

# The Evolution of the Anthropocene: From Hunter-Gatherers to a Global Geophysical Force



Will Steffen  
Chief Scientist, IGBP

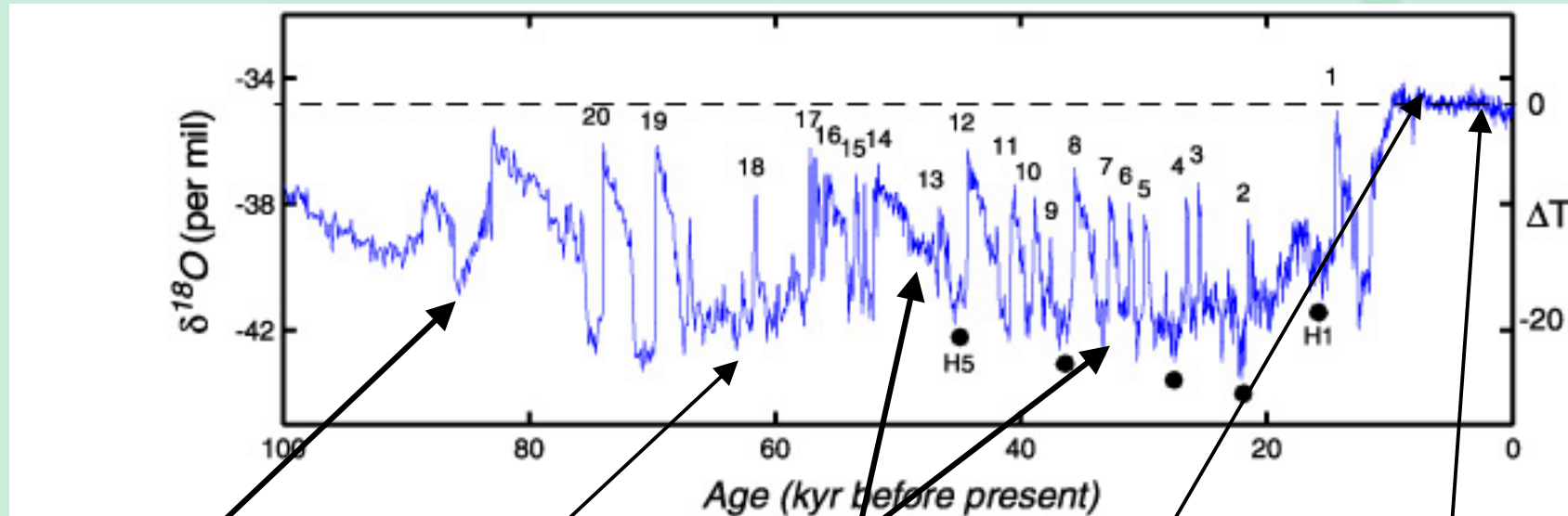
# IHOPE: Integrated History and Future of People on Earth

Bob Costanza (Leader), Carole Crumley, John Dearing, Lisa Graumlich, Rik Leemans, Eric Lambin, John Schellnhuber, Will Steffen

***Objective:*** To understand better the dynamic interactions between human societies and their environment by linking various forms of knowledge on human history and environmental change at multiple temporal scales (millennial, centennial, decadal, and future scenarios).

- Viewing the past from the perspective of human-environment systems
- Emphasis on the two-way interactions between humans and environment
- Data to test models of human-environment systems
- A reconceptualisation of history - for us as a species and for Earth as a planet

# Human Development and Glacial-Interglacial Cycling



First migration of fully modern humans out of Africa

Aborigines arrive in Australia

Migrations of fully modern humans from South Asia to Europe

Beginning of agriculture

Great European civilisations: Greek, Roman

Source: GRIP ice core data (Greenland)  
And S. Oppenheimer, "Out of Africa", 2004

# The Anthropocene Era



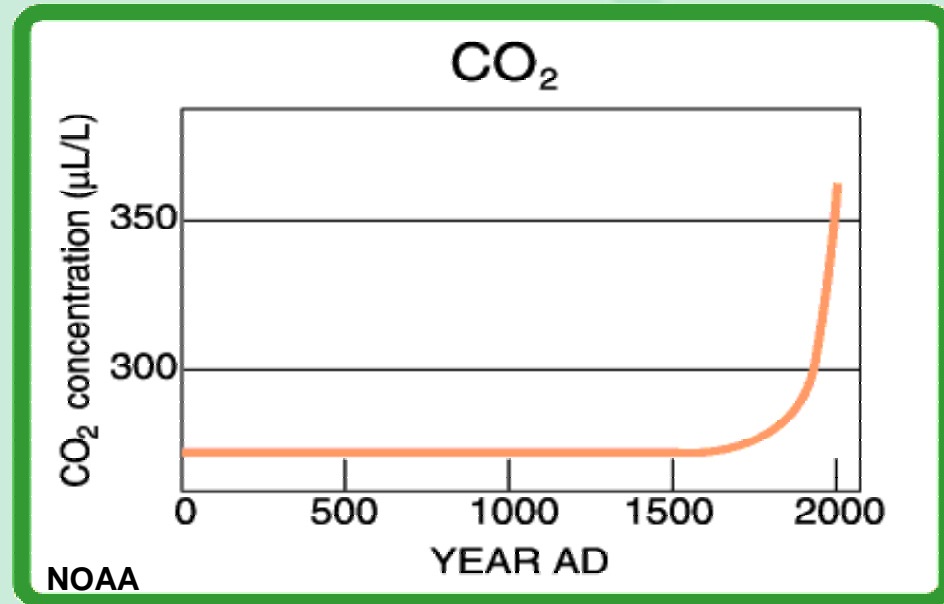
# The Stages of the Anthropocene

## **1. Pre-Anthropocene events:**

Fire-stick farming, megafauna extinctions, early forest clearing

## **2. Anthropocene Stage 1**

**(ca. 1800 - 1945).** Internal combustion engine, fossil fuel energy, sci & tech



**3. Anthropocene Stage 2 (1945 - 2010 or 2020).** The Great Acceleration, new institutions and vast global networks

**Anthropocene Stage 3 (2010 or 2020 - ?).** Business-as-usual, geo-engineering, or the Great Transition?

# Before the Anthropocene: Pre-Anthropocene Events (Pre-1800)

- Use of fire by hominids and early humans
- Megafauna extinctions
- Early agriculture/deforestation and CO<sub>2</sub> emissions
- Burning of coal for (i) smelting in China in the 1000-1200 period and (ii) for heat ca. 1000 years ago in England

# Human-Environment Systems during the Hunter-Gatherer Era

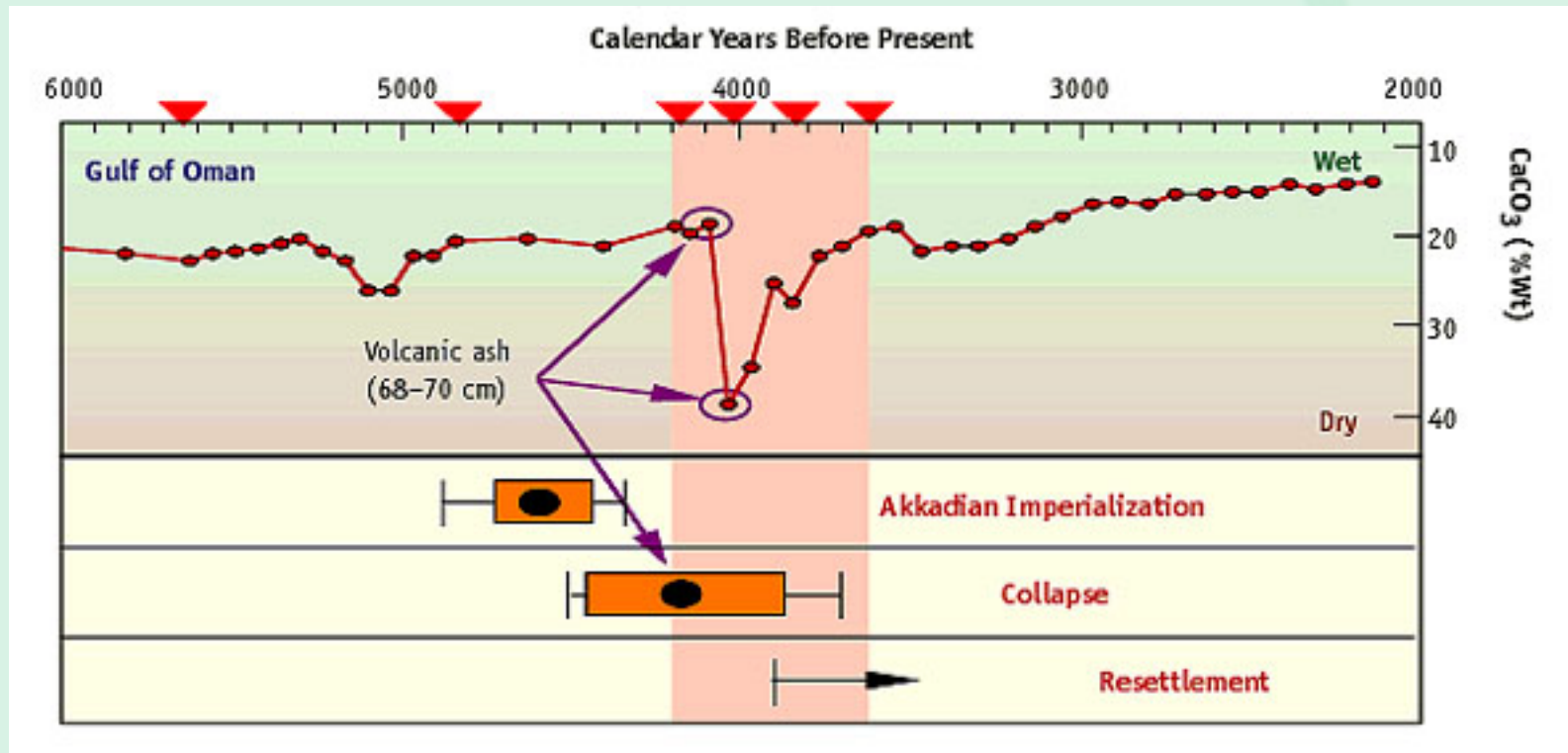
- "Fire-Stick Farming" - use of fire as a tool to modify ecosystems to favour particular desired species and to aid in the hunt. Fire was most often used to convert dry forests and woodlands into savannas and grasslands, and to maintain ecosystems in those states.
- Megafauna extinctions - large-scale (continental) extinctions of large Pleistocene mammals by hunting, perhaps in combination with climatic changes - North America, northern Eurasia, Australia.
- No discernable effect on Earth System functioning at the global scale

# Impact of Early Agriculture on the Carbon Cycle: Ruddiman's Hypothesis

- Clearing of forested land for agriculture 5000 to 8000 years BP led to measurable increases in global atmospheric concentrations of CO<sub>2</sub> and CH<sub>4</sub> (or ca 5-10 ppmV CO<sub>2</sub>)
- These increases reversed the otherwise downward trend in greenhouse gas concentrations following the mid-Holocen peak
- These human driven increases in GHG concentrations were enough to prevent the onset of the next ice age (or a mini-ice age) and to begin the present warming period. Thus, Ruddiman puts the beginning of the Anthropocene at ca. 8000 yBP.
- Ruddiman's hypothesis has been widely debated within the C cycle/climate community and is not yet accepted by most.



# Collapse of Early Civilisations



From: Cullen et al. 2000

# Possible Explanations for the Collapse of Early Civilisations

- Tainter - increasing complexity & decreasing resilience
- Friedman - waves of 'globalisation' to an upper limit of system compatibility
- Diamond - inflexibility of core societal values
- Scarborough (Maya) - self-organisation - networks of alliances and exchanges; adaptation to dynamics of natural ecosystems. Collapse due to centralisation of power around two super-cities and distortion of network flows.

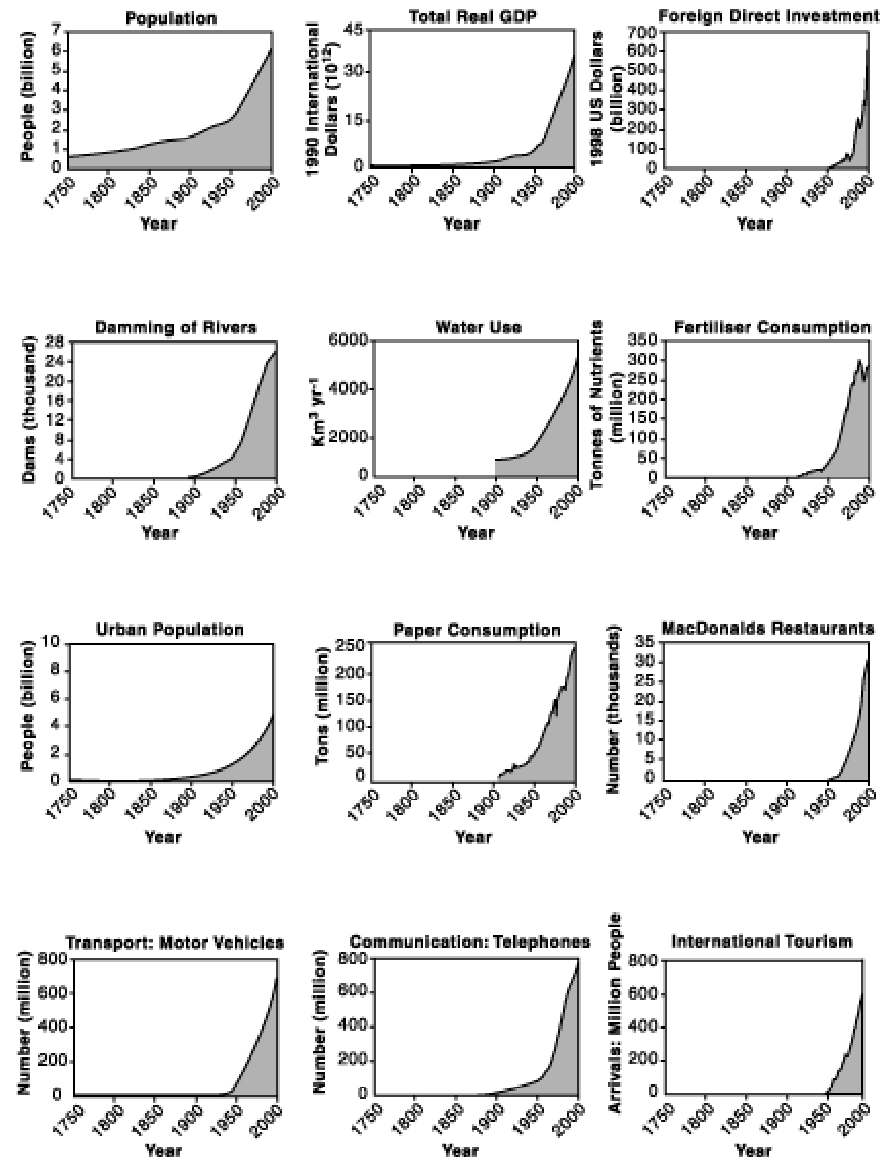
# Anthropocene Stage 1 (1800-1945)

- Evidence - increase in GHG concentrations, widespread deforestation of temperate forests, etc.
- Industrial Revolution - steam engine, fossil fuel energy systems, rapid and wide spread of these energy systems
- Flow-on effects - more efficient techniques for land clearing; synthetic fertiliser; more reliable water supply and better sanitation, leading to better public health. These developments, in turn, led to an increase in population AND their ability to consume.

# Anthropocene Stage 2 (1945 - 2010/2020)

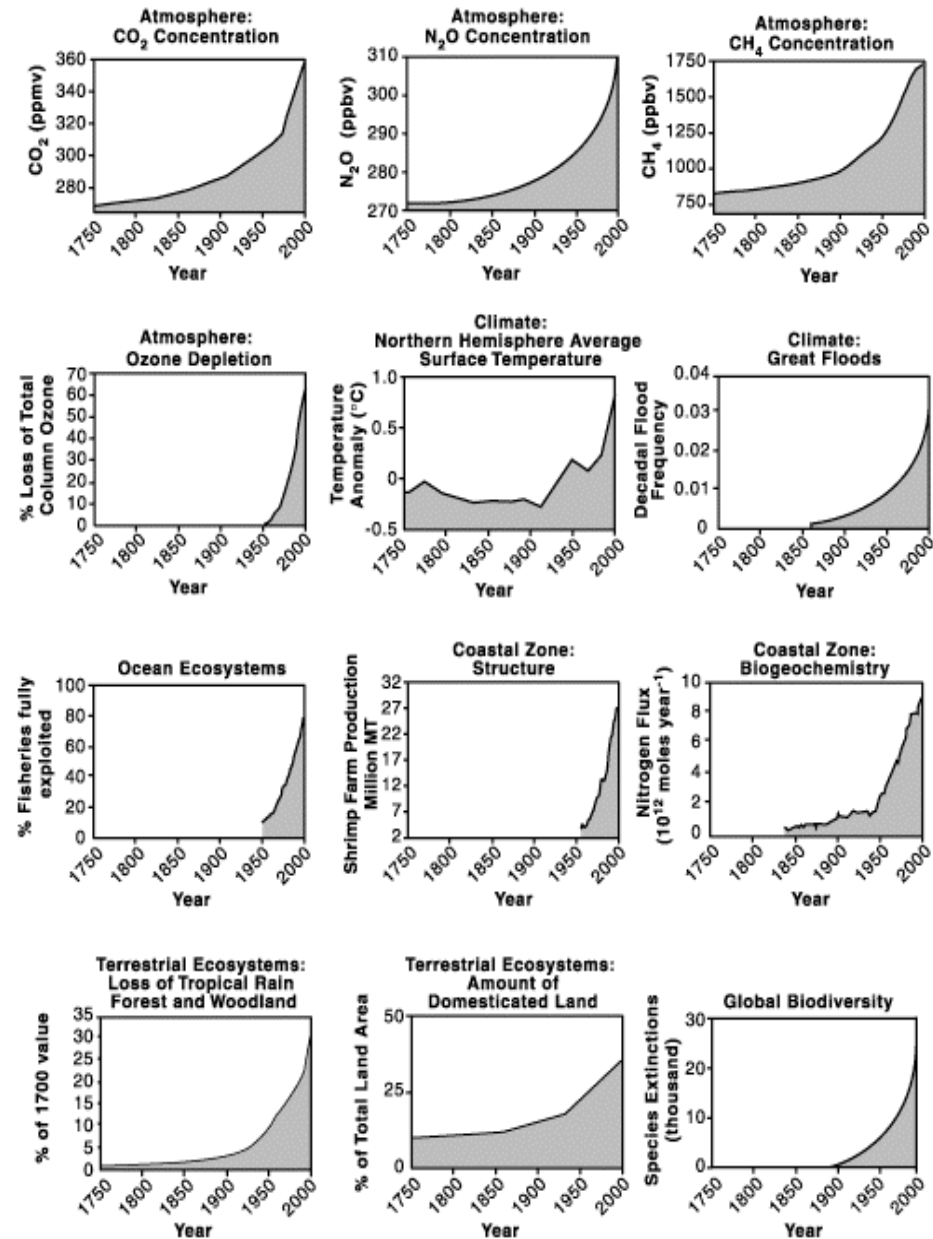
The changing 'human enterprise', from 1750 to 2000.

Note the start of the 'Great Acceleration' around 1950, when many activities began or accelerated sharply.



Responses of the biophysical Earth System to the accelerating 'human enterprise'.

The biophysical responses of the Earth System show many of the same features as the Great Acceleration in the human enterprise.



# Origins of the Great Acceleration

- Beginnings of the modern scientific approach around 1600
- Rise of technologies that support mass consumption from ca. 1750 onwards - fossil fuel energy systems, Haber-Bosch process for fixing atmospheric nitrogen
- Increased population growth from about 1700

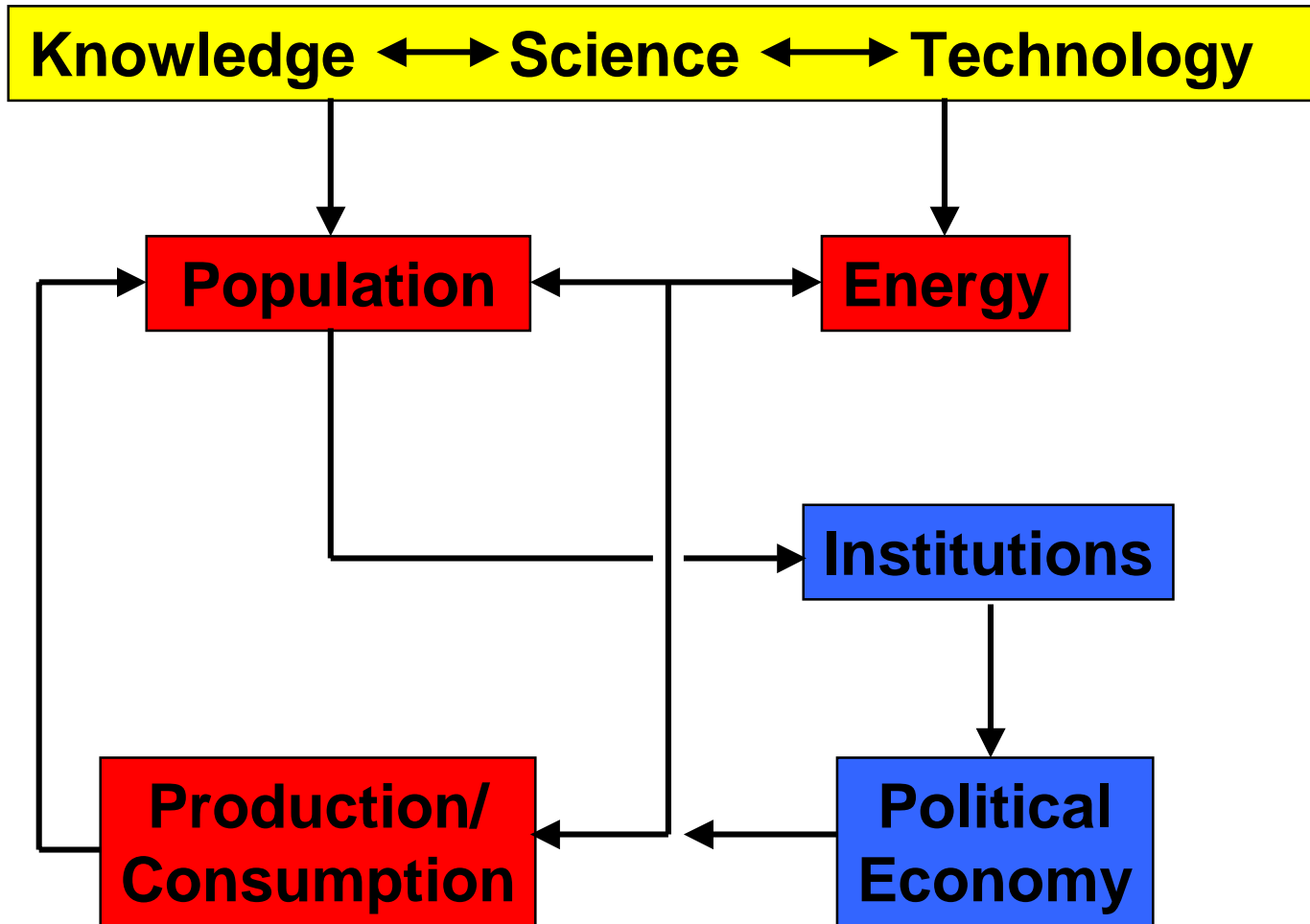
# Triggers of the Great Acceleration

- Globalisation: Global networks of communication & finance - crossed a threshold of connectivity
- Emergence of 'armies of scientists & technologists from WWII
- Dramatic shifts in political & economic structures/institutions
- Establishment of the Bretton Woods institutions

# What Drives the Great Acceleration?

- Inexpensive, convenient energy system (based on fossil fuels)
- Rapid growth in population during the 1950-2010/2020 period
- Internationalisation of science & technology; emergence of 'big science' and national science foundations
- US imposition/seduction to establish a world economy based on capitalist/neo-liberal economic principles
- Increasing commoditisation of public goods (e.g., common property resources, carbon in the atmosphere, genetic material etc. - and ecosystem services?)
- 'Growth imperative' driven by including more people in global economy & by promotion (e.g., advertising) of increasing consumption per capita





From: Hibbard et al. 2005

# The Changing Human-Environment Relationship under the Great Acceleration

## ***Complex impacts of globalisation***

- Mixed environmental impacts at local levels but homogenisation of the environment at the global level
- Loss of diversity of cultural values
- Negative environmental impacts of debt crisis

## ***Urbanisation and the environment***

- Different experiences and understanding of nature between urban and rural dwellers
- Increased wealth, rising consumption expectations
- Transformation of rural-urban linkages - 'footprints'

## ***Governance***

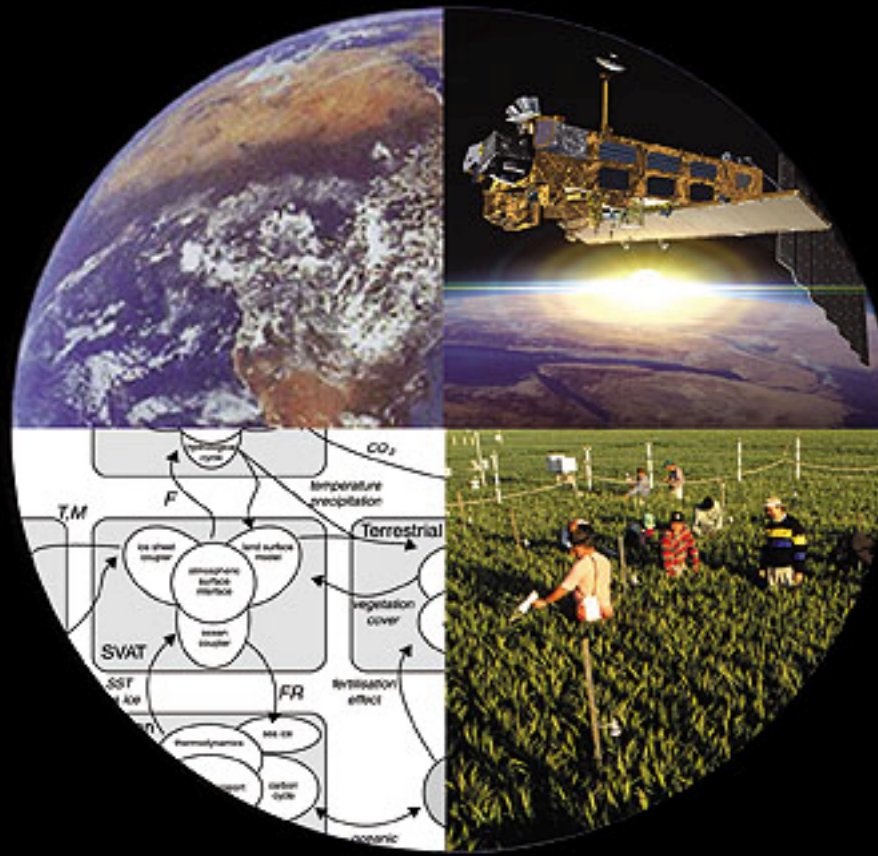
Shift to free-market economic systems

Decentralisation & privatisation of environmental management

# Signs of Deceleration?

- Rapidly declining fertility
- Emergence of environmental governance and institutions
- Technological advances, e.g. decarbonisation of energy
- Education and awareness

# Anthropocene Stage 3 (2010/2020 - ?)



# Human and Societal Vulnerability

International Herald Tribune | 5  
Wednesday, September 10, 2003

## Heat claimed 15,000 in France

### Estimate by funeral director exceeds latest by government

From news reports

**PARIS:** The number of people who died in France because of the August heat wave is 15,000, the country's largest undertaker estimated Tuesday, placing the death toll about 3,500 higher than the official government figure.

Isabelle Dubois-Costes, a spokeswoman for General Funeral Services, said the revised total includes deaths from the second half of August, after record-breaking temperatures had abated.

Late last month, the government issued its official estimate of 11,435, but the Health Surveillance Institute,

died. At the time, the government put the figure at a maximum of 3,000.

The heat wave brought suffocating temperatures of up to 40 degrees Celsius (104 degrees Fahrenheit) in the first two weeks of August in a country where air conditioning is rare. The heat baked many parts of Europe, but nowhere was

families were away on lengthy August vacations. Authorities reportedly had difficulty making contact with survivors who were away on vacation.

A team of medial experts named by the Health Ministry to conduct the first official inquiry into the crisis issued a scathing report Monday that found "an error in anticipation, organization and coordination," and said "the response was not suited" to the situation.

The experts said the "compartmentalization" of services between the health and other ministries and workers in the field prevented a pooling of available information about the scope of the crisis.

**The revised total includes deaths from the second half of August.**

# Hurricane Katrina, 2005



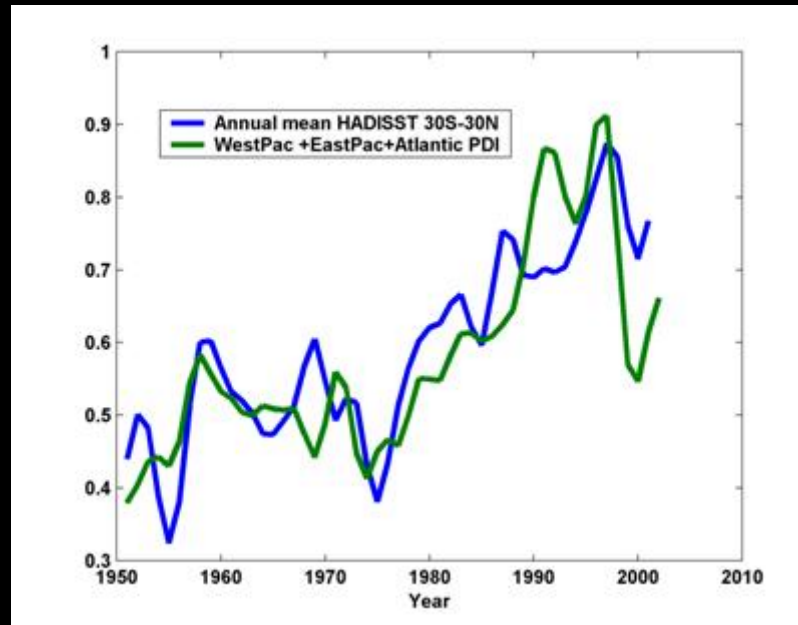
New Orleans, USA

# Destructiveness of Tropical Cyclones

$$\text{PDI} = \int_0^{\tau} (V_{\text{max}})^3 dt$$

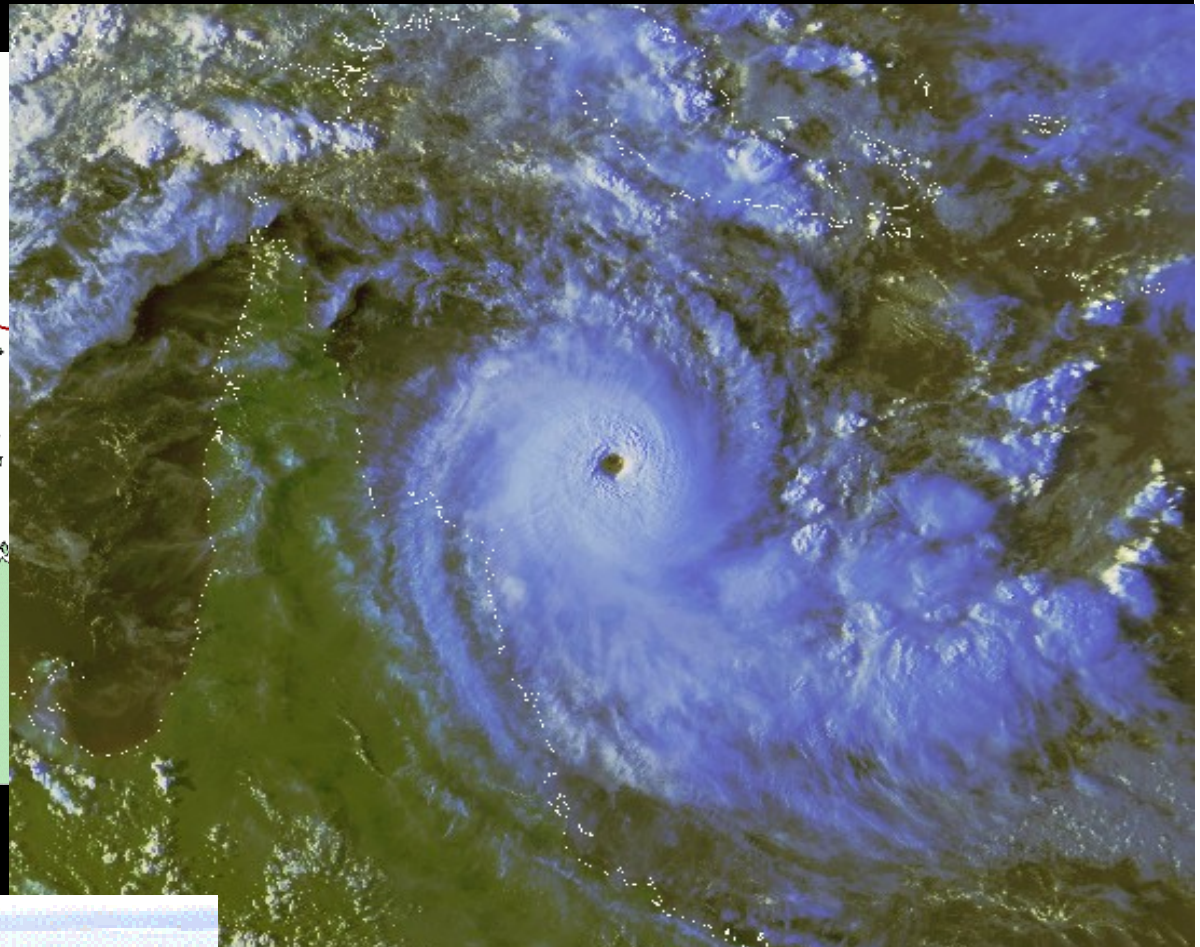
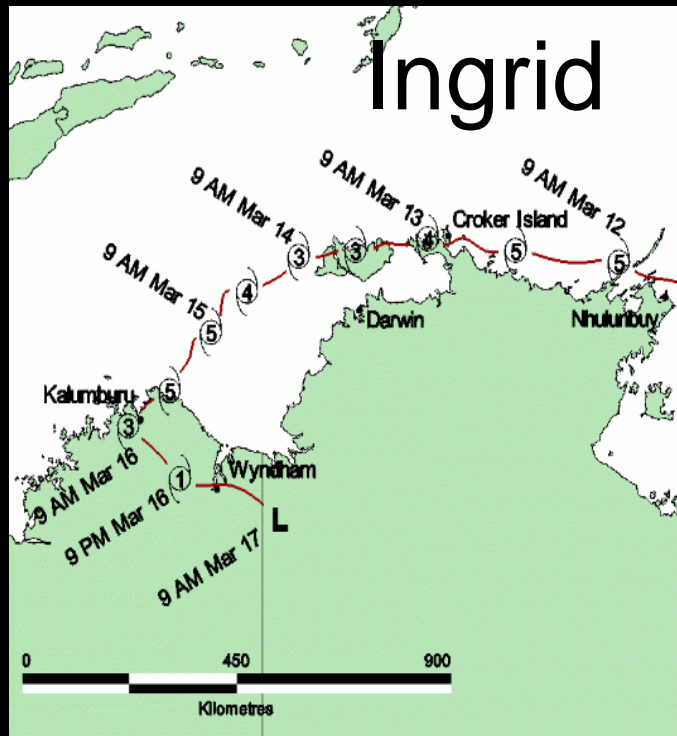
PDI = Power Dissipation Index

$V_{\text{max}}$  = Maximum sustained windspeed at 10 m

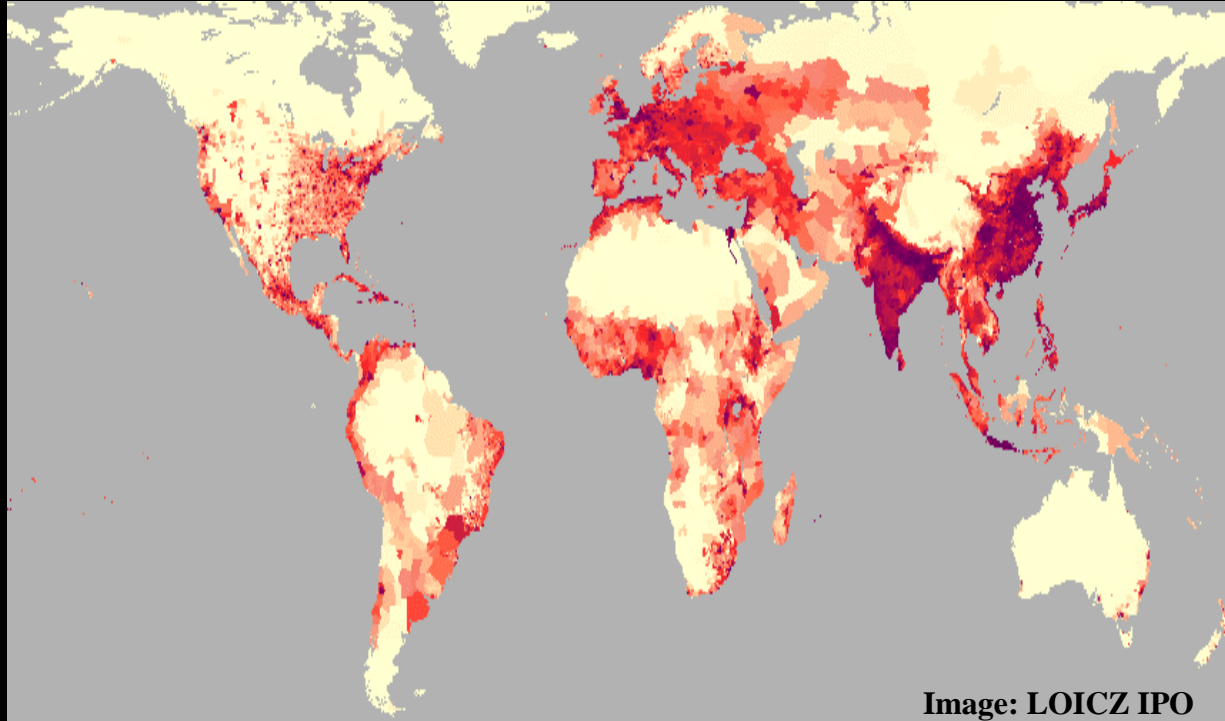


From: Emanuel 2005

# Ingrid







# Global Population Distribution

# 'Night Lights' of Earth



Image: NASA

# Simulated Night Lights

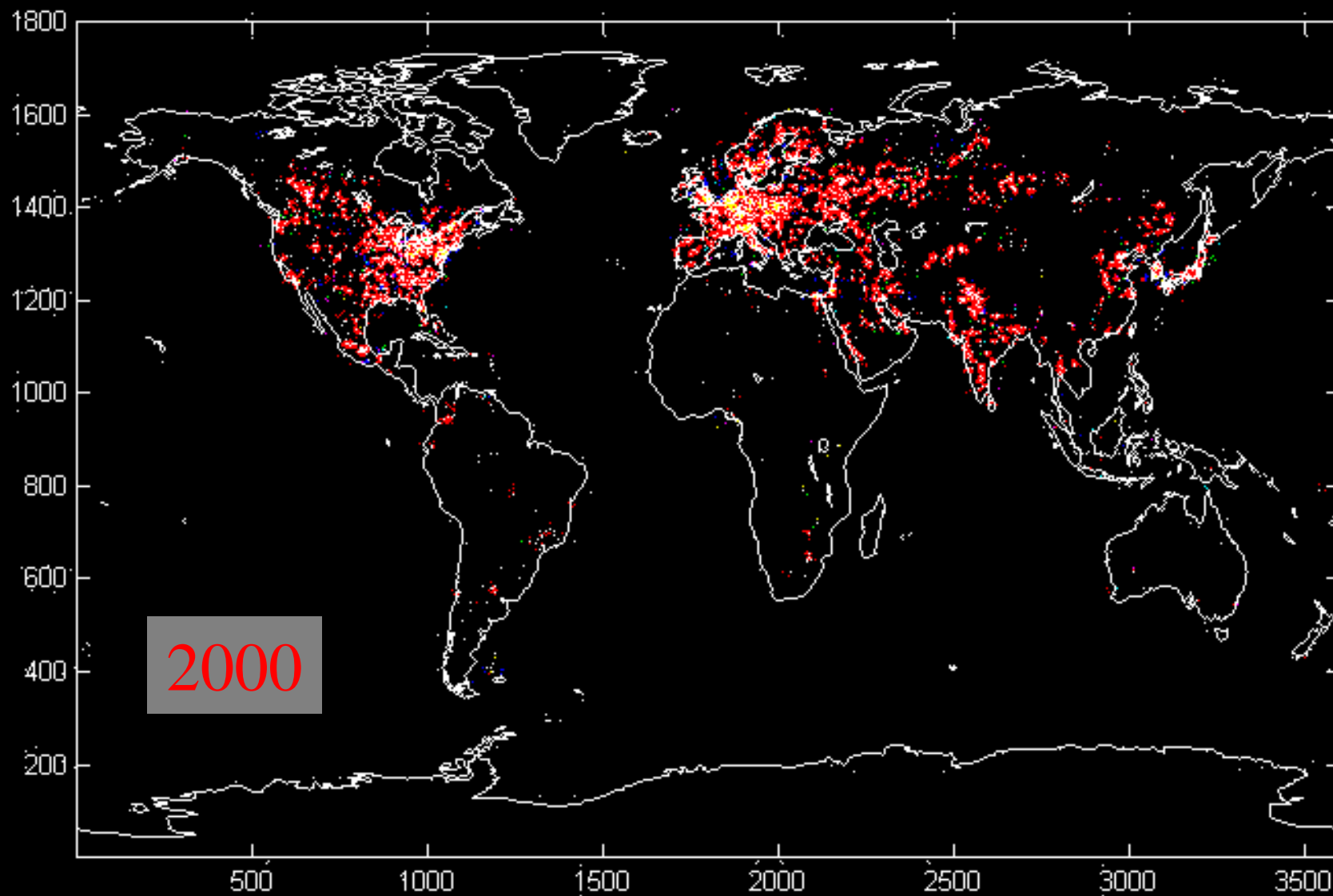


Image: H-J Schellnhuber

# Simulated Night Lights

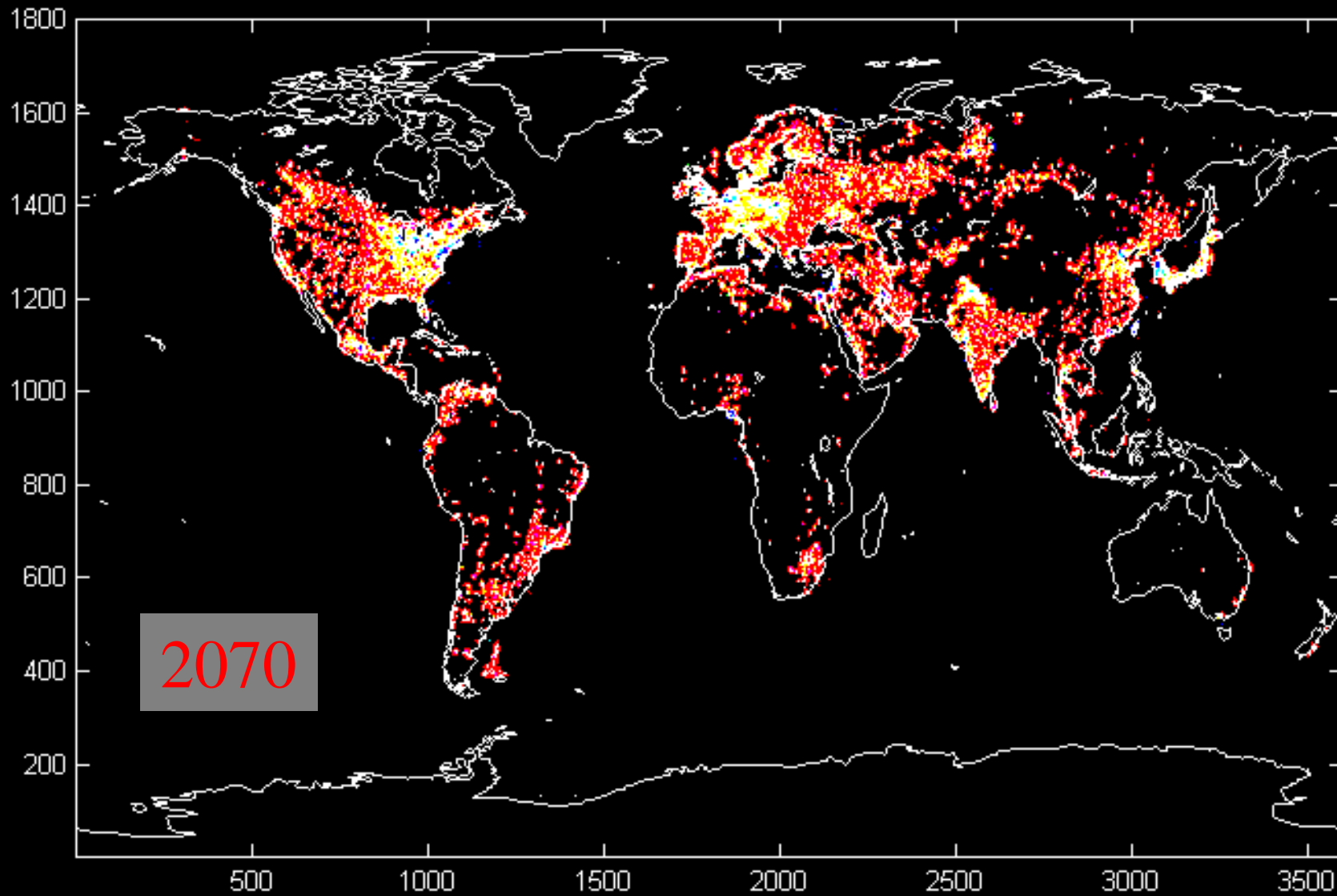
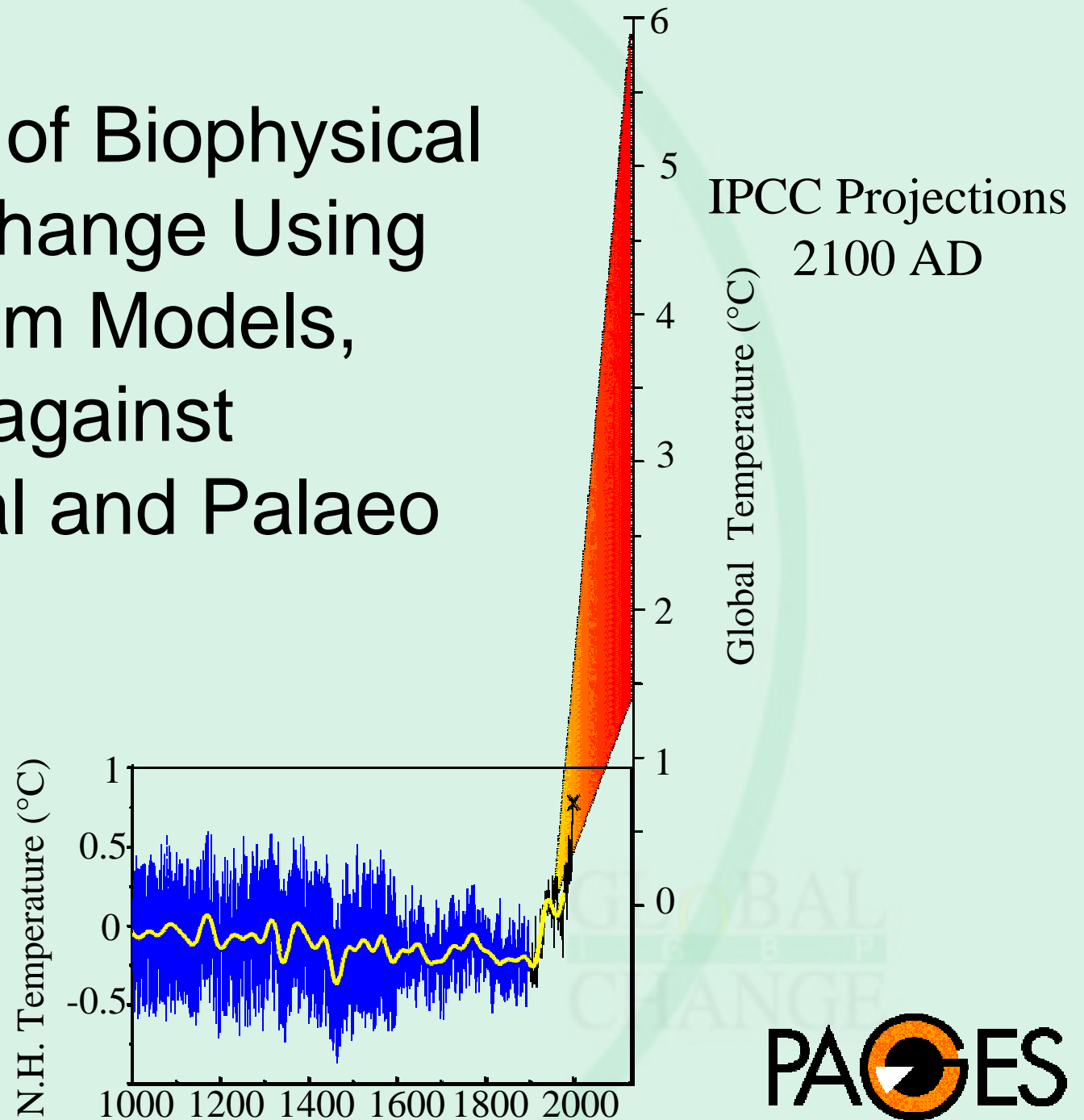


Image: H-J Schellnhuber

# Projections of Biophysical (Climate) Change Using Earth System Models, Compared against Instrumental and Palaeo Data



# Scenarios: MA Storylines



- **Global Orchestration** Globally connected society that focuses on global trade and economic liberalization and takes a reactive approach to ecosystem problems but that also takes strong steps to reduce poverty and inequality and to invest in public goods such as infrastructure and education.



- **Order from Strength** Regionalized and fragmented world, concerned with security and protection, emphasizing primarily regional markets, paying little attention to public goods, and taking a reactive approach to ecosystem problems.

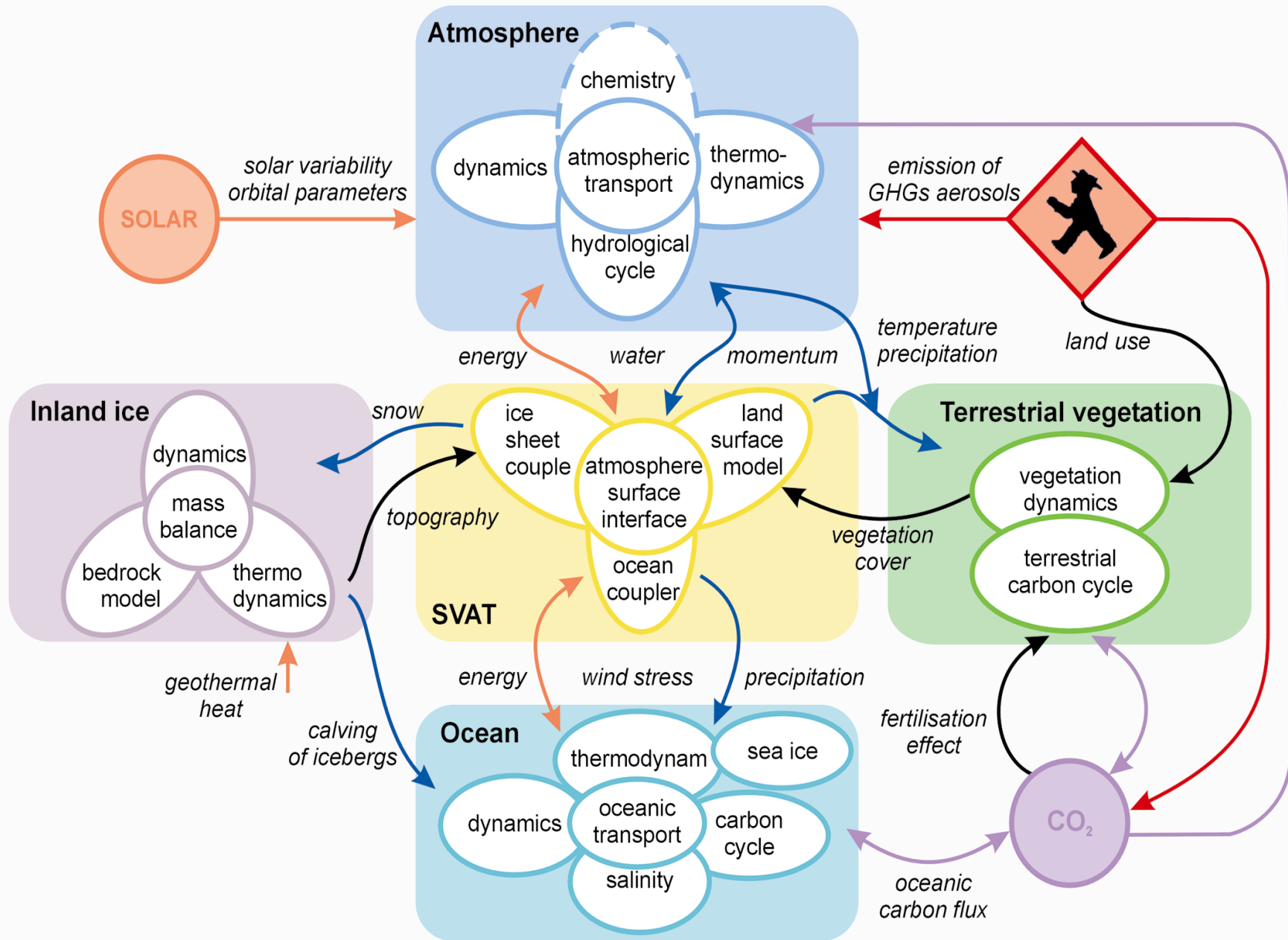
# Scenarios: MA Storylines



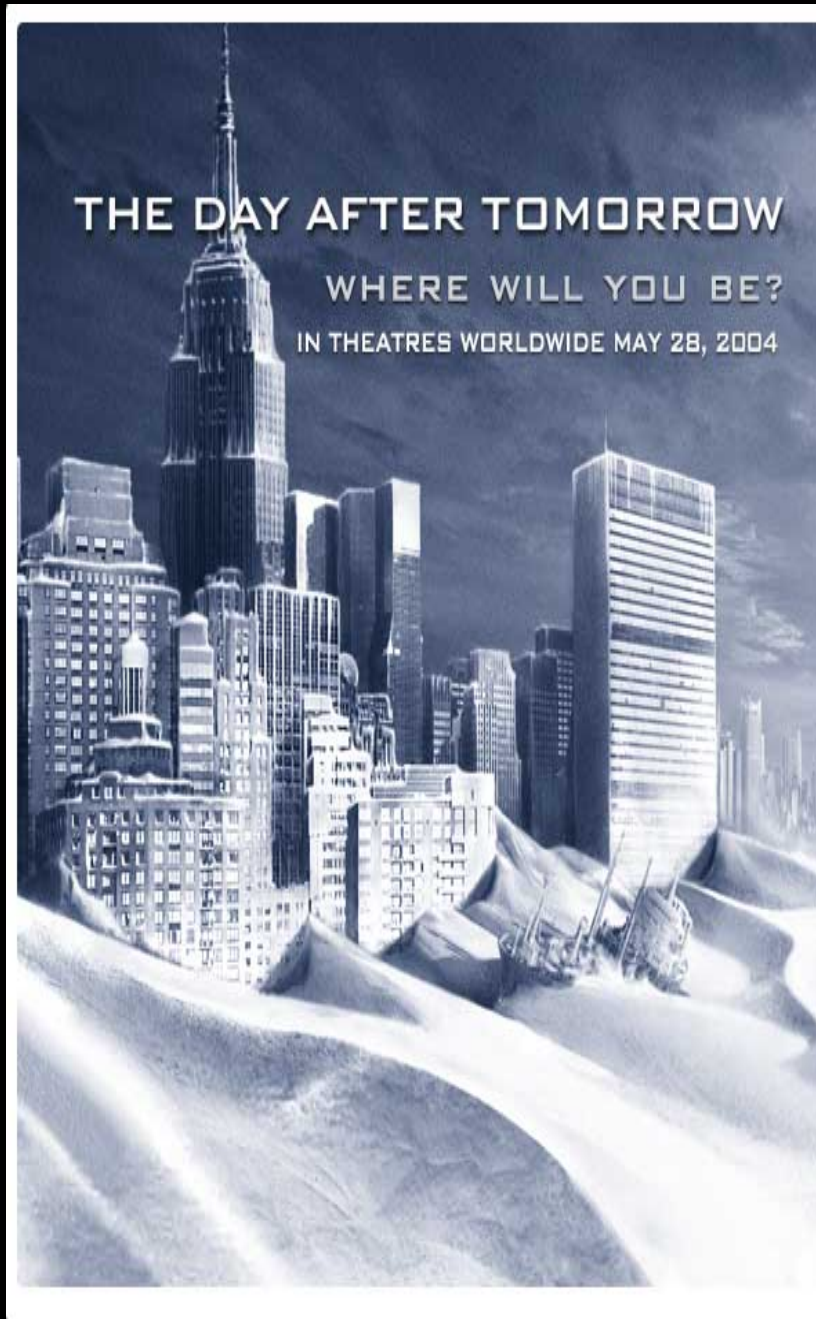
- **Adapting Mosaic** Regional watershed-scale ecosystems are the focus of political and economic activity. Local institutions are strengthened and local ecosystem management strategies are common; societies develop a strongly proactive approach to the management of ecosystems.



- **TechnoGarden** Globally connected world relying strongly on environmentally sound technology, using highly managed, often engineered, ecosystems to deliver ecosystem services, and taking a proactive approach to the management of ecosystems in an effort to avoid problems.







## Films and Books

Popular book written by scientists such as Jared Diamond:

- Guns, Germs and Steel
- Collapse

or Tim Flannery:

- The Future Eaters

Novels describing the human-environment relationship from the past to the future:

- The Cloud Atlas (David Mitchell)



Business-as-usual: humans continue to drive changes to the Earth System; somehow attempt to cope with impacts

Path to sustainability: actively manage the human enterprise to take the pressure off the planet; large changes in lifestyles and technologies

Geo-engineering: large-scale manipulation of Earth System processes. Take risks of unintended, serious side effects

