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Aerosol distribution in the northern Gulf of Guinea: local anthropogenic sources, long-range transport and the role of sea surface temperature-induced shallow circulations

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The impact of air-sea interactions in the northern part of the Gulf of Guinea on the distribution of aerosols over coastal southern West Africa (SWA) is investigated using airborne observations gathered on 2 July 2016 during the field phase of the Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa project, as well as numerical simulations. The presence of coastal upwelling along the coastline of Ghana and of high sea surface temperatures offshore of Nigeria generated a zonal overturning circulation between 0° and 10°E below 600 hPa, with enhanced subsidence south of Togo, in the eastern part of the aircraft operation area. The overturning circulation has an influence on the structure of the urban pollution plumes from Accra, Lomé, Cotonou and Lagos. It also has an impact on the complex aerosol layering resulting from long-range transport of dust and biomass burning aerosols, as evidenced from aircraft remote sensing and in situ measurements. Numerical tracer release experiments highlight the dominance of fresh emissions from Accra on the pollution plume composition observed by aircraft over the ocean. The contribution of more aged emission from Lomé and Cotonou (tracers released the previous day) is also evidenced over the ocean. Interestingly, Lagos emissions do not appear to be a player in the area west of Cotonou. The resulting composite tracer plume is also shown not to extend very far south over the ocean, mostly because emissions are transported westward above the marine atmospheric boundary layer. Westward transport was possible due to the interactions between the monsoon flow with complex terrain and land-sea breeze systems, which resulted in the vertical mixing of the urban pollution plume over land.