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Development of a dusty cirrus calendar based on satellite data

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Mineral dust particles have the potential to serve as natural nuclei for cirrus cloud formation in the upper troposphere. Several studies demonstrate that dust aerosol plays a pivotal role in initiating cirrus clouds and forming extended optically thick cirrocumulus decks known as “dusty cirrus”. Despite this, our ability to accurately identify and predict these climatically significant clouds is still limited. In this work, we propose an algorithm to identify dusty cirrus clouds based on satellite data over the Aral Sea region between 2006 and 2021. The algorithm uses the CALIOP Vertical Feature Mask (VFM) to verify the coexistence of dust particles and cirrus clouds and determine the occurrence of dusty-cirrus. To enhance the accuracy of the algorithm, temperature obtained from an external source (the GEOS-5 data product supplied to CALIPSO) is also incorporated as a constraint for cirrus cloud identification. A random selection of identified dusty cirrus events (5% of the data, 90 events) is cross-validated against other data sources including cloud top temperature (MODIS), cloud top height (MODIS), and AOD (MODIS and VIIRS). The cross-validation confirms approximately 97% of the events to be associated with dusty-cirrus. This confirms that the developed algorithm can be used for developing a dusty cirrus calendar using available CALIOP data. This calendar reveals different facts about the dusty-cirrus occurrence in the study area. Out of the 4407 available samples, 2709 cirrus cloud events are identified, with approximately 65% (1790 events) of them being associated with dusty cirrus. The average values obtained for summer, fall, winter, and spring are 54%, 63%, 66% and 75%, respectively. Annual and seasonal trend analysis reveals different increasing rates for this region. Despite the important uncertainties, our analysis and results suggest that the proposed algorithm can be used for first-order identification and statistical analysis of dusty cirrus.