Dust impact on surface solar radiation levels in Cyprus

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Introduction

Cyprus, located in close proximity to both Northern Africa and the Arabian Peninsula, frequently experiences dust events, around 50 days per year (Achilleos et al. 2020).
The island's high number of cloudless days make it an ideal location for studying the radiative effects of dust.

Aerosols

- Influential factor on surface solar radiation levels
- Can change surface radiation fluxes by both absorbing and scattering solar radiation
- Dust aerosols are known to efficiently absorb solar radiation, especially at lower wavelengths.

Motivation

This study aims to evaluate the dust direct radiative effect on solar SW radiation at ground level using both measurements for the years 2015-2022 from Agia Marina Xyliatou Station and radiative transfer modelling using Libradtran.

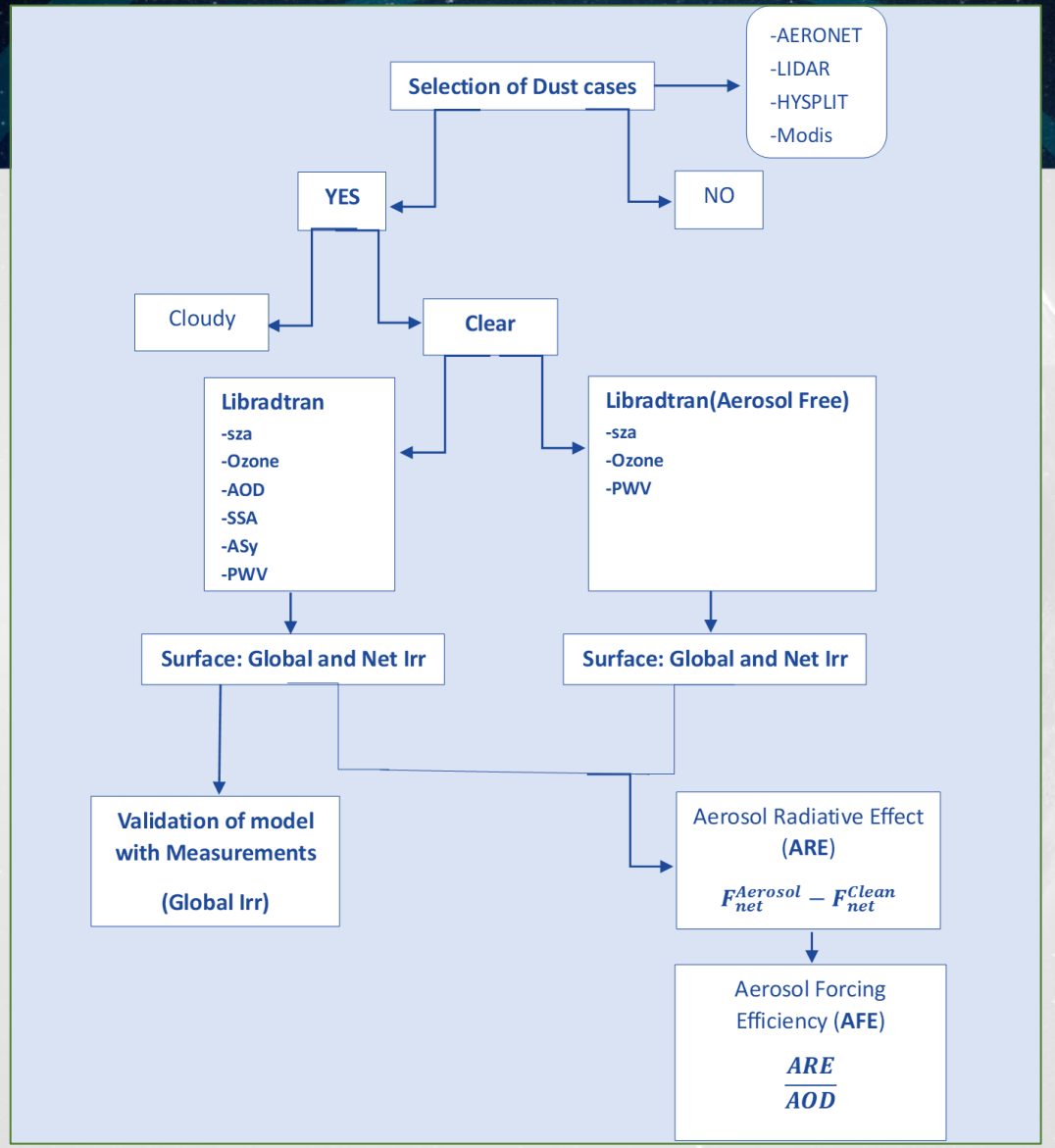
Site description/ Instrumentation

- The Agia Marina station is a remote site in the centre of the island surrounded by Forests and in the foothills of the Troodos Mountain range.(35.04N; 33.06E; 535m above sea level)
- The site is also the EMEP rural station for Cyprus since 1997. It is jointly operated in collaboration with the Department of Labour Inspection in charge of the national air quality network.
- CUT-TEPAK in Limassol-with the PollyXT lidar station.

Aerosol Remote sensing

- CIMEL CE318 sun photometer
- Fluxmeter K&Z station : broadband solar(direct + diffuse) and TIR radiation flux station
- PollyXT lidar(Limassol)

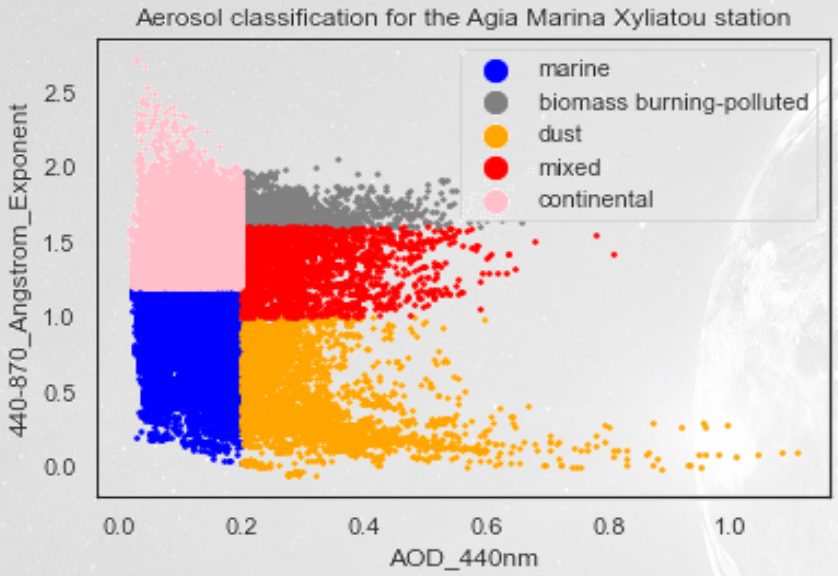
Methodology

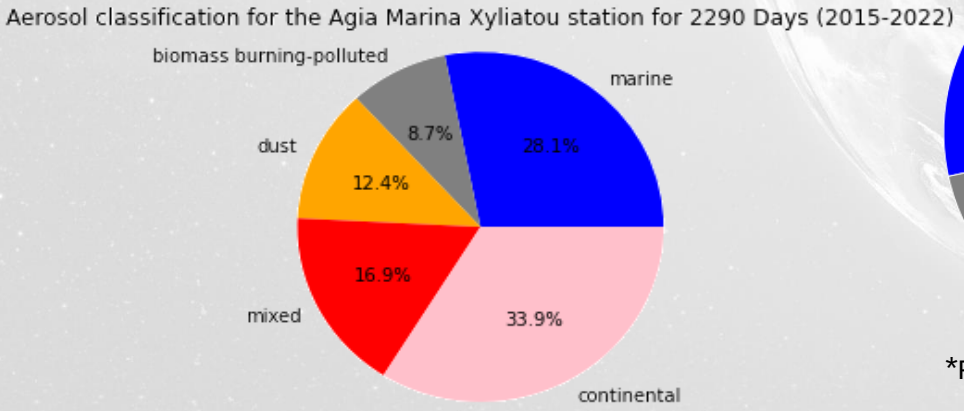


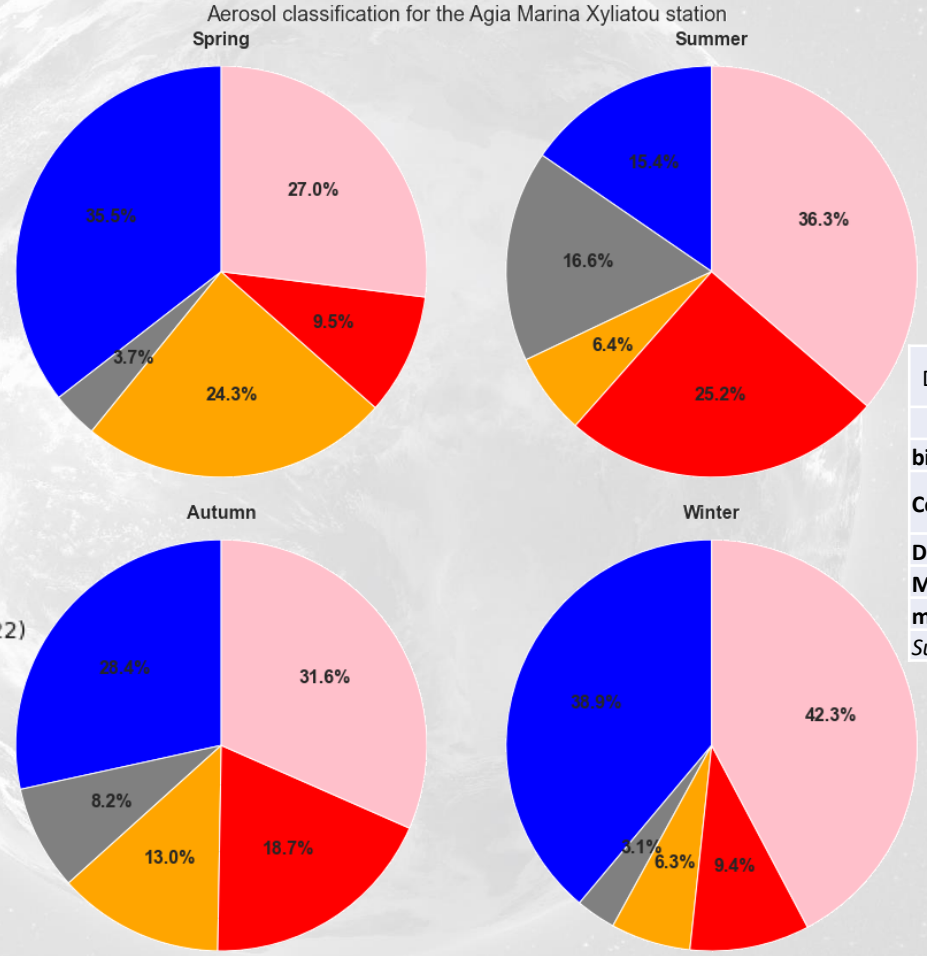
- Selection of only cloud-free, Perez et al. (1990)
- 35000 per minute measurements for June2015-March2022

AOD	Level2 AERONET
Ozone	Omi
SSA	Level 1.5 AERONET
ASY	Level 2 AERONET
Precipitable water	Level2 AERONET

Aerosol classification for the years 2015-2022
In the Agia Marina Xyliatou Station







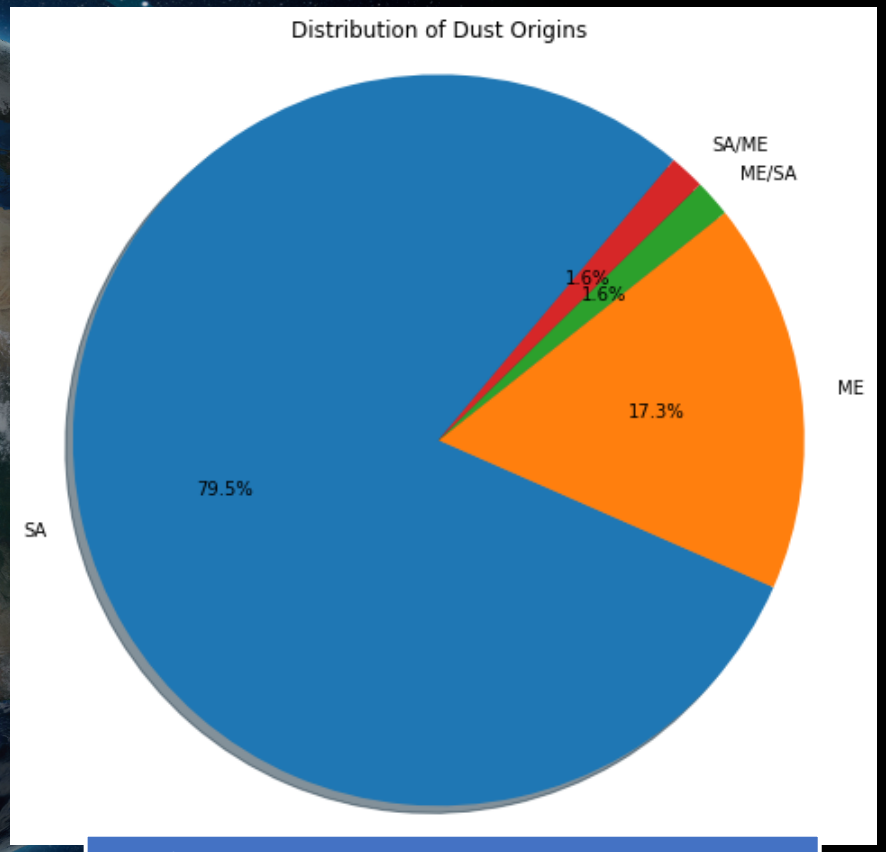
Days of every kind of aerosol for the period June 2015- March 2022

	Spring	Summer	Autumn	Winter
biomass	18	109	60	13
Continental	133	238	230	175
Dust	120	42	95	26
Marine	175	101	207	161
mixed	47	165	136	39
Sum of Days	*493*	*655*	*728*	*414*

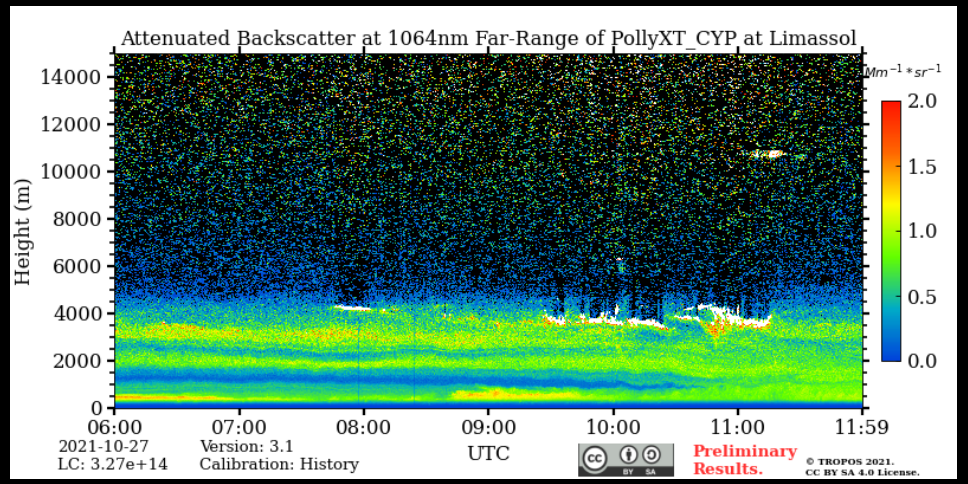
*For the aerosol classification Dubovik et al. 2002 method have been used

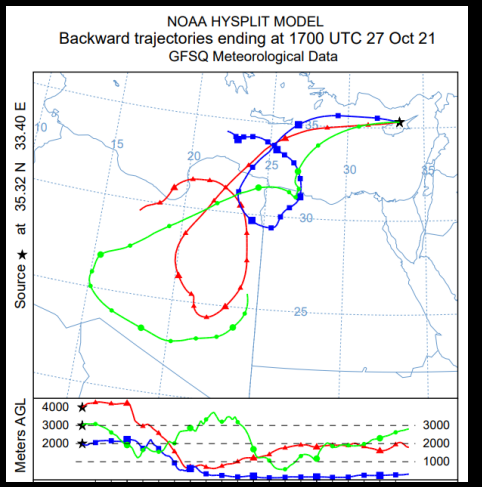
The dust origin have been checked from lidar- Modis -Hysplit

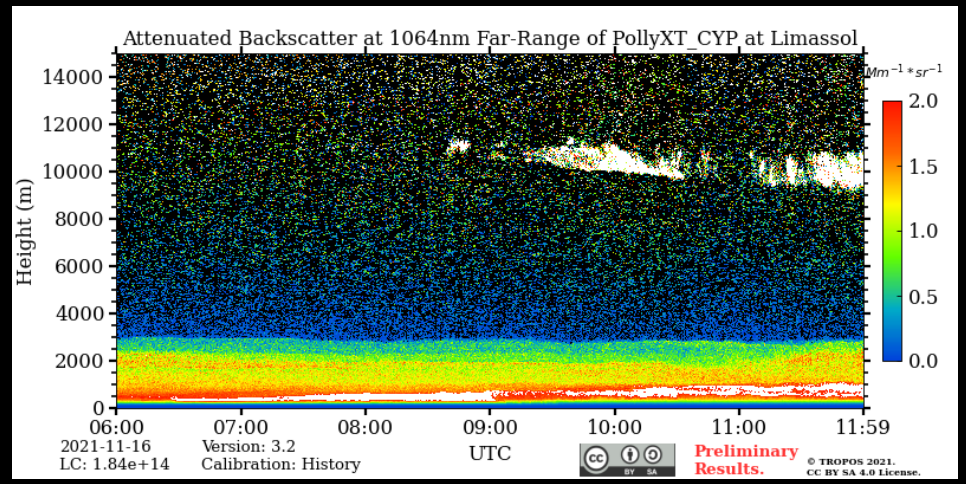
299 Days, 2538 Ground Measurements 2015-2022

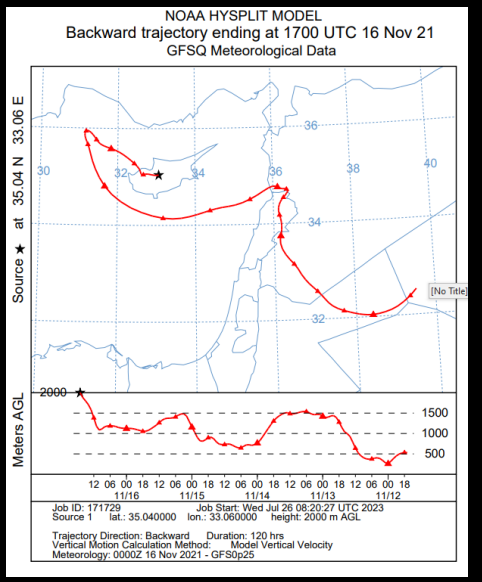


SA: Sahara
ME: Middle East
SA/ME: Sahara and Middle East
ME/SA: Middle East and Sahara





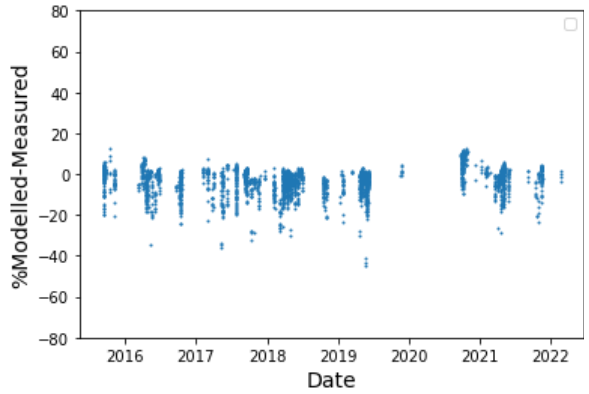




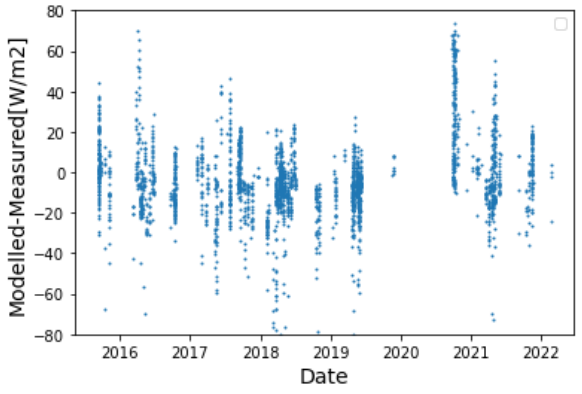
Comparison of modelled and surface based solar measurements

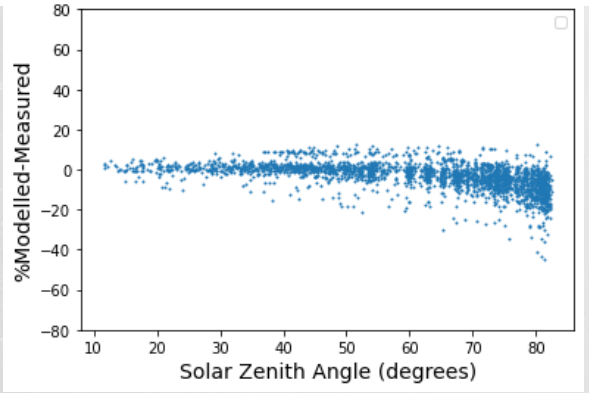
Dust

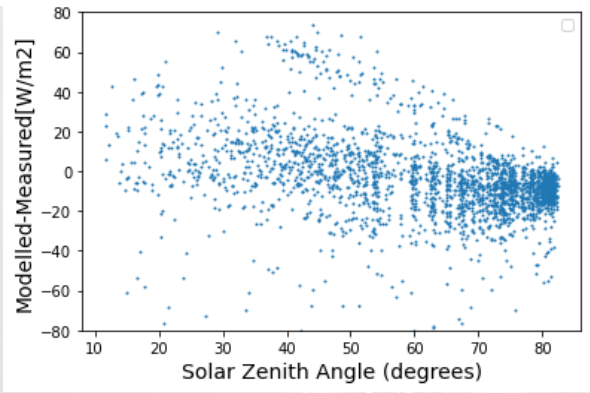
(Modelled-Measured/Measured)*100



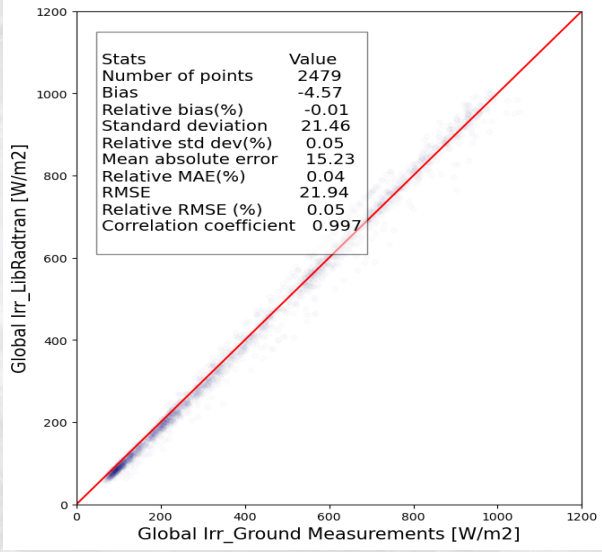
Modelled-Measured

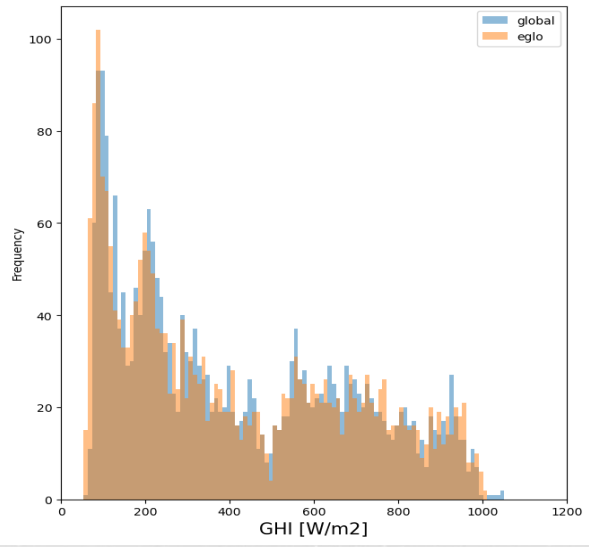




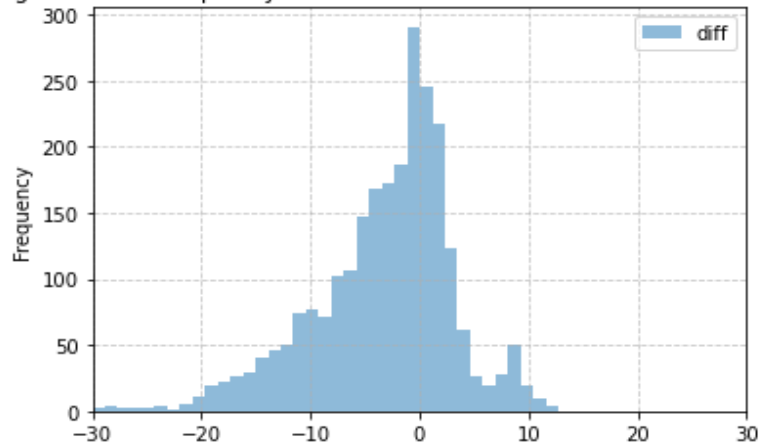


Error metrics and Scatter plots





Histrogram of the frequency of %Diff Between Modelled and Measured Global Irr



Difference (%) between modelled values and measured values of Global Horizontal Irradiance

- Effect of azimuthal response of the instrument and model limitations

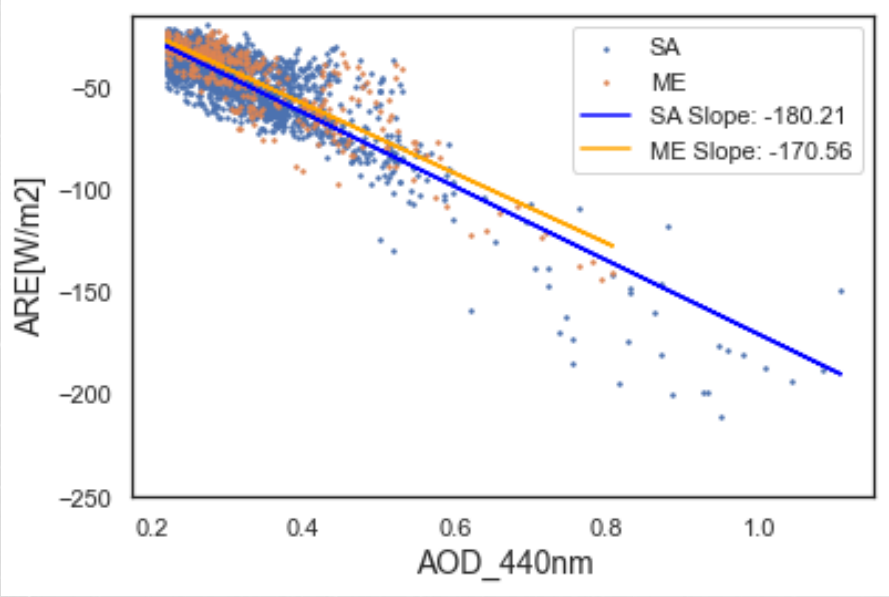
67.89% of values within ±5%
83.95% of values within ±10%
98.18% of values within ±20%

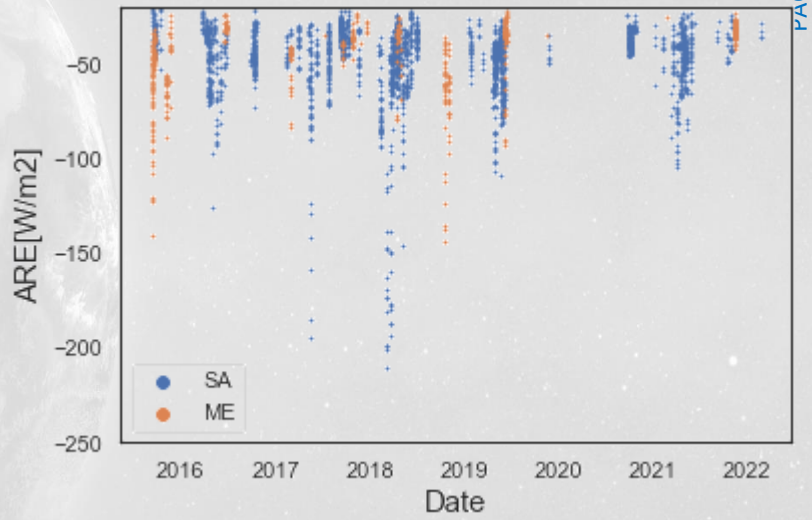
Aerosol Radiative Effect

The **aerosol radiative effect (ARE)** is defined as the change in net radiation W m^{-2} due to changes in atmospheric aerosol properties and content. This is a key quantity in the determination of climate change.

AREx = X ↓ aer − X ↑ aer − X ↓ NOaer − X ↑ NOaer

where Xaer and XNOaer are the irradiances (W m−2) for the X range under actual and aerosol-free conditions, respectively.



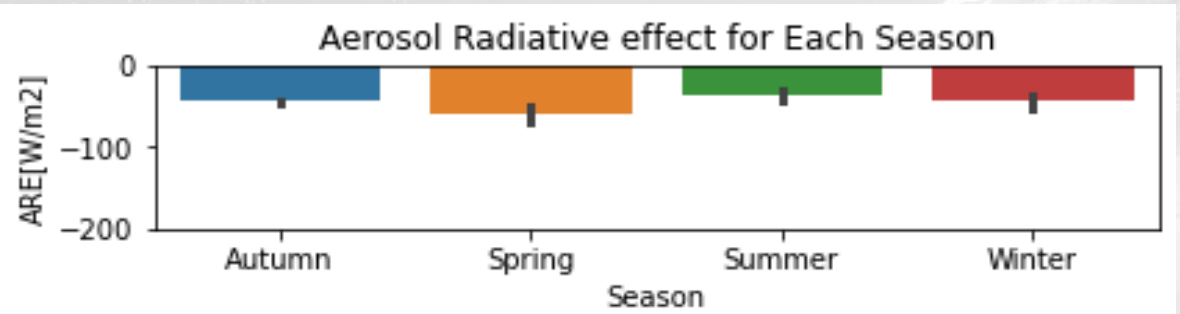


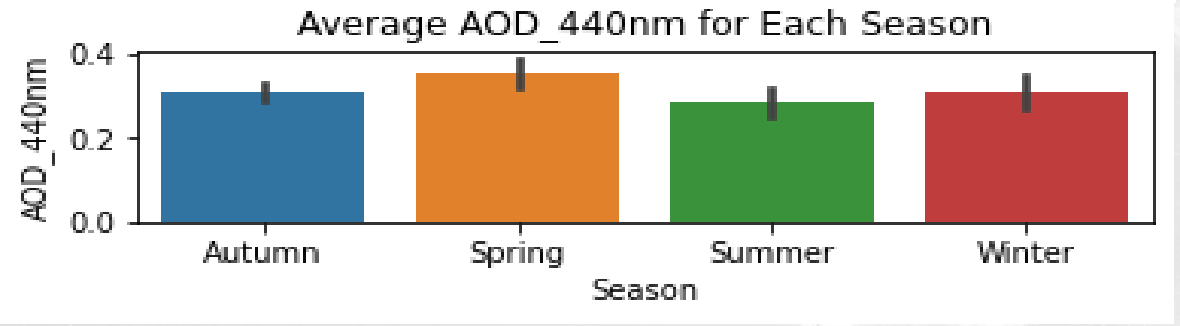
The direct **radiative forcing efficiency (AFE)** of the dust aerosol is quantify the dust radiative effect .
The AFE represents the ARE per unit aerosol optical depth (AOD).

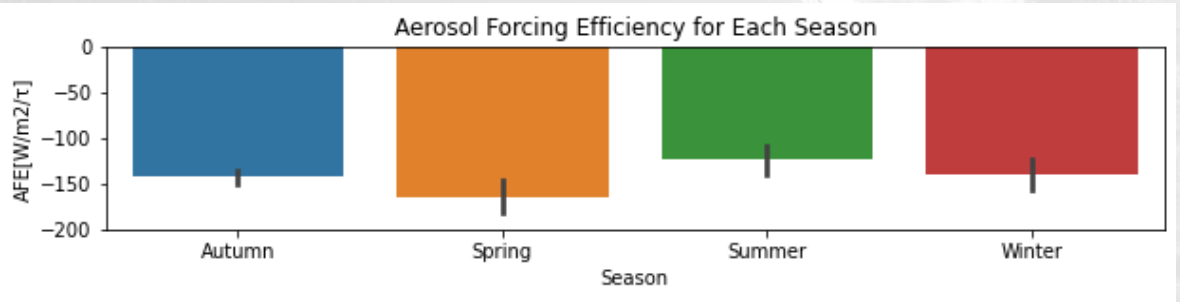
ARE: Aerosol Radiative Effect, W m^{-2}
AFE :Aerosol forcing efficiency W m^{-2} per AOD nm-unit (W m^{-2} τ^{-1})

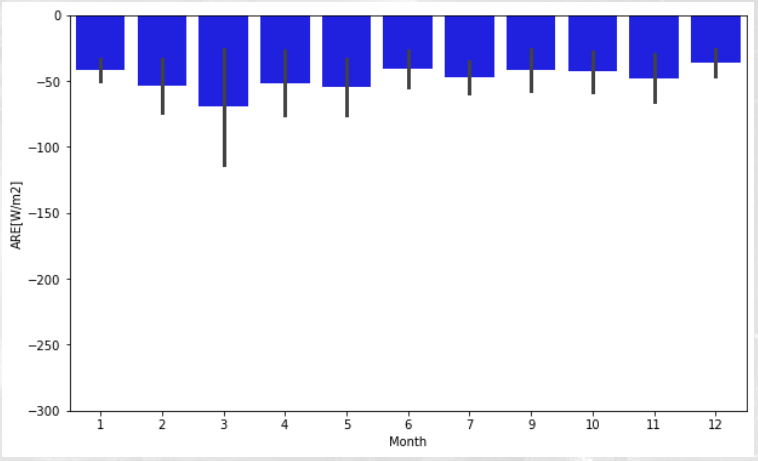
Dust-

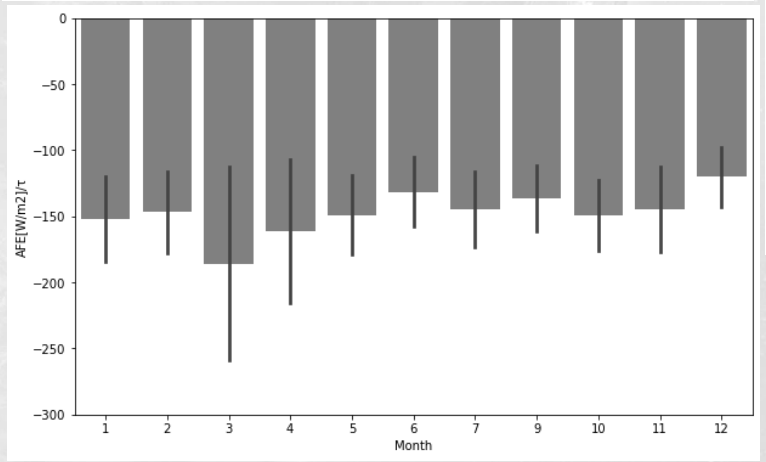
mean monthly for the years 2015-2022



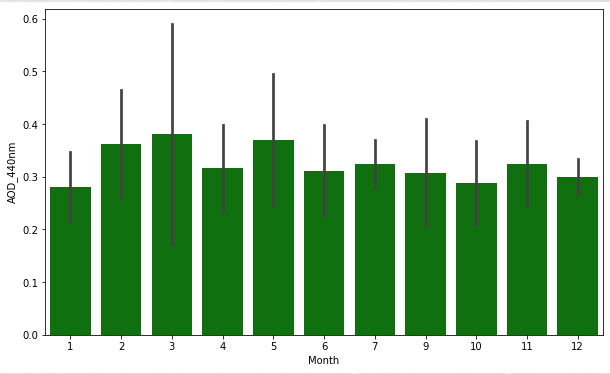




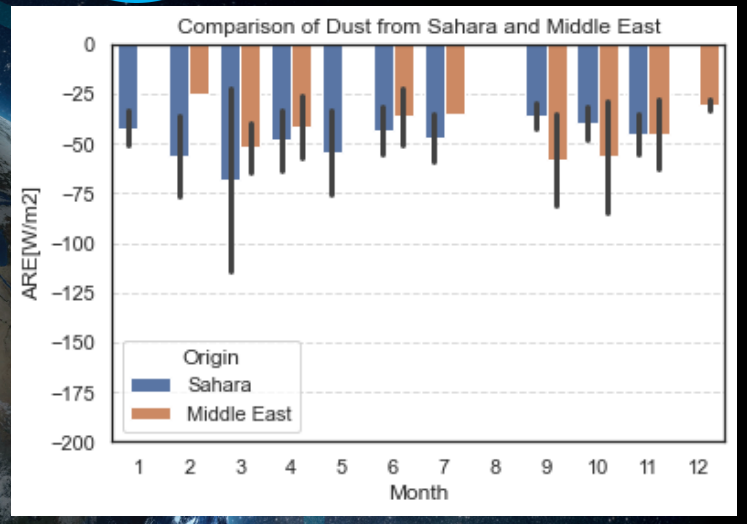


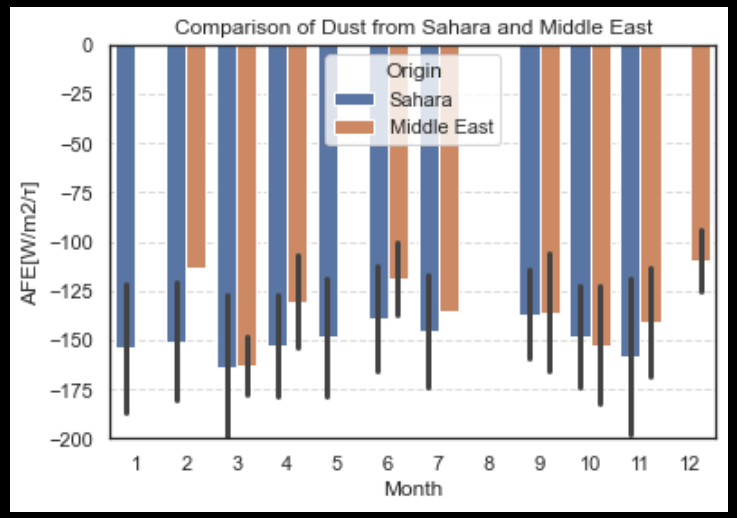


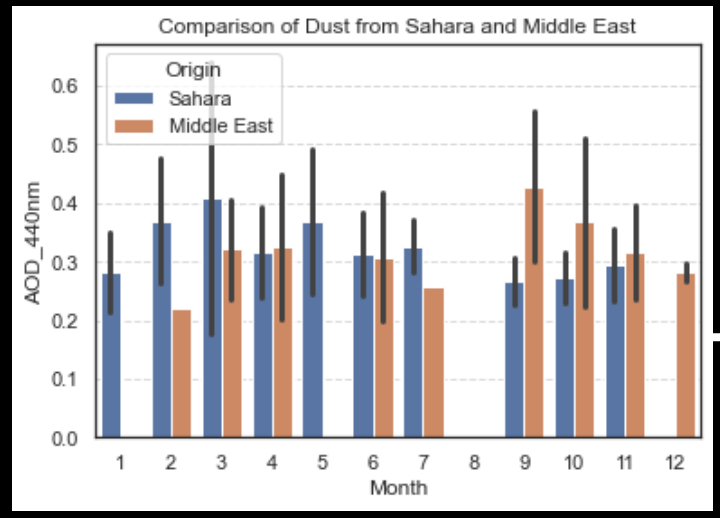
Monthly means of ARE showed a seasonal pattern with larger values in spring

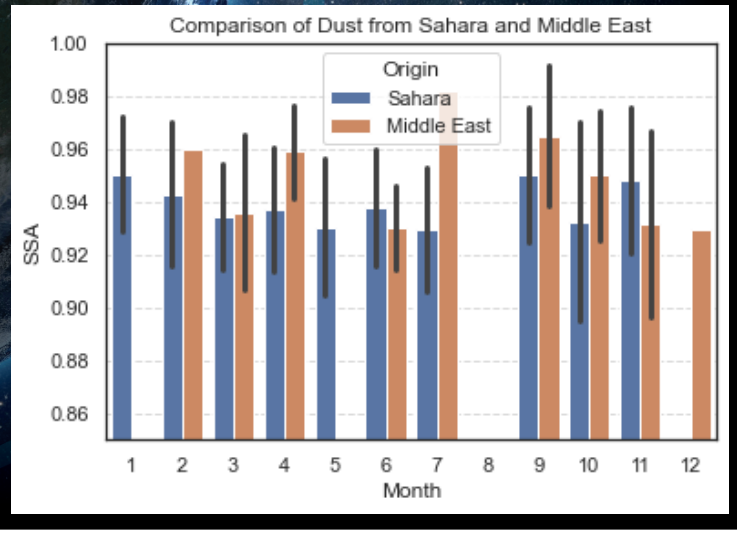


Mean monthly values for Sahara and Middle East dust . (ARE and AFE)



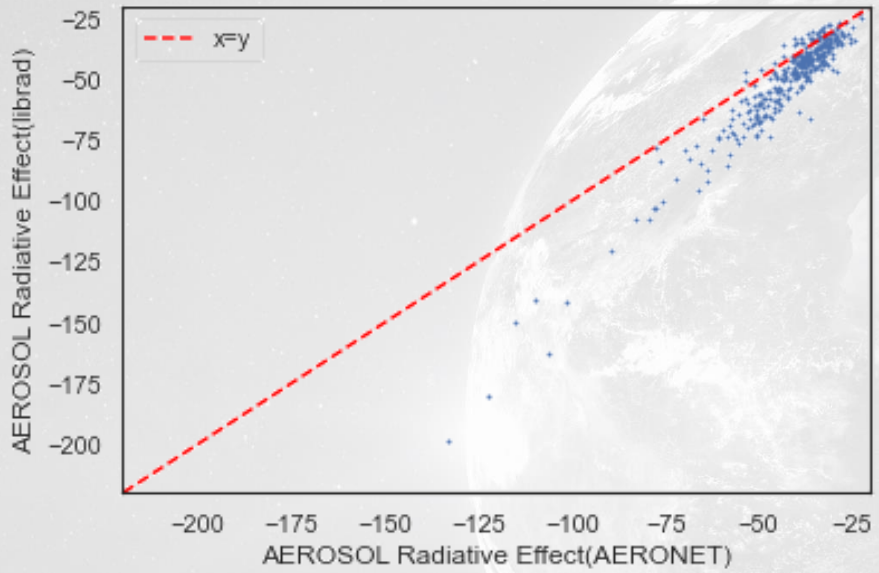


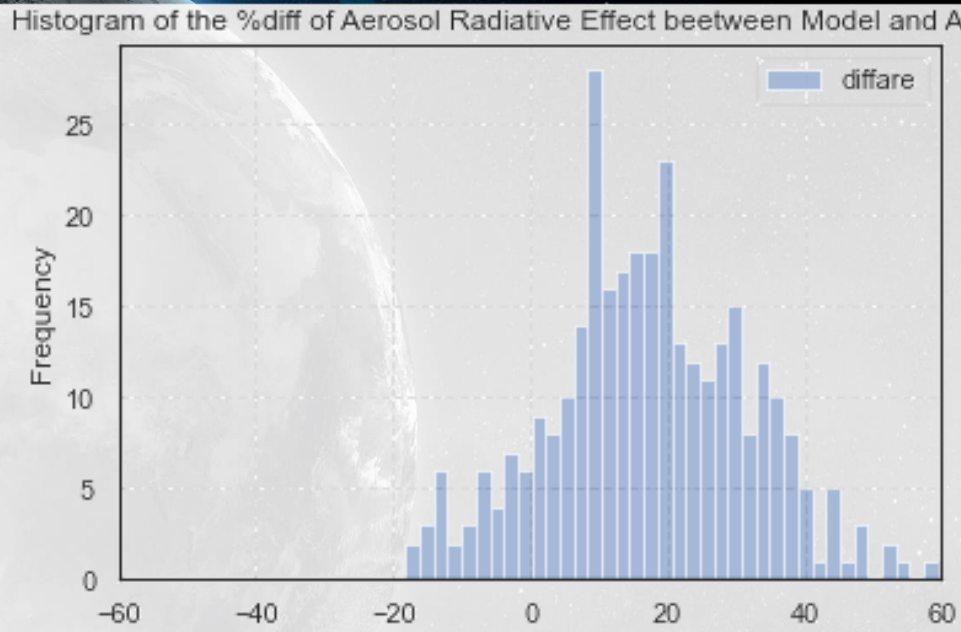




	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SA(days)	5	10	17	37	36	15	2	-	16	24	5	-
ME(days)	-	1	2	4	-	7	1	-	6	5	12	1

Comparison with Aeronet estimations





Dust	Using SW from libRadtran	From AERONET
Mean Aerosol Optical Depth	0.327	0.327
Mean Aerosol Radiative Effect(W m^{-2})	-48.120	-43.144
Mean Aerosol forcing efficiency (W m^{-2} τ^{-1})	-146.76	-150.302

Used the Rad_Forcing(BOA) and Forcing_Eff(BOA) from AERONET to compare the mean values of LibRadtran for Aerosol Radiative Effect and the Aerosol forcing efficiency.

- good agreement, however Aeronet seems to underestimates the radiative effect.

Conclusions for the analysis of 7 year of dust aerosol radiative effects at Agia Marina Xyliatou Cyprus.

- Approximately 50 days with Dust events per year
- Analysis of 2 different dust origins (Sahara and Middle East)
- ARE and AFE from both origins are quite similar
- March Reigns as the Seasonal Peak Performer.
- Our Findings Align Closely with AERONET estimations

Thank you for your attention