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Cloud cover and solar disk state estimation using all-sky images: deep neural networks approach compared to routine methods

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Shortwave radiation is an important component of surface heat budget over sea and land. To estimate them accurate observations of cloud conditions are needed including total cloud cover, spatial and temporal cloud structure. While massively observed visually, for building accurate SW radiation parameterizations cloud structure needs also to be quantified using precise instrumental measurements. While there already exist several state of the art land-based cloud-cameras that satisfy researchers needs, their major disadvantages are associated with inaccuracy of all-sky images processing algorithms which typically result in the uncertainties of 2-4 octa of cloud cover estimates with the resulting true-scoring cloud cover accuracy of about 7%. Moreover, none of these algorithms determine cloud types. We developed an approach for cloud cover and structure estimating, which provides much more accurate estimates and also allows for measuring additional characteristics. This method is based on the synthetic controlling index, namely the “grayness rate index”, that we introduced in 2014. Since then this index has already demonstrated high efficiency being used along with the technique namely the “background sunburn effect suppression”, to detect thin clouds. This made it possible to significantly increase the accuracy of total cloud cover estimation in various sky image states using this extension of routine algorithm type. Errors for the cloud cover estimates significantly decreased down resulting the mean squared error of about 1.5 octa. Resulting true-scoring accuracy is more than 38%.
The main source of this approach uncertainties is the solar disk state determination errors. While the deep neural networks approach lets us to estimate solar disk state with 94% accuracy, the final result of total cloud estimation still isn‘t satisfying. To solve this problem completely we applied the set of machine learning algorithms to the problem of total cloud cover estimation directly. The accuracy of this approach varies depending on algorithm choice. Deep neural networks demonstrated the best accuracy of more than 96%. We will demonstrate some approaches and the most influential statistical features of all-sky images that lets the algorithm reach that high accuracy.
With the use of our new optical package a set of over 480‘000 samples has been collected in several sea missions in 2014-2016 along with concurrent standard human observed and instrumentally recorded meteorological parameters. We will demonstrate the results of the field measurements and will discuss some still remaining problems and the potential of the further developments of machine learning approach.