Latest findings in climate research: 
a global perspective

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Overview

1. 20\textsuperscript{th}-century climate change: why it was unusual

2. Temperature rise and CO\textsubscript{2}: why we are certain

3. The 2 °C-target and CO\textsubscript{2} emissions
Observations since 1850 demonstrate warming of the climate system

- Global average surface temperature (°C)
- Global average sea-level change (mm)
- Northern-Hemisphere snow cover (million km²)

IPCC (2007)
Climate change has always happened – so what was special about the 20th century?

- Transition from ice age to Holocene:
  - Global average warming: about 5 ºC
  - Duration about 5000 years

- Ice Age → Holocene: 1 ºC warming in 1000 years
- 20th century: 1 ºC warming in 100 years

- Humanity is warming climate at least ten times faster than nature ever could
MPI-M-Model for IPCC 5th Assessment Report: In all scenarios, temperature will rise even more in 21st century.
We do understand why the temperature rises. Thought experiment: Change in global mean surface temperature if CO₂ is doubled

- Greenhouse effect only by CO₂: 1 °C warming
  - Simple physics; very well understood for over half a century
- Greenhouse effect by additional water vapour in atmosphere: additional 1 °C warming
  - Not so simple, but robust evidence from observations and models
- Effect due to change in clouds, which cool during the day and warm during the night: additional 0 °C to 2.5 °C
  - Biggest uncertainty in climate science for decades
- In total 2 °C to 4.5 °C warming under doubling of CO₂ concentration (climate sensitivity)

- What is the value of climate sensitivity? Core question in climate research
- How high is future CO₂ concentration?

IPCC (2007, WG1, S. 12, 631, 633)
The 2 °C-target can be met if scenario RCP2.6 is followed…
...but anthropogenic CO₂ emissions must decrease after 2020 – by 2100 to 10% of year-2000 levels
Where do we stand? CO$_2$ emissions from fossil fuels increase almost as fast as in the “highest” scenario.

Manning et al. (2010), Boden and Blasing (2011)
Summary

1. Global anthropogenic warming is happening
   - In its basics it is well understood.
   - Considerable uncertainty persists about its future strength.

2. 2°C-target: The CO₂ emissions must peak by 2020 and by 2100 must be reduced to 10% of year-2000 levels.

Thank you for your attention!
Climate Change Impacts
A World Transformed

Wolfgang Lucht, Chair in Sustainability Science
Potsdam Institute for Climate Impact Research & Humboldt University Berlin
Risks to Many
Large Increase
Negative for Most Regions
Net Negative in All Metries
Higher

+5°C

+4°C

+3°C

+2°C

+1°C

0°C

Risk to Some Regions; Positive for Others
Positive or Negative Market Impacts; Majority of People Adversely Affected
Very Low

Risks to Some
Increase
Negative for Some Regions; Positive for Others

4th IPCC Assessment Report 2007

Update Smith et al., PNAS 2009

current non-binding pledges

2 degree warming target

Risks of Large-Scale Discontinuities
Aggregate Impacts
Spatial Distribution of Impacts
Risk of Extreme Weather Events
Risk to Unique and Threatened Systems

„Reasons for Concern“
Tipping Elements in the Earth System
System State Change when Thresholds are Crossed

Source: updated after Lenton et al. 2008; Schellnhuber PIK, 2011
Worst Case Scenario for Monsoon Development

Zickfeld et al. 2005, GRL 32, 15707
Lower River Volume from Glacier Melt
Excessive Heat (>40°C)

Sea Level Rise & Low Areas
Potential Monsoon Instability

India
the 4-fold impacts of climate change
Regionally Strong Impact on Water Supply
Example: Inner Niger Delta (Mali/Guinea)

Mean daily discharge 2031-2050 at Koulikoro

River Discharge
(with use of Sélingué reservoir)

+ 1°C

+ 2°C

Day of the Year

Climate Change simulations with a statistical model in line with GCM trends.
Hydrological simulations with a detailed regional hydrological model.

Liersch, Hattermann et al., PIK, submitted 2011
... with Large Impacts on Rice Supply and Demand: Climate Change & Population Growth (to 2050)

Inner Niger Delta (with reservoir operation & without expansion of irrigation)

Rice is a major agricultural product (next to fishing and grazing)

Liersch, Hattermann et al., PIK, submitted 2011
Climate change: A huge additional factor of uncertainty in African agriculture

Müller et al., PNAS, 2011
Example Africa: Dependence of GDP on Rainfall Variations

Source: GDP Growth: Worldbank 2006
Rainfall variations: station Sima from African Rainfall and Temperature Evaluation System (ARIES) database
Flood-Related Damages in Germany

Projection of flood related damages on private houses and small enterprises: SWIM driven by the regional climate models REMO and CCLM (7 climate realizations in total). Damage functions provided by the German Insurance Association (GDV).

500 Million Euro is the observed and simulated average in the reference period 1961-2000.
World ecosystems will be rattled, start shifting

Severe ecosystem change
($\Gamma \geq 0.3$, biogeochemical and structural shifts; LPJ–DGVM)

Global land area affected

considerable ecosystem change ($\Gamma > 0.3$)

+2°C  +3°C  +4°C  +5°C

Global mean temperature increase in the year 2100

Heyder et al., Env. Res. Lett., 2011; Ostberg et al., unpublished, PIK 2011
Arctic sea ice is melting faster than expected

Sea level is rising faster than expected

Copenhagen Diagnosis, 2009
Sea Level Rise

Data:
Church and White (2006)
Scenarios 2100:
50 – 140 cm (Rahmstorf 2007)
55 – 110 cm ("high end", Delta Committee 2008)
Scenarios 2200:
150 – 350 cm ("high end", Delta Committee 2008)
Scenarios 2300:
250 – 510 cm (German Advisory Council on Global Change, WBGU, 2006)
At a Crossroads: Separating Two Different Worlds

Current Situation: Agreeing on... Meinshausen et al. in press

Actual trajectory

Agreed target