

Past, Present and Future Climate

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The Role of Teachers in Introducing and Implementing the Subject Climate Change in the High School Curriculum

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Outline (numbers refer to slide number)

3 Planets and Atmospheres

4 Plate Tectonics: Continental Drift

5 Milankovitch Theory: eccentricity cycle

6 Milankovitch Theory: Tilt Cycle

7 Milankovitch Theory: Precession cycle

8 Solar Energy

9 Other factors that affect climate

- amount of dust and aerosols in the atmosphere
- reflectivity of ice sheets
- concentrations of trace gases
- amount of clouds

10 Reflection, refraction, and albedo

Radiation can be:

Absorbed: energy is retained by a substance.

Reflected: the surface returns a portion of the energy.

Scattered: the electromagnetic waves are changed from propagating in one direction to all directions.

Refracted: the electromagnetic waves are changed from propagating in one direction to another direction.

Transmitted: energy passes through space or the media.

11 The Earth's annual and global mean energy balance

12 Schematic diagram of the Global Climate System

13 Composition of solar radiation

14 The Greenhouse Effect

15 The cooling factors

16 Feedback mechanisms: Positive Feedback

17 Feedback mechanisms: Negative Feedback

18 Temperature indicators

19 Hydrological and Storm-Related Indicators

20 Palaeoclimate proxy indicators

Tree rings

Corals

Lake and Ocean Sediments

Borehole measurements

Documentary evidence

Mountain glacier moraines

21 Tree rings

22 Coral and sediment core measurement

23 Borehole measurements

24 Ice core measurements

25 Glacier length

26 The melting snows of Kilimanjaro

27 Reconstructed global ground temperature from borehole data

(The following slides were not discussed during the lecture)

- 28 Annual anomalies of global average land-surface air temperature (LSAT)
- 29 Smoothed annual anomalies of global average sea surface temperature (SST)
- 30 Ocean heat content anomalies (upper 300 m)
- 31 Smoothed annual anomalies of combined LSAT and SST
- 32 Seasonal anomalies of global average temperature
- 33 Seasonal snow cover anomalies (in million km²) versus temperature anomalies (in °C). (p.124)
- 34 Sea-ice extent anomalies
- 35 Glacier length record from different parts of the world
- 36 The present carbon cycle

(These were discussed during the second half of the lecture)

- 37 Temperature and CO₂ concentration in the atmosphere over the past 400 000 years
- 38 Variations of temperature, methane and atmospheric CO₂ concentrations from ice core data
- 39 Sulfate, black carbon and organic carbon concentration in ice cores.
- 40 Variations in atmospheric CO₂ on different time scales
- 41 Fossil fuel emissions and the rate of increase of CO₂ concentration in the atmosphere
- 42 Surface air temperature change
- 43 Annual global and hemispheric near-surface temperatures
- 44 Annual global near-surface temperatures
- 45 Surface air temperatures
- 46 Sea Surface Temperature charts
- 47 Tropospheric and stratospheric temperatures
- 48 Looking into the future
- 49 Surface air temperature
- 50 Projected CO₂ concentrations resulting from six SRES* scenarios
- 51 SRES A2: Annual mean change of temperature
- 52 SRES A2: Annual mean change of precipitation
- 53 Projected Temperature Increase
- 54 Projected Rainfall Change (Dry Season)
- 55 Projected Rainfall Change (Rainy Season)
- 56 Patterns of Future Climate Change

First we note results assessed here that reconfirm results from the SAR:

- *As the climate warms, Northern Hemisphere snow cover and sea-ice extent decrease. The globally averaged precipitation increases.*
- *As the radiative forcing of the climate system changes, the land warms faster than the ocean. The cooling effect of tropospheric aerosols moderates warming both globally and locally.*
- *The surface air temperature increase is smaller in the North Atlantic and circumpolar Southern Ocean regions.*
- *Most tropical areas, particularly over ocean, have increased precipitation, with decreases in most of the sub-tropics, and relatively smaller precipitation increases in high latitudes.*
- *The signal to noise ratio (from the multi-model ensemble) is greater for surface air temperature than for precipitation.*

57 Patterns of Future Climate Change

A second category of results assessed here are those that are new since the SAR:

- *There are many more model projections for a given scenario, and more scenarios. The greater number of model simulations allows us to better quantify patterns of climate change for a given forcing and develop a measure of consistency among the models.*
- *Including the direct effect of sulphate aerosols according to an IS92a type estimate reduces global mean mid-21st century warming. The indirect effect, not included in most AOGCM experiments to date, is acknowledged to be uncertain, as discussed in Chapter 6.*
- *The geographic details of various forcing patterns are less important than differences among the models' responses for the scenarios considered here. This is the case for the global mean as well as for patterns of climate response. Thus, the choice of model and the choice of scenario are both important.*

58 Sources

59 For more information, please visit our web site:

<http://www.klima.ph>

List of Sources:

**IPCC Third Assessment Report, Working Group I. Climate Change
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Palaeoclimate proxy indicators

(http://www.grida.no/climate/ipcc_tar/wg1/068.htm)

Projections of Future Climate Change

(http://www.grida.no/climate/ipcc_tar/wg1/338.htm)

IPCC Special Report on Emissions Scenarios

(<http://www.grida.no/climate/ipcc/emission/index.htm>)

UNEP.Net: Climate change (<http://climatechange.unep.net/>)

Hadley Center for Climate Prediction and Research

(<http://www.met-office.gov.uk/research/hadleycentre/models/modeldata.html>)

<http://www.lareinerouge.com/articles/climat/soleilclimat/Photos/Milankovitch.jpg>

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