Human-Induced Climate Change Research – A Brief History

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***Presentation for TWN Climate Summit,* 2018-07-17**

A brief history of research on human-induced climate change

- Pre - World War II
- Modern monitoring of CO_2 begins in 1958
- First climate change projections
- Assessment of scientific findings
  - International – IPCC
  - National – Government of Canada
- Summary of recent findings
- Communication of consensus, and acting on it

THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

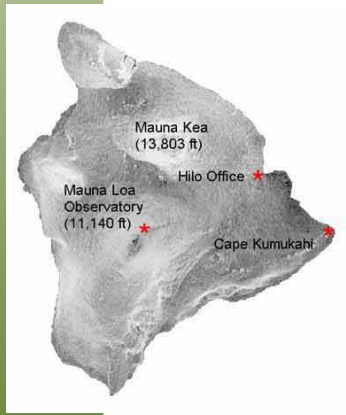
XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

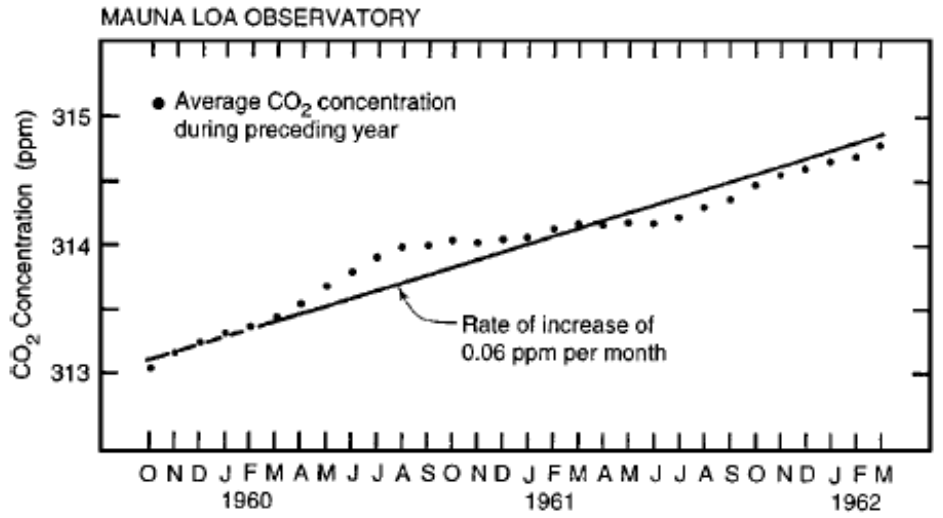
I. *Introduction: Observations of* Langley *on Atmospherical Absorption.*

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet §; and Langley was by some of his researches led to the view, that "the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to −200° C., if that atmosphere did not possess the quality of selective

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December, 1895. Communicated by the Author.
† 'Heat a Mode of Motion,' 2nd ed. p. 405 (Lond., 1865).
‡ *Mém. de l'Ac. R. d. Sci. de l'Inst. de France*, t. vii. 1827.
§ *Comptes rendus*, t. vii. p. 41 (1838).

1958: Charles Keeling begins CO_2 monitoring, Mauna Loa

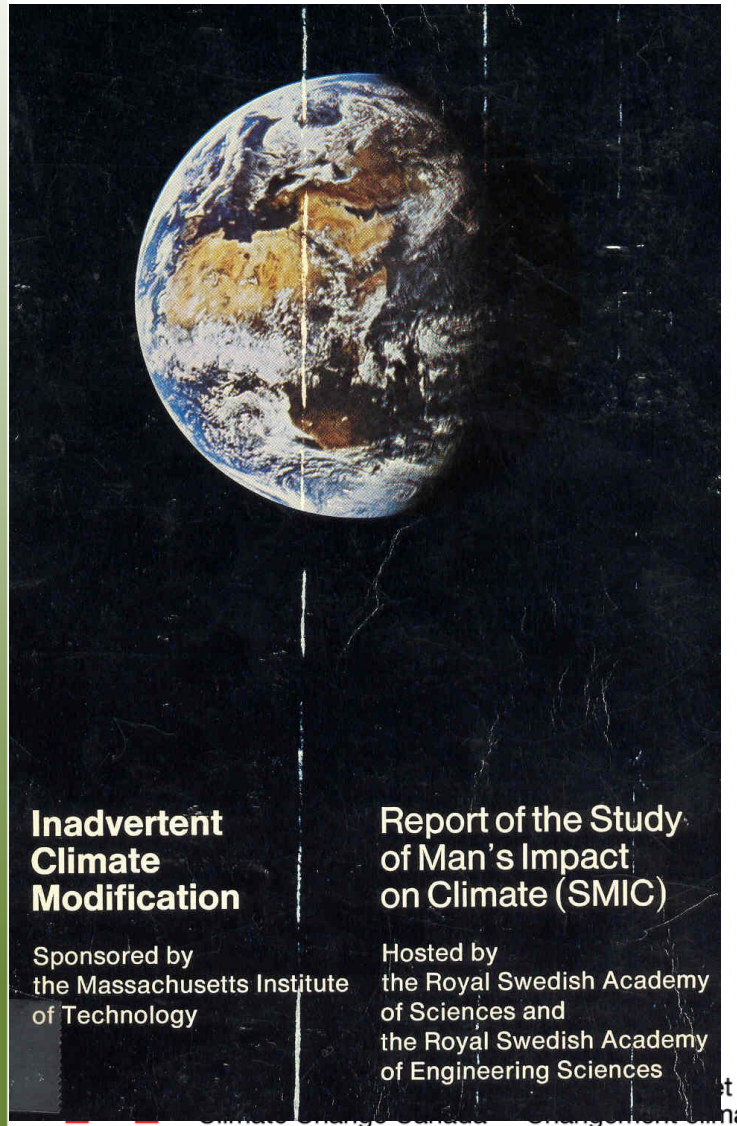




Photos from NOAA Mauna Loa Observatory web sites; graphic from Bolin and Keeling, (1963—JGR, 68:3899-3920)

Study of Man's Impact on Climate

(MIT and Royal Swedish Academies, 1971)



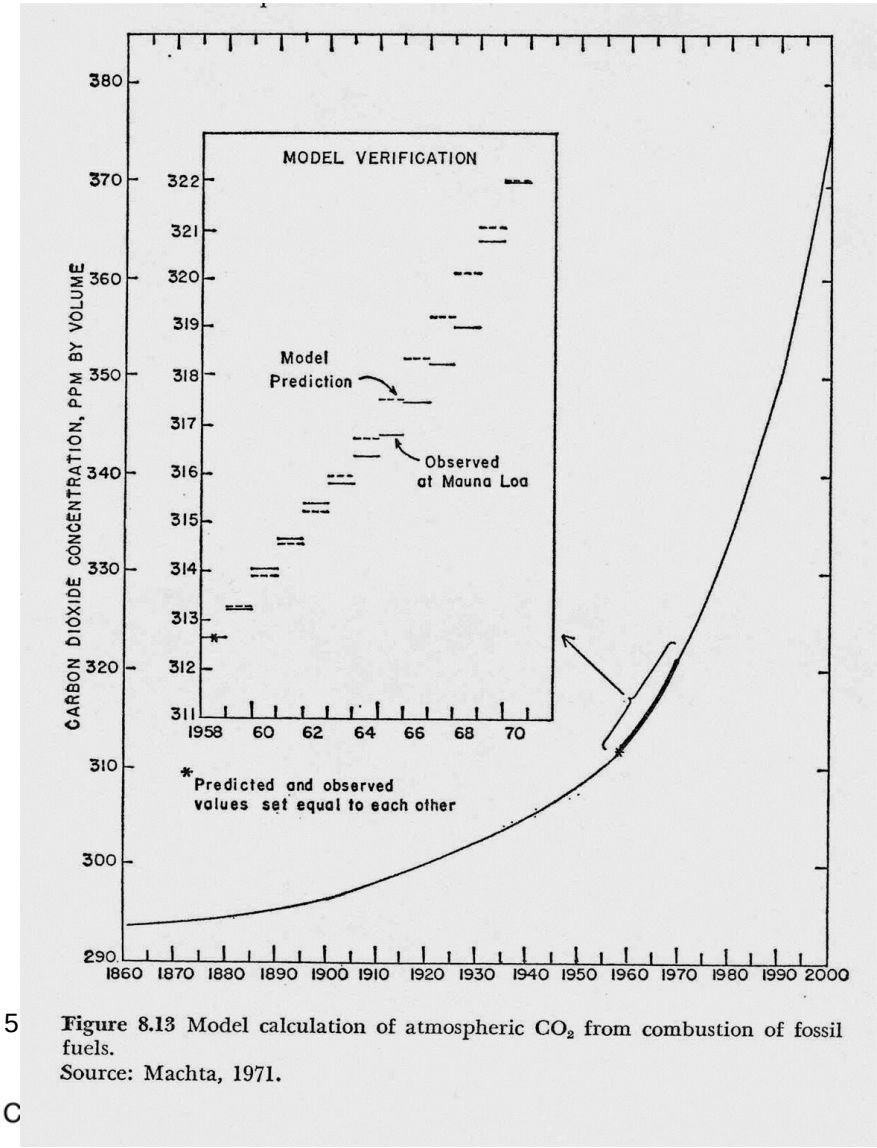
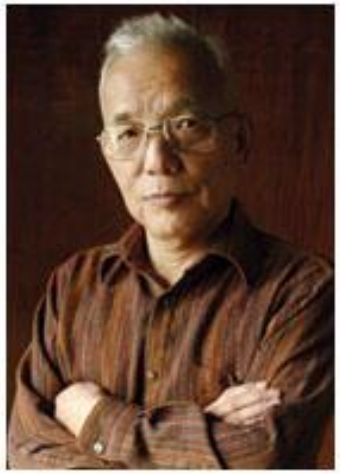


Figure 8.13 Model calculation of atmospheric CO_2 from combustion of fossil fuels.
Source: Machta, 1971.

Early application of a Global Climate Model to simulating the effects of CO2 on climate

(Manabe and Wetherald, 1975, Figure 4b)



VOL. 32, NO. 1 JOURNAL OF THE ATMOSPHERIC SCIENCES JANUARY 1975

The Effects of Doubling the CO_2 Concentration on the Climate of a General Circulation Model[1]

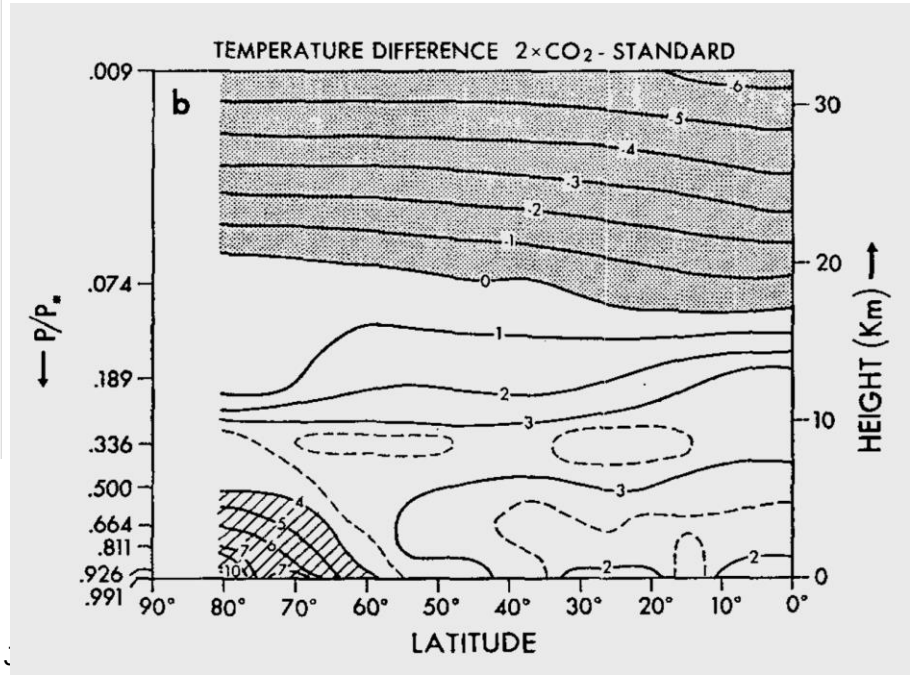
SYUKURO MANABE AND RICHARD T. WETHERALD

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, N.J. 08540

(Manuscript received 6 June 1974, in revised form 8 August 1974)

ABSTRACT

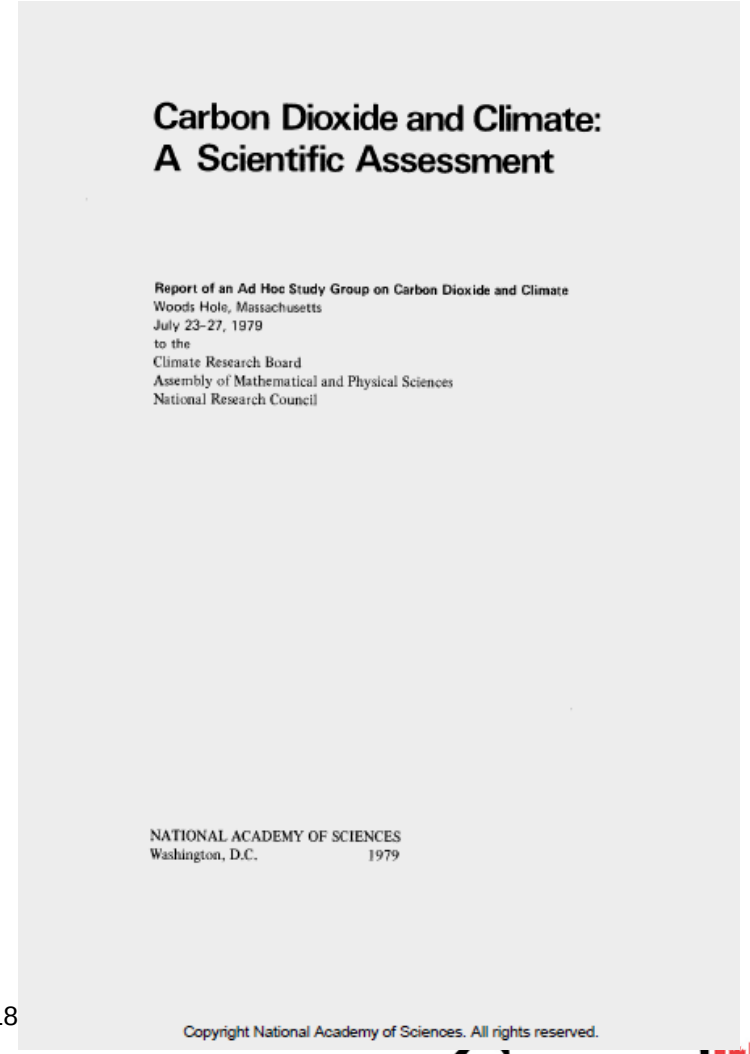
An attempt is made to estimate the temperature changes resulting from doubling the present CO_2 concentration by the use of a simplified three-dimensional general circulation model. This model contains the following simplifications: a limited computational domain, an idealized topography, no heat transport by ocean currents, and fixed cloudiness. Despite these limitations, the results from this computation yield some indication of how the increase of CO_2 concentration may affect the distribution of temperature in the atmosphere. It is shown that the CO_2 increase raises the temperature of the model troposphere, whereas it lowers that of the model stratosphere. The tropospheric warming is somewhat larger than that expected from a radiative-convective equilibrium model. In particular, the increase of surface temperature in higher latitudes is magnified due to the recession of the snow boundary and the thermal stability of the lower troposphere which limits convective heating to the lowest layer. It is also shown that the doubling of carbon dioxide significantly increases the intensity of the hydrologic cycle of the model.



Note: projected global average temperature change = +2.93 C for 2xCO2 (600 ppm)

U.S. National Academy of Sciences report on carbon dioxide and climate (1979)

"We estimate the most probable global warming for a doubling of CO_2 to be near 3°C with a probable error of ±1.5°C" *(page 2)*.

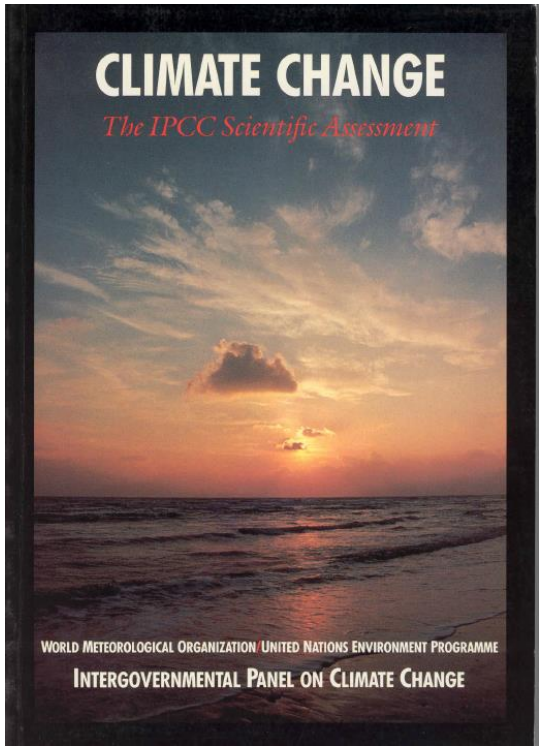


Carbon Dioxide and Climate:
A Scientific Assessment

Report of an Ad Hoc Study Group on Carbon Dioxide and Climate
Woods Hole, Massachusetts
July 23–27, 1979
to the
Climate Research Board
Assembly of Mathematical and Physical Sciences
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1979

Intergovernmental Panel on Climate Change (IPCC), 1988 - ongoing



1st publication, 1990

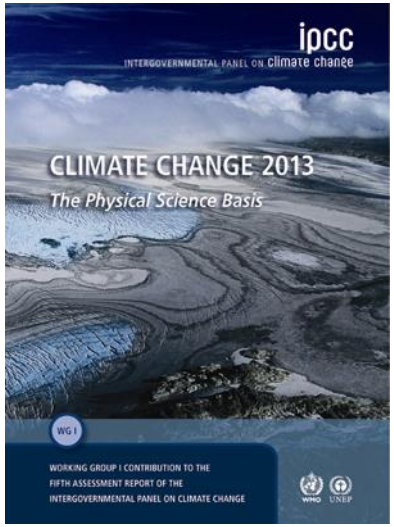
30th Anniversary ipcc
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
1988 – 2018
WMO UNEP

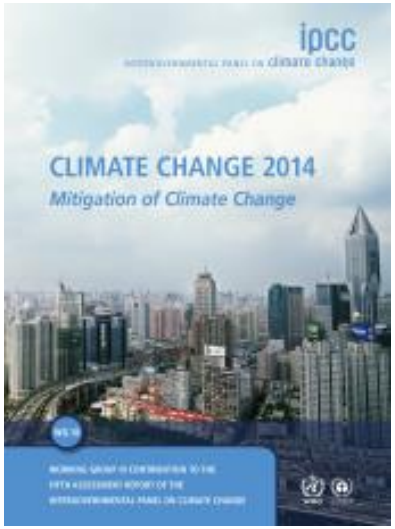
Purpose: "…to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation…" (www.ipcc.ch)

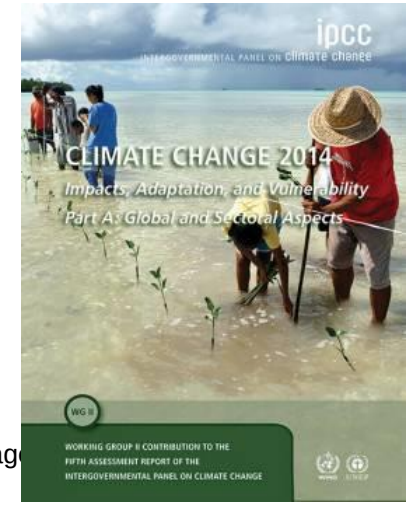
2007 Peace Prize (with Al Gore): "…for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change"

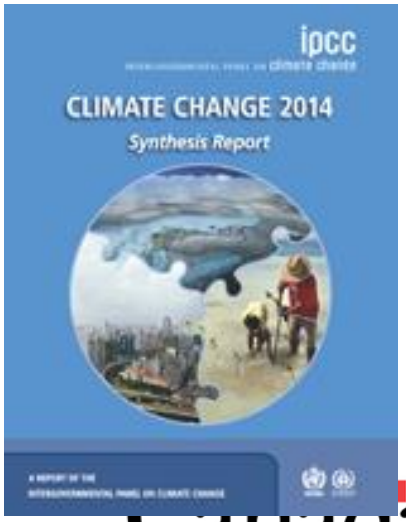
IPCC has become a key source for information on climate change

- Ongoing assessment of available research literature
  - Authors are volunteers, nominated by countries
  - Lead Authors selected by steering committee
- Reports attract international media attention
  - Authoritative, value added review and synthesis
  - Policy relevant









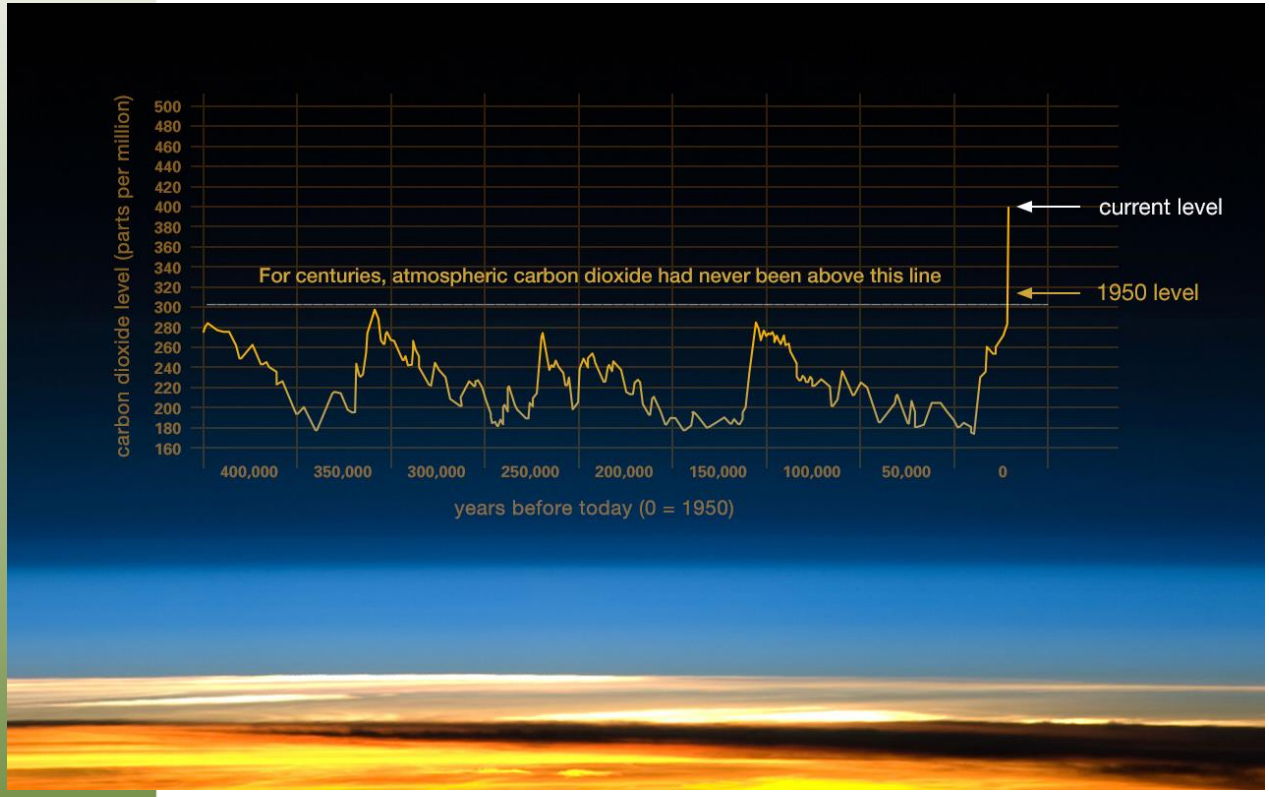
Publications from 5th Assessment Report (2013-2014); Working Groups I, II, and III, and Synthesis Report

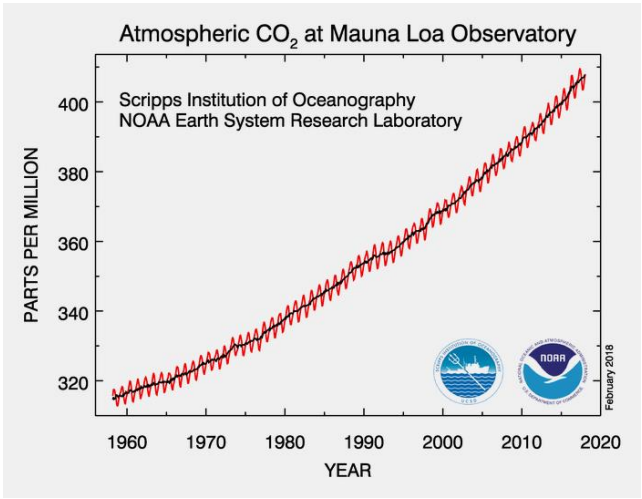
Assessment of climate change in Canada

- National assessments of climate change published by Government of Canada available at:
- www.nrcan.gc.ca

Canadian Assessment Reports (2008, 2014, and 2016, respectively)

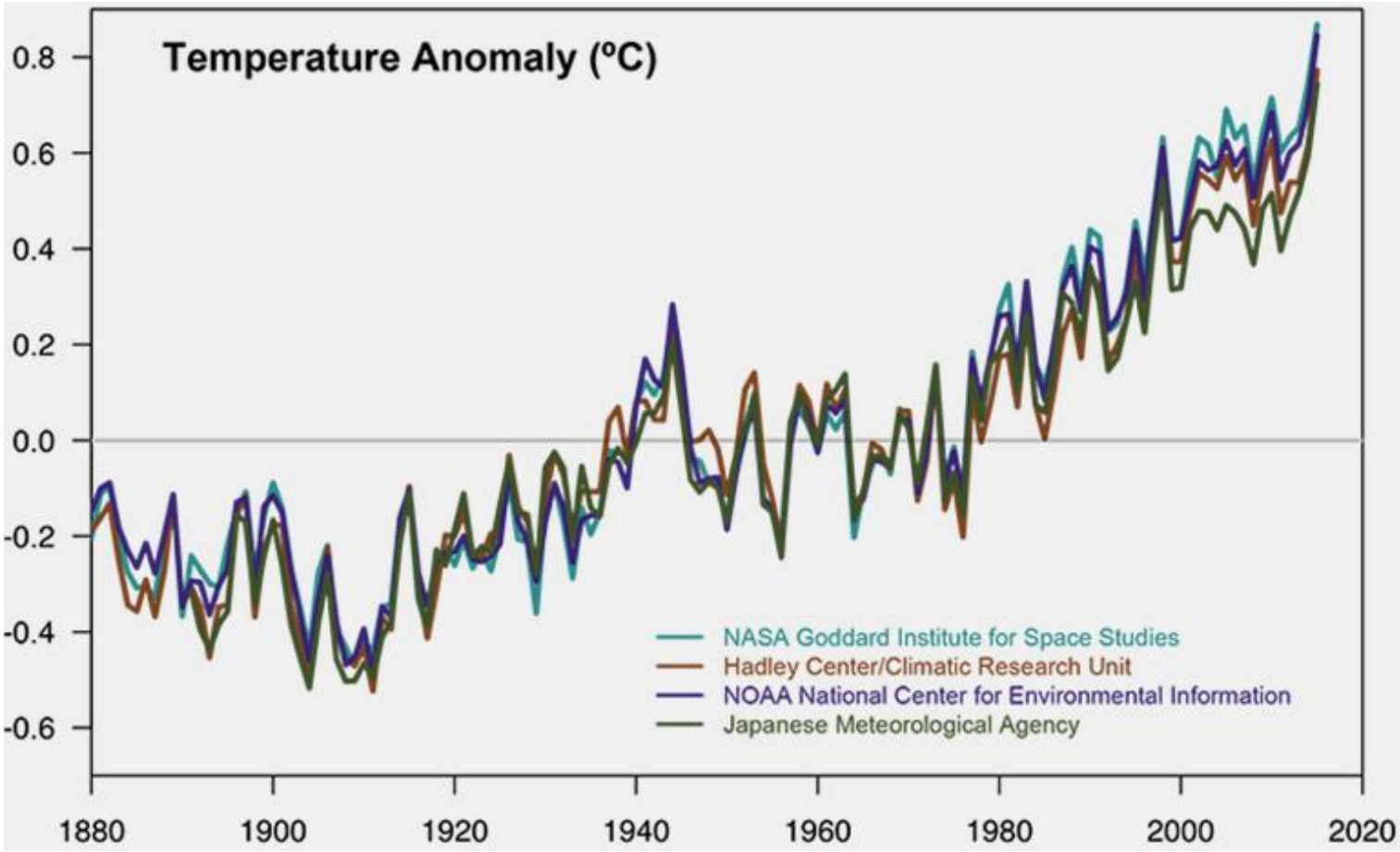
Carbon dioxide concentrations in the atmosphere *(US: NOAA, Scripps Institution)*





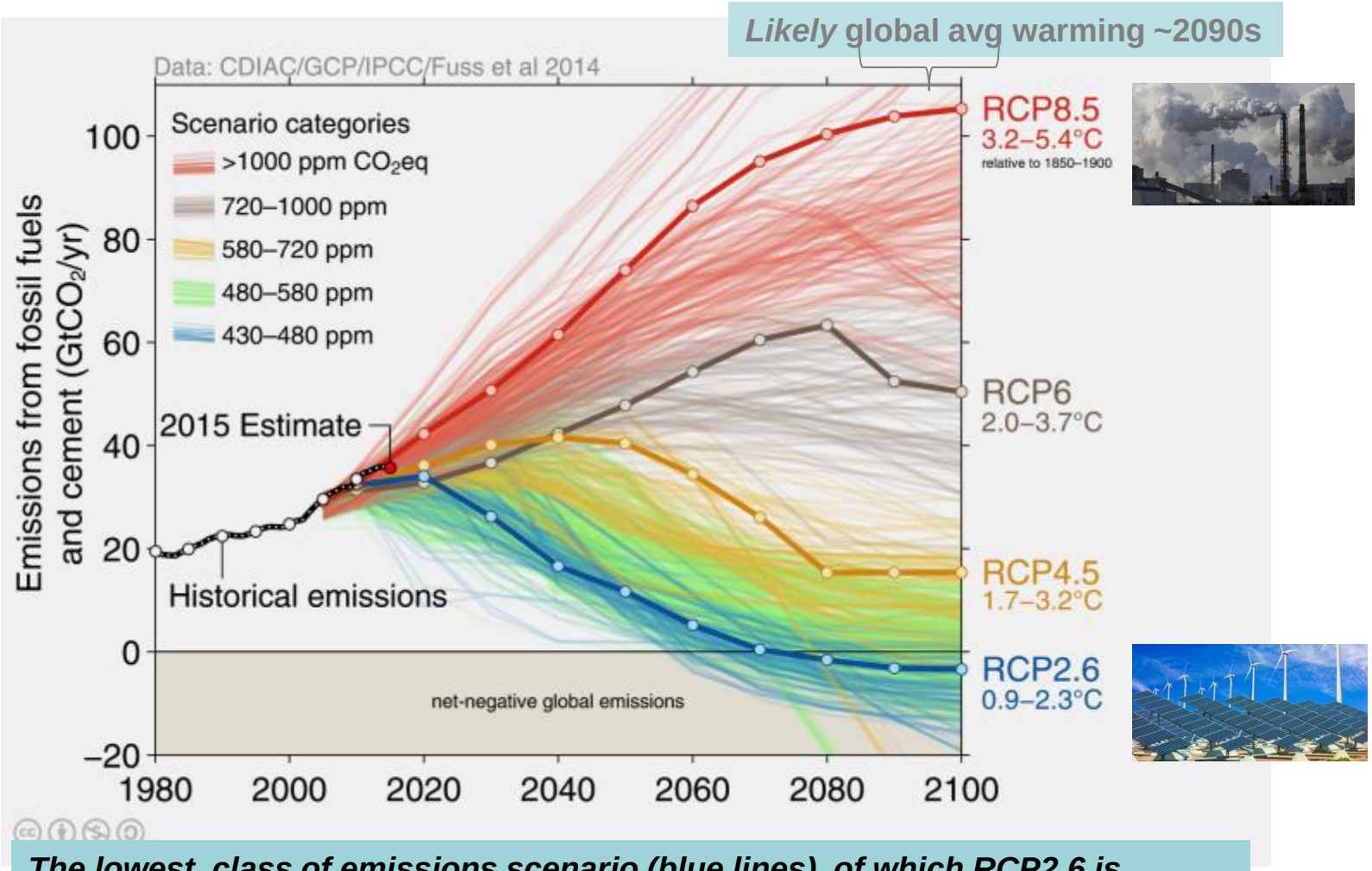
Graphics:
left - from NASA Vital Signs: https://climate.nasa.gov/vital-signs/carbon-dioxide/
right – from NOAA: https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

Global temperature, 1880-2016, compared with 20th century average *(US, UK and Japan agencies)*



Graphic from NASA Vital Signs; https://climate.nasa.gov/scientific-consensus/

Emission *scenarios* lead to a range of global temperature *scenarios*: higher emissions lead to greater warming *(from IPCC WGI presentation, 2016, at www.ipcc.ch)*



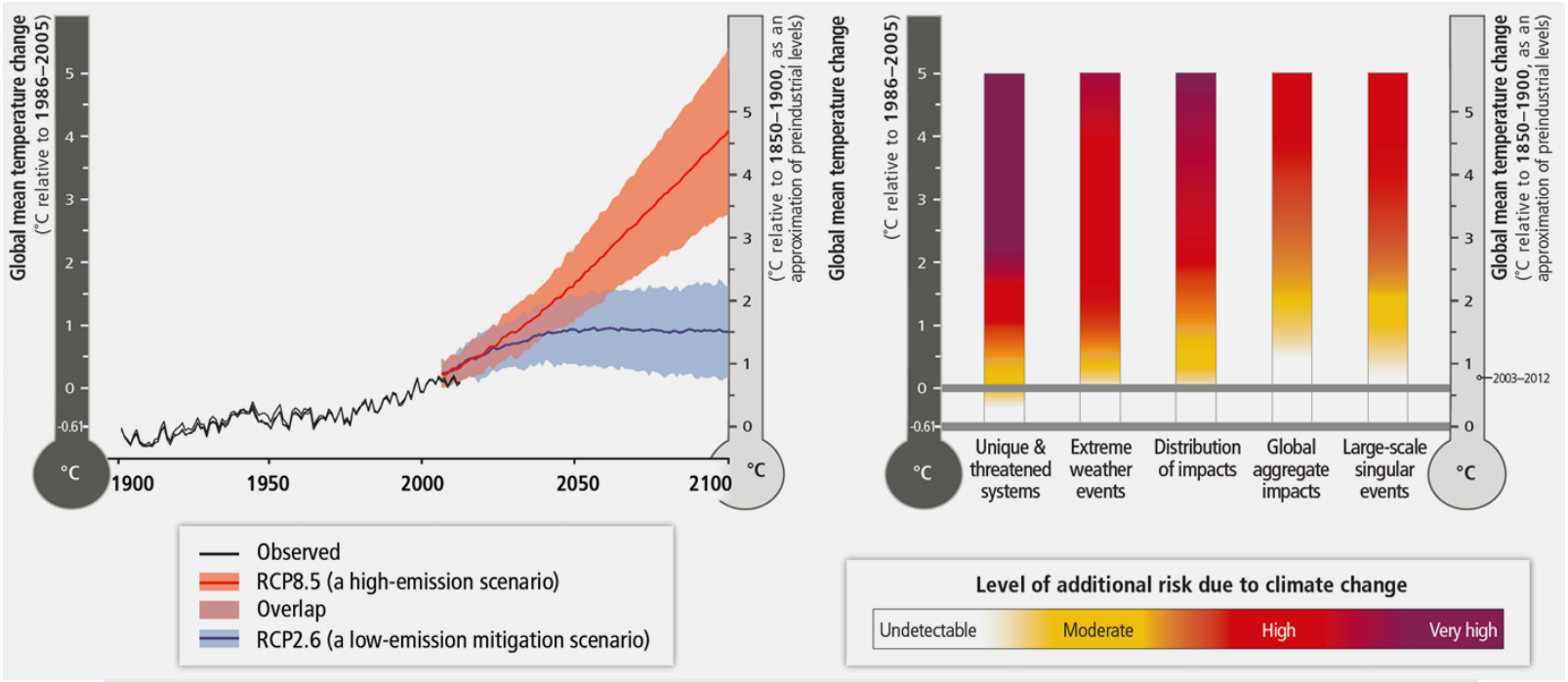
The lowest class of emissions scenario (blue lines), of which RCP2.6 is representative, is the only class assessed as likely limiting global temperature change to below 2°C.

IPCC 5th Assessment WGI (2013) Key Science Findings

- Warming over the 20th century is unequivocal and largely due to human activities
- The main cause of observed warming is human emissions of CO2 and other greenhouse gasses
- Continued emissions of greenhouse gasses will cause further warming and changes in all components of the climate system

Projected climate change will increase 5 key risks relevant to "dangerous anthropogenic interference"

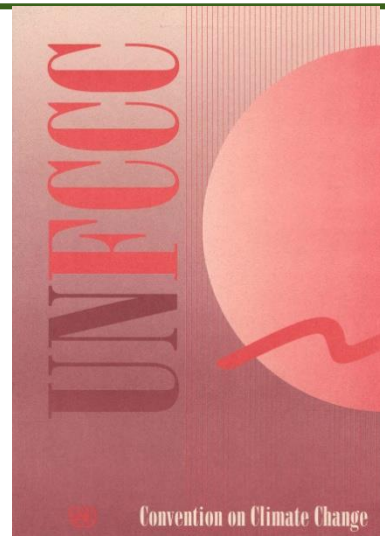
(IPCC WGII SPM, 2014, Box SPM1, Figure 1)



- ***At recent (1986-2005) temperatures, risk is rated at moderate for unique and threatened systems;***
- ***Temperature scenarios range from 1.5℃ to 4.5℃ warming above pre-industrial era by 2100***
- ***At 2℃ warming, risk is rated at moderate to high for all 5 indicators***
- ***At 4℃ warming, risk is rated high to very high for all indicators***

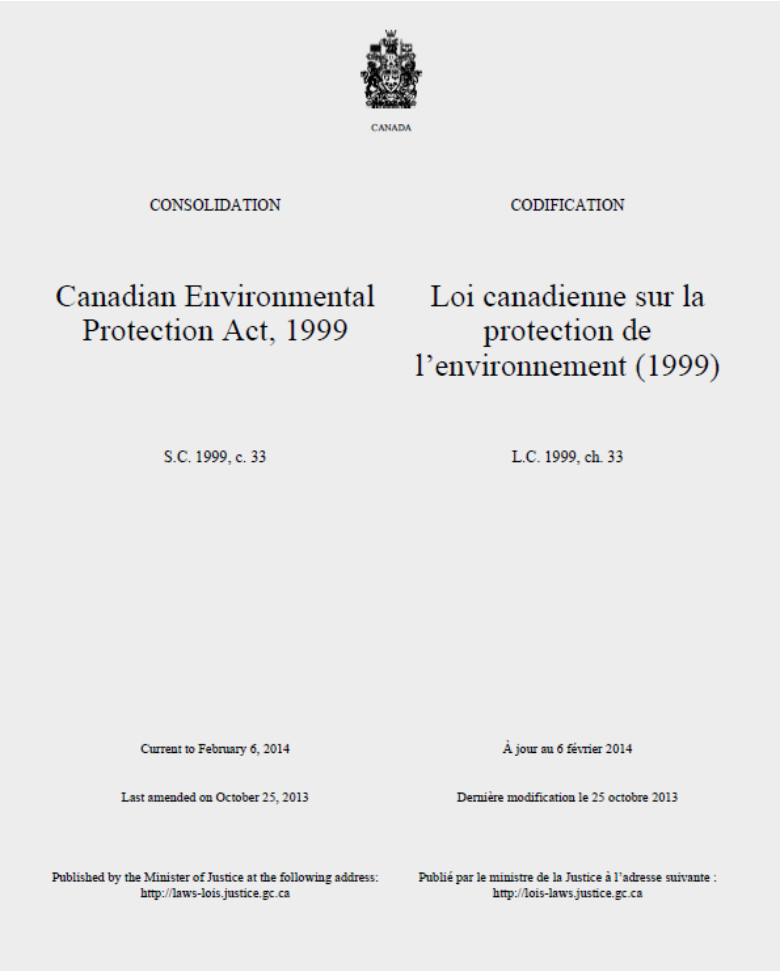
United Nations: Framework Convention on Climate Change (UNFCCC), 1992; Paris Agreement, 2015

- **UNFCCC** Article 2 – Objective:
  - "…stabilization of greenhouse gas concentrations …prevent dangerous anthropogenic interference with the climate system."
- **Paris Agreement** Articles 2, 4, 7
  - (2) "…holding the increase in the global average temperature to well below 2°C above pre-industrial levels…"
  - (4) "…aim to reach global peaking of greenhouse gas emissions as soon as possible…and to undertake rapid reductions thereafter…"
  - (7) "…establish the global goal on adaptation…based on and guided by the best available science and … traditional knowledge, knowledge of indigenous peoples and local knowledge systems…



Canadian Environmental Protection Act (1999, amended 2013)

Carbon dioxide, methane, nitrous oxide are included in the Act's List of Toxic Substances



CANADA

CONSOLIDATION

CODIFICATION

Canadian Environmental Protection Act, 1999

Loi canadienne sur la protection de l'environnement (1999)

S.C. 1999, c. 33

L.C. 1999, ch. 33

Current to February 6, 2014

Last amended on October 25, 2013

Published by the Minister of Justice at the following address: http://laws-lois.justice.gc.ca

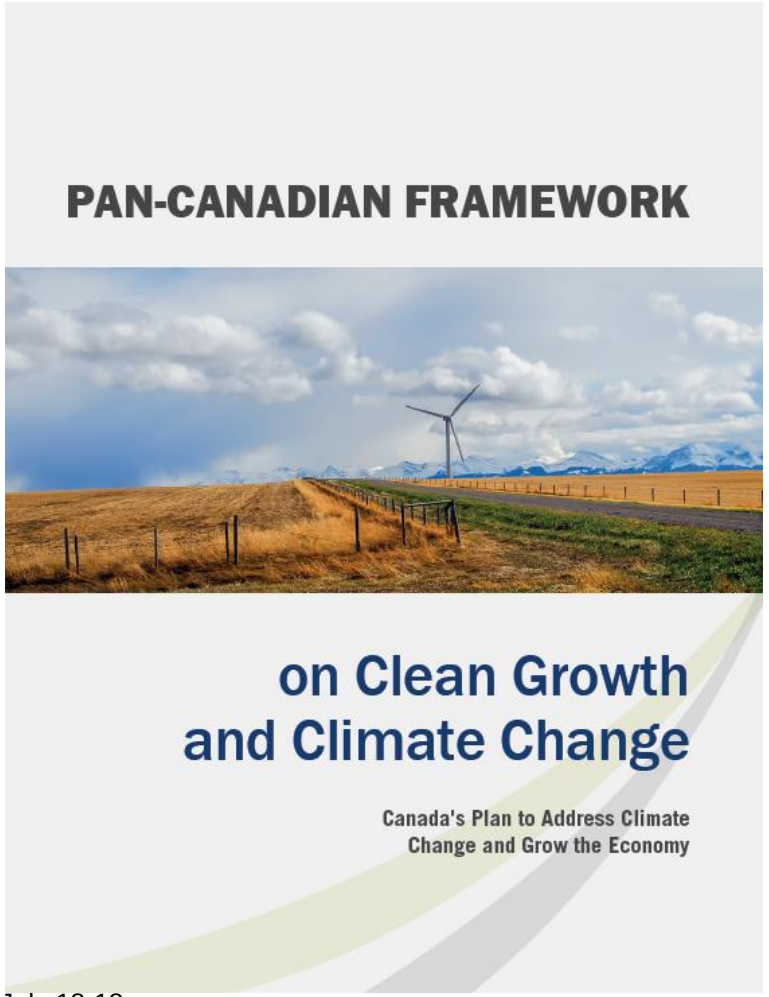
À jour au 6 février 2014

Dernière modification le 25 octobre 2013

Publié par le ministre de la Justice à l'adresse suivante : http://lois-laws.justice.gc.ca

Pan-Canadian Framework, Government of Canada (2016)

"The science is clear that human activities are driving unprecedented changes in the Earth's climate." (page 1)



Extreme weather, natural disasters, and failure of climate change policy are the greatest risks facing our world *(World Economic Forum, 2018)*

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

Insight Report

The Global Risks Report 2018
13th Edition

Environment and Climate Change Canada

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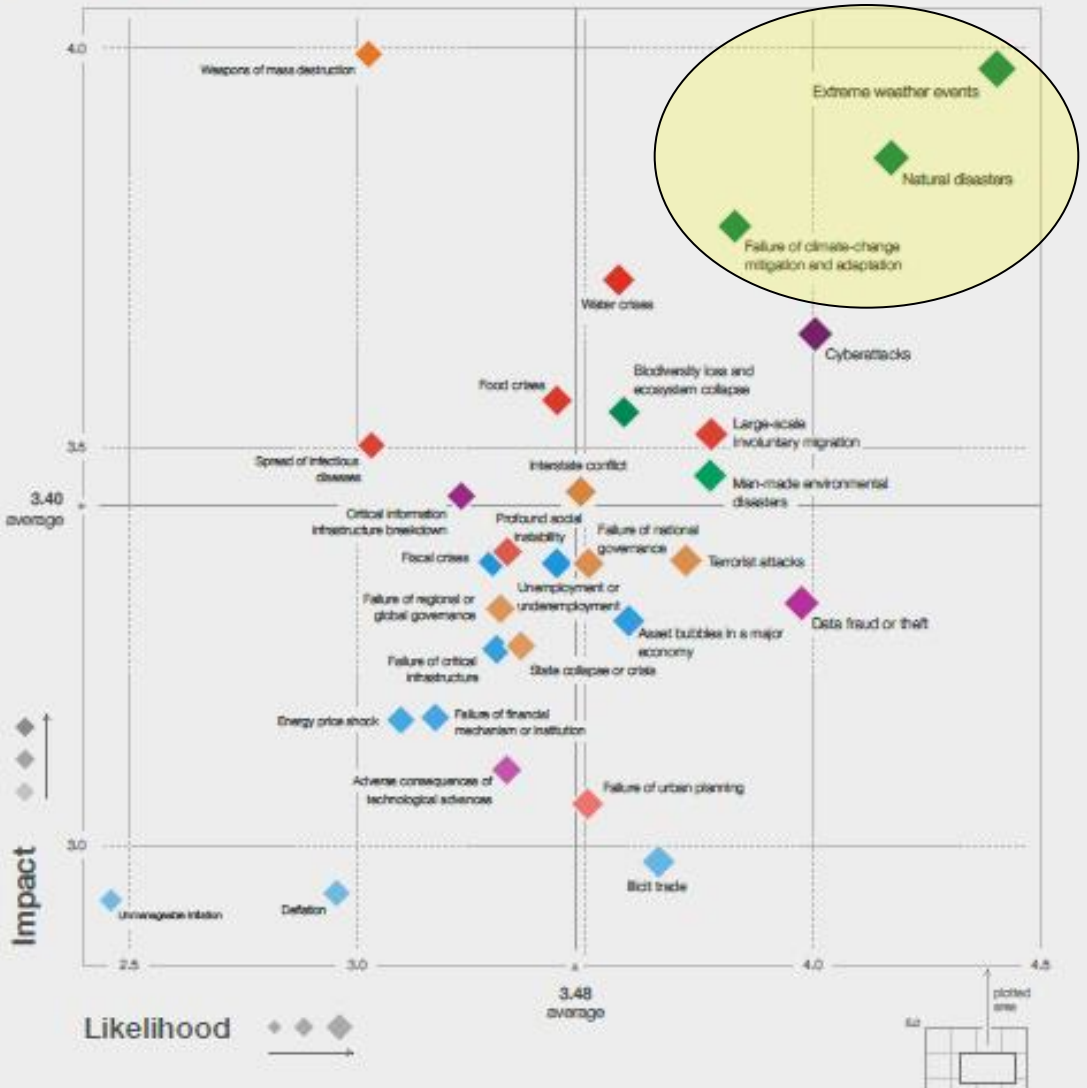
Figure I: The Global Risks Landscape 2018



Arrhenius (1896) → Keeling (1958) → Paris (2015) → …

- Learning about human-induced climate change began many decades ago
- More recently (since the 1980s…), knowledge sharing has expanded across many disciplines, aided by assessments of all relevant literature
- Awareness has increased worldwide, resulting in acceptance of science findings by governments
- The ***Paris Agreement*** has been signed by 197 countries, ratified by 178
- Events like the TWN Climate Summit are important for knowledge sharing, and enabling evidence-based decision making

For Further Information

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