Changes in Absorbing Aerosol Properties during Transport in the Southeast Atlantic

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January 16, 2023

Abstract

Biomass burning (BB) is one of the largest sources of absorbing aerosols globally and accounts for about 40% of black carbon in the atmosphere. The Southern African region contributes approximately 35% of Earth's BB aerosol emissions. During the Southern Hemisphere winter, smoke is transported over the southeast Atlantic Ocean, overlying and mixing with a semi-permanent stratocumulus cloud deck. Aerosol-cloud interactions contribute the largest uncertainty to anthropogenic forcing, and the southeast Atlantic region exhibits a large model-to-model divergence of climate forcing. This makes the region particularly valuable for understanding these interactions and was one of the factors motivating the three-year NASA ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) mission. Previous studies using ORACLES datasets have explored the distribution of aerosol and cloud particles, however, changes in some aerosol properties during transport are not well documented.

This study investigates the evolution of biomass burning aerosol properties from emission within Southern Africa, transport over land, and then over the Atlantic. Measurements from a collection of airborne in situ and remote-sensing instruments including 4STAR (Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research) along with ground-based AERONET (Aerosol Robotic Network) are combined with results from two regional models, the WRF-AAM and WRF-CAM5 to explore the changes in the optical properties of these smoke plumes as they age. The aerosol age is determined using tracers from the WRF-AAM configured with 12 km resolution over the region's spatial domain (41 ^{o}S – 14 ^{o}N, 34 ^{o}W – 51 ^{o}E). Changes in extinction, single scattering Albedo (SSA) and angstrom exponent (AE) with age as well as a comparative analysis between observations and model results were carried out using datasets from airborne PSAP (Particle Soot Absorption Photometer) and nephelometers, 4STAR, AERONET, and WRF-CAM5.

Abstract content goes here

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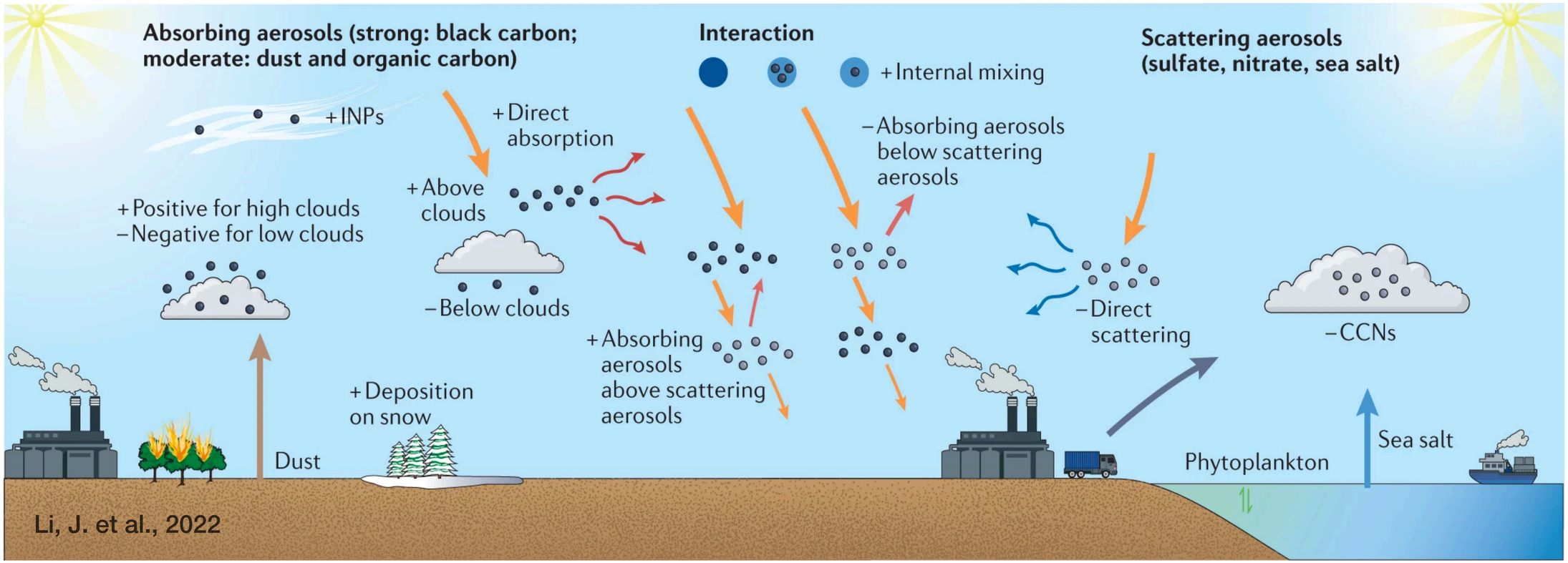
CLouds · CLimatE · Aerosols · Radiation

Background to Study

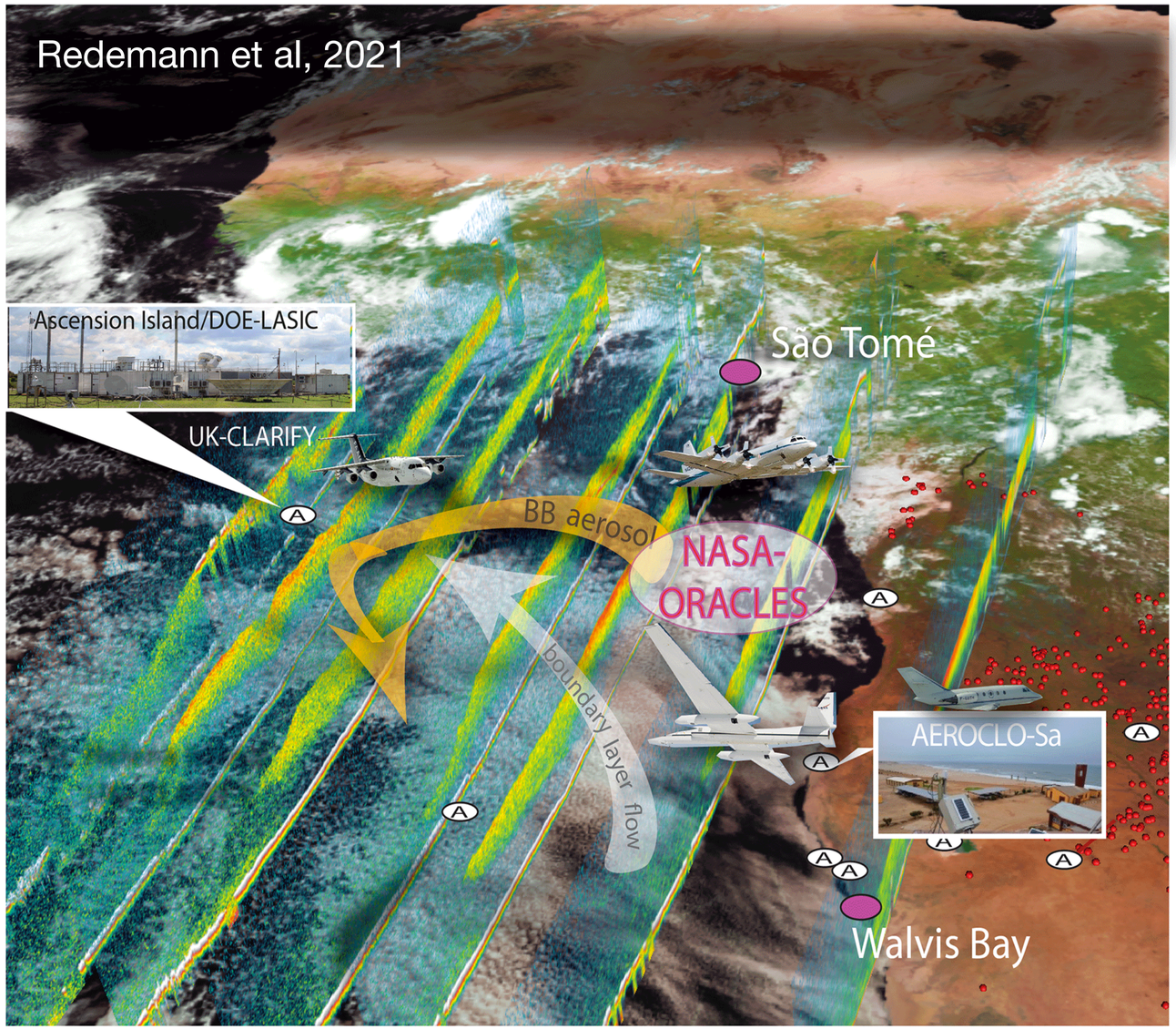
- **Biomass burning** is a large source of absorbing aerosols globally and accounts for about 40% of **black carbon** in the atmosphere.

- The **Southern African** region contributes approximately 35% of Earth's biomass burning aerosol (BBA) emissions.



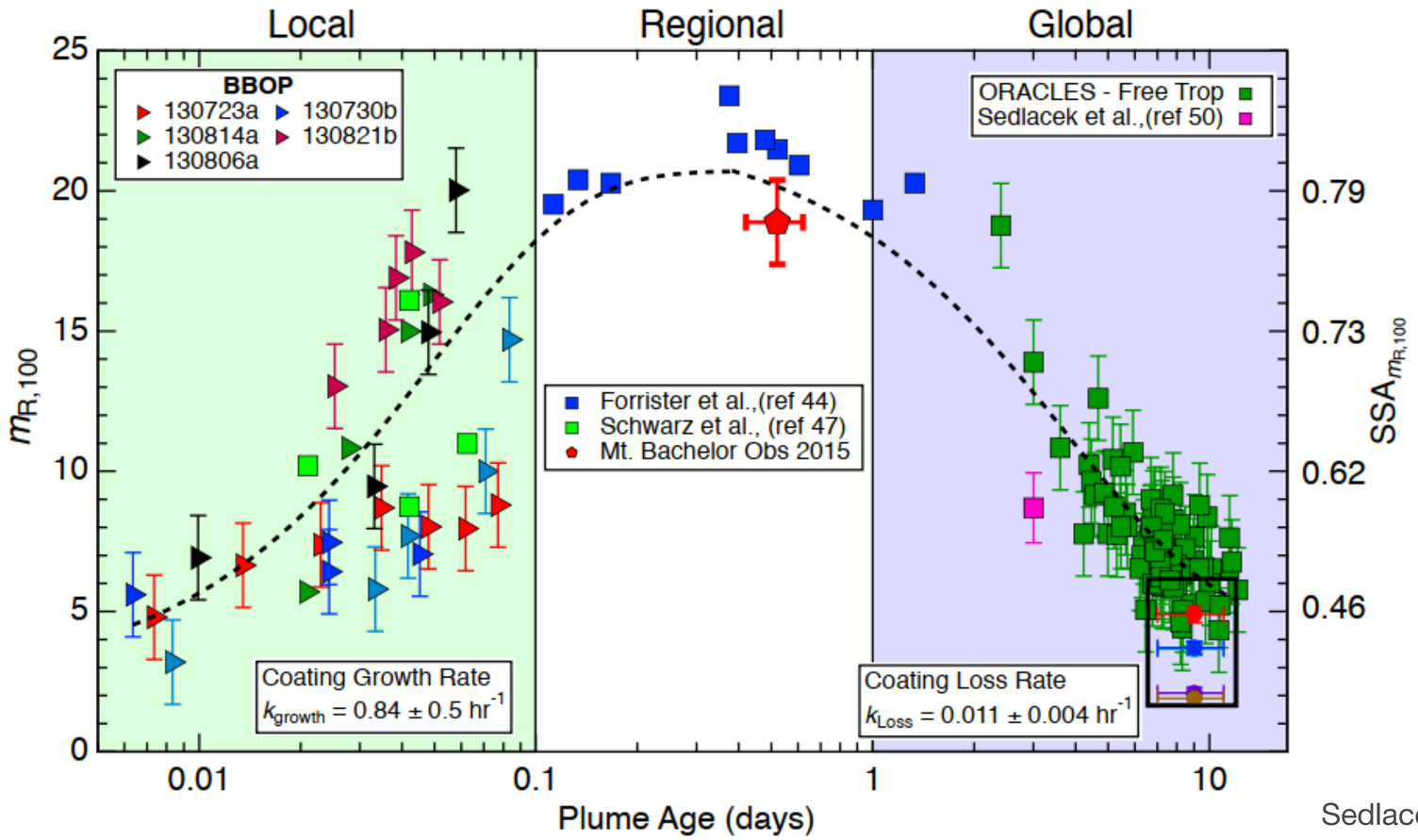
Background to Study

- The emissions are advected over the southeast Atlantic
- Different processes begin to change particulate properties.
- The **evolution** of these **properties** is not well-documented
- Single Scattering Albedo (SSA) contributes significantly to estimates of Direct Radiative Forcing (DRF)



Objective

To study the changes in BBA properties that can be detected by remote-sensed observations



Sedlacek III et al *(submitted)*

Methods - Dataset

Ground-based:

Aerosol Robotic Network **(AERONET)**

- spectral AOD, aerosol microphysics.

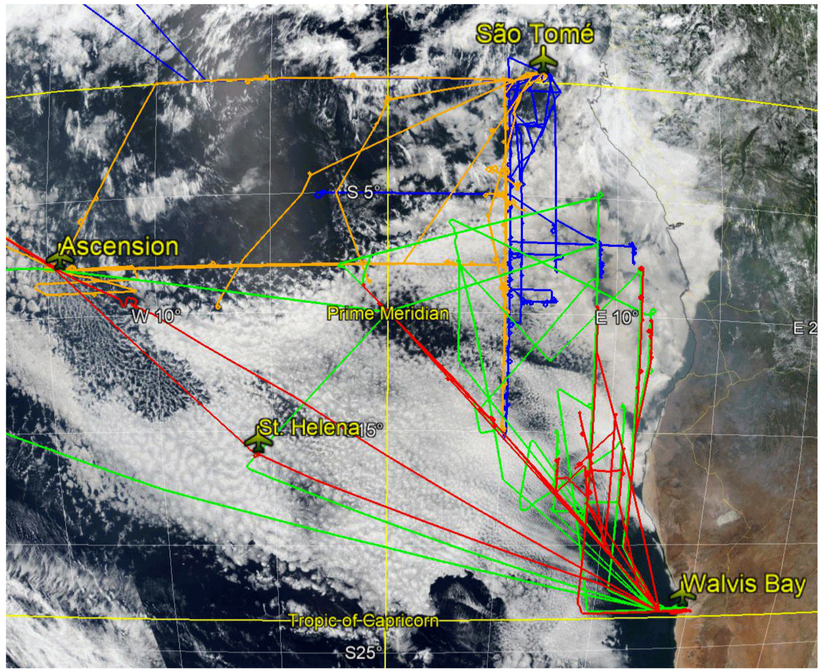
Stations: Mongu, Huambo, Namibe, Ascension

Airborne:

Spectrometer for Sun-Tracking Sky-Scanning Atmospheric Research **(4STAR)**

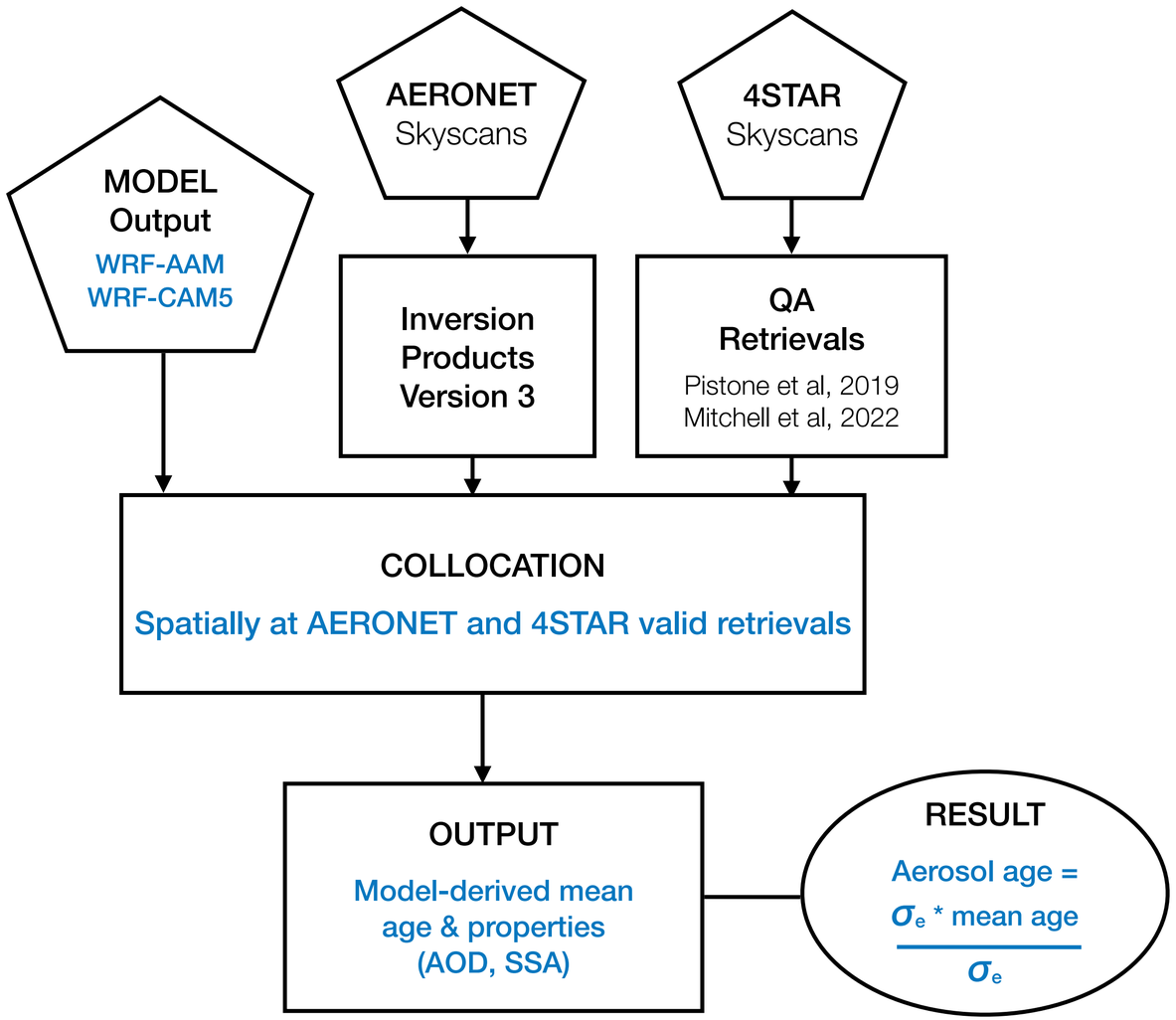
- hyper-spectral AOD, aerosol microphysics.

On P-3 in ORACLES 2016, 2017, 2018.



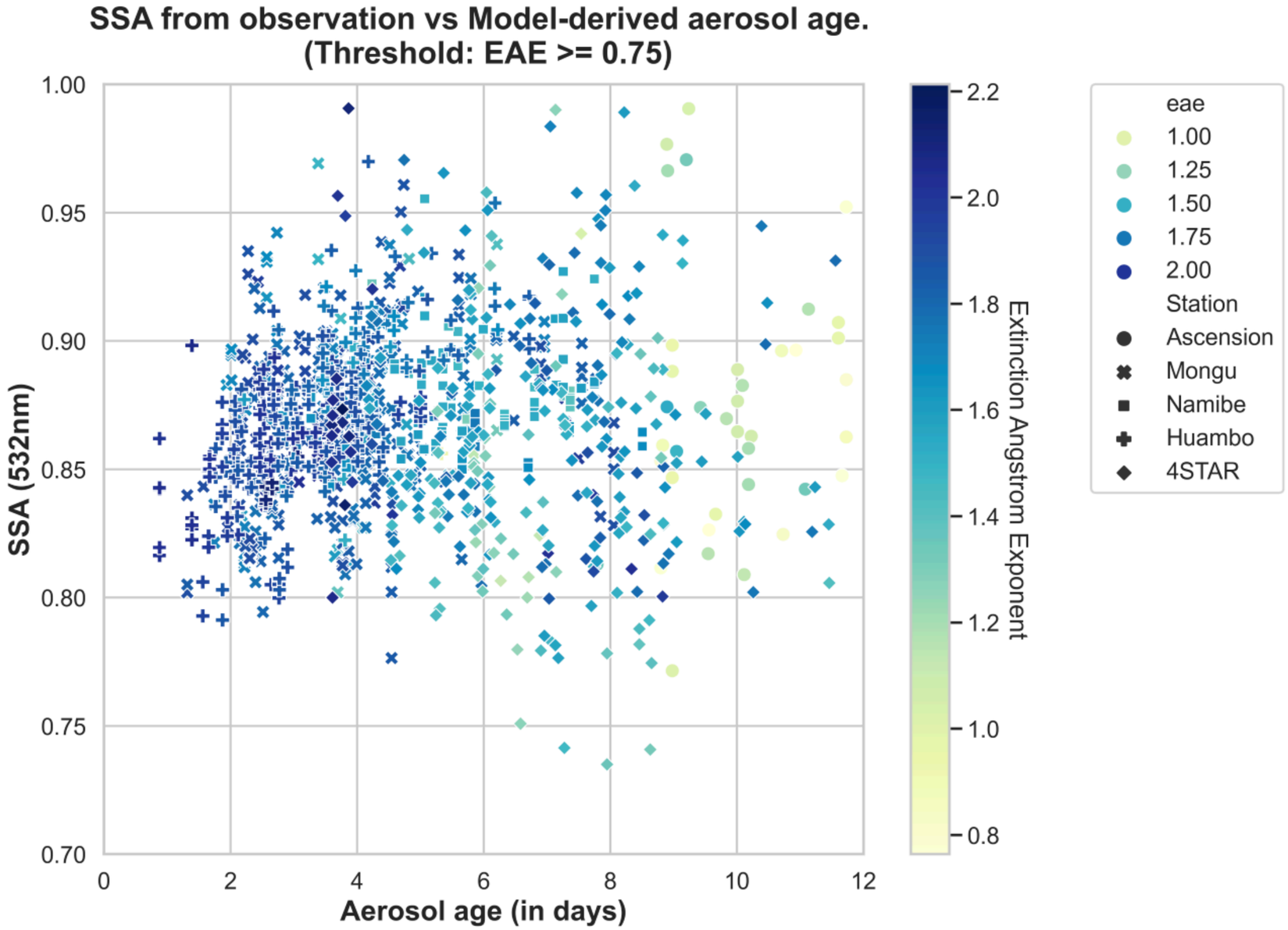
Methods - Workflow

Model/ Parameter	WRF-AAM	WRF-CAM5
Meteorology	NCEP GFS	NCEP FNL
Emission	QFED2	QFED2
Spatial Resolution	12km	36km
Domain	41◦S-14◦N, 34◦W-51◦E	41◦S-14◦N, 34◦W-51◦E
	AERONET	**4STAR**
No of Obsvervations	1600	300

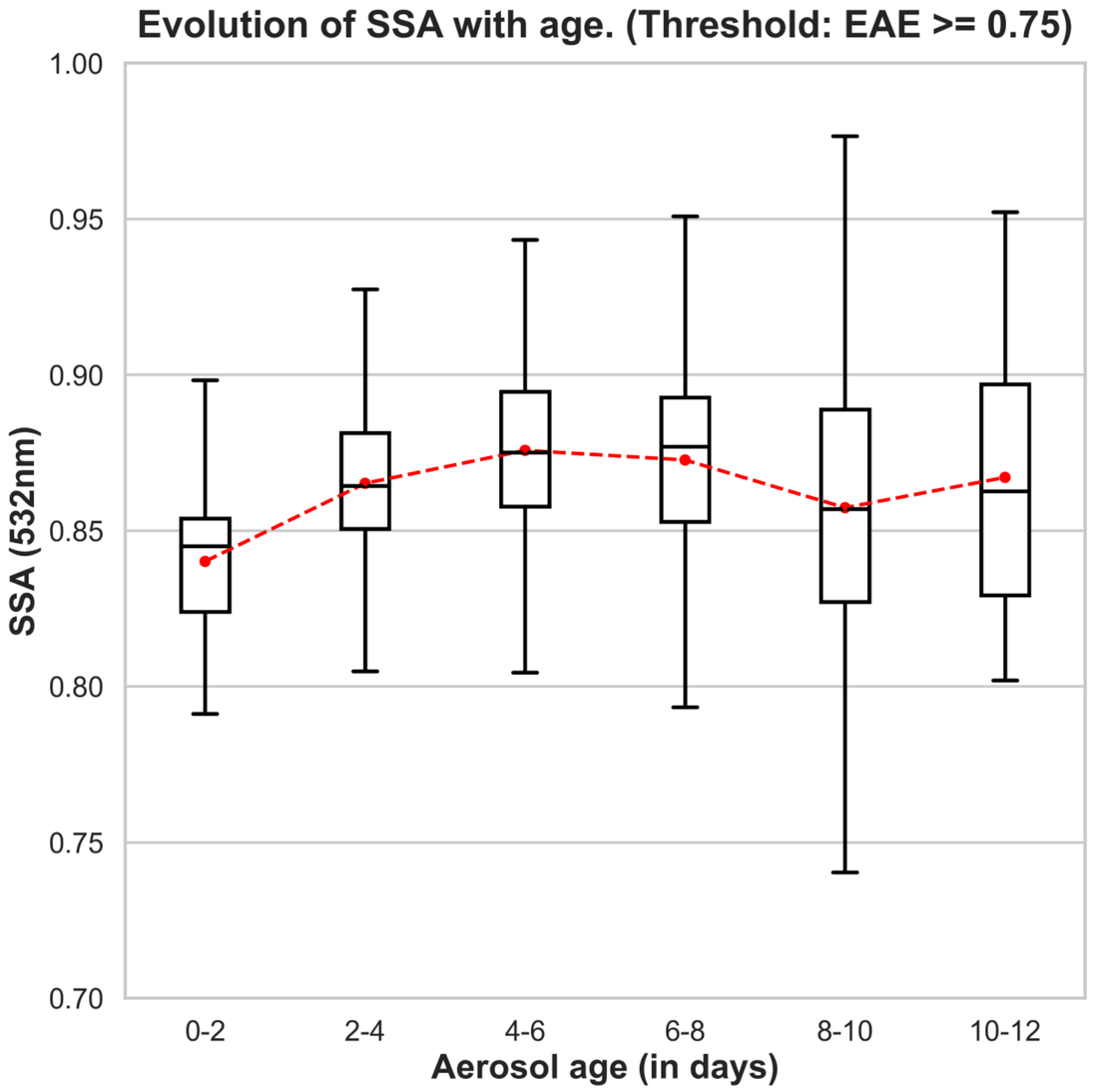


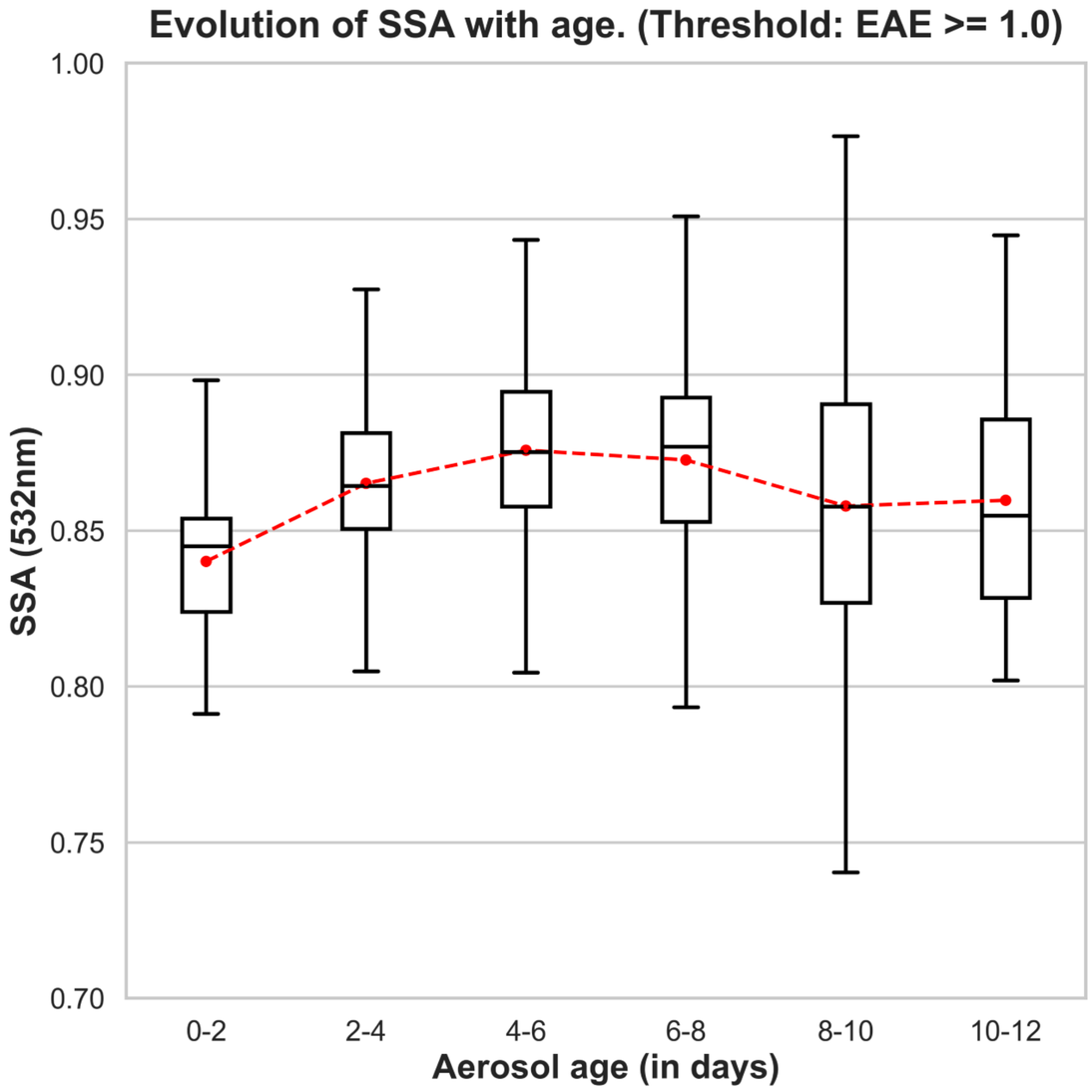
Workflow of the methodology

Results

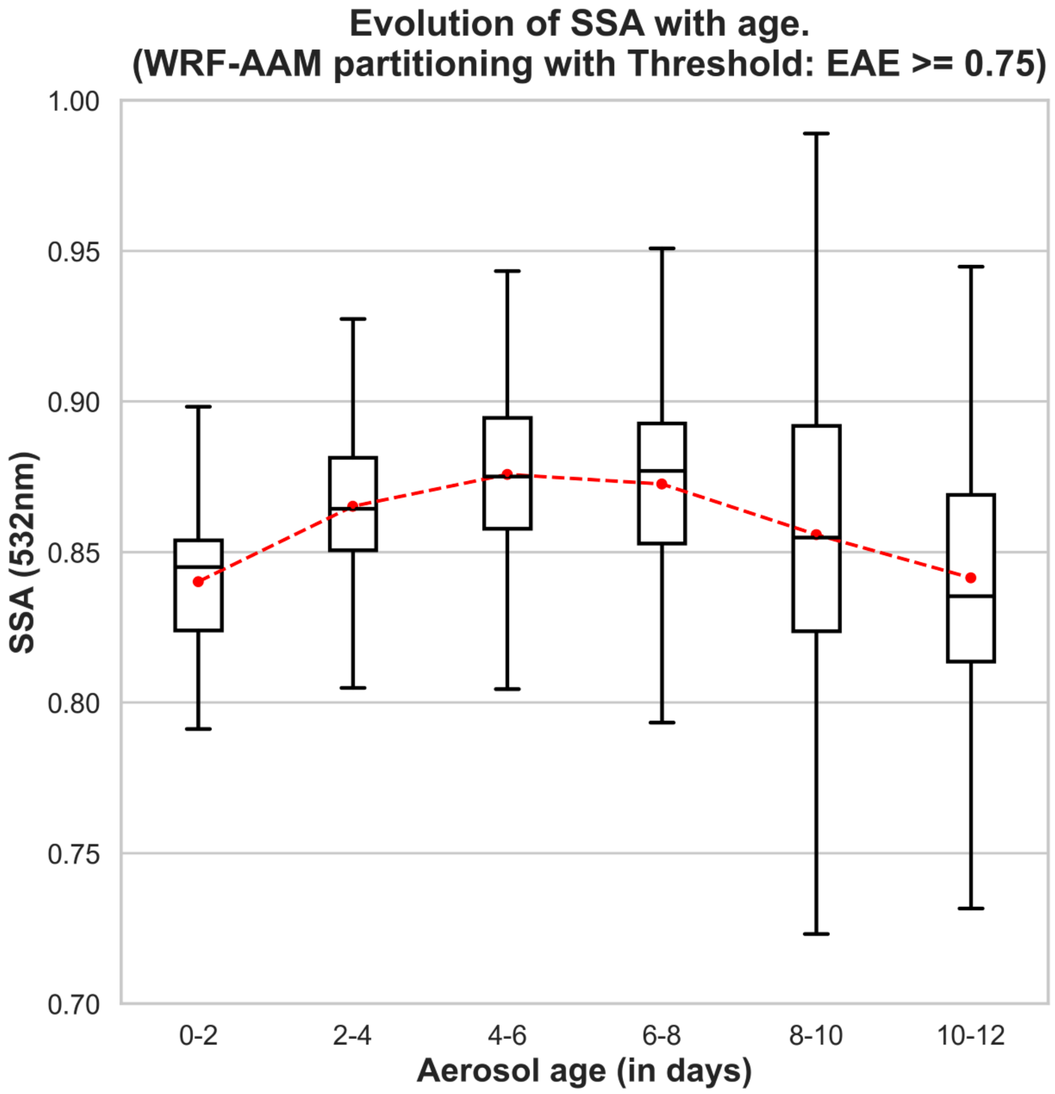

SSA from observation vs Model-derived aerosol age.
(Threshold: EAE >= 0.75)
SSA (532nm)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
2
4
6
8
10
12
Aerosol age (in days)
Extinction Angstrom Exponent
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
eae
1.00
1.25
1.50
1.75
2.00
Station
Ascension
Mongu
Namibe
Huambo
4STAR

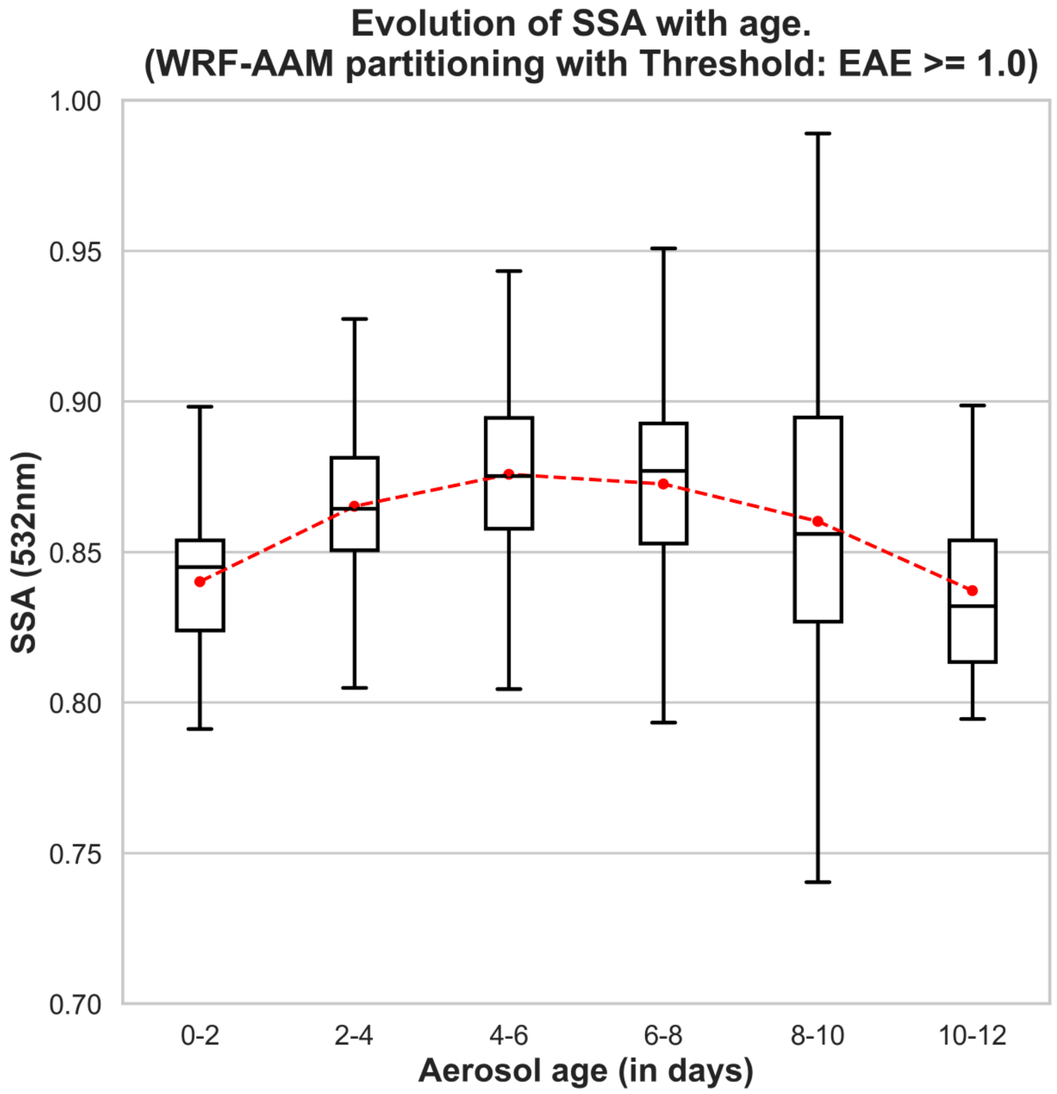
Results - No Partition





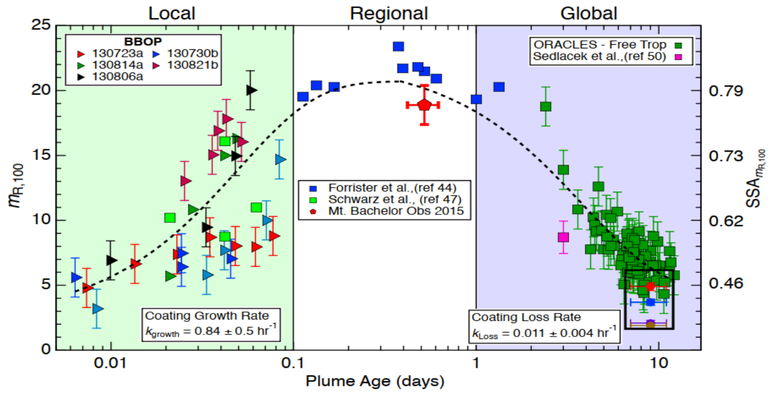
Results - Partition

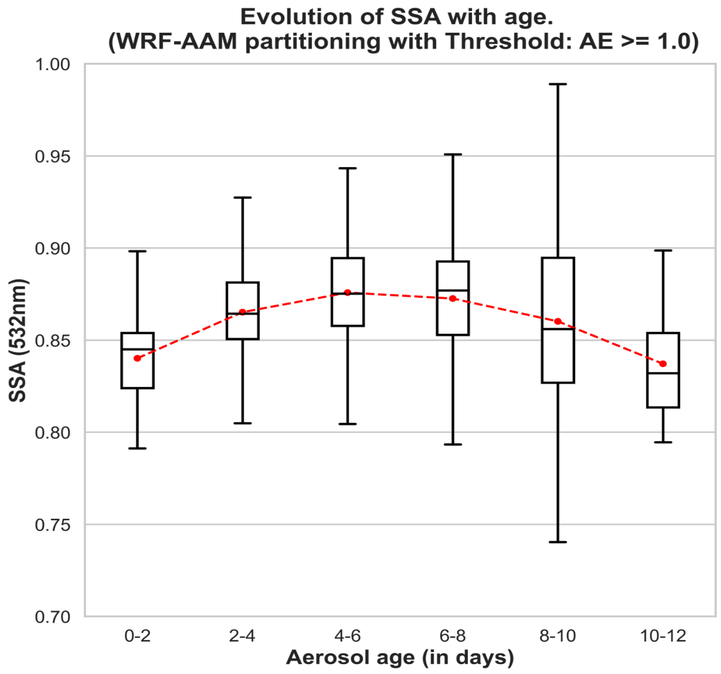




Conclusion

- Near-source samples have lower SSA and higher EAE
- Coastal aerosols have lower EAE
- Ascension Island and 4STAR measurements are oldest (8 - 12 days)
- SSA tends to peak at age 4 - 6 days
- Sharp decline in FT SSA at Ascension Island after partitioning





Future Work

- Partition BL and FT aerosol using model boundary layer products
- Study evolution from model-derived aerosol properties
- Compliment analysis with *in situ* and satellite observations
- Extend analysis to other field campaigns in the SEA (CLARIFY, LASIC) and other regions of long-range biomass burning transport

Key points

- Near-source samples have lower SSA and higher EAE
- Coastal aerosols have lower EAE
- Ascension Island and 4STAR measurements are oldest (8 - 12 days)
- SSA tends to peak at age 4 - 6 days
- Sharp decline in FT SSA at Ascension Island after partitioning

Thank you

Contact:

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