The Climate of the Anthropocene: How Humans Have Changed Our Earth

Earth, 1990, from Voyager 1 space probe 6 billion kilometers distant

Colin Summerhayes & Jan Zalasiewicz
(Anthropocene Working Group
of the International Commission on Stratigraphy)

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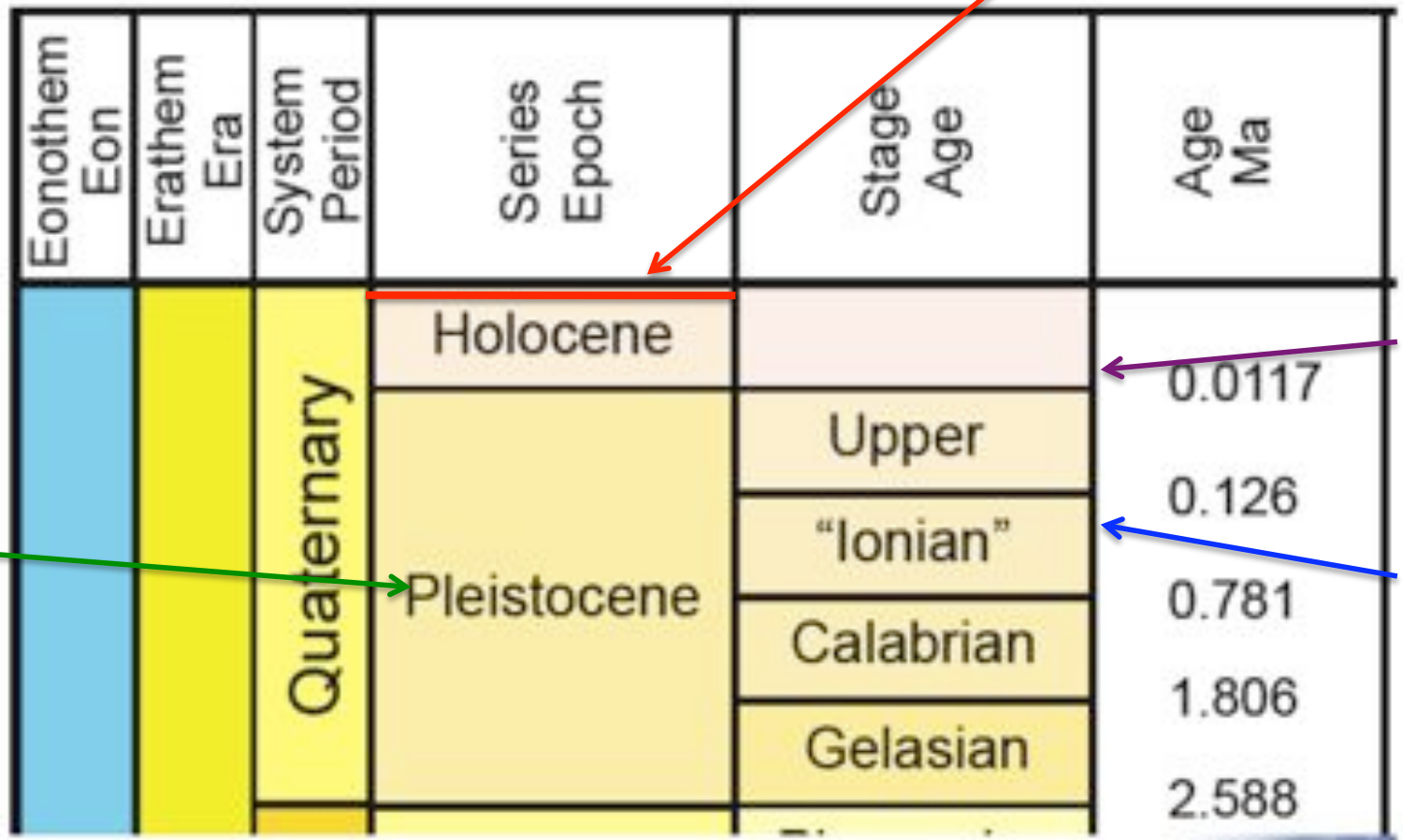
Anthropocene Basics

? Anthropocene?



First cities 10 ka

The Ice Age

Homo Sapiens c.200 ka

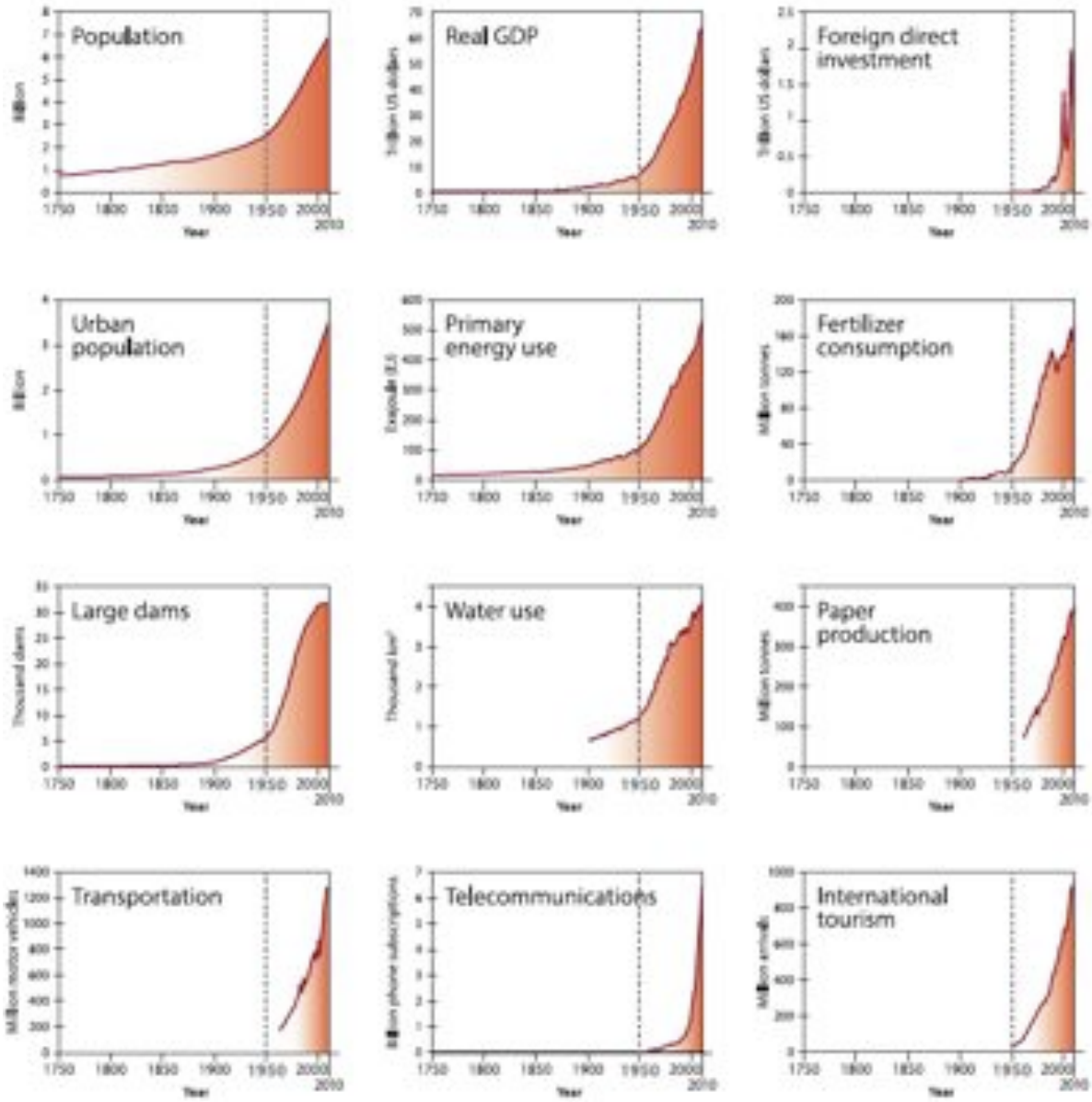
… for the younger part of the chart

The Anthropocene:
Is What We Are Doing To The Planet Creating A New Geological Epoch?

Have humans changed the Earth System such that geological deposits forming now include a fingerprint distinct from that of the current Holocene Epoch, with high potential to remain in the geological record?

If so, WHEN did that change (not necessarily the first detectable anthropogenic change) become recognizable worldwide?

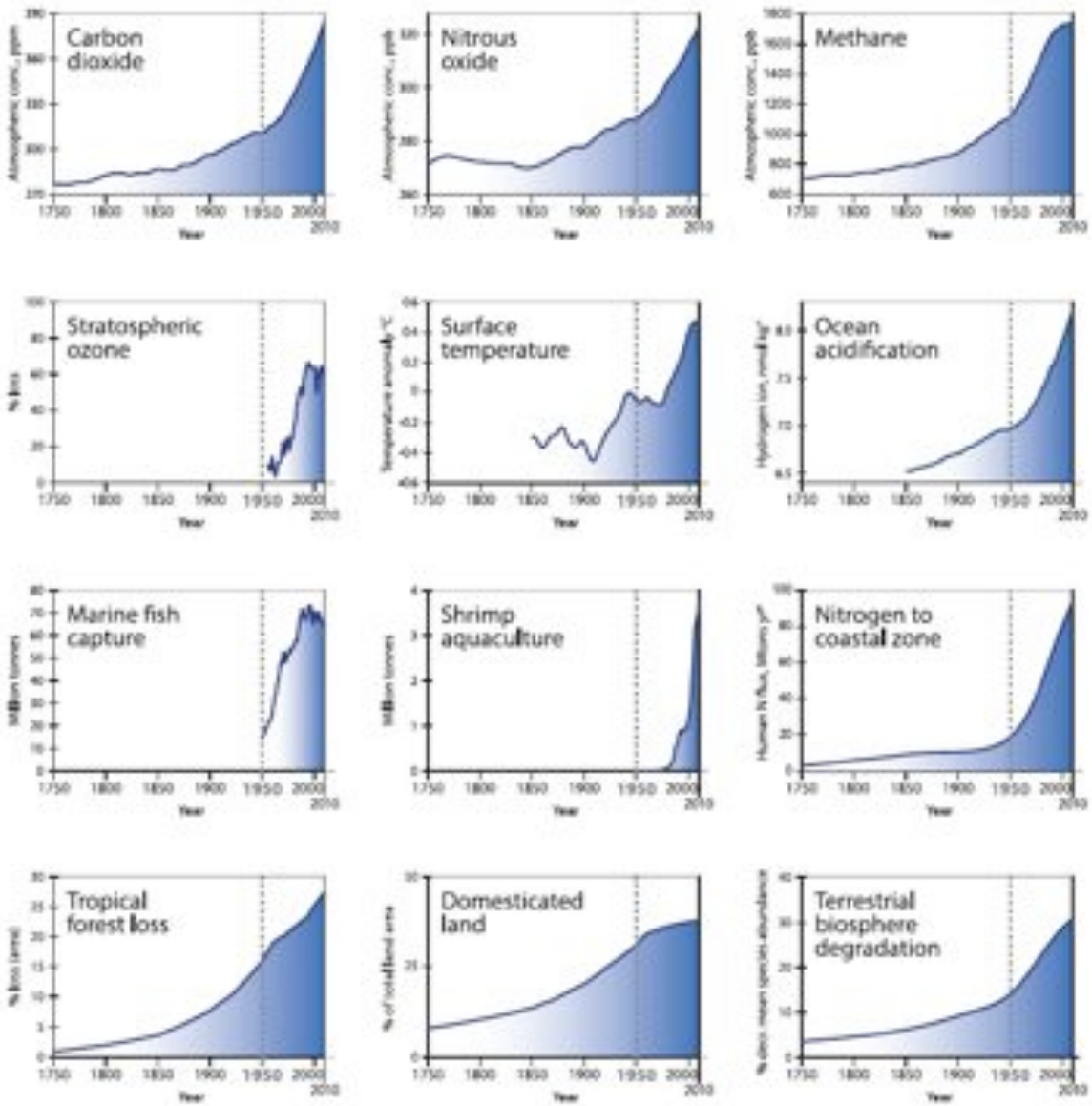
The Great Acceleration: Socio-Economic Trends Accelerate After 1950



By-product of more efficient industrial processes in WW-II, diverted to satisfy growing consumer 'needs' post-war.

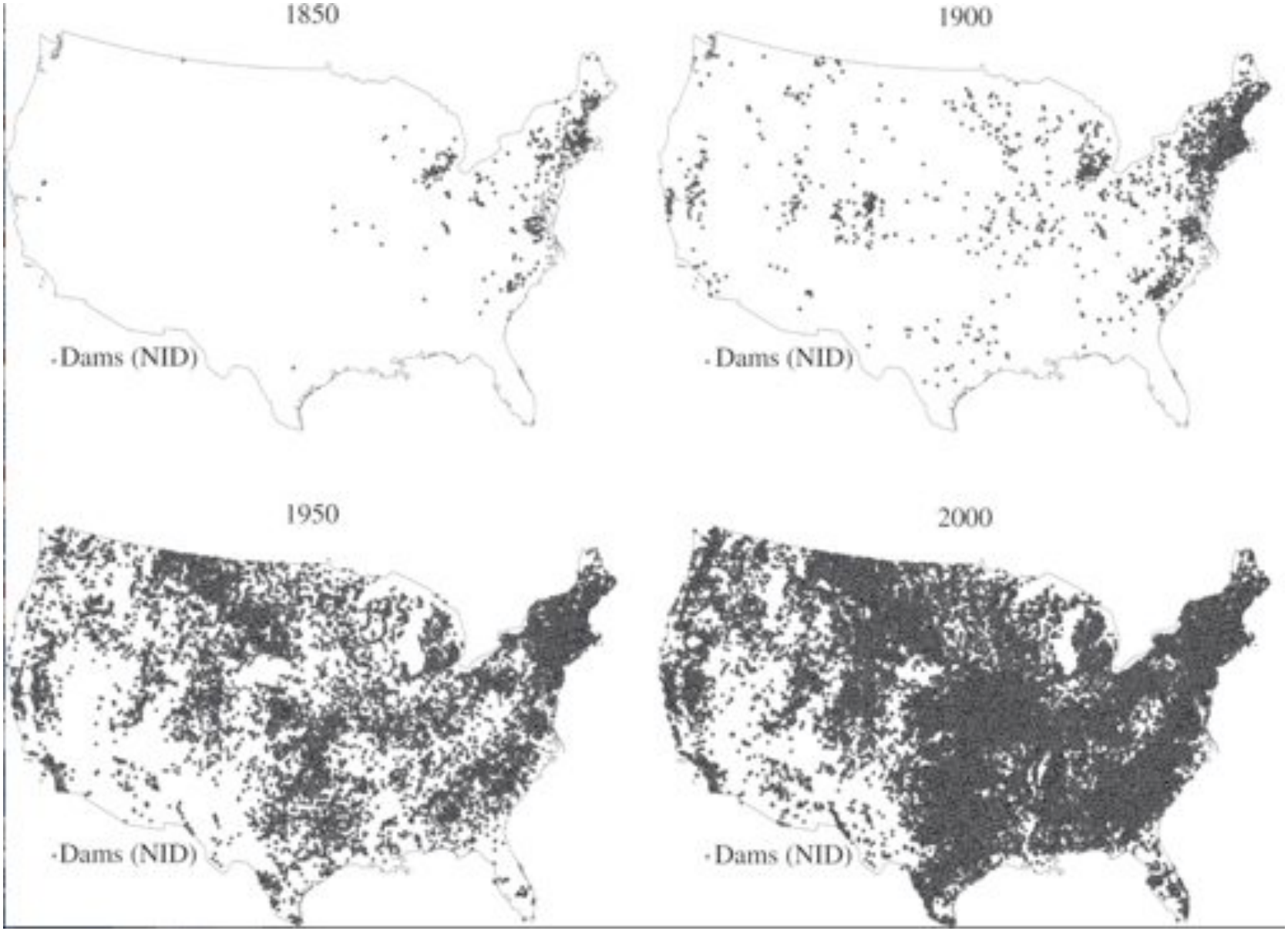
Steffen et al 2015

Products of the Great Acceleration: Earth System Trends Accelerate After 1950

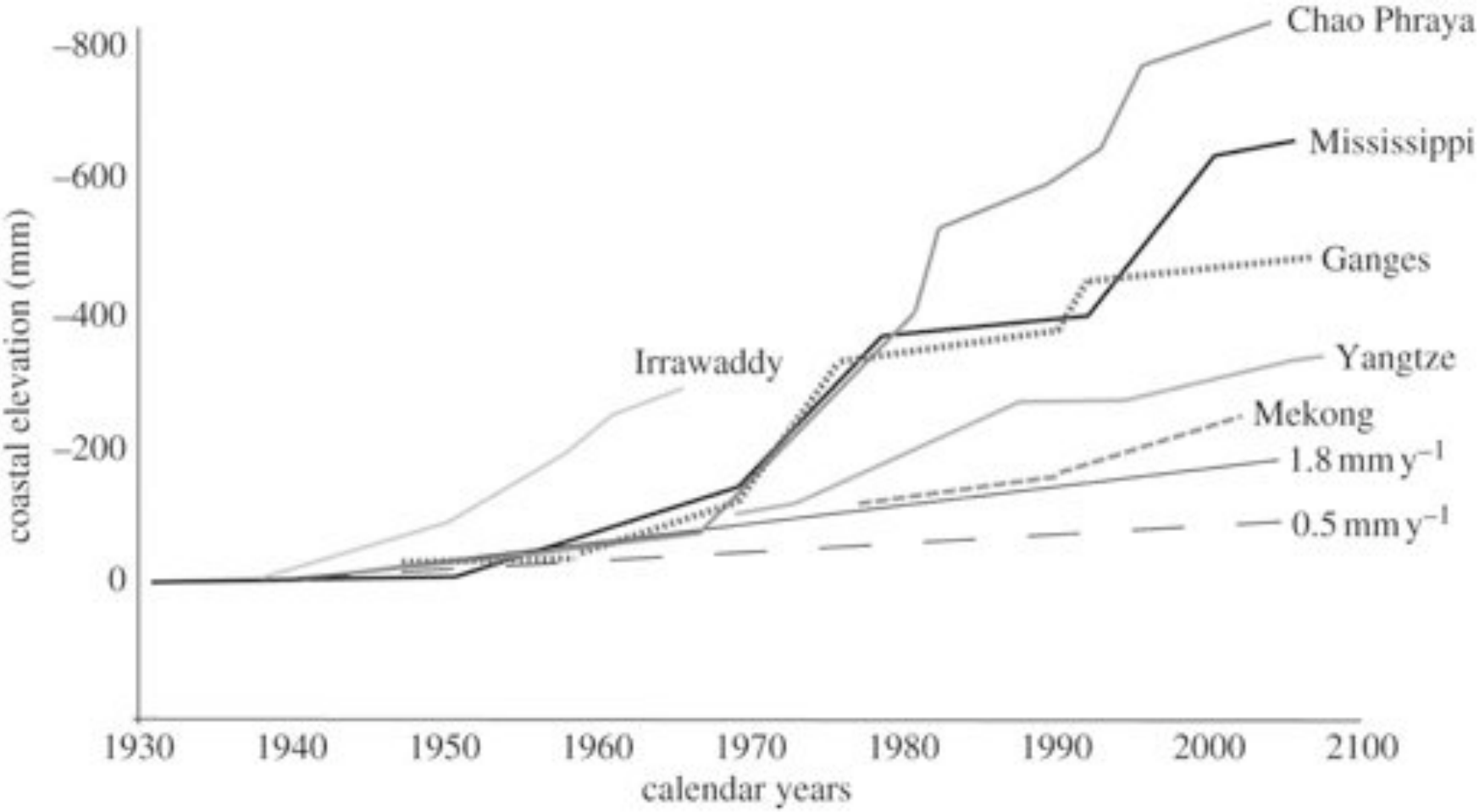


Steffen et al 2015

Global Growth of Dams (e.g. USA)

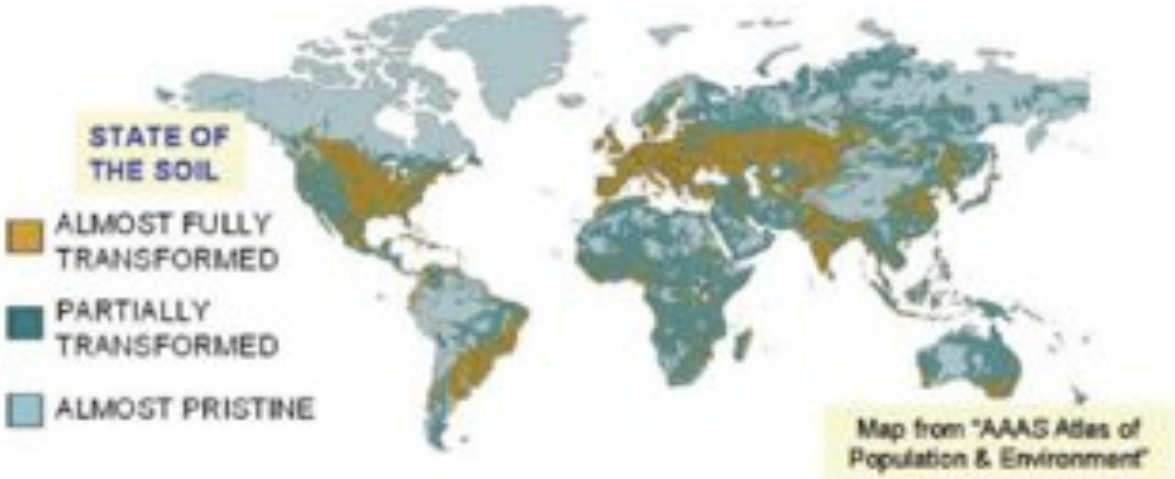


Deltas Are Now Subsiding Fast and Being Eroded



Syvitski & Kettner 2011

Transformation of Earth's Surface ("Terraforming")



Physical *technosphere*… about 30 trillion tons (50kg/m^2)

Urban areas ~11 Tt

Rural housing ~6 Tt

Pasture ~5 Tt

Croplands ~4Tt

Trawled sea floor ~2Tt

Eroded soil/land use ~1 Tt

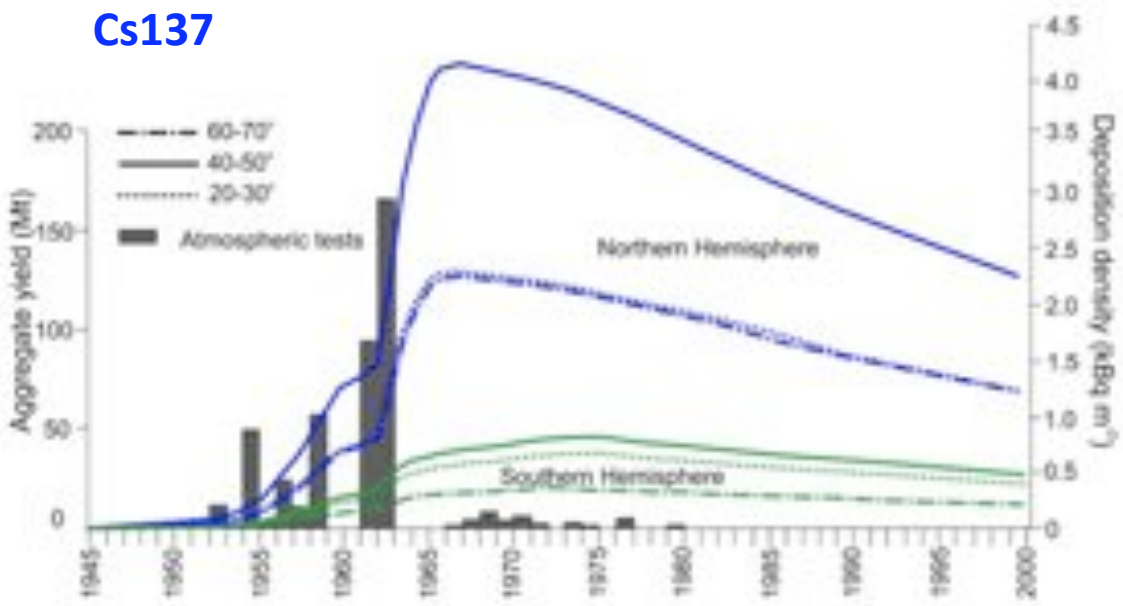
Roads ~0.4 Tt

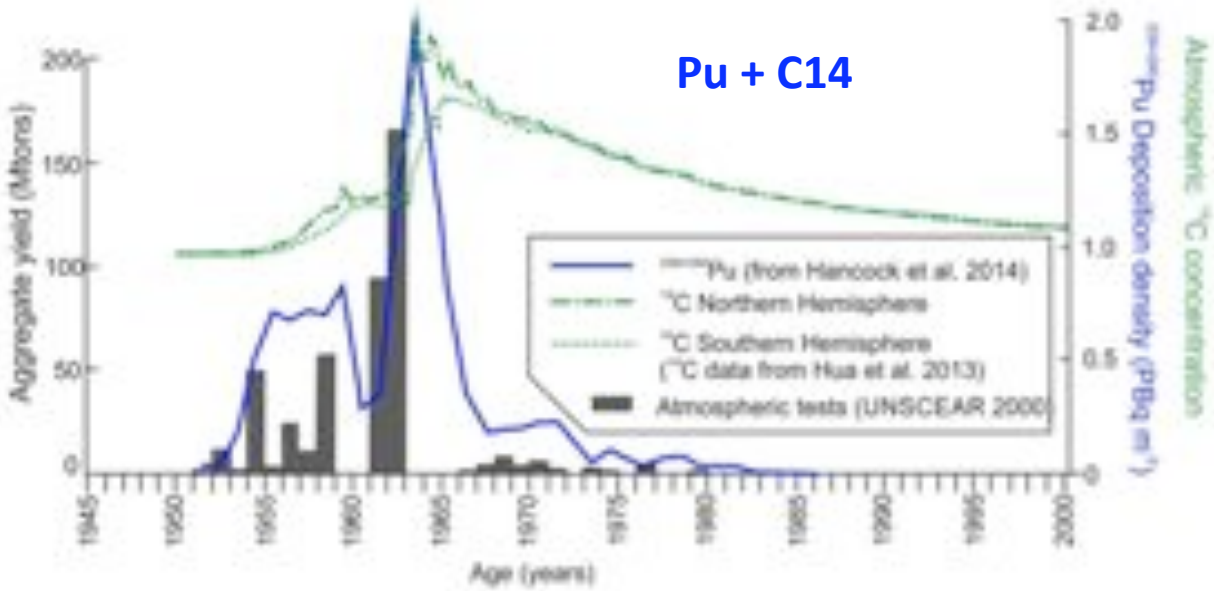
Plantations ~0.3Tt

Reservoirs ~0.2 Tt

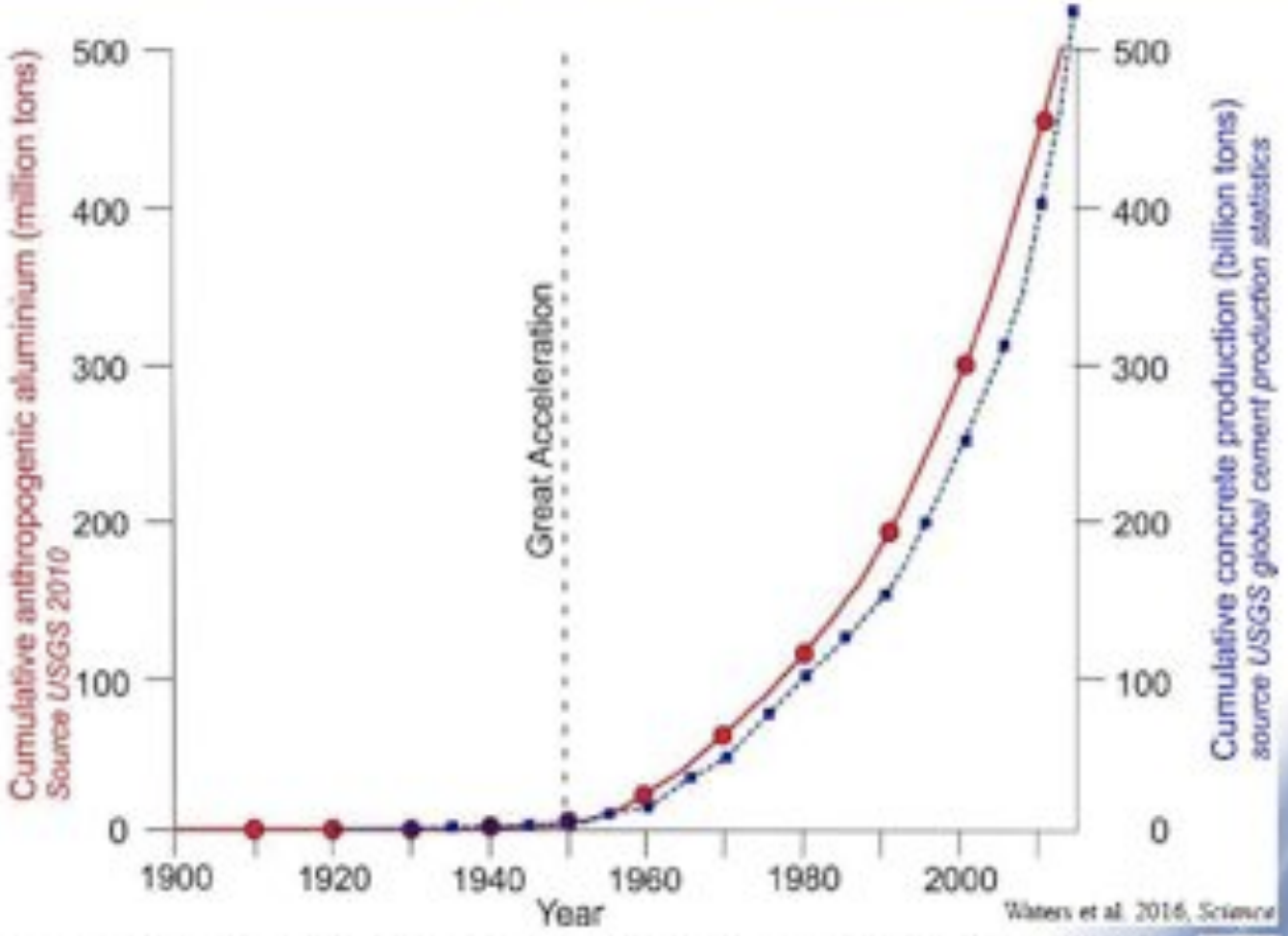
Railways ~0.02 Tt

Radiation Signal

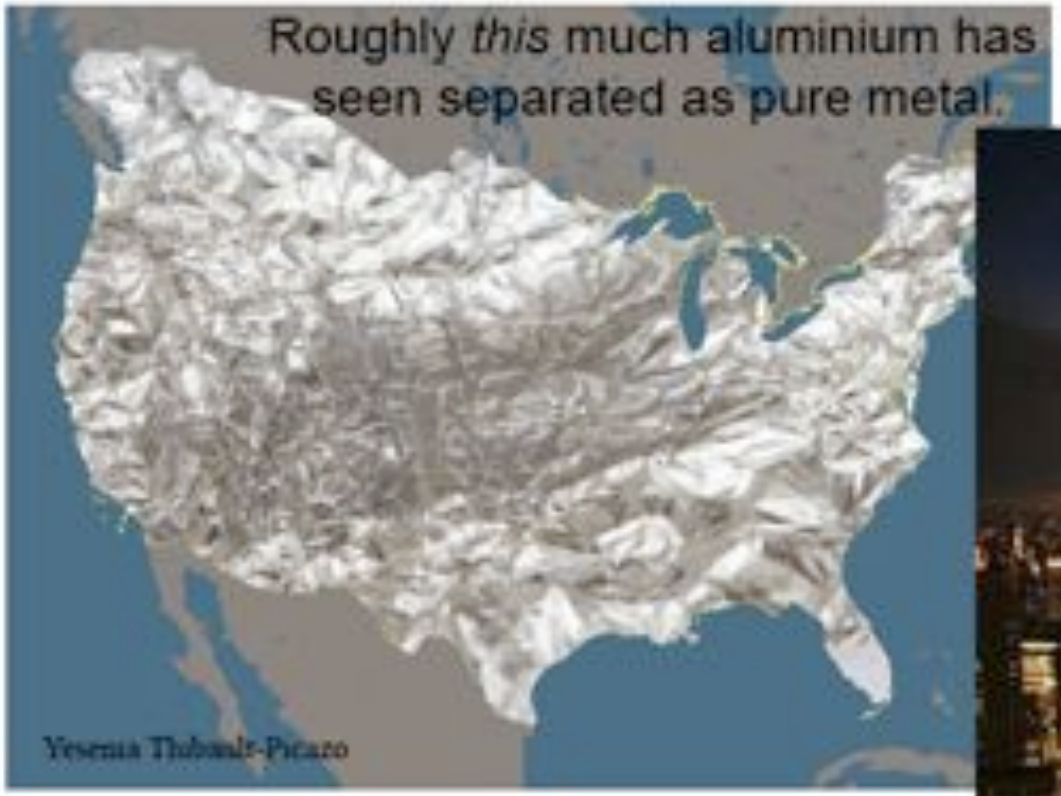




Creation and global dispersal of aluminium (35 Mt pa) & concrete (3.4 Gt pa)

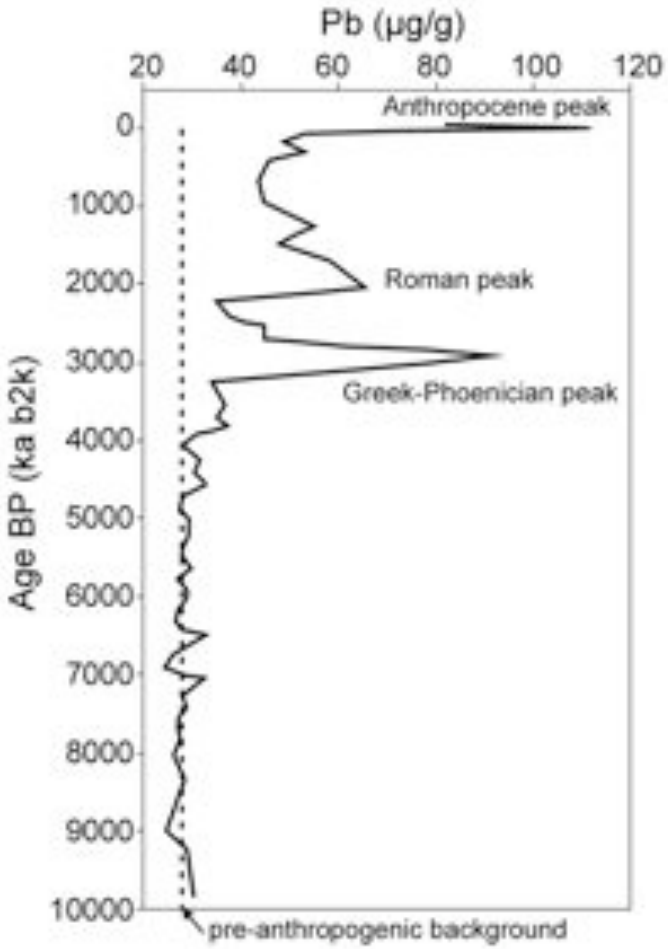


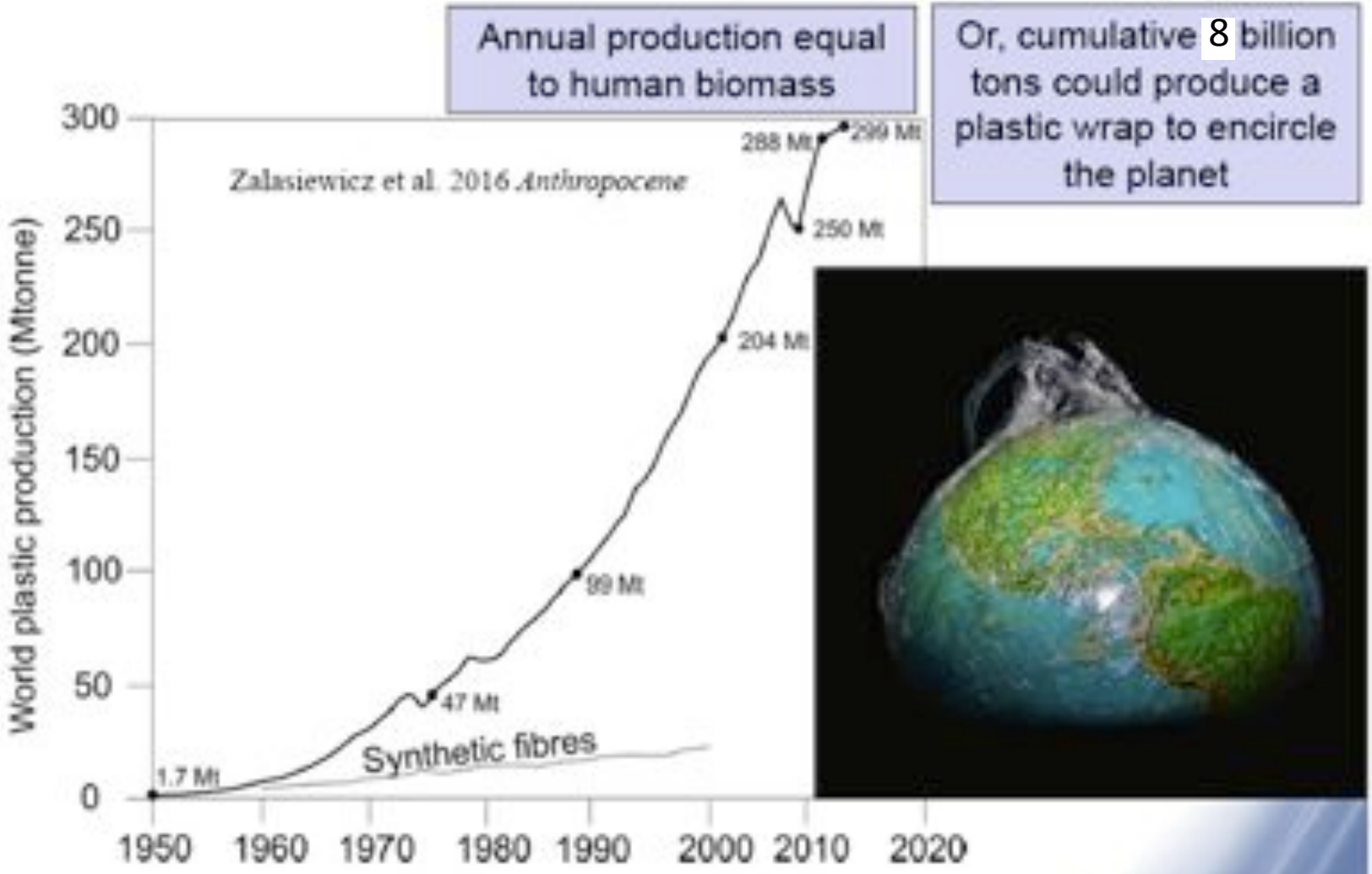
There is a clear signal in some novel lithostratigraphic indicators



The past 20 years accounts for half the concrete ever produced. Total = 1kg per m^2 across the planet

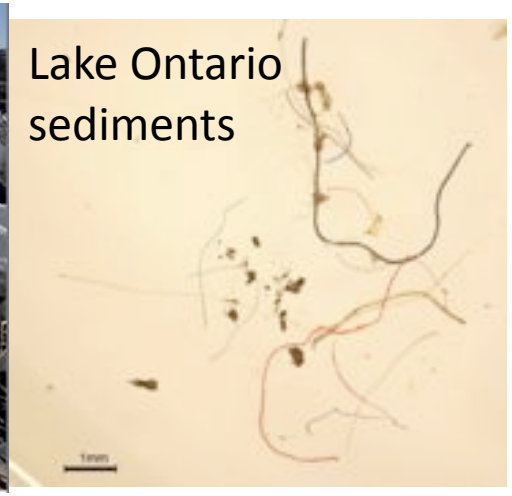
Pb in Spanish lake sediment



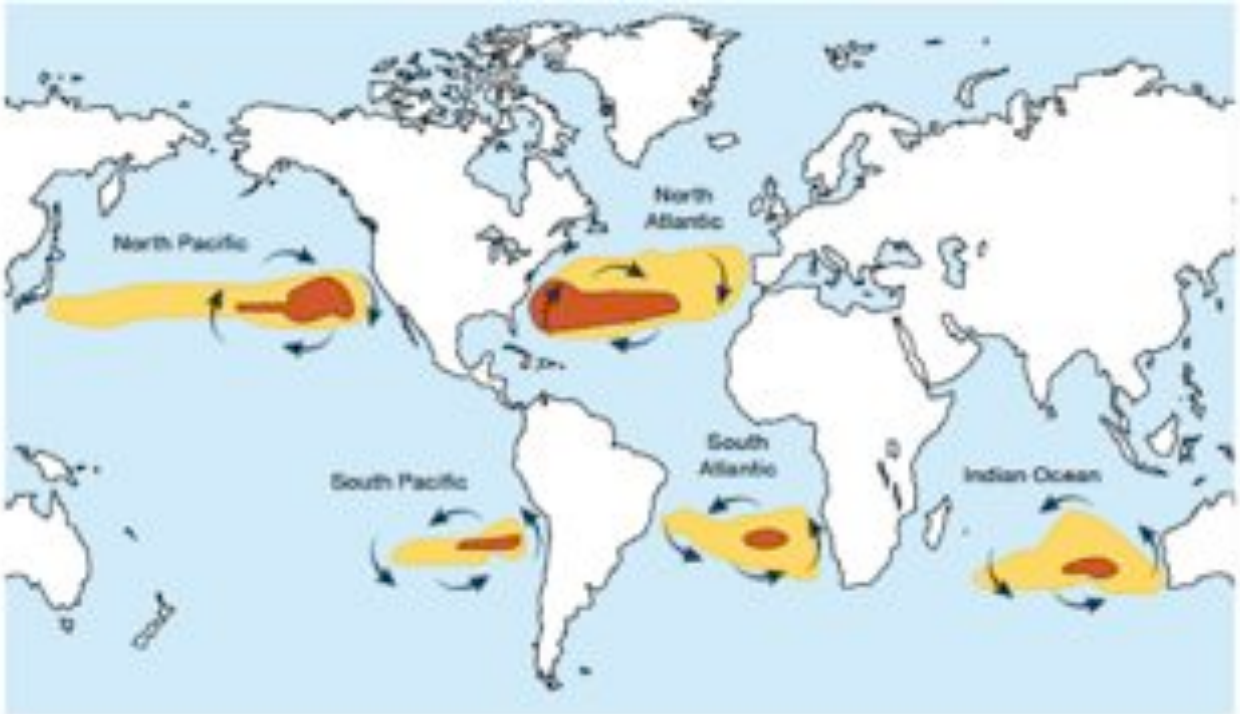


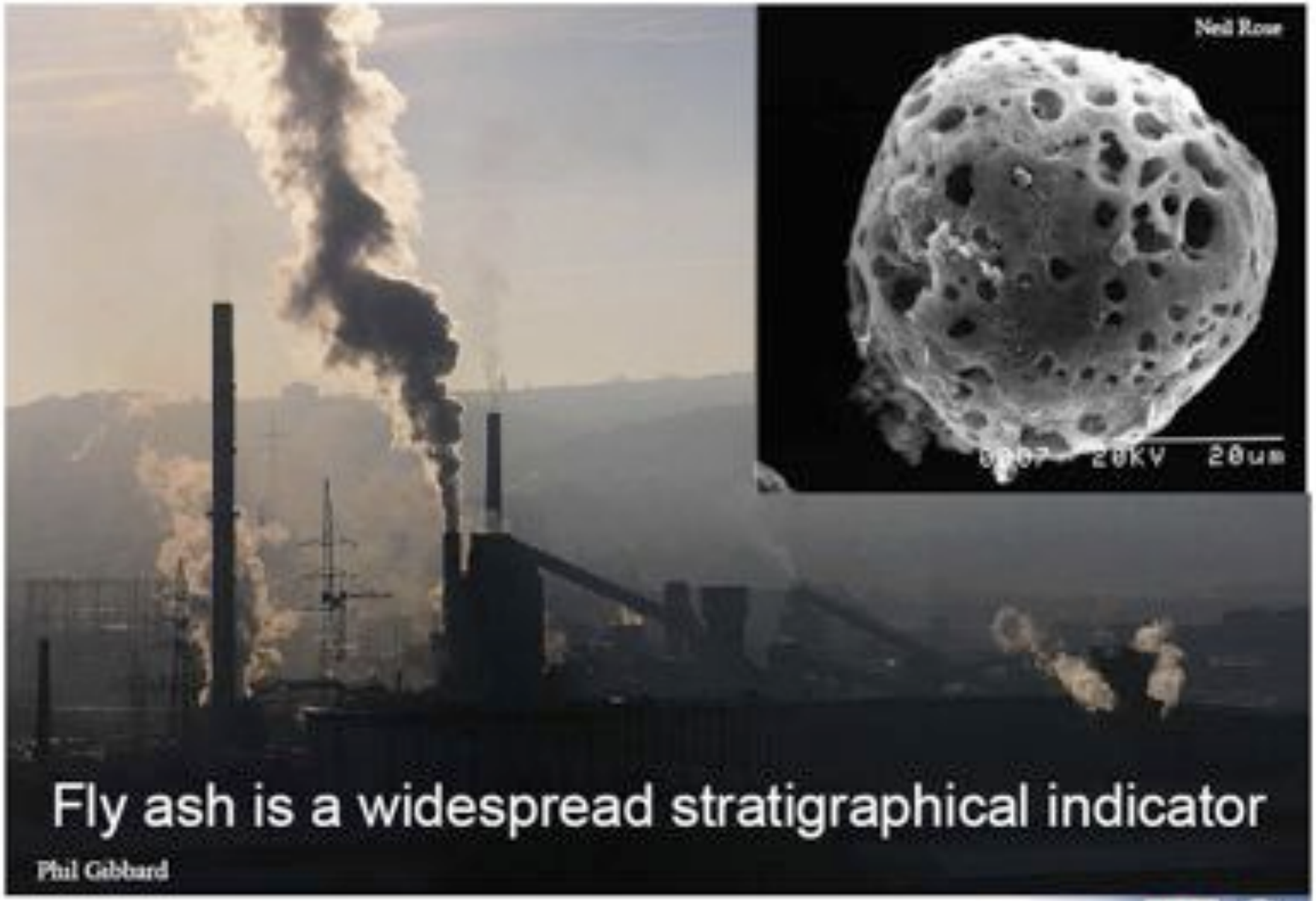
Novel organic polymers - plastics

Plastics are likewise forming part of stratigraphy



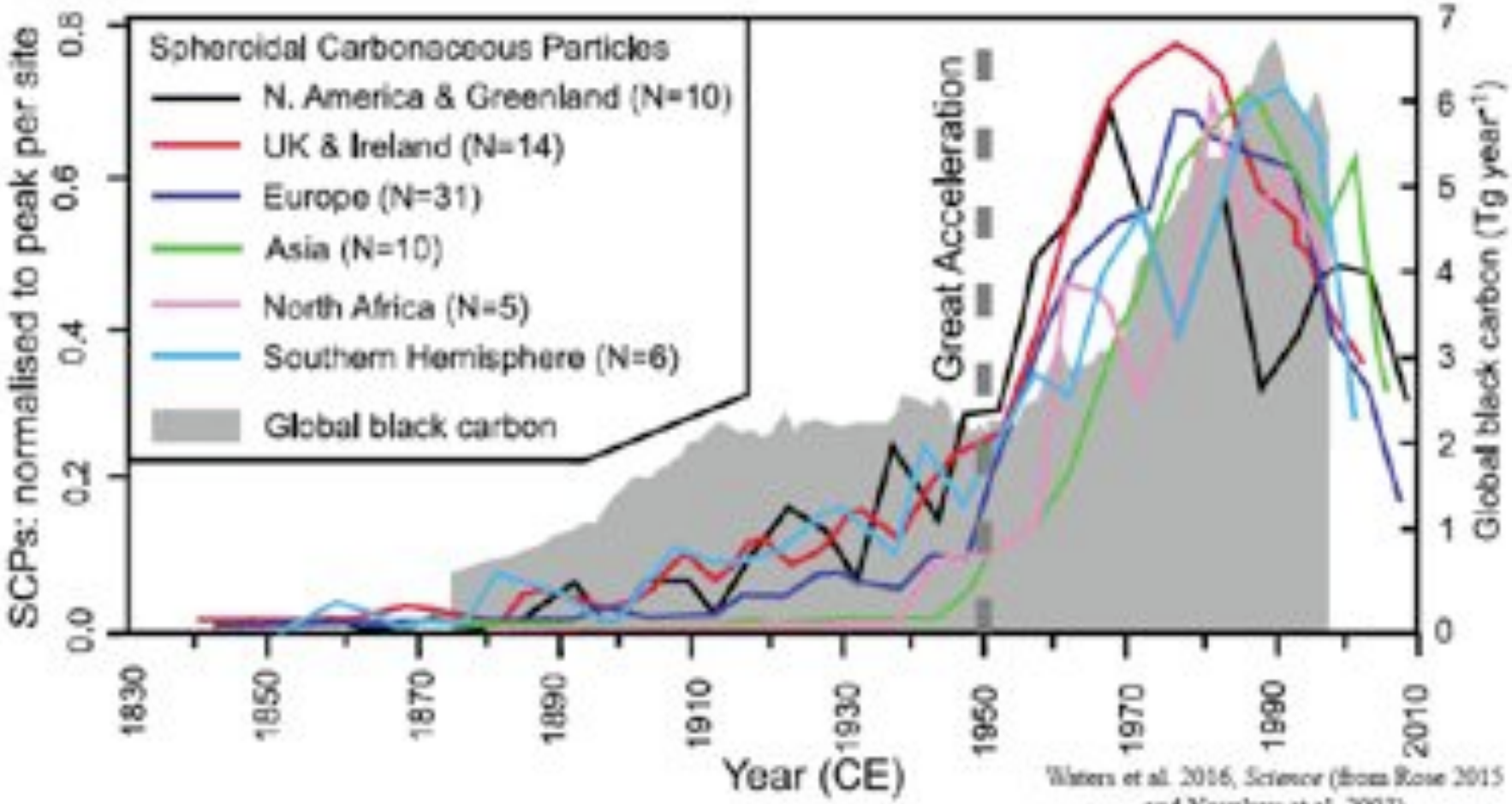
Plastics in the Ocean





Fly ash is a widespread stratigraphical indicator

Phil Gibbard

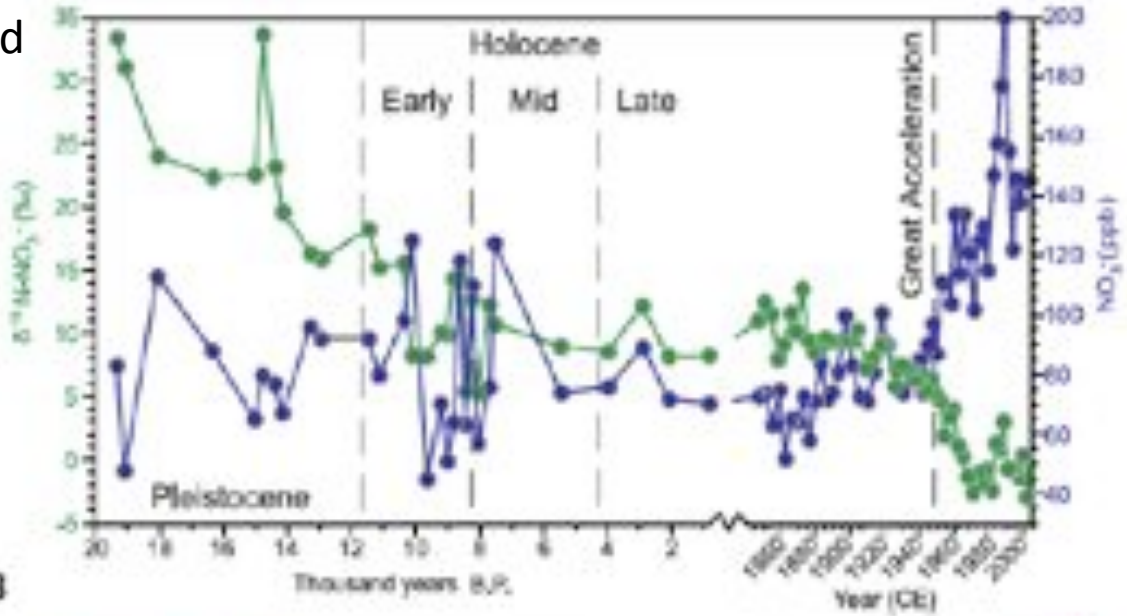


Waters et al. 2016, Science (from Rose 2015 and Novakov et al. 2003)

The fly ash signal locally begins ~1800 CE, with a sharp global upturn ~1950 CE

Perturbation of the Nitrogen Cycle

Greenland Ice signals

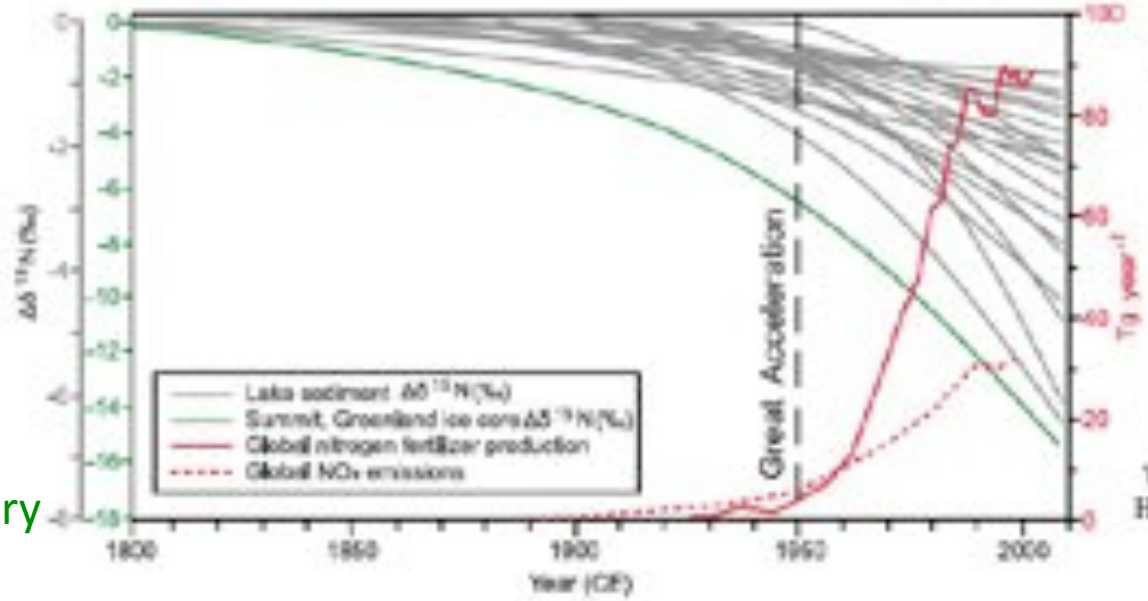


Perturbation of nitrogen cycle has roughly doubled reactive N at Earth's surface (with comparable perturbation of surface P)

Lakes

Ice Core

Relat Pre-Industry



May be recognised in ice and lake successions and cause marine dead zones

Waters et al. 2016 Science (from Holtgrieve et al., 2011; Holland et al. 2005; Wolff 2014)

NO_x emissions are from fossil fuel burning

Half the N in our bodies is artificial

USGS

Dreissena polymorpha (Zebra mussel)

Zebra mussel (Wikipedia)

Map created on 3/30/2011. United States Geological Survey

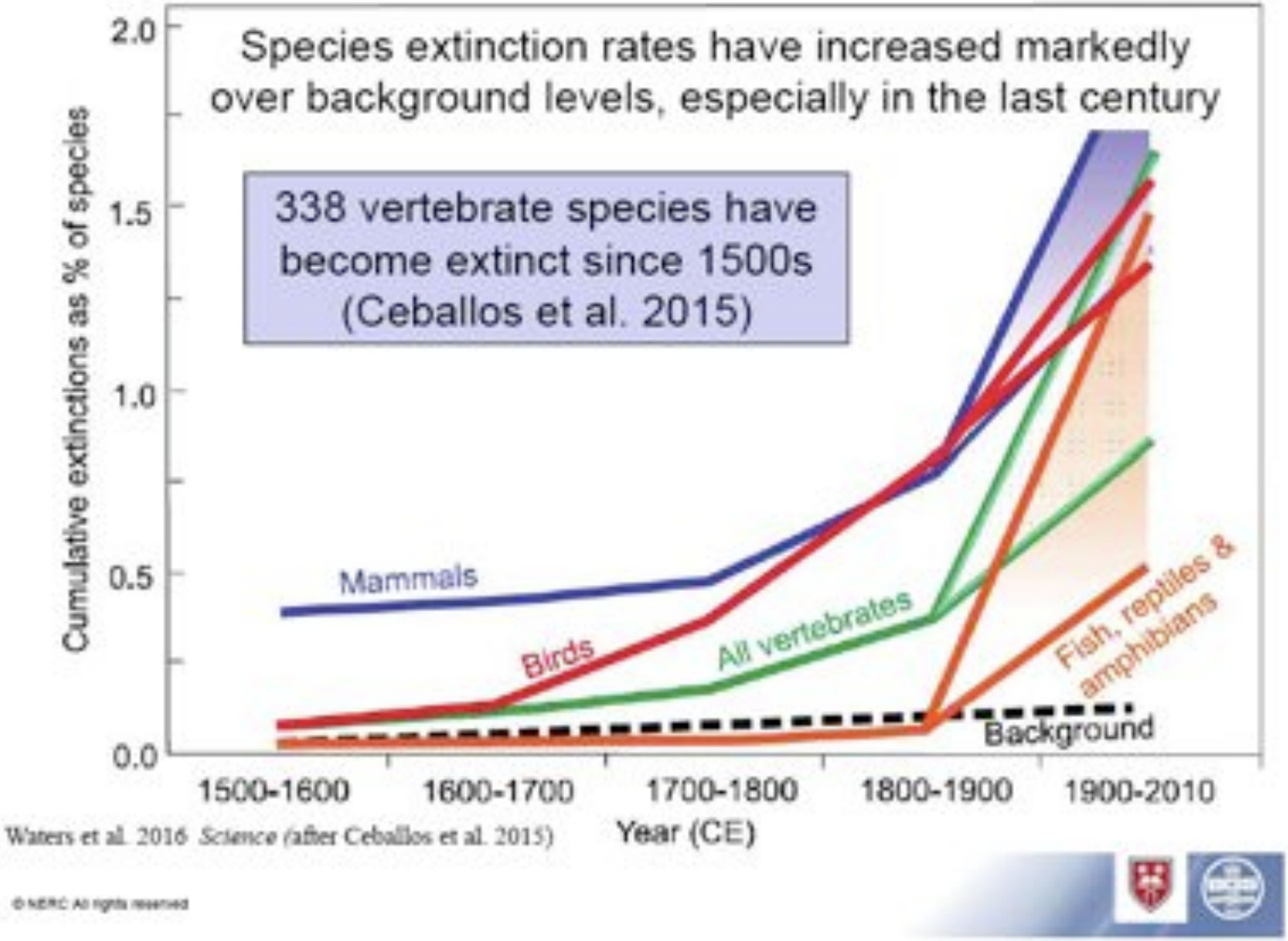
Species invasions are already at geologically unprecedented levels globally

Examples of Invasive Species

Country/Area	*Number of native species*	*Number of invasive species*
New Zealand (plants)	1,790	1,570
Hawaii (plants)	956	861
Hawaii (all species)	17,591	4465
Tristan de Cunha (plants)	70	97
Campbell Island (plants)	128	81
South Georgia (plants)	26	54
Southern Africa (FW fish)	176	52
California (FW fish)	83	50
USA (plants)	22,000	5,000

McNeely 2001, Land Use & Water Resources Research

Increasing Rates of Vertebrate Extinction



Dashed line is background rate of 2 E/MSY [extinctions per million species-years]

Assemblage changes

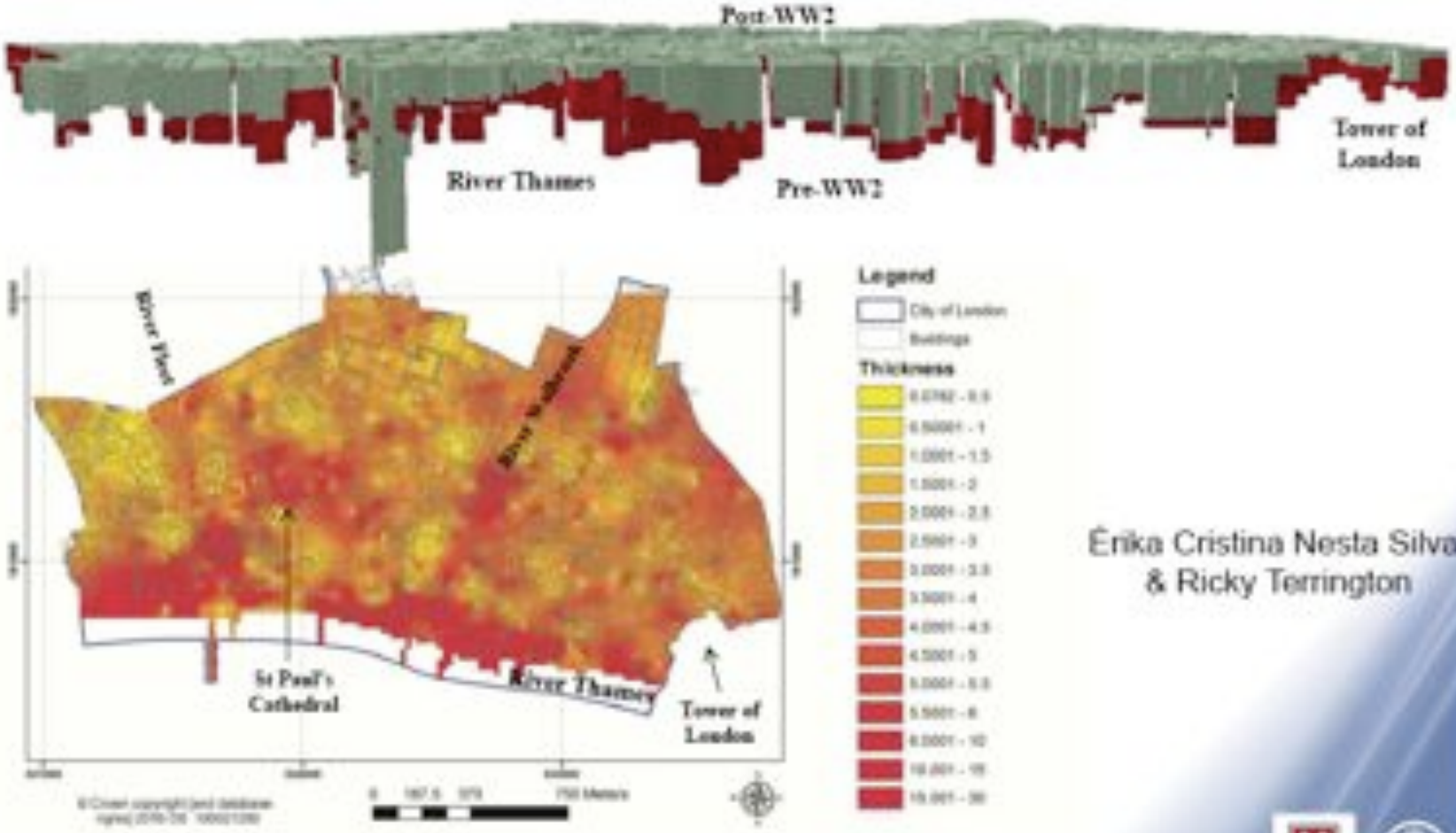
Domesticated animals
ca 65%

Humans
ca 32%

Vertebrate
wildlife
< 3%

Terrestrial vertebrate biomass (after Smil 2002)

Anthropogenic strata are extensive, mappable – and can be dated by their 'technofossil' content



Érika Cristina Nesta Silva
& Ricky Terrington

Technofossil diversity. Multiple ‘morphospecies’

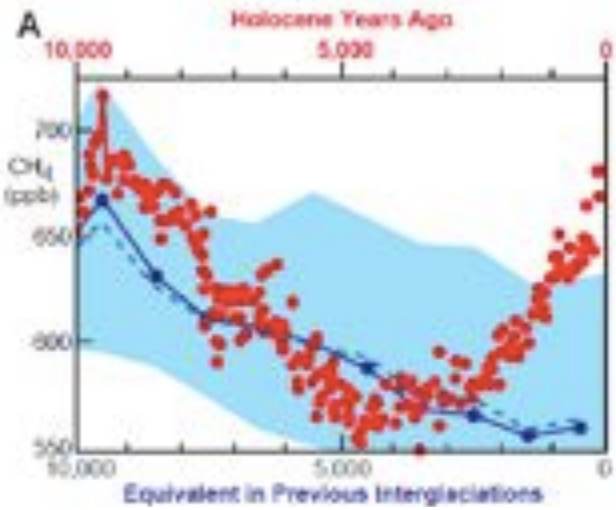
Perhaps a billion?

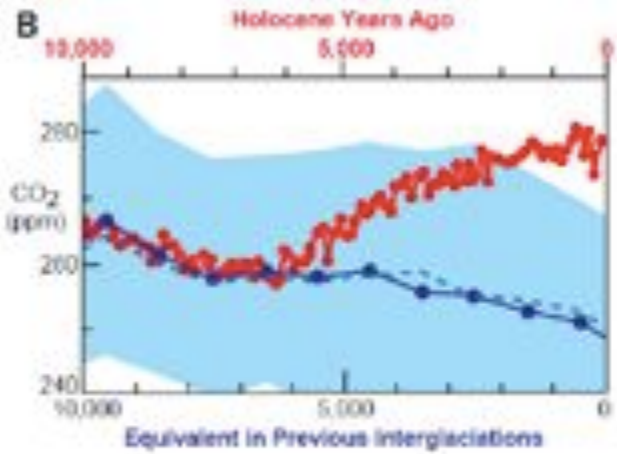
Plastic varieties allow high-resolution stratigraphy

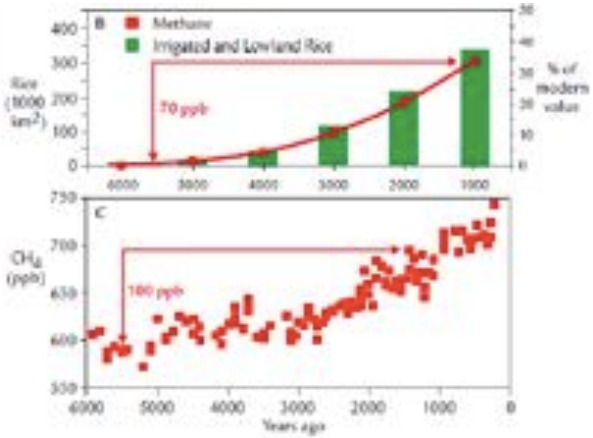
Zalasiewicz *et al.* 2016 Anthropocene

Anthropocene Climate Change

Rising Human Influence – the Lead-Into the Anthropocene





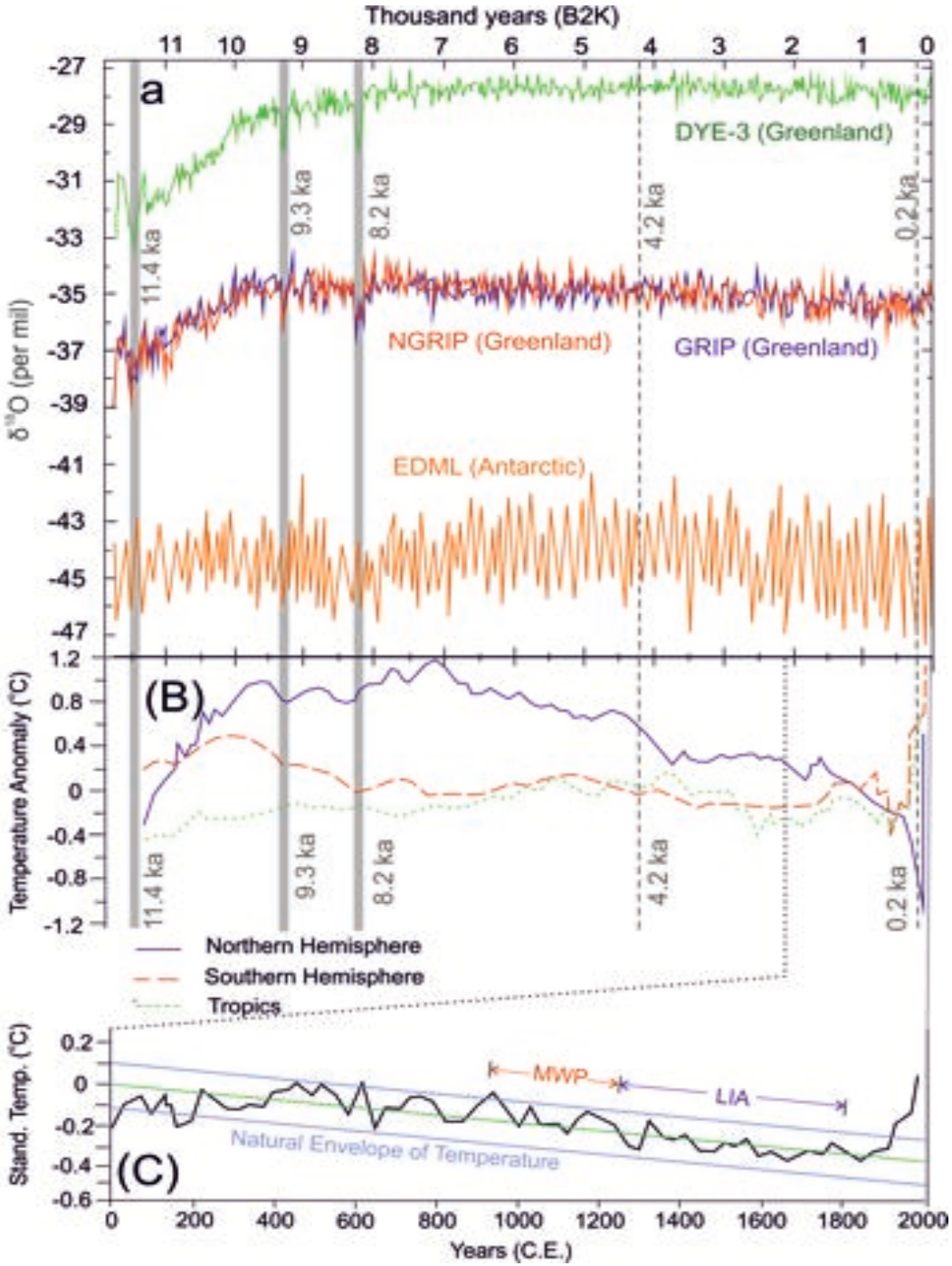


CO_2 from forest clearance?
CH_4 from rice culture?
Blue = all previous interglacials.

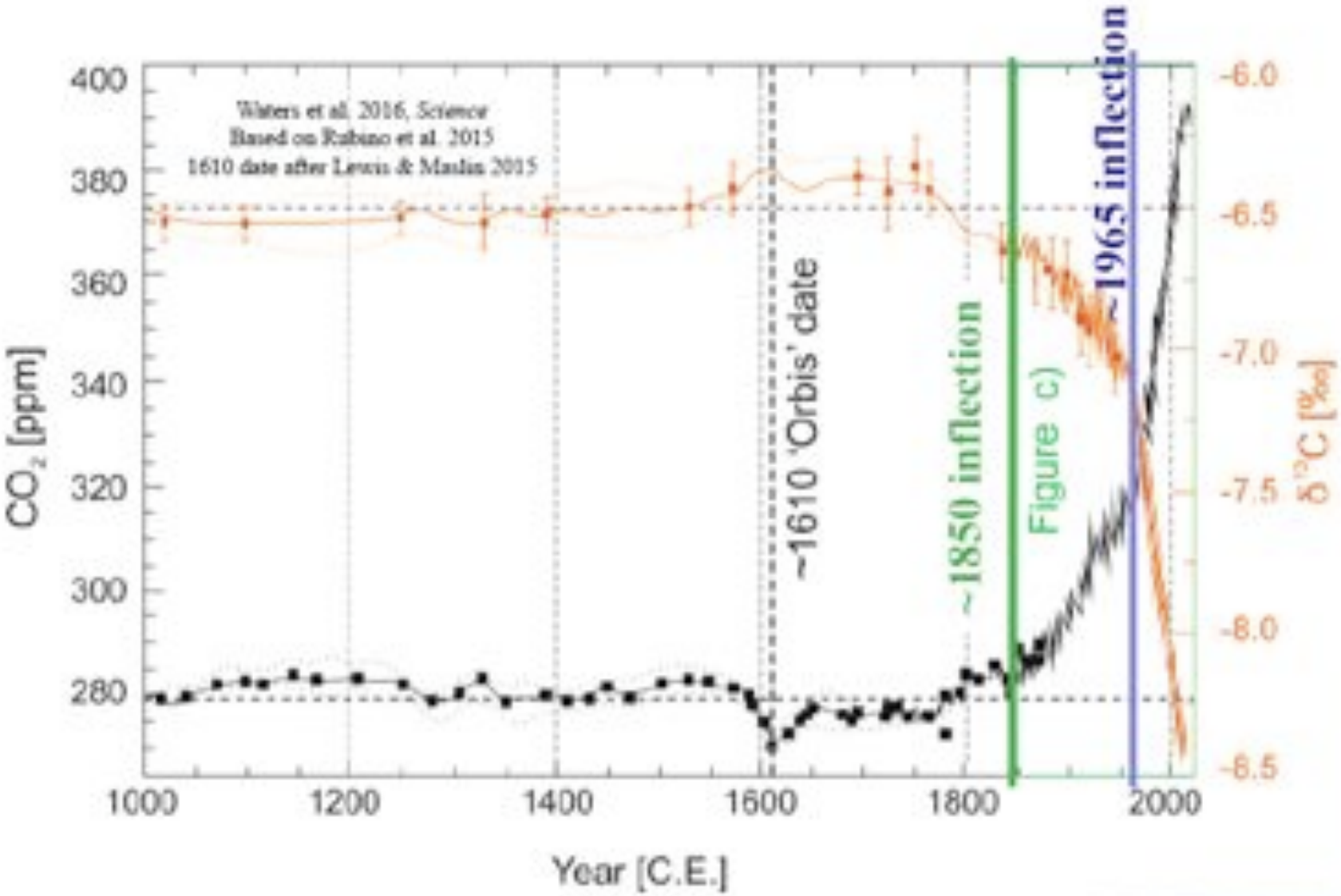
Ruddiman
et al., 2015

Global temperature has begun to depart from Holocene patterns (0.6°to 0.9°C rise from 1906-2005), and exceeded Peak Holocene interglacial Warmth in 2016.

Average global sea levels currently higher than at any point within the past ~115,000 years; 3.2 ± 0.4mm rise per year from 1993-2010.



Waters et al., Science 2016

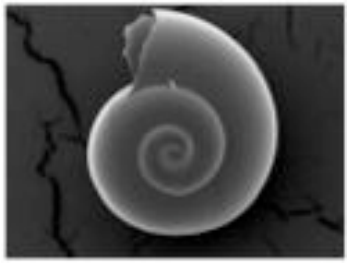


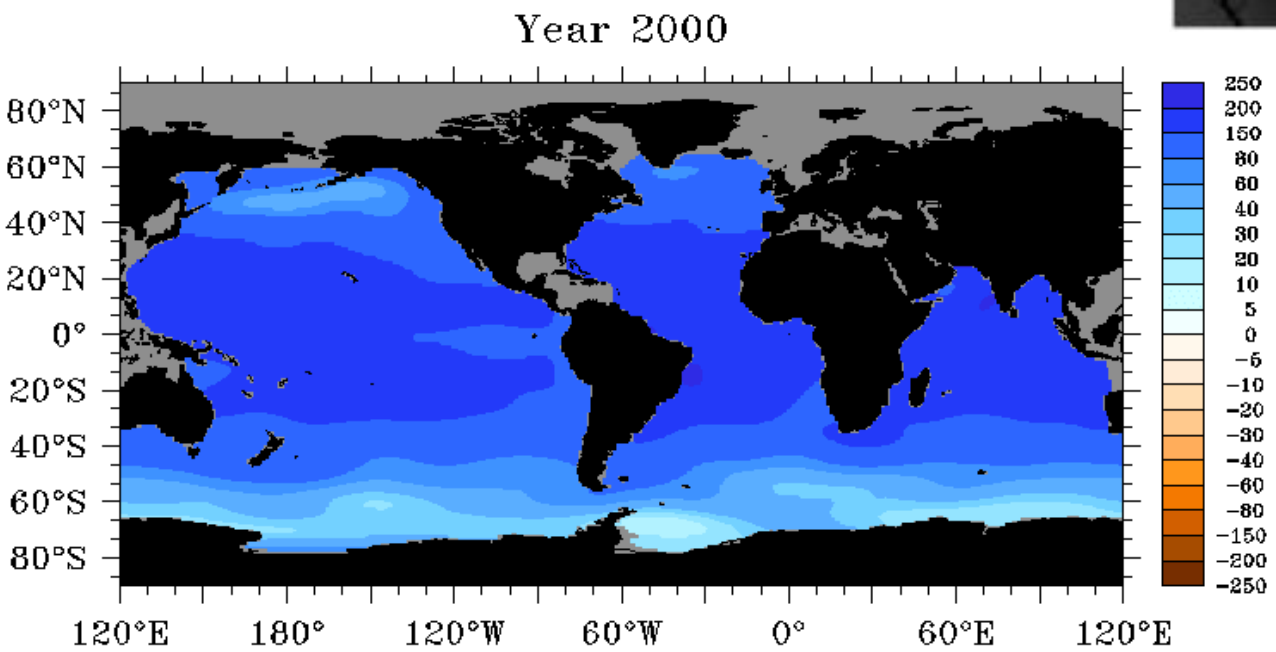
The rise is mirrored by stable carbon isotope trends

Boreal Forest Already Transforming

A Coral Free Planet?

Predicted Southern Ocean Acidification through the 21st ct.
% saturation in Aragonite ($CaCO_3$)





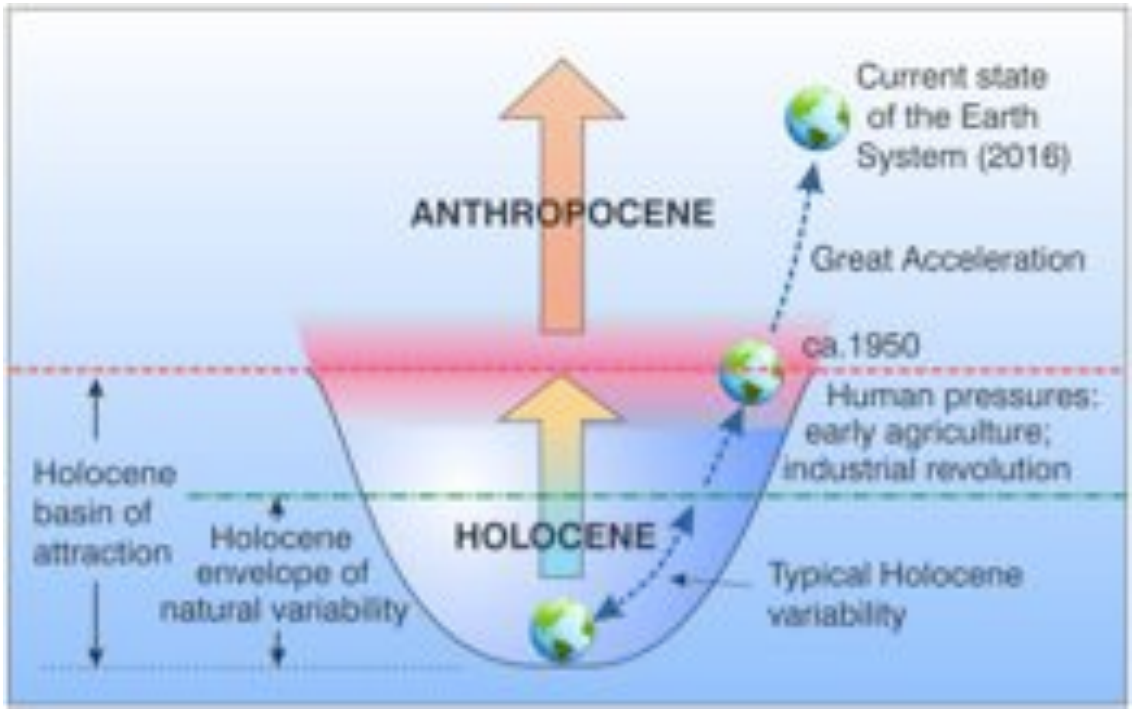
MESSAGE: Geology tells us that the great global extinctions of life took place when vast volcanic eruptions poured CO_2 into the air and ocean. Corals died out and were later replaced by new coral species. The rates of supply of CO_2 were slower than ours.

Orr et al. 2005

WELCOME TO THE ANTHROPOCENE

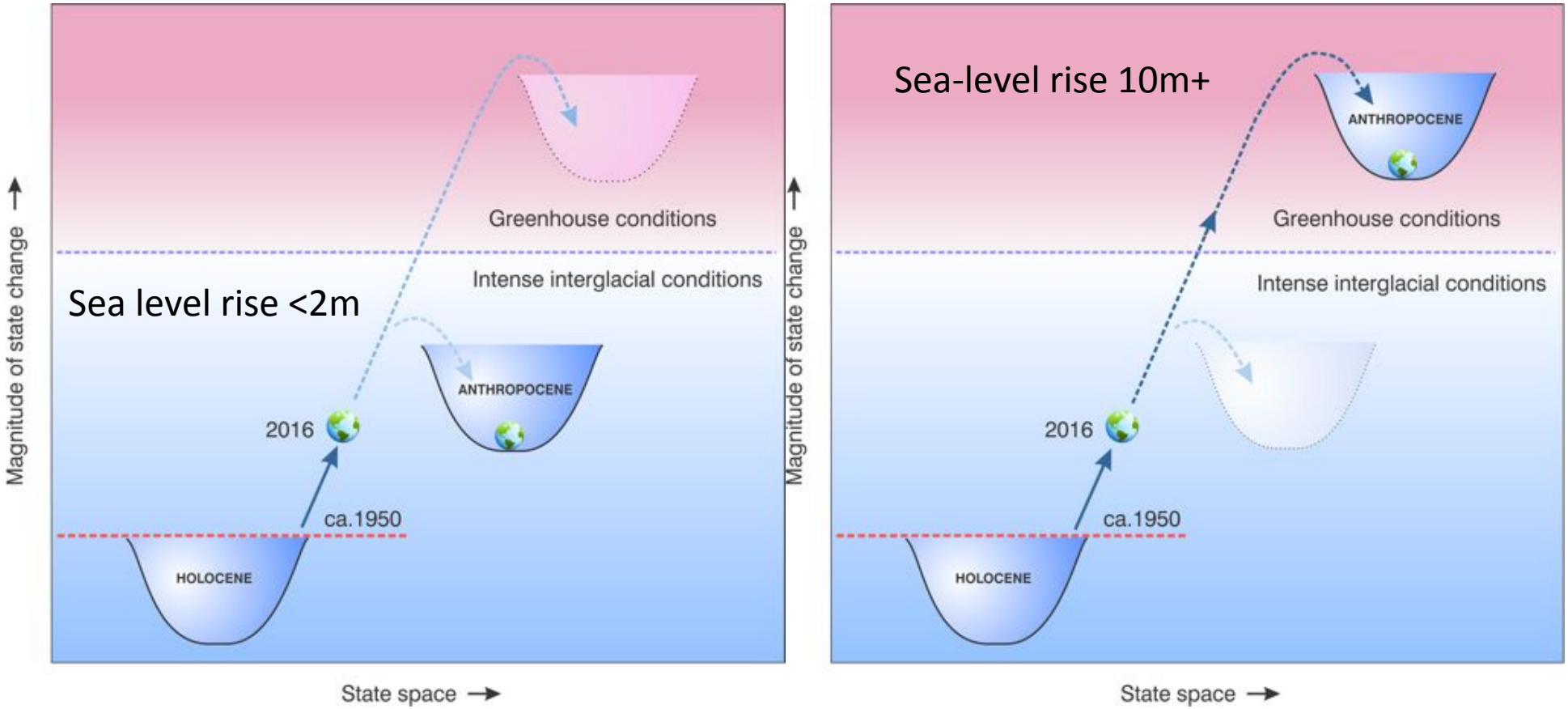
Humans have become a Geological Force

We are heading into a New Geological Dimension



Steffen et al 2016

Where do you want to end up?
(Choose Your Future Climate State)



Keep temperature rise to <2°C? OR Allow it to reach >3-5°C

Steffen et al 2016

CHOICE IS ABOUT POLITICS!!!