Impacts of Climate Change

"Projected climate changes during the 21st century have the potential to lead to future large-scale and possibly irreversible change in Earth systems, resulting in impacts on continental and global scales." (Intergovernmental Panel on Climate Change, 2001)

How will the climate change as a result of increased GHG levels?

Research by climatologists, ecologists and other scientists from around the world indicate that the impacts of climate change are wide ranging, very real, and can have long lasting repercussions for humanity and our planet well into the future. It is very likely that changes in the global climate system in the 21st century will be even larger than those seen in the 20th century. Some of the significant research findings include:

Warmer temperatures
Global average temperature will continue to increase over the next 100 years. Climate models project increases of 1.8°C (for the 'low scenario') to 4.0°C (for the 'high scenario'). This warming will not be uniform across the Earth – northern latitudes and inland areas will warm faster than other areas. For example, in the Arctic, annual temperatures could increase by 3 - 7°C; this rise could be even faster in the winter, with some areas being 10°C warmer.

Changes in precipitation patterns
Climate models project an overall increase in global precipitation, but this will not be uniform. Some areas will be wetter than they are now; others will be drier. The timing will also change. For example, in southern Africa and Australia there will be less precipitation in the winter. In some areas, heavy rainfalls/snowfalls may become more common (i.e. more precipitation in a short period) and more precipitation will fall as rain instead of snow.

Rising sea levels
The average sea level is expected to rise by 28 - 58 cm by the year 2100 (as a result of thermal expansion, decreased snow cover, and melting glaciers and icesheets).

More extreme weather events
Extreme weather events (e.g. storms, hurricanes, tornadoes, heat waves, droughts) are expected to become more frequent and more intense. The weather is expected to become more variable (i.e. to vary more from 'average' conditions).

Major shifts in climate patterns
Major climate patterns could shift. For example, climate change could intensify the droughts and floods that are associated with El Niño events. New patterns could emerge for the Asian summer monsoon (e.g. the rainfall brought by the monsoons would vary more from year to year, leading to more intense floods and droughts). The 'ocean conveyor' that brings warmth northwards from the tropics could slow or even breakdown completely. Scientists are concerned about the possibility of rapid, abrupt shifts in climate, precipitated by radical changes in ocean currents. Although the IPCC does not think these extreme scenarios are likely, the consequences would be devastating.

How can we tell if a particular event is caused by climate change?

The short answer is we can't. Not for sure. Climatic and ecological systems are too complex, and are influenced by too many variables for scientists to be able to point to a single cause for a particular event; there are usually multiple contributing factors. But, when scientists step back and look at the bigger picture – trends over time and across

regions for a variety of indicators – they feel confident in saying that the big picture changes are very likely a result of increased GHG levels from human activity. So, while you cannot say that a *particular* event is caused by global warming, you can say things like:

- "It is likely that this event/change is a result of climate change"
- "The event/change can be attributed, in part, to climate change"
- "Events like this are becoming more common and severe as a result of climate change"

Climate change is already occurring

"Warming of the climate system is unequivocal…" (Intergovernmental Panel on Climate Change, 2007)

Already, we are seeing and experiencing evidence of climate change. Scientists have observed increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea levels. The global average temperature has increased by 0.76°C in the last 100 years or so and the world is warming faster than scientists reported in 2001. Eleven of the past twelve years (1995-2006) have been the warmest on record since record-keeping started in 1850. In the western Arctic, temperatures have increased by 3 - 4°C in the last 50 years. Other changes that scientists have observed and attribute to climate change include:

- Average precipitation over land has increased by about 2 % over the past century.
- Precipitation has increased in North and South America, northern Europe, north and central Asia and decreased in the Sahel, Mediterranean, southern Africa and parts of south Asia.
- Mean sea level has risen by 10-20 cm in the last 100 years.
- The extent of Arctic sea-ice in the summer has decreased by 15 - 20% and the ice is about 40% thinner.
- Almost all recorded mountain glaciers in non-polar regions have retreated.
- Droughts are longer and more intense, especially in the tropics and subtropics.
- Cyclone activity has increased.
- The number of hot days, hot nights and heat waves has increased.
- Climate-induced changes in at least 420 physical processes and biological species or communities.

Scientists are more confident than ever before that the increase in global average temperature in the last 50 years is due to higher levels of greenhouse gases resulting from human activity.

Is climate change inevitable?

Some change is inevitable. Even if we reduced GHG emissions and stabilized CO_2 levels now, there is a time lag before the climate responds. It's a bit like stopping a huge ship or train – it keeps going even after you turn the engine off. Right now, the climate is responding to changes in GHG emissions that have occurred over the last 200 years or so. Scientists expect that global warming and rising sea levels will continue for centuries, even if we stabilize greenhouse gas concentrations. BUT we can slow the rate of change by reducing our emissions. A slower rate of climate change will give us (as well as plants, animals and ecosystems) a chance to adapt to the changes. Scientists also believe a slower rate of change is less likely to precipitate abrupt, catastrophic shifts in climate.

Impacts of climate change

"*… an overstressed world with 6.3 billion people is a risky place to be carrying out uncontrolled experiments with the climate*." (UNFCC , 2005)[1]

Human and ecological systems are adapted to the current climate, which has been relatively stable for the last 10 000 years. Large changes in climate are happening more quickly than ecosystems, species and natural processes can adapt to them without serious disruption. Moreover, these changes are happening in a world that is already stressed by human activities and development (e.g. deforestation, urban development, pollution). Stressed ecosystems and human systems are less resilient and less able to cope with the effects of climate change. For example, urban development, fences, roads, logging and other human activities limit the ability of wildlife to migrate in response to food and water shortages. Millions of people live in places that are particularly vulnerable to the effects of climate change (e.g. coastal plains, deforested hillsides), and many have nowhere else to go. Some other projected impacts include:

- **Water shortages** as a result of changes in precipitation patterns, more evaporation, and contamination of water supplies by sewage, seawater and algae blooms. Already 1.7 billion people – a third of the world population – face water scarcity. This could increase to 5 billion in 20 years, as the effects of climate change compound existing stresses (e.g. population growth).
  In Canada: In the Prairies, less snowpack and glacier runoff will lead to summer water shortages. This trend has already begun. In the Great Lakes basin, lower lake levels will affect generation of hydroelectric power, shipping and shoreline infrastructure (e.g. docks and marinas).
- **Local/regional disruptions to food production** due to floods, droughts, contamination of productive agricultural land by rising sea levels and expanding ranges of plant and animal diseases and pests.
  In Canada: Some crops may benefit from longer growing seasons and milder winters, but others will be adversely affected. For example, the drought in 2001 significantly reduced crop yields and increased the outbreaks of insects and disease.
- **Rising sea levels** will erode coastlines, flood coastal plains, increase the intensity of storm surges, contaminate agricultural land and freshwater supplies, and damage buildings, roads and other infrastructure. Intensive development and modification of coastlines has made them more vulnerable to the impacts of climate change: more than 100 million people live within 1m of sea level. Some small island nations could be almost completely covered by seawater.
  In Canada: More than 7 000 km of coastline (especially the Maritimes, Beaufort Sea and Fraser Delta) are considered highly sensitive to rising sea levels. For example, in Charlottetown, projected increases in storm surges would damage properties worth about $200 million, including over 30 heritage properties. In the Arctic, thawing permafrost and decreasing sea ice are already threatening coastal communities: "Some of our communities are eroding into the ocean in front of our eyes because of the decrease in multi-layered ice, which is allowing for larger storms to roll in." Duane Smith, Inuit Circumpolar Conference.[2]
- **More frequent and severe weather events** (e.g. heat waves, heavy rainfall events, floods, storms, hurricanes, tornadoes) will damage property and infrastructure, disrupt business and industry, and injure and kill people.
  In Canada: During the Ice Storm in 1998, 28 people were killed, 945 were injured and 600 000 were evacuated. The estimated cost was $5.4 billion. Events like the

Saguenay and Red River floods, Hurricane Juan and "White Juan", and the Okanagan forest fires will become more frequent.

- **20-30 per cent of species are likely to face an increased risk of extinction** as warmer conditions alter the forests, wetlands, and rangelands they depend on, and human development blocks them from migrating elsewhere. The natural cycles of interdependent species may fall out of sync, as species adapt at different rates (e.g. the timing of bird arrival in the Arctic may no longer coincide with availability of insects). The most vulnerable ecosystems are coral reefs and atolls, boreal forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands. *In Canada:* Polar bears, which spend most of the year living and feeding on the sea-ice, could become extinct if there is complete loss of summer sea-ice (as some models predict). Polar bears are already showing signs of stress – they are thinner and are producing fewer cubs. Caribou will lose habitat as the boreal forest shifts northward and encroaches on the tundra. In addition, the ability of caribou to find forage will be hampered by more frequent freeze-thaw cycles and freezing rain (e.g. in the winter, caribou paw through snow to get to lichens and other forage; freezing rain creates ice sheets that the caribou cannot break through).

  Other examples of projected impacts of climate change on **Canada**:
  - **Declines in fish populations** (e.g. Pacific salmon, shellfish). For example, lower river levels and warmer temperatures have already drastically reduced the spawning success of major runs of Pacific salmon.
  - **Forests** will be affected by drought, wildfire and outbreaks of forest pests (e.g. spruce budworm, mountain pine beetle). For example, drier conditions will increase the frequency and intensity of spruce budworm outbreaks and lead to more wildfires in infested forests. Warmer winters have contributed to the severe infestation of mountain pine beetles in BC (the winters haven't been cold enough to kill off the pests).

For information on the impacts of climate change on health, see Backgrounder ' Climate Change and Health Impacts'.

Did you know?

- Climate change could result in shorter ski seasons and greater dependence on snowmaking machines. For example, one study projects a 50-70% decrease in the number of ski days in southern Quebec.[3].
- In the Maldives (a small island nation in the Indian Ocean), 80% of the 1 200 islands are 1m or less above sea level. Within 100 years, the Maldives could become uninhabitable, and its 360 000 citizens would be forced to evacuate.[4]
- If temperatures stay 1.9 to 4.6°C warmer than pre-industrial temperatures for millennia, the Greenland ice sheet will melt. This would raise sea level by 7 metres - comparable to 125 000 years ago.
- The number of severe tropical storms (Category 4 and 5) has almost doubled since the 1970's (and during the same time the average surface temperature of tropical seas has increased about 0.5°C).[5]
- Since 1980, there have been 70 weather-related disasters in the USA that resulted in over $1billion damage (each). These disasters included severe droughts, wildfires,

hurricanes and severe storms/tornadoes.
http://lwf.ncdc.noaa.gov/oa/reports/billionz.html

- Typhoons and flooding in Asia were particularly severe in 2006: 17 countries were affected by severe storms, torrential rains, severe flooding and mudslides. Millions were displaced, homes and crops were destroyed, and water sources were polluted. The flooding in India was the worst in 200 years.
http://www.ifrc.org/Docs/News/06/06081401/index.asp

Abrupt Climate Change

"Abrupt climate variations in the distant past appear to have been traumatic for life on earth". (UNFCC , 2005)[6]

The climate, or parts of the climate system, could change abruptly and drastically. Evidence from paleoclimatology (the study of pre-historic changes in climate, based on analysis of ice cores, tree rings, deep-sea sediments etc) suggests that the Earth's climate system has undergone sudden, dramatic shifts in the past. Some scientists are concerned that rapidly rising GHG levels may push the oceans, and the climate, past a critical threshold, or 'tipping point'. Once the oceans and climate are in this 'new' state, it may be difficult to change them back.[7]

Sudden large changes in climate would be catastrophic for humans and for the global environment as a whole, as we would have little time to adapt to the new conditions. For example, records suggest that, in the distant past, abrupt changes in climate coincided with 'mass extinctions' – in which a large proportion of the world's species were wiped out.

Two examples of abrupt change that particularly concern scientists:

1. Disintegration of the West Antarctic Ice Sheet and the Greenland Ice Sheet, which together would raise sea levels by a catastrophic 7 m, flooding huge areas of land and submerging many islands. It would also dramatically reduce ocean salinity, which would in turn affect ocean circulation patterns.
2. Shutdown of the ocean 'conveyor belt' (thermohaline circulation) that brings warmth from the tropics northward. The Gulf Stream is the northern loop in the conveyor and is largely responsible for the temperate climate in Western Europe. If the Gulf Stream becomes too diluted with freshwater (e.g. because of melting glaciers and ice sheets), it could slow or even shutdown completely. Without the Gulf Stream, Stockholm would have a climate similar to Iqualuit; Berlin would be like Edmonton. [8]

The faster we reduce our emissions of GHG and stabilize atmospheric CO_2 levels, the less likely these drastic, abrupt changes become.

Sources and Useful Links

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