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Researchers Explore how Ships Affect Air Quality

Hundreds of large ships sail through Alaska waters each year, leaving behind smokestack emissions that are sometimes visible on satellite images. Researchers at the Geophysical Institute recently analyzed the role of ship emissions on air quality and deposition of contaminants into some Alaska national parks.

Geophysical Institute graduate student Stacy Porter followed a lead from her advisor, Professor Nicole Mölders, who was investigating whether ship emissions could be the cause of unusually high acidity levels in some Alaska ocean waters. Porter modeled emissions from cruise ships, container ships, ferries, and other vessels, and their effects on parklands near the Gulf of Alaska.

Porter consulted with maritime experts to estimate ship routes through the Gulf of Alaska. She discovered that major shipping routes existed in June throughout Prince William Sound, Cook Inlet, and around Kodiak Island.

With help from Mölders, Porter modified a model called WRF/Chem to examine the impact ship emissions have on Kenai Fjords National Park, Lake Clark National Park and Preserve, Katmai National Park and Preserve, and Aniakchak National Monument and Preserve. Her model runs were for a three-month peak in the tourist season from May 20 to August 20, once with and once without inclusion of ship emissions.

Porter developed a ship-emission inventory for the Gulf of Alaska and made some conclusions. Areas with the heaviest ship traffic–Prince William Sound and Cook Inlet–experience impacts from nitrous oxides and sulfur dioxide. She also found that 90 percent of the particulate matter spewed from ships is 2.5 microns or larger, which affects visibility. She calculated that ships reduce visibility 30 to 40 percent in Prince William Sound and up to 60 percent in Valdez.

"Poor visibility in Prince William Sound could affect tourism," Mölders said.

Model run comparisons showed that nitric acid and peroxyacyl nitrates increased due to ship emissions, and particulate matter from ship exhaust fell in the greatest quantities on Valdez, Whittier and Anchorage. Porter and Mölders also concluded that weather factors, such as wind speed and temperature, greatly affect the fate of ship emissions, and that emissions affect air quality in Lake Clark and Kenai Fjords.

In a separate study, NOAA researchers concluded in a *Journal of Geophysical Research-Atmospheres* paper that commercial ships emit almost half as much particulate matter as do cars and trucks around the world.

NASA image by Jeff Schmaltz, MODIS Rapid Response Team

EXHAUST TRAILS: Above, ship emissions are shown over the Gulf of Alaska on March 4, 2009. Hubbard Glacier, a popular Alaska cruise ship destination, is pictured below.

UAF UNIVERSITY OF ALASKA FAIRBANKS

Learning More about Subduction Zones with MOOS

Forty-five years ago, more than 100,000 square miles of Alaska broke, twisted, tilted, dropped and rose during the magnitude 9.2 Good Friday earthquake. Seward moved about 47 feet south, and Cordova migrated 46 feet southeast. Parts of Montague Island rose more than 30 feet, and areas around Portage dropped nine feet.

Today, Geophysical Institute scientists are trying to understand the structure and dynamics of the subduction zone responsible for the 1964 earthquake in an ongoing experiment. In MOOS (Multidisciplinary Observations of Subduction), researchers have deployed 34 broadband seismic stations across areas where most of the action took place during the massive earthquake.

"We want to fill in the gaps of what's going on down there between the Pacific Plate and the North American Plate," said Doug Christensen, Associate Director of the Geophysical Institute. Christensen has worked on the project since 2006 with Geophysical Institute Professor Jeff Freymueller and Geoff Abers of the Lamont-Doherty Earth Observatory in New York.

Christensen and his colleagues installed the broadband stations from the southern Kenai Peninsula all the way to the Susitna River drainage about 200 miles away to better define the contact between the Pacific and North American plates, an interface responsible for most of the volcanoes and many earthquakes in Alaska.

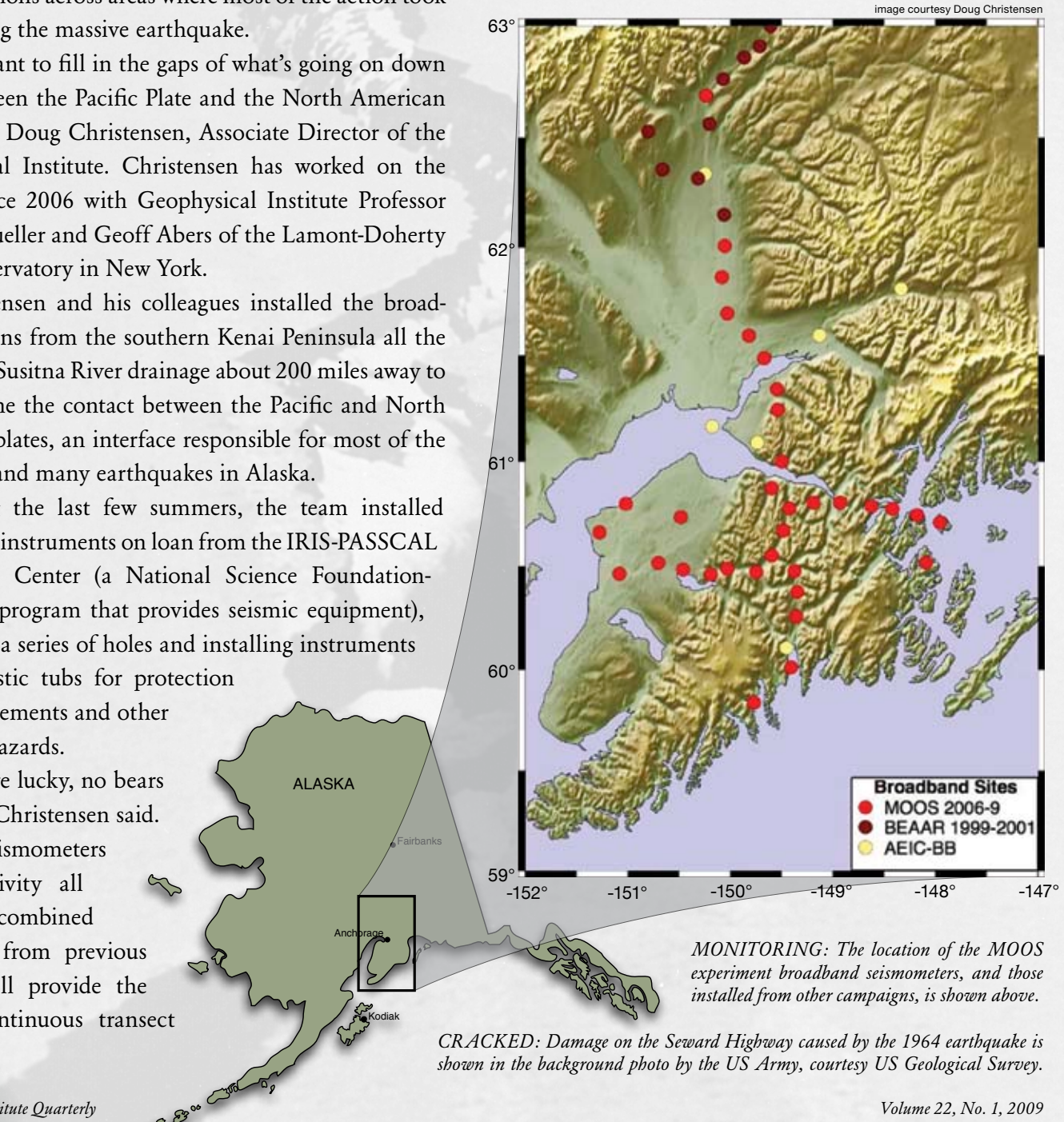
During the last few summers, the team installed broadband instruments on loan from the IRIS-PASSCAL Instrument Center (a National Science Foundation-sponsored program that provides seismic equipment), by digging a series of holes and installing instruments within plastic tubs for protection from the elements and other potential hazards.

"If we're lucky, no bears dig it up," Christensen said.

The seismometers record activity all year, and combined with data from previous studies, will provide the longest continuous transect of a subduction zone to date. The researchers will gather all of the seismometers in the 2009 summer field season and return them to the IRIS-PASSCAL center.

Data resulting from installation of the broadband seismometers in Alaska will serve an important purpose: "This deployment allows us to test several hypotheses related to the postulated subduction of the Yakutat block and the nature of the coupled zone that ruptured in the great 1964 earthquake," Christensen wrote on a poster he presented at the American Geophysical Union conference in December 2008.

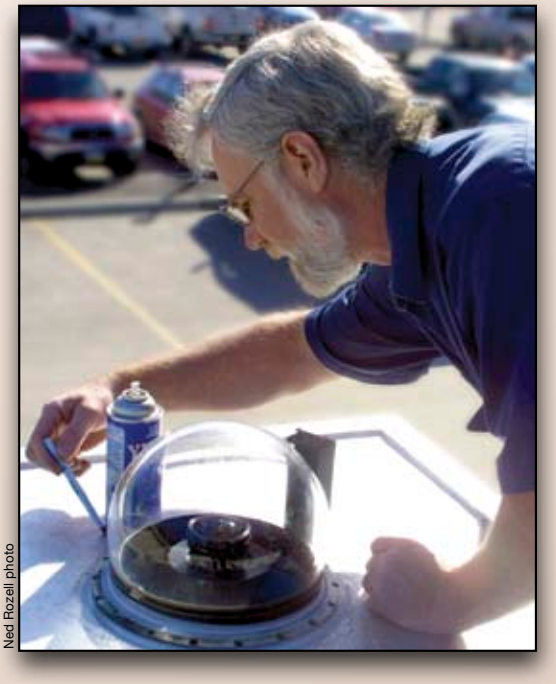
image courtesy Doug Christensen



MONITORING: The location of the MOOS experiment broadband seismometers, and those installed from other campaigns, is shown above.

CRACKED: Damage on the Seward Highway caused by the 1964 earthquake is shown in the background photo by the US Army, courtesy US Geological Survey.

Machinists and Researcher Collaborate to Create Instrument


Ned Rozell photo

After one year of work, members of the Geophysical Institute Machine Shop and Assistant Professor Mark Conde have created an optical spectrometer researchers will use to discern temperatures and winds high in the ionosphere. Among the 130 parts that make up this sophisticated tool are two stainless steel salad bowls that cost $10 each.

The nine-foot tall, sleek black instrument that weighs half a ton will first monitor the night sky above Alaska at the High Frequency Active Auroral Research Program (HAARP) facility in Gakona. The instrument, which includes a modified telescope, an all-sky lens, a Nikon lens, and the intricate brain of the unit called a Fabry-Pérot etalon, will allow researchers to detect the faint light of airglow and the aurora. Using the wavelength of that light and other information, scientists can map winds and temperatures across the ionosphere.

"It will gather information from about 90-250 kilometers (altitude), depending on what filters you use," Conde said.

The U.S. Air Force Academy funded the $380,000 project because researchers there want to investigate the role wind plays in plasma instabilities that sometimes affect communications and GPS navigation. The Air Force Academy sought out Conde and the Machine Shop because, "We make the best instruments for this purpose," Conde said.

The National Science Foundation wants two more spectrometers, which Machine Shop Supervisor Greg Shipman said his team could produce for less than the cost of the original. Conde hopes the two future instruments will be stationed north of the Arctic Circle, with one of them at Toolik Field Station on Alaska's North Slope.

Eric Huwalk of La Trobe University in Australia created the design concept for the instrument, with help from Conde. Shipman, machinist Tim Manning and Conde teamed to customize Huwalk's design. The goal of the model was to build something Machine Shop workers could quickly duplicate using easy-to-get, off-the-shelf parts along with a computer-aided design program as a blueprint.

"Everything but the camera, lens, and etalon, they made," Conde said of Shipman and machinists Manning, Jeff Nelson and Dale Pomraning.


Dale Pomraning photo


Ned Rozell photo

CREATING A NEW INSTRUMENT: Tim Manning (top) and Jeff Nelson (above) of the Geophysical Institute Machine Shop build Mark Conde's optical spectrometer. At right is a close-up view of the fish-eye lens atop the instrument.

Smoke Forecasts Online for 2009

Geophysical Institute Research Associate Martin Stuefer has teamed up with others to develop a wildfire smoke forecast system. Stuefer, himself a pilot, envisions the "UAFSmoke" modeling system as a tool for predicting the effects of Alaska wildfires.

"Pilots can say, 'If I fly to Nome, I can expect fires and smoke there and there,'" Stuefer said.

Stuefer developed the system with experts from the Arctic Region Supercomputing Center, NOAA's Global System Division, Brazil's Center for Weather Forecasting and Climate Studies, and the U.S. Forest Service Missoula Fire Sciences Lab.

Inputs to the model include the location of current fires and their size, hourly gridded meteorological fields, and even the type of forest or tundra the fire is consuming, which has an affect on the chemical composition and amount of smoke emitted. The model's information has potential for Alaska Fire Service managers trying to time prescribed burns to pose the least disruption to people nearby. Professional weather forecasters also are interested in the model.

"The wildfire smoke modeling outputs are very useful in predicting the timing and duration of smoke impacts over the populated areas of the Interior," said Michael Richmond, Fire Weather Program manager for the National Weather Service office in Fairbanks. "This will help us in issuing smoke advisories, which will aid state and local air quality officials in determining health impacts from wildfire smoke."

Wildfire smoke forecasts are updated daily during the fire season at http://smoke.arsc.edu.

WILDFIRE: Smoke is shown blowing over Alaska's Interior. Image by the Geographic Information Network of Alaska.

Cover photos: ship photo by Stan Shebs, glacier photo by Kulac/wikimedia.com

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