

EARTH SYSTEM SCIENCE AT 20 ORAL HISTORY PROJECT

ORAL HISTORY TRANSCRIPT

MARK R. ABBOTT
INTERVIEWED BY JENNIFER ROSS-NAZZAL
WASHINGTON, D.C. – JUNE 22, 2009

ROSS-NAZZAL: Today is June 22, 2009. This oral history is being conducted with Dr. Mark Abbott, who currently serves as dean and a professor at the College of Oceanic and Atmospheric Sciences at Oregon State University in Corvallis, Oregon. This interview is being conducted at the National Academy of Sciences in Washington, D.C. as part of the Earth System Science at 20 Oral History Project to gather experiences from those who have been intimately involved in various efforts in the launch and evolution of Earth System Science. The interviewer is Jennifer Ross-Nazzal. Thank you so much for joining me this afternoon. I'd like to begin by asking you how you got involved in your field of expertise.

ABBOTT: My field of expertise. I guess really started out as an undergraduate at University of California Berkeley [California], where I was really interested in combining my interest in the environment—so this is in the 1970s Earth Day kind of stuff—with my abilities in math. So I thought I'm going to do ecological modeling. Well, there weren't any undergraduate programs that did that, but Berkeley had a really good ecology program through forestry and obviously good math. I got into an undergraduate program that did that.

Graduate school, went to UC Davis [University of California, Davis, California]. Again, wanted to continue and get a PhD in that kind of program. Ended up working with a fellow named Tom [Thomas M.] Powell at the University of California, Davis, who was in the ecology group. But he was a high energy physicist by training and was studying Lake Tahoe [Nevada].

He was bringing an oceanographic mindset to the study of lakes, limnology, which had traditionally not been driven by that oceanographic view. So it was very math-intensive. A lot of statistics. Collecting data. Trying to understand the interaction between physical processes and biological processes.

I did that as a graduate program and then went and did a NATO [North Atlantic Treaty Organization]—back in the days when NATO had postdoctoral fellowships that were administered through NSF [National Science Foundation]—got a postdoctoral fellowship to work with [Sr. research scientist] Ken [Kenneth L.] Denman up in Canada at the Institute of Ocean Sciences [Sidney, British Columbia], which was a Canadian federal government lab. He had been doing the same sort of work, looking at really what's known as spectral analyses, analyzing the patterns of variance in phytoplankton, and trying to compare that with the physical dynamics in the ocean. So I worked with him. While I was there, I went to a meeting at the University of Southern California [Los Angeles, California]. It was the final meeting for a large international program called Coastal Upwelling Ecosystems Analysis, CUEA, and this had been a large international program studying upwelling ecosystems in the ocean off Oregon, off Peru, and off northwest Africa. I went to the meeting.

Why Powell let me go I don't know. But he did. While I was there—this is a long story—there was a guy named Larry [Laurence C.] Breaker, who was giving a poster. He worked at NOAA [National Oceanic and Atmospheric Administration]. He had a poster of AVHRR [Advanced Very High Resolution Radiometer] imagery of the California current. So he was looking at sea surface temperature patterns. They were seeing these large plumes going 200, 300 kilometers offshore. He was working with a guy named Gene Traganza at the Naval

Postgraduate School [Monterey, California]. So I was looking at this poster and thought gee, that's really interesting, looking at the satellite stuff.

But I was also interested that in his image there was Lake Tahoe, which was where I had done some both postdoctoral work and doctoral work. You could see temperature fronts in Lake Tahoe from space. So I told this to Powell. We got excited about it. We wrote a proposal to NASA to a guy named Ken [Kendall L.] Carder and Stan Wilson, who was managing the oceans program. They funded it. That was my first inquiry into using remote sensing to study something aquatic. Of course, it was lakes at that time.

That then continued on to applying for a position that was a joint position between Scripps Institution of Oceanography [La Jolla, California] and the Jet Propulsion Lab [JPL, Pasadena, California]. So Stan Wilson, who was at NASA Headquarters [Washington, D.C.], and Mous [Moustafa] Chahine, who was at Jet Propulsion Lab, were really interested in moving forward the field of satellite oceanography. One of the ways Stan thought to do it was to get people that would have joint positions between an oceanographic institution and a remote sensing institution, i.e., JPL. Mous Chahine was really interested in supporting that, so they advertised for positions. Well, after a long circuitous path I was hired as the biologist. Because I had oceanographic interest, I would work at Scripps, and I spent half my time up at JPL and acted as that transfer point. That's how I got into the field of satellite remote sensing. So it's a long story, but it really starts with trying to understand what is the physical-biological coupling and just using different tools, and satellites became the tool at that time.

ROSS-NAZZAL: Where were you when you heard about this new field of Earth System Science?

ABBOTT: I had this joint position. I started that in 1982. [In] 1983, I got a call from my program manager at NASA Headquarters, who at that time was Wayne [E.] Esaias, who then went on to [NASA] Goddard [Space Flight Center, Greenbelt Maryland]. Wayne worked for Stan. He said, “There’s this project called System Z, and we need somebody to be on the science and mission requirements working group.” System Z became EOS [NASA Earth Observing System]. So right at the same time, in parallel, that’s when the [VAMOS-EPIC] Bretherton Report came out, in ’84, ’85. So that whole thinking was starting in the early 1980s.

ROSS-NAZZAL: What were some of your expectations for the field when you got initially involved at this point?

ABBOTT: Being an ecologist you really saw the need for a really comprehensive set of data: physics, chemistry, and biology. Getting into oceanography you saw the interest for long time series, to look at these, because the ocean operates on these interannual to decadal time scales. I saw that what was going to come out from Earth System Science was really, a much more comprehensive observing system, and something that would be in place for a long time. Essentially indefinitely. I think when all of us younger folks started with EOS back then, that’s what we saw happening. We assumed that that would be the partnership that would happen, but that the technology and the science would evolve over time. But we also saw, and I think it came out of Rick Anthes’s [President, University Corporation for Atmospheric Research] talk today, the imperative to do it, that it was important to begin to understand how the planet operated as a planet, not just as an object of scientific curiosity but as one of societal importance.

ROSS-NAZZAL: I thought that was very interesting. What sort of projects were you working on at Scripps and JPL as you were working on this?

ABBOTT: Well, you just heard the talk. I was one of the first people to have access to the Coastal Zone Color Scanner data and the algorithms to process it. The best algorithms at that time in 1982 were at the University of Miami [Florida]. We worked out a project with colleagues there, Howard [R.] Gordon and Otis [B.] Brown, Bob [Robert] Evans at Miami, to basically set up a processing system at JPL that would take all of the west coast data, temperature and ocean color, and process it with the best algorithms and collocate so you could see the temperature patterns. Right back to Larry Breaker. You would see these upwelling filaments and plumes and then look at the biological response. We produced what was known as and funded by NASA, the West Coast Time Series, which was a predecessor to what eventually the Goddard team did on a global scale. We looked at it on a regional scale because Scripps at the time had a satellite remote sensing facility. They were collecting data. So we didn't have to go through any archive or any other separate satellite system. We had all of the data on the west coast, which was not true until the Goddard Ocean Color team really got into place in like 1986. The data lived elsewhere, and it was all fragmented. But we didn't have that problem, so we could get all the data. So we test-drove a lot of the ideas and concepts that eventually the Goddard people did and applied globally and took it much farther along.

ROSS-NAZZAL: Can you share some more detail about those algorithms and some of the other techniques you used to come up with this?

ABBOTT: Well, I think the first thing was when you're measuring ocean color most of the signal is coming from the atmosphere. It's not what you want. So you had to have the best atmosphere processing algorithms to correct, to really get what was the signal of interest that's coming from the ocean. The second problem was understanding how the sensor performance declined over time. Sensors always get worse; they just get less and less sensitive. That was really what the people at Miami worked on the most, was really understanding how to correct for the atmosphere and then, two, how was the sensor changing over time. Back in those days that took a lot of computer power. You could probably do it on your cell phone now. There weren't very many groups that had access to those algorithms. Then the next part was how do you map it and project it and sample and all that kind of stuff. But that was easy. The harder part was really understanding the atmosphere correction and then the calibration performance side.

ROSS-NAZZAL: How long did this project take?

ABBOTT: Well, we must have started it in 1983. I left there in 1988. I guess it took about three years to process the entire CZCS [Costal Zone Color Scanner] set, which was 1978 to I want to say 1984, 1986? I guess 1986. [In] 1984 it began to start to fail. I can't even remember when CZCS died now. That shows how old I'm getting.

ROSS-NAZZAL: What were the major findings of that?

ABBOTT: I think the first thing was just to see you could do a lot of comparing wind forcing with the ocean color patterns and the sea surface temperature patterns. So the first thing was really to

look at what were the dynamics of these large plumes that came off the coast. Was it just being driven by local winds? Was it something larger? I think the biggest finding on that was there was actually the fact that the winds are weaker near shore and get stronger as you move offshore. You have stronger winds offshore. This in some sense acted like a pump. As you can imagine, no different than a normal pump, you have something weak pushing something inside and something strong on the outside. That gives what's known as a torque to the system. That helped to pull those plumes offshore.

Other people were looking at seasonality patterns of those. I think it stopped when SeaWiFS [Sea-viewing Wide-Field of view Sensor] went up and the Goddard team picked that up and people started looking more at global scale stuff, but it really was a pathfinder dataset.

ROSS-NAZZAL: What do you think are the key elements in relationship to the current direction for Earth System Science?

ABBOTT: The current direction, okay. I think the first big—and it's not necessarily a great decision, but it's when NOAA pulled out. NOAA had been an active partner. I think that that broke that tenuous bridge between research and operations. I think that was the first one. I think the second big decision was not to fly copies of the first EOS platforms, to go with the whole distributed set. Now there were some advantages to doing that in that it opened it up. But because in parallel you didn't have an operational home for the first set of NASA sensors, it meant you had a disjointed and potentially short-lived time series. I think we've certainly seen that today. That's been repeated; we're beginning to get these 10- and 20-year what's going to happen next.

Those are two negative things. I think the positive one was really the formation of an integrated set of platforms, not making the disciplines go alone, and really getting people to think systematically about the Earth as a system, not just my favorite data variable or my favorite sensor. I think that was important. I think another one that was also important, and we've lost a little bit, is the whole Global Change Research Program. That is that the satellite observing was embedded in a larger set of scientific missions, understanding the ocean carbon cycle, understanding ocean circulation. I'm thinking of the World Ocean Circulation Experiment, (WOCE), JGOFS, (Joint Global Ocean Flux Study). Similar ones on the atmosphere side or the terrestrial side. So that satellites were not only interdisciplinary, they were embedded in a larger universe of scientific programs that included ground-based measurements, modeling, etc.

I think that was really important to the community at the time to have that. So the interdisciplinary, by multiple missions, the embedding. Then I think we missed on the long time series side. That's gotten us to where we are today.

ROSS-NAZZAL: What about events that you think have shaped our current direction?

ABBOTT: Events? Can you give me a hint? What kind of event?

ROSS-NAZZAL: Oh. Things like NASA administrators, new NASA administrators, or presidential administrations, 9/11 [September 11, 2001], something like that.

ABBOTT: Yes, events, events. Dan [Daniel S.] Goldin faster, better, cheaper, breaking apart the platforms. That was a huge event, and an unfortunate event, I think.

ROSS-NAZZAL: Why would you say that?

ABBOTT: Because I think again it broke the time series. There's no home for MODIS [Moderate Resolution Imaging Spectroradiometer] right now. MODIS was supposed to go to VIIRS [Visible Infrared Imaging Radiometer Suite]. That didn't happen. I think if you look at a lot of the platforms and the measurement sets that were supposed to be continued, that became much harder to continue.

Other big events. I think IPCC [Intergovernmental Panel on Climate Change], just the nature of the IPCC assessments. That's a series of events, but its formation really brought the assessment process into a much more mainstream regular part. I think it's hard to keep the effort up. It tends to become assessment for assessment's sake. But it does capture people's attention both in the public and the political sectors as well as in the scientific community. I think that that's really kept Earth systems in the fore.

I should be able to think of more than that. But those are the ones that come to mind.

ROSS-NAZZAL: The big ones. Are there any major elements that you see today in terms of Earth System Science that have shaped its current direction?

ABBOTT: Major elements. I think we still haven't gotten the commitment to a long term observing system. That's just not there. What we've got is a NOAA operational mission that really is focused on a permanent presence in space to meet short term forecasting needs, which is fine and good. You've got NASA, which is a research agency and really can't afford to commit

forever. It wants to do new things. It's a science agency. So the two of those have not come to an agreement yet, in part because the nation hasn't come to an agreement. The federal government hasn't decided how to do that. Repeat that question for me again. I had another idea.

ROSS-NAZZAL: Are there any key elements you think that have shaped the current direction?

ABBOTT: Key elements. So that's one because I think we're trying to recreate that long observing system. The other one is maybe a little bit different than what some of my science colleagues would like to hear, maybe it's because I've been a dean too long. I think we started in the early 1980s as—it was an interesting science question. We thought yes, it's important to people. I think IPCC has shown and the talks today have demonstrated again this is really important. We need to understand. What I think we as an Earth System Science community have not done well is help people to understand how they can respond to it. I think there's a bit of a disconnect between the science supply and the science demand. That is the kind of questions.

So we get into these arguments with skeptics, non-skeptics, to me that's not the argument. That is not why people are skeptical about climate change. They are skeptical about the policies that people want to impose or implement to address that problem. That's where the disagreement is. So in my state of Oregon, our legislature meets every two years. Last legislature had very aggressive renewable portfolio standards and almost like Kyoto [Protocol, International Environmental Treaty] on a state level. This legislature, with an unemployment rate of 12.4 percent that has died. Why has it died? It's died because of economics.

We're seeing this in the European Union. We're seeing it in the Congress as well, that we as scientists have presented this in some sense doom and gloom. People say, "Well, even if I believe it, what can I do about it?" So that's the second question. Then the next question they ask is, "Well, what you're asking me to do is kill my economy." They're not going to do that. We can't ask the Chinese and the Indians to say, "Guess what? You don't get to have electricity because you're going to change the climate." What we haven't done is really work on a regional scale and with people having to make economic and political decisions to see that you can have it both ways. I think that that's where we haven't really worked well with the technology community that's going to come up with carbon free energy sources and new ways to store wind energy and solar energy to get around their inherent problems with fluctuating energy supply.

How do you decarbonize the economy without killing it? One way is to kill the economy. But that's not going to happen. We've already seen, even on a state that's very green, let alone the US Congress. That's not going to happen. We in the Earth System Science community have still left it as a science question. Here's this great science. Go do something. That doesn't help me, if I'm an owner of a small business or an owner of a utility or a state legislator. I think our inability to really encompass the human dimension and really understand the human dimension as more than what are people doing, flip that question around to say, "What could people do?" We just didn't do that.

ROSS-NAZZAL: What do you think that people can do?

ABBOTT: I think ultimately it's going to be technological solutions. It's going to be technological breakthroughs. I think that there are incentives we as governments can provide to

let people explore all new things. I think we tend to try and say that there's a single answer. We still tend to think, "Okay, you got me this problem, now where's that silver bullet?" There's no silver bullet. We haven't communicated that this is a long term problem, that it's something you're going to have to try all sorts of things, from energy conservation to new energy sources to heaven forbid probably even nuclear power to try and get us through what's really a 100 to 200-year problem. I don't think we've made that message really understandable or something other than just it's either hopeless or totally threatening, and the net result of both of those is you end up doing nothing. I don't think we've done a really good job of communicating that.

ROSS-NAZZAL: I saw when we pulled some records that you're working with the state of Oregon and looking at oceans. There's some sort of agreement that's been made between [Governor Arnold] Schwarzenegger [California], your governor [Theodore "Ted" R. Kulongoski] and the state of Washington [Governor Christine Gregoire].

ABBOTT: Yes, there's the West Coast Governors' Alliance on Oceans. Again, that's another one where as the state budgets of all three of those states have gone south, there's not much going on on that. But clearly Earth System Science, unlike its space science kinfolk, people really care about the Earth and what it does. There's a lot of economic and political and social values associated with it that you don't have when you launch a mission to Neptune. We're fundamental science and applied science. I think we as Earth system scientists have been in some sense naive in how the real world works. Sometimes a little arrogant in how the real world works.

I think for example, one of the questions that we get asked a lot among—I co-chaired the Climate Change Integration Group [CCIG] for the governor, which has now been succeeded by something enshrined in the legislature called the Oregon Global Warming Commission. CCIG was business and political people and some scientists. I've used this story before, but I'll use it again. There was a guy on that group, I won't give his name, but he was a Portland [Oregon] Metro councilor. The Portland area has a metropolitan governance as well as city. There's three counties around the Portland area. He was talking one day. He said, "Here's my climate change question. I want to know how hurricane frequency and intensity is going to change on the Gulf Coast."

I actually had faculty who study that in my college, lots of people are looking at that trying to predict how global warming will affect that. He said, "But I don't want to stop there. I want to know how that's going to impact outward migration from the Gulf Coast, how many of those people will end up in the Portland Metro area, what are going to be their socioeconomic needs, and how do I build infrastructure to accommodate them in a carbon-neutral way." It was an end-to-end problem, which meant fundamental Earth System Science: how are hurricane frequencies going to change in a warmer planet—NASA funds that kind of work—to demographics to socioeconomics to thinking about public planning and infrastructure. He said, "Do I build highways here? How do I manage jobs? I can say, 'Everybody has to live in the city and not commute,' but that housing is going to be too expensive for a lot of these poor people moving from the Gulf Coast. What do I do?"

This is where the science community has not done the right kind of modeling. So we often hear we need better models, more models, higher resolution models. Some sense we miss the linkage with economics and with people: what people want, what that planner wants. He

said, “Don’t give me the answer, give me the plausible scenarios. Then I can understand where my risks are and I can build accordingly.” An insurance company doesn’t need to know an electrical fire is going to happen on June 24, 2042. It’s looking at statistics, and it’s looking at plausible scenarios, and it’s managing its risk. That’s what most business and government people want to do, even though they may not know that. We haven’t come together to align that demand for information and knowledge with what we can produce. So we’re still disconnected and we’re still arguing skeptic nonskeptic, and that’s really not the argument. That’s a smokescreen for what really the fundamental argument is. What do I do and how do I preserve my way of life and let other people advance too?

One more story. I’m on the National Science Board, which is the governing board for the NSF. We had a task force on sustainable energy. We met out at the National Renewable Energy Lab in Golden, Colorado, because one of our board members is the director of that lab. We had a fellow come from the University of Colorado [Boulder, Colorado], and he was talking about the university’s involvement in sustainability and reducing energy use. He said, “The students are doing even more. Here’s a poster they produced.” It was a poster of a person turning on a light switch, and next to that person was a polar bear in an electric chair. So next time you turn on the light switch you’re—you can see the link.

The next speaker got up and said, “It shouldn’t be the polar bear sitting in the electric chair, it really should be that kid in Africa who’s going to die of diarrhea because she had contaminated water because it didn’t have an electric water pump to bring up clean water or any way to clean it.” That’s the disconnect. We in the west tend to think things are fine. We’ve not connected with people and their aspirations I think. It’s a rambling story.

ROSS-NAZZAL: No, I think it's interesting, because you're suggesting ways that you might move forward in the future.

ABBOTT: Right, yes. I think if there was one other event in Earth System Science, it didn't get the human dimension. Probably because it was such a cultural gap between social science and physical science. They tried. The latest IPCC assessment tried to get in adaptation. That's really what people are asking for now, is how do I adapt. We're still focusing on the mitigation side intensely. Climate change is going to happen.

ROSS-NAZZAL: Just shifting gears a little bit, are there any decisions that you made that have impacted the current direction of Earth System Science?

ABBOTT: I made sure there was a fluorescence band on MODIS. I guess I could say that was one thing. I don't know. I think I was a young assistant professor when that all started. I think that there were a lot of folks. People like Dixon [M. Butler] and Shelby [G. Tilford] and Stan. They were the ones who were making the frontline decisions. But there were a lot of us down in the trenches. It was a generation that really bought into that vision. Mark [R.] Schoeberl and I always joke that we were known as the evil twins because we were always confused as to which Mark was which, because we both had mustaches at the time. We'd sit next to each other and confuse the project scientist. He would always call one of us the other's name. There was a whole cadre of young scientists who came in and really bought into that vision, that interdisciplinary vision, that integrated view of the Earth as a system. So I think it was a collective decision, not just a bunch of individuals.

ROSS-NAZZAL: Even with your involvement in Mission to Planet Earth, you were the chief scientist there.

ABBOTT: No.

ROSS-NAZZAL: That's what my research [indicates].

ABBOTT: Oh, okay. No. Yet another long sad story. That all got announced. I was going to go back and work with Charlie [Charles F.] Kennel. The lawyers stepped in, because I still had an active research program at OSU [Oregon State University, Corvallis, Oregon].

ROSS-NAZZAL: I was going to ask you how did that work.

ABBOTT: That didn't. I stayed at OSU, yes.

ROSS-NAZZAL: What do you think are some of the greatest accomplishments that you've seen over these past 20 years?

ABBOTT: The greatest accomplishments. There are an awful lot. I think you saw a lot of them today. I think you'll see some more tomorrow. The whole ocean circulation from ocean altimetry has just revolutionized our understanding of ocean circulation, ocean color, the basin scale changes, the hints of looking at fluorescence to understand phytoplankton physiology. I'm

sure if you could talk to an atmospheric science or a land person, it's the time series that are the biggest ones, the biggest change or had the biggest impact.

The second is in some sense what Waleed [Abdalati] and others were talking about. It really opened up new windows to see new processes, like the polynya in the Weddell Sea, the change in the sea ice in the Arctic, all these things that we never could have seen any other way. [James A.] Yoder's talk about productivity. So it's hard to pick out one specific thing. I think if I was to just step back and say, "Okay, you're a biological oceanographer, what's the biggest thing?" I would say it's the mesoscale ocean eddies and their impacts on ocean biology. So those are the 20-to-200-kilometer scale circulation features and how that drives ocean ecosystems because of the way they upwell and downwell nutrients, supply nutrients into the lighted zone.

There are tons of others, but those are the ones I'll just say right now.

ROSS-NAZZAL: Do you think there were any major missed opportunities?

ABBOTT: Missed opportunities. Other than the programmatic one of not linking up with NOAA in an effective way, I think that is a real missed opportunity. In terms of measurements, did anything get left behind? The synthetic aperture radar people would say they got left behind. I would say the high resolution hyperspectral folks would say they got left behind. But at the time, they were so expensive. Nowadays we'd look at them and say those were small missions, but those were unfortunate decisions. Were they really critical? I think that they were good decisions at the time, and they still probably, if I had to make them now under the same

constraints that NASA faced, I would make them again. I would not make many friends at JPL, because those were JPL missions.

But I think that the other one I guess that I would say was a missed opportunity, there was a sensor called MODIS-T. It was the tilting MODIS. That was one that also got left on the cutting room floor. Budget squeeze, I think, to meet Dan Goldin's budget constraints. That was unfortunate, because MODIS, when it was known as MODIS-N, [MODIS-Nadir], so the two MODIS that are up there permanently looking straight down, MODIS-T was supposed to tilt to avoid glint. It would have been a much, much more capable sensor, not that MODIS is bad. MODIS is very good. It's as good as SeaWiFS. MODIS-T would have been that one up above the curve. That was a missed opportunity I think.

ROSS-NAZZAL: Are there any challenges that you've encountered working with other scientists in different fields?

ABBOTT: What do you mean?

ROSS-NAZZAL: Are there obstacles or things you've had to overcome as you worked with them?

ABBOTT: Sure. I think if you look at ocean and atmospheric remote sensing, those two communities get along really well. They have very similar sorts of mindsets. It's very global. It's very process-driven, trying to understand dynamics in a certain area—what's causing the ozone hole, that kind of thing, what's causing ocean productivity.

When you dealt with the land remote sensing community, it tended to come out of the Landsat world. It's very place-oriented. This particular patch of ground kind of thing. It tended to focus on place, not process as much. That's changed a lot in the last 10 years. But boy, when EOS was getting started, it was hard. They really fought for the high resolution, "I need that 10-meter resolution." We say, "Globally, do you?" Back in those days that was a lot of data. Now it will fit on a single little chip.

NASA was going to collect a terabyte a day. That was a lot. I can buy that for \$100 and put it on my desk, but 20 years ago that was a lot of data. There was a real mindset difference. There was a lot of conflict in the early days of EOS in trying to formulate those missions, because ocean and atmosphere people tended not to be tied to—in mathematical parlance, they worked in wavenumber space, they worked on spatial scales. Whereas land people tended to work in Cartesian, XY, give me the coordinates, because I'm looking at that patch of ground and that process. I think a lot of that came because the Landsat world really grew out of the defense community photogrammetry, the airborne remote sensing, which became satellite remote sensing for looking for things, looking for objects. Where are the Russians parking those bombers? The Discoverer Program, which became known as the keystone satellite series, the first airborne photography, was started by President [Dwight D.] Eisenhower because of a purported bomber gap. So they needed photographs.

It's interesting. I'm going to actually tell a personal story on this one. Because my father was involved in that through Lockheed [Aircraft Corporation] in the late 1950s. He came up to work at Lockheed Sunnyvale [California]. On that team to build that was a forest ecologist named Bob [Robert N.] Colwell from Berkeley who had clearance at [Ernest Orlando] Lawrence Berkeley [National] Lab [Laboratory, Berkeley, California] because he was on the team to help

them understand what was fake forest and what was real forest, because they figured the Russians, the Soviets at the time, were disguising their missile bases this way.

My only remote sensing course I took ever was at Berkeley from Dr. Colwell. He would talk about measuring tree height from shadows from airborne photography. He said, “And oh, by the way, there’s this new satellite called ERTS,” [Earth Resources Technology Satellite] it was a predecessor to Landsat. So in some sense that community grew out of that mindset of looking for particular things in particular places. So it was hard to get, as we called them, the landers to think globally and to think global carbon cycle and to think global processes.

On the other hand, they really thought ecologically as well. So there was eventually I think a really nice marriage in understanding ecosystem impacts and responses to biogeochemical cycles. We tended to think cycles, heat cycles and heat budgets and carbon cycles. They tended to think species and place. There was a lot of gear grinding to get those communities to see that those were complementary ways, not one better than another. That was a challenge for a long time.

ROSS-NAZZAL: Sounds like it. Can you categorize how Earth System Science has changed over the years in terms of who was President at that point?

ABBOTT: Who was President at that point?

ROSS-NAZZAL: Did it have much impact or really not much?

ABBOTT: Dixon Butler used to tell me we always fared better under a Republican administration because they wanted science to provide them cover from having to do anything. I don't know if that was true or not. I think in some sense we did do better under [President George H.W.] Bush 41 than we did under [President William J.] Clinton, because the Clinton Administration really got into—this is a perception—Space Station as a way to keep underemployed ex-Soviet scientists from going and sharing their brains with other less friendly countries. It's really ironic, when you think of Vice President [Albert A. "Al"] Gore at that time. But we did not fare that well, budgetarily, as well as we had under the previous administration.

Under the [President George W.] Bush Administration, by that time, everything had gotten set. We can say, "Well, was it because of Kyoto or not?" I think again with NASA it was always as much a problem internal to NASA as who was President. I think Bill Fred [William F.] Townsend—we called him Bill Fred—Bill Townsend put it the right way. When you had a series of administrators who did not understand why NASA did Earth science, NASA itself has never figured out what its role is in Earth science. It's all over the map. It's something we do. It's something we don't do. We do space. We do manned program. I think as NASA has gotten older, it's still struggling with trying to figure out what's that balance.

Then on the other hand you have NOAA, which has always been deeply underfunded, and has regulatory responsibilities as well as science responsibilities. So the nation's Earth remote sensing strategy has been catch-as-catch-can. You have DoD [Department of Defense] that has its things it needs to do, and you have NOAA that has its things it needs to do. Then you have NASA.

The presidential decision directive creating NPOESS [National Polar-orbiting Operating Environmental Satellite System] was probably another big thing in the life of Earth System Science.

ROSS-NAZZAL: What was that?

ABBOTT: That was Clinton, and that was saying, “Why do we have two meteorological satellite series, DMSP [Defense Meteorological Satellites Program] and POES [Polar-orbiting Operational Environmental Satellite]?” The POES series, the NOAA-6 through whatever they’re up to now, 16, so the pre-NPOESS. When the President created that, it did two things. One, it said weather forecasting is dominant for the nation’s Earth remote sensing needs. The second thing it did was it made NASA a junior partner in that triumvirate. So NASA played a very limited role. NASA couldn’t take its science requirements for long term observing systems that it was beginning to formulate that had started with EOS and was beginning to refine with lessons learned from EOS and infuse them within the design and development of NPOESS.

DoD said, “Hey, we only care about the weather.” NOAA largely said, “We only care about the weather,” although they had some weak voices in there arguing for climate. Therefore when NASA comes in and says, “We want climate,” nobody listened. In fact, DoD hardly even listened to NOAA. In fact, NOAA hardly even listened to NOAA in terms of its climate needs.

So that was a singular event. I should have mentioned that earlier. I can’t remember the number of the PDD [Presidential Decision Directive/NSTC-2, May 5, 1994], but it was one that if we all were to look back on it, it’s one we would undo.

ROSS-NAZZAL: We heard a lot today about Dan Goldin as [NASA] Administrator. Can you characterize Earth System Science under other administrators? Dick [Richard H.] Truly? Sean O'Keefe? Mike [Michael D.] Griffin? Any significant changes?

ABBOTT: I think under Truly and [James M.] Beggs it did pretty well. It did okay. It certainly got its new start. I think O'Keefe, he was doing what the President said, and it was to save money; he was a budget guy. I think Mike Griffin just does not understand why NASA does it, period. O'Keefe comes out of it from an OMB [Office of Management and Budget] budget side and saw it as a dilution of budgetary effort. I think Griffin just didn't see any value. It should be a NOAA thing, why is this even at NASA? Oceanography? I thought there was something called National Oceanic and Atmospheric Administration, right? So I think that Mike, it just confused him.

I think that's actually a reflection of NASA internally too. The NASA Centers haven't quite figured quite where it belongs. It's hard because manned missions are viewed as the lifeblood. They're expensive. Shuttle and [International Space] Station really drew far more resources than any of us ever expected they would draw. Then you have the space science missions and the telescopes, and those are all wondrous successes, but they're getting more and more expensive. Then you have Earth, but you say, "Why are we even doing Earth? We've got these other two problem children. I don't need a third." I think NASA itself has not come up and the nation really hasn't come up with what's its role in the context of Earth science. It's really something somebody's got to come in with a vision and really push on it. I don't know. We'll see what happens in the next four years.

ROSS-NAZZAL: You did mention Al Gore a few minutes ago. Do you think that his movie [An Inconvenient Truth] and book [*An Inconvenient Truth: The Planetary Emergency of Global Warming*] had any sort of impact on Congress and the White House and the American public and their understanding of challenges?

ABBOTT: I think he certainly created a lot of press for it. I think he's created awareness, and I think that's a good thing. I think sometimes I don't agree with his approach on how to answer the questions. But I think the good thing that he's done is raised awareness of the Earth as a system. He's certainly done that. The movie and the books have done that.

ROSS-NAZZAL: Do you think it's had any sort of impact at all on Earth System Science?

ABBOTT: Only in that people are aware. I think when we started Earth System Science 20 years, 25 years ago really, it was pretty much locked up in academia. I think now you can talk to people and they actually know some of the stuff that's going on. They still confuse ozone hole with global warming. But 25 years ago, most people didn't even know. So that's a good thing.

ROSS-NAZZAL: Does Earth System Science have an international aspect the way Space Station and some of NASA's other programs do? Or is this primarily a US-led [activity]?

ABBOTT: No, I think in places there have been some real stellar successes. Between France and Japan for example. Been absolute wonderful bilateral international partnerships. Between NASA and CNES [Centre National d'Etudes] and NASDA [Japan Aerospace Exploration

Agency], which is now [JAXA], and NASA. You saw some of that today. So TOPEX/Poseidon [Ocean Topography Experiment] the whole scatterometry, ocean color, there've been really fabulous relationships between those two countries or those organizations and the United States.

ESA [European Space Agency] is a little more difficult because it's a much more complicated organization to deal with, in the sense that you've got a ministerial level, and it's just harder for us to go in and deal with. The other nations, certainly the Argentinians for example, there's a joint mission NASA Argentina that's going up. So there've been a lot of good bilateral relations.

In terms of GEO, the Global Earth Observing one, it's a mixed bag, because it's hard. You got to remember each nation has its own interest. Some are trying to develop their own spacefaring capability. The Chinese being a classic example. Others are very protective. The Indians are another example. Others are much more in the community of science and are much more willing to come in and share and partner. So once you recognize that everybody has their own needs, then you set realistic expectations. But there is no overall grand coordinated scheme, and there never will be. I just don't see. Because each nation has their own interest, and they're legitimate interests. The Europeans want to develop their own industrial capacity for remote sensing, and that's fine, they should be able to do that. They shouldn't have to have us come in and say, "Hey, we've got the sensor, you just launch it for us." Where's the value in that for them? How do they ever get on their own? You could say, "Well, they save money." But right now national interest still dominates.

But I think clearly the IPCC is a classic example of international coordination at the science level.

ROSS-NAZZAL: Do you want to talk at all about your work with the Aqua satellite?

ABBOTT: This is a sad thing. Aqua went up, and I became a dean, and I've hardly done anything since.

ROSS-NAZZAL: That's a shame. I figured you had done quite a bit with that.

ABBOTT: No. I got it up, and my science just stopped. I only right now do some work for the Navy. I have some ONR [Office of Navy Research] money. But to really work with NASA data requires you to just work on it all the time. When you're running an organization, you got to pick just little bits of science that you can do. That was one where I had an interdisciplinary team, and I was a MODIS team member, and when those came up for renewal I just said, "I'm done."

ROSS-NAZZAL: Is that the case with your supercomputer networks? That \$10 million grant that you received from NASA?

ABBOTT: Oh, actually, yes, that did its job. Because we had people doing that as part of my IDS [Integrated Decision Support] team. It's interesting because our college was a little different. It started out as just oceanography when I got there. Then atmospheric science came into us from the College of Science about 12 years ago. But when I came up in '88, the dean at that time said, "This satellite remote sensing and ocean modeling look like they're going to be big things, so I'm going to hire some smart young people in that." He got me, he got Dudley [B.] Chelton

from JPL, he got eventually Mike [Michael H.] Freilich from JPL, he got Andy [Andrew] Bennett. I guess Andy had been at Harvard [University, Cambridge, Massachusetts] doing modeling. Bob [Robert A.] Miller and a few others. So we all came in. There was an interesting alliance between modeling and remote sensing at that time. The reason I say our college is different is it's 90 percent funded by the federal government through competitive grants and contracts. We're celebrating our 50th anniversary this year. That has been true for 50 years. It's almost an FFRDC [Federally Funded Research and Development Center] with a little bit of state money and a big wad of mostly NSF but a lot of NASA and NOAA money. So about \$30 million a year grants for about 65 faculty, real research-intensive.

Before I became dean, people saw this modeling as an important thing. So that's continued. We just finished upgrading our network. Our network within our college is better than anything on the campus. We have petabytes of storage and teraflops of computing. It's not in a big supercomputer anymore. It's everybody's little deskside or a cluster in a rack. In some sense, that initial kick start got people thinking about computing and kept our college going. We're now into what I like to call our third generation of modelers and satellite remote sensing faculty. After the first wave, the second generation are full professors, and they're starting to hire postdocs and others of the third generation.

ROSS-NAZZAL: Did you come up with any new modeling techniques as a result of this grant?

ABBOTT: Not me, but my team did. People were working on all sorts of new ways of doing data assimilation primarily. There were a lot of new techniques on assimilating both in situ data and satellite data, and trying to understand the characteristics of the satellite data and how you could

assimilate it into the model in a rigorous way. There was a lot of that technique development. So that's one side, the mathematics.

The second side is much more developing more comprehensive models of the ocean ecosystem, linking physics and biology. I had a whole series of postdocs who worked with me on that. Although I was just the ecologist, I wasn't a modeler. But it's funny. I go to meetings nowadays, and people will stand up, and they were all either my postdoc or PhD student, and they're all talking modeling. So it's odd how things work out.

ROSS-NAZZAL: I think we've talked about this, but do you think that there are any other essential decisions or events that need to occur over the next 20 years that you see out there?

ABBOTT: Yes, NASA and NOAA have to figure out how they're going to play together. Somehow the country has got to come up with a strategy to have a long term climate observing system that meets science needs as well as, "operational needs." That's not retreading a weather satellite, and it's not stringing together a series of research missions, which is what we've done for the last 40 years.

Ocean altimetry is the only one that's successfully made that transition from research to operations. That took 25 years. That's one sensor. The nation hasn't said, "We need a long term permanent observing system in space to look at these long time scale processes," beyond just, "We need a permanent presence in space." That's all we've said. We'll always have a meteorological satellite ready to orbit so that we don't miss Hurricane Katrina. Until we get to the point where we say, "We always have to have a permanent presence in space to understand how ice shelf dynamics are changing over time," we're never going to get there. That's the

number one decision I think. NASA and NOAA have to figure out one, what does that system look like, and two, what are the roles and responsibilities for those two agencies, what's NASA's role and what's NOAA's role, and how do I align those together.

Because what happens now is NASA develops a system, basically a tool, and NOAA says, "Oh, well, it's going to take us 15 years to figure out how to build a budget line to get it into our portfolio. Gee, NASA, can't you just keep flying them?" That's what happened to ocean altimetry. It was only through good graces and good luck of NASA and CNES that it kept going long enough for EUMETSAT [European Organization for the Exploitation of Meteorological Satellites] and NOAA to build up the case internal to them so that they could have the budget and have a home for it.

That's one decision that has to be made. I think the second gets back to that earlier rant about the science community. We have to start thinking about how we help people adapt to climate change, and what are the issues people need to face, and how can we help them. Because we're just delivering predictions and interesting science and understanding, but for the person on the street or the person making an investment or the person making a vote, it's irrelevant. We haven't gotten down to that level of detail and understanding that really touches where people are going to make a decision. It's just out there. It might as well be Neptune to some extent. They're aware of it, and it just seems either, like we said earlier, hopeless or you're going to destroy my economy. I think we have to really have a little bit of soul searching to figure out how to do that, because that's a hard problem. I don't quite know the answers. I'm coming up on retirement. But somebody else has to think about how to do that. That's the second decision.

The third one I think is one that is really troubling. It's again for the science community at large. It's federal funding masters and academia. So this is what happens when you get older and you sit on the Science Board. You start thinking these things. It's been 50 years, 60 years now, for NSF and ONR. When the federal government said, starting with the Navy, "There's some fundamental research that we can achieve, that we need, that's better done in a university setting than within a government lab. We get better product and we get next generation engineers and scientists out of it." The university said, "Okay, if you'll pay our indirect costs, we'd be happy to do that." That partnership has been enormously successful. I think it will continue to be successful on a lot of the basic fundamental science.

However, when you look at the kinds of questions that we just asked, what I call the Portland Metro councilor question, it's incredibly interdisciplinary, and it doesn't necessarily lead to a clear publication in a refereed journal for promotion and tenure for an individual scientist. Because remember, the funding and the promotion and tenure are all still individuals. That's the whole reward structure, and that's good, nothing wrong with it. But when you think about these other kinds of questions and people working with the Portland Metro councilors to try and help, what's the metric? How do you fund them, how do you promote them?

We in the science community will tend to still look at, let's just say somebody issues a call, "We need to have a major program on ocean acidification and its impact on coastal upwelling ecosystems." What happens is that it's like a gypsy caravan shows up in your parking lot. You've got all these individual scientists who show up and say, "I've got this widget and I'll sell you, Mr. or Ms. Program Manager," and eventually you as a program manager and maybe a science steering committee can put together a program and an answer. That's okay, that's good. Again a lot of great science comes out of it. However, when you look at doing risk management

vulnerability assessments, super interdisciplinary, much more than just physics, chemistry, biology, much more than just oceanography, atmospheric science, not clear to me that model works real well. I'm not sure what that new model is. But I think it's a decision to think about how universities are organized, how we reward faculty, and how we teach students. It's something we really got to think about.

I don't think it's necessarily the answer that I see a lot of my colleague institutions doing, which is creating colleges of everything. I'm going to create a college of the environment and I'm going to create a PhD program in ecology. Again that's not much different than, well, a new gypsy has showed up at the market with a different ware. What does that program mean? It's not that we need to train everybody to be super interdisciplinary, but we need to train them enough to think about and to be able to communicate with a more diverse audience set, not only of colleagues, but of people you're talking to. Because if you look at that 50-year-old, 60-year-old tradition of academia and government, people always come to my college, 90 percent federal funded, and they say, "Well, gee, I didn't even know this college was here in Oregon. This is really killer." I say, "That's fine." Because the only people we talk to are our science colleagues through journals and our program managers in Washington, D.C. I spend more time inside the Beltway than I do in Salem, Oregon, for good reason, because 90 percent of my funding comes here. So my stakeholder set is not the guy or gal down the street, or the business owner, or the person who owns a Hewlett-Packard factory. It's a program manager within a building inside the Beltway, largely, unless it's NSF, which is in Arlington [Virginia].

If you want to take Earth System Science to the next level, we got to really think about how we teach, how we reward, and how we organize, and how we communicate, and that's not just create a mega department or a mega college. That could be, but I'm thinking that that's

probably not the right approach. There's an awful lot to say for smaller teams that are more diverse and more flexible to come together for a problem and then maybe split apart. But it's going to be a challenge for universities to think about, because they are so much organized along very strong discipline individual science grounds. It's not clear to me. They're going to do the great science stuff and engineering that's gone on for the last 60 years, and they'll continue that in the future. But the Earth System Science questions, the big ones now, the human dimension ones, what do I do about it questions, I don't know that universities are the right place. I'm not sure that federal agencies are the right organization either. We're all pretty segmented out. I'm not quite sure how this is going to play out, but it'll be an interesting experiment to watch.

Because unfortunately we have to do it, but I'm not seeing anybody that is able to do it. It comes down to people want simple answers, they want short term answers, so you got to educate them that there are no simple—Steve Rayner calls these wicked problems. Uncomfortable problems with uncomfortable solutions. Actually, I would argue with him. It's a dilemma. There is no real solution yet. You're going to be constantly trying something new and seeing what works and adjusting your strategy. That to me is probably the biggest, and it's in some sense, the unspoken discussion within the halls of academe or the agencies. I'm not quite sure that they know quite what's going to hit them.

ROSS-NAZZAL: That brings to mind another question, just looking back at '83. Then I'll let you go. This new move towards the interdisciplinary Earth System Science, were there any turf wars or people who thought we need to focus on Earth science, we're not going to look at atmospheric science, we're not going to, we don't want to.

ABBOTT: Oh, yes, there are always turf wars. I have this battle internal to my university too. When you say Earth System Science and you're at an ag [agricultural] school like me, the dean of ag sci [Agricultural Science] would say, "Well, we do that too, we work with the Earth, and we do science, and we're working in systems." You say, "Well." It was a hard argument to have. I think I had a forestry dean and an ag dean all arguing that they did Earth System Science, and my college should be all embedded in their college. I said, "Whoa, hold on." You're looking at an important—again—class of problems, but they're narrowly defined in space and time. I always tend to think in time and space scales. Maybe it's because of where I got my PhD. My adviser always said, "Think of time and space scales." It's what kind of crop do I need to grow this year, think about new varieties, cutting cycles for trees. It's very well-defined. Earth System Science is much broader and much more strategic as opposed to solution. What are the strategies I need to put in place? So there were a lot of turf wars in that. It sounds subtle and it sounds academic, but there really is a difference in the mindset and the kinds of science that the faculty and the students engage in.

There is some complementarity, there's no doubt. They should work together. But there were a lot of turf wars. I think there were some in the early days of EOS. There was a perception that everything was atmosphere chemistry, for example. Well, that's because Dixon and Shelby were atmosphere chemists. I think that that was an unfair characterization, but people who thought that could say, "But see, those two guys, we're getting dissed because they're atmosphere chemists." Those went away over time. But initially, again, you were taking a community that really had not worked this way before. I would say it probably took about five to ten years for people to get over it and get beyond that.

I think the decadal survey [Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond]; really that's another kind of event. Thinking again, that's another event from two years ago that really transformed the Earth science community, because there were several of us, me included, who thought that was a dumb as dirt idea. Because it was something that if you look at the space science communities that have done it, the astronomy community, they had done it for a long time, and they'd laid a lot of groundwork, both culturally and processwise, to manage that, and we'd never done it. I think it came out pretty good. I think I would give—and I told Rick [Anthes] and Berrien [Moore III] this—I'd give them like a B minus. It's a passing grade. But what didn't happen was a lot of community frothing and fighting, which was good. That part, they get an A. On their understanding of NASA and NOAA budgets, that's where they were lower. So their overall grade was a B minus. But I would say that was another one of those big singular events that happened. It happened probably at just the right time for the community.

So EOS was beginning to look. What's coming here at the end? We're starting to see the end of it. NPOESS is a mess. What are we going to do? So it was good to revive some of that community feeling. Brings to another issue, ties into that first, that previous diatribe on academia and organization—young faculty and young scientists. I do think that we've lost a lot of core capabilities in both science and technology. It's in part because the world is so competitive for funding, and the young ones can't take risks anymore. They've got to get tenure in six years. They can't afford any mistakes. So they tend to be much more incremental. I think that that sense of community, it's hard for them to balance that. When you look at this class of problems, and then you just even look at your core capabilities, your core competencies, even

that's at risk. Who knows how to build an ocean color sensor anymore? Used to be universities had a lot of space instrumentation capability, and that's gone.

It's interesting, when I look back, that what I think I bring to my college was in large part having worked at JPL. You say, "Well, why is that?" Because the NASA Centers involve the scientists in a real—you get hitched up to a program or you don't succeed. Mine was EOS. I see this in my colleagues who went through that and have gone on to academe. They bring a different flavor to the academic enterprise that you don't see in most people who've only spent their career in a university. There's something about having to work in a program and in a project where you understand how to balance science and technology, where you balance cost and schedule and performance, you have to work as a team with a whole range of people. That begins to get you towards that Earth System Science mentality that academe doesn't necessarily build.

I would like to see more young scientists come into Goddard and Langley [Air Force Base, Hampton, Virginia] and JPL and then go on out into academe to infuse that mindset, because it's a unique mindset. I don't know if that's happening much anymore, but I sure see that with my young faculty who've not been to Centers. They just think differently. It's, "What have you done for my lab lately?" It's not that they're selfish, they're just trying to meet what they think are the promotional goals. If you've ever worked in a project, you know you got to think about that program operating plan and where does your RTOP [Research and Technology Operating Plan] fit within that. It's a different culture.

ROSS-NAZZAL: Sounds like it.

ABBOTT: Yes, it really is.

ROSS-NAZZAL: Is there anything else you think we should talk about?

ABBOTT: No, I think that's good, I think that's enough. I don't know, there might be more.

ROSS-NAZZAL: When we send you the transcript you let us know. Thank you very much.

ABBOTT: Okay. Sure.

[End of interview]