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A new method for the selection of measuring UV sites, based on cloud classification from satellite data

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Cloudiness is the main atmospheric factor that influences ultraviolet (UV) irradiance reaching the ground. In this study, we used images from the Meteosat Second Generation (MSG) satellite to derive the cloud modification factor (CMF, the ratio the UV irradiance under the presence of clouds to the UV irradiance under cloud-free skies) and statistical methods to cluster them to a number of spatial domains. Each domain could represent an area with similar influence of clouds on UV irradiance and reveal the necessity to establish a ground-based UV station. The proposed method has been applied for Greece during 2007-2010.

A dataset of CMF gridded data at 10.30 UTC (local noon) were extracted for a domain over Greece (19-28° E, 34-42° N), splined to a 0.05° x 0.05° grid. Therefore, images of 180 x 160 pixels were used. For each pixel, we constructed a vector of its CMF values through sequential images starting from the first daily image and culminated at the last one. With this disposition of data, a set of 28800 (the total number of pixels per image) vectors was generated, whereas each vector encompasses the temporal progression of the cloudiness over a precise spatial location. In order to reduce the high dimensionality of the dataset, which often increases the noise of data, the principal component analysis (PCA) was employed prior to cluster analysis. Hence, the original dimensions were reduced to a smaller number of PCA eigenvectors that preserve a portion of up to 98% of the initial variance. Then, the k-means algorithm was applied to classify the reduced (in dimensionality) dataset. The aim of that clustering was to group together vectors with similar temporal progression of CMF values and, as a consequence, spatial segmentation of similar ground-based sites was expected to emerge. The clustering procedure contained k-means runs, which result to partitions in a variety of number of clusters ranging between 8 and 150. Due to random selection of k initial centroids at its first step, the k-means becomes sensitive to cluster stability. We faced this handicap by applying k-means multiple times per number of clusters and calculate the Davies-Bouldin and Dunn indexes for every emerged partition. In order to determine a reasonable number of clusters the L-method has been applied. Based on these results, a number of ground-based stations between 23 and 28 could be considered as adequate for monitoring the effect of cloudiness on solar UV irradiance over Greece.