Challenges Facing Humanity in the Balance Between Energy and Resource Provision and Protection of the Natural Environment

Paul Glover

University of Aberdeen

Structure

- Introduction
- A Review of Recognised Problems

  A Guide to the Inferno after Dante
- Where Geophysics Can Help

“If Life is a Journey …

…we Pass Across the Face of the Earth as Guests”

from Danube by Claudio Magris

Evidence

- The scientific and political communities are split:
  - Some say there is insufficient evidence to indicate that major environmental changes are due to man
  - Some say that the evidence of man's influence is clear

Framework

- **Whether or not the evidence is present we must not minimise the potential of environmental problems**
- **Instead, we must seek evidence either way using high quality science**

Governmental and Industrial decision-makers need high quality evidence-based science upon which to base their policies

Policy

- **In parallel, we must prepare sustainable policies to protect the environment from further harm, and to mend what damage has already been done**

The responsibility is on every Individual…

and Now is the Time to Act!

A Review of Recognised Problems

Dante's Inferno

Dante's Inferno

I AM THE WAY INTO THE DOLEFUL CITY

I AM THE WAY INTO ETERNAL GRIEF,

I AM THE WAY TO A FORSAKEN RACE.

…

BEFORE ME NOTHING BUT ETERNAL THINGS

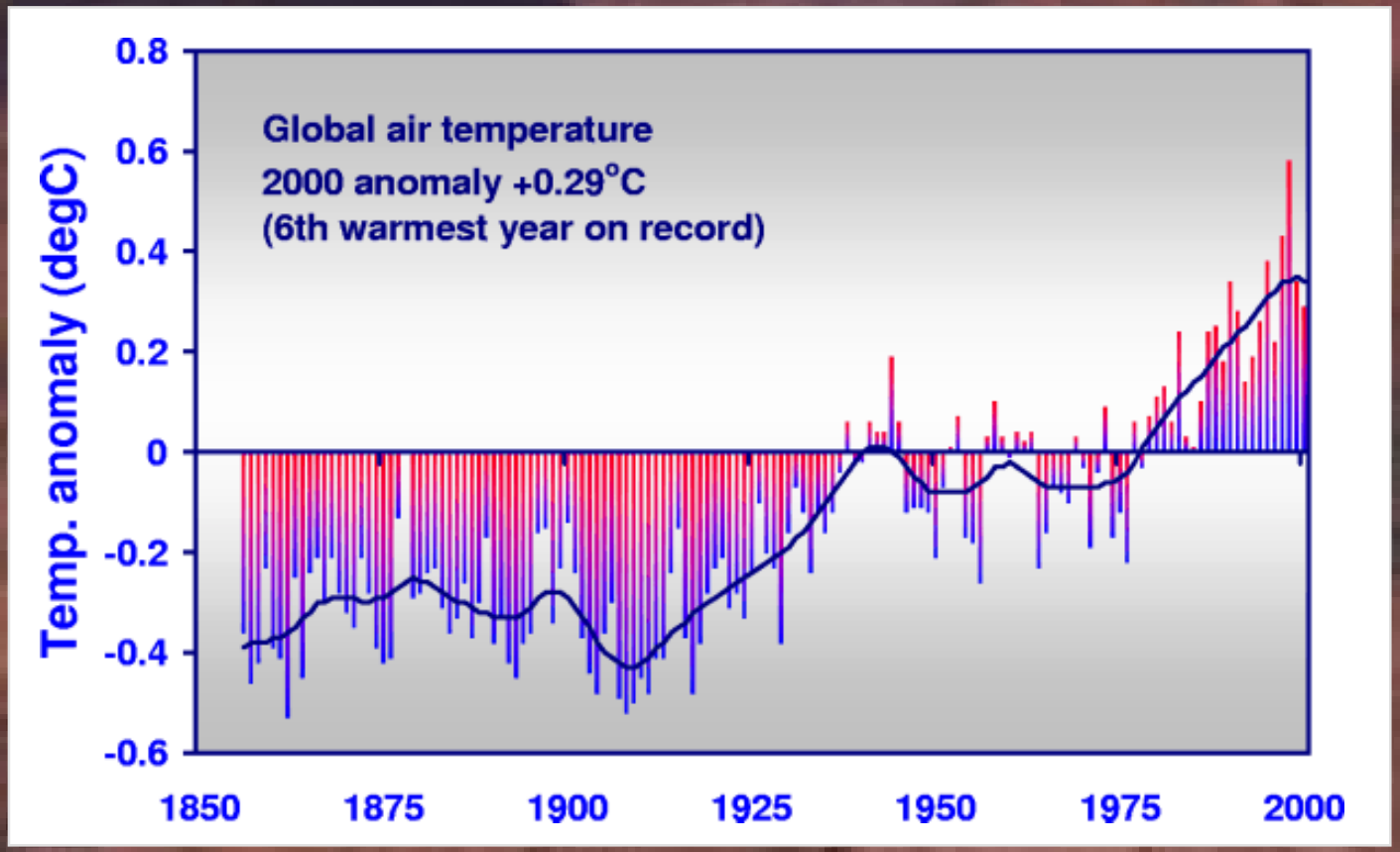
WERE MADE, AND I SHALL LAST ETERNALLY

ABANDON ALL HOPE, ALL YOU WHO ENTER HERE

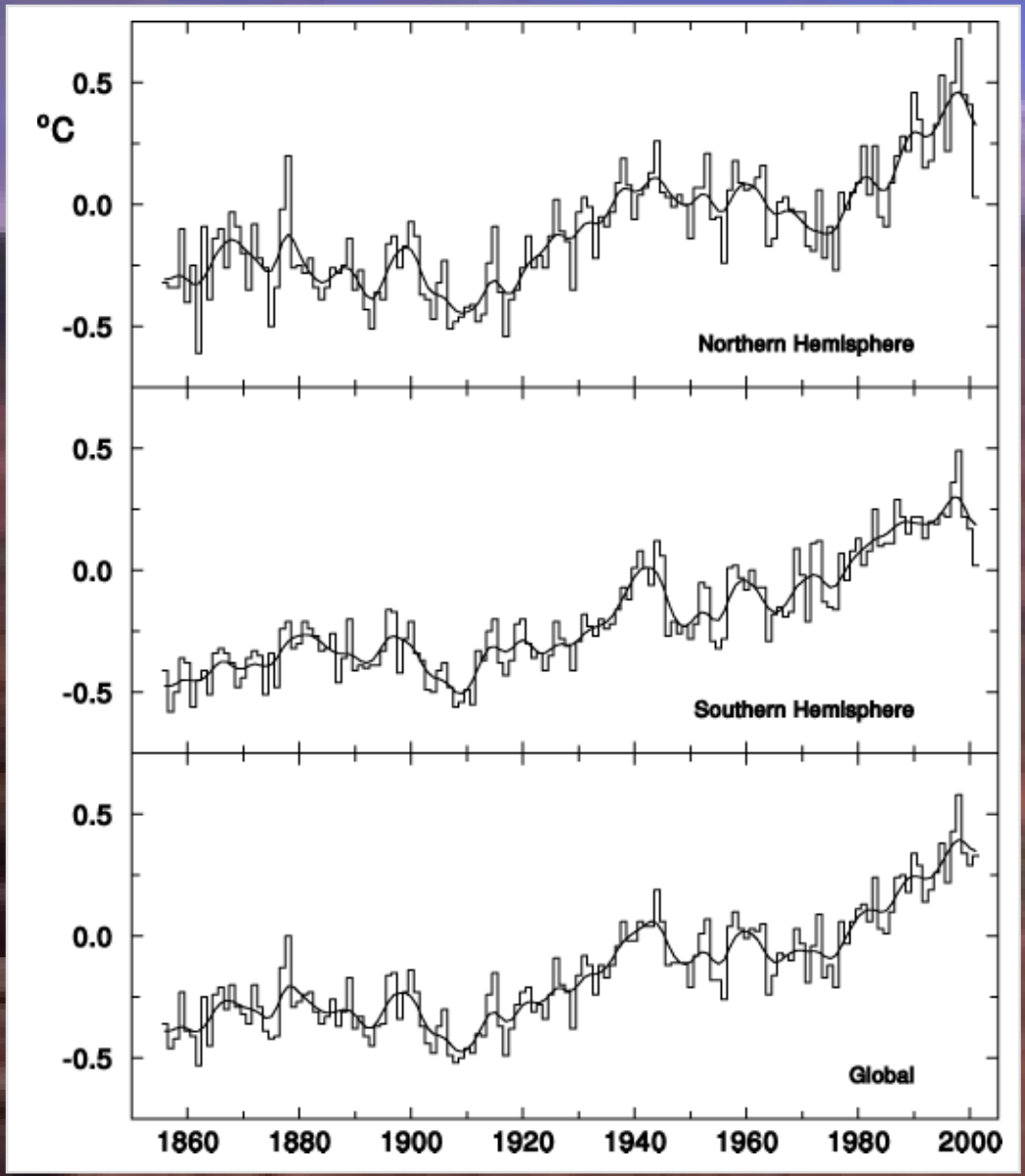
Climate Change

- The Inter-governmental Panel on Climate Change in its most recent report stated:

  "...the balance of evidence suggests a discernible human influence on the climate system"



After Jean Palutikov



After Phil Jones

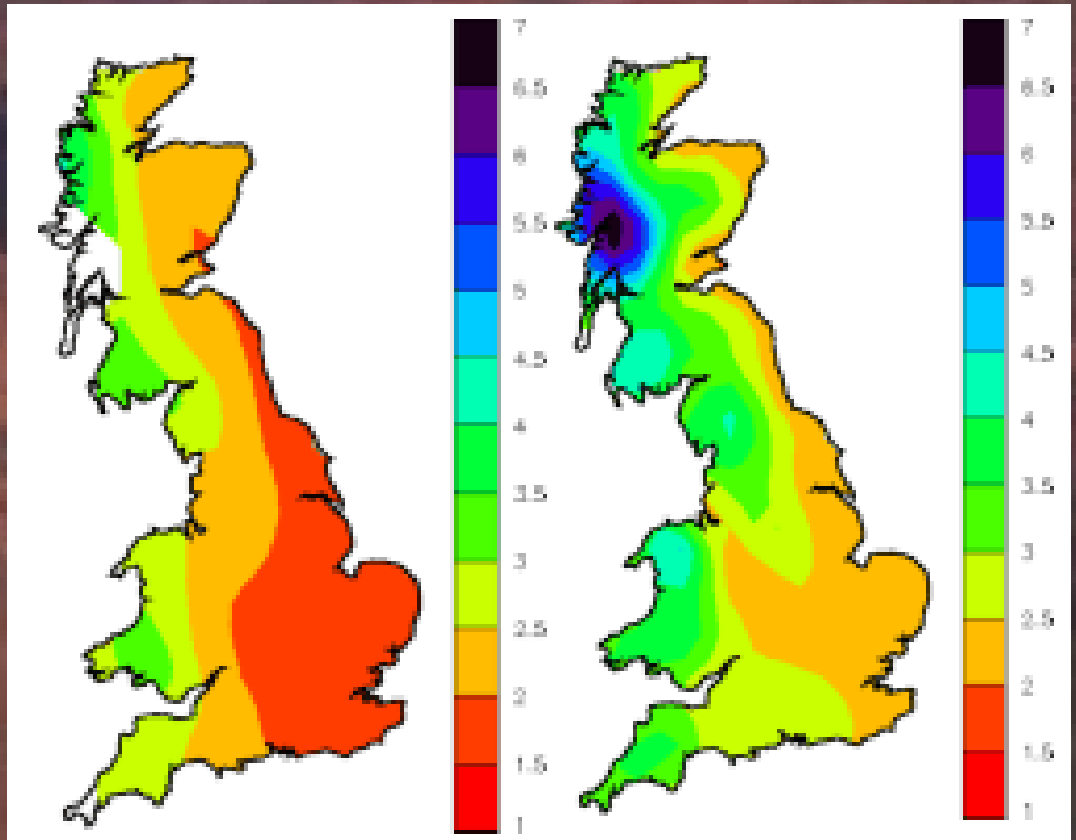
- The 1990s were the warmest decade in the series. The warmest two years of the entire series were 1997 and 1998, with the latter the warmest at 0.58°C above the 1961-90 mean.
- The seven warmest years globally have now occurred in the 1990s and 2000.

What are the Causes of Climate Change?

- **Sunspot Cycles -** Evidence for apparent correlations is not strong
- **Milankovitch Cycles -** Induced the shift from ice age to inter-glacial conditions (Time scale: 100,000 yrs), but needs to be amplified to explain the scale of the observed variations
- **Volcanic Pollution -** Individual major eruptions generate global cooling of ~0.3ºC for only a year or two: long-term influence is slight
- **The Greenhouse Effect -** Humanity has produced a substantial increase in the amount of greenhouse gases, enhancing the natural greenhouse effect, and leading to a major shift in global climate
- **El Niño and La Niña -** Sufficient to affect global-mean temperature, creating a rise and fall of a ~0.2ºC every few years. For many of the world's population, this presents a far more tangible threat than the possibility of long-term global warming

What are the Implications of Climate Change?

- Changes in temperature, precipitation and weather
- Regional extreme weather events
  - Floods (Mozambique, Sudan, Bangladesh, India)
  - Droughts (E. Africa)
  - Mudslides (Japan)
  - Avalanches (The Alps)
  - Storms
- Agricultural Failure
- Species Extinction
- Sea Level Rise
- Health



Rainfall (1961-1990) Rainfall (Predicted)

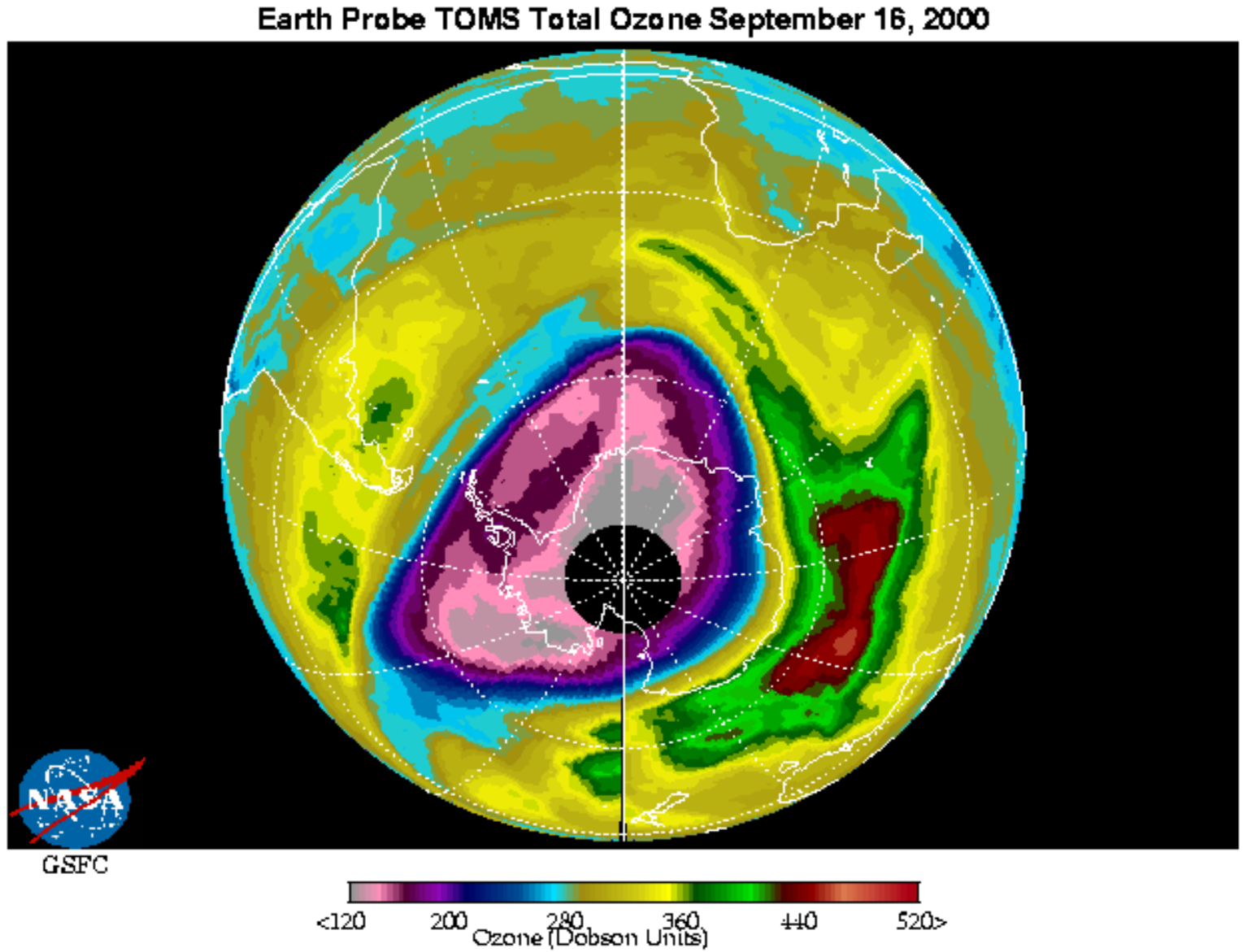
Climate Change

It is Estimated that there have Already been More than 200,000 Human Fatalities as a Result of Recent Climate Change

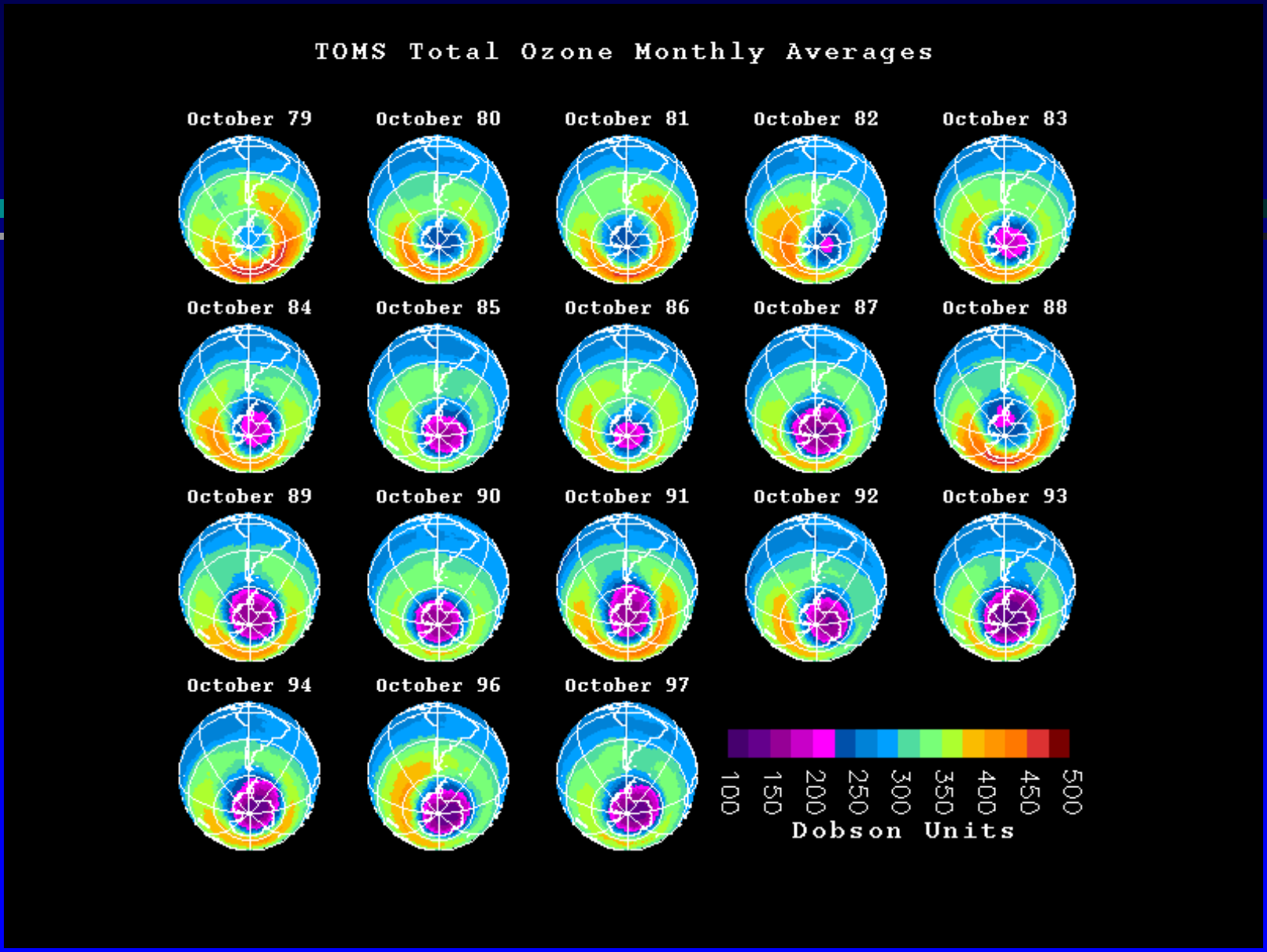
Canto 23 - The Hypocrites Address Dante

The Atmosphere

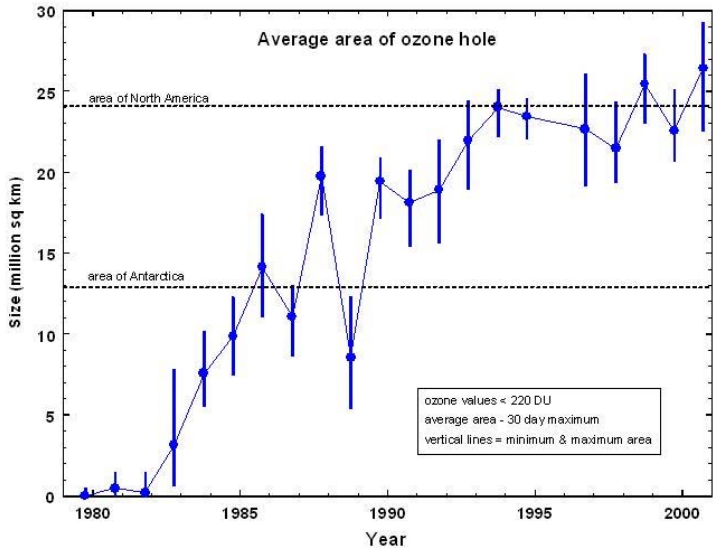
- The ozone layer protects the Earth from the ultraviolet rays sent down by the sun
- If the ozone layer is depleted the effects could be catastrophic for health - already a rise in melanomas in Australasia
- The EPA estimates that 60 million americans born by 2075 will get skin cancer because of ozone depletion - about one million of these will die
- Large Ozone depleted zones have been measured over the Poles
- The leading cause of ozone depletion is the production and emission of CFCs



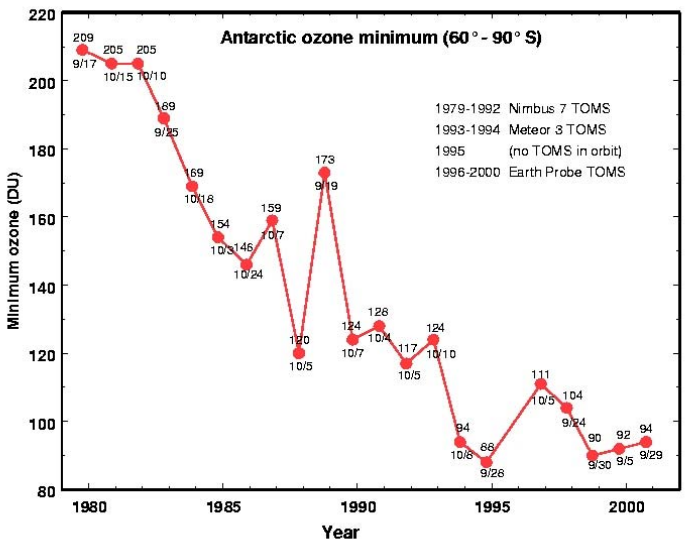
Courtesy of NASA



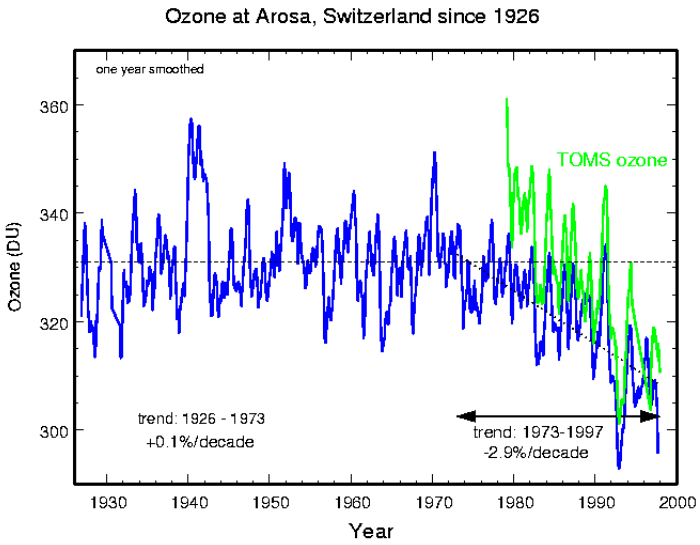
Courtesy of NASA



Area of Antarctic Ozone Hole



Concentration of Ozone



Ozone at Arosa (Ch)

Courtesy of NASA

The Atmosphere

Ozone Depletion is only One of the Environmental Problems Involving the Atmosphere - But has the Potential for Causing Millions of Deaths Globally

Canto 12 - The Rings of Glowing Souls

The Oceans

- Over the past 100 years the world has warmed by about 0.5°C
- This is due to increasing atmospheric concentrations of carbon dioxide and other greenhouse gases
- The prospect for the future is an even warmer world

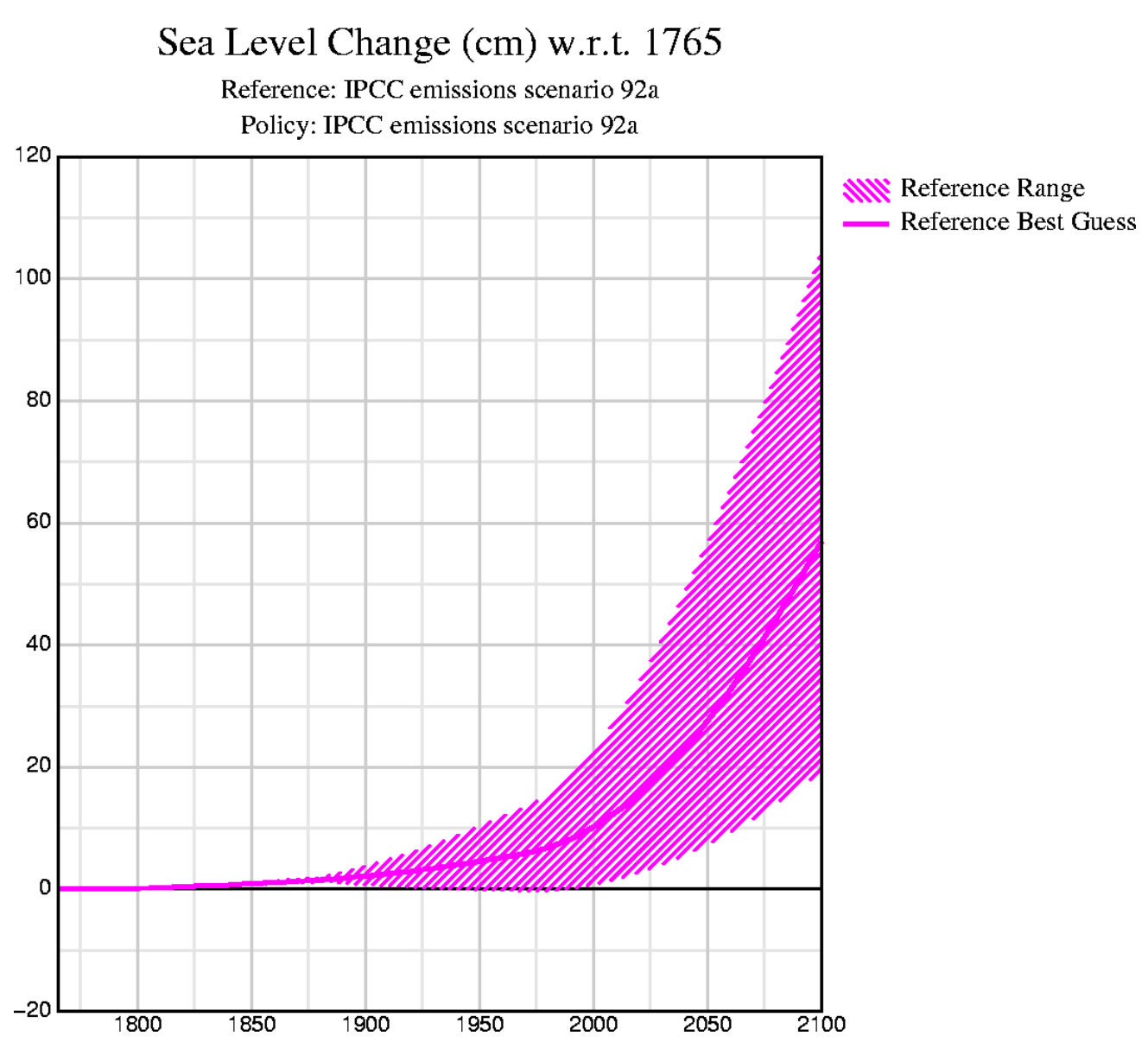
- Global mean sea level has risen substantially over the last 100 years - in the range 10-20 cm
- Global warming changes sea level mainly through thermal expansion of the ocean and by changing the net mass balance of glaciers and ice sheets

✍ **What will happen to sea level over the next 100 years?**

This is uncertain, but a continued and accelerated rise is expected

The factors contributing to the uncertainty include the following -

1. **Greenhouse gas and aerosol emissions to the atmosphere**
2. **Their effect on the radiative forcing of the atmosphere**
3. **The effect of this forcing on the climate, temperature and snowfall**
4. **Heat penetration into the ocean → thermal expansion of the ocean**
5. **The regional climate change over the glaciers, ice caps and ice-sheets (both temperature and snowfall)**
6. **The response of the glaciers, ice caps and ice-sheets to this climate change**

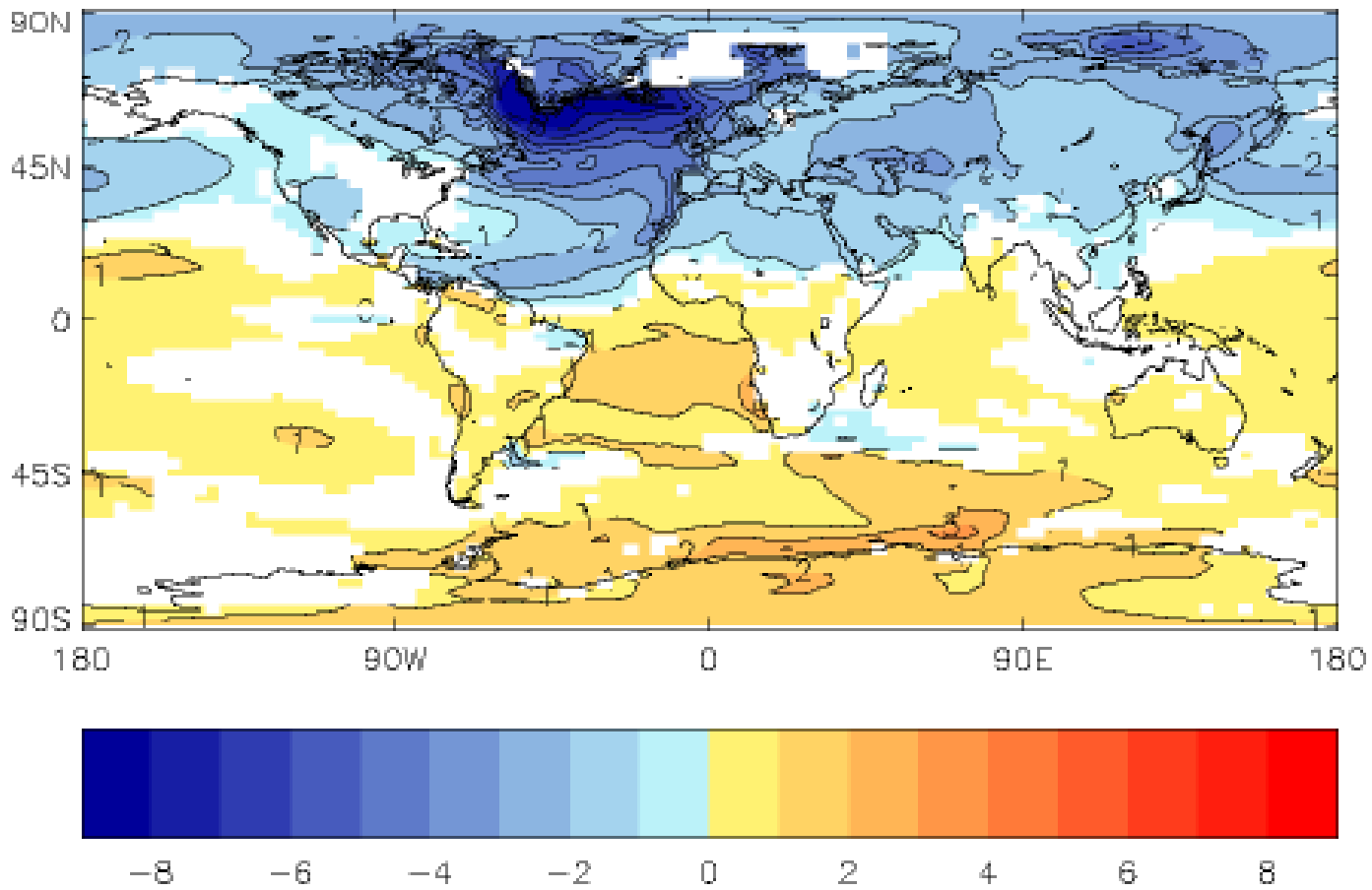


- **Modelled sea level rise from 1765 to 2100 (after Sarah Raper)**
- **By 2100 tens of thousands of square kilometres of agricultural coastal land will be inundated**

- Greenland's ice sheet is also starting to melt
- If all the ice on this huge island, which is currently over 3,000 meters thick in places, were to melt, sea level would rise by 7 meters
- However, changes to the Thermohaline circulation may prevent this

- The Thermohaline circulation (THC) has a controlling effect on changes to the Earth's climate
- There is the potential for anthropogenic influences to cause the circulation to break down rapidly (10 - 20 yrs)
- Models of the oceans have simulated a rapid break down of the THC, resulting from increased rain and warming of the North Atlantic Ocean
- Collapse of the THC would reduce N. Atlantic temperatures by as much as 8°C very quickly (10 - 20 yrs)
- London (UK) would then have similar temperatures annually to Arctic Canada

- The potentially serious impact on our climate of a THC collapse must be regarded as a ***low-risk, high-impact*** event that cannot be ignored



Temperature change 30 yrs after collapse of THC

After M. Vellinga

The Oceans

Sea Level Rise and THC Collapse have the Potential for Directly Affecting over 95% of the World's Population

Canto 33

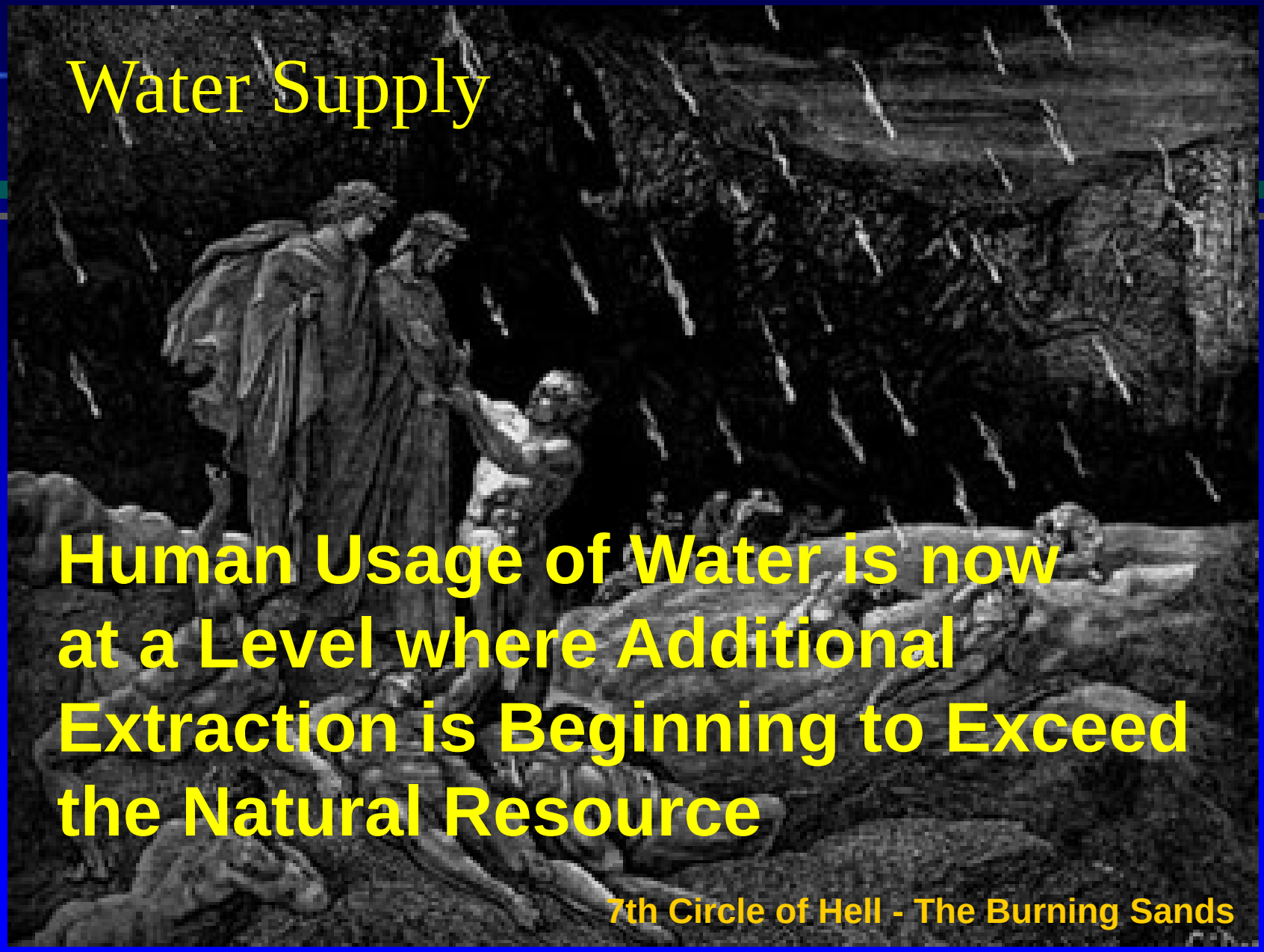
Water Supply

- World water use has tripled over the last half-century
  - 70% of all the water that is withdrawn is used for irrigation
  - 20% is used by industry, 10% for residential purposes
  - 40% of our food supply now comes from irrigated land, which now plays a disproportionately large role in the world food economy
- The demand continues to rise as we add 80 million more people each year
- Climate change will affect the efficiency of “reservoirs in the sky”, and is already affecting the snow/ice mass feeding major river systems

- Many of the world's major rivers now fail to make it to the sea, or there is very little water left in them when they do reach the sea
- The Colorado River rarely reaches the Gulf of California. It is drained dry to satisfy the agricultural needs in Colorado, Arizona and, importantly, California
- The Nile River, the lifeline of Egypt, has little water left in it when it reaches the Mediterranean.
- The Ganges, is almost dry when it reaches the Bay of Bengal. India and Bangladesh are negotiating how to divide the limited water among a few hundred million people

- China's Yellow River first ran dry in 1972 for some 15 days. It is getting worse: in 1997, it ran dry for more than half the year. For some months, it did not even reach Shandong, the last province that it flows though *en route* to the sea
- The China Daily reported that in 1995, the failure of the Yellow River lowered the grain harvest by 2.7 million tons, enough to feed 9 million people - a threat to global security!
- Other areas also affected - Mesopotamian water resources have led Iran and Turkey to the brink of armed conflict

Water Supply



Human Usage of Water is now at a Level where Additional Extraction is Beginning to Exceed the Natural Resource

7th Circle of Hell - The Burning Sands

Toxic Pollution

- Industry, agriculture and domestic consumption have produced a 1000-fold growth in release of toxins to the environment in the last 50 years
- The main concerns include:
  - POPs - Persistent Organic Pollutants
  - Endocrine Disruptors
  - Agricultural Pesticides
- They ALL now permeate the biosphere
- ALL have health implications
- ALL have been responsible for the death and disease of wildlife and humans

- POPs are toxic organic chemical compounds (including PCBs and DDT). They are primarily products from industrial processes and are present in food packaging!
- The existence of POPs is relatively recent (post WWII)
- Found everywhere (food, soil, air, water, our bodies)
- They bioaccumulate
- Highly toxic in small quantities
- Highly mobile
- Wildlife significantly suffers in Polar and Temperate regions
- The effect on Humans is unquantified

- **ENDOCRINE DISRUPTORS** are synthetic chemicals that block, mimic or otherwise interfere with naturally produced hormones
- Pervasive chemicals that have already caused numerous adverse effects in wildlife and possibly humans (fertility and developmental)
- Problems include:
  - interrupted sexual development
  - thyroid system disorders
  - inability to breed
  - reduced immune response
  - abnormal mating/parenting

- **AGRICULTURAL PESTICIDES kill natural wildlife and are toxic to humans**
- **Every year US agriculture introduces into the environment over 900 million pounds of pesticides**

"Common sense tells us that rather than pouring nearly 3 billion pounds of pesticides on our food
—and then trying to wash them off —
commission scientific studies about them
—worry about how risky they might be
—we ought to be figuring out how to use fewer pesticides in the first place."

Carol Browner, Administrator, US Environmental Protection Agency

Toxic Pollution

Toxic Pollution is now Pervasive and Dangerous - The Priority is for Governments to Invest in Remed-iation and Reduction of Packaging

Canto 15 - The Violent Against Nature

Energy Supply

Energy & Climate

- Oil, gas and coal use contribute directly to global warming and environmental pollution
- The Arctic Ocean ice has thinned by 40% in the last 35 yrs - summer ice in the Arctic Ocean could disappear entirely within 50 years
- Melting of the Greenland Ice has the potential to raise sea level by 7 metres
- However oil production is nearly at an end - World oil use expanded at only 1% per year and coal use declined by nearly 1% between 1990 and 1999
- In the same period, wind power generation grew by 24% per year, solar cell production by 17% pa, and geothermal power by 4% pa

Developing and Developed Societies

- Coal is the energy form most available to developing societies
- The increase in coal burning may continue until 2045 - 20 years after expected peak oil production
- Coal burning delivers the greatest amount of carbon to the atmosphere per unit energy produced - and has most impact upon the environment
- In developed societies cleaner gas is replacing oil and coal, and environmentally sensitive sources are being developed
- Hence, developing nations need support in the development of alternative sustainable energy sources

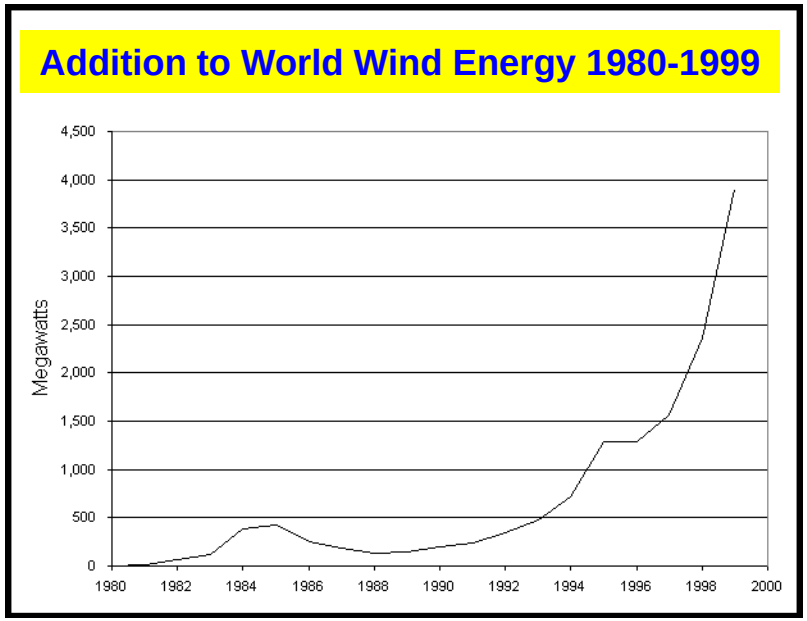
Global Security

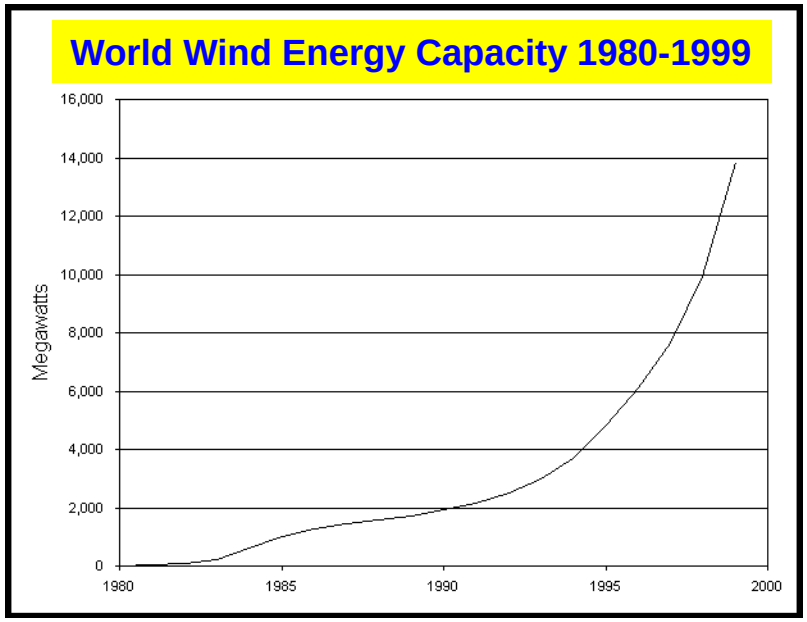
- Grain and oil are linked (about 1 bbl. oil per bushel grain)
- The United States is now dependent on imports for a record 57% of its oil - it is also the world's largest grain exporter
- The 11 OPEC members are all major grain importers
- China has an importation need for both energy and grain!
- The needs of developed societies for energy and oil derivatives is seen as a paramount right
- Such dependencies are a direct threat to global security - the Gulf War is a recent example

Sustainable Energy

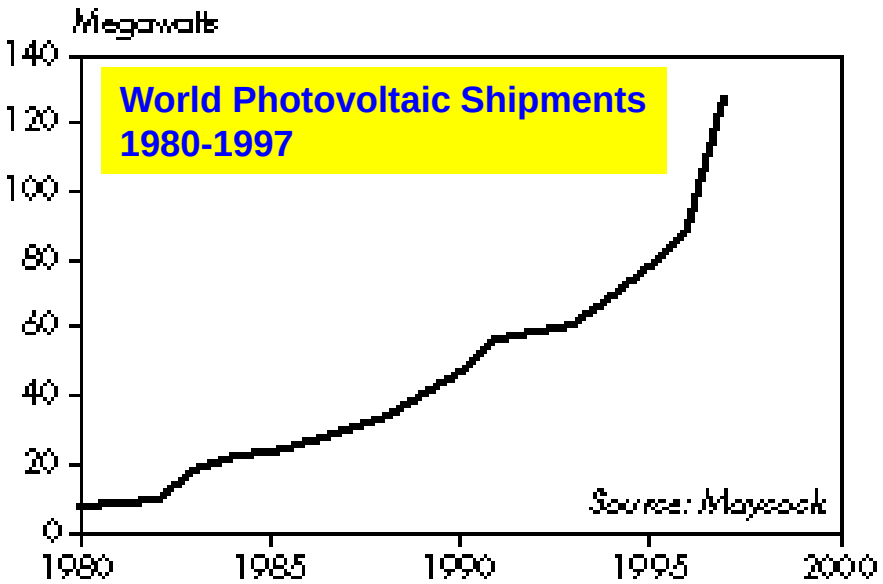
- BP is now the world's leading maker of solar cells
- All the major automobile companies are working on hydrogen fuel cell engines
- Japan has developed a roofing material that allows the roof to become the power plant for the building
- Denmark now gets 10% of its electricity from wind, for Schleswig-Holstein, Germany, it is 14%, and for Navarra in Spain, it is 22%
- The U.S. DoE indicates that N. Dakota, Kansas & Texas have sufficient wind energy to satisfy national electricity needs
- U.S. wind-generation jumped by 29% in 1999 alone

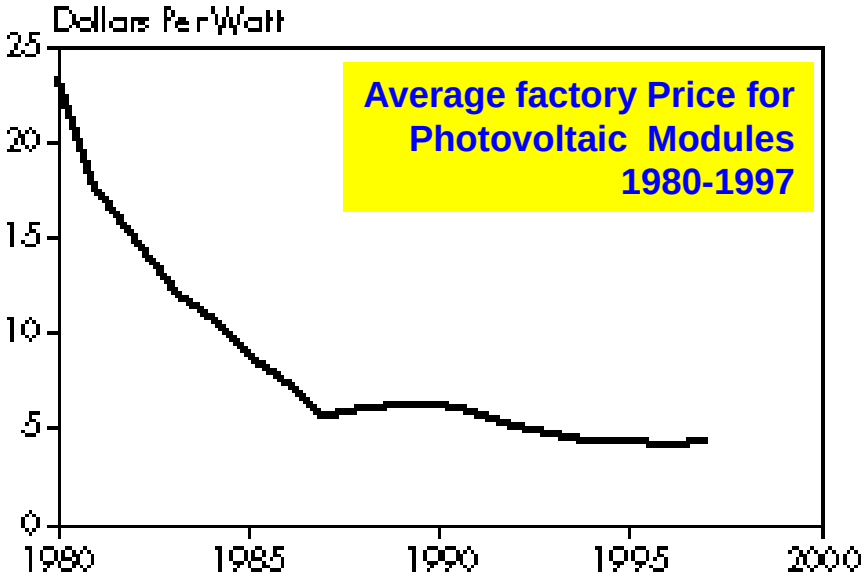
Sustainable Energy





Wind Energy





Solar Energy

Energy Supply

There are Encouraging Signs in the Development of Sustainable Energy Sources - But the Developing Economies Need Support

Canto 25 - Fires in Hell

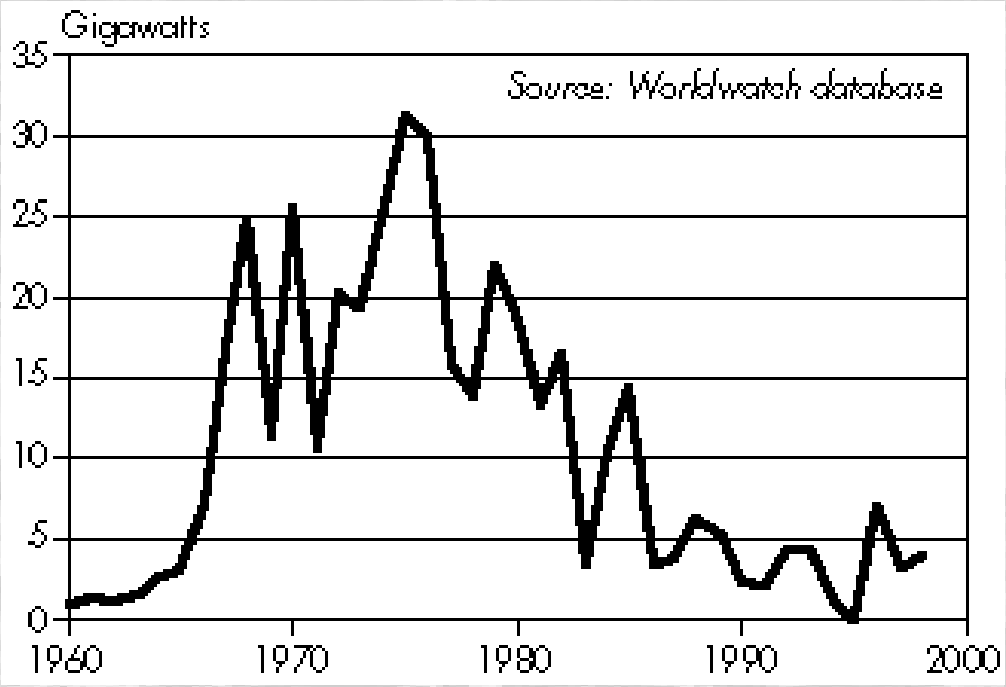
Radioactive Waste

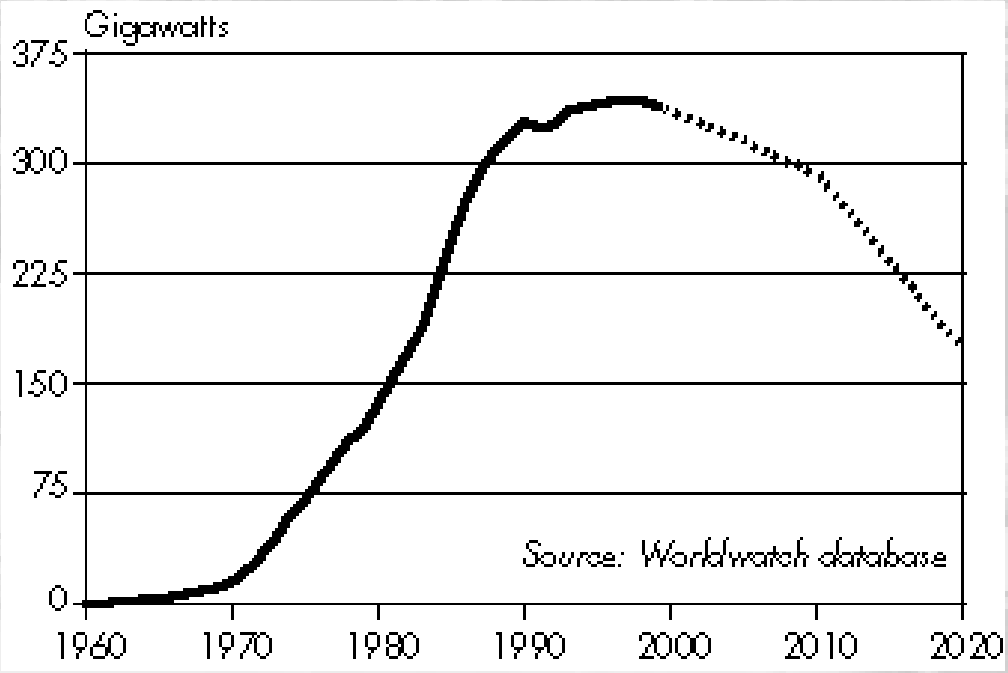
- Radioactive wastes are the by-product of:
  - Electricity generation
  - Defence
  - Medical treatments
  - Industry
  - Scientific research

The Chernobyl Nuclear Disaster

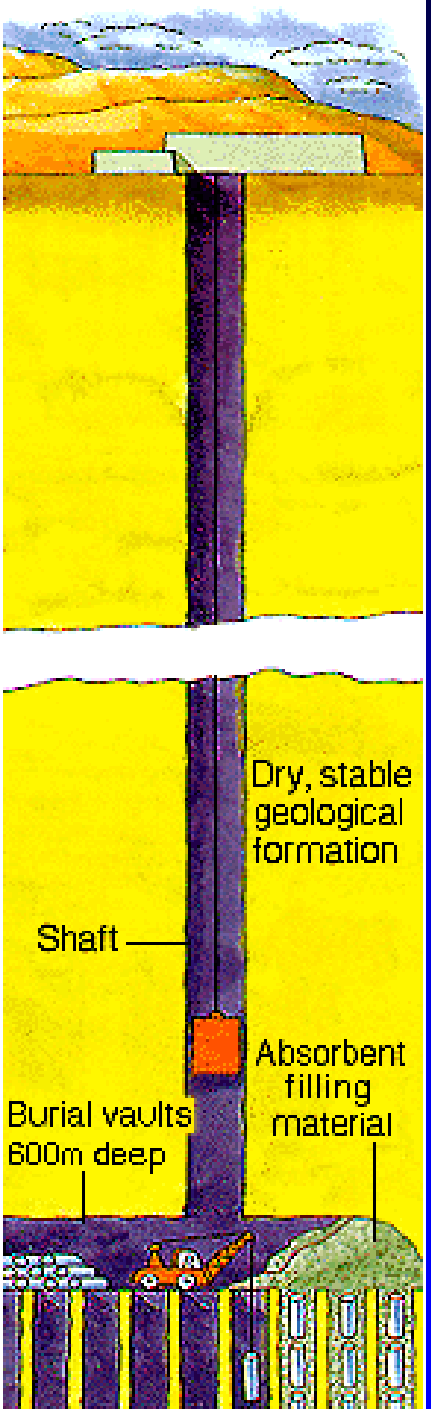
- Waste from nuclear weapons production managed by the US DOE alone includes 24 million cubic meters containing 900 million curies
- These wastes are not only dangerous radioactively, but are chemically highly toxic

- Commissioning of new nuclear plants has almost stopped
- There is control on nuclear proliferation for defence
- We still use nuclear material for medicine and industry
- The seas are littered with radwaste from dumping or abandoned submarines

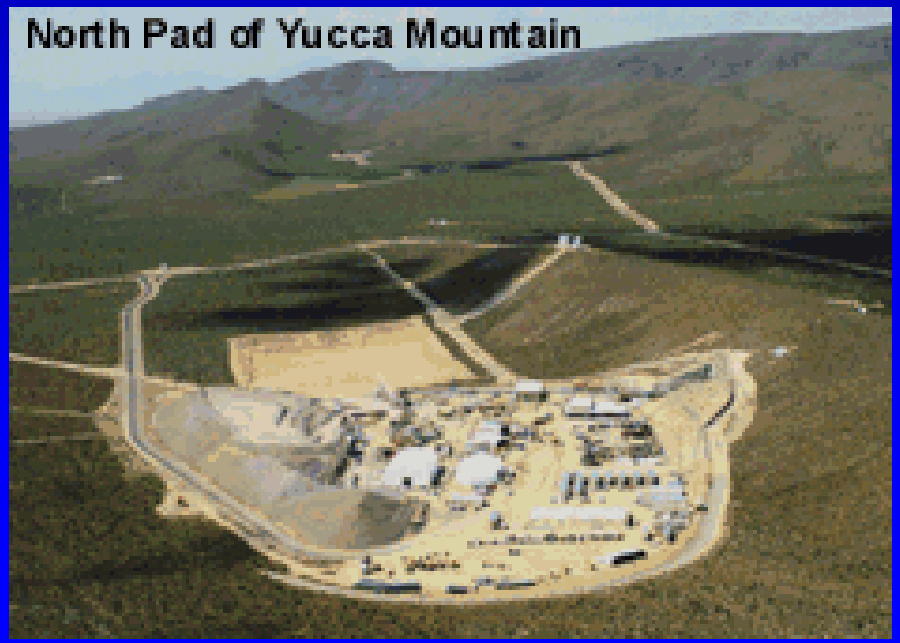




- Although nuclear power is obsolescent, removal of these facilities together with defence, medical and industrial sources will mean that there will be an increase in the amount of waste in the next 100 yrs
- Such waste must not be allowed to contaminate aquifers
- If it did, it would be extremely difficult to remediate
- It would either kill of affect the genome of whole ecosystems
- The Chernobyl Disaster is still being felt in Europe - Some UK farmers still cannot sell sheep grazed on certain pastures
- France has nuclear powered wild boars!



- The small amount of high-level wastes are managed in surface facilities and left to decay
- Larger amounts of medium-level waste are often now stored underground (but not in the UK)
- Large amounts of low-level wastes are buried in shallow land-fills - these may leak and contaminate aquifers



Radioactive Waste

There will be an Increase in Radioactive Waste in the next 100 yrs - Each Nuclear State Must have Safe Methods of Storing it.

Canto 25 - Sinners Passing through the Fire

Diagnosis

- The overall outlook is negative
- However, positive signs are emerging
  - Proliferation of environmental bodies
  - Improved attitude of national governments
  - Challenge recognised by industry
  - Recognition that research must be carried out immediately
  - Need to educate the general public and new generation

The Role of Earth Scientists

- **Earth Scientists have a pivotal role to play**
  - **All of these areas are the remit of Earth Scientists**
  - **Governmental and Industrial decision-makers desperately need high quality evidence-based science upon which to base their policies**
  - **Earth Scientists can provide it**
  - **It is the responsibility of the members of the EGS to ensure that the environment, wildlife, and human life is protected by sustainable and expanding human development**

Acknowledgements

- The Climate Research Unit, University of East Anglia, UK and the Hadley Centre
- The Worldwatch Institute
- US Department of Energy
- US Environmental Protection Agency
- Greenpeace
- UK NIREX Ltd., BP, Shell, NASA, ESA
- Dante Aligheri and The ELF Project
- Vellutello, Botticelli, Bartolomeo & Dore
- And many others