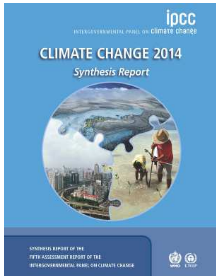
Climate Change

Environmental Health (10) on 5 Dec. 2019

- Key Concepts
  - UN-IPCC predicts "by 2100, average global temperature increases 1.8-4.0 C°, sea levels will rise, hydrologic extremes (floods/droughts) will intensify
  - Climate change affects crop/livestock production, viability of fisheries: People at hunger risk may be double by 2050
  - Climate change directly affects health through heat-related morbidity, flood/storm-related trauma and mental health, air pollution (ozone, aeroallergens, infectious diseases)
  - Weather-related health risks must be assessed as environmental stressors
  - Risk management of climate change ranges from primary mitigation of greenhouse gas to a number of adaptations: Co-benefits and unintended consequences of policy changes in the energy, transportation, agriculture must be considered in "comprehensive health impact assessment"

UN-IPCC

- United Nations **Intergovernmental Panel on Climate Change** (IPCC) was established in 1988 by World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP).
- Approx. every 5 yrs since 1990, IPCC conducted assessments of scientific work on climate change (5th report [AR5] has been published in 2014).
- http://www.ipcc.ch/ [IPCC's web site]
  - http://www.ipcc.ch/scripts/_session_template.php?page=_46ipcc.htm (46th session of IPCC, 6-10 Sep 2017, Montreal) http://www.ipcc.ch/meetings/session46/p46_decisions.pdf
  - http://www.ipcc.ch/pdf/supporting-material/EMR_COM_full_report.pdf
  - http://www.ipcc.ch/news_and_events/docs/ar5/ar5_syr_headlines_en.pdf (headlines for policy makers)
- (cf.) USA, http://climate.nasa.gov/effects/



History of IPCC

(Source: IPCC Factsheet: Timeline – highlights of IPCC history https://www.ipcc.ch/news_and_events/docs/factsheets/FS_timeline.pdf)

- 1988: UNEP and WMO established IPCC
- 1990: AR1: Scientific Assessment (WG1), Impacts Assessment (WG2), Response Strategies (WG3); UN initiated negotiation for FCCC
- 1992: Supplementary Reports for AR1; UNFCCC opened at Rio summit
- 1995: AR2: Science (WG1), Impacts, Adaptations and Mitigation (WG2), Economic and Social Dimensions (WG3)
- 1996: "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories"
- 1997: Kyoto Protocol adopted (COP3, https://unfccc.int/cop3/home.html) At least 5% reduced level from 1990 of CO_2, CH_4, N_2O has to be achieved during 2008-2012.
- 1998: Task Force on National Greenhouse Gas Inventories (TFI)
- 1999: Japan started to support TFI
- 2000: "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories"
- 2001: AR3: Science (WG1), Impacts, Adaptation, Vulnerability (WG2), Mitigation (WG3)
- 2003: "Good Practice Guidance for Land Use, Land-Use Change and Forestry"
- 2007: AR4: Physical Science (WG1), Impacts, Adaptation, Vulnerability (WG2), Mitigation (WG3); IPCC shares Nobel Peace Prize
- 2011: "Special Report on Renewable Energy Sources and Climate Change Mitigation" (WG3)
- 2013: "Climate Change 2013: The Physical Science Basis" (WG1)
- 2014: AR5 (https://www.ipcc.ch/assessment-report/ar5/)
  Climate Change Synthesis Report 2014 (https://archive.ipcc.ch/report/ar5/syr/)
- 2019: COP25 at Madrid (https://unclimatesummit.org/)

Warming forecast by IPCC

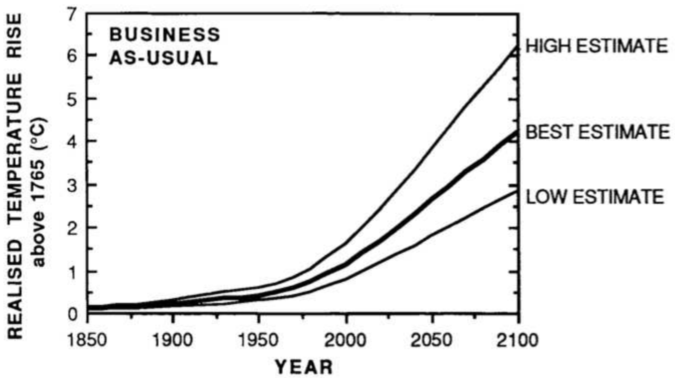


Figure 8: Simulation of the increase in global mean temperature from 1850-1990 due to observed increases in greenhouse gases, and predictions of the rise between 1990 and 2100 resulting from the Business-as-Usual emissions

Future projection based on scenarios

- Scenarios cover a range of plausible futures.
- Levels of human interference with the climate system → 4 `representative concentration pathways' (RCPs)
  - Radiative forcing levels of 2.6, 4.5, 6.0, and 8.5 W/m2 (~ 450, 650, 850, and 1370 ppm CO2eq)
  - The 4 RCPs are the basis of a new set of climate change projections that have been assessed by WG1
- Without additional and explicit efforts to mitigate climate change (`baseline scenarios')
- With the introduction of efforts to limit emissions (`mitigation scenarios')
- Collected a database of more than 1200 published mitigation and baseline scenarios.
  - In most cases, the underlying socio-economic projections reflect the modelling teams' individual choices about how to conceptualize the future in the absence of climate policy.
  - The baseline scenarios show a wide range of assumptions about economic growth (x3 ~ x8 per capita income by 2100), demand for energy (40% ~ 80% decline in energy intensity by 2100) and other factors, in particular the carbon intensity of energy.
  - Vast majority of scenarios focus on the low to medium population range of nine to 10 billion people by 2100. Although the range of emissions pathways across baseline scenarios in the literature is broad, it may not represent the full potential range of possibilities
- The concentration outcomes of the baseline and mitigation scenarios assessed by WG3 cover the full range of RCPs. However, they provide much more detail at the lower end, with many scenarios aiming at concentration levels in the range of 450, 500, and 550 ppm CO2eq in 2100.

Simulated future by plausible scenarios

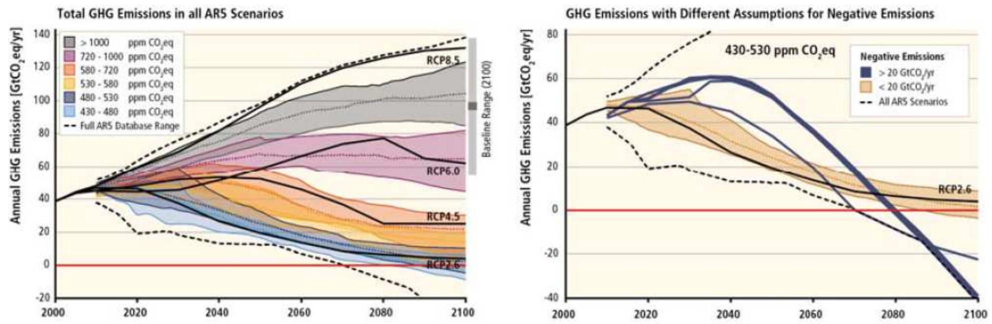
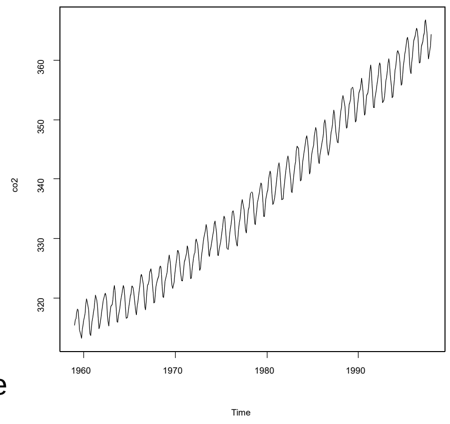


Figure TS.8. Development of total GHG emission for different long-term concentration levels (left panel) and for scenarios reaching 430–530 ppm CO_2eq in 2100 with and without net negative CO_2 emissions larger than 20 $GtCO_2$/yr (right panel). Ranges are given for the 10–90th percentile of scenarios. The grey bars to the right of the top panels indicate the full 2100 range (not only the 10th–90th percentile) for baseline scenarios. [Figure 6.7]

Greenhouse gases

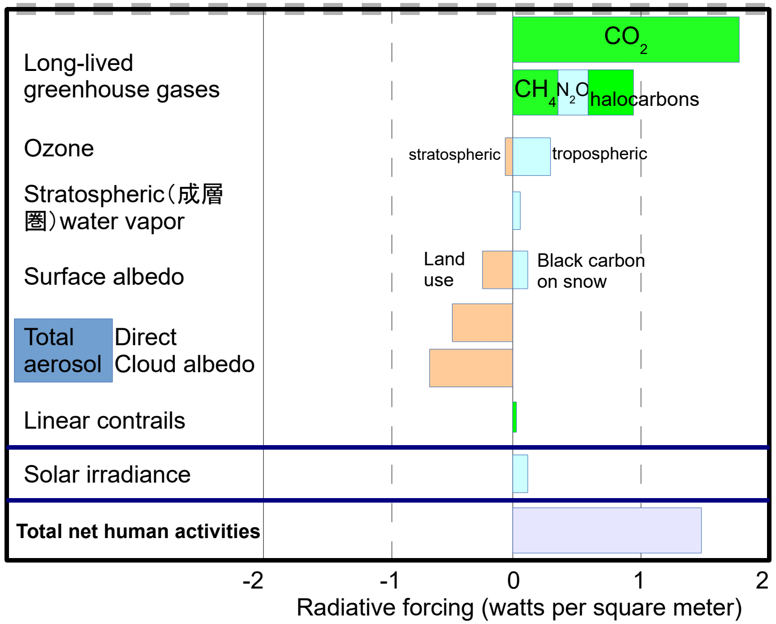
- Composition of the Earth's atmospheric gas started to change since mid-1700s: increase of CO_2, CH_4, N_2O
  - https://gaw.kishou.go.jp/publications/global_mean_mole_fractions
- Analyses of Antarctic ice cores (gases trapped in bubbles) revealed the concentration of CO_2 rose 35% (from 280 ppm in late 18C to 380 ppm in 21C)
  - It's accelerated in 20C (see, right graph).
- Higher greenhouse gas contributes to warming of the Earth, positive "Radiative Forcing" = absorbing/reemitting infrared radiation toward the lower atmosphere and the Earth's surface



Graph shown above can be obtained by typing plot(co2) in R-3.6.1 (https://www.r-project.org).

Components of radiative forcing

(modified from Fig. 10.1, pp.281 in Frumkin H [Ed.] 2010 "Environmental health: from global to local 2nd ed.", Jossey-Bass)



Main Greenhouse Gases

modified from Frumkin H [Ed.] 2010 "Environmental health: from global to local 2nd ed.", Jossey-Bass

Gases	Chemical formula	Preindustrial ppb	2005 ppb	Atmospheric lifetime (yr)	Anthropogenic sources	Global Warming Potential (GWP)
Carbon dioxide	CO_2	278,000	379,000	variable	fossil fuel, land use, cement	1
Methane	CH_4	700	1,774	12.2±3	fossil fuel, rice paddy, waste, livestock	21
Nitrous oxide	N_2O	275	319	120	fertilizer, ...	310
CFC-12	CCl_2F_2	0	0.538	102	liquid coolants	6,200-7,100
HCFC-22	$CHClF_2$	0	0.169	12.1	liquid coolants	1,300-1,400
Perfluoromethane	CF_4	0	0.074	50,000	aluminum production	6,500
Sulfur hexafluoride	SF_6	0	0.006	3,200	dielectric fluid	23,900

Projected earth system changes

- Warmer and fewer cold days and nights over most land areas: late 20C very likely occurred, likely due to human activity, future trends virtually certain
- Warmer and more frequent hot days and nights over most land areas: late 20C very likely occurred, likely due to human activity, future trends virtually certain
- Warm spells/heat waves, frequency increases over most land areas: late 20C likely, more likely than not due to human activity, future trends very likely
- Heavy precipitation events, frequency increases over most areas: late 20C likely, more likely than not due to human activity, future trends very likely
- Area affected by droughts increases: late 20C likely, more likely than not due to human activity, future trends likely
- Intense tropical cyclone activity increases: late 20C likely, more likely than not due to human activity, future trends likely
- Increased incidence of extreme high sea level: late 20C likely, more likely than not due to human activity, future trends likely

Particularly vulnerable regions

- Areas or populations within or bordering regions with a high endemicity of climate-sensitive diseases (eg. malaria)
- Areas with an observed association between epidemic disease and weather extremes (eg. El Niño-linked epidemics of malaria and dengue)
- Areas at risk from combined climate impacts relevant to health (eg. stress on food and water supplies or risk of coastal flooding)
- Areas at risk from concurrent environmental or socioeconomic stresses (eg. local stress from land use practices or an impoverished or undeveloped health infrastructure) and with little capacity to adapt

Effects on food production and malnutrition

- Drought will exacerbate malnutrition
  - 1.7 billion people (1/3 of world's population) live in water-stressed countries -> 5 billion by 2025
  - The central Asia and southern Africa may have decreased average annual stream flow
    - Glaciers of the Tibetan plateau may melt by 2035
    - Diarrhea, scabies, conjunctivitis (red eye), trachoma may increase (by poor hygiene due to depleted water resources)
  - Crops and livestock may be affected
- Rosenzweig et al. (1993) suggested that by 2060, additional 40 to 300 million people, relative to projected baseline 640 million people could be at risk of malnutrition due to anthropogenic warming
- Fisheries are also likely to be affected by Ocean warming and water acidification [ocean pH may drop by 0.14-0.35 during 21C] (then reduction of plankton abundance)

Weather extremes

- Heat waves
  - August 2003 heat waves caused 44,878 excess deaths in affected countries (Belgium, Switzerland, Germany, Spain, France, Italy, ...)
  - Urban heat island (retaining heat as a result of buildings, human activities: black asphalt and other dark surface have a low albedo; lacking in trees; no wind road) worsens the situation
- Reduced extreme cold
  - It may reduce stroke, but not linked with flu. Counter-effects are limited
- Natural disasters
  - Floods, droughts, and wildfires may increase. Not only direct victims of disasters, PTSD patients and infectious disease outbreaks (confounding factors must be controlled) are also to be paid attention
- Sea-level rise

Air pollution

- Ozone
  - Patz et al. (2004) predicted the increase in ozone exceedance days by 2050. Reduction of 9.9 good days, increase of 2.5 moderate days and 7.4 unhealthy days within 89 summer days (esp. for sensitive groups)
- Aeroallergens
  - Increase of pollen due to high CO_2
- Allergens and contact dermatitis
  - Increase of poison ivy, which causes contact dermatitis

Infectious diseases

- Water- and foodborne diseases
  - Climate change affects freshwater and marine ecosystems
  - *E. coli* O157 and other bacteria may increase due to contaminated drinking water caused by fails of infrastructure during heavy rain
  - 1993 cryptosporidium outbreak in Milwaukee (403,000 people were exposed to contaminated water)
  - Marines are contaminated by harmful algal blooms. Ciguatera ingested fish, Vibrio species (eg. V. cholerae) proliferate in warm water
  - More frequent warm days and greater humidity increase food-borne disease like salmonellosis, campyrobacter
- Vector-borne diseases
  - Mosquito-borne diseases: malaria (An.), dengue (Ae.), WNV (Cu.), chikungunya (Ae.) and Rift Valley fever (Ae.) may increase due to shortened reproductive cycles of mosquitoes in higher temperature and increase of bleeding sites after heavy rainfall
  - Tick-borne disease: Lyme disease may expand the affected area due to expansion of areas lowest monthly average temperature being higher than minus 7 degree C.
  - Rodent-borne diseases (incl. fleas associated with rodents): Hantavirus and plague may increase

Public health response

- Mitigation and adaptation
  - Mitigation = Primary prevention
    - Efforts to stabilize or reduce the production of greenhouse gases
    - Eg. Replacement of energy production by sustainable/reproducible ones (wind, solar) may reduce greenhouse gases
    - Stabilization wedges: Technologies and behavioral changes contributing to reduction of greenhouse gases can be seen as wedges, combination of wedges is a strategy to stabilize climate
  - Adaptation = Secondary prevention
    - Efforts to reduce the public health impact of climate change. Eg. increase of disaster preparedness
    - Vulnerability assessment is needed
- Co-benefits: if one strategy may contribute to multiple mitigation and/or adaptation, it will be very feasible and politically easy to accept
- Unintended consequences: eg. biofuel production may quadruple within next 15-20 years, crops as food may short, food prices may increase.
- Climate change policy: United Nations Framework Convention on Climate Chang (UNFCCC) set out a framework since 1992 through COP meetings: 1997 COP3 Kyoto protocol, overall emission of greenhouse gases should be reduced by at least 5% below 1990 level in 2008-2012. 2007 COP13, USA was only country not to ratify the treaty, but after 2008 election, USA evolved
- Ethical considerations: Developed countries must be responsible to emission of greenhouse gases, but not seriously affected. Instead, developing countries are affected. Similar discrepancy also exists between rich and poor within a country