NASA HEADQUARTERS HISTORY OFFICE ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

DR. CLAIRE L. PARKINSON
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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The questions in this transcript were asked during an oral history session with Dr. Claire Parkinson. For clarification purposes, Dr. Parkinson has edited her answers. As a result, this transcript does not exactly match the audio recording.

ROSS-NAZZAL: Today is June 26, 2008. This interview with Dr. Claire Parkinson is being conducted in Washington D.C. for the NASA Headquarters History Office. Dr. Parkinson is in Washington today to participate in the NASA Program at the Smithsonian Folklife Festival on the National Mall. Jennifer Ross-Nazzal is the interviewer, assisted by Sandra Johnson. Thanks again for joining us today. We certainly appreciate it. We know your schedule is busy.

PARKINSON: Thanks very much Jennifer. I'm pleased to be here, so thank you.

ROSS-NAZZAL: I thought we could begin by talking about if there were any specific events or people that resulted in your interest in climatology as a graduate student, or perhaps even at a younger age.

PARKINSON: My interest as a young child was math. I was totally enthralled by what you could do through the use of symbols, i.e., that math allows you to do so much with so little. Math just enthralled me and that was overwhelmingly my prime interest. So naturally I majored in math in college. However, this was in the late 1960s; the Vietnam War was going on, and civil rights were clearly not what they should be in this country at that time. There were a lot of issues that made me question how I could go into a career that is entirely theoretically oriented when so much that I opposed was going on in the world, and so that's why when I graduated from college, which was in 1970, I decided that much as I love math, I really couldn’t stay in it as my career. And that's when I decided I would switch to science, and in particular, climate issues.

On the positive side, one event in the '60s stood out hugely in my mind, and that was the first landing on the Moon in July of 1969. That landing on the Moon, when [Neil A.] Armstrong and [Edwin E. “Buzz”] Aldrin [Jr.] put down the plaque from NASA that said: "Here men from planet Earth first set foot upon the Moon, July 1969 A.D. We came in peace for all mankind." That struck me so much, "We came in peace for all mankind." More than any other event in the '60s, that made me feel proud to be an American. That was the culmination of an amazing string of inspiring NASA accomplishments in the ‘60s, all of which made me always feel really, really positively about NASA.

After moving away from theoretical math, I decided I would like to go to Antarctica. So I went to graduate school at Ohio State University [Columbus, Ohio], where they had an Institute of Polar Studies, and I specialized in polar research, both Arctic and Antarctic. I did get to the Antarctic on an expedition, which was thrilling to do. After returning to Ohio State, I attended a seminar that a scientist from the National Center for Atmospheric Research (or NCAR) [Boulder, Colorado], Warren [M.] Washington, was giving on climate modeling. Although still young, Warren was already a leader in the new field of climate modeling. I listened to that seminar and I thought, "Wow, they can use a computer to figure out where the jet stream is and all sorts of other stuff,” and I thought, "Studies like that could really employ my math more than anything I’ve been doing so far in my graduate work."

I was extremely shy at the time, but I went up to the speaker afterwards—which was a big step for me—and I asked, "How would a person get involved in studies like this?" He answered, "Well, what's your interest?", and I said, "Well, I'm in the Institute of Polar Studies here, and my interest is in the polar regions." He then asked, "What would you feel about modeling sea ice?" and I immediately replied, "That would be great!" He said, "OK, let's have you come to NCAR for the summer," and I'm thinking, "Wow, this is moving pretty fast."

So Warren got it arranged that I could go to NCAR that summer and start working on sea ice modeling, because sea ice is something they didn't have in their model yet. In fact none of the models at that time included full-scale sea ice calculations. By the end of the summer, Warren and I and my advisor at Ohio State all decided this would be a great topic for my Ph.D. dissertation. So I ended up getting funded by the National Science Foundation to spend two years—after I finished the next year of my studies at Ohio State—at NCAR developing this sea ice model.

At the end of developing the sea ice model, and still finishing up the writing of my dissertation, I went to a conference in Seattle [Washington] where I presented the results. Someone from the audience came up to me after the talk and asked me what my plans were for after I got my degree. And I said, "Well, I'm so busy getting the dissertation done that I really don't have any immediate plans yet." He then asked, "What would you think of working for NASA?," and I went, "NASA? Wow!" Immediately it became my first choice. There was no question whatsoever; that was my first choice; that's where I wanted to work. I said, "I would love to work for NASA!" So I put in an application, and the next summer, which would be July of 1978, I started working for NASA at Goddard Space Flight Center [Greenbelt, Maryland], and I've been there ever since. So I'm just about done with 30 years at NASA.

ROSS-NAZZAL: When you applied to work at NASA, what did you think that you'd be working on, or what were you told might be some opportunities there for you?

PARKINSON: I actually was really naïve. I just wanted to work for NASA; whatever they asked me to do, I'd be willing to do. I really did not know what they wanted me to work on. When I got to NASA, I was expecting that they would give me some assignment, and I would do my best at whatever the assignment was. That was my thought. Well, that's not the way it works with scientists, but I was naïve. I was from central Vermont, and everybody I knew who had a job, they'd walk into their job and they'd get assigned something and they'd do it. I had no idea that a scientist doesn't work that way.

So I got to NASA ready for them to give me my assignment, and they said, "Well, we want you to continue working on your sea ice model," and I said, "Oh, okay! Great, sure." So working on my sea ice model was a central reason why they wanted me there. But they also mentioned a different project that I could be involved in as well. Specifically, a satellite that was launched in late 1972, the Nimbus 5 satellite, had an instrument on it, the Electrically Scanning Microwave Radiometer, or ESMR, and people were working to understand the ESMR data and generate meaningful data sets from it. I said that I'd love to work on that project also, and get involved in the satellite data. So I became involved working on sea ice information derived from the ESMR data. I was working roughly half time continuing with the modeling work and roughly half time with the satellite data analysis, and as time went on it shifted more and more to the satellite emphasis.

In my first few years at NASA, I was working with Jay Zwally, Joey Comiso, Frank Carsey, Per Gloersen, and Bill Campbell, compiling the satellite data for the Antarctic sea ice, which is a somewhat easier problem than the Arctic sea ice, and so that's why we were doing the Antarctic first. The satellite data, whether it’s sea ice or something else, allow a global picture that you just cannot get any other way. Sea ice in particular is something that you simply didn't have many measurements of prior to the satellite era, because who's going around measuring sea ice? I mean, it's tough to get to the regions. It’s cold, it's dangerous, it's very tough. Some measurements exist prior to satellite data, but not enough to get a solid climate record.

Sea ice spreads over a huge area. It spreads over, in the wintertime in the Arctic, about 15 million square kilometers, which is more than one and a half times the area of the United States. In wintertime in the Antarctic, it's even more; it's about 18 million square kilometers. Even in the summertime, the Arctic still has, generally, between five and seven million square kilometers of sea ice. So it's a huge area involved. Without satellites, you can't possibly, even with an aircraft zipping back and forth, get the whole area covered in a few days or anything routine, whereas with a satellite, you can easily get at least near-global coverage every few days.

By now, our satellites can actually get near-global coverage every day. With satellites, suddenly you can get the full global picture of what’s going on. We finished the Antarctic atlas in 1983, at which time computers weren't anywhere near what they are now. So we had to do all sorts of things to develop the techniques of how to analyze the satellite data to determine something about sea ice. Other people at Goddard and other NASA Centers were developing techniques for how to analyze the satellite data for other variables. In our case, it was sea ice.

At the end of that project of getting our first book out, which was the Antarctic sea ice atlas [*Antarctic Sea Ice, 1973-1976: Satellite Passive-Microwave Observations*], we decided we would tackle the Arctic problem. By that time, I had had plenty of experience with the Antarctic book and was put in charge of the Arctic sea ice atlas [*Arctic Sea Ice, 1973-1976: Satellite Passive-Microwave Observations*]. So during the next three years, we worked on the Arctic project. There were six of us working on it, and I was the lead on this Arctic sea ice atlas project, to get the Arctic sea ice data compiled and understood, and the methods developed for how to analyze the data.

Now, this was all done with the data set that was from the Nimbus 5 satellite that was launched in December 1972, and it provided essentially a four-year record. However, by the time that we got done with these two atlases and had all the techniques developed, another satellite with a much better instrument had been launched. The ESMR instrument from the Nimbus 5 satellite was essentially a trial run, a proof-of-concept instrument to see whether or not microwave data—which is the type of data that it was collecting—to see whether or not microwave data could provide us with important data sets for various phenomena on the Earth, one being sea ice. We certainly proved with this atlas work that it was extremely useful for doing this.

Another satellite with a more advanced microwave instrument had been launched in October of 1978. And so by the time we were done with these two ESMR atlases, we had this other satellite which had a much longer record by that time, well exceeding the four-year ESMR record. The Nimbus 7 satellite, launched in '78, collected almost a nine-year record. So we were able then to shift our attention from developing the techniques and the methods of analyzing the sea ice data to actually looking at whether the sea ice cover is changing over time. By 1989, we came out with a paper—it was by myself and Don [Donald J.] Cavalieri [Parkinson, C. L., and D. J. Cavalieri, 1989, “Arctic sea ice 1973-1987: Seasonal, regional, and interannual variability," *Journal of Geophysical Research*, vol. 94]—showing that the longer record was revealing that the sea ice coverage was decreasing in the Arctic. This was one of the first indications that maybe Arctic sea ice is diminishing. Afterwards the sea ice decreases became a central focus for us, because we realized that maybe something important is happening in the Arctic, especially since, at this point, we were starting to get an interest in global warming and the possibilities of climate changes due to CO_2 [carbon dioxide].

Now in the meantime, I was continuing to do some of the modeling work. One of the things that I did was to use the sea ice model to try to see what would happen to the Arctic sea ice if indeed temperatures rise as much as scientists think they might with the eventual doubling of CO_2. The initial paper I did on that topic was for the Arctic, and it came out in 1979. It was a Parkinson and Kellogg paper, Kellogg being Will [William W.] Kellogg from the National Center for Atmospheric Research ["Arctic sea ice decay simulated for a CO_2-induced temperature rise," *Climatic Change*, vol. 2]. We looked at the Arctic case and showed the conditions under which the model simulated that the Arctic might become ice-free again, which would be the first time in a very long time, with the Arctic ice-free in the summertime. Then I did a similar study but for the Antarctic case, and that paper was with Bob [Robert A.] Bindschadler, and came out in 1984. ["Response of Antarctic sea ice to uniform atmospheric temperature increases," *Climate Processes and Climate Sensitivity* (edited by J. E. Hansen and T. Takahashi), Maurice Ewing vol. 5, American Geophysical Union, Washington, D.C.] So I was continuing to do some modeling work.

I also used the model for an entirely different study. The satellite data revealed a phenomenon that nobody had expected called the Weddell Polynya, which was a major area of open water in the midst of the Antarctic sea ice cover. It occurred in the wintertime in three of the four ESMR years and so people were thinking, "This is really interesting" and they were thinking it was likely the usual condition because it occurred in three of the four years. Well, it's never shown up again. It was just those three years that it showed up. But I did use my sea ice model to try to simulate why this might happen. In my model I changed the wind fields, and by changing the wind fields I was able to simulate a Weddell Polynya, this open water region in the midst of the Weddell Sea, which is right off of Antarctica. And I was also able to change the wind fields differently to end up with no Weddell Polynya. Now, other people working on the Weddell Polynya at the same time were looking more at the conditions of the oceans instead, and they concluded that the polynya was caused by ocean conditions. Whether it's due to the atmosphere or the oceans, I wouldn't say that I'm certain one way or the other; quite likely it's a combination of the two. But the study was a way in which I could use a model, a sea ice model, to at least show that in the *model*, this polynya could be created by changing the wind fields.

Anyway, I was working on both the modeling and the satellite data. Then after realizing that the Arctic ice was decreasing, our sea ice group at Goddard decided that we would make a major effort to continue this work and see what was happening to the Arctic sea ice through the 1990s. By 1999, we had a major paper out, by five people, all from Goddard. I was the lead author, but everybody else was important too. The other people were Don Cavalieri, Joey [C.] Comiso, Per Gloersen, and [H.] Jay Zwally. [“Arctic sea ice extents, areas, and trends, 1978-1996,” *Journal of Geophysical Research*, vol. 104]

Our paper in 1999 showed a serious decline in the Arctic sea ice. But it also showed that the ice wasn't every year getting less; it was up and down. But it was a definite decline overall. In the same year that our paper came out showing the decline of the sea ice cover from the satellite data, which is essentially showing that it's reduced in areal extent, a group from the

University of Washington [Seattle] came out with a paper showing from submarine data that the Arctic sea ice is thinning. The combination of these two papers in 1999 received a lot of press coverage, because it looked like, "Wow, from all directions the Arctic ice is decreasing." The Arctic is certainly one of the regions in the world where it looks like we're getting the strongest warming in the last few decades; and the Arctic ice cover has continued to decline, overall, through these decades.

By today, way more people are interested in the topic of Arctic sea ice. When we started the Arctic work, Goddard was the center of the world's Arctic sea ice satellite data analysis because nobody else was all that interested. By now, many groups from around the world, many groups in the US and outside the US, are very much interested in this phenomenon of the decrease in the Arctic sea ice, especially with the ramifications—and there are many ramifications. There are climate ramifications, because sea ice is white, especially if it's got a bright snow cover on it, and that means that solar radiation that reaches the ice gets reflected off, largely going back to space. If the ice cover retreats and you no longer have the ice there, that solar radiation comes in and instead gets absorbed in the ocean, staying in the Earth/atmosphere system. So the presence of the sea ice helps to keep the Arctic cold.

Now, the Arctic would be cold anyway relative to lower latitudes, but the presence of the sea ice makes it even colder, and as the sea ice retreats you get what's called in science a ‘positive feedback,’ because as the sea ice retreats, more and more radiation gets absorbed in the oceans, therefore encouraging things to warm up even more. This kind of positive feedback is one of the prime reasons why people expect climate changes to be greater in the polar regions than elsewhere. Now, that's not always the case that it is greater, but that positive feedback is a prime reason why it might be greater.

Last year, a phenomenal decrease occurred in the Arctic sea ice, way more than had occurred before. We're still not positive that this decrease is going to continue. Basically, we hope it's not. But there's certainly a big decrease. At the same time, we're doing all the same kinds of analyses on the Antarctic sea ice as we do on the Arctic sea ice, because the data set covers both hemispheres and so whatever techniques we use for the Arctic we generally also apply to the Antarctic. And in the Antarctic case, actually since the late '70s, the Antarctic sea ice has been increasing a little. That's important to know in order to keep the changes in the Arctic in context.

ROSS-NAZZAL: What do you attribute that to?

PARKINSON: Nobody knows for sure. Some people think it might be somehow connected with some kind of oscillations. It might be connected with the El Niño-Southern Oscillation. Nobody knows for sure. Another possibility is: in the 1970s, the Antarctic sea ice actually decreased quite substantially, and so the possibility exists that maybe the increases since the late '70s are a slight rebounding from the huge decrease that happened in the '70s. The decrease was so large in the '70s that even though trend-wise the trend has been upwards since the late '70s, the Antarctic sea ice amount is not back up to where it had been in the beginning of the '70s.

But that brings up another topic. This huge decrease in the '70s in the Antarctic was reported in the scientific literature in 1981 by two people from Lamont-Doherty [Earth Observatory], which is part of Columbia University [New York, New York]. They were George Kukla and Joyce Gavin. [“Summer ice and carbon dioxide,” *Science*, vol. 214] By the time that they reported this substantial sea ice decrease, we at Goddard had been doing our analyses for a few years, and we were able to see that the Antarctic ice was not continuing to decrease. So we wrote a paper that got published in 1983, by Jay Zwally, myself, and Joey Comiso, all from Goddard, and we showed that this huge sea ice decrease had been reversed. [“Variability of Antarctic sea ice and changes in carbon dioxide,” *Science*, vol. 220]

But when Kukla and Gavin came out with their paper in 1981, there was a lot of press coverage of it, and people were saying that this could be the first real geophysical evidence of global warming. And this was reasonable in terms of, yes, with warming you expect ice to retreat, and there was a huge ice decrease in the Antarctic; so it was reasonable for the press to pick up on it in that way.

But the Antarctic ice changes reversed, and so that gets to the point about what's happening in the Arctic now, with the possibility that those changes might reverse also. We saw it happen in the Antarctic, a huge decrease and yet the system did reverse. So, much as we expect the long-term trend in the Arctic sea ice cover to continue to be downward—although we don't expect each year to have less ice than the year before—we aren’t certain. If this year, 2008, has even less ice than last year, that'll be significant, because last year was such a low for Arctic sea ice coverage. We think the winds contributed to making the low sea ice conditions last year. If this year has even less ice, that'll be sad and serious, but we don't know whether this will happen or not.

ROSS-NAZZAL: I was looking at your resume, and I saw that you had done some work for Senator Al [Albert A.] Gore [Jr.] when he was working in the US Senate on the Sea Ice Specialists Panel. Can you tell us about that?

PARKINSON: That was very interesting. It was 1990, and I got invited down to Senator Gore's office in the Senate, and it was memorable. He was wanting to learn about what was going on with the sea ice and just wanting to understand it. He was extremely intelligent. He picked up things extremely quickly. He clearly didn't know much about sea ice at the time, but he quickly picked up all the key concepts. It was just Senator Gore, myself, and his Science Advisor at the time, so it was just the three of us; and the Science Advisor really wasn't saying much, so it was basically just me and Senator Gore.

The Science Advisor had told me when I walked in that the Senator had to speak on the floor of the Senate in half an hour; the meeting started at nine and therefore it would have to end by 9:15. I said, "Well, okay, whatever; I'm here to do whatever is wanted." About 9:15, Senator Gore gets on the phone and he's saying, "Change my timeslot with somebody else. I'm in a very important meeting." I'm sitting there thinking, "Important meeting? He's just talking to me!" But anyway, I thought, "Okay!" Then we kept talking, and every once in a while he would get on the phone and say, "Switch my time with somebody else"; and we ended up talking for over an hour and a half, and it was just an incredibly good discussion. He clearly picked up point after point after point about why sea ice is important to the climate system.

Then right after our meeting, Senator Gore formed the short-lived Sea Ice Specialists Panel. We only had one meeting with him, but it was shortly after my initial meeting in his office. He asked me to bring some other people from Goddard, other sea ice specialists, and there were some people who came from out of town also. So we met with him in one key meeting, during which his central focus was to initiate with the Navy an activity during which the Navy would declassify some of the submarine data. This ended up being a major benefit to sea ice studies, because submarine data were the best available data to see what the sea ice thickness had been, as at that time, satellites were not yet able to obtain sea ice thickness. A satellite is up now, launched in 2003, that can get thickness, or at least an approximation to it. But nothing in the way of satellites could get sea ice thickness as early as 1990. So the submarine data were the best possible ice thickness data, and Senator Gore really made a major effort to get those data—whatever could be declassified without a problem national security-wise—to get them declassified so that scientists could use them. Then it was a group at the University of Washington that picked up, as the submarine data were declassified, and started analyzing those data. The group, led by [Dr.] Drew [A.] Rothrock, published a paper that came out in 1999 showing the thinning of the ice cover from the submarine data. [“Thinning of the Arctic sea-ice cover,” *Geophysical Research Letters*, vol. 26]

ROSS-NAZZAL: Since his [Senator Gore’s] book has come out, have you seen any change in your work and the interest of climatology, or at Goddard?

PARKINSON: There's been a huge change in the past decade; not necessarily because of his book, but because of so many things, including [Dr.] Jim [James E.] Hansen, and including the huge range of evidence that there's serious warming going on, plus the possibility that the warming could be in large part attributed to humans, or at least in some part attributed to humans. But also an interest exists because not all the evidence is in the same direction; so there's considerable room for questioning many of the conclusions. We certainly don't know enough yet, but the interest has been so much greater than it was when I got into the field or so many of the others got into the field.

I think that for many of us, there's no way when we got into Earth sciences that we ever thought any media people would interview us about our work. I mean, there's just no way we thought that way. Then the topic became of interest to the press, and so that was definitely a change. Different people have adjusted in different ways. Some go for it and actually aggressively seek out press attention. Others won't speak to the press at all. And others are kind of in between, like me, which is to say yes, we'll answer questions when they're asked, but we don't go out aggressively seeking press attention. So it's all combinations, and certainly at Goddard in the very branch that I'm in, I could classify people into each of those three categories. There are definitely all types.

ROSS-NAZZAL: Do you do a lot of work with the current or past administrations or other Congress members?

PARKINSON: I actually don't. I haven't had much contact with Congress; no.

ROSS-NAZZAL: Okay, I was just curious about that. You've done work with satellites. Have you done any work with the Space Shuttle and maybe some of the flight crews in terms of just Earth observations of the Arctic or Antarctic ice?

PARKINSON: No, I haven't actually done that either, although one of my good friends from Goddard became an astronaut, [Dr.] Piers [J.] Sellers. So that's cool to see him as an astronaut and watch his missions in particular. But no, I haven't done that.

ROSS-NAZZAL: Okay, I was just curious if the Shuttle had contributed at all to your work.

PARKINSON: No. Not directly.

ROSS-NAZZAL: Shall we turn our attention to the Aqua Satellite?

PARKINSON: Sure. The Aqua satellite. I became Project Scientist for Aqua; at the time it was called EOS [Earth Observing System]-PM, PM referring to afternoon. There was also an EOS-AM for the morning, which became the Terra satellite, after which EOS-PM became the Aqua satellite. In fact, I became Project Scientist in April of 1993, and the Terra Project Scientist was Piers Sellers, the one who became an astronaut a few years later. I became Aqua Project Scientist in 1993. This was a mission that would not launch until 2002.

There's a heck of a lot of work before a launch occurs. First, the instruments have to be built, plus the spacecraft—what's called the bus, where you put all the instruments. The spacecraft bus has to be built, the instruments have to be built, all of the development has to take place to prepare the algorithms and the computer programs to analyze the data once the satellite is launched. So lots of pre-launch work is needed, and this was taking place in those years from 1993 to 2002. My time then was spent about half time with the Aqua spacecraft project, and the other half time still on my sea ice research.

Lots of people are involved in a spacecraft program. As Project Scientist, I was a focal point for the science, but there's also a Project Manager, and he's the one really in charge of getting the spacecraft built, getting the instruments constructed, and all that. There's a large amount of work divided between the Project Manager and the Project Scientist, but the Project

Manager, he's definitely full-time. This is very much a full-time job for a Project Manager as he prepares for a satellite to get launched, and he's got a huge amount of responsibility.

The Project Scientist, as you're coming up to launch, is concentrating more on making sure that the science teams are kept informed and are getting all the needed algorithms and software prepared for eventual data analysis. In our case with Aqua, we have five science teams. We have six instruments, five science teams, one of which is centered in Japan, which is for an instrument on Aqua, the AMSR-E [Advanced Microwave Scanning Radiometer for EOS] instrument, that's provided by Japan. So we have four US science teams and one Japanese science team. Our US science teams all have foreign members on them, and so they're not just US, but they're centered in the US.

So a lot of people are involved. These science teams are associated with one or more particular instruments, and as you're coming up to the launch date the teams are trying to get the algorithms ready that will utilize the satellite data, which come down just as strings of numbers from different wavelengths—sometimes individual wavelengths, sometimes bands of wavelengths—of radiation. You're just getting information about radiation from the satellite, but what you want to convert it into is information about the Earth. So you'll have people working on algorithms for converting the radiation data into sea ice information, other people working on converting the data into vegetation information, others sea surface temperature, others atmospheric temperature, others cloud coverage, just a huge slew of things. So the scientists are working to get all the algorithms developed; and as Project Scientist I'm a focal point for this and we have meetings and other communications to make sure everything's moving along and to help resolve any conflicts or uncertainties.

Then the launch in 2002: it was May 4th of 2002 that we finally launched. The last year before launch there are so many safety-oriented meetings. As I went through that last year before launch and all the meetings we had, I was so impressed with how much NASA cares about making sure these satellites launch safely. I realized that if they care that much about a satellite that's just got hardware on board, then obviously with the Shuttle or any other manned or womanned flight, NASA does everything it possibly can to make sure these flights are safe. But they're extremely complicated, and no one can be certain they'll be successful. With the Aqua mission, we had spent nine years working on this mission, yet we knew the night of that launch, that it could blow up. I mean, there's no assurance that these missions are going to launch and operate safely no matter how much effort is put into it, and it is a huge amount of effort. Every little thing is checked and checked and checked and checked.

Anyway, the launch was from Vandenberg Air Force Base out in California. It was in the middle of the night, at 2:55 in the morning. That was cool. The timing of the launch, people sometimes ask, "Is that for secrecy reasons or anything?" No, it's definitely not for secrecy reasons. NASA's launch schedules are always known beforehand by the public; at least as far as I know, they're always open. The precise launch timing is to get the satellite into the orbit that's desired. The particular orbit we wanted to get Aqua into would have the satellite going north across the equator at 1:30 in the afternoon and then south across the equator at 1:30 in the morning. To get it into the precise orbit that we wanted—which was also a sun-synchronous orbit, meaning that it will keep coming up at 1:30 in the afternoon as the Earth spins underneath it, all synchronized with the sun—in order to get it into that orbit, it had to be launched within a 10-minute launch window between 2:55 in the morning and 3:05. We had to launch within that 10-minute window or the launch would be delayed to the next night, when we could try again.

Fortunately, it went off successfully that first night. So much depends on the first hour and a half after launch. Of course, most people are most concerned about seeing the rocket go up and seeing the spacecraft get up and launched safely, and that was a huge moment when that happened.

ROSS-NAZZAL: Were you there?

PARKINSON: I was there, yes, I was there. That was a huge moment when the launch took place, but I had been told, "Claire, don't breathe a real sigh of relief until the solar array comes out." The solar array, or solar panel, is all folded up on launch because it's quite large, and the rocket couldn't fit the solar panel without having it folded up during launch. So it's all folded up until after the spacecraft is freed from the rocket, and then it comes out with an accordion-type unveiling. That took place one hour and twelve minutes after launch. So that's when you can breathe your sigh of relief.

It’s kind of cool, the whole launch sequence. We launched out of Vandenberg Air Force Base in California, after which the spacecraft goes south across the equator, over the South Pacific, then over Antarctica. We lose contact with the spacecraft while it’s over the South Pacific, until a station in Antarctica is able to make contact; so that's a big moment, getting the contact from the Antarctic station. Then after the spacecraft completes its passage over Antarctica it moves northward, toward Africa. NASA has stations in Africa so that we can make contact again. It was over Africa that the spacecraft separated from the last bit of the rocket. Most of the rocket falls off right at launch, within minutes of launch. But there's the second stage of the rocket that keeps pushing the spacecraft along south across the Pacific and then over

Antarctica and then northward toward Africa. It was within sight of one of NASA's ground stations in Africa that the spacecraft actually separated completely, so that was a big relief when that happened.

Then it's a little further, as the spacecraft is going over Europe for the first time, that the solar array comes out. So the solar array safely gets out, and that's when everybody can really cheer. In the mission control area out there at Vandenberg, that's a big moment there because that's the moment at which their job is done and the control shifts over to Goddard. So at that moment, we're all cheering and everybody's hugging each other. And I as the science representative, I'm thanking everybody because of course they're making this mission possible by succeeding. So that was a great, great event. So that was the launch.

After launch, there’s a 120-day checkout period to, one by one, turn on the instruments, check them all out, make sure everything's working. Then at the end of the checkout period, our so-called ‘prime mission’ starts, and it’s a six-year prime mission. We've been getting a huge amount of data, and scientists around the world are using these data.

And not only scientists, as the Aqua data have gotten way more use from non-scientists than we really expected. That's been a huge plus. We have on board the capability of direct broadcast, so therefore the satellite as it's orbiting the Earth, it's broadcasting whatever data it's collecting, and anybody with an appropriate antenna can pick the data up, can get the data immediately. Because of that, people are able to get these data real-time and use them real-time. One important group that has used the direct broadcast of the Aqua data is the US Forest Service. When there are large fires in the US, forest fires or other types of fires, they show up really well in the Aqua data. The US Forest Service is able to get these data real-time, and then use the data to help decide where to deploy their fire fighters on that particular day.

That's true with the Terra satellite also. Terra crosses the equator at 10:30 in the morning and at night. So these two sister satellites, Aqua and Terra, can together get more complete coverage because of the different times of day that they're collecting data. The US Forest Service uses both the Aqua and Terra data and the US Military uses them also, because the data show the dust storms in Iraq really well. Weather forecasters use the Aqua data because Aqua gets good atmospheric temperatures and water vapor amounts, and those are the two key things you want to forecast the weather. So the Aqua data have been used by a lot of different people in addition to the scientists, which was the prime purpose for the satellite. Its data were primarily for the science and the scientists, but they’ve been used by a lot of others also. So it's very pleasing to have this successful mission, and to feel that I'm a small part of helping this mission.

ROSS-NAZZAL: Will the mission continue? You said that there was a six-year window, but it sounds like the satellite is still operating.

PARKINSON: Yes. The satellite is still operating really well. We've got enough fuel so that we could continue operating probably until about the year 2015. So we hope that it will succeed up until about 2015. That's the hope; but each year from here on out is sort of like an extra bonus year, after the first six. So as many bonus years as we get, that's good.

ROSS-NAZZAL: Was this satellite part of NASA's Mission to Planet Earth [MTPE Enterprise]?

PARKINSON: Yes, definitely; a big part of NASA's Mission to Planet Earth, now called the Earth Observing System, EOS. Aqua's one of the main three big satellites, Terra, Aqua, and Aura; and there are a whole lot of smaller satellites in the Mission to Planet Earth, or EOS, also. So yes, Aqua is definitely a key player there.

ROSS-NAZZAL: What have you learned from the satellite itself in terms of your own research?

PARKINSON: Well, in terms of mine, I'm so much interested in the long-term that I'm still trying to hook everything into the long-term, earlier record, from NASA's Nimbus 5 satellite, NASA's Nimbus 7 satellite, and the Defense Meteorological Satellite Program's satellites from 1987 on. So those satellites still remain really important to me, but the instrument on Aqua that gets the sea ice data of the type that I study is the AMSR-E instrument, the instrument from Japan. It's done a great job in showing the sea ice. It gets more spatial detail than we've gotten with any of the previous instruments, and that's part of the reason for its name—the acronym is AMSR-E, and the 'A' is for "advanced," so it's the Advanced Microwave Scanning Radiometer for the Earth Observing System, with the E in the acronym standing for the "Earth Observing System".

AMSR-E has a large antenna, an unusually large antenna, which is what allows it to get the improved spatial detail. It gets near-global data just like the earlier instruments get near-global data, but it's got the greater spatial detail, which is great because it means that from these data not only do we get near-global coverage every day—or every two days at most, but every day generally—we also can see details that we weren't able to see with the previous instruments. We're actually able to see breaks between the ice floes. We're able to see individual ice floes and breaks within the ice cover. And so it's been a really nice advance to be able to see that spatial detail.

ROSS-NAZZAL: That's amazing. Now, something else that I had learned. We were out on the Web doing some research about you, and we understand in 1999 you went out to the North Pole and were a Chief Scientist for an expedition out there?

PARKINSON: That was cool too. Yes. It was a NASA expedition to Resolute Bay and the North Pole. Resolute Bay is a small Inuit community in northern Canada. The main purpose was the North Pole, but Resolute Bay is where we tested out all our equipment and we did some webcasts. We did webcasts both from Resolute Bay and from the North Pole—the first webcast from the North Pole, and also the first link between the North Pole and the South Pole. We had a telephone link from the North Pole to the South Pole while we were there, which is the first time that had ever been done, so that was exciting, to record a communication 'first.' But before that, we stayed in this Inuit community, Resolute Bay, for the week prior to heading to the North Pole, in order to test out everything and to work with the Inuit. In particular, we did some webcasts from the Inuit school, linked with some schools in the US; and that was an interesting exchange because the kids actually got to talk with each other and ask each other questions. A US student asked how the Inuit children could stand living so isolated, in such a small community, and an Inuit child answered emphatically: "We like it here".

We get there; it's in April; it's therefore got sunlight pretty much all the time because it's so far north [75°N]; and the first day we get there, this little kid starts following us every place. It gets to be about 10:30 at night, and I ask this little kid—I mean, it's perfectly fine to have him with us, we were happy with that, but it's 10:30 at night—so I ask, "When do you go to bed?" He goes, "Oh! We go to bed in the wintertime when it's dark out." I thought, this can't work like this. So the next day we're in the school, and I'm talking with the principal, and I explain this conversation with this little kid. And the principal goes, "Oh well, yeah. When spring comes and the sun's out and these kids have had nothing but darkness for months, they're allowed to be up all night long and you can see kids at two o'clock in the morning playing in the streets, because they've just not had light for months." The total population of the community is 205 people, so it's totally safe to be out in the streets, as everybody knows everybody in the community. It's just so different; it's such a different lifestyle.

Anyway, then we got to the North Pole, and we got there largely by airplane. But it's floating ice at the North Pole. It's sea ice; it's not grounded ice, it's floating. So if you're going by airplane, you can't necessarily know that there's going to be a big enough floe to land right at the North Pole. We had this all planned out, because we wanted to get to the exact point of the North Pole, and so we hooked up with a dogsled team, because a dogsled can much more reliably get you right to the exact North Pole, whereas with a plane, you might/might not be able to get there. So we took the plane most of the way, and then the last couple of miles it was by dogsled, with this dogsled team. That was neat to get to the North Pole by dogsled.

We did ice thickness measurements at the North Pole. That was a main purpose, to get some ice thickness measurements. And indeed, the ice was reasonably thick; it wasn't as thin as what some people were fearing. On the other hand, if you're just making measurements for a day or so, the next day it could be a bigger or smaller floe that's there, because these floes are always moving around. So you really need many more measurements for any climate change studies. But we were doing ground truth for the satellites. As we flew most of the way, we were looking at the ice cover so that we could compare it with the satellite images, and they were comparing well. The purpose was partly the ground truth, but also was the outreach effort of doing the webcasts from the North Pole. It was definitely, definitely an adventure.

ROSS-NAZZAL: Did you stay back with the Inuits every day, or did you actually stay on the ice?

PARKINSON: We stayed overnight on the ice for one night; only one night, but one night was neat to get to do. It was neat to be able to sleep overnight in tents at the North Pole. So that was neat, but we were only there for one night.

ROSS-NAZZAL: How large was your expedition?

PARKINSON: I wish I could remember exactly. It was roughly seven people in terms of the North Pole itself, and it was more for Resolute Bay.

Even the plane ride to the North Pole was so different than normal plane rides. It was naturally a very small plane, but that wasn't a main difference; the main differences related more to security and weight. On normal plane rides, everyone has to go through security. Well, on this plane ride to the North Pole, you're expected to have rifles with you because of the possibility of encountering a polar bear—in fact, we had to take rifle training, which in my case meant one shot. Certainly, rifle training was not on my list of priorities; but we were told we had to take rifle training. So I shot this rifle once, and that was it. No polar bear would have to be worried about me, that's for sure, in terms of my rifle. Anyway, you had to have rifles, and so therefore you certainly don't have any security checks when you get on the plane. But what you do have to do is, you have to take yourself and all your luggage and get weighed, yourself and your luggage. There's this big platform that you stand on with your luggage and get weighed, because the critical thing is to make sure the weight's not too much, make sure that you're going to be able not just to land safely but also to take off safely from the sea ice floe.

So it was very different from a normal plane flight. We were jammed into this plane; it was sitting-on-top-of-luggage type jamming in. It was jammed. But we had to satisfy the weight requirement. In fact, the weight requirement was such that the plane wasn't able to carry enough fuel on board to get us all the way to the North Pole. We went from Eureka, which is on Ellesmere Island, which is far north in Canada [at 80°N]. We went from a little airport on Eureka headed to the North Pole. But we couldn't carry enough fuel on board to get all the way to the North Pole and still take ourselves and our luggage.

So what the pilots had to do was: The day before we left Eureka, the pilots flew halfway with extra fuel and dropped the extra fuel in a fuel cache. They just put the fuel on an ice floe and then marked the ice floe in bright orange so we'd be able to find it, then came back. So when we flew the next day, we flew halfway and then searched around. They find the ice floe that's got the fuel cache. We land on that ice floe and dump our empty fuel bins and put the full ones on. It is different; getting to the North Pole is very different than a normal plane flight.

ROSS-NAZZAL: Yes, it sounds very rugged and frontier-like.

PARKINSON: It's exciting. It's definitely an adventure. It was an exciting, very different thing to do, because certainly my normal day is in my office doing my work. And so my normal day is very much a normal office job. It's not going out to the North Pole. But it's neat to have that experience.

ROSS-NAZZAL: Were there any other unique preparations you made besides having to go through rifle training? That's kind of an interesting safety precaution.

PARKINSON: Well, definitely we had to pay attention to make sure our clothing was layered, with good insulation; and the clothing was good. So we had to be careful about the clothing, and other than that, no, nothing other than more preparations for the webcasts. We had lots of preparations for the webcast; and the technicians had to prepare the instruments to make sure we could make contact with the satellites. That was necessary in order to get the webcasts to work. We had to have communication links through the satellites.

ROSS-NAZZAL: You mentioned so much of the outreach that you did there in Resolute Bay and then at the North Pole. Can you talk about why that was important and some of the highlights of that?

PARKINSON: Outreach is extremely important to NASA. Even right in the Space Act that established NASA back in 1958, it says that NASA needs to engage in outreach, to get its results out to the public. So outreach has always been very important to NASA; and certainly I've been involved in outreach during most of my years at NASA. Probably the first few years, not a whole lot; but since then I've been involved in a lot of outreach, just because of its importance. NASA does such incredible things, and the satellite data enable us to see the world in such a way that we just could not possibly see it without the global picture that satellites provide. It's just outstanding what information you can get from satellites, and the fact that NASA is getting this information and getting it in so many different fields—hurricane research, volcano research, land vegetation, oceanography, sea ice, land ice, etc.—it is important to reveal to the American public this information that we're getting.

It's also clearly additionally important now that we realize climate is changing in ways that are affecting humans and could affect humans a lot more in the future. For instance, although sea ice doesn't have a potential impact on sea level, because sea ice is already floating in the sea, land ice does. If the land ice melts substantially, that water is basically going to go into the oceans, and that's going to raise sea level, and that's going to affect everybody living along the coasts, because if sea level goes up, those people are going to end up getting flooded. So a lot of what we study concerns things that society's going to have to deal with at some point. Therefore, it's partly a responsibility but also partly a privilege to be able to engage in this research and engage in this outreach.

So outreach was a factor in the North Pole expedition; but it's also a factor in much of the rest of what we do. We certainly, I and other scientists, give lots of talks. I'm lucky in terms of working at Goddard because many groups come to Goddard. So I can do a lot of outreach without even leaving Goddard, because I can speak to teacher groups that come to Goddard, I can speak to student groups and others. I find this to be very rewarding if it's an audience that's clearly interested; and most of these groups, that come all the way to Goddard, they are interested.

We also get to do outreach outside of Goddard. Last year, one of the places I went to was actually the school where I had gone to high school, which was Montpelier High School in Montpelier, Vermont. That was meaningful, to get to go back to my old high school as a NASA scientist and give a presentation to the full school in the auditorium there, showing them part of what NASA does. I think that a lot of NASA people, whether scientists or engineers or astronauts or others, really do feel a sense of the importance of letting the outside world know about what we do, and it is an honor and a privilege to be able to represent NASA at other places.

Another outreach project I was involved in last year was connected with the International Polar Year, the IPY, which is going on last year and this year. There's a large amount of outreach in conjunction with that, and it's worldwide. One of the activities for the IPY was a three-day event in the vicinity of Atlanta, Georgia. It was at various locations in the Atlanta vicinity, and I was involved in that. That was exciting too, because people are interested in the polar regions just like they're interested in NASA, and so both were factors generating enthusiasm there. During those three days, we spoke at museums, we spoke at middle schools, we spoke at universities, making it a whirlwind three days of outreach.

We also create outreach products. One of the things I've been involved in for years is the NASA Science Calendar, and this goes out to lots of people. It's distributed at conferences and also to lots of school groups and groups like that. But in addition, there are many other outreach products. With each mission, we've got outreach items; we’ve got brochures, we've got pins, we've got stickers, we've got pamphlets, we've got posters, lots of outreach items.

Another outreach activity that I very much enjoy is working on books. I've been involved in writing several books and have really liked that, because when you write a book, you can describe in much more complete detail the subject matter versus, say, in a research paper which is limited to maybe ten pages or so. When you write a whole book, you can really describe something in much greater detail, and so I've enjoyed the opportunity to be able to do that also.

ROSS-NAZZAL: Would you tell us about some of those books? You had mentioned the atlases.

PARKINSON: Well, the sea ice atlases, those were important, and a big part of my first ten years at Goddard was working on the sea ice atlases. Since then, other books that I've done include a book by myself that came out in 1997 entitled *Earth from Above: Using Color-Coded Satellite Images to Examine the Global Environment*. The main title is *Earth from Above.* It's an introductory book on satellite imagery and the use of satellite data to look at the Earth. In the first chapter, it shows sample pictures that you can get from satellites using visible radiation, and the first chapter sort of closes with, "However, if you're using visible data—which are the data that our eyes see—if there's a cloud in the way you're going to see the cloud, and you might be wanting to see something at the surface instead."

So the second chapter explains the electromagnetic spectrum and why we use different wavelengths. Then the next six chapters each cover one key topic in Earth sciences. Two of the chapters illustrate their topics using microwave radiation, and those two topics are sea ice and snow cover. Two chapters use infrared data, and those highlight sea surface temperatures and vegetation. And two chapters use ultraviolet data, and those highlight ozone—for instance, describing the ozone hole—and volcanic emissions. So that's the way the book is structured.

Regarding doing books like that at NASA, a negative is that a NASA employee can't get royalties, which is too bad. But a positive is that I can use NASA funds to buy large numbers of the books and then hand them out for free to teachers, to students, to others; and that to me is just a huge, huge plus. To be able to hand these out and give these to people, some of whom simply would not be purchasing a book, and get very nice comments back about how they've learned so much from reading the book, that's a huge plus.

Now, a book that just came out last October that I was heavily involved in is a different type of book, because it wasn't written by just one person. It was an edited volume, and I'm one of four editors on this volume. It's called *Our Changing Planet: The View From Space*. This book has lots of people involved, but a central goal that the four editors emphasized was to make sure that it's written for the general public, to inform the public about the huge range of what we're getting from satellite data. So it covers way more topics than the *Earth from Above* book, which was an introduction. *Our Changing Planet* is written for the general public; you do not need a science background to understand it. But it covers all sorts of topics.

The four editors are Michael [D.] King, who was at Goddard at the time, although he's now at the University of Colorado [Boulder]; me, from NASA Goddard; Kim [C.] Partington, who's from Great Britain; and Robin [G.] Williams, who's originally from Great Britain and now is living in the US. Each of the editors also authored some chapters, but other authors came from around the world, a lot from within NASA, but others also not from within NASA. The book goes over all sorts of topics, and in just a few pages on a topic it shows wonderful satellite images, plus some other illustrations that aren't from satellites, and text that is hopefully very readable text—that's certainly the intent.

For just a sample, take the chapter on lightning and the global picture of lightning strikes around the world, how many lightning strikes you get at each location around the world. The thing that just stands out so much that nobody knew before satellites got us the global picture, is that there's almost no lightning over the oceans. The lightning is almost all over the land regions. That's incredible. Nobody knew that. There's some lightning over the oceans, but almost none, and it's satellite data that allow you to see that.

Other highlights in the book are things like a global map of night lights around the world. Here, what strikes the eye first is how well the map represents population. Australia's almost entirely dark except a few major cities around the coast like Melbourne and Sydney, which are all lit up. In the US, there’s a huge difference between the eastern half, which is so much more lit up than most of the western half except for along the coast where you've got major cities.

But in addition to showing the population, which comes out so clearly, the map also reflects poverty and wealth levels, because you need money to have all these lights on at night. So you look at a country like Cuba and see that it's very dark. That's not because of low population, it's because of a wealth issue. You look at South Korea and North Korea; South Korea's all lit up, just like Japan right close to it. South Korea's really lit up, but North Korea, it's so dark that it looks like South Korea's an island instead of being part of a peninsula. Things like that just pop right out with these images.

So the book has all sorts of wonderful global images like that, but it's also got lots of more regional and more local images, and many of those are also depicting really interesting things. Like the Larsen Ice Shelf; the book's got this sequence of three pictures of the Larsen Ice Shelf from satellites. The Larsen Ice Shelf is an ice shelf along the Antarctic Peninsula that decayed within a six-week period a few years ago, and you look at these three pictures within that six-week period, and it's like, "Wow! This entire ice shelf just crumbled in this six-week period.” This is an ice shelf that's thought to have been there for over 1,000 years, and bang, in six weeks it crumbles, and the satellites allow you to see this. The satellites, they allow us to see so much, and as I said, it's such a privilege to be able to help in my small way to transmit this information to the American public and to others, through my small but personally very meaningful role at NASA.

ROSS-NAZZAL: I'm looking at the clock. I had a couple more questions for you, but I don't know. I think we covered all of the topics you wanted to cover. Do you want to take the shuttle? Because we can come back and cover the rest of the topics, that's fine.

PARKINSON: Well, if you've got a few more questions, let's go with it.

ROSS-NAZZAL: Sure, yes. I was curious, what do you think has been your most significant accomplishment while working at NASA? You're so excited about this work that you've been doing.

PARKINSON: It's really hard for me to answer that because so much depends on exactly what one regards as significant. To me, the books are major products, and I like getting a product out. So to me, the books are major. One that I didn't mention, I wrote a book on the history of science [*Breakthroughs: A Chronology of Great Achievements in Science and Mathematics*] which was a major product, but a sideline activity. But that was a major product.

So the books are major products, but I think in my early years at NASA, the fact that we had to get the techniques developed to take the data from the satellites and convert them into something meaningful regarding the Earth, the geophysical Earth, in my case sea ice, to me, that was important, that we persisted, we got that effort done. And that effort is what's enabling everybody else now to use these satellite data so readily, so quickly, so easily. You can go on websites now and find out where the sea ice was yesterday. When we started, we took years working on a four-year data set that was years old. At that time, there was no Internet, there was no e-mail, and the computers were nowhere near as capable as they are now. So I think that that development in those early years was maybe significant in terms of enabling what's so routine now but wouldn't have been routine without all that effort that was done earlier.

[End of interview]