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THE OZONE MEASUREMENTS IN THE KHIBINY MOUNTAINS

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Abstact. The preliminary results of ozone concentration monitoring at the top of the Lovchorr mountain (1089 m, the Khibiny mountain massive) are presented. Most part of the year the monitoring station is outside the mixed layer or near its upper boundary, and the receipt of the impoverished by ozone air from the surface layer is hindered (in particular, because of the topographic characteristics of the station position). Therefore, it can be suggested that the ozone concentration at the top of the mount Lovchorr is close to that in the free atmosphere at the corresponding level. This suggestion appears to be true, as follows from a direct comparison with the results of the nearest ozone-sounding station (Sodankyla, Finland).

Introduction

Since March 15 2004, the Polar Geophysical Institute has been performing regular ozone monitoring at the top of the mountain Lovchorr (the Khibiny mountain range). The measurements are conducted at the mountain-avalanche station "Central" of the OAS "Apatite", which realizes the whole complex of the meteorological observations.

The station is located on the mountain, having a shape of a convex plateau, in its highest part (the peak altitude of the mount Lovchorr is 1100 m). The geographical coordinates of the station are 67.6° N, 33.7° E; the absolute altitude of the meteorological instrument platform is 1091 m, the air intake for the analysis refers to the height of 1095 m.

According to EMEP [http: // www.emep.int] data, the station for ozone monitoring on the mount Lovchorr is the highest in Northern Europe, all other similar stations being located not higher than 500 m (the heights of the Voss (Southern Norway) and Zeppelin (Svalbard) stations are 500 m and 474 m, respectively).

Discussion and conclusions

The choice of the monitoring site on the top of the mountain was not occasional. For several reasons, which are listed below, we suggest that the ozone concentration at the top of the mount Lovchorr is close to that in the free atmosphere at the corresponding level.

1) Synchronous monitoring of the concentration and diurnal dynamics of the ground-level ozone, performed in Lovozero, in the central part of the town of Apatity and in its suburb, has not revealed any signatures of ozone photochemical generation in the lower troposphere, including the days with the best conditions for ozone photochemical production in the surface layer [Demin et al, 2004]. This testifies to its absence at the heights larger than 1 km.
2) The year averaged maximum altitude of the mixed layer in the region considered is 610 m and only in summer months reaches 900-1050 m. Consequently, most of the year the station is at the height either exceeding the characteristic regional height of the mixed layer or near its upper border.
3) The area of the Khibiny mountains, which are situated in the middle of a hilly plain, is 30kmx50km, the tops are strongly smoothed and dome-shaped. The absolute and the relative heights are 1000-1100m and 800-900m, respectively. The small extension of the range is hardly consistent with a suggestion of strong perturbations, such as blocking of the air mass or bar formation, produced in the atmospheric currents.
4) The mountain-valley circulation in the Khibiny mountains is either weak or absent for the most part of the year. Therefore, the access of ozone-exhausted air from the surface layer to the top parts of the plateau is restricted. In approaching the station, the effect of the mountain-valley circulation is getting even smaller because of the steep slopes and the absence of a valley in the direction of the upper part of the plateau.
5) The surface of the plateau is rocky, with the vegetation of the Arctic tundra (lichens and moss) occupying not more than 1 % of the area. The scarcity of the organic substance and long persistence of snow cover (from October to June) reduce the rate of ozone destruction.
6) There is a high correlation of ozone concentration dynamics and conservative characteristics of the air mass, such as free air temperature, equivalent and equivalent-potential temperature, etc.
7) For all seasons there is no diurnal variation of the ozone concentration typical for the surface layer.

A direct comparison of the measurements at the mount Lovchorr and the results of ozone sounding of the observatory Sodankyla support the suggestion that the ozone concentration at the top of the Lovchorr mountain is close to that in the free atmosphere at the corresponding level. (Sodankyla is the nearest station that performs ozone sounding; it is 300 km to the south-west from the mount Lovchorr). The values of the ozone concentration on the top of the mount Lovchorr and above Sodankyla are shown in Fig. 1. As can be seen, there is a high correlation

between the monthly ozone concentrations on the top of the mount Lovchorr and at the altitude of 1095 m above Sodankyla (r=0.93).

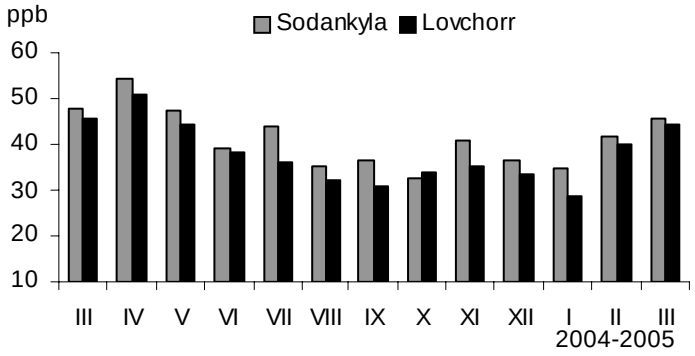

Figure 1. Month averaged ozone concentrations on the mount Lovchorr and at the altitude of 1095 m above Sodankyla

The month averaged ozone concentrations on the top of the mountain Lovchorr are smaller (by 3.4 ppb in average) than those at the same altitude above Sodankyla. This can be attributed to the effect of the forced rising of the air, when the air mass runs into the mountain obstacle. In this case, the surface air with a low content of ozone rises to the top regions of the mountains.

The above finding, in our opinion, makes possible to use the measurements on the mount Lovchorr for the estimation of the components of the ground-level ozone balance in the Kola Peninsula (for example, in estimating the contribution of the turbulent mixing to the formation of the ground-level ozone field). Thus in May, when the average maximum altitude of the mixed layer does not exceed 750 m, the maximum ground-level ozone concentration is far from that on the top of the mount Lovchorr. In July, when the maximum altitude of the mixed layer (1050 m) gets comparable to the altitude of the mount Lovchorr, the maximum ground-level ozone concentration in Lovozero approaches (in the afternoon) that on the top of the mount Lovchorr [3]. This is a strong argument in favor of the dynamical mechanism of ground-level ozone field formation, when ozone is supplied to the surface layer due to the turbulent transfer from the upper boundary layer, which is more enriched with ozone.

In fact, as the ozone concentration (including the polar day period) on the Lovchorr mountain and at the upper border of the mixed layer is higher than in the surface layer, the turbulent transfer of ozone is directed downward. There are no reasons to suggest photochemical generation of ozone in the surface layer. Previously, the same conclusion was made based on the theoretical estimations [Demin et al, 2005].

The daily concentrations of ozone on the mount Lovchorr for the period from 15 March 2004 to 15 March 2005 are shown in Figure 2.

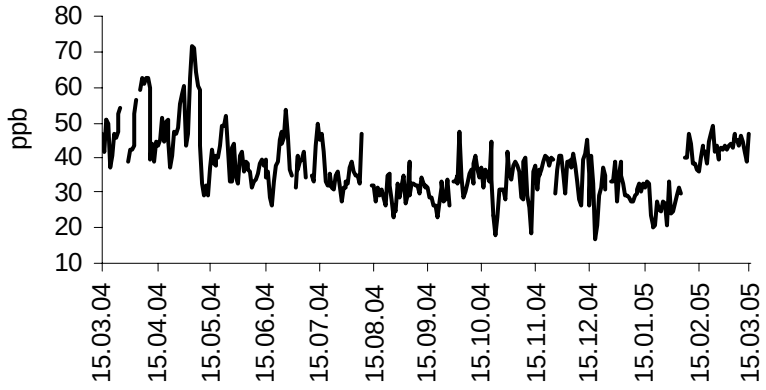

Figure 2. The daily concentrations of ozone on the Lovchorr mountain for the period 15 March 2004-15 March 2005

The recurrence of the ozone concentration on the mount Lovchorr is shown in Figure 3.

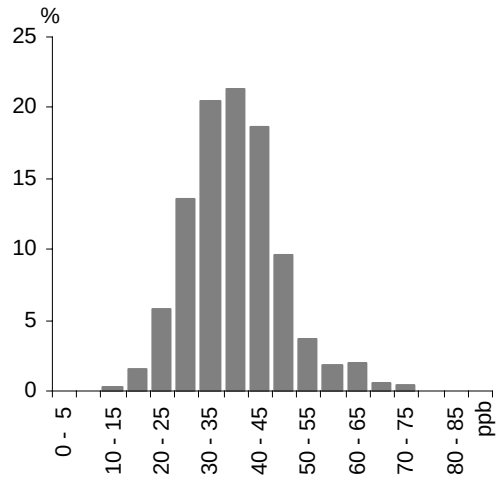

Figure 3. Recurrence of the ozone concentration on the Lovchorr mountain

For more than 83 % of the time the ground-level ozone concentrations are 25 - 50 ppb. There are no observations of ozone concentrations exceeding 80 ppb but there are spring increases in the background ozone concentrations up to 75-80 ppb (the probability is 0.04%). The high ozone concentration at the top of the Khibiny mountains is caused by the advection of the air from the industrial areas of Europe that was detected by the technique of the backward trajectories [http://www.arl.noaa.gov]. For example, the episode of high (>60ppb) ozone concentration was observed on 3-6 May 2004, when in the warm sector of the cyclone the air mass from Europe is transferred with the south winds in the lower troposphere. The increase in the ozone concentration occurred not only in the daytime but also at night, in the absence of the ultraviolet radiation. This evidences that there is no regional photochemical generation of ozone. Instead, there is an advection of the air already saturated with ozone. The changes in the ozone concentration on the top of the Lovchorr mount and in Lovozero occurred synchronously, that also confirms the advection mechanism. The ozone concentration keeps increased up to the change of the air mass and advection direction.

For all seasons there was no diurnal variation of the ozone concentration on the Lovchorr mount. But there is a high correlation (r>0.7) of the ozone concentration and conservative characteristics of the air mass (the free air temperature, the equivalent and equivalent-potential temperature, etc.), which implies the advection mechanism of ozone concentration changes on the mount Lovchorr.

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References

1. Demin V.I., Beloglazov M.I., Elansky N.F. Some results of ground-layer ozone monitoring in the Kola Peninsula under different levels of anthropogenic pollution of the atmosphere // Ecological chemistry, 13, №3, 142-150, 2004.
2. Zvyagintsev A.M., Ivanova N.S., Kruchenitsky G.M., Kuznetsova I.N., Demin V.I. Ozone content above the area of the Russian Federation in the third quarter of 2004. Meteorology and hydrology, № 11, 123-128, 2004.
3. Demin V.I., Karpechko A.Y. , Kyre E. On the role of the turbulent mixing in the formation of the ground-level ozone concentration in the Kola Peninsula. / this issue /