Evolution of biomass burning aerosols from Africa over the southeastern Atlantic

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Science background: A third of global biomass-burning emissions are produced from fires in southern Africa. Biomass-burning aerosols can stay lofted in the atmosphere for weeks with direct impacts on climate and air quality.

To improve global climate modeling, this study was performed to characterize the lifecycle of biomass-burning aerosols over the southeastern Atlantic in the vicinity of persistent marine stratocumulus clouds as they are processed downwind of fires on the continent. As the particles age, their composition changes, in turn affecting how much radiation they scatter and absorb, with direct implications on regional and global climate. This work adds extremely valuable new aerosol and cloud microphysical data to the otherwise limited body of these measurements available in the climate and air quality communities.

Main findings: The analysis, based on aircraft measurements from ORACLES (ObseRvations of Aerosols above CLouds their intEractionS) and CLARIFY (Cloud-Aerosol-Radiation Interaction and Forcing), shows secondary organic aerosol (SOA) formation during the initial 3 days of transport, followed by decreases in organic aerosol (OA) via photolysis before reaching equilibrium. The results suggest that secondary organic aerosol formation still exists after an unexpectedly long period of aging, challenging previous understanding. Aerosol absorption wavelength dependency decreases with ageing due to an increase in particle size and photochemical bleaching of brown carbon (BrC). Cloud processing, including aqueous-phase reaction and scavenging, contributes to the oxidation of OA, while also reducing large diameter particles and the single-scattering albedo (SSA) of biomass-burning aerosols. These processes resulted in fewer biomass-burning particles observed in the marine boundary layer than above the clouds, and with marine boundary layer particles that were larger, more oxidized, and more absorbing. This work, by showing that cloud processing can reduce the single scattering albedo of BB aerosol, provides an explanation for the unexpectedly strongly absorbing marine boundary layer present in the south-eastern Atlantic.

Impact: This work helps to better understand the evolution of BB aerosol and their microphysical properties over an extended aging period and may help to improve the parametrizations used in climate models. The radiative forcing of biomass-burning aerosols depends critically on how the particles were processed during their lifetime after emission from the fires. While it is not yet clear whether the findings from this study would lead to a warming or a cooling at the surface, this study makes the key point that it is important to observe and model the lifecycle of aerosols in the atmosphere to accurately simulate global climate.

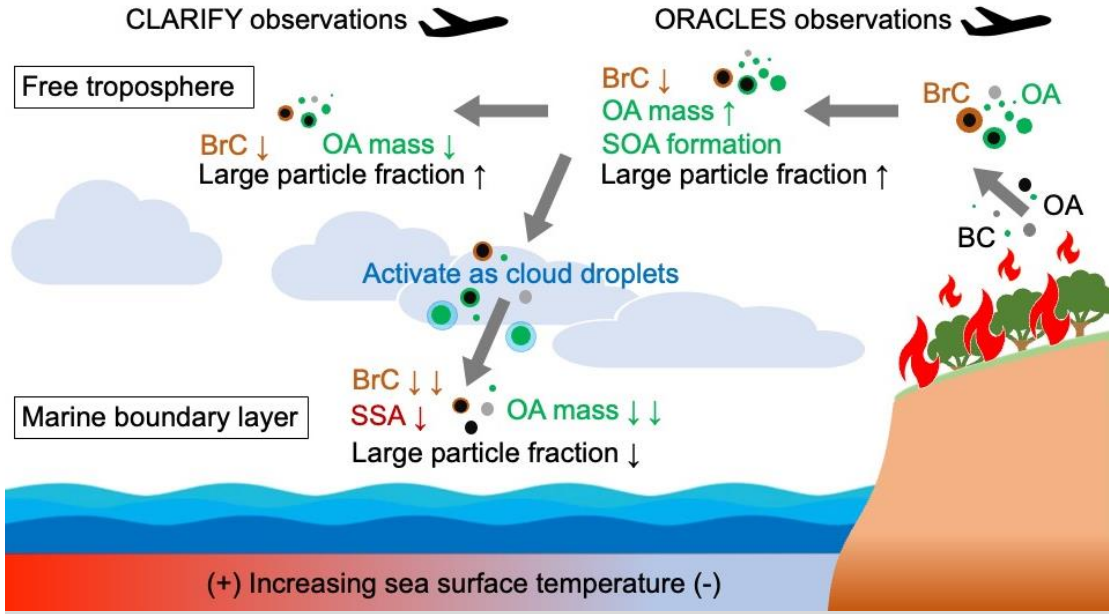

Figure. The composition and climate impacts of biomass-burning aerosols evolve as fresh emissions from the fires are transported downwind over the ocean and/or in clouds, as shown by the gray arrows. The relative abundances of various aerosol types (OA, BC [black carbon], BrC, SOA) are shown at each conceptual stage of the evolution based on the airborne observations from ORACLES and CLARIFY.

Che, H., Segal-Rozenhaimer, M., Zhang, L., Dang, C. et al. Cloud processing and weeklong ageing affect biomass burning aerosol properties over the south-eastern Atlantic. *Commun Earth Environ* 3, 182 (2022).

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