Climate

- The Breath of Life

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## Planetary atmospheric composition

- the Earth is different

<table>
<thead>
<tr>
<th></th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>98%</td>
<td>0.038%</td>
<td>95%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>2%</td>
<td>79%</td>
<td>3%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Trace</td>
<td>21%</td>
<td>0.13%</td>
</tr>
<tr>
<td>Methane</td>
<td>0</td>
<td>2 ppm</td>
<td>0</td>
</tr>
<tr>
<td>Surface temperature</td>
<td>~500°C</td>
<td>14.5 °C</td>
<td>~ -50 °C</td>
</tr>
</tbody>
</table>

**Why?** Life at work.
Sun-Earth relationship over geological time scale

**SUN**
- Becoming hotter and bigger
- Solar radiation increasing

**EARTH**
- Infrared radiation
- Tendency to warm up

Question: how to keep the surface temperature suitable for Life?
Greenhouse Effect

More carbon dioxide = warmer near the surface

To remain cool for Life
  \[\rightarrow\] constant removal of carbon dioxide
  \[\text{“by photosynthesis”}\]
The Grand Air-conditioner

Volcanoes

Atmosphere - CO₂

Inorganic World

0.2

photosynthesis

Living World

210

respiration & decomposition

Burial *

* bacterial control
The Earth’s atmosphere over geological time

(After Lovelock)
Two cycles of Life on land – still learning

Ozone layer appeared

Life invaded land.

dinosaurs

flowering plants

grasses

Man

Ozone layer appeared

(Background after IPCC 2001)
Co-evolution of atmosphere and living things

- The physical world influences the survival of various life-forms (traditional “evolution”).

- Living things in turn modify the physical world (“collective survival instinct” of Life).

- On Earth, the atmosphere and living things co-evolve.
Earth’s atmosphere
- different from those of Venus & Mars

The same Physics applied.

Life made the difference.
Atmosphere = breath of Life
Genus *Homo* emerged in low carbon dioxide atmosphere
Stable oscillations – atmosphere & plants

Modern Man \textit{Homo sapiens} emerged

Agriculture & civilization, starting about 10,000 years ago

(Background after IPCC 2001)
Changing land use

(Agriculture began)

(Background after IPCC 2001)

(Forests displaced)
Life-style based on fossil fuel burning

(Background after IPCC 2001)
Past 50 years – cities, materialism, consumerism

buring ever more fossil fuel
Last 150 years
- accelerating temperature rise

(IPCC 2007)
Simulation without human CO$_2$

(IPCC 2007)
Simulation with human CO$_2$
Last two centuries

• Physicists + Engineers
  – steam engine, machines, computers, communication means
  – amplifiers of human power

• Others
  – exploiting the means
  – amplifying human impacts on Nature
  – combustion & exhaustion
  – releasing ancient CO$_2$
The last 30 years!

The atmosphere = gases from “dead bodies”!

(background figure after IPCC, 2007)
better Physics
×
consumerism
↓
magnified CO$_2$ emission from combustion
↓
foul atmosphere
The Impaired Grand Air-conditioner

Volcanoes & *Homo sapiens*

Atmosphere - CO$_2$

Inorganic World

0.2

Living World - damaged

decomposition

Burning fossil fuel
Last two centuries

• Same Physics as before, but great differences in the atmosphere occurred - moving towards hazardous climate change.

• Life at work, this time by one species “out of control”, aided by physicists.
UnStable oscillations?

We are here now

Modern Man
Homo sapiens
emerged

\[ \text{CO}_2 \text{ concentration (ppm)} \]

\[ \text{Age (kyr BP)} \]

\[ 180, 200, 220, 240, 260, 280, 300, 320, 340, 360, 380 \]

\[ 0, 100, 200, 300, 400 \]
*Homo sapiens* especially “civilization”

- has returned ancient carbon dioxide into the atmosphere
- has moved itself into an atmospheric state the species has never seen before
- has disrupted the ozone layer
- has cut the Earth’s self-repair ability
Homo sapiens may be disabling its own perpetuation by changing the atmosphere.
Climate Change

- Not just a matter of physics, or of the physical world

- But also involves the living world, from bacteria to *Homo sapiens*
Who disrupted the breath of the Earth?

US

Can we be the solution?
Perhaps.

Time to wonder.