EGU21-5961
https://doi.org/10.5194/egusphere-egu21-5961
EGU General Assembly 2021
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Cloud regime analysis over Central Europe based on 14 years of satellite data

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The improvement of our understanding of the spatiotemporal variability of cloud properties and their governing processes is of high importance, given the crucial role of clouds in the climate system. The availability of long-term and high-quality satellite observations together with mature remote sensing techniques has made feasible the creation of multi-decadal climate data records for this purpose.

Various cloud classification techniques have been developed and applied in the past, each with distinct advantages and disadvantages, allowing studying clouds from different perspectives. One of these techniques is the creation of cloud regimes which provides information on the prevalence of simultaneously occurring cloud types over a region. This study uses the k-means clustering method, applied to 2-dimensional histograms of cloud top pressure and optical thickness, in order to derive and analyze cloud regimes over Europe during the last decade. Europe is selected for this work because it is an appropriate region for studying cloud regimes since the prevailing atmospheric circulation patterns and its diverse geomorphology, result in a mixture of diverse cloud types. In order to achieve that, the CLoud property dAtAset using Spinning Enhanced Visible and Infrared (SEVIRI) edition 2.1 (CLAAS-2.1) data record, which is produced by the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF), is used as basis for the derivation of the cloud regimes. In particular, pixel-level Cloud Optical Thickness (COT) and Cloud Top Pressure (CTP) products of CLAAS-2.1, from 2004 to 2017, are used in order to compute 2D histograms on a 1°×1° spatial resolution. Then the k-means clustering algorithm is applied, treating each 2D COT-CTP histogram of each grid point and time step as an individual data point. Various sensitivity studies on the subsampling of the data and the selection of the cloud regimes were carried out, in order to test the robustness of the method and of the results.

In contrast to the previous studies and taking advantage of the geostationary orbit of Meteosat Second Generation (MSG), on which SEVIRI is aboard, a better sampling of the diurnal cycle of clouds is thus included in the derivation process of cloud regimes. Furthermore, the annual cycle of the produced cloud regimes is examined. In addition, for each regime, the time step with its highest spatial frequency of occurrence is selected for a visual comparison with the corresponding

RGB image. Finally, a comparison of the cloud regimes against the synoptic large scale weather pattern classification is investigated. The weather pattern classification consists of 29 typical defined patterns of the daily synoptic circulation and it is produced by the German Weather Service (DWD).