Abrupt Climate Change in our Lifetime: What Would it Mean?

This podcast is of a USGS Congressional Briefing given on Capitol Hill on September 28, 2007. Hear how USGS and its partners are working to provide the science needed by resource managers and policy makers as they develop mitigation and adaptation strategies for dealing with the threat of abrupt climate change.

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Bill Werkheiser: Good morning, welcome. Thank you for taking time out of your busy day to be here today with us. My name is Bill Werkheiser, I'm the Acting Associate Director for Geology at the U.S. Geological Survey and I will be your moderator for today. Before we begin today's briefing, I would especially like to thank our sponsors, Senator Jim Bingaman, Lisa Merkowski, representatives Jim Moran and Eric Blumenauer and Wayne Gillcrest for allowing the USGS to present this briefing on abrupt climate change. I'd also like to acknowledge the Colmar foundation for science and education for providing the excellent refreshments that you had earlier today.

The topic of climate change is certainly front and center these days, you hear almost every day in the News. Here on Capitol Hill, and really in the homes and businesses across America. Clearly, climate change is not an issue, we can afford to ignore and move on into the future. We have to deal with it now. It's an issue now and will continue to be an issue throughout our lives and future generations. It will affect many of our day-to-day decisions. Simple things like the car we drive more complex things like what are the goods and services that we have available to us, and even to where we choose to live.

It's also a topic of great importance to the Department of the Interior, which oversees nearly 1/5 of all lands in the United States and provides resource management protection to much of the nation's valuable physical and living resources. In order to meet the challenges of climate change head on, Secretary Kempthorne has created a climate change task force to develop strategies and policies for a number of areas, including managing land, water and living resources, protecting wetlands and wildlife, planning for and responding to natural hazards, controlling invasive species, as well as reducing the Department's own environmental footprint. And as the Department's primary science agency, the USGS is a full participant in the task force and is actually leading the science subcommittee for the task force. And I believe the USGS, along with its partners is well-suited for that role.

We have in partnership with other agencies and universities. Over 30 years of research experience on a wide range of climate related topics. These include such things as what has been the climate in the past. How is it changed in the past, how does that rate of change compared to today's rate of change very important topics. What are the effects of climate change on our land, water and living resources.

As we look to the proper energy mix, what are the resources that we have available to us In that mix. How does climate change affect natural hazards such as floods, droughts hurricanes, wildfires. Conversely, how do natural hazards such as volcanoes affect our climate. Very important topics, and then finally, what are the key environmental indicators of climate change. These are long-term research efforts for us. With these research efforts will continue to evolve in change as the questions related to climate change, evolve in change. For example, we see the debate for climate change shifting from how and why climate change, If climate change, now to how do we slow down climate change. Can we stop it? Can we reverse it or do we have to adapt to climate change. Can we adapt to climate change, and if so how do we adapt. These are deceptively simple questions with very complex answers, and that complexity is compounded if we looked at the topic of abrupt climate change.

Now, how do you define abrupt climate change? the way we look at it, although significant, the warming trend of the earth of the past hundred years or so has been relatively gradual. But there is much scientific evidence in the past geologic record that indicates there are times when those climate change effects are very rapid. On the order of a decade or so, or several decades. So you can imagine that with all of the concern that we have now for climate change on the gradual sense, what the impact of an abrupt climate change would be on our society. It would be just immense. So this is an incredibly important topic for us today. And today we have three excellent talks. I had an opportunity to preview them yesterday and I think that you will find them very informative, on how USGS and their partners are working hard to provide the science and understanding needed by resource managers to deal with the threat of abrupt climate change.

Just as a matter of format, we have plenty of time for questions after the talk so I would appreciate if you could just hold your questions for now, and then after all the speakers come up, we can ask questions then. We are very pleased today, our first speaker Conrad Stefan, he’s a world expert on the Greenland ice sheet who will give the global view on the potential impacts of abrupt climate change. Connie is the Director of the Cooperative Institute of Research and Environmental Sciences and a professor of climatology and remote sensing at the University of Colorado. He has personally led expeditions to the Greenland ice sheet consecutively for 33 years to measure and evaluate the dynamic response of the ice to warming climate. Connie?

00:06:04:00
Konrad Steffen: Thank you very much for this nice introduction. Could you dim the lights slightly? Thank you. Dear members of the Congress be it policymaker, staff members, fellow researchers and friends it is my pleasure, my honor, to give you a briefing, this short briefing today about the cryosphere contributions to climate, to the sea level rise and it’s variability in view of a possible abrupt

climate change, even within our lifetime.

First, I will give you a short overview of this global sea level rise, what do we know from the past, and how it is currently occurring. I show that on the two big ice sheets, Greenland and Antarctica. Would also acknowledge the funding agency that supports all this different research expeditions, NASA, NSF, NOAA (through CIRES), and certainly USGS. This summarizes my talk, we are actually losing much more ice then we currently have in the past, and it's getting more dangerous.

Let's look at how do we define abrupt climate change. Abrupt climate change is actually a large scale change in the climate system that takes place over a few decades or longer. And will last for a few decades, but it causes substantial disruptions in human and natural systems. The key questions that I'm going to pose right now is “can a rapid change in glacier and ice sheets and sea level rise cause such an abrupt climate change?” Let's look at the sea level rise, as we know it today. This is the sea level rise curve from a satellite, from several satellites, from altimetry for the time period 1993 to present. That's the most accurate curve, we have to date, and you can see we have a linear increase, it has some (?) in here but for the time period there is an increase of 3.5 mm per year.

When you look at the last IPCC report, the Inter Governmental Panel For Climate Change, that report stated in 2001 that sea level increase was 1.8. So within the last 13 years, It has doubled its rise. When you look at sea level rise, it's not just coming from ice as you probably know. Half of the sea comes from thermal expansion, which is the ocean layer, the very top gets warmer. Warmer water has a bigger volume. So 50% of the current sea level rise, which is in the order of 1.5 mm is thermal expansion. If you look at the previous report that covers the period of 1960 to 2000. That part was only 0.5 mm, so it has tripled already within about 13 years. Glaciers and ice sheets in the previous report .3 mm, three times as much today for the last 13 years, about .9 mm. Greenland ice sheet was in balance during the last century, was no change. We currently see about .5 mm, and I put these numbers in relation, because millimeters is probably not a very good unit to discuss here. Antarctic ice sheet in balance as well shows about .4 mm.

What we don't know, is actually the change in the water storage all the different lakes that are artificially made that are drained. We have no idea how they actually affect, and we know they are affecting the current sea level rise as well. Let's look at the cryosphere part which is the ice sheets and the glaciers. IPCC report, published last year showed that about 1.3 mm sea level rise was the total 70% was the glacier contribution. 20% was from Greenland, 10% from Antarctica, Greenland Antarctica it self. They store up to 60 meters of sea level rise. But they are not going to melt in a very short-term. This year, Mark Myer from Boulder published a paper that showed the glacier, the sea level rise increased already to 1.8 mm where as 60% from glaciers about 30 from the Greenland ice sheet and 10% from Antarctica. I will show you now new data in the following that is only about three or four weeks old from a new satellite that shows sea level has further increased to 2.2 mm. So you can see within less than three years. We have quite different numbers. Some of it is an uncertainty as well, I admit that. But glaciers make up 50% of that signal.

Important is that Greenland and Antarctica are growing, and that's where the potential of the sea level rise increase is. And we actually look for glaciers. We do know glacier is will waste away and over the next 50 years, we will probably lose most of the smaller and mid-level glaciers. In the glaciers there is about 1 foot of sea level water stored. But once that is gone, no more glaciers can melt, the big reservoir is in here, between these two. That's why we will concentrate, by talking the following on these two.

Let's look at the Greenland ice sheet. Greenland itself is about 10,000 feet thick in the center, this is just ice. On this graph and I removed the ice. And because the ice is so heavy it pushes actually across sea level, but you can see in this blue color is all the area that is below sea level, and this is the dangerous part. You can see several areas that are actually ending into the ocean below sea level, particularly down here, and that's where we actually see very fast ice motion occurring. When we look at the current change in Greenland, the mass, it's not only the melt, you can only explain about 30% of the current sea level rise from the Greenland ice sheet by the melt. Most of it is dynamic, and I try to explain some of this. We actually have, we are able to monitor the melt of the ice sheet over the last 30 years, closely from 1979 to the present. This shows the melt extent, and you can see the wiggly curve we have a variability over time but it's continuously increasing. What you see in the red in outline that's the melt in 2005 in yellow line that's the mean the melt area for this whole time period. Melt is increasing further up and it has increased between 20 and 30% between 1979 and present in area, so we've got more and more areas that are melting. What is more impressive, if you just take the ice along the outer line here that have no snow we call that the bare ice. This area increases every year by 13% since 1979. So that means we have more area that can really melt water, and that triggers a process we call a dynamic response.

The latest image from Greenland, from GRACE. The Gravity and Climate Satellite that shows you here, the decrease, and you look at the decrease of the Greenland ice sheet. Currently, we are losing 240 giga tons or cubic kilometers of ice, total in Greenland. This is very hard to imagine but just take this volume, this to a half times all the ice we have in the Alps in Europe. I'm Swiss, so I had to make this example, but let's take all this water and drop it on the sea, District of Columbia, this will be a water column of .8 miles high and this is the volume of ice we lose every year currently on the Greenland ice sheet. And that dates from 2002 to 2006. We cannot explain that loss of ice by melt only. Most of it is actually the fast-moving ice that is moving into the ocean. But that is part of the mechanism. You can see during the summer, the water runs on top of the ice sheet and just disappears in these holes. These are called Moulin's. And I try to encourage my grad students, but none of them volunteered to go inside these moulins.

So we designed actually new equipment that goes inside, and measures where the water is going as late as last month in August, and this water can actually go all the way down to the underside of the ice sheet. What happens actually when we see this increase in melt over the last few years, we have more water pooling on the top of the ice sheet. The water pushes through, and whenever we have a warm summer and we have very accurate instruments that measure that, the ice moves much faster toward the coast.

Currently ice, were we make these measurements, move every day 1 foot. During the summer, this increase is close to 2 feet, because of the additional melt we have. That's how we explain the dynamic response that the ice is moving faster towards the ocean. Not only Greenland, the big Brother is Antarctica, again here I've removed all of the ice and you can see only the land. The outline of Antarctica is shown here, a large part of West Antarctica is grounded below sea level. This ice sits on the ocean and if there is any change in the ocean circulation or any change here. This can actually trigger a very fast response if you just take this part of the ice. That's equivalent to about 7 meters of sea level rise. Again, the latest image, my second to the last slide shows the ice loss we have in Antarctica. And this is new, we have known that this part of Antarctica is losing mass and you can see how it's going down again from the satellite measurements.

New is we are also losing mass on this part of the ice sheet. We have actually not seen before. In total, the ice loss is close to 150 gigatons, or cubic kilometers. If you add that up, Greenland and Antarctica is currently losing the same amount of all the glaciers we are melting. To summarize my talk is. It's very clear, we are losing mass from the glaciers at an accelerated rate. There is about 400 giga tons per year. There is enough ice to contribute at least 1 foot or more to the sea level rise over the next 100 years. We have seen very rapid changes in Greenland, mainly the thinning of the ice sheet and the fast motion. This explains how we actually lose some of this ice. We cannot model that fast motion of the ice sheet. There is no model that can predict it and we have to understand the processes.

I make the analogy for the ozone hole discovery in the 1970s. We are seeing a signal based from the gravity satellite that we are losing mass. We are trying to understand the processes, we have some hypothesis, but it has a large effect, because if you take that signal, and make an extrapolation, it is way bigger than the last IPCC reported, which is .5 meter sea level rise. There is a potential change, for rapid change of ice volume in West Antarctic, as well as the large glaciers in Greenland. The future changes of ocean circulation that can be produced by changes in wind, etc. are not well understood. They have the potential to make an abrupt climate change, because these are the big energy volumes that can melt a lot of ice from underneath. Currently sea level rise is increasing by 2.2 mm per year. This is a new number. This is for this year, it has increased every year by a substantial rate. If you take the current ice loss and extrapolate that for the future it will be actually larger than the .5 meter that has been proposed by IPCC. It can be as large as 1 meter, more than 3 feet, or more if you take that dynamic response of the ice sheet. Thank you for your attention.

00:18:57:00
Bill Werkheiser: Thank you, Connie. Our next speaker is Tom Armstrong from the U.S. Geological Survey, Tom is the Senior Adviser for Global Change Programs at the USGS. He has served as the Department of the Interior's representative to the US climate change science program. He heads the US delegation for several international climate change committees, and he chairs the Department of Interior climate change task force science subcommittee. Tom?

Tom Armstrong: Thanks Bill. Good morning everybody. Thank you for attending today. What I'm going to do is try to build on what Connie already talk about and try to bring in the essence of what abrupt climate change is and I'll talk about it in terms of cause and effect. We will look at the start of the talk some examples of the linear kinds of change that Connie mentioned earlier with the gradual kind of climate change that we've been seeing. Significant in human history. Significant with response, but small in comparison to what we see in the geological record related to abrupt climate change.

To start with, I want to just get this out on the table because one of the question is that we get all of the time is "is climate change human induced or is it naturally occurring?" And the simple answer is that it is both. If you look at the IPCC 2001, the tar report, the third assessment report. You will see this slide in here which I think is very educational. Start with the bottom one, will we are looking at with the red line is basically the observation of thermometers worldwide since 1860 to the year 2000. That shows the temperature profile in climate change over that period of time. All forcings means both natural, and human induced. And what we have under that is the model runs of 20 general circulation or global climate models.

You can see that when we take into consideration both natural forces to climate, as well as human forces, including emission of greenhouse gases. We have a good mimicking of the models to the observational record. If you go up to, box A though at the top there, you can see that up in here, when we look at just natural forces related to climate change in the models and run the model simulation over that period of 1860 to 2000 that there are places, especially in the most recent part of the modern record where the models underestimate the observations.

If we look at the anthropogenic forces only, without putting in the natural forces, you can see that in the last part of the century, the anthropogenic forces model actually model, the observational record very well, but during the Industrial Revolution period in this area right in here, it actually over estimates the climate change. Again, you really need to look at both natural forces, the natural part of the climate cycle as well as the anthropogenic. We can argue forever about how much is which. But it is very clear that humans have had a significant impact on climate in that period of 1950 to 2000.

What we are really interested in here, though, is getting past the debate of what is human induced versus naturally occurring, and talk more about what are the effects. What are the responses of ecosystems, of human society, of the physical system of the planet Earth to changing climate. Well, if you go back to this last slide. You will see that this change, although rather dramatic according to many people, including Al Gore's Inconvenient Truth that is certainly significant in human history. But that is gradual and small compared to what we see in the geological record.

What I want to show you now is the ice core from Central Greenland. Probably someplace where Connie has made coffee or pancakes out on the ice sheet over that 33 years, I can't believe he's been working there that long. And what we are looking at on the x axis is present day right here, this is for the year 2000. The paper by Richard Alley from Penn State, going back in time 20,000 years. This ice core record lined in blue is the temperature profile over that period of 20,000 years. And several important points to note is that compared to the earliest part of the record, the first 10,000 years of that 20,000 year record, the last 10,000 years have been relatively stable. The temperature has fluctuated due to climate variability and natural forces, but not a lot compared to what we have seen in the previous 10,000 years.

Also, I want you to take into consideration that little blip right there. That little climate variability signal that noise in the stability record is huge in terms of human history. That is when the Vikings landed on Greenland. That's also when the Vikings left Greenland and started to move into North America and back over to Iceland, and to Scandinavia. Small changes in climate can have major impacts on humans and their behavior. But compare that to what we see in this Y/D, the Younger Dryas period. About 15,000 to 11,000 years ago, where we saw temperature swings over decades or hundreds of years of up to 20°F. That's abrupt climate change. Significant temperature changes sustained for decades or longer over very short periods of time. And that's really what I want to get across in this talk is that the geologic record is littered with these.

We go to the Vostok ice core in Antarctica, we look at a 400,000 year record. The stuff I showed you before, is this noise right here. Not a lot to see in the signal, compared to that, to that, to that, and to that where we have large abrupt changes in temperature over decades or hundreds of years. And notice the cyclicity of these changes occurring at approximately 100,000 year intervals related to what we believe are natural forces in the orbit of the Earth around the sun in this case. Natural variability over 400,000 years. Natural climate cycle with major abrupt events. So the question then becomes are these things that are naturally occurring going to occur in the future, and the answer is we don't really know for sure, but based on the geological record, if the past is the key to the future, the chances are yes, they will. We just can't tell you when.

What we also can't tell you is if you look at the current CO2 levels in the atmosphere in the intensity coupling of temperature versus CO2 which we have not seen in that 400,000 year record before, is what kind of impacts are humans having with greenhouse gas emissions on bringing the system, which is in dynamic equilibrium in a natural state into disequilibrium. Will we cross thresholds that we just have not seen before. Again, the answer is we don't know. But Connie, along with Jack McGee and others led by USGS are working with the climate change science program on putting together a synthesis and assessment product dealing with the science of abrupt climate change and what we should be looking for in not only the geologic record, but the present record that might be sentinels of change that will give us a fingerprint of what might trigger these events, and what the environmental responses might be.

So let me go in that direction, a little bit. I want to get back to so, what do we see on the landscape in terms of changes related to climate change. And really the changes I'm about to talk about, and I wont talk about all of them, but they include the debate over the intensity and frequency of strong storms. Connie already very well articulated the fact that we are looking at accelerated rates of sea level rise. The propensity for floods, for drought, and habitat change. These are all things that we can now relate directly or indirectly, in some way shape or form to changing climate. But that's linear climate change. That's climate change of gradual proportions compared to abrupt climate change events.

So the next couple of things that I'm going to talk about in terms of ecological and environmental responses to climate change are for linear changes to climate. Think about what would happen if we had an abrupt climate change event with an order of magnitude or two greater rate of change and magnitude of change. And I'm going to start with one that Sue Hazeltine in our audience is very familiar with talking about hear up on the hill in a few hours, and that's the issue of climate change, sea ice loss and polar bear Habitat.

The USGS has been working to support the Department of the Interior in providing science information on polar bears and the linkage to sea ice declines and climate change for the proposed listing of the polar bears as a threatened species. I can't go through all the details, but what I will tell you is that we have linked the global climate models probabilistic and deterministic habitat models together to show that there is a linkage between sea ice loss and sea ice declined, related to climate change and polar bear habitat. And if you look, these are in nine administrative reports that have just been recently released by the USGS on the science that we have conducted with our partners in academia, the Canadian government and elsewhere, what we see is that with declining sea ice in the Arctic region in the Arctic Basin. A substantial degradation of the optimal polar bear habitat throughout the circum arctic some areas in deed in the Canadian archipelago that by midcentury, shows some increase the potential increase in optimal polar bear Habitat, but substantial decreases throughout the circum arctic. Again in response to sea ice decline and climate change.

Another example is the degradation of permafrost, and I won't go through all the details, but suffice to say here in the blue record, we see a decline of permafrost area, and volume in terms of millions of kilometers squared and the projected based on different carbon emission scenarios, for human carbon emission to the atmosphere from the global climate models, and what we see is a dramatic change increase or acceleration into the future by 2100 of permafrost thaw and degradation throughout the Arctic to the point where only Greenland and parts of the Canadian archipelago are projected to have any real substantial permafrost by the end of this century. This has significant impacts on Native communities on oil and gas pipeline infrastructure and on road and transportation networks, as well as many other things with human and economic significance.

Going back to where Connie was and he ended with the issue of about 1 meter of sea level rise or more by the end of the century looked extrapolating the rates that we are seeing today with the accelerated loss of ice in Greenland and Antarctica. If we were to look in the Gulf Coast area around Louisiana, what we have done here is to show an inundation map, an area where today, based on the land surface today what would be underwater with 1 meter of sea level rise, and we can see how significant that is with New Orleans down in here. The economic significance of this as well as just the social significance is huge. So those are changes that are already occurring. They are changes that are occurring that at what might be the start of an abrupt change event. They may be part of just a linear change of climate brought on by the combination of both human and natural forces.

What would happen, what would these changes look like, how would we adapt, how would we mitigate something that had a rate that was an order or to magnitude greater or even a magnitude of total change, an order or two magnitude greater than what were seeing today. Those are some of the future science challenges about the science of abrupt climate change. And things that we are working on with our partners like Rick Rosen at NASA or at NOAA and the climate change science program, is developing better ways to forecast changes in state. These are state changes in the environment and the physical system that we are looking at. Can we forecast better the accelerated rates of these changes? Right now our modeling capabilities deal with linear changes, not nonlinear accelerated changes like Connie had mentioned about sea ice. Same with the climate models and the response models. We need to better link those changes of state and system response like we have with the polar bears and sea ice decline. We need to look more at system thresholds and their potential triggers. Those tipping points that may be out there that may be the sentinel, the early warning system of the changing climate and abrupt climate change events. And all along throughout this we need to develop better adaptation and mitigation strategies for dealing with this kind of significant change.

We're not saying these changes are going to occur, but we want to make sure that we are prepared that if they do occur, we have strategies for how to adapt and to mitigate them. And finally going back to the Department of the Interior’s climate change task force.

One of our key visions in the development of a climate effects early warning system. A vision in which we have an integrated national capability for monitoring across the country at all scales of both time and space focus on early detection and forecasting to support adaptation and mitigation strategies so that there aren't any surprises, and that we can do something about it before the damage is really done. We want to develop an information, dissemination, and decision support system that is truly useful to decision makers, not just science that is handed off to them, but science that's integrated seamlessly with the decision-making process. And then finally for next generations and beyond, I want to make sure that we leave the capacity and the start, the legacy of development of protection plans for sustaining our national trust resources through early detection of change.

So Dan Kimball will get up next, and I know Bill will introduce him. But I want to, when you see Dan and his talk on Everglades, think about that change that linear change in the significance of what he is about to show and then think about what that would be like with a magnitude or more greater change in rate and magnitude. Thank you.

00:32:43:00
Bill Werkheiser: Thanks Tom. Our next and final speaker for this morning is Dan Kimball. Dan is the Superintendent of the Everglades and Dry Tortugas National Parks, and I think you'll seeing in Dan’s talk that Dan will take this information, all the scientific information presented by Connie and Tom and translate that into some real world examples of things he has to deal with on a day-to-day basis. As the park superintendent, Dan leads the park's involvement in the restoration of the Everglades. He has served as the chief of the National Park services water resources division. He has been the acting Superintendent of Zion National Park, and assistant to the National Park service deputy director. Dan?

00:33:51:00
Dan Kimball: Good morning, my name is Dan Kimball, Superintendent of Everglades and Dry Tortugas National Parks, and I just want to thank all of you for coming, and I'd like to thank the U.S. Geological Survey for the invitation to be part of this panel today. Following Connie and Tom's presentations, I'd really like

to offer some thoughts at the ground level, and from the perspective of a land manager that is managing a park every day and really a like to focus on three things.

One is the vulnerability, regardless of whether were talking about the IPCC or some bigger numbers that was just been alluded to. The vulnerability of places like Everglades and Dry Tortugas National Parks, particularly with regard to sea level rise. Second, I'll talk a little bit about the expected effects of climate change on both the natural and the built environment, and I'll use the two parks here as examples of that built environment, and finally a number of actions that we've taken to learn about, mitigate, and adapt to climate change.

A little bit of orientation here, this is the map here for Everglades National Park. This area right here, is surrounded by Big Cypress and Biscayne National Parks over here. It's a very large place, 2300 mi.^{2}, is the third-largest park in the lower 48. The only parks are bigger is death Valley and Yellowstone. A little bit different park. It's at the very end of a long peninsula and its surrounded by close to 7 million people, right at our doorstep. One area I'd like to point out here, that I'll be talking about in a few minutes is Florida Bay. A very sensitive area of the park about a half million acres, and this is also the largest wilderness area east of the Rockies. I'm also the Superintendent of a little park, it's a 100 mi.^{2} out here 70 miles to the West of Key West called Dry Tortugas National Park. It's a 19th-century Fort, and I'll show some photos of that in just a second. This is the photo on the left here is the classic Everglades, the river of grass. It's flat as a pancake and 60% of the park is less than 3 feet in elevation. Maximum elevation in the park is 11 feet. I lived in Colorado for 30 years, and I drive, this is a sign on our main park road. It identifies one of the key features in the park.

One of our major land forms, It's the divide between the two major drainages in the park. Taylor slough and Shark River slough. And that tells you kind of what we are faced with a major divide in the park elevation, 3 feet. This is Dry Tortugas National Park, Fort Jefferson in this area right here. It's a 19th-century Fort, and what I'd really like to point out here is it's surrounded by a moat wall. That's kind of our last line of defense. The park also has a spectacular tropical marine resource or reef system. That is also very sensitive to climate change. Particularly temperature.

We've been looking a lot at climate change information and projections and as you heard this morning, the numbers are changing almost weekly, and we focused on the IPCC, the last report, the 2007 report, that talked about seven to 23 inches with six different models. Talked about it, excluded, it had a footnote on future dynamic changes that could occur, which we have heard this morning are occurring, and really no rate of change projected. But the data in South Florida, we've had about 9 inches of sea level rise in the last 75 years. Also, something that we haven't heard about to much this morning is we're talking about a temperature increase as well. And then something very important to us in

South Florida, this increased cyclonic activity, i.e., increase in hurricanes in intensity and frequency. We've done some basic overlays of the park, we took the 7 inches and overlaid it on our topography and also the 23 inches. With 7 inches, in this kind of aqua color is areas that are inundated. About 10% of the park under the 7" scenario, and you start to look here under the 23 inches above 50 to 60% of the park is now not freshwater resource, but is a marine resource. In terms of habitat, we tried to simulate what's going on with the help of our partners with the U.S. Geological Survey. This magenta color is the shallow freshwater Marsh. As you can see over here in 2100. This is the 23 inch sea level rise scenario. That's basically gone. It's much more over a marine system. You see the mangroves over here on the coastline have now advanced onto the landform of the Everglades and the high ground. And then there is an area right here that is kind of a dark green. Those are the pinelands, that's the last remnant of pineland community in South Florida. And you can see over here, that would be gone, would be inundated. Pictorially this is kind of what it looks like this is what looks like right now.

This is the classic short hydro period fresh water marsh, would probably transition to something like this more of a mangrove dominated and saltwater dominated environment. Probably have fewer of these alligators, and perhaps more of these crocodiles. Crocodiles are more of a saltwater species. One of the concerns we have is this is the Cape Sable seaside sparrow. A number of you probably have heard about. It's an endangered species, and a number of their subpopulations in the park under the 23 inch scenario would be eliminated.

We've gotten some help from the U.S. Geological Survey to look at some mangrove distribution, you can see the red, black and white mangroves going from the historic, where we are right now, this is actually a meter, you can really see the advancement to higher ground and that's quite a change. And then it's not only just what happens on the surface, a big issue is what happens to groundwater. We've got something we call saltwater intrusion. The Miami Dade County is very concerned about that because we get all of our water from groundwater our freshwater system that's fed by the Everglades and if you get a higher sea level, you get the salt water intrusion, and that's kind of where we are today.

We've been getting help from the U.S. Geological Survey to really look at this salt water interface, and as the sea level comes up, you get more intrusion and more impacts on the freshwater well fields. We are also concerned about coastal erosion. This is the area out in Cape Sable. A pretty sensitive area out in the very western part of the park and out in this area there is a lot of green sea turtle nesting, and we are concerned about how higher sea levels would affect those species.

And then I'd just talk for a minute, wanted to mention that the initial slide about Florida Bay. This is a very sensitive area, and when you look at increases in water level, and also increases in temperature we could get increased algae blooms. The increase in saltwater would likely result in an impact, an adverse impact on sea grass and a number of other adverse impacts. And this is one of the premier fishing spots in the United States. Florida Bay. And recently the national wildlife Federation and Florida wildlife Federation did report that is actually, if you have a chance to look at it, it's on the Web site. It's called An Unfavorable Tide.

This is probably the best assessment of impacts of sea level rise on fishing. Because we would look at a change in species, this is a great bonefishing area, and right now they are estimating that fishing in Florida Bay is about a $70 million per year increment to the Florida economy. So we are very concerned about fishing and we have fishermen that are very concerned about sea level rise. We are also concerned about effects on our built environment. This is an area that we call flamingo. It's our only overnight accommodations in the park and you can see here that they are built very close to the Bay and are concerned about the sea wall. We also have 40 backcountry "chickies" in the park that would be subject to sea level rise. These are the campsites, because there's really nothing, no place to camp that is dry.

So we built these quite a few chickies around the park, and we’ve had to rebuild them after the cavalcade of hurricanes that we have been faced with. Out at the Fort, I mention this moat wall. You can see that we’ve got about 4 feet of freeboard on the moat wall that protects the Fort itself. And we are continuing to monitor the effects of sea level rise on the moat wall. We are also seeing the coral bleaching in the park. The increases in temperature and to that spectacular coral resource that I was talking about. There are some upsides with climate change.

We get questions a lot of questions about how do I access the Everglades, well you can see here that if you got a veneer of more water, there will be more access. We’re also looking down at Florida Bay. Our Rangers say, if we had additional 2 feet, we wouldn't quite deal with these groundings that we see every day out there, and so I guess there is an upside. And then it wouldn’t be an Everglades talk if I didn't spend a minute talking about our python outbreak in the park. We have caught over 200 pythons, that’s an invasive species. You can tell here, you have probably seen this one, it was a classic one that was on the Internet, where python tried to eat a six and a half foot alligator, and I guess it was just too much. But it gives you an idea of what we are faced with in the park, and we are estimating, now, based on the densities we are finding that there could be 150,000 of these in the park.

I've asked our biologist if climate change could solve this problem. And they said no, Dan, they seem to do just fine in saltwater, and they really like hotter environments. In fact, take a look at this slide, this is a USGS slide, this is the current distribution right here. If you look at the changes in temperature that have projected by 2100, this is the suitability range for the python. You notice it comes right up here to the D.C. area, so get ready.

Lets talked for a minute about hurricanes. There, as has already been mentioned here, is quite a raging debate about hurricanes in terms of intensity and frequency. There are a lot of people that are saying yep it's happening, take a look at the last few years. There are others at the National Hurricane Center, Max Mayfield and others that are just saying nope, we’re just in a multi-decadinal oscillation every 40 years we get in a batch of hurricanes, and that's where we are.

So this climate change publication that we put out, we spend quite a bit of time dealing with the hurricane issue, because I think that is the one that we always get asked at the park. We really are trying to provide a balanced view. I’ll tell you one thing, whether they are caused by climate change or not. One thing we know is that with increased sea level is that we’re getting just like New Orleans, we’re getting storm surge. This is out at Dry Tortugas when hurricane Charlie came in in 2004 we sustained quite a bit of damage at the park. This is hurricane Wilma following hurricane Katrina brought in 9 feet of storm surge into flamingo, and this is our flamingo lodge that's still currently closed, not because of wind damage, but because of storm surge.

So what are we doing about all of this? Well one thing we are doing is where doing everything we can to advance the comprehensive Everglades restoration plan. This was the historic flow path, a large amount of freshwater came out of Lake Okeechobee. Today we are looking at a system that is designed for flood protection and water supply, where we're taking large amounts of water and sending it to tide with these arrows, and then we are bringing small amounts to a canal system, and a piddly amount into the park. We are trying to implement something we call a planned flow, which is bring water down and restore this flow. And my point here is that to respond to all the climate change impacts, particularly sea level rise, we’re trying to bring freshwater in to basically be a barrier to that saltwater that is coming into the system.

It's really important, and when we do that we will get a healthier ecosystem that is more resilient to climate change. It's not cheap. The numbers have changed since I put this slide together. It's not 11 billion. It's probably 15 billion and it's going to take a while, but we look at this that it's the way to at least attacked this in some way is to restore the ecosystem and get a healthier and more resilient ecosystem. We are doing the same thing out at Fort Jefferson at the Dry Tortugas. This is the park, this is Fort Jefferson that I showed a picture of. We’ve set aside with the state of Florida 46% of the park is in no-take Marine reserve. There is no fishing in there, you can't anchor, we're really trying to do everything we can to protect the fragile coral system there. And we're hoping that again we’ll have an ecosystem that is healthier and more resilient to climate change.

We are doing a lot of science, this is our research and supply vessel out at Fort Jefferson, the motor vessel Fort Jeff, and it's doing a lot of science, taking a look at that research natural area, the no-take marine reserve area and were also doing a lot of monitoring within the park. The USGS within the park and right next door has close to a hundred gauging stations like this that are looking at water flow, water depth, changes in sediment, changes in vegetation. So we are really trying to learn about how climate change is affecting us right now. We are also adaptively managing.

This is a cottage that was down at flamingo after the storm surge at Wilma, after Wilma. That's in the process of being demolished, and a replacement we're looking at elevated structures like this. We're also looking at the effects of storm surge. We had some docks down at flamingo. We've learned by exactly what happened. These were traditional docks. They are like this today, they haven't been reopened yet, that's a safety hazard. Very close to that we had floating docks on the other side of a plug and they came through the storm just fine so from now on we're building floating docks. And then at the Fort, we're working hard to restore the moat wall, we're doing everything that we can. As I said, this is our last line of defense, and we are also doing a lot of things to restore the Fort itself to make it more resilient to hurricanes. This was not caused, this was exacerbated by storms, but we just received word that we are going to start our second phase of the restoration with a $7 million Fort wall stabilization program. We are doing some mitigation. There are some canal's that were cut. We're getting a lot of saltwater based on that 9 inches of sea level rise into the freshwater backcountry.

We had some failed dams, and we are in the process in certain cases, we decided it's important to mitigate, we can go in and re-plug these to try to get the saltwater out. And we are also doing another quite a few other things. We're working hard with a climate friendly park's program, we've inventoried our emissions into the park, sustainable designed, we are trying to do everything we can to green up park and importantly lead by example. We are part of the Department of the Interior's climate change task force that was referenced earlier. And another thing that I'm pretty proud of, we're part of a local Miami-Dade climate change advisory task force, where the county realizes that we are in a very vulnerable place, and they've pulled together a lot of various interest to try to figure out the things we can do to really mitigate and adapt to sea level rise, changes in temperature, and also hurricanes.

And finally we're doing a lot of education and outreach and whether it's the nightly news, whether it's this climate change publication that I talked about. There was quite a, we were interviewed in a big part of this recent backpacker magazine, and it seems that about every three days the Miami Herald runs an article. So, we are really using the parks for a platform. And finally just to summarize, the resources at the parks are really are very vulnerable to climate change. We're monitoring, learning about climate change and potential impacts.

You can see even this morning with the recent information, where trying to keep up with the science, which is a huge challenge in and of itself. We're restoring resources to make them more resilient to climate change and as I've noted today that we're taking mitigation adaptive measures as appropriate. And finally, and this is a really important part of it, is educating the public in using the parks as a platform to talk about climate change and the challenges that these very vulnerable places have. Thanks a lot.

00:50:35:00
Bill Wekheiser: Thank you, Dan and thanks to all our speakers, where I thought was a very interesting briefing. I hope that after our short time together you have a better sense of what abrupt climate change is and what it might mean to you. I also hope you a better sense of how the information that the USGS and others provide can help you as you make your decisions to help ensure a healthy planet, a sound economy, and a secure nation for future generations. Now before I bring the panel up for questions, I'd just like to make two announcements, one is that there are a series of handouts on the table over here. If you had not had a chance to get those, please do, they are very interesting. And the other thing is that our next briefing in the climate change series will be held in November, and the topic will be the effects of climate change on wildlife and human health, and we look forward to that. At this time, I'd like to bring the panel, the speakers up to answer any questions you might have.

Any questions?

Question: I'm wondering when we are talking about climate change in the debate we're focusing right now on CO_2. Shouldn't it be water and a little bit more (?) realistic in encompassing discussion than just picking one of the major (?), but it's not necessarily the whole story?

Konrad Steffen: If you talk about CO_2, that's one of the causes and it is probably one of the most important ones. We have methane. We a lot of other causes that you realize are equally important. But the cause is still, the amount of (?) CO_2. But what is actually the affect of it is sea level rise has many different applications.

Question: But as the public policy debate goes forward to it, would you agree, I sort of think it should be run to the majority of things, even though CO_2 is the greater of the cause, but again, it would be a shotgun approach (?).

Konrad Steffen: (?) especially when I talk about sea level rise. Most people don't realize this is the global average that in some regions it will be much higher. Some regions will actually have a minus sea level rise, where the ocean is predicted to go down, but that's quite complex.

Tom Armstrong: Can I go ahead and answer that. To add to that question, it is a broader more holistic issue, than even greenhouse gases. When we talk about mitigation, and a lot of debate, and a lot of discussion is occurring, and rightly so, on, how do we mitigate CO2 or greenhouse gases in the atmosphere? Keep in mind that the IPCC 4th assessment report that just came out, showed the emissions scenarios for the global circulation models for CO2, a wide range of scenarios from worst-case to best-case. But regardless of the scenario picked, over the next 40 to 50 years, CO2, in terms of atmospheric concentrations, will pretty much stay on the same increased trajectory regardless of what we do. And it doesn't mean we shouldn't be talking about mitigation, but that's one prong of a discussion on policy that also needs to include adapting over the course of the next 40 to 50 years to the inevitable change that will occur.

Question: Just following up on that, I'm wondering if you have any sense in how much tropospheric ozone or Arctic haze, as well as deposition of soot and aerosols that might be contributing to the rapidity or loss of sea ice and glaciers?

Konrad Steffen: There is actually just a new, there is a new study going out that looks at the soot count, and it has been shown that due to the wildfires that have increased in Alaska, for example, we get more soot on Greenland as a direct link that the soot is actually distributed (?) reflectivity of the ice sheet, which enhances the melt. So there is a direct link between the increase in soot and the increase in melt. The causal effect is not understood, we know the dynamics of the atmosphere (?) very good link. In addition, we just finished a study that showed in Colorado. I live in Boulder. The increase in early melt is directly linked to the drying of the West, because you have a very dry surface that picks up the dust puts it on the snow and the snow gets darker. You have an earlier melt. We lose actually that water storage that we usually have in the spring much earlier, so the whole system there is changing.

Question: In the study of the meltwater, (?) was going on, I wondered, what kind of a program can you imagine of expanding the study to the point where, in some future year you could consider effectively plugging the hole like that? Or more actively trying to slow the process? I know it's too early to understand what’s going on, but…

Konrad Steffen: Actually you cannot really plug the system. Moulins are something that we have known for many centuries. They were started actually in the 1800s on the glaciers in the Alps, and that's a natural system that the water reaches down and we cannot stop it of melting its way down. We actually were asked by some people which make some studies in the Alps, how can we reduce the melting of the glaciers because some of these cable car systems are anchored in the ice in they are actually able to put some highly reflective blankets over a glacier part which reduce its melt, but that's not a solution for the Greenland ice sheet. Its way too big, and we cannot interfere with that kind of a large system so I don't really see a solution. It's not plugging an outlets, because it melts its way down every year, that's what we realize now.

Question: In terms of the USGS efforts to expand their work on forecasting climate change and providing information on, let's say, how impacts in ecosystems or areas like the Park Service, or the park areas. How much of that work through CCSP in the collaboration with other agencies like NASA or with NOAA?

Tom Armstrong: A lot, in fact I was just going to say what you said at the end as my response to question. It really, in terms of linking climate forecasting to response, USGS's strength is really in understanding the responses in the terrestrial and freshwater and coastal ecosystems. But our partners at NOAA, like Rick Rosen and others at NASA, The U.S. Department of Agriculture, NSF. The 13 partners of federal agencies that are part of the climate change science program are coordinating to work more closely to establish joint priorities on topics like abrupt climate change to link the strengths of all the different agencies so that we have better climate forecast linked to habitat models or ecological models across all these agencies. So, CCSP is a great focal mechanism for doing that.

Question: You talk quite a bit about 1 meter sea rise and mentioned that there are models that indicate it could be as high as 7 meters. I wonder if you could talk a little bit more about the discussion among scientists trying to reduce this variability?

Konrad Steffen: I think the increase of 7 meters (?) that model is a potential increase in case the whole West Antarctic would disappear. That's not the case in the near future. The point we would like to make is the current IPCC report is based on the melting of the ice sheets. But it has no dynamic component that the ice is moving faster into the ocean, and that's the more recent observation we do and the upper limit for the pure melting of the ice sheets and melting of glaciers give an indication that thermal expansion in the ice will give you at the maximum about a half a meter sea level rise by 2100. We do see however that the dynamic is almost two thirds of the signal right now, and purely based on that kind of a response, we see the upper limit of half a meter is not sufficient as an upper limit, it can be easily 1 meter or more. We also make the point that we cannot model it yet, because we only start to understand the process of that dynamic motion. So that is the current understanding. I'm going off to actually Sydney tomorrow, where we have an IPCC meeting, where exactly this cause, how can we make a better forecast for the sea level, because it is currently inadequate.

Question: The Superintendent spoke about a 35-year plan, that I think is tending to help adapt, or perhaps mitigate rising sea level, and maybe I'll put Connie also on the spot, sorry, but does he have 35-years based on what you are seeing now going on, is that a realistic timeframe for people to be reacting to abrupt climate change and are these plans being staged in a way that if things are to really move much more rapidly, we're flexible enough to adjust?

Dan Kimball: Well, you have raised a really good question. We have even in the last month, we have gotten together with the Corps of Engineers, the South Water Management District, The Department of Interior and a lot of other local partners as well and really tried to look at the ecosystem restoration, the plan as I had up there, with different sea level rise scenarios, and we're just cranking those into the models now to look at full performance to the system. Right now we are sending about on average about 1.7 billion gallons are going out of Lake Okeechobee to the coast, the overall goal, as I showed, is to move it to the south. It's not just important from the standpoint of the ecosystem. We need to bring that water in to replenish freshwater supplies for the lower East Coast of Florida. Where those storage areas are, are very high. Now I'm not sure they get a to Tom’s, the 7 meters, but the storage areas that are a key component of increasing storage for the Everglades, the restoration effort, are high. Now they are going to be high and wet. That's the idea, and so those in almost any scenario makes sense. To question is, is what are the performance benefits on the fringe and particularly in projects like there's a project in Biscayne Bay coastal wetlands that is very, very low, next to Biscayne Bay, and almost under any scenario, those features of the project are questionable, and those are being evaluated very carefully.

Question: In the past, mitigation has been the main point of discussion when we are talking about climate change strategies, and I was wondering if that adaptation has just kind of recently come to the forefront? so I was wondering if you could possibly discuss If the whole adaptation research and also strategies for the future?

Tom Armstrong: Well, I’ll give it a shot and I’ll let you talk about the specifics. One of the key elements of what we're doing with the climate change task force at the Department of the Interior is looking at adaptive management strategies for dealing with climate change. As I mentioned earlier with the question before, there is no doubt that over the next 40 to 50 years, adaptation will be a big part of our land and water resource management challenge and our policymaking at the Department of the Interior. The DOI task force is comprised of three subcommittees. I chair the Science subcommittee. Abe Hasvold from the deputy Secretary's Office chairs the Land and Water Management subcommittee, and Bob Faber from the Solicitor's Office, chairs the Legal and Policy subcommittee. All three of those subcommittees are interacting together to bring science, resource management, and legal and policy issues together to develop adaptive management and mitigation strategies. I’ll let Dan talk about the specifics, but it's what you just asked in terms of the question is really the focus of what we are trying to do. Bring better, more science, more current information, as you saw it's dramatically changing, quickly changing to the decision-making process and to adaptive management strategies.

Dan Kimball: I showed a couple slides of some of adaptive management we are doing with a built environment. One of the other things we're looking at is exactly how we do some adaptation with natural systems. One of the things that we have been talking about with our partners with the South Water Management District, the Florida Fish and Wildlife Conservation Commission in terms of adaptation. You need to provide some migration routes if the water is coming up, and we try to link natural areas. I would use that as example of adaptation. We are also looking at kind of a wide range of other mitigation measures for example, at Cape Sable, Seaside Sparrow. Talking to the Fish and Wildlife Service, maybe we ought to think about translocation of (?) species and…just some examples for you.

Question: I apologize, I arrived in late so you may have covered this. But, California passed its Senate Bill 32 last year, and the governor has been active speaking about it and sets the goal of reducing gas emissions by 2020 to their 1990 number. As a part of that debate, a key issue has been can we modify the development patterns, we're talking housing communities, more compact development to reduce the footprint of communities and emissions from live trucks and cars, (?), Can you just comment upon that as a strategy? Does that make sense? The League of California cities is currently involved in California with discussion with environmental groups and State Legislators on trying to focus on a development footprint strategy as a key aspect of implementing SB 32 over the next 15 weeks.

Dan Kimball: I'll just touch on it from the standpoint of Miami-Dade County, and the task force that I'm lucky to be part of. One of the things that they're looking at is exactly the footprint, not only our carbon footprint in the county, but also our footprint from the standpoint of where we continued to build, whether they're condos or whatever they happened to be the developmental footprint, and there are recommendations we have a built environment subcommittee that's really looking at the kind of where we should, in light of sea level rise particularly in Miami Dade County. Do you continue to build in areas that are vulnerable like I pointed out? We are soon going to have a web site for that task force, and I think a lot of the things that you talking about, we're trying to address in Miami-Dade County and the Board of Commissioners is very concerned about it. The other thing that happened recently is the governor Christ held a climate change summit and passed a number of Executive Order's in terms of the carbon footprint for state facilities and there are a number of, a green team actually that's led by the Secretary of the Department of Environmental Protection for the State of Florida, Mike Sole, that's coming up with very specific recommendations for Florida, to advance a number of Executive Order's that the governor signed.

Tom Armstrong: Can I add to that bill? I actually personally applaud any effort to try to reduce the footprint of our carbon footprint. The Department of the Interior is working on energy efficiency strategy to reduce its carbon footprint. I think all efforts are admirable, but I think there is another side that we need to also keep in the context here. What we talk about with climate change today, the global teleconnection is huge. What's done locally is important, and we need those efforts, but we have to realize that the Globe needs to do something as well. What China does, what India does, what the United States does, it's all equally important. One of the things that USGS, we do regularly is to provide an energy assessment of the energy mix in the total energy needs forecasted out about 30 to 50 years. Current trends right now in the most recent energy estimates are that energy demand will go up, especially in China and India, but globally by 30 to 50% over the next 50 years. That energy has to come from somewhere, and right now, the energy mix prediction is that it will come from coal, which is one of the worst of the greenhouse gas emitters. So the change in that energy demand has to be taken into consideration when we look at any CO2 mitigation strategy.

Question: Yeh, you know, Dan, you mentioned that bringing in new freshwater into the Everglades is to help with the mitigation, and because it's going to make it a more viable ecosystem, and withstand the changes. I have heard other sides talking about this is what we need to do across the board, that we need to reduce the other environmental stressors to the greatest extent possible, to help these ecosystems adapt, and survive, and thrive in a climate changing world. And Tom, he just mentioned the problem with coal, and so we see a lot of other problems like acid deposition, deposition of Mercury, and there are consequences to that as well, so what extent does the work you are doing in providing policymakers with that kind of information, what else can we be doing in terms of reducing other emissions? A lot of focus is on CO2 and rightly so, but, what else should we be doing to make these ecosystems more resilient?

Tom Armstrong: What I really want to focus on on your question is really the whole issue of carbon sequestration. Because it also goes back to acid mine deposition and other issues related to the environmental degradation of carbon and fossil fuels. But, on the carbon sequestration component of that, the USGS has put together a national assessment, a methodology of accessing the nation for geologic sequestration, looking across the country at the geologic framework including abandoned mine lands to figure out where would be a good place to put CO2 that is currently in the atmosphere or injected back into the atmosphere, re-injecting it back into the ground. The plan is to develop the national assessment over the year and then to carry out a national carbon sequestration, a full assessment of geologic sequestration over the next two years following that. But there's also a plan for looking at evaluation of bio-sequestration as well. But part of that is also looking at how carbon, in terms of abandoned mine lands, or acid mine drainage, impacts the environment, and there are links to climate change with that as well.

Dan Kimball: That's a good question. There is a lot more to the Everglades restoration than just bringing freshwater into the lower part of the system. If you think about the ecosystem restoration, it's kind of like a three legged stool. You've got, what we call getting the water rights, quality, quantity timing and distribution so we know, in addition to bringing that big flow vector down the water needs to be in the proper quality, particularly with respect to nutrients. The second thing that we need to do is get the habitat right, and so that means if we're going to bring water in, we need to deal with exotic wildlife and exotic vegetation and wildlife like those pythons I showed today. We need to take care of that as well. And the other thing is part of the restoration, we need to recognize that it has to be compatible with a built environment. That 7 million people that I was talking about, they are not moving. So we have to develop a restoration plan that provides for flood protection and water supply. That's the trick is doing all three things, but it gets, it’s a lot more than flow, it gets to a lot of things you are talking about with quality, timing, distribution. There is a lot more to restoring the ecosystem than just bringing the freshwater. The beauty of bringing the freshwater is that it can bring down, just like John Adornato, the Regional Director for the National Parks Conservation Association, has been talking about, is if you can bring that freshwater head in. That's one thing we really can do to stave off the sea level rise that we talked about this morning.

Question: I would like to ask you both from your personal experience, with the Everglades, and also more broadly, and maybe some you want to (?) it's my impression is that the climate change science program funds research and is not, for the most part funding programmatic operations, having to do with, perhaps, I don’t know whether this is true for the Everglades, but looking, if you were a park manager somewhere else understanding what the impacts of climate change might be on the resources that you are managing and figuring out how to adapt or mitigate your gas emissions. So my first question is is that true, are there, do climate change science program funds actually go to be used for backwoods kind of programmatic kinds of operations? If they're not, do they come out of your programmatic budgets and what's the adequacy between the two of those for what you know about personally, that your sense more broadly of the adequacy of the funding for agencies that are supposed to manage federal resources?

Tom Armstrong: In terms of the climate change science program, it’s actually part of the mandate of the U.S. Global Change Research Act, and the reauthorization of the act. A big part of what we are doing is not just doing the basic fundamental research, although that's a critical component. There is the “so what” of the research, and that is the conveyance and transfer of science information in a manner that's usable by decision makers and policymakers. Right now, the question is still an important one, because at the climate change science program, in my experience as one of the principles for the Department of the Interior, is that each of the individual 13 agencies has its own operating budget for how it handles information dissemination and decision-support. It's not really effectively coordinated through CCSP, we do have human behavior and decision-support interagency working group that is sort of waxed and waned over time, like climate. But it's one that we all of the 13 principles agree needs to be reinvigorated, revitalized and their needs to be coordination of those individual operating budgets across the 13 agencies in a more unified way so that the end goal is greater than the sum of the parts. We’re not there yet, but we're getting there.

Dan Kimball: One of the things we have in south Florida, is we have an integrated science plan that includes the research that is being carried out by USGS, Fish and Wildlife Service, and the National Park Service. We have our largest group of scientists in the National Park Service at Everglades National Park. A lot of them are working on the restoration, but they are also working on a wide range of other things, including climate change. We are also fortunate in the Everglades. We have five USGS scientists that are stationed at the park and every two years we take a look at the science plan, and we work with (Terrence) “Rock” Salt who is our lead person for the Secretary, Department of Interior for South Florida. And as we work on this integrated science plan, I would envision that the next round, there will be a lot more, we are learning on this, the whole business with climate change, and I would think that the science plan would be much much more focused on climate change and what it means to the restoration, but I think we have a good seamless operation in south Florida, with the researchers that are involved in climate change.

Question: I just ask, to what degree do you think that that is true, in less high-profile areas. For example, the rest of the National Parks, or the Fish and Wildlife refuges, or others, I mean is this, is that being taken care of in a widespread way or is it just specific to your location?

Tom Armstrong: The DOI climate change task force is taking up that issue of integrating across it’s resource management bureaus and USGS, the issue of information dissemination and decision-support. It's one of the basic tenets of what we are trying to provide to the Secretary by this December. So we're taking a more, just like with CCSP, we are trying to take a more coordinated and unified approach to it.

Bill Werkheiser: Okay, I think we are about out of time, thank you gentlemen. Thank you for coming out and we will see you all in November.

01:16:30:00 End