

Capital Reporting Company
Baker, Daniel

1

1

INTERVIEW OF

2

DR. DANIEL BAKER

3

4

5

6

7

8

9

October 11, 2013

10

11

12

13

14

15

16

Conducted by Troy Cline

17

18

19

20

21

22

23

**Capital Reporting Company
Baker, Daniel**

2

1 P R O C E E D I N G S

2 MR. CLINE: Well, again, thanks so much.
3 This is -- and, Brian, it's already recording,
4 correct? Yeah, I think we're recording. There we go.

5 DR. BAKER: Okay.

6 MR. CLINE: And from the questions that we
7 talked about or that Carolyn sent to you, they're
8 pretty --

9 DR. BAKER: Uh-huh.

10 MR. CLINE: -- straightforward and very
11 general.

12 DR. BAKER: Yes.

13 MR. CLINE: And so what I'll do -- usually
14 in these kinds of interviews, since the interview is,
15 of course, about you and the content of what you're
16 talking about, unless something conversational
17 definitely comes up, I'll speak up, and we'll talk
18 about it, but often what I'll do is ask the question
19 and get it started, and you can repeat the question as
20 you answer, and then we'll generally edit anything
21 that I say, normally, out so that we just have an
22 interview --

**Capital Reporting Company
Baker, Daniel**

3

1 DR. BAKER: Okay.

2 MR. CLINE: -- of you kind of like NPR. And
3 if I have to do a voiceover later, we can deal with
4 that, and that'll work out just fine. Otherwise, if
5 something comes up that we can talk about, that would
6 be really cool. Of course, I want to -- have to ask
7 you about *Gravity* at some point. I don't know that
8 we'll use it.

9 DR. BAKER: I haven't seen it. It's been
10 highly recommended to me, but --

11 MR. CLINE: It's really good.

12 DR. BAKER: -- I usually don't go to movies,
13 but this sounds like it might be worthwhile.

14 MR. CLINE: It's actually -- dramawise and
15 the way it looks is phenomenal, what we saw in the 3-D
16 IMAX. And I -- after a couple hours of that, I walked
17 out. It took me about three hours to feel like I was
18 even on Earth again.

19 DR. BAKER: Well, let's try to make that the
20 same kind of story about space weather, shall we?

21 MR. CLINE: Yeah, let's do it. I think that
22 sounds great.

Capital Reporting Company
Baker, Daniel

4

1 DR. BAKER: Okay? Good.

2 MR. CLINE: Okay. So we'll get started now.

3 So, Dan, thank you so much for your time. We really
4 appreciate it. And we have some questions for you and
5 would like to learn more about who you are and what
6 you do. And before we get started, could you just
7 give us an introduction of who you are and what you're
8 doing?

9 DR. BAKER: Yeah. Let me introduce myself.
10 My name is Daniel Baker. I'm the Director of the
11 Laboratory for Atmospheric and Space Physics at the
12 University of Colorado in Boulder. I'm also a
13 Professor of Astrophysical and Planetary Sciences and
14 a Professor of Physics here at CU Boulder.

15 I'm a researcher doing work in the areas of
16 space physics and planetary science. I'm involved in
17 several different NASA missions and several NSF
18 programs, but one of my primary research interests is
19 really about the space environment, its effects on
20 human technology, what we now call space weather.

21 MR. CLINE: Now, with what and when were you
22 involved in space weather research? I know this -- we

**Capital Reporting Company
Baker, Daniel**

5

1 often, in the -- in space weather living history, talk
2 about space weather and all the way back to as far as
3 people were involved with it from the beginning and
4 sort of how they got to where they are now and the
5 impact that's had.

6 DR. BAKER: Yes. I've been involved in
7 space weather research, even before it was probably
8 called space weather research. My involvement goes
9 back -- I'd really trace my involvement back to my
10 earliest undergraduate work with James Van Allen and
11 subsequent work with -- at the California Institute of
12 Technology with Edward Stone.

13 But probably first recognition of how
14 important the applied side of our discipline is really
15 came about in my early work as a staff member briefly
16 and then as a group leader at the Los Alamos National
17 Laboratory. There, I really worked on programs that
18 were often involved classified kind of research, but
19 looking at the effects of the space environment on
20 what we would call operational satellites, trying to
21 understand whether the effects that were being seen,
22 operational anomalies on spacecraft, were caused by

Capital Reporting Company
Baker, Daniel

6

1 the environment or something more nefarious.

2 And so I really began to realize that the
3 basic scientific work we're doing, trying to
4 understand the Sun, understand the variability of the
5 Sun, understanding the variability of the space
6 environment that's often driven by solar changes
7 really can have profound effects on the operation of
8 space systems and ground systems, and so -- from those
9 earliest days.

10 And this would date back to the 1980s, let's
11 say, of understanding the dramatic effects that the
12 space environment can have on technological systems.
13 I really got very engaged in that at that time, and
14 it's continued to be an interest as well as a passion
15 and a vocation for me to pursue those kinds of
16 questions.

17 MR. CLINE: Now, what are some of the key
18 events or turning points that you remember in space
19 weather research and the work you've done?

20 DR. BAKER: Yeah, there were many key
21 events, I would say many turning points in the way
22 that space weather has evolved. But I would -- I

Capital Reporting Company
Baker, Daniel

7

1 would, again, trace a lot of things back to the
2 working as a researcher, as a scientist at the Los
3 Alamos National Lab, of seeing that there were events
4 that were a complete puzzle to the people in the
5 Department of Energy or in the U.S. Air Force,
6 complete puzzle as to why certain things were
7 happening to their operational sensors, and then being
8 able to look at the corresponding kind of scientific
9 data, understanding the -- and seeing what the Sun was
10 doing at the same time as some of these operational
11 anomalies. You know, the light bulb sort of goes on
12 when you see that very disruptive events occur only
13 under certain space physics or certain geophysical
14 kind of conditions.

15 And so that was really very rewarding to me.
16 I found it very rewarding to know that I was
17 advancing, you know, pushing back the frontiers of
18 space science, but also being able to use that
19 improved understanding to help national -- important
20 national programs perform better and at least
21 anticipate when those kinds of operational problems
22 might arise.

Capital Reporting Company
Baker, Daniel

8

1 Going forward a bit further, as I moved from
2 Los Alamos to the NASA Goddard Space Flight Center, I
3 also got very involved there in looking more at the
4 kind of operational systems that NASA was running; for
5 example, the TDRS satellites, the large communication
6 satellites that -- at geostationary that NASA
7 operates.

8 There too, I was able to use the expertise
9 that I developed in understanding the space radiation
10 energetic particles and their variability to help
11 those people at NASA who were working with contractors
12 to try to improve the design of major spacecraft
13 systems and to improve operational capabilities.

14 Of course, moving on into the later part of
15 the '90s and into the 2000s, being here at the
16 University of Colorado in Boulder, I've worked very
17 closely with my friends and colleagues at the Space
18 Weather Prediction Center at NOAA, here just across
19 town.

20 And, once again, we've developed some, I
21 think, remarkably useful tools. Among these has been
22 a system that takes observed space weather

Capital Reporting Company
Baker, Daniel

9

1 information, such as solar wind speed, and through
2 numerical prediction techniques, allows the NOAA
3 people to predict what the energetic particle
4 environment in the magnetosphere is going to be. It's
5 used -- it's been used for a number of years now. I'm
6 very gratified by that.

7 Also have been involved in working with many
8 other colleagues through NSF-supported work, such as
9 the Center for Integrated Space Weather Modeling, to
10 help see that the so-called Wang-Sheeley-Argge-Enlil
11 Model, the model that observes the Sun and then uses
12 those observations to predict what the solar wind
13 properties near Earth are going to be, to really see
14 that go from a strictly research kind of a tool to now
15 a truly operational space weather tool, that's in the
16 -- operating in the National Center for Environmental
17 Predictions.

18 So over the decades, I would say, that my
19 work has gone from being very science-oriented to
20 being work that tries to identify when there could be
21 a good link or a good hook to the more national needs
22 or international needs and especially operational

Capital Reporting Company
Baker, Daniel

10

1 system needs and to be able to make those kind of
2 connections. And it's a gratifying thing to be able
3 to do both basic research, but also research that has
4 a strong public purpose.

5 MR. CLINE: When you talk about operational
6 systems, are you primarily talking about satellite
7 systems, or are we talking about international systems
8 that affect us directly down here on Earth, on the
9 surface?

10 DR. BAKER: Yeah. When I use the word
11 "operational," it's a very encompassing term. It
12 really can mean satellite systems; for example,
13 communication satellites or reconnaissance satellites
14 operating, for example, at geostationary orbit. It
15 can also mean satellite systems such as the Global
16 Positioning System satellite constellation that's
17 operating at about half geo altitudes. It can involve
18 low-altitude spacecraft communication and remote-
19 sensing kind of spacecraft.

20 But I hasten to add that a lot of the work
21 we're doing now has relevance to what are really
22 ground-based systems. This can include the electric

Capital Reporting Company
Baker, Daniel

11

1 power grid, and it can include comm systems,
2 communication systems that involve radio communication
3 or other such things.

4 So we have really, as a society, have built
5 a cyber-electric cocoon that goes from -- I suppose
6 you might say from the surface of the earth or even
7 below the surface of the ocean all the way to sort of
8 the farthest reaches of our Earth's magnetosphere, and
9 all of those are extremely interesting scientifically,
10 but they also are the home for many systems that we
11 rely upon for our daily societal needs. And so I
12 really use the term "operational" to include all the
13 things that we as a society depend on.

14 MR. CLINE: In your experience, one of the
15 hats that you've worn has -- as being an astronaut,
16 and in your experience with humans in space and human
17 exploration of space, how does your -- has your
18 research, do you believe, impacted how humans can live
19 and survive in space, perhaps for long periods of
20 time?

21 DR. BAKER: Yes. I -- while not an
22 astronaut myself, I have been very interested in how

Capital Reporting Company
Baker, Daniel

12

1 the effects of the environment on humans in space has
2 occurred. And, of course, again, my work involvement
3 goes back probably to the 1980s or so, when longer-
4 duration kind of human space flight was really getting
5 underway.

6 And a lot of my research was directed toward
7 understanding very energetic particles as are trapped
8 in the Earth's radiation belts; also, as a result from
9 powerful coronal mass ejections and solar flares from
10 the Sun. And understanding those high-energy
11 radiations and how they interact with both robotic and
12 human life forms in space really has been another
13 gratifying aspect of this, to be able to take our very
14 basic research and to try to understand how these
15 high-energy particles occur, when they will occur,
16 when they won't occur, try to provide both alerts and
17 warnings for the times when the most severe space
18 radiation is going to occur, but also trying to
19 provide green-light kind of conditions when things
20 will be benign and relatively free from risks to human
21 and other life in space has really been an important
22 component to this.

Capital Reporting Company
Baker, Daniel

13

1 And, you know, we recognize that the
2 radiation in space is one of the really tall poles
3 when it comes to threats, and it's really one of the
4 most sort of immutable risks that we have, for humans
5 having long-duration space flight. And so trying to
6 develop a deeper physical understanding of the Sun, of
7 the magnetospheric environment and other places where
8 humans will be operating, and being able to provide
9 genuine long-term as well as short-term prediction of
10 the space radiation changes is probably one of the
11 most important things NASA can pursue.

12 MR. CLINE: When you speak about making
13 predictions, at what point, typically, does a
14 prediction begin, like within the research? Does it
15 start with the flare or coronal mass ejection and then
16 you make predictions based off of that when the impact
17 or how much the impact would be, and/or does it --
18 does the prediction process for you now start earlier
19 than that? Like are there understandings of the Sun
20 and the dynamo of the Sun in such a way that you can
21 actually -- you're almost to the point of being able
22 to predict when there may be a flare?

Capital Reporting Company
Baker, Daniel

14

1 DR. BAKER: Well, the issue of being able to
2 make predictions about the space environments is an
3 intriguing one. Often it's attributed to either Neil
4 Spore, if you're very intellectual, or to Yogi Bear,
5 if you're not so intellectual, but the statements is
6 that predictions are hard, especially about the
7 future.

8 And what we, of course, recognize is that
9 our chances of predicting what's really going to be
10 disruptive to human interests really has to start
11 pretty early, with very deep fundamental understanding
12 of the Sun, variability of the Sun, the variability of
13 the space environment; ultimately the things that are
14 going to reach and impact the near-Earth environment.

15 And so think -- if you look at what's
16 happened over the last, say, decade or slightly more
17 than a decade, the progress has been tremendous in our
18 ability to issue accurate predictions, forecasts,
19 alerts. And I think it's really come about because we
20 have been looking back further and further in the
21 sequence of events, the chain of events that
22 ultimately leads to a disruptive space weather event,

Capital Reporting Company
Baker, Daniel

15

1 looking more deeply, and trying to peer, even, into
2 the interior of the Sun through helioseismology,
3 keeping a very close eye on the Sun, active regions on
4 the Sun, getting a deeper understanding of which
5 active regions are most unstable, when they might go
6 unstable.

7 All of these things sort of precondition us
8 to be ready to act pretty smartly when a major solar
9 disturbance thing occurs. But then having the
10 observing platforms, not only from the Earthward point
11 of view, but around the Sun, to look at the three-
12 dimensional Sun in as much detail as possible, and
13 then feeding that information as quickly as possible
14 into numerical models and to predictive models and
15 being able to follow that outward.

16 We, of course, have a long way to go in
17 order to have absolutely precise and accurate
18 forecasts and alerts, but we've come further faster
19 than I think almost anyone could have imagined, say, a
20 decade ago. And it gives me great optimism that we
21 are going to be able to continue to improve our
22 insights, our physical understanding, and that this is

Capital Reporting Company
Baker, Daniel

16

1 going to go from insight to foresight, and that kind
2 of progression is just what we need in order to serve
3 societal needs, in my opinion.

4 MR. CLINE: And that was a perfect answer to
5 that, because my next question was going to be about
6 your idea of where we can go from here as far as
7 making predictions and foresight in in the future --

8 DR. BAKER: Yeah.

9 MR. CLINE: -- of space weather.

10 DR. BAKER: Well, it's -- to me, it's a very
11 interesting thing. I go back, often, to the kind of
12 ideas of Arthur C. Clarke, who talked -- who said that
13 information is not knowledge, and knowledge is not
14 wisdom, and wisdom is not foresight. We have to -- we
15 have to continuously progress along that, of taking
16 all the vast information we now have about the space
17 environment, about the Sun. We have to convert that
18 information into actionable kind of knowledge.

19 And actionable knowledge, to me, really
20 means to develop the wisdom to understand what's
21 important about the system, what's less important, and
22 then to be able to convert that to the real kind of

Capital Reporting Company
Baker, Daniel

17

1 foresight that will provide the -- provide for the
2 needs of human society.

3 We've seen, in recent times, that we've --
4 that models that start out to be just curiosity-driven
5 research kind of models can be adaptive, can be
6 utilized, and there's nothing as useful for improving
7 our insight as to try to predict real-world
8 circumstances, figure out why we didn't do so well, go
9 back and tweak things, and continuously improve the
10 process, the chain.

11 And this, I believe, has been one of the
12 most important components of the dramatic improvements
13 in capabilities over the last decade has been going
14 from simply curiosity-driven science to this research,
15 which I like to say is basic research with a high
16 public (ph) purpose.

17 MR. CLINE: I love that quote. I might
18 change my quote on my personal pages to what you just
19 said. So it was information is not knowledge,
20 knowledge is not wisdom, and wisdom is not foresight?
21 Did I get that right?

22 DR. BAKER: Right. Correct. Right.

**Capital Reporting Company
Baker, Daniel**

18

1 MR. CLINE: That's brilliant. Do you have
2 the -- these are incredible answers to these
3 questions. Thank you so much.

4 DR. BAKER: You're welcome.

5 MR. CLINE: Do you have any additional
6 stories that you'd like to share or anything that
7 stands out in your mind of an experience you've had or
8 a storm or people you've met or any type of experience
9 like that?

10 DR. BAKER: Well, I would like to relate to
11 you one experience. It's quite recent, actually, and
12 I might also relate to you something from longer ago,
13 but I have often thought what does it take for us to
14 communicate as a research community to policymakers?
15 And just completed a paper which just appeared online
16 for the *Journal of Space Weather*, and it looks at an
17 event that occurred in July of 2012, and the wonderful
18 NASA spacecraft, STEREO Ahead, STEREO A, was observing
19 the Sun, saw a hugely powerful coronal mass ejection,
20 a halo kind of event, headed clearly right toward the
21 spacecraft.

22 All other NASA assets, the Earth and the

Capital Reporting Company
Baker, Daniel

19

1 other interplanets of the solar system, were all sort
2 of congregated diametrically opposite to this
3 spacecraft in their orbits. But this coronal mass
4 ejection went from the Sun to the spacecraft in about
5 18 hours. This is immensely fast. The original
6 clocked speed was something like 3,500 kilometers per
7 second, one of the fastest coronal mass ejections ever
8 seen.

9 And so we were very curious about this is a
10 hugely powerful event. If this had occurred a week
11 earlier, it would have hit the Earth. But we've often
12 asked for -- we've sort of in our minds asked for a
13 demonstration kind of experiment that wouldn't really
14 harm all of the Earth and its -- and human
15 technologies, but would still allow us to sort of look
16 at how bad can space weather get? And this was a very
17 nice, very convincing, to me, demonstration kind of
18 experiment.

19 And so we've taken the observations from the
20 STEREO A spacecraft, run them through our models of
21 what would have happened at the Earth, began to see
22 that this storm, had it occurred -- had the Earth been

Capital Reporting Company
Baker, Daniel

20

1 in the way, would have been larger than any storm, a
2 solar storm or geomagnetic storm, that occurred in the
3 20th century and, in fact, in many ways, would have
4 been comparable, probably, to the storm -- the famous
5 storm observed by Richard Carrington in 1859, so 150
6 years ago.

7 And so to me, this is a very recent
8 illustration, a shot across the bow, if you will, a
9 demonstration of the Sun's power, even during what
10 many would call a relatively weak solar activity
11 cycle. Some have called this a wimpy solar maximum.
12 But what we see is that the Sun, even at its wimpiest,
13 is capable of hugely powerful outbursts and that
14 oftentimes it's more a matter of timing and luck than
15 it is anything else, whether the Earth is going to be
16 impacted or not. So we don't have to go back 150
17 years into the moldy old records of the Victorian Age
18 to really see a solar storm that would have been
19 absolutely devastating, in my opinion, to human
20 technology.

21 So what do we do with this? It seems to me
22 that we as a society should learn the lessons of the

Capital Reporting Company
Baker, Daniel

21

1 present as well as the past. We should take this kind
2 of experience, this kind of demonstration that the --
3 that nature has chosen to perform for us, use it to
4 good effect, play it through our models, play it
5 through our societal dependences, and, in a sense, war
6 game (ph) the whole business of space weather to now
7 understand what if -- what if this storm had occurred
8 a week earlier and the Earth had been in the line of
9 fire, rather than just one of Earth's emissaries,
10 STEREO A, and really use this for power companies, for
11 spacecraft operators, for communication needs, all of
12 the things that we depend on so much. We now have a
13 good object lesson has been performed by nature, and
14 we ought to learn good lessons from it.

15 So that's a -- to me, that's an interesting
16 recent development and one that I think we should all
17 pay heed to. The other thing I'd like to say is that
18 while "space weather" has been a much-used term in the
19 literature and publications in the last decade, it
20 really goes back to probably the earliest times.

21 And I had talked about my -- one of my early
22 mentors, James Van Allen, and after visiting with him

Capital Reporting Company
Baker, Daniel

22

1 and giving a talk at his 90th birthday party, sent me
2 a very kind letter, and in it, he had just remarked
3 that he was very interested in the work that I was
4 doing on space weather, but that, in many ways, he
5 considered himself, from his earliest days, to have
6 been involved in space weather too.

7 So even his work, going back to the 1950s
8 and '40s, Van Allen recognized that the thing that we
9 now call space weather has been almost seamlessly
10 linked back to the earliest work in the -- in the
11 Space Age back at the beginning of the Sputnik Era.
12 And so we shouldn't think that we've just invented
13 this recently. It's really something that's been with
14 us for a long, long time.

15 MR. CLINE: That's amazing, and I love that
16 you brought in Van Allen. That means a lot.

17 DR. BAKER: Great.

18 MR. CLINE: I have one question I was going
19 to ask. You actually answered -- I was going to ask
20 you about your experience with one of the larger
21 storms and what that was like, and you just walked
22 through that, so I think that's going to be a real

Capital Reporting Company
Baker, Daniel

23

1 interesting listen for a lot of our people.

2 DR. BAKER: Great.

3 MR. CLINE: And also what they'll do is
4 they'll take many of these statements and different
5 things that you've said, and they'll take quotes and
6 pieces out of it and build that into other parts of
7 this online tool that they're creating so people
8 can --

9 DR. BAKER: Excellent.

10 MR. CLINE: -- experience that, so that
11 should be --

12 DR. BAKER: Good, good, good.

13 MR. CLINE: That should be really good.

14 DR. BAKER: Good.

15 MR. CLINE: All right?

16 DR. BAKER: Good.

17 MR. CLINE: Well, that was wonderful. I
18 really --

19 DR. BAKER: Well, I'm glad. I hope I've --

20 MR. CLINE: Yeah.

21 DR. BAKER: -- answered in small ways the
22 things you were trying to get. And --

**Capital Reporting Company
Baker, Daniel**

24

1 MR. CLINE: You certainly did.

2 DR. BAKER: -- of course, if you have other
3 questions or things you'd like to follow up on, I'd be
4 happy to work with you more. Okay?

5 MR. CLINE: Oh, that would be great. What
6 we'll do -- that would be wonderful, because Carolyn
7 Ng will go through this and have a transcript made.

8 DR. BAKER: Okay.

9 MR. CLINE: And she'll go through and do
10 some basic editing, and then after that's done, she
11 sends the final version out, and I believe she sends
12 it to everybody who's been interviewed so they can
13 take a good, close look --

14 DR. BAKER: Okay.

15 MR. CLINE: -- and strike out anything or
16 move something around, and then that comes to the
17 editor. So we can do quite a bit of editing work on
18 it in the meantime.

19 DR. BAKER: Okay. Okay.

20 MR. CLINE: But most of what you said was --

21 DR. BAKER: Well, I'm sure I said many
22 idiotic things, so I'll look forward to you guys

Capital Reporting Company
Baker, Daniel

25

1 catching those.

2 MR. CLINE: I don't think you did. I think
3 everything was pretty straightforward and right on. I
4 think you've done this before.

5 DR. BAKER: Well, I hope it's useful, as I
6 say, and --

7 MR. CLINE: It is.

8 DR. BAKER: -- I'll be delighted to be part
9 of this project. It just sounds great.

10 MR. CLINE: Well, thanks so much.

11 DR. BAKER: You're welcome. Thanks for
12 calling. And good luck with getting it all sorted
13 out. Okay?

14 MR. CLINE: I really appreciate that.

15 DR. BAKER: Thanks, Troy.

16 MR. CLINE: Uh-huh. Bye.

17 DR. BAKER: All right. Bye.

18 (Whereupon, the interview of Dr. Daniel
19 Baker was concluded.)

20

21

**Capital Reporting Company
Baker, Daniel**

26

1 CERTIFICATE OF TRANSCRIPTION

2

3 I, MARY E. YOUNG, hereby certify that I am not
4 the Court Reporter who reported the following
5 proceeding and that I have typed the transcript of
6 this proceeding using the Court Reporter's notes and
7 recordings. The foregoing/attached transcript is a
8 true, correct, and complete transcription of said
9 proceeding.

10

11

12

13

Date

Mary E. Young

14

Transcriptionist

15

16

17

18

19

20

21

22