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PHYSICS & SOCIETY

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Note from the Editor

2015 was an eventful year for topics at the intersection of physics and society. A climate deal in Paris, the framework of a deal concerning nuclear weapons with Iran, a renewed focus on sexism in science, ongoing battles over federal funding of scientific research and more. In our newsletter during the last year, we printed articles about geomagnetic disturbances, nuclear waste, nuclear warhead verification, plutonium demilitarization, and nuclear disarmament.

For me personally, 2015 was the year that I decided to fully explore the intersection between physics and politics. In November, I won election to the New Jersey General Assembly by running a candidate-specifc micro-targeted voter model developed by fellow physicist and member of this Forum, Sherrie Preische. We benchmarked the model against historical results and everything we did during the campaign was based upon predictive scores from the model. The political "experts" thought I had no chance to win and while our model couldn't predict the final margin of victory, 78 votes out of more than 34,000 cast, it accurately predicted the final outcome for all four of the candidates in the race several months before election day. I ran with only one campaign promise – to use evidence to make decisions, no different than what each of us does every day. In New Jersey, the Legislature is a part-time job so I feel quite fortunate that I can keep my job at Princeton and continue to edit this newsletter.

Speaking of newsletters, we kick off the first issue of 2016 with a listing of FPS-sponsored sessions at the upcoming March and April meetings. While these sessions are one of the prime activities of our Forum (along with this newsletter), our Executive Committee has a request on page 3 for your input on ways we can expand. Our former Chair, Aviva Brecher, has written a letter to the Editor about creating a new FPS award and I always appreciate hearing from you on issues that you feel are important and of interest to our readers. In 2015, the US restored diplomatic relations with Cuba and our main article for this issue is a fascinating look at how science and scientists can help break down walls between countries. As always, we end with book reviews put together by our Book Editor, Art Hobson and his outstanding team of reviewers.

Finally, I need your help in identifying topics and authors that are willing to submit articles for publication in future issues of the newsletter. In the end, it is you that make this newsletter what it is and I welcome your suggestions and your submissions.

Happy 2016!

Andrew Zwicker
azwicker@princeton.edu

IN THIS ISSUE

APS 2016 March Meeting • Forum on Physics & Society • March 14-18 Baltimore, MD

MONDAY, MARCH 14 • 2:30 PM *(with History of Physics)*

SESSION C14: The Author in Dialogue: Steven Weinberg's "To Explain the World"

Chair: Joe Martin, Michigan State University
Room: 310
Speakers: Steven Weinberg, Reflections of a Whig Physicist
Gerald Holton,
F. Jamil Ragep, To Explain Copernicus: The Islamic Scientific and Religious Contexts
William Thomas, The Diagnosis of Error in Histories of Science
Jennifer Ouellette

MONDAY, MARCH 14 • 2:30 PM *(with Division of Biological Physics)*

SESSION C55: The Physics of Epidemics

Chair: Walter Beyerler, Sandia National Laboratories
Room: Hilton Baltimore Holiday Ballroom 6
Speakers: Victoria Davey, Mitigating Infectious Disease Outbreaks
Charles Macal,
Timothy Lant
Michael Washington, What do Public Health Officials Expect from Modelers During a Response to an Epidemic or Outbreak?

THURSDAY, MARCH 17 • 8:00 AM *(with Division of Biological Physics)*

SESSION R55: The War on Cancer: Physics Enters the Fray

Chair: Arian Pregenzer, Sandia National Laboratories
Room: Hilton Baltimore Holiday Ballroom 6
Speakers: Anna D. Barker, Why is Physics Important to Cancer Research?
Robert Austin, Evolution, Physics, and Cancer: Disrupting Traditional Approaches
Krastan Blagoev, Physics Insights into the Nature and Structure of Cancer
Chris Adami, Information, Physics, and Cancer
Michael Graham Espey, The National Cancer Institute's Physical Sciences - Oncology Network

THURSDAY, MARCH 17 • 11:15 AM *(with History of Physics)*

SESSION S14: The Iran Nuclear Deal: Physics, Physicists and the Historic Agreement

Chair: Micah Lowenthal, National Academy of Science
Room: 310
Speakers: R. Scott Kemp
Ernest Moniz
Gotz Neuneck
Anton V. Khlopkov

SATURDAY, APRIL 16 • 10:45 AM

Recent Discoveries in Planetary Science and their Potential Impacts on Physics and Society

Recent discoveries by planetary scientists studying the near universe suggest an increasing probability for the existence of other life in the universe. We explore the potential impacts of a discovery of such life on physics and society as a whole.

SATURDAY, APRIL 16 • 1:30 PM

Modernizing Nuclear Weapons

Modernizing US nuclear weapons is hotly debated: is the stockpile populated well for the future? What changes encourage proliferation? What do we have to know before making informed decisions? This session will address these and other questions.

SUNDAY, APRIL 17 • 10:30 AM

Politicizing Science: Benefits and Costs

Science has always been influenced by religion, money and values. This session will explore the relationship between politics and science, how today's environment compares to that of the past, and how scientists can make things better or worse. (Speakers: Joel Primack, Rush Holt, Spencer Weart

SUNDAY, APRIL 17 • 3:30 PM

Fracking and Physics

Hydraulic fracturing, fracking, injects fluid under pressure into porous rock to extract petroleum and natural gas. Fracking improves production but may harm the environment. The technology and its social and environmental impacts will be discussed.

WANTED: A FEW GOOD IDEAS

The purpose for which the Forum on Physics and Society was founded is to address issues related to the interface between physics and society as a whole, and FPS has a proud track record in doing so. For example, issues related to arms control and energy have been central themes. The Forum's effectiveness in addressing these complex issues demands the active involvement of many of its members. As of now, vehicles for the Forum's activities are this newsletter, invited sessions at meetings and short courses on selected issues. However, up until now, these activities have not engaged the majority of Forum members. We are therefore seeking ideas for projects that will expand participation in Forum activities. We request that any suggestions be sent to Ruth Howes at: rhowes@bsu.edu.

Arian Pregenzer, Chair
Ruth Howes, Chair-Elect,
Allen Sessoms, Vice-Chair
Micah Lowenthal, Past-Chair

LETTER TO THE EDITOR

As a long time FPS member and former Executive Committee and Chair, I have been particularly appreciative of the lifelong substantive contributions to FPS initiatives and activities from people like David Hafemeister and Ruth Howes. I especially enjoyed the FPS History documenting major contributions made by the Forum over the years, compiled by Dave and posted in the latest newsletter issue. I propose that a new FPS award specifically recognizing such lifetime leadership and contributions to FPS be established. I hope that the ExCom will consider this proposal at its next meeting.

Sincerely and with my thanks for disseminating this suggestion,
Aviva Brecher, PhD (ret.)

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COOPERATION ON GPS METEOROLOGY BETWEEN THE UNITED STATES AND CUBA

BY RICHARD ANTHES, ALAN ROBOCK, JUAN CARLOS ANTUÑA-MARRERO, OSWALDO GARCÍA, JOHN J. BRAUN, AND RENÉ ESTEVAN ARREDONDO

The events leading to the installation of a U.S. GPS receiver to measure precipitable water in Camagüey, Cuba, and the related collaboration of U.S. and Cuban scientists are described.

COOPERATION ON GPS METEOROLOGY BETWEEN THE UNITED STATES AND CUBA. It is a truism that the atmosphere does not recognize geographic or political borders, and because of this, there has often been cooperation between meteorologists in countries that disagree on many other issues. A prime example of this cooperation was the visit of the American Meteorological Society (AMS) delegation to China in April and May 1974 (Kellogg et al. 1974).

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CORRESPONDING AUTHOR: Richard Anthes, University Corporation for Atmospheric Research, 3090 Center Green Dr., Boulder, CO 80301
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The abstract for this article can be found in this issue, following the table of contents.
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In final form 24 September 2014

Interactions between Cuba and the United States have been minimal in most respects since 1959 and the U.S. embargo of Cuba that began 19 October 1960. The embargo, which continues today, is a commercial, economic, and financial embargo—it prohibits all exports to Cuba except for some food and medicine. Cuba is a member of the World Meteorological Organization, through its Instituto de Meteorología (INSMET). INSMET is a government organization that carries out many of the functions of the National Oceanic and Atmospheric Administration's (NOAA) Office of Oceanic and Atmospheric Research and the National Weather Service (NWS).

Travel of U.S. citizens to Cuba and of Cubans to the United States has also been severely restricted since 1960. The economic embargo forbids the spending of money in Cuba by U.S. citizens without a license from the U.S. Department of the Treasury. However, there is a general license in effect for people in certain categories, including diplomats, journalists, and academics. This means that U.S. university scientists are free to travel to Cuba, as long as they work on academic pursuits during the visit, with the intention to produce scientific publications. This license has allowed the U.S. authors of this article to travel to Cuba several times. But the existence of the general license is not widely known. As a result, scientific

GENERAL LICENSE FOR U.S. SCIENTISTS TO COOPERATE WITH CUBAN SCIENTISTS

U.S. Department of the Treasury rules for cooperation with Cuba may be found online (www.treasury.gov/resource-center/sanctions/Programs/pages/cuba.aspx). Specifically, the relevant portion of the general license for scientists is that the general license includes the following:

"E. Full-time professionals conducting professional research or attending certain professional meetings

"1. Professional research. Full-time professionals are authorized to engage in Cuba travel-related transactions and such additional transactions that are directly incident to conducting professional research in their professional areas pursuant to § 515.564(a)(1) of the Regulations, provided that their research (1) is of a noncommercial academic nature; (2) comprises a full work schedule in Cuba; (3) has a substantial likelihood of public dissemination; and (4) does not fall within certain categories listed in § 515.564(c)-(e)."

interactions between the two countries, which are generally apolitical in nature, have been rare. As described in a recent *Science* editorial, "The official relationship between Cuba and the United States has been frozen for over half a century, restricting scientific cooperation in many fields" (Fink et al. 2014 and related letter Antuña-Marrero et al. 2014). See the sidebar for a brief discussion of the general license.

An exception to the rule has been the cooperation between Cuban and U.S. meteorologists in the respective national weather services (the NWS in the United States and INSMET in Cuba) on tropical cyclone forecasting. Since the days of the Jesuit priest Father Benito Viñes (Ramos Guadalupe[1] 2014), Cuban meteorologists have been leaders in forecasting Atlantic hurricanes, and have shared their forecasts and research methods freely with the United States. Even with the restrictions on discourse between the two countries, hurricane forecasters in Havana, Cuba, and Miami, Florida, freely share their data and forecasts, and hold frequent telephone conferences when tropical storms threaten the region.[2] The National Hurricane Center frequently flies its hurricane hunter aircraft over Cuba when the island is threatened by approaching storms.

However, aside from the cooperation between operational forecasters, interactions between U.S. and Cuban research meteorologists over the past 60 years have been rare. It therefore seemed like somewhat of a miracle when in May 2014 a team of atmospheric and geodetic scientists from UNAVCO and the University Corporation for Atmospheric Research (UCAR) sent and helped set up a global positioning system (GPS) receiver to measure atmospheric water vapor at the Grupo de Óptica Atmosférica de Camagüey (GOAC) at the Camagüey Meteorological Center in Camagüey, Cuba. GOAC (www.goac.cu) is part of INSMET (Antuña-Marrero et al. 2012). The GPS receiver immediately began to produce observations that can be used to estimate precipitable water (Fig. 1).

Even with slowly thawing political relations between the two countries, with the embargo still in full force, and the strict International Traffic in Arms Regulations (ITAR), how could scientists in the United States send any technical equipment to Cuba, much less sensitive instrumentation involving GPS technology?

This success story in scientific cooperation has several threads dating back over two decades. It was not a result of anyone's long-range strategic plan nor a piece of some larger diplomatic strategy to bring about a rapprochement between the two countries. Instead, like many international success stories, it resulted from individuals from both countries who over the years found common interests and developed mutual trust and were willing to work hard on overcoming the bureaucratic and political restrictions on both sides. It also involved a lot of luck and serendipity.

We begin the story with a workshop held 20 years ago at a North Atlantic Treaty Organization (NATO) Advanced Research Workshop on "The Effects of the Mount Pinatubo Eruption on the Atmosphere and Climate," Rome, Italy, 26–30 September 1994. Here, Alan Robock (then at the University of Maryland) met Juan Carlos Antuña-Marrero (research scientist at INSMET). Antuña-Marrero had contacted Robock by e-mail expressing his desire to attend the University of Maryland as a graduate student working on observing

[1] Luis E. Ramos Guadalupe is the director of the Historical Heritage Section of the Academia de Ciencias de Cuba (Cuban Academy of Sciences). Oswaldo García translated his biography of Father Benito Viñes into English, which was another result of the 2007 visits described in this paper. This biography (Ramos Guadalupe 2014) is available from the AMS.

[2] The NWS National Hurricane Center in Miami is a World Meteorological Organization–designated Regional Specialized Meteorological Center (WMO RSMC) for hurricane forecasts. This RSMC, as part of its regional responsibility, coordinates hurricane forecasts with Caribbean meteorological services.

the stratosphere after volcanic eruptions. Like most other graduate programs, Maryland requires scores from the Graduate Record Exam (GRE) and Test of English as a Foreign Language (TOEFL), but GRE and TOEFL exams are not offered in Cuba. As a result of their personal meeting, Robock vouched for Antuña-Marrero, and Maryland made an exception, offering him admission to the graduate program with a research assistantship, supported by a National Aeronautics and Space Administration (NASA) grant.

It took a full semester for Robock to get the U.S. Department of the Treasury to agree to pay Antuña-Marrero as a graduate research assistant under his NASA grant, so Antuña-Marrero did not arrive in Maryland until January 1996. There had been an unusual 50-cm snowfall the day before, and when Antuña-Marrero arrived, he saw snow for the first time in his life. The next day, as Robock's houseguest, he shoveled snow for the first time.

In 1998 Antuña-Marrero received his master of science degree from the University of Maryland working on lidar and satellite observations of stratospheric aerosols for use in climate modeling. Three years later (6–8 March 2001), Robock and Antuña-Marrero organized the First Workshop on Lidar Measurements in Latin America, in Camagüey. In 2002 Antuña-Marrero earned his doctor of philosophy (Ph.D.) from Rutgers University working with Robock. His dissertation title was "Comparison of SAGE II and lidar stratospheric aerosol extinction datasets after the Mt. Pinatubo eruption." Antuña-Marrero then returned to Camagüey to continue his meteorological research.

A second thread of this story begins in July 2003 when Oswaldo García, professor of Meteorology, then chair of the Geosciences Department, now the Department of Earth and Climate Sciences, at San Francisco State University (SFSU), met Mayra Santana, then working for INSMET, at the Sixth International Conference on School and Popular Meteorological and Oceanographic Education that was held in Madrid, Spain. García was born in Havana in 1947. His interest in meteorology was sparked as a small child by the spectacle of the "nortes," the local name for the occasional cold-air outbreaks from North America during the winter. Nortes interrupt the placid trade winds that characterize the climate of Havana and generate huge waves that crash over the city's iconic Malecón seawall. García immigrated to the United States as a 13-year-old with his family after the Cuban Revolution and continued to pursue his interest in meteorology. He received his Ph.D. from the Atmospheric Science Department at the University at Albany, State University of New York; did postdoctoral work at the University of Hawaii at Mānoa; and worked at the NOAA/Environmental Research Laboratories in Boulder, Colorado, before joining the faculty at SFSU.

The 2003 meeting in Madrid led to an invitation for García to attend the III Congress of the Cuban Meteorological Society in December 2005 in Havana. At this meeting, García's first trip back to Cuba since he left in 1961, he made a presentation describing SFSU's outreach efforts to increase interest in meteorology as a career among underrepresented minorities and took the opportunity to meet with many Cuban meteorologists. During this visit he was impressed by the eagerness of Cuban meteorologists to learn more about their American counterparts and made a commitment to help increase the meteorological collaborations between the two countries.

The third and final thread in the story was also developing at about this time. A heterogeneous network of GPS stations in the Caribbean was taking shape, primarily focusing on the use of GPS for surveying and solid earth science applications. John Braun, a scientist at UCAR who had a close relationship with scientists and engineers at UNAVCO, received funding from the National Science Foundation (NSF) to install a small network

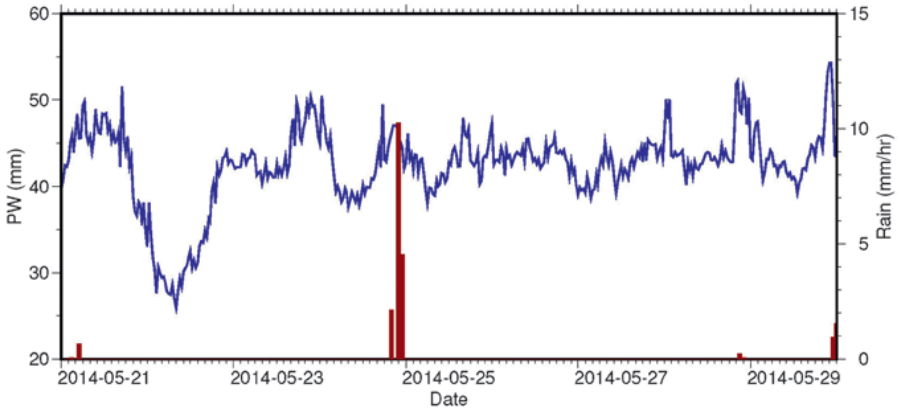

Fig. 1. Time series (21–29 May 2014) of precipitable water (PW; mm) at INSMET site in Camagüey, as measured by the GPS receiver. Also shown is the rainfall (red bars) collected from the Vaisala WXT collocated with the GPS. The time series starts on 21 May 2014, the first full day of data collected from the GPS station.

of ground-based GPS stations in the Caribbean for atmospheric applications.

A few months after García's trip to Havana, on 18 April 2006, San Francisco State University hosted a meeting of UCAR's University Relations Committee. García had met Rick Anthes, president of UCAR, two years earlier in Boulder during a meeting of the UCAR Academic Affiliates and they became good friends and colleagues. Robock was also at the 18 April meeting. During dinner, García and Anthes discussed the possibilities of scientific collaboration with Cuba and begin making plans for the visit of a UCAR–SFSU delegation to visit Cuba at the earliest opportunity.

The opportunity came sooner than expected, when Anthes was elected president of the AMS in late 2006, to serve in 2007. García put him in touch with the president of the Cuban Meteorological Society (SOMETCUBA), Andrés Planas, who invited him to visit Cuba to discuss possible collaborations between the two societies and the UCAR and Cuban scientific communities. This led to a visit on 27–30 March 2007 by Anthes, García, Karyn Sawyer [director of UCAR's Joint Office for Science Support (JOSS)], and Tim Spangler [director of UCAR's Cooperative Program for Operational Meteorology Education and Training (COMET)]. During meetings with SOMETCUBA and INSMET, the delegation discussed several potential joint research projects with their Cuban hosts (Figs. 2 and 3). On the afternoon of 28 March, the UCAR delegation visited the INSMET headquarters in Casablanca, across the bay from Havana, and one of numerous topics discussed was the possibility of installing a ground-based GPS receiver in Cuba. Braun had asked Anthes to bring this opportunity to the attention of INSMET leadership (Fig. 4). According to Anthes's summary of the meeting, written shortly after the visit:

> Rick Anthes invited Tomás Gutierrez (INSMET Director) and collaborators to write a paper for the *Bulletin of the American Meteorological Society* (*BAMS*), focused on the present state of meteorology in Cuba. He then presented INSMET with a book on the use of GPS for obtaining precipitable water estimates, and urged Dr. Gutierrez to consider John Braun's invitation to set up a GPS station in Havana that would help expand SuomiNet (Ware et al. 2000) into the Caribbean. Drs. Gutierrez and Mario Carnesoltas led the visitors on a tour of INSMET's facilities and viewed UCAR's website. Dr. Gutierrez showed strong interest in obtaining real-time precipitable water vapor information for the Caribbean basin and agreed to consider the possible deployment of a GPS station at INSMET's headquarters.

Fig. 2. Oswaldo Garcia, Mayra Santana (INSMET), Rick Anthes, Karyn Sawyer, Mario Carnesoltas, and Mirella and Andrés Planas on the roof of the INSMET site in Casablanca, Havana, 28 Mar 2007. (Photo by Rick Anthes.)

The presence of García during this first meeting was an essential part of its success. He not only acted as chief translator and active participant in all the discussions throughout the meetings, but his being a native Cuban helped in building an open and trusting relationship between the two sides.

In a completely independent event, two weeks before the UCAR–SFSU visit to Havana, Robock had visited Camagüey on 11–14 March 2007 to discuss continued collaboration with Antuña-Marrero and also visited Havana and INSMET. During his visit, Robock made Antuña-Marrero aware of UCAR's upcoming visit to Cuba to explore scientific cooperation, and a few months later, during August 2007, Antuña-Marrero wrote to Anthes expressing his interest in establishing cooperation and setting up the preliminary basis for future contacts.

Soon after the March visit, SOMETCUBA President Andrés Planas invited Anthes to give the keynote talk at the V Congress of the Cuban Meteorological Society. Anthes and his wife, Susan, visited Havana on 1–5 December 2007. García had planned to accompany them but had difficulties obtaining his visa. As the days to departure from Miami counted down, García optimistically expected the visa to arrive at any moment and even traveled from San Francisco, California, to Miami at his own expense the day before the scheduled flight to Havana. But in the end his visa did not arrive, and Rick and Susan Anthes, neither of whom speak Spanish, went to Havana anyway. The venue of the V Congress of the Cuban Meteorological Society was held in El Capitolio (National Capitol Building; Fig. 5). Despite not having García as a translator, Anthes had further discussions with INSMET about putting a ground-based GPS receiver at the INSMET weather observatory in Casablanca. It was clear that the Cuban scientists were still interested in this instrument and its observations, as well as collaborations with the United States, but only slight progress had been made since March.

Fig. 3. Tim Spangler (director of COMET, UCAR), Luis E. Ramos Guadalupe, and Rick Anthes in front of SOMETCUBA headquarters 28 Mar 2007. (Photo by Rick Anthes.)

Over the next two years, García continued to work quietly with both sides to keep the GPS meteorology idea alive. On 1–3 December 2009, García and Braun visited Cuba and continued discussions of putting a ground-based GPS receiver in Cuba. The discussions between Braun and Mario Carnesoltas held during this meeting helped clarify some technical questions and gave both sides a better understanding of the many hurdles, both technical and bureaucratic, that needed to be overcome before this project came to fruition.

On 12 January 2010, a magnitude 7.0 (Mw) earthquake occurred near Leogane, Haiti, killing at least 100,000 people and highlighting the susceptibility of the Caribbean to a range of geohazard events. In response to this catastrophe, the NSF funded the Continuously Operating Caribbean GPS Observational Network (COCONet) project. The aim of this infrastructure project is to develop a large-scale network of geodetic and

Fig. 4. Anthes demonstrating SuomiNet, a network of GPS receivers operating in the United States, at INSMET, Casablanca, Mar 2007. Behind Anthes are (left to right) Oswaldo García, Jesus Dole [head of Information Technology (IT) at INSMET], Daniel Martinez (head of Physics within the Atmosphere Department of INSMET), and Mario Carnesoltas. (Photo by Tim Spangler.)

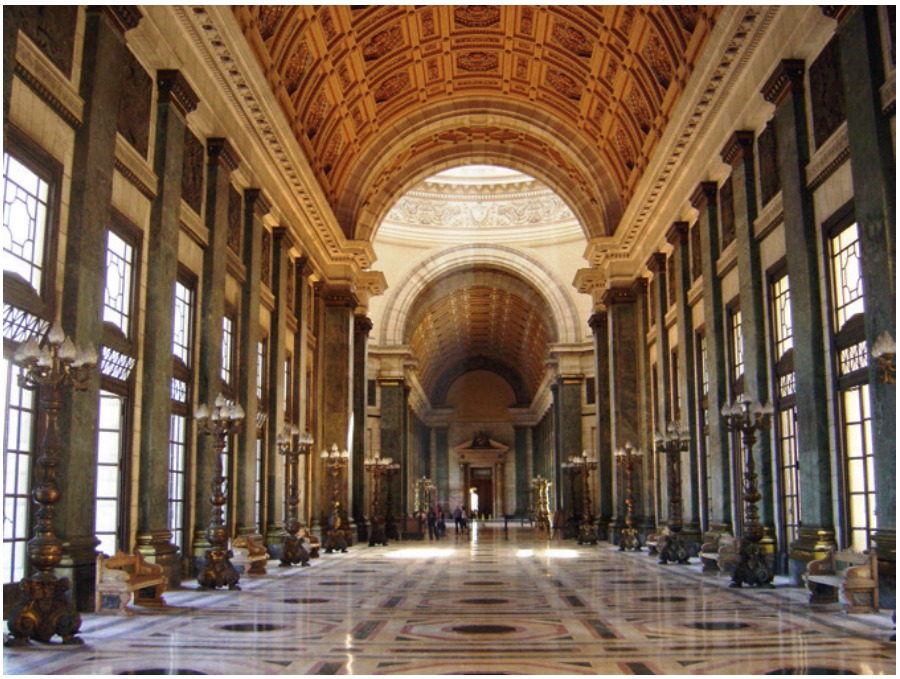

Fig. 5. Salon de los Pasos Perdidos, inside El Capitolio in Havana, venue of the V Congress of the Cuban Meteorological Society, 4 Dec 2007. (Photo by Rick Anthes.)

atmospheric infrastructure in the Caribbean that will form the backbone for a broad range of geoscience and atmospheric investigations and enable research on process-oriented science questions with direct relevance to geohazards (Braun et al. 2012). The significance of this project was that it created momentum in the Caribbean region for an international observational network to support geohazard research with an accompanying free and open data policy.

In the fall of 2010 the Robock thread of this story began to connect with the UCAR thread. As described in detail online (http://climate.envsci.rutgers.edu/Cuba/), Fidel Castro Ruz, now retired as president of Cuba, had discovered Robock's work on nuclear winter and asked Tomás Gutiérrez to invite Robock to Cuba to give a "lecture on climate change." Gutiérrez contacted Antuña-Marrero, who was on a working visit at the University of Valladolid, Spain, asking him to contact Robock and to invite him to attend a workshop on climate change to give a talk on his work. After arriving for his 14 September visit, Robock, now at Rutgers University, was asked if he minded that the comandante attend his talk. Robock agreed and Castro not only attended the talk, but participated vigorously in the discussion (Fig. 6). On this visit Robock also met Castro's son, Fidel Castro Diaz-Balart, who is science advisor to the president of Cuba, and is shown with Robock, Antuña-Marrero, and Gutierrez at the Hotel Nacional in Fig. 7.

Fig. 6. Fidel Castro making a point to Alan Robock, 14 Sep 2010, in Havana. (Photo taken by Fidel Castro's photographer, signed by Fidel Castro, and presented to Alan Robock after his lecture.)

A month later, in October 2010 at the annual UCAR meetings in Boulder, Robock described his trip to Cuba and his meeting with Fidel Castro to Anthes and García, who mentioned that they had been trying for three years to send a GPS receiver to Cuba. Robock met with Braun and agreed to help. Robock made Antuña-Marrero aware of the COCONet interest in installing a GPS receiver in Cuba, establishing contact between himself, Braun, and García. Antuña-Marrero expressed the GOAC interest of having access to GPS technology to continue the building of state-of-the-art

instrumental research capacities locally at Camagüey. It was at this time that the effort to establish a GPS receiver in Cuba shifted from Havana to Camagüey, largely because of Antuña-Marrero's and GOAC's strong interest and efforts on the Cuba side.

The week after Robock returned from the trip to Cuba, he received a phone call from the Cuban ambassador to the United States, Jorge Bolaños, who told him how happy Fidel Castro was with his visit, and invited him to lunch at the United Nations that week. Robock could not make that engagement, but the week after the October UCAR meeting, he accepted Bolaños's invitation to visit him in Washington, D.C. At that meeting, among other things, Robock asked Bolaños for help in arranging for the GPS to be installed in Cuba.

Fig. 7. Juan Carlos Antuña-Marrero, Alan Robock, Fidel Castro Diaz-Balart (son of Fidel Castro and science advisor to the president of Cuba), and Tomás Gutierrez (director of INSMET) at the Hotel Nacional in Havana, 15 Sep 2010. (Photo by Alan Robock.)

Meanwhile, the COCONet project was moving forward and on 3 and 4 February 2011 the COCONet Workshop for Community, Science, Station Siting, and Capacity Building was held in Puerto Rico. Juan Carlos Antuña-Marrero was invited to attend the meeting and had his trip supported by UNAVCO using the Office of Foreign Assets Control (OFAC) general license. Antuña-Marrero flew from Cuba to Panama but was not allowed to board the plane to Puerto Rico. He had previously applied to travel to NASA's Goddard Space Flight Center (GSFC) for an extended visit and there was a snafu in his passport and visa status. Antuña-Marrero had to return to Cuba on the next plane. Despite the travel problems, Antuña-Marrero was able to communicate to the workshop participants his continued interest and desire to participate in the project. At this point, the newly created COCONet siting committee made a commitment to provide instrumentation for Camagüey, assuming all logistical paperwork was approved.

Antuña-Marrero eventually resolved the issues with his passport and visa and was able to travel to GSFC for a visit there, under the Yoram Kaufman Visiting Fellowships Program, from 12 March to 30 April 2011. Because of bureaucratic obstacles on the Cuban side, the visit, planned for five months, was reduced to seven weeks. The leadership and decisive support from NASA and the University of Maryland, Baltimore County, through the Goddard Earth Sciences and Technology (GEST) Center Visiting Fellows Program (Raymond Hoff, director) and the office of Maryland Senator Barbara Mikulski, made possible the first extended visit of a Cuban scientist to a NASA facility that we know of.[3] (Robock had once arranged for Antuña-Marrero to visit NASA GSFC while a student at the University of Maryland, College Park, to attend a seminar on lidar observations of the stratosphere.) The visit was conducted under the guidance of and with scientific support from Dr. Loraine Remer and granted Antuña-Marrero the opportunity to learn about the advanced capabilities of the Moderate Resolution Imaging Spectroradiometer (MODIS) aerosols dataset and ongoing NASA aerosol research. While at GSFC, Antuña-Marrero was free to travel within the United States and on 21–23 April 2011 he visited Boulder, spending time with the Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) and UNAVCO and staying

[3] The sponsorship of this visit was made possible by a relaxation of the rules of academic interactions between the United States and Cuba by President Barack Obama in January 2011. The modified general license allowed "sponsorship, including the payment of a stipend or a salary, of a Cuban scholar to teach or engage in other scholarly activity at the sponsoring U.S. academic institution" [76 Fed. Reg. 19 (28 Jan 2011), Rules and Regulations].

at Braun's house. Logistics of his visit to UCAR were complicated, as there were many limitations put on what UCAR staff could do for him during his visit (by the U.S. Department of State and UCAR's attorney). Most of the discussions were on putting a GPS receiver at the INSMET weather station in Camagüey. A key outcome of this visit was a signed memorandum of understanding between UCAR, INSMET/GOAC, and UNAVCO to pursue collaborative research.

On 28 and 29 June 2011, Antuña-Marrero was able to attend the COCONet Network Operators Meeting in Port-of-Spain, Trinidad, where he reiterated the commitment by his research group to participate in COCONet. He was befriended by a number of Latin American scientists at the conference who assured him of their support within the broader COCONet community.

Over the U.S. Thanksgiving holiday (22–25 November 2011), Rick Anthes and his wife, Susan, John Braun, and a professor from San Francisco State University, Andrew Oliphant, visited Antuña-Marrero in Camagüey to tour his research facility and discuss the siting of a GPS receiver. The Camagüey chapter of SOMETCUBA (President René Estevan Arredondo) hosted the visit (www.goac.cu/sometcuba/act_vams.php). García had planned to accompany them, but once again his visa did not arrive on time and at the last minute he had to cancel. After their meetings in Camagüey, the Anthes, Braun, and Oliphant rented a car and drove to Ciego de Ávila, Cienfuegos, and then to Havana for meetings with INSMET and SOMETCUBA. On this trip, it was learned that progress was being made on getting Cuban authority approvals for a GPS receiver sent to Camagüey.

Three weeks later on 12–16 December 2011, Robock was part of an American Association for the Advancement of Science (AAAS) delegation visit to Havana to enhance scientific cooperation (Antuña et al. 2012). During the visit, he met again with Fidel Castro Diaz-Balart and urged the approval of the GPS installation in Camagüey. Robock emphasized that there were no security concerns for Cuba with the installation. Dr. Castro responded that while he knew that, the Cuban military would need to be convinced. Anne Thompson [president of the Atmospheric Sciences Section of the American Geophysical Union (AGU)] and Robock (past president of the Atmospheric Sciences Section of AGU) continued discussions on U.S.–Cuba scientific collaboration with Antuña-Marrero, and made plans to have him attend the 2012 AGU Fall Meeting.

During the AAAS visit, Tomás Gutierrez instructed Armando Muñoz, who was in charge of all the required paperwork to be conducted in Havana, to work with Antuña-Marrero. Muñoz played a key role in the process of getting the approvals from all of the involved Cuban institutions. He demonstrated professionalism and persistence in complying with each one of the formality procedures requested by the several Cuban institutions that were required to approve the import of the instrument. In some cases, he had to draft more than one version of the same document, each time getting the signatures and approval stamps of the required officers.

Muñoz's efforts succeeded and on 23 October 2012, Cuba granted a Cuban GPS import license, valid until 23 April 2013 (the import license was later renewed on 8 April 2013 and was valid until 8 October 2013).

At the December 2012 AGU meeting in San Francisco an informal meeting attended by Robock, Antuña-Marrero, Braun, and UNAVCO (UNAVCO President Meghan Miller, Glen Mattioli, Karl Feaux, and Jim Normandeau) was held to discuss logistical constraints in exporting equipment from the United States to Cuba. UNAVCO agreed to take the lead in applying for an export license. This process was tedious, with multiple resubmittals and clarifications, but eventually, on 6 June 2013, the U.S. Department of Commerce approved an export license for UNAVCO to ship a GPS receiver to Camagüey, leading to the establishment of the station as part of the broader COCONet project.

However, the U.S. approval of the export license did not end the bureaucratic process. On 9 October 2013, Antuña-Marrero wrote to Robock:

> Dear Alan:
>
> We are now dealing with the Agency in Charge of the Import. Having all the official documents in their hands (because it is an import from the US) they are requesting additional approval letters from the Foreign Affairs Offices of the Ministry of Sciences, the Ministry of Commerce and International Cooperation.
>
> Interviews have already been requested with the people in charge of those offices to hand them letters (signed by Tomás) explaining why their letters are required and handing then copies of all the official documents. Then we should wait from then to produce the letters to be back to the Import Agency.
>
> Regards, Juan Carlos

Fig. 8. Group in front of GOAC in Camagüey 23 Nov 2011. Back row from left to right: Dositeo García Bargados, director of the Camagüey Meteorological Center (CMC), Juan Carlos Antuña-Marrero (GOAC), Karel Agüero Rodríguez (Forecast Department, CMC, and member of SOMETCUBA board), Carlos E. Hernández Bruneta (GOAC and member of SOMETCUBA board), Iomaris Pérez Abraham (Clima Department, CMC, and member of the SOMETCUBA board), John Braun (UCAR COSMIC), and Rick Anthes (UCAR president and AMS president). In front, from left to right: René Estevan Arredondo (director of GOAC and president of the Camagüey chapter of SOMETCUBA), Boris Barja González (GOAC and member of SOMETCUBA board), and Andrew Oliphant (professor of geography, San Francisco State University). (Photo by Rick Anthes.)

But on 22 November, Cuba renewed the GPS import license for the third time until 22 May 2014, and on 10 January 2014 Antuña-Marrero announced that the GPS import permission for Cuba had finally been granted by all the different authorities. All the necessary approval documents were provided by the Import Agency to Cuban Customs, paving the way for UNAVCO to ship the GPS receiver from Boulder to Havana in April via DHL Express, where it cleared customs and was then moved from Havana to Camagüey.

After the GPS receiver arrived in Camagüey, GOAC personnel led by its director, René Estevan Arredondo, conducted the refurbishing of the GOAC instruments site, setting up electrical and network connections for the GPS receiver and the associated automatic weather station. Both instruments plus a camera (for remotely monitoring the instrument's status and its security) were installed in advance of the arrival of the UCAR–UNAVCO team (Fig. 8).

Fig. 9. Group on roof of GOAC's instrument site in Camagüey after installation of the GPS receiver (white domed instrument, center). In front: Braun (UCAR COSMIC). Behind Braun, left to right: Nelson Diaz Spencer (GOAC), Jorge Rosas Santana (GOAC), Jim Normandeau (UNAVCO), Iralmis Yipsy Platero Morejón (GOAC), René Estevan Arredondo (director, GOAC), Juan Carlos Antuña-Sánchez (GOAC), Frank García Parrado (GOAC), Albert Rodríguez Vega (Clima Department, CMC, Ph.D. student, GOAC), and Juan Carlos Antuña-Marrero (GOAC). (Photo by John Braun.)

With the instrument and site prepared, Braun and Jim Normandeau (a UNAVCO field engineer) traveled to Camagüey during 19–25 May 2014 to help install the GPS receiver and get it running properly (Fig. 9). The first successful observations were made during this trip, and on 22 May 2014 Antuña-Marrero wrote:

> Dear Alan, Rick and Oswaldo:
>
> The GPS has been installed and it is running taking measurements. There is only one pending thing that Jim will do at UNAVCO (setting up an IP address) for finishing the real time transfer of the measurements.
>
> Our team had a very fruitful exchange with John and Jim and Rene. I think that we will be able to keep it running and the data flowing to UNAVCO. We also learned how to get the meteorological data on real time for future local uses.
>
> We have enjoyed the visit of John and Jim both in the professional and personal sides.
>
> Best Regards
>
> Juan Carlos

With the successful establishment of the GPS receiver in Camagüey and the joining of Cuba into the international COCONet research network, this story ends. But the collaborations, friendships, and collegial relationships established since 1994 leading to this milestone will go on for many years.

ACKNOWLEDGMENTS. Tomás Gutierrez, Fidel Castro Diaz-Balart, Armando Muñoz, Mario Carnesoltas, and Andrés Planas provided strong support to this project and to Cuba–U.S. scientific interactions in general. We thank the National Science Foundation for its support of UCAR and UNAVCO. The COCONet project is funded by the National Science Foundation under Awards EAR-1042906 (UNAVCO) and EAR-1042909 (UCAR). We also thank the Cuban Academy of Sciences, SOMETCUBA, the Camagüey Chapter of SOMETCUBA, the American Meteorological Society, the American Association for the Advancement of Science, and the American Geophysical Union for their support of Cuba–U.S. scientific cooperation.

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Natural Capital: Valuing the Planet

By Dieter Helm, Yale University Press, $32.50, 296 pages, ISBN 978-0300210989, Hardcover

Extrapolating from humanity's current course, the world in which we will find ourselves by the end of the century will be more populous (by several billion), more ecologically impoverished, have fewer non-renewable resources available, and will feature a hotter climate. Dieter Helm suggests in Natural Capital a means for governments and policy makers to prevent this deterioration of the natural resource base that threatens our future economic growth and quality of life.

A professor of Economics at Oxford and the chair of England's Natural Capital Committee, Helm advocates putting a price on natural resources and ecosystem services, with the goal of keeping the world's net value of natural capital constant. Our current economic system emphasizes short-term GDP growth decoupled from long-term consequences of ecosystem damage and resource depletion (global warming, soil exhaustion, watershed damage, etc.).

Fixing this situation requires developing an accounting system that assigns value to natural capital, as well as implementing policies to require compensation for resource depletion. For a model of how to extract fossil fuels without depriving future generations, Helm cites Norway's Oil Fund, established in 1990. The fund invests the profits of petroleum extraction in order to offset future decreases in oil revenue.

This model aims for cost neutrality; money raised by taxing emissions and depletion of resources would fund restoration of natural habitats and defray costs associated with permitted amounts of pollution. Helm anticipates that controlling emissions and ecosystem damage by taxation and permits rather than banning them outright will draw opposition from those he describes as "fundamentalist" environmentalists.

This rejection of the "save everything" mentality is a key premise of Helm's system of natural capital management. Rather than aiming for zero growth or zero development, the system permits substitution, in which compensation would be required for loss of wilderness and non-renewable resources. For example, habitat destruction arising from the building of housing developments would be counterbalanced by restoring ecosystems elsewhere.

The refutation of "save everything" is one of several sacred cows slaughtered in Natural Capital. Other radical principles include the following:

We cannot depend on limits to growth (eg, peak oil) to limit population growth or economic development—scarcity will not provide damage control in the near term. Thus, our focus should be on preserving renewable resources. Failure to maintain our resource base will limit our economic growth more than depletion of fossil fuels.

The "develop now, conserve later" approach to global poverty eradication is wrongheaded. The poor have the most to lose from depreciation of natural capital. Global policy initiatives should not attempt to equalize wealth across the globe in the current generation. Our focus needs to be on the next generation, whom we deprive of natural capital under the assumption that they will be wealthier than us and will be able to cope with the damage. In fact, the coming generations, strained by the burden of anthropogenic global warming and resource degradation, may be less well off than we are today.

Natural resources and ecosystems should not be considered "priceless"—maintaining the net amount of natural capital requires that resources be assigned a finite price. This allows for the preservation of resources in aggregate; economic growth depends on consumption of resources, but the depletion of fossil fuels and damage to renewable resources is permitted provided equivalent substitution is priced in.

Government regulation is an essential part of the system. The current "patchwork quilt" of regulation is insufficient, and in many cases has been developed under the influence of corporate pressure. While private trusts and non-profit organizations would play a role in preservation and restoration, government oversight of non-public assets is needed to maintain accountability.

Most importantly, the author refutes the ideas that we cannot afford the luxury of conservation and that growth and environmental protection are mutually exclusive. As an economist, Helm provides a sorely needed voice of authority to argue that the consequences of business-as-usual are a major threat to our economic future, and that future growth requires taking action now to curb the damage.

Natural Capital provides convincing arguments for an economic system that explicitly values natural resources, and describes realistic policies to conserve those resources. Its approach to sustainability focuses squarely on limiting the damage of consumption rather than reducing demand for natural capital in the first place. Attempts to reduce pressure on natural resources by reducing energy use and eating lower on the food chain are dismissed as attempts to achieve a zero-growth society, a "utopia" that is "never going to happen" (p. 37). Although population projections are repeatedly invoked as part of humanity's pressure on natural capital, the author does not address the role of policy in reducing population growth, or any other government policies that would reduce demand for natural capital. Readers interested in how government regulation or private action could reduce consumption will not find guidance in this book.

In general, this is not a book in which to find actionable suggestions for the ordinary citizen. One of the few avenues for action described for the average person is membership in private clubs, which may have an interest in preserving

natural habitat for recreational use (eg, fishing). Although not mentioned in the text, a good example of such a club is the Surfrider Foundation, an American non-profit organization dedicated to preservation of coastal habitat. Overall, however, the role of individual action is heavily downplayed.

The future of our society would be brighter if the framework advocated by Natural Capital was adopted by our systems of government. The need for politicians and public policy-makers to understand the principles of natural capital management is compelling. In spite of the author's experience on England's Natural Capital Committee, guidance for how such a system would be implemented is a conspicuous omission. It would be beneficial to know what lessons the author has learned from chairing the Committee, and how to best influence public policy and embark upon the path described in the book. Natural Capital gives a thorough description of the desired end result and the reasons for it—one hopes that his next book describes how to get there from here.

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How to Build a Habitable Planet: The Story of Earth from the Big Bang to Humankind

By Charles H Langmuir and Wally Broecker, Princeton University Press, Princeton and Oxford, 718 Pages, 2012, Price $43.95 ISBN: 9780691140063 (Hardcover), ISBN: 9781400841974 (eBook)

Carl Sagan once said, "These are some of the things hydrogen atoms do given 15 billion years of cosmic evolution." This book describes those things and the path that the hydrogen atoms have taken from before they were hydrogen shortly after the Big Bang to human civilization. It is an ultimate historical and scientific perspective of our planet and the universe.

Although the narrative is full of rich scientific description, the authors assume no prior knowledge from the reader. Concepts from a variety of sciences (astronomy, physics, geology, chemistry, biology, etc) are introduced as they are needed. They gradually build on one another to provide a thorough and complete story of how our universe, planet, and civilization have come to be bit by bit. Overall it is very accessible and could even be used as an introductory text for a college astrobiology course.

Each chapter starts with a motivating illustration and brief narrative to set the scene. This is followed by a formal introduction to the chapter, a thorough discussion, a summary, and a list of supplemental readings. Many illustrative black and white figures are provided in each chapter, along with 16 color pages with select color figures as an inset.

The stage is set with a discussion of the power and limitations of scientific reductionism, the idea of a system, and the need to take different approaches to finding answers over a wide range of spatial and temporal scales. A scientific theory rating system (0-10) is introduced and referred back to many times throughout the text. For example, the formation of the moon by a giant impact gets a 5-6 on the scale whereas plate tectonics is a perfect 10.

The story starts with the beginning of the universe describing the transition from particles to atoms and looking carefully at how stellar processes and nuclear stability affect chemical abundances. Key concepts of density and volatility are introduced and related to the structure and functionality of inorganic and organic molecules. On a molecular level the composition of Earth is intertwined with the overall structure of the planet as a whole.

The formation of the solar system and Earth in particular is discussed in detail. The history of the planet from its formation onward is intimately connected to the history of life. In order to start the timeline, it is necessary to establish the age of Earth, and we are presented with conflicting views from a Biblical perspective, a naive scientific perspective, and a geological perspective. Ultimately the conclusion of a 4.5 billion year old Earth uses evidence from many sources (Earth's geological record, meteorites, radiometric dating, etc). Puzzling together a timeline of the co-history of life and planet with what has survived since ancient times is a work in progress, but the authors layout the pieces and fit them together.

While discussing volatiles in Earth's atmosphere we begin to see important modifications life has made to the planet to keep it habitable over time. An important part of keeping volatiles mixing is the global jigsaw puzzle of plate tectonics. The evidence for plate tectonics is presented in detail including the paleomagnetic record, earthquakes, and volcanic activity. The theory with its strong evidence only took about 5 years for a practically complete acceptance in the scientific community. From the understanding of plate tectonics, mantle flow can be studied. Mantle flow drives chemical fluxes between the surface and interior of the planet. This determines the chemical composition of the atmosphere and oceans and long term climate stability and is therefore important for both physical and biological properties of the planet.

As the narrative progresses the connection between our physical planet and life is made stronger. For several chapters the story turns the focus toward life and its origin and evolution. This is never addressed as a stand-alone question, but rather in the context of the planetary history because the evolv-

ing planet and evolution of life are completely co-dependent. Through biological processes, life reduces carbon and adds O2 to the atmosphere. This creates a surface environment in a high oxidation state and reservoirs of reduced carbon that get locked up in the subsurface by geological processes. The separation of these two reservoirs creates a planetary fuel cell that provides energy for modern life.

The evolution of life depends on many external factors. Mass extinction events are important because, while they reduce biodiversity on short time scales, they also open up opportunities for other life to survive. This increases biodiversity in the long run. Life also depends on the climate (which it also affects). To this end the authors take a close look at climate cycles on various timescales.

Over time the evolution of life has led to an increase in energy utilization. Low on the scale of energy utilization is the first life, anaerobic single-celled organisms. With the production of O2 aerobic life with higher energy utilization became possible. At the top of this ladder is our human civilization that has found ways to exploit the reduced carbon reservoirs, quickly draining the planetary fuel cell and other resources. The authors argue that humans are on the way to using billions of years of banked resources in just a few centuries.

The penultimate chapter focuses on the consequences that this great and rapid energy expenditure have on the planet: climate change, ocean acidification, and loss of biodiversity. Humans are bringing about rapid change in a system that has been slowly changing for billions of years. The authors put our current state into the context of the entire history of the planet and project forward to a dismal future outlook. The book suggests possible solutions such as population control, alternative energy, and carbon sequestration and storage, and discusses pros and cons of each.

The final chapter proposes that the habitability of Earth is not unique since the history of the planet has been governed by physical laws. Examples of failed habitability (Mars and Venus) are given and extra-solar planet detection techniques are explained in hopes of understanding the number of Earth-like planets in our galaxy. This is a rapidly growing field. By the authors' own admission their words are outdated immediately upon publishing; for example the number of habitable planets currently known is already an order of magnitude up from the ~200 in the book. Finally, there is a look at the terms in the Drake equation that allow a probabilistic estimation of the number of intelligent civilizations we might be able to contact. A key term is the lifetime of the civilization. How long do intelligent civilizations last? With our recent history we are left to wonder about our own.

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