Climate Change: Challenges and Opportunities

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“... The sum of all likely fossil-fuel demands in the early decades of the [21st] century might … greatly increase the emission of carbon dioxide into the atmosphere and by doing so bring up average surface temperature uncomfortably close to that rise of 2°C which might set in motion the long-term warming up of the planet.”

Possible adverse effects from predicted climatic changes affecting Malta could occur because the « greenhouse effect » (...). Changes in the global atmosphere may occur even sooner than some scientists have predicted and are mainly the result of man’s industrial activities and the scant regard he has at times paid to the effects resulting from his intimate interactions with the environment.
Introduction

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Warming is Unequivocal

- Rising atmospheric temperature
- Rising sea level
- Reductions in NH snow cover
Extension of the Arctic ice cap

September 1979

September 2005

September 2007

The pink line indicates the average ice cap extension since 1979
Energy cycle without greenhouse effect

Solar radiation

- 100%
- 20%
- 50%

26%

4%

Infrared

-18°C
Energy cycle *with* greenhouse effect

Solar radiation

- 100%
- 20%
- 50%

Clouds

- 26%
- 4%

Convection, etc...

- 30%

Infrared

- 60%
- 10%

Water vapor ($H_2O$)

- 105%

Carbon dioxide ($CO_2$)

- 95%

+15°C
CO₂ concentration measured at Mauna Loa (3400 m)

Source: Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/)
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Expected CO$_2$-concentrations are higher than observed at any time over last 800 000 years.
Carbon cycle

Units: GtC (billions tons of carbon) or GtC/year

Atmosphere
pre-ind: 597

partie III
Ocean
38000

partie IV
Combustibles fossiles (charbon, pétrole, gaz naturel)
3700

partie II
Physical, Chemical, and Biological processes
70.5

partie I
photosynthesis
120
respiration
119.5
décomposition
2300
matière organique en décomposition
rivières
1

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Carbon cycle

Units: GtC (billions tons of carbon) or GtC/year

partie I
- photosynthesis
  120
- 2.6 sinks
- matière organique en décomposition
- décomposition
  2300
  -40
- rivière

partie II
- physical, chemical, and biological processes
  119.5
- respiration
  70
- 70.5

partie III
- déforestation (& land use changes)
  1.6

partie IV
- Fossil fuels
  6.4
- Combustibles fossiles

Atmosphere
pre-ind : 597 + 3.2/an

Ocean
- 38000 +120

Units: GtC (billions tons of carbon) or GtC/year

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Number of papers published on climate change
Why the IPCC?

Established by WMO and UNEP in 1988

to provide policy-makers with an objective source of information about

• causes of climate change,
• potential environmental and socio-economic impacts,
• possible response options.
What is the IPCC (GIEC in French) ?

- IPCC : Intergovernmental Panel on Climate Change
- Created by World Meteorological Organisation (WMO) & United Nations Environment Programme (UNEP) in 1988
- Mandate : assess the science of climate change, impacts and adaptation, mitigation options
- Advises Climate Change Convention
- Nobel Peace prize (2007)
- Web : http://www.ipcc.ch
IPCC Reports are policy-relevant, NOT policy-prescriptive
The IPCC Fourth Assessment Report (2007)

+130 countries

around 450 lead authors

around 800 contributing authors

+2500 scientific expert reviewers

+18000 peer-reviewed publications cited

+90000 comments from experts and Governments
Next IPCC Report
(published 9 May 2011)

Special Report on Renewable Energy Sources and Climate Change Mitigation
IPCC Working Group I: climatology

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Attribution

Are observed changes consistent with expected responses to natural forcings?

IPCC (2007): “Warming is unequivocal, and most of the warming of the past 50 years is very likely (90%) due to increases in greenhouse gases.”
Climate projections without mitigation


Global GHG emissions (GtCO₂-eq / yr) vs. Year

Global surface warming (°C) vs. Year

Post-SRES (max)
Post-SRES (min)

Post-SRES range (80%)
A1B
B1
A2
A1Fl
A1T
B2
Year 2000 constant concentrations
20th century

NB: écart par rapport à la moyenne 1980-1999

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IPCC lower estimate by 2100

IPCC upper estimate by 2100

Last ice age.

Temperature change (°C) from today's average

Years before present

Glaciers retreat from Britain.

Growth of civilization
Multi-model mean changes in precipitation (mm/day) (2090 relative to 1990, A1B scenario)

IPCC, AR4, WGI, Ch. 10, p.769, Fig. 10.2
Projected regional change over the 21st century

- Seasonally, the largest warming is *likely* to be in northern Europe in winter and in the **Mediterranean area** in summer

- Annual precipitation is *very likely* to increase in most of northern Europe and decrease in most of the **Mediterranean area**

- The annual number of precipitation days is *very likely* to decrease in the Mediterranean area

- Risk of summer drought is *likely* to increase in central Europe and in the **Mediterranean area**

IPCC, AR4, WGI, Ch. 11, p.850
More heavy precipitation and more droughts....
More heavy precipitation and more droughts....
## Climate change and extremes (IPCC AR4 WG1)

<table>
<thead>
<tr>
<th>Phenomenon and direction of trend</th>
<th>Likelihood that trend occurred in late 20th century (typically post 1960)</th>
<th>Likelihood of a human contribution to observed trend</th>
<th>Likelihood of future trends based on projections for 21st century using SRES scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer and fewer cold days and nights over most land areas</td>
<td>Very likely</td>
<td>Likely</td>
<td>Virtually certain</td>
</tr>
<tr>
<td>Warmer and more frequent hot days and nights over most land areas</td>
<td>Very likely</td>
<td>Likely (nights)</td>
<td>Virtually certain</td>
</tr>
<tr>
<td>Warm spells / heat waves. Frequency increases over most land areas</td>
<td>Likely</td>
<td>More likely than not</td>
<td>Very likely</td>
</tr>
<tr>
<td>Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas</td>
<td>Likely</td>
<td>More likely than not</td>
<td>Very likely</td>
</tr>
<tr>
<td>Area affected by droughts increases</td>
<td>Likely in many regions since 1970s</td>
<td>More likely than not</td>
<td>Likely</td>
</tr>
<tr>
<td>Intense tropical cyclone activity increases</td>
<td>Likely in some regions since 1970</td>
<td>More likely than not</td>
<td>Likely</td>
</tr>
<tr>
<td>Increased incidence of extreme high sea level (excludes tsunamis)</td>
<td>Likely</td>
<td>More likely than not</td>
<td>Likely</td>
</tr>
</tbody>
</table>

Virtually certain > 99%, very likely > 90%, likely > 66%, more likely than not > 50%
What if the Gulf Stream is affected?

- Based on current model simulations, it is very likely that the meridional overturning circulation (MOC) of the Atlantic Ocean will slow down during the 21st century.
  - longer term changes not assessed with confidence
- Temperatures in the Atlantic region are projected to increase despite such changes due to the much larger warming associated with projected increases of greenhouse gases.
Ice sheet melting

• Melting of the Greenland ice sheet
  – Total melting would cause 7 m SLR contribution
• Melting of the West Antarctic Ice Sheet
  – Total melting would cause 5 m SLR contribution
• Warming of 1 – 4°C over present-day temperatures would lead to partial melting over centuries to millennia
IPCC Working Group II: Impacts, Vulnerability, and Adaptation
Figure SPM.2. Key impacts as a function of increasing global average temperature change (Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway)

**Global mean annual temperature change relative to 1980-1999 (°C)**

**WATER**
- Increased water availability in moist tropics and high latitudes
- Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes
- Hundreds of millions of people exposed to increased water stress

**ECOSYSTEMS**
- Up to 30% of species at increasing risk of extinction
- Increased coral bleaching
- Widespread coral mortality
- Terrestrial biosphere tends toward a net carbon source as:
  - ~15%
  - ~40% of ecosystems affected
- Ecosystem changes due to weakening of the meridional overturning circulation

**FOOD**
- Complex, localised negative impacts on small holders, subsistence farmers and fishers
- Tendencies for cereal productivity to decrease in low latitudes
- Productivity of all cereals decreases in low latitudes
- Tendencies for some cereal productivity to increase at mid- to high latitudes
- Cereal productivity to decrease in some regions

**COASTS**
- Increased damage from floods and storms
- About 30% of global coastal wetlands lost
- Millions more people could experience coastal flooding each year

**HEALTH**
- Increasing burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases
- Increased morbidity and mortality from heat waves, floods, and droughts
- Changed distribution of some disease vectors
- Substantial burden on health services

\[\text{Global mean annual temperature change relative to 1980-1999 (°C)}\]

\(^{\dagger}\) Significant is defined here as more than 40%.

\(^{\ddagger}\) Based on average rate of sea level rise of 4.2 mm/year from
Figure TS.6. Projected risks due to critical climate change impacts on ecosystems

- > 4°C: Major extinctions around globe (as exemplified for USA and Australia)
- ≥ 40% of global ecosystems transformed (culminating in biome changes)
- Few ecosystems can adapt; 50% of nature reserves cannot fulfill their objectives
- Extinction of 15-40% endemic species in global biodiversity hotspots

- Widespread coral mortality (reefs overgrown by algae)
- Major changes in polar systems; Globally, ~20-30% of species committed to extinction
- Extinction risk for polar species; Risk terrestrial biosphere becomes net C source
- ≥ 15% of global ecosystems transformed (culminating in biome changes)
- Major (~20-80%) loss of Amazon rainforest and its biodiversity
- Loss of ~50-65% fynbos, ~10-80% of various fauna in S. Africa
- ~40-50% loss of endemic plants in S. Africa, Namibia
- Major (~50%) loss of rainforest habitat in Queensland
- Coral reefs bleached
- ~10-15% of species committed to extinction
- Loss of 8% freshwater fish habitat in N. America
- Polar ecosystems increasingly damaged
  - Increased coral reef bleaching
  - Amphibian extinctions increasing on mountains
20% - 30% of plants and animals species likely at “increased risk of extinction”

if $\Delta T$ 1.5°C - 2.5°C (above 1990 temperature)
Figure TS.7. Sensitivity of cereal yield to climate change
Effects on Nile delta: 10 M people above 1m

(Time 2001)
With 1 metre sea-level rise: 63000 ha below sea-level in Belgium (likely in 22nd century, not impossible in 21st century) (NB: flooded area depends on protection)

Source: N. Dendoncker (Dépt de Géographie, UCL), J.P. van Ypersele et P. Marbaix (Dépt de Physique, UCL) (www.climate.be/impact)
With 8 metre sea-level rise: 3700 km$^2$ below sea-level in Belgium
(very possible in year 3000)
(NB: flooded area depends on protection)

Source: N. Dendoncker (Dépt de Géographie, UCL), J.P. van Ypersele et P. Marbaix (Dépt de Physique, UCL) (www.climate.be/impact)
Daily mortality in Paris (summer 2003) (IPCC AR4 Ch 8)
Mediterranean ecosystems: Key vulnerabilities (1)

Threats from desertification were projected due to expansion of adjacent semi-arid and arid systems under relatively minor warming and drying scenarios.

Warming and drying trends are likely to induce substantial species-range shifts, and imply a need for migration rates that will exceed the capacity of many endemic species.
Mediterranean ecosystems: Key vulnerabilities (2)

Vegetation structural change driven by dominant, common or invasive species may also threaten rare species. Overall, a loss of biodiversity and carbon sequestration services may be realised over much of these regions.

IPCC, AR4, WGII, Ch. 4, p.226
Key hotspots of societal vulnerability in coastal zones: Mediterranean

- Coastal areas subject to multiple natural and human-induced stresses, such as subsidence or declining natural defences

- Coastal areas with tourist-based economies where major adverse effects on tourism are likely

IPCC, AR4, WGII, Ch. 6, p.337, Table 6.8.
I Risks to unique and threatened systems
II Risks from extreme climate events
III Distribution of Impacts
IV Aggregate Impacts
V Risks from large-scale discontinuities

Source: IPCC TAR WG2 (2001)
What does IPCC tell us on mitigation?

♀WG3: Mitigation
The lower the stabilisation level the earlier global emissions have to go down.
All sectors and regions have the potential to contribute by 2030

Note: estimates do not include non-technical options, such as lifestyle changes.
The pricing of carbon is effective:

Negative correlation between fuel price and consumption

Source: Factor Four
Role of Technology, following IPCC AR4

- Energy conservation & efficiency
- Fossil fuel switch
- Renewables
- Nuclear
- CCS
- Forest sinks
- Non-CO₂

Cumulative emission reduction (GtCO₂-eq)

- 2000 - 2030
- 2000 - 2100

- Emissions reductions for 650 ppm
- Additional reductions for 490-540 ppm

IMAGE
MESSAGE
AIM
IPAC
N/A
Choice A…

• … is privileging the short-term and amounts to being as clever as the ostrich hiding her head in the sand
• … is like continuing to dance in the Titanic ballroom, while unaware of the approaching collision
Choice B

• Here, humanity pays more attention to the IPCC and to scientists who work on the subject
• Humanity uses the IPCC reports like radar antennas combined with GPS systems, which at the same time make it possible to anticipate the obstacle and to find an alternate way
• NB: Radars and GPS which missed on Titanic
• Humanity sees the beauty and the fragility of the branch on which we are all seated
• Humanity understands that the Sun provides us each hour the same quantity of energy as what humanity consumes in total in one year.

• Visionary leaders and actors at all levels see the opportunities offered by a long-term and sustainable vision, including in profitability (among other reasons because non-renewable energy and other natural resources will become more costly; being super-efficient means being more competitive as well).
What did « The Economist » say in 1990 already?

• “Being dirty has lots of costs: being greener than the competition may have many advantages”

• “For far-sighted companies, the environment may turn out to be the biggest opportunity for enterprise and invention the industrial world has seen.”

(Frances Cairncross, The Economist, 8 September 1990)
Warming has not « stopped »: Global (land & ocean) mean surface temperature change from NASA GISS until 2010

Global Land–Ocean Temperature Temperature Index

Annual Mean

5–year Running Mean

Temperature Anomaly (°C)

1880 1900 1920 1940 1960 1980 2000

Source: NASA GISS
A wise man said this at a recent UN climate conference:

…The Zen practice of breaking through mental boundaries provides a good theme for the days ahead when negotiators would have to break through the tendency to consider the short-term costs while neglecting the long-term economic opportunities. *(Michael Zammit Cutajar, Kyoto, 1997)*
Let us break the mental barriers Michael Zammit Cutajar mentioned in Kyoto in 1997, because we only have one of these...

Painting by the Maltese artist Luciano Micallef

This painting commemorates the 20th anniversary of when Malta proposed the concept of ‘conservation of climate as part of the common concern of mankind’ in the UN General Assembly.

Source: MINISTRY for RESOURCES and RURAL AFFAIRS
Useful links:

- www.ipcc.ch : IPCC
- www.unfccc.int : Climate Convention
- www.skepticalscience.com: answers to « skeptics »
- www.climate.be/vanyp : my slides and other documents