

Supplement of

Global aerosol mixtures and their multiyear and seasonal characteristics

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In order to facilitate the uptake of the findings of this work, spreadsheets (EXCEL) of gridded (1x1 degree) cluster values at the multiyear and seasonal timescales are made freely available at: <http://apcg.space.noa.gr/aeromap/>. In particular,

- Gridded (1x1 degree) cluster indices for multiyear mean global aerosol mixtures
- Gridded (1x1 degree) cluster indices for seasonal mean global aerosol mixtures: DJF, MAM, JJA and SON.
- A table of descriptive statistics (mean, standard deviation, median and inter-quartile range) of the 5-component (BC, OC, SU, DU and SS) percentage composition for each cluster of the multiyear mean global partition.
- Tables of descriptive statistics (mean, standard deviation, median and inter-quartile range) of the 5-component (BC, OC, SU, DU and SS) percentage composition for each cluster of seasonal mean global partitions: DJF, MAM, JJA and SON.
- A table of 50 optical and microphysical aerosol parameters extracted from the AERONET inversion data record for each cluster of the mean multiyear global partition including: spectral parameters (AOD, ASYM, AAOD, SSA, CRI-R, CRI-I, LR), the mean percentage of spherical particles ('%Sphericity'), the mean AVSD (in 22 logarithmic radial bins from 0.05 μm to 15 μm), AVSD-derived microphysical parameters (r_f , σ_f , V_f , r_c , σ_c , V_c associated with the fine and coarse modes 'f' and 'c' respectively), and the fine mode fraction η .
- Tables of 50 optical and microphysical aerosol parameters extracted from the AERONET inversion data record for each cluster of the mean seasonal (DJF, MAM, JJA and SON) global partitions including: spectral parameters (AOD, ASYM, AAOD, SSA, CRI-R, CRI-I, LR), the mean percentage of spherical particles ('%Sphericity'), the mean AVSD (in 22 logarithmic radial bins from 0.05 μm to 15 μm), AVSD-derived microphysical parameters (r_f , σ_f , V_f , r_c , σ_c , V_c associated with the fine and coarse modes 'f' and 'c' respectively), and the fine mode fraction η .

S1. The 2000-2006 mean global AOD (500nm) as a proxy

In this section we present the results of comparing the mean total global AOD (500nm) with annual means for the study period (2000-2006 inclusive).

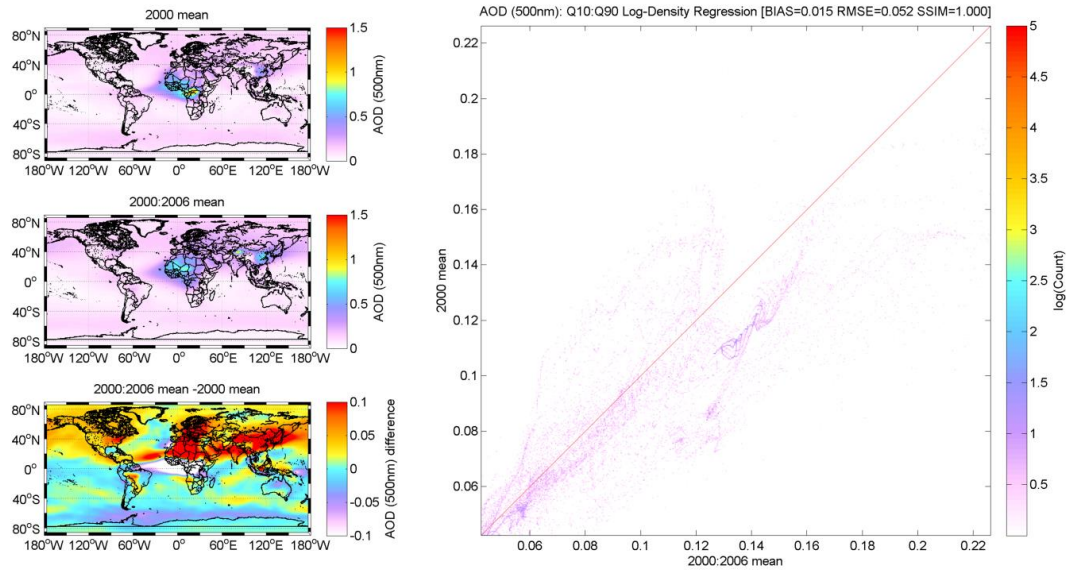


Fig. S1. *left panels:* Maps of the mean total global AOD (500nm) for the year 2000 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2000 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

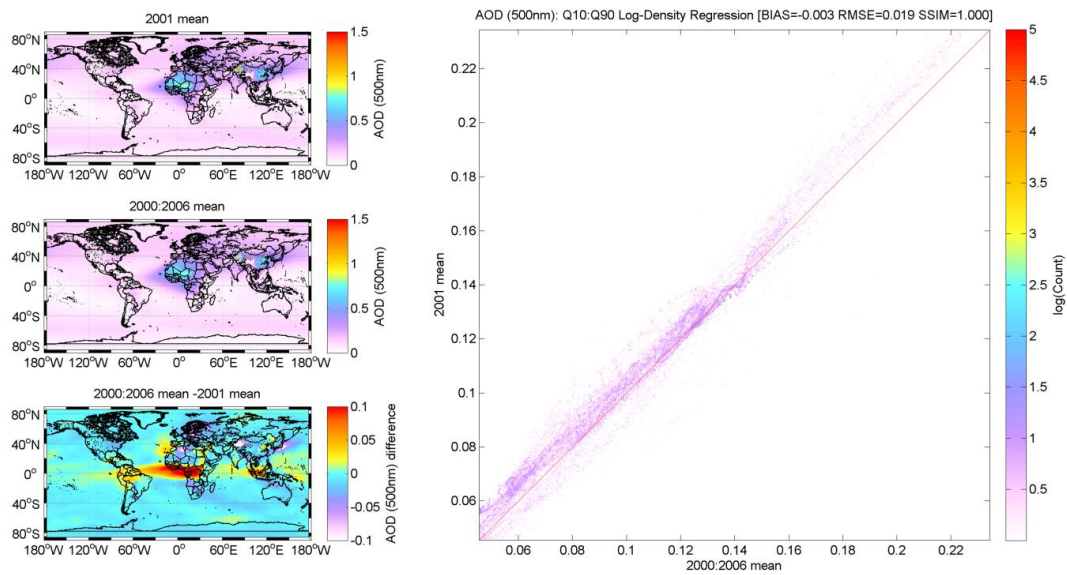


Fig. S2. *left panels:* Maps of the mean total global AOD (500nm) for the year 2001 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2001 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error

and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

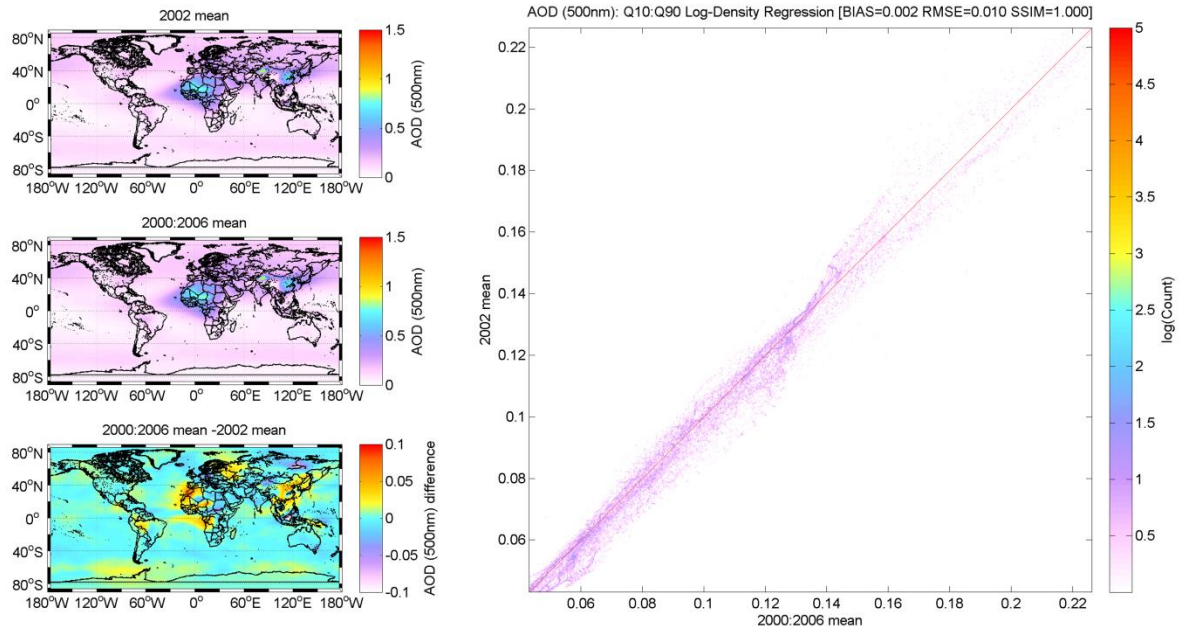


Fig. S3. *left panels:* Maps of the mean total global AOD (500nm) for the year 2002 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2002 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

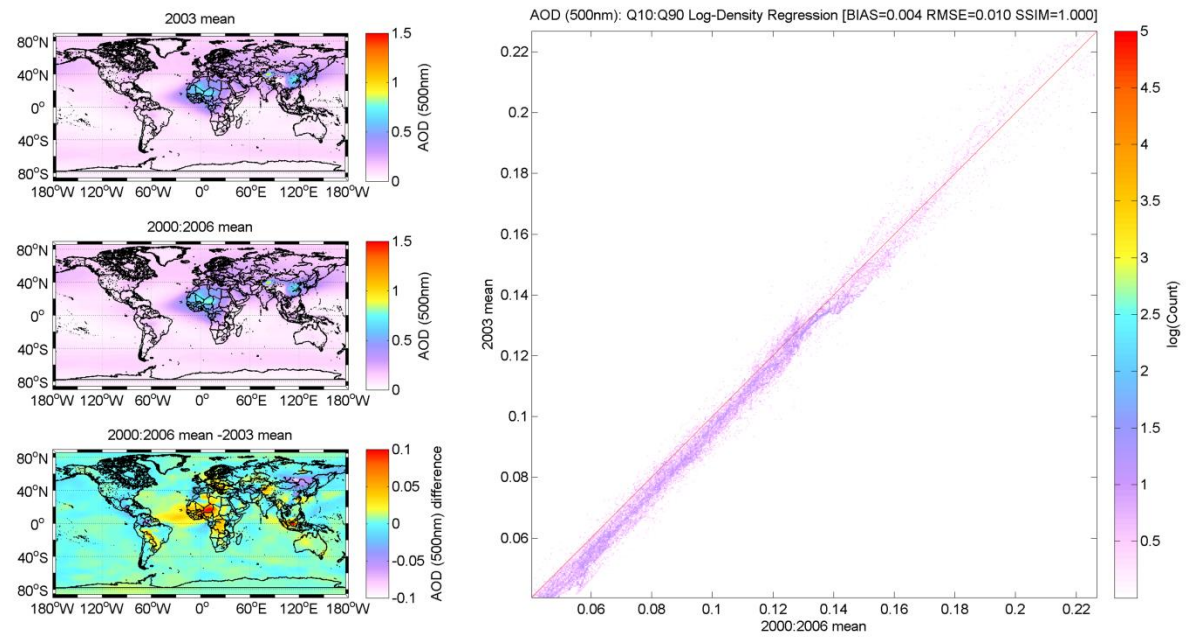


Fig. S4. *left panels:* Maps of the mean total global AOD (500nm) for the year 2003 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2003 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error

and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

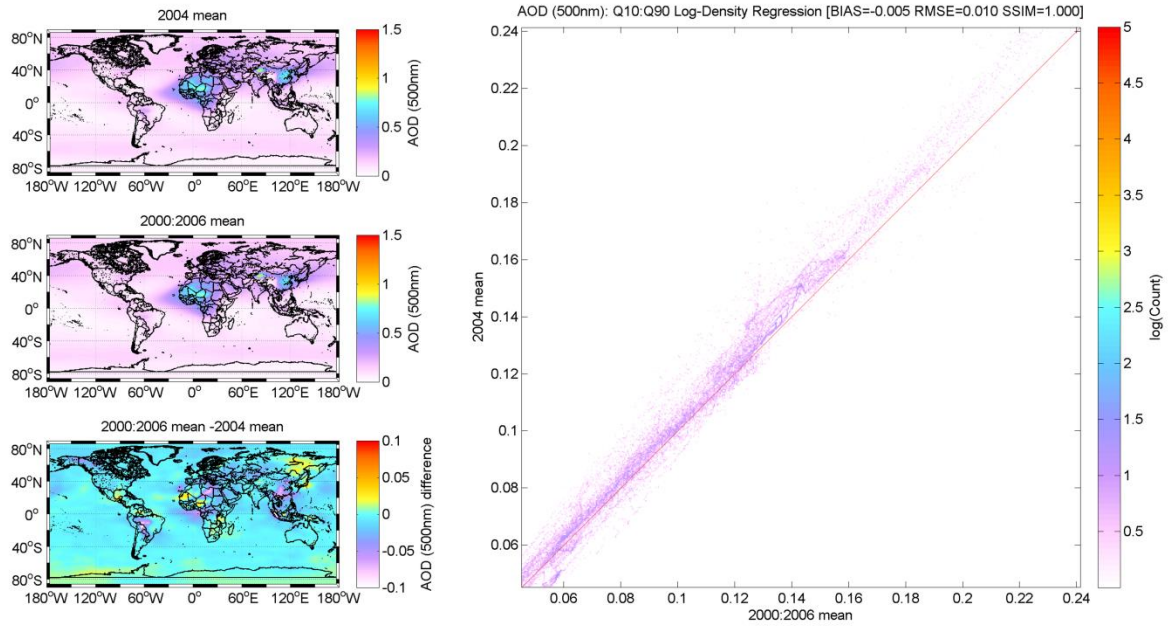


Fig. S5. *left panels:* Maps of the mean total global AOD (500nm) for the year 2004 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2004 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

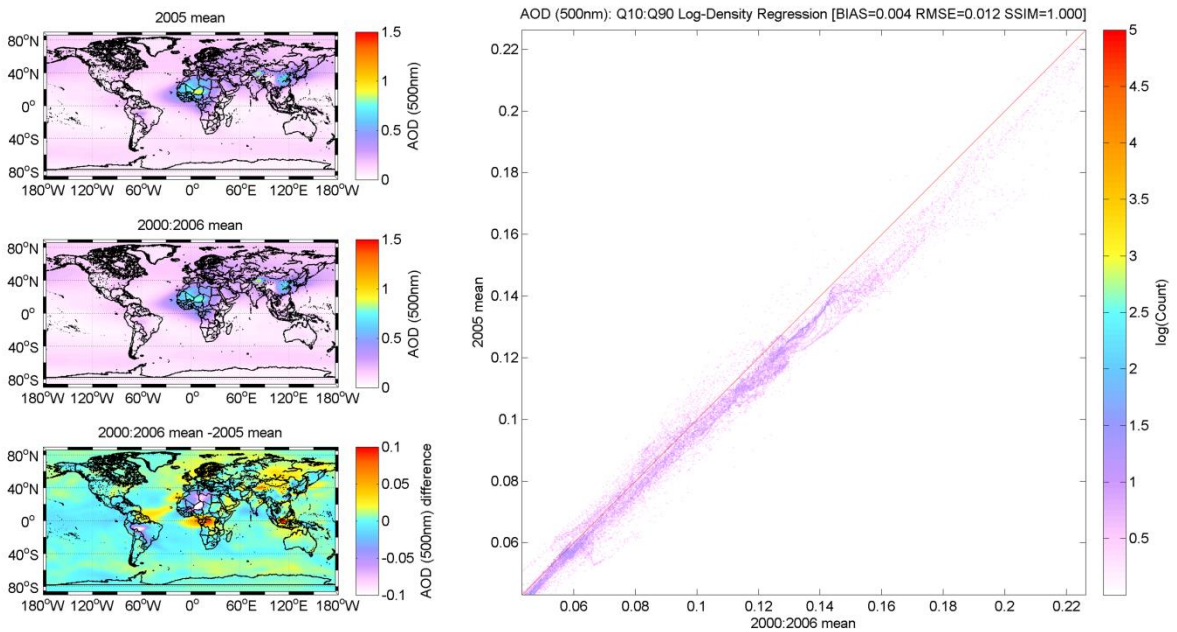


Fig. S6. *left panels:* Maps of the mean total global AOD (500nm) for the year 2005 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2005 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error

and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

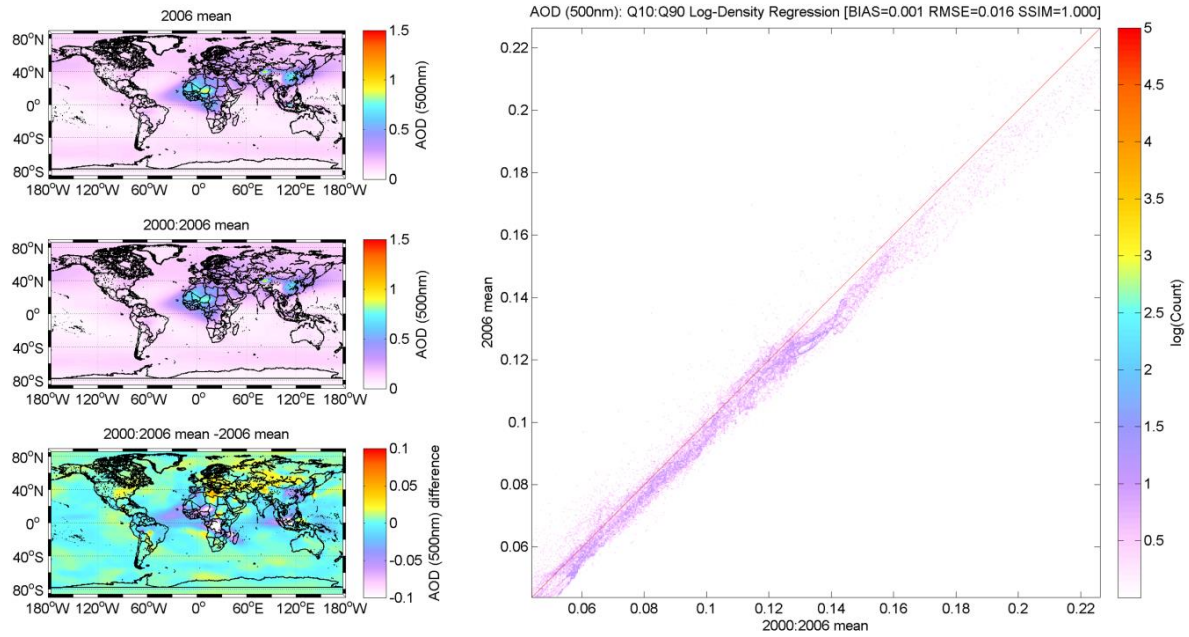


Fig. S7. *left panels:* Maps of the mean total global AOD (500nm) for the year 2006 (top), 2000-2006 inclusive (centre) and the difference (bottom). *right panel:* a log-density plot of the year 2006 mean total AOD (500nm) against the 2000-2006 (inclusive) mean. ‘RMSE’ is the root mean squared error and ‘SSIM’ is the value of the mean structural similarity index over all 64800 gridded (1x1 degree) pixels.

S2. Cluster analysis of the multiyear mean

In this section we present the descriptive statistics of the clusters obtained by applying the cluster analysis technique described in Section 3.1 to the multiyear GOCART data, as well as bar charts of the composition and the resulting taxonomy.

Table S1. Descriptive statistics of the global mean mixtures extracted from the multiyear GOCART data record by application of cluster analysis.

GOCART V4 Pixels	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
AOD (500)	0.17	0.06	0.16	0.40	0.19	0.20	0.14	0.10	0.10	0.09
%BB (Mean)	35.9	14.0	12.5	5.7	61.2	11.2	10.4	15.0	9.0	34.2
%SU (Mean)	27.4	44.6	54.7	13.0	29.7	31.0	43.1	66.1	28.8	45.0
%DU (Mean)	30.7	4.7	25.6	80.2	6.0	53.1	27.0	4.7	3.8	6.8
%SS (Mean)	5.9	36.7	7.2	1.1	3.1	4.7	19.5	14.1	58.4	14.0
%BC (Mean)	5.9	3.0	3.4	1.7	9.3	3.2	3.2	3.4	1.7	6.7
%OC (Mean)	30.1	11.0	9.1	4.0	51.8	8.0	7.2	11.6	7.3	27.5
%BB (St.D.)	7.4	4.1	3.1	3.7	8.5	5.5	2.7	5.2	2.4	6.5
%SU (St.D.)	5.7	6.3	4.9	5.5	6.6	7.9	4.0	7.1	4.1	6.6
%DU (St.D.)	8.2	2.2	4.6	8.1	5.2	7.8	5.6	4.3	1.4	4.7
%SS (St.D.)	3.3	5.4	3.2	1.9	3.2	4.5	4.8	8.5	6.4	7.8
%BC (St.D.)	1.2	1.0	0.9	0.8	1.8	1.2	0.7	1.3	0.6	1.2
%OC (St.D.)	6.8	3.2	2.5	3.1	7.4	4.8	2.1	4.3	1.9	5.8
%BB (Median)	35.8	12.4	11.5	4.9	60.6	9.3	9.6	14.4	8.2	33.3
%SU (Median)	27.2	44.6	54.8	13.2	28.8	31.1	42.6	64.5	28.4	44.3
%DU (Median)	29.8	4.3	25.4	79.6	3.8	53.5	27.5	3.0	3.5	5.3
%SS (Median)	5.7	36.8	7.5	0.4	2.0	2.2	19.0	13.2	58.9	12.7
%BC (Median)	5.8	2.6	3.2	1.6	9.4	2.8	3.0	3.0	1.5	6.6
%OC (Median)	29.9	9.8	8.3	3.2	51.6	6.4	6.6	11.1	6.7	26.5
%BB (IQR)	10.7	5.2	2.9	3.4	14.5	6.9	2.5	7.3	3.0	10.2
%SU (IQR)	7.6	10.9	6.6	9.0	9.6	11.7	6.0	7.9	6.6	8.6
%DU (IQR)	12.2	1.3	6.3	13.7	6.5	13.2	9.9	5.3	1.5	7.0
%SS (IQR)	4.7	9.1	3.4	0.6	3.0	8.4	6.9	15.6	11.2	13.5
%BC (IQR)	1.7	1.4	0.8	1.2	2.6	1.5	0.9	1.6	0.6	1.5
%OC (IQR)	9.9	3.8	2.3	2.4	12.6	4.9	1.7	5.9	2.4	9.0

Fig. S8 below shows stacked bar charts of mean aerosol mixtures obtained at the seasonal timescale:

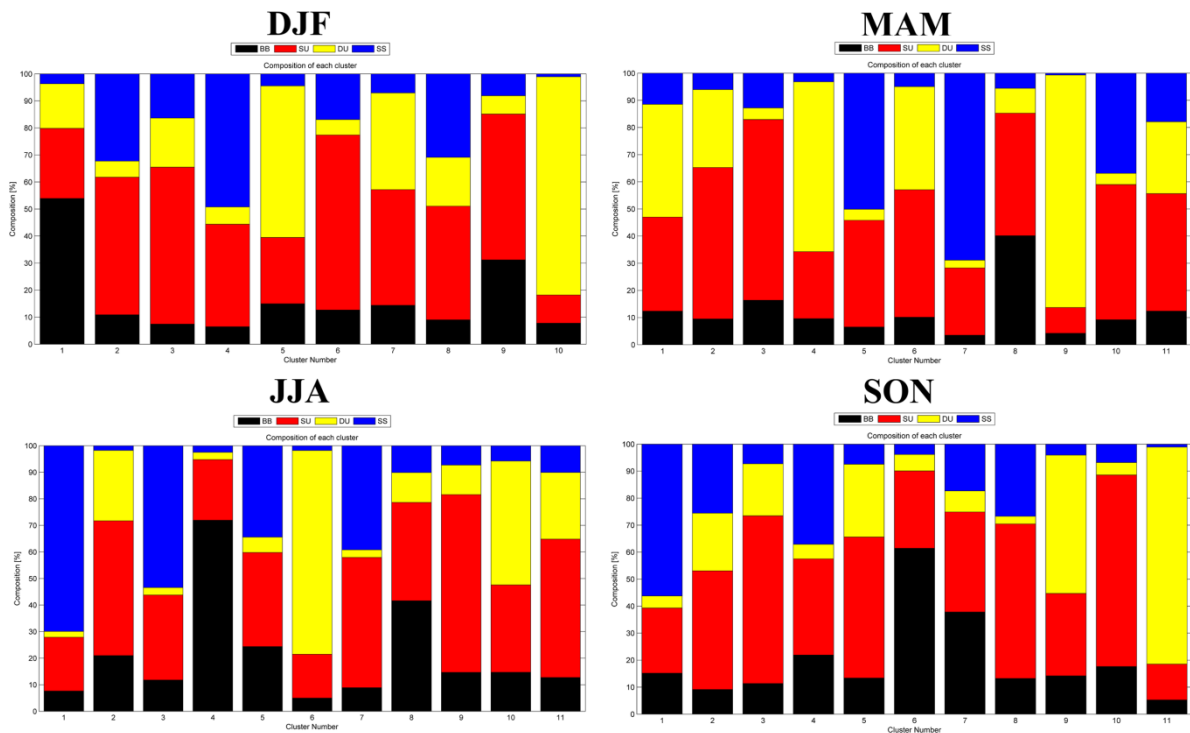


Fig. S8. Colour-coded stacked bar charts displaying the aerosol composition of each cluster for the global mean GOCART data at the seasonal timescale as represented by the monthly triplets: DJF, MAM, JJA and SON.

Applying the naming convention logic described in Section 3.2 to these 4 partitions leads to the following taxonomy:

Table. S2. Taxonomy of aerosol mixtures for the seasonal global mean partitions. The ‘object’ is highlighted in bold capital font and is the dominant aerosol type. The ‘adjectives’ preceding it are in increasing order of percentage contribution. For cases where more than one aerosol type is dominant (to within 1 standard deviation) then these are highlighted as multiple ‘objects’.

	DJF	MAM	JJA	SON
Cluster 1	Dusty Sulfurous SMOKE	SULFUROUS DUST	MARINE	Sulfurous MARINE
Cluster 2	Marine SULFATE	Dusty SULFATE	Smokey Dusty SULFATE	Dusty Marine SULFATE
Cluster 3	Dusty SULFATE	SULFATE	Sulfurous MARINE	Dusty SULFATE
Cluster 4	Sulfurous MARINE	Sulfurous DUST	Sulfurous SMOKE	Smokey SULFUROUS MARINE
Cluster 5	Sulfurous DUST	SULFUROUS MARINE	Smokey MARINE SULFATE	Dusty SULFATE
Cluster 6	SULFATE	DUSTY SULFATE	DUST	Sulfurous SMOKE
Cluster 7	DUSTY SULFATE	Sulfurous MARINE	Marine SULFATE	SULFUROUS SMOKE
Cluster 8	Dusty Marine SULFATE	Smokey SULFATE	SULFUROUS SMOKE	Marine SULFATE
Cluster 9	Smokey SULFATE	DUST	SULFATE	Sulfurous DUST
Cluster 10	DUST	Marine SULFATE	Sulfurous DUST	SULFATE
Cluster 11		Marine Dusty SULFATE	Dusty SULFATE	DUST

S3. Cluster analysis of the seasonal means

In this section we present the results of applying the cluster analysis technique described in Section 3.1 to the multiyear GOCART data extracted for each season (DJF, MAM, JJA and SON).

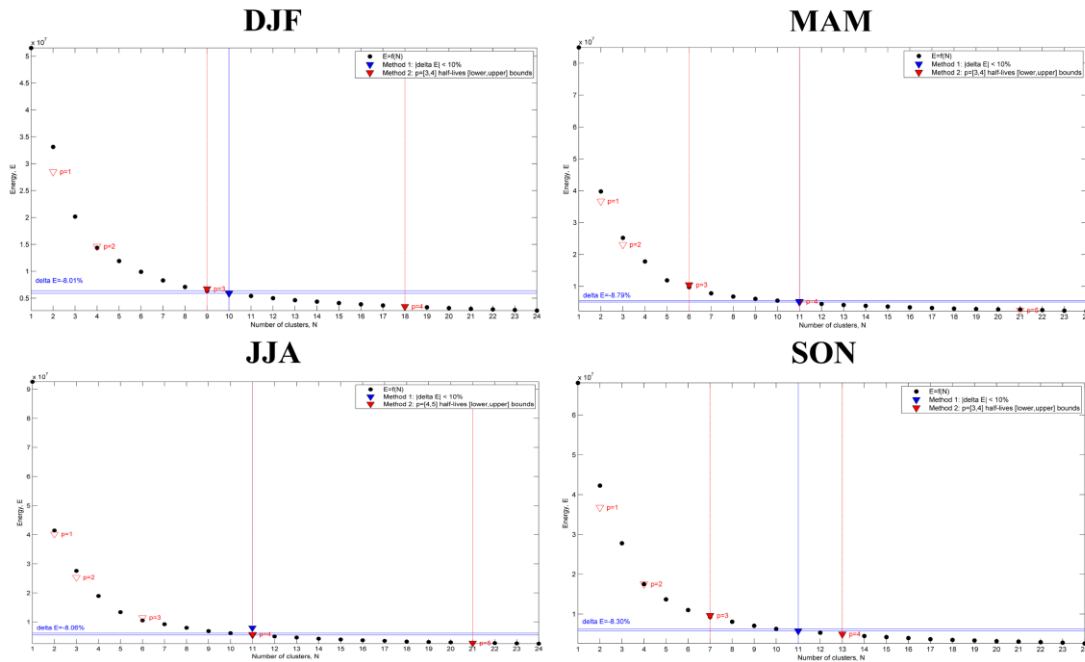


Fig. S9. Graphs of the norm of the Euclidean distance (‘Energy’, E) with the number (N) of clusters (1-24) for the mean percentage contribution of BB, SU, DU and SS to the total AOD (500nm) at the seasonal timescale as represented by the monthly triplets: DJF, MAM, JJA and SON.

Table S3. Descriptive statistics of the global mean mixtures extracted from the season (DJF) GOCART data record by application of cluster analysis.

GOCART V4	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10
Pixels	2128	10842	12092	11315	2016	12251	2970	5495	4043	1648
AOD (500)	0.32	0.07	0.12	0.12	0.22	0.06	0.14	0.11	0.11	0.35
%BB (Mean)	53.9	10.9	7.5	6.5	15.0	12.6	14.4	9.0	31.2	7.8
%SU (Mean)	25.9	50.9	58.0	37.9	24.5	64.7	42.8	42.0	53.9	10.5
%DU (Mean)	16.5	5.9	18.2	6.4	56.1	5.7	35.8	18.1	6.8	80.7
%SS (Mean)	3.7	32.3	16.3	49.2	4.5	16.9	7.1	30.9	8.1	1.1
%BC (Mean)	7.5	2.6	3.0	1.6	3.7	2.9	4.5	3.0	6.4	2.0
%OC (Mean)	46.4	8.3	4.5	4.9	11.2	9.8	9.9	6.0	24.8	5.8
%BB (St.D.)	10.1	3.5	2.1	1.9	9.9	3.2	7.9	3.3	6.4	4.9
%SU (St.D.)	9.1	4.5	3.9	3.7	8.3	5.6	7.5	4.0	7.1	5.9
%DU (St.D.)	10.1	2.7	3.3	3.8	7.7	2.9	6.9	4.0	5.0	7.1
%SS (St.D.)	3.4	4.8	4.7	5.3	5.0	5.5	5.6	5.5	5.6	1.5
%BC (St.D.)	2.3	0.8	0.8	0.7	1.8	1.0	2.1	0.8	1.8	1.0
%OC (St.D.)	8.5	2.9	1.4	1.5	8.7	2.6	6.6	2.8	6.2	4.1
%BB (Median)	51.6	10.7	6.5	5.8	11.9	12.7	12.7	8.0	30.0	6.0
%SU (Median)	25.9	50.7	58.3	37.6	25.5	63.5	42.8	41.8	54.6	9.4
%DU (Median)	14.1	5.7	17.6	4.9	56.4	6.7	35.2	18.3	5.1	81.0
%SS (Median)	2.9	32.0	17.9	48.9	2.0	17.1	5.5	30.5	7.7	0.6
%BC (Median)	7.4	2.6	2.7	1.4	3.1	2.8	4.3	2.8	6.1	1.7
%OC (Median)	45.1	8.0	3.9	4.6	7.9	9.7	7.0	5.1	23.5	4.4
%BB (IQR)	12.9	4.2	1.3	2.4	12.9	3.7	13.7	4.1	9.0	4.6
%SU (IQR)	13.1	6.8	5.0	5.6	10.8	3.9	11.2	5.9	9.7	11.0
%DU (IQR)	14.6	3.3	4.2	4.0	11.6	4.8	9.9	5.0	6.4	12.1
%SS (IQR)	4.8	7.8	5.4	8.3	5.7	6.4	5.9	8.8	9.4	0.8
%BC (IQR)	3.0	0.9	0.7	0.9	2.1	0.8	3.1	1.1	2.3	1.0
%OC (IQR)	10.9	3.3	0.7	2.0	11.2	3.0	11.0	3.3	7.5	3.8

Table S4. Descriptive statistics of the global mean mixtures extracted from the season (MAM) GOCART data record by application of cluster analysis.

GOCART V4	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Pixels	5251	8592	4296	2481	9099	7172	8513	3690	2488	9294	3924
AOD (500)	0.20	0.22	0.08	0.28	0.06	0.23	0.10	0.10	0.49	0.04	0.14
%BB (Mean)	12.3	9.5	16.4	9.6	6.5	10.1	3.5	40.1	4.2	9.2	12.4
%SU (Mean)	34.7	55.8	66.5	24.7	39.3	47.0	24.8	45.1	9.5	49.8	43.3
%DU (Mean)	41.5	28.7	4.3	62.5	4.1	38.0	2.8	9.1	85.6	4.1	26.4
%SS (Mean)	11.5	6.1	12.8	3.2	50.1	5.0	68.9	5.6	0.7	36.9	17.9
%BC (Mean)	3.2	2.7	3.5	2.6	1.7	2.9	0.9	6.9	1.3	2.3	3.5
%OC (Mean)	9.1	6.8	12.9	7.0	4.8	7.2	2.6	33.2	2.9	6.9	8.9
%BB (St.D.)	6.0	3.1	7.1	5.3	1.8	3.2	0.7	9.6	2.4	3.8	6.1
%SU (St.D.)	4.0	3.0	8.4	6.3	4.1	3.1	3.6	9.3	4.6	4.3	4.5
%DU (St.D.)	4.5	3.1	3.4	6.6	2.3	3.7	1.0	7.4	6.4	2.3	5.4
%SS (St.D.)	4.6	2.6	7.2	4.1	4.7	2.4	4.8	5.1	1.2	4.8	5.1
%BC (St.D.)	1.0	0.8	1.6	1.1	0.5	0.8	0.2	2.0	0.5	0.9	1.4
%OC (St.D.)	5.4	2.4	5.7	4.5	1.3	2.5	0.5	9.1	2.0	3.0	4.8
%BB (Median)	10.3	8.5	15.7	8.4	6.0	9.1	3.4	39.3	3.7	7.5	10.5
%SU (Median)	34.8	55.3	65.5	24.2	39.1	47.2	24.2	47.1	10.1	49.8	43.4
%DU (Median)	41.4	29.1	3.5	62.3	3.6	37.1	2.6	7.0	85.3	3.7	28.1
%SS (Median)	12.1	6.3	12.4	1.2	49.8	5.5	69.6	3.8	0.3	37.6	17.4
%BC (Median)	2.9	2.4	2.9	2.2	1.6	2.6	0.8	7.0	1.2	2.0	3.0
%OC (Median)	7.1	6.1	12.7	5.9	4.4	6.4	2.5	31.9	2.4	5.5	7.4
%BB (IQR)	4.5	1.2	11.2	6.2	1.5	2.1	1.0	13.4	2.7	3.4	9.5
%SU (IQR)	4.2	3.9	8.3	9.4	6.9	4.9	6.0	13.8	7.3	5.3	5.3
%DU (IQR)	6.0	3.5	4.2	11.2	1.5	4.6	1.0	10.2	10.8	1.4	5.7
%SS (IQR)	5.2	2.2	13.0	3.2	7.5	3.1	8.4	6.1	0.3	5.8	6.9
%BC (IQR)	1.2	0.3	2.1	1.6	0.5	0.5	0.3	2.9	0.8	0.8	1.9
%OC (IQR)	3.0	1.1	9.1	4.7	1.1	1.6	0.8	12.9	1.9	2.7	7.3

Table S5. Descriptive statistics of the global mean mixtures extracted from the season (JJA) GOCART data record by application of cluster analysis.

GOCART V4	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Pixels	8887	12154	10096	1894	3194	3010	6280	2784	6014	3063	7424
AOD (500)	0.10	0.14	0.06	0.23	0.07	0.43	0.05	0.11	0.18	0.19	0.15
%BB (Mean)	7.6	21.0	11.8	72.0	24.4	5.0	8.9	41.6	14.7	14.7	12.7
%SU (Mean)	20.3	50.7	32.0	22.8	35.4	16.5	49.0	37.0	67.0	32.9	52.1
%DU (Mean)	2.2	26.5	2.8	2.7	5.8	76.7	2.8	11.2	11.1	46.6	25.1
%SS (Mean)	69.9	1.8	53.4	2.5	34.4	1.8	39.2	10.1	7.3	5.8	10.1
%BC (Mean)	1.4	4.3	2.7	11.4	4.9	1.7	2.1	7.3	3.6	3.6	3.8
%OC (Mean)	6.2	16.7	9.1	60.6	19.4	3.3	6.8	34.3	11.0	11.1	9.0
%BB (St.D.)	1.8	4.0	3.8	9.5	5.3	2.6	2.0	8.0	4.9	7.0	2.2
%SU (St.D.)	3.1	4.5	4.8	6.8	4.6	5.7	4.7	7.5	6.0	6.0	4.7
%DU (St.D.)	0.5	3.4	1.2	2.4	4.3	8.7	2.3	8.8	6.4	8.5	4.8
%SS (St.D.)	4.4	1.5	4.5	3.1	6.3	2.6	6.0	6.5	6.9	5.8	4.4
%BC (St.D.)	0.3	0.7	1.1	2.6	1.0	0.9	0.7	1.6	1.2	1.2	0.6
%OC (St.D.)	1.6	3.6	2.9	8.0	4.6	2.0	1.5	7.3	4.3	6.3	2.2
%BB (Median)	7.2	19.8	10.9	71.3	24.2	4.5	8.2	41.0	14.0	12.6	12.2
%SU (Median)	19.8	51.4	31.3	23.5	34.6	16.7	48.7	36.2	66.0	32.3	52.0
%DU (Median)	2.0	26.6	2.5	1.9	3.7	76.2	2.2	8.3	12.5	45.6	24.5
%SS (Median)	70.3	1.5	53.1	1.4	35.5	0.3	40.7	9.5	5.0	5.3	9.4
%BC (Median)	1.4	4.0	2.6	11.3	5.0	1.5	1.8	7.1	3.5	3.4	3.6
%OC (Median)	5.9	15.8	8.2	60.6	19.2	2.9	6.4	33.9	10.6	9.0	8.5
%BB (IQR)	1.9	4.2	6.0	16.3	6.5	3.1	1.4	12.9	5.8	9.6	2.3
%SU (IQR)	4.7	5.3	7.4	10.1	6.0	8.2	4.4	10.4	7.9	9.0	6.0
%DU (IQR)	0.7	3.5	1.0	2.1	4.4	13.8	0.6	14.5	12.3	14.2	7.2
%SS (IQR)	7.3	1.0	7.4	2.3	9.7	3.0	5.7	10.7	9.8	7.2	5.5
%BC (IQR)	0.4	0.7	1.9	4.0	1.3	1.2	0.7	2.3	1.2	1.5	0.8
%OC (IQR)	1.6	3.6	4.2	13.7	5.7	1.9	0.9	11.6	5.3	8.4	2.7

Table S6. Descriptive statistics of the global mean mixtures extracted from the season (SON) GOCART data record by application of cluster analysis.

GOCART V4	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Pixels	8532	6154	8472	15186	6949	2947	4785	3349	2384	3665	2377
AOD (500)	0.12	0.11	0.14	0.07	0.12	0.16	0.10	0.06	0.17	0.14	0.36
%BB (Mean)	15.2	9.1	11.4	21.9	13.4	61.4	37.8	13.2	14.2	17.6	5.2
%SU (Mean)	24.2	43.9	62.1	35.6	52.2	28.7	37.0	57.2	30.5	71.0	13.3
%DU (Mean)	4.4	21.4	19.2	5.4	26.9	6.1	7.8	2.8	51.2	4.6	80.3
%SS (Mean)	56.2	25.6	7.3	37.1	7.5	3.8	17.3	26.7	4.1	6.8	1.1
%BC (Mean)	2.4	3.4	3.5	4.0	4.1	10.0	7.2	3.3	3.8	4.4	1.7
%OC (Mean)	12.7	5.8	7.9	17.9	9.2	51.4	30.6	9.9	10.4	13.2	3.6
%BB (St.D.)	2.3	1.8	2.3	3.9	3.7	9.2	6.0	4.2	9.7	6.8	3.7
%SU (St.D.)	3.0	4.5	3.8	4.3	4.2	6.3	6.7	5.5	7.9	7.1	6.3
%DU (St.D.)	1.3	4.9	3.1	2.0	4.5	7.1	7.0	3.6	8.9	3.6	8.9
%SS (St.D.)	5.6	5.1	3.8	4.5	4.0	3.6	7.8	5.6	4.4	4.6	1.9
%BC (St.D.)	0.4	0.7	0.8	1.1	1.2	2.1	1.3	0.9	1.6	1.8	0.9
%OC (St.D.)	1.9	1.5	1.9	3.0	2.8	8.0	5.2	3.7	8.6	5.7	3.1
%BB (Median)	15.0	8.8	11.4	20.7	12.5	60.0	37.2	12.8	9.6	15.7	4.6
%SU (Median)	24.0	43.4	61.1	35.3	52.8	28.0	36.5	57.7	30.5	70.9	13.3
%DU (Median)	4.1	22.3	19.6	5.3	25.9	2.8	4.9	0.9	51.4	4.5	79.2
%SS (Median)	56.3	24.6	7.1	37.1	7.0	2.6	19.1	26.4	1.8	6.1	0.3
%BC (Median)	2.3	3.2	3.3	3.6	3.8	9.9	7.1	3.2	3.3	4.2	1.6
%OC (Median)	12.6	5.4	8.2	17.0	8.7	50.7	30.0	9.5	6.2	11.5	2.7
%BB (IQR)	3.2	1.9	2.1	5.2	2.4	13.5	9.4	6.0	12.7	9.7	3.8
%SU (IQR)	4.8	6.0	5.5	6.8	5.9	8.0	7.0	8.6	12.3	9.6	10.9
%DU (IQR)	1.4	9.1	4.4	1.4	3.5	7.2	7.5	2.9	14.0	6.4	15.9
%SS (IQR)	9.8	7.2	3.6	6.7	5.1	4.0	13.4	7.4	7.0	7.4	0.6
%BC (IQR)	0.6	0.9	0.5	1.6	0.6	2.9	1.6	1.6	2.1	2.4	1.4
%OC (IQR)	2.6	1.2	1.9	3.5	1.8	12.5	8.2	5.6	10.1	7.6	2.4

S4. Cluster characteristics of the seasonal partitions

In this section we present the summary tables and graphs of mean values of optical and microphysical aerosol parameters extracted from the AERONET inversion data record for each cluster of the mean seasonal (DJF, MAM, JJA and SON) global partitions including: spectral parameters (AOD, ASYM, AAOD, SSA, CRI-R, CRI-I, LR) at central wavelength of 440, 675, 870 and 1020nm, the mean percentage of spherical particles ('%Sphericity'), the mean AVSD (in 22 logarithmic radial bins from 0.05 μ m to 15 μ m), AVSD-derived microphysical parameters (r_f , σ_f , V_f , r_c , σ_c , V_c associated with the fine and coarse modes 'f' and 'c' respectively), and the fine mode fraction η . Values are calculated from the L2.0 V2 inversion product unless accompanied by a '*' whereby the value is calculated from the L1.5 V2 inversion product.

Table S7. Descriptive statistics of key optical and microphysical parameters extracted from the global AERONET inversion record in each cluster for the season (DJF).

AERONET L2.0 Pixels Records	Cluster 1 8 358	Cluster 2 8 1372	Cluster 3 33 4080	Cluster 4 2 744*	Cluster 5 18 4834	Cluster 6 33 7739	Cluster 7 57 14149	Cluster 8 13 929	Cluster 9 23 3056	Cluster 10 18 9800
AOD (440)	0.19	0.08	0.06	0.14*	0.42	0.11	0.12	0.12	0.20	0.27
AE (440/675)	0.92	0.63	1.73	1.14*	1.07	1.76	1.55	1.09	1.41	0.72
H2O	3.62	2.82	0.49	1.56*	1.17	0.95	0.80	1.15	2.34	1.27
ASYM (440)	0.72	0.75	0.72	0.69*	0.72	0.70	0.71	0.73	0.71	0.75
P180 (440)	0.20	0.41	0.15	0.26*	0.19	0.17	0.17	0.23	0.19	0.18
AAOD (440)	0.057	0.005*	0.062	0.017*	0.138	0.056	0.073	0.052	0.070	0.083
SSA (440)	0.90	0.95*	0.90	0.90*	0.87	0.93	0.90	0.93	0.90	0.89
LR (440)	90.1	39.4*	108.4	65.5*	94.5	92.2	96.4	99.8	98.4	96.4
CRI-R (440)	1.424	1.449*	1.418	1.542*	1.432	1.432	1.466	1.412	1.441	1.442
CRI-I (440)	0.011	0.003*	0.018	0.012*	0.014	0.010	0.016	0.015	0.016	0.008
$r(f)$	0.15	0.18	0.18	0.15*	0.16	0.17	0.17	0.19	0.17	0.16
$\sigma(f)$	0.47	0.49	0.46	0.46*	0.48	0.45	0.47	0.50	0.46	0.50
$V(f)$	0.02	0.01	0.01	0.01*	0.05	0.01	0.02	0.01	0.03	0.02
$r(c)$	2.35	2.70	2.92	2.69*	2.54	2.96	2.89	2.68	3.02	2.26
$\sigma(c)$	0.71	0.69	0.68	0.66*	0.65	0.67	0.68	0.68	0.69	0.63
$V(c)$	0.06	0.04	0.01	0.058*	0.08	0.02	0.02	0.02	0.03	0.10
η	0.28	0.15	0.50	0.26*	0.31	0.58	0.51	0.44	0.41	0.20
% Sphericity	63.4	95.6	95.5	51.3*	33.8	86.3	72.3	97.9	96.4	2.6

While 1372 Level 2.0 records were extracted for cluster 2, there were no records containing data for the spectral parameters AAOD, SSA, LR and the CRI. In order to estimate the values of these parameters, we extracted a total of 1074 analogous records in this cluster from the Level 1.5 dataset at the sites: Amsterdam Island, Cape_San_Juan, Coconut_Island, Dunedin, Honolulu, Manila_Observatory, Prospect Hill, Rio Pedras, Roosevelt Roads, Sable_Island, Tahiti, and Tudor Hill, and used them to calculate an estimate of the mean values. For cluster 4, only 8 Level 2.0 records were available. As such we extracted all 744 available records in this cluster from the Level 1.5 dataset at the sites: Azores, Bonanza_Creek, CEILAP-RG, Crozet Island, Guam, Kapoho, Mace Head, Marambio, and Santiago, and then proceeded to calculate estimated mean values of all parameters.

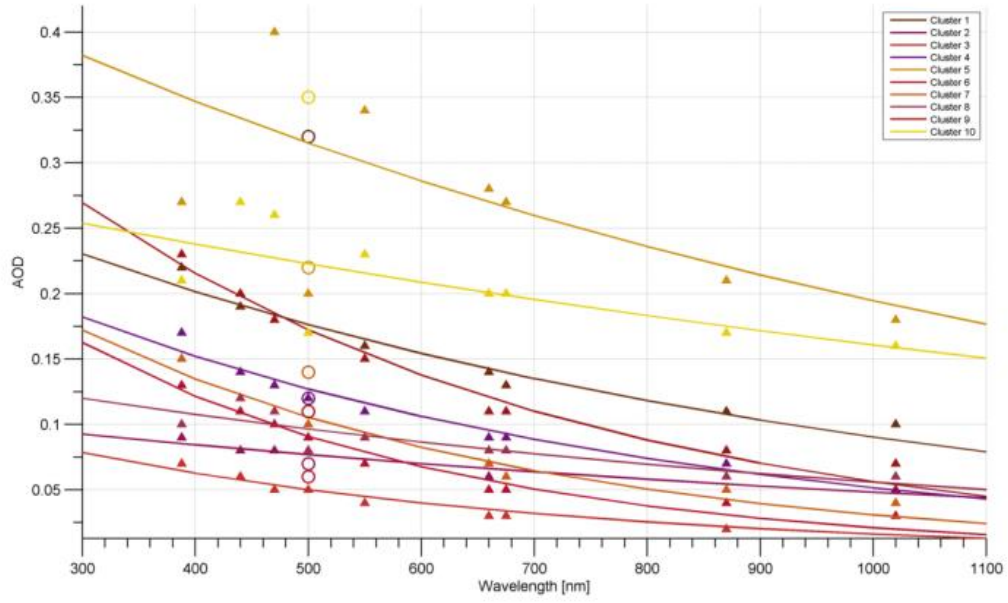


Fig. S10. Optimized least square regression fits to the spectral behaviour of mean values of the AERONET-derived AOD for each cluster during the season (DJF). The circles at 500nm are the mean cluster values of the total AOD obtained by GOCART.

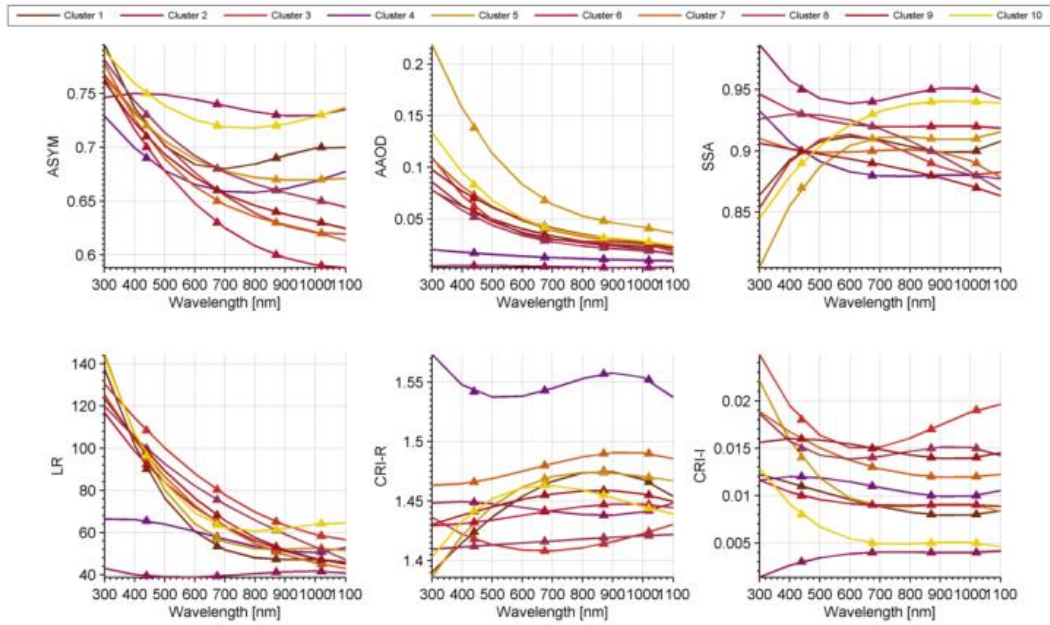


Fig. S11. Spectral behaviour of the global mean values of key optical parameters (ASYM, AAOD, SSA, LR) and microphysical parameters (CRI-R and CRI-I) for each cluster from extracted AERONET data at 440, 675, 870 and 1020nm during the season (DJF).

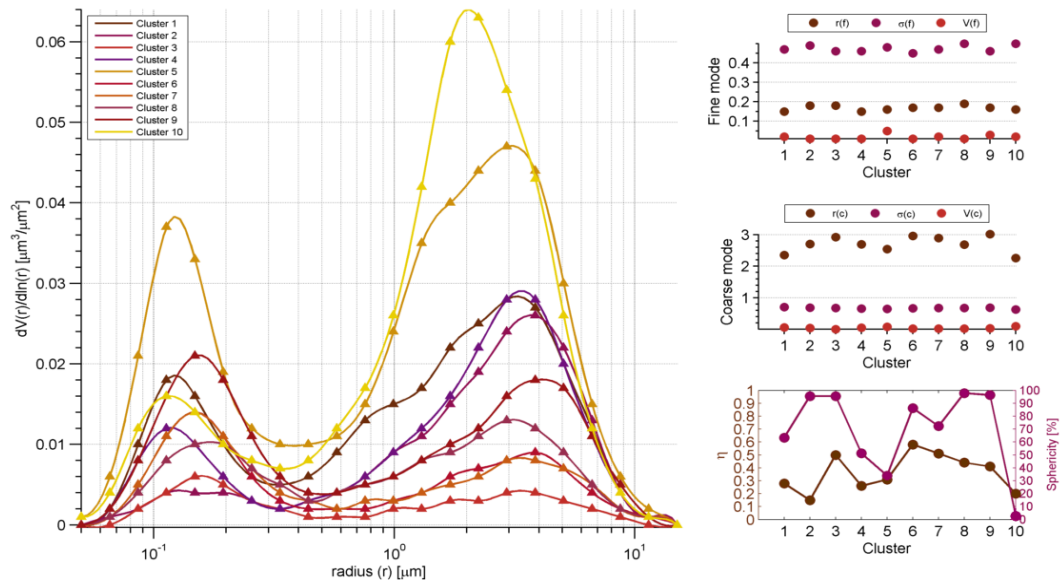


Fig. S12. Global mean size distributions for each cluster together with the derived fine and coarse mode parameters (r_f , σ_f , V_f and r_c , σ_c , V_c respectively) during the season (DJF).

Table S8. Descriptive statistics of key optical and microphysical parameters extracted from the global AERONET inversion record in each cluster for the season (MAM).

AERONET L2.0	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Pixels	18	58	18	28	2	45	0	25	26	1	15
Records	3380	15023	2645	10340	451*	9083	157*	4170	11823	871*	1909
AOD (440)	0.07	0.19	0.20	0.19	0.05*	0.19	0.03*	0.25	0.39	0.07*	0.07
AE (440/675)	1.19	1.62	1.47	1.09	0.78*	1.52	0.62*	1.62	0.38	0.71*	1.21
H2O	1.13	1.08	2.19	1.25	1.60*	1.05	0.89*	2.36	1.44	3.98*	1.83
ASYM (440)	0.71	0.70	0.71	0.72	0.72*	0.71	0.75*	0.69	0.75	0.73*	0.71
P180 (440)	0.23	0.19	0.18	0.20	0.34*	0.18	0.25*	0.19	0.21	0.31*	0.26
AAOD (440)	0.105	0.033	0.040	0.088	0.004*	0.050	0.010*	0.068	0.064	0.006*	0.030
SSA (440)	0.88	0.95	0.95	0.89	0.92*	0.93	0.64*	0.92	0.91	0.93*	0.94
LR (440)	92.7	81.9	91.3	77.9	45.2*	85.6	78.4*	90.2	71.7	49.6*	69.6
CRI-R (440)	1.458	1.437	1.425	1.507	1.511*	1.458	1.559*	1.445	1.483	1.503*	1.446
CRI-I (440)	0.010	0.007	0.007	0.009	0.008*	0.009	0.194*	0.013	0.004	0.005*	0.003
r(f)	0.16	0.16	0.17	0.16	0.17*	0.16	0.26*	0.16	0.16	0.17*	0.16
$\sigma(f)$	0.48	0.44	0.45	0.47	0.49*	0.45	0.56*	0.43	0.58	0.51*	0.48
V(f)	0.01	0.02	0.03	0.02	0.00*	0.02	0.00*	0.03	0.02	0.00*	0.01
r(c)	2.46	2.49	2.84	2.43	2.55*	2.38	2.76*	2.97	2.14	2.78*	2.39
$\sigma(c)$	0.73	0.72	0.67	0.70	0.73*	0.71	0.65*	0.69	0.62	0.70*	0.70
V(c)	0.02	0.02	0.03	0.05	0.02*	0.02	0.01*	0.03	0.21	0.04*	0.03
η	0.26	0.52	0.46	0.28	0.18*	0.47	0.36*	0.47	0.11	0.14*	0.35
% Sphericity	9.3	91.0	77.2	27.6	87.0*	56.0	87.1*	98.6	1.0	66.2*	63.1

While 36 and 114 Level 2.0 records were extracted for clusters 5 and 10 (cluster 7 did not encompass any sites), there were no records containing data for AAOD, SSA, LR and the CRI at this level of quality assurance. Furthermore, since the number of Level 2.0 records is low for both clusters, we extracted a total of 451 full records for cluster 5 from the Level 1.5 dataset at the sites: Amsterdam Island, Rottneest Island and Dunedin, and a total of 871 full records for cluster 10 from the Level 1.5 dataset at the sites: Kapoho, McMurdo, Nauru, REUNION_ST_DENIS, South_Pole, and Tahiti. For cluster 7, a total of 157 full records from the Level 1.5 dataset at the sites: CEILAP-RG, Crozet Island, Marambio, Utsteinen, and Vechernaya_Hill was used. We then proceeded to use this data to calculate mean values of all parameters.

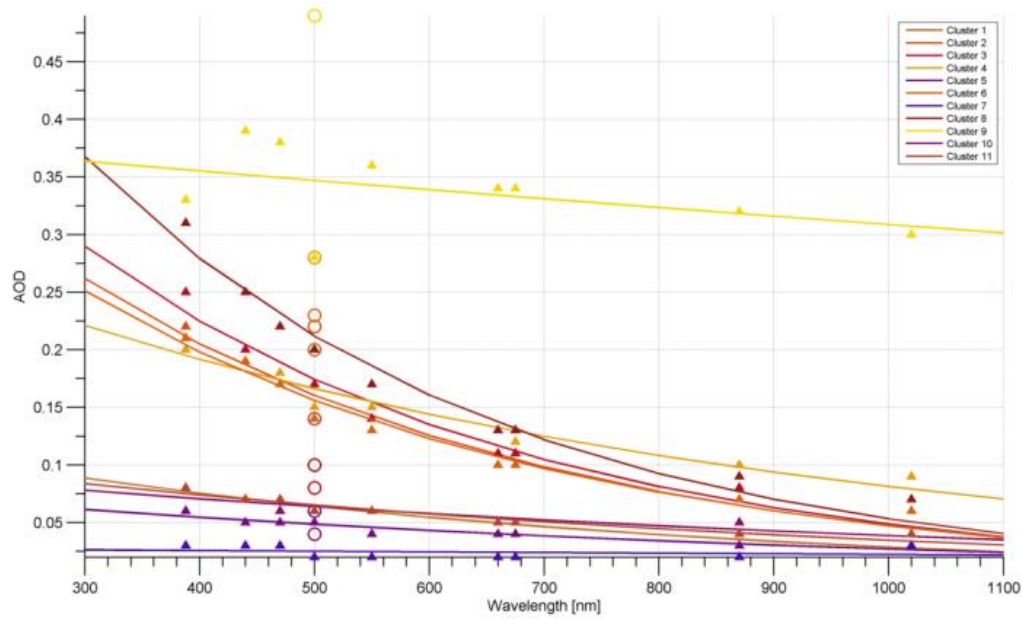


Fig. S13. Optimized least square regression fits to the spectral behaviour of mean values of the AERONET-derived AOD for each cluster during the season (MAM). The circles at 500nm are the mean cluster values of the total AOD obtained by GOCART.

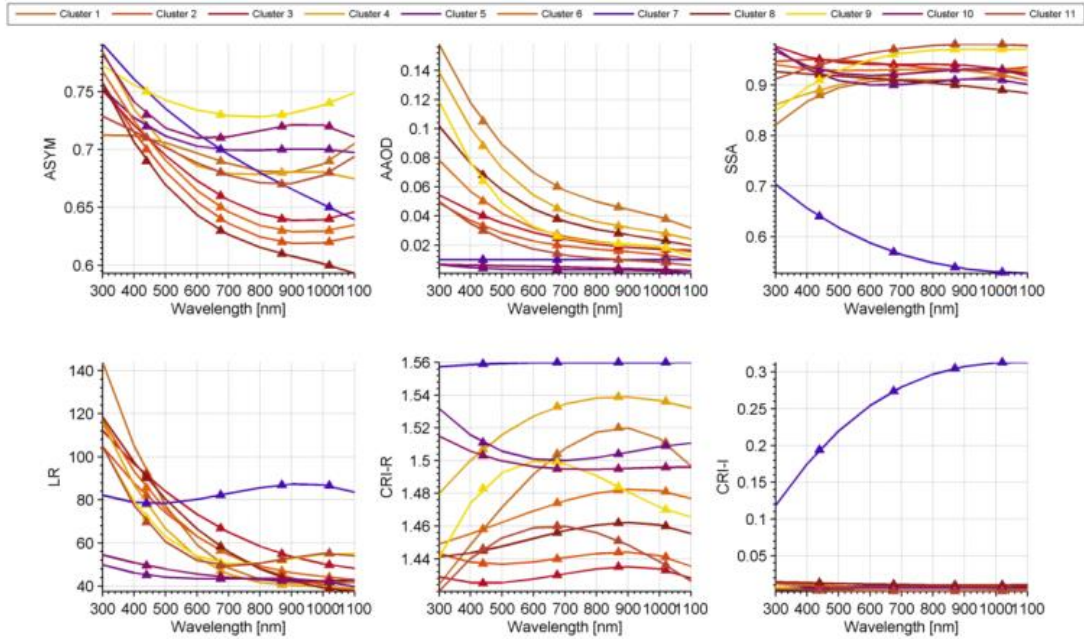


Fig. S14. Spectral behaviour of the global mean values of key optical parameters (ASYM, AAOD, SSA, LR) and microphysical parameters (CRI-R and CRI-I) for each cluster from extracted AERONET data at 440, 675, 870 and 1020nm during the season (MAM).

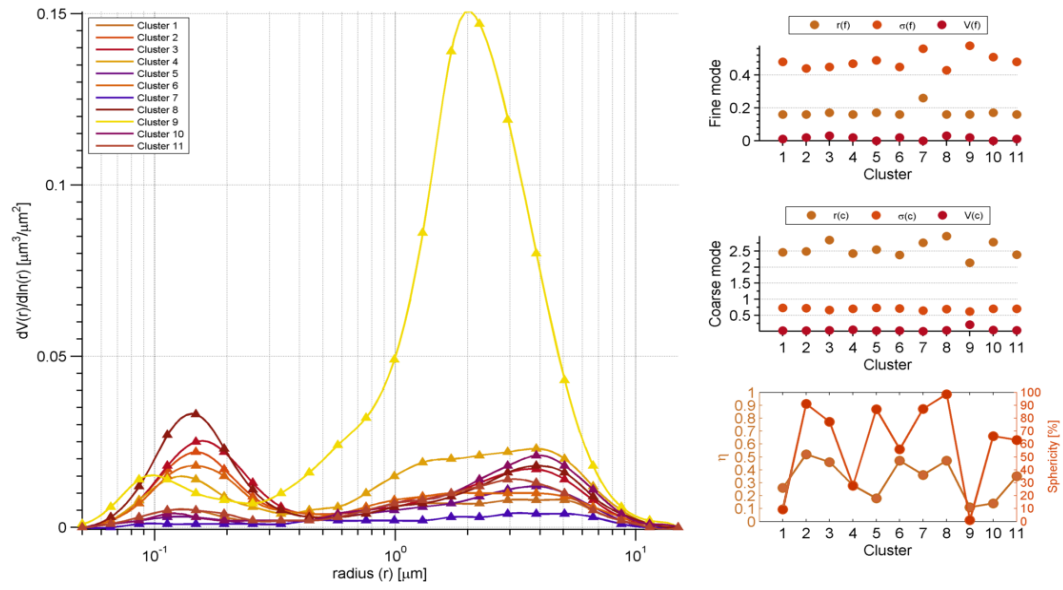


Fig. S15. Global mean size distributions for each cluster together with the derived fine and coarse mode parameters (r_f , σ_f , V_f and r_c , σ_c , V_c respectively) during the season (MAM).

Table S9. Descriptive statistics of key optical and microphysical parameters extracted from the global AERONET inversion record in each cluster for the season (JJA).

AERONET L2.0	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Pixels	0	51	2	21	5	31	0	13	82	32	16
Records	102*	6466	771*	1792	2419*	3478	333*	1043	6195	2921	1525
AOD (440)	0.03*	0.18	0.06*	0.26	0.07*	0.45	0.07*	0.14	0.28	0.19	0.27
AE (440/675)	0.78*	1.60	0.89*	1.74	1.10*	0.50	0.58*	1.41	1.72	1.34	1.64
H2O	0.66*	1.99	2.91*	2.05	1.38*	2.40	4.37*	1.95	2.53	1.94	2.65
ASYM (440)	0.74*	0.70	0.72*	0.67	0.70*	0.74	0.73*	0.69	0.71	0.72	0.71
P180 (440)	0.21*	0.19	0.31*	0.18	0.22*	0.21	0.33*	0.20	0.17	0.19	0.17
AAOD (440)	0.011*	0.043	0.005*	0.080	0.012*	0.055	0.006*	0.077	0.026	0.051	0.030
SSA (440)	0.63*	0.94	0.92*	0.89	0.90*	0.92	0.92*	0.87	0.97	0.92	0.95
LR (440)	95.9*	80.4	50.4*	89.2	79.1*	67.3	46.8*	100.7	84.8	78.6	87.4
CRI-R (440)	1.558*	1.453	1.498*	1.488	1.519*	1.501	1.505*	1.422	1.415	1.464	1.389
CRI-I (440)	0.137*	0.008	0.006*	0.020	0.020*	0.004	0.006*	0.020	0.005	0.007	0.006
r(f)	0.25*	0.16	0.17*	0.15	0.16*	0.16	0.18*	0.15	0.17	0.16	0.16
$\sigma(f)$	0.55*	0.42	0.49*	0.40	0.47*	0.53	0.50*	0.45	0.43	0.45	0.42
V(f)	0.00*	0.02	0.00*	0.03	0.01*	0.03	0.01*	0.02	0.04	0.02	0.04
r(c)	2.40*	2.92	2.60*	3.18	2.65*	2.31	2.82*	2.80	3.02	2.63	2.76
$\sigma(c)$	0.67*	0.69	0.69*	0.69	0.73*	0.62	0.69*	0.71	0.67	0.67	0.67
V(c)	0.01*	0.03	0.03*	0.03	0.02*	0.23	0.03*	0.03	0.02	0.04	0.03
η	0.47*	0.47	0.17*	0.53	0.35*	0.12	0.15*	0.39	0.65	0.34	0.58
% Sphericity	92.8*	84.7	84.8*	98.9	92.6*	2.4	86.9*	94.5	98.6	43.1	94.7

While 224 and 294 Level 2.0 records were extracted for clusters 3 and 5 (clusters 1 and 7 did not encompass any sites), there were no records containing data for AAOD, SSA, LR and the CRI at this level of quality assurance. For these four clusters (1, 3, 5 and 7) we therefore extracted a total of 102 full records for cluster 1 from the Level 1.5 dataset at the sites: CEILAP-RG and Marambio, a total of 771 full records for cluster 3 from the Level 1.5 dataset at the sites: Amsterdam_Island, Crozet Island, Dunedin, McMurdo, and Tahiti, a total of 2419 full records for cluster 5 from the Level 1.5 dataset at the sites: Adelaide_7, ARM_Gan_Island, Ascension_Island, Canberra, CEILAP-Bariloche, Coleambally, Lucinda, Milyering, Perth, Petrolina_SONDA, Puerto_Madryn, REUNION_ST_DENIS, Rottneest_Island, and Trelew, and a total of 333 full records for cluster 5 from the Level 1.5 dataset at the sites: Kapoho, Manus, Nauru, South_Pole_Obs, Utsteinen, and Vechernaya_Hill. We then used this data to calculate mean values of all parameters.

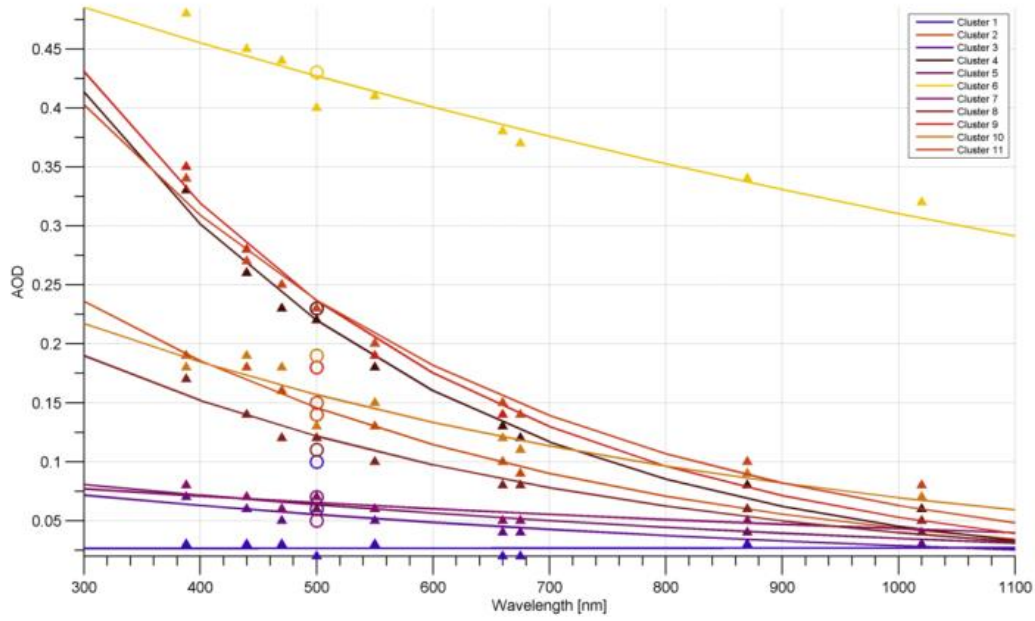


Fig. S16. Optimized least square regression fits to the spectral behaviour of mean values of the AERONET-derived AOD for each cluster during the season (JJA). The circles at 500nm are the mean cluster values of the total AOD obtained by GOCART.

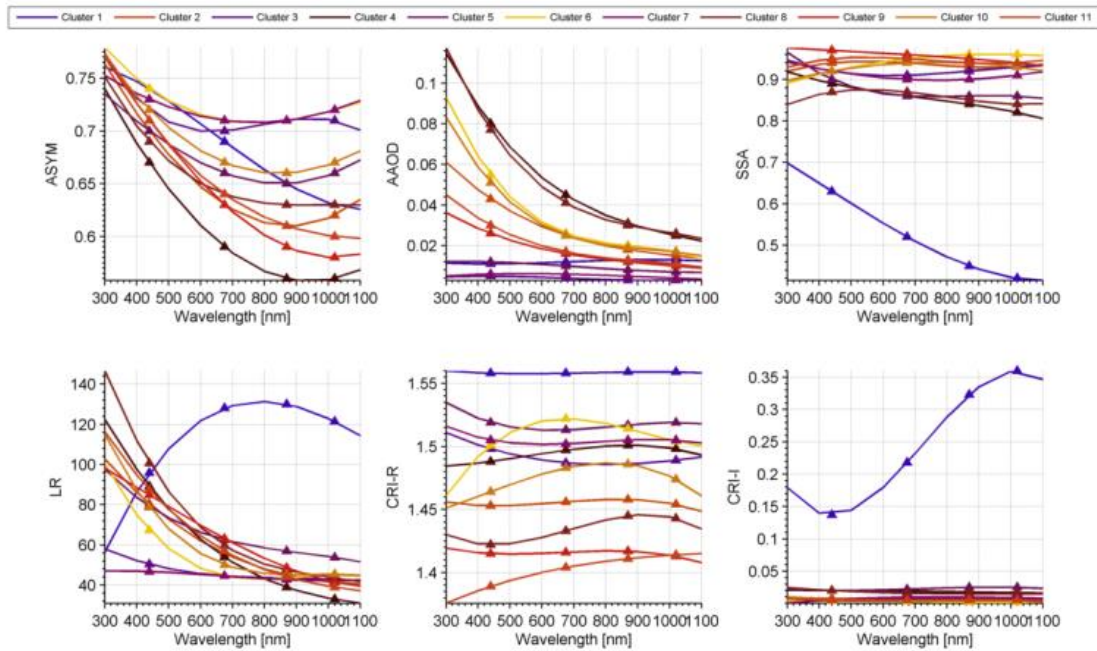


Fig. S17. Spectral behaviour of the global mean values of key optical parameters (ASYM, AAOD, SSA, LR) and microphysical parameters (CRI-R and CRI-I) for each cluster from extracted AERONET data at 440, 675, 870 and 1020nm during the season (JJA).

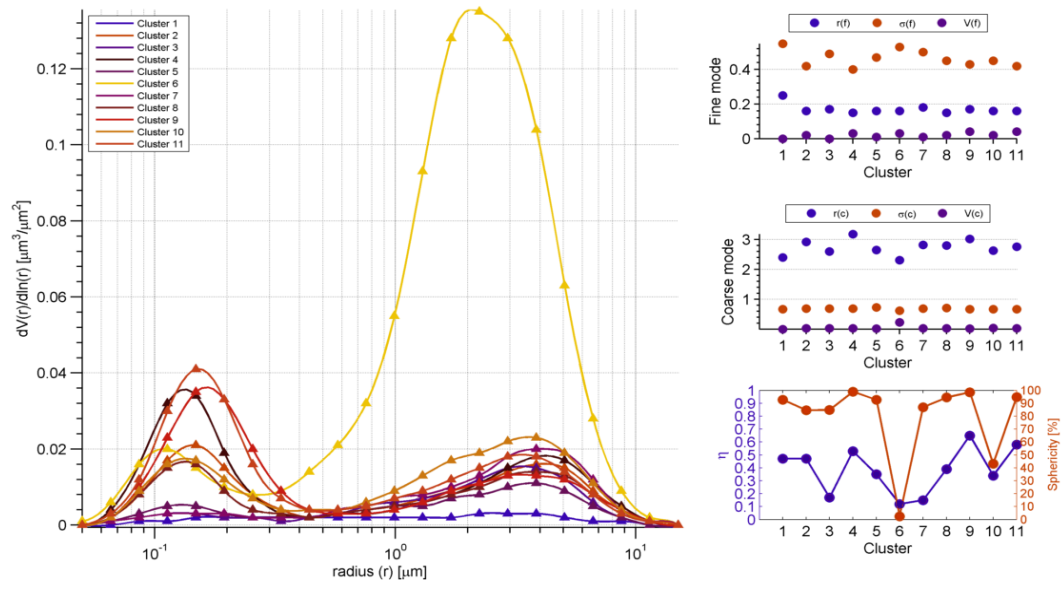


Fig. S18. Global mean size distributions for each cluster together with the derived fine and coarse mode parameters (r_f , σ_f , V_f and r_c , σ_c , V_c respectively) during the season (JJA).

Table S10. Descriptive statistics of key optical and microphysical parameters extracted from the global AERONET inversion record in each cluster for the season (SON).

AERONET L2.0	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Pixels	1	4	51	3	52	28	15	5	23	43	28
Records	197*	268	9554	626*	15055	5671	2044	930	9738	10516	14096
AOD (440)	0.04*	0.06	0.16	0.07*	0.14	0.44	0.16	0.03	0.20	0.18	0.34
AE (440/675)	0.78*	1.56	1.61	0.97*	1.54	1.62	1.49	2.46	1.26	1.72	0.71
H2O	0.90*	2.09	1.40	2.62*	1.48	2.69	1.50	1.39	1.77	1.85	2.14
ASYM (440)	0.73*	0.70	0.71	0.71*	0.71	0.68	0.69	0.68	0.71	0.71	0.74
P180 (440)	0.15*	0.24	0.18	0.34*	0.18	0.18	0.20	0.26	0.19	0.17	0.19
AAOD (440)	0.016*	0.025	0.040	0.008*	0.055	0.080	0.063	0.001*	0.071	0.039	0.047
SSA (440)	0.69*	0.95	0.94	0.91*	0.92	0.90	0.90	0.98*	0.91	0.95	0.92
LR (440)	121.2*	72.6	90.1	48.9*	94.5	86.4	93.7	55.7*	85.0	91.9	80.2
CRI-R (440)	1.587*	1.450	1.421	1.495*	1.438	1.473	1.427	1.537*	1.470	1.409	1.461
CRI-I (440)	0.103*	0.007	0.008	0.008*	0.011	0.017	0.015	0.002*	0.011	0.007	0.005
r(f)	0.22*	0.16	0.17	0.16*	0.16	0.15	0.15	0.17	0.16	0.17	0.16
$\sigma(f)$	0.56*	0.44	0.44	0.48*	0.44	0.40	0.44	0.49	0.45	0.43	0.49
V(f)	0.00*	0.01	0.02	0.01*	0.02	0.06	0.02	0.00	0.02	0.03	0.03
r(c)	2.45*	2.35	2.88	2.70*	2.88	2.92	3.02	3.51	2.66	3.07	2.31
$\sigma(c)$	0.70*	0.70	0.68	0.72*	0.68	0.71	0.69	0.67	0.66	0.65	0.63
V(c)	0.01*	0.01	0.02	0.03*	0.02	0.04	0.03	0.01	0.06	0.02	0.14
η	0.46*	0.40	0.52	0.18*	0.47	0.56	0.38	0.65	0.34	0.60	0.17
% Sphericity	99.0*	98.5	93.4	94.8*	66.4	98.6	93.2	61.8	41.6	96.5	7.8

While 930 Level 2.0 records were extracted for cluster 8, there were no records containing data for AAOD, SSA, LR and the CRI at this level of quality assurance. For this cluster, we extracted a total of 527 analogous records from the Level 1.5 dataset at the sites: Andros_Island, Bermuda, Coconut_Island, Guam, Honolulu, Kapocho, Manus, Mauna_Loa, Nauru, Prospect_Hill, and Tudor_Hill, to estimate these parameters. For cluster 1 only 2 Level 2.0 records were available. As such we extracted 197 complete records from Level 1.5 data at the sites: CEILAP_RG, Crozet_Island and Marambio, and then proceeded to calculate mean values of all parameters. In the case of cluster 4, while 142 Level 2.0 records were extracted, there were no records containing data for AAOD, SSA, LR, CRI and the % sphericity at this level of quality assurance. For this cluster, we extracted a total of 626 analogous records from the Level 1.5 dataset at the sites: Amsterdam_Island, Dunedin, McMurdo, REUNION_ST_DENIS, Tahiti, Utsteinen, and Vechernaya_Hill, and used this data to estimate the values of all parameters.

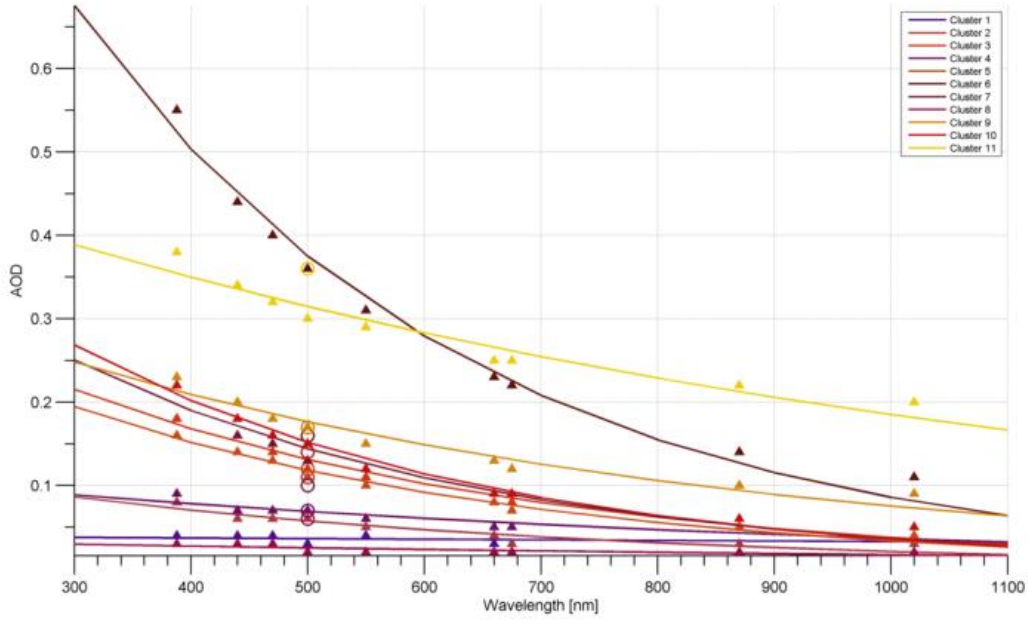


Fig. S19. Optimized least square regression fits to the spectral behaviour of mean values of the AERONET-derived AOD for each cluster during the season (SON). The circles at 500nm are the mean cluster values of the total AOD obtained by GOCART.

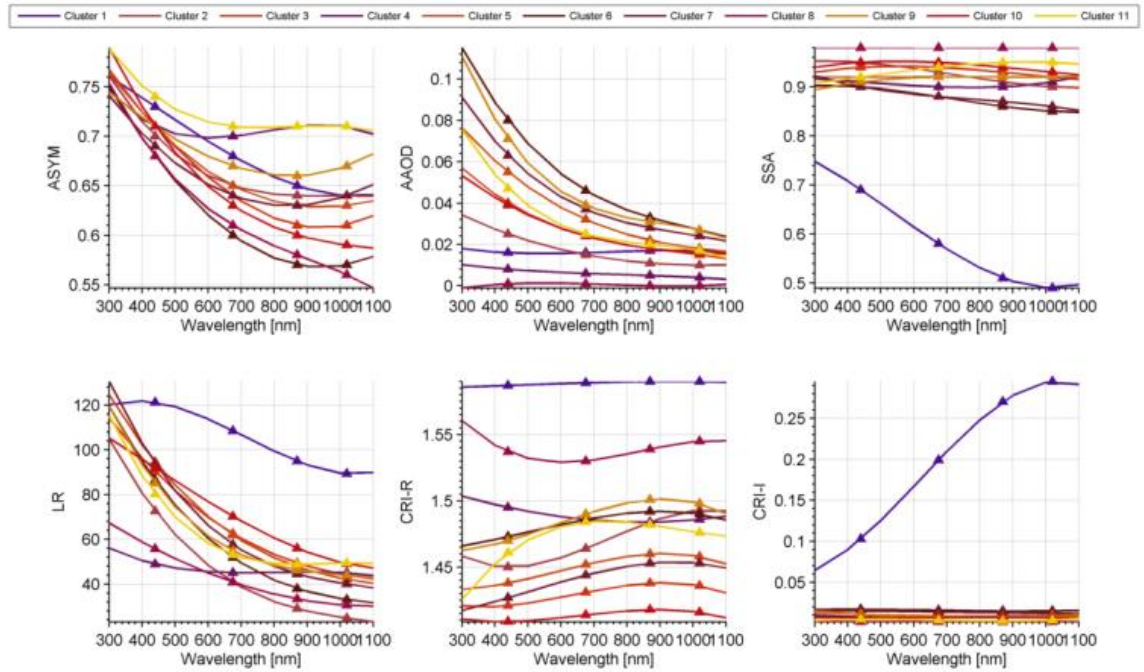


Fig. S20. Spectral behaviour of the global mean values of key optical parameters (ASYM, AAOD, SSA, LR) and microphysical parameters (CRI-R and CRI-I) for each cluster from extracted AERONET data at 440, 675, 870 and 1020nm during the season (SON).

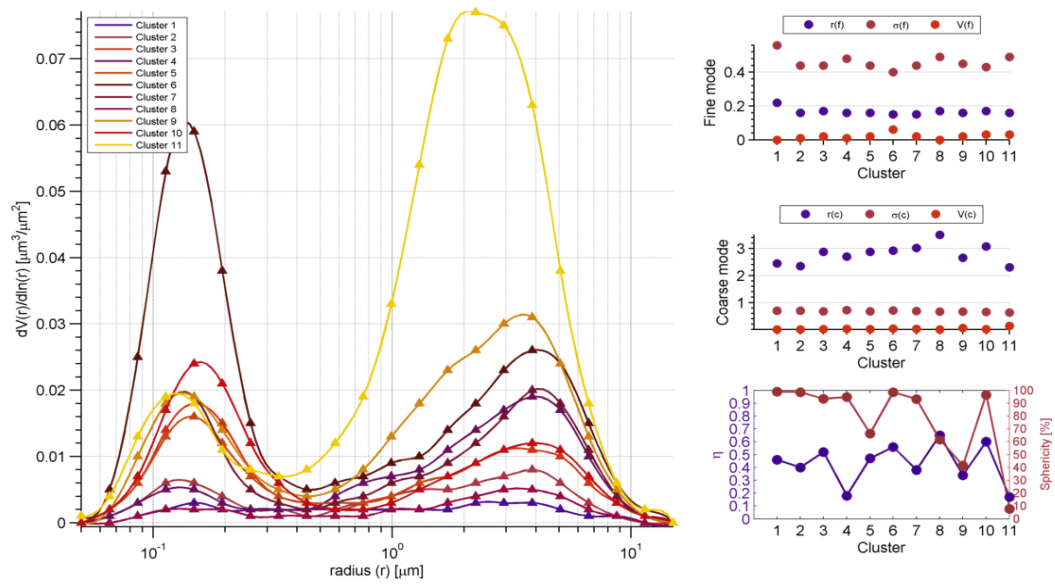


Fig. S21. Global mean size distributions for each cluster together with the derived fine and coarse mode parameters (r_f , σ_f , V_f and r_c , σ_c , V_c respectively) during the season (SON).

S4. Bivariate parameterizations of seasonal global aerosol mixtures

In this section we present the results of parameterizing the AERONET data record with pairs of optical and/or microphysical parameters commonly used in aerosol classification studies described in detail in the main text of the manuscript.

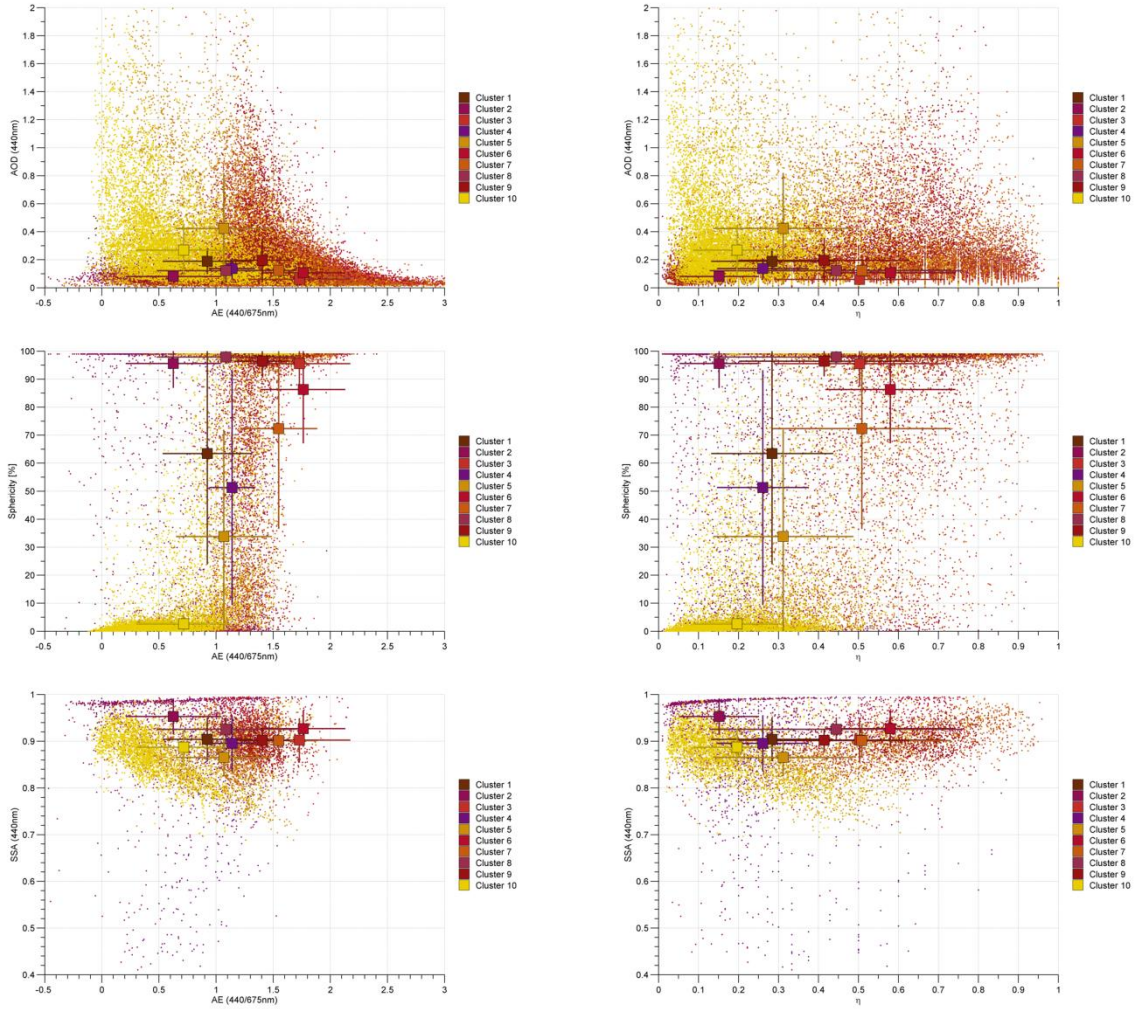


Fig. S22. Cluster means (squares) and standard deviations (lines) overlaid on the AERONET data record (points) for the season (DJF) parameterized by pairs of optical and/or microphysical parameters commonly used in aerosol classification studies.

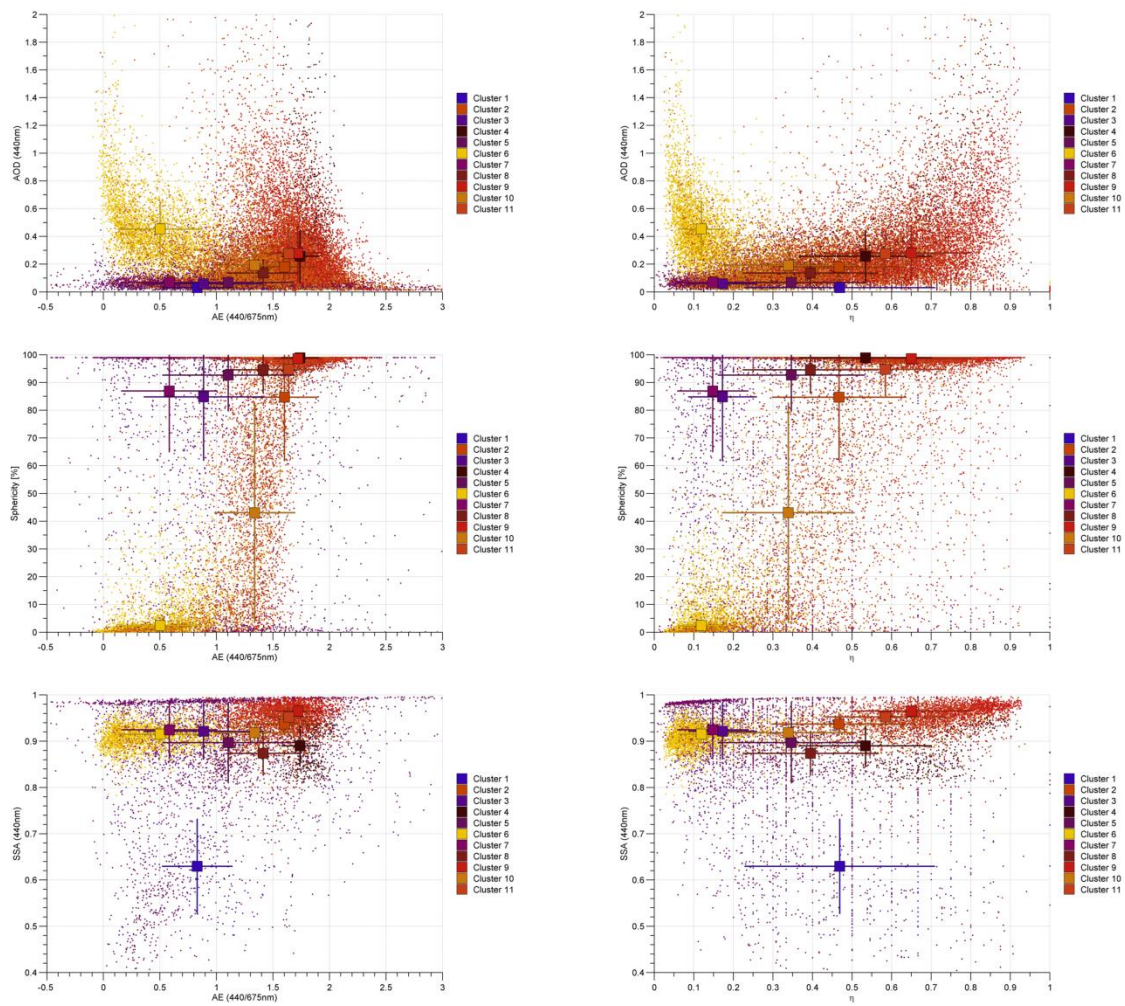


Fig. S23. Cluster means (squares) and standard deviations (lines) overlaid on the AERONET data record (points) for the season (MAM) parameterized by pairs of optical and/or microphysical parameters commonly used in aerosol classification studies.

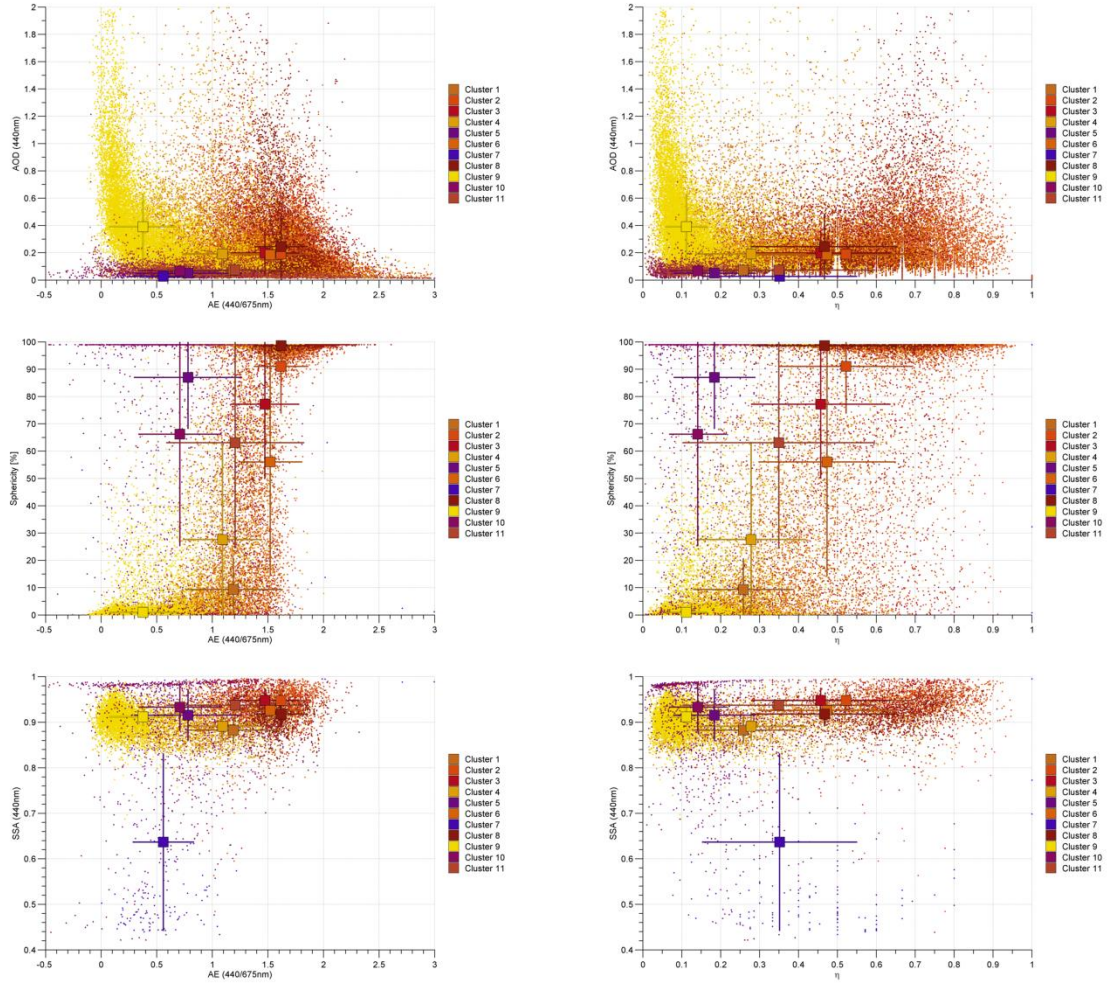


Fig. S24. Cluster means (squares) and standard deviations (lines) overlaid on the AERONET data record (points) for the season (JJA) parameterized by pairs of optical and/or microphysical parameters commonly used in aerosol classification studies.

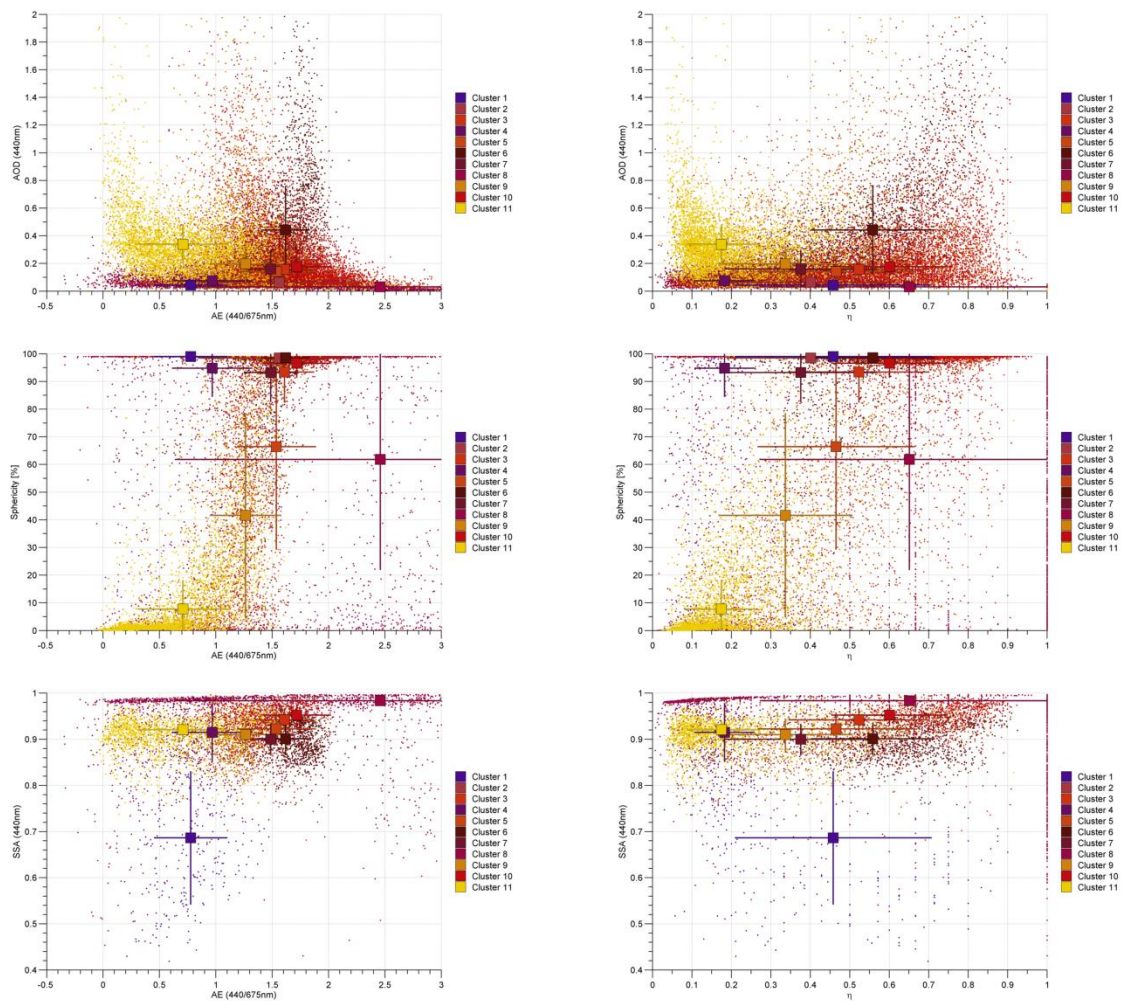


Fig. S25. Cluster means (squares) and standard deviations (lines) overlaid on the AERONET data record (points) for the season (SON) parameterized by pairs of optical and/or microphysical parameters commonly used in aerosol classification studies.