

Observing noctilucent clouds from Hungary with NLC wakeup application

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Abstract




The bluish noctilucent clouds are observable only during the time of summer solstice. They are most commonly observed at latitudes between 50 and 70 degrees, but there is evidence that corroborates their gradual increase which may be linked with the slow climate change. We summarize the discovery of noctilucent clouds after the eruption of volcano Krakatoa. We also describe their formation and types, then demonstrate the Noctilucent Cloud (NLC) WakeUp Android application developed by us. This tool can help us to calculate automatically the detection windows of noctilucent clouds depending on the date and the solar elevation angle.

Observing Noctilucent Clouds from Hungary with NLC WakeUp Application

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The bluish noctilucent clouds (NLCs) are observable only during the time of summer solstice. They are most commonly observed at latitudes between 50 and 70 degrees, but there is evidence that corroborates their gradual increase which may be linked with the slow climate change. We present the discovery of noctilucent clouds after the eruption of volcano Krakatoa. We also describe their formation and types, then demonstrate the Noctilucent Cloud (NLC) WakeUp Android application developed by us. This tool can help us to calculate automatically the detection windows of noctilucent clouds depending on the date and the solar elevation angle.

Occurrence and Observation of Noctilucent Clouds

The generally bluish-noctilucent clouds (NLCs) or night-shining clouds are spectacular atmospheric optical phenomena which appear only around the summer solstice in the vicinity of the northern hemisphere. They are made of fine water-ice crystals, 0.5 to 1 micrometer and formed in the mesosphere (around 83 km) higher than any other clouds in Earth's atmosphere. They become visible from the surface only during the deep twilight when they are illuminated by sunlight from below. NLCs are most commonly observed between the 40°–90° latitudes, but the most and the brightest NLCs are observed around the 60° latitudes (Kokkonen, 2005; Lindholm et al., 2006). Interestingly, since the recent past most and most people observe it from lowest latitudes. The first NLC's of the given year in the Northern Hemisphere usually occur in May, however Hungarian observers can look for the NLCs only from mid-June until the end of July (Table 1, Figures 1-2).

Their formation is linked to the summer solstice period because the temperature of the mesosphere is the lowest during that time instead of winter when ~130 km, which is ideal for the formation of these clouds besides the very low humidity (von Zahn, 1999; Thomas, 1991). The ice-forming nuclei and water vapor necessary for the creation of ice clouds can be found in the mesosphere as previously mentioned quantities as contrast to the troposphere, which is the lower and denser layer of the atmosphere, therefore their possible presence and occurrence are most to be discussed separately.

Sources of Water Vapor and Ice Nuclei

Connection with NLCs detected after the catastrophically and highly destructive eruption of Krakatoa in 1883 or after the Tambora event in 1998, we can mention volcanic eruptions and water-rich materials at the natural sources of water (Fegle, 1967; Schödel, 1999; 2001; Leng, 2007). A part of water vapor is deposited to the mesosphere due to the reaction of methane with hydroxyl radicals due to complex reactions of methane. The methane molecules can fall apart between 40 km and 70 km due to the effects of sunlight, therefore water molecules can form in the reaction of hydrogen with atmospheric oxygen (Thomas et al., 2005). This chemical process is straightforward in the troposphere, but a key in the extremely dry mesosphere. In addition water vapor can be added to the mesosphere as a result of anthropogenic influences, because during the combustion of open water fuels water is released among other materials. The amount of mesospheric water vapor is constantly decreasing as a result of the photoionization and the intensity of this reaction is strongly dependent on the solar variation (Nishitani, 1984; Sementsov et al., 2005; Gopalswamy et al., 2006). 1.9 to 10%–40% more water molecules remain in the mesosphere during the complete maximum (Zhang et al., 1997; Dandl et al., 2007). It is likely that a large number of NLCs detected from Hungary in 2009 (Table 1) can also be associated with an unusually long summer minimum. Ice nuclei may be added to the mesosphere with slow air flows or they can originate from ionosols (Oshitsu et al., 1967; Tomo et al., 1982; Kopp et al., 2003; Apthomas et al., 2009).

Multifarious Morphology of Noctilucent Clouds

The NLCs have great diversity in morphology: four basic types (I, II, III, IV) with sub-groups (a, b, c) and four complex forms (N, P, V, O) are known. The most (I) is the simplest form, which is generally present in the background of other types and similar to the supersaturated high-level clouds. Bands (II) are often occurring in groups arranged roughly parallel to each other. Its bands are with blurred and ill bands are with clearly visible boundary edges. Waves or ribbons (III) and whisks (IV) with ring structure can also appear. In most cases, two or more types can simultaneously be observed. The brightness of NLCs is classified according to a 5-point scale (1-5), where 1 means a very weak and 5 means an extremely bright and dominating phenomenon (Lindholm et al., 2006).

Long-term Increase

The discovery of NLCs in 1883 had enormous importance in the meteorological and geophysical research. The descriptions and instrumental analysis of observations networkly recorded several details from that unknown part of the atmosphere. Based on long-term observations it is also revealed that NLCs appear more often and more brighter and they are observably from more and more southern latitudes over time. Those can be associated with the changes of the atmospheric composition and the increasing water vapor concentration. These long-term changes may be connected to the global climate change and human activities (Thomas et al., 1999; 2001; 2003; Kwasniewski, 2002; von Zahn, 2003). These grounds are still uncertain, further research is needed to explore the accurate formation and behavior of NLCs. It is addition to investigating this phenomenon with the ADM research (Autonomous Lidar in the Mesosphere), it is important to conduct terrestrial visual observations which may help to answer the open questions (Walker, 2011). Although, for these researchers who regularly observe NLCs, it is very time-consuming to search for all calculation time to do that exactly when they need to monitor the northern horizon. We developed an Android application which can make a plan for observers.

The services of the NLC Wake Up application

The NLC Wake Up application was developed primarily for research purposes and for photographers who would like to observe NLCs. As a first step, the application determines the locations of the observers, based on the GPS service of their smart phone, thereafter it calculates the current observation angles of the Sun (Figure 3). After the evening time was setting and the solar elevation reached 4° below the horizon (when the observation window opens), the application plays an arbitrary ring tone, namely it alerts the researcher or the photographer in order to have the opportunity to observe NLCs. Unfortunately, the observations can not be predicted, as the observer is forced to look for the NLCs through the whole possible observation period and measurements can only be performed if they really appear. The NLC Wake Up application provides the same alert even when the entire observation reached 15° below the horizon (when the possible visibility period ends), thus the application indicates the researcher that it is not worth to continue the monitoring. These alerts repeated in the early hours as well. The application can also use the data of an online weather monitoring service, in which case the observer is informed, only when the conditions are appropriate for observing NLCs. It would be useless to get up at night and look for this mesospheric phenomena if they are already covered by lower tropospheric clouds.




Figure 2: Noctilucent clouds observed by A. Farkas from Mágocsd, Hungary, on 22/23 July 2009.

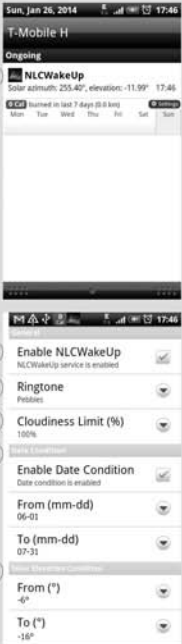


Figure 3: Screens of the NLC WakeUp Android application. (1) The activated application shows the current solar azimuth and elevation angles. (2) The check mark indicates that the service is installed. The user can set (3) an arbitrary ring tone, (4) a vibration time, above which the application sends the alerts, (5) a date period and (6) a range of solar elevation when the alerting application operates.

Year	Date (UTC)	Observed NLC Form	Brightness	Maximum Duration
2007	2007-06-29	III, IV, V, C, O	3	1
2007	2007-07-01	III, IV, V, C, O	3	1
2007	2007-07-02	III, IV, V, C, O	3	1
2007	2007-07-03	III, IV, V, C, O	3	1
2007	2007-07-04	III, IV, V, C, O	3	1
2007	2007-07-05	III, IV, V, C, O	3	1
2007	2007-07-06	III, IV, V, C, O	3	1
2007	2007-07-07	III, IV, V, C, O	3	1
2007	2007-07-08	III, IV, V, C, O	3	1
2007	2007-07-09	III, IV, V, C, O	3	1
2007	2007-07-10	III, IV, V, C, O	3	1
2007	2007-07-11	III, IV, V, C, O	3	1
2007	2007-07-12	III, IV, V, C, O	3	1
2007	2007-07-13	III, IV, V, C, O	3	1
2007	2007-07-14	III, IV, V, C, O	3	1
2007	2007-07-15	III, IV, V, C, O	3	1
2007	2007-07-16	III, IV, V, C, O	3	1
2007	2007-07-17	III, IV, V, C, O	3	1
2007	2007-07-18	III, IV, V, C, O	3	1
2007	2007-07-19	III, IV, V, C, O	3	1
2007	2007-07-20	III, IV, V, C, O	3	1
2007	2007-07-21	III, IV, V, C, O	3	1
2007	2007-07-22	III, IV, V, C, O	3	1
2007	2007-07-23	III, IV, V, C, O	3	1
2007	2007-07-24	III, IV, V, C, O	3	1
2007	2007-07-25	III, IV, V, C, O	3	1
2007	2007-07-26	III, IV, V, C, O	3	1
2007	2007-07-27	III, IV, V, C, O	3	1
2007	2007-07-28	III, IV, V, C, O	3	1
2007	2007-07-29	III, IV, V, C, O	3	1
2007	2007-07-30	III, IV, V, C, O	3	1
2007	2007-07-31	III, IV, V, C, O	3	1
2007	2007-08-01	III, IV, V, C, O	3	1
2007	2007-08-02	III, IV, V, C, O	3	1
2007	2007-08-03	III, IV, V, C, O	3	1
2007	2007-08-04	III, IV, V, C, O	3	1
2007	2007-08-05	III, IV, V, C, O	3	1
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