Document generated on 04/25/2024 5:03 p.m.

Geoscience Canada

Comments and Reply

Volume 27, Number 4, December 2000

URI: https://id.erudit.org/iderudit/geocan27_4car01

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Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this article

(2000). Comments and Reply. *Geoscience Canada*, *27*(4), 186–188.

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Due to the vast apparent incompleteness of Clague and Turner's paper and their early admission in their paper that "there is considerable uncertainty and debate about the rate and magnitude of warming, and about regional variations in warming," and "Furthermore, the impacts of warming on the Earth's hydrological regime remain uncertain," I strongly urge these geoscientists to reconsider their intent to widely distribute this material.

These authors had a wonderful opportunity to provide a balanced look at this nasty atmospheric trend, and I am so disappointed with their effort. Some items, incomplete to say the least, that I feel should be included in such a study are as follows:

1. Comparison of time-dependent CO_2 levels with base station temperature change: I know of one station at 51°N up to 1970s.
2. Projection of decline in fossil fuel availability: is this factor in the computer models?
3. Production of CO_2 in nonhuman generators (vulcanism, coal fires, forest fires, for examples), and comparison to human generators of CO_2.
4. Data on snowpacks. There have been some record snowpacks in this area recently.
5. Changes of CO_2 composition in atmosphere throughout geologic time.
6. Recycling mechanisms of CO_2 on Earth. The oceans, for example, are huge absorbing pools for carbon dioxide. That's how most of the limestone of the world was made.
7. Cloud cover and its causes and effects on climatic factors. Warmer oceans mean more evaporation, more precipitation, more cloud cover on elevated land, more cooling, more snow. Garibaldi Alpine Ice Advance in southwestern British Columbia, for example, coincides with Hypsithermal at 6600 years BP, the hottest and driest time in the last 10,000 years!
8. Climatic indicators as recorded in Holocene paleobotanical and terrain studies. There is a wealth of data in this work, including that done on recent lacustrine deposits, and the numerous raised alluvial fans that have been studied.
9. Geothermal activity, oceanic rift zones, near-surface magma chambers, terrestrial hot spots, *etc.* all contribute to (or perhaps control) warming and/or cooling. Some of the hot spots in oceanic vents are boiling, and most have not been discovered yet.
10. The authors conveniently ignore actions that have been undertaken to reduce CO_2 emissions, however insufficient. This is no accident, it is a reflection of their bias.

There is much more, but you get the idea. Clague and Turner's treatment of this subject is grossly oversimplified, incomplete, biased, and misleading, and provides absolutely nothing new. It is no wonder they boast that this mirage-like study only took a few months to throw together.

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REPLIES

Dear Editor:

Murray Roed criticizes our paper, and the poster on which it is based, claiming that they are "three steps backward." Dr. Roed is entitled to his opinion, but we believe he is wrong. Let's examine his three principal criticisms.

1. **Misleading the Public.** Roed claims that we present an unbalanced view of the factors that control climate and cause it to change. He argues that we completely ignore major natural causes of climate change. This is not true. One section of the paper, titled, "Climate Has Always Changed," deals with major natural fluctuations in climate in late Pleistocene and Holocene time. As well, Figure 5 summarizes global carbon sources and sinks. Both of these themes are developed at greater length in the poster.

It is true that the paper and the poster emphasize the likely role that humans play in causing climate to change: this was our objective and requires no apology or further explanation. Unlike Roed, we believe that there is a very high likelihood that human activity will alter climate and that the human impact, over the short term, will outweigh the effects of the natural factors that Roed mentions. Certainly "oscillations of Earth's orbit, inclination of its axis, and related planetary forces" alter climate, but they do so over time scales of thousands of years to hundreds of thousands of years, and will have no appreciable effect over the next 100 years, the period of concern here. Likewise, pole reversals and changes in the positions of plates are irrelevant to the discussion on the time scale of the next century.

Roed considers our illustrations "gross generalizations that have no place in any serious scientific publication." We point out that our *Geoscience Canada* paper is not a scientific article, but rather a description and overview of an educational product. Our drawings are purposely generalized to get ideas and messages across to the poster users, primarily grade 10-12 students and teachers.

Roed believes that many of our illustrations are misleading and cites Figure 11 (Okanagan Valley water budget) as an example. According to Roed, this figure "is particularly troublesome (my home) since it is the exact opposite of the real situation in terms of groundwater at least". Let's examine his concerns. The purpose of Figure 11 and its companion text is to illustrate a likely deficit in the summer water budget in the semiarid Okanagan Valley, given the predicted increase in evapotranspiration under a warmer climate (Coulson, 1997). The figure depicts lowered water tables

due to this predicted increased evapotranspiration. Roed's criticisms make it clear that he is confusing the impact of clearcutting of forests, which can cause a rise in the level of the local water table, with the impact of extended summer drought on forests. Secondly, Roed asserts that the slight historical decrease in stream flow in Okanagan Valley relates to increased storage in reservoirs and increased retention within aquifers, although he provides no references to support this claim. In contrast, we show on our figure reduced stream flow due to reduced ground water supply to streams. We base our interpretation on recent research on the impact of climate change on stream flow in Okanagan Valley and nearby watersheds (Leith and Whitfield, 1998), which is referenced on the poster. This research documents lower summer flows in small unlogged watersheds for the period 1984-1995, a time of warmer climate, relative to flows during the period 1970-1983, which was a cooler period. Leith and Whitfield (1998, p. 228) attribute reduced stream flow during the 1984-1995 period to reduced ground water inputs. We, therefore, stand by our illustration as a useful presentation to the public of current scientific understanding. If Roed knows of contrary research findings, he should cite them. Otherwise, he is open to his own criticism of "misleading the public."

2. Insufficient Research. Roed concludes that we are guilty of not thoroughly researching our paper and poster. The yardstick for this claim is that we included only 14 references in our paper. We believe that the paper is properly referenced. We rely heavily, although not exclusively, on two comprehensive documents: one, the 1995 Intergovernmental Panel on Climate Change Report (IPCC, 1996), and the other a thorough summary of anticipated impacts of climate change in British Columbia and Yukon (Taylor and Taylor, 1997).

Roed must realize that it wasn't just Clague and Turner who produced the poster on which the paper is based. Eric Taylor and Bill Taylor, two atmospheric scientists with Atmospheric Environment Service, were part of the group that, collectively, created the poster. A steering committee, comprising, among others, biological, ocean, soil, and forest scientists and educators, contributed to the poster and verified its accuracy. Before the poster was published, it was signed off by the Geological Survey of Canada, Environment Canada, Agriculture and Agri-Foods Canada, Fisheries and Oceans Canada, British Columbia Ministry of Environment, Lands and Parks, and British Columbia Ministry of Forests. We find Roed's claim of insufficient research to be particularly puzzling in light of the large number of experts who contributed to, and vetted, drafts of the poster prior to publication.

3. Rush to Proliferate. "A scary mission to quickly distribute and market their cartoon-like images to schools"? Actually, the poster was developed over a period of 13 months, not a few months as Roed claims. We involved a large and diverse group of stakeholders in our effort and proceeded cautiously. Drafts of the poster were reviewed by our steering committee and educators.

Roed ends his letter with a list of 10 items he thinks should have been included in our paper. In the case of some items, Roed reiterates that we should have devoted more attention to natural controls on climate, a criticism we have addressed above. A few of the items are irrelevant to our paper. For example, fossil fuel availability and usage will inevitably decline, but not before the effects of high carbon dioxide concentrations in the atmosphere have altered climate. And yes, oceans are important carbon sinks, but atmospheric carbon dioxide levels will continue to increase before a new equilibrium is reached between atmospheric and oceanic carbon dioxide. The so-called "Garibaldi alpine ice advance" did not occur 6600 years ago during the "hottest and driest time in the last 10,000 years," as Roed claims, but rather about 5000-6000 years ago after the Hypsithermal warm period had ended (Ryder and Thomson, 1986). Finally, Roed states that we "conveniently ignore actions that have been undertaken to reduce CO_2 emissions." It is true that we do not mention such measures in our paper, but one of the poster panels is devoted to "meeting the climate change challenge." This panel includes photographs of a solar panel farm and a wind turbine, and includes the following statement: "Our climate crisis has created a demand for good ideas that will reduce our greenhouse gas emissions – new technologies, alternative energy sources, progressive government policies, and lifestyle choices..."

Dr. Roed concludes his letter with the statement "Clague and Turner's treatment of this subject is grossly oversimplified, incomplete, biased, and misleading, and provides absolutely nothing new." Simply put, he is wrong.

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Dear Editor:

I feel compelled to respond to Murray Roed's letter on the paper by John Clague and Bob Turner published in volume 27, number 3. I strongly resent the implication that I was not a "*bona fide* arms-length reviewer" for this article.[1] I was not in any way associated with either of the authors in their preparation of the poster or the article describing it. I suggest that Dr. Roed either explain his statement or retract it publicly because I believe it impugns my good name.

When I was asked to review the article, I understood that it was because I am knowledgeable about the public awareness of science and also a broadly experienced earth scientist. The article serves to describe to fellow earth scientists the development and distribution of a poster addressing global warming in southern British Columbia. The article succeeded in this goal and it was from this point of view that I reviewed it. I am certain that the authors will address the scientific concerns raised by Dr. Roed, so I will not address them here. However, I do not agree with Dr. Roed's assertion that the public is being misled; rather the public is getting information in a form it can understand. In terms of the level of research, the article is well founded; it is necessarily simplified for the purpose of communication with the public.

I think Dr. Roed misunderstands the nature of communication with the public. The message must be brief, simple and visual if it is to make an impact.

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[1]Clague and Turner's paper was reviewed internally at GSC Vancouver before submission to *Geoscience Canada*, and was reviewed by two referees for *Geoscience Canada* and by me as editor. All agreed on publication following very minor changes, which the authors completed. I invited Clague and Turner to submit their paper and I am pleased to see it in print. R.W. Macqueen, editor.

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