Climate Change: Challenge and Opportunities for International Shipping

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International Maritime Organization,
London, 24 October 2017

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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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In Puerto Rico, Hurricane Maria created the worst humanitarian crisis in the US for decades

Source: FEMA, 24-9-2017
Temperature Change From 1961-1990 Average

Lying With Statistics, Global Warming Edition

Temperature Plateaus — 1912-2012

Degrees Celsius


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
What is happening in the climate system?

What are the risks?

What can be done?
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
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 CO₂ concentration: the Keeling curve

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

Data from Scripps CO₂ Program  Last updated January 2017

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: 100%
- Infrared: -18°C
Energy Cycle with Greenhouse Gases

Solar Radiation

Convection, etc...

H₂O, CO₂, ...

Infrared

+15°C
CO$_2$ Concentration, 25 May 2016 (Keeling curve)

Latest CO$_2$ reading
May 25, 2016

407.96 ppm


Source: scripps.ucsd.edu/programs/keelingcurve/
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
- 280 ppmv (1ppmv = 2.2 GtC)

Ocean
- 38000 GtC

partie I
- photosynthesis: 120 GtC
- respiration: 119.5 GtC

partie II
- Physical, Chemical, and Biological processes: 70 GtC
- décomposition: 2300 GtC

partie III
- Combustibles fossiles (charbon, pétrole, gaz naturel): 3700 GtC

partie IV
- vanyp@climate.be

Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get GtCO₂)
Carbon cycle: perturbed by human activities
(numbers for the decade 1990-1999s, based on IPCC AR4)

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

Atmosphere

- Photosynthesis: 120 GtC
- Respiration: 2.6 GtC
- Sinks: 2.6 GtC/year
- Physical, Chemical, and Biological processes:
  - 70.5 GtC

Pre-ind: 597 GtC + 3.2 GtC/year

Ocean

- 38000 GtC +120 GtC/year
- 2300 GtC

Déforestation (& land use changes)

- 1.6 GtC

Fossil fuels

- 6.4 GtC

Combustibles fossiles (charbon, pétrole, gaz naturel)

- 3700 GtC -244 GtC/year

Stocks!

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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 CO$_2$ concentration

Three stabilisation scenarios: RCP 2.6 to 6
One Business-as-usual scenario: RCP 8.5

AR5, chapter 12. WGI- Adopted version / subject to final copyedit
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.
Maps of temperature changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario
Winter (DJF) seasonal changes in heavy precipitation (%), 2071-2100 compared to 1971-2000

IPCC, AR5, WG II, Chap. 23, p. 1277
Precipitation change Equatorial Pacific (annual)
Sea level due to continue to increase
Effects on the Nile Delta, where more than 10 million people live less than 1 m above sea level.
With 8 metre sea-level rise: 3700 km² below sea-level in Belgium (very possible in year 3000) (NB: flooded area depends on protection)

On the frontline: The Maldives
(here with the IPCC Focal Point)
In front of Environment Ministry, Maldives, Aug. 2015
In front of Ministry of Foreign Affairs, Maldives, Aug. 2015
MINISTRY OF FOREIGN AFFAIRS
Disproportionate storm impact (1998-2009) on Asia-Pacific SIDS population & GDP

Table 29-5 | Top ten countries in the Asia-Pacific region based on absolute and relative physical exposure to storms and impact on GDP (between 1998 and 2009; after Tables 1.10 and 1.11 of ESCAP and UNISDR, 2010).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Absolute exposure (millions affected)</th>
<th>Relative exposure (% of population affected)</th>
<th>Absolute GDP loss (US$ billions)</th>
<th>Loss (% of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Japan (30.9)</td>
<td>Northern Mariana Islands (58.2)</td>
<td>Japan (1,226.7)</td>
<td>Northern Mariana Islands (59.4)</td>
</tr>
<tr>
<td>2</td>
<td>Philippines (12.1)</td>
<td>Niue (25.4)</td>
<td>Republic of Korea (35.6)</td>
<td>Vanuatu (27.1)</td>
</tr>
<tr>
<td>3</td>
<td>China (11.1)</td>
<td>Japan (24.2)</td>
<td>China (28.5)</td>
<td>Niue (24.9)</td>
</tr>
<tr>
<td>4</td>
<td>India (10.7)</td>
<td>Philippines (23.6)</td>
<td>Philippines (24.3)</td>
<td>Fiji (24.1)</td>
</tr>
<tr>
<td>5</td>
<td>Bangladesh (7.5)</td>
<td>Fiji (23.1)</td>
<td>Hong Kong (13.3)</td>
<td>Japan (23.9)</td>
</tr>
<tr>
<td>6</td>
<td>Republic of Korea (2.4)</td>
<td>Samoa (21.4)</td>
<td>India (8.0)</td>
<td>Philippines (23.9)</td>
</tr>
<tr>
<td>7</td>
<td>Myanmar (1.2)</td>
<td>New Caledonia (20.7)</td>
<td>Bangladesh (3.9)</td>
<td>New Caledonia (22.4)</td>
</tr>
<tr>
<td>8</td>
<td>Vietnam (0.8)</td>
<td>Vanuatu (18.3)</td>
<td>Northern Mariana Islands (1.5)</td>
<td>Samoa (19.2)</td>
</tr>
<tr>
<td>9</td>
<td>Hong Kong (0.4)</td>
<td>Tonga (18.1)</td>
<td>Australia (0.8)</td>
<td>Tonga (17.4)</td>
</tr>
<tr>
<td>10</td>
<td>Pakistan (0.3)</td>
<td>Cook Islands (10.5)</td>
<td>New Caledonia (0.7)</td>
<td>Bangladesh (5.9)</td>
</tr>
</tbody>
</table>

Note: Small islands are highlighted in yellow.

(Yellow= Small Islands)

IPCC AR5 WGII Chapter 29
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-related drivers of risk for small islands include:

- Sea level rise (SLR),
- Tropical and extratropical cyclones,
- Increasing air and sea surface temperatures, and changing rainfall patterns

• (+ Acidification)
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)
Risk = Hazard x Vulnerability x Exposure
(Katrina flood victim, New Orleans, 2005)
Synthesis: 5 key Reasons For Concern

Level of additional risk due to climate change

- Undetectable
- Moderate
- High
- Very high

AR5, WGII, Box SPM.1 Figure 1
Only scenario RCP2.6 allows avoidance of the red (high additional) risk zone.
Cumulative emissions of CO$_2$ 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.
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
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.
Changement 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(...)
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
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.
Integration of efforts can be constructive
Conclusions

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 opens so many opportunities, as Humanity is forced to challenge past practices, innovate, and integrate research results in meaningful actions by all: governments, 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 adopted by the UN in 2015
Only together...
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