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Smell of Salt Air Surprisingly Detected a Mile High and 900 Miles Inland

http://www.sciencedaily.com/releases/2010/03/100310134150.htm

ScienceDaily (Mar. 11, 2010) — The smell of sea salt in the air is a romanticized feature of life along a seacoast. Wind and waves kick up spray, and bits of sodium chloride -- common table salt -- can permeate the air.

It is believed that as much as 10 billion metric tons of chloride enters the air mass through this process each year, but just a tiny fraction -- perhaps one-third of 1 percent -- does anything but fall back to the surface.
The bit of chloride lingering in the air can react with nitrogen oxides, formed when fuel is burned at high temperature, to form nitryl chloride, a forerunner of chlorine atoms, the most reactive form of chlorine. Those atoms can contribute to smog formation in coastal areas.

Now, in a surprise, researchers have found that this chemistry thought to be restricted to sea spray occurs at similar rates in air above Boulder, Colo., nearly 900 miles away from any ocean. What's more, local air quality measurements taken in a number of national parks across the United States imply similar conditions in or near other non-coastal metropolitan areas.

"It's there. We know it's there. But we don't have a good handle on where that chloride comes from," said Joel Thornton, a University of Washington associate professor of atmospheric sciences and lead author of a paper documenting the findings, published March 11 in *Nature*.

After sea spray, the largest global source of chlorides is coal burning, with biomass burning not far behind. Thornton said potential sources of chloride in the Boulder-Denver area include smoke from fireplaces, chemicals used on icy winter roads or even air drifting in from giant salt flats in Nevada and Utah, but there currently is no sure way to know the source.

In February 2007, a team including Thornton prepared to set out from Boulder for a research cruise from Long Island Sound to Iceland via Norway. The plan was to sample nitryl chloride levels in marine air, which computer models predicted would not exceed 50 parts per trillion.

Before leaving, the scientists decided to test the equipment they would use to detect airborne nitryl chloride on the cruise by sampling the air in Boulder, a mile above sea level.

"That night when we just nonchalantly stuck our tube out the window, we were getting readings of 500 parts per trillion in Boulder," Thornton recalled. Those levels turned out to be comparable to what the scientists later recorded on the research cruise, indicating the computer models greatly underestimate nitryl chloride in the air near the Earth's surface.

The researchers returned to Boulder in 2009 to take more comprehensive measurements from a park 150 feet above the city, away from obvious chloride sources. They confirmed their earlier observations, and they gathered further confirmation from the national park air quality monitoring systems.

"We expect this to be occurring in other places as well," Thornton said. The research focuses on a specific form of nitrogen oxides present only at night -- during the day it is broken down by even the faintest sunlight. It is commonly thought that much of the ozone- and haze-forming pollutants generated in metropolitan areas during a busy weekday are removed from the air during hours of darkness. The new research calls that into question, Thornton said.

The work suggests the nighttime form of nitrogen oxides reacts with haze particles containing chloride to form nitryl chloride, which in turn forms chlorine atoms and regenerate the smog-forming nitrogen oxides when the sun rises.

Chlorine atoms can reduce the lifetime of atmospheric mercury gas, as well as greenhouse gases such as methane. In polluted urban areas, they also enhance production of ozone, a key ingredient of smog that is potentially toxic to animal and plant life.

"Because of these impacts, we'd like to know what happens to these nitrogen oxides in nighttime air, where do they go, what do they do," Thornton said. He acknowledged that unraveling and understanding the ramifications of the findings will not be simple.

Co-authors are James Kercher; Theran Riedel, Glenn Wolfe and Becky Alexander of the UW; Nicholas Wagner, Julie Cozic, John Holloway, William Dube, Ann Middlebrook and Steven Brown of the National Oceanic and Atmospheric Administration's Earth Systems Research Laboratory in Boulder; and Patricia Quinn of the National Oceanic and Atmospheric Administration in Seattle. The work was funded by grants from the National Science Foundation and the National Oceanic and Atmospheric Administration. End

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Journal Reference:

1. Joel A. Thornton, James P. Kercher, Theran P. Riedel, Nicholas L. Wagner, Julie Cozic, John S. Holloway, William P. Dubé, Glenn M. Wolfe, Patricia K. Quinn, Ann M. Middlebrook, Becky Alexander & Steven S. Brown. **A large atomic chlorine source inferred from mid-continental reactive nitrogen chemistry**. *Nature*, 2010; 464 (7286): 271 DOI: 10.1038/nature08905

The reddish glow from the city lights of Boulder, Colo., is the result in part of the light being scattered by haze particles. UW scientists have discovered unexpected chemistry involving the pollutants that make up the haze. (Credit: Phil Armitage)

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