Application of the lidar method to determine the influence of dynamic atmospheric conditions on the concentrations and particle size distribution functions of the marine aerosol

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The thesis presents the results of research into the application of the lidar method to determine the dynamics of the marine aerosol in the marine boundary layer under various hydrometeorological conditions. It was found that this method permitted the rapid measurement of the optical properties of aerosols over distances greater than the limits of the breaker zone. By employing several wavelengths the lidar can provide very accurate information about the size distribution of aerosols as well as their concentrations under various weather conditions and at different altitudes above the sea surface.

The ensemble of aerosol particles was assumed to consist of nonabsorbing spheres, the density distribution function of which is exponential; hence it was possible to compile an algorithm for solving the lidar inverse problem. The principal assumptions of the method are as follows:

- a minimum of two laser radiation wavelengths are employed;
- the extinction coefficient ratios are independent of the location of the target on the sensing beam path;
- the extinction coefficient to backscattering coefficient ratio is independent of the location of the target on the sensing beam path.

The lidar method enabled the following parameters to be determined in the marine boundary layer along the sensing distance:

– mean aerosol concentration,

– aerosol number concentration,

– mean aerosol mass,

– aerosol mass and concentration gradients,

– aerosol fluxes,

– aerosol flux gradients,

– aerosol residence times.

In the marine boundary layer above the breaker zones of the southern Baltic Sea, the size distribution function and the concentration of the aerosol depend on the speed, direction and duration of the wind. The results of this work indicate that when winds are northerly, the particles in the marine boundary layer above the breaker zones of the southern Baltic Sea can be assumed to be marine aerosols. When winds are from other directions, especially from the south, the particles are a mixture of marine aerosols and particles of terrestrial origin. With southerly winds the aerosol concentrations, masses and fluxes in the marine boundary layer above the breaker zones are significantly higher than with northerly winds, and in addition do not differ substantially with offshore distance. It was found that in the case of northerly winds the breaker zone was readily distinguishable by the aerosol concentrations, the masses or fluxes of which were higher when compared with those of the open sea. When winds are southerly, it is not so easy to determine the breaker zone range, as the mean concentration of aerosols is constant along the sensing beam path.

The lidar method allows variations in aerosol size distribution function, aerosol fluxes and their residence times to be determined as a function of two different formulae for the roughness coefficient, and takes into account developing roughness and fully developed roughness, diverse sea bottom types with various slopes, and different weather conditions with changing wind velocity, direction and duration. The procedure has been verified experimentally on two types of Baltic Sea bottoms; provided that the wind conditions and sea-bottom type are known, it enables a good estimation of aerosol dynamics in the coastal zone to be made.

It is also possible to determine the residence times of aerosols of various sizes in the marine boundary layer above the breaker zones. Aerosol residence times were found to depend mainly on the speed and duration of the wind and on the thickness of the turbulently mixed air layer above the breaker zones.

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