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Ethics and Climate Modeling

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Why Ethics and Climate Models?

The word ethic derives from the Greek *ηθος* meaning (Liddell and Scott, 1989, p. 349) one's 'disposition or character', and also 'accustomed place', in particular, 'the haunts or abodes of animals'. We are circling around the concept of qualities, an ambiguously defined word related to 'kind', or 'type.' Character derives from words meaning 'mark' or 'imprint.' So ethics is related to what qualities are imprinted on us, what makes us a certain type of person. The words also imply a sense of order. Ethics tells us something about a certain order in our lives. If we extend this concept, we enter the realm of rules of behavior, what human behavior *ought to be*. Ethics often is an exploration of *ought to be* versus what *is*, where our actual behaviors are often incongruent with what they ought to be according to our stated values.

I find the definition of 'accustomed place' of great interest. An accustomed place is where we often find ourselves, a place where we dwell, a habitat. Our behavior in such a place is regular and comfortable. Ethics provides a frame for living life in a certain way, according to certain *principles* – a word related to imprint, by the way. There is a pattern of regularity embedded in an accustomed place. We know where things are, the proper place for everything, even if the place is messy. Ethics provides us with an accustomed way of life. An embodied dwelling that provides us with a sense of comfort. We know what to do in a certain situation. Of course the extreme of this is that life becomes prescribed and rigid. Religious codes can create this sort of accustomed place, an abode that becomes a prison. Science often creates this type of dwelling place when it falls into scientism. There is warning for us here. We need to regularly circumambulate our

accustomed place of dwelling and question its purpose. This is the gift of philosophy, which requires of us that we ask questions about our ways of knowing, being and living.

What of the definition of ethics as, ‘haunts or abodes of animals?’ Nonhuman animals are known for their ability to live as a part of their environment, not apart from their environment. I would argue that animals are less likely to destroy the environment they inhabit. Animals are more integrated within their ecology. Thus an abode of animals implies an approach to living that ensures a close interaction between place and being. An ethics arising from this perspective is one of interdependent relationship, an ethics of care. It does not establish rules of behavior separated from the context of living. If we define rules of behavior before understanding our environment, our potential for relating to the environment is artificially separated from the world. To the extent an ethic supports our ways of relating, we live less destructively.

This exploration of various definitions of ethic provides us with a better starting point for a discussion on ethics and climate modeling. How do ethics inform us of how we develop and apply climate models? What are the characteristics of climate modeling? As far as a place is concerned, how should we situate – place – climate modeling in the larger context of climate change? Are there places where models are more appropriate than other places? What role do climate models play in defining our relationship with our environment? Do models provide a context that enables different ways of relating to the world? Can model simulations enhance awareness of our place in the world? These are important questions to ask, and provide a motivation for exploring the topic of ethics and climate modeling.

This essay is structured as follows: First I explore how climate modeling is a form of representation. I also discuss the ethical issues related to creating a climate model. I then consider the place of climate modeling within the greater field of climate change. I look at the ethical issues that arise when using climate models to understand how humans are changing the climate system. I then explore the specific questions in the previous paragraph. I conclude with how climate models raise ethical issues about knowing the future and what to do with this information.

Climate Models as a Means of Representation

How do ethics inform us of how to develop and apply climate models? What are the characteristics of climate modeling that are relevant to climate change? Climate models are constructed to produce representations of the world, which are based on fundamental laws of physics, such as conservation of mass, energy and momentum. Numerical methods are used to solve these equations on supercomputers.

In Plato's Republic, Socrates explores the idea of how we know the world. To illustrate his ideas, he tells the story of how humans dwell in a cave, where they are forced to look at a wall, upon which are projected representations of things in the world. These are not the real things in themselves, but shadows of the real things. Socrates argues that if a person were to break free and look behind them they would see the things used to project the shadows on the wall. If they were to actually leave the cave and see the world outside, they would be astounded by the real world. Socrates goes on to state that if such a person were to return to the cave and explain the existence of this outer world to those in the cave, they would be punished for their radical pronouncements about the world.

Climate modelers look at their computer screens upon which are projected their model results. The features seen on their screens are not reality, only a representation of a reality. Modelers need to remember there is a real world beyond the model simulations, and that it is healthy to leave their cave every once in a while and go out to experience that world. There is an ethical responsibility for them to do this, where the experience of the outer world puts them in touch with the very things they are modeling. Climate modelers frequently do use large observational databases that come from satellites or analyzed global products. These are invaluable datasets to have and use for model evaluation. However, there is also something to be said for actually going out into the world and observing on one's own. I am talking about being more connected to the very world you are attempting to represent.

With respect to the fate of modelers, they often find themselves attacked by fellow scientists and climate skeptics. Some scientists are critical of how models are developed, what assumptions are made about small-scale processes, while climate skeptics generate disinformation to confuse the public. Using climate models, scientists can look at future representations of the world, and many people react negatively to these 'projections.' The scientists have an ethical responsibility to show their climate projections to the wider public, and convey these representations in a way that people can understand.

Ethics of Climate Modeling

Important ethical issues arise in developing climate models. Choices need to be made in how certain physical processes are numerically represented in models. For example, the typical spatial resolution of a climate model is a few hundred kilometers.

This means that any process larger in scale than this can be explicitly represented by fundamental laws of physics, like Newton's third law of motion. What about climate processes that occur on spatial scales smaller than a few hundred kilometers? Clouds are a good example of such a process. Clouds range in sizes from a few hundred meters to thousands of kilometers. The smaller sized clouds need to be included in the climate model, but cannot be explicitly represented, they must be parametrically represented, or parameterized. For many of these processes there is no unique way to include them into models, which gives rise to a multiplicity of models. The modeler must choose a particular way to include clouds in the model. The choice may be based on basic science, observations, or personal bias. Does the modeler choose a parameterization because it makes their model look good with respect to a certain feature, even though the parameterization is less physically based? What is the moral high ground given the subjectivity involved in this aspect of modeling?

Another ethical area that arises in developing a climate models is in 'tuning.' When climate models are created they often *a priori* will not agree with a fundamental metric such as the global average amount of solar energy absorbed by the entire climate system. This is a quantity that is very sensitive to the simulated clouds in the model. Too much cloud cover reflects too much solar energy away from Earth's climate system. Too little cloud cover leads to more solar energy being absorbed by the system than is observed. The global amount of cloud cover can be adjusted or tuned by changing parameters in the cloud parameterization. Usually the cloud amount is tuned to make the model's global solar budget agree with observations. Is this an unethical practice for the modeler? It can be argued that this is acceptable, since we do not have sufficient

observations to constrain the cloud properties that are tuned. A utilitarian argument would be that tuning provides us with an acceptable model to use for looking at changes in climate, where without tuning we would have a model climate that would be in error with current observations.

Given that we have created a climate model, globally tuned it, and tested it against observations, the model can be used to understand why the climate has changed in the past, and how the climate may change in the future. The modeler is now faced with another issue. The climate system responds to changes in the concentration of greenhouse gases in the atmosphere, e.g. CO₂, changes in the amount and type of particles in the atmosphere, i.e. air pollution, and changes to natural factors such as particles arising from volcanic eruptions or changes in the sun's output of energy. These factors, human made or natural, act to force the climate in a particular direction, i.e. either to warm the climate system or cool the climate system. As such, these factors are called the forcing of the climate system. In order to understand how our climate has changed in the past, or will change in the future, we need to know how the forcing factors have changed or will change.

Reconstructing the historical records of all the greenhouse gases, human generated particulates, volcanic particulates and solar variations for the past century is a challenging endeavor (e.g. Hansen et al. 1998). This is especially true for the history of human generated particulates, or air pollution. At present there is no unique reconstruction of these particles. There are also a number of volcanic and solar reconstructions for the modeler to choose from. Greenhouse gases are fairly well defined thanks to direct atmospheric measurements and ice core records, where tiny bubbles

trapped these gases through time. The climate modeler needs to choose a combination of these forcing factors that they feel best represents the record of forcing over time. A different forcing history will lead to a different temperature simulation. There is no *a priori* means to choose the 'best' forcing history. Yet, the modeler wants their model to do a credible job in simulating the past temperature record. Certainly a necessary condition for a climate model is that it reasonably reproduce the past global temperature record. The ethical issues arise when choosing the forcing factors, again does one choose factors based on the answer they produce, or the reasonableness of the forcings?

Presenting output from climate models can be a challenge to modelers. Should the modeler tailor what they show with regard to whom they are showing the results?

Climate models generate a tremendous amount of information, and this information needs to be reduced to a form that can be assimilated by a wide range of individuals. Making choices in how the information is presented raises ethical issues. Should the modeler only show the good results from the model, the results that compare well with observations? If the modeler does this, they create a false sense of how well the model can represent the world. If the modeler shows the bad results from the model, those areas where the model fails to compare well with observations, then will people generalize and judge the model as useless? Will special interest groups take the poor results and use them to argue that climate models cannot be trusted? If the modeler knows this to be the case, they may be less inclined to provide information to these people. Then, the modeler can be accused of hiding model information.

The modeler is also faced with the choice of how to present climate model results. This is true with any scientific information, but especially with information that can and

will be used by various sectors of society: the media, the government, and the private sector. The modeler can create images that focus ones attention on a dramatic change in a specific area. They can create images that downplay a model deficiency in a certain area. There is clearly a subjective element to all of this. The modeler has to establish a code of ethic around how to display information from their model. They have to create images that provide a ‘value neutral’ picture of model simulations. Of course this is impossible. The modeler’s value system is bound to enter at some point in the process. One could argue that aspects of the modeler’s value system actually enhances the quality of the presentation, for it is based on years of trial and error in how to present information to a broad audience. There is also an aesthetic aspect to this work that goes beyond the quantitative. Creating just the right image can convey a tremendous amount of information to people.

Ethics of Using Climate Model Results

Once climate model simulations have been carried out, how should the results of these simulations be treated? Clearly the scientists that developed the model and carried out the simulations should have the ability to verify the simulations were carried out correctly, i.e. there were no errors in model coding, forcing data used, etc. These scientists should also have the right to publish aspects of their simulations in the peer reviewed scientific literature. One aspect of these publications is an accurate description of the assumptions, development procedure, forcing data, etc. that was employed to make the model simulations. Modelers have been criticized for not adhering to this level of description in publications. For example, a detailed description of how a model was tuned

rarely, if ever, appears in a scientific publication. To many the process of model tuning remains a mystery. There are also no rules requiring modelers to publish both good and bad aspects of model simulations. If model output is available to the community at large, then the community can look at both aspects of a model, but not all model development centers allow open access to all model simulations.

Scientists also use climate model results to understand how the climate system works, what are the mechanisms that create the modes of variability observed in the system? What are the mechanisms that amplify small forcings into large signals? What role do the various components – atmosphere, ocean, land, biosphere, etc. – play in determining Earth’s climate? A good climate model can be a laboratory to explore the answers to these questions. The ethical issues within this realm of climate applications are similar to any scientific discipline. One does not falsify results and mislead their peers. The modeler provides information to others so that they may verify the results. Note there is a subtle difference. In many science disciplines experiments can be reproduced with a high degree of accuracy in other laboratories around the world. Climate models are not identical. The same experiment carried out with two different climate models may yield dissimilar results. The models may have different climate sensitivities, so that for the same forcing the climate response differs. So unlike the fields of physics or chemistry, for climate modeling inter-model reproducibility is not guaranteed.

The Place of Climate Models in an Ethics of Climate Change

What is the place of climate modeling within the larger context of climate change? It is important that models be placed within an appropriate context. As stated, models are representations of the world. Climate change is global in extent and involves many facets of the Earth system, physical, chemical, biological, and ecological. Climate models provide a way to synthesize much of this information. Models provide a means to interconnect the various disciplines that study global change.

Social scientists studying the effects of extreme events on social systems can connect with physical scientists who actually define and carry out the model simulations. Biologists studying the impacts of climate change on species diversity use model simulations to project how these species will be affected by shifts in climate regimes. Thus, model simulations may act as a bridge within the climate change community.

Ethical responsibilities are rich within this network of research. A need for ethics arises when communities are in relationship. Norms for engagement arise either spontaneously or through careful thought. Within the climate change arena these norms are ill defined. The connections with the modeling community have occurred on an 'as needed' basis. The danger with this approach is that people may assume too much about the information provided by others. The shadows on the walls become the ideal forms existing outside of the cave. Value is added to a simulated model feature that is incongruent with what the modelers actually wanted to provide to the user community. More emphasis needs to be placed on exploring norms of engagement within the global change community. At present there is no forum for such a discussion. There is no one

organization that exists to host such a discussion. I would suggest that the environmental ethics community is one place such a discussion could begin to take place.

Climate models play an important role in helping define our relationship with the environment. Models provide us with a tool to see our role in changing the climate system. Models provide a contextual framework for us to study the role of humans within the global environmental system. By carrying out experiments with climate models we can ask ‘what if’ questions about the future. The various scenarios for future emissions of carbon allow us to see how important our choices around energy use are to the overall climate system. More integrated models will actually be able to look at human activity as a feedback within the climate system. All of these aspects of climate modeling can help humans to better understand their role in the larger environmental system. Ultimately, we are an integrated part of the system.

Looking at the results from climate model projections forces us to face ethical issues around how we treat the environment. By studying climate model projections we are made more aware of the power humans now have within the global system. Never before have humans had the ability to alter the global climate system.

Models provide a means to see how a relatively small forcing – a few watts per meter squared – can amplify into major implications for the physical and biological processes of Earth. There is an ethical responsibility on modelers to create better ways of communicating this scientific information to the broader public. A barrier to effecting change in our uses of energy represents the lack of understanding about the climate system and how it works. It is important that the modeling community strive to find better images and narratives to convey their science to the greater community. However,

I must confess that this is not the most important barrier to affecting change in people's awareness around climate change. Issues around personal and social value systems and the connection between these values and behaviors are far more important to the issue of climate change.

Do models provide a context that enables different ways of relating to the world? Models here should not be interpreted as only the most comprehensive coupled global climate models. Models of simpler design can also lead to a better understanding of our place within the environment. The Daisyworld model developed by James Lovelock and others has provided a simple, but effective, means for considering how small forcings of the climate system are amplified or dampened by biologic processes. Similarly, so-called models of intermediate complexity allow for the incorporation of slow time scale processes, e.g. glacial processes, deep ocean mixing, so that we can look at the long range implications of increasing greenhouse gases.

Models extend our perception of time and global climate change. We need an environmental ethic that extends beyond the here and now. Earth's climate system has a memory that extends for millennia. Thus, what we do to Earth's energy balance today remains in the system for a very long time. The long time response of the system is one reason why it has taken so long for concern to grow around the global warming issue. In establishing an ethic around global change, we need to incorporate this sense of memory.

Can model simulations enhance awareness of our place in the world? Assuming an ethics of global change includes an awareness of our relationship to the environment, how can models enhance this awareness of our place in the world? I believe model simulations can play a role in raising awareness with regards to our relationship to

Earth's climate. Model simulations provide a graphic image of the whole world. As such, model simulations have the ability to stimulate our imagination around our place and role in the environment. Visualization techniques can draw one into imagining what the world is like and how we may be changing it. The fascination with computer games is based on this principle. We enter a world and become a part of it. We become involved in the evolution of the world. Through changes in parameters within a climate model, we see our relational place within our world. There is much to be explored in this area, i.e. the use of climate simulations coupled with software technology to raise awareness around global climate change.

We can think of climate models as analogous to the role the telescope played in the Copernican revolution. The invention and perfection of the telescope enable humanity to look out at new worlds and also realize our place within the universe. This was an awe inspiring event, but also a disturbing event, e.g. witness the plight of Galileo. The telescope as tool opened a new view of our place in the world. The use of technological tools to shift awareness around our relative place in the world has happened throughout history.

I believe we could argue that climate model simulations have shifted our awareness, and have the potential for continuing to shift our awareness of our place in Nature. For over a century – beginning with the work of Arrhenius – we have created models of the climate system to look at global climate change issues. These models have grown in sophistication and complexity and continue to be used to look at how we may affect Earth's future. The figures of projected rise in global temperature over this century are present in people's minds. These figures create concern and also a feeling of despair.

These effects clearly show the power of model simulations to stimulate reflection and concern about our role in Earth's climate. A greater challenge is to better understand how climate models can create more awareness around our interdependency within Nature and how changes in our behavior can change the feelings of despair into ones of creative and imaginative solutions to the problem of global warming.

Climate Modeling and Cassandra

A grand goal of climate modeling is to create a model so good that it can realistically simulate Earth's climate in virtually every aspect. Assume for a moment that climate modelers finally achieved this goal. They finally created a model that could realistically simulate all aspects of Earth's climate system. The model could simulate the regional changes of temperature, precipitation, vegetation, carbon uptake, ocean circulation, etc. The model could be run for the past century and capture all of these features. It could even simulate climates of the distant past. Assume that this was achieved not by tuning, or adding unrealistic physics, but was achieved by including the best science into the model. This would be a monumental accomplishment. The Holy Grail of modeling would exist, the perfect prediction tool for understanding Earth's climate. Imagine that a giant computer was made available for climate predictions, and that our best scenario for energy use was made available to the modelers. They could then carry out a prediction of what Earth's climate would be at any time for any region in centuries to come. They could with great certainty tell the peoples of the world what the future would be like.

Would the world listen to the modelers? Would these predictions have an impact on human behavior? This is a question worth asking, for many scientists are expending a lot of energy in trying to build such a model? I am reminded of the myth of Cassandra. Cassandra was a woman who was tutored by Apollo, god of knowledge, arts and prophecy. Apollo fell in love with Cassandra, but she did not reciprocate his love. In his anger the god cursed Cassandra. He gave her the gift of perfect foresight, but added the condition that no one would believe her predictions of the future. Would the perfect model predictions suffer the same fate? Would people believe the model predictions? Would they use the model simulations to alter their behavior?

If ethics is about our place in Nature, then how can climate modeling *displace* our relationship to the environment? Ethics is also about considering places of shadow. Where is the shadow of modeling? Following prediction is control. If we can predict how Nature will respond to actions made to it, then perhaps we can control the direction that Nature follows. We can control the climate system by applying the appropriate forcings to the system.

This idea of controlling Nature is not new. The history of technology is full of examples of how humans developed techniques to locally control their environment. Our use of fossil fuels is now inadvertently controlling the climate system. Geoengineering proposes to use technology to regulate the global climate system. Many of the proposals are quite lofty, such as surrounding Earth with reflective mirrors to regulate the amount of solar energy reaching the planet. Others involve injection of sulfur into the stratosphere to mimic volcanic aerosols that reflect solar energy to space. Some propose to modify marine biological activity to increase uptake of carbon into the oceans. Some

of these ideas to control Nature are being tested in climate models. There is an implicit assumption in this approach, which is that the models contain all of the necessary processes – feedbacks – to accurately predict how the climate can be controlled.

What is the ethical dimension of using climate models in this way? Climate modelers need to show responsibility when it comes to applying models to control the environment. I am not suggesting that modelers be prohibited from carrying out thought experiments on geoengineering. I am suggesting that modelers be very careful in stating the limitations of their experiments. The problem is even with this level of care, results from these experiments can still be used to argue for certain forms of geoengineering.

Conclusion

I have explored the ethics of climate modeling by considering the stages of model development, simulations and application to future climate change. What has guided my exploration is how ethics relates to character and place. I have argued that climate modelers are faced with important ethical questions in all aspects of their work. Little formal discussion has taken place on the topic of ethics and climate modeling. Especially needed is an ethics among those using climate model simulations for their research. I hope the questions I have explored will stimulate further dialogue on these issues.

I have also explored how climate models change our awareness with regards to our place within Nature. Model experiments provide a context for how sensitive Earth's climate is to what we do. Our values and behaviors force the climate system to respond in dramatic ways. As such, climate models provide a means for us to better understand our integral relationship with the environment. What may arise from this understanding is an

ethics of care for the environment. At this point in our history we are in desperate need of an ethics of care. Climate models have a role to play in effecting such an ethics, I hope modelers explore this dimension of their vocation, and can find new ways to relay the importance of their work to the greater public.

References

Liddell and Scott, 1989: An Intermediate Greek-English Lexicon, Oxford University Press.