

Abstract

Determining the impact of aerosol on the Earth's climate system, in recent decades has been of great interest to researchers worldwide. Regular measurements and intensive studies of particles suspended in the atmosphere are required to fully assess the significance of aerosol impacts. Mineral dust, for simplicity called also desert dust due to the fact that its main sources are desert areas characterized by extremely dry land surface and little vegetation cover, is one of the most important aerosols observed in the atmosphere. Rising temperatures, which favor droughts and desertification, increase the number of potential sources of mineral dust aerosol emissions. The complicated feedback between mineral dust and climate makes it very difficult to predict the future of the planet, given the dynamic changes already taking place.

This PhD thesis comprises a comparative analysis of long-range inflows of desert dust and its mixtures over Central Poland, in particular optical properties obtained from modern lidar surveys. The data used for the analysis come from measurements made in 2013-2020 with the 8-channel Aerosol-Deolarization Raman lidar PollyXT operating at the Remote Sensing Laboratory (RS-Lab) of the Institute of Geophysics, Faculty of Physics, University of Warsaw.

The measurements performed according to the recommendation of the EARLINET lidar network of the ACTRIS research infrastructure allowed the recovery of high-quality sets of profiles of intense and extensive aerosol optical properties. In particular, this dissertation is the first scientific work to include the study of rare measurements of the aerosol linear depolarization coefficient at 355 nm.

The cases of mineral dust inflows over Warsaw were identified on the basis of lidar measurements and three independent models, which allowed for: (a) calculation of backward trajectories of air mass transport (HYSPLIT model), (b) analysis of the optical thickness of desert dust predicted over the area of Europe and the Mediterranean Basin (BSC-DREAM8b model) and (c) assessment of the probability of occurrence of aerosol mixtures (mineral dust, sea salt, particles from biomass combustion and sulfates) over the studied area (NAAPS model). The research resulted in the creation of a calendar of inflows as well as unique database of optical properties of mineral dust and its mixtures,

which provides comprehensive information for further studies of aerosol microphysical properties.

The dissertation discusses how the optical properties of mineral dust vary with the degree of hydration, distance from the emission source, and the amount and type of admixtures of other aerosols. It was shown that aerosol properties strongly depend on the intensity of mineral dust transport and the stage of inflow evolution, e.g. during its initial phase the observed values of depolarization ratio are much lower than during the full development of inflow or its disappearance. For the first time, the ratio of coarse- and fine-sized desert dust particle fractions in the observed layers was investigated. It was found that the coarse particle fraction does not dominate over the fine fraction, and furthermore that it decreases during the disappearance of the layer. Aerosol properties during inflows were also analyzed in relation to meteorological parameters and local climatic data. This was not explored so far in Polish scientific works.

The comparative analysis showed an increase in the number of observed episodes of the presence of mineral dust in the atmosphere over Poland, as well as an increase in the thickness of the layer formed by the aerosol, and also an increase of the inflow duration. An increase in the intensity of transport of desert dust over the area of Central and East-Central Europe caused by climate change was confirmed.