Climate Change – the science and the challenges for water

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Weather, Climate and Climate Change

“Weather” = conditions today
“Climate” = average meteorological conditions over 30+ years

What Causes the weather to change?

**Short time step (1-2 years)**
- Day/night, Winter/summer
- Weather -- instantaneous meteorological conditions

**Medium time step (10 years)**
- Sunspot cycles -- 11 year cycle
- Efficiency in atmospheric trapping of solar energy -- the ‘Greenhouse’ effect

**Long time step (more than 1000 years)**
- Earth orbit and tilt of axis = ‘Milankovitch’ cycles -- links to geological climatic fluctuations
The Greenhouse effect

• Greenhouse gases slow the escape of infrared radiation to outer space
  - the Greenhouse effect makes life on Earth possible
  - if it did not exist most of the planet would be covered in ice

• Greenhouse gases include CO$_2$, O$_3$, NO$_x$, CH$_4$, H$_2$O

• Fluctuations in Greenhouse gas concentrations are observed in ice cores

• Greenhouse gasses change naturally over many centuries and sometimes quickly after a large volcano eruption.

• Since 1850 humans have added a lot of greenhouse gases.
Human influences on Greenhouse gasses

Direct effects

• Aerosols
  - Dust from mining, car exhaust, SO$_2$ from burning coal

• Adding gasses into the air
  – burning of fossil fuels (oil, coal natural gas) produces CO$_2$
  – burning of biomass (wood, peat) produces CO$_2$
  – use of Chlorofluorocarbons ("CFCs") in air conditioners and freezers

Indirect effects

• Land Use Change
  - removing trees (which capture and concentrate CO$_2$ into wood)
  - draining marshes which releases methane (28x more powerful than CO$_2$)
Climate Change: A long history

• 1824 Joseph Fourier discovered that gases in the atmosphere might increase the surface temperature of the Earth.

• 1862 John Tyndall measured the radiative properties of gases.

• 1896 Svante Arrhenius calculated that doubling the CO₂ concentration would add between 4.0 and 5.7 degrees Celsius to the temperature of the planet.
Measurements of CO$_2$

1960 Charles Keeling started measuring carbon dioxide at Mauna Loa Observatory, Hawaii.

Since 1960 the CO$_2$ concentration has risen from 315 parts per million (ppm) to 410 ppm – a 30% rise in 60 years.

Using the simple prediction of Arrhenius, this might cause temperatures to rise by 1.4 °C.
Future Greenhouse Gas Emissions & temperature

Source: IPPC
What does that mean?

- The relationship between CO\textsubscript{2} and the planet's temperature has been predicted from the fundamentals of physics.

- We have over 60 years measurements of CO\textsubscript{2} and it has already risen by 30% since 2060.

- The science of physics suggests that this will cause the atmosphere to heat up by about 1\degree C - it has happened as predicted.

- We do not know what the CO\textsubscript{2} content will be in the future but we do know that it is likely to increase for at least the next 20-30 years.

- The physics suggests that this means that the world temperature will continue to rise.
What does that mean for each country?

Higher temperatures mean

- Irrigated crops will need more water
- River basins will be slightly drier .. but in some areas more evaporation will occur from the sea, causing more clouds and higher rain where the moist air meets the coast
- Snow fields and glaciers will get smaller

Also

- More energy will be stored in the atmosphere, casing stronger storms, typhoons and cyclones
- More turbulence and uncertainty in the ocean currents
- The sea water will expand and cause global sea level to rise

Local conditions including air currents and ocean currents will cause the effects to be different in different places
Case study #1 - Bangladesh

Population
164 million people
GDP per capita $1,500
Area 147,000km²
Population Density >1000persons/km²
Large areas of rice production

Water resources
Annual Monsoon rain (1500mm)
3 very large rivers (Ganges, Brahmaputra and Meghna)

Hazards
River flood
Cyclone (storms)
Many areas < 1m above sea level

Future problems
Sea level rise
Water diversions in India
Predicting changes in Crop production

**EXTERNAL FACTORS**
- Climate:
  - Rain
  - Temperature
  - Atm. CO₂

**SITE SPECIFIC FACTORS**
- Water quality of rivers, groundwater, rainfall
- Monsoon flushing
- Sea level rise
- Groundwater salinity intrusion

**CROP RESPONSE MODELS**
- Yield reduction
- Potential yield (kg per ha)
- Actual yield (kg per ha)
Climate change – Monsoon rains decrease
Climate change – heat stress limits crops
India is planning for climate change

48 new dams are being planned to capture water from the Himalaya mountains.
Summer drought – river water salinity

Water diverted and used in India

Sea level rise
Summer drought – crop damage

Water diverted and used in India

Sea level rise
Case study #2 - UK

**Population**
68 million people
GDP per capita $40,000
Area 242,000km²
Population Density 274 persons/km²

**Water resources**
Annual rain (700-1500mm)
Few large rivers (Severn, Trent, Thames, Dee)

**Hazards**
Very few, localised flooding only.

**Future problems**
Water stress in South and East especially around London.
Sea flooding in London, Portsmouth and Hull
UK Water “stress” — where >50% of river water is used
Drier summers, Higher temperatures
Drier summers, Higher temperatures
Drought -> change crops from Grains to Grapes
Drought -> less groundwater, lower river flow

Possible inter basin water transfer plan
Drought -> educate on water saving

Before 2000 there were no water meters for water supply to houses. People were lazy about water use and were not concerned by leaks.

In 2003 the UK suffered a major drought. Water use in people gardens and for washing cars was stopped by law.

Water meters introduced in 2010

Thames Water and the Environment Agency began a programme of education people about water wastage.

Web pages are used to inform and educate water users.
Water resource conservation – (control all pumping)
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HARD ENGINEERING SOLUTIONS

Develop new Water resources (desalination)

Build new reservoirs

Inter basin water Transfer
Water resource conservation – (control all pumping)

Water saving at home

Pipe leak detection and repair

Water recycling from sewage

Develop new Water resources (desalination)

Build new reservoirs

Inter basin water Transfer

SOCIAL SOLUTIONS

HARD ENGINEERING SOLUTIONS
Thank you for listening

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