Fizyka procesów klimatycznych
Wykład 14

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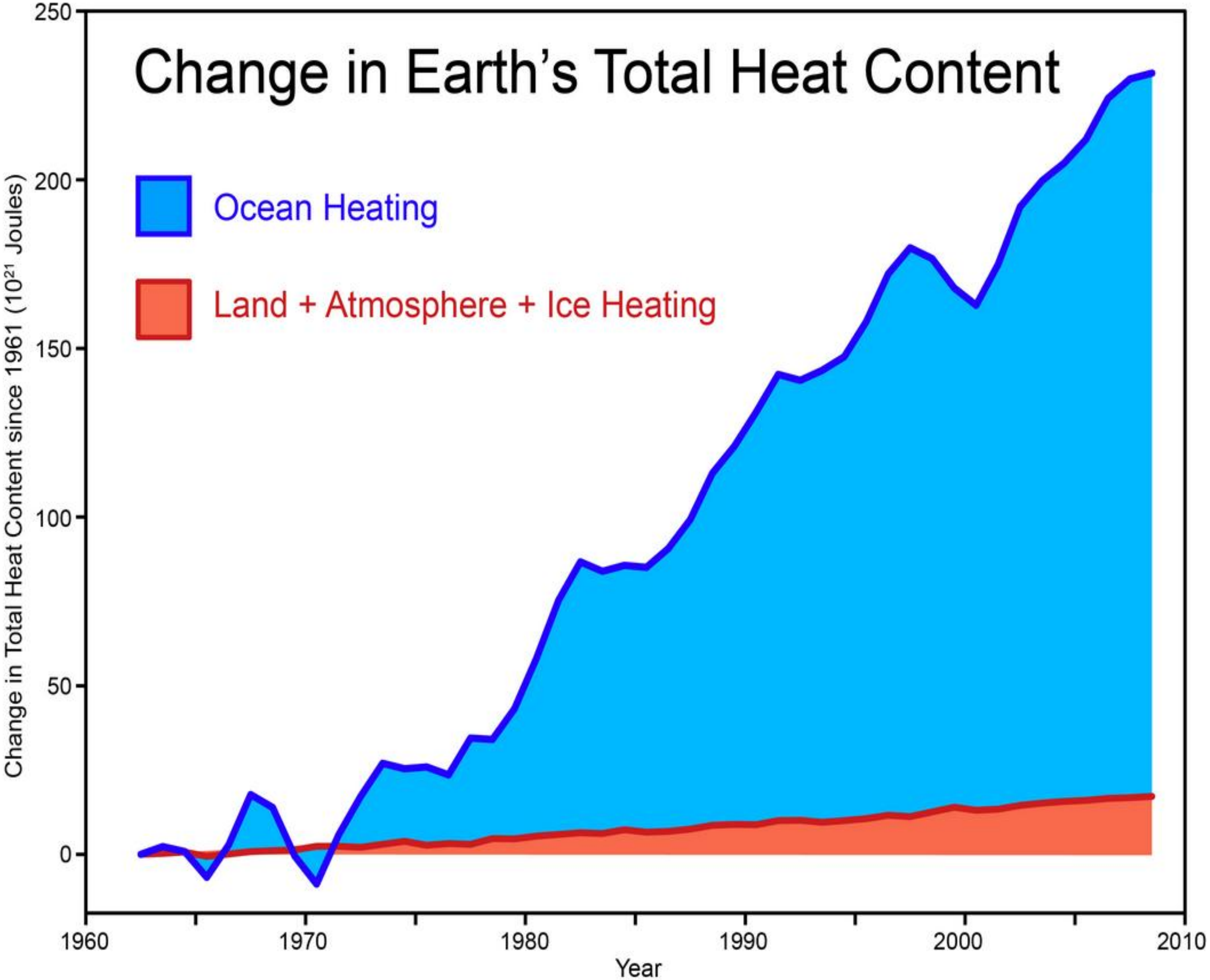
Zmiana klimatu =

naturalna zmienność klimatu (wiele elementów)

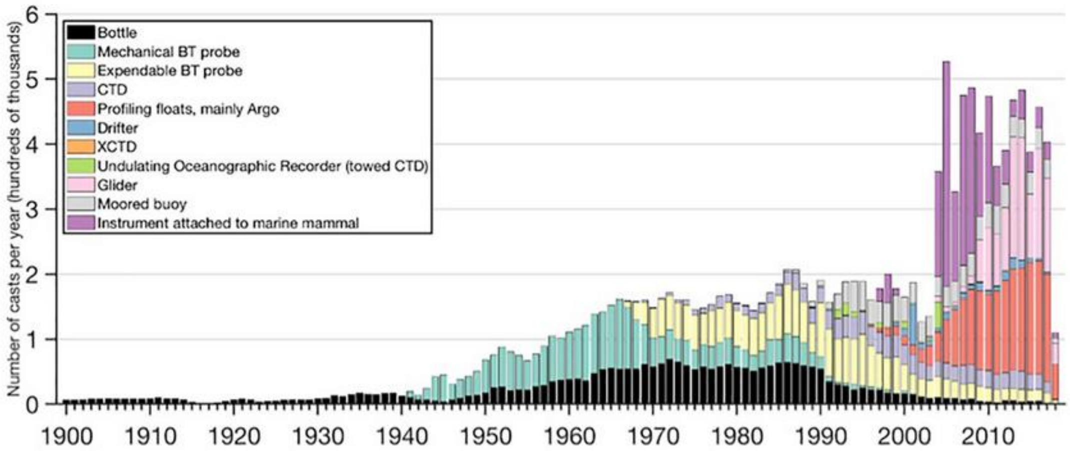
+ odpowiedź na wymuszenia (czasem mówi się o trendzie)

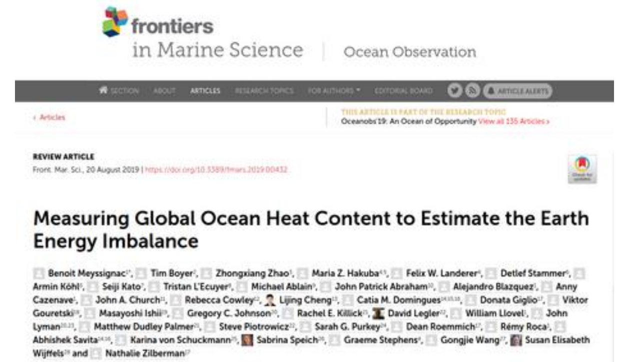
Jak określić za co odpowiada naturalna zmienność a za co trend?

Atrybucja



Church, J. A., N. J. White, L. F. Konikow, C. M. Domingues, J. G. Cogley, E. Rignot, J. M. Gregory, M. R. van den Broeke, A. J. Monaghan, and I. Velicogna (2011), Revisiting the Earth's sea-level and energy budgets from 1961 to 2008, Geophys. Res. Lett., 38, L18601, doi:10.1029/2011GL048794.





frontiers in Marine Science | Ocean Observation

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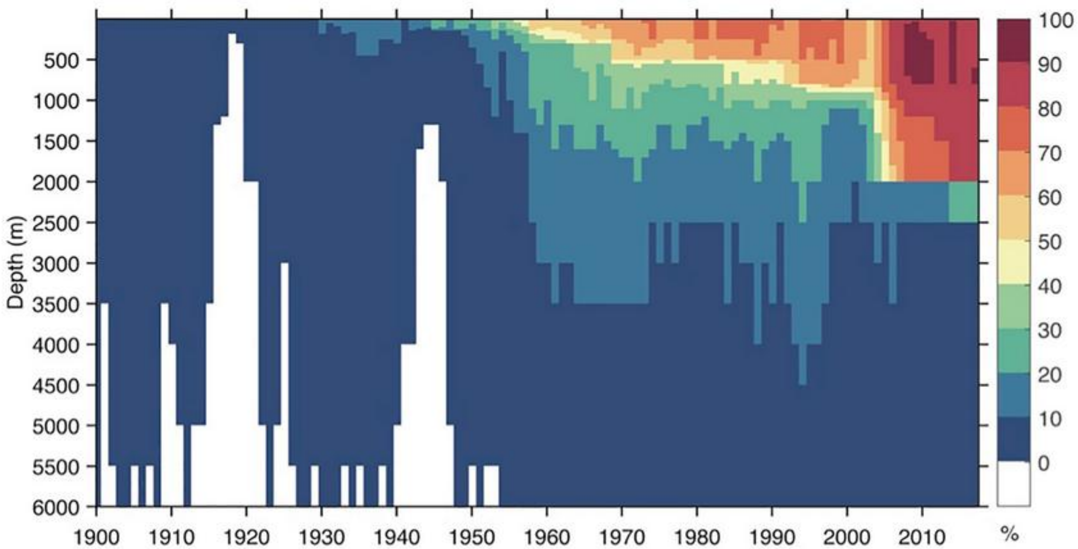
‹ Articles

THIS ARTICLE IS PART OF THE RESEARCH TOPIC
Oceanobs'19: An Ocean of Opportunity View all 135 Articles ›

REVIEW ARTICLE
Front. Mar. Sci., 20 August 2019 | https://doi.org/10.3389/fmars.2019.00432

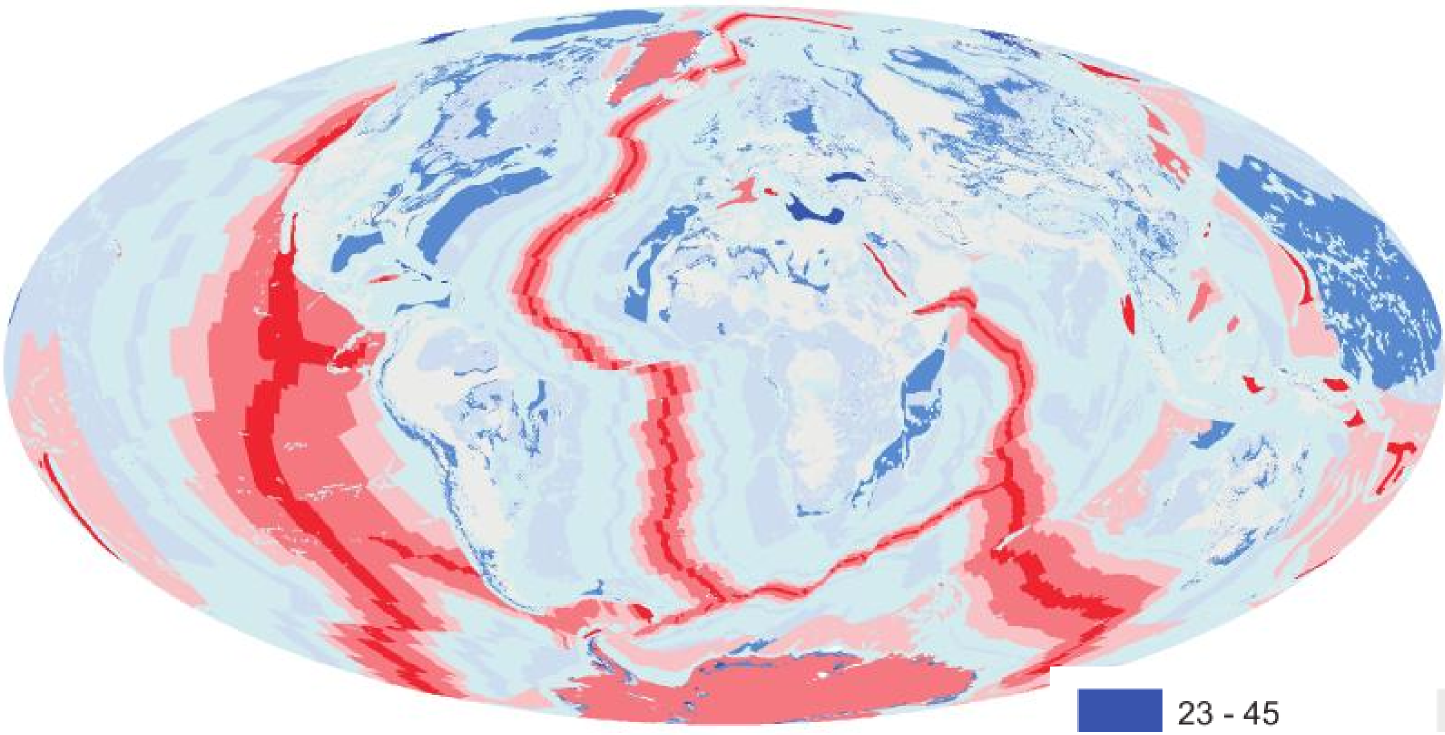
Measuring Global Ocean Heat Content to Estimate the Earth Energy Imbalance

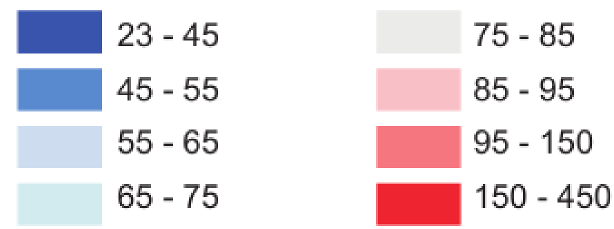
Benoit Meyssignac, Tim Boyer, Zhongxiang Zhao, Maria Z. Hakuba, Felix W. Landerer, Detlef Stammer, Armin Köhl, Seiji Kato, Tristan L'Ecuyer, Michael Ablain, John Patrick Abraham, Alejandro Blazquez, Anny Cazenave, John A. Church, Rebecca Cowley, Lijing Cheng, Catia M. Domingues, Donata Giglio, Viktor Gouretski, Masayoshi Ishii, Gregory C. Johnson, Rachel E. Killick, David Legler, William Llovel, John Lyman, Matthew Dudley Palmer, Steve Piotrowicz, Sarah G. Purkey, Dean Roemmich, Rémy Roca, Abhishek Savita, Karina von Schuckmann, Sabrina Speich, Graeme Stephens, Gongjie Wang, Susan Elisabeth Wijffels and Nathalie Zilberman



Number of subsurface ocean temperature profiles per year by instrument type 1900–2017. [BT, Bathythermograph; CTD, Conductivity- Temperature-Depth; XCTD, Expendable CTD]. (Lower) Percentage (%) of data coverage for 3 × 3 boxes over the global ocean area from 5 to 6000 m.

Energia geotermalna



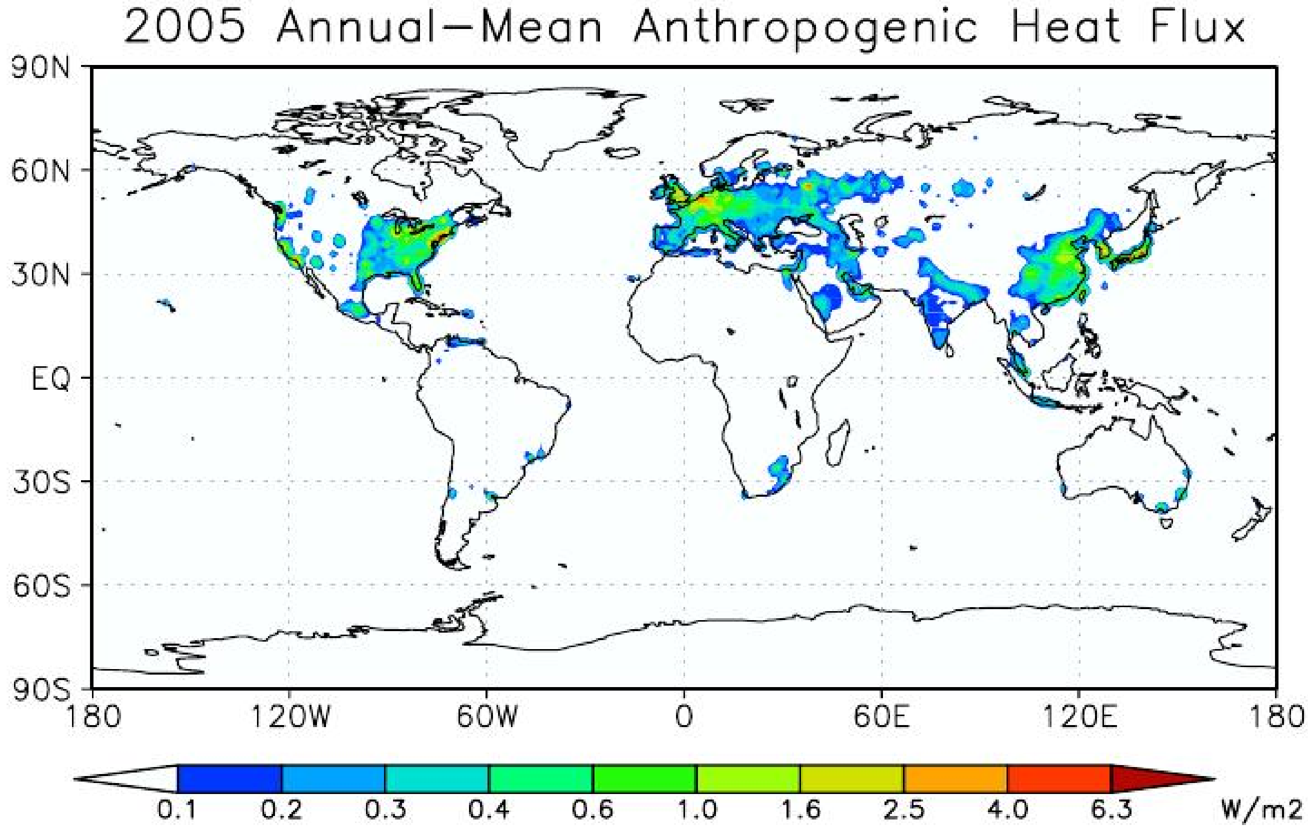


Strumień ciepła pochodzącego z wnętrza Ziemi w mW/m^2 (mW=1/1000W)

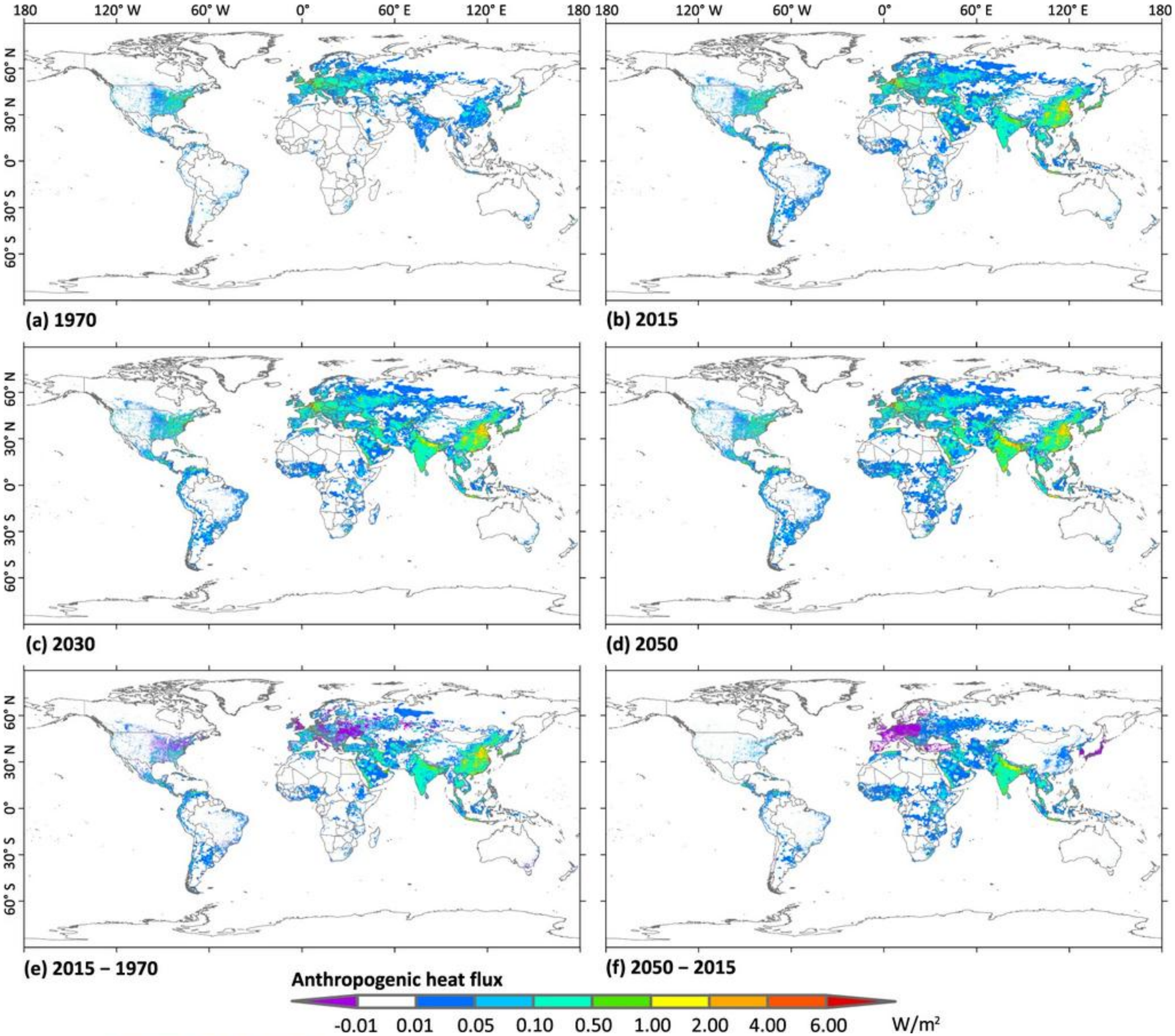
Table 7. Summary of continental and oceanic heat flow from our preferred estimates.

	Area (m^2)	Heat Flow (TW)	Mean Heat Flow ($mW\ m^{-2}$)
Continent	2.073×10^{14}	14.7	70.9
Ocean	3.028×10^{14}	31.9	105.4
Global Total	5.101×10^{14}	46.7	91.6

Davies, J. H., D. R. Davies. 2010. Earth's surface heat flux. Solid Earth 1, no. 1: 5-24.



Flanner, M. G. (2009) Integrating anthropogenic heat flux with global climate models, Geophys. Res. Lett., 36, L02801



Data Descriptor | Open Access | Published: 31 July 2019

A new global gridded anthropogenic heat flux dataset with high spatial resolution and long-term time series

Kai Jin, Fei Wang, Deliang Chen, Huanhuan Liu, Wenbin Ding & Shangyu Shi

Scientific Data 6, Article number: 139 (2019) | Cite this article

Atmos. Chem. Phys., 11, 13421–13449, 2011
www.atmos-chem-phys.net/11/13421/2011/
doi:10.5194/acp-11-13421-2011

Atmospheric Chemistry and Physics

Earth's energy imbalance and implications

J. Hansen[1,2], M. Sato[1,2], P. Kharecha[1,2], and K. von Schuckmann[3]

[1]NASA Goddard Institute for Space Studies, New York, NY 10025, USA
[2]Columbia University Earth Institute, New York, NY 10027, USA
[3]Centre National de la Recherche Scientifique, LOCEAN Paris, hosted by Ifremer, Brest, France

Received: 2 September 2011 – Published in Atmos. Chem. Phys. Discuss.: 29 September 2011
Revised: 30 November 2011 – Accepted: 7 December 2011 – Published: 22 December 2011

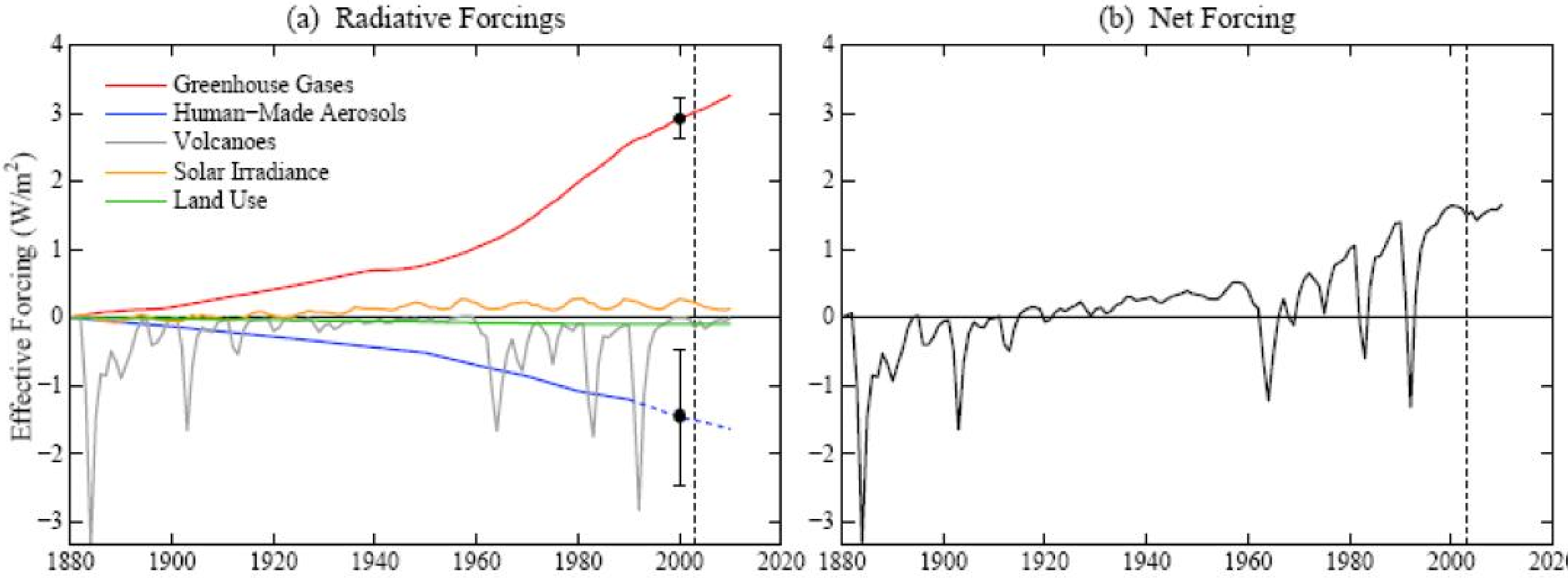


Fig. 1. Climate forcings employed in this paper. Forcings through 2003 (vertical line) are the same as used by Hansen et al. (2007), except the tropospheric aerosol forcing after 1990 is approximated as −0.5 times the GHG forcing. Aerosol forcing includes all aerosol effects, including indirect effects on clouds and snow albedo. GHGs include O_3 and stratospheric H_2O, in addition to well-mixed GHGs. These data are available at http://www.columbia.edu/~mhs119/EnergyImbalance/Imbalance.Fig01.txt.

The lag of the climate response can be characterized by a climate response function, which is defined as the fraction of the fast-feedback equilibrium response to a climate forcing. This response function is obtained from the temporal response of surface temperature to an instantaneously applied forcing, for example a doubling of atmospheric CO_2. The response function for GISS modelE-R, i.e., the GISS atmospheric model (Schmidt et al., 2006) coupled to the Russell ocean model (Russell et al., 1995), is shown in Fig. 3.

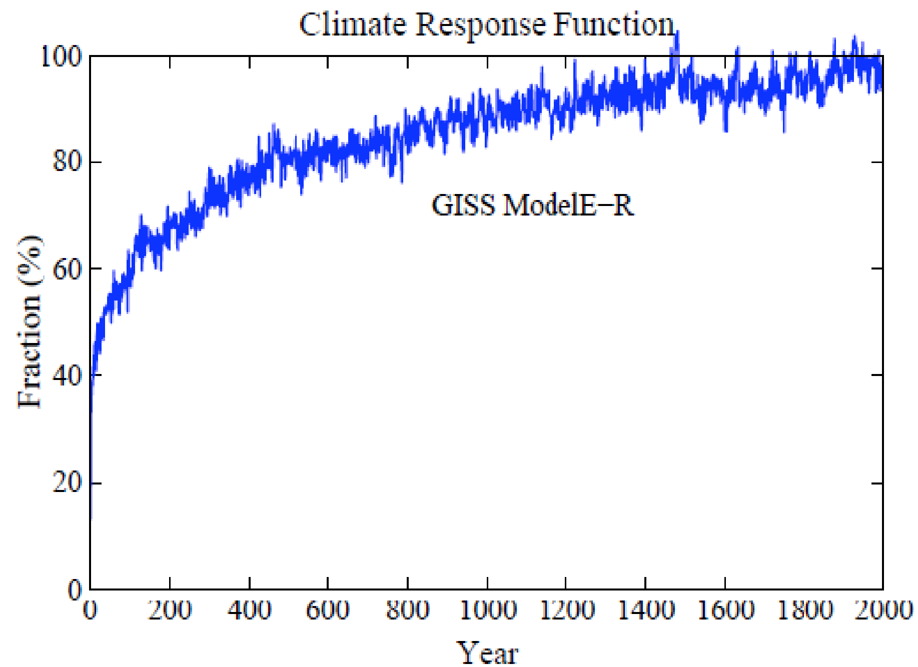


Fig. 3. Climate response function, $R(t)$, i.e., the fraction of equilibrium surface temperature response for GISS climate model-ER, based on the 2000 yr control run E3 (Hansen et al., 2007). Forcing was instant CO_2 doubling with fixed ice sheets, vegetation distribution, and other long-lived GHGs.

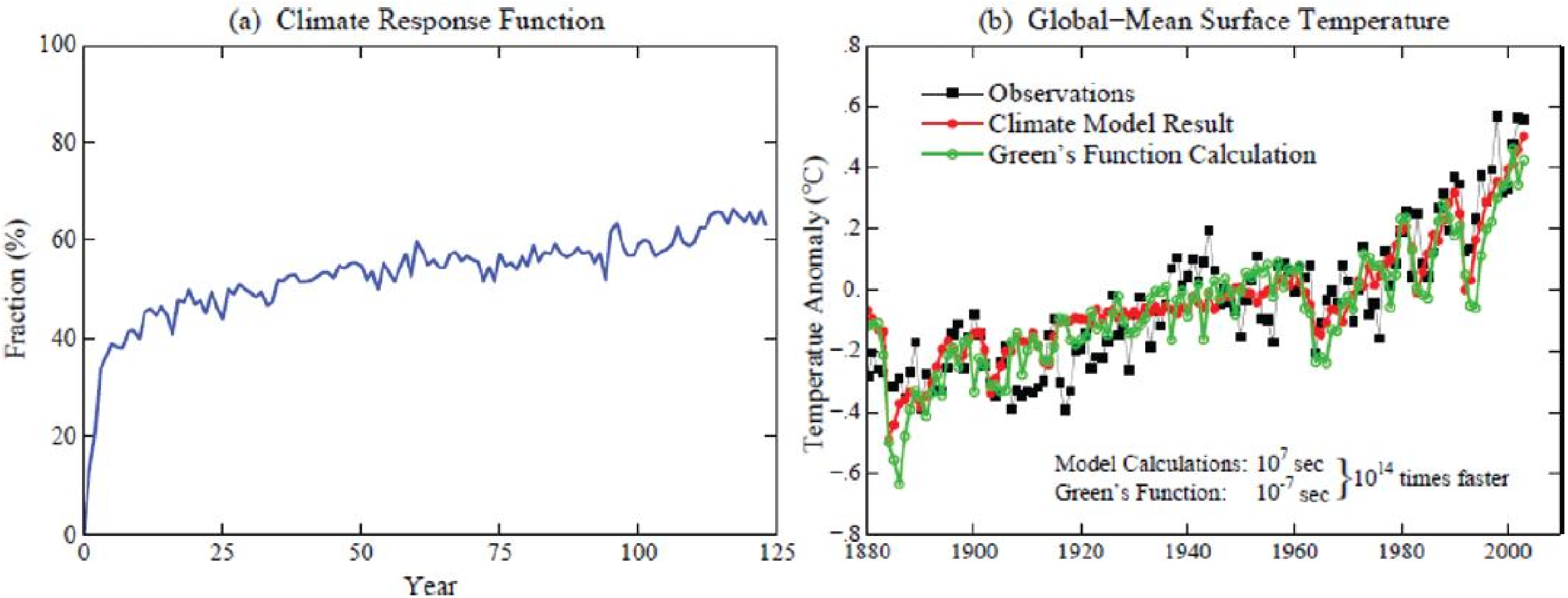


Fig. 4. (a) First 123 yr of climate response function, from Fig. 3, **(b)** comparison of observed global temperature, mean result of 5-member ensemble of simulations with the GISS global climate modelE-R, and the simple Green's function calculation using the climate response function in **(a)**.

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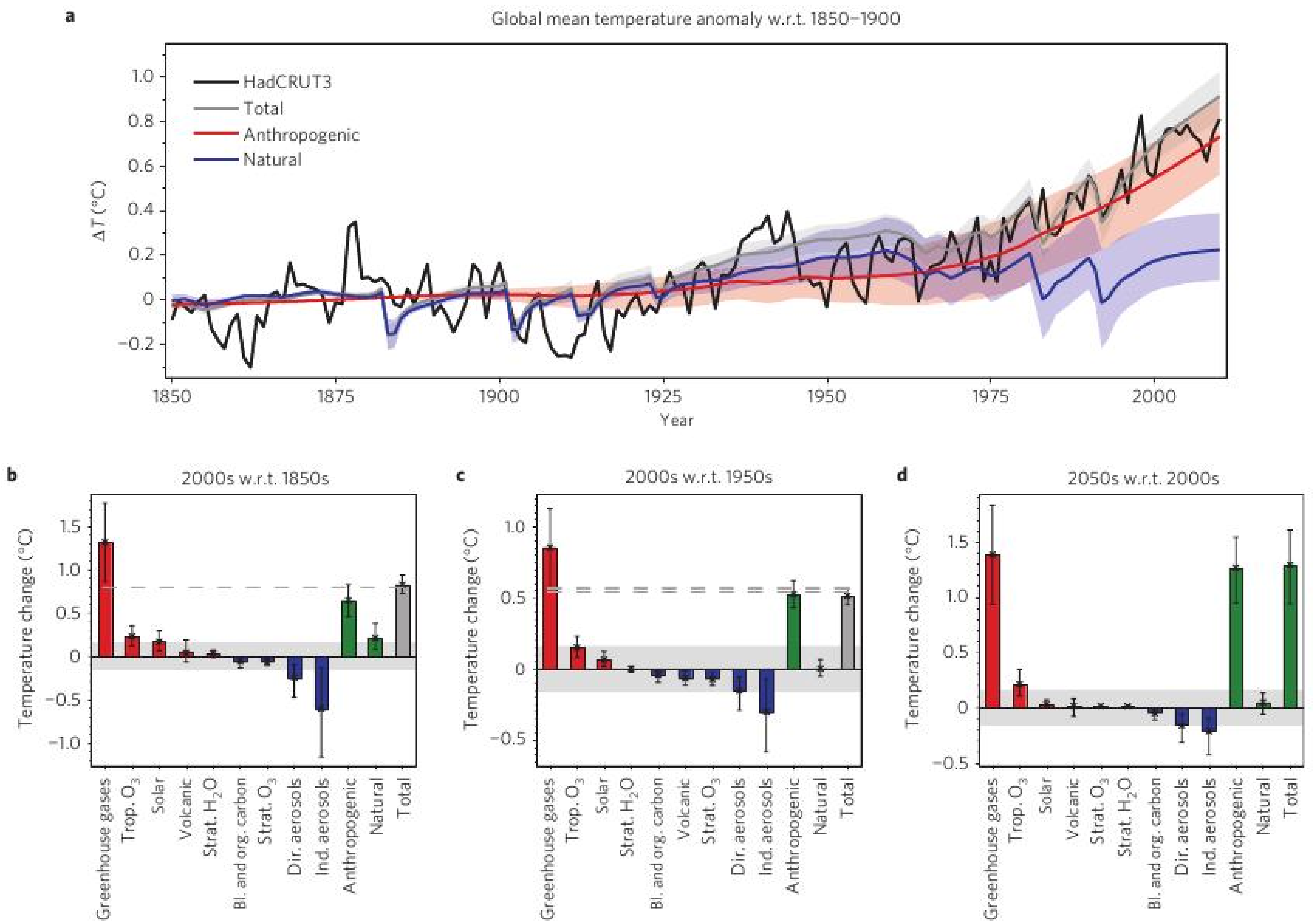


Figure 3 | Contributions of different forcing agents to the total observed temperature change. a, Time series of anthropogenic and natural forcings contributions to total simulated and observed global temperature change. The coloured shadings denote the 5-95% uncertainty range. **b–d**, Contribution of individual forcing agents to the total decadal temperature change for three time periods. Error bars denote the 5-95% uncertainty range. The grey shading shows the estimated 5-95% range for internal variability based on the CMIP3 climate models. Observations are shown as dashed lines.

Inny, statystyczny sposób atrybucji (rozdzielania sygnałów różnego pochodzenia) – regresja wieloliniowa.

GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L18701, doi:10.1029/2008GL034864, 2008

How natural and anthropogenic influences alter global and regional surface temperatures: 1889 to 2006

Judith L. Lean[1] and David H. Rind[2]

Received 2 June 2008; revised 1 August 2008; accepted 8 August 2008; published 16 September 2008.

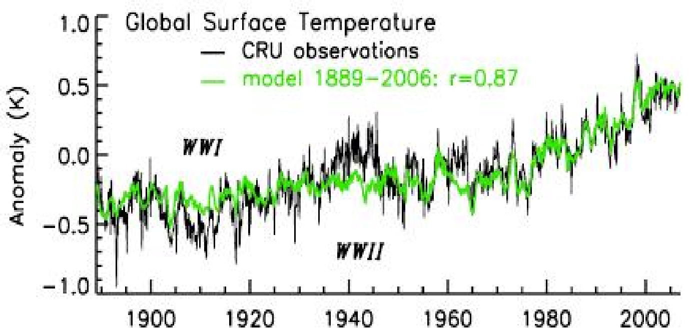


Figure 1. Compared with the CRU monthly mean global temperature time series (hadcrut3vcgl) is an empirical model obtained from multiple regression for the period from 1889 to 2006, inclusive. The value of *r* is the correlation coefficient for the global temperature observations and empirical model. Largest differences occur at the times of the two World Wars when observations were sparse.

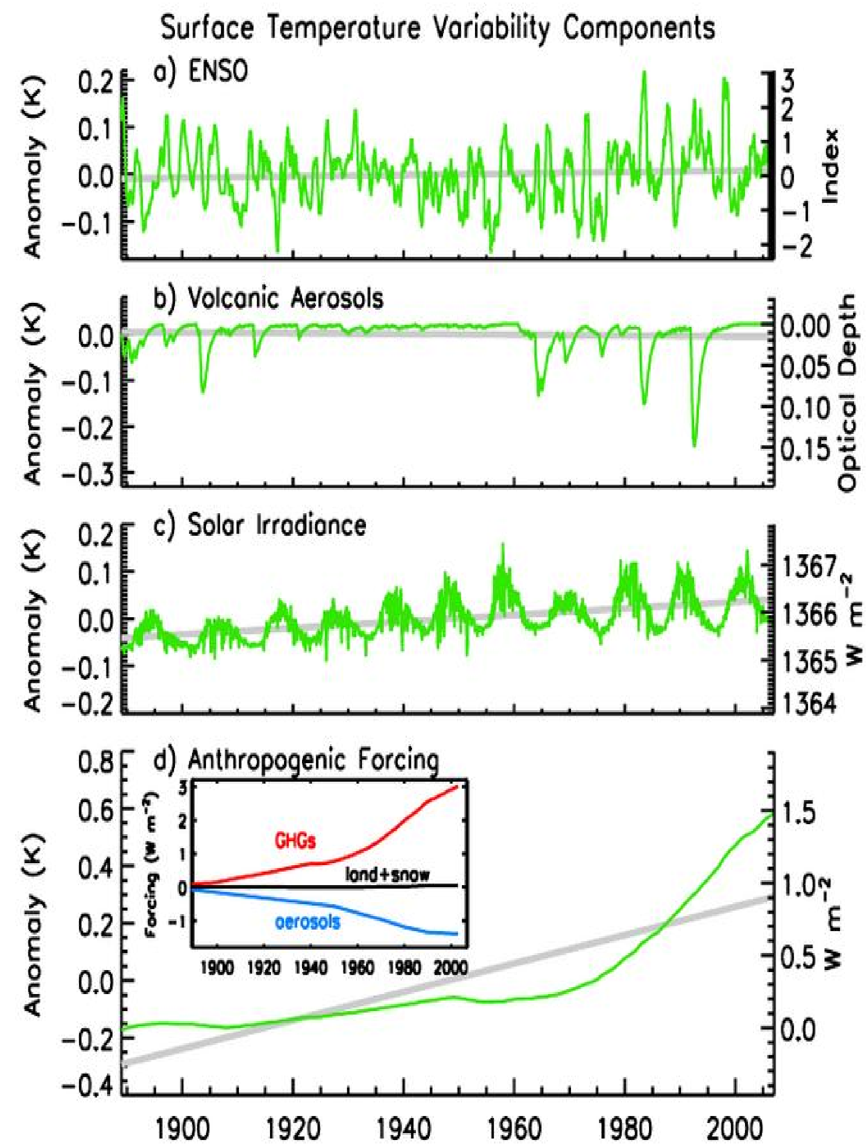
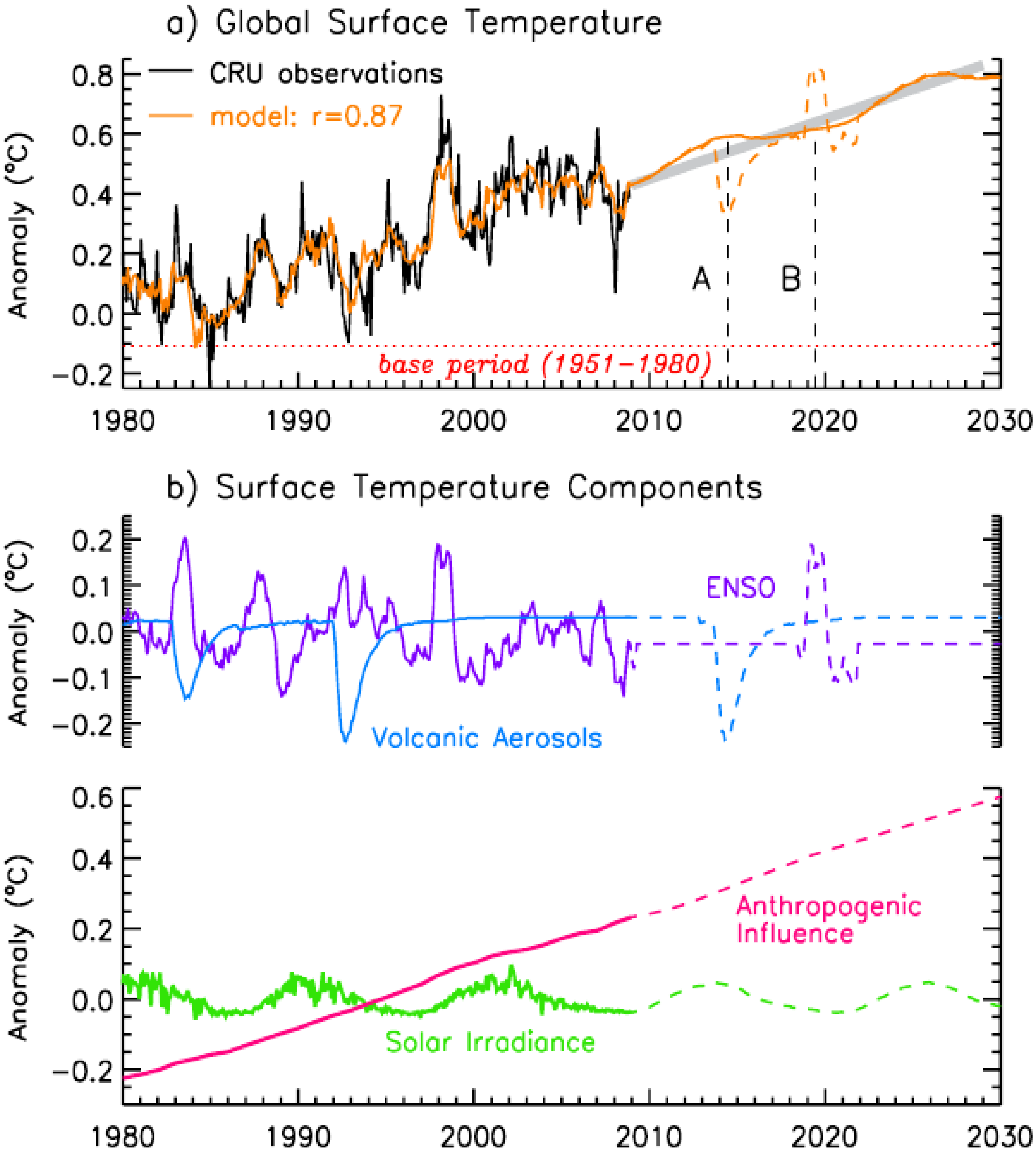


Figure 2. Reconstructions of the contributions to monthly mean global surface temperatures by individual natural and anthropogenic influences (at appropriate lags) are shown. The right hand ordinates give the native scales of each influence and the left hand ordinates give the corresponding temperature change determined from the multiple regression analysis. The grey lines are trends for the whole interval. The inset in Figure 2d shows the individual greenhouse gases, tropospheric aerosols and the land surface plus snow albedo components that combine to give the net anthropogenic forcing.



Wpływ różnych czynników na średnią globalną (średnie miesięczne) temperaturę powietrza przy powierzchni Ziemi w latach 1980-2008

Lean and Rind, 2009: Geophys.Res.Lett. 36, L15708, doi:10.1029/2009GL038932, 2009

Jak określić czy jakieś pojedyncze zdarzenie, np. huragan czy fala upałów jest efektem globalnego ocieplenia czy zdarzyłoby się niezależnie od ocieplenia?

Atrybucja zjawisk ekstremalnych.

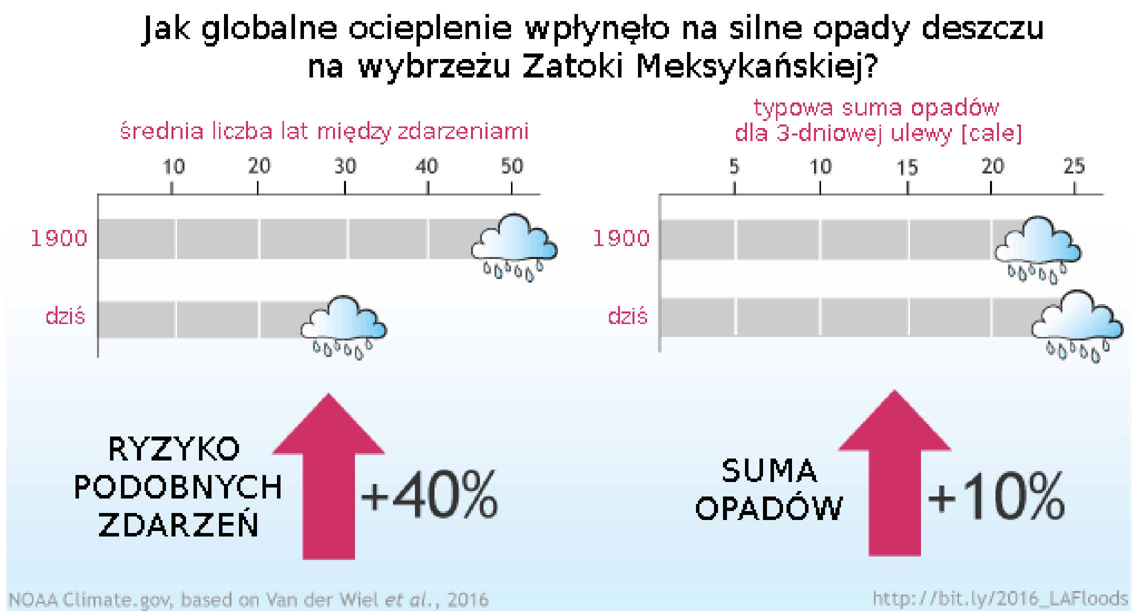
Czego możemy dowiedzieć się dzięki atrybucji?

Zależnie od rodzaju analizy, badanie atrybucyjne może nam powiedzieć, czy globalne ocieplenie spowodowało (lub spowoduje), że zjawiska konkretnego typu są (lub będą) częstsze, niż w przypadku, gdybyśmy nie spowodowali globalnej zmiany klimatu. Możemy dowiedzieć się, jak zwiększyła się (lub zmniejszyła) przeciętna liczba lat pomiędzy kolejnymi tak intensywnymi zjawiskami, jakie jest prawdopodobieństwo wystąpienia określonego zjawiska oraz jak zmieniło się ono w związku z globalnym ociepleniem.

Czasami analiza atrybucyjna odpowiada również na pytanie, o ile globalne ocieplenie wpłynęło nie na prawdopodobieństwo wystąpienia zjawiska lecz na jego parametry.

Czego nie możemy dowiedzieć się dzięki atrybucji?

Analiza atrybucyjna nie powie nam czy globalne ocieplenie „spowodowało” konkretne wydarzenie. Gdy ludzie pytają, „czy wichurę na Pomorzu spowodowała zmiana klimatu?” chcieliby usłyszeć odpowiedź „tak” lub „nie”. Tymczasem takiej odpowiedzi nie można udzielić. Możemy powiedzieć, że globalne ocieplenie miało w zdarzeniu udział, że było jedną z przyczyn, ale nie jedyną czy dominującą.



W połowie sierpnia 2016, powoli przesuwająca się burza przyniosła w niektórych rejonach Luizjany ponad 60 cm opadów. Analiza atrybucyjna (Van der Wiel i in., 2016) wykazała, że częstość występowania takich zdarzeń w związku z globalnym ociepleniem wzrosła, i o ile w 1900 roku miały one miejsce średnio raz na 50 lat, to teraz już aż raz na 30 lat. Ponadto, ilość deszczu, jaka typowo występowała podczas „ulewy spotykanej raz na 30 lat” była na początku XX wieku o 10% mniejsza niż dziś (przykładowo, 54 cm vs. 60 cm).

Diagram obrazujący schematycznie, z jaką ufnością podchodzimy obecnie do wyników analiz wiążących zmiany w występowaniu i natężeniu poszczególnych typów zjawisk ekstremalnych ze zmianą klimatu. Na osi poziomej mamy poziom zrozumienia wpływu globalnego ocieplenia na zjawisko, na pionowej – możliwość wykrycia tego wpływu.

https://www.climate.gov/news-features/understanding-climate/extreme-event-attribution-climate-versus-weather-blame-game

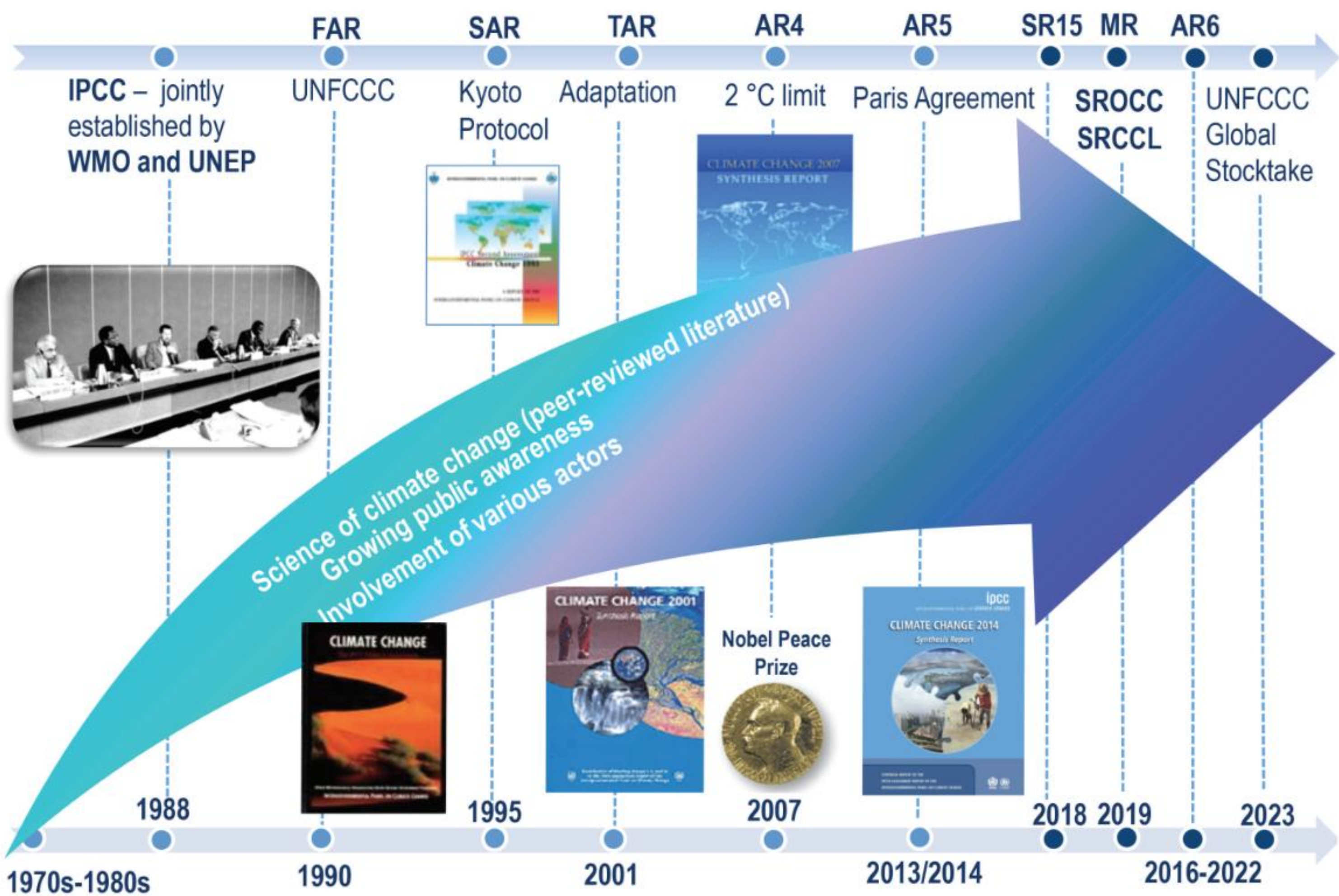
Intergovernmental Panel on Climate Change

Międzyrządowy Zespół ds. Zmiany Klimatu

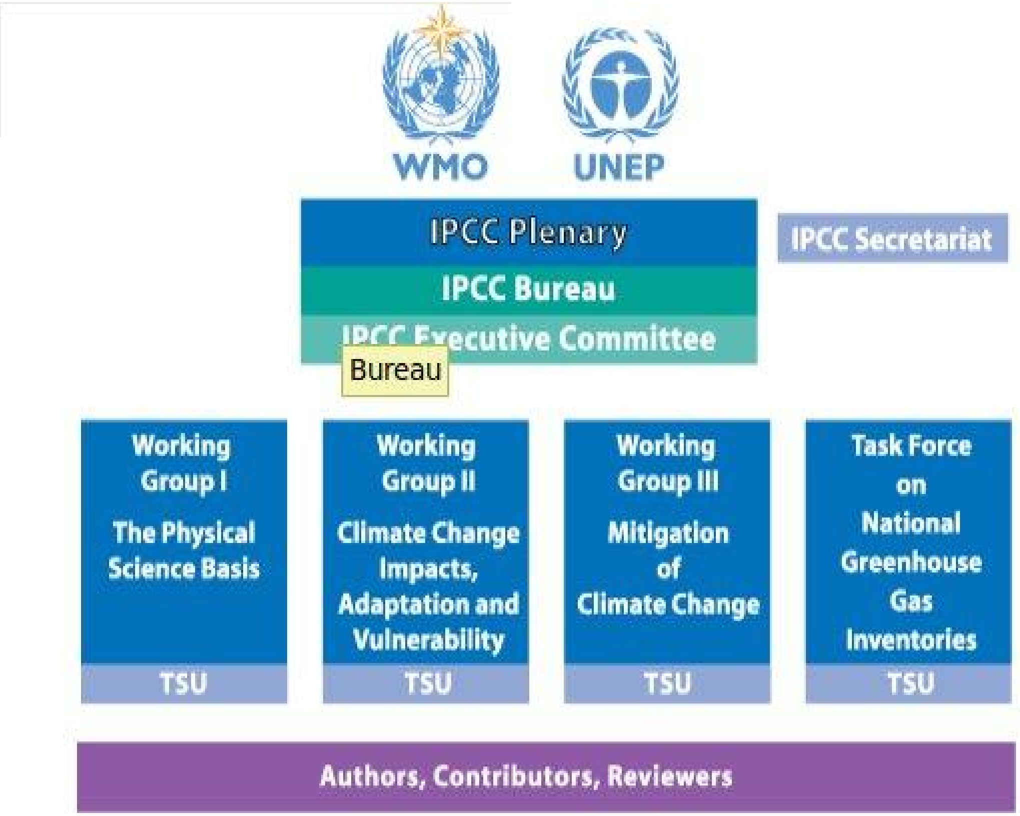
– organizacja założona w 1988 przez dwie organizacje Narodów Zjednoczonych:
Światową Organizację Meteorologiczną (WMO) oraz Program Środowiskowy Organizacji Narodów Zjednoczonych (UNEP) w celu oceny ryzyka związanego z wpływem człowieka na zmianę klimatu. Siedzibą organizacji jest Genewa.

Zadaniem Panelu jest przygotowywanie przeglądów wiedzy na temat przyczyn zmiany klimatu, możliwych skutków przyrodniczych, ekonomicznych i społecznych oraz rekomendacji dotyczących mitygacji zmian oraz adaptacji do tych zmian.

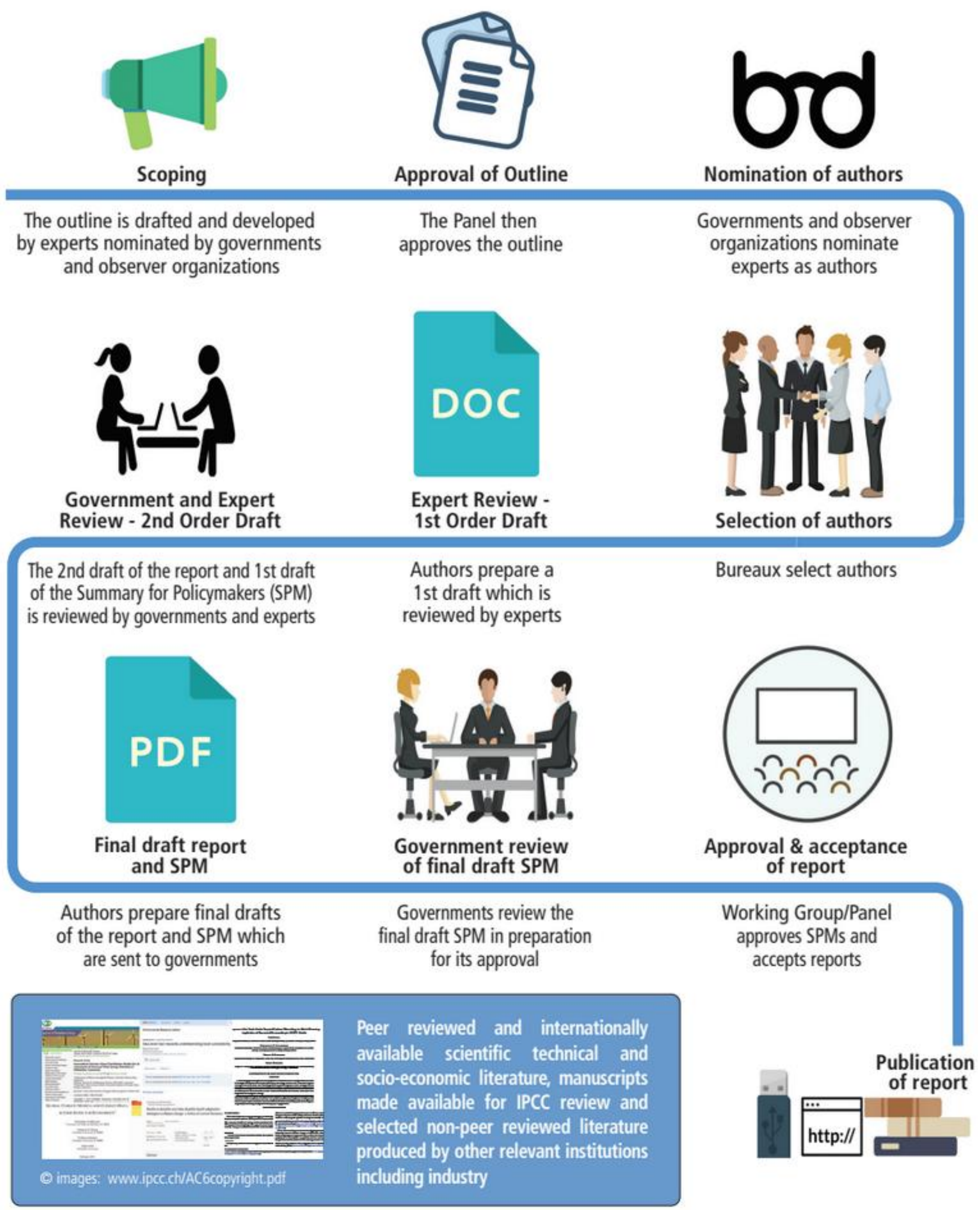
IPCC contribution to climate science and policymaking



Struktura IPCC



How the IPCC prepares its report



Przykład recenzji jako „expert reviewer”

Working Group I Contribution to the IPCC Fifth Assessment Report

SOD Formal **Government** Review

Reviewer: Government of Poland

No	Chapter	From Page	From Line	To Page	To Line	Comments
1	7	7	10	7	11	Why “Until”??? This sentence is misleading. Something like: “Clouds consist of droplets and ice crystals resulting from
2	7	7	27	7	28	“...relatively sharp edges and fine scale variations in-cloud properties...” citations should be added. E.g., from recent
3	7	7	54	8	16	Fig.1 should be redrawn. It is unclear and hard to follow.
4	7	9	1	9	4	Brenguier paper focuses on small-scale fluctuations only. There are original experimental (in-situ) papers about wide
5	7	10	51	11	48	For the sake of completeness at the end of this section an information on DNS modeling of cloud properties should be
6	7	31	13	31	13	Seifert et al., 2010 – there are two more papers by (different) Seifert and the others in the reference list
7	7	42	44	42	44	is “acti0vity” should be “activity”
8	7	49	50	50	9	Figure 7.19 summarizes probably the most important result of this chapter an should be elaborated to be more informative.
9	7	12	30	12	37	Figure 7.7 should be updated including information on DNS modeling of cloud processes
10	7	58	31	58	31	Is “as water condenses and releases latent heat” should be “as water condenses, converts into precipitation falling down
11	7	59	47	59	50	is “aerosol-radiation” should be “aerosol – solar radiation” . Some aerosols interact in IR.

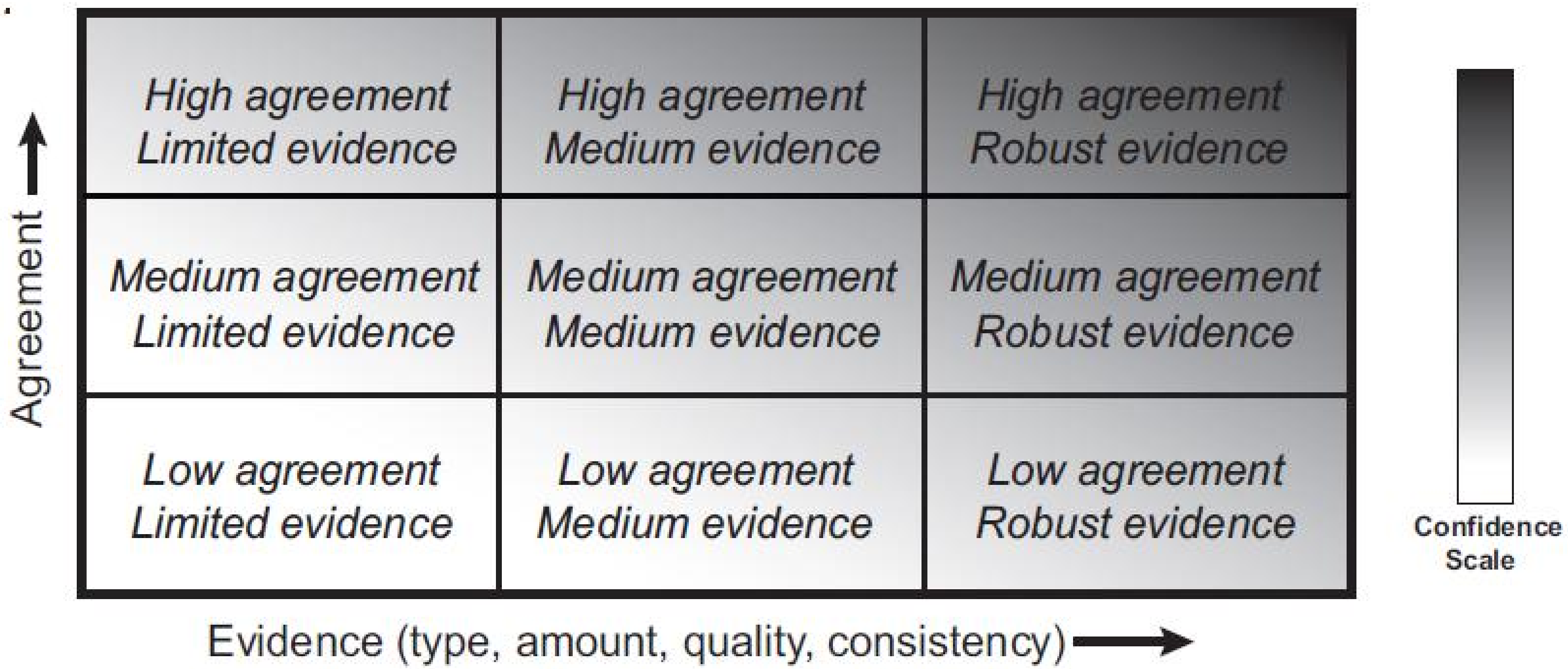
More than 830 Authors and Review Editors from over 80 countries were selected to form the Author teams that produced the Fifth Assessment Report (AR5).They in turn drew on the work of over 1,000 Contributing Authors and about 2,000 expert reviewers who provided over 140,000 review comments.

For the Fourth Assessment Report (AR4) released in 2007, over 3,500 experts coming from more than 130 countries contributed to the report (+450 Lead Authors, +800 Contributing Authors, and +2,500 expert reviewers providing over 90,000 review comments).

Słowniczek niepewności

prawdopodobieństwo	określenie ang.	określenie pl.
99-100%	*virtually certain*	*niemal pewne*
90-100%	*very likely*	*bardzo prawdopodobne*
66-100%	*likely*	*prawdopodobne*
33-66%	*about as likely as not*	*średnio prawdopodobne*
0-33%	*unlikely*	*mało prawdopodobne*
0-10%	*very unlikely*	*bardzo mało prawdopodobne*
0-1%	*exceptionally unlikely*	*niezwykle nieprawdopodobne*
	dodatkowe terminy	
95-100%	*extremely likely*	*wyjątkowo prawdopodobne*
>50-100%	*more likely than not*	*raczej prawdopodobne*
0-5%	*extremely unlikely*	*wyjątkowo nieprawdopodobne*

Słowniczek ufności



IPCC First Assessment Report 1990 (FAR)

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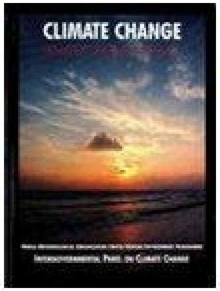

Working Group I:
Scientific Assessment of Climate Change
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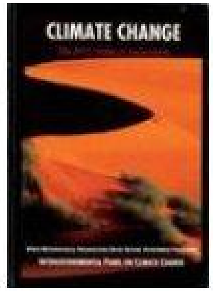

Working Group II:
Impacts Assessment of Climate Change
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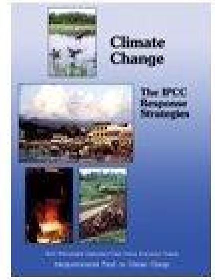

Working Group III:
The IPCC Response Strategies
CLICK HERE

First Assessment Report
Overview Chapter (PDF)
Also in: Chinese - French - Russian - Spanish

1.0.1 ***We are certain of the following:***

- There is a natural greenhouse effect which already keeps the Earth warmer than it would otherwise be.

- Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs) and nitrous oxide. These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth's surface. The main greenhouse gas, water vapour, will increase in response to global warming and further enhance it.

1.0.3 ***Based on current model results, we predict:***

- An average rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2—0.5°C per decade) assuming the IPCC Scenario A (Business-as-Usual) emissions of greenhouse gases; this is a more rapid increase than seen over the past 10,000 years. This will result in a likely increase in the global mean temperature of about 1°C above the present value by 2025 (about 2°C above that in the pre-industrial period), and 3°C above today's value before the end of the next century (about 4°C above pre-industrial). The

2. Impacts

2.0.1 The report on impacts of Working Group II is based on the work of a number of subgroups, using independent studies which have used different methodologies. Based on the existing literature, the studies have used several scenarios to assess the potential impacts of climate change. These have the features of:

i) an effective doubling of CO_2 in the atmosphere between now and 2025 to 2050;

ii) a consequent increase of global mean temperature in the range of 1.5°C to 4.5°C;

iii) an unequal global distribution of this temperature increase, namely a smaller increase of half the global mean in the tropical regions and a larger increase of twice the global mean in the polar regions;

iv) a sea-level rise of about 0.3—0.5 m by 2050 and about 1 m by 2100, together with a rise in the temperature of

1992 Supplementary Reports

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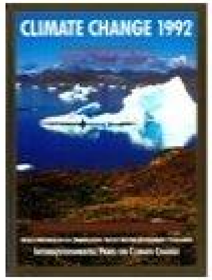
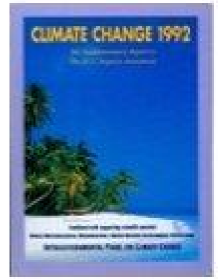


The Supplementary Report to
The IPCC Scientific Assessment

CLICK HERE



The Supplementary Report to
The IPCC Impacts Assessment

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The IPCC 1990 and
1992 Assessments

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IPCC Second Assessment Report: Climate Change 1995 (SAR)

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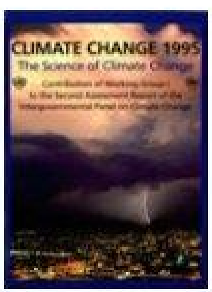
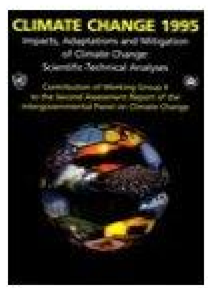
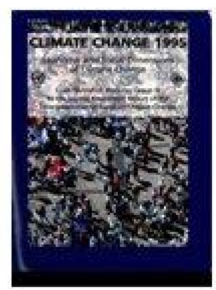


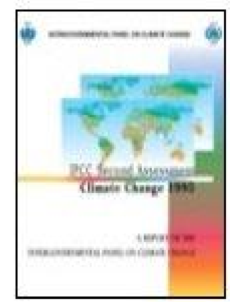
Working Group I:
The Science of Climate Change
Full Report (PDF)



Working Group II:
Impacts, Adaptations and
Mitigation of Climate Change:
Scientific-Technical Analyses
Full Report (PDF)



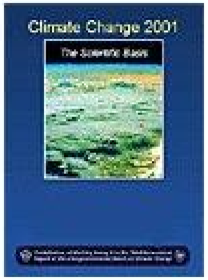
Working Group III:
Economic and Social
Dimensions of Climate Change
Full Report (PDF)



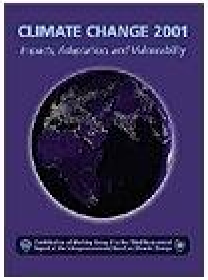
IPCC Second Assessment
Full Report (PDF)
Errata

Arabic - Chinese - French-
Russian - Spanish

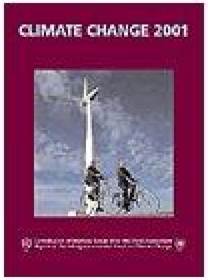
IPCC Third Assessment Report: Climate Change 2001 (TAR)



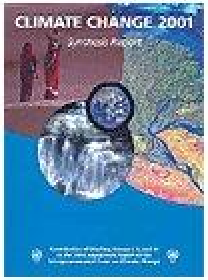
Working Group I:
The Scientific Basis



Working Group II:
Impacts, Adaptation and Vulnerability



Working Group III:
Mitigation



Synthesis Report

WG1 - Summary for Policymakers

The Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) builds upon past assessments and incorporates new results from the past five years of research on climate change[1]. Many hundreds of scientists[2] from many countries participated in its preparation and review.

This Summary for Policymakers (SPM), which was approved by IPCC member governments in Shanghai in January 2001[3], describes the current state of understanding of the climate system and provides estimates of its projected future evolution and their uncertainties. Further details can be found in the underlying report, and the appended Source Information provides cross references to the report's chapters.

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.

Since the release of the Second Assessment Report (SAR[4]), additional data from new studies of current and palaeoclimates, improved analysis of data sets, more rigorous evaluation of their quality, and comparisons among data from different sources have led to greater understanding of climate change.

The global average surface temperature has increased over the 20th century by about 0.6°C.

- The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ± 0.2°C[5], [6] (Figure 1a). This value is about 0.15°C larger than that estimated by the SAR for the period up to 1994, owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data. These numbers take into account various adjustments, including urban heat island effects. The record shows a great deal of variability; for example, most of the warming occurred during the 20th century, during two periods, 1910 to 1945 and 1976 to 2000.
- Globally, it is very likely[7] that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record, since 1861 (see Figure 1a).
- New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely[7] to have been the largest of any century during the past 1,000 years. It is also likely[7] that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year (Figure 1b). Because less data are available, less is known about annual averages prior to 1,000 years before present and for conditions prevailing in most of the Southern Hemisphere prior to 1861.
- On average, between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in daytime daily maximum air temperatures (0.1°C per decade). This has lengthened the freeze-free season in many mid- and high latitude regions. The increase in sea surface temperature over this period is about half that of the mean land surface air temperature.

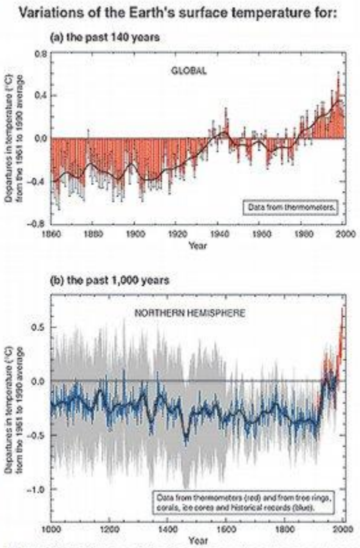
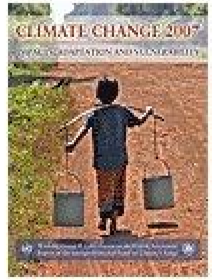


Figure 1: Variations of the Earth's surface temperature over the last 140 years and the last millennium.

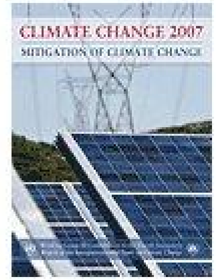
(a) The Earth's surface temperature is shown year by year (red bars) and approximately decade by decade (black line, a filtered annual curve suppressing fluctuations below near decadal

IPCC Fourth Assessment Report: Climate Change 2007 (AR4)

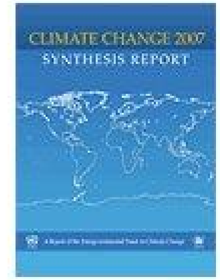
Working Group I Report
"The Physical Science Basis"



Working Group II Report
"Impacts, Adaptation and Vulnerability"



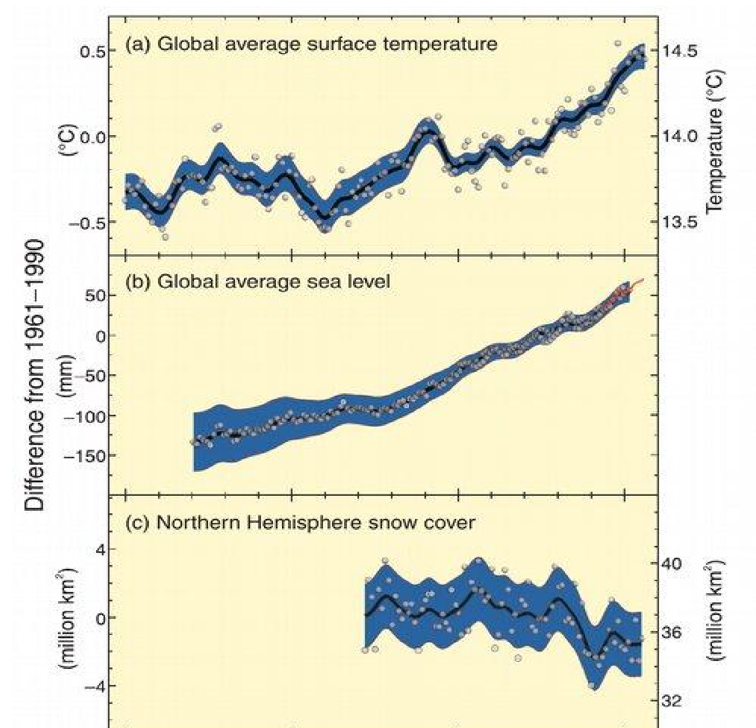
Working Group III Report
"Mitigation of Climate Change"



The AR4 Synthesis Report

1. Observed changes in climate and their effects

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (Figure SPM.1). *{1.1}*



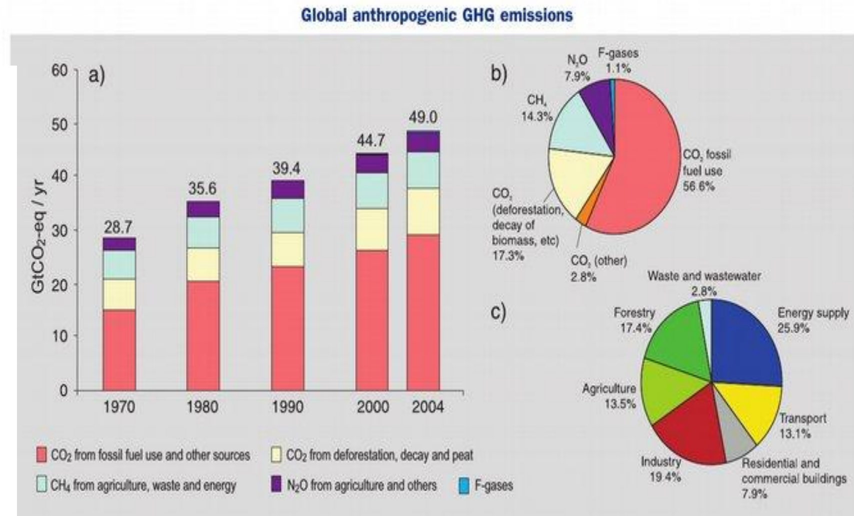
2. Causes of change

Changes in atmospheric concentrations of greenhouse gases (GHGs) and aerosols, land cover and solar radiation alter the energy balance of the climate system. *{2.2}*

Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 (Figure SPM.3).[5] *{2.1}*

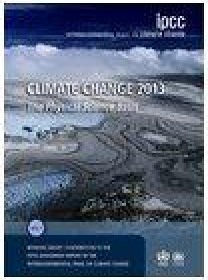
Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions grew by about 80% between 1970 and 2004. The long-term trend of declining CO_2 emissions per unit of energy supplied reversed after 2000. *{2.1}*

Global atmospheric concentrations of CO_2, methane (CH_4) and nitrous oxide (N_2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. *{2.2}*

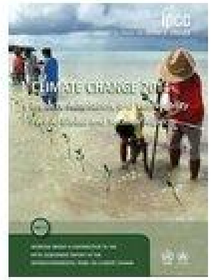


ure SPM.3. (a) Global annual emissions of anthropogenic GHGs from 1970 to 2004.[5] (b) Share of different anthropogenic GHGs in total issions in 2004 in terms of carbon dioxide equivalents (CO_2-eq). (c) Share of different sectors in total anthropogenic GHG emissions in 2004 erms of CO_2-eq. (Forestry includes deforestation.) {Figure 2.1}

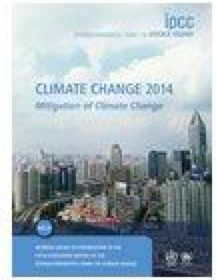
IPCC Fifth Assessment Report



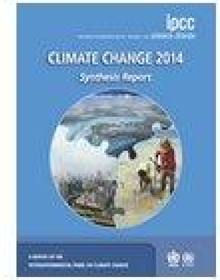
Working Group I Report
"Climate Change 2013: The Physical Science Basis"



Working Group II Report
"Climate Change 2014: Impacts, Adaptation, and



Working Group III Report
"Climate Change 2014: Mitigation of Climate Change"



"Climate Change 2014: Synthesis Report"

SPM 1. Observed Changes and their Causes

Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. *{1}*

SPM 1.1 Observed changes in the climate system

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen. *{1.1}*

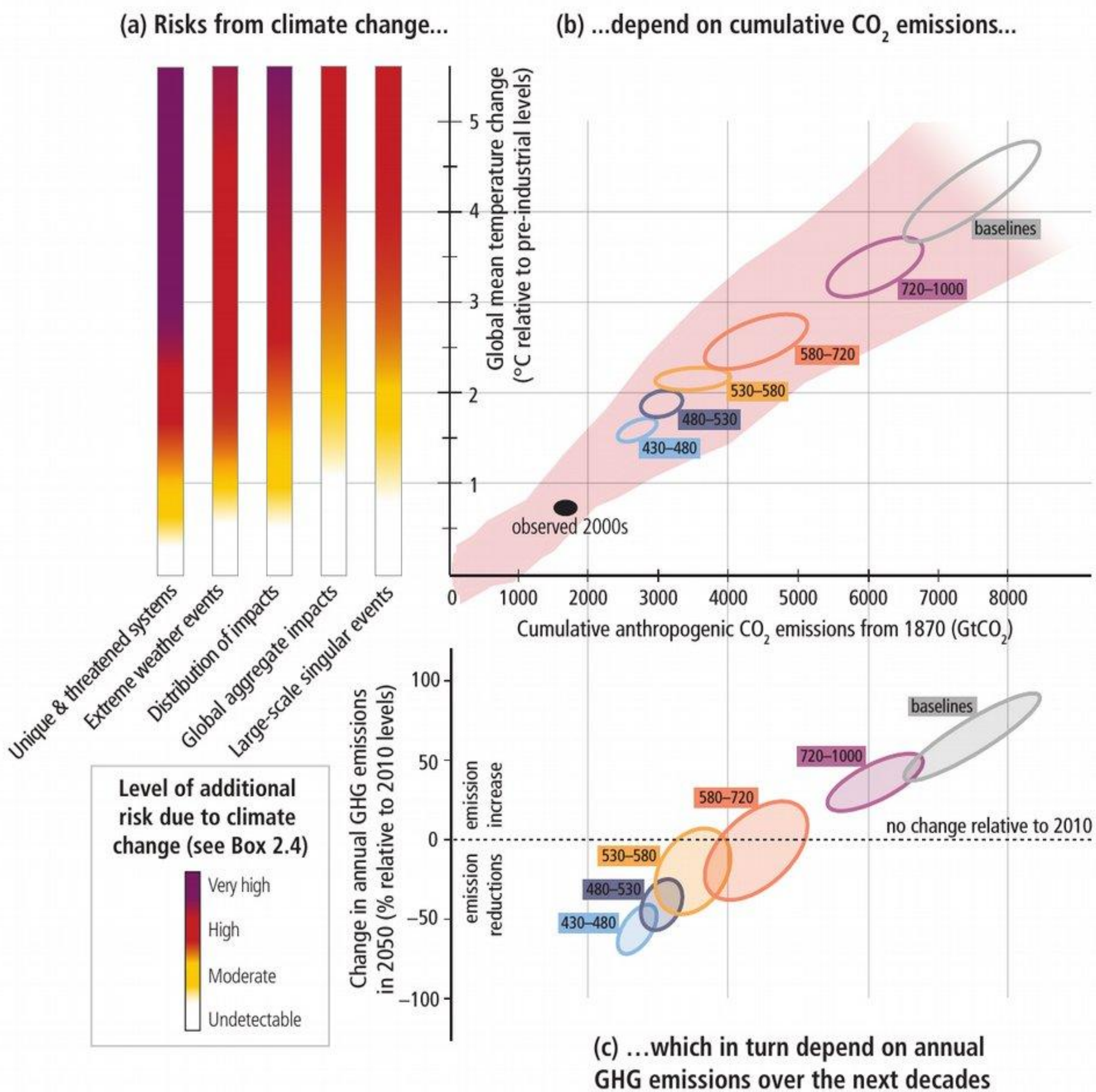


Figure SPM.10 | The relationship between risks from climate change, temperature change, cumulative carbon dioxide (CO_2) emissions and changes in annual greenhouse gas (GHG) emissions by 2050. Limiting risks across Reasons For Concern **(a)** would imply a limit for cumulative emissions of CO_2 **(b)** which would constrain annual GHG emissions over the next few decades **(c)**. **Panel a** reproduces the five Reasons For Concern *{Box 2.4}*. **Panel b** links temperature changes to cumulative CO_2 emissions (in $GtCO_2$) from 1870. They are based on Coupled Model Intercomparison Project Phase 5 (CMIP5) simulations (pink plume) and on a simple climate model (median climate response in 2100), for the baselines and five mitigation scenario categories (six

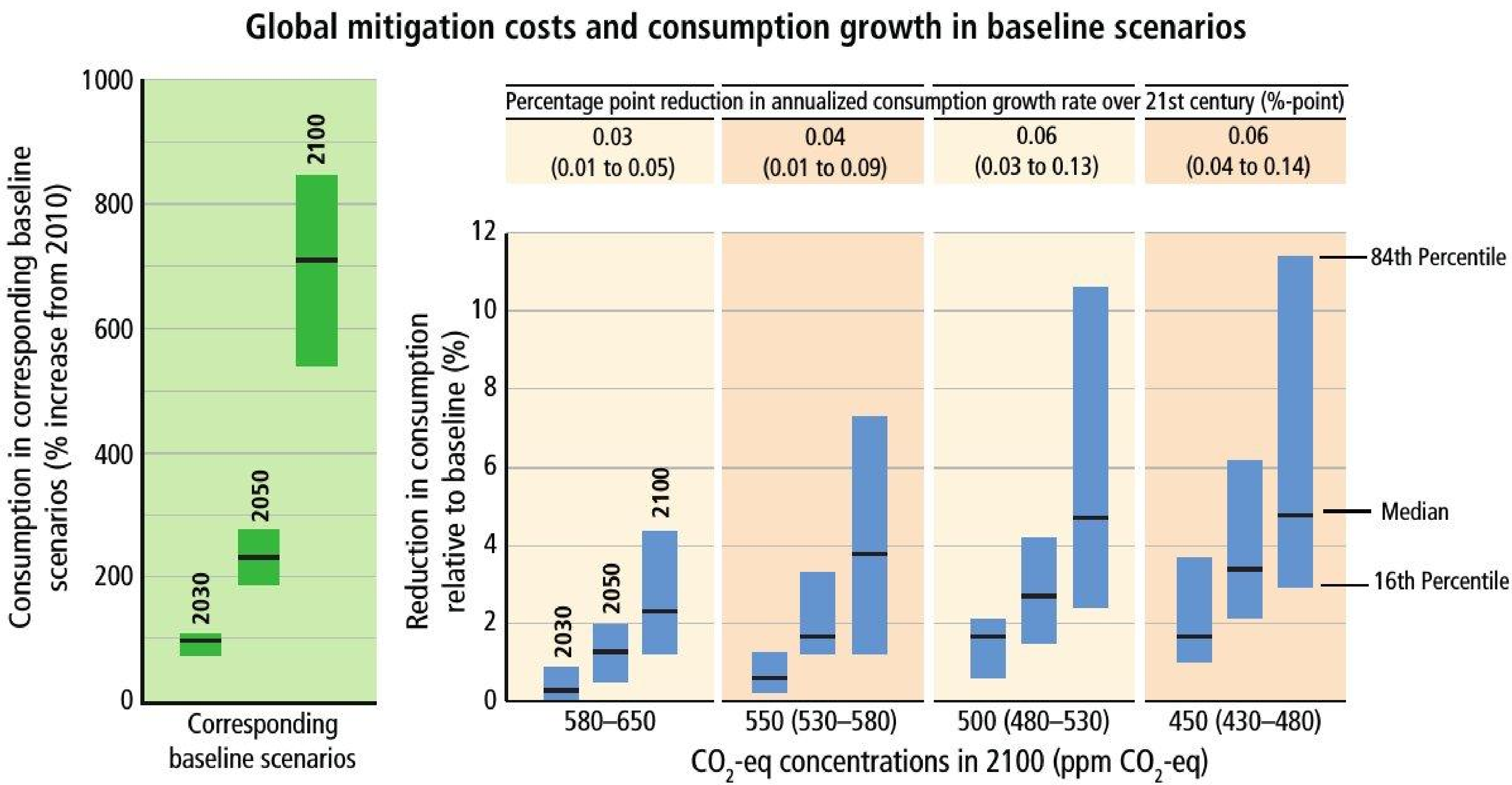
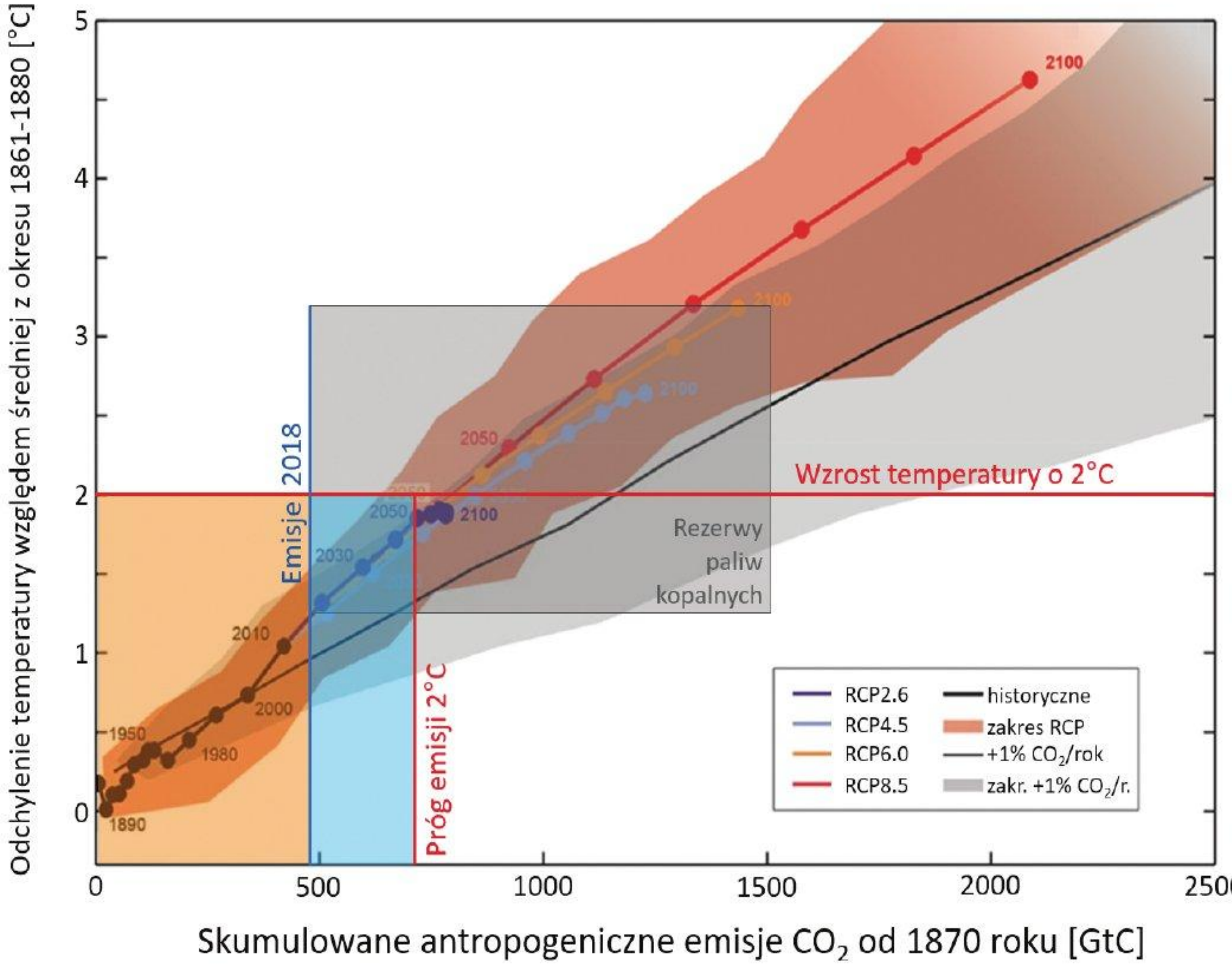


Figure SPM.13 | Global mitigation costs in cost-effective scenarios at different atmospheric concentrations levels in 2100. Cost-effective scenarios assume immediate mitigation in all countries and a single global carbon price, and impose no additional limitations on technology relative to the models' default technology assumptions. Consumption losses are shown relative to a baseline development without climate policy (left panel). The table at the top shows percentage points of annualized consumption growth reductions relative to consumption growth in the baseline of 1.6 to 3% per year (e.g., if the reduction is 0.06 percentage points per year due to mitigation, and baseline growth is 2.0% per year, then the growth rate with mitigation would be 1.94% per year). Cost estimates shown in this table do not consider the benefits of reduced climate change or co-benefits and adverse side effects of mitigation. Estimates at the high end of these cost ranges are from models that are relatively inflexible to achieve the deep emissions reductions required in the long run to meet these goals and/or include assumptions about market imperfections that would raise costs. *{Figure 3.4}*



Zależność między sumarycznymi emisjami CO2 a wzrostem temperatury.
Pozioma czerwona linia – 2°C ocieplenia, pionowa czerwona linia – skumulowane emisje dla >66% prawdopodobieństwa nieprzekroczenia progu 2°C.
Obszar niebieski pozostała suma emisji po 2018 roku – budżet węglowy.
Aktualne emisje to ok 10 GtC na rok.

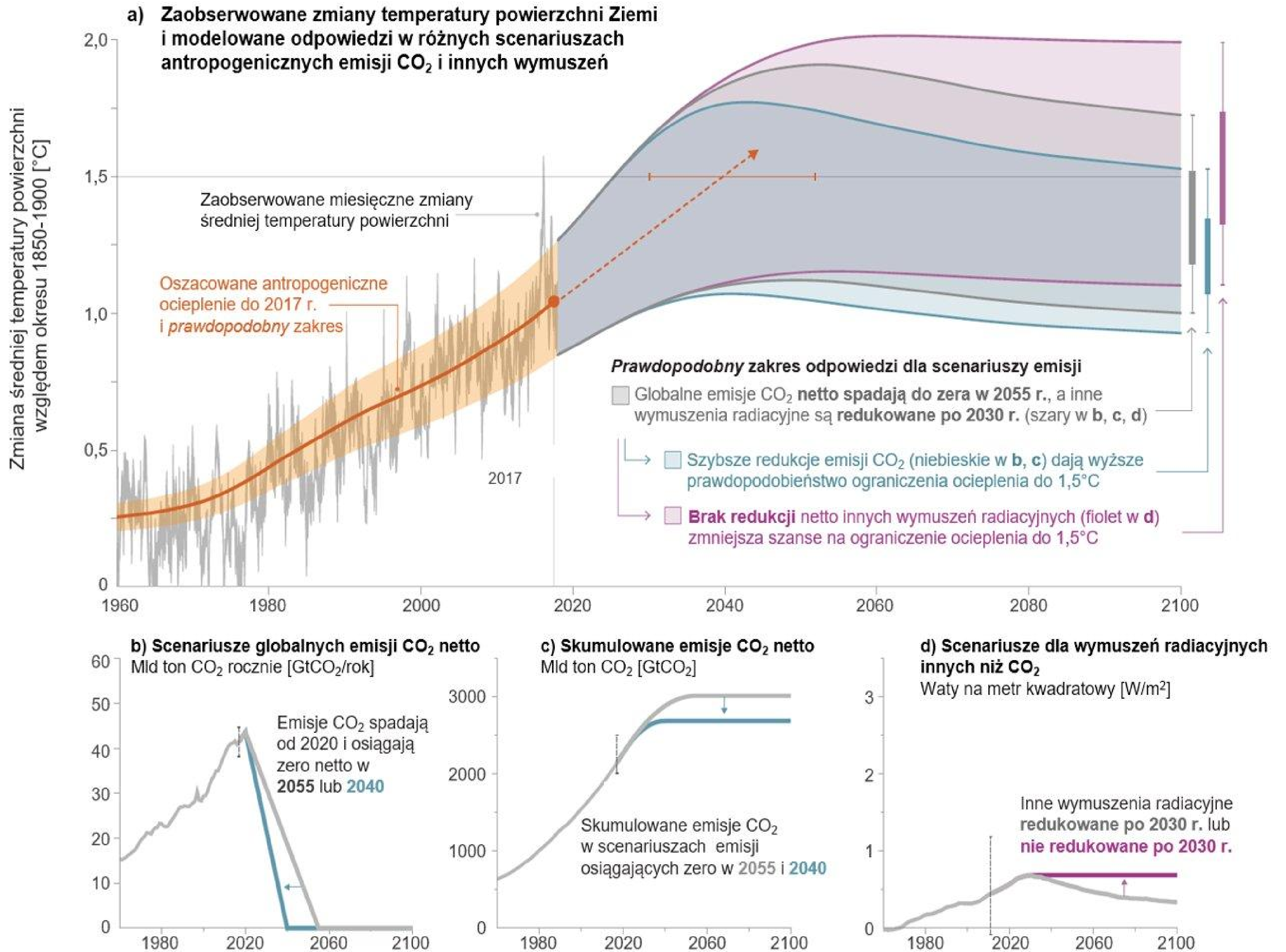
INTERGOVERNMENTAL PANEL ON climate change

Globalne ocieplenie klimatu o 1,5°C

Specjalny Raport IPCC dotyczący następstw globalnego ocieplenia klimatu o 1,5°C ponad poziom sprzed epoki przemysłowej oraz związanych z tym globalnych scenariuszy emisji gazów cieplarnianych, w kontekście wzmacniania odpowiedzi globalnej na zagrożenie zmianą klimatu, wspierania zrównoważonego rozwoju oraz działań na rzecz wyeliminowania ubóstwa.

Podsumowanie dla Decydentów

Skumulowane emisje CO_2 i inne przyszłe wymuszenia radiacyjne zdeterminują szanse na ograniczenie ocieplenia do 1,5°C



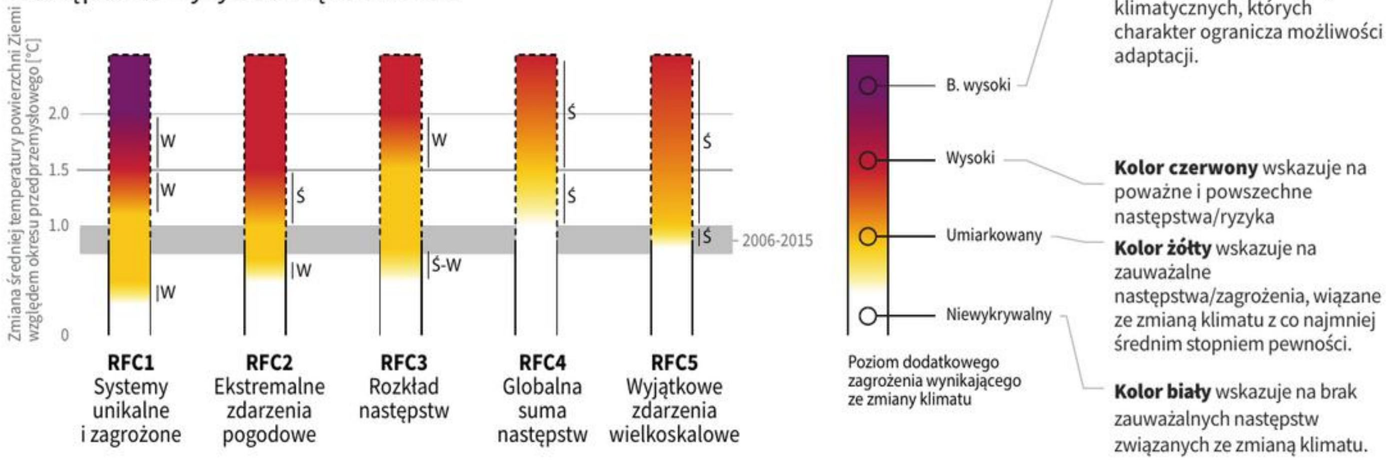
Szybsze redukcje emisji CO_2 zmniejszają

Maksymalny wzrost temperatury jest zdeterminowany przez skumulowane emisje CO_2 netto oraz

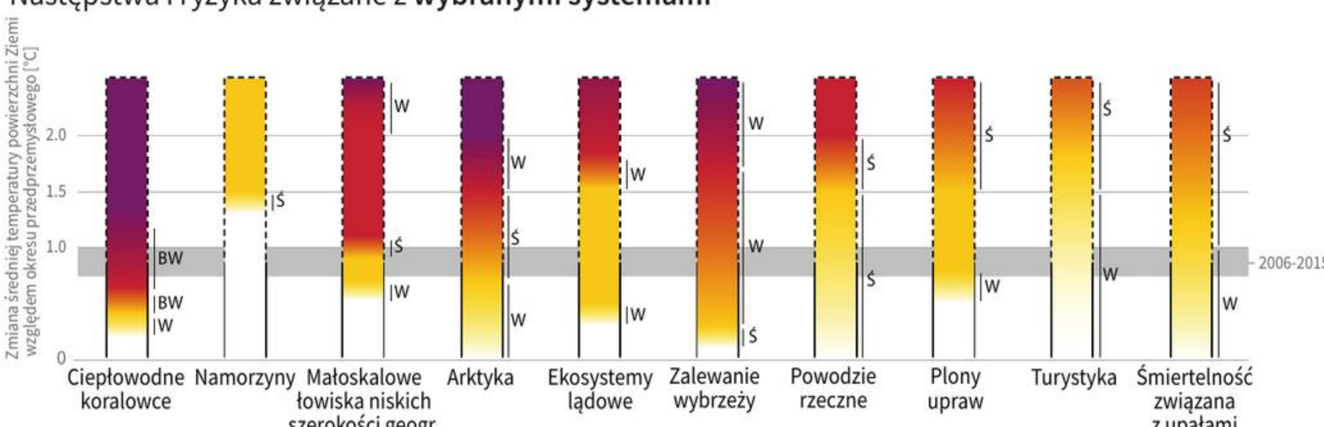
Jak wielkość globalnego ocieplenia wpływa na skutki i/lub poziom zagrożeń w wybranych domenach (ang. *Reasons for Concern*, RFC) oraz wybrane systemy antropogeniczne i ekosystemy.

Pięć sfer zagrożeń (RFC) ilustruje następstwa i ryzyka związane z różnym poziomem globalnego ocieplenia dla systemów antropogenicznych i środowiska naturalnego w różnych sektorach i regionach.

Następstwa i ryzyka związane z RFC



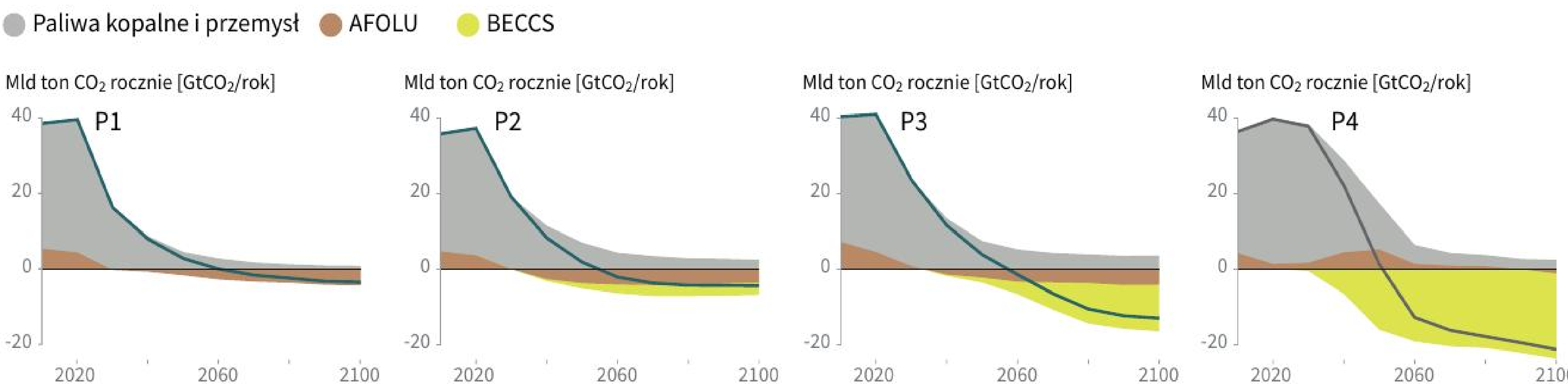
Następstwa i ryzyka związane z **wybranymi systemami**



Charakterystyka czterech przykładowych scenariuszy modelowych

Redukcje emisji netto, niezbędne dla ograniczenia ocieplenia do 1,5° bez przekroczenia tego progu lub z jego niewielkim przekroczeniem, mogą zostać osiągnięte za pośrednictwem różnych strategii mitygacyjnych. We wszystkich scenariuszach wykorzystane są technologie usuwania dwutlenku węgla (ang. *Carbon Dioxide Removal*, CDR), jednak ich skala różni się między scenariuszami, podobnie jak wkład bioenergii z wychwytem i sekwestracją dwutlenku węgla (ang. *Bioenergy with Carbon Capture and Storage*, BECCS) i pochłanianie w sektorach rolnictwa, leśnictwa i innego użytkowania terenu (ang. *Agriculture, Forestry and Other Land Use*, AFOLU). Ma to implikacje dla emisji i innych charakterystyk scenariuszy

Udziały poszczególnych składowych w globalnych emisjach CO_2 netto dla czterech przykładowych scenariuszy



P1: Scenariusz, w którym społeczne, biznesowe i technologiczne innowacje skutkują spadkiem zapotrzebowania na energię w 2050 roku przy jednoczesnej poprawie standardu życia, szczególnie na Globalnym Południu. Mniejszy system energetyczny pozwala na szybką dekarbonizację wytwarzania energii. Zalesianie jest jedyną wykorzystywaną opcją CDR, technologie CCS i BECCS nie są stosowane.

P2: Scenariusz, skupiający się na zrównoważonym rozwoju, w tym m.in. efektywności energetycznej, rozwoju społecznym, konwergencji gospodarczej i współpracy międzynarodowej, a także zwrocie w kierunku zrównoważonych i zdrowych wzorców konsumpcji, niskowęglowych innowacji technologicznych i dobrego zarządzania terenem, przy ograniczonej akceptacji społecznej dla BECCS.

P3: Pośredni scenariusz, w którym rozwój społeczny i technologiczny przebiega zgodnie z trendami historycznymi. Redukcje emisji osiąga się głównie przez zmianę sposobu wytwarzania energii i produktów, a w mniejszym stopniu przez zmniejszenie popytu.

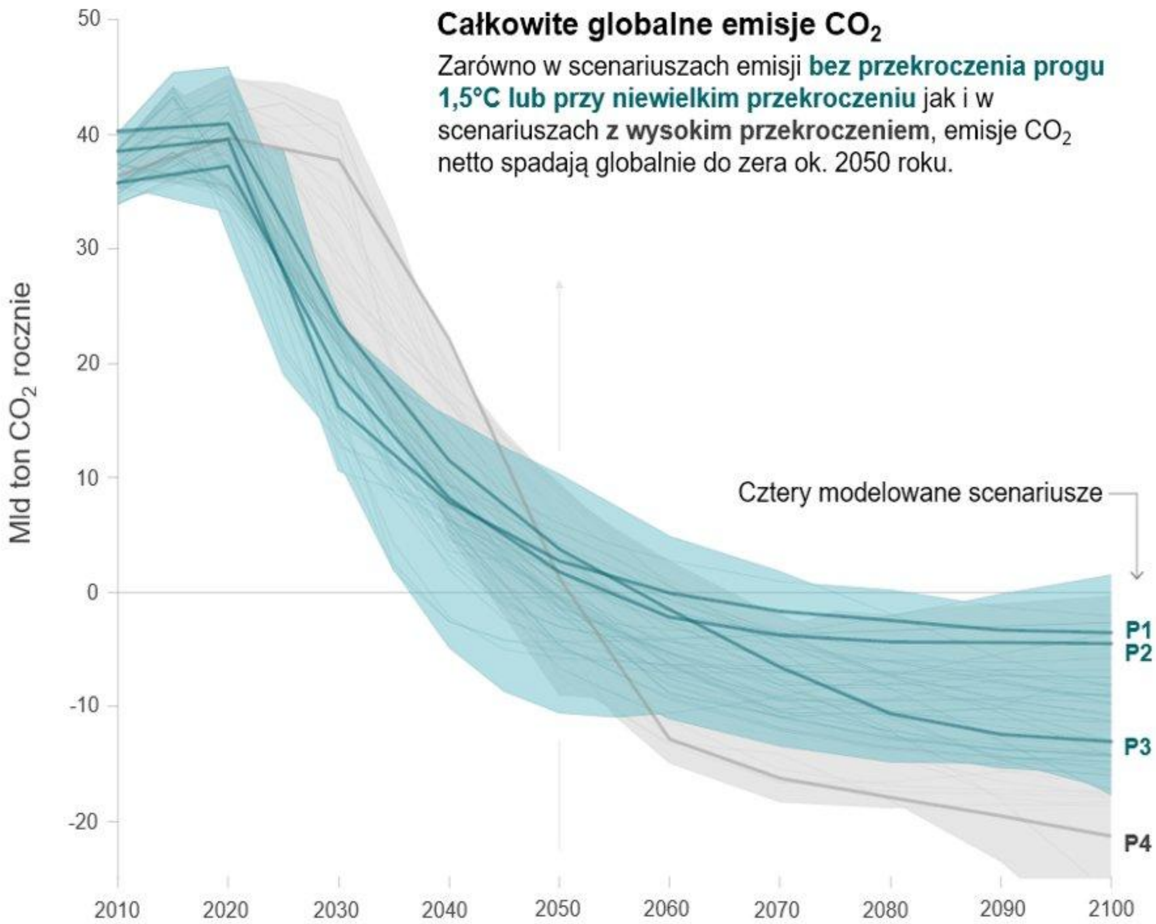
P4: Scenariusz intensywnego zużywania zasobów i energii, w którym wzrost gospodarczy i globalizacja prowadzą do powszechnego przyjęcia wysokoemisyjnego stylu życia, wliczając w to wysokie zapotrzebowanie na paliwa transportowe i mięso. Redukcje emisji osiąga się głównie dzięki zmianom w technologiach, przy silnym poleganiu na CDR, głównie BECCS.

Globalne scenariusze emisji

Ogólna charakterystyka zmian antropogenicznych emisji CO_2 netto oraz emisji metanu, sadzy i tlenku azotu w scenariuszach emisji pozwalających na ograniczenie globalnego ocieplenia o 1,5°C bez przekroczenia tego progu lub z jego niewielkim przekroczeniem. Emisje netto definiowane są jako antropogeniczne emisje pomniejszone o antropogeniczne usuwanie. Redukcja emisji netto może być prowadzona na różne sposoby zilustrowane na rysunku SPM3B.

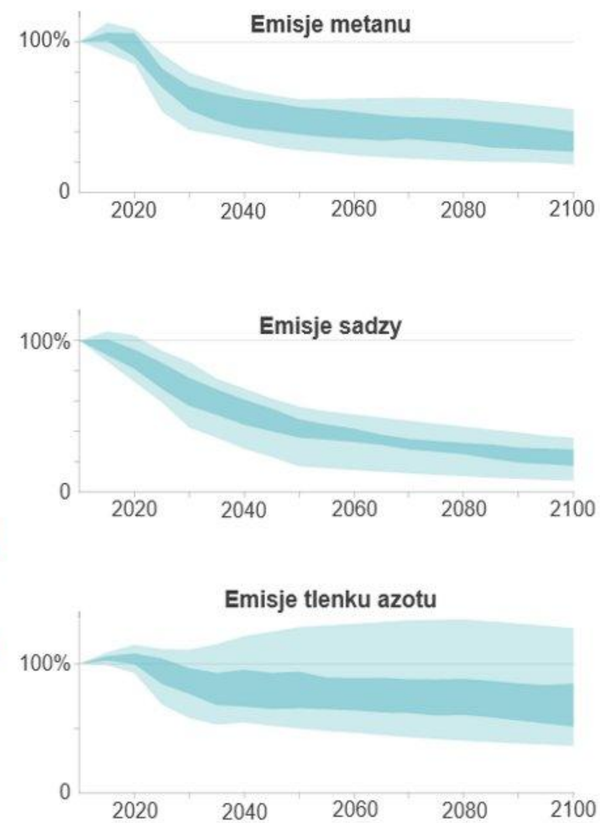
Całkowite globalne emisje CO_2

Zarówno w scenariuszach emisji **bez przekroczenia progu 1,5°C lub przy niewielkim przekroczeniu** jak i w scenariuszach **z wysokim przekroczeniem**, emisje CO_2 netto spadają globalnie do zera ok. 2050 roku.



Inne poza CO_2 emisje względem 2010 roku

Emisje substancji innych niż CO_2 są redukowane także w scenariuszach **bez przekroczenia progu 1,5°C lub przy niewielkim przekroczeniu**, jednak globalnie nie spadają do zera.



Czas spadku emisji CO_2 netto do zera

Cienkie linie pokazują: 5-95 percentyl,

Scenariusze bez przekroczenia progu 1,5°C lub z niewielkim przekroczeniem

Scenariusze z **wysokim przekroczeniem progu 1,5°C**

SPECIAL AND METHODOLOGY REPORTS

- Methodology Report on Short-lived Climate Forcers
- Global Warming of 1.5°C
- Climate Change and Land
- 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- The Ocean and Cryosphere in a Changing Climate

SIXTH ASSESSMENT REPORT

- AR6 Synthesis Report: Climate Change 2022
- AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability
- AR6 Climate Change 2022: Mitigation of Climate Change
- AR6 Climate Change 2021: The Physical Science Basis

FIFTH ASSESSMENT REPORT

- AR5 Synthesis Report: Climate Change 2014
- AR5 Climate Change 2013: The Physical Science Basis
- AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability
- AR5 Climate Change 2014: Mitigation of Climate Change

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09 DECEMBER 2020 | REPORT

Emissions Gap Report 2020

Authors: UNEP, UNEP DTU Partnership

For over a decade, the UNEP Emissions Gap Report has provided a yearly review of the difference between where greenhouse emissions are predicted to be in 2030 and where they should be to avoid the worst impacts of climate change.

DOWNLOAD THE FULL REPORT

What's new in this year's report

The report finds that, despite a brief dip in carbon dioxide emissions caused by the COVID-19 pandemic, the world is still heading for a temperature rise in excess of 3°C this century – far beyond the Paris Agreement goals of limiting global warming to well below 2°C and pursuing 1.5°C.

However, a low-carbon pandemic recovery could cut 25 per cent off the greenhouse emissions expected in 2030, based on policies in place before COVID-19. Such a recovery would far outstrip savings foreseen with the implementation of unconditional Nationally Determined Contributions under the Paris Agreement, and put the world close to the 2°C pathway.

The report also analyses low-carbon recovery measures so far, summarizes the scale of new net-zero emissions pledges by nations and looks at the potential of the lifestyle, aviation and shipping sectors to bridge the gap.

*To view this report in other UN languages, please click on "**Languages**" on top right of header*

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- Key messages
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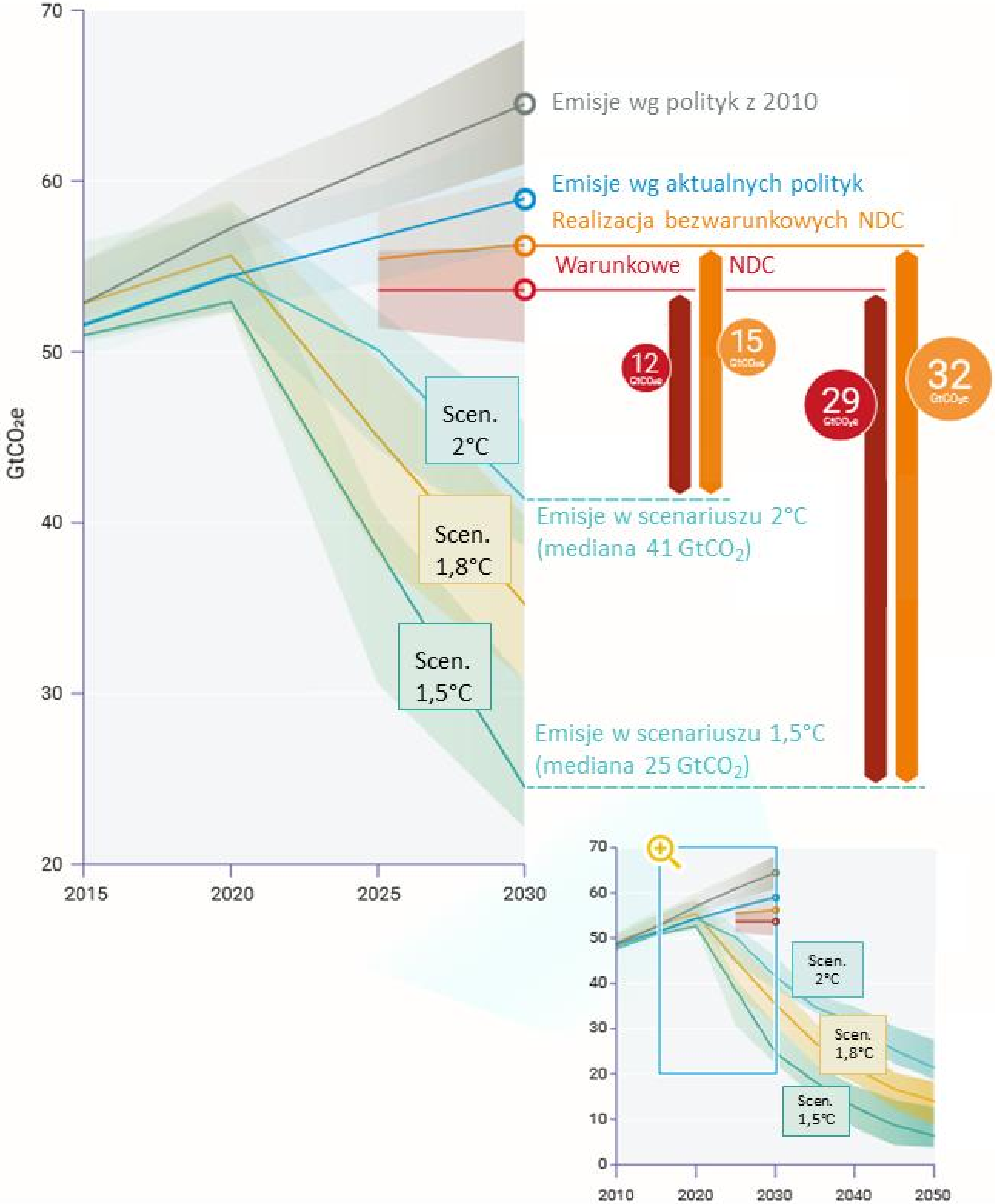
- Frequently Asked Questions
- Annexes
- Webinar
- UN SG Message on Emissions Gap Report
- The Six Sector solution to Climate Change
- Press Release



GtCO₂e
Emisje wg polityk z 2010
Emisje wg aktualnych polityk
Realizacja bezwarunkowych NDC
Warunkowe NDC
12
15
29
32
Scen. 2°C
Scen. 1,8°C
Scen. 1,5°C
Emisje w scenariuszu 2°C (mediana 41 GtCO2)
Emisje w scenariuszu 1,5°C (mediana 25 GtCO2)
2015
2020
2025
2030
2010
2040
2050

Temperatura pewnego letniego dnia w Polsce w 2099 roku.
Mapka z: https://nex.nasa.gov/nex/projects/1356/