2014

Changing The Climate Narrative: How A Long-Term Climate Change Might Save Our Lives

Natalie P. Harreld
Claremont McKenna College

CLAREMONT McKENNA COLLEGE

CHANGING THE CLIMATE NARRATIVE:
How a Long-term Climate Change Might Save Our Lives

SUBMITTED TO

PROFESSOR J. EMIL MORHARDT

AND

DEAN NICHOLAS WARNER

BY

NATALIE P. HARRELD

FOR

SENIOR THESIS

2013–2014

APRIL 28, 2014

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I wish to acknowledge Professor Morhardt for giving me the opportunity to tackle this big, cumbersome topic. I would like to thank my cat, Orion, for all the company he kept me throughout the writing process. Thank you to my family for their support, not only in through thesis, but for these past four years. I also want to give a special acknowledgement to Elizabeth Malone for her book *Debating Climate Change*. Without it I would not have been able to piece all of this together. And last, but not least, thank you to Carl Sagan for the inspiration to pursue the hard and big questions, even when it can make me feel so small.

ABSTRACT

The goal of this paper is to offer new insights into the climate change debate by shifting away from the heated anthropologic arguments that dominate politics, media, and popular science. Instead, I choose to rely on the long-term impacts of a changing climate on our planet. The paper begins with a break down of key processes involved in short-term and long-term climate change, using the latest research. After a foundational understanding of climate sciences is established, we will discuss the failure of the climate change debate in educating the general public about the facts of a changing climate. Finally, the importance of long-term foresight in climate policy and education, and how this perspective could drastically progress the climate debate, will be discussed.

1
Why Can't we all Just Agree on Climate Change?

"Consider again that dot. That's here. That's home, That's us…the history of our species lived there-on a mote of dust suspended in a sunbeam…There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known."[1]

– Carl Sagan, Astronomer, Astrophysicist, Cosmologist, Author, Professor.

Climate change news, data, and opinions have dominated the media landscape for the past few decades. Time continues to march closer to those frightening deadlines drawn in the proverbial sand not that long ago by scientists. Just a few months prior to the publishing of this essay the United Nation's Intercontinental Panel on Climate Change (IPCC) released *Climate Change 2013: The Physical Science Basis*, warning of the severe failings of world nations in meeting short-term environmental goals.[2] The profound impact that climate change may have on our society still lies in the unknown, and won't be fully understood until the changes have already happened. Even with all the remaining unknowns, there is a plethora of strong evidence pointing to anthropologic (human induced) climate change, enough for the IPCC to state:

> It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused

---

[1] Sagan, C. Pale blue dot: a vision of the human future in space. New York:

[2] IPCC, 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

> by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together.[3]

Yet, there is still a large portion of the U.S. population that deny and/or underestimate the impact of climate change. What is more of a concern is the nature of the climate change debate in mass media. With the ever increasing importance of the climate in politics, a dramatic division of opinions has been drawn along party lines that has resulted in a conversation about 1) whether humans impact the climate and 2) if so, how to "stop" and/or "reverse" climate change. Yet, I believe this is the wrong conversation to be having. Climate change is a reality of our planet's ecosystem, something that will occur (and has occurred many times) whether humans were present or not. The focus on anthropologic climate change has stalled the debate on how our society is to act in the face of a changing climate. While concern should remain for the impact human's have on the climate, we first need to build into our psyche that the climate is a changing thing, and if we are to survive we must build an adaptable society. Therefore, rather than focus on the convoluted and controversial issue of anthropologic climate change, a strong focus on long-term climate change should be initiated.

The Importance of Perspective

Before moving onto the gritty and exciting issues of climate change, we need to discuss the importance of perspective. One of the most difficult aspects of climate change is the wide array of standpoints we must hold to fully understand it. The media often talks about how climate change may result in a sudden disaster

[3] IPCC, 17.

or apocalypse—and during the late 1990's and early 2000's even Hollywood cashed in on the frenzy with a number of climate disaster movies. While the earth certainly can be devastating in a sudden flash, more often its processes are slow, slow, slow. A sudden earthquake, tsunami, or hurricane can be devastating to humans, but they pale in comparison to the forces of climate change. In Earth's history it wasn't that long ago that all of today's continents were connected in a landmass we now call Pangaea (about 200 million years ago), and as we will discover later, it won't be that long (from Earth's perspective) until there is a new super continent. In the more near-term, in the next one hundred years it is likely that sea level will approach a heigh not seen since the last interglacial period 129,000 to 116,000 years ago.[4] Only a mere 20,000 years ago the earth was in a deep glaciation, where ice and snow covered most of today's landmass. Every few ten thousand years and hundred thousand years the earth as a whole undergoes drastic climatic changes, known as glaciations. That these changes are driven by the earth's relationship to the sun is an astonishing, and often under discussed, fact.

Moving forward in this essay will require the fluid movement of perspective, as we tackle issues on various temporal and spatial scales. I believe to truly understand the importance of climate change we must grasp both the importance of the human lifetime and of the earth lifetime. If we, as a species wish to survive on this planet we must learn how it changes and begin developing a society that embraces adaptation as part of its ethos. Life on Earth has adapted

[4] IPCC, 8–24.

over and over again, and as products of that system I believe we too will discover ways to adapt our society to survive. The Carl Sagan quote above highlights the importance of perspective; after all we are truly but a small blue dot suspended in a sunbeam.

Global Warming versus Climate Change

Not long ago "global warming" was the de facto term rather than climate change. Today, "global warming" is still in use, but is widely acknowledged as being misleading and has been replaced by "climate change." When climate change first came to the attention of scientists and the media it was because the global average temperature was increasing, thus "global warming." Often the term is confused with meaning that all areas of the world must warm, however, because of the many different forces at work in the earth's climate, different areas will experience different levels of change, some even will experience cooling. In the past century the global average temperature has increased by about 0.65 to 1.06 degrees Celsius.[5] This isn't the first time the climate has experienced such a change in global temperature, as the climate warms and cools over the course of tens of thousands and hundred of thousands of years. Currently our climate is in the middle of an interglacial period where the climate is undergoing a relative warm phase. However, the speed of the warming recorded in the past hundred years is why scientists are concerned about the human impact on the environment, but we will address this later. "Climate change" is the more accurate label that

[5] IPCC, 5.

encompasses both the long and short terms, and thus affording us flexibility in discussing the climate.

Climate versus Weather

Very quickly I want to establish the difference between climate and weather, as this is a very common mistake that is made in the media, and is something that often influences people's opinions on climate change. For clarity's sake I am going to use the definitions provided by the latest IPCC:

> Weather describes the conditions of the atmosphere at a certain place and time with reference to temperature, pressure, humidity, wind, and other key parameters (meteorological elements); the presence of clouds, precipitation; and the occurrence of special phenomena, such as thunderstorms, dust storms, tornados and others. Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Classically the period for averaging these variables is 30 years, as defined by the World Meteorological Organization. Climate in a wider sense also includes not just the mean conditions, but also the associated statistics (frequency, magnitude, persistence, trends, etc.), often combining parameters to describe phenomena such as droughts.[6]

And, therefore, by extension climate change is a variance in the mean conditions over longer periods of time. A day's or even a season's weather may have little to no relevance in the climate conversation—making remarks, for example, about mild winters irrelevant. From a climate point of a view, a mild winter may lead us to ask if there have been decades worth of milder winters than average, but would

[6] IPCC, 123.

not lead us to make a snap judgement about the state of the current climate based on one season's worth of data.

The Failure of Climate Science in the Media

While the climate movement kicked off in the early 20th century with Aldo Leopold's *A Sand County Almanac* (1949)—and then gaining national and international attention in the 1960's and 70's with works such as *Silent Spring* (1962) by Rachel Carson hitting the public's core—it wasn't until the 21st century that the issue of climate change truly became an international phenomenon and talking point. The changing climate, and the human impact on it, has arguably been the focus of the scientific community since its inception. After all, science is the process of understanding how the universe works, naturally leading to asking how humans fit within and impact the environment. Charles Darwin's *On the Origin of Species* (1859), and the process of evolution, drastically changed our understanding of both the scale of nature and of time. Ever since Darwin, we have been looking back in search of answers about how to move forward.

Only in the past century did climatology become a major field of science. Climatologists concern themselves with the many processes of the climate, from how the ocean currents flow to how the earth is impacted by the sun's radiation. The advancement of technology in the mid and late twentieth century greatly advanced the field, allowing for more and more accurate historical observations and model predictions of the future. Scientists' ability to analyse million year old sediments to uncover the mysteries of Earth's historical climate, and use that data in a computer model to predict future climate patterns has only

been possible for the past several decades, and highly accurately only for a few years. In many ways the rapidness of advancement in our understanding of our climate is astonishing, but we are still learning and discovering. And as climate science progressed in the 1970's into the 21st century, the growing concern over the climate began to make its way into other sectors of society.

By the end of twentieth century, climate had become a key part of conversation for politicians, policy makers, and non-profit workers. The Second Climate Convention in 1990 greatly changed the political landscape, resulting in the first international agreement on climate policy. Within only a few decades climate went from a specialty topic to a mainstream talking point. Such a drastic shift in public attention has made climate change a social and political hot topic, while also resulting in a deafening polarisation. The rapidity of climate change's rise in importance has meant much of the general public has relied on learning from media sources, rather from school and textbooks. Because of this delay in our knowledge distribution system, climate change has perfectly played into America's political system. In the American two party system liberals fight for change and progress, while Conservatives fight for the status quo. Both of their ideologies make climate change clearly preferable to the Liberal mind-set, making perfect sense why Liberals, and not Conservatives, would be behind preparing for the impacts of climate change. Interestingly, the opinions of those who identify as independents vary greatly depending on short-term weather patterns rather than

global climate patterns.[7] The political ideologies go a far way to explain why there is a hesitancy to acknowledge anthropologic influences on the climate, as well.

Although human induced climate change has gained considerable support in the past decade, there are large parts of the population of the United States that don't believe humans are to blame for the modern changing climate. A Gallup poll from 17 and 18 March 2014 recorded that only 57% of Americans blame humans for "global warming" (Gallup's terminology) with four in ten Americans "say[ing] the seriousness of global warming is generally exaggerated in the news."[8, 9] And a more telling poll on 8 April 2014 reveals only 34% of Americans "worry a great deal about climate change."[10] There is a wide spread denial and apathy for climate change before even taking into account human influences. When anthropologic climate change is part of the debate, the support and concern decrease even more.

Popular opinion articles, such as "5 Scientific reasons That Global warming Isn't Happening" and "A Really Inconvenient Truth: Global Warming is Not Real," demonstrate the effectiveness of using doubt against climate change and the climate sciences. Articles of this nature rely on the many unknowns and

---

[7] Hamilton, L.C., Stampone, M.D., 2013. Blowin'in the wind: Short-term weather and belief in anthropologic climate change. Weather, Climate, and Society 5, 112–119.

[8] "A Steady 57% in U.S. Blame Humans for Global Warming." A Steady 57% in U.S. Blame Humans for Global Warming. http://www.gallup.com/poll/167972/steady-blame-humans-global-warming.aspx (accessed March 18, 2014).

[9] "Americans Most Likely to Say Global Warming Is Exaggerated." Americans Most Likely to Say Global Warming Is Exaggerated. http://www.gallup.com/poll/167960/americans-likely-say-global-warming-exaggerated.aspx (accessed March 18, 2014).

[10] "Gallup News Minute: Americans Unconcerned About Climate Change." Gallup News Minute: Americans Unconcerned About Climate Change. http://www.gallup.com/video/168389/gallup-news-minute-americans-unconcerned-climate-change.aspx (accessed March 18, 2014).

uncertainties that exist in the evidence for anthropologic climate change. And both of these articles urge for their readers to read the science behind the debate, insisting the science used by liberal media is incorrect.[11, 12] But in here lays a major problem for the science community as a whole: science papers are difficult to understand for the majority of the population. Science writing, whether scholarly or popular, is read by a select group of individuals. Only scholars, researchers, and students take time to read the dense, complicated work that is found in peer-review journals. It is often the case that a published paper requires expertise in advanced fields of science to be understood, limiting the accessibility even within the science community. There is a sore lack of clear and concise articles explaining the latest findings for public, non-expert consumption. Even reports, like the IPCC, are dense, thousand page documents with many technical terms. And again, the process of integrating climate sciences into school curriculums is a slow, arduous process. As earlier discussed, the fact that "global warming" remains to be a common term used in media, but has been almost nearly eradicated in science publications, demonstrates the malaise at which the scientific community can effectively communicate and explain the most current scientific thoughts and theories to the general public.

The media's attempt to educate the public on climate change has shrunken the entire field of work down to popular sound bites. Erik Swyngedouw (2014)

---

[11] Hawkins, J., 2014. "5 Scientific Reasons That Global Warming isn't Happening. http://townhall.com/columnists/johnhawkins/2014/02/18/5-scientific-reasons-that-global-warming-isnt-happening-n1796423 (accessed March 10, 2014).

[12] Scott, J., 2012. "A Really Inconvenient Truth: Global Warming is Not Real." http://policymic.com/articles/3824/a-really-inconvenient-truth-global-warming-is-not-real (accessed March 11, 2014).

discusses the overly apocalyptic nature surrounding climate change discussions. Poignantly, he points out the liberal media's reliance on using "ecologies of fear" that paint an image of a world that is void of life, and in particular human life, or at least void of life as we understand it. He states:

> …our ecological predicament is sutured by millennial fears, sustained by an apocalyptic rhetoric and representational tactics, and by a series of performative gestures signalling an overwhelming, mind-boggling danger, one that threatens to undermined the very coordinates of our everyday lives and routines, and may shake up the foundations of all we took and take for granted.[13]

The truth of his argument can be seen in the popular titles given to articles about climate change. Popular titles often evoke the apocalyptic such as "WATER WARS," "Global warming '30 times quicker than it used to be,'" and the very direct "Global warming and ozone loss: Apocalypse soon."[14] While the impacts of climate change are potentially going to be vast and dramatic, it is worrying to see such dramatization of such an important issue. Of course, apocalypse rhetoric has existed throughout human history, but todays "environmental apocalyptic future…is pure negativity."[15] The dialogue around climate change requires a shift in mentality, one that the science community has so far failed to change.

An important step to begin shifting public understanding of climate change is through discussion about the long-term functions and nature of climate change. The disinterest and denial in climate change stems back to many facets of society, from politics to economics to media to the science community, that have failed to

---

[13] Swyngedouw, E., 2014. Apocalypse Forever? Post-political Populism and the Spectre of Climate Change. Theory, Culture, & Society 27(2-3), 214–232.
[14] Swyngedouw, 218.
[15] Swyngedouw, 219.

discuss climate change effectively. News media can be blamed for their focus on the political debate surrounding climate change, exacerbating the issue of misinformation. However, news media use of "hyping" in pursuit of clicks and views is nothing new. Politics is also strewn with misinformation and self-interest that hinders an open, honest discussion. Both politics and media play important roles in the climate debate, but they are not the origin of information. The experts actually studying climate processes need to begin making bigger strides in effectively communicating with the public. Otherwise, the rest of the population will continue to absorb the doom and gloom media interpretation of the climate sciences. Only those who possess the knowledge can actively share it accurately, and therefore the burden to educate falls on the science community. How we choose to tell the story of climate change will also greatly impact how we choose to deal with it. So far the story we have chosen to tell isn't working, and that is why I am calling for a narrative shift.[16]

The rest of this essay is an attempt to begin guiding the climate change conversation in a new direction. There is no way ignoring that climate change is one of the biggest hurdles to survival our species has yet faced. We must prepare our society and future generations to be able to adapt with our planet, and that begins with understanding the history of our planet and its relationship with the solar system. The earth might only be a mote of dust suspended in a sunbeam, but

---

[16] Paschen, J.-A., & Ison, R., 2014. Narrative research in climate change adaptation Exploring a complementary paradigm for research and governance. Research Policy, 1–10.

that rapidly changing mote of dust is our solitary known place to survive.

2
The Ins and Outs of Climate Change

"Is it political if I tell you that if we burn coal, you're going to warm the atmosphere? Or is that a statement of fact that you've made political? It's a scientific statement. The fact that there are elements of society that have made it political, that's a whole other thing."[17]

– Neil Degrasse Tyson, Astrophysicist, Frederick P. Rose Director of the Planetarium at the Rose Center for Earth

Before delving into the various arguments and narratives about climate change it is vital that we establish a solid, basic understanding of climate science. This chapter will offer an overview of climate change within the short-term and long-term. Entire textbooks are devoted to this topic, so this overview will certainly be overly simplistic, but I hope it makes up for lack of detail in accessibility. In addition, the following will focus solely on the facts of climate change in an attempt to avoid the politicisation, allowing discussion of anthropologic impacts. Debate about how to frame the climate story will continue in chapter 3.

Greenhouse Gas Effect

The way most conversations about climate change begin is to discuss greenhouse gasses (GHGs). While this essay's aim is to focus on the long-term climate, understanding the greenhouse gas effect will help us better understand some of the more complex forces at work in the long-term.

---

[17] "'Cosmos' returns to TV, with a big bang." 'Cosmos' returns to TV, with a big bang. http://www.usatoday.com/story/life/tv/2014/03/08/fox-cosmos-series-with-neil-degrasse-tyson/6059985/ (accessed: April 1, 2014).

So, imagine the earth, but without clouds, water vapour, carbon dioxide, and every other minor atmospheric gas and dust particle. What is left is an atmosphere of oxygen and nitrogen, the sun's radiation, and the oceans and landmasses. The earth absorbs the radiation from the sun, and in return radiates its

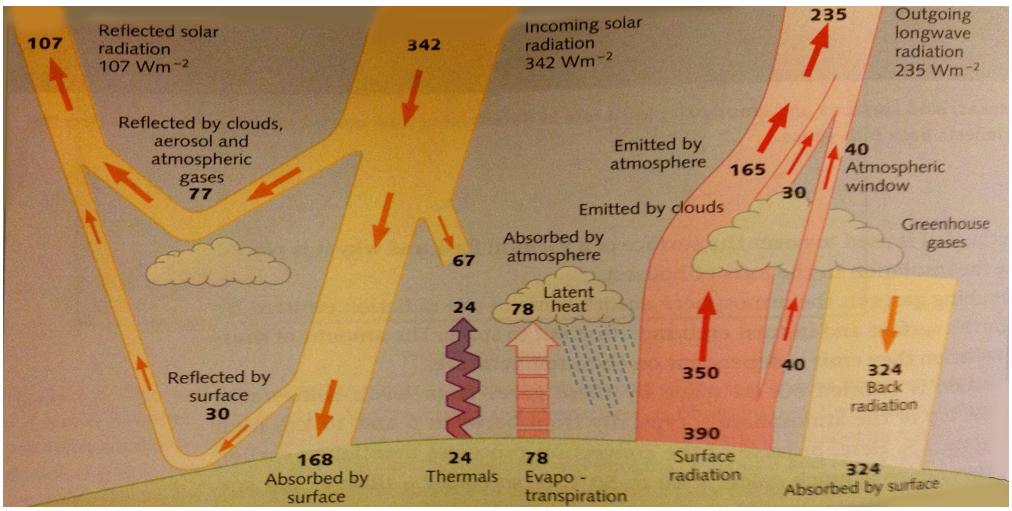

Figure 2.1 *Radiation energy system on Earth, units in Watts per square metre.*
Source: **Houghton (2009)**

own amount of thermal energy. In any system, the energy put into it must equal the energy that leaves it—the law of conservation of energy: energy is neither created nor destroyed, but changes form. The relationship, or system, between the earth and the sun functions the same. In our simplistic model the sun radiates about 1370 watts of energy on every square metre of the area around Earth's atmosphere that faces the sun. But since so little of the atmosphere faces the sun directly, only around 342 watts hit every square metre. Even less makes it all the way to the surface of Earth, as about 6% of the radiation is reflected back into space by the levels of the atmosphere. About 10% of the radiation is reflected back by the sea and land, leaving around 84%—about 288 watts per square metre—to heat the surface (Figure 2.1). The earth radiates thermal energy (the same type of energy that radiates off of our own bodies) back into space, and balances the

equation. Interestingly, the results of this experiment put the earth's yearly average air surface temperature at -6° Celsius, about twenty degrees too cold.[18] The discrepancy results from what is called the "greenhouse gas effect."

If we now return all those gasses we removed from the atmosphere earlier, including carbon dioxide, water vapour, and a few others, the earlier discrepancy disappears. Those other atmospheric molecules absorb the earth's thermal radiation, causing an added 20 to 30°C, giving the earth the climate we know so well today. Of course GHGs have another side to them, one that gets all the media attention. The production of various GHGs by our society (mostly carbon dioxide, chlorofluorocarbons, and water vapour) is the source of so much concern for anthropologic climate change. Any large influx of these gasses, and the atmosphere will begin absorbing even more of the earth's thermal radiation, resulting in higher average global temperatures. The 2013 Intercontinental Panel on Climate Change (IPCC) has stated that:

> The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. Carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification.[19]

While it is certainly important that levels of GHG have not been as high as they are now for 800,000 years, what I want to highlight is that today's levels are not unprecedented. The concern isn't how high levels are, but how quickly those

---

[18] Houghton, John. Global Warming: The Complete Briefing. Cambridge University Press, 2009, 19–20.
[19] IPCC, 11.

levels have been reached—the 40% increase in roughly a century due to industrialisation. GHGs play a vital role in the regulation of the earth's climate, without them we wouldn't be here, and without them climate change wouldn't occur.

Warnings from Mars and Venus

The greenhouse gas effect isn't unique to Earth, but plays a role on all planetary bodies with any amount of atmosphere. The formation of an atmospheric layer results in the same type of effect as seen on Earth, but we have yet to find a case that produces the same results (i.e. life). Venus offers an extreme warning of out of control greenhouse gasses. At a similar size to Earth Venus has an atmosphere that results in about 100 times more pressure than on Earth, and is nearly all carbon dioxide. If on the surface it would look like worldwide dust storm. And even though hardly any sunlight reaches the surface of Venus the temperature has been recorded to be around 525°C. While little sunlight penetrates Venus's atmosphere, the surface's thermal radiation can't escape either, resulting in a greenhouse effect of nearly 500°C.[20]

On Mars, our closest neighbour, the situation is quite different. The Mars atmosphere has about 1% of the pressure relative to Earth, and its atmosphere is nearly completely carbon dioxide based. The presence of the carbon dioxide currently results in a very small greenhouse gas effect, but more interesting are the past climates of Mars. Mars is the only other planet we have dropped sophisticated

[20] Houghton, 27.

rovers on, allowing us to gain insight into the climate, past and present. In fact, we have begun compiling a historic climate record of Mars dating back 20 million years, giving us our first insight into the functions of another world's climate change system. We now believe that Mars has gone through a number of large climatic shifts that seem more chaotic than Earth's due to its more volatile orbit and axis (which, as we will get into later, impact solar radiation levels, and in turn the greenhouse gas effect). The continued research of Mars climate variations may reveal deeper insights into the workings of Earth's.[21]

Climate Forcings & Feedback Loops

Climate forcings are the many different factors that impact our climate. Radiation from the sun, the radiation from the earth, the orbit of the earth around the sun, temperature, wind, reflectivity (albedo), water temperature, salinity, atmospheric carbon dioxide levels, oceanic carbon dioxide levels, and plant vegetation are but a few climate forcings that impact our climate. We have already discussed the GHG forcing, which is actually made up of many other forcings (carbon dioxide levels, sun radiation, etc.), and it is a perfect demonstrator of just how complex environmental systems can get. Understanding how all these forcings impact our climate individually, how they combine together, and how they impact one another is the bread and butter of climate science. All of the forcings impact one another in some way, and scientist have come to refer to these relationships as feedback loops. Feedback loops are probably one of the most

[21] Haberle, R. M., Forget, F., Head, J., Kahre, M. a., Kreslavsky, M., & Owen, S. J., 2013. Summary of the Mars recent climate change workshop NASA/Ames Research Center, May 15–17, 2012. Icarus, 222(1), 415–418.

important concepts of climate change to understand, and isn't talked about nearly enough in the media. Feedback loops are systems of interconnected climatic forcings "that can either amplify ('positive feedback') or diminish ('negative feedback') the effects of a climate forcing."[22] In essence, if one forcing is triggered it can lead to an entire climate feedback occurring that may amplify or diminish that initial triggering forcing. Many feedback loops act as self-regulating barriers, keeping the climate in its current ideal state, but others can cause large amounts of change. One of the best examples is the ice-albedo feedback loop

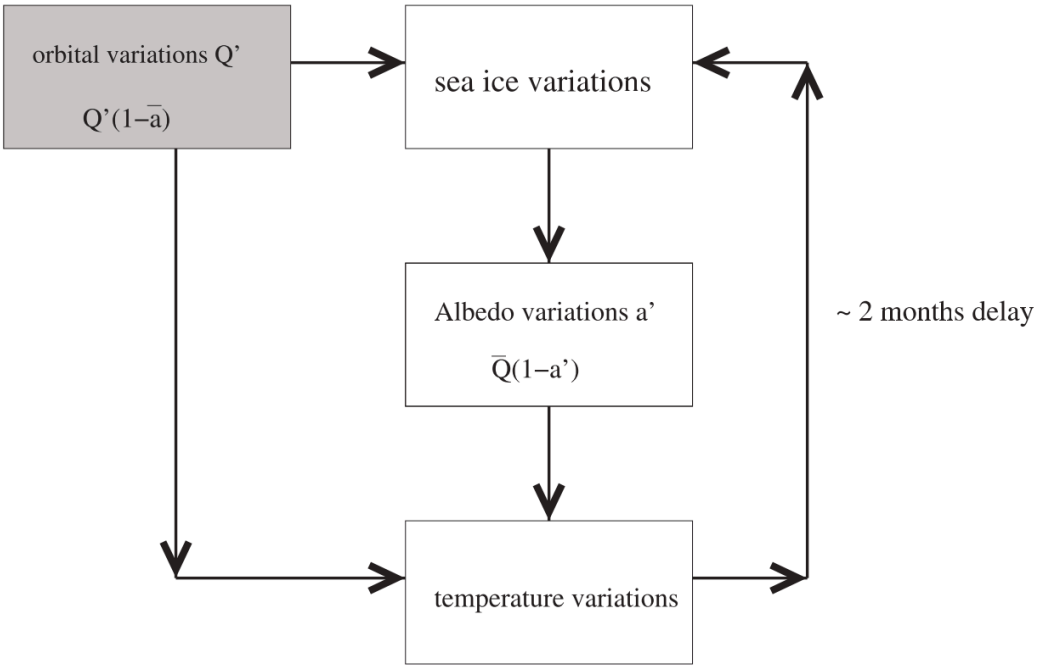

Figure 2.2 *Ice-albedo feedback loop. Example: Solar radiation changes lead to temperature decrease, which lead to more ice and a higher albedo/reflectivity, resulting in more radiation being reflected back into space, further decreasing temperatures. Feedback delay shown to be about 2 months.* ***Source: Timmerman et al. (2009)***

[22] Cubasch, U., D. Wuebbles, D. Chen, M.C. Facchini, D. Frame, N. Mahowald, and J.-G. Winther, 2013: Introduction. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 127–129.

(Figure 2.2). As we have discussed radiation enters the atmosphere, a portion of it immediately are reflected back by the atmosphere and the other portion reaches the surface, warming the planet. However, objects also possess certain amounts of reflectivity—a white piece of paper will glare in the sun and a black piece of paper won't. Objects with high reflectivity are said to have a high albedo, and, as we'd expect, reflect the sun's radiation back into space. When, over the course of a year, temperatures begin to drop (i.e. winter) more ice builds up, and therefore more radiation is reflected back into space, resulting in more cooling. This type of feedback loops is deemed 'positive' because it enhances the initial effect—colder temperatures. A major 'negative' feedback is carbon dioxide fertilisation. As more carbon dioxide is introduced into a system, plants absorb more and more carbon dioxide to grow, releasing oxygen into the atmosphere, resulting in lower levels of carbon dioxide. Here the plants abate the initial effect—carbon dioxide increase—as they remove carbon dioxide from the atmosphere, and dilute the atmosphere further by releasing oxygen.

Both of the mentioned feedback loops play important roles in our climate's functioning, but they are but two of hundreds. There are also many feedback loops that can function as both positive and negative, such as clouds (which play very complicated roles in our climate that we don't yet fully understand). We can see a few more of these systems, and their impact in Figure 2.3. Scientists use these feedback systems to better understand the potential impacts of changing any one of the many climate forcings, as well as changing many at once. Feedback loops

are the basis of many of the climate models that predict future climates under different conditions.

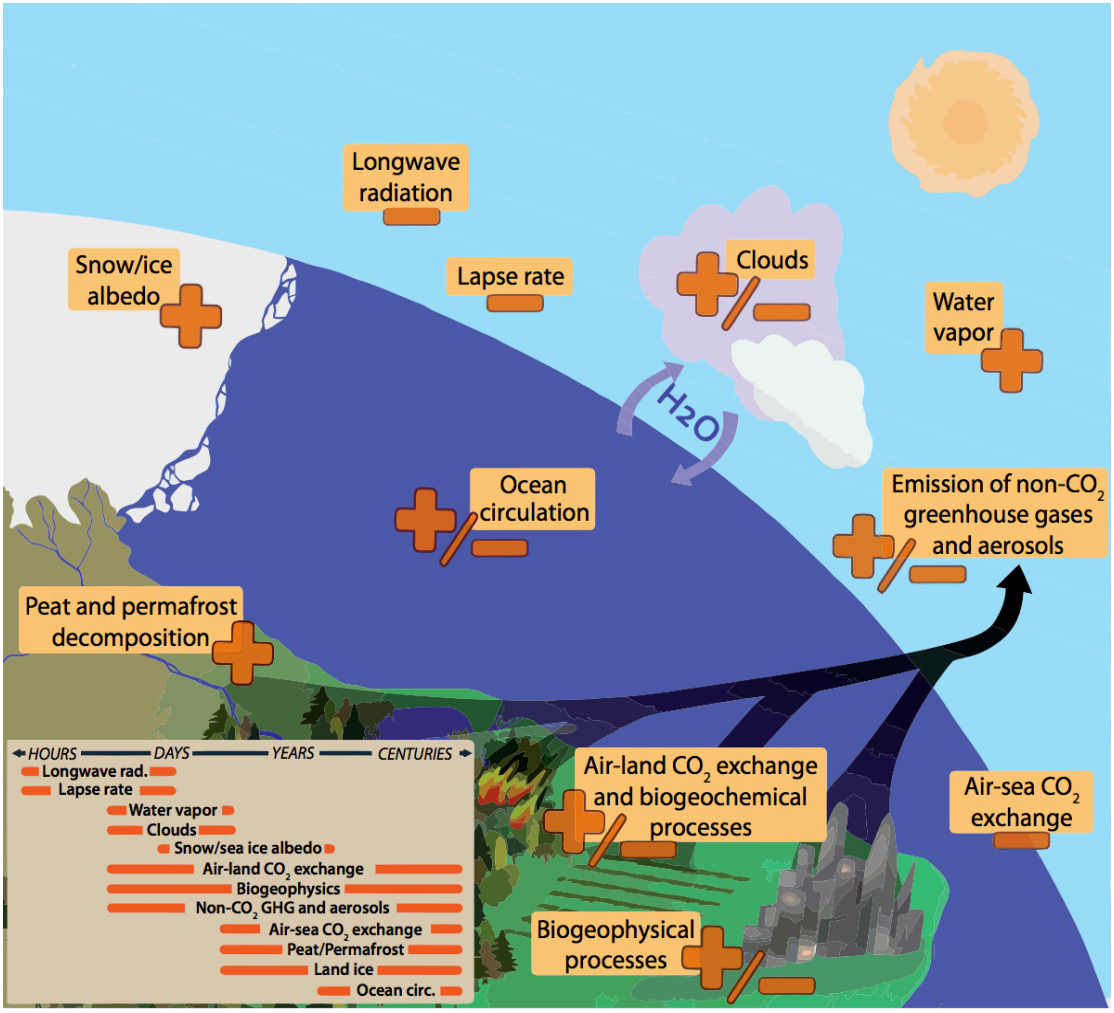

Figure 2.3 *Demonstration of a few of the negative, positive, and negative/positive feedback loops present on Earth with timescales (bottom left).*
Source: IPCC (2013)

Climate Change in the Oceans

The oceans play a number of vital parts in the climate system. The oceans first and foremost circulate heat around the globe through conveyer belt like systems that connect through the world. The most famous of these systems is the North Atlantic Current (NAC), which is often discussed in relation to climate change. The importance of these currents is the distribution of cold and warm water that results in different weather systems and climates all over the world. The

reason that the east coast of the United States has colder weather than the more northern United Kingdom is because of ocean currents. The Gulf Stream carries warm water from the equator region northward toward the UK, warming the entire region, leaving the eastern seaboard of the U.S. colder (Figure 2.4). Depending on the average temperature of the ocean, the currents themselves can drastically change. During the Late Pliocene glaciation 3.6 million years ago the North Atlantic Current was weakened so drastically because of cooling temperatures that the current shifted southward, resulting in the glaciation of most of northern

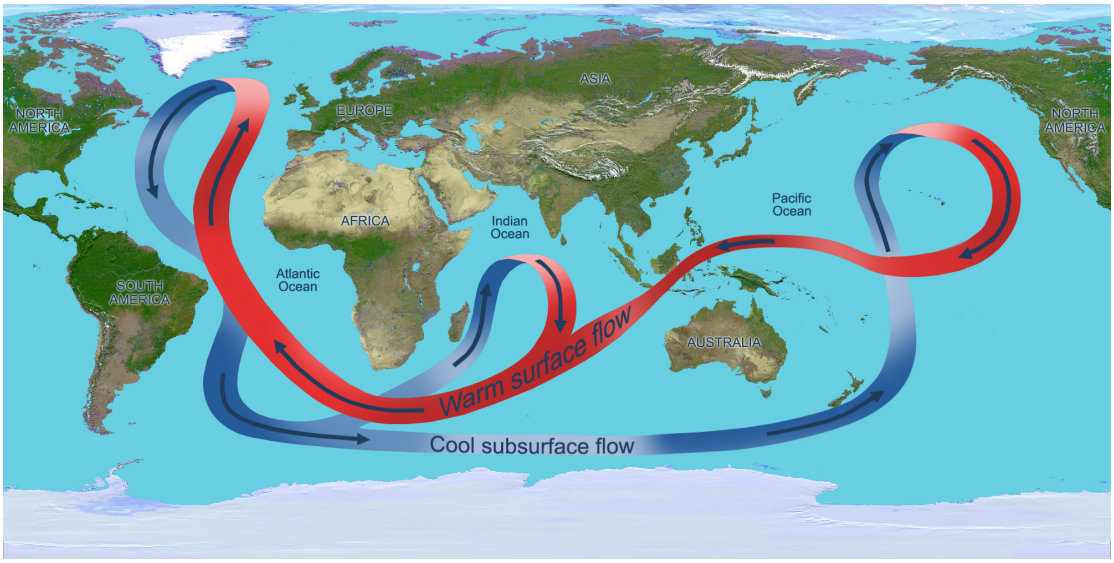

Figure 2.4 *Simplified global ocean current system. Red is warm water and blue is cold water*
Source: NASA/JPL

Europe. The currents act as a major feedback loop, regulating temperatures regionally and globally.[23]

The ocean currents also transport nutrients and organisms around the world through a process of upwelling and downwelling. As water changes in salinity

---

[23] Naafs, B. D. a., Stein, R., Hefter, J., Khélifi, N., De Schepper, S., & Haug, G. H., 2010. Late Pliocene changes in the North Atlantic Current. Earth and Planetary Science Letters, 298(3-4), 434–442.

(saltiness) and temperature it change its location relative to the surface. Warmer, fresher water is lighter than colder, saltier water and therefore sits on the surface. Over the course of a year, water circulating around the globe moves levels from the deep to the surface, and vice versa. During the winter, when warm water in the Atlantic moves northward, from the equator to the Artic, it cools allowing an upwelling of nutrient rich deep water to begin mixing with the now cooled, less nutrient rich water. There are points of upwelling and downwelling throughout the globe that can change seasonally, and allow for the transfer of important nutrients that sustain whole ecosystems, including fisheries.

Along with nutrients the currents also allow for the absorption of carbon dioxide. Organisms that use carbon dioxide absorb it from the nutrient rich water, allowing the oceans to absorb even more carbon dioxide from the atmosphere, acting as a "carbon sink." The ocean absorbs about 25% of the carbon dioxide emitted by humans a year. The influx of carbon dioxide is, unfortunately, resulting in acidification. As carbon dioxide chemically reacts with the water it creates carbonic acid, which in turn creates bicarbonate. The process of creating bicarbonates requires individual carbonate ions, which organisms are reliant upon for survival. One of the first major observed ecosystems impacted by this phenomenon was and is the coral reefs, which are seeing a dramatic decline.[24]

The nutrient transfer also allows for small organisms known as plankton to blossom in the spring and summer. Plankton populations absorb carbon dioxide in

[24] Hoegh-Guldberg, O., Mumby, P. J., Hooten, A. J., Steneck, R. S., Greenfield, P., Gomez, E., … Hatziolos, M. E., 2007. Coral Reefs Under Rapid Climate Change and Ocean Acidification. Science , 318 (5857), 1737–1742.

their metabolic process, removing it from the ocean and thus acting as a "biological pump." About 1% of these tiny organisms fall to the bottom of the dead ocean, taking their absorbed carbon dioxide with them, allowing more carbon dioxide to be absorbed at the surface levels. The removal of carbon dioxide by plankton is important in maintaining both atmospheric carbon dioxide levels, as well as maintaining biological viability. However, the increased acidification and temperatures are threatening plankton populations. Warmer water temperatures will result in more stratification between the surface layer of water and the deep water where the nutrients are located, resulting in less and less nutrients being available. If the temperatures of the oceans increase enough the plankton feedback system may diminish significantly due to lack of nutrients.[25] Also, acidification is damaging the reproduction capability of plankton.[26] It can be expected that as the nutrients become scarce the plankton will not be able to maintain their population, slowing down the carbon dioxide feedback system. [27]

There are a large number of other issues on going in ocean ecosystems, but we don't have the time to cover them all here. Understanding the concepts discussed here will aid us in our understanding of the long-term drivers of climate change.

---

[25] Steinberg, D. K., Lomas, M. W., & Cope, J. S., 2012. Long-term increase in mesozooplankton biomass in the Sargasso Sea: Linkage to climate and implications for food web dynamics and biogeochemical cycling. Global Biogeochemical Cycles, 26(1).

[26] Riebesell, U., Zondervan, I., Rost, B., & Tortell, P., 2000. Reduced calcification of marine plankton in response to increased atmospheric CO 2. Nature, 407, 2–5.

[27] Houghton, 43.

Orbital Forcings

In this section, the drivers behind long-term climate change will finally take centre stage. Variations in the earth's climate over the course of its entire history can be tracked down to three instigators: eccentricity, obliquity, and precession (Figure 2.5). Eccentricity is the amount the earth's orbit around the sun "wiggles." Over the course of about 100,000 years the earth's orbit moves in and out relative to the sun, becoming more circular or more elliptical over time.[28] Eccentricity is the slowest of the three processes. Obliquity, or tilt, is the angle at which the earth spins about its axis. Currently the earth sits at about a 23.5° angle, but varies between 21.6° and 24.5° over the course of about 41,000 years. Precession is the rotation of the earth's axis. Imagine a spinning top, notice how while it spins it also wobbles around its centre. The earth does the same thing, spinning every twenty-four hours, but also "wobbling" every 23,000 years. Together the three orbital forcings work together to drive the glaciation cycle on Earth. As discussed earlier, the earth relies on the

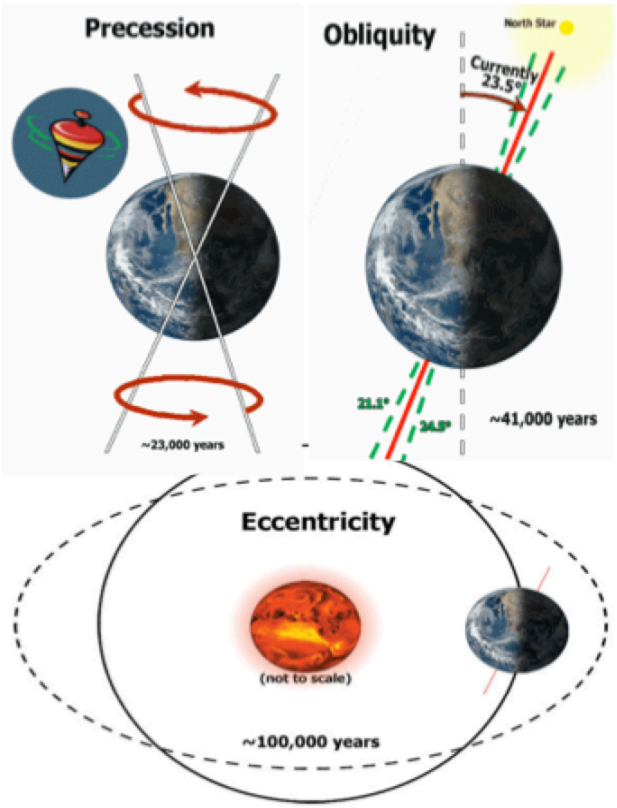

Figure 2.5 *Precession, Obliquity, and eccentricity.*
Source: Climate Science Investigations

[28] Houghton, 85

sun's radiation for energy; however, the distance of the earth to the sun, as well as the angle of the earth relative to the sun, impacts how much energy reaches Earth. Eccentricity is the most obvious of forces. During periods where the orbit is more elliptical, climate "is affected by the time of year that the earth is closest to the sun," causing more variation in seasons.[29] Precession has a similar effect to eccentricity. As the earth wobbles the point that is closest to the sun (the perihelion) varies month to month. When the perihelion is in January the southern hemisphere is close to the sun, and therefore is warmer than the northern hemisphere. The opposite is true when the perihelion is in July. To understand

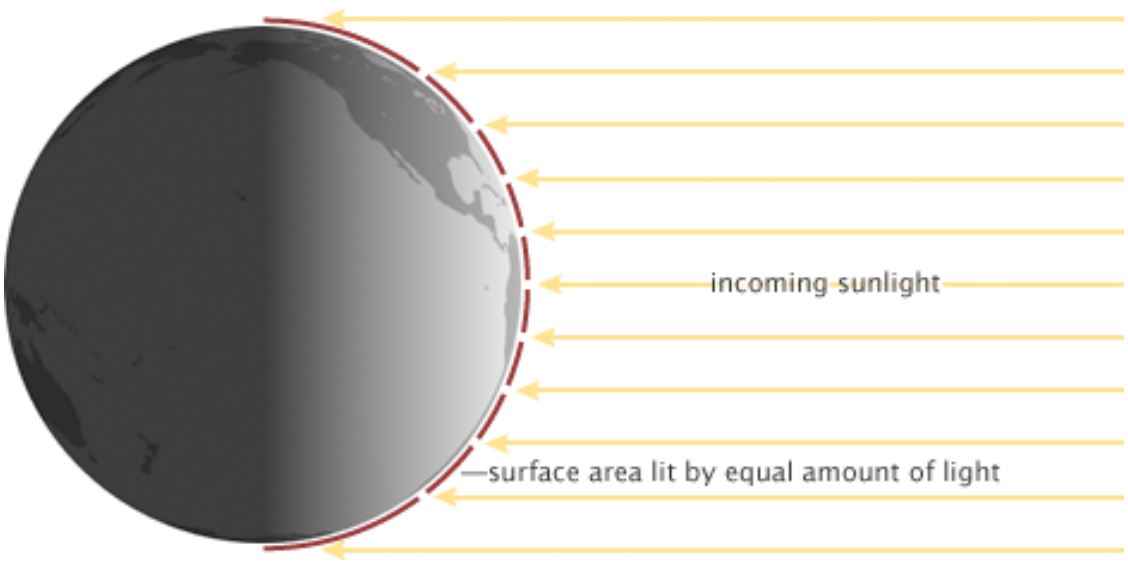

Figure 2.6 *Spread of sunlight over Earth. "Flatter" regions have higher concentrations of energy input than curved regions.*
Source: NASA/Earth Observatory

obliquity, flux first needs to be explained. Flux is the amount of energy absorbed by a certain area depending the shape of the area. More energy is concentrated on flatter areas (such as the equator region) than in rounded areas (such as the polar regions) where the light is spread out over a greater surface area (Figure 2.6). As

[29] "The Cause of Glaciation." Climate Science Investigations. http://www.ces.fau.edu/nasa/module-3/temperature-trend-changes/causes-glaciation.php (accessed March 27, 2014).

the earth changes its tilt, the angle at which sunlight hits certain regions change. When the tilt is lower, closer to 21.6°, seasons are more mild. The milder seasons cause a snow build up over the winter that doesn't melt during the cooler summers. The snow build up can kick start a glaciation period (consider the ice-albedo feedback loop discussed earlier). All three of these forces can work together over the course of time to cause great variations in the earth's climate. Patterns in Earth's climate history align with orbital variations, making eccentricity, precession, and obliquity three of the most important forces in climate change.

This quick overview of climate change should serve as a helpful aid as we move forward in our discussion about how to best frame the climate debate. Far too often opinions are voiced without even possessing the basic processes discussed in this chapter. I highly urge you to continue to learn even more about the many forcings, feedbacks, and systems that drive and impact our climate. I also want to acknowledge little discussion was given to the biological ramifications of climate change. Of course, why we even care about climate change is because of the biological implications, but it isn't the main focus of this essay. The next chapter will deal with how current dialogue about climate change is framed, and how it is failing.

3
The Predominant Climate Arguments in Science and Media

"I'm no longer sceptical. I no longer have any doubt at all. I think climate change is the major challenge facing the world."
– Sir David Attenborough, naturalist[30]

"I'm not saying the warming doesn't cause problems, obviously it does. Obviously we should be trying to understand it. I'm saying that the problems are being grossly exaggerated. They take away money and attention from other problems that are much more urgent and important. Poverty, infectious diseases, public education and public health. Not to mention the preservation of living creatures on land and in the oceans."
– Freeman Dyson, physicist and mathematician[31]

Climate change has become one of the most volatile debates in recent time. Debate still rages on in the media about the significance of climate change, and even whether it is happening. As demonstrated in this essay, climate change is a real process, and it is a process we need to deal with, whether humans are responsible for recent changes or not. The fact that only half of the U.S. population is concerned about the human impact of climate change,[32] and only a third are greatly concerned about climate change at all,[33] is deeply worrying.

---

[30] "Sir David Attenborough Condemns Climate Change." Sir David Attenborough Condemns Climate Change. http://www.treehugger.com/corporate-responsibility/sir-david-attenborough-condemns-climate-change.html. (accessed March 20, 2014).
[31] Dyson, Freeman. "Winter Commencement Address." Lecture, Winter Commencement Address from University of Michigan, 2005.
[32] "A Steady 57% in U.S. Blame Humans for Global Warming." A Steady 57% in U.S. Blame Humans for Global Warming. http://www.gallup.com/poll/167972/steady-blame-humans-global-warming.aspx (accessed March 18, 2014)
[33] "Gallup News Minute: Americans Unconcerned About Climate Change." Gallup News Minute: Americans Unconcerned About Climate Change.

Worse still is that those who do agree that climate change is an urgent issue spend more time yelling at each other over how to fix the problem rather than ensuring climate change is fully understood by the general population and action is actually taken. We could simply say that two extreme camps, environmental purists (renewables only) and economists (market driven development), blame each other for misdirecting the actions necessary to address the problems we face, as well as "accuse others of not understanding either the science or the scope of the problem."[34] The extremes within the climate debate limit the effectiveness of the narrative being told. When actions are taken, depending on the camp, it is either not enough, too much, uniformed, and/or a mistake. There is an unwillingness to work together on an issue as important as climate change, and that unwillingness is even more detrimental with so much of the population still unconvinced. So, although attitudes about climate change have progressed in the past two decades, the arguments being presented are turning out to be worse than ineffective, but harmful.

The Arguments of Climate Change

In *Debating Climate Change* (2009), Elizabeth Malone outlines a plethora of perspectives on the climate change issue, and also provides insight to their effectiveness in the pursuit of agreement. By interviewing a wide range of people with varying opinions on climate change, Malone attempts to find a common

---

http://www.gallup.com/video/168389/gallup-news-minute-americans-unconcerned-climate-change.aspx (accessed March 18, 2014).

[34] Malone, Elizabeth L. Debating Climate Change Pathways Through Arguments to Agreements. Earthscan, 2009.

ground in the climate debate. Interestingly, she notes that the arguments surrounding climate change have not changed at all since the early 1990's, if not earlier. The worldviews of various groups of people continue to dictate the outlook they hold when it comes to deciding what to do about climate change. These views go on to create controversy, even when two perspectives seemingly share almost all the same beliefs. Elizabeth Malone outlines eleven "argument families" that she feels accurately cover the field of opinions, and they are worth covering here.

1. Climate isn't changing; the science is incorrect or incomplete.
2. Climate is changing, but people needn't do anything. Either human beings are not to blame and/or they will find ways to adapt as it happens, just as they have in the past.
3. Climate change is subject of scientific investigation, and further research will provide knowledge.
4. The world needs more of the tools of modernity to address climate change, particularly development and implementation of effective treaties, conventions, protocols and other policy mechanisms.
5. The world needs more of the tools of modernity to address climate change, particularly new technologies for the energy system.
6. The world needs more of the tools of modernity to address climate change, particularly reduction of emissions, from all sources.
7. The world needs more of the tools of modernity to address climate change, particularly preparation for adaptions that will be necessary.

8. The world needs more of the tools of modernity to address climate change, particularly creation of markets for environmental goods.
9. The world needs more of the tools of modernity to address climate change, particularly, all feasible mitigation and adaptation actions.
10. Climate change is another instance of rich and powerful countries preserving their hegemonic positions.
11. Climate change reflects human being's broken relationship with the natural world.[35]

Issues of climate change that have gripped the news in the last few years certainly are reflected in these eleven "families." From economic solutions, such as carbon tax and trade (#4, #6, #8) to Gaia theory (#11), it is all covered. Malone discusses how even the people who fall into one of the eleven groups find issues to quarrel about with those in their groups. For example, she discusses how issue #5, technology, brings people together who agree that technology is the solution to our climate issues, but quickly people disagree on what technologies to use, and whether new technology needs to be developed or not. The entire group of debaters, however, do "agree that climate change is happening, that it must be addressed, and that technology is all or most of the answer," even if within that scope no consensus can be found.[36] Every argument faces similar problems: a group of people who agree on a general narrow narrative, but disagree on what specific actions to take within that. If there are so many divisions of insight and

[35] Malone, xii.
[36] Malone, xiii.

opinion, how can we ever hope to actually begin building effective policy, technology, and infrastructure to handle the effects of climate change?

Finding Common Ground

One answer might be science, another might be politics or economics, but as we have discussed in chapter 2, all have failed to penetrate the public mind effectively. The science community is reliant on the political and media processes to share the knowledge it finds, and with that reliance comes uninformed voices, adding more argument to an already congested conversation. What we have to ask ourselves then is there a chance that enough people can be educated fast enough in order to begin making better, more knowledgeable decisions about our future? History suggests no. In fact, this route has been sought a number of times before, in the form of international conventions. Whenever nations have come together on the world stage to discuss climate change it is under the guise of science and knowledge. And even when the majority of the nations agree on the facts (Kyoto Protocol), choosing how to act strikes up a circular, endless debate.

Malone believes that the answer lies in the debate itself. By observing the social patterns of the climate debate, we might uncover avenues to proceed to agreement. [37] The evolution of the climate change debate into a more interdisciplinary conversation likely holds an important key into understanding how to better move forward, but rather than have many sectors yell at each, make concerted efforts to work together. Of all the arguments listed above, we can find that similarities do exist. After all, if I say the sky is green and you say it is blue,

[37] Malone, 16.

we can agree there is a sky. All parties of argument, at the very least, take the climate change discussion very seriously, if not climate change itself. Another common factor is a reliance on using scientific data to support an argument. Even the most staunch climate change critics turn to science to make their case. Within an argument group the most common binding influence is worldview. For example, someone who believes argument #2 from above, humans are not responsible for changing climate, often has an economic worldview where nature is a hard to change thing.[38] These worldviews bind the argument groups together, making it difficult for collaboration across groups to occur. Malone points out that no matter where one lays on the spectrum of arguments the same process of communication will occur:

> But in all these responses, individuals, groups, and societies attempt, first to connect new problems with their experience and, second, to develop solidarities based on shared trust and knowledge. Again, a principal medium of these attempts is language. In discourse, in arguments, they make connections based on shared understandings, attempt to co-create further shared understandings and work towards increasing their audiences' adherence to certain arguments, and work towards increasing their audiences' adherence to certain arguments.[39]

Although climate change has become an important issue, we unfortunately have failed to successfully create a productive conversation. What is now lacking is an overall theme to build solidarity across all of the argument groups, Too many of the different families of argument get caught up in minute difference between sides, leaving contradicting and confusing messages for the public to try and make sense of. Identifying that our failure to find a shared narrative is the first step

[38] Malone, 93.
[39] Malone, 125.

forward, but before trying to discover a narrative that binds many of the different groups together, we have to identify what, if anything, is specifically keeping groups apart.

Discerning the Problem

When scientists began the climate change debate in the late twenty-first century the narrative they chose to pursue stuck, influencing the debate to today. From a scientific perspective climate change is one of the biggest puzzles to unlock. They observe past environments, solve mathematical problems, and discover unknown processes and life forms because it is what they are passionate about. Climate change is a series of facts that are uncovered and shared, but there has been historically little to no concern "with the human implications of such change, nor of choices that could be made."[40] So, when the issue of anthropologic climate change first came up, it was done from the factual inquiry of a scientist's perspective. However, the general public and other fields process the world very differently. Social sciences prescribe to the importance of interpretation, and how certain things impact one's life. So while a natural scientist will ask "Why is carbon dioxide increasing so much?" a economist will ask, "How does increasing carbon dioxide impact the choices a consumer or supplier make in the market place?" These are very different approaches to the same issue. So, when scientists first began unveiling the worrying signs of an unprecedented rapid change in our climate, the social scientists began asking their unique set of questions on the issue, and a worrying divide began to appear, and is still present today.

[40] Malone, 19.

Social scientists have discovered that for the most part people aren't that concerned about climate change. Even those who believe it is an issue aren't terribly concerned with it (only a third of the U.S. population in 2014 is concerned). After years of debate, after international conventions, and after scientific breakthroughs, there just still isn't a wide concern about climate change. I believe the source of this issue is two-fold: 1) a lack of practise in looking beyond the short-term, and 2) an over reliance on anthropologic climate change to raise concern. These two points are closely related. Anthropologic climate change, for a number of reasons, ruffles the feathers of many people. It has acted as a roadblock in the attempts to progress the climate conversation forward. Scientists rely on using anthropologic climate change because it seems to make the issue more relatable and urgent for today's society. Whether this is because the realities of human impacts on the environment go against the interests of particular groups, or because it has become politicised to the point where conservative refuse to even engage in the debate, the conversation leads back to the first point. While in the next hundred years we are likely to see some change[41], there is a larger issue at work. Our inability to look beyond the short-term, and consider how technology, science, and policy of today will impact not just the next generation, but also the generations of the 22nd century and after is really what is at the crux of this issue. We must move away from our dependence on using anthropologic climate change to raise concern for our actions, and begin building a narrative around long-term climate change.

---

[41] IPCC, 7.

4
Long-term Climate Change & a New Perspective

So far we have determined that the climate change debate is awash with many different voices, all staunchly fighting for their solution to be heard. The number of different voices isn't the real problem because in an issue as complicated as climate change many voices and perspectives are needed. What is missing, however, is a unifying idea that successfully pushes the different groups to work together to educate and act. Paschen and Ison (2013) highlight the importance of narrative driven conversation in climate change. They state, "…[narrative] research therefore necessitates the production of diverse views and knowledge(s), while driving a holistic understanding of the socio-ecological system of interest."[42] In this chapter long-term climate change will be shown to be an affective unifying narrative.

Shifting the Paradigm

In chapter 1 we discussed the sensationalism and apocalyptic driven story behind climate change with media stories titled, "Global warming and ozone loss: Apocalypse soon." Later, we established that the narrative behind the climate change debate relies too heavily on the anthropologic changes on our planet, and that this narrative is fuelling division where the overarching narrative should be "creat[ing] the interactive social space for the production of diverse narratives."[43] While certainly a social space has been created by the current approach, it has

[42] Paschen and Ison, 2.
[43] Paschen & Ison, 4.

failed by generating animosity and distrust. Paschen and Ison (2014) argue that we require a paradigm shift in the climate conversation by bringing in the local perspectives and stories of people and how they are impacted by the climate. They put forward the narrative theory as their solution:

> Narrative theory's two central premises are, first, that human experience, cognition and values are organized around culturally specific plots and archetypical narrative structures, and second, that relating an experience through story-telling is already doing 'knowledge work', or learning, through the reflective reworking and developing of knowledge content.[44]

I believe this theory holds a lot of possibility in opening up the climate dialogue to more people, especially voices that aren't given the opportunity to be heard. Through the social science process, quantitative data is collected through polling and questionnaires, and is supported by personal stories. Narrative theory acknowledges that data and facts alone aren't enough to understand the scope of an issue. And while climate change is a factual, scientific issue, the impact of it and the choices we need to make about it are very much social issues. Furthermore, the narrative theory accepts that the scientific and the social process are not separate from one another. Both the scientific discourse and the socio-political discourse come together, making the line between rational and non-rational difficult to discern.[45] This perspective allows us to better understand the mind-set of those who seemingly discrediting the scientific facts often used in the climate debate. Often scientific facts are not the ones used by a person to form their opinion, and part of the debate needs to accept the many other datasets beyond the scientific as being factual. What also makes narrative theory an

[44] Paschen & Ison, 4.
[45] Paschen & Ison, 5.

attractive tool to use in the climate debate is that it naturally sets itself up to create conversation through the use of storytelling. Educational studies have been using this method for years, having established the importance of storytelling in learning environments.[46, 47, 48] It is then little surprise that this could be a extremely effective way of moving the debate forward, beginning to free the conversation from pandering and indecisiveness. However, Paschen and Ison believe that the narrative theory is "what the human-induced climate change demands."[49] And here I disagree. I do not think developing narrative-based research alone will be enough to push the climate debate forward, but it is an important factor.

I believe that we need to take a narrative-based approach, but focus on telling the story of the long-term climate change. The climate constantly changes over the course of centuries and millennia, and yet we rarely give time to talk about the processes driving it. Since the climate has become a major issue all we have focused on is the human impact. While anthropologic climate change is important it should not be the driving factor of this debate, as it is far too controversial and heated to promote productive conversation. Shifting the focus to long-term climate change removes the anthropologic from the spotlight, and also creates a more thoughtful approach to the issue. By looking at climate change on

---

[46] Rooth, A. B. The importance of storytelling: a study based on field work in northern Alaska. Uppsala: Acta Universitatis Upsaliensis, 1976.
[47] Scheurich, J., & Young, M., 1997. Coloring epistemologies: Are our research epistemologies racially biased? Educational Researcher, 26(4), 4–16.
[48] Dyson, A. H., & Genishi, C. The need for story: Cultural diversity in classroom and community. Urbana, IL: National Council of Teachers of English, 1994.
[49] Paschen & Ison, 7.

time scales of thousands, hundreds of thousands, and millions of years the way we understand the impacts changes drastically.

A Long-term Focus

Mitchel et al. (2012) discuss the movement of the continents over the course of hundreds of millions of years. The continents move over time, and two major theories have been produced to explain how they move. One theory, introversion, suggests that the Atlantic Ocean will close to form a supercontinent from Europe, Africa, and the Americas. Another theory, extroversion, suggests the opposite that the Pacific Ocean will close, forming a supercontinent between Asia and the Americas. However, both of these theories don't fully explain our data records of past continents, and so Mitchel et al. developed a new theory called orthoversion. Orthoversion predicts that new supercontinent will form in the Artic Ocean as northern America and Asia come together. Their new model can accurately predict past supercontinents, and the landmass movements seen in the model stand up to our geological records.[50] Their paper exemplifies the type of work that can shift how we think about climate change.

By framing the climate discussion in the context of continental shift we immediately can begin looking at some of our current issues in a different light. While a paper of this nature offers little to no practical tools to answer vital questions about how to regulate our economy or develop policy, it does offers us

[50] Mitchell, R. N., Kilian, T. M., & Evans, D. a D., 2012. Supercontinent cycles and the calculation of absolute palaeolongitude in deep time. Nature, 482(7384), 208–11.

insight into how to go about asking and answering those questions. By starting with a mind-set focused on the long-term time scale, the debate over what actions to take today will naturally consider the impacts further down the road than the next fiscal year. This narrative allows us to begin to grasp the changes that have occurred and will occur on our planet, independent of human impacts.

A long-term focus also acknowledges the large-scale changes climate change brings, but without becoming apocalyptic. Long-term climate change science acknowledges that the change has happened before, and will happen again. Life has survived it before, and so did our early ancestors 10,000–20,000 years ago. Building a society that will survive changes we face today, as well as changes yet to come, will require work, but it is by no means the end of the world. And anthropologic factors aren't ignored, but rather become one of the many issues we need to be taking into consideration. Let us first establish an ethos built around a climate that naturally changes, and then investigate how our actions may lend to that change. Through reducing the anxiety surrounding climate change, hopefully clearer heads can prevail in directing a more productive dialogue. To best demonstrate how focusing on long-term climate can result in this perception alteration it is best to delve more deeply into the science behind long-term climate variation—namely orbital forcings.

Orbital Forcings Revisited

As discussed in chapter 2, orbital forcings are the drivers behind climate change. The earth's relationship with the sun is constantly changing, and this

change impacts almost every aspect of our climate through feedback loops.[51] While work is continual being done to better understand what feedback loops are triggered and how they function, we do have a strong grasp on the impact of orbital changes.[52] One of the first people to see the connection between long-term climate variations impacting changes in solar radiation influx and changes in our eccentricity (orbit), precession (axis), and obliquity (tilt) was named James Croll in 1867. But it wasn't until Milutin Milankovitch fully developed Croll's theory in 1920 that it began becoming widely accepted in the scientific community. Since then, the cycles of change we can see in the climate (glacial-interglacial cycle) have been known as Milankovitch cycles, which we now know account for at least 60% of the variation in our climate record, dating back millions of years.[53] An example of the Milankovitch cycles can be seen in Figure 4.1. Graphs similar to, and including, Figure 4.1 are created using ice cores from Antarctica or the Artic, as well as from sediments from the bottom of the ocean, allowing us to recreate past temperature and atmospheric data based off of air bubbles trapped in the ice or sediments. The depth the data was retrieved can determine the age of the samples, similar to how trees are dated using the number of rings in their trunk. The peaks and troughs of carbon dioxide, temperature, solar radiation, and oxygen can be seen lining up over the course of time. As we can see the cycles don't align

---

[51] Abe-Ouchi, A., Saito, F., Kawamura, K., Raymo, M. E., Okuno, J., Takahashi, K., & Blatter, H., 2013. Insolation-driven 100,000-year glacial cycles and hysteresis of ice-sheet volume. Nature, 500(7461), 190–3.

[52] Erb, M. P., Broccoli, A. J., & Clement, A. C., 2013. The Contribution of Radiative Feedbacks to Orbitally Driven Climate Change. Journal of Climate, 26(16), 5897–5914.

[53] Houghton, 86 & 128.

completely, nor do they occur in a perfect pattern. This variation is something that is continually being researched and explained. So far what we have determined is that there is actually a pattern, but one that is more complicated than simply looking for a rise and fall. As discussed earlier, precession, obliquity, and eccentricity all operate at different time scales (23,000, 41,000, and 100,000 years, respectively). So it isn't much of surprise that as these cycles depend on an alignment of these forcings. Further, glaciations can be fully explained by orbital forces, but deglaciations (or terminations) require both orbital forces and ice volume to align.[54]

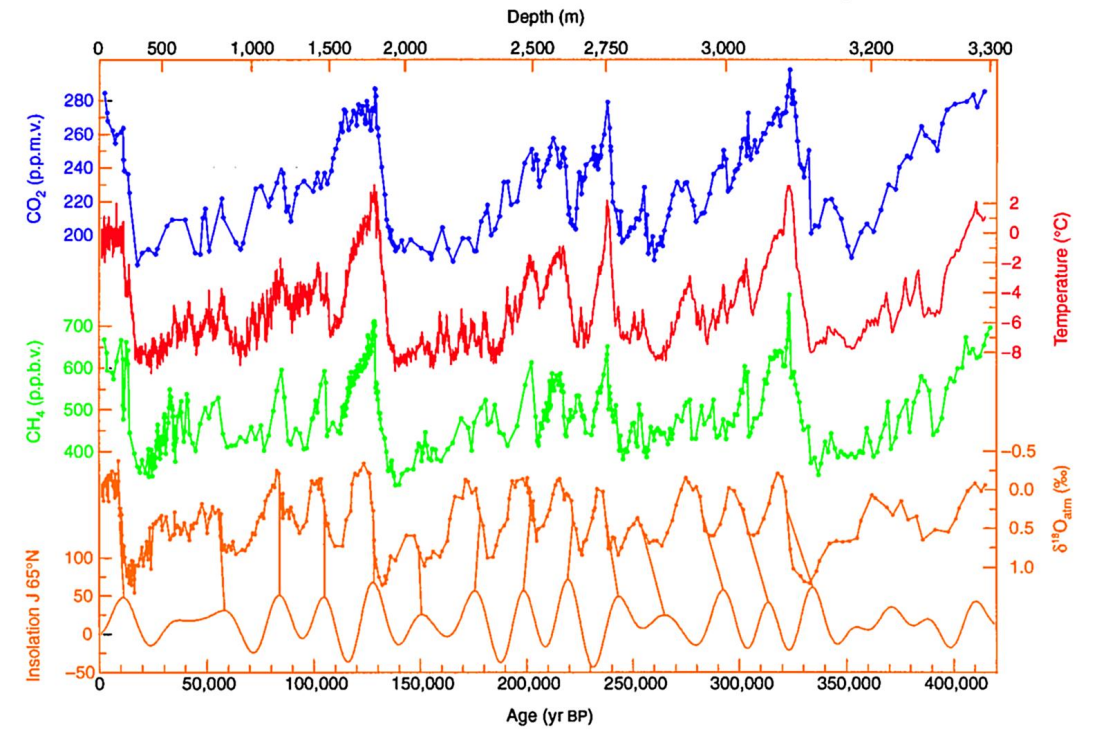

Figure 4.1 *Milankovitch Cycles dating 420,000 years back in time. Data from Vostok, Antarctica ice core records.*
Source: Wikimedia Commons

[54] Parrenin, F., & Paillard, D., 2012. Terminations VI and VIII (~ 530 and ~ 720 kyr BP) tell us the importance of obliquity and precession in the triggering of deglaciations. Climate of the Past, 8(6), 2031–2037.

Another source of debate in the science community is which of the three orbital forces are most important. There are very strong 100,000-year cycles in our data sets, suggesting that eccentricity is the main driver behind large climate change events, and many scientists agree.[55] Yet, there are too many instances in between the large events when eccentricity fails to explain changes in the climate, suggesting that obliquity and precession play larger roles in driving the many glaciation events in history. And here is yet another debate, which of obliquity and precession more greatly influence glaciation and deglaciation events.

Parrenin and Paillard (2012) explain exactly how much a role obliquity and precession play in two deglaciations they refer to as "Terminations VI and VIII." VI was roughly 530,000 years ago and VIII was roughly 720,000 years ago. They built a climate model using the orbital cycles to test which of obliquity or precession is stronger. They discovered that in all eleven of the termination points they tested both obliquity and precession played important roles. For termination VI obliquity was more important, but for termination VIII precession was more important. They conclude that both forces are necessary in the glaciation-deglaciation process.[56] Peter Huybers (2011) puts forward similar findings. Huybers studies the glaciation cycles during the Pleistocene era, the past million years, to determine the role both obliquity and precession play in glaciation events, and more specifically the role of precession. Huybers takes an interest in precession because of its shorter cycle (23,00 years) versus that of obliquity

[55] Ganopolski, A., & Calov, R., 2011. The role of orbital forcing, carbon dioxide and regolith in 100 kyr glacial cycles. Climate of the Past, 7(4), 1415–1425.
[56] Parrenin, F. & Paillard, D., 2036.

(41,000 years), making it much harder to mathematically determine precession's impact. He uses ice core records to build a mathematical model that significantly supports Milankovitch's theory that both precession and obliquity play important roles in glaciations.[57] Yet, the truth of the matter is that none of these forces work alone. Huybers is right to point out:

> The climate system is thoroughly interconnected across temporal and spatial scales, and, just as neither obliquity nor precession act in isolation no one region should be expected to exert exclusive influence upon deglaciation.[58]

Scientists are taking this next step by evaluating how feedback loops are impacted by orbital forcings. Abe-Ouchi et al. (2013) investigates the role of ice sheets in relation to 100,000-year eccentricity cycles. The paper makes the step forward in research between the long-term orbital forces and the relatively short-term feedback loops that regulate the changes. There are so many different processes that contribute to the climate that we will likely always be pursuing some question about how it functions. What is important, however, is how begin to associate these seemingly difficult to connect processes. Also, Abe-Ouchi et al. choose to focus on the global and long-term picture, basing their research in a different narrative framework from a large number of other papers. Research, like that of Abe-Ouchi et al., can set the standard for a new narrative driven approach that is focused on long-term climate change.

The requirement in climate science research to look across all spatial and temporal scales extends to the climate change debate. There isn't one answer or

---

[57] Huybers, P., 2011. Combined obliquity and precession pacing of late Pleistocene deglaciations. Nature 480, 229-232.
[58] Huybers, 232.

one solution that will set our society on course to great success. But having a common narrative that binds us together to work towards a society that is capable of adapting to climate change is an important first step. I truly believe a narrative driven by long-term climate can be the connecting force between all the argument families, fostering a healthy debate that results in an expansion of knowledge and results.

5
Conclusions

"The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate. Visit, yes. Settle, not yet. Like it or not, for the moment the Earth is where we make our stand."[59]

- Carl Sagan, Astronomer, Astrophysicist, Cosmologist, Author, Professor.

Earth our only home, and only choice is to develop a flexible society capable of surviving many different climate change events. Though our technology today is contributing to the forces that change our climate, we will not develop technology that allows us to control our global climate anytime soon. And certainly none will be developed soon enough to address the many changes that are already occurring that are and will affect the global population. We must start developing policy, infrastructure, and technology that begin to address the issue of not only the impended climate change events of the next century, but for centuries to come. Clearly the paradigm that was established at the beginning of the climate discussion is failing us. The current paradigm has failed to grasp the scope of climate change and has failed to motivate the necessary action and concern throughout society.

The climate change debate raises many old issues, but in new light. Unsurprisingly, the human populations that will be most affected by the projected climate change will be the poorest populations, many located near the equator. Rising temperature in both the atmosphere and oceans are expected to greatly impact food and water resources, and more worrying, adaptation measures are

---

[59] Sagan, C. Pale blue dot: a vision of the human future in space. New York: Random House. 1994.

likely to be too expensive for those who need it most.[60] Indeed, human rights issues are at the centre of much of the climate change debate. The Human Development Report (HDR), published by the U.N., outlined the many humanitarian issues that we face. Most of the issues won't be new, but exacerbations of already established problems, such as malnourishment and disease. Gasper et al. (2013) fully analysed the HDR, discerning the wide impact climate change will have on the billions of the poor:

> A stage of climate change that is not immediately dangerous for most of the affluent is already past the danger point for millions of poor people: '262 million people were affected by climate disasters annually from 2000 to 2004, over 98 per cent of them in the developing world;' and 'The 1 billion people currently living in urban slums on fragile hillsides or flood prone river banks face acute vulnerabilities.' Much of the human development damage is irreversible; being born in a drought year in a poor country, for example, markedly increases one's likelihood to be malnourished years later.[61]

The threat is already very real for large parts of the world population, but because they possess little of the social power need to affect change their voices go unheard. The HDR also stresses against framing the climate as something we are approaching, rather than something that is present today.[62] The impacts are beginning to be felt, and will continue to be felt, even if the best mitigation goals are met.[63] These issues harken back to the current climate narrative that insists on

---

[60] Barnett, J., & O'Neill, S., 2010. Maladaptation. Global Environmental Change, 20(2), 211–213.

[61] Gasper, D., Portocarrero, A. V., & St.Clair, A. L., 2013. The framing of climate change and development: A comparative analysis of the Human Development Report 2007/8 and the World Development Report 2010. Global Environmental Change, 23(1), 28–39.

[62] UNDP, 2007. Human Development Report 2007/8 – Fighting Climate Change – Human Solidarity in a Divided World. UNDP and Palgrave Macmillan, New York.

[63] Gasper, D., Portocarrero, A. V., & St.Clair, A. L, 32.

focusing on human-induced climate change, resulting in a finger pointing game. The HDR recognises that "different policy instruments and a fuller institutionalization of its human rights concerns are required,"[64] but we really need a whole shift in perspective that incorporates the stories of those affected.

Taking action on climate change requires a fully interdisciplinary process. The closest the world has become to needing such cooperation between almost every field of society was the allied powers during the World Wars. We now need that level of cooperation across governments, fields of research, and economic institutions. Up to this point, the climate debate has been tackled by many different sectors of society on their own, but there has not yet been a unifying force to bring them together. I truly believe the science and ideas behind long-term climate change offer the first step in that direction. The failure to disperse the basic knowledge of climate change on this planet is hindering the dialogue from progressing. The burden of moving this narrative forward, however, falls on the science community to begin reaching out to both academic peers and the general public to discuss the realities of the climate system on Earth. The inevitability of change to our climate should motivate us to progress the debate past an argument of who did it and whose going to pay. Understanding the processes that drive the earth's climate system makes the obsession with answering the anthropologic climate question seems irrelevant.

The future of our civilisation requires the progression of our understanding of how the climate functions on long-term scale. The process of developing technology, infrastructure, and policy that is built to change over time will only

[64] Gasper, D., Portocarrero, A. V., & St.Clair, A. L, 28.

start once we start developing an understanding of changing climate into our ethos. A society that is built to adapt to future climate changes will be a society that is also conscious of the impact it has on the climate. Shifting the paradigm is just the beginning. More research needs to be done using a narrative driven approach using this long-term framework. Hopefully, this narrative can help us begin shifting our society toward becoming climate conscious and adaptable.

References

Abe-Ouchi, A., Saito, F., Kawamura, K., Raymo, M. E., Okuno, J., Takahashi, K., & Blatter, H., 2013. Insolation-driven 100,000-year glacial cycles and hysteresis of ice-sheet volume. *Nature*, *500*(7461), 190–3.

Barnett, J., & O'Neill, S., 2010. Maladaptation. Global Environmental Change, 20(2), 211–213.

Cubasch, U., D. Wuebbles, D. Chen, M.C. Facchini, D. Frame, N. Mahowald, and J.-G. Winther, 2013: Introduction. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 127–129.

Dyson, A. H., & Genishi, C. The need for story: Cultural diversity in classroom and community. Urbana, IL: National Council of Teachers of English, 1994.

Erb, M. P., Broccoli, A. J., & Clement, A. C., 2013. The Contribution of Radiative Feedbacks to Orbitally Driven Climate Change. *Journal of Climate*, *26*(16), 5897–5914.

Ganopolski, A., & Calov, R., 2011. The role of orbital forcing, carbon dioxide and regolith in 100 kyr glacial cycles. *Climate of the Past*, *7*(4), 1415–1425. doi:10.5194/cp-7-1415-2011

Gao, L., Nie, J., Clemens, S., Liu, W., Sun, J., Zech, R., & Huang, Y., 2012. The importance of solar insolation on the temperature variations for the past 110kyr on the Chinese Loess Plateau. Palaeogeography, Palaeoclimatology, Palaeoecology, 317-318, 128–133.

Gasper, D., Portocarrero, A. V., & St.Clair, A. L., 2013. The framing of climate change and development: A comparative analysis of the Human Development Report 2007/8 and the World Development Report 2010. Global Environmental Change, 23(1), 28–39.

Haberle, R. M., Forget, F., Head, J., Kahre, M. a., Kreslavsky, M., & Owen, S. J., 2013. Summary of the Mars recent climate change workshop NASA/Ames Research Center, May 15–17, 2012. Icarus, 222(1), 415–418.

Hamilton, L.C., Stampone, M.D., 2013. Blowin'in the wind: Short-term weather and belief in anthropologic climate change. Weather, Climate, and Society 5, 112–119.

Hawkins, J., 2014. "5 Scientific Reasons That Global Warming isn't Happening. http://townhall.com/columnists/johnhawkins/2014/02/18/5-scientific-reasons-that-global-warming-isnt-happening-n1796423 (accessed March 10, 2014).

Hoegh-Guldberg, O., Mumby, P. J., Hooten, A. J., Steneck, R. S., Greenfield, P., Gomez, E., … Hatziolos, M. E., 2007. Coral Reefs Under Rapid Climate Change and Ocean Acidification. Science , 318 (5857), 1737–1742.

Hughes, T. P., Carpenter, S., Rockström, J., Scheffer, M., & Walker, B., 2013. Multiscale regime shifts and planetary boundaries. Trends in Ecology & Evolution, 28(7), 389–95.

Houghton, John. Global Warming: The Complete Briefing. Cambridge University Press, 2009, 19–20.

Huybers, P., 2011. Combined obliquity and precession pacing of late Pleistocene deglaciations. Nature 480, 229-232.

IPCC, 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Malone, Elizabeth L. Debating Climate Change Pathways Through Arguments to Agreements. Earthscan, 2009.

Merlis, T. M., Schneider, T., Bordoni, S., & Eisenman, I., 2013. The Tropical Precipitation Response to Orbital Precession. *Journal of Climate*, *26*(6), 2010–2021.

Mitchell, R. N., Kilian, T. M., & Evans, D. a D., 2012. Supercontinent cycles and the calculation of absolute palaeolongitude in deep time. *Nature*, *482*(7384), 208–11.

Naafs, B. D. a., Stein, R., Hefter, J., Khélifi, N., De Schepper, S., & Haug, G. H., 2010. Late Pliocene changes in the North Atlantic Current. Earth and Planetary Science Letters, 298(3-4), 434–442.

Parrenin, F., & Paillard, D., 2012. Terminations VI and VIII (~ 530 and ~ 720 kyr BP) tell us the importance of obliquity and precession in the triggering of deglaciations. *Climate of the Past*, *8*(6), 2031–2037. doi:10.5194/cp-8-2031-2012

Riebesell, U., Zondervan, I., Rost, B., & Tortell, P., 2000. Reduced calcification of marine plankton in response to increased atmospheric CO 2. Nature, 407, 2–5.

Rooth, A. B. The importance of storytelling: a study based on field work in northern Alaska. Uppsala: Acta Universitatis Upsaliensis, 1976.

Sagan, C. Pale blue dot: a vision of the human future in space. New York: Random House, 1994.

Scott, J., 2012. "A Really Inconvenient Truth: Global Warming is Not Real." http://policymic.com/articles/3824/a-really-inconvenient-truth-global-warming-is-not-real (accessed March 11, 2014).

Scheurich, J., & Young, M., 1997. Coloring epistemologies: Are our research epistemologies racially biased? *Educational Researcher*, *26*(4), 4–16.

Shindell, D., Kuylenstierna, J. C. I., Vignati, E., van Dingenen, R., Amann, M., Klimont, Z., … Fowler, D., 2012. Simultaneously mitigating near-term climate change and improving human health and food security. *Science (New York, N.Y.)*, *335*(6065), 183–9.

Steinberg, D. K., Lomas, M. W., & Cope, J. S., 2012. Long-term increase in mesozooplankton biomass in the Sargasso Sea: Linkage to climate and implications for food web dynamics and biogeochemical cycling. Global Biogeochemical Cycles, 26(1).

Swyngedouw, E., 2014. Apocalypse Forever? Post-political Populism and the Spectre of Climate Change. Theory, Culture, & Society 27(2-3), 214–232.

UNDP, 2007. Human Development Report 2007/8 – Fighting Climate Change – Human Solidarity in a Divided World. UNDP and Palgrave Macmillan, New York.

"Americans Most Likely to Say Global Warming Is Exaggerated." Gallup. http://www.gallup.com/poll/167960/americans-likely-say-global-warming-exaggerated.aspx (accessed March 18, 2014).

"The Cause of Glaciation." Climate Science Investigations. http://www.ces.fau.edu/nasa/module-3/temperature-trend-changes/causes-glaciation.php (accessed March 27, 2014).

"'Cosmos' returns to TV, with a big bang." USA Today. http://www.usatoday.com/story/life/tv/2014/03/08/fox-cosmos-series-with-neil-degrasse-tyson/6059985/ (accessed: April 1, 2014).

"Gallup News Minute: Americans Unconcerned About Climate Change." Gallup. http://www.gallup.com/video/168389/gallup-news-minute-americans-unconcerned-climate-change.aspx (accessed March 18, 2014).

"Incoming Sunlight." Climate and Earth's Energy Budget. http://earthobservatory.nasa.gov/Features/EnergyBalance/page2.php. (accessed March 30, 2014).

"NASA Study Finds Atlantic 'Conveyor Belt' Not Slowing." Earth Observatory. http://www.jpl.nasa.gov/news/news.php?release=2010-101. (accessed April 1, 2014).

"Sir David Attenborough Condemns Climate Change." Tree Hugger. http://www.treehugger.com/corporate-responsibility/sir-david-attenborough-condemns-climate-change.html. (accessed March 20, 2014).

"A Steady 57% in U.S. Blame Humans for Global Warming." Gallup. http://www.gallup.com/poll/167972/steady-blame-humans-global-warming.aspx (accessed March 18, 2014).