

Badanie własności optycznych aerozoli na podstawie synergii obserwacji satelitarnych i pomiarów naziemnych

Abstract

Atmospheric aerosol is an important component of the atmosphere as it influences radiative balance and thus the climate of the Earth. Aerosol particles interact directly with radiation and indirectly they modify the microphysical properties of clouds. In order to determine the precise role of aerosol in climate processes, taking into account fluctuations of the amount of aerosol in the atmosphere, it is essential to carry out large spatial scale monitoring of aerosol optical depth (AOD). Changes in the amount of atmospheric aerosol and its composition are related to emissions from natural sources as well as to those of anthropogenic origin. As to the latter, city agglomerations are of great importance as they emit large amounts of particles and bring about significant changes in aerosol composition.

Monitoring of aerosol optical depth on a large spatial scale can be performed with the use of satellite instruments. Remote sensing of atmospheric aerosol optical properties is related, however, to a number of problems and limitations, of which one of the most significant difficulties is to estimate surface reflectance. This thesis deals with a method of data integration that has been developed in order to improve the estimation of values of surface optical properties and which, in turn, translates into reduced uncertainties when retrieving aerosol optical depth.

The use of remote sensing data in order to retrieve information on the physical properties of aerosols entails the necessity of employing inverse methods. In chapter 2 a definition of an inverse problem and basic methods to solve it are presented. In addition, a radiative transfer equation, which is employed as a forward model, is described, as are several simplifications used in the process of solving this equation.

Chapter 3 summarises the main substantial problems related to the satellite remote sensing of atmospheric aerosol. The most important methods used in the satellite research of aerosol are also described. The review of algorithms provided includes both methods developed for polar and geostationary satellites. Finally, algorithms designed for retrieving aerosol properties based on SEVIRI data are listed and characterised.

Chapter 4 discusses the construction of two algorithms designed to retrieve the optical properties of atmospheric aerosol. These two different, 1- and 2-channel methods, are based on the

synergy of satellite data, ground-based measurements and numerical model outputs. In both cases, an optimal interpolation method was used to estimate a first approximation of the spatial distribution of aerosol optical depth. Information on the spatial distribution of AOD on the reference day was derived from the MODIS instrument or MACC or NAAPS models. Following the correction of the aerosol background the next step is to estimate surface reflectance on the reference day. The value of surface reflectance obtained is then used to retrieve spatial distribution of aerosol optical depth over a period of ± 10 days.

A validation of the constructed algorithms is presented in chapter 5. A comparison of the SEVIRI AOD with sun photometer observations showed quite a good concordance. The smallest differences, for both methods, were registered for the Belsk station. The mean bias of AOD was between -0.02 and 0.02 and the root mean square was about 0.04-0.05. Similar results were obtained for a comparison of AOD calculated for the whole territory of Poland and MODIS data, and also for AOD on the reference day taken both from MODIS and from MACC. Mean bias was usually lower than 0.01, and rms was about 0.04-0.06.

Chapter 6 deals with an analysis of the influence of city agglomeration emissions on aerosol optical properties' spatial distribution in the context of the optimal interpolation method. Long-term observations of aerosol optical depth and the concentration of particulate matter with diameter $< 10 \mu\text{m}$ collected in Warsaw and the surrounding area indicate the minor influence of local emissions.

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