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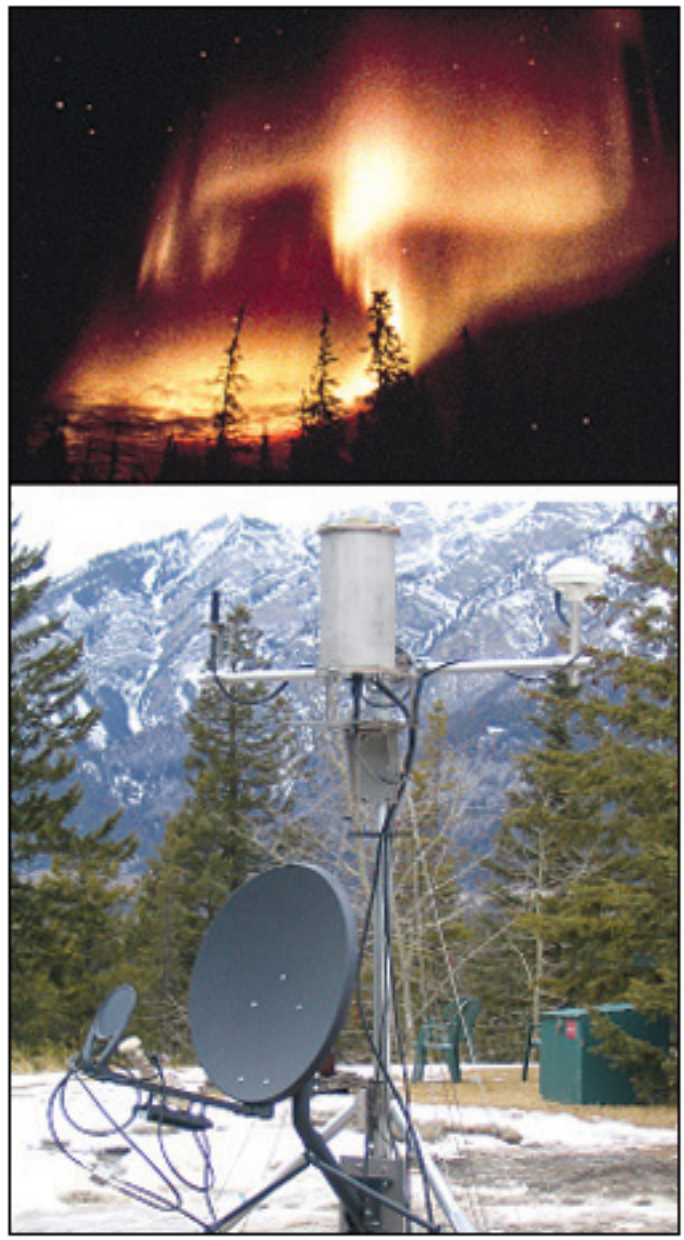
Capturing The Light Fantastic

by Dan Black

There's a digital camera clicking away just outside Keith and Edith Olson's house near Manitoba's Whiteshell Provincial Park, and it's not "shooting" bear or moose. Its wide-eye is pointed up, way, way up at something grander, at a celestial phenomenon that has intrigued scientists and inspired legends since ancient times. From now until spring, the little automated camera--and 19 others like it across Canada and in Alaska--will take roughly 45 million nighttime photos--one every three seconds--of the Aurora Borealis or Northern Lights.



TOP PHOTO: CANADIAN SPACE AGENCY; BOTTOM PHOTO: THEMIS CANADA

From top: An aurora hangs brightly beneath a starry sky; Attached to the top of a tripod, the metal housing containing the camera resembles a stovepipe at this temporary location in Alberta.

The cameras, which will likely be operating for at least the next six years (mostly during the winter months), are being used by researchers to gain a better understanding of the greenish-white light that appears to hang and billow like a set of mammoth window sheers across the dark northern sky. Already they are capturing some spectacular images.

People who witness an aurora are often transfixed by its enchanting and massive size--a scale so large it can circle the top of the globe, and reach altitudes of 500 kilometres. Even luckier are those who get to witness the unfolding of an even more colourful sequence that involves the aurora getting brighter and moving toward the south. Within minutes, these sky watchers are treated to a wreath of light that seems to come alive, often breaking into many bands that move back overhead and to the north in a cosmic dance of red, purple, white and blue. And although there is no scientific proof, there are many who swear they've heard the aurora produce a "crackling" sound.

Aurora displays also occur near the South Pole where they are known as Aurora Australis. They too have been the subject of much study, but it is in the north where--owing to Canada's huge landmass and some cutting-edge Canadian science and technology--researchers are helping to settle a long-standing debate over what triggers the aurora's more colourful personality. Scientists also hope their studies will advance our knowledge of more distant and exotic objects and phenomena in the universe.

Dr. Eric Donovan, associate professor of physics and astronomy at the University of Calgary, is directing the Canadian team, part of an international mission funded by NASA and the Canadian Space Agency. The latter is funding the Canadian side of the mission to the tune of $2 million, money that's being spread over eight years. In addition to the cameras or Ground-based Observatories (GBOs), the mission involves a number of satellites, five of which will be deployed this fall--and that is where NASA's financial resources and most of the U.S. effort is focused.

The name chosen for the mission is THEMIS, after the Greek goddess of justice, wisdom and good counsel. It is also an acronym for a painstakingly long name that only space scientists can love: Time History of Events and Macroscale Interactions during Substorms. It is that last word--substorms--that is the immediate focus for THEMIS. But to understand why is to first understand the Northern Lights and how they work.

The name Aurora Borealis was given to us by the 17th century Italian astronomer Galileo. It translates into "the red dawn of the north." Galileo thought the luminescence was due to reflected sunlight in the atmosphere, but scientists now know the aurora is powered by solar wind--an ever-present stream of particles (ions and electrons) that blows off the sun with an average speed of 400 kilometres a second, expanding outwards through space and streaming around the Earth like water around a rock. "This solar wind undergoes dynamic interactions with Earth's magnetic field, which presents a barrier to the flow of solar wind, and effectively carves out a wind-sock-shaped cavity known as the magnetosphere," explains Donovan.

The motion of the solar wind past the magnetosphere provides energy which drives large-scale electrical currents that flow throughout the magnetosphere where they join with the upper atmosphere. The solar wind interacts with Earth's magnetic field, distorting it and creating a very long downstream tail. The energy from the solar wind builds up in this tail and is released unpredictably in bursts of particles and currents. It is these quick bursts or substorms that spark the more spectacular displays.

It has taken a lot of science and technology to understand this process, and Canada has earned a lot of kudos in this field. Indeed, even before scientists were uttering the world THEMIS, the world benefited from another Canadian ground-based aurora observation network called CANOPUS. Established in the 1980s, this array of space physics ground-based instruments was, by the mid-1990s, recognized as the best array of its kind in the world. "Overall, Canada's stature in this field is way disproportionate for the amount of money it spends," explains Donovan. "We have gotten a lot of bang for the dollar. We have gotten a lot of recognition on the international scene by doing clever things and taking full advantage of our geography. Our role in THEMIS may be the quintessential example of this."

The THEMIS cameras or all-sky imagers form an array that covers a lot more area of the northern sky with better time resolution than has ever been achieved before. The equipment that went into each unit was purchased by NASA, and the design and assembly came primarily from scientists at the University of California at Berkeley and at the University of Calgary. Members of Donovan's team designed much of the software that runs each GBO, and tested the system at a small observatory at Athabasca University just north of Edmonton.

Donovan is confident the GBOs will help scientists settle that old debate over the precise timing and location of the substorm "trigger." One main school of thought has the trigger located at approximately 60,000 kilometres away from Earth, on the side facing away from the sun. The other school places it further away, in a different region where different physics are at work. Events occur in both regions within a few minutes, but the objective with THEMIS is to

Events occur in both regions within a few minutes, but the objective with THEMIS is to establish once and for all which one leads and which one follows. The five satellites will be spread out across the region, and the ground-based cameras will be observing the effects of the process in the aurora.

Dr. William Liu, a senior scientist with the Canadian Space Agency, says the Canadian portion of THEMIS represents the largest aurora imaging experiment of its type ever mounted. "The important thing to remember is that Canadians came up with the general idea of having the ground-based imaging components of such missions to provide real-time observation of the aurora.... This was very much appreciated by the international community and led directly to our involvement in THEMIS."

Liu says the fundamental debate about the trigger and when it happens is an important question because it could tell us more about other explosions or interruptions that are happening in the universe. "We regularly have eruptions on the surface of the sun, we have eruptions in the galaxy with stars exploding. These eruptions are happening everywhere, and it is widely believed that the fundamental physics behind them is more or less the same, but certainly we can't send a space craft to the centre of the galaxy to observe, so this is our only opportunity to investigate 'locally' what is happening."

It is also hoped that scientific explanations from THEMIS will help replace old myths regarding a phenomenon that has already provided clear evidence of how the Earth's atmosphere protects us from the fatal effects of the solar wind.

Another benefit of studying the Northern Lights is that it increases our knowledge of major solar storms which have caused serious problems down here on Earth. In 1989, a magnetic storm caused a massive power outage in Quebec. In 1994, a violent magnetic storm put Canada's Anik satellites out of commission for several days, cutting off transmissions to many print and electronic media.

Donovan describes the substorm trigger mystery as a classic "chicken or egg" type question. "Canada has the largest readily accessible landmass under the aurora region and so from a geographical standpoint is the best place in the world to carry out large-scale ground-based observations.... And so this project involves the operation of existing Canadian instruments and the 20 cameras in the THEMIS array."

Besides being the lead Canadian scientist on the mission, Donovan is responsible for the development of a made-in-Canada science program that will allow Canadian scientists to benefit for years to come from the project. The Calgary group has also spun off a small high tech imaging company as a result of their work.

Besides locating a camera on top of the Olson's outbuilding near their house north of Pinawa, Man., the Calgary team has deployed two more in Manitoba and four in the Northwest Territories. The Yukon, Nunavut, British Columbia, Alberta and Ontario each have one camera while Quebec and Labrador have two each. "It's really exciting to be part of this project," says Edith Olson who for years taught science at the local junior high school. "When I was a kid in fifth grade I started a scrapbook on the astronauts and I've always loved science, particularly space science.... I think it will be an excellent way to learn about what's going on up there."

The Olsons have been treated to some spectacular auroras. "Our acreage is former crop land and it gets very dark at night," says Edith. "Some nights you come out and the aurora is in colour.... Usually it is green, but sometimes you get reds and purples. It's amazing, and I'm glad to be living in such a cool place."

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Some people say the camera looks like a cappuccino machine with a bubble on top, but to Edith it looks more like a stovepipe. "Keith built a little wooden platform for it to compensate for the pitch of the roof. The rest of the GBO, including a bright orange box containing the high tech equipment, sits on the ground next to the building."

Hosting one of the units involves a little bit of custodial work. Every couple of months she or Keith will go out and change the GBO's hard drive, and send the full one off to Calgary. Real-time images taken by the camera are transmitted directly from each site--via the Internet--to the lab. The larger images--with better resolution--are stored on the hard drive. In total, the hard drives at each site collect a massive amount of data--about one gigabyte a night. "I sometimes joke with my friends that I'm now working for NASA," says Keith with a dry chuckle.

Aside from that, the Olsons and other custodians have to make sure there is always power to the unit and that the bubble over the lens isn't obstructed. "We are here. We are around and we are happy to make sure nothing is amiss with it," says Edith. "Keith is an industrial arts electronics teacher and so it is right up his alley...."

Two provinces to the west, Mike Greffen climbs up onto a bright orange box and begins to play his fiddle among the mountains near Banff, Alta. The deployment and site manager for THEMIS Canada is in his element, taking a break from testing one of the GBOs. This particular unit, which last May was one of the last to be deployed, is earmarked for Fort Simpson, N.W.T. "I'm doing a lot of travel--a lot of work, but I feel like I'm the one who is having all the fun. I'm renting snowmobiles, climbing radio towers and around people's backyards and up on roof tops. I'm visiting all kinds of neat little towns with interesting people, and I've gotten flat tires in the middle of nowhere. I've driven or fought my way up muddy roads and I've seen my share of black bears and mosquitoes."

The Olsons remember him crawling around their backyard at three in the morning in order to determine whether it was dark enough for a GBO. "We need dark--beyond what most people say is completely dark," says Greffen. "In fact, we have had to redefine dark. There can't be any yard light or any tall object that would be picked up by the camera's wide view."

When he arrives in a community and explains what he is working on he is usually met with awkward glances. Sometimes he finds it useful to name drop, like when he was in need of an extra cable. "Saying that you are working on a NASA project usually gets you that cable."

While Donovan and other researchers are anxious to find the trigger, they--like a lot of people--are mesmerized by the beauty of the aurora. "It may be a strange thing for a scientist to say, but not a single scientific thought crosses my mind when I'm looking up at it," he says. "I have seen it many times...while cross-country skiing at night in the river valley in Edmonton...and elsewhere, but it has never occurred to me to think about the science while I'm watching it."

Greffen likes the fact the aurora has a beautiful connection to nature, folklore and art. "Every once in a while I am at one of these sites where the cameras are and I look up and see a spectacular show. It's a real blessing to be working on a physics problem that also has such a natural beauty to it.... The Inuit have all kinds of stories...and I am told that in some places the word aurora means caribou."

Donovan remembers a night in 1981 when he was a university student vacationing with friends along the shore of Lake Huron. "It was one or two in the morning. We happened to be looking north over the water and there was a beautiful star field above and then this light started to dance up over the horizon. The three of us sat there transfixed for an hour or more. It was like

dance up over the horizon. The three of us sat there transfixed for an hour or more. It was like nothing I'd ever seen.

"When you are fortunate enough to see a display like that in a really beautiful, natural setting--and it is clear and bright, and there are stars behind it--it changes the way you look at the night sky. You say to yourself, 'this can't be happening.' It's surreal. It is unbelievably beautiful.... The colours are so pure and the shapes and the dance and the quietness of it...."