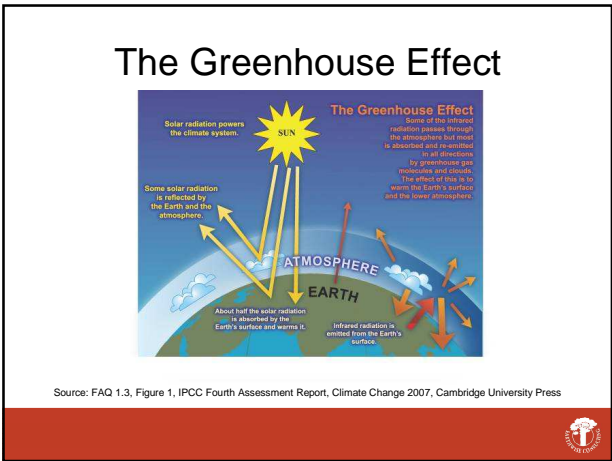
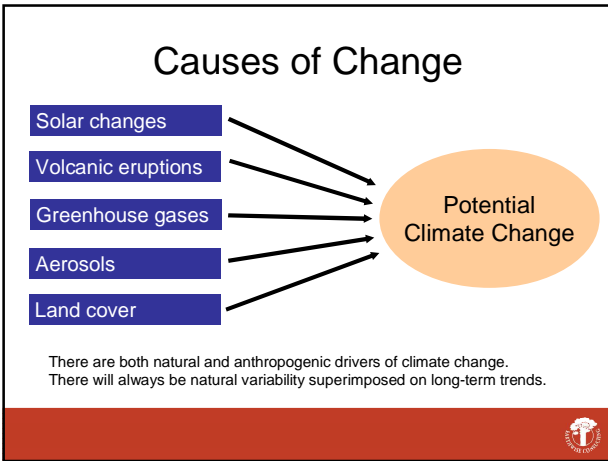
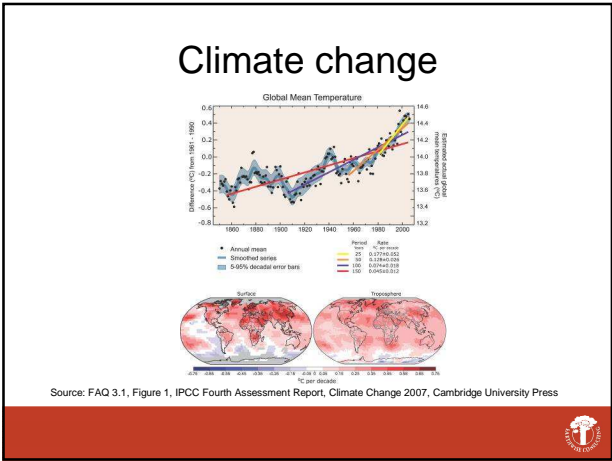
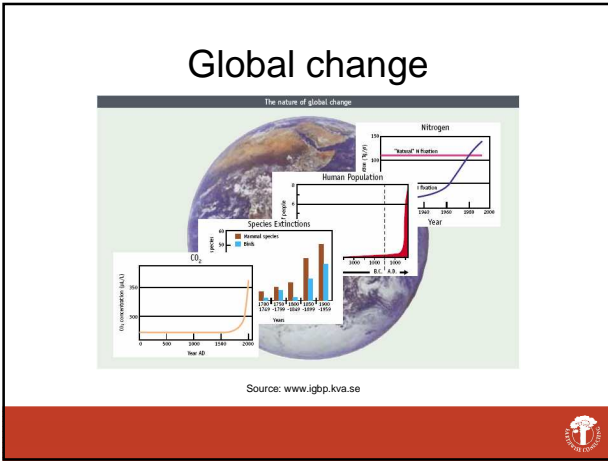


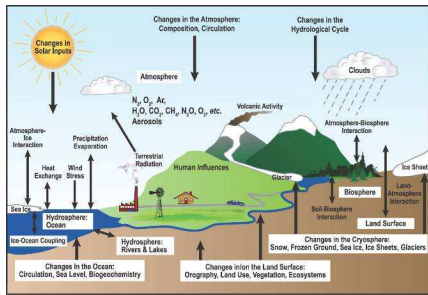


## Overview

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



## The Climate System

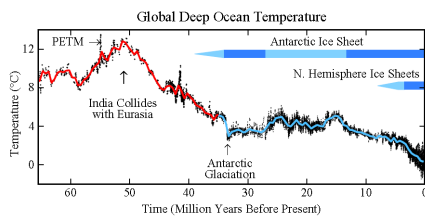


Source: FAQ 1.2, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press

## Understanding climate change

- Paleoclimate history
- On-going global observations
- Climate models

## Cenozoic Era



50 million years ago (50 MYA) Earth was ice-free. Atmospheric CO<sub>2</sub> amount was of the order of 1000 ppm 50 MYA. Atmospheric CO<sub>2</sub> imbalance due to plate tectonics - 10<sup>-4</sup> ppm per year.

Source: Jim Hansen <http://www.columbia.edu/~jeh1/>

## Cenozoic Era compared to now

### 1. Dominant Forcing: Natural ΔCO<sub>2</sub>

- Rate ~100 ppm/My (0.0001 ppm/year)
- Human-made rate today: ~2 ppm/year

**Humans Overwhelm Slow Geologic Changes**

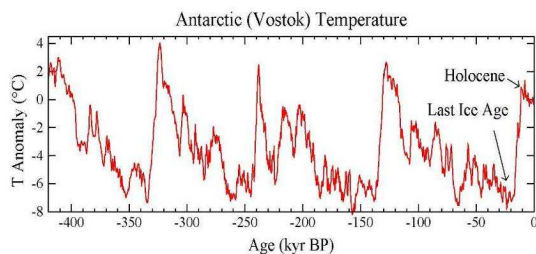
### 2. Climate Sensitivity High

- Antarctic ice forms if CO<sub>2</sub> < ~450 ppm
- Ice sheet formation reversible

**Humans Could Produce "A Different Planet"**

Source: Jim Hansen <http://www.columbia.edu/~jeh1/>

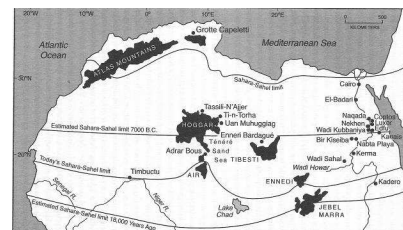
## Vostok ice core records



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

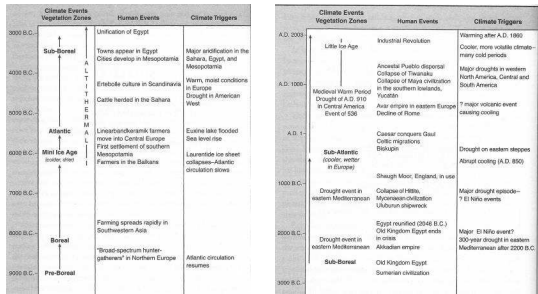
Source: Jim Hansen <http://www.columbia.edu/~jeh1/>

## Climate shifts



Source: Brian Fagan, *The Long Summer: How Climate Changed Civilization*, Basic Books, 2004

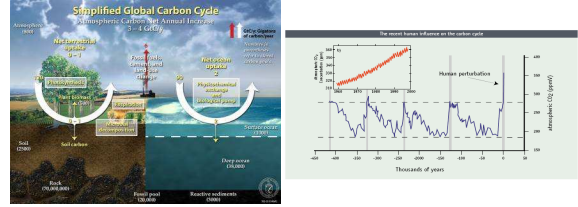
# Holocene changes



Source: Brian Fagan, *The Long Summer: How Climate Changed Civilization*, Basic Books, 2004



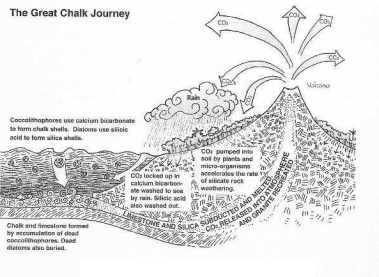
# The carbon cycle



Source: www.igbp.kva.se



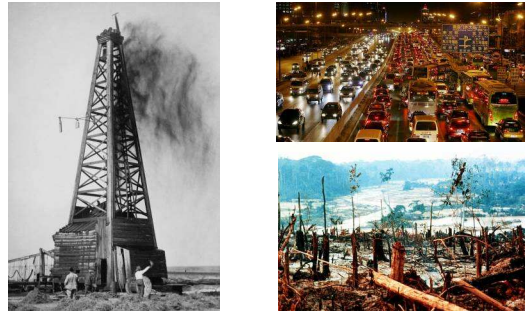
# Carbons longest journey



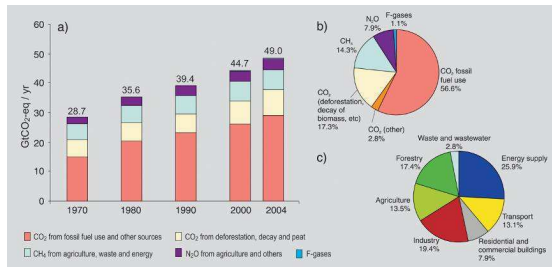
Source: Stephan Harding, *Animate Earth: Science, Intuition and Gaia*, Green Books, 2006



# Human influence



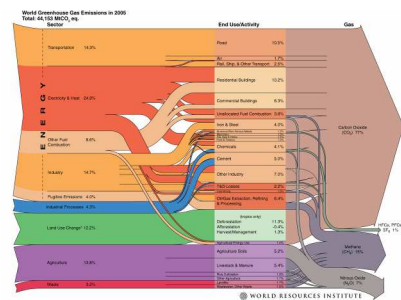
# Global greenhouse gas emissions



Source: Figure 2.1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press



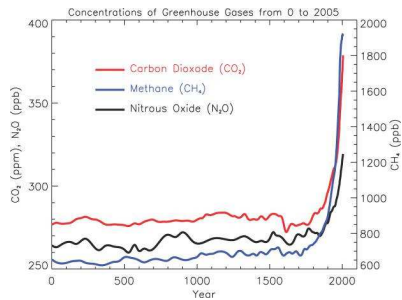
# Global greenhouse gas emissions



WORLD RESOURCES INSTITUTE



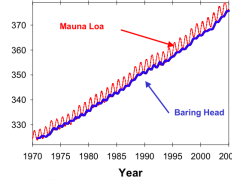
## Changes in Greenhouse Gases



Source: FAQ 2.1, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press



## Globally, greenhouse gas concentrations are increasing



Carbon dioxide, ppm  
(CO<sub>2</sub> 379ppm, CH<sub>4</sub> 1780ppb, N<sub>2</sub>O 319ppb)

- 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.



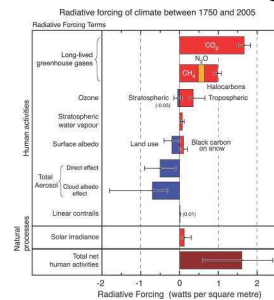
## ... and increasing



Canadian Tar sands, Source: National Geographic



## Radiative Forcing



Source: FAQ 2.1, Figure 2, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press

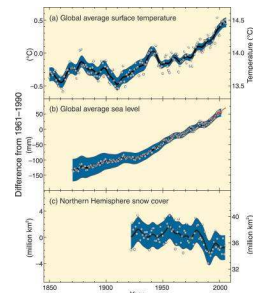


## Buzz groups (5 mins)

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



## Observed climate changes



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



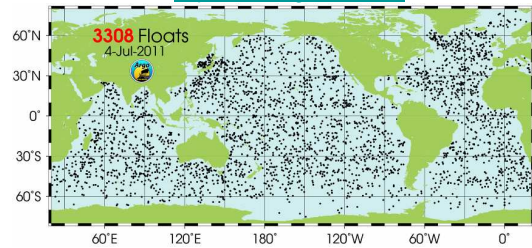
## Consistency of observations

- 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

<http://www.argo.ucsd.edu>

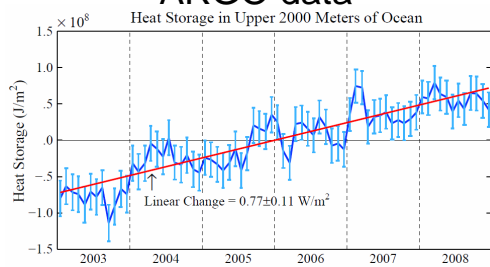


### What is Argo?

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

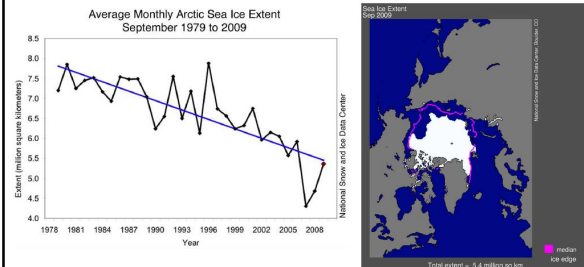


Knowledge of Earth's energy imbalance is improving rapidly as ARGO data lengthens.

Data source: von Schuckmann et al. *J. Geophys. Res.* 114, C09007, 2009, doi:10.1029/2008JC005237



## Arctic sea ice area at warm season minimum

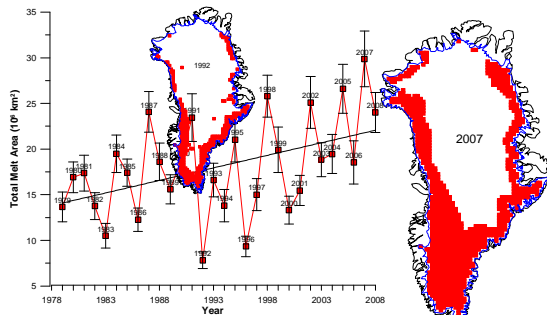


September sea ice extent based on satellite microwave observations

Data source: National Snow and Ice Data Center



## Greenland total melt area



Source: Jim Hansen <http://www.columbia.edu/~jeh1/> Graph credit: Konrad Steffen, Univ. Colorado



## Surface Melt on Greenland

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



Source: Roger Braithwaite, University of Manchester (UK)





## Jakobshavn Ice Stream in Greenland

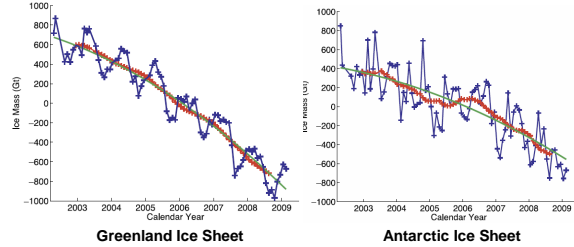
Discharge from major Greenland ice streams is accelerating markedly.



Source: Prof. Konrad Steffen, Univ. of Colorado



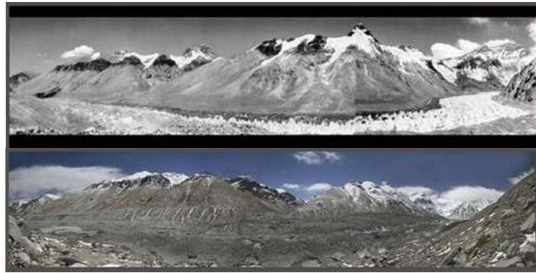
## Gravity Satellite Ice Sheet Mass Measurements



Source: Velicogna, I. *Geophys. Res. Lett.*, 36, L19503, doi:10.1029/2009GL040222, 2009.



## Himalayan (Rongbuk) Glacier

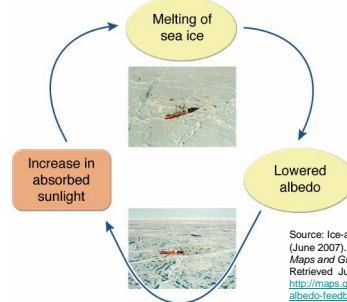


Rongbuk, the largest glacier on Mount Everest's northern slopes, in 1968 (top) and 2007. Glaciers are receding rapidly world-wide, including the Rockies, Andes, Alps, Himalayas. Glaciers provide freshwater to rivers throughout the dry season and reduce spring flooding.

Photos: Chinese Academy of Sciences and Greenpeace/John Novis



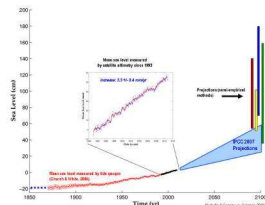
## Positive feedback



Source: Ice-albedo feedback process. (June 2007). In *UNEP/GRID-Arendal Maps and Graphics Library*. Retrieved July 6, 2011 from <http://images.grida.no/go/graphic/ice-albedo-feedback-process>



## 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



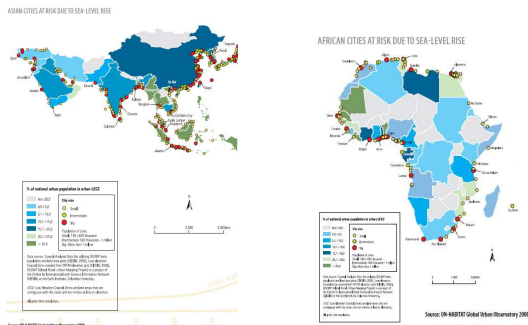
## The Arctic as a Messenger of Global Processes, May 2011

- "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



Coral Reef Fiji

Photo credit: Kevin Roland

# More drought

**Special report: Catastrophic drought in the Amazon**  
The Independent, 4/2/2011

A widespread drought in the Amazon rainforest last year caused the "lungs of the world" to produce more carbon dioxide than they absorbed, potentially leading to a dangerous acceleration of global warming.

**The wrath of 2007: America's great drought**, The Independent, 11/6/2007

America is facing its worst summer drought since the Dust Bowl years of the Great Depression. Or perhaps worse still.



Drought Stricken Area (1934), Alexandre Hogue.

**Ministers call emergency summit as drought looms**  
The Independent, 15/5/2011

One of the driest springs on record has sparked fears for agriculture and wildlife, while crews 'work to the point of exhaustion' to battle forest fires

**UN warns of severe food crisis in Horn of Africa**  
The Independent, 29/6/2011

The worst drought in 60 years in the Horn of Africa has sparked a severe food crisis and high malnutrition rates, with parts of Kenya and Somalia experiencing pre-famine conditions, the UN said yesterday.

# More floods

**Record floods put 20,000 at risk**  
The Independent, 21/6/2011

More than 40 miles of dykes are in danger of being breached in an eastern Chinese province where floods have caused \$1.2bn in losses, authorities said yesterday, as the country neared a critical point in battling seasonal rains.

**Flooding hits southern Thailand**, The Independent, 2/11/2010

Thailand's prime minister today called flooding in the south that has displaced thousands of people "one of the worst natural calamities" to hit the country.



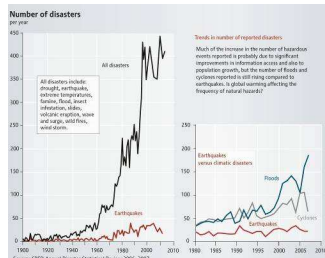
**Residents flee ahead of Mississippi floods**, The Independent, 9/5/2011

Residents of Memphis have begun to abandoning low-lying homes as the dangerously surging Mississippi River threatens to crest in coming days just shy of a 48.7ft record set by a devastating flood in 1937.

**UN: Pakistan floods ravage lives of millions**, The Independent, 3/6/2010

The worst floods in memory in Pakistan have devastated the lives of more than three million people, a UN spokesman said today while outrage over the unpopular government's response to its people's plight spreads.

# Number of reported disasters

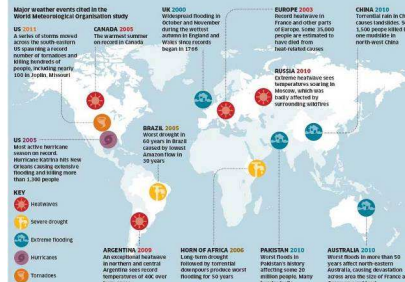


Possible Causes:

- Climate change
- Increased exposure
- Increased reporting

Source: Number of Disasters per Year. (2009). In UNEP/GRID-Arendal Maps and Graphics Library. Retrieved July 6, 2011 from <http://maps.grida.no/go/graphic/number-of-disasters-per-year>.

# Extreme weather link 'can no longer be ignored'



Scientists are to end their 20-year reluctance to link climate change with extreme weather – the heavy storms, floods and droughts which often fill news bulletins – as part of a radical departure from a previous equivocal position that many now see as increasingly untenable.

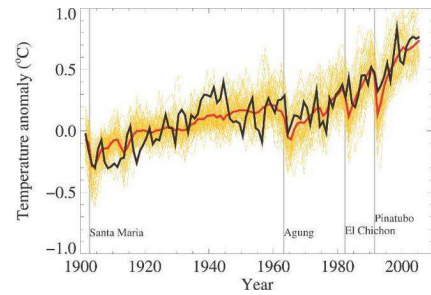
The Independent, 17/7/2011

## Buzz groups (5 mins)

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



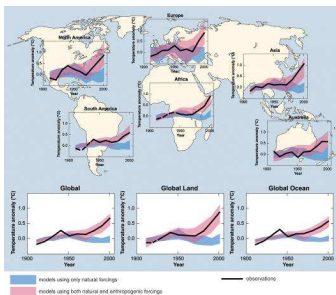
## Reliability of climate models



Source: FAQ 8.1, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press



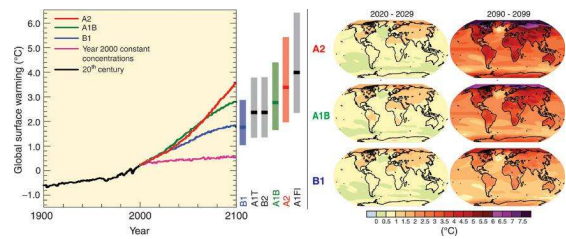
## Is warming due to natural variability?



Source: FAQ 9.2, Figure 1, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press



## IPCC Projections



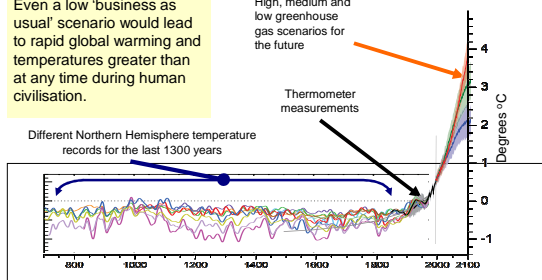
Source: Figure 3.2, IPCC Fourth Assessment Report, Climate Change 2007, Cambridge University Press



## Future warming in historical context

Even a low 'business as usual' scenario would lead to rapid global warming and temperatures greater than at any time during human civilisation.

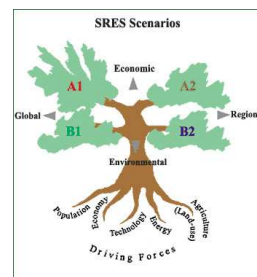
High, medium and low greenhouse gas scenarios for the future



Source: Andy Reisinger



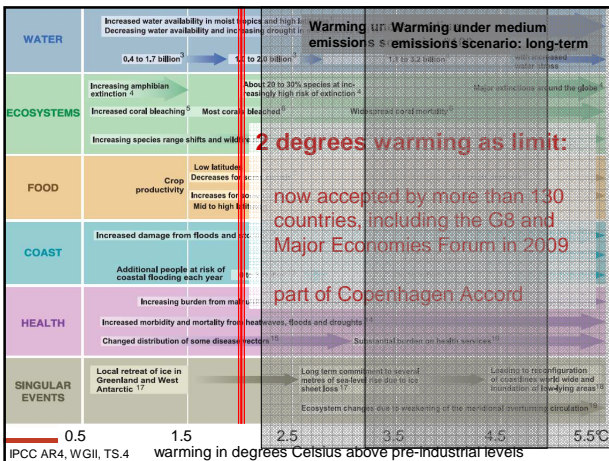
## What's in a number: 350ppm or 450ppm?



Source: IPCC





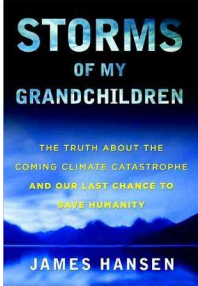


## Concentration targets

**What concentration of GHGs gets us to 2°C?**

- 450ppm CO<sub>2</sub>-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 CO<sub>2</sub>

Phenomenon	Target CO <sub>2</sub> (ppm)
1. Arctic Sea Ice	300-350
2. Ice Sheets/Sea Level	300-350
3. Shifting Climatic Zones	300-350
4. Alpine Water Supplies	300-350
5. Avoid Ocean Acidification	300-350

→ Initial Target CO<sub>2</sub> = 350\* ppm  
\*assumes CH<sub>4</sub>, O<sub>3</sub>, Black Soot decrease


## Jim Hansen's assessment

**Target CO<sub>2</sub>:**

**< 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 (Qomolangma).

© Greenpeace / John Novis

## 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 10 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

