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Retrieval of cloud optical properties from multispectral remote sensing data using machine learning

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Earth observation from satellites is the only possible way to investigate the main properties of clouds and their variability at the global scale. A standard method for retrieval of cloud optical thickness and droplet effective radius from remote sensing data is the bispectral approach that is used to produce the Moderate Resolution Imaging Spectroradiometer (MODIS) cloud products [1, 2]. The method is based on the independent pixel approximation assuming plane-parallel, horizontally and vertically homogeneous clouds for each pixel of the satellite image. This simplification was implemented due to high computational cost of 3D radiative transfer simulation. However, the observed radiance is affected by both vertical structure cloud structure and the net horizontal radiative transport in inhomogeneous cloud fields.

The alternative approach that takes into account the horizontal heterogeneity of cloud fields has been proposed due to the enhanced capacity of state-of-the-art computing equipment [3-5]. It consists in the use of machine learning technology. Nowadays, neural networks are increasingly applied to solution of inverse problems because are well adapted to find non-linear statistical relationships between target and input variables. The general idea to solve the inverse problem is to combine realistic models of cloud fields and the results of 3D simulation of solar radiation transfer in a cloudy atmosphere to train the neural network. The analysis of the performed calculations showed that the results of the cloud optical thickness and effective droplet radius retrieval by the new approach turned out to be more accurate compared to the results obtained within the current Lookup table method that assumes the uniform plane-parallel clouds [5].

In the study, we describe general principles of an original algorithm implementation for retrieval of cloud optical properties using machine learning technology. The characteristics of cloud field and radiance databases used for training of the neural network are presented. We discuss the feasibility of the realized approach to retrieving the inhomogeneous and fractional stratocumulus cloud parameters from multispectral radiance data.

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Keywords: retrieval algorithm, clouds, Monte Carlo method, machine learning

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