The climate debate: basic science and possible actions

Alberto Troccoli
Weather & Energy Research Unit, CSIRO
Weetangera Primary, Canberra, November 2011
Outline

1. Earth System
2. Weather Observations
3. Models of the climate
4. Weather vs Climate
5. Climate forcings
6. Climate response
7. Possible actions
Sunlight passes through the atmosphere and warms the Earth’s surface. This heat is radiated back toward space.

Most of the outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the Earth and the lower atmosphere.
Mars
Thin atmosphere
(Almost all CO₂ in ground)
Average temperature : -50°C

Earth
0.03% of CO₂ in the atmosphere
Average temperature : +15°C

Venus
Thick atmosphere containing 96% of CO₂
Average temperature : +420°C

### Comparison of Venus, Earth, and Mars

<table>
<thead>
<tr>
<th></th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface pressure relative to Earth (bars)</td>
<td>90</td>
<td>1</td>
<td>0.007</td>
</tr>
<tr>
<td>Major greenhouse gases (GHG)</td>
<td>CO₂</td>
<td>H₂O, CO₂</td>
<td>CO₂</td>
</tr>
<tr>
<td>Temperature if no GHG (°C)</td>
<td>-46</td>
<td>-18</td>
<td>-57</td>
</tr>
<tr>
<td>Actual temperature (°C)</td>
<td>477</td>
<td>15</td>
<td>-47</td>
</tr>
<tr>
<td>Temperature change due to GHG</td>
<td>+523</td>
<td>+33</td>
<td>+10</td>
</tr>
</tbody>
</table>
Physics becomes very complex pretty soon

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology
Human Activity & interaction with Climate

- **Mines**
- **Power stations**
- **Factories**
- **Cities**
- **Transport**
- **Crop and livestock production**
- **Growing trees**
- **Ocean**

**CO₂ and other greenhouse gas emissions**

**Absorbing CO₂ and other greenhouse gas emissions**
Monitoring the weather from space
Monitoring the weather from the ground
Monitoring the oceans

- Descent to depth: ~10 cm/s (~6 hours)
- 1000 db (1000m), Drift approx. 9 days
- 6 -12 hours at surface to transmit data to satellite
- Total cycle time: 10 days
- Float descends to begin profile from greater depth: 2000 db (2000m)
- Salinity & Temperature profile recorded during ascent: ~10 cm/s (~6 hours)
Computer Models to Simulate Climate
Weather what is happening outside right now
Climate vs Weather

Climate is the *average* of local weather conditions over a period long enough (>30 years) to provide a reliable average that includes the inevitable peaks and troughs of natural variability.

So climate integrates all weather and its variability.
Temperature change

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology
Temperature and CO₂ concentration in the atmosphere over the past 400,000 years (from the Vostok ice core)

**CO₂ concentration, ppmv**

- The graph shows the CO₂ concentration in parts per million (ppmv) from year before present (present = 1950) over the past 400,000 years.

**Temperature change from present, °C**

- The graph illustrates the temperature change from the present day over the same time period.
The rise and fall, along the curve, is caused by the ‘inhalation’ of large amounts of CO2 by Northern hemisphere plant life during NH spring and summer, and the ‘exhalation’ of carbon back into the air during NH autumns and winters.

50 years of CO2 observations show an increase of 2.2 parts per million per year.
This rate of increase is extremely fast geologically.
CO₂ evolution

For 650,000 years, atmospheric CO₂ has never been above this line ... until now

current level

1950
Atmospheric Carbon Dioxide Concentrations & Temperature Change

- Predicted future levels
- Current levels

CO₂ concentrations in the atmosphere (Antarctic Ice Core)

Temperature change compared to the present temperature

Thousands of years ago
Projected surface temperature changes for the late 21st century (2090-2099). The map shows the multi-AOGCM average projection for the A1B SRES scenario. Temperatures are relative to the period 1980-1999. {Figure 3.2}

Some systems, sectors and regions are likely to be especially affected by climate change.

- **Systems and sectors:**
  - particular ecosystems: terrestrial: tundra, boreal forest and mountain regions because of sensitivity to warming; Mediterranean-type ecosystems because of reduction in rainfall; and tropical rainforests where precipitation declines;
  - coastal: mangroves and salt marshes, due to multiple stresses;
  - marine: coral reefs due to multiple stresses; the sea ice biome because of sensitivity to warming;
  - water resources in some dry regions at mid-latitudes and in the dry tropics, due to changes in rainfall and evapotranspiration, and in areas dependent on snow and ice melt;
  - agriculture in low latitudes, due to reduced water availability;
  - low-lying coastal systems, due to threat of sea level rise and increased risk from extreme weather events;
  - human health in populations with low adaptive capacity.

- **Regions:**
  - the Arctic, because of the impacts of high rates of projected warming on natural systems and human communities;
  - Africa, because of low adaptive capacity and projected climate change impacts;
  - small islands, where there is high exposure of population and infrastructure to projected climate change impacts;
  - Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.

Within other areas, even those with high incomes, some people (such as the poor, young children and the elderly) can be particularly at risk, and also some areas and some activities.

---

**Ocean acidification**

The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic with an average decrease in pH of 0.1 units. Increasing atmospheric CO$_2$ concentrations lead to further acidification. Projections based on SRES scenarios give a reduction in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g. corals) and their dependent species.
Tones of Equivalent Carbon emission per Capital in 2008
<table>
<thead>
<tr>
<th>Vital Signs of the Planet</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sea Ice Mass</strong></td>
<td>↓ 38% since 1979</td>
</tr>
<tr>
<td><strong>Carbon Dioxide</strong></td>
<td>↑ 385 parts per million</td>
</tr>
<tr>
<td><strong>Sea Level</strong></td>
<td>↑ 50 mm since 1992</td>
</tr>
<tr>
<td><strong>Global Temperature</strong></td>
<td>↑ 1.3 °F avg. temp. since 1895</td>
</tr>
<tr>
<td><strong>Ozone Hole</strong></td>
<td>8.5 million square miles (latest)</td>
</tr>
</tbody>
</table>

http://climate.nasa.gov/
Sea level changes
Sea level changes

Recent Sea Level Rise
23 Annual Tide Gauge Records
- Three Year Average
- Satellite Altimetry

Sea Level Change (cm)

1880 1900 1920 1940 1960 1980 2000
Sea level changes

Post-Glacial Sea Level Rise

Meltwater Pulse 1A

Last Glacial Maximum

Thousands of Years Ago

Sea Level Change (m)

Santa Catarina
Rio de Janeiro
Senegal
Malacca Straits
upper bound
Australia
Jamaica
Tahiti
Huon Peninsula
Barbados
lower bound
Sunda/Vietnam Shelf

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology
Carbon Penalty
Carbon Penalty
Possible Actions
ANYTHING WE DO REQUIRES ENERGY
CO₂ EMISSIONS (per passenger per kilometre)

- AGV: 2.2 gr CO₂
- Bus: 30 gr CO₂
- Van: 115 gr CO₂
- Airplane: 153 gr CO₂
Annual greenhouse gas emissions from 'standby' power

### Dustbin bags CO2 -e per year

<table>
<thead>
<tr>
<th>Device</th>
<th>kg CO2 -e per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee machine</td>
<td>1</td>
</tr>
<tr>
<td>Mobile phone charger</td>
<td>1</td>
</tr>
<tr>
<td>Handheld vacuum cleaner</td>
<td>1</td>
</tr>
<tr>
<td>Electric toothbrush</td>
<td>1</td>
</tr>
<tr>
<td>Computer</td>
<td>1</td>
</tr>
<tr>
<td>Bread maker</td>
<td>1</td>
</tr>
<tr>
<td>Cordless home phone</td>
<td>1</td>
</tr>
<tr>
<td>Answering machines</td>
<td>1</td>
</tr>
<tr>
<td>Microwave</td>
<td>1</td>
</tr>
<tr>
<td>Computer monitor</td>
<td>1</td>
</tr>
<tr>
<td>Modem</td>
<td>1</td>
</tr>
<tr>
<td>Play station</td>
<td>1</td>
</tr>
<tr>
<td>Printers</td>
<td>1</td>
</tr>
<tr>
<td>VCR</td>
<td>1</td>
</tr>
<tr>
<td>Stereo</td>
<td>1</td>
</tr>
<tr>
<td>TV</td>
<td>1</td>
</tr>
<tr>
<td>Scanner</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7370</strong></td>
</tr>
</tbody>
</table>

**Note:** The chart illustrates the annual greenhouse gas emissions from 'standby' power consumption of various household devices, with the total emissions amounting to 7370 kg CO2 -e per year.
Things we can do ...
Things we can do ...
Things we can do ...
Things we can do …
Hydro Power

- Reservoir
- Intake
- Penstock
- Generator
- Powerhouse
- Turbine
- Long Distance Power Lines
- River
Wind Power
Solar thermal (Hot Water)
Solar Power (photovoltaic)

Option 1 - Equipment needed to generate solar electricity and feed it into the electricity grid.
Geothermal Power

Power extracted from heat stored in the earth
How the Proposed Renewable Energy Network Might Look

- Solar CSP
- Wind
- Hydro
- Solar PV
- Biomass
- Geothermal
CLIMATE SUMMIT

WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?

- ENERGY INDEPENDENCE
- PRESERVE RAINFORESTS
- SUSTAINABILITY
- GREEN JOBS
- LIVABLE CITIES
- RENEWABLES
- CLEAN WATER, AIR
- HEALTHY CHILDREN
- ETC. ETC.
Even if your action won’t make a huge difference … think of what happened if 7 billion people did the same thing.

So, why not start making your little contribution!
Weather & Energy Research Unit (WERU)
Dr Alberto Troccoli
Phone: 02 6246 5759
Email: alberto.troccoli@csiro.au

Doesn’t it make you feel insignificant?

Thank you

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology
Monitoring the weather from the ground

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology