



CLIMATE CHANGE MADE CLEAR

THIN ICE

The Inside Story of Climate Science

a context for teaching and learning about climate science and related issues in the NZ Science curriculum

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THIN ICE on the road

Using the “Thin Ice” video as a context for teaching and learning in the NZ Science curriculum

A Teacher’s Guide – August, 2015

Compiled by Doug Sheppard, Terry Burrell and Shane Delaney - Onslow College, Johnsonville, Wellington

1. Introduction

The Vision statement in the NZ Curriculum describes young people who are “Connected to the land and environment, Members of communities and International citizens actively involved participants in a range of life contexts...contributors to the well-being of NZ (environment) ...and informed decision makers”

<http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Vision>

Now that we’ve stopped arguing about whether Climate Change is really happening, the big questions we are left with include:

“What can be done about it?”

“How can schools play a role in this?”

“How can this Thin Ice video resource and the accompanying resources on the Thin Ice website be best used to support effective teaching and learning in NZ schools?”

“What might this look like in our classrooms?”

Three teachers at Onslow College in Wellington have collaborated to compile this Teachers’ Guide to support the Thin Ice roadshow. This resource exemplifies several teaching units and explores the potential cross-curricular links between Science and the Social Sciences curricula.

This Guide is intended to stimulate discussion and exploration within each school, rather than to deliver a “ready to use” unit. Some starter questions are provided to assist teachers in developing their own authentic learning programmes, making use of the Thin Ice video and tapping into other resources (relevant research projects, community initiatives, whanau expertise) that are available locally. NCEA assessment opportunities are suggested for senior units.

An example of an earlier collaboration between Onslow College and the Thin Ice project, reflecting the approach anticipated for this guide, can be found at:

<http://www.nzscienceteacher.co.nz/teacher-education-in-science/secondary/examining-a-changing-world-teaching-climate-science-in-new-zealand/#.VamutaSgoSU>

2. Junior Sciences

Why use Climate Change and the THIN ICE film in a Junior programme?

- *Rich and vitally relevant context for 21st Century youth*
- *Global issue – range of views so opportunities for using Social inquiry*
- *Examining evidence / data analysis and critical thinking are key NOS aims*
- *Develops students scientific literacy*
- *Students get the chance to engage with scientists and real science*
- *Need to generate hope and action competence rather than apathy or despair which tends to lead to paralysis*

Exploring cross-curricular links between Science and Social Studies.

Teachers from both science and social sciences undertook an exercise to explore how they might strengthen cross-curricular links between junior social studies and science. Beginning with a 'topic' list of current science and social studies units they identified places where the key concepts overlap to some extent. Next they mapped the Curriculum Achievement Objectives at Level 5 for both the Sciences and Social Sciences Learning Areas (appended). The overlaps are extremely obvious at this level! When students get the chance to explore the same big idea from both a science and society perspective they achieve far richer learning that is also more likely to result in informed action around issues such as Climate change and sustainability. Thin Ice, which asks the provocative question “can we trust the scientists or are they pedalling a lie?”, was incorporated into a Science/Social studies unit for a Year 10 class to make use of the links!

In Social Studies this class explored and discussed such ideas as:

Antarctica as the final frontier/land mass to be inhabited by humans

Who is responsible for administering the continent?

What rights various nations had there?

The ethics/likelihood of mining etc in the future

Environmental impacts of scientists/others living there

The focus of their social inquiry was decision-making and how that happened, as well as its implications.

In Science, a broader study was undertaken, beginning with the basic chemistry required for understanding Climate and Ocean chemistry. A lot of work happened around the Nature of Science – how scientists work and analyse data to generate evidence, how data is collected and processed from a range of sources to explore a single idea. Links were made to biological and geochemical Carbon-cycling and modelling was explored –both physical modelling of atmosphere layers and predictive modelling of climate systems. Students attended a workshop at Te Papa where they were able to meet and interact with real scientists who had worked in Antarctica on climate-related research. During a session on Ice core and snow layer evidence relating to past temperatures/carbon dioxide levels, students tried on Antarctic clothing. They handled Antarctic deep sea organisms and Antarctic seabird specimens, heard about research into the circa-polar migrations.

As well as the Thin Ice resource, a wealth of relevant material available via NIWA, Science Learning Hub, etc was used in the science programme to scaffold students to a deep understanding on the causes and implications of climate change, especially for NZers.

Using Climate Change as the context, students covered a wide range of the basic concepts typically covered at Curriculum Level 4:

- *Understand that scientists' collect evidence and interpret it via logical argument to develop scientific theories*
- *Scientists use models to understand and to communicate their ideas*
- *Recognise the importance of multiple variables in complex systems*
- *Use basic chemistry vocabulary, symbols, and conventions*
- *Develop competence in basic chemistry facts including atomic structure, elements, compounds and mixtures*
- *Use their visual and numerical literacy to evaluate evidence and argument in popular and scientific media*
- *Explore a socio-scientific issue, gather relevant scientific information, draw evidence-based conclusions and take action where appropriate.*
- *Investigate the interdependence of living things in an ecosystem. (Living World)*
- *Investigate the composition, structure, and features of the geosphere, hydrosphere, and atmosphere. (Earth systems-Planet Earth & beyond)*
- *Investigate how heat from the Sun, the Earth, and human activities is distributed around Earth by the geosphere, hydrosphere, and atmosphere. (Interacting systems-PEB)*
- *Explore patterns associated with physical phenomena such as light and heat (Physical world)*
- *Investigate the chemical and physical properties of different groups of substances, eg acids and bases and fuels (Chemical world)*

The lesson outline for a possible science unit follows:

Lesson sequence for a possible Year 10 Climate Change unit:

Week 1	<p><i>Watch Thin Ice video **</i></p> <p>What do we need to know to really understand this climate science?</p> <p>Begin and end with Continuum activity (Students place themselves along a continuum from ☺ strongly agree to ☹ strongly disagree in response to a question: e.g. Can we trust the scientists?)</p>	<p><i>Familiarity with Chemical language and symbols</i></p> <p>Establish existing knowledge from Yr 9</p> <p>What are particles made of? Brainstorm, modelling, video... (exploring representations and mental models)</p> <p>Elemental bingo</p> <p>Writing exercise using 3 levels of writing frames</p>	<p><i>Flame tests to explore evidence for differences between elements</i></p> <p>Relating evidence to atomic structure – electron levels and spectral emissions (details unimportant but NOS ideas vital)</p>	<p><i>Review of elements/compounds/mixtures - link to representations at particle level.</i></p> <p>Air as a mixture of elements and compounds</p> <p>What's a molecule?</p> <p>Model making - Molymods</p>
Week 2	<p><i>What's the nature of atmosphere?</i></p> <p>Video clip - Atmospheric fall – Felix Baumgartner</p> <p>https://www.youtube.com/watch?v=FHtvDA0W34I</p> <p>Collect information on layers of atmosphere and model it (include scale)</p>	<p><i>Analysing atmospheric makeup</i></p> <p>Graphing – units used %/ppm</p> <p>Pie graphing of normal atmospheric composition</p> <p>Compare with Mars and Venus' atmosphere?</p>	<p><i>Natural Greenhouse effect on Earth</i></p> <p>Explore the Goldilocks zone</p> <p>Why is it so important for life on Earth?</p> <p>What are the Greenhouse gases?</p> <p>Model molecules</p>	<p><i>Extension of Atmospheric ideas</i></p> <p>Climate versus weather</p> <p>Albedo effect</p> <p>What about the Ozone layer?</p> <p>Sources of various Greenhouse gases?</p>
Week 3	<p><i>Enhanced Greenhouse effect</i></p> <p>Student search for best animation/explanation on line for this effect and explain it to one another</p>	<p><i>Students communicate their understanding of the Enhanced Greenhouse Effect and resulting Climate change using either dance, song, art, etc.</i></p>	<p><i>Interconnected processes:</i></p> <p>Carbon cycle - compare various representations - bio/geochemical</p> <p>Carbon chemistry and alkane fuels</p> <p>Molymods again – model combustion</p> <p>Explore chemical language - simple words equations then symbol equations</p>	<p><i>Role of carbon and combustion in CC</i></p> <p>Explore combustion and incomplete combustion in simple practicals with Bunsen burners</p> <p>Explore other carbon fuels: Alcohol, biogas</p>
Week 4	<p><i>Causes of enhanced Greenhouse effect</i></p> <p>Analyse significance of each factor</p> <p>Examining evidence for Climate change:</p> <p>Keeling curve - deciphering of graphs</p>	<p><i>Likely impacts of Climate change for NZ</i></p> <p>Sort into social, economic and environmental impacts</p> <p>Videos of Pacific impacts – Kiribati Islands</p>	<p><i>Evaluation of various actions to reduce Climate change and mitigate inevitable effects</i></p> <p>Get political? How to mobilise for action when govt won't...</p> <p>Act locally and think globally...is it enough? DEBATE?</p>	<p><i>Reflection (and assessment?) on learning</i></p> <p>Extended writing task (using differentiated writing frames) as evidence of learning in this unit.</p>

****Concurrently in Social Students they undertake the viewpoints activity (below)**

Examining a variety of viewpoints on Climate Change.

Do these people believe Climate Change is happening, or do they consider it a made up myth? Their viewpoint will show their **values position** on Climate Change. The evidence for their viewpoint is in their words.

Your Task: In your groups, discuss each statement and come to some conclusions then record your ideas in your workbooks:

- name the individual
- state whether they think climate change is happening
- look for the evidence in what is written/said. The evidence part is the most important thing here.

Freeman Dyson, Professor of Biology, Auckland University:

"Climate change is a real problem, partly caused by human activities, but its importance has been grossly exaggerated. It has become a hip topic of discussion. Discussion completed by people that do not have a science background and therefore often get the facts wrong".

"It is far less important than other social problems such as poverty, infectious diseases, deforestation, the extinction of species on land and in the sea, not to mention war, nuclear weapons and biological weapons".

"We do not know whether the observed climate changes are on balance good or bad for the health of the planet".

Jim Hansen, director of NASA'S Goddard Institute for Space Studies:

"The argument about whether there is global warming is over. I have no idea why people still think it is not happening. They are simply ignorant to think that global warming is a myth. It is now clear that, after thirty years, we have been in a strong global warming trend at a rate of about 0.2 Celsius per decade for the past 30 years, [meaning] there has been 1 degree Fahrenheit (0.56 degrees Celsius) global warming in the past 30 years. The Earth is now at its warmest level in the period of collecting data, that is, since the late 1800s. The evidence from the data that we have gathered over the last few decades makes this issue dead in the water."

Naomi Oreskes, Associate Professor of History at the University of California, San Diego:

"Many people have the impression that there is significant scientific disagreement about climate change. It's time to lay that misinformation to rest. There is a scientific consensus on the fact that the Earth's climate is heating up and human activities are part of the reason. People must take note that the key word is part. We need to stop repeating nonsense about the uncertainty of global warming and start talking seriously about the right approach to address it. The time to address this issue is now."

"The basic picture is clear, and some changes are already occurring. A new report by the Arctic Climate Impact Assessment—a consortium of eight countries, including Russia and the United States—now confirms that major changes are taking place in the Arctic, affecting both human and animal communities, as predicted by climate models."

Former American Vice President ***Al Gore***

"The science is extremely clear: Global warming may not affect the frequency of hurricanes, but it makes the average hurricane stronger, magnifying its destructive power. In the years ahead, there will be more storms like Katrina, unless we change course. Indeed, we have had two more Category 5 storms since Katrina—including Wilma, which before landfall was the strongest hurricane ever measured in the Atlantic."

"This summer, more than 200 cities in the United States broke all-time heat records."

"This summer, parts of India received record rainfall—37 inches fell in Mumbai in 24 hours, killing more than 1,000 people. The new extremes of wind and rain are part of a larger pattern that also includes rapidly melting glaciers worldwide, increasing desertification, a global extinction crisis, the ravaging of ocean fisheries, and a growing range for disease 'vectors' like mosquitoes, ticks and many other carriers of viruses and bacteria harmful to people."

Bert Sylvester, local resident of Petone, Hutt City, Wellington.

"To be honest, I have no idea. I have noticed a change in the weather cycles recently but I think that it is just mother nature doing her thing. I hear that there is some evidence that is trying to support it but that kind of stuff goes straight over my head."

If people think I am going to stop driving to work to help keep down the carbon emissions, then they have it wrong. Like many people, I have to live for today and not worry about the future."

Johnny Garcia, Young New Zealander of the year participant

"What time is lunch?"

David Archer, Professor of Geophysical Sciences from University of Chicago:

"The warming of the past several decades has been faster and risen to higher temperatures in the past decades than has been seen in thousands of years. Rising CO₂ [carbon dioxide] levels can easily explain the warming, but there is no alternative explanation that does not involve rising CO₂ or predict further warming. Scientists have done their job, it is time now to confront the reality of human-induced climate change resulting from emission of CO₂ from fossil fuel consumption."

Paul Epstein, Associate Director of the Centre for Health and the Global Environment at Harvard Medical School:

"The most coherent explanation is that climate is changing because of burning of fossil fuels and felling forests. The health, environmental, and economic costs of inaction are rapidly becoming unmanageable. Stabilising the climate will require a clean energy transition that will also benefit public health, improve energy security, and can become the engine of economic growth for this 21st century.

"We're seeing changes in asthma, heat wave deaths and the spread of infectious diseases that are indicative of enormous changes affecting the environment. Climate and disease are stalking humans, wildlife, agriculture, forests, and marine habitat; which are our life support systems."

Caroline Powers, owner of Fairlight Industries that produces jet airplanes:

"There is no way that the activities of humans have contributed to the temperature of the planet going up. It is a con that the science world has come up with to keep themselves in a job. It is perfectly natural to have the temperature of the planet going up. We in business are being told that it is our factories that are making all the carbon. If we close the factories we will have another issue on our hands.....unemployment.

Exploring the links between Sciences and Social Sciences Learning Areas at NZC Level 5:

From <http://nzcurriculum.tki.org.nz/Curriculum-documents/The-New-Zealand-Curriculum>

<p>Sciences</p>	<p>In science, students explore how both the natural physical world and science itself work so that they can participate as critical, informed, and responsible citizens in a society in which science plays a significant role.</p>	<p>Social sciences</p>	<p>In the social sciences, students explore how societies work and how they themselves can participate and take action as critical, informed, and responsible citizens</p>
<p>Level 5 Achievement Objectives: <i>Students will gain knowledge, skills, and experience to:</i></p> <ul style="list-style-type: none"> -Understand that scientists' investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument. -Develop and carry out more complex investigations, including using models. -Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables. -Begin to evaluate the suitability of the investigative methods chosen. -Use a wider range of science vocabulary, symbols, and conventions. -Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy). -Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate. -Investigate the interdependence of living things in an ecosystem. (Living World) <ul style="list-style-type: none"> -Investigate the composition, structure, and features of the geosphere, hydrosphere, and atmosphere.(Earth systems-Planet Earth & beyond) -Investigate how heat from the Sun, the Earth, and human activities is distributed around Earth by the geosphere, hydrosphere, and atmosphere. (Interacting systems-PEB) -Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving movement, forces, electricity and magnetism, light, sound, waves, and heat. For example, identify and describe energy changes and conservation of energy, simple electrical circuits, and the effect of contact and non-contact on the motion of objects. (Physical Inquiry) -Investigate the chemical and physical properties of different groups of substances, for example, acids and bases, fuels, and metals. 		<p>Level 5 Achievement Objectives: <i>Students will gain knowledge, skills, and experience to:</i></p> <ul style="list-style-type: none"> -Understand how systems of government in New Zealand operate and affect people's lives, and how they compare with another system. -Understand how the Treaty of Waitangi is responded to differently by people in different times and places. -Understand how cultural interaction impacts on cultures and societies. -Understand that people move between places and how this has consequences for the people and the places. -Understand how economic decisions impact on people, communities, and nations. -Understand how people's management of resources impacts on environmental and social sustainability. -Understand how the ideas and actions of people in the past have had a significant impact on people's lives. -Understand how people seek and have sought economic growth through business, enterprise, and innovation. -Understand how people define and seek human rights. 	

Links between Key Competencies, Nature of Science (NOS) aims and Science Capabilities:

Science capabilities	Gather and interpret science	Use evidence	Critique evidence	Interpret representations	Engage with science		
Key Competencies	Thinking			Using Language, symbols & text	Relating to others	Managing self	Participate & contribute
	Research			Scientific language e.g.	Tolerance	Work in a team	Work in a team
	Evaluate			Chemical and physical symbols	Listening and consider others' views	Meet goals	Consider others
	Draw conclusions			Graphs, charts			Suggest actions
	Problem-solve			Scientific models	Impact on other cultures		Take action
	Using models						
	Curiosity						
	Critical evaluation						
Reflection							
Nature of Science	Understanding about science			Communicating in science	Participating and contributing		
	Investigating in science						

Embedding teaching and learning within a rich context such as Climate Change ensures we address a comprehensive range of our key science goals. Students have many opportunities to develop vital competencies, attitudes and skills.

3. Level 1 Science

A possible course, or a part of a course, could be constructed around some key focus questions:

- Are humans destroying our planet?
- Can't the planet just mend itself?
- How are ocean organisms/plants affected by changes in pH and temperature?
- How can the actions of one individual (me) make a difference? Isn't it a waste of time?

The Thin Ice video makes a superb starting activity and resources from the Thin Ice website provide rich extension opportunities.

Such a course might be assessed using the following NCEA Achievement Standards with tasks that use a Climate Change context.

Science 1.6 Investigate implications of the use of carbon compounds as fuels:

Implications of the use of carbon compounds as fuels consider the importance and effects of their uses and combustion products on humans or the environment and could include: the efficiency of fuels, air or thermal pollution, effect on global climate, ocean acidification, use of non-renewable resources and/or food crops for fuels.

Science 1.10 Investigate life processes and environmental factors that affect them

Life processes may be selected from: support and movement, reproduction, sensitivity, growth, excretion, nutrition, and gas exchange. At least two of these processes must be selected.

Environmental factors that affect life processes may be internal or external factors and may include: temperature, pH, light intensity, photoperiod, moisture levels, concentration of gases, hormone levels, and nutrient supply.

Science 1.14 Demonstrate understanding of carbon cycling

Carbon cycling includes the addition, removal and storage of carbon.

Addition means the release of carbon into the atmosphere as carbon dioxide and methane by:

- respiration, excretion, decay
- combustion eg the burning of fossil fuels
- volcanic activity.

Removal means removing carbon from the atmosphere by:

- photosynthesis eg by phytoplankton, forests
- dissolving in water eg in the surface of oceans.

Storage means holding carbon as:

- short-term storage eg by forests
- long-term storage by sediments, carbonate rocks (limestone), coal, oil, natural gas and subduction resulting in carbon-rich metamorphic and igneous rocks.

4. Level 2 Earth and Space Science

Building on their general science studies at level 1 NCEA, students at Onslow College can study Earth and Space Science (ESS) at Level 2 and beyond. The level 2 course recognises that Earth is the only planet we know of (so far) to have abundant and complex life. The course explores the formation of Earth and the Solar System, including how the processes operating in the atmosphere, the solid earth and the oceans could have led to the evolution of life on Earth. Students critically evaluate scientific information presented to the public and how it applies to current issues in ESS, such as Climate Change. An ESS course at level 2 is a superb addition to any student's programme of learning, especially those aspiring to careers in media studies, journalism and other social sciences, since it offers the opportunity for developing real critical thinking and scientific literacy. A possible course structure (with suggested assessment) follows:

<p>Overview:</p> <p>The Big Picture</p>	<p>Students will have a broad introduction to the 'big pictures' of the course including:</p> <ul style="list-style-type: none"> • History of human understanding of the Universe • The Big Bang • How we know what we know (or think we know) 	<p>This unit could be assessed using:</p>
<p>Practical Investigation</p>	<p>Students will carry out a practical investigation, in an Earth Science context, including:</p> <ul style="list-style-type: none"> • developing a purpose and method • collecting and processing data • reaching a conclusion and then explaining the underlying science. 	<p>Carry out a practical Earth and Space Science investigation ESS 2.1 (91187)</p>
<p>Communicating Science</p>	<p>Students will research and report on a current issue Earth and Space Science. Students will also critically evaluate the validity of information reported to the public and justify a position on an issue such as Climate Change.</p>	<p>Examine an Earth and Space Science issue and the validity of the information communicated to the public ESS 2.2 (91188)</p>
<p>Restless Planet</p>	<p>Students will learn about earthquakes, volcanoes and tsunamis in and around New Zealand and explain them in terms of processes in the geosphere, hydrosphere, biosphere and atmosphere.</p>	<p>Investigate how organisms survive in an extreme environment ESS 2.4 (91190)</p>
<p>It's a Tough Life</p>	<p>Students will investigate 'extremophiles'; organisms that have been found to survive in the most extreme environments on Earth. This will lead on to contemplating the likelihood of life existing elsewhere in the Universe.</p>	<p>Demonstrate understanding of the causes of extreme Earth events in New Zealand ESS 2.5 (91191)</p>
<p>How to make a Galaxy</p>	<p>Students will learn about stars and planetary systems, including their characteristics and the stages in their formation and 'lifecycles'.</p>	<p>Demonstrate understanding of stars and planetary systems ESS 2.6 (91192)</p>

5. Level 3 Earth and Space Science

This Level 3 course has been adapted to focus on the theme of Climate Change, with THIN ICE as a key resource. The course structure is:

Topic and key ideas		Assessed by Achievement Standard
Investigating some Earth processes	Earth processes: This topic is your chance to do some experiments to find out for yourself about some of the processes that happen in Earth Science. What is the effect of temperature and salinity on water density? Where can we observe this locally?	ESS 3.1 (91410) v1 Internal <i>Carry out an independent practical Earth and Space Science Investigation</i>
What does it matter to me?	ESS issues: Global warming, climate change, fracking, ocean acidification, peak oil, renewable energy, what laws would be appropriate in a Martian settlement? Some of these issues you will have heard about but how much do you know? Does it matter to you? In this topic you will have the chance to explore one issue for yourself and develop your own opinion.	ESS 3.2 (91411) v1 Internal <i>Investigate a socio-scientific issue in an Earth and Space Science context</i>
How old? Really?	Geological dating methods: Geologists and anthropologists keep coming up with these really old ages for ice, soils, rocks and fossils. But how do they know how old they are? How reliable are these ages? How do they compare with each other? Do some research into an event and understand how it all fits together.	ESS 3.3 (91412) v1 Internal <i>Dating a geological event</i>
Splash Planet – all you need to know about the sea.	The ocean system: Two thirds of this planet of ours is covered by ocean, but how much do you know about it? Where does all that water come from? How come the ocean has more CO ₂ in it than the atmosphere? How do the oceans transport heat around the world and so control our climate and weather? What role do the oceans play in global warming?	ESS 3.4 (91413) v2 External <i>Demonstrate understanding of the processes in the ocean system</i>

Windy Wellington – why?	The atmosphere system: What is this stuff we call air? Why is it the way it is and where did it come from? What causes it to move around so much, particularly here? What actually controls our climate and how does it do it? Issues of our place and our age – learn more about something we take for granted, and how we are affecting something so critical.	ESS 3.5 (91414) v1 External <i>Demonstrate understanding of processes in the atmosphere system</i>
Outside our Planet – What’s Up?	Space: We just landed a robot probe on a comet – why do we spend so much money on such projects? In this topic you can explore in depth some event or discovery such as this, or explaining where life might be possible elsewhere in our Solar System, or how we are finding new planets in other systems.	ESS 3.6 (91415) v1 Internal <i>Investigate and aspect of astronomy</i>

6. Further details of some of the key assessment activities

Practical Investigation (ESS3.1)

A feasible practical investigation for Y13 students at Secondary Schools that has relevance to climate processes and climate processes is not an easy matter. We settled on an investigation into trying to get an understanding of one of the fundamental processes in Ocean and Atmosphere dynamics, that being density differences and the mixing of fluids of differing densities.

The investigation chosen is the mixing of waters in estuaries, to attempt to instil an appreciation of what density differences are caused by, and how this can be detected and the reluctance with which such waters mix.

The practical investigation involves selecting a suitable estuary and devising an investigation that can be simply, quickly and safely carried out. This could be in school time but we do not provide for this: the small teams are expected to do the fieldwork in their own time. In the process they also learn a lot about tidal cycles and the effects and timing of tides, which our city kids have not really thought about.

Students collect small samples in bottles according to how they have planned their investigation, and the measure temperature and whatever other variable that they have specified (e.g. depth, time, tidal cycle).

A Socio-Scientific Issue (ESS3.2)

Students research one of two issues and come to some position. One issue is the evidence for and against human-induced climate change, and the other is rules/regulations for human settlement on Mars. The first is obviously Climate Change related and the second at least involves thinking about the effects of human activities in planetary systems.

Other relevant subjects for projects could be more specific consequences of climate change, such as:

- Ocean acidification
- Renewable energy options: pros and cons.
- Polar ice – is it expanding or contracting?
- CO₂ as a “fertilizer” – how much is too much?
- Organic agriculture – good for the world or not?

Geological Dating (ESS3.3)

This unit is focused on evidence for the timing of the Little Ice Age in Antarctica, and the dating techniques used in dating Ice Cores. A lot of evidence for past climate change, and insights into causes, consequences and mechanisms comes from the study of glacial ice cores, mainly in Greenland and Antarctica. A paper has been recently published about a New Zealand-hosted study which used ice cores to look for evidence of a climatic event and used a variety of dating techniques to ascertain the age of the ice at different depths.

The assessment criteria require that students explain how dating techniques work and how they have been used and how they relate to each other. This topic is generally regarded by students as being very difficult, but it does force them to try and make sense of original scientific papers.

Ocean Systems (ESS3.4) and Atmospheric systems (ESS3.5)

These topics study the basic processes in the Atmosphere and the Oceans and greenhouse effect and carbon cycling are explicitly emphasised as a result of the Climate Change focus in the course.

THIN ICE DVD - Chapters and times

		56 minute version	73 minute version
1	Introduction	3:01	3:16
2	Antarctica	3:34	5:43
3	Ice and Climate	11:52	10:14
	CO2 Today		4:11
4	Greenhouse Effect	11:20	11:17
5	Global warming	3:00	6:21
6	Arctic Changes	3:18	4:24
7	Southern Ocean	6:19	9:02
8	Computer Models	4:56	2:54
9	Past Climate	4:04	6:53
10	Our Future	5:23	7:39
11	Credits	0:30	1:49

THIN ICE DVD - Video shorts

1.	Negotiations on the international stage	5:12
2.	Intergovernmental Panel on Climate Change	4:51
3.	CO ₂ and Climate	6:08
4.	It's not just CO ₂	3:02
5.	Shrinking Tropical Glaciers	4:33
6.	Thermohaline circulation	5:49
7.	Drilling beneath the Ice	4:02
8.	Forty thousand pairs	9:02
9.	Human effect on Climate	4:13
10.	Business as usual	4:42
11.	Being a Scientist	4:20

FREE VIDEO RESOURCES AT www.thiniceclimate.org

Antarctica and the ice core story		
-	A slice of Antarctic Snow – Nancy Bertler	2:40
-	Analysing an Ice Core – Nancy Bertler	5:54
-	Shrinking tropical glaciers – Lonnie Thompson	4:34
A polar journey		
-	Getting there - Dan Dixon/Paul Mayewski	2:07
-	Travelling across the ice - Dan Dixon/Paul Mayewski	4:50
-	Coring for climate history - Dan Dixon/Paul Mayewski	3:55
Climate information from ice cores		
-	Ice Age cycles, temperature and CO ₂ – Tim Naish	3:05
Carbon Dioxide today		
-	Measuring atmospheric gases, Baring Head, New Zealand Katja Riedel & Martin Manning	9:32
-	How CO ₂ traps the Sun's warmth – Hugh Mortimer & Neil Bowles	4:16
The Greenhouse Effect		
-	Myles Allen talks about how CO ₂ warms climate	3:44
-	Ray Pierrehumbert talks about how CO ₂ warms climate	5:55
Modern Global warming		
-	Taking the temperature – Myles Allen and Phil Jones	6:07
-	Factors besides CO ₂ – Myles Allen and Wally Broecker	2:55
The Changing Arctic		
-	Life in the Arctic – a Sami view	6:33
The Southern Ocean		
-	Heading out to sea -Lionel Carter & Mike Williams	3:29
-	On station – Lionel Carter & Liz Sikes	5:37
-	Oceans and climate – James Rae & Craig Stevens	3:42
-	Thermohaline circulation - Wally Broecker & Lionel Carter	5:50
-	Taking the pulse – Scott Nodder & Craig Stevens	3:09
-	Oceans and CO ₂ – Lionel Carter & James Rae	5:41
-	Forests of the ocean – Ros Rickaby	3:36
-	Out of our comfort zone – Lionel Carter & James Rae	5:05

FREE VIDEO RESOURCES (continued)

Climate Models			
- What at past climates say about CO ₂ and warming – Matt Huber	8:44	- Implications from rising CO ₂ levels – Stefan Rahmstorf	6:09
Past Climates		- View on temperature rise – Malte Meinshausen	8:08
- Geological record of past warm climates – Martin Brasier	4:43	- Trapping and storing CO ₂ – Martin Blunt and Daniel Koseli	6:13
- The ANDRILL operation – Alex Pyne, Tim Naish, David Harwood	4:22	Climate Negotiations	
- View a freshly drilled core	4:34	- Climate Change as seen by UN negotiators and scientists	5:13
- Past warm periods and ice sheet melt – Tim Naish	4:45	- Inside the IPCC – Martin Manning	4:51
The Future		Personal reflections	
- Life in coastal Antarctica – Katie Dugger & Brian Karl	8:10	- Changing attitudes over the last 100 years – Sir Lloyd Geering	5:22
- Views on business-as-usual – Matt Huber, Myles Allen, Tim Naish	4:42	- A warming planet and the legacy issues – Myles Allen	4:14
		- Being a scientist – personal thoughts – several scientists	4:22

Links to other useful resources:

- <http://thiniceclimate.org/>
- <http://www.sciencelearn.org.nz/Contexts/Icy-Ecosystems> including practical activities...
- [Investigating impacts of ocean acidification](#)
- <https://www.niwa.co.nz/education-and-training/schools/students/climate-change-global-warming-and-greenhouse-gases>
- <http://www.learnz.org.nz/argofloats142/argo-floats-tracking-pulse-world-oceans> virtual-field trip with links via Science learning hub
- <http://userfr.co.nz/climate-change-series> (Book A - 23 activities : weather & climate, atmosphere, in the greenhouse, oceans. Book B - 23 activities: carbon cycle, past climate, biological, geological and social impacts. Photocopiable resources - activities and investigations)
- <https://royalsociety.org/policy/projects/climate-evidence-causes/>
- <http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes/>
- <http://www.csiro.au/Outcomes/Climate/Understanding.aspx>
- <http://www.gns.cri.nz/Home/Learning/Science-Topics/Ice-Snow/About-Ice-Cores>
- <http://www.royalsociety.org.nz/teaching-learning/resources/gamma/climate-change/>
- For some light relief (Warning: profanities , but very effective)
http://www.salon.com/2014/05/12/watch_john_oliver_and_bill_nyes_brilliant_take_down_of_climate_change_deniers/