POLAR RESOURCES NEWSLETTER
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A Stratospheric Mosh Pit: Ozone Science

If the South Pole is a hotbed for ozone-depletion studies, the stratosphere over the arctic is a "tantalizing teaser." So says Susan Solomon, of the National Oceanic and Atmospheric Administration's (NOAA) Aeronomy Laboratory, in Boulder, Colorado.

Solomon knows ozone. In 1986, she and colleague Dave Hofmann of NOAA's Climate Monitoring and Diagnostics Laboratory in Boulder were among the first to explain the process by which stratospheric ozone is depleted in Antarctica. Even now, as spring comes to Greenland, they both have ozone experiments at Summit Station, due to a rare boreal stratosphere (the sky roughly six to 30 miles above Earth) and some last-minute logistics scrambling (see accompanying story).

The South Pole has seen a lot of ozone research in part because the isolated giant of a landmass that is Antarctica, along with its surrounding oceans, makes air circulate above it in a relatively predictable fashion. In the winter, westerly air circulation swirls into a vortex, which traps the air in the sunless sky, and allows it to grow colder and colder.

There is no big, stable land mass directly under the sky at the North Pole, and air currents whoosh above the various continents in the northern hemisphere, knock into mountains and each other, and lead to relative atmospheric instability. As Andy Clarke, of NOAA/CU Boulder's Cooperative Institute for Research in Environmental Sciences (CIRES), explains, "to put it simply, there's a lot more weather in the north." And he knows that first-hand: he's at Summit Station now, running experiments for Hofmann and Solomon.

This winter, weather conditions created a rare stable vortex over the North Pole, and the isolated air whirled around in the dark sky (just as it usually does in the Antarctic), growing even colder. In fact, it was colder than it had been in decades.

At around -112º F degrees, polar stratospheric clouds (PSCs) form. PSCs are chemically different than regular clouds, and they are the first of three ingredients crucial to the chemical mosh pit that mangles ozone. As Hoffman explains it, "In a process called heterogeneous chemistry, the PSCs provide a platform for unusual reactions to occur that end up destroying ozone."

Filling the balloon with helium..

Chlorine and bromine are the chemicals necessary for stratospheric ozone loss; their presence is the second required element in the phenomenon. These chemicals are found in the stratosphere as a result of human activities. "Industrially-produced chlorofluorocarbons, or CFCs, make up

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Planes, Sleds, and Snowmobiles

How Spontaneous Logistics Work in Greenland

State-of-the-art ozone studies, as undertaken at Summit Station recently, involve some last-minute logistics scrambling, the appeals of leading scientists—and a couple of snowmobiles. Or so we learned in February, when the stratosphere over Greenland started looking a little bit like the stratosphere over the South Pole (see accompanying story).

So, it happened like this: Andy Clarke had just returned to Boulder from the South Pole on February 1st, prepared to settle back in to his role as operations manager for NOAA's five ozone observatories, when Boulder ozone gurus Dave Hoffman and Susan Solomon asked him if there was any chance to run up to Summit to make some measurements.

While the GEOSummit Observatory at Summit Station captures a variety of atmospheric data, the measurements Hofmann and Solomon wanted to study required instruments, equipment and expert personnel not presently on site at the station. Knowing how things work, Clarke said no—it was too late to place the experiments at Summit. But, knowing how things work, he then called VPR logistics manager, Tom Quinn, who said, Clarke recalls, "'I think we can do it.'"

Since Clarke had just returned from the South Pole, where he had been training the new wintering technician to carry on with NOAA's ozone work, he had already cleared the time-consuming medical processing required for polar work. So he flew in to Summit Station on February 11th. Clarke had with him just enough equipment to start launching the helium-filled balloons that carry instruments to measure ozone in the air column as it ascends (and

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a whopping 85% of today's chlorine in the atmosphere," notes Solomon.

The third essential ingredient for ozone loss is the sun a'dawning. Ultraviolet (UV) and visible light works on the chemical compounds to get the party started.

So it goes like this: Chlorine molecules produced from CFCs strike the molecular "platform" of the clouds, transforming into substances that react rapidly with sunlight in the polar spring the instant the sun comes back. These substances are the bad actors that react with ozone in the chemical mosh pit. The molecules bash into each other, transform into something that gobbles ozone, transform further, grab some more ozone, mosh a little more, and so on for a good, long time, destroying ozone all the way. To alter the metaphor, "It's like a singles bar, but without the drinking," laughs Hofmann.

The reactions continue to occur, and ozone continues to be depleted, until the sun's UV light has warmed the stratosphere enough to stop PSCs from forming. So, as Hofmann says, "light triggers the reaction, and shuts it off, too."

What's the big deal about ozone loss? Stratospheric ozone acts like Earth's sunscreen, shielding us from the havoc caused by excessive exposure to ultraviolet light. "If you've ever had sunburn, you know it hurts," Solomon emphasizes. "And it can also damage your eyes, as well as ecosystems."

To measure ozone levels, researchers like Andy Clarke release helium-filled balloons carrying an instrumented payload into the sky. To launch the 100-foot balloon, a researcher only needs to fill up about 10 percent of its total volume, as the gas will expand in the thinning atmosphere as it ascends.

Clarke contends with a 12-foot balloon with a very long tail (almost 90 feet!), on the end of which is a payload with instruments. It's a bit ungainly. At the South Pole and other observatories, he works out of launching structures with specially built doors that accommodate the inflating balloon. At Summit, Clarke has been working outside in temperatures hovering around -50 F degrees. "There's no question this is the most difficult place I've ever had to launch these balloons," he comments. He won't even attempt a launch if there's wind.

The ozone-sampling instrument itself, the current digital version developed by Hofmann for the pioneering Antarctic ozone studies in 1986, is brilliant in its simplicity. It's an instrument containing two chemical-filled cells connected by a current-carrying bridge. "Ozone makes the cell act like a battery," explains Hofmann. "A current flows if there's ozone in the solution. The current weakens as the ozone disappears; when there is no ozone there is no current." At the same time, another instrument captures standard meteorological data like temperature, air pressure, and humidity. All of the data are sent to logging instruments on the ground via telemetry, where they are recorded for later analysis.

Meanwhile, Dr. Solomon's spectrometer works on the ground, and gets at the chemical composition of the stratosphere by measuring light wavelengths. Solomon is particularly interested in OClO, a chemical compound resulting from the ozone-destruction process. Her experiment clarifies the data in the balloon profile by separating depletions caused by chemical breakdown from those that may be caused by atmospheric mixing between the stratosphere and lower altitudes.

While the official findings await complete analysis, Clarke says he is "definitely seeing bites out of the ozone." Hofmann agrees that though the thinning over Greenland is "not anything like the ozone 'hole' over Antarctica and dynamical processes cannot yet be ruled out, there is a fairly substantial reduction in the ozone profile." "The Arctic teased us again this year," adds Solomon. "First it was cold, then it warmed up fast. So we got a glimpse of ozone loss, but only a glimpse. It's so much easier in the Antarctic."

It's not clear if the stratospheric activity is a fluke or a trend. "Some climate warming models say ozone depletion should become worse," says Hofmann. "As we get more carbon dioxide in the atmosphere and the surface warms, the stratosphere will cool in response. The models suggest a connection." But, Solomon adds, "There's more to it than just temperature. Another thing carbon dioxide may do is change the storm tracks that keep the Arctic warmer than the Antarctic in the first place - and if that happens a lot in the future, we could actually see a warmer Arctic and less ozone depletion there. Right now we just don't know which way it will go, which is why it's so great to have this year's data."

Up, up, and away!

Here, the two ozone gurus agree. "It is important to set a baseline," says Hofmann. He would like to return to Greenland, perhaps even next year, to capture the baseline. "We need the before and the during," Hofmann says. "[This time,] we only got the after."

Many thanks to Dave Hofmann, Susan Solomon, and Andy Clarke for providing information for this story.

Planes, Sleds, and Snowmobiles
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descends) the stratosphere, about 30 miles up.

While Clarke was making his way to Summit, VPR was working to scrape together the gas needed to launch the balloons, which amounted to seven 100-pound cylinders of helium. Between Summit and Kangerlussuaq, the team found almost half of that needed. After scouring Greenland, the remainder was found in Sisimuit, 125 miles from Kangerlussuaq.

Of course, in Greenland, you can't get there from here. Scheduled flights between the two towns wouldn't move the helium to Kangerlussuaq in time for the Twin Otter flight onward to Summit. So VPR got the Kangerlussuaq snowmobile club involved, whose members were game to ride to coastal Sisimuit and fetch the helium on sleds. But the club turned back because their sleds sank in the deep snow. At which point VPR's Mark Begnaud and Ed Stockard made their own attempt on snowmobiles, only to be foiled by bad weather. Finally, Blue Water Shipping Company brought the helium on snowmobile-towed sleds from Sisimuit, arriving just in time for the Twin Otter flight.

Which then was delayed due to weather for four days.

Meanwhile, back at NOAA's Aeronomy Lab, Solomon had arranged for scientist Jason Siefert to hand-carry a spectrometer to Kangerlussuaq, to avoid potential shipping and customs delays. The instrument would gather the light-refraction data Solomon would analyze back in her lab. The plan came off without a hitch, which could not be said of other elements of the logistics story.

At Summit, Clarke was discovering that the latex balloons he had brought with him were losing their elasticity and bursting in the very cold stratospheric conditions. As a result, the team would need to switch to a more rugged polyethylene balloon. Of course, they'd need more helium, almost double that which had already been scraped together. Since Greenland was fresh out, VPR turned to Copenhagen, and discovered a supply—a very expensive supply.

Just then, as budget planners were beginning to hyperventilate, the phone rang. Air Greenland, the Twin Otter contractor, had some bad news: mechanical problems would prevent their Twin Otter from flying to Summit Station. However, the company would find a different carrier, which turned out to be Flugfelag, located in Iceland. Once VPR got this news, staff got on the horn, tapped Iceland's helium supply, and got a much less expensive supply of cylinders shipped in time to be loaded on the Twin Otter.

Since this is Greenland, the Flugfelag team then waited in Iceland for five days for the weather to clear over Summit Station before dropping the helium off there en route to Kangerlussuaq.

Hey, it's a harsh island.

GREENLAND
News From the Field

Kangerlussuaq: On March 21st the first 109th Air Guard C-130 flight for the year arrived in Kangerlussuaq in support of the annual Host Tenant meeting. Two VPR staffers caught the flight to Kangerlussuaq. One of the VPR crew, Brad Johnson, was on his way to Summit to start his summer stint as Heavy Equipment Operator a bit early, helping dig out the Station, which has been buried this winter due to high winds and accumulation. Ed Stockard, the Kangerlussuaq Cargo Coordinator, came in to support the Twin Otter flight that would take Brad to Summit and stayed on in Kangerlussuaq for a week longer to help get ready for summer operations, which are right around the corner. The Raven put-in crew arrives April 6th, Kanger staff on April 11th, and Summit summer crew arrives on April 18th!

Northern Greenland: Plans are almost complete for an April Nares Strait campaign to recover and redeploy a series of moorings for the Canadian Arctic Throughflow Study (CATS). Camp staff will put-in to the site near Lafayette Bay on April 4th, with the research team arriving on the 10th. For more, go to http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0230354.

Summit: Summit Station continues to dig out. By March 13th the Greenhouse and Big House roofs were clear and the Station began to feel a lot more open. Last week, high winds again piled snow around Summit, reversing weeks of hard work. But last week also brought help in the snow clearing effort. On March 23rd a Twin Otter brought fresh strawberries and Brad Johnson, bringing the population to six. The staff was happy to see Brad and he's been hard at work clearing snow.

Visit the following web sites for more information about research and operations at Summit:
http://summitcamp.org
http://www.geosummit.org
http://summit.unh.edu
http://www.ramas.uni-bremen.de/ramastext.html

Andy Clarke of NOAA has completed 20 ozonesondes and is looking forward to seeing some final results. He'll stick around until the summer science tech arrives so that he can do some training/turnover before heading home. See cover articles for more about this project.

This week Summit enjoyed calm weather. The wind was at or below 10 knots for most of the week with a few brief periods of winds in the 15-20 knot range. The outside air temperature was correspondingly low during calm periods. With only 2 more weeks left of Phase III, the crew is busy with construction tasks and the never-ending snow removal.

ALASKA
News From the Field

The "Beaver" at Ivotuk.

Alaska Office

- The Alaska crew is busy planning for the busy upcoming season. Naomi Whitty is working on project plans and air contracts, and she participated in the Marine Biological Lab's annual planning meeting, March 11-13. Naomi also squeezed in time the following week to participate in an Anchorage aircraft safety course held by Learn to Return for NSF-sponsored researchers. Jill Ferris joined the Alaska office during Naomi's absence to lend a hand. Matt Irinaga is ordering supplies and preparing gear for issue. He heads to Barrow on April 8th with researcher Craig Tweedie and VPR staffer Chico Perales. The three are doing preparatory work for the large tundra manipulation project, headed by Walt Oechel, that's starting up this spring. For more on the science go to http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0421588.
- The "Beaver" landed in Ivotuk with VPR's Tracy Dahl and Roy Stehle, who performed generator maintenance and installed a new Netcam for the power/communications system running year-round experiments there. For more images and information from Ivotuk visit: http://www.windband.org/alaska/ivotuk and http://transport.sri.com/ivotuk/, and http://www.uaf.edu/water/projects/atlas/metdata/Ivotuksites/10m/current.html

Upcoming Research

- Skip Walker's biocomplexity of frostboil ecosystems team plan fieldwork from April 10-16, including flying out of Deadhorse to Howe Island for a day of sampling on April 13. For more go to: http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0120736
- The Breck Bowden-led hyporheic processes team travels to Toolik from April 10-22 with helicopter work April 16-20. http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0327440
- Working on his part of the Larry Hinzman – led collaborative research on freshwater storage in the Arctic, Kenji Yoshikawa will conduct helo-supported aufeis work out of Toolik Field Station (TFS) and Deadhorse April 21-23. http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0229705
- Doug Kane also flies out of TFS on April 26-27 for spring melt work. Project details available at: http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0335941
- The Black Rapids Glacier camp put in for Echelmeyer/Truffer's work on basal process is scheduled for April 22. More at: http://www.vecopolar.com/arlss_reports/arlss_projectsdetail.asp?cbPropNum=0115819

The VPR family continues to grow! Marin Kuizenga and husband Jeff Merkel welcomed Matteo Taavi into the world on March 10th at 8:34pm. He was a healthy 8 pounds, 11 ounces and 21.75 inches.

In the news…

The winter 2004/2005 issue of Witness the Arctic features articles on GEOSummit and EarthSLOT. Online editions are available at: http://www.arcus.org/Witness_the_Arctic/index.html