Climate Change and Its Impacts On Humankind
Andreas Fischlin
Senior coordinating lead author of chapter on ecosystems of the Fourth Assessment Report of IPCC «Climate Change 2007» Working Group II
• Climate is important
• Climate change is real and human made
• Climate change can impact all sectors, including human health
• Climate change poses huge challenges:
  – Climate change effects are delayed
  – Impacts are uneven, geographically and socially
• It matters a great deal whether and how we solve the climate change challenge!
Climate Is Important!
Lucerne \(~4\rightarrow 23\) Ma BP (Miocene)

Lucerne \(18000\) a BP (>LGM)
# Context of Past Epochs

## Phanerozoic

### Cenozoic

#### Paleogene
- Paleocene
- Eocene
- Oligocene

#### Neogene
- Miocene

#### Quaternary
- Pleistocene
- Holocene

### System Period

<table>
<thead>
<tr>
<th>Series Epoch</th>
<th>Stage Age</th>
<th>Age Ma</th>
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<tbody>
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<td></td>
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<td>11.608</td>
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<td>Chattian</td>
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<td></td>
<td>Maastrichtian</td>
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### Age

- 65.5±0.3 Ma

### Global Standard Section and Point (GSSP)

[www.stratigraphy.org/](http://www.stratigraphy.org/)
On IPCC

Intergovernmental Panel on Climate Change
Nobel Peace Prize 2007 for IPCC
1) Wide Authorship

- 1369 Authors
- >2500 Reviewers
- >130 Countries
- 3 TSUs
2) Transparent

Recruitment of authors

- Sep 2004: LA1 (Lead Author 1)
- Dec 2004: LA1 (0th Draft)
- Mar 2005: LA2
- Aug 2005: 1st Draft
- Jan 2006: LA3
- Apr 2006: 2nd Draft
- Sep 2006: LA4
- Nov 2006: 3rd Draft
- Apr 2007: Plenary
IPCC Key Points

- Governments need information
- IPCC formed 1988 under auspices of the UN
- Has to provide assessments of science of climate change
- Scientific community contributes widely and on a voluntary basis (fluctuation 75% TAR->AR4)
- Substance of IPCC reports in hands of scientists
Impressions From Kyoto 1
IPCC Key Points

- Governments need information
- IPCC formed 1988 under auspices of the UN
- Has to provide assessments of science of climate change
- Scientific community contributes widely and on a voluntary basis (fluctuation 75% TAR->AR4)
- Substance of IPCC reports in hands of scientists
Anthropogenic climate change is real

Unmitigated climate change would cause major impacts

A drastic climate change is still avoidable
Anthropogenic climate change is real

Unmitigated climate change would cause major impacts

A drastic climate change is still avoidable
Anthropogenic climate change is real

Unmitigated climate change would cause major impacts

A drastic climate change is still avoidable
Anthropogenic climate change is real. Unmitigated climate change would cause major impacts. A drastic climate change is still avoidable.
Does Climate Change?
So-called counter-evidence?
So-called counter-evidence?
So-called counter-evidence?

1945 - 1950
So-called counter-evidence?

![Chart showing data points from 1850 to 2000 with a highlighted area from 1976 to 1981. The chart indicates there is None! in the highlighted period.]
Observed Temperatures

11 out of 12 years (1995–2006) are warmest ever measured!

Ranking 12 warmest:

After Figure TS.6 (IPCC, 2007b. Technical Summary (TS) WGI)
Observed Temperatures

Assuming no interannual autocorrelation

\[ p < 1.15 \times 10^{-24} \]

11 warmest out of 12 years
Observed Temperatures

After Figure TS.6 (IPCC, 2007b. Technical Summary (TS) WGI)

13 warmest years after 1990
(from 1880 – 2006)

p < 0.001

(autoregressive and long-memory “approach”)

Zorita et al., 2008. Geophys. Res. Let. 35
IPCC used several Temperature Records

Bad, bad cheating job!

Trenberth et al., 2007. IPCC WGI AR4
Unequivocal Warming

Trenberth et al., 2007. IPCC WGI AR4
Global vs. Local Warming:

In Switzerland twice as much warming!

(MeteoSchweiz)
Changes in Precipitation (1900-2005)

Smoothed anomalies (%) over continents

After Figure 3.14 (Trenberth et al., 2007. IPCC WGI)
Human Made?
Ex. CO₂

AIRS (Atmospheric Infrared Sounder) July 2008 CO2 (ppmv)
Greenhouse Gases

**CO₂**  Fossil fuels, Deforestation (Land use change)

**CH₄**  Livestocks, Landfills, Rice cultivation, Gas pipe leakages

**N₂O**  Fertilisation

**CFCs**  Heat pumps, cleaning etc.

Figure SPM.1 (IPCC, 2007a. Summary for Policy Makers (SPM) WGI)
Human and Natural Drivers of Climate Change

Radiative Forcing Components

- **CO₂ bulk**: On average, it stays more than 100 years in the atmosphere:
  - 75% - 4.5a; 50% - 27a;
  - 33% - 75a; 25% - 300a;
  - 20% - 500a; 10% ~40'000a

- **Human dominance**

Figure SPM.2 (IPCC, 2007a. Summary for Policy Makers (SPM) WGI)
Past Climate Change?
# Context of Past Epochs

## Phanerozoic

### Cenozoic

<table>
<thead>
<tr>
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<th>Neogene</th>
<th>Quaternary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eocene</td>
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<td>Oligocene</td>
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</table>

<table>
<thead>
<tr>
<th>Maestrichtian</th>
<th>Danian</th>
<th>Selandelian</th>
<th>Thanetian</th>
<th>Ypresian</th>
<th>Lutetian</th>
<th>Bartonian</th>
<th>Priabonian</th>
<th>Rupelian</th>
<th>Chattian</th>
<th>Aquitanian</th>
<th>Burdigalian</th>
<th>Langhian</th>
<th>Serravallian</th>
<th>Tortonian</th>
<th>Messinian</th>
<th>Zanclean</th>
<th>Placenzian</th>
<th>Gelasian</th>
<th>Calabrian</th>
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<td>13.82</td>
<td>11.608</td>
<td>7.246</td>
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<td>3.600</td>
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<td>0.781</td>
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<td></td>
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## GSSP

International Commission on Stratigraphy

Global Standard Section and Point (GSSP)

[www.stratigraphy.org/](http://www.stratigraphy.org/)
Was it the sun?
Evidence from the past: 650’000 a BP (ice cores)

2009: ~387 ppm

CO₂

Temperature °C

280 ppm

(Siegenthaler et al., 2005)
Past Climate Changes

Yes, it was the sun!

Milankovitch cycles und past ice ages

Obliquity: 41’000s
Precession.: 23’000s
Eccentricity: 100’000s
Current Climate Change?
Is it now also the sun?

No!
Do We Humans Cause It?

Yes!

It’s us!

Not the sun!

Figure SPM.4. IPCC, 2007. SPM WG I
Future Changes?
Warming Over Present Levels

Figure SPM.5: Multi-model global averages of surface warming (relative to 1980–1999) for the scenarios (IPCC, 2007. Summary for Policy Makers WGI)

- Post-SRES range (80%)
- B1
- A1T
- B2
- A1B
- A2
- A1FI
- Year 2000 constant concentrations
- 20th century

Global surface warming (°C)

Year

+6.4°C
+4°C
+1.8°C
+1.1°C
Figure 10.8: Projected surface temperature changes - multimodel means (Meehl et al., 2007. IPCC WGI)
Warming Unevenly Distributed
(IPCC A2 SRES ~2100)

IPCC, 2007. SPM WG I
Is climate change real? Human made? Dangerous?

Yes!

Yes!
Anthropogenic climate change is real. Unmitigated climate change would cause major impacts. A drastic climate change is still avoidable.
Any Impacts?
Since 1970 observed impacts on physical and biological systems

577 studies, 28’671 data series: 94% physical, 90% biological systems match warming expectation of 1970-2004!

IPCC, 2007c. SPM WGII
Unsere Gletscher schmelzen

Morteratsch glacier
Thawing of Permafrost and Glacier Retreat
Thawing of Permafrost and Glacier Retreat
Biological Systems - E.g. Phenology


MeteoSwiss - Federal Office of Meteorology and Climatology
MeteoSchweiz - Bundesamt für Meteorologie und Klimatologie

Bud break

1808

2006 2007 ?
Future Climate Change Impacts?
Global Warming Affects All Sectors

The warmer the more negative impacts!
## Global Warming Affects All Sectors

**IPCC, 2007c, WGII SPM**

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>WATER</th>
<th>ECOSYSTEMS</th>
<th>FOOD</th>
<th>COASTS</th>
<th>HEALTH</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Increased water availability in moist tropics and high latitudes**</td>
<td>Up to 30% of species at increasing risk of extinction**</td>
<td>Complex, localised negative impacts on small holders, subsistence farmers and fishers**</td>
<td>Increased damage from floods and storms**</td>
<td>Increasing burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases**</td>
</tr>
<tr>
<td>1</td>
<td>Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes**</td>
<td>Most corals bleached**</td>
<td>Tendencies for cereal productivity to decrease in low latitudes**</td>
<td>About 30% of global coastal wetlands lost**</td>
<td>Increased morbidity and mortality from heat waves, floods, and droughts**</td>
</tr>
<tr>
<td>2</td>
<td>Hundreds of millions of people exposed to increase water stress**</td>
<td>Widespread coral mortality**</td>
<td>Tendencies for some cereal productivity to increase at mid- to high latitudes**</td>
<td>Millions more people could experience coastal flooding each year**</td>
<td>Changed distribution of some disease vectors**</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Terrestrial biosphere tends toward a net carbon source as: ~15%** Ecosystem changes due to weakening of the meridional overturning circulation**</td>
<td>Productivity of all cereals decreases in low latitudes**</td>
<td></td>
<td>Substantial burden on health services**</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Cereal productivity to decrease in some regions**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- ** indicates medium strength of evidence.
- * indicates strong evidence.

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Andreas Fischlin — Coordinating Lead Author IPCC AR4 — ETH Zurich, Switzerland
Human Health?
How Climate Change Affects Health

Confalonieri et al., 2007. Health. IPCC AR4 WGII, Fig. 8.1
Health Impacts Summary

- Large differences (regional, social)
- Likely Millions affected
- Child growth affected by malnutrition => health consequences (incl. adult)
- Injuries, deaths, illnesses due to heat waves, floods, storms, fires (yet less cold victims)
- Cardio-respiratory morbidity and mortality incl. O$_3$ diseases and diarrhoeal diseases
- Changes for vector transmitted diseases (Malaria, Dengue, Filariasis, Schistosomiasis)
Water
Freshwater Supply and Climate Change

IPCC SRES A1B

1: Thickness of small island freshwater lens declines from 25 to 10 m due to 0.1 m sea level rise by 2040-2080

2: Streamflow decreases such that present water demand could not be satisfied after 2020, and loss of salmon habitat

3: Groundwater recharge decreases by more than 70% by the 2050s

4: Flooded area for annual peak discharge in Bangladesh increases by at least 25% with a global temperature increase of 2°C

5: Electricity production potential at existing hydropower stations decreases by more than 25% by the 2070s

6: Increase of pathogen load due to more heavy precipitation events in areas without good water supply and sanitation infrastructure

Adger et al, 2007 - Kundzewicz & Mata, 2007 - IPCC AR4
Precipitation Changes (Summer)

- Precipitation at high latitudes **very likely** to increase
- Precipitation at low latitudes **likely** to decrease

Figure SPM.7: Relative changes in precipitation 2090-2099 vs. 1980-1999 (IPCC, 2007a. SPM WGI)
Runoff from the Swiss Alps

Mean Runoff [mm/day]

Winter  Spring  Summer  Fall

after Beniston, 2007

IPCC SRES A2

Runoff from the Swiss Alps
Runoff from the Swiss Alps

Mean Runoff [mm/day]

Winter Spring Summer Fall

2071-2100 1961-1990

after Beniston, 2007

IPCC SRES A2
Runoff from the Swiss Alps

Mean Runoff [mm/day]

Winter
+90%

2071-2100

1961-1990

after Beniston, 2007

IPCC
SRES A2
Runoff from the Swiss Alps

Mean Runoff [mm/day]

Winter +90%
Spring -5%
Summer -45%
Fall -30%

2071-2100
1961-1990

after Beniston, 2007

IPCC SRES A2
Runoff from the Swiss Alps

Mean Runoff [mm/day]

- Winter: +90%
- Spring: -5%
- Summer: -45%
- Fall: -30%

Increased flood risk
Increased drought risk

after Beniston, 2007
Heavy Precipitation Events

Winter


+75%
A World of Drought

- Many dry areas are getting drier as soils dry out
- Observed sea surface temperature (SST) and links to the pattern of rain in Africa?
- SSTs and Sahelian rainfall have varied in the past
- Some studies suggest links now to the widespread ocean SST trends and global warming
More Heat Spells - European Trends

Anomalies from mean summer temperatures (JJA)

2003
Changes In Extremes - R, Drought

Figure 10.18: Multi-model projections of changes in extremes (Meehl et al., 2007. IPCC WGI)
Indirect Effects
Food: Quantity and Quality
Agricultural Yields and CO$_2$-fertilisation
Agroproductivity by 2050
without adaptation

~2050 change

+ cereals
− stock

Easterling et al., 2007. Figure 5.4: Agroproductivity (IPCC, 2007. WGII)
Animal borne Diseases
Malaria
### People at Risk of Malaria ~2080

<table>
<thead>
<tr>
<th>Region</th>
<th>A1F1</th>
<th>A2</th>
<th>B1</th>
<th>B2</th>
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<td>&gt; 3</td>
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<td>World</td>
<td>100</td>
<td>227</td>
<td>−141</td>
<td>416</td>
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</table>

van Lieshout et al., 2004. Global Environ. Change
MOSCOW, August 5 (Itar-Tass) — Forest fires burning peat leaves no chance for a gulp of fresh air as the people increasingly angry about the authorities, who fail to react to the situation.

The death toll from the disasters has risen to 14. 13 of Belarus, 2 of the Constitutional territories of Russia. According to the Russian government, 111,500 hectares of forest and peat land burned in the past 14 days.

Of the 24 peat fires 13 are in the Moscow Region — the region where the choking smog more than anybody else. In the Moscow, Tver, Leningrad and Vologda regions visibility was no more than 100 meters.

In some areas of the city the quality of air pollution exceeds the level 45 times the tolerance limit. For example, in the Krasnogorsk region dirty smoke is so strong that two or three packs of cigarettes over several hours. A local air quality Crisis Center is providing advice: wear a mask while outdoors, if possible, and to wear wet masks outdoors.
Observed Trends of Increasing Fire Prevalence
mostly in boreal and subtropical zones

Section 4.4.5 (Fischlin et al., 2007. IPCC WGII)
Observed Trends of Increasing Fire Prevalence
mostly in boreal and subtropical zones

Section 4.4.5 (Fischlin et al., 2007. IPCC WGII)
Storms
Floods, Storms, Fires and Other Extreme Events Cause Injuries and Deaths (direct exposure)
Temperature
Frequency of Extreme Events

Fig. 2.32, Folland et al., 2001. IPCC WGI TAR

Biggest Effect if both mean and variance become bigger
Frequency of Extreme Temperatures

-Alcamo et al., 2007. Regional chapter: Europe. IPCC WGII (after Schär et al., 2004)
Heat Days and Tropical Nights

Dramatic increases in low-altitude river basins of southern Europe

Number of days with Tmax > 35°C and Tmin > 20°C

(Fischer & Schär, 2009, ENSEMBLES, submitted, mean of 5 models)
Prevalence of Heat Stress

Number of days with apparent temperature ≥ 42°C
(large heat stroke risk with extended exposure)

Particularly Impacted River Basins:
- Tagus
- Ebro
- Rhone
- Po
- Tiber
- Danube
- etc.

2061-2990
Apparent temperature (heat index > 90) based on T and air humidity

Impacted Cities:
- Lisbon
- Seville
- Cordoba
- Marseille
- Milan
- Roma
- Napels
- Budapest
- Belgrade
- Bucharest
- Thessaloniki
- Athens
- etc.

(Fischer & Schär 2009, mean of 5 ENSEMBLES models)
Swiss Temperature Series 1864-2002

Average of 4 Stations: Zürich, Basel, Berne, Geneva
Swiss Temperature Series 1864-2003

Average of 4 Stations: Zürich, Basel, Berne, Geneva
Swiss Temperature Series 1864-2003

Average of 4 Stations: Zürich, Basel, Berne, Geneva
Other Swiss Temperatures Breaking Records

**July**

**Fall**

**April**
Summary
Impacts on Human Health

The warmer, the more negative the impacts!

From Figure SPM.2
Future Impacts?

Plenty!
Including some fatal ones!
Anthropogenic climate change is real.

Unmitigated climate change would cause major impacts.

A drastic climate change is still avoidable.
What Can Be Done?
Adaptation AND Mitigation
Warming Over Present Levels

Figure SPM.5: Multi-model global averages of surface warming (relative to 1980–1999) for the scenarios (IPCC, 2007. Summary for Policy Makers WGI)
Warming Over Present Levels

Figure SPM.5: Multi-model global averages of surface warming (relative to 1980–1999) for the scenarios (IPCC, 2007. Summary for Policy Makers WGI)

0.74 + 0.6 = 1.34°C
+0.6°C
Adaptation AND Mitigation
Current atmosphere 777 GtC
Need We Mitigate? By How Much?
Max 2°C?

Equilibrium global mean temperature above pre-industrial (°C)

Reductions of GHG emissions required from Annex I countries:

2020: -25% .. -40% (vs. 1990)
2050: -80% .. -95% (vs. 1990)

(Gupta et al., 2007. IPCC AR4 WGIII)

In Developing Countries:

2020: -15% .. -30% (vs. BAU)

Reasons of Concern

Knowledge TAR 2001

Smith et al., 2009. PNAS u. Fischlin, 2009
Reasons of Concern

Knowledge AR4 2007

Smith et al., 2009. PNAS u. Fischlin, 2009
Reasons of Concern

Knowledge

TAR 2001

Smith et al., 2009. PNAS u. Fischlin, 2009
Reasons of Concern

Knowledge AR4 2007

Safety Mar-gins?

Fischlin, 2009. GAIA, 18: 193-199
Need We Mitigate?
By How Much?

Yes! A Lot!
No, since ...
Global CO₂ Emissions

Figure SPM.3: GHG emissions in 2004 by sectors [CO₂-eq]. IPCC, 2007. WGIII SPM.
High Technical and Economic Reduction Potentials by 2030es

Total: 78% of 1990 Emissions
Really Too Costly?

GDP without mitigation

GDP with stringent mitigation

<1 year

~2030

3%
Cumulative Emissions [1751-2004]

Flux in 2004

Flux Growth in 2004

Population in 2004

D3-Least Developed Countries

D2-Developing Countries

India

China

FSU

Japan

EU

USA

National & Regional Share of Fossil Fuel Emissions

Raupach et al. 2007, PNAS
Responsibilities for Composition of Atmosphere in 2000

Höhne, N., et al., 2007. Ad-hoc group for modelling and assessment of historic contributions to climate change, Ecofys Germany
Fig. SPM.3a: Per capita GHG emissions (all Kyoto gases, including LULUCF). IPCC, 2007. SPM WG III
Summary:

- Climate is important
- Climate change is real and human made
- Climate change can impact all sectors, including human health
- Climate change poses huge challenges:
  - Climate change effects are delayed
  - Impacts are uneven, geographically and socially
- It matters a great deal whether and how we solve the climate change challenge!
Thanks for your attention!