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PRE-PROCESSING OF THE CLOUD SPECTRA REGISTERED AT GROUND BASED REMOTE SOUNDING IN THE VISIBLE SPECTRAL RANGE

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Abstract. A method is proposed for pre-processing of the registered spectra of different morphological types of clouds registered with 57-channel ground-based radiometer in the spectral range from 387 to 902 nm. The method consists of transforming the primary measured spectra to uniform experimental conditions and decreasing the dimension of the handled spectra through selection of the maximally informative spectral channels. The application of this pre-processing procedure minimizes the negative influence of a number of factors determining the experimental conditions.

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1. Introduction

The radiative properties of clouds have been investigated intensively in the recent years [1]. The International Satellite Climatology Project [2] and the Atmospheric Radiation Measurement Project [3] are outstanding examples of the problem importance widely recognized by the world scientific community. The cloud amount influences strongly the radiation transfer in the Earth's atmosphere while the clouds classes can be used as an indicator for the undergoing thermal processes. Nowadays, clouds are observed by airborne, mainly satellite, and ground based instruments. The latter are visible and infrared radiometers and scanners, microwave radars and radiometers, lidars, ceilometers, pyrometers and visible and thermal infrared video cameras [4]. Neither of all above mentioned measuring apparatus is superior. They are rather supporting each other.

The methods of deduction of cloudiness and cloud parameters based on radiometric data can be divided into three classes. The first class uses the radiation transfer equation for estimating the registered radiance. The obtained results are subjected to a threshold test to detect cloud-free, partly cloudy, or cloud-filled pixels in an image. Such methods are used in [5] for satellite and in [6] for ground-based radiometric data. The second class methods are based on texture or cluster identification in the multidimensional

space of the object's spectral characteristics. The latter can be signals measured in different radiometer channels of indices of these signals. Such methods are applied in [7] for two- dimensional clusters. The third class methods are neural network based. The multilayer perceptron was used in [8] and the self-organizing map was applied by [9].

In this paper we propose a pre-processing algorithm aimed to prepare for cluster analysis the data registered with a 57-channel radiometer having a working spectral range from 387 to 902 nm.

The pre-processing of the primary measured quantities is a compulsory stage of the correct interpretation of the data.

On the one hand, the necessity of such a pre-processing comes from the great differences in the primary non-processed data which are registered when sensing clouds belonging to a certain type. These differences are caused by the action of a number of factors determining the experimental conditions and changing both the measured spectral characteristics and calculated statistical characteristics of the objects. Basing on our three years practice [3] and the publications by other authors [6, 11, 12] we can distinguish at least four factors: (A) Irradiation of the object by direct or scattered solar radiation; (B) Solar elevation angle h_S related with the measuring daytime; (C) Radiometer elevation angle h_R or the cloud position on the sky; (D) Presence of different types anthropogenic aerosols (AA) between the radiometer and the observed object. Neither of above mentioned factors influences separately the registered signal. The difference $h_S - h_R$ dominantly determines the irradiation conditions in cloudless sky or if only a few clouds appear. Opposite, if the sky is totally covered with low clouds, e. g. Nimbostratus, the same difference has only slight influence. The smaller the values h_R the bigger the AA influence.

On the other hand the real time processing of multidimensional images requires much memory and high processing power.

Therefore the aims of the registered data pre-processing can be defined as: (a) transforming of the "raw" primary data to equivalent experimental conditions and (b) from pattern recognition point of view decreasing the dimension of the spectra through selection of the maximally informative spectral channels.

2. Experimental Setup

The handled spectra were recorded with radiometer VIS-1 in winter/spring conditions during 1995/97 in the region of Sofia Airport, Institute of Electronics-BAS and Institute of Geophysics-BAS. Pictures were taken of all observed clouds and further the clouds were classified according to [14].

The principal schematic of the radiometer VIS-1 is shown in Fig. 1. The radiometer contains four parts: optical head (OH), power supply unit (PS), controlling and registering electronics unit (CR) and scanning unit (not shown in the figure). The unit OH consists of a receiving telescope (*1*) (telescopic photographic objective type JUPITER-36B 35/250, a polychromator and a linear photodiode array type Panasonic MN512K (*6*). The received radiation flux is focused by (*1*) on the entrance slit (*2*) which is