NOCTILUCENT CLOUDS

MARK ZALCIK (bgg_skymerchant@hotmail.com) AND MICHAEL BOSCHAT
astronomymike5@gmail.com)

Noctilucent cloud display of 2013 July 3-4, 0340 MDT. The spectacular clouds climbed to the zenith and beyond in morning twilight as seen from Edmonton, Alberta. Photo by Alister Ling.

The summer twilight skies at northern latitudes are occasionally graced with a beautiful phenomenon: noctilucent clouds (NLC), also known as polar mesospheric clouds (PMC), a term more commonly used when referring to satellite observations of the clouds. They are ice clouds forming over the summertime poles, the result of meteor dust drifting down from space combining with water ice diffusing up from Earth's surface; the two components meet at the mesopause, the top of the mesosphere at 80 km height, with a thin formation zone of 80–82 km. It is at these heights that the coldest temperatures on the planet occur, 150 K. The water ice is thought to be one of the decomposition products of methane, one of the greenhouse gases, originating at Earth's surface, and broken down by sunlight in the stratosphere. Thus, NLC, whose brightness and extent in the twilight sky can be a truly memorable sight, possess a connection to both astronomy and global climate change.

NLC have until recently been considered a rare phenomenon. Indeed, though globally NLC have been known since 1885, the first sighting in North America was not until 1933, the details being published by Vestine in his paper Noctilucent Clouds in JRASC in 1934 (Vol. 28).

With such a sudden onset of the phenomenon of noctilucent clouds toward the end of the 19th century, going from nonexistent to suddenly being there, one may surmise that NLC can be climatically erratic. Have the clouds continued on a trajectory of increasing frequency and geographic extent over the past two centuries? Actually, the historic visual monitoring record has revealed, since the 1960s when NLC have been surveyed systematically, that an increase in frequency has occurred. However, the rise has been slight and statistically insignificant. The 1960s did in effect mark the advent of a new epoch characterized by increased sightings of NLC compared with previous decades. But the apparent jump in activity seems to have been simply due to more people being clued in about the phenomenon and more individuals submitting reports to various agencies. This decadal trend has continued into the 21st century.

With websites such as Spaceweather (www.spaceweather.com) and the Noctilucent Cloud Observers' Homepage (www.nlcnet.co.uk) providing a showcase for sightings and gorgeous photos of NLC, one gets the impression that NLC are indeed a commonly observed night-sky denizen.

Two remarkable trends have surfaced in the last two decades. One is the gradual equatorward extension of sightings during the Northern Hemisphere season, culminating with sightings on 2019 June 9/10 and 23/24 by Don Davis of Joshua Tree, California (34.1° N). The other trend is a reduced response of NLC incidence to solar activity. Historically, during the years around sunspot maximum, there have been fewer sightings of NLC due to heating of the mesosphere by increased radiation from the Sun. But during the last two solar maxima, in 2003 and 2014, NLC sightings remained at high levels. PMC monitored by satellite showed a similar tendency (see the paper by Mark Hervig et al., published in *Geophysical Research Letters, 46, 10*, 132–10, 139).

A more recent and compelling trend has been the robust increase in NLC activity over the last few years. Previously, an active NLC season would have a total of over 50 NLC-active nights. In North America, the totals in 2018, 2019, and 2020 were, respectively, 62, 65, and 73. The extra active nights have been for the most part already packed into the core of the season, resulting in fewer NLC-free nights in June and July.

Historically, in North America, the area where NLC have been most frequently observed has been the northern prairies, in the latitude range 53°–60° N. South of ~53° N, the NLC become rapidly out of range; north of 60° N, the skies are too bright in summer. (cont. on p. 4)

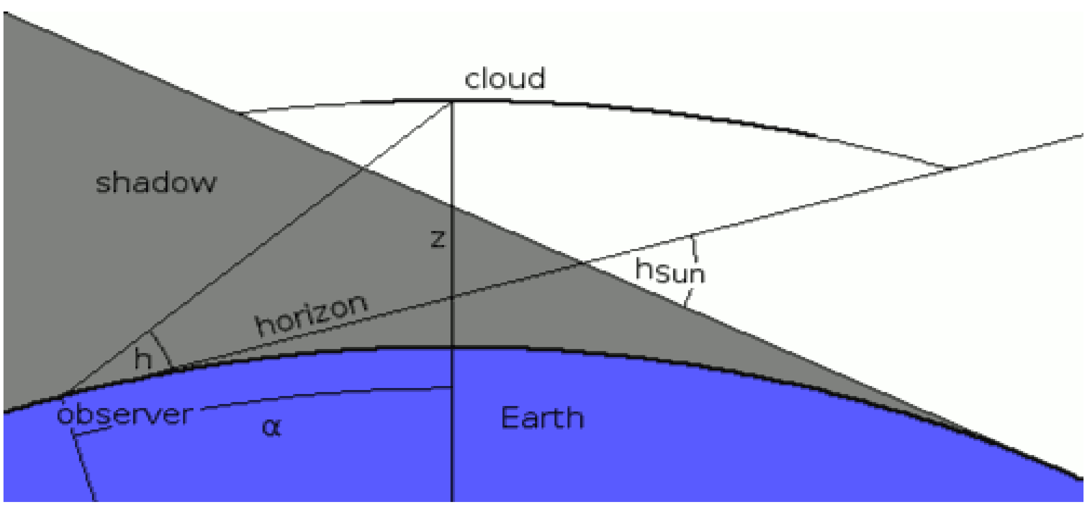


Diagram showing geometry of NLC observing. Tropospheric clouds are much lower than NLC and thus remain in shadow, whereas NLC ("cloud") are high enough to scatter sunlight skimming past the limb of the planet and are hence visible to the distant observer. Figure courtesy of Horst Meyerdierks.

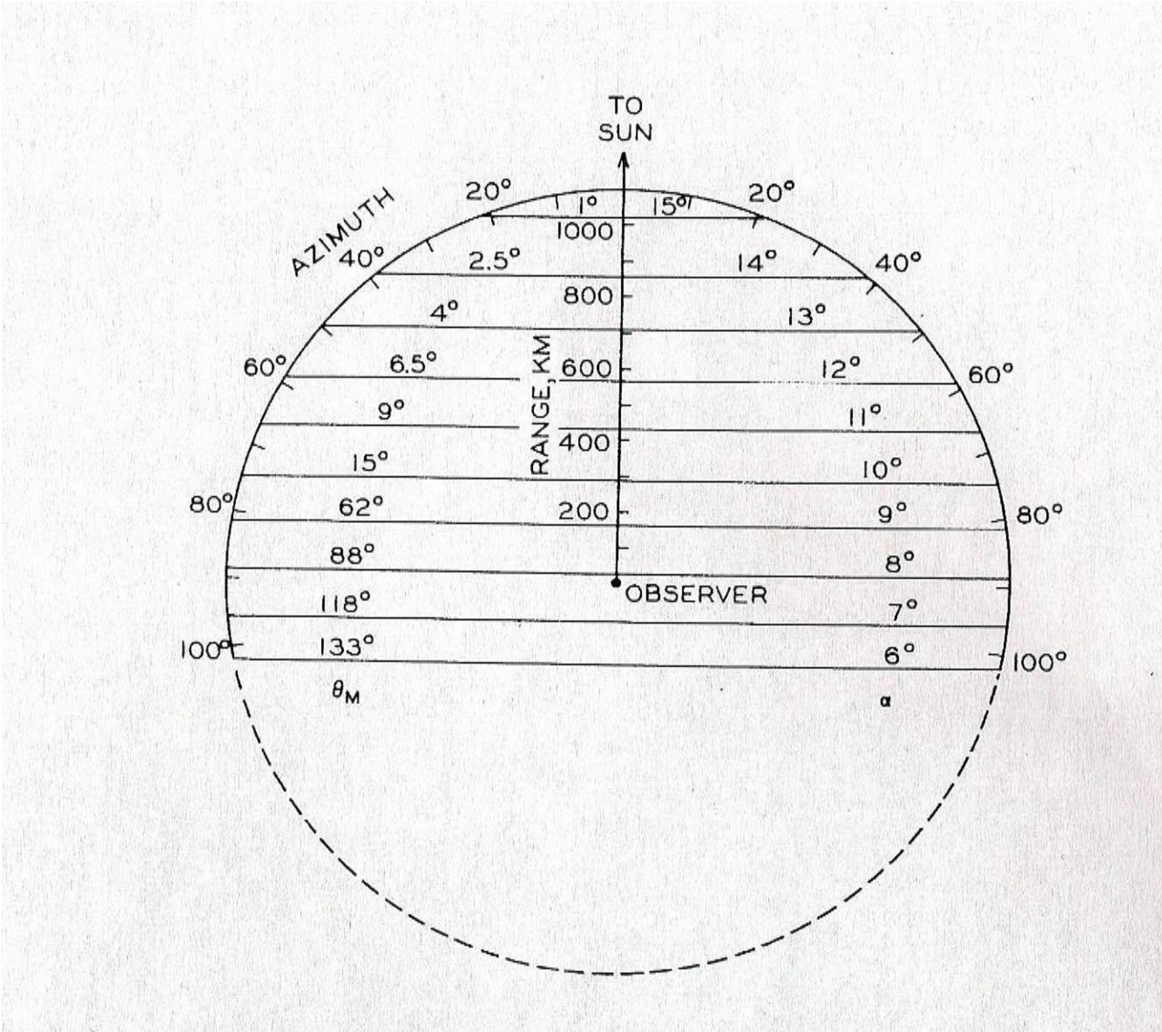
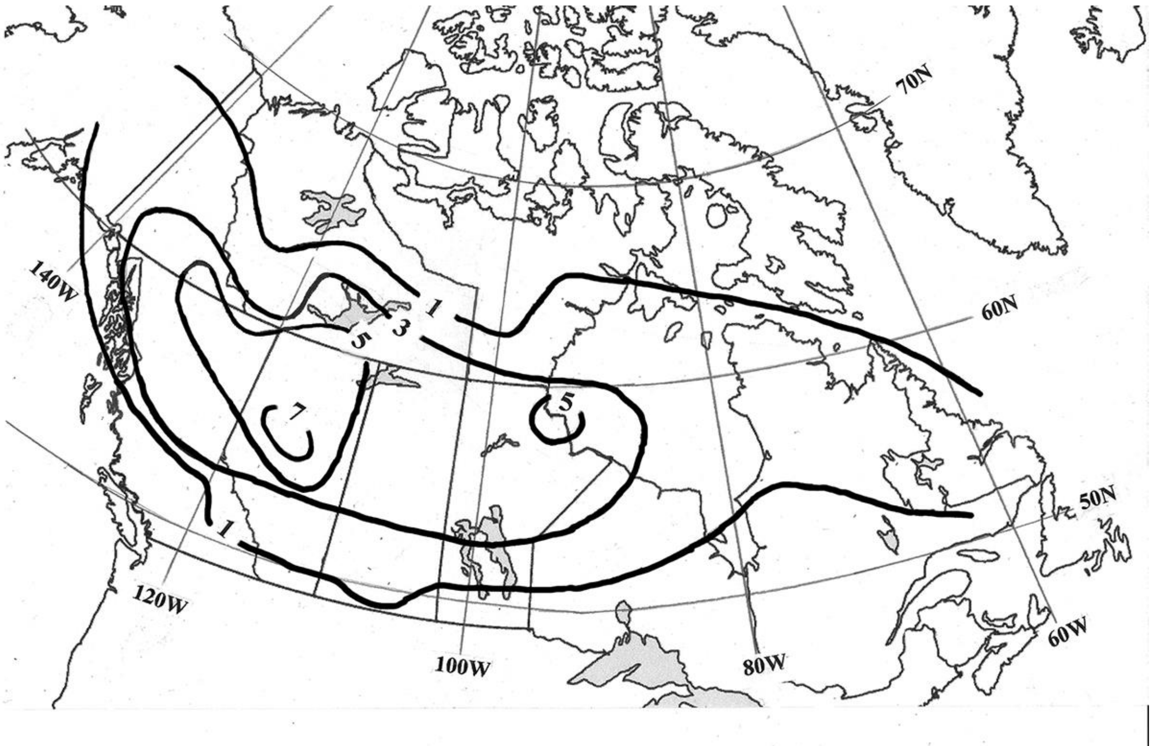


Diagram showing portions of the local sky NLC can occupy at various degrees of solar depression (cascading numbers on the right side). Numbers on the left side are corresponding maximum elevations of NLC. At 15° of solar depression, NLC are but one degree above the horizon. When the Sun is only 6° below the horizon, NLC can extend over 40° past the zenith. (From Noctilucent Clouds*, by Benson Fogle, University of Alaska publication R-177, 1966)*



Map showing average seasonal sightings of NLC based on observations by weather and airport personnel in Canada and Alaska from 1964-77. Sky checks were conducted on an hourly basis each night during the NLC season. The best place on the continent to view NLC is the area around Lesser Slave Lake in northern Alberta, with an average of seven sightings per season. Note that If observing is instead done continuously through the night, or a camera is used to help detect faint displays, or an observer drives to alternate sites to avoid weather cloud interference, seasonal sighting totals can increase significantly. Edmonton observer Mike Noble has tallied as many as 49 NLC-active nights in a single season!

Around cold-water coasts, weather clouds have a negative effect on NLC detection. Along the 49th parallel in western Canada, and especially in eastern Canada, NLC are a rarer phenomenon, with a handful of displays per year and one display every few years, respectively, being the norm.

A flat, dark horizon, attempting to observe through one's entire twilight period, and the use of binoculars—all have shown to greatly increase one's chances of spotting NLC.

Digital photography has shown to reveal very faint NLC at the threshold of unaided-eye visibility. NLC are exclusively seen within the twilight arch. They begin to be illuminated by the Sun when it is 16° below the horizon, barely within astronomical twilight; at this time, the NLC are less than 1° above the local horizon. The other limit of NLC visibility is quoted at 6°, the start of civil twilight, yet this is a softer figure as it is possible, during spectacular displays, to follow NLC nearly to sunset/sunrise. During the 10° solar depression interval, NLC can appear at any time and in any part of the twilight oval, though they are usually rooted at some point along the northern horizon, since the clouds are situated hundreds of kilometres downrange toward the pole. Look for cirrus-like formations, often with a silver-blue tinge, the result of absorption of cloud-to-observer light by ozone. NLC move very slowly and their motion is usually to the west or southwest.

When recording information about a display of NLC, in addition to measurement of azimuth and altitude extent of the display, details of the structure and brightness of the clouds can also be noted. With regard to NLC structure, the principal types are: Type I – Veil; Type II – Bands; Type III – Billows; Type IV – Whirls. Some of the sub-classes are mentioned below along with some other types of structure:

I	Veil – a featureless patch lacking well-defined structure. Veils often form a background to other forms.
IIa	Bands – long streaks with diffuse, blurred edges.
IIb	Bands – long streaks with sharply defined edges.
IIIa	Billows – shorter, more closely-spaced streaks. Billows sometimes lie across bands, giving the appearance of a comb or feather.
IIIb	Billows with undulating wave structure, like waves on a body of water.
IVa	Whirls – partial rings of NLC with a more contorted appearance than bands or billows. Type IVa whirls have a small radius of curvature, 0.5–1 degree.
IVb	Whirls with a larger radius of curvature, 3–5 degrees.
IVc	Whirls with large-scale ring structure.
O	"Other" – does not fit into the types I-IV classification
S	Knots – sometimes seen when two bands intersect
P	Billows crossing a Band
V	Net-like structure

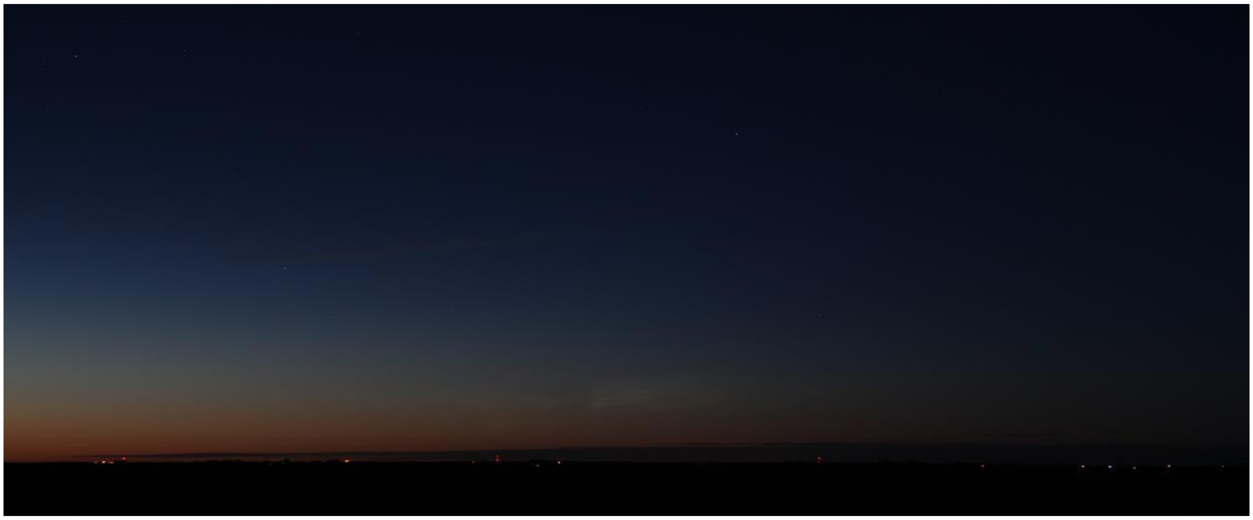
With regard to NLC brightness designations, the three choices used by the NLC CAN AM North American surveillance network are: 1–faint; 2–moderate; 3–bright.

NLC types and brightnesses are listed on the bottom of the sample NLC report form provided here, and photographic examples also appear in this supplement.

NLC are an area of study much within the realm of citizen science. They can be seen with the unaided eye, with a pair of binoculars the only equipment needed. The aforementioned websites welcome observations; as well, the NLC CAN AM network (coordinator: Mark Zalcik), which has followed NLC since 1988, encourages observers to submit details of their observations, be they positive or negative. Good luck, and have fun!

A paper on the 25 years of NLC observing by staff at the La Ronge flight service station in Saskatchewan has recently been published. It is titled "In Search of Trends in Noctilucent Cloud Incidence from the La Ronge Flight Service Station (55N 105W)" and it can be found in the August 2014 issue of the *Journal* of the Royal Astronomical Society of Canada, Vol. 108, No. 4. In a more recent issue, Vol. 110, No. 61, there is a comparison of NLC CAN AM observations with those from the 1960s and 1970s, the paper titled North American Noctilucent Cloud Observations in 1964-77 and 1988-2014: Analysis and Comparisons.

NOCTILUCENT CLOUDS — GUIDE TO TYPES AND BRIGHTNESSES



Type I – Veil Brightness 1 – Faint
Mike Noble, 2012 June 27/28, 0004 MDT

Type IIa – Bands with diffuse edges Brightness 2 – Moderate
Mike Noble, 2012 June 30/July 1, 0002 MDT

Type IIb – Bands with sharp edges Brightness 3 – Bright
Mike Noble, 2012 July 18/19, 0029 MDT

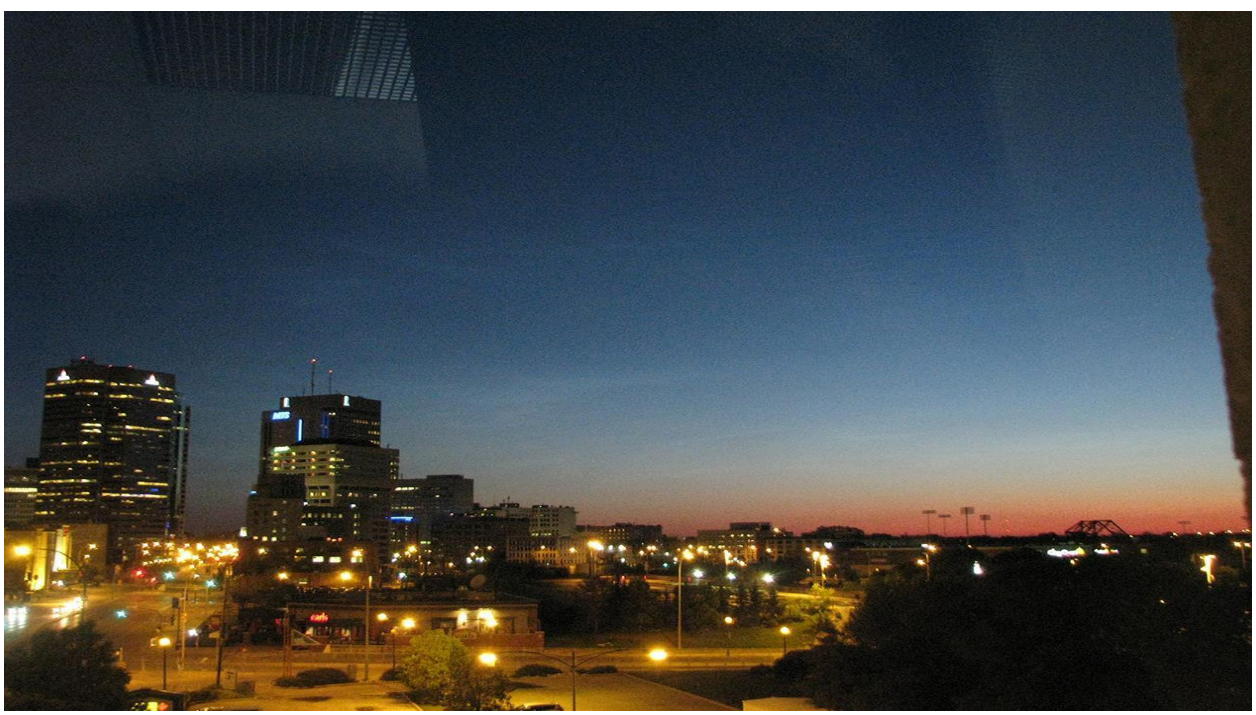
Type IIIa – Billows with short streaks Brightness 2
Mike Noble, 2012 June 27/28, 0228 MDT


Type IIIb – Billows with undulating wave structure Brightness 3
Alister Ling, 2015 June 17/18, 0030 MDT


Type IVb – Whirls with angular radius of 3–5 degrees Brightness 3
Mike Noble, 2012 July 19/20, 0258 MDT

NLC GALLERY

Robert Lalancette, airline pilot, photo from aircraft



Sandy Massey

Bruce McCurdy

Jay Brausch, Glen Ullin, North Dakota, 46.8° N

Alister Ling

Mike Noble

Mark Zalcik

AUGO 2 automated camera, Athabasca University Geophysical Observatory

Alister Ling

Mike Noble

Richard Huziak

Mike Noble

Mark Zalcik

Jay Lavender

Mike Noble

Alister Ling

Michael Boschat, Halifax, Nova Scotia, 44.6° N

Dick Daigle, McMinnville, Oregon, 45.2° N

Joseph Shaw, Bozeman, Montana, 45.7° N

Bob King - NLC and Comet NEOWISE, 2020.

Yuichi Takasaka–2019 June 9