Investigation of global aerosol regime developments from pre-industrial times to the future

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Scientific questions

- How to derive aerosol regimes based on different aerosol properties simulated from global aerosol simulation?
- How are the present-day global aerosol regimes spatially distributed?
- How do the global aerosol regimes develop in time (from pre-industrial times to the future)?

Simulations

- The simulations were performed using the ECHAM/MESSy (Jöckel et al., 2010, 2016) equipped with the aerosol microphysical sub- module MADE3 (Kaiser et al., 2014, 2019).
- Different time-slices were chosen, from pre-industrial times (1750 and 1850), to present day (2015), and future (2050) under three different SSPs scenarios (O'Neill et al., 2017 ; Gidden et al., 2017): SSP1-1.9, SSP2-4.5 and SSP3-7.0.

Methods

- The investigation of aerosol regime developments through time are realized by using a combination of K-means classification (*unsupervised machine learning method*) and Random Forest (*supervised method*).
- Aerosol classifications are conducted on two scales: a primary classification which captures the large scale pattern of global aerosol distributions, and a secondary classification (sub-classification) which identifies fine within cluster structures of primary clusters.

Results and summary

- Lower tropospheric aerosol regimes during pre-industrial times are mostly represented by clean clusters (background, marine and continental level 1 cluster), and the biogenic- and mineral-dust-dominated clusters over Africa (Fig. 1 and 2).
- The lower tropospheric aerosol regimes in 2050 differ from the present-day case mainly in the extent of the clusters representing polluted regions: in the SSP3-7.0 scenario, developed (developing) countries shift towards clean (polluted) clusters, while in the SSP2-4.5 and especially SSP1-1.9 scenarios, a global trend of developments towards cleaner conditions is evident (Fig. 1 and 2).
- The secondary classification demonstrates that the pre-industrial background cluster displays higher aerosol loads in northern polar regions than at high southern latitudes, which is consistent with the present-day pattern (Fig. 3).

Acknowledgments

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Development of global aerosol regimes through time for the low tropospheric case (surface to ~700 hPa)

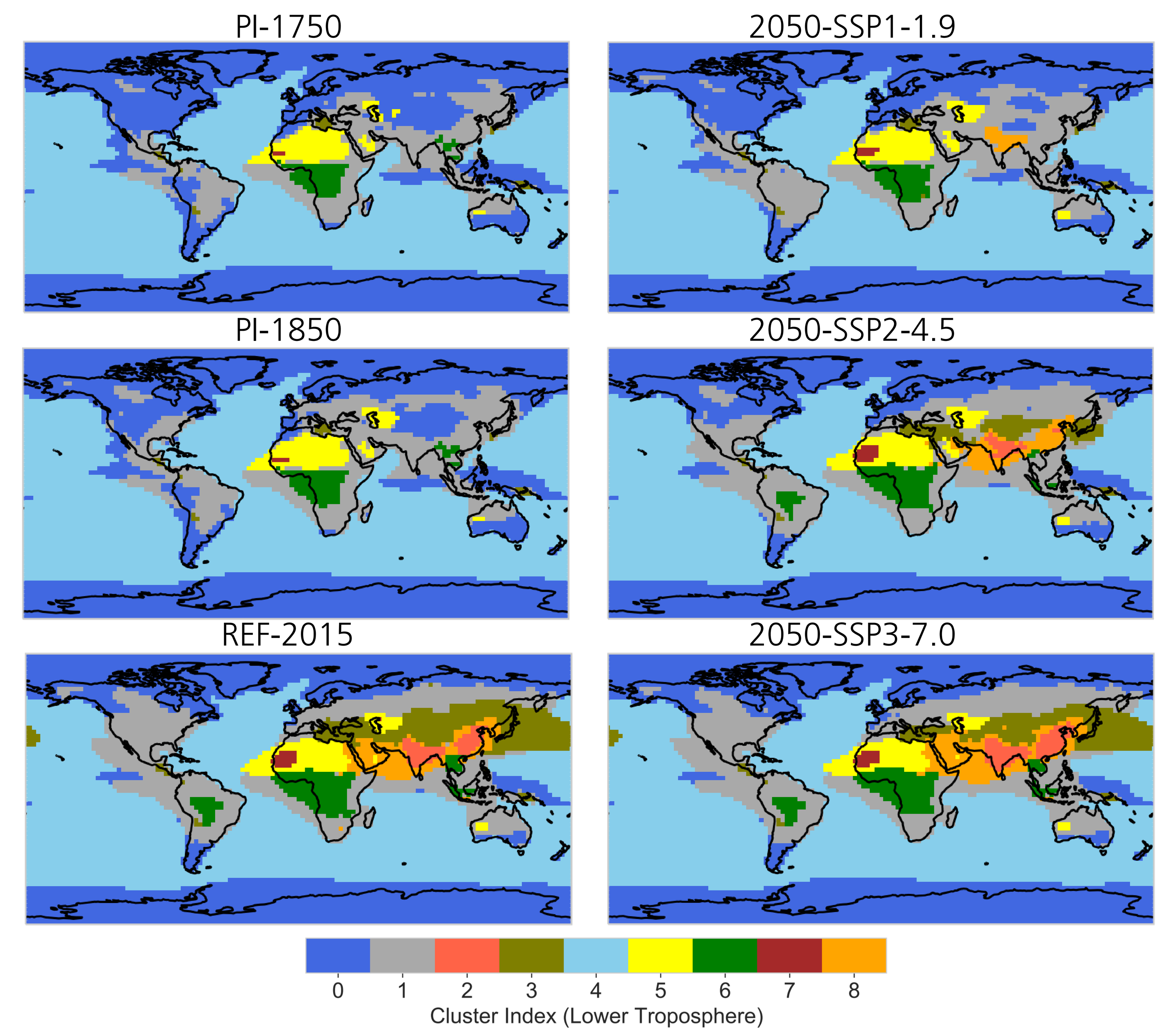

Figure 1. Primary aerosol regimes identified for different time slices and scenarios for the lower tropospheric case, each color/index represents one primary cluster.

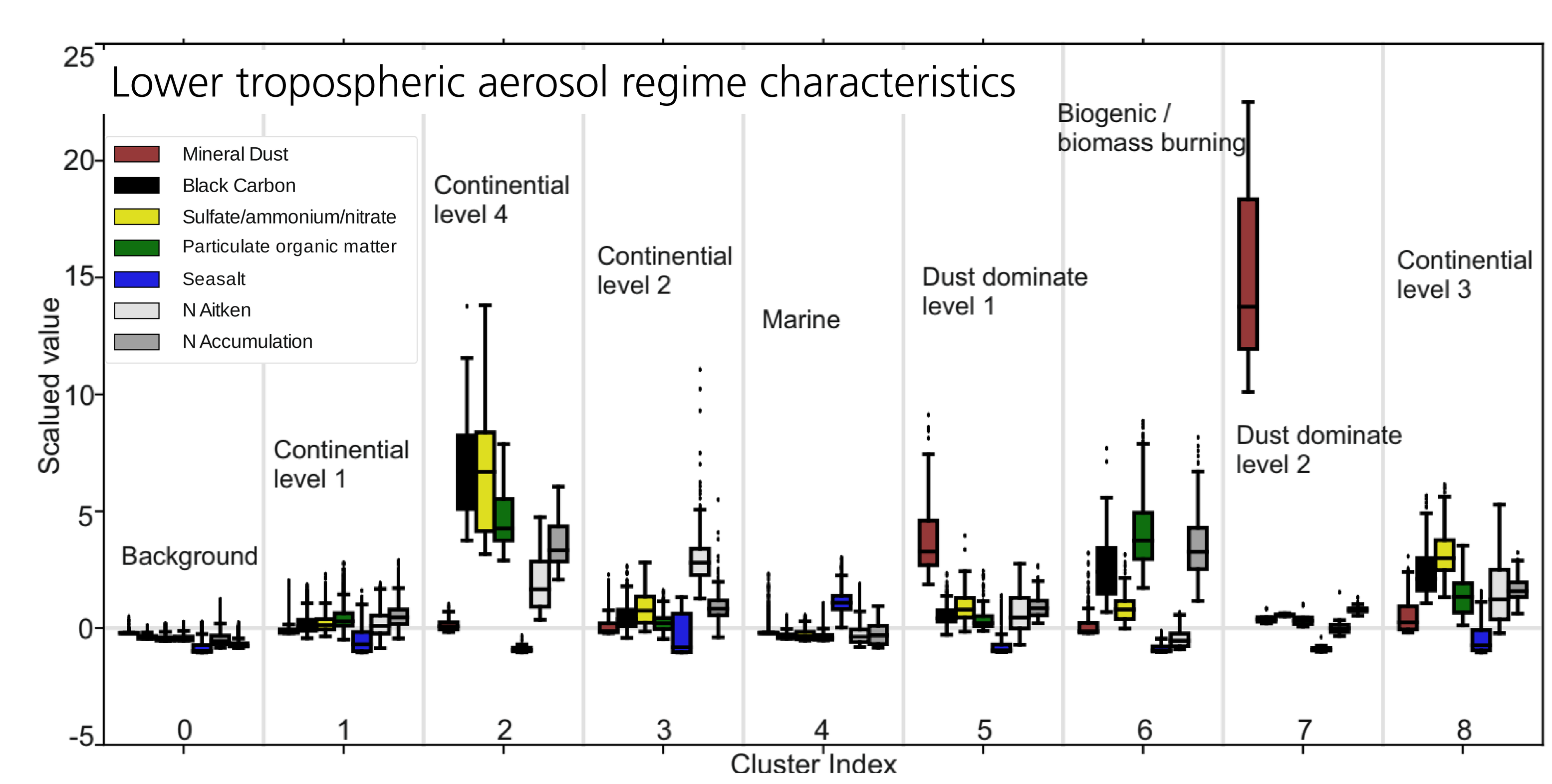

Figure 2. Data distributions of the seven considered aerosol properties (legend) within the identified primary aerosol regimes in Fig. 1, and cluster name assigned to each cluster.

Sub-classification for the primary cluster 0 (background cluster)

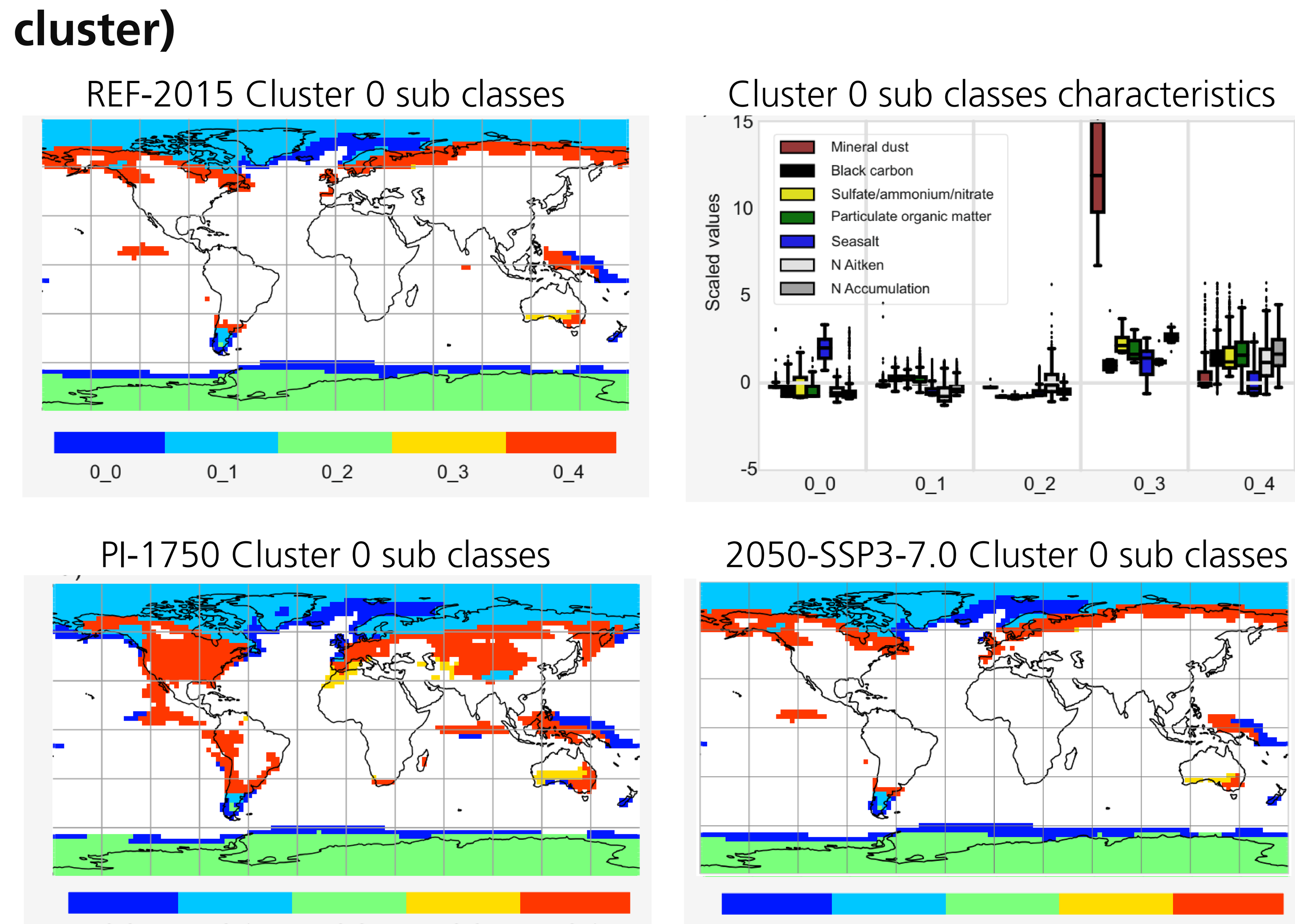

Figure 3. Secondary aerosol regimes (sub-classification) for the case of primary cluster 0 (the background cluster) in Fig. 1.

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