Weighting aerosol with MERIS

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The measurements of the mass concentration of aerosol in terrestrial atmosphere is of great importance for a number scientific disciplines, climate studies, pollution monitoring, and aerosol transport. Therefore, the aerosol particulate matter mass concentration (e.g. PM10, particulate matter with diameters of aerosol particles smaller than 10 microns) is measured in thousands locations worldwide on a regular basis. Ground measurements, however, are quite expensive and limited with respect to the spatial coverage. On the other hand, satellite measurements enable the observation of large areas (e.g., Europe) in a short time interval with varying resolution depending on the instrument. In particular, the MEdium Resolution Imaging Spectrometer (MERIS) onboard ENVISAT has the resolution 0.3km$\times$0.3km, which is sufficient for pollution monitoring on a fine scale. The task of this paper is to present a novel technique for the determination of the aerosol mass concentration from spaceborne observations. The idea of the technique is quite simple. The proposed method is based on the retrieval of the Aerosol Optical Thickness (AOT) in the spectral range 412-670nm, from satellite data. The most recent family of these algorithms is presented and discussed by Kokhanovsky and de Leeuw (2009). The derived spectral AOT can be presented in the following form:

$$\tau(\lambda) = \beta\lambda^{-\alpha} . \qquad (1)$$

Here λ is the wavelength, β is the value of AOT at $\lambda = 1\mu m$ and α is so – called Angstrom parameter. Clearly, α is determined by the size of particles being larger for smaller scatterers. It approaches 4.0 for molecular scattering and zero for large particles such as in dust clouds uplifted from the desert surfaces during dust storms. In this work we propose simple parameterizations for dependencies of α and average extinction cross section of particles C_{ext} on the effective radius of particles defined as the ratio of the third to the second moment of the aerosol size distribution. This enables to relate the columnar number of particles n (measured in m^{-2}) to the retrieved values of AOT (its value at 412nm is used) and the derived parameter α. In particular, it follows:

$$n = \tau C_{ext}^{-1} . \qquad (2)$$

Here n can be related to some average number concentration of aerosol particles N and the aerosol layer thickness L with the following simple equation: $n = NL$. Therefore, if L can be estimated, then also the particulate matter concentration $m = NV\rho$ (in $\mu g / m^3$) can be derived. Here ρ is the density of aerosol particles and V is their average volume. It is difficult to estimate L from space. Therefore, it is proposed to retrieve the columnar particulate matter concentration $M = mL$, which does not depend on the vertical extent and the position of the aerosol layer in atmosphere, in the absence of information on the aerosol position and thickness.

The corresponding retrieval technique was implemented in the C++ code and run using MERIS data, provided by the European Space Agency, for a single day over Germany (October 13th, 2005). The maps of AOT, Angstrom parameter, effective radius of particles, and particulate matter vertical columns (PMVC) were prepared. It was found that measurements from a satellite correlate well with ground measurements of AOT and Angstrom parameter. The good enough correlation between satellites derived PM values and ground measured PM values averaged over a large area was observed. But correlation of the local ground measured and satellite derived PM is quite poor, which can be explained by different spatial scales of corresponding techniques. Nevertheless, the derived PMVC maps represent spatial patterns of the aerosol distribution on a large scale in a correct way. They can be used by environmental agencies for assessing related environmental risks and health indices in a fast and reliable way.

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Kokhanovsky, A.A., & de Leeuw, G. (2009). *Satellite Aerosol Remote Sensing Over Land,* Berlin: Springer-Praxis.