From Atmospheric to Earth System Science:

A Historical Perspective and Future Challenges

Guy P. Brasseur

Max Planck Institute for Meteorology

Hamburg, Germany

Part 1.

The Science: Past, Present and Future

The Planet under Stress

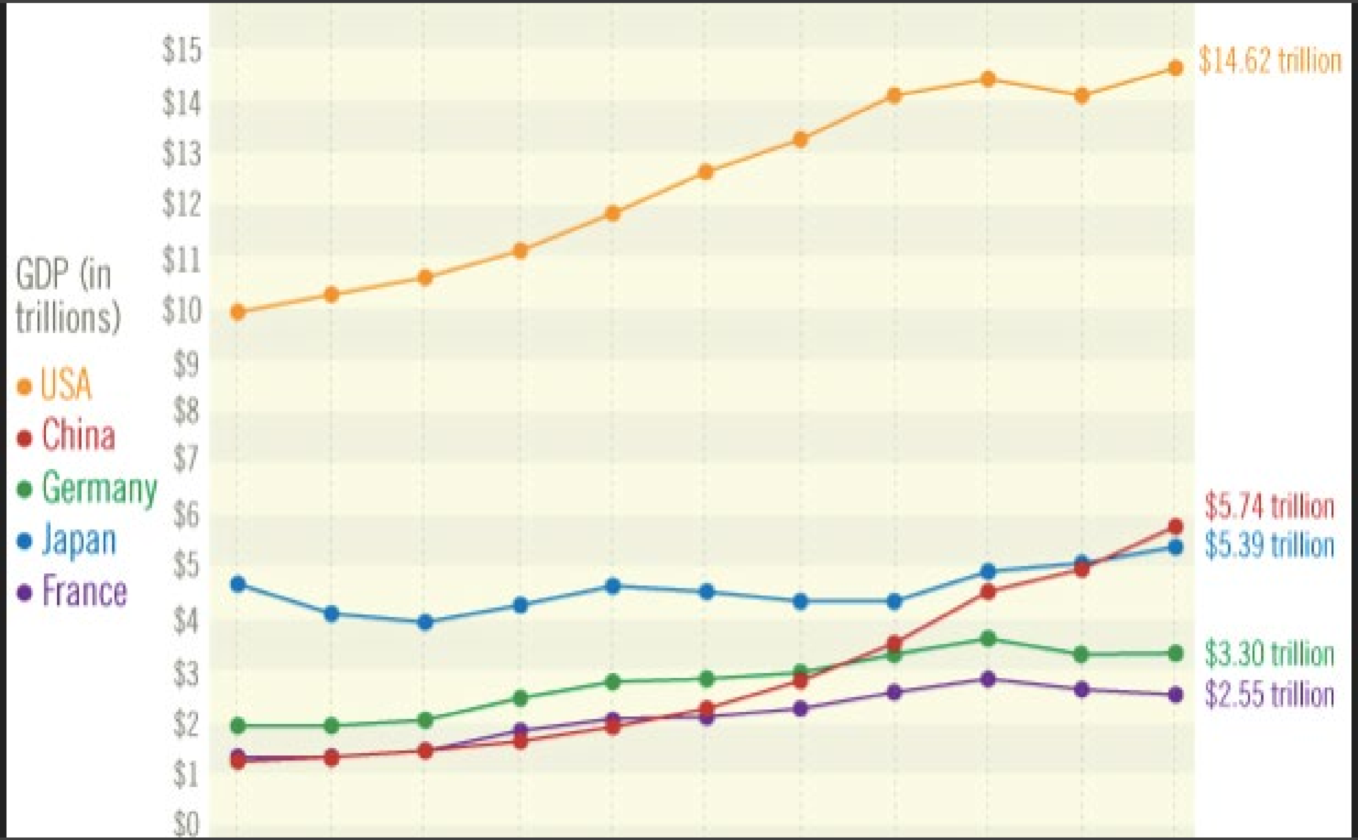
A Profound Transformation of the Earth System is Underway

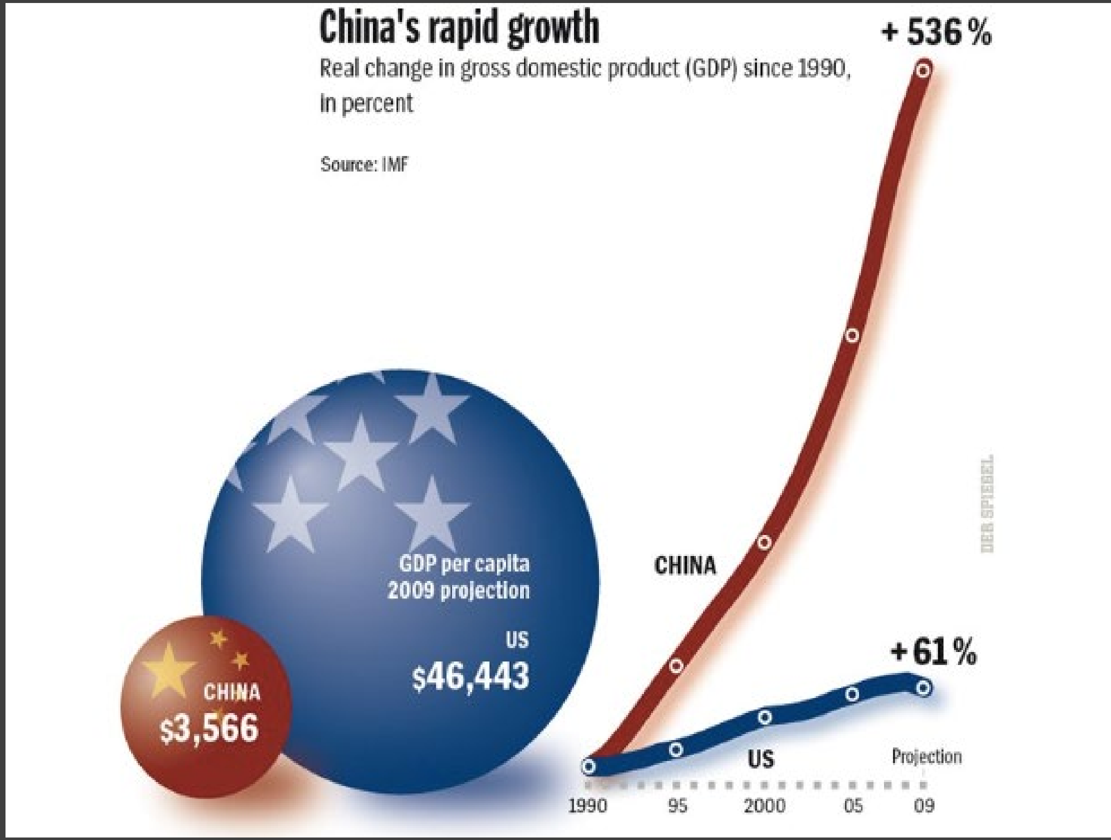
During the last 50 years,

- the human population has risen from 2 to 7 billion,
- economic activity has increased ten-fold,
- the connectivity of the human enterprise has risen dramatically through globalisation of economies and flow of people, information, products and diseases.
- Intensification and diversification of land-use and advances in technology has led to rapid changes in climate, biogeochemical cycles, hydrological processes and landscape dynamics.

Population has been growing rapidly

Gross Domestic Product (trillons $)





Inequalities in the World

The food available to a family in different parts of the world

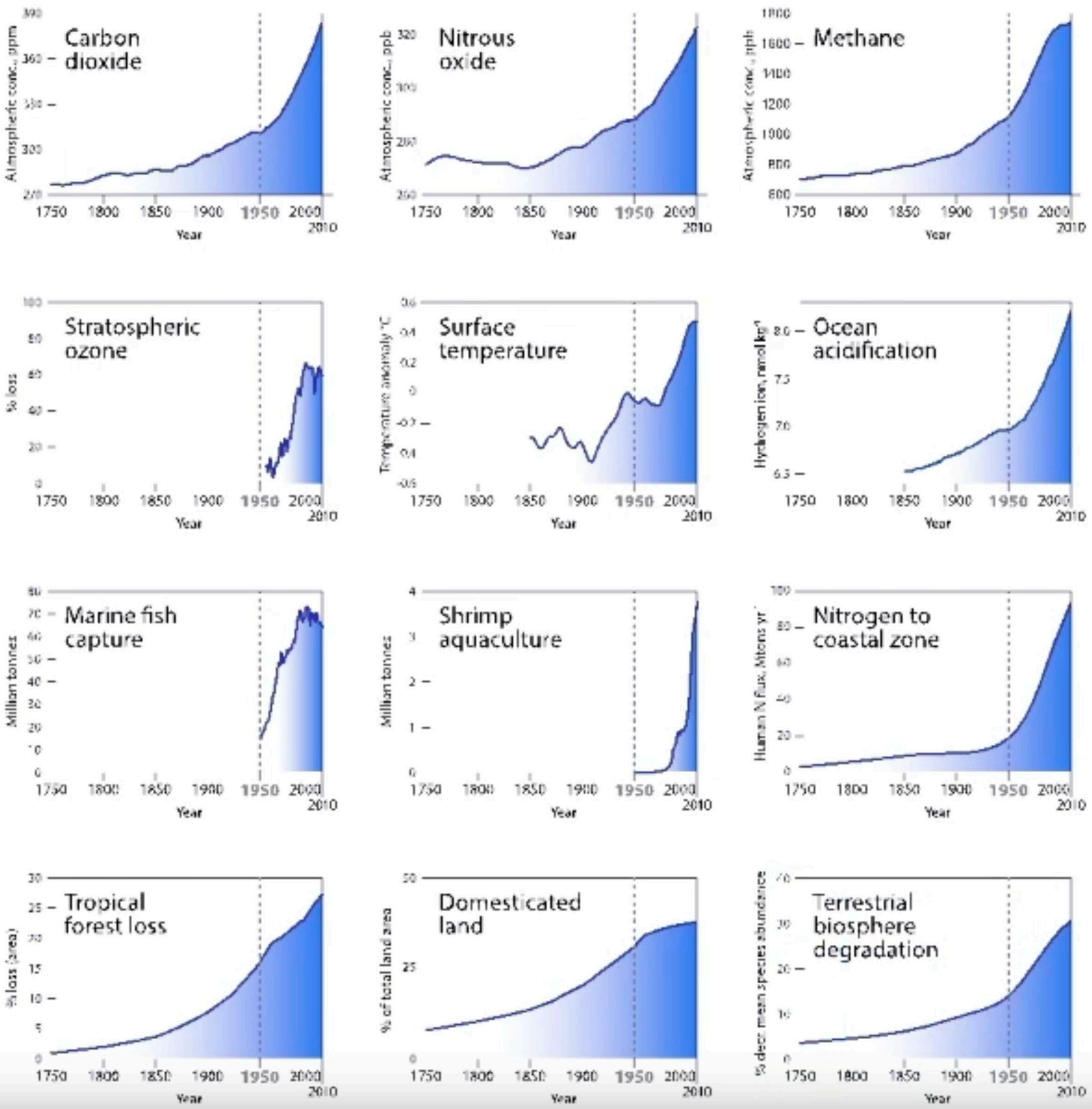
Source: W. Cramer
Chr. Müller,
PIK

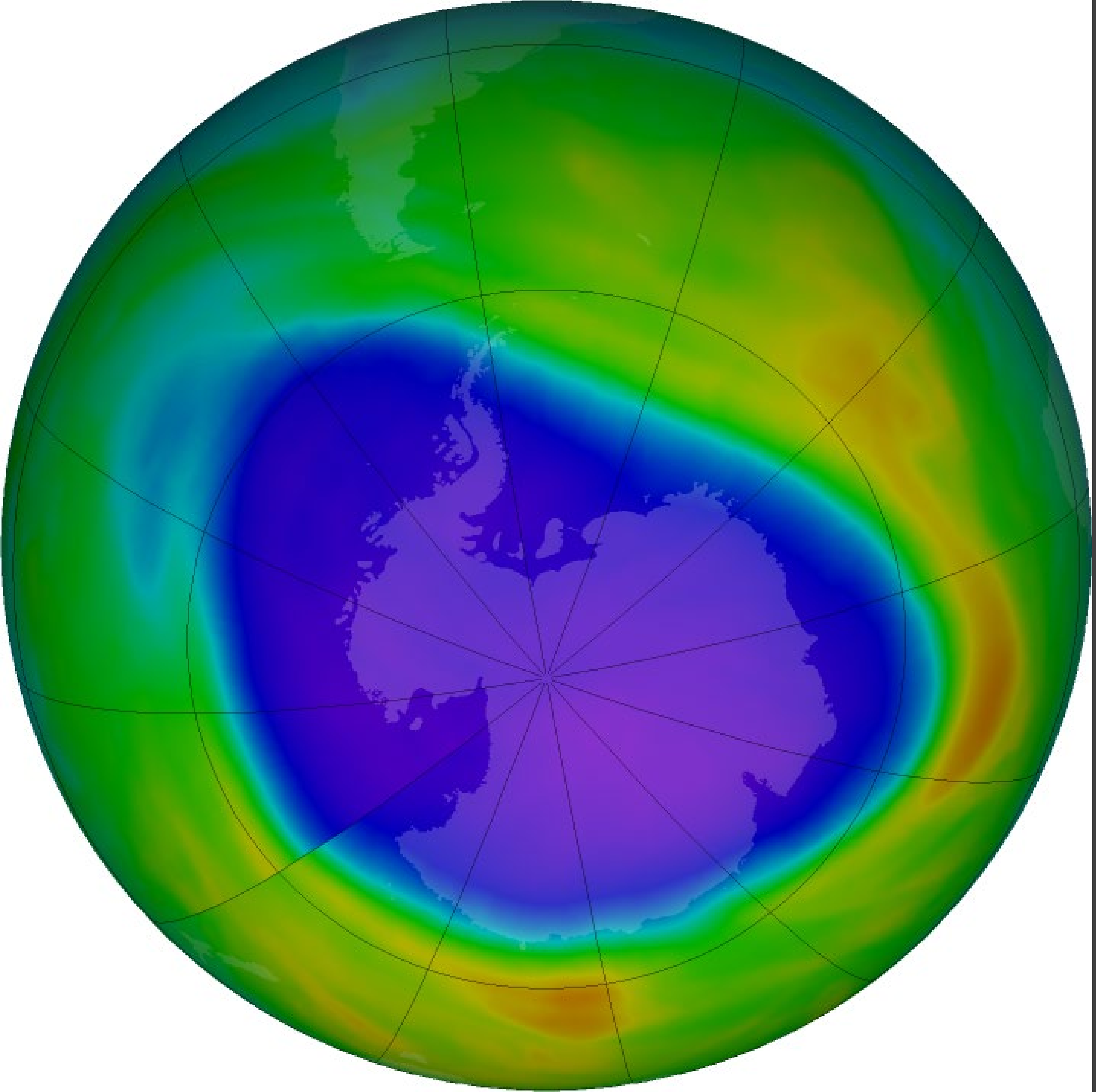
The Great Acceleration

Global Impact

- Greenhouse gases
- Ozone depletion
- Climate
- Marine ecosystems
- Coastal zone
- Nitrogen cycle
- Tropical forests
- Land systems
- Biosphere integrity

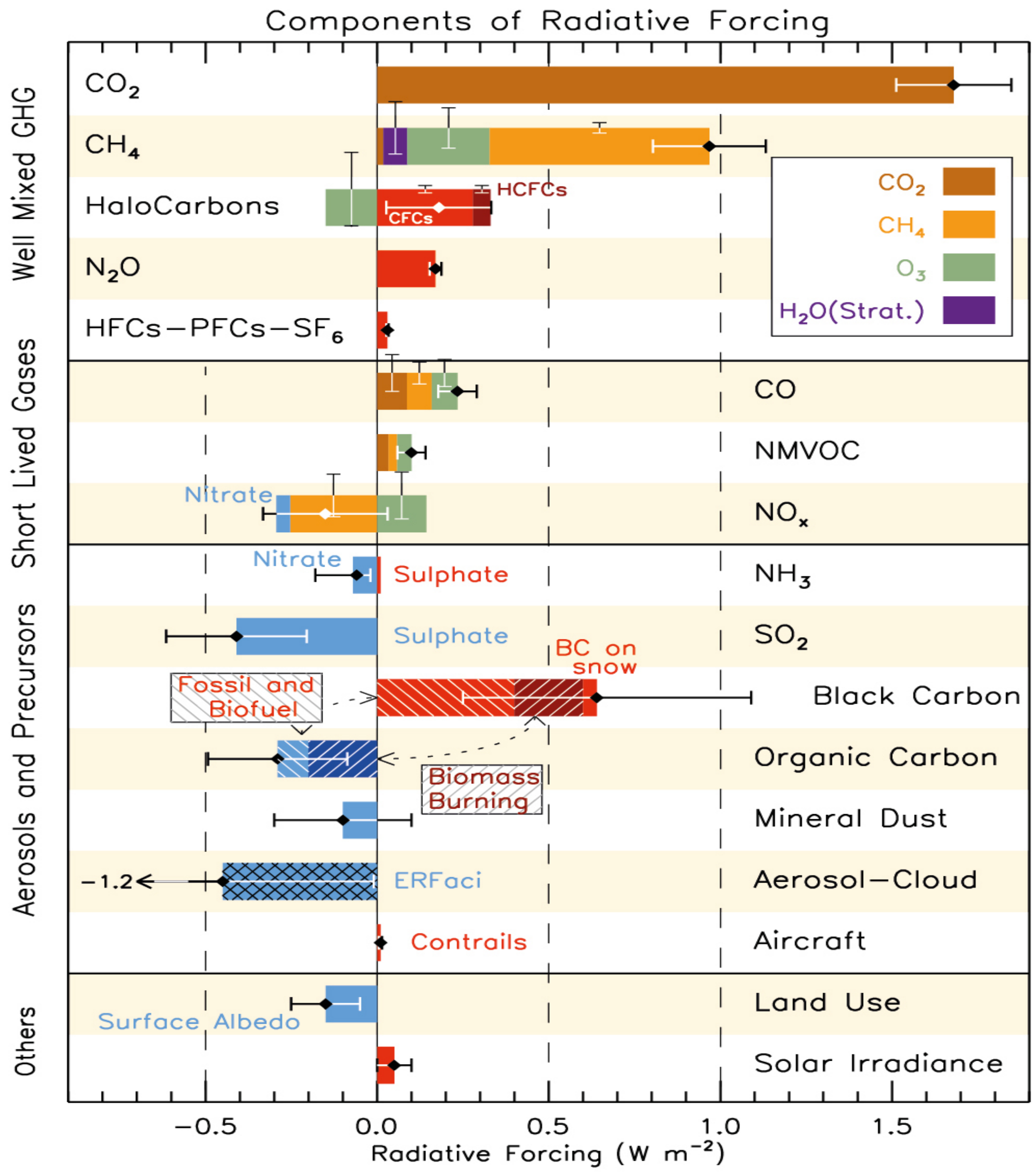
Earth system trends





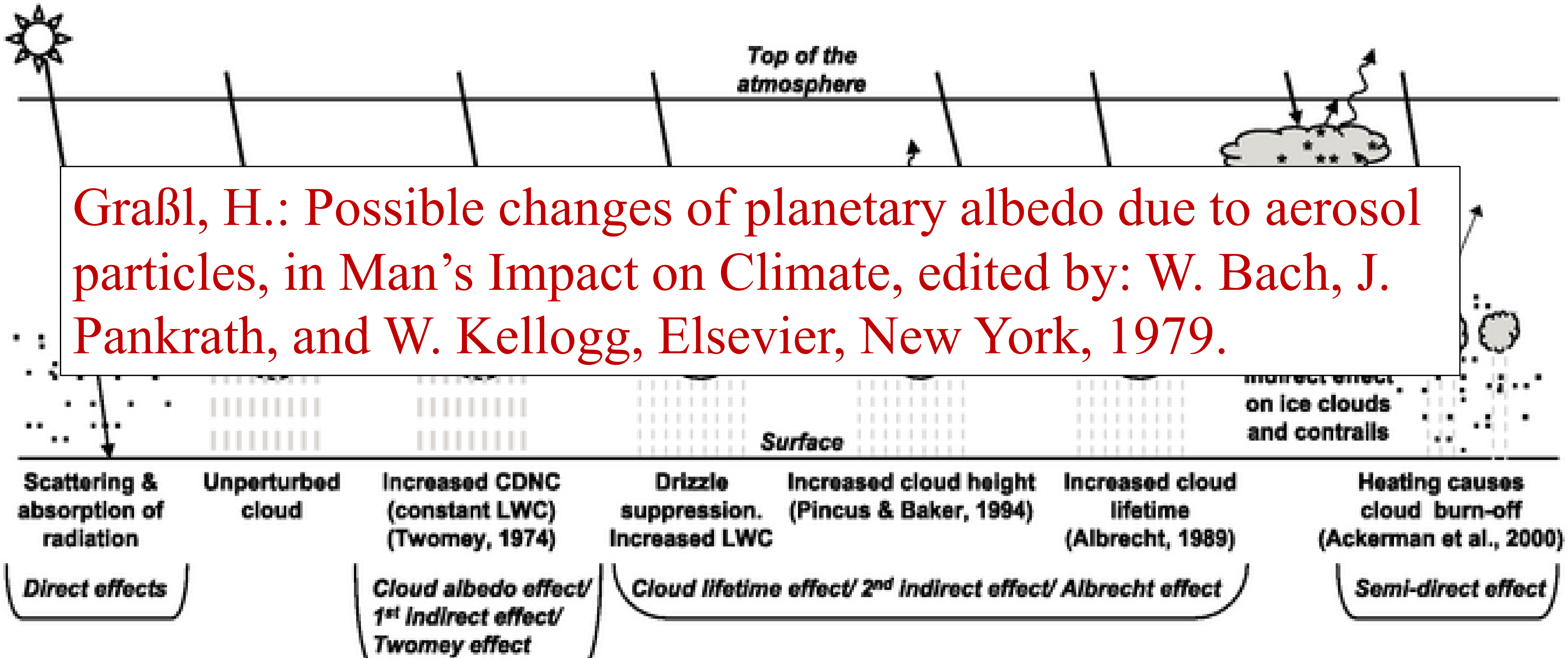
The Ozone Hole 23 September 2020

Ozone protects the biosphere including humans from harmful solar radiation



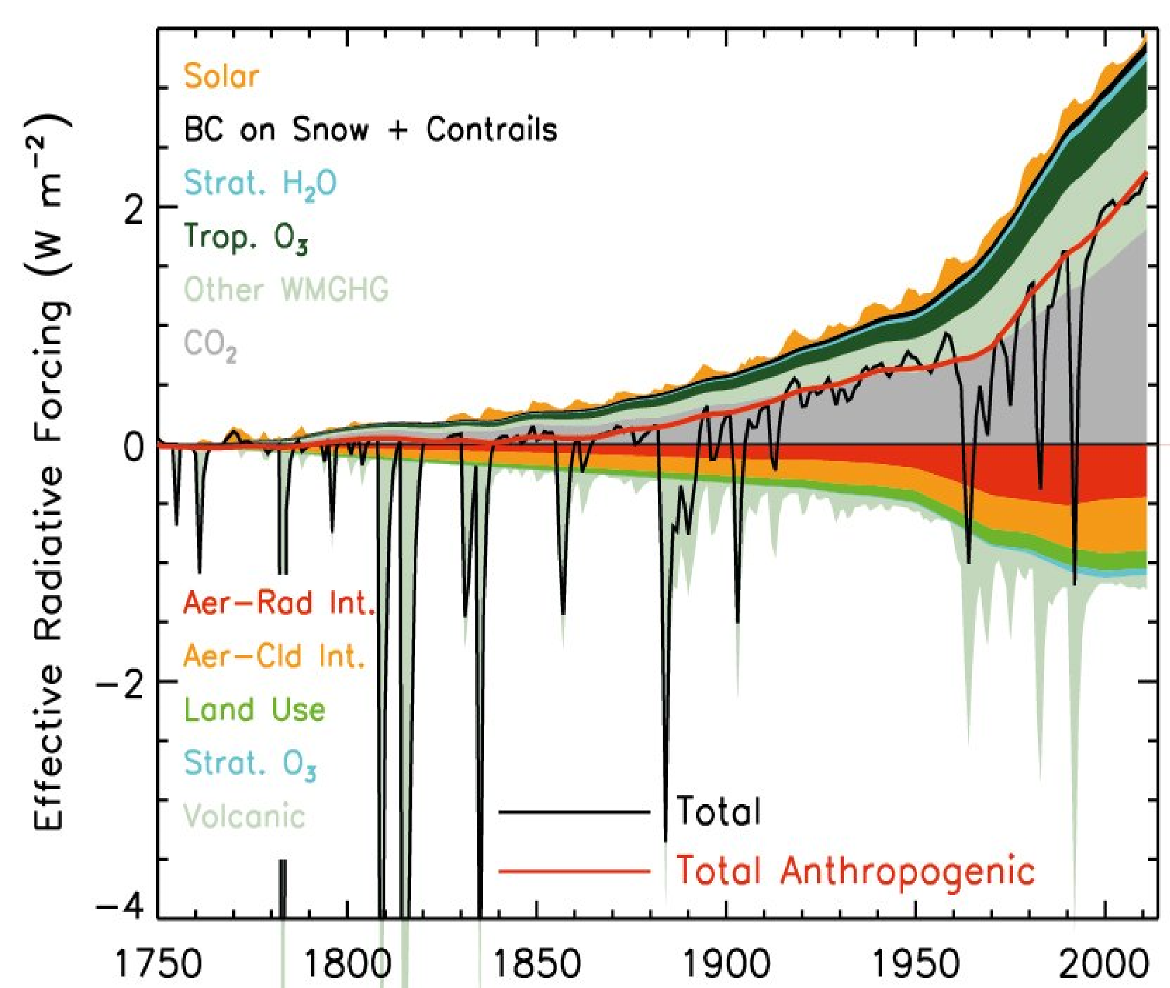
Components of Climate Forcing

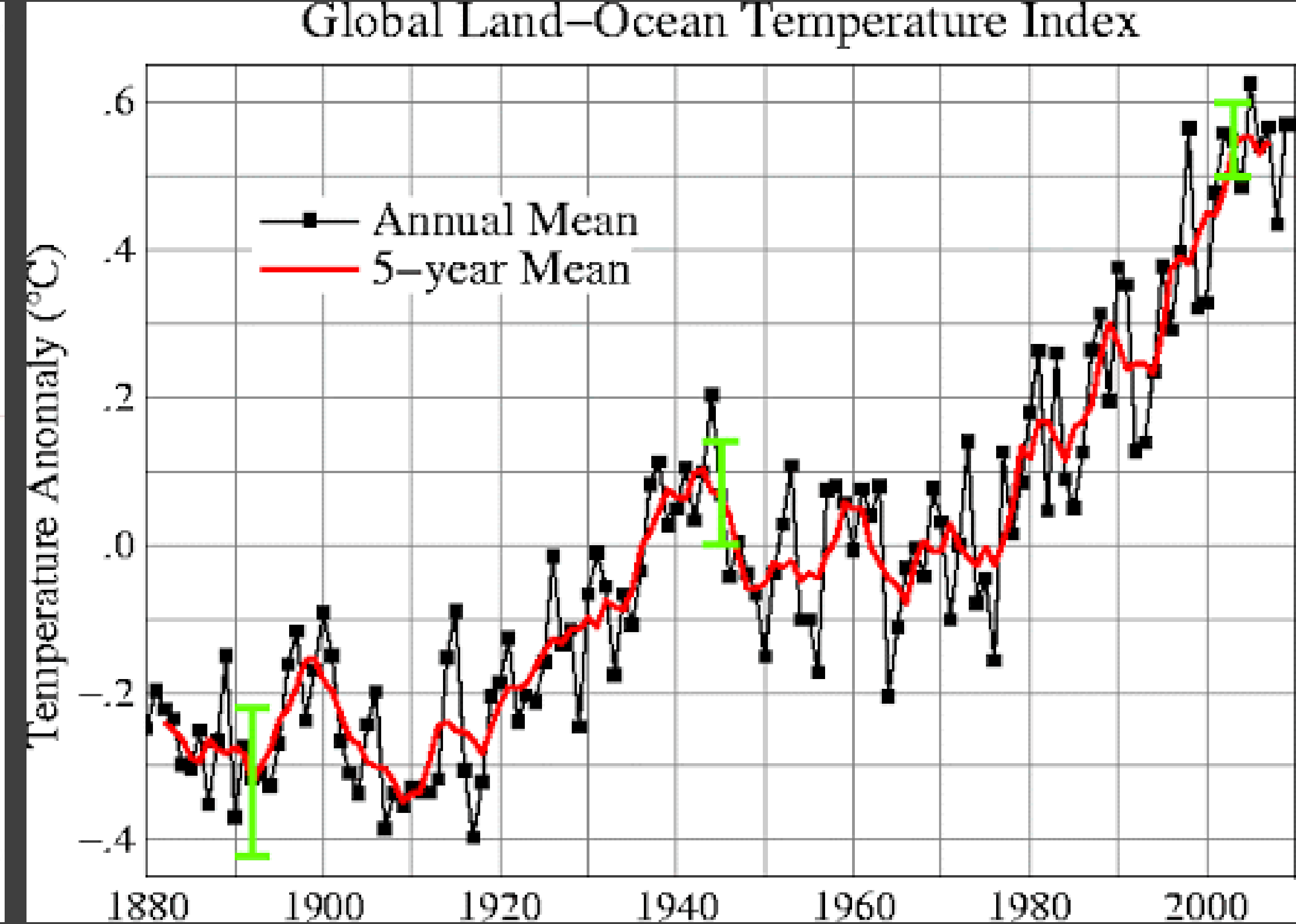
The Indirect climate Forcing: Aerosol and Clouds



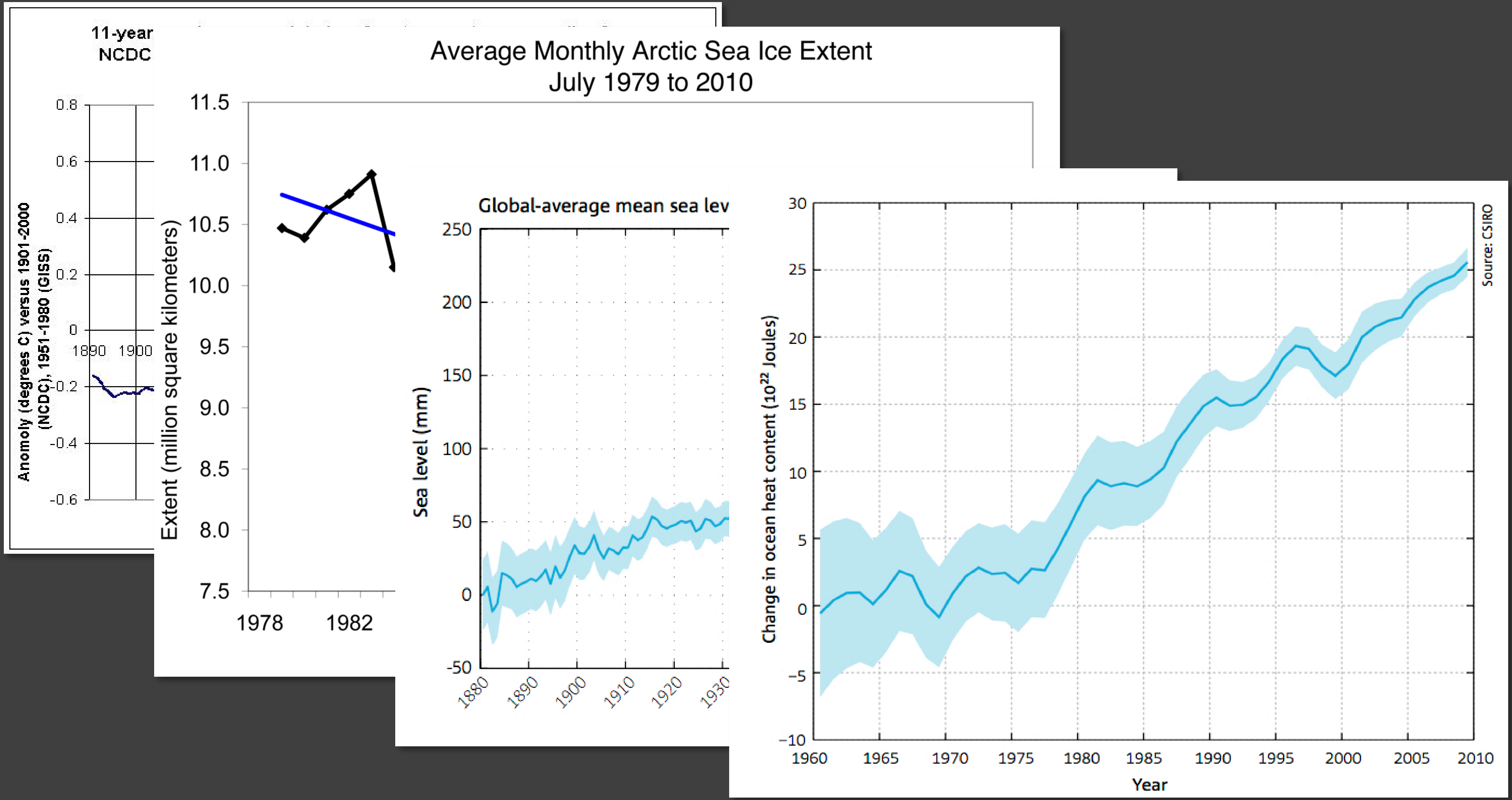
Graßl, H.: Possible changes of planetary albedo due to aerosol particles, in Man's Impact on Climate, edited by: W. Bach, J. Pankrath, and W. Kellogg, Elsevier, New York, 1979.

Climate Forcing and Temperature Trend



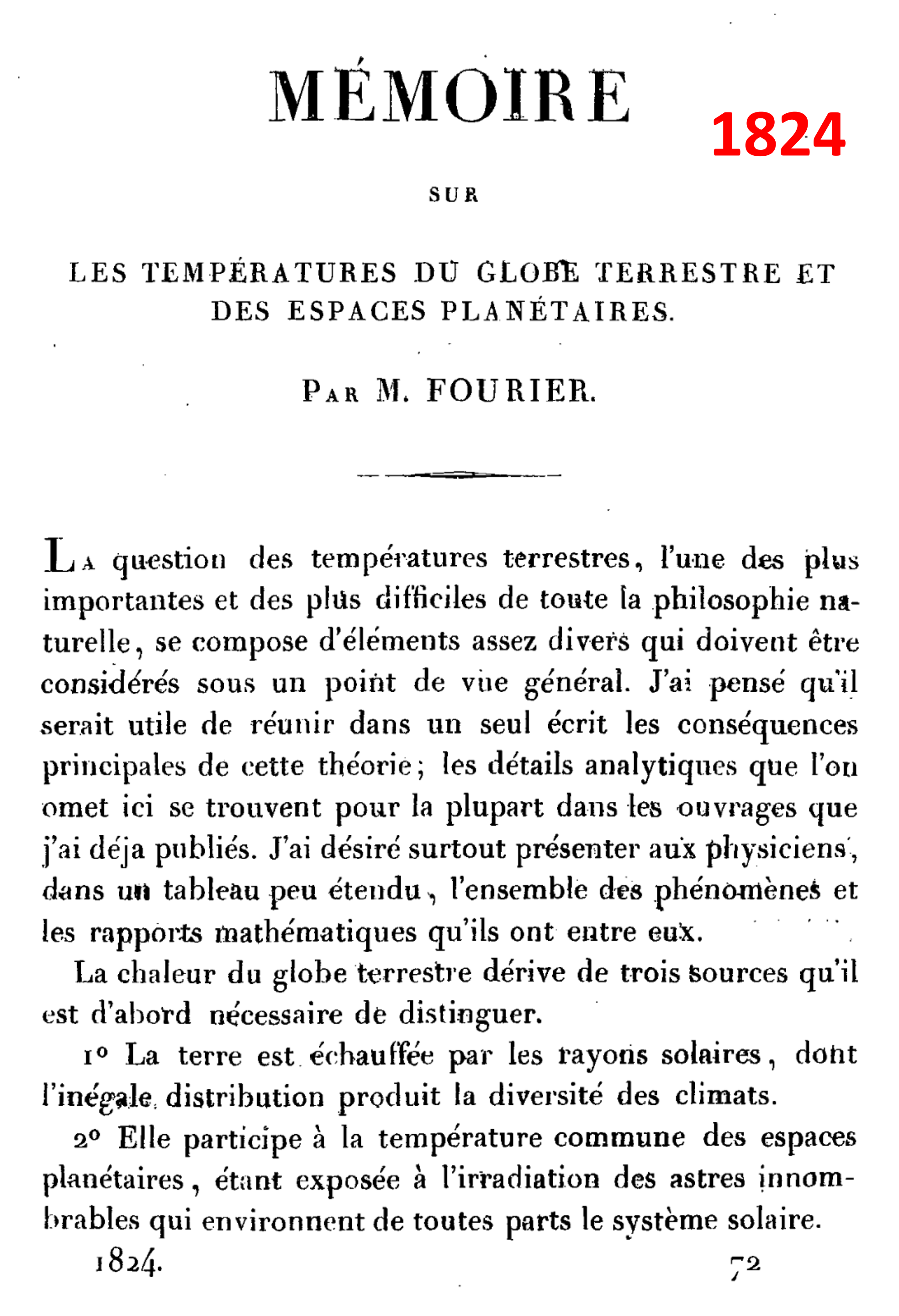


Climate System Trends



A Historical Perspective

Fourier and Tyndall



1824

MÉMOIRE

SUR

LES TEMPÉRATURES DU GLOBE TERRESTRE ET DES ESPACES PLANÉTAIRES.

PAR M. FOURIER.

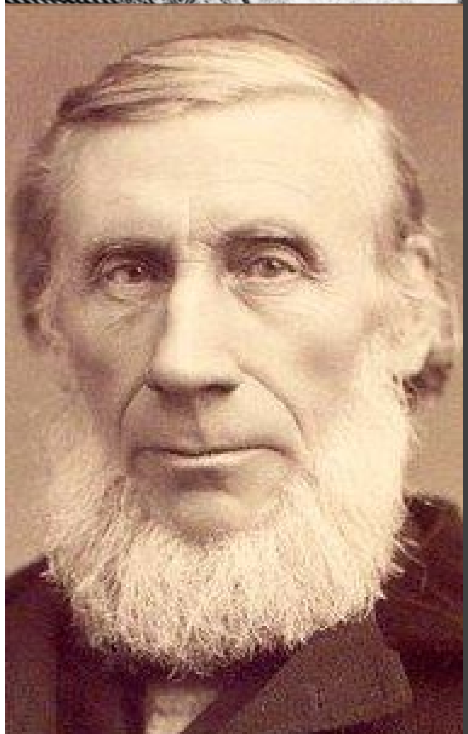
LA question des températures terrestres, l'une des plus importantes et des plus difficiles de toute la philosophie naturelle, se compose d'éléments assez divers qui doivent être considérés sous un point de vue général. J'ai pensé qu'il serait utile de réunir dans un seul écrit les conséquences principales de cette théorie; les détails analytiques que l'on omet ici se trouvent pour la plupart dans les ouvrages que j'ai déja publiés. J'ai désiré surtout présenter aux physiciens, dans un tableau peu étendu, l'ensemble des phénomènes et les rapports mathématiques qu'ils ont entre eux.

La chaleur du globe terrestre dérive de trois sources qu'il est d'abord nécessaire de distinguer.

1° La terre est échauffée par les rayons solaires, dont l'inégale distribution produit la diversité des climats.

2° Elle participe à la température commune des espaces planétaires, étant exposée à l'irradiation des astres innombrables qui environnent de toutes parts le système solaire.

1824. 72



In 1861, Irish physicist John Tyndall showed that gases such as methane and carbon dioxide absorbed infra-red radiation, and could trap heat within the atmosphere. They "would produce great effects on the terrestrial rays and produce corresponding changes of climate".

In 1896, Swedish scientist Svante Arrhenius is the first to calculate the sensitivity (5 ^{0}C) of climate to a doubling of atmospheric CO_2

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.*

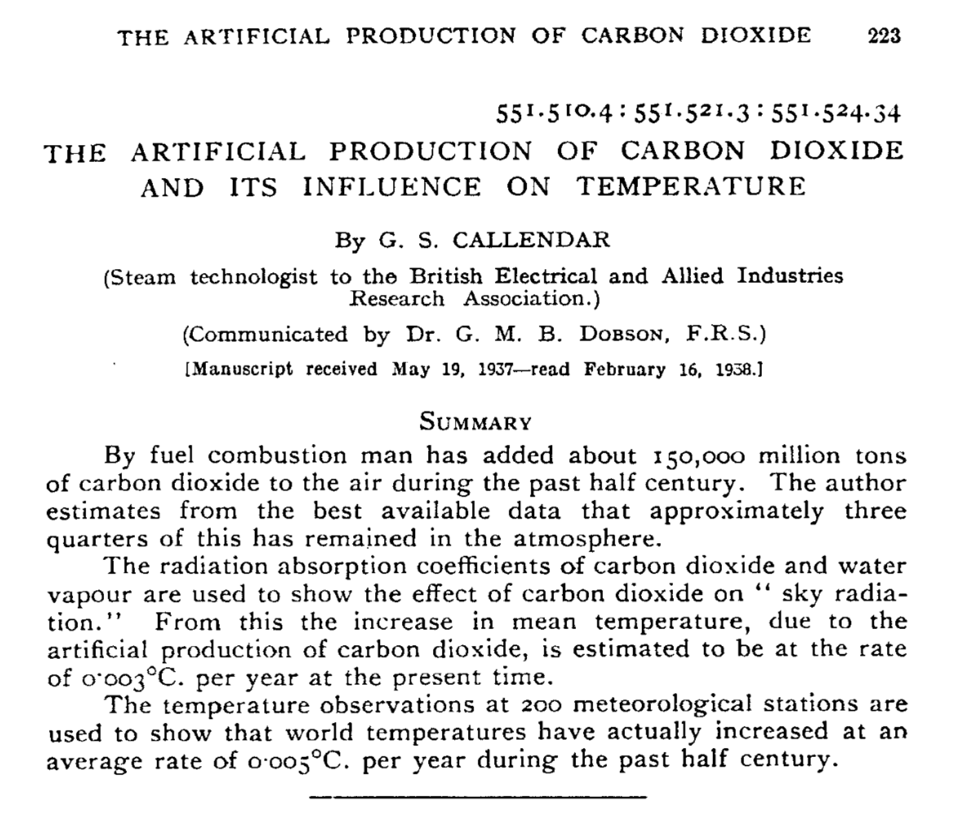
A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another 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).



551.510.4 : 551.521.3 : 551.524.34

THE ARTIFICIAL PRODUCTION OF CARBON DIOXIDE AND ITS INFLUENCE ON TEMPERATURE

By G. S. CALLENDAR

(Steam technologist to the British Electrical and Allied Industries Research Association.)

(Communicated by Dr. G. M. B. Dobson, F.R.S.)

[Manuscript received May 19, 1937—read February 16, 1938.]

Summary

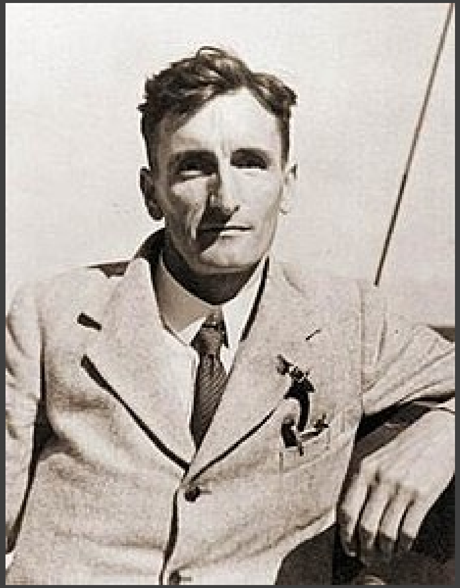
By fuel combustion man has added about 150,000 million tons of carbon dioxide to the air during the past half century. The author estimates from the best available data that approximately three quarters of this has remained in the atmosphere.

The radiation absorption coefficients of carbon dioxide and water vapour are used to show the effect of carbon dioxide on "sky radiation." From this the increase in mean temperature, due to the artificial production of carbon dioxide, is estimated to be at the rate of 0·003°C. per year at the present time.

The temperature observations at 200 meteorological stations are used to show that world temperatures have actually increased at an average rate of 0·005°C. per year during the past half century.

Guy Stewart Callendar (1898-1964)

In 1938, Steam engineer Guy Callendar predicts a temperature increase of 0.3 ^{0}C per century, which should delay the "return of the deadly glaciers".



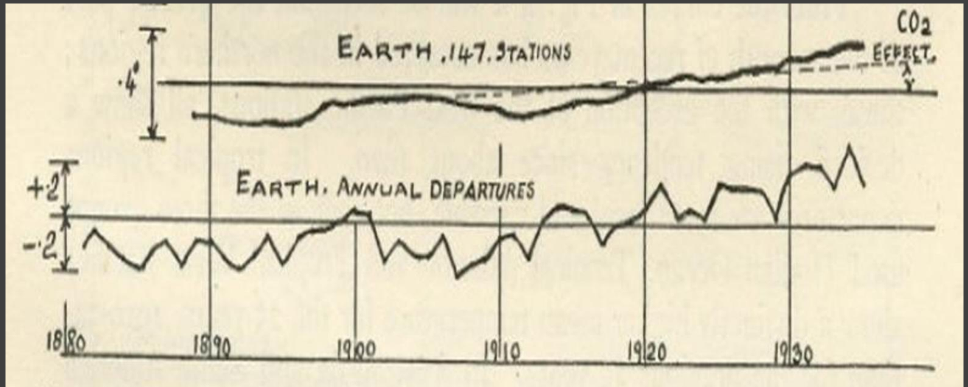


Fig. 4.—Temperature variations of the zones and of the earth. Ten-year moving departures from the mean, 1901-1930, °C.

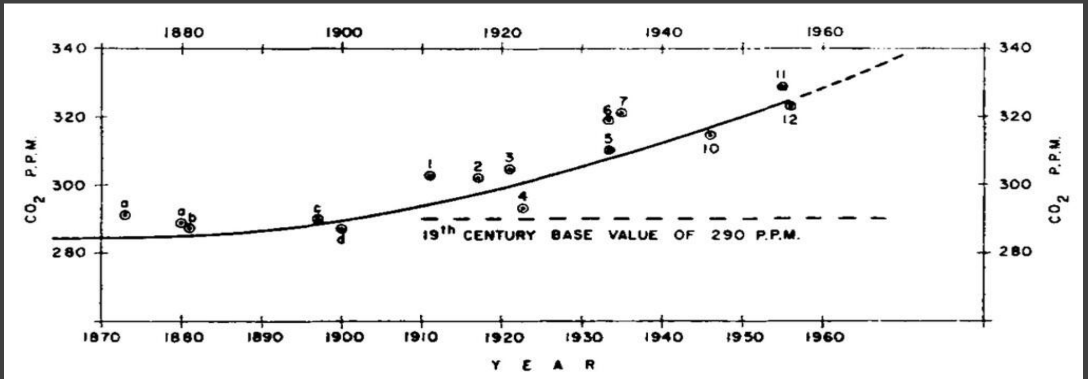
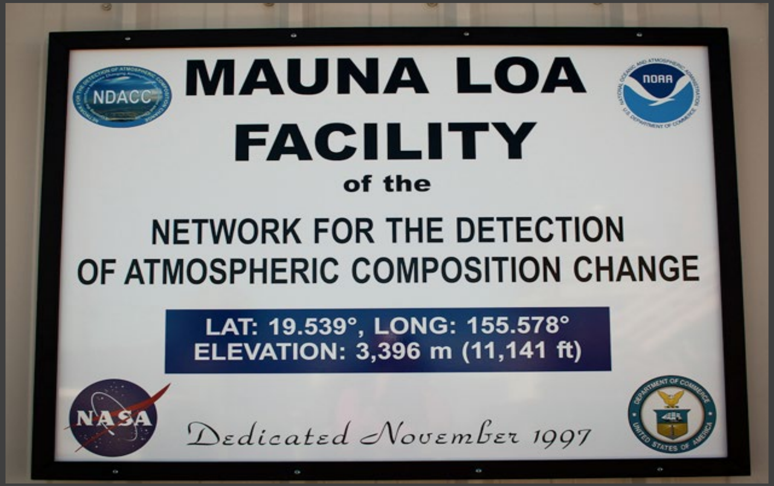
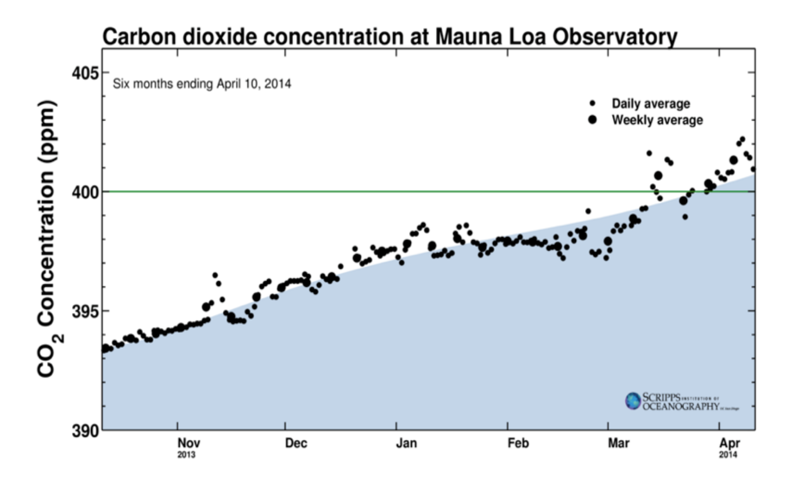


Fig. 1. Amount of CO_2 in the free air of the N. Atlantic region. 1870—1956. Full curve, amount from fossil fuel (See Appx. Table B. for numbered obs. points, and text Table 1 for the 19th century obs. points.)

Charles David Keeling

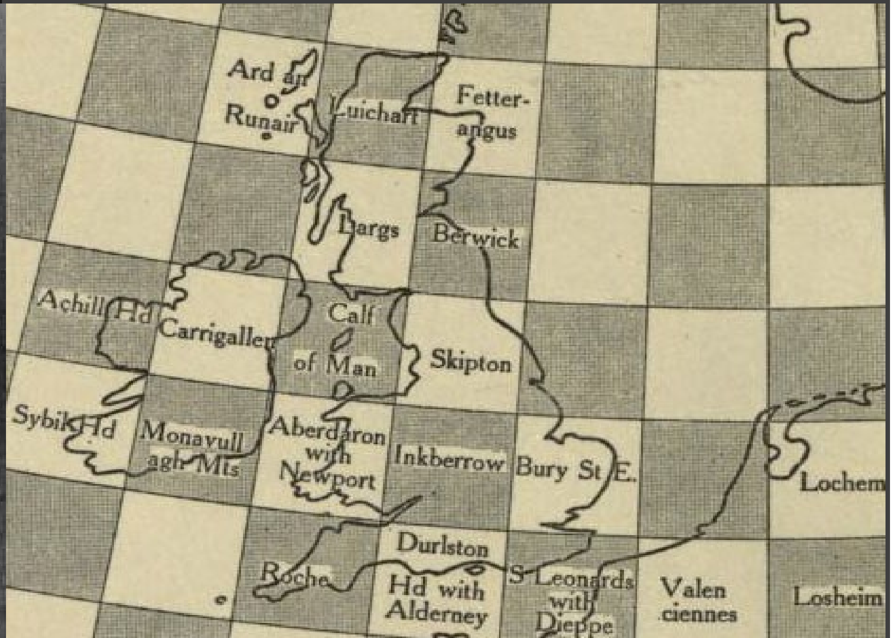
Starting in **1958**, monitoring of CO_2 at the Mauna Loa station shows that the level of this greenhouse gas is gradually increasing in the atmosphere even in remote areas: the problem is a global problem.

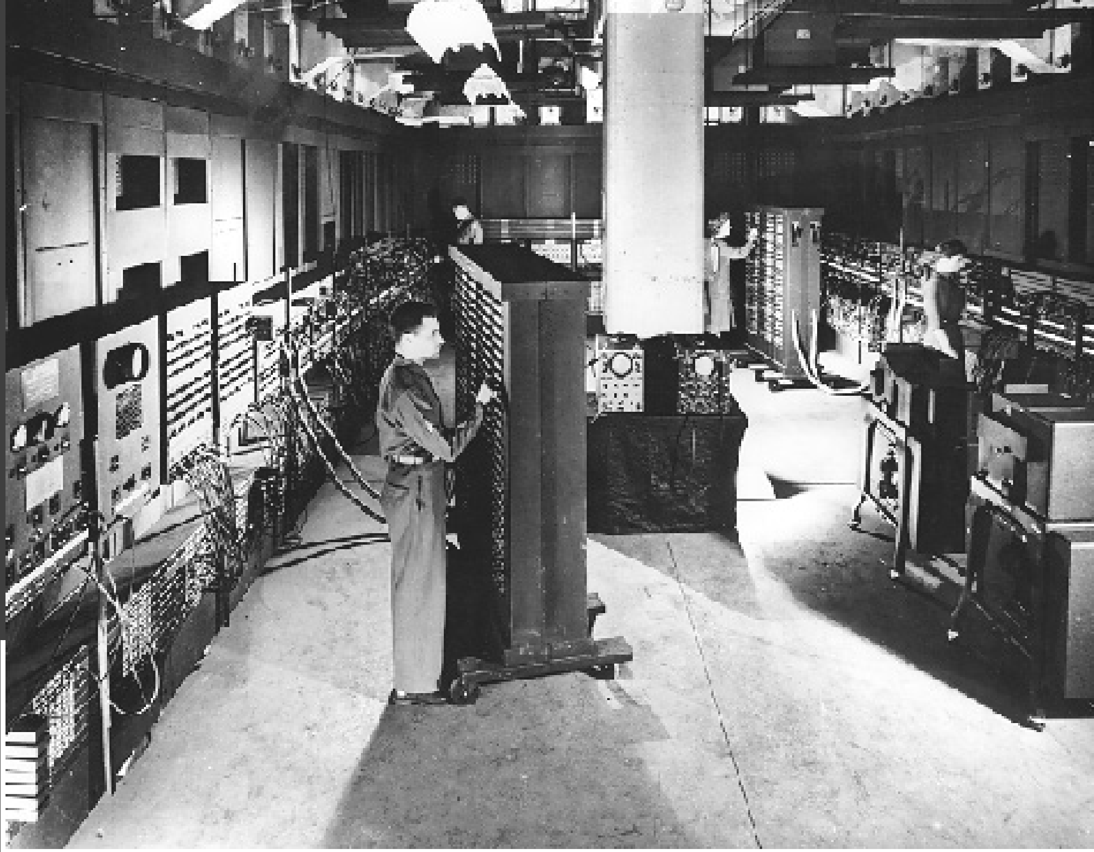




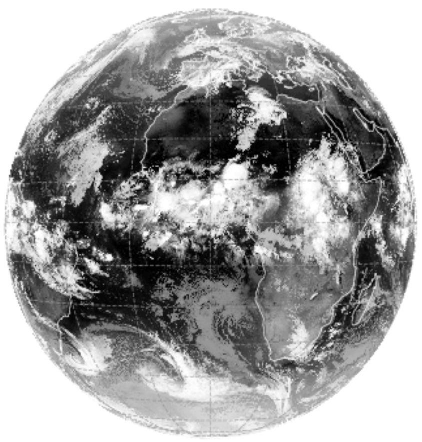
A Century of Tremendous Progress

Numerical Weather Forecast

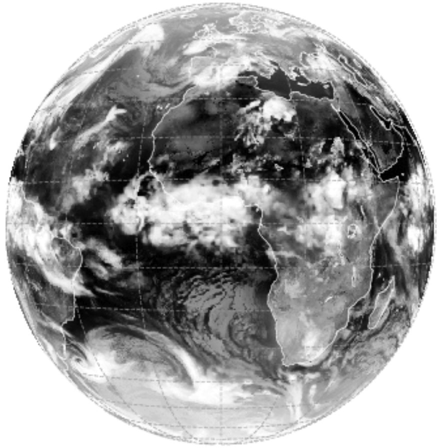




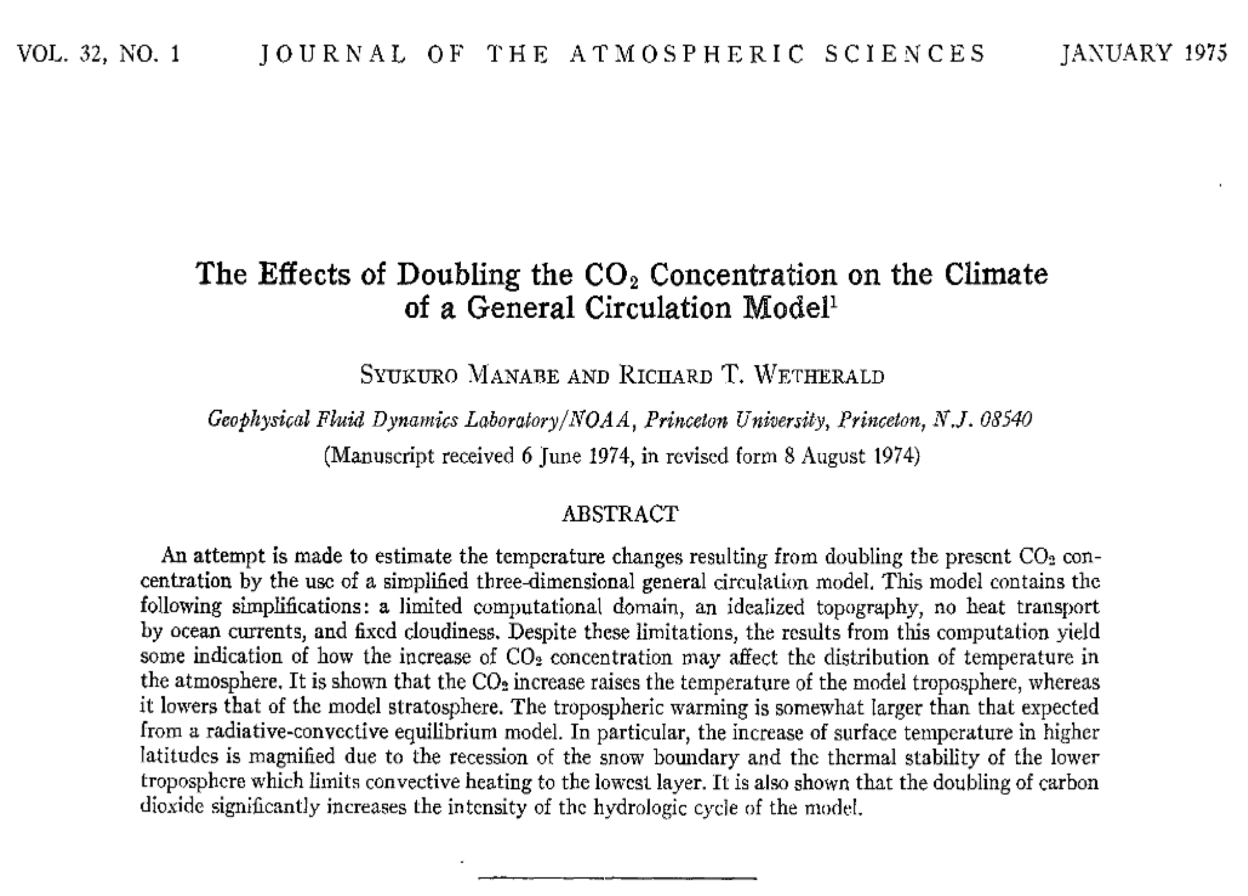
Meteosat 9 IR10.8 20080525 0 UTC



ECMWF Fc 20080525 00 UTC+0h:



In **1967**, at the NOAA Geophysical Fluid Dynamics Laboratory in Princeton, Syukuro Manabe et Richard Wetherald make a first calculation of the effect of greenhouse gases using a 1-D radictive convective model. They derive in **1975** with a general circulation model and derive the effect on climate of a doubling in CO_2.



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.

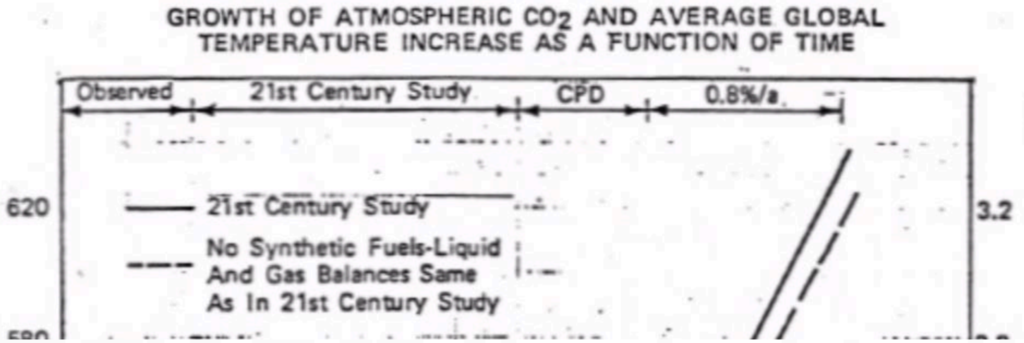
EXXON RESEARCH AND ENGINEERING COMPANY
P.O. BOX 101, FLORHAM PARK, NEW JERSEY 07932

Cable: ENGREXXON, N.Y.

M. B. GLASER
Manager
Environmental Affairs Programs

Almost 40 years ago

November 12, 1982

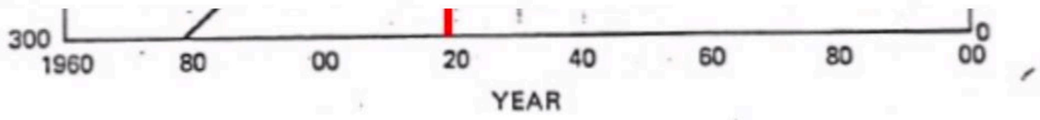


Predictions of the climatological impact of a carbon dioxide induced "greenhouse effect" draw upon various mathematical models to gauge the temperature increase. The scientific community generally discusses the impact in terms of doubling of the current carbon dioxide content in order to get beyond the noise level of the data. We estimate doubling could occur around the year 2090 based upon fossil fuel requirements projected in Exxon's long range energy outlook. The question of which predictions and which models best simulate a carbon dioxide induced climate change is still being debated by the scientific community. Our best estimate is that doubling of the current concentration could increase average global temperature by about 1.3° to 3.1°C. The increase would not be uniform over the earth's surface with the polar caps likely to see temperature increases on the order of 10°C and the equator little, if any, increase.

H. N. WEINBERG

Attachments

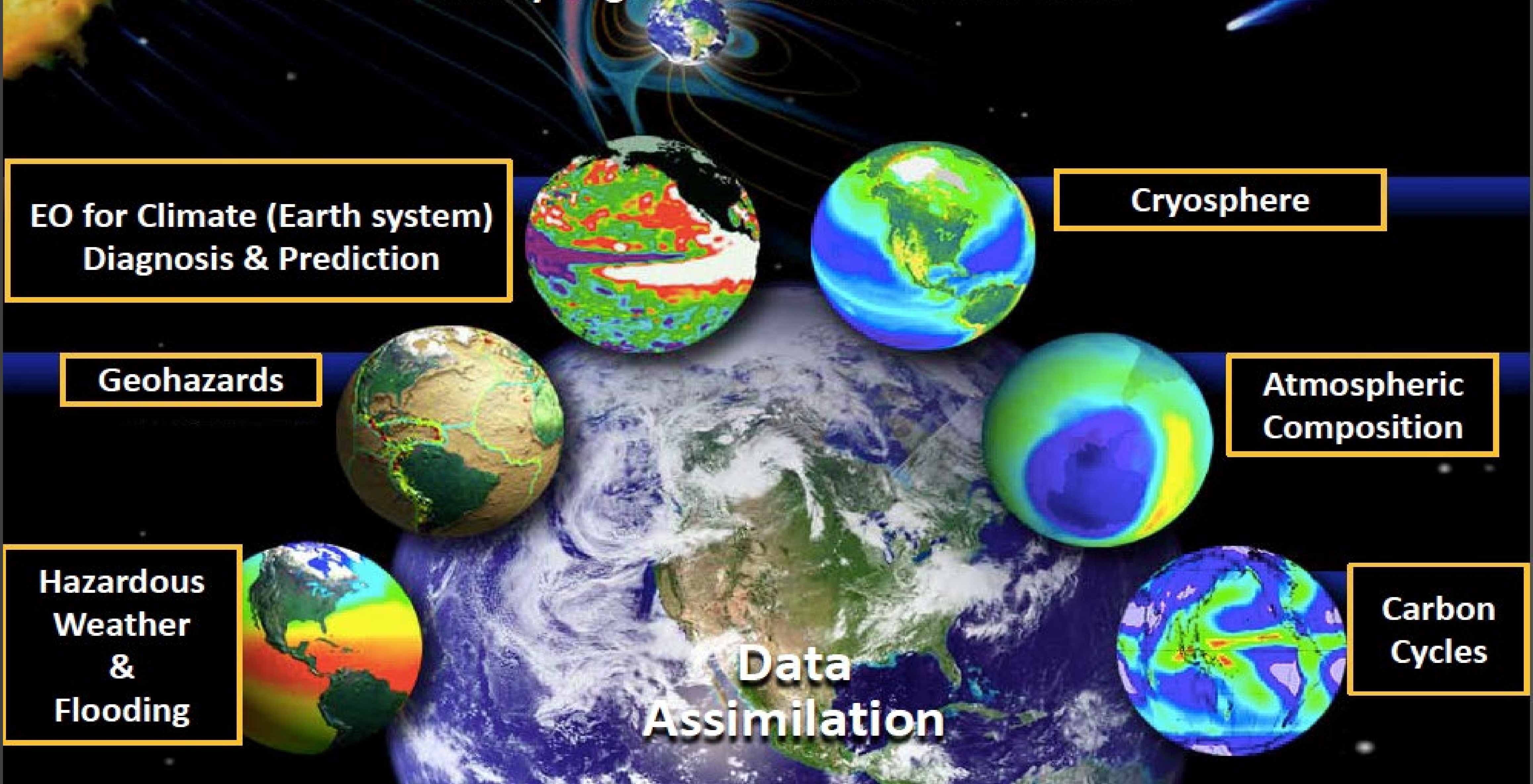
NOV 15 1982



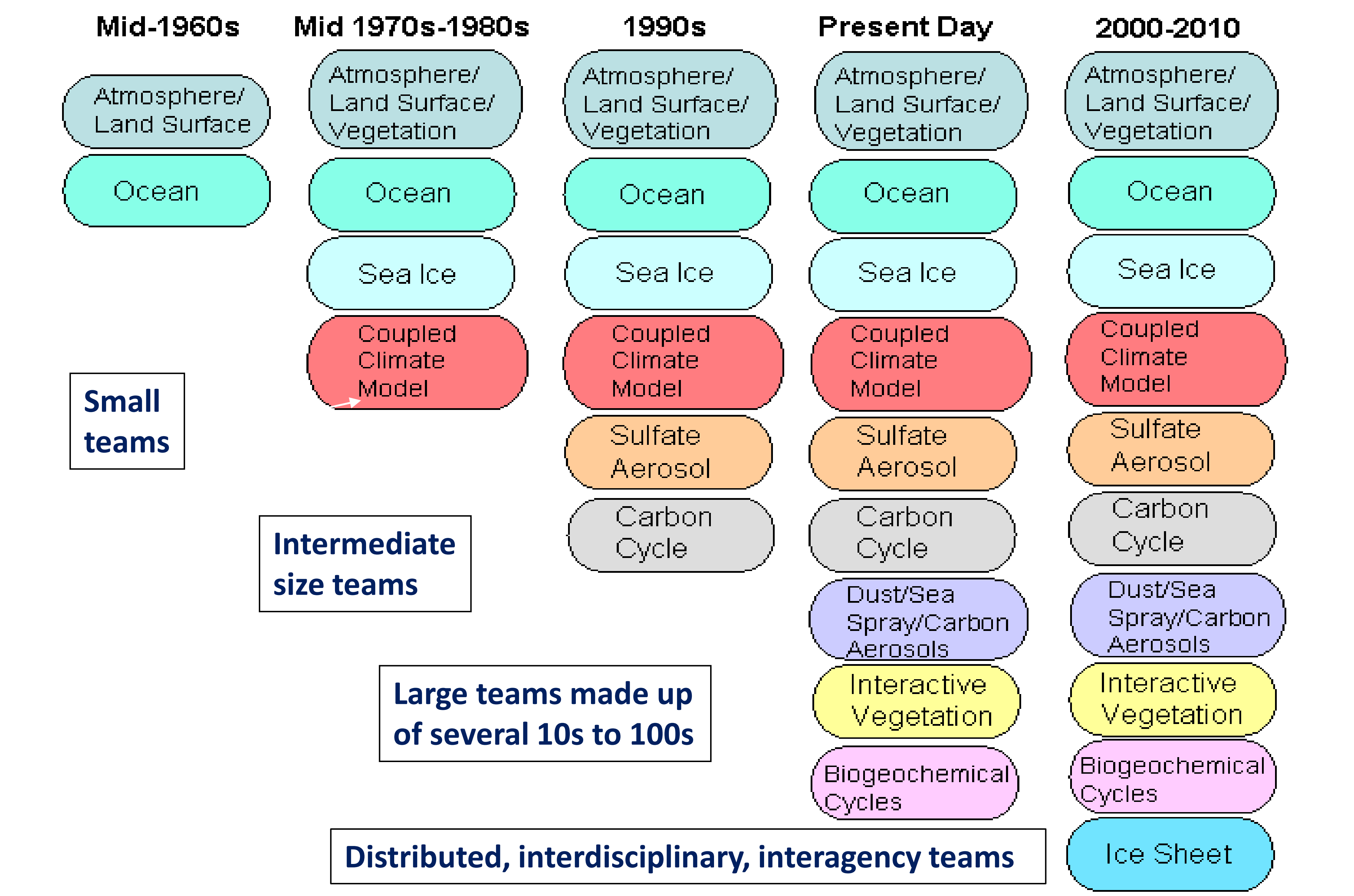
CO2 = 412 ppm

Earth System Science: the big picture

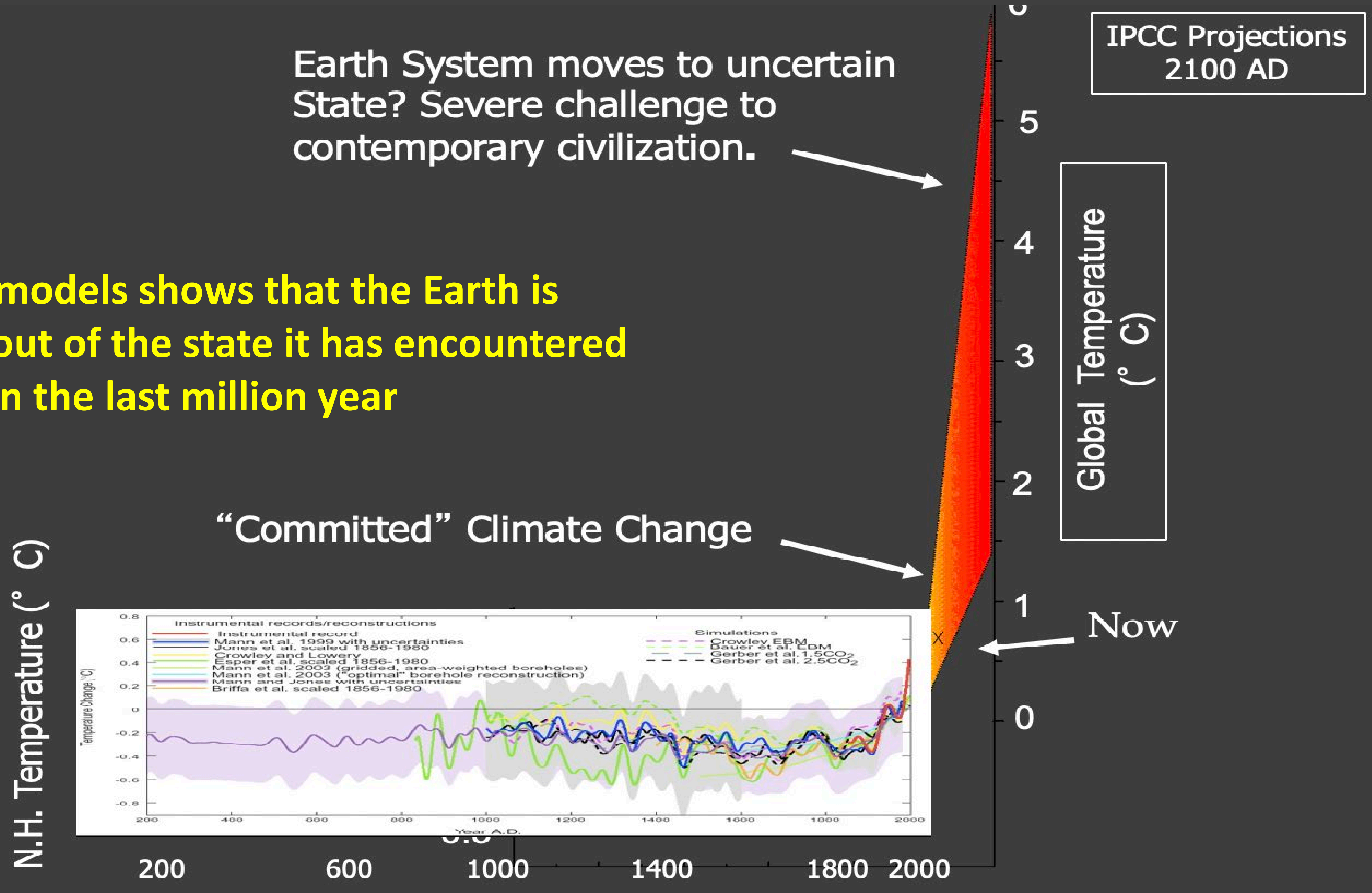
Ability to give the earth a "health check"



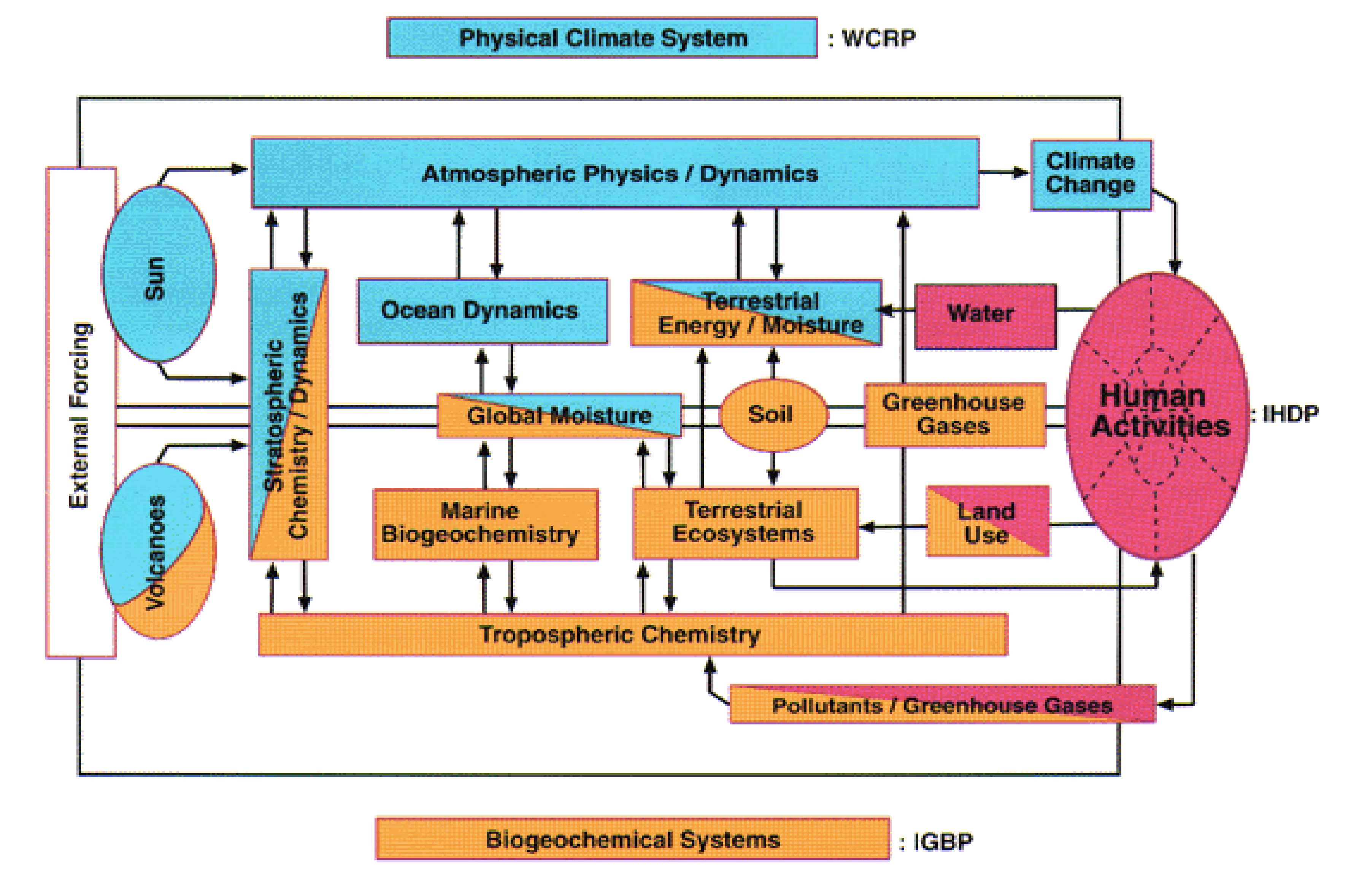
Timeline of Climate Model Development

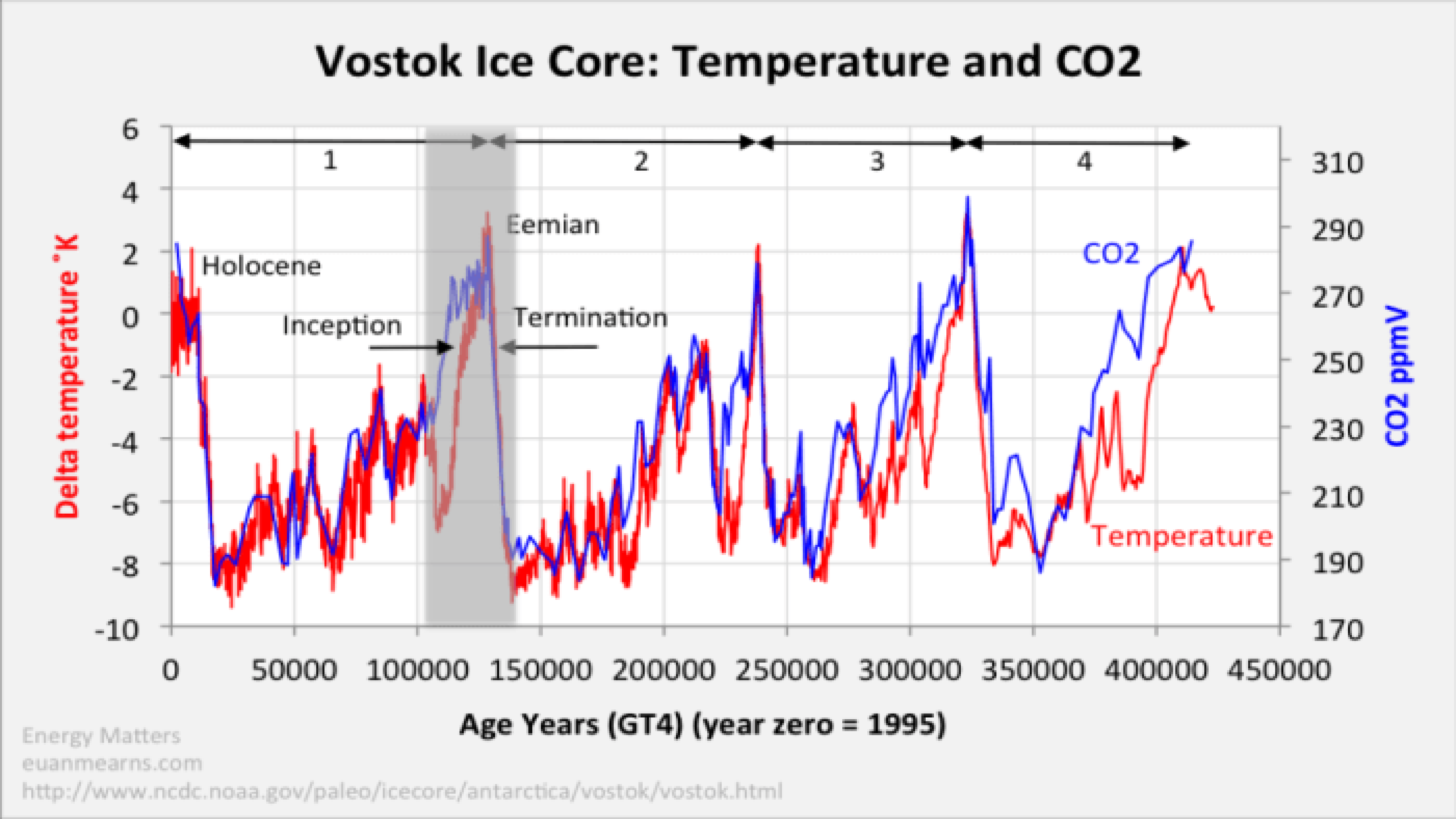


Climate models shows that the Earth is moving out of the state it has encountered at least in the last million year



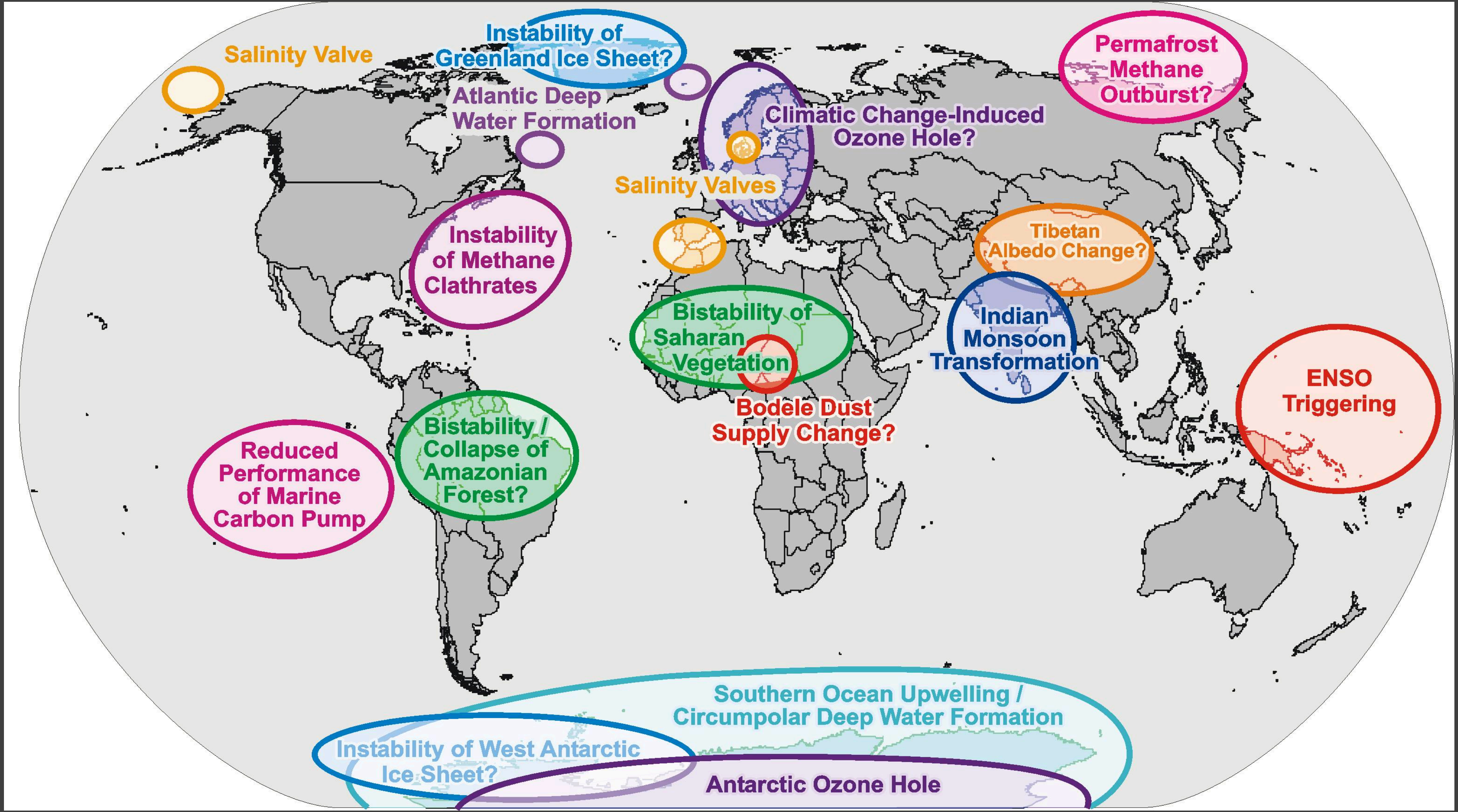
Bretherton's diagram shapes global change research for the decades ahead





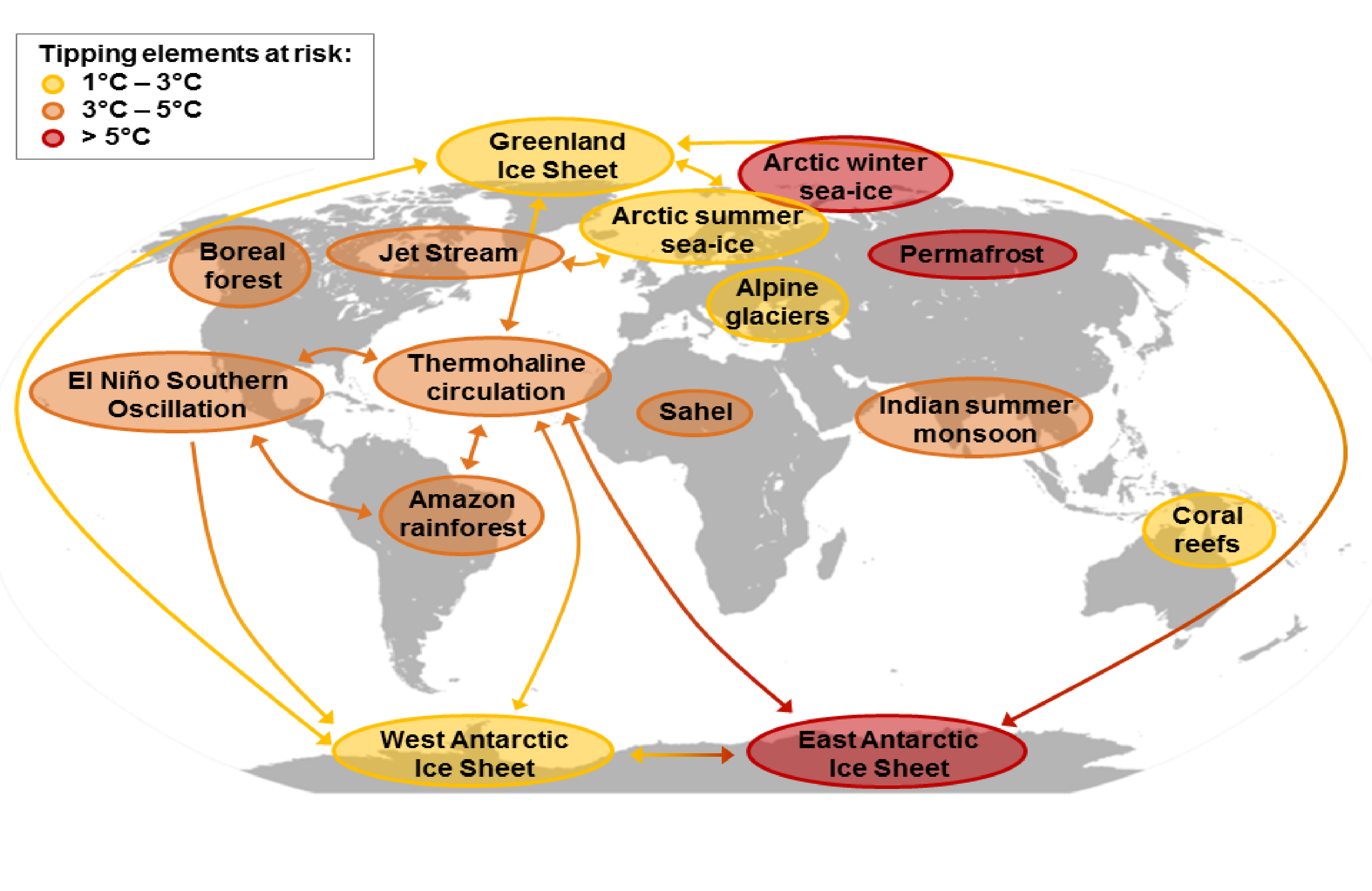
Vostok Ice Core: Temperature and CO2
1
2
3
4
Eemian
Holocene
Inception
Termination
CO2
Temperature
Delta temperature °K
CO2 ppmV
6
4
2
0
-2
-4
-6
-8
-10
310
290
270
250
230
210
190
170
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
Age Years (GT4) (year zero = 1995)
Energy Matters
euanmearns.com
http://www.ncdc.noaa.gov/paleo/icecore/antarctica/vostok/vostok.html

Tipping Elements in the Earth System



Source: Schellnhuber, after Lenton et al, PNAS, 2008

Tipping Cascades



Source: J. Donges and R. Winkelmann in Steffen et al. 2018

International Programs and Environmental Diplomacy

An Important Milestone

This conference was followed by other UN conferences in Rio de Janeiro in 1992 and 2012.

- ***The landmark UN Stockholm Conference*** in 1972 recognized that:
- science and technology should be used to improve the environment,
- research and education in environmental sciences should be promoted,
- cooperation on international issues should be regarded as essential.

UNEP

United Nations Environment Programme

environment for development

Climate Change | Disasters & Conflicts | Ecosystem Management | Environmental Governance | Chemicals & Waste | Resource Efficiency | Environment Under Review

Mission

"To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations."

Climate Change

Introduction | Science | Tools | Partners

United Nations
Framework Convention on Climate Change

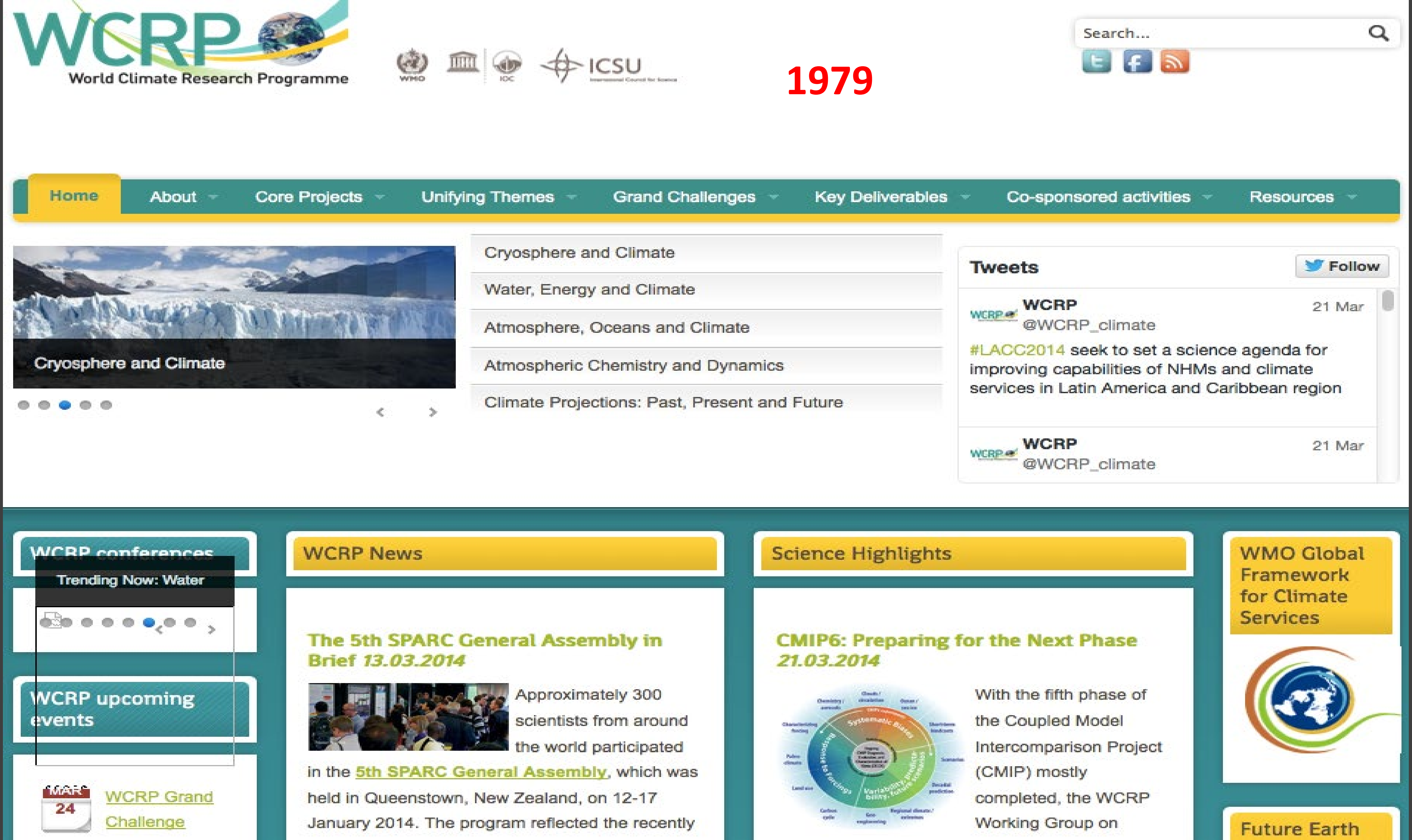
Adaptation
Building resilience to climate change

Mitigation
Moving towards low carbon societies

REDD+
Reducing Emissions from Deforestation and forest Degradation

Finance
New finance models for the green economy

1979


WCRP
World Climate Research Programme
WMO
IOC
ICSU
Search...
Home
About
Core Projects
Unifying Themes
Grand Challenges
Key Deliverables
Co-sponsored activities
Resources
Cryosphere and Climate
Cryosphere and Climate
Water, Energy and Climate
Atmosphere, Oceans and Climate
Atmospheric Chemistry and Dynamics
Climate Projections: Past, Present and Future
Tweets
Follow
WCRP
@WCRP_climate
21 Mar
#LACC2014 seek to set a science agenda for improving capabilities of NHMs and climate services in Latin America and Caribbean region
WCRP
@WCRP_climate
21 Mar
WCRP conferences
Trending Now: Water
WCRP upcoming events
MAR
24
WCRP Grand Challenge
WCRP News
The 5th SPARC General Assembly in Brief 13.03.2014
Approximately 300 scientists from around the world participated in the 5th SPARC General Assembly, which was held in Queenstown, New Zealand, on 12-17 January 2014. The program reflected the recently
Science Highlights
CMIP6: Preparing for the Next Phase 21.03.2014
With the fifth phase of the Coupled Model Intercomparison Project (CMIP) mostly completed, the WCRP Working Group on
WMO Global Framework for Climate Services
Future Earth

GLOBAL IGBP CHANGE International Geosphere-Biosphere Programme

1987

Member zone | Site map | Press | Contact

Science for a sustainable planet

ABOUT RESEARCH & PROJECTS EVENTS PUBLICATIONS MULTIMEDIA PEOPLE NEWS GLOBAL CHANGE NETWORKS SEARCH

ABOUT

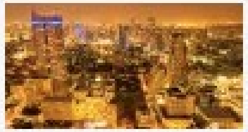
- WHAT WE DO
- ORGANISATION
- VISION
- HISTORY
- SUSTAINABILITY
- ACRONYM LIST
- GET INVOLVED
- GUIDELINE DOCUMENTS
- LOGOS

photo: NASA-Visible Earth

About

IGBP was launched in 1987 to coordinate international research on global-scale and regional-scale interactions between Earth's biological, chemical and physical processes and their interactions with human systems. IGBP views the Earth system as the Earth's natural physical, chemical and biological cycles and processes AND the social and economic dimensions.

LATEST NEWS



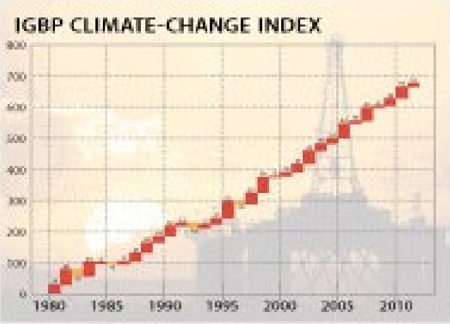
Mar 20, 2014

Conference - Global Challenges: Achieving Sustainability

Translate with Google Translate

FOLLOW US

IGBP CLIMATE CHANGE INDEX



SIGN UP!

Sign up for news alerts. Become part of the network

NEXT EVENTS

Apr 7 - Apr 11, 2014

29th IGBP SC Meeting

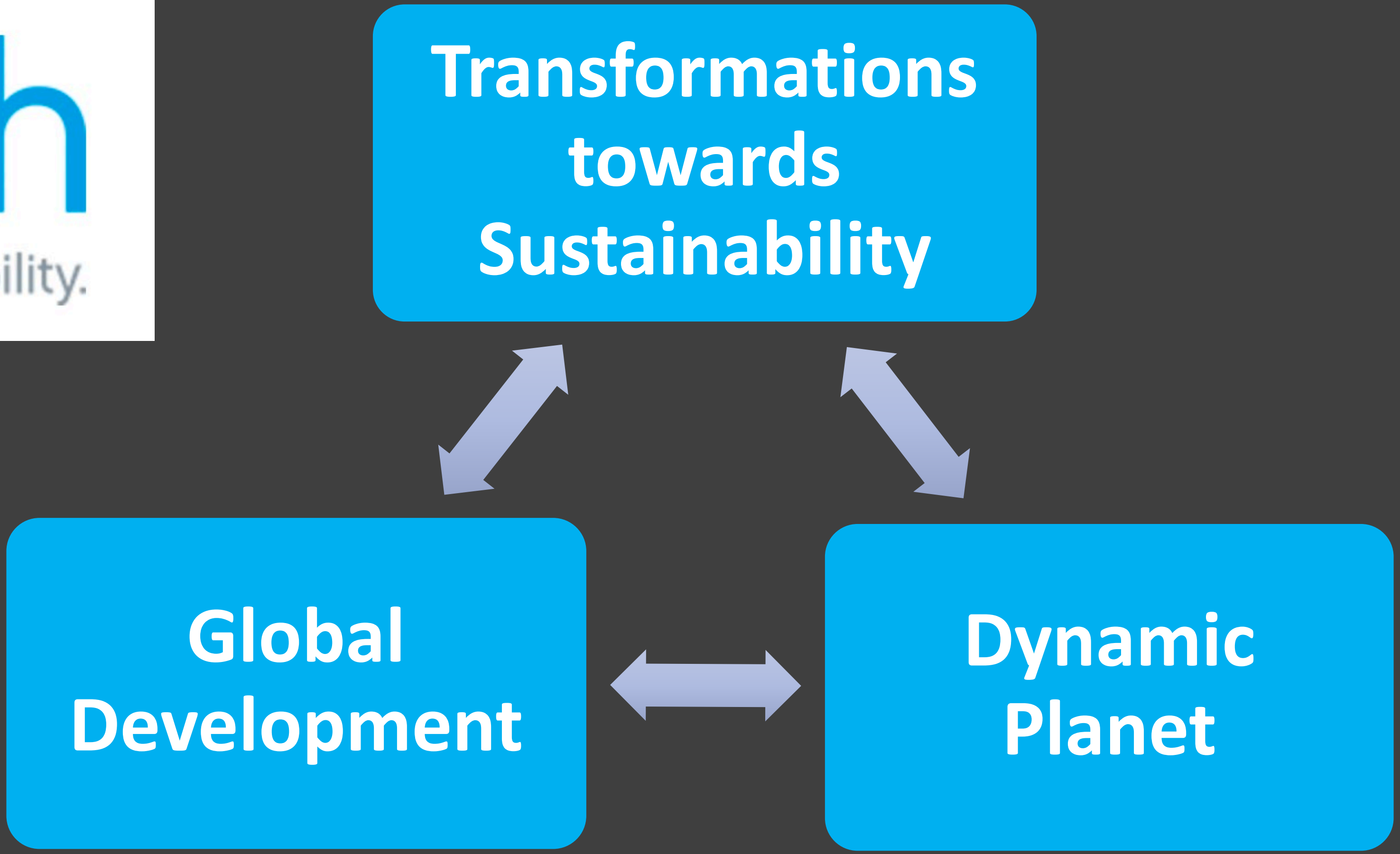
Apr 7 - Apr 12, 2014

Arctic Science Summit

futurearth

Research. Innovation. Sustainability.

- Water-Energy-Food Nexus
- Ocean
- Transformations
- Natural Assets
- Sustainable Development Goals
- Urban
- Health
- Finance & Economics
- Systems of Sustainable Consumption and Production
- Decarbonisation
- Emergent Risks and Extreme Events



Observing systems, models, theory development, data management, research infrastructures


SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Environmental Security for Humanity

Security is not only maintaining territorial integrity and domestic peace.

It must value economic prosperity, stability, health and well-being of populations.

Citizens should have full access to our global commons and the right to be protected from the extreme environmental disruptions:

- Access to clean air
- Access to clean water
- Access to safe food
- Access to natural resources

Environmental prediction of environmental factors is key to address this issue.

What has the climate scientific community brought to the table of decision-makers ?

- The earth is warming and will continue to get warmer
- Most of the warming is caused by human activities.
- The Earth should be viewed as an integrated system with interactive physical, biological, chemical, economic, social and cultural components.
- The consequences of climate change will be global and regional. They will be severe: polar melting, rising sea-level, more extreme events, impacts on the biosphere and on the economy.
- Thus: the decision of reducing emissions is not rooted in the lack of knowledge, but in the political process.

Key to Success for Interdisciplinary Programs

- Shared concepts and languages
- Collaboration between those who excel in their own field
- Joint proposal development
- Sub-projects to allow individuals to succeed in their own field
- Intellectual mutual respect
- Long-term commitment
- Good communication, joint location
- Stakeholder participation

Part 2.

The Response

The Societal Context

The societal context

- The emissions of greenhouse gases continue to increase:
  - The Paris agreement specifies legally binding targets (2^0C and, if possible, 1.5^0C), but current national contributions to emission reductions point to a world warming larger than 3^0C. We may go to 4^0C.....
- The first impacts of climate change appeared earlier than predicted:
  - Melting of the Arctic and removal of ice in the western Antarctic
  - Frequency of wildfires (California, Australia)
  - Intensity of hurricanes and typhoons
  - Loss of biodiversity, destruction of coral, multiplication of bugs

Example of Climate IMPACT: the Permafrost in danger

The northern permafrost region stores 1672 Pg C, nearly 90% of it in perennially frozen soil. This is about double the amount of carbon in the atmosphere

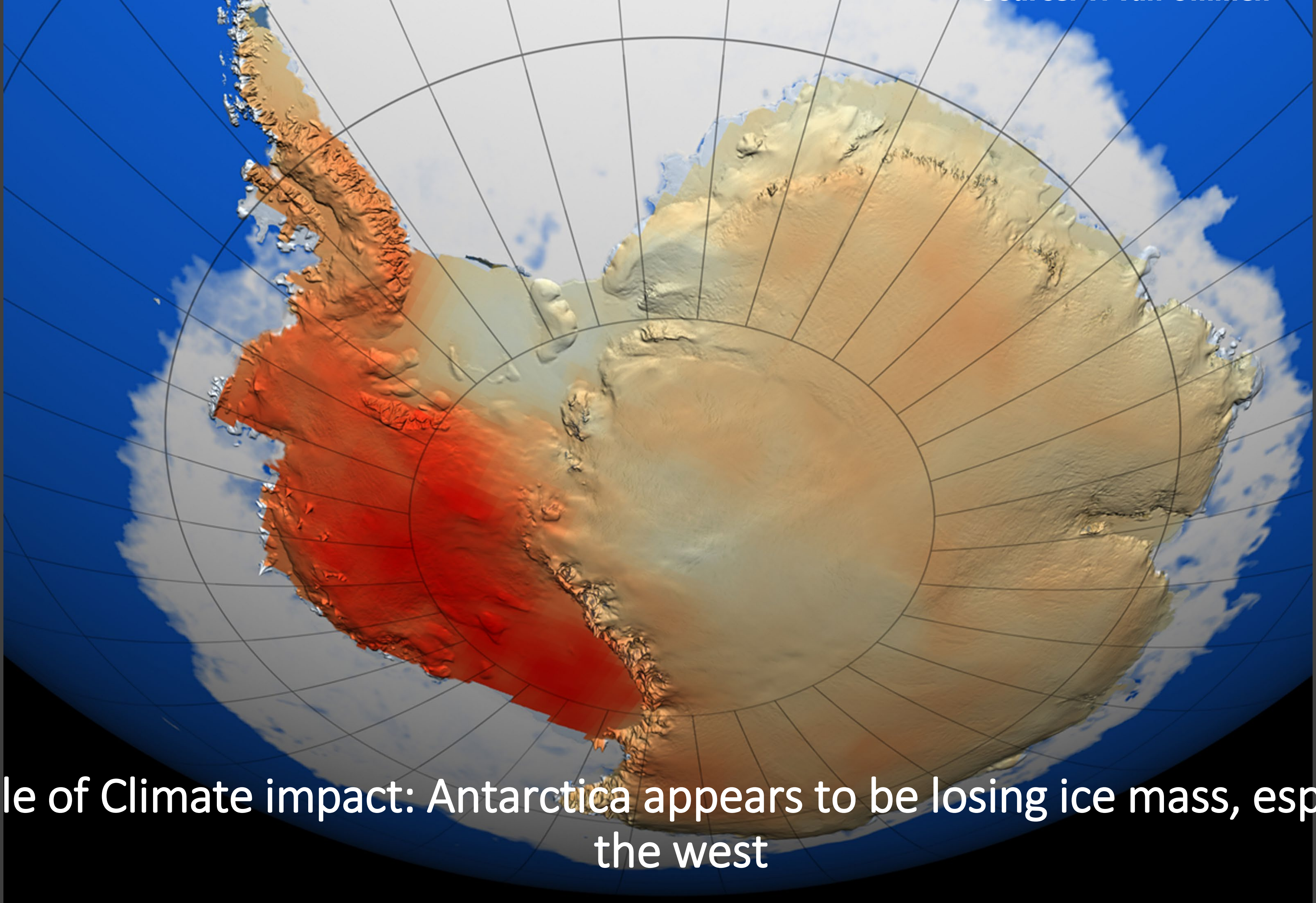
Tarnocai et al. 2009

Photo: Edward A.G. Schuur

Photo: Edward A.G. Schuur

http://earthobservatory.nasa.gov/IOTD/view.php?id=36736

Source: T. van Ommen

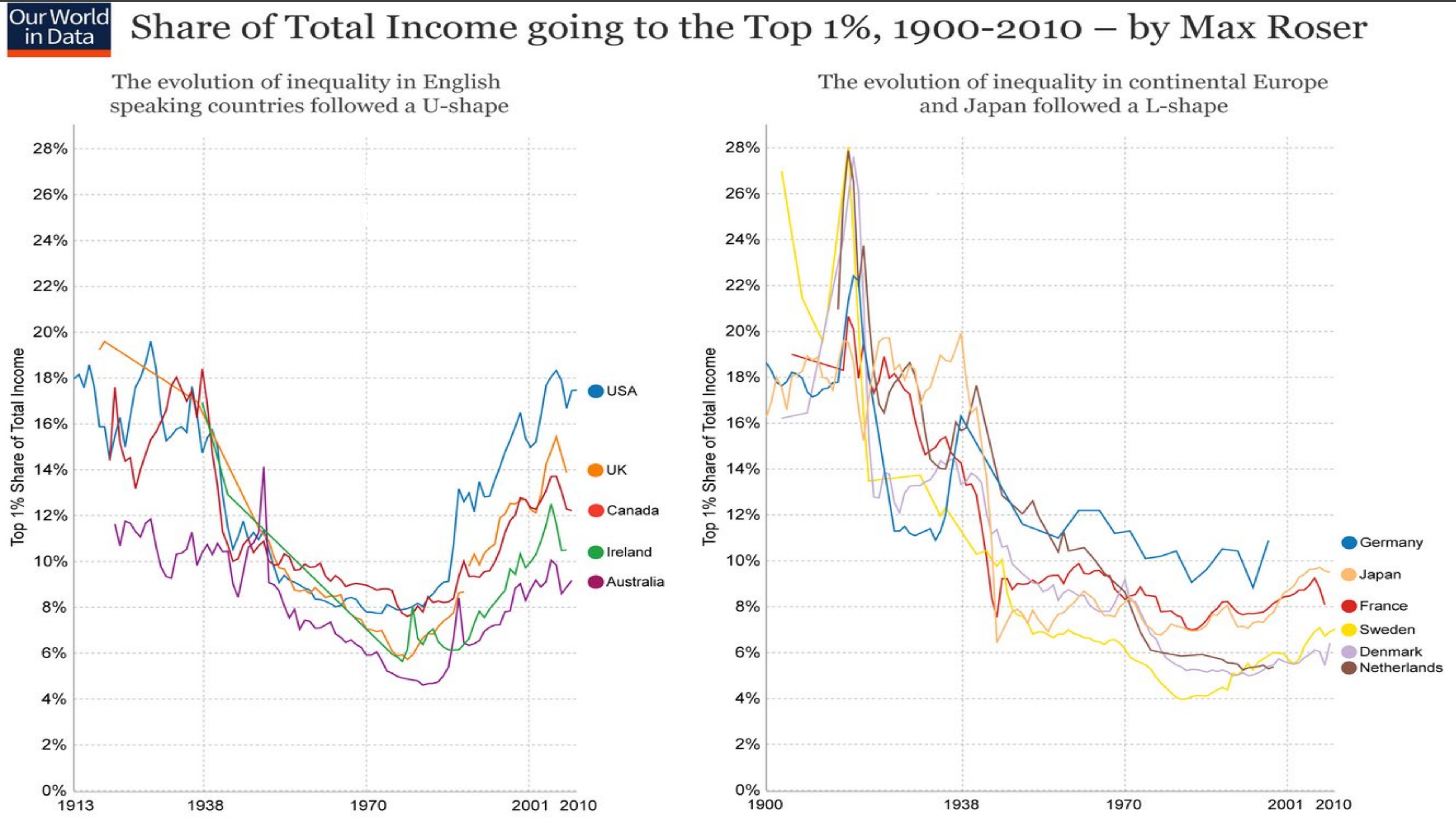


Example of Climate impact: Antarctica appears to be losing ice mass, especially in the west

The political context has also changed

- The political context has changed dramatically with two dominating poles increasingly replacing the traditional parties:
  - Populist movement
  - Ecological movement
- Profound questions remain about the future of the world:
  - The future of the European Union,
  - The relations between Russia, Asia and the western world,
  - The role of Africa, the migration questions,
  - Increasing inequalities in society

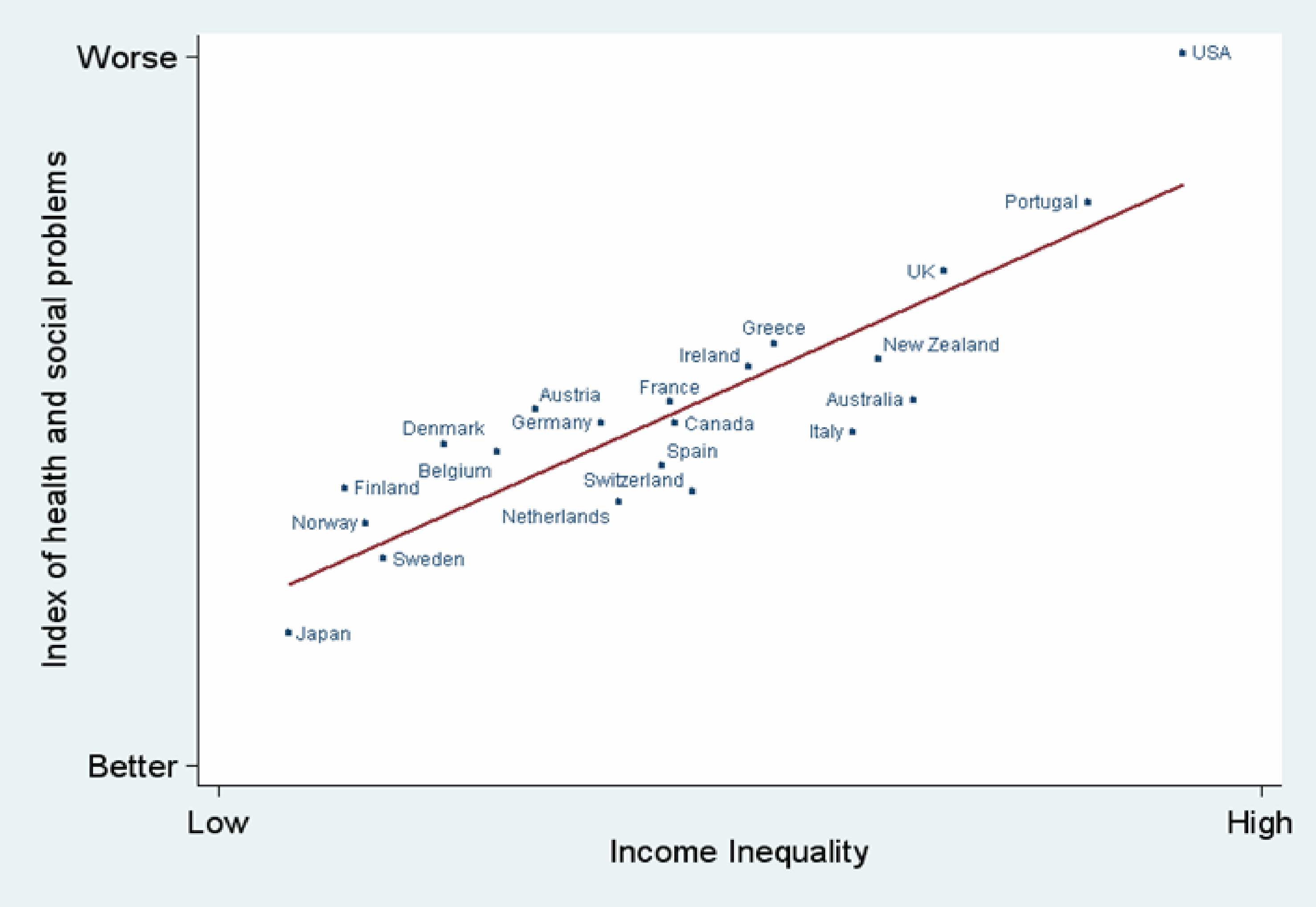
Evolution of Income Equality



Source: S. van der Leeuw

Health and Social Problems are Worse in More Unequal Countries

Index of:
- Life expectancy
- Math & Literacy
- Infant mortality
- Homicides
- Imprisonment
- Teenage births
- Trust
- Obesity
- Mental illness – incl. drug & alcohol addiction
- Social mobility



Source: Wilkinson & Pickett, The Spirit Level (2009)

www.equalitytrust.org.uk

The Equality Trust

Pickett and Wilkinson 2015


THE ECONOMY BY KILLING LIFE = INSANITY
LOSING NEMO
THERE IS NO PLANET B
WHAT I STAND FOR IS WHAT I STAND ON!
THE OCEAN IS RISING AND SO ARE WE
DON'T BE A FOSSIL FOOL
We shouldn't have to do This But here we are Begging you
EXPECT RESISTANCE
CLIMATE CHANGE STRIKE 2019
STOP FRACKING WITH MOTHER EARTH
YOU'LL DIE OF OLD AGE WE'LL DIE OF
TELL THE TRUTH
I HAD UR FUTURE LET US HAVE OURS
NOT THE CLIMATE
SAVE OUR
WINTER IS NOT COMING
WE CAN SAVE THE
DO WE REALLY NEED
SAVE THE EARTH
FFF

Today, similarities exist between the climate change and the COVID pandemics movements

The role of scientific knowledge in the political process:

- Long-term: The Paris agreement would not have taken place without input from the science.
- Several scientific questions regarding the long-term evolution of the Earth system remain open.
  - Feedbacks between the biogeochemical and climate systems
  - Feedbacks between the hydrological and climate systems
  - Future storage of carbon by the ocean and the continental biosphere.
  - Irreversibility of climate change
  - Regional impacts of climate change and the question of habitability

The role of scientific knowledge in the political process:

- Short-term: For economic sectors, scientific knowledge represents only one input among many in the decision process.
- Many questions are posed by these sectors:
  - Improving seasonal to decadal prediction of weather and the hydrological cycle.
  - Providing more information at the regional scale.

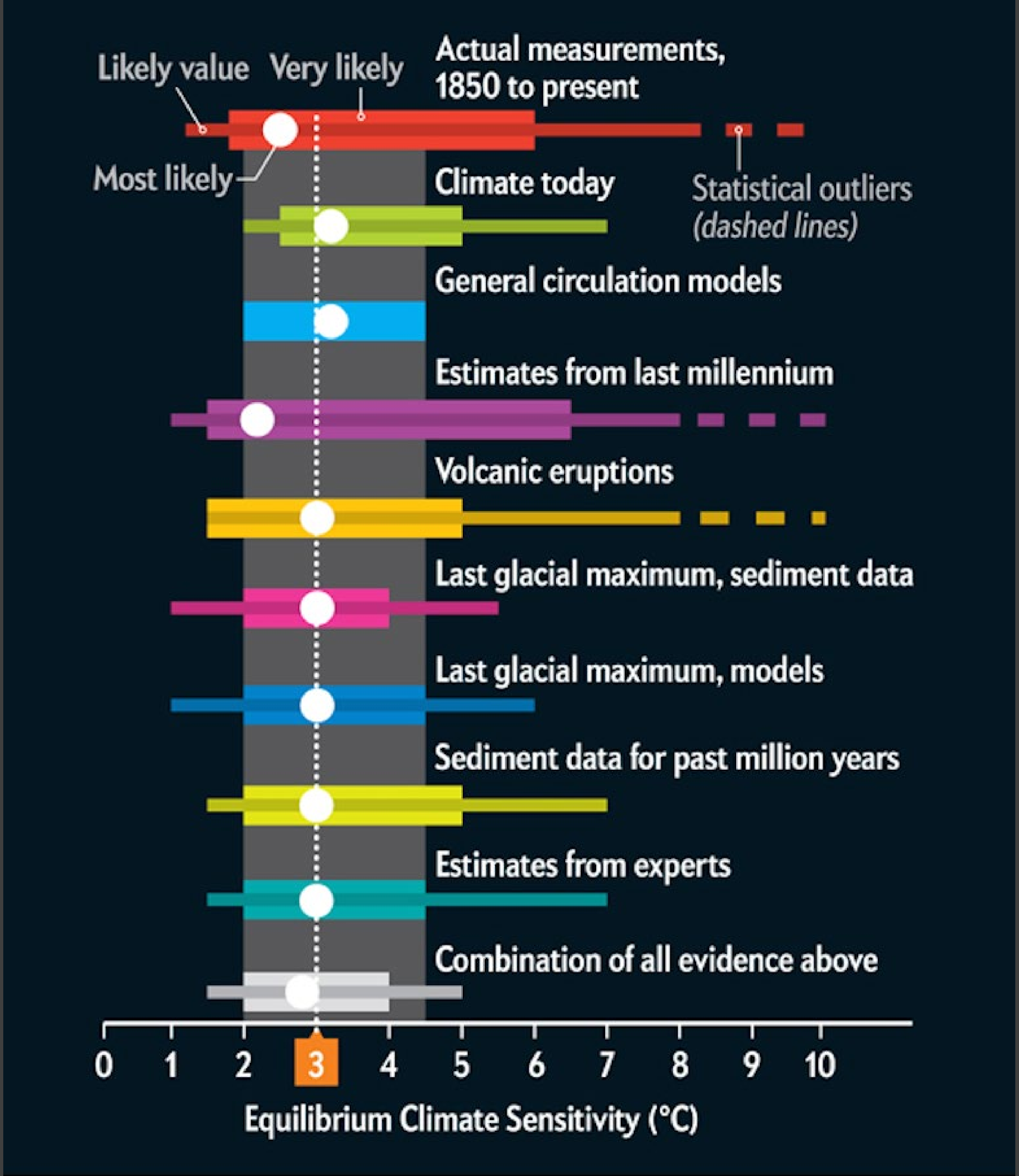
Three scientific questions that the scientific community should address

What scientific knowledge should be provided by WCRP to support the political process?

- Question 1: How sensitive is climate to GHG emissions, and which emissions are compatible with the Paris's targets?
- We need to reduce the uncertainty in the climate sensitivity (2-6 ^{0}C).
- We need to better understand the evolving fluxes in the carbon cycle: and to determine where anthropogenic carbon goes.
- We need to better assess the budget of short-lived climate forcers such as methane and ozone.

- Strategy: We need to an integrated and fundamental understanding of the multi-scale physical and biogeochemical processes that determine the evolution of climate and hence of the socio-economic system.

Equilibrium Climate sensitivity



What scientific knowledge should be provided by WCRP to support the political process?

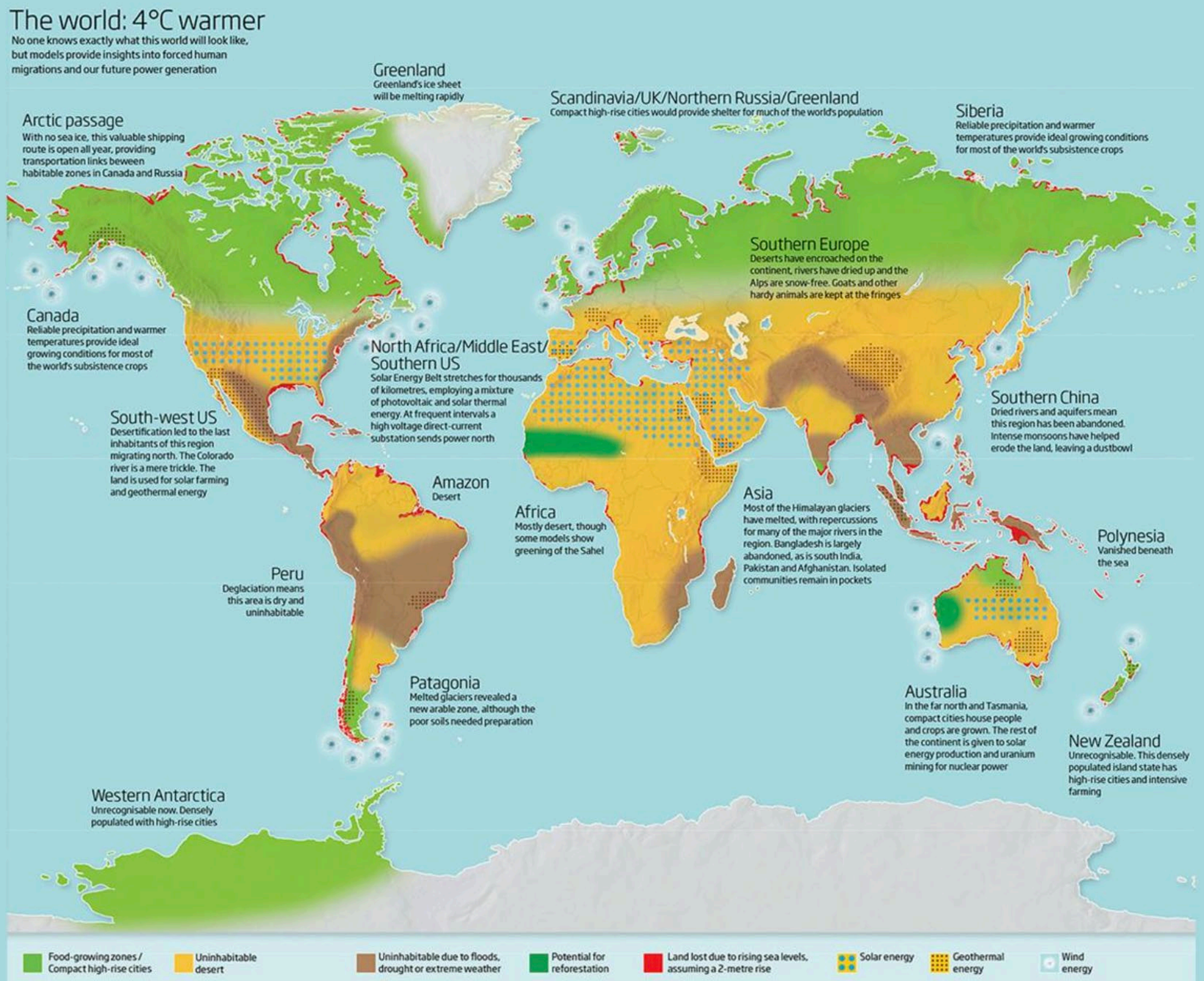
- Question 2: How can we better manage the effects of climate variability and short-term changes?
- How will climate change affect weather in different regions of the world?
- How will climate change and variability affect the biosphere and hydrosphere including food productivity?
- Which strategy should we develop to make rapid progress in our skills to predict the evolution of the Earth system on seasonal to decadal scales?

- Strategy: We need to push the frontiers of predictions for sub-seasonal to decadal timescales across the different components of the climate/Earth system at the global and regional scales.

What scientific knowledge should be provided by WCRP to support the political process?

- Question 3: What will be the consequences of a (plausible) warming larger than required by the Paris' agreements (3, 5 or 7^{0}C)?
- How will a world respond to a 5 ^{0}C warming?
- Which regions of the world are likely to become inhabitable?
- Will tipping point(s) be crossed with irreversible and dramatic environmental and economic consequences?
- What future is possible? (plausible social economic world under climate change)
- What would be the impact of climate intervention?
- Strategy: We should facilitate the development of a new generation of coupled earth system models that explicit represent global storms, deep convection ocean eddies and land-atmosphere interactions (1 km) and provide reliable information with reliable regional precision.

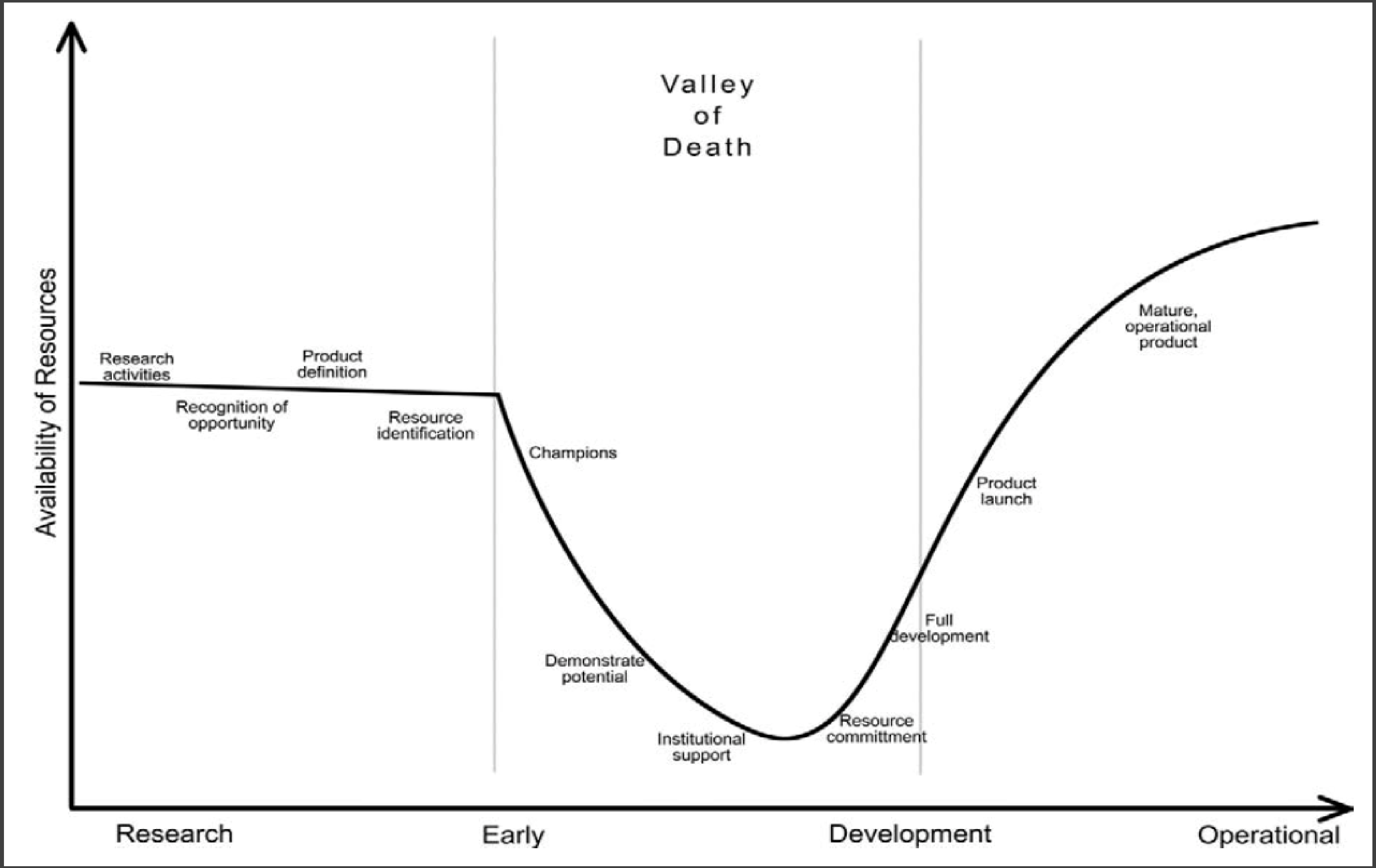
The World under a 4^0C warming



Communicating science to society:
Climate Services

CLIMATE CHANGE BUILDING
UNDER CONSTRUCTION
ADAPTATION
MITIGATION
Durban 2011
SOLAR ACTIVITY
HUMAN RIGHTS
PRECAUTIONARY PRINCIPLE
NO GLOBAL DEAL
MEDIA
scepticism
fear
indifference
blame
ENERGY SECURITY
MONTREAL PROTOCOL
COPY ? PASTE
COMMON BUT DIFFERENTIATED RESPONSIBILITIES
LAW AND GOVERNANCE
POLLUTERS PAY
Health
LUXURY EMISSION
SOCIAL TRANSFORMATION
FOOD SECURITY
SOCIAL COST
SOCIETY
FUTURE GENERATIONS
RESPONSIBILITY
CLIMATE JUSTICE
RELIGION & CLIMATE
CLEAN DEVELOPMENT
POVERTY REDUCTION
MILLENNIUM GOALS
VALUES
DEVELOPMENT
GLOBAL COMMONS
Cap-and-Trade System
COMMODIFICATION
AIR 1%=$
H_2O 1%=$
STERN
Discount rate 1% GDP
INVESTMENT
MONEY
PROFIT
LIMITS TO GROWTH
BIOFUEL
USSR Hot Air
low carbon economy
CARS
ECONOMY
REDD
DEFORESTATION
Under Construction by
UNFCCC IPCC
EU USA
China India
AOSIS WMO
Greenpeace
OPEC
Umbrella Group
G2 / G20/ G77/ G??
Annex I / Annex II
Non-Annex
CH_4
PROBABILITY
UNCERTAINTY
ICE SHEET
ALTERNATIVE ENERGY
MODELING
MELTING GLACIERS
UNDER CONSTRUCTION
CO_2 STORAGE
OCEAN ACIDIFICATION
SEA LEVEL RISE
DATA EVIDENCE
AGRICULTURE
DROUGHT
DEFORESTATION
SCIENCE
SAVE THE PLANET
UN
Cancun 2010
KYOTO 1997
RIO 1992
IPCC
OIL
BIODIVERSITY
MEDIA
Version 3.0 (October 2010)
Concept: Kurbalija. Illustration: Marcetic
DiPLO
www.diplomacy.edu
This drawing illustrates Diplo's approach to training and research on climate change.
Creative Commons by DiploFoundation

“The Valley of Death”



Source:
Barr et al.,
2009

International Development of Climate Services
Bridge between Science and Society

- **Climate services** involve the production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning.

- **Climate services** ensure that the best available climate science is effectively communicated with agriculture, water, health, and other sectors, to develop and evaluate mitigation and adaptation strategies

Climate Services Partnership

GFCS
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

Essentially two different approaches for Climate Services

1. Top-down approach: Development of large data bases and dissemination of data available to users. Extension of Meteorological Services.
2. Bottom-up approach: Initiation of dialogue with stakeholders and identification their specific needs. Towards solutions to their problems. Extension of research groups involved in adaptation science.

Dialogue with Stakeholders

- Every case study/user/potential user is different
- The decision-making context is key
- So a sectoral focus is important

i.e., Need to know the 'who' and the 'what'

- Can't assume that users know their needs *a priori*
- Sending out questionnaires is not optimal (interviews and focus groups work better but more time consuming)

- These steps are complex and time consuming but are very important

Climate and COVID-19

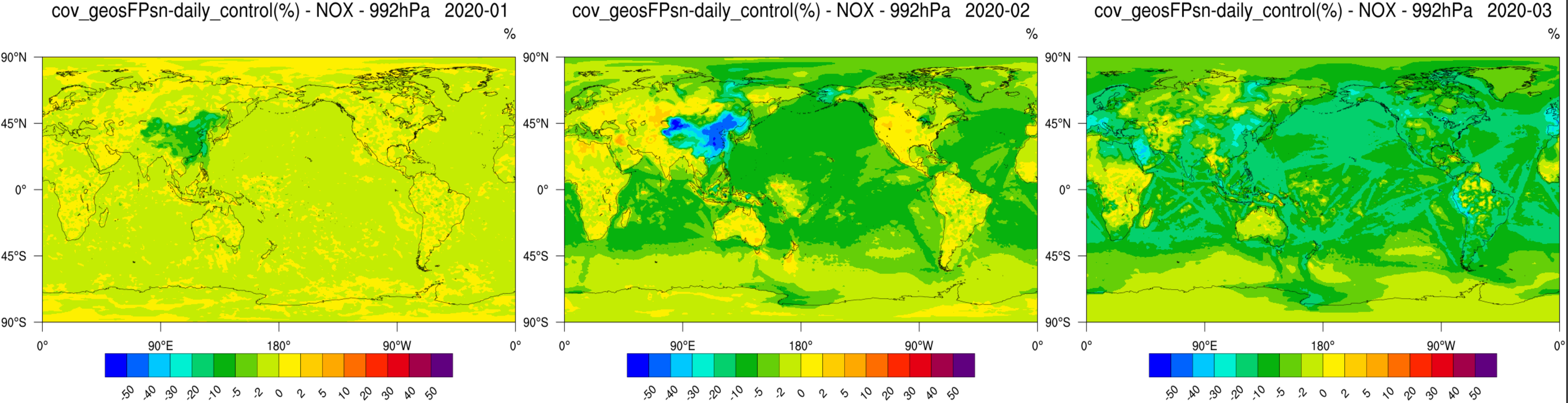
Are there relations between the COVID-19, air quality and the climate question?

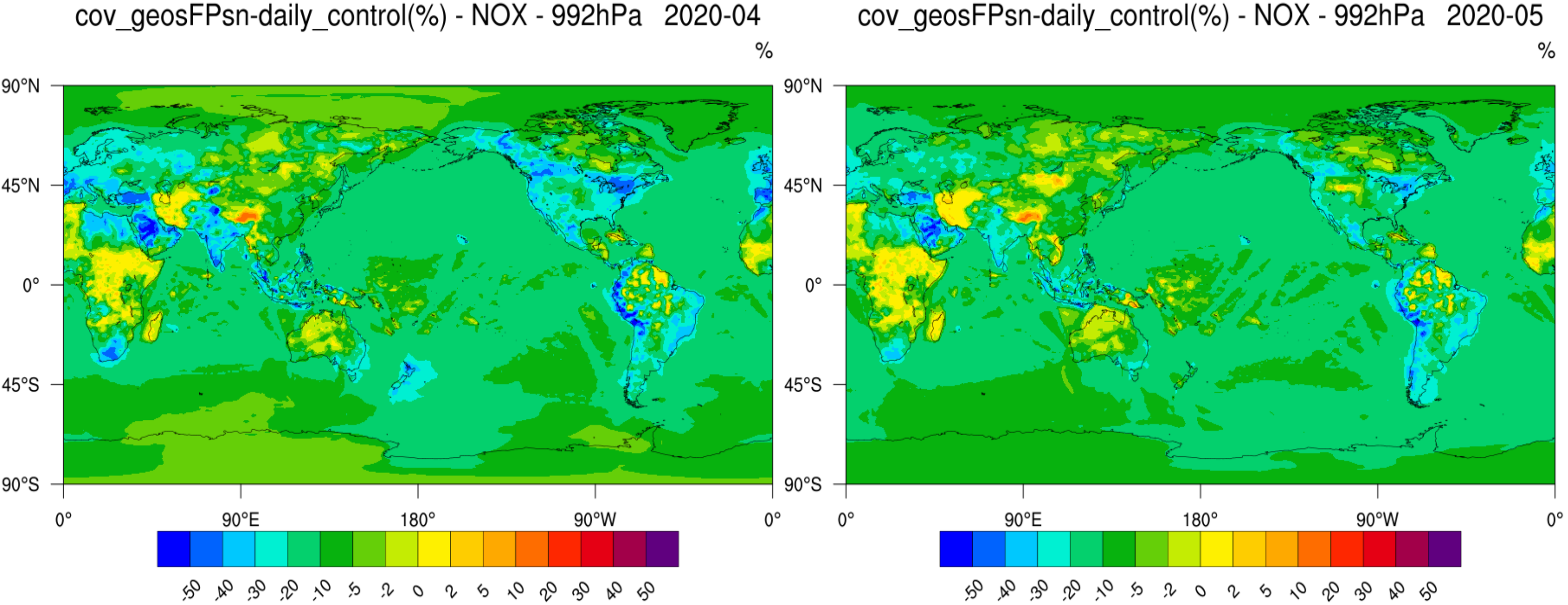
Questions

- How did the air pollution situation changed during the COVID-19 pandemic? What were the mechanisms of these changes?
- Will air quality (aerosol) in turn affect the spread of the virus? How? Do masks protect us from the smallest particles?
- If the pandemic continues for another one or two years, how would the air quality and climate change, human health and the environment? How should we face these problems?
- Are the pandemics an adjustment of the earth system to natural or anthropogenic disturbances?

The air quality has been affected by the reduction in economic activity during the COVID-19 pandemics.

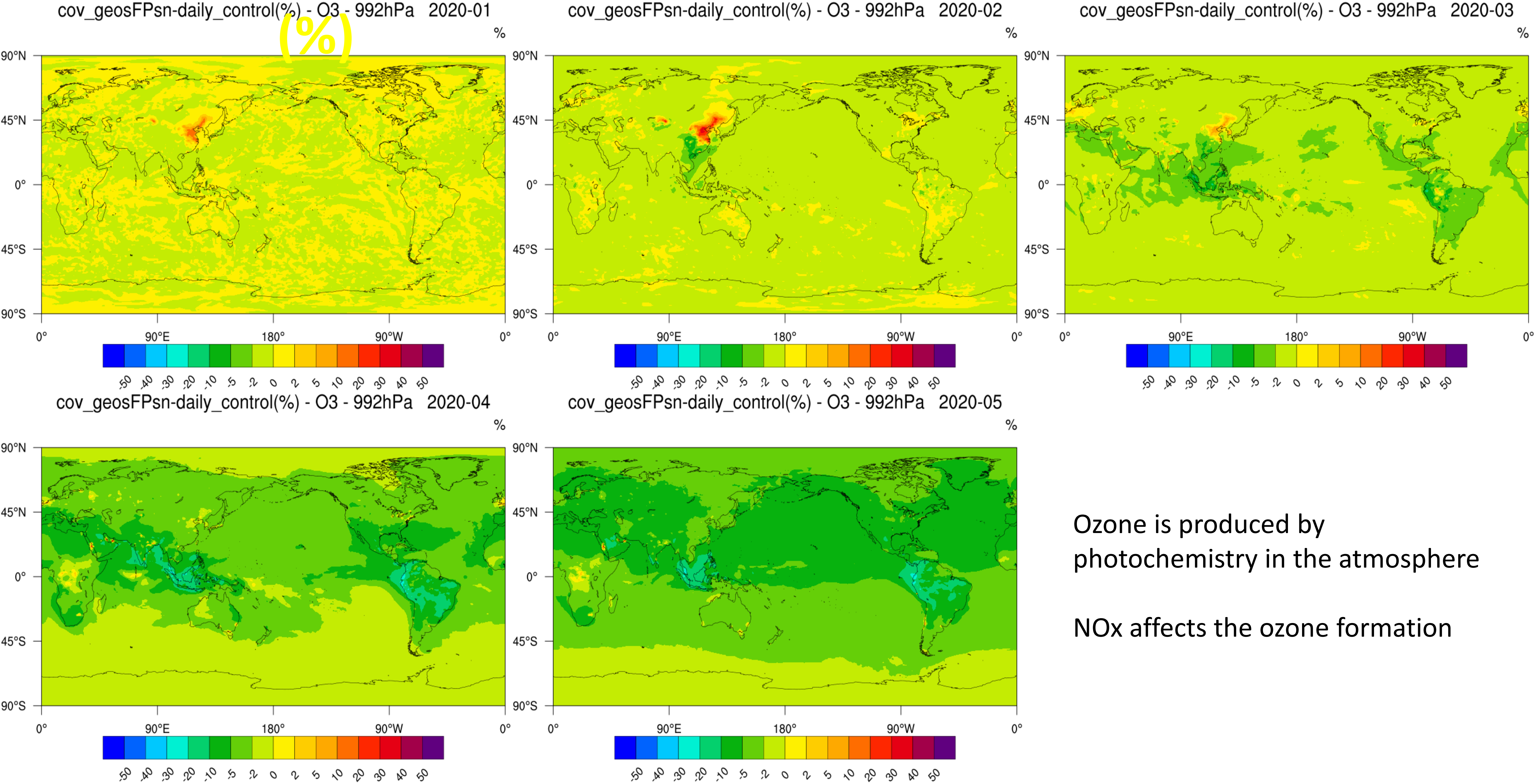
Impact of COVID-19 on global surface NOx (%)





NOx are emitted by combustion: automobiles, industry, residential

Impact of COVID-19 on global surface ozone (%)

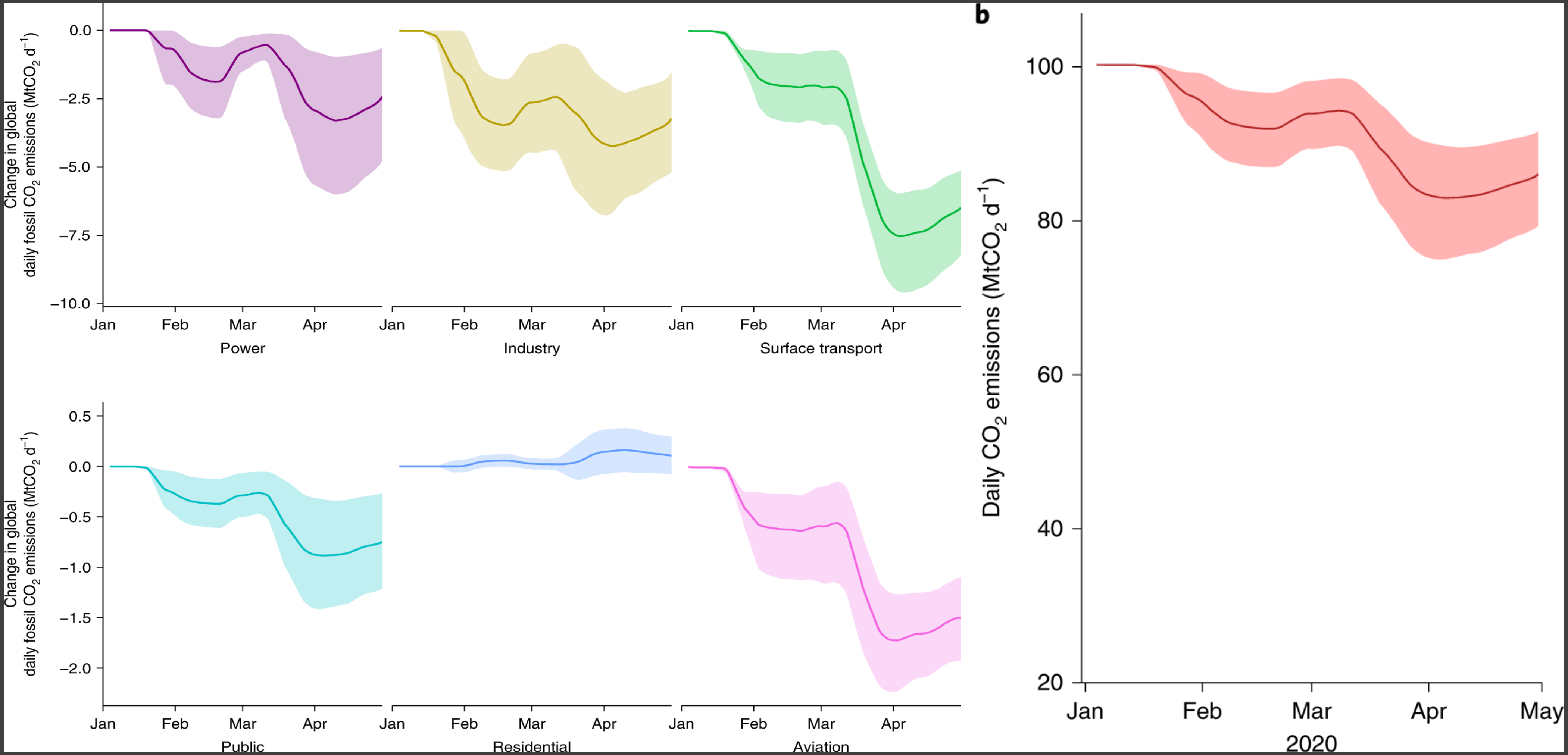


Ozone is produced by photochemistry in the atmosphere

NOx affects the ozone formation

The emissions of CO_2 have decreased during the COVID-19 pandemics, but with limited effect on climate change

Reduction in global CO2 emissions during the COVID-19 pandemics



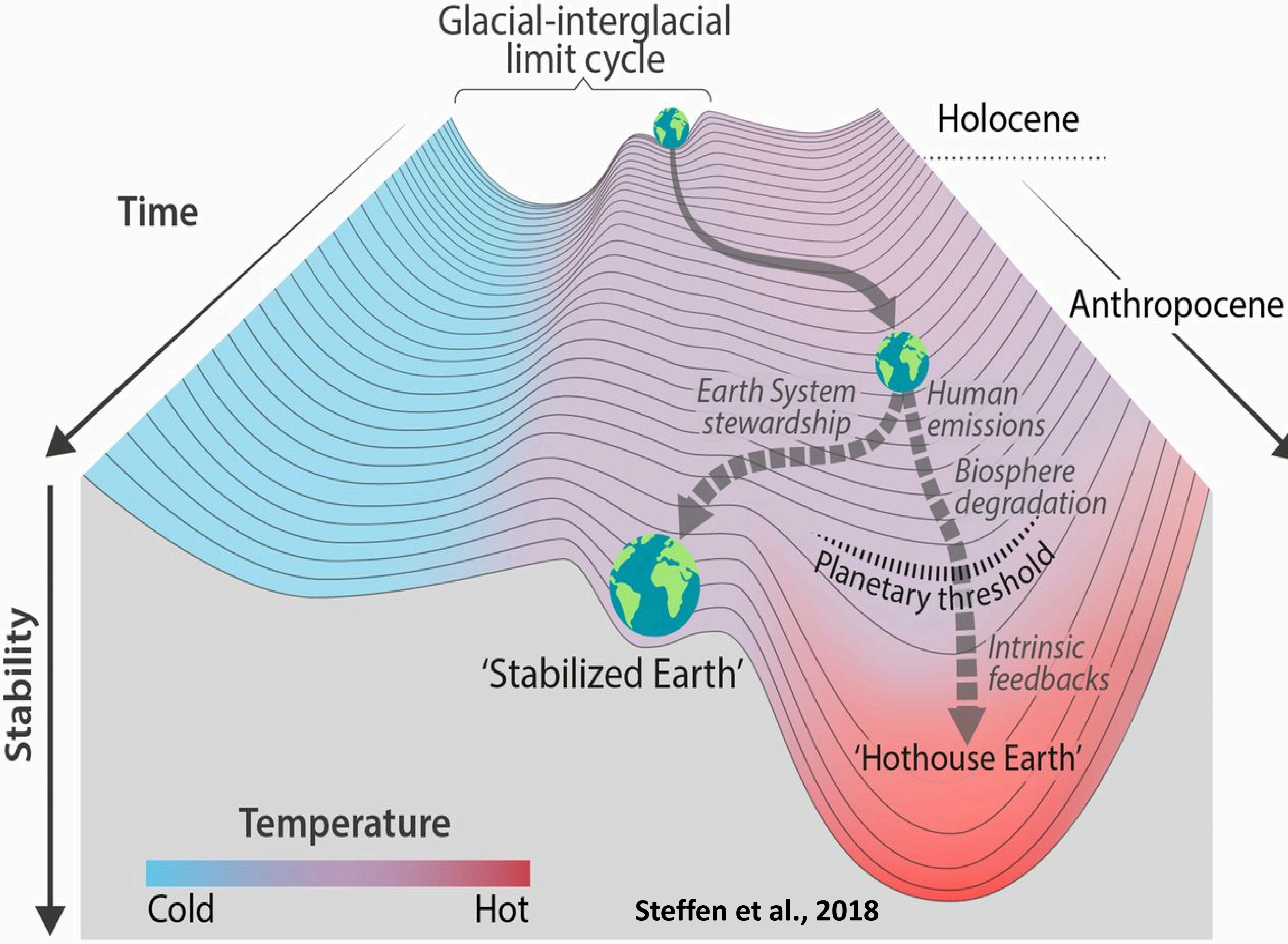
LeQuéré et al., Nature Climate Change, 2020

Similarities in human reactions to the threat of a pandemics and to climate change

- Both pandemics and climate change were predicted disturbances to society.
- Nevertheless, societies were not prepared to respond to COVD-19 as they are not acting regarding climate change.
- Both topics require scientific information and involve the contribution of the scientific community.
- In both cases, the results of the science are disputed by other actors in society.

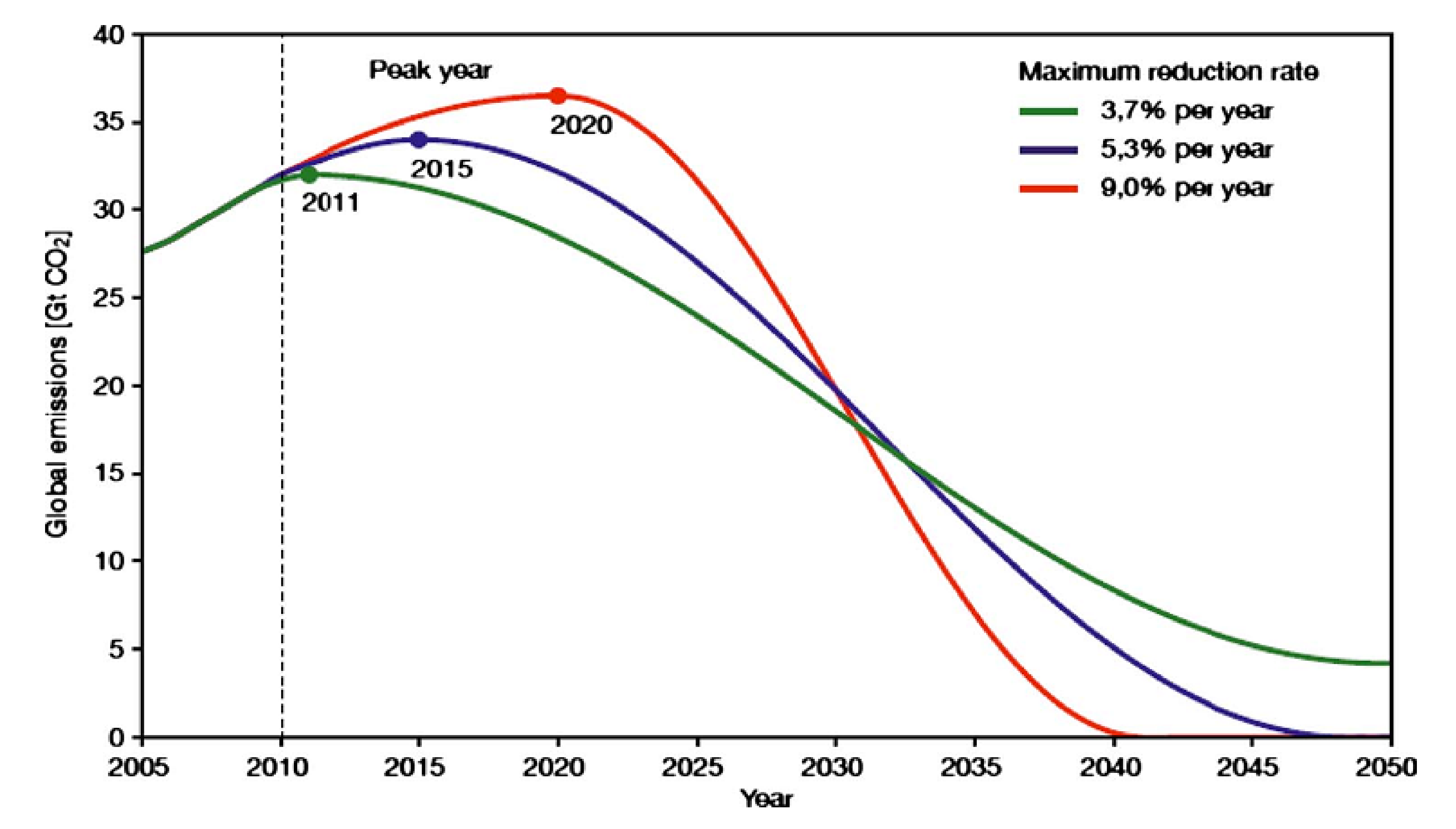
Final Thougths

Which trajectory for the Earth System in the Future?



Steffen et al., 2018

To keep the warming under 2 degrees Celsius, we have to urgently decrease the emissions of CO2 following these trajectories:



- *Messner et al. (2010)*


An Uncertain Future on a Much Hotter Planet?
A Return to Holocene-like Conditions?
We need to decide which direction we want to take

Thank You

"Science exists to serve human welfare. It's wonderful to have the opportunity given us by society to do basic research, but in return, we have a very important moral responsibility to apply that research to benefiting humanity."

Walter Orr Roberts