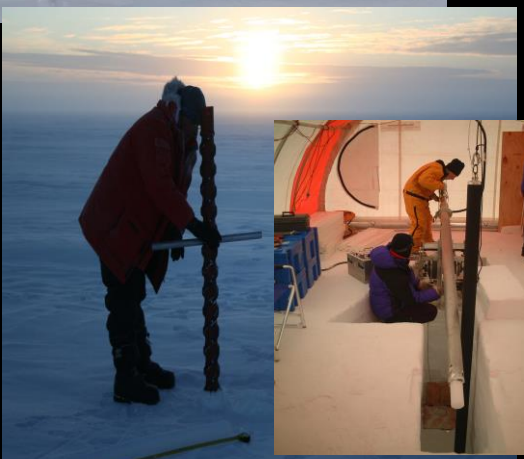
# The Anthropocene:
## Global Change and the Earth System

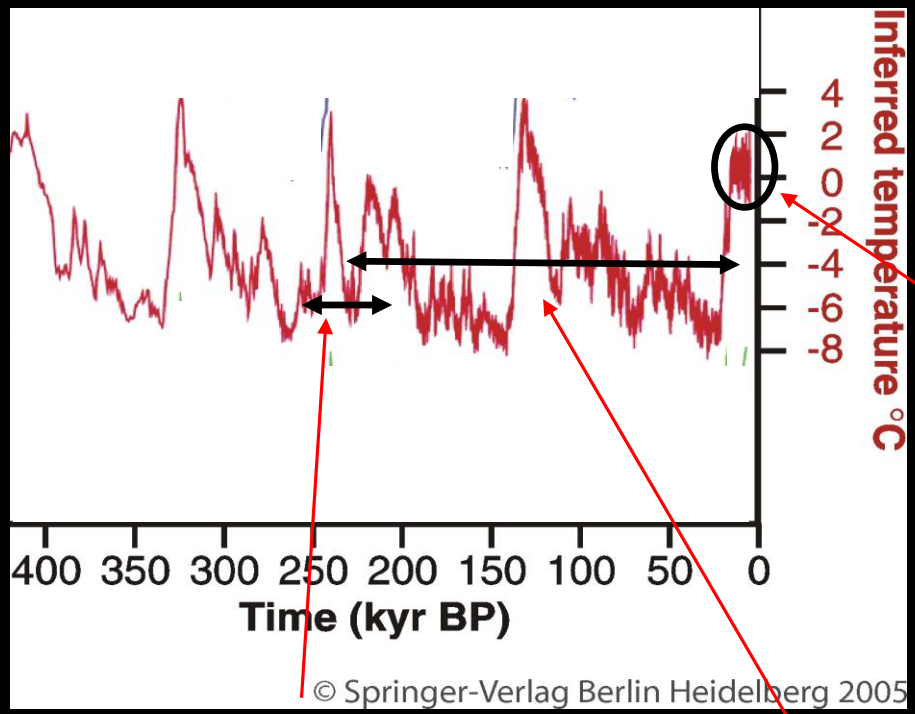
**Will Steffen**

**Emeritus Professor, Australian National University**

**Senior Fellow, Stockholm Resilience Centre**



# Human Development
and
# the Earth System



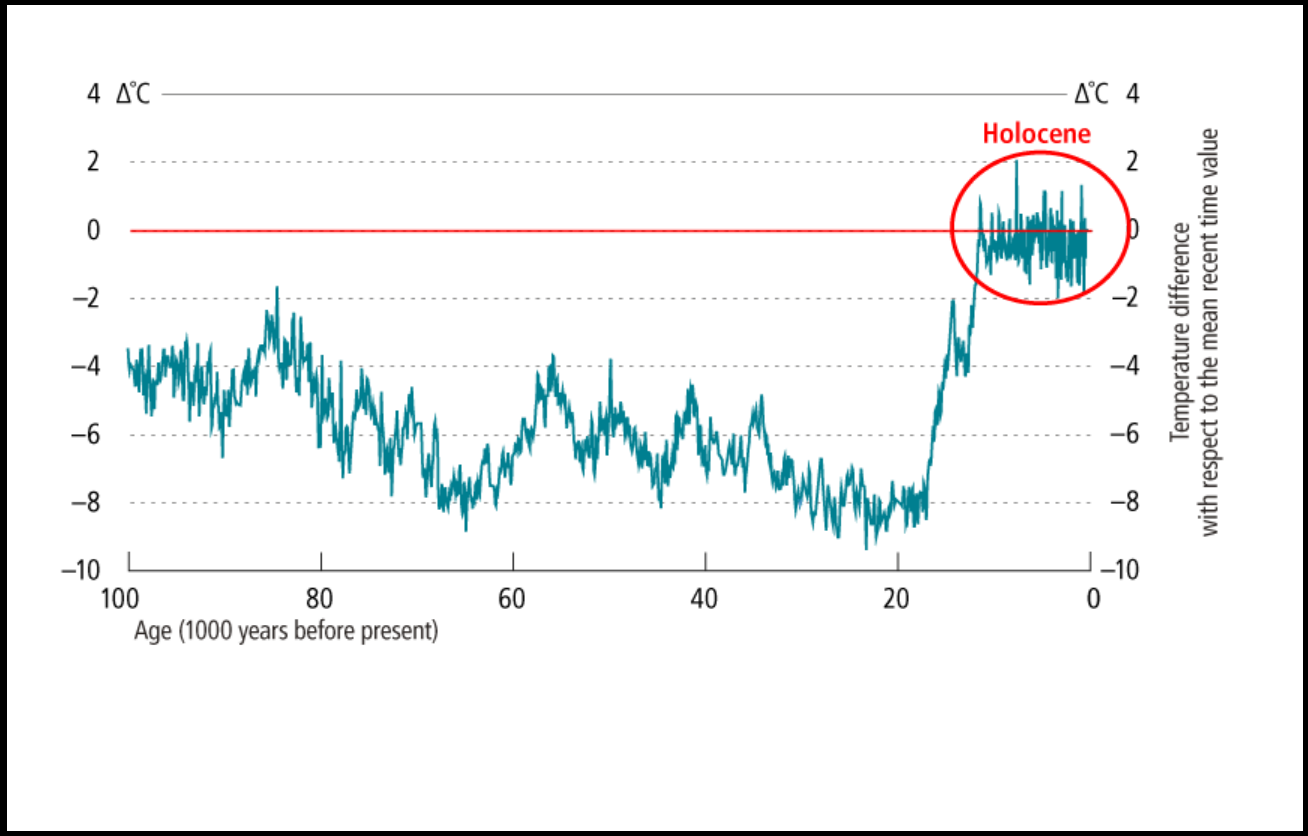

**Beginning of agriculture**

**Evolution of fully modern humans in Africa**

**Hunter-gatherer societies only**

**Adapted from Steffen et al. 2004; ice core data from Petit et al. 1999**

# Human Development and Earth System Dynamics



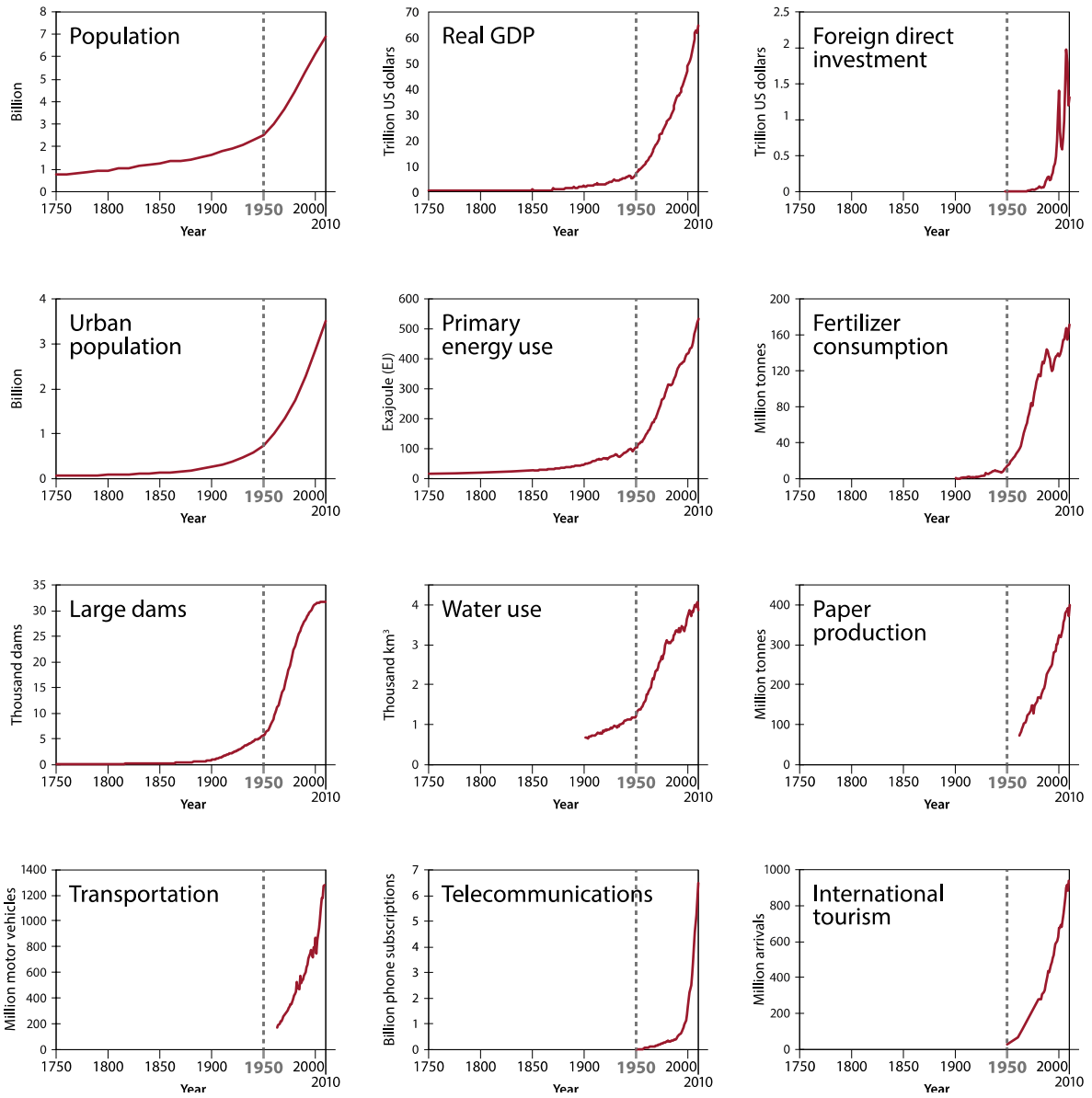

Source: J. Rockström and N. Nakicenovic
Data from Petit et al. 1999 and Oppenheimer 2004

# The Great Acceleration

## The Human Enterprise

- **Population**
- **Economic Growth**
- **Freshwater use**
- **Energy use**
- **Urbanization**
- **Globalization**
- **Transport**
- **Communication**

## Socio-economic trends



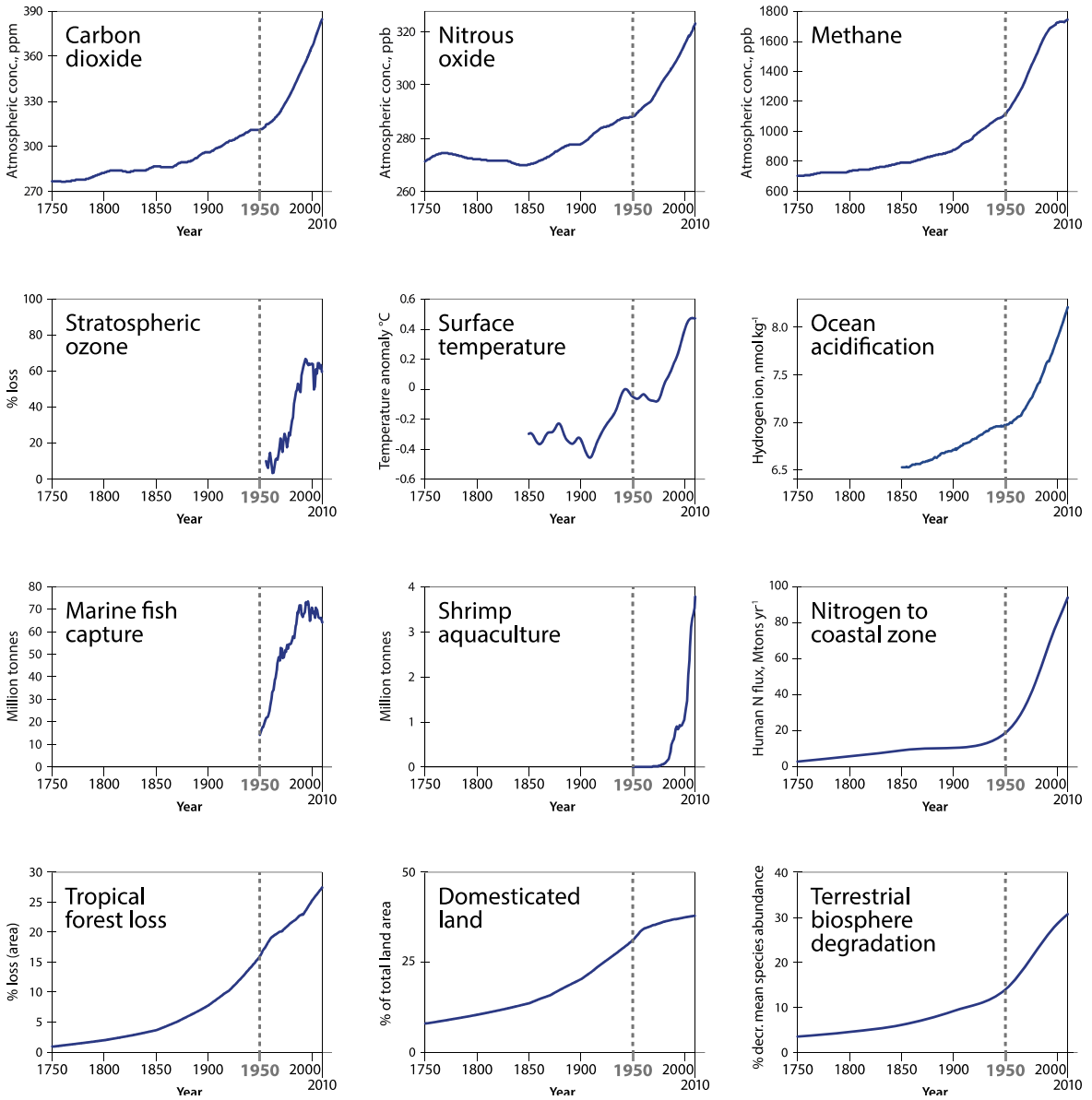

**Steffen et al. 2015**

# The Great Acceleration

## Global Impact

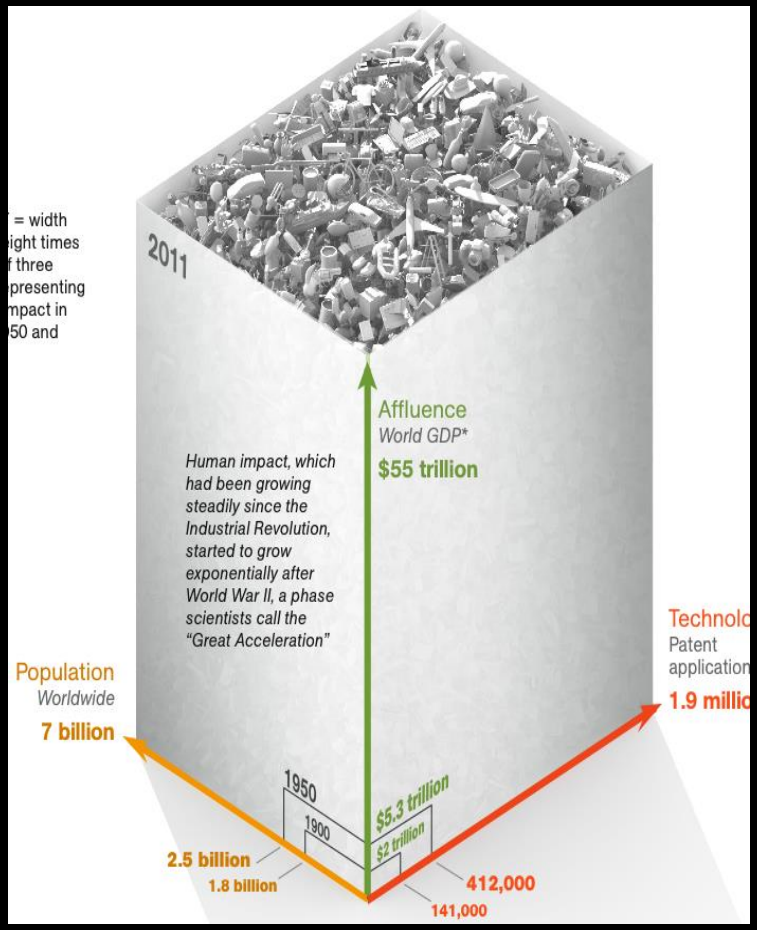
- Greenhouse gases
- Ozone depletion
- Climate
- Marine ecosystems
- Coastal zone
- Nitrogen cycle
- Tropical forests
- Land systems
- Biosphere integrity

Earth system trends




Steffen et al. 2015

# Visualising the Great Acceleration




$$I = P \times A \times T$$

I - impact

P - population

A - affluence

T - technology

**Holdren and Ehrlich 1974; National Geographic 2011**

# IGBP Newsletter 41: May 2000

## The "Anthropocene"

by Paul J. Crutzen and Eugene F. Stoermer

The name Holocene ("Recent Whole") for the post-glacial geological epoch of the past ten to twelve thousand years seems to have been proposed for the first time by Sir Charles Lyell in 1833, and adopted by the International Geological Congress in Bologna in 1885 **(1)**. During the Holocene mankind's activities gradually grew into a significant geological, morphological force, as recognised early on by a number of scientists. Thus, G.P. Marsh already in 1864 published a book with the title "Man and Nature", more recently reprinted as "The Earth as Modified by Human Action" (2). Stoppani in 1873 rated mankind's activities as a "new telluric force which in power and universality may be compared to the greater forces of earth" [quoted from Clark (3)]. Stoppani already spoke of the anthropozoic era. Mankind has now inhabited or visited almost all places on Earth; he has even set foot on the moon.

The great Russian geologist V.I. Vernadsky (4) in 1926 recognized the increasing power of mankind as part of the biosphere with the following excerpt "... the direction in which the processes of evolution must proceed, namely towards increasing consciousness and thought, and forms having greater and greater influence on their surroundings". He, the French Jesuit P. Teilhard de

panied e.g. by a growth in cattle population to 1400 million (6) (about one cow per average size family). Urbanisation has even increased tenfold in the past century. In a few generations mankind is exhausting the fossil fuels that were generated over several hundred million years. The release of $SO_2$, globally about 160 Tg/year to the atmosphere by coal and oil burning, is at least two times larger than the sum of all natural emissions, occurring mainly as marine dimethyl-sulfide from the oceans (7); from Vitousek et al. (8) we learn that 30-50% of the land surface has been transformed by human action; more nitrogen is now fixed synthetically and applied as fertilizers in agriculture than fixed naturally in all terrestrial ecosystems; the escape into the atmosphere of NO from fossil fuel and biomass combustion likewise is larger than the natural inputs, giving rise to photochemical ozone ("smog") formation in extensive regions of the world; more than half of all accessible fresh water is used by mankind; human activity has increased the species extinction rate by thousand to ten thousand fold in the tropical rain forests (9) and several climatically important "greenhouse" gases have substantially increased in the atmosphere: $CO_2$ by more

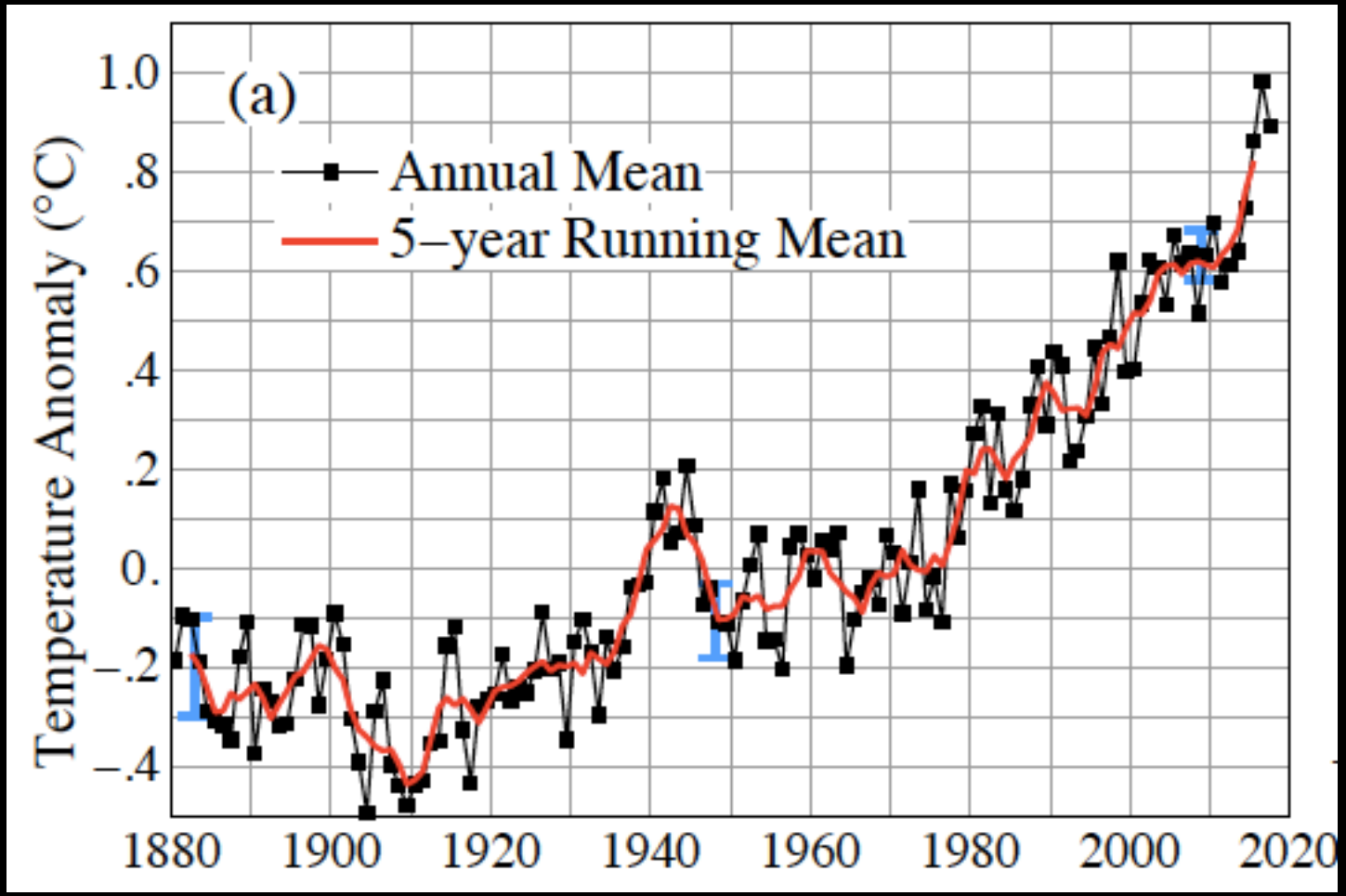
groves. Finally, mechanized human p
dation ("fisheries") removes more th
25% of the primary production of t
oceans in the upwelling regions and 3
in the temperate continental shelf
gions (10). Anthropogenic effects are a
well illustrated by the history of biotic communities that leave remains in lake sediments. The effects documented include modification of the geochemical cyde in large freshwater systems and occur in systems remote from primary sources (11-13).

Considering these and many other major and still growing impacts of human activities on earth and atmosphere, and at all, including global, scales, it seems to us more than appropriate to emphasize the central role of mankind in geology and ecology by proposing to use the term "anthropocene" for the current geological epoch. The impacts of current human activities will continue over long periods. According to a study by Berger and Loutre (14), because of the anthropogenic emissions of $CO_2$, climate may depart significantly from natural behaviour over the next 50,000 years.

To assign a more specific date to the onset of the "anthropocene" seems somewhat arbitrary, but we propose the latter part of the 18th century, although

# Climate Change

Global Average Temperature Anomaly, 1880-2017

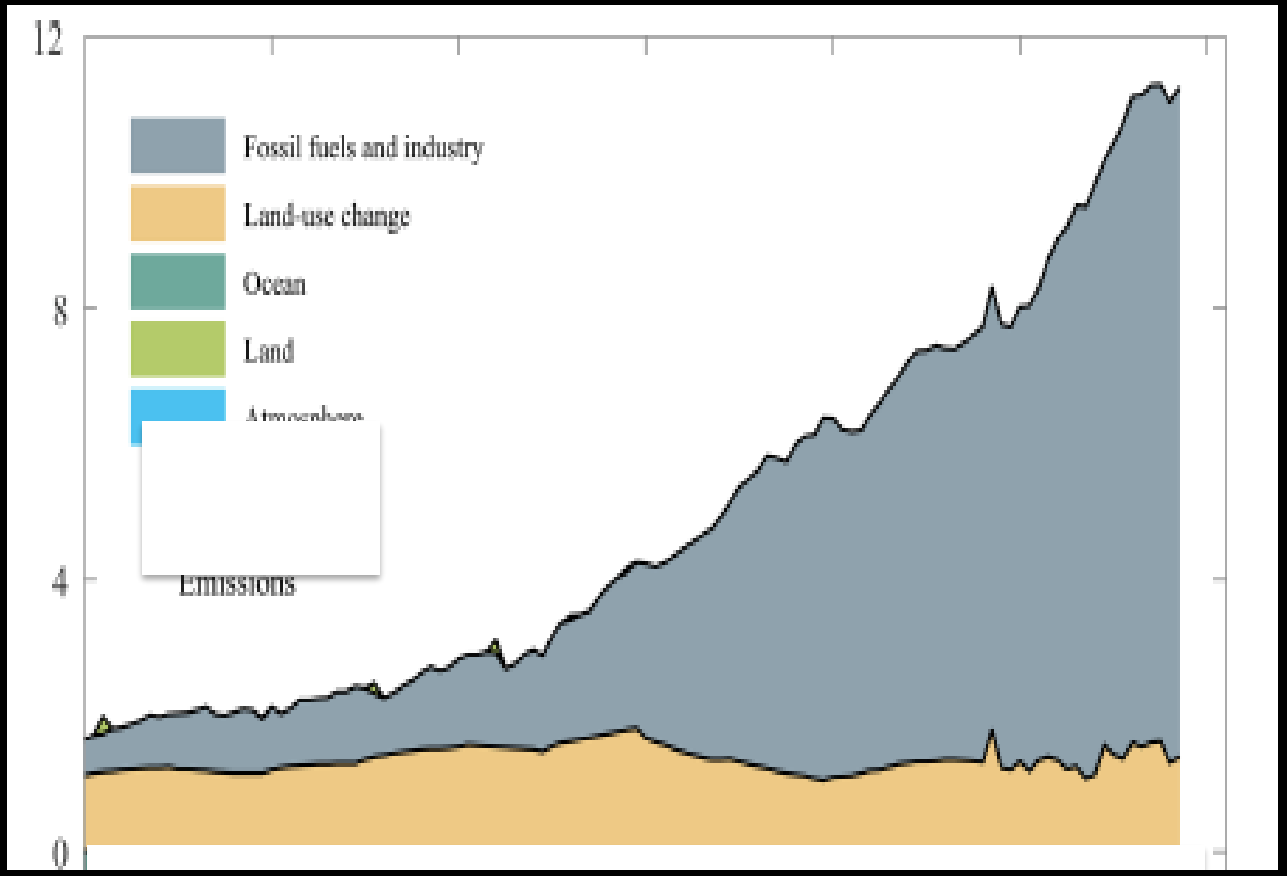



**Baseline is 1951-1980**

**NASA 2018**

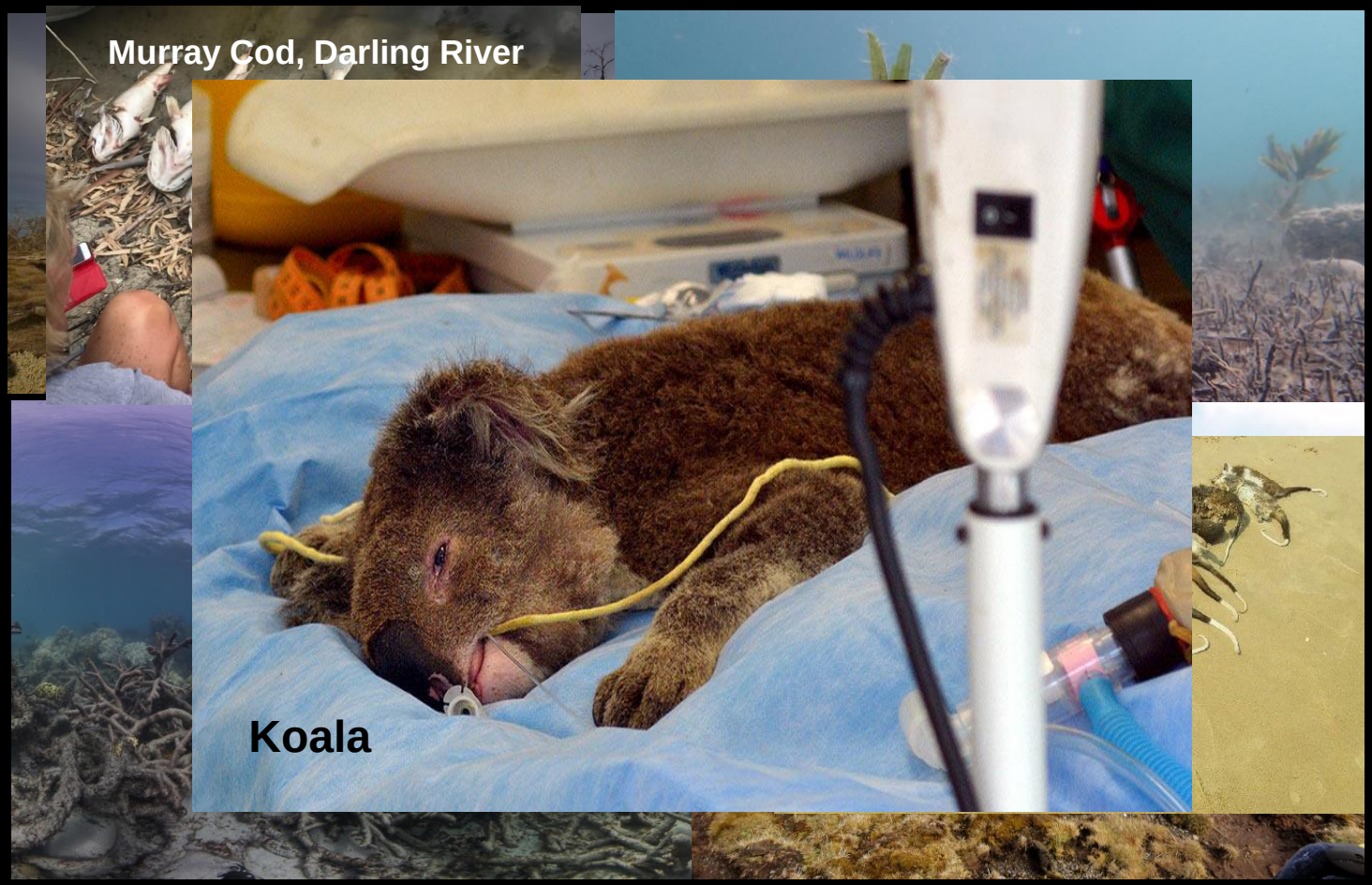
# Global Carbon Dioxide Emissions

Gt C $yr^{-1}$




Source: Le Quere et al. 2018

# This is What Climate Change Looks Like



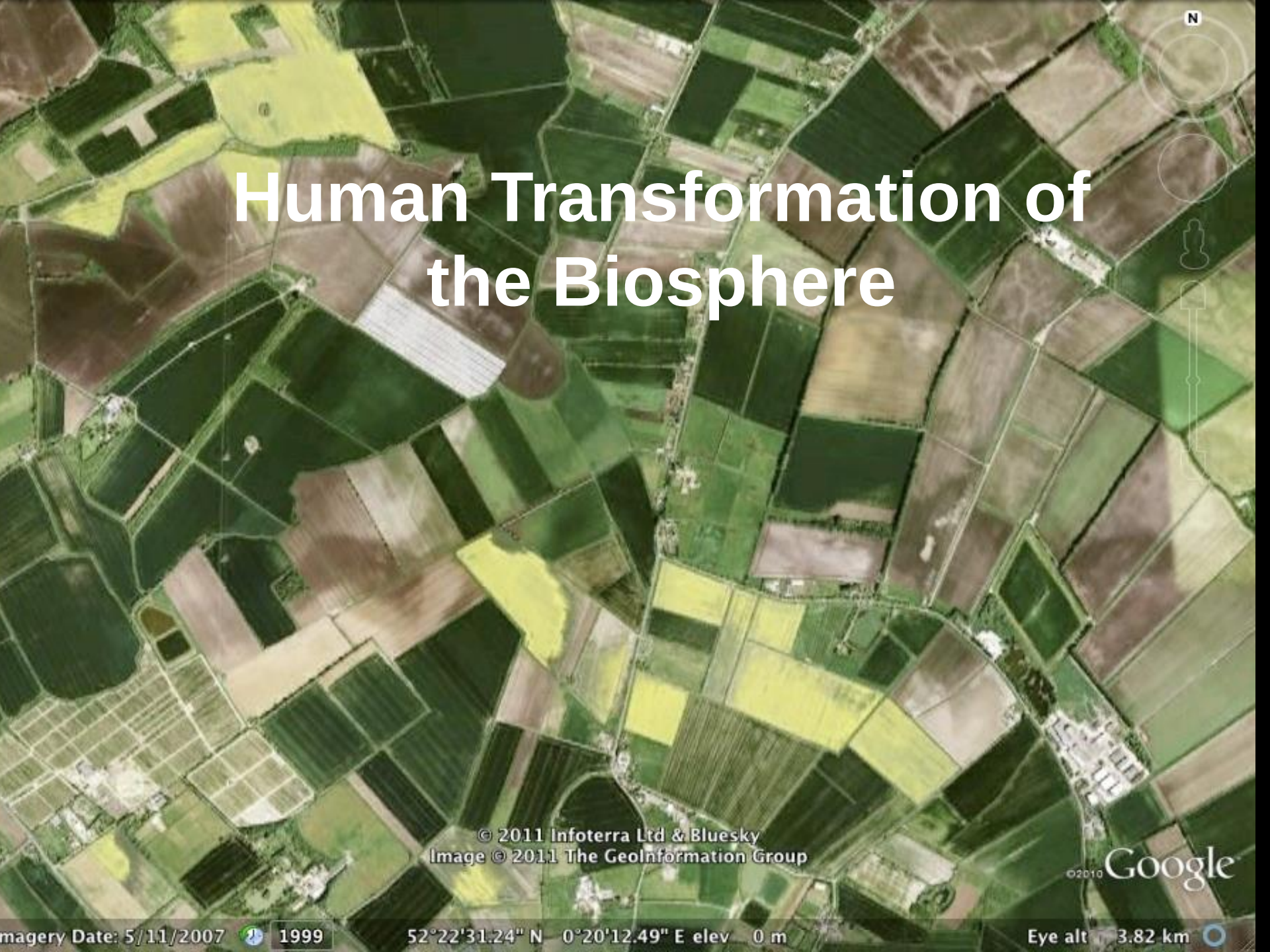

Hughes et al. 2019; Climate Council of Australia

# The Security Risk:
# Climate Change as a Threat Multiplier

## The Syrian Crisis

- Iraqi refugees
- Weak government
- Worst drought in recorded history - A million flood into cities

IPCC AR5 WG1 Report 2013


Human Transformation of the Biosphere
© 2011 Infoterra Ltd & Bluesky
Image © 2011 The GeoInformation Group
©2010 Google
magery Date: 5/11/2007
1999
52°22'31.24" N 0°20'12.49" E elev 0 m
Eye alt 3.82 km

# Nature’s Dangerous Decline

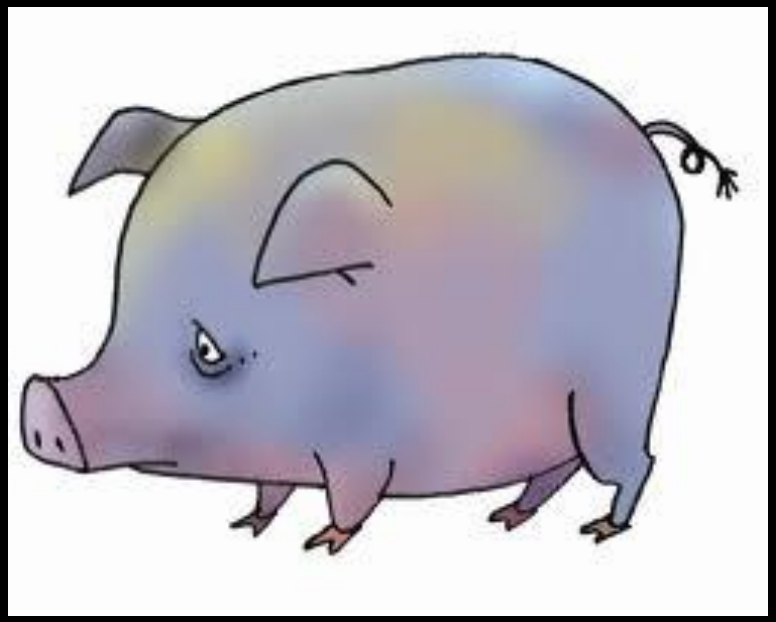
**Nature is declining globally at rates unprecedented In human history**

**Around 1 million animal and plant species are now threatenedwith extinction, many within decades.**

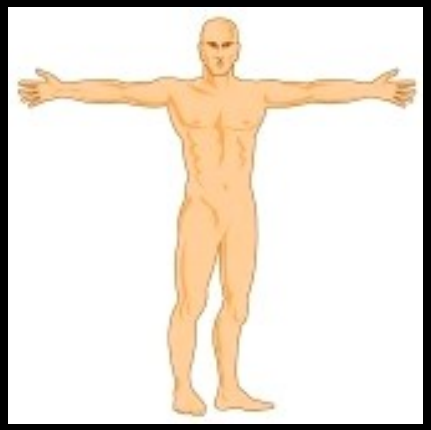
**The web of life on Earth is getting smaller and increasingly frayed.**

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019

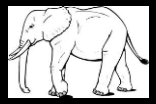
# Terrestrial vertebrate biomass



Domesticated animals
ca 65%



Humans
ca 32%



Vertebrate
wildlife
< 3%

Smil 2002

# Stratigraphic Definition of the Anthropocene

Have humans changed the Earth System such that geological deposits forming now and in the recent past include a fingerprint distinct from that of the Holocene Epoch?

If so, when has the change become recognizable worldwide?

**Source: C.N. Waters et al., *Science*, 2016, (synthesis paper by the Anthropocene Working Group)**

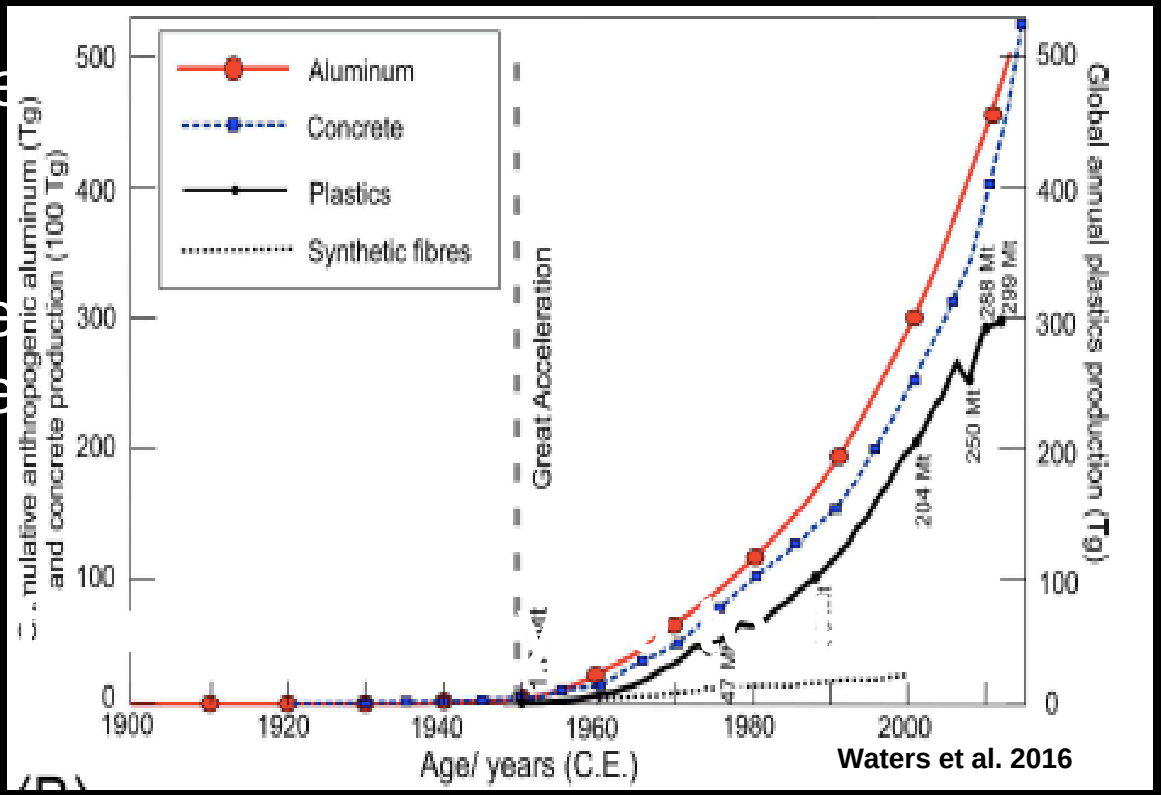
# Formalization of the Anthropocene: Current Status

Jan Zalasiewicz, Convenor
Anthropocene Working Group (AWG)
University of Leicester, UK

Should the Anthropoce
Scale?

Should the base of the
around the mid-20th ce

**'YES' won the**




Waters et al. 2016

AWG Newsletteer, May 2019

# The climate system, the biosphere…

# What about humans and our systems?

*Perspectives and controversies*

THE ANTHROPOCENE REVIEW

# The geology of mankind? A critique of the Anthropocene narrative

The Anthropocene Review
201X, Vol XX(X) 1–8

DOI: 10.1177/2053019613516291
anr.sagepub.com
SAGE

**Andreas Malm and Alf Hornborg**

**Abstract**

The Anthropocene narrative portrays humanity as a species ascending to power over the rest of the Earth System. In the crucial field of climate change, this entails the attribution of fossil fuel combustion to properties acquired during human evolution, notably the ability to manipulate fire. But the fossil economy was not created nor is it upheld by humankind in general. This

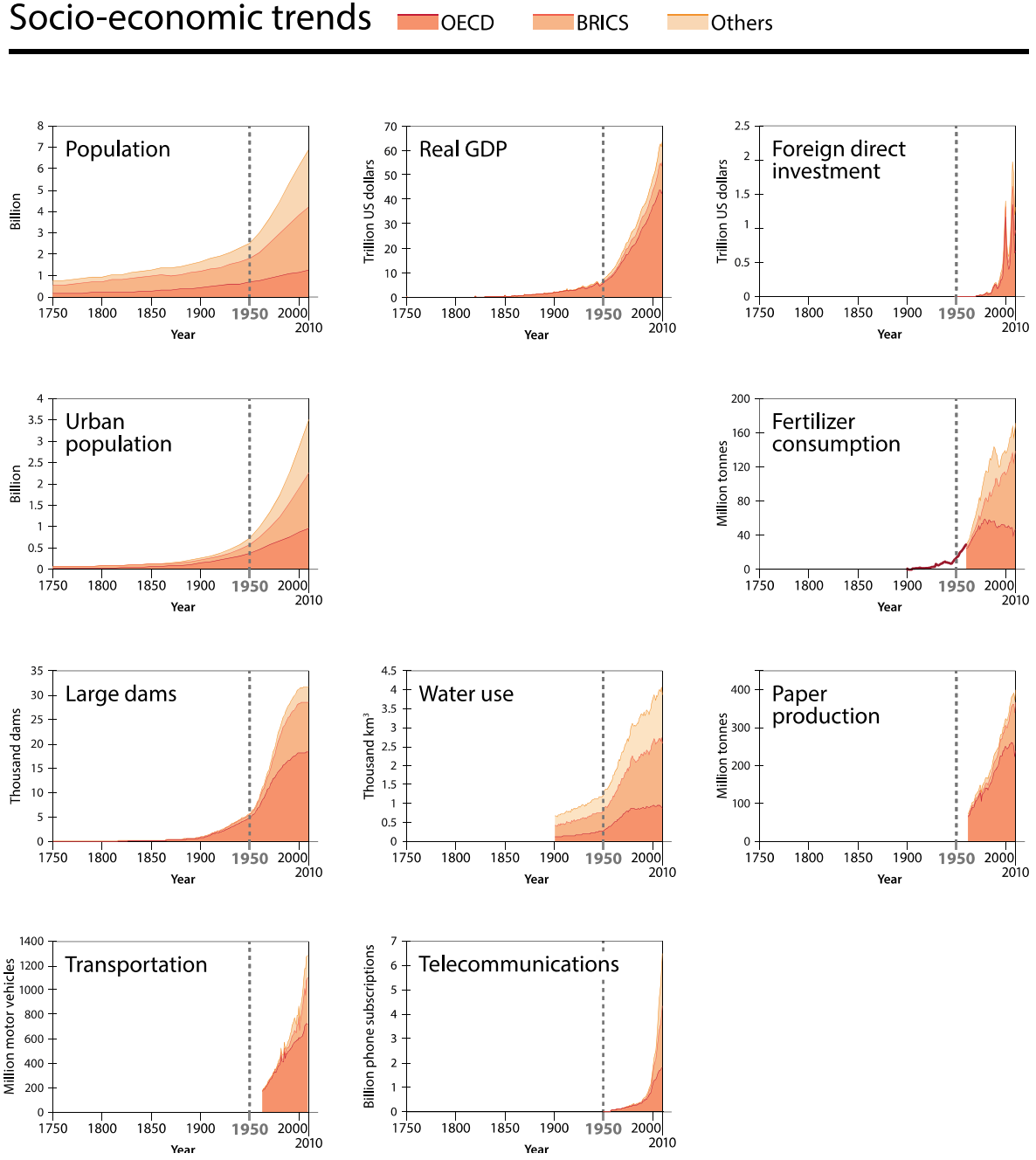
It is not correct to consider “mankind” or “humankind” in general

The fossil fuel-driven, consumption oriented, globalised economy was not created by humankind **<u>in general</u>**.

“Intra-species inequalities are part ….of the current ecological crisis and cannot be ignored in attempts to understand it.

# Equity Issues

- Population
- Economic growth
- Fertilizer use
- Urbanization
- Globalization
- Transport
- Communication



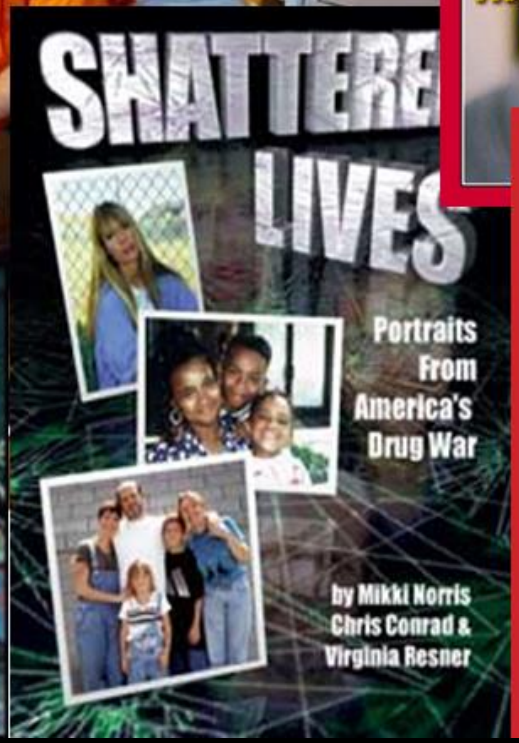

Steffen et al. 2015

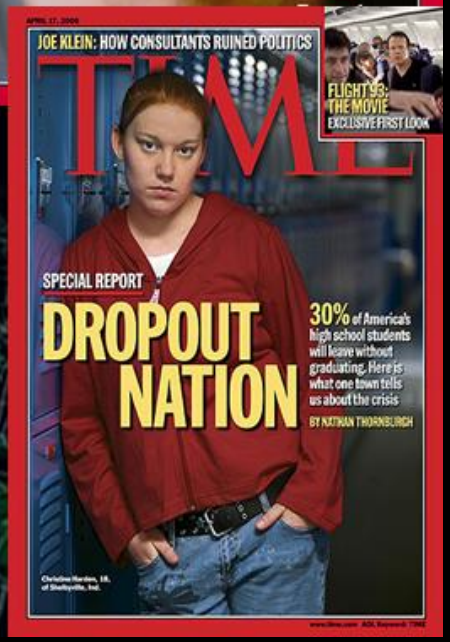

DECEMBER 9, 1993
$1.95
TIME
SPIES, SPIES, EVERYWHERE
The U.S. Roundup Accelerates
Children Having Children
Teen Pregnancy In America


101

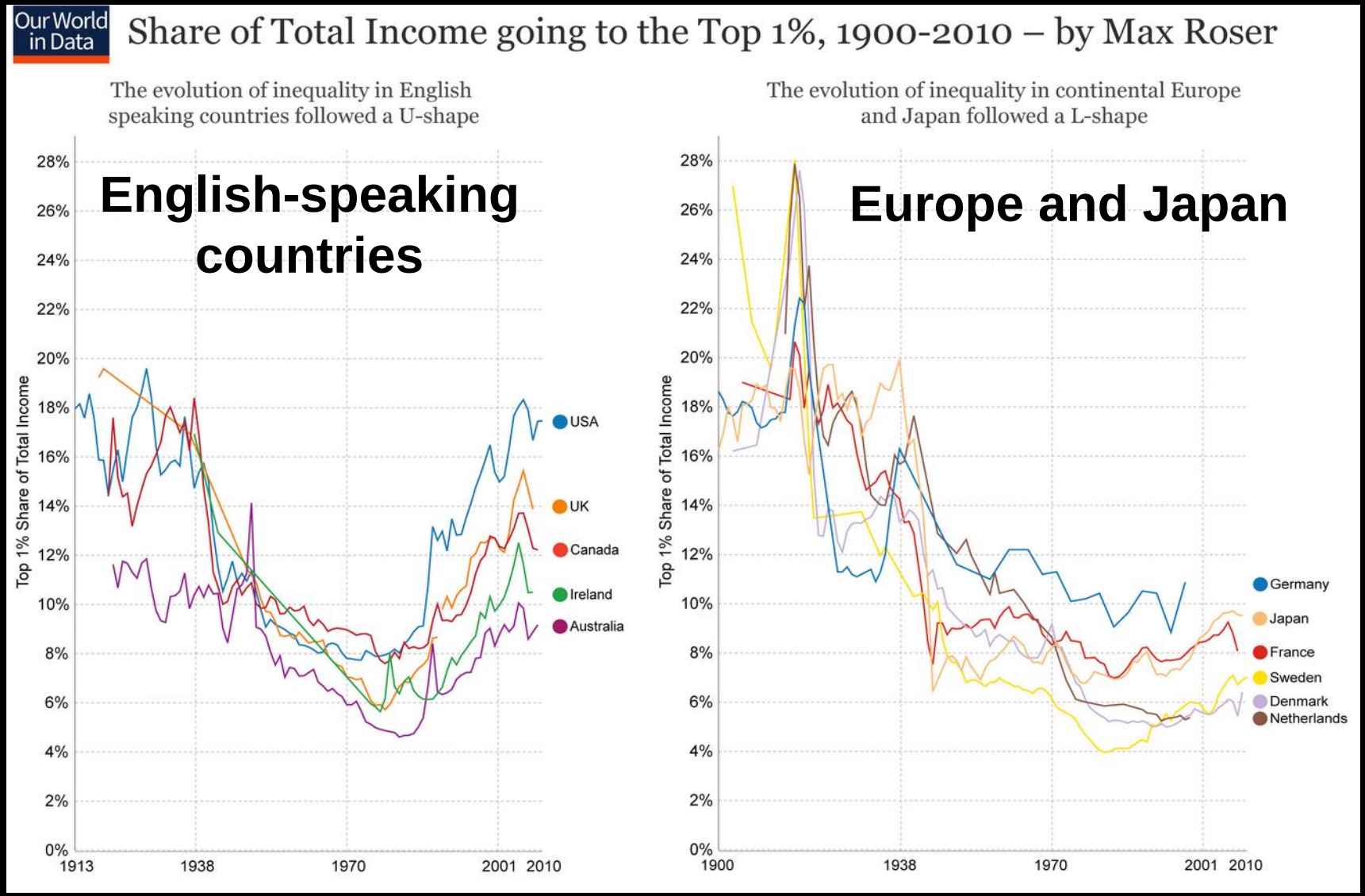

TIME
SPECIAL REPORT/SCHOOL VIOLENCE
Is Jeff Gordon good for NASCAR?
JIM CRAMER on should you day trade
HOW TO SPOT A TROUBLED KID
DEPRESSION: Do pills help or hurt?
How bad is the copycat problem?
The tide turns on guns


ANTI SOCIAL BEHAVIOUR


SHATTERED LIVES
Portraits From America's Drug War
by Mikki Norris
Chris Conrad &
Virginia Resner


APRIL 17, 2006
JOE KLEIN: HOW CONSULTANTS RUINED POLITICS
TIME
FLIGHT 93: THE MOVIE
EXCLUSIVE FIRST LOOK
SPECIAL REPORT
DROPOUT NATION
30% of America's high school students will leave without graduating. Here is what one town tells us about the crisis
BY NATHAN THORNBURGH

# Evolution of Income Equality

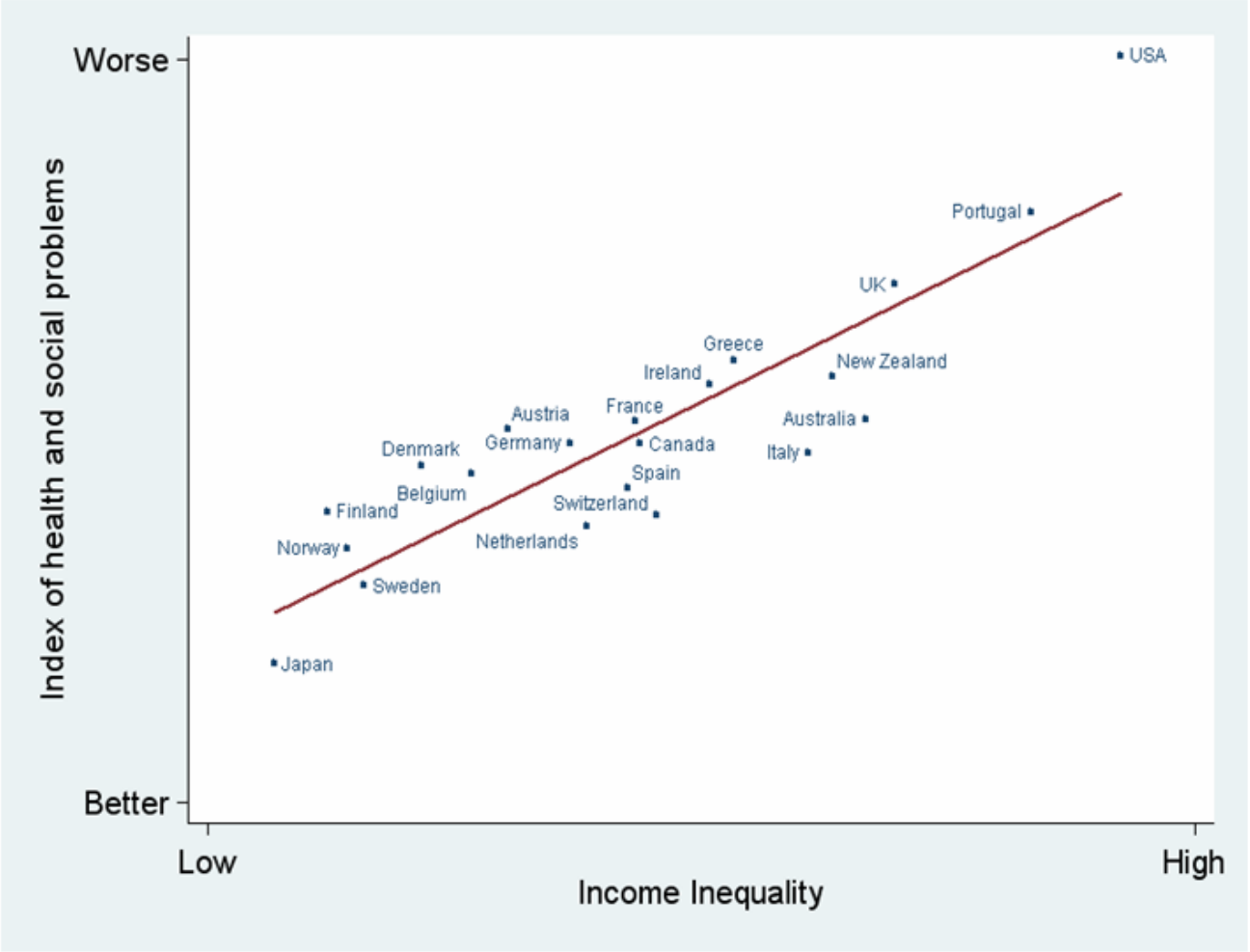



Source: S. van der Leeuw

# 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)*

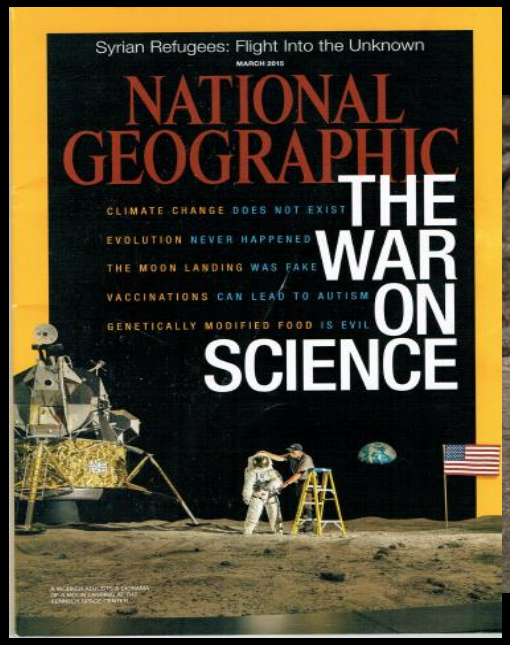
www.equalitytrust.org.uk

The Equality Trust

**Pickett and Wilkinson 2015**

# System Incompatibilities?







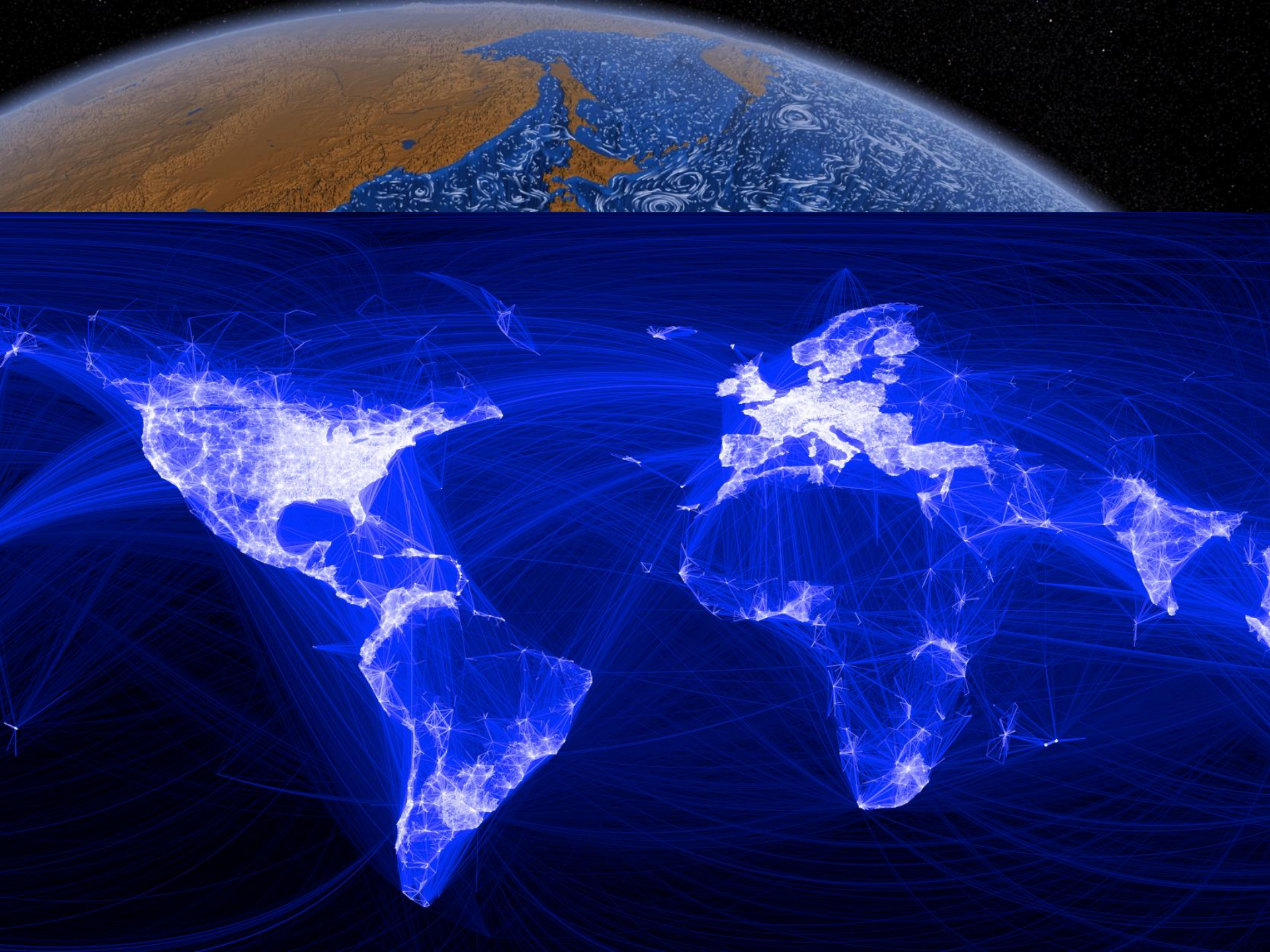


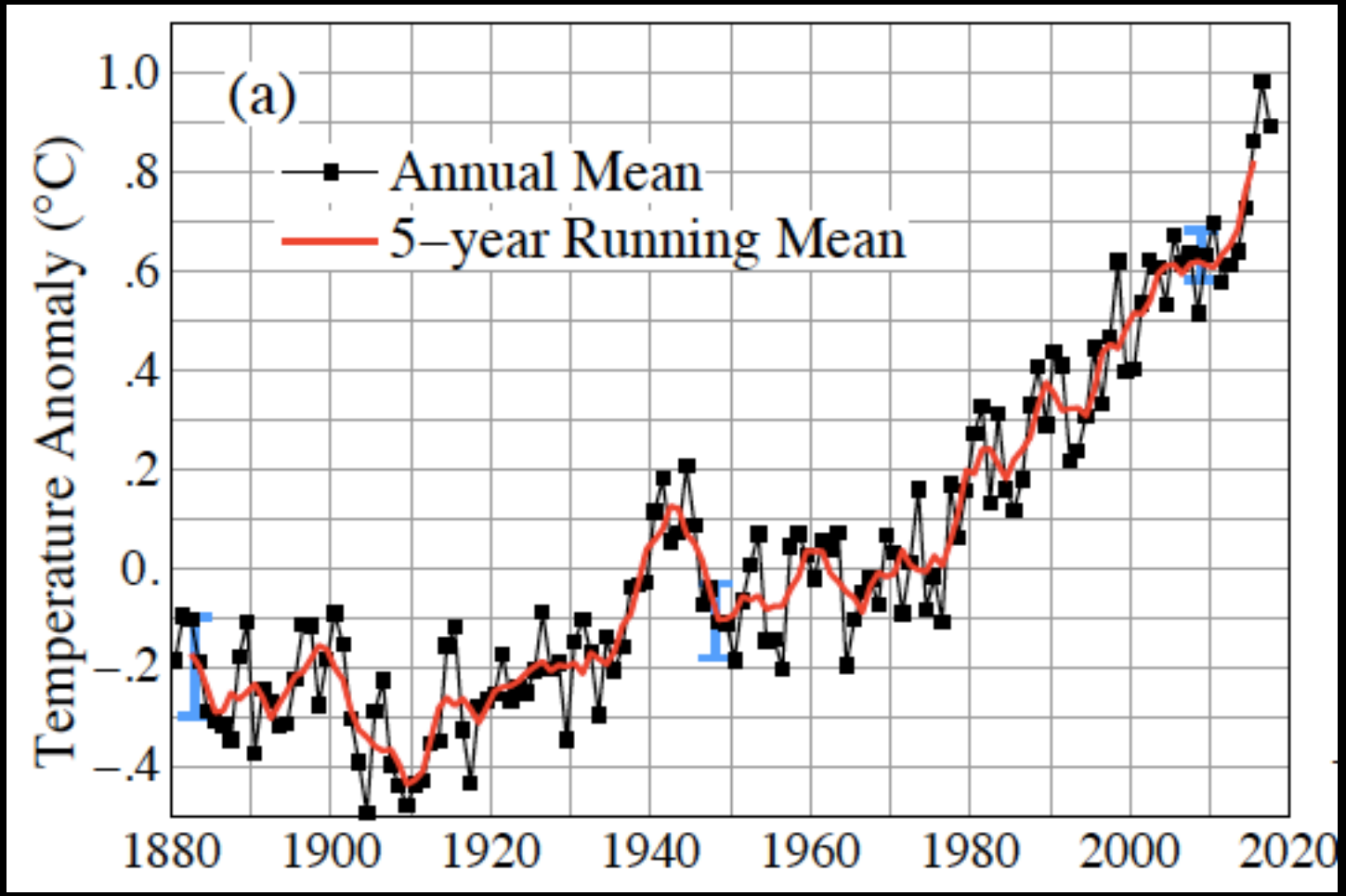

Photo: O.Henriksson/Azote

# Our planet is a single system…

# …the Earth System

# Climate Change

Global Average Temperature Anomaly, 1880-2017



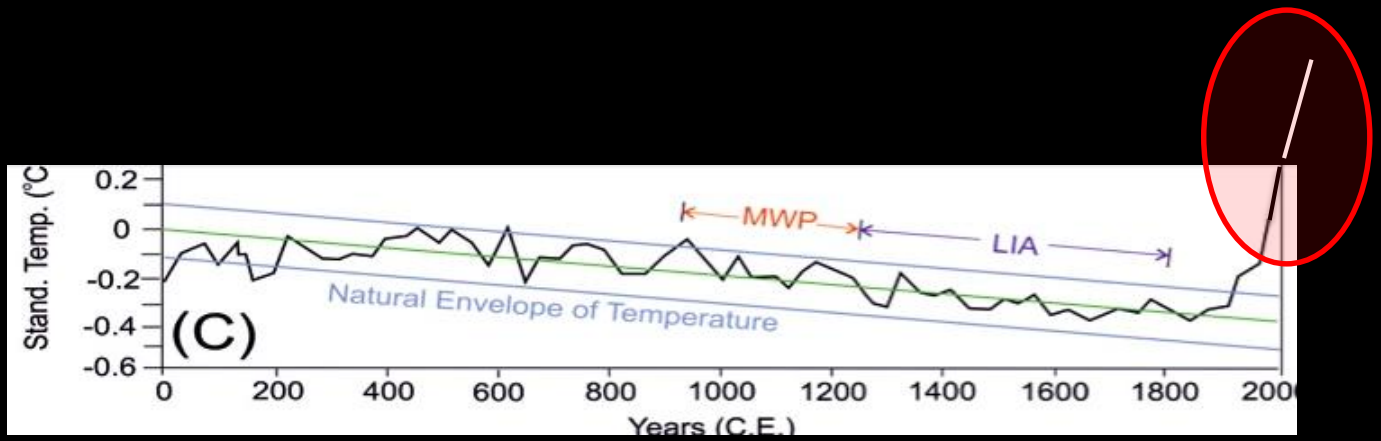

**Baseline is 1951-1980**

**NASA 2018**

# An Earth System Perspective

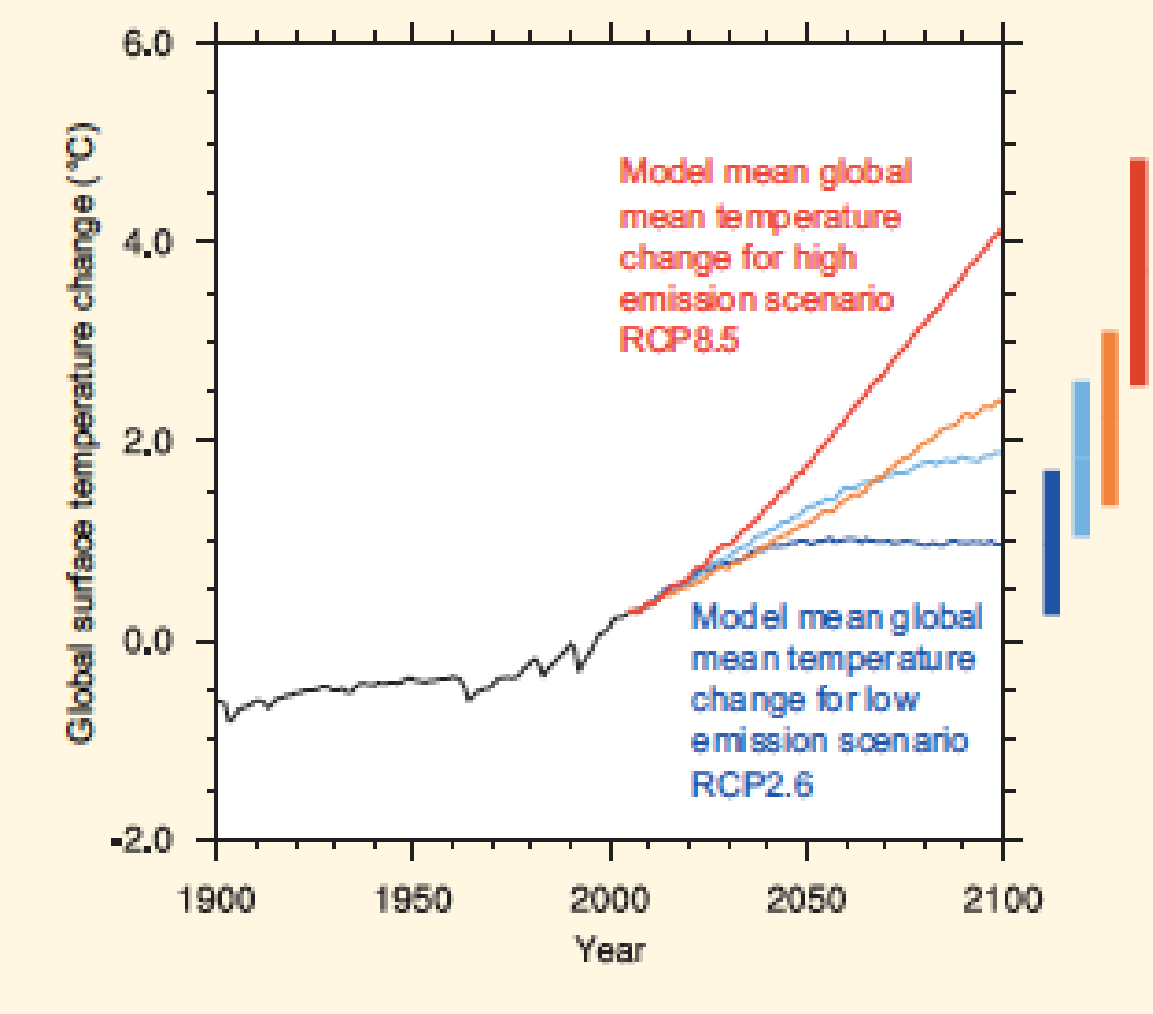
Temperature rise:
Beyond the envelope of natural variability!

**Human influence**




**Summerhayes 2015**

# IPCC temperature projections




IPCC 2013

**Earth System moves to a new state? Severe challenge to contemporary civilisation. Possible collapse?**

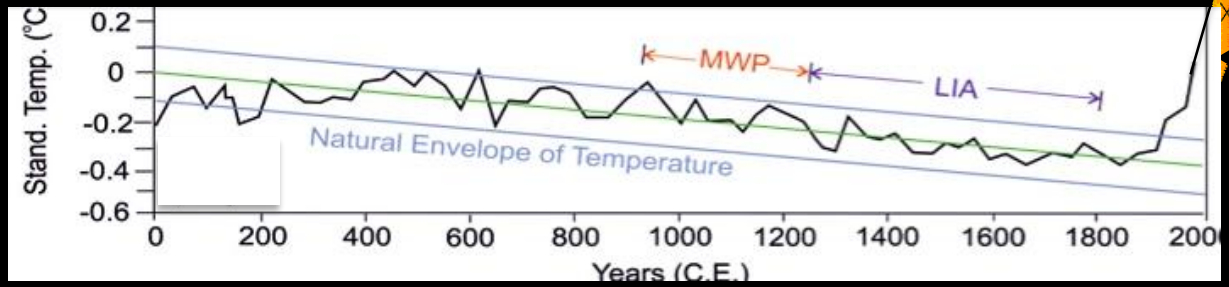
**Tipping Points?**

**Committed**

IPCC Projections 2100 AD

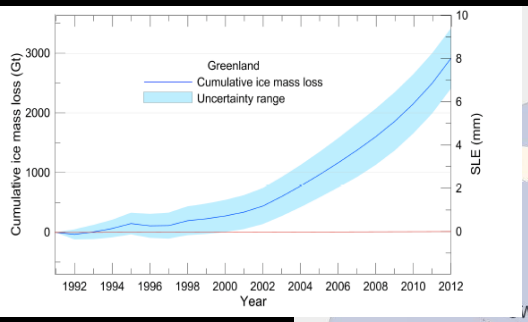
Global Temperature (° C)

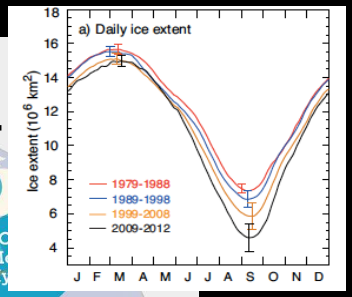
6
5
4
3
2
1
0

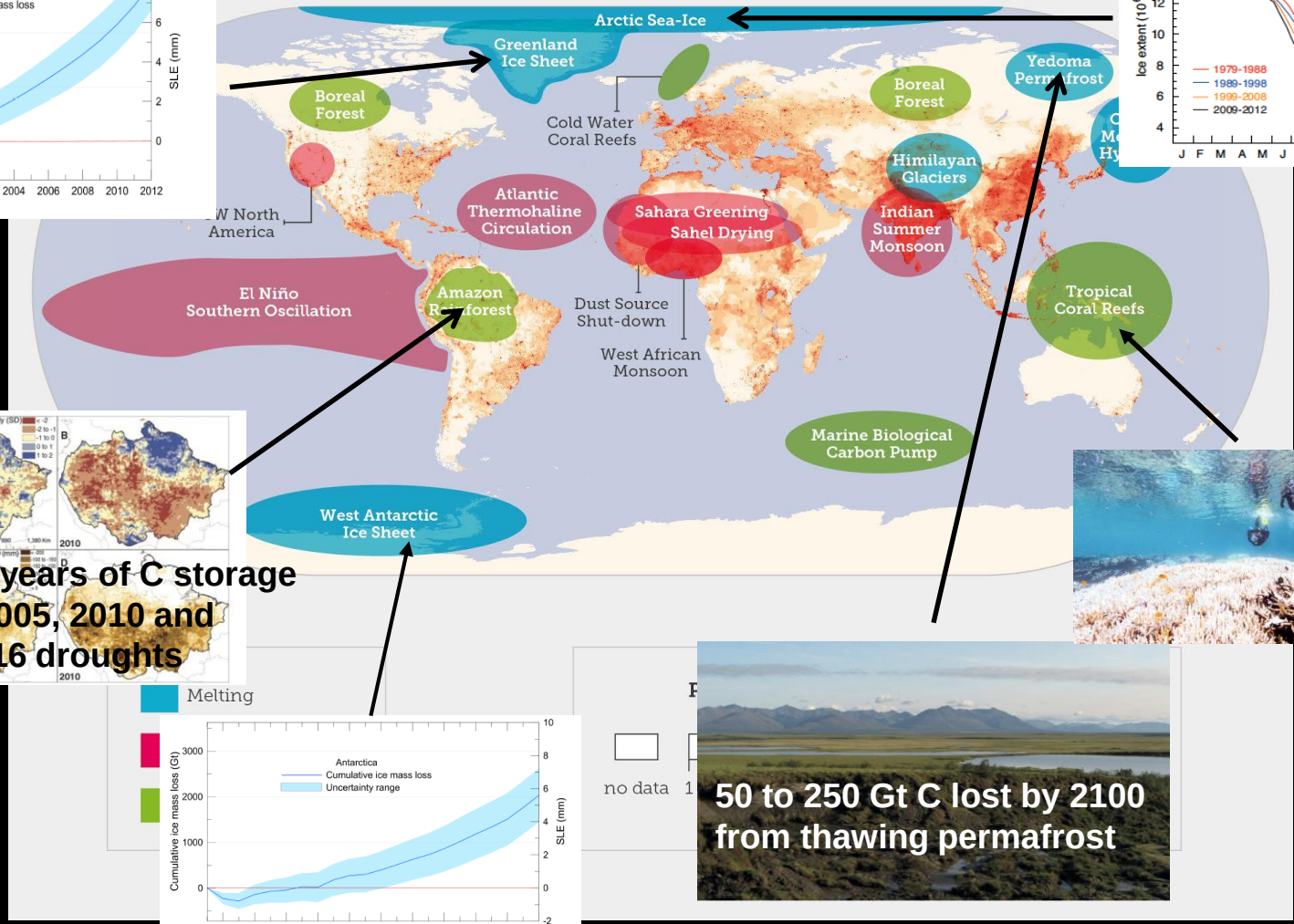


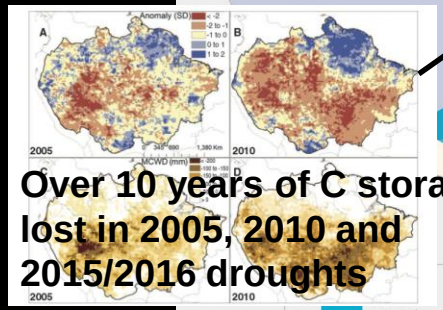

**Summerhayes 2015**

# Tipping Elements in the Earth System

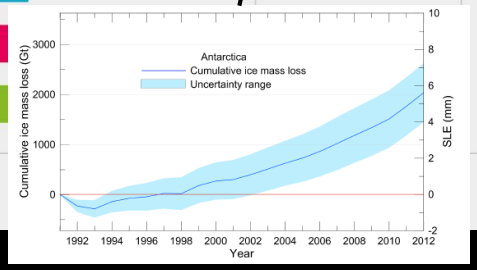



**Over 10 years of C storage lost in 2005, 2010 and 2015/2016 droughts**

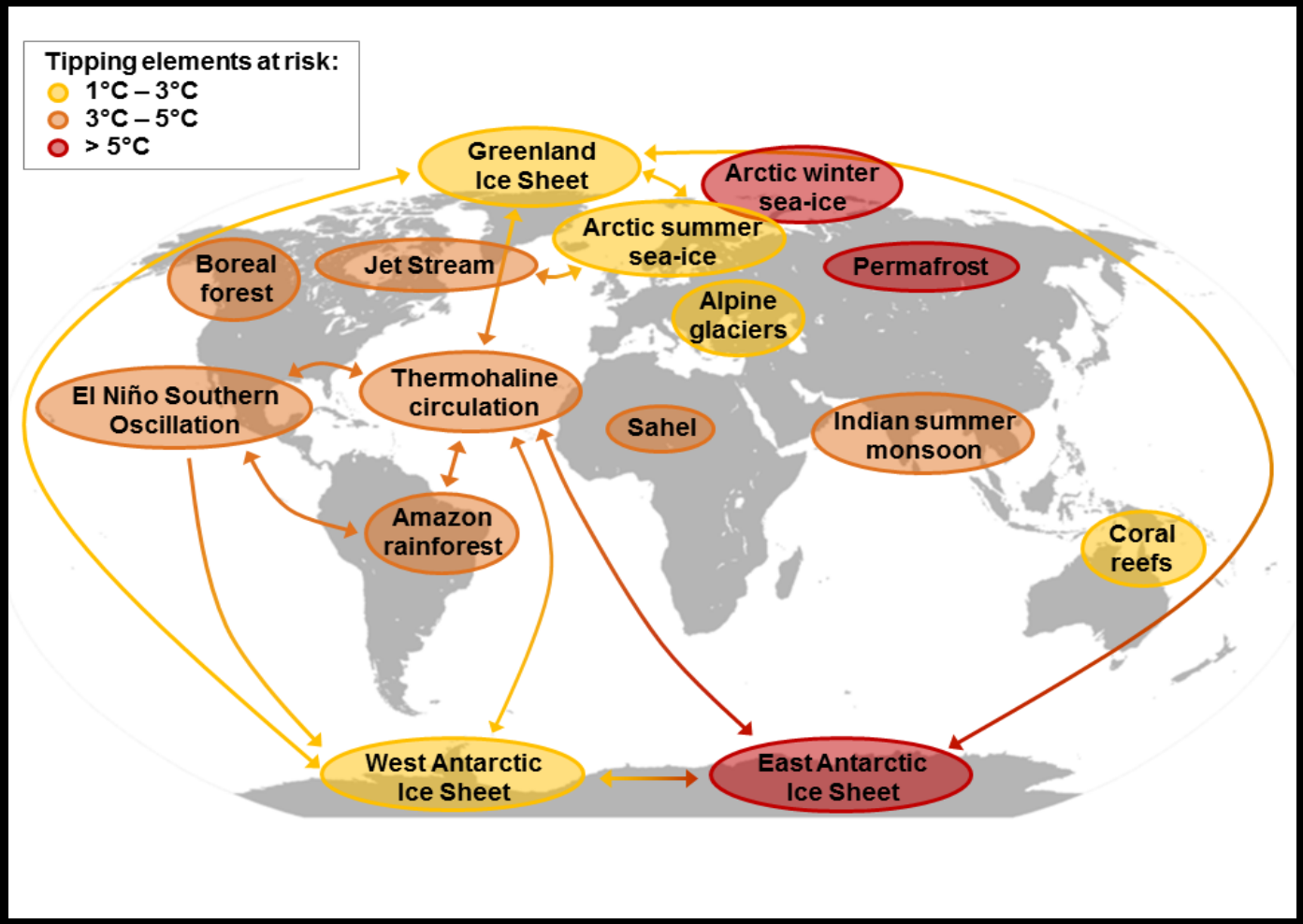





**50 to 250 Gt C lost by 2100 from thawing permafrost**

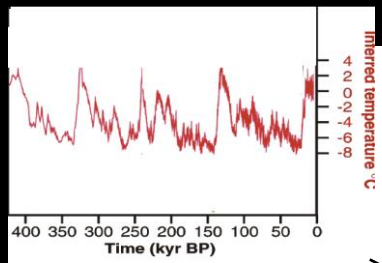
**Huber, Lenton, and Schellnhuber, in Richardson et al. 2011**

# Tipping Cascades



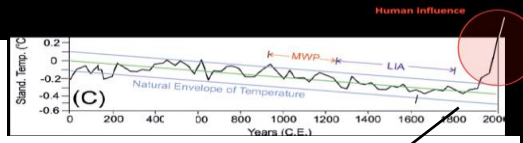

Source: J. Donges and R. Winkelmann in Steffen et al. 2018

# Earth System Trajectories




Time

Glacial-interglacial limit cycle




Holocene

Anthropocene

Earth System stewardship

Human emissions

Biosphere degradation

Planetary threshold

Intrinsic feedbacks

'Stabilized Earth'

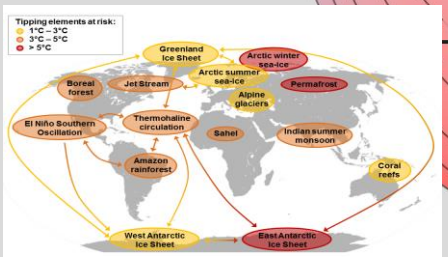
Hothouse Earth'

Stability

Temperature

Cold

Hot




Steffen et al. 2018


**“The astonishing force of consumer culture has swamped traditional customs, values, and aspirations, replacing them with a devotion to money, materialism and branded identities that has left tradition a smoking rubble.”**

Fritjof Capra and Pier Luigi Luisi

The Systems View of Life

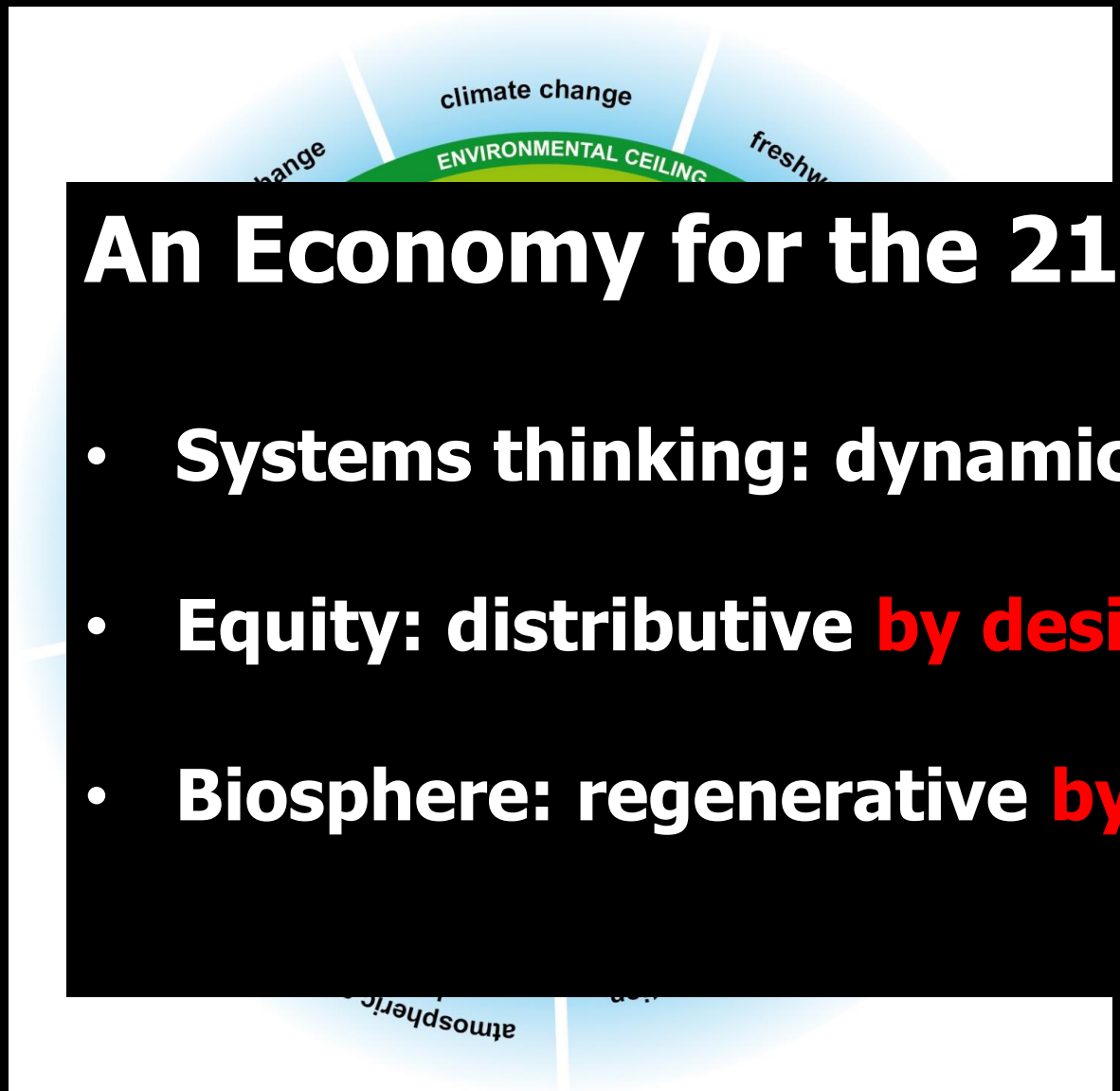
…Our world today is dominated by a global economic system with disastrous social and environmental impacts – “predatory capitalism”.... We are the only species on Earth who destroys its own habitat, threatening countless other species with extinction in the process.

# Greta Thunberg

**“You have stolen my dreams and my childhood with your empty words. People are suffering. People are dying. Entire ecosystems are collapsing. We are in the beginning of a mass extinction, and all you can talk about is money and fairy tales of eternal economic growth.**
**How dare you!”**

**Excerpts from G.T. speech at United Nations, New York, September 2019**

# The ‘Doughnut’: a safe and just space for humanity




## An Economy for the 21st Century

- **Systems thinking: dynamic complexity**
- **Equity: distributive by design**
- **Biosphere: regenerative by design**

Prof Dipash Chakrabarty
University of Chicago

# Homo-centric v. Zoe-centric
## (human-centric v. life-centric)

Contemporary society is based on a homo-centric approach, but the Anthropocene demands a zoe-centric approach.

“epochal consciousness” v. “departmental thinking”

**Tanner Lectures in Human Values, Yale University, 2015**

Prof Carl Folke
Stockholm Resilience Centre
and
Beijer Institute of Ecological Economics

On humanity's challenge in the 21st century:

# "Reconnect to the biosphere"

*We're only here for a short amount of time to do what we've been put here to do, which is to look after the country. We're only a tool in the cycle of things. …(we) go out into the world and help keep the balance of nature. It's a big cycle of living with the land, and then eventually going back to it....*

An Elder, Noongar People. From: 'Elders: Wisdom from Australia's Indigenous Leaders'