IRS2012-157
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

Optical Modeling of Aerosol Extinction for Remote Sensing in the Marine Environment

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Concentration and distribution of aerosols is the important factor for various optical remote sensing and environmental monitoring applications, understanding the Earth's radiative balance, studying cloud properties, etc. The most essential factors affecting the ocean wave destruction are considered to be sea state, fetch, surface wind speed and tidal dynamics; it is also significantly modulated by amplitude of ocean swell, wave spectra and geometry of coastal line.

Based on these facts presented investigation seeks to contribute to better understanding of visibility decrease and other optical effects of the atmospheric aerosol eventually aiming for a development of a robust algorithm for aerosol extinction forecast. In the study we consider the coastal physical effects and ocean processes as functions of wind speed, its direction, fetch, relative humidity and altitude above the sea level.

While taking into account variability of marine and coastal aerosols, the paper focuses on the detailed description of the developed aerosol model and optical properties of aerosol. We discuss the developed algorithm and comparison of our results with available observational data and with the aerosol extinction results obtained by known software.

It is known that, the surface layer aerosol of the marine and coastal atmosphere, its microphysical and optical characteristics determine the aerosol extinction coefficients $\sigma(\lambda)$, essentially depending on the type of air mass parameter (AMP), the speed and the direction of wind, fetch and relative humidity. Also it is highly sensitive to altitude structure, especially, in the range of heights 0-30 meters.

The aerosol size distribution function of the coastal aerosol microphysical model with particle radii 0.01–100 μm may be expressed as a sum of four modified lognormal functions.

The principal feature of the model is the parameterization of the amplitudes and the widths of the various modes as functions of fetch and wind speed.

Thus, having obtained the aerosol size distribution and the refraction index it is possible to calculate the aerosol scattering $\alpha(\lambda)$ and the extinction $\sigma(\lambda)$ values by means of the classical Mie solution assuming the spherically-shaped aerosol particles.

The aerosol substance is submitted as a combination of four materials: dry substance, sea salt and water.

Wind speed is important factor determining of aerosol extinction spectra in the coastal zone. Our simulations reveal that the spectrum of $\sigma(\lambda)$ has a relatively slight gradient in of the average values of wind speed and for small values of fetch. The spectrum becomes to be more distinguishable when wind speed increases.

It is interesting to note that the model used in our simulations allows to observe computationally a so-called "dilution effect" of the sea-salt aerosol. The effect is possible to explain assuming that greater fetch values are related to the marine conditions, and smaller values of fetch correspond to the coastal conditions.

Based on the comparison with the observational results we can draw that the model is capable to realistically describe the impact of the different factors, viz. - meteorological parameters, geometrical features of shoreline, wind mode and etc. To take into account air dynamics in the model AMP might be replaced by fetch parameter. As a final result, the model is able to reproduce experimentally observed effects and regularities of the spectral and altitude profiles $\sigma(\lambda)$ in the visible and IR wavelength bands.