Clouds, clouds, burning bright

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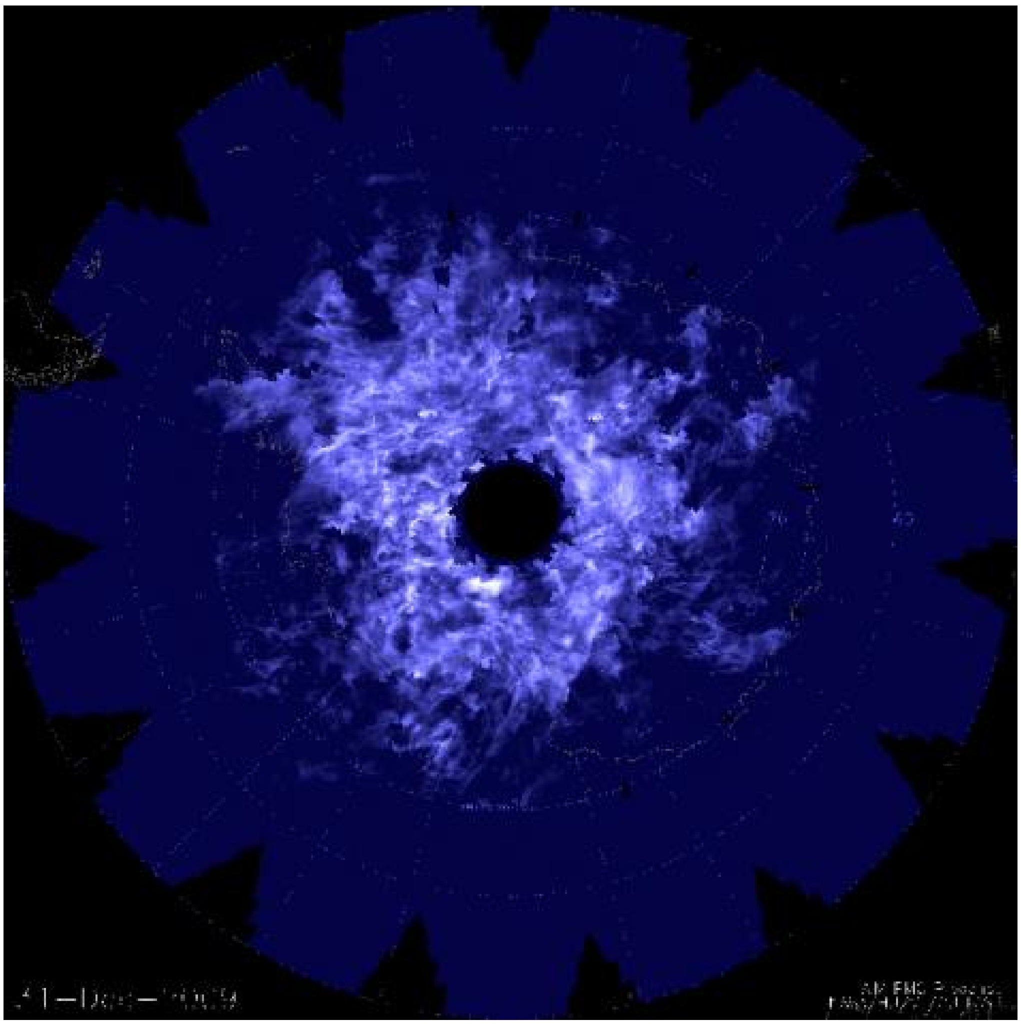

Looking down from above, AIM captured this composite image of the noctilucent cloud cover above the Southern Pole on December 31, 2009. The 2009 cloud season began a month earlier than the 2010 season did. Credit: NASA/HU/VT/CU LASP

(PhysOrg.com) -- High up in the sky near the poles some 50 miles above the ground, silvery blue clouds sometimes appear, shining brightly in the night. First noticed in 1885, these clouds are known as noctilucent, or "night shining," clouds. Their discovery spawned over a century of research into what conditions causes them to form and vary – questions that still tantalize scientists to this day. Since 2007, a NASA mission called Aeronomy of Ice in the Mesosphere (AIM) has shown that the cloud formation is changing year to year, a process they believe is intimately tied to the weather and climate of the whole globe.

"The formation of the clouds requires both water and incredibly low temperatures," says Charles Jackman, an atmospheric scientist at NASA's Goddard Space Flight Center in Greenbelt, Md., who is NASA's project scientist for AIM. "The temperatures turn out to be one of the prime driving factors for when the clouds appear."

So the appearance of the noctilucent clouds, also known as polar mesospheric clouds or PMCs since they occur in a layer of the atmosphere called the mesosphere, can provide information about the temperature and other characteristics of the atmosphere. This in turn, helps researchers understand more about Earth's low altitude weather systems, and they've discovered that events in one hemisphere can have a sizable effect in another.

Since these mysterious clouds were first spotted, researchers have learned much about them. They light up because they're so high that they reflect sunlight from over the horizon. They are formed of ice water crystals most likely created on meteoric dust. And they are exclusively a summertime phenomenon.

"The question people usually ask is why do clouds which require such cold temperatures form in the summer?" says James Russell, an atmospheric scientist at Hampton University in Hampton, Va., who is the

Principal Investigator for AIM. "It's because of the dynamics of the atmosphere. You actually get the coldest temperatures of the year near the poles in summer at that height in the mesosphere."

Noctilucent clouds streaming across the sky in Utrecht, The Netherlands on June 16, 2009. Credit: Robert Wielinga

As summer warmth heats up air near the ground, the air rises. As it rises, it also expands since atmospheric pressure decreases with height. Scientists have long known that such expansion cools things down – just think of how the spray out of an aerosol can feels cold – and this, coupled with dynamics in the atmosphere that drives the cold air even higher, brings temperatures in the mesosphere down past a freezing -210º F (-134 ºC).

In the Northern hemisphere, the mesosphere reaches these temperatures consistently by the middle of May. Since AIM has been collecting data, the onset of the Northern season has never varied by more than a week or so. But the southern hemisphere turns out to be highly variable.

Indeed, the 2010 season started nearly a month later than the 2009 season.

Atmospheric scientist Bodil Karlsson, a member of the AIM team, has been analyzing why the start of the southern noctilucent cloud season can vary so dramatically. Karlsson is a researcher at Stockholm University in Sweden, though until recently she worked as a post-doctoral researcher at the University of Colorado. A change in when some pretty clouds show up may not seem like much all by itself, but it's a tool for mapping the goings-on in the atmosphere, says Karlsson.

"Since the clouds are so sensitive to the atmospheric temperatures," says Karlsson. "They can act as a proxy for information about the wind circulation that causes these temperatures. They can tell us that the circulation exists first of all, and tell us something about the strength of the circulation."

She says the onset of the clouds is timed to something called the southern stratospheric vortex – a winter wind pattern that circles above the pole. In 2010, that vortex lingered well into the southern summer season, keeping the lower air cold and interfering with cloud formation. This part of the equation is fairly straightforward and Karlsson has recently submitted a paper on the subject to the Journal of Geophysical Research. But this is not yet the complete answer to what drives the appearance of these brightly lit clouds.

AIM researchers also believe there is a connection between seemingly disparate atmospheric patterns in the north and south. The upwelling of polar air each summer that contributes to noctilucent cloud formation is part of a larger circulation loop that travels between the two poles. So wind activity some 13,000 miles (20,920 km) away in the northern hemisphere appears to be influencing the southern circulation.

The first hints that wind in the north and south poles were coupled came in 2002 and 2003 when researchers noticed that despite a very calm lower weather system near the southern poles in the summer, the higher altitudes showed variability. Something else must be driving that change.

Now, AIM's detailed images of the clouds have enabled researchers to look at even day-to-day variability. They've spotted a 3 to10 day time lag between low-lying weather events in the north – an area that, since it is fairly mountainous, is prone to more complex wind patterns – and weather events in the mesosphere in the south. On the flip side, the lower atmosphere at the southern poles has little variability, and so the upper atmosphere where the clouds form at the northern poles stays fairly constant. Thus, there's a consistent start to the cloud season each year.

"The real importance of all of that," says Hampton's Russell, "is not only that events down where we live can affect the clouds 50 miles (80 km) above, but that the total atmosphere from one pole to the next is rather tightly connected."

Hammering out the exact mechanisms of that connection will, of course, take more analysis. The noctilucent cloud season will also surely be affected by the change in heat output from the sun during the upcoming solar maximum. Researchers hope to use the clouds to understand how the sun's cycle affects the Earth's atmosphere and the interaction between natural- and humankind-caused changes.

"These are the highest clouds in Earth's atmosphere, formed in the coldest place in Earth's atmosphere," says Goddard's Jackman. "Although the clouds occur only in the polar summer, they help us to understand more about the whole globe."

AIM is a NASA-funded Small Explorers (SMEX) mission. NASA

Goddard manages the program for the agency's Science Mission Directorate at NASA headquarters in Washington. The mission is led by the Principal Investigator from the Center for Atmospheric Sciences at Hampton University in Virginia. The Laboratory for Atmospheric and Space Physics (LASP), University of Colorado, Boulder, and the Space Dynamics Laboratory, Utah State University, built the instruments. LASP also manages the mission and controls the satellite.

Provided by NASA's Goddard Space Flight Center