Climate change in southwestern British Columbia: Extending the boundaries of earth science

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Engaging critical thought is the cornerstone of education

SUMMARY
Humans are altering the composition of the atmosphere, causing climate to change. Scientists predict that by the middle of the 21st century, average global temperatures will be several degrees warmer than today. The change in climate will be the largest and most rapid of the last 10,000 years and will have profound effect on our lives and the ecosystems that support us.

This paper describes a new, graphics-rich, colourful poster dealing with climate change in southwestern British Columbia. The poster, which is being used as a template for six other regional climate change posters in Canada, discusses the science of climate change, possible impacts of climate change over the next 50 years in southwestern British Columbia, and the challenge of dealing with this issue. The target audience for the poster is students in grades 10-12, colleges and universities, their teachers, and the educated general public. In preparing the poster, we were guided by the principle that to educate is to engage critical thought.

RÉSUMÉ
La présence des humains sur Terre altère la composition de l’atmosphère, ce qui entraîne des changements climatiques. Les scientifiques prévoient qu’au milieu de 21ème siècle, la température moyenne du globe se sera élevée de plusieurs degrés au-dessus de la moyenne actuelle. Ce changement climatique sera le plus important et le plus rapide des derniers 10 000 ans et affectera en profondeur nos modes de vie et les écosystèmes qui assurent notre survie.

Le présent article décrit une nouvelle affiche très riche en graphiques et en couleurs qui porte sur les changements climatiques dans la portion sud-ouest de la Colombie-Britannique. Cette affiche qui sert de modèle pour six autres affiches sur les changements climatiques d’autres régions au Canada, traite de la science des changements climatiques, de diverses hypothèses d’impact des changements climatiques des prochains 50 ans dans le sud-ouest de la Colombie-Britannique, ainsi que des défis que pose ces changements. La clientèle visée comprend les élèves de la fin du secondaire, les étudiants des niveaux pré-universitaire et universitaire, de leurs enseignants et professeurs ainsi que les couches instruites du grand public. Tout au long de la confection de la présente affiche, nous avons été guidé par la conviction que l’instruction provient d’une réflexion critique.

GETTING THE JOB DONE
The idea of a climate change poster stemmed from two independent initiatives, one by the Pacific Division of the Geological Survey of Canada (GSC) and another by Atmospheric Environment Service (AES). Bob Turner and John Clague of the GSC had just completed their Geoscope Vancouver poster and map (Turner et al., 1996, 1998; Clague et al., 1997) and were looking for opportunities to build on their experience of creating geoscience educational products. Eric Taylor and Bill Taylor, two AES atmospheric scientists, had recently spearheaded the British Columbia-Yukon part of the Cross-Canada Climate study (Taylor and Taylor, 1997).

At the encouragement of Sandy Colvine, Director of the GSC Pacific Division, these four people got together in August 1998 to discuss the possibility of producing a poster on climate change issues in British Columbia. They were joined by Nancy Grenier, an Environment Canada communications officer, and Bertrand Groulx, a graphic designer and veteran of the Geoscope Vancouver project. This group of six constituted a core group that over the next 13 months took the climate change poster from concept to reality.
Figure 1. Temperature Rising (reduction of 90 x 156 cm poster: Turner and Cline, 1999).
The core group was aided by a steering committee, consisting of 15 scientists, educators, communication experts, and representatives of environmental groups such as Greenpeace and the Pembina Institute. The steering committee provided scientific information and relevant photographs and graphics, vetted drafts of the poster, and generally kept the core group on track.

**POSTER STRUCTURE AND CONTENT**

The climate change poster borrows heavily from the Geoscapes Vancouver poster in philosophy and structure. Effective public communication is predicated on the use of simple, jargon-free language and graphic imagery. *Temperature Rising* is an attractive, full-colour, illustration-rich poster focusing on climate change in southwestern British Columbia (Fig. 1; Turner and Clague, 1999). Like *Geoscapes Vancouver*, it consists of an eye-catching central image surrounded by thematic panels.

The central image is an oblique, satellite view of the Pacific Northwest seen through a window in a fabricated cloud cover that extends to the Earth’s horizon. At the top of this image is the poster title, an evocative thermometer with an upward-directed red arrow, and a collage of six attention-getting photos. Introductory text presents key messages: by altering the composition of the atmosphere, we are changing our climate. By the middle of this century, average temperatures in southwestern British Columbia will be several degrees warmer than today (Fig. 2), and winters will be wetter and summers drier. This text also points out that these changes will be the largest and most rapid of the last 10,000 years and will have profound effects on our lives and the ecosystems that support us.

The panels surrounding the central image fall into three categories: the science of climate change, potential impacts of climate change on southwestern British Columbia, and the personal and societal challenge of dealing with the issue. In preparing the poster, we were guided by several principles:

- Topics familiar and relevant to residents, such as air pollution, fisheries, agriculture, forestry, and sea level rise, were selected for inclusion since people pay more attention to issues that directly affect them.
- The main messages are carried through photographs and drawings with a minimum of text.
- Block diagrams are used to convey geological relationships and the landscape in three dimensions.
- Much time was spent experimenting with graphic elements such as colour, typefaces, background patterns, and layout to make the poster attractive and something that people would want to display.

**Poster Topics**

- Is climate changing?
- Climate has always changed
- Why is climate changing now?
- The air we breathe
- Coastal floods and failing slopes
- Rising seas
- Salmon in hot water
- Low-water blues
- Forests in transition
- Down on the farm
- How do we measure up?
- Let’s meet the challenge

**SCIENCE OF CLIMATE CHANGE**
Three panels deal with the science of climate change. Each of these panels is framed around a question or an assertion intended to engage the viewer in critical thought: Is climate changing? Climate has always changed; Why is climate changing now? [The sources of statements on climate change and its impacts are Intergovernmental Panel on Climate Change (1996), and Taylor and Taylor (1997).]

**Is Climate Changing?**
Although the jury is still out, most atmospheric scientists are now convinced that we are entering a period of rapid climate change. Average surface temperatures over much of the Earth are 0.5-1°C warmer now than they were in the late 1800s at the end of the Little Ice Age (Fig. 3). Scientists are debating whether warming during the 20th century is part of the natural rhythm of climate or is the early sign of human-induced greenhouse warming. The hot years of the 1980s and 1990s, however, are so unusual (Fig. 3) that a natural cause seems unlikely. Eleven of the last 16 years were the warmest years of the last century, and 1998 may have been the warmest year of the last 1000. This period has also been one of numerous extreme weather events, including the 1997 Red River flood, the 1998 Quebec ice storm, and devastating hurricanes and floods in Central America and Venezuela. Scientists are quick to point out that awareness of weather catastrophes has improved in recent decades due to improved media coverage and that, with population and economic growth, society is at greater risk of such catastrophes. Nevertheless, some scientists have argued that extreme weather events have increased in recent years, consistent with predictions that these events will become more common as climate shifts to a new regime.

**Climate Has Always Changed**
A key contribution that earth scientists make to the climate change debate is that climate is naturally variable on all time scales and that this variability makes it difficult to discriminate human-induced from natural climate change. For more than one billion years, Earth’s climate has alternated between glacial (“ice house”) and nonglacial (“greenhouse”) states. The most recent of major glacial periods, the late Cenozoic, culminated in the Pleisto-
Figure 6 Pollutants can be trapped beneath a layer of warmer air in the Fraser Valley east of Vancouver. Airborne pollutants are typically carried east from Vancouver by prevailing westerly winds (Turner and Clague, 1999).

cene Epoch, with the episodic growth and decay of the large continental ice sheets in the middle latitudes of the Northern Hemisphere. As pointed out on the poster, what is now Vancouver was buried beneath nearly 2 km of glacier ice as recently as 15,000 years ago. Climate change of smaller scale has occurred throughout the present interglaciation (the Holocene). Insolation in the Northern Hemisphere was greater and climate was warmer during the early Holocene than it is at present. In contrast, a variable, but cooler climate characterized parts of the late Holocene, culminating in the so-called “Little Ice Age” that began in the 13th century and ended in the mid-19th century (Grove, 1988).

Why Is Climate Changing Now?
Water vapour, carbon dioxide, and some other gases strongly affect the temperature of the Earth's surface. Nearly one-third of the incoming short-wave radiation from the Sun is reflected back into space by clouds and the Earth (Fig. 4). The remainder is absorbed by the Earth and its atmosphere. Atmospheric carbon dioxide and water vapour, however,
absorb long-wave radiation emitted by the Earth. This heat-trapping mechanism is referred to as the “greenhouse effect.” An extreme example of the greenhouse effect is the atmosphere of Venus, our planetary neighbour. Venus’ atmosphere is 98% CO₂, and surface temperatures on the planet reach 430°C.

The main greenhouse gases, aside from water vapour, are carbon dioxide, methane (CH₄), and nitrous oxide (N₂O). CH₄ and N₂O absorb far more long-wave radiation than CO₂ and thus are much more potent greenhouse gases. However, CO₂ has the greatest influence because it is much more abundant than the other two gases.

So what determines the amount of CO₂ in Earth’s atmosphere? Huge amounts of carbon are stored in the Earth in fossil fuels and sedimentary rocks, on the surface in vegetation, peat, soils, and in the oceans (Fig. 5). Carbon occurs in the atmosphere mainly in the form of CO₂. Before the Industrial Revolution, additions of CO₂ to the atmosphere were roughly balanced by removals, and atmospheric concentrations of these gases did not vary much. Since the 1700s, however, CO₂ concentrations in the atmosphere have increased 30%, and concentrations will probably double from pre-industrial levels in the next 40-60 years (Intergovernmental Panel on Climate Change, 1996). The cause of the rapid buildup of CO₂ is human activities, notably burning of fossil fuels, agricultural practices, and deforestation. The continuing buildup of these gases is expected to be the main cause of climate warming.

A DIFFERENT FUTURE

Most atmospheric scientists now agree that increases in greenhouse gases will cause the Earth’s surface to warm. However, there is considerable uncertainty and debate about the rate and magnitude of warming, and about regional variations in the warming. Furthermore, the impacts of warming on the Earth’s hydrological regime remain uncertain.

Progress is nevertheless being made in predicting climate responses to increases in greenhouse gases, largely through construction of sophisticated general circulation models (GCMs) with the aid of powerful high-speed comput-

circulation. Precipitation is also expected to change, with projected increases in the tropical and sub-tropical Atlantic and in the Arctic, and decreases over many continental areas.

All of this will change ocean circulation and salinity. As climate warms,
we may see a stronger El Niño pattern established in the Pacific Ocean. The tropical Pacific is projected to warm by 4-5°C by the end of the 21st century, whereas the North Atlantic either will not warm or will be cooler than today. An increased high-latitude freshwater flux and changed temperatures may slow down thermohaline circulation in the North Atlantic, and temperatures in northern Europe may either warm much less than in other continental areas or even decrease.

What are the projections for Canada? The GCMs suggest that much of Canada will be an average of several degrees warmer in the middle of this century than during the 20th century (Fig. 2). The largest changes are predicted for Arctic Canada, although pronounced warming is likely to occur as well in the southern underbelly of Canada. The models predict that southern British Columbia will have longer, warmer, and perhaps drier summers and warmer, wetter winters. The number and severity of fall and winter storms may increase because warmer air masses are able to

Figure 10  Dry lake bed near Okanagan Falls in southern Okanagan Valley; photograph taken in the summer in the mid-1990s (Ole Westby).

Figure 11  Okanagan Valley water budget (Turner and Clague, 1999).

Figure 12  Possible expansion of grasslands in southern British Columbia under a warmer drier climatic regime. (left) distribution of grasslands at present; (right) possible distribution of grasslands at the end of the 21st century (Turner and Clague, 1999; source of information, Hebd, 1997).
hold more water.

Such predictions, of course, carry considerable uncertainty, but it is worth considering the likely impacts of such a different climate.

**IMPACTS**

Six panels on the poster address some possible or expected impacts of climate warming in southwestern British Columbia.

**Air Quality**

Vancouver, Penticton, Kelowna, and some other cities in southern British Columbia lie within valleys bounded by mountain walls that trap polluted air (Fig. 6). Airborne pollutants are usually dispersed by winds, but on calm days they can become concentrated beneath a layer of warmer air aloft. "Bad air" days and related health costs will increase if summers become warmer, drier, and longer, as predicted by GCMs.

**Floods and Landslides**

Warmer, wetter winters may bring an increase in the number of floods, especially in coastal British Columbia. Small streams are especially susceptible to this change in climate as they respond quickly to intense storms and to rain-on-snow events. In contrast, the largest rivers, such as the Fraser River, have large drainage basins, and crest in late spring and early summer. They are less likely to respond in the same way as small streams to a change to a warmer, wetter winter climate.

Wetter winters mean less stable slopes and more landslides. Debris flows, slumps, and rockfalls will become more common if our climate gets wetter.

**Sea Level Rise**

Most mountain glaciers will shrink as climate warms, and water from the melting glaciers will raise sea level. The effects of climate warming on the regime of the Greenland and Antarctic ice sheets, which hold 99.7% of the water that is locked up in glaciers, is less certain. A worst-case, although unlikely, scenario involving collapse of the marine-based West Antarctic ice sheet over a period of perhaps a few hundred years due to destabilization of buttressing ice shelves at its margin, would raise sea level 6-8 m. Sea level will also rise due to thermal expansion of ocean waters.

Given uncertainties in the amount of glacier melting and ocean warming, only a very broad range of values can be given for future sea-level rise. A rise of 10 cm to 1 m over the next 100 years is most likely, barring collapse of the West Ant-

![Figure 13](image-url)  
*Figure 13* Per capita carbon dioxide emissions for different countries and regions (Turner and Clague, 1999; source of information, World Resources Institute).

![Figure 14](image-url)  
*Figure 14* A bad situation unfolds slowly (Wackernagel and Rees, 1996).

![Figure 15](image-url)  
*Figure 15* Future consequences of the choice we make today about curtailing greenhouse gas emissions (Turner and Clague, 1999).
arctic ice sheet. The impact of this sea-
level rise will be greatest in areas where
the Earth is slowly subsiding due to
tectonic forces and sediment compaction,
such as the Fraser River delta, just south
of Vancouver. Conversely, the impact will
be less in areas of rapid uplift.

Rising seas will erode shores of
loose sediments. Parts of the coastline of
the Strait of Georgia are bordered by
bluffs of unconsolidated Pleistocene
sediments that, even today, are eroded by
waves during winter storms (Figs. 7, 8). A
rise in sea level will substantially increase
the erosion.

Higher seas may also flood deltas,
tidal marshes, and other low-lying coastal
areas. Fraser delta tidal marshes are
important habitat for waterfowl, shore-
birds, and salmon fry. Even a small rise in
sea level may drown the marshes or
squeeze them against sea dykes that
protect communities on the delta plain
from flooding.

Salmon
Pacific salmon live in cool ocean waters,
and southern British Columbia is near the
southern limit of their range. Warming of
the North Pacific Ocean could force
salmon northward, reducing their num-
bers in rivers in southern British Colum-
bia. Warm-water fish, such as tuna and
mackerel, may take their place.

A warmer climate also poses
problems for salmon as they move upriver
to spawn (Fig. 9). Salmon stop eating and
rely on stored fat when they enter fresh
water for the swim upstream. Salmon are
cold-blooded animals; their metabolism is
tied to the temperature of the surround-
ing water. If the water is too warm,
salmon use up their energy stores and are
unable to reach their spawning grounds.
Warmer water also increases the risk of
bacterial and fungal infections in salmon.

The Water Balance
and Stream Flow
Summers are dry and hot in the interior
valleys of southern British Columbia (Fig.
10), and climate warming will affect the
water balance in these valleys (Fig. 11).
Less precipitation may fall as snow, in
which case less water will be stored in the
mountains over the winter. Evaporation
and plant transpiration will increase
during the longer, warmer summers. Lake
levels may fall, while the demand for
irrigation and municipal water will
increase, especially in valleys such as the
Okanagan that are experiencing explosive
population growth.

Stream flow in the southern
British Columbia interior has changed
over the last 30 years (Leith and Whit-
field, 1998). Spring runoff starts earlier
and autumn rains come later, extending
the period of low summer flow. More
precipitation falls as rain than as snow in
autumn, therefore snowpacks are smaller.
Smaller snowpacks result in lower stream-
flow in summer. These trends will
continue if climate continues to warm.

Longer, warmer summers and
lower summer stream flows may affect
hydroelectric power generation. In the
future, some reservoirs may not fill to
their present levels and the amount of
electricity generation from them will be
less than today.

Forests
As climate warms, some plant species in
British Columbia will extend their range
northward and to higher elevations.
Drought-resistant trees such as Douglas
fir (Pseudotsuga menziesii) and Ponderosa
pine (Pinus ponderosa) will be favoured
over trees requiring more moisture such as
spruce (Picea). Grassland may replace
Douglas fir forests in some areas (Fig. 12)
and trees will invade alpine meadows.
Plants adapted to the new climate regime
will appear first in areas disturbed by fire,
logging, and extreme drought. Changes in
forest composition, tree growth, fire
frequency, and insect infestation will
affect how and where trees are harvested
and replanted.

Agriculture
Climate change is expected to bring
warmer year-round temperatures, wetter
springs, and drier summers to important
agricultural areas in southern British
Columbia, including the Fraser Lowland
and the Okanagan and Similkameen
valleys. Vineyards and orchards, currently
limited to the southern Okanagan, could
spread as far north as Kamloops in the
Thompson valley. Severe winter cold may
be reduced, but the drier warmer summer
climate will increase drought during the
growing season. Warmer winters may also
increase insect pests. Wetter springs on
the coast may delay planting, reducing
the benefits of warmer weather during the
growing season.

Never doubt that a small
group of committed people
can change the world. Indeed,
it is the only thing that has.
Margaret Mead

MEETING THE CHALLENGE
Canadians rank second in per capita CO₂
emissions (Fig. 13); we represent 0.5% of
the world's population, but produce 2%
of global CO₂ emissions. One reason for
our high carbon emissions is our cold
winters, but the main reason is our
profligate use of energy.

A 50-60% reduction in present
global emissions of CO₂ would be
required to stabilize atmospheric CO₂
concentrations at current levels. Under
the Kyoto Protocol, participating coun-
tries set an average emission reduction
target of 5.2% below 1990 levels by
approximately 2010; Canada's target is
5%. Far from reaching these targets,
however, Canadian CO₂ emissions will
likely be larger than 1990 levels by 2010.

The last, and perhaps most
important, panel of the poster addresses
the issue of meeting the challenge posed
by climate change. Many people question
whether we should act to reduce green-
house gas emissions. Some people are not
convinced that our alteration of the
atmosphere will actually cause climate
to change. Others point out that the magni-
tude and rate of change are unknown.
Individual and societal inertia in response
to this issue are also caused by other
factors: 1) the situation is unfolding in
slow motion; it is not perceived as an
immediate crisis (Fig. 14); 2) the most
serious impacts are decades away; 3) the
issue is so complex, it's hard to pinpoint
cause and effect; 4) the cause of the
problem is invisible; 5) we assume
someone else is working on a solution;
and 6) some of the impacts may be
positive (people living in Winnipeg likely
might say, "bring on those warmer
winters").

So why should we act? The risks
are high and we need to proceed cau-
tiously when our actions may have long-
term negative consequences (Fig. 15). The precautionary principle tells us that we should reduce greenhouse gas emissions now to lessen the negative impacts of climate change on our children and grandchildren. The longer we wait to take action, the fewer options we may have for dealing with climate change.

We can slow the rate and eventual magnitude of climate change by reducing our greenhouse gas emissions. But we will also have to adapt because some climate change is now inevitable. Carbon dioxide molecules have lifespans of decades or even centuries in the atmosphere.

PRODUCTION AND MARKETING
Production of the climate change poster required collaboration of scientists working for the Geological Survey of Canada, Environment Canada, the Canadian Forest Service, Agriculture and Agri-Foods Canada, Fisheries and Oceans Canada, British Columbia Ministry of Environment, Lands and Parks, British Columbia Ministry of Forests, Royal British Columbia Museum, and Simon Fraser University. Input was provided by several other groups including the Greater Vancouver Regional District, David Suzuki Foundation, Pembina Institute for Appropriate Development, and the Sea to Sky School of Environmental Education.

The production team included a graphic designer, two contract draftspersons, and the GSC digital cartography unit in Ottawa.

Two drafts of the poster were circulated to scientific advisors for review. Following review and approval by contributing government agencies, final digital files were transferred to the GSC in Ottawa. The poster was translated into French, and both English and French versions were printed. The entire process from conception to public release took 13 months.

It’s one thing to produce a poster, but quite another to ensure that it is used. We involved educators in the production of the poster and have marketed it extensively. The poster is available through GSC offices in Vancouver, Calgary, and Ottawa. The poster, teachers’ resources, and additional information on climate change may be accessed at www.climatechangecanada.org. Thanks to a grant from the Climate Change Action Fund, the poster is available to teachers at no cost and may be purchased by others for only $5. We launched the poster in a secondary school and have given climate change workshops for teachers in collaboration with the Greater Vancouver Regional District. We have also teamed up with the Pembina Institute and Greater Vancouver Regional District to ensure further distribution of the poster. We are now preparing ancillary products for teachers, including overhead and slide sets of the poster images.

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