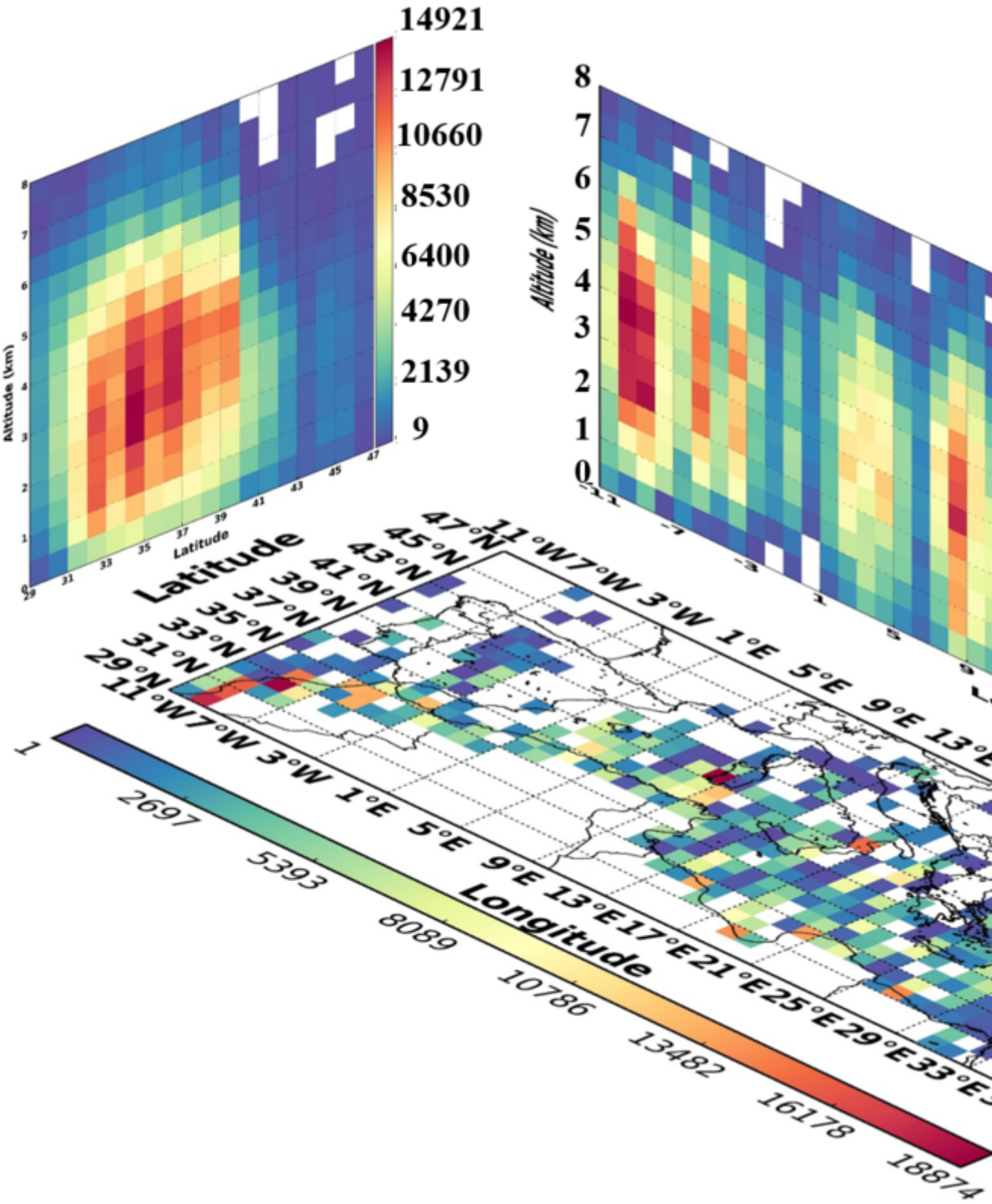
Mediterranean desert dust outbreaks and their vertical structure based on remote sensing data



The well-known scientific journal Atmospheric Chemistry and Physics (ACP) has recently published the paper titled Mediterranean desert dust outbreaks and their vertical structure based on remote sensing data as a discussion paper in ACPD, the scientific discussion forum of ACP.

This study presents the intense Mediterranean desert dust outbreaks' 3D structure, over the period Mar2000–Feb2013. The desert dust (DD) episodes are identified through an objective and dynamic algorithm, which uses satellite retrievals (MODIS, TOMS and OMI) as inputs.

The performance of the satellite algorithm is evaluated versus AERONET and PM10 data. The geometrical characteristics of the identified DD episodes are analyzed using the collocated CALIOP profiles as a complementary tool.

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Abstract: The main aim of the present study is to describe the vertical structure of the intense Mediterranean dust outbreaks, based on the use of satellite and surface-based retrievals/measurements. Strong and extreme desert dust (DD) episodes are identified at 1° × 1° spatial resolution, over the period March 2000–February 2013, through the implementation of an updated objective and dynamic algorithm. According to the algorithm, strong DD episodes occurring at a specific place correspond to cases in which the daily aerosol optical depth at 550 nm ($AOD_{550\ nm}$) exceeds or equals the long-term mean $AOD_{550\ nm}$ (Mean) plus two standard deviations (SD) value being smaller than Mean + 4 · SD. Extreme DD episodes correspond to cases in which the daily $AOD_{550\ nm}$ value equals or exceeds Mean + 4 · SD. For the identification of DD episodes additional optical properties (Ångström exponent, fine fraction, effective radius and Aerosol Index) derived by the MODIS-Terra & Aqua (also AOD retrievals), OMI-Aura and EP-TOMS databases are used as inputs. According to the algorithm using MODIS-Terra data, over the period March 2000–February 2013, strong DD episodes occur more frequently (up to 9.9 episodes $yr^{?1}$) over the western Mediterranean while the corresponding frequencies for the extreme ones are smaller (up to 3.3 episodes $yr^{?1}$, central Mediterranean Sea). In contrast to their frequency, dust episodes are more intense (AODs up to 4.1), over the central and eastern Mediterranean Sea, off the northern African coasts. Slightly lower frequencies and higher intensities are found when the satellite algorithm operates based on MODIS-Aqua retrievals, for the period 2003–2012. The performance of the satellite algorithm is assessed against surface-based daily data from 109 sun-photometric (AERONET) and 22 PM_{10} stations. The agreement between AERONET and MODIS AOD is satisfactory (R = 0.505 – 0.75) improving considerably when MODIS level 3 retrievals with higher sub-grid spatial representativeness and homogeneity are considered. Moreover, the evaluation analysis using other AERONET spectral optical and microphysical properties during the days of episodes as well as surface PM_{10} concentrations also provides strong support of the successful performance of the satellite algorithm. The CALIOP vertical profiles of pure and polluted dust observations and the associated total backscatter coefficient at 532 nm ($?_{532\ nm}$), indicate that dust particles are mainly detected between 0.5 and 6 km, though they can reach 8 km between the parallels 32 and 38° N in warm seasons, while an increased number of CALIOP dust records at higher altitudes is observed with increased latitude, northwards to 40° N, revealing an ascending mode of the dust transport. However, the overall intensity of DD episodes is maximum (up to 0.006 $km^{?1}$ $sr^{?1}$) below 2 km and at the southern parts of the study region (30–34° N). Additionally, the average thickness of dust layers gradually decreases from 4 to 2 km moving from south to north. In spring, dust layers of moderate-to-high $?_{532\ nm}$ values (~ 0.004 $km^{?1}$ $sr^{?1}$) are detected over the Mediterranean (35–42° N), extending from 2 to 4 km. Over the western Mediterranean, dust layers are observed between 2 and 6 km, while their base height is decreased down to 0.5 km for increasing longitudes underlying the role of topography and thermal convection. The vertical profiles of CALIOP $?_{532\ nm}$ confirm the multilayered structure of the Mediterranean desert dust outbreaks on both annual and seasonal basis, with several dust layers of variable geometrical characteristics and intensities.

Citation: Gkikas, A., Basart, S., Hatzianastassiou, N., Marinou, E., Amiridis, V., Kazadzis, S., Pey, J., Querol, X., Jorba, O., Gassó, S., and Baldasano, J. M.: Mediterranean desert dust outbreaks and their vertical structure based on remote sensing data, Atmos. Chem. Phys. Discuss., 15, 27675-27748, doi:10.5194/acpd-15-27675-2015, 2015.

Animation:

The 3D animation represents the total number of pure and polluted dust observations (according to the CALIOP-CALIPSO aerosol classification scheme) during intense Mediterranean desert dust outbreaks, for the period 2006-2013. The calculations have been made for 14400 "boxes" of 1 x 1 surface area and 500 m height up to 8 km, covering the broader area of the Mediterranean basin. The desert dust outbreaks have been identified based on an objective and dynamic algorithm which is applied for the period March 2000 - February 2013. For its operation, MODIS-Terra, EP-TOMS and OMI-Aura satellite retrievals are used as inputs.

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