(THIS IS A DRAFT)
Minutes

LEGISLATIVE COMMISSION ON GLOBAL CLIMATE CHANGE

Tuesday 7 March 2006
10:00 a.m.
Room 643 Legislative Office Building

The Legislative Commission on Global Climate Change convened its second meeting on Tuesday 7 March 2006 at 10:00 a.m. in Room 643 of the Legislative Office Building with Mr. John Garrou, Co-Chair, presiding. Other members present were: Representative Joe Hackney, Co-Chair, Senator Charlie Albertson, Senator Janet Cowell, Senator Robert Pittenger, Representative Becky Carney, Representative Pricey Harrison; Representative Alice Underhill; Representative Winkie Wilkins, Mr. Thomas , Dr. Douglas Crawford-Brown, Mr. Walter Clark, Dr. Dolores Eggers, Dr. Edward Erickson, Mr. Barry Eveland, Dr. George Everett, Mr. Robert J. Glaser, Mr. Preston Howard, Mr. Michael Nelson, Mr. Mitchell Peele, Dr. Daniel Phaneuf, Dr. Sethu Raman, Dr. Stanley Riggs, Mr. Michael Shore, Mr. Robert Slocum, Dr. Stephen Smith, Mr. James Stephenson, Mr. Tim Toben, Mr. Ivan Urlaub, Ms. Susan Tompkins, and Dr. Godfrey Uzochukwu. Absent were Representative Wilma Sherrill, Ms. Caroline Choi, and Mr. Tom Profeta.

A copy of the meeting notice for this meeting, a copy of the agenda and the visitor's registration are attached to these minutes as **Exhibits A, B, and C**.

Mr. Garrou called the meeting to order and welcomed everyone to the second meeting of the Commission of Global Climate Change. He thought the first meeting was useful and educational and hopes everyone did too. He and Representative Hackney agree to waive opening remarks so he called on Mr. Givens to talk about our agenda for today.

Mr. Givens thanked the co-chair, greeted the members and visitors and gave a few brief items. First of all, two members of the Commission have advised me in advance they could not attend, Ms. Choi from Progress Energy and Mr. Profeta from Duke University. If you will let us know when you will be absent we will make every effort to collect materials for you and see that you get them at a later meeting.

A number of materials have been distributed, which I will note for the record, Senator Pittenger distributed two items, one on his letterhead and a folder capturing John Locke Foundation. These items are attached to these minutes as **Exhibits D and E**. We have a newspaper article reprinted which someone had distributed. The newspaper printing is from Dr. William Schlesinger who was one of our presenters at our last meeting (**Exhibit F**). We have a publication called North Carolina Coastal Federation Coast Report that was submitted by Commissioner Jim Stephenson (**Exhibit G**). You also have a sheet of information by our first presenter Dr. Robert Balling (**Exhibit H**). Our agenda today will focus again on the questions of science and also the update on the parallel process

undertaken by the Division Air Quality and the Department of Environment and Natural Resources, the Climate Action Plan Advisory Group.

Our four science speakers today are Dr. Robert Balling, he appears at the request of Senator Robert Pittenger. He is from Arizona State University. Dr. Stanley Riggs is a member of the Commission. He volunteered to present. He is a Distinguished Research Professor in the Department of Geology at East Carolina University. His specialty is sea level rise. Robert Jackson who is from Duke University is Professor of Biology and Professor of Environmental Science at the Nicholas School; and Dr. Sethu Raman a member of the Commission is the State Climatologist. There is adequate time for discussion among the members and I am sure you will take advantage of it.

We asked each of you to submit a brief one paragraph biographical statement. For legislative members, we can make one for you based on information we have but for other members we would appreciate it if you would do so. You are reminded to submit your reimbursement forms and remind visitors in the back to sign the attendance list. We will be happy to answer any questions.

Please note that we have scheduled two additional meetings, Tuesday 4 April and Tuesday 25 April in this building. The 4 April meeting will be downstairs in the Finance Committee Room 544 and the 25 April meeting will be back in this room. This is on the back of your agenda so that you will have a copy of it. Have not announced a meeting time, but I think we will continue meeting at 10:00 a.m. Mr. Givens thanked the chairman.

Mr. Garrou called on Professor Balling to present. Mr. Garrou asked Professor Balling if he preferred questions to be asked at the end or if he minded being interrupted. Professor Balling preferred to have questions at the end of his presentation.

Mr. Balling thanked the Commission for having him and started off with a graph that is seen throughout the climate change literature. The slides are attached as **Exhibit I**. It shows the build-up of carbon dioxide over the past 100 years in the atmosphere. It tells an interesting story, and obviously it shows that carbon dioxide levels continue upward. But I remind you, that international bodies have been meeting for more than 15 years to try to slow down the increase in the concentration of greenhouse gases and the reward for all the effort to date, has been the largest increase in CO_2 that occurred in 2005. So, no doubt about it, CO_2 is increasing and I am sure you are aware there is equally no doubt about it that there are other greenhouse gases that contribute to warming of planet earth. These are also gases that human activities are putting into the atmosphere. They act to trap heat energy that would otherwise escape into space. They are all part of the mix of greenhouse gases that one must deal with in this debate. This is not news. I am here to tell you that the greenhouse effect is real. We've known about this for over 100 years. We can do calculations here to show that concentrations of greenhouse gases warm the earth otherwise the earth would be uninhabitable. And I could also show you that if concentrations of greenhouse gases were to rise and all else were to be held equal we would have the planetary temperature of the earth go up.

I am not here to tell you that there is some problem with the theory of the greenhouse effect. I'm also fully aware that models are run throughout the world and the models tell us about the same story. Whether it's a fairly simple model run at my university or very sophisticated models run in Colorado, when carbon dioxide levels doubled there is no doubt that the earth warms, there is no doubt that the bulk of the warming occurs in the high latitudes, occurs at night, occurs at winter, occurs over land. This is seen over and over. North Carolina is not particularly ground zero in the warming of the world but none-the-less, North Carolina is projected to undergo warming as the concentration of greenhouse gases increases.

However, were we to go over to the library and look at the articles that are published that described the numerical models of climate on which this castrophy is based, we would find out that there are enormous uncertainties with the way the models handle clouds and rain and water balance and ocean currents and the way that handle certain energy transfers in the atmosphere and the way they handle biology and the way they handle ice, and the list goes on and on. And you would come away from the library experience fully aware that the numerical models upon the prediction is based are highly uncertain. None-the-less they are wonderful achievements in computing and demonstration of understanding of atmospheric processes and it's a prediction of warming that we cannot take lightly. These models are not that bad and they do predict warming in the future.

It's only lightly that you go out and see what was happening. And if you were to assemble the temperature record from throughout the world you get this well known and well understood in many ways presentation of the temperature of the earth. And it shows that the temperature is going up. As I look up there I see the temperature from about 1975 onward marching upward. We've heard over and over that the temperature of the earth is increasing. I am here to tell you the temperature is increasing. There is no doubt about this in the scientific community. Since a little doubt in the scientific community that at the present time, meaning over the past three decades, the temperature of the earth has been going upward.

Up until about 1975 or so it seems that we knew why. It was often pointed out that we were recovering from the little ice age. And that the planetary temperature was on the rise and it was also known that the solar output was increasing. And it appears in looking at the professional literature that up until about 1975 or 1980 the increase in solar output seemed to well explain the increase in planetary temperature. But as you will note in the diagram the solar output has not been increasing in the most recent 15 or so years and yet the temperature of the earth has continued to rise.

This brings us to the big question of why the temperature of the earth is going up when the solar output is not going up and its made it fashionable to conclude that human activities are contributing to some extent to the buildup of the planetary temperature. If you were to break down where the temperature is increasing, you would find a lot of the increase is occurring in the high latitudes at night in the winter, etc. So I, among with all other scientists, agree that there is an anthropogenic signal in the record. We don't know

if it completely explains the warming of the most recent 25 years but it certainly would contribute to the warming. And before you sit here and think well this is the most unprecedented warming that we've ever seen, I would call your attention to the same diagram and look back at 1910 to1940. The recent warming was basically replicated once before in the historical record. We are recovering from the little ice age we would expect warming to occur. I'm not sure the warming would not have occurred if no human had ever walked the earth over the past 100 years. And for at least a 15 or so year period we talked a lot on the global warming circuit about the satellite record. And the satellite record has shown here also it indicates that over the past 25/26 years that warming has occurred. Warming accentuated a bit by having a large El Niño late in the record. None-the-less the satellite record today does show that the temperature of the earth is warmer today than it was back in 1978 when the record begin. So we have compelling evidence that the temperature of the earth is on the up rise and has been on the rise for the past 2/3 decades.

So what's the debate I guess? The debate comes around when you start to place the warming in the context of what has occurred over the past 1000 years. This plot shows what has happened to the Northern Hemispheric temperature over the last 12,000 years. I think most of us would agree that thankfully we pulled out of the last glaciation about 12,000 years ago and the temperature of the earth rather rapidly increased to bring us into this rather pleasant inner glacial. And as I look at this plot, I see that over the past 10,000 years the temperature of the earth has produced various climate optima. We've had many small ice ages, we've had many climate optima and if we look up here at the last 1,000 years we see that doing the medieval warm period the temperature of the earth may have been as warm as the temperature of the Northern Hemisphere is today. We see that there was a recognizable little ice age that was well documented in the professional literature and for about 400 years humans had to cope with this little ice age. And fortunately for you and for me, about 130 years the earth rebounded from the little ice age to bring us the warm period that we enjoy today.

When I look at this diagram I see nothing unusual about the warming of the most recent 30 years. Seems to have been replicated many times during the inner glacial and from a diagram like this, one could make a credible augment that there may not be such a strong link between carbon dioxide concentrations and the warming signals seen in the northern hemisphere. But as you've seen, there are others who don't buy into the diagram that you just saw. There is a wildly juicy story in climatology about the construction of this hockey stick curve, which does make the most recent warming look highly unusual. I notice here that the medieval warm period of the Northern Hemisphere all but disappears through the ice age, all but disappears and suddenly we are left with this tremendous warm up during the period of industrialization and during a period when the carbon dioxide levels of the atmosphere rose exponentially. This diagram looks alarming, very popular with the IPCC. But all I can tell you is our same trip to the science library would revealed some interesting details about miss-calculations in constructing the diagram, it also would reveal some interesting personal stories to say the least.

Now I know in your state, you might be concerned obviously, that global warming could somehow enhance the strength and number of hurricanes. I would like to read from IPCC – says climate models give no consistent indication whether the tropical storms will increase or decrease in frequency or intensity as climate changes. Neither is there any evidence that this has occurred over the past few decades. That was the IPCC assessment in 1990. And in 1996, IPCC which I am somewhat an active member, says in conclusion it is not possible to say whether the frequency, area of occurrence, time of occurrence, mean intensity or maximum intensity of tropical cyclones will change. It's hardly a ringing endorsement to gear up for more hurricanes or more intense hurricanes in your state. And in the 2001 assessment, we see changes globally and tropical and extra tropical storm intensity and frequency are dominated by inner decadal and multi-decadal variations with no, and that's a gigantic word in IPCC, no significant trend evident over the 20th century.

You could have no end to speakers come here who are among the best hurricane scientist in the world, and they would decouple any idea that there is some link between elevated CO_2 and hurricane activity. Others continue to say that there are all sorts of problems with severe storms. IPCC is fairly clear on this. They say no systematic changes in the frequency of tornado, thunder days or hail events are evident in the limited areas analyzed.

Once again, this is hardly some ringing endorsement for the idea that we are about to face an immediate future of severe weather, elevated climate variability that has not been the conclusion of the IPCC. Your state also will confront the problem of sea-level rise and looking at the scientific literature on sea level rise, I can announce to you today that the sea level is rising. The sea level is rising at approximately 1.8 milliliters per year. The problem is it has been doing this for 8,000 years and it's been consistently moving along here after the end of the last ice age. The sea level has been rising and as Church et al. noted, it says "decadal variability in sea level is observed, but to date there is no detectable secular increase in the rate of sea level rise over the period 1950 – 2000". I would agree the sea level is rising but there is no evidence that there has been some increase in sea level rise.

I will end with this one, this is the most damaging in some way, graphic in the greenhouse debate. What this shows, in the top part of the yellow curve and this comes from IPCC and elsewhere, is the business as usual prediction of what would happen if we did absolutely nothing. We did nothing, China did nothing, Australia does nothing and its noted on the top of the yellow bar the temperature of the earth would continue to rise in our life times and achieve some of around one degree increase by the years 2050. That's fair enough. We can argue that number all day. What's interesting here is what would happen had we in 1990 stabilized the emission of greenhouse gases? That's what Kyotos is all about. Its let get the globe back to the 1990 levels of CO_2 emission. If you go back to 1990 levels of emissions, and stabilize 1990 what do you think happens? The atmosphere continues to see a build up of carbon dioxide and you follow along the bottom of the blue bar. Stabilizing emission in 1990 would have little effect what-so-ever on the climate system. There's the top of the blue bar and the top of the blue bar is

what would have happened had you walked out of Keota in December of 1997 waved a magic wan and stabilized the emission until 1990 levels. And as you note, darn blue bar goes up pretty high, gets up pretty close to where you would get anyway. Well we're not even close to stabilizing emissions of CO_2, you may know that the United States is 13, 14, or 15 percent above 1990 levels. We're nowhere near the target of seven percent below 1990 levels. And the rest of the world has a similar story to tell. So if you were to go out today and draw this, and say maybe the North Carolina Commission can somehow get Australia on board, get these European nations to suddenly start showing a decline in CO_2 emissions, get the United States on board, get Canada back on the tracks, get India and Pakistan and China to slow up a bit, I have bad news for you. That if you were to run the plot out here, you would find out that you would save no more than one hundredth to two hundredth of a degree. That's if you can get the whole globe involved, let alone just the state of North Carolina.

I know that Al Gore has a new book coming out, it's called "The Inconvenient Truth" and I just have a funny feeling this diagram is not the inconvenient truth that he'll be talking about throughout that book. And yet it is an inconvenient truth for a group like yours. I mean it's very difficult to see what you can do that will ever have any impact on the global climate system or the levels of CO_2 in the atmosphere.

I wish you luck. I've been called the greenhouse skeptic throughout my career and I must tell you that I am skeptical much could be done in North Carolina to impact the carbon dioxide levels of the atmosphere. Thank you very much.

Mr. Garrou – Thank you. Questions?

Mr. Cecich – Could I ask you to the separate the two thoughts here: first, the question of the rise of carbon dioxide in the atmosphere associated with human activity and help us understand that science and as opposed to the second part that says we in North Carolina can't really do anything that would change the build up of greenhouse gases. One is the science, which I am not sure I understood completely. You say you do agree that the increase in CO_2 is unique to this current period geologically and it is associated with human activity.

Dr. Balling – Let me answer that one. There is absolutely no one that I know of with any credibility who doesn't believe that the increase in CO_2 has been caused by human activities. You can do the calculation of how much coal China burns every year and you can do the calculation of fossil fuel consumption in the US and you can get a fair notion of how much carbon is going into the atmosphere. And there are carbon budget scientists throughout the world who are able to indicate what the residual amount might become in the atmosphere. And I know very few people who don't believe that the build-up of CO_2 is caused by human activities.

Mr. Cecich – So it is caused by human activities?

Dr. Balling – I don't think there's any question about it.

Mr. Cecich – So then, should it not be a concern to us as a society, regardless of the questions whether we do anything about it in North Carolina to effect a change. As a society, should we be equally concerned about it?

Dr. Balling – Obviously somebody is changing the atmospheric chemistry on a global scale. We should be looking into the issue what will this mean? I can't imagine how much more concern we could have. Our government is spending billions of dollars per year to show concern, do research, and find out what it will mean to the planet earth to have higher levels of CO_2? So I would argue that we're plenty concerned and that the United States and other countries of the world have made an enormous commitment in research to find out what this means. The UN has made a phenomenal commitment to assess the science of what will happen as CO_2 levels continue to rise. So of course it's a concern. I mean there are individuals who lose sleep over this and there are other people who think it's glorious that the carbon dioxide levels of the atmosphere are increasing.

Mr. Cecich – You argue that it is such a global issue, there is no sense in trying to make a change at the state level.

Dr. Balling – With all respect, you could announce today that North Carolina is about to vanish from the face of the earth and it would not show up on this diagram. Or you could announce tomorrow that we're going to buy every one in North Carolina their own SUV and have everyone double their amount of coal burning to produce water and it just doesn't show up on the diagram. The problem is trying to deal with such a global issue. We're looking at a state group and it just seems like anything you come up with will be dwarfed within minutes by the emission of CO_2 from places like China.

Dr. Smith - A couple of quick questions. Being a student of science, I know that in the scientific profession there are a number of different opinions and people tend to banter back and forth looking at things. I've got a couple of questions here, but first, how you reconcile your position with the fact that the vast majority of scientist have come together and basically say not only is obviously there is a concernable finger print on this but there is a growing number of those scientists that are becoming concerned and encouraging action. How do you reconcile your sort of out liar position there?

Dr. Balling – I don't see my position as out liar at all. There is nothing I said today that I didn't take basically from the IPCC report. I wasn't out here bringing in material from web pages almost everything I have would be from the mainstream literature. I told you today that I also think that there is a finger print and I would agree that there are scientists one after another who would say let's do something, let's do something, we only have just one planet let's do something. And so often, you say what do you want to do, the answer seems to be let's conduct research. Not a bad idea if you're scientists in my position to argue that we need to fund more research right now. So I like everyone else show concern argue that more research should be funded but by no means do I lay in bed tonight believing that by riding my bicycle to school every day, I'm helping to fight global warming.

Dr. Smith - And so along a similar track you made reference to the fact that you felt like state actions really don't matter. My experience in environmental policy is that states tend to aggregate together and nations do, there are a number of states that are obviously beginning to take action across the United States. And it just happens to be this current administration has not adopted a policy yet. But there is movement and ultimately when action is taken it's going to come back to the state and local level where those actions are going to become manifest and taken. So I guess I'm trying to understand the national government obviously needs to be a part of it but wouldn't you think that if you want to get an inflection point, that you would actually see the need for activity to be taking place at the state and local levels because indeed these are the laboratories of democracy and this is really where the rubber meets the road, where most action takes place. I just want to clarify, are you saying that you don't think that any states anywhere should take any action on this as the consensus continues to build that we need to get an inflection point in our missions and stabilize the climate, or do you feel that it's only for national governments to do?

Dr. Balling – Wow, you ask many things there. One you mentioned that this administration has really not done much so far in climate change. I remind you that previous administration had three years to present this Kyoto protocol to the senate and they never did. I remind you that John Kerry ran for president and never said one word about the Kyoto protocol and what he would do. So it's a little unfair to say one administration or another. I never saw this as political at all. Then you say you think the rubber is going to meet the road at the state level. I agree and it's at the state level where people might begin to question you and say well what is this costing me and what are we gaining by doing it? And if the state implements some policy that begins to cost the tax payer any amount of money, the tax payers are going to demand to know then what is it I get for this investment and when I stand up and tell them the answer is absolutely nothing, the rubber will hit the road and it will be at the state level.

Dr. Smith - Thank you.

Dr. Balling – You're welcome.

Mr. Garrou – Other questions?

Mr. Glasser - Dr. Balling I am from the scientific community and I appreciate your being with us today.

Dr. Balling – Thank you.

Mr. Erickson - Is it my impression that what you're saying is that regardless of what we in North Carolina do and what we do as a business community that the temperature over the next 50 – 100 years, regardless of what we put in place will not change? And secondly, I ask, is the chart that we have in front of us widely accepted in the scientific community?

Dr. Balling – I am not sure that there is nothing that North Carolina can do to make global temperature stabilize. Let's face it, the United States is only 1.54% of the earth's surface. North Carolina becomes a small part of that, the total emissions from North Carolina globally is not particularly large. And with you beginning to fiddle around with the emission levels, it would never be measured out in Hawaii where the measure of carbon dioxide is made. I believe you're absolutely correct in assumption that what happens in North Carolina is not going to have an impact on global carbon dioxide concentrations, of course. The other thing you asked about this diagram is it widely accepted in the scientific community? There are many versions of this. And some are harder to read than others. Some are more stylized than others. But if you were to go to the IPCC reports that make it painfully clear that if we want to stabilize the concentration of carbon dioxide in the atmosphere, we're going to see the need to have a massive reduction in carbon dioxide emissions worldwide. Emission of carbon dioxide is not the same as concentration. You could stabilize the emission, you would still put carbon into the atmosphere and it would still buildup and we would still achieve a doubling in the middle of this century. So I look at that diagram, and I don't know how many folks would argue that it is inaccurate, it's stylized for sure, but you would find many versions of it in the IPCC report, some easier, some harder to read. Even Jim Hanson's now saying, if we adopted the Kyoto protocol for full participation, we would still see only a few hundredths of a degree spared over the next 50 years. There might be a few argue the next 100 years when you start to see more benefit of course.

Mr. Glasser - Mr. Chairman. Follow-up? Mr. Balling if you were to take that out for another 50 years would it spike up or would it continue to run a straight line?

Dr. Balling – There would be no reason to expect it to spike up. But when you start to talk about over the next 100 years, there are all sorts of surprises out there over the next 100 years. I imagine somebody in the 1900s thinking about what North Carolina would be like in 2006. The person might be a little shocked at what happened so I think a lot of climate scientists are reluctant to go past 50 – 100 years out. But there are a few that are starting to say, look if we continue to burn fossil fuels for 200 and 300 years, that this could so dramatically change atmospheric chemistry that we could expect to melt the ice sheets and all sorts of horrible things could happen. But the overwhelming literature still deals with what happens given a doubling of carbon dioxide which will occur sometime within the next 50 or so years.

Mr. Garrou – Thank you very much. One more question.

Mr. Erickson – I've got two questions, one is just a quick summary of what you said. I am an economist and I think about cost and benefits and my take on what you said is that for North Carolina to do anything significant in terms of what happens here, it would be all cost and no benefit?

Dr. Balling – Yes, I once wrote that it would be an infinitely indefensible position. That if you are interested in cost benefits, the instant you tell me their cost and you can see effectively there is not benefit, well of course there could be benefits of having

technology that cleaner. I mean North Carolina could benefit 1000 ways from great ideas of the group, but to sell the idea that you're fighting global warming becomes absurd.

Mr. Erickson – And secondly, you didn't touch on it, but are there any benefits to an increased concentration of carbon dioxide in the earth's atmosphere?

Dr. Balling – Well sir, there are thousands of articles that have been published about the biological benefits of elevated CO_2. And obviously, plants evolved in a world with much higher CO_2 and I have one colleague who says, we're sending the Topeka system home again. They would actually prefer to be in a higher CO_2. This issue seems too good to be true at first, it seems the plants grow bigger, they are more water use efficient, they are more resistant to drought, they can say that they are less susceptible to stress of the ozone and sulfur dioxide, just sounds wonderful. I am fully aware of people, including people in this room, who published reports, well before you think it's all good, there are weeds that also like higher CO_2 levels and there are other kinds of plants that you may not want that have higher levels of CO_2. But I think most would agree that the plants of the world do very well with having higher levels of CO_2. In terms of your breathing carbon dioxide you can relax, and even if we took CO_2 into the thousandth of parts per million, which is probably going to be achieved in this room today, but there is no harm to humans who might breath that air.

Mr. Erickson – Thank you.

Mr. Garrou – Thank you very much sir.

Dr. Balling – Thank you.

Mr. Garrou – Our next speaker is Dr. Riggs from East Carolina University. And I'll ask you the same question Dr. Riggs would you rather wait until the end for questions.

Dr. Riggs – Yes.

Mr. Garrou – OK.

Dr. Riggs – As a coastal geologist, we look at modern dynamics, modern processes to understand what's happening today and we look backwards to get a history of where the earth has been (Abstract, **Exhibit I**). In the state of North Carolina we have a very incredible record of climate change and sea level change through time that we've been able to take apart. I'm going to talk a little bit about climate change and sea level change and storm dynamics. I'm going to summarize a lot of data, a lot of information and I'm going to deal with it at several different scales. I'm going to start at the very big scale and we've going to zoom down to the very small scale that the first speaker was talking about. At the end of the talk, I'm going to come back to the cost to society and to our North Carolina economy of doing nothing in response to these ongoing changes. To me the real question and the important question that we should be asking is, how does climate change affect what's going on? It's not what's causing the climate change, it's

the important questions. We can't stop the climate change but we can do something about it. The impact of climate change can be very dramatic and particularly in down east North Carolina were we're dealing with counties of land that are only a foot or two above sea level. The changes are pretty dramatic so what I'm going to do is take you on a little tour of our database. Our database is very big, we don't deal a lot with models, we deal with the earth and the samples from the earth. I co-directed this program called The North Carolina Coastal Geology Cooperative. It's a US geological survey funded program. We have 40 different scientists working on this, 20 of them at East Carolina University, the other 20 are scattered from the University of Pennsylvania, University of Delaware, VIMS, the North Carolina Geological Survey. It's a big cooperative system. We're in our sixth year of dissecting coastal North Carolina and the results of this are pretty intriguing and pretty important to the state and to the future of this.

And this is a Time cover magazine from 2001 that talks about global warming. In my opinion, global warming is just half the equation. We have to add global cooling in there like any coin, bad penny or otherwise what we're looking at are two sides of the issue and global cooling is equally as important hearing this. Now if we look at the history of the earth, most of the earth's history of its 4.6 billion years has been very warm, much warmer than it is today. If we go back, this particular plot shows a time back to 65 million years on this axis up today on this axis, the history of the earth is mostly warm. We've had four major glacial episodes during the 4.6 billion years that we've had a record of the existence of the earth. I'm not going to talk about the earlier ones. I've spent some portion of my life chasing some of these around the globe. They're very major systems, but when they happen, they're pretty dramatic and traumatic to the earth's system. We're coming back out from about 60 million years ago on this particular one. We've got nice warm conditions, hot house conditions and about 25 million years ago the climate starts to fluctuate and we begin to develop Southern Hemisphere glaciation about 25 million years ago. And it oscillates around the world's ocean went sort of crazy through this period of time and we get up here to about 1.8 million years ago and we begin to develop, the climate goes really funny at this point and time and we go in the Northern Hemisphere glaciation. Now both poles glaciated and we go into a series of temperature fluctuations that range from about 16 degree up here. The average global temperature down to about 10 degrees average global temperature and the ice and the climate oscillated back and forth through here between 10 and 20 times in the last 1.8 million years. Now this is a close up that this is the last million years of that time. This is a million years ago. And you say ok you're not interested in a million years of time. But whether we like it or not, humans were not around during those first three glacial episodes, they haven't been around in a major component for the last million years. We did have people on the earth at the point of one million years ago. But what we're dealing with today as a modern population of people till we get all the way up here. Here's zero, that line right there represents ten thousand years ago in red are the interglacial episodes, in blue are the glacial episodes. These are the cold climates, these are the warm climates, and the climate change as we went from one million years ago from warm to cold, to warm to cold, to warm to cold, warm-cold, bah, bah, bah all the way down through here and the ones we're going to focus on are these right here. I'm just going to make a simple reference to this one. But this is the last glacial maximum

when the earth was cold, which happened 18 to 20 thousand years ago. This is ten thousand years ago when we reached our approximate temperature of what the earth is today. So let's zero in on that, this is what the earth looked like 18 to 20 thousand years ago when we had glacial ice covering the northern half of North America, covered a good share of Europe, and a very large portion of Asia. The only source of this much fresh water which is up to two miles thick, is out of the world's oceans. It is evaporated out of the oceans and accumulates on land. It takes a very different climate condition to do that than we have existing today. In order to get that much water up here on land we have to get it out of the ocean.

This was the shoreline 18 thousand years ago. It's a global shoreline, we can go all the way around the world, we can find it, we can find coral reefs at that level. If you go deep sea fishing you may fish on one of those coral reefs. There's ledges eroded in the continental slope of North Carolina here where that shoreline existed. If you were living in North Carolina at this particular time, 18-20 thousand years ago, you would have had to go about, depending on Cape Hatteras, 15 miles seaward off of Wilmington, North Carolina. You would have had to go 60 miles seaward if you wanted to go fishing, swimming or anything else at the Coast.

Sea level dropped approximately 400-425 feet below where it is today to get that much water tide up on the continent. As the climate began to change, starting about 16-18 thousand years ago it started to warm, the glacier started to melt, recede and water flowed back into the ocean and sea levels started to rise, came up across the continental shelf to where it is today, which is the brown line. We still have a lot of ice left in Antarctica and Greenland. If we were to melt all that ice right now, the shoreline would be about where I-95 is today. And in fact, that is the origin of our Coastal Plain. The ocean has been back and forth across the Coastal Plain many, many times in history, the soils, the topography, the river drainage basins, the Barrier Islands, the estuaries are all a product of this glaciation/deglaciation, massive changes in the sea ice. Now as the climate changes, this glacial environment here is pretty harsh and we end up with a tunder environment that comes way down – all these climatic belts condense and migrate southward. And so in North Carolina when we core out, when we have thousands of cores out here, the basal cores that we get when we're looking at the glacial maximum sediments we find spruce and fir trees. Trees that today live in the Barrio Forest of Maine and Canada. They migrated this far south, all the pollen records show this and in fact, North Carolina would not have been a pretty place to be at the time of the maximum glacier. It was very cold, very nasty, it was semi-arid, and we had massive storms that came through. Two, three, four storms a year, that would dump anywhere from 25-50 inches of rain in an event to build a river system that doesn't exist today. The rivers exist but they were very big braided streams, the kind that you find in tunder conditions and desert conditions today. Today we are heavily vegetated, that are locked in, and it's a different, totally different climatic regime given vegetation, etc. as you well know.

Ok, 18 thousand years ago this is where the shoreline was off the edge of the slope, this is a diagrammatic figure. As we begin to change the climate, there was a general warming and as sea level rose, when we ran into a pile of sand out here, we built a Barrier Island.

We might have had an estuary behind it and then sea level rose again, we abandoned some of those out there. We did not just marsh the Barrier Islands across the continental shelf here, for reasons you will see in just a minute to where we are up there today. Now this is the old standard climate curve that's been in the literature for a long time and has been pretty well documented and re-documented. It's similar to the one that was shown by the previous speaker that goes back to 18 thousand years ago up to the present here. This is temperature along this axis, this is the average global of 15 degrees centigrade, this is the oscillation around that as we came out of the glacial maximum back here 18-16 thousand years ago. And you will notice some very major oscillations that took place here in this period of time. Some of these, and the reason I am pointing this out, is that some of these have been very dramatic. This one right here coming out of the under drias, we came out of that from almost maximum glacial conditions to almost modern conditions in several decades. And this has been documented by many people looking, not only at ice cores and sea levels data and deep sea cores and so forth. In North Carolina we have a record of this younger dryas event and we came up and flooded the system very quickly as we came around here. It got warm and then it oscillated back and forth around this sort of median level here. On the bottom axis I put the population of humans and we started back here with just a few millions of people and by the time we get up here to the industrial revolution we got about one billion people on the surface of the earth. By the time we get to the time when I was born, we have about two billion people and we are today at 6.5 billion people and growing, and with the projections to go somewhere between 7 and 9, 10 billion people. Now this is what North Carolina looked like 18 thousand years ago and I put on the outline of the Barrier Islands here just as an indicator. They did not exist at that time, but I put them on here to let you know where we are. This is Pamlico Creek, which is now Pamlico Sound. It was a drainage system, a secondary drainage system that came out here underneath the Village of Ocracoke off shore combined with the Tar River that came out here and the Neuse River that came out here under Portsmouth, they combined in here, next week we'll have a ship out here to map all this, it goes off across the continental shelf, we don't know quite where it crosses the shelf, but it goes ultimately into the Hatteras Submarine Canyon off there. This is the Roanoke River, our largest river, it came out here, the Cistacanny came down here across the continental shelf went through a canyon down into the Abyssal Plains through the Hatteras Submarine Canyon.

This drainage basis and the next drainage out here we're in the process of drawing those based on our offshore work out here. The continental shelf was coastal plain at this particular time. We have forest out there, we have peat deposits, we find oysters out there, we find land, mammals, mass (inaudible) and so forth out there that we harvest off the bottom. And of course, this is what North Carolina looks like today. So the rising sea level brought that shoreline all the way across the continental shelf to where it is today to produce this particular map.

Now we have a sea level curve that we've been developing that's based on a very extensive age dating database. This is for North Carolina. We came up, this is 10 thousand years ago, this is today and this is depth below present sea level. This is where we exist right here today. Now this is an important plot. In red are the century and

millennium scale fluctuations in the ocean levels and in blue are the decadal scales of the climate fluctuations that I'll talk about in just a minute that we know exist. It's a little harder to document the details of that because we don't have the age control, we can't age date things as fine as that. But sea level came up very fast here at first, we flooded and produced the first Barrier Islands here, and then they sort of, sea level dropped a little bit and we went up above higher than we are now, we dropped again and went up above it. We have a sequence of building of these Barrier Islands.

Now if we zero in on the last eight hundred years of sea level change, this is the little ice age come along here, same event that the previous speaker talked about, sea levels only rising at a very low rate at this point and time, it's sitting here oscillating a little bit and then by the end of the little ice age, what we call the anthroprecence, which is the beginning of the industrial revolution which took place about 1784-85 with the development of the steam engine. The earth was warming up significantly and as there is a direct correlation between the temperature of the earth and sea level. A very strong pattern because the relationship of melting of the ice and formation of the ice. And in all stages we see this, so here we have a warming period, sea level is rising fairly abruptly, 1.5 feet per 100 hundred years. You say big deal, eastern North Carolina has 5, 6, 8 counties which are all very close to sea level, Dare County, Hyde County, Tyrrell County, Pamlico County have very little land that is more than a foot, foot and a half above sea level. With a one and a half foot rise in sea level, we can see major changes out there that are taking place with every single storm event that we have.

All of North Carolina's beaches are eroding in response to this rising sea level that average rates from 3-15 feet per year, depending on where you are and some of the other variables. This happens to be at south Nags Head, if you own that cottage or house right there, you need to think about selling it. This is the rate of recession of the shoreline at south Nags Head, this is 1840, 1849 I think is the date on that to 1998 and if you look at the land lost associated with that 750 feet up here in the north to 900 feet down here in the south, you calculate it out it comes to 5-6 feet per year. Well 5-6 feet per year is misleading, first of all, I will not get into that because these are all storm driven events and it goes back 50 feet and then it might actually build up 10-20 feet and then the next storm comes up and goes back another 100 feet and so the storm impact is what drives this system.

And the storms don't only effect the Barrier Islands, we have 4000 miles of estuarine shorelines the storms come across, Pamlico Sound, Albemarle Sound, they build a tremendous storm surge back there. We took this picture of this particular shoreline in the summer of 2003 and went on the cover of a book I was producing at that time. After Hurricane Isabel went by the guy that owns this called me and said I had better get back over there and take the picture again because it wasn't the same thing. In one half hour, he stood on the bank of this thing and watched the storm surge come in, it was only an eight foot storm surge, it took about one-half hour for that storm with a storm surge up here to erode this tight clay bank and he lost 80 feet of shoreline. This red line is in line with where I took the first picture. That's his shoreline after that storm went through. And we're building a major housing development back here because the guy got tired of

losing so much land, so he thought he would pass it on to somebody from Raleigh or Ohio.

The marsh and the wetlands are eroding also at equal rates. This is false color imaginary, the red are photosynthesing plants, pines and bay trees. This is transitional vegetation and the greens in there are the marsh grasses. And this is a 1983 photograph right here. This is what that looked like at that particular time rising sea level drowns these trees. The transition zone vegetations coming in and you can just see the marsh starting. This is a picture that was taken about here and in 1983 and by 1998 you can see how far the marsh is encroached into the swamp forest. This is what it looks like today out here at the same spot. This marsh is, this is a direct response to rising sea levels and drowning of this marsh shoreline in Dare County. Now the other thing, is that we have these sites all over out there and after Isabel we went back to the site and a marsh looks like a marsh, looks like a marsh and I looked at it and I said nothing has changed here. My research assistant said you want to bet a bottle of wine, and I said yes and she proceeded to map it with her GPS and we lost 125 feet of shoreline in half an hour again in response to a very small hurricane that came across the south. Now we have 4000 miles of estuarine shoreline folks, and that's a major land lost with a minor storm.

Is global warming for real? Many natural cycles operates within the earth's heat machine, global climate change always has been and will continue to be a major part of the earth's history regardless of the human role. We've had many ice ages and many ups and downs of this system without any human influence. That's a fact, ok. There are major causes to these climate changes that include things like fluctuations and output of solar energy, the earth's orbital path around the sun, oscillates and gives us different amount of heat input, earth's testism, the movement of the plates and formation of the oceans and where the continents are at any given time and changes in the atmospheric conditions which may or may not be in part driven by humans, now that humans are on board.

Let's take a look at storms themselves and coastal dynamics. I'm going to come back to this whole business of why we should care about this and why we need to deal with this to change the focus of our questions. What is the function of a Barrier Island system? Barrier Islands and their beaches are energy absorbing sponges that have contact between the atmosphere and the ocean and the land. They are high energy systems. These systems are built by storms, they're maintained by storms, they need storms to be healthy. That's the reason they are there period. That doesn't mean we can't use them, but we had better, if we're going to use them, we had better understand some storm dynamics and sea level dynamics and things like that. And I would argue that this is not the function of a Barrier Island or a beach. And we have a lot of these in North Carolina and more coming. These in red on this particular map are the southeastern US and the Gulf Coast states which happen to be the targets of all our hurricanes. This is hurricane alley sitting in here, this is also the location of the biggest and most extensive set of Barrier Island systems in the world period. There is no place that has a Barrier Island like we have on the east coast and down in the Gulf of Mexico. These are a product of these hurricanes. That's why they're there, it's low slope, we got lots of sand, the storms come

in, they pile that sand up and build that barrier estuarine system. North Carolina alone has had 46 major hurricanes in the last 150 years. That's one per three years. But statistics don't work very well because that's not what's driving the system. It's not just every year we get the same number there are some very definite patterns and I want to talk briefly about the patterns of these storms. 2005 was an awesome storm year, we had record everything, 27 name storms, 15 hurricanes, 7 major hurricanes which are category three or higher. Only one of these affected North Carolina this year, almost every one of them came into the Gulf and that's the function of the climate set up and the weather set up at the time these things formed. I think maybe our next speaker will get into that a little bit more.

I'm going to take Katrina as an example, here. Katrina started on the hot water current here, out in what we call the Gulf Stream. And if started to build and it was headed toward North Carolina along the Gulf Stream. But there was a high pressure system here and it couldn't go that way, so it turned, went across Florida, built, built, built to a category five. Then as it came to shore, it slowed down to four as a major hurricane. And over four major hurricanes came ashore in the gulf this past year. I am going to show you the consequences. This is a category three-four storm, North Carolina hasn't had a category three or four since 1950's and 30's we had a cluster of them. We had a whole cluster in the 50's and in fact, we can work backwards and date the origin of our different Barrier Islands and to the major storm events that have happened since Europeans have been here.

This is what happened to the Barrier Islands, and when you think about Katrina from North Carolina's point of view, you need to forget about New Orleans. We don't have a big hole in the ground, New Orleans is 10 to 20 feet below sea level and it's too bad all the news focus is just on New Orleans. Mississippi and the rest of the barrier coastal system really got wiped out. This is the ocean shoreline here, it's not a Barrier Island, but there is nothing left except the trees. There is not a building left period, clean. This is what happens to the Barrier Islands.

This is Dolphin Island and you can see a few houses here, I'll show you more in just a minute. Hurricane Ivan, which was a major storm, came across and produced all these incredible tidal channels and back barrier shoal systems says it eroded the sand off the front side. This was in 2004, then Katrina came along and it completely did in the island. Now this next diagram here, this is people that are part of our project, they're mapping this using a (inaudible) system with the USGS data, where they fly the coast and they have sort of an airborne fedometer that looks at the variation and elevation. This is the most detailed piece of data I'm going to show you but it may be the most important slide I show you today. This is what the Dolphin Island looked before Hurricane Ivan and before Hurricane Katrina. This is the road, this is the ocean or the golf out here, you can see it has a little beach. This is the estuary back here. This is what it looked like after Hurricane Ivan and you can see the front row of houses is now in the surf zone, the road is buried and you can see that there are more shoals piled up on the back side here. This is what it looked like after Katrina and there aren't many houses left, there are just a couple that arrows that same house and it takes the sand off the front side and off the top

of the front side and builds the back barrier part of this system. This is what a photograph of that looked like and this takes the elevation difference from this survey and this survey and in green is the deposition and in red is erosion. Those red spots, that's where the houses were and you can see that it eroded, and deposited. If you have a rising sea level and in the island not much happens on a nice pretty summer day, you lie there on the beach and it's not going anywhere. Things don't happen on those pretty days. They happen in the storm events and they happen on the big ones. And the barriers back step during these big storms and we've watched the back step here and this is another figure from the Santa Rosa Island in Florida.

This is Hurricane Ivan and there was a geologist by the name of Stone down here that did a profile across here. And the importance of this, there is a Barrier Island, there's sea level, this is two to three meters above sea level, that's ten feet. That's pretty good elevation, you would build a house there. And what it did was the island receded this direction, took the top off of it and built it back here. What we've done is re-established the equilibrium of that Barrier Island to the new sea level event. And this is the second profile that shows the same thing. Now why is that important? That's important in North Carolina because we can look at about 75% of our coast and we can see exactly the same structures, these big (inaudible) off Dolphin Island again with a tidal channel, the big shoal systems back here on the back side that built this island about 250 years ago. They had a Katrina year that came ashore in Portsmouth and built that. We can see Pea Island, for example, we see exactly the same structure and we can see it happening because we have aerial photography and so forth in 1932, 33, 36 that shows this process happening. And most of our barriers are set by the same big storms that we've experienced in the gulf here.

Now in North Carolina, talking about storm frequency and intensity, you can do all kinds of statistics on these things and most of the statistics don't work because we only have a brief record. But there are some very definite patterns that we see. Between 93 and 2005 US mid-Atlantic Coastal reached and experienced the highest tropical storm activity in recorded history. We've had more storms here in North Carolina, we just came out of a period with 30 years with very few storms. Eleven category one and two hurricanes made land fall in North Carolina during this period. They were all small storms. Small storms are accumulative, they do a little bit of work, little bit of work. But they are sort of like a teaser, it's the big one that does the real work and we haven't had a big one since the 50's.

This particular year we only had one but what would happen if a cat. three or four hurricane like Ivan or Katrina made land fall in North Carolina coast. And the next time any of you go to the beach, I want you to think about that, a 20-30 foot storm surge coming across the Barrier Islands. This is a pattern that's real, this is what we see from the turn of the century back here up to 2000. If we plot sea surface temperature of the Gulf Stream and the Luke currents, what we see is a warm period of the ocean, a cooler period these are the surface currents, the things that feeds the hurricanes, warm period, cool period, warm period. And if we plot the hurricane patterns from that we see the cool periods as indicated here that they're exactly the same as this period and this period and

we get very few hurricanes and they don't tend not to be too big. The warmer periods where we tend to get a lot more hurricanes and we also have this cluster that goes into the gulf, we have this cluster that comes up to North Carolina. The consequence of that is this map right here which is a Noah map, billion dollar climate, weather disasters from 1980 and 2005, you see the hurricanes, the number of events in red are 16 to 20 in black are 21 to 25. All the hurricane states are in red here, I think Georgia should have been in black. But Florida and North Carolina are king here. We are the ones that catch it and we also have the best of all barriers.

Whether there are all humans in coastal dynamics, the humans play a dramatic role but I can show you all the counties have exactly the same pattern. This is a population change from about 5000 people here back in 1900 and it's just a slow, growth until we get to 1970 and then it just takes off. And we have growth rates that are 76 to 150 percent going on up here now.

But even more interesting is the pattern of hurricanes. Back here in the 30's we had a cluster of hurricanes, this is northern most North Carolina. Most of those of the 30's came in on the southern coast. But here's a very important cluster, we built a lot of our coastal system around that. In 1950 you will notice there is our category three storms, we had 1, 2, 3, 4, I can't count them. We had a whole cluster of them that came in, one year we had three in a row, just like the Gulf of Mexico. And we can date most of the big changes back to those events.

People had a big impact down here, this is a 1932 aerial photo of Kitty Hawk. This is the Highway 12 which was just paved prior to this, you can probably still smell the tar mat, fresh tar mat there. You can see an occasional house out here on the beach, but not much. Here's the old Village of Kitty Hawk, by 1999 there is not empty space in here any more. But more important, Highway 12 is now in the ocean. This is 1999, we've had a whole series of hurricanes, the rest of these houses are mostly gone. This is your DOT desperately trying to hold Highway 12 down there. This picture I took on March 31, 2003 putting in a set of sand bags, it was a house down in the surf zone. Three weeks later on April 22, this wasn't even a storm, this was just a spring tide. Took out everything and went in there and this is what's left of the highway up here you can see it's under cut and rebuilt again and we had Isabel come along and we lost the whole system again. And it's been rebuild, rebuild, rebuild. It's time to back off of that area.

Now the Outer Banks themselves, as most of our Barrier Islands used to be, is to be dominated by over washed property inlands. And this is a picture showing Pea Island, what it looks like from an airplane and what it looks like from the ground level. Now you wouldn't buy a house out here because that's not a friendly ocean out there and so what we learned back in the 30's was that if we started building a fort wall around this, we may sell this property to somebody. No locals lived out there on the beach. I may remind you that they live back in the Maritime Forest in the wide parts of the island. They go out there to fish and they use that front side but that's the highest hazard land in the world out there. Well by building this fort world, we learned all about moving sand and we were able to trap sand and we built these monster dune ridges and grass them,

from Virginia line all the way to Ocracoke. Every dune you see down there is a man made dune that's been rebuilt not once, but hundreds of times. After every storm the bulldozers are down there pushing sand as fast as we can. And DOT after some of these storms will have 20/30 bulldozers out there putting sand back. Now if you go over the top of this dune ridge, what you see on the other side is a (inaudible) dune with a next high tide. These are out of equilibrium, they do not stop shoreline recession at all and they're out of equilibrium and they erode as fast as you push it up there in response to storms.

Here's an aerial photo coming out of Avon, Highway 12, the initial Highway 12 came out to here, it went to sea, so they moved it back here. Every curve in the road out there is a move of the highway. It used to come down here, this is Highway #2 and then a storm took it out and it moved it back here Highway #3 and you can see there is double dune ridge now because we are trying desperately to save it by 1999. We had little Hurricane Dennis and here comes Highway 3 out here, it went to sea and we moved it back here now this road is back here to point where you can spit into the Pamlico Sound. There is no place to move that road any longer.

I'm going to say a few words about inlets here because we have developed a bad habit of filling these inlets to try to hold on. In 2003 our project did a big study in this area because this was our #1 site for future inlets. We ran sand mix in here, we drilled in here, we got instruments in there right now to measure what's happening to the fluid dynamics and the sand. And two months later we had a little storm called Isabel that blew an inlet exactly through where we had projected, particular inland. It was a nice experiment, but it was very costly for the state of North Carolina and for the people that lived out there.

This is the 1860 shoreline and you can see that it's receded over an island's width since 1860. The average rate of erosion is seven feet per year, but again it goes in storms. And by building this dune ridge and by putting that sand back there and closing that inlet, what we've done is stop the movement of sand across the island by natural dynamics through over washing inlets. That area needed an inlet to build a flood type delta back there. That needed it more than any place else and when you blow that hole open you can see in a matter of days, you can see the sand starting to accumulate back here as a flood type delta. Had we let that build for a few months back here, this island would have had a whole new rebirth and would have had another several hundred years in its history because we would have given it a back that it could move on to. That is the evolutionary process here. By filling that this was a severe economic problem here. There were other options, the science was never on the table, the decision was made politically to close this down and get the economy going back, which was important. But it's also important for the long term health of these barriers, to let that inlet go. We did close it down, we closed it in five weeks if I remember right at $5-6 million dollars, something like that, but it's a band aid. This is still the top #1 priority for an inlet. The next storm that comes across, it will blow that out again. We did not solve anything except putting that road back there and getting Hatteras Village back in business. But from the long term business of rising sea level, we didn't solve anything. And there's 84%, we produced as inlet vulnerability index and everything in red, green and blue, has

been and will be an inlet many times in the past and will be in the future depending on the storm as this island narrows. An island narrowing comes from what we've done as humans on here and building that dune wall preventing the natural dynamics from happening. Eighty-four percent of this could have an inlet in it tomorrow if the right storm came across. And if we put enough storms across it or big enough one, we can do more than that. Sea level is rising, ocean shore lines are receding everywhere. In North Carolina, over washed inlet dynamics are cut off by development, barrier, dune ridge and vegetation. The estuarine shoreline is now eroding so we have islands thinning or narrowing and ultimately collapse. This is how we knew that island was going to collapse and produce thinning. It's not enough sediment in that, I don't have time to get into sediment business, but sediment is a very big player and you can harvest most of the sand on these weak parts of the island in a couple of pickup trucks, probably.

This is the short term future for North Carolina Outer Banks based on the processes that are going on and what we've seen happen in the past and it would not take very much more than a Hurricane Katrina or Ivan to do this in one storm, or a whole series of small storms. This is what we call our decadal scale change if we go into a nonstormy period it could take 10-20 years for this to happen. These areas are collapsing so fast DOT can't hold roads on these spots anymore. The people who live out here want beach nourishment to hold the beach out here and so forth.

This is the long term future, it's going to drown over to the Chesapeake Bay, we're going to drown through the Alligator River here, what was the coastal swamp forest over here will evolve in the marsh. This will become an open marine bay and the good side is that we will have very high quality water and good fisheries again. We will solve our pollution problem back here. The bad side of this is that a big hunk of our Barrier Islands will be gone and that's a century scale of prognosis. And what that's based on are series of core holes back here in Pamlico Sound were we've drilled in here and when we look at the cores, just like a tree ring, the top, let's start at the bottom here. At bottom we got mud down here, and mud can only form in low energy systems. This happens to be fresh water mud and then we get marine sand coming in that was the first flooding when sea level came up. We can age date that so we know when the water finally got into North Carolina and started to flood up here. Then we went to an estuarine mud. And to get an estuarine mud, we have to build a Barrier Island system here and close that off. But we built the first barrier here and then later we go back to marine sand again and then we reform the barrier, we get an estuarine mud and then we go back to marine sand again. Now this marine sand is even more important than these others because this sand right here is dominated by all the organisms that live in the gulf stream. To get the gulf streams across the continental shelf, now the gulf stream didn't go across there, but the gulf stream waters came in. To get that back into Pamlico Sound we have to have most of these barriers gone and so if you plot that on this, we're going back and look at that same climate curve I showed you before, this is the 15 degree line right here. This goes back to about 900 years a.d. up to the present and we have the medieval warm period, the same thing that the previous speaker was talking about. And as sea level rose above this, if you remember the sea level curve, the barriers collapse due to an inadequate supply of sand. They're sitting up there in that inner stream divider, they're just sitting up on a

little ridge. And we're only talking about a meter rise in sea level, not a whole lot. And then we drop down here in the little ice age and they reformed again, they reformed starting all the barriers out there except the big fat ones began forming about 1500 a.d. That means they're not very bloody old, but they formed in here before the colonist landed here. This is the little ice age and if you were a developer, this is the time for you to have been out there on the beach developing because all the beaches were creating and they were building. And then we came out of the little ice age, we're starting to warm, the warming climate, there has been oscillations in here and we're sitting up here and if you look at the next slide, we put this whole thing together, this is our sea level map and we have the first formation of the barriers back here. And they did ok through this period of time but when sea level got up here and the climate warms in the medieval warm period, we had a Barrier Island collapse and then they reformed again and then we came up here, (inaudible) this is medieval warm period and they collapsed again and then they reformed again here.

Nobody knows where the sea level is going in the future, but there's no reason to believe it's not going to do the same thing here. We're already beyond this red line which is a line that the IPCC projected here. We're sitting here at 1.5 ft. per century already and if sea level increases or global warming increases, we'll be up to 3 ft. rise in sea level very quickly. At three feet rising sea level, North Carolina will lose probably a significant, as much as 30-40 percent of its Coastal Plain out there, the lower Coastal Plain. That's a lot of land lost, a lot of people lost, a lot of economic lost. Well the responses to this receding shoreline and rising sea levels, hard stabilization, North Carolina doesn't allow this for good reasons and I hope that we're smart enough to never allow this. Soft sand stabilization, I put soft in parenthesis because sand bags are hardly soft, that's almost a misnomer, but we do lots of things here, like beach nourishment, beach barrier dune ridges, etc. to try to stabilize this. But the reality is if we've got a rising sea level and these storms are coming in the consequences are pretty severe. This high hazard zone here which is the ocean front, it's selling for up to two million dollars a lot. It's the highest hazard land in the world and it is absolutely guaranteed to go to sea, it's guaranteed to get wiped out in the next storm. The state and federal governments are investing a lot of money trying to hold the line that we can't hold for very long. It's very temporary and we start looking long term, next generation, two generations, we got to start thinking about process here.

There are some places where I think we need to move on, retreat, critical for simple over washed island barriers, some of these Barrier Islands have no business being built on in the first place and trying to hold that there in a rising sea level changing climate, this is what hardened shore lines do everybody knows that. This is, ten years ago we went into this present hurricane cycle, North Carolina had twelve miles of beach nourishment that was being done on a regular basis, Carolina Beach, Kerry Beach, Wrightsville Beach and Figure Eight Island. Today we have 120 miles of North Carolina beaches that want nourishment projects now. They want it now. To hold the economy, to hold the line to try to stabilize everything and the questions is can we stabilize it, should we stabilize it, is that really what we want to do. We will not have Barrier Islands there very long if we do. Twenty-five miles of the Outer Banks are presently collapsing and DOT cannot hold

the road there, they have these hot spots that the science panel has to meet over frequently. Beach replenishment is proven not to be the best long term solution it's a very temporary band aid. The Atlantic margin, if you look at the history of beach replenishment projects, in red are those projects that don't last one year. In yellow are the ones that last one to five years and you can see most of them last one to five years. But if you're paying 30 million dollars and you happen to have one like this, this is at Carolina Beach, 1986, a beautiful nourished beach, you can see the old rock sitting back underneath here. Any by 1987 this is what it looked like. The cost of moving that sand, if you can find the right sand and every place does not. The best sand is already on the beach, and the sea floor is not full of sand. Onslow Bay is on rock and you can find little pockets of sand here and there, but it's a very expensive operation. It is not a long term solution.

In Cape Hatteras Lighthouse we finally decided we would put in three grinds here that were broken before they even finished building them in 1969. They caused severe upstream, downstream problems. Steel sheet piles were put in here, rocks, enumerable layers of rocks, zillion layers of sand bags and in one of the storms, I think it was a 1973 storm they even bulldozed off the parking lot and dumped it out there in a desperate effort to save it. Finally decided it is time to retreat and move that lighthouse back.

North Carolina is faced with a similar situation right now at Pea Island. We're (inaudible) a bridge here and the present position of the political world and some of the public out here are trying to hold the line. In red here are the areas that DOT can't hold the line anymore. There is no place for that road anymore there. And the cost of doing beach nourishment for the next 50 to 75 years out there is absolutely phenomenal. There's an alternate proposal to retreat again and deal with new approaches to these various problems of infrastructure out there. This would be a back barrier cause way that would get the bridge out of the area and build a road back here. These weaker parts of the barrier systems are going to have to be dealt with with respect to some very new way of thinking.

I'm going to end here reminding everybody that four major gulf storms of 2005, Hurricane Katrina everybody knows about, most people didn't pay much attention to Wilma, that went in a little further south. Rita did quite a bit of damage and Dennis was a minor storm. But right now, these four storms resulted in an estimated, and it is estimated because the money hasn't been all spent yet by any means, minimum of what, these are known numbers, 120 billion dollars in damages and almost 15 hundred deaths. One hundred and twenty billion dollars, this will probably go to 200 billion. And if we do nothing, this is what we're looking at in North Carolina. Numbers will not be that big, but we're looking at a total, we get a category three, category 4 we're not in a very healthy position down there. We can and we must do better.

Let me just finish this whole thing with a summary statement. The extent to which human activity is causing global climate warming, is not the most important question. Yes we should know that and we will know it as we keep working on it and it's controversial. That's not what we should be dealing with here. The cost of these four

hurricanes, that I mentioned, to the United States and to the local governments, the state government, in fact if any one of those storms came ashore in North Carolina, it would break the bank here. And it would be a very ugly situation. If you haven't dealt with what's going on down there in Mississippi and Louisiana, get on a plane. It's really grim. Anything other than that tsunami in December that matches the impact of these storms. And North Carolina is counting on the coastal area for its future economic development. And this is really serious stuff, and we're asking for a major, major impact on this. And I just think that this Commission is a very important commission to deal with. Thank you.

Mr. Garrou – Thank you Professor Riggs. Questions? Yes sir, Mr. Clark

Mr. Clark – Thanks to scientists like Stan Riggs we've learned a lot since 1974 when North Carolina passed what was at that time a fairly progressive piece of legislation, North Carolina's Coastal Area Management Act. But in light of what we have learned since 1974, it seems to me based on what you're saying that we really need to rethink that act and how it dictates how we develop the shoreline and what we do in response to a rising sea level. Just like your comments on that.

Professor Riggs – I don't think for a second that we abandon the Barrier Islands. I love going down there as much as anybody and there are better places on those barriers to do what we want to do. And there are some places we shouldn't be doing it. There are islands down there, I will not use any names here, if you are a real estate, you ought to pay attention to some of these maps. Some of these islands are going down fast and after each one of these storms, we have a political body that stands up and takes a hard stand, the state's not going to go back and rebuild the infrastructure. And then six months later we're doing it and we're back in the same situation. It is not very often that you can't pick up the Raleigh News and Observer after one of these storms and somebody from Ohio says why didn't somebody tell me. Well we're an educated society and we should know enough to ask these questions. However, we as the leaders in the state have not done a very good job at dealing with this as a process and the dynamics of this system. And if we want this for something beyond just our present generation, and we're bilking it, we're getting a lot of money out of it, it's a big part of North Carolina's economy. If we want this for not just your grandchildren, we're going to have to take care of it and think how we approach it in a different way. We can encase it in steel, make it an economic system, but we will not have a Barrier Island period. These barriers are absolutely unique in the world and they are resources that North Carolina can build with. To the people down there, it's a very important part of the economy. But we've got to do better because if we get a category three or four, they're wiped out, they're gone. And we ought to learn from what happened in the gulf here.

Senator Pittenger – Thank you. Dr. Riggs I appreciate your comments this morning. In one of your graphs you showed what you called the anthroprecence period from 1784 to present, couple hundred years or so, and so we see that phase in context with previous slides over tens of thousands of years with the same types of variations in climate. I believe I understood one of your slides to indicate the natural phenomenal is not induced by man. So I'm sensitive to the issues that you related for the Barrier Islands, at the same

time, I did want to clarify that from the remarks that you did give that these occurrences happen unrelated to what man has done or not done.

Professor Riggs – Absolutely, just like the first speaker said, we can't get bogged down in the question of how humans are having an impact on the earth. The population, the use of resources, we don't have to use CO_2 to justify an energy program. We're running out of energy. I spent a good share of my career as director of a international geologic society program dealing with resource development in third world countries. And I worked all over the world working with energy resources, fertilizer resources, water resources. Most of the world does not have very much and we have scraped the cream off the top of this energy resource, the fossil fuel resource here for a very brief period of time. That last 250 years of the industrial revolution, we have utilized a very major portion of that resource. And if you start thinking beyond this generation to the next generation, the generation after that and you start thinking about nine billion people on the surface of the earth and the impacts that that population and technology is going to have. Are we having an impact today? You're darned right we're having an impact today and it's getting bigger and bigger. We can move mountains, we can tear up the earth, we can change the atmosphere to the point where we destroy it. And I think that the justification for an energy program is the fact that we don't have a whole lot of cheap good energy left anymore. We got everybody booming in the world and the demands on that energy are going to be overwhelming as well as the impact on the climate. So to me that issue at the moment is a non-issue. That doesn't mean we shouldn't deal with it, I think we need to deal with it, but the energy question has its own justifications. And if we want to, we need to develop a better energy program in this country, in this state. We need to deal with that. We have to better stewards of this or our resources are gone. Our water is already down the toilet in North Carolina. We have more fresh water in the Coastal Plains than any place else in the world almost other than southern Florida. And we're losing our aquifer system at the rate of 10-12 feet per year. The rivers are coming down, they're sewers. I live on the Tar River and I watched over the years, I've watched it go to sewer. And its not big industry necessarily, it's all the people, the cumulative impact of you and me that are affecting these resources. We've got to clean up our act. We've got to do better at it and as we build, we can only build if we have a good resource base. That's the future, in North Carolina we have a resource base and we have got to deal with that.

Senator Pittenger – Thank you. I do agree that we need a better working policy as related to climate change. Your comments were well received. Thank you.

Representative Wilkins – Thank you Mr. Chair, a couple of things Dr. Riggs. There was a grant about core soil samples, it wasn't dated, am I to take that that's a 900 year period?

Dr. Riggs – I don't know which graph you're talking about.

Representative Wilkins – Ok, yes sir. Does that reflect a 900 year period, because 900 years was mentioned immediately after that.

Dr. Riggs – No, the bottom of that core is about 8000 years. The base of that was fresh water when Pamlico Creek was fresh water and so all we've got is a whole flooding cycle that started about 8000 years ago and the first time we built a piece of the Barrier Island was about 5000 years ago and we built some more of it about 3000 years ago and it collapsed and we built the last part of it 1500, sorry, 1580.

Representative Wilkins – Thank you, I picked up 900 from another graph, I guess. My other thing, I'm a surf fisherman, surf fishermen observe very closely, and talk even more than that, and they talk frequently on the coast about 20 year hurricane cycles. Any of the data that you run across, does that support it?

Dr. Riggs – Yes, in fact, that one chart I showed from the literature, which was published just this past year or two in nature showed about a 25-30 year cycle. That one that had the red and the blue temperatures, sea surface temperature on it and that's about what it was but the thing you've got to remember about these patterns and cycles, we only have a hurricane record that goes back to 120 years. And before that it's all word of mouth and historical. Now in the geological record, we can see these events, so we can pick out the really big ones, we can't pick out the little ones, can't put the details together.

Representative Wilkins – Thank you sir, thank you Mr. Chair.

Dr. Smith – Dr. Riggs you brought up some obviously profound things for people to think about and I appreciate you bringing it to our attention. I have just a couple of questions I want to clarify on some of your graphs. You had a chart where you were showing a relationship of, I take it, the sea surface temperature of some of the Luke currents and other (Dr. Riggs – that's the same one I think he was talking about). Right, and it appears that there are these cycles that we come into. I wasn't clear on the actual extent, cause it looked like we were in an up tick towards the end of where it cut off. And I noticed some of your slides were cutting off over the past 10 years or so, but there was this up tick. My question is, if there are these cycles, could you imagine a scenario where because my understanding is that the concentrations that we're seeing in CO_2 are somewhat unprecedented at least in the most recent past. And that that can have a tendency to keep temperatures elevated, obviously what we're talking about, which then was exasperate or possibly prevent some downward movement. So we could be seeing some period where we're going to see increased sea surface temperatures and Luke currents on top of whatever natural fluctuations we have with hurricanes. I mean would you say that's possible and maybe even likely. And given that there are these patterns of hurricanes that happen and we think we're entering into a phase where we're going to see increased frequency. Those are complex because of obviously upper level winds and this, that and the other. But there is clearly a relationship between sea surface temperature and hurricane intensity. My understanding is that particularly in the last few years, there's been some fairly sophisticated work coming out of MIT and Princeton and Georgia Tech that shows a relationship between actual temperature and the hurricane intensity and beginning to correlate that possibly with global warming. And you show these warming periods that the Outer Banks becomes, it looks like almost a series of

arrows just coming right after the Outer Banks. I take it from that slide that you were communicating that you're saying that as sea surface temperatures increase, the likelihood of the Outer Banks getting hit by hurricanes is going to increase pretty dramatically. Because there seems to be a relationship between those, and my point is, if you have these increased sea surface temperature, increased hurricanes, possibly increased hurricane intensity at the same time with what you described as a break down in the Barrier Islands and some people have postulated it that without these Barrier Islands, the surge comes in and this, that and the other, that you would be greatly concerned, I mean that you've got the dynamics with the population growth and whatever. But that the sea surface temperature relationships are going to cause more intense hurricanes reaching further into the state and that these two things are centerjestically coming together and going to exasperate each other.

Dr. Riggs – What do you want me to say?

Dr. Smith – Well I guess what I'm getting at is the previous speaker and then you have referenced these patterns. My concern is that normally you have these fluctuations, but we may be locking the fluctuation to the upward where we're not going to get the downward fluctuation.

Dr. Riggs – You're asking me if I believe that there's a relationship between humans and global warming?

Dr. Smith – And then the relationship to that then could cause an exasperation of what the natural cycles are and maybe not allow them to go down anymore and only up tick them which is going to cause a lot more problems.

Dr. Riggs – I personally think that we are having an effect on the CO_2. I'm not a chemist or an atmospheric scientists and I can't tell you, in fact, my understanding of the whole CO_2 question. I have spent a good share of my life as an oceanographer and I know how CO_2 moves into the oceans and moves through the system on a bigger scale. And there are times in the earth's history when CO_2 is much higher, much higher. There are times when it is much lower and it seems to be absolutely correlated with temperature. The CO_2 is a very important part of the whole limestone cycle, coral reefs and there are periods in geologic history when there's a tremendous concentration of formation of these things out of the world's oceans. And it seems to be periods of time when all these limestones are weather and the CO_2 goes back and you've got to be able to sort all that chemistry and complexity out of this thing. If you want to understand what the human overprint is on this and I surely can't do that. I don't understand it. I can show you a plot, not my work, but from the people who are doing the ice core work where we have a 750 thousand year record of climate change in those ice cores, and they're beautiful. I mean this is just an incredible data set. And they show an absolute correlation between CO_2 and air temperature back through time. A lot of these same scientists project that humans are going to increase that and show a much bigger spike on it, I can't address that. I would not be surprised if it's not true, but I also know that the ocean becomes a big sink for this. We don't know what the ocean role is in this. The modelers approach

the natural earth systems very simplistically. And there are no systems that are simple and I'm not being down on modelers, but a modeler will work with three, four, five variables (inaudible) system. When I talk about inlet probability, we have 24 variables that we plug into our inlet variable, a modeler tells me that that's ridiculous. Give me the most important ones, but we don't know the most important ones. I can intuitively sit down and deal with 24 variables and deal with everything from grain size to slope of the shelf to composition, to geometry of the system. But a modeler can't do that yet. And so I have an intuitive understanding for drilling and for knowing where these things happen in the past and how they form. They go beyond what the model capability is.

Dr. Smith – It's where the models and the empirical observation come together that you begin to develop confidence and that's what I think we're beginning to see. You've seen it in your work and I think we're beginning to see it in the climate. Mr. Chair, one last thing, when we have a break, I am going to pass around to the other members of the commission some information about sea level, which is consistent with what we are hearing, but I think gives some sources of some stuff and I would like to just let people know that I'll get it passed around soon. Thank you very much.

Senator Pittenger – Mr. Chair, could I just ask one last brief question?

Mr. Garrou – Yes sir.

Senator Pittenger – Dr. Riggs, then to confirm that CO_2 variations have occurred for thousands of years, and you say consistent with the change in temperature.

Dr. Riggs – That's what it appears to me.

Senator Pittenger – Thank you very much.

Mr. Garrou – Thank you very much Professor Riggs. Our next speaker is Robert Jackson, Professor of Biology and Environmental Sciences at Duke.

Mr. Givens – While Dr. Jackson is coming up, I just note that the lunch break is estimated and estimated not with great accuracy. We did want to hear Dr. Jackson's presentation before lunch. Then there'll be further discussion and presentation and discussion after lunch whenever that falls.

Dr. Jackson – Can people hear me without the mike?

Mr. Garrou – No, we need it for the recording.

Dr. Jackson – That was easy. Can people hear me now? (PowerPoint presentation – **Exhibit J**) Well I know you all want to go to lunch. So they asked us to keep it short and I am going to try to do that. I essentially have two points to make today, and two only. Those two points are first, that there is a direct link between human activity and greenhouse gases and the rising earth's temperature. And the second point is to stop

viewing this sort of as a migraine headache. Start viewing this as an opportunity to shape North Carolina, to shape our state in the way that we want it. By shaping I mean, both economically and environmentally. So those are the two messages for my talk and I want to go through now and give you a bit of information and background. A little bit of data as well.

So the background, I'm in the Nicholas School of the Environments Earth Science at Duke. I also direct the Center on Global Change and as part of our mandate in the Global Change Center which is in the Provost Office, I also direct the new Department of Energy, it's called Southeastern Regional National Institute for Climate Change Research. It's a brand new program that has been set up in the past year. There are four of these regional centers in the country. The one for the southeastern US is based at Duke in the Global Change Center that I run.

So I come at this with a lot of different perspectives. I mentioned my first point and that's that the consensus in the scientific evidence is overwhelming that there is a link between human activity and greenhouse gases and the warming of the earth. Now these are just three statements. We've already heard about the IPCC, the intergovernmental panel on climate change that's just finishing up its next go round right now, will be out in 2007 officially. But you're already hearing about it in the news a little bit. What did they say last time in 2001? There is new and stronger evidence that most of the warming observed of the last 50 years is attributed to human activities. Now that's a thick report, but that's right in the front. So that's a group of more than 2000 scientists and by what you're hearing in the news media, lately, the next report, five, six years later is going to be even stronger language. But it's not just about the IPCC. The IPCC has become somewhat political, in a sense people are trying to sort of push it in a political direction. So let's back up from the IPCC and say what are some of the other scientific institutions saying about this issue. So let's switch gears and go to the meteorological society, our premiere meteorological group in this country, more than eleven thousand members. Because human activities are contributing to climate change, we have a collective responsibility to develop and undertake carefully considered response actions. Not if, not whether human activities are contributing to climate change, because human activities are contributing to climate change.

All right, let's take a different group, a group that I'm intimately involved with, the American Geophysical Union more than forty thousand are scientist. I am the president of about ten sections in this society. We have about four thousand members. So I'm intimately familiar with the official climate change statement for AGU, as we abbreviate it, just as a similar organization to the Meteorological Society.

The American Geophysical Union, what's the official statement released last year. Scientific evidence strongly indicates the natural influences cannot explain the rapid increase in global near surface temperatures observed during the second half of the twentieth century. Now the pros may not be great, but the message is there. All right, so those are three bodies, thousands of people, over and over again, the message is the same.

There is a direct link between human activity and greenhouse gases and the warming of the earth. Is it the only thing that's involved, no, but there is a strong link.

You all know about the greenhouse phenomenal. The single diagram, so what do we mean by that – short wave radiation comes in, long wave radiation is admitted back from the surface like you would study in the physics class. A greenhouse works because it traps that radiation and keeps the air around those plants warm and allowing us to grow those plants under cold conditions, well clouds, carbon dioxide, water vapor in the atmosphere. These do the same thing as the earth surface is re-radiating, re-radiating that long wave radiation back up in the air, some of it is left behind. It is trapped inside the layer of the atmosphere. This is a good thing as we've already heard a couple of times today, without greenhouse gases the earth would be a frozen ball of ice and none of us would be here. So it's really no uncertainly about that, we are here because greenhouse gases are in the atmosphere. And those greenhouse gases are a good thing.

Right now a little bit of history, we've heard about some uncertainties. So let's back up and ask what did people know before my grandparents were born? How much did we know about this issue? In 1827 Jean Baptiste Fourier first describes how atmospheric gases trapped heat. He was the first person to use the analogy of a greenhouse, almost 200 years ago. In the 1890's Svante Arrenhius, a famous Swedish chemist, but really an amazing scientist, chemistry, geology, costomology, absolutely a phenomenal person - awarded the Nobel Peace Price in 1903. He and another person independently proposed in the 1890's that a build up of carbon dioxide, from fossil fuel burning would warm the earth further. Why this was over one hundred years ago. Now in a previous life, as an engineer, I knew Arrenhius and Foya, about like Shirley McClain. It's because Foya you knew from that class as Foya transforms, Arrenhius you know from your chemistry class, reaction kinetics and various things. These are scientific giants who have been thinking about this more than 100 years ago and are already established the links, fundamental links of what greenhouses do and the environment. Does that mean you know exactly how the warming is going to occur in the next 50 to 100 years? Absolutely not, are we pretty darn confident that if we keep pumping carbon dioxide and other greenhouse gases into the atmosphere, the earth's going to warm. Yes, we're pretty confident.

In 1958, the last person I have up here, Charles David Keeling. Many of you know him or of him and he's well known because he started the famous monitoring trace. The first person to set up a monitoring station at the top of a volcano to measure carbon dioxide beginning in 1958. And his measurements were important because it was the first time we documented this increase in carbon dioxide, a little bit each year, by each year, by each year as it went up. It's been going up every year since then and now more than 40 years. So there's some history here. Yes there are some uncertainties. Yes there are some things that we don't know. But there are a lot of certainties too and people have been thinking about this for well over 100 years. And there are aspects of this that are not rocket science, greenhouse gas is warm more, greenhouse gas is warm more.

There's David Keeling's trace, you've probably seen a graph like this more times than you care to count and you will probably see it again in this Commission too. On the Y

axis we have time here, dating back 1860 to 2000, I'm sorry that would be X axis on the Y axis, there's a parts per million of carbon dioxide. And you see Keeling's trace in that gold on the right as you look at the screen. So the ice core record provides the numbers on the left side of the figure and then the Keeling trace provides the right side. So not only did his data teach us that carbon dioxide is going up, they also taught us something about the way it works. Look at the oscillation in that graph, every year it seems to go up a little, every year it goes down a little bit. That's the bias for your breathing in the Northern Hemisphere. That's leaves coming out in the summer time, pulling carbon dioxide out of the air, respiring that carbon dioxide back to the atmosphere in winter. That's the bias for your breathing. But on top of that dynamic signature is this incremental march upwards which is a direct result of human activity. Regardless of what you think about climate change, there is no doubt, there is no uncertainty that we've increased the carbon dioxide concentrations to levels we haven't seen in hundreds of thousands to millions of years at least. And it is very likely that the temperature will continue to go up because of that.

That was a 150 year record let's look at a 450,000 year record. This is one of several, the famous ice core traces and as you move from left to right on the X axis you're going from back in time to present day at 0. And then on the Y axis here you have the carbon dioxide concentration in parts per million. So you see several ice age cycles embedded in that graph, when CO_2 concentrations are high, the earth is relatively warm. There's not a temperature graph on this one, I'll get to that in a minute. When CO_2 concentrations are low, we are deep in an ice age. You see these oscillations are about every 100 year time scale and have nothing to do with human activity. Then you see us come out of that last ice age about 10,000 years ago. We go up to where that dashed line is and then something different happens. That line keeps going up for carbon dioxide. That's the imprint of human activity. That's the burning of fossil fuels in the environment. So you see there it says current 2001, today we're pushing 375, 380 parts per million, well above the oscillations we seen for the last half million years.

I apologize to some of you in the back because this is a bit hard to see. But this is a similar graph, we have two Y axes in this case, we have a CO_2 graph at the top of this figure that you've just seen with time, in this case going from left to right, (inaudible), and on the other Y axis is temperature. The only thing that you really need to see with this figure, or to take home from this figure, is the correspondence between carbon dioxide and the dormant greenhouse gas and the earth's temperatures go back in these ice ages. These are put together, the temperature records are put together through a number of proxies, coil tree rings, ice topes, and many factors. Now this graph does not prove that carbon dioxide causes the ice age. The causes are answered in and out of the ice age, we don't really know exactly why we go in and out of ice ages. Nobody can answer that question yet. But it is clear that there's a very tight correspondence between the amount of carbon dioxide and other greenhouse gases in the atmosphere and the earth's temperature. You can see that with your eyes, you don't need a PhD you don't need a college degree to see that. Once again, here's where we are now about 380 parts per million in the year 2006. So again, we've sort of taken ourselves out of the natural

projectory of the last half million years and even more as you look back farther into the record.

Now let's talk a little about the last 1200 years. So this is an article that came out just a couple of weeks ago. Now I know you've already seen examples of how our wonderful pros in science, not exactly our strong point, but what you hear about on the news often are articles that come out of Science and Nature and various scientific publications. There are articles just rolling out week after week now talking about different aspects of both the climate change effects on two weeks ago on the Greenland ice cap and evidence of increased melting. A paper just this week, announced on Thursday about Antarctic data and ice lost there, I thought it was a complicated piece, but a brand new paper. I would encourage you to read, if you want to, the original articles at least to follow in the press. These data are coming fast and furious now, whether we're talking about climate, whether we're talking about butterflies, insects, birds that change their ranges in response to the warming earth. The evidence is rolling in and there's something really unusual going on here.

We've talked a little bit about sort of the hockey stick. This is an article out last month, Science, Osborn and Briffa, I'm not sure how you pronounce that last name. Two different takes on the hockey stick that we've already seen. Alright, these are two graphs with the same data but slightly different takes on normalization and statistical treatments. There is an infinite number of ways to analyze various data sets like these. So you can think of these two analyses as book ends for some of those ways. Alt the top you see an analysis that shows evidence of the medieval warm period, about 1008 years, the most obvious period there, where you see the little sharp peaks of red. You see some evidence for the recent, relatively recent cooling of the medieval cooling period around 400 years ago that blue where it dips downward.

On the top graph, now you see that giant red blob, ok that's us today. That's sort of the broken hockey stick at it's worse manifestation. The bottom figure is a different take on the data, it shows some evidence of the medieval warm period, it shows the cooling more recently, but it also shows even more dramatically this drip with fossil, this drip upwards with fossil fuels. So I guess I would say that by far, the way the prominence of the data is, doesn't suggest that the hockey stick is broken. The hockey stick may not be perfectly flat, but it's that giant red blob on the right side of those curves that what we're dealing with here. And that giant red blob, by all those statements that I've already shown you, and by many, many other pieces of evidence is linked to human activity in greenhouse gases almost certainly. And that's with as much confidence as we will ever be able to say. Almost certainly.

Another take, narrowing it even more in the last 120 years or so, our annual global surface temperatures for the land and ocean together on the top, ocean in the middle, then the land at the bottom. These are degrees centigrade or degrees Fahrenheit. Fahrenheit depending on the X and Y axis. And again you see this anomaly, the last blip in 25 or so years recently where the graph gets very red. Now as we've already seen, the earth's temperature does not track carbon dioxide and other greenhouse gases perfectly. There is

not a perfect correspondence between the increase in carbon dioxide concentration and the earth's temperature. And you see that particularly in the first 20-30 years of the century where there is upward blip that probably isn't due primarily to carbon dioxide. It has some other contributing factors like increases in the sun's rays and things like that. But there is no known natural explanation, for the last 25 years. Not volcanoes, not sun spots, not anything else that we can come up with. And that's why there's so much confidence, as year after year rolls in 2005 being the warmest year on the instrument record since the beginning of our records. So these data are rolling in. Is CO_2 the only player? Does methane and other greenhouse gases, are they the only players? No, are they major players in the earth's climate system and temperature? Absolutely, we know that, we knew that 100 years ago, almost 200 years ago.

Now personally I don't like the hockey stick graph, I don't think the hockey stick graph really tells us what it's like, what's really happening to the earth's surface. This is a different graph. So instead of asking what's happened everywhere on earth and then let's combine that together in one number, let's see what happens different places on earth. So this is a record of temperature change for the last 25 years, 1976-2000. A red dot is warming, a blue dot is cooling, a big dot is warming more, a little dot is not much change. The biggest red dot that you see, in particular, through temperature and especially northern latitudes, that one degree centigrade per decade. So in the last 25 years, of this graph's record, there are places that have warmed two and one-half degrees centigrade. Large area that have warmed two and one-half degrees, approximately four degrees Fahrenheit now.

We'll talk about global warming being 50 years or 100 years into the future. No, global warming for large parts of the earth, especially up north, is here now. It's changing right now as you look at the permafrost, fires in Borro Forest, it's our life time, we are not talking about our grandchildren. There are some blue dots on this graph. You will notice less change over the oceans. That's not so much of a surprise. The oceans have very high buffering capacity, very high heat capacity to absorb changes in temperature. You don't see a lot of dots in Antarctica for example. That doesn't necessarily mean no change, we don't have many stations in Antarctica. So we don't have very good data down there. Imagine putting 20 weather stations across the United States and then trying to conclude what's going on with Antarctica's climate or the US's climate. But there's a lot of red on that graph. Ok now, now where does it really get uncertainty, it gets uncertain when we go to the future. The uncertainty is how much warming. Alright nobody can answer that question exactly. Why is that? Well you've already heard some of the reasons. We don't have perfect knowledge of the relationship between greenhouse gases and temperature, we don't know exactly how many people there's going to be in 2050 or 2100. We don't know exactly what each person is going to use, how much they might drive, how much they will eat, what kind of home they will live in. We don't have all that data, so the best we can do is build scenarios and try and predict the amount of greenhouse gases that there will be in the atmosphere in the future and then what the effects on the climate system will be. That's really the two step process that we need for perfect certainty here. We're looking at the hockey stick again on the left, and then you're looking to where we're heading. Where the best models suggest we're heading.

Now there's a huge range on that graph and the top of that graph for those of you in the back and can't read it is about six degree centigrade at the top. Does that mean that we're going to head to six degrees centigrade? I don't know. The bottom of that graph is about two degrees centigrade for this century. So somewhere in that range, but most estimates are in the neighborhood of five degrees Fahrenheit, six degrees Fahrenheit, something like that. Nobody knows.

I guess the question I want to ask you is do you really want perfect certainty? I mean do we have to know exactly what that temperature number is going to be for North Carolina to figure out what we should do. I would hope that the answer is no. But there's lots of good evidence for this and again our mind set here is to stop thinking about climate change and global warming as a sort of migraine headache that's just a pain for us and start thinking about how we shape our state in the image that we want it.

Just a few more graphs and I'll finish. It's not just about carbon dioxide as we already heard. These are four graphs showing carbon dioxide concentrations upper left, nitrous oxide concentrations upper right, methane concentrations lower left and sulfate aerosols. They all show the same thing in the last 150 years, a dramatic up tick in those greenhouse gases. So we don't have to talk just about carbon dioxide. There are even greater uncertainties in some of these trace gases, methane's a hard beast as well. But they're all telling us essentially the same thing. Now we try and tease apart different aspects of warming. Warming is complicated as you've already heard. I will not dispute that. This is a figure from the IPCC that tries to factor in or identify or attribute aspects of warming to particular things. So anything above that solid line that you see in this figure is a warming force, a forcing factor we call it. Anything below that line is a cooling force. And that's what's happening in our climate now relative to 1750, 250 years ago. So that big giant bar on the left of the greenhouse gases, I believe these are watts per meter square the units on the graph, it not up there. But you see that big graph being the greenhouse gas is carbon dioxide is the largest one. You see a contribution for methane there that's very real. Orders of magnitude less common in our atmosphere are much stronger greenhouse gas. You see nitrous oxide, hallo carbons, the CFC's, HCFC's. These are very strong greenhouse gases.

You see ozone effects. You see a stratosphere of cooling effect. Well what in the world is that? That's the ozone whole. That's the ozone that's been removed from the stratosphere and ozone is a greenhouse gas. You can astrosphere that goes on in fact. What's that? That's pollution, that's atrospheric pollution, that smog. Then you see these other bars, sulfate, a little bit of cooling, biomass burning. These are effects that lift particles out of the atmosphere and block that sunlight from reaching the earth's surface. And then you see a large uncertainty around aerosols. There are some big uncertainties and exactly what will happen to our climate. Clouds are one, we can't predict clouds perfectly in the future and different clouds do different things, white clouds reflect light, dark clouds absorb light. Then aerosols are particulates in our atmosphere also uncertain. But again you want a first order of response greenhouse gases begin warming that giant ball on the left side. Those are our greenhouse gases. If we tackle one thing first, it makes sense to tackle the largest thing first.

My last data slide. I just want to think about time scales a little bit. I've already said that I think global warming, especially up north is occurring right now, this is a today issue in our lifetime issue. I think that's true for the state of North Carolina too. But there are time scales here that we need to think about. We've heard a little bit about stabilizing CO_2, how difficult that will be. It's going to be hard, it will take a lot of work and will take some changes to stabilize carbon dioxide. Because to stabilize carbon dioxide, which is that purple graph, the purple line there you see, it goes out about 100 years and then flattens about 150 years. To stabilize CO_2, we have got to drop CO_2 emissions dramatically. So in this figure what happens, we start on the left, CO_2 emissions peak and it says in this case, 0 –100 years from now, drops down substantially, only then over time can CO_2 stabilize.

What we're talking about here today, first and what Kyoto tries to do. Kyoto was a small step. What Kyoto tries to do is at least start to slow that projectory of increase. Kyoto on its own is not enough to stabilize carbon dioxide concentrations. Once CO_2 stabilizes, let's play the scenario game, CO_2 stabilizes a century to three centuries from now, temperature stabilizes shortly after that, that's the red line and continues to go up a little bit. There are things that are going to go up for a long time after that. Now let's just take two examples on here, we've already talked about the sea level rise a bit. Now the blue dash line is sea level due to ice melting. Well now why is that? Think about how an ice cube melts, right it doesn't melt all at once it melts from the outside in. And obviously, when we're talking about ice packs like Antarctica we have to take in account how much snow is coming in and other things. But just that simple ice cube analogy, when you bring an ice cube out on the counter and set it there, it doesn't melt like that, it melts from the outside a little bit at a time. That thousand-year time scale is what we're talking about, Grand Artica and Greenland and other ice caps. Even when temperatures stabilize, because you're melting that ice cap from outside in every year a little bit more is being sliced off and you're working your way in on that ice cap.

Now how about the other one, sea level rise due to thermal expansion. That's the solid blue line, that's also still rising in a thousand years. That's not rocket science either, that's a high school, bench top experiment where you take a beaker of water and you heat it up. And why does it take a thousand years, because most of the ocean isn't in contact with the atmosphere right now. It's hundreds of feet in some cases thousands of feet away from the atmosphere it hasn't seen the atmosphere for 500 years, in many cases 1000 years. So this is what we're looking at. I believe that the rationale for acting on global change is right now and I've already said that a couple of times. It is North Carolina today, we've already heard some reasons that CO_2 is hard and that we haven't done a good job of reducing carbon dioxide emissions. Well these data, I just want to show, to point out that these have effects for not just a couple generations but for dozens of generations.

Now, I began this talk with a list of three bodies to establish the link between greenhouse gases and warming. Let me pick three others that looks like the same slide, different groups. National Academy of Sciences 2001, the national body set up to try and answer

our scientific questions for the government. Greenhouse gases are accumulating at earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. It's pretty simple. American Association for the Advancement of Science their formal statement in 2000. These are five years old now, we're still talking about the same things. The world is warming up, pollution from greenhouse gases such as carbon dioxide and methane is at least partly to blame. We will never say more than that, no one is ever going to be able to say the earth is warming entirely due to greenhouse gas emissions. Even if it were, we could not say that because we would not know with certainty.

But again, the message is that greenhouse gases are going up and they are at least in part the blame for what we're doing. And finally, I guess a quote I've already shown you just from that recent paper. Looking at this sort of hockey stick time frame and the newest analyses are still reinforcing that the warming we're seeing in the past 25-30 years is really unusual and does not have historical precedent in our instrument record or our proxy record unless you start going back millions and millions of years to the carbon empress and other areas, hundreds of millions of years ago, tens of millions of years ago.

I'm done. So a couple of years ago I wrote a book, I published a book and I have some comments in that book. This is the first comment, this is a Raz Chaus comment, says how to deal with the upcoming recession, inflation, depression, ice age, greenhouse effect, energy crunch, population explosion and complete end of the world in the year 2000. Robinson Davies also happen to be one of my favorite writers, he has a quote from his Samuel March Banks book, the world was scheduled to end today but something must have gone wrong. I guess what I want to leave you with is that this is not about the end of the world, this is about quality of life that we have and the kind of world that we have now and for future generations. And if we think about what we want to do with this, I want to stop, I guess stop thinking about global warming alone, let's start thinking about all the different issues that face North Carolina. It's not just about global warming, is it, it's about ozone and pollution and if we lick global warming we solve most of our air quality problems too. That's the attitude that I hope the Commission will take in trying to figure out what is the right course of action in this state. And the fact that if I'm 100 pounds overweight and it hard to lose the first 10 pounds and somebody says well that's not going to solve the problem because you're still 90 pounds overweight. We need to take that first step. At some point, I need to lose that weight and if riding my bike to work does not change the international CO_2 curve, that's one thing, but it changes a little bit. Might not show up on the graph, it makes me a healthier person and it's a first step. That is the message I hope I leave you with today and this is my state, this is something I care a lot about and I want us to figure out a way to do this in ways that are least disruptive to businesses as possible. That you know, doesn't tell a power company like Duke Energy or Progress Energy to scrape a coal plant that they've just spent billions of dollars on. We need to find a way to do this intelligently, but quickly because climate change is now. Thank you very much.

Mr. Garrou – Thank you sir. Questions?

Dr. Eggers – Dr. Jackson, I especially appreciate your comments at the end about future generations because I think we sit here as a room full of stewards for not just children and grandchildren but great, great, great grandchildren and their great, great, great grandchildren. So the stakes are pretty high, they would have some things to say if they could be here. Would you please go back to the slide that was approximately like this?

Dr. Jackson – This one?

Dr. Eggers – Thank you. Yes. So we have received some materials from the John Locke Foundation and they have included the slide, this is an IPCC Northern Hemispheric temperature reconstruction for the past 1000 years. It's difficult to see because the lights are on full and things, but there is a very dark single line in the midst of all of that kind of arrow bars there. And one of the criticisms is that maybe we can't trust this because it seems to smooth out the medieval warming period and the little ice age and then show this big up spike at end. So can you explain why this seems to smooth those out?

Dr. Jackson – Sure, I will also switch to a different slide very briefly. Data analysis and smoothing depends on what time interval you take. Is it a five-year running average, is it a 25-year running average, a 100-year running average. There are all sorts of ways to analyze these data. The longer time period you use, the smoother your signal is going to look. The up ticks will be lower, the down ticks will be shorter. Now this is sort of more like the typical hockey stick sort of presentation that Robert was talking about earlier. I tried to bracket that with this new data set to show here is sort of two different approaches, bookends if you will, to what that graph might look at. So anything you see over that top red line in the upper graph is sort of what we would call a 99 percentile image. That means that there is less than one percent likelihood that this is sort of a normal phenomenal in that interval. Now you do see in that upper figure a couple of times back in this one period in particular where it ticks up above that line, that 99 percent line briefly. So that was an unusual work period, but you don't see the thickness of that bulge at any time in the record and you don't see the height of that bulge at any time in the record. So that's just kind of one book end, a different way, a different analysis and this is in a paper that just came out a couple of weeks ago in the Journal Science. The bottom one is a different take on the instrument record. That take on the instrument record says there's nothing like this that happened in the last 1000 years or so. Alright now which one of those two figures is absolutely right? I don't know. There are 1000 figures in between those two, but everyone of them shows this giant blimp of red at the end. That the overwhelming evidence suggest is due to greenhouse gases and human activity, that's the part of the figure we ought to be focusing on, in my opinion.

Senator Pittenger – Thank you Mr. Chairman, thank you Dr. Jackson for your presentation. I do appreciate it. You offered a number of quotes by some impressive organizations, I'd like to get your reaction if I could to some similar type organizations. One of which you mentioned was the National Academy of Sciences. The quote from them states a causal linkage between the build-up of greenhouse gases and the

atmosphere and the observed climate changes during the 20th century cannot be unequivalently established.

Dr. Jackson – Can you give me a little more to go on there, so when was that, what report, I don't know what the context for the statement was but the National Academy of Sciences was one of the quotes that I put up there before. I'm sorry, I'll let you answer my question as I ramble on. The National Academy right now is organizing a group of people to sort of analyze this hockey stick debate and put it to rest once and for all. That's what's going on right now. I'm sorry I interrupted you.

Senator Pittenger – That's all right. The book I think for that was called Climate Change Science: Analyses of Some Key Questions page 17?

Dr. Jackson – Ok that's right, now read the quote for me one more time please.

Senator Pittenger – I don't have it with me here, I think its 2001. But I'll have to go back, cause the others are from 2002. You mentioned projecting the future, we couldn't know for certainty what that would be and that as I understand it that there are variables in there, whether it's vapor or clouds or particles. The statement that IPCC made about that was that the clouds can either cool or warm the climate depending on their composition and let the United Nations and IPCC just state the clouds represents different source of potential error in climate control simulation. Well if this is true, shouldn't we be very reflective on what we do in terms of the impact, economic impact in our state and the answer to that I've seen show that to implement, for example, the Kyoto protocol would cost about 550 million dollars. The impact to the state tax revenue would be around three billion dollars annually. And the impact on energy cost annually to the consumer would be about 2.3 million dollars. So I'm a little bit concerned that we would be making decisions with enormous economic impact so there is not really a good understanding of why we need to do that, particularly related to the variables that are out there.

Dr. Jackson – You said a couple of things in sequence there, let me try and remember each one in order. This was a quote that I had put up before, greenhouse gases are accumulating the earth's atmosphere as a result of human activities causing surface air temperatures and subsurface ocean temperatures to rise. This was a National Academy of Sciences report, 2001. So that was my quote. I tried to tackle a little bit this issue of clouds and other things, the Senator was absolutely right, clouds are a major uncertainty – we will not totally resolve the cloud issue in my life time, I think I can say that with confidence. I can also say I still think that has essentially nothing to do with the reasons for deciding what we decide. Let me explain what I mean by that. It comes back to looking at the size of these bars, for example. You know, we have this large greenhouse gas bar on the left and we have clouds coming and going. Now you can imagine the earth's temperature going up incrementally as we load the atmosphere with CO_2 and the clouds are coming and going. Clouds are short lived phenomenal, there may be more clouds in the future in certain areas, there will likely be less clouds in some areas in the future. But that's sort of a second order signal on this greenhouse gas term that we're

loading year after year after year. And so the aerosol and clouds are two of the biggest uncertainties as I've already said, but there is no evidence and no suggestion in the scientific literature that those terms are going to overwhelm this greenhouse gas term. Now I guess another issue deals with uncertainty. Let's take an often used analogy, let's take smoking and lung cancer. If you smoke, are you always going to have lung cancer? No. If you get lung cancer, are you automatically a smoker? No. Can we predict exactly who is going to get lung cancer if you smoke? No. Does that matter to a rational policy decision about smoking? If we want to save lives and money, we don't have to know exactly who is going to get lung cancer to know that it makes prudent financial and environmental sense for us to tackle this thinking issue. There are uncertainties still today in the relationship between smoking and cancer. We can still make intelligent decisions to save ourselves money and lives, I believe, despite some of these uncertainties. Let me finish by saying there are other uncertainties that plague you too, it's not just what the exact term do to clouds, but what the exact warming or cooling do to aerosols. Let's talk about the uncertainty in our economy for not doing anything, for businesses not to know what's going to happen in the future if we allow temperature to warm slowly. Let's talk about uncertainty to our environment, to our agriculture and there may be some pluses in agriculture with increased growth, there may be some minuses with increased pest and such. We don't have perfect certainty with any of these. But there are strong costs, big cost to uncertainties in the other direction. I believe what we want to do, is to lessen that uncertainty as much as we can by keeping that greenhouse gas turned down as much as possible. It's just playing it safe, I don't believe you can attribute a particular hurricane to global warming we cannot attribute Katrina to global warming. We can only attribute things to global warming that we build up over long periods of time and with large data stats. That's the conservative nature of our business. So if somebody ask me if this heat wave is due to global warming. I don't know. I can't answer that question, but there are uncertainties with not doing something about this that affects our economy and our environment directly. I believe those uncertainties are bigger than worrying about what the precise term do to clouds or aerosols is.

Mr. Toben – Thank you Mr. Chairman, thank you Dr. Jackson. Very much appreciate your comments. I appreciate you bringing up the analogy to the tobacco industry as well. My first job after graduate school was with RJ Reynolds Tobacco Company. And I spent several years there in the 80's at a time when we were being sued by folks in most states and each of those trials we would parade out the same small handful of scientists to question, to cause a relationship between cigarette smoking and lung cancer and we got away with that for about 20 years and it's come home to roost. I hope we will not do that in this case. In looking at the data from IPCC, the osterobodies that you bring to bear, IPCC, the National Academy of Sciences, the American Geophysical Union, the American Geological Society, agree that human activity is having an impact certainly on increases in CO_2. The data that I've seen are putting 7-10 gigatons of carbon in the atmosphere but you know that growing with China and India. My question is to the point of the first speaker this morning, why would North Carolina institute policy change that would agreeable have modest impact on the global picture. Any why have countries signed on to Kyoto protocol that are smaller than North Carolina? And why have municipalities signed the mayor's climate protection act when clearly their individual

cities and towns are going to have little impact on this problem? Can you just speculate about that please?

Dr. Jackson – Yes, that a difficult issue. But first of all, the atmosphere is a sense of tragedy of the commas, right. I can dump what I want in my spot of the atmosphere and it goes everywhere and mixes around. That's one of the fundamental problems with this issue, our pollution doesn't just stay in North Carolina and other people's pollution comes here. But pollution I'm using that liberally to include carbon dioxide in this case and other greenhouse gases. So why should we use anything, we've heard earlier today about, so all this talk about greenhouse gases in 2005 was the largest emissions internationally for the world ever. Go back to that diet analogy, I'm 100 pounds overweight, the first couple, the first five pounds may not save my life, but I've got to take that first step. Now North Carolina, if you look at internationally, I believe is about 20^{th} or 25^{th}, if you looked at North Carolina as a country, we would be about 20^{th} or 25^{th} in terms of CO_2 emissions. So we're pretty big, first of all. I think there are two reasons that people are acting, one of them is because I think I have a fundamental trust in people. I'm an optimist by nature and I think people see this as is an issue that we've got to tackle one way or another and we want to do this in a way that not only does not cost us a lot of money, but can save us money and improve our environment and that takes me to my second point. People who are acting on this issue see the connections across the environment. It's not just about global warming. It's about everything, it's about our waste, it's about what we pay to the federal government if we have ozone concentrations that are too high, it's about the link between pollution and lung cancer, emphemeza, bronchitis, stroke that don't factor into the cost of coal and other forms of energy that we use. I'm not here to criticize energy companies, tobacco companies or anybody else here. I am a strong advocate that without private industry getting involved with the very early on we will not accomplish anything in this. So the reason I think the countries are acting on this is because they see this as an opportunity. They see this as a way of transforming our environment, transforming the way we use energy, the amount of money that leaves North Carolina because we have to buy energy from someone else. We ought to be looking at conservation, renewables, all kinds of other approaches. They see this as an opportunity and we're going to be left behind.

Senator Pittenger – Mr. Chair I would just like to clarify. I gave some statistics when I was talking about the cost related to implementation. The cost on higher energy cost to the consumer is 2.3 billion not million.

Mr. Glasser – Mr. Chairman thank you. Mr. Jackson thank you for being with us today and I appreciate Dr. Eggers comments regarding our children's children. My question to you on the graph that talked about the next thousand years, did you state that regardless of what action we put in place today, that the earth's temperature would not stabilize for the next 100 to 300 years?

Dr. Jackson – Did I state that the earth's temperature would not stabilize for the next 100 to 300 years? I believe that's accurate, yes.

Mr. Glasser – Does that mean that it's a waste of time?

Dr. Jackson – I don't think so, it just means that this is how the earth's system works. There are these factors that come in to play. We talked about two of them, ocean level and such, they take a long time to play out. So what that means to me is that it's going to take 100 to 300 years to stabilize the earth's temperature. If we could stabilize CO_2, not emissions but concentration today, it's going to take a couple hundred years for a lot of things to come to equilibrium and 1000 years or more for many other things to come to equilibrium. For me the take home message to that is we got to get to work. But I believe that is correct, yes.

Mr. Everett – Rob, I have a couple of questions and I'm not sure who best can answer them, maybe some of the other speakers as well. But when you look at your seventh figure, I'm interested in everybody's opinion on what made those graphs go up, historically, almost vertically. Temperature.

Dr. Jackson – Someone stop me when I get there. This one?

Mr. Everett – Yes, what makes those graphs go vertically when they go vertical historically and to be consistent with kind of what you're saying at a point where those CO_2 levels reached their zenith in the past, did sea level continue to rise for several hundred years beyond that?

Dr. Jackson – Let me try to keep track on that. I think two questions there. So one of the things you notice about this figure is that the warming and the cooling isn't even, right? There's a dramatic drop off, a dramatic cooling at times, a dramatic warming as we come out of an ice age, and the answer as to what triggers that, nobody knows. We don't know what triggers that. The person who figures that out will be a famous earth scientist. There are a lot of people working on this today, we don't know the answer. We are not sure that it's CO_2, no one can answer the question. Does CO_2 rise first dramatically and then by the earth's temperature? We don't have the resolution to suggest that. So all we know is that this is a correlation, this is not a causable relationship. So I think one thing to notice is that there is an abrupt change and then the second part of your question, George what was that one?

Mr. Everett – So what happens when CO_2 levels get to the peak and if you're following sea level rise at the same time, you know, essentially if there is this close connection you would think that the sea level would continue to rise beyond that peak in CO_2 level, is that what the data might show? I just don't know.

Dr. Jackson – Yes, I'm not certain, but I think the thing to keep in mind here is that this is a five hundred thousand year time scale with where each of those data points might be, a thousand or couple of thousand years apart at least. And that the sea level rise we're talking about, centuries maybe two thousand years, I'm not sure that the resolution is there to be able to answer that. I would refer that question to Dr. Riggs.

Dr. Riggs – Coming out of these glacial events seems to be very traumatic compared to going in them. In every one it's this way.

Dr. Jackson – There's a lot we don't know about the earth's system. This was an exciting time to be earth system scientist, but there's a lot we do know too.

Mr. Garrou – Other questions? Mr. Shore.

Mr. Shore – I have a data question and I certainly endorse or support your point about us looking at this issue in terms of opportunity and that could be a lesson for this Commission as we go forward. My data question, could you go forward one slide and I'm comparing this to data that was presented by the first presenter and also I think replicated in the John Locke information that has the graph over the last 10,000 years of temperature and this graph, although there is no source in the document which shows the medieval warm period roughly seeming to be to the same magnitude of the temperature today, which is very different from what is shown on the one on the screen. So are you able to reconcile the difference, what's going on here and are you familiar with this other presentation of the data?

Dr. Jackson – I don't know if that presentation comes from perhaps the 2003 McIntyre manuscript, I'm not sure to be honest with you. Let me take some guesses and Robert might be able to make some comments too. I think one of the reasons to encourage people to pay attention to what comes out, is because each of these analyses are based on a different proxy that we call them and by proxy, what I mean is we don't have a temperature, we don't have a thermometer out there measuring the earth's temperature 1000 years ago, we didn't have one. So we have to figure a way to infer what the temperature was. I referred to a couple of these, tree ring growth might be one of them, tree ring width, coral growth is another one, different isotopics signatures. There are a whole host of proxy records to use to try to construct these. So one possible answer to that is that it used a different set of proxies to determine what the range of temperature was. Another possibility that I've already referred to is that it used a different statistical approach to analyzing those. I am not sure without having the exact paper, but all those things come into play. What are, let me finish and I'll turn it to Robert, one of the things that's important here, this is not about one paper, it cannot be about one paper. The way science works, as we all know, and the other speakers have talked about is not just one paper, it's hundreds of papers. It's what all the data says together tell us. Not just picking out one particular one, be like trying to say something about a recession in North Carolina, by picking out a couple of households and saying well this household their income's gone up 20 percent this year and their spending is up, so there's no recession. It doesn't tell us what's going on with the economy, you get as much data as you can and you look at it together. That's what these new approaches are trying to do. So I would guess it's a combination of which proxies were used and what analysis were used. And Robert might comment.

Dr. Balling – I want to clear that up, the graph comes from a series of papers by Dansgaurd et al. and from a paper by Shonezieci. It was interesting today that when Dr.

Riggs spoke, he showed proxy records from the barrier islands. If you recall, the medieval warm period and the little ice age was painfully obvious in everything that he showed. And so he would add to the mountain of evidence that this is a very real phenomenal and certainly a real phenomenal that affected North Carolina.

Dr. Riggs – I agree with that, I would not say the medieval warm period and the little ice age are quite obvious on these graphs too. They're there. They're obvious, so I agree with Robert.

Mr. Garrou – Other questions? If not, thank you for listening. We will have a break for lunch now and we need to start promptly at 1:30.

Afternoon Meeting

Mr. Garrou – Mr. Givens is going to tell us a little bit about the handouts that you received.

Mr. Givens – I just note for the record Mr. Chairman that three items were distributed to you, the slides from Dr. Ballings' presentation (**Exhibit K**) also a one page sheet entitled Global Warming and North Carolina (**Exhibit L**) from Senator Pittenger and then material entitled Global Warming Is Real (**Exhibit M**) and that's from Commissioner Smith.

Dr. Smith – Can I just respond? There's a couple other things in there also, the first is a Scientific America article talking about global warming, towards the back you'll see a handout that was done by a scientist for us on sea level rise, it basically talks about some of the more recent papers that have come out, about some of the relationships on sea level rise and the last is just an article about the rapid ice melting that we're seeing which is somewhat unprecedented, at least in recent time. There's not just that one article, there are a couple of things towards the back that I would draw your attention to.

Mr. Garrou – Ok. Thank you. Our next presentation will come from Sethau Raman, the state climatologist and we welcome you sir.

Dr. Raman – Good afternoon, I hope you all had a good lunch and it is really a great pleasure to be here. I'm thankful for the opportunity. (Handout **Exhibit N**) The climate comes in various scales as some of the speakers have pointed out. There is a global scale, then there is the regional scale and there is the masial scale and here is a micro scale. Basically, most of the information on weather you get on TV channels or anywhere else is of micro scale. What is happening to (inaudible) air temperature? Then you have this middle scale where you have how the temperature or the precipitation, these are the two (inaudible) together weighing in on a masial scale which is of upward of 100 to 200 kilometers. This is more like sea breeze circulation. And in North Carolina, we also have this famous Sand Hills circulation which has to do with the changing soil types and soil moisture and vegetation. And then we have this regional circulation which brings in the storms of different kinds, the tropical, (inaudible), with latitude mixed with tropical

storms. And then there is this global change where we can average them all out and then try to find out the temperature change. So this afternoon I'm just going to address the regional change and the local change in the climate in North Carolina. That is the scale I will be talking about and hopefully call this presentation Climate Radiation, not calling it a climate change. So these are basically climate variations and I'm not going to talk much about the hurricanes, some people ask me are your going to talk about hurricanes, the hurricanes, the intensity as well as the frequency. We have done some research on the web site, but I'm going to mostly talk about the temperature and the precipitation trend in North Carolina.

To begin with let's just figure out whether we can wash the cars or water the lawns in the next few days and the conditions right now are related to drought conditions. This is based on input from State Climate Office and North Carolina Drought Management Advisory Council on which we are a part of. And as you can see we're basically here, so we are in the moderate drought. We're already four to five inches behind normal since January 1st and the other places are basically abnormally dry over the coastal area and even the mountains, they had so much precipitation last summer, haven't had much in the past two months as you know. So as the climate changes one of the things people have to worry about is the drought. Drought is something that creeps in before you know it's already there, unlike flash floods, which we know that it is coming and it goes in a flash, whereas the drought slowly sits in. So this is the latest drought condition I thought I should inform you coming from the State Climate Office of North Carolina.

The things I would like to talk about this afternoon is I want to give a brief introduction of what the State Climate Office of North Carolina is and what it does in addition to the climate information that we provide. And then I want to give you a brief presentation on North Carolina Teleconnections. Something happening somewhere affects North Carolina, and how does that happen and what are the findings? And then I'm going to show you a few slides on observing North Carolina's climate, which is our main job. Our focus is North Carolina and then I'll show you some results on short term trends in North Carolina that we've already done and also longer term North Carolina climate trends. Short term is more like 50 years, longer term is in the order of 100 years.

So then I'll begin with a summary slide. See North Carolina has a beautiful climate, in fact that's one of the reasons why I came here. I lived in Long Island for ten years and I had an offer from New York University and North Carolina State University. And the first thing I looked at was what the North Carolina climate is like? In fact this is the information we provide for many industries that come to North Carolina. And they look at different things and once they see our climate, they always want to come here. Such a beautiful climate, you want the cool temperatures in the summer, go to the mountains, or go to the ocean, or if you like hot and humid weather climate, stay in the Piedmont. So we have all kinds of weather climate across North Carolina. And we are blessed with very good rainfall, ranging from 100 inches over here, if you really want a lot of rainfall, 100 inches over there and about 40 inches over here, and some of you haven't seen much in the past few months. But the temperature is also beautiful, so we have a very beautiful climate and we want to hang on to it if we can, when we can, sometimes it is beyond our

control, so that's our climate. The State Climate Office of North Carolina is a public service center for climate environment interactions and these are the staff and students who work there and also I wear three hats. I teach in our department, Meteorology and Oceanography students and I do research and I'm also involved in extension and research. And we have a bit of a interaction with the Department of Geography, UNC Chapel Hill, contrary to the news, we do work with Chapel Hill people. Then, (inaudible) Board Associates Climatologist and I have several people that work with them and our major strength is in terms of graduate students and undergraduate students who work with us. So we have research projects and undergraduates sort of help us with many projects and in the process learn many things too. The history of the State Climate Office was established in 1976 when the National Weather Service decided not to be involved with climate type of forecast for agriculture and there is one in each state. Most of the 50 states have one, maybe one or two don't. And then it started in Chapel Hill, transferred to N.C. State in 1980 and then Dr. Davis and I have had the privilege of being the state climatologist since 1996. And October 1998 it became a public service center that was established by the UNC President and UNC Board of Governors. And today, this is what people say, we are the number two climate office in the US out of the 50 state climate offices, number one is Oklahoma. We are very well funded.

Our mission is to provide the most accurate climate information to the citizens of North Carolina and we also assist North Carolina state agencies in climate, environment issues and other obligations. We also establish and maintain several automated weather stations across North Carolina with a system of applications such as agricultural and environment. And we also try to increase public awareness of North Carolina climate, by going into different communities, (inaudible), schools and others. And we also do some research that is essentially related to North Carolina weather and climate. In education we start all the way from kids age 12, and undergraduate and graduate students are already mentioned.

The summer belt regions we do agricultural research, based on the data we collect, we provide advisories for crop management and we have a real time high resolution weather model for agriculture. In terms of modeling, I have done, in the past 30 years, modeling of micro scale, masical scale. I'm not a global modellist, but some of the ideas that we have in this scale are agreeable to global modeling as well. Then we do partner with state agencies for example in 2002, we connected with (inaudible) in cooperation with the Division of Water Resources and then there was a drought buster team that was formed, maybe because of that the drought ended a few months later. In 2002 we had a major drought and we worked with DNER, the air quality people, and we installed and maintained sensors, needed by the Division of Air Quality, particularly along the mountains and western North Carolina to kind of keep track of what's coming into the state, I guess. And of course we have help to save millions of dollars in federal transportation funds with providing important data. And we work with the DNER Water Resources, as I mentioned, we had an adult monitoring concept and also we are now putting together a comprehensive water resource data base where you can get everything in one place. It's almost ready. And we work with the Department of Transportation, so they need to know where it rains too much so that they work with the construction

people, to build construction, so we clearly need a web site for them. And we work with private agencies, private companies like Duke Power. We just put together and drew a drought climbing system for Catawba basin for Duke Power. And we are also working with North Carolina Electric Cooperatives to provide more automated weather stations, but here it's a site sub-station we're doing.

In education, we teach undergraduate and graduate students, but we also work with kids through 12th grade. As you can see here, these are 7th graders and 8th graders, Brad Stackhouse, Rob Collins and Alex Vall and Melissa Gregory. And they did a study on global warming and urban heating just last semester. They are just finishing it up and in fact, their project won the (CNCMS) City Neal Campus Middle School 2006 Science Fair first place. And last year the group that worked with the climate office went all the way to the state level.

Now some of the research findings we see if the climate warms and the sea surface temperature changes somewhere else, is that going to affect North Carolina? It is a critical question and the global telecommunications or teleconnections, as we call it, for example, the sea surface temperature warming up in the eastern Pacific due to El Nino/ Non El Nino cycle and it called El Nino/Southern Oscillation. We try to find if there is a warming of sea surface temperature, what will it do to North Carolina's weather and climate and based on almost 50 years of data, with many El Nino imbedded in them, they come every two to seven years. And in fact, in terms of climate prediction on a real time basis, that probably has the best signal possible. In terms of saying with assurance, saying with confidence, what will happen to the weather in the next season. First thing the people look at is whether that is an El Nino or Non El Nino or is it neutral. Right now we are in a Non El Nino phase. So for example, if you are having an El Nino what happens is in winter storms, there are a lot more winter storms, like an El Nino year, typically you can get 10 to 12. But as a Non El Nino year in the winter, you get like five. So we have major flash floods in the mountains during the last El Nino which was 1997-1998. And so this is again based on 100 years of data so basically what you see is the coastal different participation increases and then in the summer, which is June, July, August, there is a decrease in the precipitation and again during the winter the precipitation starts increasing, both for coastal, piedmont and mountain all three of them, so we have an increased precipitation in winter and decreased precipitation in summer. One of the reasons, of course, is when you have an El Nino, you have a strong year over north Atlantic and so the number of hurricanes reduces drastically. And some of the precipitation we get in the summer is due to the hurricanes making land fall either directly on the coast or as we call back door hurricanes, that make land fall from the Gulf of Mexico and then track toward the mountain region.

Then we also find that when you have an El Nino type of event in the winter you get cooler than normal temperatures and warmer than normal temperatures in the summer. In fact, during the 1997-98 El Nino, we had a fairly big drought type of situation. In fact, the one that we had at the time, declared emergency for all 50 counties, and then came hurricane Bonnie once the El Nino weakened in late August. And then we got some much wanted precipitation.

Now one of our missions is to observe North Carolina climate. The day in and day out we are looking at the climate of North Carolina. And of course, what is climate? Yesterday's weather is today's climate, so we observe weather as well as climate. So if you go our web site, we have several stations, actually 100 stations in North Carolina where you can get the previous hour's weather immediately. And then it goes into a climate data base and becomes a climadata. So we have basically more than 1000 active stations and these are, some are obsolete, some are just babies. So they have maximum temperature, minimum temperature and the accumulated precipitation for 24 hours. So this is more than 1000 stations in North Carolina. But hourly data we have only 200 sites and some of them are our own and some of them are National Weather Service, some of them are FAM municipal Air Force stations and so they all have different types of data. But others have the most comprehensive which we call the NC ECONet, that's the North Carolina Environment and Climate Observing Network, which we started a few years back. We have data for about seven or eight years now and it is continuing. We have 28 stations across North Carolina that includes five that is supported by a Division of Air Quality, and one by Emergency Management, but we are maintaining it and several university stations. So there are about 28, we hope to go to 30 pretty soon. These are all new stations and our idea is to eventually have one in each county so that our 100 data observing stations, which not only gives all the routine meteorological data, but also soil temperatures, soil moisture which is very, very important for weather forecasting, agricultural management and many other things, so this is all from all these stations. Look this is a ten meter automated weather station sending permission every hour on the hour to the State Climate Office where we do quite a bit of (inaudible) and put it on the site for public use.

Now the short term variations I wanted to talk to you about, this is one of the MS thesis topics of one of my graduate students, who is now my lead (inaudible), so where he took the 50 stations of precipitation and temperature across North Carolina and looked at how the temperature varied and how the precipitation varied over this 50 year period and then plotted contour curve. What you see here was done 50 years up to 1998, 48-98. And what we see from that, the maximum temperature trends shows the pin point 0 to 5, to defined .05 degrees Fahrenheit, apparently along the course and then there are also some areas which are cooling in those 50 years. So there is some warming along the coast and there is some cooling in the middle. And the precipitation trends again there is a deficit in precipitation in the northern coastal part and an increase in the southern part. And what we found is not enough data points here to be really confident about this tremendous increase in precipitation here. But there are precipitation trends across North Carolina of varying degrees. But this is only 50 years and so one of the main problems we have in climate data analysis is we do not have enough data. We do not have enough observation and so many times the article will have proxy type of observations, tree rings and ice cores and things like that. And they have their own assumptions and so there's nothing like actually observing what it is. This analysis I'm going to show you is from what is called the Historical Climate Network. We have only five of those stations in North Carolina. They go back 100 years, so they have data for 100 years and believe me those people who have been collecting data, these are corporately observers, they are

really within (inaudible). They don't care if it rains or snows, they will go collect the data. And we have some others archived, hand written data, meticulously recorded and those folks of our forefathers, I think they really loved bringing in this stuff than me for example. I won't say than you, but than me. They are really, really, really meticulous in collecting the data. And so this data is pretty good and these have been quality controlled by the National Climatic Data Center and that's what I'm going to show you next.

We just picked randomly some stations along the coast like Elizabeth City, Goldsboro, Southport and some stations along the piedmont region, which is like Henderson, Chapel Hill, and Monroe and then we also picked up three along the mountains, Banner Elk, Lenoir, and Waynesville. And these have 100 years of unbroken data, a few solid years, some more, some a little less. I'm just going to show you how the temperature has been varying over some of these stations and we need to do all 25 stations to be more systematic. But I will show you what I have.

And this is the coastal, Elizabeth City, this shows a mean temperature over 100 years from 1911 - 2001, this is more like 90 years, and the trend line you can see there is a lot of variation. You do have the North Carolina weather and climate response to many things that were mentioned before, one is the El Nino/Non El Nino and another is the Pacific (inaudible) oscillations, which is the change in the Pacific Ocean surface temperature over ten year cycles an El Nino/Non El Nino is just a sub-state of that. And we also have north Atlantic oscillations in temperatures changing them we have these 20 year oscillation in the preseason temperature because of the currents changing over the north Atlantic. So you can see some of these things happening there, but there is a trend at least in this data, as 3.17 degrees over 100 years. And we looked at the precipitation for the same 100 years, not much change. The weather rarely changed over 2.3 inches degrees over 100 years. And later I'll show you which variation one can believe based on statistics because we have to make sure they are statistically significant. And there is also another issue in many of these things, one of the uncertainties in climate issue is the land use pattern. We did a study many years back, an undergraduate from Shaw University did it for us, we looked at Raleigh, for example, and then looked at the temperature how it varied before organization and after organization. There's quite a big change. So the land use is another area one has to be careful about in this analysis.

Now we go from the coastal area, I'm just showing only one station because of the time but I have data for other stations also. Chapel Hill, for example, over 100 years, 1892 to 1998, I think we are going up to 2002. So it's from 1892, it's almost more than 100 years, so you see the change of about only 1.16 degrees for over this much time. And we will see later on whether this is significant or not. And there will be data also looking at the maximum temperature that was the mean temperature. So you take the maximum temperature, take the minimum temperature take the average that's the mean temperature and the maximum temperature you don't see much of a change. You see the change is fairly flat. Then if you do the minimum temperature, then you do see some change, like 1.93 degrees over 100 years and again you see that these oscillations because of other features, larger scale features. Then precipitation, the thin line is basically quality control precipitation and we only made sure that there is not much of a difference between

quality control and the raw data, so that there is no artificial quality control injected into the data. And here you see about 4.1 inch degrees over 100 years, this is in the piedmont or Chapel Hill annual precipitation has decreased. There is a hint of decrease but there is also tremendous variations and then when we do the statistically significance we may see this to be not that significant, we'll see it later.

Then the winter precipitation is basically a small decrease, almost flat, and spring is almost flat 0.28 inch over several or 100 years. And the summer there is a significant decrease at least in terms of the number. This may not pass the statistical significance test, but again there is about five inch decrease over 100 years. But in fall there has been an increase that means probably because of more hurricanes coming through this region in the time period.

Then we looked at another station, Monroe because the location of that station is a little bit off the town of Monroe. So the land use is not a major issue in there and so there we find it's about two degrees increase over 100 years. In the mountains, very little change in terms of the temperatures 0.52 degree decrease over 100 years, it's almost flat, constant. Of course there was a change in precipitation about 2.79 inches, which again we found not to be statistically significant. If you have tremendous variations and then the straight line may not be statistically significant. So in terms of changes I have just summarized here the changes for example, the ones that are in red are big changes like 3.17 increase over 100 years, is probably the leading change and the rest are kind of changes somewhat, but not very significant.

The precipitation generally there is a decreasing trend over piedmont and not much on coastal area or the mountains. This is an important slide, well which ones can you believe, which ones may be don't have enough data, we cannot say for sure. These are correlation coefficients, we can see that the data that we showed there is a statistically significant change in Elizabeth City and Goldsboro in terms of temperature, mean temperature, and then again in the piedmont, Henderson and Monroe. We took 0.6 as being statistically significant considering the number of years only 100 years. And of course in the mountains there is not much of a change. In terms of precipitation, none of them passed the significant test, the temperature, at least some of them do. And again the maximum temperature none of them are statistically significant, the variations are too much. But in terms of minimum temperature, you see that much of the average temperature increase is because of the mean temperature increase. The minimum temperature increase can come in two ways. One is in terms of land use, more oscillation or another one in terms of the greenhouse gases. And that is still to be dissolved.

So in summary, one thing we are sure, even if we have warming of the globe in other areas and the sea surface temperature go up, we can have an effect in North Carolina. And that is mainly due to larger scale circulations, like this El Nino/La Nino proves beyond doubt. But this particular significant variation in North Carolina climate at some locations particularly in the minimum temperature and one thing for sure is we need to improve the density of climate observations in North Carolina for our future generations

and also for us to make sure that we covered all grounds. So this is not only climate or environmental issues for which these observations will be very helpful. Thank you.

Mr. Garrou – Thank you sir. Are there questions for Dr. Raman?

Representative Underhill – Thank you Mr. Chairman. I was wondering what budgetary requirement would be to put such a station in every county, how much would that cost?

Dr. Raman – Oklahoma is the real good role model in this. They have 110 stations and the state appropriation it's actually funded by the state. It is like 1.1 million dollars and we did a budget estimate on this, it's about six hundred thousand dollars to maintain in North Carolina because we have other funds to do the other one.

Senator Pettinger – Thank you Mr. Chairman. I thought the one slide, yes sir, is a very good presentation, but toward the end on the mean temperatures, my eyes aren't good enough to read this, if I recall correctly, the increase in Elizabeth City was about three degree and the Charlotte area it's about 0.5.

Dr. Raman – The Charlotte area which …

Senator Pettinger – The urban area was the variation was much less than the rural coastal. I think, yes that's the one right there. That's right Elizabeth City, coastal … It was just interested that the urban area had less of a change.

Mr. Garrou – Other questions? Yes sir.

Dr. Uzochukwu – Dr. Raman do you have any information about Greensboro. We experience droughts from time to time.

Dr. Raman – Yes we do, as I mentioned in the 100 year data, although the precipitation data was not statistically significant, basically toward a 90 percent confidence interval. Because of the tremendous variations, some years we get a lot of precipitation some years we get less precipitation. But the trend is clear it looks like there is a trend toward less precipitation, drought type of conditions in the piedmont over the past 100 years, we see that is contributed by decreasing some of the precipitation. So we have, for example in 2002 and again in 2004, a high pressure system that just sneaks on us. Again in 2005 there is this high pressure system that sneaks on us so it steals the hurricanes away from us, but it also prevents conductive rainfall, thunderstorms. So in fact, believe it or not, the summer is when we have the maximum precipitation of all the seasons. That is because of thunder storm activity. And then if you have a high pressure system sitting on it the thunder storm doesn't fall and that seems to be the reason for the piedmont. So there is a trend for decreasing rainfall although it is not statistically significant, goes back 100 years.

Dr. Urlaub – Looking at your data and that you have several places where the mean temperatures didn't statistically significant in its increase, I'm wondering why is it going

up, because what I've gathered from the various scientific presentations so far, and data presentations is that we've even had Dr. Balling acknowledge that the increase in CO_2 did an incredible increase that's unprecedented in the 450,000 years is anthropogenic in nature, primarily. And that increasing CO_2 acknowledged by all of our scientists can result in increasing temperature. And then also, where's that CO_2 coming from and we had one presentation that told us about 80 percent of it is coming from use of energy resources. So I'm trying to link up the pieces and what I'm seeing here is that we have scientist that people from the outside would say come from across the political spectrum and this issue has been heavily politicized over the years. And they're all telling me the same thing, what I'm hearing is that CO_2 is going up and that would drive temperatures to go up. They agree where CO_2 is generally coming from and that can do things like add a lot of energy into the oceans and raise the temperature of the oceans and add more energy in the atmosphere, and perhaps increase the propensity of the atmosphere that dissipates that energy. And it could manifest itself as more storms and more severe storms or both. If you could entertain a question for a minute, acknowledging all of that, what does this future look like, where is this temperature increase coming from and since our CO_2 concentration is so high and if we continue with our business as usual path, we have received indication that it could more than double in concentration in the atmosphere. Where are we headed with adding all of this energy into our oceans, are we looking at more ice storms because of more humidity off of the ocean, it's a lot of potential scenarios here that I'm curious about?

Dr. Raman – Yes. Often, I have shown how the temperatures have changed over the past 100 years in several places in North Carolina. The different variations in this presentation and others are we're looking at local, regional climates. And there has always been a problem of don't kill it from global models into regional scale, into local scale, because the scale is an issue that is quite complex. So the one aspect is the land use itself, land use changes can cause changes in temperature but this is not acknowledging that major slide where land use was the small portion and then climate modelers claim that the (inaudible) reason the modeling that the greenhouse gases are the major component of this whole thing. But in terms of climate there are a lot of unanswered questions one has to deal with. So there are two issues, the greenhouse gases can increase the variation that the air receives that could change the temperature. But how does it relate to local changes, this is a difficult question right now to answer. (Inaudible) is still trying to wrestle with it.

Dr. Urlaub – Can I follow up?

Mr. Garrou – Yes.

Dr. Urlaub – Then I just read an article in Scientific American yesterday and it was fascinating that these different teams of scientists have been able to trace the isotopic signature of CO_2 and they can say what has actually come from power plant emissions and what has not. And they're looking at the CO_2 in the atmosphere and in the soil and in the ocean. They found that in the Atlantic, especially in the north Atlantic, the concentration of CO_2 that they followed the signature back to from energy generations,

electricity generations and fuel combustion. What they found is that in the Atlantic it has penetrated to very deep depths of the ocean, which is significantly changing the pH of the ocean and then also the flow of the currents. So any significant change in the future flow of the currents coupled with an increase in temperature in the ocean surface temperature that we're seeing, how would you expect that to impact North Carolina climate?

Dr. Raman – First of all, I think it's probably sulfate particles that you're talking about not CO_2 we cannot find exactly from CO_2 where it comes from but most of the fossil fuels, they emit black carbon particles, in fact I was involved in an experiment called Indian Washington experiment in 1999, where we were trying to trace back where the pollution was coming from. This was from Indian sub-continent. So from the soot particles, one can say where it's coming from, then it has to be from other generations and things like that. So that's probably what they have looked at. But there is a change in the sea surface temperature at one part of the globe, it can affect another part. The El Nino/La Nino is a very good example of that. The next El Nino I can tell you, some confident meteorologist will never tell you, do forecast that confidently as you know. But I can tell you El Nino will cause more precipitation in North Carolina in the winter. That much we know for sure.

Dr. Urlaub – But specifically I was asking about the Atlantic temperature off of hard coast, the temperature rise there, what kind of impacts do you see there?

Dr. Raman – In fact, I'm not showing it, we have looked at the precipitation distribution over Fayetteville over the past 50 years, and you see the detail oscillations because of the north Atlantic oscillation. North Atlantic temperatures do change some of the circulations. But mostly the Pacific Ocean is what we are concerned about because that's where most of the air masses come from.

Senator Pittenger – Thank you Mr. Chairman. I would just like to clarify, with due respect to the previous comment, I believe I understood that our first two speakers, Dr. Riggs and Dr. Balling, to state that there is no correlation between increased CO_2 and the climate change caused by human activities and that increased CO_2 was due to natural causes. Dr. Riggs stated that CO_2 levels in the atmosphere changed dramatically over the last tens of thousands of years.

Mr. Cecich – I thought specifically asked the question, did he correlate CO_2 increases with temperature and he said absolutely. He's not here now I take it. So I ask that question directly.

Senator Pittenger – Who's he?

Mr. Cecich – I thought the response was that yes, there was definitely a relationship. Our first speaker Dr. Balling from Oklahoma.

Senator Pittenger – I had lunch with Dr. Balling today and I can assure you he did not say that.

Mr. Cecich – I thought I heard, well we'll have to ask the other people, but that was the specific question that I asked him.

Senator Pittenger – I can get a written statement from him for you.

Mr. Garrou – We have a record of what your question was and what he said and we'll look it up. Any other questions? Thank you very much Professor. To remind you at the last meeting we determined that we would have a report each meeting from the Climate Action Plan Advisory Group of DNER and Brock Nicholson will give us that report now so that we can keep up with what they're doing as they're working in parallel to what we're doing.

Mr. Nicholson – Thank you Mr. Chairman. (Handout **Exhibit O**) What I would like to briefly do today is in this report just give you a quick review of the CAPAG, Climate Action Plan Work Group Process, very briefly. The report on our first meeting was held on February 16th. Share with you a list of members and then talk a little bit more about the work group process that we have set up and commenced, at least initially commenced. We haven't really had any first meetings yet, but I'll tell you about that and which work groups are set up and the members at this time. And then how the CAPAG and these technical work groups can help this Commission. I'll talk about that a little bit and just briefly share with you some of the emissions inventory results that were prepared actually by DNER and DOT with the assistance of consultants for our report that was submitted to the Legislature in September. This is an emissions zone, greenhouse gases both in a base year and projected. And then give you a little insight on some discussion that occurred at that first meeting regarding perhaps options to consider for policy and other mitigation options.

The purpose and goals in the CAPAG and again I hope I've sufficiently defined these acronyms, but I assume this term will take on a life of its own. But basically the charge is to develop climate action plan recommendations. And this will be a range of individual policy actions or mitigation actions. We will look particularly at the cost and benefits of these proposed actions or recommended actions and especially on economics, we want to understand the co-benefits that such an action may have for various industry sectors in North Carolina. We do believe there are plenty of opportunities for there to be positive economic benefits for various sectors, particularly the forest products industry. Across its whole range of activities, agricultural industry as well as general business and industry in terms of saving energy, quite frankly, the various measures that could be considered here. So we think it's not just a one way cost kind of issue for the benefit of the environment and reducing greenhouse gases. Certainly, that's a goal we want to achieve but we think there are also economic benefits to society to include even increased jobs in various sectors, maybe creating new industries. And part of our analyses will attempt to quantify those expected benefits including jobs.

It is a consensus, state cola process, one of the advantages we see in this effort is that we have all of the parties around the table at the same time considering these options and

doing a give and take and understanding what we really need to do in terms of analysis on these various options and the part of the advisory group is to give guidance to us and the consultants on what we need to do in terms of analyses. And certainly, last but not least to support this Legislative Commission in what you feel are important technical questions.

Again, I mentioned this is a facilitated state cola process it is consensus based decision criteria including greenhouse gas reduction potential, cost effectiveness, co-benefits and cost, like I just mentioned, feasibility issues. Is it a great blue sky idea or is it really practical and feasible? And of course again, I emphasize the economic analyses that we will do in this process.

I think I presented this last time, sort of a ten step process. The red indicates some of the activities that have already begun here. I will not read down through this, it's in your notes and hopefully not too fine a print. But basically, it's to again consider all the possible options, everybody has an equal opportunity to put options on the table at the outset and we will evaluate those, go through a process and hopefully come to some consensus on the configuration and recommendation.

The first meeting was really kind of a get together and welcome for the get started meeting. We did cover the Clean Smokestacks Act report findings and recommendations, we did talk about this process that's occurring by this body and we reviewed some of the history of state climate actions around the country. We talked about our process, settled in on that, we talked a little bit about emissions inventory and we did just go around the table and look at some suggestions that people might have on what we should be looking at or how we might begin to analyze those possible actions. And we did form the technical work groups solicited indications of interest for the technical work groups and we had some limited public input at that meeting also.

The members are from many diverse backgrounds including several from this Commission. In fact, I think my count recently is about nine or ten members from this body are also on the advisory group or on a technical committee, maybe not on the advisory group itself and we're pretty flexible about that. And I'll recommend you look at the list on the back side of the handout here. On the left hand page are the members of the advisory group and then I'll talk about the work group a little bit later. Well I guess right here, actually.

The work groups that we have broken it into are by necessity, I guess as a practical matter you have to divide it up somehow and you need to have a meaningful number. But this is the break up that I think most any optional suggestion that might be offered, we'll fit it into one of these work groups and give it a fair consideration. But energy supply, power generation of all sorts, residential, commercial, industrial energy use, and industrial processes, and of course between those two, I guess it's every aspect of energy production and consumption at various options for maybe operating in a more efficient manner. Transportation and land use, certainly, fill a broad area there. Agriculture and

forestry options and then cross-cutting issues, are reporting, registry, outreach in education and so forth.

The members, these if you would, subcommittees of the Climate Action Plan Advisory Group, 40 plus members from many diverse backgrounds, includes again, several of the Commission members on this Commission. Open to others, and I might want to emphasize this point, if there are other members of this Commission that wish to participate on a work group, you are certainly welcome. We would really welcome that additional participation if you wish. And it also includes experts who are not necessarily the advisory panel members but can offer considerable technical resource. And I commend you to see the handout, I will make one note on the handout, we inadvertently included Mayor Pat McCory on here and we're yet to solicit his agreement to participate. So I apologize to him and anyone else that we should not have had on there, but I wanted to point that out. We would like to have his involvement, but we have not secured that yet. I might mention also that as far as the technical work group and maybe I'll give a slide that gets into this a little bit later, is that we have our consultant and various members of the technical team that will be handling each of the work groups as advisors, as leaders, as technical resources, also. And that's from the Climate Change Strategy Workgroup.

The role of the technical work groups is provide recommendations, certainly, identify potential mitigation, policy options, identify early priority options for analyses, obviously this is important at the outset of the process. A crash strong proposal option, including policy design and implementation methods, proven methods for cost benefit analysis, assist with data and analysis, identifying sources of data and so forth. Assist with evaluation of additional issues, such as co-benefits and detail cost break down, as needed. Identify and develop alternative approaches for policy options. Certainly people from different diverse perspectives may have a better way to do it so to speak or propose it and we want to hear that if it's time. And contribute to drafting language for the final report and options to be carried back to the Climate Action Policy, Common Action Plan Advisory Group itself.

The first meetings which we hope to kick off here in about another week and a half to two weeks by phone. Many of these meetings will be by conference call, by the way, to the technical workers. But certainly to review and expand the list of potential options, and I'll remind you that those options are contained both in what the climate consultant has actually provided for us on 250 potential measures taking the advantage of having the people stops around the country. Plus specifically what we had in our report to the Legislature in September and it's to review the emissions inventory and forecast which I'll share with you a little bit of a summary momentarily. And to review proposed technical work plan and meeting schedule for the particular group and prepare suggestions for the next meeting.

Support, again, facilitated from upwards of 15 climate center strategies members, the task force here, as well as state agency, technical folks and there are these five work groups as

I mentioned again. And I think I mentioned there being a facilitator and lead consultant for each member of the consulting team.

Now I want to go back to just touch on a little bit the section in the legislation for this Commission and point out that some of the ways that the Climate Action Plan Advisory Group and the technical work groups can support and have in a sense provided some base line information towards this Commission, it's contained in Section 5B, C, D and F. Note how we have perhaps already given you some starting point for your work.

First of all under "B" Actions Taken By Others to Address Global Warming – We have completed a compendium of existing state and regional actions on climate change in the US for the CAPAG and that is certainly available to this Commission. And under "C" An Examination of the Emissions of Greenhouse Gases – We did deliver a base inventory plus projections for two future years as part of the Clean Smokestacks Action requirement. "D" An Evaluation of the Economic Opportunities - and as I said already, we particularly want to focus on the economic opportunities here for these various options under this charge of this legislation. That's one of our primary tasks under this effort. The cost, certainly, will be analyzed as part of this effort. In specific language in the legislation, we talked about this Commission shall consider and integrate the findings of the Clean Smokestacks Act reports that we turned in and prepared in September. They were actually a series of three reports, the last and third being submitted this past September with a number of specific recommendations in it to be further considered. And I guess on that point in terms of the ruling advantage I see in both this body and the Climate Action Plan Advisory Group, is that the Advisory Group will really be focusing, maybe a little more narrowly than this body on those particular actions or mitigation measures that makes good sense for the state. And it's done it in kind of an environment of stake holders around the table at one time. So we have the advantage of, again, that give and take in sorting through those options and certainly this Commission has full advantage of the results of that dialogue, in particular with common members. I think you will certainly share that advantage of that stake holder give and take in that process.

Our economic sectors, I think we've sort of touched on this, again, our work groups are lined somewhere along these lines and intend to cover all aspects. And particularly under waste management down there I want to emphasize we want to look at options for dealing with our immense amounts of bio-waste that we have in the state and potential for alternative fuels that can provide for North Carolina. We also have good greenhouse gas reduction benefits. Policy mechanisms, again, just as a review, recommendations could take the form of voluntary agreements, technical assistance, information and education, that's a very important one. People understand what they can do, financial incentives is probably a big one here. They don't all have to be regulations or laws or requirements with them being laid out options that make good sense from an economic incentive standpoint. The codes and standards for energy efficiency, maybe we really need to look at what codes we have and maybe where we need to fill in a little bit there. Again, market based approaches, reporting and registries, which we think is a very important aspect down the road, especially if we get to our carbon market concept where

people that take actions to help sequester carbon, really can get paid for that. I mean there is value in taking those actions, and then certainly others.

I don't know how clear this is to you, but it just gives you a quick snap shot of the percentages of where greenhouse gases come from in North Carolina versus the US. You can see electricity is a pretty big one. Transportation is a very large one at 29 percent in North Carolina. Industry wise we're a little bit less than the national US average. But electricity use and transportation together, you can see in North Carolina is 70 percent by the label up there versus about 58 in the national total. And then in terms of trends for the future up to 2020, you can see some of the sectors are, I don't know how clear it is in your handout, but the electricity again is the top one, the big one up there. And in this particular calculation, the narrow yellow line is electricity imports, so in this calculation, we do account for activity in North Carolina that demands electricity even though it's produced outside as a net electricity import in North Carolina. Then residential/commercial institutional is sort of the purple one, that's not insignificant so you can see where codes might come into play there. And transportation gasoline is the darker, sort of purple I guess, below the violet color and the diesel is the gray one below that and then they get a little bit smaller as we go down. Agriculture being near the bottom and waste management right on the bottom there, in terms of emissions of your greenhouse gases, in this case, it's the million metric tons of CO_2 equivalent, so it's other greenhouse gases that converted to CO_2 equivalent.

Well, I mentioned I was going to give you a little bit of feedback from some of the verbal suggestions when we kind of went around the room at our first meeting and it's sort of divided between policy ideas, and we like calling policy actions or mitigations measure ideas too, and then information request. I don't know that we want to spend the time going all the way down the list, but in terms of policy ideas, maybe touching on a few of them and again I hope you can read that in the fine print. Energy efficiency and conservation has got to be up there, renewable energy sources, again, nuclear power was mentioned. Environmental portfolio standard which was talked about much like a renewable portfolio standard except there more in depth broader than just production of electricity derived from certain renewable sources that includes credit for energy efficiency too from the extent it can be quantified. Our public benefits fund which are some terms perhaps you are familiar with, transportation controls, anti-idling technologies to save fuel again, a tremendous amount of diesel fuel is consumed in this country every year just by idling trucks.

Forest and agricultural carbon sequestration, I think that's an obvious one again. Forest health protection that was mentioned as something we need to pay attention to. Agricultural waste regeneration, recycling, market forces, the four regulations, make sure we get some desired results by looking at options for market and financial incentives to do it versus the regulation, kind of commanding control approach. Certainly education is a big one and the last suggestion here was link state action to regional and national policy options.

In terms of information request, ways of looking at some of the options, there were suggestions to use, what we call, full-life cycle analyses in terms of cost. Use best information and analytic resources, of course, we would want to do that. Examine how regulations effect greenhouse gas emissions. We're doing something in a regulatory context that just doesn't make sense in terms of preventing us from either getting the benefits of reduction of greenhouse gases or in itself is maybe creating more. Certainly, using a transparent means of examining benefits and cost of various policy options or action options touched on that already, we definitely want to emphasize that. And examine the cost to consumers who are producing greenhouse gas emissions with special attention to lower income sent to consumers. And understand that in natural systems, we need to insure quality of life and how to connect these to management of public and private lands, water bodies, military bases, etc. Examine the threat to disturbances to forest, and when we look at cost, ask cost to whom? Examine the win-win options, obviously, examine the regulatory barriers, somewhat akin to the one I mentioned earlier. Institutional barriers to greater energy efficiency especially are the things that we obviously need to consider in terms of (inaudible). Way of doing business that precludes getting maximum benefit to energy efficiency improvements. Ask how North Carolina can lead our cultural change towards a stable development, ask how do we educate the public about these issues, again the issue about education coming in here. How can we restructure our communities to better conserve resources and increase energy efficiency? Again, kind of touching a little bit on the land use area, examine trend toward conversion on agricultural land.

Schedule – we have our next meeting on May 15th here in Raleigh. There's a pretty good gap in time but we hope to get work groups and committees doing a good bit of work prior to the next meeting of the Clean Air or the Climate Action Plan Work Group. And we're really targeting a total of six meetings, so this will be our second of six in May and running through the spring of 07, probably June 07 is the general time frame. Certainly, the work product that we're looking for is a recommended climate action plan that will be presented to this body and to the legislature or as appropriate to the administration. So the summary here, I think I showed this slide last time, but I think it certainly describes pretty well what we feel like our process is here and we think it's one of the compliments that support the efforts of this Commission. Provides that sort of technical support to this Commission in the focus of looking at mitigation actions or policies as opposed to maybe some of the broader questions that you'll be facing here in this Commission. We sort of focus on that, provide that self service to this group too. Certainly emphasizing, economic boast to the state economy, including estimates of jobs, job gains to the extent we can do that. We'll certainly try to do that. And certainly, on going coordination with and reporting to this Commission. So with that I will be glad to answer any questions.

Mr. Garrou – Thank you Mr. Nicholson. Any questions?

Senator Pittenger – Thank you very much Mr. Chairman. Thank you for a good presentation. On the public benefits, that slide, if you could help me understand the transportation controls. What all do you mean by that?

Mr. Nicholson – Well, I think what I was reflecting there are comments that members had made, kind of going around the table and I don't know if I can correctly convey all of the thoughts that they had in mind. But certainly the broad question of since it's such a large part of our inventory, surely we need to look at possible things that could be done to look at reducing emissions from that sector, I hate to guess what some of the options could be, but I suppose they could range all the way from minimizing vehicle miles traveled through various programs, whether it be public education incentives, or even fuel economy in state vehicles, for example, or rather fleets in reducing the emissions from that sector. But I think it's the whole gimmick, I don't think we precluded or focused on any particular, narrow aspect of that now. It's any and all things that could be possibly considered in that sector.

Senator Pittenger – I would like to say I think there are a lot of excellent benefits to what some of your recommendations that are related to global climate change.

Mr. Nicholson – Right and I think that's what we want really try to draw out in this process is to understand those that just makes good sense and they're on right.

Ms. Tompkins – Mr. Nicholson are we to understand that the only states or regions that are in your compendium of the models we might look at, non of which seem to be in the southeast, is that correct? I'm looking at Appendix B in a book we got last month.

Mr. Nicholson – Well, you're probably speaking of the ones that have actually gone through a similar formal stake holder process that we're describing here, I presume.

Ms. Tompkins – Looking at the report of 2004.

Mr. Nicholson – Ok, 2004 – I'm trying to recall all that were in there, but I presume we were talking about (inaudible) Sound, Connecticut, Arizona, New Mexico and Pennsylvania and others. I don't think we're limiting ourselves, but certainly we referred to those specific processes and measures that have come up through those that we want to I guess take advantage of some thoughts that others have put into it. But, that's certainly not a limited list of potential measures for us to look at, by any means.

Ms. Tompkins – So can we understand that you will be looking at our regional and nearby states?

Mr. Nicholson – In terms of regional, one of the recommendations that we made as you recall, is for us to seek opportunities with our neighbors in this region. And we actually have initiated that process in a very informal manner so far with Georgia, South Carolina and Tennessee where we commenced calls with the air directors. And at this point and time, we are just discussing with them what we're doing, inviting them to kind of observe, if you would, and try to encourage them to look at doing similar things, especially with the question of registries and record keeping and doing those kinds of inventories. If there's a sense that to make that most meaningful, it can't be just one state doing it, kind of an isolation, it really ought to be done as a broad region if not really a

whole country. And so we'll be looking at those opportunities too. Tom Peterson, who is our consultant, I think, is going to help me with part of our response.

Mr. Peterson – I am Tom Peterson. I am the Executive Director of the Center for Climate Strategies and we've been invited to assist DNER with their process. The compendium of actions that is included in the CSA report and will be included in broader form for the DNER processes, it's based on actual state actions that have been undertaken in all 50 states and all sectors and across all different types of policy mechanisms. It includes actions that were taken directly to reduce greenhouse gases, but also includes actions that were not undertaken for that reason but have that as practical effect. So things that are coincidental in nature as well as things that were done deliberately to reduce greenhouse gas emissions, but any of that have the net effect of actually having reduced the emissions.

Mr. Garrou – Other questions of Mr. Nicholson? Thanks Tom. In the back.

Mr. Hanes – Thank you Mr. Chairman. My name is Matt Hanes, I work for Piedmont Natural Gas. Last week, the EPA issued a draft, Greenhouse Gas Emissions Inventory, for the entire United States. Has the Division of Air Quality had a chance to look at it and if so are they going to respond with any sort of comments?

Mr. Nicholson – Well I think the quick answer is no we have not had a chance to look at it. I think we want to look at it and then we'll decide what kind of response we need to give. We feel like our inventory is certainly more specific to the state and we'll certainly compare it with what EPA has compiled. I think the last point I would like to draw your attention to is this slide here which has our Division of Air Quality website on it, as well as a website that we've set up for this CAPAG process, http://www.ncclimatechange.us, so I recommend that you, they're linked together, can go directly to http://www.ncclimatechange.us, you will see essentially the report of each of the meetings, schedules and also once we start looking specifically at options, you'll see a lot of material on this site. It will be coming pretty quickly, so again I would recommend that and again I would solicit any interest by any of the members here that would like to participate. I know we have some that are and I think they're pretty enthusiastic so we would welcome any others who would like to help out on this part of the process.

Mr. Garrou – Thank you. As you will see that's the end of our formal agenda of presenters for today, but as we did last time, and I think we'll do in the future, I would like to open the floor for any discussion that the members would like to have for suggestions about future meetings and what not.

Senator Albertson – Thank you Mr. Chair, just a comment and a question, as a non-scientist, I of course have to rely on what the scientific community tells me when it comes to me having to make a decision about this issue, I know President Clinton, I've heard him say that global warming is taking place and I was reading an article that quoted President Bush at the GH Summit meeting in Glen Eagle, Scotland and I would like for staff to find out, in fact, if this is his quote. "I recognize that the surface of the earth is

warmer and that an increase in greenhouse gases causes by humans is contributing to the problem". I would just like to know if that is in fact a quote from him if someone can find out.

Dr. Crawford-Brown – On that issue I can say that is the quote, I was one of England's representatives at the GH meeting. I didn't vote for George Bush but well done, well done George. You will find that quote to be accurate. Doug Crawford-Brown. I like the presentations we've had today, I'm going to ask a question about when we'll move past those presentations for the following reason. I think there are two sins of uncertainty, one is the sin of hiding uncertainty and there are plenty of us on the environmental side that have hidden the uncertainty. A colleague of mine, Jim Hanson, sit up in congress one time and said, scientists should not be talking about the uncertainty of climate change. That it's going to play into political motives and boy I took him to task on that. There's only one thing as bad as hiding the uncertainty and that's hiding behind the uncertainty and I also want us as a committee not to do that. I think that it was nice to have Robert Balling here today, it was nice to have Robert Jackson here today, without being too controversial, I'll say I don't care what their opinion is, I don't care what the opinion of a scientist is, I care about what the opinion of science is and science has spoken through the National Academy of Sciences, through the American Association of Science and so forth. And that voice has been pretty clear, having said that though, I think the uncertainty is still pretty large and I would like for us to move past the uncertainty very quickly on this Commission but then always keep in mind that the policies that we adopt have got to be consistent with that level of uncertainty. My contention would be that uncertainty is pretty profound here, it certainly is large, larger than the uncertainty I deal with in any other environmental area. But I do want us to move pretty quickly over to asking questions like: What are we going to do now in the face of that uncertainty?

Mr. Garrou – Thank you. Mr. Toben.

Mr. Toben – I also am comfortable moving past the discussion about the uncertainties and agree that there are numerous ones. I am kind of moving to the point where it seems to me that whether it's another round of speakers or just a structural shift, that the questions of how far must we go in greenhouse gas emissions to reach this inflection point that folks are talking about, is the question that I would like to see discussed and, you know, to get to some point of understanding of, folks today said well Kyoto doesn't take us far enough. Well, what does take us, you know, far enough in order to at least begin to move that curve to hit that inflection point that folks are talking about. And then I think the other thing that I hear that folks are pretty much in agreement with is the question of how do we do that in a way that is basically net neutral to the state economy. I don't think there is anybody here that wants to slow down the economy or to depress the economy with these actions. But, you know, I read comments like the one from Paul Anderson from a year ago and these are industrial folks, these are folks that have clear vested interest in the outcomes of discussions like this and he stated in a speech on April 7, 2005, Paul Anderson of Duke Energy, "Global climate change is one of the most pressing issues of our time, few scientists disagree that the climate is changing, but there is much debate about it causing effect. Nevertheless, there is general agreement that

climate change is likely, being influenced by human activity and reducing greenhouse gas emissions has become a worldwide political and social imperative. It is an imperative where American leadership is not just needed, it is required. But it's clear to me now that we have to move to mandatory measures to get real results in a fair manner. Let me underscore an important point on global climate change, we have great faith in American innovation, demand needs to be less carbon intense that will spur the kind of technological innovation that we saw in the last century. Innovation that propelled us to become the world's leading economy. Set the right goals and Americans can and will lead the way." And then again from a company within our state here, ALCOA, has concluded in their positioning statement from 2005, that available evidence in the case of greenhouse gas emissions from human activities effect climate. We recognize the risk of significant climate changes and issues of vital importance requiring action and have committed to reducing our direct GHG emissions to 25 percent below 1990 baseline on a worldwide basis by 2010, but the potential significant additional reductions through major technology improvement. So my point in reading these two is just that, I think it would be useful to begin to move from the discussion of science, to a discussion of where we need to go and how we get there in a way that doesn't negatively impact the state.

Senator Pittenger – Mr. Chairman I would like to hear from some additional people, I have submitted three names to Mr. Givens, one from Harvard, one from MIT, and one from UPA. In fact, Dr. Vinson from MIT is a member of the National Academy of Sciences and I just think it's some good folks that have something to say to us before we make some decisions that could be a bit premature.

Senator Cowell – I think the move to work forward, I had submitted to both of you some ideas on how to break down into work groups and in terms of marrying some of the work that the, I forget what the name of the committee is, but Brock Nicholson reported parallel committee. If we could start breaking down into those groups on utilities and transportation and energy and maybe put science to as a separate work group, we could start moving at a more rapid pace and getting into some of the questions I think we all want to get to.

Mr. Garrou – Thank you, one of the things we do have to consider though is not to duplicate the effort of the DNER group. So we'll have to give some thought to how to tie the two things together. Thank you.

Dr. Crawford-Brown – I've got to respond to the idea of having more people come in. If the rules of engagement here are the one side brings in experts and then the other side brings in experts, like under the old Frye rules in court, we're going to be here all year long and the science skeptic side is going to run out of people way, way, way before we do on the other side of this issue. It's just isn't a contest in that regard, but the courts dealt with this ten years ago when they switched from the Frye rule to the Daulbert rules in science and said, look it's not an issue of whether you can get a scientist to support your position. Of course, you can do that on any issue, you can do that. The issue is how do those scientist stand in relation to the scientific bodies that have passed judgment on these issues. And again, we can do this all day long if we want to it will be the same set

of ten or eleven people who will come in on the science skeptic side. And I'll tell you as a scientist, I'm already a skeptic, you've already convinced me that uncertainty is massive in this regard.

Representative Wilkins – Mr. Chair I really didn't want to be recognized but since we're there you might as well hear from me. At some point everybody in this room is going to have to come to understand that whatever comes out of this Committee and becomes final action, it's going to have to be something that the senators and representatives can sell. If we can't see it to our colleagues, we might as well pack up and go home now.

Mr. Shore – So these are some comments on what our process could be to move from our science discussion to getting into the heart of the issues that the legislators might bring to their colleagues and so a couple of things crossed my mind. First, we have two input processes going on, one is that we are gathering information ourselves, the second is that the DNER process will provide some results to us and I think what might be helpful to start thinking about now and maybe have a discussion on during the next meeting, is what do we want the end process to look. So a year from now, we start wrapping up this work, what is it that we're delivering, are we pulling out five key recommendations, do we have a compendium of ideas that legislatures could choose from, do we have some common statement on the science, a whole ray of things. Where are the win-win opportunities, what will the carbon market place mean to North Carolina, what do we want the end result to look like and as we get a sense of that, then we can come back and figure out in the ten meetings or so, that we'll have, what needs to happen for us to get to a result. Senator Cowell mentioned subcommittee, if we were to have subcommittees, how would those be integrated with DNER's process already. So I would love to think more as a group what this process should look like.

Mr. Urlaub – Along the lines of the last few comments, I would like to say that I really would like to avoid another meeting like today. I think we've had two where we've had a lot of scientific information, a lot of duplication of even slides that were presented to us in the PowerPoint. What criteria do we want to apply here? I'm hearing statements from individuals, when we get away from the science presentations and discussion, people are sharing criteria with us, with each other here on how we want to evaluate the deliverable of this Commission. Perhaps we can have a discussion on what criteria we want to apply to our decision making process. Maybe we need some kind of filter for us all to run our discussion through. I've heard one, you know, economically cost neutral. I've heard another that we don't want to replicate other efforts. Generally, we've seen that there's this severe problem that's global and it's local and how much of a dent can we make in it, we've discussed that. Now what can we actually do and what basis do we want to make those decisions. I would really like to get to that. I think everyone's spoken their uncertainty. We've had some very convincing analogies on how uncertainty has been dealt with in the past on smoking and other issues. And we have to do right by our state economy. We have to continue growing economically and we have some serious decisions on the table we can address through climate change. So I look forward to moving on. Thank you.

Mr. Glasser – Let me suggest to everybody that everybody on this Commission comes to this issue from an entirely different place. There are some of you who have long since made up your mind about these issues based on a lot of information, a lot of reading, a lot of expertise. There are others in the Commission who are essentially new to the issue, so the decision as to how to proceed and how quickly to move to those things that all of us are interested in, has to be something of a comprise between those polar opposites.

Mr. Urlaub – Can I follow up? I would like to recommend a process that is more discussion oriented amongst the Commission members. I'm not hearing from a lot of Commission members and if they do feel that they're lacking knowledge, I would like to hear what remaining issues instead of saying I would like to hear it from scientist X, Y, and Z. Maybe I would like to better understand the issues X, Y, and Z and maybe we can go from there. I feel like a lot of these scientific issues that we've raised are ones that were resolved in the professional journals and through professional discourse in these various associations over the last seven to ten years. And I don't think all of us are PhD's in these fields and could resolve these ourselves. But we could have more discussion to figure out what we want to understand better.

Mr. Glasser – Mr. Chairperson, speaking from a businessman's point of view. I actually value the discussions both in the first meeting and today's meeting and it's interesting to hear the points that didn't come up in the first discussion that came up in the second discussion, and that is important for me to hear. The thing that's missing for me is I think the problem is readily determined and easy to understand. But what's missing and we've heard no conversation is, what's the economic cost to do anything about it. If there's anything that we should be discussing, is what's the economics of whatever plan we decide, and that conversation has been missing in the last two days. Other than a few conversations from Senator Pittenger, that's been the only comment about the economics of a fix. So if anything, I would suggest some discussion regarding the economics of anything we do decide. Thank you Mr. Chairman.

Dr. Eggers – I've had some frustration or concern about exploring uncertainty for a long time. I realize we come from different backgrounds in this room and that people have varying levels of expertise on the issue. There's a significant majority of scientists internationally on this planet who are coming to the table and basically saying approximately the same thing or agreeing to the same thing that they think global warming is real and a concern and I guess approximately next month the next IPCC report will come out and according to BBC last week, that report will contain language that is different from previous reports. Previous reports said that global warming either is happening or it's about to, we're not sure. And the report that's about to come out says we're seeing it now. So that will be kind of interesting, there's additional movement in that direction. We can bring in more people and more people and we can bring in three people who are skeptics and two people who aren't and I don't think it's a good use of our time to spend a lot of time on that. There's tremendous expertise and ability in this room that should, I think be used in other ways. Also, additional people will not change the fact the majority of scientists are weighing in on one side, and there is an increasingly

small minority on the other side. But I think a good analogy for folks who don't come out of the scientific community might be having a heart attack and we've all had not heart attacks, but we've had experiences where we've gone to doctors and gotten different opinions or perhaps a wrong opinion. And if a person has a heart attack they might say get ten opinions, let say eight or nine of those doctors say you should put in a stint. Then one doctor says what you need is goat's milk, you know. And then another doctor says go exercise and take aspirin and you'll be fine. Most people would really consider the fact that the vast majority of doctors are saying one thing and that's because we recognize the value of expertise in that area and it's the same here. So I would request to the co-chairs that you consider how we spend our time in the future, at least if there are more folks showing basically the same slides, that you also allow people to present ideas that could constructively contribute to us moving forward. Making recommendations that in the end really, you know, the legislature will decide whether they're acted on anyway.

Dr. Smith – Thank you. I want to go back to this concept of how we proceed and how we can keep the dialogue going but given that bringing everybody together, everybody's time is very valuable and we want to be as productive as possible, plus my understanding is that we'll be taking a very significant break during the legislative session. I like the idea of these committees. I don't anyway want to stifle the scientific discussion. I think it will be real positive, but much of it could happen at a subcommittee level where we do have some ongoing dialogue about the science and we could have, I think, agreements to disagree on certain points. To get to the point that the gentleman wanted to focus on economics, I think you're not going to be able to do that at a macro level, you're actually going to have to do it at a sector level to really begin to get the clarity and understanding because different responses and different potential opportunities are going to affect different sectors in different ways. And my sense from seeing the process that DNER has put together is that they made an attempt to break into some sectors and I would like to focus the conversation for a few minutes on how this group could interact with that. Because there are some of us that are serving in both capacities, I think there is a value in efficiency because much of the discussion that we will be having and struggling with here is going to be welded there and I know that I'm busy and I know that George over there at Duke Energy is busy, but we're both going to be wanting to focus in on some of the same points about the utility sector. And so I would like to understand how we might be able to interact more substantially and maybe ask Brock and the others there at DNER if, I take it there's an open invitation to participate, maybe this group can provide some guidance and charge that some of those subcommittees and see if we can work effectively together. Because I think that would be a vehicle that we can begin to dig into some of these economic questions and then be able to report back, based on not hearing it for the first time, but actually having formulated our thinking somewhat at the subcommittee level and then bringing subsistence work back to this group so that when we do get everybody together, we're not sort of randomly put together, but we're actually bringing together with a very sharp focus. But we can begin to narrow down on those points what we need to discuss at this level.

Mr. Garrou – As we consider this issue of the subcommittees I think it would be good if we could hear from you about (a) what subcommittees you think we should have and (b)

what subcommittees you might be interested in participating in, (c) how you think we could interface with DNER's efforts.

Dr. Smith – Well I think that the Senator mentioned earlier, I think clearly there is, from just looking at the break out of some of the pie charts, I mean we know that the utilities sector is going to be an area that we need to focus in on because of both it's contribution, potentially it is it's known contribution to the problem, and the fact that responses will have ripple effects through the economy, how we deal with that. We also know transportation is a significant sector that we need to address and then I think there is the opportunity and the impact associated with the industrial sector on some of the small business commercial sector. My understanding is that all three of those have been identified. There's also the Ag and forestry, which I think is both potentially impacted and potentially a winner in this in some of that. So I think those are four that I see significant overlapping that we should find ways to bridge very clearly. Now I would add, some of the comments about the science, that we ought to have a place where we can continue a robust scientific discussion and in no way to stifle it. I think a committee of those who want to engage and learn more and hear from various people might be a fifth potential option as opposed to spending 90 percent of these meetings, you know, sort of barreling back and forth. I think that we could probably crystallize some of the issues more effectively at a subcommittee level.

Senator Cowell – I think marrying some of the prothesis that some of the other states have done is not a negative but a benefit and that we can learn all of the things that they have produced, and really start on their shoulders and build from there. And I think Mr. Peterson, who was here earlier, his website, I think the breakdown by sector in addition to maybe having a science committee is pretty typical across the country from the websites I've looked at and I think that would be a good way to go.

Mr. Howard – Mr. Chairman like a lot of other people here, I'm coming at this from a not so educated perspective. I've been trying to education myself over the last couple of months. And I have a lot of respect for Dr. Crawford-Brown and what he just said. I don't disagree that the science as best I've been able to read is kind of unified around the global warming. The real question for me is that level of uncertainty and I'm trying to get my hands around that and I don't know what it is, I don't know how much to be concerned about it. But as we move forward to develop policies for our state, I want to understand what that level of uncertainty is and factor that into whatever policies that we ultimately adopt. Also, I am part of the work group that Brock and the Division of Air Quality has put together as are a number of other people sitting around this table. That group has already divided itself into some subgroups. I can't imagine that there's very much discussion that's going to take place at any one of those subgroup meeting, that I'm going to want to miss, I should say and I don't personally like the idea of separating this Commission into subgroups to study certain areas. I want to learn about the science, I want to understand science, I want to learn about what it's going to mean to the electricity sector because we're all going to have to pay for it. I want to know what it's going to mean to the manufacturers because that's who I represent. I want to know what it's going to mean to the residential home owner, because I am one. So I just want to

caution us not to in the interest of trying to satisfy those on the Commission who already are leap years ahead of me in their understanding of this issue, not to leave the rest of us behind.

Mr. Shore – I respect Preston's point at the same time that for us to be efficient, I think we need to figure out how we can best use our time as a committee and as individuals. This is a huge issue and if we are to try and eat the whole elephant at once, we will get no where. So I would encourage us to really think about what do we want this end product to look like, how do we divide up, how do we bring things back to the whole Commission so everybody has the benefit of the individual work. And also, since there are so many pieces, I don't know if there doesn't need to be some kind of steering committee or something, maybe the chairs and George Givens would do this work, but if there doesn't need to be some group that doesn't deal with the substance of the issues but here all these things are being farmed out to the various DNER committees, there might be other issues that this group decides to look into. How are all these things taken, integrated, made useful, made part of a whole.

Mr. Toben – One solution may be to pursue this parallel path of subcommittees and to report back at each full Commission meeting from each of those groups so that no party is excluded from the findings or the opportunity to question the subcommittees about their findings. It may very well be that in a scientific committee there would be a majority and a minority opinion that would come from the subcommittee process. But the discussion or the debate would not slow down the progress of any of the other subcommittees who might be able to generate ideas for mitigation measures in that meantime.

Dr. Smith – I want to respond. I think Preston makes a very good point. I think for a number of us there's a high degree of interest in participating in the number of different committees because I think that these things do ultimately intersect in many ways in our lives. But I actually would argue that subcommittees may actually be the best way to get your answers because you can focus in more ways in the subcommittees than trying to bring all the information and bounce it around in a one day process here. I think you can go deeper in a subcommittee to get answers to your questions and I think it gives you the opportunity, there's no limit to the number of subcommittees that people could participate in that they're interested in. So I would see that it actually gets you more to where you would want to go, I don't think there's any way that we need to break this or limit which ones people can participate in. The other question I would have is maybe we can ask Brock or his consultant to clarify how transparent the work that is going to be going on is, because I in no way want to encourage participation in some sort of subcommittee process that doesn't make everything completely transparent and immediately available to people if for some reason they are unable to participate so that we can understand. Because again, Michael's analogy is good, this is a very big elephant, I think we've got to break it into bite size pieces and my suggestions would be to think about how we do that.

Mr. Garrou – Mr. Nicholson you want to respond to that?

Mr. Nicholson – I do, first of all we are absolutely transparent and that's one of our program design features, certainly. We have everything on the web, all the meetings that are announced and really we have a provision for the public to observe and again, I want to emphasize that and invite anyone on this Commission to join the work groups. One of the real values we see in the work group is the way it is set up, and I know it's probably arguably a very burdensome way of doing it perhaps. But we think we have a very broad representation of all of the so called stake holders that have any interest in this, we will sit there all together in this public meeting and discuss the options: what needs to be done in terms of analyzing those options, directions to the consultant to help with that analysis, and what other sub-options or alternative options that anyone might have on that. And it goes through a process of voting, if necessary, but certainly a consensus based process on, if you would, designing that option and the right features and so forth. And that will be brought back here, so I would offer that as a very important value to the process and again we invite anyone in this group to help. Certainly, it might make sense for this Commission to have similar subcommittees. I think what we're offering is that sort of full service process if you would and maybe an option for the Commission is to utilize our DNER process subcommittees for those subject matters looking specifically at policy actions or mitigation measures, potential ones and then sorting through that process. And then those other subject areas, perhaps like the science that we're not going to focus on. Then maybe greater emphasis on this Commission for those kinds of committees, but I just offer that as a thought.

Senator Pittenger – Mr. Chairman your analysis I felt was good in terms of assessing where each of us are coming from. I feel like, respectively, that a lot of you represent organizations and you do so sincerely and with good intent. But you have a vantage point and in your advocates for significant change and policy that would address climate change. The others of us are still searching and this has been new to me. Since the day I got appointed I've been digging and reading and not that I don't have an opinion, but I'm still learning and I don't think having just two meetings to invite in some experts that we've over killed it. It maybe enough for you all, but I understand that, but I would welcome having some folks come in that are much smarter than me and say here's some facts you ought to consider.

Mr. Garrou – We've heard a lot good suggestions, and I say that sincerely, and not all of them are contradictory. So what I would suggest is those of you who made these suggestions, if you would email Mr. Givens and just sort of outline those so we'll get them in front of us. And then we'll synthesize all of this and I think we'll be able to come up with a procedure that won't make you entirely happy, but we'll address most of the issues that's been raised here today. That is we'll try to make sure that we can bring everybody along at a speed that they're comfortable with in terms of education about the issues that we deal with the economics, which we clearly need to do. But that we manage this process in a way that we can come out with a product at the end that is meaningful. That is, if we begin with the end in mind and which is what I think Mr. Shore was talking about. So we will do that, we will come back to you with our conclusions about how we should do this and I hope that we will be able to satisfy these considerations.

Representative Hackney – Let me add to that, I appreciate, like my co-chair, all the suggestions, there's an old saying among lawyers, that when all else fails go back and read the stature. And I would suggest that some of you should go back and read the legislation because the road map is pretty much there, and it doesn't tell us exactly how to get there, it doesn't tell us who to hear from, but it tells us pretty much what we're to study and what we're to do about it. And I think that you'll find that the co-chairs are going to stick pretty closely to this charge that we have in the law and that we want to do a good job of it. Keeping in mind that part of perhaps unstated goal here is public education and public discussion in North Carolina at a state government level for the first time. And I think that has value in and of itself and so I hope you have enjoyed learning about what DNER is doing, I know I have, some of you may have known more about it than others as members are very diverse. I hope you've enjoyed hearing from the expertise that we have already and I think personally, we should hear some more and not just in committees. The work that we're about is ultimately to recommend and Mr. Wilkins made a point that I will just reiterate, you need to go fast enough to get the job done and you need to go slow enough to make sure that you're bringing everybody along with you when you get to the end. So I think that's a good goal for all of us.

Dr. Uzochuckwu – Mr. Chairman, I had sent an email regarding the schedule for these meetings. Tuesdays are not very good for us because we teach and some of those classes are held once a week. Once you miss two times like the meetings coming, you miss two weeks of lecture that is not good for the students.

Dr. Smith – As we're wrapping up, at some point we're going to be struggling with solutions and I just wanted to point out that a colleague of mine is going to be mailing each member of the Commission a DVD on issues of energy and I would hope that you pay attention to it, particularly, I think that the most important part to zero in on is the last part of this video. He spends a significant amount of time, at a very personal level with his family and I think at a very lay person level talking about real solutions to a number of energy challenges that we have, obviously. So please be on the lookout for this, it is called Kilowatt Hours and I would encourage you, if you get it, to take a look at and I think it will help enlighten a little bit on some of issues that we may be struggling with.

Mr. Everett – Yes Mr. Chairman, could we get copies of the first two presentations this morning sent to us maybe?

Mr. Garrou – Surely.

Mr. Givens – With regard to Dr. Ballings we did distribute the PowerPoint and we can certainly follow those Dr. Riggs presented you with a brief abstract but he did not want to disseminate his PowerPoint at this time. Let me just say generally that we also, the staff, have been taking notes on all of these things. I would ask that each of you who have thoughts and recommendations to send them to us, detail in particularly including topics and presenters and perhaps any help you can offer in recruiting relative experts, will be welcomed. I have learned, in the last few weeks that I'm not quite as famous outside the

state of North Carolina as I am in and so we are looking at a number of people already, but any help that you can offer, there's certainly more expertise out there than there is up here on this part of the podium. One of our thoughts has been that we can continue to work on the science and talk about other topics at the same time, and we're looking for ways to do that.

Mr. Everett – Mr. Chairman I wonder if we're making a mistake by continuing to focus on the whole issue of climate change. It appears to me that when you look at the source of the problem, if there is one that Brock put up, it's an energy issue and regardless of what you think about climate change or what's happening to the climate or not happening the issue is related to energy.

Mr. Garrou – I think I agree with you, but I echo the words of the co-chairman, we've got a stature that we have to deal with.

Mr. Givens – One other comment with regard to the schedule of meetings, we only scheduled out for two more meetings and I apologize to the Dr. from A&T. He did indicate that he was having trouble meeting Tuesdays. Any consideration for scheduling that would impact us in the fall, if you would let us know those things we'll try to factor those in. It is enormously difficult to find a date that even the majority of people are comfortable with.

Dr. Riggs – Energy is an important part of this, but it's only one piece of the equation. Climate change is real, it's happening and the environment is probably going to pay for it first. And we have to keep the environment on the table at the same time as we deal with the energy component.

Mr. Garrou – If there's no other business to come before the Commission, we are adjourned. Thank you very much.

The meeting adjourned at 3:30 p.m.

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Mr. John Garrou
Presiding Co-Chair

Thelma T. Utley
Committee Assistant

LIST OF EXHIBITS

EXHIBIT A	**Meeting Notice**
EXHIBIT B	**Meeting Agenda**
EXHIBIT C	**Visitor's Registration**
EXHIBIT D	**Handout provided by Senator Pittenger to Commission members on observations from leading scientists regarding natural cause to climate change and newspaper clipping on global warming in context of history**
EXHIBIT E	**Handout provided by John Locke Foundation – Spotlight – Breaking the 'Hockey Stick'**
EXHIBIT F	**Newspaper clipping provided to Commission members - Warming is here. Now what do we do? By William H. Schlesinger.**
EXHIBIT G	**North Carolina Coastal Federation – State of the Coast Report - Global Warming: The Impending Storm**
EXHIBIT H	**For Immediate Release - Dr. Robert Balling**
EXHIBIT I	**Coasts In Crisis: Climate Change, Sea-Level Rise, and Storm Dynamics by Dr. Stanley Riggs provided to Commission members.**
EXHIBIT J	**PowerPoint presentation by Dr. Rob Jackson**
EXHIBIT K	**PowerPoint presentation by Dr. Robert Balling**
EXHIBIT L	**Reading material distributed to Commission members provided by Senator Pittenger**
EXHIBIT M	**Reading material provided by Dr. Stephen Smith**
EXHIBIT N	**PowerPoint presentation by Dr. Sethu Raman**
EXHIBIT O	**PowerPoint presentation by Mr. Brock Nicholson**