



**PolarTREC Public Science Report
Armando Caussade
IceCube Neutrino Observatory
South Pole, Antarctica 2014**





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Why should a teacher go on science expeditions?

A teacher should go on science research expeditions for two reasons: (1) to bring a real life story which will make a strong impact with students, fellow teachers and community audiences; and (2) to learn how scientists work, and how real science is done, which makes for better STEM teaching.

Throughout this report I will further elaborate on these two ideas. I will also explain how my PolarTREC expedition has had a positive impact on my teaching, and provide a summary with metrics of all educational activities in the first 90 days from my return.

Description of activities

In November 2013 I was selected as a participant for the 2014–2015 Antarctic field season of PolarTREC, a professional development program managed by Arctic Research Consortium of the United States (ARCUS) and funded by the United States National Science Foundation (NSF), that pairs scientists with teachers to provide field deployments to polar regions. I was chosen after a competitive review process as one of 12 successful candidates from a national pool of about 190 applicants, and paired with James Madsen, PhD, a physicist at the University of Wisconsin and a key researcher at the IceCube Neutrino South Pole Observatory.



Armando Caussade at the Geographic South Pole, near Amundsen-Scott Station in the Antarctic plateau.

I traveled to Antarctica in January 2015, spending a total of 18 days. From January 11 to January 21, I deployed to the Amundsen-Scott South Pole station, where I successfully conducted ten days of maintenance and support work at the IceCube Neutrino Observatory. While transiting to and from the South Pole, I stayed for eight additional days at the McMurdo Station in Ross Island near the Antarctica coast. Thus, I was able to visit two of the three permanent research stations that the United States operates in Antarctica.

In February 2014 I attended a 6-day training session conducted by ARCUS in Fairbanks, Alaska. Later on, in July 2014, I spent two weeks at the University of Wisconsin–River Falls where I volunteered—under the supervision of Dr. Madsen—as an Upward Bound summer instructor. Also, in July 2014, I visited the Wisconsin IceCube Particle Astrophysics Center (WIPAC) in Madison, Wisconsin, where the IceCube main office is located.

During my stay at the South Pole I assisted IceCube researchers in three main areas: (1) maintenance and troubleshooting with the ARA (Askaryan Radio Array) neutrino detector, a new experiment that will measure radio waves generated by the interaction of neutrinos with the Antarctic ice; (2) maintenance and troubleshooting with the muon taggers at the IceTop experiment, which has been designed to study the interaction of cosmic rays with the Earth's atmosphere; and (3) measurements of snow accumulation over IceTop tanks, since the IceCube researchers believe that the volume of ice above the tanks may affect cosmic ray detection.



Armando Caussade doing snow accumulation measurements with the IceTop experiment at the South Pole, with the IceCube laboratory in the background.

As part of my PolarTREC duties, I also kept daily, bilingual (English and Spanish) journals complete with hundreds of pictures, which ran for most of January 2015. Additionally, during my stay at the South Pole, I participated in two live Internet presentations—one of which featured me as the main speaker—which were attended by hundreds of people worldwide.

In the months after my return from Antarctica, I have kept a busy agenda with education and outreach activities, which is the subject of the following sections of this report.

How are you going to link this back to your classroom? Refer to classroom strategies and needs assessment.

In my needs assessment I had stated that Puerto Rico is a Hispanic, historically underserved and underrepresented jurisdiction in STEM disciplines. Interest in STEM learning is very evident—especially in the 12 to 18 age group—but the opportunities are limited. So, from the beginning I saw my participation in a PolarTREC expedition as an opportunity to bring new opportunities to the people in specific STEM areas such as polar science and high energy astronomy.

As to how have I linked my experience back in my classroom, I have so far taught 80.25 hours of class where I have directly discussed my South Pole expedition, out of a grand total of 200 hours throughout the semester and at three different academic institutions. As a result, approximately 190 students have been exposed to my PolarTREC experience. An explanation follows.

1. St. John the Baptist Regional Major Seminary (i.e., Seminario Mayor Regional San Juan Bautista), a Catholic inter-diocesan seminary and extension center at Pontifical Catholic University of Puerto Rico, where I teach four undergraduate, 3-credit courses (two every semester) as a primary instructor, in astronomy, mathematics and computer science.

During my mathematics course for this semester I have devoted about 10% percent of class time (about 4.5 out of 45 contact hours) to discussing topics related to my South Pole expedition, so the link to class here is very straightforward. My whole student body (eight seminarians) enjoyed two 90-minute lectures in which I presented the full, 230-slide presentation on my work with IceCube, plus I screened 'Antarctica: a Year On Ice', a 90-minute documentary film by Anthony Powell, which is regarded by many as the best ever documentary about Antarctica.

My astronomy class has enjoyed a more subtle link to my expedition, as I have incorporated insights about how scientists work and how science is done. With my knowledge about the IceCube experiment, I am now better prepared to share with my students the full cycle of research in astronomy, from project inception and funding, to observations, to published results.

For example, when discussing the discovery of external galaxies by Hubble in the 1920's, I now explain his entire research process starting with his drawing upon H. S. Leavitt's discovery

of the period-luminosity relationship of Cepheid variable stars, his data acquisition using the Hooker 2.5-meter telescope at Mt. Wilson (1922 to 1923), his analysis of data (1923 to 1924), his results for the distances of “spiral nebulae” (1924), and finally, the publication of his discovery (late 1924 to early 1925) which ensued the conclusion of the “Great Debate” of astronomy.

Yet, students who are enrolled in astronomy (a total of four seminarians, three of which are also enrolled in math, and also benefit from the discussions there) were delighted to attend a supplementary, 105-minute evening lecture about my expedition, that was hosted by the Seminary for the benefit of the faculty, and also of students who are not enrolled with my courses.

Total audience: 13 students (9 out of 9 of my own students, plus 4 other students).

Total time discussing topics directly related to my South Pole expedition: 6.25 hours.

Breakdown: 4.5 hours Mathematics
 [see above] Astronomy
 1.75 hours Supplementary evening lecture hosted by the Seminary

2. EcoSTEAM @ G Works, Inc., an after-school STEM program in supporting three schools for the Puerto Rico Department of Education, under a grant from the 21st Century Community Learning Centers federal program, where I teach astronomy to students from 5th to 12th grade, with 8 to 16 contact hours per student and a yearly audience of approximately 300.

Here I have devoted 75% percent of class time (73.5 hours out of 98 hours) to topics related to my South Pole expedition.

I teach at three different schools, with a full rotation lasting exactly one year (semester 1 at one school, semester 2 at another school, and summer school at yet another). However, for the semester of January to May 2015, I was given by my employer the option of completing a full rotation within the semester, which I gladly accepted. This gave me the opportunity to reach the largest possible number of kids and share with them the results of my PolarTREC expedition.

In addition to sharing my full, 230-slide presentation on my work with IceCube, I also did six screenings of the ‘Antarctica: a Year On Ice’ documentary film by Anthony Powell, plus three screenings of ‘Chasing the Ghost Particle’, a 30-minute documentary about IceCube, from WIPAC and the Milwaukee Public Museum. The screenings, however, were done only at Pedro Rivera-Molina school where I had considerably more class time at my disposal.

Total audience: Approximately 160 out of about 300 enrolled students.

Total time discussing topics directly related to my South Pole expedition: 73.5 hours.

Breakdown: 31.5 hours Pedro Rivera-Molina elementary and middle school (5th to 9th)
 18 hours José Collazo-Colón high school (10th to 12th)
 24 hours Alfonso Díaz-Lebrón middle school (7th to 9th)

3. *Metropolitan University's Center for Sustainable Development (i.e., CEDES, Centro de Estudios para el Desarrollo Sustentable) in collaboration with the School of Continuing Education, where I teach four 12-hour astronomy extension courses as part of an 8-course, 100-hour professional certificate program that I co-designed and co-manage.*

As my courses are offered in late spring, early summer, early fall and late fall, I am just starting out with my first class for 2015 ('Astronomy for Everyone'). But I have already given a 30-minute presentation on my work at the South Pole that was attended by my full student body.

Enrollment for the program is usually between 14 and 18, but it is my belief that my participation with a PolarTREC expedition was a key factor in attracting a total of 20 persons for this season.

Total audience: 20 students out of 20 enrolled students.

Total time discussing topics directly related to my South Pole expedition: 0.5 hours

From your needs assessment, what are three to five things you expected to learn during your experience? Did you learn them? Why or why not?

As per my needs assessment, I expected to learn both factual science (high energy astronomy, polar science, etc.) and also how scientists work and how real science is done. I did possess a basic level of knowledge on these topics which I already conveyed in the classroom, but was seeking a hands-on experience that would help me to strengthen these areas.

Upon arriving in Antarctica I immediately understood that there is simply no substitute to actually traveling to the field, living and working there. So, about 90% of what I now know was new, practical knowledge acquired through my PolarTREC expedition. And the straight answer is yes, I learned everything that I expected. A summary of my learning follows:

Polar science:

- I learned how travel logistics work in the polar regions, with safety regarding weather conditions being paramount. I learned about ski-equipped airplanes and on three occasions actually flew in an LC-130, perhaps the world's best and most reliable aircraft.
- I learned about jet lags and large time zone differences—17 hours in my case—to which I quickly adapted. I became familiar with the International Date Line, and I also experienced a regimen of continuous 24-hour sunshine and learned to adapt to it.
- I experienced temperatures as cold as $-30\text{ }^{\circ}\text{C}$ and windchills down to $-43\text{ }^{\circ}\text{C}$, which I had never felt before. I learned how to wear extreme cold weather (ECW) gear and how to keep warm when working at the field. I also felt the harsh dryness of the Antarctic.

- I saw rapidly changing weather conditions on the Antarctica coast and learned about the Antarctica Weather Danger Classification scale (i.e., condition 1, 2 or 3). At the South Pole I frequently watched solar halos, a rare phenomenon in the tropics where I live.
- I experienced the effects of living and working at a barometric altitude of 3,200 meters, which I had never felt before, although fortunately the effects were extremely mild for me. I saw stronger effects on other people, though.
- I learned how lodging works in two of the three permanent United States Antarctic stations, and I understood the intricate logistics behind waste processing, recycling and reuse. I also learned about snowmobiles and other specialized vehicles for snow and ice.
- I learned about the different fields of research that are currently being conducted in Antarctica (eg., climate and meteorology, glaciology, geology, particle physics and astronomy) and actually got to talk to a number of prominent researchers.
- I learned about the history of Antarctic exploration and particularly about the geography of Antarctica. I gained a new awareness of the Antarctic treaty and about the stringent ecological regulations that are in effect in the Antarctic region.
- I saw and photographed the Antarctic fauna. I was able to identify a number of species including specimens of the Adélie penguin (*Pygoscelis adeliae*), the Weddell seal (*Leptonychotes weddellii*) and the South Polar skua (*Stercorarius maccormicki*).
- I saw and photographed the Antarctic Plateau where the geographic South Pole sits. I also saw and photographed a number of volcanoes (both active and extinct) in the Antarctic coast such as Mt. Erebus, Mt. Terror and Mt. Discovery.

High-energy astronomy:

- I learned more about neutrinos—subatomic particles that are nearly mass-less and rarely interact with matter—and cosmic rays—charged particles, i.e., pieces of atoms, originating in outer space that strike the Earth from all directions—and specifically about theories explaining the origin and generation mechanism of these particles.
- I learned how the IceCube Neutrino Observatory works, namely by timing and measuring the intensity and direction of blue Cherenkov light that is detected by photomultiplier sensors buried below the South Pole ice, and which originates from muons that are emitted when and where a neutrino from space hits the nucleus of atoms in the ice.
- I learned about how the IceCube Neutrino Observatory was constructed, namely by using hot water drills to insert steel strings into the ice at great depths, into which 5,160 sensors were attached. I learned that the Observatory occupies one kilometer of ice below the frozen surface, and that it took almost six years to construct (2005 to 2010).

How scientists work and how real science is done:

- I learned that science requires lots of field work—sometimes in remote areas of the world and under difficult work conditions—and that data analysis and presentation of results are only but a small part of work that is expected from scientists. This field work usually entails deployment of new instrumentation, upgrading, maintenance and troubleshooting.
- I learned how meaningful science results are obtained from IceCube data. I learned that after analysis of three years worth of raw data (2011 to 2013), and after sifting of irrelevant and uncertain data, a total of 37 verified, high-energy neutrino events have been identified, which in turn has made possible the creation of a neutrino map of the sky.

From your needs assessment, what were the three to five concepts you would like to teach “better” or differently? How does this impact your students?

As per my needs assessment, I wanted to learn more—and strive to teach better—concepts of high-energy astronomy such as cosmic ray detection, neutrino detection, as well as the theories and models that attempt to explain the emission of these particle.

Also, as per my needs assessment, my idea was to bring not only the facts, but also the story of my South Pole expedition—a unique, personal experience with an authentic, original voice that will be both captivating and memorable. People like listening to stories, and they remember them more vividly than just bare concepts. Children, particularly, are attracted to and compelled by stories, as these are concrete experiences of someone’s life and not mere abstractions.

The short answer is that I, indeed, feel my experience has brought about a meaningful impact.

In my estimation about 25% of my improvement has to do with having learned more about my topics of interest, and also about how scientists work and how science is done. But the other 75% percent is due to the simple fact that I can now speak with a greater authority about Antarctic science, high-energy astronomy, and science generally, based on real life experience. Concrete experiences engage audiences more effectively than pure, theoretical knowledge.

My results in engaging audiences are summarized in the next few lines. I do not yet have student evaluation results from this semester’s classes, nor do I have I attempted an objective comparison of my pre-expedition and post-expedition teaching, but I feel the following observations—even if purely anecdotal—give a general idea of the results achieved after my return.

- Audience interest seems consistently high. This is evidenced by the following: (1) audiences of all types stay focused throughout my lectures, irrespective of contact time, which can range from 5 to 120 minutes; (2) audiences react quickly to unexpected questions that I

ask; and (3) spontaneous applause by audiences is a common reaction.

- Students and teachers, particularly, get so passionate about the topic that they insistently ask about opportunities to visit Antarctica and the polar regions. I have taken advantage of this interest to tell people about PolarTREC (which works with teachers), about Girls on Ice (which works with female students, age 16 to 18) and other, similar programs.
- I have been told by audiences that the photographs that I use in my presentations truly look real and alive. Father J. L. Negrón (PhD), the chancellor at St. John the Baptist Regional Major Seminary—where I teach four undergraduate STEM courses—attended one of my lectures, and said that the images literally “took him” to the South Pole.
- I have been informed about people memorizing my classes and/or lectures and then retelling them, complete with details, to other people. Middle school kids who are my students seem particularly inclined to do this with their parents, but I have also been informed of this occurring with community audiences.

From your outreach plan, are there any activities that you will pursue, post-expedition, that the public should know about? Other ideas on how you’ll share this experience with the public and/or your peers?

I had expressed that I felt there was a need for polar science education and outreach in Puerto Rico, as knowledge about this aspect of geoscience is basically nil. Throughout my career I have attended presentations—here in the island—with renowned scientists on all main branches of science, but never have I seen a live lecture on this topic.

I also wrote that I have perceived a need to involve Puerto Rican educators with real, meaningful research projects in the STEM arena. This needs to change, and the transformation needs to take place immediately. I explained that I would like to volunteer as a role model in this context. I myself—as most STEM educators in the island—had never, before my PolarTREC expedition, had the chance to connect with researchers and do real science

Since my return to Puerto Rico—from Antarctica—I have had the privilege of giving 26 invited lectures where I have shared my South Pole experience. This includes over a dozen events at schools, four at colleges and universities, three at churches and non-profits, one at a large 2-day STEM convention and another one at the Puerto Rico Science Teachers Association (PRSTA) 2015 annual convention. Total direct audience is 1,242 persons, while total lecture time is 25 hours with 7 minutes (which translates into an average of 58 minutes of contact time per event).

Three of these presentations—including my lecture at the aforementioned PRSTA convention—were directed specifically to secondary level teachers, with 39 persons attending. Total number of educators reached at all events is around 60. This figure does not include people reached through my extension courses (where the student body consists of about 25% secondary level

Another interview was published as a half-page full-color item on page 2 of the April 9, 2015 edition of "Índice – El Norte", a weekly regional newspaper of northern Puerto Rico (see screenshot below).

2

Sacrifican mono en Bayamón

DANIEL RIVERA VARGAS
 Para INDI-CE EL NORTE

EL CUERPO de Vigilantes del Departamento de Recursos Naturales y Ambientales (DRNA) no logró capturar al mono que apareció en la zona de Bayamón el domingo y optaron por sacrificarlo.

El comisionado del Cuerpo de Vigilantes, Ángel Cruz, dijo que "como última alternativa" se optó por sacrificar en cuatro ocasiones con rifles calibre 22, luego de que accesorios de línea para que ninguna persona pudiera salir lesionada con los tiros de los empleados del DRNA.

"Se agotaron todos los recursos para atraerlo vivo. No pudimos darle por el alto follaje. Tuvimos que sacrificar la especie, ya que el lugar donde se encontraba es cerca del Municipio de Bayamón y el animal se puso agresivo. La preocupación era que, de dejarlo allí por la noche, pudiera moverse a un punto donde causara daños a la ciudadanía, metiese a una casa, a una tienda, a un hospital, y hay un parque público donde juegan niños", señaló Cruz, sobre el macaco rhesus, color crema, de dos pies de alto.

MACACO RHEBUS

18
 Los días que el profesor batucista estuvo en Antártida

SACRIFICIO RIVERA CRUZ
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BAYAMÓN El único puertorriqueño que ha logrado visitar el lugar más remoto del mundo llegó a la Universidad Central de Bayamón (UCB), en la Ciudad del Chicharrón, para inspirar a estudiantes con la emocionante historia de su helada travesía.

El profesor de astronomía, Armando Causade, ofreció una conferencia a los estudiantes de Ciencias de la UCB para narrar su experiencia en el Polo Sur como parte de su intervención en el observatorio de neutrones IceCube, ubicado en Antártida.

"Si a mí me seleccionaron para esta experiencia, la voy a usar para traer algo positivo a Puerto Rico", declaró Causade a INDI-CE EL NORTE.

El científico admitió que le gustaría convertirse en una inspiración para que otros profesionales como él persigan sus metas.

"El propósito es que a través de mi experiencia los jóvenes en Puerto Rico aprendan un poco más sobre las ciencias. Es importante ser un elemento inspi-

Geographic South

La monoestreada brilló a miles de miles de distancia.

ador para estos estudiantes que tal vez con mi experiencia, dentro de 15 años también irán al Polo Sur a hacer más de lo que hice", destacó Causade, ex-presidente de la Sociedad de Astronomía de Puerto Rico.

Causade partió hacia la Antártida el pasado 2 de enero como parte del programa PolarTREC, en el que fue el único batucista seleccionado para prestar durante 18 días sus conocimientos astronómicos en el Polo Sur.

Una experiencia que según el profesor le obligó a preguntarse con orgullo, ¿cómo he llegado aquí?

El astrónomo ofreció una conferencia a los estudiantes de la UCB en Bayamón.

EXPERIENCIA ÚNICA
 Armando Causade compartió sus fantásticas vivencias en el Polo Sur

EDP University

- Enfermería
- Terapia Física
- Diseño de Moda Digital
- Programación de Computadoras

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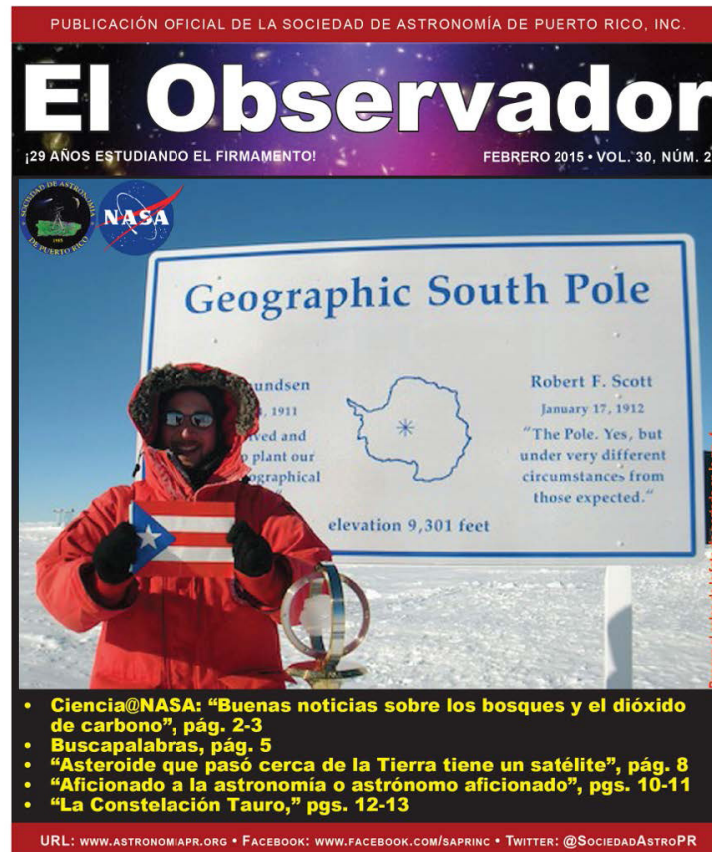
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After my return, I have also done two television interviews (16 minutes and 9 minutes) and one radio interview (30 minutes), for a total of 55 minutes of air time.

These results have—in good part—been made possible by the invaluable help provided by the Puerto Rico Astronomy Society (PRAS), which has put all its resources at my full disposal. PRAS has allowed me to enjoy free, priority access to a press advisor (Mr. Juan Villafañe) as well as an event coordinator (Mrs. Natalia Sosa), who have both devoted long hours to set up and manage such a busy agenda of media engagements and invitations as a guest lecturer.

PRAS was also the venue for the second public talk I gave after my return—setting up a large university amphitheater with state-of-the-art audiovisual technology—and even had a picture of me featured as the February cover of its monthly magazine, “The Observer” (see screenshot below), which is funded and endorsed by NASA Puerto Rico Space Grant Consortium, and is mailed free every month to over 100 schools—both public and private—in Puerto Rico.



To wrap up, the aforementioned results make up only about half of my intended outreach agenda for 2015, which is still a work in progress.

Photographs in pages 1, 2 and 3 taken by Armando Caussade / PolarTREC / NSF.