EARTH SYSTEM SCIENCE AT 20 ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

DIXON M. BUTLER
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is June 3rd, 2010. This oral history is being conducted with Dr. Dixon Butler in Washington, DC. Interviewer is Rebecca Wright. This is the third interview with Dr. Butler as part of the Earth System Science at 20 Oral History Project, a project to gather experiences from those who were involved in various efforts in the launch and evolution of Earth System Science. Dr. Butler serves as a professional staff member on the Commerce, Justice, Science Subcommittee for the Committee on Appropriations of the United States House of Representatives. Included in his responsibilities are NASA, the National Science Foundation, Office of Science and Technology, and climate change. Thanks again so much for meeting with us on this project.

BUTLER: Glad to.

WRIGHT: We ended your last session with you explaining the events around the arrival of Dan [Daniel S.] Goldin [as NASA Administrator]. Before we get to that, I just had a couple questions I wanted to see if you'd help us summarize; it's a rather large question. Through your interviews you shared with us so much of bringing so many different types of agencies together, even within NASA different factions that came together. That in itself is such a challenge. Can you give us some pointers on how the differences of these agency priorities were able to come together so you could develop the EOS [Earth Observing System]?

BUTLER: Yes. [I've] given a fair amount of thought to the interagency part of this. One of the reasons the US Global Change Research Program was able to come together has to do with the leadership and what the leadership considered its priorities. There was a point where what was coming together was NASA, NOAA [National Oceanic and Atmospheric Administration], the National Science Foundation [NSF], and the US Geological Survey [USGS]. This was right at the beginning of the Bretherton Committee, not in the planning of EOS *per se*.

I believe it was a man named Dallas [L.] Peck who was head of the US Geological Survey. A wonderful, very fine, nice man. Earth science, or GEO [geosciences], as it's called at the NSF—Bob [Robert W.] Correll had come in from the University of New Hampshire [Durham] and was in charge of it. He ended up, even though he was on two-year-at-a-shot leaves from New Hampshire, staying there for ten years heading GEO. Bob played a major role. Shelby [G. Tilford] was leading Earth Science, which at the time was just a division at NASA Headquarters [Washington, D.C.]. Different people were involved at NOAA. It's funny, people have told me exactly who they think was responsible but it was a little murky.

When we started off there were some tensions, particularly with the man who was staffing it at USGS, but not with Dallas Peck. I think what ultimately made it all work is the lead people at each of the agencies had getting this done as a higher priority than trying to further the singular objectives of their individual agencies. When you have that, you can get it done. It's much like, "Okay, we're going to go fight this war, and everybody comes, and yes, there will always be some tensions between the army and the navy and the air force, but people get the message." Pre-9/11 [September 11, 2001 attack on World Trade Center and Pentagon] you saw lots of reports of the lack of cooperation within the multitude of intelligence agencies. When

you're confronting a threat, that should end up going away. But it only goes away when the effective leaders—doesn't have to be the top of something—but the person who's the effective leader puts that effort at a higher priority than either the current or the future objectives of the agency. Then you have common purpose, then you can make it happen.

There's an analogue situation that happens in building Earth System Science as an intellectual endeavor, and it's posed a great problem. I never gave this deep thought, but one day, in just the briefest of conversations with Ralph [J.] Cicerone, who today is head of the National Academy of Sciences, brought it home to me so quickly. When we were concerned about understanding ozone depletion, we brought together laboratory photochemists and people [who] did all manner of different kinds of field measurements, with people who did numerical modeling, with people who looked at satellite data, with statisticians—people who were literally statisticians, they were not into the atmosphere at all—with people who had a more meteorological background and understood the dynamics of the atmosphere.

What enabled us to come together intellectually and work as an integrated community was we had a problem we were trying to solve. It was an important problem. At the time it was a unique environmental problem in its scope. And it worked. One of the reasons it worked, maybe the reason it worked, is we were joined in solving a problem that we embraced as a common problem. Doesn't mean we were all at risk for skin cancer—but vicariously on behalf of mankind we saw it as a problem that we were coming together to address, at least to address in terms of saying to people, "Problem! Here's the nature of it. Here's our understanding of it. Here's our predictions."

There is a general scope about how much can a human being do cooperatively. I've read recently some article that says one of the differences between human beings and chimpanzees is

chimps can identify with about 50 individuals in the group. Human beings tend to be able to relate to about 150 or more. Obviously some of us can relate to far more and some of us have mental difficulties and can't relate to anyone. Generally that lines up with a piece of wisdom that was out there 25 years ago in the science community. Other than with collaborators, most scientists can write one good refereed journal article a year. They've got collaborators, maybe three of them put out three with multiple authors—but basically that's most people's reasonable pace. You can read about one article a day. Well, 200 workdays, that says you can read 200 papers, and you can write one. You can collaborate with 200 people, and 200 people have a way of forming, therefore, an intellectual community to address a problem.

When you get to Earth System Science, as the IPCC [Intergovernmental Panel on Climate Change] process demonstrates, you're now dealing with collaborations in the thousands. It makes it very difficult. In Earth System Science we encountered that problem plus another. The other problem, the one that Ralph Cicerone really helped point out, is the Bretherton Committee created this concept of Earth System Science, of studying the Earth as a system. It infected everything in the Earth Observing System as well. The essence of it came down to the emphasis on holding things together.

I think I explained with EOS, back when it was System Z, the seminal thought was what joined the disparate disciplines of Earth science together was water. It's having water in its three phases that makes Earth, Earth. What makes Earth System Science, the energy cycle, the global hydrologic cycle? Water. And a set of biogeochemical cycles of the fundamental elements: carbon, nitrogen, sulfur, phosphorus being the key ones. You can also go into the things that are in the minerals that all living things want for some random one of their amino acids or proteins

or some reaction, like a little bit of magnesium or manganese, or a little bit of zinc or iron for that matter.

So biogeochemical cycles, hydrologic cycle, energy cycle; each of them is dealing with something that to a pretty high degree of accuracy is conserved within the Earth system. The problem gets to be that we intellectually created this construct—which made sense. Ultimately, there is the Bretherton Diagram illustrating all the connections. Wonderful visual to symbolize a very integrated—reductive but insightful concept that is really Earth System Science.

But we didn't exactly have a problem. So in building the collaboration, it was "we all need to collaborate," as opposed to we have a specific problem to drive the collaboration. Today, one could say yes we have global warming—or really global climate change—because it's not so much the warming as it is the sea level rise, and the acidification of the oceans, and the whole swirl of shifts in the hydrologic cycle, like wet areas getting wetter and dry areas getting drier. It's all of that together coming from greenhouse gases, and therefore a more rapid pace of change than is normal or than the biosphere is used to adapting to.

That is the problem. And that has enabled people I think to make the kind of progress they have, but inevitably they break up into subgroups. The glacier melting people, there are probably a couple hundred intellectual workers in that area. They are able to come together through the IPCC process, share all of their results, because there is a focused problem. It's an even greater challenge when you need 140 countries' representatives to sign off on virtually every word in your assessment of the science, which is the process that Susan Solomon told me ultimately she had to achieve running just the Volume I process, which is the science part of the process of the IPCC.

I think that gets at the answer to your question. The keys are leadership, a commitment to a common problem, and a common problem that in effect is so valued that the leadership involves a certain amount of self-sacrifice. It doesn't mean you're going to go take a bullet. What it does mean though is you're not going after your selfish need, you're going after the community need.

Just as an aside, there are certainly arguments out there that would say that's why human beings evolved the ability to talk, which is also the ability to abstract. It's that the conversation builds the ties to the group of 50, or then 150 or more, for collaboration in the hunt, so you do what the group needs instead of what you need. You don't suboptimize to yourself, even when you're out of sight of the rest of the group. The ultimate ethical test. Do you stop at the red light when no one's around? That, I think, somebody named Rushworth [M.] Kidder described as really the essence of ethics: do you do the right thing when no one's watching? In this case it wasn't so much no one was watching, but that is the way you get multiple agencies to work together in the government.

WRIGHT: One of the essential factors, as I read it, in making this come together was your role as an advance planner. Can you share with us what you feel are the skills—and why is it necessary to have someone not necessarily in that title but in that role to advance the project and formulate how it's going to advance? What were all those duties that you took on in that role as an advance planner?

BUTLER: I did make reference to Frank [T.] Martin teaching me to be one in about 25 minutes in his office, and I wish I could remember all the things he said to me still. There were a number of

elements, some of them fairly practical, little P politics. But everybody needs people with vision. Again, if you're going to draw people together, even if it's just the components of a division within a program at NASA Headquarters, like the planetary program, the heliophysics program, or astrophysics, or for that matter Earth Science at NASA Headquarters—even just at that scale, somebody's job needs to be embracing the full. Not just as the boss manager, who's got to go run [the organization] and worry about personnel.

What the advance planner is at their best, in the best of situations and times, is a person who embraces a knowledge—admittedly not as deep as the individual experts' managing pieces of the program—a knowledge of the program, an embrace of that program, preferably a fairly inclusive embrace if you're really going to get things done. You already begin to see a tie back to that you are behaving in an intellectually selfless way. It's not truly selfless in the most idealistic sense, but you're not pursuing your individual subset objective as a scientist or an engineer or whatever. In general, people like this at NASA would be scientists by background. You've got to embrace that. You've got to be seeing what's needed both in scientific terms—but in Earth science you've got to see what's needed in much larger intellectual terms.

It helps if you also have a sense of the agency mission. If you can see what the agency mission is, that's great too. There's also seeing the interagency mission. Let's say in astrophysics. There's a lot of ground-based astronomy going on. There's now ties to all the accelerator stuff because the big questions have become dark energy, dark matter, things that bring together high-energy particle physics with all the astronomy disciplines other than planetary and solar astronomy. You want to see that as an intellectual horizon. You want to see what our government needs and your agency's role within it. You want to embrace the suite though of that intellectual set of efforts within the agency. Having an advance planner ideally is

having a point person who wakes up in the morning saying, "Gee, I can't wait to go do that, that's what I want to do."

It helps to have some preparation to do that. Just as an aside, I would say I would not have been able to do what I did for the Earth Observing System had not I upon my return to NASA Headquarters from being a congressional science fellow been assigned as the advance planner to go help the oceanography people. I was an atmospheric scientist, admittedly stratosphere more than meteorology, but I knew the atmosphere side. We only had an atmosphere and an ocean side in the division at that time. I also knew some space physics because of going to Rice [University, Houston, Texas] where space physics was the dominant force really in the department [of Space Science and later Space Physics and Astronomy].

When I went over to the oceanographers, Stan [W. Stanley] Wilson and his gang—and I felt they were a really tight group—they taught me satellite oceanography. They took me under their wing. They didn't ever view me as having really joined the group, even when later on as a manager I did things that really helped the field beyond their, I think, expectations. I never really became part of that tight-knit oceanography group, but I learned. I learned what was important to them; I learned what they needed; I got Stan's vision of satellite oceanography, and I carry it with me to this day.

At some point I had to pick up ecology vision. I didn't really know it; I didn't really understand the biological stuff. I certainly didn't know the geology stuff, but somehow it came to me fairly easily. When Burt [Burton I.] Edelson put us on the track of coming together across all of Earth science, even with the inside NASA group of ten that did the System Z plan and got things started first, we taught each other things about our separate scientific backgrounds. We gave each other a kind of advance planner's breadth. Then of course we, in some ways, were

functioning together. Not everybody on the committee, but several of us were functioning as advance planners.

It helps to have that embrace. It helps to have a context. Then you need the magic, which I would describe as the vision. Of course it's magical to be willing to embrace other people's objectives, it is magical to not have a tin ear when you look at the broader agency, interagency, government intellectual need. But seeing the path ahead becomes very important. Frankly, for any advance planner who might ever listen to this tape, I didn't start with all those. I'd always been out there. I think I was prone to sort of having a vision and being able to look ahead, but I certainly didn't have the broad intellectual embrace. I didn't understand satellites or engineering spacecraft or launch vehicles or the details of orbits and orbital dynamics, but I learned.

It was okay to start and then learn, but you had to be open to it. At the same time you had to be empowered by management, by your job assignment, to do it. Frankly, at some point as EOS matured, and in some ways as I ceased being an advance planner, a whole lot of skills—I had to understand the orbital mechanics to deal with and help chair meetings where we came to decisions about well, are we going to put EOS primarily in a 705-kilometer Sun-synchronous orbit which has a certain inclination and certain coverage patterns, but a 16-day repeat pattern in its ground tracks—all that was an understanding that had to be built up, and it had to be built up actually in the EOS Science and Mission Requirements Working Group. Enough of them had to get that, but I had to get it for sure as the chair.

I learned things about remote sensing instrumentation. I never had Shelby Tilford's understanding of optics and some of the remote sensing instruments, or that of many of my colleagues, but I had enough. I had enough of a sense of spacecraft engineering and what the

real issues were, and radio frequency interference, and electromagnetic interference on board the spacecraft, and booms and cooling and being able to point away from the Sun for where you're shedding your heat, and gathering the sunlight, and rotating joints. You need that, but the point is you can learn it. And you can learn it on the job.

Having an advance planner is really having somebody who's, if you will, receptive, where it's soil which is ready to have all these seeds grow in it, and a role to go learn, and a management that wants them to do that. It really helps, if you're going to be successful, that you hit the times when the things are saleable. For some reason, I was listening to the old folk rock song from Ecclesiastes [3:1] Turn! Turn! Turn! [(to Everything There is a Season) by Pete Seeger]. Well, there are seasons to sell, and seasons to prune back, and NASA goes through them. It's a lot nicer if you're hitting [the season to sell]. On the Earth Observing System you'd have to argue we hit glitches, we hit lean times, but it was as sustained effort, and if you think about it, I began working on the Earth Observing System as System Z in late 1981 or early 1982, and I didn't have any idea where it was going or what was going to happen. We didn't have a new start until fiscal year 1991. The [Space Shuttle] *Challenger* [STS 51-L accident], as I said before, gave us a three-year setback, but we were able to ride that rhythm through.

Some things hadn't been. George [F.] Esenwein had led an ICESat [not the one that eventually came into being, but a large satellite with SAR and other instruments] study, which had a lot of precursor elements, particularly on the oceanographic side of EOS. It didn't go. Part of it was we [EOS] hit the resonance with what increasingly was needed. In other words, the need to understand the global environment wasn't a need that went away. Events did not overtake us.

I would say in planning things of the time and technological complexity and scope—and by that I mean development time—NASA tends to move a lot better on times of half decade to a decade and longer for getting anything done. You need to be finding problems, needs, things that will persist in the national commitment. The Moon was going to be out there for the Apollo program, it wasn't going to go away between 1961 and 1969. The problems of the global environment, if anything, got worse or more urgent, at least in the public perception, between 1981 and 1991. What is a shame is that there was a certain amount of going to sleep in parts of the '90s, and particularly in the 2000-2008 time period. We really didn't keep paying enough attention, but the problem has been one where you ride through that [and the commitment of public funding that goes with it].

WRIGHT: When putting together proposals you referenced one time that there was a risk of combining research missions and operational missions because sometimes resources tended to go to operations, and the research could get undermined. How was it put together where both could be taken care of and you knew the risk was acceptable?

BUTLER: When you go to space there are a lot of things you can't do. You can't just go plug into the wall. You can't touch something and ground it. You're there. In effect, every spacecraft we have is a robot, not a very human robot or anthropomorphic robot, but it's a robot. It may be getting lots of commands from Earth, but it's on its own. If it's Hubble [Space Telescope], you can get the Space Shuttle there, you can go fix it, but most of the time it's on its own. It's, in a very real sense, launched. That means it's got finite resources. It's like an island in that sense. There's only so much resource there. If, for instance, you've only got so much

power, you've only got so much solar collector, you can only charge the batteries up so much. If some of the batteries fail you've only got less power.

If you [have] got to choose which instruments get the power to continue to operate and you've got a need to provide weather forecasts or ocean forecasts every day 24/7 [24 hours a day, seven days a week] for public safety, and you've got an investigation looking at climate change in an intellectual way over the coming decades, you don't get to choose climate change; you just don't. You can balance these in the research and operational portfolio of an agency, of a government for sure—if you can't you're in trouble—and certainly of a global economy. Nobody talks about we need to spend 20 percent of GDP on research and development. No, we talk about 3 percent. We know how to balance. Setting the balance correctly is a mess, and it's a mess we experience politically right now in some very awkward ways.

Your body, threatened in a certain way, will reserve all of its functions for your core; it'll keep the brain going, it'll keep the heart and lungs going, it will abandon the rest of you if necessary. Operations [such as NOAA delivery of forecasts] are like that. They're your bread-and-butter got-to-do-it. Research is on a longer timescale, and although you've got to do it, you don't necessarily have to do it today—and that's one of the problems in Earth science. You cannot come back tomorrow and take Earth's data [for] today. You must take today's data today, you cannot come back and take it tomorrow. You may be able to infer it, but it's not the same, it's not as good. That is a compulsion that Earth science has that is flirted with in certain kinds of high-energy astrophysics but generally is absent from most of science. It's not just the satellites. It's *in situ*, it's all the ground-based stuff, it's in the water—all of Earth science has that flavor. That kind of trade shows up in lots of places.

WRIGHT: Tell us about how things began to change when you got a new NASA Administrator, and then how you eventually transitioned over to a new job.

BUTLER: It happened in stages, but I will have to say this, planning the Earth Observing System up through—I referred to it earlier—the day I got through the steering committee with the EOS AO [Administrative Operation] selection, life was pretty exciting. I could wake up in the morning and go to work saying I'm off to be the wizard. I've made references to beginning to lose control after that, and I certainly did. There was a time when at least one of my colleagues, Jim [James C.] Dodge, said to me, "EOS is in your head."

It wasn't [that] there weren't 100 scientists working on it and project office people and all this effort, but in many ways it was very fluid because I embodied the ideas. Not in my body, but they were in my thought, in my consciousness, more, and in a more integrated way, than [in] anybody else's. That also clearly, to hark back to your earlier question, is a critical thing to be an advance planner for a particular mission or an integrated set of missions. EOS is really more an integrated set of missions. It's critical to have somebody who has it all in their thought. They don't have to know everything. They don't have to know all the depth, but they have to know enough of the depth. It's a lot of fun to be that person, and it's really painful to stop being that person. It doesn't happen all at once, but it does gradually happen. I would have to say I wasn't conscious that unhappiness was flowing from that cause, but in retrospect an awful lot of it did.

In any case we had the EOS new start. We had to go through the [Edward A.] Frieman committee exercise. We had the [Senator Barbara A.] Mikulski number of $11 billion. Shelby and Wes [Wesley T. Huntress] had come up with the structure where I was running this ill-conceived science, mission operations and data analysis basically protodivision. It wasn't really

a branch, [it] had branches within it. It wasn't really yet officially a division because we were still an uberdivision under Shelby, under Len [Lennard A.] Fisk as an office at NASA, but a lot of things were coming along.

Ceasing to be the EOS Program Scientist was the beginning of loss of control. Then several things began to happen, and there did come a moment when we went to having a new Administrator, Dan Goldin. He was very much brought in as I've said before through the [National] Space Council. The former head of the Johnson Space Center, who was the person I referred to as being on the outs, who was at Space Council, was very much the person who Dan Goldin owed for coming into his job. That would be important to understand, at least from the perspective I have.

The Bretherton Committee at this point is done, EOS planning is done, we're into moving out. We're beginning to launch things like TOPEX/Poseidon [Ocean Topography Experiment], getting toward Upper Atmosphere Research Satellite [launch]. We've grown up. I described [previously] how we basically aspired to follow the model of the big guys, we thought human spaceflight were the big guys. We never asked ourselves the right questions about what we really need to be doing. We were embarking down that path. Space Station [Freedom] was under way. We had the big Reston [Virginia] group really doing its systems engineering, holding it together. Given its embrace of multiple Centers in the agency, not a bad model. It attracted a lot of very good people.

Dan Goldin comes in and becomes Administrator. Initially things don't change very much. It's still the George H. W. Bush administration. We still have a pretty good relationship between Earth science through Senator [Albert A.] Gore, who people are taking seriously. We also have for instance the MEDEA [Measurements of Earth Data for Environmental Analysis]

project, which was something instigated by Gore as a senator, which was then embraced by the Central Intelligence Agency [CIA]. I can say on a declassified basis [MEDEA] involved looking at national technical means data with environmental scientists to see what of that data would prove useful to doing what EOS and Earth System Science were all about, how those data could eventually—or all data through declassification—be brought to bear on this problem. It was a really good effort, and as I understand it, that is an effort that has been brought back to life today. It was wonderful, and I was really benefited by getting to participate. They didn't need me but I learned a lot, and I was just lucky to get included. Stopped here.

I will also comment that all of the scientists brought in were men. A woman at CIA was in charge of it, but it was the worst example of an old boys' club I've ever seen. Not in the sense that we worked badly or we went out drinking together, not that kind of stuff. But you looked around the room and there was only male scientists. Every single solitary one. It was very odd. But with a woman in charge from the CIA. Which was not bad, it's just ironic.

There's a [presidential] election going on. Bill [William J.] Clinton and Al Gore win. A number of things happen, but one of the first ones is Dan Goldin moves Peggy [Margaret G.] Finarelli out of her associate administratorship into being a very high-level assistant to the Acting Deputy Administrator, who was by the way a wonderful man. Peggy goes off and does that in her very capable way, but her capabilities were way beyond that job.

Len Fisk gets ousted. In my view Len Fisk, who had come to NASA from being vice president for research and management of the University of New Hampshire—no land grant college or land grant university or major university has ever had anybody with that portfolio—and Len could do it. Len was a wonderful manager, and a first-rate scientist, and a heck of a good person. He could see ahead too. He had every bit of visionary business. If you ever need

to look at why, you go look at the EOS Building at the University of New Hampshire, which stands for Earth, Oceans, and Space. But it is not accidental that it is named the same thing as the Earth Observing System. They went and got an earmark to build that building because they could see what was coming in a way that professors at Harvard [University, Cambridge, Massachusetts] were totally blind to.

So Len is out, and in my view Len should have been seriously considered for president of Harvard or president of Cornell [University, Ithaca, New York]. He was that caliber of leader. [He went to the] University of Michigan [Ann Arbor], he went and was the department head. It's an important department, it's a nice job. He went back to doing his science. He's continued to make strong contributions to the community, he's a happy man. But the people of the United States did not get from him what they could have gotten from him.

The plan is [to] divide what had been his integrated Office of Space Science and Applications—which had been together at this point for more than a decade, but has oscillated between separate parts and together several times in NASA history—to take it apart. Big new Earth Science field is going to get to be its own Office of Earth Science. Wes Huntress gets named Associate Administrator for Space Science. Shelby is named Acting Associate Administrator for Earth Science. Somebody gets the "indoor sports," which means life sciences and materials, a disparate group only joined together by their using the fact that you're in orbit to get you to very, very, very, very small amounts of gravity.

Now there's an important key thing that happens right here before any of the other mess. You split up the turf; each of these areas is going to need a certain number of management people. Now where there was one secretary to the associate administrator [AA] there will be two. There will be two secretaries to the deputy associate administrator. My memory is you got

to be a GS [government service level]-10 as the secretary to the AA, you got to be a GS-9 as the secretary to the deputy, [for] division directors you could be an 8, all the other secretaries were capped at 7s. It's an interesting pyramid. All of a sudden there's new opportunities. Same thing on the administrative side. There's going to be a few more people because it's less efficient when you split the organization up. It doesn't get more efficient, it gets less efficient in this particular case, and often [this] is the case.

Small organizations are more efficient when they're forced to run lean. My businessman father-in-law—and mother-in-law—used to say anybody who's worth X at a big corporation is worth three X at a small one. Because at a small one you can't afford to have anybody not clicking on all cylinders. In the government you don't quite work that way.

So there are going to be a bunch of opportunities here. This uncorked an enormous set of racial tensions that frankly I was blind to and I think so was just about everybody else. I learned more about good management—I don't know if I said this in another interview, but if I did it's worth repeating. What happened was there just began to be people on the edge of filing suits, because it looked like all the plum new particularly administrative positions were, quite honestly, going to white folks. Not good. So Shelby and Wes Huntress, they had most of this problem to deal with. I don't know how the other people got out of it but they didn't go deal with it, they just went on their merry way and weren't a part of this.

They basically formed a team to listen to the complaints. Five people were chosen for this team. Four of them were from space science and only one was from Earth science, but that didn't matter. There was a person who was a secretary, there was a person who did low-level administrative, there was a person who was a science manager, and there was somebody else in there, and there was me. I was the only senior executive. So there was somebody who was like

a GS-7 and somebody who was like a 10, somebody who was a 12 or a 14, and somebody who was a 15, and me. We were commissioned as a group to hear the complaints. Since as a senior executive I'm management in Earth science, I could not hear the complaints from the people who were in the Earth science office and did not, but I sat in on the space science ones.

One of us was Hispanic, one of us was black. I was told that the person Earth science was supposed to put on was the person who was our lead budget administrative—get the grants out, make sure Shelby had his budget stuff together position, like a GS-14, a really good person in that job. Happened to be African-American. Lovely woman. I don't know why she couldn't do it. I don't know if she wasn't acceptable to people—because there was a clear sense that these five people had to be acceptable. This is the one time in my life when I was all of a sudden the acceptable one. You might say why was I the acceptable one? The reason was because I've got interracially adopted children.

Shelby always avoided management training, and so I always avoided management training. Whether that was wise or not is anybody's guess, depends on the quality [of the training]. The management training I got was really painful, but I took it to heart and I still believe it was pretty good. I got it through serving on this group. We heard stories. Some of them were really hard to hear, and you felt people's pain. And I didn't get to hear the ones in Earth science. You also had a sense that some of these people didn't really perceive their own abilities very accurately, that shall we say they viewed themselves as more capable than they were, and they were already being treated perfectly fairly.

But there was one overarching injustice—and there probably were some others, but there was one I saw. I wish I could remember the woman's name. She had been Jeff [Jeffrey D.] Rosendhal—who was the chief scientist, I've referred to him helping me learn and get ready to

do the whole AO process—she was his right-hand person in dealing with the NASA Advisory Council that we had to deal with, [and] running the steering committee that had to approve AOs and AO selections. She was a GS-12, African-American, didn't seem all that really good to me. Seemed okay, but I was never impressed.

She was always winning awards at NASA for her outside good citizenship. She and her husband organized all these tutoring programs for poor kids in the District of Columbia. She was always getting like the best public citizen kind of award. Not once, I think several times. Who knew? It all finally made sense. She'd been held down, she'd been prevented from being promoted to GS-13 by some people at NASA, and I think I know who they probably were, but by this time they've retired. There were some people who were racists. There's a lot more of that still around than any of us care to believe or admit unfortunately. It raises its ugly head in so many ways.

What I learned was you get treated badly like that. Through no fault of your own, because of some characteristic of you in the eyes of others, you don't get the promotion and job accomplishment and job progress you deserve. You can't leave and go somewhere else, or you don't think you can, or you choose not to. You bottle up. You don't achieve, and you're not as good an employee. You don't work as hard to be as good an employee because it's not going to get you anywhere. You're demotivated. Then you begin to look like you don't deserve what you deserve. It all becomes a loop. The nice thing this process did was rip that loop apart. I think almost immediately this woman was a GS-14, which she deserved to be. I lost track because she was in space science and I was in Earth science. I assume she began to achieve more at work, not just outside. That was an amazing lesson about discrimination.

We also went to touchy-feely discrimination training, which wasn't bad. You learn things there too. As a parent of children who were identified by people who saw them as black, not as interracial—the President [Barack H. Obama] we think of as black, but he's interracial too like my kids. I did learn things out of that as well, but this really taught me. It also taught me another lesson. What we had here was actually more of a socioeconomic educational background set of discrimination than a racial one in my view. Yes, there was this critical example and there might have been some other examples of real racism. But that was the historical racism example that was just a poster child and to this day is haunting.

We had people palling around with people who were their underlings, their employees in some cases or people who were down a notch, maybe not directly reporting to them. It might turn out that maybe those people you were palling around with had gone to college. I would certainly confess that I had a much easier time dealing with a college-educated secretary than a non-college-educated secretary. I'd grown up in a middle-class family that had been in the middle class for multiple generations, with me being three. I didn't necessarily relate to everybody. One of the things I will say about my oldest kid, who is interracial, is one of the blessed things about him is he can relate to anybody. CEOs, fancy art collectors, the people of the highest taste, the guy on the street, the guy pointing a gun at you, whatever, he can deal with. I could not. I didn't understand it. I think a lot of my colleagues, particularly white colleagues more in management, didn't have that common touch that reached everybody.

So they were friends with people in the office, they didn't think anything about it. All of a sudden we're in this reorganization, there are job openings. The people they had befriended may have been the most qualified but it looked like they were getting the jobs because they were their friends. A bunch of people probably got promotions they didn't deserve but they got them,

and the problem got laid to rest. I'm pretty confident we didn't have any racism left that would have taken effect or been acted upon in the office. Things were good, things were better. Things were never that tense again. And it helped a lot of people's careers.

I then became a division director with four branches under me: I had an EOSDIS [EOS Data and Information System] branch, I had a mission operations and data systems branch, another data branch, [and] I had two science branches under me. I came to realize that I couldn't continue to be the buddy of some of these people. We'd hired Martha [E.] Maiden. One of my former colleagues, Bob [Robert J.] Curran, had left NASA Headquarters, and in the fullness of time had ended up working for a person who was a support contractor. He knew me well. He picked Martha Maiden out of his company and made her be the chief scientist in their bid, knowing that she would relate to me well. That's pretty phenomenal. We got Lisa Shaffer in this, Peter [W.] Backlund in this, oodles of people, Mary Blazek was one. Bob Curran got these people together. They won, they became our support contractors, Lisa got hired back into the federal government, Martha Maiden got hired in the federal government [and] is responsible for EOSDIS to this day, Peter Backlund got hired, ultimately went and now works for University Corporation for Atmospheric Research.

These people were like social friends. Martha and her husband came to my wife's and my big party we threw for our 40th birthdays and 20th wedding anniversary. I had to stop doing that. Martha did feel like kind of a sister to me. I realized I had to be much more constrained and not socialize so much with these people. There were ones I certainly related to and got along with, but what I couldn't do for all I couldn't do for one. Hard, hard, hard lesson, painful, involved some self-sacrifice. When people say it's lonely at the top, this is part of what they should mean, that you have to play fair if you're going to lead an organization—or it'll be a lot

better if you do. I would also say there were always tensions within Earth science because Bob Watson and I were Shelby's proteges, and I used a lot of my protegeship to argue for some people who Shelby couldn't stand. At the end of the day that created tensions. It created tensions with Stan Wilson, which I've already referred to.

I don't remember how long a period of time this was, but there came a moment when Dan Goldin was confident enough that he could remove Shelby. We were in a meeting somewhere with Shelby and he got called to the Administrator's Office and told he was out of a job. He's a career civil servant, you couldn't literally fire him, but Shelby at that point as a senior executive had accrued more than a year's worth of annual leave—he had all the years, he had the age, and he retired. It was really painful.

NASA really as an institution deserves to feel bad for treating somebody this way. Shelby came there as an okay researcher from the Naval Research Labs and built NASA leadership. NASA was the leader in Earth science in the United States—in the world. The US Global Change Research Program would not have existed without what we did. We also dominated the stratosphere. Shelby couldn't have done it alone—I like to think I helped, I know Bob Watson helped, particularly on the stratosphere stuff, also in the Earth System Science stuff rather bluntly, a lot of other people helped, virtually everybody helped. Whether Shelby liked them or not, they got pulled in. The vision was good. It worked.

And what does NASA do? They fire the man. Why? That's an interesting question, and I'm not sure I know completely the answer. I have some hunches. Shelby wasn't popular with everybody. There were some very powerful people outside in the professorships who didn't like Shelby for one reason or another. I certainly know some of them had strong ties to Al Gore. Also at some point here Bob Watson leaves and goes to the Office of Science and Technology

Policy [OSTP] and becomes something of a Gore protege. I think this all runs through the same set of interpersonal relationships because Bob was as tight with these people in the professorship as he was with Shelby, if not maybe even slightly tighter.

Ironically, these are people who I knew and had relationships with also. Whatever the forces were—Watson was at OSTP as Associate Director for Environment, and he told me he just politically couldn't lift a finger to save Shelby. That's never made any sense to me. The only way it makes any sense is these other outside connections, which may have been not unrelated to Bob moving to OSTP, and Al Gore—that whole nexus may have had something to do with it. In any case, it happens. It's deeply upsetting. It's pretty crushing to Shelby.

A couple of nice things do happen. One of them—Bill [William F.] Townsend is the deputy, and he's staying the deputy. It's a good thing it's Bill Townsend. As I've explained before, a man who is an engineer, project manager, program manager, also has this full embrace of science—who knew? A kid growing up out on eastern shore Virginia, gets out of high school, goes to work at NASA. Ends up as a person who they spot as a young pretty-early married kid, and get him to go to Virginia Tech [Polytechnic Institute and State University, Blacksburg] and get a degree, and then he comes [back to Wallops Flight Facility, Virginia] and he's just wonderful. Who knew?

Shelby had gone to Vanderbilt [University, Nashville, Tennessee] and had a PhD. But who knew? He wasn't like God's gift to Naval Research Labs. But boy, he was strong. NASA has that potential with people. I certainly didn't know I was going to do marketing or be an advance planner. When I got my PhD I never thought I would work for the National Aeronautics and Space Administration, and here I am most of my career, certainly the best parts, the most accomplished parts of my career were certainly there.

Bill Townsend does have a party for a number of us as managers with our spouses and for Shelby and Jackie [Tilford] out at his house in Annapolis [Maryland], which is sad, but it's a nice thing. Peter Backlund ultimately, once Charlie [Charles F.] Kennel is brought in, organizes this big intellectual, almost like the professor going emeritus kind of party, in honor of Shelby. As I said before, Charlie Kennel makes it clear and says in that meeting nobody's ever done this before, no one has ever built a science program of this scope and this quality in the federal government in the history of the Republic. It's true, and it's still true. I don't know the war on cancer well enough, the Human Genome Project. But it didn't ever work quite the way it was built up by Shelby. US Global Change Research Program is still there, and it's in the process of getting well again and maybe doing more of its real job again. It's outlived his service in the federal government. It's quite a statement.

Now we go on and we're under more pressure to downsize, and a lot of the things I've already discussed. Reviewing EOS happens. There is fortunately a magic moment when they put all the science back together. That was earlier where all the science got put back together under Bob, and I only had the EOSDIS and the mission operations and [data analysis].

There comes a moment at which Dan Goldin decides—I don't know this firsthand, but what makes sense to me and the way I explain it to myself is the person who had been at the Space Council who had been instrumental in his becoming Administrator has now become the center director of the Johnson Space Center, and wants control of the Space Station. This requires disestablishing Reston [Space Station systems engineering group], and also Goldin decides to use it as a paradigm for all of NASA Headquarters, all the different codes. So we are told in Earth science that Goddard [Space Flight Center, Greenbelt, Maryland] is going to take over here in Earth science. It's not that there's not going to be a NASA Headquarters, but also

we've had to downsize support contractors, which I've already described having too many of. I think I see a way we can run Earth science from NASA Headquarters effectively with 50 people, and I still stand by that, [it] was good [as an approach]. I'm not sure they ever quite got to that point.

Earth science, not being a fair-haired child for Administrator Goldin, figures the only way it can survive is to do what he says. The front office basically just decides to do what Dan says. I still remember Mike [Michael R.] Luther, who's head at that point of spaceflight—and I'm head of the satellite operations and the data system stuff—going out for a meeting with a person at Goddard and being treated really not very well. It's clear that Headquarters above us have said to Goddard you're going to form an office and in effect take over most of the management responsibilities from these guys; they're going to be nominally program managers, but program integration is going to be done by this man at Goddard. Nice man, his claim to fame is he had actually chaired the source evaluation board for the EOS Data and Information System contract. He'd done a good job of that.

I thought he was pretty good. I certainly didn't think he was as good as me. I know he wasn't as good as Mike Luther as a manager. But you got to give him the job, and they tried to work things this way. Space science under Wes Huntress, not being so much under the gun and also being able because of heliophysics (solar terrestrial stuff)—they were little satellite people. They're good for technological innovation. They're very good if you're measuring the solar wind and the magnetosphere and the ionosphere because you're flying in the medium you're measuring, so you interfere with it as little as possible. Earth science we're doing mostly remote sensing, solar physics you're doing remote sensing, astronomy is certainly remote sensing. But you want to perturb a medium as little possible to measure it. When you're looking at the light

coming from it you're not perturbing it really much at all. If you send laser and radar signals in you're perturbing it but very slightly usually. [If] you're flying through it, the only way to perturb it slightly is to be as small as you can as a satellite so you go to the little satellites. Mr. Goldin liked those.

I think Wes was pretty successful in just holding this whole revolution at bay. They never said oh Goddard you're in charge of our stuff too. But Earth science, we felt we had to, we did it. Certainly undermined the value of the job I had, of the job Mike Luther had. Then we got to downsizing NASA Headquarters civil service wise. In the fullness of time 40 SES [Senior Executive Service] jobs were moved out to field centers. There were going to be 39, I made it 40.

What happened first of all though is in a very painful moment EOSDIS began to be a subject of some controversy. The Goddard group wasn't really doing all that good a job. The contractor was wrong, there were all these outrageous expectations and there was a lot of upset. I was no longer the program scientist for EOS. They decided to have, in trying to reach out to the Europeans, an EOS investigators meeting in Paris. I didn't think it was justifiable for me to go, so I didn't go. Ghassem [R.] Asrar is now the program scientist. Ghassem goes. Stan Wilson has left the agency. Berrien Moore is there, Mark Abbott is there, lots of people are there. From what I heard afterward, with Berrien in the lead, they were all upset about EOSDIS and its cost. They write a letter to me and Charlie Kennel complaining about it. Charlie Kennel views that, I believe, as a threat to his getting his next job because he's not at NASA forever. He's there for a couple years, and on to another job. He's already a member of the National Academy of Sciences. He's accomplished what he wants in plasma physics. He's looking to

move up the line as a science leader. His mentor is Frieman, who's now head of the Scripps Institution of Oceanography, and is still mentoring Charlie even though Charlie is in his 50s.

Anyway, Charlie does not react well to this. There's pressure to define the costs. People don't model the costs of data systems very effectively, and they don't give me good answers. But being somewhat naive and idealistic, I figure if you're in charge—[I was] trying to feel like I'm in charge—you got to own the problem. So I ended up taking responsibility for doing this. Went off, had the project do all kinds of things. Project did an okayish job not a great job, but I took the fall. Goddard deserved to take the fall not me but I ended up taking the fall. So as this downsizing pressure comes along, they basically say okay Dixon, your division. Admittedly, my division is the one to get rid of. If you're downsizing, I fully agree, because we're partly stuff that belongs with research and we're mostly stuff that belongs with the flight missions, so I don't fight that.

They're going to combine us into one organization. They advertise and let us compete to be the division director of that division. Mike applies. Luther applies. I'm not even going to apply, but my employees all are feeling vulnerable and I got 20 of them. My secretary in particular is saying to me Dixon you got to apply. So three weeks left or something, I apply. I give it my best shot, and I invest some emotion and some self into trying to win. They pick Mike, and they should pick Mike. Mike is the right choice; he really is the right choice. I may be this leader advance planner type but this is not my job, and not where I would have been the better choice. He was clearly the better choice. I'm a little upset, but I'm not terribly crushed. On the other hand I don't have really that much to do.

My employees are by and large cast to the bloody wind. They have to go off and find other things to do. Some of them catch on. Martha for instance does manage to take over

EOSDIS, some of them go to Goddard. It's a mess. It's not good for any of their careers, with maybe one exception. I had one GS-13, she goes to Goddard and moves up the line, does a great job in data systems type work. Vanessa [L.] Griffin is her name. A lot of them were already GS-15s. Some of them were GS-14s and weren't going to ever make 15. But still it wasn't good for their careers and I always felt bad that all these people from Reston—I got ten people from Reston. Half my division were Reston alums [alumni], people who'd been counseled to come work for me because I was thought well of. I really felt sad about them.

I'm there without portfolio. Senior executive without portfolio, hanging around. This plan to move SESs out is only beginning to be developed at this point. So Kennel has got me, I no longer have a division, and people are trying to call it the overall data system view. I'm chairing the Interagency Working Group on Data Management for Global Change at the working level. Charlie Kennel says to me go pull this together. And we come up with all these ideas of a federation, a data system of data systems. Like an internet is a network of networks. We get scientists involved, and we're pulling—because the Earth science community is dependent upon the data systems at NOAA, not just EOSDIS. It needs all this data together. The more it functions in an integrated common way the better.

That theme by the way comes up in a different way. There's an interagency group led out of the Department of the Interior, usually out of US Geological Survey, called the [Federal Geographic Information [Committee]. It's dealing with geospatial information, information that can be located to a place on Earth. It could be in three dimensions or two dimensions depending on whether it's surface or in the atmosphere, but generally geospatial data. Could be below the surface, like the oil wells.

Geographic information systems technology has gone from its nascent days around 1970 at Harvard in the School of Design to ESRI [Environmental Systems Research Institute], the company that I think even today has 80 percent market share in geographic information systems in the world. Same guy, Jack Dangermond, goes home to California to his family landscaping business, and his family landscaping business becomes ESRI. Of course he's enormously wealthy, great guy, he's a great public citizen, as far as I know no children. He and his wife are philanthropic; he's very committed to helping do the right thing. This technology is coming along, it's not very user-friendly—it used to be you'd take a semester course to learn to be somebody who could use geographic information [systems], a college-level semester minimum to get so you could really even use the software. But the software was so powerful, it was worth it, and they kept making it better and more user-friendly and more powerful. It's critical, and it's behind all these things like Google Maps and all that stuff today. It's just oh of course. It's like oh yeah I have a word processor—it's that kind of statement to a person who deals with geospatial data. Oh, GIS, of course. It's gotten to be that way now, but wasn't that way quite then.

As a mark of the fact that we were now in the information age, this interagency committee where I am named as the NASA rep [representative] is chaired by Bruce [E.] Babbitt, the Secretary of the Interior. I'm the most junior person at the table. There are other people who are Senate-confirmed presidential appointments. I think there's an assistant secretary of agriculture representing ag. Most of the people are career guys and gals, most of them guys. He's very well staffed, Secretary Babbitt is. He's been a governor. Generally good governors know (I think) or get a feel for being more executive than the typical politician does, and he has that feel. Although predisposed to resist and be very turfy, I say, "Hey, Secretary of the

Interior,"—he's chairman—"we're going along," which was the wise decision, and stood us in good stead there.

But I remember this incredible day. They're talking about data standards for roads. There's working groups for roads, and working groups for water features—what we're trying to do is get standards so if you've got geographic information at the US Geological Survey and geographic information at the US Department of Transportation the roads will line up. Would be nice. Is a road the side or the median? Made sense to me for it to be the median, but people had chosen for various reasons different things. Then you've got all the states and localities might have chosen yet other things. "Well, we've got a paper street, so it's the median of the paper street, which is the right-of-way"—which often is your front yard, not the median of the actual asphalt or concrete. You get the idea.

Guys from the Department of Transportation say well, Mr. Secretary, we've really got some problems with this. They're hemming and hawing and saying basically we don't want to cooperate—not in so many words. Secretary Babbitt just looks across the table at them and says so today at lunch with Secretary [of Transportation Federico F.] Peña, you want me to tell him that his department has decided not to cooperate on this. These guys could see their careers going up in flames, it was like they were running out of the room backpedaling backwards. It's like no, no, no, no, we'll cooperate, oh yes sir yes sir yes sir, sorry we even raised this. It showed the power.

That was for me the most potent symbol I ever saw that we were now in the information age. A cabinet secretary was chairing an interagency working group on data standards for information systems. The fact that he was in the chair made it a far more effective group. Even people like me wouldn't have been anywhere near so cooperative.

NOAA and NASA had to cooperate internationally—partly because of weather, meteorology, oceanographic data, partly because we were part of an international organization, and in doing Earth System Science you certainly had to be. You needed the data from the whole world, and you needed all the people cooperating. You need the *in situ* data from other countries where you can't necessarily get access or afford to be there. We hit upon something where we couldn't commit to the national standards because we had to commit to the international standards. We brought that to him, and he understood, and we didn't get beat up for it. It was understood that we were committed to the standards to the maximum extent, except where those national standards were being overruled by international cooperation concerns. He understood the problem we were dealing with, which wasn't just US infrastructure.

So I'm without portfolio, we come up with the idea of a federation. I was going nuts. My heart wasn't completely in this, but somehow I managed to do something that people, I think, thought was a good job. We've already got these Distributed Active Archive Centers [DAACs]. We talk about ways that a data system can participate. We called ourselves a confederation of data systems, because that got you away from the idea of primacy. Lot of states' rights in that idea; individual data systems would have their own privileges. Bruce Babbitt was off working getting data standards for the geospatial data, so we didn't have to necessarily be impositional. We worked on interfaces for data exchange, things of that nature. It was a wonderful experience in some sense. We wrote it all up, and Charlie Kennel was really impressed with it.

Then we're sitting around and I've done this, and I don't want to keep doing it. I don't have a division to run, I don't really have a science portfolio, and I don't know what's going on. I'm like this floating person. So I'm out there trying to apply to go be a university person. I

quickly discover that the university science community does not value service that you've done in the executive branch at all. They believe that they should have the right to come in and do things like be associate administrators or be directorate heads at NSF. They don't believe that the people who've done that service inside for science have a right to come do jobs on their campuses. I was more qualified to be a vice president for research than I was to be a dean, and more qualified to be a dean than I was a professor. But they insisted that you've got to be a professor to be the dean. I understand that, but it rules out people like me because I left the research world so young in my career.

I also didn't want to leave Washington. My wife and I love it here. It's our kind of place, and the kids are still growing up. Academic jobs look like they're just out of my reach. Nobody likes my resume. I apply to be Assistant Administrator of NOAA for Oceanic and Atmospheric Research, a job for which I believe I am fully qualified. They don't rate me as highly qualified, they barely rate me as qualified, they don't even consider me. I thought I was probably still qualified to take over the National Mapping Division of USGS. That doesn't come my way. Not unlike what's happening to Shelby by the way. Shelby is on the outside, he goes from having about nine different potential jobs to getting none of them. So I'm not getting other government jobs in Washington. I'm casting about for what to do.

I finish Charlie's assignment, and Charlie is leaving. He's going to go back and be the chief academic officer at UCLA [University of California, Los Angles]. So he's gotten past—the EOSDIS disaster has not gotten blamed on him. He's got his big job coming, and he's very pleased and proud of it. He's been a professor at UCLA, now he's going to be like the top academic official there, just under the chancellor.

A man named Jim [James G.] Lawless had been a manager of life science kind of research at [NASA] Ames [Research Center, Moffett Field, California]. Jim had done a stint as Shelby's deputy, much as Wes had. Jim [and I] decide to go to lunch together. He has now just spent just shy of a year being the chief scientist at the GLOBE [Global Learning and Observations to Benefit the Environment] Program. At this point I'm getting a little discouraged. I don't know what I'm going to do next except just sit there as a dolt at Headquarters being the person they can't fire. By the way, Charlie has left, and they don't have anybody to replace him.

Jim says, "Well, I'm leaving GLOBE." He's the second chief scientist at GLOBE. The first one came, Barry [Barrett N.] Rock, did a great job, left. The key is if you leave before 12 months, even a day before 12 months, your *per diem* is not taxable. If you stay that anniversary day, your entire year retroactively becomes taxable. Your entire per diem becomes taxable income, because you're not really on travel; it's not really travel expense being reimbursed. So there's a big incentive to get out of there before the tax man gets you.

They've been looking around, and think they've got some candidates for being the chief scientist at GLOBE. I liked the idea of GLOBE, but I liked the idea of GLOBE because I was then, and I am still today, on the board of the Virginia Environmental Endowment. I'm actually its longest-serving director. I'm head of its board, which is something I've always had permission to do. I was appointed to that board by a federal judge.

Virginia Environmental Endowment is a small grant-making organization but a 501(c)(4), not (c)(3). It was formed by initially Allied Chemical [Corporation] taking $8 million of money and putting it in the endowment and agreeing to have nothing to do further with the endowment as part of a federal judge reducing their pollution sentence for Kepone pollution of

the James River from $11 million to $3 million. The federal judge appoints the US attorney to be the first president of the board and appoints some other people. There's seven members of the board.

After a while the board begins to turn over. Early in its turnover, I get appointed—there was an earlier turnover. Actually when I went on the board Tom [Thomas K.] Wolfe, the author, was on the board. Judge [Robert R.] Merhige appointed me. I actually replaced my mother-in-law, because my parents-in-law were two of the seven original directors. They left the board, I went on. A woman named Jinks [Virginia] Holton, former first lady of Virginia, and the mother-in-law of the immediately past governor of the Commonwealth—she and I joined the board together.

Through that I had become aware of work through the Izaak Walton League in Save Our Streams where they have volunteers—not scientifically trained volunteers, including schoolchildren—out there taking measurements of streams, macroinvertebrate measurements in particular. They are in the Commonwealth of Virginia at that time, and probably still today, the primary source of information about the waterways of the Commonwealth of Virginia and the state of the waters environment.

If EPA [Environmental Protection Agency] needs data, most of the data is not collected by the state, it's collected by the Izaak Walton League Save Our Streams program. It shows me amateurs can collect good-quality data—if it's good enough for regulation it's good enough for research—and do it as volunteers with training. So I believe in the GLOBE precept. Briefly stated, GLOBE was—and is, or at least should be still—a program involving kindergarten through 12th grade students all over the world collecting research-quality environmental

measurements while improving their achievement in science and mathematics educationally and raising the community's awareness of the environment.

I would now argue that it's not K-12, it's K-16. GLOBE's critical thing is because data are of research quality, they are therefore acceptable for student research. If you want to teach students how to think like a scientist and you never have them act like a scientist, you cannot learn to be a scientist. It's like saying we want kids to know how to write and never asking them to write. It's stupid. We ask them to be able to effectively deconstruct and analyze text, but we don't do that in the sciences. We think a science research paper is go to the Internet and look up facts about ozone depletion and write what in essence is a history term paper. That's not science research and it doesn't teach anyone to be a scientist.

The right way to do it is inquiry. To do inquiry you have to be able to look at data—preferably collect some of it or you can also use other people's. You can also deal with modeling eventually. But it's nice if you actually get your hands on the data. Some of it is yours, you understand how it's collected. You ask that data questions: hypotheses, testable questions, whatever you want to call it. You use whatever mathematical skills you have, even if it's just very primitively as a kindergartener. Certainly arithmetic is enough for a lot of things. You do that in the environment, it actually is research, valuable. But the key is that it's useful for students in order to do inquiry. That is the cornerstone of reforming science and engineering education in the world, but hopefully in the United States first.

National Academy has said that very firmly in its 1996 study laying out its recommendations for National Science [Education] Standards K-12. I think it's been said longer than that. [Mevil] Dewey of the Dewey Decimal System was pointing this out a century ago. The science community for certainly decades has embraced this as the way to go. GLOBE—

because of the quality of the data, your data and data like it collected by other schoolchildren anywhere in the world—you can ask questions and expect the data to make sense. Made-up data, it's just impossible to make made-up data susceptible to having real questions asked of it. Mother Nature, the laws of nature, hold the data together. You take it reasonably well, with scientifically valid protocols and calibration and all the things—which are also steps you need to learn to understand to think like a scientist: how good is this data, what's it good for, how well can it be used—these are incredible questions in Earth System Science that underpin EOS.

In an earlier talk I know I mentioned a key thing is when you're just doing operational weather forecasting you didn't have to do calibration, but if you're looking at decadal trends in climate you've got to calibrate the best you can. You've got to intercalibrate between one satellite instrument dying and the next one starting, so it's better if they overlap in orbit. You've got to have *in situ* measurements to calibrate with what you're seeing remotely and what's really happening in the system you're observing. It just goes on and on and on. GLOBE teaches kids that, teaches teachers to teach kids that.

I believe in the GLOBE mission. I obviously still do, although [now] I see the mission somewhat differently. I believe in it, and you heard me say some things that are potentially interpretable as criticism of Al Gore, but this was Al Gore's baby. In the paragraph in his book where he proposes the GLOBE Program, he criticizes Mission to Planet Earth. He says, "I'll show you a Mission to Planet Earth, let's get these schoolchildren out there collecting data." So I went from doing the program he was criticizing in that paragraph to being the chief scientist of the program he was proposing. That is irony. But I loved it, and I loved both of them, and they're connected.

We had at that time science principal investigators selected through the National Science Foundation backing every measurement. Every measurement protocol had a science group standing behind it who was committing to use the scientific data the students would provide. That element has gone away in the program, but interestingly enough—I was at GLOBE, and I'd become the chief scientist, and I'd been there maybe a year. We're having a science conference for GLOBE. I'm missing my old NASA days inside. I'm not bemoaning to anybody, but I'm in this brave new world and I've left my old world. Scientist after scientist stands up and talks about the use of their [GLOBE] data in concert with satellite data, and I saw the connections.

We gave every school a subset of a Landsat [satellite] scene, when that was a big deal and hard to get and they were expensive. We bought the scenes, had them carved up, and gave them to schools, and provided free software that was developed at Purdue [University, West Lafayette, Indiana] and maintained by Purdue for free. We would teach the trainers of countries and US cooperating partners how to use that software to analyze their Landsat scene and locate things, and we GPS-ed [Global Positioning System] everything. It was just incredible and wonderful. The ties to the satellites were amazing. Didn't tie to everything—blue-water oceanography, we weren't going to put the kids out in boats, but you get the idea.

Charlie Kennel leaves and I pop off to GLOBE. About a year into it they finally advertised to replace Charlie, and I'm thinking about applying. They're not really openly advertising, but I'm still a senior executive. My job has been transferred to Goddard. Peggy Finarelli by the way is at GLOBE. Lyn Wigbels is at GLOBE. By the time I get there Peggy is the deputy, Lyn is in charge of international affairs—so you've got these three NASA SES Headquarters refugees there. Peggy, Lyn and I are each assigned to different field centers, and I'm at Goddard. I expressed some interest in applying to be [associate administrator], and it

became very clear that that was not a good idea. Fortunately the person who really pointed that out to me was Lisa Shaffer, who'd been my deputy. It wasn't right, and ultimately Ghassem Asrar stepped into that job. Poor thankless situation for him at the end of the day, but he stood the test for a number of years and did that. That's how I went off to GLOBE.

This is, I think, also important for NASA oral history. It's painful, but once I went to GLOBE, I still had a lot of these people who'd worked for me or worked with me. NASA is in essence implementing a program which had my fingerprints all over it. I'd go back and visit at NASA Headquarters. Two hours at NASA Headquarters would depress me for a day and a half. Things at NASA Headquarters were so down that after a year the people had been down so long they didn't remember where up was. What had been enormously exciting, particularly in the 1980s, just dynamic as could be—the management jobs inside the Earth Science Division under Shelby were jobs of immense community leadership, intellectual leadership. Great excitement and great accomplishment. The people were accomplishing miracles. They were doing amazing stuff.

Those days were waning. They were building EOSDIS, they were building EOS. Things were getting there so the work was important. A lot of research was still going on, but in terms of the *esprit de corps*, the good feeling, and it's not back now. It's better, but it's never gotten that good again. Part of the problem is it's a lot easier to both attract leaders and inspire people to go beyond their ordinary capacity in these kind of management jobs, which were really leadership jobs of segments of the field, backed up by money to make grants with, by satellite missions to guide or formulate. It isn't that good now, and part of that is it becomes much harder to attract the best people. The good people you get, you don't turn them into great people. They

don't go beyond their ordinary capacity. I'm afraid we're still in that situation. It's better. It's way better actually, but it needs to get better still.

That will be a challenge, but it's a challenge that once NASA transitions its human spaceflight to something more similar I believe to the vision President Obama has laid out, which is a more balanced vision. It's a vision which will restore Earth science to where it should be and where Earth System Science needs it to be, which is not do everything, but it does need a $2.2-billion-a-year buying power by fiscal year 2014. The President's 2011 budget runout projects it will be back to that buying power, which it should have never left but did. It lost $1 billion worth of that buying power. That's all good stuff, but it has to be well done. You can't afford to invest that much at NASA if the NASA stuff doesn't become high morale, high achievement just like it was. I'm hopeful, but it's not there yet.

I want to go back and say one of the other wonderful things I learned through the Interagency Working Group on Data Management for Global Change dealt with libraries. The [US] Department of Agriculture, USDA, was represented by their Ag Library people. People in the library world and the information science world are together. One of the symbols of that is a woman came to work for me. She came as a loaner to me, like an IPA [Intergovernmental Personnel Act]. Kathleen [M.] Eisenbeis. Kathleen, just before she got there, won the prize from the American Library Association for the best library PhD thesis of the year. It was written about Landsat data. I began to understand that the sense of library and data system and archive—they're not separate worlds anymore, they come together, and that's an important point to recognize, and I think is recognized.

When we got all that money to go do EOSDIS, I was very turfy, and we all [at NASA] looked down on Tom [Thomas N.] Pyke, who had been head at NESDIS [National

Environmental Satellite Data and Information Service]. He was sort of a client of ours because we bought his satellites and data systems for him, particularly his satellite data systems for him—not his ground-based data systems, not his archives. He was responsible for all the satellites and all the data stuff at NOAA. He'd come out of the National Bureau of Standards, now NIST [National Institute of Standards and Technology], had been involved in setting standards that enabled the Internet to exist, etc. We didn't think much of Tom. We looked down on him.

We looked down on NOAA pretty much all the time. There were some people at NOAA we had awe of. The people at Geophysical Fluid Dynamics Laboratory [GFDL], particularly Jerry [D.] Mahlman. Some of the people who worked for him, Susan Solomon and the other people at the Aeronomy Lab in Boulder [Colorado]—we funded those people. The people at the GFDL wouldn't take our money. Jerry Mahlman was very suspicious. He thought NASA would put political constraints on him. We never did that. I explained that with Jim [James E.] Hansen. We weren't going to do that, but Jerry didn't want it. He didn't need it, he did okay without our money. Susan Solomon was a grantee. Most of the people in the Aeronomy Lab got extra money out of NASA. They were as good as anybody around. Maybe better in Susan Solomon's case, most knowledgeable person about the stratosphere and mesosphere on the planet.

Working with those people was great, but in general we looked down on NOAA institutionally. What a mistake. We cooperated with them but we looked down on them. Tom got a lot of that feeling. That was a really classic mistake, and it came in two forms. One is when we were creating Distributed Active Archive Centers for EOSDIS, we chose the US Geological Survey's archive at the EROS [Earth Resources Observation Systems] Data Center to be our land-surface data center. They were supposed to get the HIRIS [High Resolution Imaging

Spectrometer] data, the MODIS [Moderate-resolution Imaging Spectrometer] land products, they'd get the US copy of the Japanese ASTER [Advanced Spaceborne Thermal Emission and Reflection Radiometer] data, they'd get the Landsat data.

There's more land-surface data in Sioux Falls, South Dakota than anywhere else on Earth. That was a really smart move. It was forced on me by Shelby and Len, but it was the right thing to do. We didn't do that with the National Climatic Data Center—now run by Tom [Thomas R.] Karl—in Asheville [North Carolina]. We could have so helped, EOSDIS money, on upgrading NOAA archives and helping the problems they couldn't get adequate funding for through NOAA. But we didn't do it, and that was somewhat my doing. We did do it with one of the NOAA data centers, and that's the Snow and Ice Data Center in Boulder, Colorado. Still an EOS DAAC, an EOSDIS DAAC as they called it. Snow and Ice Data Center did wonders for us. There's some convergence at what was called the Alaska SAR [Synthetic Aperture Radar] Facility [Fairbanks] where we were going to keep SAR data. I don't know how that's all worked out really, because that's mostly foreign data.

The other mistake is—Tom is a real data system maven. I didn't know data systems. I was a really awful choice to put in charge of EOSDIS. If I had simply gone to Tom and gotten his and his people's technical help, EOSDIS would have been far better and a much better success. You say well how do you know that? Well, because Tom is the one who took me on as head of GLOBE to be the chief scientist. Then I had to become his deputy when Peggy Finarelli retired. Then, under the aegis of the Senate Appropriations Committee, they zeroed GLOBE funding at NOAA. NASA at my urging did step in and continue its $5-million-a-year commitment, which they're still continuing at exactly $5 million a year, and took over the GLOBE Program.

I had to take over from Tom, who by this point was the chief information officer of the US Department of Commerce and certainly needed to not be doing GLOBE anymore. But still cares about GLOBE to this day, as do I. There are a bunch of GLOBE alumni who are still GLOBE people in a network out there. That's how I learned how good Tom was on data systems and how connected—I came to just have a lot of admiration. He's got quirks, I've got quirks, everybody's got quirks, but I came to have a deep admiration and realized how we had misjudged him and how someone of arrogance—and this is maybe a broader lesson—we misjudged the people with whom we should cooperate, people whose advice we should go get, people maybe who we should go rely upon.

It's humbling, but it does go back to are you committed to the agency as like a person, agency as a corporation, or are you committed to the mission. Now for NASA in Apollo of course those became synonymous. For too much of NASA they're still synonymous as the fantasy of Apollo. That someday we're going to be told a destination, a schedule and all the money you ever want. The agency only got to do that once. Those days are not coming again. It requires significant humility to go recognize when and where you need to deal with others, how to cooperate and support them in their missions, not just them support you in yours, and where to step beyond your narrow agency mission to the leadership mission that the nation and the world needs.

I hope as we move forward in human spaceflight beyond International Space Station that the international partners are brought to the table before we stake out everything. Going back to when I was a spokesman for Earth System Science, which I think I spoke about somewhere back in there, leadership was the key thing to that whole Sally [K.] Ride study [NASA Leadership and America's Future in Space: A Report to the Administrator], because NASA was about leadership.

You can almost hear the management consultants. Lunar base, manned sample return from Mars, unmanned sample return from Mars—NASA leadership, NASA monolithic singular leadership. Well, you don't have any choice in Mission to Planet Earth but to do it cooperatively with the rest of the world. You needed their data. There was no way to do this on just the US taxpayer. There was no way to get access to all the data that you were going to need for the ultimate mission.

We pitched leadership as this is leadership where people will follow. Not simply say oh that's leadership. They would say we're joining. I know I said this before, but it's worth repeating. When I walked in to give the ultimate briefing, like ten minutes of vugraphs, in the old NASA Headquarters Building, to Administrator [James C.] Fletcher—and Neil [A.] Armstrong was at the table, I never got to see him and they didn't introduce me to anybody. The lights were such that they were enough in my eyes I couldn't make out the people around that little U-shaped table, that little bitty Administrator's conference room. I got to come in. But as I'm walking in the door Administrator Fletcher is saying to Neil Armstrong, "Now this is a case of leadership where other people will follow." We had them, and we did. In the fullness of time, we haven't done a lunar base, we haven't done a manned Mars sample return although I know somebody's done an asteroid. We have not gone to the surface of Mars with human beings, and we're not going any time soon because we don't know if human beings can survive the trip. Mission to Planet Earth, at least the low Earth orbit part of it is there.

We had in mind a whole geostationary complement that's never happened. I don't know if it will. But geostationary observations are still there on the operational basis and the suite of low Earth orbit stuff is there. I think hopefully the replacements will be there before the stuff that's there dies. It will go on.

Since this is really Earth System Science at 20, I think GLOBE may be actually a nice symbol. It became far more than Mr. Gore had in mind, wonderful as his vision was, because it was real students taking real data. But it also was sharing that data. It's cooperative. You go to meetings with GLOBE students and teachers. I went to two GLOBE Student/Teacher Conferences. At one of them I was almost being treated like some ridiculous rock star by these teenage, giggly Japanese girls. It was just hysterical. They were terrific, and they had done this wonderful data collection, which is how they'd gotten the privilege to be the ones representing Japan with their teacher. They'd done great work, and they liked me because I'd talked to them on the phone or sent them emails helping them do the analysis.

At the first one of these we were in the forest outside Helsinki, and we had students from Africa who'd never seen a forest. We had a hailstorm, and there were kids who'd never seen a hailstorm. These were teenagers, and you would see kids walking arm in arm—boys and girls walking arm in arm a little more than chaperones maybe liked—but you'd see them building ties. There were kids there from China. There were kids there from Egypt. There were kids there from Israel. There were kids there from the United States. There were kids there from Japan. There were kids there from Argentina who got there because the woman who ran GLOBE in Argentina was playing golf and ran into the president of the country and said it would be bad if our children didn't get to go, and he arranged for them to have the money to take a school group from Argentina with their teacher chaperone types to this meeting. Holy cow.

Second one I got to go to was in Croatia. The Croatians joined GLOBE when the cannons were still hot in 1996 [after the Balkans war]. People in GLOBE said how can you do this. They said how can we not. They wanted a tie for their children back into the world. They

were, at least at the time I left GLOBE, for several years before, the number one GLOBE country in the world. A higher percentage of their schools were in GLOBE than in the United States.

We got GLOBE leadership in Benin. We got GLOBE leadership in Finland, in Germany. It's so bizarre, all kinds of crazy places. Country coordinator from Bahrain. Wonderful. A country coordinator of GLOBE in Lebanon at the training in Cyprus—she was Druze. We had Qataris, three men and a woman. They were great. They were hysterical, had a great time with each other. She really wasn't supposed to shake hands with the men when she was being congratulated for having gone through the training. She did once and then she didn't the second time, and we all understood. I watched Croats and Serbs, teachers—because they can speak Serbo-Croatian to each other, same language, different written letters—I watched them talk across the table in the training. What wonders.

In the end for NASA, and more generally for multiple agencies and multiple governments, when you are more concerned about getting the job done, when you are not so turfy about supply—leadership is not an economic commodity. Getting to be in the administrative leader position may be something only one person gets to do, but I've cited many examples where people were leaders who weren't in that job or weren't in that job yet or were better leaders before they got that job. It is something that can be done. Cooperation is something that can be done. Investing in the mission that is worth it can be done. It can surmount everything from international tensions to just simple bureaucratic rivalries. That's what you need to do. The wonderful thing about Earth System Science is it requires it.

WRIGHT: I'd like to ask you about how you've been able to continue your vision and your mission as part of the staff at the House of Representatives.

BUTLER: First of all, you need to get the next transition. I've been at GLOBE for seven years, it's clearly time to move on. I've coedited the Teachers' Guide through three different editions. Every protocol in there has my fingerprints all over it.

NASA says, reacting to some administration pressure, that they're going to privatize GLOBE. So I run, not very well admittedly, a process to select somebody to be the partner in a cooperative agreement notice to do GLOBE. We choose the University Corporation for Atmospheric Research, which I would have to say has proven to be a mistake, and I think they know I feel that way because they have not done a first-rate job. They have not done a second-rate job in my view. They've got leadership problems there and a whole slew of other things.

So what's NASA going to do with me now? Once before I went to GLOBE and now at GLOBE my string is run out. They're going to park me in a closet somewhere at Goddard. As a senior executive I'm going to be responsible for overseeing this cooperative agreement notice, which I could do with 5 percent of my time. To be fair, if you're Ghassem Asrar—at this point he's still the associate administrator—he's beginning to have people say on advisory committee meetings, I'm told, well we had a real sense of mission and vision when Dixon was here. You don't need Dixon sitting there in the wings when you're the associate administrator, that's just not right. I'm not a real threat because I'm not coming back to be associate administrator, that's not happening—but you don't need that symbol sitting there. So nobody's going to know what to do with me. I'm not ready to quit.

I always dreamed, from my congressional science fellowship, of going back and doing appropriations for Mr. Obey, [Representative] David [R.] Obey of 7th District of Wisconsin. I spent my congressional science fellowship in his personal staff office when he was in his sixth

term. He has just announced his retirement from the Congress. He's been there now over 40 years. As a matter of fact, President Obama came to the celebration for his 40th anniversary of joining the Congress, and it was just wonderful. Prez [the president] didn't stay long but he came, gave him a hug, said unbelievably appropriate and wonderful words about him, and left.

I've come back from the second of these Student/Teacher Conferences I've gone to over my years at GLOBE. GLOBE has been privatized, September 1st everybody's got to be gone. My people, some of them are going to work, moving to Boulder. A lot of them are looking for jobs, a lot of them have moved on with their lives—it's a real mess personnel-wise. We're tidying up things, we're packing up, we're trying to transition all the stuff to UCAR—all the records, all the everything, which I hope to heaven they preserve.

Then I get back from Croatia and there's a phone message that I've gotten a call from a man named Scott Lilly. Scott was the legislative director of Mr. Obey's office when I was a science fellow. Really the best way to say it is he was Dave Obey's alter ego for years. Democrats are in the minority, it's 2003. Mr. Obey is the ranking Democrat on the House Appropriations Committee. Therefore he is in charge of minority staff, which is maybe 20 percent the size of the majority staff. But it's appropriate, and a lot more appropriate than when he first went into minority because the staff had grown from maybe ten to 23. It's been treated nicely, it's built up a real capability.

There's a message from Scott Lilly on my phone. I thought he's called, I really want to go. So I pick up the phone and I call Scott. Scott says, "I got this crazy idea. We need somebody to be the minority clerk for the Energy and Water Subcommittee." I said, "I'm your guy." That phone conversation ends, and a day goes by. I said, "Is it what I want to do? Yes."

After two days I call Scott and I say, "Scott, what do we do?" and he said, "Come up and see me." So I go up and see him. This is like early July, almost exactly seven years ago.

I say, "Scott, what do we have to do to make this real?"

He said, "Shake my hand." I shook his hand. He said, "Fine."

I said, "When do you want me?"

He said, "Now."

I said, "I got all these people. They're going through all this aggravation, trauma. I think I need to stay with them," so I put him off for five weeks. They did indicate I needed to come up and sit through the Energy and Water full committee markup as an observer to see what I was getting into. The position that I was going to occupy had been vacant since the 1st of June. They didn't call me the first day it was vacant, but they had this idea, [and] Scott told me the job was mine. He did tell me he was going to retire. In fact he didn't retire for another six months, but I was his last hire on the Appropriations Committee staff.

It's ironic and maybe important. Tuck [it] away in the archives of NASA, although it's not so much NASA history. While the position I was going into, minority clerk for Energy and Water, was vacant, one of the other members of the staff under Scott was fulfilling it. A young, terrific guy named Rob [Robert] Nabors [Jr.], who was really the utility infielder. When Scott retires, even though he is the youngest person with a clerk-like job on the staff, Rob takes his place and becomes the minority staff director. When [Democrats] take the majority he becomes the majority staff director. When President Obama becomes President, he becomes the Deputy Director of the Office of Management and Budget, which after a while he leaves to become special assistant to the White House Chief of Staff Rahm [I.] Emanuel. Rahm is phenomenal. [Nabors] could cover a subcommittee like that while covering a couple others and do a great job.

It was just amazing. I learned a fair amount from him, but I didn't have long enough contact for enough.

I went to do Energy and Water. Energy and Water is a subcommittee of Appropriations, was in 2003 and I would say continued through till the end of Republican control of the House, and maybe even into the early days of Democratic control of the House, the most bipartisan place left in the House of Representatives. Appropriations was traditionally pretty bipartisan. That was beginning to fall apart, but Energy and Water—thank goodness for all those Corps of Engineers water projects and even some Bureau of Reclamation water projects—kept it together.

There was pretty much a bipartisan consensus about what to do at the Department of Energy. It was and remains a subcommittee that believes in all of the above. If you're going to deal with the energy crisis, deal with all the different energy technologies. That actually isn't its biggest job; the Department of Energy [DOE] is primarily a nuclear weapons and cleanup after nuclear weapons agency. The Obama administration started that it's gone back to having a much larger portfolio in energy, but we began that work some time ago.

So how have I kept my [credentials] alive? First of all, I think the idea behind hiring me was you had a PhD physicist dealing with the Department of Energy so no one at DOE—nobody in the weapons program, no arrogant person from a weapons lab—could ever stare across at the committee staff and say oh you wouldn't understand, to [try and] hide things from us. I was in the club, I had the union card. They couldn't say it to me—even if it was true they couldn't say it to me. By and large, it didn't turn out to be true most of the time. I didn't have to know detailed physics of nuclear explosions. I did have to remember physics I'd long forgotten, but I had always been fascinated by nuclear weapons. I had always been fascinated by nuclear energy. All of a sudden I have to do them. I got to see the first constructed plutonium trigger as

they're called, or plutonium pit as they're called inside the agency, as close to me as I am to you that was made. Over a decade [ago] in the United States, environmental problems shut down our ability to make nuclear pits [when the FBI raided the Rocky Flat DOE facility in Colorado].

It was wonderful. But my real value was the fact that I'd been a program manager. Most of the people who come to Appropriations come from budget offices or congressional affairs [offices] or now a few people are even coming from other committees and member offices. I'd run programs, and my knowledge as a person who had actually run programs made the biggest difference. When the Department of Energy said oh no we can't have a competition that competes people inside the labs with people in the outside university community, I could look across the table and say there's one federal acquisition regulation for the government. It applies at NASA as much as at DOE, and I have run those selections, I have made them work that way. You can do it, I've done it. They went back and asked the lawyers and the lawyers finally said that of course you can do it. I never quite got them to do it as intimately as I wanted, but in essence they took that on and started doing it, at least in their science solicitations. Desperately needed. If you don't do it, the labs will ultimately decay in quality. Just as NASA centers did before we started doing it—particularly the Langley [Research] Center got improved in the way I've referred to earlier.

I have a great time, I have a great rapport with the Republican chairman. But what am I really doing? To the extent that there's any tie back to all this Earth System Science stuff, it's climate change. But it's not the understanding of it; it's the how are we going to deal with it in an energy policy. The energy policy is a problem for us anyway because it's wrecking the balance of payments, it threatens international security, oil prices are going through the roof, certain less-than-ideally-friendly nations that hold a gun to our head for a critical supply that's

needed for the economic viability of the United States. Energy policy has the nice by-product of it makes the country more secure. It makes the country's economy better—it helps the trade deficit, therefore the economy writ large. It also happens to be what's critically needed in most cases to deal with climate change: mitigating greenhouse gas warming. I get to work on that.

Mr. Obey, while we're in the minority, remembers back to [James E. "Jimmy"] Carter administration levels of spending. I get ordered to pull together an analysis of where we are versus where we were. I initially don't do a very good job. Rob is a little patient with me, [and] I actually pull together a wonderful piece of work as an Appropriations staffer, looking back at the whole appropriations level of government investment in energy research across all the technologies going back to the Carter administration. I have the entire budget history year-by-year of the Department of Energy. I have online the ability to get the inflation adjustment corrections, which I then apply. I make graph after graph, I write up stuff, I talk about CAFE [Corporate Average Fuel Economy] standards for mileage of cars—it turns out in a nutshell by the time I'm writing this report, nuclear, all renewables together, and even fossil energy research investments by the United States government have fallen to less than 25 percent of what they were in the fiscal year '80 budget of Jimmy Carter in real dollar buying power. The good news is conservation, which is the best leverage investment, has only fallen to 54 percent of what it was. On the Democratic side we start noodging to come back. Mr. Obey gives speeches using this information. Mr. [Representative Peter J.] Visclosky, who is the ranking Democrat on the [sub]committee, I have to give him exactly the same stuff.

Particularly when you're in the minority, the staff works for the chairman, not for the subcommittee chairman. For the ranking, not the subcommittee ranking. But when you're in the minority there's only one of you for a subcommittee, and you're a lot tighter with the full

committee. It's not like there's a front office doing full committee and you're off in separate subcommittee offices, the way you are in the majority. You feel very much like the chairman or the ranking member's personal person, not the subcommittee ranking. If you're subcommittee ranking, it's not quite the power position. It's the in-waiting position, so you're not as sensitive to [not having the minority clerk really work for you].

Mr. Visclosky used the same stuff. I feed it to a speechwriter and help lay out all the technical stuff and he gets a professional speechwriter, and gives a great speech laying all this stuff out and making these points using anecdotes from his own life, terrific speech. That was fun.

[Democrats] take the majority, January 2007. The fiscal year 2007 appropriations bills have not passed. The decision is made to get out of the year and we'll do a yearlong continuing resolution, but we will have some extra money to use that we can provide anomalies. [An anomaly to a continuing resolution is any change to the funding levels or conditions contained in the previously enacted appropriations law.] First thing we do, $300 million extra for Energy Efficiency and Renewable Energy area at the Department of Energy. That's taking them up I think from $1.1 billion to $1.4 billion so it's not an insignificant increase. That increase I think lays the stage for what was done through the stimulus program. I don't do [energy and water] anymore so I haven't gone back and done the analysis, but I think it helps.

Then we start working on the fiscal year '08 budget. Now I'm the majority clerk, meaning I'm the person in charge of the staff of the subcommittee doing Energy and Water. Mr. Visclosky is now the chairman. It is not a good year in many ways—I have enormous problems—but in a leadership sense it's worth covering here. I put my foot down and we made sure that we add $300 million more to renewable and conservation. Also at the end of the day

[the appropriation] sacrificed science increases that had been projected because at the very endgame in December we're having to do an omnibus appropriation—fold a bunch of bills together, pass it, it's late, we've been in a continuing resolution for ten weeks—and in that process have to cut some significant money out. The Democratic Congress had aspired to $20 billion more than President Bush will sign off on. So negotiations happen, we have to cut a bunch out of energy and water. We've put a major emphasis on nuclear nonproliferation. I'm not backing off on that, we hold on to every penny of that. We take some hits in nuclear weaponry, we take some hits in nuclear cleanup but not too badly.

For conference—with Pete [Pietro V.] Domenici being the ranking senator but still very influential on the Senate side—we take renewable and conservation R&D [research and development], treat it just about as well as we were going to anyway. I cut 300 million, 400 million bucks out of the science budget for the Department of Energy Office of Science. They still get an increase that's slightly larger than the amount of earmarks that had been added in that account. They don't get really very much. But we put the priority where it belonged, first on nuclear nonproliferation. We have to give money to the Corps of Engineers politically, they actually get extra money. It's crazy, but that's just politics. It's not bad for the country's infrastructure either. And we put the money on renewables and conservation. To the extent we have to, we put some money in nuclear energy, which I also don't feel bad about. Science takes big hits but we get there. Cleanup takes some hits but we get through it. I don't get through it, but eventually with only slightly extra cuts my staff manages. One of them has to take over, because I get deathly ill and am out of there.

When I come back full-time, I'm reassigned to a different subcommittee, not as the clerk. And this is where it really makes a difference again. This is when all of a sudden I'm at the

Earth System Science at 20 conference. I'm assigned to the Commerce, Justice, Science Subcommittee. Since I'm still really not clicking on every single cylinder, they start me out with the National Science Foundation, which is in the first interview, and the Office of Science and Technology Policy. I don't do NASA.

But I'm given a hunting license to deal with climate change issues. I'm sitting next to the person who has the Department of Commerce, including NOAA. My clerk has got NASA. I know the guys over on Interior and Environment Subcommittee who deal with the USGS and the Department of Interior, who's the other really important agency that's not in the Commerce, Justice, Science portfolio. So I make noises about climate change. I learn about STEM [Science**,** Technology**,** Engineering**,** and Mathematics] education because the chairman tells me to learn about STEM education, which GLOBE has prepared me to do. I know what inquiry is, I understand.

I was shying away from organizing a hearing. When I was doing Energy and Water I kept my hands off of NASA. I figured my colleagues—that would be interference with their turf. Climate change, I'm given an excuse to interfere with people's turf, so I did. But I'm also an asset. I know satellites. Nobody else knows from satellites other than the people up on the defense [sub]committee dealing with the defense satellites. So I'm useful. As the year goes by and I get stronger, they give me NASA science, aeronautics and education.

Then end of the year comes, starting in the new process for the fiscal year '11 budget, but also leftover pieces of '10. I have all of NASA as a responsibility. So what am I able to do? I'm able to advocate for a return to the right observing system. I don't know if it made any difference, but I was so upset, I wrote a memo. I sent it to the Office of Science and Technology Policy; I sent it to OMB [Office of Management and Budget]. I don't think OMB ever actually

got it because of email, but OSTP did it. President's budget did everything I dreamed it should do to really—almost, with one minor exception, everything needed to upgrade the observing system parts. There's some other things still needed.

I have a much more balanced view of space- and ground-based now and how much is needed in ground-based. That's really the growth area. The satellite set will get back to being a fairly big complement—it'll need to evolve some. But ground-based is where new technology is going to enable measurements in the soil, below the surface of the ocean and right above, under tree canopies—that's automated, consistent, calibrated, networked. That's, I think, where the revolution will come. Take a decade or more, but we'll get there, and the revolution will begin very soon in that kind of measurement systems. It already has begun really in the ocean. I'm able to advocate for those things.

Now I'm more worried about trying to make sure we have the information to inform good policy decisions—so that people would know beyond a shadow that this climate change problem was real, and how real it was. We didn't want to exaggerate it. No scientist I have ever known wants the results to be more fearful—the Earth keeps serving up scarier and scarier climate change stuff. Scientists do not want [climate change or global warming] to melt the Greenland ice cap. They do not want it to flood all of southeast England, south Florida. They don't want 1 billion people on Earth to be environmental refugees. Nobody wants that. Our job as scientists, the people who still really are practicing scientists, is to give their best judgment about what it looks like is going to happen. Somebody tells them here's a mitigation strategy, they have an obligation to say how well it looks like it might or might not work. That's the scientist's role. They're human; they want it to be better, not worse. That's why they're giving

the warnings. That's why they do the IPCC, even though it takes away from their own science research.

Energy policy is really mitigating climate change, which in many ways is also meaning really mitigating environmental change. We've now seen a nonclimate environmental change in the Gulf [of Mexico] that's not so good [2010 BP oil spill], and energy policy is related to that as well. You don't have to drill where it's so dangerous and so deep if you've got alternatives, and the alternatives come to market. If you send the right price signals you'll make the right decisions about deep-water drilling, which I'm not prepared to say is yes or no. I just know you don't mismanage the technology.

Going on from there looking forward, it's now—much to my sadness and certainly not anticipated by me 30 years ago—the fat is in the fire. The climate change is happening. It is upon us. It is too late to not have significant climate change affect us, affect our way of life, affect our infrastructure. It doesn't have to be a disaster, but it does need to be anticipated and particularly anticipated in various ways we manage it. If the water fall in the Sierra Nevada [mountains] is going to be more intense but not snow, we're going to need reservoirs because we can't count on snowpack to store it for the growing season. We're going to need to physically store it for the growing season. Something that in low-tech ways is being done in the Himalayas today as the glaciers melt, is to build catchments that then can keep areas irrigated when it's needed in the growing season. But you got to know, you've got to anticipate. If you're going to go put your energy-intensive server farm somewhere, you would like to know there's going to be enough affordable electricity there. It just goes on and on and on. Things like that.

We're going to have to make adaptation decisions, and those adaptation decisions in my belief are going to get down to things at the local level. The primary environmental decisions in

the United States are not made at EPA, they're not made in the federal government, they are not made by state governments. They are made by city and county zoning boards. That is where we really make environmental policy that really matters in the United States the most. Clean Air Act is important, Clean Water Act is important. We're cleaning up the Chesapeake Bay in part because of zoning decisions or land use decisions about buffer zones in farming, about chicken ranches and all their poultry waste, about hog farms.

These are all land use changes, land use decisions. That's where the action is. We're going to have to make adaptive decisions about land use and other things that are very localized, that do not lend themselves very well to all that much satellite observation and are going to require granularity in the observing system that's going to require being at the surface. And we're going to need every schoolkid and amateur and automated system and robot that isn't flying we can get our hands on to know enough to get to where we can empower the adaptation decision.

I get to still care about and have an influence on the observing, the informing, the documenting—I get some minor influence on the mitigating. But everybody gets the mitigation game now. And lots of great, bright—brighter than me—good people are working at it. DOE is awash with renewable energy money now, more than they probably know how to intelligently spend. The pendulum has way swung. I think we're probably going to get some decent nuclear energy progress, but it takes time. That's like the space business, you work on something for a long time before you see the benefits there. They work on decadal, longer timescales, like NASA flight missions do.

Now I think the real thing is building the science and engineering educational structure in the United States. I'm not going to build it, but I'm helping the Congress go after making the

funding decisions and green-light the right things to finally do the right things in science education. They're going to be essential to the future economic competitiveness of the United States, and to building a body politic that can deal with issues that come in decadal timeframe. We're not the frog who sits there as the water starts to boil. That's not a human being. We don't have to be like that, but we're acting like that to some extent. How do we get beyond that? By, in my view, being better educated in how to think like a scientist, not just how to think like a social scientist and a humanitarian or humanist.

It's not just the humanities and social science. We have to have within our body politic most of us able to deal with quantitative information, drawing qualitative conclusions as necessary, and asking questions of those things—not being blind to that. The sharper and better we are at that, the more we will achieve economic prosperity, and the more we will deserve the worldwide leadership that that economic prosperity and that disproportionate use of world GDP justifies. The only thing it justifies is if you use it well, and you got to use it well to benefit everybody.

NASA deserves a $2.2-billion-a-year Earth science budget only if it is doing that within the community observing and documenting Earth System Science. Informing policy decisions in the process, and informing investment decisions—public, private, individual. That's a big theme as I see it, and that's how it all works. Some of that hasn't changed, career sweep, but it sure has gotten a lot clearer. It's gotten a lot more substantive. It's like things have been colored in. But some of that, particularly some of the moral framework, has never been gone.

WRIGHT: Sounds like you have a whole lot more to do.

BUTLER: Well, I hope so. I hope to keep doing it; I hope to keep making a contribution. That's what I'm here to do. If I don't have a contribution to make, then hopefully I'll have the wisdom to go do something else or go watch other people do it. And it's really nice. The [Capitol] Hill jobs are less demanding than the job was at my most intense periods at NASA Headquarters. I don't wake up in the morning saying I'm off to be the wizard anymore, but there are times when we're staffing the movement, the conferencing of an appropriations bill—which is my favorite time, because that's when it becomes real—when we are pushing an agency to do better, when we are able to inspire, when we are able to empower—and by we I mean people like me staffing the elected representatives and pushing the executive branch to green-light the good stuff—to empower people to do the kinds of things that I got to do at NASA, that Shelby Tilford got to do at NASA, that Bob Watson got to do at NASA and OSTP and the World Bank, and person after person has gotten to do—it's quite something.

The fact that it isn't quite that wonderful every single day is okay. It's just a package, and it's not a bad package. It's a package I'm very happy to do. The odd thing is I'm willing to say I'm happier having my job than almost any of my colleagues are.

WRIGHT: Maybe because you have so much. Like you said, it's that bringing it all together to make it better.

BUTLER: Yes. Scott Lilly, when I was interviewing to be a congressional science fellow in Mr. Obey's office, said, "What are you here to accomplish?"

I said, "I'm here to learn." At that time that's why I was there. I didn't understand the process, I didn't know how power worked, I still probably to some extent don't. But I was there

to learn, which is then a knowledge that empowers you. When people ask me that today of course I have good answers, and when people asked me that once the EOS vision was there, when people asked me at NASA—I knew what I was there to do. When I was at GLOBE I knew what I was there to do. On the Hill both in Energy and Water and now in Commerce, Justice, Science I know what I'm there to do. That's really a good thing.

WRIGHT: Well, I've kept you for a while, but it's been so much good stuff so thank you so much. I appreciate all the time that you've given to the project.

BUTLER: I'm glad to. It's fun for me because I didn't keep notes, and I didn't keep a diary—which I should have so I could have gone off and written a book. I have met a man this year who actually did his PhD research in part on the things I left in the files at NASA. This, almost in a certain personal sense, gives me a sense of well you got to plant something in the NASA oral history. It'll be there, not just those papers. It'll be there in your voice. It's nice because it's an opportunity to share what one has learned, and hopefully that'll provide a little wisdom, a little caution, and a little perspective.

WRIGHT: And a whole lot of information. Thanks so much.

BUTLER: You're welcome.

[End of interview]