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Night light. *Noctilucent clouds brighten a Finnish evening.*

Signs of Wet Weather in the Polar Mesosphere?

Thickening clouds and strange radar echoes are drawing new attention to this remote layer of the atmosphere

FOR YEARS, ATMOSPHERIC SCIENTISTS KNEW so little about the mesosphere that they referred to it as the "ignorosphere." But lately they've seen enough to know that something's afoot in the mysterious swath of sky above the much-studied stratosphere.

Every summer since 1981, some 90 kilometers above the north and south poles, research radars have elicited unexplained high-frequency echoes. And over the same period, researchers have noticed that noctilucent clouds—the highest clouds on Earth, which streak the polar mesosphere just after dark on summer nights—have been growing steadily brighter and more common. Is there a connection between the two phenomena? Nobody knows, but some researchers think the mesosphere is starting to feel the far-reaching effects of human activity. "It seems the more we learn about the mesosphere, the more we're realizing how sensitive it may be to global change," says Gary Thomas, an atmospheric physicist at the University of Colorado at Boulder.

Thomas and other atmospheric scientists are hoping that a recent burst of mesospheric research will yield a clearer picture of the processes at work there. In the meantime, though, they are guessing that the echoes and the thickening clouds may have something to do with the global buildup of methane, a greenhouse gas released by livestock, rice paddies, and deforestation. By breaking down into water molecules in the mesosphere, the methane might supply raw material for clouds and provide a source of heavy ions, which might help sculpt the electrical structure of the mesosphere into radar-reflecting contours.

It was observations of the radar echoes that first sparked interest in the mesosphere in 1981. Aeronomer Ben Balsley and his colleagues at the National Oceanic and Atmospheric Administration in Boulder reported that high-frequency—50 megahertz—signals from the Mesosphere-Stratosphere-Troposphere radar at Poker Flat, Alaska, were echoing off the very top of the mesosphere, the mesopause. Since Balsley's report, several other radar stations have recorded the echoes at even higher frequencies, up to 933 megahertz.

The echoes had to be coming from electrons in the mesosphere, and their high frequency suggested that the electrons were interacting with dense layers of particles, says physicist James Ulwick of the University of Utah's Stewart Radiance Laboratory in Bedford, Massachusetts. "The electrons are sticking to something up there like paint," adds Richard Goldberg, a physicist at the Goddard Space Flight Center in Greenbelt, Maryland.

What the electrons are sticking to, Thomas suggests in an article slated for the November *Reviews of Geophysics*, may be hydrated ions: water molecules that have acquired a positive charge in the ionized environment of the mesosphere. One reason for believing proton hydrate ions might be the culprit, he says, is the fact that they are stable only at extraordinarily low temperatures. And the mesopause is coldest—its temperature falling as low as 110 degrees Kelvin—in the summer months, when the echoes are detected.

A major source of the water molecules that would form the positive ions, Thomas says, may be methane. Most water vapor in the atmosphere freezes out before it gets to the mesosphere, but methane would survive to reach the atmosphere's outer layers, where sunlight-driven reactions would convert it to water. That process may also be fueling the buildup of noctilucent clouds, he thinks. Atmospheric methane has nearly doubled since 1900 while noctilucent clouds became nearly 10 times brighter according to Thomas and his colleague Eric Jensen.

In addition to providing more water to make clouds, the rising methane may also be helping to seed their formation. Lower in the atmosphere, the droplets or ice crystals that make up a cloud generally take shape around grains of dust or sea salt; in the mesosphere, the cloud seeds are provided by meteoric dust and—Thomas and other atmospheric physicists are guessing—proton hydrate ions. Thus, a methane-driven rise in mesospheric water might also mean more cloud nuclei.

Not every atmospheric scientist accepts all aspects of this scenario. Michael Gadsden, a physicist at Aberdeen University in Scotland, points out that it takes extremely low temperatures to freeze the sparse water of the mesosphere into ice particles. Gadsen says the temperature at the mesopause has inexplicably decreased about 7 degrees Kelvin in the last 30 years—enough, he thinks, to account for some of the recent cloud buildup. As for the radar echoes, Wesley Swartz, an electrical engineer at Cornell University, thinks that along with proton hydrates, charged aerosols might also be playing a role.

In any case, some of those conjectures may soon be firmed up. Goldberg, Ulwick, Swartz, and 35 other researchers from an eight-country consortium have just wound up NLC-91, a concerted effort to explore the polar mesosphere. In Kiruna, Sweden, and Heiss Island, Soviet Union, from 24 July to 10 August, they aimed radars at the mesosphere and fired 31 rockets into it to trace ions and electric fields. Sorting through NLC-91's mountain of data, Ulwick says, will take months, but NLC-91 scientists hope their data will help untangle the web of cause and effect—if there is one—linking noctilucent clouds, radar echoes, proton hydrate ions, and methane. If Thomas' methane connection is born out, yet another layer of atmosphere will be feeling the hand of man. ■ RICHARD STONE