INTERVIEW

OF

ERNIE HILDNER

P R O C E E D I N G S

MR. HILDNER: Ernie Hildner.

MR. CLINE: Hi, Ernie. How you doing? It's Troy Cline.

MR. HILDNER: Hi, Troy. Your caller I.D. came up very oddly.

MR. CLINE: I thought it would since we're using my -- our audio engineer's Skype number. I want to make sure -- I thought you'd get a strange number. So when I call Joan later on, I might have to forewarn her that it's a different number calling.

MR. HILDNER: Okay.

MR. CLINE: So how you doing?

MR. HILDNER: I'm doing all right. Thank you. And you?

MR. CLINE: I'm doing pretty well. I think we have everything set up on this end to just be recording as we talk. And we actually have it set up so that my voice will be recording on a separate channel than yours, believe it or not. And that way if I'm talking with you, we can either keep me in or he can easily edit me out without much trouble. So it

should make it pretty cool. And you're --

MR. HILDNER: Okay.

MR. CLINE: -- you're coming through loud and clear.

MR. HILDNER: Sounds like plausible deniability to me. Okay.

MR. CLINE: It certainly works. Well, do you want to just go ahead and get started and we'll just open up a conversation about the first question.

MR. HILDNER: Okay.

MR. CLINE: And when I say the question, it's always good, again, just to kind of repeat the question as you answer. That way, if we do cut me out, then it won't be a problem and everyone knows what you're talking about and why.

MR. HILDNER: Okay.

MR. CLINE: So do you have any questions before we actually start the real interview?

MR. HILDNER: I don't think so. And given that everything can be edited if they come up during the process, why we'll just deal with them then I guess.

MR. CLINE: Okay. Yeah, that's no problem. And you can hear me okay. Right?

MR. HILDNER: Yes.

MR. CLINE: All right. Awesome.

Well, thanks again for agreeing to do this. This should eventually, once we have the tool put together and a web site put together, it should put -- have quite an impact or they're anticipating just thousands of people being able to listen to this and -- and go through the tool on line and either listen to the full podcast or just pieces and parts of all the different podcasts.

MR. HILDNER: Uh-huh.

MR. CLINE: So it'd be really nice to have a big mix. Well, let's --

MR. HILDNER: (Inaudible.)

MR. CLINE: -- go ahead and get started.

MR. HILDNER: Do it.

MR. CLINE: Again, thank you so much, Ernie, for your time. We really appreciate it. And we wanted to ask you a few questions. And by all means, feel free to expand on anything you'd like, and we'll

just go with it.

And if there's something else that catches -- catches my ear, I might ask a few separate questions or we'll just -- we'll keep talking. I'll try to keep quiet as much as possible because we're here to hear what you have to say.

EXAMINATION

BY MR. CLINE:

Q But our first question is, basically what -- what is your primary research interest and what you're doing now, for instance; and also, what is it that you like so much about it.

A Well, what I like about my research was the fact that it was -- let me start over.

Q Yeah. You know, that's no problem. And just make sure -- we'll try to keep my -- I'll try to keep my energy up, make sure yours is up and all the passion you talked a little bit about yesterday, and I think we'll be good.

A Okay.

Q All right.

A Truly my primary research interest -- and

it's in the past tense because I'm now retired -- my primary research interest was in the solar corona and then moving out in the interplanetary medium and then the consequences here at earth.

And my initial research for my Ph.D was in how quiescent prominences form, and then I got into the Skylab world. So became quite fascinated with coronal mass ejections.

And one of the fascinating things about that was that it -- nobody had ever seen the corona like that before. Eclipses were so rare. And artificial eclipses from the earth's surface were so bothered by sky brightness that when we made artificial eclipses from space with a black sky, we suddenly -- and had routine monitoring of the sun -- we saw phenomena some people had imagined and speculated and hypothesized about but they could not prove.

And we were the first to -- our experiment team was the first to actually see and verify and discover things that nobody had thought of in a corona. And that was a whole lot of fun.

Q Now, what year, about what time frame was

that happening and how did you -- were you able to pull off such an accomplishment like that and actually watch an eclipse from space?

A Well, you build a telescope and you put a -- the way we did it, you build a telescope and you put a disk in the front that blocks out where the sun would be and you very carefully center the telescope on the sun, you have to dump the sun's heat, but then you look at the faint atmosphere around the sun called the "corona."

And what we saw were these ejections from the sun that simply had not been seen before. There were some ground-based measurements taking scans around the sun of brightness that saw depletions, but they didn't know whether that material had fallen back into the sun or whether it had actually been blown out into interplanetary space.

And, of course, when the earth is in the line of fire of one of these explosions coming out from -- these blobs of material coming out from the sun, then that's when we have the space weather effects here on earth.

And so it was brand new stuff and it was very exciting to be part of the Skylab team because another set of instruments on board were the X-ray telescopes. And -- because you cannot -- because the earth's atmosphere absorbs X-rays, you can't see astronomical objects in X-rays from the ground. You have to go to space.

And we saw coronal holes for the first time and M-regions that -- so named because there were recurring geomagnetic -- magnetic storms were understood to exist on the sun but nobody knew what they were until Skylab saw the coronal holes.

That wasn't our instrument. But since we were sitting at tables next to each other and since we operated as a unit, then it was also extremely exciting to see this brand new phenomenon that explained something that people had puzzled about for 40 years.

Q And would you mind explaining for some of our listeners exactly what a coronal hole is and based on, I suppose, the research and discoveries that your team had.

A Well, a coronal hole got named that because when you look at the sun in X-rays, where there is more material, the sun is brighter.

And the very first images that came back from the sun showed that there were regions that were dark. It looked like you were looking down into a hole. Instead of the fluffy solar corona visible in X-rays elsewhere, you were just looking right down to the surface of the sun which is so cold that it doesn't emit X-rays.

So it turns out that these are regions sort of like the part in your hair where the magnetic field lines that come up and permeate the atmosphere of the sun start to go, say, to the left on one side and to the right on the other side and down the middle they are straight up or they are not coming back and lying back down onto the sun the way the hairs do on your head either side of the part in your hair.

The result is that the hot solar atmosphere finds it very easy to escape in that region. It's not downed by those closed magnetic fields, those loops of magnetic fields, but rather can come straight out. It

spends no time near -- or very little time near the surface of the sun and so the density of the material there is much lower.

And that's why it's dark and that's why we call them "coronal holes" but it's almost like fire hoses in that -- those regions, fire hoses of material streaming outward from the sun very rapidly.

Q So that makes sense with, often I've heard of auroral activity or activity around the earth even when there's a large coronal hole in our direction.

A That's -- well, a few days later, yes. The sun rotates every 28 days. Think of a fire hose coming out from the sun and it sweeps by under the sub earth point and then two or three days later the material that the fire hose nozzle was squirting finally arrives at the earth.

So it's making spirals around the -- in the interplanetary medium but eventually that material comes out and hits earth and causes geomagnetic disturbances and aurorean and all the other phenomena that space weather cause.

Q Now, one of our questions that we had also

was -- and you already are explaining some of this due to the understanding in finding coronal holes from a space point of view, with what and where were you involved in other aspects of space weather research including what you've just been describing.

A Well, I was -- yeah, Skylab was exciting times. I was an experiment scientist on the coronagraph. But as I say, with the five instruments, the five telescopes that we had, worked together.

And we had cooperative observing plans so that we operated the telescopes jointly toward -- to try to answer specific solar questions.

And then I moved on to become the chief of the solar science -- Solar Physics branch at Marshall Space Flight Center for five years. And then I came to Boulder and became the director of what was then the Space Environment Center where NOAA was doing operational space weather forecasting.

So my personal involvement was -- in research was pretty much with the Skylab era and then trying to understand solar magnetic fields better when I went down to Marshall, they had a solar

magnetograph. And then being the director of a research outfit at NOAA trying to improve the space weather forecasts.

Q Do you have the sense that the work that you and the team did with Skylab actually ignited some of the excitement, if not a lot of it, for the public, the government, NASA to learn more about space weather?

A There's no question about that. The Skylab was transformational in quite a number of ways. In 1968, NOAA had started to make daily predictions of flare probabilities and geomagnetic storm probabilities. But those were pretty crude.

And the Skylab project was so well-funded that NOAA got enough money to set up a worldwide observatory network to keep the sun under continuous observance in visible light and bring those results back to one location, actually two locations, one in Boulder at the home location and one down in Houston during Skylab to help with the operations of Skylab.

We changed the observing program. This was novel. This was transformational. Every day with a

teletype message based on what was the sun was doing.

And there was a huge wrangle over that because NASA had been involved in shorter missions before. And every minute of the astronaut's time, what they would be doing during a day was, in fact, scripted before the rocket ever left the ground.

And this was very new and uncomfortable to the flight controllers that they would allow a bunch of long-haired crazy sandal-wearing hippie scientists -- the astronauts what they'd be doing tomorrow on a day-by-day basis. And that was just a cultural shift for NASA.

But the result was that, one, we had a worldwide network of observatories; two, we had brand new never before available observations of the sun and we had those data coming down in real time. And the understandings that developed after Skylab shut down were, as I say, transformational in many ways to the understanding of space weather.

The other thing that Skylab -- although they were aware a little bit of the radiation hazard of sending astronauts to the moon and back, those are

still pretty short trips. Putting guys up for three months at a time, you got to worry about solar flares and the energetic particles.

And so suddenly, there's a whole radiation health component that NASA got interested in doing research and trying to understand the space weather aspects of that.

And now, of course, that's hugely important if we're ever going to go to Mars because that's such a long mission.

Q Well, that's right. And I -- my understanding is that for low earth orbit types of things where we might have humans in space in low earth orbit, they're still vulnerable, of course, to radiation and storms but not nearly as vulnerable as they would be if they were further away from the earth or outside of the magnetic field.

A That's absolutely correct. The earth's magnetic field provides a principal shield. And then for those of us poor mortals that have to stay on the ground, the atmosphere density helps a lot. But, yeah, once you get outside the earth's magnetic field,

you are much more at risk from radiation hazards.

Q Now, I believe that you have actually -- some of these events that you've been talking about and discoveries were actual turning points in space weather history.

And our third question actually says, you know, what are some of the key events or turning points in your space weather research and you've actually been answering that already.

A Well, good.

Q Do you have any other type -- anything else that you would like to add that you would like for our listeners to hear?

A Well, some key events and turning points, the going back even farther to my mind space weather -- interest in space weather, although it wasn't called -- actually started in World War II when it was noticed that high frequency radio transmissions were interrupted and affected by --

Q Hey, Ernie.

A -- solar --

Q Could I interrupt for just a second? There

was a small moment there -- you're fine now -- but there was just a moment where your voice bleeped out.

So right when you said there -- I guess that the key term wasn't space weather or space weather term wasn't used, it was right before that, but you bleeped out.

But you're back now. So you might want to start at the beginning of that, if you wouldn't mind.

A Okay. The first key turning point in space weather to my mind -- although, the phenomena weren't called "space weather" at that time -- it was during World War II when the high frequency HF radio communications were -- seemed to be disrupted and connected with the phenomena on the sun. The mechanisms weren't clear but the correlation was very clear.

And so the -- each military force had its own little research unit which was forced then -- into a propagation laboratory part then of the National Bureau of Standards when it moved to Boulder, Colorado.

But ever since then, the government has had

a -- well, before NASA was formed a research component in looking into space weather.

As near as I can remember, space weather wasn't -- there are several references using that term in the literature earlier, but it never caught on until George Siscoe, then a meteorology -- professor in the Meteorology Department at the University of California, Los Angeles, started using the term in his public talks and papers.

And then that got people realizing that it wasn't just a research effort like an astronomical or astrophysical research but actually it had application like meteorological research has application to what people actually feel and are influenced by.

So that was the first. And then as I said, Skylab came along and really galvanized everything, both with money and with understanding. I was trying to remember when NASA started up the Living With The Star program, but that name is absolute genius. Anybody who hears it, says, what does that mean? And living with our star, you've got to adapt to its angry moments. And that's different and that got people

thinking about the consequences of space weather.

Another huge turning point was when NASA launched the WIND spacecraft, so we actually could see and get data about coronal mass ejections headed toward earth. As I think I said earlier, it's rare that earth is in the line of fire of a coronal mass ejection. Usually they go off into some other part of the interplanetary medium, but -- so you don't know, in fact, when you see a coronal mass ejection whether or not it's going to hit earth.

So having a sensor upstream one hour then enables you to say -- to switch from a alert to a real warning that it's about to hit, take action if it will help. And so WIND, still up there, still operating, has been a wonderful turning point.

I think another turning point from my mind -- and you are, of course, getting the perspective of a guy who's been in operations, who's very interested in how space weather improves so it helps customers as well as how it improves intellectually in terms of the research and understanding -- but another huge -- along those lines, another huge jump forward was I

think the Wang-Sheeley-Arge model that actually was the first to try to use the observed characteristics of a CME near the sun and predict how strong the effect would be at earth.

Now, it's been superseded by the Enlil model that Dusan Odstrcil and his colleagues have developed, which is an even better three-dimensional model with MHD. But that -- both of those, the one following on the other by 15 years, was -- were just wonderful.

And the stereo spacecraft have done a wonderful job of getting different views of what's going on at the sun. And when they got around to 90 degrees from the sun earth line, then they could actually see the coronal mass ejections that were about to hit earth.

And otherwise, we had had to inhere from observations near the earth sun line which ones were going to hit earth. But they got very good observations of what was going to happen.

Q Now, with --

A Well --

Q -- the stereo moving, it's continually

moving around either side of the sun. Eventually, we'll lose that field of view. Correct? And do we have plans for how we're going to be able to see what's coming around after that?

A It's my understanding that after the stereo spacecraft go around the far side of the sun and start to come back around towards the front side, that they will be useful again.

Q That's great.

A But I --

Q Okay.

A -- an expert on what -- where that stands at the moment either technologically or financially.

Q Well, it's interesting listening to the different aspects and history -- historic parts of space weather because you see the importance of discoveries and how things were discovered, things that weren't expected, and what an impact that made immediately on people, on society.

It just really brings home the fact that we need to continue this type of research in a major way, especially with all the satellites and technology and

-- and people talking about venturing further and further into space.

A You're absolutely right that the more we learn about space weather and -- the better becomes our ability to predict it and its consequences.

And as the world becomes more technologically dependent upon things like GPS and the electric power grid that are affected by space weather, then it's certainly not a solved problem by any stretch of the imagination. If, at anything, it should have growing emphasis as we go forward.

Q That actually sounds perfect. I'm -- it's funny, I'm looking at the clock, we've already been doing this for 25 minutes and it's all really good. I think there's going to be just minor editing so far.

There's quite a bit of interesting information from Skylab all -- in past, that was pretty interesting. I love the information you talked about with the wind spacecraft. I don't think I've heard anybody talking about that one yet in some of these interviews.

A If you are -- this is off the record.

Q Uh-huh.

A If you are a fair researcher, the WIND space craft is irrelevant.

Q I'm so glad that you brought it up because it brings even more about the space weather fleet, if you will, that's out trying to understand what's going on and be better -- being better at predictability and predicting space weather events. Wow, how exciting is that.

Are there any other areas before -- I think we have quite a bit of really good information here, and I'm wondering if there are other pieces of information you'd like to share, we can certainly talk about that and then edit that in as we need to.

A Well, there is the whole -- I was preparing mentally and then I went back and looked at your questions. And I see that they are research, research, research.

Q Yeah.

A But there's a whole other side and that is the administrative side. I already mentioned -- okay, let me -- let me back up so that you don't have to

edit this.

In addition to the research side of space weather, there's a whole organization and -- organizational and administrative component to advancing space weather research and operations. And that has gradually grown in many ways. And there are some big turning points there, some milestones. It is -- you first have a voice crying in the wilderness, this is important, listen to me.

And then over time that messiah attracts followers and they start to spread the message and eventually there is enough realization that people are willing to organize themselves into cooperative ventures and to seek funding for increased activity in this area.

And again, Skylab was transformational in that it showed the need and the value. And suddenly within a decade after Skylab, huge understanding of what was going on so that space weather products for affected users were much more useful. And that, of course, fed back so that there were more people doing that, interested in space weather.

And then in 1994 there was a meeting held with the -- with Bob Corell, then director of geosciences at NSF, and George Siscoe pitched a -- the idea that there should be a national space weather program -- a National Space Weather Service, in fact, is what it was called in an article by Siscoe -- Latko -- George Latko, Lou Lanzerotti, Ernie Hildner, and Rich Behnke in EOS in 1994.

And that actually led to the National Space Weather Program, seven agencies in the United States government organized under the Office of the Federal Coordinator for Meteorology. Because there was no other place to put it, so space weather, let's put it under meteorology.

And that office's purpose within NOAA is to coordinate what all the agencies do in particular areas like hurricane research or drought research. And so we got space weather under that umbrella in 1994.

And then in 1999 NOAA started holding what today is called "Space Weather Week," which brought together the researchers, the operators that used the

forecasts and the information, and the service providers, the forecasters. And about 250 people showed up. And it has grown almost every year since then.

And over 350 people showed up at the most recent one in 2013, but it has been a continuing vibrant forum for the users to say what they need, the researchers to say, well, we could provide something like this if there's any demand for it, and the forecasters listening to both sides and saying, okay, we can make a product that has validity and that is useful and we will modify or add what we do to take advantage of the new knowledge and serving people with new needs.

So then another huge milestone was the establishment -- and I'm trying to remember when that was -- in the early 2000s of the CCMC, the community modeling center -- Cooperative Community Modeling Center, which is at Goddard Space Flight Center.

And there, people can submit their models for testing. And if they survive the testing, then users can run those models in real time to see what

their predictions of space weather are and how -- if they relate well to reality, then they can use those in what they do.

It is intended -- it was originally intended to be a validation effort so that these could go into -- these models, this new understanding, could go into daily operations.

Finally, I would say that a major turning point in the acceptance, if you will, of space weather is the fact that the space environment center joined -- fully joined and became a part of -- a full part of the National Weather Service, the nation's meteorological service, in 2005 which made the American Meteorological Society, not just the American geophysical union, be interested in space weather.

And at the national meeting of -- annual meeting of the American Meteorological Society there always is -- there has now started to be since then a major component of space weather.

And so the meteorologists, both the broadcast meteorologists on TV, the meteorology departments at universities, the -- and other folks

who would not have been exposed to space weather particularly, now at their own societies national convention see the emphasis that is given to space weather.

So there's been a whole governmental and public acceptance of space weather that has gone on at the same time as the research side, driven largely by NASA and NSF, have developed a better understanding of space weather.

Q So it's interesting to hear all of that because, in many ways, it sounds like we are still at the forefront of actually creating space weather history.

A Well, I'm retired, but I do keep the little finger of my left hand involved, yes.

Q You know something, we didn't do at the beginning that we need for the audio engineer and also we might be able to edit it in, is basically just for you to state your name and what you do.

Usually, I open it up with that and we forgot to do that. So would you mind doing that for just a second?

A I noticed that you didn't and wondered, but okay.

Q That's what I forgot.

A I'm Ernest Hildner. I'm retired. I was for 19 years the director of the space weather component of the National Oceanic and Atmospheric Administration. It had several name changes, Space Environment Laboratory to more recently Space Weather Prediction Center.

In that capacity, I was overseeing the research that NASA -- that NOAA did on space weather and the daily forecasts and the real time alerts when something happened that were produced by the center.

In addition, I assisted with defining the instruments that would fly on NOAA's geostationary and polar orbiting spacecraft, principally flown for meteorological and climatological purposes.

And I worked very closely with an NSF and with the NASA's Office of Solar and Heliospheric Physics to optimize what we could do and how we could best utilize research observations and understandings for operations.

And the WIND spacecraft is a wonderful example of that where they worked with Dick Fisher so that we could -- NOAA could get antennas around the world to track wind in real time and a very low bit rate channel was added to WIND so that it could send down real time information to these spacecraft; whereas, the high rate science information came down to NASA antenna -- antennas at a few space places around the world and eventually on subsequent spacecraft.

We worked with NASA so that a subset of the science data, when it came down to the NASA tracking stations, would immediately flow into the NOAA system and be available to the forecasters.

So the connection between NASA, NSF, and NOAA was very tight and I think mutually beneficial so that the research had benefits, taxpayers -- tangible financial benefit to the taxpayers and the university research funded by NSF had pay-offs.

Q Well, that sounds perfect. That -- I'm so glad we did that. I was like -- the audio guy here is like, oh, you need to ask him a little about himself

to begin with, I'm like, yeah.

So thank you so much. We'll probably edit that and put it up towards the beginning.

A The other thing I forgot to do is to say "hi" to Barbara Thompson. If she's going to edit this, please put -- Barbara in there.

Q Oh, we will. We'll make sure she gets that. She'll -- she'll be able to hear part of this and Carolyn Ng will go through -- and actually the entire interview will be transcribed first -- and then Carolyn and Barbara go through and start reading and listening and editing. And then we send it to the audio person who turns it into the final podcast.

And I've actually already created the intro and exit bumpers for each of these podcasts. And the first one should be going live relatively soon on the Sun-Earth Day web site.

And then once the Space Weather Living History tool is created on line, then bits and pieces parts will be added as is -- as is appropriate to the sections of that tool. So you'll -- you should be hearing yourself quite often.

A Okay. -- people are you interviewing?

Q We have upwards of, oh, gosh, I've already interviewed probably ten to 12 different people. And then we, I think, have about 20 at least on the list.

And then bits and pieces and parts of those are used for various aspects of the tool. But all of the interviews this year will appear, in some part, on the Sun-Earth Day web site.

So I can send you -- unless you already have the Sun-Earth Day link, we can send you that as these interviews are ready and you can just download, listen to them. And they'll be podcast so you can listen to them on -- from iTunes as well.

A Well, one never sounds as smart when one listens to one self as when one was talking.

Q Oh, you might be amazed. Well, we'll do some pretty interesting audio sound engineering to some of this. And, yeah, they come off sounding just incredibly great. We've been surprised at how well the Skype interviews actually do. They end up sounding pretty strong.

A Are you planning to interview George Siscoe?

Q I can find out. I know that -- I don't have -- it would shock me if we aren't, but I could certainly find out from Carolyn.

A Okay. Well, he and Lou Lanzerotti would -- are legendary and both as contributors and as being there at the beginning.

Q Yeah, I just wrote their names down and Carolyn will hear this, so I'm sure they have to be on the list. They -- I would be shocked if they weren't. But if not, they will be now.

A I hope so. I hope.

Q Oh, yeah, absolutely.

A Okay. It's been good ranting, venting.

Q It's far from that. It's just been a great interview. Thank you so much.

A Well, you're very kind to say so. And it's a pleasure to run my mind back over my professional history.

Q Yeah, isn't it. You're -- it's always shocking how much you've actually done when you're asked to sit down and go over it.

A Well, it is fun, yes.

Q Okay. Well, thanks again. And we will certainly be in touch with you soon as they're ready to do some of the editing of the transcripts so that you can take a look at that.

A -- forward to that.

Q All right. Thanks so much, Ernie. Really appreciate your time.

A Okay. Thanks, Troy.

Q Uh-huh. Bye.

(Whereupon, the interview of ERNIE HILDNER, was concluded.)

CERTIFICATE OF TRANSCRIBER

I, JANET M. RICE, a Transcriber, do hereby certify that I transcribed the audio tapes(s) of the proceedings had upon the hearing of this case, previously captioned herein, that I thereafter had reduced by typewriting the foregoing transcript; and that the foregoing transcript, consisting of Pages 1 to 34 both inclusive, constitutes a true, and accurate record of the proceedings had upon the hearing of said cause, and of the whole thereof.

WITNESS my hand as Transcriber this 26th day of August, 2013.

_____
JANET M. RICE
Transcriber

