Wintertime air chemistry to be studied

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A sophisticated chemistry laboratory, packed into a room-sized container, travels up and down the Boulder Atmospheric Observatory (BAO) in Erie, Colo., to sample the atmosphere from the ground up to nearly 1,000 feet. Credit: NOAA

NOAA scientists and their colleagues from Boulder, Colo., and across the country have gathered in Erie, Colo., for a month-long study of the chemistry of the wintertime atmosphere, which they hope will shed light on some scientific mysteries.

The central question they will tackle: Exactly why and how does a compound usually associated with the atmosphere near oceans — nitryl chloride — also form during the winter nighttime in land-locked regions such as the foothills of the Rocky Mountains?

The question is important to answer because of the implications for both climate and air quality. Nitryl chloride breaks apart quickly as the sun rises to release chlorine atoms. Chlorine atoms can react with many other compounds, contributing to smog formation, and can also influence chemical cycles that destroy or produce various greenhouse gases, including ozone and methane.

“Nighttime formation of nitryl chloride is a gateway to forming more highly reactive chlorine atoms,” says Steve Brown, the scientist at the NOAA Earth System Research Laboratory (ESRL) in Boulder who is leading the study in Erie. “It changes the atmosphere’s starting point for the next day.”

Brown and colleagues first observed the phenomenon three years ago while testing instruments in Boulder in preparation for an experiment in the Arctic. Brown designed this winter’s comprehensive study, dubbed Nitrogen, Aerosol Composition, and Halogens on a Tall Tower (NACHTT), which will take place from mid-February to mid-March and will make use of NOAA’s Boulder Atmospheric Observatory, more informally known to locals as the Erie Tower.

Two years ago, Brown and University of Washington scientist Joel Thornton investigated the nitryl chloride mystery a little further and were surprised to find that during the night, chloride compounds in the atmosphere were interacting with nitrogen oxide pollution, ultimately forming nitryl chloride. Nitrogen oxides are emitted during the combustion of fossil fuels. But exactly where the atmospheric chloride comes from in a region so far from the oceans, and how the nighttime

chemistry unfolds to produce nitryl chloride, are not fully understood.

The Erie Tower will give the scientists a distinct advantage in looking at the wintertime atmosphere, which is made up of “layers” that don’t mix well. As a consequence, what’s in the air and its chemical interactions vary with height, and therefore can’t be fully understood by making measurements only at ground level. A new mobile “Tower Laboratory” platform built at NOAA will carry more than one ton of instrumentation up and down the 300-meter tower, characterizing the chemistry at different heights.

Brown and other scientists in ESRL’s Chemical Sciences Division are working with colleagues from the University of Colorado, the University of Washington, the University of Virginia, the University of Toronto, the University of New Hampshire, the National Center for Atmospheric Research, Colorado State University and the Max Planck Institute in Germany.

The NACHTT researchers will bring with them an arsenal of instruments, many of them custom built, to solve the mystery of nitryl chloride. “This time we’ll be able to measure many more compounds, and they should give us the clues we need to pin down the source of the atmospheric chloride,” said Brown. Some of the likely suspects include wood burning, pollution from power plants, and road de-icing chemicals.

Airborne particles could help answer many questions, and instruments operated by scientists William Keene of the University of Virginia and Ann Middlebrook of ESRL will tackle this piece of the puzzle. “By measuring what’s in airborne particles of different sizes, we’ll get a handle on not only the chlorine sources but also the possible climate implications of these particles,” said Keene. Some particles in the atmosphere can act to cool climate by reflecting sunlight, while others such as soot can have a warming effect because they absorb heat.

Whatever the outcome of the NACHTT, the study is sure to advance the understanding of what goes on in the air in the dead of winter, and at night — two little-studied aspects of the chemistry of the atmosphere. It's possible that the chemistry could apply to other regions and other seasons, even the summertime in Los Angeles.

"This is just the beginning of the story," notes Brown.

Provided by NOAA

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