NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
VOICES ORAL HISTORY ARCHIVES
IN PARTNERSHIP WITH NOAA HERITAGE AND THE NATIONAL WEATHER SERVICE

AN INTERVIEW WITH W. PAUL MENZEL
FOR THE
NOAA 50TH ORAL HISTORY PROJECT

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MADISON, WISCONSIN
OCTOBER 26, 2019

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Molly Graham: This begins an oral history interview with Paul Menzel for the NOAA 50th Oral History Project. The interview is taking place in Madison, Wisconsin, on October 26th, 2019. The interviewer is Molly Graham. We'll start at the beginning. Could you say when and where you were born?

Paul Menzel: Okay, I was born in 1945 in Heidenheim, Germany. At that point, I don't remember very much. My first memories are really when we came to the United States, and we lived in a suburb of Washington, D.C., a place called Langley Park. My father, at that time, worked for the Naval Ordinance Laboratory. He was a government scientist. Then we moved out a little further to Silver Spring, Maryland, and I grew up then in the school system and in the warm environment of Washington D.C., which was really a sleepy government town at the time. Most of the people worked for the government or the various universities. I had what I considered to be a pretty complete education in the high school system there. I went to Northwood High School, and I took chemistry, physics, math, and I really enjoyed history and literature, too. So it was a very good offering. When I graduated in 1963, I went to the University of Maryland as initially a math major, and then I switched over to physics. As an undergraduate at the University of Maryland, I enjoyed the courses, and they had me as a student laborer on one of their Van De Graaff projects, so I had some experience with experimental physics and nuclear physics. I enjoyed mathematical puzzles and unified field theory, the theory of all forces. There should be some unified explanation for gravity, for electricity, for nuclear forces. That fascinated me, but I got more realistic then, as I went to graduate school. I decided, well, I should probably work on something where I could get a job. So I switched over to solid-state physics. That was during the turbulent times in Madison. We had a lot of discourse, both polite and violent, about what was going on in Vietnam and in general with the government. So I guess everybody was radicalized in one direction or another, and the physics department was no exception because the Sterling Hall bombing came in 1970. I think some of the faculty felt like the liberal policies within the department and within the university had helped enable this type of radical behavior. At any rate, I survived all of that, and I went on to get my PhD in the band structure theory of alkali halides. This was exciting in a way because it required me to do some of the mathematical things I enjoyed. In those days, we had limited computer capacity, and you had to figure out a way to simplify the problem to get a solution. With crystals, there are symmetries so that if you rotate the crystal a certain direction, it would still be the same crystal. That rotation implied that you would have energy states that would be redundant, and so you were able to take a very large matrix and break it off into small matrices, and then you could solve those with a reasonable amount of computer time. So it was really a reduction of a big problem into lots of little problems. It took me a while, but I got my degree. I was teaching the whole time, also. Just a side comment, nowadays you wouldn't bother with the symmetry, your computers are so big you would just throw the big matrix in there and find out what all the eigenvalues were. The eigenvalues would be the energy states. You'd say, "Oh, there are five of them that are the same." Well, before, when I did this, I knew five of them would be the same, so I chunked out one-fifth of the matrix, and just said that's the only piece we need. It was good work, and my advisor, Professor Chun C. Lin, he was kind of a stern fellow, but very much on my side. A story that I remember, though – he's a Chinese professor – just before I had my PhD oral examination, I felt a little vulnerable. I've put in a lot of years on this, and what if I go in there and fail this exam? So I was reaching out to him before the examination and looking for some reassuring words. Then he said to me, "You are the cause of your own problems." I thought, "Huh." It took me several years to realize what he was saying was I have the power. I put myself into this; I have the power to come out successfully. So I did a year post-doc and was sniffing around for jobs. The biggest opportunity was right across the street when Verner Suomi suggested that – actually, a colleague of mine who had gone to work with Verner had suggested that there was enough work for another person, and I should come and talk to Suomi. This was in 1975. At that time, I didn't know where I wanted to go, whether I wanted to be in Madison or somewhere else, but I definitely wanted to continue university environment work. I thought I could be faculty or a researcher for quite a while and enjoy it. Anyway, so I went over to talk to Suomi, and he was very engaging. We talked about this and that. He wanted to know a little bit more about my physics background, and he seemed to value that. At some point in the interview, he said to me, "Do you know any meteorology?" I thought, "Uh oh, here it goes." I said, "No, I don't know any at all." He said, "You're perfect. I'll teach you all I want you to know." So that was just a very memorable interview because I thought he at least he would want some familiarity with his field. My first job, then, was working with Verner Suomi and Bill Smith, Larry Sromovsky, and Hank Revercomb on what was to be the first geostationary sounding instrument. The geostationary sounder would basically have the same viewing perspective, and you'd be able to do this frequently, like every hour, maybe every half-hour. The sounding was to sample the infrared spectrum in multiple spectral bands that would be sensitive to different layers of the atmosphere, going from the bottom to the top. You could, from that, infer something about temperature and moisture changes with altitude, in other words profiles or soundings. So that was kind of neat. It was a first-time breakthrough type instrument, and here I was; I was working on it. My job was to help with the infrared calibration. The calibration was a little more complicated because you like to reference it against the black body. A black body, you know the temperature, you know how it's emitting, and you can figure out for different spectral pieces of the infrared spectrum what a known source would be. The problem was that the black body was internal to the instrument. So when you looked at the black body, you weren't getting the same view that you would when you looked at the earth. Because when you looked at the earth, you also had the foreoptics. So we figured out a model on how to account for the foreoptics, and we were able to calibrate the instrument I think quite successfully. That small job then put me front and center in the whole VISSR [Visible Infrared Spin-Scan Radiometer] Atmospheric Sounder team. That was the name of the instrument, the VISSR Atmospheric Sounder [VAS], and that launched in late 1980. We then had the unique responsibility, the University of Wisconsin, to be the auxiliary ground system so that we would be checking what was happening at the NOAA ground system at Wallops Island, Virginia. We had a reception facility here. NOAA had one there. We could check whether the preprocessing and actually the reception from the satellite were correct. If we both got the same thing, that was fine. If Wallops had a problem and we didn't, then we knew it's not the satellite, it's at Wallops on the ground and vice versa. So you could figure out whether the satellite was healthy and whether we were reading the signals correctly. So with that responsibility, I morphed into being the scheduler. I could schedule this satellite for doing sounding or doing imaging, and very soon, because this was a demonstration, VAS also had to do operational functions. So I was able to work with NOAA, the people in Washington, to figure schedules where we would deliver the half-hourly full-disc imagery, but in the spare time, we would do soundings, or we would do other things. That was pretty heady stuff. We just had a brand new satellite in geostationary orbit. I was a new hire at the University of Wisconsin, and I was in the middle of scheduling this instrument so it would deliver interesting scientific data. The other person that I worked with a lot in that time was Bill Smith, the father of what's called the HIRS instrument, High-Resolution Infrared [Radiation] Sounder. It was in polar orbit, and he had created a lot of the software to take these radiances and turn them into temperature and moisture profiles. Now he was going to do it with this geostationary instrument, the VISSR Atmospheric Sounder. So I was really lucky to work with two of the pioneers in satellite remote sensing, Verner Suomi and Bill Smith, right away after my PhD in theoretical solid-state physics. One of the things that was attractive and remarkable was how well connected both Bill Smith and Verner Suomi were with the international community. They went to different countries and gave lectures, offered new information about how to do things with these satellites and basically how to take the information from the satellites to improve weather forecasts. And that required numerical weather prediction and data simulation, and also getting these radiances that were measured into some representation of the atmospheric state. Both Suomi and Smith had been practically [to] every continent in the world, offering help and advice. It soon became clear to me that I really wanted to participate in this international aspect. Some of it was training, and some of it was learning. You go and learn how people are using the data; you offer how you use it and what caveats there are. This led to my realizing when I participated in some of these international conferences that the NOAA satellites, back to NOAA-5 and the TIROS-N instruments, were some of the best ambassadors the United States ever had, because wherever you went, people were grateful for the fact that there was a satellite system up there that would help them with their weather forecasts where they only had a few balloon launches. Australia was a good example. They had maybe seven to nine locations where they launched balloons every twelve hours, and the rest of it, the oceans, and the continent were almost a data void. But when you put the satellites over there every twelve hours – or, with two of them, more like every six hours, they were able to infer something about the atmospheric state that would help them with forecasting the weather. They became some of the best users of satellite data early on, the Australians. In fact, Bill Smith spent a year down there working with them on the data assimilation problem. Those were exciting times because we now had polar orbiting and geostationary information, which meant frequent and also global information about the atmospheric state, and could this help to improve weather forecasts, and the Australians had shown it can. What we needed to do now in the northern hemisphere was to match that. We had a lot more balloons, a lot more ancillary data, so the satellite impact wasn't as impressive as it was in the southern hemisphere where you had a data void, or at least a data scarcity. So in the early years for me, I'm working at the University of Wisconsin for Verner Suomi and Bill Smith; I'm helping out with the geostationary sounding instrument, and I'm starting to participate in some of these international conferences. Then the flipping point came for me in 19 – I think it was 1981, we had a visitor to the building at the Space Science and Engineering Center, a Dr. Mervin Lynch from Australia, who invited Suomi to come down and teach at the Western Australia Institute of Technology for a semester. Suomi said, "You know, I can't go, but there's a young guy down the hall, why don't you talk to him?" That young guy was me. Professor Mervyn Lynch came into my office and offered this idea to "Come down for a semester and teach. It'll create more collaboration and cooperation between the two hemispheres, and Perth is a great place to be." So I went home to my wife, Nancy, and I said, "I've just been asked to come down to Perth, Australia." She says, "Oh, yeah, let's go. That looks like a wonderful place" National Geographic had an article on Perth. I said, "You know, I don't know. What if I go down there and make a fool of myself?" She said, "That's so far away. Who will know?" So I took my bravery pills, to use Suomi's phrase, and we went to Australia in 1983 to Perth, and I taught for a semester at the Western Australia Institute of Technology. It was a great experience. We liked Perth. I liked teaching. This was the first time I'd really done teaching in applications with meteorological satellites – a class on remote sensing. It was challenging to pull all the material together, but I learned more than the students did, probably. It was also wonderful to be in a culture that was similar yet very different. English was spoken, sometimes with a very broad "A" where you barely understood people, but the Australians were wonderful people to be with for a semester, and we, since 1983, have made something like a dozen trips back for various times, a semester or for a week. It became a place we wanted to spend more time. That also exposed me to the utility of Bill Smith's mantra, where you help people use the data. The satellite data we understand. We think we know how to make good use of it, but it's really important for people to apply local knowledge. For instance, in Perth, you had these very hot summer days, and you needed to know whether you were going to get a cooling in the afternoon or not. Local knowledge is that if the wind continued off of the desert, it would stay hot, and you'd have a very hot night. But if the wind came in from the ocean – Perth was right on the Indian Ocean – the Fremantle Doctor, as it was called, would cool you off at night. The Fremantle Doctor is named for the port city Freemantle to Perth. So I thought this is local knowledge that really ties in well with satellite data. You can see some of this from the satellite, and you can expand this beyond just Perth, but for the whole coastline. So this became something that I was fortunate enough to be able to do - to give lectures periodically in different places, share what we thought we knew about the satellites, and encourage people to use their local knowledge to really enhance it. I couldn't do as well as they could in Perth or in L'Aquila, Italy or wherever. So that was Australia in 1983. In July of 1983, I'm thinking, "Do I go back to SSEC. Do I stay here?" At that time, the VISSR Atmospheric Sounder was beginning to be more than a demonstration. People wanted this data routinely, so NOAA hired me to schedule and to put together a team to demonstrate the utility of the VISSR Atmospheric Sounder in operations. It was a demonstration within the operational community of the utility of the VAS instrument. We put together a small team. We hired two people, Roney Sorensen and Tony Siebers, to do the routine processing, and NESDIS put together an advanced satellite products team and placed it here with Bill Smith's government group. That was, then, a continuation of my first work with Suomi where we scheduled the instrument, we produced sounding and derived products from soundings, and put them out there routinely every hour for the [National] Weather Service and for other research folk to look at and see if the utility was as great as we were saying it was. So, I came back then, to Madison and I continued working for NOAA from 1983 until 2007. I was still stationed in Madison. I never, other than going to Perth, left this building during my whole government and university career. That was really a nice transition back to Madison, working for NOAA, working for this project that we thought was great. Now we had to convince other people that it was great. Let's take a break right now.

MG: Sure.

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MG: Okay, back on.

PM: So we're back in Madison, it's 1983, I have a team of people, and we're starting to produce what we think are useful products with the VISSR Atmospheric Sounder, which we called "VAS," or some folks said, "VAS" [Vahs]. We're starting to see a lot more people in Washington, especially within the National Weather Service. We were demonstrating how to derive from of these radiances, the atmospheric variation in temperature and moisture. During this time, there was a change in the strategy within the data assimilation community, largely because the southern hemisphere was getting very good impact on the numerical weather prediction, but the northern hemisphere wasn't quite caught up yet. I explained a little bit earlier that there was a data density of conventional data, balloons, and other observations in the northern hemisphere, which was competing with the satellite data. It was finally decided that we should be assimilating radiances and not the soundings themselves. This, then, made the focus of my group a little less on the numerical weather prediction and more on "nowcasting." What's going to happen in the next several hours? We can show you soundings, we can say the atmospheric stability is increasing or decreasing, but the utility of these soundings every hour in data assimilation and numerical weather prediction were getting to be a challenge. People were working more from, "Let's assimilate the radiances; let's not assimilate the soundings." So we worked a lot with the Weather Service. One of the useful products from the VISSR Atmospheric Sounder was the cloud heights. We could tell how high the very high clouds were. This became important because the Weather Service was going to the ASOS system, the Automated Surface Observing System. So these were balloons and other things that were launched in automated fashion, but they had one deficit in that they could not see above twelve thousand feet from the ground. Of course, the satellite is perfect for above twelve thousand feet, so this was one area where the VISSR Atmospheric Sounder really got traction with the Weather Service. Tell us how high the clouds are, where the ground based observer or the ASOS wasn't going to necessarily see it. This would complete their cloud cover maps with a combination of ground observations and satellite observations. So we had a customer there, but we were still trying to figure out how best to assimilate time changes in radiances or time changes in soundings where the geostationary perspective can really help. You can see it every hour. You can even see it every half hour, whereas every six hours or every twelve hours with a polar orbiting satellite, you can't see how things are changing. We like to say with the geostationary satellite, you can see the process itself, whereas, with the polar orbiting satellite, you'll see the effects of the process. You'll see that something has changed. There's been a tornadic event, and you'll see that the ground has been destroyed or disheveled, whereas with the satellite in geostationary orbit, you can watch the convective development, and you can actually see, "Oh, there is a funnel cloud." So we were a little disappointed that we didn't have more impact in the forecasting, but in the nowcasting we were continuing to demonstrate some utility in these time changes, and we had the ASOS customer, where they wanted the high clouds. In the area of high clouds, I ended up focusing a fair amount then on the upcoming NASA Earth Observing System [EOS]. NASA was going to put together a fifteen-year demonstration of the future technology that NOAA should be embracing when we go down the road. So now we're talking late '80s, and NASA is going to embark on the Earth Observing System in the '90s. They put out a feeler for who wants to be on the science teams and what do you want to do. I proposed to do the cloud [product] development from the MODIS [Moderate Resolution Imaging Spectroradiometer] instrument – the Moderate Resolution – I can't remember what MODIS is right now, I have to look it up.

MG: Moderate Resolution Imaging –

MP: Spectroradiometer. Thank you. At any rate, I was going to do a global mapping of clouds with this wonderful instrument that was basically like a one-kilometer version of the HIRS. The Bill Smith instrument was now turned into an imager with lots of spectral bands, and the cloud properties and the cloud cover globally would be a fun project to work on. My proposal was accepted, and I became part of the team. So I was working with the clouds from geostationary for ASOS, and I was working the clouds from polar orbiting for NASA to see if we could make global cloud maps. This required a fair amount of travel to MODIS science team meetings and also to Weather Service meetings. Within NESDIS [National Environmental Satellite, Data, and Information Service], we were trying to figure out what's the best combination of algorithm development and engagement of the Weather Service. At that time, we had leadership changes. We went from – I can't remember first names, I just remember last names – [John] McElroy to Tom Pike, and from Tom Pike onwards, then I think to Bob Winokur. This was also an interesting moment. Verner Suomi kept giving me these opportunities. He sent me to Perth, and at some point, he was talking to the head of NOAA at the time – and his name eludes me right now, but I'll come up with it, and the head of NOAA said, "I need a new director of NESDIS, the National Environmental Satellite and Data Information Service. Do you have any ideas?" He suggested me to the current head of NOAA, and I get this phone call from – Tony Calio was the name of the director at the time, and he says, "I want you to think about being the director of NESDIS." I said, "I already work for you. I work at Wisconsin, but I'm part of NESDIS." He says, "Never mind, just think about this." So I was offered the assistant administrator [position] in NESDIS. I thought about it, but I said, "I really don't want to move to Washington. I'd like to continue what I'm doing." So I turned it down, but that was a heady moment. This was maybe being promoted three or four levels up, so it was a compliment that Verner Suomi had bestowed upon me, and Tony Calio had taken it seriously. At any rate, I got visibility through that and other things, so eventually, I was not just Advanced Satellite Products Project team leader, I also became the chief scientist within the Office of Research and Applications, which then became STAR, Satellite Applications and Research, something like that. So my major responsibilities as the chief scientist was to continue coordinating international work, and I'll get back to that, but to also help NOAA evolve its remote sensing assets. Of course, what we wanted to do was to improve this geostationary sounding project, so I spent a lot of time as the chief scientist working with Jim Purdom, who was my boss then – he was the director of the Office of Research and Applications – and Greg Withee, who was then the [administrative head] of NESDIS, to see if we can go to high spectral resolution infrared observations from geostationary orbit. The broadband VISSR Atmospheric Sounder offered you maybe three of four pieces of information about the vertical variation of temperature and moisture. If we went to high spectral resolution in the infrared we thought we could do something like eight to ten layers of the atmosphere, so it truly would give you a better depiction of the variation in the vertical of both temperature and moisture, and it would better match what the model was looking for. The models now had forty layers in the vertical, and we could offer more the four with high-spectral resolution infrared. This would be an ambitious program, but the technology was catching up. And we thought that it would be the perfect way to evolve from the VAS instrument, which had become the operational GOES-8 through 15 sounder, and we were now trying to work our way into the future. The Earth Observing System had demonstrated the value of high spectral resolution [infrared] with the polar orbiting AIRS [Atmospheric Infrared Sounder] instrument, and that was beginning to have a nice impact on numerical weather prediction. So the idea now of matching this with hourly high-spectral-resolution-infrared seemed like the perfect match. The program was started, and the technology, as I said, was mature enough, but people were beginning to worry about the volume of the data. Rather than twelve spectral bands of the infrared, you would now have thousands. This caused a conundrum about how the ground processing would be established. There, also, technology was helping. There were parallel processing schemes with small computers. We thought this was pretty well-resolved, but in the end, it was decided it was too high risk a project for an operational agency like NOAA/NESDIS to undertake this. The hope was that NASA would demonstrate it with a geostationary demonstration. The GIFTS [Geosynchronous Imaging Fourier Transform Spectrometer] instrument was something that was established as a program within NASA and the Air Force, and I think the Navy was also involved. That looked like we were going to get the demonstration, but for various financial reasons that never came about. So I felt a little bit like my time as a chief scientist for NOAA was not as successful as I would have liked. Because I would have liked to have NESDIS take on this geostationary high spectral resolution infrared sounding, which now is being embraced internationally. The Europeans are launching it in 2023, the Chinese launched it two years ago, the Japanese are planning it, so our international partners are working their way towards this better capability in geostationary orbit, and we, who had the idea and the technology and the demonstration, are still planning on how to do it. We haven't decided yet that we're going to do it.

One of the things that I haven't talked about – through the international meetings and through the warm embrace of our colleagues in different continents, I became more involved in the World Meteorological Organization [WMO]. I would attend meetings where we would talk about how to evolve the Global Observing System. In fact, I became the chairman of the – these were working groups [expert teams], and it eventually ended up being called "Evolution of the Global Observing System," and before that, it was a complicated acronym [Observational Data Requirements and Redesign of the Global Observing System]. But, you would have people from different continents, different operational agencies, different research agencies getting together to plan on how to better utilize the observing system that we already had. After the U.S. was leading with the polar orbiters [and geostationary satellites], very quickly Europe contributed a geostationary satellite, and then the Japanese contributed a geostationary satellite. The Russians had polar orbiters and geostationary satellites. India did also. Coordinating these for the better utilization of weather forecasting globally for mankind was something the World Meteorological Organization had taken on. We were now talking, "This is what we have. How do we better utilize it? How do we evolve this to the best [configuration]? We don't need Russian and U.S. and European satellites in the same polar orbits; let's distribute them in time. The geostationary satellites, let's put them in a distributed fashion around the globe, and when one has a problem, let's even work on how to offer back-up systems." We had a problem, and Europe shared a Meteosat with us. The Japanese had a problem; we shared a GOES with them. So this was a wonderful environment to work in. When you went into the WMO building, you saw people from around the world. To me that was, again, just a reminder that I was working on things that were of relevance globally. During the chairing of the working group, or actually, it was called the Expert Team on the Evolution of the Global Observing System, I became charmed or – what's the right word? – enhanced is the wrong word. I became very charmed by the city of Geneva, and I applied for but did not get a job to be the head of the World Weather Watch. It turned out that I never even applied because by the time [the WMO received my application], I was sixty-two years old, and that was beyond the age limit where they would hire people fresh into a job. But I've maintained a love affair with Geneva. In fact, one of the pictures up on the wall is from Geneva, and Nancy and I enjoyed our experiment with French and just exploring the city, a lovely city. But back on the work part – the evolution of the Global Observing System really was well-coordinated. As I say, especially in geostationary orbit, the idea of better vertical resolution through better infrared spectral resolution was really getting traction so that the Chinese, who became major contributors to the Global Observing System in the last twenty years, the Japanese, and the Europeans have picked that up. In other areas, the microwave instruments kept improving. NASA, through its Earth Observing System, really demonstrated improved microwave instruments with more spectral bands, and these became the breadwinners for the data assimilation folks. The Advanced Microwave Sounding Unit (AMSU) had a large impact on improving numerical weather prediction along with the AIRS instrument, and then, later on, the polar orbiting hyperspectral [infrared] instrument, IASI [Infrared Atmospheric Sounding Interferometer] and CrIS [Cross-track Infrared Sounder] also became incredibly important for improving the weather forecasting. The microwave is wonderful because it really is not affected by clouds other than really precipitating clouds, so you have much better coverage. The challenge is that the footprint is very large and also the surface emissivity from land and ocean has to be characterized very correctly, very accurately. The infrared is troubled by clouds unless you get very clever cloud clearing or cloud transmission calculations. The infrared, however, gives you the best depiction of moisture, and moisture, in the end, is going to be the most important parameter in a numerical weather prediction model. And better depiction of it in terms of its vertical variation and horizontal variation is incredibly important for estimating atmospheric stability. And seeing where it's going to go [unstable] in the next four to six hours. So the conversations in the WMO, the evolution of the Global Observing System, helped sort of channel those efforts internationally, and that was a very rewarding job. So as I look back on my NOAA time as a chief scientist, I was able to talk to some of the senior administrators, try to convince them how we should evolve our [satellite] system, and kept them apprised of where the rest of the world was going. Meanwhile, I was able to do a little bit of science working with the MODIS data and also with some of the advanced sounder data from the GOES sounders on GOES-8 through 15. When I was told that I was too old for the WMO job, I realized I probably should be morphing into a more relaxed environment. I was traveling a lot to Washington and other places, so I retired from NOAA in 2007, and I accepted a position here at the University of Wisconsin, where I was the first Verner Suomi Distinguished Professor. Verner had passed on, and there was a professorship in his honor, and I was the first recipient. I taught, I did some research, and I gloried in this wonderful title that I had been given by the university. I did that for three years, and pretty much, I continued working towards high spectral resolution information, better use from polar orbit, and acceptance from geostationary orbit. I still continued processing the cloud data that we have from MODIS and also from the HIRS instruments that Bill Smith gave us from 1975 onwards. So we have more than a forty-year record of what's happened with clouds and moisture. We're still fine-tuning how to make best use of it in a climate sense. I still have the opportunity to work with young people who come through here. That's one of the real privileges with the university. You have clever young people who are eager to take on the challenge of the future. So what am I now? I'm seventy-four years old. I still am lucky enough to do this part-time. I get to go to conferences. I still get to hear what's happening within the international community as well as the national community towards getting a better fingerprint of what's happening with the planet.

MG: It's all so impressive. I want to ask you a number of follow up questions if I could.

PM: Sure

MG: I'm also curious about your decision to go to the University of Maryland for your undergraduate education.

PM: Yes, I was quite keen on going somewhere other than the University of Maryland, and I'd gotten a fellowship to go to Cornell, but it didn't pay for everything. My father said, "Maryland is a hundred dollars a semester, and it's an excellent education. I can afford this. Cornell is going to put a stress on the pocketbook." So I went to Maryland. And he was right. It was a very affordable education. It's a bit eye-opening now. In-state tuition is something like five thousand dollars a semester, and at that time, I think a semester with books and tuition cost my father something like two hundred dollars. But that's another conversation.

MG: What brought you to Madison? Was it all the programs you've described?

PM: I was interested in high energy physics, high energy theory, Van De Graaff work. That was my experience, and I applied to many schools, but the two that I decided I should think about going to were the University of Wisconsin and the other one was Berkeley, California, the University of California at Berkeley. Two things entered into this – this is 1967 – and one was that we had taken a road trip as a family and gone through Madison. I think it was in 1959 or 1960, and I just remember it well. We drove up to Lake Mendota at the end of Park Street, and the sun was setting, and people were swimming in the lake, and there were lots of golf courses. I enjoyed playing golf. I just had a very favorable impression that this university was right on the lake. It was like the French Riviera, except it was right here in Madison, Wisconsin. The other thing that played in my mind was that California, I thought, was set for some turbulent times because Ronald Reagan had just been elected Governor, and some of the radical thinking was starting to surface in California. Little did I realize it was surfacing in Madison, also. We had the Dow Chemical riots the first year I was here.

MG: Tell me about that. I wanted to ask you about the student movements and protests on campus.

PM: Well, I was never much of an activist in that sense. I think if you characterize me, I favor liberal thinking. I don't know how far left I've been, but I've been left most of my life. It seemed to me that there was a lot of unrest. I was a teaching assistant here. I wanted to do the teaching, so I didn't have a research assistantship. With a teaching assistantship, there was a lot of contact with students. You could tell that the students wanted their voice to be heard, that things that were happening, especially in the transition from the – what's the right word? – the enthusiasm, the empowerment felt when Kennedy became president to the good things that

Lyndon Johnson did in terms of civil rights and some of the other programs – Social Security, those types of things, where ideas became programs that were initiated in the Great Society that would help people stand with equal footing. Then we had the Vietnam War, and we're starting to be told that things were better than they really were. I don't want to call it lies, but it didn't make sense that we were over there. More and more people were going, and we started to know people that weren't coming back, or that came back and they were in pretty tough shape. So it seemed like big government wasn't necessarily doing the things the Great Society should be doing. There was that feeling on campus here. We would be teaching, and tear gas would float into the room. Students would start coughing. It was tough. I was teaching various courses, but one of the courses that I remember the most is Physics for Poets. Dr. Robert March had put together some lectures on the grand ideas in physics and how to communicate them to non-physics majors. His opening premise was everybody enjoys good music, but they don't necessarily know how to read music, so people should be able to enjoy the ideas of physics, but they don't have to know the equations. I really enjoyed the challenge of communicating relativity and some of the other breakthrough ideas from physics without getting buried in the mathematics.

MG: That's appealing to me.

PM: Right. It was a good time, and we all had bell-bottomed pants and long hair and grand ideas. Some people wanted to go further to tear the whole thing down, and I think I was more willing to nudge it in a better direction again. But it was a very active time, and it just kept escalating until we had the campus-wide riots. I forget exactly when that was—'69, '70. It culminated with the Sterling Hall bombing in Madison.

MG: In the physics department.

PM: Yes, [the building that houses] the Physics Department. I had just passed my preliminary examination. As a reward, I took a summer's trip to Europe, and I was in Switzerland – I think it was Bern, Switzerland – and I opened the newspaper, and it said Sterling Hall had been bombed. So I wasn't even here. I was curious as to whether some of my research had taken a hit, but I was pretty lucky. My office was in the basement at that time. We had boxes of programs, and I had something like about ten boxes. Only three of them were damaged by water. I still had the cards, but I had to figure out how to retype them. So a very modest inconvenience compared to some people who lost all their research and in one case, his life.

MG: Did you know that professor who died?

PM: He was a graduate student, actually. Robert Fassnacht. I certainly saw him in the halls, but I didn't really know him. His case, of course, has been publicized. It was unfortunate. He was in the building late at night, finishing off an experiment because he was headed off to a vacation. I think the bombers tried to be responsible. They wanted to do an empty building, but it wasn't empty. I came back and filled in those three boxes again and did my symmetry calculations of the alkali halides and finished my PhD in 1974.

MG: What was the mood on campus after that event?

PM: It was pretty somber. There was some finger-pointing, as I indicated, in the physics faculty that this tolerance of far-left behavior or ideas within the students had enabled this kind of arrogance that you should go and destroy society and then rebuild it. I think mostly people were looking forward, “Let’s get through this. This shouldn’t happen again. Let’s understand why it happened, but let’s move on.” I think that’s mostly what we did on campus.

MG: Were people following along in the news? I know the bombers escaped to Canada.

PM: Yes, well, two of the bombers, I think they went there. Everybody was apprehended pretty soon, except for one.

MG: Who is still at large.

PM: Who is still at large, and for a while they thought he was the Unabomber. I don’t know if we’ll ever know what happened to him, but Canada obviously seemed like the place to escape to, or into the wilds of Montana. Yes, there were a lot of connections – everybody knew somebody who knew them or had shared a beer with them. They were just students on campus that got radicalized. They went pretty far left. In fact, my wife, who was a teacher of English at West High, she taught with the woman whose Volkswagen van was stolen to perform the bombing. So Madison’s small enough that you know somebody who knows somebody.

MG: You mentioned the Van De Graaff experiments. I didn’t know what that was.

PM: Well, Van De Graaff is a particle accelerator. So at the University of Maryland, they had put together a facility where you accelerate particles, and you slam them into other particles to see what kind of nuclear reactions you get. I was working on something where you took protons, and you bombarded beryllium 9-with these protons, and you ended up with boron-10 and gamma radiation. The boron-10 is in an excited state, so when it goes back down to its ground state, it emits gamma radiation. So we were trying to understand the structure of the nuclear atoms. My participation in this was to continue to focus the proton beam on the beryllium, to make sure it stayed there in case there’s a building vibration or whatever. So we would go in there with our little radiation badges and try to line up the beam and go back out. It’s not clear that we always did it in the safest way. I ended up getting leukemia many years later, and we didn’t know why. One of the suggestions was maybe it was from the gamma radiation of this p-gamma experiment.

MG: How's your health now?

PM: Actually, I ended up with the kind of leukemia that if anybody has to get it, this is the one you should get. It was hairy cell leukemia. After I took interferon for about ten years, they came up with something that was really suppressing it, the 2CDA (chlorodeoxyadenosine) treatment. The last treatment I had was in 2000. I don't think we're rid of it, but it's not traceable right now, so I'm very healthy in that regard.

MG: Do you have other colleagues who have gotten sick?

PM: No. We dispersed into different corners of the world, and we have lost touch. I never wanted to go back to the University and say, "Hey, I think this happened." Nobody knows for sure whether "A" implies "B."

MG: You mentioned your wife, and I was curious if you met her around this time.

PM: I met Nancy near the end of my PhD, and she was just finished her work and was starting teaching at West High, an English teacher. Yes, we married in 1978. That was good.

MG: You recently had an anniversary.

PM: That's right. Forty-one years

MG: That's nice. Can you explain a little bit more about your thesis research?

PM: Sure. The idea with the band structure calculation of alkali halides – we wanted to know what were the natural states when you have lithium fluoride, for instance. What crystal structure could harbor energy and understand what energy states the electrons will be in, how long they will be in that energystate, and when it will be released. In particular, it became more important later on when you introduced point defects. In other words, you have this perfect crystal of an alkali halide, but then you, either on purpose or by nature, introduce a defect, and that perturbs the energy states either to your advantage or disadvantage. Solid-state materials can take advantage of these things. It's been so long ago I half forget some of these things, but I've been told at least some of the work that I did there bore fruit later on in some of the solid-state applications down the road, but I was gone by then.

MG: You've written a number of articles, about a hundred and fifty-eight peer-reviewed publications. I'm curious about what that process is like for you or if have some papers that stand out to you as particularly important.

PM: Well, actually, that one stands out to me because it was a summary of remote sensing and how physics ties into it. Chun Lin said people in the physics world need to know how important physics is in other fields, so I should write this article. I took on writing the article, along with Hank Revercomb and Dave Tobin; I used some of their work to show how the understanding of molecules lead to a better understanding of the high spectral resolution infrared sounding of the atmosphere, in particular, carbon dioxide and water vapor. It was kind of a nice prodding that he gave me to do this article, and that went into a physics journal, and it's really about meteorology. It sort of confirms again what Suomi said: if you know physics, you can be useful in other fields. In general, one of the other articles that I'm quite proud of is the article about the applications of the geostationary sounder. On GOES-8 and onwards, we had an operational sounder. We had the demonstration with the VISSR Atmospheric Sounder, but then we had an operational sounder where it didn't have to share time with the imaging function, it was just the sounder. We were able to do some nice things about tracking atmospheric stability, the cloud heights for the automated surface observing systems. It was kind of documenting in a peer review way how useful this instrument can be, even if it isn't high spectral resolution in the infrared. Another paper that took quite a while to put together was, "What have we learned about clouds in these many years of HIRS and MODIS observations." The article was more, "This is what we're trying to learn," and how we have now data and how this data is being turned into data products relevant to cloud properties. That represented a lot of years of research, and it's still part of what I'm working on now. We're not done with that. Those three articles stand out. There have been some international articles about how the observing is evolving and how we got to where we are.

MG: And you wrote a textbook that you teach from.

PM: That's right. That's an outgrowth of my trip to Perth in 1983. I just kept building on that and borrowing from other people. And I found that in a lot of the third world countries, or the less opulent countries, even twenty dollars for a textbook is way too much. So I used the WMO to publish this book, and say, "Give it away to wherever it's useful." I will continue to fiddle with it. That was in 1995 that I think we put out the first version from the WMO, somewhere around there. I just, in fact, last month, put it a few more sections. I put it online, and people who are interested can go and grab it and use it. It's some three-hundred-eighty pages, and some of it is probably not up to date, but I still fiddle with it. It's been translated into – in Indonesia, they've translated it; in Russia, they've translated it. So it gets some application where people need a textbook, but they don't have the money to pay for one.

MG: What's the title of the textbook?

PM: *Remote Sensing Applications with Meteorological Satellites*, (APPMETSAT?).

MG: The acronyms are very hard to keep track of.

PM: Yes, that's one thing. Every field now has an alphabet soup. I heard a talk from some mathematician talking about computers, and I got lost immediately.

MG: In doing my research for your interview, I had to keep a code and write everything out so I could understand it.

PM: Yes. In fact, you could tell when I was doing my recitations just now, I can't remember some of these acronyms.

MG: Tell me a little bit more about Suomi. It sounds like you had a nice personal and professional relationship with him.

PM: Yes.

MG: What was his title? The grandfather of –?

PM: Well, he's actually the father of satellite meteorology. We wrote a book about it; it's right up there. In fact, if you're interested, I have an extra copy I could give you. He was an extraordinary man - he had more ideas than he had time to exercise. Not all of his ideas were good, and he probably realized that, so he collected around him people that could have an enthusiastic dialogue with him, but also tell him when his idea really wasn't needed or wasn't on the mark. I guess almost all great people care a little bit about how they're viewed, and he needed to get recognition, so he had a desire to do great things so that people would say those are great things, but in the process, he really did. After World War II, it took a while, but they put together the international geophysical year. The Russians announced, and promptly the U.S. did, too, that they would make a satellite contribution. This was an international geophysical year where – international coordination to observe the geophysics of the earth. This prompted the space race. Sputnik was the result of that. Then the U.S. had a lot of efforts to put a satellite into space. The difference – the Russians really had rockets, and then they put dogs and people into their rockets. In the U.S., we had rockets, and we put instruments into our rockets. The Russians had some instruments too, eventually, but our first push was to put some instruments in there so that we could take some data from space – there was sort of a race in the U.S. also. Which rockets do we use? The German rockets from Wernher von Braun, or something that the military independently puts together? So there were the programs that were competing with each other. The first successful experiment was on Explorer with the German rockets from Wernher von Braun, where we discovered the Van Allen Belts, these belts of particles that circle around the earth. [James] Van Allen was a professor at Iowa. Then there was a push to put earth viewing instruments up, and Suomi was one of the people who happened to be in the right place at the right time. He proposed to measure the radiation balance of the earth – a very simple idea. Suomi's ideas were always simple but brilliant, and this was to take a white ball and a black ball and to measure the visible and infrared radiation balance. Incoming solar radiation is primarily in the visible. The outgoing earth radiation is primarily infrared. The white ball will reflect the visible but absorb the infrared. The black ball will absorb them both, so you can differentiate from black and white to figure out what the difference is between the visible and the infrared. He had various incarnations of this (bolometer?) or radiometer, and he had something like three or four tries with different rockets before he finally succeeded in 1959. That was to measure this radiation balance of the earth. This was the first experiment where it looked at earth and actually told you something about cloud cover because the radiation balance in clear skies versus cloudy skies is very different. So the military got interested in this and pretty soon started doing imaging with radiometers – black ball, white ball and more sophisticated instruments for mapping the clouds. The whole cloud mapping came forward from Suomi's time with observations from polar orbiting satellites in the infrared and visible. The other thing about Suomi is he was always thinking about his next idea, or what the application was, and sometimes his ideas came from strange places. He's a Wisconsin man – actually, he was from Minnesota, and he went down to Chicago, the University of Chicago, and got his degree there, and then he was asked to come to Iowa and also asked to come to Wisconsin. He chose Wisconsin because he asked the people in Iowa, "Where do you go on vacation?" They said, "Wisconsin." So he said, "Why shouldn't I live where people go to vacation?" And he became a Packer fan, or at least he was watching the Packers one Sunday, and this was just when they started instant replay, where they would play it backwards and forwards, and he says, "That's what I need for weather. I need an instant replay to see the development of a system." He kept thinking the only way to do that is to put an instrument in geostationary orbit because you're watching it all the time. Then he had friends in high places at NASA and was able to convince them to put his camera on a geostationary satellite. That happened with the ATS-1. So he really is the first person to put in observation from polar orbit and geostationary orbit that would take measurements of the earth. So he justifiably gets the title "Father of Satellite Meteorology." But he was temperamental and impatient and wanted to see his ideas bear fruit. It wasn't always easy working with him, but it was rewarding.

MG: Were you ever present for these satellite launches?

PM: Yes, NOAA was very good about inviting people to the satellite launches if they had worked on it, and I'm pretty sure – yes, I went to see the GOES-8 launch from Florida. It was a little tricky because you never know for sure you're going to launch – could be cloud overcast or could be high winds, but we were lucky this went off pretty much within a day of when it was scheduled, and you have this great roar of the rocket in the middle of the night, and you have people that are telling you, "Yes, yes, that piece is supposed to fly off," and "Yes, that's about when you're going to get separation," and "Oh, yes, we've made orbit." So it was kind of exciting. Then there's a little bit of a party, and everybody goes to sleep.

MG: Aren't these launches sometimes in the middle of the night?

PM: This one was. If I recall correctly, it was about two in the morning, yes.

MG: I'm a little bit confused about where NOAA comes in and where the University of Madison comes in. It seems like some of the projects you've worked on and positions you've had are part of the NOAA effort.

PM: They are. There's a good story there. It's a Suomi story. Verner Suomi had a very good relationship, I've already indicated, with NASA, but also with NOAA. At the time, it was ESSA [Environmental Science Services Administration], and I don't think it was NESDIS yet, but Dave Johnson was one of the pioneers of satellite and weather work in the United States. He and Suomi were good friends and collaborators. At some point, Bill Smith, with his sounding ideas and sounding instruments from polar orbit, started working with Verner Suomi for the sounder from geostationary. The VISSR Atmospheric Sounder was a collaboration between the two of them. Verner decided it would be best if Bill Smith brought his team and moved it to Wisconsin for a while. That was fine with Bill because he had been a graduate student here, so he brought his folks out here to work on the VISSR Atmospheric Sounder, and it was a government group that grew to be almost twelve people over time, but initially, I think it was just five people. We launched. We had a good demonstration of the geostationary sounding, and the team was still here. They were working on this and also the TIROS-N soundings. Verner said, "I need for you guys to be more secure, that you won't be pulled back to Washington. Let me work with Dave, and we'll get a permanent NOAA presence here at the University of Wisconsin." Dave Johnson said, "Sure." So they put together what is the Cooperative Institute for Meteorological Satellite Studies to formalize this NOAA engagement in the University of Wisconsin. It really started in 1976 when the group came here. I think it got formalized in the early '80s. I forget the year. But it was because NOAA wanted people working with Verner Suomi that we had NOAA folks here. Shortly after that, Tom Vonder Haar, who had worked on this net flux radiometer on Explorer 7, formed the Cooperative Institute [for Research in the Atmosphere] at Colorado State University, CIRA. The foundations of the Vonder Haar Cooperative Institute and the Suomi Cooperative Institute are somewhat different, but NOAA has had a presence at both of those universities. There are other universities, too, but those are the two that I can speak about most.

MG: Are they all partnered with the university?

PM: Yes.

MG: There are maybe a dozen cooperative institutes around the country.

PM: Yes, some are joint institutes; some are cooperative institutes. Now NOAA has a cooperative institute at the University of Maryland, at Colorado State University, at Wisconsin, and I'm forgetting one. Also, they have CREST [Cooperative Center for Earth System Sciences & Remote Sensing Technologies] at City College of New York, which is not a cooperative institute, but it's a cooperation with the City College of New York. City College of New York is a wonderful place because it has people from all backgrounds – ethnic backgrounds and also financial backgrounds, so you get a spectrum of people where this is just a wonderful opportunity for them to get this education and contribute to the global remote sensing enterprise.

MG: Good.

PM: I'll just add to [my comments on] City College – I was lucky enough to spend a semester teaching there while working for NOAA. This was one of the things that NOAA did. They allowed me to teach and also do research and then later on to be chief scientist; there was a lot of freedom in my job responsibilities. One semester, I taught at CREST, so I firsthand got a taste of the wonderful student variety that you get when you go to New York City. That was nice.

MG: When you would do these things, would your wife take time off from work and join you?

PM: Yes, sometimes she would be there only half the time. When I was in Geneva, I was stationed at the WMO for two months. She was able to join me for a month until the semester started at school. When I was at City College, she came for the Easter breaks and the other times. But we spent some time apart when I did these more lengthy engagements, but every time I went to Australia, she came along.

MG: Were you familiar with the NOAA reorganization of the 1970 and its history?

PM: Less so. Being at Wisconsin and working at the university, I was aware that Bill Smith and the Satellite Applications Lab and the research part of NESDIS was being reorganized, but less familiar with it. I knew some of the names, and I got to know those people then – Harold Yates and Krishna Rao. Then later on some of the other folks, but I was sort of secluded from that in a sense. I was here at Wisconsin working, and people came out here. Gradually, I became more aware that for this to become useful, it has to be routine and operational, and NESDIS is the agency that does that. So we started working a lot with NOAA/NESDIS as the years went on, especially with the VISSR Atmospheric Sounder.

MG: Was NESDIS also formed in 1970, or did it have a history previous to that?

PM: It was NESS [National Earth Satellite Service], and then it became NESDIS. I think when they assumed the archiving responsibilities; that's where the "D" –NOAA Environmental Satellite and Data Information Service came in. I don't know exactly when that happened.

MG: How is that data archived? So many people have access to it, and it's being used in many different ways.

PM: That's another Suomi story, actually. From the polar orbiters, you had modest data volumes. You had the direct reception. You had a subset that was stored when you went over the poles in Wallops Island in Virginia, and then there's Gilmore Creek, I think, in Alaska. You would have downbursts of subsets of that data, but the volume was pretty small. With the geostationary satellite, you have this constant pouring of data, and Suomi didn't want that data to go to waste. So he encouraged his son, Eric Suomi, into synchronizing the spinning satellite, a hundred RPM with a Sony recorder at a hundred RPM, and you had what was called the video cassette archive. So we started archiving all of the geostationary satellite data, initially just the U.S., then also the Japanese, which was also a spinner and also the Meteosat, which also a spinner. The most complete geostationary satellite archive was here in Wisconsin. In time, NOAA said, "Well, we really have to be responsible for that. It's great for you guys to do it as a backup, but let's transfer this to Asheville, North Carolina, for the NOAA facility there to be archiving that data. So it went from video cassette archive to IBM tapes, and now I think we even have the storage capacity online. The volumes that you can store directly into the computer are huge compared to what we were able to put on these little video cassette tapes. But before the videocassettes, you had what were called slant track tapes, where somehow or other you would tape it on a slant on a regular recording tape, and you would get higher data density. But these were quite perishable, and getting the slant track tapes to have any sort of lifetime that would be useful for research was tricky. But data storage continued to bea big problem. In fact, on the very first experiment, the biggest problem was storing the data and getting it down to the ground stations. This was the net flux radiometer back on Explorer 7. So that's always been an issue.

MG: It sounds like part of your recent research is comparing data from forty years ago to now.

PM: Well, what we're trying to do is take the whole archive and use the same algorithm on these measurements, so that we derive the cloud properties in the same way, and when we see a change in cloud properties, it's not because we changed the instrument or changed the algorithm, it's actually because the cloud properties changed.

MG: How are they changing?

PM: Well, surprisingly enough, the cloud cover has stayed pretty constant in the forty years. It depends on how big your [measurement] footprint is, but with the HIRS instrument, where you have a footprint of about twenty kilometers. With a twenty-kilometer footprint going day and night with two polar orbiters for forty years, we get a cloud cover of about seventy-five percent of the globe is covered with clouds. You would figure that's going to change – it has the northern hemisphere and southern hemisphere change with the seasons. You figure that with more jet air traffic and the associated contrails and things, you'd have more ice clouds. I can't tell you that we can see that yet. We're getting a handle on what goes into these clouds in terms of cloud condensation nuclei, but the macrophysical – in other words, the number of clouds and water versus ice, it hasn't changed appreciably in these forty years. The coverages are changing gradually. It's fascinating. The signals are there; they're very small. I sometimes feel like a cat sitting in front of a hole in the floorboard. I know there's a mouse in there, but it hasn't come out yet, so I'm waiting for the "aha" moment with this dataset. I think we're getting much better at processing it.

MG: What about the ozone hole? Are the satellites looking at that?

PM: Not the satellite instruments that I've been working with, but for sure, the ozone-sensitive instruments that were on some of the early NASA experiments. They helped identify the ozone hole. Initially, they were throwing away this data because it was off-scale. Somebody finally said, "No, no. We'd better look at the whole range," and they discovered yes, there is this hole. The discovery of that hole led to an international effort to regulate the chlorofluorocarbons that were causing it. In fact, I think I just read that the ozone hole is the smallest it's been in a long time this very winter. That's a success story. I hope we can have some more success stories like that where the satellite observations will tell you we need to react to something that's going on here.

MG: Something else you've talked about is international cooperation, and I didn't know if any of that was changing.

PM: At the science level and the person to person level with all of the continents and the different people we've been working with, it's still very robust, but obviously, the U.S. relationship with China is more difficult. China has a lot of satellites now that they're contributing to the WMO global observing system. Within the United States, currently, we feel that it's dangerous to rely on anything Chinese for our weather forecasts. I don't know if that was the right word, but we're really not taking advantage of the satellite contributions that China is making to the global observing system, whereas if you go to Europe, weather prediction folks there are making maximum use and getting benefit from the Chinese satellites. So we still have some government to government issues that I hope can be resolved, but the people-to-people or scientist-to-scientist working relationships are very robust.

MG: You might have talked a little bit about this, but the IRC working group, can you say a little bit more about what that was?

PM: Yes. The International Radiation Commission. They basically help coordinate some of the work that was been done in observing the earth with satellites. One of the things they came across early on is that there were lots of different people processing these radiances into soundings. They thought that could be a problem if one country has a forecast from their soundings that's totally different than another country's forecast, or at least I'm assuming that was one of their concerns. So they wanted a group of scientists, international scientists, to come up saying, "This is the algorithm to use for processing radiances into temperature and moisture soundings." That was the ad hoc group from the International Radiation Commission that was put together to come up with this answer, and it turned out there was no one answer. We [the ad hoc group] basically said there are advantages to this approach and that approach. Either way, statistical or physical retrievals of temperature and moisture – either statistics based on past performance, or physical based on the physics of radiation going through the atmosphere, you'll get good answers. But the best application is with local tuning. So you have the local tuning of that algorithm. So for nowcasting and for local numerical weather prediction, at the regional [level] there is no one answer. There were guidances, but there was no best algorithm, and that was really the report that went back to the International Radiation Commission from the working group that was put together.

MG: Is that group still meeting?

PM: That's the group that, at some point, became the International TOVS Working Group that conducts study conferences. TOVS was the instrument [providing measurement] wherefrom we were producing the soundings. TIROS-N and had the microwave and infrared instruments on board. They started meeting in 1983, and they've been meeting roughly every eighteen months since then. In fact, the next meeting of that group is going to be outside of Montreal next week. We had the twentieth meeting here a while [ago], so this is in well in the twenties now, and it's become a group where you have exchange of information of how do we use these satellite radiance measurements and where should we be going as a community into the future? So it really complements what the WMO expert team on the evolution of the global observing system is doing. And practical information, too – software exchanges and, "By the way, there's a calibration problem with this instrument on that channel." So it's an information exchange opportunity, as well as papers. Science papers are read, and obviously, people go out for beers afterward.

MG: Do you plan to attend?

PM: I'm not going to be attending that, because I'm headed back to Perth, Australia. I have a PhD student who finished her work there, but now we have to publish some of it. So we're going to take her big thesis and collapse it down into a couple of useful papers.

MG: Wow. Is there a center outside of Montreal? I noticed that some of the places where meetings have been convened are centers of aerospace.

PM: You know, I don't know. I don't know who the host is in Canada this time. More often than not, though, these meetings require some financial support for travel, so NOAA/NESDIS has been quite good about supporting that. EUMETSAT, the European satellite agency, and the host country, now – Canada obviously is probably sponsoring some of this also. The major contributors are the numerical weather prediction centers or satellite research labs, and they will support their own travel, but to get people from the less wealthy countries, you need to help with travel. Typically we get a pretty good distribution of folks, so I think that attendance is now into the hundreds; a hundred to a hundred and fifty folks come to these meetings. The very first one, I think we had something like sixteen people. That was held outside of Innsbruck, Austria, because Professor Hans Bolle was very keen on hosting this. So you have a local host, and he wanted to show you not only the university in Innsbruck but also the environment, what a wonderful place it is to be.

MG: My brother lives there.

PM: Does he? Yes, Igls continues to be one of our favorite venues for the International TOVS Study conferences. Five or six of them have been held there, and we're hoping to go back again.

MG: Were you still teaching at the University of Wisconsin when you joined the Advanced Satellite Products Team?

PM: After I taught in Australia, I was asked every now and then to teach here at the university for a semester. Yes, I was teaching when I was at the Advanced Satellite Products Team, and I continued that during my NOAA existence. They were very tolerant of that. We always advertised that was a good way to be recruiting for future NOAA employees by engaging and mentoring the students.

MG: Did it work out that way? Are you finding former students who are employed by NOAA?

PM: Yes, a lot of them. A lot of my former students are in Washington.

MG: Can you describe what MODIS [Moderate Resolution Imaging Spectroradiometer] is? I couldn't quite get my head around it.

PM: The MODIS Science Team. There were several instruments on the Earth Observing System where they put together a science team based on proposals that were being funded by NASA. The MODIS instrument had some trade-offs before it was launched. In fact, it was supposed to be two instruments, and it ended up being collapsed into one instrument. Vince Salomonson was the science lead, and he put together three teams, one for atmosphere, one for oceans, and one for land studies. That was a group maybe of thirty or forty principal investigators, and we would meet periodically. I was on the atmosphere team. Mike King led the atmosphere team. One of the big issues with the atmosphere, of course, was clouds, the microphysics of clouds, as well as the coverage and macrophysics. So my contribution there was using the CO2 channel, CO2 slicing technique, for determining the height. Once you have the height of the cloud, you can say something about the cloud phase also – water versus ice. That was a very nice program because it was sustained for a long period of time. Typically, you write a proposal, and you're funded for three years, and then you have to go looking elsewhere. With the MODIS Science team, you were able to engage in a long-term project, helping the instrument be refined, and then verifying after launch that it really is the instrument you though it was going to be, and if it isn't, these are the adjustments we can make. Then you start tracking your measurements and turning them into records of cloud cover. NASA did a wonderful thing there, by sustaining science teams for a long time, so you had continuity of effort. The other thing they did was they made a decision to distribute the data in direct broadcast, globally. So, much like the NOAA satellite, NASA said, "Okay, we'll take these research satellites, and we'll broadcast the data, so that somebody who wants to buy an antenna can get the data and make it useful. It was a gift to the international community, because this was a demonstration of future capability, and it wasn't quite clear yet to the operational agencies, should we sink energy into this, receiving it and using it operationally, because it's maybe only going to be here for a couple of years. But then it turned out to be around for decades. So it's a demonstration that a research instrument, when robust enough, can have a large influence on what the operational communities could be doing. It's really a precursor of future operational instruments. So grab it and get used to it and get comfortable with it. The other thing NASA did is they collected all this data, and they formed a data information service, EOSDIS [Earth Observing System Data and Information System], where you could get on the internet and grab local datasets in Italy and Australia or wherever you're teaching or researching. You could grab data from the archive and demonstrate what the satellite data looks like in their backyard. You'd say, "Now, what's this over here?" They'd say, "Oh, that's where the Pyrenees river outflow is running into the lakes," or "That's pollution coming from the Po River into the Adriatic." Things that you could guess at, but they could confirm it. So the direct broadcast of the EOS [Earth Observing System] instruments and then the data archive – wonderful contributions that NASA made toward lifting everybody's game in how to use remote sensing on the planet. I can't overpraise NASA for this; it was a great contribution. NOAA, of course, continues to have direct broadcasts of their data to the international community, but NASA gave a taste of these future wonderful instruments that we're still putting into space now. AIRS became CrIS and IASI [Infrared Atmospheric Sounding Interferometer], and MODIS became VIIRS [Visible Infrared Imaging Radiometer Suite], and Europe is now launching an imager from their polar platform. So people have already had a taste of what this data looks like and how to use it, so the operational versions will be well-received, and we won't waste a lot of time getting used to it.

MG: This might be a silly question, but are you ever frustrated that not more people know about how this all works or are aware of this work being done and its impact?

PM: I don't think frustrated is the right word. People really, I think, enjoy and appreciate satellite pictures of the earth. They're a little used to it now, but, still, when you have fires in California, or you have a volcanic eruption in Mexico, it's the satellite imagery that gets people interested in what's happening, and I think there's an appreciation. I don't always know that they know the difference between NASA and NOAA. Everybody knows NASA, because of manned space flight, and the picture from the moon looking back at the earth. People are less aware that NOAA is the weather service, National Weather Service, and that the satellites that are used routinely are launched and operated by NOAA, but I think people appreciate it. Whenever there's a congressional movement to cut funding or whatever, there's a lot of local and national support for these programs.

MG: How's NOAA faring in this current administration?

PM: I'm less familiar with it on a day to day basis, but there was a lot of publicity that either we would privatize a lot of this, or there would be less money for it. I think Congress has continued to sustain NOAA, not only its operations but also the development of the future instruments that they're trying to launch. It hasn't increased, but it hasn't decreased as far as I know. The same thing is true with NASA's earth science mission. It's going through a major reorganization right now, but I think there's still a fair amount of support for the earth science that NASA does. There might be a reorganization in the works, where you're combining NASA and NOAA in terms of earth science, but I'm unaware of it. But that wouldn't be horrible. I think the research and operational parts should work more closely together. The last decadal survey said that NOAA and NASA should work more closely on earth science. So if that requires a reorganization, maybe that would be okay as long as it doesn't require a huge budget cut.

MG: That reminds me to ask you about the Modernization and Associated Restructuring [MAR] of the National Weather Service. Was your work impacted in any way?

PM: Not that I'm aware of. Maybe I should be aware of it, but we've continued here as normal.

MG: You have so many honors and awards that you've received as a part of your work. It's probably too many to list here, but I was curious if there were some that were especially meaningful to you.

PM: Well, they're all meaningful in the sense that I know people have to put a lot of effort into writing the justification for it. You're never quite able to thank them for it. So right now, I'd like to thank all the people who made these awards possible for me. It's nice to be recognized, and it just makes you realize that your work is possible because of the support of a lot of other people. It's sort of a standard statement, but you are at the receiving end of the honor because you had wonderful colleagues and other people that preceded you with wonderful ideas. It was an honor to be recognized by NOAA, my agency of employment. It was an honor to be recognized by the American Meteorological Society, our major meeting place, and source of information exchange. And then there were various international honors. From Australia, I was awarded the Haydn Williams Fellowship. There's one for all of Australia every year, and I grabbed it for one year. That's really something. More recently, Russia recognized me with the Yuri Gagarin Medal. I've had people that have been beating my drum internationally, and I'm the recipient of awards that are very humbling.

MG: I also wanted to ask – it sounds like you've had a number of really terrific mentors in Suomi and Lin. Have you mentored others?

PM: Well, I don't know that I ever matched their level of mentoring, but I've had a lot of students that I've taught for a semester, who've gone on to work in Washington and other research labs. Probably one of my more unique experiences - I had two students from Italy, Paolo Antonelli and his wife Giulia, who had a semester course with me here. They came back to me and said, “We don’t have this in Italy. There isn’t a remote sensing class where we have the hands-on experience that you’ve given us. You’ve got to come and do this in Italy.” I said, “Well, I don’t have a whole semester that I could give you.” They said, “Well, why don’t we do this for ten days? Jam your whole semester into ten days.” I said, “Well, I don’t think we can jam the whole thing in there, but let’s try it.” So we started these international remote sensing schools. The first one was in Bologna, Italy in, 2001, where for ten days, I gave some lectures, and then we had labs, and Paolo was the engine to get the students to advertise that this was going to be good for you and we’ll have a good time. We got a local host that provided a lab with computers, which later became less necessary as students brought their laptops. We did this for I don’t know how many remote sensing schools. I’ll say we had about twenty remote sensing schools, with about twenty students each time, mostly in Italy, but also in Poland and other locations in Europe and eastern Europe. Those are some of the most rewarding times because you live together. It was almost – you were thrown into an environment where they couldn’t get away. We ate, we drank, and we taught together. I still have students when I go somewhere, they will host me, or we’ll just share some memories. So that evolved, and we had the remote sensing schools. EUMETSAT got interested in it because they wanted some of their future people to have a background in remote sensing, and they started to sponsor the schools. It became a bit more formal, but it was still quite good. These people, they’re colleagues now, and they began to excel in their own ways, but I had, perhaps, a small part in getting them there.

MG: Before we wrap up, I also just wanted to ask you about the evolution of satellite technology. What did the early technology look like, such as kite flights?

PM: Yes. It’s interesting. This ties in a little bit when we’re talking about Operation Paper Clip and bringing over some of the rocket technology from the Germans after World War II. The first part of technology with remote sensing of the earth was using some of the rockets that they had – either the technology was copied, or they actually had some of the rockets themselves, and they were launching them out of White Sands. This was something that was called the Little Steps Program. It started with putting a camera on the rocket, launching it, and then letting it crash back down to earth. The camera would be totally destroyed, but they would have a canister with the film, and they would rush out and take the canister and develop it. To their joy, they found that they had gotten pictures of the earth’s edge and cloud pictures. These rocket pictures then really stimulated the appetite for what satellites could later on do. That’s an early example. You had a rocket, you had a camera, and you had a data archive. The data archive was the only part that you really had to make sure was impact-proof, and they were able to develop. Subsequently, you had onboard recorders that could beam back some of the data, but the data storage and the data communication satellites were the part that was most challenging. You could put a camera on and get pictures, but how would you transfer that picture from the satellite back down to earth? So as the satellites got more advanced, you had smaller footprints, which means you had even more data as you covered the earth. You had more spectral bands, and then you had basically more instruments. So the data storage became huge, and transferring that down to earth was still an issue. For instance, in the VIIRS, the Visible Infrared Radiometer Suite that’s onboard the current operational satellites, we have such a small footprint that we couldn’t transfer all of the data down. So what they did was they started averaging it as it goes from the nadir to the limb. The limb footprint is quite a bit larger, and they said, "Well, let's go to a constant footprint." So they averaged some of the data in the center. We were outraged because we wanted the highest resolution data, but they couldn't get all that data down. So they averaged in the middle so that the data volume would be appropriate. So data storage and data communications continue to be a challenge, and we're orders of magnitude more adept at this than they were in the early days. The other area is the detector technology, the solid-state detectors that we use for detecting infrared radiation, HgCdTe,, mercury cadmium telluride, and then also InSb, indium antimonide. The sensitivity on those and the ability to make them in smaller wafers has just been phenomenal in the last twenty years, to the extent that we now can do these high spectral resolution instruments with detector systems that can capture all the radiation. Other than that, physics is still there; you still need a big mirror to get a small footprint. You also need some sort of mechanism to clear out the last signal, get it back to zero and then capture the new signal, and do that very rapidly. There are wonderful advances, and there's still even more wonderful ones coming that I have no idea about, I'm sure of it.

MG: Maybe we'll have to do another interview in the future.

PM: Well, I hope I'm here to see all of that, yes.

MG: Looking back, is there anything else that stands out to you that we haven't talked about?

PM: Well, I hope I've communicated how lucky I feel to have been working with people that were there at the very beginning and marching on forward in time. The things that have changed and improved with the weather information and the environmental information about the planet, especially from satellites, have just skyrocketed in the forty years that I've been involved in this, and that's just been a gift.

MG: Great. Well, this has been such a treat. I think I've gotten to the end of my questions unless there's something else I'm missing.

PM: No, I appreciate your effort to put this together. I don't know if I'm the right one to talk about the history, but as you can tell, I've enjoyed my trip on this road, and I hope that other people will choose to go down the same avenue.

MG: Well, maybe this interview will be inspirational. I've certainly learned a lot. This is something I knew nothing about before I started researching it, and you just make it sound exciting, important, and relevant.

PM: Thank you.

MG: Thank you.

------------------------------------END OF INTERVIEW------------------------------------

Reviewed by Molly Graham 12/10/2019
Reviewed by W. Paul Menzel 12/20/2019
Reviewed by Molly Graham 12/28/2019