The Challenge of Climate Change: Also an Opportunity

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(*) SDEWES-12 = 12th Conference on Sustainable Development of Energy, Water, and Environment Systems
Yesterday, 4 October, was the 60th anniversary of the Sputnik-1 launch in 1957
Saturn, as seen on 25-4-2016 from a 3 million km distance by the Cassini satellite launched in October 1997, 40 years after Sputnik
That small blue dot is the Earth, a seen from Cassini, orbiting Saturn, 1.44 billion km from us, on 19-7-2013
Our atmosphere is thin and fragile
(as seen by ISS crew on 31 July 2013)

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Recovering Stratospheric Ozone Layer (our anti-UV shield), thanks to Montreal Protocol, according to Copernicus (EU Earth Observation Programme) 25-9-2017

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Lessons from the ozone hole recovery

- The Earth’s atmosphere is fragile
- Understanding it is crucial
- Human influence can threaten global habitability
- Determined human action can reverse the degradation of our environment and climate and put us on a sustainable development pathway

There are many opportunities associated

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Let us think about the future of these children from Machakos (Kenya) in a warming climate.

JPvY, April 2015
In Germany, many residents weren’t prepared for the mass flooding as the rain pelted down (May 2016)

Matthias Schrader / AP
In Puerto Rico, Hurricane Maria created in 2017 the worst humanitarian crisis in the US for decades.

Source: FEMA, 24-9-2017
Closer to here: 11 September 2017, Dubrovnik, after torrential rains (more frequent in a warming climate)

Source: The Dubrovnik Times
Lying With Statistics, Global Warming Edition

Global average temperature anomaly (1850-2015)

Source: NASA GISS
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 (adaptation & mitigation).

WMO=World Meteorological Organization
UNEP= United Nations Environment Programme
Inter-governmental Panel on Climate Change (IPCC): Organization Structure

- IPCC plenary comprises of all countries in the world
- IPCC Bureau comprises of 34 elected members; IPCC elects its Bureau every 6-7 years
- 3 Working Groups & a Task Force on National Greenhouse Gas Inventories
- Authors, Contributors, Reviewers, Review Editors
IPCC writing cycle (4 years, 831 Lead authors for AR5)

- Plenary decides table of content of reports
- Bureau appoints world-class scientists as authors, based on publication record
- Authors assess all scientific literature
- Draft – Expert review (+ Review editors)
- Draft 2 (+ Draft 1 Summary for Policy Makers (SPM)) – Combined expert/government review
- Draft 3 (+ Draft 2 SPM) – Government review of SPM
- Approval Plenary (interaction authors – governments) – SPM and full report
- NB: The scientists have the last word on what is in!
IPCC Assessment Reports

- FAR 1990
- SAR 1995
- TAR 2001
- AR4 2007
- AR5 WGI 2013
- AR5 WGII 2014
- AR5 WGIII 2014
- IPCC AR5 Synthesis Report
What is happening in the climate system?

What are the risks?

What can be done?
Key messages from IPCC AR5

→ Human influence on the climate system is clear
→ Continued emissions of greenhouse gases will increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems
→ While climate change is a threat to sustainable development, there are many opportunities to integrate mitigation, adaptation, and the pursuit of other societal objectives
→ Humanity has the means to limit climate change and build a more sustainable and resilient future
Temperature spiral

Global Mean Temperature in °C relative to 1850 – 1900

Graph: Ed Hawkins (Climate Lab Book) – Data: HadCRUT4 global temperature dataset
Available on http://openclimatedata.net/climate-spirals/temperature
2014, 2015, 2016= warmest years since 1880
Arctic Sea Ice Cover (1979-2016)

Northern Hemisphere Sea Ice Anomaly
Anomaly from 1979-2008 mean

-0.973
Plateau Glacier (1961)
(Alaska)


Greenland Ice Mass Loss 2002-2009
Derived From NASA GRACE Gravity Mission

Greenland

Velicogna, Geophysical Research Letters, 2009

•Contributes to sea level rise
Change in average sea-level change

(IPCC AR5 WGI (2013))
Coral reefs are dying

American Samoa (from www.globalcoralbleaching.org)
Atmospheric CO$_2$ concentration: the Keeling curve

Mauna Loa Observatory, Hawaii and South Pole, Antarctica
Monthly Average Carbon Dioxide Concentration

Source: https://scripps.ucsd.edu/programs/keelingcurve/

Red: Mauna Loa (Hawaii, 3400 m a.s.l);
Black: same data with seasonal correction
Energy Cycle Without Greenhouse Gases

Solar Radiation

20% 26% 4%

Infrared

-18°C
Energy Cycle with Greenhouse Gases

Solar Radiation

- 100%
- 20%
- 50%

26%

Convection, etc...

4%

Infrared

60%

10%

95%

+15°C

H₂O

CO₂

...
CO\textsubscript{2} Concentration, 25 May 2016
(Keeling curve)

Latest CO\textsubscript{2} reading
May 25, 2016


Source: scripps.ucsd.edu/programs/keelingcurve/
The concentrations of CO$_2$ have increased to levels unprecedented in at least the last 800,000 years.

(Lüthi et al., 2008, NOAA)
Carbon cycle: unperturbed fluxes

Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get GtCO₂)

Atmosphere
pre-ind: 597 GtC

partie III
Ocean
38000

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

Physical, Chemical, and Biological processes
70.5

respiration
119.5

photosynthesis
120

matière organique en décomposition
2300

décomposition

rivières
1

partie I

280 ppmv (1ppmv = 2.2 GtC)

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Carbon cycle: perturbed by human activities
(numbers for the decade 1990-1999s, based on IPCC AR4)

Atmosphere
- 280 ppmv + 1.5 ppmv/yr (1ppmv = 2.2 GtC)
- pre-ind : 597 GtC + 3.2/yr

Ocean
- 38000 +120

Fossil fuels
- 6.4
- Combustibles fossiles (charbon, pétrole, gaz naturel)
- 3700 -244

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

Stocks!

partie I
- photosynthesis: 120
- décomposition: 2300 -40

partie II
- respiration: 2.6 sinks
- Physical, Chemical, and Biological processes: 119.5

partie III
- 70
- 1.6 déforestation (& land use changes): 2.2

partie IV
- 70.5
- 6.4 Combustibles fossiles

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A Progression of Understanding: Greater and Greater Certainty in Attribution

AR1 (1990): “unequivocal detection not likely for a decade”


AR3 (2001): “most of the warming of the past 50 years is likely (odds 2 out of 3) due to human activities”

AR4 (2007): “most of the warming is very likely (odds 9 out of 10) due to greenhouse gases”

AR5 (2013) «It is extremely likely (odds 95 out of 100) that human influence has been the dominant cause... »
RCP Scenarios: Atmospheric CO₂ concentration

Three stabilisation scenarios: RCP 2.6 to 6
One Business-as-usual scenario: RCP 8.5
Only the lowest (RCP2.6) scenario maintains the global surface temperature increase above the pre-industrial level to less than 2°C with at least 66% probability.
18-20000 years ago (Last Glacial Maximum)
With permission from Dr. S. Joussaume, in « Climat d’hier à demain », CNRS éditions.
Today, with +4-5°C globally

With permission from Dr. S. Joussaume, in « Climat d’hier à demain », CNRS éditions.
North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)

IPCC WG1 Fifth Assessment Report (AR5)
Maps of temperature changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario
North Europe - Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)

IPCC WG1 Fifth Assessment Report (AR5)
Winter (DJF) seasonal changes in heavy precipitation (%), 2071-2100 compared to 1971-2000

IPCC, AR5, WG II, Chap. 23, p. 1277
Sea level due to continue to increase

(IPCC 2013, Fig. SPM.9)

(Ref: 1986-2005)
Effects on the Nile Delta, where more than 10 million people live less than 1 m above sea level.
Global ocean surface pH (projections)

Ocean Acidification, for RCP 8.5 (orange) & RCP2.6 (blue)

IPCC AR5 WGI, Fig SPM 07
Oceans are Acidifying Fast …

Changes in pH over the last 25 million years

- It is happening now, at a speed and to a level not experienced by marine organisms for about 60 million years

- Mass extinctions linked to previous ocean acidification events

- Takes 10,000’s of years to recover

Turley et al. 2006

“Today is a rare event in the history of the World”

Slide courtesy of Carol Turley, PML
Climate change impacts are already underway

- Tropics to the poles
- On all continents and in the ocean
- Affecting rich and poor countries (but the poor are more vulnerable everywhere)
Potential Impacts of Climate Change

- Food and water shortages
- Increased displacement of people
- Increased poverty
- Coastal flooding
Risk = Hazard x Vulnerability x Exposure
(Katrina flood victim, New Orleans, 2005)

AP Photo - Lisa Krantz (http://lisakrantz.com/hurricane-katrina/zspbn1k4cn17phidupe4f9x5t1mzdr)
Synthesis: 5 key Reasons For Concern

AR5, WGII, Box SPM.1 Figure 1
Only scenario RCP2.6 allows avoidance of the red (high additional) risk zone.
Cumulative emissions of CO₂ largely determine global mean surface warming by the late 21st century and beyond.
Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.
The window for action is rapidly closing

65% of the carbon budget compatible with a 2°C goal is already used
NB: this is with a probability greater than 66% to stay below 2°C

Total Carbon Budget: 2900 GtCO₂

Amount Used 1870-2011: 1900 GtCO₂

Amount Remaining: 1000 GtCO₂

NB: Emissions in 2011: 38 GtCO₂/yr
Stabilization of atmospheric concentrations requires moving away from the baseline – regardless of the mitigation goal.

Based on Figure 6.7

IPCC AR5 Synthesis Report
Can temperature rise still be kept below 1.5 or 2°C (over the 21st century) compared to pre-industrial?

• Many scenario studies confirm that it is technically and economically feasible to keep the warming below 2°C, with more than 66% probability ("likely chance"). This would imply limiting atmospheric concentrations to 450 ppm CO₂-eq by 2100.

• Such scenarios for an above 66% chance of staying below 2°C imply reducing by 40 to 70% global GHG emissions compared to 2010 by mid-century, and reach zero or negative emissions by 2100.
Mitigation Measures

- More efficient use of energy
- Greater use of low-carbon and no-carbon energy
  - Many of these technologies exist today
  - But worldwide investment in research in support of GHG mitigation is small...
- Improved carbon sinks
  - Reduced deforestation and improved forest management and planting of new forests
  - Bio-energy with carbon capture and storage
- Lifestyle and behavioural changes
All sectors and regions have the potential to contribute by 2030 (avoided emissions compared to BaU: the higher, the better)

Note: estimates do not include non-technical options, such as lifestyle changes.

IPCC AR4 (2007)
• Substantial reductions in emissions would require large changes in investment patterns e.g., from 2010 to 2029, in billions US dollars/year:
  (mean numbers rounded, IPCC AR5 WGIII Fig SPM 9)

• energy efficiency: +330
• renewables: + 90
• power plants w/ CCS: + 40
• nuclear: + 40
• power plants w/o CCS: - 60
• fossil fuel extraction: - 120
Mitigation can result in large co-benefits for human health and other societal goals.
If well designed, measures to prevent climate change could offer so many opportunities:

- Co-benefits in reduced pollution, health improvement, employment, gender equality, food security, reduced poverty, energy independence...

- Opportunities to shift the tax burden away from labour and implement sustainable development

- Opportunities to integrate research results in a useful, policy-relevant way, across disciplines (including social sciences)
sur les Changements Climatiques 2015

COP21/CMP11

Paris, France
Paris Agreement

- Article 2:
  - (...) to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
    - Holding the increase in the global average temperature to **well below 2 °C** above pre-industrial levels and to **pursue efforts** to limit the temperature increase to **1.5 °C** above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
    - **Increasing the ability to adapt** (...) and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;
    - Making **finance flows consistent** with a pathway towards low greenhouse gas emissions and climate-resilient development
Paris Agreement

- Article 4:
  - 1. (...) Parties aim to reach **global peaking** of greenhouse gas emissions **as soon as possible**, recognizing that **peaking will take longer for developing country Parties**, and to undertake **rapid reductions thereafter in accordance with best available science**, so as to achieve a **balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century**, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty
  - 3. Each Party’s successive nationally determined contribution will represent a progression(...)
“Getting 196 Countries To Agree On Climate Change Was The Easy Part. Now comes the real work.”

(C. Figueres, World Economic Forum 2016, Davos)
Delaying additional mitigation to 2030 will substantially increase the challenges associated with limiting warming over the 21st century to below 2°C relative to pre-industrial levels.
Comparison of global emission levels in 2025 and 2030 resulting from the implementation of the intended nationally determined contributions

UNFCCC, Aggregate effect of the intended nationally determined contributions: an update
http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf
Walking the talk...

- Energy audit of our home
- Strong external insulation (wood fibre)
- Ultra-efficient windows
- Airtightness inspecting + heat-recovery mechanical ventilation
- Oil furnace replaced by geothermal heat pump principally fed with PV pannels
- Non-tropical wood
- Small, used electric car
- Electric bicycles
Trying to be coherent (external insulation)
J’essaye d’être cohérent...
Please go and see the latest movie with Al Gore

An Inconvenient Sequel: Truth to Power
Last Advice

Explore how you could contribute to IPCC activities:

- Nominations to become AR6 author are open until 27 October 2017 (check [www.ipcc.ch](http://www.ipcc.ch))
- Regular opportunities to contribute as expert reviewer (check [www.ipcc.ch](http://www.ipcc.ch))
- Publish literature relevant to the IPCC work, and bring it to the attention of IPCC authors
Conclusions (1/2)

The challenge is huge: transform the world in a few decades so that the whole world activities are decarbonized, while poverty and hunger are eliminated;

Addressing it open so many opportunities, for research in all disciplines and accross disciplines and for integrating results of this research in meaningful actions by all: governments, cities, businesses, NGOs, and citizens;

It opens also economic opportunities, and opportunities to address in a synergistic manner other societal goals, such as the 17 Sustainable Development Goals discussed by Prof. Slaus this morning, including the modesty and compassion he pleaded for;
Conclusions (2/2)

Last but not least, addressing this challenge, together, will allow us to look our children and grand children into their eyes when they will ask us how we contributed to avoiding the announced environmental collapse.

Buddhist saying: Courage is the gateway to happiness

In a nutshell: Yes we can !
Only together...
My book (in French)
De Boeck supérieur, (2015)
Broché: 16 euros
E-book: 13 euros
Useful links:

- [www.ipcc.ch](http://www.ipcc.ch): IPCC (reports and videos)
- [www.skepticalscience.com](http://www.skepticalscience.com): excellent responses to contrarians arguments
- **On Twitter:** @JPvanYpersele and @IPCC_CH