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Sunlight-absorbing aerosol amplifies the seasonal cycle in low-cloud fraction over the southeast Atlantic

Abstract

Absorbing aerosols directly alter the thermodynamic structure of the atmosphere and change cloud properties as the cloud entrains the aerosols. However, cloud formation and dissipation are also affected by variations in weather conditions such as water vapor distribution, wind shear intensity, and atmospheric stability. Finally, the influence of various effects determines precipitation variations and the radiation budget. To understand the aerosol-cloud interaction with the accompanying meteorology, this study selected satellite (MODIS, SEVIRI), ground-based (cloud radar, single-particle soot photometer (SP2)), and ERA5 reanalysis data to analyze the relationship between aerosol loads (e.g., aerosol optical depth (AOD), black carbon mass concentration (rBC)), cloud properties (e.g., cloud fraction (CF), low-level cloud types (St, Cu)), and vertical weather structure (e.g., potential temperature, mixing ratio) over Ascension Island. The study focused on July to October in 2016 and 2017, including the influence of long-range transport from Central Africa biomass burning and included seasonal variation from winter to spring.

Compared to the observational and reanalysis data, the seasonal variability of low-level cloud was amplified with increasing absorbing aerosols. In July, the aerosols remained within the boundary layer, and the decrease of CF and precipitation on smoky days was mainly influenced by aerosol-cloud interaction. In September, the position of the subtropical high and the intensity of African easterly jet significantly influenced the aerosols transport and the clouds distribution. Additionally, weaker subsidence in the free troposphere and the thermodynamic instability of the boundary layer resulted in higher cloud tops. In October, further transport of moisture suppressed the dissipation of cloud tops. Combined with higher cloud droplets on smoky days suggested a complex interaction between aerosols and weather systems on clouds. Overall, the effects of the synoptic scale on clouds cannot be overlooked when studying aerosol-cloud interactions. Weather variability can lead to different results for higher aerosol loads.

Keyword

Aerosol semi-direct effect, Cloud physical properties

References

Zhang, J. and Zuidema, P.: Sunlight-absorbing aerosol amplifies the seasonal cycle in low-cloud fraction over the southeast Atlantic, Atmos. Chem. Phys., 21, 11179–11199, https://doi.org/10.5194/acp-21-11179-2021, 2021.