

Integrated Water Resources Management as a Tool for Adaptation to Climate Change in the Caribbean: Module 2 Drivers and Impacts of Climate Change



UNESCO-IHE
Institute for Water Education



Credits and Acknowledgements

- Slides are adapted from Cap-Net 2009 Training Slides unless otherwise stated. See <http://www.cap-net.org/training-material/iwrm-as-a-tool-for-adaptation-to-climate-change-english/>
- Unless otherwise stated, case studies and examples are provided from ***Cap-Net, WMO/APFM, UNESCO-IHE, REDICA and GWP-C. 2015. (Draft) IWRM as a Tool for Adaptation to Climate Change with Caribbean Case Studies. Training Manual and Facilitators Guide. Cap-Net.***
- This training package is produced by Global Water Partnership - Caribbean and CAPNET/Caribbean WaterNet with Funding from the GWP-C Water Climate and Development Programme (WACDEP)
- WACDEP is executed by GWP-C in Partnership with the Caribbean Community Climate Change Centre (CCCCC)

Goal and Objectives of the session

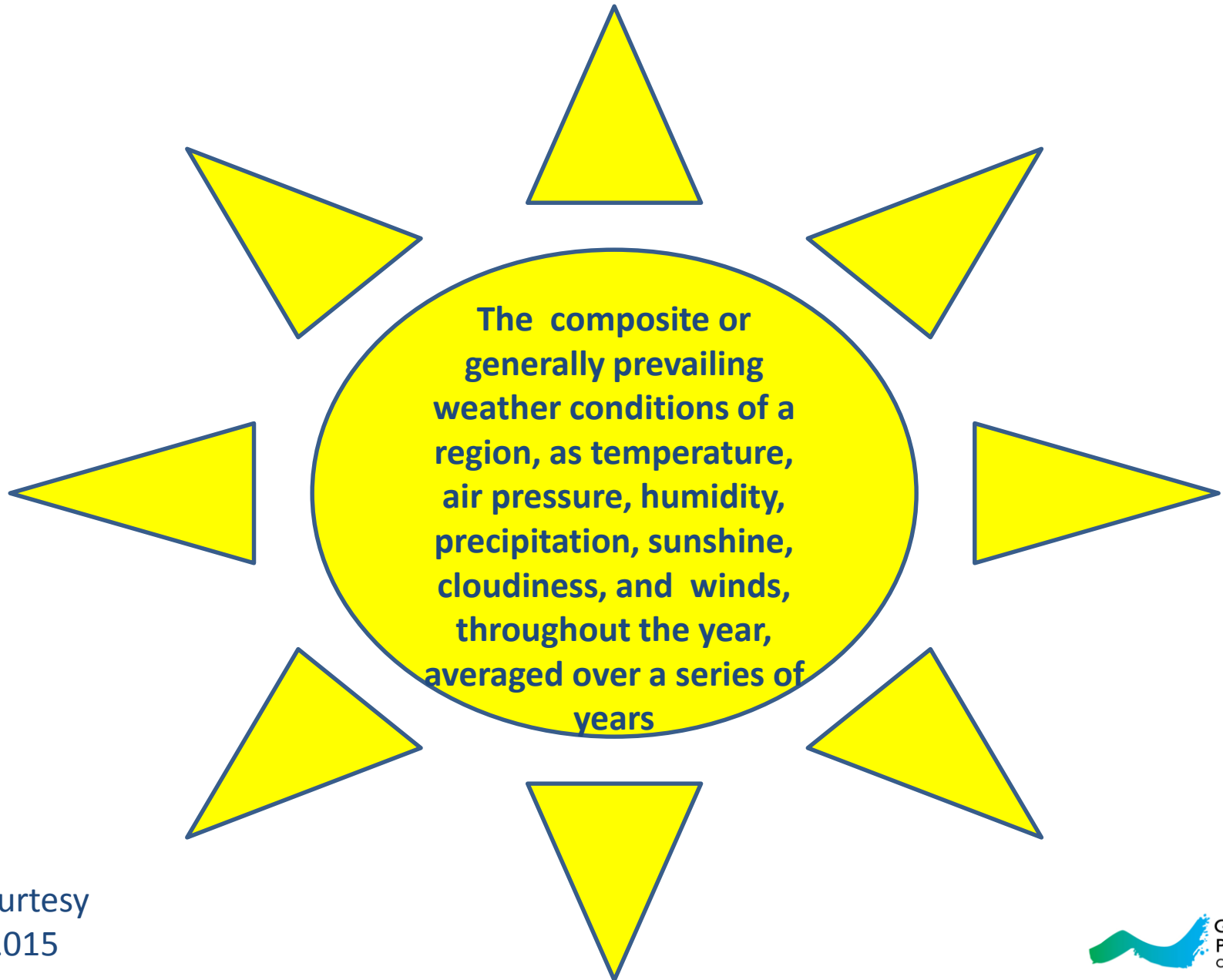
At the end of this session, participants will have a better understanding of :

- The drivers/physical science basis of climate change
- The general impacts of climate change
- The impacts of climate change in the Caribbean

What is Weather?

**The state of the atmosphere
with respect to wind,
temperature, cloudiness,
moisture, pressure, etc.**

What is Climate?



What is the difference between Climate and Weather?

Climate varies over **seasons and years**
unlike
weather which varies from **day-to-day**

What is Climate Change?



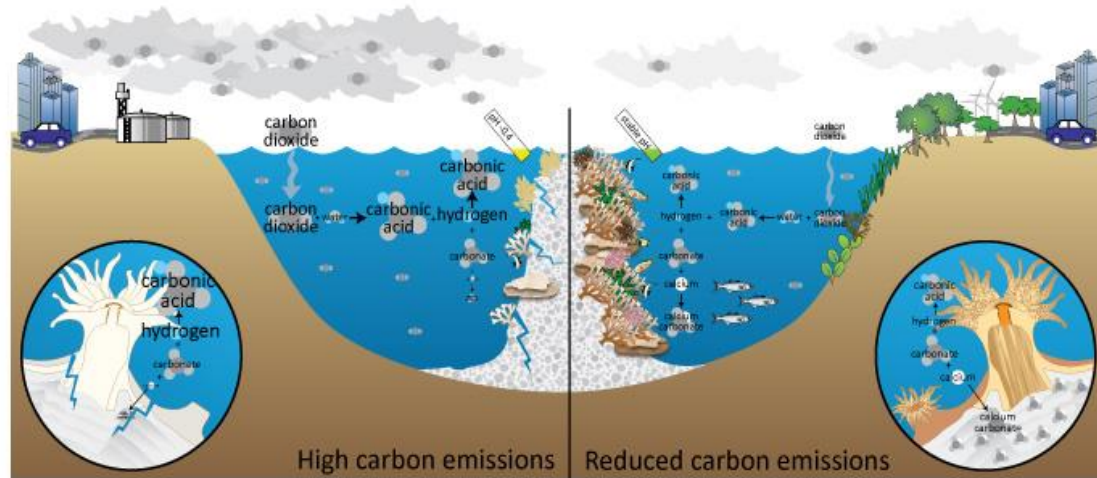
Global Warming

A Long
Term
continuous
change

Any change in
climate over time
whether due to
natural variability
or as a result of
human activity



Sea level rise



Ocean acidification

© Copyright, Great Barrier Reef Foundation, Australia, 2008

What is Climate Change?

Any change in climate over time whether due to natural variability or as a result of human activity

Natural Climate Change

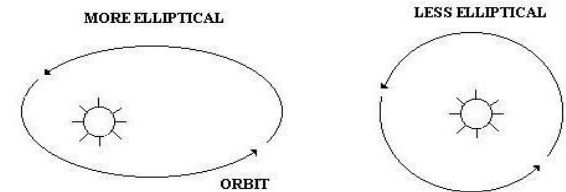
The Sun - Source of Heat Energy in Earth
 Atmosphere System – Solar Constant not
 Changing – Annual Solar Radiation Amount
 Entering Atmosphere Not Changing

Earth's 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 – Earth's Axis Wobbles like a Spinning Top – Points to Different Spots in Sky during Cycle of 23 - 26K years

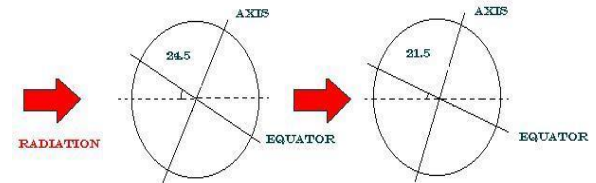
Chronology of Temp Change Established for 450K years through Oxygen Isotope Analysis & Statistical Analysis of Climate Sensitive Organisms show Good Correlation with above Three Processes

ECCENTRICITY



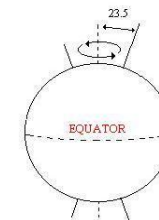
PERIODICITY:
100,000 YEARS

AXIAL TILT

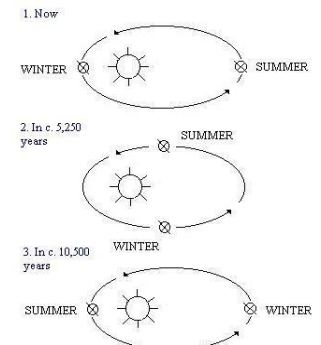


PERIODICITY:
41,000 YEARS

PRECESSION



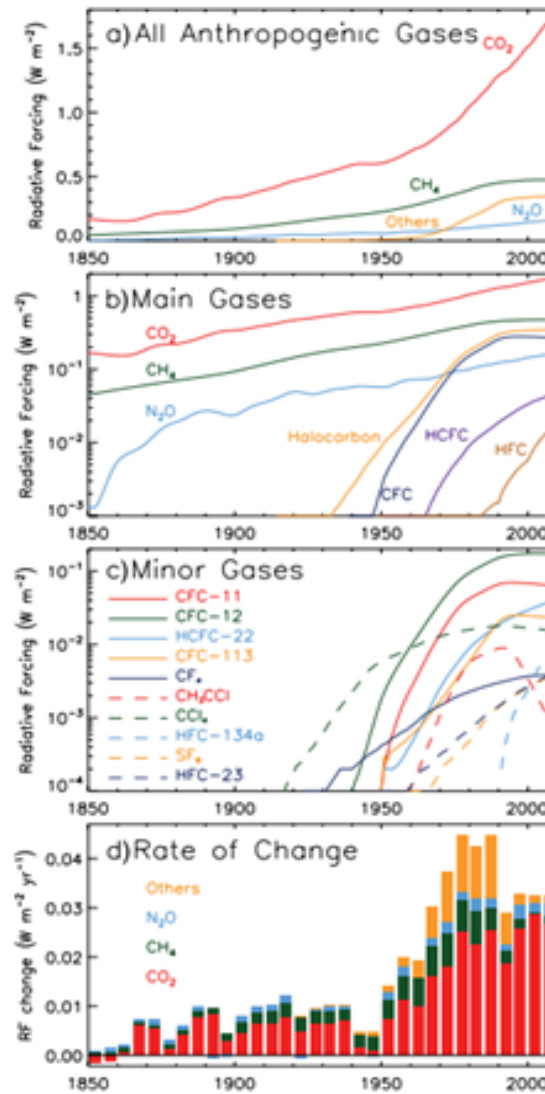
PERIODICITY:
C. 23,000 YEARS



Climate Change due to Human Activity

Radiative Forcing

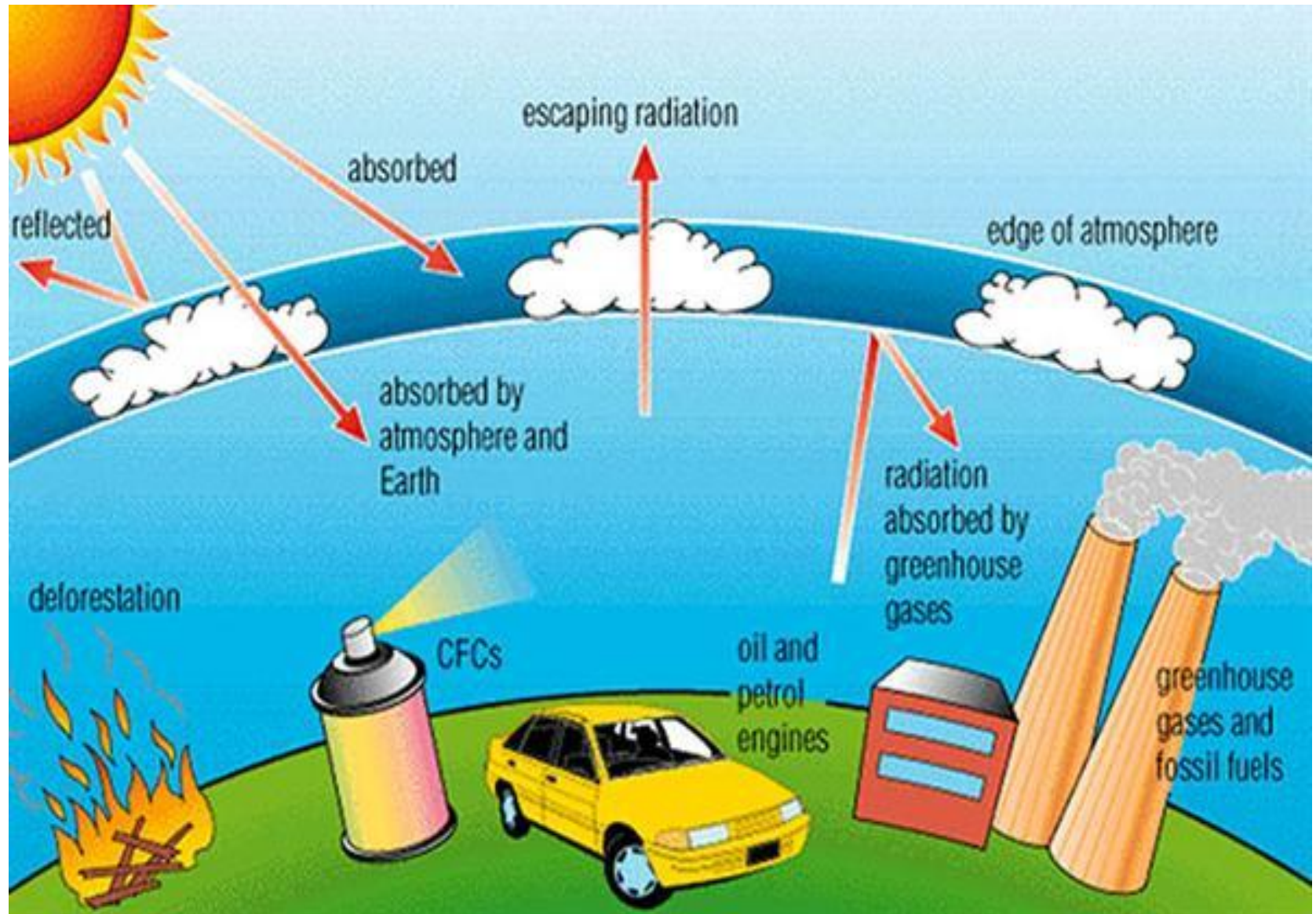
- There is a balance between incoming solar radiation and outgoing terrestrial radiation.
- Any process that alters the energy balance of the earth-atmosphere system is known as a radiative forcing mechanism.



Radiative Forcing due to concentrations of CO₂, CH₄ and N₂O from 1850-2011

(a) Radiative forcing (RF) from the major well-mixed greenhouse gases (WMGHGs) and groups of halocarbons from 1850 to (b) as (a) but with a logarithmic scale, (c) RF from the minor WMGHGs from 1850 to 2011 (logarithmic scale). (d) Rate of change in forcing from the major WMGHGs and groups of halocarbons from 1850 to 2011.

Radiative Forcing/Greenhouse Effect



Climate Scenarios, Pathways

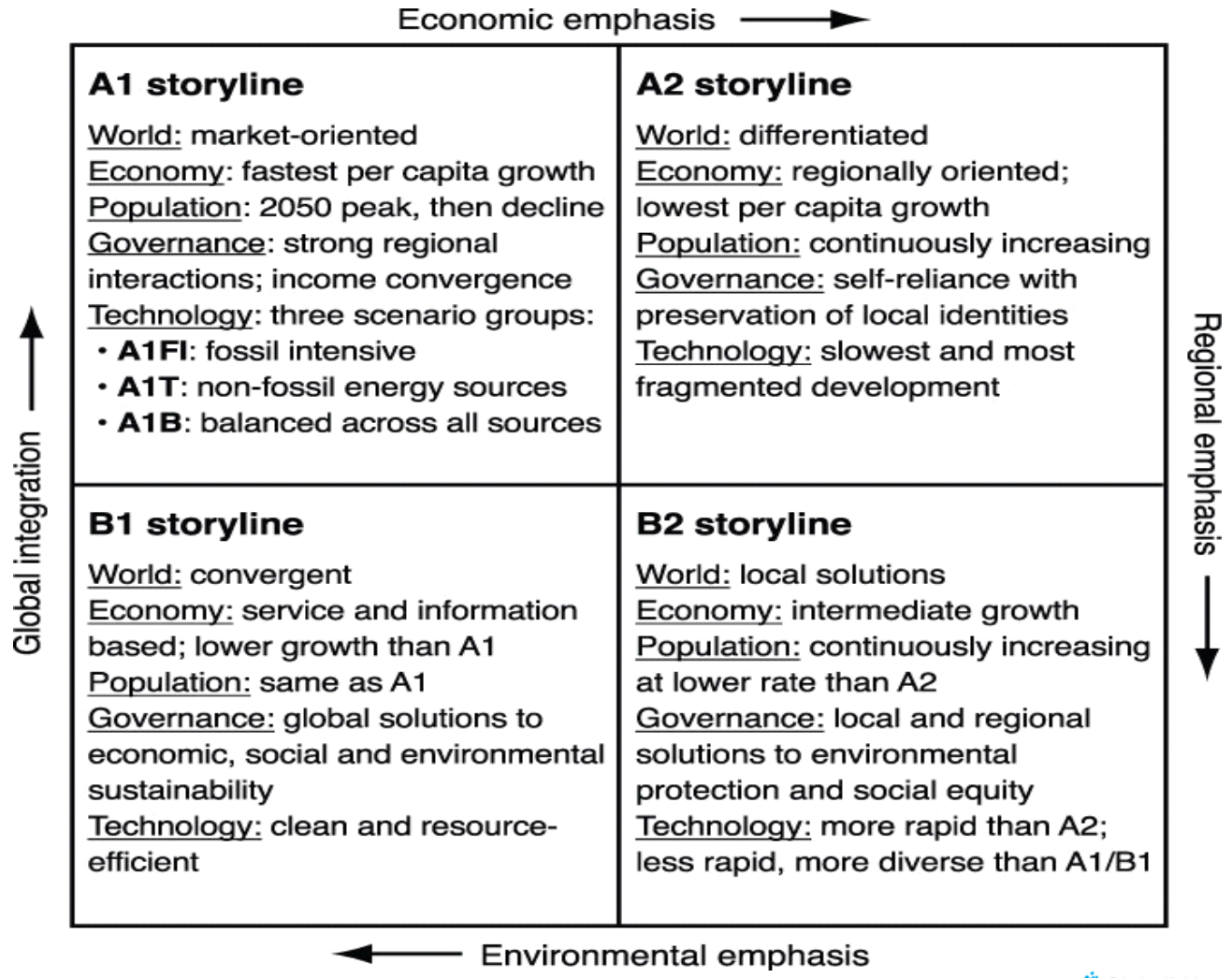
Definitions:

- **AR5**- Working Group 1 Fifth Assessment Report
- Representative Concentration Pathways (**RCPs**)- in AR5 an additional set of scenarios were developed and modelled to represent future emissions scenarios with a pathway or trajectory of GHG concentration over time. Four RCPs have been developed RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 (the numbers in each indicates the amount of radiative forcing produced by GHGs in 2100)
- **SRES**- Special Report on Emission Scenarios, a report by the IPCC

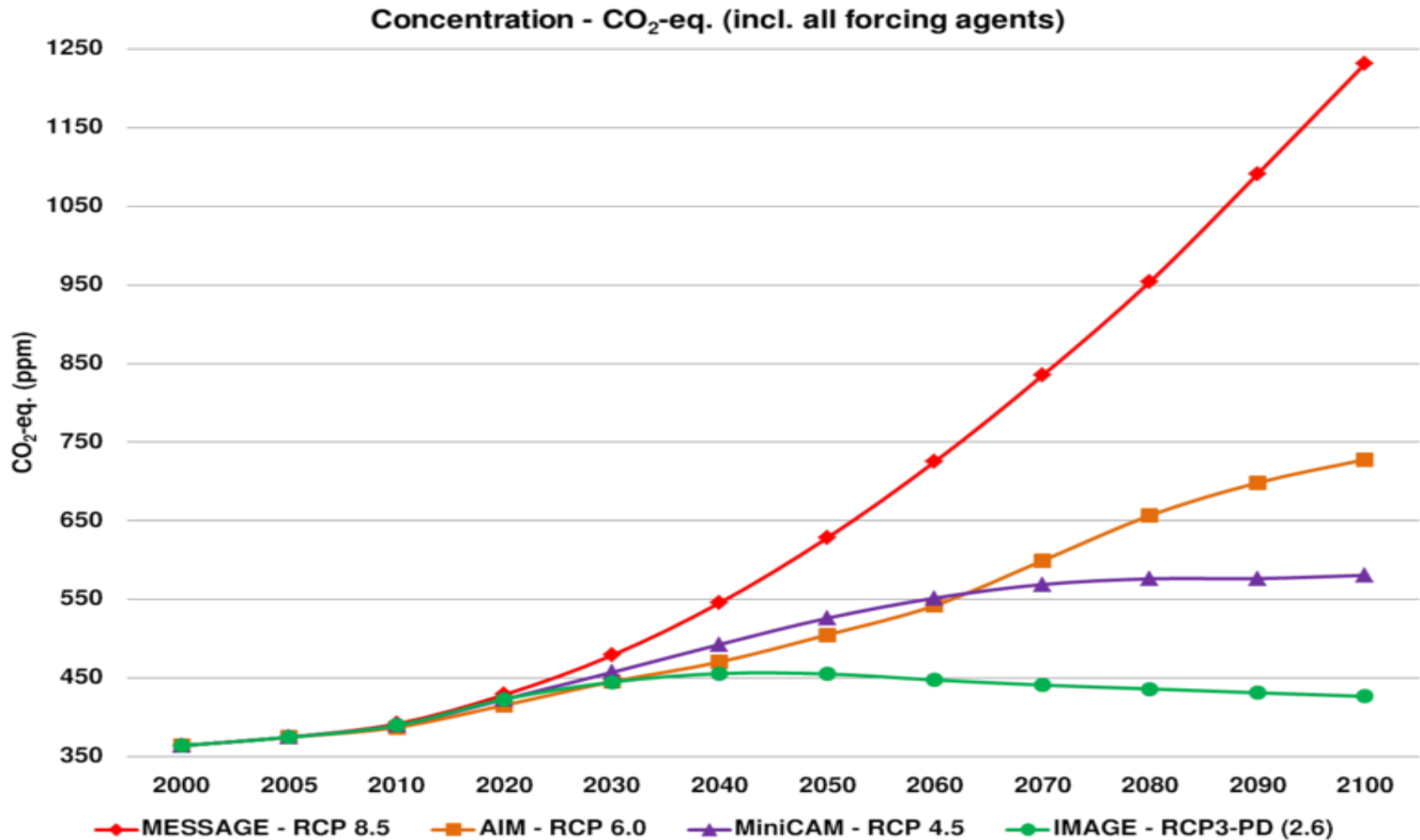
Special Report on Emission Scenarios (SRES)

Scenarios considered by the IPCC in their *Third Assessment Report* of 2001

IPCC: Intergovernmental Panel on Climate Change

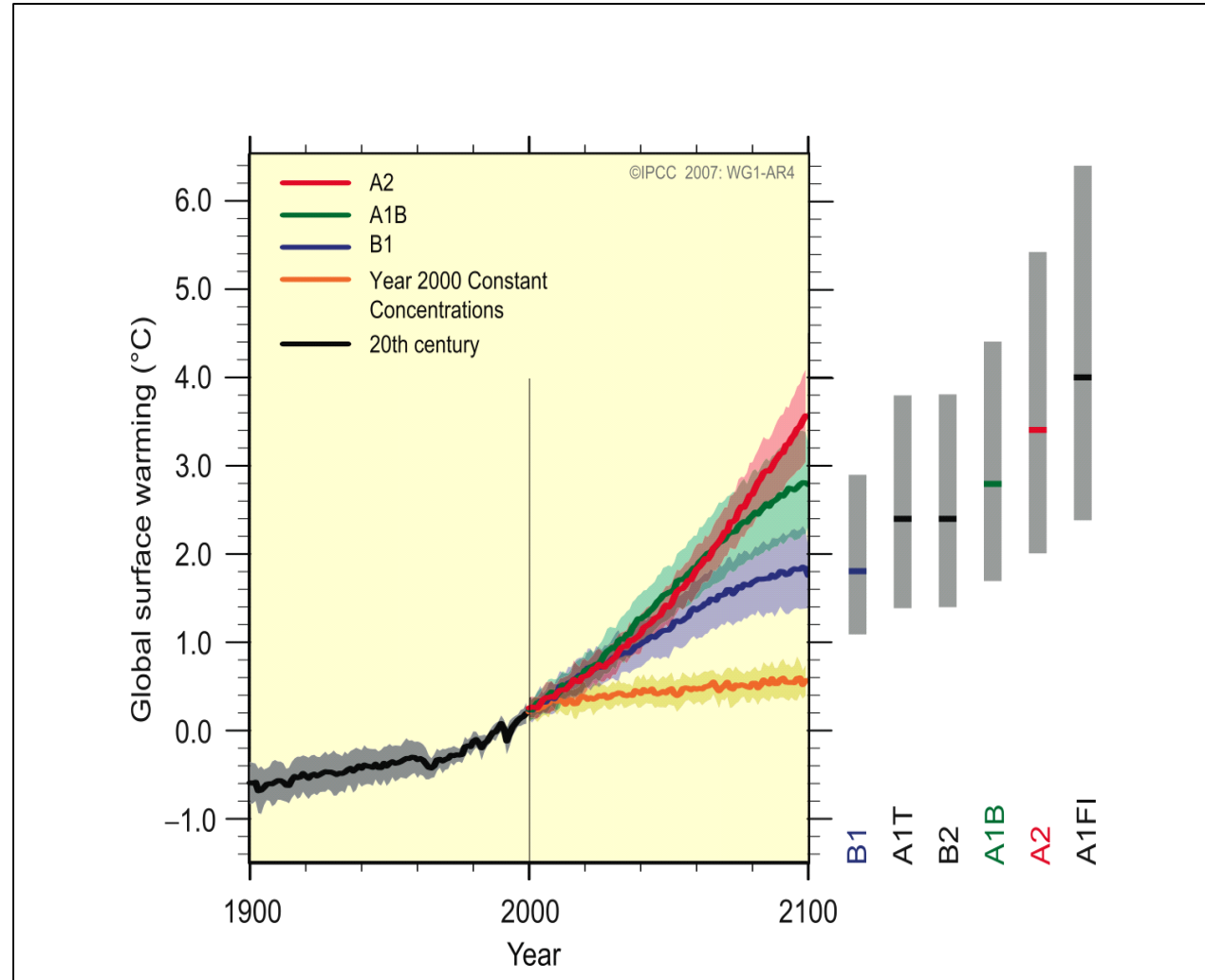


Representative Concentration Pathways

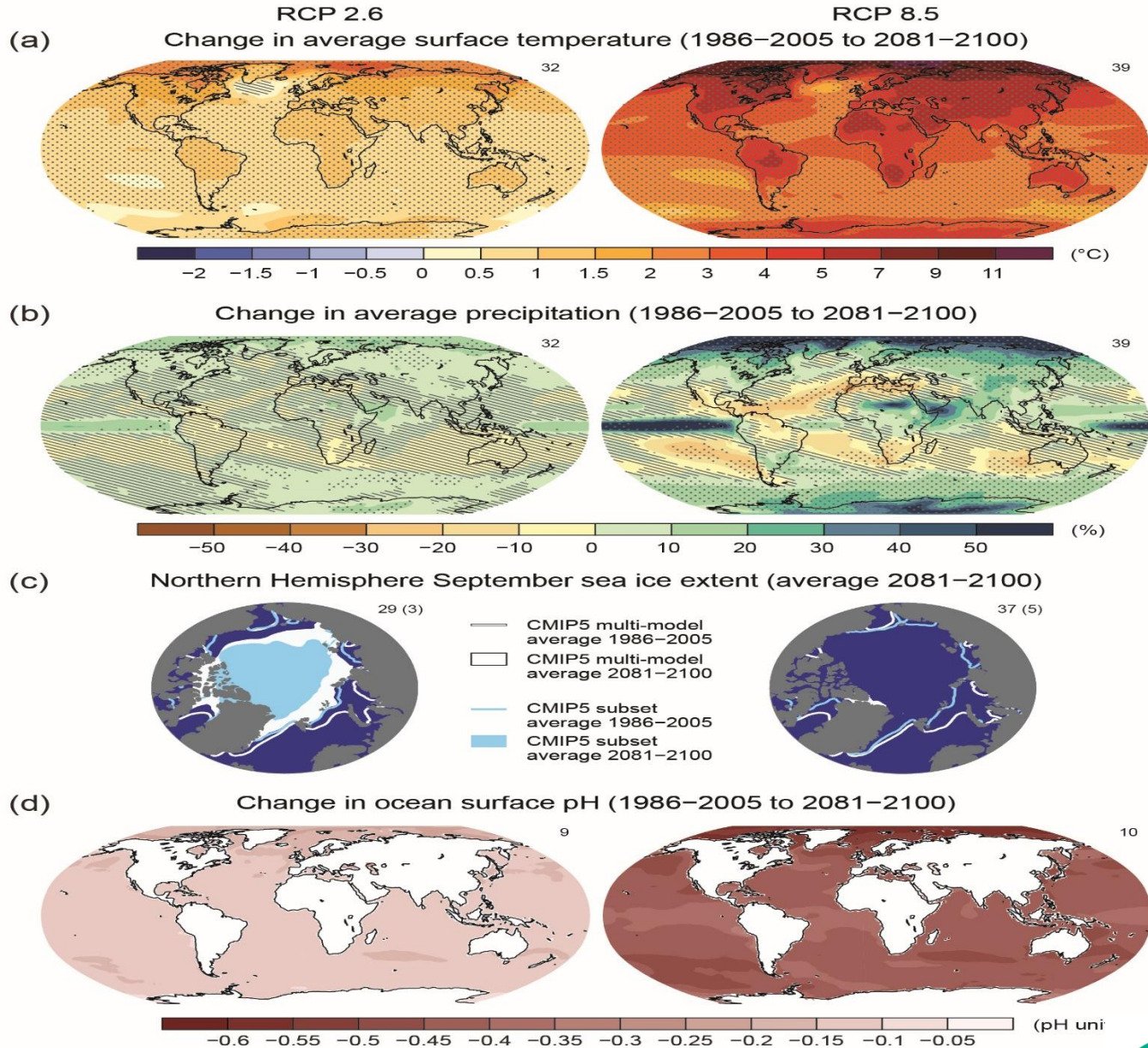


Observed and Projected Temperature Change

Multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations

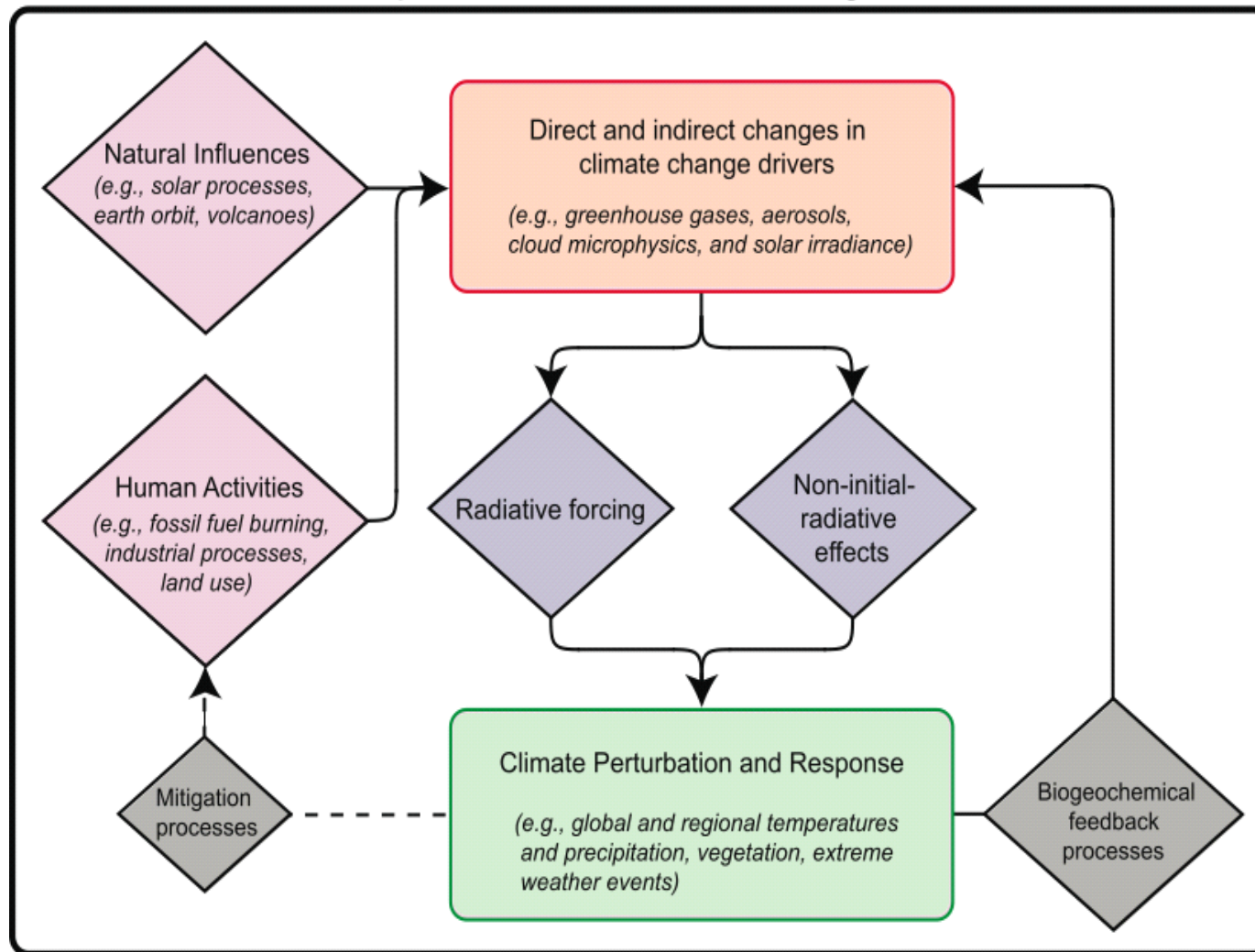


What do scientists expect?



Climate change is also affected by feedback processes

Components of the Climate Change Process



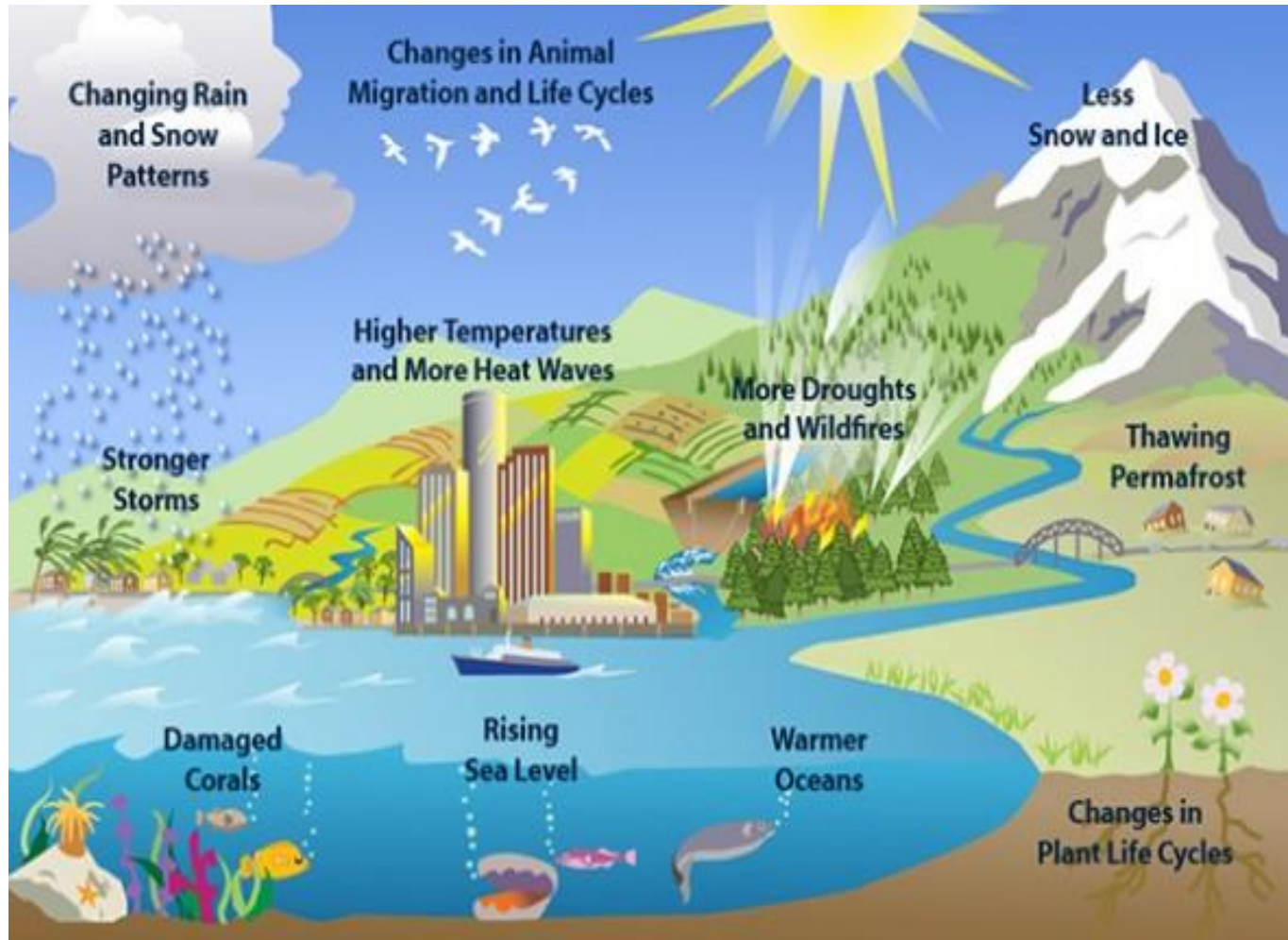
Climate Variability

The way climate fluctuates yearly above or below a long-term average value (affects weather variability – extreme weather events)

What is the difference between climate change and variability?

- Overall change in average conditions e.g. Reduction in overall rainfall in the Southern Caribbean
- Variability- Rainfall during unexpected periods.

Impacts of Climate Change (CC) and Climate Variability (CV)



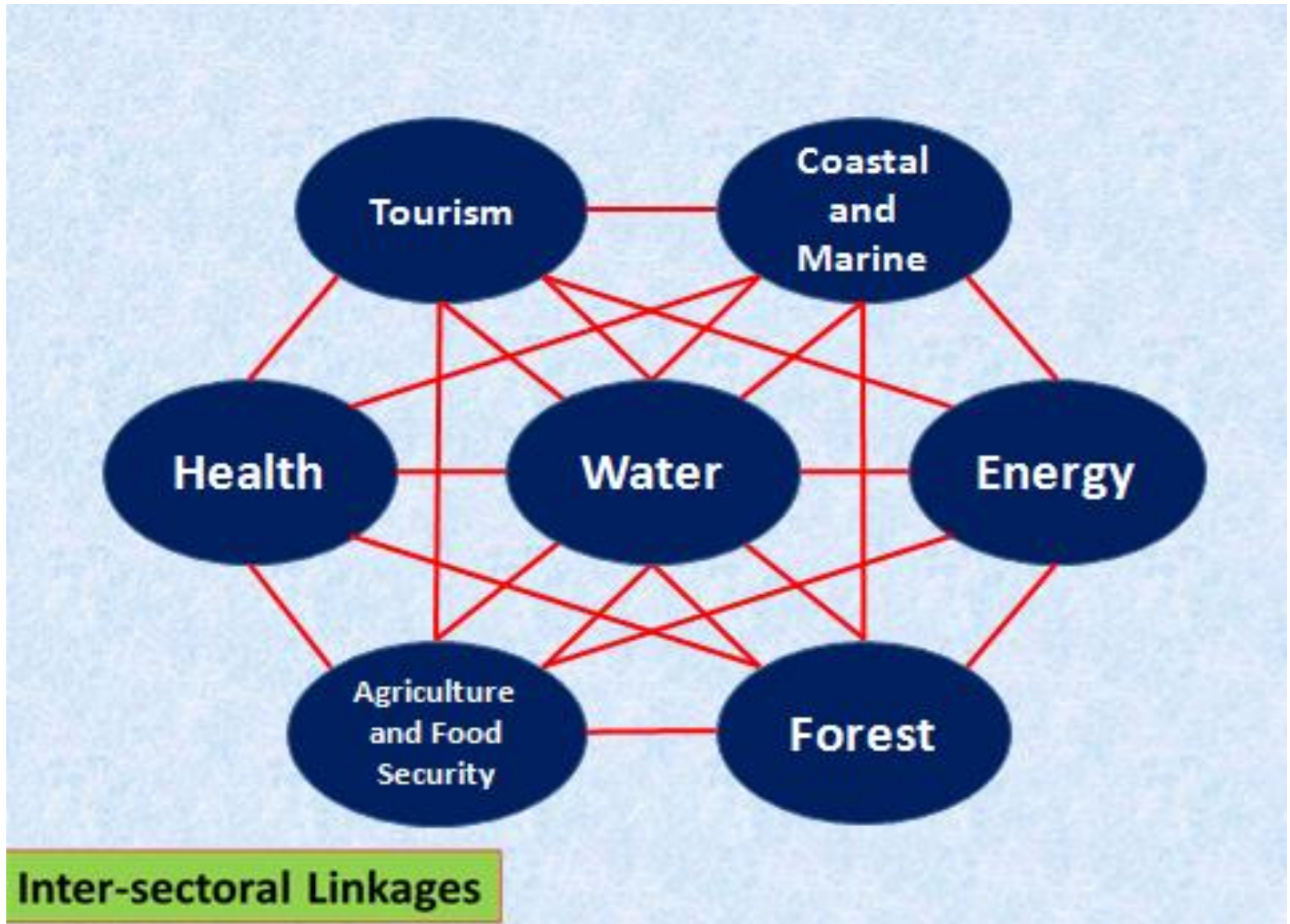
How do these changes in temperature and rainfall patterns affect us?

- Direct impacts on:
 - Health: Heat strokes
 - Energy: More energy needed for cooling
 - Agriculture: Plant wilting due to higher temperatures
 - Fisheries: Less oxygen available
 - Tourism: Higher temperatures- affect daytime tours- heavy rainfall stuck indoors
 - Infrastructure: Damage due to intense hurricanes

How do these changes in temperature and rainfall patterns affect us?

- **Indirect impacts**
- through impacts on temperature and rainfall which **affects water availability and water quality with then impact on**
 - Agriculture
 - Fisheries
 - Tourism
 - Infrastructure

How and What will CC/CV impact?



CC/CV impacts on Agriculture

- Possible positive impacts because of increased CO₂ concentrations and length of growing season
- Strongly dependent on water (amount and timing):
 - Rain-fed agriculture: precipitation
 - Irrigated agriculture: water supply
- Examples:
 - Insufficiently treated wastewater used for irrigation > water-borne diseases
 - Too much precipitation: direct damage to crops, soil erosion
 - Too little precipitation: direct damage to crops
- Strong regional and local differences: those least able to cope (smallholder farmers in marginal areas) will be affected hardest



CC/CV impacts on Agriculture

Biophysical

- Physiological effects on crops, pasture, forests, livestock (quantity, quality)
- Changes in land, soil, water resources (quantity, quality)
- Increased bush fires; resulting land slippage (eg. Dominica)
- Increased weed and pest challenges
- Shifts in spatial and temporal distribution of impacts
- Sea level rise, changes to ocean salinity and acidity
- Sea temperature rise causing fish to inhabit different ranges; damage fish habitat

Socio-economic

- Decline in yields and production
- Reduced marginal GDP from agriculture
- Fluctuations in world market prices
- Increased expenditure on imports (Caribbean Region spends >USD\$ 3.5 billion/yr)
- Changes in geographical distribution of trade regimes
- Increased number of people at risk of hunger and food insecurity
- Migration and civil unrest.

CC/CV impacts on Fisheries

- Increased stress on fish populations:
 - Higher temperatures > less oxygen available
 - Increased oxygen demand
 - Deteriorated water quality
 - Degradation of coastal fisheries nurseries and habitat
 - Sea Level Rise and disease impacts on aquaculture fisheries
 - Species are moving poleward as sea temperatures rise
 - Plankton mass has declined in many areas

CC/CV impacts on Health

Mediating process	Health impacts
<i>Direct effects</i>	
Change in the frequency or intensity of extreme weather events (e.g. storms, hurricanes, cyclones)	Deaths, injuries, psychological disorders; damage to public health infrastructure
<i>Indirect effects</i>	
Changed local ecology of vector, water and food borne agents	Changed incidence of diarrhoeal and other infectious diseases, vector borne diseases e.g. Dengue and Chikungunya
Changed food productivity through changes in climate and associated pests and diseases	Malnutrition and hunger
Sea level rise with population displacement and damage to infrastructure	Increased risk of infectious diseases and psychological disorders
Social, economic and demographic dislocation through effects on economy, infrastructure and resource supply.	Wide range of public health consequences: mental health and nutritional impairment, infectious diseases, civil strife.

CC/CV impacts on Transportation

➤ Impact on navigation:

- Reduction in the flow quantity or its distribution over the year shall result in reduced river levels
- Big boats cannot be used thus more boats are required for the same loads, increasing cost, energy use and emissions

➤ Impact on infrastructure

- Increase in the rainfall intensity can severely damage the transportation infrastructure due to exposure to higher flooding than the infrastructure is designed for.
- Other examples?



Picture Courtesy CCCCC, St. Lucia 2010 after Hurricane Tomas

CC/CV impacts on Energy Sector

- Temperature increase leading to increased energy demand and less availability of cooling water
- Energy system highly dependent on hydropower, i.e. on water availability
- Periods of low flow can create conflicts with other users.
- Damage to energy infrastructure

CC/CV impacts on Ecosystems

Ecosystem: A Biotic community and its Abiotic environment functioning as a system (plants and animals and the environment they inhabit)

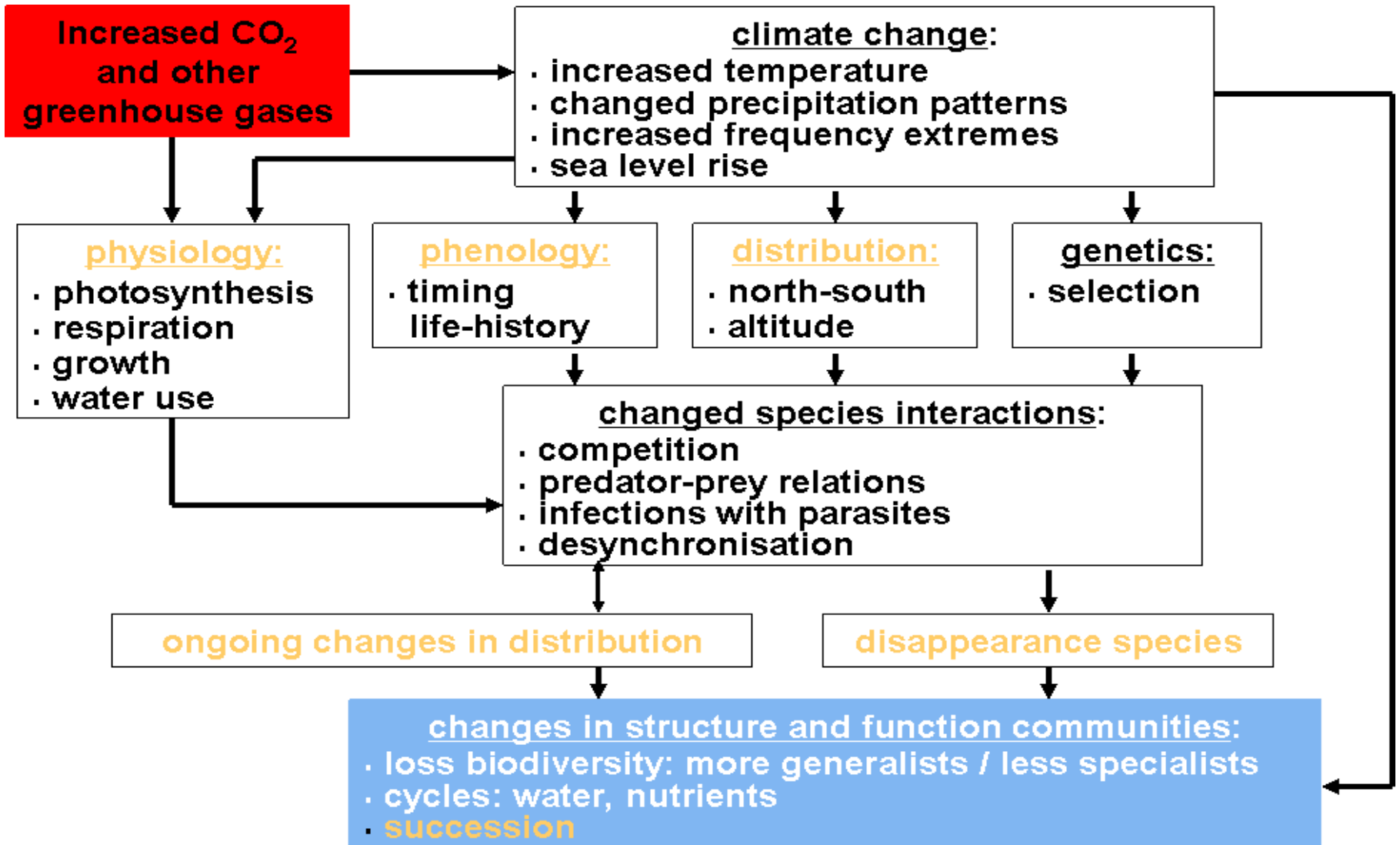


Source: <http://www2.southeastern.edu/orgs/pbrp/lessons/definitions/ecosystem.html>

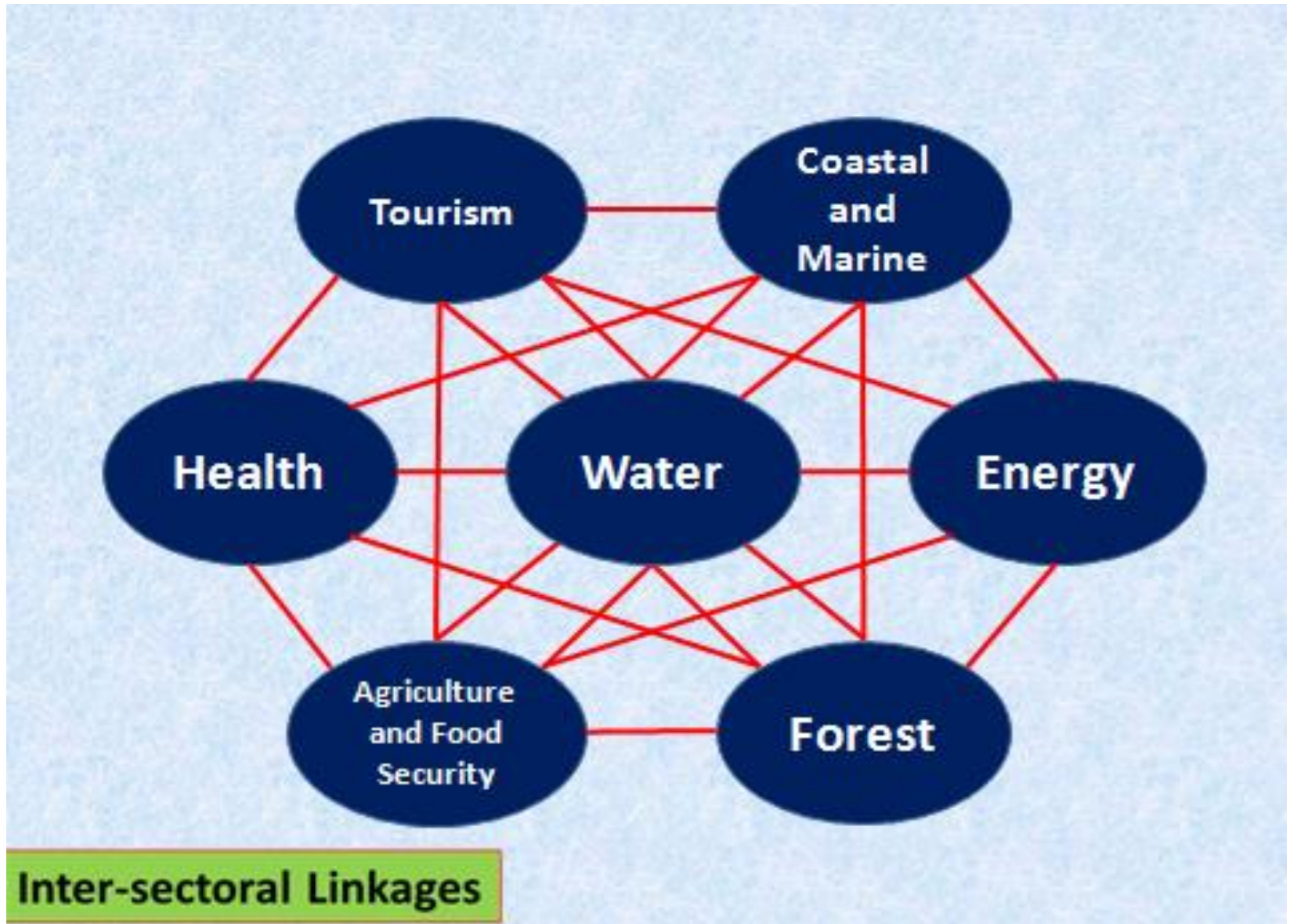
CC/CV impacts on Ecosystems

- Ecosystems tolerate some level of CC/CV and, in some form or another, will persist
- They are increasingly subjected to other human-induced pressures
- Exceeding critical thresholds and triggering non-linear responses > novel states that are poorly understood
- Extension of southern species to the north
- Changes in geographical distributions of fish species
- Extension of alpine plants to higher altitudes
- Spread of disease vectors (e.g. malaria, Lyme disease, bluetongue) and damaging insects
- Extinction (global vs local)/invasion exotics

CC/CV impacts on Ecosystems



How and What will CC/CV impact?



CC/CV is a major factor impacting on water resources

Latest International Panel on Climate Change (IPCC) Report- March 2014

Water is mentioned 33 times in the report

- Report- http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf
- IPCC Video- <https://www.youtube.com/watch?v=jMIFBJYpSgM&list=PL8HWK0G9m3B49SUiBln7IkfVcvwboZe9>
- UNFCCC Video- <https://www.youtube.com/watch?v=ZUqgVpyLFRQ>

CC/CV and Water Basics

Increased temperatures due to the greenhouse gas effect

- Impacts on the hydrological cycle
 - Changes in precipitation, frequency, intensity
 - Surface Runoff
 - Ecosystems
- Impacts on sea level rise
 - Groundwater availability
- Extreme weather events
 - Hurricanes, Floods and Droughts

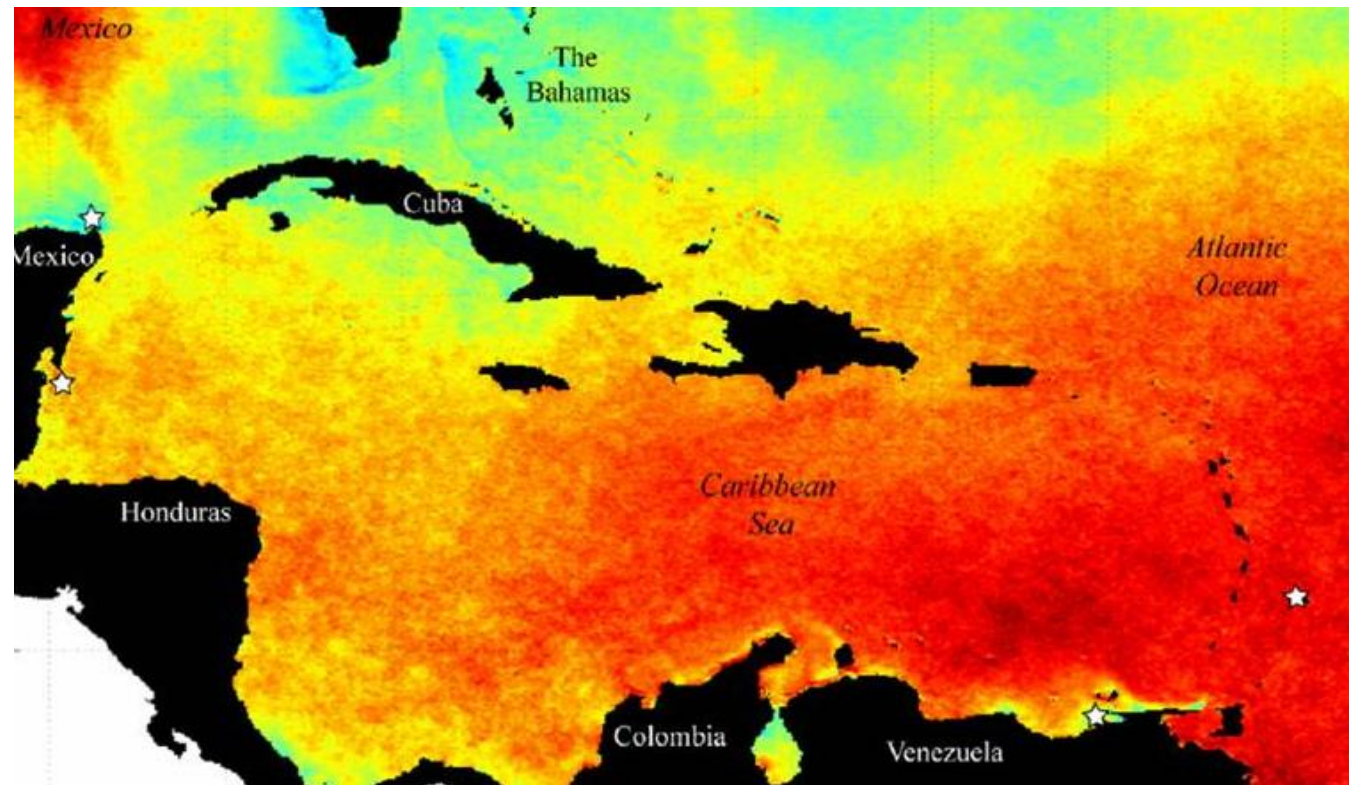
Overall impact on water quantity and water quality

The impact of CC/CV on water resources will be explored in Module 3

Impact of CC/CV in the Caribbean: Increased temperatures

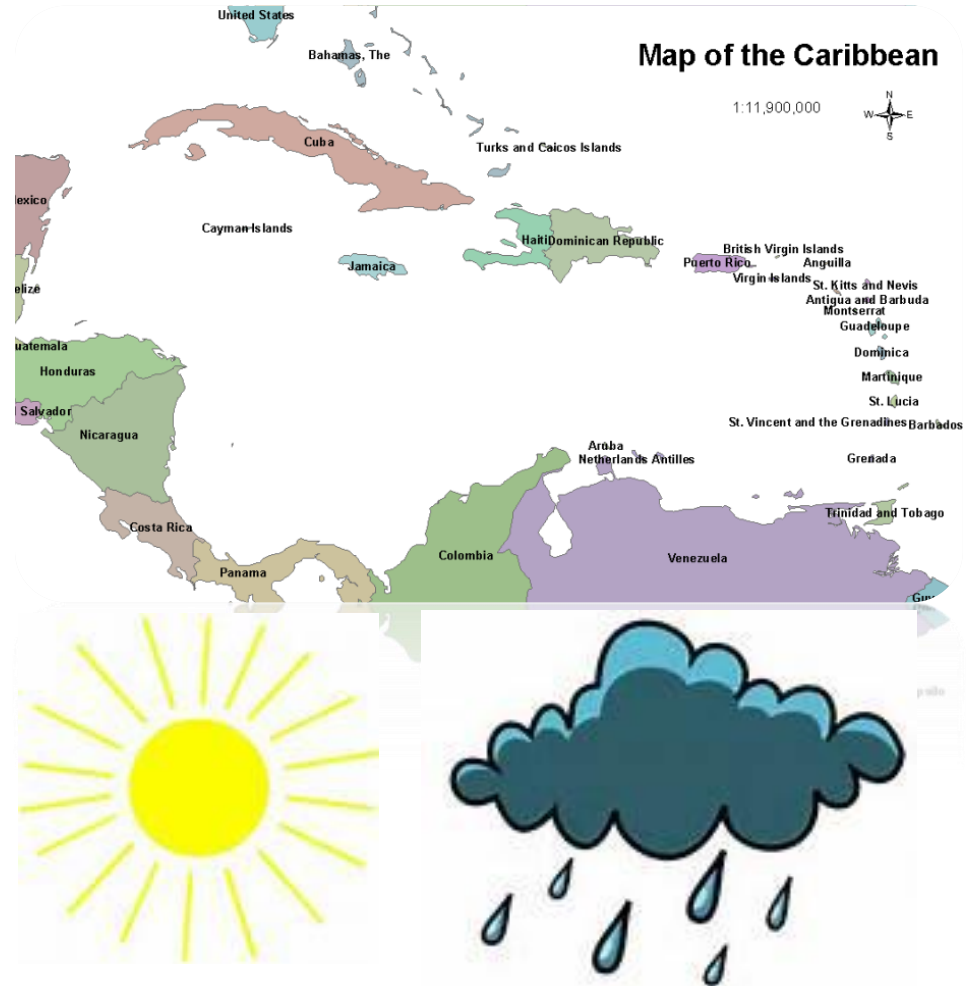
The number of very warm days and nights is increasing dramatically and very cool days and nights are decreasing

The Caribbean Sea has warmed by **1.5°C** over the last century.



Impact of CC/CV in the Caribbean: Rainfall

- Main Caribbean basin-
Drier
- Possible wetter
conditions in the
northern Caribbean
- Drier & longer dry season
- Drier mid-year, wetter
end of year
- When rain does fall-
heavy downpours
- More intense hurricanes



References: Cashman et al (2010), Trotman (2012)

Climate Change Mitigation and Adaptation

Mitigation: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities

Source: 18.1.2 Differences, similarities and complementarities between adaptation and mitigation, Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability, https://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch18s18-1-2.html



Climate: Resilience

The ability of a social or ecological system to resist, absorb, accommodate and recover from the effects of a (climate) hazard in a timely and efficient manner while retaining the same basic structure and ways of functioning (GWP-C and CCCCC 2014).



Adaptations to the impact of CC/CV on the Caribbean water sector are needed to address general water sector needs

- **Climate is one of many environmental and non environmental factors impacting on Water Resources**
- Increasing demand/competition for water due to population growth, competing economic sectors.
- Dwindling water resources- pollution, deforestation, poor land management
- Poor governance, unsuitable policies, legislation etc.

Debates about CC/CV vis a vis water sector– moot point as actions needed anyhow.

CC/CV- greater urgency

Thank You

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