NASA HEADQUARTERS HISTORY OFFICE ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

DR. CLAIRE L. PARKINSON
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is June 1, 2009. This oral history interview with Dr. Claire Parkinson is being conducted at the Goddard Space Flight Center in Greenbelt, Maryland, for the NASA Headquarters History Office. Rebecca Wright is the interviewer, with Sandra Johnson.

We thank you again for making time on your schedule. This is a continuation of your oral history session that was first conducted on June 26, 2008, and there you shared information about how you began your career with NASA. Before we move on to other topics, I'd like to ask you to expand on one topic you mentioned the last time we talked. We talked about the advantages that working with satellites brought to scientists and researchers, such as being able to, "Get the full global picture of what's going on." But in order to fully utilize that capability, you and your colleagues had to do all sorts of things to develop the techniques of how to analyze the satellite data. In that statement you were studying sea ice, but you added that other people at Goddard and other Centers were developing techniques for analyzing data for satellites as well. Would you explain in more detail the types of techniques that you developed, and how you actually developed the process to develop those techniques?

PARKINSON: First, thanks very much for coming out here to Goddard, Rebecca and Sandra. Thank you. In terms of the techniques, when the satellite sends us data, it's sending us data regarding whatever radiation it receives in the wavelengths and bands that it's collecting data in. So we get back all these numbers that reflect radiation levels, but what we're really interested in are aspects about the Earth system: sea ice, vegetation, sea surface temperature, atmospheric temperature, cloud cover, whatever the individual scientist might be interested in. So for instance, when the group of us studying sea ice started in the 1970s looking at the initial satellite data regarding sea ice, we had to determine how to take those data that were just data regarding radiation, and how to convert them into data regarding sea ice.

In the sea ice case, we had this fortunate circumstance that in microwave regions of the electromagnetic spectrum, sea ice emits very differently from the water that's surrounding the sea ice. It turns out, somewhat counter-intuitively, that the ice actually emits more at some of these microwave wavelengths than the water does, even though ice is clearly colder than the water. Still, it will emit more at some of these wavelengths. For us, the important thing is that there's a sharp difference and that we know what the difference is. Whether sea ice emitted more or less wouldn't really matter as long as we knew what that difference was, so that when the data come down, and we're aware of exactly where the data had been collected as the satellite moved from over the ocean to over the sea ice cover and all of a sudden there's this real jump in terms of the radiation values that the satellite's collecting at these microwave wavelengths, then we've got a good clue that it's probably just crossed this boundary between water versus ice.

To get more quantitative about it, we develop equations that are termed algorithms, sets of equations termed algorithms, that enable us to calculate from the satellite data what percentage of the area that the radiation came from, what percentage of that area is covered by ice versus water. To give a simplistic example that will get across the sense here, at one of the wavelengths that we used a lot early on, the value for water came out about 135 Kelvin, and this is called a brightness temperature. It's related to the radiation that's coming from the surface.

So the water recorded a brightness temperature of about 135, whereas ice recorded a brightness temperature of about 235. So if at one location we got a value that was, say, 185, which would be halfway in between, then our calculation using just that one channel of information would show that at that location the ocean surface is half-covered by ice and half-covered by water, whereas if we got a value that was much closer to the water value, then our calculation would come out with a lower concentration of the ice.

So we basically start from that very simplistic viewpoint. But we also understand that not all water has exactly the same value of 135, and not all ice has exactly the same value of 235. So there are complications depending on whether the ice is really thin or thick, whether it's got ponds of water on it, whether it's got a snow cover on it. There are all sorts of things that can complicate the picture. And that's why it becomes valuable to have more than just one channel of information, to have several channels of information and then to try to use those different pieces of information to get a better end product, in terms of not just what the percentage of the ice is but how much of that ice might be the older ice versus the younger ice, or the thinner ice versus the thicker ice. Then there are also other complications such as the fact that for the radiation to get from the surface up to the satellite, it goes through the atmosphere, and so the atmosphere could have impacts that we then try to filter out also. So additional pieces of information obtained through additional channels on the satellite instrument help us to sort out some of these complications.

Now, in addition to just sorting out, like what percentage is ice versus what percentage is water, especially in the beginning we had to think, "What kinds of things do we really want to show?" We get a huge amount of data coming down to us, but what in that data shows us something that's really of interest? At first, we were mainly interested in just mapping out what the satellite data showed in terms of where the ice is and getting a really good feel for the seasonal cycle, how the ice cover changes from summer to autumn to winter to spring. In the beginning, we actually thought that was going to look pretty much the same one year after another after another. After just two years of data, we knew, "No, this does not look exactly the same one year after another." So we started to understand that there is a big difference between years, and we started to try to figure out how best to plot results to highlight the differences between the years, and then how to plot other aspects.

Once we had a long enough data set so that we could actually see that not only were there differences from one year to another, but there seemed to be some trends in the data that maybe were long-term trends, maybe were tied in with some cycles in the Earth system. There are many cycles in the system that people are aware of, such as the North Atlantic Oscillation and other cycles in the system. So we tried to compare the changes in the ice with different cycles in the system, to see if maybe there was a cyclical pattern. As we got more and more data—and by now, we've got over 30 years of satellite data of the Arctic sea ice and the Antarctic sea ice—by now, we can see that there actually are some trends that are fairly prominent, even though there's a lot of variability from one year to another, a lot of cases where the satellite data go up and down and up and down. They certainly go hugely up and down during the course of the year because there's way more ice in the winter than there is in the summer.

But we also see long-term trends, and in the Arctic case, these have generated a lot of widespread interest because those trends by and large have been downward, and lessened sea ice is very likely connected with the fact that the Arctic region has been warming. So the warming is probably a big factor in producing the lessened sea ice. But also in return, the lessened sea ice contributes to the warming because as you get less sea ice, that's less of a very reflective white surface that sends solar radiation that comes down and hits the surface, sends it back into space.

So as time has gone on, we've realized that we need to look at more methods and different techniques of how to show the data, because we've found different things that we want to look at. Whereas at first we were just trying to see how well the satellite data could depict the sea ice cover, since then we've become much more interested in what is it showing us about how the sea ice cover is changing. That's true of colleagues in other fields also, in terms of looking toward the best presentation of how the satellite data are revealing changes in the Earth system. So all this requires revised techniques of what we're showing and how we're showing it.

WRIGHT: As your techniques are becoming revised, are tools also? Are there certain types of tools, like software tools—?

PARKINSON: Software tools have improved dramatically. Back in the 1970s when satellite data were fairly new, everything we wanted to do we had to, in large part, think through and develop, such as what color scale to use to show the data. That has changed a lot also. Originally, we used a color scale that had lots of different colors on it because it was very useful for scientists to be able to see all the distinctions that this color scale with lots of different colors on it would show. However, as the public has become more interested in the results, it's become clear that a color scale with a whole lot of different colors confuses the issue rather than helps to enlighten people. So we've certainly changed color scales in order to make things more immediately apparent to the viewer who is not planning on sitting for hours analyzing the data themselves. What color scale is best is very different depending on whether you're aiming at other scientists versus whether you're aiming at the general public. So we've revised things as we've gone along.

Computers have increased so dramatically in terms of the speed of the calculations and in terms of the software tools available, so that now if somebody wants to take a stream of data and make an attractive plot from it, there are software tools where you can just say, "Here's the data, plot it up," essentially, and the software tool will give you a nice plot. But these tools were developed by us at Goddard, and other people elsewhere, by meticulously figuring out how to get the computer to plot the things that we wanted plotted. Tools are so much better now, and it's so much easier to get the plots made because of what's available.

WRIGHT: Now that you have—and I use the word "now" loosely—through this evolution of the last 30 years, you have these software tools, does it impact more of the accuracy of the data, whereas maybe before the software tools your results might have been based on trends? I mean, how do the tools affect the clarity and the accuracy of what your results are?

PARKINSON: I would say our numerical results have improved in accuracy more because of improvements in the instruments on the satellites. However, in terms of the presentation of the results, a huge improvement has come by the fact that now our images can be created and go through the printing process all digitally versus when we used to have to go through a photographic process. For our plots, the fact that those can be digitally produced to a high quality now, because of the really nice software packages for getting good plots out, is a gigantic plus versus the procedure we used to have, which was to have draftsmen actually draft the lines. Now, good as the draftsmen might have been, there's no way they can draft the lines with the precision that a computer doing it digitally can do, and so the digital presentation of the data and the use of digital processes all the way through is a huge improvement in terms of the accuracy of the published plot. So it might not be that much of a change in terms of the numbers, if we include numbers in the text or in a table, but in terms of the plot, the fact that the computer can digitally get the plot drawn exactly right versus having a draftsman approximate it is a gigantic plus.

WRIGHT: When you first started more than 30 years ago, there were not many of you doing this type of work. Have you seen an increase of people entering your field, and if so, do you attribute it to the fact that the data are so much more bountiful more people to get their hands on?

PARKINSON: There's been a huge increase in the number of people involved, and certainly the fact that it's so much easier now is a big factor. Another big factor is the fact that the field of climate studies is now recognized as a very important field, whereas when we started the work, certainly sea ice was not something that hardly anybody really thought much about or thought had much impact beyond the Arctic and the Antarctic regions where it existed. Now people realize that the climate system is so intertwined that changes in any element of the climate system are going to have impacts elsewhere. So the fact that it's become clear that it's an important topic has been a big factor, as well as the fact that it's become a whole lot easier. When we started in the 1970s, Goddard was the main place in the entire world examining sea ice from satellite data. Now somebody can be sitting at a desktop computer in an office or even at home and start using the data and have a whole lot of data that they can easily get off the Internet. So the situation has changed dramatically.

WRIGHT: Has the instant information access allowed you a more viable exchange of information between colleagues, whereas in the past you might have gone once a year or had an exchange through formal presentations? Is that still pretty much the formality, at formal symposiums and meetings, to exchange information, or are there results and exchanges over the Internet as results are defined?

PARKINSON: There is a huge difference in terms of how easy it is to exchange information. Email is widely used, and it also makes it overwhelmingly easier to collaborate with people who you might never actually see face-to-face. Because of being able to exchange all aspects of the work you're working on, including the text and the figures and the data, readily through email and the rest of the Internet, it just allows collaborations and exchange of information that's tremendously increased over what it used to be.

WRIGHT: Working in the history field, we find sometimes documents and memos that are 30 and 40 years old that have been tucked away in a file, and there's always that concern that now exchanges of information through email are only as good as the delete file. So do you find where you are having to store and document information a little bit differently than you might have 10 years ago when you receive it as such?

PARKINSON: I'm finding there is a huge problem because of the volume. I do think that the speed that's allowed through email has the negative effect that therefore you might get very preliminary things being exchanged, and as a result you might get an overload of different versions and sometimes it becomes a real issue to figure out which are the important versions versus which are not the important versions. So it has negative as well as positive consequences.

WRIGHT: A little more challenging there, isn't it?

PARKINSON: Yes.

WRIGHT: Can you talk about how you exchange information with, for instance, some of the other federal agencies, like working with NOAA [National Oceanic and Atmospheric Administration] or EPA [U.S. Environmental Protection Agency] or how you work with those, or if you do?

PARKINSON: In my role as the Project Scientist of Aqua [a satellite of the Earth Observing System], there are actually lots of interconnections with other agencies and with universities and with different countries, as well as different places within the U.S. NOAA in particular is one of our prime collaborators, partly because they have some very good scientists who are interested in the climate change issues, but also because they have weather forecasting responsibilities. They have collaborated with us on Aqua since the beginning of the initial stages of the formulation of the Aqua project. We provide the Aqua data to them really quickly, so that they get it within hours of when the data are collected, in order for them to be able to incorporate it into the weather forecasts. Clearly for a weather forecast, data are not all that valuable if they're a few days late, which is so different from most scientific uses of data where you don't expect to get data within a few days of when they're collected; you expect to get the data in a much longer time-frame after a lot of corrections have been incorporated. So we work a lot with NOAA; NOAA is our prime collaborator in terms of any federal agency in the U.S.

However, there are others that we're really pleased have found that our Aqua data have been really useful to them. The U.S. Forest Service has found that the Aqua data can show forest fires really well, and so the U.S. Forest Service has used these data in order to determine where to deploy the firefighters, because with the satellite data they're able to see exactly how far spread the fires are. The Environmental Protection Agency, EPA, has used the data for some of their air quality analyses. The Department of Defense has used the data for monitoring things like dust storms. The U.S. Department of Agriculture, USDA, has been involved in some of the analyses using some of the data for agricultural studies.

So the Aqua data have been used by a lot of people, and again, the closest collaboration is with NOAA in terms of the U.S. One of our instruments, one of our prime instruments, is a Japanese instrument, and so there's a lot of involvement with the Japanese also, as well as with other countries where they're just using the data. But the Japanese have been a prime collaborator in terms of providing a major instrument on the satellite. So we have lots of collaborations around the world and within the U.S.

WRIGHT: As Project Scientist, are you responsible for releasing that data, or is it set up where it immediately flows to, for instance, NOAA?

PARKINSON: Fortunately, the system is set up so that I have no immediate connection with that string of data that ends up quickly getting to NOAA. The string of data comes into Goddard to the Mission Operations area of Goddard, and they're able to bring the data down from the satellite to Goddard and then distribute it out to the various places that need it. In the case of NOAA, the data have to get distributed out immediately.

WRIGHT: I know that in your other interview, you talked about how important it was to do part of outreach, that you enjoy talking to students and teachers that, of course, they come here. What other ways do you disperse your findings and encourage the next generation of researchers?

PARKINSON: The main way that we disperse our science findings is through scientific publications, and that's mainly through journal articles, also sometimes through chapters in books. But it's mainly through journal articles and also through presentations at scientific conferences. So those would be the primary ways of getting our science results out. But both of those ways are to scientists versus to the general public or to students. In order to get the results out to the general public and to students, NASA has a whole range of things that we do, and I've been involved in quite a few of them. Certainly, I've gone into classrooms and talked to students. I've also been involved many times when groups of teachers and groups of students come to Goddard, and I've given presentations to them.

I've also written a book titled *Earth from Above* that is essentially for the younger generation, especially for those in the younger generation who might be interested in getting into Earth sciences and especially into satellite remote sensing of Earth sciences as a career. I've also been involved in NASA's annual calendar that we put out with really nice NASA imagery in it and captions that tell the reader something about the images; and involved in some of the posters that NASA produces that go to lots of schools, teachers, universities; and involved with creating cards called lithograph cards that show results. We recently did one on our sea ice results, and it's kind of cool because they're small cards that hopefully just get people at least curious or maybe interested, and if they read the text on the back, they'll learn information about what's on the front of the card. So lots of outreach like that.

Recently, there was an event at the [Smithsonian National] Air and Space Museum, and I went down there and helped to staff an exhibit showing satellite imagery and changes in the Earth highlighted by looking at pairs of satellite images. We had a small group of different pairs of satellite images that showed neat things about how you can look at the satellite images and see changes that are occurring in the Earth system. That kind of event always tends to be rewarding if a lot of people show up and you feel that they really are getting interested in it. That happened that day. That was a Saturday several weeks ago.

WRIGHT: What's the most important message that, as a climatologist and/or a scientist, you want to share with these people when you talk with them? Or that you would like to share at any point, the statement or the message you just want to tell folks?

PARKINSON: In terms of the most important message, I'd say the most important is that we live on a marvelous planet with many intricately intertwined systems that we do not yet fully understand, but that we should be conscientiously trying to preserve or at least not further damage. That, I think, is the most important message, in terms of importance. But when I'm talking with children, often another point that I really want to get across is that science is just an incredibly exciting field to go into, and that if they have any interest in trying to further our understanding of any element of the world around us, that they should seriously consider going into science as a career.

WRIGHT: If you don't mind, if you could take that further and just share with us that you spent your life and your whole career in this work, and now it's an everyday topic. More and more people are becoming conscious and somewhat even more respectful of the fact that we need to take care of our Earth, and maybe you could share with us some of the changes that you've seen in people's attitudes over the last years, and maybe some of the ones you'd like to see in the future.

PARKINSON: I have certainly seen a big change. Among the changes that I'm very pleased to have seen is I think people have become far more aware of damage that we can sometimes do by being needlessly wasteful. And I do think that the younger generation is growing up with a bigger awareness that they should try to conserve more, that they should try not to waste as much. Certainly in my mind, that's a huge plus. Aspects that I find more troublesome would be, I find that with the increased media attention to the climate change issue, there's become an awful lot of polarization between people who feel very strongly that humans are adversely affecting the climate and feel very strongly that something should be done about it, versus other people who feel equally strongly that some of the suggestions of what should be done about it are going to be even more damaging than what's being attempted to be corrected. I find that the polarization in the science community as well as in the public is troublesome, and I feel it's a huge negative impact of the increased attention to climate change.

So I have mixed feelings. I feel some of the increased attention has been very good, other of the increased attention has been very unfortunate. I wish that the discussion could be more civilized in some cases than it seems to have become, because I do feel that the issues are extremely important. But I feel that the various people addressing the issues all have something important to bring to the table, and that it's too bad when the friction ends up not allowing a civilized discussion to take place to try to advance the effort of doing whatever is best for the planet and for society at large. Now all these comments, as I'm saying these, I realize any comment that I make that relates to policy like that, I'm stating as an American citizen, not as a NASA employee. That's important in terms of, as a NASA employee I have repeatedly been told I'm allowed to say anything I want, but if I'm saying something that's policy-related, I should say I'm saying it as an American citizen, I'm not saying it as a NASA employee. However, when I present the results of my science, whatever those results might be, that's as a NASA employee.

WRIGHT: From the statement that you just made, I'm going to assume that there has been a discussion with you and your colleagues—I guess because some have tried to politicize the science of climate. We know just by reading the recent history that it has become somewhat of a political football, not just here in the United States, but globally. How has that influenced, or has that influenced how you've been able to progress on your work in any way?

PARKINSON: It has not really impacted me directly in terms of the work that I do. It's impacted me more in terms of concerns about the discussion becoming too polarized. But in terms of the work that I do, none of the work that I do has been stopped or slowed down or speeded up because of external influences like that.

WRIGHT: Do you have any colleagues that have somewhat opted to not continue the work because they feel political impact or political pressure on them moving forward in their findings? I know sometimes when things get so challenging, sometimes some of the best people will just stand aside because it's not worth the struggle. I didn't know if you've encountered any of that, those feelings, or have heard of those feelings from any of your colleagues that just kind of throw their hands up and say they're moving on to something else.

PARKINSON: Offhand I can't think of anyone who quite said that, although I would understand it if they did. What I have seen is a sharp contrast between different individual scientists in terms of how much they will deal with the media. I have found that some simply will try not to deal with the media at all and will basically not reply to media requests, whereas I've found others who enjoy the media attention and will definitely spend a lot of time with the media and sometimes actually aggressively seek out media attention. I'd say in terms of the people I know, the majority are intermediate between those two extremes, and certainly I would place myself as intermediate between those two extremes. In my case, I'm willing to talk with the media when they call, often referring them to somebody else if I feel like somebody else might be the more appropriate person, but willing to answer questions if they're asking me something that I feel I am the appropriate person to answer. So I think there's a range of responses. I've certainly seen a range of responses in terms of my colleagues.

WRIGHT: One of the issues that's been in the media, I guess for the last 10 years and especially the last few years, is almost a proposed deadline, that we only have so many years to change how the world is responding to the climate changes if the world wants to stop or reverse these trends, which almost gives an indication that your field of science has now moved up into a higher level of importance. Do you feel that this information that's being distributed through the media is, based on your trends and based on your findings, a statement that we all need to contend with, or do you feel it's something that we need to—and if you want to think about this one, we can always come back to it. But just reading some things, some scientists will say that it's at the time that we need to look at it more closely. So I just thought I'd ask and see where you thought we were at this point.

PARKINSON: I feel that it's very important for us at this point to recognize that humans are having an impact and to try to lessen that impact. That doesn't mean that I necessarily agree with the people who say we've only got 10 years or so; in fact, my feeling is more along the lines of: there are a heck of a lot of unknowns. I feel that with all those unknowns, the cautious route would be to try to limit any further damage that we might be doing, not because we know what would happen 10 years or more from now, but because we're not sure, and it could be really bad, what might happen. So I would like to see a lessening of our emissions of gases to the atmosphere. I certainly want to see a lessening of our dumping garbage into the oceans and all sorts of things like that. But I also recognize that industrialization has provided us with a whole lot that humans are not about to do without now. So my feeling is: limit as much as we can; and we can limit a lot just by being less wasteful. We can cut back considerably and yet can still maintain our basic lifestyles.

WRIGHT: You've spent so many years in your field. You must have encountered some obstacles and challenges along the way to be able to accomplish as much as you have. Is there some areas of challenges or some major obstacles that you can think of that you'd like to share with us that, talk about how it kind of made you stop and think, and then you had to learn how to figure out how to keep going based on getting over that challenge after you've encountered it? I'm sure everything hasn't been smooth sailing. Or was it just the adventure of discovery as you've gone along?

PARKINSON: There have been many challenges. Everybody's set of challenges, obviously, is different. In my case, I would say the biggest challenge for me actually is the fact that I have a problem with seizures, and this makes me far less capable at some moments than at others. I would say my greatest challenge has been to deal effectively with that. It becomes very tricky at times. If a seizure is big enough, like a grand mal type seizure—which I fortunately very rarely have—but if it is, then in some ways it's easier to deal with because you have the seizure, everybody sees you're having it, and when you're done with it, you just get over it. It becomes more of a challenge, the smaller seizures where I'm the only one who knows I'm having them, and then that's difficult because I know I've become less capable temporarily, and yet if there are other people in the room, it's like I don't want to say anything because I don't want to look like I'm coming up with some excuse. But on the other hand, it's troublesome exactly how best to deal with it. My way normally is, as much as possible, to simply be quiet. If I'm having a seizure and I don't have to be involved in a conversation, I just won't be. But it is difficult. So I would say that's been my biggest personal challenge, although there have been lots of other things. But all the other things are kind of outweighed by that one.

WRIGHT: I could see that, yes. Have you had any setbacks or encountered any challenges because you were a female in such a scientific community?

PARKINSON: No. In terms of the impact of being a female, I would say that as a scientist, I really haven't had major obstacles put in my way because of being a female. I would say major obstacles put in my way because of being a female were more as a child, because as a child there were certainly many things I couldn't do because of being a female. Fortunately, times have changed, and so girls growing up now are allowed to do a lot of the things that I wasn't allowed to do. Among the things I wasn't allowed to do would be I wasn't allowed to be on any of my high school athletic teams. There was not a single sport that my high school allowed a female to participate in, whereas the boys had all sorts of sports that they could participate in. I wasn't even allowed to have a paper route. Fortunately, times have changed, and girls growing up now don't have those disadvantages. But those disadvantages, they not only are bad for the time period, but they also mean that as an adult, you haven't had some experiences that males had, and so therefore there are differences.

Now in terms of being a female in the scientific community, I would say I don't feel that I was ever denied a promotion or an award because of being a female. So I don't feel anything explicit like that has ever happened to me. But I do feel, especially early in my career, that sometimes I wasn't listened to in the way that a male might have been listened to. I do feel that was more earlier in my career than now. But I also feel that certain aspects of my personality that are more common with females than with males do lead to disadvantages. A prime example there would be that I tend not to speak anywhere near as assertively or aggressively as a male might tend to speak in the same circumstances. For instance, if I present a result, I might be inclined to present it with more qualifiers that might make it look less important as a result. Or if I present an idea, I might present it as, "Well, one possibility might be," whereas a male might present it much more assertively as, "Oh, the best idea we could consider would be," something like that. So I don't feel I'm being mistreated because of being a female, but I do feel there are aspects of my personality that do put me at a disadvantage, and some of those aspects are related in some way to being a female.

WRIGHT: Are there aspects that have been an advantage? Do you find yourself to be more patient sometimes?

PARKINSON: I do find myself to be more patient than some of my colleagues sometimes, and that sometimes is very good. I don't know if that's a male/female contrast so much—it might be; I'm just not sure, because I certainly have some male colleagues who I feel are very patient also. I have some male colleagues who are very impatient; but I have seen a mixture. Now in terms of my colleagues, they are overwhelmingly male, so I don't really have good statistics in terms of male/female differences because I just haven't worked with anywhere near as many females as I have with males.

WRIGHT: We've talked about satellite and software tools, and of course the Internet access. Are there other aspects or elements through the last years that you see as being very vital to advancing your field of science? Maybe access to travel, is it easier or harder to get access to some of the areas that you want to physically go see?

PARKINSON: Travel is an interesting topic that you bring up. In terms of travel, I've always been able to travel as much as I want, but by now, I think it's become clear that plane travel is one of the most serious culprits in terms of greenhouse gas emissions to the atmosphere. So I feel that people concerned about the environment should put more effort into restricting their travel, and that certainly does become more viable now with the Internet and other technological advances such as the telephone, which of course has been around for a long time now. Because of technology, we don't physically have to go places as much as might have been warranted in the past. However, in terms of scientific field work, if you want to collect data, you've still got to go to the place. Certainly travel has become easier than it used to be decades ago, although in the last 10 years it's probably become more difficult because of the increased rules and regulations at the airports. So in some ways it's certainly become easier than it would have been in the early 20th century before you had a lot of commercial airplane flights; but it's become tougher both for the reason of the increased regulations at airports and also for the recognition that any plane travel is emitting greenhouse gases to the atmosphere. Overall, people concerned about the environment should try to limit the amount of plane travel they do.

WRIGHT: Where do you see yourself moving? Not physically, but where would you like to see your field go in the next 10 years or the next 20 years? Do you see it discovering more or moving into different aspects? Do you have a crystal ball that you see where you're going?

PARKINSON: I don't have a crystal ball that's going to give me much insight into this; however, I would say that a very important aspect of where the field should be going is greater interdisciplinary research. Most work in Earth sciences has been of a disciplinary nature, meaning that some people study sea ice, some people study ice sheets, some people study the atmosphere, some people study the oceans, some people study very limited things in the ocean or the atmosphere or the ice or the land or vegetation. I think by now, we have enough clues and solid evidence that the system is hugely interconnected and that we really can't understand any aspect of it completely unless we understand the other aspects too. It's a hugely interconnected system, and this hugely interconnected nature of it is also part of the reason why we can't know for sure what the climate is going to be like 10 years, 20 years from now. There are just too many interconnected aspects that are not fully understood yet.

WRIGHT: Do you have some other thoughts or some other experiences you'd like to share with us today?

PARKINSON: No, I think you've pretty much covered it.

WRIGHT: Okay, we can stop for now and if we think of some things you'd like to add, you can do that with us as well. So thank you so much again.

PARKINSON: Thank you, Rebecca. Thank you, Sandra.

[End of interview]