EARTH SYSTEM SCIENCE AT 20 ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

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The questions in this transcript were asked during an oral history session with Dr. Shelby G. Tilford who has amended the answers for clarification purposes. As a result, this transcript does not exactly match the audio recording. This oral history session is a continuation of an interview conducted on June 23, 2009, at the National Academy of Sciences, Washington, DC, during the Earth System Science at 20 Symposium.

WRIGHT: Take us back to the late 1980s when plans are moving along and you've got them going, and then tell us how they progressed with the systems and the committees to the next step.

TILFORD: In that time frame, we had put together the agencies with various elements of the US GCRP [Global Change Research Program]. We had, at that time, I think established the International CEOS [Committee on Earth Observing Satellites], which included essentially every country that was involved in space systems related to observations of Earth. Some country representatives didn't attend very much, but we had a very large attendance at almost every meeting, and we tried to meet two to three times a year rotating the location of the meetings.

We had a lot of cooperative efforts going. There was a very big interest in almost all the countries to be a participant in this effort. I would have to say that Japan, France, England, and Germany were the big players, but we also had a number of individuals from Brazil, plus representatives from several smaller countries, who were extremely interested in CEOS because they wanted to get involved in the space program. At the same time they wanted to make sure that the remote sensing information that NASA, ESA [European Space Agency], or Japan or any of the individual, single country, space organizations in Europe were available to them. If someone did an assessment of Brazil's forests, or whatever, they wanted to make sure they were part of it, so that number one, they would understand it, and I think too, that they didn't trust the other countries, including us, to do an unbiased job.

We overcame that by including them on everything that we did. We shared data and made sure that the PIs [Principal Investigator] that were involved in forest analyses, from either Landsat [Land Remote-Sensing Satellite] or one of the other satellites with lower resolution, got involved. We made sure that there was an exchange of information and exchange of people. They would let us come down and visit on many numerous instances and perform *in situ* ground truth observations/verifications, which was at first extremely important because we weren't really sure how our different satellites with different resolutions could resolve reality in terms of forest cover. As you can imagine, if you've got a small road and see it with Landsat, that's easy. But if you have a small road and look at it with a lower resolution instrument like AVHRR [Advanced Very High Resolution Radiometer] or some other instrument, you probably wouldn't detect or see it.

We cooperated very well. I think in a few years, with the cooperation of several universities, Goddard [Space Flight Center, Greenbelt, Maryland], and a lot of industry people, with members of the Brazilian Space Agency, and their University investigators, they were comfortable, we were comfortable. That turned out to be one of the earliest products of the international cooperation from that point of view.

We had similar agreements with France in terms of oceans. I think I mentioned before, they were jointly involved in the topography [TOPEX-Poseidon] mission to precisely measure ocean height, which had never been done before. I think we mentioned why, but there were a number of these cooperative efforts. The English had instruments on UARS [Upper Atmosphere Research Satellite], joint data sharing agreements, participation in several instrument teams for other satellites, and there were other joint efforts. Germany had several instruments they flew on Shuttle, including their X-band synthetic aperture radar. So the international program, from the Earth Science point of view, was working well.

There were similar agreements in astronomy, astrophysics, and space plasma physics. We had many joint programs with Japan, the flight of the NSCAT scatterometers on the Japanese ADEOS [Advanced Earth Observing Satellite] spacecraft, the joint Japan-US TRMM [Tropical Rainfall Measuring Mission] mission, which was the first measurements of global rainfall and rainfall over the ocean, experiments on the Shuttle, etc. There was a lot of data sharing.

In the late 1980s things were moving extremely well. We obtained a new start in 1990 for the Earth Observing System [EOS], which was a lot larger at that time than it is now. I also mentioned that we had planned for three sets of satellites, and there were still two when I left. That was cut back to a single set of satellites after I retired.

In that period of time it was also the beginning of the GCRP [Global Change Research Program] from an integrated point of view within the US government. We had all the agencies on board, thank goodness. This is at the same time that the international people started meeting in terms of not at agency level but at a national level. The international ozone assessments were taking place on a regular basis and in a few years CO_2 [carbon dioxide] and climate assessments began on regular basis. In 1988 the first international IPCC [Intergovernmental Panel on Climate Change] was established by the WMO [World Meteorological Organization] and the UNEP [United Nations Environment Programme]. In 1990 the IPCC published its first assessment; I think it was originally biannually. These reports addressed the state of the world climate, evaluated the risk of climate change caused by human activity, evaluated assessments and impacts of the production and role of CO_2.

When it became elevated to that point, of course, in both cases, it had to be the heads of the government or designated representatives of heads of the government, because we're talking about international policy-making now. With ozone, we went through similar evaluations, which resulted in international policy agreements. In the first decade of the international discussions, in both the international ozone and climate discussions, [Robert T.] Bob Watson from our program office, was the primary US scientific spokesman, and played a significant role in the scientific assessments [of climate] until he was replaced by the administration because the policy heads were not in agreement with the scientific conclusions.

I don't think there were any proposed policy agreements with respect to CO_2 until later. Then for all practical purposes, I think it became more political than scientific, especially when it got down to—as I'm sure you'll remember, and which I wasn't really a part of at this time—but when it came down to regulations on CO_2, as you know, the United States would not sign the UN's proposed agreement. This wasn't an ideal agreement, I would agree, but at least it could have been reworded slightly, from my point of view, to have been much more amenable. But it wasn't, and it still isn't, but it may be next year.

We evolved from a NASA program to a US program on trying to understand Earth as a system. Then it evolved along with the international program to become an integrated International Earth Observation Program, with a few exceptions, of course. I forgot to mention the Soviets, but they were an important player, and the fact that we talked to each other I thought was a good step for breaking down the Cold War. It really did put some trust in both sides of the system that things could be done together, and I thought that was a very worthwhile effort.

WRIGHT: Tell us about your work with the United Nations [UN].

TILFORD: We very early got to know the leaders of the UN environmental group, Dr. Peter Thatcher and his group stationed in Nairobi [Kenya]. They were interested in much broader things than NASA was at the time. Specifically, issues for them were food, habitat, forest, and species preservation or destruction, whichever way you want to look at it. Peter Thatcher happened to be a US citizen, and his deputy was a citizen of the UK [United Kingdom], and so we brought them onboard right quick. When we would have discussions at CEOS, we would invite them along. Since that time, there have been a number of US individuals who have temporarily served in that office for periods of one to three years. We still have an unofficial working relationship between some of our people and some of theirs.

We cooperated and offered them the same data rights for non-commercial uses, any country with a need at that time, if they wanted the data, just like we'd offer any scientists the data. So it took up a little bit of time, but I think overall it was probably worth it, but I'm not sure how much they utilized the data. They need to utilize the data a lot more in the UN, but it may be way down on their list. They still have some serious problems in the developing countries, and it is hard for us to even realize what those are until you visit some place like Kenya, and that's one of the more developed ones.

We tried, we did, and I don't think there was ever very much contention except when it was elevated to the political level, and that's a whole different set of arguments. We really didn't want to repeat the errors that we experienced when we went to that original UNEP meeting in 1982. We wanted to get them involved and at least be part of the process in name, if not in spirit. It was in spirit, but I don't think there were many contributions. Let's say it that way. They were going to be receivers, not providers. But we did, and I think still do, through the international office especially, have relations with UNEP. Of course now, you've got to remember, I've been gone for 15 years which is a long, long time in this business.

WRIGHT: It's interesting for us to listen to all of the steps that you put into place, and then you changed gears. You went to the commercial side, where you attempted to do some things with Orbital Sciences Corporation.

TILFORD: Well at the time I quote, "retired," Orbital was very interested in the commercialization of satellites. We had been through the Landsat issue, which never worked and probably never would. On the other hand, at the same time, we had put up an ocean color measuring instrument, and it had been extremely successful and well-received, especially by the fisheries and industries that wanted to use data for commercial purposes. We wanted to put another one up too, but there was a lot of reluctance to do that. So Orbital Sciences made a proposal that if we put up part of the money to buy data up front, that they would launch and provide commercial data with a certain amount of free data to the scientific community. That wasn't completed when I left NASA; in fact, it was Stan Wilson's organization and [William] Bill Townsend, who worked under me, who had negotiated these agreements.

At that time I really was not interested in going back to work for a while. However, [Robert] Bob Lovell had been a fellow Division Director for NASA's communications programs in the same office [Office of Applications] as the Earth Science Division before leaving to work with Orbital Sciences Corporation; he immediately began trying to get me to join Orbital

Sciences. I explained several times that I was not ready to go back to work, but after about three months and numerous discussions, we finally agreed that I would work part time only (~ 50% based upon Company activities), at Orbital with the Title of Chief Scientist. Orbital thought since I was involved in the Earth Science Program, maybe we could do some other similar things commercially.

I could not work on the ocean color satellite program because of potential conflict of interest, but then we started looking at other things that Orbital might do.

The one thing that weather people, both forecasters and researchers, want more than anything else which we've never been able to provide, is global tropospheric wind measurements, because temperature measurements are great, but the temperature profiles have to be inverted—mathematically converted to calculated winds. There are a number of inversion processes, but none of them are very precise in the terms of just how fast the wind is moving and what direction at what altitude.

What you're trying to do is take a series of temperature profiles using one method or another. One way to measure temperature profiles in the atmosphere is to use rawinsonde weather balloons. These balloons are released from a number of global locations and are tracked by radar techniques to obtain height, location, temperature, and sometimes humidity. Currently there are about 100 locations where the balloons are launched supported by the US, and perhaps a total of 800 at all locations around the globe. These observations are measured twice a day from most of these locations.

Another technique is used on aircraft to measure the same parameters. Global measurements are obtained from satellites. Usually some infrared CO_2 temperature profile measurements are utilized, because the way you do that, you have a series of individual rotational lines in the CO_2 molecules in the infrared, and you precisely measure these series of lines to determine altitude and temperature. Then you try to invert that temperature profile into a wind profile, and it is very difficult. In other words, with any of these techniques, the global wind profiles are not very accurate. If you have a wind LIDAR [Light Detection and Ranging Instrument], essentially what you do is let this instrument rotate around in different directions and altitudes, measure the laser backscatter, essentially measuring the Doppler backscatter in different directions. You automatically have an accurate wind direction and wind speed, as a function of altitude at high spatial resolution on a global basis and on a more frequent basis which is pretty nice to have.

We spent much of my five years trying to develop a commercial or semi-commercial satellite tropospheric wind measuring system. Because of the lack of the technology development after three plus years, we just said, "We can't do this yet." There was not a laser available of the correct wavelength that was powerful enough or stable enough or had a sufficiently long lifetime. We tried all kinds of concepts. We even went to a Gatlin gun [rotating] laser, where we were going to put several lasers around the optics, and use one until it burned out, and then another, then another. But the lasers just weren't available in 1996–1998 time frame, and they're still not available today.

That did lead to some interesting research by some of the people who were involved. Actually, as I mentioned earlier, one of the scientists that was involved was a principal investigator who had flown on the Upper Atmospheric Research Satellite. The major winds in the upper atmosphere are a whole lot easier to measure than in lower atmosphere; this is because of the concentration of molecules are a lot less. He used an etalon interferometer where you have an oxygen spectral line that is a real sharp line in the red part of the spectrum, and by measuring the Doppler shift of that line with respect to the satellite and subtracting out the satellite's motion, you can measure the wind speed and direction. He did that on UARS, and measured global stratospheric winds. It was really a neat experiment and the data were extremely useful for better understanding global stratospheric circulation. Never has been repeated, unfortunately.

Now he has developed a very much smaller instrument, but one that can utilize small and very low power lasers that can be mounted on various platforms that need instantaneous wind information, i.e., airplanes, helicopters, wind turbines, etc.

But we wanted to measure winds in the troposphere on a global scale, that's where the weather is that affects the surface. In the stratosphere there's ozone and temperature and various other species, but the winds up there are quite different. The tropopause is an interesting media. As you move up in the troposphere, the temperature starts decreasing until you reach the tropopause. At that point the temperature begins to increase again. This is where the stratosphere begins. All the photo-chemistry takes place in this region, because ultraviolet sunlight is not completely filtered out at this altitude. You excite a lot of different molecules and species that do not occur in the troposphere because the UV [ultraviolet] sunlight is filtered out as at the lower altitudes. The tropopause occurs when the temperature quits decreasing and starts increasing.

The temperature increases in the stratosphere up to a point where there are fewer and fewer oxygen molecules to be converted to ozone, then it starts to decrease again. You then get up to another layer called the mesosphere, and above the mesopause, it starts heating up again. But now, this heating is due to electrons bombarding the atoms and molecules, creating a partially ionized layer. The mesosphere is a transition region, and above that is the ionosphere where you have ionized atomic species rather than neutral atomic and molecular species. I thought you'd like to know the difference.

WRIGHT: It's very interesting.

TILFORD: I was involved in several other projects in which Orbital was successful in winning, building, and launching satellite experiments. One was a new satellite to measure the UV solar spectral and the solar constant, SORCE [Solar Radiation and Climate Experiment], developed for the University of Colorado, which has now produced solar variability for about eight years in the UV spectrum and for the total solar output.

At this time Orbital was very involved in the two different programs. One was taking over a land-looking instrument for commercial purposes, which unfortunately when they launched it, after I left, the rocket didn't work, so that was quite a blow for their organization. The other major project at that time was a series of—I think it was 28 low-orbiting communications satellites – the ORBCOMM satellite program, which would provide telephone and location communications over the entire globe. I don't know whether you remember all the things that went on with respect to global telephone communications, but after a few years this component was sold to an independent organization. I think it's still going on, because Orbital has received orders for additional satellites. Since I wasn't in the communication area, I really didn't have very much to do with that. I only worked part-time there the whole five years. At this time Orbital did not have the resources to continue many of their desired objectives in Earth Sciences, so we agreed that I could now go do what I tried to do five years earlier.

WRIGHT: Since you're here in Washington, DC, for this symposium to celebrate and to recognize the accomplishments of Earth Systems Science during the last 20 years, as you look back and look at the accomplishments, do you see a missed opportunity? Do you have some thoughts that you could go back and do things different or to make things better than they are now?

TILFORD: I've thought about that, and I think that I could have, but not with the people who were in charge of NASA at that time. We lost at several levels in the last two years that I was at NASA. To be honest, if we'd completed the program as laid out, it would have been a fantastic transition from research into operational observational and data systems. We could have had a much more robust and useful EOS data system. Data archiving, retrieval, and distribution are some of the biggest problems that any environmental agency has right now, which I think is demonstrated with NOAA's [National Oceanic and Atmospheric Administration] inability to put enough money into their [National] Climatic Data [Center] as it exists today in Asheville [North Carolina]. Hopefully that will improve shortly. They did get a significant increase, but with that, they also received an increase in responsibilities in terms of the new Climate Program, which is not well defined.

I think in terms of measurements, what has been demonstrated in the last few days is that the Earth Observing System has accomplished much and in a very robust manner. I'm pleased and amazed—a lot of good new measurements, improved models and understanding of what has been happening, and in many cases, why many physical changes are occurring.

WRIGHT: We were at the event last night [National Academy of Sciences] where a picture of all of the satellites was displayed.

TILFORD: Yes, and that's a sad picture when you go to the second slide, isn't it?

WRIGHT: Yes. Would you like to talk about that for a moment? As you're going back through the list, because you had your hands in so many, is there a favorite one?

TILFORD: Not really. Originally I was really enthused about UARS because it was an integrated satellite, and it was going to measure a lot of things and really contribute to the ozone issue to hopefully define it to the point that there would be no doubt that there was an ozone reduction. We got to that point, and then we verified it. That was a lot of satisfaction because really this is the second thing I'd ever done with satellites. The first one was the solar constant measurement on Solar Max [Solar Maximum Satellite] mission. Of the ten solar constants instruments, that have flown since SMM [Solar Maximum Mission], I may have been the selection official on most of them. [I wasn't the selection official on the first one, but it was my recommendation]. So just measuring a solar constant to a precision of one tenth of a percent, over this period of time, that's pretty neat too.

WRIGHT: That's pretty amazing, yes.

TILFORD: Over 20-something years. It was from '76. Yes, that is a long time.

WRIGHT: It was a good investment.

TILFORD: It was. Still is. Without that one nothing else matters. If the solar output starts changing in any direction, we need to know it. However, if it changes very much in either direction we can't do much of anything about it. It has had bumps in it before, as some of the data showed today. Dr. Judith Lean from NRL [US Naval Research Laboratory] gave an excellent summary on the measurements, and interpretational developments regarding the solar output measurements at this meeting. On the other hand we have only 30 years of measurements on something that been operating for at least 100 million years to about 4.5 billion years. [That's 30 years in 100,000,000 years or 4,500,000,000 years, not a lot of information on any absolute scale, but with the understanding that the most recent data is probably the most relevant.].

Most recent variations have been explained in terms of solar phenomena such as sunspots, faculae, plages, etc. Sunspots reduce the energy output of the sun. Faculae enhance the sun's energy output. In each case it's less than ~5 watts/m^2, compared to a total output of about 1361 or 1365 watts/m^2 (calibration differences, we think). If you average it out over a few months, the two phenomena just about balance each other out. We've never seen a major long term variation between the two which we cannot identify or rationalize, which makes it pretty good for us here on the surface.

But no, EOS has to be the one that counted.

WRIGHT: It's pretty amazing, the amount of data. Are you surprised that there is so much data now that they're having some challenges to use it all?

TILFORD: No. Well they do have some challenges, part of which might could have been much smaller because we didn’t have the resources in the EOSDIS [Data Information System] to do what we set out to do, and it was reduced and it was reduced and it was reduced.

We had several contractors that simply couldn’t meet the specifications they had signed up for. We changed contractors, or NASA changed contractors, two or three times. It doesn’t look exactly as we designed it in terms of specifics, but it’s come a long way in doing much of what we wanted it to in terms of being a distributed data system. The PIs have become much more involved in it than I expected them to, which is almost a necessity at the early stages until you start being able to reduce data on a routine basis that the community as a whole will accept.

I think today in the civilian world, it is probably, the most complicated and useful environmental data system that exists. If I look at some of the other programs, I wish we could expand it into what they do. I really would like to see that happen, between NOAA, USGS [United States Geological Survey], and NASA. It has made progress. I think it will eventually merge, but it’s going to take political pressure more than anything else. It just won’t work otherwise.

But NOAA data, USGS data, and NASA’s ocean data, and atmospheric data should all be accessible through the Internet in an integrated manner where you can not Google [search engine] it, but do something equivalent to Google to go find what you’re looking for, and pull it out and use it just like we use Google information today. But it’s a lot more complicated in terms of the number of bits. We’re talking about millions and millions of terabytes, petabytes. I don't have any idea when we’ll get there, or if we ever will.

WRIGHT: It sounds like everything you had your hand in was a bit complicated. Was there anything simple?

TILFORD: No. We tried to make a step forward in everything we did. I don't think on EOS we flew anything that did not require several technology developments in terms of resolution, in terms of sensitivity, in terms of stability, in terms of calibration. Every one of them that I can think of was a state-of-the-art development effort. We may have flown—no, I think we even changed technology on the UV and the solar constant and many of the other measurements. Yes, I think we changed that, the calibration capability. So no, I cannot think of anything simple—nothing was simple, very few things were even routine.

WRIGHT: At any point did you consider technology your best friend or your biggest enemy?

TILFORD: Both. Yes. It is. We made such strides in the last twenty years in technology. Well, look what we have done in our lifetimes. We had automobiles and airplanes, barely, and look where we are today. We didn't really believe we would ever see a man on the moon, or communicate the way we do today on the Internet, or that most dictionaries (books) would become obsolete. This has been a great time to be here.

WRIGHT: What would you like to see happen with Earth System Science in the next five years or 20 years? What do you think is an important issue?

TILFORD: Really, what I would like to see is something equivalent to EOS become operational, in an operational agency, not a research agency. But I think NASA is the only agency where that might happen, unfortunately, although this sounds like an oxymoron.

On the other hand, NASA has to keep making technology developments with the participation of all the university scientists who have ideas and who are capable.

NASA has a lot of good scientists, but we've got to go where people have ideas other than those ingrained at NASA. What I have seen is that—and since I've left, especially—there's been a tremendous interchange of scientists. Part of it I hope we initiated, because I kept rotating people from Centers into NASA Headquarters [Washington, DC] and keeping them for two years or so and letting someone else come in.

From all the Centers, I had deputies from Ames [Research Center, Moffett Field, California] and JPL [Jet Propulsion Laboratory, Pasadena, California], Marshall [Space Flight Center, Huntsville, Alabama], Langley [Research Center, Hampton, Virginia]. Everyone was participating in the Earth Science Program. I tried to get them involved and come and spend time. We also had a lot of university people who rotated through the program office.

What I've seen, since I've been here this week is that there are a lot of people who used to be at NASA who are now at universities, and there are several people at universities who have come to NASA. I think that is just fantastic from my point of view. The only thing missing is continuity with respect to how the agency and the government operate. That's a hard lesson to learn. I know. So from that point of view, I think things are progressing.

I'm mostly worried about the ability to have continuity in data. That's the largest issue! I don't know how it can be fixed. It takes more budget, it takes more people, and it takes a lot of people that I'm not sure exists in terms of building the instruments and developing the technology. So from that point of view, that's really my biggest concern.

But now, what I'd like to see is EOS into an operational capability and somewhere that it would be supported for as long as it's needed, and I don't know how long that is. As we develop new instrumentation with higher resolution and more sensitivity, then it should be transitioned into the operational phase. That was sort of the mode we used with the first polar orbiting satellites. It was called TIROS [Television Infrared Observation Satellite] here and it was called NPOESS [National Polar-orbiting Operational Environmental Satellite System] there. That's been a difficult job in the last decade.

NPOESS, that's the advanced instruments for climate sensing that were supposed to be put on NOAA's polar orbiting platform. I know that there was a huge overrun, and the budgets didn't quite fit, and as a result many of these new instruments were removed, or eliminated, and they were in limbo for some time. I think what has happened is that NASA has said, "Okay, we'll fly the first system of the Climate Observing System as a prototype," but that doesn't include very many measurements. That's where the hard part is, a lot of measurements/observations are just going to die, and there's no replacement. As you saw the measurement satellites blacked out during last evening's presentation, that's what's happening. Some of the very important instruments like the altimeter and scatterometer, they are just not going to be there.

WRIGHT: All but one of the satellites is on borrowed time? Is that what they were referring to?

TILFORD: Yes, within a five-year lifetime. I hope like all the other instruments, those last few that faded out, the current instruments continue to last longer. But on a five-year lifetime prediction, they will all disappear; they're all gone except one. That's scary.

WRIGHT: Yes. Are there any more that you helped conceive being developed?

TILFORD: There are a number of new things that were proposed with respect to the decadal survey, which the NRC completed three years ago, which I've had nothing to do with.

I might add that the decadal survey, from my point of view is a massive step backwards for NASA, and for the US. You might say it is what NASA was doing before 1980, technology demonstrations of new, or enhanced technologies. I'm really sorry that the National Academy Sciences [NAS] did not step up to recommending an Earth Sciences Program that would provide much more information as environmental issues require more understanding, as the problems of water availability decreases, as energy requirements grow, etc., as the population continues to expand on an exponential basis. We are behind the eight ball and I believe it will continue to deteriorate.

Regarding the instruments recommended by the NAS committee, many of those are just enhancements in concept to some of the things that are being flown on EOS or that have been flown on other missions. There are a few new things in there, so I think between the Europeans, the Japanese and the joint efforts there, that'll be helpful. I would not be a bit surprised in five years that we have fewer US observations than Japan and Europe do, and Russia perhaps, and most likely China also. China's very aggressive in this area, and they probably won't share their data.

WRIGHT: That was actually leading into my question that you shared with us yesterday. That was such a monumental decision to have the data shared with all partners, and then learning that the capabilities within the US are beginning to decrease. But it also seems that the care to learn more about climate change is increasing.

TILFORD: Yes!!!!.

WRIGHT: We don't know how much yet in the United States, but from what you're saying, it's increasing throughout the world. How is that going to change when these other countries start taking the lead in putting up these satellites?

TILFORD: It's going to make the United States look very bad, I think. In fact I expect it to have very large negative impacts upon our economy, and our lifestyle. We really need more information to better predict and evaluate droughts, floods, weather events, hurricanes, improved long-term impact analyses on crop production, energy production, water availability, etc., etc.

We probably will still have a polar platform for weather and a geostationary platform for weather. Those are NOAA-funded instruments. We'll have a few research instrument satellites. The rate things are going, and the cost overruns that have been experienced in recent years, there are fifteen satellites proposed in the decadal survey. Now a decadal survey means to me ten years. Well, my estimate is that based on the funds that are available and the complexity of the missions, we'll be lucky to fly four in the next ten years. Maybe five, but I think four.

WRIGHT: Will it be difficult to pick which four?

TILFORD: They have already supposedly picked which four, but they're not necessarily the same first four that I would pick if I were doing it. I would have lobbied very hard to do something different than what the decadal survey is, because my idea of Earth Science is making enough measurements at once so that you can understand what you're doing, rather than flying one instrument at a time every three to five years to demonstrate it will make a measurement, which is the approach that I think the decadal survey has proposed.

WRIGHT: I liked your statement yesterday to us in the end, when you said that it was important to go measure and then try to learn from what those measurements were.

TILFORD: Well that's true, because frequently we know what we want to measure, but we frequently find out what we want to measure is not quite what we wanted in order to understand or predict the phenomena that we're interested in, and what we get is maybe sometimes a lot better than what we set out to do, and sometimes its worse.

WRIGHT: Do you have an interest to become very involved with the next 10 years?

TILFORD: I'm probably not going to live for the next 10 years. You've got to remember, I am over 70 now, so I'm lucky I'm still moving. But no, I just don't think I would have the energy to do what I did 15 years ago. It took a lot of long days and a lot of trips, a lot of meetings, and a lot of being away from home.

WRIGHT: What do you think is the greatest accomplishment that you were able to achieve while you were in your field?

TILFORD: EOS and EOSDIS, and providing the opportunity for hundreds of young scientists to become seriously involved in trying to better understand how the Earth System behaves.

It's been fun.

WRIGHT: Even the hard days, I guess, were fun?

TILFORD: Oh, yes. Some of them weren't as much fun as others. But no, EOS has turned out to be not as good as I wanted it to be, but it's turned out a lot more information than I ever thought would come to pass in my lifetime. It worked. It's the nearest thing we've ever had to having an integrated observing system for a good portion of Earth. Not all of it.

WRIGHT: I know that you now, in your spare time, work with students at schools. Do you have an opportunity to share with them some of what they can't see up in the sky?

TILFORD: I occasionally give a seminar, not too frequently. Most of my work has been actually refurbishing computers for elementary school children, and I think that's fun, too. I volunteer one day a week with the Salem [South Carolina] Lions Club's "Computer for Kids" program in Oconee County, South Carolina. There are about a dozen of us, all except a couple are retired from various and quite different professions. In the past 5½ years we have provided about 1,900 refurbished computers to individual (primarily underprivileged) elementary children for their own use. The county school system makes the selection as to which children receive the computers,

All these older computers have been donated by individuals or numerous industries within about a 50 mile radius. We have been able to get approximately 75 – 80 percent of the donated units repaired or reprogrammed and ready to be put in back use by the young recipents. We're also delaying dumping all of these older units into the landfill, and we remove all recyclable components and send them for recycling. There's nothing like seeing a kindergartener or a first, second grader come in and get a computer, and look up at his older brother or sister and point a finger at them and say, "This is my computer, and you're not going to use it."

WRIGHT: You've created a power, haven't you?

TILFORD: Well you know what's going to happen when they get home, but right now the little one is in control because they've got the computer. So it's fascinating. I'm just amazed every year, first-graders come in, and we'll start telling them how you hook it up, and they'll turn around and look up and say, "I know how to hook it up." They know more than their mother and dad about what to do, how to do it, what it does, and I just can't believe that first-graders can pick up this ability and understanding this fast.

WRIGHT: They know so much.

TILFORD: We also have given ~ 400+ computers to the elementary schools to set up computer laboratories so that they can teach 20 - 25 children at a time the fundamentals of computers. There was one picture, these 20 little second-graders all there sitting in front of the computers with great big smiles on their faces. That's neat, too. Different.

They're now part of the system. There are a number of children who do have resources to get computers, and almost all parents who are not on welfare or having very, very low paying jobs—most every family of any means has a computer. But we have a large number of unemployed people in our county. We also have a large number of South American immigrants.

WRIGHT: They all want to learn, all those children.

TILFORD: All of them need to learn. All of them.

[End of interview]