Ultra-clean marine boundary layers over the southeast Atlantic

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Background

Why the southeast Atlantic?

- Seasonal biomass burning aerosol layer overlies stratocumulus deck–interaction uncertain

Why focus on 'ultra-clean' MBL in region heavily impacted by biomass burning?

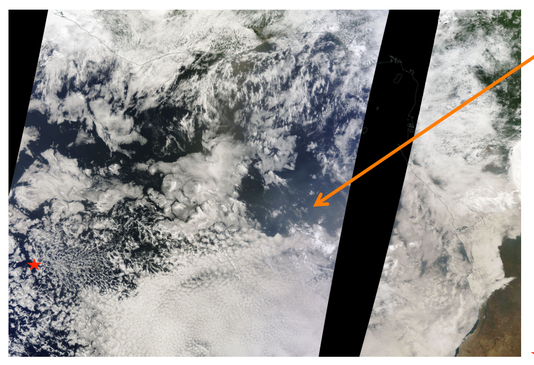
- Processes driving variability in MBL aerosol number crucial for cloud-mediated forcing

Guiding research questions:

1. Do ultra-clean conditions occur over the SEATL, and what is their place in broader surface aerosol variability?
2. Are ultra-clean conditions associated with enhanced precipitation?
3. Do signatures of biomass burning remain on ultra-clean days?

Layered **A**tlantic **S**moke **I**nteractions with **C**louds:
ARM Mobile Facility → Ascension Island (ASI)
June 2016 – October 2017

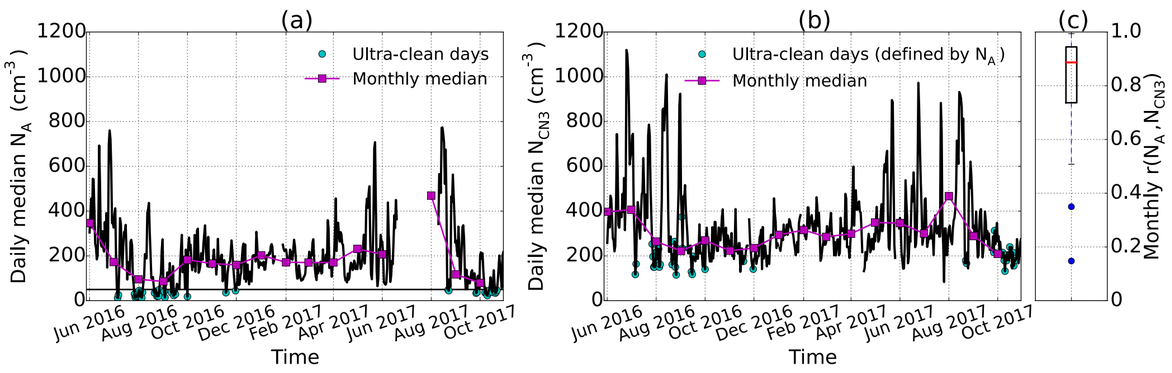
Ultra-clean day = daily median UHSAS (accumulation mode) aerosol number < 50 cm^{-3}



Terra/MODIS true color image from Aug. 24, 2016, an ultra-clean day at ASI

Part I: Ultra-clean days at ASI

Aerosol number from UHSAS (N_A) & Ultra-fine (>3 nm) CPC (N_{CN3})



N_A and N_{CN3} usually very well correlated (r > 0.8)

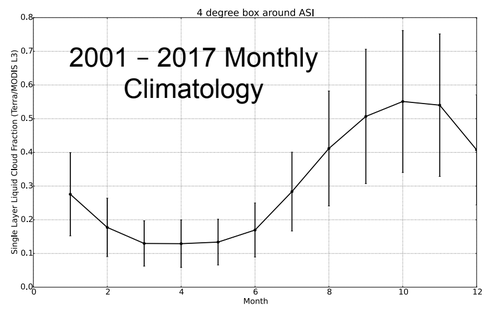
41 ultra-clean days (28 in 2016, 13 in 2017) → all between July & November (primary biomass burning season)

High variability in surface aerosol during early biomass burning season

- Smoke intrusions evident in N_A and N_{CN3} from May – August
- Often precede extended ultra-clean periods in July/August
- August 2016 (12 days) and October 2017 (9 days) have most ultra-clean days of their respective years → persistence in both ultra-clean & polluted conditions

Why the seasonality?

We hypothesize a central role for low clouds through vigorous coalescence scavenging. In other words, you need clouds to get ultra-clean days.



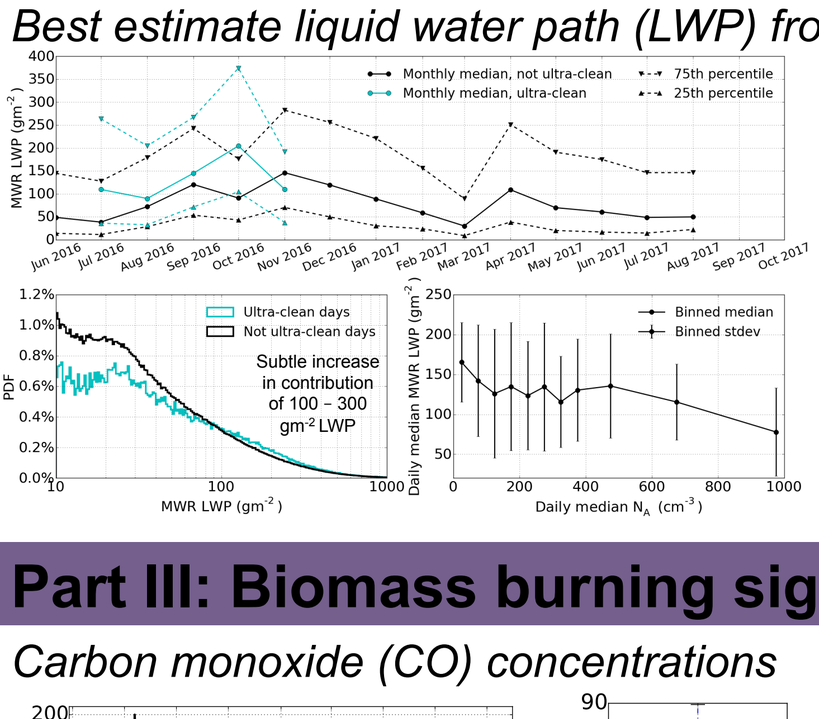
Climatological liquid cloud fraction around ASI peaks in months we observe ultra-clean days

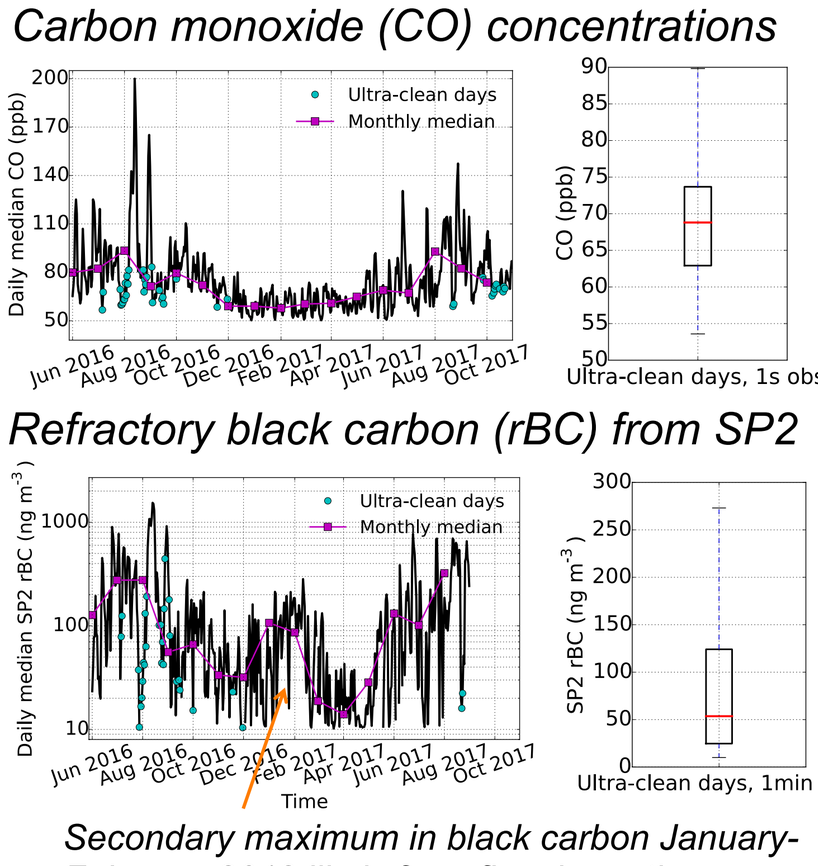
Ultra-clean & polluted: many similar BL trajectories

Not just air mass origin; but somewhat more from cleaner mid-latitudes

Part II: Precipitation signatures

Best estimate liquid water path (LWP) from 2-ch. microwave radiometer (MWR)

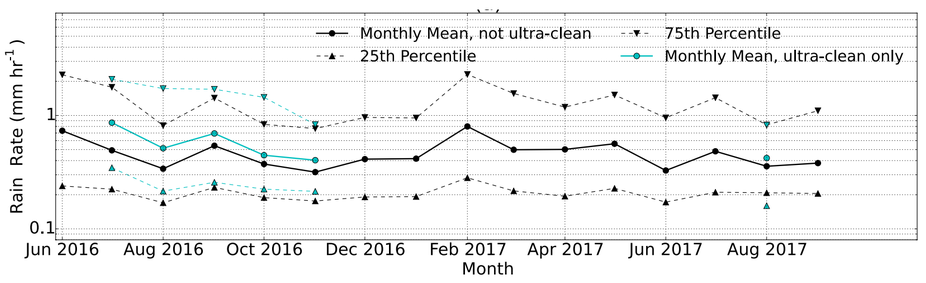




Higher LWP (across statistics) on ultra-clean days within a month → **possible sign of heavier drizzle/ coalescence scavenging**

Median LWP lower for higher daily median N_A but **minimal sensitivity and large spread for daily median N_A ~100 – 500 cm^{-3}**

Rain rates from Parsivel2 Laser Disdrometer



Ultra-clean days do exhibit higher surface rain rates than non-UC days within the same month

Part III: Biomass burning signatures

Carbon monoxide (CO) concentrations

Refractory black carbon (rBC) from SP2

Secondary maximum in black carbon January-February 2018 likely from fires in northern Africa – where is CO signature?

Ultra-clean days feature variable CO and black carbon

- Never as high as large smoke intrusions (>100 ppb CO, 500 – 1000 ng m^{-3} rBC)
- But – often elevated relative to non-biomass burning periods/ seasonal minimums
- **Ultra-clean days are not completely explained by a lack of contact with biomass burning smoke → further supports a role for drizzle scavenging**

Key Points

1. Ultra-clean days are notable feature in surface aerosol variability at ASI during early part of primary biomass burning season
2. Ultra-clean conditions are associated with relatively higher LWP clouds and higher surface rain rates at ASI
   → *Continuing work*: *LWP along back trajectory using co-located passive microwave satellite retrievals*
3. CO and rBC suggest many ultra-clean air masses have muted but observable interaction with biomass burning smoke; further work on balance of sources and sinks needed

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