INFLUENCE OF THE LARGE AEROSOL PARTICLES ON THE INFRARED PROPAGATION IN COASTAL AREAS

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ABSTRACT

Extinction of IR radiation in the marine boundary layer is dominated by scattering and absorption due to atmospheric aerosol. This is important to optical retrievals from satellite, remote sensing, backscatter of light to space (including climate forcing), cloud properties etc. In unpolluted regions the greatest effects on near shore scattering extinction will be a result of sea-salt from breaking waves and variations in relative humidity. The role of breaking waves appears to be modulated by wind, tide, swell, wave spectra and coastal conditions. These influences will be superimposed upon aerosol generated by open ocean sea-salt aerosol that varies with wind speed.

The focus of our study is the extinction and optical effects due to aerosol in a specific coastal region. This involves linking coastal physical properties to oceanic and meteorological parameters in order to develop predictive algorithms that describe 3-D aerosol structure and variability.

1. THE CODE MaexPro 3.0

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. The performance of electro-optical systems can be substantially affected by aerosol particles that scatter and absorb electromagnetic radiation.

An empirical model was developed describing the aerosol size distributions in the Mediterranean coastal atmosphere which has been coupled with Mie theory to yield the code MEDEX (MEDiterranean EXtinction) for the aerosol extinction [1-4].

Taking into account the marine and coastal aerosol variability the basic attention in the paper will be given to the description of developed code MaexPro 3.0 (**Ma**rine **Ae**rosol **Ex**tinction **Pro**file) [5], to an influence of relative humidity and a wind mode on the aerosol extinction forecast, to the comparison of the results calculated with help MaexPro 3.0 with available accessible experimental data and with the forecast of aerosol extinction on the code NAM and ANAM (Navy Aerosol Model and Advanced Navy Aerosol Model) [6,7].

1.1. The basic features of the code MaexPro 3.0

The key element of MaexPro 3.0 is empirical microphysical model MEDEX.
The particle size distribution of the code MEDEX is similar to models NAM and ANAM is submitted as the sum of four modified lognormal functions. In against available models NAM and ANAM amplitude and width of various modes is parameterized as functions of the fetch (distance that an air mass travels over water).

1.2. Calculations the aerosol scattering and extinction coefficients

Using known Mie programs for spheres, microphysical model MEDEX allows one to make calculations of the aerosol scattering and extinction coefficients spectral profiles $\alpha(\lambda), \sigma(\lambda)$. These programs are based on the following ratio Mie between the particle size distribution (*dN/dr)* and factors of aerosol scattering, extinction and absorption:

Coefficient of aerosol scattering:

$$\alpha(\lambda) = \int_{r=0}^{r=\infty} K_s(\rho, m) \frac{dN(r)}{dr} \pi r^2 dr;$$

Coefficient of aerosol extinction:

$$\sigma(\lambda) = \int_{r=0}^{r=\infty} K(\rho, m) \frac{dN(r)}{dr} \pi r^2 dr;$$

Coefficient of aerosol absorption:

$$\sigma(\lambda) - \alpha(\lambda).$$

Where $K_s(\rho, m)$ and $K(\rho, m)$ are the particle scattering and extinction efficiency factors, as a function of the complex optical index of refraction *m*,

$\rho = \frac{2\pi r}{\lambda}$ is size parameter, and λ is the optical wavelength.

The refractive index *m* for sea salt and the waters as proposed by F. Volz [8-10] is used in the code MaexPro 3.0.

It is necessary to note, that in the overwhelming majority of cases in the marine atmospheric surface layer distinction between $\sigma(\lambda)$ and $\alpha(\lambda)$ in the visible band are not beyond tool mistakes.

1.3. Extrapolation of the humidity growth factor f_H

Besides calculation of coefficients of aerosol extinction is carried out with use of the following extrapolation connected to the profile of the humidity growth factor f_H:

$$\left(\frac{\alpha_H}{\alpha_{0m}}\right) = \left(\frac{0.037}{1.017 - f_H / 100}\right)^{0.84},$$ where α_{0m} coefficients of aerosol extinction at $H = H_0$.

Calculation of structures f_H is carried out under following conditions:

- if 20 m $\leq$ H $\leq$ of 25 m then $f_H = f_{25M}$;
- if H $\leq$ 20 m and $f_H \leq f_{25M}$, then $f_H = f_{25M}$;
- otherwise, if H $\leq$ 20 m, $f_H = (f_{25M}+7) \times H^{-0.03}$.

Extrapolation suits at 40 % < *RH* <98 %.

1.4. Area of applicability of the code MaexPro 3.0

The code 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 %. The resolution at spectral interval 0.2 - 12 µk is 0.001 µk.

1.5. Interface of the code MaexPro 3.0

MaexPro code develops for calculation spectral and vertical profiles of aerosol extinction coefficient $\alpha(\lambda)$, aerosol sizes distribution, area distribution, volumes distribution, modes aerosol extinction spectra is submitted. The program carries out calculation $\alpha(\lambda)$, as functions of atmospheric effects using standard meteorological parameters, aerosol microphysical structure, a spectral band and a height of the sensor location place. Interface the code MaexPro 3.0 looks as follows (fig.1): at the main working window the top part of the window is intend for the task of input parameters, the bottom – for results of calculation.

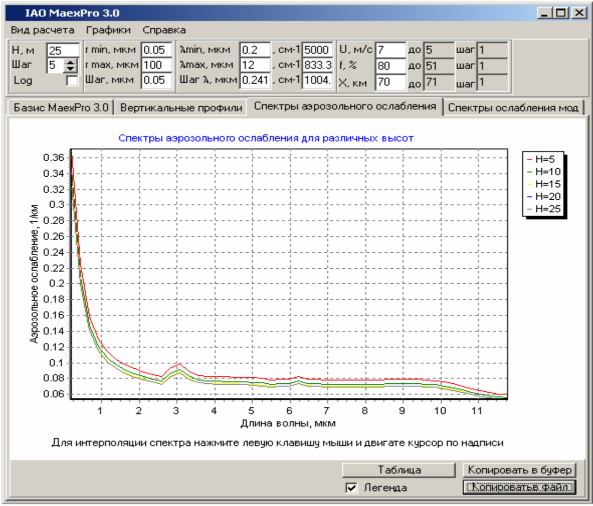

Fig. 1. Interface of the code MaexPro 3.0

2. RESULTS OF COMPARISON WITH THE EXPERIMENTAL DATA RECEIVED IN IAO

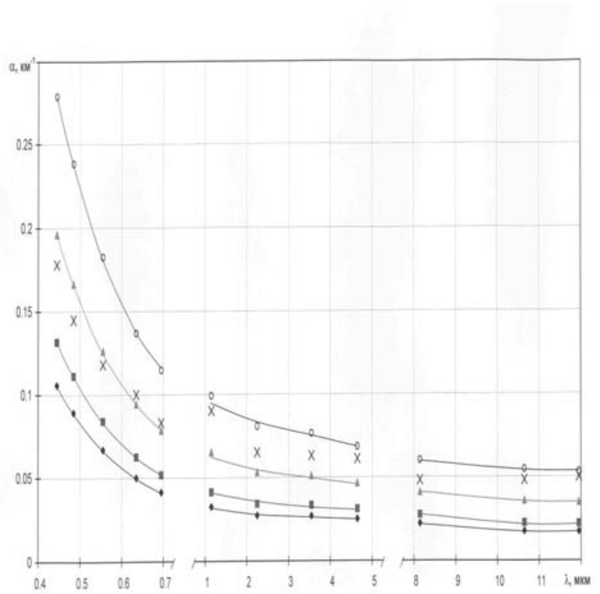

Fig. 2. Aerosol extinction spectrum $\sigma(\lambda)$ at height H = 2.5 m for fetch X = 30 km, wind speed U = 3.3 m/s and for various relative humidity: ♦ - *RH* = 66 %, ■ - *RH* = 75 %, ▲ - *RH* = 85 %, **o** - *RH* = 90 %.

On fig. 2-4 are show results of comparison between the aerosol extinction calculated by the code MaexPro 3.0 with experimental data received in IAO SB RAS at transmission measurements of a spectral transparency in coastal environments [11]. Results of calculation are received for entrance meteorological parameters and heights of a sea level close to conditions of the

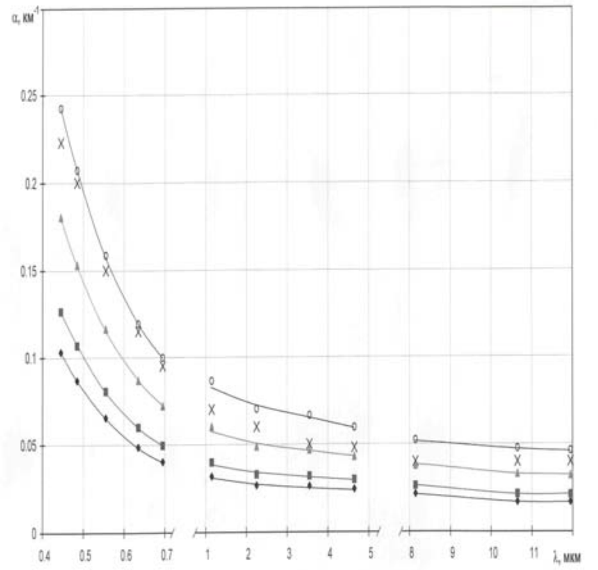

Fig. 3. Aerosol extinction spectrum σ(*λ)* at height H = 4 m for fetch X = 30 km, wind speed *U* = 3.3 m/s and for various relative humidity: ♦ - *RH* = 66 %, ■ - *RH* = 75 %, ▲ - *RH* = 85 %, **o** - *RH* = 90 %.

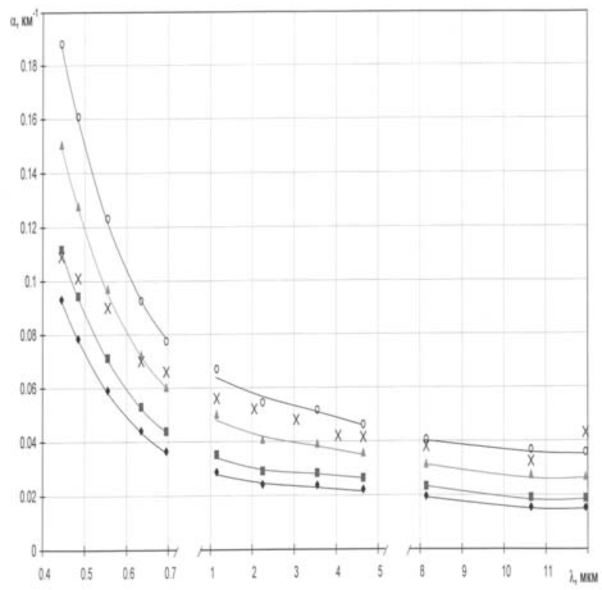

Fig. 4. Aerosol extinction spectrum σ(*λ)* at height H = 20 m for fetch X = 30 km, wind speed *U* = 3.3 m/s and for various relative humidity: ♦ - *RH* = 66 %, ■ - *RH* = 75 %, ▲ - *RH* = 85 %, **o** - *RH* = 90 %.

experiment.

Fig. 2-4 illustrate an agreement between the α(λ) spectral behavior and the experimental results received in IAO in the coastal environment.

3. RESULTS OF COMPARISON WITH THE CODE ANAM

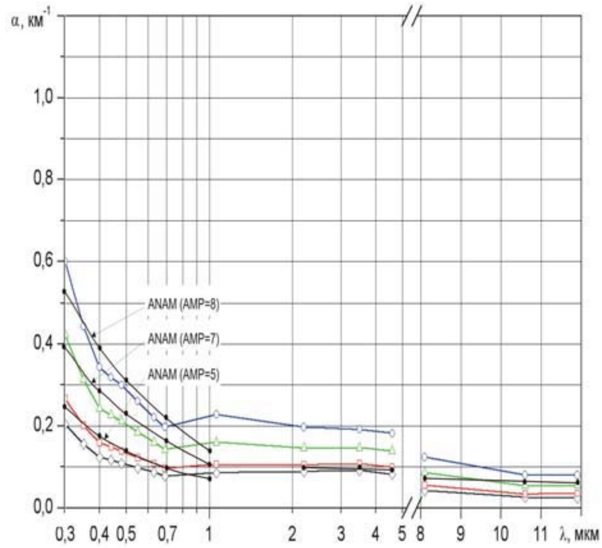

Fig. 5. Aerosol extinction σ(*λ)* spectrum at height H = 20 m for fetch X = 3 km, wind speed *U* = 3.3 m/s and for various relative humidity: ♦ - *RH* = 66 %, ■ - *RH* = 75 %, ▲ - *RH* = 85 %, **o** - *RH* = 90 %.

On fig. 5 are show results of comparison between the aerosol extinction calculated by the code MaexPro 3.0 and by the code ANAM [7].

Despite of different key entrance parameters of models the fetch for MaexPro and the air mass parameter (AMP) for ANAM fig. 5 illustrates a good agreement between the α(λ) spectral behavior for visible and near-infrared spectrum band as prediction by the code MaexPro 3.0 at fetch, equal 3, and the results received on the code ANAM at AMP, equal 5, 7 and 8.

4. RESULTS OF COMPARISON WITH EXPERIMENT EOPACE

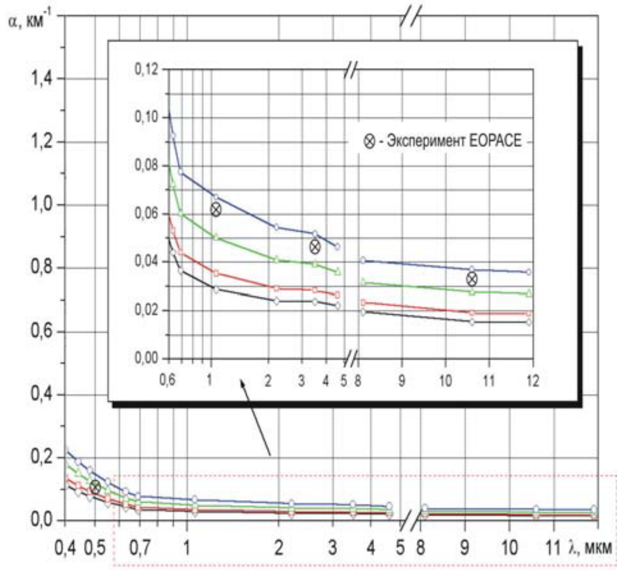

Fig. 6. Aerosol extinction spectrum σ(*λ*) at height H = 20 m for fetch X = 30 km, wind speed *U* = 3.3 m/s and for various relative humidity: ♦ - *RH* = 66 %, ■ - *RH* = 75 %, ▲ - *RH* = 85 %, **o** - *RH* = 90 %.

Fig. 6 also show the agreement between the α(λ) spectral behavior as prediction by the code MaexPro 3.0 and the available results in near- and mid-infrared spectrum band received during the 5-yr program Electro-Optical Propagation Assessment in Coastal Environment (EOPACE) [12].

5. SUMMARY

The paper presents the modeling data of the aerosol extinction coefficient predicted by the code MaexPro depending of fetch, height of sea level and meteorological parameters.

The forecast of σ(λ) by the code MaexPro 3.0 realistic reflects the influence on aerosol extinction of known effects of a coastal zone.

The σ(λ) prediction by the code MaexPro 3.0 correspond to the results received on the code ANAM.

The forecast of σ(λ) profiles by the code MaexPro 3.0 is in an agreement with available experimental data.

The code MaexPro may assess the propagation conditions at using satellite remote sensing data to monitor coastline variation and to analysis the eroding, depositing features and evolution process will be of great significance for the river mouth regulation, river course planning, and coastal protective project program and trend prediction of coastal evolution.

6. REFEERNCES

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