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Sign and magnitude of the semidirect sffect from elevated smoke layers are sensitive to layer properties and cloud–smoke gap

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The absorption of radiation by carbonaceous aerosol can result in mean local heat perturbations of several Kelvin per day. Subsequent rapid-adjustments to the atmosphere lead to changes in radiation fluxes, referred to as semi-direct radiative effects.
The SE Atlantic is a region that experiences periodic plumes of strongly absorbing smoke that are transported over extensive semi-permanent marine stratocumulus. Before mixing with the cloud layer the elevated plumes are often separated by smoke-free gaps for extended periods of time.
We use the high resolution MetOffice large eddy model to investigate the diurnal cycle of the semi-direct radiative effect from elevated smoke layers above marine stratocumulus cloud. We use a range of experiments to investigate the sensitivity of the semi-direct effect to the gap to layer, thickness of the layer, and smoke aerosol optical depth (AOD). We find a pronounced diurnal cycle driven by changes in cloud-top entrainment that impact daytime coupling to the surface and boundary layer water content. Subsequent changes to the cloud liquid water path drive periods of both positive and negative semi-direct radiative effects, which are sensitive to the amount of time the plume persists over the cloud.
Contrary to published literature, the presence of an overlying layer of absorbing aerosol does not systematically exert a negative semi-direct radiative effect. Instead we show that both the sign and magnitude of the daily mean semi-direct radiative effect of above-cloud smoke layers is sensitive to the smoke layer position, thickness, AOD, persistence, and properties of the boundary layer. Thus, rapid adjustments to atmospheric temperature perturbations caused by above-cloud absorbing aerosol both enhance or mitigate the direct radiative effect.