itself since the beginning of the 19th century because of a changed approach in agriculture, more intensive stock breeding, the accumulation of by-products, the mining industry and the increasing consumption of natural gas.

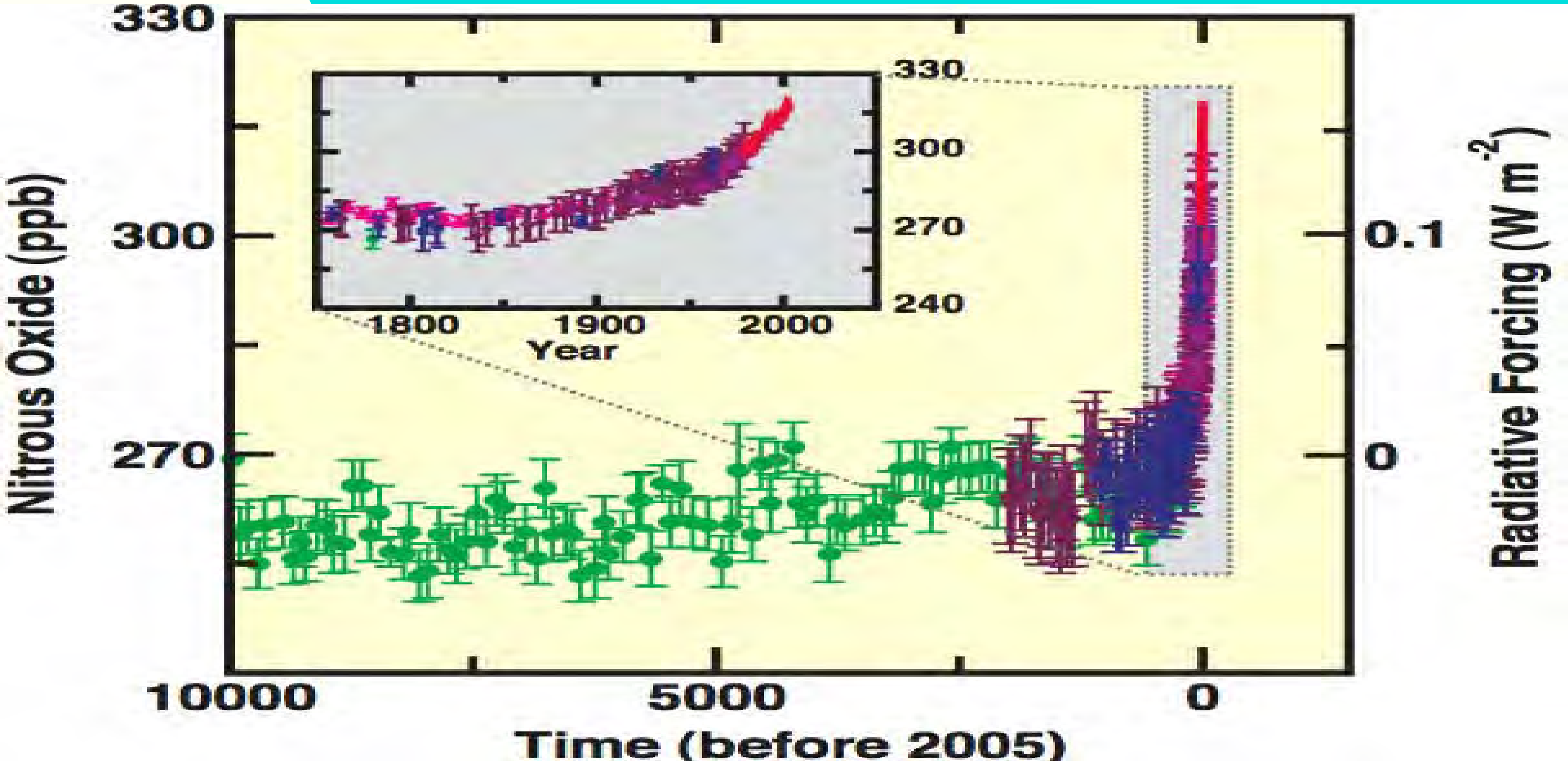
- Current concentration is a lot higher than the pre-industrial values: from 715 till 1732 in the 90's , in 2005: 1774 ppb; highest value since 650.000 years and a lot higher than the natural limit: from 320 till 790 ppb
- Last years: slower increase.
- Life span: 10 – 15 years.



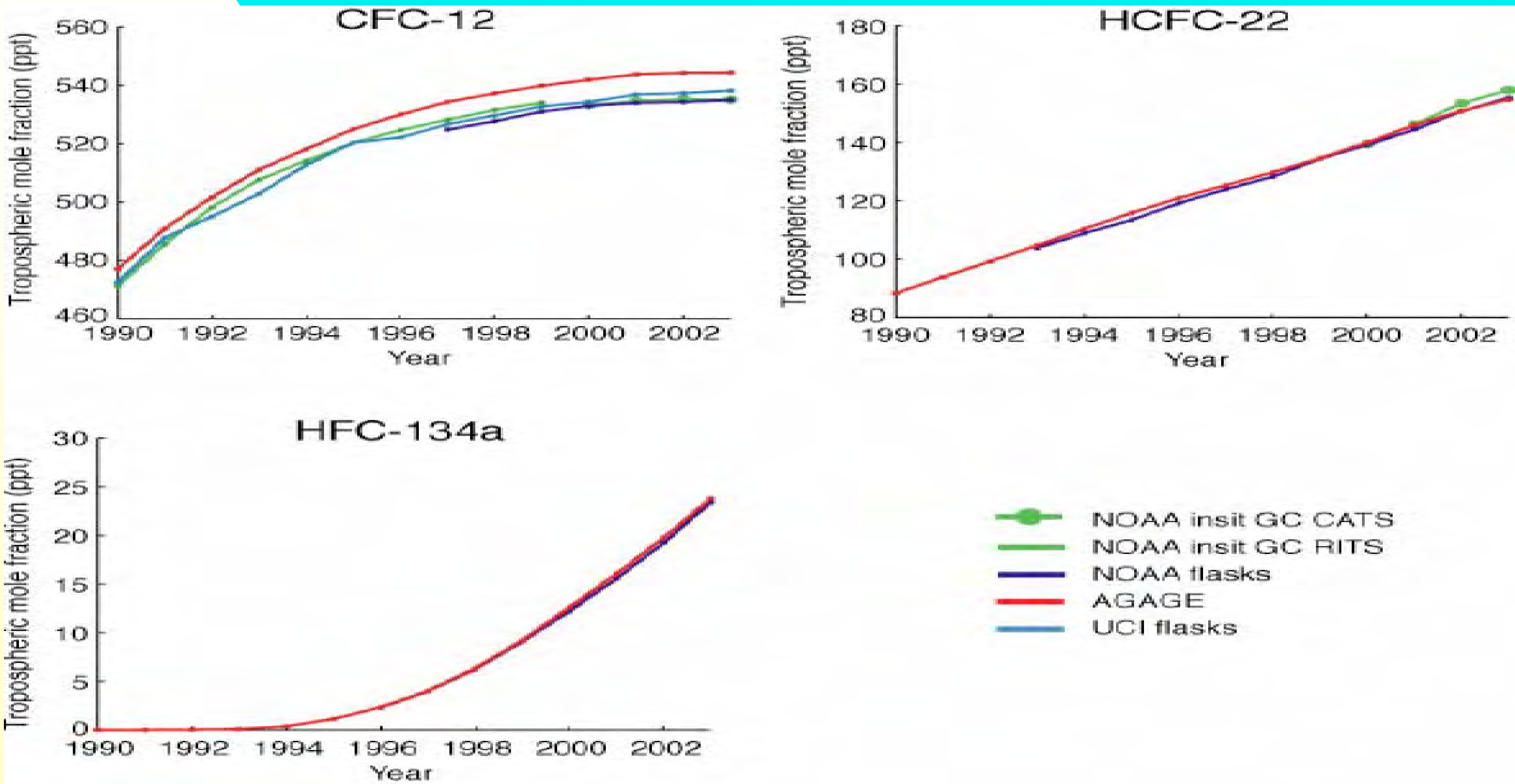
Time (before 2005)
2000
1500
1000
500
Methane (ppb)
1800
1900
2000
Year
0.4
0.2
0
Radiative Forcing (W m^{-2})

3) **Nitrious oxide N2O :** = laughing gas. Great amounts are given off in the air by the natural vegetation, but also the burning processes in power plants and cars, and intensive agricultural activities give off this gas.

- Pre-industrial value of 270 ppb up to 319 ppb in 2005.
- The life span of this gas in the atmosphere is 120 years.
- The growth speed has almost stayed constant since 1980.



4) **Chlorofluorocarbon CFC , HCFC and Halogens and Freon gasses** are human-made compositions of chloride, fluorine and carbon. They are used in refrigerators and for the production of isolation material and as gasses in spray cans.



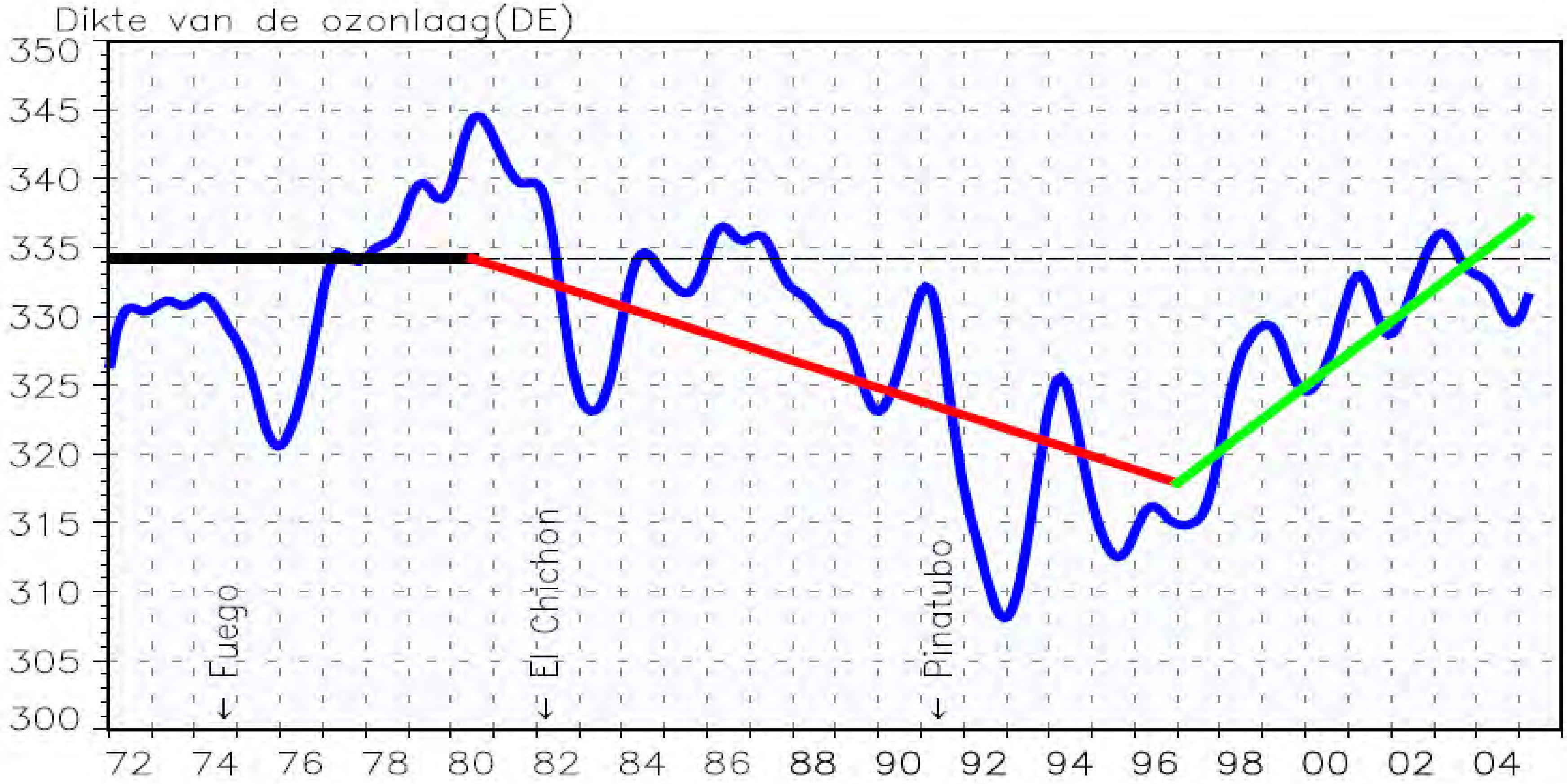
As these CFC's and Halogens are of big inertness, they are not broken down near the earth's surface but escape to the higher layers (the lower stratosphere) where they react with the ozone and break it down. CFC's are powerful greenhouse gasses and have a life span of 50 - 500 years. Their emission by human beings is a lot higher than their slow decomposition. Because they already feared the decomposition of the ozone by these gasses in 1975, an international agreement was signed in 1987: "the protocol of Montréal" to decrease the contribution of the CFC's and to half the use. (Halogens life span 12 – 110 years)

5) **Ozone O3 : = Ozone and greenhouse.** Ozone appears both in the troposphere (about the bottom 10km of the atmosphere) as in the stratosphere (the layer above). The concentration of tropospheric ozone, a greenhouse gas, has increased and this contributes to the warming of the earth. The concentration of the stratospheric ozone on the other hand has decreased. This has little effect on the temperatures on the earth's surface. The stratospheric ozone is of great importance for the filtering of harmful solar radiation.

✓ The decrease of the stratospheric ozone is caused by chlorofluorocarbons (CFC's). Measures were taken internationally to limit the production of CFC's. If the agreements are followed well, the ozone layer will recover slowly, now that the substances that break off the ozone have reached their peak at the millennium. The greenhouse effect, however, could delay this. According to the theory of the reinforced greenhouse effect, the warming of the troposphere goes hand in hand with the cooling of the stratosphere. This could slow down the recovery of the ozone layer.

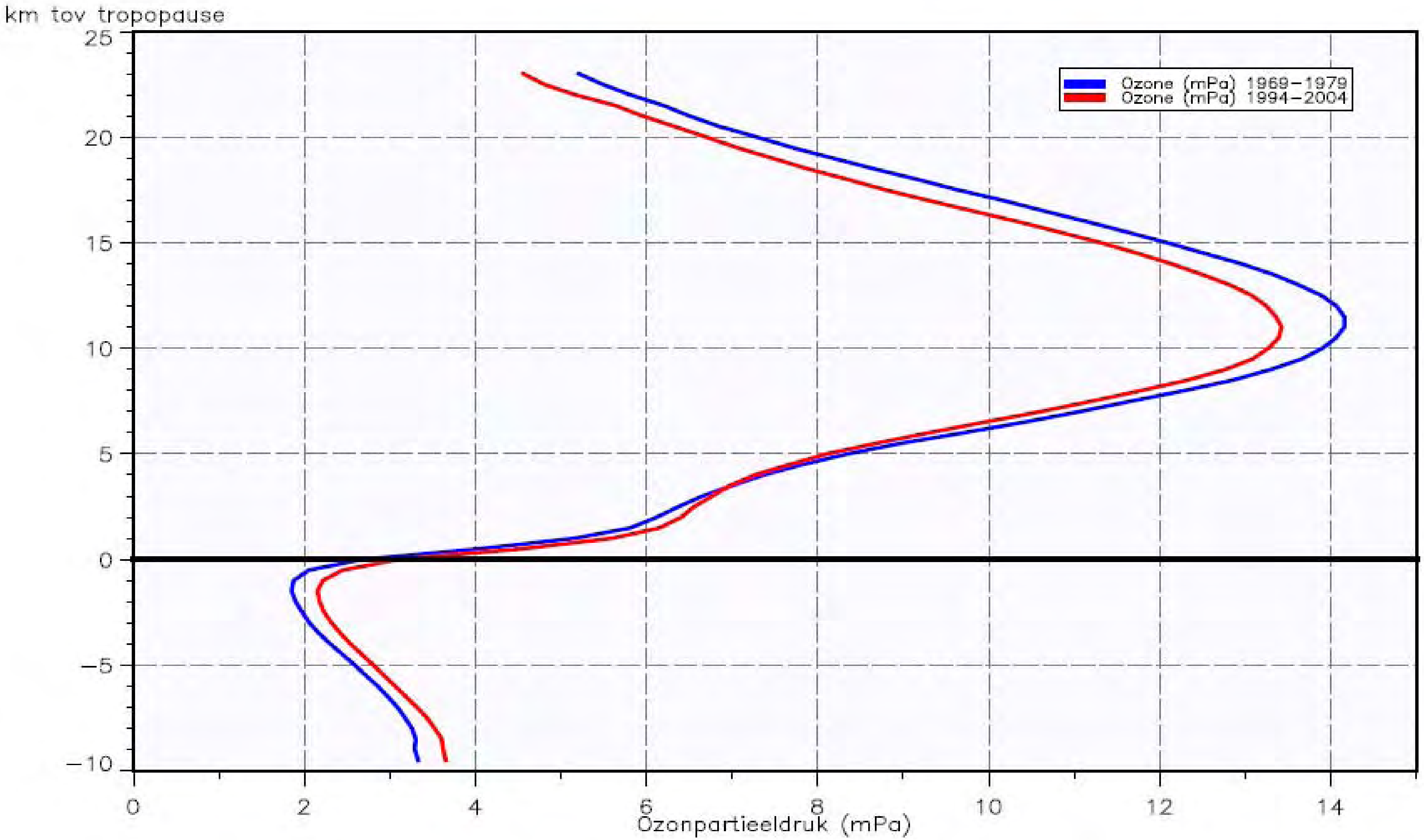
✓ The RMI has a long tradition in the observation of the ozone layer. Since 1969 we perform ozone observations three times a week. These observations are done with a balloon and give vertical profiles of pressure, temperature, relative humidity, wind and ozone up to a height of about 32 km. This way the RMI disposes, together with Hohenpeißenberg (Germany) en Payerne (Switzerland), of one of the longest series of ozone profiles in the world.

Figuur 16: Dikte van de ozonlaag boven Ukkel met een stapsgewijze trendberekening (1972-2004)

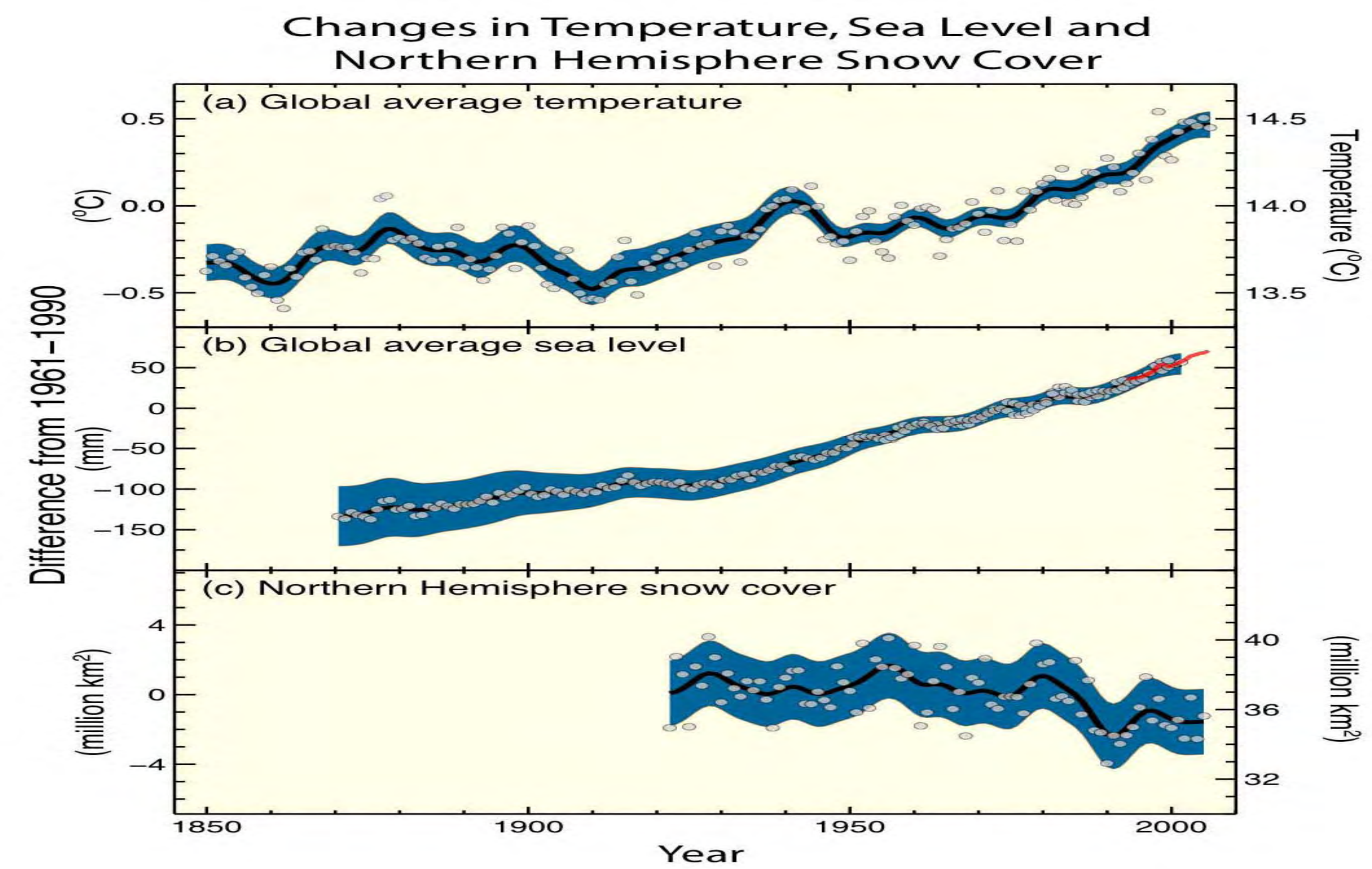


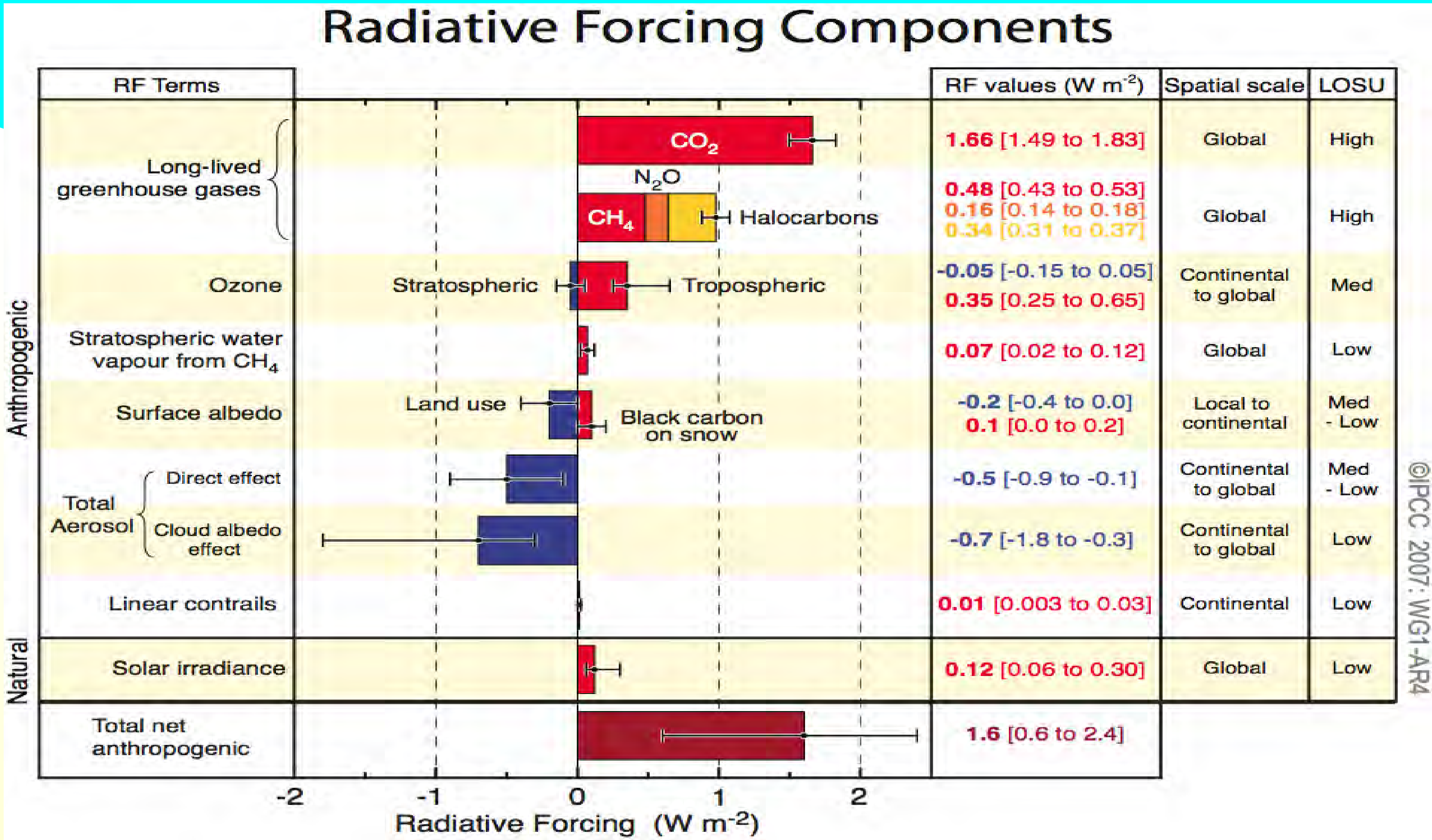
Deze figuur toont het voortschrijdend jaargemiddelde van de dikte van de ozonlaag te Ukkel (blauwe lijn) en een stapsgewijze trend gebaseerd op een constante waarde voor 1980 (zwarte lijn), en twee trendstukken, één tussen 1980 en 1997 (rood) en één tussen 1997 en 2004 (groen).

Figuur 17: De verticale verdeling van ozon (in mPa) als functie van de hoogte t.o.v. de tropopauze voor twee verschillende periodes (1969-1979 en 1994-2004)



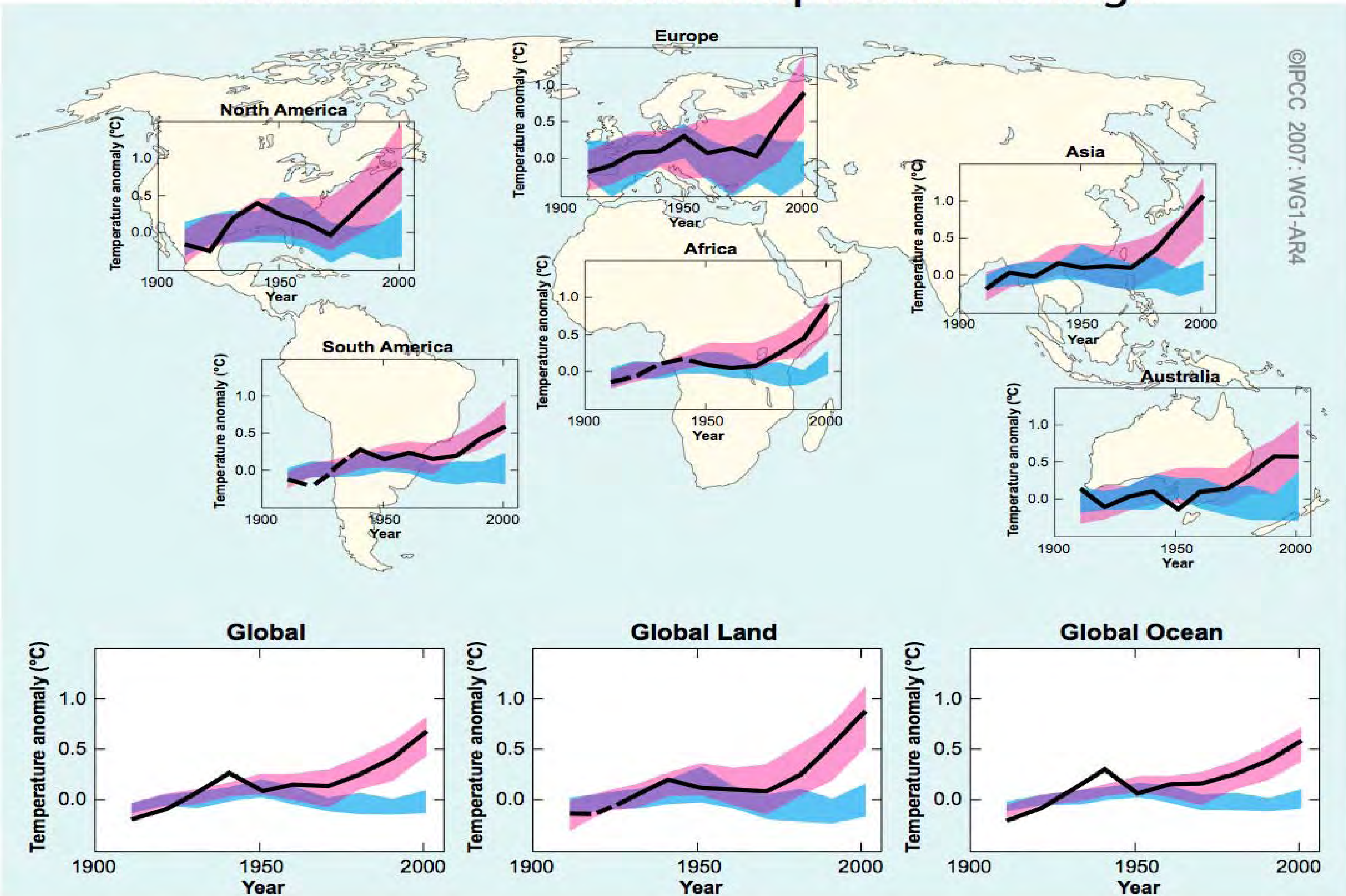
How has the climate already changed?





LOSU = Level Of Scientific Understanding

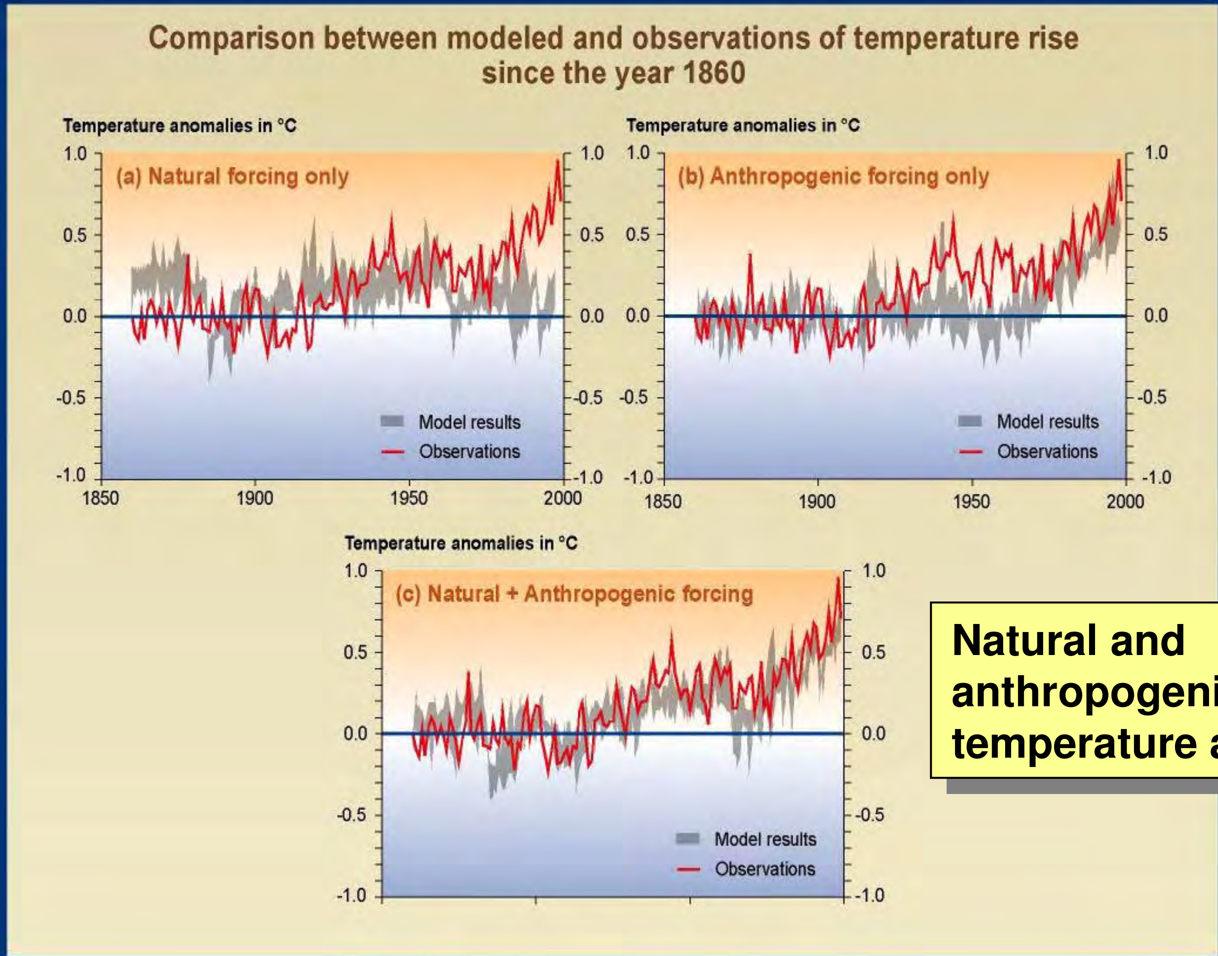
Global and Continental Temperature Change



How will the climate evoluate even further?

IPCC = Intergovernmental Panel on Climate Change has as a goal to provide policymakers of objective information about climate changes. They also indicate what could be the consequences for the environment and society. With climate changes we mean both natural as human-caused changes. The IPCC was founded in 1988 and all the members of the UNEP (United nations Environment Program) and/or the WMO (World Meteorological Organisation) can take part in this. The IPCC consists of 3 study groups and one Task Force.

* **Study group I : "Science":** focuses mainly on the scientific aspects of the natural and human-caused climate changes.



Natural and anthropogenic temperature anomalies

SYR - FIGURE 2-4

IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

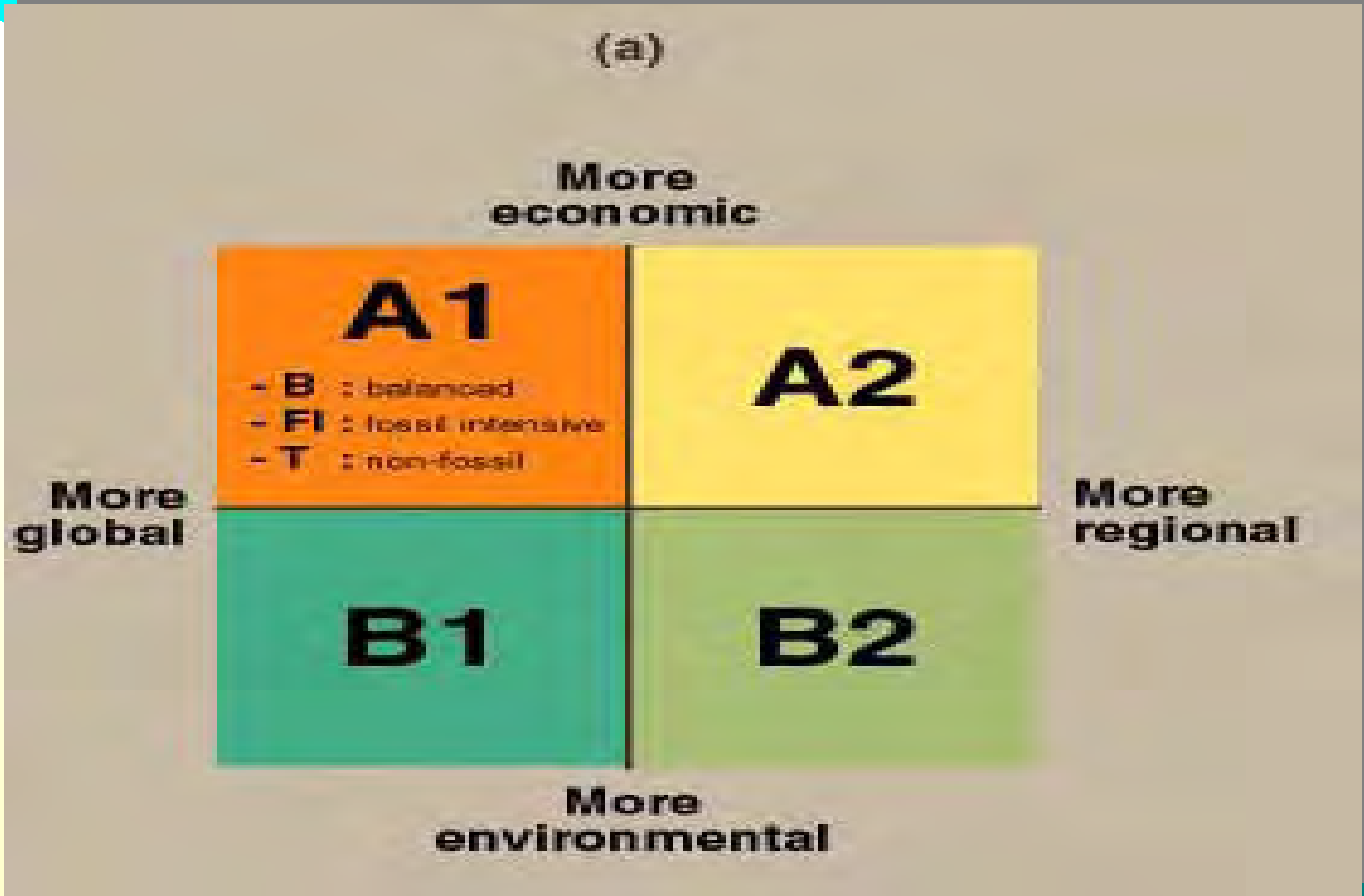
Study group II : «Impact and adaptation » covers the vulnerability of human activities and natural systems for climate change and discusses about the possibilities for adaptation.

Study group III : « Mitigation » focuses on the possibilities to push back the human-caused climate changes, including the accompanying economic issues.

The Taskforce on National Greenhouse Gas Inventories develops scientifically correct methods and procedures to be able to establish the emission of greenhouse gasses per country and observes the way this happens..

Since 1990 the IPCC publishes five year records (AR) existing of 3 parts (one of each study group). The last (fourth) AR report dates from February 2007. The third one (2001) was used to support the Protocol of Kyoto. Besides these AR there are also Special Reports (SR) in which specific subjects are being handled. The AR and the SR are accompanied by SPM reports for the lazy people under us. SPM stands for Summary for Policymakers and summaries the huge reports.

One of the SR handles about the **emission scenarios. (based on 4 great world views for the future)**



The SER – scenarios take into account:

- growth of the world's population
- economic growth
- technological developments
- investment patterns (more or less money for durable energy, more or less demand for energy-intensive products, ...)
- future energy needs → more or less emission of greenhouse gasses

The IPCC has established 4 future world views:

♦ **A1** = future world view with very rapid economic growth, a peak of the world's population halfway 21st century an a decrease afterwards. There is also a fast introduction of new and more efficient technologies. With this world view come 3 scenarios:

→A1FI : fossile intensive

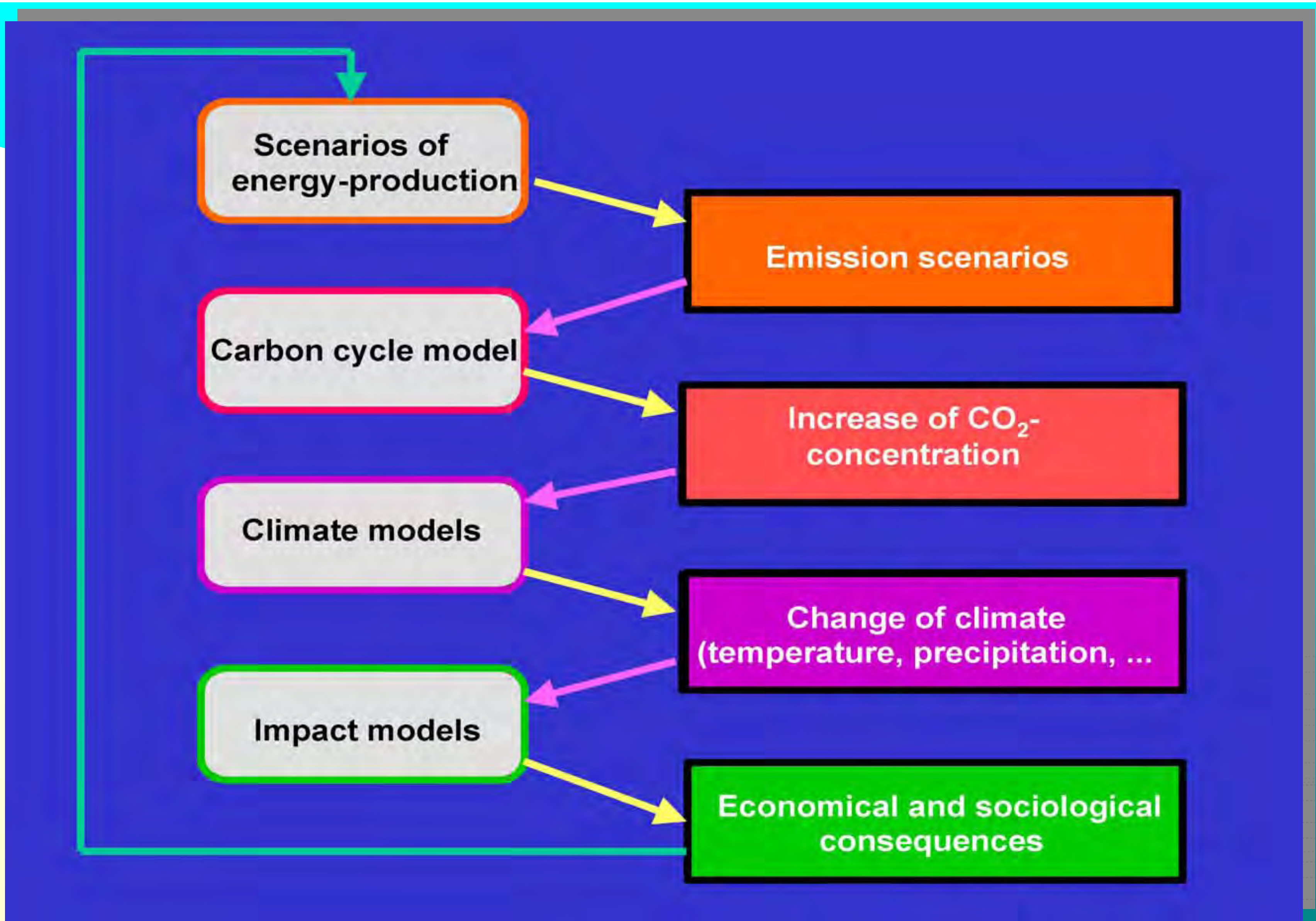
→A1T : non-fossil energy sources

→A1B : balanced energy sources with which we are not too dependant on one single energy source.

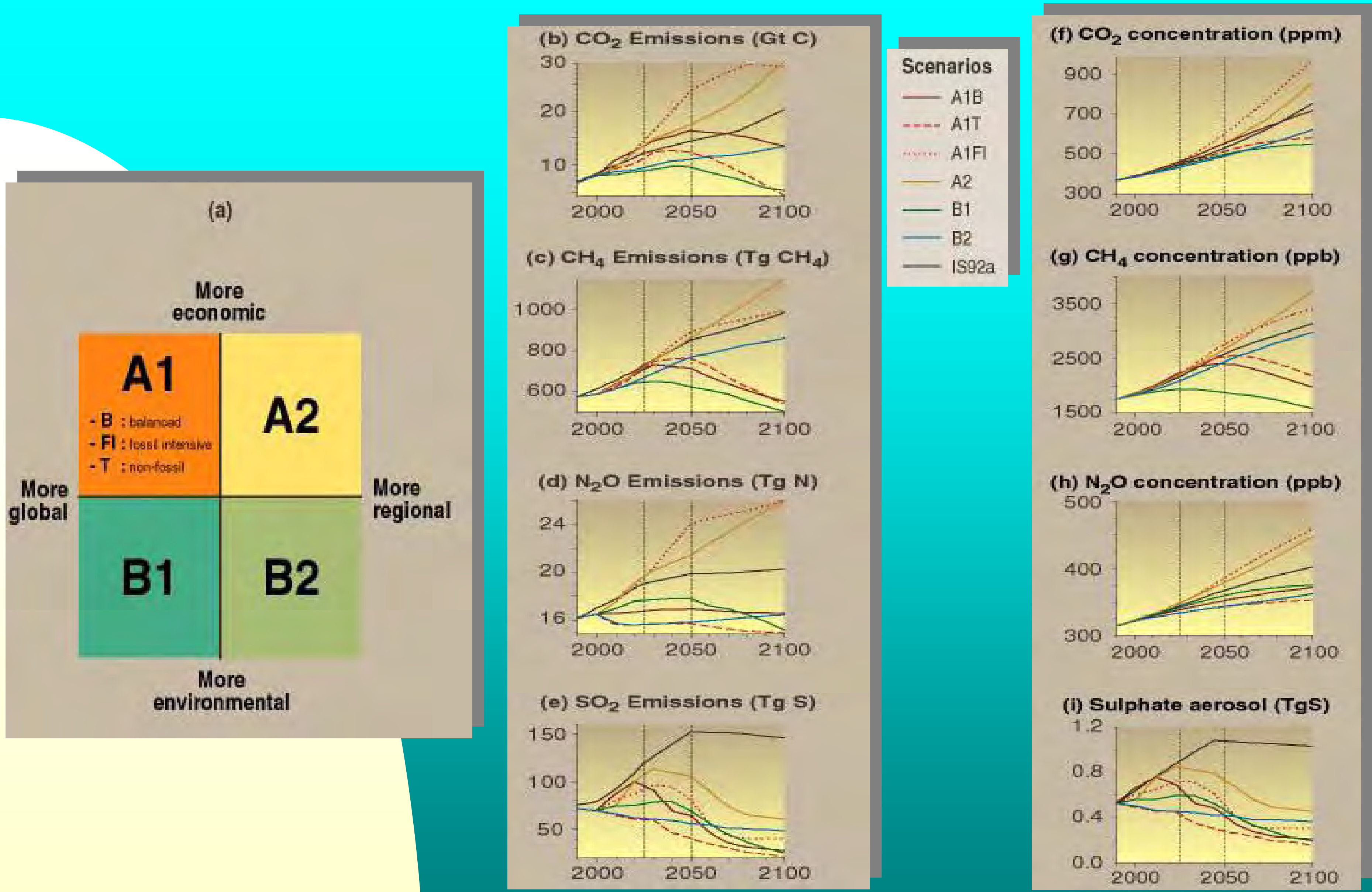
♦**A2 =** a very heterogenic world. A continuously growing population, the economic growth is mainly regional, which means that the economic growth and the technological changes are more fragmentised and their progress is slower than in the other world views.

♦**B1** = peak in the world's population about halfway the 21st century and afterwards a decrease like in A1, but rapid changes in the economic structures aimed on services and information on the economy, the decrease of material needs and the import of clean and efficient energy sources. The emphasis lays on worldwide solutions for social, economical and durable development of the environment without additional climate initiatives.

♦ **B2** = in this world view the emphasis is on local solutions for social economical and environment-friendly durability. The world's population continuously rises but not as fast as in scenario A2, intervening levels of economic development, and slower but more divers technological changes than in B1 and A1. This world view and this scenario is mainly locally, regionally oriented.

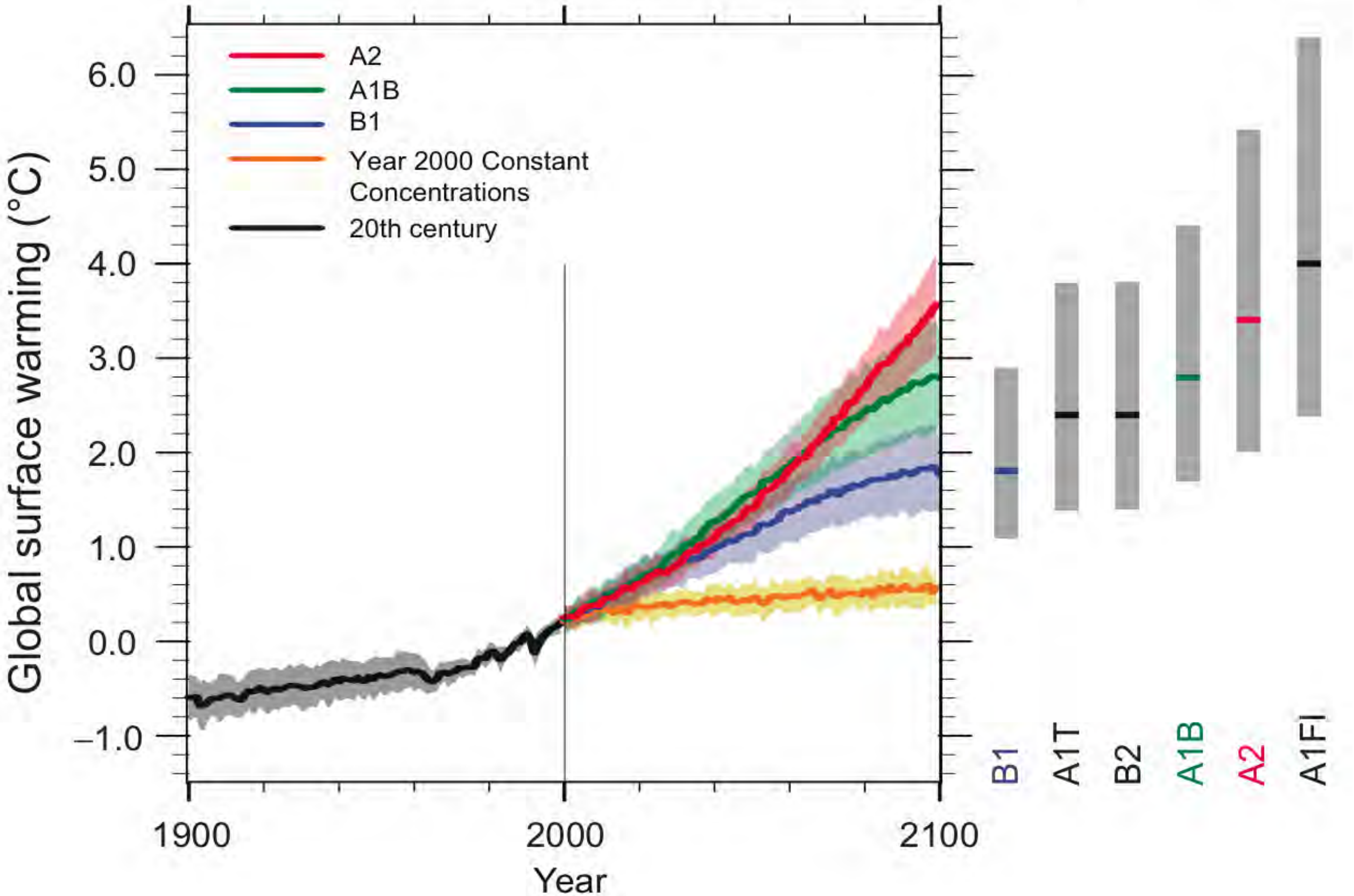


The information chain leading to a climate projection



emissions **concentrations**

Multi-model Averages and Assessed Ranges for Surface Warming



Conclusions from climate projections for the world climate in 2100

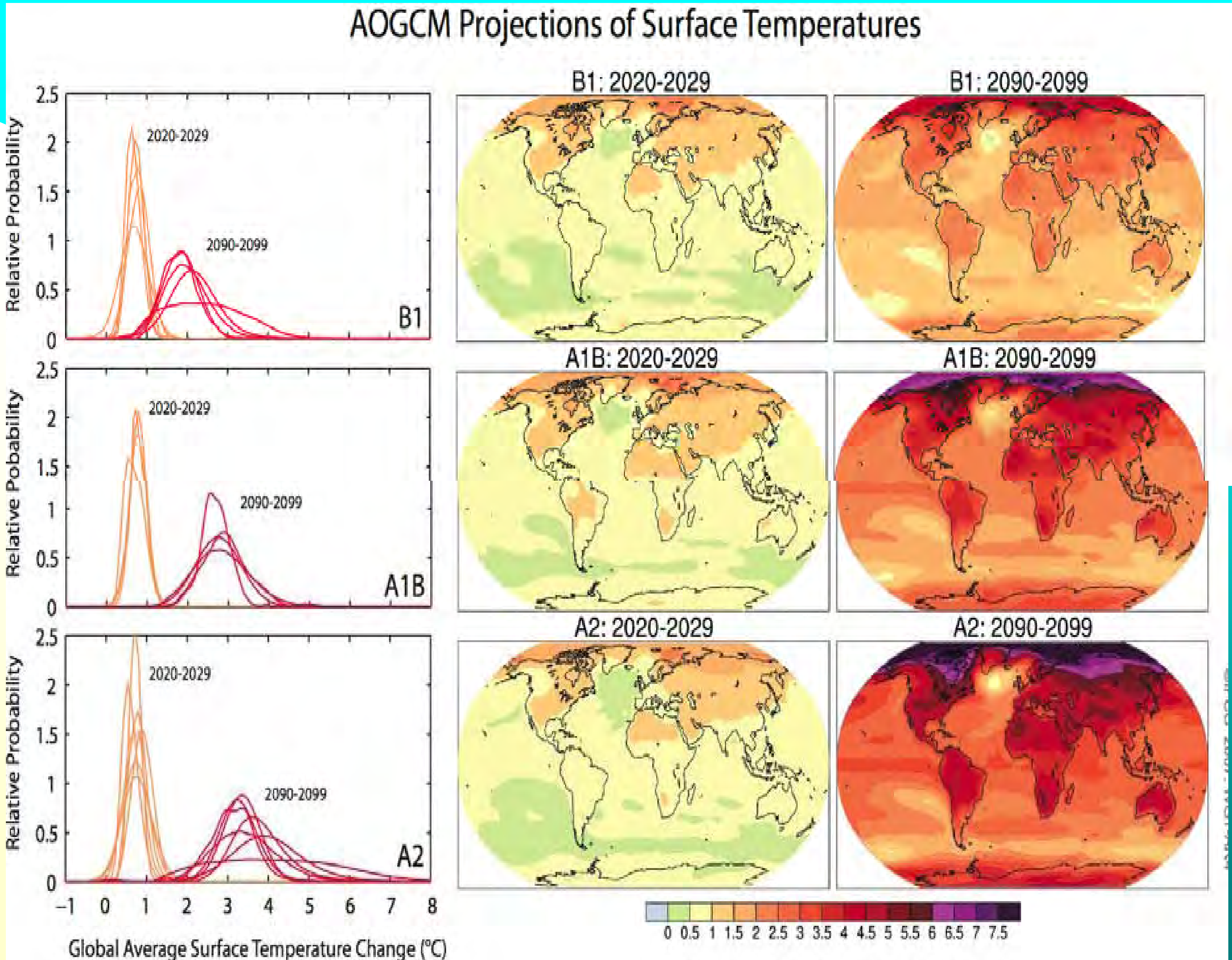
- World average temperature will rise with a value between 1,1°C and 6,4°C ; > 66% chance that the value will lie between 2° and 4,5 ° C; best estimate = about 3°C and the chance that it is lower than 1,5°C = < 10%. The last 100 years the temperature has risen with ~ 0,74°C worldwide.

  Attention : CO2 = 450 ppmv means + 2°C = point of no return

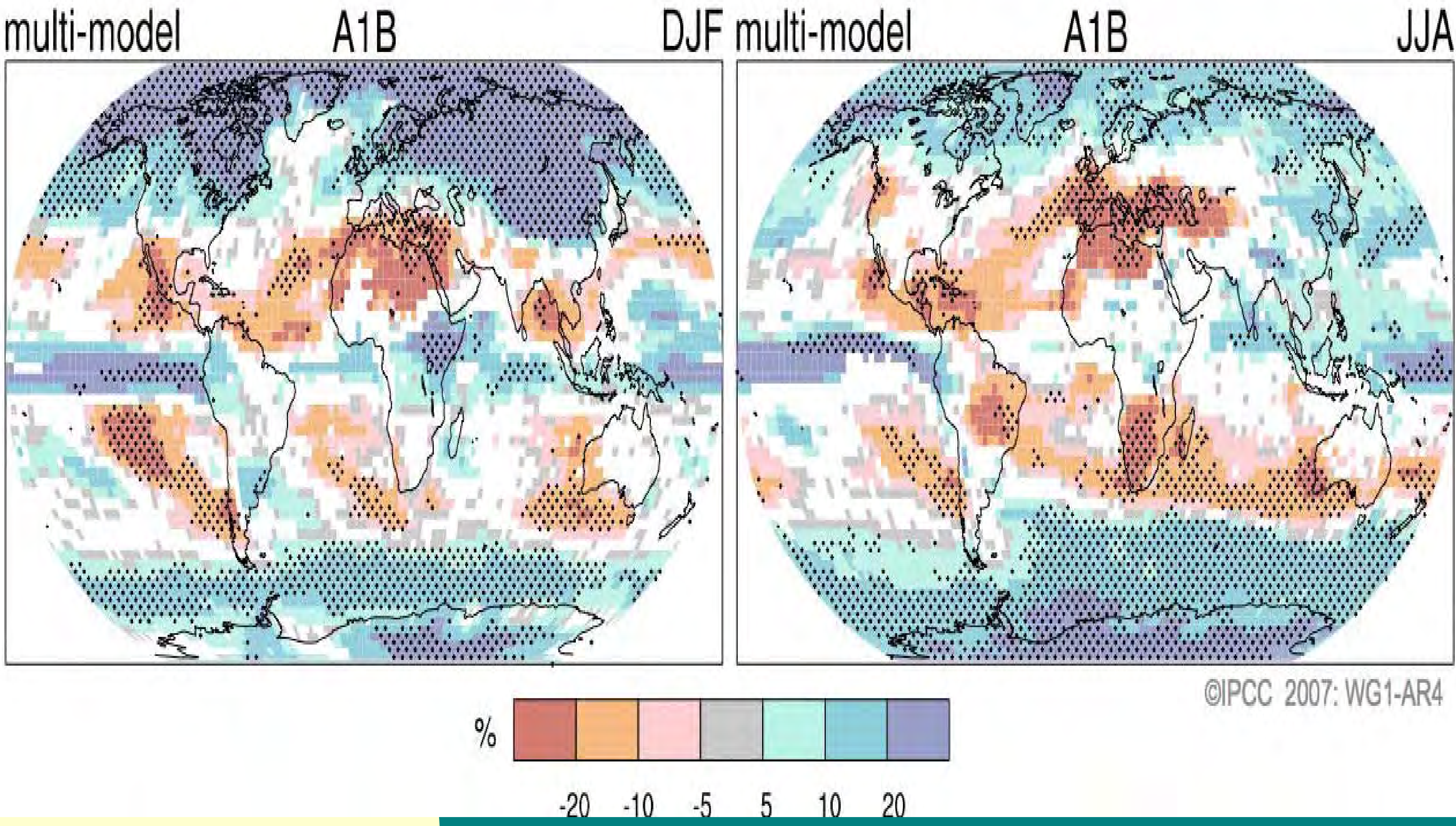
- Rise of the sea level during the 20th century = ~ 17 cm. By the year 2100 this will be 28 – 58 cm more as a result of thermal expansion of oceans, melting of glaciers and small ice caps, and the steady shrinking of big ice caps in Greenland and Antarctica.

  But: can rise to 1 m and there is great uncertainty about the crumbling away of the borders of the ice caps; apparently in accelerated tempo.

- Snow cover will further decrease: has already decreased the last 50 years with 7 % in the Northern Hemisphere. This is why less solar rays are being reflected and the temperatures rises faster
- Warmer en less cold days and nights all over the land areas: certainty = > 99%
- Rise in frequency of tropical days and nights all over the land areas: > 99%.
- Rise in frequency heat waves: > 90%
- Rise in events of heavy precipitation in certain parts of the continent: > 90%
- Droughts in some areas: > 66% ; think about the area around the Mediterranean
- Intensifying activity tropical cyclones: > 66%

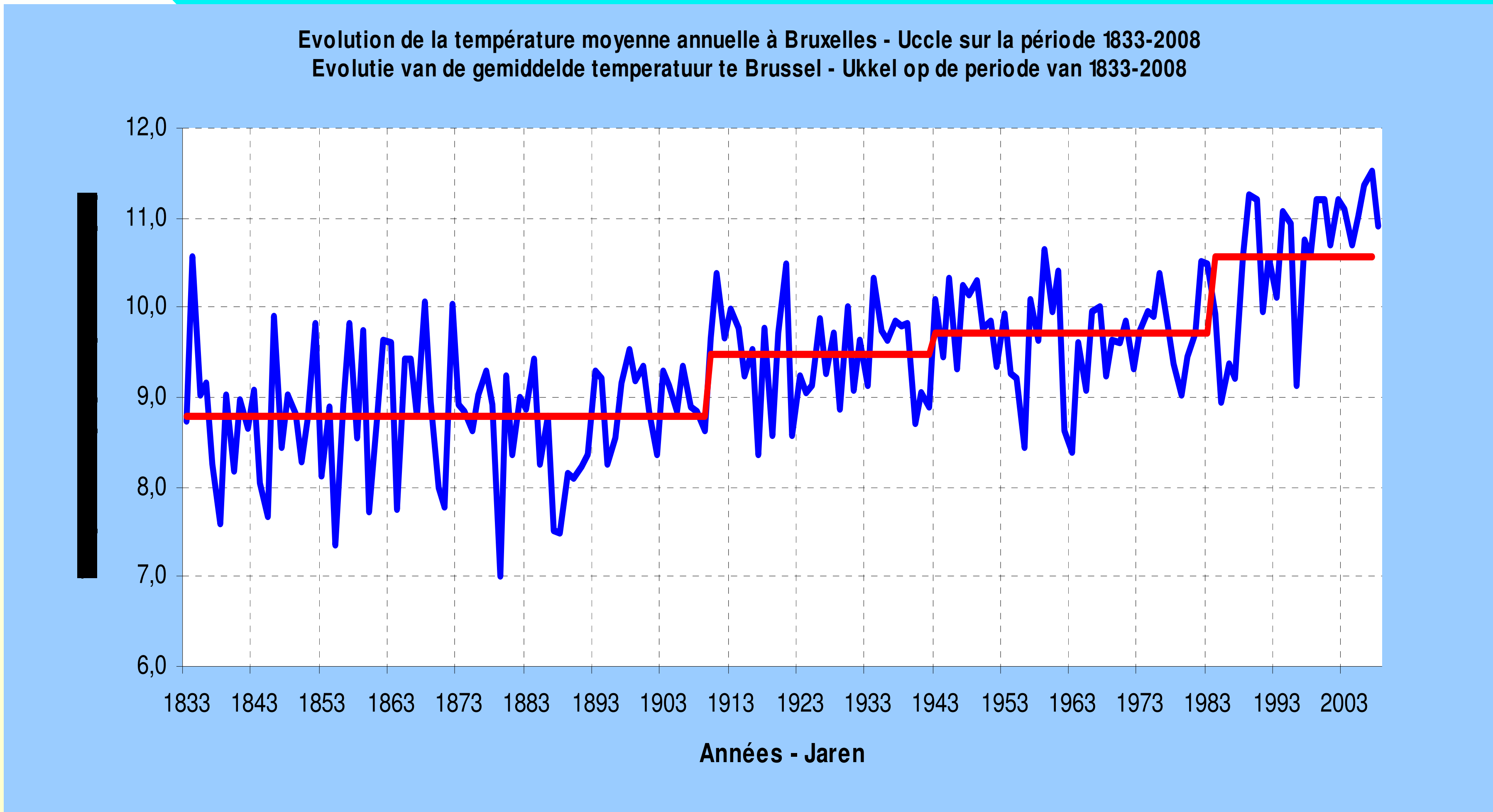

AOGCM Projections of Surface Temperatures
B1: 2020-2029
B1: 2090-2099
A1B: 2020-2029
A1B: 2090-2099
A2: 2020-2029
A2: 2090-2099
Relative Probability
Relative Pobability
2020-2029
2090-2099
B1
A1B
A2
Global Average Surface Temperature Change (°C)
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5

Projected Patterns of Precipitation Changes

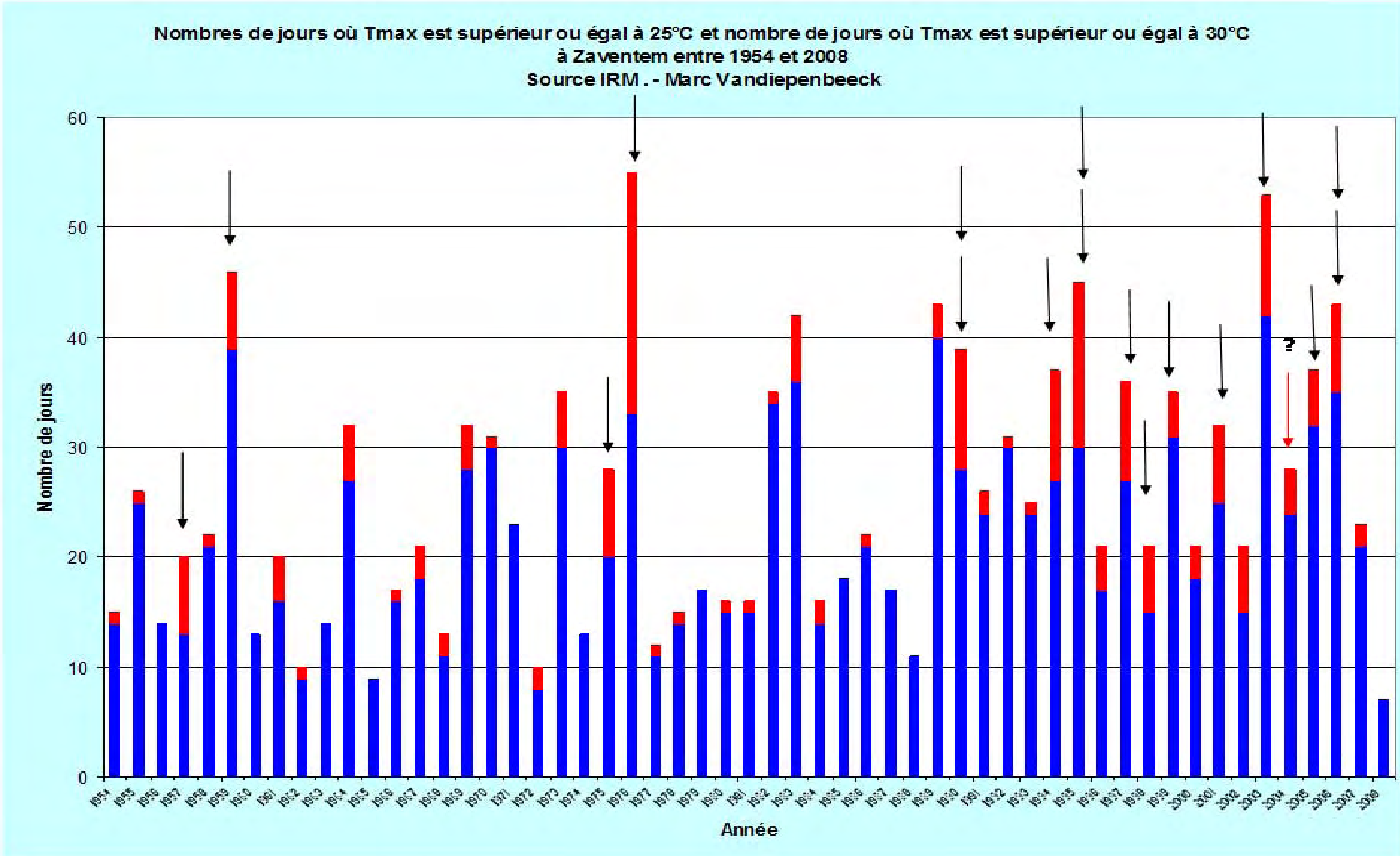


And what about our country?

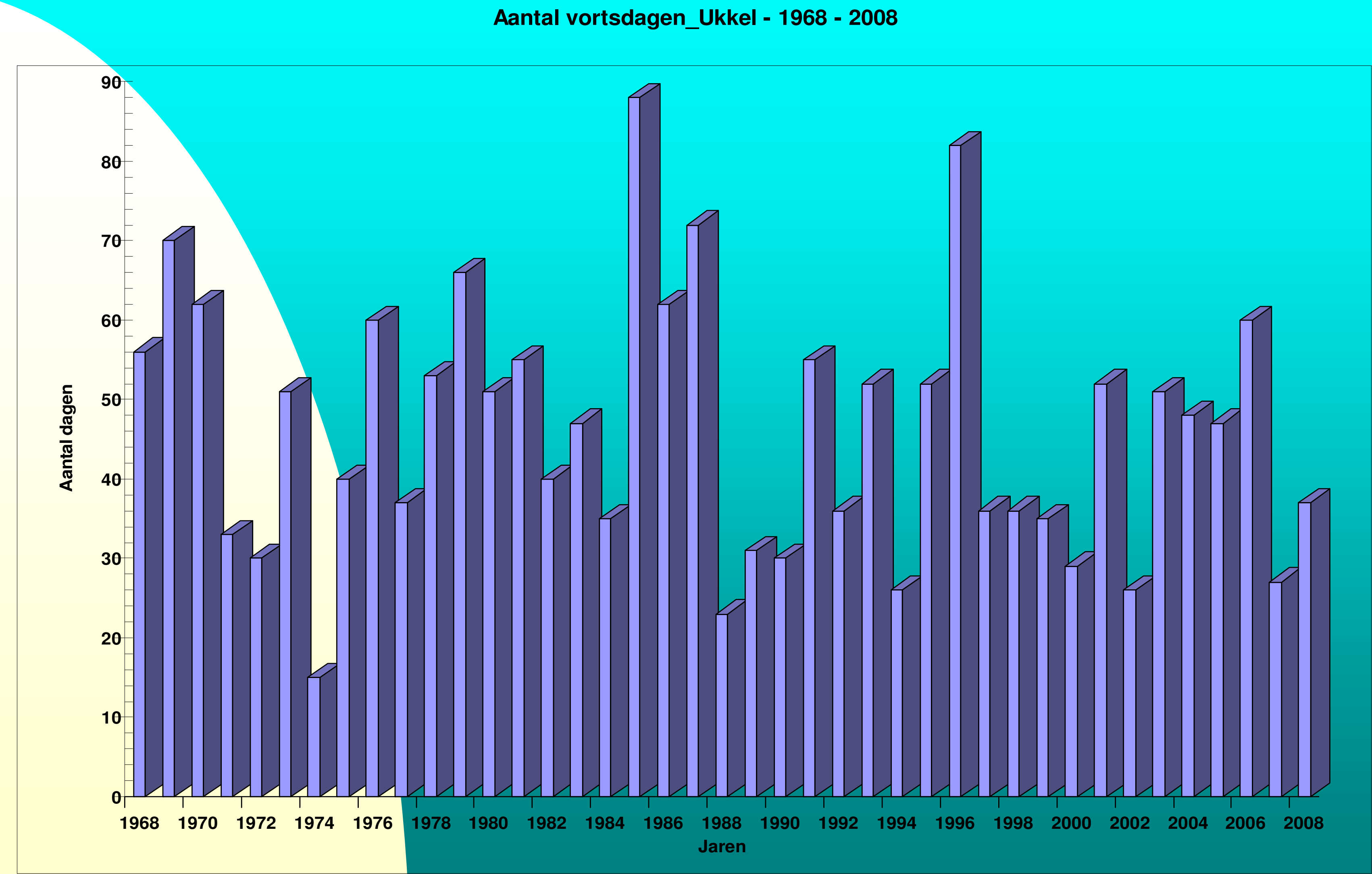
❖ Evolution of temperatures



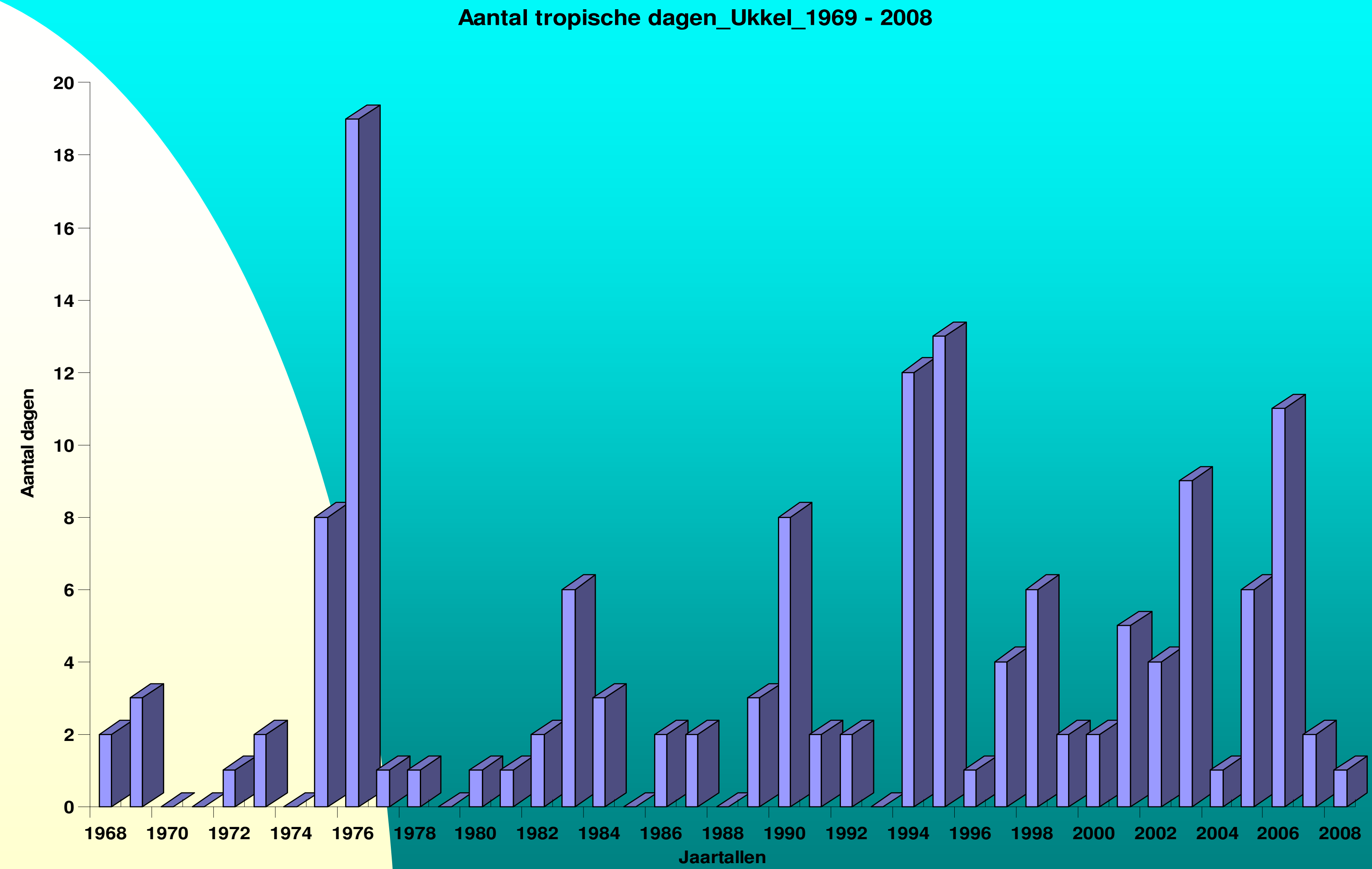
❖ HEATWAVES: Data Zaventem 1954 - 2008



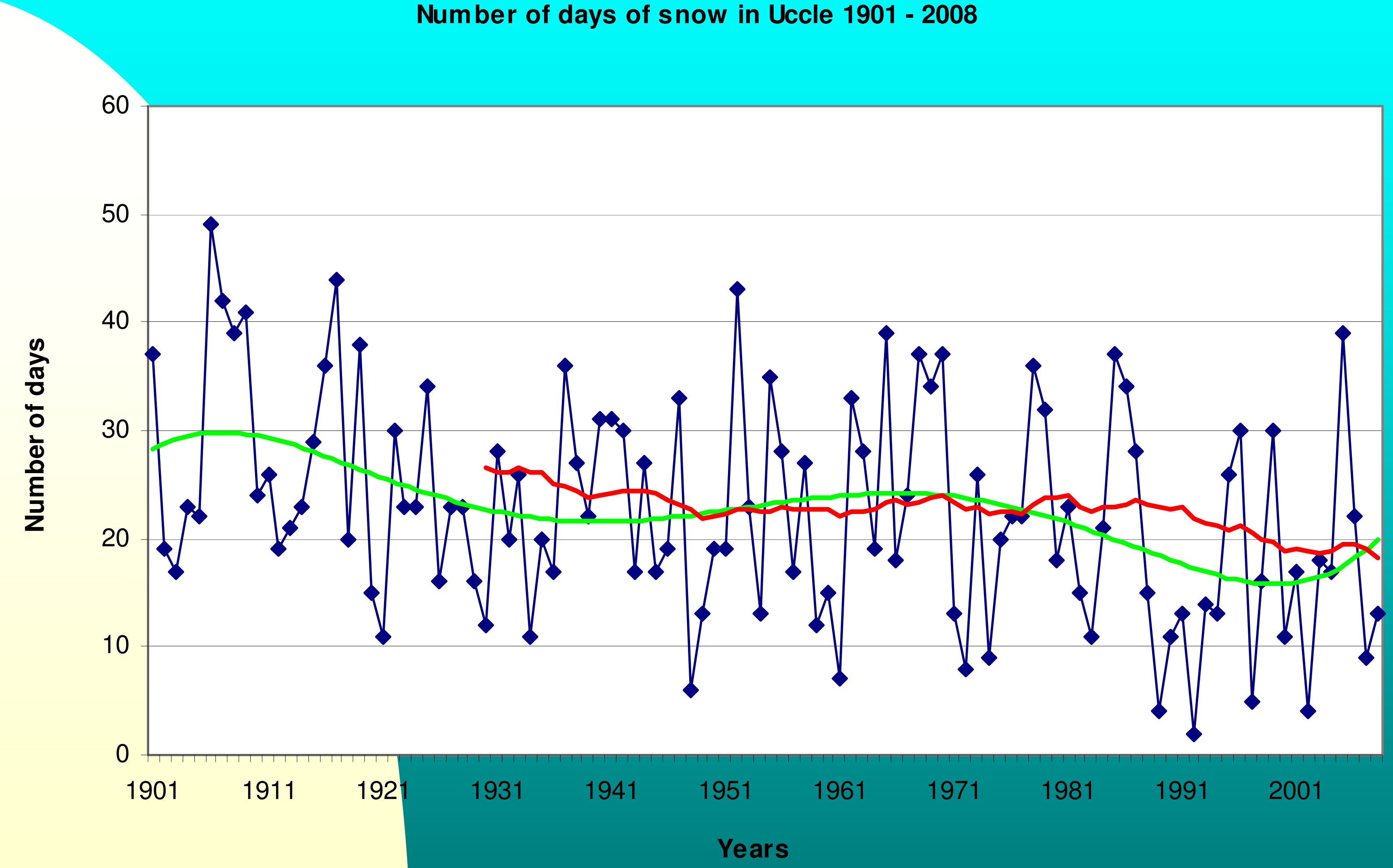
❖ Number of frost days: Data Uccle 1968 - 2008



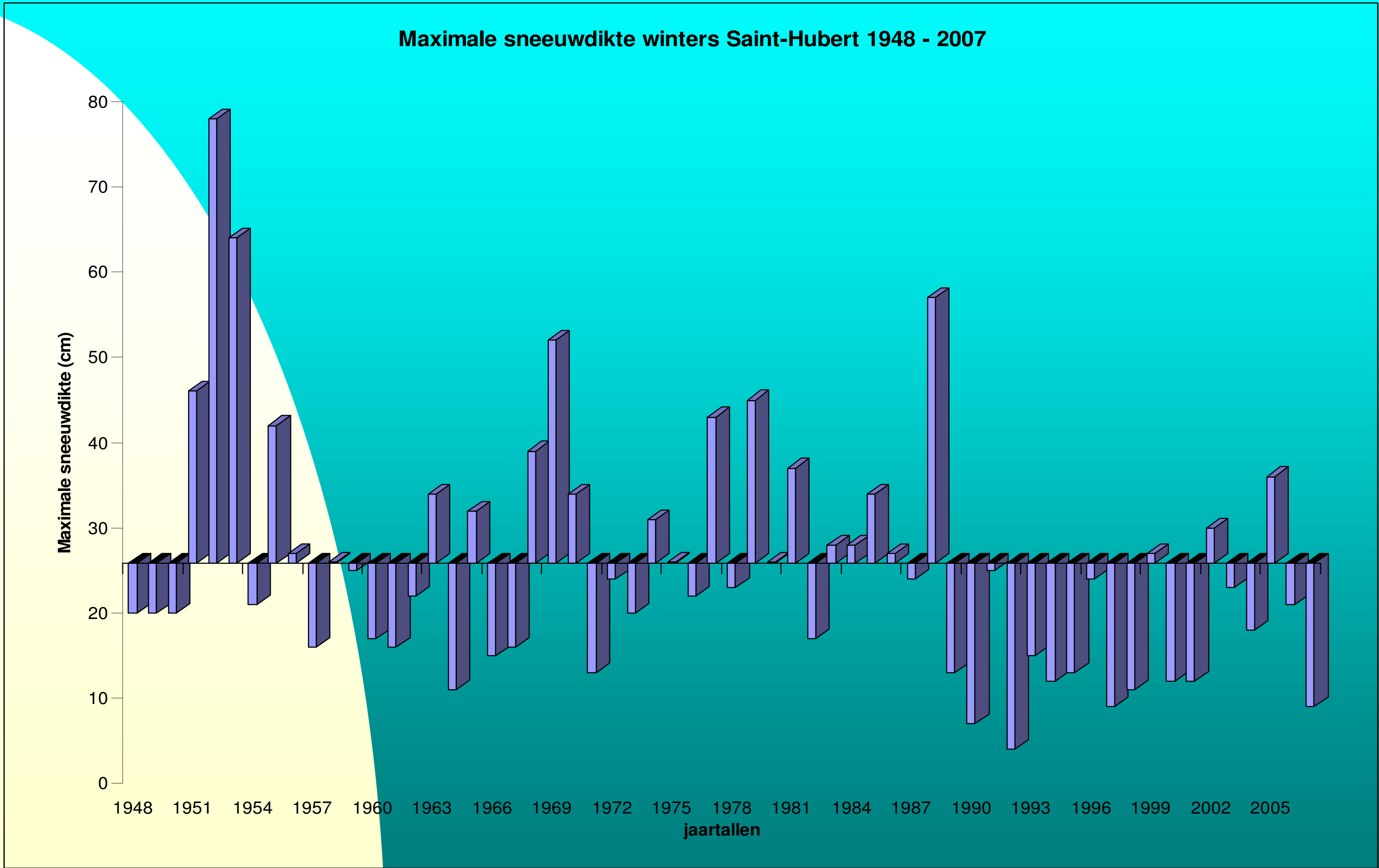
❖ Number of tropical days: Data Uccle 1968 - 2008



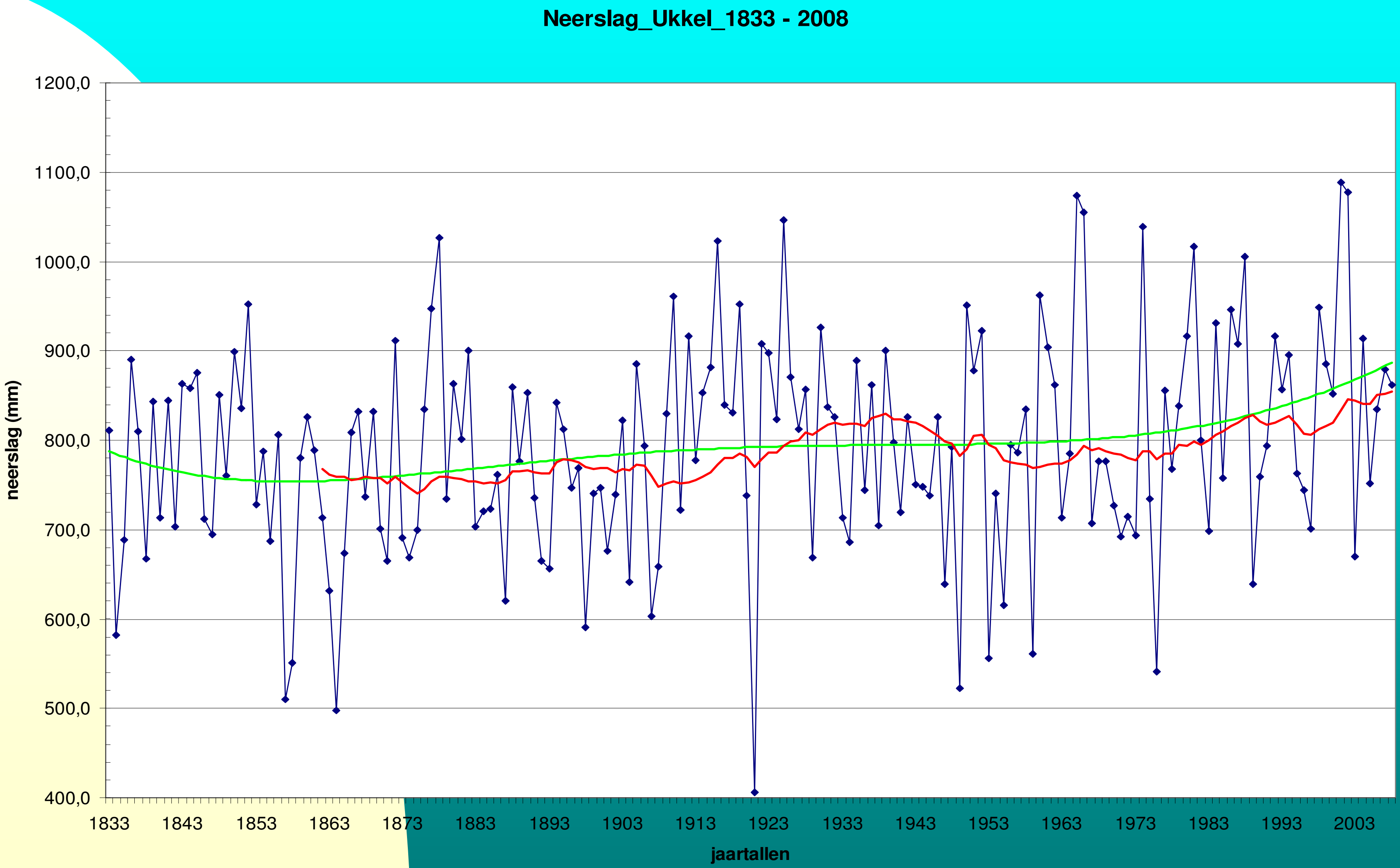
❖ Number of days with snowfall : Data Uccle 1901 - 2008



Snow cover Saint-Hubert 1948 - 2007



❖ Changes in precipitation regimes

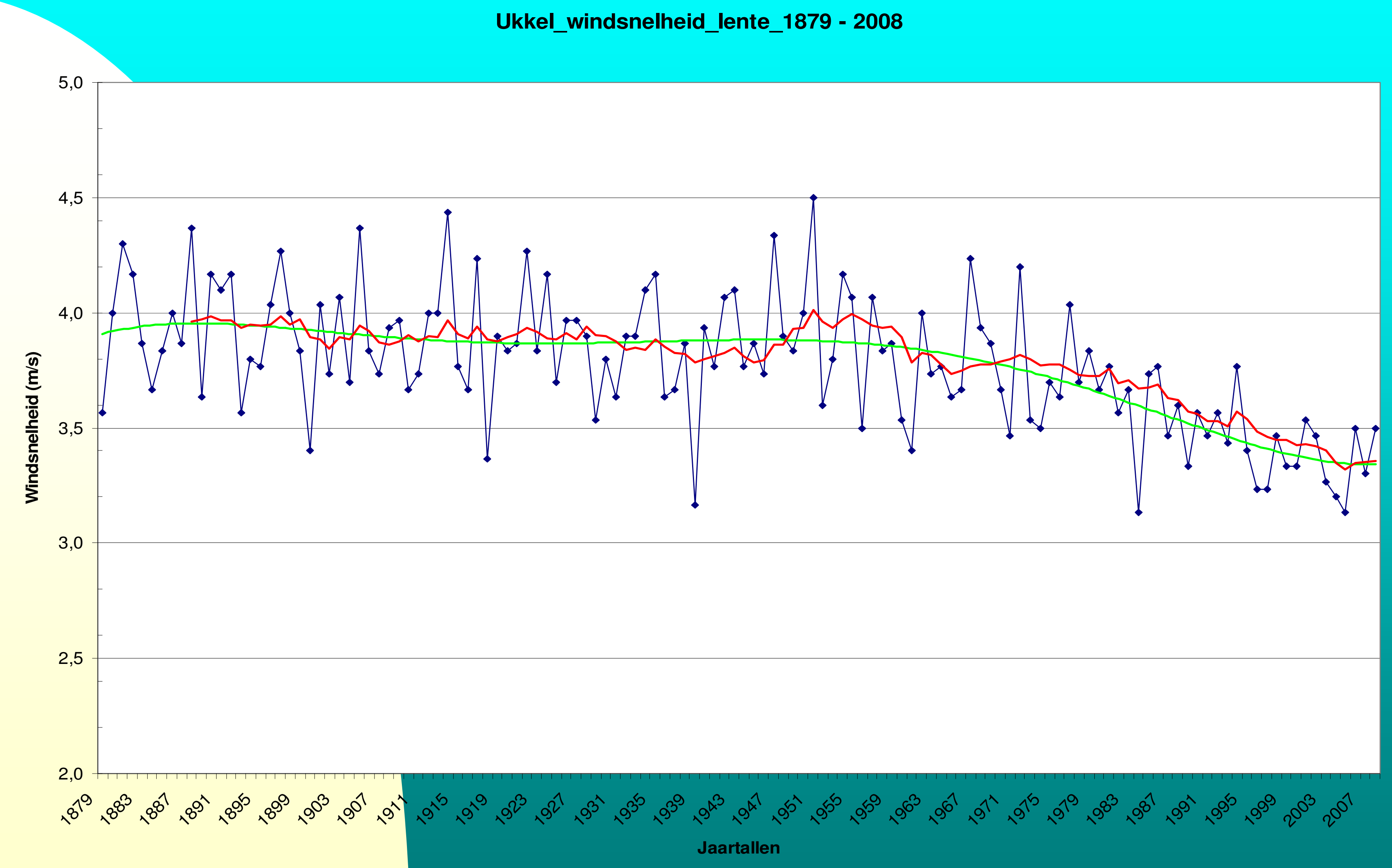


Change in precipitation regimes: global in Belgium

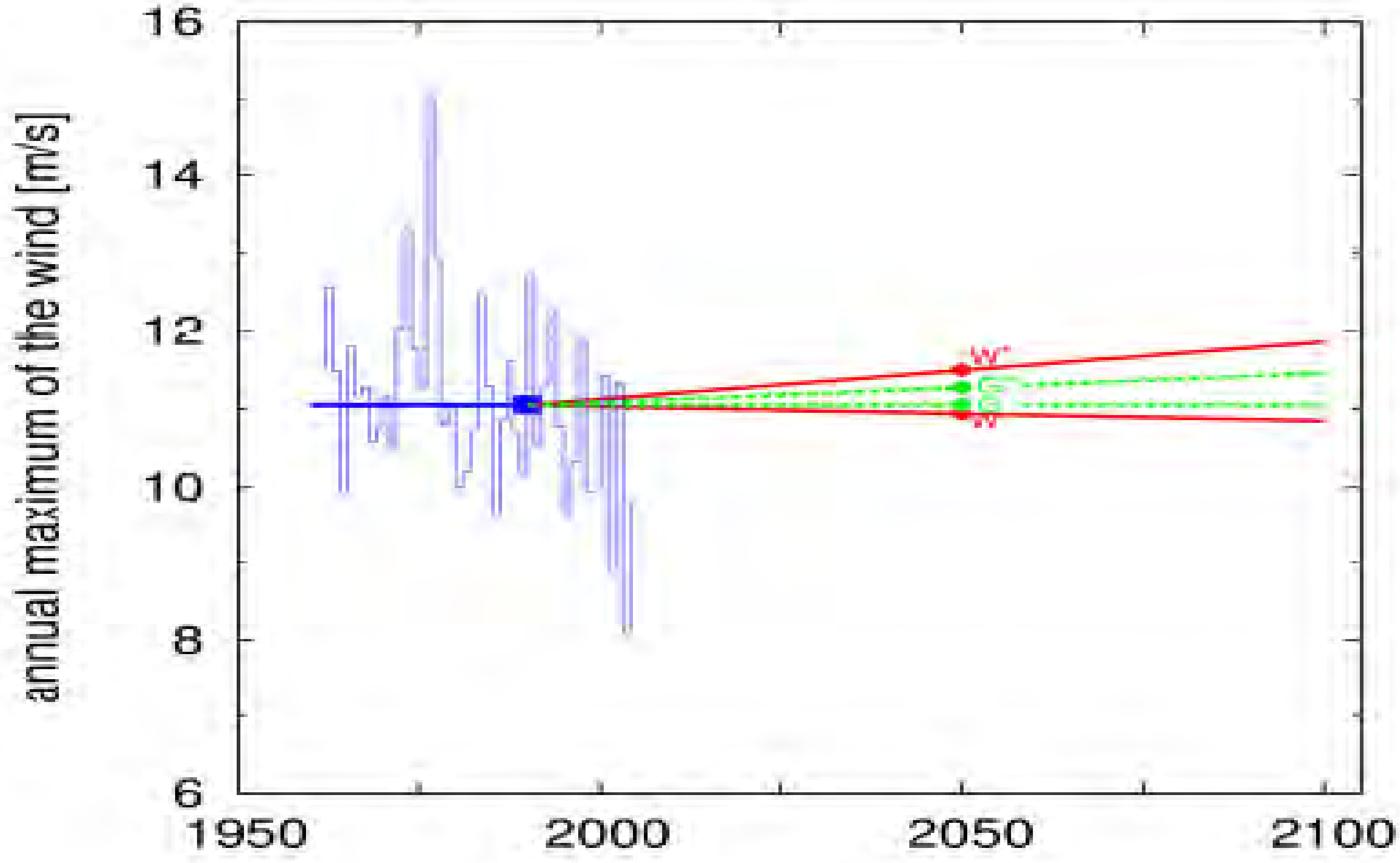
- Study precipitation between 1900 and 2006: light rise on a yearly basis of ~ 5 %
- Season bound: almost identical or decreased during the summer months and a rise in amounts of precipitation during the winter period when cumulated over a period of 10 – 15 days

- Winter : jump (rise) in 1909
- Spring : jump (rise) since 1964
- Summer and autumn: no noticeable evolution
- year : jump (rise) in 1908
  - Striking is that for the return periods > 10 y and duration of precipitation > 5 days, the values of the parameters are systematically higher than during the period 1950 – 2003 compared to these from the period 1898 – 1950. So the risk for extreme precipitation for periods > 5 dagen has increased.

❖ Average wind velocity Uccle 1879 - 2008

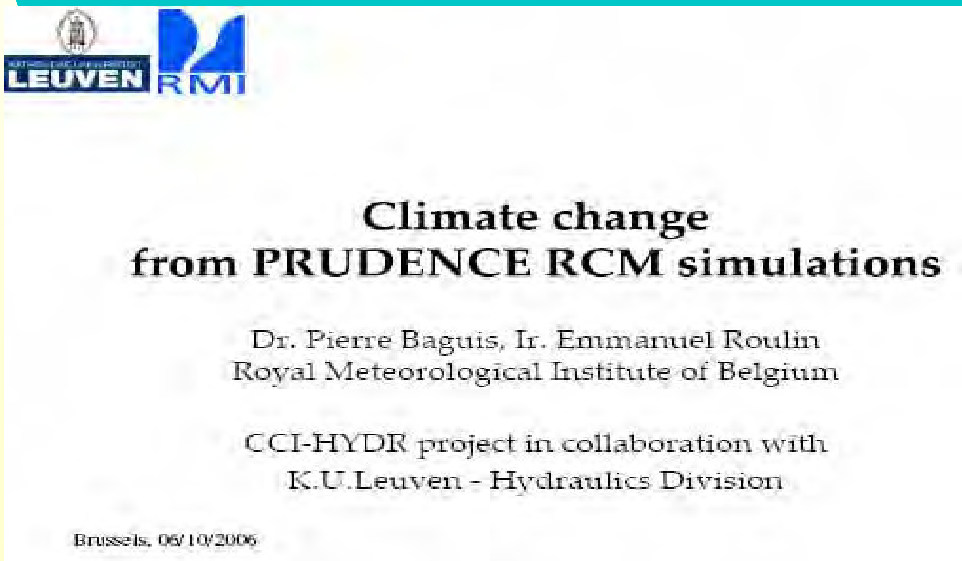


Wind climate Belgium

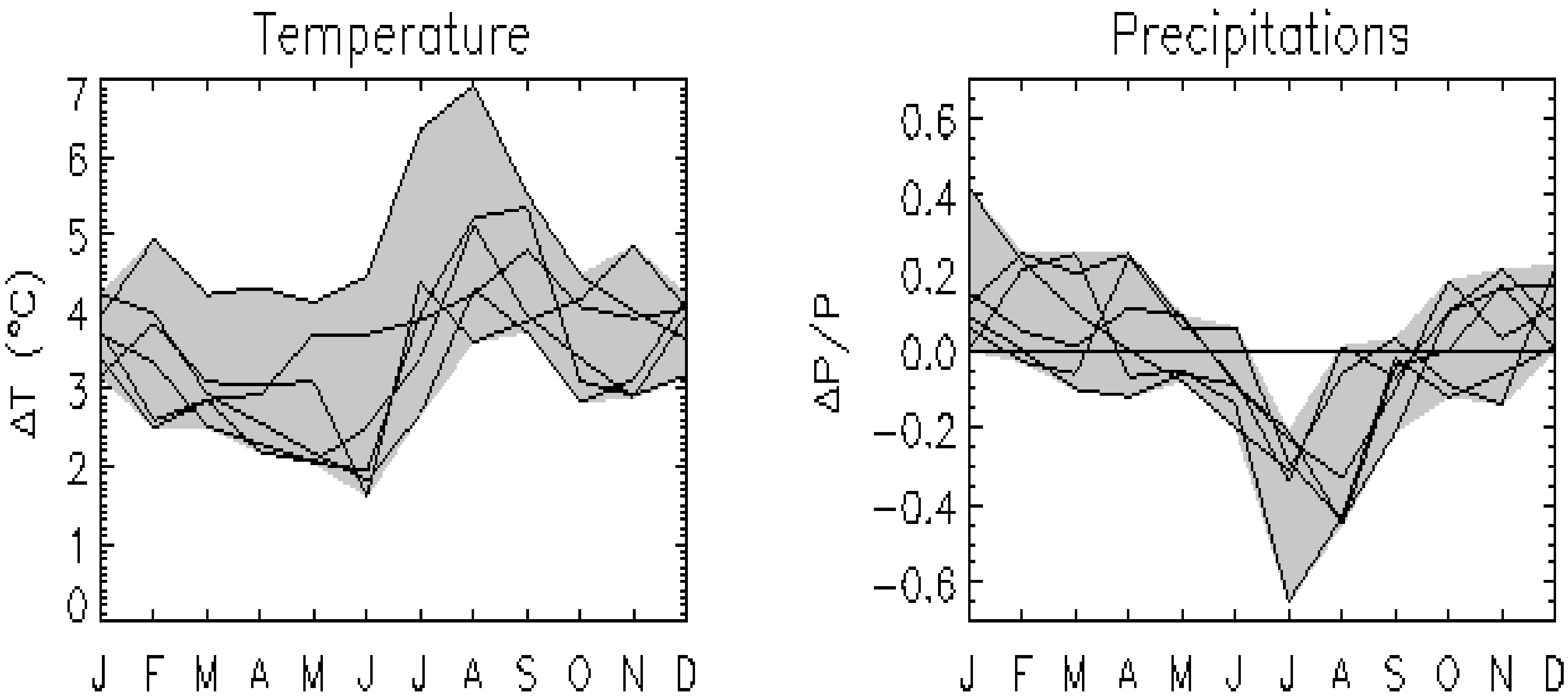


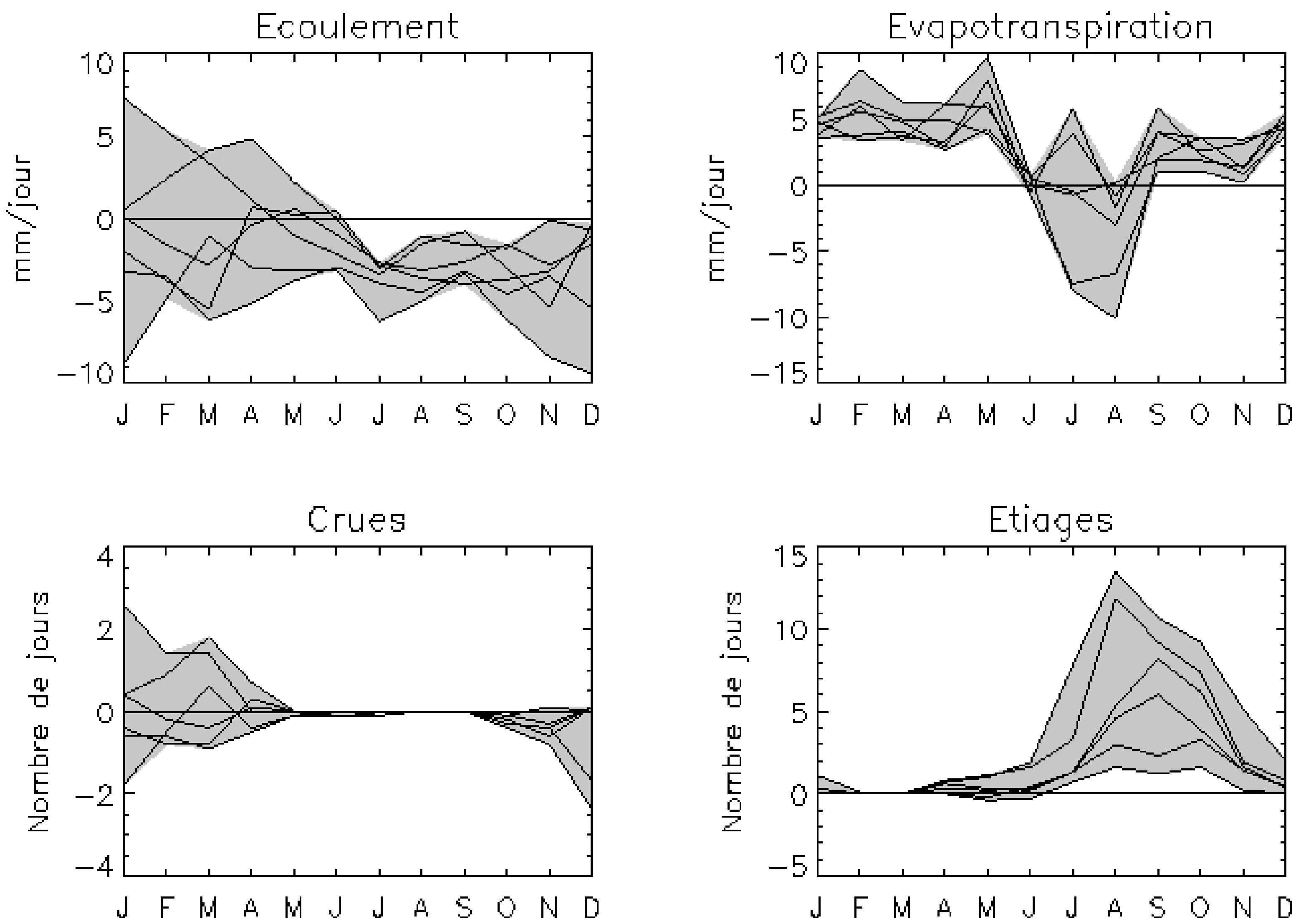
❖ Project Prudence RCM : KULeuven - RMI

- Part of RMI in CCI – HYDR = Climate Change impact analysis on hydrological extremes along rivers and urban drainage systems.
- period 2006 – 2009 : 2 phases.
- GCM : Big scale in time and space; monthly results and 300 km grid.
- RCM : Small scale ; daily results and 25 to 60 km grid.
- Start from the greenhouse emission scenarios in the 21st century.



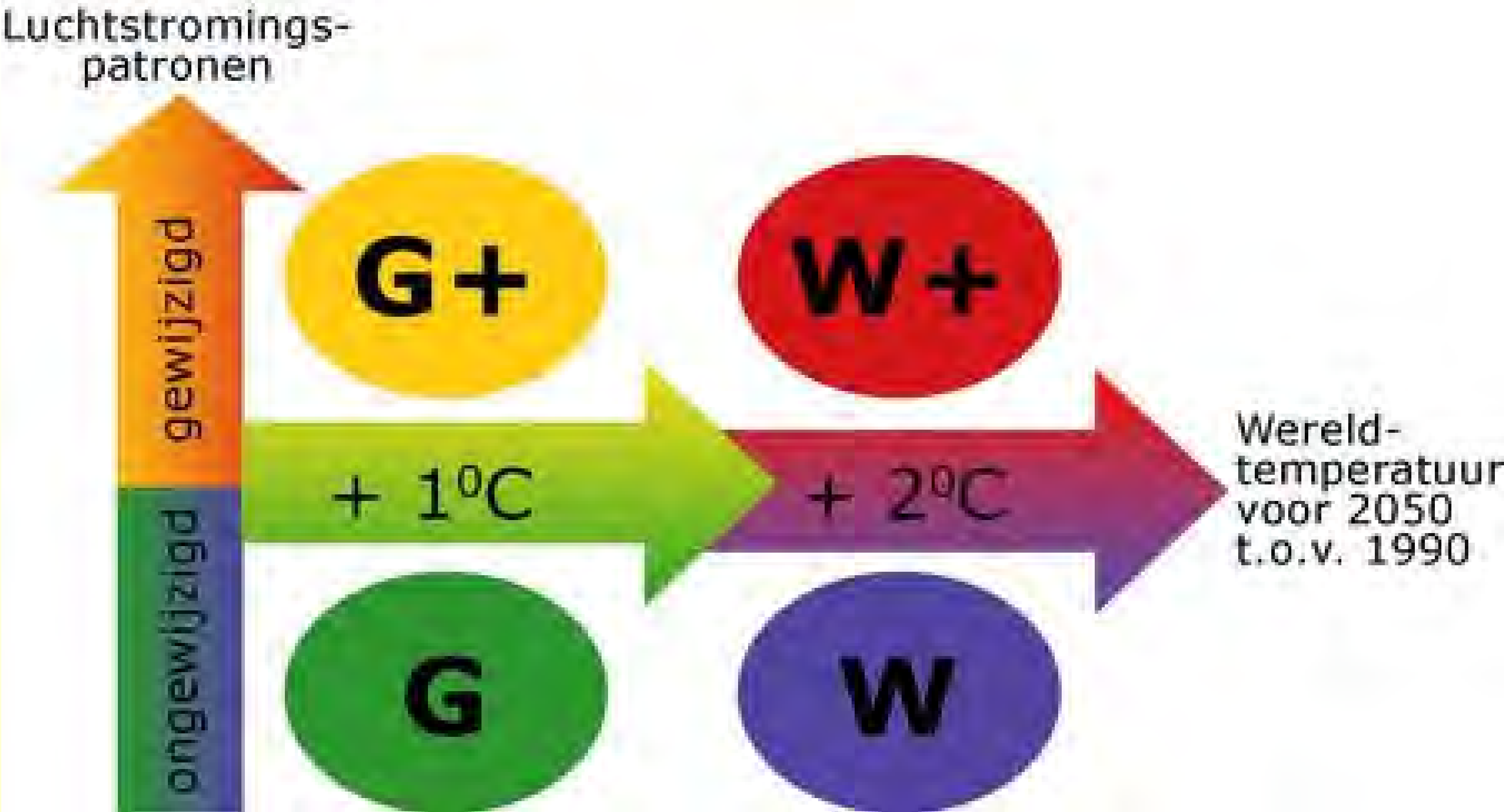
Results regional climate simulations Belgium




Ecoulement
mm/jour
10
5
0
−5
−10
J F M A M J J A S O N D
Evapotranspiration
mm/jour
10
5
0
−5
−10
−15
J F M A M J J A S O N D
Crues
Nombre de jours
4
2
0
−2
−4
J F M A M J J A S O N D
Etiages
Nombre de jours
15
10
5
0
−5
J F M A M J J A S O N D

KNMI Scenarios 2006

IPCC + RCM + outgoing observations



Code	Name	Explanation
G	Moderate	1°C rise in temperature on earth in 2050 compared to 1990 no change in patterns of air current in Western Europe
G+	Moderate +	1°C rise in temperature on earth in 2050 compared to1990 + winters are softer and wetter because of more wind from the West + summers are warmer and dryer because of more wind from the East
W	Warm	2°C rise in temperature on earth in 2050 compared to 1990 no change in patterns of air current in Western Europe
W+	Warm +	2°C rise in temperature on earth in 2050 compared to 1990 + winters are softer and wetter because of more wind from the West + summers are warmer and dryer because of more wind from the East

Conclusions and points of dicussion

- Belgium: moderate maritime climate with great differences in time and space for temperatures , precipitation and extreme values. Assign climate changes to single events is scientifically incorrect.
- Potential future evolutions of the climate (so-called projections) (IPCC) happen with help of the OCGCM's based on emission scenarios. The projections are very different and this is even more obvious on a regional scale. There are insecurities as a result of imperfections of the models, internal variability inherent in the climate system and evolutions of the anthropogenic reinforcement of the climate system that are hard to assess. (the anthropogenic factor is heavily dependant on the socio-economical evolution which is hard to predict).
- A climate change says something about the average weather in the future. On top of that is the 'most likely future' not necessarily the most relevant future to take into account. Especially for the great range in, for example, rises of temperature that all occurred.

- The climate scenarios do not describe an abrupt climate change as a result of the standstill of the 'warm Gulf stream' or the unexpected melting of the ice caps in Greenland and West Antarctica. Climate models still show major shortcomings for these aspects because of insufficient scientific knowledge. Moreover, the indications of fast changes in the observations are very unsure, although not impossible.

- On top of that the climate scenarios don't include phenomena of which it is not sure if they are realistic, like 'super storms' that are a lot more violent in Europe now than ever before.

- The climate models differ substantially in their calculation of the global rise of temperatures. This is the result of insecurities concerning the future emission of greenhouse gasses and our limited knowledge of the complex processes in the climate system. What's more, there are fundamental limits to the predictability of complex systems like the climate system.

What can we **probably** expect in our region and in the Northern Hemisphere?

- Temperatures will keep rising. Mild winters and hot summers will be more frequent.
- Winters will get wetter and intense amounts of precipitation will increase.
- The average wind velocity decreases: no indication of a rise in extreme storms.
- Sea level keeps rising but slower than predicted before.
- The rise in temperature is most obvious in the Northern Hemisphere.
- A rise in the amount of precipitation on moderate latitude, a decrease in the subtropics.
- The rise in the temperatures happened in two phases in Uccle: 0,8°C between 1833 and 1910, a relatively stable temperature between 1911 and 1987 and afterwards from 1987 till 2006 a rise of ~1,0° C.
- The rise observed between 1987 and 2006 was in Belgium ~ 1,0°C. A rise of + 2°C for 2050 lies within the estimations of the OCGCM and should not be mistaken with the goal of the EU to prevent a dangerous disruption of the climate system.
- At the moment the sea level rises 1 – 3 mm/year, but this is very variable depending on the area.

Thank you for the invitation and your interest

Climate-robust crop science: Modelling climate-change impacts across scales

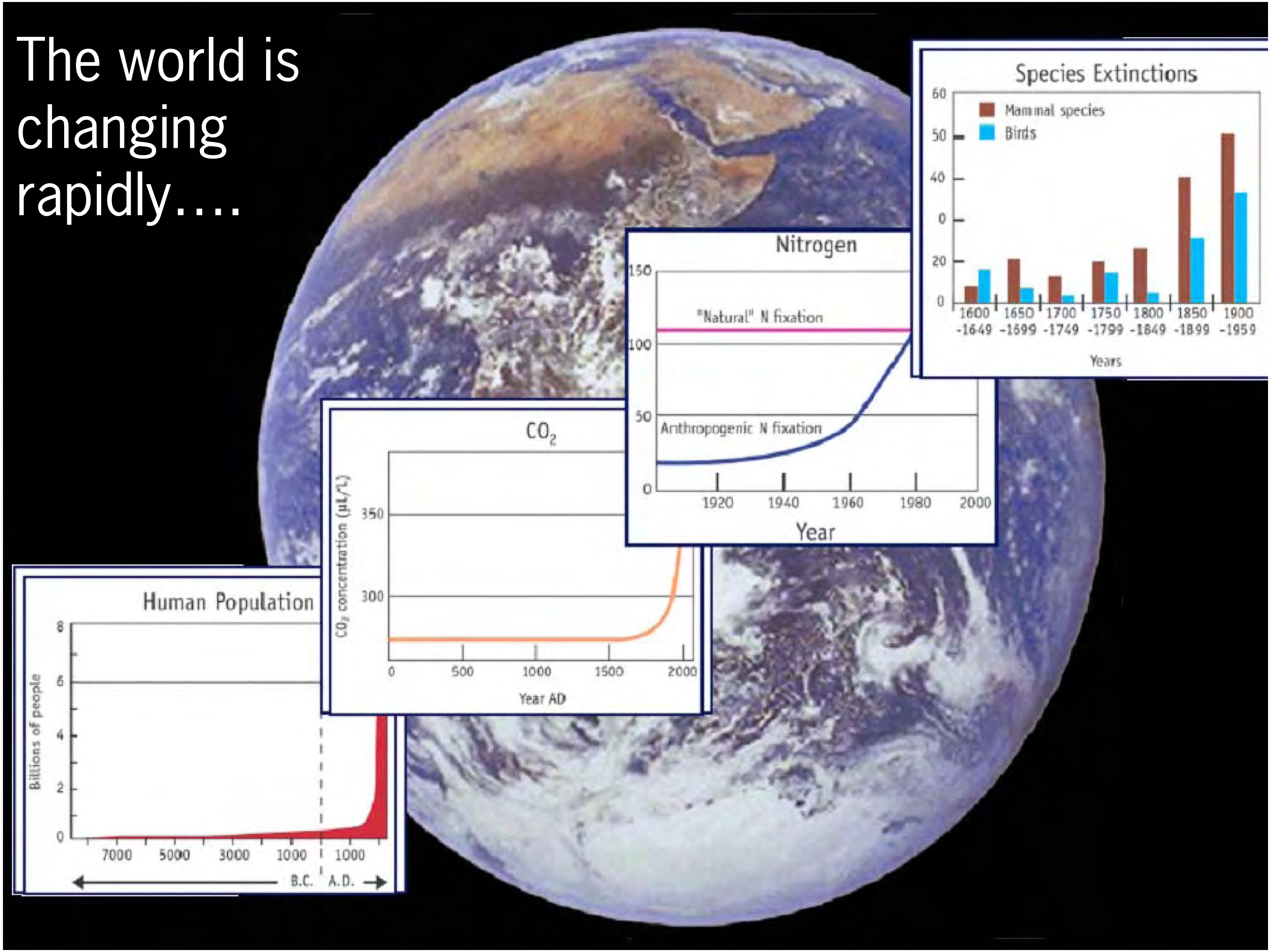





Paul C. Struik and Holger Meinke

Centre for Crop Systems Analysis, Wageningen University, Wageningen, the Netherlands

The world is changing rapidly….



Adapt or Mitigate?

Climate Warning

Adapt

Mitigate

TEMPORAL

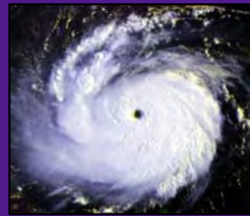
now **future**

SPATIAL

field farm catchment region state

ECONOMICAL

enterprise business industry sector

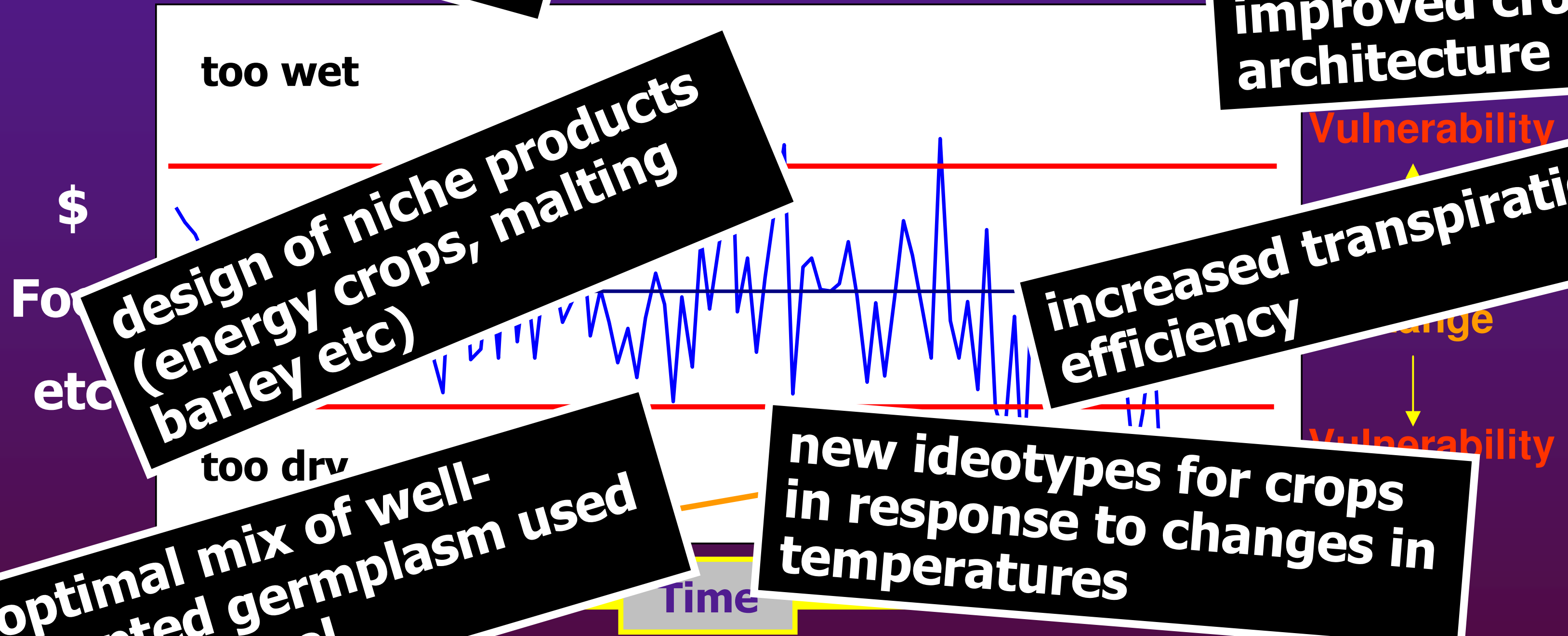


Risk expo… …lnerability and …ptation

functional genomics

improve plant nitrogen uptake and redistribution

improved crop architecture



design of niche products (energy crops, malting barley etc)

increased transpiration efficiency

new ideotypes for crops in response to changes in temperatures

optimal mix of well-adapted germplasm used at farm level

staygreen

…continuation of current climate trends (rainfall, max temp… …)

…lt greater enterprise vuln…

…ng appropri… …f adaptation,

plannin… …ad of these changes.

pest-resistant crops (Bt crops)

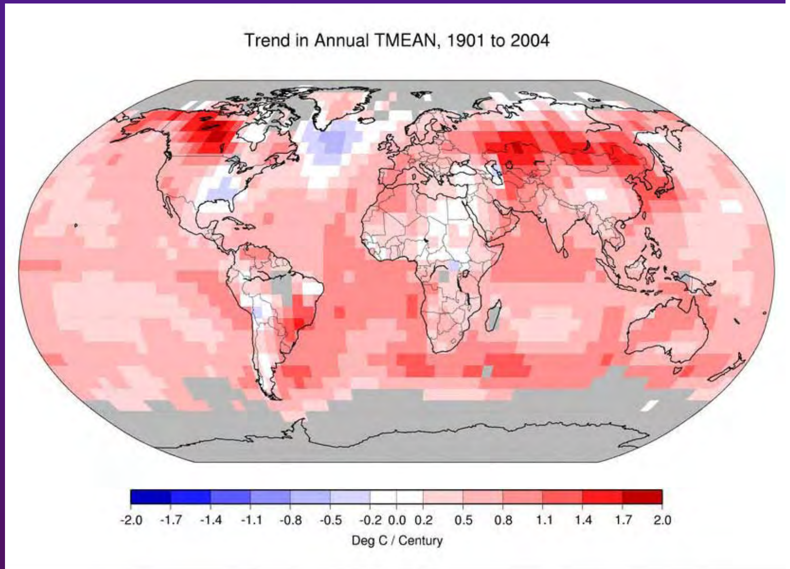
root systems design

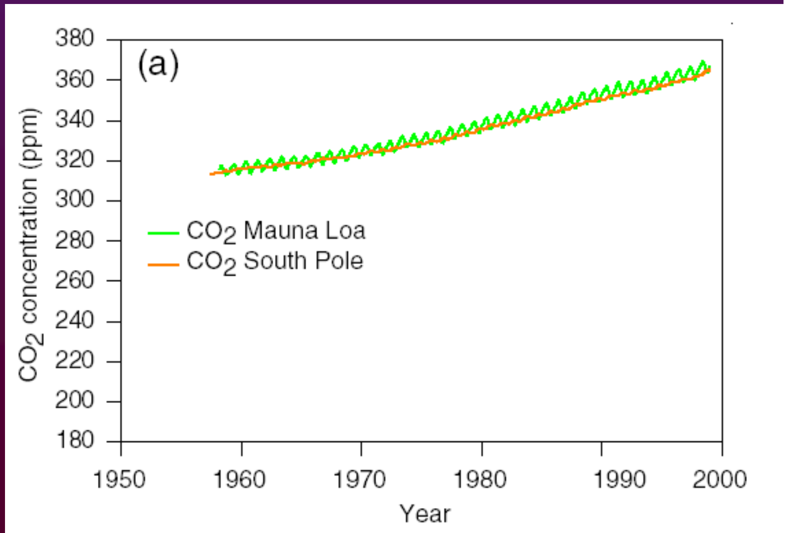
Degrees of certainty – it's a matter of risk management

Certain

CO_2 increases will continue

The 20th century has seen the greatest warming in at least 1000 years and natural forces can't account for it all. The five hottest years on record were 1998, 2005, 2002, 2003 & 2001.





Degrees of certainty – it's a matter of risk management

Highly likely

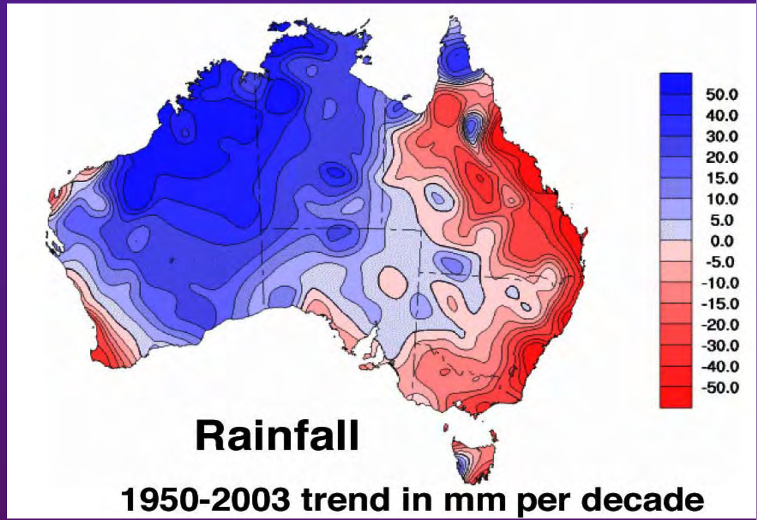
Temperatures will continue to increase

Sea levels will continue to rise

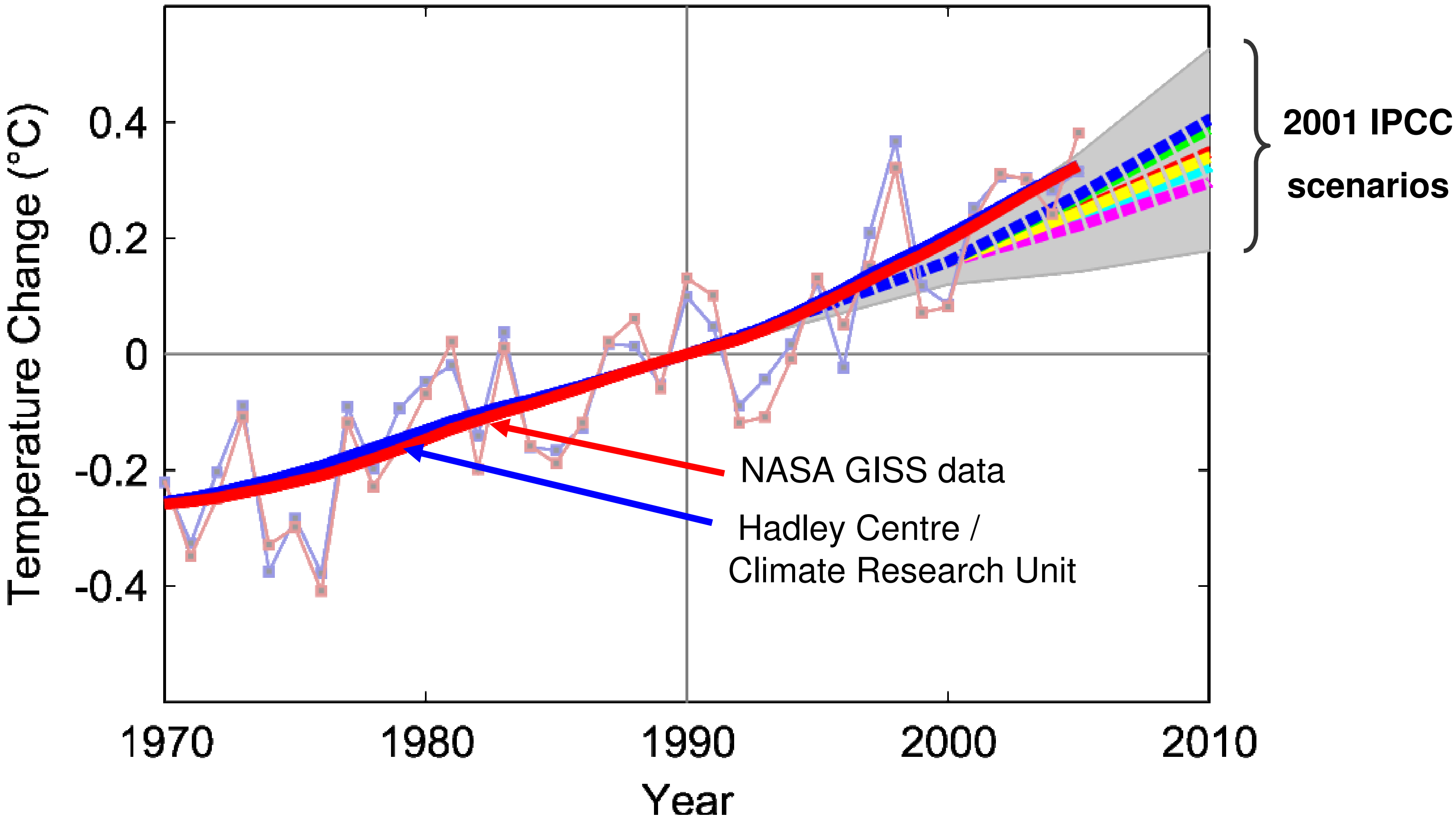
Rainfall patterns will change (likely ongoing decline for Eastern Australia)

Possible

Thresholds might be crossed that could lead to climate shifts

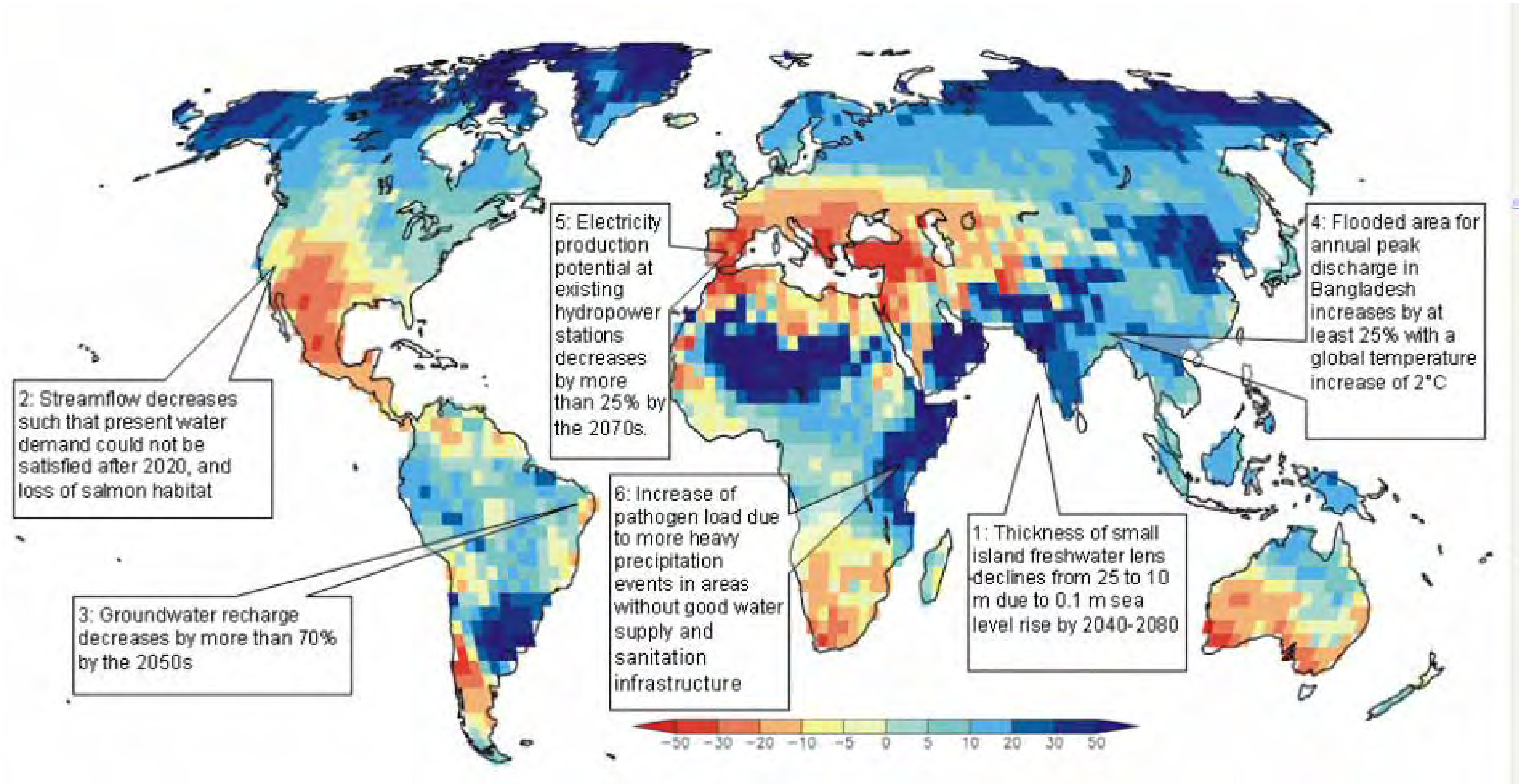


We are tracking at the upper end of the scenario curves



Rahmstorf et al. 2007

Change in annual runoff (2081-2100 vs 1981-2000) averaged over 12 climate models

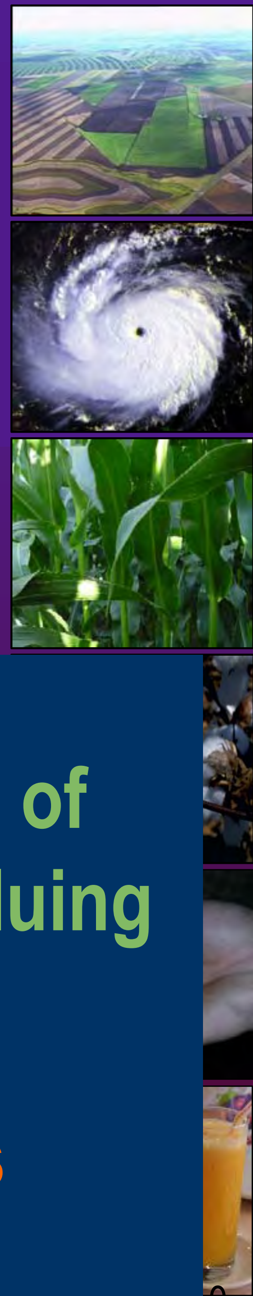


IPCC 2007

Agriculture as a CAS

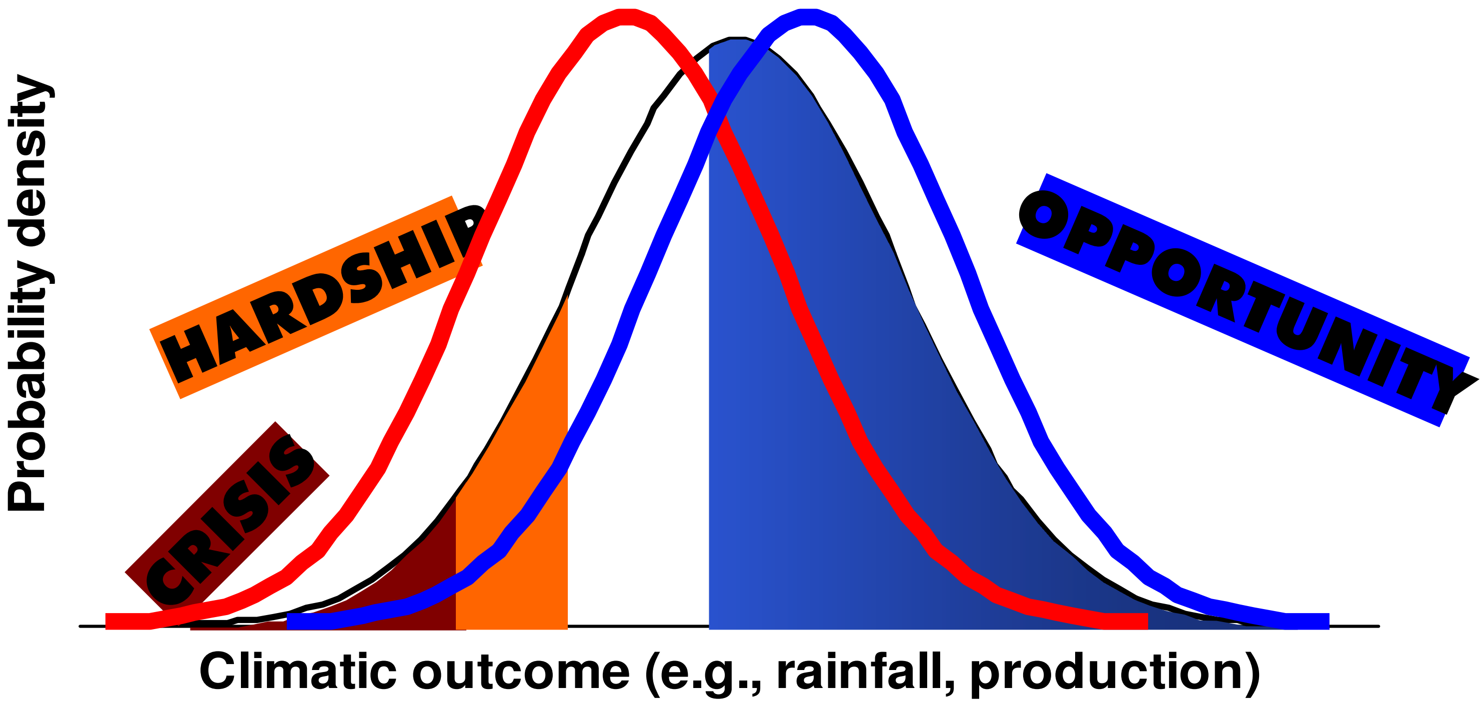
(Complex Adaptive System):

order emerges rather than being predetermined



Complex systems resulting in intractability of cause and effect can be perceived as devaluing scientific input.

We can reverse this through good systems analysis and modelling.



Without adaptation With adaptation

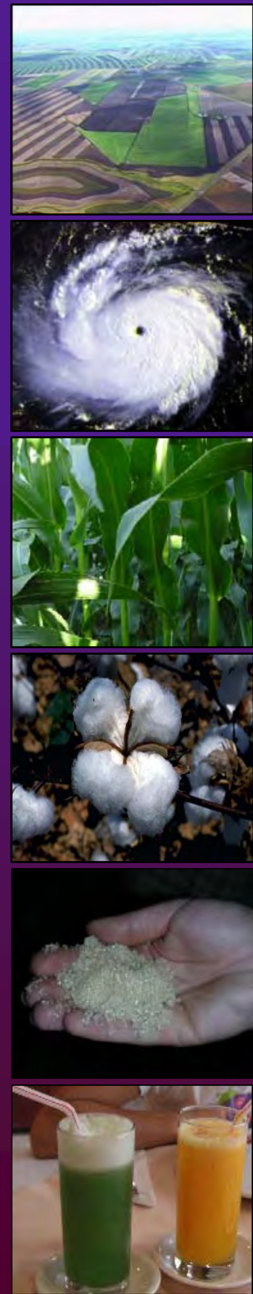
innovation by design

The role of simulation modelling in agricultural risk management

Two core functions

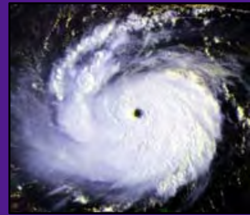
1) enhanced heuristic role of models in management decisions, education and policy development

2) increasing role for models in the understanding of genetic regulation and anticipated responses to genetic alterations (G x E x M).

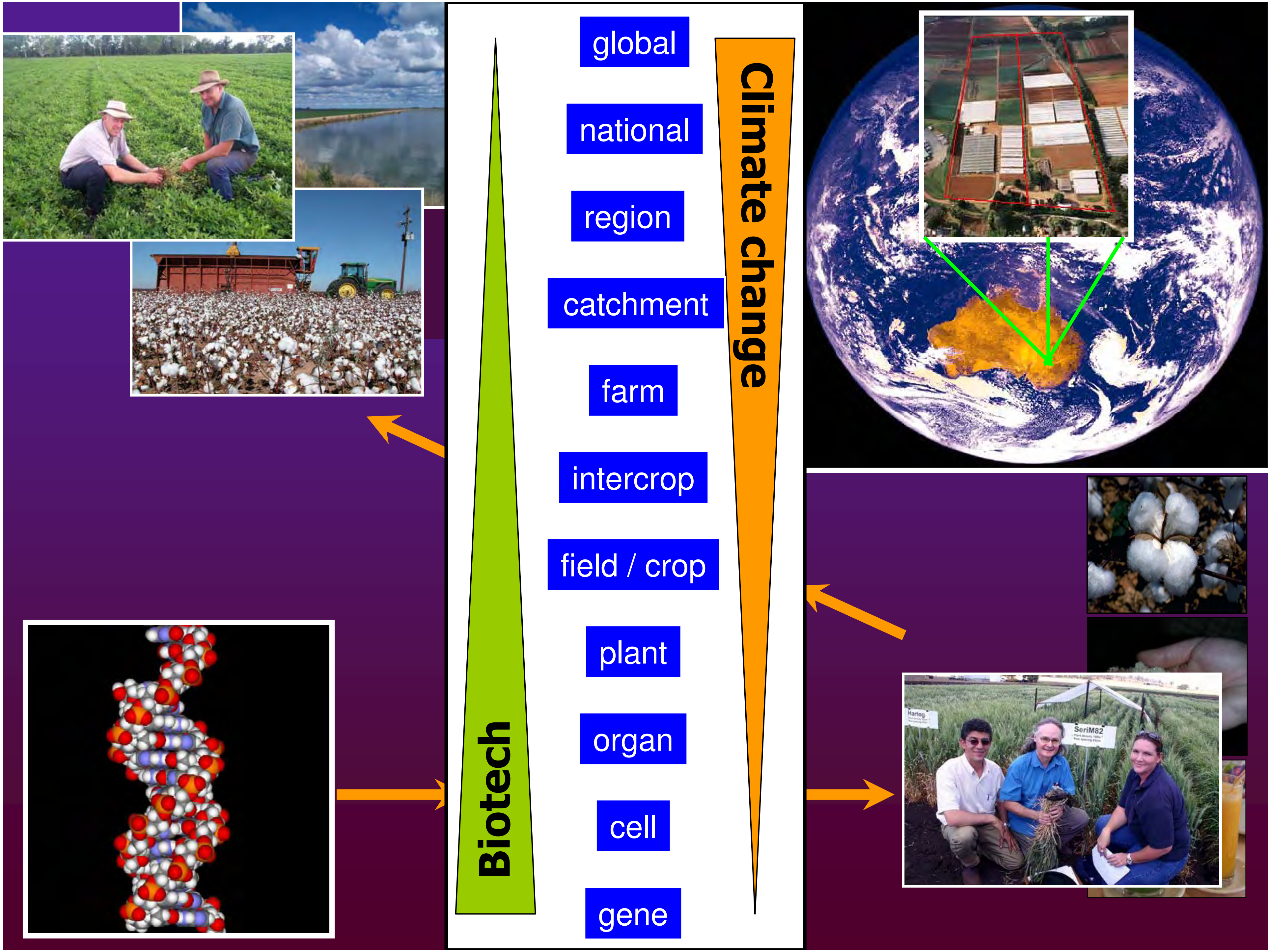


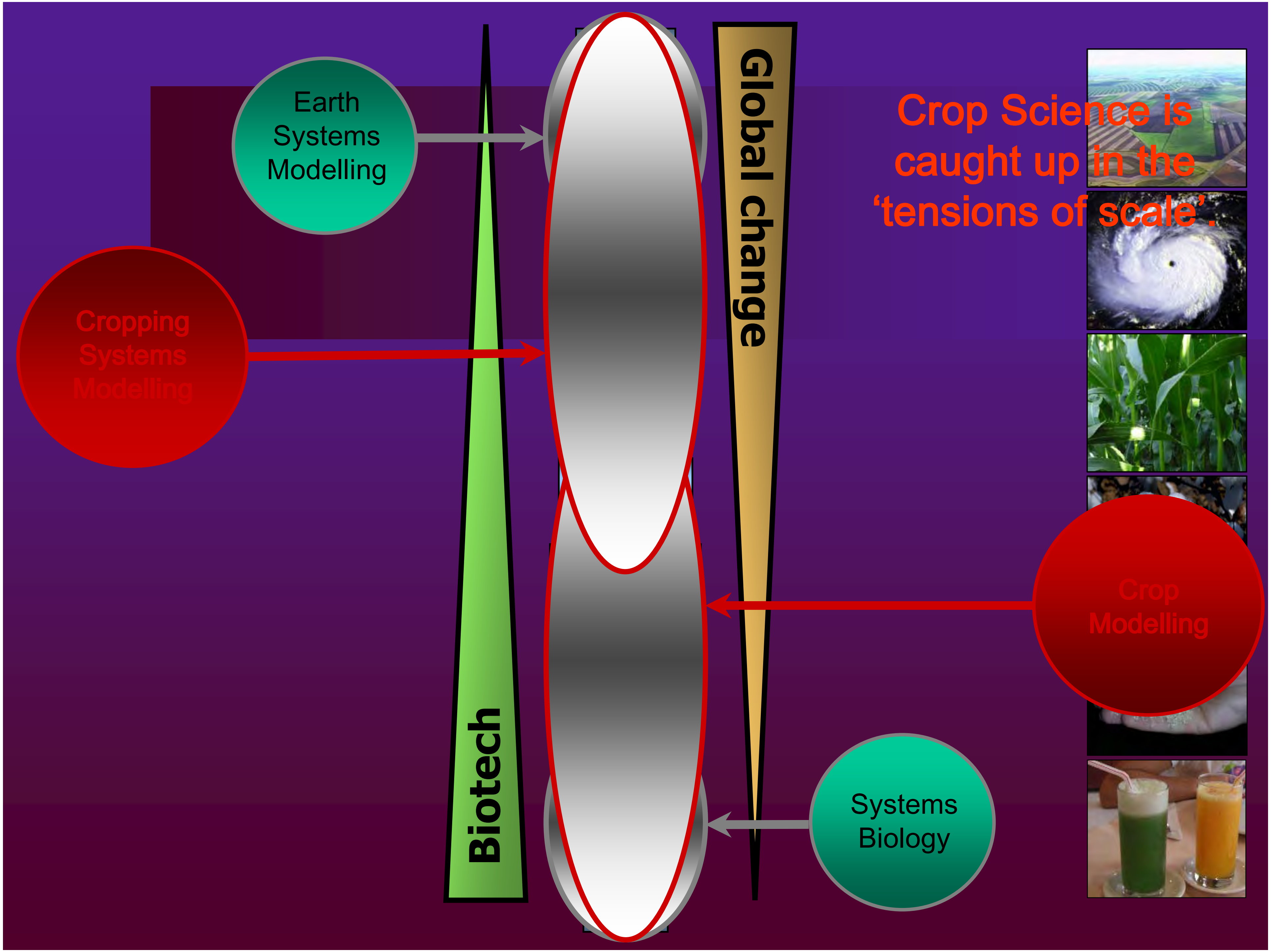
innovation by design

The role of simulation modelling in agricultural risk management



- Faced with complex problems people often go straight from denial to despair without pausing in between and doing something about it.
- Modelling can help to reduce complexity, create new insights and suggest novel solutions.
- Modelling is a journey across disciplines, temporal and spatial scales.
- The objective of physiologically weighted marker selection is to “package” gene networks into genotypes by developing “search strategies” to find them on the GENE-ENVIRONMENT landscape


global
national
region
catchment
farm
intercrop
field / crop
plant
organ
cell
gene
Biotech
Climate change
Hartog
SeriM82


Earth Systems Modelling
Cropping Systems Modelling
Biotech
Global change
Crop Science is caught up in the 'tensions of scale'.
Crop Modelling
Systems Biology

Relevant trends

- Increasing world population and wealth
  - Increasing demand for food
  - Growing demand for safe and healthy nutrition
  - Increased pressure on environment, land usage and nature
- Scarcity of fresh water and energy
- Climate change
- Competing claims: Food vs Energy
- Increasing urbanisation and population density
- Increased disease pressure, invasive pests

Food prices to remain high for now: FAO

Reuters, Posted online: Wednesday, April 09

The United Nations' Food and Agriculture Organisation on Wednesday said global commodity prices were far from easing in the short term owing to tight supply-demand situation and warned of flare ups over food shortage.

Food crisis will take hold before climate change, warns chief scientist

The Guardian, Friday March 7 2008

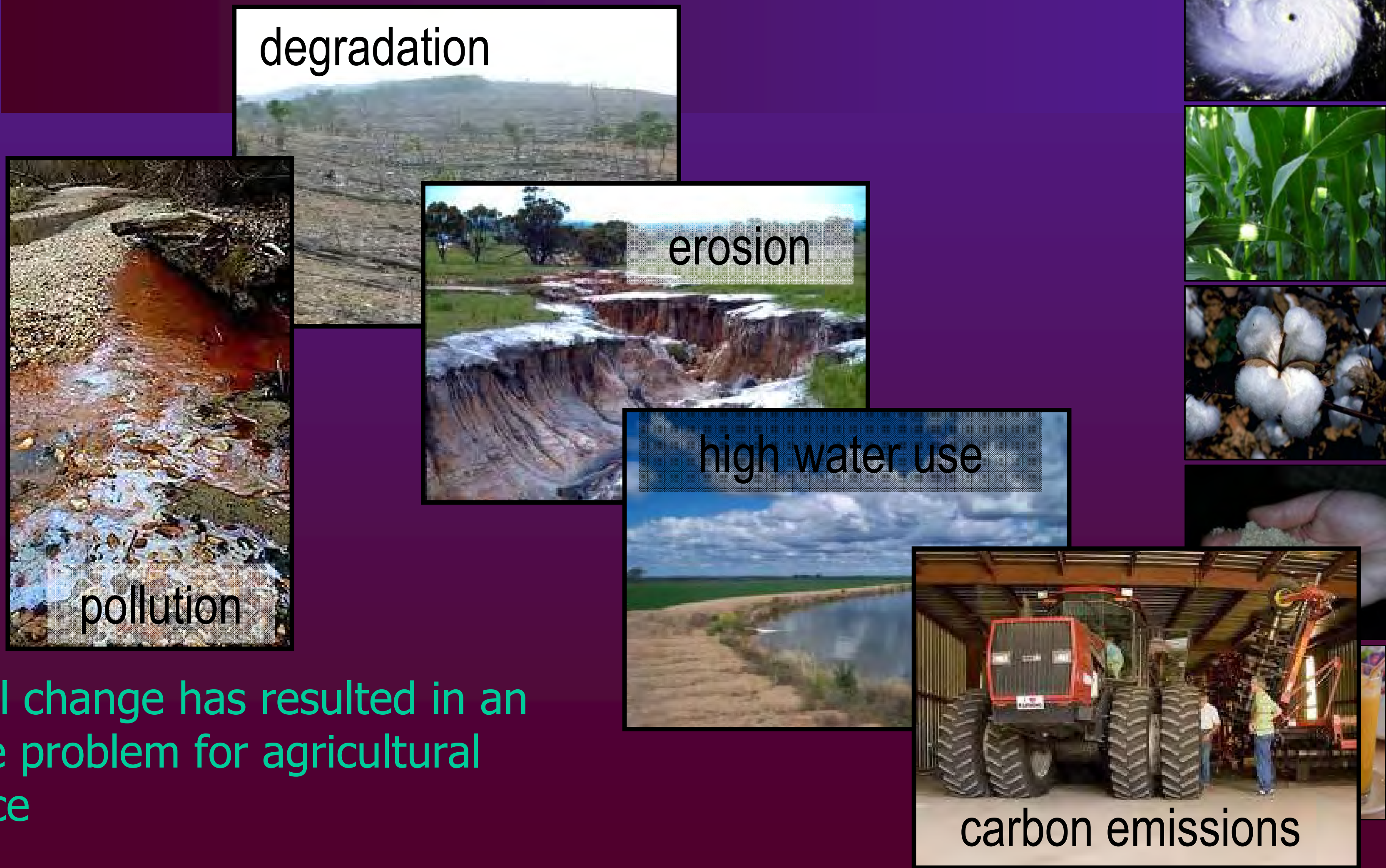
... Professor John Beddington said the global rush to grow biofuels was compounding the problem, and cutting down rainforest to produce biofuel crops was "profoundly stupid". He predicted that price rises in staples such as rice, maize and wheat would continue because of increased demand caused by population growth and increasing wealth in developing nations. He also said that climate change would lead to pressure on food supplies because of decreased rainfall in many areas and crop failures related to climate. "The agriculture industry needs to double its food production, using less water than today," he said.

Climate change serious - beer affected

From: NEWS.com.au April 08, 2008

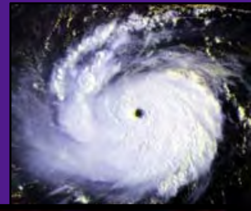
BEER will be short supply, more expensive and may taste different as climate change affects barley production, a scientist says.

Frequently agricultural activities are seen in association with environmental problems such as . . .



Global change has resulted in an image problem for agricultural science

… while the ecosystems services provided by the agricultural sector are less visible.



Modelling that bridges scales and connects disciplines

- The 20th century was the century of analysis based on new discoveries and exploring biological systems in ever increasing detail (from discovery of DNA to mapping of the human genome), creating new disciplines in the process

- The 21st century is rapidly becoming the century of synthesis with much greater emphasis on holistic approaches and creating new insights at the interfaces of disciplines (transdisciplinary)

Unpacking the G x E x M Box

G for genotype

Functional genomics, gene expression, GMOs, MAS

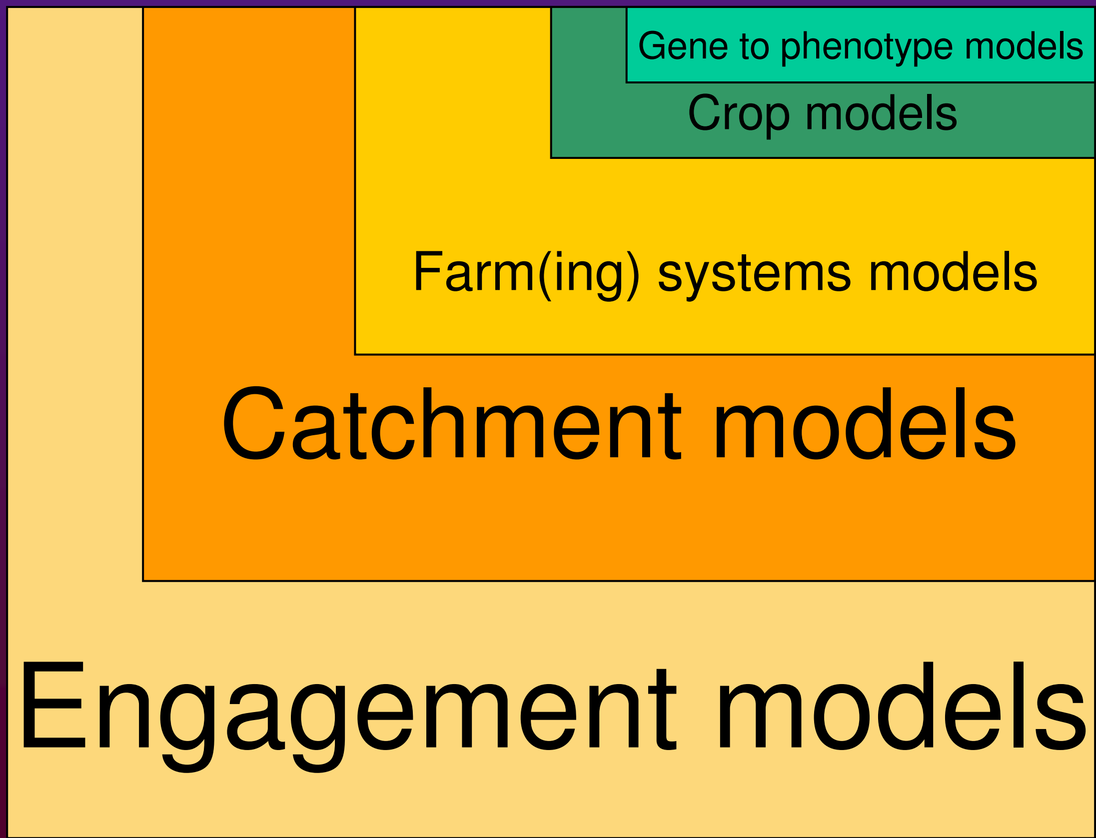
E for environment

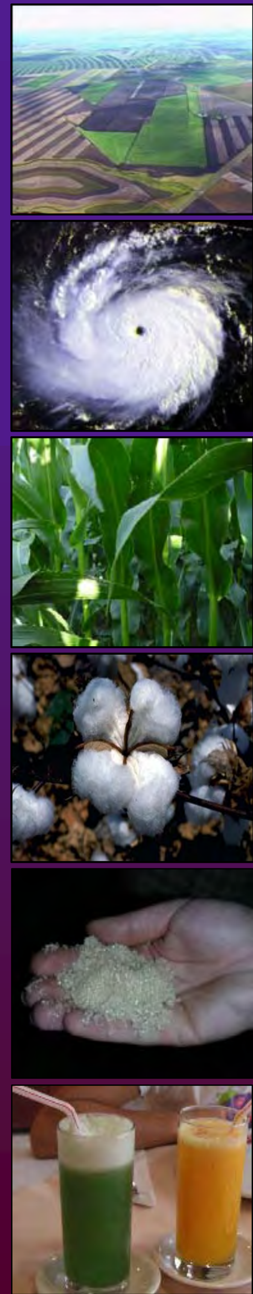
Climate, weather, greenhouse climate, soils

M for management

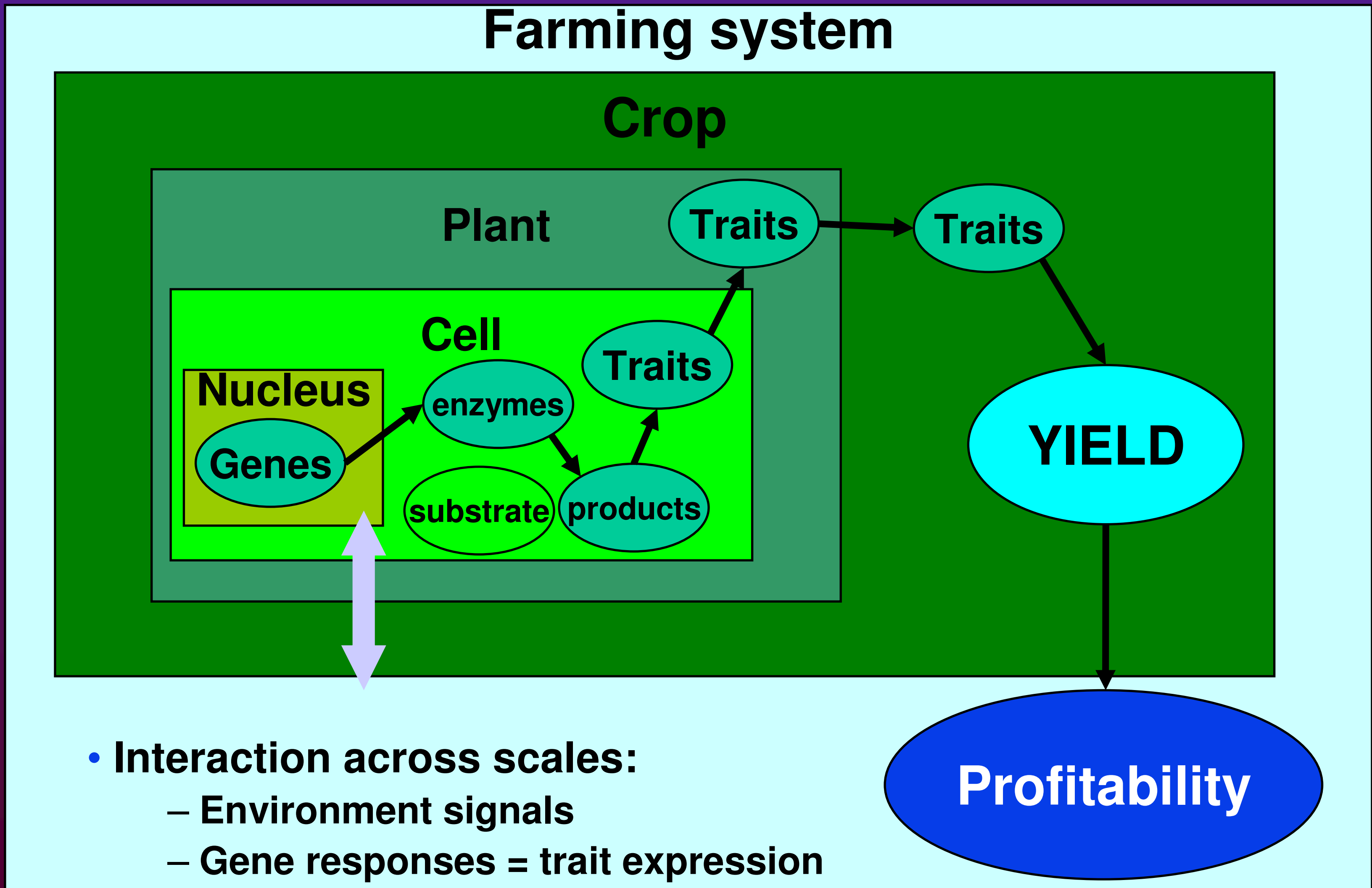
Plants, crops, fields, farms/greenhouses, communities

What type of model do we need?



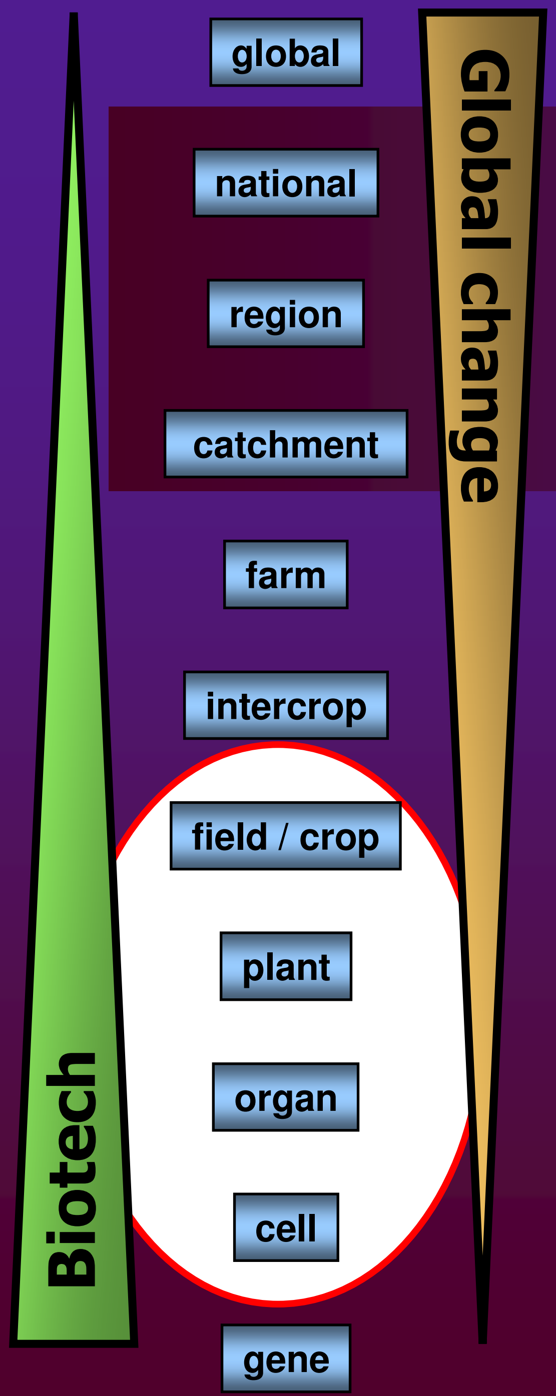


Genes in Environments: the full 'systems' view?



- **Interaction across scales:**
  - **Environment signals**
  - **Gene responses = trait expression**

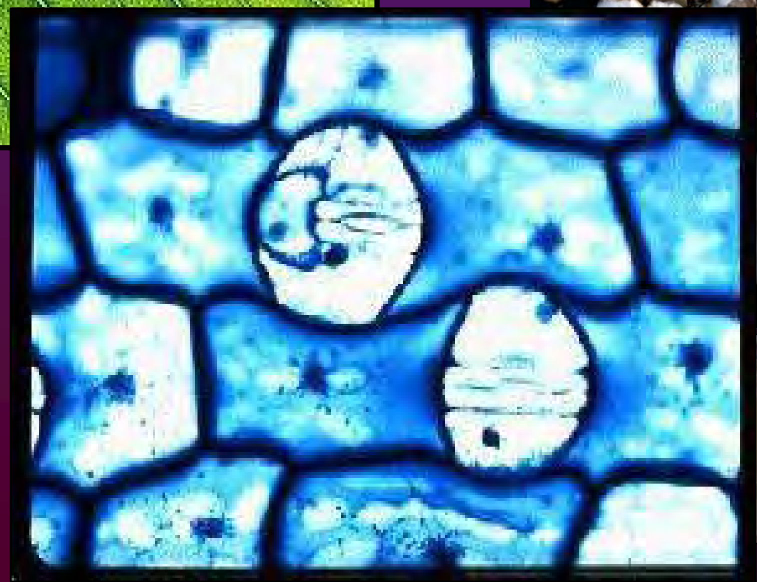
Hammer, G., Sinclair, T., Chapman, S. and van Oosterom, E. (2004). On systems thinking, systems biology and the in silico plant. Plant Physiology 134: 909-911.

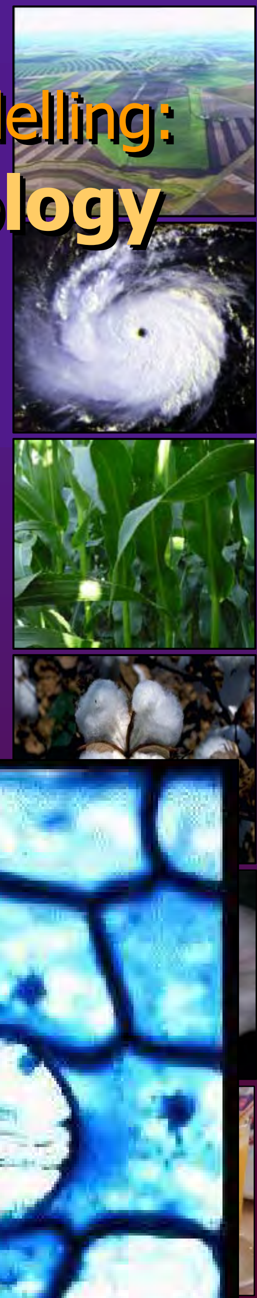


Example 1

biochemical photosynthesis modelling:

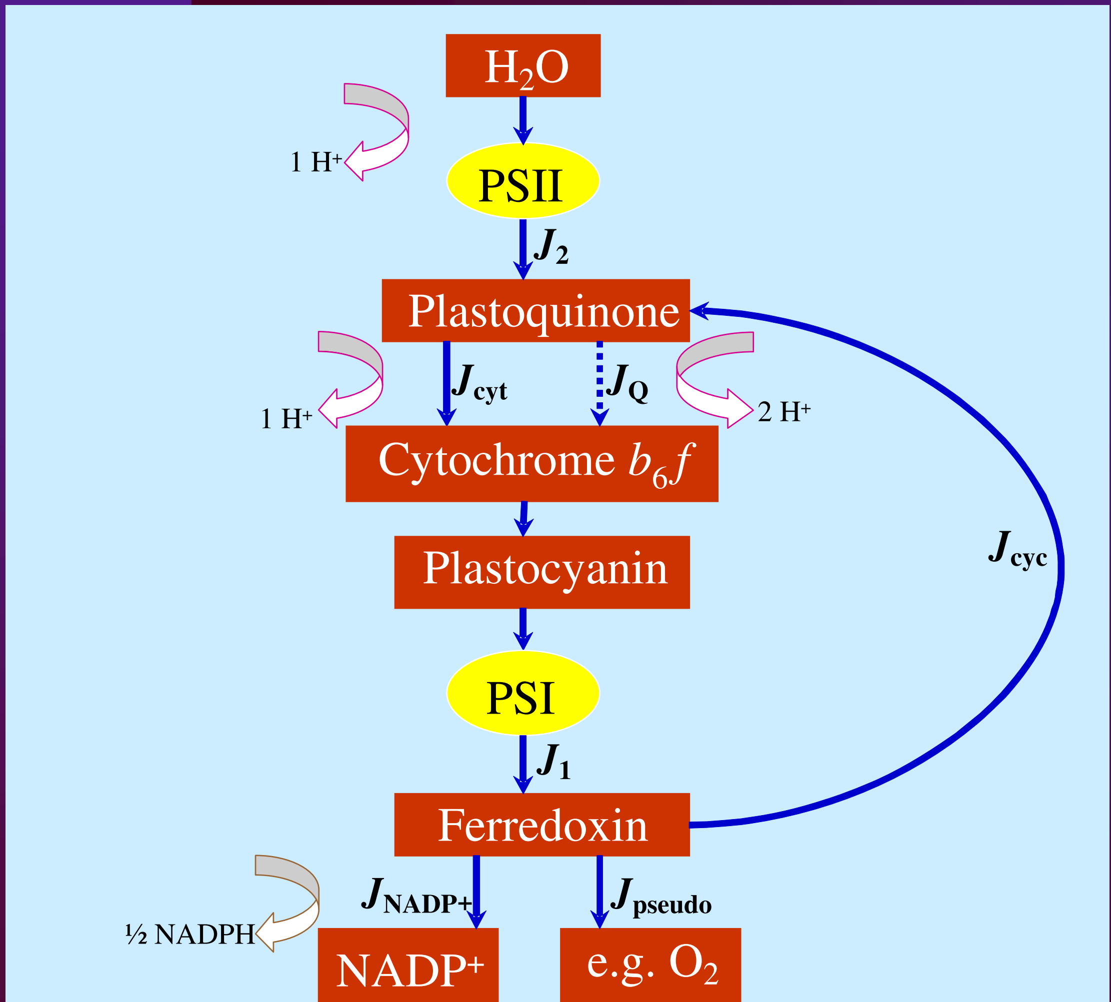
Towards **Crop Systems Biology**

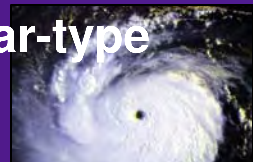




Is the whole more than the sum of its parts?

Linear and alternative e⁻ transport pathways of photosynthesis





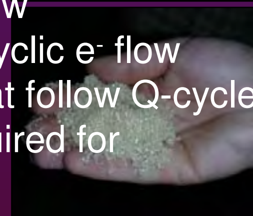
An extended Farquhar-type model:

$$A_j = J_2\left(1-\frac{f_{pseudo}}{1-f_{cyc}}\right)\frac{C-\Gamma_*}{4C+8\Gamma_*}-R_d$$

$$1-f_{cyc}-f_{pseudo}=\frac{(4C+8\Gamma_*)(2+f_Q-f_{cyc})}{h(3C+7\Gamma_*)}$$

$$J_2=\left(\alpha_{2m}I_{abs}+J_{max}-\sqrt{(\alpha_{2m}I_{abs}+J_{max})^2-4\theta J_{max}\alpha_{2m}I_{abs}}\right)/(2\theta)$$

$$\alpha_{2m}=\frac{\Phi_{2m}(1-f_{cyc})}{\Phi_{2m}/\Phi_{1m}+1-f_{cyc}}$$

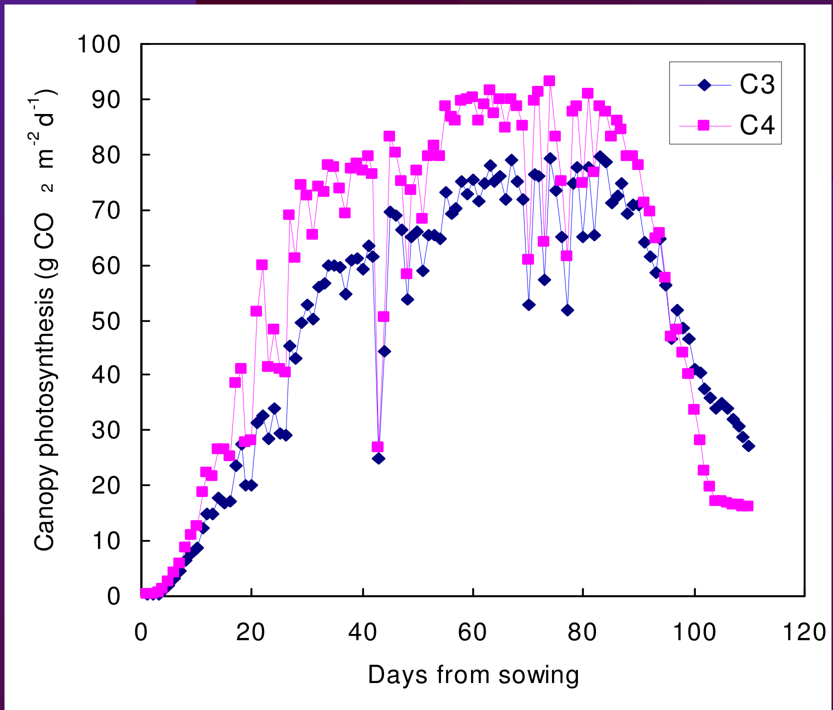


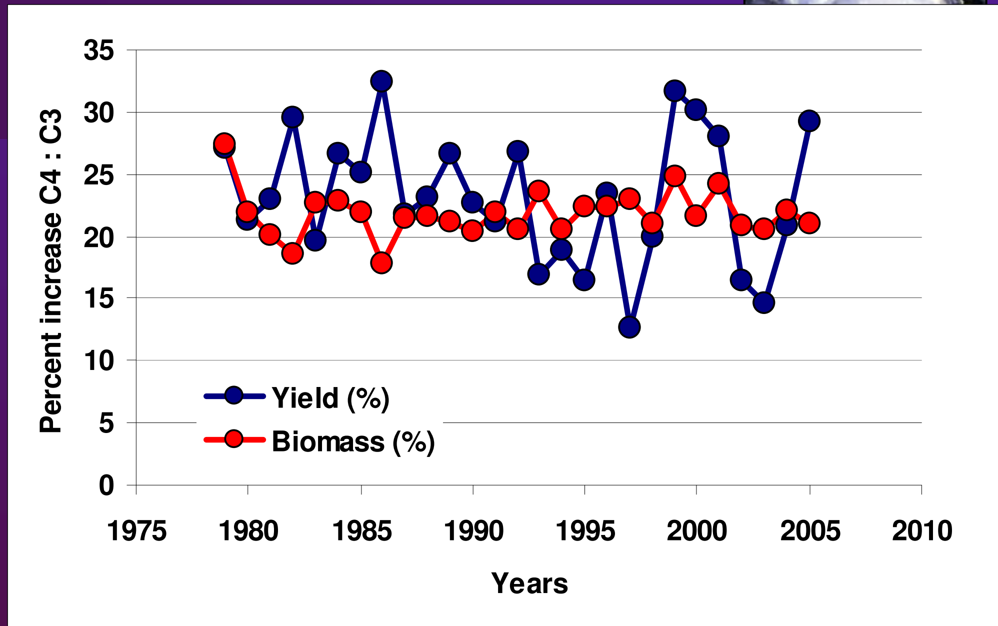
F_{cyc}= fraction of cyclic e⁻ flow
f_{pseudo}= fraction of pseudocyclic e⁻ flow
f_Q= fraction of electrons that follow Q-cycle
h = number of protons required for synthesizing 1 ATP

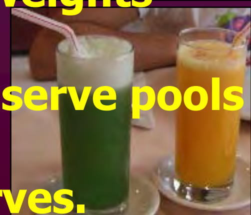
Yin, van Oijen & Schapendonk 2004. PC&E 27: 1211-1222.

Assessing the effect of genetic engineering - C_3 vs C_4 rice: the effect on grain yield, simulated by GECROS

IRRI dry season, duration 80+30 d, N_{upt} = 220 kg/ha







Assumptions

Same GN m^{-2} & plant height → structural stem weights comparable;

higher canopy photosynthesis invested in the reserve pools and translocated to support grain filling;

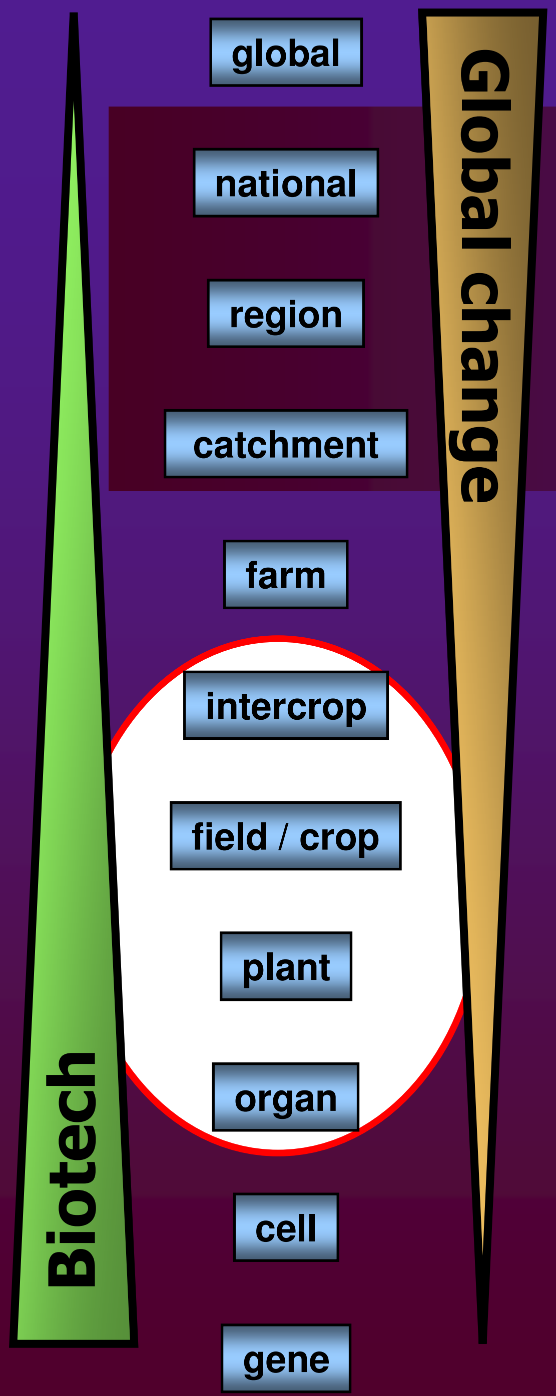
C4 rice has sufficient capacity to hold high reserves.

Yin & Struik 2008. New Phytologist.

Summary Example 1

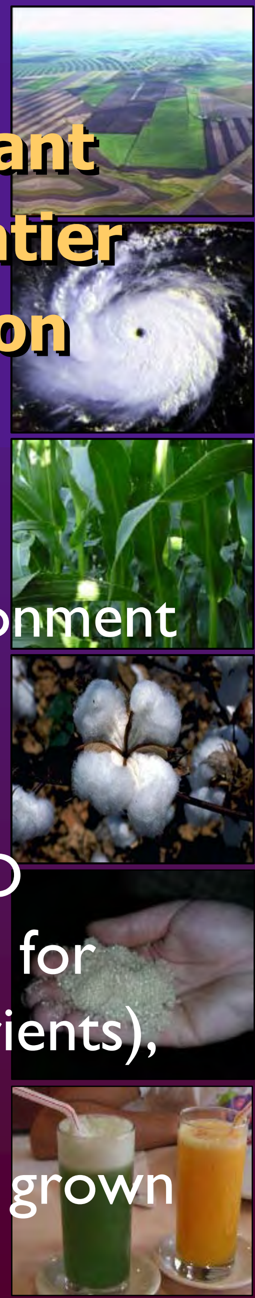
Modelling as the bridge between systems biology, crop physiology, plant breeding and adaptive management

- Extrapolate QTL information from one environment to new environments
- Improve phenotyping strategies
- Dissect a complex trait into simpler component traits
- Integrate biological understanding into cropping systems responses
- Assist in adaptive management



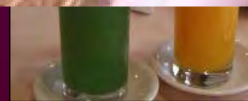
Example 2

Functional-structural plant modelling – the new frontier linking form and function



- Functional-structural modelling investigates plant / crop / environment interactions in space and time
- includes the modelling of the 3D structure of plants, competition for resources (light, water and nutrients), including interactions with soil organisms (e.g. quality of coffee grown under shade trees)

Example: Coffee production systems in Ethiopia



From: www.mesob.ch/gallery/gallery_main.htm

Most Ethiopian coffee is grown on small farms or private gardens …

… but there is a trend towards open sun plantations.

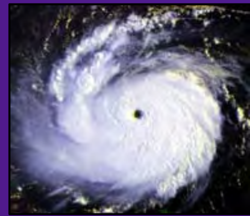
Which system to choose?

Multi purpose ‘garden’ systems:

- risk management through diversification
- improved quality
- price premium possible: ‘organic’ shade grown coffee; bonus for maintaining biodiversity

Open sun plantation:

- higher yields
- requires high inputs and skilled management
- high risk of failure if these are not provided



FSPM : functional-structural feedbacks

sun, light filtering of upper storey

coffee tree architecture

light environment

Coffee: fruit growth, branching

Impact on companion crops and shade trees

Virtual Plant Network
WAGENINGEN UR

Climate change and potato






Increased CO_2, increased temperature, change in precipitation patterns and more extreme weather will result in:

More yield at higher latitudes (50-60 °N)

Less yield at lower latitudes

More effects of climate change

Poorer quality (lower dm%, more physiological disorders)

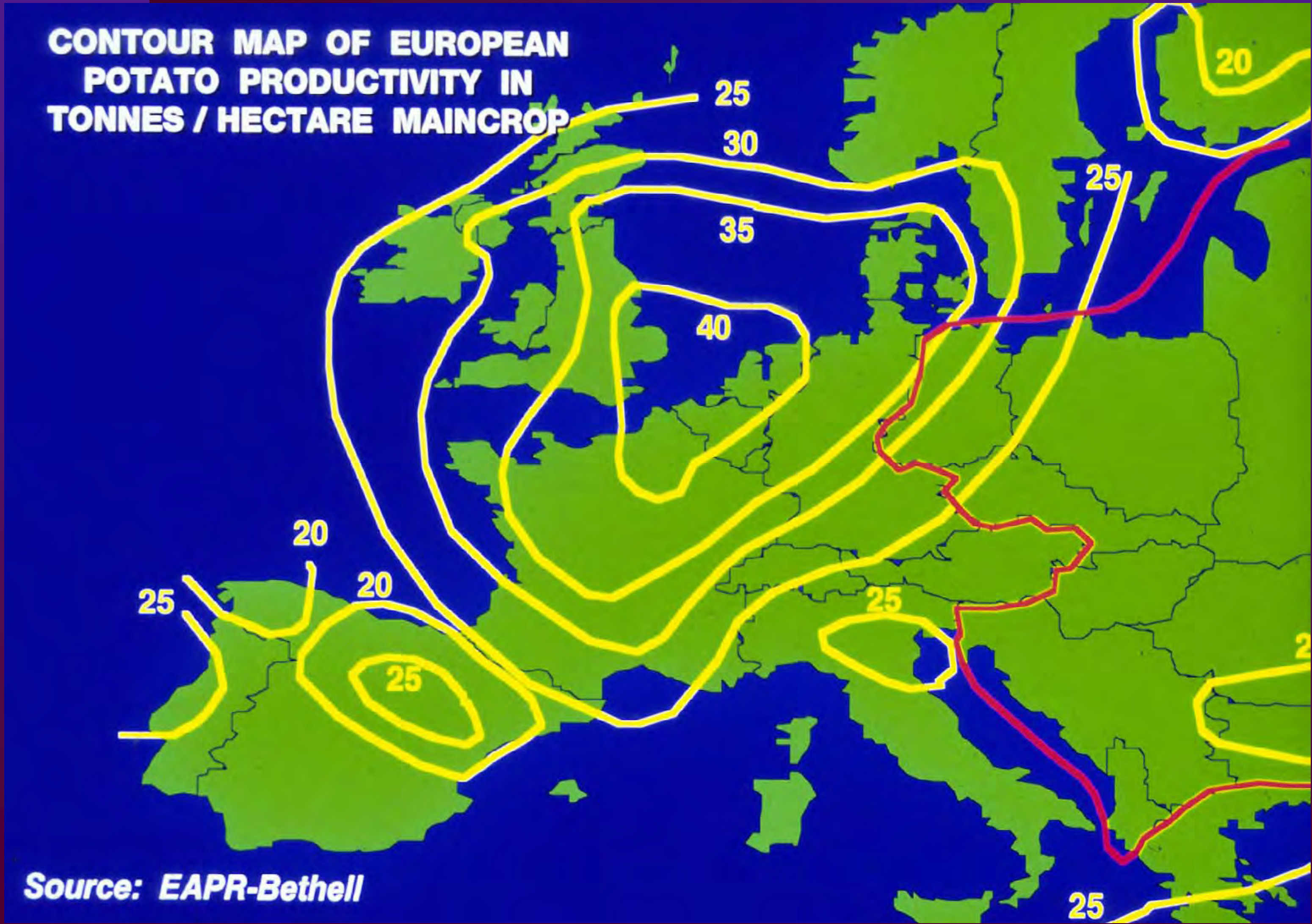
More disease pressure (earlier infection with LB, more brown rot, etc.)

More pest pressure (more cycles of nematodes per year, expansion of Colorado beetle, etc.)

More vector pressure (aphids, cicadas)

Many of these changes will happen during our life time!

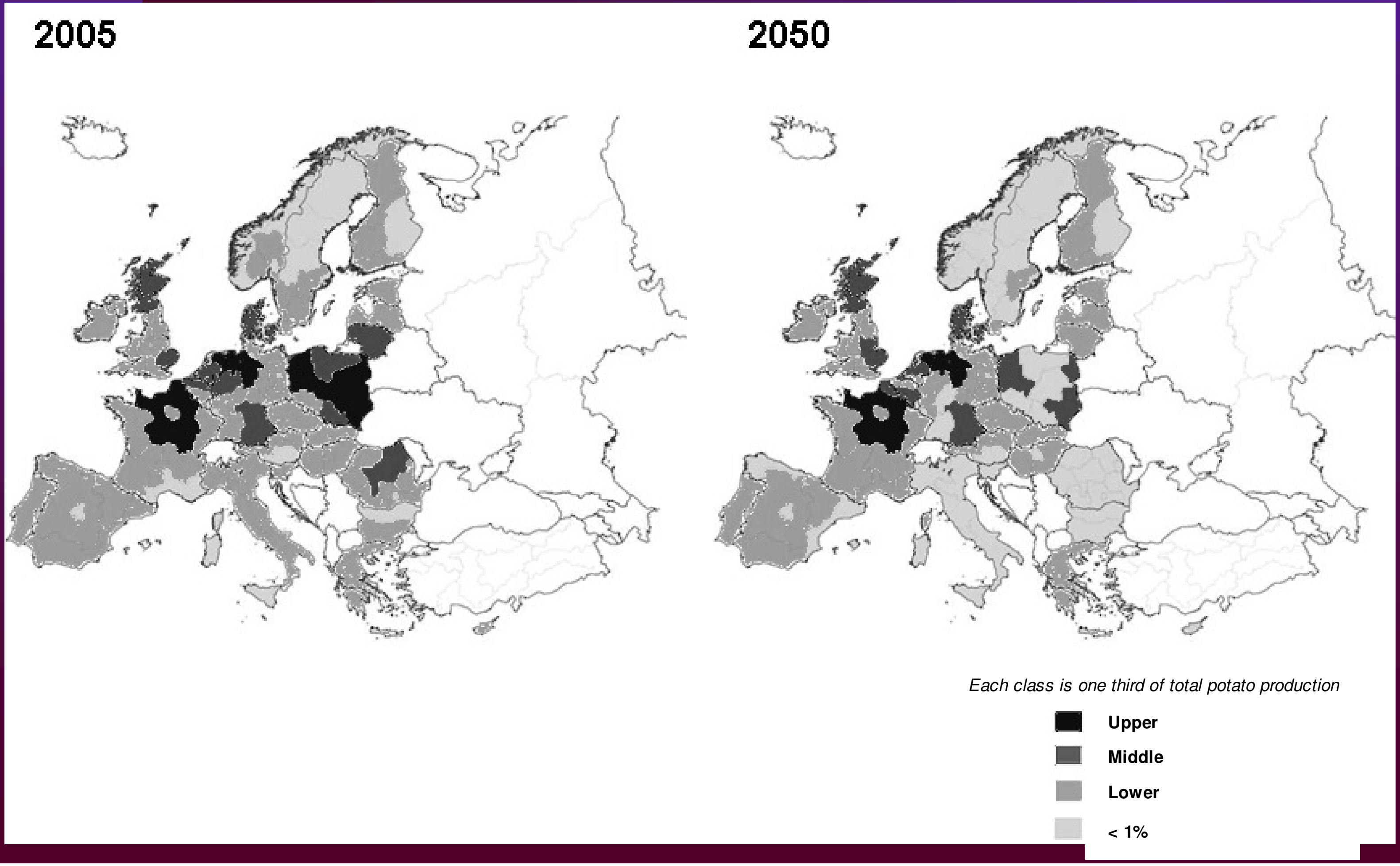
Example 3:
Climate change: Potato productivity



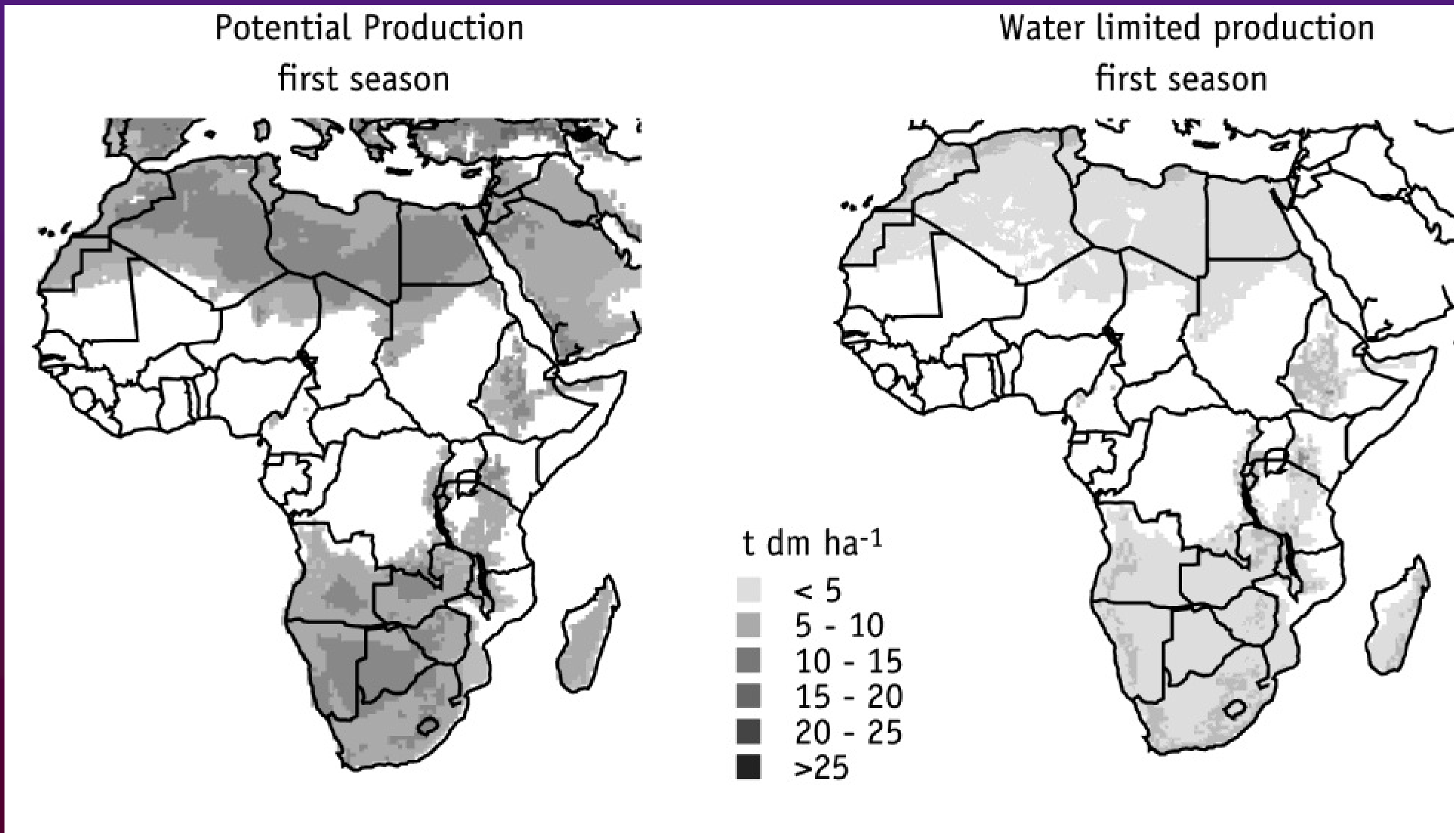


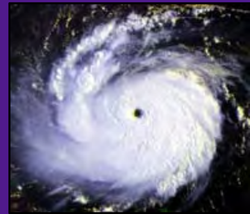



Potato production areas given market globalization and climate change

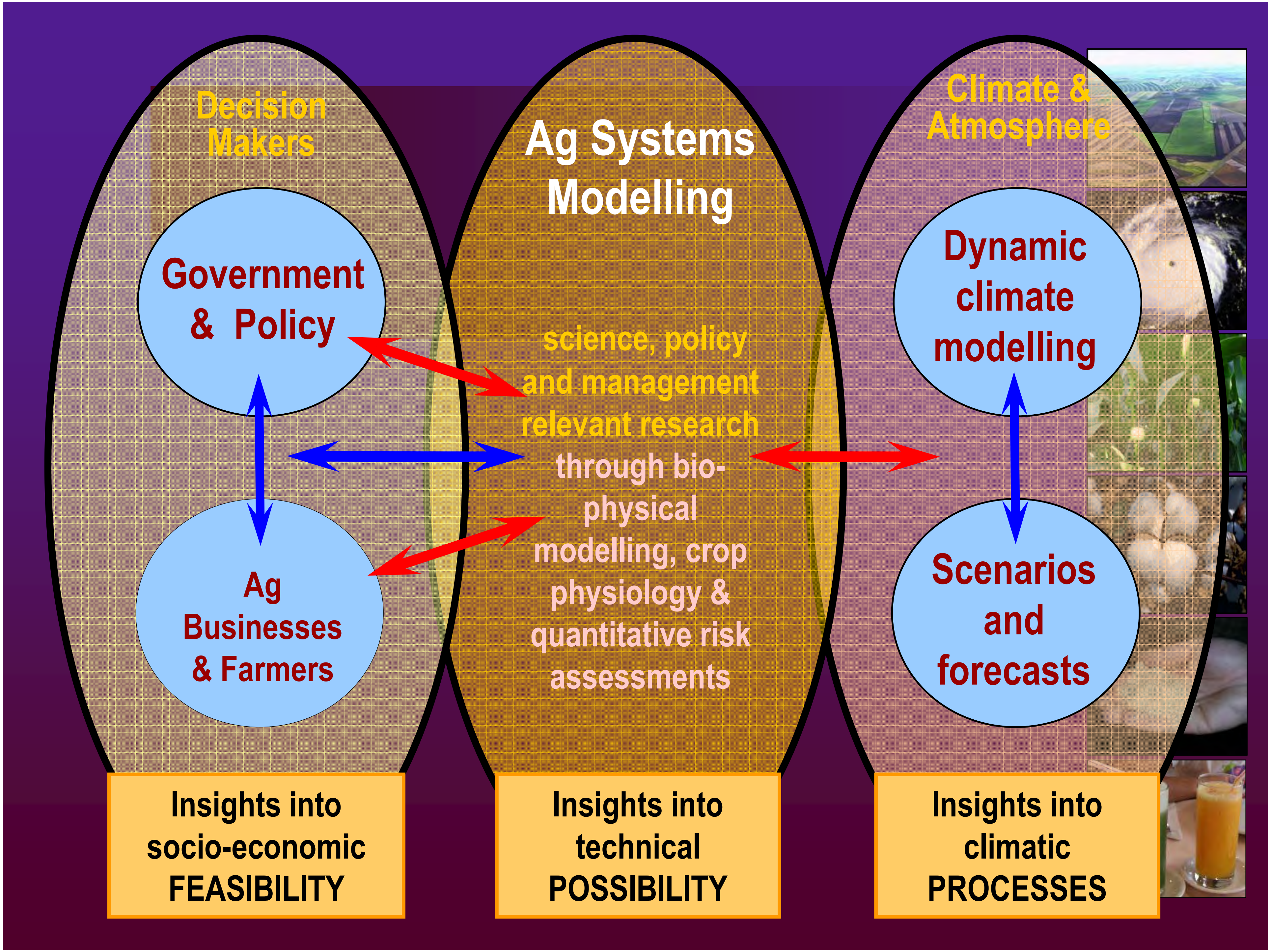


Calculated potential (left) and water limited yields (right) for Africa (Haverkort et al., 2004)






Decision Makers
Government & Policy
Ag Businesses & Farmers
Ag Systems Modelling
science, policy and management relevant research through bio-physical modelling, crop physiology & quantitative risk assessments
Climate & Atmosphere
Dynamic climate modelling
Scenarios and forecasts
Insights into socio-economic FEASIBILITY
Insights into technical POSSIBILITY
Insights into climatic PROCESSES

Guiding principles for good systems modelling

Salience

Provide information that people need

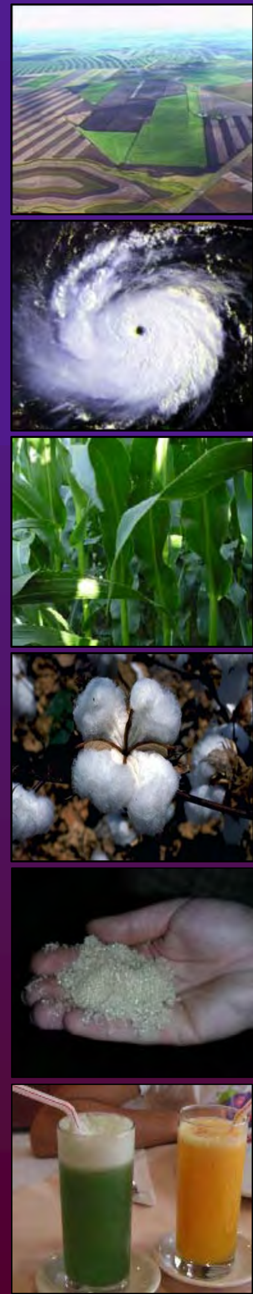
Credibility

Tell people what we know AND what we don't know

Legitimacy

Avoid advocacy, be transparent and fair

Meinke et al., 2006, Climate Res. 33: 101–110



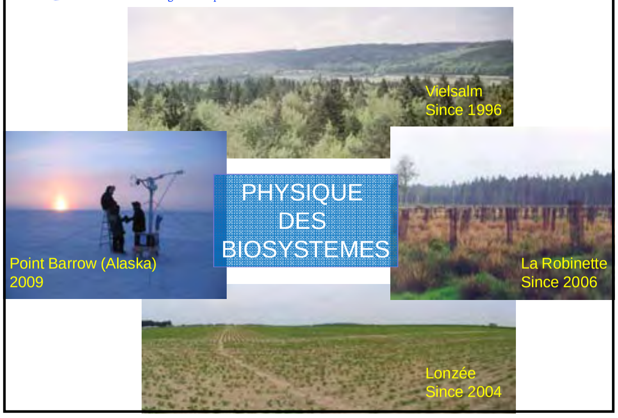

Thank you for your attention!
Flávio Gassen

gembloux
faculté universitaire
des sciences agronomiques

Carbon balance of a pluri-annual cropping system (4-year rotation) : impact of climate and cropping management

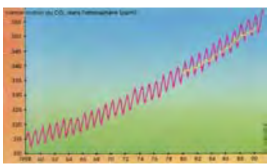
M. Aubinet, B. Bodson, C. Moureaux,
D.Dufranne, F. Vancutsem,

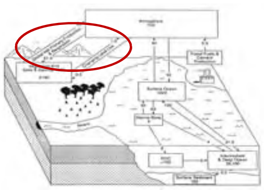
gembloux
faculté universitaire
des sciences agronomiques



gembloux
faculté universitaire
des sciences agronomiques

State of the art, 1995





Keeling et al. (1990):
3.2 GT C / yr

Schimel et al. (1995) :
4.6 GT C / yr

Necessity of better quantifying and understanding
Exchanges between biosphere and atmosphere

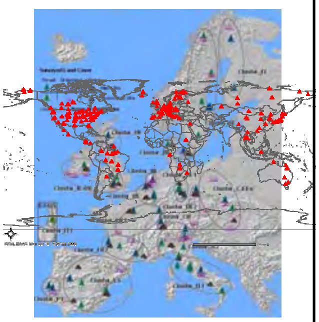
gembloux
faculté universitaire
des sciences agronomiques

Eddy covariance method

- CO_2, H_2O, sensible heat, momentum
- Long term (> 10 years)
- Half hour frequency
- Ecosystem scale

Eddy covariance networks

- Euroflux (16 sites 1996)
  - ➔ Carboeuroflux (2000)
  - ➔ CarboEurope(2004)
- Fluxnet (over 400 sites)

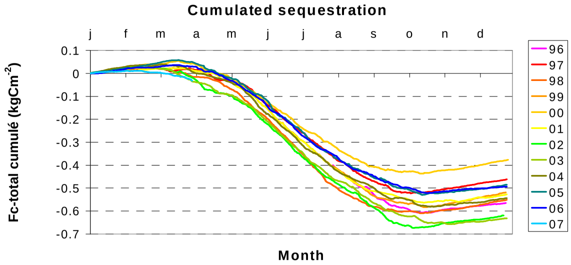


Objectives

- How much ?
  - To quantify the European carbon sink strength
  - To evaluate its uncertainty
- How could it change ?
  - How will it evolve under changing climate ?
  - What are the mechanisms controlling the fluxes ?
- What can we do ?
  - To quantify the effect of management on fluxes

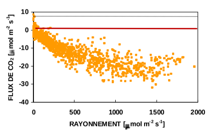
How much carbon is sequestrated ? How does it vary from year to year ?

Vielsalm 1996 - 2007



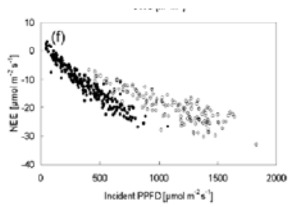
(Heinesch, pers. comm.)

What are the flux responses to climate factors ?



Day NEE response to light

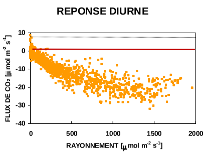
- Depends on :
  - Light regime



Lonzée

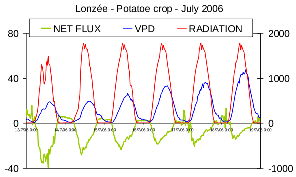
Moureaux et al., 2006

What are the flux responses to climate factors ?



Day NEE response to light

- Depends on :
  - Light regime
  - Species
- Modulated by VPD



Lonzée

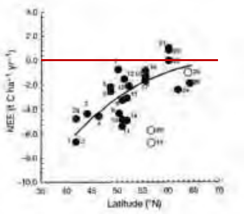
Hoyaux, Dufranne, comm. pers.

gembloux faculté universitaire des sciences agronomiques

gembloux faculté universitaire des sciences agronomiques

Can we extrapolate fluxes at the European scale ?

First NEE assessment at regional scale based on first Euroflux data (1997)



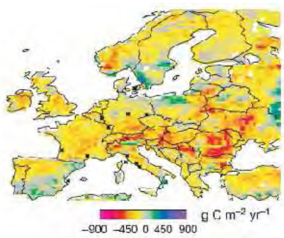
Valentini et al., Nature, 2000

gembloux faculté universitaire des sciences agronomiques

What is the impact on fluxes of extreme events ?

Impact of 2003 Heat wave based on CarboEurope data.

Granier et al., 2007

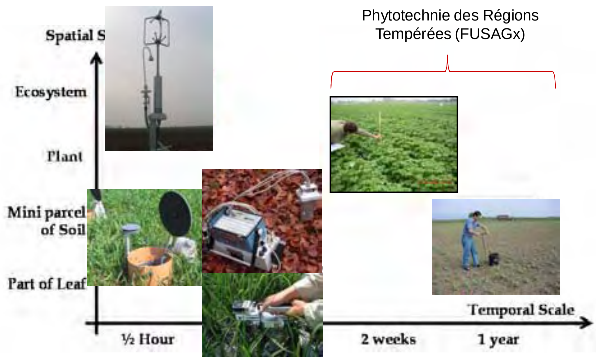


Ciais et al., 2005

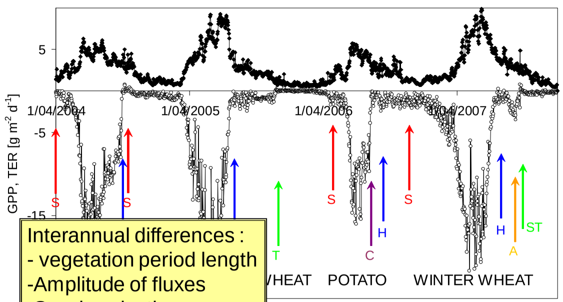
The Lonzée site

- Site
  - Crop cultivated for more than 70 years
  - Since April 1st, 2004
  - 4 year rotation
  - Area = 12 ha
  - Flat and homogeneous
- Meteo
  - T_{moy} = 10°C – P_{annual} = 800 mm

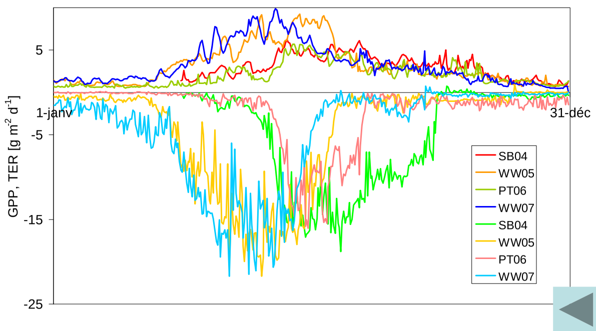
Measurements



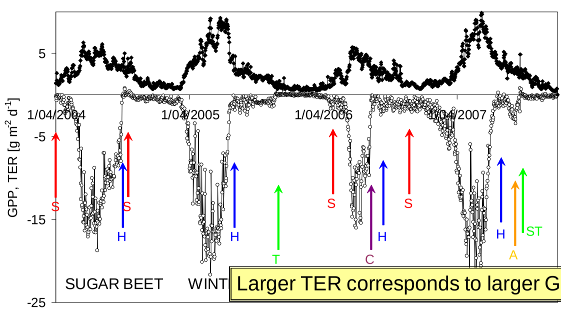
Results – TER and GPP



Interannual differences :
- vegetation period length
-Amplitude of fluxes
-Synchronisation

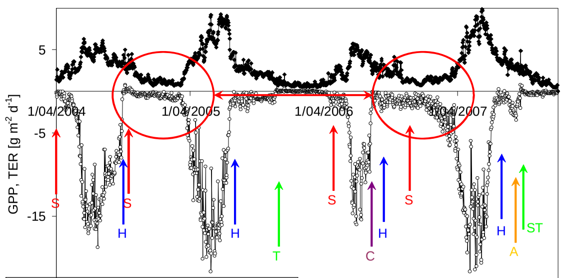


Results – TER and GPP



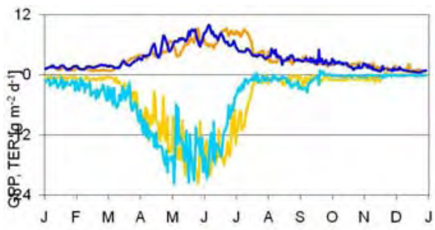
Larger TER corresponds to larger GPP

Results – TER and GPP



Interannual differences due to Climate

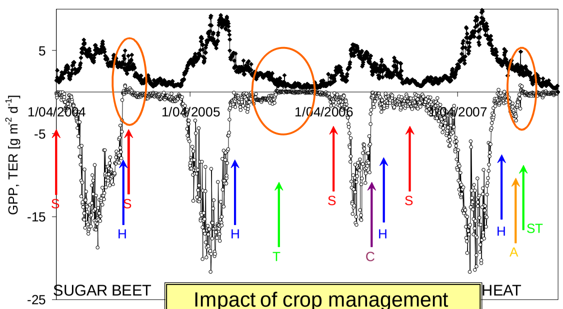
Results – Interannual variability



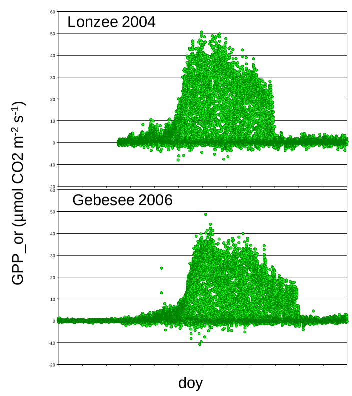
Dufranne et al, submitted

2007 :
- Earlier development stages
- Larger GPP
- Lower NPP and harvest

Results – TER and GPP



Impact of crop management (ploughing, tillage, crop residues)



Courtesy of W. Kutsch

Rotation carbon budget (in kg Cm^{-2})

	SB - 2004	WW- 2005	P - 2006	WW-2007	IC	Total
Export	Roots : 0.63	Grain : 0.37 Straw : 0.19	Tuber : 0.29	Grain : 0.31 Straw : 0.14		1.93
Import			Mother T: -0.04		Slimes : -0.07	-0.12
NEE	-0.80	-0.63	-0.31	-0.73	0.88	-1.59
NBP	-0.17	-0.07	-0.06	-0.28	0.81	0.22

In the whole, the crop behave as a carbon sink (400 gC m^{-2} yr^{-1}) over 4 years

If exportations are considered as immediately re-emitted, it behaves as a source (55 gC m^{-2} yr^{-1})

Rotation carbon budget (in kg Cm^{-2})

	SB - 2004	WW- 2005	P - 2006	WW-2007	IC	Total
Export	Roots : 0.63	Grain :	Tuber :	Grain :		
Import						
NEE	-0.80	-0.63	-0.31	-0.73	0.88	-1.59
NBP	-0.17	-0.07	-0.06	-0.07	0.81	0.43

The result is much influenced by year 2007: If 2007 had been a « normal » year, the source would have been larger (100 gC m^{-2} yr^{-1})

In the whole, the crop behave as a carbon sink (400 gC m^{-2} yr^{-1}) over 4 years

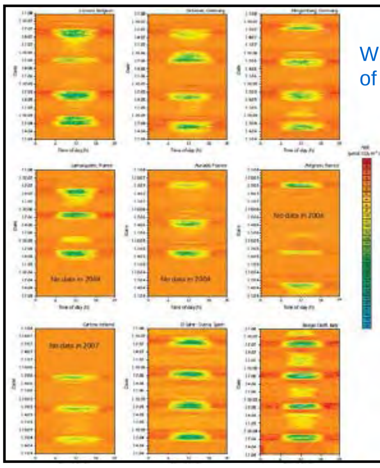
If exportations are considered as immediately re-emitted, it behaves as a source (55 gC m^{-2} yr^{-1})

Uncertainties on carbon budget (in kg Cm^{-2})

Uncertainties are of the same order of magnitude as the budget but the budget is always « on the source side ».

Uncertainties due to crop sampling are of the same order of magnitude than those due to eddy covariance

	0.63	0.37 Straw : 0.19	0.29	0.31 Straw : 0.14		
Import			Mother T: -0.04		Slimes : -0.04	1.93
NEE	-0.80	-0.63	-0.31	-0.73	0.88	-1.59
NBP	-0.17 (0.09)	-0.07 (0.06)	-0.11 (0.04)	-0.28 (0.06)	0.79 (0.03)	0.22 (0.14)



What is the representativity of these measurements ?

Net flux
Four years at nine European sites

Kutsch et al. (in prep.)

Conclusions (about Eddy covariance technique)

- Eddy covariance is a useful tool to quantify net fluxes exchanged at ecosystem scale.
- Allows evaluating :
  - carbon sequestration at ecosystem scale
  - Flux response to climate
  - Interannual variability
  - Impact of extreme events

Conclusions (about crop fluxes)

- Crops behave as a sink of comparable intensity as forest, (but the carbon is rapidly re-emitted).
- Large interannual variability, (mainly) due to crop differences.
- Some impacts of management on NEE can be identified.
- The carbon content decreases of about 60 gC m^{-2} yr^{-1} (1.5 % of soil carbon content).
- Climate conditions in 2007 moderated the source intensity.

Perspectives

- Impact of crop management on GHG budget :
  - Deep ploughing vs surface tillage
  - Straw exportation (2nd generation biofuels)
  - Fertilisation
- Using models to better understand mechanisms, i.e., soil respiration
  - Mechanistic model – daily time scale
  - Calibrated/ validated on experimental data
- Study fluxes of other greenhouse gases
  - N_2O, CH_4

Climate change :

Impact on crop pests

Michel De Proft

Centre wallon de Recherches agronomiques

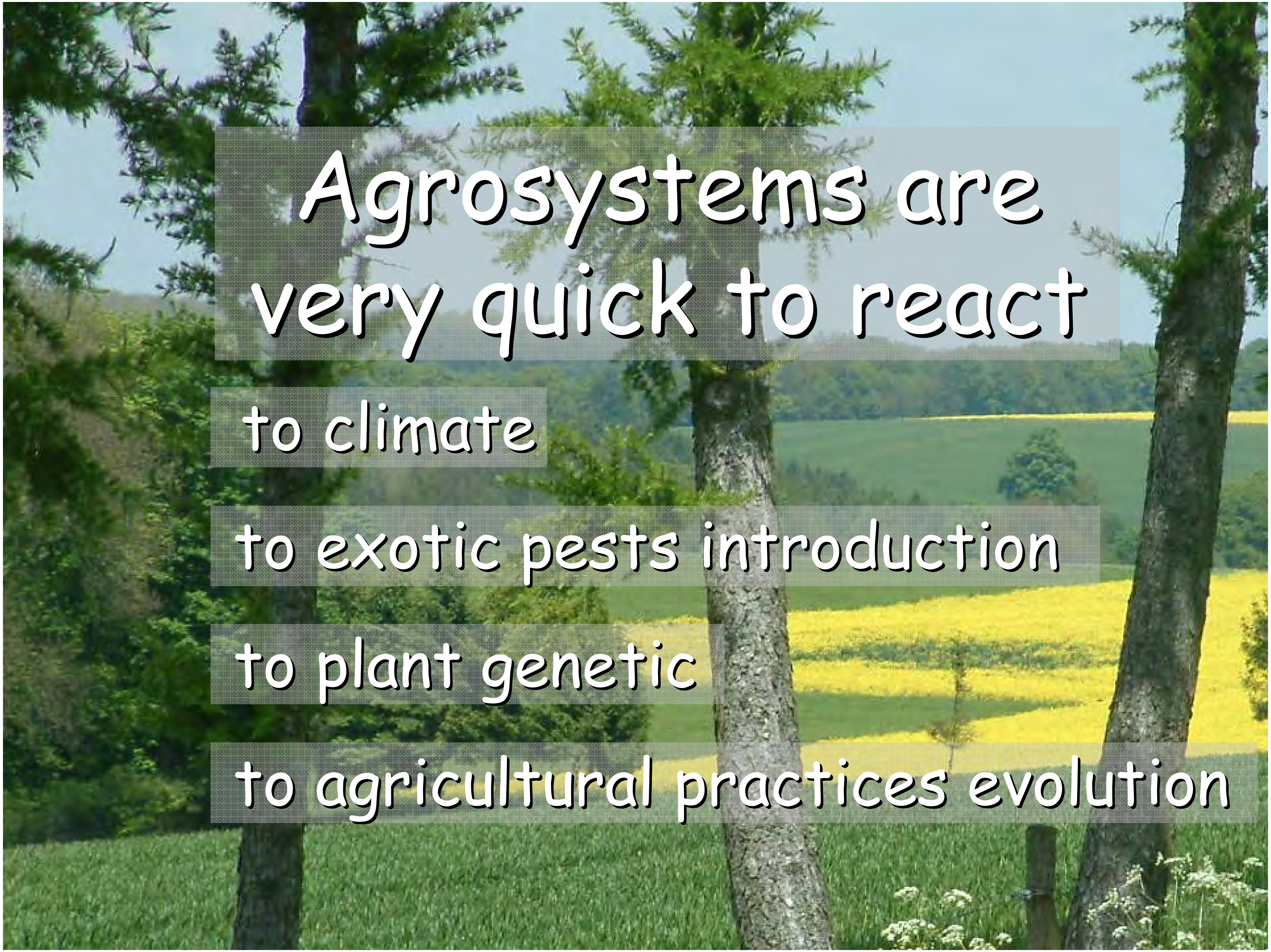
Gembloux

Gembloux, 03/04/2009

Centre wallon de Recherches agronomiques

CRA-W Gembloux

RÉGION WALLONNE


Agrosystems are very quick to react
to climate
to exotic pests introduction
to plant genetic
to agricultural practices evolution

Mean temperature increase (globe)

- ➔ Especially in northern hemisphere
- ➔ Especially near the poles
- ➔ Move of isotherms

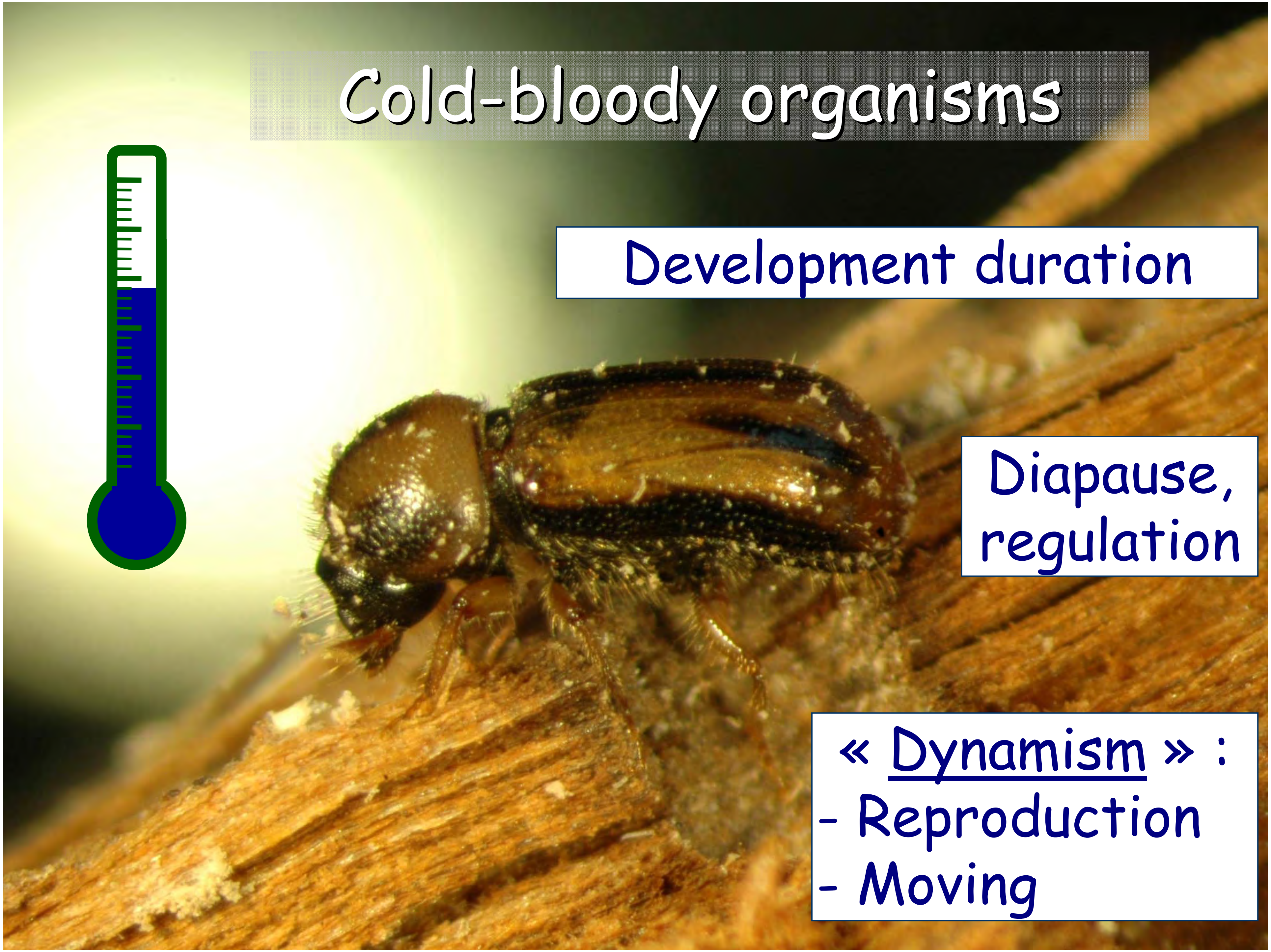
More water in the atmosphere (globe)

- ➔ More precipitations (globe)

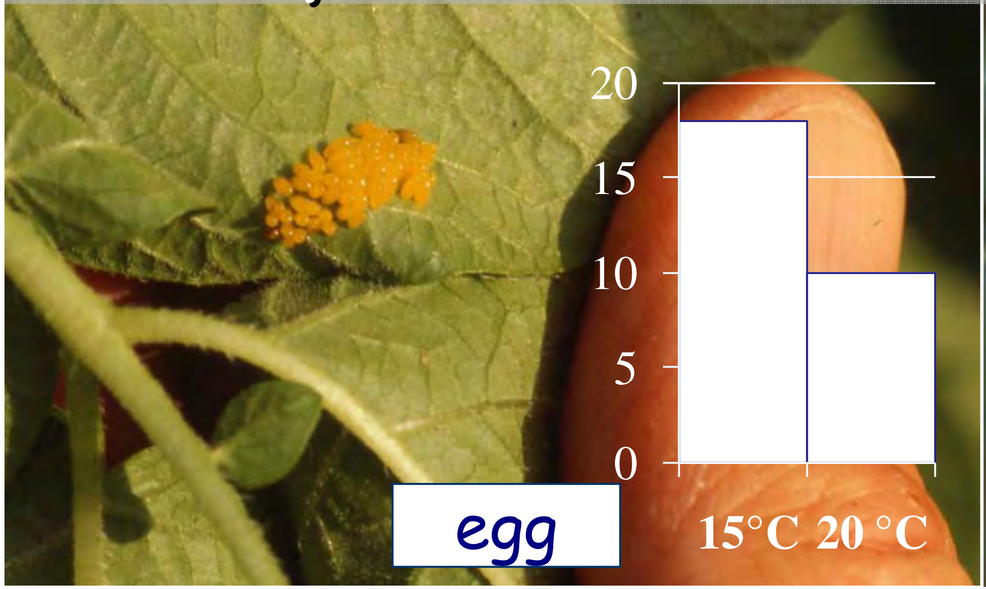
Increased frequency of extreme events

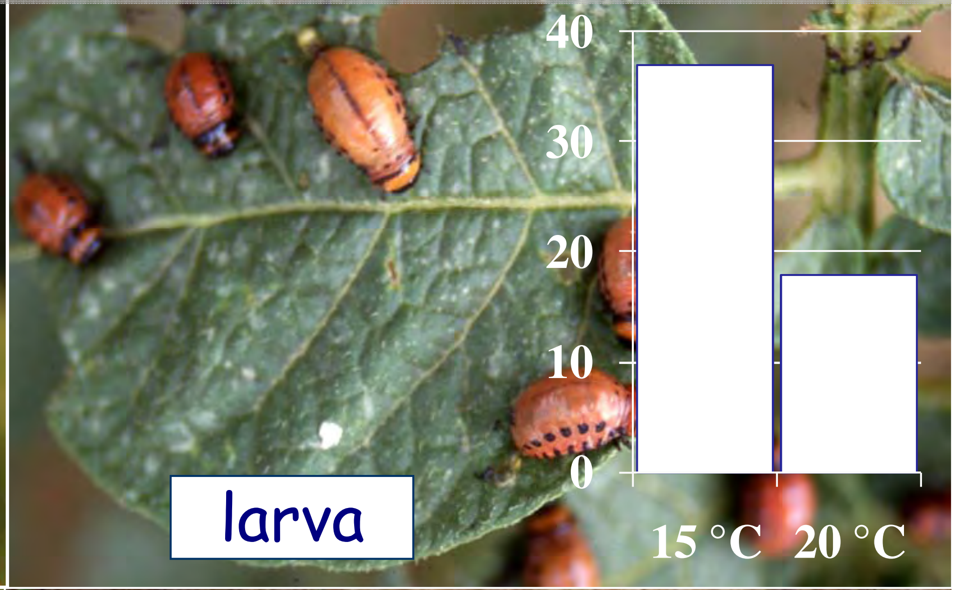
- ➔ Storms, droughts, heat waves

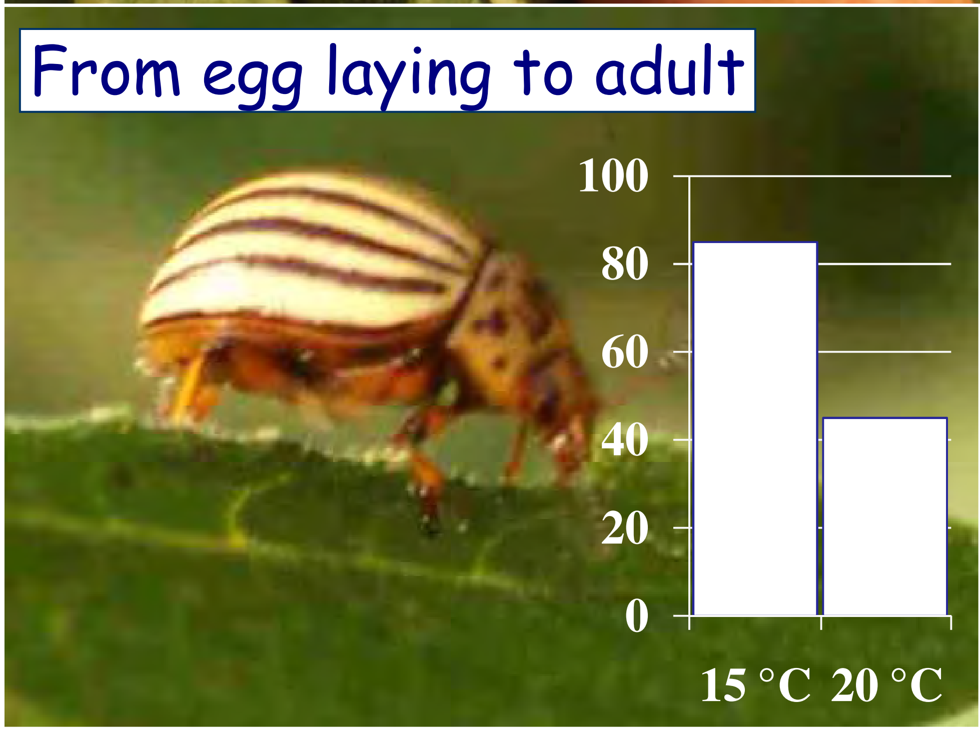

Less cold winters
Wetter summers

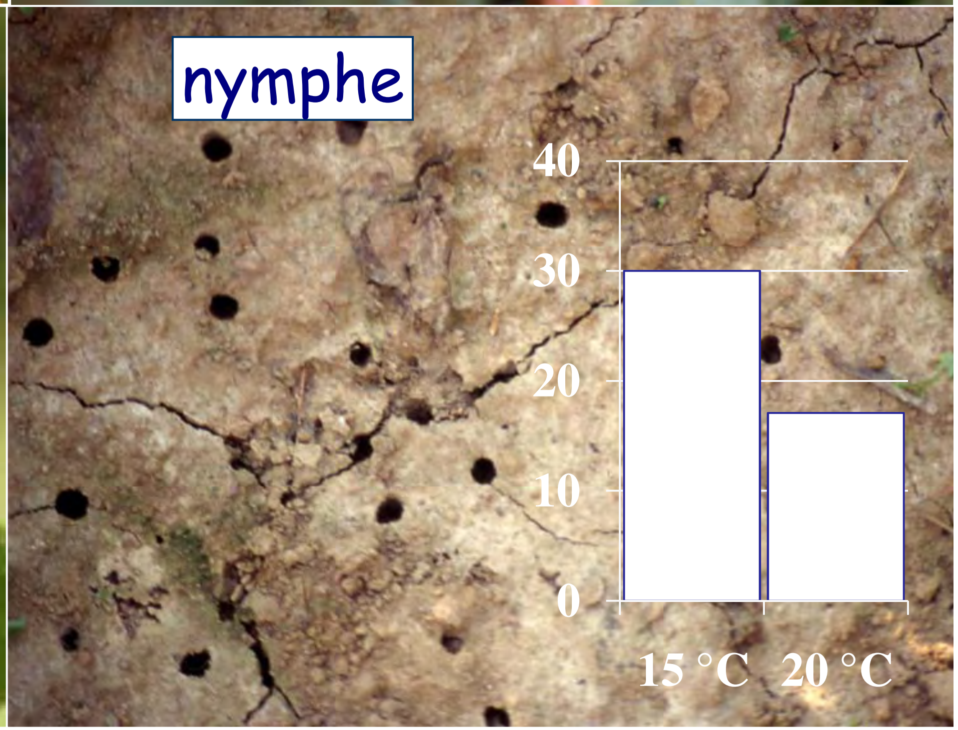

Cold-bloody organisms
Development duration
Diapause, regulation
« Dynamism » :
- Reproduction
- Moving

Development of the colorado beetle









Accelerated development

<u>Univoltin species</u> : less change

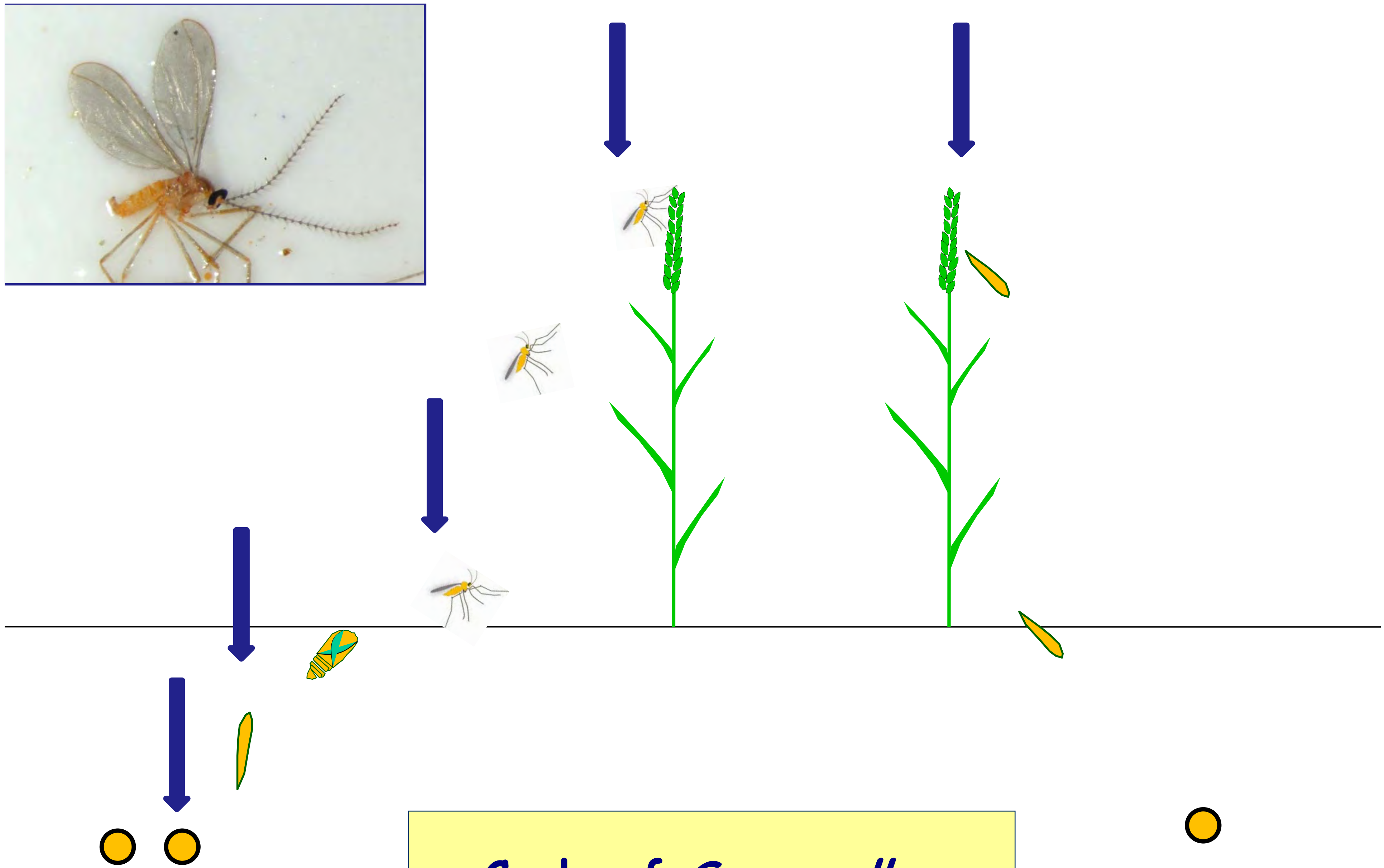
<u>Polyvoltins species</u> : more generations / year

- ➔ Populations inflation, Damage increase
- ➔ Damage periods staggering, generations' overlaps
- ➔ Increased risk of resistance to pesticides

Diapause, quiescency

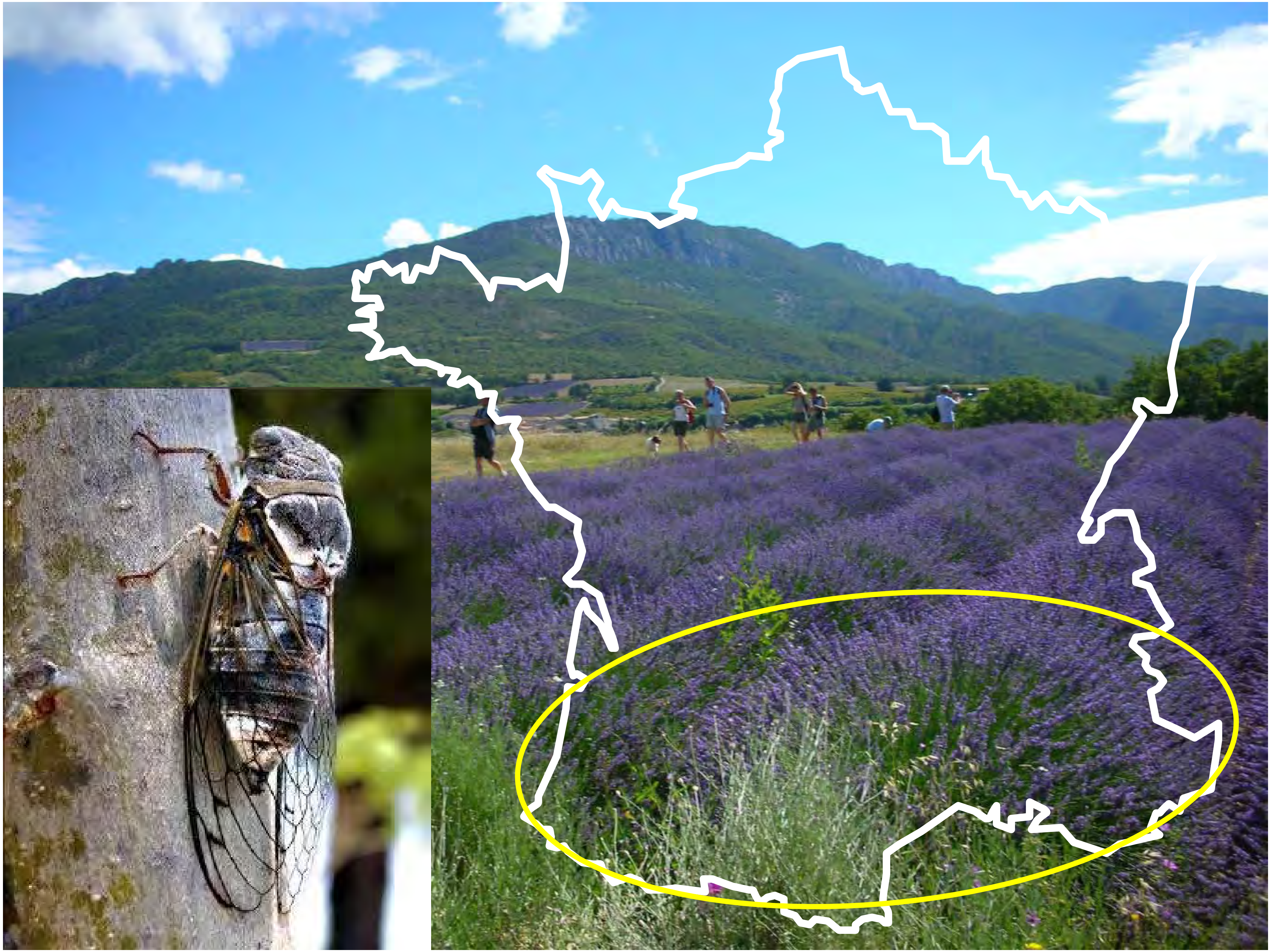
Physiological <u>blocking</u> of the development	Temporary <u>stopping</u> of the development
-Day length, -Cold need, - ...	- Lack of heat, - Lack of water, - ...


Wheat orange blossom midge
(Sitodiplosis mosellana)



Cycle of S. mosellana


The « north rush » ?



Moving towards north : permanent ou temporary ?

⇒ ***Reproduction conditions :***

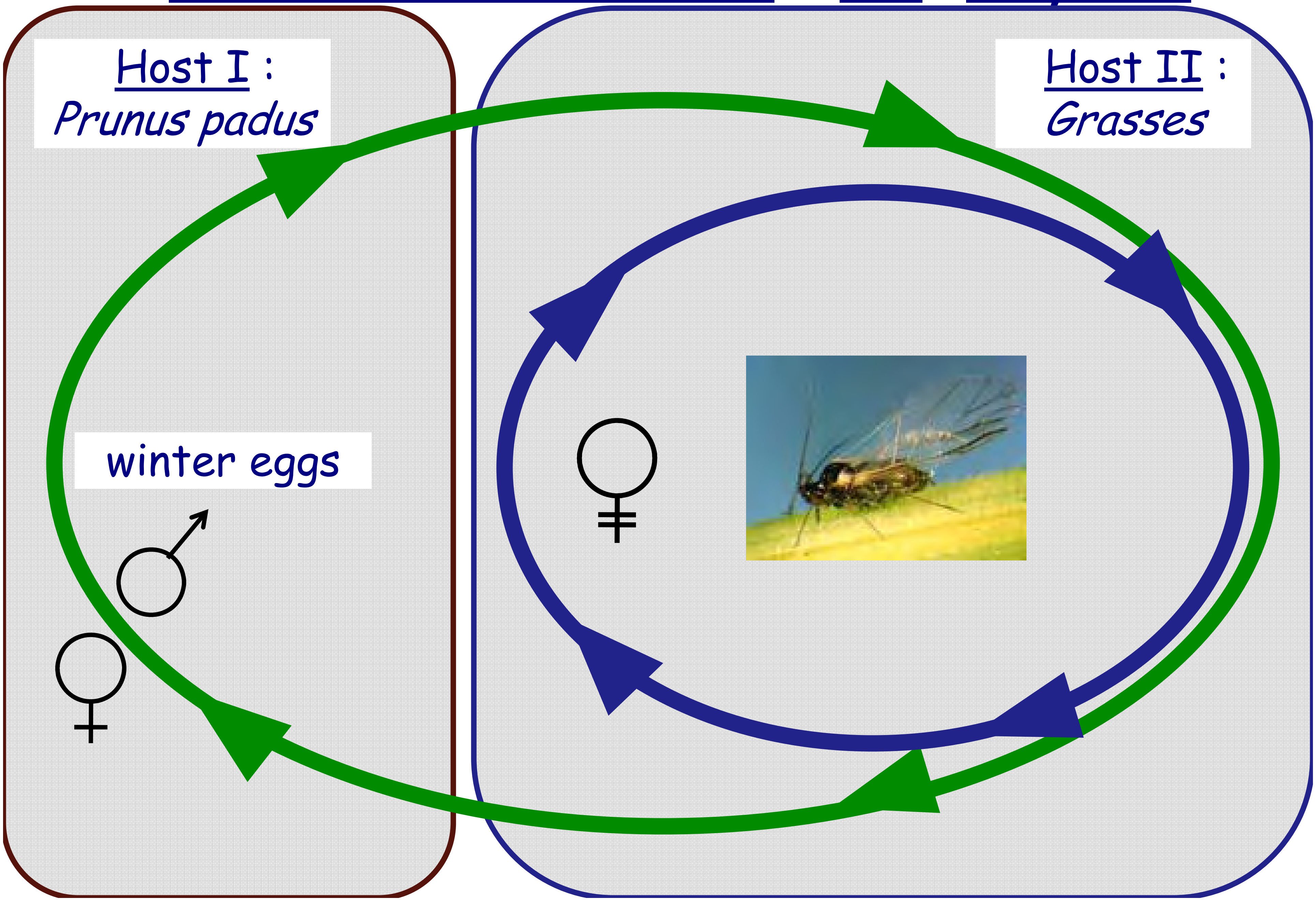
⇒ ***Extinction conditions :***

Varying distribution areas

Ex : spring beetle in sugar beet

Chaetocnema concinna

Survival to winter ex: *R. padi*



1999 & 2000:

Big lesions colonized by

Trypodendron domesticum
and
Trypodendron signatum

Two saprophageous species of fagaceae

The event :

• Appeared simultaneously in the belgian Ardenne and in the next regions of France, Germany and Luxembourg

- **Occured over > 320-350 m altitude**
- **Especially on the higher parts of slopes**
- **Concerns all classes of age**
- **Beech forests growing on rich soils as well as on poor soils.**

=> CLIMATE ACCIDENT

Spring 2001:

Attack of *Trypodendron*
On « healthy » trees

=> Surprising phenomenon

Phénomènes similaires:

attaques de scolytes saprophages sur arbres vivants

- **en Nouvelle Zeelande sur Notofagus**
- **en Colombie Britanique sur bouleau, érables, etc**
- **en Californie sur chêne**
- **Etc.**

Ips Typographus & Pityogenes chalcographus

Conclusions

=> Biovigilance

=> Early detection of emergent problems

=> Attention for secundary pests

=> « Eternal truthes » and models in question :
need of continuous validation **<u>in the field</u>**

Climate change: challenges, risks and impacts on cropping systems
April 3, 2009. Gembloux, Faculté universitaire des sciences agronomiques

Climate change, an imminent threat for trees

Laurent PFISTER & Jean-François HAUSMAN

Centre de Recherche Public – Gabriel Lippmann, Belvaux, Grand-Duchy of Luxembourg
Department Environment and Agro-biotechnologies
41, rue du Brill
L-4422 Belvaux
Grand-Duchy of Luxembourg

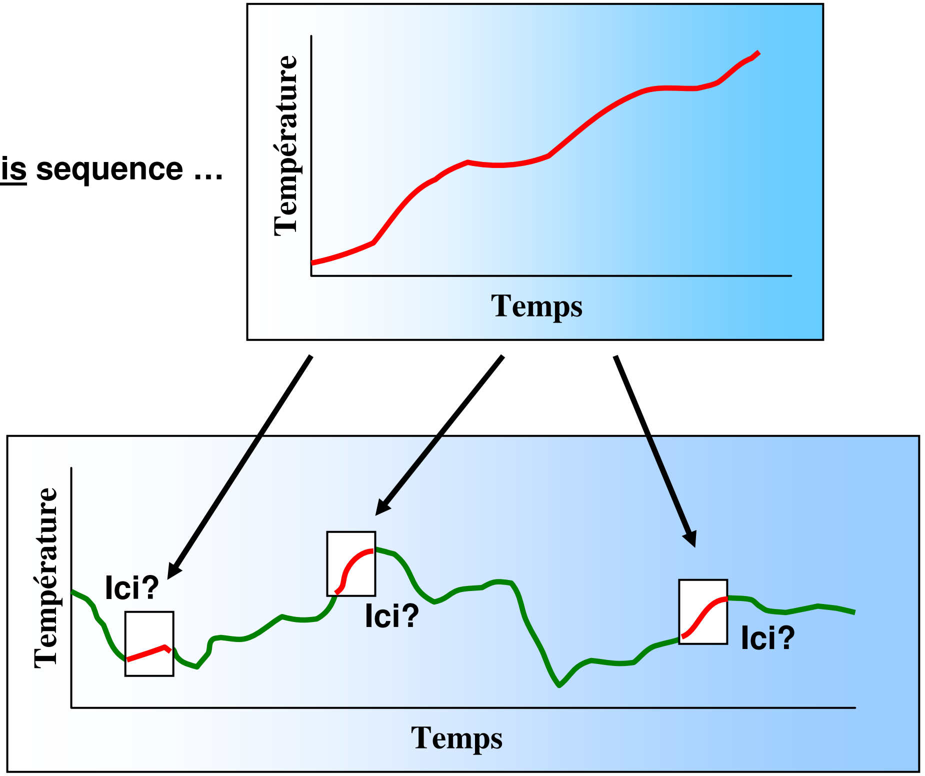
1. The natural variability of climate

- Climate variability or climate change ?

The fundamental question:

Where to locate this sequence …

… in this sequence ?



Source: http://science.nasa.gov/headlines/y2000/ast20oct_1.htm

2. 600 years of documented climate variability in Luxembourg

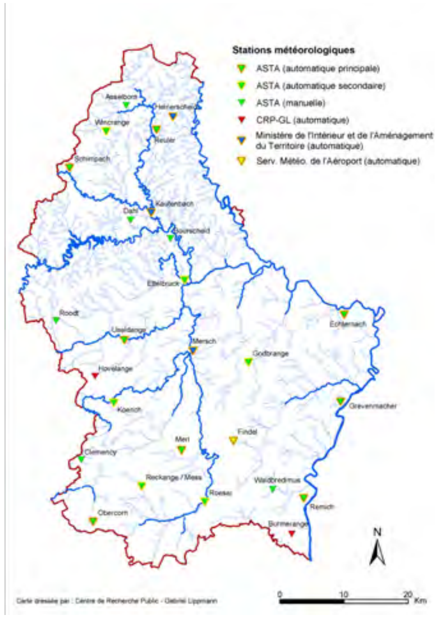
Available instrumental data sources:

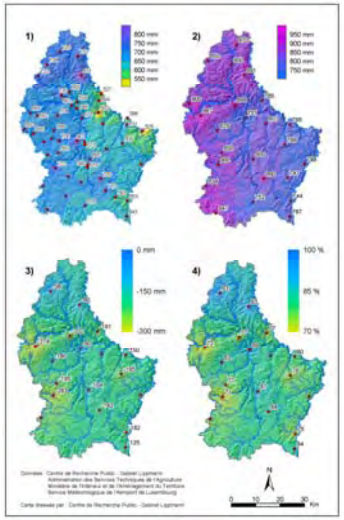
- **Temperature recordings (daily since 1838 – Luxembourg-city)**

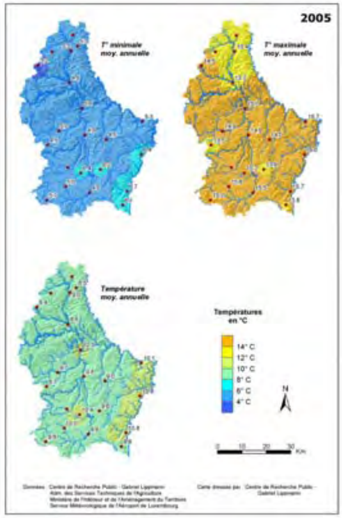
- **Precipitation measurements (daily since 1854 – Luxembourg-city)**

Available proxy data:

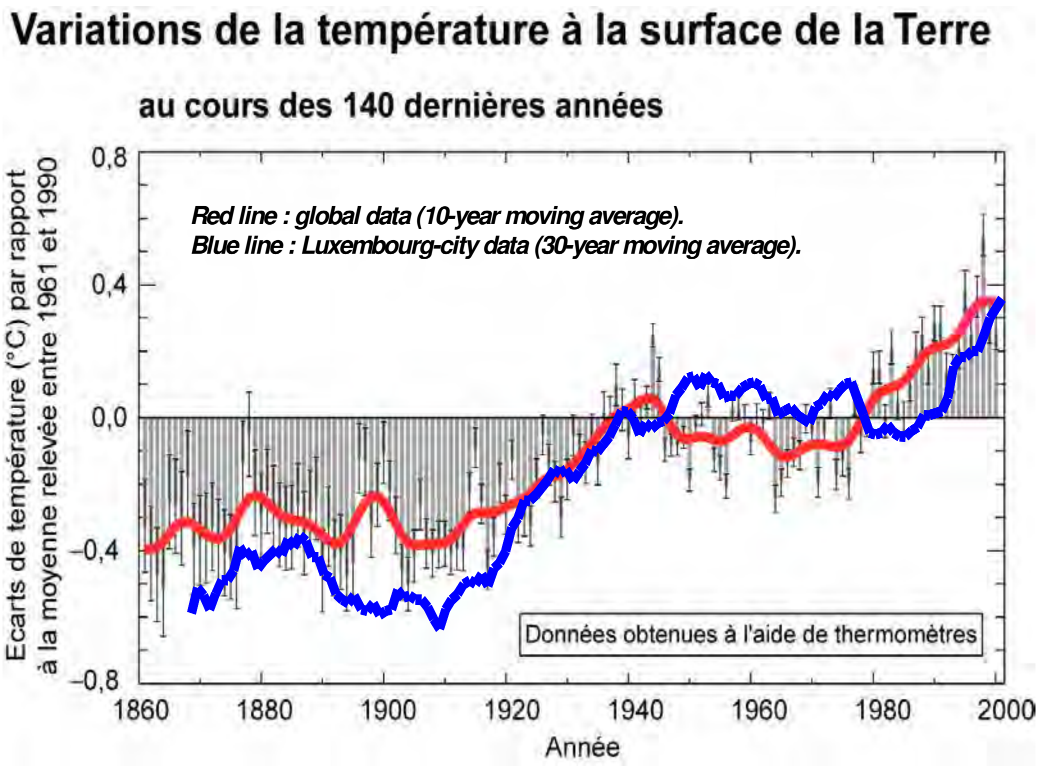
- **Wine quality and quantity data since +/- 9th century A.D.**





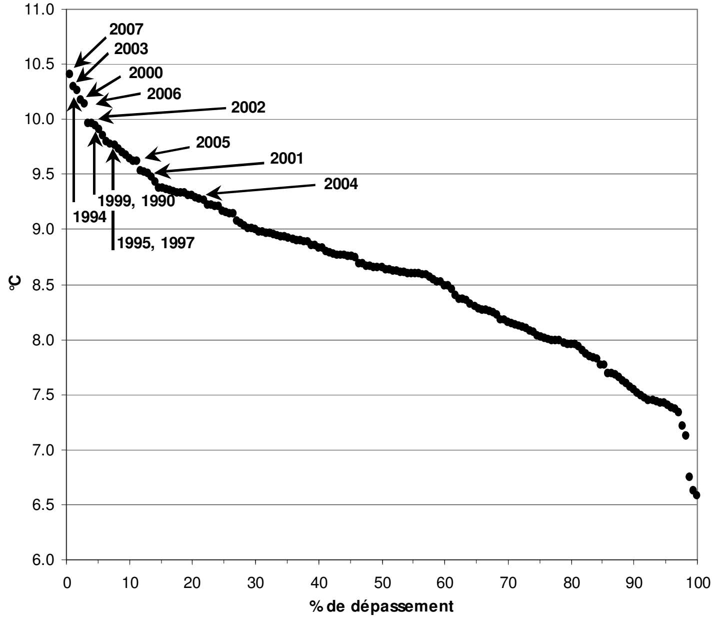


2. 600 years of documented climate variability in Luxembourg



IPCC (2001), Summary for Policymakers. In: Climate Change 2001: The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom. Updated with data from Luxembourg-city by the Public Research Center – Gabriel Lippmann, Belvaux, Grand-Duchy of Luxembourg.

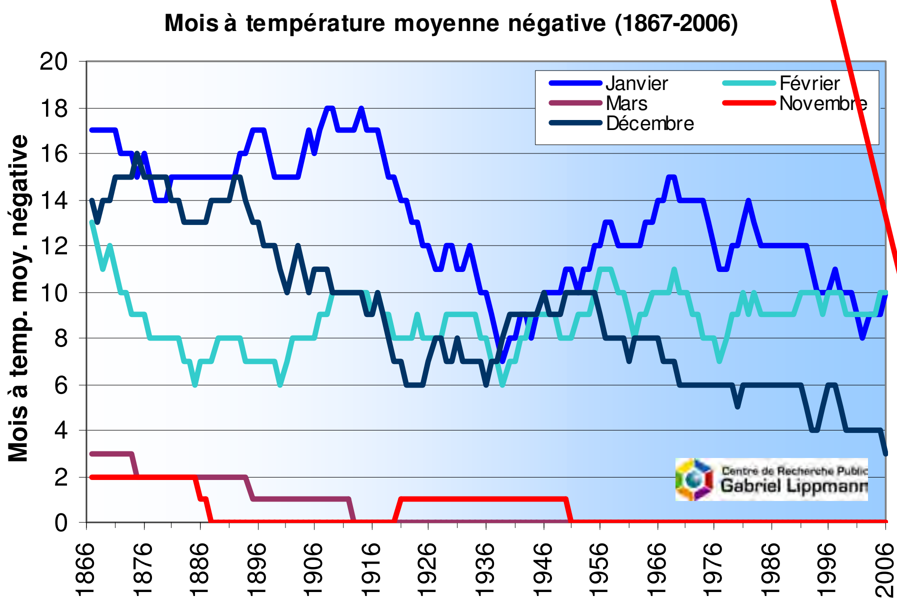
Substantial temperature increase (Luxembourg-city – 150 years)

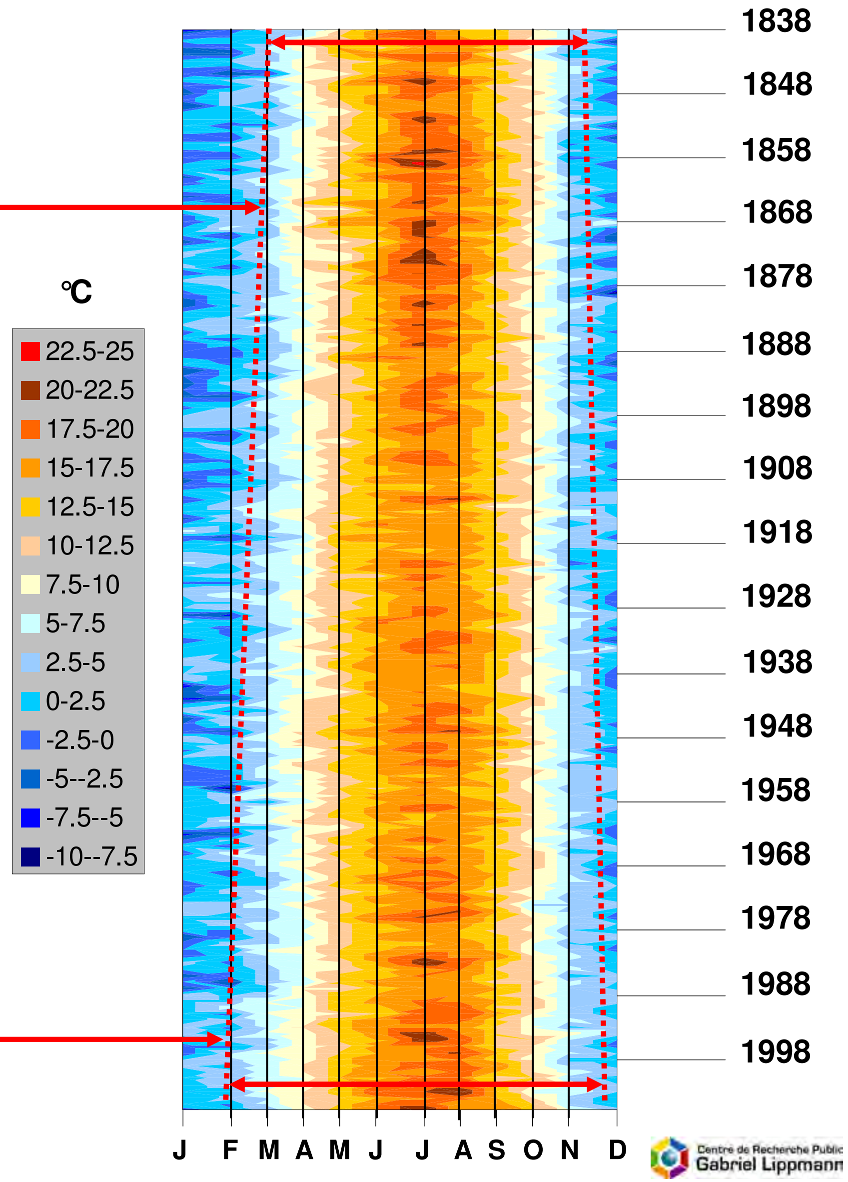


2. 600 years of documented climate variability in Luxembourg

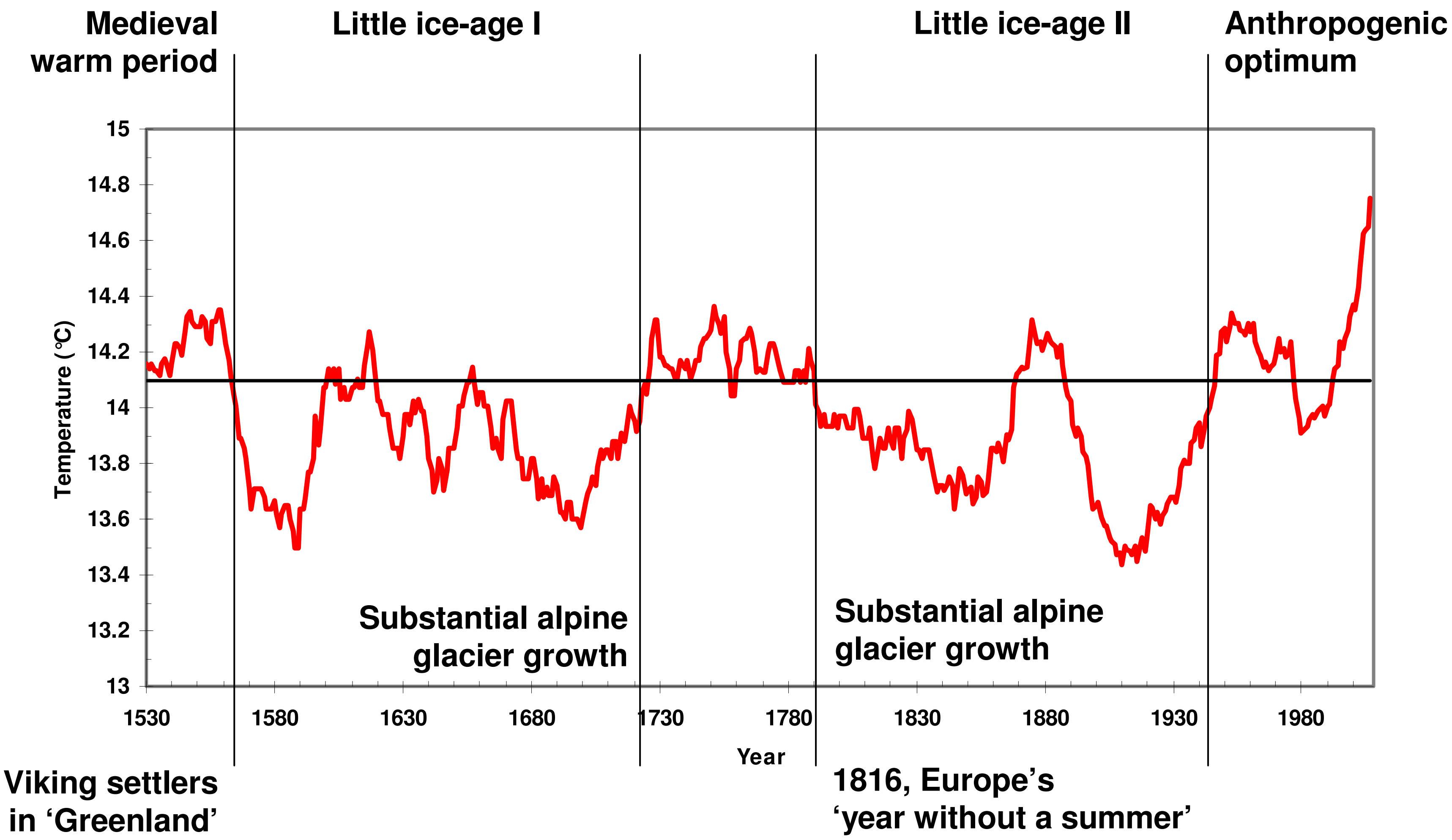
Mean monthly temperature from 1838 to 2006

Increase of winter temperatures





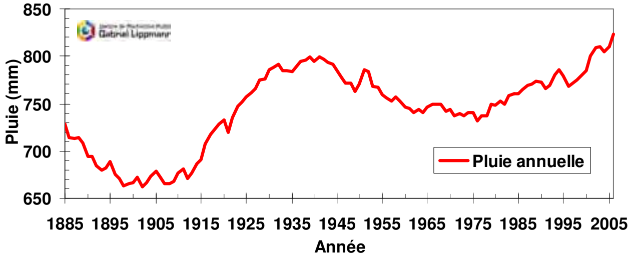
2. 600 years of documented climate variability in Luxembourg



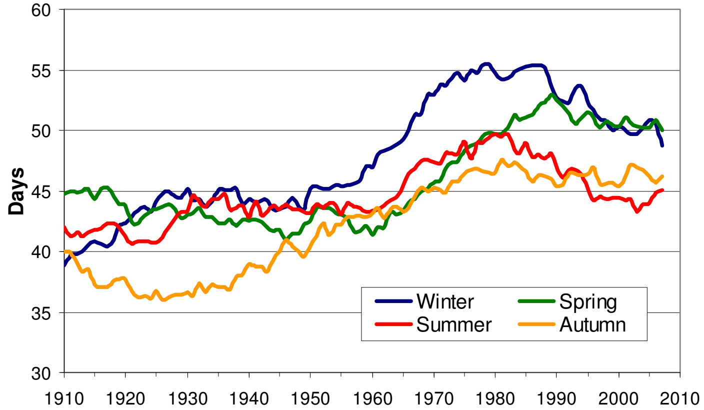
2. 600 years of documented climate variability in Luxembourg

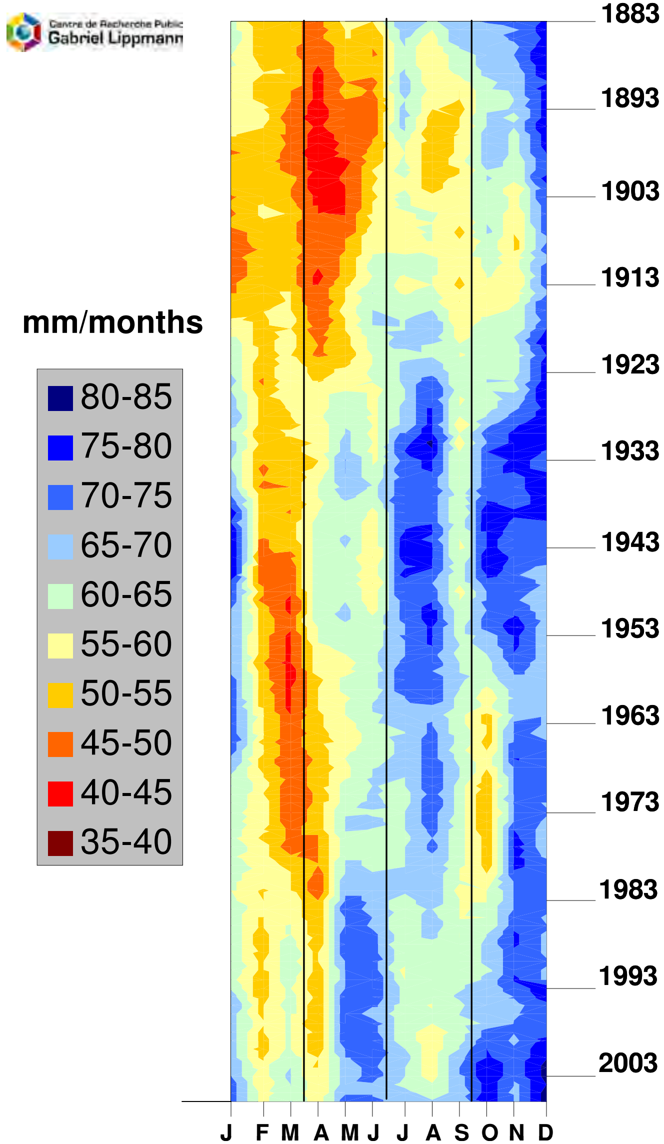
Mean monthly rainfall
from 1883 to 2006 (30-year moving average)

Redistribution of seasonal precipitation



Cyclonic atmospheric circulations (GWL), 1910-2008
30-year moving average

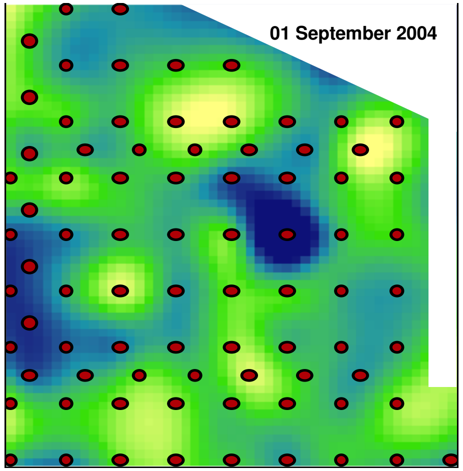




3. Rainfall interception by forest canopies & litter

Example of a beech forest in the Huewelerbach experimental site (L):

⇒ Major process in the hydrological cycle (up to 20-25% of total incoming rainfall)



Experimental plot

Huewelerbach

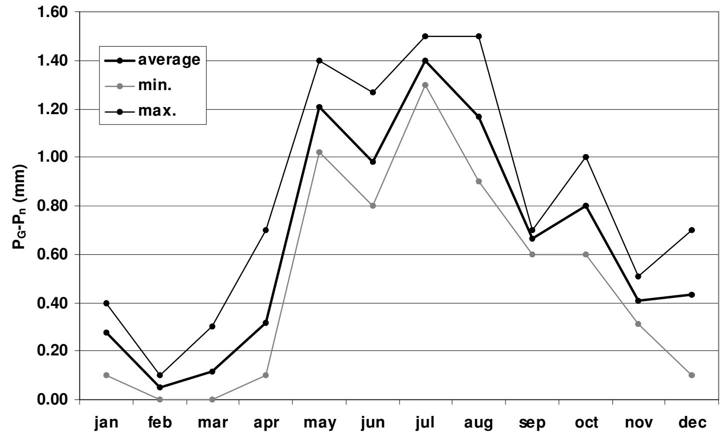
Beech stand

Throughfall

37 mm

15 mm

Rainfall (27/08 – 01/09) **= 27.6 mm**
Throughfall (27/08 – 01/09) **= 23.2 mm**
Interception = +/- 15%

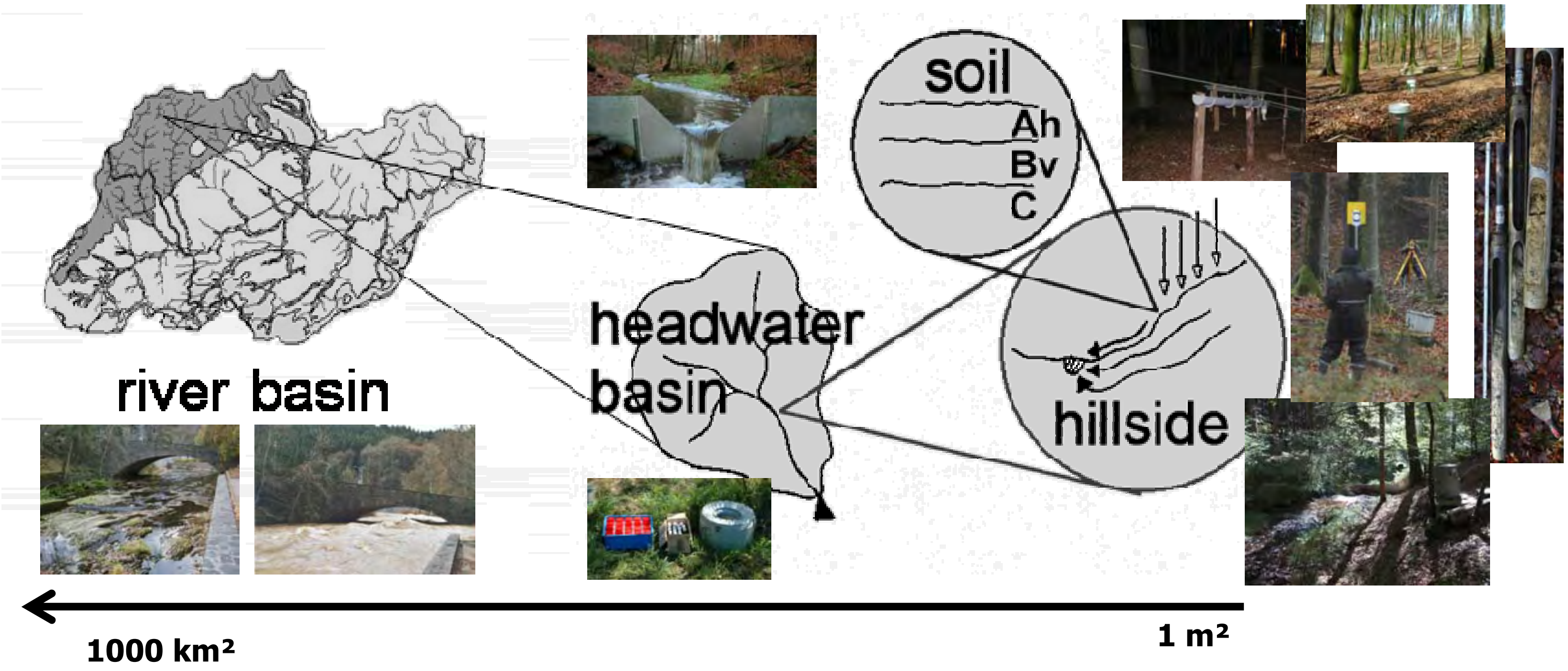


Spatial variability of throughfall, documenting preferential water input spots over forest soils.

Temporal variability of canopy storage capacity.

3. Rainfall interception and climate variability

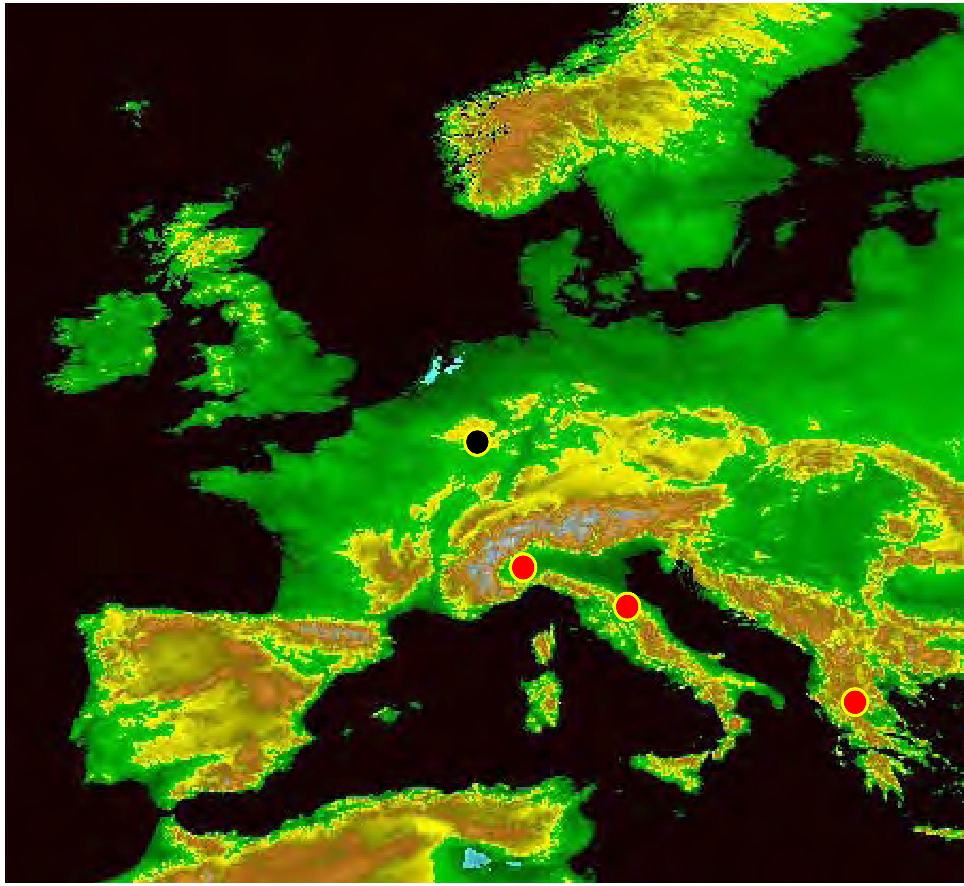
Climate, as an overarching factor, strongly influences the spatio-temporal distribution of the dominating runoff generation processes across scales.



Fluctuations/changes in climate conditions can ultimately lead to redistributions in forest species compositions and thus eventually on the water balance of our hydrosystems (subject to many feedback mechanisms).

4. Future climate conditions

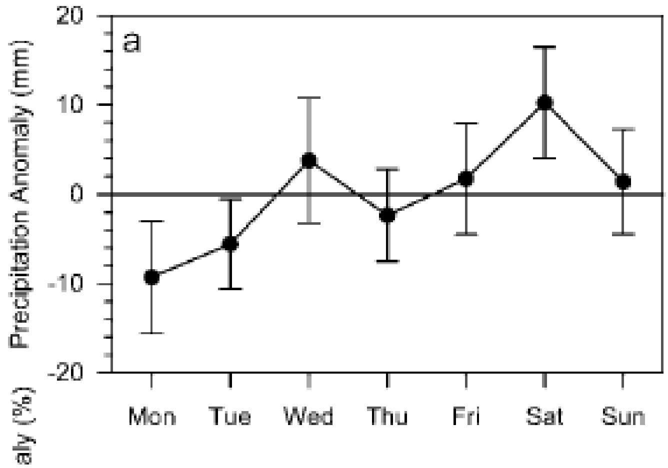
Hydro-climatological extremes ?



5. Still not convinced?

- From Monday to Saturday, rising precipitation abnormality
- Then decreases
- Cyclical basis

- Is there any
  natural cycle of 7 days?



Germany, 12 stations, 1991-2005
Source: Baumer et Vogel, 2007 Geophys. Res. Lett

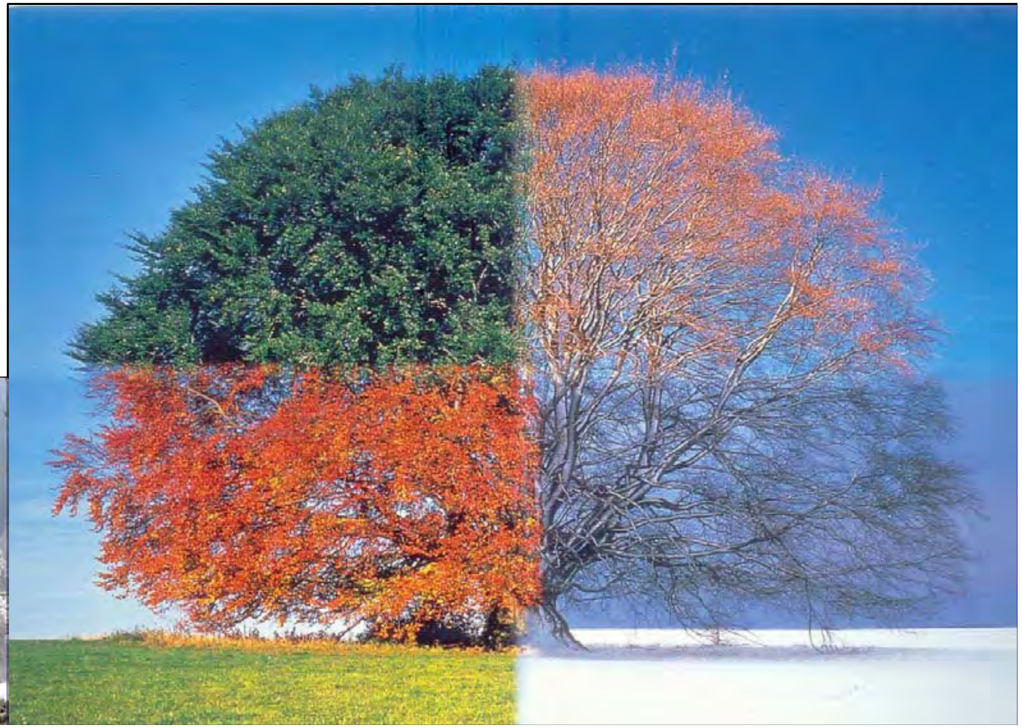
6. Trees in Benelux?

- Mainly beech and oaks
- Noble hardwoods (*Sorbus sp., Fraxinus excelsior, Prunus avium, Alnus glutinosa, Acer sp., Tillia sp. Juglans sp., Pyrus pyraster …)*
- Pioneer trees *(Betula sp., Populus sp., Salix spp.,* …)
- Conifers

7. Expected changes in Benelux?

- Increasing temperature
- More frequent and more intense precipitations (winter)
- Less frost days (spring)
- Extended growing season (spring and fall)
- Longer, more intense and more frequent drought periods (summer)
- Thunderstorms and storms

Will an average increase in temperature of 2°C have so much effects on trees?



Centre de Recherche Public
Gabriel Lippmann

8. Milder winter and fewer frost days during spring

Consequences

- Earlier bud flush
  - Buds: increased freezing susceptibility
- Earlier flowering
  - flower/ young fruits: frost damages
  - Insect pollinators and flowering (Prunus, Malus…)

Ash tree (*Fraxinus excelsior*)

- Leaf bud developmental stages

- From stage 3 on: frost sensitivity in spring induces bud necrosis and forking

9. Extended growing season

Milder spring and fall

- Forest ecosystems equilibrium disruption
- Affect seed dormancy
- Affect pathogens

Probability to happen?

- It is already happening

PLANTENTUIN OPENT VOOR HET EERST AL OP 10 MAART

Te vroeg in bloei

De lente is in het land en de eerste tekenen zijn te zien in het Arboretum van Kalmthout. Omdat veel planten er nu al tot vier weken vroeger dan normaal beginnen te bloeien, opent de plantentuin zelfs voor het eerst in zijn geschiedenis op 10 maart de deuren, bijna een week vroeger dan normaal. «Dat hebben we te danken aan een uitzonderlijk zachte winter en een bijzonder warme februari», zegt Abraham Rammeloo, conservator van het Arboretum.

JOOST FREYS EN DAAN VLEUGELS

RODODENDRON

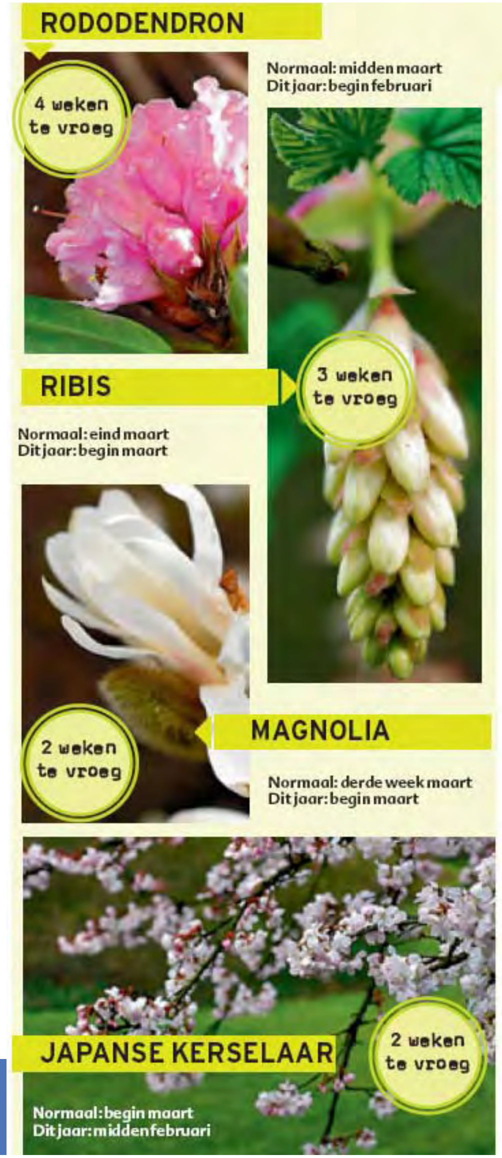
Normaal: midden maart
Dit jaar: begin februari

SPEENKRUID

Normaal: eind februari
Dit jaar: begin februari

3 weken te vroeg

March 2008
Source: KULeuven



RODODENDRON

4 weken te vroeg

Normaal: midden maart
Dit jaar: begin februari

RIBIS

Normaal: eind maart
Dit jaar: begin maart

3 weken te vroeg

MAGNOLIA

2 weken te vroeg

Normaal: derde week maart
Dit jaar: begin maart

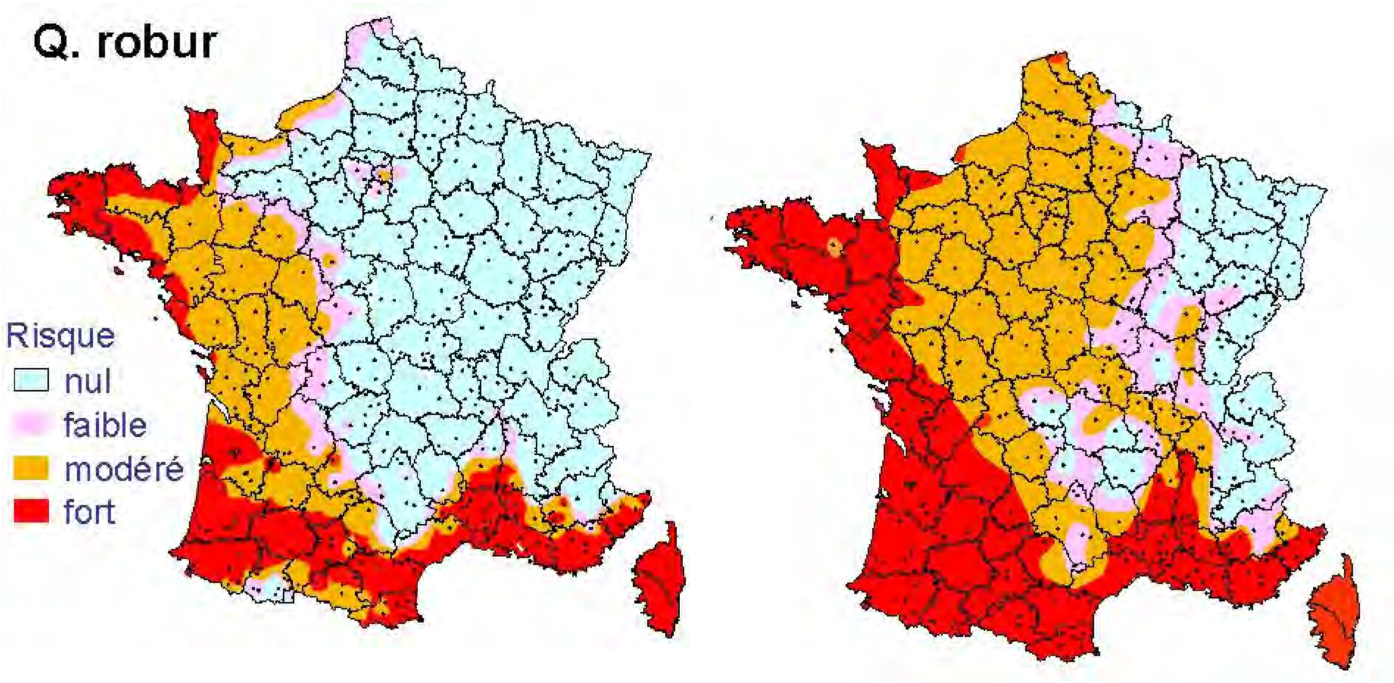
JAPANSE KERSELAAR

2 weken te vroeg

Normaal: begin maart
Dit jaar: midden februari

10. Pathogens or insects?

Milder winter would promote development of
Phytophthora cambivora on *Quercus robur*



Existing: 1968-1998

Predicting 2068-2098

Source: INRA Bordeaux

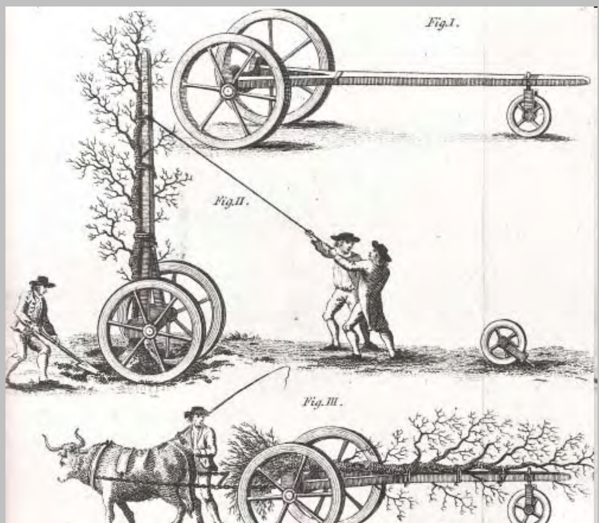
11. Tree moving

Climate modifications will

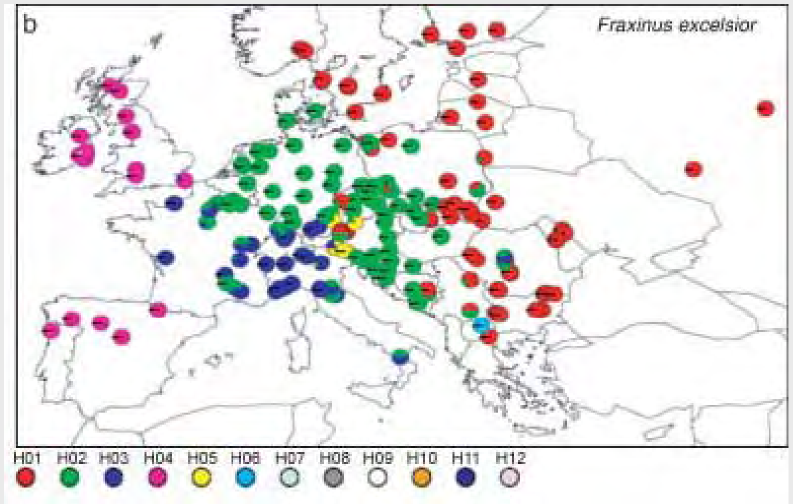
affect phytogeography and species distribution within Europe

Tree migration is not a new research topic:

Transplanting trees, 1794, Hayes

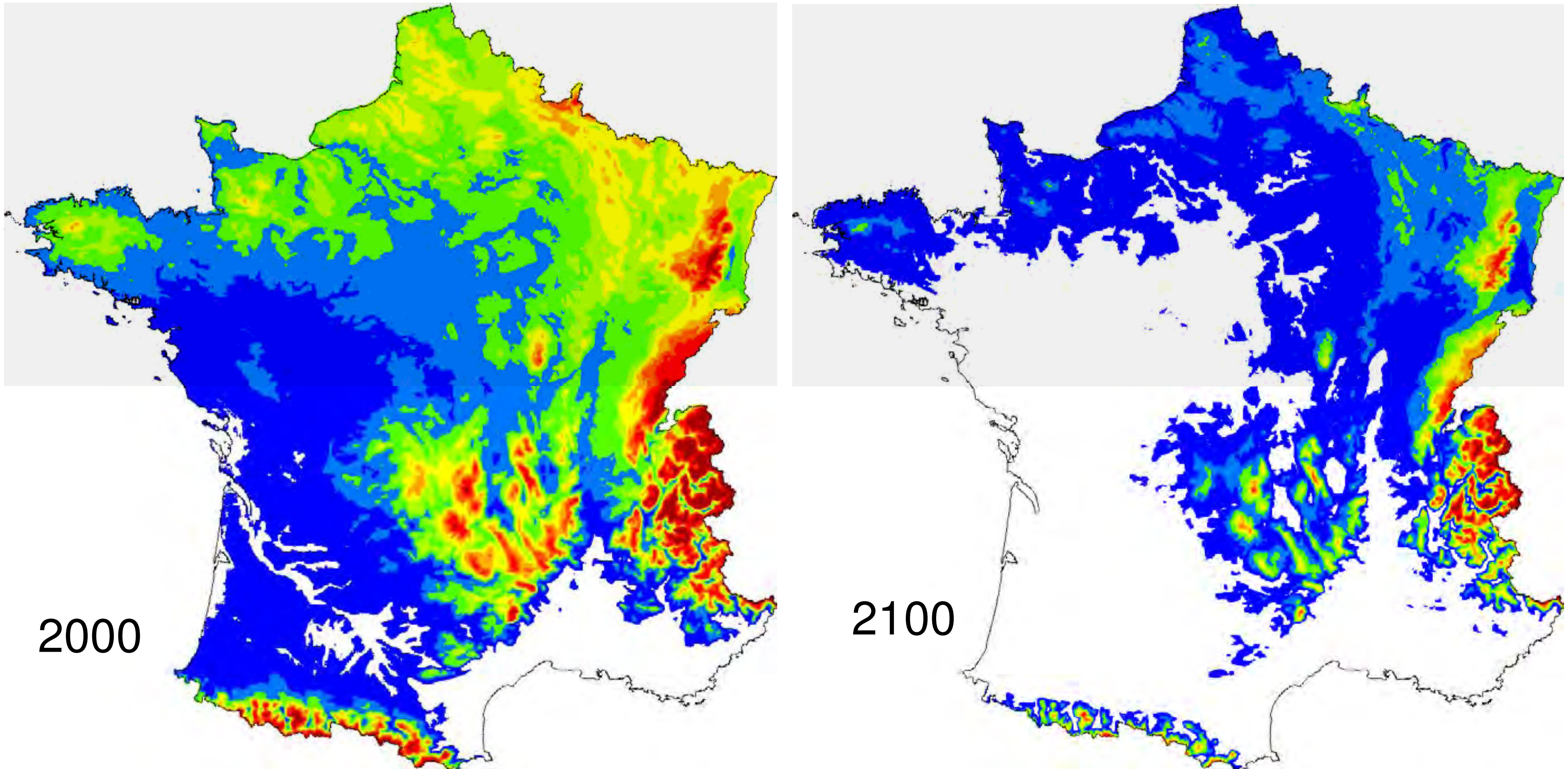


- Fraxinus excelsior migration routes in Europe
- CpDNA SSR
- 10 000 year-based (Heuertz et al 2004)



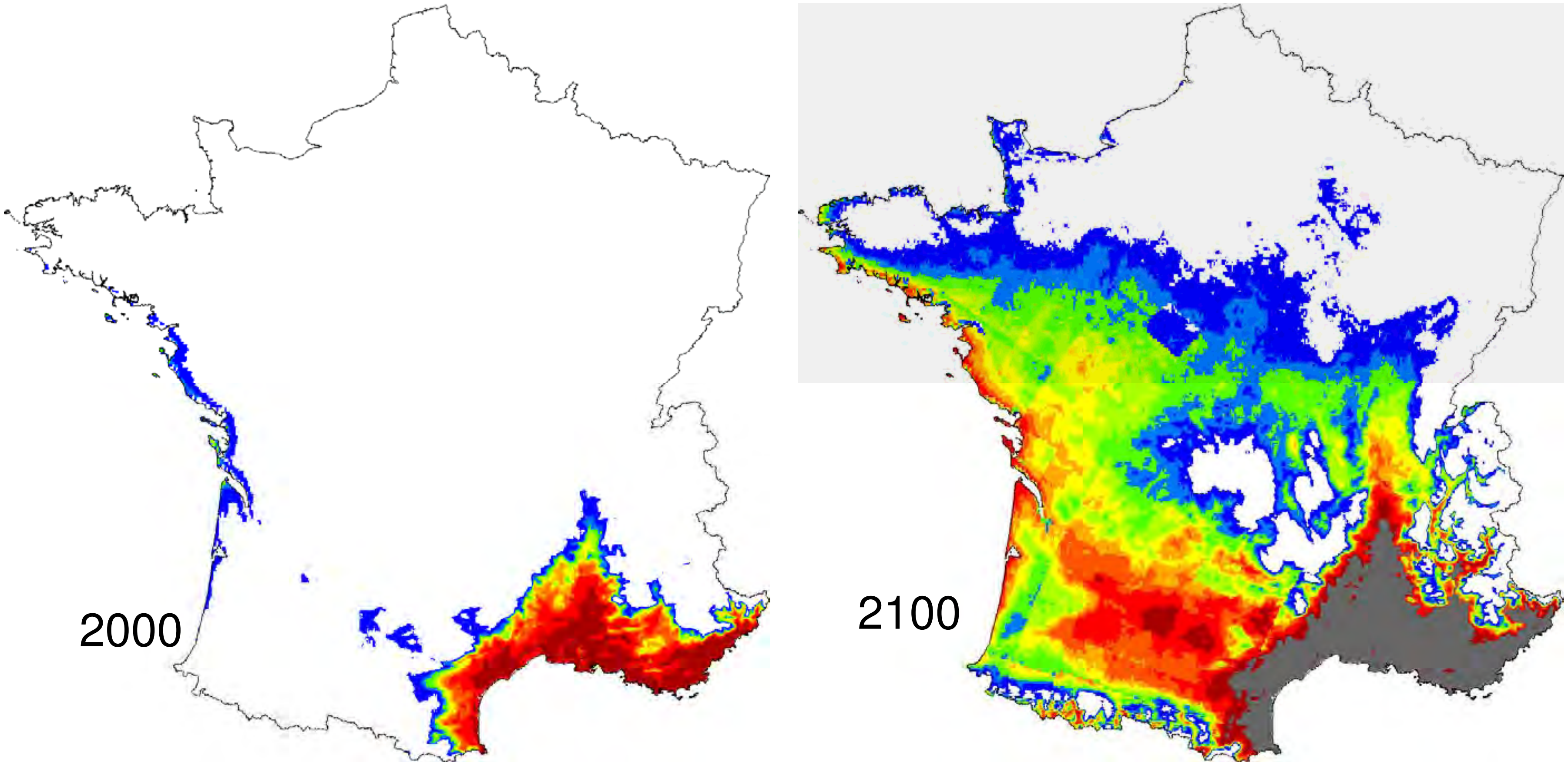
11. Tree moving

Fagus sylvatica in France
Based on an average rise of 2.5°C
(INRA, Nancy)



11. Tree moving

Quercus ilex in France
Based on an average rise of 2.5℃
(INRA, Nancy)



12. Summer drought

Longer, more intense and more frequent drought periods
Mainly in summer

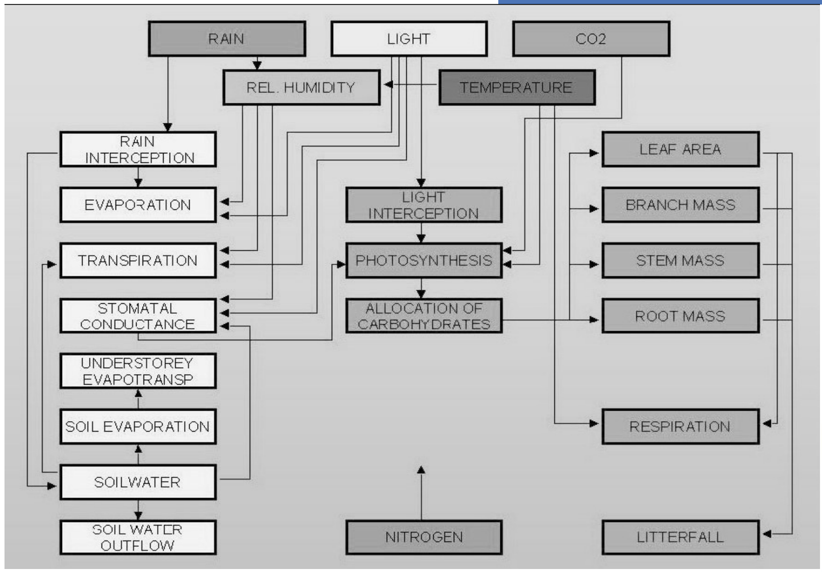
- Forest as Carbon wells?
- 2003 drought in Europe
- 30% reduction of primary productivity in forest
- Corresponds to a 0.5 GtC deficit

- Decreased water availability
- Reduced evapotranspiration
- Reduced yield
- Long term effects of drought period on forest

- Example: 1975-1976 drought affected development of Dutch Elm Disease by allowing *Scolytus* to invade and breed in healthy areas in UK (Gibbs and Gregs, Forestry, 1997)

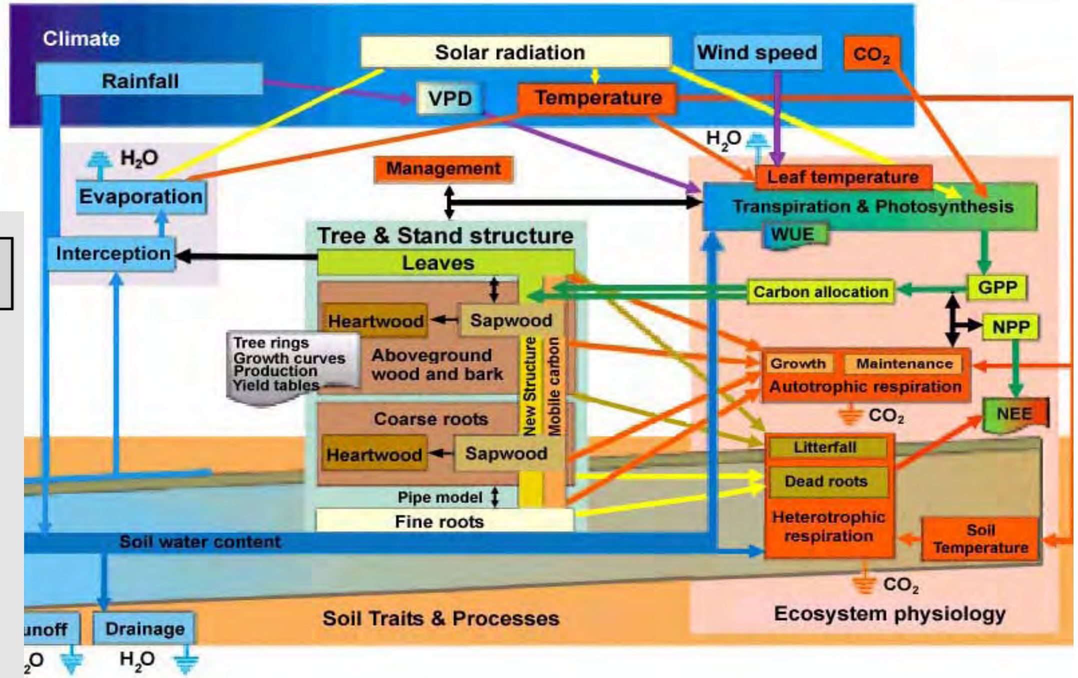
13. Forest long life-span and models

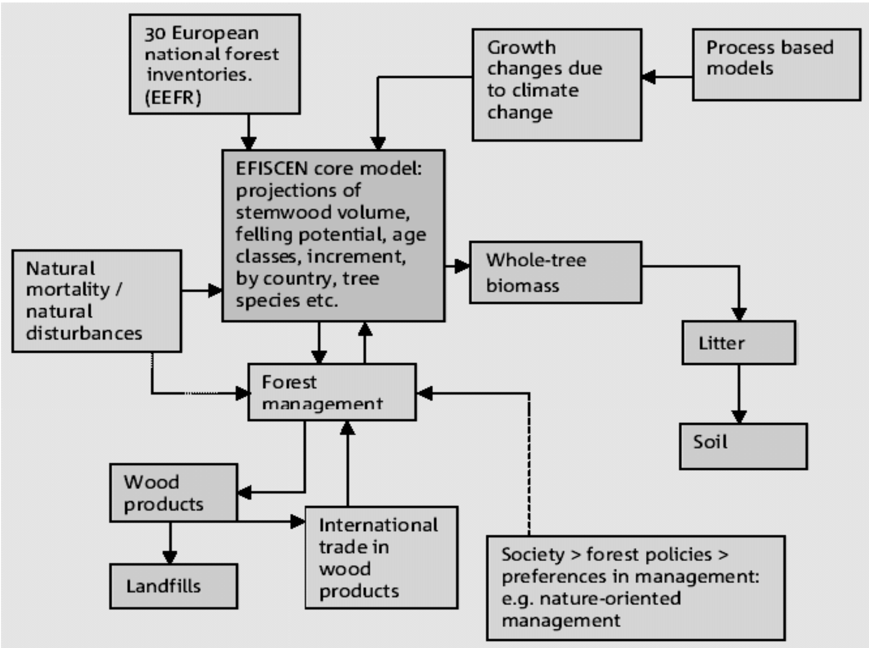
Centre de Recherche Public Gabriel Lippmann



BIOMASS model

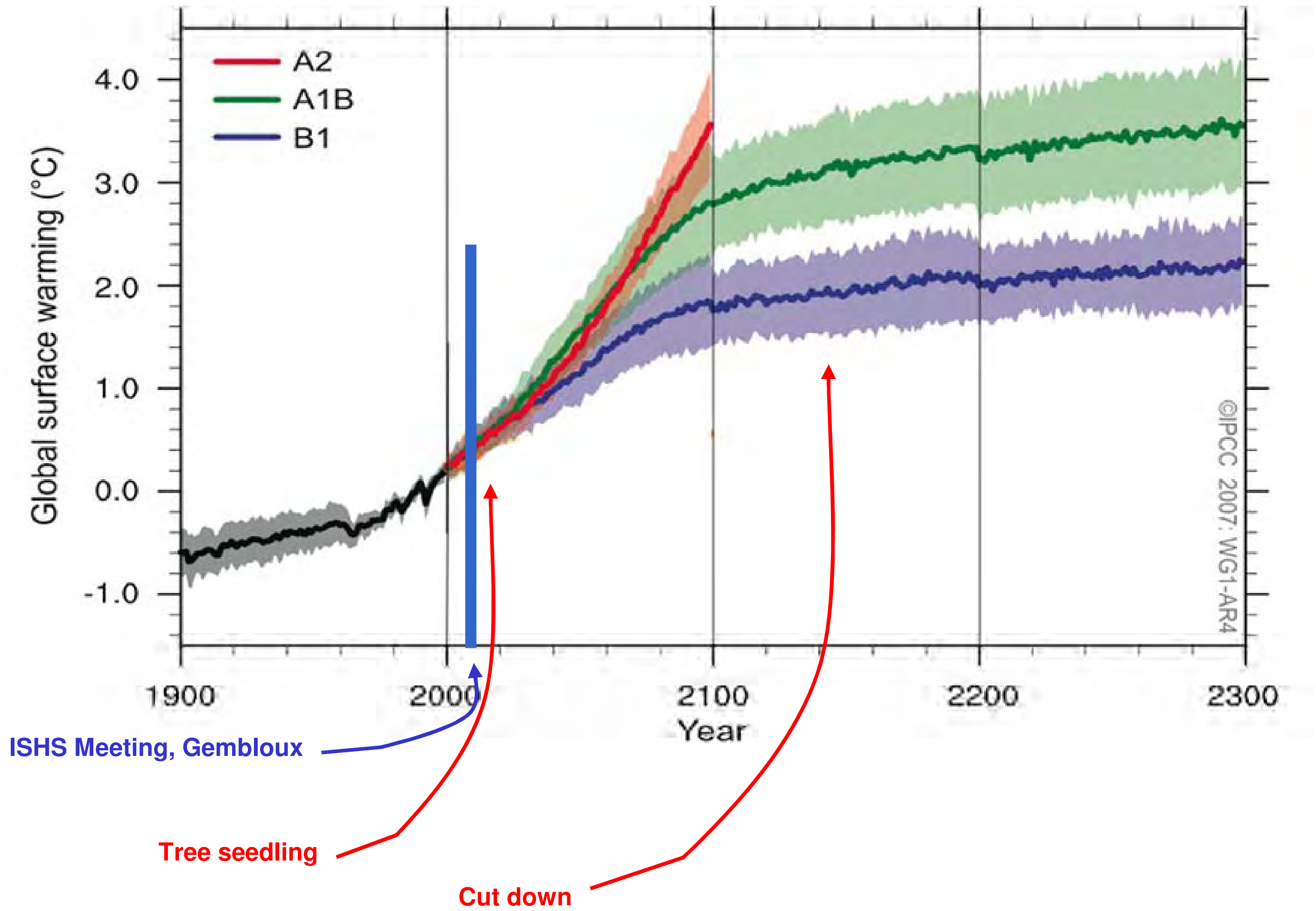
GOTILWA model



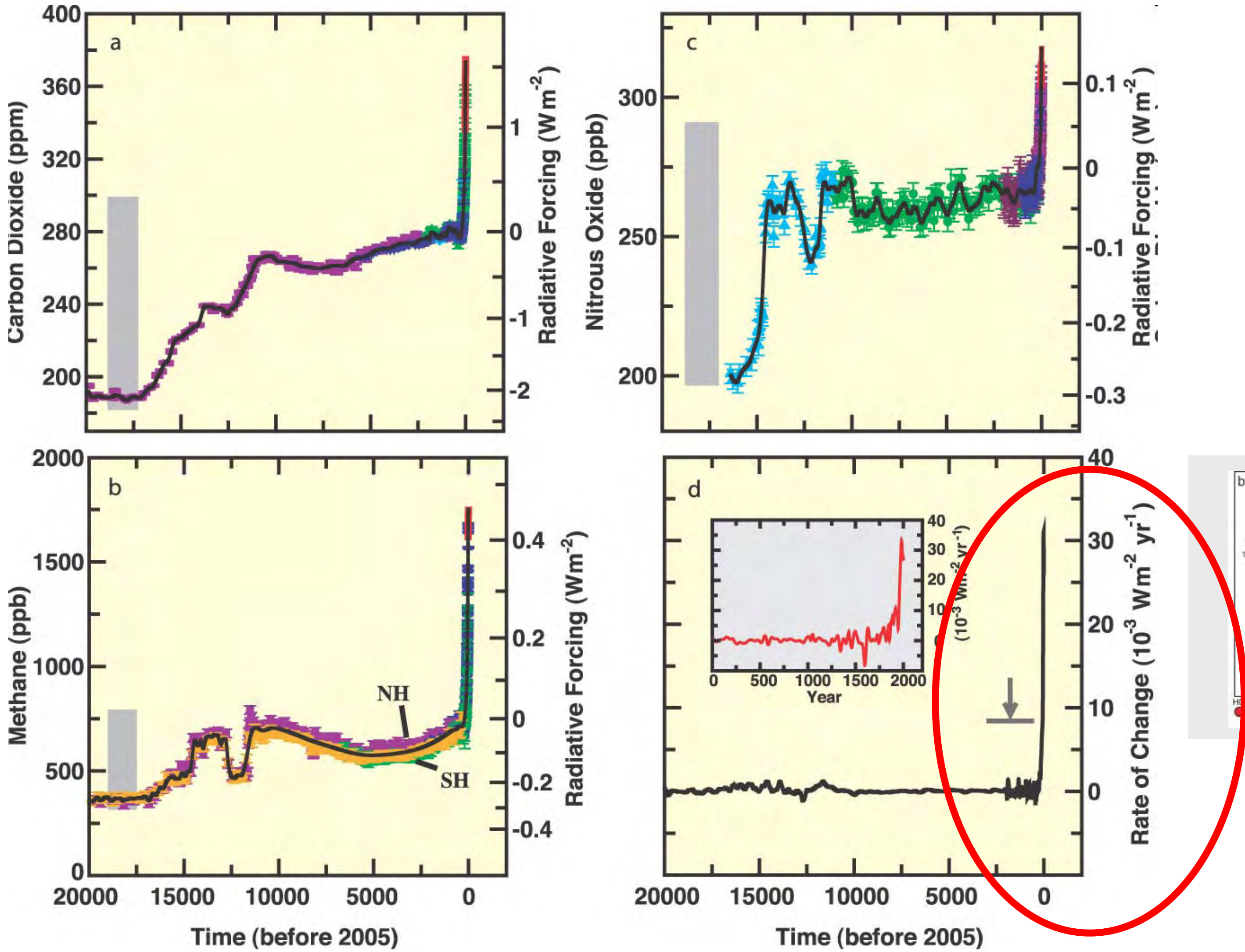


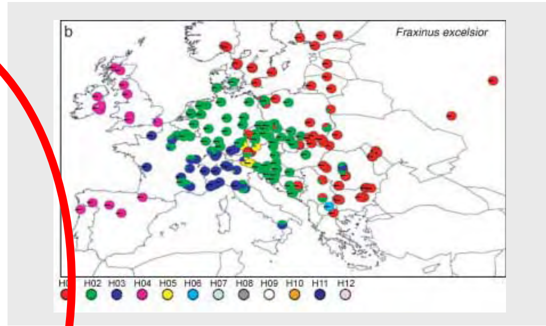
EFISCEN model

14. Forest long life-span



15. Change rapidity



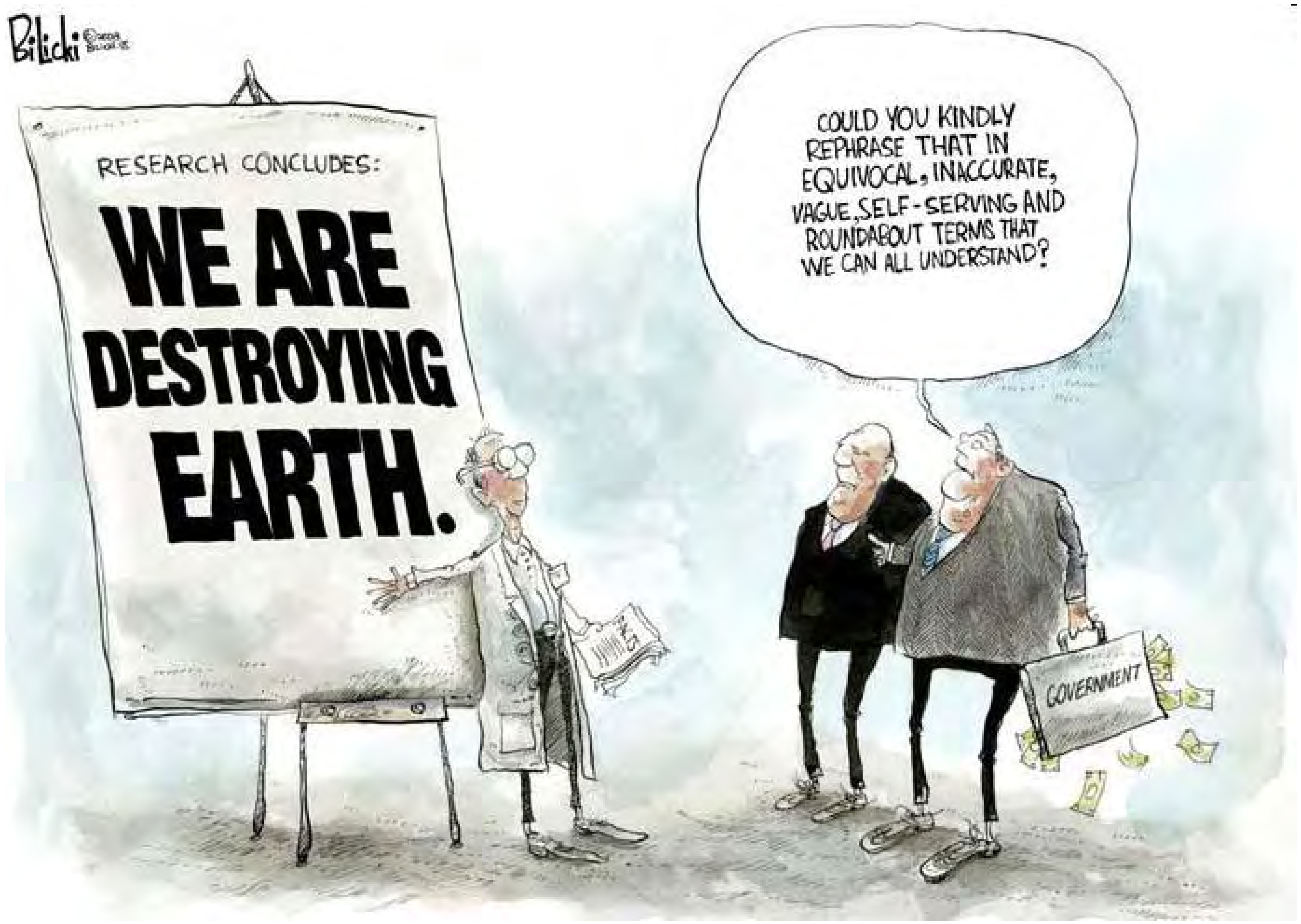


16. What can we do?

Awareness is needed
- Scientists, general public, decision makers…
- At all levels…

… including ourselves

And any action in that direction is welcome:
- reduce heating / air conditioning by 1°C in the offices
- travel by train instead of plane to attend a meeting
- replace incandescent lighbulb by economical ones in the labs
- organise yourself so that your presentation is finished in time and that the participants of the conference will be in time at the train station.



Thanks for your attention !

Detecting weeds by artificial vision in carrots: towards optimization of herbicide use

Piron A., Destain M.-F.
Mechanics and Structure Laboratory
Department of Environmental Sciences and Technologies
Gembloux Agricultural University

piron.a@fsagx.ac.be
destain.mf@fsagx.ac.be

Horticulture and herbicides

- There is significant potential for the reduction of GHG emission by reducing the amount of pesticides both in manufacturing (15%) and applying phases (30%)

- Weed control continues to cause a problem for horticulture
  - One solution is the use of Precision Horticulture

Precision horticulture

- Precision horticulture is the use of advanced horticultural management systems based on a spatial information platform. It includes:
  - Development of spatial information tools
  - Use of remote sensing tools
  - Development of proximity sensing tools (e.g. image processing based sensors)
  - New data capture tools in the field (micro-sensors)
  - Sensor fusion of the information provided by several sensors (temperature, solar radiation, plant growth,)
  - Etc.

Image processing based sensors

- Existing tools = Local positioning systems for mechanical weeding using machine vision
  - Mechanical weeding between the rows: the distance between the rows is known
  - In-row cultivation: the plant spacing in the row is known

Mechanical weeding between the rows

- An articulated mechanism produces a lateral displacement of the cultivator relative to the tractor
- This displacement relative to the plant rows is measured by a machine vision system and used in a feedback control loop
- The localisation of the cultivator between the rows is thus very accurate

Cultivation of beans

Eco-Dan

In-row cultivation: the plant spacing in the row is known

- Images analyses of the crop are performed
- Individual plants are tracked through the image by applying a predetermined grid
- The weeding rotors are working around each individual plant
- The in-row rotors are then followed up by a set of inter-row cultivation units to complete the all round cultivation process

Robotcrop InRow (Garford)
• Performance: 2 plants/s
• Weeding coverage of up to 98.5% surface area has been achieved

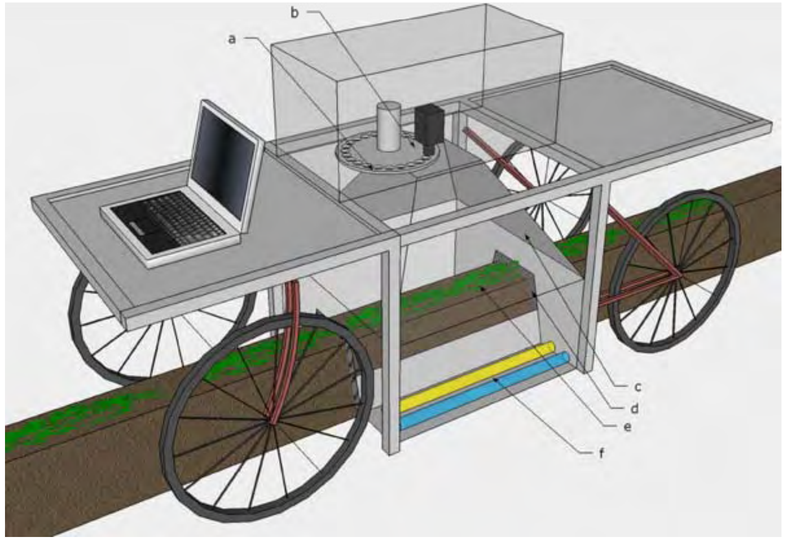
In other cases, there is no commercial solution…

- It is still a difficult task to recognize by machine vision weeds which are mixed with plants in a random manner
- Example: carrots
  - Carrots are densely sown
  - They do not follow a regular pattern
  - Some weeds are very similar to plants regarding their shape or colour
  - Weeds are often overlapping

Typical organic carrot lines with weed infestation at an early growth stage.

Recognition on basis of the spectral reflectance (1)

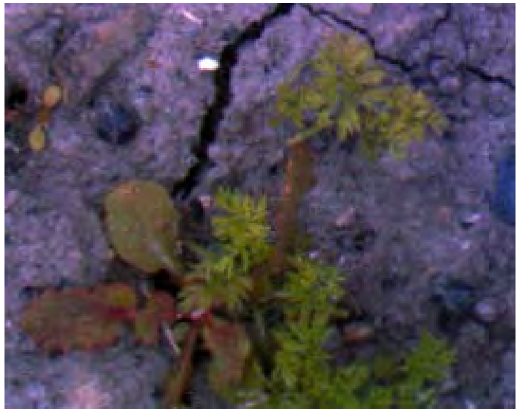
- Goal
  - To select the most appropriate wavelengths for the image acquisition
- Method
  - Filter wheel equipped with 22 band pass interference filters
  - Selection of the best combination of 2, 3 and 4 filters to get the best classification accuracy

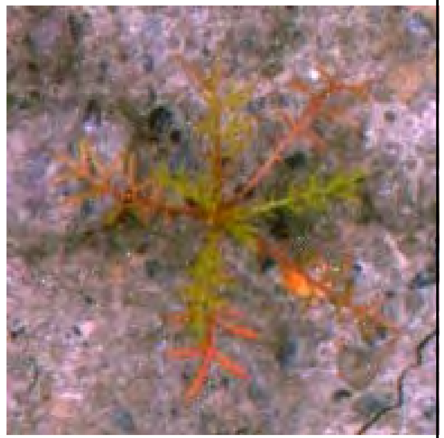


a. Filter wheel
b. Camera
c. Reflector
d. Brushes
e. Carrot ridge
f. Lighting

Recognition on basis of the spectral reflectance (2)

- Results
  - Best combination of filters: 450-80, 550-80 et 700-50 nm
  - Classification accuracy = 72 %

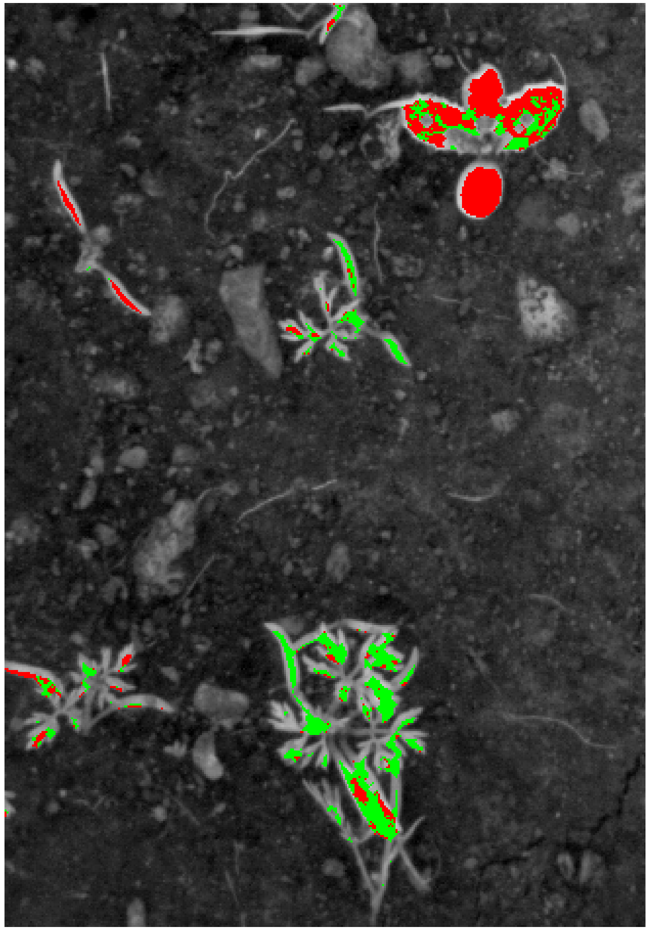




gembloux
faculté universitaire
des sciences agronomiques

Recognition on basis of the spectral reflectance (3)

- Results
  - A given plant may have different spectral characteristics, with following consequences:
    - In some cases, the centre of the weeds is correctly classified while the outer regions are misclassified
    - Cotyledons are nearly systematically misclassified

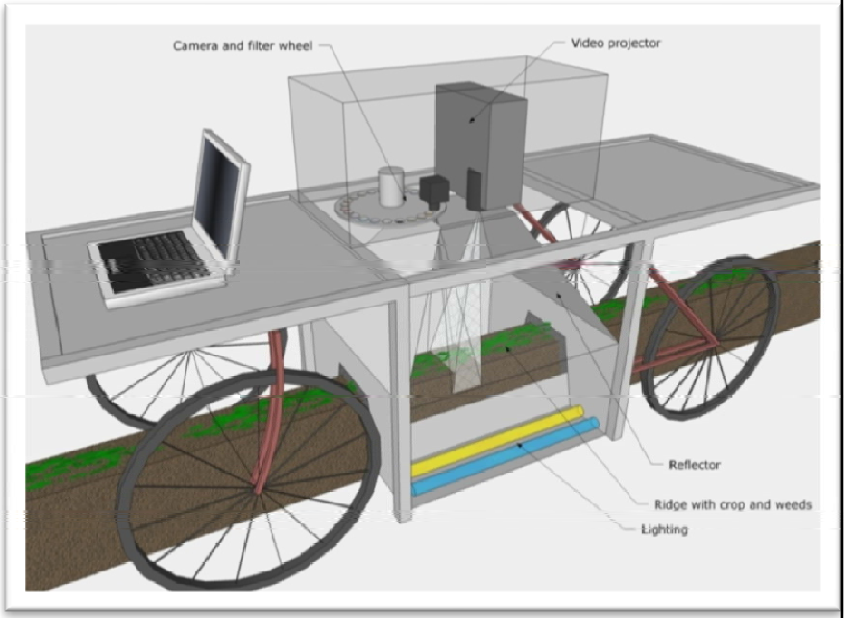


Recognition on basis of plant height (1)

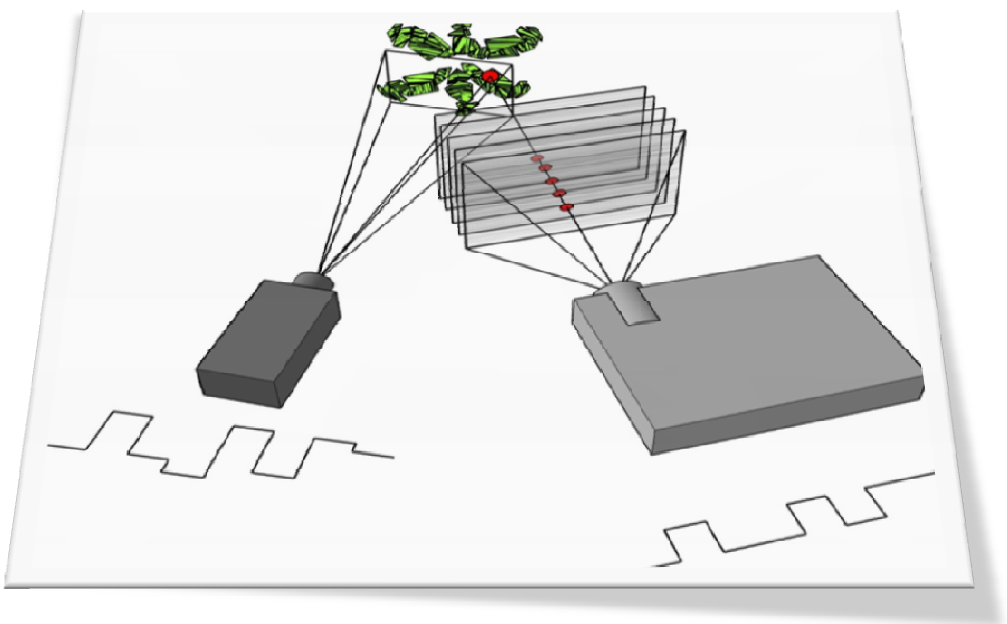
- Goal
  - To discriminate plants and weeds on basis of the height difference
- This relies on following assumption: *the carrots height is more uniform than the weeds heights*

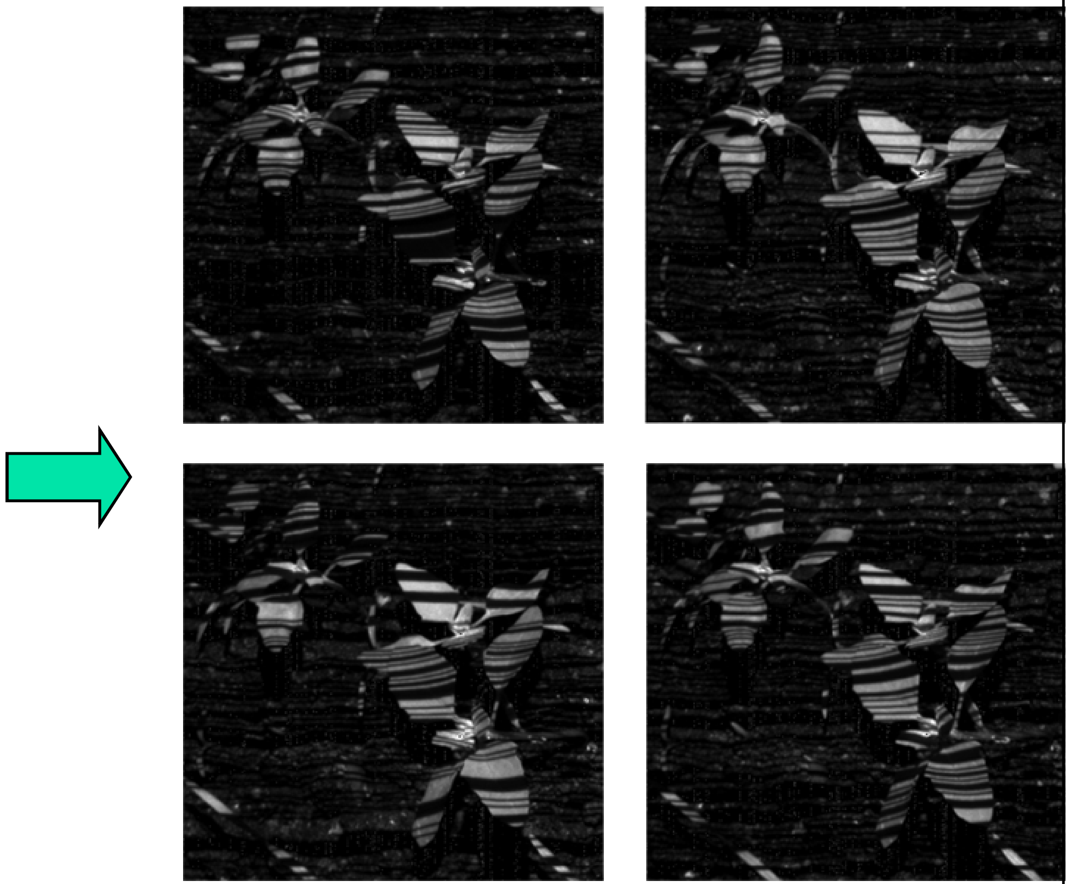
Recognition on basis of plant height (2)

- How to measure the plant height ?
- Active stereovision:
  - A set of light patterns produced by a video projector is projected onto the scene
  - A camera is used to image the projection of the pattern on the scene
  - The plant height is computed



Recognition on basis of plant height (4)

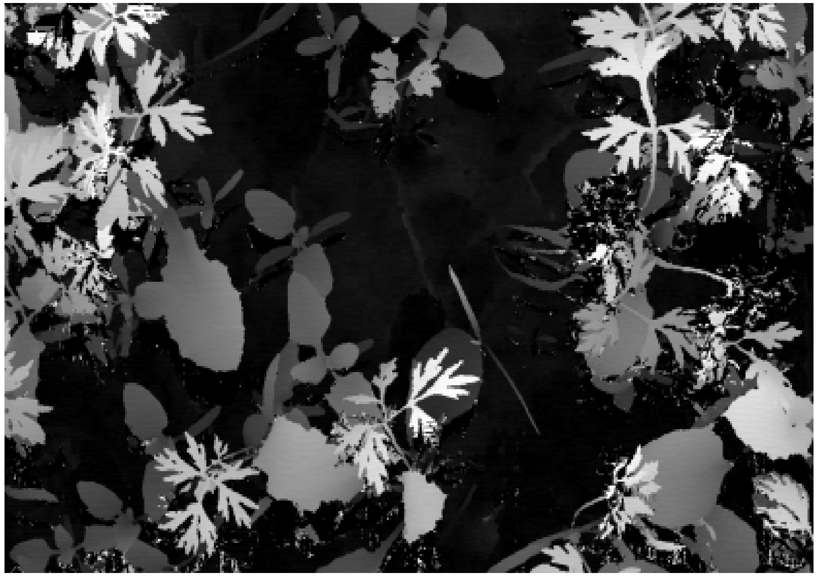




gembloux
faculté universitaire
des sciences agronomiques

Recognition on basis of plant height (5)

- Results

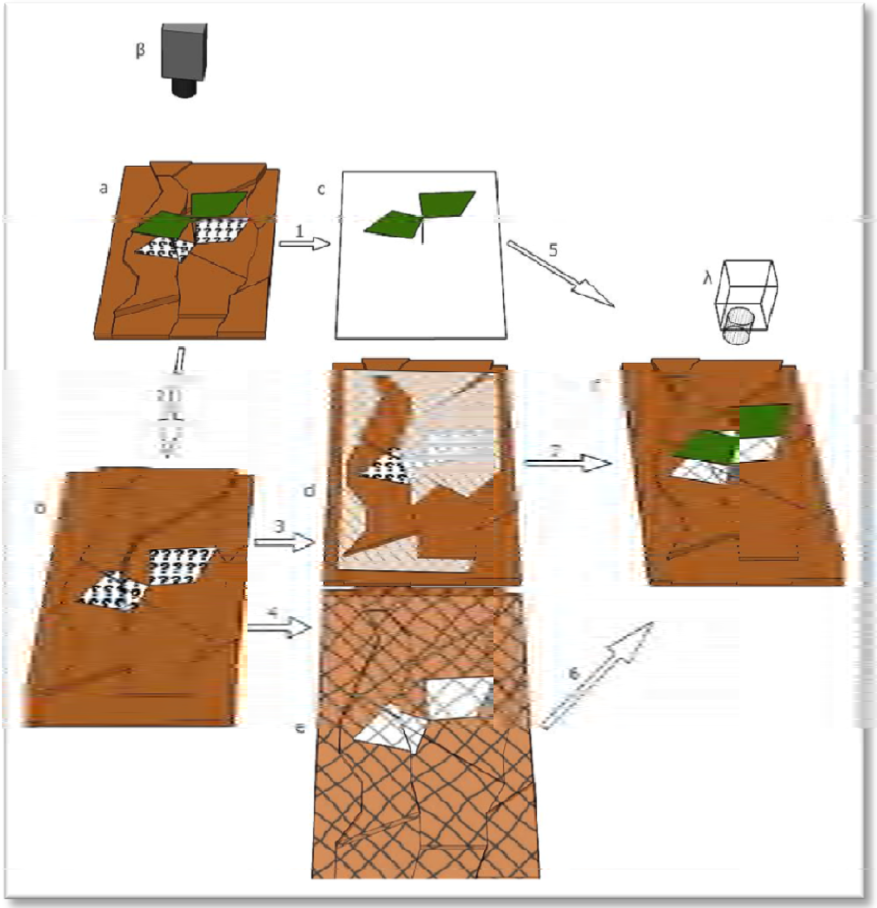


The brighter pixels are near the camera

The soil unevenness clearly appears (this justifies the applied correction)

Recognition on basis of plant height (6)

- The computation of the actual plant height implies several stages
  - Classification soil / plant (multispectral) (1,2)
  - Plane fitting through soil (3)
  - Surface fitting through soil (4)
  - Combination of reconstructed soil with plant pixels (5,6)
  - « Alignment » of ridge and camera (7)



Recognition on basis of plant height (7)

- Results
  - The results are better than those obtained with the spectral reflectance (72%)

	Parameter	
	Non corrected plant height	Plant height parameter
Overall	*66*	*83*
Carrots	75	85
Weeds	57	80

Thank you for your attention

UNIVERSITEIT GENT

FACULTEIT BIO-INGENIEURSWETENSCHAPPEN

Models as effective tools for optimizing irrigation: a typical example

Kathy Steppe[1], Dirk J.W. De Pauw[2] & Raoul Lemeur[1]

[1]Department of Applied Ecology and Environmental Biology, Laboratory of Plant Ecology
[2]Phyto-IT

Ghent University, Faculty of Bioscience Engineering, Coupure links 653, B-9000 Ghent, Belgium

Ghent University Laboratory of Plant Ecology

Outline of the presentation

- Introduction
- New methodology for irrigation scheduling
- Test of the prototype
- Conclusions

Introduction

Irrigation scheduling involves two important steps

Determination of how much water must be supplied

Determination of when this water must be supplied

In the past, sensors to continuously monitor…

plant water status

soil water status

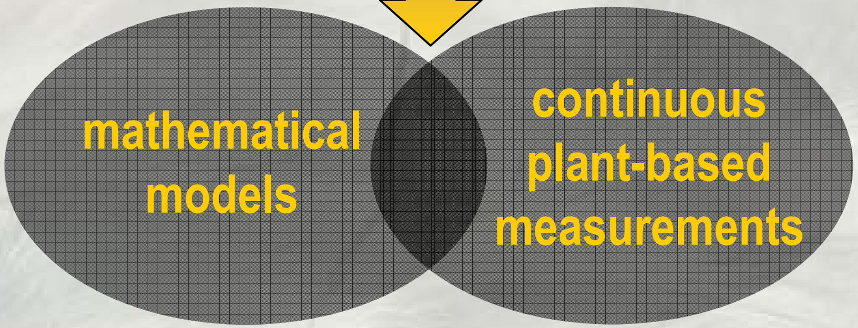
have been proposed as useful tools for irrigation scheduling

Ghent University
Laboratory of Plant Ecology

These **approaches are limited** in the sense that they only provide information on whether or not irrigation is needed…

These **approaches are limited** in the sense that they only provide information on whether or not irrigation is needed…

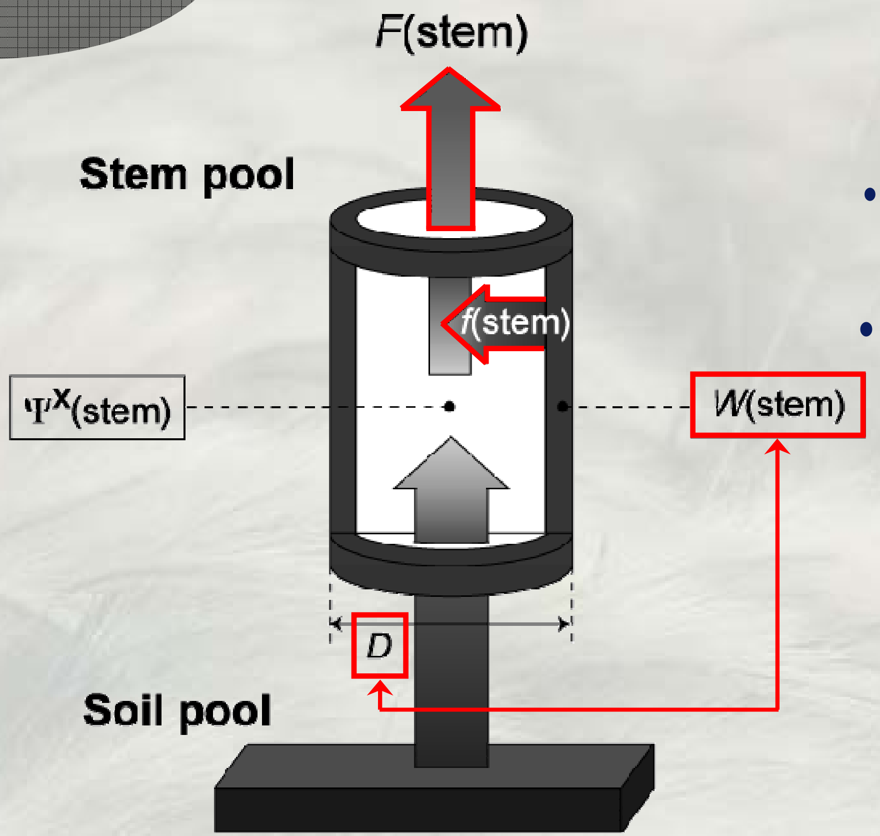
a possible solution…



"a new generation of irrigation strategies"

Ghent University
Laboratory of Plant Ecology

an interesting mathematical model

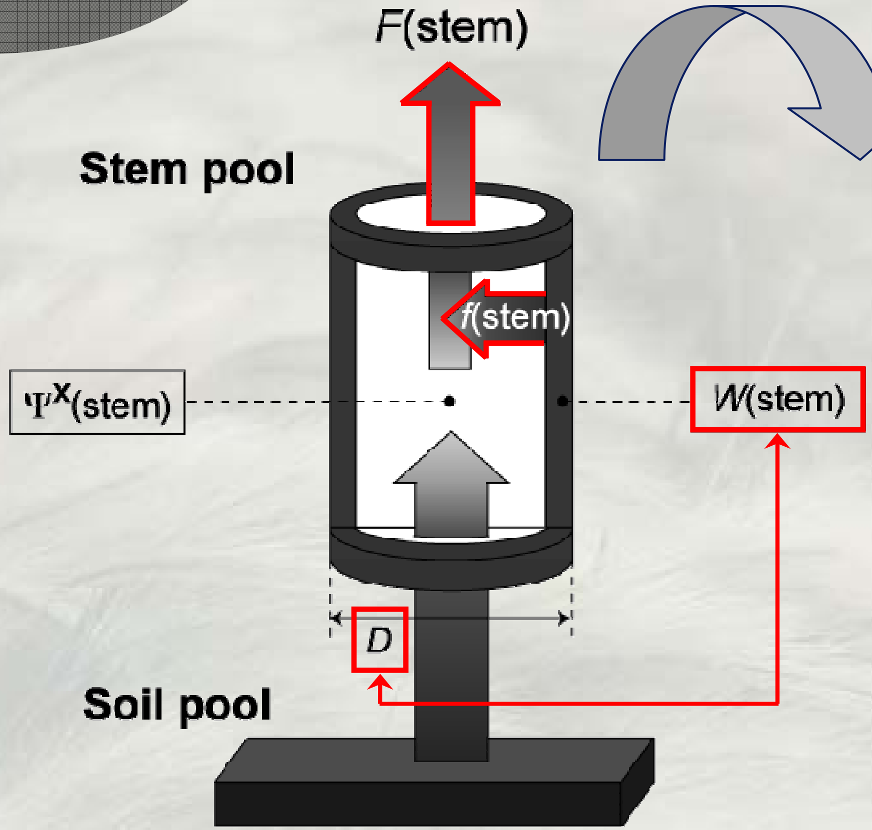


Steppe *et al*. (2006) A mathematical model linking tree sap flow dynamics to daily stem diameter fluctuations and radial stem growth. Tree Physiology 26:257–273

Model concept

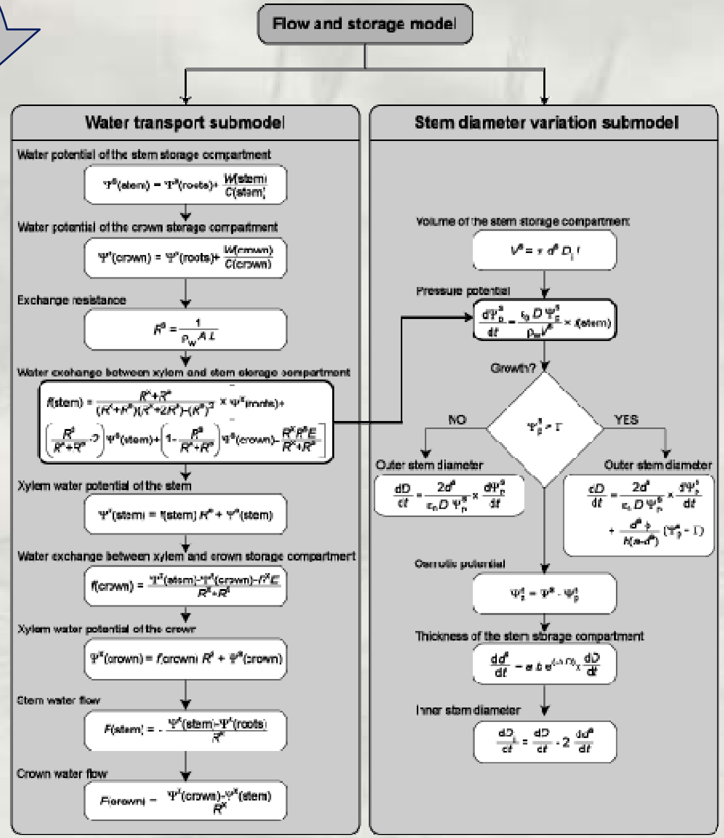
- direct flow paths
- water flow in and out of storage pool
  - → change in water content *W*(stem)
  - → change in stem diameter *D*

an interesting mathematical model



Steppe *et al*. (2006) A mathematical model linking tree sap flow dynamics to daily stem diameter fluctuations and radial stem growth. Tree Physiology 26:257–273

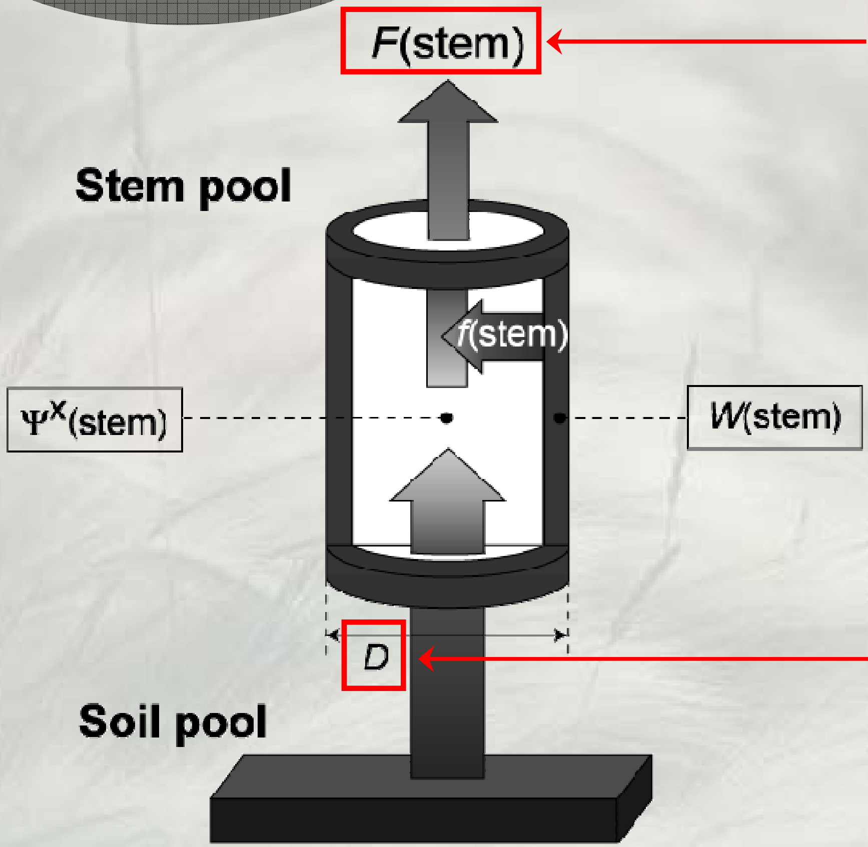
Mathematical translation



The new methodology for irrigation scheduling

an interesting mathematical model

plant-based measurements



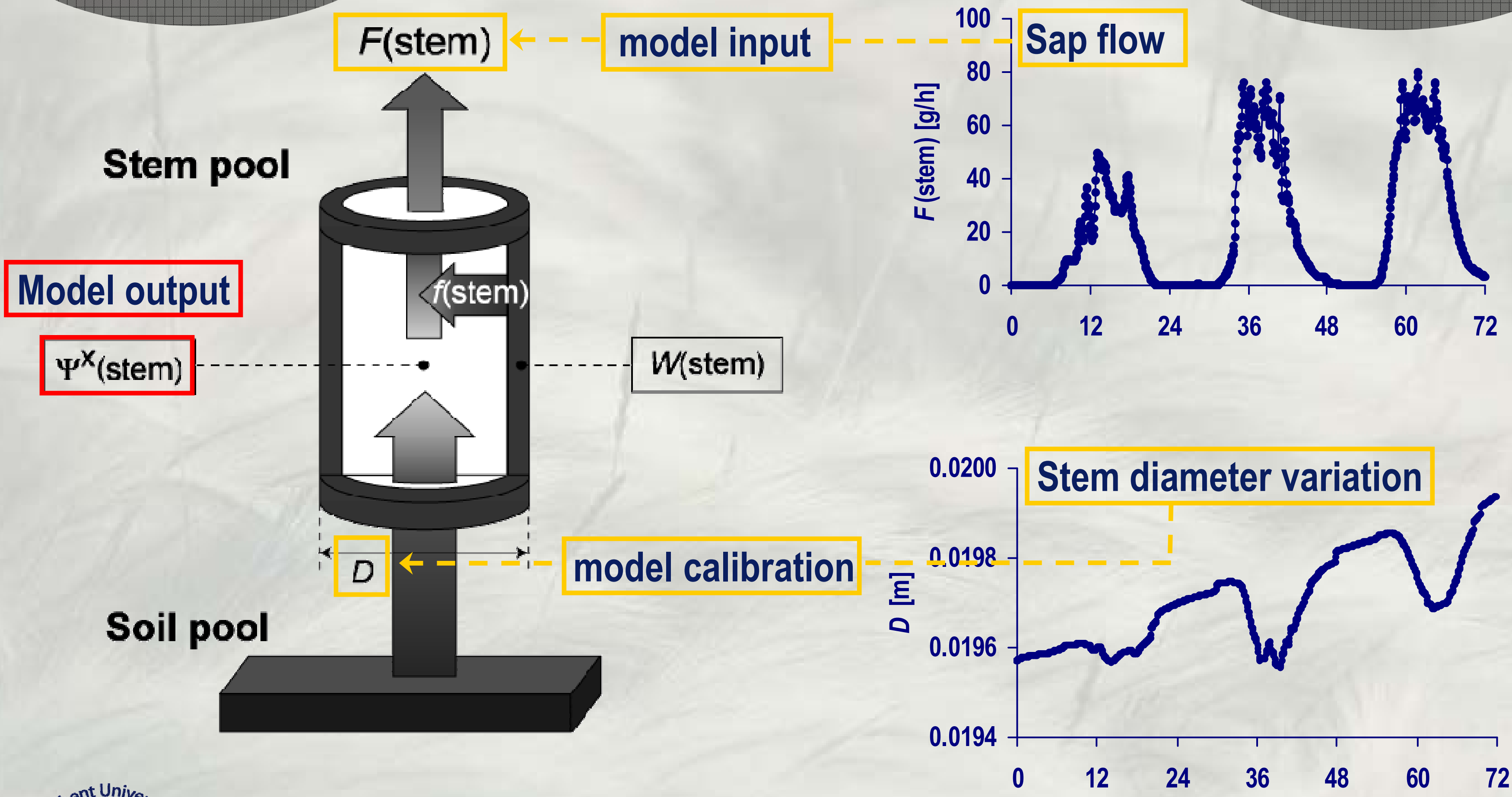
sap flow sensor
(sap flow stem *F*(stem))

detail

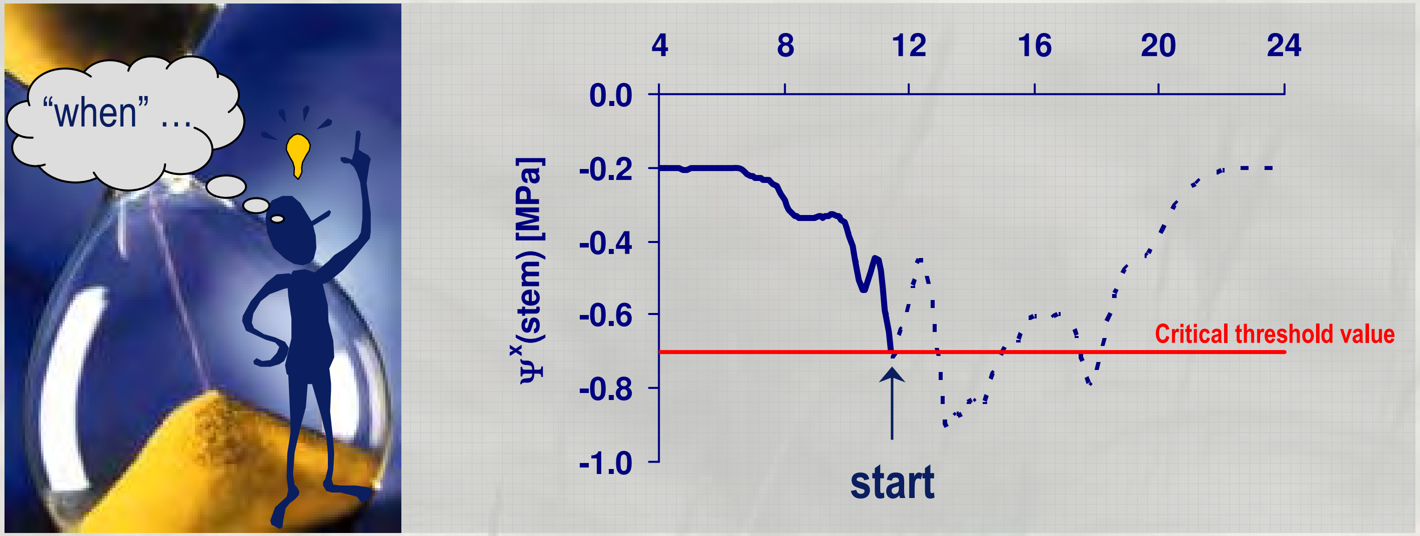
LVDT sensor
(stem diameter variation *D*)

an interesting mathematical model

plant-based measurements

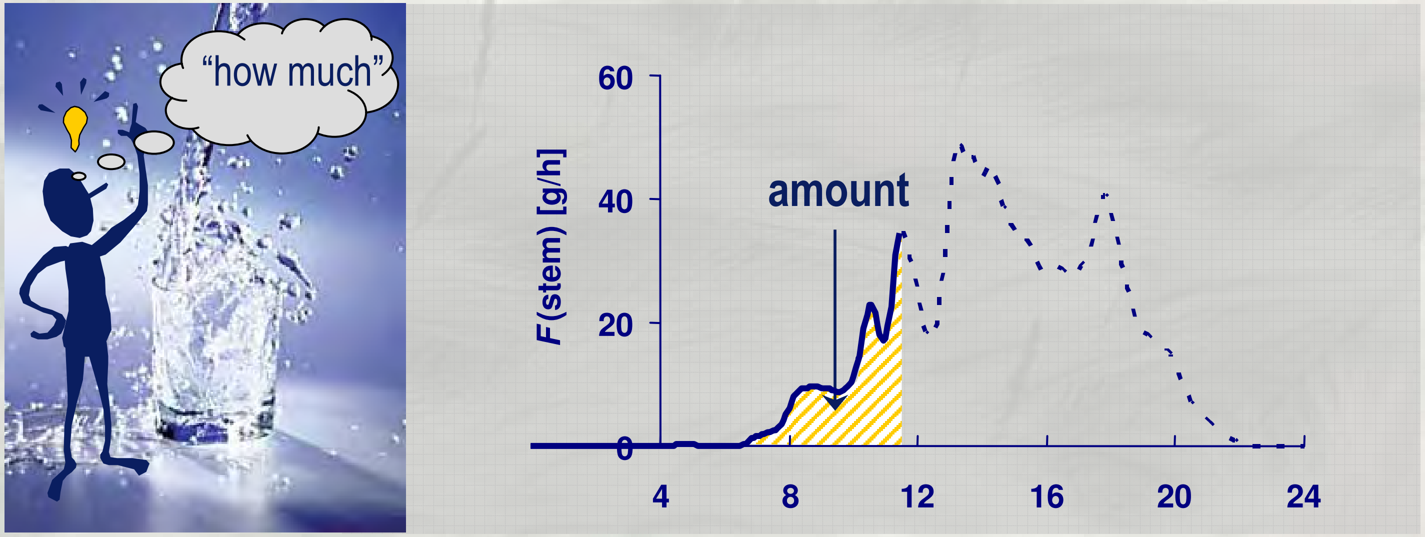


STEP 1:

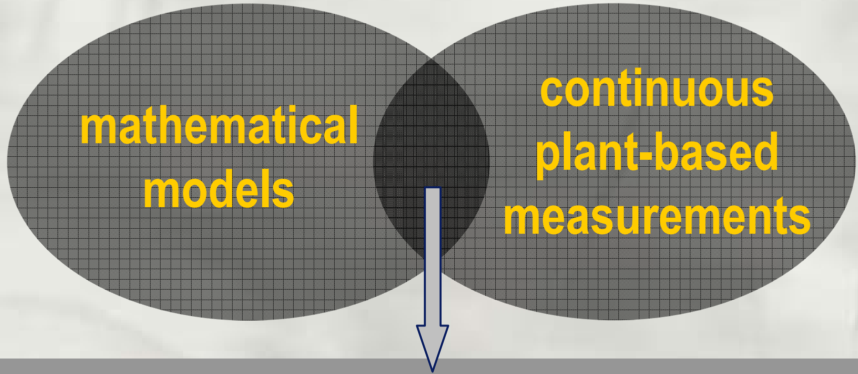


"when" ...
4
8
12
16
20
24
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Ψx(stem) [MPa]
Critical threshold value
start

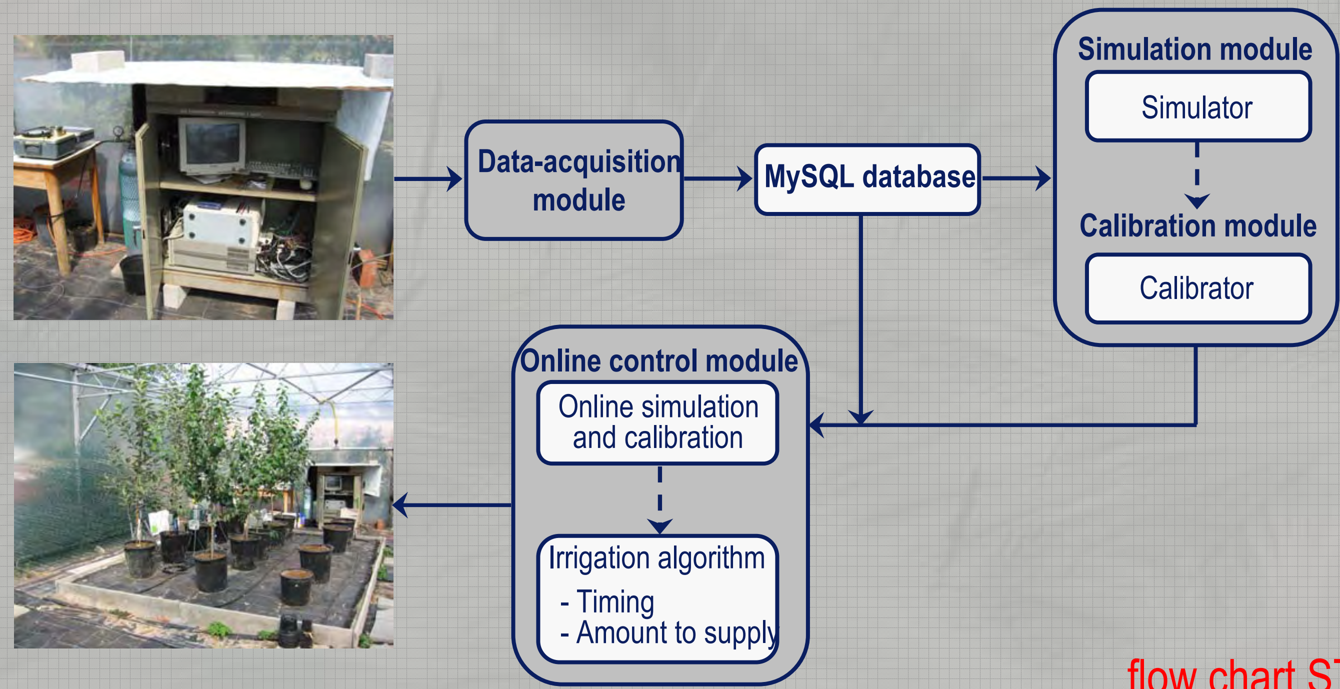
STEP 2:



"how much"
60
40
20
0
F(stem) [g/h]
amount
4
8
12
16
20
24



STACI = tool to link the mathematical model with plant-based measurements



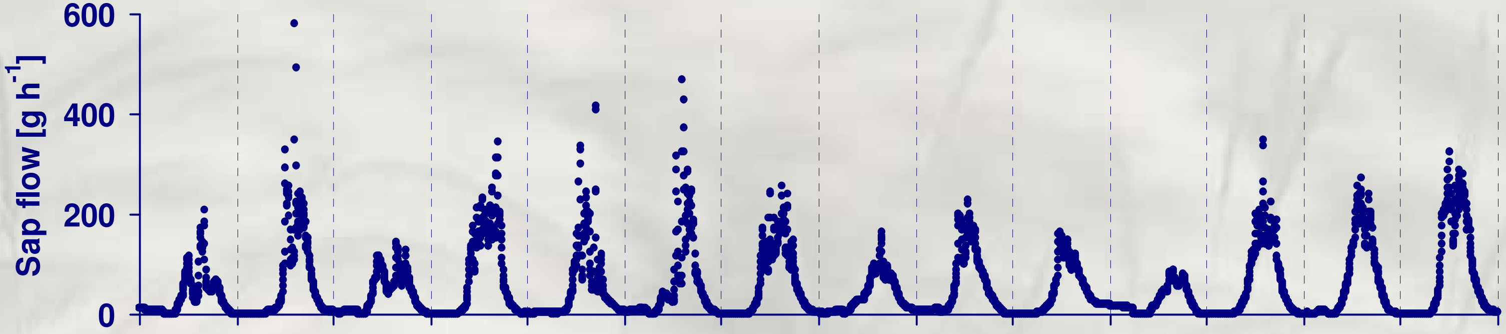
flow chart STACI

Ghent University Laboratory of Plant Ecology

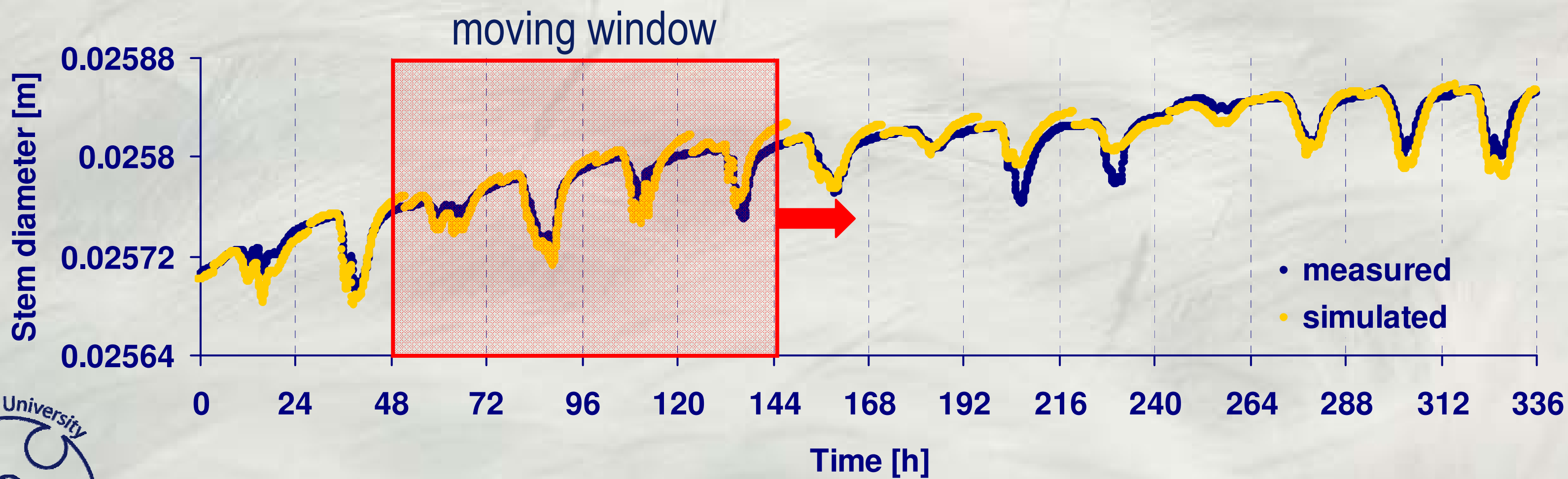
Test of the prototype

Steppe *et al*. (2008) A step towards new irrigation scheduling strategies using plant-based measurements and mathematical modelling. Irrigation Science 26: 505-517

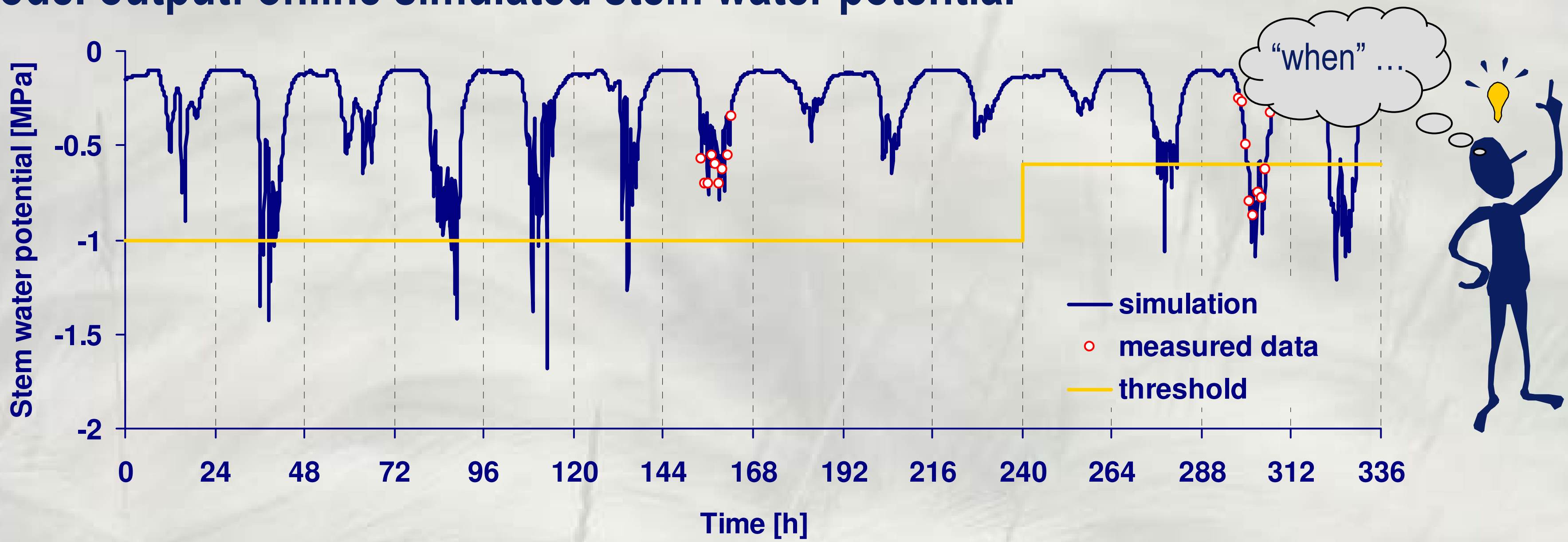
Model input: sap flow pattern

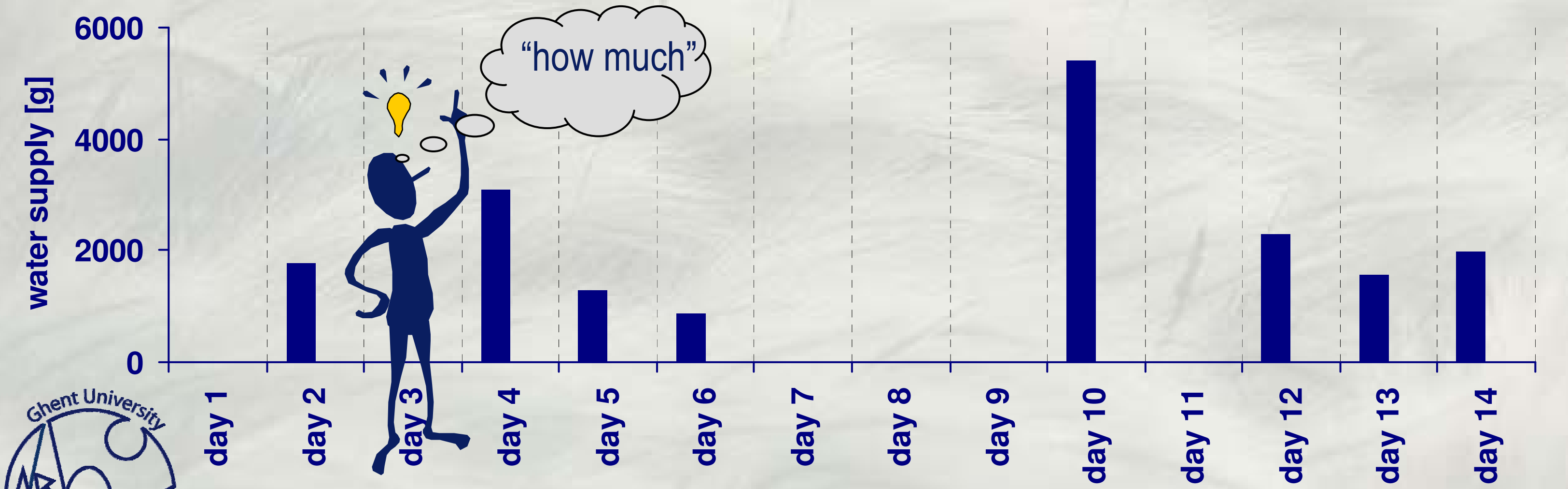


Model calibration: stem diameter variation



Model output: online simulated stem water potential





Conclusions

1/ A **new generation of irrigation strategies** presents itself, whereby **mathematical models are used in combination with plant-based measurements** to provide information on “when” and “how much” irrigation should be applied

2/ The **software STACI** can be used to solve problems related to possible temporal variability of the model parameters

3/ A test of the prototype showed that **greater precision in the application of irrigation water is possible**

4/ The new methodology also **permits induction of mild stress**, eventually for quality improvement

Discrepancies in the analysis and interpretation of climate change data

A. Kunz and Michael M. Blanke, University of Bonn Germany

Weather and phenology data were analysed from 50 year records (1958-2007) at Campus Klein-Altendorf of the University of Bonn in the proximity to Holland and Belgium (190 km East of Gembloux). The weather data included air and soil temperature, precipitation and frost and the phenological data of the beginning and end of flowering, harvest, yield and leaf drop of 4 apple and pear varieties. While our data analysis compared the last 20 years with climate change (1988-2007) with the 30 previous years without climate change (1958-1987) and partially **confirms results of other authors such an earlier flowering, earlier harvest and earlier leaf drop**, it **contradicts** in the following

1) **increased threat of frost** (due to the combination of remaining April spring frosts and more advanced, more frost-sensitive flowering stages) in contrast to reported/forecast less frost (DWD, 2007)
2) a **shorter flowering period**, also after warm winters in contrast to reported longer flowering periods particular after warm winter with pollination problems (Legave, 2008);
3) a **longer fruit development** (due to more advanced flowering than harvest in contrast to reported shorter fruit development (Ruess, 2009), which requires a re-think of the T-stage harvest date prediction
4) **earlier leaf drop**, which contradicts/waives any issues of longer vegetation period at a time when the fruit trees have no leaves

Since the results seem to depend on the method of data analysis (long-term average versus regression), we analysed our and reported data to explore the potential reasons for the apparent discrepancies and showed at least two reasons:

a) linear regression lines through short term (e.g. 30 years) data sets
b) use of the temperature (>5°C) based vegetation period rather than a phenology based units; this could be more suitably called ‘phenological or pomological period’. The complete talk can be viewed also on this Benelux website and in the special climate change issue of Erwerbs-Obstbau 3/2009.

Blanke, M.M, and A. Kunz, 2009: Beschreibung des rezenten Klimawandels und sein Einfluß auf Kernobst am Standort Klein-Altendorf. Erwerbs-Obstbau (Springer Heidelberg) 51 (3), 00- 00 (in print)- special climate change edition