Report on the workshop 'Preparing for and adapting to climate change in the Caribbean'

Report prepared by

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With comments from

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1. Objectives and overview of the workshop

The workshop 'Preparing for and adapting to climate change in the Caribbean' was designed for government personnel in the UK Overseas Territories in the Caribbean. It was funded by the UK Government's Overseas Territories Environment Programme, and organised by the Cayman Islands Government Department of Environment, the UK Tyndall Centre for Climate Change Research and the Caribbean Community Climate Change Centre based in Belize.

The purpose of the two day workshop in the Cayman Islands was to communicate the science of climate change to government officials and decision makers in the UK Overseas Territories in the Caribbean and to explore ways of preparing for and adapting to climate change.

The workshop was held from 2nd – 3rd June 2005 at the Marriott Resort Hotel, West Bay Road, Grand Cayman, Cayman Islands, B.W.I. Over 60 people attended the workshop. Participants comprised visitors from four UK Overseas Territories in the Caribbean (Anguilla, British Virgin Islands, Montserrat and Turks and Caicos Islands), a representative of the UK Government Department for International Development and members of the Cayman Islands Government.

2. Workshop description

Day 1 reviewed the science of climate change and considered how the Caribbean islands might be vulnerable to climate change. The first half of the day considered climate science and the arguments for and against human-induced climate change; it reviewed the impacts of climate change and the potential effects on the UK Overseas Territories. The second half of the day considered both areas of vulnerability in small islands, and how climate change can make islands more vulnerable.

Day 2 involved a consideration of how other Caribbean islands have started to prepare for climate change and brought together some ideas on constraints to adaptation. The morning session considered what specifically can be done to adapt to the impacts of climate change and how other parts of the Caribbean have started to cope with this global challenge. The day ended with a discussion about how climate change fits into the wider question of sustainable development.

The workshop programme is attached as Annex 1.

3. Overview of Day 1 – climate change science and vulnerability

His Excellency, The Governor of the Cayman Islands Mr. Bruce Dinwiddy CMG welcomed participants to the workshop – the text of his speech is attached as Annex 2.

The Honourable Mr Kurt Tibbetts, Leader of Government Business then provided the opening remarks, these are attached as Annex 3.

The keynote address by Professor Mike Hulme explored the changing relationship between society and climate, summarised the scientific basis for the claim that human-induced climate change is now happening and provided a summary of the likely future changes in climate for the Caribbean. For a summary of his presentation please see Annex 4.

4. Climate change impacts and science. Day 1 – morning session

A series of breakout groups followed. First there was a presentation on the links between climate change, extreme weather and hurricanes by Mr Fred Sambula, for a copy of this presentation, please see Annex 5. Mr Sambula reviewed the science of climate change and the impacts of climate change. He noted that there was no clear understanding of why there were multi-decadal hurricane frequency cycles, although it is known that hurricane frequency is related to the strength of the Thermohaline Circulation and the warmth of the sea. To prepare for climate change the group suggested that there needs to be better preservation and protection of the natural environment; more education for policy makers, the population, schools, tourists and visitors; there needs to be a sound policy, supported by institutional frameworks to give the policy teeth; there needs to be individual behavioural change – i.e. we all need to take responsibility and play our part; it is important to create regional links and to exploit existing ones, e.g. the strength of the Alliance of Small Island States (AOSIS) in the climate change negotiations; there needs to be good environmental monitoring, e.g. through the Global Earth Observing Systems (GEOSS); and good environmental governance.

Dr Neville Trotz first outlined some uncertainties about the extent of future climate-related impacts on the Caribbean. He also explained the constraints with modelling future climate changes in the region, such as utilising data from global climate models which have resolutions of 300 km – such grid size being too coarse for small islands - and the need for regional models to have resolutions of 20-50 km. Models with smaller resolution are now starting to be used in the region. He then investigated the consequences of waiting for more accurate information to become available. Dr Trotz concluded that there are two main issues: there is no certainty about the type of changes that we might experience in the future; and we have no idea when those changes will start to affect us. Waiting will provide us with clearer answers to these two questions, however waiting may also make it too late to respond to the challenges.

Climate skeptics' arguments were explained and countered by Professor Mike Hulme, see Annex 6. The group explored the importance of skeptics in science, as Prof Hulme pointed out – there needs to be skepticism in science for science to break down old ways of thinking and to move forward – this is natural and healthy. In this area there are three main questions that are being explored: is the climate

changing; why is it changing; and do we have to change our behaviour in response? In answer to the three questions it was agreed that there is enough evidence to reveal that the climate is changing. It was also agreed that there are multiple pressures on the climate system and there is evidence to show that both natural and human factors are causing the change. The question of whether or not we have to change our behaviour is the most difficult question and takes the debate beyond simply one of science. Depending on one's value systems and politics, there is justification for delay and taking no action today and also justification for taking action. There is no definitive answer to this last question. While recognizing this uncertainty, it is possible to take advance action that is 'no regrets'; i.e., it will generate benefits irrespective of whether action was needed or not.

There are also climate 'contrarians'. These people dispute well-established scientific evidence and theory and can be easily argued against.

The likely flood risk and coastal erosion threats were described by Professor Andrew Watkinson, see Annex 7. He outlined the approach that had been taken by the UK Foresight team in looking at the question of future flooding (http://www.foresight.gov.uk/Previous_Projects/Flood_and_Coastal_Defence/index.html). The aim of the project had been to produce a challenging and long-term (30 - 100 years) vision for the future of flood and coastal defence in the whole of the UK that took account of the many uncertainties, was robust, and could be used as a basis to inform policy and its delivery.

The group then turned their attention towards issues relating to flooding and coastal erosion in the Cayman Islands. These included

- The assessment of flood risk and production of flood hazard maps
- Risk awareness
- The different flooding risks associated with storm surges and precipitation
- The role of planning and planning enforcement in reducing flood risk
- Increasing resilience through measures such as building codes
- Making full use of historical experiences and the experiences of other island communities
- Working with nature and natural drainage areas
- Transparency and public participation in the decision making process relating to flood risk management

5. Conclusions from the morning session on Day 1

Professor Mike Hulme concluded that there appeared to be five main themes emerging from the discussion groups, these were:

- education and communication to all (including schools, public, government and visitors to the islands);
- environmental governance (consultation, transparency in decision making, open information, good legislation and enforcement)
- regional cooperation (UKOTs, CPACC/MACC, AOSIS)

- sound science in environmental monitoring
- long term sustainability (working with nature and valuing assets, working with business community)

6. Vulnerability to climate change impacts. Day 1 – afternoon session

Dr Trotz then presented his keynote address focussing on the vulnerability of small islands in the Caribbean to climate change. This address is attached as Annex 8.

The breakout discussions that followed this focussed on: the vulnerability of the Caribbean to sea level rise by Ms Judi Clarke; the likely impacts of climate change on small Caribbean islands by Prof. Mike Hulme; coral bleaching, tourism and climate change by Prof Andrew Watkinson; and assessing island vulnerability to climate change by Dr Neville Trotz.

Ms Clarke noted that vulnerability is the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, it is a function of the character, magnitude, rate of change, sensitivity and adaptive capacity. Small islands are *vulnerable to sea level rise* because they are small, low-lying, coastal and resource-constrained, there are often poor construction standards and building practices, there is often building in vulnerable areas and natural barriers, such mangroves and coral reefs are often degraded. Sea level rise is caused by both thermal expansion and freshwater inputs from melting ice caps and glaciers. Over the past 100 years the sea level has been risen 25 cm, the sea is expected to rise another 9-88 cm over the next 100 years. From these changes, islands can expect more coastal flooding, worsening effects from storm surges, and increased beach erosion. Indirectly this can create adverse impacts on tourism, fisheries, water supply, agriculture, land tenure and other socio-economically important areas.

In managing sea level rise there are three main means of achieving this: reducing vulnerability; increasing resilience and building adaptive capacity. In terms of reducing vulnerability, it was agreed that the role of seawalls needed to be explored and set backs for building needed to be of suitable distance either from the high water mark or line of permanent vegetation (historic vegetation line). It was noted that in the UK the government had officially stopped protecting parts of the coast, in Florida some building codes require that if a property is damaged then it cannot be rebuilt without new conditions applying. Existing laws within the region need to be enforced and enforcement has to be prioritised by governments. Resilience could be increased by good insurance practices whereby those who protect their homes and build them with climate change in mind should be rewarded. This was undertaken by two companies in Barbados however it is likely to be stopped as none of the other companies signed up to this. This could be an opportunity for regional cooperation, whereby the Caribbean governments collectively approached the re-insurance companies to encourage the insurance companies to initiative discounts for pro-active adaptation, or penalties for mal-adaptation. This could be supplemented by Annual Earth Day/World Environment Day initiatives such as tree planting and

mangrove rehabilitation. Using mangroves and other natural features to buffer storm impacts and sea level rise was universally agreed to be a good idea.

Adaptive capacity could be built through exploiting disasters when they happen and generating a community sense of the bigger threats facing the islands. Addressing climate change issues through disaster mitigation planning has proven useful in other parts of the Caribbean. Hazard mapping, and a strong building code based on future climate change, rather than historical information, was also viewed as critical. A public-private dialogue on what to do about sea level rise should be initiated.

The likely impacts of climate change on small Caribbean islands were reviewed by Prof. Mike Hulme, see Annex 9. The main impacts are expected to be: higher temperatures, which could cause impacts on the elderly, poor and those in low income housing; more intense rainfall which could lead to flooding; sea level rise, causing coastal erosion and flooding; warmer and more acidic oceans causing a change in the characteristics of ocean flora and fauna; a possible change in hurricane intensities.

Coastal biodiversity, tourism and climate change was discussed by Prof Andrew Watkinson, see Annex 10. The group heard that the cover of hard coral on reefs in the Caribbean had declined by 80% over the last 25 years as a result of a range of drivers but primarily over-fishing, pollution and development. Climate change through increases in sea surface temperatures was now posing an additional stress on coral reefs. Beaches were similarly under threat from sea level rise, especially where they were backed by developments. Consideration was then given to the pattern of tourism on the Cayman Islands with 280-300,000 people arriving per year by air for long stay holidays and 1.8 million by cruise ships. The importance of maintaining healthy beaches and corals for the tourist industry was stressed. Planning and development were major issues for the maintenance of beaches in the face of sea level rise, while it was agreed that all conceivable measures should be taken to reduce the stresses on corals to increase their resilience in the face of climate change. This could involve a reduction in the fishing pressure on reefs, rotational diving on reefs to allow recovery from physical damage, reductions of pollution and development. The importance of education was also stressed.

Dr Trotz noted that vulnerability stems from economic, social and physical causes. Economic vulnerability can be pre-existing and this can be exacerbated after a disaster. For example, after Ivan in Grand Cayman, property prices rose by 30%, demand for rental properties rose and so did rental prices. With other hazards there is the potential for long term shifts in the economic structure, and exceeding the country's economic carrying capacity could exacerbate this. The loss of property and the loss of livelihoods following a hazard can create social vulnerability, as can the disruption of education through school closures. Natural systems can be weakened through pressure being exerted, for example through excessive tourist pressures, such as high cruiseship tourist concentrations. There is a Caribbean Network of

Community-based Vulnerability Audits. Buildings should be built with local conditions in mind and should be part of a longer term adaptation and rehabilitation strategy.

7. Conclusions from the afternoon session on Day 1

Dr Trotz concluded that while there were clear areas of vulnerability, much research had already been undertaken which could be applied to reduce future areas of vulnerability, such as the vulnerability assessments and identification of communities at risk under various regional programmes, or under the disaster mitigation umbrella.

8. Overview of Day 2 – adaptation and sustainability

Day 2 began with a keynote address by Dr Neville Trotz on 'Adaptation in practice – learning lessons from other Caribbean Islands,' see Annex 11. This presentation explained the approach to adaptation undertaken by CARICOM countries in the region through projects such as Caribbean Planning for Adaptation to Climate Change (CPACC) and Adapting to Climate Change in the Caribbean (ACCC). He briefly summarised the CPACC and ACCC projects, many of their components are being implemented through the follow-on project 'Mainstreaming Adaptation to Climate Change' (MACC). Dr. Trotz revealed that environmental monitoring was already going on in other parts of the Caribbean through these and other programmes. Mr Richard Beales of the UK Government Department for International Development then discussed how the MACC project could be extended to the UK Overseas Territories, and explained that the extension of MACC to the UK Overseas Territories has been given approval and is likely to begin in September 2005.

9. Adaptation and sustainability. Day 2 – morning session

Four workgroups were then formed to discuss how priorities could be set in the four of the five main areas identified by Professor Mike Hulme on Day 1. The groups discussed a range of issues focussing on the process by which the priority could be reached, as well as the desired outputs from the priority area.

Professor Andrew Watkinson and Mr Gerard Gray from Montserrat explored options for improving **environmental monitoring and for good science** and their importance in setting priorities. They believed that long term data collection is important, but there are challenges associated with the collection of that data: it is costly; there may need to be a legal requirement for this; there need to be standardised methods for comparison across countries, for example indicators; there needs to be some central facility for data collection, processing and distribution; there needs to be some means of sharing data and for translating this into useable information for policy makers. The data that should be collected in every country is: air temperature, sea surface temperature, rainfall, sea level rise and rigorous biological indicators such as flowering and nesting.

Dr Trotz and Ms Lisa-Ann Hurlston explored the value of **regional cooperation.** Of importance are the process by which regional cooperation occurs, the tools which can be used to facilitate cooperation and the constraints to cooperation. The group found that the process by which regional cooperation occurs depends on such factors as buy-in by governments, private sector interests and other groups of the risk factor; identification of national priorities (which will define both national and regional programmes); and need for collective action or voice. In terms of the latter, regional initiatives are necessary where a collective regional voice can give more power to an issue than a single group, this could be in the area of climate change negotiations, with the UKOTs participating as part of the Alliance of Small Island States (AOSIS). Tools to facilitate regional cooperation are existing and new memberships in professional associations, especially in the private sector and service groups as well as public sector affiliates, and relationships with regional academic institutions. In addition, a central data collection and reporting agency was thought to be a useful resource for vital information and assistance. Regional initiatives may also be useful where there are high costs attached to a project, for example a regional early warning system for a specific hazard. However, it was recognised that there are many occasions where the unique nature of each island cannot be represented by a regional initiative, for example in building codes, where each island faces different stressors. Engagement with the private sector may be helpful in some areas, for example in putting regional pressure on the insurance industry to provide incentives for more sustainable building design.

A number of constraints to regional cooperation were identified including the lack of membership of the UKOTs in existing regional initiatives and in the form of a lack of funds for technology/instrumentation purchase or regional movement, although the latter could be overcome through the use of modern telecommunications. Constraints to adaptation can exist in the form of contradictory policies by different arms of government, by lack of enforcement of legislation, or by poor legislation within a country. Despite the constraints, it was agreed that regional cooperation can derive certain benefits: regional insurance pool, legislation (look at collectively, but tailor to each OT), data and technology transfer; and human resource capacity building.

Ms Judi Clarke and Ms Lynda Varlack worked with their group to consider **education and communication**, and their role in setting priorities for climate change. They were emphatic that any strategy needs to have clearly defined objectives (e.g. to build awareness of climate change science, climate change impacts and adaptation options with the stakeholder community to bring about policy changes); clearly defined target audiences (politicians, developers, schools, youth, visitors, tourists, resource users, media and government agents); a communication strategy (methods to ensure engagement, e.g. round table discussions, individual behavioural changes, participation in data collection); key messages (focus on issues of interest to each audience, e.g. waste, transport, land use, jobs); and specific activities (recognise successes publicly, establish a coordinating agency to monitor/prompt the process). To ensure that strategies fulfil a real information need,

it was agreed that a knowledge baseline be first conducted within the target groups being considered.

The overall goal of any strategy should speak to citizenship and stewardship of the stakeholders – which is consistent with many countries' sustainable development goals. Many countries already have a sustainable development agenda, or at least the consideration of this concept within national development plans. Existing mechanisms should be used for the communication of climate change. More specific objectives for the communications strategy should be defined in collaboration with the target audience such that it is of significant relevance to them.

Some ideas generated by the group included key messages for specific groups, e.g.
TOURISTS/VISITORS: "Help us where you live. Lobby your government for lower emissions"
DEVELOPERS: "Smart growth. Build green and save $"
POLICY MAKERS: "Policies that are good for current and future generations"

Professor Mike Hulme and Mrs Gina Brooks-Hodge chaired the session on **good environmental governance**. Their group looked specifically at: enforcement legislative framework, transparency in decision making, consultative processes, open information, institutional capacity, and legislative reform. They concluded that public consultation and transparency should be mandated in legislation. Planning meetings should be open, with a representative mix of the population, an equal gender balance, a good mix of the private and public sectors, technical groups and civil society. Enforcement should be acknowledged as absolutely fundamental to successful implementation of a good governance strategy, and it should be undertaken by technical experts. If there is no will to enforce the legislation then there is no point in having the legislation. There may be a need to reform the legislative framework to promote good environmental governance.

10. Conclusions from the morning session on Day 2

In wrapping up the morning session, Dr Trotz concluded that environmental monitoring and the appropriate use of science, regional cooperation, education and communication, and good environmental governance were all central elements that had to be considered when setting priorities for adapting to climate change. For adaptation to occur there has to be science to underpin any action taken. Once the science is clear then it is a matter of changing human behaviour throughout society, this is where the other three elements are important.

11. Adaptation and sustainability. Day 2 – afternoon session

The final session, chaired by Professor Tim O'Riordan on 'sustainability planning and climate change,' reviewed the main elements of sustainability, i.e. caring for the environment and living with nature, caring for the employee and supporting the labour force, community involvement in planning, having a longer term vision and ensuring that business planning goes hand in hand with this longer term vision. After

his presentation (see Annex 12), Professor O'Riordan organised a round table discussion of critical issues that need to be explored when incorporating climate change issues into wider sustainability planning.

Professor O'Riordan noted that for the most part, the Caribbean Island chain is noticeably vulnerable to prolonged and unavoidable climate change. The islands have economically vital coastlines which are exposed to storm conditions and sea level rise. Heavy downpours cause localised and extensive flooding. Hotter sea surfaces that are climate change driven may also be adding to existing human stresses on coral reefs, inshore fisheries, and marine-based tourist attractions. Hurricanes may be strengthened from their normal patterns, though we do not know for sure. In essence, climate change, vulnerability and adaptation are serious matters for the Caribbean economy, society and environment. Climate-related events (storm, flood, drought, heat, health impacts, marine biota shift, beach erosion, building change) all add ultimately to possible additional costs of loss of income, loss of property value, insurance and utility bills, and evacuation of those who cannot afford to be without a home or an occupation.

The pattern of future growth in small islands driven by large financial investments and tourism is currently on a course that could well add to climate change impacts and vulnerabilities. Despite planning regulations, that are designed to stop inappropriate growth and development, beach fronts are still being lost, beaches narrowed by coastal squeeze caused by buildings and sea-defences encroaching on the sand, and by buildings that cross into important natural areas which should be left alone for biodiversity and drainage purposes.

Key concerns about climate change and areas for sustainability planning

The main drivers of climate change vulnerability are:

1. Development on beaches and on land that violate regulations for planning, siting and building design because scientifically sound professional advice is being ignored or overturned by non-elected, non-representative, non-transparent planning commissions.

2. Growth of new buildings (apartments, homes, tourist accommodation, etc.) that is not sensitive to fundamental ecosystem functioning processes, or to the possible consequences of unusual rainfall and storms.

3. Marine life is sensitive to sea temperature, coastal pollution, tourist use, recreational use by local people, and by storms. Climate change could bring sea temperature rise and acidification of the ocean surface due to increased carbon dioxide absorption. The most sensitive species habitats and locations need to be clearly mapped and protected by comprehensive and widely understood laws.

4. After hazardous events (e.g. hurricanes and landslides), existing housing is being rebuilt in the same locations to broadly the same architectural style. Yet many should be set back from vulnerable coasts. Many need to be redesigned for rainwater diversion and some could be designed for renewable energy, notably photovoltaic cells (solar panels).

5. The science of climate change, impacts and vulnerabilities is well researched but remains somewhat remote from the business world, to the developers, to tourist promoters and to the general public. Yet there is a distinct groundswell of interest throughout the Caribbean, and a recognition, widely held, that climate change related events may have very severe social and economic implications especially to the most vulnerable and marginalised.

6. Following the workshop there is momentum to consider climate change, now is the time to build on it by refreshing the breadth and scope for public involvement to embrace the principles and practices of sustainable development.

10. Conclusions from the afternoon session on Day 2

There were several very general messages that ran through the workshop. First it is important to consider how to address the causes of climate change as well as the consequences of climate change. While the small Caribbean UK OTs are barely contributing to the emission of greenhouse gases that are contributing to climate change, the islands could move to a carbon neutral economy to then take the moral high ground to use as leverage over the larger polluting nations. Regional cooperation may be the only way to create pressure on the world's leaders to make a change to their carbon emissions. Island participation in lobbying organisations such as the Alliance of Small Island States (AOSIS) and supportive regional networks, such as the Caribbean Alliance for Sustainable Tourism (CAST), is important in promoting these issues regionally and in generating additional regional influence. Second, education and science communication is important to all: those within government, the private sector, individuals, communities, service and business groups as well as tourists and visitors. Finally, a lot of good will exists between the Caribbean Community Climate Change Centre, the Tyndall Centre for Climate change Research and the UK Overseas Territories in the Caribbean. Building on these relationships could foster the beginning of the process towards active adaptation to climate change, before it is too late.

Specific recommendations coming from the workshop include:

1. Develop a set of Caribbean-wide annually-updated climate indicators to monitor the basic elements of climate change throughout the region.

2. Develop a Sustainable Development Framework based on Island-specific planning principles and critical indicators.

3. Widen the science base, by strengthening the relevant Departments of Environment and Natural Reserves to improve the scope and depth of their research teams and monitory arrangements. Ensure the managers of critical natural resources (marine, wetland), health related matters, housing and settlement design are trained to observe, report and to integrate their findings into a comprehensive research evidence database for the whole region, as well as locale by locale.

4. Establish a national resource conservation authority to research and map key habitats and species on land and water. Ensure that this database has teeth in guiding and planning decisions. Extend planning management jurisdiction to the marine sector and to all removals of natural materials.

5. Establish a building code for all new build and reconstructed property that meets highest energy efficiency standards, low carbon use, drainage and best waste management practices.

6. Establish comprehensive sustainability audits for:

- the cruise ship business
- water management and drainage
- carbon "neutral" economy for all the Caribbean
- transport (including internal and international air travel)
- waste management including the closure and redesign of landfill sites.

These audits should look at changing mechanisms for raising revenue for carbon-based activities to fund carbon neutral activities. This could come about via an extension to the Environmental Protection Fund. This should be earmarked for establishing a sustainability framework, for widening the research and monitoring base, and for creating the elements of a long term, more self containing "smart" growth economy.

7. Expand the network of Caribbean wide studies of community vulnerability and adaptation to climate change, based on sustainability principles yet specifically community driven through local community forums.

8. Champion pilot schemes of exemplary practice by all members of the Caribbean community so that the very best of innovative practice in planning, building designing, community involvement and education communication are championed throughout the region.

The workshop was closed by Mrs Ebanks-Petrie who reminded the group that a lot of work still remained to be undertaken, although there were several advances that had been made through the workshop.

Annex 1: Workshop programme

Preparing for and adapting to climate change in the Caribbean

A climate change workshop
Funded by the UK Government's Overseas Territories Environment Programme,
Managed jointly by the UK Department for International Development
and the Foreign and Commonwealth Office.

2nd – 3rd June 2005
Marriott Resort Hotel, West Bay Road, Grand Cayman, Cayman Islands, B.W.I.

Objective

The purpose of the two day workshop in the Cayman Islands is to communicate the science of climate change to government officials and decision makers in the UK Overseas Territories in the Caribbean and to explore ways of preparing for and adapting to climate change.

Overview

Day 1 – Climate science, future climate scenarios, impacts, vulnerability and adaptive capacity in the Caribbean.

Day 2 – Adaptation to climate change, lessons learned from adaptation to climate change in other Caribbean islands and sustainability planning.

Speakers and facilitators

- Mr Dick Beales, Senior Natural Resources and Environment Advisor, Department for International Development, HM Government, London, UK.
- Ms Judi Clarke, Consultant, Caribbean Community Climate Change Centre, Barbados.
- Mrs Gina Ebanks-Petrie, Director, Department of Environment, Cayman Islands Government.
- Ms Lisa-Ann Hurlston, Environmental Assessment Officer, Department of Environment, Cayman Islands Government.
- Prof Mike Hulme, Climate scientist, Tyndall Centre for Climate Change Research, UK.
- Prof Tim O'Riordan, Sustainability planner, School of Environmental Sciences, University of East Anglia, UK.
- Mr Fred Sambula, Director, Meteorological Services, Cayman Islands Government
- Dr Emma Tompkins, Environmental economist, Tyndall Centre for Climate Change Research, UK.
- Dr Ulric Trotz, Climate change adaptation, Manager, Mainstreaming Adaptation to Climate Change (MACC) project, Caribbean Community Climate Change Centre, University of Belize Campus, Belize.
- Prof Andrew Watkinson, Coastal planner, Tyndall Centre for Climate Change Research, UK.

Day 1 – Climate change and vulnerability (Thursday 2nd June 2005)

8.00 – 9.00 Check-in, Coffee and pastries

9.00 – 9.10 **Welcome Address** (His Excellency The Governor of the Cayman Islands Mr. Bruce Dinwiddy CMG)

9.10 – 9.20 **Opening Remarks** (Hon. Kurt Tibbetts, Leader of Government Business, Cayman Islands Government)

9.20 – 9.30 **Overview of Project and Purpose of Workshop** (Mrs. Gina Ebanks-Petrie, Director, Department of Environment, Cayman Islands Government)

9.30 – 10.45 **Keynote Address: The changing relationship between society and climate** (Prof. Mike Hulme).

10.45 – 11.15 Break

11.15 – 12.30 **Parallel Discussion Sessions Climate science and impacts**

Group 1: Climate change, extreme weather and hurricanes (Mr. Fred Sambula)
Group 2: What are the consequences of waiting for more accurate information to become available? (Dr. Ulric Trotz)
Group 3: Climate skeptics' arguments explained and countered (Prof. Mike Hulme)
Group 4: Flood risk and coastal erosion threats (Prof Andrew Watkinson)

12.30 – 12.50 **Feedback from parallel discussion groups** (chaired by Prof. Mike Hulme)

12.50 – 1.00 **Wrap up of parallel discussion sessions** (Prof. Mike Hulme)

1.00 – 2.00 Lunch

2.00 – 3.00 **Keynote Address: How vulnerable are Caribbean islands to climate change?** (Dr. Trotz)

3.00 – 3.20 Break

3.20 – 4.25 **Parallel Discussion Sessions: Vulnerability to climate change**

Group 1: How vulnerable is the Caribbean to sea level rise? (Ms Judi Clarke)
Group 2: Likely impacts of climate change on small Caribbean islands? (Prof. Mike Hulme)
Group 3: Coastal biodiversity, tourism and climate change (Prof Andrew Watkinson)
Group 4: Assessing vulnerability across the Caribbean (Dr. Ulric Trotz)

4.25 – 4.45 **Feedback from parallel discussion groups** (chaired by Dr. Ulric Trotz)

4.45 – 5.00 **Wrap up of parallel discussion sessions and Close of Day 1** (Dr. Ulric Trotz)

5.00 – 6.00 **Drinks reception – Peninsular restaurant, Marriott Beach Hotel**

Day 2 – Adaptation and sustainable development (Friday 3rd June 2005)

8.00 – 9.00 Coffee and pastries

9.00 – 9.15 **Overview of Day 1 and Objectives of Day 2** (Mrs. Gina Ebanks-Petrie, Director, Department of Environment, Cayman Islands Government)

9.15 – 10.15 **Keynote Address: Adaptation in practice – learning lessons from other Caribbean Islands** (Dr. Ulric Trotz)

10.15 – 10.30 **Extension of Mainstreaming Adaptation to Climate Change (MACC) Project to the UK Overseas Territories** (Mr Dick Beales)

10.30 – 10.45 Break

10.45 – 11.50 **Parallel Technical Sessions: Setting priorities for adapting to climate change**

Group 1: Good Environmental Governance (Mrs Gina Brooks-Hodge; Prof Mike Hulme)
Group 2: Science and Environmental Monitoring (Mr Gerard Gray; Prof. Andrew Watkinson)
Group 3: Education and Communication (Miss Lynda Varlack; Miss Judi Clarke)
Group 4: Regional Cooperation (Miss Lisa-Ann Hurlston; Dr. Ulric Trotz)

11.50 – 12.15 **Feedback from parallel technical groups** (Chaired by Dr. Ulric Trotz)

12.15 – 12.30 **Wrap up of parallel technical sessions** (Dr. Ulric Trotz)

12.30 – 1.30 Lunch

1.30 – 2.30 **Keynote Address: Sustainability planning and climate change** (Prof. Tim O'Riordan)

2.30 – 3.45 **Plenary discussion: 'No-regrets adaptation strategies'** (Chaired by Prof. Tim O'Riordan)

3.45 – 4.15 Break

4.15 – 4.30 **Wrap up of plenary session** (Prof Tim O'Riordan)

4.30 – 4.45 **Close of Workshop** (Mrs. Gina Ebanks-Petrie, Director, Department of Environment, Cayman Islands Government)

Annex 2: Welcome address by His Excellency, The Governor of the Cayman Islands Mr. Bruce Dinwiddy CMG.

I am delighted to welcome this entire group to the Cayman Islands.

I am sure that many of you know that these islands have seen a lot of change over the past 30 years. There have been exceptional rates of economic growth bringing economic and social development that was unimaginable 50 years ago. This growth has brought many financial benefits to the people of the Cayman Islands, for which we are grateful. During the growth years we were exceptionally lucky to have survived relatively unscathed from the storms, floods and droughts that are frequently experienced in this part of the world.

Last year we experienced the wrath of Hurricane Ivan which brought many changes, we lost homes and businesses, part of our labour force became homeless and had to leave the islands. We are still experiencing the after-effects of Ivan on our economy and our society, as are our neighbours throughout the Caribbean. Ivan along with the three other major hurricanes that blasted through the Caribbean last year created unimaginable economic losses, suffering and stress associated with both the living through the storms and the subsequent long process of recovery. It is clear to those of us who experienced hurricane season in the Caribbean last year that we need to be better prepared for hurricanes and for environmental hazards of every kind. We know for a fact that preparedness for both the event and the recovery period afterwards reduces the extent of damages and the costs of recovery.

We are told that climate change is likely to bring with it more intense storms, more rain, more drought, more heat and more variable weather globally. These changes in the weather will effect the way in which we live and do business. Unfortunately there is some degree of uncertainty about how climate change impacts will be felt and where they will occur. This uncertainty makes it extremely difficult to prepare, but based on our experiences during Hurricane season last year, we know that if we are not prepared, then we will suffer. We are fully aware that learning more about the impacts of climate change is the first step in the process of preparing. It is for this reason that we are hosting this climate change workshop.

But learning must be followed by action, and I hope that this will not be just a workshop where you enjoy your lunch and a chat with colleagues. This is an opportunity to take the first step towards implanting climate change adaptation actions. As I said before, preparedness reduces damages, but preparedness also allows us to exploit opportunities. We do not yet know what opportunities climate change will bring but let us find them and benefit from them. I hope that you leave this workshop with ideas both for what we can do about climate change, but also with ideas about how we can benefit from it.

Climate scientists tell us that there will be shifts in regional weather characteristics, so all the islands in the Caribbean will experience similar impacts. This means that all of us in the Caribbean, without exception will have to cope with these impacts, and all of us need to start preparing. Luckily we are not starting from scratch, there are examples of good practice in preparing for climate change in many parts of the world including the Caribbean and the UK. There has already been a successful 5 year climate adaptation programme that has helped 13 islands in the Caribbean start to think about climate change, the potential impacts and how the islands can start to prepare. This initiative which was called CPACC – an acronym that stands for Caribbean Planning for Adaptation to Climate Change – was managed by Dr Trotz and funded by the United Nations. The UK Government is now working with Dr Trotz to extend the CPACC programme to the UK Overseas Territories, and Mr Beales, a representative from DfID will be talking to us about this tomorrow. By getting the UK Overseas Territories up to speed in the knowledge already gained in the CPACC programme should take us several steps forward in our preparedness. In addition to the regional CPACC programme the UK Government has also established a UK Climate Impacts Programme which has the mandate of communicating climate change and assisting businesses, communities and government in preparing for climate change. There are many lessons that can be learned from both CPACC and UKCIP and our links with both organisations will be useful when it comes to making our own preparations.

However, the UK Overseas Territories in the Caribbean are all small islands, we are not the UK, we do not have population of some of the bigger Caribbean islands. I do not need to tell the audience here today that in small islands we are always resource constrained – we cannot always have an expert in everything resident on our island. Regional networks of expertise are already important and a regional network of climate change experts will become increasingly so, whereby countries rely more on their neighbours who have may have expertise on different aspects of climate change.

What we have here today in this room is a network of experts within the UK Overseas Territories in the Caribbean. We have with us from Anguilla the Director of Environment and the Deputy Director of the Tourist Board. From the British Virgin Islands we have with us the Senior Disaster Management Manager, the Environmental Education Officer and the Chief Conservation and Fisheries Officer. From Montserrat we have the Senior Forestry and Environment Officer. From Turks and Caicos we have the Director of Environment and Coastal Resources and an Environmental Officer. From the Cayman Islands we have many representatives, I will not name them all, but to give you an idea of the range of interest in this subject we have representatives from Agriculture, Education, Environment, Environmental Health, Finance and Investment, Meteorology, Planning Public Works, Risk Management, Social Services and many others. One of the aims of this workshop is to nurture and encourage the development of this knowledge network. The UK Government has funded this workshop and is keen to promote adaptation to climate change in the Overseas Territories, so I hope that this workshop marks the start of

many things: the start of a regional UK OT climate change knowledge network; the start of climate change preparedness in the UK OTs; the start of our ability to see the benefits that climate change can bring; and also the start of some long and healthy inter-governmental collaborations.

Thank you.

Annex 3: Opening remarks by The Honourable Mr D. Kurt Tibbetts JP, Leader of Government Business.

Good morning.

It is my privilege to welcome you to the first ever workshop on climate change and sustainability in the Cayman Islands.

Globally, climate change is emerging as an issue of fundamental importance to our every day lives, presenting countless challenges to both present and future decisions. In particular, climate change and climate variability are expected to profoundly impact small island developing states both regionally and worldwide - - -island states who account for less than 1% of the greenhouse gas emissions driving climate change - - - island states whose societies will inherit the greatest adversity from these emissions and who, at the same time, will require the greatest ability to adapt to the resulting climate changes.

Countries such as the Maldives are already beginning to feel the effects of climate change on their economies, cultures and ecological systems. As a result, they are having to learn to live with climate change-related risk, especially that of sea-level rise. Fortunately however, advocacy groups, such as the Alliance of Small Island States, by their active participation in international climate change negotiations, are giving voice to these small nations. And, they are helping raise awareness to the plight and challenges facing small island states that will inevitably occur because of climate and sea-level related changes. As well, some small island states are starting to benefit from international funding geared toward adaptation responses, like that of the Caribbean regional assistance programme – Caribbean Planning for Adaptation to Global Climate Change or CPACC (pronounced see pack). We hope sincerely that Caribbean Overseas Territories will also have the opportunity to participate in this regional programme. In fact, we are expecting to receive some encouraging news on this matter tomorrow.

Observations of past regional trends in the Caribbean provide us with a good idea of what our future climate will be like. For example, the average temperature within the region increased by more than 0.5ºCelcuis over the last century. At the same time, sea levels rose 10-20 centimetres during this period. Over the last few decades, climatologists have observed additional trends such as an overall reduction in total regional rainfall and the occurrence of fewer Atlantic hurricanes during El Niño events. While there is still some uncertainty in the precise predictions, it is widely accepted that climate changes likely to occur in our region will include the following:

1) an increase in the intensity of rainfall but a decrease in total precipitation leading to increased risks of droughts;
2) higher sea surface temperatures with the potential to significantly impact coastal ecosystems and resources; and
3) increased storm intensity with higher risks of flooding and coastal erosion.

Events such as Hurricane Ivan, which devastated several Caribbean islands last year, provide valuable insight into what may be in store for us as a region of small islands experiencing climate change. Ivan left nearly two thirds of Grand Cayman under water for significant periods during and after the storm. A recent damage assessment of Ivan's impact on the Cayman Islands, carried out by the Economic Commission for Latin America and the Caribbean, concluded that the disaster, in dollar terms, totalled US$3.4 billion. Perhaps the following facts will help us to understand the extent of this devastation to the Cayman Islands:

- this figure of US $3.4 billion exceeds the total 2004 hurricane season damage to Grenada, Jamaica, the Dominican Republic and Bahamas combined.
- the damage caused is equivalent to roughly 183% of Cayman's Gross Domestic Product; and
- the resultant damage is estimated at $75,700 per person, the highest per capita storm damage cost ever encountered by the Economic Commission for Latin America and the Caribbean.

Having said this, one can certainly agree with His Excellency The Governor, who rightly mentioned that preparedness for such threats is key to reducing damages and the costs of recovery. It is critical therefore, that we incorporate the lessons learned from Hurricane Ivan and other past weather experiences into improved sectoral plans, hazard management, and disaster mitigation strategies.

In cannot be overstated that climate change poses significant, and possibly disastrous impacts to our region if we do not build on the old and what we already know, while looking to newer approaches. In this regard, I view the network of Caribbean regional experts and delegates present here today, as being vital to the sharing of knowledge and experiences which can assist to shape the policies necessary to mitigate the impacts of a warmer world.

In the coming decades the impacts and challenges associated with climate change are likely to be outside past or recent experience, and we must therefore prepare to expect the unexpected. Like most of our Caribbean neighbours, the Cayman Islands are subject to exceptional physical and economic vulnerabilities. Explicitly, we are all highly dependent on the sustainability of our countries' resources, we are extremely vulnerable to external factors and natural disasters, and as small economies we all rely on but a few economic sectors. For example, here in Cayman, tourism and finance primarily drive our economy. Tourism is weather and natural resource dependent, and finance can be decidedly mobile. It is also not difficult to see how other economic sectors, such as fisheries, agriculture, water, housing, and infrastructure development, also become extremely vulnerable to climate change. Not to be minimised is the vulnerability of lower income groups, the elderly and children. Even our biodiversity and culturally important features are at risk.

Our vulnerability will also increase through knock-on effects. For instance, the European Union's target of reducing greenhouse gas emissions by 60% by 2050, may

have significant implications for air travel to the Caribbean and regional stay-over tourism. Consequently, economic diversification may be moved to the forefront of our livelihoods and future sustainability. We must then, prepare for this eventuality by identifying all sectors and areas of vulnerability and employing strategies, with definite implementation timeframes, to lessen these vulnerabilities.

Ladies and gentlemen, taking adaptive action to cope with the impacts of climate change before the impacts actually occur inevitably requires faith in scientific-related information. It will also require tough legislative reform, which may be initially unpopular, as well as tough decisions regarding the reduction of user conflicts or over-use of certain resources, and discarding the status quo approach to development planning.

The aim of this workshop is to use the information currently known and being presented today, to assist the Caribbean territories in identifying planning priorities and developing strategies not only for climate change but also for sustainability on a whole. Planning for adaptation to climate change simply makes 'sustainable' sense. Through consultative processes, both nationally and regionally, I am confident we will all prevail at building resilience to climate change through proactive decision-making and policy implementation.

I am excited that the Cayman Islands are hosting this momentous occasion for the Caribbean Overseas Territories. This workshop marks the beginning of regional collaboration which is long overdue on this extremely important issue. I would like to extend a very warm welcome to our visiting climate scientists and environmental policy experts who are here to share their knowledge and expertise with policy makers and planners from across the Overseas Territories. Hopefully you will get us to think about how our climate is inextricably linked to our day-to-day lives, and why then, different sectors are extremely vulnerable.

I look forward to hearing from the regional experts who have assisted other Caribbean nations in developing outline adaptation plans. This workshop and other events earlier this week have not only brought together groups from across the Caribbean to share ideas, but have also served as springboards in raising the profile of climate change in small island states, which is a significant first step in actually making changes. I look forward to two days of thoughtful, fruitful discussion, and to working with the Department of Environment and other relevant government agencies as well as the private sector to carry forward the recommendations emerging from this workshop in the context of a national plan to address the issues related to climate change.

Thank you.

Annex 4: Keynote presentation by Professor Mike Hulme on the changing relationship between society and climate

Climate change: what's the problem?

Professor Mike Hulme

Tyndall Centre for Climate Change Research

Cayman Islands, 2-3 June 2005

- **Our changing relationship with climate**
  - **Our changing vulnerability**
  - **The changing climate risks**
- **Long-term planning and infrastructure**

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… our changing relationship with climate …

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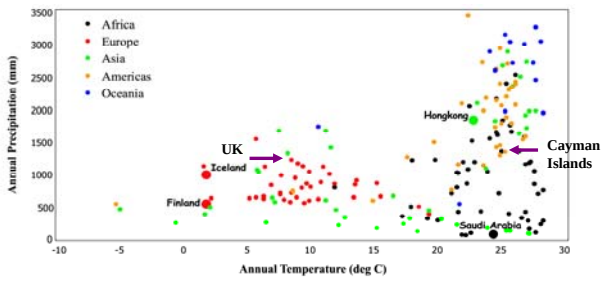
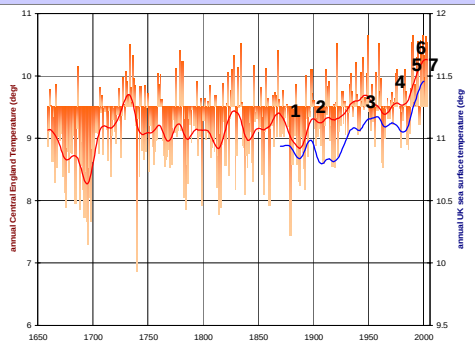
Climate regimes of the world



Source: Tim Mitchell

UK warming ….



Severe gale 1879 – building codes

- **Storm force gale with 130km/hr winds on 28 December 1879, destroyed the newly opened Tay River Bridge in Scotland**
- **Over 70 lives were lost**
- **The disaster led to the introduction of building codes in the UK for the first time**
- **It also stimulated the wider monitoring and application of wind speed data**

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"Monsoon" 1917 – military planning

- **An unanticipatedly wet August 1917 in northeast France coincided with the launch of the British Army's offensive known as Passchendaele**
- **Rainfall was 250% of average and the mud, slime and floodwaters seriously hampered the battle**
- **Over 200,000 Allied lives were lost and the offensive got nowhere**
- **As a consequence, all future British military operational planning paid more careful attention to climatic statistics**

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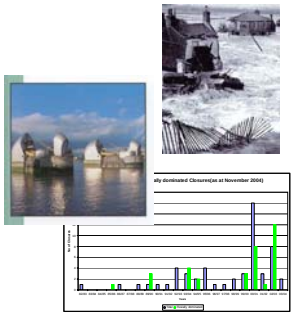
Annex 4: Keynote presentation by Professor Mike Hulme on the changing relationship between society and climate

Storm surge 1953 – coastal flooding



- A 6m tidal surge and strong winds on 31 January 1953 caused devastation along large areas of eastern England
- 307 lives were lost in the UK
- The disaster led to the design and eventual construction of the Thames Barrier, protecting London from future surges
- The Barrier is being increasingly used to protect the City from flood risk and is now being re-designed to allow for climate change

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"Hurricane" 1987 – weather warnings

- Gusts of over 150 km/hr during the night of 16/17 October 1987 caused extensive damage over southeast England
- 15 million trees were destroyed, power failures were widespread, and economic losses ran into several £100m
- The "hurricane" changed the way weather forecasts were communicated to the UK public - the introduction of a system of "severe weather warnings", now covering all types of extreme weather

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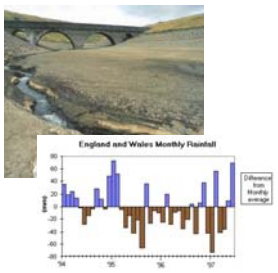
Drought 1995-97 – water management



- Rainfall was below average in England and Wales in 20 of the 26 months from March 1995 to April 1997 – two dry summers and two dry winters
- Serious water shortages resulted in some regions of England
- New Government legislation was introduced, requiring water companies by law to meet basic minimum water service standards
- All new water company management plans must now explicitly take future climate change into account

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Floods 2000 – flood protection

- Sustained heavy rainfall in autumn 2000 caused widespread flooding across many UK river basins
- 100,000s of people were affected, and 1,000s suffered mental health problems
- This led to the issuing of new planning guidance about building in flood plains
- The government also undertook a review of future long-term flood risks and how they should be managed

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Heatwave 2003 – health care

- Record high temperatures (>37°C) in southeast England (and west-central Europe) in early August 2003
- 15,000 premature deaths across west-central Europe, mostly the elderly
- This led to UK National Health Service issuing a "Heatwave Plan for England" to minimise future adverse effects on human health

… our changing vulnerability …

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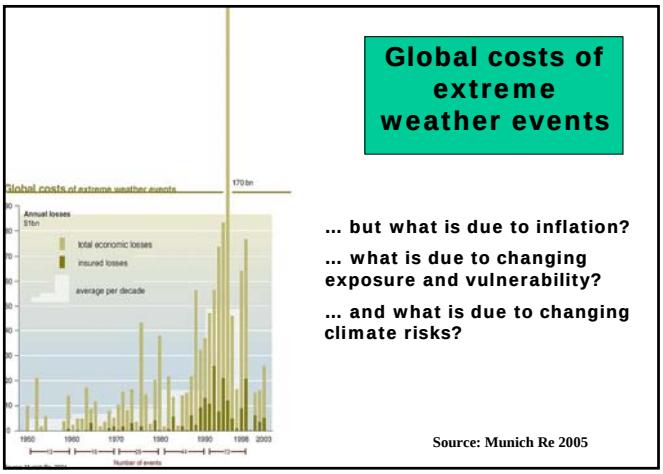
Annex 4: Keynote presentation by Professor Mike Hulme on the changing relationship between society and climate



Global costs of extreme weather events

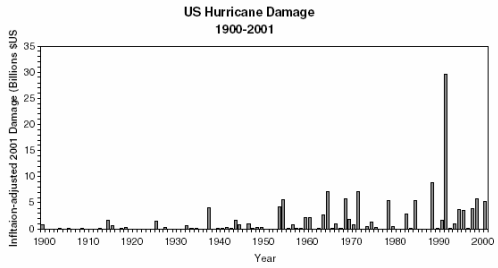
… but what is due to inflation?

… what is due to changing exposure and vulnerability?

… and what is due to changing climate risks?

Source: Munich Re 2005

US Hurricane Damage



Source: Roger Pielke, jr.

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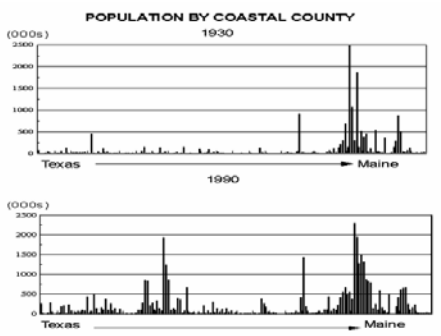

Changing exposure

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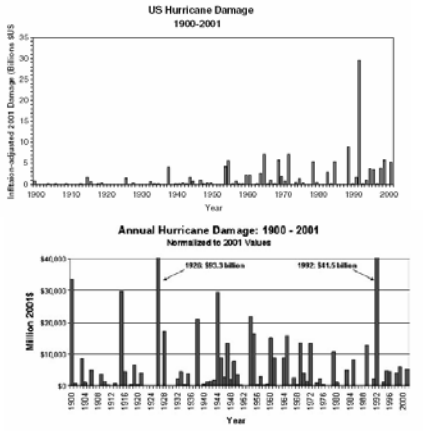

Need to distinguish between changing vulnerabilities and changing climate risks

Source: Roger Pielke, jr.

Changing Cayman Islands …

1940s
- **no visitor arrivals**
- **no banking and trust licences**
- **no hotels**

1970s
- **23,000 visitor arrivals**
- **81 banking and trust licences**
- **16 hotels**

2000
- **407,000 visitor arrivals (plus over £1m cruiseship arrivals)**
- **580 banking and trust licences**
- **ca. 100 hotels**

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… changing climate risks …

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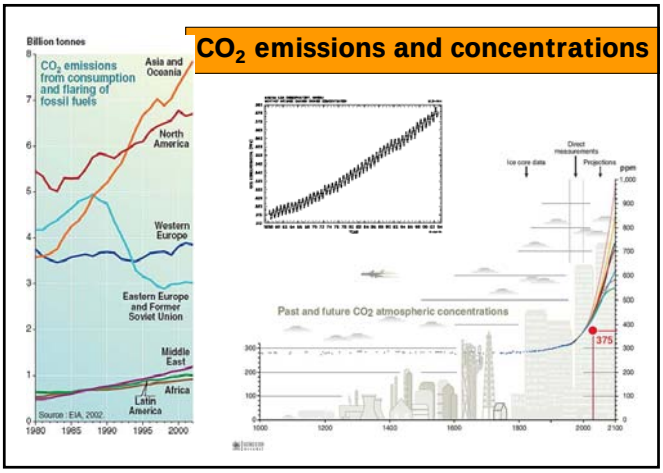
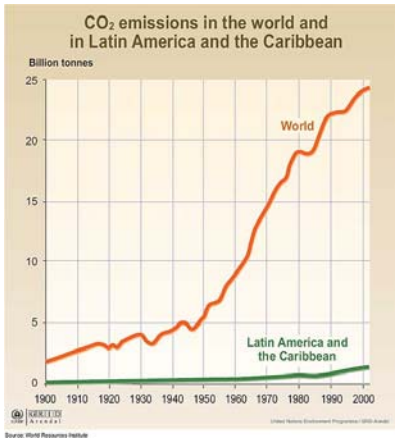
Annex 4: Keynote presentation by Professor Mike Hulme on the changing relationship between society and climate

CO_2 emissions and concentrations

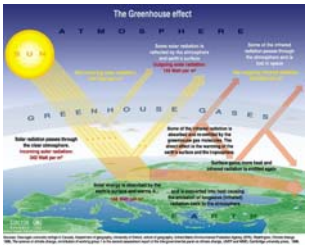


CO_2 emissions in the world and in Latin America and the Caribbean



This talk is not about mitigation – or about global climate policy

The greenhouse effect and the climate sensitivity



The <u>climate sensitivity</u> is defined as the amount by which the world will warm at the surface if the concentration of carbon dioxide in the atmosphere is doubled

It's value is somewhere between about 1 and 10 deg Celsius

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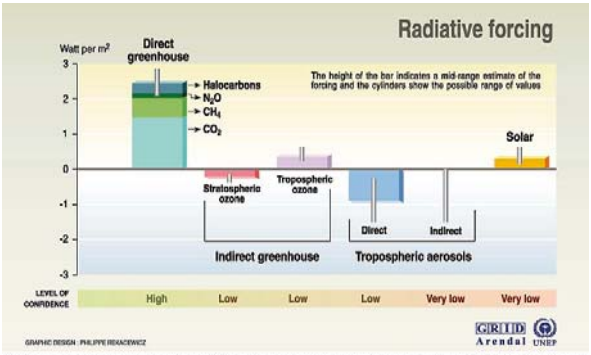
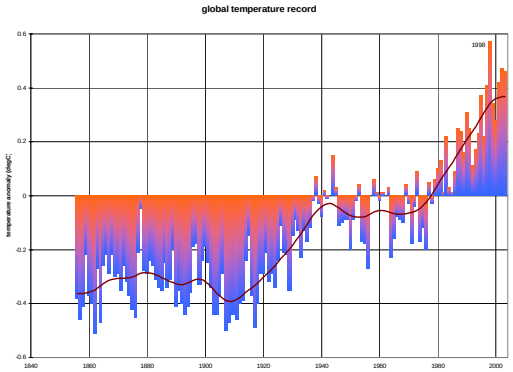
It's not just carbon dioxide …



Source: Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

Global warming – the reality



Retreating Glaciers Worldwide Vernagt Glacier - Austria

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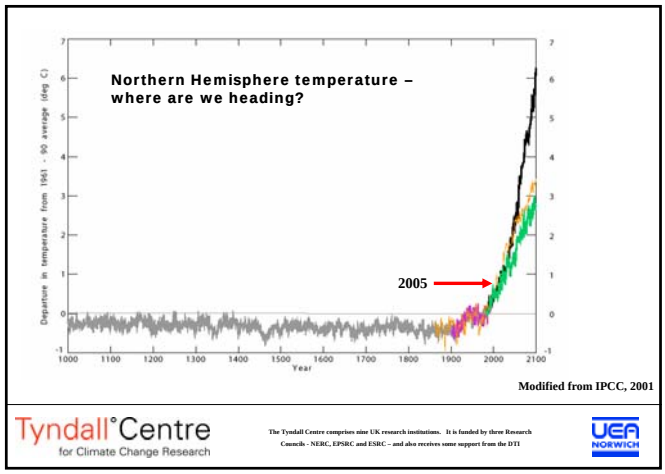

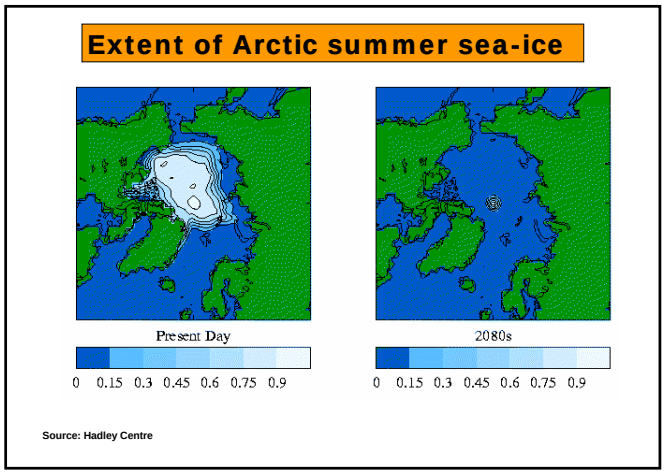

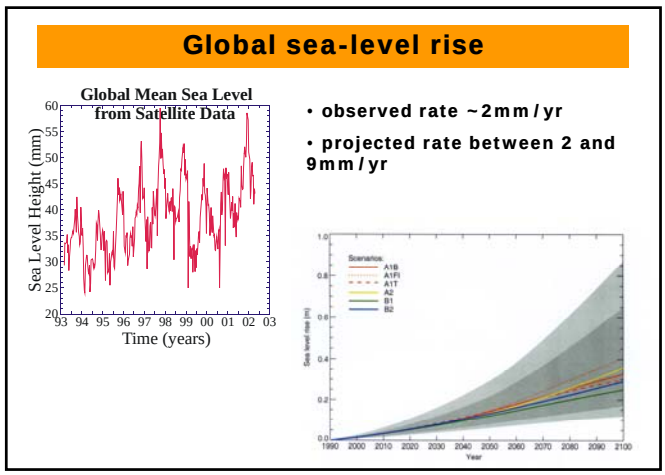

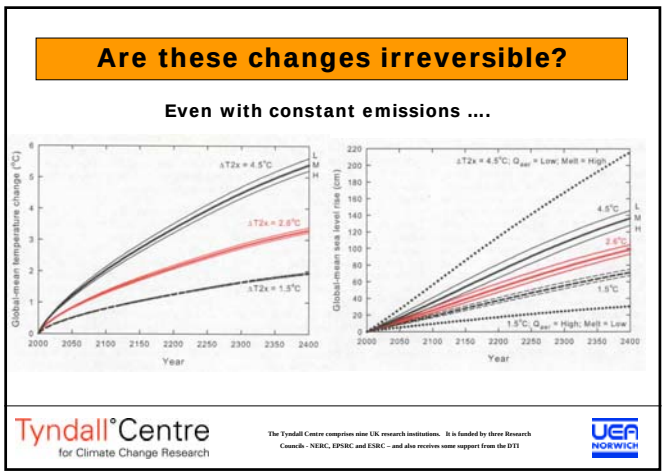

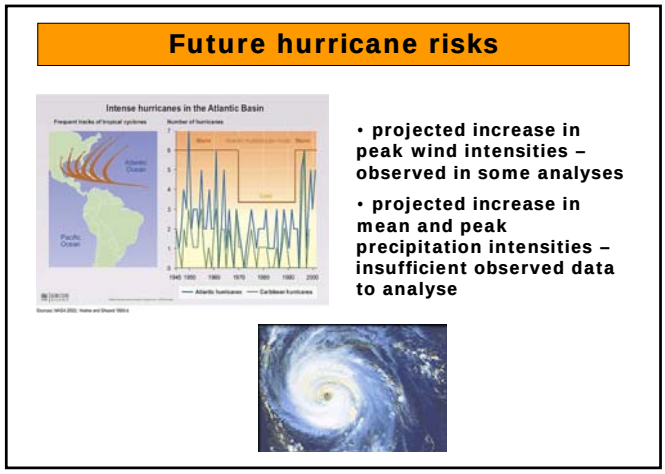

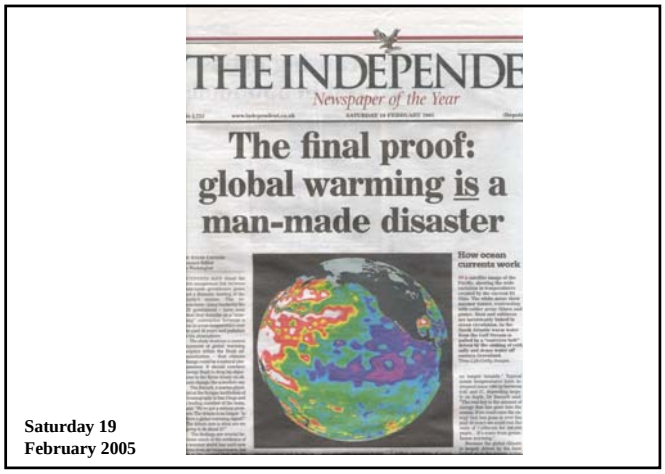

Annex 4: Keynote presentation by Professor Mike Hulme on the changing relationship between society and climate

… long-term planning and infrastructure …

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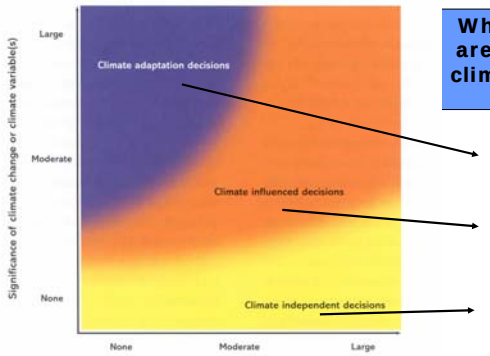
What decisions are sensitive to climate change?



Design ground floors as flood domains

Structural design and roofing materials

IT and telecommunications services in hotel

Source: UKCIP/EA

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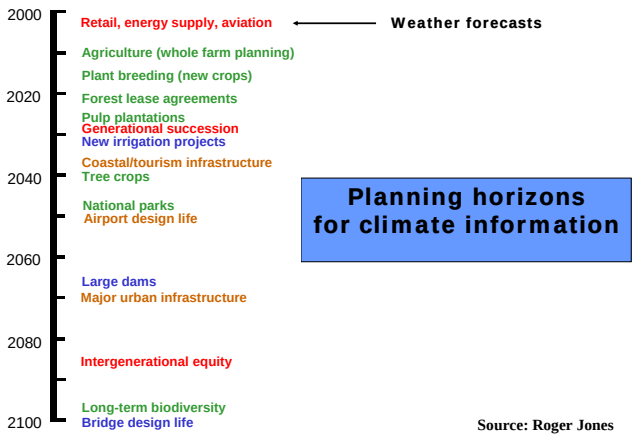


Planning horizons for climate information

Source: Roger Jones

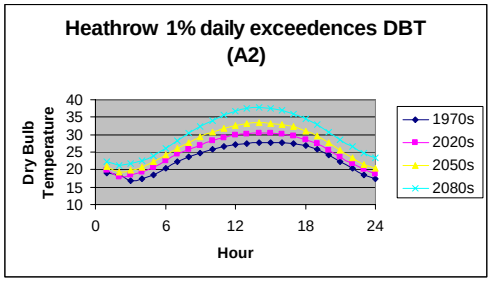
Tools for adaptation planning

UK national climate scenarios

Risk assessment framework

UK climate change programme

Climate scenarios for building design



Source: Geoff Levermore

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The Tyndall Centre comprises nine UK research institutions. It is funded by three Research Councils - NERC, EPSRC and ESRC – and also receives some support from the DTI

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Climate scenarios for flood protection

Chart 2.3 Number of properties in the UK at high risk from intra-urban flooding – today and in the four future scenarios in the 2080s

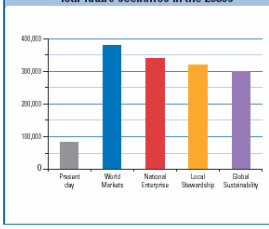
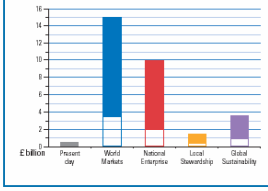


Chart 2.4 Average annual damage from intra-urban flooding for the UK in the 2080s (£ billion) the coloured bars show the range of possible values for each scenario



Tyndall Centre for Climate Change Research

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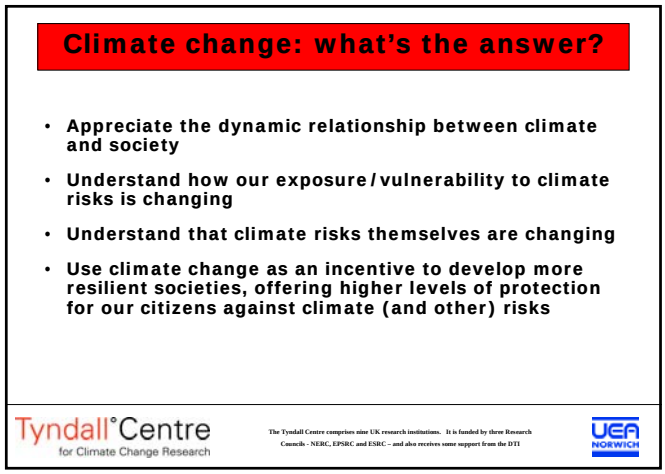
Annex 4: Keynote presentation by Professor Mike Hulme on the changing relationship between society and climate



Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

CLIMATE CHANGE & HURRICANES

DOE CLIMATE CHANGE CONFERENCE, 2-3 JUNE, 2005

By: Fred Sambula, M. Sc., Chartered MCIPD, FRMetS,
Senior Manager Meteorological Services, Cayman Islands

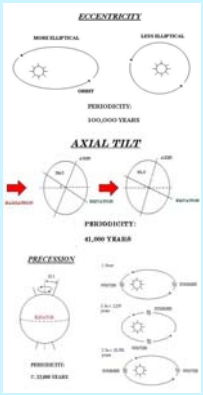
IS GLOBAL WARMING HAPPENING & WHAT DOES THIS MEAN FOR HURRICANE FREQUENCY & INTENSITY?

Special Thanks To

- NWS/NOAA
- Dr. Chris Landsea, HRD, NHC. Miami
- Dr. William Gray, Colorado State University
- Dr. Lixion Avila, NHC, Miami
- Tyrone Sutherland, Coordinating Director, CMO
- Chester Lane, Director, Barbados Meteorological Service
- Dr. Kenrick Leslie, Director, Caribbean Community Climate Change Center

Main Drivers in Natural Climate Change – Long Term

- The Sun - Source of Heat Energy in Earth Atmosphere System – Solar Constant not Changing – Annual Solar Radiation Amount Entering Atmosphere Not Changing
- Earths Rotation – Milutin Milankovitch
  - Orbital Eccentricity – Shape of Orbit changes during a cycle of 100K years from Near Circular to Elliptical and back
  - Tilt of Axis of Rotation today about 23.5 deg But in a Cycle of 41K years Varies Between 21.5 – 24.5 deg
  - Precession – Earths Axis Wobbles like a Spinning Top – Points to Different Spots in Sky during Cycle of 23 - 26K years
- Chronology of Temp Change Established for 450K years through Oxygen Isotope Analysis & Statistical Analysis of Climate Sensitive Organisms show Good Correlation with above Three Processes



Drivers in Climate Change – Short Term

- ENSO
- Sunspots
- The Big One
  - Human Impact

Is Global Warming Happening?

Themes To Be Briefly Explored

Climate

- Climate versus Weather
- Climate Change &Some Causes
- Some Climate Change Impacts on the Environment
- Monitoring the Climate

Hurricanes + Climate Change

- Environmental factors that control hurricanes
- The next couple of decades
- Climate Change & Major Atlantic Hurricanes

Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

How About This Climate We're Having?

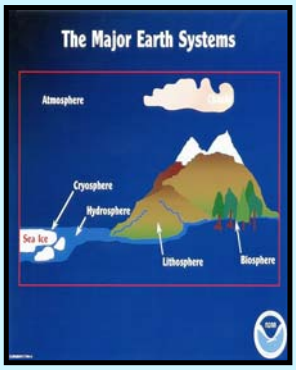
"Climate" and "weather" are very different terms.

Weather - happens in any given place in the short term days or weeks

Climate - average weather conditions over the long term – weather patterns tracked over years

Climate is what to expect- Weather is what you Get (Chester Lane)

The Climate System



NOAA Slides by Forecast Systems Laboratory.

•Climate determined by the workings of a system composed of the atmosphere, ocean, ice sheets, and land.

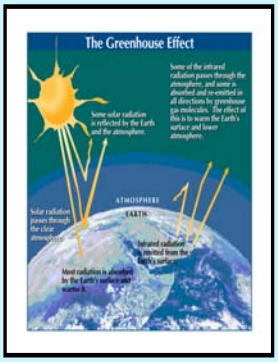
•The oceans (hydrosphere) affect climate by storing and releasing heat, which in turn makes some parts of the world wetter than others and/or warmer. Similarly - Lithosphere

•Even sea ice—part of the cryosphere—affects the climate by reflecting the sun's energy, creating a cooling effect.

•Trees and plants—the biosphere—affect climate by storing and releasing carbon and carbon dioxide, a heat-trapping gas.

•Clouds part of the atmosphere affect climate in a number of ways—for example, they can exert a cooling effect that slows the evaporation of water.

•Even people affect it—by burning nonrenewable energy such as oil, which releases carbon dioxide, a heat-trapping gas.



•Our planet's atmosphere traps heat much like a garden greenhouse does.

•Sunlight enters the greenhouse (atmosphere) and warms the soil, plants, and ocean (earth).

•About 30 percent of the sun's energy is reflected back into space (Albedo). But the remainder is absorbed by "greenhouse gases" in the atmosphere and earth's surface, where it helps warm the planet.

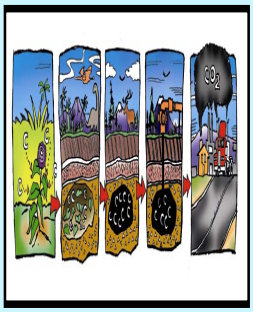
•The earth radiates heat back to the atmosphere, where it is absorbed by "greenhouse gases" such as carbon dioxide and methane. This further warms the earth.

•But some of the energy is emitted back into space. This prevents the planet from overheating.

•This "greenhouse effect" is a natural phenomenon that makes our planet warm enough to be livable.

•Without it, our planet would be 60 degrees Fahrenheit/16 deg Celsius colder than it is today.

Greenhouse Gases: The Carbon Cycle



•Here are some of the natural sources of carbon dioxide emissions:

•Trees and plants, which draw carbon dioxide from the atmosphere and then return it when they die.

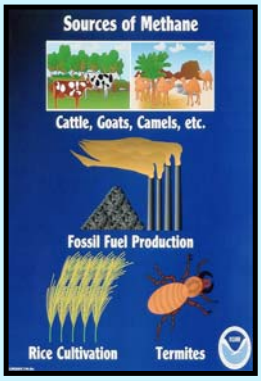
•Plants in the ocean do the same.

•Animal and human respiration return carbon dioxide to the atmosphere.

•But burning of fossil fuels—oil, gas, coal—is the only one that is not a natural part of the carbon cycle, but rather is added by human activities.

•There are also "carbon sinks," which take in and store more carbon than they release. Carbon sinks such as the oceans and forests counterbalance some of the carbon emissions, but not all.

Greenhouse Gases: Methane



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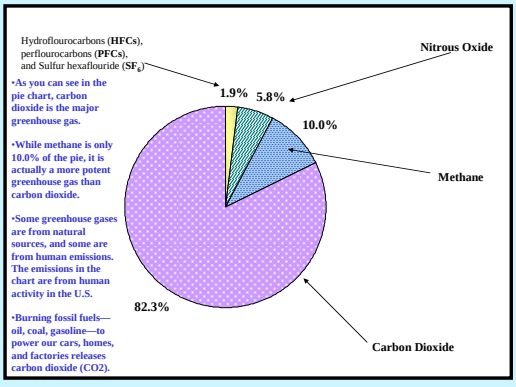
•These are some of the sources of methane

Methane is a more potent greenhouse gas than carbon dioxide.

Landfills (your city garbage dump) actually accounted for 65% of methane emissions in 1996, from human activities. Livestock account for the second highest level of methane emissions.

1996 Total U.S. Greenhouse Gas Emissions



•As you can see in the pie chart, carbon dioxide is the major greenhouse gas.

•While methane is only 10.0% of the pie, it is actually a more potent greenhouse gas than carbon dioxide.

•Some greenhouse gases are from natural sources, and some are from human emissions. The emissions in the chart are from human activity in the U.S.

•Burning fossil fuels—oil, coal, gasoline—to power our cars, homes, and factories releases carbon dioxide (CO_2).

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 1996. U.S. EPA publication #236-R-98-006

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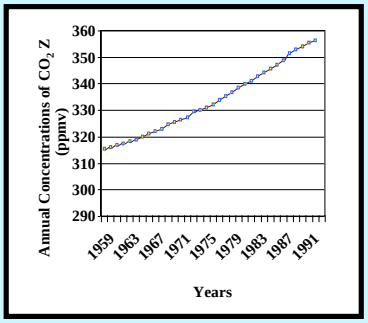
Atmospheric Concentrations of CO_2

Mauna Loa, Hawaii 1959-1992



Source: Trends'93 A Compendium of Data on Global Change, Oak Ridge National Laboratory, Publication no. ORNL/CDIAC-65. Mauna Loa data from C.D. Keeling and T. Whorf

- Several locations around the world have been measuring ambient concentration levels of carbon dioxide in the atmosphere for many years.. One of the best sites is the Mauna Loa site in Hawaii—considered a favorable site for measuring undisturbed air with minimal influence on measurements from possible local vegetation or human activities.
- The Mauna Loa record shows a 12.8 percent increase in the mean annual concentration of carbon dioxide, from 315.83 parts per million by volume (ppmv) of dry air in 1959 to 356.24 ppmv in 1992.
- Scientists rely on Antarctic ice core samples to measure carbon dioxide levels prior to the era of direct atmospheric measurements such as those at Mauna Loa.

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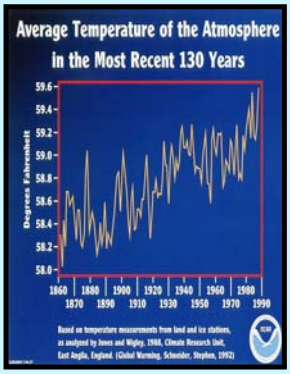
Understanding Climate Change

- Climate change is a natural process—as shown by the glacial periods when there is ice (colder climate), and interglacial periods when the ice shrinks (warmer climate).
- Human activities can intensify the greenhouse effect by increasing the concentration of greenhouse gases in the atmosphere.
- This further warms the earth—global warming—leading to climate changes.
- Scientists from around the world are looking for clues to understand natural and human-induced climate change.

Global Warming



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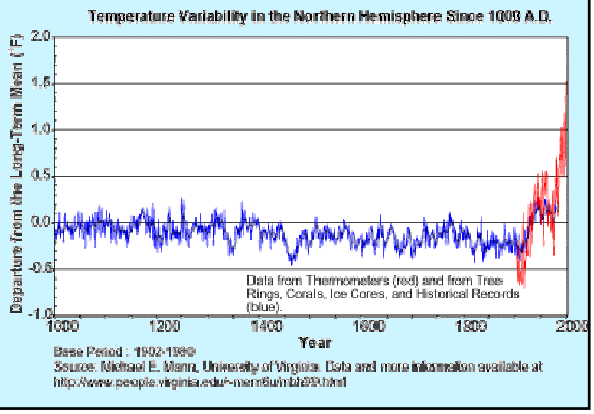
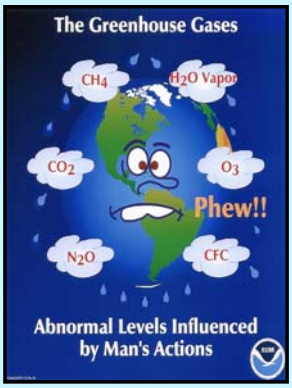
- Question: What do we mean by "global warming"?
- Global warming means an increase in the earth's average temperature.
- In fact, global temperature has increased about 1 degree Fahrenheit/0.5 Celsius in the past century.
- That doesn't sound like much, but the average global temperature during the Ice Ages was only about 9-12 degrees Fahrenheit, 4 -6 Celsius colder than today, and the world has a very different climate today than it had then.
- Even if we take steps now to reduce our emissions of greenhouse gases, the globe could warm up at a rate faster than it has in the past 10,000 years.

Temperature Variation In The Northern Hemisphere



What Is Global Warming?



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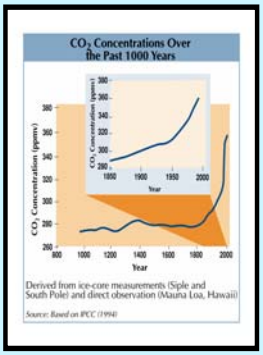
- The present warming happened during a period when human activities began to increase the carbon dioxide and other greenhouse gases in the atmosphere (Industrialization).
- Most scientists believe that global warming will continue.
- Important to note that global warming is a different problem from ozone depletion. The so-called "ozone hole" is caused by the release of chlorofluoro- carbons (CFCs), which break down the ozone layer. CFCs,. main impact is destruction of the ozone layer.
- Global warming refers to an increase in the earth's average temperature. And global warming is caused mainly by an increase in greenhouse gases like carbon dioxide and methane.

What the Experts Say About Climate Change



- How do we know the climate is changing? Over the past century, CO2 levels in the atmosphere have increased from 280 parts per million to nearly 360 ppm. During the same time, global temperatures have risen nearly 1 degree Fahrenheit.
- Recent studies indicate - northern hemisphere, spring is arriving sooner and fall later. (Longer Hurricane Seasons?)
- The UN and World Meteorological Organization established a panel of 2,000 leading scientists to assess the available science on climate change. This group, the Intergovernmental Panel on Climate Change (IPCC), looked at some of the indicators of global warming:
  - Melting glaciers worldwide (e.g., glaciers in Montana's Glacier National Park are now one-third the size they were in 1850).
  - Sea level has risen, indicating that ocean temperatures have increased (water expands as it warms).
- In 1995 the panel of 2,000 scientists concluded that "the balance of evidence suggests a discernible human influence on global climate

Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

Climate Models: Another Tool for Understanding Climate Change

- Scientists also use climate models—computer simulations of climate—to study the potential effects on our climate of increasing carbon dioxide levels and other greenhouse gases in the atmosphere.
- Based on these climate models, the Intergovernmental Panel on Climate Change—the IPCC—predicts the earth will warm an additional 2-6 degrees Fahrenheit/ by the year 2100.

How Do We Take the Earth's Temperature?

Records of temperatures on land come from weather stations around the world. Scientists use the instruments to track temperatures, rainfall and other precipitation, wind speed, and barometric pressure – Today WMO sponsors GCOS part of WWW

Specially designed ocean buoys take additional measurements at sea.

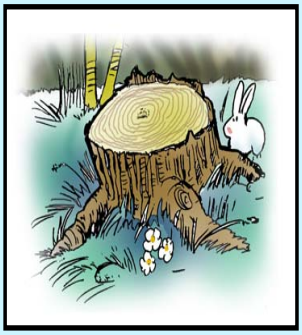
Instruments on satellites and weather balloons take readings of the lower atmosphere. Earlier studies showed a slight cooling in the atmosphere. But as scientists have made corrections for decay of the satellites' altitude, the satellites now are also reporting a warming trend.

Taking the Earth's Temperature -Ice Core

Weather station records date back approximately 100 years. To understand climate change on longer time scales, scientists have to rely on other sources of information.

Air bubbles inside of ice core samples from Greenland and Antarctica tell researchers about the long-term history of the planet's climate, along with coral cores.

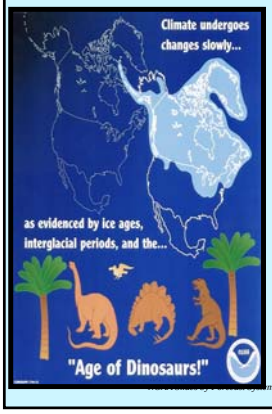
How Do We Take the Earth's Temperature?



Tree rings are another way to reveal past trends in temperature and periods of drought and rainfall. Thickness or Growth of Ring depends on Temp & Precip.

Tree rings and ice cores show that concentrations of carbon dioxide in the atmosphere have been going up.

Long-Term Climate Change

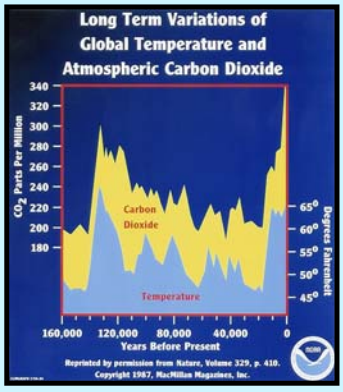


30,000 years ago up to about 15,000 years ago, great ice sheets as much as two miles thick covered much of North America. At the end of the Ice Ages, mastodons and other large mammals began to disappear.

A "Little Ice Age" gripped Europe for several hundred years and was at its strongest between 1570 and 1730. Severe winters caused famine, and the effects were felt even into the beginning of the 19th century.

NOAA Slides by Forecast Systems Laboratory.

Long-Term Climate Change (cont.)



Although these long-term climate changes may have been affected by changes in solar radiation, greenhouse gases produced by human activities appear to have an increasing influence on temperatures.

Carbon dioxide levels and temperatures have fluctuated in remarkably similar cycles.

Four of the warmest years since 1400 A.D. occurred during the 1990s, and global temperatures in 1998 set a new record since reliable historical records began in the 1880s.

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Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

El Niño-Southern Oscillation

Not all climate changes are on decades to centuries time scales. Scientists have recently learned to predict seasonal climate changes associated with annual changes in the El Niño-Southern Oscillation (called ENSO).

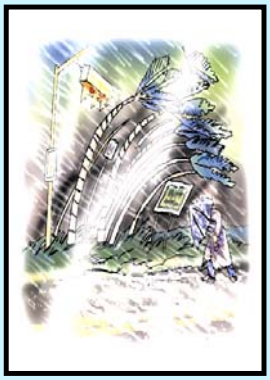
El Niño - above-normal sea surface temperatures that typically appear around Christmas time in the Eastern Pacific Ocean. El Niño, means "the little boy" or "the Christ Child." The opposite, below-normal sea surface temperatures, is referred to as La Niña.

During El Niño years, the easterly winds that blow across the Pacific weaken and no longer cause cold water to rise to the surface. This ocean-atmosphere interaction affects weather around the world.

Record-breaking El Niño - winter of 1997-1998 caused unusual (but predictable) weather in parts of the U.S.—flooding in the Southeast, an ice storm in the Northeast, and flooding in California.

Scientists cannot say with certainty that global warming is affecting El Niño or La Niña events. But a recent study by scientists suggests that global warming may be worsening the effects of El Niño. El Niño events have become more frequent with greater climate impacts over the past century.

Weird Weather: Global Warming



Extreme weather events include ice storms, hurricanes, floods, droughts, and heat waves. Scientists cannot say for sure that the recent spate of extreme weather events are proof of global warming - Possible that as global warming happens, we might see more extreme weather events.

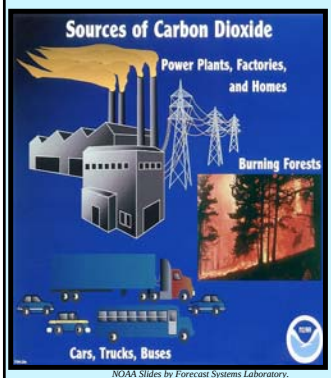
Weather is naturally variable. Short-term climate changes, such as an El Niño event, can influence climate around the world leading to extreme weather events that impact human society.

Examples:

- New England ice storm of January, 1998: Damages approached $3 billion in Canada and $400 million in the U.S.
- Hurricane Mitch Oct. 1998: - devastated Honduras, killed nearly 6,000 people - left 3 million homeless - damages of $5 billion - dumped nearly 6 feet of rain in some areas in less than a week.

20

Are Humans Changing Climate?



NOAA Slides by Forecast Systems Laboratory.

Today, many human activities, especially burning of fossil fuels (oil, gas, coal) contribute greenhouse gases, primarily carbon dioxide, to the atmosphere.

Humans burn fossil fuels in power plants to generate electricity, in factories to manufacture goods, and in homes to power our appliances and provide light, heat, and air conditioning.

We also burn fossil fuels to provide transportation, like cars, buses, and airplanes.

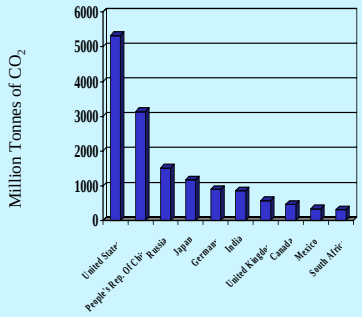
And we release carbon dioxide through cutting and burning forests.

CO_2 Emissions From Fossil Fuel Combustion: 1996

Last two centuries, humans used fossil fuel resources at an increasing rate.

1996 - humanity released about 23 billion tons of carbon dioxide into the atmosphere every year by burning fossil fuels. U.S. alone released 5.3 billion tons in 1996 from fossil fuel combustion.

Developing countries like China and India - increasing use of fossil fuels faster than industrialized nations like the U.S.

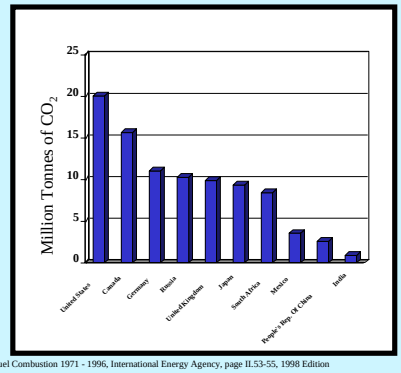


Source: CO_2 Emissions from Fuel Combustion 1971 - 1996, International Energy Agency, page II.4-5, 1998 Edition

CO_2 Emissions Per Person: 1996

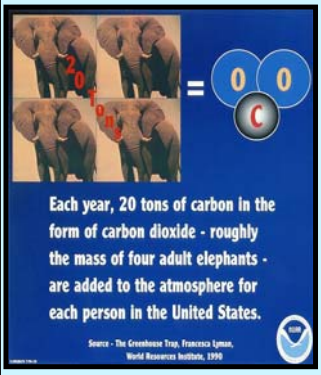
As you can see by this graph, per capita emissions in industrialized countries like the U.S. are much greater than per capita emissions in developing countries like China and Mexico.

Nevertheless, China's population is so huge that its total emissions (as shown in slide 22) are beginning to look like those of the U.S.



Source: CO_2 Emissions from Fuel Combustion 1971 - 1996, International Energy Agency, page II.53-55, 1998 Edition

U.S. Emissions



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USA's use of energy in 1990 was so high that each person's emissions roughly equaled the mass of 4 elephants.

That number higher today.

Should something be done about that?

Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

Why Should We Care?

Don't know exactly what will happen with global warming or what the impacts will be or where or when they will hit hardest.

Scientists have a pretty good general idea of what may come - possible impacts could be far-reaching and could cause serious problems:

1. **Sea level can continue to rise, eroding beaches and increasing the damage from storms and leading to loss of wetland habitats. Some island nations may disappear.**
2. **Increasing temperatures are likely to affect human health:**

   Warmer temperatures will mean mosquitoes can spread to areas that were previously too cold for them to survive. Mosquitoes carry infectious diseases like Malaria and Encephalitis - Coral Reef Destruction (Bleaching)
3. **Ground-level ozone pollution may worsen, increasing respiratory diseases like asthma.**
4. **Deaths from heat waves will rise.**
5. **Some plants and animals may face extinction if habitat changes. Difficult to achieve Sustainable Development**

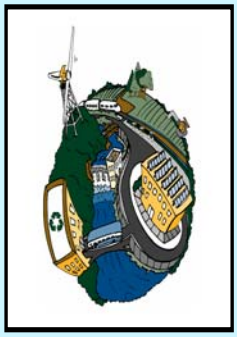
Why Should We Care?

Changing weather patterns could affect agriculture. Northern states could actually experience longer growing seasons. No freeze in Florida Citrus Belt? Some areas could have frequent droughts.

Some forests may disappear, leading to extinction of wildlife species—changes in biodiversity.

Economic effects: Billions of dollars in property damage from sea level rise and (worsening storms.?)

What Can We Do About Global Warming?



Simple steps each of us can take that will help reduce our emissions of greenhouse gases. Just a few examples:

Recycling saves the energy required to manufacture new products.

Give your family car a day off by riding your bike, taking the bus, walking.

Plant trees—they absorb carbon dioxide.

Read and learn about global warming.

Save electricity by turning off the TV and lights when you're through with them.

Go solar—a solar system to provide hot water can reduce your family's carbon emissions by about 720 pounds a year.

Encourage others to take these simple actions.

What Can We Do About Global Warming?

Here are some more ideas:

- **Preserve forests—they act as carbon dioxide "sinks" —in other words, they absorb carbon dioxide.**
- **Develop renewable energy technologies to reduce dependence on fossil fuels.**
- **Use energy more efficiently. For example, the federal government has a variety of voluntary partnership programs with industry to reduce greenhouse gas emissions by using energy more efficiently.**

Earth Smart Shopping

One of the federal programs is called ENERGY STAR: Look for products with the ENERGY STAR label on household appliances, computers, heating and cooling equipment, windows, and light fixtures.

These products use less energy, save you money on your utility bills, and help protect the environment from global warming. For example, you can reduce your home's heating and cooling costs up to 15 percent with ENERGY STAR windows.

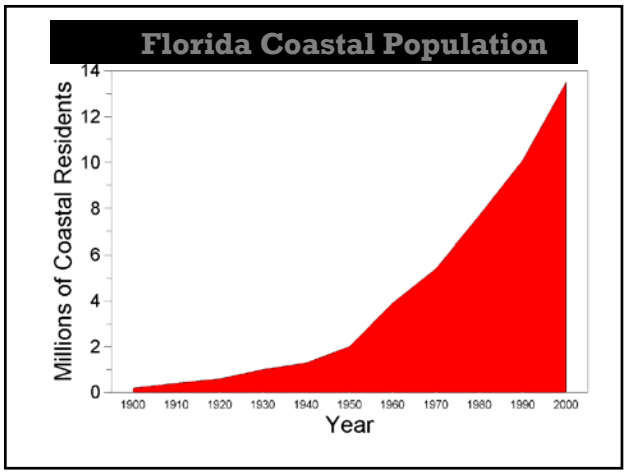
If all homes in the U.S. were refitted with ENERGY STAR windows, would save $7 billion in energy costs over the next 15 years. Similar advice for Caribbean States

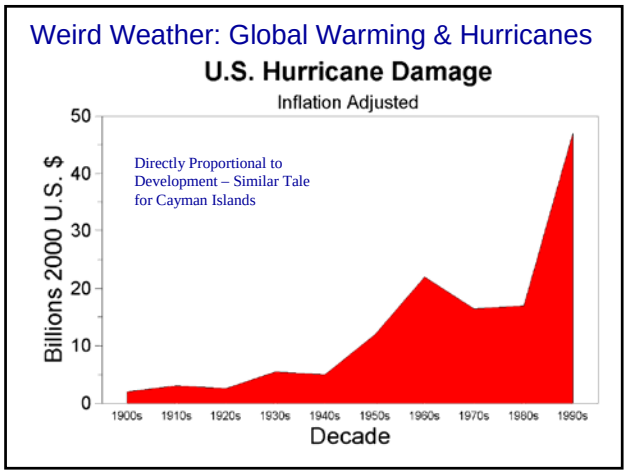
Climate Change
Weird Weather: Global Warming & Hurricanes

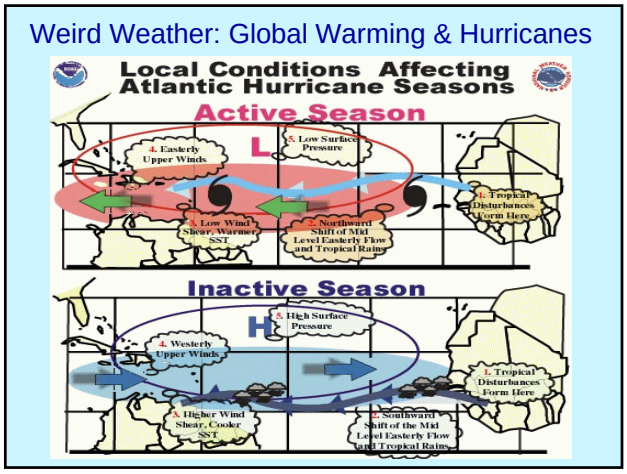
Some Questions

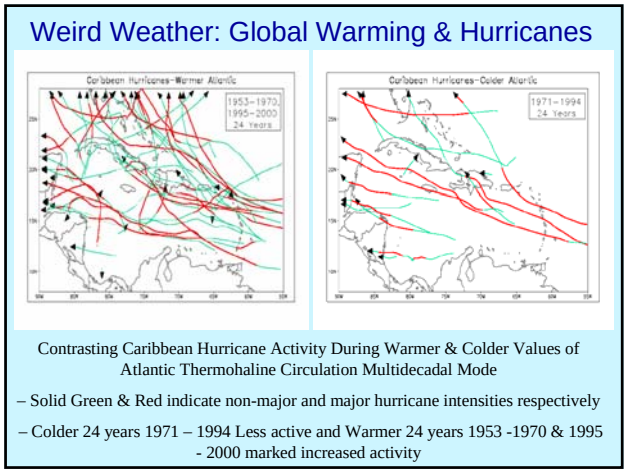
- **Why have hurricane damages gone way up?**
- **How have hurricanes changed in the past?**
- **What environmental factors control hurricanes?**
- **What will the next couple decades bring?**

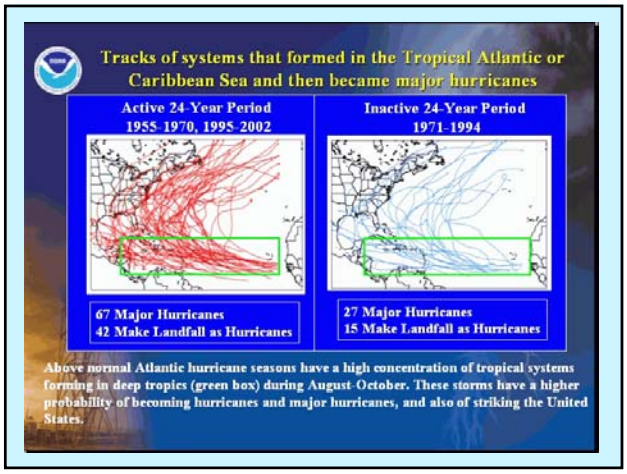
Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

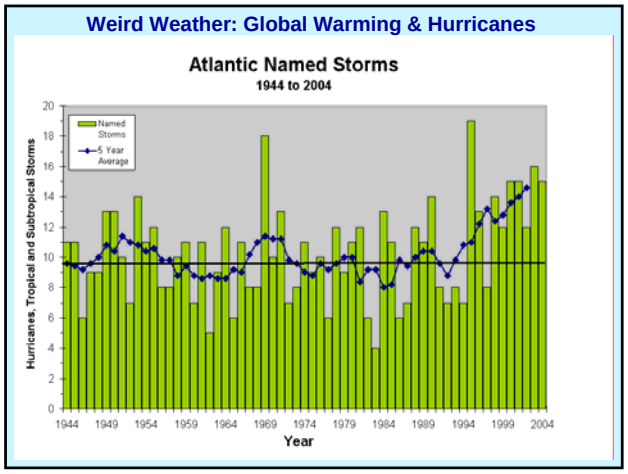






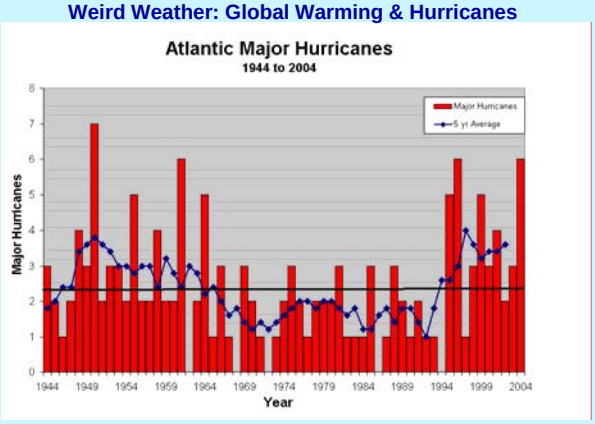




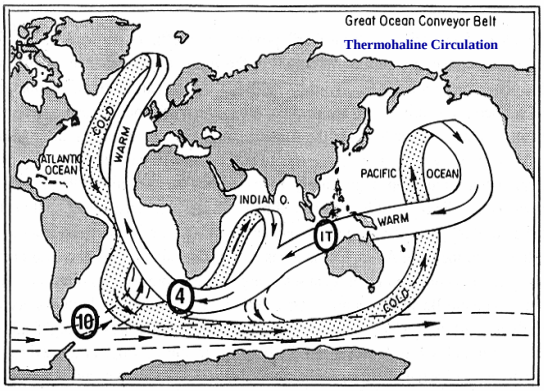


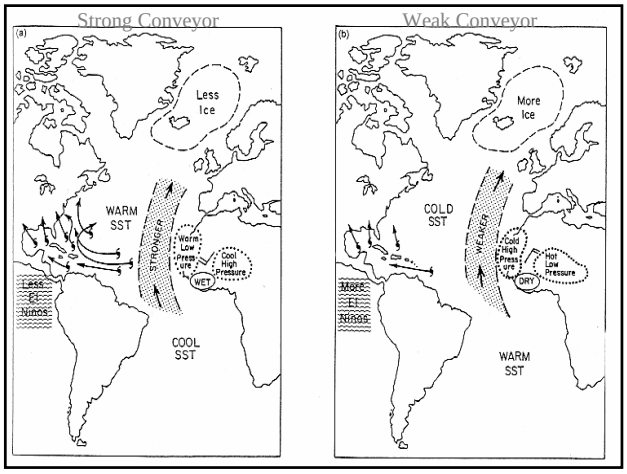
Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

Weird Weather: Global Warming & Hurricanes



Weird Weather: Global Warming & Hurricanes





Dr. Bill Gray
Colorado State University

Increased Major Hurricane Activity Since 1995

Is unprecedented landfall of four destructive hurricanes in a seven-week period related in to human-induced climate changes?

If global warming were the cause of the overall increase in Atlantic basin major hurricane activity of past nine years (1995-2003), - Would expect to see similar activity in the other storm basins as well (ie., West Pacific, East Pacific, Indian Ocean, etc.) – Has not occurred

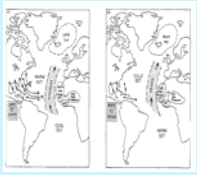
Tropical cyclones worldwide are summed - show slight decrease since 1995 – Reliable Documentation that warming of about 0.5°C during the 25-year period of 1970-1994 accompanied by a downturn in Atlantic basin hurricane activity.

Heightened Atlantic major hurricane activity of 2004 season, increased Atlantic major hurricane activity of the previous nine years related to multi-decadal fluctuations in the Atlantic Ocean thermohaline circulation (THC)

Major hurricane activity in the Atlantic has been shown to undergo marked multi-decadal fluctuations that are directly related to North Atlantic sea surface temperature anomalies

When Atlantic Ocean thermohaline circulation strong, Atlantic equatorial trough (ITCZ) becomes stronger. Stronger ITCZ - more favorable conditions for development of major hurricanes in the central Atlantic. Since 1995, the THC been flowing more strongly, also connected increase in major hurricanes in the tropical Atlantic.

Dr. Bill Gray
Colorado State University

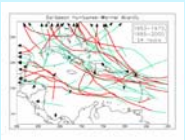


Increased Major Hurricane Activity Since 1995

Major reconfiguration of distribution of Atlantic SST anomalies began in mid-1995- has largely persisted to present

SSTs have become about 0.4 to 0.6°C warmer than normal since 1995

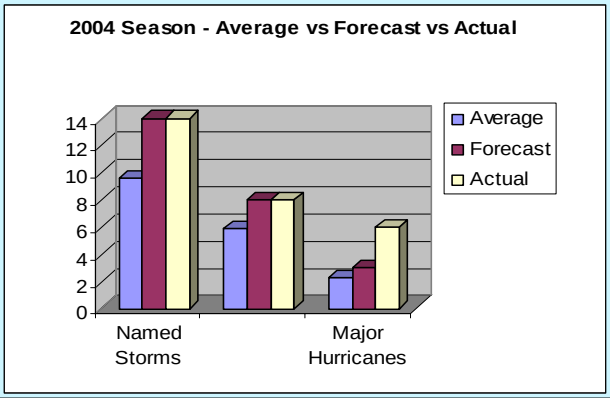
It was the strengthening of the Atlantic Ocean thermohaline circulation (THC) which led to these Atlantic basin changes



Historical and geographic evidence going back thousands of years indicates that shifts in the Atlantic multi-decadal thermohaline circulation tend to occur on periods of about 25-50 years.

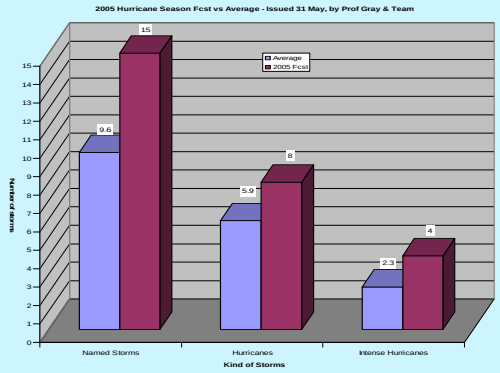
If the recent ten-year shift follows prior occurrences, it is likely that enhanced Atlantic basin major hurricane activity will persist through the early decades of the 21st century in contrast with the diminished major hurricane activity that was present from 1970-1994

2004 Season- Average vs Forecast vs Actual

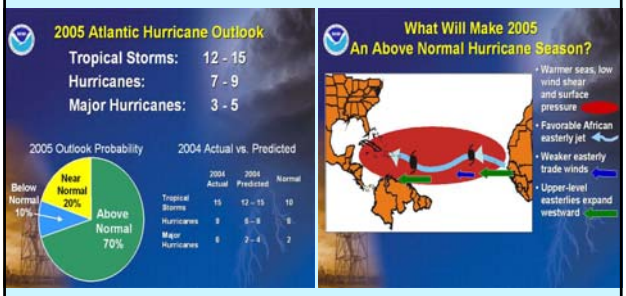


Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

2005 Hurricane Season - Forecast vs Average



NOAA 2005 HURRICANE OUTLOOK



2005 -Storm Names

Arlene
Bret
Cindy
Dennis
Emily
Franklin
Gert
Harvey
Irene
Jose
Katrina
Lee
Maria
Nate
Ophelia
Philippe
Rita
Stan
Tammy
Vince
Wilma

Bearing the Heat

In Conclusion

If we do nothing about global warming, the consequences for Caribbean nations could be severe.

Taking actions now is similar to taking out an insurance policy. You may never need it, but you are thankful you have one if a disaster strikes.

Do it not just for us but also for future generations and other animals and plants who share the planet with us.

Realize that the Caribbean is extremely Vulnerable
High degree of exposure to Natural Hazards
- **Hurricanes, Droughts, Flooding, Landslides etc.**
- **Economies mainly Agriculture but Increasing Tourism**

High degree of sensitivity
- **Fragile Ecosystems (Coral Bleaching)**
- **Human Systems – Coastally Situated Infrastructure**
- **Small Economies Susceptible to External Shocks**

Low Adaptive Capacity
- **Limited human, technical and financial**
- **Policy**

Bearing the Heat - Conclusion (Contd.)

- **Policy & Decision Makers must incorporate Climate Change Impacts into future National Development Plans.**
- **Relevant Scientific & Technical Bodies should Educate & Inform Policy makers in the area of Climate Change & Global Warming Issues to ensure Awareness & Sensitivity to possible National Impacts.**
- **Caribbean – 28 Insular & Coastal States + 10 Territories Bordering the Caribbean Sea, Gulf of Mex – Area 5M sq. Km – Estimated Pop 40 million, 28 million live in Coastal Cities, Villages Or Towns- 38% classified as Poor**
- **Caribbean Emits less than 1% of Global GHG but will be most impacted by inevitable GCC – Region must Adapt to GCC Impacts**
- **Policy (Approach to Adaptation)**
  - **Action to Reduce Vulnerability – Many of These Actions are also Sustainable Development Actions**
  - **Address Limited Regional Capacity – Focus on Building Human & Technical Capacity to Adapt to Adverse Impacts of CC**
  - **Get with GEOSS Initiative enhance knowledge of the planet through a coordinated and sustained global monitoring systems from space, from the oceans and land - *It began with the 1st Earth Observation Summit (Washington, July 2003 - When 33 (now 60) countries Led by Ministers of Govt.) and 20 (now 40) International Agencies:***

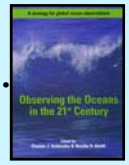
It began with the
1st Earth Observation Summit
(Washington, July 2003)

When 33** (now 60) **countries** (Canada led by former Environment Minister Anderson) **and 20** (now 40) **International Agencies:

- ✓ ***Affirmed the need for timely, quality, long-term, global information as a basis for sound decision-making, and***
- ✓ ***Recognized the need to support:***
  - ***A comprehensive, coordinated, sustained Earth observation system or systems;***
  - ***A coordinated effort to address capacity-building needs related to Earth observations;***
  - ***The exchange of observations in a full and open manner with minimum time delay and minimum cost, recognizing relevant international instruments and national policies and legislation;***
  - ***The preparation of a 10-year Implementation Plan, building on existing systems and initiatives***

Annex 5: Presentation by Mr Fred Sambula on the links between climate change, extreme weather and hurricanes

GEOSS technical approach …



- Based on existing observing, data processing, data exchange and dissemination systems,
- Encouraging and accommodating new systems as needs and capabilities develop
- Three types of functional components:
  - To acquire observational data;
  - To process data into useful products; and,
  - To exchange, disseminate and archive shared data, metadata, and products.

GEO Participant obligations apply only to those self identified contributions

Socio – Economic Benefit Areas

- Disasters; **Strengthen International Charter**
- Human health; **Air quality, water related disease vectors**
- Energy; **Decision support tools for optimization of energy use**
- Climate variability and change*; **Work mainly through GCOS and improve reporting to World Data Centres**
- Water resource management; **Evaluate use of Space based systems to measure water quality, promote integrated water management**
- Weather*; **improve use of information to avoid loss of life and property, fill data gaps in oceans**
- Ecosystems (terrestrial, coastal and marine); **Harmonization of observing methodologies, reduce the gap in observing capacity (north – south / temperate – tropical)**
- Agriculture / combating desertification; **Standards for land cover mapping … concentrate efforts on food insecure regions**
- Biodiversity. **Interoperability standards for data**

Bearing the Heat - Conclusion Contd.

- **More Aggressive Education Policy Needed to Change Behaviour & Attitudes at Policy Making Level.**
- **How Are We Scientists Going To Do This?**

THANK YOU

ANY QUESTIONS?

Annex 6: Presentation by Professor Mike Hulme on climate skeptics' arguments explained and countered

Climate change: can the science be trusted?

- Scepticism, contrarianism and denial
- Climate science
- Social science and economics
- The IPCC process
- The role of science in policy

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The Tyndall Centre comprises nine UK research institutions. It is funded by three Research Councils - NERC, EPSRC and ESRC – and also receives some support from the DTI

UEA NORWICH

Sceptics, contrarians and denial

- Scepticism entails a degree of disbelief and doubt, challenging assumptions, emphasising uncertainties
- As such, a sceptical attitude is an underpinning of modern science … we should all be sceptics
- 'Contrarian' rather than 'sceptic' might therefore be linguistically more appropriate
- Some would argue that scepticism has converted to 'denial'

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What drives contrarians?

- Psychology?
- Fame?
- Belief?
- Career/position?

… the same things that drive non-contrarians …

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Five criticisms of climate science

- "CO2 concentrations follow temperature, rather then the other way round" – e.g. Dietze
- "Previous centuries were warmer than the 20th century" – e.g. Soon/Baliunas, McIntyre/McKitrick; cf. Mann et al.
- "The global instrumental temperature record exaggerates recent warming" – e.g. Michaels, Christy; cf. Fu et al. 2004
- "Global sea-level is not rising" – e.g. Mörner
- "To much credibility is given to global climate models" – e.g. Lindzen, Stott

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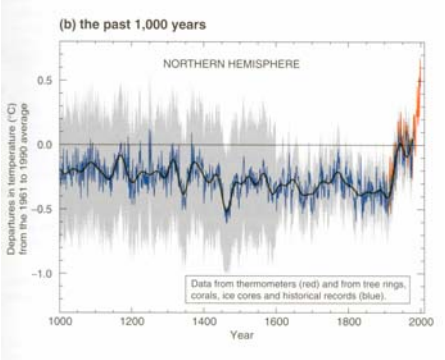

The IPCC hockey-stick graph

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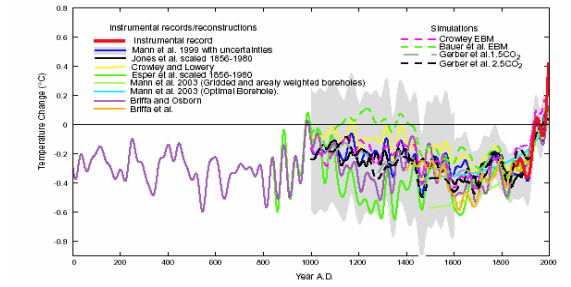

Mike Mann's response

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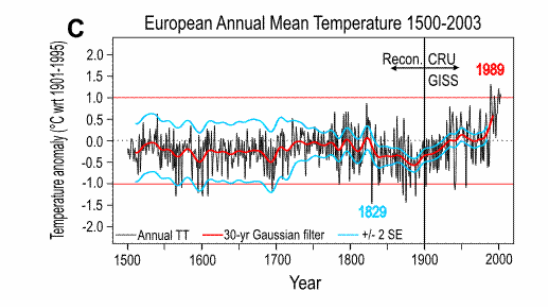
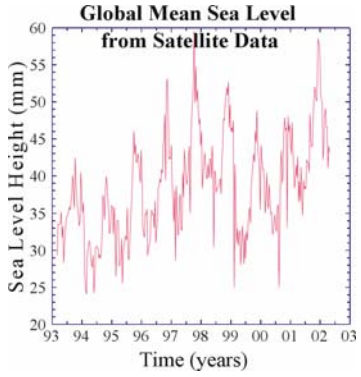
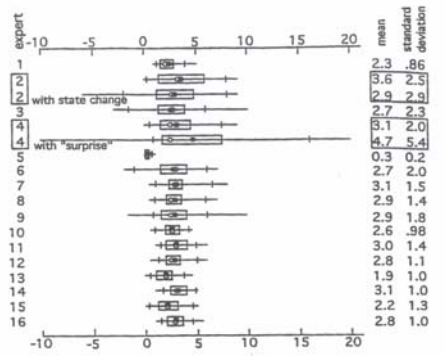
Annex 6: Presentation by Professor Mike Hulme on climate skeptics' arguments explained and countered



New European Evidence, Luterbacher et al., Science 2004



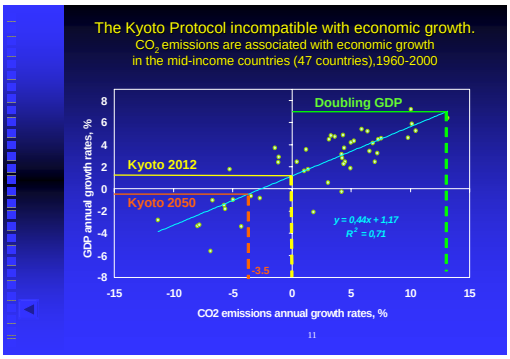
Source: James Clark, Wheaton College, USA



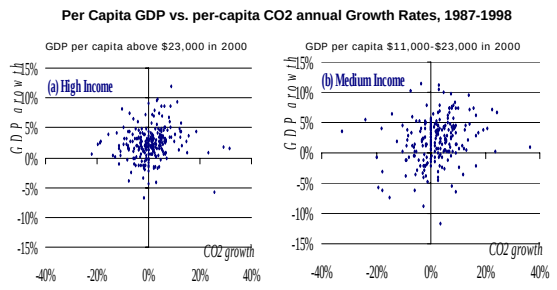
Expert elicitation of the climate sensitivity; Morgan and Keith 1995 … … which one is the sceptic?

Three criticisms of climate change social science and economics

- **"The costs of implementing the Kyoto Protocol vastly outweigh the resultant benefits" – e.g. Morris, Lomborg, Illiaranov**
- **"Enhancing adaptation to climate variability, however caused, is really what matters" – e.g. Stott/Lomborg**
- **"No-one can define what is 'dangerous climate change' so mitigation efforts are ill-founded" – e.g. Bush, Russian Academy**



Relationship between emissions and GDP growth – disappears for medium and high-income when measured per-capita



Sources: CO2 emissions, CDIAC; GDP, World Bank (Purchasing Power-corrected)

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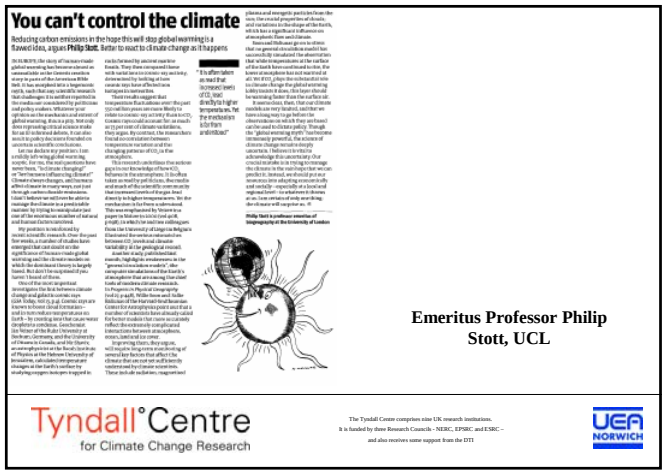
You can't control the climate

Reducing carbon emissions in the hope this will stop global warming is a flawed idea, argues Philip Stott. Better to react to climate change as it happens

Emeritus Professor Philip Stott, UCL

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Criticisms of the IPCC Process

- **"Forces consensus, whereas science is not a consensual activity" – e.g. Reiter, Lindzen**
- **"Fails to identify and use the best experts" – e.g. Reiter, Mörner**
- **"Is a government-led and government-constrained exercise and therefore is not independent" – e.g. Boehmer-Christiansen, Singer**

Question … ***"How valid are these criticisms? Do they matter?"***

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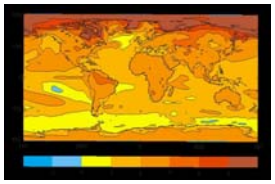
Conclusion?

What then is the role of science in public policy? Have we over-sold science to our politicians and our public? Are these arguments really about science or about values and worldviews? Have we blurred the boundaries?

"[Neither politicians nor scientists] want to give up on the pretense that these controversies are about science. To do so would be to abandon the high ground created when one can claim to have 'the facts' on one's side. The resulting charade, where everyone pretends that science can save us from politics, undermines science by turning it into nothing more than ammunition for opposing ideologies. Even more dangerously, it damages democracy by concealing what is really at stake—our values and our interests—behind a veil of technical language and competing expertise."
[D.Sarewitz, Hiding behind science, May 2004]

Annex 7: Presentation by Professor Andrew Watkinson on the likely flood risk and coastal erosion threats

Climate change

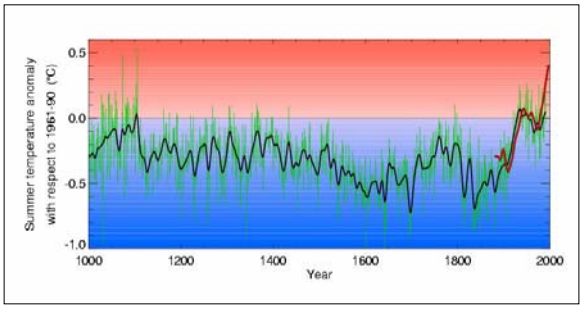


Andrew Watkinson
University of East Anglia
Tyndall Centre
for Climate Change Research

Climate change

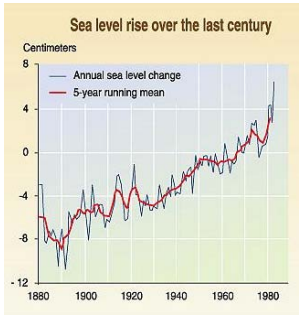
- **The climate of the world is changing**
- **We can already see significant impacts of climate variability**
- **There is an intimate coupling between non-climate and climate futures**
- **Future climate will be different from our historic statistics**

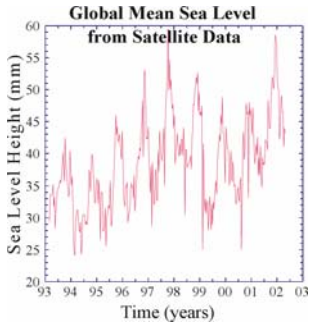
Northern Hemisphere temperature since 1000 AD



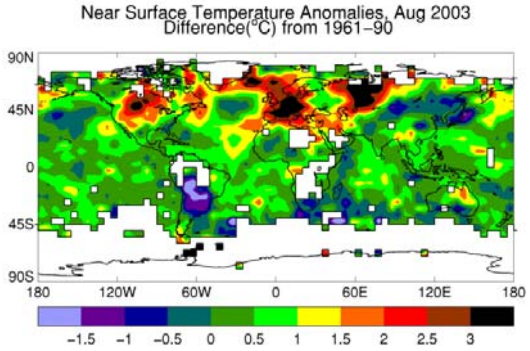
Increasing *sea levels*

1-2 mm per year



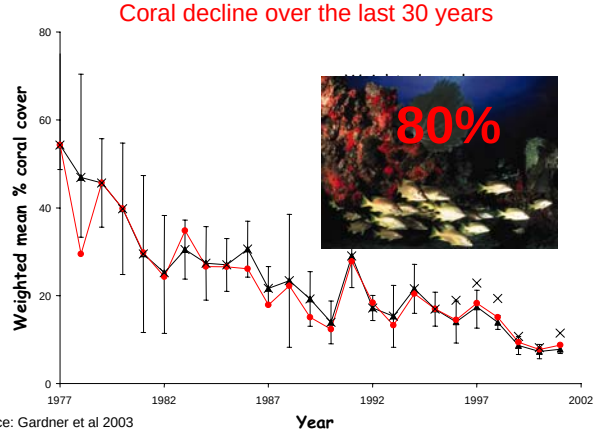


Extreme events



How vulnerable are coastal ecosystems to global climate change?

Coral decline over the last 30 years

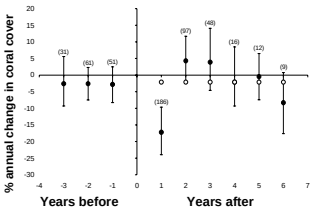


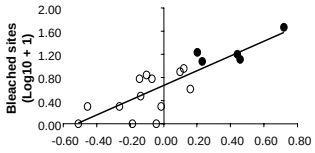
Source: Gardner et al 2003

Annex 7: Presentation by Professor Andrew Watkinson on the likely flood risk and coastal erosion threats

How vulnerable are coastal ecosystems to global climate change?

Responses to hurricanes and temperature



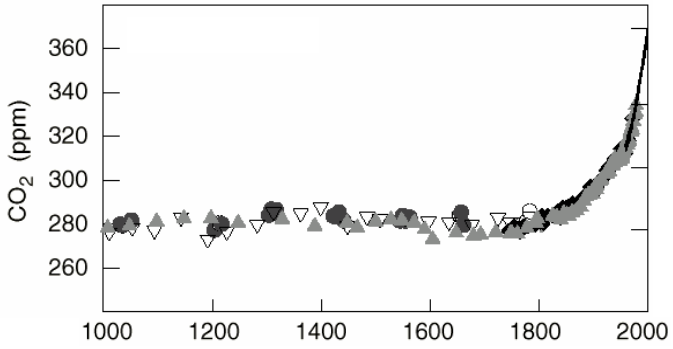


Source: Gardner et al 2005

Source: McWilliams et al 2005

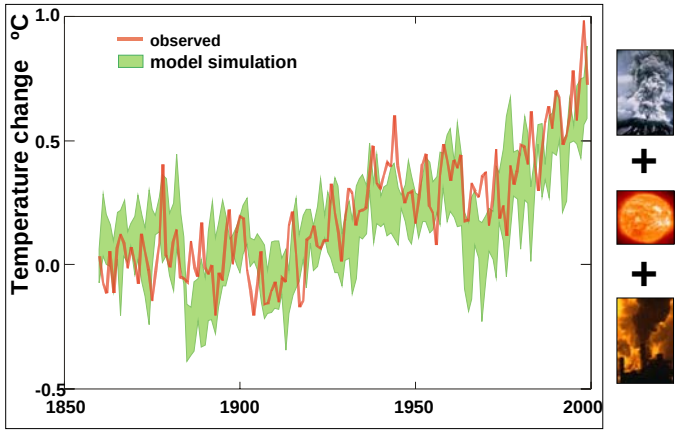
Carbon dioxide in the atmosphere

has risen by over 30% due to human activities

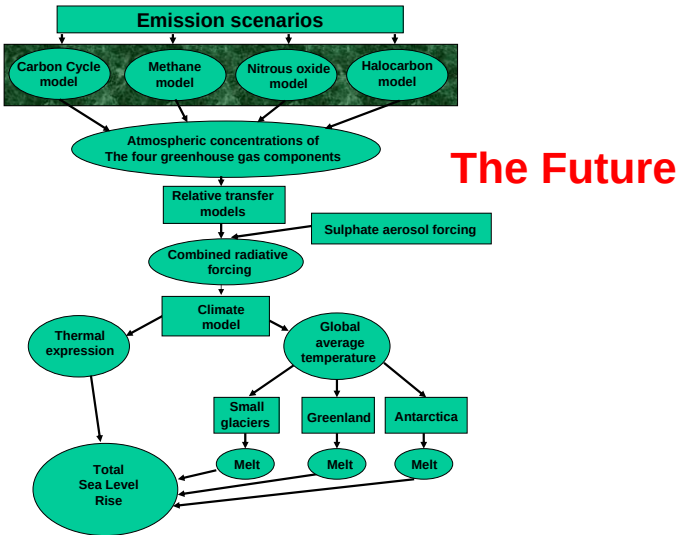


Source: Hadley Centre

OBSERVED AND SIMULATED CHANGE natural & man-made factors



Source: Hadley Centre

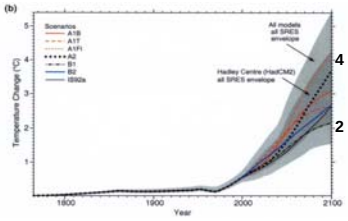


The Future

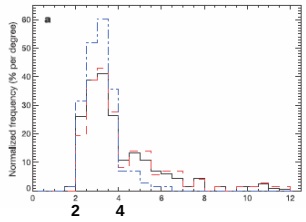
Climate change:

temperature

IPCC 2001

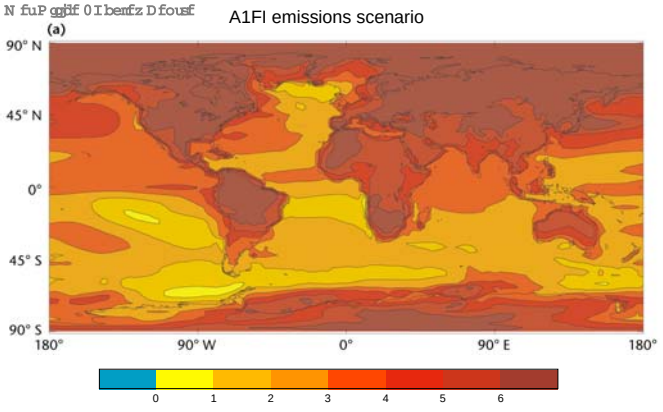


Stainforth et al 2005



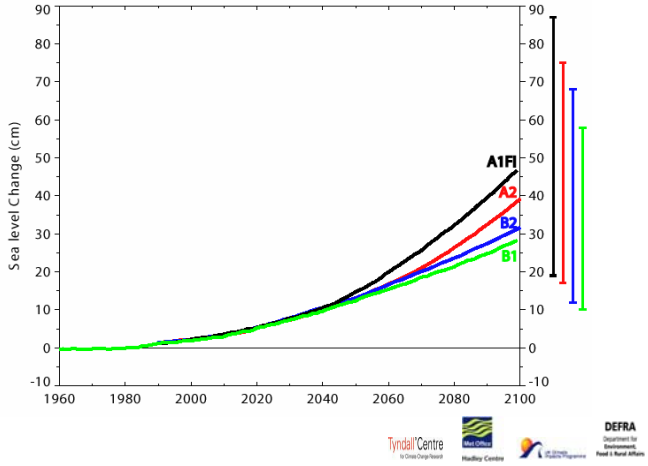
PATTERN OF ANNUAL TEMPERATURE CHANGES 2080s relative to present day

A1FI emissions scenario

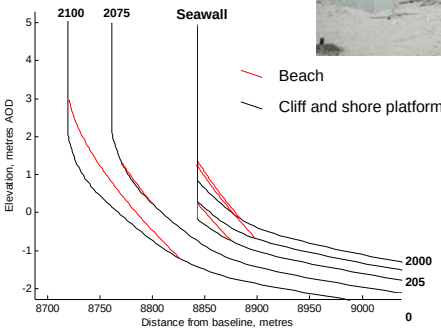


Annex 7: Presentation by Professor Andrew Watkinson on the likely flood risk and coastal erosion threats

Sea level change: Four IPCC scenarios

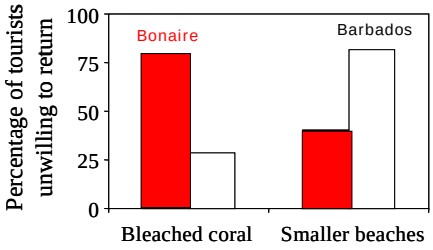


Holding back the sea



Source: Mike Walkden

Tourism and climate change



- Climate change can have an economic impact on Caribbean tourism through alteration of environmental features important in destination selection.
- It is possible to mitigate the impacts of climate change by focusing management efforts on features important to tourism.

Source: M. Uyarra et al 2005

Annex 8: Keynote presentation by Dr Trotz on the vulnerability of small islands in the Caribbean to climate change

Vulnerability of Caribbean Islands to Climate Change

Ulric O'D Trotz, Ph.D
Project Manager
Mainstreaming Adaptation to Climate Change (MACC) Project

What is "vulnerability"?

- The degree to which a system is susceptible to, or unable to cope with, adverse effects of *climate change*, including *climate variability* and *extremes*.
- It is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its *sensitivity*, and its *adaptive capacity* (IPCC TAR, 2001).

Vulnerability of SIDS

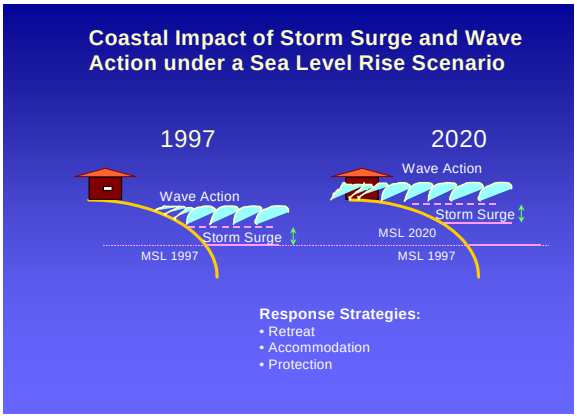
- Small size
- Narrow economic base and sensitivity to external market forces
- Limited natural resource base
- Limited human capacity
- High population densities in low-lying coastal areas

Climate change issues

- Sea level rise
- Changes in:
  - precipitation patterns
  - air temperatures
  - sea surface temperatures
  - incidences of extreme events
  - intensity and (frequency ??) of hurricanes

Consequences of sea level rise

- Coastal inundation
- Soil& aquifer salinization
- Degradation of coastal ecosystems – mangroves, reefs
- Beach erosion
- Storm surge exacerbation



Annex 8: Keynote presentation by Dr Trotz on the vulnerability of small islands in the Caribbean to climate change

Consequences of changing precipitation patterns

- Agriculture
- Health
- Water
- Recreation
- Disasters

Consequences of increased air temperatures

- Health (heat stress, vector-borne diseases – dengue, malaria)
- Agriculture
- Tourism

Consequences of increased sea surface temperatures

- Reefs
- Fisheries
- Hurricane intensity

Chart showing relationship between wind speed and costs of damage.

Storm	Class	Year	Estimated 1990 Insured Losses (000's)	Estimated 1990 Insured Losses if Maximum Wind Speed Increases by		
				5%	10%	15%
Hugo	4	1989	$3,658,887	$4,902,705 34%	$6,514,172 78%	$8,542,428 133%
Alicia	3	1983	$2,435,589	$3,382,775 39%	$4,312,884 77%	$5,685,853 133%
Camille	5	1969	$3,086,201	$4,120,733 34%	$5,438,332 76%	$7,095,008 130%
Source: Clark, 1997.						

Consequences of increased incidence of extreme events

- Loss of life
- Loss of livelihood
- Destruction of infrastructure
- Disruption of development plans
- Socio-economic impacts - tourism, services

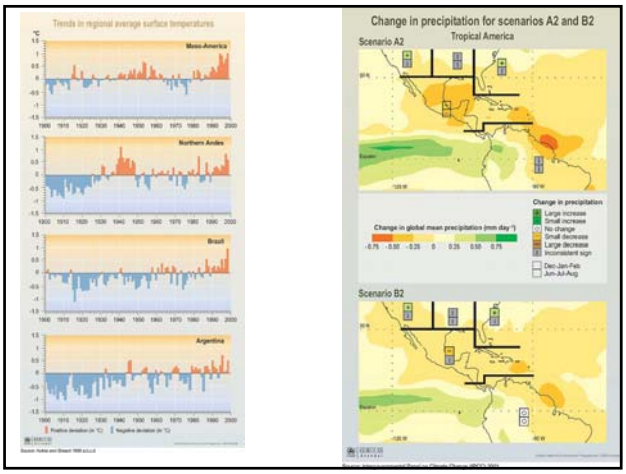
Annex 9: Presentation by Professor Mike Hulme on the likely impacts of climate change on small Caribbean islands

Some impacts of climate change on small Caribbean islands

Professor Mike Hulme

Tyndall Centre for Climate Change Research

Cayman Islands, 2-3 June 2005



Changing climate risks and the Cayman Islands

- More extreme temperatures
- Heavier rainfall
- Rising sea-level
- Warmer and more acidic ocean waters
- More intense hurricanes

Planning for the future is not like planning in the past

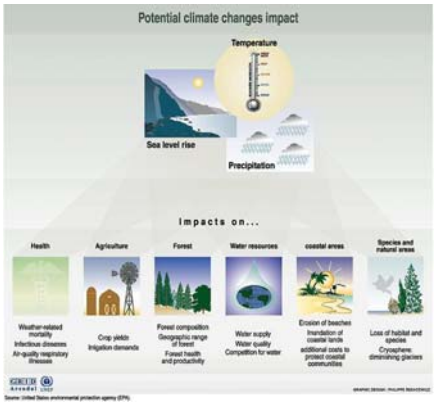
Potential impacts on atoll countries

Land loss due to sea-level rise
Shifts in species competition and composition
Negative effects on reef fish populations
Salinisation of coastal soils and water lenses
Larger storm waves and more intense flooding
Decline in food security – crops, fish
Adverse effects on tourism – quality, safety
Infrastructure damage – economic impacts
Greater human health risks – vector-borne disease

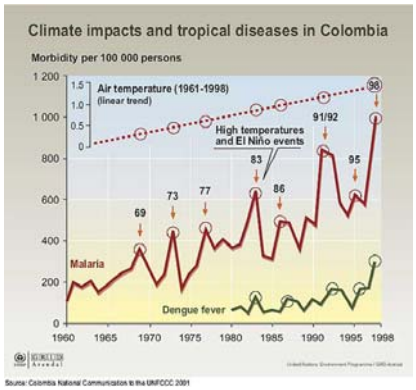
Source: Nurse and Sem, IPCC, 2001

Potentially vulnerable sectors for small islands

Fisheries
Tourism
Health
Infrastructure
Insurance
Migration and remittances
Water



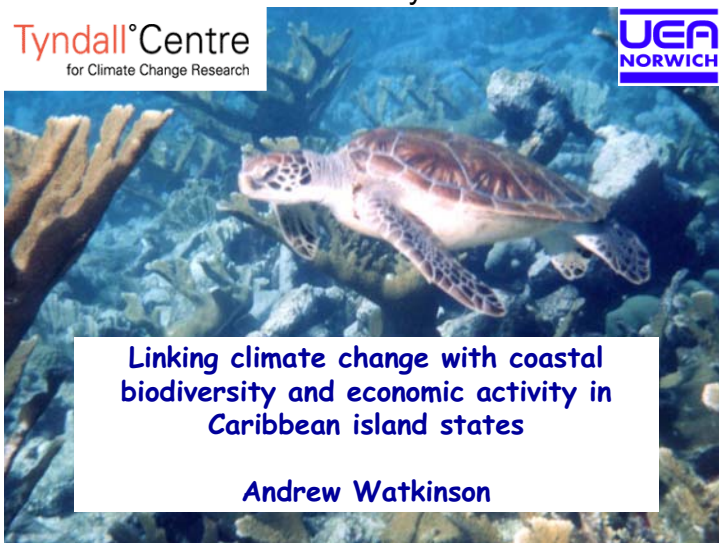
Annex 9: Presentation by Professor Mike Hulme on the likely impacts of climate change on small Caribbean islands



Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

Tyndall Centre for Climate Change Research

UEA NORWICH

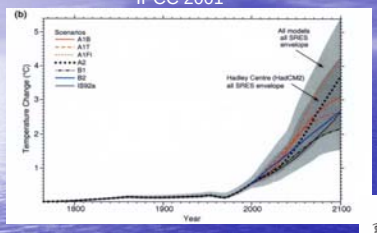


Linking climate change with coastal biodiversity and economic activity in Caribbean island states

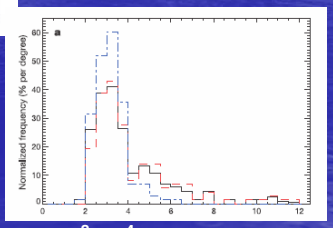
Andrew Watkinson

Climate change

IPCC 2001



Stainforth et al 2005



2 4

Sea level rise and coastal biodiversity

Hurricanes and coral reefs

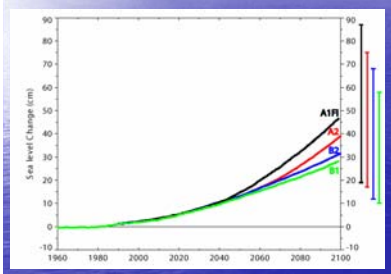
Temperature and coral bleaching

Climate change and Caribbean tourism

Sea-level rise and coastal biodiversity

Marianne Fish et al. - Conservation Biology 2005

Sea-level rise



- Small island states particularly vulnerable
- SLR likely to contribute to coastal habitat loss

Loggerhead (*Caretta caretta*)

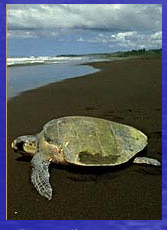
Green (*Chelonia mydas*)

Hawksbill (*Eretmochelys imbricata*)

Turtles of the Caribbean

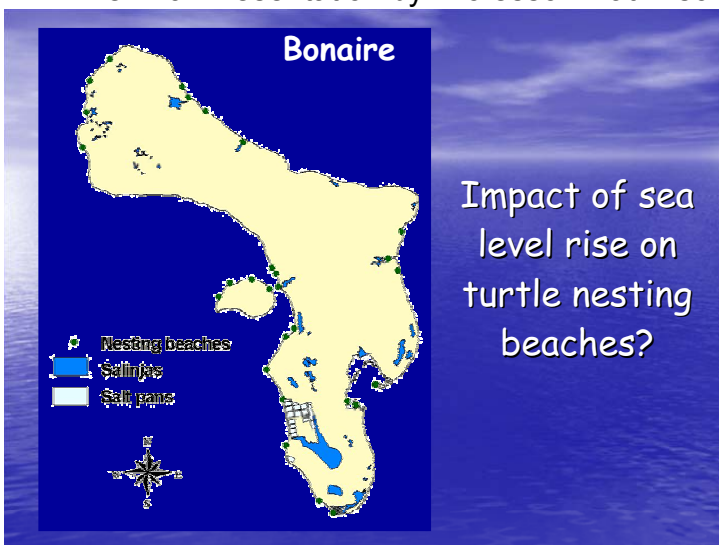
Leatherback (*Dermochelys coriacea*)

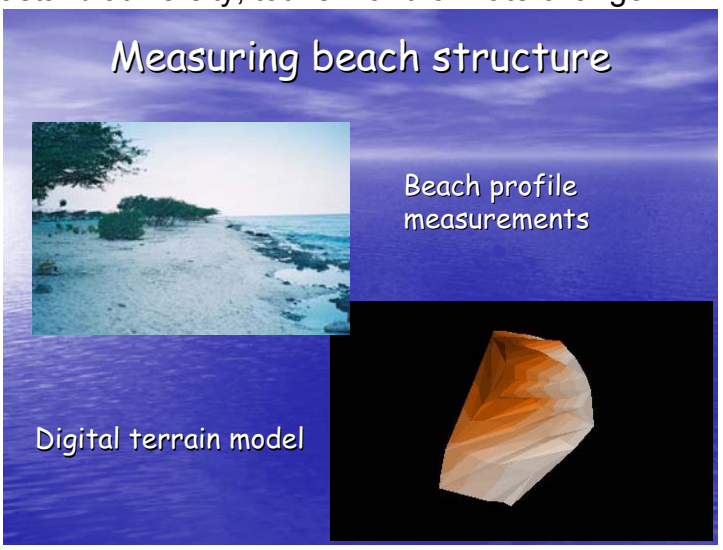
Kemp's Ridley (*Lepidpchelys kempii*)

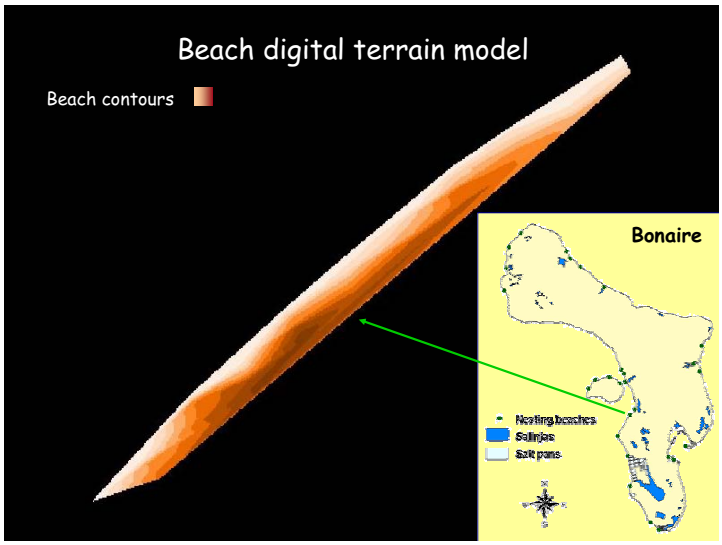


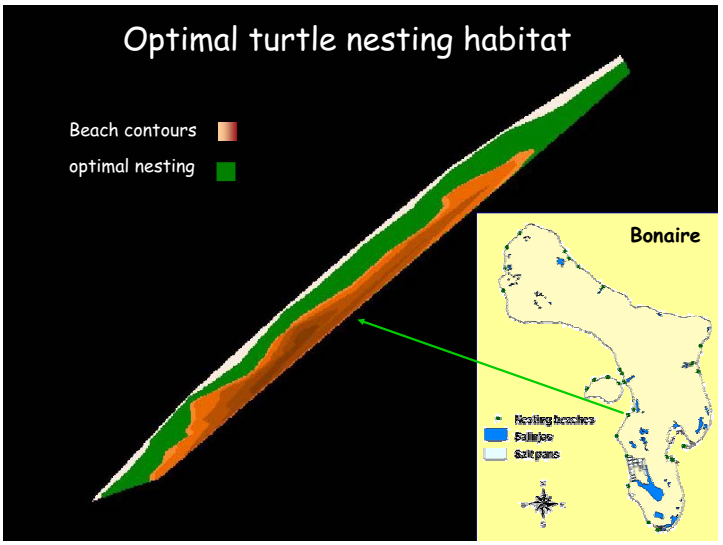
Olive Ridley (*Lepidochelys olivacea*)

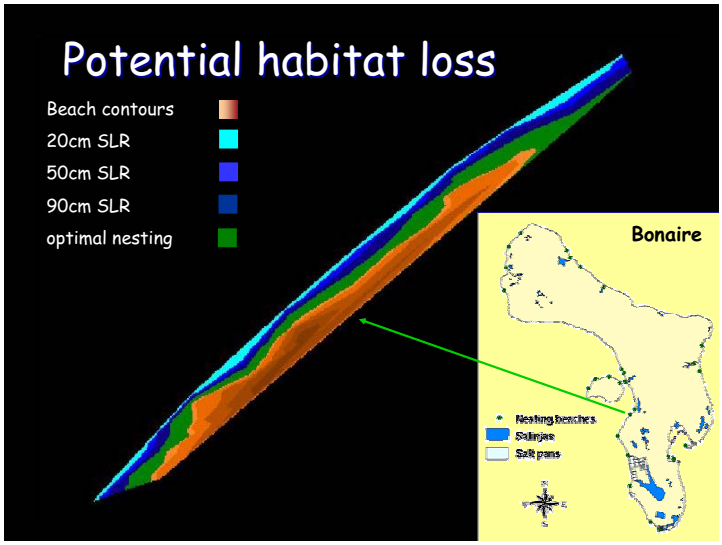
Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

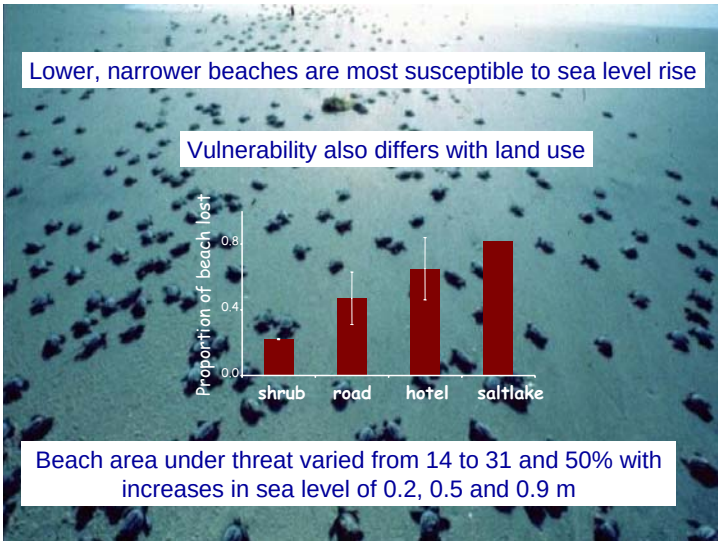












Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

In summary ……

Turtle nesting habitat is already seriously threatened by development and sea-level rise is likely to exacerbate these problems

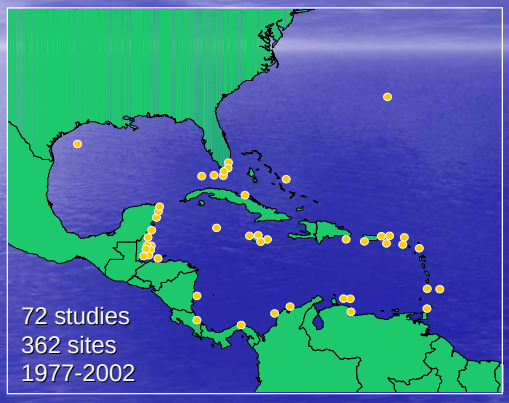
Potential for beaches to migrate inland is critical – this depends on levels of development

To retain beaches in the face of sea level rise buffer areas around them must be large enough to take long term physical changes into account and there must be adequate set-back regulations

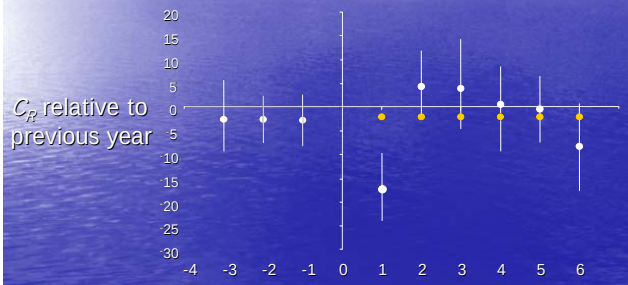
Hurricanes and Caribbean coral reefs

Toby Gardner et al.
Science 2003
Ecology 2005

Distribution of study sites

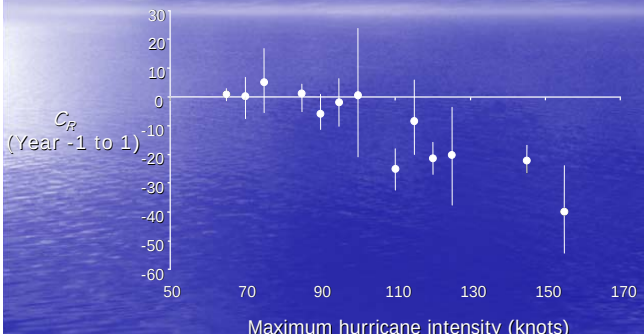


Temporal pattern of coral cover before and after a hurricane



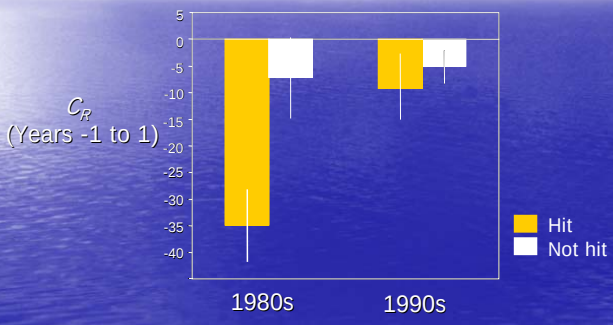
Gardner et al 2005 Ecology

Correlate of immediate loss: hurricane intensity



Gardner et al 2005 Ecology

Effect of hurricanes on rate of coral decline: first year



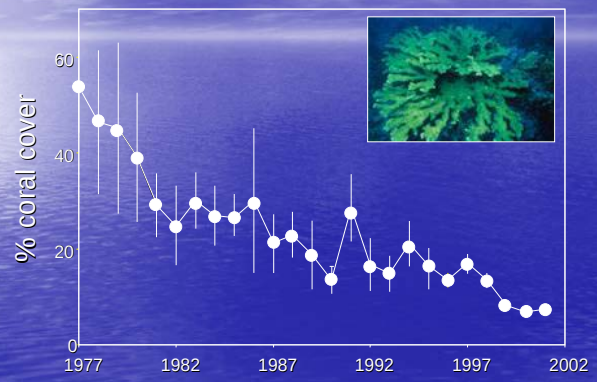
Gardner et al 2005 Ecology

Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

In summary…

- Large immediate impact
- No signs of recovery
- Decadal differences: important in 1980s, not as important in 1990s
- Now for a slight digression

Temporal trend in coral cover

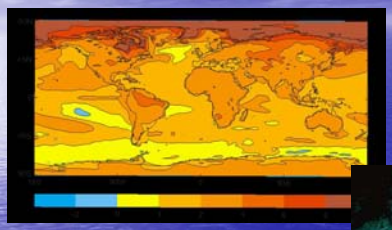


Gardner et al. *Science* 2003

An average Caribbean reef

	1977	2001
Live coral	54%	13%
Macroalgae	3%	15%
Bare space	8%	36%
Turf algae	10%	32%
Soft coral	6%	5%
Sponge	7%	5%

Temperature and coral bleaching



John McWilliams et al

Ecology 2005

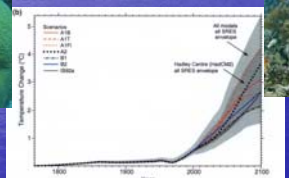
Dinoflagellate algae

'Zooxanthellae'

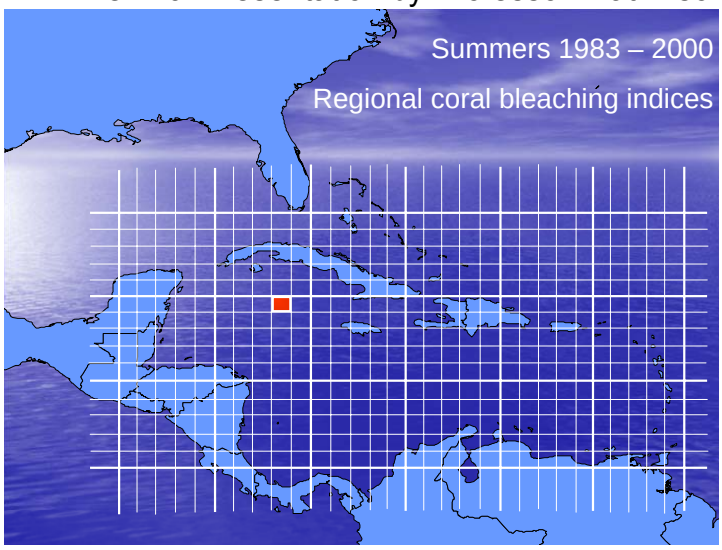
Provide nutrition to coral host via photosynthesis

Coral colony

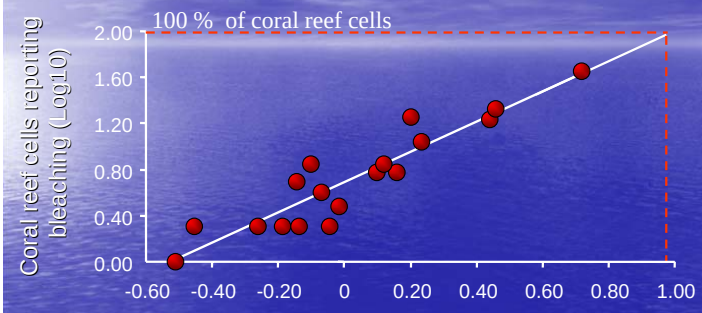
What impact will increasing temperatures have on corals?



Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

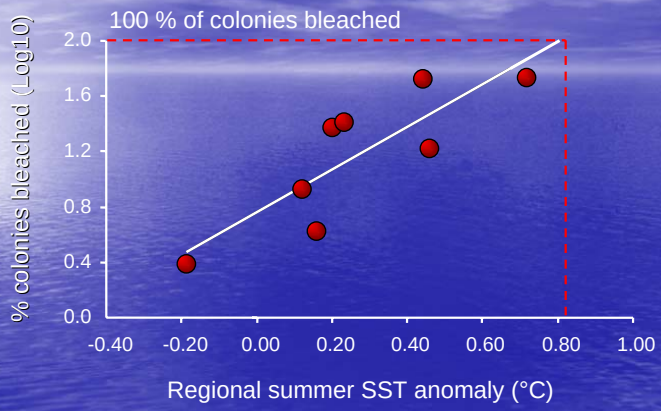


Geographic extent of coral bleaching 1983 - 2000



McWilliams et al 2005 Ecology

Intensity of coral bleaching



McWilliams et al 2005 Ecology

In summary .....

Increases in regional SST of 0.1°C will result in:

- 35% increase in the geographical extent of bleaching (e.g. 10 → 14 cells)
- 42% increase in the intensity of bleaching (e.g. 10% → 14% of coral colonies affected)

Future predictions

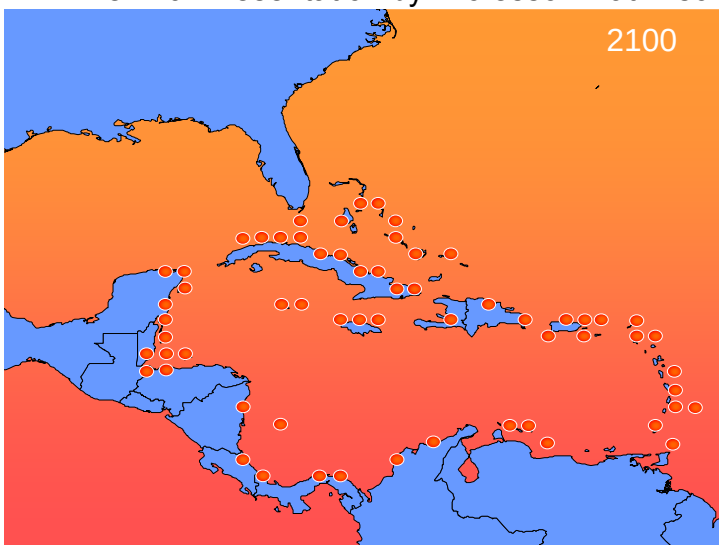
- Regional temperatures of +1°C relative to 1961-90 mean expected to cause coral bleaching across entire Caribbean (i.e. all 92 cells and average 100% of colonies affected at any site)
- Will we get to a point when temperatures of +1°C become the norm?
- Minimum increase in SST of +1°C expected by the end of the 21st century (IPCC)

Can corals adapt to warming?

- Some corals have survived mass extinctions brought on by natural climatic variability in the past (e.g. 75,000 years ago)
- Corals can acquire more heat-tolerant strains of zooxanthellae, but…

- Increasing incidence of coral bleaching suggests that rate of increase in thermal stress currently is greater than the rate of adaptation

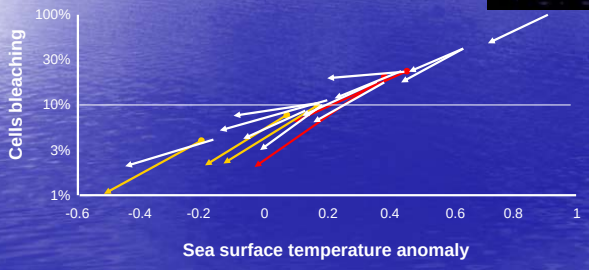
Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change



Consequences of chronic bleaching

- Minimises recovery time between successive bleaching events
- Building of reef framework slows down
- Erosion of framework will probably outpace replenishment

Why has there been less bleaching in the Caribbean than in the Pacific?



Evaluation of the potential economic impacts of climate change on Caribbean tourism industries

Maria Calvo Uyarra et al

Climate change issues addressed

Coral bleaching
- related to sea temperature and El Niño

Altered beach structure
- sea level rise

Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

Tourist questionnaires

Marine features
Coral diversity
Coral cover
Coral health
Fish diversity
Amount of fish
Presence of sea turtles

Terrestrial features
Beach size
Sand quality
Low no. of tourists
Landscape
Bird diversity

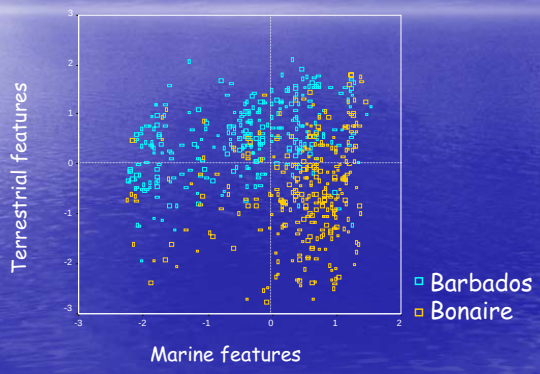
Sea & Air conditions
Air temperature
Water clarity

Health conditions
Low probability of disease
Absence of malaria
No vaccinations required

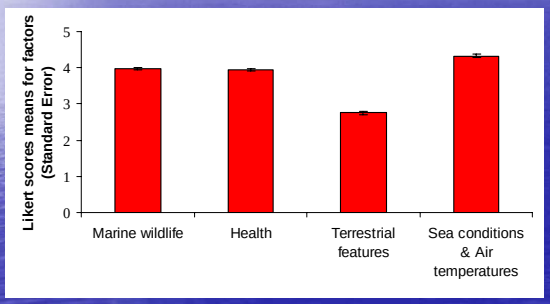
Why go to the Caribbean?

- Warm temperatures, clear waters and low health risks were the most important environmental features determining the selection of Bonaire and Barbados as holiday destinations
- But why go to Barbados as opposed to Bonaire?

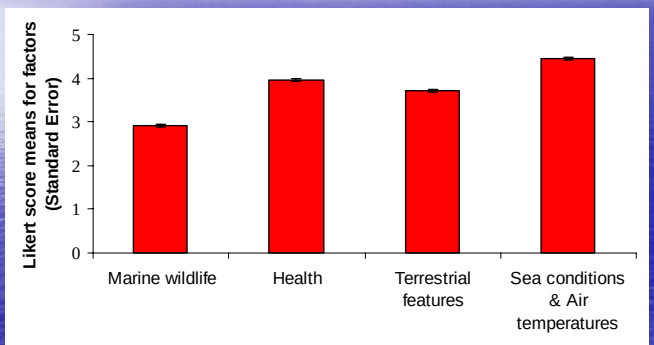
Comparison of tourist responses



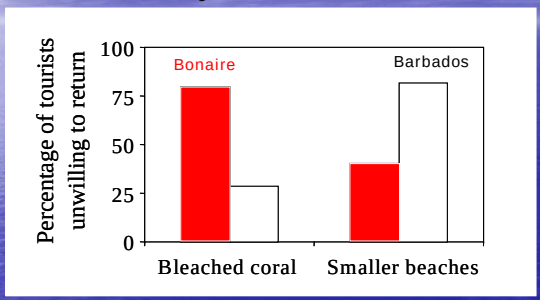
Bonaire respondents



Barbados respondents



What would make the tourists less likely to return?



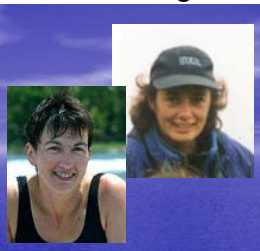
- Climate change can have an economic impact on Caribbean tourism through alteration of environmental features important in destination selection.
- It is possible to mitigate the impacts of climate change by focusing management efforts on features important to tourism.

Annex 10: Presentation by Professor Watkinson on coastal biodiversity, tourism and climate change

Conclusions

- Climate change will impact on both coastal biodiversity and economic activity in the coastal zone
- Sea level rise will reduce turtle nesting if development is not controlled
- Hurricanes on average produce a 17% decline in coral cover in the year following the hurricane
- A 1°C rise in sea surface temperatures has the potential to produce intense bleaching across all sites
- Economic activity is dependent upon ecosystem health in the coastal zone

Thanks



- Isabelle Côté, Jenny Gill
- Toby Gardner, Marianne Fish, John McWilliams, Maria Uyarra
- The many people who have worked in the Caribbean and contributed data

Annex 11: Keynote presentation by Dr Trotz on Adapatation in practice - learning lessons from other Caribbean islands

Adaptation in practice: learning lessons from other Caribbean Islands

Ulric O'D Trotz, Ph.D
Project Manager
Mainstreaming Adaptation to Climate Change (MACC) Project

What is adaptation?

- An adjustment in natural or human systems to a new or changing environment.
- Adaptation to climate change refers to adjustment in natural or human systems in response to expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC TAR, 2001).

Traditional approach to adaptation

- Vulnerability assessments
- Definition of climate change hazard (monitoring, climate models)
- Assessment of climate risks and impacts on key sectors
- Developing adaptation responses

However, problems with application of traditional approach to the Caribbean region

- coastal vulnerability studies hampered by lack of baseline data
  - Near shore bathymetry
  - Coastal morphology
  - Contour maps below 25 ft. contour
  - Geo-referenced cadastral information
  - GIS base maps and remote sensing
  - Coastal data sets
  - Sectoral data sets (water, agriculture)

Also…

- Uncertainty of the definition of climate change hazard
  - What is extent of climate change risk the region will face in the future?
  - What climatic change are we talking about:
    - 1 or 2 degree temperature rise by 2030
    - 1 cm. sea level rise by 2030

Hence the need for region-specific climate change projections

- Work on regional climate models now in it's infancy
- Hadley Centre PRECIS model - 25 km and 50 km resolution
- Japanese Earth Simulator model - 20 km resolution

Annex 11: Keynote presentation by Dr Trotz on Adapatation in practice - learning lessons from other Caribbean islands

Caribbean approach

- Involves multidisciplinary/ multi-stakeholder national consultations to define:
  - critical sectors / systems / communities / livelihoods at risk from climate change;
  - adaptation options ("no-regrets") available to ameliorate impacts of those risks; and
  - a plan for the implementation of those options.
- Seek political endorsement for the adaptation policy and implementation plan which is the final output of this exercise

Outcomes from Caribbean approach

- 11CARICOM countries have drafted or finalised climate change adaptation policies and implementation plans
- St. Lucia and Dominica have received cabinet approval.
- Extensive public awareness at all levels

More specifically, the process led to to the identification of "no regrets" adaptation options

- Water Sector
  - Inventorising water resources
  - IWRM
  - Water harvesting
  - Demand and supply side management
  - Aquifer recharge
  - Watershed management

"No regrets" adaptation options

- Agriculture
  - Short term forecasts / early warning systems
  - Use of traditional knowledge
  - Salt tolerant varieties
  - Drip irrigation
  - Niche marketing

"No regrets" adaptation options

- Human Settlements
  - Hazard mapping (floods , landslides, storm surges)
  - Land-use planning
  - Building Codes
  - Insurance
  - Setbacks

Lessons learnt

- Climate change issues cannot stand on their own. They need to be integrated into national development plans.
  - This is referred to as "climate proofing" NDP's or " mainstreaming" climate issues in NDP's (MACC)
  - "No regrets" options also contribute to country's sustainable development agenda and as such, may be more accepted by policymakers
  - Another opportunity for the promotion of National Climate Change Adaptation is in "DISASTER MITIGATION"

Annex 11: Keynote presentation by Dr Trotz on Adapatation in practice - learning lessons from other Caribbean islands

Climate Change and Disaster Mitigation

- Paradigm shift in region from disaster response to disaster mitigation
- Opportunity for collaboration e.g developing common tools—hazard maps, early warning systems, vulnerability assessments.
- Consideration of climate change issues in both disaster mitigation and response.

Climate Change and Disaster Mitigation in the Caribbean

- Under the ACCC project a set of guidelines for incorporating climate change into natural hazard impact assessment was completed in collaboration with the CDB
- MACC working with CDERA in the following areas:
  - Developing common tools for vulnerability assessment
  - CUBiC revision
  - Sensitising disaster managers to climate change issues.

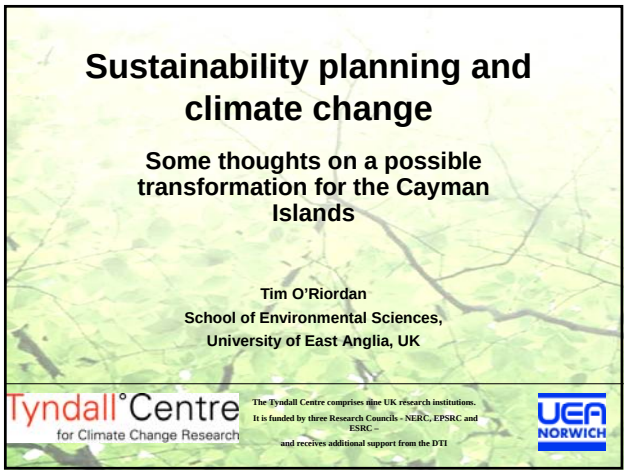
Public Education and Outreach (PEO)

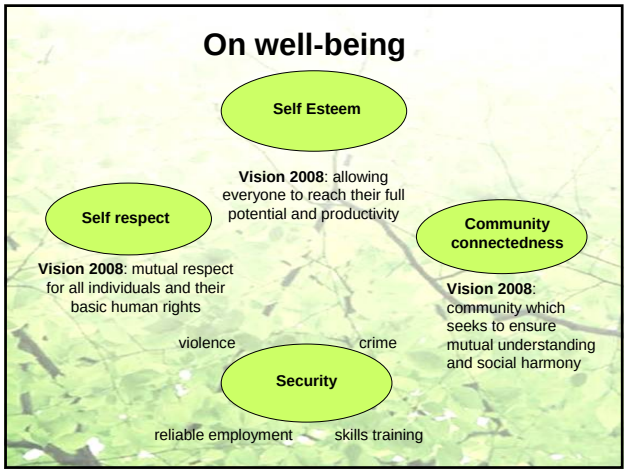
- Of critical importance to all climate change work in the region
- Under the ACCC project Regional PEO strategy developed. Elements of strategy will be implemented under the MACC project.

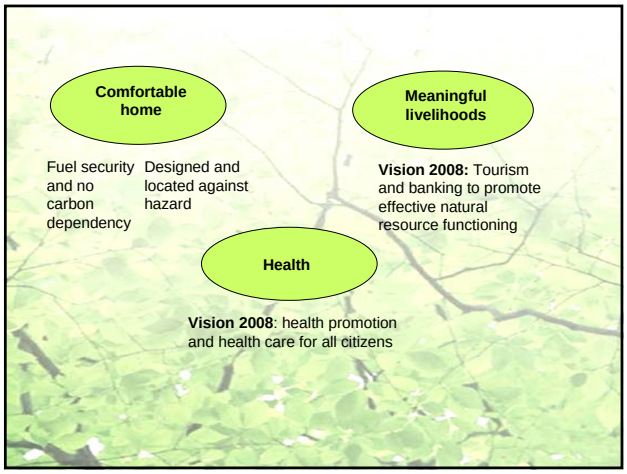
Regional PEO strategy

- Has been endorsed by CARICOM Ministers
- Identifies key target publics to be engaged
- Developed a toolkit on climate change for use in the region
- Identifies the need for it to be customized to suit individual countries.

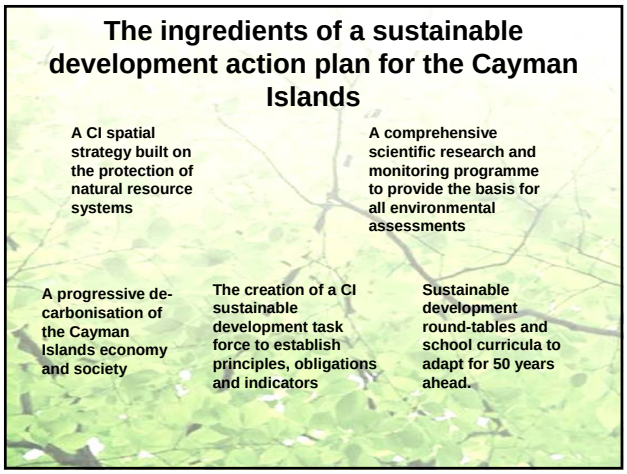
Annex 12: Keynote presentation by Professor Tim O'Riordan on sustainability planning in small islands







Annex 12: Keynote presentation by Professor Tim O'Riordan on sustainability planning in small islands



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