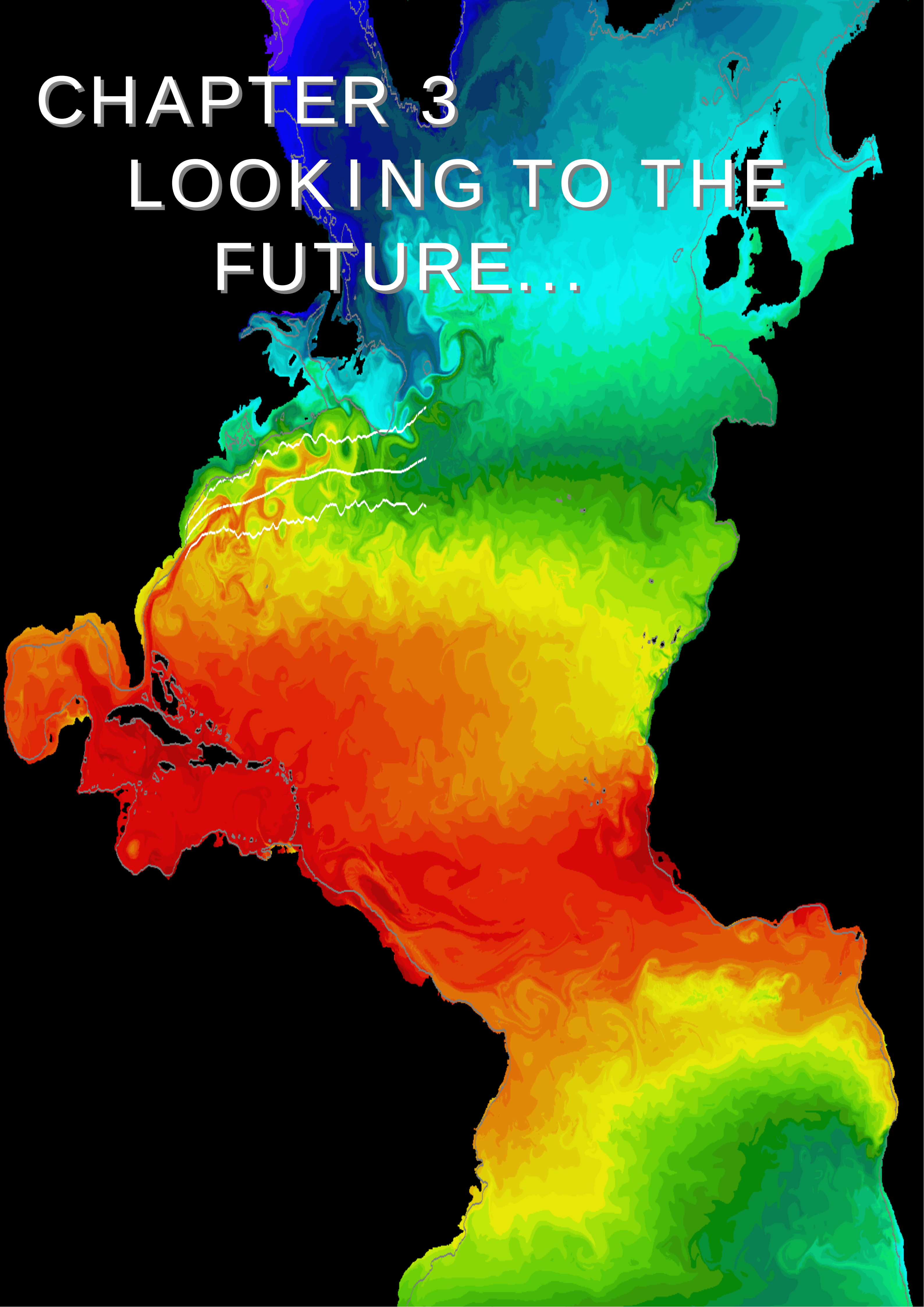
CHAPTER 3
LOOKING TO THE FUTURE...



CHAPTER 3 - LOOKING TO THE FUTURE

Nearly every day a new report seems to be released identifying potential consequences of climate change if we fail to act now. On what are these predictions founded and can we have confidence in them? What do they predict will happen to our planet and our island?

CHAPTER 3 - LOOKING TO THE FUTURE

Global Climate Forecasts

3.1 How do we Predict Climate Change?

3.2 What will Happen in the Future?

3.3 Can we be Confident in our Predictions?

3.4 How will the Global Climate Look in the Future? - Short-Term

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Regional Climate Forecasts

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3.8 How will Jersey's Climate Look in the Future?

The science behind climate change is solid. Observations on a global and local scale show that globally climate is changing and temperatures increasing.

The next question is what will happen in the future? Climate forecasting is not an exact science and predictions are uncertain. However, with ever increasing resources devoted to this topic, forecasting skills are continually improving.

This chapter addresses how computer models are used to predict global climate. It considers the accuracy of the predictions and the confidence we can have in them. We examine the output of the models in terms of climatic influence and human impacts.

The second section examines how regional models are used to forecast climate on a local scale. The UK Hadley Centre's forecasts for the Channel Islands are discussed providing an indication as to how our local climate may change in the coming century.

3.1 HOW DO WE PREDICT CLIMATE CHANGE?

Andrew Casebow

Day-to-day weather variations and changes in climate over long timescales are predicted using computer models. The models simulate the working of the real atmosphere by solving a series mathematical equations based on well-established laws of physics. These laws define the behaviour of the atmosphere and hence our weather and climate, but they only approximate reality.

Two things have helped to improve the performance of weather and climate models in recent years. First, research has increased our knowledge of the real world, which is fed into the models and second, the speed and power of computer calculations has increased markedly, allowing much more detail to be represented in the models. The process of modelling the climate is explained in Box 1.

IMPROVEMENTS IN THE SCIENCE

The climate system is highly complex with many potential interactions and feedbacks. As modelling capabilities have improved, more of this complexity has been included in the models. The Hadley Centre's current 'state of the art' climate models include fully interactive clouds, oceans, land surfaces and aerosols, as well as detailed chemistry and carbon cycle calculations. It is worth thinking about why these processes are important and a few examples are highlighted here:

1. Clouds affect the heating and cooling of the atmosphere.

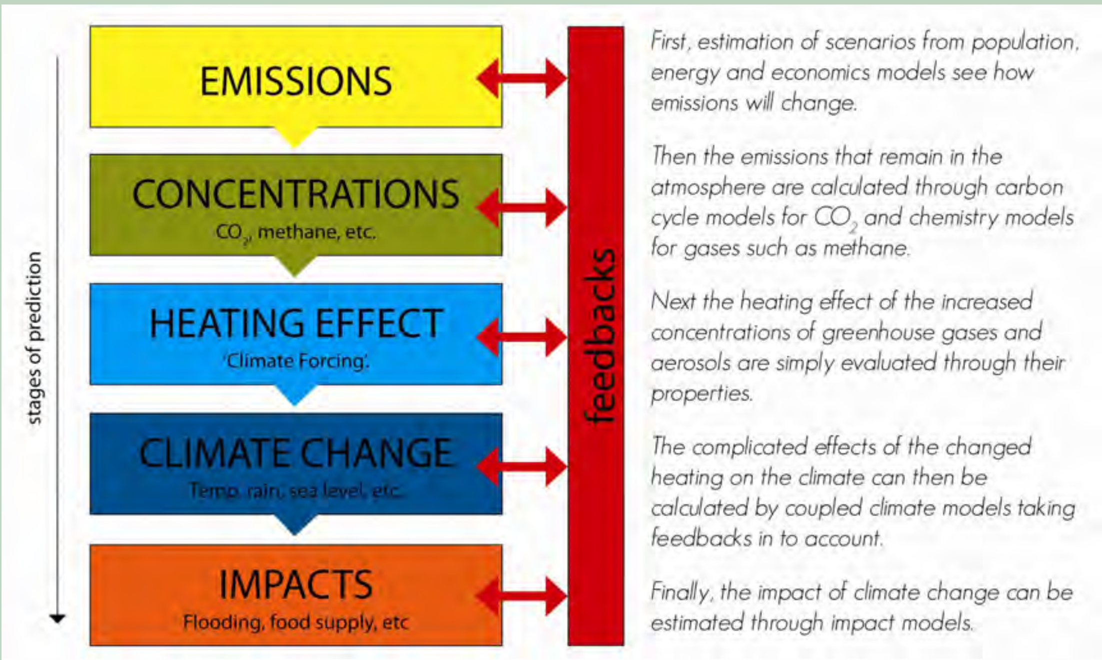
On a cloudy day less radiation (heating) from the sun reaches the Earth's surface, but on a cloudy night less radiation escapes so some of the heat generated in the day is trapped and the temperature near the surface remains relatively warm. The detailed properties of the clouds are also important. Cirrus cloud high up in the atmosphere lets sunlight through but traps infra-red radiation, which stops heat escaping from the surface. Low-level clouds reflect sunlight and trap little infra-red radiation and so result in a cool surface climate.

2. The oceans take much longer to warm up than the land.

They also move heat around the globe. For example, the North Atlantic drift, an extension of the Gulf Stream brings warm water from the Tropics to northern Europe, and has a strong effect on our temperatures.

3. Land surface properties influence how much radiation is absorbed.

Land covered in trees are darker in colour, absorbing more and reflecting less radiation than deserts and ice covered areas for



Box 1

Image Credit: Planet Guernsey and Chris Regan, 2007 instance, which reflect more and absorb less radiation.

4. Aerosols.

These atmospheric particles, such as sulphate and black carbon are produced naturally from volcanoes and forest fires, as well as by humans from fossil fuel power stations and other industrial activity. They have a short term cooling effect by reducing the amount of sunlight reaching the surface (the so-called dimming effect).

5. The chemistry and carbon cycle determines how much CO_2 remains in the atmosphere.

Currently the biosphere (plants, soils, and phytoplankton) absorbs half the CO_2 produced by man. However, this may not continue indefinitely as soils could start to release carbon if temperatures rise too much.

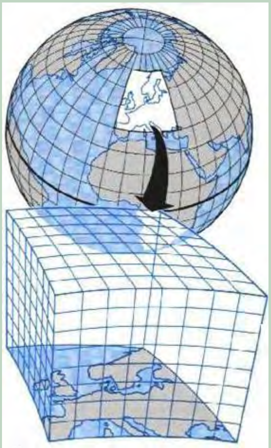
THE RESULTS

Dr Vicky Pope, Head of the Climate Predictions Programme at the UK Met Office's Hadley Centre notes: *"The latest computer models predict similar possible global average temperature changes to models used five or ten years ago, but we are much more confident that they are correct, because they are based on so much more information."*

Now that man-made climate change is established beyond reasonable doubt and further global warming is inevitable, it is even more important to improve predictions of climate that we are likely to experience in future.

How have climate models developed?

(a) An example of an early computer used for climate modelling, even room-filling machines had less than 1% of the power of a 1990's laptop.



(b) As computing power and modelling skill improved the globe was first broken into a flat grid to create two dimensional models before improvements to technology and knowledge allowed 3D representations with interaction between vertical layers. Models of the ocean and atmosphere were eventually linked to allow heat exchange.

(c) Supercomputers worth millions of pounds are now used for climate modelling. Despite the high processing power models can still take days to complete a run due to the number of calculations required.

(d) The findings of climate models are now integrated into other models called 'impact models'. These models determine how factors such as ecology, the economy or available resources (e.g. crops) may change in response to the climate.

3.2 WHAT WILL HAPPEN IN THE FUTURE?

James Le Ruez

We are all familiar with campaigns to encourage us to lessen our contribution to climate change, be it as simple as turning down a thermostat, switching off equipment or taking the bus to work. However, due to the existing greenhouse gases in the atmosphere we are already locked into a certain degree of climate change. Even if all greenhouse gas emissions stopped tomorrow, we would still see the effects of climate change for many years.

The inevitability of these changes is due to thermal inertia, mainly from the oceans, where heat is released into the atmosphere long after it is absorbed. The long lifetime of CO_2 and other greenhouse gases means that their effect will continue for many years.

With current atmospheric greenhouse gas concentrations, models suggest average surface air temperature would increase by about 0.5°C by 2100 and 1°C by 2400. Sea levels would also increase by 11 cm by 2100 due to thermal expansion alone and continue to increase by approximately 10cm a century. This projected increase is more than twice the 5 cm rise that has occurred since the 1950's. In addition, fresh water from melting ice sheets and glaciers could at least double the sea level rise caused by thermal expansion.

However, we know that carbon emissions will not stop immediately and climate change predictions must try to account for future emission changes.

If we assume they continue at the current level, models suggest warming of between 2° to 6°C by the year 2400 and a sea level increase of about 25cm a century.

EMISSIONS SCENARIOS

It is highly unlikely that emissions will remain at their current level. Developed nations continue to use increasing amounts of energy and recently carbon emissions from less developed nations such as India and China have risen markedly. On the other hand, energy efficiency is improving and some fossil fuel supplies are becoming less abundant. Conflicts and political instability can also have a major effect upon the availability of fossil fuels.

A Global Scenario

It is difficult to determine a specific global storyline (see opposite page). Although Britain is moving towards an A1T or B1 scenario China's dependence on coal means it fits into the A1FI story-line.

The fourth IPCC Assessment Report models use four scenarios with six assumptions depending on the nature of future economic development and whether energy and fossil fuel usage remain high or decrease. The likely greenhouse gas emissions associated with each scenario are fed into climate models to determine the climatic impact of each (see Box 1).

CLIMATE IMPACT MODELS

Recently, scientists have taken a different approach, reducing the complexity of the climate aspect of models to incorporate other considerations in more detail. This frees up computer power to allow greater analysis of the impacts of climate change for example, on population, whether rainforests flourish or decay in different atmospheric conditions and how food crops may benefit or suffer. Economic aspects such as demand and availability of oil and gas and the resultant price changes can be factored into the models by altering the emissions of greenhouse.

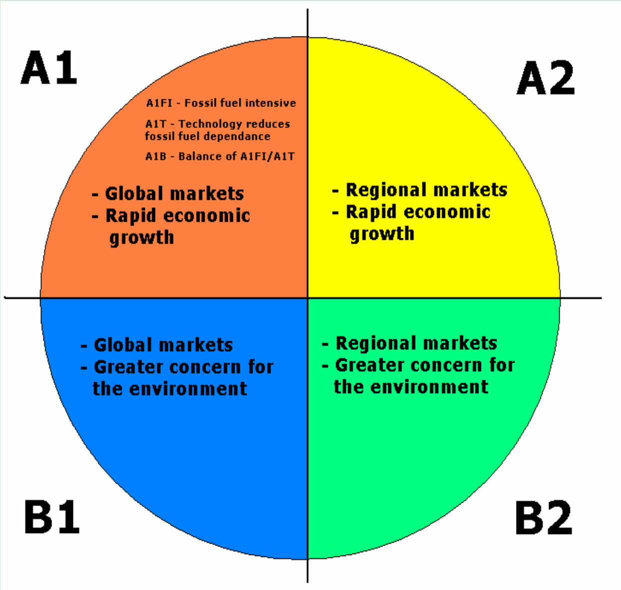
Box 1
What are the scenarios?

(a) The IPCC have issued a Special Report on Emissions Scenarios (SRES). The different scenarios can be thought of schematically as a circle split into four segments.

The upper half of the circle are the ‘A Scenarios’ and these represent a future where there is rapid economic development over the next 100 years. The lower half of the circle are the ‘B scenarios’ and these indicate a world where the environment’s well being is of greater importance than economic growth. The circle can also be split into its left and hand side.

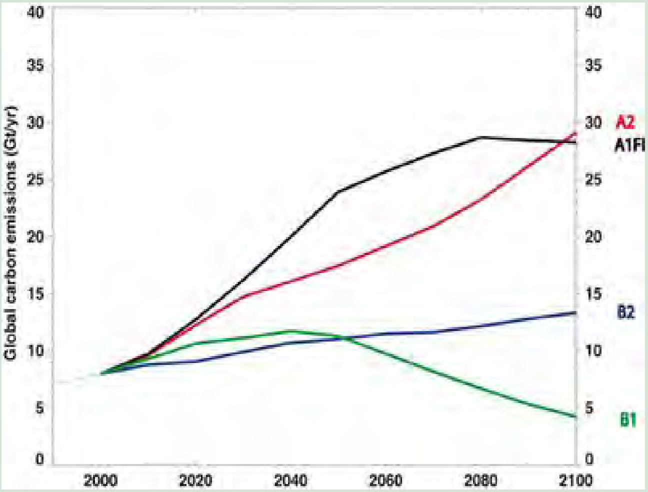
The left hand side, the ‘1 scenarios’ represent a future where development is global in scale. This is compared to the right hand side, ’the 2 scenarios’ where development is focussed regionally. One scenario is not considered any more likely than another and importantly, none of these scenarios include consideration of global warming mitigation initiatives.

(a)



(b) This plot details the emissions of carbon dioxide each year until 2100 for both the two lowest and two highest emission SRES assumptions. The B1 scenario results in the lowest emissions with annual emissions beginning to fall by 2040. The A1F1 scenario is the only other scenario where annual emissions peak by 2080. This is due to the high use of fossil fuels until now, meaning the supply of these fuels has reached a maximum and can no longer be sustained. As the A2 scenario does not suffer from this over-use, revealing highest annual emissions by 2100 of nearly 30 gigatonnes CO_2.

(b)



3.3 CAN WE BE CONFIDENT IN OUR PREDICTIONS?

James Le Ruez

ACCURACY

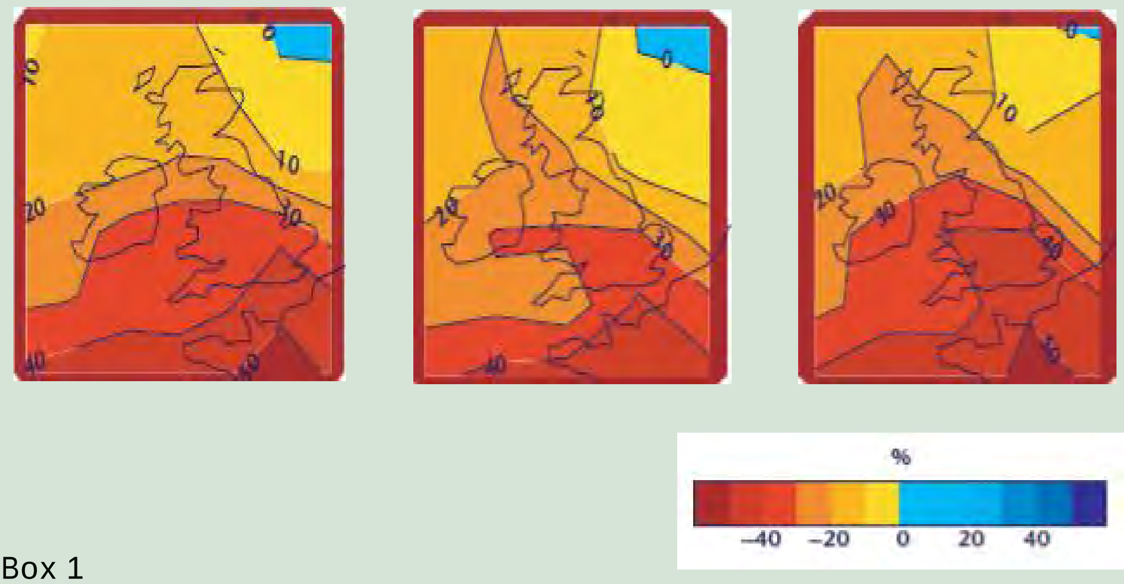
Using a range of starting conditions, all of equal likelihood, in a set of different models, a range of possible outcomes can be determined as shown in Box 1. The closer the outcomes from the different model runs, the greater the confidence we can have that the results produced closely approximate the future.

Despite advances in technology and expertise, climate models do not account for everything. For example, due to the complexity of ice sheet flow, a realistic model of its affects has not yet been established. As understanding of our climate improves further and computer power increases, this and other effects currently excluded will gradually be incorporated in more sophisticated models.

ATTRIBUTION

Models can also be used to attribute known historic changes in climate to certain factors. By running a model from a given time in the past using historical data and including or excluding various forcing factors, we can see how the model forecast compares with what has known to have happened. If a model performs poorly with a certain element excluded, it is clear that element has considerable influence on the climate. Such experiments have highlighted the influence of greenhouse gases in the atmosphere.

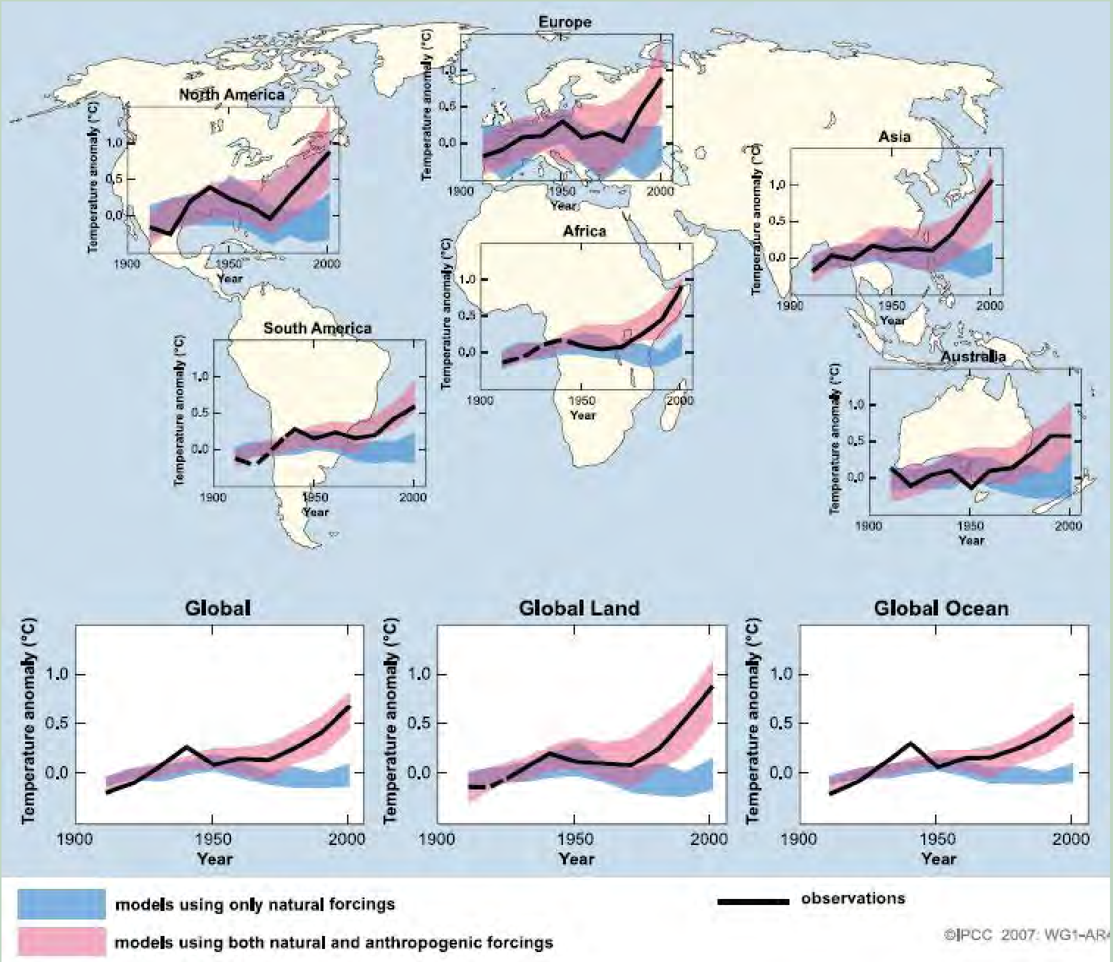
In the SRES scenarios in section 3.2, modellers took 1900 as a starting point and used two scenarios. The first used natural factors only, the other included natural factors and greenhouse gases resulting from human influences. The results of such experiments, conducted by the IPCC are shown in Box 2. They reveal that excluding greenhouse gases results in an inaccurate temperature profile for the last century, supporting the hypothesis that greenhouse gases have had an influence on the climate over the last century as discussed in Chapter 2.



Box 1

One method used to improve the confidence in a model is to use multiple runs. These three predictions of changes in summer mean temperature by 2100 were generated by using the Hadley Centre Regional Climate Model and the output is consistent with similar runs from other global climate models.

Source: Hadley Centre



Box 2

It is *likely* that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica. The observed patterns of warming, including greater warming over land than over the ocean, and their changes over time, are only simulated by models that include anthropogenic forcing. The ability of coupled climate models to simulate the observed temperature evolution on each of six continents provides strong evidence of the human influence on climate.

IPCC CONFIDENCE

The IPCC are very careful in the language they use to identify the confidence in their projections. They use statistical measures to establish the percentage chance of a forecast result being true and link their language to these statistics.

IPCC definitions of probability of occurrence:

Virtually certain: more than 99%
Extremely likely: more than 95%
Very likely: more than 90%
Likely: more than 66%
More likely than not: more than 50%
Very unlikely: less than 10%
Extremely unlikely: less than 5%

Source: IPCC, Fourth Assessment Report, 2007.

3.4 HOW WILL THE GLOBAL CLIMATE LOOK IN THE FUTURE?... IN THE SHORT-TERM

James Le Ruez

The previous articles have highlighted how the forecasts generated by computer models are the result of many decades of scientific experience and represent the best predictions of the future we can achieve. Here we highlight what these models indicate is the most likely climatological outlook in both the short and long term.

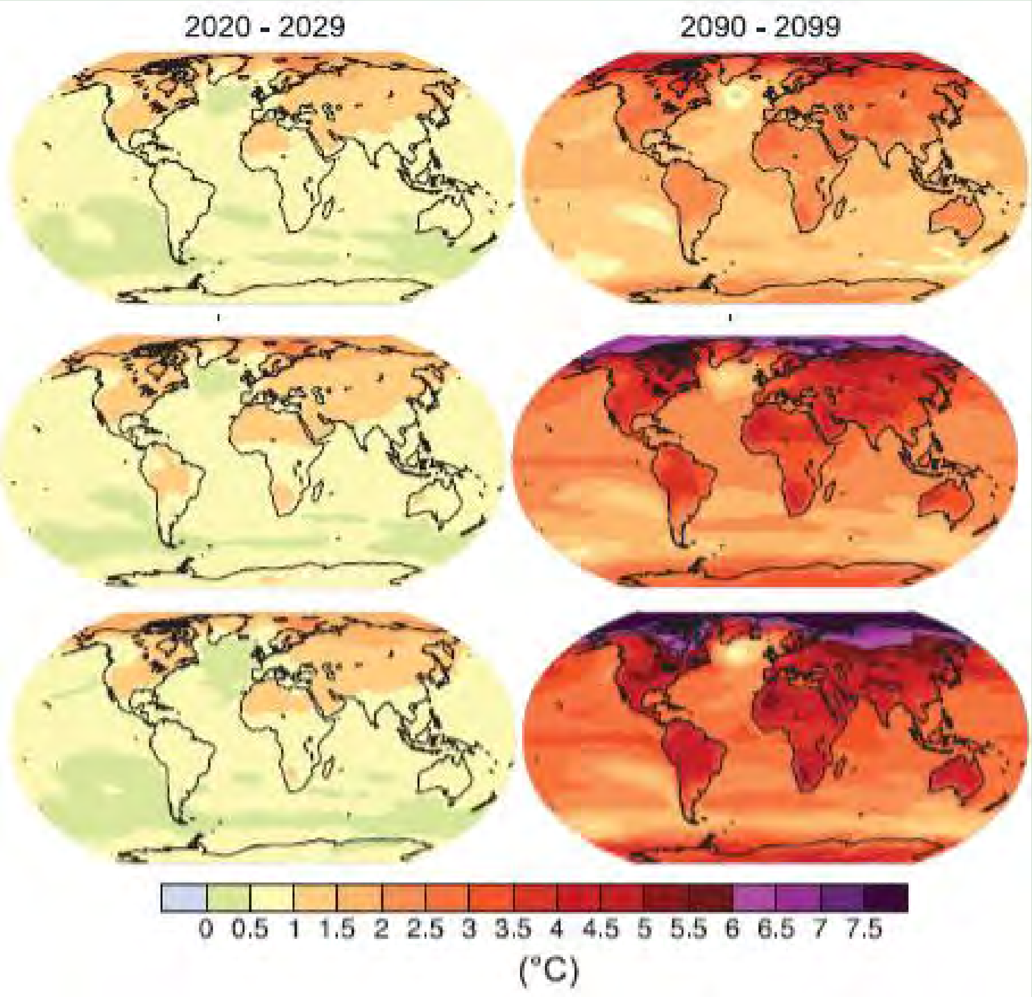
TEMPERATURE

Projected warming in the 21st century shows scenario independent geographical patterns similar to those observed over the past several decades. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean. See Box 1 below.

It is *very likely* that hot extremes, heat waves and heavy precipitation events will continue to become more frequent.

PRECIPITATION AND STORMS

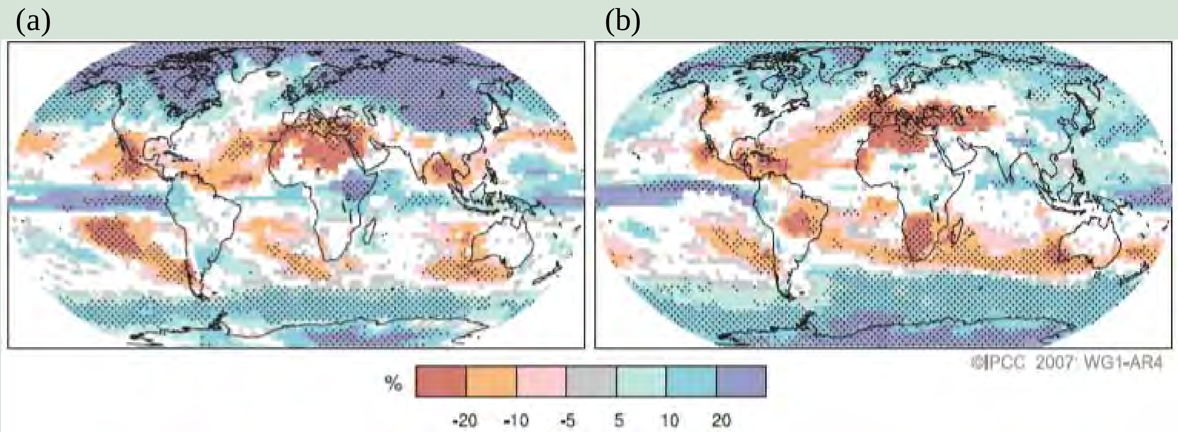
Extratropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half century.



Box 1

Global temperature forecasts under different emissions scenarios, Top = B1, Middle = A1B, Bottom = A2. The greatest temperature rises are predicted to be over land rather than sea and the poles as opposed to the equator. Temperature rise is relative to the 1980-1999 average.

Source: IPCC, AR4, 2007



Box 2
Relative changes in precipitation (%) for the period 2090-2099, relative to 1980-1999. Values are averages based on the SRES A1B scenario for Dec-Feb (a) and Jun-Aug (b). Multiple models were used and white areas indicate regions where less than 66% of the models agreed in the sign (i.e. positive or negative) of the change. Stippled areas are where more than 90% of the models agree in the sign of the change.

Increases in the amount of precipitation are *very likely* in high latitudes, while decreases are *likely* in most subtropical land regions (by as much as about 20% in the A1B scenario in 2100), continuing observed patterns in recent trends (See Box 2 above).

Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

ICE AND THE OCEANS

Dynamical processes related to ice flow, not included in current models but suggested by recent observations, could increase the vulnerability of the ice sheets to warming, increasing future sea level rise. Understanding of these processes is limited and there is no consensus on their magnitude.

If radiative forcing were to be stabilised in 2100 at A1B levels, thermal expansion alone would lead to 30cm to 80cm of sea level rise by 2300 (relative to 1980 – 1999). Thermal expansion would continue for many centuries, due to the time required to transport heat into the deep ocean.

The Meridional Overturning circulation (MOC) is a key process in North Atlantic oceanic circulation including the Gulf Stream Based. Current model simulations predict that it is *very likely* that the MOC will slow down during the 21st century however, It is considered *very unlikely* that the MOC will undergo a large abrupt transition during the 21st century.

Current global model studies project that the Antarctic Ice Sheet will remain too cold for widespread surface melting and is expected to gain in mass due to increased snowfall.

Contraction of the Greenland Ice Sheet is projected to continue to contribute to sea level rise after 2100. Current models suggest that ice mass losses increase with temperature more rapidly than gains due to precipitation.

REFERENCE

Sourced from the IPCC 4th Assessment Report. For the full report go to http://www.ipcc.ch/

3.5 HOW WILL THE GLOBAL CLIMATE LOOK IN THE FUTURE?... IN THE LONG-TERM

Andrew Casebow

Most projections of future climate change focus on this century. The obvious reason for this is that beyond this period relatively accurate predictions become more difficult. They also become less meaningful to most of us when the predictions are for a period of time beyond human contemplation, and beyond the possible lifetimes of our immediate descendants.

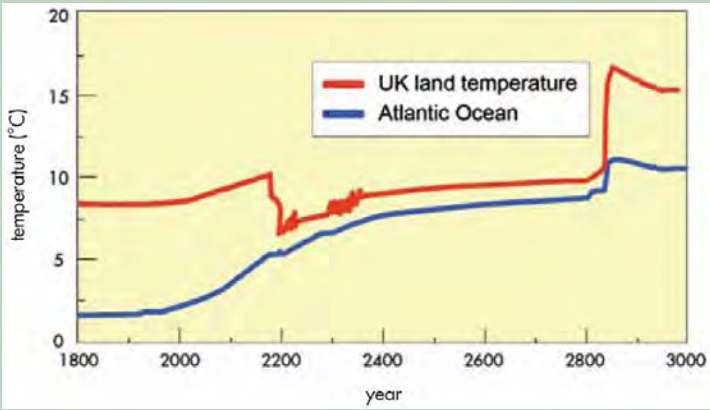
Projections for the period 2080 – 2100 leave the near surface air temperature and sea level still rising, and in some models the rate of change seems to be still increasing. However, climate changes will not stop occurring. If, as many predictions indicate, greenhouse emissions are still increasing, albeit at a slower rate, and temperature increases are still occurring, then where will all this lead?

THE TYNDALL REPORT

In 2006, the UK Environment Agency commissioned a report into climate change over the next 1000 years from the Tyndall Centre for Climate Change Research. This shows that decisions over the next few years by the major greenhouse gas emitting nations (and by us all), will leave a legacy of increasing climate change over the next millennium unless there is a major reduction in emissions.

Obviously the storylines, or possible scenarios, that lie behind the climate change models will vary enormously, and as a consequence the change in the earth's climate could be quite minimal if appropriate long term action is taken immediately, or severe if humanity adopts a 'business-as-usual' approach. The report notes that:

"The most important potential contributor to the long term forcing of the climate system by human activities is the amount of fossil fuel carbon we emit to the atmosphere as the greenhouse gas CO_2. The reasons are that the potential emissions of CO_2 are huge and it has a long lifetime in the atmosphere; even after ~1000 years, at least ~15% of CO_2 emitted will remain in the atmosphere."



Box 1

(a) Abrupt climate change events as seen in the North Atlantic region. Surface temperatures drop about 3°C at around 2200 as the Greenland ice sheet completely melts. At around 2800 Arctic ice disappears and the gulf stream becomes vigorous causing North Atlantic seas to heat by up to 8°C.

(b) Northern hemisphere sea ice area in million square km. Sea-ice rapidly retreats from the Arctic Ocean and at around 2800 it disappears competely.

Source: Tyndall Centre Report (2006)

The report says that by the year 3000:

- Temperatures could rise from 1.5^{o}C (if emissions are minimised) to as much as 15^{o}C (if we continue burning fossil fuels), which is more than double what the IPCC predict on the centennial timescale.

- Only the minimum emissions scenario can prevent global temperatures from rising more than 2^{o}C above pre-industrial levels. This is thought to be the maximum warming acceptable without the risk of long-term dangerous consequences (defined in the report as 'a global sea level rise of 2m, because it would flood many low lying cities and displace hundreds of millions of people').

- Sea levels will still be rising at the end of the millennium and could reach 11.4m above the pre-industrial level by 3000. Low lying areas of Jersey and the UK, including London and many major cities, would be threatened by sea level rise.

- Ocean pH is predicted to fall dramatically (increasing acidity), posing a threat to marine organisms.

- Abrupt climate change events could occur (see Box 1). Business-as-usual emissions could lead to *"a rapid climate change event in the 22nd century."* One model predicts a southward shift in a diminished Gulf-Stream caused by melting of the Greenland ice sheet, which might result in a reduction in the surface temperature of the Atlantic Ocean. Another prediction suggests that a rapid increase in global temperature could occur in the 2600's / 2800's. Arctic ice could disappear all year round with the "*thermohaline circulation (the Gulf Stream) becoming very vigorous"* causing North Atlantic seas to heat by up to 8^{o}C, accompanied by UK land temperature increases of up to 5^{o}C.

However, the Report notes that *"This should not be treated as a prediction but rather as an indication that continual increase in emissions could lead to an event of this type".*

"Only by minimising emissions can dangerous climate change be avoided: in all except the most stringent emissions reduction scenario, Greenland ice sheet melt begins between the early 22nd and early 23rd century"

CONCLUSION

"We have presented a sobering picture of potential climate change on the millennial timescale. Whilst great uncertainties remain, our relatively conservative assumptions still produce the result that only by starting to reduce CO_2 emissions in the very near future, and continuing to reduce them such that they are zero by 2200, can we avoid dangerous climate change on the millennial timescale."

REFERENCE
For more see 'Climate Change on the Millennial Timescale (2006).' Tyndall Centre for Climate Change Research, Norwich, UK

Tipping Points

James Le Ruez

This article touches on the potential disintegration of summer sea ice in the Arctic. This is a scenario that is commonly discussed as a 'tipping point'. A tipping point is essentially a type of extreme feedback system. It occurs where a small change in one state may initially only have small effects but at some 'tipping point' the system can flip and rapidly go into another state. In the case of the Arctic ice, models suggest that small changes in fresh water content of the oceans could lead to rapid disintegration of the ice pack.

There is also the existence of 'unknown unknowns' - tipping points which we not aware of. An example happened in relation to the Antarctic ozone hole, where unexpected chemical reactions on the surfaces of ice particles lead to much more efficient destruction of ozone in the polar vortex than had been expected. This made what was an existing concern into a much more serious problem.

By their nature, we are not able to assess how important any such surprises might be and it is impossible to rule them out entirely.

3.6 WHAT IMPACTS WILL CLIMATE CHANGE CAUSE GLOBALLY?

James Le Ruez

The IPCC Working Group II addresses 'Climate Change Impacts, Adaptation and Mitigation'. The following excerpts are taken from the Group's 'Summary for Policy Makers' within the IPCC Fourth Assessment Report. The scale and timing of impacts will vary with the amount and timing of climate change and, in some cases, the capacity to adapt.

FRESHWATER RESOURCES AND THEIR MANAGEMENT

- Drought-affected areas are likely to increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk.
- In the course of the century, water supplies stored in glaciers and snow are projected to decline, reducing water availability in regions supplied by melt water. More than one-sixth of the world population currently lives in these zones.

ECOSYSTEMS

- This century, the resilience of many ecosystems is likely to be exceeded by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g. land-use change, pollution, over-exploitation of resources).
- Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change.
- Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C.

FOOD, FIBRE, AND FOREST PRODUCTS

- Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease.
- Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes.
- Globally, commercial timber productivity rises modestly with climate change in the short- to medium-term, with large regional variability around the global trend.
- Regional changes in the distribution and production of particular fish species are expected due to continued warming, with adverse effects projected for aquaculture and fisheries.

COASTAL SYSTEMS AND LOW LYING AREAS

- Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. Increasing human-induced pressures on coastal areas will exacerbate the effect.
- Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals.
- Coastal wetlands including salt marshes and mangroves are projected to be negatively affected by sea-level rise especially where they are constrained on their landward side, or starved of sediment.
- Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-

populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable.
- Adaptation for coasts will be more challenging in developing countries than in developed countries, due to constraints on adaptive capacity.

INDUSTRY, SETTLEMENT AND SOCIETY

- The costs and benefits of climate change for industry, settlement and society will vary widely by location and scale. Overall, however, net effects will tend to be more negative the greater the change in climate.
- The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanisation is occurring.
- Poor communities can be especially vulnerable, in particular those concentrated in high-risk areas. They tend to have more limited adaptive capacities, and are more dependent on climate-sensitive resources such as local water and food supplies.
- Where extreme weather events become more intense and/or more frequent, the economic and social costs of those events will increase, and these increases will be substantial in the areas most directly affected. Climate change impacts spread from directly impacted areas and sectors to other areas and sectors through extensive and complex linkages.

HEALTH

- Projected climate change-related exposures are likely to affect the health status of millions of people. The worst affected will be those with low adaptive capacity and are likely to suffer increases in malnutrition and consequent disorders for example:
    - Increased deaths, disease and injury due to heatwaves, floods, storms, fires and droughts;
    - The increased burden of diarrhoeal disease;
    - The increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone;
    - The altered spatial distribution of some infectious disease vectors (e.g. mosquitoes).
- Studies in temperate areas have shown that climate change is projected to bring some benefits, such as fewer deaths from cold exposure. Overall it is expected that these benefits will be outweighed by the negative health effects of rising temperatures worldwide, especially in developing countries.
- The balance of positive and negative health impacts will vary from one location to another, and will alter over time as temperatures continue to rise. Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives, infrastructure and economic development.

REFERENCE
For the full IPCC summary of impacts, adaptation and mitigation including likely impacts on specific regions see:



3.7 HOW DO MODELS PREDICT REGIONAL CHANGE?

James Le Ruez

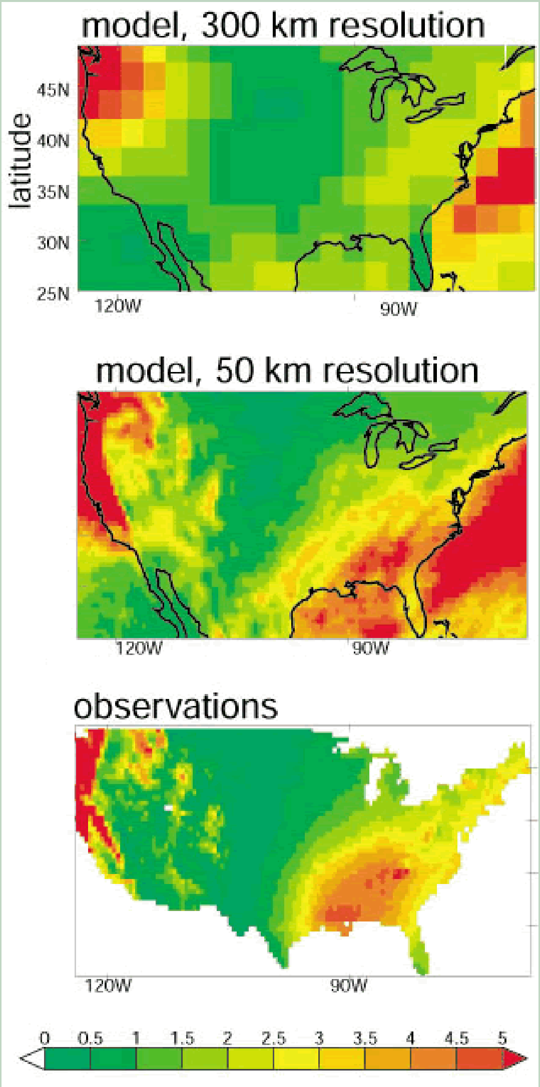
Modelling on a regional scale is important, because local features such as topography, urbanisation and land use influence the climate. Similarly, local winds, clouds or small scale temperature anomalies (e.g. rivers running into the ocean cooling the local sea) can influence larger scale systems.

As discussed earlier, global climate modelling is generally carried out using a grid system to determine land, sea and physical parameters. However, the spacing between grid points is usually too big to identify small scale features like clouds, mountains and islands. At the regional level climate modelling is advantageous because some local features can be resolved and smaller phenomenon can be identified. This improves the number of considerations within climate predictions so helping to improve accuracy.

Unfortunately, high resolution global models are impractical at the moment because the enormous number of grid points and the consequent number of calculations require too much time to process. So, to include local effects in a climate model only a small area of the world can be analysed – a regional climate model.

Concentrating on a small region of the globe introduces a further issue, one that can be highlighted by returning to the concept of global models. Conceptually, global climate models are relatively simple – the energy entering the system is equal to the energy that leaves it. In this case, the energy source is the Sun and we know enough about the amount of energy it provides to the atmosphere to assess its influence on the climate accurately.

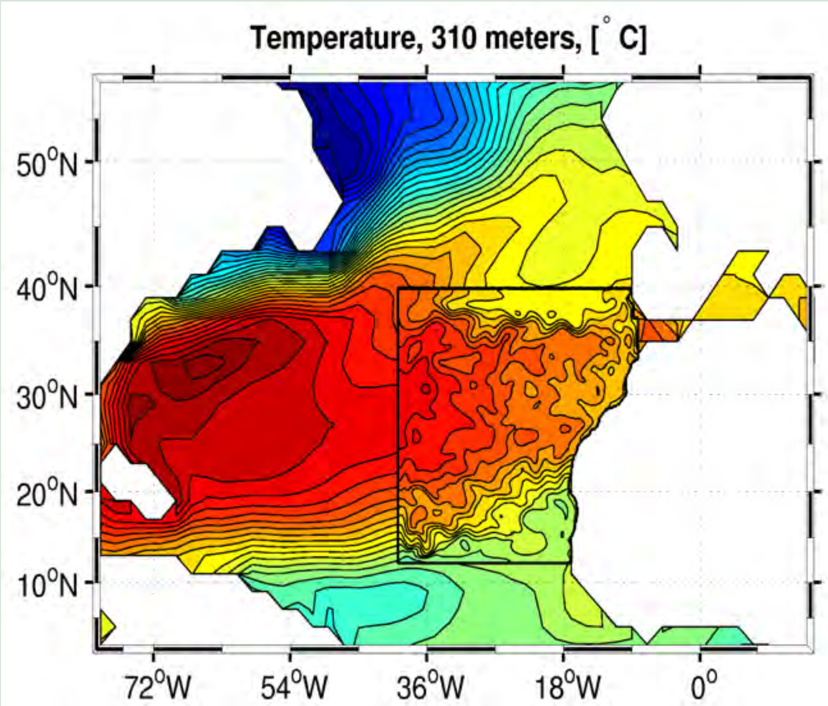
On a regional scale the energy balance is not constant as ocean and atmospheric currents move energy from one region to another. For northwest Europe the Gulf Stream is a simple example of such an ocean current. To overcome the problem of energy transport a regional model uses input from a global model for conditions at the boundary of the region enabling the movement of energy through the region and allowing local impacts of climate change to be studied in greater detail. Such regional models are said to be 'nested' within a global model.



Box 1

Predicted rainfall over U.S. by a 300km and 50km resolution model in mm/yr compared to observations. Although the 300km resolution model can be used globally the regional 50km model produces more accurate results.

Box 2

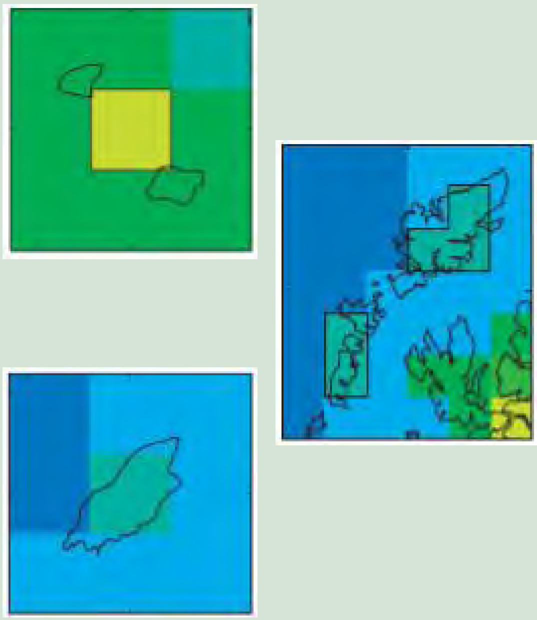


(a) An example of a 'nested' climate model. This plot shows the ocean temperature at 310 m depth where heavy hot and salty water flows out of the Mediterranean over a sill in the straits of Gibraltar.

To concentrate computer power on the outflow from the Mediterranean, a higher resolution model is 'nested' within a lower resolution model that provides the 'boundary conditions'.

(b) Global climate models can now operate at cell size of around 100km with roughly 40 layers in both the oceans and the atmosphere. However, this resolution is too large to conduct impact studies of a local area, making regional models necessary. For example, the report into the impacts of climate change for islands within the British Irish Council used a regional model with a cell size of 25km square, but even at this resolution the model cannot separate Jersey and Guernsey. A single cell between the two islands was used to represent the Islands instead.

The accompanying graphics (b), highlight how between one and five cells were needed to represent the different British Islands at the 25km scale.



Upper left, Channel Islands.
Lower left, Isle of Man.
Right, Western Isles.

Sources:
(a) www.seas.harvard.edu/climate/gebbie/home.html
(b) BIC Report, 2003

3.8 HOW WILL JERSEY'S CLIMATE LOOK IN THE FUTURE?

Andrew Casebow

Global average temperatures have risen by about 0.7°C over the last 100 years, and temperatures in Jersey have risen at a similar rate, particularly in the past few decades.

Climate models prepared by the UK Met Office's Hadley Centre for Climate Prediction and Research, predict a rise of between 1.5°C and 5.8°C in the global annual average temperatures between 1990 and 2100. This range of prediction is the result of using multiple model runs and take into account various future scenarios. In this case, the 'SRES' scenarios (also described in Article 3.2) are used under different terminology to specify the level of emissions generated:

High Scenario (A1F1)
Rapid economic growth, continuously increasing populations peaking in mid-21st century and a reliance on fossil fuels (business as usual).

Medium-High Scenario (A2)
More self reliance, continuously increasing populations, economic growth.

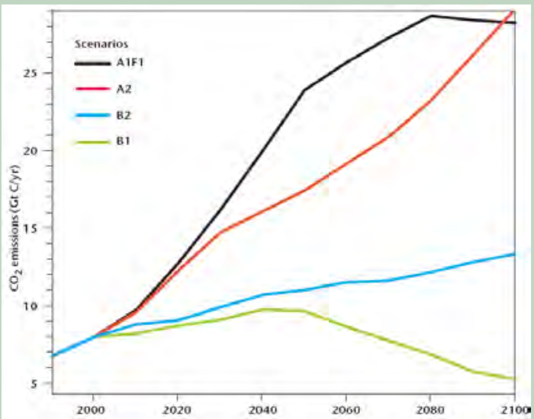
Medium-Low Scenario (B1)
Population peaks mid-21st century, clean and efficient technologies, reductions in material use, social and environmental sustainability, improved equity.

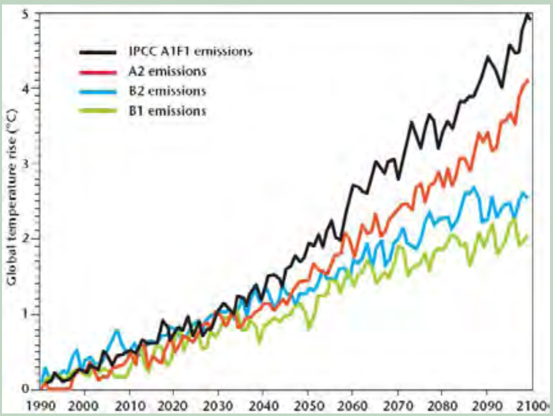
Low Scenario (B2)
Local solutions to sustainability, increasing population but at a lower rate, less rapid technological change.

The emissions of CO_2 and resultant change in global average temperature for these four emissions scenarios calculated by the Hadley Centre global climate model is shown in Box 1. Despite the immediate and rapid divergence of future emissions paths, the warming over the next 40 years or so is predicted to be much the same. This is mainly due to the very long effective lifetime of CO_2 in the atmosphere and the inertia of the climate system. Warming over the next few decades is already built into the climate system from current emissions and those over the past few decades. On the other hand, warming by the end of the century does depend on how emissions change in the future; roughly 2^0C for the lowest emissions scenarios and 5^0C for the highest.

LOCAL SCENARIOS

The scenarios of temperature (maximum and minimum) and precipitation (rainfall) are presented in map form. Maps are shown for all four emissions scenarios, and for all three 30 year time periods - 2020s (2011-2040), 2050 (2041-2070), and 2080 (2071-2100). The maps that follow have been prepared by the Hadley Centre and identify by their box outline a grid square covering the land and sea area of the islands. A single 25km grid square, located for the purposes of the map mid-way between the two islands, has been taken to represent both Jersey and Guernsey.





Box 1

(Left): Emissions of carbon dioxide, 1990-2100, in the four SRES emissions scenarios. (Right): Global mean temperature change, relative to 1990, predicted by the Hadley Centre global climate model (HadCM3) for each of the four SRES emission scenarios.

Under the medium-high scenario of climate change the average annual temperature in the Channel Islands will increase by 3^{0}C by 2080, but this masks a seasonal change from an average of 3.8^{0}C in the summer to an average of 2.4^{0}C in the winter. A similar seasonal difference is likely to be seen in rainfall (precipitation) that shows a modest 4% annual reduction, but this masks a dramatic 45% reduction in summer rainfall and a 24% increase in winter rainfall. These predicted trends appear to agree with the observed seasonal rainfall trends highlighted in Article 2.6.

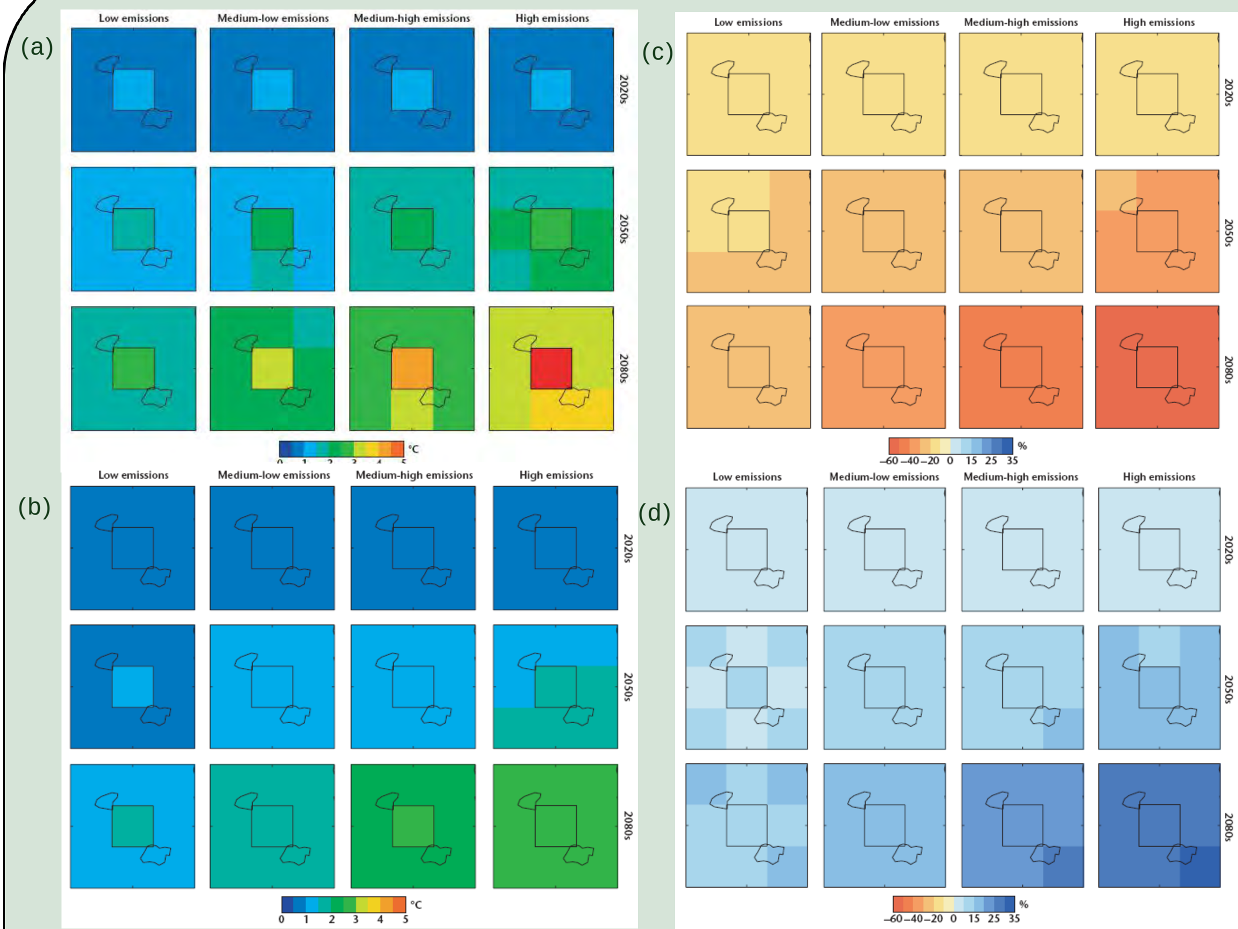
The frequency of hot days in the Channel Islands is expected to increase 4 or 5 fold by the 2080's under the medium-high emissions scenario, with a 70-85% reduction in frosts. The number of heavy rainfall days is expected to increase by 30-50% in winter but to decrease by 40-50% in summer.

Sea level is expected to increase by between 9 and 69cm by the 2080's; taking account of the different future emissions. When the effect of land movement is added the net rise varies from 14 to 74cm. With a sea level rise of 30cm the change in height of a once-in-50-years storm surge is predicted to be up to 0.5m.

The North Atlantic Ocean circulation, which includes the gulf stream, is predicted to decrease in strength by about 20% over the next 100 years, but not to switch off during that period. The temperature predictions above take account of the reduced heating due to these gulf stream changes.

USE OF CLIMATE CHANGE SCENARIOS

The main use of climate change scenarios is in carrying out assessments of the impacts that climate change may have on socio-economic sectors such as infrastructure, agriculture, water resources, and coastal and river flood defenses. In this way, adaptation can be planned well in advance, so that damages and costs can be minimised, and perhaps some potential benefits realised.



Box 2

a) Change in summer-average maximum temperature. b) Change in winter-average minimum temperature. c) Change in summer-average precipitation. d) Change in winter-average precipitation. (All relative to the 1961-1990 average).

CHAPTER 4
IMPACTS ON THE ISLAND...

Image Credit : James Le Ruez

CHAPTER 4 - IMPACTS ON THE ISLAND

There will be no avoiding the impacts of climate change locally. How will global change reverberate through Island life and what changes will be seen from the ground up?

CHAPTER 4 - IMPACTS ON THE ISLAND

Global Fallout
- 4.1 How Will Climate Change Influence the Economy?
- 4.2 International Climate Change Agreements
- 4.3 What About the Developing World?

Industry
- 4.4 Will Climate Change Affect Jersey Businesses?
- 4.5 The Role of the Finance Sector in a Low Carbon Economy
- 4.6 Climate Change and the Rural Economy
- 4.7 The Future of Fisheries
- 4.8 Tourism: Will the Industry Benefit or Suffer?

Biodiversity
- 4.9 Regional Biodiversity
- 4.10 Island Habitats
- 4.11 Island Species
- 4.12 Plankton, a Climate Change Indicator?
- 4.13 The Effects of Climate Change on Intertidal Species

Health
- 4.14 Human Health in a Changing Climate
- 4.15 Insect and Climate Change: What a Pest!
- 4.16 A Changing Climate for Animal Health
- 4.17 Climate Change, A Growing Problem for Plant Health?

Infrastructure
- 4.18 Sea Level, of Rising Importance?
- 4.19 Our Future Water Supplies in a Changing Climate

5.0 Where Do We Go From Here?

Climate change over the coming century will happen. Chapter Three has shown that although predictions made by scientific institutions aren't concrete, there is significant statistical confidence and scientific reasoning backing them up.

Jersey, is a unique place and as a result will be impacted by climate change in unique ways. It is crucial that we are aware of the potential impacts so we are best prepared to plan for them.

This chapter summarises how different aspects of the Island will be affected by climate change. It firstly examines the global (primarily economic) effects that will cascade through to Jersey. It then goes on to study three further key aspects of Island life.

From banking to insects it appears that there is a climate change impact that will affect us all.

4.1 HOW WILL CLIMATE CHANGE INFLUENCE THE ECONOMY?

James Le Ruez

The Stern Review was published in October 2006 and represents the most thorough thinking on the economic consequences of climate change. The Review was headed by Sir Nicholas Stern, Head of the Economics Service and Adviser to the UK Government

The Stern Review adopted the methodology explained in Box 1 overleaf. The key message from the Stern review is strong and clear; it concludes that:

'the scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response';

'If we don't act [to reverse climate change], *the overall costs and risks of climate change will be equivalent to losing at least 5% of global Gross Domestic Product (GDP) each year now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more.'*

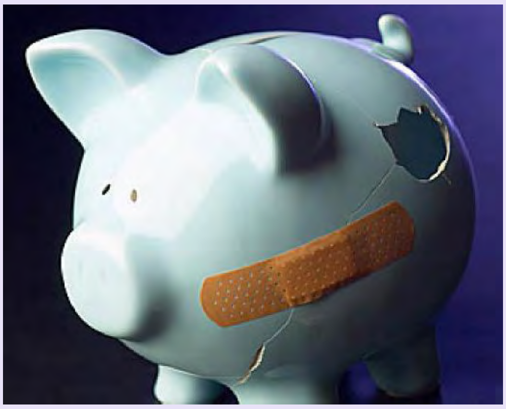
'In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.'

The Review states that if no action is taken to reduce emissions, the scientific evidence points to atmospheric greenhouse gas levels reaching double pre-industrial levels by 2035 and so committing us to a global average temperature increase of over 2°C. If this occurred it raises the likelihood to over 50% that the temperature rise would exceed 5°C. The Review believes that even more moderate levels of future emissions will result in '*serious impacts on world output, human life and on the environment'*.

Despite this alarming picture the conclusion is more positive :

'Although the costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly'.

The Review recommends the following action:



"For every £1 invested now, we can save £5, or possibly more, by acting now."

Then Prime Minister Tony Blair's comments to the BBC on the Stern Review

1. Adapting to climate change

Steps must be taken to build resilience and minimise costs. This is especially relevant to the next two to three decades and the level of climate change that is already unavoidable. It is important to recognise that it is the poorest countries that are most vulnerable to climate change.

2. Stabilising greenhouse gas emissions

The impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere can be stabilised from current levels of 430ppm to between 450 and 550 ppm CO_2. Although a challenge, the costs of doing this are far below allowing greenhouse gas concentrations to rise and then attempting to deal with the consequences of this.

3. Making an international response to climate change

All countries must take action. Developing countries should not be required to bear the full costs of action alone; mechanisms like carbon markets can deliver finance to support low-carbon development.

4. Decoupling growth from greenhouse gas emissions

In particular 'decarbonising' the power sector by 60% by 2050. Stern concludes that '*the world does not need to choose between averting climate change and promoting growth and development*'.

5. Technology co-operation

Technology and innovation delivering low-carbon technologies and boosting energy efficiency must be widely shared, through informal or formal international co-operation.

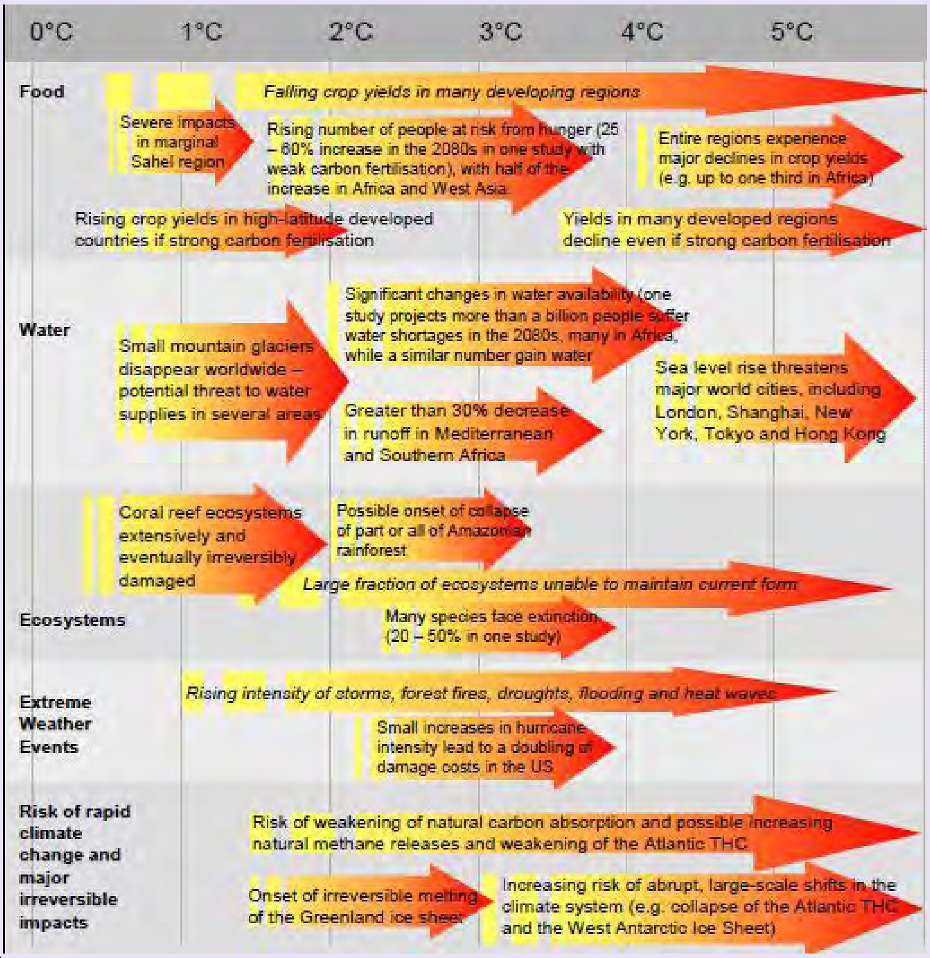
6. Placing a social cost on carbon

In economic terms greenhouse gases are an externality. Those generating greenhouse gases do not experience the full cost to society of their generation.

By putting an appropriate price on carbon, through taxes, trading or regulation, people pay the full social cost of their actions. This will encourage the switching away from high-carbon goods and services to low carbon alternatives.

A number of studies have attempted to quantify the social cost of carbon. In early 2002, the UK suggested £70 per tonne of carbon (tC) (within a range of £35 to £140/tC) as an estimate for the cost of the global damage of carbon emissions.

Global mechanisms like the EU Emissions Trading Scheme, attempt to account for the social costs of carbon in two ways. Targets are set for carbon emissions but the trading of carbon as a commodity allows free markets to make emission reductions in the most cost efficient way. Importantly, because of the global nature of emissions, the schemes to deliver reductions can be located anywhere.



Box 1

The Stern team completed a review of scientific literature which determined temperature increases expected as a result of different concentrations of greenhouse gases in the atmosphere.

Changes in temperature were linked to the impacts upon different aspects of the planet and its population (left).

The effect of these impacts on the global economy was compared to the cost of stabilising greenhouse gas emissions at different levels.

Hence they were able to determine the best course of action to avoid major future economic consequences.

4.2 INTERNATIONAL CLIMATE CHANGE AGREEMENTS

James Le Ruez

The majority of nations have now placed combating climate change high on the political agenda accepting the need to make cuts in greenhouse gas emissions.

THE KYOTO PROTOCOL

The Kyoto Protocol is an agreement made under the United Nations Framework Convention on Climate Change. Countries ratifying the protocol commit to reducing their emissions of CO_2 and five other greenhouse gases. If countries maintain or increase emissions of these gases they can engage in emissions trading with compliant countries. The Protocol now covers more than 160 countries (Box 1) globally and over 55% of GHG emissions.

Under Kyoto, Governments are separated into two overall categories:

1. Non-Annex 1 countries or developing countries – These have no greenhouse emission reduction targets.

2. Annex 1 or developed countries – These have accepted emission reduction targets. By 2008-2012, the global target is for Annex 1 countries to reduce their GHG emissions by 5% below their 1990 levels.

HOW DOES KYOTO WORK?

As well as making domestic emission reductions Annex I economies can meet their reduction targets through three "mechanisms":

- Joint Implementation (JI) - applies in transitional economies mainly covering the former Soviet Union and Eastern Europe
- Clean Development Mechanism (CDM) – applies in Non-Annex I economies
- International Emissions Trading (IET)

Both JI and CDM are "project based mechanisms" and these involve the development and implementation of projects that reduce greenhouse gas emissions overseas. These projects generate carbon credits that can be sold on the carbon market so they both reduce greenhouse gas emissions and generate an additional income stream for the project.

Even if all countries meet their Kyoto targets, global emissions are only expected to fall by 1-2% and a number of the main contributors, most notably the USA have still not signed up to achieving these targets although the new administration is expected to make progress.

Jersey became a signatory to the UN Convention on Climate Change in 1994 but has no specific carbon reduction target. The Kyoto Protocol was extended to the Island in 2006 and Jersey's greenhouse gas emissions figures have already been included within the UK's "assigned amount" which was submitted to the EU on 15th January 2006.

INTERNATIONAL EMISSIONS TRADING

The rationale behind emission trading is to ensure that the emission reductions take place where the cost of the reduction is

Box 1

Participation in the Kyoto Protocol: green indicates states parties, yellow indicates states with ratification pending, and red indicates those that signed but declined ratification of the treaty.

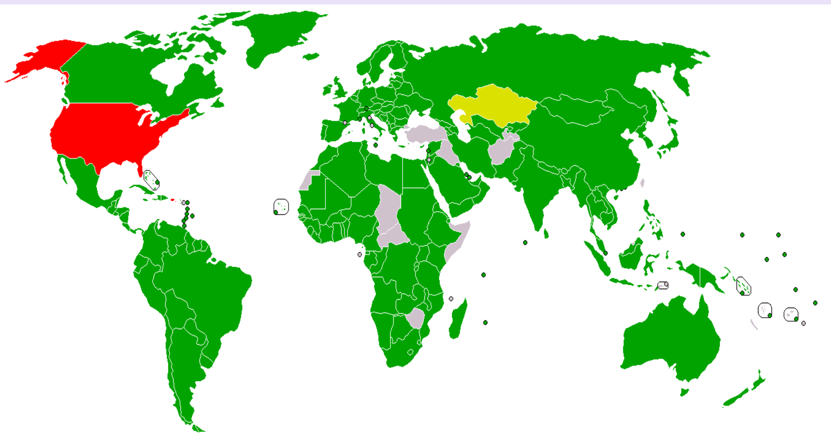


Image Credit: Wikimedia

Box 2
High emitters of carbon can purchase credits on the carbon market to compensate for their pollution of the atmosphere. Alternatively, they may alter their operations, for instance by installing new technology, to reduce their emissions to the specified 'cap'. The profits from selling credits can be invested into projects approved by the United Nations as part of the Clean Development Mechanism, such as this wind farm in the Netherlands.

lowest thus lowering the overall costs of combating climate change. Emissions Trading is particularly suited to the emissions of greenhouse gases because they have the same effect wherever they are emitted.

The EU Emissions Trading Scheme (ETS) is central to the European Union's long-term policy to reduce carbon emissions and works on a "cap and trade" basis. Governments can regulate the total amount of emissions produced by setting the overall cap for the scheme. Individual companies have the flexibility of determining how and where the emissions reductions will be achieved.

EU Member States are required to set emissions limits for all installations in their country covered by the scheme. Each installation is then allocated emissions allowances for the particular phase in question. The scheme currently covers electricity generation and the main energy intensive industries such as refineries, paper, and heavy manufacturing. If a company emits more than their allowance they can meet their limit by purchasing allowances from the market. This provides revenue for CDM projects. Alternatively, if a company emits less than its allocation, they can sell the surplus allowances.

Emissions trading gives companies the flexibility to meet emission reduction targets according to their own strategy (Box 2). Essentially, businesses can choose to reduce emissions on site or buy surplus allowances from other companies. The environmental outcome is not affected because the amount of allowances allocated is fixed. However, by allowing participants the flexibility to trade allowances, the overall emissions reductions are achieved in the most cost-effective way possible.

IMPACTS IN JERSEY

Jersey is not involved in the EU ETS. Although a signatory to the Kyoto Protocol the lack of an emissions target means that at present there is no 'cap' for the Island. Furthermore, the majority of island businesses are not sufficiently large emitters to fall under such a scheme.

The most likely potential relevance of the scheme to Jersey is for companies trading in carbon credits.

4.3 IMPACTS ON THE DEVELOPING WORLD

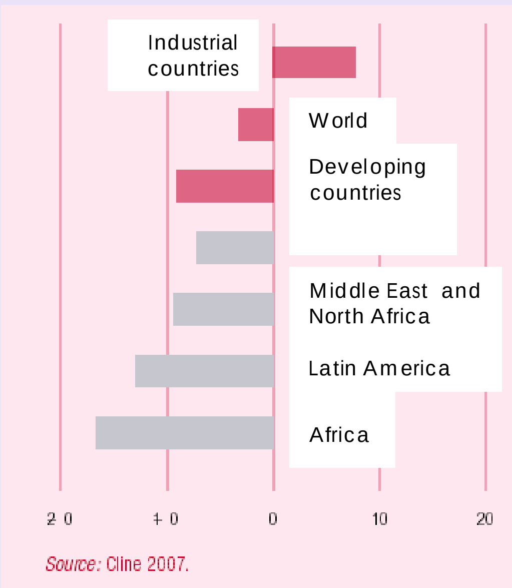
James Le Ruez

"Across developing countries, millions of the world's poorest people are already being forced to cope with the impacts of climate change. These impacts do not register as apocalyptic events in the full glare of world media attention. They go unnoticed in financial markets and in the measurement of world gross domestic product (GDP). But increased exposure to drought, to more intense storms, to floods and environmental stress is holding back the efforts of the world's poor to build a better life for themselves and their children."

United Nations Human Development Report 2007/2008

Exposure to the impacts of climate change is only forecast to get worse in the near future. The world is committed to a certain degree of climate change and adaptation to such impacts will prove difficult for poor nations for years to come.

Looking to the future we see a danger that progress built up over generations to cut extreme poverty, improve health, nutrition and education could be reversed as conditions become increasingly difficult for basic survival. The majority of the world's one billion poor people depend on agriculture for their livelihoods, yet, it is the human enterprise most susceptible to climate change (Box 1).



Box 1
Change in Agricultural output potential (2080s as % of 2000 potential
Change in agricultural potential is only positive for industrial countries where technology and science will allow adaptation to negate the impacts of climate change.

While the world's poor walk the Earth with a light carbon footprint they are bearing the brunt of unsustainable management of our global resources.

In rich countries, coping with climate change to date has largely been a matter of adjusting thermostats, dealing with longer, hotter summers, and observing seasonal shifts. Cities like London and Los Angeles may face flooding risks as sea levels rise, but their inhabitants are protected by elaborate flood defence systems.

By contrast, when global warming changes weather patterns in the Horn of Africa, it means that crops fail and people go hungry, or that women and young girls spend more hours collecting water. And, whatever the future risks facing cities in the rich world, today the real climate change vulnerabilities linked to storms and floods are to be found in rural communities in the great river deltas of the Ganges, the Mekong and the Nile, and in sprawling urban slums.

There are no obvious historical analogies for the urgency of the climate change problem. Stockpiles of nuclear weapons have threatened societies but the appreciation that mass destruction would ensue has thus far avoided either side acting. Climate change, in contrast, is a situation where if nobody acts we are taking a guaranteed route to a further build-up greenhouse gases, and to mutually assured destruction of human development potential.

BALANCING THE PLAYING FIELD

Emitting one tonne of CO_2 in Jersey has the same effect as emitting one tonne of CO_2 anywhere in the world. However, the impacts of one tonne of CO_2 are not the same in Jersey as they are elsewhere. However, we argue that the Island have an obligation to ensure that globally we do not look back in 50, 100 or 500 years and wonder why we did not take strong enough action. As the 2007/2008 Human Development Report states:

"It is our generation that will leave a legacy either as those that took action or those who failed."

Some may argue that globally our Island's emissions are negligible, but the counterview is 'where is the point where emissions change from being insignificant to significant?' We have a responsibility to set an example that will be followed by others.

We cannot deny developing countries a technological and economical revolution that will provide their citizens with better lives. It is through following the western world's example that developing countries are using 'dirty' fuels such as coal and oil.

Tools such as the Clean Development Mechanism and Emissions Trading provide an infrastructure by which countries will be able to develop without reliance upon dated technology. A global effort is required to ensure that these mechanisms fulfil their potential and ensure a better life for future generations.

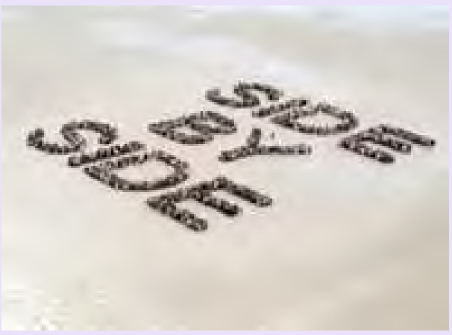
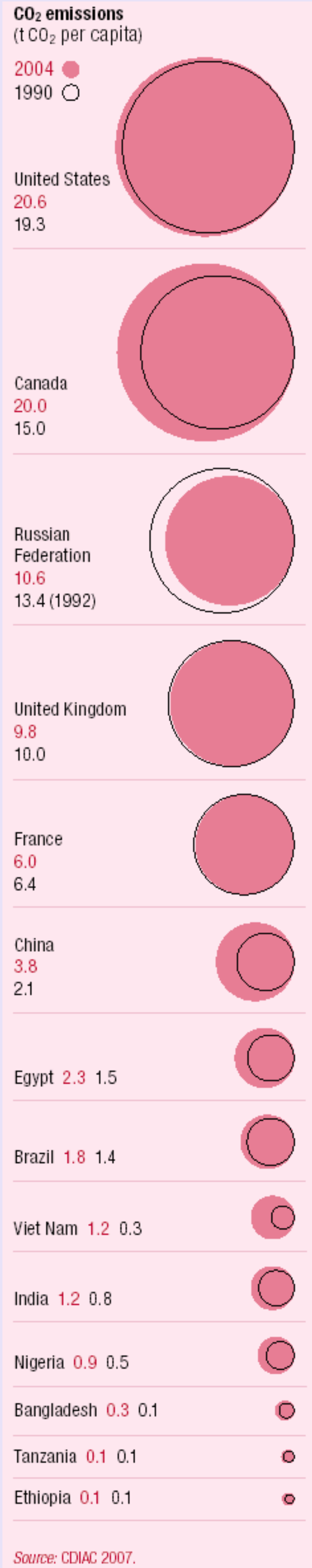


Image credit: http://www.unconditionalcompassion.com/sub/JerseySidebySide.htm

REFERENCE
Sourced from the UN Human Development Report 2007/2008.
For the full report go to:
http://hdr.undp.org/en/



Box 2
This graphic reveals the large difference in per capita emissions between developed and non-developed nations.

4.4 HOW WILL CLIMATE CHANGE AFFECT JERSEY BUSINESSES?

The ECO-ACTIVE Business Team

All businesses will be affected directly or indirectly by climate change and although the media focuses on the negatives it's not all doom and gloom. Climate change also presents opportunities that businesses can take advantage of.

The challenges and opportunities arising from predicted climate change impacts will be specific to individual businesses and we consider some of them here.

OPPORTUNITIES

New technologies and services :

Internationally government policies require increased standards and in particular compliance with emission reduction targets. The main opportunities in the UK are considered to be within meeting tighter building standards, supply of biofuels, energy efficiency products and generation of renewable electricity.

Consumer choice:

people are increasingly aware of climate change and conscious of the power of their purchasing decisions. For example, the Co-Op identified that 51% of British people chose a product or service based upon a responsible reputation. There is a demand for 'green' alternatives in all business sectors which provides opportunities for diversification and expansion.

Increased operational efficiency:

Increasing operational efficiency by using fewer raw materials and lowering overheads by reducing electricity and waste disposal bills boosts company profitability. This principle can be applied to all aspects of a business. Furthermore there is an increasing recognition that items once considered to be 'rubbish' can be used for other purposes. There is potential to reduce disposal and raw material costs and even create new revenue streams.

Supply chain and markets :

Procurement policies are increasingly incorporating environmental as well as financial costs. Through improving a product's environmental performance a business can gain a competitive advantage. Retailers, such as Marks and Spencer under their 'Plan A' initiative, demand strict environmental standards of their suppliers. Local growers that can meet this standard will have access to a market that their competitors may not.

CHALLENGES

Energy price increases:

All businesses rely on energy even if only at a minimum through heating and electricity consumption and transportation. In a global market of increasing energy costs Jersey is vulnerable since it is reliant on petroleum products (70% of the total).

In addition the availability of energy at predictable and affordable prices are critical for businesses to plan ahead and price accordingly. Steep increases in oil prices over the summer and autumn of 2008 bought the effects of price spikes sharply into focus.

Energy generation is a significant contributor to climate change and resources of hydrocarbon fuels are finite all of which points to recent price fluctuations being the beginning of a longer-term trend. By taking measures to reduce energy use now, companies can make significant savings on their energy bills and gain a competitive advantage.

New Regulations:

With agreements like the Kyoto Protocol in place Jersey has an international commitment to reduce its greenhouse gas emissions. Although voluntary measures will play a role, regulations may need be introduced to ensure compliance. For example the proposed tightening of the standards on new buildings to ensure highest thermal performance through more stringent Building Bye-Laws. In this case, although initially presenting challenges to architects and builders, the occupier will ultimately benefit from a higher quality more energy efficient property with lower running costs .

Physical Vulnerability:

Over the longer term, more severe weather patterns such as increasingly intense summer heat waves and winter storms as well as rising sea levels could have an impact on transportation and other infrastructure. This could have numerous effects on a business network, including an increase to insurance premiums due to increasing claims from impacts such as flooding.

It is no coincidence that more has been written here about the challenges faced by businesses rather than the opportunities. Being aware and prepared for the potential impacts of climate change is the crucial first step businesses
can take.

In light of this the Environment Department has developed the Eco-Active accreditation scheme that can help prepare businesses for the potential impacts while increasing profitability.

ECO-ACTIVE BUSINESS

What is ECO-ACTIVE BUSINESS (EAB)?

EAB is a free-to-implement scheme that provides a framework for businesses identify and reduce their impact upon the environment. The EAB model has been tailored to suit the needs of local businesses. It was developed and implemented in partnership with Standard Chartered, the Gerard le Claire Environmental Trust, the Economic Development Department and the Planning and Environment Department with the aim of *'putting the environment at the heart of local businesses'*.

What does EAB involve?

EAB is not about asking the impossible. Every business has an impact upon the environment and this can reduced through incremental structured improvement. The scheme is successful because it is designed to operate and be led from within the business itself. This allows organisations to chose the appropriate actions and approaches for their organisation whilst drawing upon the expertise of the EAB team and the Planning and Environment Department.

There are three levels to the scheme with the highest level - 'Leader' Status equivalent to nationally accepted Environmental Management Systems.

What are the benefits?

EAB has many benefits including:

- Increasing efficiency;
- Reducing costs;
- Ensuring legal compliance and;
- Improving company reputation.

Where can I find out more?

http://www.gov.je/ecoactivebusiness

4.5 THE IMPACT OF A LOW CARBON ECONOMY ON THE FINANCE SECTOR

The ECO-ACTIVE Business Team

Jersey is an established international financial centre with nearly 50 banks as well as some 175 licensed trust and company administrators, over 100 investment managers, stockbrokers, fund managers, leading international accountancy firms and some of the biggest names in the offshore legal world. In 2006 it was estimated that £188 billion was held in Island accounts with the sector employing some 12,000 staff.

Banking is the primary focus of this article but many of the issues discussed will cascade into the 'umbrella' of fiduciary services.

It is not envisaged that there will be the same sort of direct local impacts of climate change on the banking sector in the same way as the agriculture or tourism industries. For example, drought will not directly impact on financial products and services to the same extent as it would on the success of a local crop.

However, the indirect impacts of climate change and the resulting transition to a low carbon economy could fundamentally change how banks do business in the future.

This article draws upon a revealing study by Entec in 2007 into the impact of the 'carbon economy' on banking.

Image credit: www.Jersey.com

REFERENCE
Sourced from Entec.

CARBON DISCLOSURE & ACCOUNTABILITY

Investors are increasingly putting pressure on banks to take responsibility for the environmental impact of their investment projects. Banks are evaluating their carbon exposure, disclosing their carbon footprint and putting together action plans to progressively reduce this footprint.

For example the World Bank has committed to tracking the carbon footprint of its core developments in the energy and transport sectors. The Bank of America has committed to a 7% reduction in indirect emissions within their energy and utility portfolio.

CREDIT RISK

In the current climate no financial institution can afford to ignore risk. Legislation to mitigate climate change and the increasing cost of carbon may expose clients to new risks and potentially even heighten the possibility of default.

If the bank incorporates a carbon dimension in credit decision-making a bank's loan book can be more resilient.

MARKET RISK

As climate change drives the full cost of carbon to become increasingly incorporated into the market 'carbon inflation' will become a new element in price setting especially in the energy sector. In addition, as the physical impacts of climate change intensify, the prices for key commodities such as food and water may increase thereby putting an upward pressure on interest rates.

SUSTAINABLE INVESTMENTS

Banks have substantial resources at their disposal that can be used to support sustainable projects. They therefore have a key role to play in the development of low carbon technologies. For example, in 2008, HSBC committed £100 million of funding for renewable generating capacity in partnership with the Carbon Trust.

COMMERCIAL BANKING

In a similar way the decision making process involved in commercial loans can assist the growth of low carbon industries. Banks need to reappraise their appetite for risk in carbon intensive sectors (e.g. cement, mining, oil, power generation, and transport) and assist their clients in reducing this risk through reducing the carbon intensity of corporate business.

INVESTMENT BANKING

Climate change will impact on the value of investments, assets and commodities. The ability to be able to analyse climate change risks and opportunities over the short and long term as we shift to a low carbon economy is essential. For example, how will a portfolio's value by affected by rising carbon costs and are there opportunities for investment in low carbon technology?

MARKETING & REPUTATION

Client and employee expectations of good corporate governance are increasing and ignorance of climate change impacts is no longer accepted.

Over the last year or so the reputation of the global finance industry has taken a battering. Positive early action in the above areas will help in rebuilding reputations. Inaction or poor decision-making will cause further damage.

This exposure is not some distant prospect, but has already started to materialise. For example, a consortium of leading environmental groups have lobbied global financial corporations, some with branches in the Island, to stop financing the expansion of coal-fired power stations around the world.

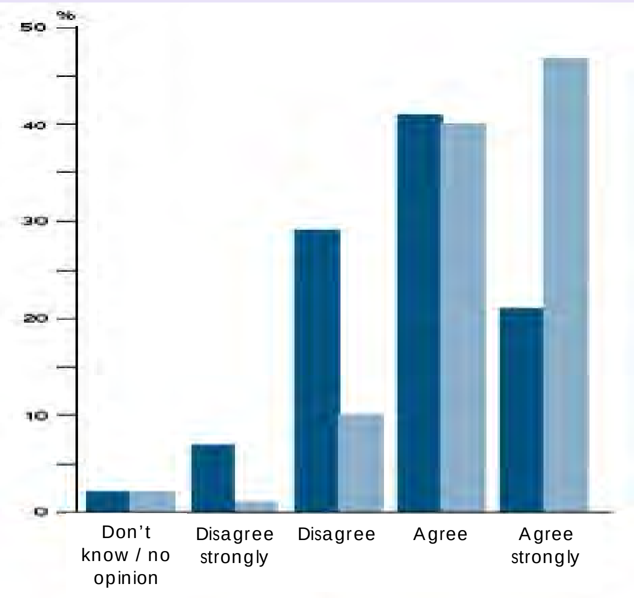
A POSITIVE WAY FORWARD

The transition to a low carbon economy will have numerous repercussions to the finance sector. Climate change provides opportunities for the finance industry to gain a competitive advantage through taking early action. Many forward thinking Corporates have already demonstrated their commitment for example, signing up to the 'equator principles' which ensure that projects receiving finance are sound both ethically and environmentally.

Box 1 illustrates the results of a survey of business leaders, with 45% of those surveyed strongly agree that climate change represents business opportunities for their companies.

Where should the banking sector start?

- Investigate and understand where market opportunities lie in a low carbon economy.
- Understand and measure the bank's wider carbon footprint, including products, services and investments.
- As a sector work towards a standardised method for carbon reporting.
- Introduce carbon considerations into the decision making process.



Box 1

Results of an opinion survey of over 1,000 business leaders taken at The Prince of Wales May Day Business Summit on Climate Change, May 2007.

Dark blue bars - 'Climate change presents a considerable business RISK for my company

Light blue bars - ' Climate change represents a considerable business OPPORTUNITY' for my company'

4.6 CLIMATE CHANGE & THE RURAL ECONOMY

John Jackson and Iain Norris

We have seen how under the IPCC medium and high emissions scenarios the Channel Islands will see a 3ºC increase in average temperatures by 2080. As a result Jersey may expect that the frequency of hot days in summer will be 4 to 5 times greater and in winter there will be an almost total absence of frost. A 45% reduction in summer rainfall is contrasted with 24% increase in winter rainfall.

Climate change and green house gas emission mitigation will be one of the greatest challenges to the agricultural industry in the 21st century. The following article explores how these challenges will impact on Jersey's agricultural industry.

GROWING SEASON

The growing season is usually defined as when the soil temperature is over 5ºC. In practice Jersey's soil temperature only falls below 5ºC on a very few occasions each winter allowing crops to grow slowly during the autumn and winter period.

Climate change will increase soil temperatures throughout the year enhancing crop growth in the warm, wet winters and reducing crop growth in the dry hot summers when water availability is the limiting factor.

Such changes will challenge current husbandry practices in the Island, presenting new problems and opportunities. The agricultural industry must have to respond using sustainable husbandry techniques, together with a flexible approach, in order to ensure a viable future.

CROPPING

Yields may be expected to increase as a result of higher atmospheric CO_2 concentrations, rainfall and temperatures in the early part of the year. Conversely higher temperatures and lower rainfall in the summer may well reduce yields making certain crops uneconomic. For example, Jersey Royal potatoes for export are usually planted between January and March and harvested after a 12 week growing period. Reduced frosts in winter may mean that potatoes could be grown earlier extending the high priced early market period.

Competition from countries such as Egypt, Canary Islands and Madeira could also be reduced due to increased temperatures and reduced rainfall in these areas.

The warmer weather in Jersey may mean that the expensive plastic crop covers used in spring become unnecessary so reducing costs.

The longer growing season could see increased crop diversification with the introduction of crops such as grapes, olives, grain maize, kiwis, herbs, sweet potatoes and pharmaceutical crops such as borage. These provide new opportunities to expand the type and volume of crops produced for local retailers and the UK market.

Increased awareness of climate change may well lead to a reduction in consumer demand for imported foodstuffs from around the world so increasing demand for

Image credit: www.Jersey.com

a wide range of locally grown products.

PESTS & DISEASE

Warmer weather could result in an increase in pests and diseases in the Island. For example Potato Blight thrives in warmer, wetter conditions. The Colorado Beetle (shown above) is currently found on the French mainland and could become a greater threat if its geographical range moves north (see also Article 4.15).

Pesticides, whose manufacture depends on oil, are likely to become more expensive and less available accentuating crop health problems.

HUSBANDRY

Inorganic fertiliser production generates nitrous oxide emissions (a potent greenhouse gas) and if restrictions are placed on production they could become uneconomically priced. This could result in a greater reliance on animal manures, recycled organic fertilisers and less intensive husbandry methods.

Decreased summer precipitation could lead to a lack of water availability for crop irrigation or force farmers to construct expensive reservoirs to preserve the excess rainfall in winter.

Increased winter rainfall may result in an increase in soil erosion from the cotils used for early crops making their cultivation environmental unacceptable.

The increasing price of fuel could limit the use of cultivation techniques dependent on large diesel tractors. These may have to be replaced by minimal cultivation techniques which would also assist in soil moisture retention.

Farmers may have to consider producing their own renewable fuels such as bio diesel from cereal crops, biogas from anaerobic digestion and heating fuel from long term coppicing.

Advances in science may well mitigate some of the problems caused by climate change. For example, plant breeding companies are developing new varieties of crops which are more efficient at using nitrogen from soil reserves thus reducing their need for fertilisers. In addition, drought resistant plants are being developed with the ability to reduce water loss by restricting the opening of the leaf stomata through which water evaporates.

However, the use of these techniques could reduce yields and are usually the intellectual property of multinational companies which is likely to result in increased production costs. The development of such crops by the use of gene transfer (GM crops) is likely. This could raise the issue of market resistance within the EU due to actual or perceived environmental problems.

4.6 CONTINUED...

LIVESTOCK

The iconic Jersey cow has been exported to many countries around the world with hotter and drier climates than Jersey and has proved her ability to produce high quality milk on an economic basis. This does not mean that the dairy industry will be immune to the effects of climate change.

The advantages of warmer growing conditions will promote grass growth extending the grazing season and reducing the expense the dairy industry faces from imported compound feeds.

Livestock farmers will have the opportunity to grow a greater range of feed crops such as, soya beans, grain maize and Lucerne which will reduce their dependence on costly imported feeds. Our current cold winters have resulted in livestock having to be housed in enclosed buildings.

Warmer winters and hot summers will result in a need for open, airy buildings with reduced specifications and potentially lower construction costs.

Climate change will also have adverse effects on livestock husbandry. Very hot summer days above 25ºC will result in dairy cows reaching their higher critical temperature. The cow's response will be to reduce feed intake, drink more water and seek shelter in order to reduce body temperature.

Dairy farmers may have to bring the cows into shaded housing to avoid the hottest part of summer days, provide sprays of water to cool the animals down and also provide conserved feeds to replace grazed grass. If current winter housing designs are not improved, cattle could begin to overheat in winter due to density of stocking and inadequate ventilation.

White skin pigs kept outside will increasingly suffer from sun burn. Outdoor pig production may not even be possible in the later part of the 21st century unless pigs are housed appropriately, provided with water sprays or different coloured pigs are kept outside with wallows where they can cool off and cover themselves in a mud sunscreen.

Historically, sheep have been developed to retain their wool. For future production

systems there will be a need for short fleeced animals that can keep cool and because (the value and use of wool is reducing).

Wetter winters and a longer growing season will mean that farmers will need to graze grass crops when the soil is wet. This will increase the need for good quality tracks to get the animals to and from the grazing fields.

In order to gain the maximum benefit from grazed grass their may be a need to restructure the current dispersed fields into easily accessed consolidated blocks of land. In addition, the rapid spread of the Blue tongue virus across Europe is a good indication of how pests and diseases currently unknown in Jersey could threaten the welfare of our livestock.

CONCLUSION

It is clear that in order to respond to the challenges of climate change Jersey will require a modern, efficient and profitable agricultural industry able to implement the changes necessary for a sustainable future. The industry will need to employ modern technology and not be bound by custom and tradition. It will need to use imported oil based products more efficiently and reduce their overall use by generating more of their energy needs from their own resources.

New crops will be seen in the Island and new methods of husbandry will have to be developed for arable crops and livestock. Servicing the needs of local consumers and producing environmentally friendly products to provide profits for reinvestment in new technology will be a key part of a successful strategy in response to the imperatives of climate change.

Image credit: www.Jersey.com

4.7 THE FUTURE OF FISHERIES

Simon Bossy and Andrew Casebow

Chapter 1 highlighted the changes to the local marine climate that have been observed over the last seventy years at St Helier Harbour. At a regional level, surface temperatures of the North Atlantic have risen by around 1°C in the last thirty years and this variation is also detected in the offshore waters of the English Channel (see Box 1). The impact of climate change upon plankton will be highlighted in Article 4.12.

The Fisheries and Marine Resources Section is responsible for protecting and ensuring the sustainable use of the Island's marine resources whilst maximising the overall benefits to the people of Jersey. A changing climate will result in new challenges as the ecosystems that inhabit our local waters change. As with all ecosystems it is important to separate the long term influence of climate from regional and local influences (such as over-fishing, eutrophication, sea defences and pollution).

The Channel Islands are situated on the convergence of Boreal (cold temperature) and Lusitanian (warm temperature) marine bio-geographical regions. The overlap of these regions promotes increased species richness in our waters. However, being at a boundary of two different water types means that changes in marine climate are having a noticeable impact. Coldwater species at their southern limit are likely to lose their 'climate space' and migrate northwards as temperatures increase. Other, warm water, species are likely to spread into island waters from France or further south.

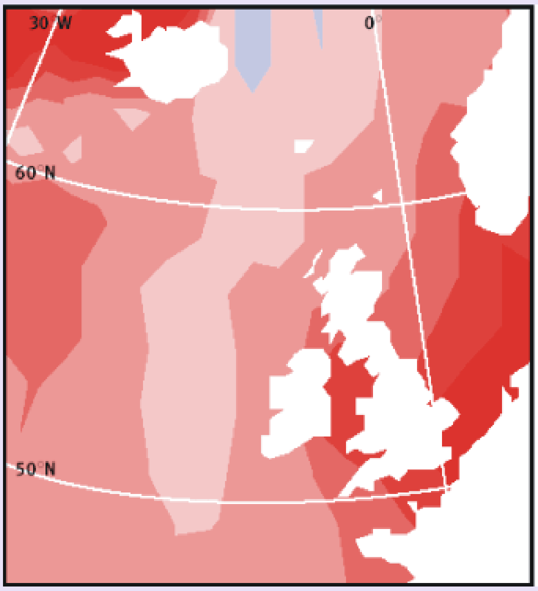
Such migration is possible due to the natural mobility of fish. Regional displacement of species is now well documented and has been occurring for many years. For example, Red mullet and sea bass used to be rare North of the English Channel. In 1985 North Sea catches of these species were 10 and 31 tonnes respectively but by 2005 these species had become commercially viable with catch of 700 and 558 tonnes respectively. Although such changes may not necessarily be defined as negative impacts (such movements may even create new fishing opportunities) the long term influence of such displacement upon fragile ecosystems are not yet fully understood.

Local observations mirror these trends with a marked increase in the abundance of bass (warm water species) in recent years with a decrease in catch of cod (a cold water species). However, as well as direct impacts on the types of fish that will be caught, there will also be migration of less commercial species. As a result of their low commercial value it will be more difficult to monitor and assess the populations of such species. For instance, the Marine Climate Change Impacts Partnership (MarClim) identify that non-native marine organisms such as japweed and Chinese mitten crab are spreading and becoming established in UK waters.

Furthermore, changes to the oceanic environment including temperature, salinity and acidity may create a marine environment more susceptible to plankton blooms and jellyfish swarms.

INDIRECT CLIMATE CHANGE EFFECTS

The direct impact of climate change on marine species comes from the warmer oceanic temperature and salinity patterns.



Box 1
Reanalysis data suggests there has been a 0.6 - 0.8°C rise in temperature per decade between 1981 and 2000 in the Bay of Granville.

Source: NOAA-CIRES Climate Diagnostics Center, Boulder, USA, Web site at http://www.cdc.noaa.gov/

There are potentially many more indirect effects, some of which may be applicable to local fisheries:

Fluvial impacts: Jersey's location within the bay of Granville means it is subject to outflow from many French estuaries. As a result of the fresh water input the local habitat is of lower salinity in the south east which increases away from the French coast. Drier summers will reduce the freshwater input from French rivers altering salinity patterns. Furthermore, the nutrients contained in such outflows will also decrease.

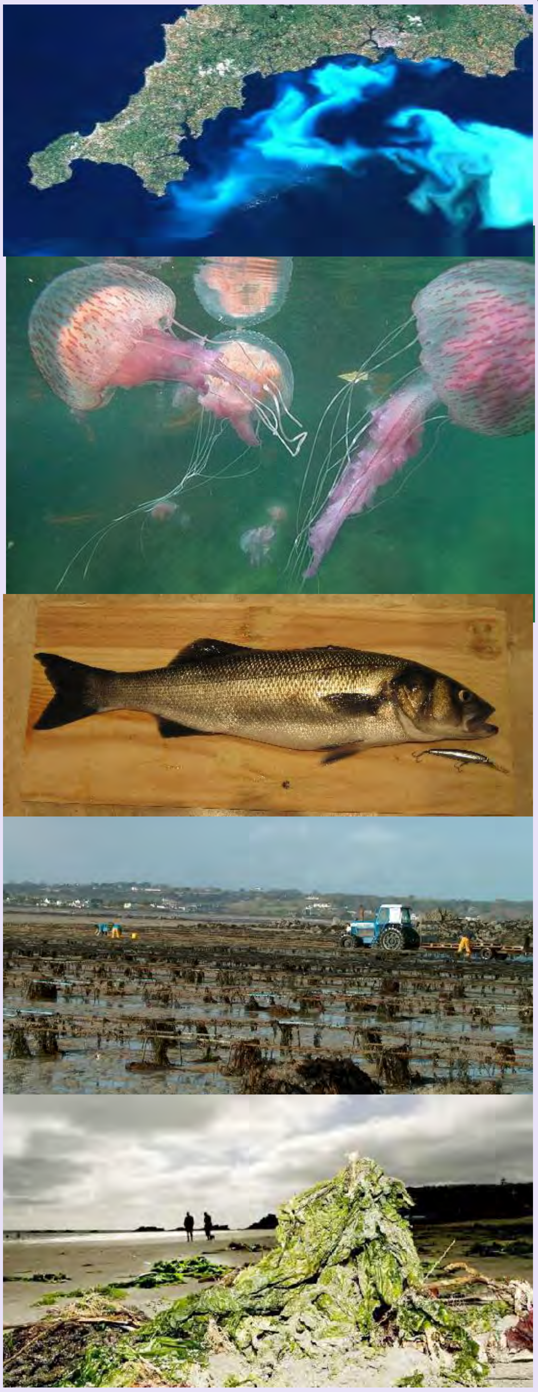
Flushing: Heavy rainfall events in winter without adequate drainage improvements will increase flushing from the land. Inter-tidal species may be impacted by the contents of such flushing. For example, shell fish farms may be contaminated if diseases, such as *E.coli,* are washed onto beaches from fields containing animal waste.

Inter-tidal exposure: Jersey has a significant number of fish farms that are inter-tidal, i.e. exposed to the air or the sea dependant on the tidal height. Extreme heat due to Increased maximum temperatures cause death of such shellfish (especially juveniles) when exposed at low water.

Non-marine species: Changes in the climate will introduce different species to the land, birds are an obvious example due to their mobility. Such species may be more or less predatory of marine species impacting upon the ecosystem balance.

Sea defences: Potentially improvements to sea defences will be required. These can impact upon the profiles of beaches and near-shore currents changing habitats. Furthermore, they may be seen as an opportunity for rocky shore species to colonise new habitats.

Seaweed Blooms: The unattractive sight and odours caused by decomposing seaweed already occur locally and are of additional concern during the tourist season. Although recent blooms are not attributed to climate change alterations in oceanic properties may make seaweed or macro-algal blooms more common. As well as being a nuisance seaweed is important in the local eco-system as its decomposition provides nutrients to beach fauna.



Box 2

TOP TO BOTTOM: Algal blooms like this one off the south west UK may become more common with a changing marine climate as may blooms of jellyfish. Bass is a delicacy we are likely to see more of locally in the future and could heat waves or run-off from fields impact upon the Island's oyster farms? Finally, will sea lettuce blooms like this at St Aubin reduce or increase in the future climate?

4.8 TOURISM: WILL THE INDUSTRY BENEFIT OR SUFFER?

Jersey Tourism

A beautiful, natural environment and a good climate are two key factors in the appeal of any holiday destination.

Jersey is no different and climate change will undoubtedly impact on the island and the nature of its long-established tourism industry.

TOURISM IN EUROPE

As a result of climate change, south European holiday hotspots are predicted to see increases in temperature and increasing spells of uncomfortably hot and humid conditions with heat waves of over 40°C. This may lead to a greater risk of fire and malaria-bearing mosquitoes.

In a changing climate the weather conditions in northern Europe may become more appealing to tourists than the Mediterranean and a revival of northern European resorts could ensue.

LOCAL EFFECTS

Below we examine some potential impacts on the industry and highlight their possible consequences.

Warmer Year-Round Climate

Climate models predict that the local climate will become more Mediterranean in feel over the next 100 years. The British Irish Council scenarios support this conclusion suggesting that Jersey's average maximum temperature in the summer will rise by 1°C by 2020, 2-3°C by 2050 and 3-5°C by the 2080's. Meteorological records show that maximum summer temperatures observed through the early 21st Century hover around the 28-32°C mark. Forecasted rises will not, unlike the Mediterranean, result in uncomfortably hot temperatures for the next 50 years or so.

Although temperature extremes will have an impact.

Consequences: New Markets

At present, Jersey's primary audience falls into the 45+ age category and comprises mainly couples from the UK who will take a short break in the island staying for 4 or 5 days. We know that Jersey has a beautiful environment but a warmer, year round, climate may attract new visitors and encourage those visitors to stay for longer.

In addition, it could increase the Island's appeal to the family market and reduce reliance upon wet weather facilities that are currently in short supply. Visitors are increasingly seeking active pursuits on their holidays and a more favourable climate will allow the already established marine leisure industry to grow.

Demonstrating an Island Commitment to Sustainable Tourism

The consumption of energy and water in holiday resorts and large hotels around the world can put substantial pressure on local resources and ecosystems. Consequently, conscientious travellers are becoming more selective about the destinations they choose and avoiding long-haul flights in order to minimise carbon emissions.

In Jersey, the majority of hotels and attractions are smaller and the infrastructure more able to service their needs and so their impacts are arguably less than elsewhere. Nevertheless there are clear financial and environmental benefits resulting from more efficient resource management. These pressures will increase in the future when we consider the increased need for air conditioning and refrigeration in a hotter summer climate. Implementing Environmental Management Systems, provides a framework for achieving these objectives and the Green Tourism and ECO-ACTIVE Business schemes provide local guidance for the sector and uptake has been encouraging and is expected to grow.

Consequences : Holidaying Closer to Home and Increased Visitor Numbers

Transportation links are key to the success of any tourism destination yet make a major contribution to global greenhouse gas emissions. The price of holidays is likely to increase in the future as fuel prices rise and the effects of global carbon trading mechanisms effect in particular the aviation industry.

Increasing costs of transportation are likely to reduce the demand for long haul destinations. This could result in Jersey becoming a more appealing destination because of its proximity to the UK and Europe particularly if Jersey can effectively communicate a commitment to sustainable tourism to the marketplace.

In 2006, 73% of visitors traveled to Jersey by air. As a short-haul destination the impacts of global actions to reduce air travel and increasing fuel costs are likely to be less of a deterrent than for long haul destinations. Sea travel and the proximity to Europe and its rail network are additional advantages.

Degradation of Popular Tourist Destinations

Certain popular global visitor destinations are likely to be adversely affected by climate change, such as the impact of increasing sea levels in Florida and the Maldives. Extreme weather such as tornadoes, floods and drought will have an adverse impact even if seasonal or one off occurrences. This can take time to recover from, particularly where resorts and other tourism infrastructure have to be rebuilt. Other effects in developing nations such as food and water shortages can destabilise the country. In addition, there may be increased health risks such as malaria.

Consequences: Local Degradation?

Jersey will not escape the effects of climate change. Local wildlife and flora may suffer and changes in the marine climate could impact on marine life.

However, if we are able to rise to the challenges presented by climate change Jersey could be in a strong position to mitigate and adapt to such change. As a result, the Island has the opportunity remain a safe and appealing tourist destination for many years to come and may even benefit from the decreasing popularity of other destinations.

Tourism is a global business and the impact on the local industry cannot be seen in isolation. In the long term, climate change will result in different impacts on different visitor destinations. There will be significant change to the way visitors travel and use energy as costs increase and taxes are introduced.

However, in the short term, we would expect Jersey's climate and natural beauty to remain an attractive proposition for visitors and to see the continued development of this established industry and its positive effect in diversifying the local economy.

Box 1

Active, outdoor pursuits like walking and kayaking may become important to Jersey's appeal as a tourist destination in the future.

Image credit: www.Jersey.com

4.9 CLIMATE CHANGE & REGIONAL BIODIVERSITY

Mike Freeman

We are already noticing the impacts of climate change in Jersey. But what is likely to happen in the longer term as a result of predicted climate shifts, and what, if anything should we try to do about it?

JERSEY'S UNIQUE LOCATION

Geographically the Island is interestingly placed. It lies on the boundary between the Boreal (cold temperature) and Lusitanian (warm temperature) climatic zones. Although politically we are close to the UK, in natural history terms the Island has much more in common with the Europe. When the sea level rose after the last ice age Jersey was the last channel island to retain a land bridge connection with the mainland which meant that many species were able to colonise.

The factors that enable plants to grow in particular areas are complicated, but one of the major factors is climate. The concept of suitable climate space has been used in the Biodiversity Requires Adaptation in Northwest Europe under a CHanging climate (BRANCH) project. Funded by the EU the project investigated the potential impacts of climate change on a range of species.

These projections do not deal with other important environmental influences such as the local or micro-climate, which may contribute greatly to the survival ability of species. For example in Jersey, the flora of the north coast heaths is markedly different from the south west heaths, a function of aspect and slope rather than climate.

WHY WILL ONE SPECIES BE AFFECTED MORE THAN ANOTHER?

A very important factor is the way individual species grow and survive.

The study of the reason why a particular plant species grows in one place and not in another is called autecology. Records from autecological studies help us to understand how plants will react to a changing climate. For example the type of roots, flowering and symbiotic relationships with other species may all play important roles.

In a particular habitat certain factors favour a particular species; for example altitude, hydrology, soil pH, slope or aspect and community interactions will have a strong bearing on how plants will react to climate change.

Unfortunately our knowledge of these issues is very limited. Although one of the upsides of climate change might be that recording and analysis of the effects of the changes will provide valuable information, we should not forget that we are carrying out an experiment whose outcome we do not know.

Continuing research funding is essential. By recording change in species distribution and the corresponding change in habitats we are better able to understand the underlying processes. The more we understand ecological processes, the better equipped we will be to ameliorate the undesirable effects of climate change.

The potential suitable climate space maps come with a warning; they only deal with climate and where there could be suitable climate conditions. They provide an indication of the degree of change which may occur but do not cover the other factors which may influence the distribution of species, including the ability of species to move into new climate space. The following articles attempt to outline the potential effects of climate change without over-interpreting the projections in the maps.

ACKNOWLEDGEMENTS

Maps courtesy of the Biodiversity Requires Adaptation in Northwest Europe under a Changing Climate Project and Berry, P.M.

For more information see: http://branchproject.org/.

Many thanks to Dr Pam Berry of the Environmental Change Institute, University of Oxford for her contribution to articles 4.9, 4.10 and 4.11.

Box 1

An iconic species of Jersey, the agile frog, *Rana dalmatina.* Changes in suitable climate space are not a potential threat to the species directly.

Pollution through agricultural chemicals and low water levels during the breeding period are of concern. Increased flushing of agricultural chemicals during heavy precipitation events may become more common as could low breeding levels during periods of drought.

4.10 HOW WILL CLIMATE CHANGE ALTER THE ISLAND'S HABITATS?

Mike Freeman

Jersey's Biodiversity Strategy identifies two priority terrestrial habitats - coastal heathland and sand dune. Four other habitats - wet meadow, woodland, marsh and walls and banques - are identified as being important in a local context (Box 1).

Although no firm predictions can be made, it can be deduced from the scientific literature and from observed changes in recent times, how climate change is likely to impact upon the Island's habitats. The following sections examine these potential consequences.

SAND DUNES

Predicted changes in sea level and the threat of storm surges will cause increased erosion. This will result in some threat to nearly all of the species found in Jersey's internationally valuable sand dunes.

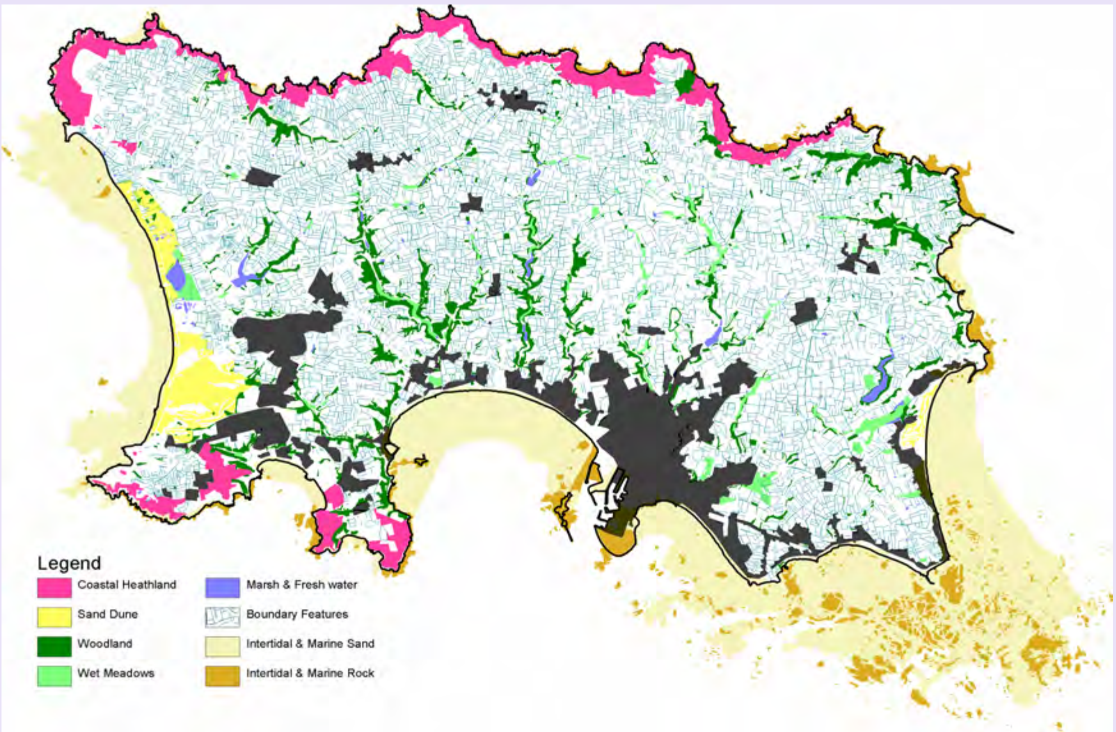
Some specific plants, such as the early purple orchid, may find things difficult when the conditions described under the 2080 scenario are reached. However, plants like sea holly which thrive in dry hot coastal conditions seem unlikely to change very much.

COASTAL HEATHLAND

Species such as blackberry and hawthorn may struggle as climate change progresses to 2080. Very broadly it is predicted that the suitable climate space of species with present distribution on the French and Spanish Atlantic coast will move north and westward. This includes such favourites as honeysuckle and blackberry and even *Erica cinerea* (bell heather) and *Calluna vulgaris* may be negatively affected over the long term. Molinia may lose suitable climate space and all wet habitats will be under pressure in summer due to lack of rainfall.

WET MEADOW

Changes in the seasonality of heavy rainfall are likely to affect the water regime of wet meadows mainly found at the base of Jersey's steep-sided inland valleys. By 2100, there is expected to be up to 50% less precipitation in the summer, and up to 30% more in the winter. Combined with the increases in extraction for agriculture and industry, low summer water levels may affect the wet-loving plants and associated insect and animal species.



Box 1

The SoJ Biodiversity Strategy identifies sand dune and wet meadow as the 'priority' terrestrial habitats with the other four non-tidal habitats designated as 'important'.

The important service provided by wet meadows in times of heavy winter rainfall is to provide attenuation of waterflow and allow recharge of aquifers, storing water for the drier summers. Although recreating traditional meadow management is a challenge, it would be far better to allow reversion to willow carr and wet woodland than to continue the current practice of draining and culverting streams in these meadows, in an attempt dry them out and to move the water into the sea as fast as possible.

WOODLAND

Woodland in Jersey is often adjacent to wet meadows. The steep valley sides are typically sycamore dominated deciduous woodland containing sweet chestnut, oak, ash and holm oak. At the base of the valleys are often wet meadows with a stream running through, and at the top of the valley sides the level of the land changes abruptly to a relatively level plateau. Heavy rainfall events often cause localised erosion and this may become more pronounced in the future.

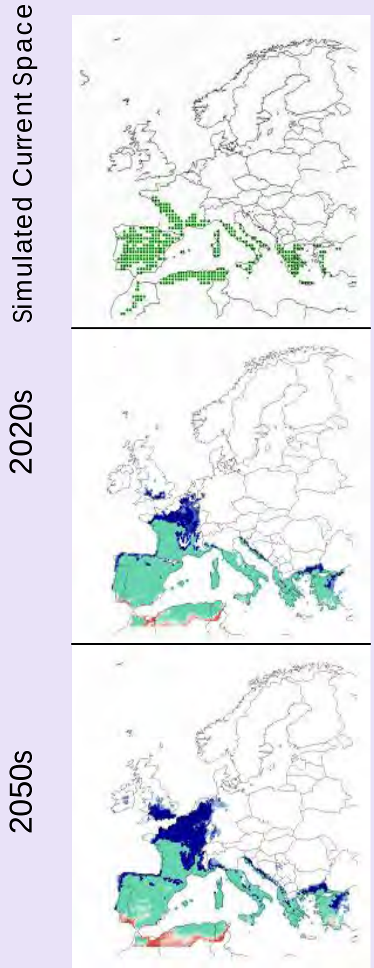
The valley side woodlands have very shallow soil so in summer they may suffer; the climate space predictions for common woodland tree species show that potential suitable climate space could increasingly be lost. Holm oak, already far more common in Jersey than in the UK with its heavy evergreen canopy, may increase (Box 2).

WETLANDS

As with wet meadows, the remaining wetlands in Jersey, like St Ouen's pond and Grouville marsh, provide valuable storage and attenuation services. The changing rainfall patterns will alter the ecology of these areas. The common reed, *Phragmites australis,* the typical plant of these areas may have limited suitable climate space by 2080. Furthermore, water shortages in summer may exacerbate the risks to survival of wetland areas in Jersey. The value of these areas as refuge and feeding places for migratory birds will increase if the water regimes can be maintained by making sure they are not affected by land drainage or extraction.

WALLS AND BANQUES

Predictions of how climate change may affect the walls and banques which are so characteristic of the Island's landscape is immensely complicated. These features can be found all over the Island. They vary from dry stone walls or stone faced banks with little vegetation in the dry western parts of the Island, to banks with hedges and trees in valleys. The physical form of the walls and banques is unlikely to alter. Of greater concern are the changes that may occur to the various trees and shrubs that provide the habitat for many species in these locations.



Box 2

Changing potential suitable climate space under a HadCM3 A2 scenario for Holm oak. The species is already established within the Island's woodland with BRANCH projections showing gain of climate space northwards into Southern England, Wales and Ireland (blue regions) with loss in northern Africa (red regions) (full key in article 4.11).

4.11 HOW WILL CLIMATE CHANGE AFFECT THE ISLAND'S SPECIES?

Mike Freeman

Four of Jersey's plant species, on the Biodiversity Action Plan, were considered in the BRANCH project. Potential climate change impacts on these plant species and a selection of animal species are examined here.

Although no detailed studies have been carried out, the following assessment draws upon the views of the Ecology Division in consideration of recent scientific literature and locally observed changes.

FLORA

- Wild asparagus, *Asparagus officinalis*

Recorded at the sand dunes in St Ouens and the south coast cliffs, it appears to be slightly increasing in numbers (although this is probably a function of increased survey effort). The climate space maps indicate that potential suitable climate space for this species will continue to be available.

- Wild Strawberry, *Fragaria vesca*

This has declined recently probably from increased enrichment of hedgerow and bank from fertilizer overspill. Suitable climate space is not predicted to diminish in Jersey.

- Yellow Horned-poppy, *Glaucium flavum*

A plant which thrives in the hot dry conditions around the west and south coast. Although its habitat might be damaged by sea level rise and increased storms , its suitable climate space is not predicted to decline in Jersey (see Box 1).

- Shore Dock, *Rumex rupestris*

This is likely to suffer loss of coastal habitat due to sea level rise. Suitable local climate space is predicted to remain up to the middle of the century. Since this species typically favours wet freshwater patches at the base of sea-cliffs, the changes in water availability may have an adverse effect.

REPTILES AND AMPHIBIANS

- Green Lizard, *Lacerta bilineata*

These are currently on their northern most limits in Jersey, although some small colonies are reported in the UK. It's predicted that suitable climate space for *L. bilineata* is predicted to make strong gains locally. This may mean that the lizard will become much more common in Jersey, although habitat availability will still be an issue.

- Wall Lizard, *Podarcis muralis*

Similarly, the suitable climate space for wall lizards is predicted to make strong gains, and conditions are likely to become more favourable. The distribution of *P. muralis* is at present restricted to various small parts of the Island for reasons that are not fully understood. Since we have made public appeals for sightings the known areas have increased, indicating that habitat availability may not be as limiting as at first thought. The gains in suitable climate space may , as with *L.. bilineata*, enable *P. muralis* to become more widespread in Jersey.

- Agile Frog, *Rana dalmatina*

This is also on its northern limit in Jersey. Suitable climate space is predicted to spread north and west. Climatic space will continue to be available in Jersey. The present threatened status of the frog is not considered to be primarily due to climate. Pollution by agricultural chemicals is still a problem with general low water levels during the breeding period contributing.

BIRDS

The following species are included in the Biodiversity Action Plans because they are showing severe declines. Projected changes in simulated suitable climate space are likely to have an impact but habitat availability, connectivity, and management are extremely influential.

- Skylark, *Alauda arvensis*

From 2020 to 2050 the suitable climate space for skylark is predicted to show loss in Jersey. This factor, exacerbated by increased disturbance, development and changing agricultural practice, may severely threaten the future of the skylark in the long term.

- Cirl Bunting, *Emberiza cirlus*

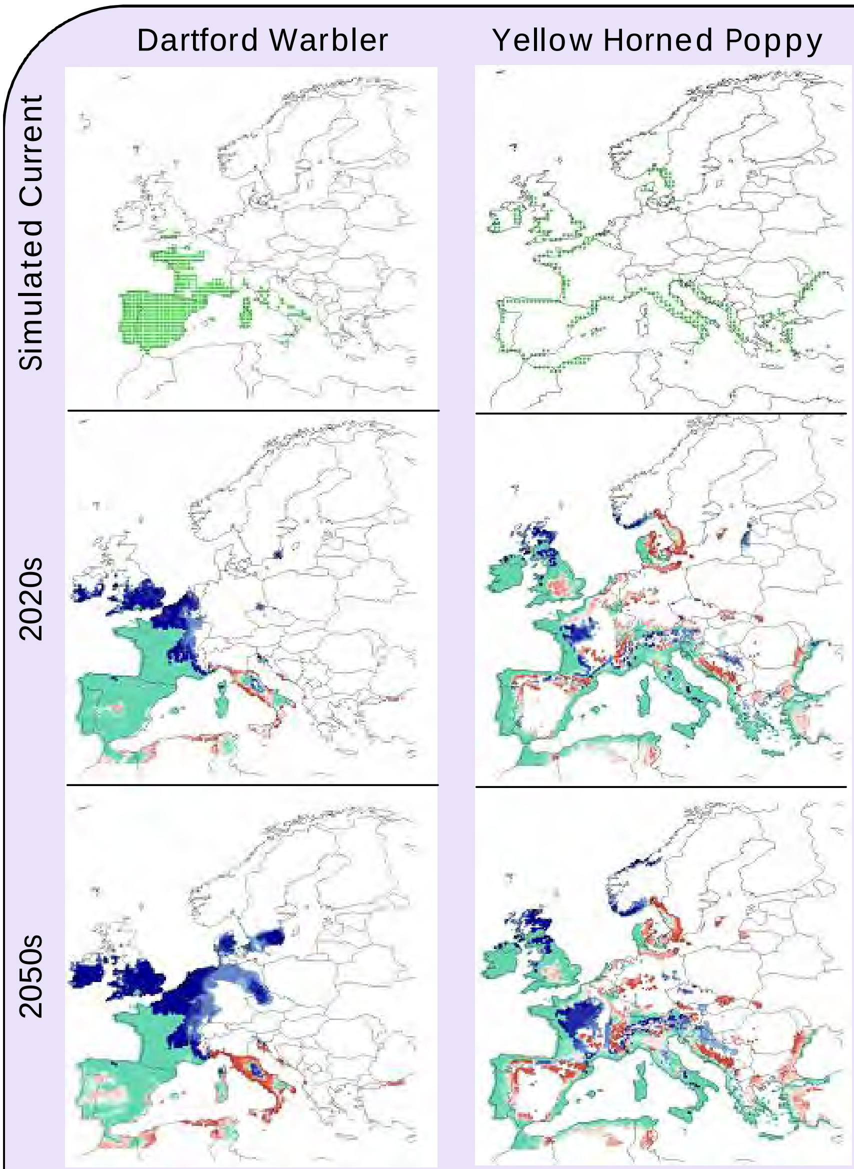
The predicted change in simulated climate space for Cirl Bunting shows that the climate should still be suitable into the 2050s. Habitat loss and availability of winter food and food during the breeding season continue to be cause for concern.

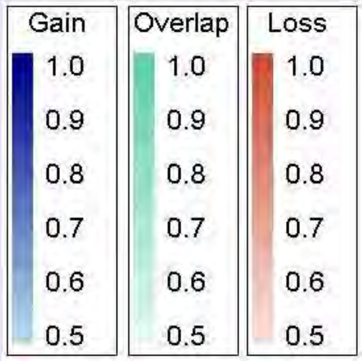
- Stonechat, *Saxicola torquata*

Suitable climate space for Stonechat is also predicted to remain available into the future. Habitat loss and disturbance, lack of food in winter and during the breeding season will have to be addressed if the local population is to recover.

- Dartford Warbler, *Sylvia undata*

Suitable climate space for this heathland bird is predicted to remain available into the future. Drier summers are likely to increase the risk of gorse fires which are very damaging. Habitat loss due to change in agricultural practice and disturbance continue to contribute to decline (see Box 1).





Box 1

The complexity of predicting the future distribution of species is dependant on many factors. These model forecasts focus on the influence of climate space and some species produce clearer pictures than others. For example, the Dartford warbler reveals a northward shift into the southern areas of the UK and Ireland and eastward into central Europe. In contrast, the Yellow Horned Poppy, which favours coastal habitats, is predicted to spread inland in some areas but lose space inland in other regions. This highlights the difficulty in making confident predictions.

4.12 PLANKTON, A CLIMATE CHANGE INDICATOR?

D. G. Johns and M. Edwards
Sir Alistair Hardy Foundation for Ocean Science

The plankton community, with both plant (phyto-) and animal (zoo-) constituents, represents the base of the marine food web, and thus any changes can influence higher forms of marine life (such as fish).

Zooplankton consist of not only permanently planktonic organisms, such as small crustacean called copepods (Box 1), which provide an extremely important food source for larval fish, but also temporary members, such as the larval stages of crabs and lobsters.

Long term (1958 to present day) sampling by the Continuous Plankton Recorder (CPR) survey has enabled the study of changes in abundance, community composition, and peaks in seasonal timings, which can all impact higher up the food chain, and are often attributed as indicators of climate change.

Here we discuss changes in the abundance and distribution of zooplankton in recent years, and show the results for one species, the copepod *Clausocalanus*, which is indicative of warmer , more southerly waters. The long-term changes of *Clausocalanus* (Box 2) show that it has increased six-fold during the past 15 years.

SENSITIVITY TO CLIMATE AND OTHER FACTORS

Zooplankton, being near the very bottom of the food web and having a rapid generation time, can respond to climate change quicker than many higher organisms. They are therefore good indicators, and have been used in previous studies. Many are of economic importance, either directly as the larval stage of exploited species, or indirectly as the food of other species.

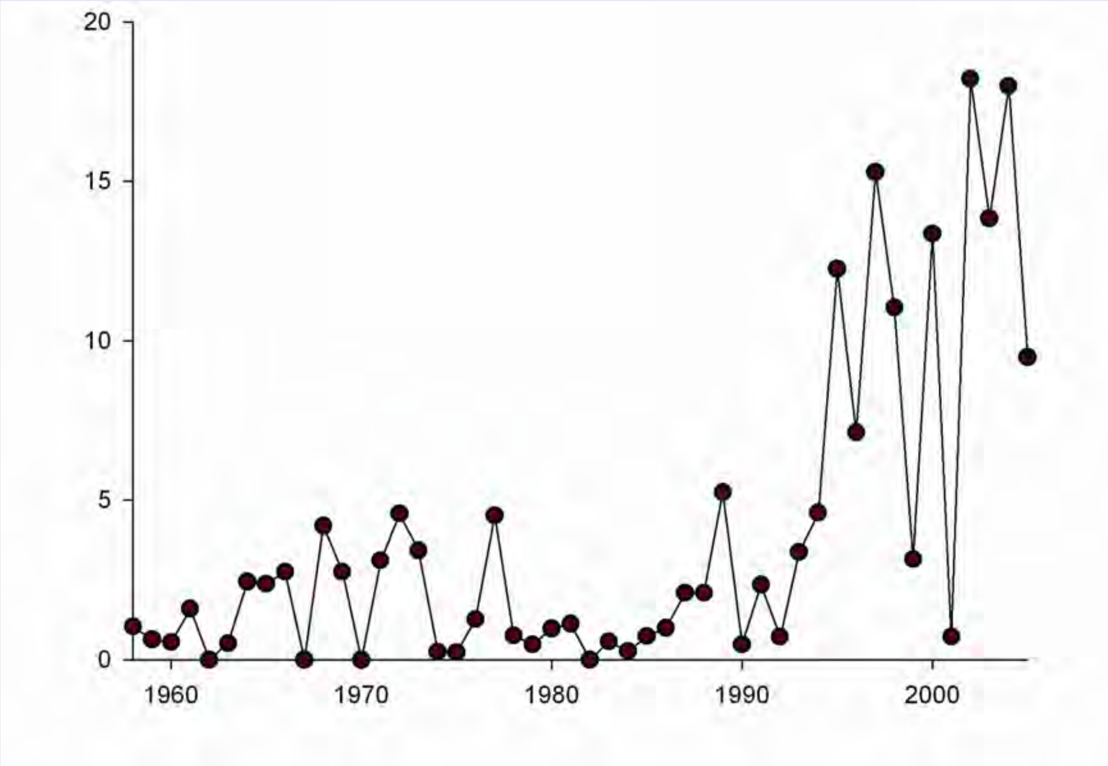
CHANGE OVER TIME AND LIKELY IMPACTS

Analysis of long-term plankton data for the English Channel and Channel Islands has shown the following changes in response to climate warming:

Image Credit: Planet Guernsey

Box 1

The copepod *Clausocalanus*, which is indicative of warmer waters.



Box 2

Plot of the long term abundance of Clausocalanus, an indicator of warm water.

- Changes in temperature have affected the lowest elements in food webs, and this has propagated upwards.

- Copepod species have shifted 10o northwards, due to increased sea temperatures.

- Increased temperatures have likely allowed successful invasion by warm water species. These may have moved further northwards as waters warmed, or been introduced via the ballast water in ships.

- There has been a change in one of the most abundant and important copepods, *Calanus*, with the colder (previously more abundant) species declining and the warmer water species increasing. But, the combined number of both species has dropped, meaning there is potentially less food for larval fish.

- The start of seasonal cycles have changed, getting earlier, potentially causing a mis-match between inter-dependent organisms.

- An increase in the occurrence of *Noctiluca scintillans*, a potentially harmful (to fish and invertebrates) phytoplankton species.

These trends are likely to continue, due to an increase in warming, and will have an effect on which fish species (both fin- and shell-) can be commercially harvested in the future.

REFERENCES:

The Sir Alistair Hardy Foundation for Ocean Science (SAHFOS) is an international charity that operates the Continuous Plankton Recorder (CPR) survey. The Foundation has been collecting data from the North Atlantic and the North Sea on biogeography and ecology of plankton since 1931(http://www.sahfos.ac.uk)

4.13 THE EFFECTS OF CLIMATE CHANGE ON INTERTIDAL SPECIES

N. Mieszkowska, R Leaper, J. Hill, A.J. Southerward & S.J. Hawkins
Marine Biological Association of the UK

Intertidal animals and plants live at the margin between the sea and the land and so these organisms are subject to changes in both environments. They can therefore serve as early warning indicators for the impacts of climate change. The larval stages of many species can be indicative of changes occurring in offshore waters. Low intertidal and subtidal kelp beds are nursery grounds for juvenile fish, and are also an important part of the near-shore community. Longterm data sets exist for intertidal invertebrates around the coast of the British Isles, including data collected in Guernsey during the 1950s, 1970s, 1980s and, more recently since 2000s. These data allow the responses of species to fluctuations in the climate to be determined.

SENSITIVITY TO CLIMATE & OTHER FACTORS

Intertidal species are subject to wide fluctuations in temperature, and are often already living close to their thermal tolerance limits. Rapid warming of the climate that has occurred in the English Channel over the last two decades (Box 1) has altered the environmental regime of the intertidal zone and species that are fixed to rocks or move only small distances are being forced to adapt or die.

CHANGE OVER TIME

Analysis of data from the 1950s, 1960s, 1980s and 2000s showed the following changes to intertidal species in the English Channel in response to climate warming:

- Warm water ‘southern’ species of topshells, limpets, barnacles and seaweeds have extended their eastern range limits in the English Channel by up to 120km.
- Population abundances for southern topshells have increased six fold as sea temperatures have warmed. Similar changes have occurred in southern barnacles.
- Cold-water ‘northern’ species of limpets, barnacles and seaweeds have shown reductions in abundance and some retraction in their southern limits.
- These changes in northern species are not as marked as the increases recorded in southern species.

Experimental research showed that these changes appear to be driven by increased reproductive success of adult organisms as spring and summer temperatures have risen, and increased over-winter survival of juveniles for southern species in response to milder winters. In addition, indirect effects of climate change occurring via competition are affecting the relative abundances of northern versus southern species of barnacles and limpets.

A major study of the impacts of climate change on marine biodiversity in Britain and Ireland over the last 50 years (the MarClim

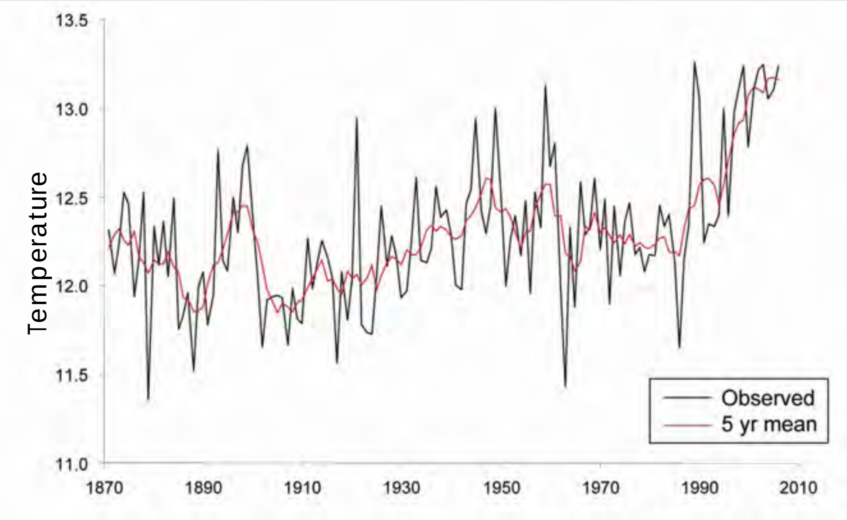


Image Credit: Planet Guernsey

Box 1
Mean annual sea surface temperature for the coastal waters of the English Channel. Note that the off-shore surface temperature is very similar to that recorded in St Helier harbour, (Article 2.7) with the same upward trend in recent years.

project, see also Article 4.7), has been undertaken with a view to predicting likely future climate impacts. The MarClim team has predicted the following changes:

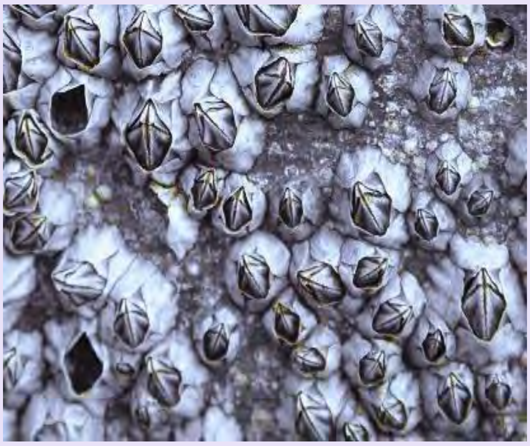
- Further pole-wards expansion of warm water species.
- Continued contractions in the southern range limits and abundance of northern species.
- Increased invasions of non-native species are likely to occur, and expand their range if already established.
- A short-term increase in biodiversity may occur followed by a longer-term decline in biodiversity as native species of northern, cold water origins are lost from an increasing number of shores.
- There is the potential for huge changes to British marine inter-tidal ecosystems within the next 50-80 years, and Jersey will not be exempt from this.

LIKELY IMPACT

The shores in the Channel Islands host southern, warm-water species of intertidal species including the topshell *Gibbula pennanti* that are not currently found on the British mainland. Such species are predicted to colonise shores in southwest England as future climate warming opens up new regions of suitable thermal habitat. The island is thus an important 'stepping stone' for the spread of non-native species onto the British mainland.

Northern cold-water species that are currently present on the island, including kelps that provide nursery grounds for juvenile fish are predicted to decline in abundance as temperatures continue to increase. Non-native species including the Japanese seaweed Sargassum muticum and Australasian barnacle Elminius modestus (Box 2) have already invaded Jersey and Guernsey and are predicted to increase in abundance as the climate continues to warm.

Image Credits: Planet Guernsey



Box 2

(a) The invasive Japanese seaweed *Sargassum muticum* (above)

(b) The invasive Austalasian barnacle *Elminius modestus* (top right).

Both species have been transported to British coastal waters within the ballast water of international ships.

REFERENCES:

Prof. Steve Hawkins, Nova Mieszkowska and Rebecca Leaper of the MBA have been regular visitors to Jersey, Guernsey and the English Channel coastlines of England and France carrying out research on intertidal species.

Marine Biological Association of the UK: http://www.mba.ac.uk/.
Marine Biodiversity and Climate Change (MarClim project): http://mba.ac.uk/marclim/

4.14 HUMAN HEALTH IN A CHANGING CLIMATE

Health Protection Section

The following sections highlight some concerns over the potential health effects of climate change.

Effects of Higher Temperatures

Current predictions suggest higher temperatures will result in 3 extra summer heat–related deaths per year. This could be offset by approximately 33 fewer cold deaths in winter, but it is still 3 deaths too many.

Predicting severe heat waves and their effect is difficult, but the impact of not being prepared is significant. For example, there is a 1 in 40 chance that by 2012 South-Eastern England will experience a heat wave that will cause perhaps 3,000 immediate heat-related deaths and a further 6,350 heat-related deaths (Source, Health Protection Agency). In terms of thinking about risks to health, a risk of 1 in 40 is high.

Excessive summer heat could result in a deterioration in the quality of work and living conditions. This may result in greater reliance on air conditioning and therefore greater energy use - as fuel poverty becomes more prevalent this directly impacts on health.

Bacteria multiplies faster in warmer temperatures. This means there is the potential for more food poisoning incidents. There could be up to 14,000 (14.5%) more cases of food poisoning, including Salmonella, per year in the UK (Source, Health Protection Agency).

There could be more algal blooms in sea water in the future. This would affect bathing water quality and potentially contaminate shellfish.

Diseases such as Malaria (carried by mosquitoes), are likely to spread north as Northern Europe warms up. Evidence suggests that outbreaks of malaria in the UK and Jersey are likely to be rare, however Health Authorities need to remain alert to the possibility of outbreaks in other European countries. It is not unreasonable to believe other disease carriers may arrive in the UK and Jersey bringing diseases with them. Other diseases of concern include Lyme Disease or Encephalopathya carried by ticks and mosquitoes. Although the chance of such diseases becoming established in the UK or Jersey is very low, the Island will need to remain vigilant.

Sea level rise

An increase in sea level of between 9-69cm is likely by the 2080s will hopefully be controlled through improvements to our sea defences. The effect on Jersey of an extreme sea level increase (although this is not thought to be likely during the next 100 years) could be catastrophic. For example parts of the hospital, Jersey Electricity power station, sewage treatment works, energy from waste plant, fuel farm and many domestic properties around the coast would be under water.

Flooding associated with sea level increase or changing storm patterns could cause the release of sewage into the environment as the Island's infrastructure fails. This increases the chance of illnesses including Cholera, Typhoid, *E.coli* and viruses. Flooding also carries the direct risks of injury and drowning. Globally, sea level changes could have a significant impact on migration so influencing the spread of disease.

Extremes of weather

More periods of heavy rainfall (over short

> *"Climate change is perhaps the most significant environmental problem which mankind will face in the coming century. Efforts to reduce the extent of climate change are of course important, but it is likely that we will have to deal with at least some impacts on health"*
>
> Sir William Stewart Chairman Health Protection Agency said in the report "Health Effects of Climate Change in the UK" an update of the Department of Health Report 2001/2002

periods), is likely to increase the bacterial loading of surface water. There is a clear risk to drinking water supplies as the risk of contamination rises.

Increase in ultra violet light

With an increased exposure to ultra-violet light, cases of skin cancers are expected to rise. It is believed there could be 50 extra cases per year locally by 2050. New evidence also suggests that UV exposure is a cause of some types of cataract. This could result in 3 extra cataract cases per year in Jersey by 2050.

Air pollution

Air pollution levels continue to change. Concentrations of a number of important pollutants are likely to decline over the next half century, which is good news. Unfortunately the concentration of ozone is likely to increase. Significant changes are predicted for the UK with conservative assumptions suggest up to 1,500 extra hospital admissions and deaths per annum.

Mental & Social Effects

The mental health of the population may benefit from warmer weather for longer periods, potentially reducing the number of depressive illness cases. The milder climate is also likely to be more conducive to outdoor activities helping the population to get out and exercise more.

WHAT SHOULD BE DONE?

Higher Temperatures: Ensure the population has access to information to help them cope with possible changes; buildings should be designed to provide a comfortable climate through design rather than reliance on air conditioning.

Storms: Building regulations should ensure structures can cope with any potential increased weather extremes. The Islands' drainage and essential infrastructure must be future proof.

Water Levels: It is important that sea defences are maintained to keep the population safe.

Box 1

Top to bottom: An increased risk of skin cancer; possible infection from various 'disease' vectors such as this tick; potential exposure to disease such as salmonella; increased likelihood of algal blooms; and greater dependence on air conditioning are all potential consequences of the future climate.

Keep track of Change: Our Department has already taken measures to address the future consequences of climate change on health. It is now important to move forward and produce a quantitative assessment to help assess the health risks of the future climate.

4.15 INSECTS AND CLIMATE CHANGE: WHAT A PEST!

Scott Meadows

MODELLING CHANGE

As we have seen in previous sections, climate modelling is complex. Current work suggests that under a warmer climate many European and exotic insect species could establish in Northern Europe and could potentially cause serious problems. Changes in other factors such as rainfall, humidity will also impact upon insect populations.

Climatic change will also introduce indirect consequences such as increased plant growth or plant stress (e.g. from drought) making them more susceptible to attack by pests and pathogens.

CROP ALTERATION

Any prediction of the change in range of insect pests must also account for the variability in ecosystems for example the suitable vegetation availability and type.

Crops grown locally may alter as climate prevents the production of historically grown species. In turn, insect species which are currently viewed as pests could become less relevant, whilst new crops may provide an ecological niche for pests that are not currently considered. One of the most likely effects of climate change may be the alteration of the balance between insects, their natural enemies and their host plants. When considering all these levels of complexity, predictions become even more difficult make.

JERSEY'S LOCATION

Jersey, with its close proximity to the European mainland, has always been an interesting area from a species distribution point of view. Southerly and easterly air flows regularly deliver insects that are not indigenous, ranging from Colorado beetle, various Southern European lepidopteran species, and occasionally migratory locusts. Ordinarily these visitors would not be able to establish here. However, insects are amongst the most versatile and easily moved organisms on the planet, and also some of the hardest to control. Climate change may allow some of these visitors to become resident.

Strategies are already in place to monitor for certain migrants, the most important currently being the Colorado Beetle. As climate change effects are felt, it is likely that more monitoring programs will be implemented against potentially damaging migrants. There will need to be a greater focus on bio-security – detection of non-indigenous species as they arise and effective environmentally acceptable solutions for their control.

PUBLIC HEALTH

Another risk is not direct damage from new insects, but what they bring with them. Insects are extremely efficient vectors of viruses and diseases that can affect plants, animals and humans. Potential consequences as a result of new vectors are discussed in the other articles in this section.

CHANGE HAS BEGUN

Over the last few years anecdotal evidence has suggested that climate change is already having an effect on the insect fauna of the Island.

The first example of this is the two spotted spider mite (*Tetranychus urticae*) (Box 1a).

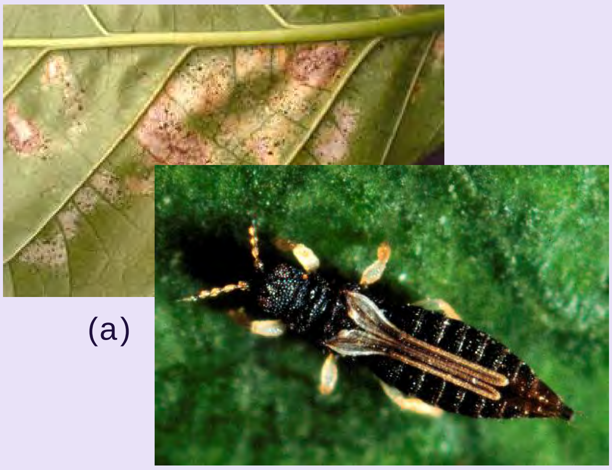
(a)

(b)

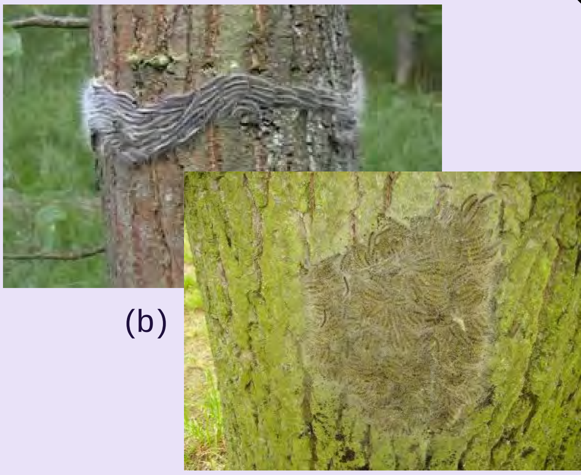
Box 1

(a) The two spotted spider mite (*Tetranychus urticae*) and (b) The fuschia gall mite (*Aculops fuchsiae*)

Both species are now present in Jersey having once been restricted to warmer climes.



(a)



(b)

Box 2

(a) The Greenhouse Thrips *(Heliothrips haemorrhoidalis)* originally of South America was detected in Jersey in 2007.

(b) Evidence of the oak precessionary moth, detected in Jersey in the summer of 2007.

This is a global pest of a wide range of food and ornamental crops. At Jersey's latitude it causes most problems in glasshouses. Ordinarily it would enter hibernation-like state in the late autumn, triggered by falling light and temperatures. However, for approximately 5 years it has been observed remaining active throughout the year and has been observed on outdoor plants both early and late in the growing season.

Similarly, in 2006, *Aculops fuchsiae*, the Fuchsia Gall mite (Box 1b), was confirmed in over 100 Jersey gardens. Originating from sub-tropical areas this pest was most likely introduced by a private collector, but has found conditions suitable enough to establish and spread rapidly, killing most of the plants it infests.

Similarly, in the summer of 2007 large ornamental trees in parks in Jersey suffered attack from *Heliothrips haemorrhoidalis,* the Greenhouse Thrips (Box 2a) which is a tropical South American species. In Britain it is almost always restricted to glasshouses but the warm, damp conditions of the summer of 2007 allowed the pest to multiply massively. In both these cases it is fortunate that the pests are destructive of non-indigenous, largely ornamental species that contribute very little to the Islands' ecosystem unlike native species such as oak or heather.

In 2007 the Oak Processionary Moth (Box 2b) was detected in Jersey. Originally from central and southern Europe the moths are posing an increasing threat as their range is being extended by the warming European climate. This pest is a major defoliator of oaks, and consecutive defoliations can cause death of a tree. This insect also poses a human hazard as the backs of older caterpillars are covered with thousands of pointed defensive bristles containing a toxin. Even if the larvae are not handled, the hairs break off readily, become airborne and can cause rashes or breathing difficulties for some people.

It is important to remember that nature is adaptive and able to moderate populations if change is not too rapid. This is demonstrated with predator-prey interactions. A new species may arrive, find a suitable food source and multiply rapidly, creating economic or environmental damage. Often its arrival will be followed by the arrival of its parasites, predators and diseases. This was the case with the Oak Processionary Moth in Jersey. In all the nests found almost 100% of the caterpillars had been parasitised, either by a local fly species, or by a non-native which had followed the Oak Processionary Moth on its northern migration restricting the size of the infestation.

CONCLUSION

It is very difficult to accurately predict the changes in the insect population in Jersey as a result of climate change. There is a need for increased vigilance and awareness, communication with other European countries so we know what might be headed our way, and an ability to be able to react accurately and appropriately when threatening incursion, be it on the grounds of plant, animal or human health, does occur.

4.16 A CHANGING CLIMATE FOR ANIMAL HEALTH

Linda Lowseck

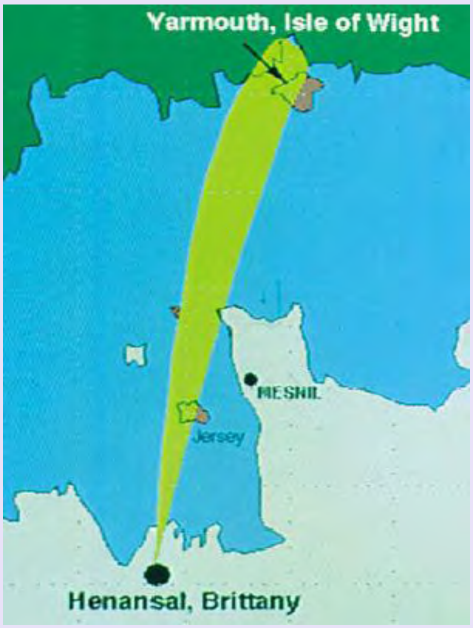
Worldwide, humans suffer a range of diseases transmitted from wild or domesticated animals. Topical examples include avian influenza, Severe Acute Respiratory Syndrome (SARS) and West Nile fever. Furthermore, there are many diseases that, although not transferable to humans, cause pain, suffering or even death to our pets and livestock. By the end of the 21st Century the spread of diseases of animals could be very different to how things look today.

In order to assess the potential impact of climate change the combinations of factors and events that interact to cause animal disease must first be established. From this baseline, any factor or event that may be influenced by climate change can be assessed to forecast how it will differ in the future. However, any single disease is likely to be affected by many factors that cannot be predicted with confidence. These include changes to livestock management, the physical environment, developments in animal genetics, scientific and technological advances as well as extreme weather events.

As discussed in previous articles, the spread of vectors will have a major influence on the transmission of diseases. Such vectors include types of flies, midges, ticks, snails and mosquitoes. A direct effect of a warmer climate may, for example, limit current populations of mosquitoes as the environment becomes too dry. Conversely, the habitat suitable for mosquitoes may extend if humidity or rainfall patterns increase. Furthermore, indirect effects may influence vector populations, for example the increased temperature and drier conditions could still allow population growth due to increased water storage areas (i.e. tanks) creating new breeding sites.

Disease may also be spread through pathogens or parasites in the air. The heat and humidity of the local environment can influence the longevity of vectors outside of a host animal. Box 1 highlights the example of foot and mouth disease that spread from France to the UK on the wind.

In contrast, diseases transmitted directly between animals at close contact are unlikely to be severely impacted by climate change. However, as highlighted in Box 2, the location of such diseases may alter according to the habitable climate space of a species.



Box 1

In 1981 Foot and Mouth Disease spread from Brittany to the UK. The wind carried the vector 150 miles and crossed Jersey causing one case of the disease locally. On the mainland, 400 animals had to be slaughtered and animal movement in Hampshire and the Isle of Wight was restricted.

THE FUTURE

With respect to 'tropical diseases' the easiest way to consider their spread is to look at countries that experience the same climate today as is forecast for here in the future. Essentially, Jersey's climate is expected to be more Mediterranean in feel in the future. Vectors common in this location at present, such as *Culicoides imicola,* that carry bluetongue and African Horse Sickness are likely to invade our shores. West Nile virus has also occurred in Italy and the south of France in recent years, as have Phlebotomous sandflies that carry leishmaniasis – a very serious disease of dogs that is also transmissible to humans.

In consideration of livestock climate change is most likely to have a negative

Box 2

Bird flu will not be directly impacted by climate change as the flu is passed through contact either directly between birds or through their faeces.

However, there is potential for spread of the disease - in a changing climate the migration routes of different birds may change. This can alter the areas which are likely to be impacted by infected birds and should be of consideration to those planning for such outcomes.

effect through extreme rainfall induced flooding. For example, Anthrax spores may be disturbed from the soil to contaminate water or animal slurries (containing diseases such as *E. coli*) may breach sludge tanks and disperse over large areas.

Fortunately, the spread of major avian influenza (see Box 2), brucellosis, Bovine Spongiform Encephalopathy (BSE), Classical Swine Fever, Foot and Mouth, Rabies and Salmonella are all transmitted by close contact so the direct influence of climate change is likely to be minimal.

WHAT CAN WE EXPECT?

Climate change will affect diseases in many ways. It will influence the behaviour of the pathogen, the host and the vector, both directly and indirectly. The number and variety of possible diseases and disease vectors, the processes affecting them, and the uncertainty of climate change forecasts makes predicting future animal diseases an extremely complex science.

Case Study: West Nile Virus

Identified in 1937 it is increasingly clear that West Nile virus (WNV) will thrive in the future climate of Northern Europe. The virus excels in mild winters coupled with prolonged droughts and heat waves - all features that are expected locally as climate change sets in.

WNV is transmitted by mosquitoes to birds, horses and humans and can cause inflammation of the brain, brain lining and spinal cord. The mosquito vector breeds well in pools underground and is therefore suited to urban drainage.

During droughts these pools are a rich food source as rotting organic material and the scarce availability of water draws in birds, helping to circulate the virus. High temperatures accelerate virus development, which means that there is a greater chance that the virus is transferable whilst the mosquito is alive.

All of these factors enhance the possibility that infectious virus levels will build up in birds and mosquitoes living in close proximity to humans. The disease is clearly a threat - in 1999 seven New Yorkers died from the disease and sixty-two others were infected.

Closer to home a study of British birds found ‘evidence’ of WNV in 20 species including crows, magpies, swallows, chickens, turkeys and ducks. These birds were healthy but the virus antibody was found indicating that the birds had come in contact with the virus. It is thought the virus was brought to the UK by migrating birds but is said to provide no immediate threat to humans at present.

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P. Gale *et al*, Veterinary Record, ‘Predicting the impact of climate change on livestock disease in Great Britain
http://news.bbc.co.uk/2/hi/science/nature/3079425.stm Images in Box 1 and Case Study - Foresight Report, Image Box 2: www,chinapost.com.tw/news_images/2007 1209/p2a-1.jpg

4.17 CLIMATE CHANGE, A GROWING PROBLEM FOR PLANT HEALTH?

Steve Thompson

Amounts of disease in plants are dependent on the interactions of three main factors:

- Pathogens (e.g. fungi or bacteria)
- Susceptibility of host plants
- The environment

The interactions can be visualised as a triangle, referred to as the 'disease triangle' (Box 1). The length of each side of the triangle is proportional to the sum total of the characteristics of each component that favour disease. For example, the more favourable the environmental conditions that help the pathogen (e.g. temperature and humidity), the longer the pathogen side would be. This would cause the area of the disease triangle to increase representing a greater potential amount of disease.

WHAT CAN WE EXPECT?

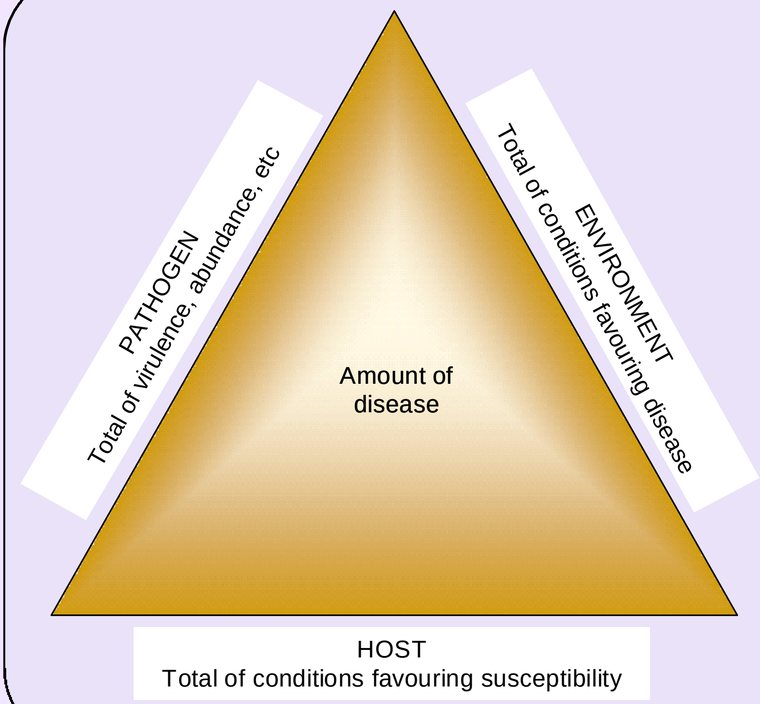
A warmer climate with wetter winters will result in an increase in length of all three sides of the disease triangle although this may be mitigated somewhat should summers become drier.

We can illustrate this in real terms using the example of late blight which affects the Jersey Royal potato (Box 2).

Occurrences and the severity of cases of late blight are expected to increase as are most other diseases currently present in crops, countryside and gardens in Jersey. Root and stem rots and bacterial problems on brassicas and other vegetables will result in greater pesticide usage to combat falls in productivity.

There are likely to be more outbreaks of notifiable diseases such as fireblight, which will severely compromise hawthorn hedgerows and apple orchards throughout the island unless comprehensive control measures are routinely undertaken. Leaf spot, rust and mildew problems on ornamental and flowering garden plants will increase.

A warmer climate may allow new, currently 'exotic' diseases to become established. An example is pitch canker of pine, originally a new world fungal disease that is regarded as the major threat to over 30 species of *Pinus,* including those found in Jersey. The disease became established in northern Iberia. It is presently limited to areas exhibiting Mediterranean climates as it is transmitted



Box 1
THE DISEASE TRIANGLE

The length of each side of the triangle is proportional to how favourable that component is in allowing the growth of disease. In this case, as each side is equal the environment, host and pathogen are all equally conducive to the spread of disease.

Climate change is likely to make the environment more hospitable, the host (i.e. the plants) more stressed and therefore susceptible, and the pathogen longer living - thus lengthening all sides of the disease triangle.

by beetle vectors that are unable to survive prolonged periods of cold winter weather. Authorities, such as the European Plant Protection Organisation, believe that pitch canker will migrate northwards in future years as milder winter temperatures allow significant numbers of beetle vectors to survive over winter and subsequently spread the disease.

PESTICIDES

The majority of pesticide manufacture is dependant upon oil which is already suffering severe prices rises. If this trend continues pesticides will become more expensive and less available leading to greater crop health problems. Oil based inorganic fertilisers with their nitrous oxide emissions could become uneconomically priced. If they also have restrictions placed on them limiting their use it will lead to greater reliance on animal manures, recycled organic fertilisers and less intensive husbandry methods.

CONCLUSION

Climate change is likely to cause increased disease in contemporary commercial crops, indigenous plants and trees, and ornamental and garden plants.

Case Study - Late Blight and Jersey Royals

The pathogenic fungus which causes late blight, *Phytophthora infestans*, requires a minimum temperature and humidity before it produces infectious spores and infects new host potato plants.

Warmer, wetter winters will result in a greater number of spores being produced early in the year and so the lengths of the environment and pathogen sides of the disease triangle will be increased.

Host susceptibility will also increase because plants will grow faster and so produce more soft, green tissues which are more easily infected.

The effects of late blight on a protected (indoor) crop of Jersey Royal potatoes.

The appearance of late blight on a potato plant leaf showing spore production.

It follows that increasing the length of all three sides of the late blight disease triangle will increase its area and thus the amount of late blight that will affect potato crops.

Drier summers will limit disease levels because the lengths of the pathogen and environment sides will decrease. Unfortunately, this limiting factor will be slight as more extreme weather conditions will cause plants to become more stressed resulting in the host side of the triangle to increase further.

4.18 SEA LEVEL, OF RISING IMPORTANCE?

James Le Ruez and John Renouf

The British Irish Council (BIC) Report into climate change scenarios for islands within the BIC region suggests:

'Sea level will rise over the next century and beyond, mainly due to the thermal expansion of the ocean as it picks up heat from the greenhouse warming in the atmosphere. In addition the melting of glaciers and land ice will add water to the oceans ... There is great uncertainty in the calculation of each of these components of sea-level rise, different climate models give very different estimates even for the same emissions scenario'

The potential global sea level increases until the 2080s are highlighted in Box 1. There is considerable uncertainty associated with these predictions, plus further complications due to the movement of the land itself. The BIC scenarios conclude that by the 2080s the lower estimate of sea level increase is 9cm and the upper estimate is 69cm (excluding the movement of land).

Of great concern to the local population will be the potential for flooding through the 'storm surges' as witnessed to devastating effect in March of 2008. Damage to infrastructure including the sea wall, flooding of properties and erosion of the coastline were witnessed as strong westerly winds combined with high tides in a spring cycle. Box 2 highlights the BIC report's predictions for the increase in the height of a storm surge suggesting such events could worsen.

OUR SEA DEFENCES

In 2007 the UK consultancy HR Wallingford published their report commissioned by the States of Jersey entitled, 'Climate Change Jersey, Effects on Coastal Defences'. This established that:

'Adaptive improvement will be required in order to maintain or improve the present standard of protection against coastal flooding despite higher tidal levels and possibly larger waves.'

'It is likely that maintaining the existing high standards of coastal defence enjoyed by Jersey will require an increasing budget, and it will be important to allocate the available funds in a transparent manner, that reflects the urgency and extent of the risks of flooding or erosion at different location'

It is clear from these comments that more demanding storm surges can be expected in the future and that climate change will directly influence the expenditure of not just local businesses, but also the States of Jersey.

VULNERABLE AREAS

As detailed in articles 1.6 and 1.7, understanding the processes at work in the island now and in the past provides insights into potential threats of sea encroachment.

Swamps and marshy areas occur all round our coastal bays. Their occurrences are patchy both in space and time. This indicates that they were originally formed when the barriers (mainly of sand) that separated them from the rising sea were finally breached and the area behind flooded. Barrier breaching of this sort is documented in post-Neolithic time.

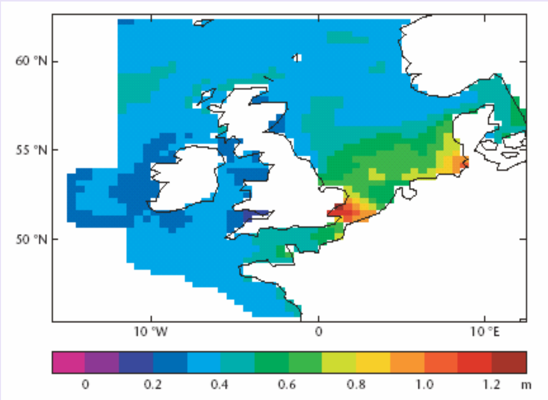
Box 1

Potential increase in global sea level predicted using a variety of models and emissions scenarios.

N.B. More recent and evolving data suggest these are very conservative estimates.

Emissions scenario	2020s	2050s	2080s
Low emissions	4–14 cm	7–30 cm	9–48 cm
Medium–Low emissions	4–14 cm	7–32 cm	11–54 cm
Medium–High emissions	4–14 cm	8–32 cm	13–59 cm
High emissions	4–14 cm	9–36 cm	16–69 cm

Source: BIC Report, 2003



Box 2

The 1 in 50 year storm surge is expected to be around 50cm higher towards the end of the 21st Century. The necessity of the Thames barrier which may not prove adequate defence in the future is high-lighted by the increase of around 1m in the Thames estuary.

It must be noted that encroachment onto land areas can be held back for long periods of sea level increase. Often the final breaching of such barriers will have occurred during a phase of extreme weather. This is of immediate relevance considering extreme weather events are predicted to increase in frequency.

The case of Goose Green Marsh is illustrative of this point. The coast road between Beaumont and Bel Royal is built on a natural sand barrier and separates the present sandy foreshore from a low lying marsh, which is well below high tide level. With high tides and a southerly wind the sea overtops the sea wall and spills water across the car park. If events became that little more extreme, in combination with sea level increase, there could be serious flooding of this low lying land.

REFERENCES:

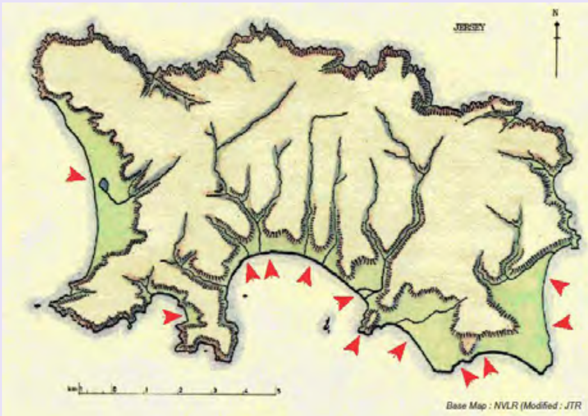
British Irish Council Report into Climate Change Scenarios 2003, www.british-irishcouncil.net/climatechange

Climate Change Jersey, Effects on Coastal Defences, HR Wallingford, 2007

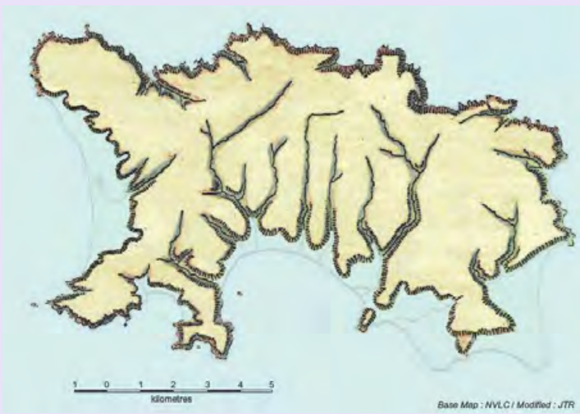
Our Future Coastline

The maps below highlight ways of looking at future coastline predictions.

The first map identifies areas at risk of inundation (red arrows) either because they are marshy areas already below present high tide levels and kept safe by natural sand barriers and/or sea walls or because they would be seriously affected by a rise of as little as 1m. A rise approaching the order of 1m - one of the several predictions already made for 2100 AD - would require improvements to current sea defences in most coastal areas.



The second map offers a longer term prospective based on a consideration of the contrast between the soft sediments of the island's coastal plains and the underlying hard rocks if no protective barriers are present. Erosion down to bedrock could occur with only a slight rise in sea level because the soft rock/hard interface is only slightly above sea level along the coastline shown on this map where the present coastline is ghosted in.



Map Sources: Terrametrics and Rybot.

4.19 OUR FUTURE WATER SUPPLIES IN A CHANGING CLIMATE

Tim Du Feu and Colin Cheney

The potential impacts of climate change on the environment as a whole are likely to be dramatic, not least in terms of water resources upon which all living organisms are dependant.

PROCESSES

All of Jersey's fresh water resource originates from rainfall. The Island receives an annual average rainfall of 884 mm (1968 to 1996), of which 618 mm is lost to the atmosphere via evaporation and plant transpiration. This leaves an average annual balance ('effective rainfall') of 266 mm. Part of this runs off the land to form streams that fill the water supply reservoirs. The reminder sinks into the subsurface to provide recharge to the groundwater aquifers.

Aquifer recharge predominantly occurs during the winter months when rainfall is at a maximum whilst evaporation and transpiration are at a minimum. Stream flows are also normally greatest during the winter months when consumer demand is lowest and it is during that period that storage reservoirs are replenished.

During the summer months stream flows are reduced but in the absence of significant rainfall are maintained by groundwater discharge. Summer stream flow volumes are commonly considerably less than consumer demand but nevertheless currently help to maintain reservoir levels during drier periods.

In drought years, a drier than normal winter may be followed by a particularly dry summer. Under such circumstances, stream flows remain at below average volumes during the winter and reservoir storage deficits from the previous summer are not replenished. In addition, little or no aquifer recharge may occur under such conditions. This can result in groundwater levels, already low at the end of summer, continuing to decline through the winter and then declining even further during the succeeding summer.

As groundwater levels decline, reduced aquifer discharge results in lowered stream flows and downward migration of stream headwaters (i.e. a stream does not form as high in the valley as they had done previously). Borehole and well yields may also decline and, during extreme events, some may dry entirely. Unfortunately, such a decline in available water resources is generally matched by booming water demand from consumers and groundwater abstractors, thereby exacerbating the problem. Historically this has resulted in supply restrictions as the available resource dwindles.

RESOURCES

Public supply in Jersey is overwhelmingly dependant on surface water reservoirs (Box 1) as a source of supply, although these supplies can be augmented by the output from a desalination plant during particularly dry periods.

Box 1
In the future the balance between the replenishment of Island reservoirs (such as Handois above) by rainfall in the winter, and their drainage through usage and dryness in summer, will be important.

More rural areas, particularly those outside of the main public supply area, are dependant primarily on groundwater abstraction from boreholes or wells, although a limited number of properties obtain supplies from rainwater harvesting, augmented by tankered water in drier periods.

Water demand is increasing with time as the population increases, new housing and commercial premises are constructed and, with increasing affluence.

Total public water supply has followed a fairly steady upward trend, increasing from 6.834 million litres in 1996 to 7,291 million litres in 2005. The total quantity of groundwater abstracted is uncertain but has been estimated at 3,600 million litres per annum. The enactment of the Water Resources (Jersey) Law 2007 will permit the collection of information that will allow a full assessment of this volume to be made in the future.

PROBABLE EFFECTS OF CLIMATE CHANGE

The reality of climate change has now been widely accepted, however the precise consequences are as yet not well defined. Recent studies and modelling conducted by the Hadley Centre indicate that the mean annual temperatures are likely to increase by 3^{o}C by the 2080s. Summer rainfall is predicted to decrease by 45%, whilst winter rainfall is predicted to increase by 24%.

Box 2
Water resources are stretched by a number of factors other than climate. Pollution is an obvious example regularly monitored by the Environment Department .

This might suggest that increased winter rainfall would result in increased runoff to reservoir storage and increased recharge to the subsurface aquifers. However, the higher annual temperatures will cause an increase in evaporation during both the winter and summer months and an extended growing season will result in higher levels of water uptake by transpiration during the winter.

Winter rainfall, although higher, is predicted to be more variable. This uncertainty in the ability of winter rainfall to fill storage reservoirs ready for the drier summers, and the lower recharge rates to reservoirs predicted during the drier summer, may require an increase in the Island's reservoir capacity (Box 1) as a safeguard measure.

Alongside the predicted changes brought by climate change, is the overall increase in water demand as the Island becomes more developed and households generally use more water thirsty appliances.

These extra demands placed on a scarce resource can partly be countered by water metering of households, design of new housing developments and increasing public awareness of responsible and sustainable water use.

The frequency of sporadic droughts may increase. It is therefore essential that the water resources in the Island are fully understood and the impacts of climate change are managed accordingly.

Groundwater abstraction from boreholes and wells is an 'unknown' within the Island's water balance equation. Registration of these is one key function of the Water Resources (Jersey) Law, 2007. Safeguarding the quality of the water resource is also important and achieved through the Water Pollution (Jersey) Law, 2000.

WHERE DO WE GO FROM HERE?

Louise Magris

The evidence put forward in this publication shows that human activity is accelerating global climate change on Jersey and that the effects are likely to be serious and certainly can not be ignored.

The answer to the question 'what should be done about this?' is twofold and encompassed by 'mitigation' and 'adaptation' actions.

Mitigation involves taking actions to reduce greenhouse gas emissions and to enhance carbon sinks aimed at reducing the extent of climate change. *Adaptation* involves taking action to plan for and minimise the impacts of climate change.

1. CLIMATE CHANGE - MITIGATION

The Island became a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) in 1994. The Kyoto Protocol under this agreement was extended to the Island in 2006. Countries that ratify this protocol commit to reduce their emissions of CO_2 and five other GHGs. The Protocol now covers more than 160 countries globally and over 55% of global greenhouse gas (GHG) emissions.

Because Jersey has ratified the Kyoto Protocol thorough the United Kingdom it does not have an allocated emissions reduction target. However as a signatory to Kyoto, Jersey must honour its commitment to take part in concerted actions to reduce emissions. Jersey has much to gain by adopting challenging targets for the reduction of energy use and consequent reduction in emissions and a wide range of policy options were put forward in the Energy Policy Green paper that was consulted upon in 2007/2008.

THE ENERGY POLICY GREEN PAPER

The proposed goal of Jersey's energy policy is to achieve 'Secure, Affordable, Sustainable Energy'. This recognised that energy is essential to our quality of life, our economy and social equity.

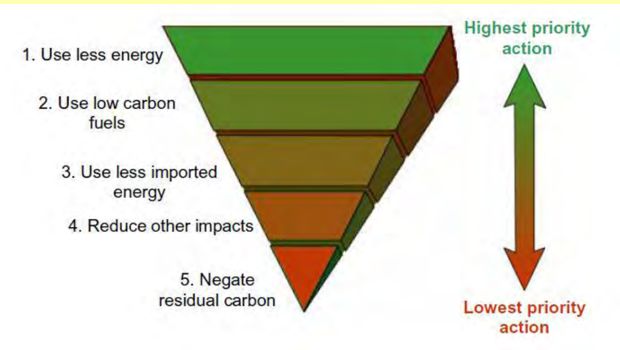
The Green Paper put forward a number of options that described the fiscal, legislative and policy measures to achieve this goal. The measures proposed fall into the following categories:

- Doing more with less – reducing energy use;
- Adopting sustainable energy solutions;
- Ensuring a secure and resilient energy supply;
- Preparing for the future.

To help make sense of the priority for action, an Energy Hierarchy for Jersey was established (Box 1). In this hierarchy the first step is to reduce energy demand.

AN ENERGY POLICY WHITE PAPER

An Energy Policy White Paper is being developed to incorporate the feedback received during the Green Paper's consultation period. It continues to be steered by a cross-department Ministerial group led by the Minister for Treasury and Resources and comprising the Minister for Planning and Environment and the Minister for Economic Development. The principles of the Green Paper, including the energy



Box 1

A Proposed Energy Hierarchy for Jersey.

The Energy Hierarchy accepts that all forms of energy have economic, social and environmental consequences and by ranking these, it assists in prioritising Jersey's energy choices.

Source: Energy Policy Green Paper

hierarchy, have been endorsed already by the Council of Ministers and will be fundamental to the White Paper which is expected to be bought before the States in the Summer of 2009.

Considerable progress on two critical work streams have already begun ahead of the publication of the Energy White Paper :

AN ENERGY EFFICIENCY SERVICE FOR JERSEY

Funding for the first phase of an 'Energy Efficiency Programme' was agreed by the States of Jersey in September 2008. The programme will help low-income and vulnerable households reduce their energy bills and improve the energy efficiency of their homes by providing up to 100% grants for a range of measures including loft and cavity wall insulation. A full service will be offered incorporating, inspection, supply and fitting through approved contractors.

The funding for the first year of this grant programme is from the States who agreed one years funding of £1 million and is supported by a voluntary contribution of £500,000 from the Jersey Electricity Company. The intention is that this initiative will act as a stimulus to recurring funding and more substantial States funded programmes to encourage people to use energy sustainably and to act on climate change.

The Minister for Treasury and Resources will return to the States in September 2009 to demonstrate progress and seek agreement for ongoing funding.

RENEWABLE ENERGY FOR JERSEY

The Energy Policy Green Paper identified the potential for the exploitation of renewable energy, at a large enough scale to displace fossil fuel imports in the long-term.

In Summer 2008, the Minister for Planning and Environment appointed a Tidal Power Steering Group (TPSG) to advise him how the Island might best exploit tidal stream technology in its territorial waters. The TPSG was chaired by the Constable of Grouville who reported back to the Minister in December 2008.

The unanimous conclusion was that tidal power could, in the medium term, make a significant and increasing contribution to the energy requirements and security of the Island for the rest of this century and that the possibility should be actively pursued by an appropriately qualified and mandated group. The Minister warmly received these recommendations in December 2008 and asked for the TPSG to advise him on the format of the mandated group with a remit to :

- Investigate funding options around the environmental and technical investigations;
- Investigate the legislative and commercial framework necessary to attract resource developers;
- Negotiate with our neighbouring jurisdictions to explore potential collaborations both in harnessing the resource and selling to potential markets.

The TPSG will report back to the Minister in Spring 2008.

2. CLIMATE CHANGE - ADAPTATION

The fourth category of policy measures proposed in the Energy Policy Green Paper was 'preparing for the future'. This refers to the need to adapt for the degree of climate change that inevitably will affect Jersey. Regardless of the success of global measures to mitigate emissions, because of atmospheric inertia and the volume of greenhouse gas emissions already released, there will be a continued degree of climate change.

Some work has already been done to ensure that the Island is prepared. For instance there has been a major review of the Island's coastal defences taking into account the predicted sea level rise over this century

The Energy White Paper will identify the need to bring forward a strategy to measure and cope with the effects of climate change. The physical effects, for example on the rural economy, are relatively straightforward to understand. However, the biggest challenge will be in preparing for a changed global economy and world population inhabiting a very different physical environment than that which we see today.

SOURCES:

The Energy Policy Green Paper and the report 'Tidal power for Jersey - Options and opportunities' are both available at http://www.gov.je

STATES OF JERSEY CONTRIBUTORY AUTHORS

Planning and Environment Department

Dr. Simon Bossy : Simon gained his Ph.D. from Portsmouth University and has more than 20 years experience in marine resource management. He is the head of Fisheries and Marine Resources Section and holds responsibility for the management of marine stocks within the 800 square miles of Jersey's territorial waters.

Colin Cheney : Colin is the Department's Hydrogeologist with extensive experience since training at at University College, London. He is a Chartered Geologist and a Fellow of the Geological Society of London.

Dr. Tim Du Feu : Tim is Head of Water Resources in the Environmental Protection Team. He has spent 15 years working for British and German intergovernmental technical aid projects mainly in Africa. This included completing the first co-management plan for Kainji Reservoir in Nigeria. Tim returned to Jersey in 2000 to complete his Ph.D. in tropical reservoirs at Southampton and Hull University.

The ECO-ACTIVE Business Team : Consists of the Assistant Directors for Environmental Policy and the Department's Education and Awareness Officer. The Eco-Active Business scheme aims to assist businesses improve environmental performance and is implemented in partnership with the Jersey Enterprise a section of the Department for Economic Development.

Mike Freeman : Mike is principal ecologist for the Environmental Management and Rural Economy team. He has extensive experience working as an ecologist since 1980 when his career began by leading on the first restoration project of its type in Jersey at les Mielles des Morville, St Ouen’s Bay, a large landfill site restored to dune – like habitat

Jersey Meteorology Department : Headed by Principal Meteorological Officer Tony Pallot, the team of 16 staff record, observe and forecast the weather for the Channel Islands. They also hold responsibility for the Island’s long term climate record and take a keen interest in climate research. Several sections were written and edited by Frank Le Blancq who is a forecaster in the Jersey Met Department and Fellow of the Royal Meteorological Society. Over the years he has written a variety papers on climate and weather for a range of professional journals.

John Jackson : Qualifying in 1978, John taught in an Agricultural Further Education College for 16 years before joining ADAS (Agricultural Development and Advisory Service) consultancy service with a portfolio of commercial farming clients. He joined the Jersey Agriculture and Fisheries Department in 1998 and is now an Agricultural Advisor specialising in farmed livestock. His role includes managing the Countryside Renewal Scheme (CRS) and the Rural Initiative Scheme (RIS).

James Le Ruez : James is a Project Officer within the Environment Department’s Policy and Awareness Division and was the primary author of this publication. Jersey born, James has BSc in Ocean Science from the University of Plymouth and an MSc in Climate Change from the University of East Anglia.

Linda Lowseck : Linda graduated from the Royal (Dick) Vet Schools, Edinburgh and has 25 years experience in States veterinary medicine including the control of notifiable diseases and zoonoses. She joined the Department in 2006 as the States of Jersey’s Veterinary Officer.

Dr. Louise Magris : Louise is Assistant Director for Environmental Policy and gained her Ph.D. in Ecology from Queen Mary College, London in 1998. She moved into environmental policy in 2006 leading on the development of an energy policy for Jersey and the ECO-ACTIVE programme.

Scott Meadows : Scott was Entomologist and Laboratory Manager for the Department for 11 years previously studying entomology at Imperial College London. He is now Head of Plant Health, providing advice on the control of non-indigenous pests.

Iain Norris: Iain graduated from Reading University in 1977 and joined the Agricultural Development and Advisory Service. In 1993 He joined the States of Jersey, Agriculture and Fisheries department as a Horticultural Consultant with a special interest in Jersey Royal Potatoes, daffodils and brassicas. He helped develop the Rural Economy Strategy in 2005 and is a Member of the Institute of Horticulture.

Steve Thompson: Steve joined the Department as a Scientific Officer in 2000 and became Plant Pathologist in 2006 after completing his M.Sc. At Imperial College, London. In 2006. He specialises in plant disease diagnostics and control.

Economic Development Department

Jersey Tourism : Jersey Tourism is part of the Economic Development Department with the remit to market and promote Jersey as a tourist destination., enhance the tourism product, facilitate bookings and provide relevant information for potential and actual visitors to the Island.

Health and Social Services Department

Health Protection : This section provides advice, guidance, legislative and administrative control in order to maintain a safe and healthy environment for those living and visiting Jersey.

EXTERNAL CONTRIBUTORY AUTHORS

The Environment Department would like to thank the following individuals and institutions for their contributions to this publication:

Dr. Andrew Casebow : Andrew is States Agriculture and Environment Adviser in Guernsey. Andrew is a graduate member of Magdalene College, Cambridge, and of the University's Geography Department where he undertakes research on climate change and sustainable island development. He and his family have loved living and working in the Channel Islands for over 20 years.

Chris Regan: Chris is a Marketing Communications Executive for the States of Guernsey. He is currently undertaking study with the Open University towards a BSc in Physical Science. Chris was born in Guernsey where he lives with his family.

Prof. Nicholas McCave : Born in Guernsey Nicholas has been the Woodwardian Professor of Geology at Cambridge University since 1985. A fellow of St John's College and Head of the Earth Sciences Department from 1988-1998 his research interests include the deep circulation of the oceans in relation to climate change.

Dr. John Renouf : John was formerly curator of the Museum in Jersey. He trained as a geologist at London University and studied geology in Brittany for his doctorate. He now specialises in the study of former sea levels and consults as a geologist on archaeological matters.

David Johns and Martin Edwards of The Sir Alistair Hardy Foundation for Ocean Science (SAHFOS): SAHFOS is an international charity that operates the Continuous Plankton Recorder (CPR). The foundation has been collecting and interpreting data from the North Atlantic and the North Sea on biogeography and ecology of plankton since 1931.

N Mieszkowska, R Leaper, J Hill, A.J Southward and S.J Hawkins of the Marine Biological Association (MBA): The MBA is a Learned Society and one of the UK's leading marine biological research institutes. Their mission is to promote scientific research into all aspects of life in the sea and to disseminate to the public the knowledge gained. Prof. Hawkins, Nova Mieszkowska and Rebecca Leaper have been regular visitors to Jersey, Guernsey and the English Channel Coastlines of England and France carrying out research on intertidal species.

Online for a greener life

www.ECO-ACTIVE.je