
جمهورية مصر العربية
وزارة التعليم العالي والبحث العلمي
الهيئة القومية للاستشعار من البعد وعلوم الفضاء
National Authority for Remote Sensing and Space Sciences

# Applications of Remote Sensing in Air Quality Aerosols & Gases

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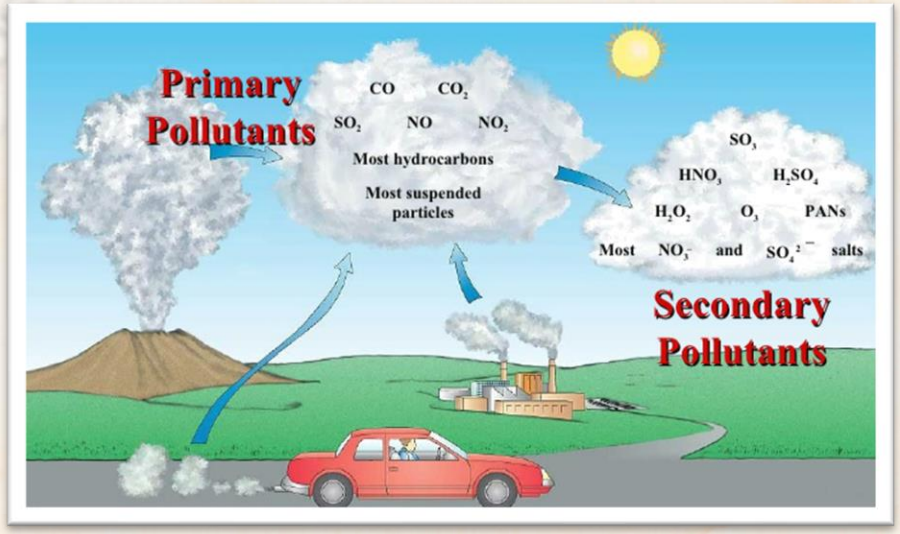
# Outlines

- Introduction
- Satellite observations for air quality
- Case study 1: Aerosol monitoring
- Case study 2: Gases monitoring
- Conclusion
- Recommendation

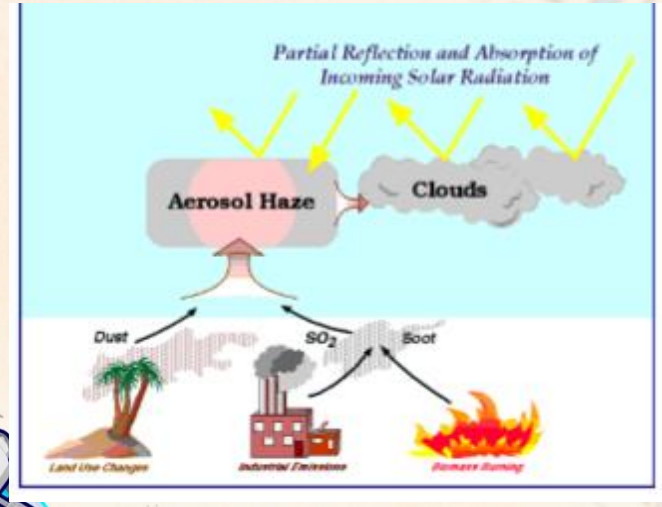
# Introduction

- Air pollution is a mixture of particulate matter with different diameters and trace gases (e.g. ozone, nitrogen oxides, sulfur oxides, and carbon monoxide).
- Pollutants release into the atmosphere from various anthropogenic and natural sources.

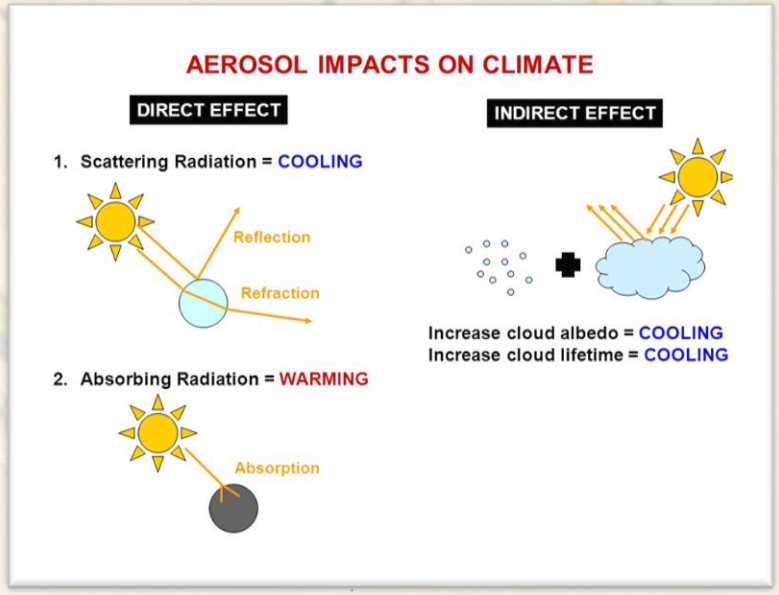



# Impacts of Air pollution

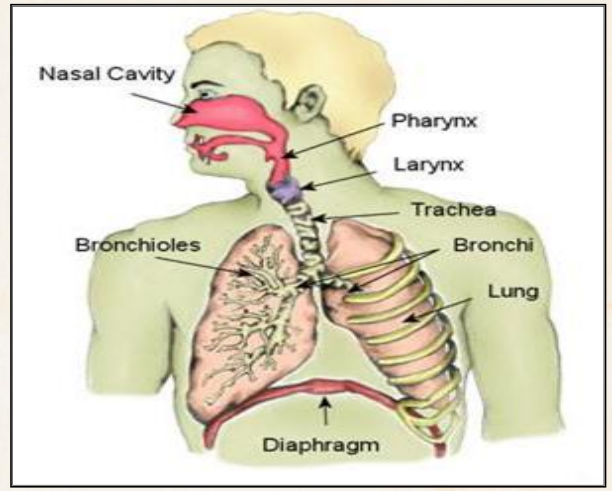
## Radiation Budget




## Climate

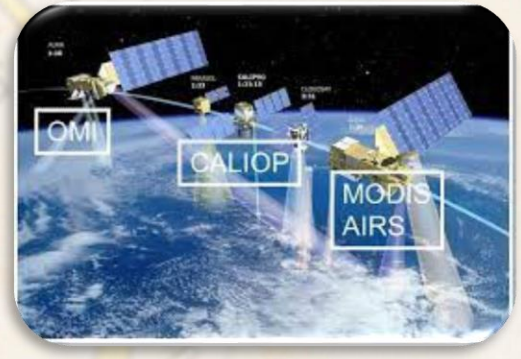


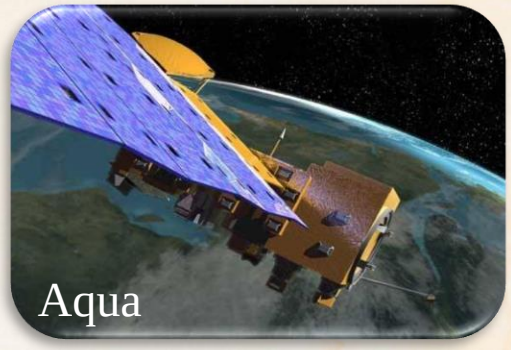

## Health & Comfort



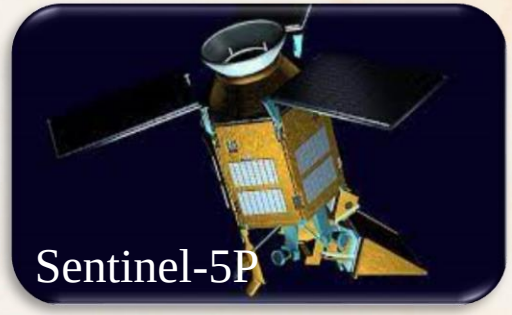
# Satellite observations for air quality studies

- Multiple satellites can observe air pollutants including gases and aerosols such as **MODIS, MISR, VIIRS, OMI, AIRS and Sentinel-5P**.
- Ground-based stations (AERONET)
- **<u>Advantages:</u>**
  - ✓Fill in the gaps of air quality monitoring from ground-based stations.
  - ✓High spatial and temporal coverage, worldwide.



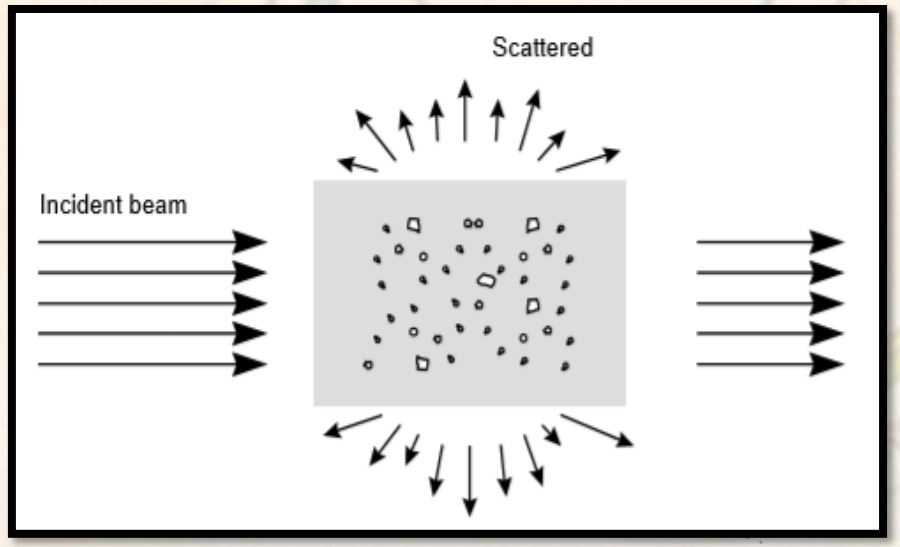



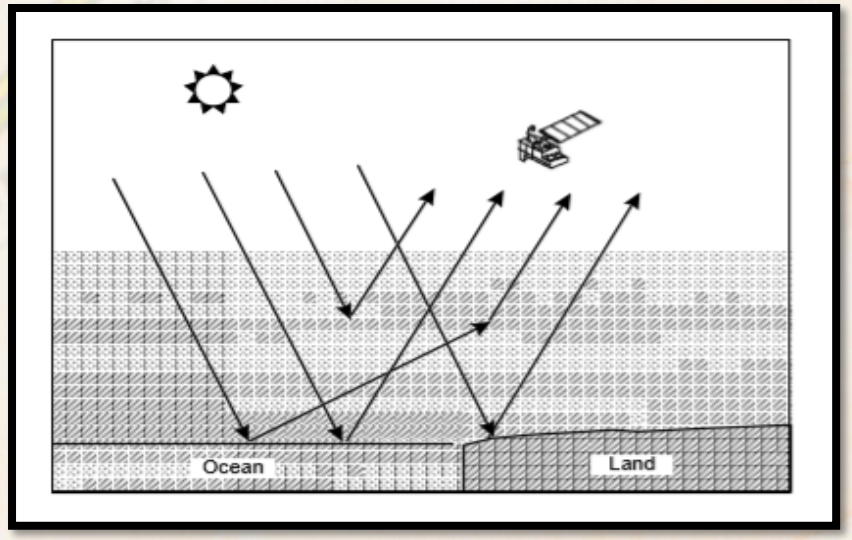




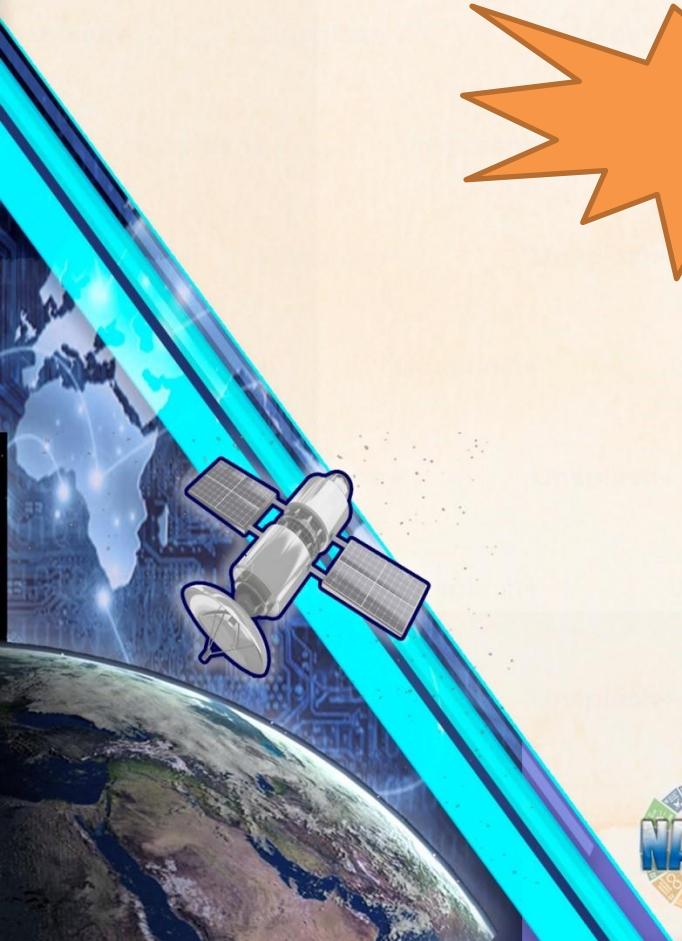
# Theoretical Background

- Satellite measurements of air pollutants are based on the pollutant's behavior in the atmosphere to reflect and absorbs visible & infrared light.



# What we can observe from space?



$SO_2$

CO

$NO_2$

$O_3$

Aerosols (AOD)

$CH_4$

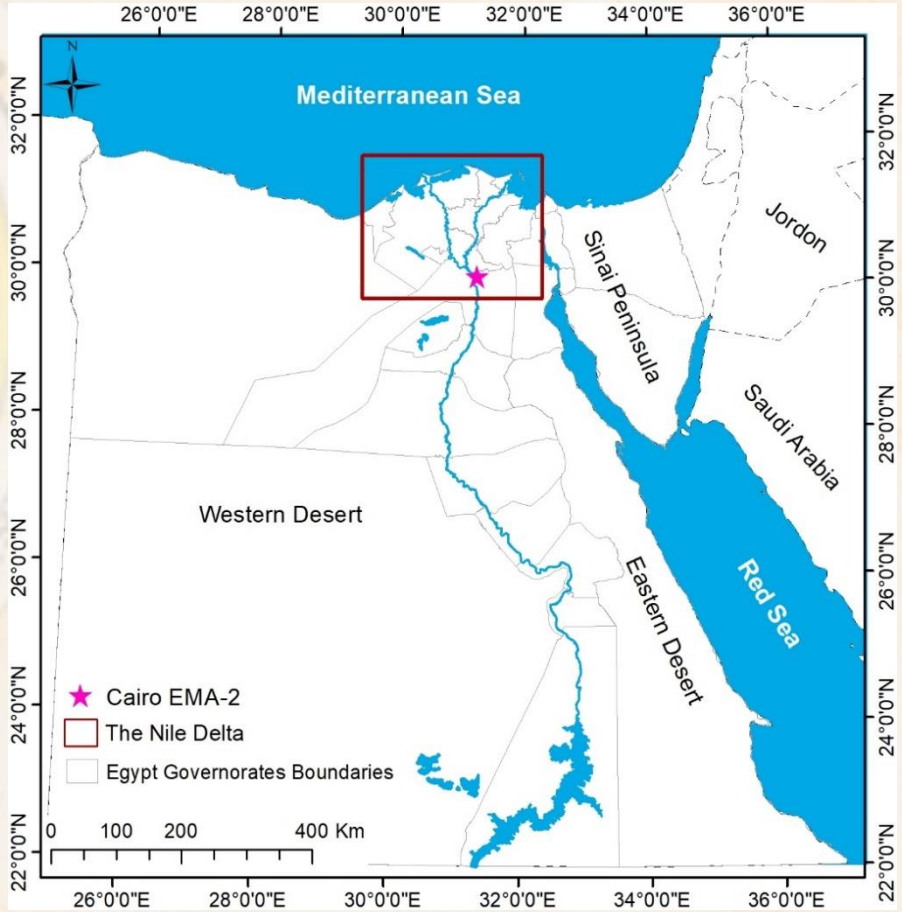
$CO_2$

Formaldehyde

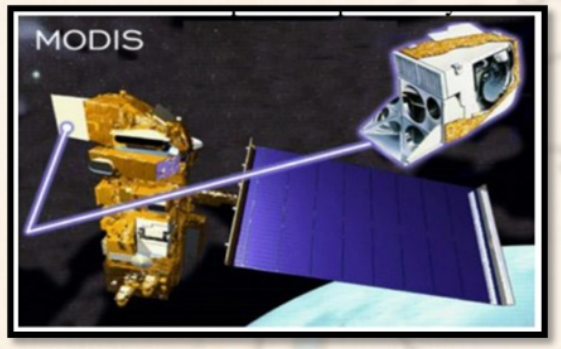
# Case Study 1:
# Monitoring Atmospheric Aerosols

## Objectives

- Function remotely sensed data to provide a full understanding of the aerosol climatology in Egypt for the period 2012-2020.
- Analyse the aerosol optical, radiative, and physical characteristics over Egypt.



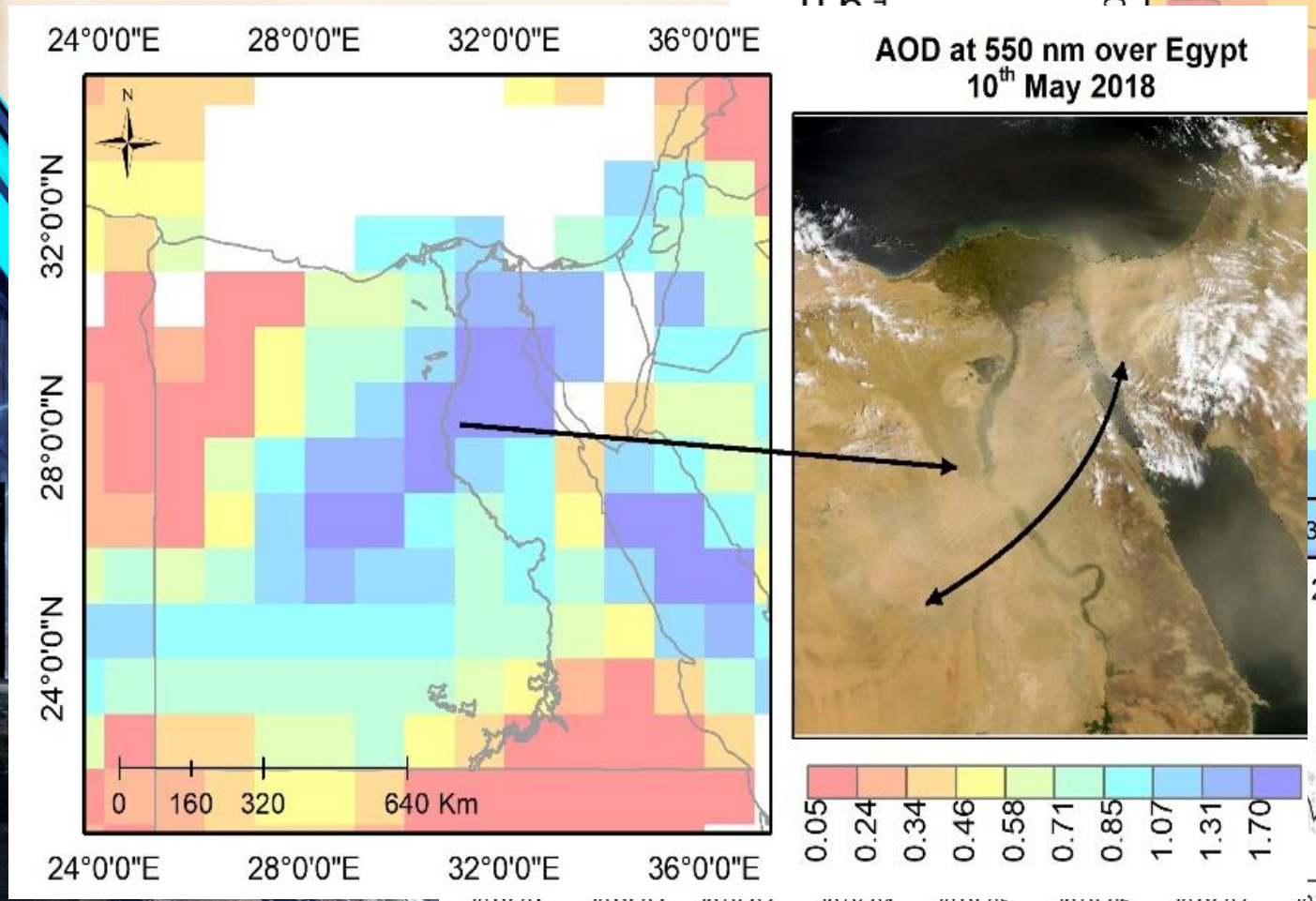
# Data Sets



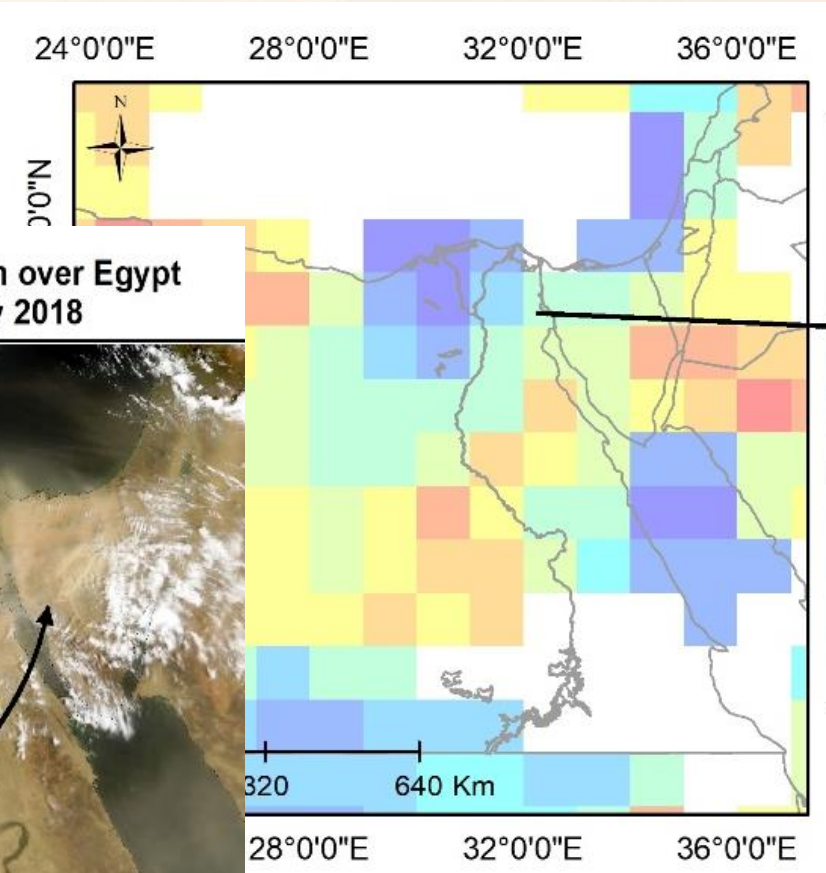


- **Satellite Observations**
  - MODIS
    - AOD
    - Fire
  - OMI
    - UVAI
  - MISR
    - AOD
- **Ground-based Networks**
  - AERONET (Cairo EMA-2 Station)
    - AOD
    - AE
    - SSA
    - Volume Size Distribution
- ***In-situ* Measurements**
  - EEAA Monitoring Networks
    - $PM_{10}$
  - Field Survey
    - handheld particle counter "Lighthouse 3016"

# Results


24°0'0"E
28°0'0"E
32°0'0"E
36°0'0"E
32°0'0"N
28°0'0"N
24°0'0"N
N
0
160
320
640 Km


AOD at 550 nm over Egypt
10th May 2018
0.05
0.24
0.34
0.46
0.58
0.71
0.85
1.07
1.31
1.70


24°0'0"E
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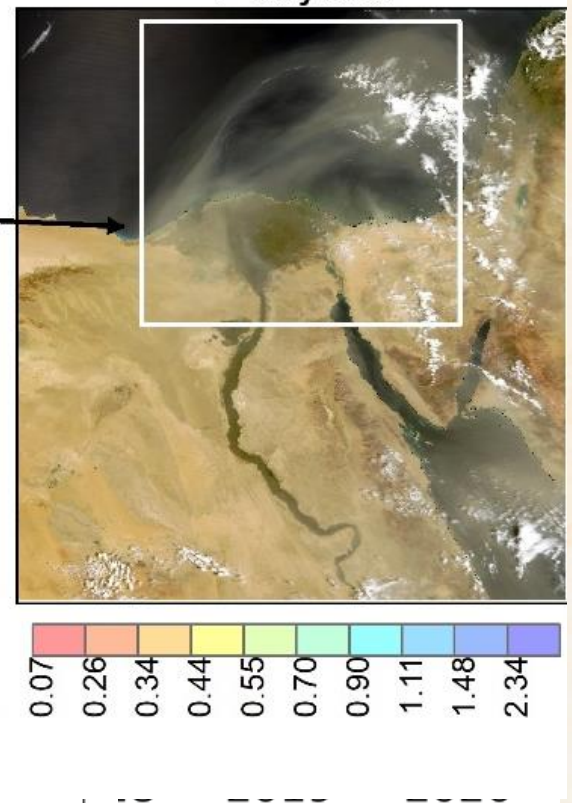
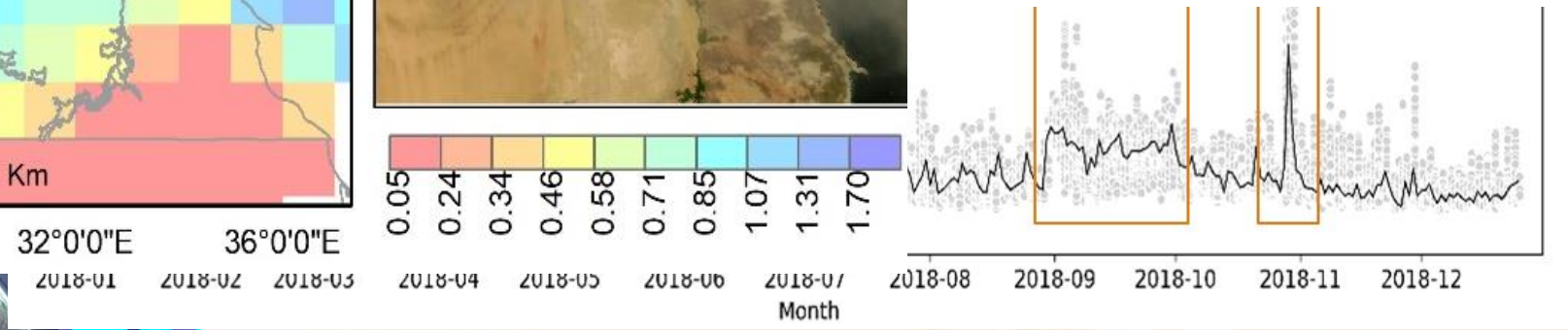
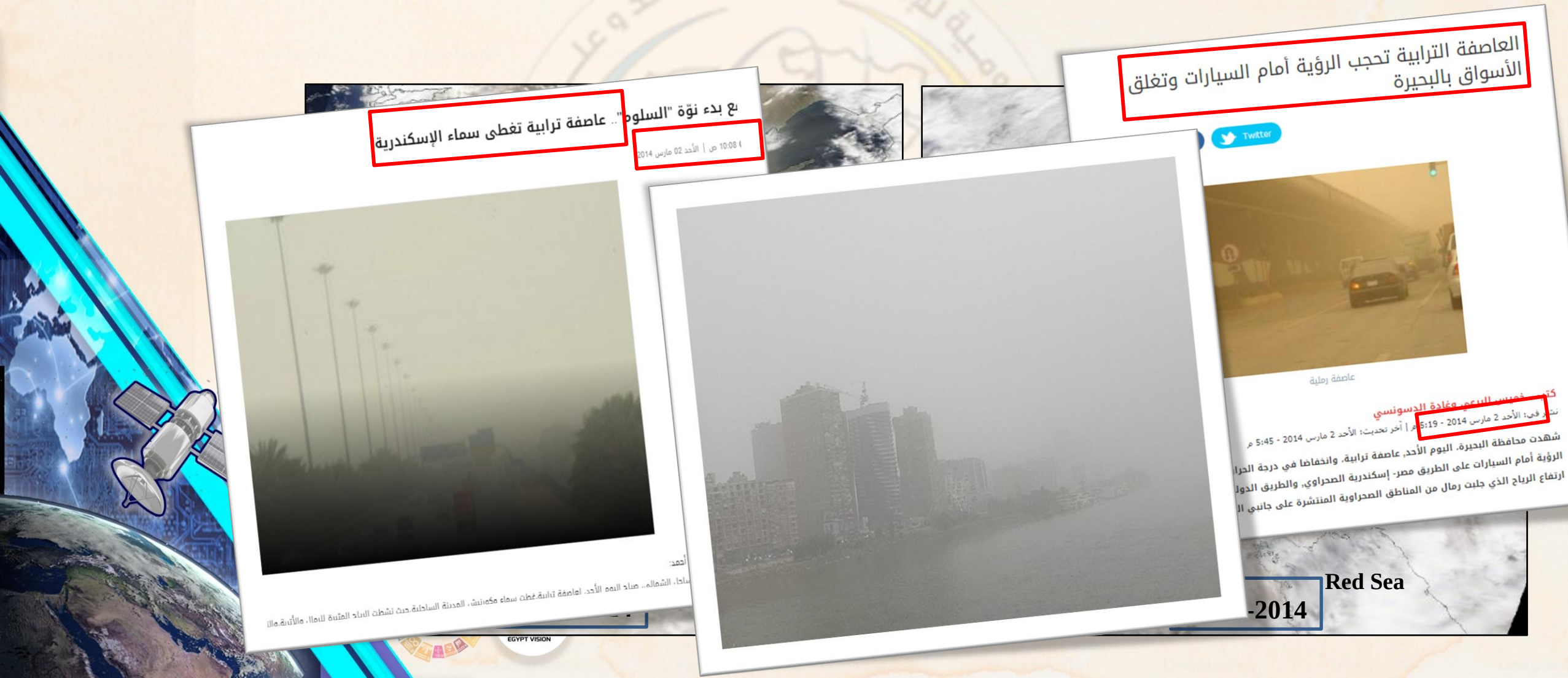
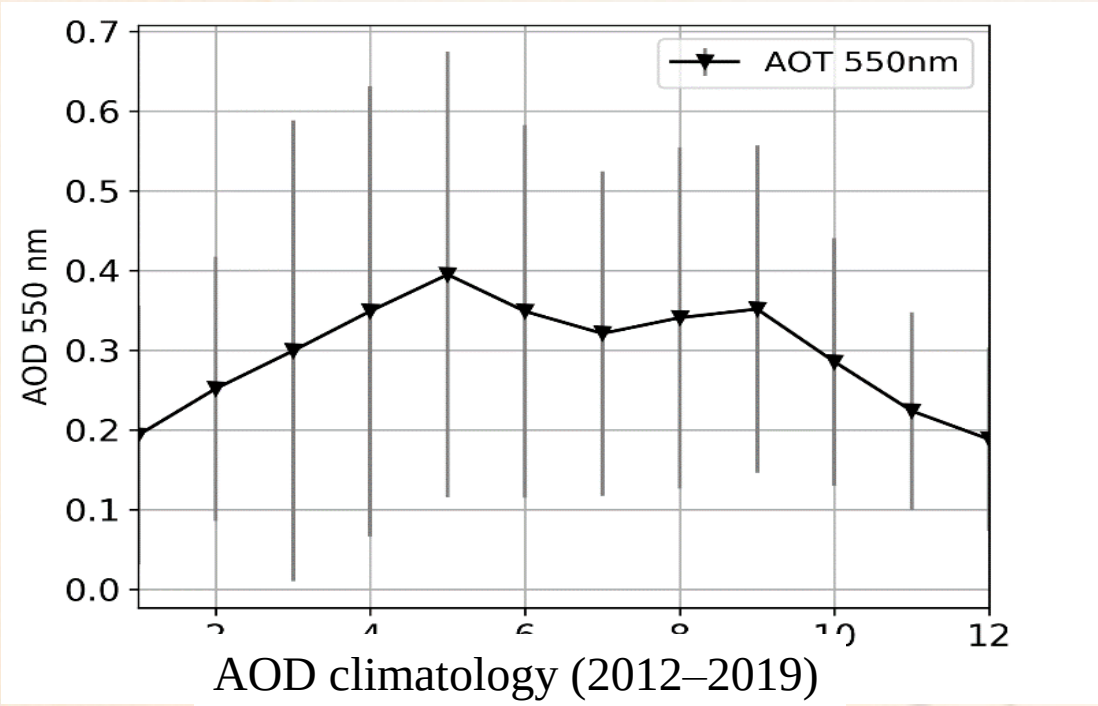
32°0'0"E
36°0'0"E
N
320
640 Km


AOD at 550 nm over Egypt
1st May 2018
0.07
0.26
0.34
0.44
0.55
0.70
0.90
1.11
1.48
2.34


2018-01
2018-02
2018-03
2018-04
2018-05
2018-06
2018-07
2018-08
2018-09
2018-10
2018-11
2018-12
Month

- A dust storm Observed on two consequent days 2nd Mar. 2014 (AOD= 3), (3rd Mar. 2014) with AOD= 1.6.
- At this time, Egypt (North-Coast cities) suffered from low visibility and high wind.
- The Egyptian Meteorological Authority forecasting systems warned people from exposure to this dusty wind due to the surface air depression coming from Libya during this period.





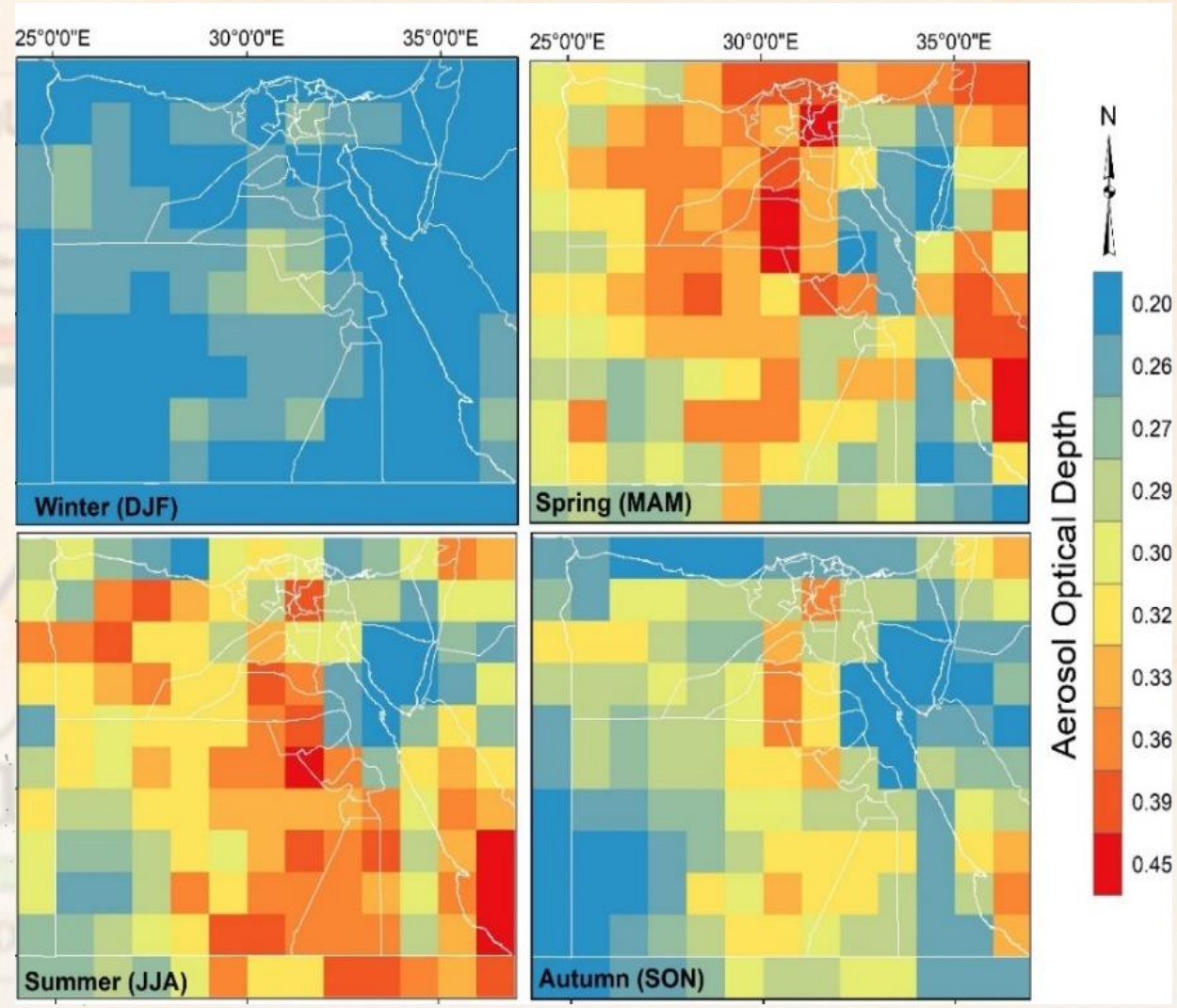

AOD climatology (2012–2019)

Winter *(DJF)*: Max = 0.29

**Spring *(MAM)*: Max = 0.42**

**Summer *(JJA)*: Max = 0.45**

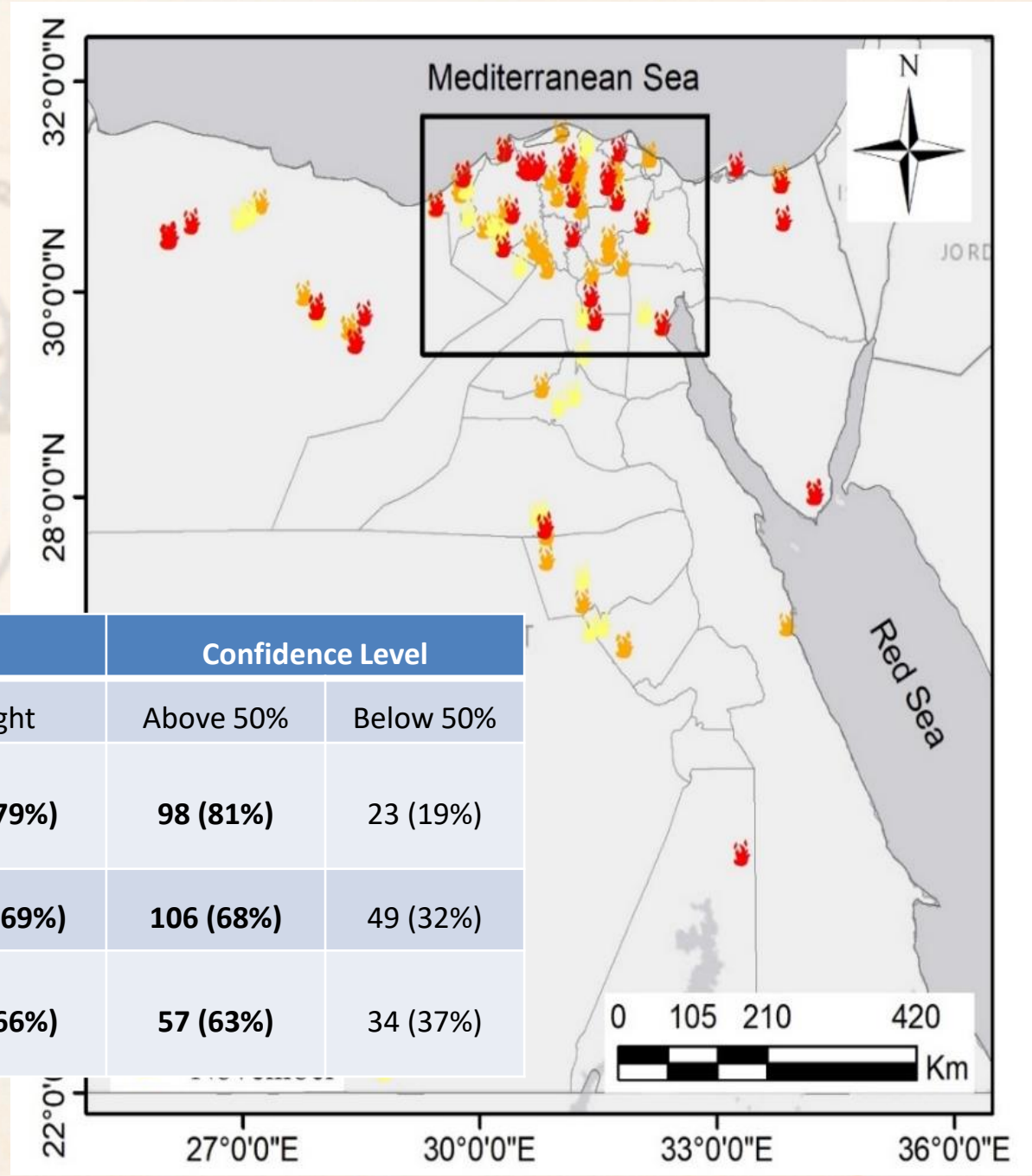
Autumn *(SON)*: Max = 0.35




*Seasonal variations (2012–2019) of AOD using level-3 combined Dark Target and Deep Blue MODIS Terra at 550 nm*

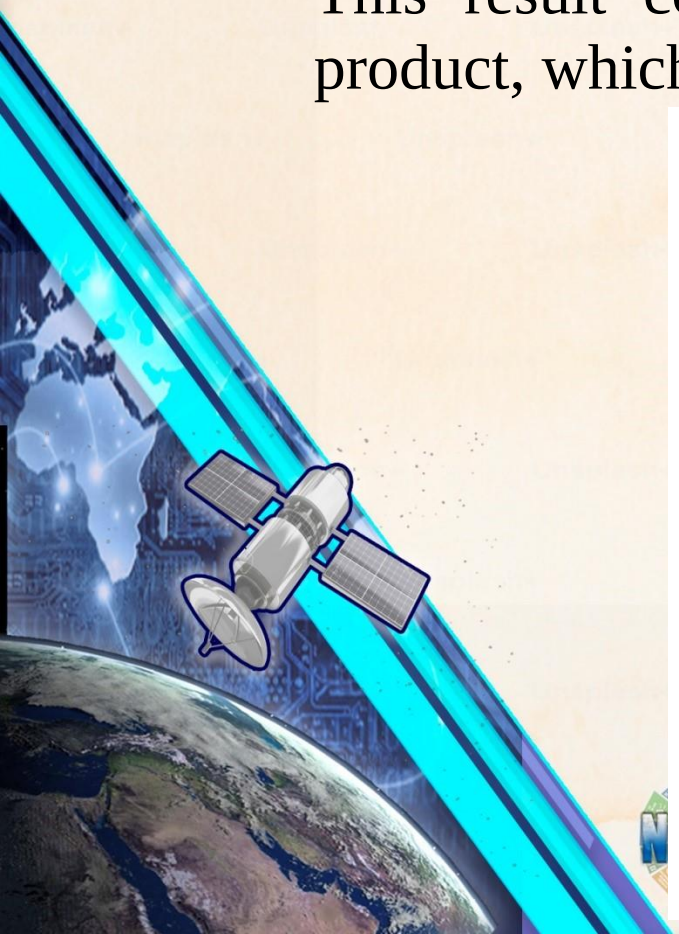
- There were **367** fire incidents, 42% in Oct., 33% in Sep., and 25% in Nov.
- **(71%)** of the fire occurred **at night**.
- **261** fire incidents have **above 50% confidence level**.

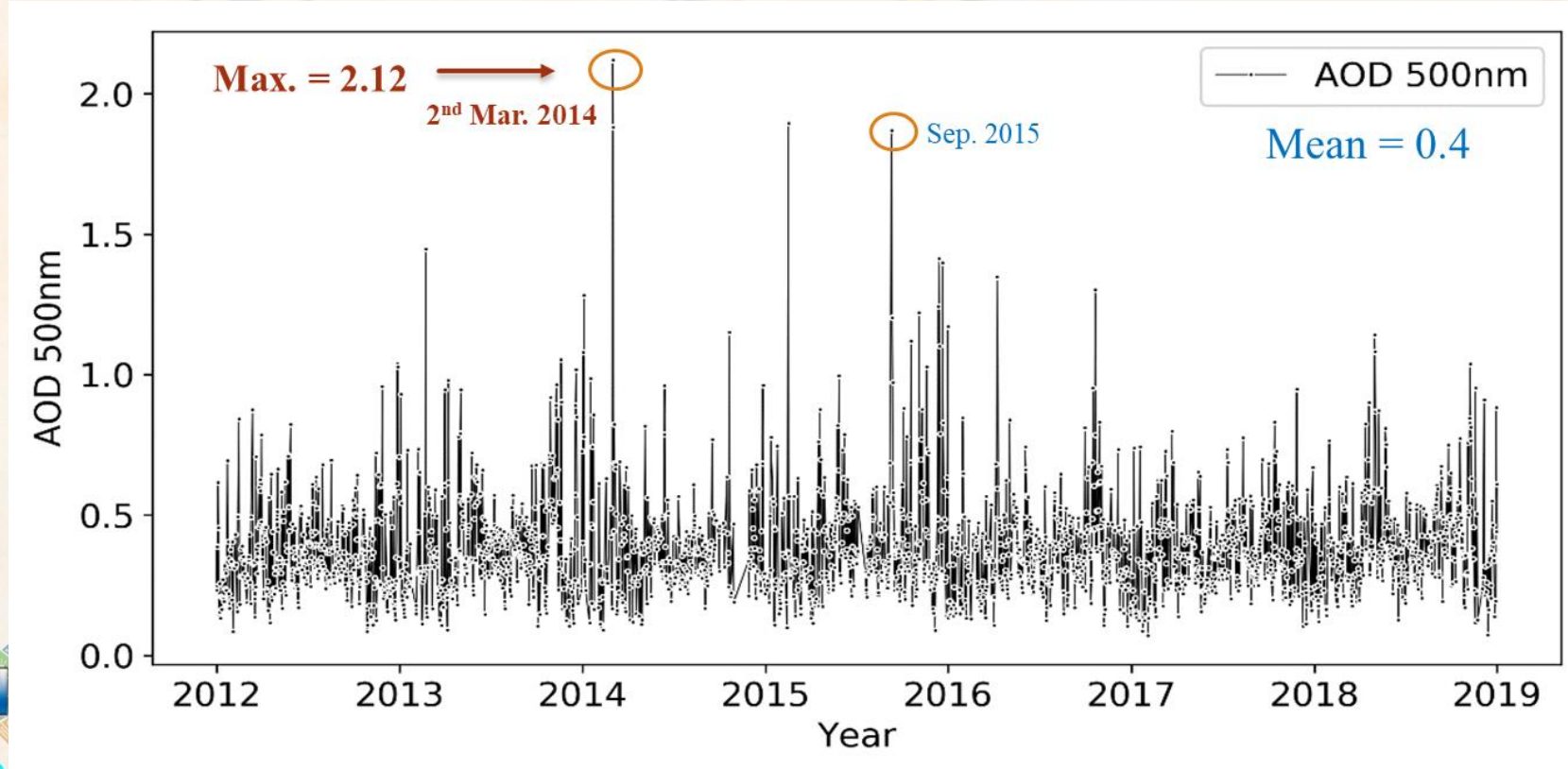
| Month (2018) | Number of Observations | Time | | Confidence Level | |
|---|---|---|---|---|---|
| | | Day | Night | Above 50% | Below 50% |
| **Sep.** | 121 | 26 (21%) | **95 (79%)** | **98 (81%)** | 23 (19%) |
| **Oct.** | 155 | 48 (31%) | **107 (69%)** | **106 (68%)** | 49 (32%) |
| **Nov.** | 91 | 31 (34%) | **60 (66%)** | **57 (63%)** | 34 (37%) |

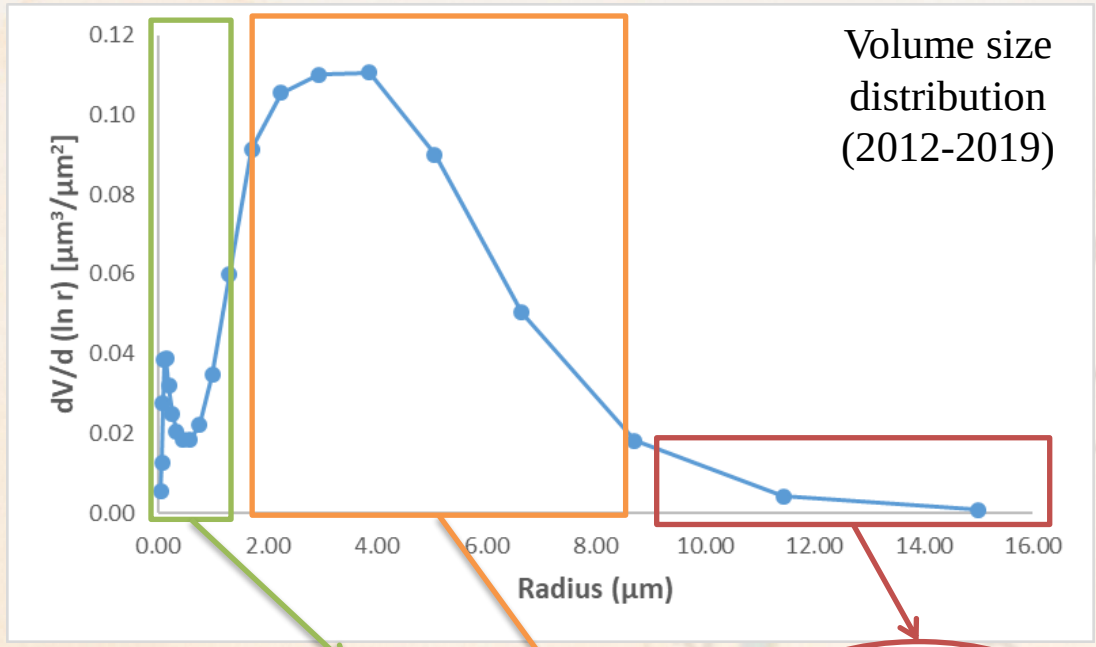


# Ground-based stations (AERONET)

- The highest AOD (2.12) was recorded in 2014 on the 2nd of March, followed by 1.88 on the 3rd of March 2014.
- This result complies with the previous findings based on the MODIS AOD product, which showed high AOD in the same period of the year.





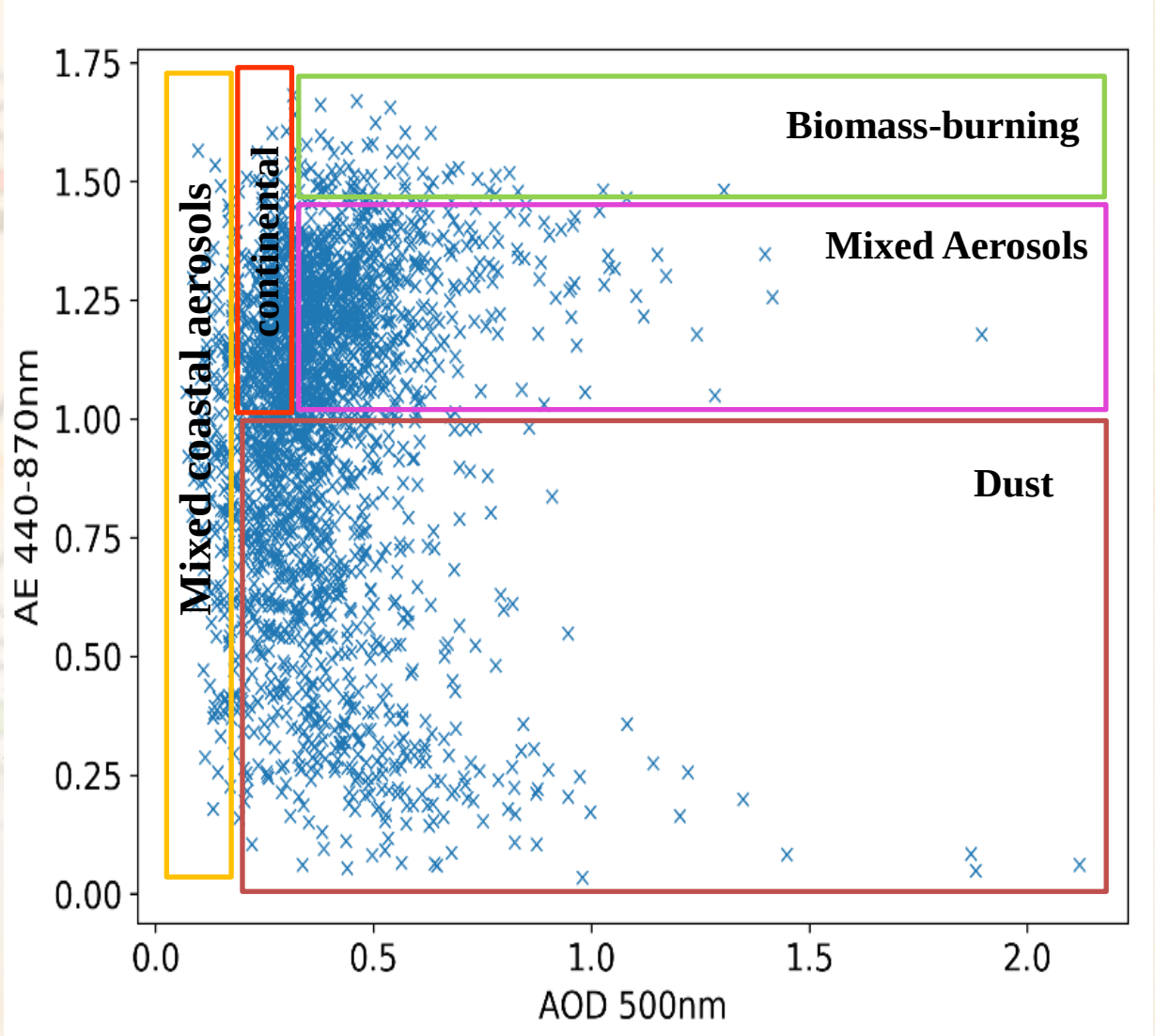



Fine particles (e.g. anthropogenic and biomass burning aerosols) (< 2.5 µm)

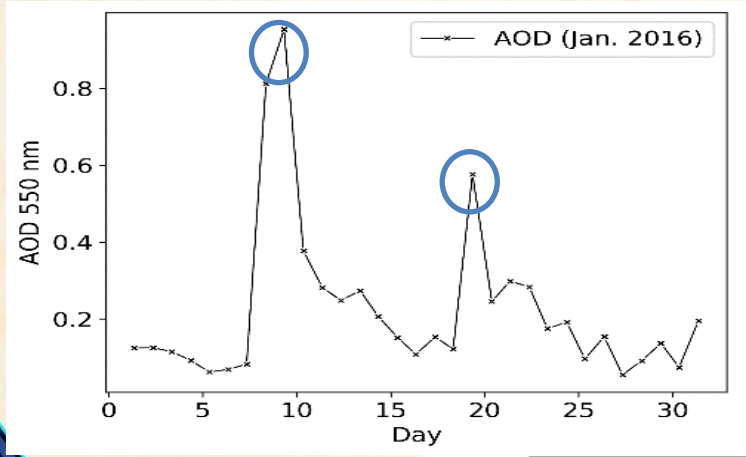
Low Volume size coarse-mode particles with a radius > 2.5 µm

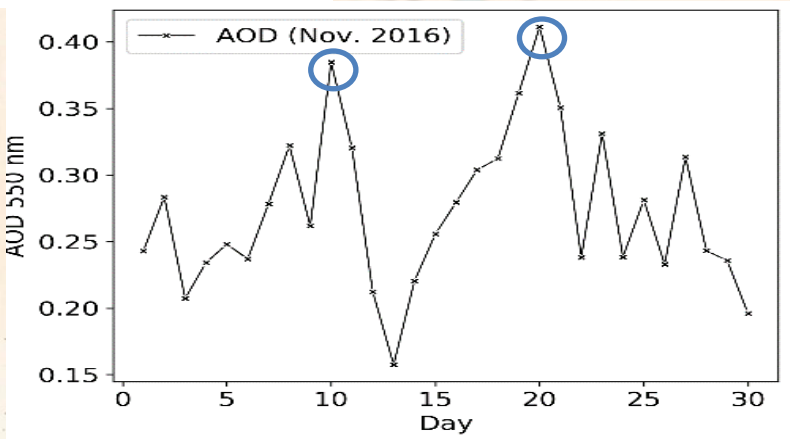
High Volume size distribution coarse-mode particles with a radius > 2.5 µm (e.g. Dust Aerosols)

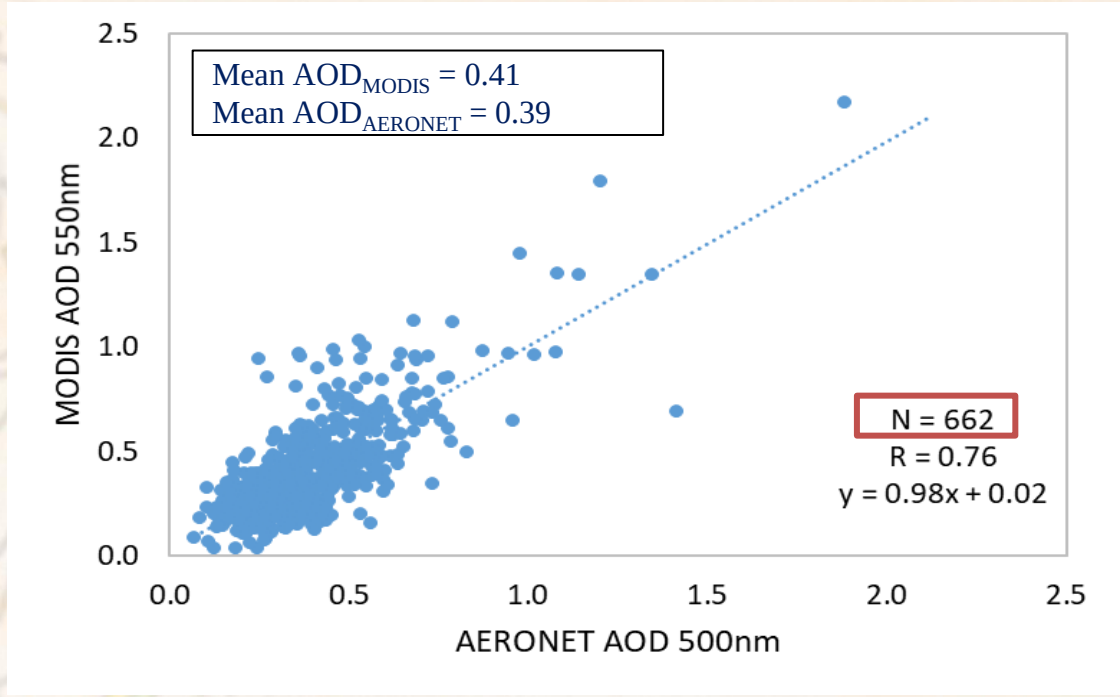
Based on the correlation between AOD and AE we can determine aerosol type based on the size variations.

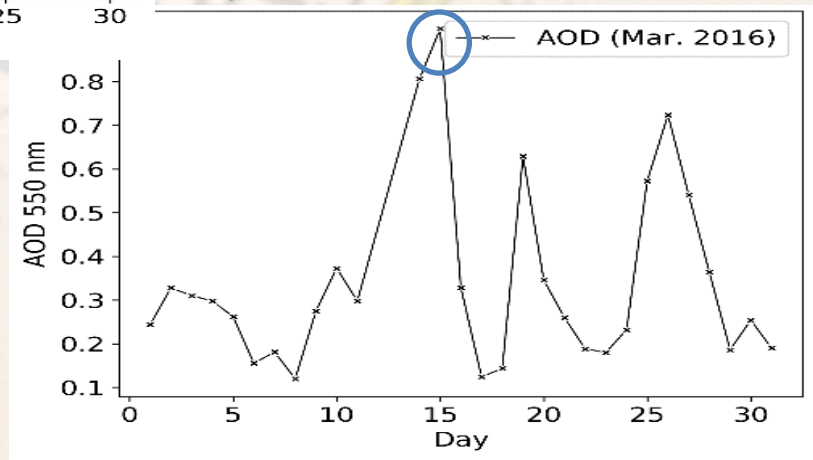


# Validation



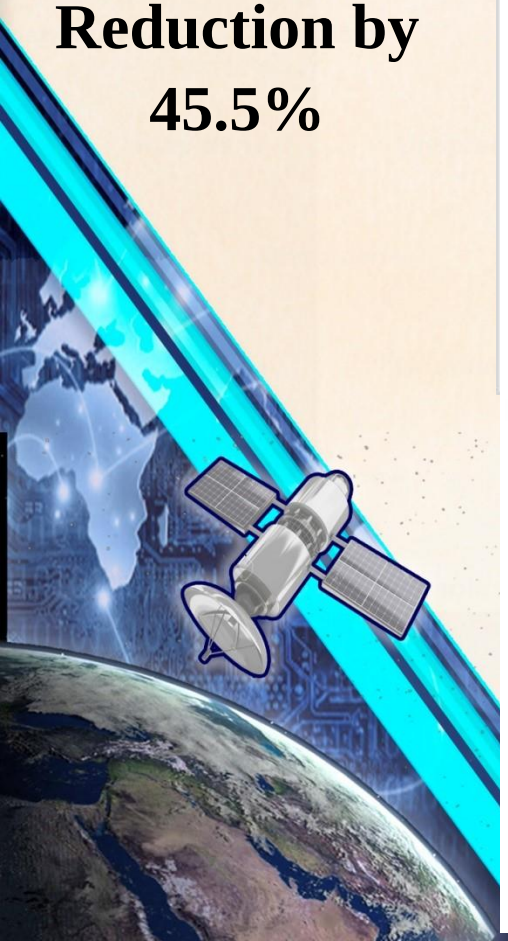

**Dust storms in 2016 (EEAA)**

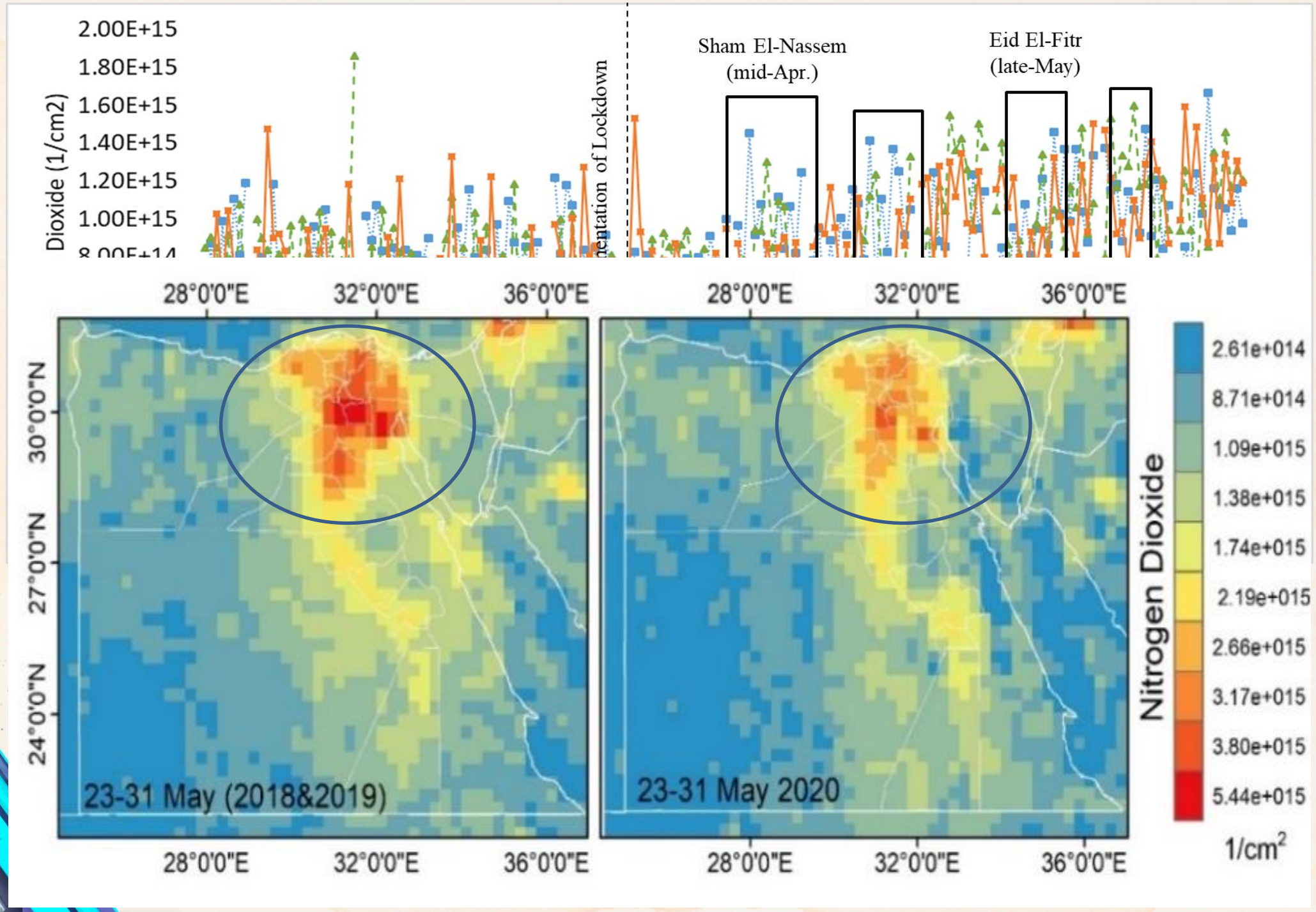
# Case Study 2:
# Monitoring Gaseous Pollutants

- A nationwide lockdown is enforced in Egypt from 15th Mar till the end of June 2020 due to COVID-19 contagion.
- Investigate the degree of improvement of air quality over Egypt during Jan.-Jun. 2020.
- Explore the spatial and temporal variations in aerosols and trace gases ($O_3$, $NO_2$, CO).
- Compared with the same months from the previous 2-years (2018 and 2019).

# Nitrogen Dioxide $NO_2$

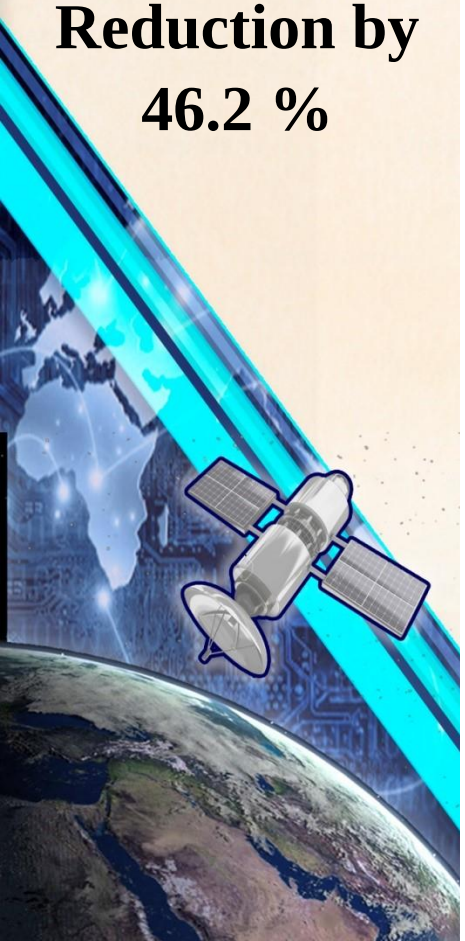
**Reduction by 45.5%**

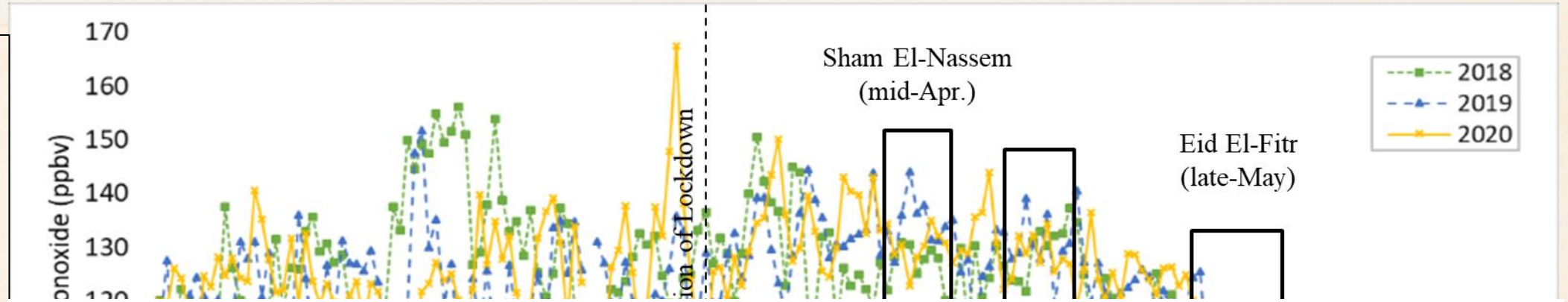


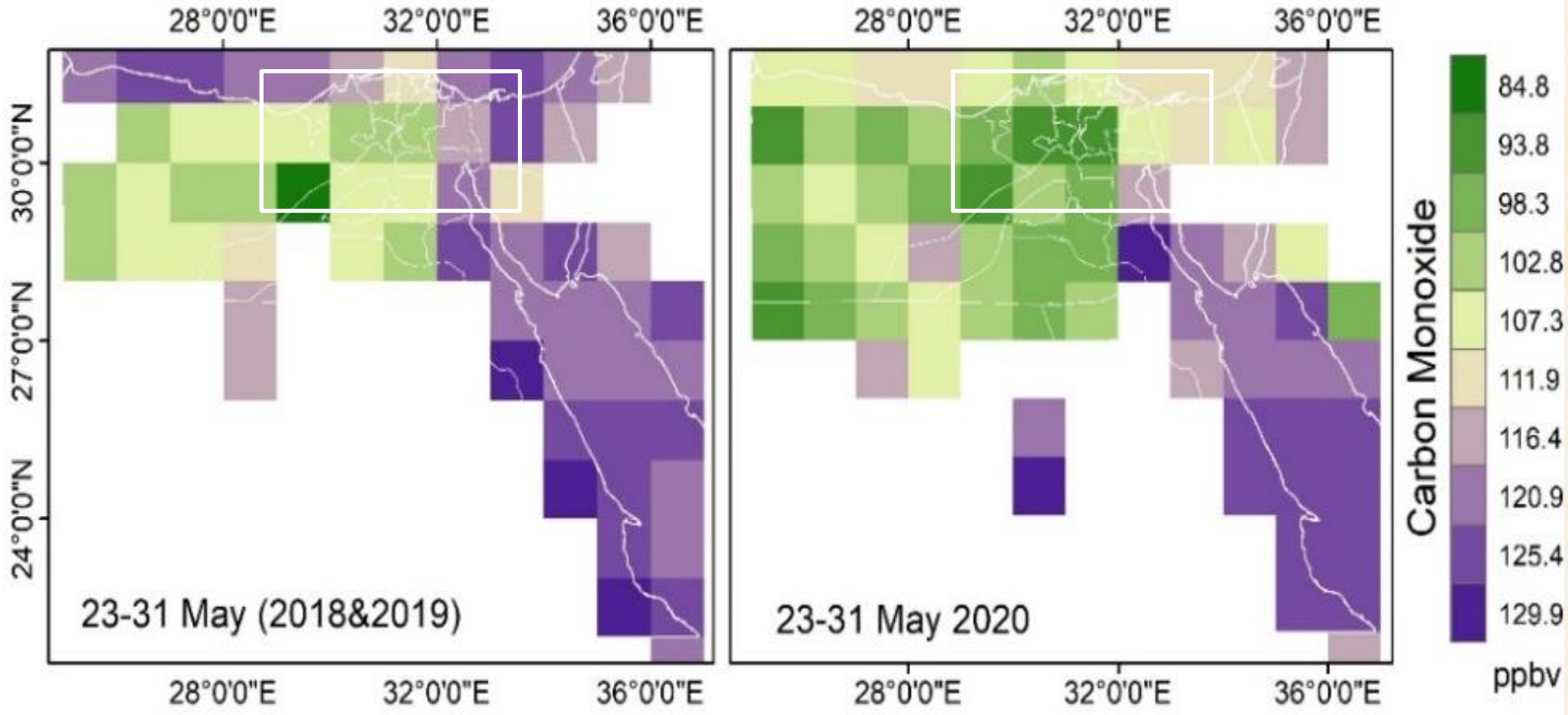


# Carbon Monoxide (CO)

**Reduction by 46.2 %**

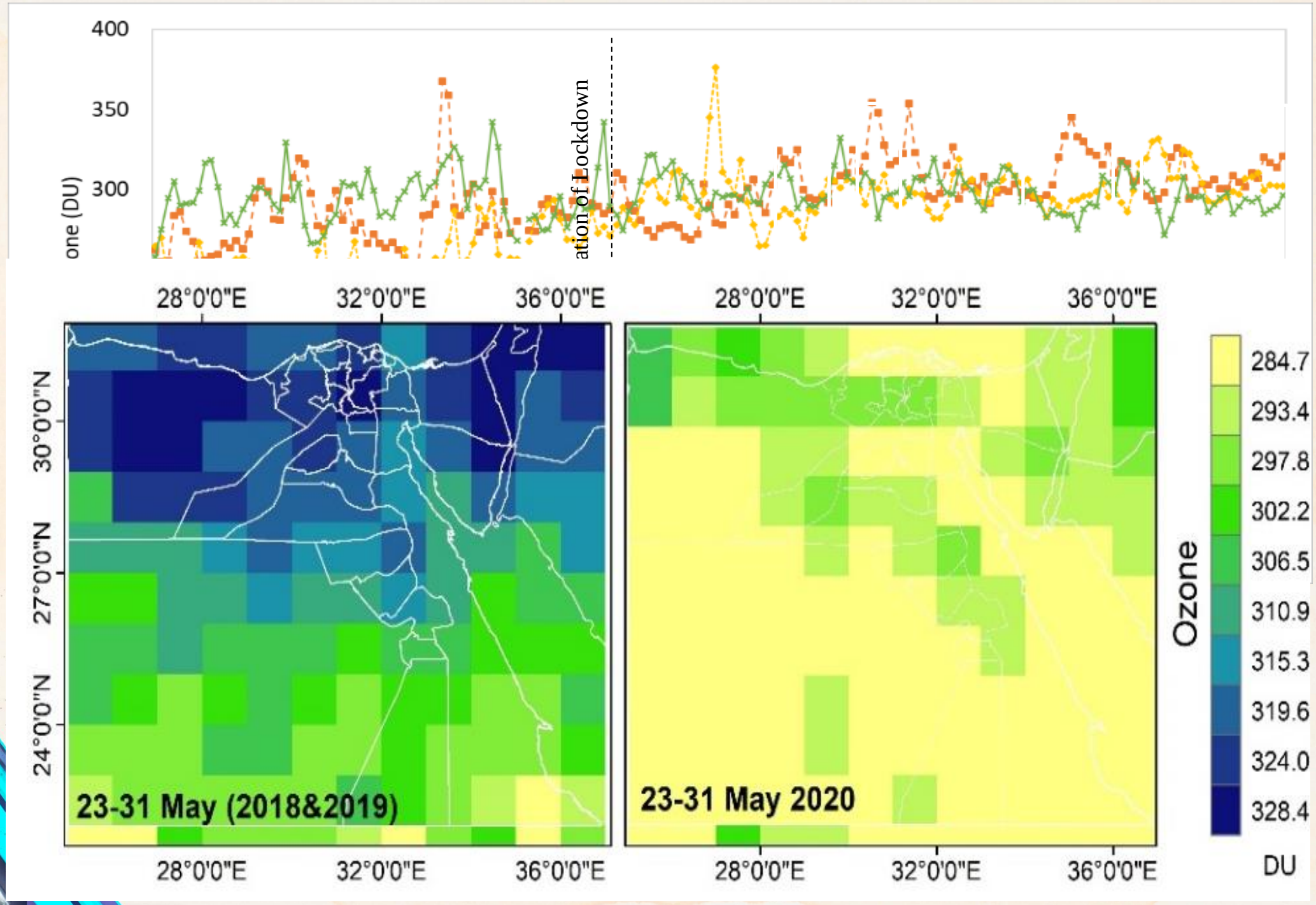




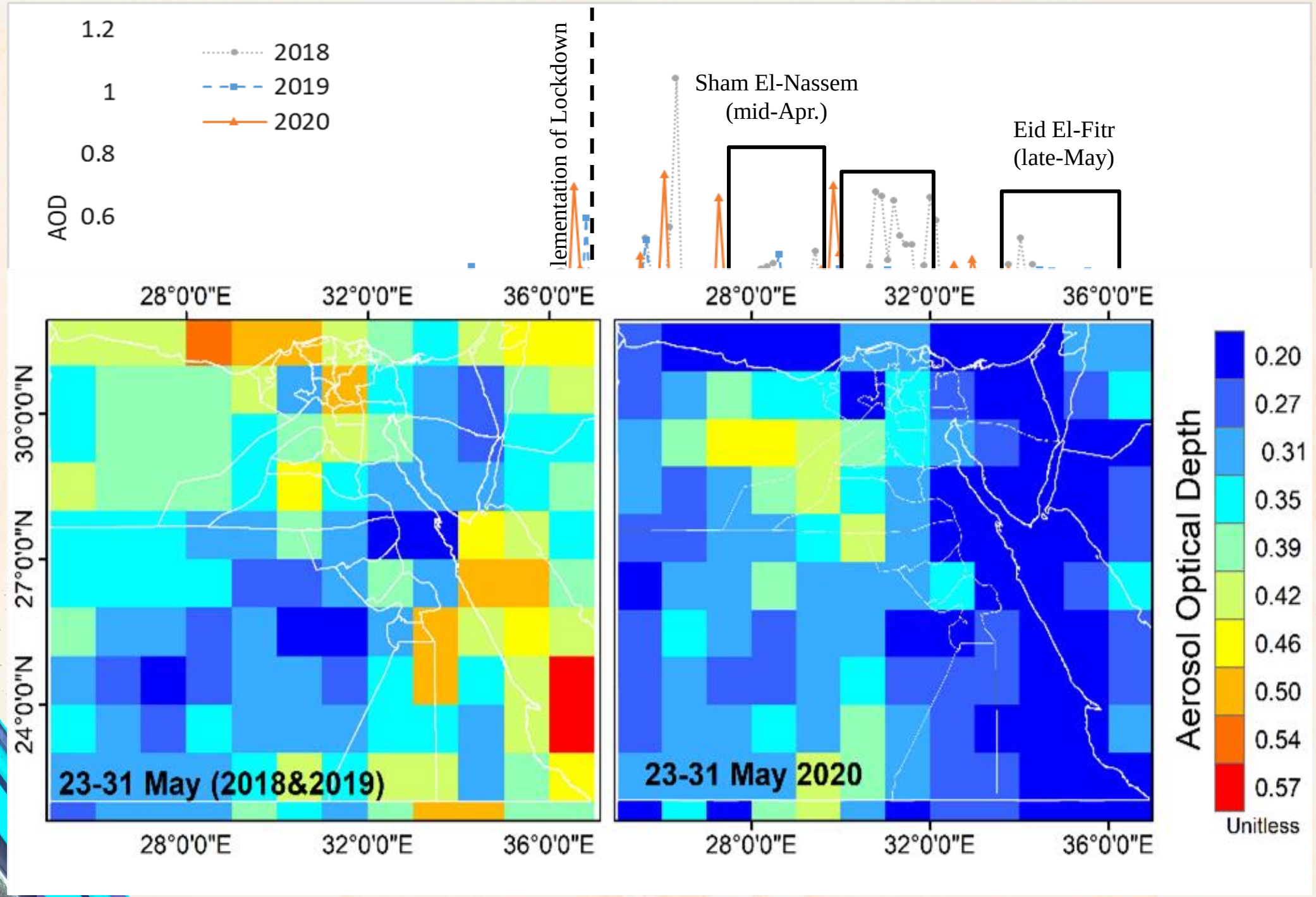
# Ozone ($O_3$)

**Reduction by 61.1%**



# Aerosols

**Reduction by 68.5%**



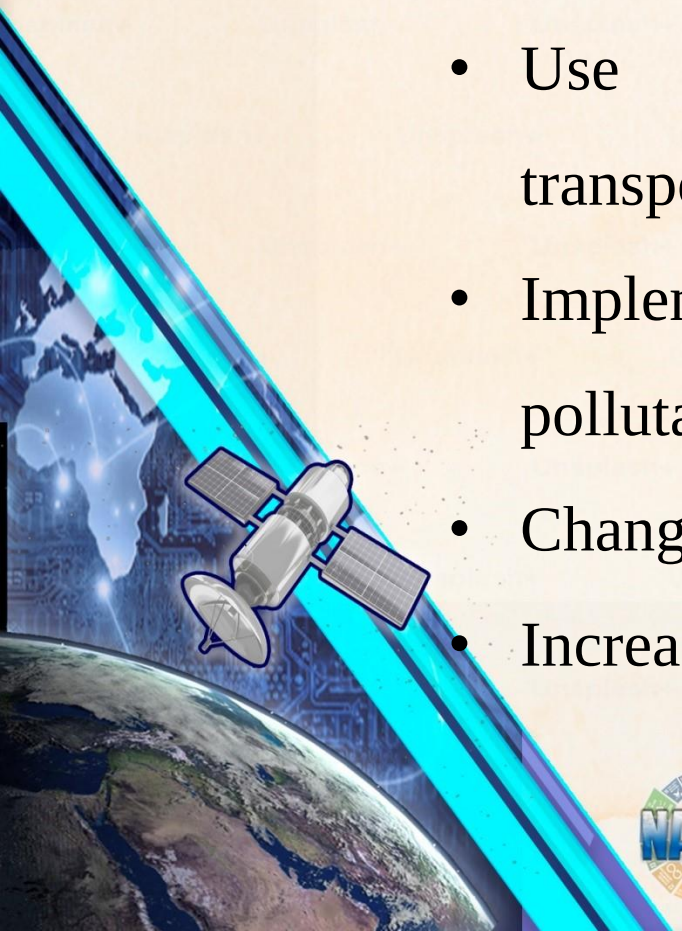
# Conclusion

**Remote sensing is an efficient tool for monitoring and assessing air quality.**

- Remotely sensed data as well as ground-based measurements showed very high efficiency to monitor the aerosol properties.
- Aerosol loading in Egypt has a seasonal mode of variation.
- Human activities have a great contribution to air quality degradation in the country.

# Recommendations

- Increase vegetation cover (trees-belt) to avoid the transport of air masses loaded with dust particles during dust storms.
- Use renewable energy sources especially in the industrial and transportation sectors to improve air quality.
- Implement advanced technologies that control and filter the emitted pollutants and convert them to safe components (Industry & Transport).
- Change human behavior and daily lifestyle to reduce air pollution.
- Increase public awareness (Students, farmers, workers, ..ect).



# THANK YOU

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**Remote Sensing of Environment**

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