SPECIAL EDITION

UNDER THE SPONSORSHIP OF THE FOUNDATION FOR RESEARCH ON BIODIVERSITY (FRB) AND THE CONSORTIUM CLIMATE-ENVIRONMENT-SOCIETY

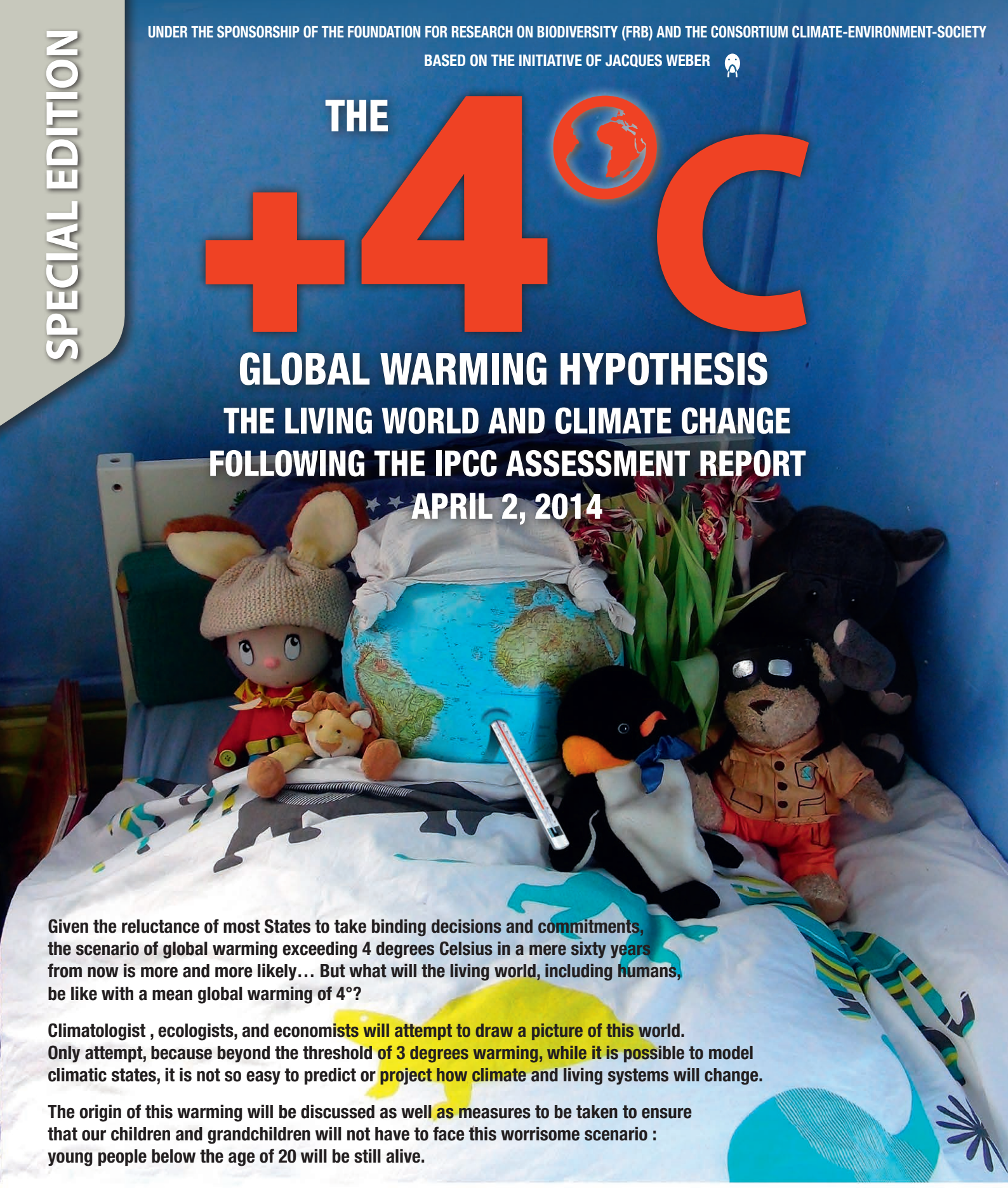
BASED ON THE INITIATIVE OF JACQUES WEBER

THE +4°C

GLOBAL WARMING HYPOTHESIS

THE LIVING WORLD AND CLIMATE CHANGE FOLLOWING THE IPCC ASSESSMENT REPORT

APRIL 2, 2014



Given the reluctance of most States to take binding decisions and commitments, the scenario of global warming exceeding 4 degrees Celsius in a mere sixty years from now is more and more likely… But what will the living world, including humans, be like with a mean global warming of 4°?

Climatologist , ecologists, and economists will attempt to draw a picture of this world. Only attempt, because beyond the threshold of 3 degrees warming, while it is possible to model climatic states, it is not so easy to predict or project how climate and living systems will change.

The origin of this warming will be discussed as well as measures to be taken to ensure that our children and grandchildren will not have to face this worrisome scenario : young people below the age of 20 will be still alive.

SPEAKERS

GILLES BOEUF - HERVÉ LE TREUT - SYLVIE JOUSSAUME - JEAN FRANÇOIS SOUSSANA - NATHALIE FRASCARIA-LACOSTE - FRANCK LECOCQ - DANIELLE NOCHER

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HOW WILL A +4° WARMER WORLD AFFECT LIVING ORGANISMS?

Gilles BOEUF

Professor at the Collège de France, Chairman of the national Museum of natural History (MNHN) and Senior Expert of ORÉE

The IPCC assessment report forecasts a 4°C global warming for 2060-2100 which is the topic of our symposium. Temperature has a very significant influence on living organisms. From the origins of life up to the Triassic period (200 million years), animals had the same body temperature as that of their external environment, but went on to become spontaneously homeothermic, i.e. with a constant body temperature independent of the external environment. They are nevertheless very intimately temperature-dependent. Human beings are also totally thermoregulated. The heatwave of 2003 led to 15,000 deaths in France, most of them in the north, and doctors still remember the deep physical and mental suffering of those they received in the hospitals. The 2009 heat wave that killed 100,000 people in Russia sparked the wildfires in Ukrainian wheatfields which led to food riots.

On Earth the natural thermal extremes range from -89°C in Antarctic ice and -1.86°C in the ocean to around 60°C in the air and 350°C in hydrothermal springs. For living organisms, they range from -80°C to 150°C in the case of extremophilic bacteria. Among the warm-blooded animals, some birds can survive in groups at -60°C in 200 km/h winds in the Antarctic. In high mountain areas or in very cold areas psychrophilic organisms survive in temperatures between -50°C and 0°C. Human beings are mesophilic and thrive in average temperatures of 0°C to 35°C; thermophiles live at temperatures of 35° to 60° and hyperthermophiles go even further. Temperature is therefore an essential abiotic factor.

The Earth supports life because its mass and distance from the Sun enable the presence of water in its three forms: ice, water vapour and liquid water. All life forms are in fact made up of water - human beings themselves are made up of two thirds water.

Temperature also accelerates chemical reactions. Because of its physiological needs, in order to breathe a goldfish must draw in 1 litre per hour over its gills in 5°C water whereas it needs to draw in 1 litre per minute at 30°C. Likewise, the growth and behaviour of trout are dependent on water temperature: they only live in rivers in the south of Norway but have to travel as far as the North Sea. Temperature therefore determines the geographic growth and distribution of these non-thermoregulated animals: the higher the temperature, the less distance they travel. Temperature also has an influence on the sex-ratio of certain animals such as crocodiles.

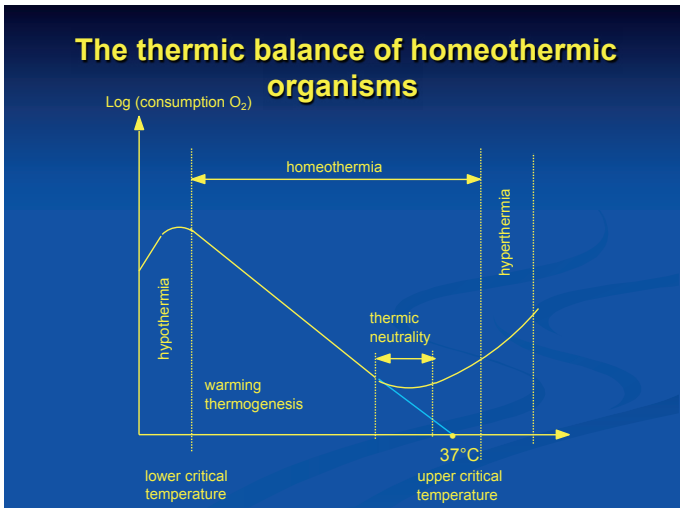
In common with all thermoregulators, human beings are limited in their capacity to maintain a constant temperature. This capacity is asymmetrical which means that man withstands hypothermia better than hyperthermia. Some animals can live at temperatures in the vicinity of absolute zero, but the heat record is only 150°C for bacteria in hydrothermal springs.

Biodiversity is reducing for a number of reasons: pollution, the destruction of ecosystems, the spread of invasive species, overexploitation and also climate change.

The current temperature change is taking place too fast for animals to be able to adapt. A very good example of participative science has shown that over the last 18 years, European butterflies have had to cover 114 kilometres and birds 33 kilometres to the north to find their optimum temperature. If the global temperature rises by 1°C, to do this they will have to cover 250 kilometres to the north (Nature Climate Change, January 2012).

Lastly, the frequency of the El Niño phenomenon is expected to undergo considerable variations due to the change in surface temperature in the South Pacific Ocean and wind-inversion. This will result in the depletion of stocks of pelagic organisms in coastal areas, and thus of the sea birds which feed on them and the fishermen who catch them.

Living organisms are therefore extremely temperature-dependent, whether or not they are warm-blooded. Many emerging diseases could also be linked to these specific changes.



From Hermann and Cier, 1976

PUTTING FACE ON CLIMATE CHANGE: MID LATITUDES

Hervé LE TREUT

Director of the Pierre Simon Laplace Institute and Review editor of the Intergovernmental Panel on Climate Change (IPCC) Group 2 report

During my last discussion with Jacques Weber I mentioned how difficult it was to make 4°C warming forecasts. The future is filled more with risks than with entirely forecastable phenomena. The IPCC Group 2 report makes strong use of methodology in order to comprehend these territorial and systemic impacts of climate change and how to protect ourselves against them. This development of a capacity to reduce our state of dependency with regard to climatic hazards is actually known as “adaptation”.

This adaptation has often been considered as a defence process too dangerous to mention, as some would see it as an alternative which would exempt us from reducing greenhouse gas emissions. But it becomes necessary when faced with the inescapable character of the changes which inevitably result from the continuing increase in CO_2 emissions, which is itself linked to the increasing number of people capable of producing these emissions.

Of course, adaptation is not enough: according to the results of modelling presented in the latest IPCC report, limiting the warming to 2°C means not exceeding the current level of greenhouse gas emissions and even reducing them by a third by 2050, or even moving to negative emissions from 2080.

But adaptation does make it possible to consider the practical consequences of global warming on the scale of a country like France, and here we come to the subject of my presentation – even though the passage from a global diagnosis to local consequences is difficult due to the accumulation of uncertainties inherent to the different scales of space.

All the models agree with the forecast of a global warming all over the planet, except perhaps in the region of the Gulf Stream. The direct consequences of this warming are multiple (ice melt, sea level rise, impacts on vegetation and living organisms) and correspond to the most forecastable part of the changes to come. The currently observed changes which confirm the forecasts of models over the last 50 years make them all the more predictable. On the other hand, it is much harder to forecast indirect consequences such as local rainfall, even though the models — which are mostly in disagreement as to the consequences of a moderate 2°C warming — converge more closely in the case of a four-degree warming.

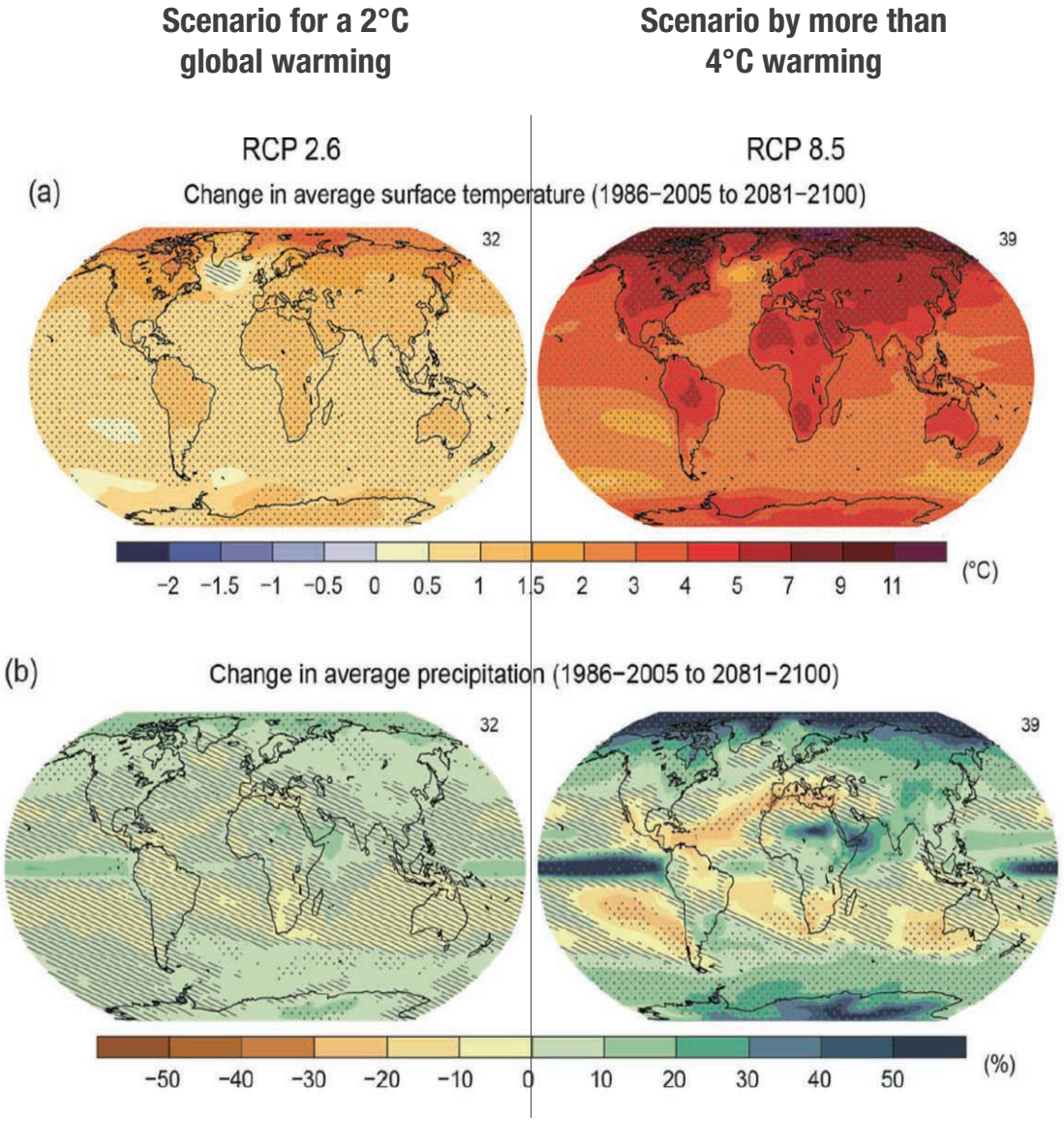
This stems from the fact that climate change will upset the natural variability of the climate system (and atmospheric circulation), creating new risks which will often occur as surprise events. This is why the IPCC report insists on the notion of vulnerability to continental or local climate risks, the adaptation being defined with regard to risks rather than sure forecasts.

I have chosen to illustrate this approach by mentioning a collective work on the scale of the Aquitaine region which highlights a series of risks in a practical manner. There are for example health risks which could recreate and amplify situations experienced in a more or less remote past: during summer heat waves, Bordeaux is often the hottest region in France. A situation which is bound to recur frequently. We must remember that the Landes was subject to malaria in the past and that a warming could recreate conditions for vector-borne diseases. On a regional scale, all the risks are interconnected: health risks and water erosion risks conceal economic and pollution problems, etc. One of the major challenges for Aquitaine, besides the preservation of a rare agricultural heritage with vines and forests, bears on the protection of fragile environments such as the mountains and the coast whose natural evolution may be strongly modified in the scope of climate change.

If one takes the coast as an example, even if it is difficult to detail the changes according to events, adapting to climate change implies first and foremost more respect for natural conditions, for example by preserving dunes to help protect towns. Lacanau, originally a seaside town, is currently considering retreating behind a dune belt. The coast also illustrates the limits of adaptation: in a four-degree warmer world, many low areas in Aquitaine or elsewhere incur a real risk of submersion. The building of seawalls is often only a temporary solution as the only real adaptation consists of retreating, a situation which must be anticipated as early as possible.

Mountain areas are also a very fragile environment, which poses the very real problem of threats to living organisms because altitudinal zonation is temperature-dependent. New species appear while others disappear, and this will create new problems. Should the objective of a natural park be to preserve traditional endemic species or to allow species from elsewhere to establish themselves on its territory to survive? Moreover the mountains are a zone of economic transitions which are also sensitive to climate change.

The Aquitaine study has revealed that there is a wealth of information about possible evolutions on the scale of our regions, but that it is only very partially used by public authorities. Regions are also places which make it possible to better understand the necessary reduction of greenhouse gas emissions, which requires energy saving in habitat, transport and territorial policies. Even if global policies and negotiations are indispensable, a territorial filiation of attitudes and actions is all important to interest and motivate citizens in the face of the challenges which lie ahead.



Legend :

The colours show the average of the models which were part of the international CMIP5 exercise and were included in the 2013 IPCC Group 1 report.

The small dots show an agreement between models on local changes, the oblique bars a disagreement. It is much harder to forecast precipitation.

CLIMATE CHANGE, BIODIVERSITY AND AGRICULTURE

Jean-François SOUSSANA

Scientific Director for the Environment at the National Institute of Agronomic Research (INRA) and Lead author of the IPCC Group 2 report

Climate change is reflected not only by an increase in temperature, but also by the strong variability of temperatures and rainfall. The planet recently experienced extreme heat waves in Western Europe, Russia and the United States, resulting in forest fires and the loss of crops. The floods which struck England very recently also represent a threat to crop production.

Climate change has reduced progress in wheat and corn yields over the last 30 years. It leads to pressure on global agricultural prices, even if the fluctuating price of oil also has a role to play in this. Climate change is also linked to forest dieback, particularly in Europe. The speed of warming exceeds the migration capacities of animal and particularly plant species and limits their adaptation. Variations in plant phenology and the behaviour of animal species have been well-researched, and have resulted in a modification of farming practices: for example, in Châteauneuf-du-Pape the grape-harvest has thus been moved from late September to the end of August.

The recent IPCC report presents the first consolidation of the indicators of changes observed in all sectors: physical systems (snow and glaciers, water, coastline), terrestrial and marine ecosystems, biodiversity, food production and lifestyles. In Europe, the effect of climate change has been confirmed on snows and glaciers but is more difficult to ascribe in the case of water resources. In comparison with other trends the effect of climate change is major for forests and fisheries and relatively minor for agriculture.

In Europe a 4°C scenario will result in an increase in the frequency of heat waves and droughts by the end of the century. The impacts are very largely negative on median agricultural yields at the end of the century, with 40% of studies anticipating a reduction of up to 25%. Global warming will therefore halt the progress brought about by agricultural technology and modernisation. The risks of forest fires will multiply compared with the current period, with a significant risk increase towards the north and east of Europe. Climate change will lead to considerable variations in the potential for catching fish and a reduction in the size of catches, and this also concerns the Atlantic Ocean. Coral is already suffering from the considerable negative impacts of ocean acidification and global warming and these impacts should increase in all areas of the world at the end of the century.

Global warming therefore has complex, cascading and mutually interacting impacts: modifications in the extent of snow cover and tree species, increased forest fire risk, atmospheric feedbacks due to an increased emission of methane and CO_2 and a change in albedo. The complex nature of these interactions makes them difficult to understand. Other major changes concern biomes, such as the reduction of forest surface area.

Three major risks have been identified in Europe:

- Floods, and their impacts on infrastructures and populations;
- Water restrictions, and the impacts on agriculture and ecosystems;
- Health, particularly in the case of heat waves.

Adaptation implies a strengthening of “green” and “blue” belts and investing in the forest for its biodiversity as well as its role as a carbon sink. There are a number of solutions available for adapting agriculture in the short or medium term, some of which are spontaneously carried out by farmers while others are the result of planning and selection. INRA is carrying out research along these lines on the varietal adaptation of major crops and grain and fruit quality. INRA’s priority programme focuses on three points: the resilience of agriculture and forest to climate variability, long-term climate projections, and planned adaptation. Lastly, we are working with 21 European countries on research programming in order to strengthen mutual coordination and efficiency.

QUESTIONS AND ANSWERS

Emmanuel GARBOLINO, Lecturer at the Risk and Crisis Research Centre (Sophia Antipolis) of the French Graduate Institute MINES ParisTech

I am currently supporting a doctoral candidate who is working on the synergy between the use of soil, particularly in urban development, and the impact of climate change on the territory. How can public policies integrate the results of research? It is difficult to adapt laws and specifically environmental law to these dynamic phenomena.

Hervé LE TREUT

There is effectively a lack of places where technical know-how can be shared and which are representative of civil society. All too often, the exchanges stay at a general level.

Franck LECOCQ

This is actually an essential issue: the norms must be stable to be predictable but must also evolve according to the climate.

Marie-Christine CORMIER-SALEM, Director of Research at the French research organisation for the development (IRD)

One must insist on the importance of preserving biological and cultural diversity. We have a lot to learn from the way farmers manage drought in Africa, from the genetic diversity of varieties to their crop systems and methods.

Emmanuel DELANNOY, Director of the Inspire Institute

A large number of maps on global warming are still too global and describe phenomena on the scale of very vast regions. The answer needs to be highly contextualized on a regional level. This raises the question of local farming practices and also of the participatory breeding of rare and traditional species, for both crops and livestock.

Jean-François SOUSSANA

I absolutely agree with the last two contributions. Traditional know-how is a factor in achieving resilience. Many experts believe that the diversity of crops and production systems is one answer to increased climate variability.

Lionel LARQUÉ, Executive Secretary of the Alliance between sciences and society

Beyond the sharing of product know-how, research programmes must be built jointly, i.e. have diversified stakeholders take part in their development and implementation.

Hervé LE TREUT

I fully agree with this statement, especially as all the problems are interconnected. On the other hand, interdisciplinary research is still in its infancy.

Raymond ZAHARIAS, Former Programme Manager at the National Centre for Space Studies (CNES)

Reducing greenhouse gas emissions is a good target, but first and foremost we must focus on the obstacles which prevent the reduction of these emissions. This is the debate between informative science which is policy-relevant and a scientific world which could become policy-prescriptive. Bruno Latour thinks the IPCC should become policy-prescriptive. Without going that far, it is now obvious that the debates are carried out in the scope of current rules. What would happen if we changed these rules? A modification of the discount rate would disrupt the prospects for greenhouse gas reduction.

Franck LECOCQ

There is considerable feedback on the existing policies for fighting against global warming which is now being analysed.

Jean-François SOUSSANA

Another example is that of the massive increase of individuals' insurance policies in the United States, following violent storms and flooding, before they dropped to their former level a few years later. This illustrates the difficulty of long-term thinking.

Hervé LE TREUT

IPCC is not sufficient, but it is also important that it should not disappear. Its reports are now unanimously agreed on and are considered to be a cornerstone of the debate.

Georges EMBLANC, Consultant in environmental education for WWF

Transferring knowledge to the general public is a major problem. For example, only two Parisians out of 2.8 million made the trip to attend a public debate on the Crue Seine Bassée flood risk management project.

A 4°C HOTTER EARTH: FOCUS ON THE ARCTIC AND WEST AFRICA

Sylvie JOUSSAUME

Director of the French Consortium Climate Environment Society,
and Review editor of the IPCC Group 1 and synthesis reports

Climate models are numerical models which help us to have a better understanding of the way the climate system works and forecast its possible evolution following a variety of scenarios. These models divide the Earth into "boxes" where they numerically resolve the basic principles of physics to simulate winds, currents, rainfall and the exchanges between the atmosphere, oceans and continents. They allow us to study the impact of human activities such as greenhouse gas emissions. In order to present the characteristics of a climate which is warmer by 4°C, I am going to use the simulations carried out for IPCC which correspond to the business as usual RCP8.5 scenario presented in the recently published IPCC report.

The results of the models show that global warming is not uniform: it is more marked on the continents than on the oceans and stronger in the Arctic where it reaches 8°C or more. Consequently, all the simulations agree on a disappearance of Arctic sea ice in summer which would lead to the risk of highly sea-ice dependent animals becoming extinct. The polar bear has become one of its symbols. Others see a positive element in this as an ice-free sea would offer new sea routes.

All the models also agree on a decrease in rainfall and increased drought in the Mediterranean basin. The trend is not as clear for Sahelian Africa, with a tendency towards decreased precipitation in Western Africa as opposed to an increase in Central Africa. However, in Sahelian Africa the models do not agree and it is therefore still difficult to predict rainfall variation in Africa, a region for which rainfall is a critical need. It is therefore not that easy to determine what a world warmer by 4°C would be like.

Nevertheless, in a 4°C warmer world, Western Africa would undergo a warming of the same order of magnitude. A study carried out by a project from our Consortium (www.gis-climat.fr) on the impact of global warming on farming in West Africa shows a systematic decrease in agricultural yields due to warming; an increase or decrease in rainfall would only mitigate or accentuate this decrease (by 10% to 40%). It indicates that the crucial factor for agricultural production is temperature, and results also show that future prospects are on a very different scale from the modulations already experienced in the past.

A village in North Cameroon

Beyond the impacts of global warming, we must consider the adaptability of societies. Jacques Weber liked to take the example of a population in North Cameroon which is extremely well-adapted to a very arid environment. During a conference organised by our Consortium in May 2010, Jacques reckoned that this population had little chance of withstanding global warming, even in the case of IPCC's most favourable hypothesis. Climate change will drive them down to the plains, a move which will induce conflicts of access to resources, violence and long-distance migrations.

The extent of the challenge posed by climate change is not so much the increase in temperature but more the speed of its progress. The Earth has already undergone more than 4°C warming during the Cretaceous era. At the end of the last Ice Age the Earth also warmed up by 4°C and if we compare this warming to that which is projected in an RCP8.5 scenario, we can see a number of similarities. However, the major difference is that the global warming at the end of the last glacial maximum took place over several thousand years, whereas the RCP8.5 scenario of an increase in greenhouse gas emissions due to human activity predicts an increase in temperature of 4°C in just 100 years! To cope with such rapid changes, the only solution is the drastic reduction of greenhouse gas emissions.

WHY SHOULD WE TAKE ACTION TO AVOID A 4°C TEMPERATURE RISE? AN ECONOMIC POINT OF VIEW

Franck LECOCQ

Economist, Director of the International Research Center on Environment and Development (CIRED) and Lead author of the IPCC Group 3 report

The IPCC assessment report studies various possible global warming scenarios for 2100. In the most emission-intensive RCP8.5 scenario, the annual average temperatures will rise by 4°C on the surface of the Earth by 2100. This scenario shows an extremely rapid progression: the increase will already be 2°C more in 2060 and will progress beyond 2100. The deadline may seem remote, but my children will grow old in this context and my grand-children will experience it. In this scenario, climate forcing will be a major factor of this future society. Such a temperature increase would also exceed nonlinear thresholds.

What would the economic consequences be? The Working Group 2 contribution to the IPCC assessment report points out the fact that there are few studies on this subject. However, in the small number of studies listed, human consumption would decrease by between 1.5% and 4.5% for such temperature increases, in comparison with a climate impact-free world. Let us set aside the questions of methodology that these figures pose and accept them as they are for the time being. The important point is that they can appear to be low in view of the economic growth scenarios listed by Group 3, in which the future average consumption per head in 2100 is between 3 and 7-8 times higher than it is today. Even if consumption only "tripled" and there was 10 % climate change damage, our descendants would remain on average 2.7 times richer than we are. Under these conditions, should we not be investing in more urgent issues than climate change? Economists such as Thomas Schelling have defended this position, which to me seems a dangerous one.

Firstly, will we be that much richer in 2100 in the RCP8.5 scenario? If economic growth is very high and it leads to significant greenhouse gas emissions, fossil energy resources will rapidly be exhausted and their price will increase. This in turn will lead to increased pressure in favour of energy efficiency. We therefore need to be very optimistic about the abundance of cheap fossil resources in order to make sense of high economic growth and high emissions. The RCP8.5 scenario can in fact also be reached in a world with a vast population, much slower economic growth, very little technological progress and low energy efficiency. Therefore, a 4°C warmer world does not necessarily imply high growth, in fact quite the reverse.

Moreover, the calculations based on a growth scenario with no climate change impact, as recorded by the IPCC Group 3, on which the 2100 impacts listed by Group 2 were then superimposed, show obvious limits. It is rather as if we were acting as if the two processes were independent from each other, despite the fact that we know that climate change will have a continuing effect on the growth process. For example, variability and climate shocks play a very important role, but in a way which is not yet fully understood (this explains why the models used by Group 3 run cautiously with no impact). If the interaction between growth and climate change were to be taken into account, it is likely that it would lead to a final growth which is lower than the growth projected by the Group 3 scenarios.

Next, a 1.5% to 4.5% decrease in consumption is an average which masks considerable disparities from one region to the other. It must also be remembered that the impact of the Second World War on global consumption was 5%. The changes resulting from climate change are actually not marginal but structural changes: whole sectors can disappear, as for example tourism in middle and high mountain areas. The development paths of whole territories are therefore likely to change significantly. But history shows that it is difficult to manage transitions on a territorial scale.

Lastly, anticipating impacts costs much less than reactive adaptation, especially as we will not be able to adapt to the irreversible damage. Adapting means reducing all the risks all over the territory and in all sectors and the very sharp asymmetry between the two is encouraging us to work on reducing greenhouse gases.

In conclusion, even if the estimations of the economic impacts of the 4°C temperature increase may at first glance seem low– and I must reiterate that these studies are still few and far between – the economic analysis offers solid arguments for action and adaptation as well as mitigation. It also highlights important knowledge gaps, specifically as concerns the interaction between climate change and growth on the one hand, and the systemic impacts of climate change on the other.

2070 AND +4°C

Nathalie FRASCARIA-LACOSTE

Professor at the French Graduate Institute in Science and Engineering AgroParisTech, Assistant-Director of UMR 8079 Ecology, Systematics and Evolution, and Senior Expert of ORÉE

Our current conceptions of the future are founded on very isolated, controlled and probably out-of-date projections. Scientists actually work on stable contexts, but here we are faced with a complete dislocation of our basic references. Therefore we have to reinvent, redraw and recreate. In 2008, Patrick Lagadec wrote: *"The shocks which will accompany the new worlds of risk will require operating methods that will no longer be able to rely on our visions of a government providing solutions for inert groups of human beings anaesthetized by media crisis communication."*

A change of paradigm is necessary. Groups of human beings must try and collectively find the answers to the challenges they are going to encounter. In 1993, Jacques Weber wrote: "to govern is to foresee". To his way of thinking, it was necessary to rethink the logic of governance to conduct human affairs collectively, reinvent stakeholder responsibility and the functioning of leadership.

To Jacques' way of thinking, the idea of this conference was to enable the collective development of probable futures or alternative visions of the future in order to anticipate mutations, forecast their effects and talk about them in the form of stories. Einstein said that in times of crisis imagination is more important than knowledge, so let's take a leap forward in time to understand the exercise.

Here is my story:

"Today is April 2 2070. The sea level has risen drastically all over the world, resulting in vast human migrations. The world's seven deserts have spread by 40% and drinking water has reduced dramatically despite progress in desalination. The use of coal, combined with the unfounded hopes and miscalculations for the underground storage of carbon, has led to a CO_2 concentration in the vicinity of 900 ppm. The air has become difficult to breathe and fuel oil has tripled in price. The springs have dried up and dramatic reductions in the use of nuclear energy have been recorded. Sulphur and nitrogen deposits in the forest are less worrying than those of heavy metals. The extreme temperatures cause ozone peaks practically every day. Invasive species, more frequent droughts and the soaring need for heating wood has destroyed the forests. We are therefore living in extreme conditions, not to mention wars and rising poverty…"

I will conclude with these lines written by Jacques Weber in 1991: *"Rethinking development implies thinking about the very long-term objectives allocated to growth, from the moment that these are no longer provided. But these objectives cannot be quantitative (indeterminacy of the future, variability and uncertainty). They must be formulated in terms of goals and can only be ethical choices. These choices must dictate what sort of planet we want in the very long term; and the environment is one which is really not suitable but is the one that everybody uses, these objectives must dictate who we want to use the world.*

It is only from such choices that we can examine the paths to follow and the actions to undertake and how to implement these in the short and medium term.

Adaptative management of this kind will require considerable efforts to be made towards understanding on the one hand the variability of natural systems and on the other the mechanisms by which societies can adapt to this variability.

Therefore, economics must once again become political economics: studying the relationships between people with regard to material things would help to qualify the criteria by which political economics claims to allocate them as effectively as possible, and in doing so, would interact with the other social sciences.

Economics, law, sociology and political science are also involved. Taking into serious account the objective of growth leads us to consider disciplines as of secondary importance: the subject-matter of the question is more important than questioning the subject-matter itself. It is imperative that the very long-term choices are made and they will be made as soon as growth loses its objective.

Social science will either contribute by means of supported and rebuttable arguments or it will become laden with fanaticism of all kinds, whether profit-based or religious fanaticism".

DEBATE WITH THE PUBLIC

Christian VICENTY, Head of Operations in China and Russia for the General Directorate for Competitiveness, Industry and Services (DGCIS) of the Ministry of Economic Regeneration

Has IPCC modelled the evolution of the methane-producing Siberian permafrost which is a factor accelerating the greenhouse effect?

Sylvie JOUSSAUME

The effect is thought to remain limited. Nevertheless, the models do not include permafrost which we are still trying to understand and represent.

Hervé LE TREUT

IPCC does not carry out research itself, but develops existing research. Besides, methane is still a relatively recent research subject.

Muttiah YOGANANTHAN, Joint Manager of the Métamorphose Cooperative Society

IPCC economists always consider that growth means wealth. As Jacques Weber used to say, we need to put the economy back into the environment, don't we?

Franck LECOCQ

IPCC is the result of existing research, of which a large part continues to use classical indicators such as the GDP. Studies are beginning to use other metrics measures to evaluate the impacts, but here again this field of research is still not highly developed. Integrated modelling work aims specifically at standardising the different representative elements of the economic system and the operating of the technical system. The approach is very complex, but climate change has been a major stimulus for the development of this type of research.

Thierry DEDIEU, Head of Climate Department at the French Democratic Confederation of Labour (CFDT)

I was struck by the insistence on the local level for adaptation. Is adaptation compulsory and if so, to which scenario? Does mitigation take place on a global level?

Jean-François SOUSSANA

The local character of adaptation can be explained by the diversity of the systems involved, but it poses global questions in all sectors and in all the regions of the world. Moreover, the adaptation efforts of isolated stakeholders such as farmers are not sufficient in regard to the challenges. They require effort to be made in research and development, governance and even insurance. All these dimensions overlap. Mitigation itself requires the opening of a global dialogue.

Gilles BOEUF

Adaptation means adapting to an event which has already occurred. In this case, it should be more a case of "pre-adapting", i.e. setting up the conditions necessary to be able to react in a timely fashion. Time is of the essence here. A politician is elected for a few years whereas the issue concerns the whole planet for a very long time.

Hervé LE TREUT

The advantage of the local approach is that it concerns members of the community, and as such it is often faced with representational problems: representing climate change requires practical representations. In addition to this, the individual raising of awareness to these issues does not sit well with international negotiations.

Jean-François SOUSSANA

You have to know how to communicate on uncertainties and variabilities. The scientific community should work on the means of giving the population a practical perception of these phenomena. In agriculture, which is our field, we are considering setting up a portal on adaptation which would enable the general public and professionals to formulate in a practical sense the consequences of adaptation measures according to a given scenario. The term of «pre-adaptation» must not conceal these changes that are already taking place.

Geneviève ANCEL, Coordinator of the Dialogues en humanité non-profit organization

We get the feeling that the higher you rise in institutional responsibilities, the more you are in denial. On the other hand, do we really have enough faith in the capacity of our fellow countrymen to imagine a desirable future?

Franck LECOCQ

Non-professional bodies bear some responsibility for this. They may play a considerable role not only in the dissemination of information, but also for the exchange of ideas and good practices and the defining of common strategies. For example, the foresters were mobilized very early on as they were already suffering from the effects of climate change.

Sandrine BRIGAULT, Hydrogeologist, teacher and scientific mediator

Could the economic and industrial world not have duties towards territorial humanity? We need local and adaptative laws. The scientific, political and responsible world must not leave room for fanaticism. What can we do to make sure that the transition is made peacefully? Why not organize symposiums where citizens and elected representatives could share their ideas with scientists?

Gilles BOEUF

Scientists reach out to citizens. For example, the Museum is launching participative science activities. The problem is how to reach those who do not attend conferences and never open the environment pages of their newspaper. Moreover, these initiatives

do not actually help us to improve our relationship with the political world. Private enterprise and associations must also help in lobbying. Robert Barbault and Jacques Weber played a considerable role in this.

Nathalie FRASCARIA-LACOSTE

The scenario I presented is only one of several. It was actually provocative and intended as a homage to Jacques Weber.

It is based on co-construction which consists of associating scientists, managers, sociologists and philosophers in order to pinpoint new fields of research on which to work. This concept is used a great deal in English-speaking countries.

Emmanuel DELANNOY

As Antonio Gramsci said, "the pessimism of knowledge does not prevent the optimism of action". Current intellectual poverty is terrifying. We really must get down to work in order to make sure that everyone has a future.

Lionel LARQUÉ

We must go beyond interdisciplinary dialogue and gather together all the social, intellectual, political and economic forces to meet the challenge posed. In contrast to centuries past, the vast majority of social and economic stakeholders now respond to reason, basing their work on strategies of a rational nature.

Hervé LE TREUT

The observations made today rely on the continued emission of greenhouse gases. We have not broached transition scenarios or solution areas, which give rise to fairly strong dissension. They are actually an expression of mental blocks and ignorance. In a CEVIPOF poll, 70% to 80% of those surveyed believed that global warming is important, but fewer than 20% identified greenhouse gases as the possible cause. Therefore, the general public is not aware of the conceivable remedies.

Jean-François SOUSSANA

Today we are in line with Jacques Weber and the 4°C warming scenario. Many other trajectories are possible. Among them are available measures which could divide greenhouse gas emissions by four or which could preserve biodiversity. It is important to present these solutions too.

Hélène LERICHE, Head of Biodiversity of ORÉE

Thanks to the contributors, whom I would like to thank, the symposium has talked a lot about citizens, scientists and politicians. Businesses are also stakeholders in the debate. All the initiatives and ideas must be valued in order to build other possibilities.

Claire TUTENUIT, Director General of the Companies for the Environment non-profit organization (EPE)

Jacques Weber often used to complain that biodiversity was not sufficiently talked about and that public awareness is dependent on biodiversity. Those who see migrating birds return in January can only conclude that there is an enormous change under way.

CONCLUSION

Gilles BOEUF

The mission of researchers is to clarify the current important questions on scientific foundations. We do not intend to come over as defeatists, but we want to encourage people to roll up their sleeves. Neither is it a question of accusing past generations: we are all the sum of past history. The scientific world must support its comments but it cannot always guarantee them as there are often doubts. Participative science gives citizens responsibility and raises awareness by encouraging collaboration between scientific and public spheres.

On the other hand, every ecological evolution has social impacts. The questions raised today are urgent: change is already under way and this acceleration is the main thrust of the problem. Temperature change, ocean acidity, fishing resources, agricultural yields and new pathologies are all emerging problems which must encourage us all to react better together.