The role of carbon in climate change: a life-cycle-thinking approach to a complex issue

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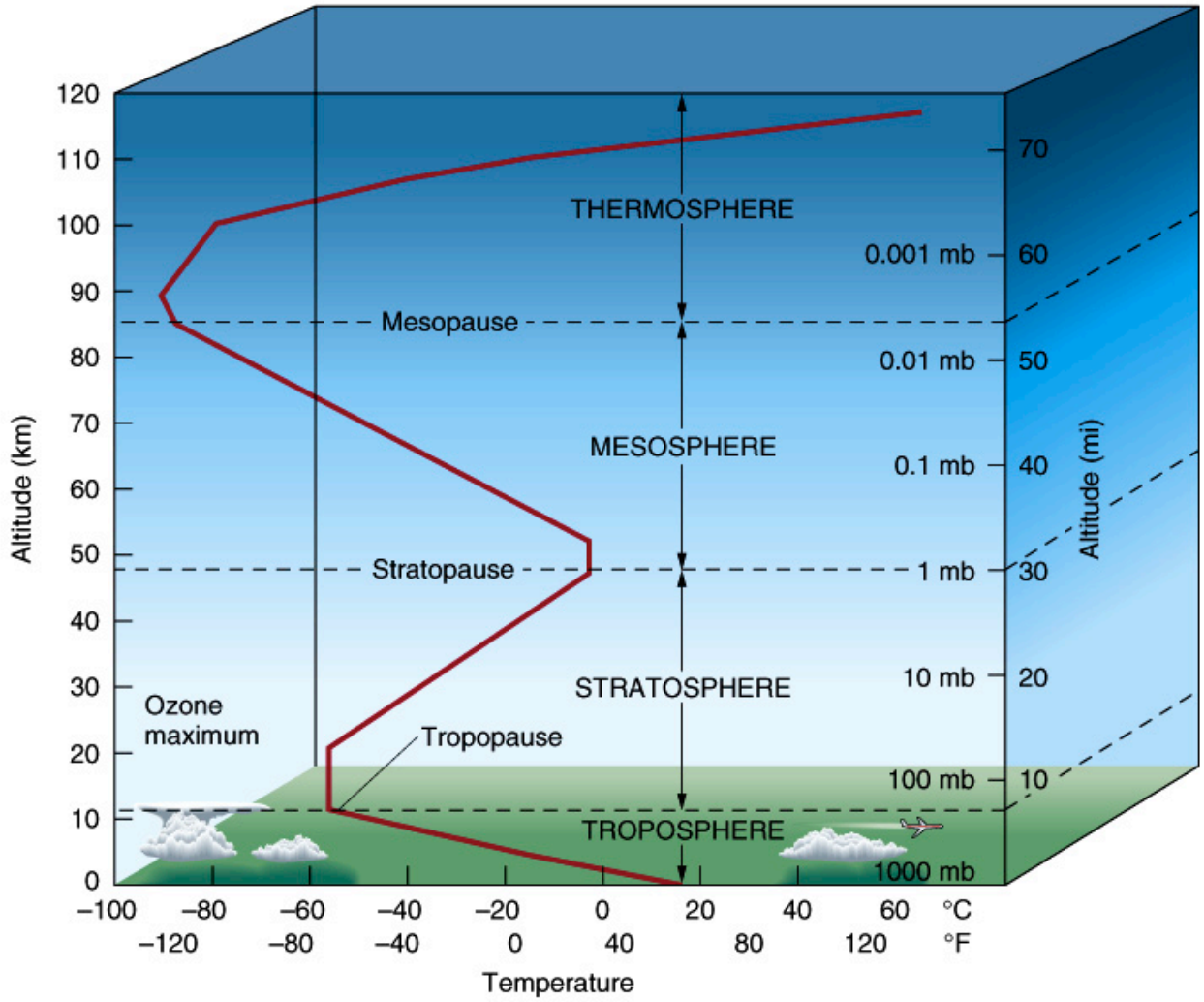
20th December 2012

United Nations Educational, Scientific and Cultural Organization

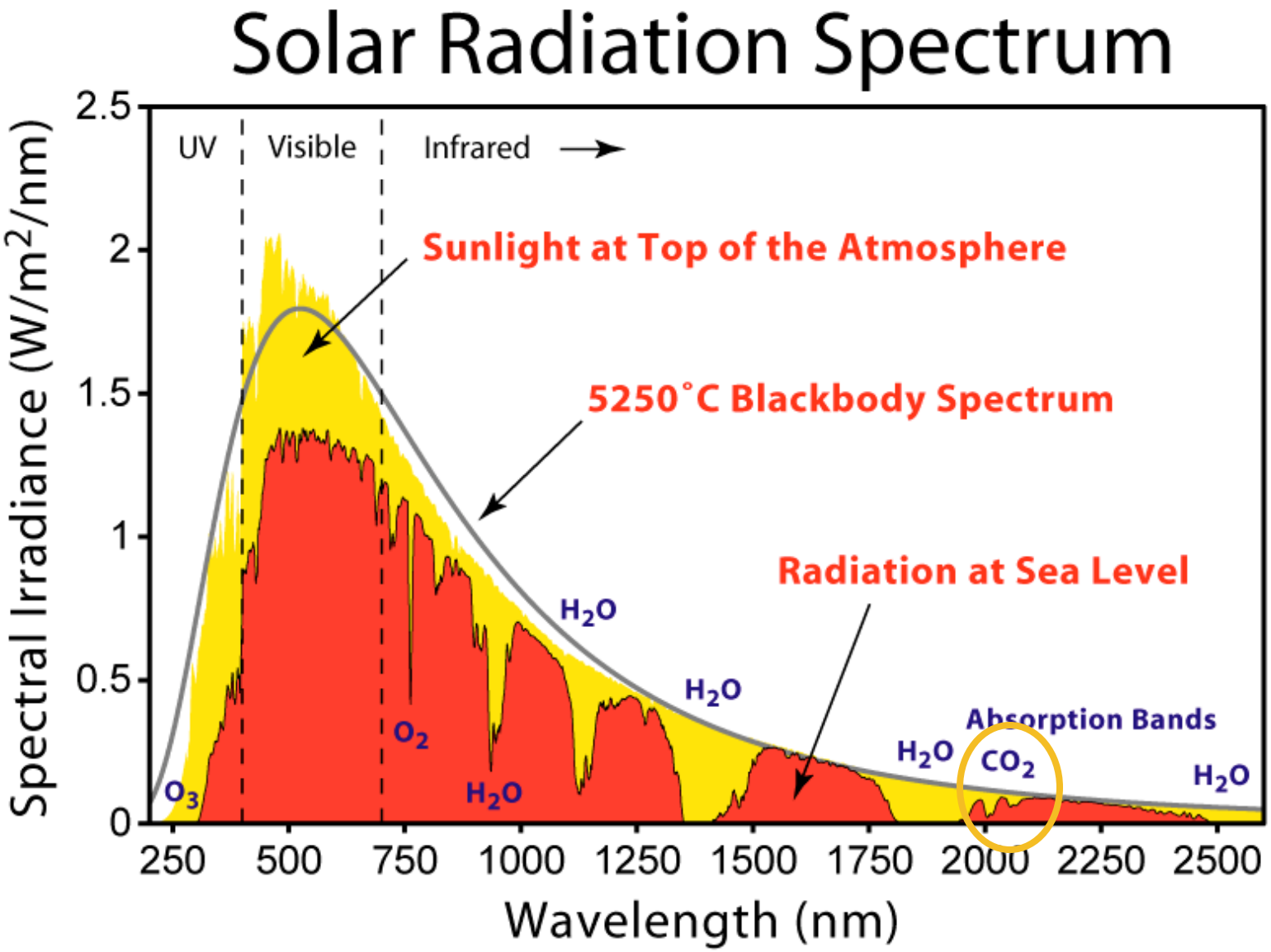
UNESCO Chair in Life Cycle and Climate Change

UNIVERSITAT POMPEU FABRA

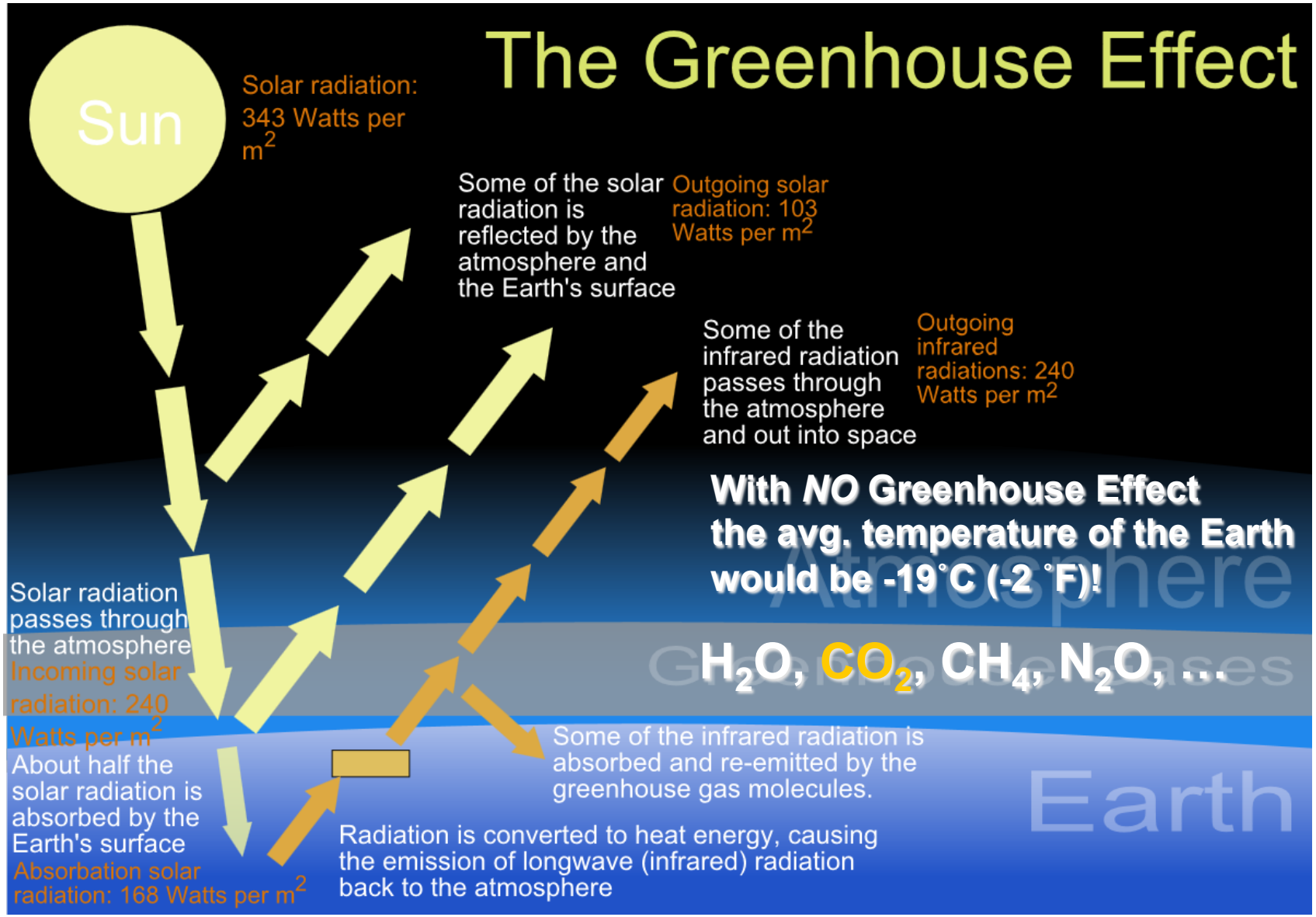
The Earth's atmosphere



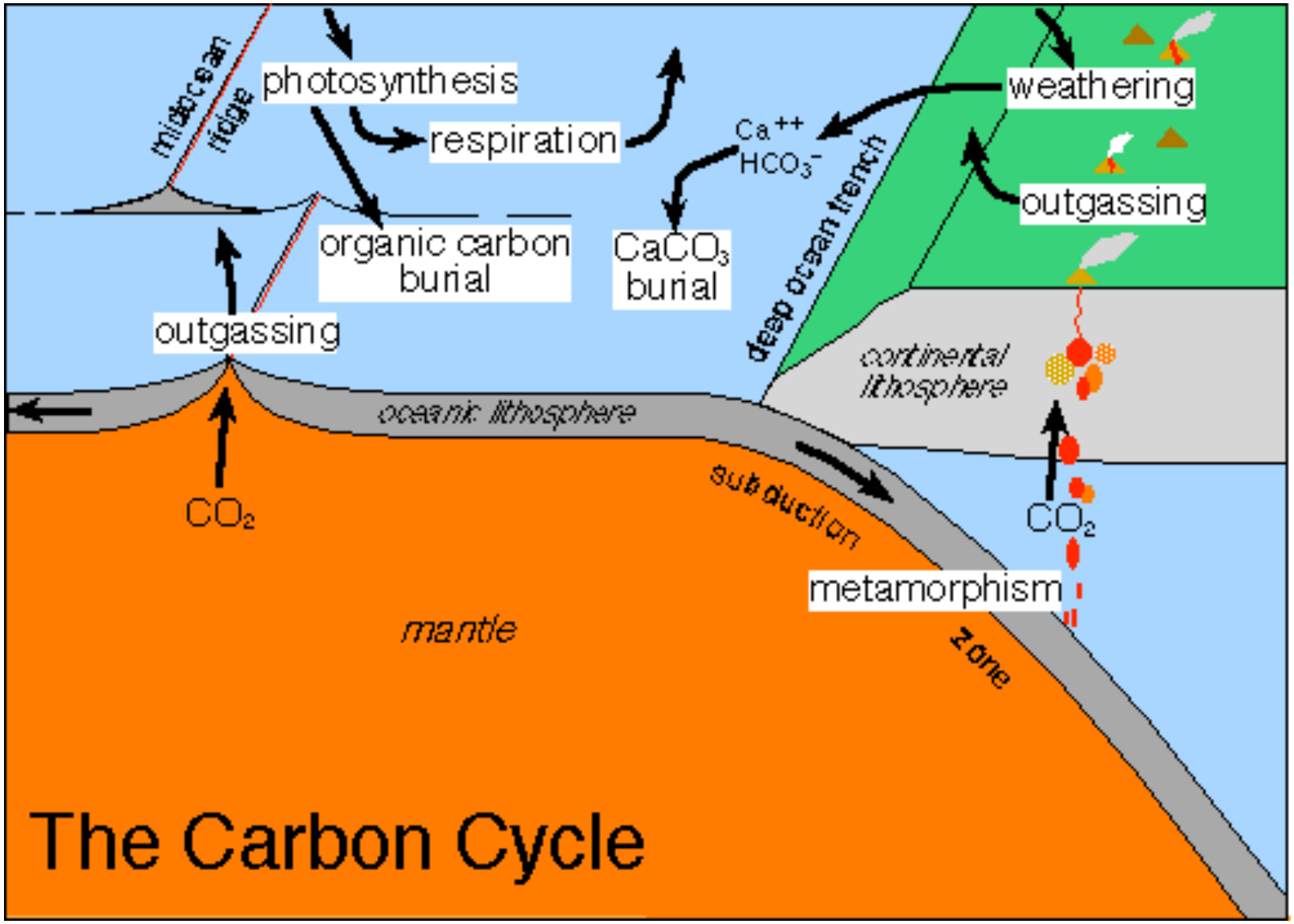
Solar Radiation



The Greenhouse Effect



The Carbon Cycle



The Carbon Cycle

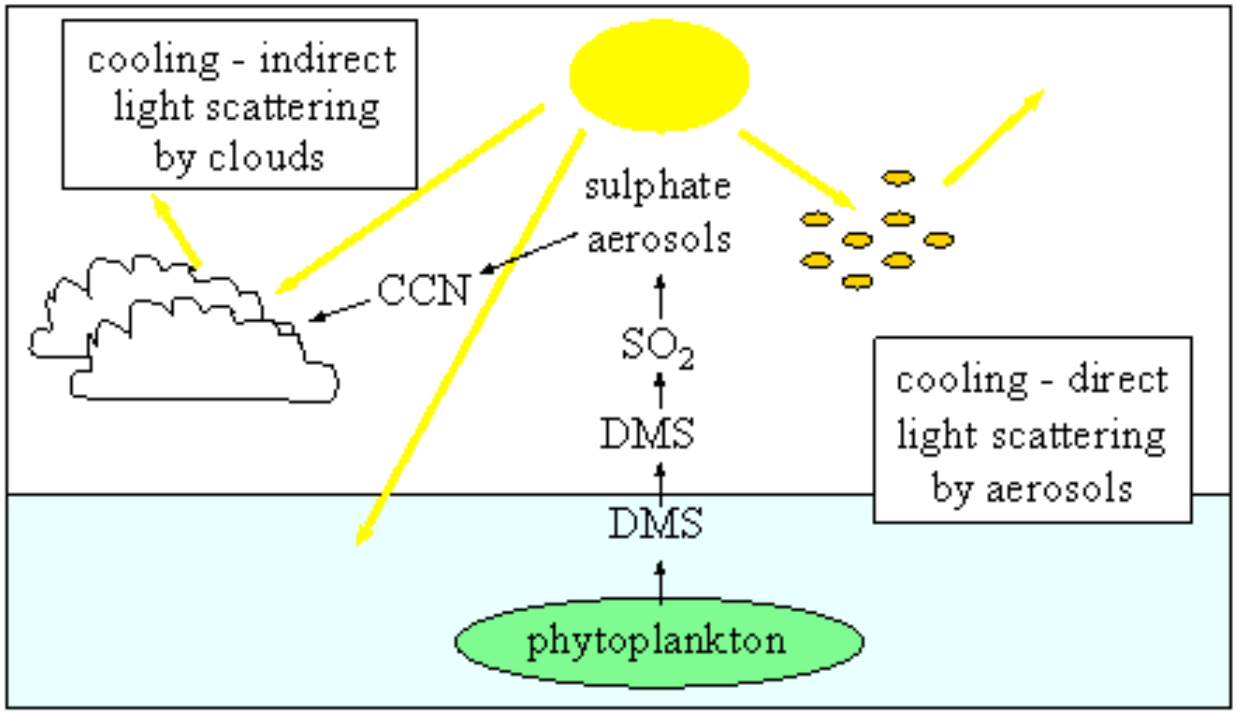
Exchange pool:

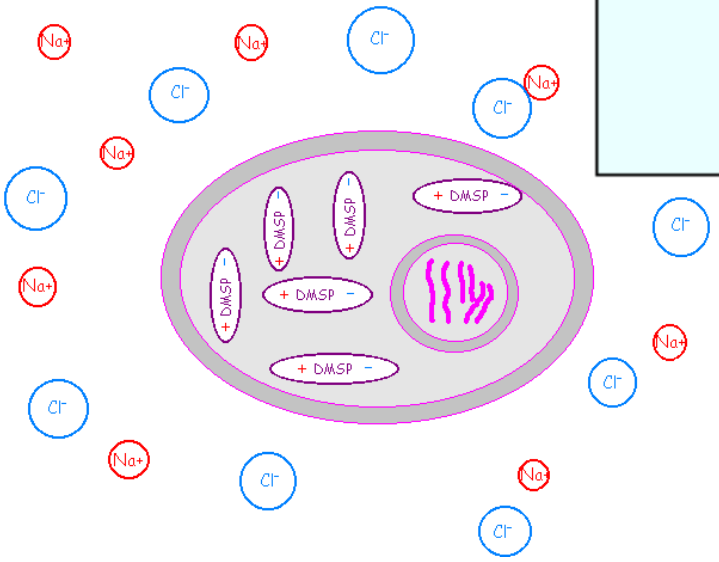
- The primary source of **carbon** to the atmosphere is **outgassing** from the Earth's interior at mid-ocean ridges, hotspot volcanoes, and subduction-related volcanic arcs.
  - Some of the outgassed carbon **remains as CO_2 in the atmosphere**
  - Some is **dissolved in the oceans as HCO_3^-**
  - Some is **fixed by photosynthesis as biomass**

Reserve pool:

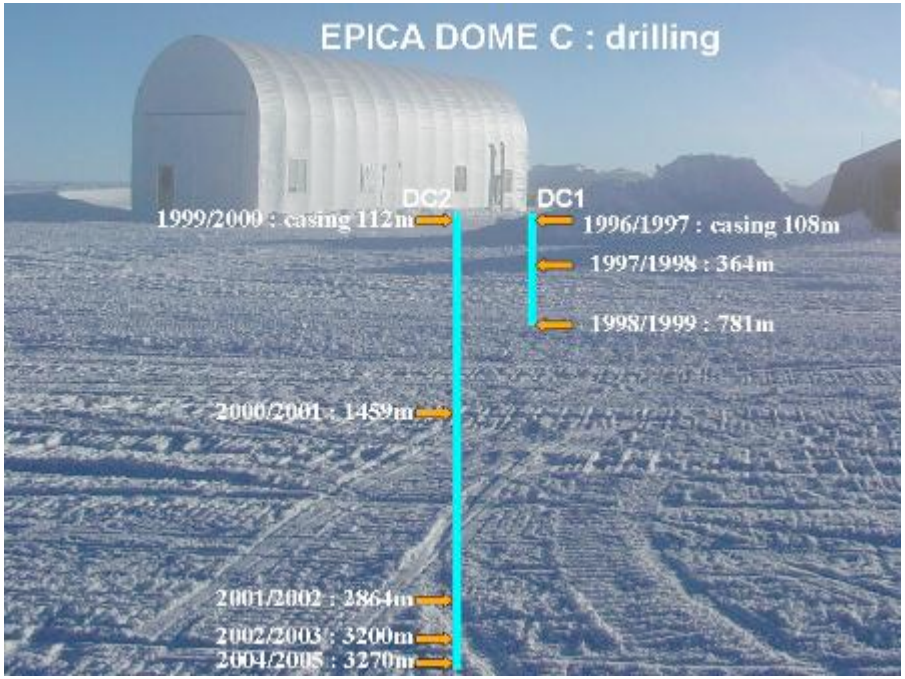
- Carbon is *slowly* removed into **long-term storage** through
  - **Pedogenesis** (soil formation)
  - **Fossil fuel formation** (especially coal and black shales)
  - **Sedimentary carbonate rock formation** (largely biogenic)

Homeostatic climate control





Climate records



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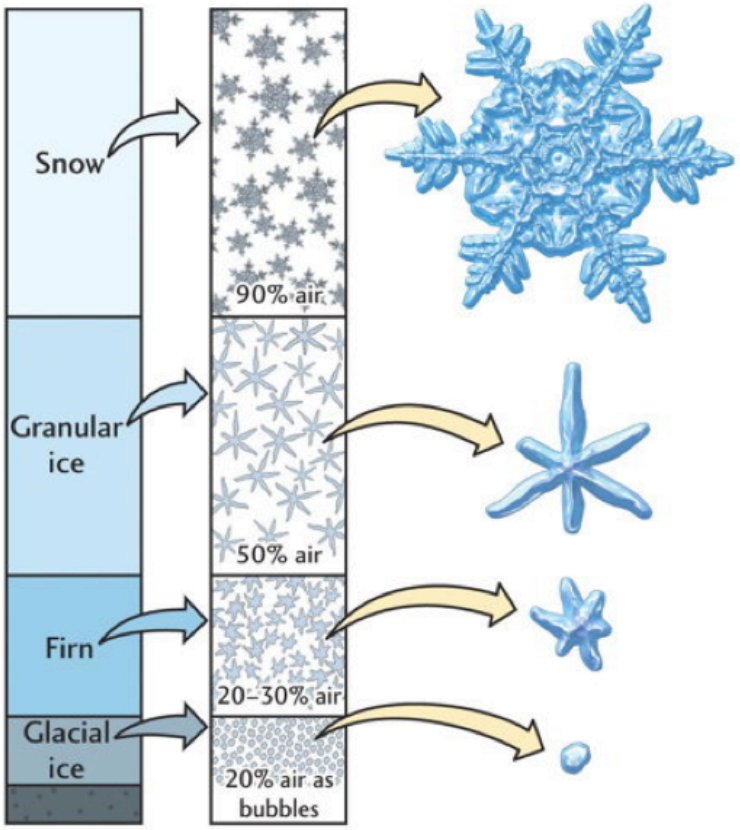

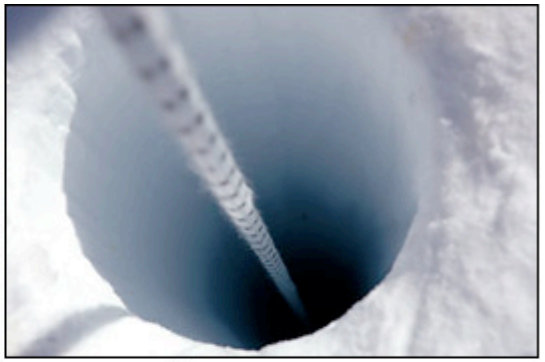

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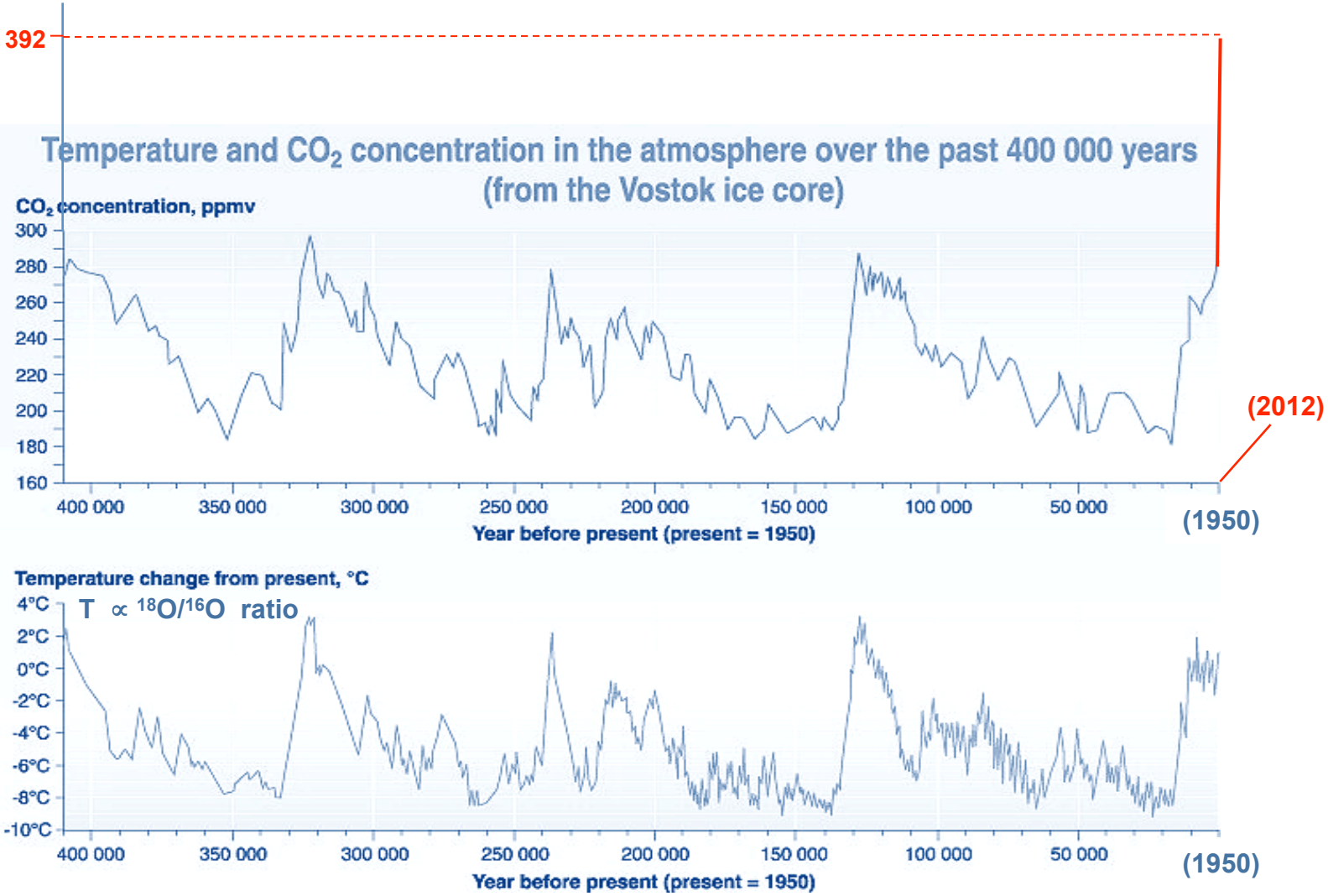
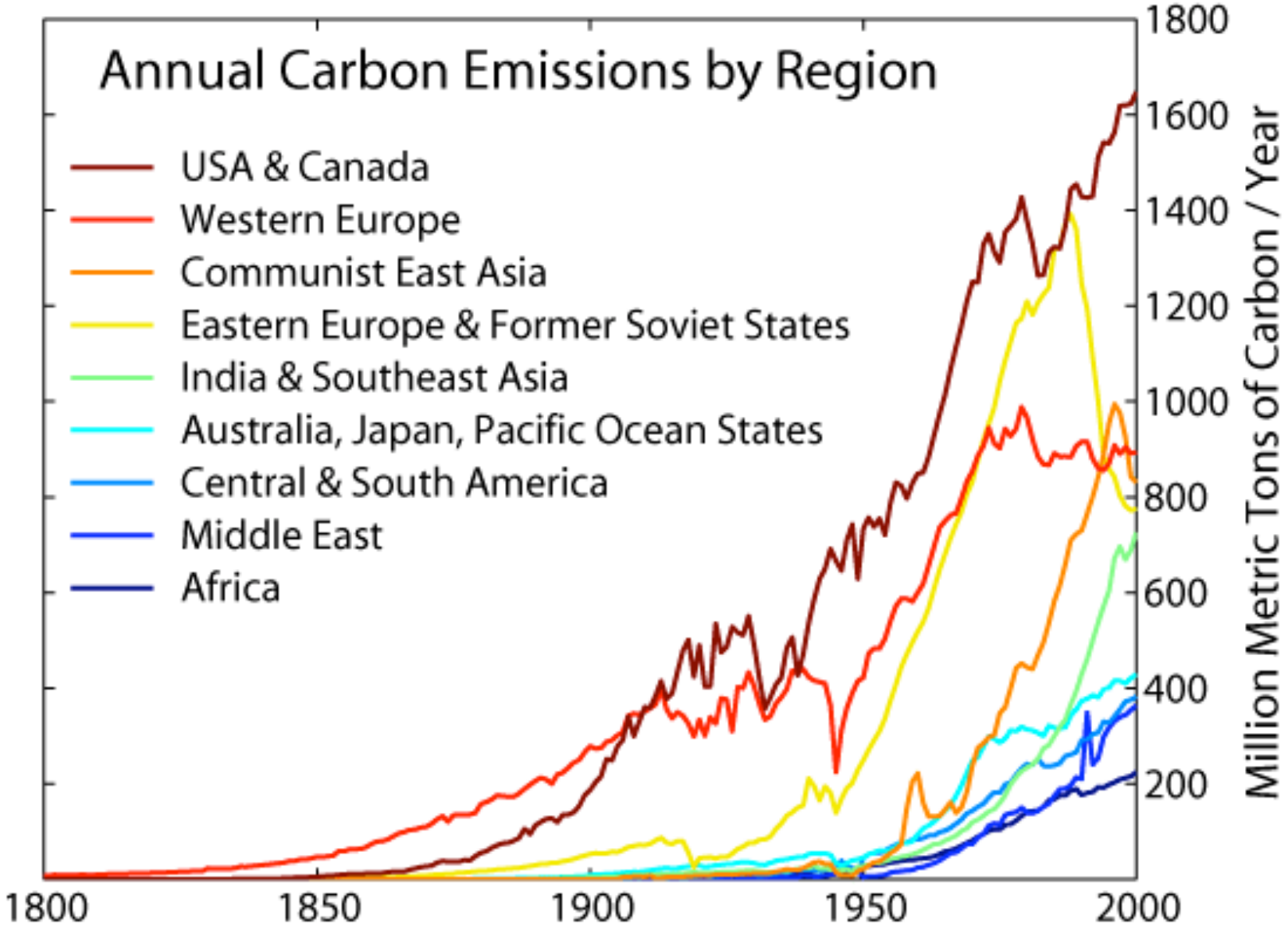


Source: J.R. Petit, J. Jouzel. et. al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, *Nature* **399**, pp 429-436, 1999

Anthropogenic carbon emissions



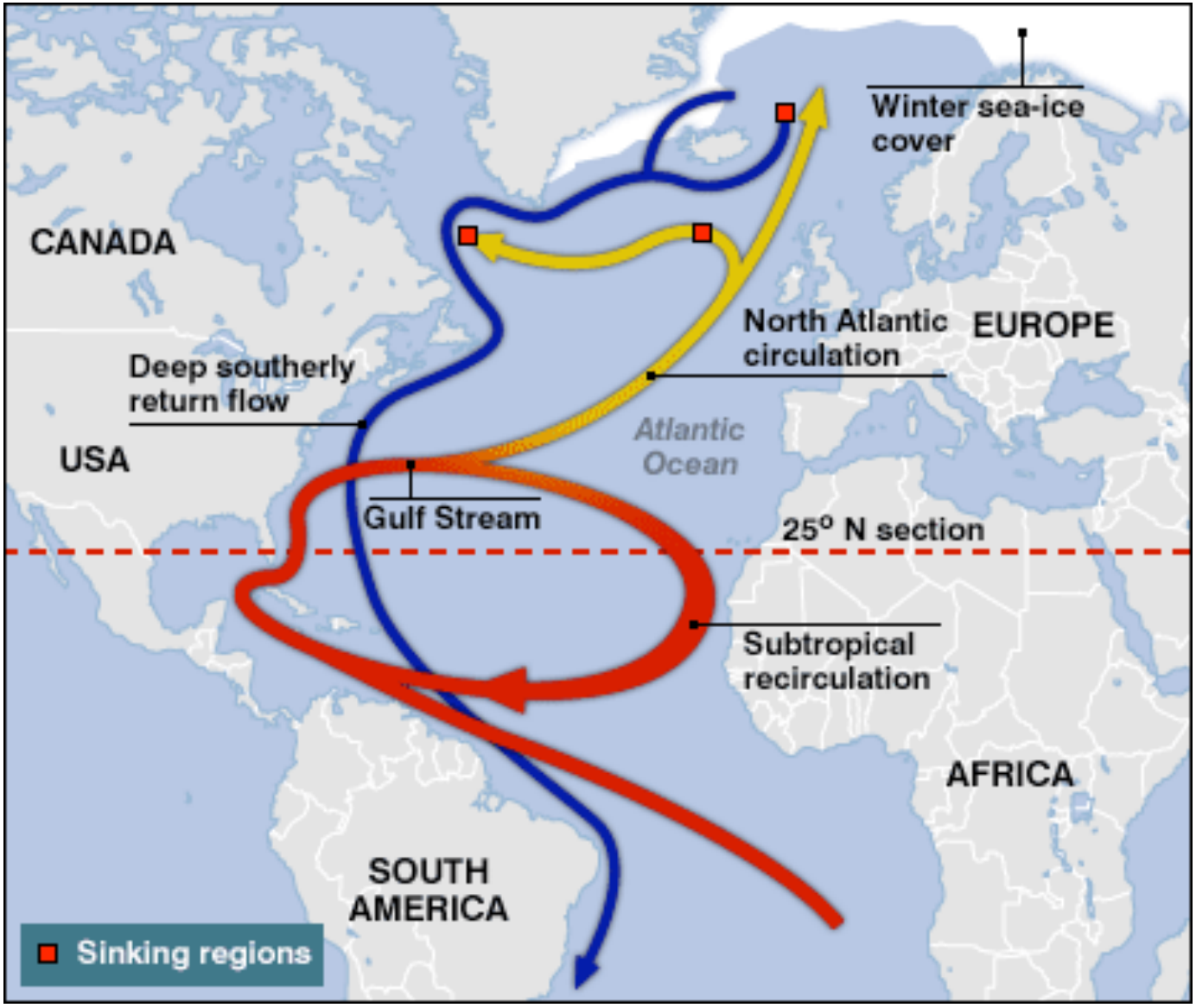
Fossil fuel burning

Deforestation

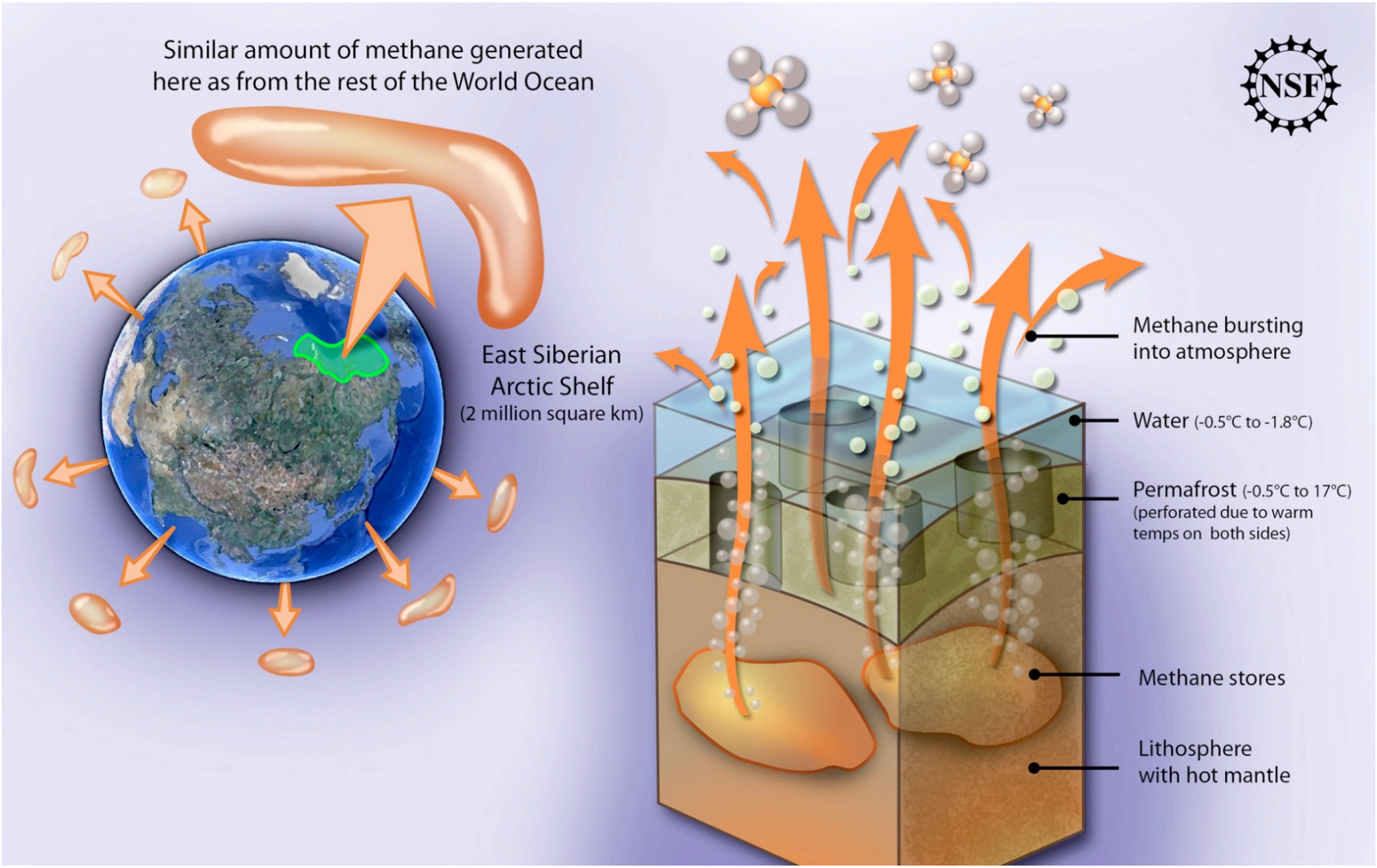
Soil erosion

Cattle husbandry

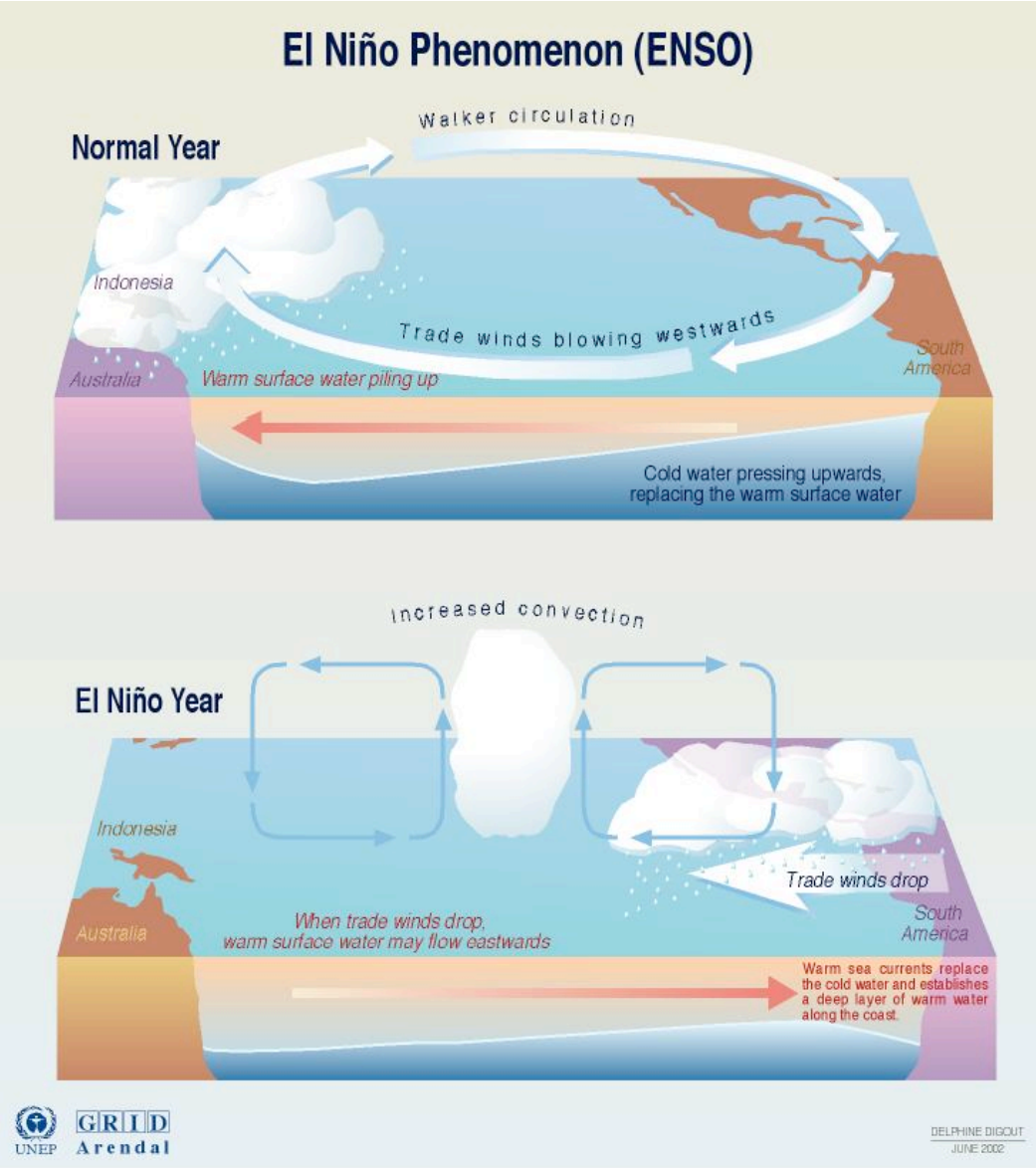
Non-linearity and unpredictability: Oceanic 'conveyor belts'



Non-linearity and unpredictability: Arctic methane



Non-linearity and unpredictability: El Niño Southern Oscill.



Sources: Climate Prediction Center-NCEP; NOAA.

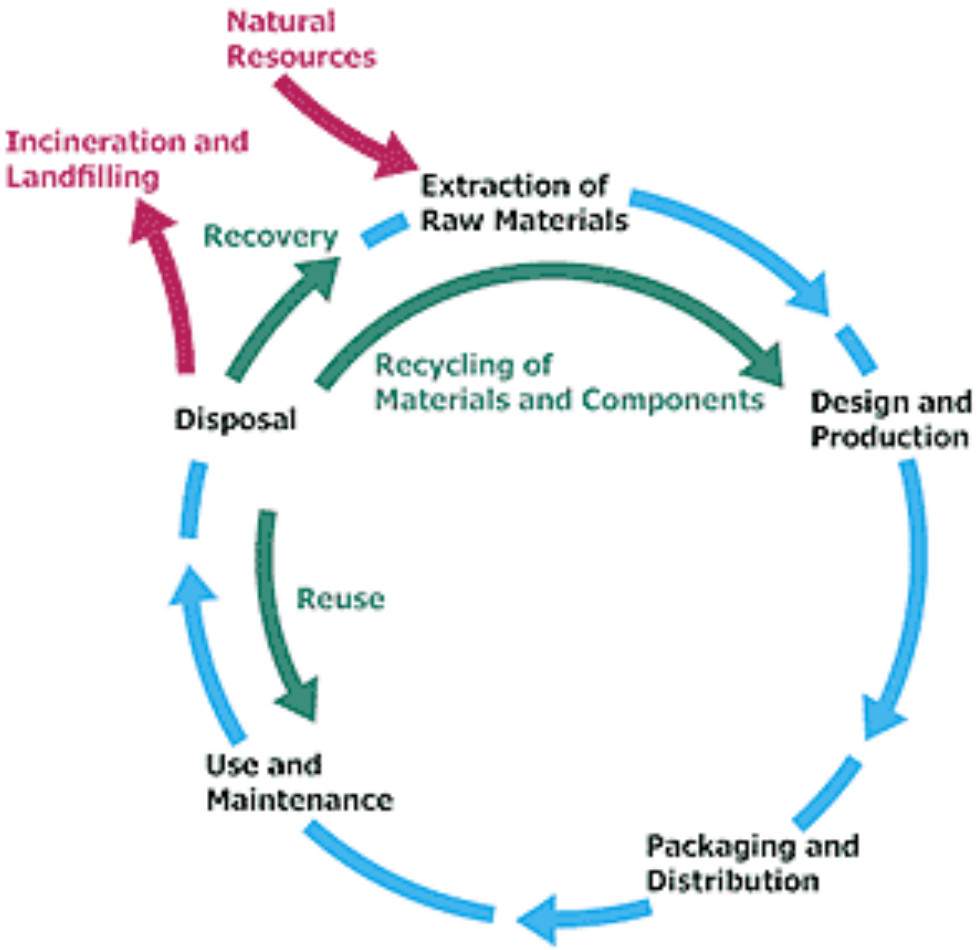
Two possible reactions

1. **Anosognosia** *(noun):*
   Real or feigned ignorance of the presence of disease.

2. **Precautionary principle**:
   "if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is *not* harmful falls on those taking the action".

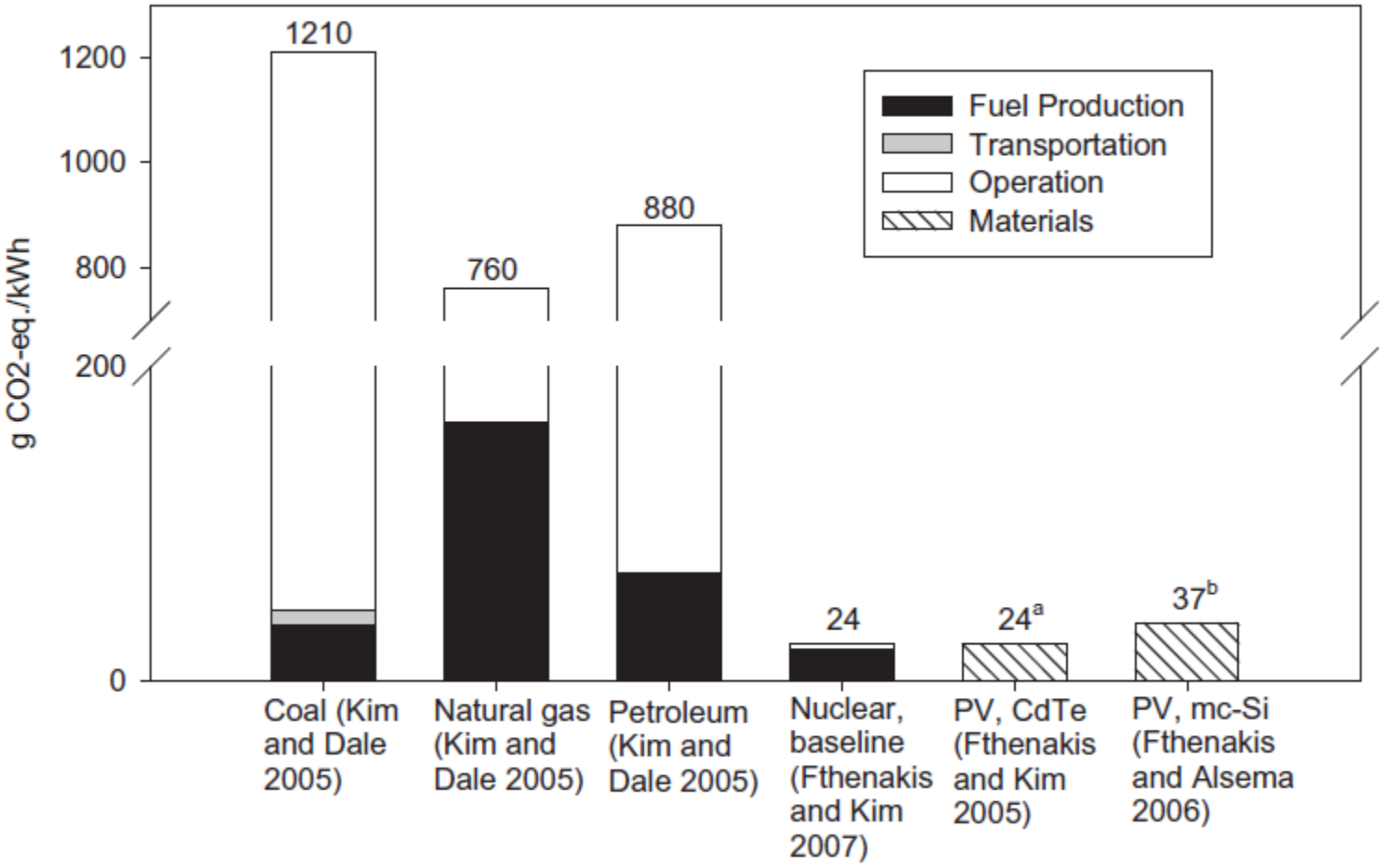
- In some legal systems, as in the *law of the European Union*, the application of the precautionary principle has been made a statutory requirement.

Technological fixes: the importance of Life Cycle Thinking



Technological fixes: the importance of Life Cycle Thinking

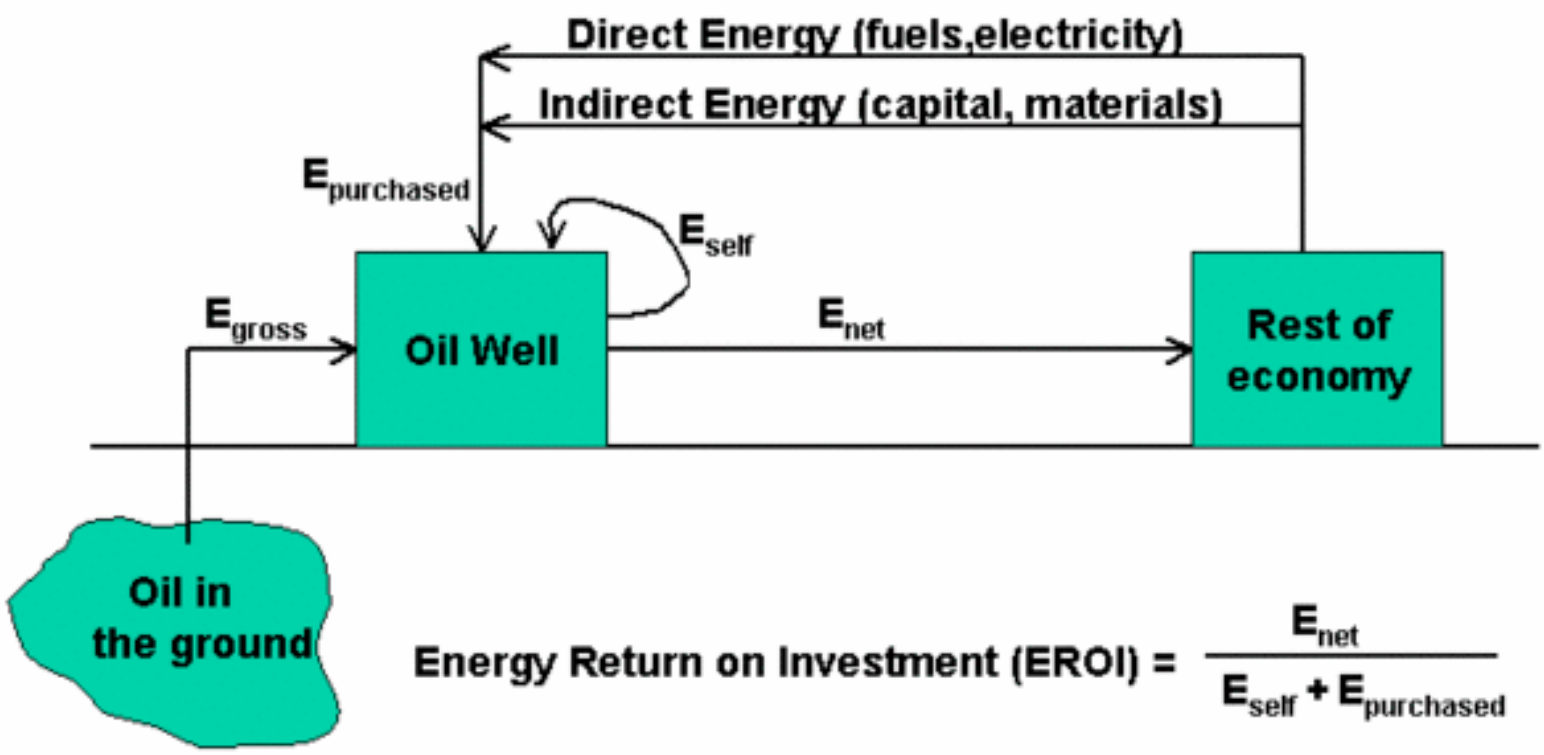
- The search for alternative (*less carbon-intensive*) energy sources…



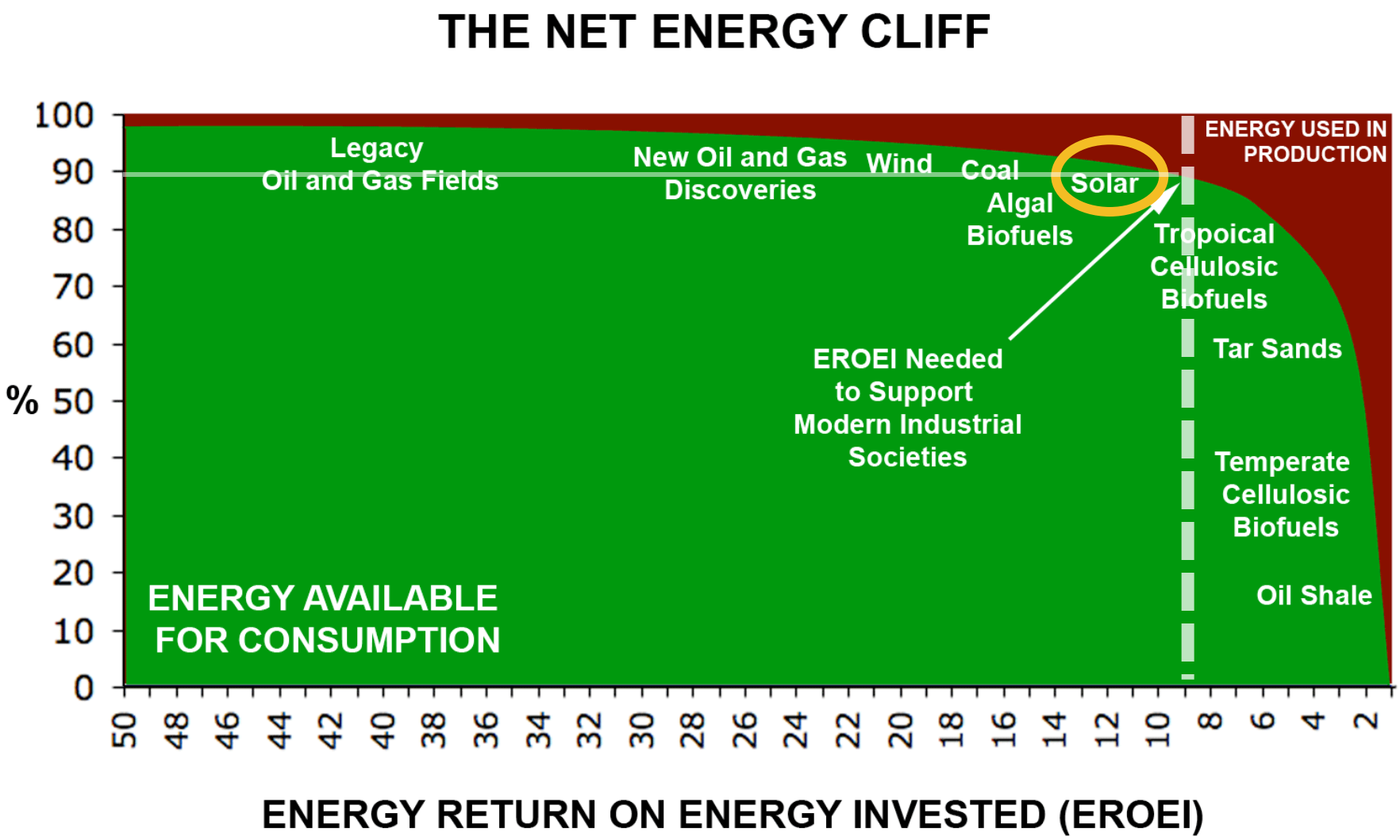
Technological fixes: the importance of Life Cycle Thinking

- The search for alternative (*less carbon-intensive*) energy sources…

  …must obey the laws of physics!



Technological fixes: the importance of Life Cycle Thinking



EROI of Photovoltaics: new calculations

Energy Policy 45 (2012) 576–582

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The energy return on energy investment (EROI) of photovoltaics: Methodology and comparisons with fossil fuel life cycles

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ARTICLE INFO

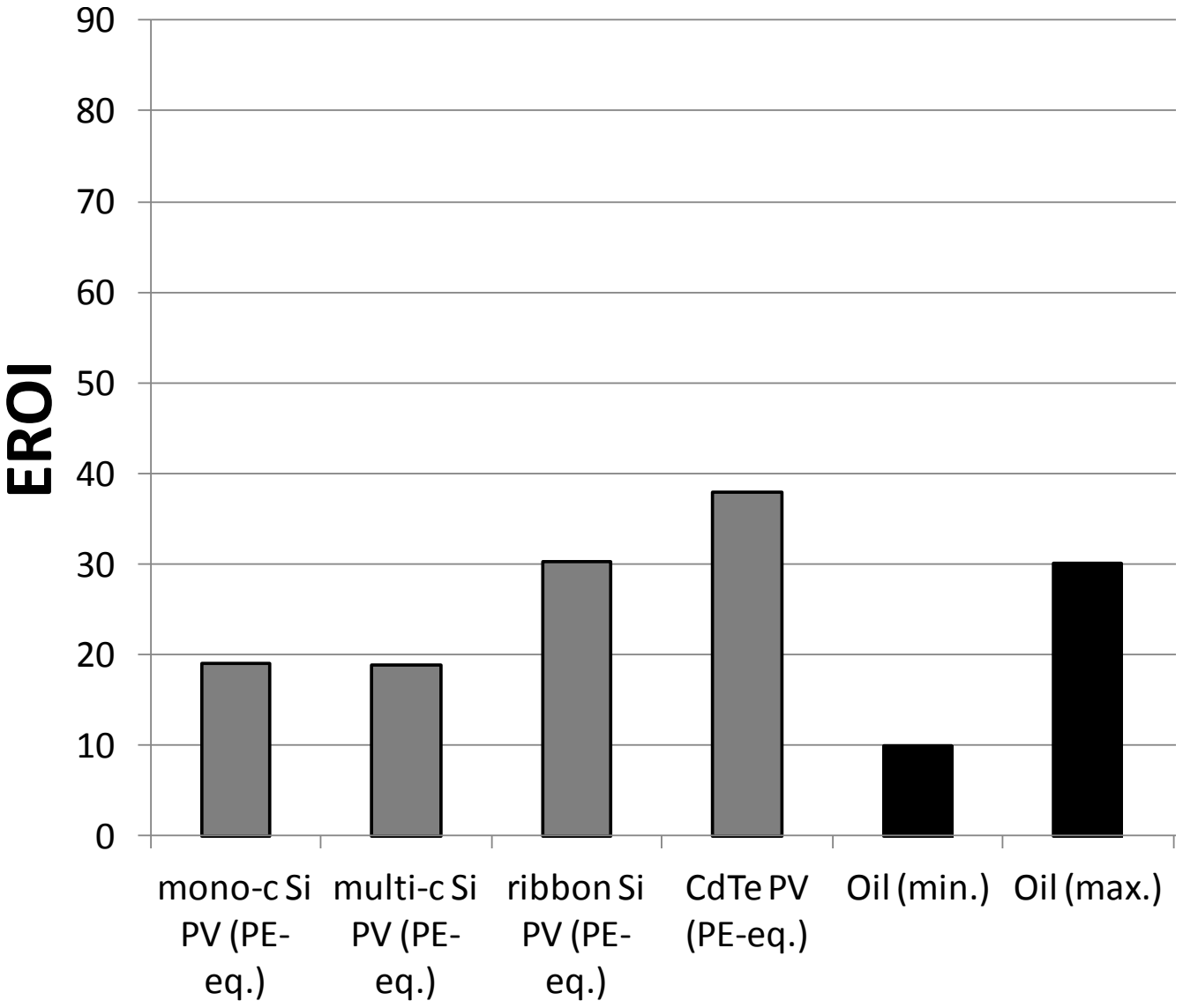
Article history:
Received 11 August 2011
Accepted 5 March 2012
Available online 21 March 2012

Keywords:
EROI
Photovoltaics
Electricity

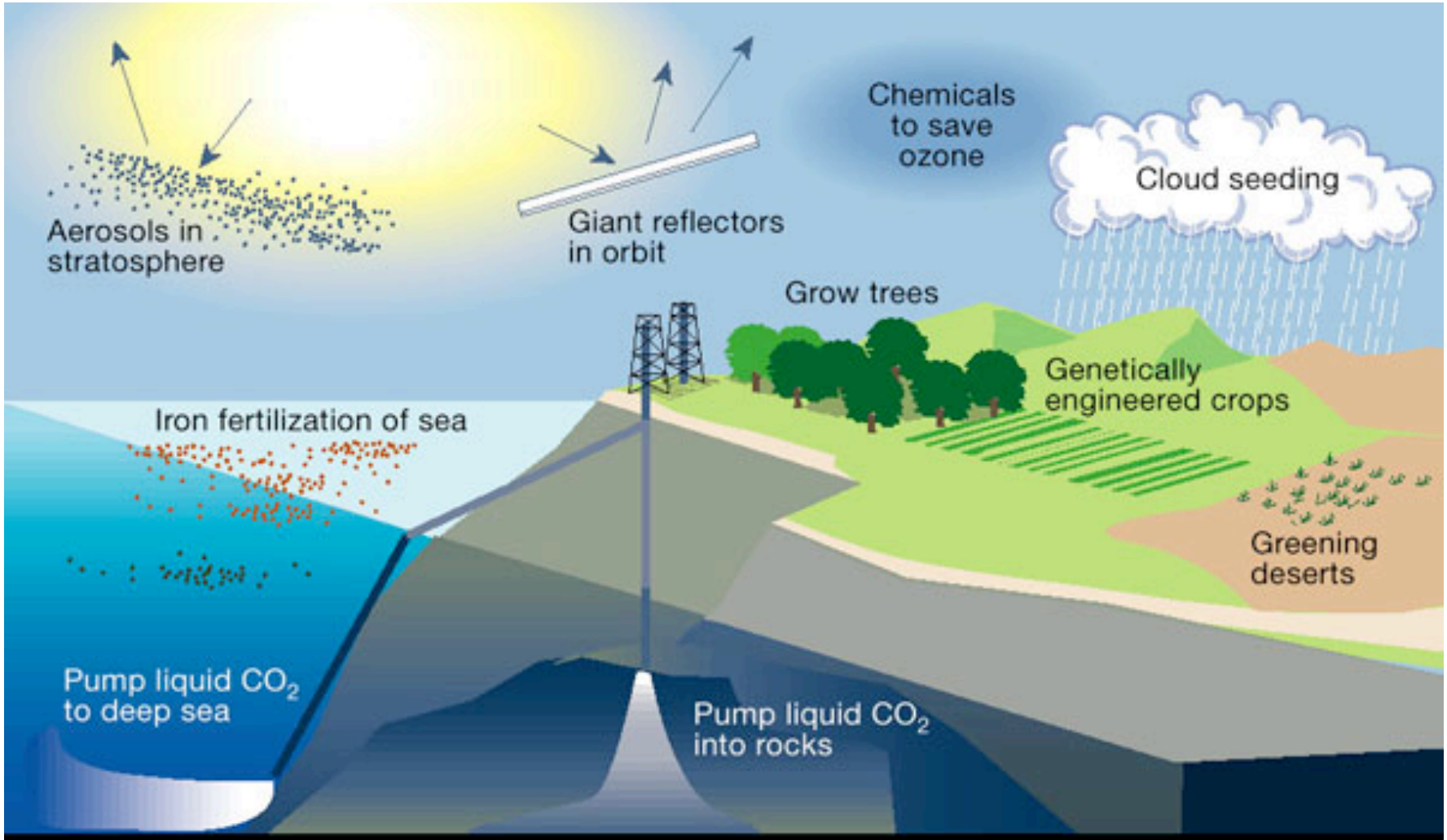
ABSTRACT

A high energy return on energy investment (EROI) of an energy production process is crucial to its long-term viability. The EROI of conventional thermal electricity from fossil fuels has been viewed as being much higher than those of renewable energy life-cycles, and specifically of photovoltaics (PVs). We show that this is largely a misconception fostered by the use of outdated data and, often, a lack of consistency among calculation methods. We hereby present a thorough review of the methodology, discuss methodological variations and present updated EROI values for a range of modern PV systems, in comparison to conventional fossil-fuel based electricity life-cycles.

EROI of Photovoltaics: new calculations

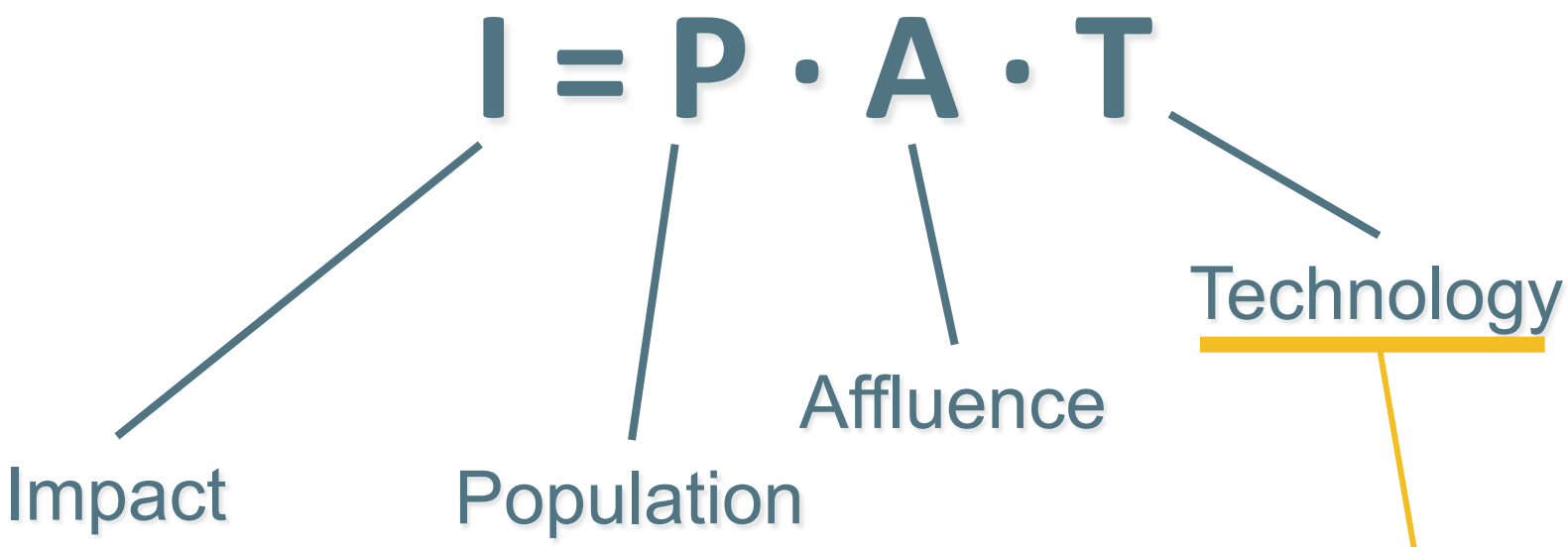


Geo-engineering solutions: uncertain and risky



Schematic representation of various climate-engineering proposals (courtesy B. Matthews).

Beyond technological fixes



Kaya identity:

$$CO_2 Emissions = (Pop) \cdot \left(\frac{GWP}{Pop}\right) \cdot \left(\frac{EnergyCons.}{GWP}\right) \cdot \left(\frac{CO_2 Emiss.}{EnergyCons.}\right)$$

Addressing ‘P’ and ‘A’

- **‘The Limits to Growth’** (Club of Rome/MIT, 1972)
- **‘De-growth’** (Georgescu-Roegen, 1979)
- **‘A Prosperous Way Down’** (Odum and Odum, 2001)
- **‘Sustainable retreat rather than sustainable development’** (Lovelock, 2006)

Conclusions

- Recognizing the problem
- Life Cycle Thinking
- ‘Out of the box’ thinking
- Paradigm shift
- ‘Way down’ does NOT have to mean ‘back to the cave’!

Thank you

- Questions?
- Comments?
- Concerns?

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