SUMMARY OF THE REPORT ON THE RESULTS OF LIDAR MEASUREMENTS OF ATMOSPHERIC POLLUTION BY AEROSOL PARTICLES OVER THE SCANDINAVIA HIGHWAY

Conclusion

Due to the strict restrictions to cross the border of the Russian Federation with the Republic of Finland set both on the Russian and Finnish sides in order to prevent the spread of the coronavirus infection, additional trips were carried out to the border with Finland within the framework of the project, including at the moment of the stable transfer of aerosols from Finnish territory. The direction and stability of this transfer was tracked using the Doppler lidar of the mobile lidar complex.

The upper boundary of the aerosol layer was determined, according to the range corrected lidar signals obtained using the mobile lidar complex at a wavelength of 532 nm. The vertical distribution of aerosols has the following regularities: the aerosol layers were located up to a height of 1.5 - 2 km during the observation period, while the concentration of aerosols decreases with height, and the maximum values are, as a rule, at the low observation point. Also a sharp decrease in concentration was observed at altitudes of 500 - 1000 m with an increase of altitude. In addition, a lot of layers were identified with compaction and dispersion of aerosols at various heights. It is noted that no significant aerosol layers were detected alongside the Scandinavian highway in Russia and by the transfer from the Republic of Finland during the measurement period from 2019 to 2020.

The results of data processing and subsequent modeling performed using the mobile lidar complex in the period from 2019 to 2020 showed that the concentration of aerosol particles at altitudes from 500 to 1000 m took on average the values in the range from ca. 1300 to 2800 particles in one cubic centimeter, from 600 to 1700 particles in one cc for 1000-1500 m and less than 1150 particles per cc for heights over 1500 meters. The values tend to rise at lower altitudes, as a rule. For the observation period under review, the vertical profiles of the concentrations of aerosol particles do not differ significantly in general. The presence of dense aerosol layers is noted at the Pobeda site on April 23, 2019, in Kondratyevo on October 15, 2019, Kondratyevo and Gavrilovo on November 1, 2020, as well as at the Kondratyevo and Gavrilovo points on November 6, 2020. However, taking into account the direction of transfer in the atmosphere, it can be noted that during the western and northwestern transfer (from Finland) at all measurement points observed on August 16, 2019 and November 6, 2020, the number concentration of particles

is increasing when moving from the border with Finland towards St. Petersburg. This allows us to conclude that a slightly lower concentration of aerosol particles was noted on the territory of Finland during the measurement period.

In the course of observations at the Kondratyevo point, the concentration of aerosol particles at the moment of transfer from the Republic of Finland on August 16, 2019 was lower than at other points, so the maxima made 1260 particles in one cm (the height of 481 m) at the Kondratyevo point, 2070 particles per cm (the height of 552 m) at the Gavrilovo point and about 2400 particles per cm (in the range of heights of 500-820 m) at the Pobeda site. There is also a trend: the number concentration of aerosols increases at all heights with the distance from the Republic of Finland. On November 6, 2020, the concentration of aerosols by transfer from Finland to an altitude of 1 km is less than in Gavrilovo. Moreover, in both cases, there was an aerosol layer at approximately the same height from ca. 500 to 600-800 meters with the values of maximum concentrations of aerosol particles equal to 2620 elements per cubic meter during the transfer from the Republic of Finland and 3790 elements per cm in Gavrilovo. The wind direction at different observation points undergoes significant differences above 1 km, which means that aerosols could have other sources of formation.

During the period under review, a large number of aerosol layers were observed, which can have different areas of formation and also spread over large territories. The masses of aerosol particles concentrated in them can settle on the route section, and under certain meteorological conditions can rise and transfer to nearby territories. The used autoregressive model allows one to estimate the concentrations of aerosol particles in the boundary layer for most measurements. According to the extrapolation results, the concentration of aerosol particles at a height of 1 m ranged from 1670 up to 6990 particles per cm, while the average value is about 4200 particles per cm. The value of the surface concentration of aerosol particles during the transfer from Finland is approximately two times less than on the territory of the Russian Federation.

Modeling of the propagation of aerosol particles from the Scandinavian highway using the autoregressive model made it possible to estimate the decrease in the content of aerosol particles by the distance from the highway. The concentration of aerosol particles decreases strongly by the distance from the route at low altitudes. So, for example, at a height of 2 meters from the ground level, the concentration at a distance of 500 meters decreases 5-8 times without regard to natural barriers such as, for example, a forest area. The values of aerosol concentrations continue to fall when modeling of their transfer from the highway at heights of from 5 meters and higher, but at a lower speed. At the same time, at an altitude of 40 meters, and in some cases even at 20 meters, the concentration of aerosols increases when transfer from the road, since the route is considered as a source of pollution by modeling, and other sources are not taken into account. Concentration

maxima during the transfer from the highway with regard to the wind at a height of 2 meters were in most cases at a distance from the route no more than 20 meters with an average value of 1740 particles per cubic meter. The maxima for heights of 3 and 5 meters were observed at a distance of no more than 100 meters with average values of 1070 and 580 particles per cm, at a height of 10 meters - at a distance of 100-200 meters with an average concentration of 250 particles per cm, and at high altitudes over 200 meters with a maximum concentration of no more than 200 particles per cubic meter. At an altitude of 40 meters, and also in some cases at an altitude of 20 meters, the concentrations increased constantly and maxima were not observed at a distance of up to 500 meters. The higher the aerosol rises above the highway, the farther it spreads from it.

It should also be noted that the modeling was carried out without regard to significant natural barriers such as, for example, a forest area. In case of a sufficiently large barrier, the concentrations of aerosol particles can be significantly less than the simulated ones.

The vertical structure of aerosols is highly dependent on synoptic processes and thermal stratification. A large amount of atmospheric inversions were observed during the research, which lead to the formation of layers with an increase in the number of aerosol particles. The transfer of aerosol particles from the Scandinavian highway has an unequal distribution due to the different landscape of the territory, form of housing, meteorological conditions, secondary input of pollutants and other factors.