Spatio-temporal variability in cloud microphysical properties over the South East Atlantic

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1. Introduction

The first Intensive Observation Period (IOP) for ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) was based in Walvis Bay, Namibia between 27 August and 27 September 2016.

In-situ cloud probes installed on the NASA P-3 aircraft are used here to investigate cloud aerosol interactions.

Instrument	Measures	Range
CAPS (CAS)	N(D)	0.58 – 50µm
CIP	N(D)	25 – 1600µm
Hotwire	LWC	0.58 – 50µm
PCASP	N(D)	0.1 – 3um
2DS	N(D)	10 – 1280µm
HVPS	N(D)	150µm – 1.92cm
King Hotwire	LWC	~ 5 – 50 µm

Table 1: Measurement range of instruments

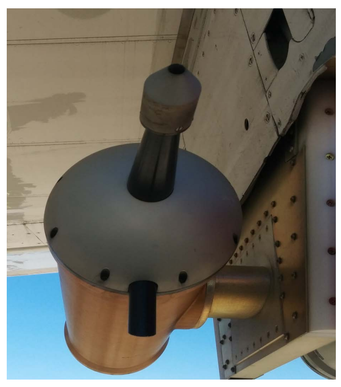

Fig. 1: CAPS and PCASP Probes mounted on the P-3

An ubiquitous stratocumulus cloud deck in the SE Atlantic can be affected by biomass burning (BB) aerosols from Africa. Because aerosols subside as they advect off the coast, they frequently initially overlay the cloud deck, and are later mixed into clouds. This location offers a unique environment to:

- understand how the composition, concentration, age and vertical separation between aerosols and clouds affect cloud microphysical properties

2. P-3 Research Flight 5

P-3 Research Flight 5 (PRF5) on 6 September 2016 surveyed the mixing between cloud and aerosol layers at different locations off the coast of Africa (Fig. 2)

Four sawtooth legs (S1-S4) profiling below, above and within the cloud deck were conducted. S1-3 lied on the same longitude while S4 was closer to the African coast.

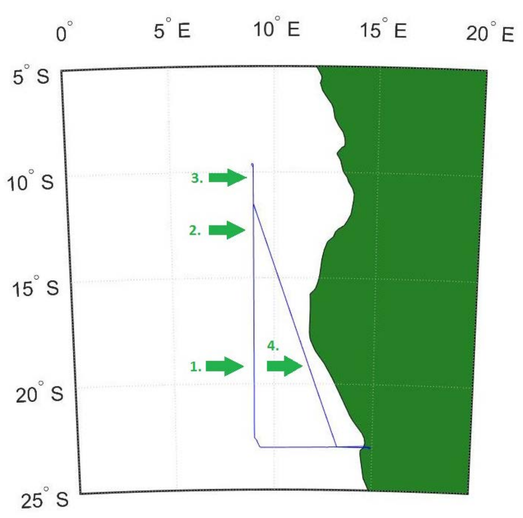

Fig. 2: Flight path for PRF5 on Sept. 6, indicating locations of the sawtooth profiles (African continent in green)

Data from the CAS, CIP, 2DS and HVPS are combined to determine how the cloud liquid water content (LWC), number distribution function N(D) and effective radius (r_e) varied with height, location and aerosol concentration.

3. Sawtooth Profiles

Lower aerosol concentration (~10/cm^3) noted above S1, aerosol layer (~50/cm^3) subsiding into cloud during S2-3 and separation between aerosol (~50/cm^3) and cloud layer closer to the coast (S4).

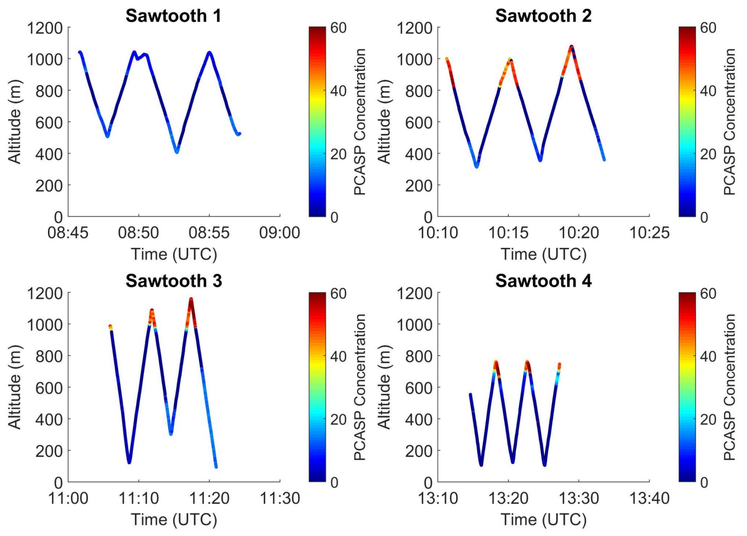

Fig. 3: Altitude profile of sawtooth legs, color coded to PCASP number concentration (#/cm^3)

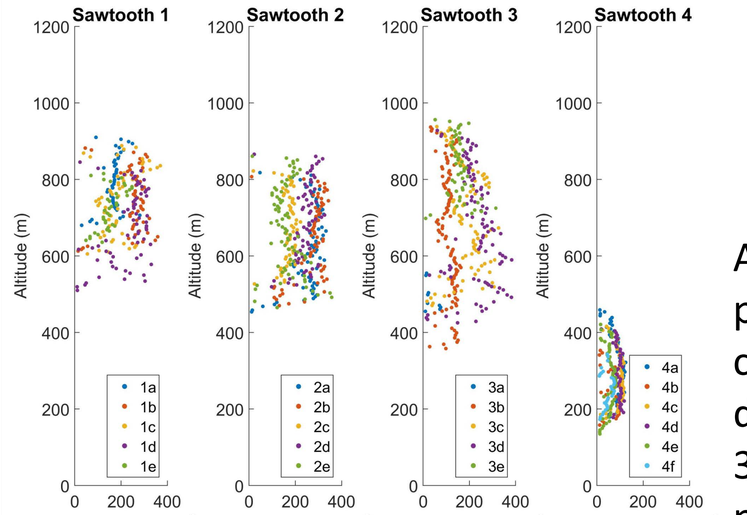

Fig. 4: Altitude profile of sawtooth legs, color coded to King LWC (g/m^3)

Cloud base for S1-3 was ~600m while clouds encountered during S4, sampled closer to coast, were lower in altitude with cloud base close to 200m.

Good correlation between King LWC and CAS LWC derived from droplet size distributions with R = 0.772.

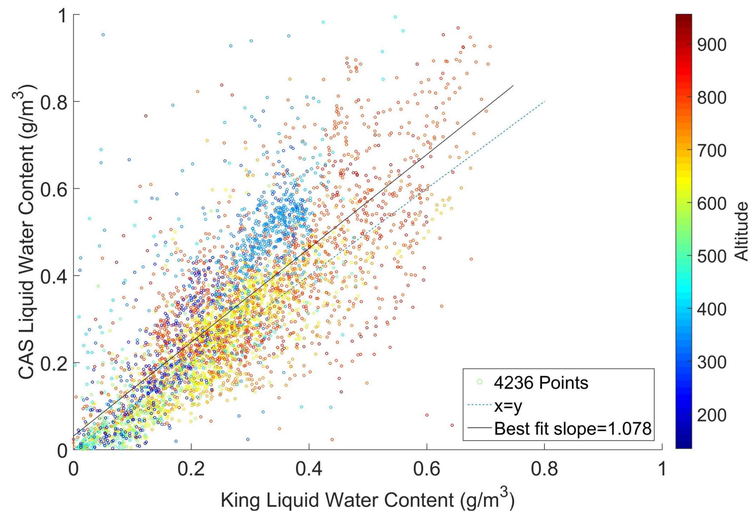

Fig. 5: Scatter between king LWC and CAS LWC within cloud (CAS droplet concentration > 10/cm^3).

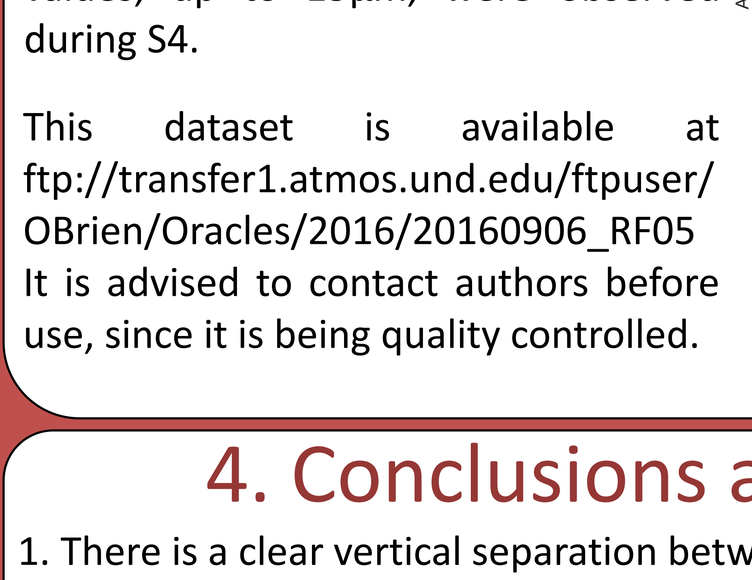

Fig. 6: CAS droplet number concentration (within cloud) versus altitude during each profile, color coded to the individual profile legs.

Although LWC remained ~ constant during profiles, substantially lower droplet concentrations, ~50/cm^3, were observed during S4, as opposed to values closer to 350/cm^3 during S1-3, suggesting the presence of larger droplets.

Effective radius between 5-10µm was observed during S1-3 while greater values, up to 15µm, were observed during S4.

This dataset is available at ftp://transfer1.atmos.und.edu/ftpuser/OBrien/Oracles/2016/20160906_RF05

It is advised to contact authors before use, since it is being quality controlled.

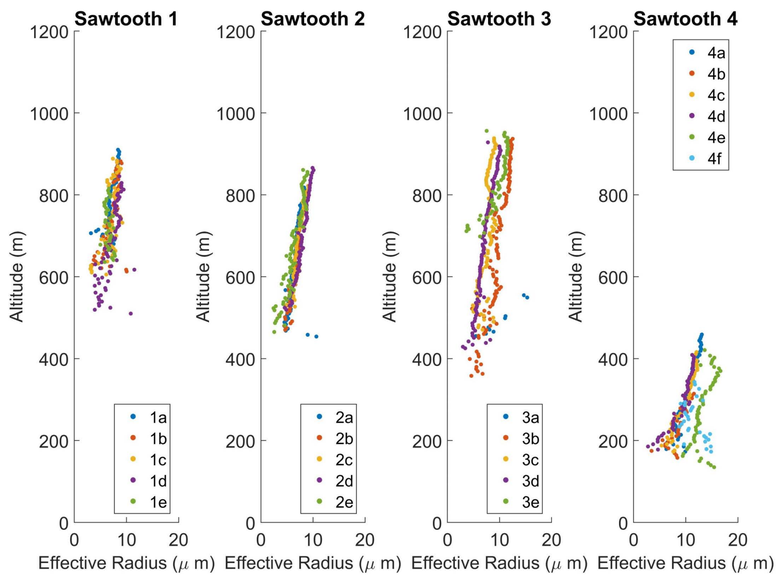

Fig. 7: CAS effective radius (within cloud) versus altitude during each profile, color coded to the individual profile legs.

4. Conclusions and Future Work

1. There is a clear vertical separation between the BB aerosol and cloud deck near the coast of Africa with the aerosol layer subsiding into the cloud deck as it is advected away from the coast.
2. For constant LWC, there is lower droplet concentration and larger droplets closer to the coast.
3. Similar analysis will be done for level legs within the cloud during PRF5 and for other research flights; cloud parameters derived from in-situ measurements will be compared against those retrieved from remote sensing retrievals.

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