A climatology of global aerosol mixtures to support Sentinel-5P & EarthCARE mission applications

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1 Rationale

In support of atmospheric composition studies that are planned for Sentinel-5P and EarthCARE **we present a newly-derived global climatology of aerosol mixtures**.

Since constraining aerosol type with satellite remote sensing continues to be a challenge, the global climatology presented here can help **to inform the choice of components and mixtures in aerosol retrieval algorithms used by instruments such as TROPOMI & ATLID** and to test retrieval results.

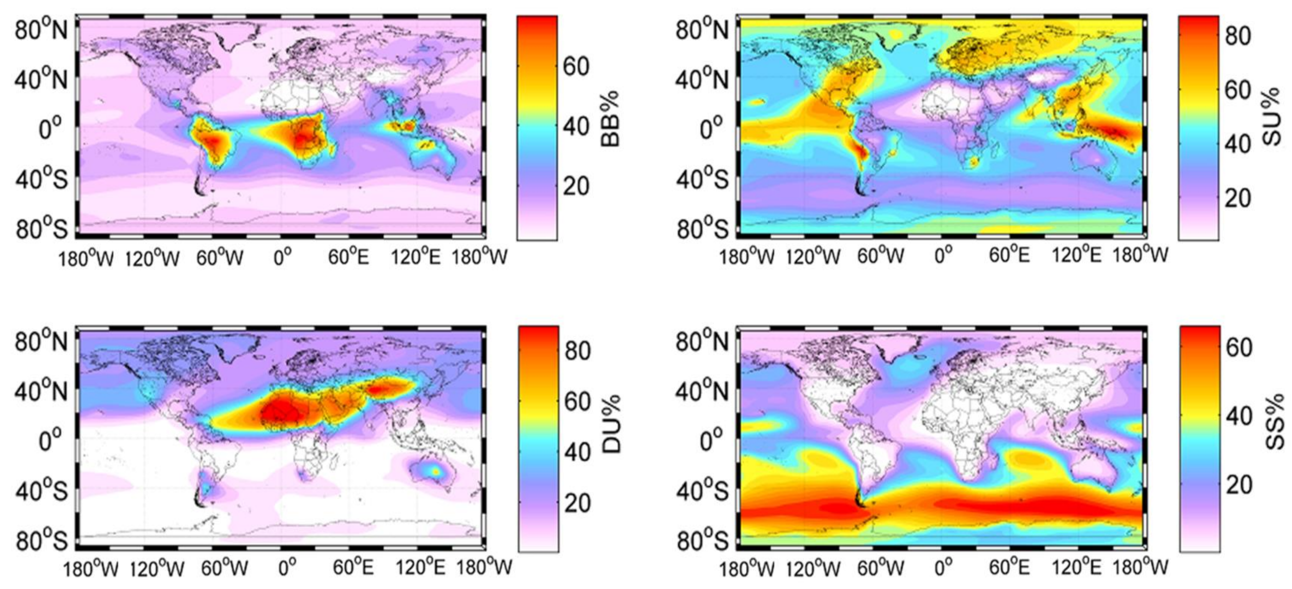

Fig. 1. The 2000-2006 mean percentage contribution of BB, SU, DU and SS to the total AOD (500nm) output from the GOCART model .

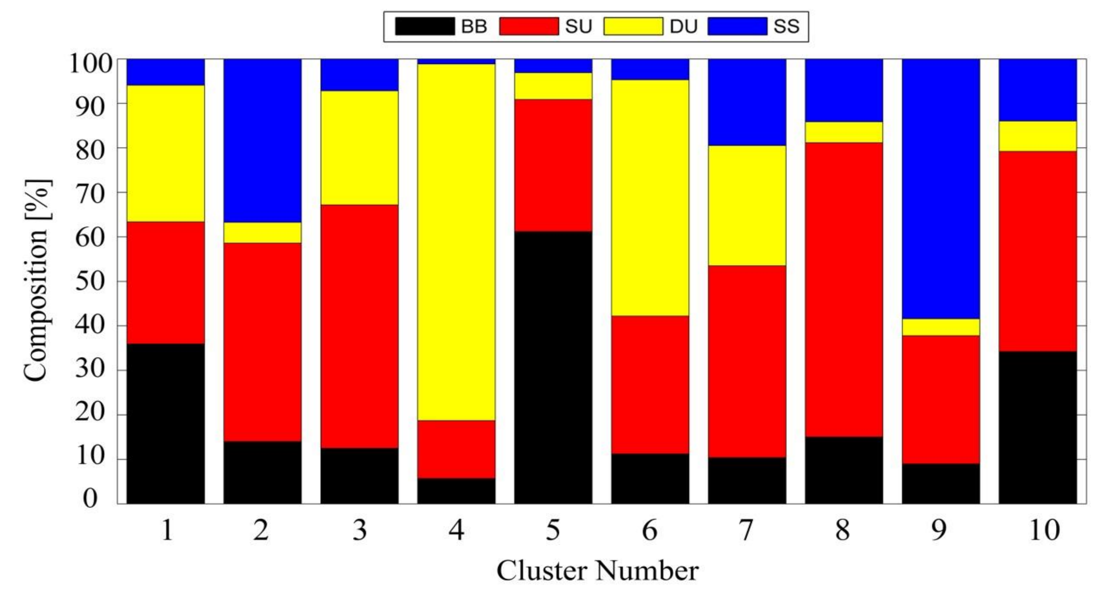

Fig. 2. A bar chart of the composition of each of 10 clusters resulting from clustering of the 4-species GOCART data in Fig. 1.

2 Methodology

The global climatology was obtained by clustering with a k-means algorithm, 7 years of 3-hourly, gridded 2.5 x 2 degree aerosol optical depth (AOD) data for sulfate (SU), biomass burning (BB), mineral dust (DU) and marine sea salt (SS) aerosol output from the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model [**Chin et al., 2000**] whose global means are shown in **Fig. 1**. A stopping condition (cluster centres do not change by more than 10%) led to **identification of ≈10 clusters for 2 cases: i) the global multiyear mean** (**Fig. 3**) **and ii) global seasonal means** (not shown here). Analysis of the percentage contribution of each of the four different aerosol types in each mixtures (**Fig. 2**) together with assignment to primary colours then allowed for true colour-mixing and the generation of easy-to-interpret maps and a straightforward naming convention and taxonomy (see **Fig. 3**).

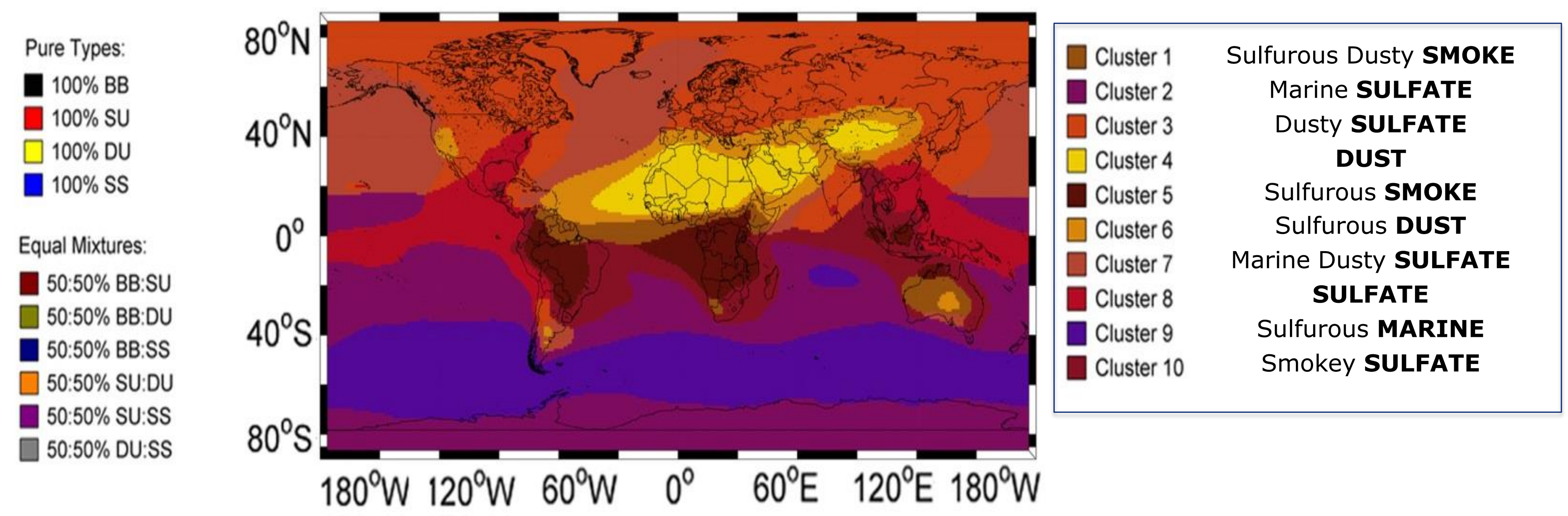

Fig. 3. The spatial distribution of aerosol mixtures resulting from clustering of the global mean GOCART data. Colours are produced by mixing black, red, yellow and blue in direct proportion to the percentage contribution of each 'pure' aerosol type (BB, SU, DU and SS) in each cluster.

3 Results

To further help characterize the mixtures, **aerosol robotic network (AERONET) Level 2.0 Version 2 inversion products were extracted from sites within each cluster**. This is shown for dust and biomass-burning dominated clusters in **Fig. 4**. The AERONET data were used to estimate the mean climatological values in each cluster of key optical parameters: the asymmetry factor (ASYM), the absorption AOD, the single scattering albedo (SSA) and the lidar ratio (LR) estimated from the SSA and the phase function at 180° [**Boyouk et al., 2010**] and microphysical parameters: the fine fraction (η), the %Sphericity of particles and the volume (V) size distribution (dV/dlnr) as a function of particle radius (r) as shown in **Fig. 5**. In the context of the observational constraints and uncertainties associated with AERONET retrievals [**Dubovik et al., 2000**], bivariate analysis of different parameter pairs suggests that mixtures dominated by DU and SS in particular can be detected with reference to their fine mode fraction (η) and % Sphericity as shown in **Fig. 6**.

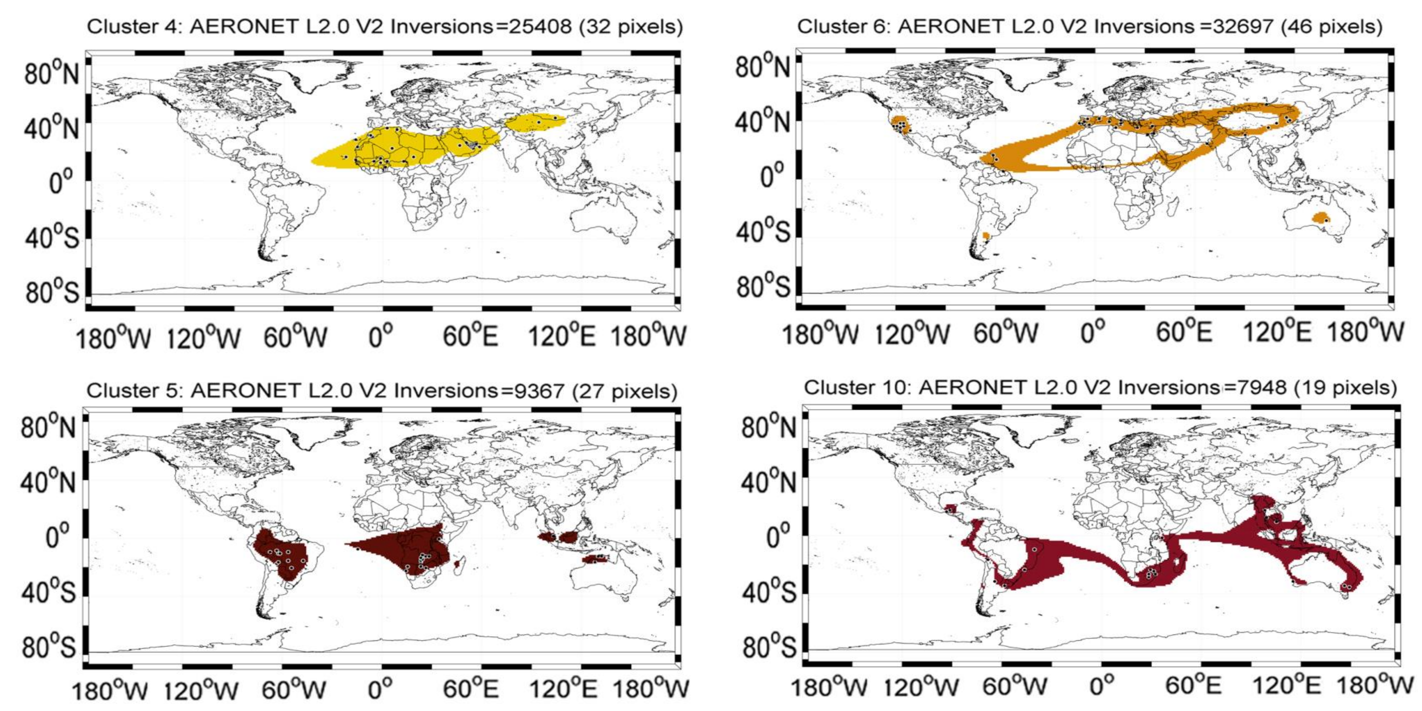

Fig. 4. The spatial distribution of aerosol mixtures associated with the dust–dominated clusters (4 and 6) and smoke-dominated clusters (5 and 10) together with the location of AERONET sites contributing inversion products.

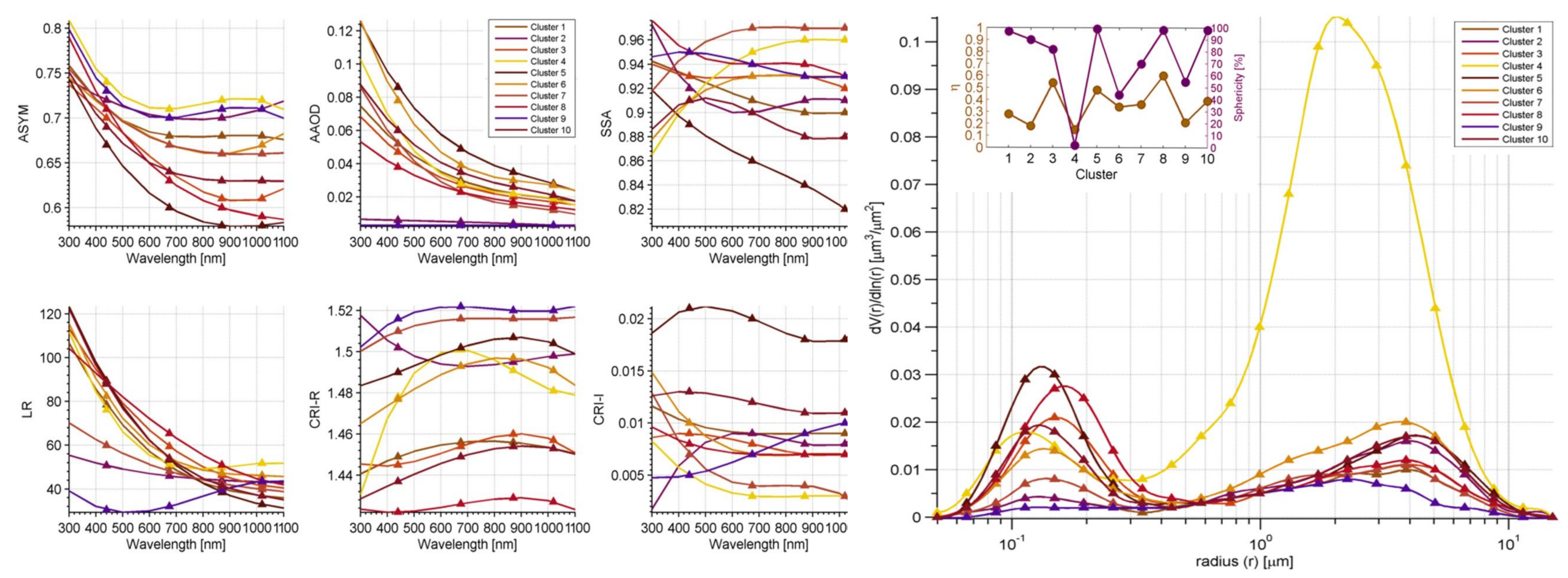

Fig. 5. ***(left)*** Spectral behaviour of the global mean values of key optical parameters and microphysical parameters for each cluster from extracted AERONET inversions at 440, 675, 870 and 1020nm ***(right)*** the size distribution, fine fraction and % Sphericity for each cluster.

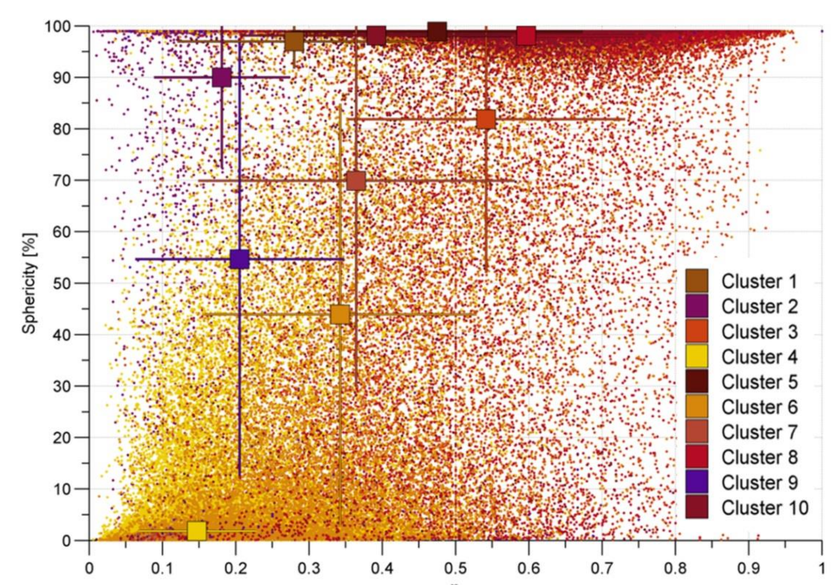

Fig. 6. The location of cluster centers overlaid on AERONET inversion products for {% Sphericity, η}. Error bars extend out to 1 standard deviation on both parameters and all wavelengths are given in nm.

4 Interpretation

The gridded global multiyear mean and seasonal partitions of AOD and compositional aerosol mixtures comprise a climatology that can be refined by high temporal and spectral resolution, cloud-free observations produced by Sentinel-5P and EarthCARE instruments. This preliminary reference framework (available at http://apcg.meteo.noa.gr/AEROMAP) can:

i) **enable tests of the effect on look-up table derived retrievals of initializing retrieval algorithms used by OMI/TROPOMI or CALIOP/ATLID with aerosol type mixtures**

ii) **help fine-tune aerosol type selection methods used in existing algorithms by referring to mean and seasonal optical and microphysical properties of mixtures**

iii) **allow comparison of retrieved aerosol types with those expected from the climatology**

iv) **contribute to the assessment of region and season-specific aerosol type assumptions.**

References

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This research was partly funded by the project "THESPIA" (Foundation of synergistic and integrated methodologies and tools for monitoring, managing and forecasting environmental parameters and stresses) under the call "Development proposals of Research Agencies-KRIPIS" of the Operational program "Competitiveness and Entrepreneurship".

regions at the centre of development

Co - financed by the Hellenic Republic and the European Union - European Regional Development Fund, in the context of the O.P. Competitiveness and Entrepreneurship (OPC II) and the R.O.P. Attica, R.O.P. Macedonia - Thrace

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