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OBSERVATIONS OF POLAR STRATOSPHERIC CLOUDS OVER MURMANSK IN JANUARY-FEBRUARY 2010

V.D. Tereshchenko, V.A. Tereshchenko, S.M. Chernyakov (*Polar Geophysical Institute, Murmansk, 183010, Russia; E-mail: vladter@pgi.ru*)

Abstract. The results of photographic observations of polar stratospheric (nacreous or mother-of-pearl) clouds over Murmansk in January-February 2010 are presented. Heights of the stratospheric clouds are estimated, conditions of their formation and the impact on the total ozone content in the atmosphere are discussed.

Introduction

On January 11 and 19, February 8 and 10 2010 in Murmansk, from 6:30 to 12:30 UT in the angular sector of ± 20 degrees from the south at altitudes of 15-25 km polar stratospheric (nacreous or mother-of-pearl) clouds were observed. The similar beautiful and rare phenomenon was recorded over Murmansk on 29 January 2008 [Tereshchenko and Tereshchenko, 2009], and in January 1997 and December 2003. Over the entire history of Atmospheric Physics nacreous clouds were observed slightly more than 100 times. By virtue of the rarity of this phenomenon, these clouds are poorly understood. They are highly reflective capacity thanks to it they shine, shimmering, as sea shells.

Observations of stratospheric clouds began with the end of the 19th century. As it turned out, these beautiful clouds play the significant role in the destruction of the stratospheric ozone layer. For the first time they were found under the ozone holes in the Antarctic and therefore received the name of the polar stratospheric clouds [McCormick et al., 1982]. Since they formed in the stratosphere at altitudes of 20-30 km, they are often simply called stratospheric clouds. The appearance of the observed cloud has some similarities with the cumulus, stratocumulus, cirri and cirrocumulus clouds with a very strong iridescence, i.e. with iridescent plays. They are formed and exist in the polar stratosphere in both hemispheres during the polar winter [Solomon, 1999]. In the Antarctic, they appear from June to September and in the Arctic they appear from December to mid-March [Saitoh et al., 2002], when the temperature at the height of 20 km drops to minus 80 °C and below.

The clouds have many kilometers the thickness and length. They are composed of ice crystals of spherical shape with dimensions of less than 10 microns. The structure of these particles includes: water, nitrogen oxides, and sometimes small amounts of chloric and sulfuric acids, as well as solid particles of other substances. According to their chemical composition, they are divided into three types: clouds, containing nitric acid and water, clouds, that include super cooled droplets of sulfuric acid, and clouds, composed exclusively of water crystals. In the conditions of the polar night air pollutants are not subjected to destruction by ultraviolet light and freeze. In spring, ultraviolet rays cause chemical reactions of substances accumulated in the clouds, converting harmless substances to highly active radicals, which react with ozone and cause reduction in its content in the atmosphere. However, until now it does not yet disclosed the nature of the clouds of nitrogen-water ice, contributing to the chemical activation of these radicals. Some of scientists consider that the main sources of formation of nacreous clouds are deep degassing of the Earth [Marakushev, 1998] and emissions of industrial gases.

In the work, the results of photographic and visual observations of stratospheric clouds are presented and the lower boundary of the cloud field is estimated. Assumptions about the possible relationship between the appearance of nacreous clouds and some geophysical phenomena are made.

Results of observations

In Figure 1 the polar stratospheric clouds which were observed above Murmansk on 11 January 2010 from 07:20 UT are shown. At 10:30 UT they have been closed by grey clouds of the lower level. This day the sun was under the line of horizon. The height of the lower border of the cloudy field, found based on the concept of the equivalent radius of the Earth [Tereshchenko and Tereshchenko, 2009], was 20-25 km. According to high-altitude sounding of the Murmansk management of the Hydrometeorological Service the temperature of air at these heights fell up to minus 85 °C. In the Figure, two types of nacreous clouds are shown. They are similar to stratocumulus (at the left) and cumulus (on the right). Clouds have very rich plying iridescent coloring. Such color spectrum is given by fine crystals of water and nitric acid about the identical size, which form the clouds and refract sunrays. By our estimations, the clouds of the second type were on the distance about 50 km from the place of observation (68.948° N, 33.063° E) in the southwest direction. Under the form and luminescence, they were similar to clouds, which were observed in Murmansk on 29 January 2008.

In Figure 2 nacreous clouds which have appeared on 19 January are represented. Clouds of this type possess rich playing iridescent coloring. On appearance, they have some similarity with irisation of high cirri, which are formed at lower heights - below 13.5 km.

Fig. 1. Nacreous clouds above Murmansk on 11 January 2010

Fig. 2. The same, that in Figure 1, but on 19 January 2010

The polar stratospheric clouds which have been found out in the stratosphere on 8 and 10 February 2010, under the form and coloring were similar to clouds in January (Fig. 3). However, average heights of the lower border of the cloud field were lower by 5 km and were 15-20 km. Duration of registration of these clouds was by 2 hours more, i.e. about 6 hours. Clouds were observed at not only sunrise and sunset but also when the Sun was above the line of horizon.

Fig. 3. The same, that in Figure 1, but on 8 and 10 February 2010.

Satellite observations of nacreous clouds allow to determine precisely enough sites, the sizes and dynamics of clouds. In Figure 4 photos of clouds from satellite DMSP [http://spidr.ngdc.noaa.gov/spidr/querydmsp.do] and from the Earth are given. Photos of clouds have been made on January 29, 2008. In the photo at the left, it is visible, that clouds were observed not only in Murmansk, but also in Northern Norway.

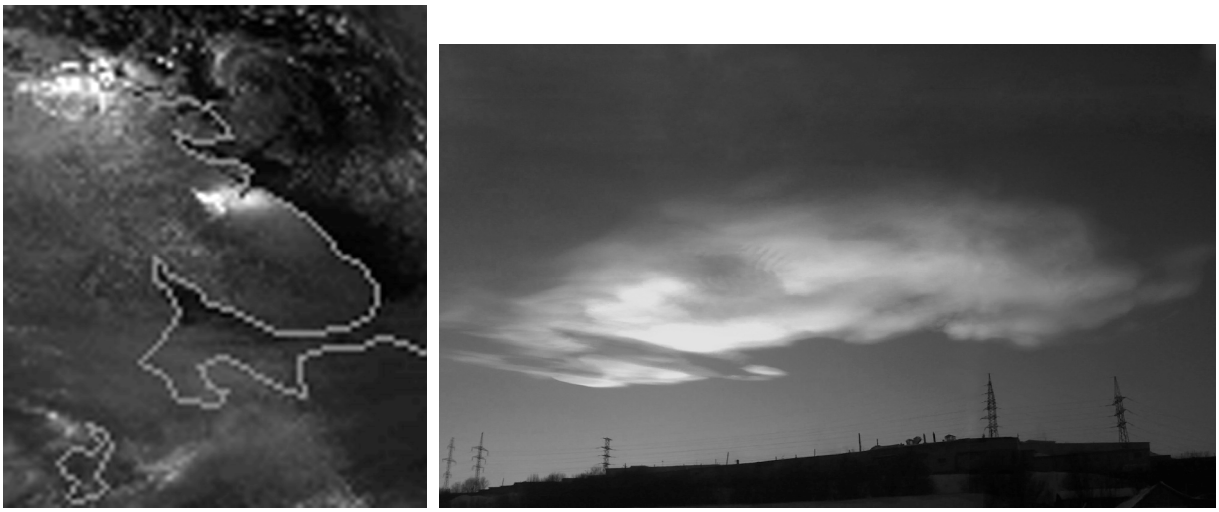

Fig. 4. Photographic observations of clouds from the Earth and from space

The analysis of heliogeophysical conditions in January-February 2008 and 2010 has shown, that in the days of detection of the polar stratospheric clouds the Sun was quiet, and geomagnetic activity was low. The daily Kp-index of geomagnetic activity was in the range of values from 6 up to 13. Therefore space factors could not lead to increasing of temperature of the stratosphere for these days.

Discussion

Occurrence of nacreous clouds is connected with temperature in the stratosphere. Decrease of temperature in the stratosphere below some level leads to formation of stratospheric clouds. The temperature, moreover, depends on the content of ozone. The more content of ozone is in some layer of the atmosphere, the more heat it accumulates. Accordingly, the less content of ozone is in the atmosphere, the less its temperature is. Now the amount of ozone in the stratosphere decreases, especially in the Arctic and Antarctic regions.

The main mechanism of destruction of the ozone layer is formations of stratospheric clouds of nitric-water ice. Supporters of human-induced concept consider that clouds make active chlorine from anthropogenic-volcanic reservoirs, which have uniform distribution in the atmosphere of the Earth. Each spring warming process amplifies formation of chemically active atomic chlorine. As a result, of the reaction of free chlorine with ozone there is destruction of the ozone layer and formation of so-called "ozone holes". The further rise in temperature conducts to evaporation of ice and the ozone layer starts to restore.

Supporters of the endogenous hypothesis do not deny a role chlorine-containing freons in the process of destruction of the ozone layer though put under doubt the essential contribution human-induced processes to concentration of the ozone in the atmosphere. The basic contribution to formation of nacreous stratospheric clouds and, accordingly, in destruction of the atmospheric ozone is brought with deep hydrogen degassing of the Earth [Marakushev, 1998]. The main places of such degassing serve rift structures of oceans and the hot points of the Earth fixed by destruction of its ozone layer. Fixing of ascending fluid streams by ozone holes testifies that water-hydrogen jets reach the stratosphere, generating the extended ice clouds promoting destruction of the ozone layer. The Iceland region of destruction of the ozone layer is the closest to Murmansk. Therefore, in Scandinavia nacreous clouds can be observed almost every winter.

Half an hour before the beginning of the strong earthquake in China on May 12, 2008 on distance of 430 km from the epicenter of shocks iridescent stratospheric clouds have appeared [http://news.qq.com/a/20080513/004283.htm]. It can be evidence of the endogenous hypothesis of destruction of the ozone layer.

The important results for the hydrogen hypothesis concerning the ozone anomaly have been received by geologists of the Kola Center of Science of the Russian Academy of Sciences in the town of Apatity [Syvorotkin, 2005]. Monitoring of allocation of hydrogen in Hibinskie Mountains (over a long period here intensive allocations of methane and hydrogen were registered) and the total content of ozone in Murmansk in April 2005 has shown synchronism of these processes: strengthening of hydrogen degassing and decrease of the total content of ozone. The experiment has confirmed correctness of the hydrogen concept. Presence of the ozone anomaly above Kola

Peninsula at this time has been fixed also by the American space satellite "EarthProbe" <http://toms.gsfc.nasa.gov/eptoms/epsat.html>. Later, in 2007, in Hibinskie mountains connection of deep degassing with gravity influence of the Moon and the Sun was found out.

The main function of hydrogen at formation of stratospheric clouds is generation of water. Water is formed at direct influence of hydrogen on ozone, and also during its returning from lower thermosphere as a product of burning, as water vapor. It is theoretically established, that at heights of 120-200 km there is a spontaneous ignition and burning out of hydrogen [Nikolaev and Fomin, 1997]. Water vapor formed at combustion of hydrogen falls down to the heights of the tropopause (10-15 km). Under certain conditions water vapor at the heights of the mesosphere and the stratosphere can turn to the smallest pieces of ice which amount is enough for formation of noctilucent and nacreous clouds. During burning of hydrogen also atomic oxygen is formed, which combining with molecular oxygen turns to ozone. Capacity of such source of ozone is proportional to the contents of molecular hydrogen in the lower layers of the atmosphere. It apparently will allow looking at the reasons of occurrence of ozone holes in a new fashion.

For formation of stratospheric clouds, besides other conditions, the most important and necessary condition is low temperatures. One of the mechanisms of cooling of the atmosphere at the stratospheric heights is connected with a flow of airstreams over the big obstacles (mountain ridges, etc.). At such passage oscillations of air are formed. In the case when the airstream operates constantly during some time it forms steady waves from the lee side of mountains. These leeward waves represent streams of waves, which rise and fall several times. In the areas where they rise, air extends and cools. Above Scandinavia frequently the western winds saturated with moisture from Atlantic Ocean blow. Feature of location of the Scandinavian mountains plays a barrier role regarding to the western winds. They block the western winds, creating leeward oscillatory movements that lead to local cooling of the area of the atmosphere above mountains and thus conditions for formation of polar stratospheric clouds are created.

Conclusions

Results of visual and photographic observations of the polar stratospheric clouds in Murmansk in January-February 2010 are presented. Based on the concept of equivalent radius of the Earth the height of the lower border of cloud field is determined. Assumptions of possible dependence between occurrence of nacreous clouds and some geophysical phenomena are made. Conditions of formation of stratospheric clouds and their influence on the total content of ozone in the atmosphere are discussed.

Scientific researches of these clouds are very important for the best understanding of the processes taking part in the stratosphere. In fact, the stratosphere plays an important role in our life. First, here is the ozone layer, which protects us from destructive influence of solar radiation. Second, influence of the dynamic processes taking part in the stratosphere affects also on troposphere dynamics. Researches show, that circulating processes in the stratosphere with the certain delay influence on troposphere circulation. It can serve as a key to creation of more exact techniques of long-term forecasting weather anomalies. Researches of nacreous clouds will allow scientists to solve riddles of processes of condensation water vapor, conditions of its existence and to determine character and speed of movements of air at the stratosphere.

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