THE COASTAL AEROSOL MICROPHISICAL MODEL

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ABSTRACT

The aerosol microphysical model of the sea and coastal atmosphere surface layer developed within the framework of joint researches of the atmosphere surface layer and interaction of ocean - land - atmosphere is considered.

The given model is based on long-term files of the experimental data received in a different season for Baltic, Mediterranean and Northern Seas at researches microphysical and a chemical composition of marine and coastal aerosol. The model is executed for particles sizes of 0.01 - 100 μm on radius and advanced by present time for a heights range 0 – 25 m. Ranges of wind speed change make 3 – 18 m/s, sizes of fetches up to 120 km, relative humidity (RH) 40 – 98 %.

The received results are discussed in comparison with available microphysical models.

1. INTRODUCTION

Aerosol of the marine atmospheric surface layer plays the important role in radiation balance of the Earth on borders of interaction Ocean-Continent-Atmosphere. They basically determine scattering and absorption of electromagnetic radiation in a visible band and exert determining influence on extinction in IR windows of a transparency. It is important both for the formation laws forecast of a climate, and for lines of the application connected to the forecast of the performance assessment electro-optical systems in coastal environments.

While the impact of the molecules rather constantly and can be relatively well assessed with use of various wide known codes MOSART, FASCODE, MODTRAN, SPARK (Russia, GOI), the effects of aerosols are more difficult to infer due to large spatial and temporal variations in concentration and composition.

Therefore the attention of our researchers has been concentrated mainly on studying of visibility decrease and on optical effects from aerosol influence in specific coastal region with the purpose the algorithms development of the aerosol extinction forecast, where there is a connection of coastal physical effects with ocean processes at change of meteorological parameters.

Taking into account the marine and coastal aerosol variability the basic attention in the paper will be given to the description of developed microphysical model MEDEX (Mediterranean Extinction) [1-5], to an influence of relative humidity and a wind mode on the particle size distribution, to the comparison of the results calculated with help MEDEX with available experimental data.

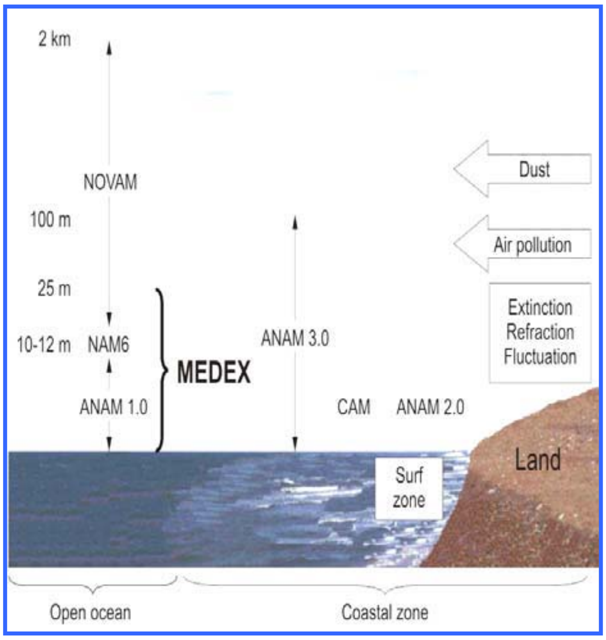

Fig. 1. Existing aerosol models of the sea and coastal atmosphere surface layer.

The model that is most frequently used for prediction of aerosol extinction in the marine atmosphere until recently (the beginning 90 years) is the US **N**avy **A**erosol **M**odel (NAM) proposed in [6] (Fig.1).

The model is based on long-term files of the experimental data received at height 10 – 12 meters above sea level. In a consequence many updating of the given model have appeared and now there is a sixth version of model. The model provides reasonable prediction for the aerosol extinction of optical radiation for sea conditions, for conditions of Open Ocean for heights 10 – 12 meters.

However experimental researches of the beginning of 90 years have shown that model NAM gives essentially differing results at the prediction for the aerosol extinction at other heights. Especially essential differences are observed on the IR band 3-5 and 8-12 microns in conditions of a coastal zone.

So, experimental results of the particle size distribution as functions of height above sea level *(dN/dr)*, received in [7], show essential variations of microphysical structure of particles both aerosol and the transparency from measurement height.

Besides results of microphysical structure of marine aerosol as the functions of relative humidity (RH) show, that at change of RH up to 70 %, the relative size of aerosol particles changes insignificantly, however, since 70 %, the sharp increase in the marine aerosol particles size is observed.

The wind mode is other important factor determining microphysical structure of aerosol particles of the coastal zone in a measurement point. In papers [1-5] have shown essential dependence of the particle size distribution sea aerosol from size fetch (distance that an air mass travels over water). It illustrates at Fig. 2 where essential change of the particle size distribution is shown at change fetch.

2. THE BASIC FEATURES OF THE COASTAL AEROSOL MICROPHISICAL MODEL

The particle size distribution *N(r)/dr* of the coastal aerosol microphysical model is submitted as the sum of four modified lognormal functions similar to models NAM and ANAM (Advanced Navy Aerosol Model) [2], according to the up-to-date representations.

As against available models NAM and ANAM *N(r)/dr* parameterization versus sizes of fetch and wind speeds.

These empirical ratio are received from the regression analysis of dependence of concentration of an aerosol from speed of a wind and size of area of dispersal of waves. The fourth mode represents the biggest particles which produced from waves whitecaps.

The distribution function shape is resulted depending on change meteorological parameters and heights above sea level.

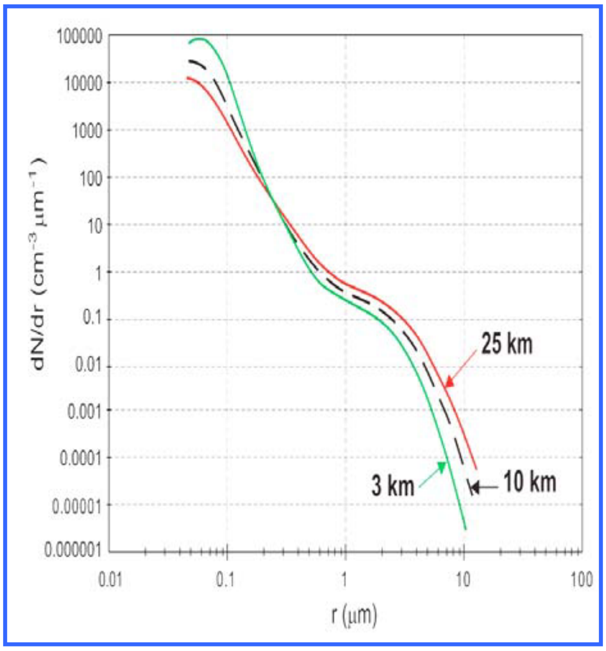

Fig. 2. Influence of the fetch size on the particle size distribution.

$$\frac{dN}{dr} = \sum_{i=1}^{4} \frac{A_i}{f} \exp\{-C_i (\ln r / f r_{0i}))^2\},$$

where f – the humidity growth factor, dependent from RH. $f = \left(\frac{2-S}{6(1-S)}\right)^{1/3}$, f (at 80 %) =1;

$S \equiv RH/100$ - saturation index.

A_i denotes the i^{th} mode amplitude and C_i is the width of the i^{th} mode *and* r_{oi} – the modal radiuses equal 0.03; 0.24; 2 and 10 microns.

$A_1 = -25100 \ln (X/X_0) + 150040;$

$A_2 = 10^{\{(0.0296 \ln [(X/X_0) - 0.045] U - 0.385 \ln (X/X_0) + 2.1675\}};$

$A_3 = 10^{\{(0.046 \ln [(X/X_0) - 0.0437] U - 0.465 \ln (X/X_0) - 0.523\}};$

$A_4 = 10^{\{(0.0095 \ln [(X/X_0) + 0.0168] U + 0.1424 \ln (X/X_0) - 3.2\}}.$

$C_1 = -0.190 \ln (X/X_0) + 1.679;$

$C_2 = -0.148 \ln (X/X_0) + 1.698;$

$C_3 = -0.295 \ln (X/X_0) + 2.188;$

$C_4 = 10.$

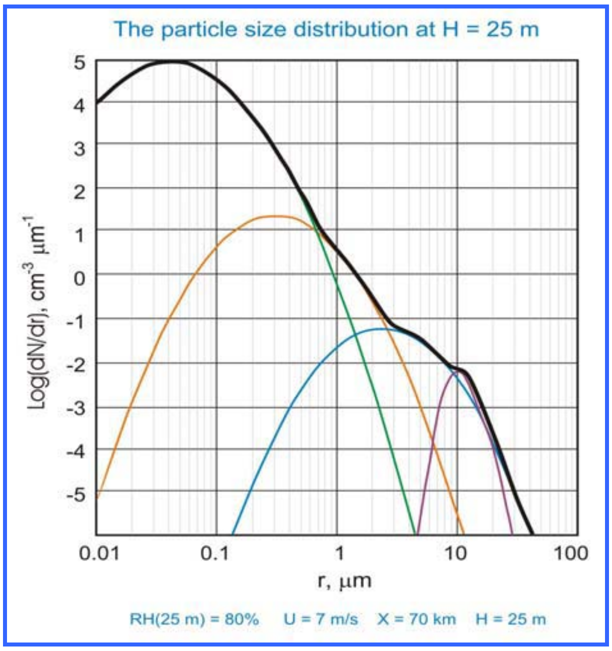

Fig. 3. The particle size distribution of the coastal aerosol microphysical model at relative humidity RH=80%, wind speed U = 7 m/s, fetch X = 70 km, and height H = 25 m.

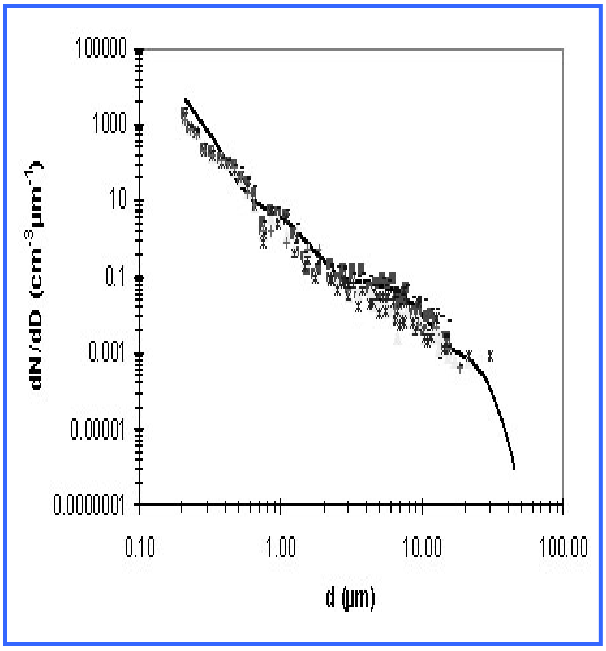

Fig. 4. Experimental (the points, circles and crosses) and calculated (the line) the particle size distribution dN/dr by the model for fetch X = 3 km and wind speed U = 9.5 – 10.5 m/c.

These empirical ratios are received from the regression analysis of the particle size distribution dependence from the fetch size.

The fourth mode represents in the model the biggest marine aerosol particles which origin communicates with a wind mode with the mechanism blow off spray from crests of collapsing waves (Fig.3).

Area of applicability of the coastal aerosol microphysical model. The model suitable for the particles sizes spectrum 0.01 - 100 microns on radius and advanced by present time for the range of heights 0 – 25 m, up to heights where in our opinion, there are the most essential changes of microphysical structure.

Ranges of change of a wind speed make 3 – 18 m/s, sizes of fetch up to 120 km, RH - 40 – 98 %.

On Fig. 4 and 5 examples of comparison between particle size distribution measured in the Mediterranean (the points, circles and crosses) and distribution predicted using the coastal aerosol microphysical model (the line) for the same meteorological parameters and values fetch are submitted.

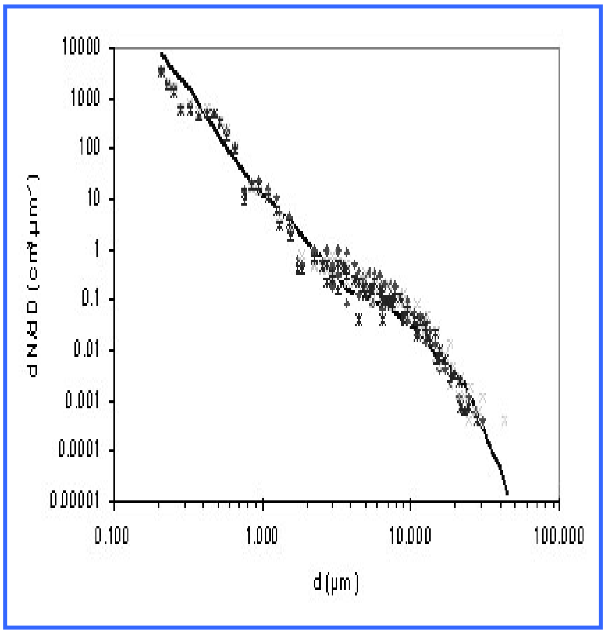

Fig. 5. Experimental (the points, circles and crosses) and calculated (the line) the particle size distribution dN/dr by the model for fetch X = 25 km and wind speed U = 12.5 – 13.5 m/c.

Fig. 4 and 5 show a good agreement between the coastal aerosol microphysical model and the measurements.

3. SUMMARY

The calculation results by the model predict a good agreement with experimental data depending of meteorological parameters.

The forecast of dN/dr by the model is in the agree with the experimental data received in different geographical areas by different authors.

The model provides a wealth of information for testing and developing retrieval algorithms for various combinations of remote sensing devices used at the marine and coastal environment.

4. REFEERNCES

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