Less Entrainment of Above-Cloud Smoke into Pockets of Open Cells in the Remote Southeast Atlantic

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Introduction

The CLARIFY field experiment deployed the UK FAAM aircraft to Ascension Island in the remote SE Atlantic during Aug and Sep 2017. The aim was to study aerosol-cloud-radiation interactions during the African biomass burning aerosol (BBA) season, when extensive BBA plumes are transported far offshore in the free-troposphere above the semi-permanent stratocumulus cloud deck. The aircraft campaign provided synergistic measurements alongside the LASIC deployment of the mobile ARM facility.

Entrainment of the BBA into the boundary layer has potentially large but poorly constrained impacts on the cloud properties. This poster presents a case-study showing a possible cloud regime dependence on entrainment of elevated BBA plumes, with much lower entrainment in the region of Pockets of Open Cells (POC) shown in Fig 4 than the surrounding cloud field.

Aircraft Flights

C051: 5th Sep 2017 09-12 Z. Measured cloud upwind of POC.

C052: 5th Sep 2017 14-18 Z. Measurements in and upwind of the POC. Cloud upwind of the POC dissipated in the afternoon.

Key points

Fig 1: Aircraft profiles show that a free-tropospheric BBA plume pervades across both cloud regimes (see also satellite data in Fig 5). Upwind of the POC, there is evidence from PCASP and carbon monoxide (CO) measurements of entrainment of BBA into the boundary layer. Cleaner conditions were measured in the POC, with a pristine layer beneath the trade-wind inversion and new particle formation occurring. Low CO and new particles indicate limited entrainment of BBA into the POC.

Fig 2: Composite of aircraft measurements in the boundary layer also show enhanced precipitation and lower cloud drop number concentrations in the POC.

Fig 3: Surface based observations from Ascension Island show a marked drop off in aerosol and CO as the POC moves over the site late on 5th Sep. This is co-incident with active precipitating cumulus clouds in the POC that are efficient at removing aerosol via collision-coalescence processes.

Fig 4: Back trajectories show that air beneath the lifting condensation level (LCL) originates from the south-east and remains over the Ocean. Air just beneath the trade-wind inversion has recently been entrained into the boundary layer and originates from a region of extensive biomass burning in continental Africa. This is consistent with the aerosol profiles measured upwind of the POC in Fig 1.

Fig 5: Satellite observations show the POC formed early on 4th Sep to the south-east of Ascension Island. This co-incides with an increase in cloud effective radius within the POC.

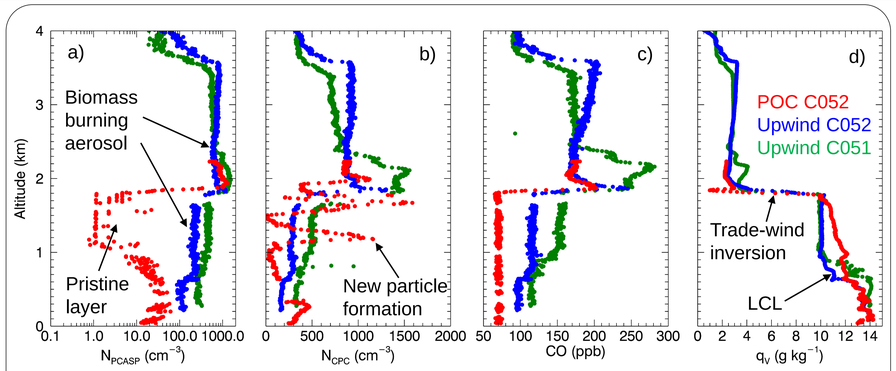

Fig 1: *Example aircraft profiles within and upwind of the POC showing a) aerosol concentration (D>100 nm) b) aerosol concentration (D>3 nm) c) carbon monoxide d) water vapour mixing ratio.*

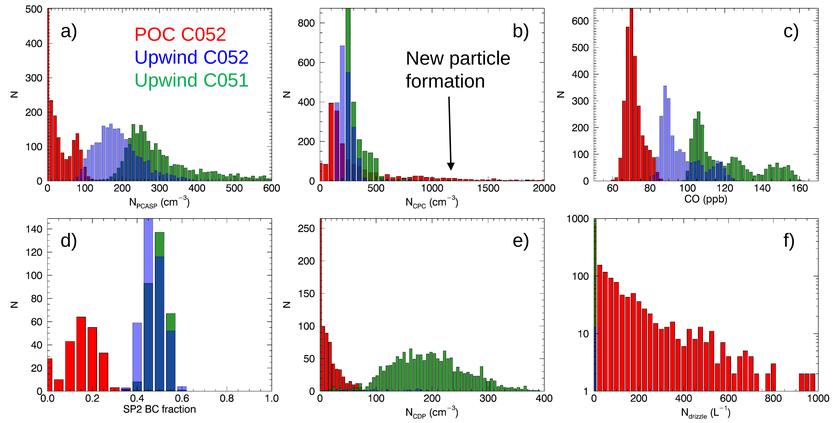

Fig 2: *Histograms showing aircraft boundary layer measurements of a) aerosol concentration (D>100 nm) b) aerosol concentration (D>3 nm) c) carbon monoxide d) aerosol black carbon fraction e) in-cloud drop concentration f) in-drizzle drop concentration (D>100 µm).*

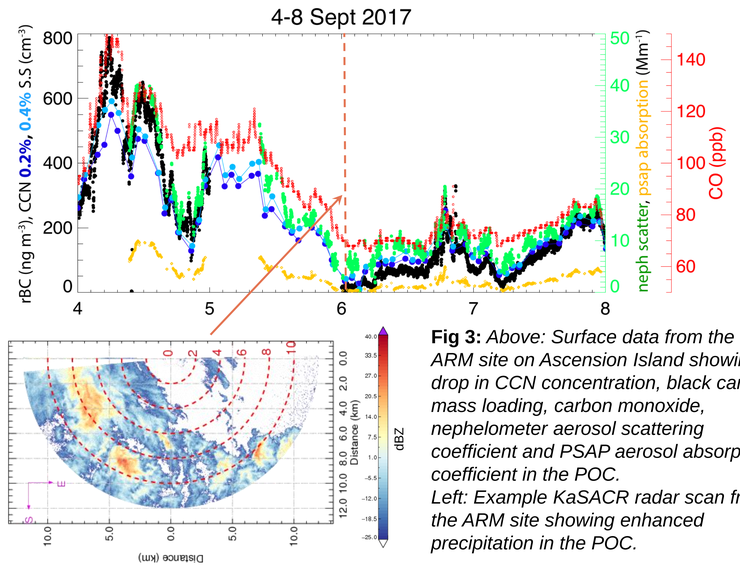

Fig 3: *Above: Surface data from the ARM site on Ascension Island showing a drop in CCN concentration, black carbon mass loading, carbon monoxide, nephelometer aerosol scattering coefficient and PSAP aerosol absorption coefficient in the POC. Left: Example KaSACR radar scan from the ARM site showing enhanced precipitation in the POC.*

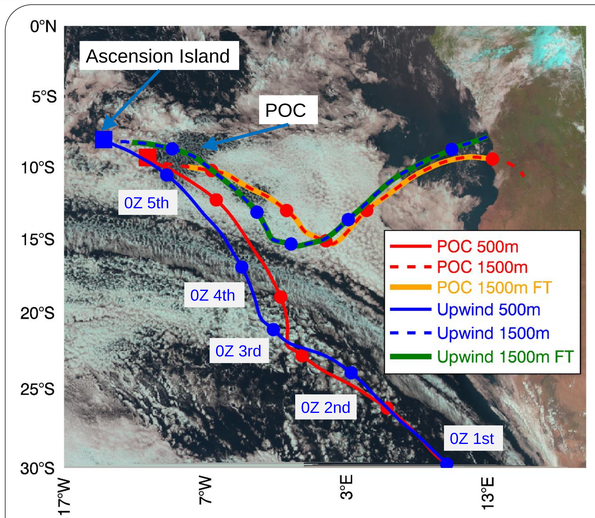

Fig 4: *NAME 5-day back trajectories driven with meteorology from the Met Office global NWP model. Start points (filled squares) are run from the location and times of aircraft profiles from flight C052 within (red) and upwind (blue) of the POC. The trajectories begin at two heights in the boundary layer i) beneath the LCL (500 m) and ii) beneath the trade-wind inversion (1500 m). Filled circles along the trajectories are the locations at 0Z each day. The thicker orange and green lines indicate when the 1500 m trajectories are in the free troposphere (relative humidity < 30%). The SEVIRI satellite image is at 10:00Z on 5th Sep.*

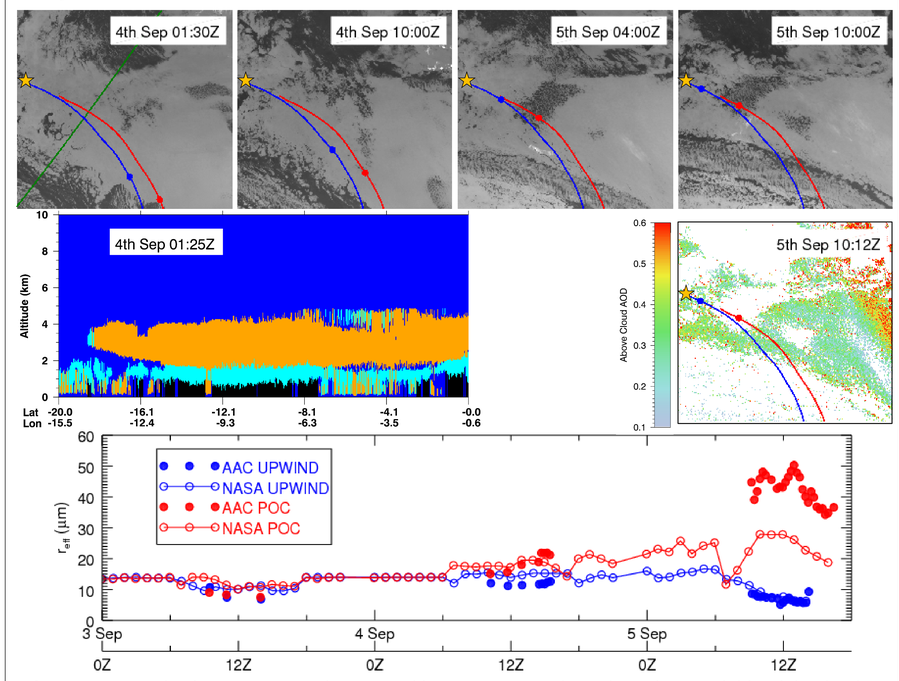

Fig 5: *Top panels show SEVIRI IR imagery with 500 m start-point trajectories overlaid, originating in the POC (red) and upwind (blue). The circles show the location along each trajectory at the times of the imagery. Ascension Island is marked with an orange star. The green line is the track of the CATS space-borne lidar. Middle panels show the corresponding CATS feature mask (orange = aerosol, cyan = cloud) and SEVIRI above cloud aerosol optical depth. Bottom panel shows a time-series of cloud drop effective radius along the trajectories from two SEVIRI retrievals (NASA = VISST/SIST algorithm, AAC = SEVIRI aerosol above cloud algorithm).*

Key message

Entrainment rates of overlying BBA into the POC are small and insufficient to replenish the loss of boundary layer aerosol via efficient collision-coalescence and precipitation processes.

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CATS lidar data were obtained from the NASA Langley Research Center Atmospheric Science Data Center.
NASA VISST/SIST data were obtained from the NASA Langley Cloud and Radiation Research Group.