Cloud physical properties derivation from AVHRR imagery by means of the Vectorized Earth Observation Retrieval (VEOR) method trained against PATMOS-x data

Jan Paweł Musiał [a], Jędrzej Stanisław Bojanowski [b]

[a] Institute of Geodesy and Cartography, Modzelewskiego 27, PL02-679, Warsaw, Poland
[b] Meteo Swiss, P.O. Box 257, CH-8058 Zurich-Airport, Switzerland

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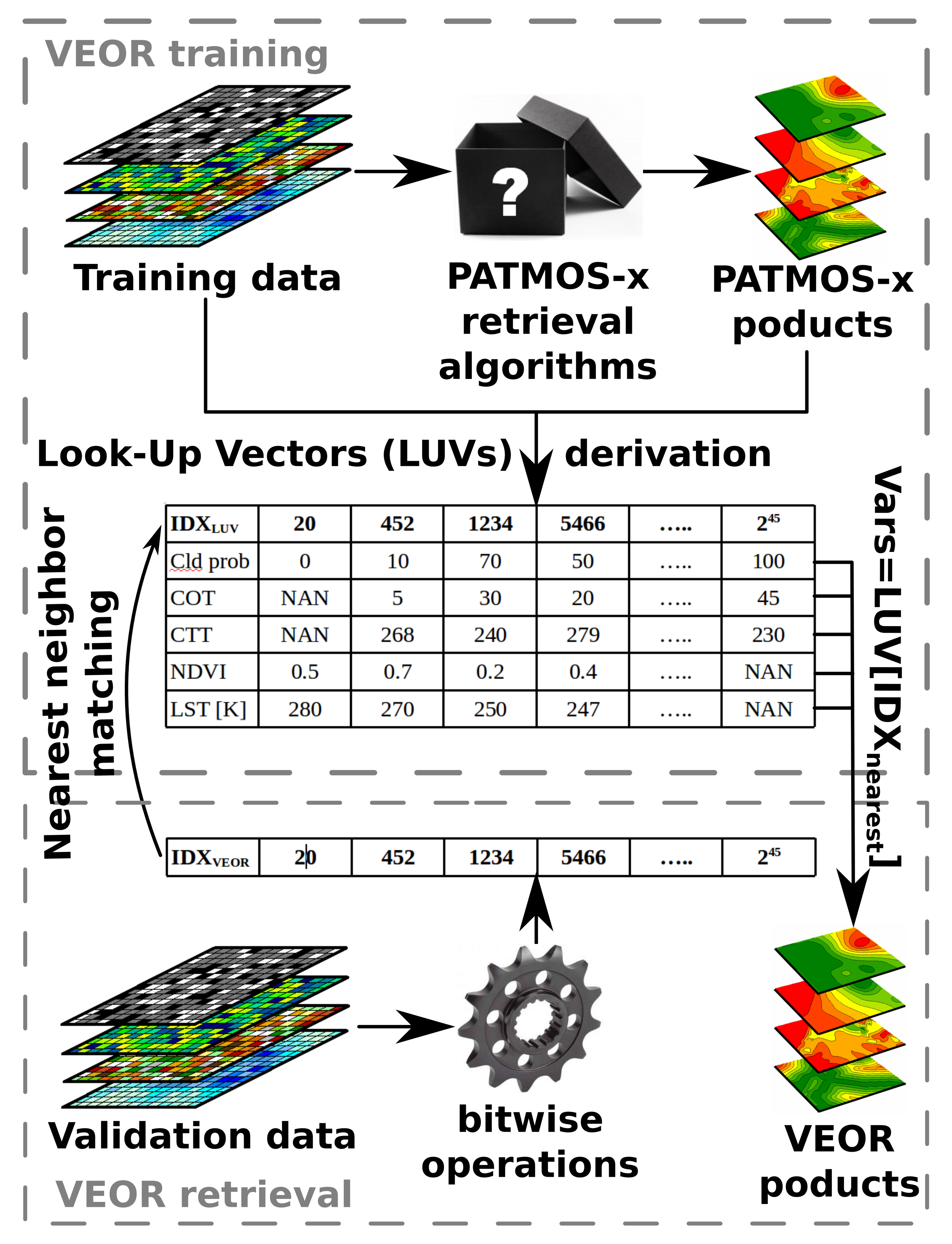
Introduction

The Vectorized Earth Observation Retrieval (VEOR) algorithm is a successor of the Probabilistic Cloud Mask (PCM) algorithm (Musial et al., 2014a) which has been successfully applied to AVHRR data for cloud and snow masking and for low stratiform cloud detection (Musial et al., 2014). Generic formulation of the VEOR retrieval allows for extending its methodology to a wide range of satellite cloud products such as: cloud optical depth, hydrometeor effective radius, cloud physical state, cloud top temperature/height, and liquid water path. Its processing time is shorter than of other methods due to utilizations of the Look-Up Vectors (LUVs). The presented study was performed to evaluate applicability of the VEOR to a robust global AVHRR dataset.

VEOR algorithm description

The VEOR algorithm utilizes the LUVs which describe pixel position within a multidimensional sparse matrix composed of spectral, angular and ancillary data. At the beginning of VEOR training the input datasets are combined by means of bitwise operations and step functions (see Musial et al., 2014) to form a vector of unique indexes (IDX_{LUV}). Further, for each index value a corresponding mean estimates of selected PATMOS-x products is computed. This involves accumulation of all pixel values that match a specific index from all training datasets. Examples of the LUVs generated during the VEOR training are depicted on the right.

During the VEOR retrieval input imagery is combined by means of the step functions and bitwise operations to form a IDX_{VEOR} index. Then the position of each IDX_{VEOR} is located within the IDX_{LUV} by means of nearest neighbor algorithm that incorporates binary search methodology. As a result $IDX_{nearest}$ is produced that is further utilized to extract estimates of several products (COT, CTT, etc.) from the LUVs generated during the VEOR training process. Ultimately, extracted VEOR estimates are stored as separate products.



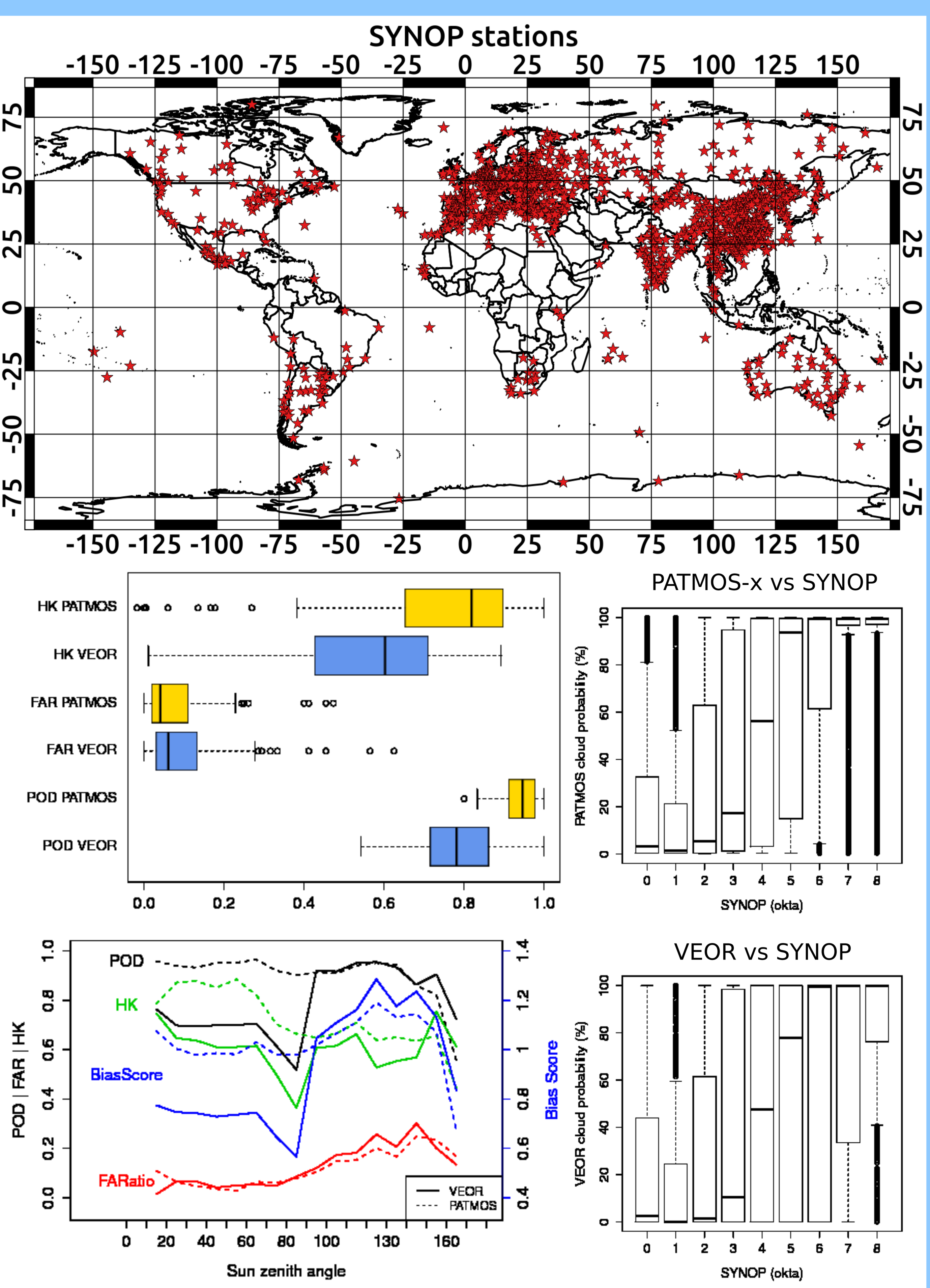
Input data

The study is based on 1000 PATMOS-x GAC AVHRR datasets originating from NOAA18,19 and METOP-A satellites. 70% of imagery was used for VEOR training and 30% for validation. Only reflectances and land use data were used without aid of NWP data.

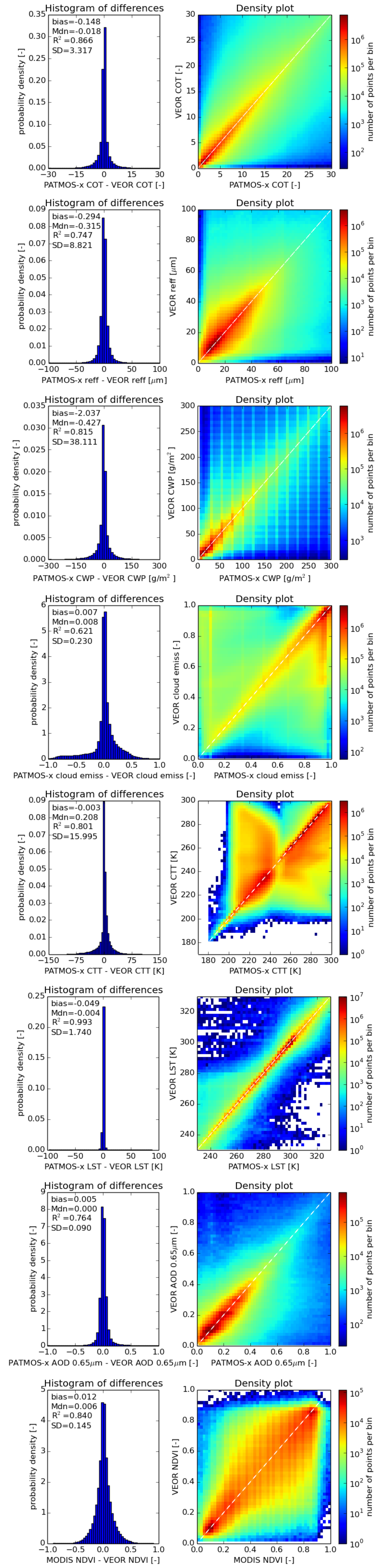
Results

The VEOR algorithm was applied to 300 randomly selected PATMOS-X scenes. As a result 8 satellite products were generated covering different types of satellite retrievals spanning from cloud physical properties through AOD and LST derivation to vegetation indices. The acquired data sets were compared to corresponding PATMOS-X products to produce histograms of differences and scatter plots presented on the right. It is apparent that in all cases VEOR algorithm was able to perform retrieval however its accuracy varies for different products. This is due to the fact that VEOR retrieval was perform (on purpose) using only land cover dataset to evaluate influence of auxiliary data on PATMOS-x retrievals.

Furthermore, the cloud probability products originating from both algorithms were validated against SYNOP observations (see graphs on the left). The acquired results revealed higher accuracy of the PATMOS-x cloud mask over the VEOR retrieval that significantly varies with the sun zenith angle. This is due to the fact that VEOR algorithm was trained using NWP snow cover data that introduced confusion between cloud and snow categories. This issue can be overcome using accurate snow mask product.



VEOR vs PATMOS-x



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