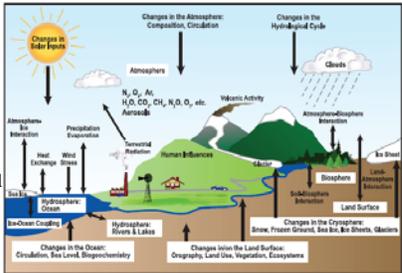


**Climate Change – Why it matters to and for Canadians**

Presentation to Geography 2153 - Environment, Economy and Society  
Gordon McBean, CM, O.Ont., PhD, FRSC  
The University of Western Ontario

## The global climate system

- Interacting components: atmosphere, ocean, land surface, sea ice, glaciers...
- Processes are complicated and all components are interconnected



## Climate System and its Science

CLIMATE is the STATISTICS of Weather. We need to look at averages over space and time.

The system is complex and our understanding is based on decades of scientific study

- Archimedes, Newton, ...
- 1824 - Fourier - first paper on greenhouse effect
- 1896 - Arrhenius - theoretical model of Greenhouse
- 1950's
  - International Geophysical Year - 1957
  - Revelle - carbon cycle and oceans
  - Phillips - atmospheric circulation models
- 1960's
  - Manabe - climate models
  - 1967 - start of Global Atmospheric Research Program
  - First weather satellites
- And onward

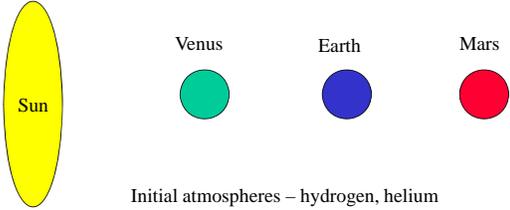
## The climate system

- Climate as a Problem in Physics - plus math, chemistry, biology
- The atmosphere - a compressible fluid
  - 6 state variables - wind (u,v,w), pressure (P), temperature (T) and water content (q)
  - 6 equations - in 3 dimensions plus time
    - Newton's laws of motion (3 components)
    - Conservation of Mass - air, water content, ...
    - Equation of state - ideal gas
    - Energy equation - 1st Law of Thermodynamics
    - Adding the chemistry makes it more complex, biology even more so
- The Ocean - also a fluid -
  - same set - exchange salt for water content
- Land surface, cryosphere, biosphere
  - more difficult

## Time Scales for Climate System

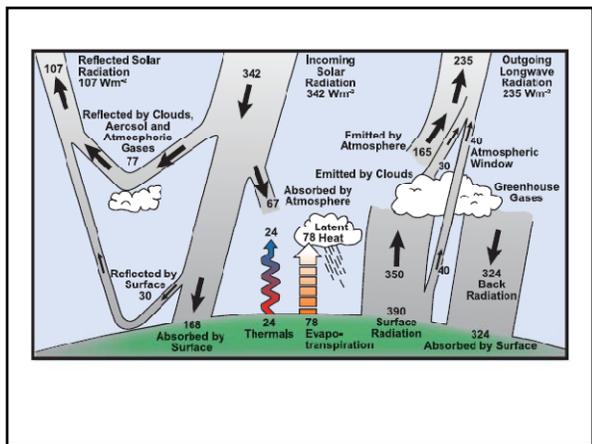
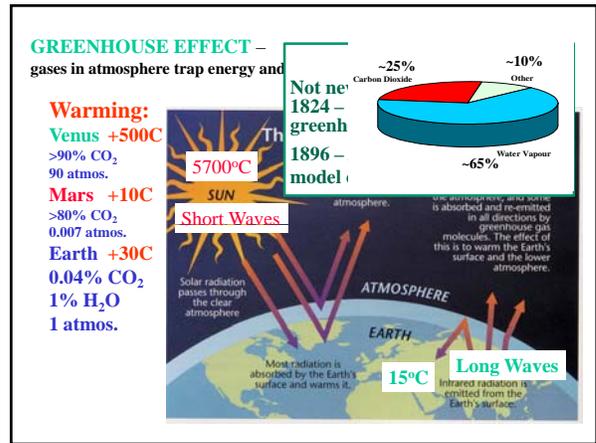
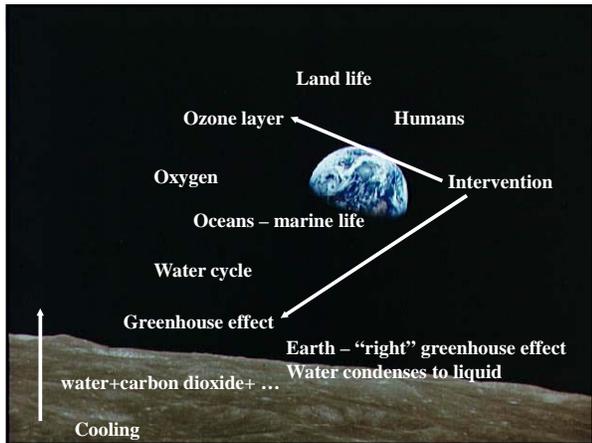
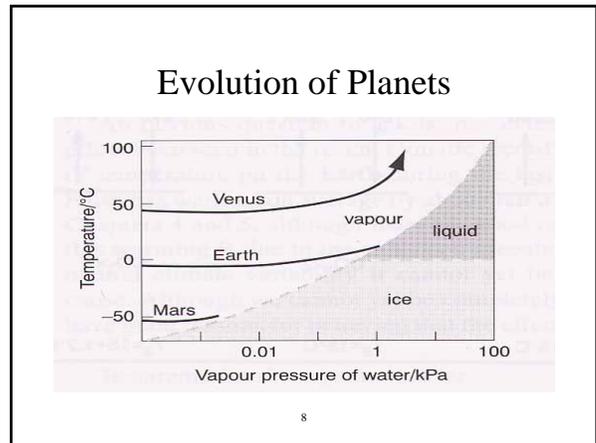
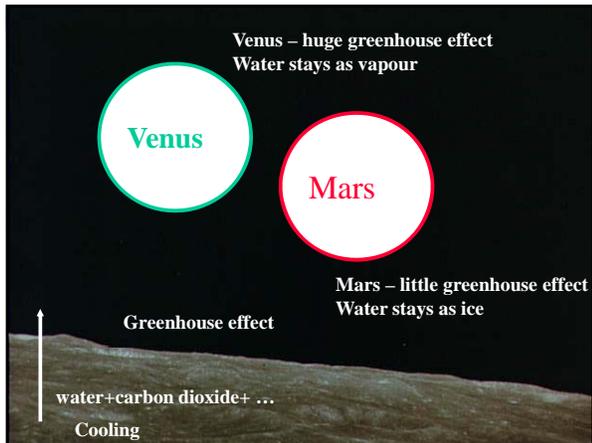
• Water cycle	10 days	Quick - Temp
• Ocean response	years to centuries	Oceans control the response time and magnitude
• Emissions to globe	years	global issues
• Methane gas	10 years	
• Carbon dioxide	100 years	
• End-use technologies	years	responding
• Supply technologies	decades	
• Social standards	decades	
• Infrastructure, ...	decades	

## The beginning

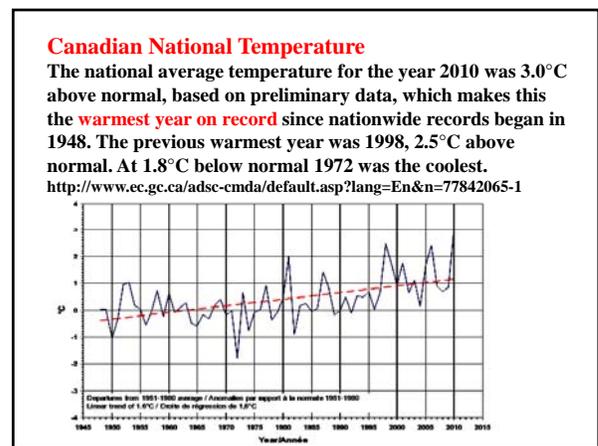
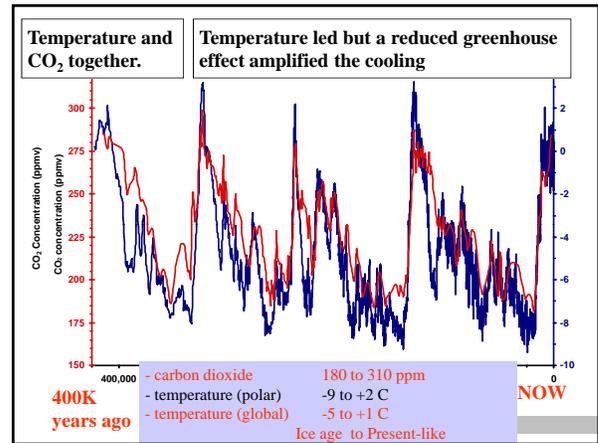
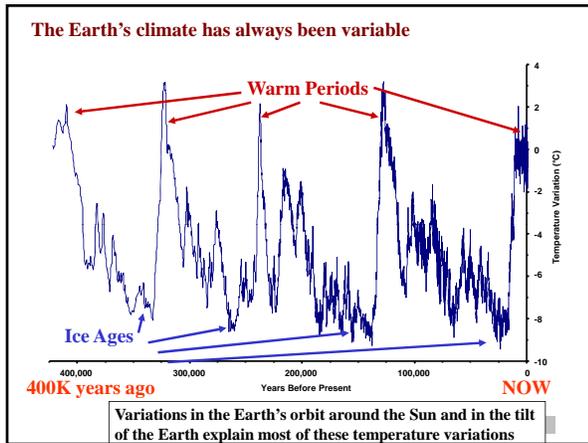
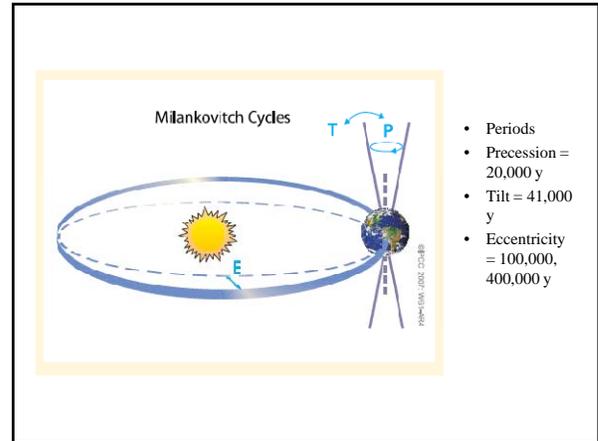
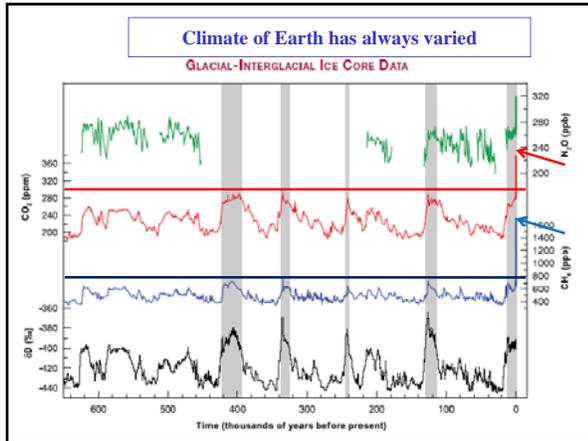


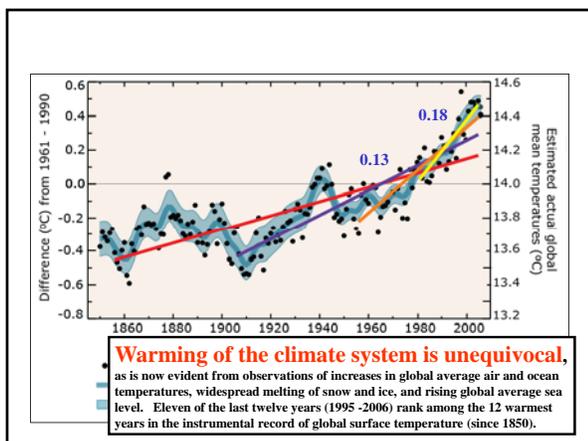
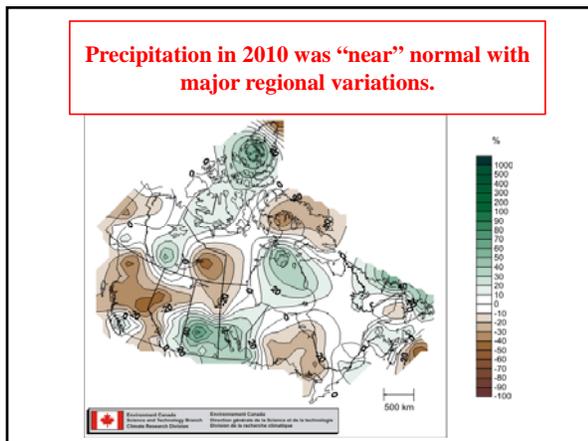
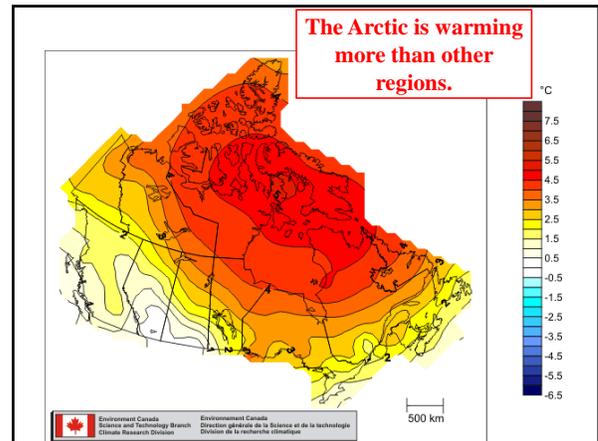
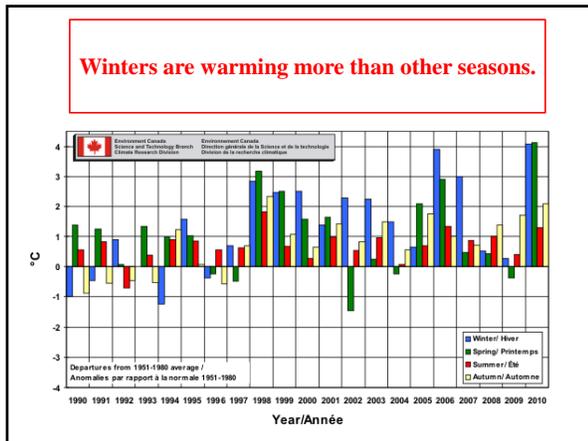
Initial atmospheres - hydrogen, helium  
Solar wind - blow them away  
Temperatures - initially hot

6



- Earth's climate has varied considerably over its billions of years history. Factors include:**
- **the Sun and its changing intensity**
    - 11 year solar cycle – 0.1% variation
    - millions of years for larger, more gradual change
  - **Variations in the Earth's orbit around the Sun and the tilt of the Earth's axis of rotation**
    - 20,000 yrs to 400,000 yrs
  - **Collisions with outside bodies – asteroids**
    - very long intervals between
  - **Changes in composition of the Earth's atmosphere**
    - Volcanic eruptions – cool the planet - random
    - Greenhouse effect – the topic of concern today

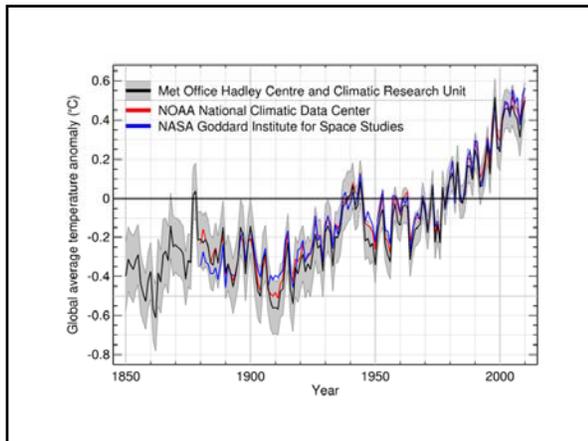




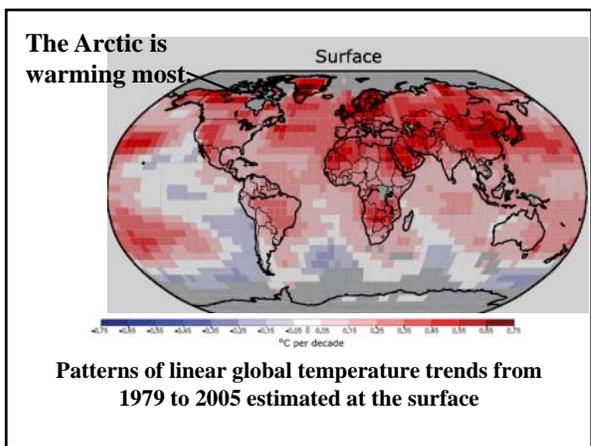
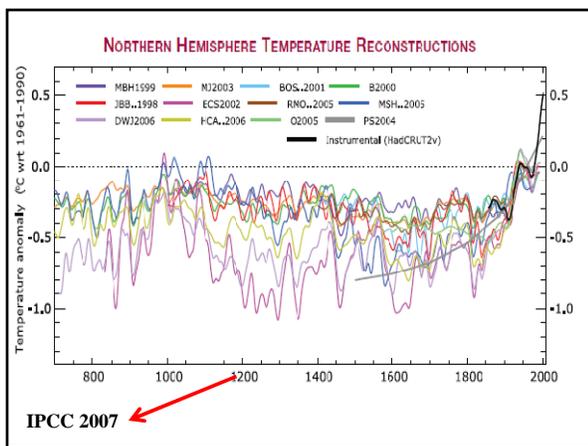
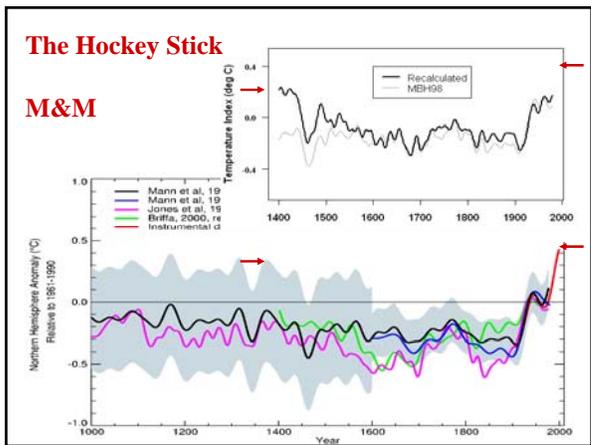
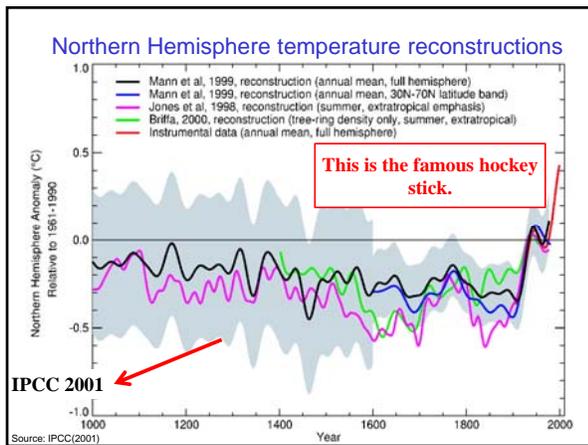
**World Meteorological Organization  
Geneva, 20 January 2011 (WMO)**

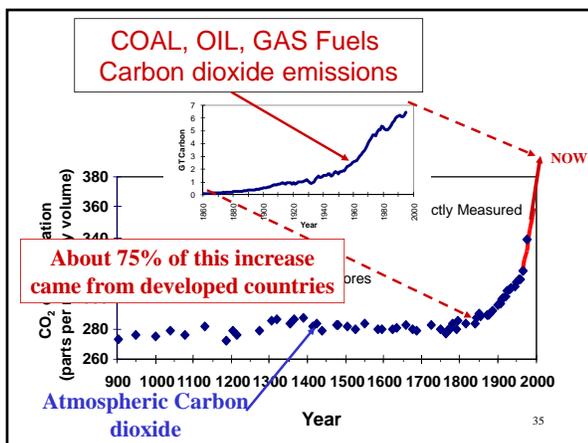
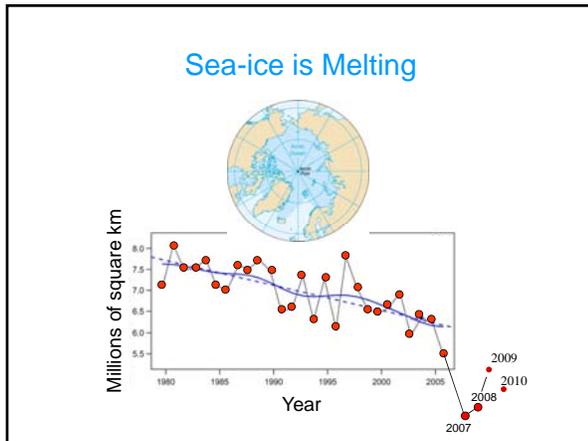
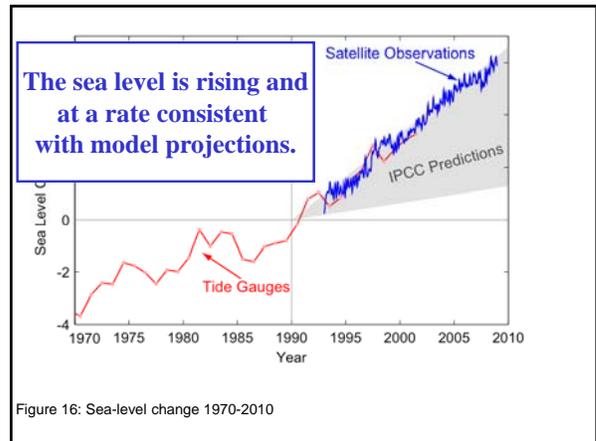
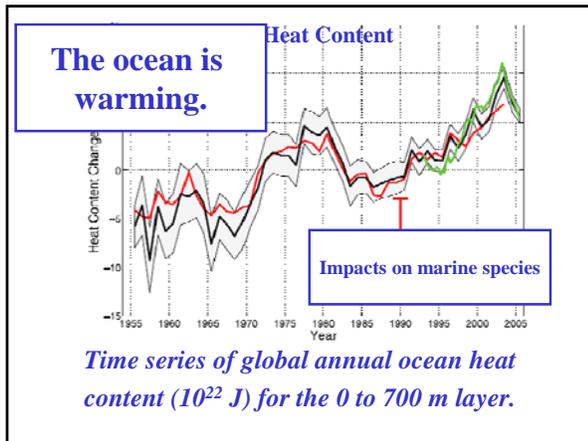
The year **2010** ranked as the warmest year on record, together with **2005** and **1998**, according to the World Meteorological Organization. Data received by the WMO show no statistically significant difference between global temperatures in 2010, 2005 and 1998. In 2010, global average temperature was 0.53°C above the 1961-90 mean. This value is 0.01°C above the nominal temperature in 2005, and 0.02°C above 1998. The difference between the three years is less than the margin of uncertainty ( $\pm 0.09^\circ\text{C}$ ) in comparing the data. These statistics are based on data sets maintained by the UK Meteorological Office Hadley Centre/Climatic Research Unit (HadCRU), the U.S. National Climatic Data Center (NCDC), and the U.S. National Aeronautics and Space Administration (NASA).

Arctic sea-ice cover in December 2010 was the lowest on record, with an average monthly extent of 12 million square kilometres, 1.35 million square kilometres below the 1979-2000 average for December. This follows the third-lowest minimum ice extent recorded in September.



“The 2010 data confirm the Earth’s significant long-term warming trend,” said WMO Secretary-General Michel Jarraud. “The ten warmest years on record have all occurred since 1998.”  
 Over the ten years from 2001 to 2010, global temperatures have averaged 0.46°C (0.83°F) above the 1961-1990 average, and are the highest ever recorded for a 10-year period since the beginning of instrumental climate records. Recent warming has been especially strong in Africa, parts of Asia, and parts of the Arctic, with many subregions registering temperatures 1.2 to 1.4°C above the long-term average.





- A global climate model is a computer program which solves the mathematical equations describing this complex system.

- Even using powerful super-computers, such models must compromise the level of detail that is represented.

... and solved numerically on state of the art supercomputers at the Canadian Meteorological Centre

NEC SX/6

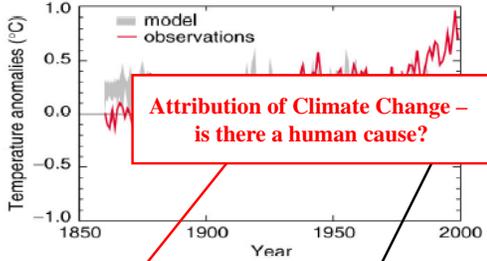
- 10 nodes
- 8 cpu/node
- 8 gigaflops/cpu

640 gigaflops (peak)



1 gigaflop = 1 billion arithmetic operations per second

Compare observations with model simulations



Temperature anomalies (°C)

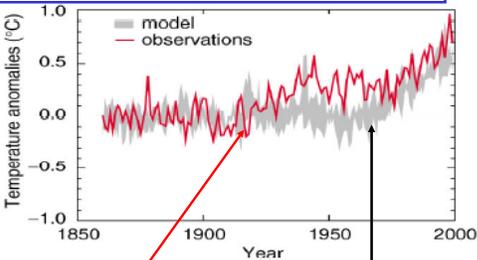
Year

Observations

Attribution of Climate Change – is there a human cause?

Climate simulated by model with volcanoes, solar variations and other **natural** factors included.

Compare observations with model simulations



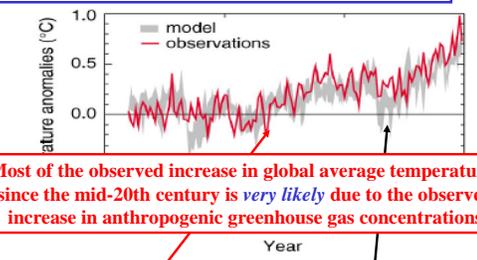
Temperature anomalies (°C)

Year

Observations

Climate simulated by model with greenhouse gases, aerosols, “**anthropogenic** factors” included.

Compare observations with model simulations



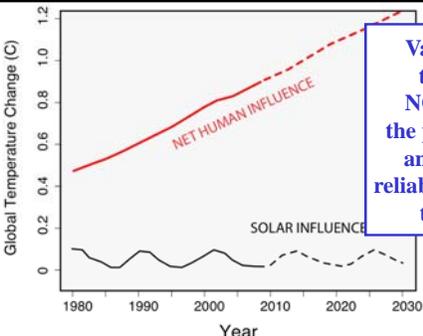
Temperature anomalies (°C)

Year

Observations

Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.

Climate simulated by model with natural and anthropogenic **all** factors included.



Global Temperature Change (C)

Year

NET HUMAN INFLUENCE

SOLAR INFLUENCE

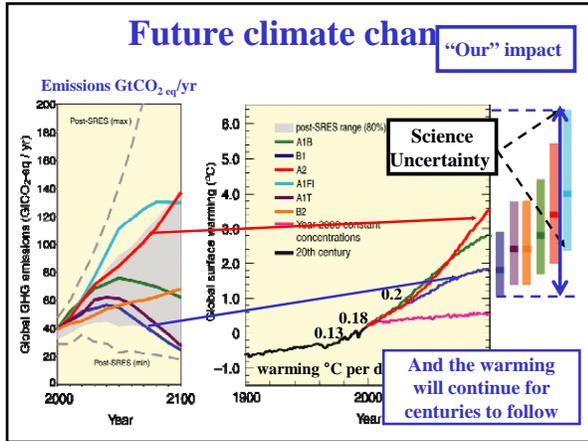
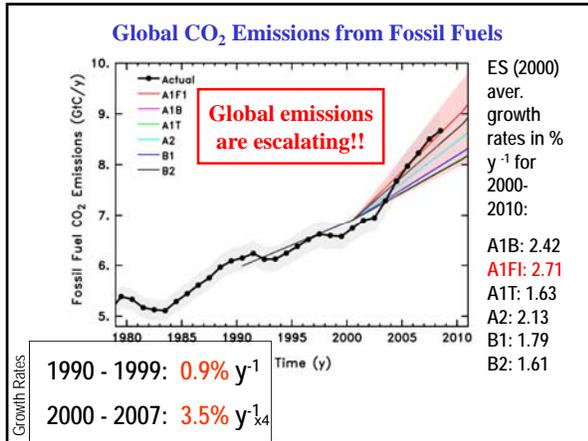
Variations in the Sun do NOT explain the past warming and are not a reliable predictor of the future.

We are seeing climate change and we are the main cause.

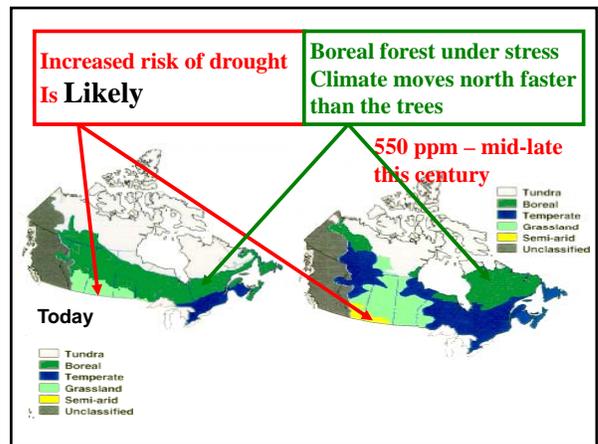
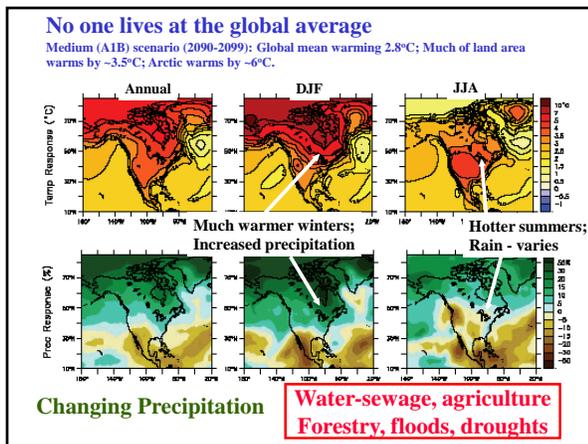
“Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.”



And Canada is a significant contributor to that increase



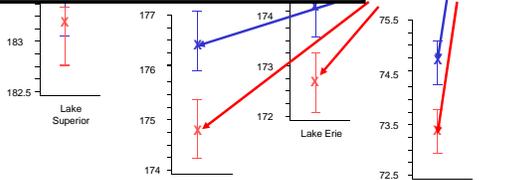
Canadians will have to "adapt"  
*"making adjustments in our decisions, activities and thinking"*  
 because of observed or expected changes in climate, in order to moderate harm or take advantage of new opportunities



## Warmer temperatures

Warmer lakes and changing climate resulting in more invasive species in lakes and ecosystems

1 metre drop in lake level possible



How will this change our access to water, sewage disposal, shipping and recreation?

X Average  
X Projected  
(CCC Government Minister & Quinn, 1996)

In Europe - Record setting August 2003 (more than 70,000 deaths) will be every second summer – by mid-century

- Actions:**
- Better design our structures and cities
  - more green space-shade-use of passive cooling
  - Heat alerts and responses – medical advice
  - Cleaner air

More frequent hot days – virtually certain  
Warm spells – very likely

### No Breathing Room National Illness Costs of Air Pollution

Canadian Medical Association (CMA) August 2008

1. In 2008, 21,000 Canadians will die from the effects of air pollution.
2. By 2031, almost 90,000 people will have died from the acute effects of air pollution. The number of deaths due to long-term exposure to air pollution will be 710,000. ...
10. 11. In 2008, economic costs of air pollution will top \$8 billion. By 2031, these costs will have accumulated to over \$250 billion.

With warming and more smoggy days – these numbers will increase.  
The processes that result in air pollution are much the same as those that produce greenhouse gases.

\$500M for the August 19, 2005 wind, rain event

More heavy precipitation events – very likely

### Wind Damage to Infrastructure

The Insurance Research Lab for Better Homes

### Number of Category 4 and 5 hurricanes, by ocean basin

Ocean Basin	1975-1989	1990-2004
NORTH INDIAN	1	7
SOUTHWESTERN PACIFIC	10	22
NORTH ATLANTIC	16	25
EAST PACIFIC	36	49
SOUTH INDIAN	23	50
WEST PACIFIC	85	116

The number of intense cyclones is increasing

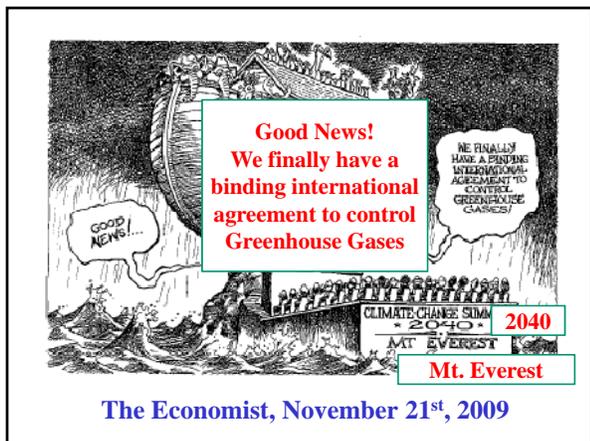
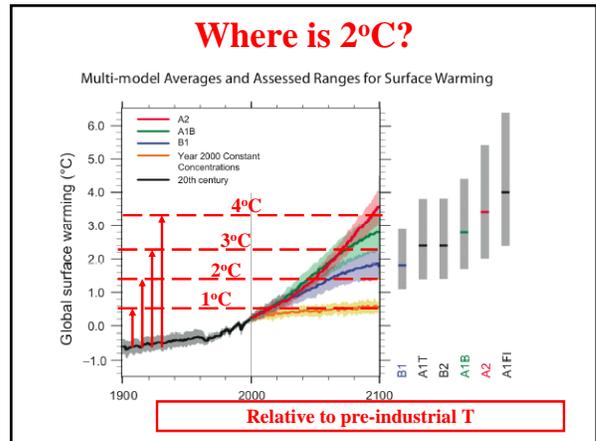
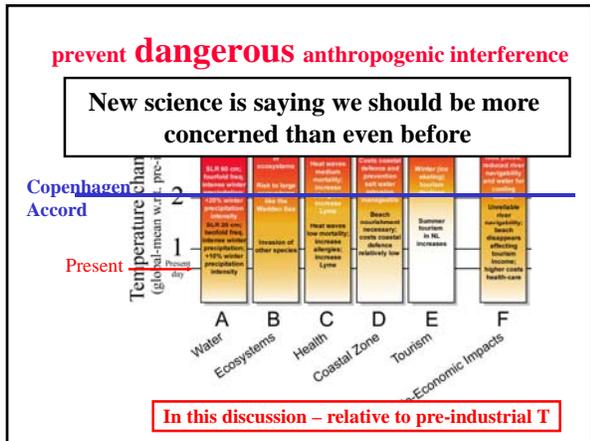
It is likely that future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

The apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period.



### Copenhagen Accord

- 1. We underline that climate change is one of the **greatest challenges** of our time. We emphasise our **strong political will to urgently combat climate change ... prevent dangerous anthropogenic interference with the climate system, ... increase in global temperature should be below 2 degrees Celsius, ...**
- 2. We agree that **deep cuts in global emissions** are required according to science, ... **peaking of global and national emissions** as soon as possible, ....



## UN FCCC – Bali (2006) report card

- Parties of the Kyoto Protocol
  - Emissions reductions compared the base year of 1990 for 2003 or 2004 showed a wide range.
  - European Community (target -8%)
    - 1.7% (decrease)
      - Germany (-16.7%) and the United Kingdom (-14.6%).
    - Japan (target -6%) + 8.3% (increase)
    - Canada (target -6%) + 26.5% (increase)

61

61

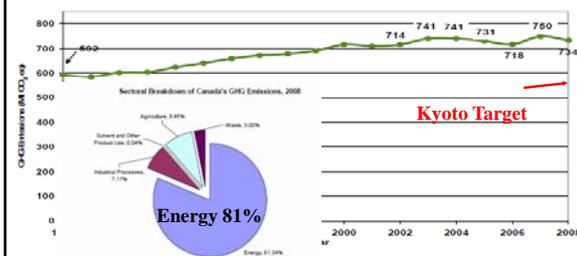
## Change in GHG Emissions 2005 Relative to 1990



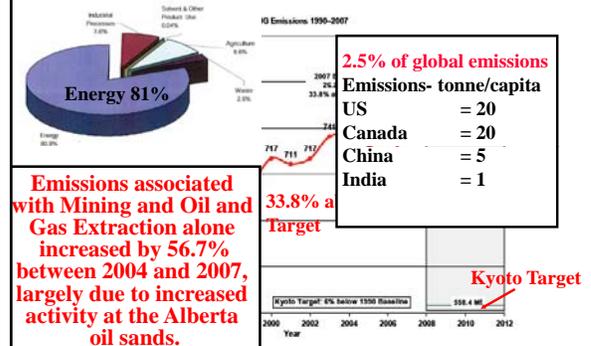
## CANADA'S 2008 GREENHOUSE GAS INVENTORY

A Summary of Trends: 1990-2008

Figure 1 – Canada's GHG Emissions 1990-2008



## Canada's Emissions to 2007



## By Province/Territory

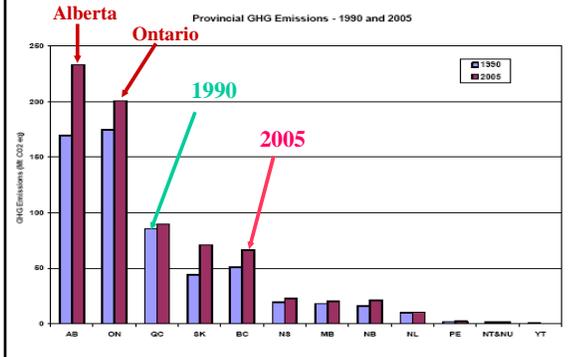
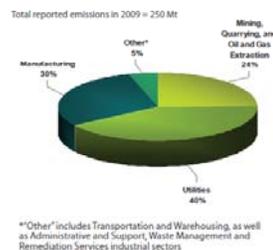


Figure 1: Industrial sector contribution to 2009 reported GHG emissions



**Minister of the Environment on Canada's climate change plan**

- June 4, 2009, C.D. Howe Institute

- Climate change ... most important public policy issues of our time ... long-term view and set a policy framework in place ..., to achieve the kinds of transformational goals that we have in our society. ...now and 2050.
- By end 2009 ... bold and forward-looking climate change policies with respect to all sources of carbon emissions in Canada.
- a low-carbon future - **carbon capture and storage**. The largest carbon capture and storage projects in the world today are operated either in Canada or in Norway.

*Economist March 2009*

- “**Carbon Capture and Storage — Trouble in Store,**”
- explores the problem areas related to this issue
- Cost - present estimates of \$40-\$90 per tonne of emissions reductions, possibly lowering to \$35-\$60 per tonne some time after 2030 with advances in technology and large-scale deployment.
- “**For the moment, at least, CCS is mostly hot air.**”

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**Canada’s GHG emission targets**

- On January 30, 2010, as part of a commitment under the Copenhagen Accord, the Government announced a new target of 17% reduction from 2005 levels, a target the same as the United States.
  - According to Environment Minister Prentice, the Government had planned this all along.
- This target is weaker than the earlier Harper commitment and, if implemented, would increase emissions in 2020 by about 2.5% relative to 1990 levels.

**Businesses ask Ottawa to price, not regulate emissions**

SHAWN McCARTHY  
OTTAWA— From Wednesday's Globe and Mail  
Published Tuesday, Feb. 01, 2011 7:33PM EST

- An overwhelming majority of Canadian industrial companies want the Harper government to put a price on greenhouse gas emissions rather than impose strict regulations that limit them, a new survey finds.
- Individual business groups – from the Canadian Council of Chief Executives to the Canadian Association of Petroleum Producers – have urged Ottawa to move forward with a market-based system that would create certainty for companies that have to make long-term investment decisions.
- Environment Minister Peter Kent has rejected calls for a cap-and-trade system or carbon tax, saying the government will instead follow the U.S. lead and impose regulated limits on emissions from major industries.

**The Climate Change Performance Index  
A Comparison of the Top 53  
CO<sub>2</sub> Emitting Nations**



2008-Canada – 51<sup>th</sup>; 9<sup>th</sup> in top 10

2007-Canada – 46<sup>th</sup>; 8<sup>th</sup> in top 10



2006-Canada – 46<sup>th</sup>; 7<sup>th</sup> in top 10

Country	Share of the Global CO <sub>2</sub> Emissions* in Percent	CCPI Rank
United Kingdom	2.2	3
Germany	3.4	5
India	4.2	10
China	14.9	29
Japan	4.8	34
Italy	1.8	38
Canada	2.2	46
Russia	6.1	48
South Korea	1.8	49
USA	22.9	52



Country	Share of Global CO <sub>2</sub> Emissions*	CCPI Rank
Germany	2.94%	5 (1)
India	4.46%	7 (5)
United Kingdom	1.92%	9 (16)
Korea, Rep.	1.70%	41 (54)
Japan	4.33%	43 (45)
Italy	1.60%	44 (44)
China	20.02%	49 (43)
Russia	5.67%	54 (53)
USA	20.34%	58 (56)
Canada	1.92%	59 (54)

2009-Canada – 59<sup>th</sup>; 10<sup>th</sup> in top 10

CCPI Rank	Country	Score**	Partial Score	Country	Score**	Partial Score
1 <sup>st</sup>	---	---	---	41	Korea, Rep.	48.1
2 <sup>nd</sup>	---	---	---	42	Romania	47.9
3 <sup>rd</sup>	---	---	---	43	Japan	47.1
4	Sweden	64.7	64.7	44	Italy	47.1
5	Germany	62.3	62.3	46	Poland	46.9
6	France	62.2	62.2	47	New Zealand	46.3
7	Italy	62.1	62.1	48	Roland	46.1
8	Brazil	61.4	61.4	49	China	45.9
9	United Kingdom	60.4	60.4	50	Austria	46.0
10	Denmark	60.4	60.4	51	Greece	44.7
11	Norway	60.5	60.5	52	Malaysia	44.3
12	Hungary	60.9	60.9	53	Cyprus	43.3
13	Norway	59.9	59.9	54	Brazil	42.6
14	Mexico	59.1	59.1	55	Australia	41.7
15	Portugal	58.8	58.8	56	Ecuador	40.6
16	Switzerland	58.2	58.2	57	Luxembourg	40.4
17	Argentina	57.1	57.1	58	United States	39.8
18	Lithuania	56.2	56.2	59	Canada	39.9
19	Latvia	56.1	56.1	60	Saudi Arabia	32.8
20	Morocco	53.8	53.8			

**Yes,  
Canada is one of the worst  
“performers” in the world  
on climate change.**



It one of Canada's 2020 target is among the worst in the industrialized world, and leaked cabinet documents revealed that the governments is contemplating a cap-and-trade plan so weak that it would put even that target out of reach.

“Canada has made zero progress here on financing, offering nothing for the short term or the long term beyond vague platitudes. And in last night's high-level segment, Canada's environment minister gave a speech so lame that it didn't include a single target, number or reference to the science. “Canada's performance here in Copenhagen builds on two years of delay, obstruction and total inaction. This government thinks there's a choice between environment and economy, and for them, tar sands beats climate every time. Canada's emissions are headed nowhere but up. For all this and more, we name Canada the Colossal Fossil.”



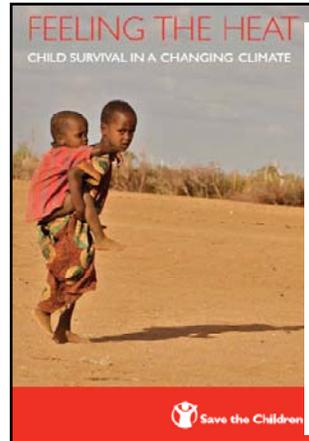
**CHILD HEALTH NOW**  
TOGETHER WE CAN  
END PREVENTABLE  
DEATHS

**Serving the children of  
The world?**

**CHILD HEALTH NOW –  
the causes of the emergency**

**Climate Change and Health**

children are more vulnerable  
...harder to obtain their  
rights  
Climate Change is felt most  
strongly in already **poor and  
often agriculturally marginal  
settings**, ... high levels of child  
illness and death.  
Climate change is already  
believed to account for over  
150,000 deaths and 5 million  
incidences of disease annually,  
**By 2050 up to 150 million  
people could be displaced due  
to desertification, water  
scarcity, floods and storms,  
...children disproportionately  
affected**



**FEELING THE HEAT**  
CHILD SURVIVAL IN A CHANGING CLIMATE

- The direct effects of climate change on child survival**
  - Diarrhoea and water-borne diseases
  - Malaria and other vector-borne diseases
  - Hunger and malnutrition
  - Increasing frequency of disasters
- The indirect effects of climate change on child survival**
  - Weakened health systems
  - Impact on fragile livelihoods
  - Increased migration and displacement
  - Impact on urbanisation
  - Additional burdens on women
- Interventions to tackle child survival**
  - Strengthening health systems
  - Food security and nutrition
  - National planning to address adaptation
  - Integrating climate risk information
  - Investing in child-centred disaster risk reduction



**Climate change as a National  
Security Issue**

**The United Kingdom**

- *“Providing security for the nation and for its citizens remains the most important responsibility of government.”*
- **Security challenges:** terrorism, weapons of mass destruction, trans-national organized crime, global instability and conflict, failed and fragile states and civil emergencies.
- **Climate change ...“potentially the greatest challenge to global stability and security and therefore to national security. Tackling its causes, mitigating its risks and preparing for and dealing with its consequences are critical to our future security, as well as protecting global prosperity and avoiding humanitarian disaster.”**

**Climate change is a long-term issue**  
**Issues of intergenerational and international equity**



**Western**      **The End**



**Thank you for your attention**

Institut für Catastrophische  
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Séismes Catastrophiques