ESTIMATION OF AEROSOL OPTICAL PROPERTIES USED IN THE ATMOSPHERIC CORRECTION OF SEAWIFS IMAGES OVER BALTIC SEA

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INTRODUCTION

Standard atmospheric correction of SeaWiFS and MODIS images to retrieve water-leaving radiiances from the Baltic Sea often fail. Current algorithms to remove the contribution of the atmospheric molecules and aerosols from the measured SeaWiFS and MODIS top-of-atmosphere radiance use reflectance in near infrared (NIR) to assess the aerosol optical properties, which are then extrapolated into the visible wavelengths according to 16 predefined aerosol models. We investigated the variation of aerosol optical properties over the Baltic Sea region on the basis of sun photometer measurements at two locations – Gotland in Sweden and Tõravere in Estonia – in combination with in situ aerosol size distribution measurements. Aerosol optical thickness calculated from a size distribution is compared with similar data derived from cloud-free SeaWiFS images over the closest water bodies – the Pärnu Bay and the Baltic Sea.

METHODS

Ground-based measurements of atmospheric aerosol size distributions (10 nm -10 µm) were carried out from June 17 to September 12, 2002 on the eastern coast of the Baltic Sea, in Pärnu, Estonia (58.267° N, 24.508° E) with the electric aerosol spectrometer EAS of Tartu University. The measurement station locates almost on the line Gotland - Tõravere, where the AERONET sun photometer data were collected. The distance between the two stations is about 610 km. The calibrated and validated level 2 aerosol optical thickness τₐ at wavelengths 440 and 870 nm and the Ångström parameter α(440-870) were downloaded from a global database (http://aeronet.gsfc.nasa.gov/) for comparison with the similar data derived from three SeaWiFS images, where both stations and the Pärnu Bay were cloud-free (13.07, 16.07, 03.09, year 2002). Optical properties of the measured aerosol were calculated by Mie theory and from this the τₐ values at 7 SeaWiFS bands were estimated. Using aerosol components and predefined types (Hess et al., 1998), the best fit between the measured and modeled aerosol distribution was found.

RESULTS AND DISCUSSION

The measured and calculated τₐ have rather similar behavior in the period of 1 June - 6 September, 2002 (Fig. 1). Towards end of summer, higher τₐ values were more common than at the beginning of June or the end of September. There was a short period from 6 - 9 September, when the Tõravere τₐ had remarkably higher values than that of Gotland and τₐ (870) reached up to 0.88. In general, the Tõravere τₐ had slightly higher values (τₐ(870) = 0.116 ± 0.127) as compared to the similar values from Gotland (0.085 ± 0.087). These low values show a very clean atmosphere above the Baltic Sea and are consistent with the period of 1999 – 2000, when only the data from Gotland station are available. By the ground measurements the variability of τₐ(440) is smoother (range 0.16 - 0.66) than estimated from the Tõravere and Gotland stations (Fig. 1), however, the increase towards the end of summer and the peaks in τₐ on 9 - 17 August and 25 - 29 August can be easily recognized. A peak at the beginning of September is not seen for this period, and the Pärnu data are more similar to the Gotland measurements, probably due to local winds blowing from the west. Permanently higher τₐ values may refer to the local dust-like particles located close to the ground, which may be typical in a small town during dry seasons.
The choice of aerosol types in SeaWiFS images is presented as histograms on Fig. 2. In SeaWiFS processing, either the highest (T50) or the lowest types (O99) are often used over the Pärnu Bay. Oceanic aerosol type (7 - 27%) is not realistic in this region at all. The tropospheric types show a rather clear atmosphere, but by the published chemical analyses of the Baltic Sea aerosol studies, it contains also a seasonally variable absorbing soot component. The problem may be related not only to the missing proper aerosol models in SeaWiFS processing, but to a poor estimate of NIR radiances in rather turbid water.

The 16 aerosol models (Oceanic, Maritime, Coastal and Tropospheric) used in the standard processing of SeaWiFS and MODIS images do not take into account strongly absorbing aerosols (Gordon & Wang, 1994). Only three of the components (Hess et al., 1998) - water soluble, insoluble and oceanic particles - cannot be used since they do not fit successfully the measured spectra, and as seen from Fig. 3, the best agreement with the measured spectra was archived when soot particles were included. The model simulations using a local measured or an urban aerosol type in atmospheric correction resulted in more realistic results than when only oceanic/maritime and continental types were used.

CONCLUSIONS

Despite different meteorological conditions in the two AERONET stations around the Baltic Sea there is a good coincidence of $r_t$ at all measured wavelengths. The impact of very clean atmospheric conditions over the Baltic Sea is that the aerosol model selection in SeaWiFS processing becomes uncertain and an unrealistic oceanic type is often used. It is suggested to use a local type of aerosol in the processing of SeaWiFS images over the Pärnu Bay, but it needs to be tested over other areas of the Baltic Sea.

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