

Guide to the Science of Climate Change in the 21st Century



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This Guide was prepared as a community service. Its sole purpose is educational. It follows the outline of a course presented at the University of Calgary since 2007 titled 'The Science of Global Warming and Climate Change'.

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Readers of the Guide are encouraged to express their opinions to the author by email, ManzGSCC@shaw.ca.

**Title Page: Eco Print, 'Alexandra's Playground', by Nora J. Manz - 2020
Nora's eco-prints reflect the unexpected wonder of human relationship with nature.**

Preface

The effects of global warming and climate change are being experienced. The effects are negative, significant and appear to be increasing in severity. Society, individuals, entire communities, local to international, on a global scale are being traumatized. The preservation/ protection of all valued aspects of society and the natural environment requires adaptation to the effects of what is now being called ‘the new normal’ yet to be defined and possibly within our control.

Climate is distinct from weather. Weather is a day-to-day phenomenon and when averaged over long periods of time will describe climate. Today climate and most of the forces and elements that ultimately define it are understood. Strategies to use this knowledge to predict climate change have been developed and are able to Guide adaptation and mitigation efforts.

If it is accepted that global warming and climate change are occurring and that there will be serious impacts society urgently requires some idea what these might be. Forecasts/ predictions need to be made. These include:

- Identification of what the impacts might be. What needs to be adapted to?
- Who will be affected? How will they be affected?
- When do we need to adapt?
- What must we do? How do we prepare?
- What will it cost?
- How will I be affected and what do I do?
- Can we stop/ manage/ avoid/ limit the need to adapt (mitigation)?

These are global questions requiring global discussion to arrive at workable global answers and decisions that can be acted on. We all breath the same air. Everything we do affects the whole planet.

Society is divided into at least four groups as it pertains awareness and belief in the science of global warming and climate change.

1. Those who are actively engaged in learning the science as represented by the scientists, want to understand the impacts of climate change, wish to prepare to adapt to its impacts, and actively take steps to eliminate or at least reduce the factors contributing to the

phenomena of global warming (mitigation).

2. Those who are aware there is a problem and are willing to rely solely on ‘experts’ or a group representing experts for their views. They might be intimidated by the experts and feel reluctant to express their views or they might have the ability to understand the science but have limited desire to learn and assess the science for themselves.

3. Those who do not believe the claim that global warming and subsequent climate change are caused by human activity. This is the so-called denialist community. Their perspectives include:

- Climate has always changed and it is simply a natural process which we cannot do anything about.
- Humans are simply not capable of being a cause for global warming and climate change. We are in the hands of a higher spiritual being. It is our fate.
- It is part of a conspiracy to damage or destroy the economy, our way of life, the fossil fuel industry, a political faction, etc.
- The science of global warming and climate change is not sufficiently developed to be taken seriously.

4. Those who simply ignore the issue altogether for a variety of reasons.

- They believe that they are incapable of understanding the problem and therefore cannot contribute to the solution.
- They do not have access to information that would assist them to understand the problem and therefore cannot contribute to the solution.
- Their opinion is worthless or won’t be heard so let someone else address the issue.
- Let others deal with the problem, if there is one, and leave them alone.
- They don’t know that the problem exists.

One of the more interesting aspects of the global warming and climate change conversation is that people with little or no real understanding of the science find it possible to accept that it (global warming and climate change) is occurring, believe the impacts on our global environment are and will be devastating and that drastic measures must be immediately taken to mitigate its occurrence. When science discusses the nature and impacts of climate change (observed or forecast) or what mitigation activities must be taken the information and advice

are accepted as the sage advice and assessment of experts with very little if any understanding of the science and therefore without the ability to defend the expert perspectives. With knowledge of the science of global warming and climate change, even some of it, it is possible to contribute to very important discussions, not just defending the science but also those dealing with research needs, information collection, education and study and advocating for the support for funding these activities.

With some knowledge of the science of global warming and climate change it is possible to counter the questionable arguments of the denialist community or support the arguments of the experts.

With some knowledge of the science of global warming and climate change it is possible to teach others, to spread the word regarding the serious impacts on the horizon if no action is taken with the ability to explain the background science to people of all ages, relationships, backgrounds, education, profession, political views, governance responsibilities, social status, nationality, race, religion, wealth, etc. in a language and manner they are familiar with and in a manner that they would relate to. Everyone can become an activist – over a tea, in the office or in front of an audience of thousands. Some must become activists, as individuals or by supporting or becoming part of organizations operating at the local, provincial, national and international levels.

Knowledgeable persons, world wide, need to stand up, present themselves and communicate the nature and seriousness of climate change. It is a need. They need access to information on the science.

It is very important that information on the science of climate change be obtained from ‘knowledgeable and trustworthy’ sources. It is a serious problem when sources are ‘ignorant, uninformed, dishonest or have biases that favour their agenda’. The quality of the information provided will determine the quality and nature of perspectives, assessments and selection management solutions.

If people wish to develop knowledge of the science for global warming and climate change and find the need to accept opinion and advice from others, they must choose their advisors, their experts, their ‘gurus’ carefully.

The purpose of this Guide is empowering individuals who don’t want to rely solely on ‘experts’ by providing them the opportunity to learn the science for themselves, at least provide a solid overview. It is hoped that this would allow them to be able to identify true scientific experts and to form conclusions based on accepted scientific knowledge; and, enable them to continue the learning process themselves. Not all people are able or willing to take the time to learn the science, even at a rudimentary level, and must still accept the opinion and advice of those knowledgeable of the science. But learning even a little about the science is a great help and if the individual is capable of learning, even a little, developing some understanding of the science

may be viewed as a social responsibility.

A word about science. What is science? Why should we trust it? Why should society be guided by scientists?

Science is the systematic study of nature, the world and the universe. It includes us, humans. It includes but is not limited to the study of physics, chemistry, biology and social behaviour. It also includes the study and development of methods to use science to support human endeavour such as engineering, agriculture, medicine, psychology, sociology, and education. Scientific study and the resulting knowledge are responsible for virtually every aspect of modern life, food, shelter, security, transportation, sports, recreation, health care to name a few. Society relies on science and the creation of more science.

Science is performed by people known as scientists. Everyone is a scientist to some degree; but people who are referred to as scientists have taken special training, usually in a college or university in order to maximize the benefit from previously developed scientific knowledge and from the knowledge that is in the process of being refined (dialogue within the peer and mentor community).

Scientists practice what is known as the **scientific method**. A good definition of the scientific method is: a method of procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses. Criticism is the backbone of the scientific method.

When scientists wish to ‘share’ their work with other scientists they automatically solicit review and criticism. Scientists may wish to publish their work in scientific journals known for publishing quality scientific research. But before this can happen their work is peer reviewed (critically reviewed) by other independent scientists knowledgeable in their field of study. Deficiencies are identified and corrected before the work is published. The peer review helps ensure that the work reported meets the minimum standards for integrity and significance. Peer reviewed scientific contributions allow for the growth of knowledge in any particular field of study. Knowledge gained in this way may be called ‘scientific knowledge’ and is trusted to be the most accurate available.

It should be clear that the scientific knowledge, on any subject, builds on previously developed or collected knowledge. This is particularly true for mature subjects (subjects for which there is substantial knowledge). Occasionally there is confusion when observations appear contradictory or theory is not supported but these ‘bumps’ provoke intense scrutiny and resolution and even better science. Scientific knowledge grows with the accumulation of scientific knowledge and the acquisition of more, improved and new observations. Frontiers of knowledge are advanced slowly. Hypotheses are always being tested using available theory, data and analytical ability. Anomalous observations and phenomena provoke close examination and explanation – more supporting science may be needed. Developing consensus is a slow

but necessary process.

The ‘science of climate change’ is very complex but is well developed. Recent innovations in data acquisition and computational capabilities have enhanced the ability to consider more and greater details of the global climate system. This in turn has resulted in a better understanding of the science of global warming and climate change and the ability to predict adaptation and mitigation needs.

Governance must be performed on the basis of accepted science though this might be the greatest challenge individuals who assume governing responsibilities may have. In democracies or near democracies the leadership is determined by the electorate; that is, individuals. For leadership to consider the global warming and climate change situation seriously, the electorate (individuals) must also take it seriously. The electorate must be educated and leadership must be encouraged to take the advice of available expertise which governments have the responsibility to support.

Individuals (including leadership) must be empowered with a knowledge and trust of science and scientists. All segments of our community need to participate freely in the discussion - all ages, all genders regardless of nationality, religion, philosophy, politics, wealth, education, profession – everyone. The discussions can occur using every available form of discourse and expression, internet, social media, radio, television, writing, debate, music, song, drama, theater, dance or art. Everything that can be done to further this process and identify strategies to counter the threat of climate change is important and serves not only the individual, but the country and the planet.

Science is blind to agendas. Science is not faith based. It is not magical. It is reality. It is truth. It must be the foundation on which we base our decisions.

Science is science – it simply is. There is only one science.

Global warming and climate change are happening and our global community must at least attempt to limit its impact.

There are many sources which describe the science of climate change. Most have their origins in the various publications of the United Nations Intergovernmental Panel on Climate Change (UN IPCC) or sources that have contributed to them. For reasons of accuracy and completeness the IPCC publications are substantial documents. For most people they are very difficult to read and understand even in a synopsis form. If its any comfort there are few if any scientists who can say they understand all of the subjects included in the science. But scientists believe scientists.

The science as described in this Guide is complete, presented in a logical fashion and to the extent possible is up-to-date and correct. Considerable effort has been made to make the

subject material as clear as possible, to facilitate self-learning and to connect the content to existing and future knowledge sources. The subject material is not ‘dumbed down’.

This Guide is intended to be read and understood by anyone who is sincerely interested in learning about the science of climate change.

For some the Guide will become their entry point into the science of climate change as it is actually being performed – potentially life altering, career altering, opportunity for advocacy or a determinant in career choice.

Writing this Guide was an important community service. I was able to do it so I did.

A note on this publication.

A perfectly good question is: “Why is this Guide published and distributed for free on the internet?” There are a few reasons:

1. Much of the best material presented such as photographs and graphs are proprietary and only available without cost if there is no commercial gain. The Guide would be too expensive. If the material was excluded the Guide would be incomplete and dated.
2. The process of publishing a book-type Guide would take a long time. The Guide needs to be available asap.
3. Most of the references used are web sites. The material is high quality, available and free of charge but is dynamic. There unpredictable changes. The updates can be managed if the Guide is published on the internet – not so if it was published in book form which would limit most of the material referenced to works previously published in hard copy – not a good choice in todays information environment and a serious issue that the Intergovernmental Panel on Climate Change deals with. The Guide provides information to the youth of today
4. Critical feedback from readers can be reviewed and assessed. The Guide can be edited very easily when required.
5. The Guide is a living document. It will evolve.

Acknowledgements

The United Nations Intergovernmental Panel on Climate Change undertook and succeeded in synthesizing the scholarly work of thousands of researchers from all scientific disciplines to create the field of study and applied science now known as Climate Change. The foresight and commitment of the many people and nations to recognize and proceed to address and resolve the challenge of climate change to humanity and all life on Earth is impossible to overstate.

The support of the University of Calgary, Faculty of Continuing Education was invaluable to the development of this Guide by virtue of their faith in me as a scientist, scholar, educator and concerned citizen of the world. They provided the encouragement and resources necessary for the development of the course on the science of global warming and climate change. The students of the course contributed more than they know. It is an honour to have this work recognized by the Alberta Order of Excellence.

Thanks go to the numerous people who reviewed and edited the drafts of this Guide to ensure that it was readable and understandable to the intended audience. Roy Schneider was particularly helpful.

Dedication

This Guide is dedicated to all those who wish to learn about climate change, in particular the youth of today, future generations, including my son, his wife, and my grandchildren.

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