Climate change science, current developments and what it means for Small Island Developing States

Overview
- Climate change science
- Understanding climate change
- Some local experiences/perspectives
- Summary of implications for Small Island Developing States

Global change

Climate change

Causes of Change
- Solar changes
- Volcanic eruptions
- Greenhouse gases
- Aerosols
- Land cover

There are both natural and anthropogenic drivers of climate change. There will always be natural variability superimposed on long-term trends.

The Greenhouse Effect

Source: www.igbp.kva.se

Source: FAQ 3.1, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press

Source: FAQ 1.3, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press
The Climate System

Understanding climate change
- Paleoclimate history
- On-going global observations
- Climate models

Cenozoic Era

Cenozoic Era compared to now
1. Dominant Forcing: Natural $\Delta CO_2$
   - Rate $\sim$100 ppm/My (0.0001 ppm/year)
   - Human-made rate today: $\sim$2 ppm/year
   Humans Overwhelm Slow Geologic Changes
2. Climate Sensitivity High
   - Antarctic ice forms if CO$_2$ $\leq$ ~450 ppm
   - Ice sheet formation reversible
   Humans Could Produce “A Different Planet”

Vostok ice core records

Climate shifts

Earth’s history provides important information on global warming. Recorded human history occurs within the Holocene warm period.

Source: Jim Hansen [http://www.columbia.edu/~jeh1/]


Source: FAQ 1.2, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press
Holocene changes


The carbon cycle

Source: www.igbp.kva.se

Carbons longest journey


Human influence

Global greenhouse gas emissions

Source: Figure 2.1, IPCC Fourth Assessment Report, *Climate Change 2007*, Cambridge University Press
Changes in Greenhouse Gases

Globally, greenhouse gas concentrations are increasing

- Since 1750
  - carbon dioxide increase 35%
  - methane increase 150%
  - Nitrous oxide increase 18%
- Human activities emit annually ~7,000,000,000 tonnes of carbon dioxide
- About half of this stays in the atmosphere
- Present carbon dioxide concentrations highest for 650,000 years, likely 20 My.

... and increasing

Canadian Tarsands, Source: National Geographic

Radiative Forcing

Buzz groups (5 mins)

- What are the key messages from the presentation so far?

Observed climate changes
Consistency of observations

- Surface temperatures increasing
- Atmospheric water vapour content increasing
- Ocean heat content increasing ...
- ... now directly linked to sea level rise
- Greenland and Antarctic Ice Sheets losing mass
- Glaciers and snow cover declined
- Arctic sea ice extent decreasing
- More intense and longer droughts
- More frequent heavy precipitation events over land
- Tropical cyclone intensity increasing (North Atlantic)

ARGO

What is Argo?
Argo is a global array of 3,000 free-drifting profiling floats that measures the temperature and salinity of the upper 2000m of the ocean.

ARGO data

Knowledge of Earth's energy imbalance is improving rapidly as ARGO data lengthens.

Arctic sea ice area at warm season minimum

September sea ice extent based on satellite microwave observations

Greenland total melt area

Melt descending into a moulin, a vertical shaft carrying water to ice sheet base.

Surface Melt on Greenland
Jakobshavn Ice Stream in Greenland

Discharge from major Greenland ice streams is accelerating markedly.

Source: Prof. Konrad Steffen, Univ. of Colorado

Gravity Satellite Ice Sheet Mass Measurements

Greenland Ice Sheet

Antarctic Ice Sheet


Himalayan (Rongbuk) Glacier

Rongbuk, the largest glacier on Mount Everest’s northern slopes, in 1968 (top) and 2007. Glaciers are receding rapidly worldwide, including the Rockies, Andes, Alps, Himalayas. Glaciers provide freshwater to rivers throughout the dry season and reduce spring flooding.

Photos: Chinese Academy of Sciences and Greenpeace/John Novis

Positive feedback


Sea level rise

- IPCC 2007 projects 0.18 to 0.59 m sea level rise by 2100
- A further 0.1 to 0.2 m rise possible from increased ice sheet discharge
- An even larger contribution from ice sheets cannot be ruled out

The Arctic as a Messenger of Global Processes, May 2011

- “Arctic snow and ice are melting much faster than expected. This warming has local and global consequences, especially for global sea level rise which is now expected to be greater than previously projected (0.9-1.6 m by 2100).”

http://amap.no/Conferences/Conf2011/programme.html
Cities at risk from sea level rise

Stresses on Coral Reefs

More drought

More floods

Number of reported disasters

Extreme weather link ‘can no longer be ignored’
Buzz groups (5 mins)

- What climate changes have you observed/experienced, or are aware of?

Reliability of climate models

Is warming due to natural variability?

IPCC Projections

Future warming in historical context

What’s in a number: 350ppm or 450ppm?
Setting policy targets

2 degrees warming as limit:
- now accepted by more than 130 countries, including the G8 and Major Economies Forum in 2009 part of Copenhagen Accord
- IPCC AR4, WGII, TS.4
- Warming under medium emissions scenario: 2100
- Warming under medium emissions scenario: long-term

Concentration targets

What concentration of GHGs gets us to 2°C?
- 450ppm CO₂-equivalent concentrations result in warming of 2°C as the best estimate, …
- … but climate science is uncertain: 450ppm could result in warming between 1.4 and 3.1°C …
- … so there is a roughly 50% chance that warming could exceed 2°C even if we stabilise concentrations at 450ppm

Jim Hansen
- Heads the NASA Goddard Institute for Space Studies in New York City
- Since the late 1970s, he has focused his research on Earth's climate, especially human-made climate change
- Designated by Time Magazine in 2006 as one of the 100 most influential people on Earth

Jim Hansen's assessment

Assessment of Target CO₂

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>Target CO₂ (ppm)</th>
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</thead>
<tbody>
<tr>
<td>1. Arctic Sea Ice</td>
<td>300-350</td>
</tr>
<tr>
<td>2. Ice Sheets/Sea Level</td>
<td>300-350</td>
</tr>
<tr>
<td>3. Shifting Climatic Zones</td>
<td>300-350</td>
</tr>
<tr>
<td>4. Alpine Water Supplies</td>
<td>300-350</td>
</tr>
<tr>
<td>5. Avoid Ocean Acidification</td>
<td>300-350</td>
</tr>
</tbody>
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→ Initial Target CO₂ = 350° ppm
*assumes CH₄, O₃, Black Soot decrease

Jim Hansen’s assessment

Target CO₂:
< 350 ppm
To preserve creation, the planet on which civilization developed

Local experiences

A Buddhist Monk stands in front of the Everest Mountain in the Himalayan mountain range. He holds an empty bucket, symbolizing the loss of water from the region. The Pu Mai village depends on the water source from the Rongbuk Glacier Mount Everest (Gomolangma).
Preeca Siri, Thailand

He said he has heard about the global warming and climate change because he goes to many meetings about the environment. But his village and himself work on environmental protection so he think that the cause of global warming is human beings.

Luu Chi Kien, Viet Nam

The main reason for higher temperatures is the forest destruction and also because of the mining of coal.

Sonam Chhering Gurung, Nepal

When I was 13 or 12 years old the lake near the Gangapurna Glacier was very small, the glacier was a massive chunk of ice. But now everything is gone. The lake has enlarged massively. The receding of the glacier is progressing leaving the bare rocks behind.

Alfredo, Italy

I want to believe that maybe for the generation for my son, maybe some change. Maybe one day some change. The human race is not stupid like that and maybe one day say ‘stop it’... and some change...

What it means for SIDS

- A 450ppm target gives a high chance of significant impacts on SIDS
- Global sea-level rise of above 1m by 2100 is increasingly a possibility
- More extreme events
  - Extreme rainfall
  - Extreme temperatures/drought