Supplementary Information

Vertical profiles of the aerosol mass concentration observed by unmanned airborne in-situ and remote sensing instruments during a dust event

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S1. Mass Concentration Calculation from OPC_a

The mass concentration profiles of the coarse and fine particles were calculated from the size distribution measurements recorded by OPC_a. Before converting the aerosol number concentrations to mass concentrations, the OPC measurements were averaged over 30 s. This was found to be optimal for suppressing a high frequency noise of the OPC raw data and at the same time for maintaining a relatively high spatial resolution of ≈ 80 m in the vertical direction. The number concentration (dN) of each size bin was converted to volume concentration according to $dV(r) = dN(r)\frac{4}{3}\pi r^3$, where r is the mean radius of the size bin. The volume concentration of particles with diameters larger that 1 μm were summed and multiplied by ρ_d yielding the coarse mode mass concentration (the same procedure was followed for the fine mode particles). The variability in the number size distributions averaged every 30 s propagated an uncertainty[1] of the order of 10% in the estimated volume size distributions and the mass concentrations of the particles. Similar calculations but using ρ_{nd} were performed for the fine fraction.

S2. POLIPHON Method - Error Calculation

The uncertainties of β_d and β_{nd} in equation (1) of the main manuscript were calculated using the Monte-Carlo method[5]. For each input parameter of equation (1), we generated 100 normally distributed random numbers. The values provided in Table S1 were used as the mean parameter and the standard deviation of the normal distributions. Then, 100 β_d and β_{nd} values were calculated for each point in the atmospheric column and from these the mean values and the standard deviations (errors) of β_d and β_{nd} were estimated. For equations (2) and (3) the uncertainties were calculated analytically using the error propagation law[1].

S3. Measurements of the Dust lidar Ratio

One of the important input parameters of the POLIPHON algorithm is the S_d value, which for the analysis described here was measured by the LIDAR. Actual measurements of S_d were only possible during night-time when the Raman channels were operating. We assumed constant S_d values for all the events analyzed here. This was supported by the backtrajectory analysis showing that the air masses arriving at Cyprus on 15-04-2016 at01:00 UTC and 07:00 UTC had the same origin (North Sahara) and the same aerosol composition (dust; as depicted by the LIDAR).

The vertical profiles (recorded between 00:00-01:40 UTC on 15 April and retrieved by the

Raman method) of α (at 355 nm, 532 nm), β (at 355 nm, 532 nm, 1064 nm), S (at 355 nm, 532 nm), extinction and backscatter related Å ($Å^{\beta}_{355/532}$, which was calculated from α and β at 355 nm and 532 nm) and δ^p (at 355 and 532 nm) are plotted in Figure S2. The particle depolarization ratio at 532 nm between 3-6 km, ranged from 27 to 31%, which are typical values for pure Saharan dust[2–4]. From 2 to 3 km altitude, δ^p was ranged between 0.1 and 0.3 as a result of the entrainment of anthropogenic particles into the dust layer. This vertical distribution of the aerosol particles is also confirmed form the $Å^{\beta}_{355/532}$ which decreases gradually up to 3 km, reflecting that the coarse particles started to dominate over the fine particles with increasing height.

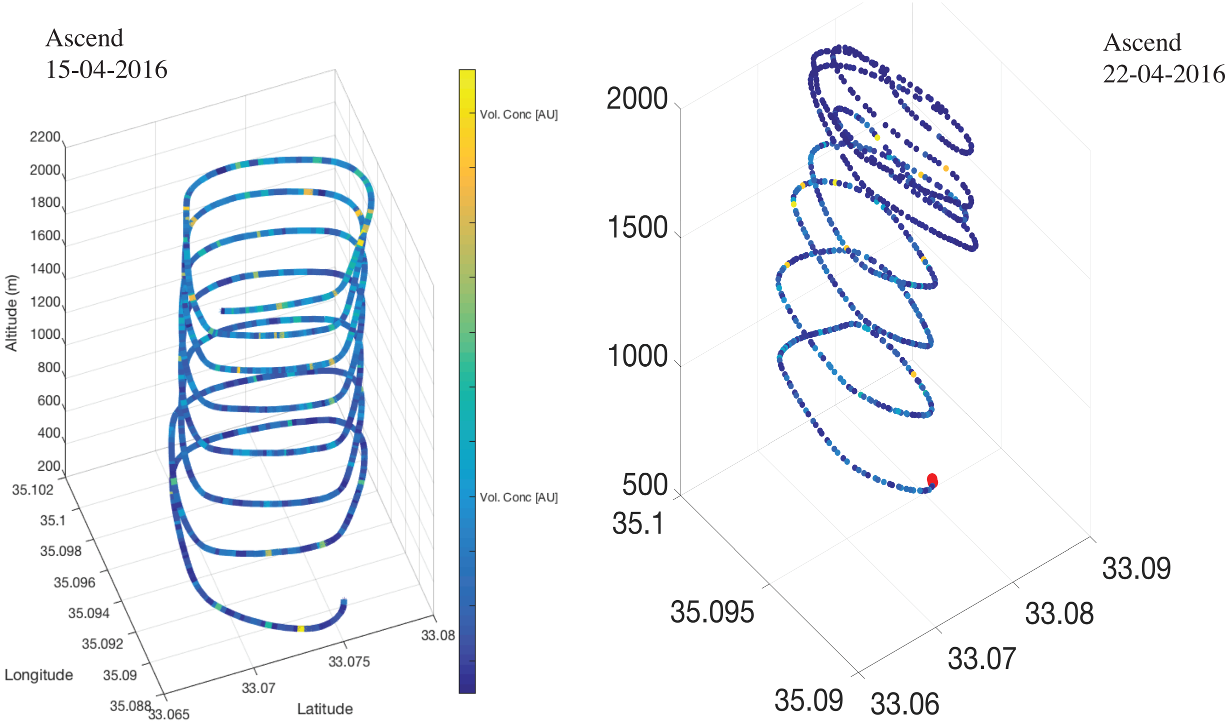

Figure S1: UAV flight patterns.

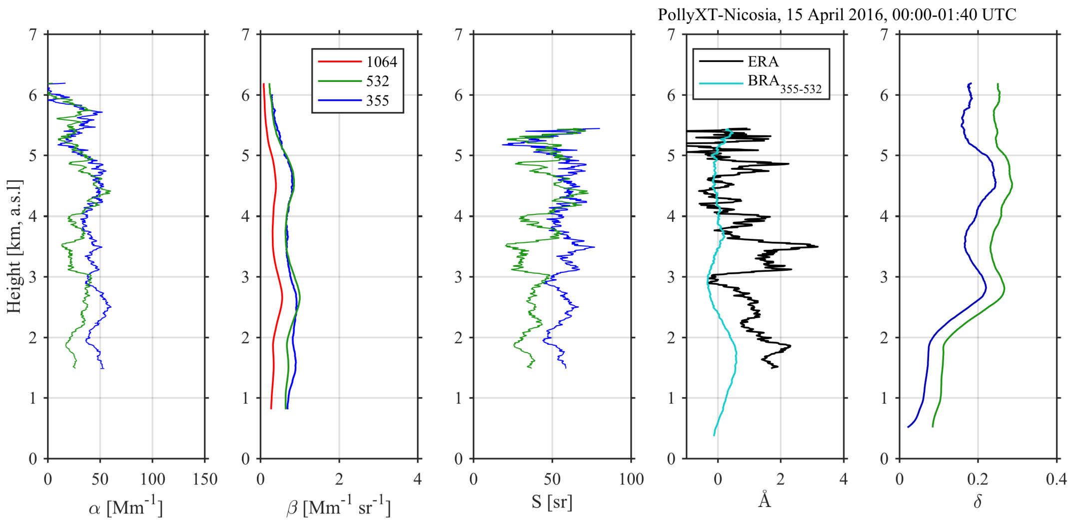

Figure S2: Night-time vertical profiles of extinction coefficient (355 nm; 532 nm), backscatter coefficient (355 nm; 532 nm; 1064 nm), LIDAR ratio (355 nm; 532 nm), Ångström exponent (extinction and backscatter related (355 nm; 532 nm)) and particle depolarization ratio (355 nm; 532 nm).

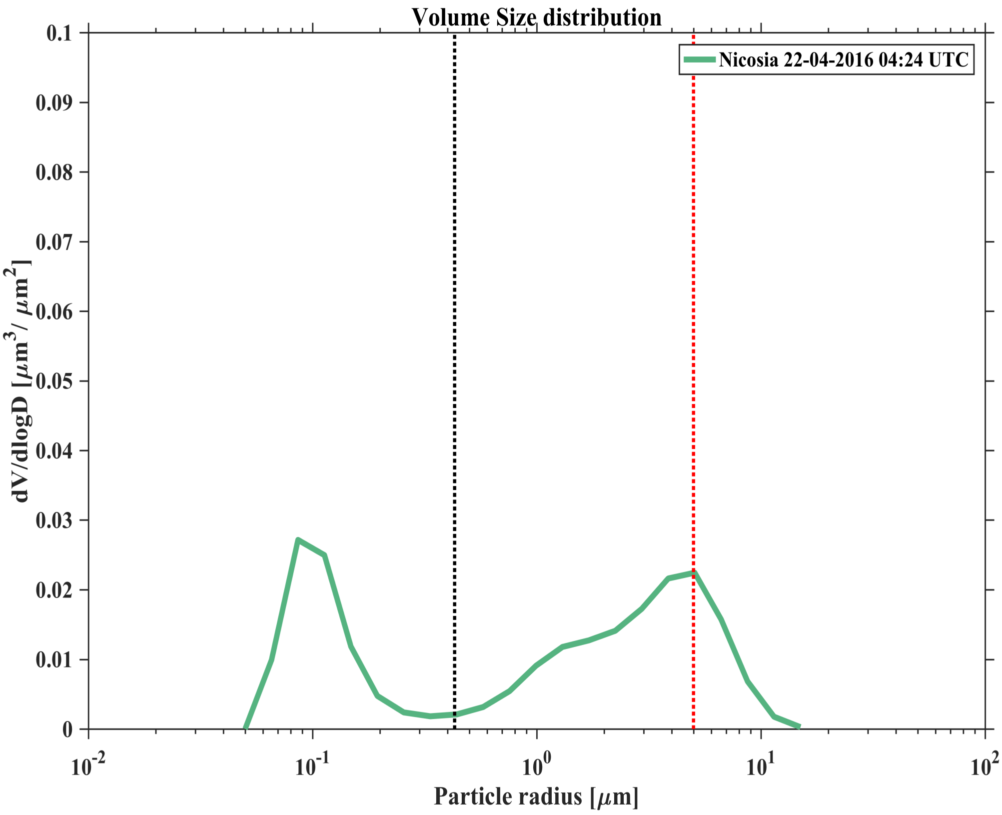

Figure S3: Column-integrated volume size distribution measured with the sunphotometer over Nicosia at 04:24 UTC on 22 April 2016. The black and red vertical lines indicate the inflection point and the upper limit of particle size measured by the OPC_a, respectively.

References

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