Aerosol Physical and Chemical Properties and Their Relationship With CCN at the AMF-Azores Site

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Introduction

- Aerosol physical and chemical properties and their influences on clouds present the largest uncertainties in estimating anthropogenic forcing of climate change and in predicting future climates.
- Global climate models do not account for the internal properties of aerosols and tend to over- or under-estimate their effects.

Motivation

The primary goal of this study is to use case studies over the AMF-Azores site to address two Scientific Questions (SQ):

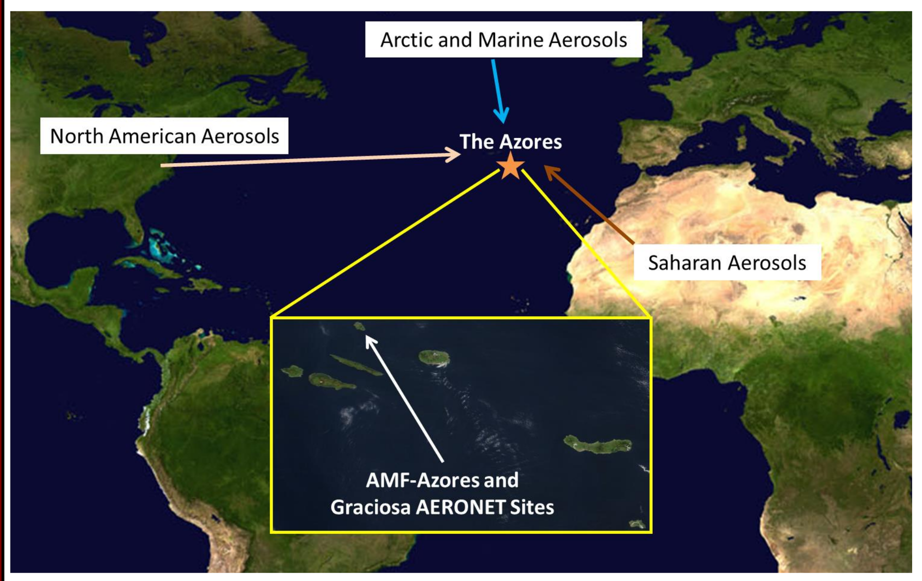
1) What are the various aerosol types over this area?

2) Are there significant influences of various aerosol types on cloud condensation nuclei (CCN)?

Data and Methodology

- Use AERONET retrievals of AOD ≥ 0.25 to identify cases of aerosol plumes over the AMF-Azores site.
- Use volume size distribution to investigate fine and coarse mode aerosol contributions.
- AMF-Azores aerosol and CCN retrievals will provide useful information on aerosol type and cloud properties.
- Use HYSPLIT backward trajectory model in order to verify the origins and pathways of different types of aerosols that can impact the retrieved low level cloud microphysics.

Azores Site



Discussion – Figure 1

- Arctic and marine aerosols are typically sea salt.
- North American aerosols generally consist of fine mode, urban/industrial pollution and biomass burning types.
- Saharan (N. African) aerosols are coarse mode, mineral dust.

Figure 1: The Azores consists of a chain of islands in the eastern Atlantic which is affected by several types of aerosols. This region is also affected by semi-permanent air masses (e.g., Azores High and Azores Low) which can advect various aerosol types from North America, Africa, and the surrounding ocean.

AMF-Azores: Dust Case

Discussion – Figure 5

- Scattering coefficient – weak and inverse spectral dependences denote large, coarse mode aerosols
- Absorption coefficient – strong spectral dependence in the visible (440-550 nm) denoting mineral dust
- Mean CCN magnitude shows a decrease coinciding with an increase in the scattering and absorption coefficients
- Weak correlation shown in (c)
  - Likely due to the large number of supermicron dust aerosols

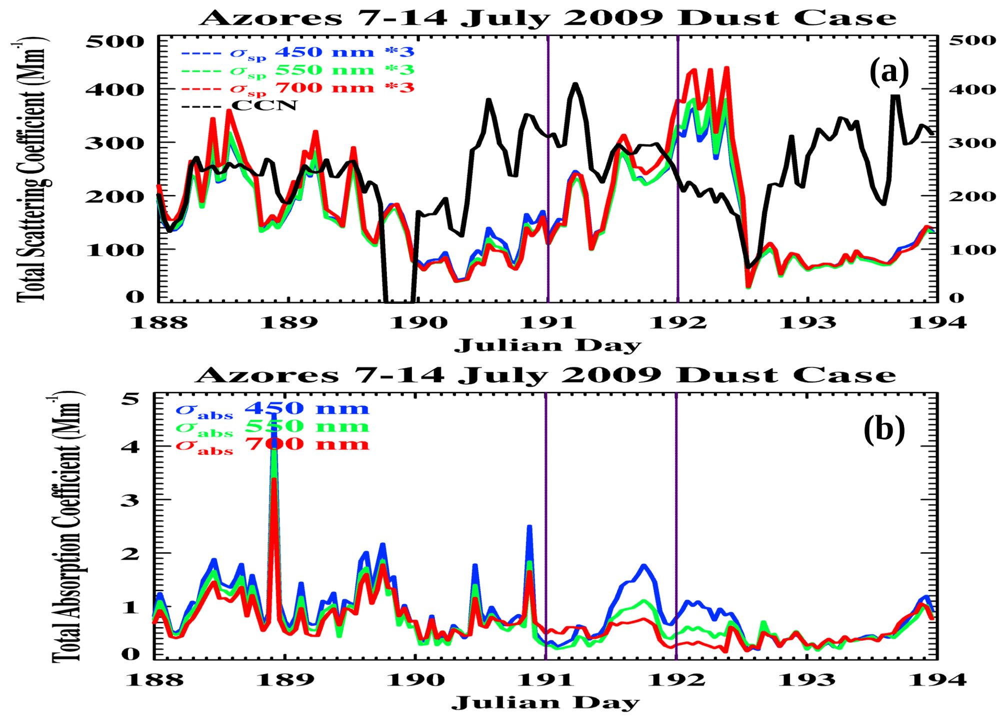
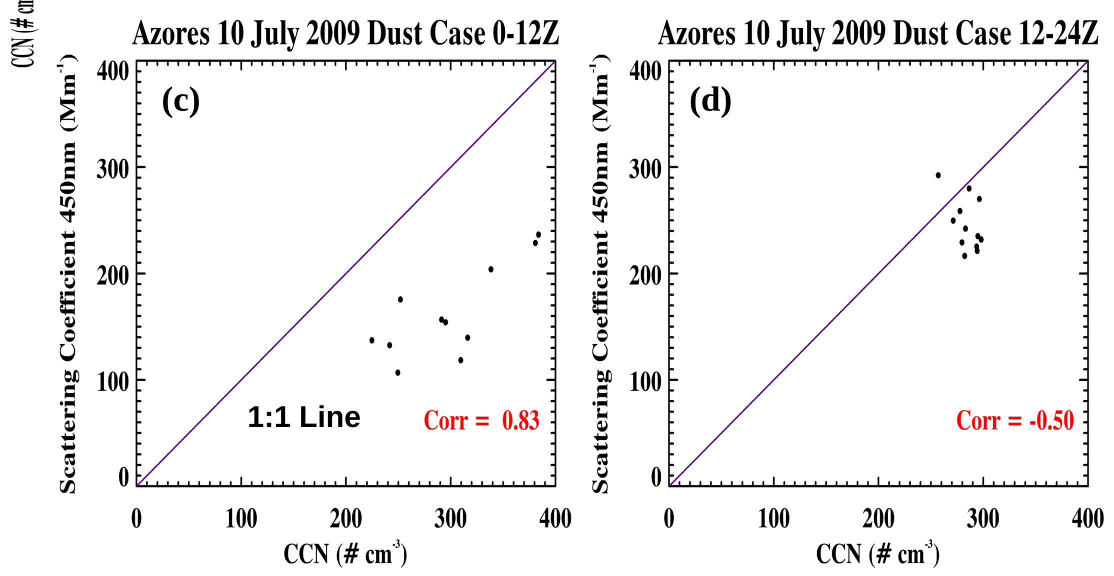


Figure 5: (a) Scattering coefficient is multiplied by 3 in order to match magnitude of CCN, (b) absorption coefficient, and (c-d) correlation between CCN and scattering coefficient.



AMF-Azores: Mixed Cases #1

Discussion – Figure 6

- Scattering coefficient – weak spectral dependence for 9 May; moderate for 13 May
- Coarse mode dominates the first case but little similarity to the 10 July dust case
- Fine mode is dominant in second case suggesting possible pollution and biomass burning aerosol mixture
- Absorption coefficient – weak spectral dependence for 9 May case
  - Absorptive properties of volcanic ash can resemble coarse mode pollution aerosols
- Strong correlation between CCN and aerosol loading in both cases

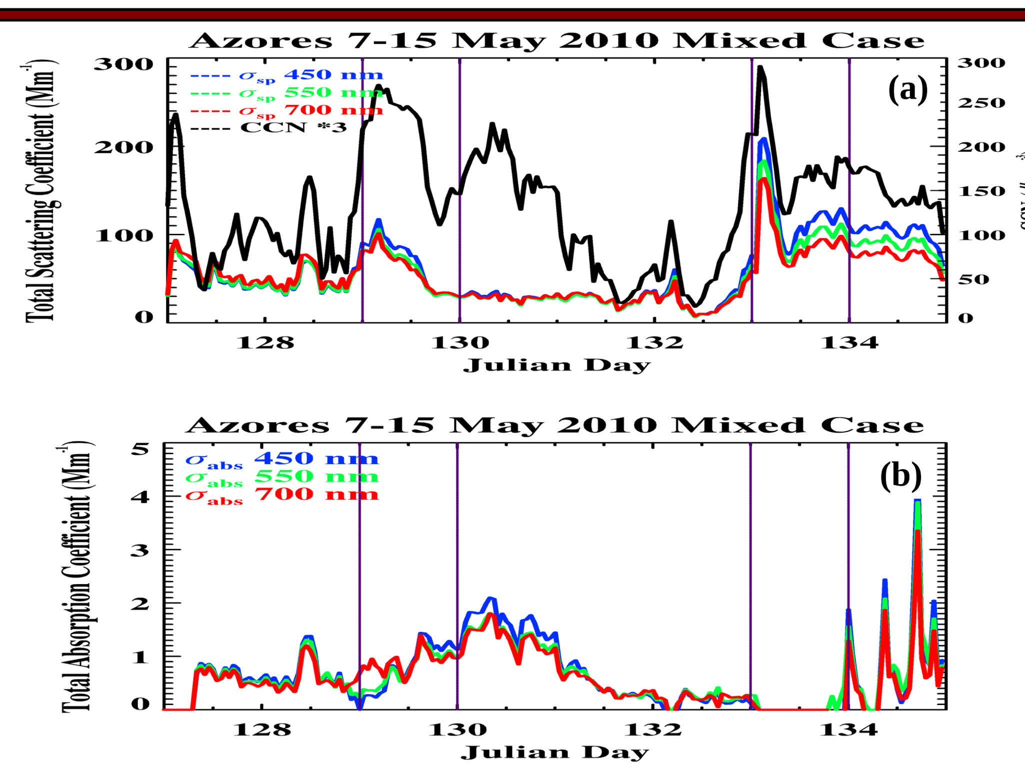
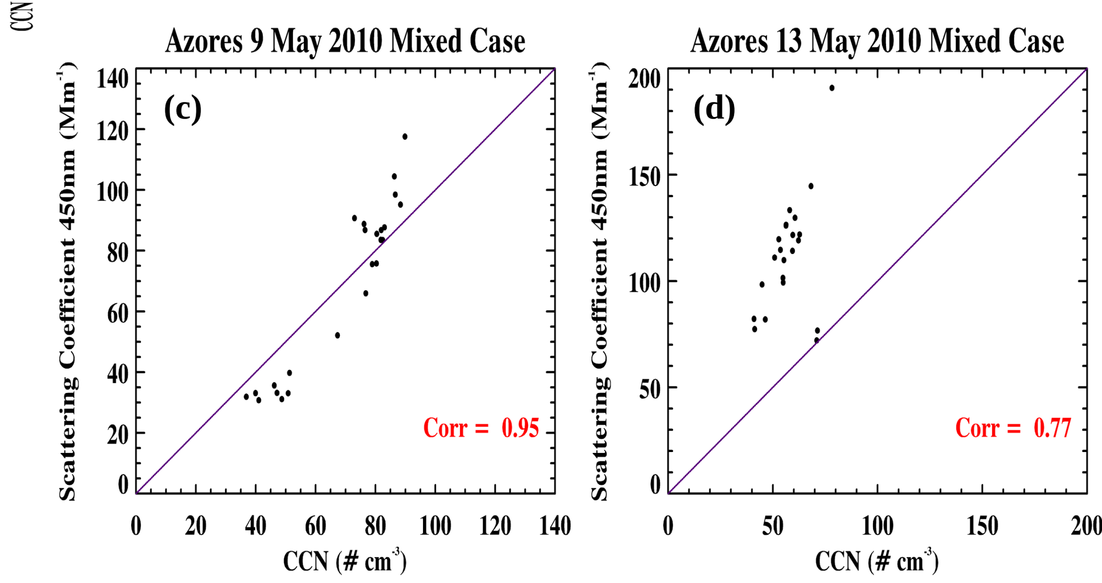


Figure 6: (a) CCN is multiplied by 3 in order to match magnitude of scattering coefficient, (b) absorption coefficient, and (c-d) correlation between CCN and scattering coefficient.



AMF-Azores: Mixed Cases #2

Discussion – Figure 7

- Scattering coefficient – spectral dependence is moderate in both cases
- Absorption coefficient – increases over the time interval; weaker spectral dependence for 7 September case, moderate for 8 September case
- Indicative of mixed aerosol type; mainly pollution and mineral dust
- Moderate correlation in (c) and negative correlation in (d) due to mineral dust aerosol influence
- This case has properties of both the July and May cases

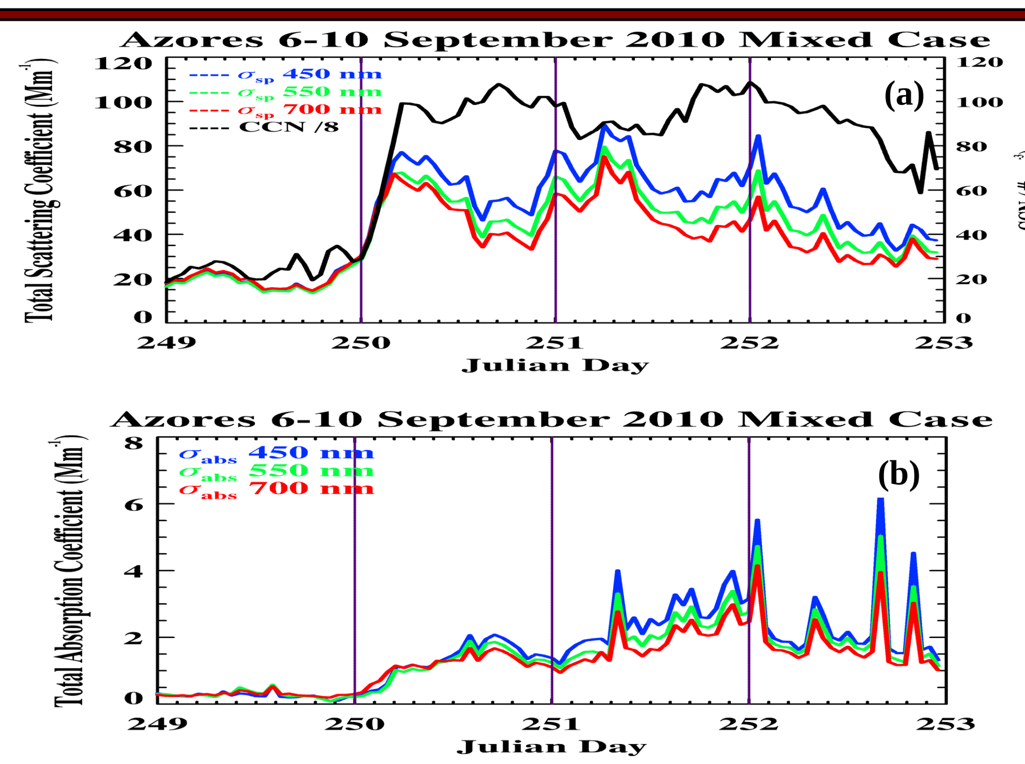
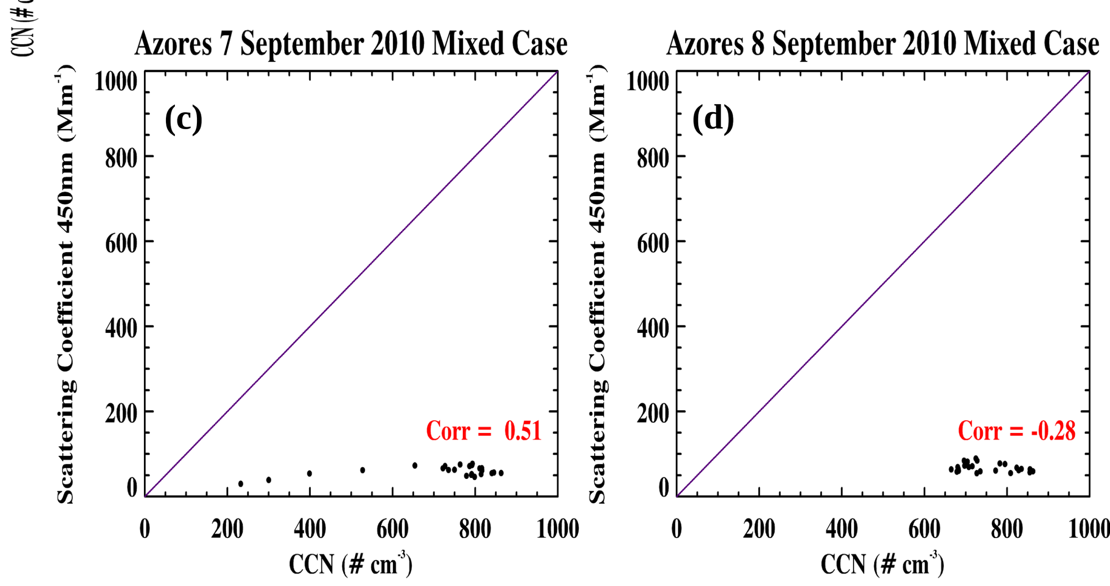
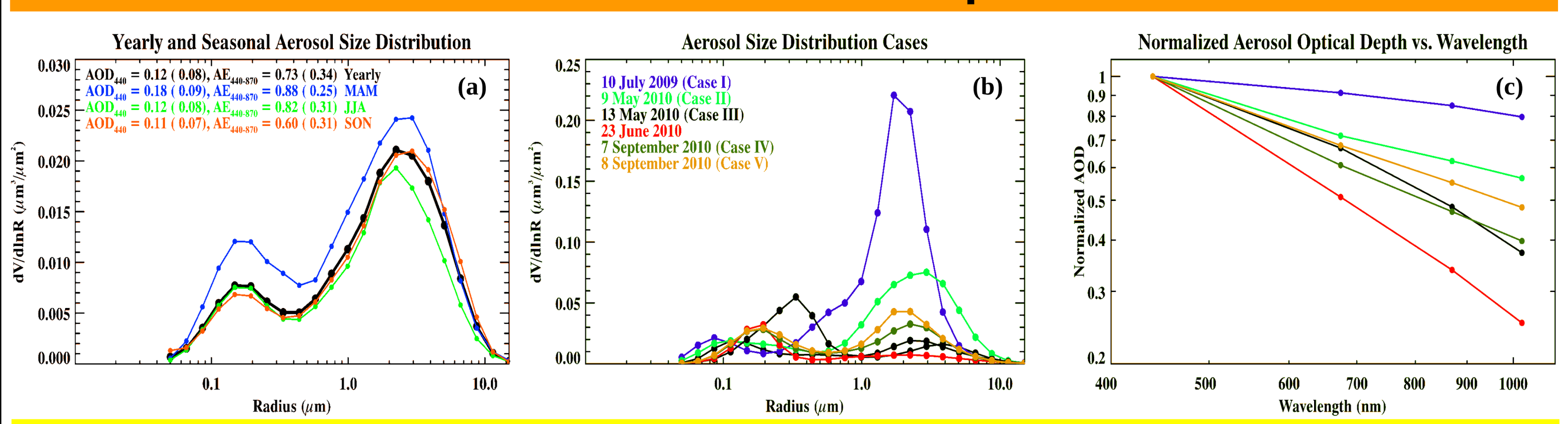


Figure 7: (a) CCN is divided by 8 in order to match magnitude of scattering coefficient, (b) absorption coefficient, and (c-d) correlation between CCN and scattering coefficient.

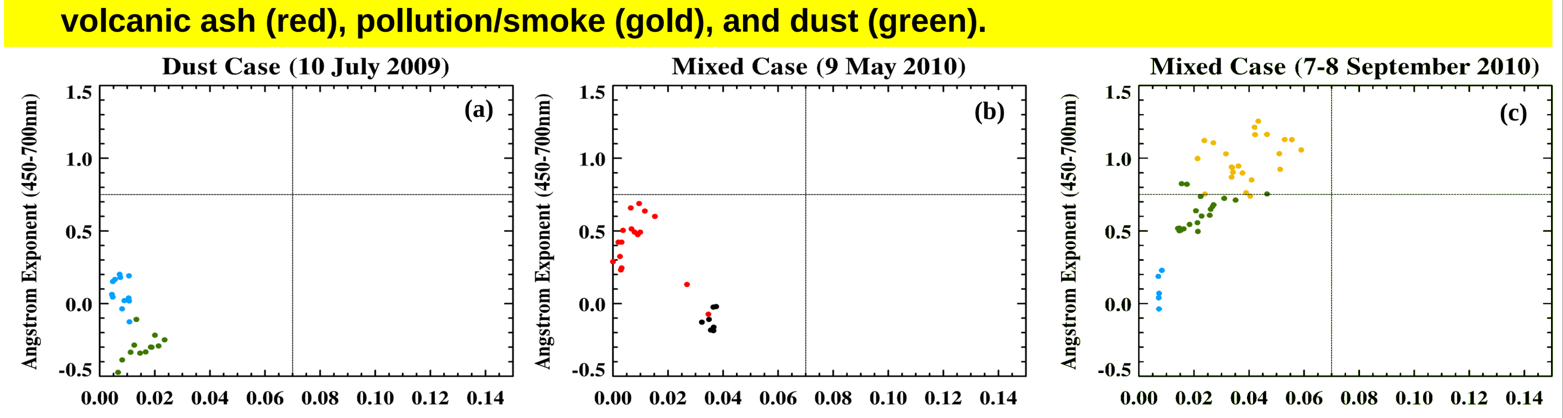


Retrieved Aerosol Properties

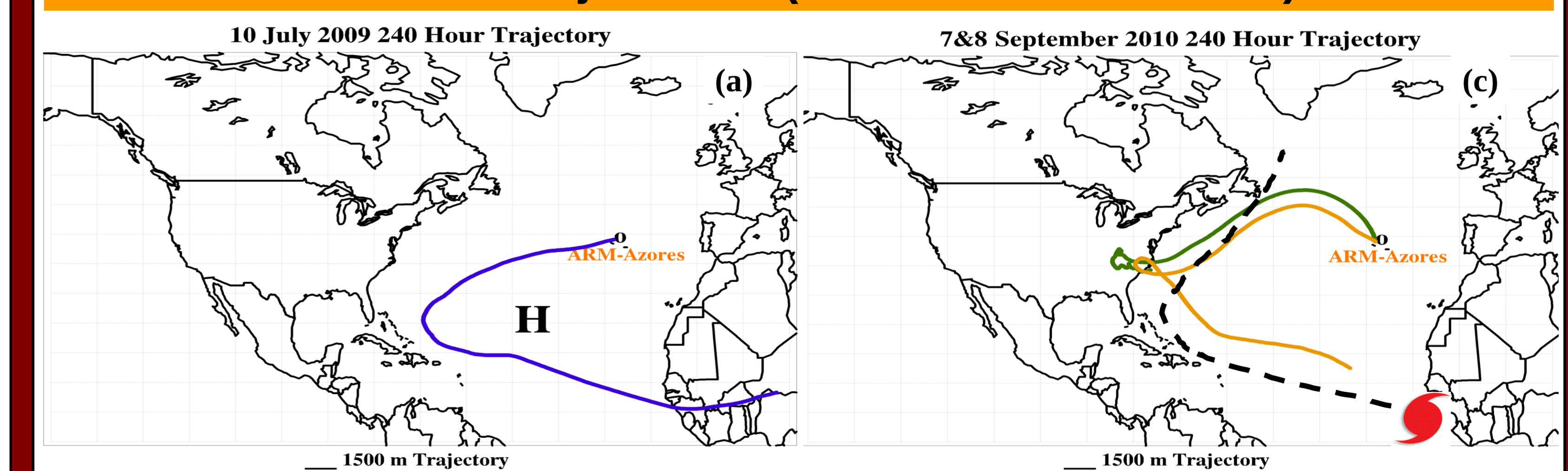


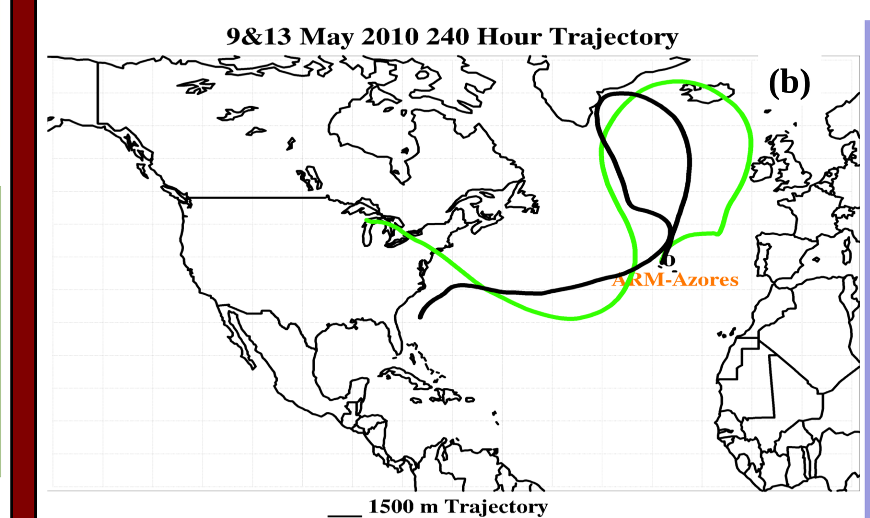
Discussion

- Figure 2 (top) – AERONET retrieved aerosol size distribution for (a) the year and (b) each specific case. (c) Spectral dependence of each case with coarse mode having the weakest dependence and fine mode with the strongest dependence.
- Figure 3 (bottom) – *Logan et al. (2013)* aerosol classification method with sea salt (blue), volcanic ash (red), pollution/smoke (gold), and dust (green).



HYSPLIT Trajectories (1500 m A.G.L. altitude)





Discussion – Figure 4

(a) 10 July – Saharan dust transported by a strong Azores High pressure system

(b) 9 May – Volcanic ash from Iceland advected to the Azores within 72 hours after an eruption

13 May – Pollution and biomass burning aerosols from North America

(c) 7 & 8 September – A combination of North American pollution and Saharan mineral dust from Hurricane Earl

Summary

- Several aerosol plumes were detected over the Azores by the AMF and AERONET observational platforms during the 2009-2011 study period. They were identified as containing mineral dust, pollution, and biomass burning by the *Logan et al.* (2013) method. Volcanic ash was also detected.
- The magnitude of CCN was affected by the presence of these aerosols by increasing with fine mode aerosols (pollution and biomass burning) and decreasing in the presence of coarse mode aerosols (mineral dust).
- Changing synoptic patterns were responsible for the varying aerosol source regions as pointed out by *Rémillard et al.* (2012).

Future Work

- Conduct longer term study in other parts of the world to determine how different types of aerosols influence CCN in both marine and continental settings (e.g., ARM-SGP and ARM-ENA sites)

Acknowledgements

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