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RESEARCH PAPER

Proposal for a High-Resolution Particulate Matter (PM_{10} and $PM_{2.5}$) Capture System, Comparable with Hybrid System-Based Internet of Things: Case of Quarries in the Western Rif, Morocco

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ABSTRACT

Atmospheric models today represent all significant aerosol components. Atmospheric aerosols play an important role in the air, globally through their action on the Earth's radiation balance and locally through their effects on health in heavily polluted areas, they vary considerably in their properties that affect the way they absorb and disperse radiation, and they can thus have a cooling or warming effect, they impact on the formation and life of clouds is one example. Among the main sectors of activity releasing emissions of PM10 (fine particles with a diameter of less than 10 µm) and a diameter of less than 2.5 µm (PM2.5) is the industrial sector, in particular the extraction industry of building materials. The aerosols emitted by this type of industry are composed mainly of a mixture of dust, sulphates, carbon black and nitrates, is clearly perceptible in many continental regions of the northern hemisphere. Improvements in in situ, satellite and surface measurements are needed. However, the mechanisms by which aerosols interact with the environment are extremely complex and still poorly understood. This study is based on satellite atmospheric models to have spatiotemporal variability of concentrations of fine particles smaller than 10 µm in diameter (PM10) and smaller than 2.5 µm in diameter (PM2.5) at the level of the western Rif part of Morocco, home to a large number of extraction quarries and thus offering a high-resolution particle capture system (PM10 and PM2.5).

Keywords: Atmospheric aerosols, Air pollution, IoT, Quarries, Western Rif.

INTRODUCTION

Rock-mining industries, although they are generally located far from urban centers, contribute massively to particulate air pollution. Indeed, these industrial units emit large quantities of aerosols (Balestra, et al, 2020). These are transported and dispersed by the wind over large areas, which can affect the various components of the environment. The Aerosol used both to describe particles in the atmosphere, pressurized bottles or inhalation suspensions in some medical cures, is a source of confusion and ambiguity (Yuan et al,

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2020). Strictly speaking, an aerosol is defined as a mixture between condensed phases (solid or liquid) and a gas, an aerosol particle being understood as a solid or liquid particle suspended in the air within this mixture (Voigt et al., 2013).

Tropospheric aerosols are important because of their strong influence on the climate system through direct and indirect effects. These include the direct effect of diffusion and absorption of radiant energy, and the indirect effect of altering the microphysical properties of clouds, and thus their radiative properties and lifetime (Jeoung et al, 2020) (Boucher & Haywood, 2001).

However, the very high levels of fine particles in urban and peri-urban atmospheres are responsible for the phenomena of reduced atmospheric visibility and, above all, lead to air pollution that is dangerous for health, probably responsible each year in Europe for hundreds of thousands of hospitalizations and tens of thousands of deaths (Kuehn, B. M. 2021). They are, moreover, at the origin of the deterioration of historical monuments by the action of their acid component on limestone and marble (Ding et al,2021). Given the seriousness of their effects on health and the environment, it is essential to set up emission reduction and control policies adapted to local and regional specificities. This can only be undertaken on the basis of an in-depth knowledge of the properties of atmospheric particles, their emission sources and the transformations they undergo during their transport in the atmosphere (Allan et al, 2009)(Zou et al, 2020). They also attract attention because of their adverse effects on visibility (Watson, 2002) and human health (Delfino et al. 2005; Pope III, 2006). Therefore, the spatial approach and temporal variation of aerosols is essential to understanding, but remains a complex subject due to its ephemeral nature and the complexity of their physical and chemical properties (Ramanathan et al., 2001). Particle size is considered a key parameter in defining the impact of particulate matter (PM) on human health; in particular, fine particles (PM2.5 and PM10) pose a greater health risk than coarse particles (PM10) (Oberdörster et al., 2005) .With the progress of industrialization and the development of the automobile fleet, the problem of air contamination by gaseous chemicals, aerosols and suspended particulates has now gone far beyond the rich countries and, with Morocco's economic development in recent years, it is likely that the country will also be increasingly confronted with this problem (Nejjari et al., 2016).The objective of this study is to make a satellite observation focusing on west of the Rif of Morocco and to propose a high-resolution capture system for particles (PM10 and PM2.5) comparable to hybrid satellite models.

MATERIELS AND METHODS

The study sector is located between the cities of Ceuta and Bab Taza. Precisely in a part of the Rif mountain range situated in the north-west of Morocco (represented in figure 1). This Rif chain is an alpine age chain, whose geosynclinal orogeny is characterized by a repeated and chained orogenic movements and late magmatic and post-tectonic appearances (Wildi et al., 1977). The Rif chains are made up of 3 concentric structures that form an arc whose concavity is turned towards the Mediterranean. From the centre of this arc towards the periphery we find a coastal Paleozoic zone, followed by a middle Jurassic zone of high limestone mountains known as limestone chains (Subject of our study) and finally a peripheral zone of flysch. The first two zones constitute the internal domain of the Rif or what is called the Northern Rif (Fattah et al,. 2021) (Benmakhlouf & Chalouan, 1992).

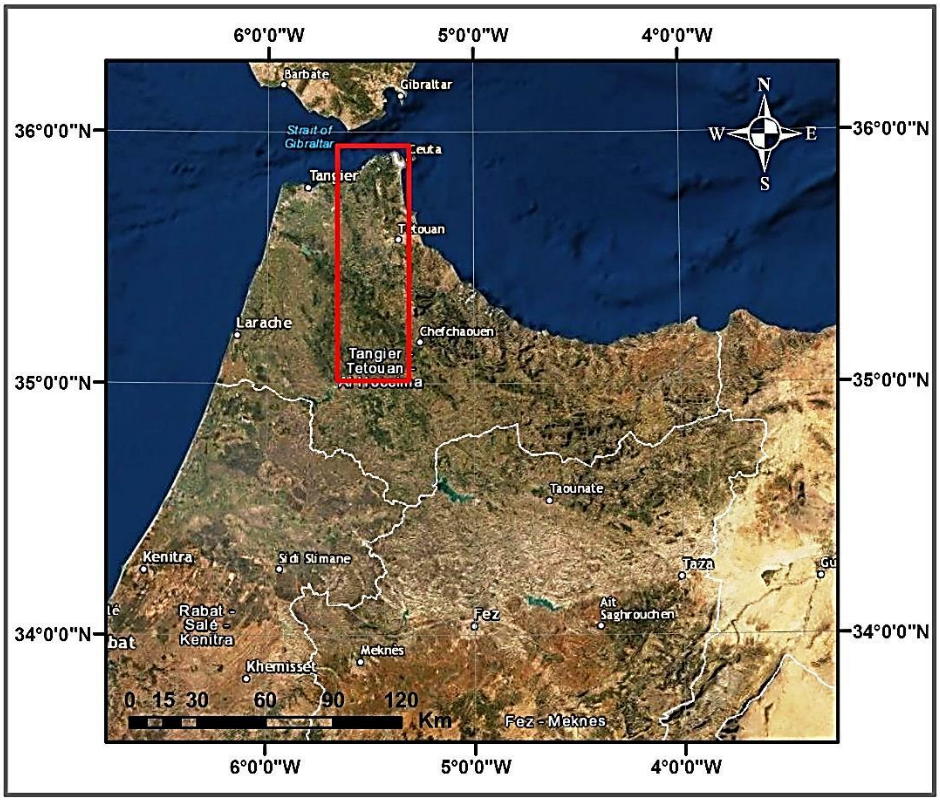


Fig 1. Map of Sites Study

The Rif region is the northern region of Morocco, bordered by the Mediterranean Sea to the north and to the east, the plains separating it from the Middle Atlas Mountains to the south and the Atlantic Ocean to the west. The territory is very rugged with high mountains and the climate is mild with heavy rainfall in winter. The main cities of the Western Rif are Tangier, Tetouan and Chefchaouen (Wildi et al., 1977).

In this article working on the area of the following coordinates (figure 2): -5.6678, 35.0842, -5.2942, 35.9521.

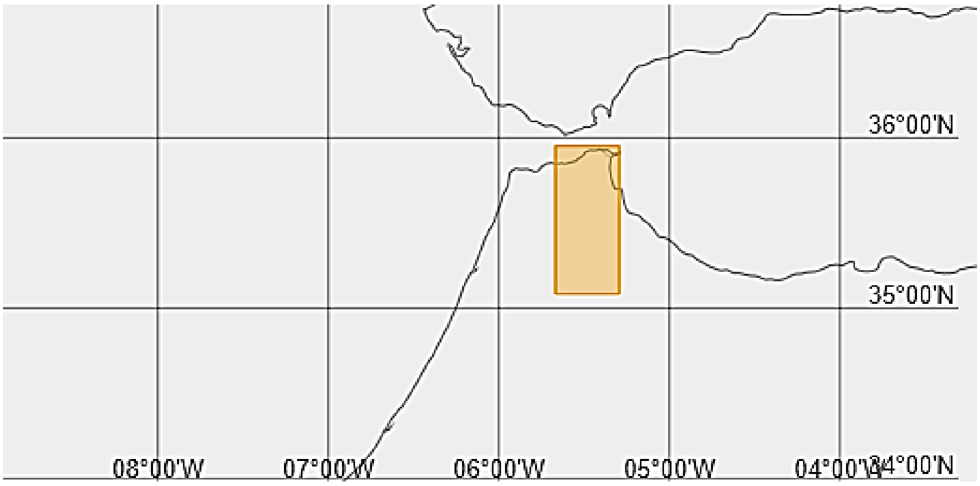


Fig 2. Study area

Satellite particulate matter (PM) estimates were based on a new satellite-based space-time model developed to predict PM 1.0 and PM 2.5. These were based on the Moderate

Resolution Imaging Spectroradiometer (MODIS) sensor over the Terra and Aqua satellites.

Using this NASA satellite and method (MERRA-2) modern era retrospective analysis for research and applications, version 2 (MERRA-2) is a NASA atmospheric reanalysis for the satellite era using the Goddard Earth Observing System model, version 5 (GEOS-5) with its Atmospheric Data Assimilation System (ADAS), version 5.12.4. The MERRA project focuses on historical climate analyses for a wide range of weather and climate time scales and places NASA's suite of EOS observations in a climate context (Laj & Sellegri, 2003; Wargan et al., 2017).

The optical thickness of aerosols is one of the widely used satellite products for PM modeling. The extent to which aerosols prevent the transmission of light by absorption or scattering of light. Aerosol Optical Depth (AOD) or Optical Thickness (τ) is defined as the extinction coefficient integrated on a vertical column of unit cross-section.

The extinction coefficient is the fractional depletion of radiation per unit path length (also called attenuation, especially with reference to radar frequencies). The optical thickness along the vertical direction is also called normal optical thickness (compared to the optical thickness along the oblique path length).The total optical thickness of aerosols is at 550 nm from the Moderate Resolution Imaging Spectroradiometer (MODIS), at 865 and 869 nm from the Sea WiFS wide field of view sensor, at 443, 555, 670 and 865 nm from the Multi-angle Imaging Spectroradiometer (MISR_), and at a number of wavelengths between 342 and 500 nm from the Aura Ozone Instrument (OMI) (Randles et al., 2021).

Dust consists of small solid particles. Dust particles are generally between 1 and 100 µm in diameter. Dust can either be suspended in the atmosphere as aerosols or accumulate as sediment on the earth's surface. Because of the variety of sources that can give rise to dust, it can be composed of many different substances, both organic and inorganic (disc.gsfc.nasa.gov/).

The spatial and temporal variability of particulate matter (PM) pollution in the environments of the western Rif of Morocco during one year.

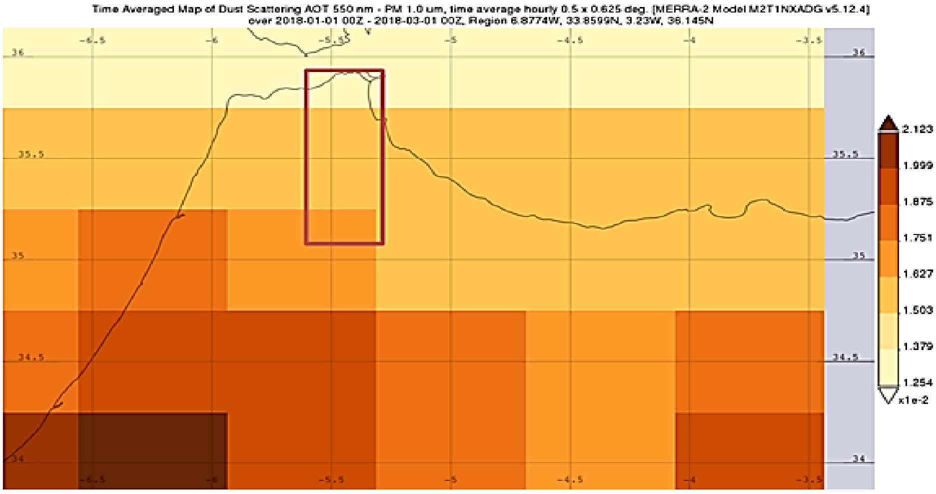


Fig 3. Averaged Map of Dust Extinction AOT 550 nm - PM 1.0um monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Janv - 2018-Mar, Region North of Morocco

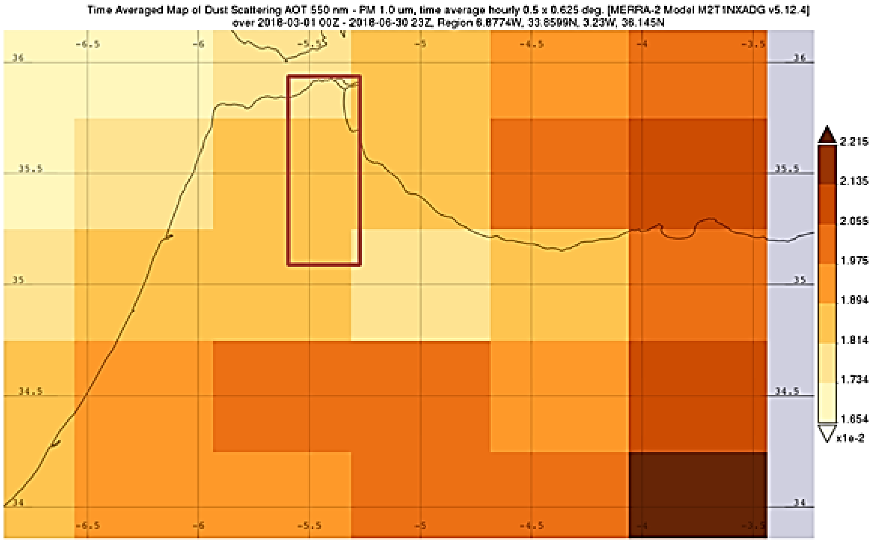


Fig 4. Averaged Map of Dust Extinction AOT 550 nm - PM 1.0um monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Mar - 2018-Jun, Region North of Morocco

Figure 3 shows a variation the Dust Extinction AOT 550 nm - PM 1.0 for the duration of the month January to March its variation of PM 1 varies between 1.254*e-1 to 1.751*e-1, and we see the concentration of PM (Figure 4) is higher than Figure 4 varies between (1.654 to 1.814)*e-1 for the month of March to June.

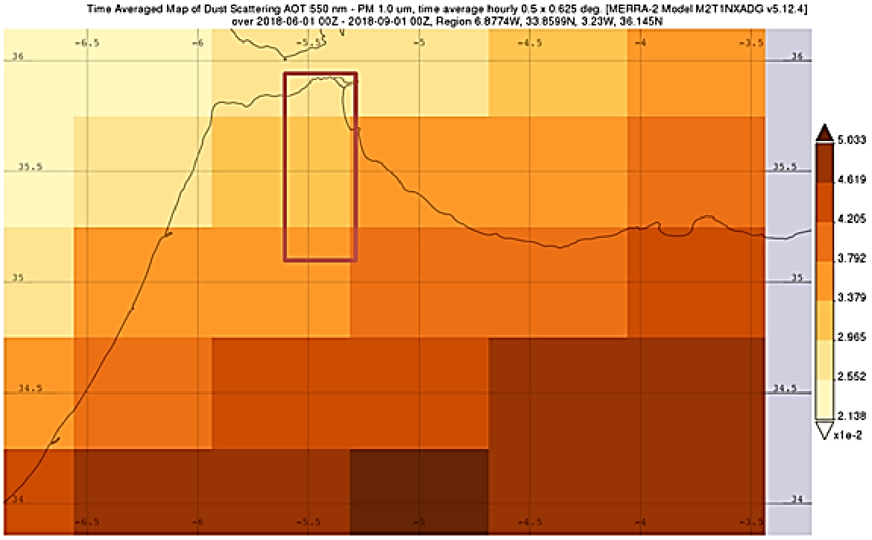


Fig 5. Averaged Map of Dust Extinction AOT 550 nm - PM 1.0um monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Jun - 2018-Sep, Region North of Morocco

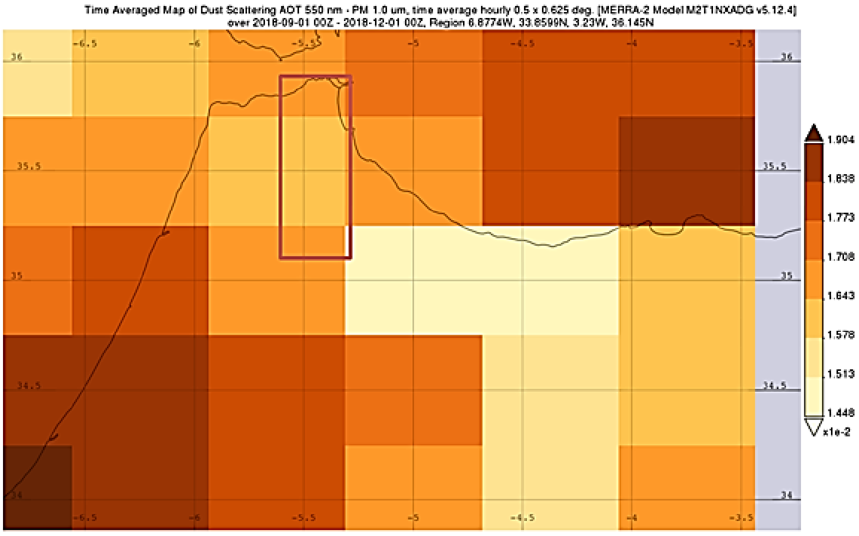
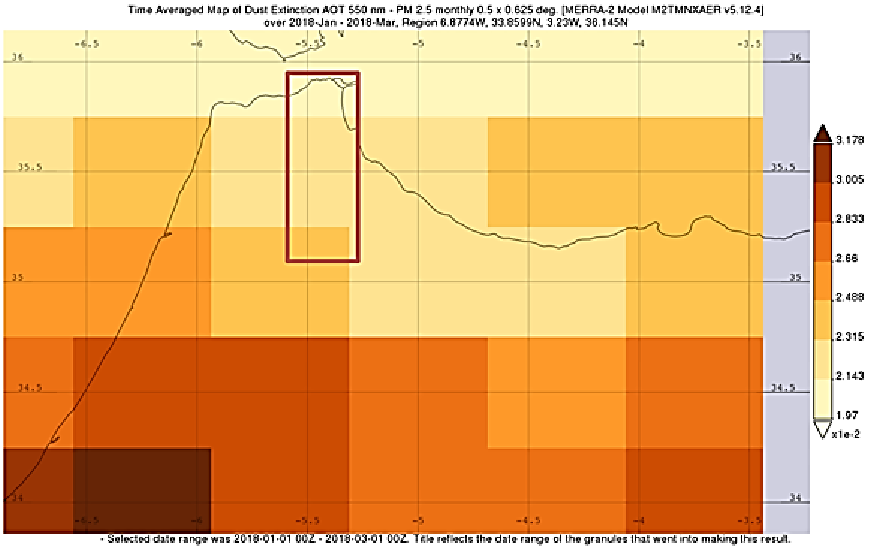


Fig 6. Averaged Map of Dust Extinction AOT 550 nm - PM 1.0um monthly 0.5 x 0.625deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Sep - 2018-dec, Region North of Morocco [12]

On the other hand, the month from June to September we notice that Dust Extinction AOT 550 nm - PM 1.0 for our study area varies between 2.138*e-1 to 3.379*e-1 (figure 5) that is a high concentration compared to other spatiotemporal figures. For the figure 6 we notice a decrease of variation of extinction of PM 1.0 to the scale of 1,513*e-1 to 1,708*e-1

From the 4 figures it can be seen that from June to September there is a higher concentration of fine particles than in the other figures.



- Selected date range was 2018-01-01 00Z - 2018-03-01 00Z. Title reflects the date range of the granules that went into making this result.

Fig 7. Averaged Map of Dust Extinction AOT 550 nm - PM 2.5 monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Janv - 2018-Mar, Region North of Morocco

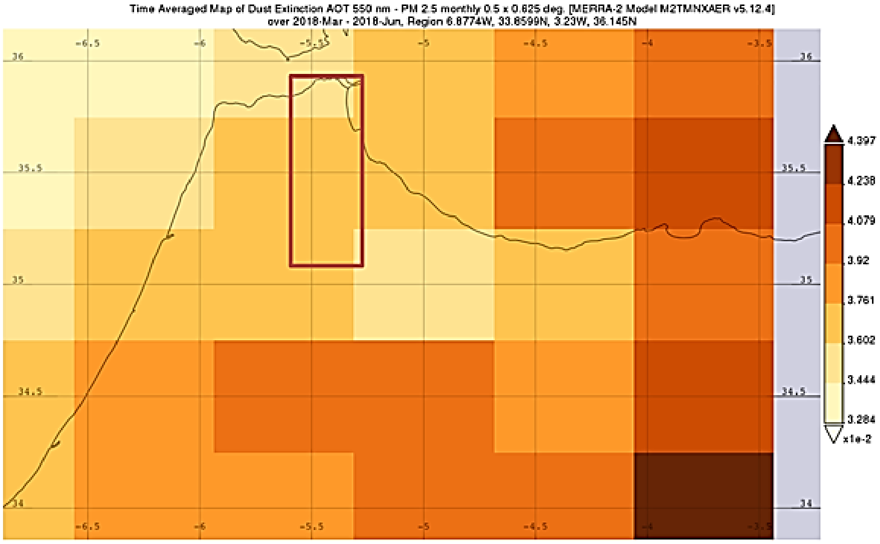


Fig 8. Averaged Map of Dust Extinction AOT 550 nm - PM 2.5 monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Mar - 2018-Jun, Region North of Morocco

The variation of the Dust Extinction AOT 550 nm - PM 2.5 for the duration of the month January to March its variation of PM 2.5 varies between 1, 97*e-1 to 2,488*e-1 Figure 8, and the variation of figure 8 is higher than figure 7 between 3.28*e-1 and 3.602*e-1.

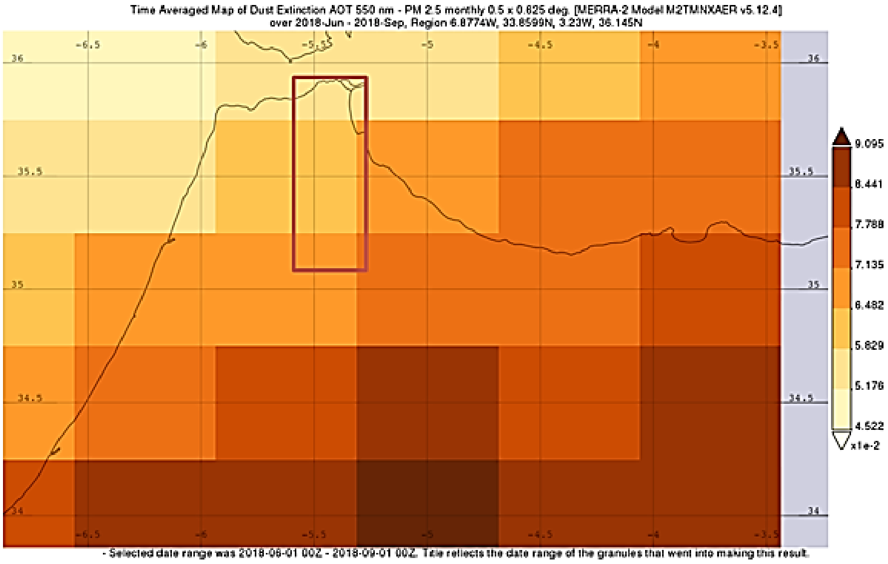


Fig 9. Averaged Map of Dust Extinction AOT 550 nm - PM 2.5 monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Jun - 2018-Sep, Region North of Morocco.

In figure 9 we see an increase in the variation of the Dust Extinction AOT 550 nm corresponding to the PM 2.5 (5,178 to 7,135)*e-1

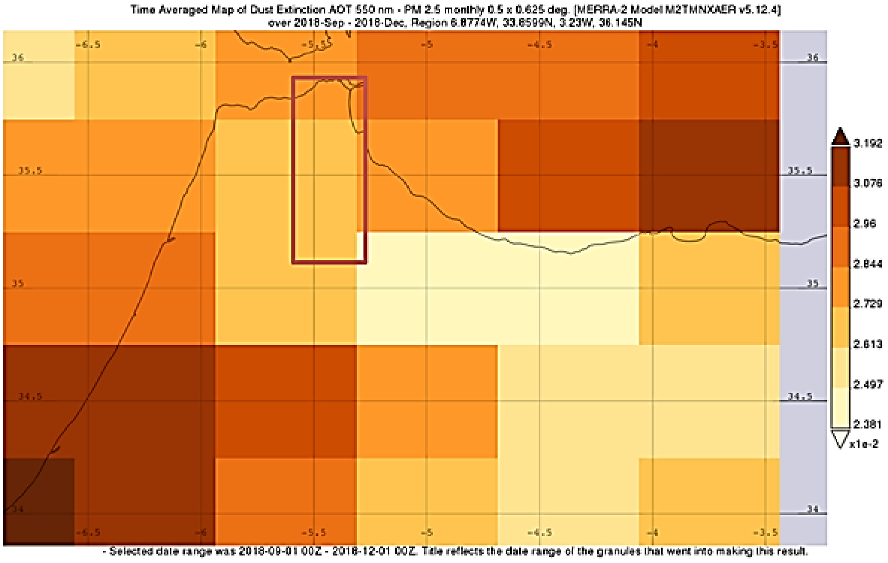


Fig 10. Averaged Map of Dust Extinction AOT 550 nm - PM 2.5 monthly 0.5 x 0.625 deg. [MERRA-2 Model M2TMNXAER v5.12.4] over 2018-Sep - 2018-Dec, Region North of Morocco

According to figure 10 we have a variation more or less low than figure 10 of the order of (2.497 to 2.844)*e-1.

So we notice that the spatiotemporal figure: (figure 9) of a variation the Dust Extinction AOT 550 nm - PM2.5 higher for the month of June to September, and it is the same for the PM 1.0 a higher concentration than the other figures 3, 4, and figure 6.

In regard to monitoring weather and atmospheric conditions, we will develop and implemented a new system. Our system will be based on internet of things (IoT) relays with sensors both meteorological and aerial parameters. The realized framework to be produced includes a programmable board as central management unit (Azrour et al, 2021) (Mabrouki et al, 2019). Then all sensors and devices can be connected to it directly or indirectly. The connected sensors will be able to measure meteorological and aerial information from their environment. The captured values will be transmitted to the map for local processing. After simple processing, the programming board will transmit the processed values to the computer which includes the database. The stored information will be accessible accessed remotely via the web page. When an unwanted value is detected, an alert message will be sent to the end user via e-mail. The main components of the proposed system are shown in Figure 11.

There are several well-established methods for high-resolution solid particle measurements, such as the Cone Element Oscillating Microbalance (TEOM) (disc.gsfc.nasa.gov). The gravimetric principle describes a quantitative determination of an analysis based on the mass of a solid. These well-established high-precision devices are all generally large, stationary and expensive, and therefore very little deployed. Based on artificial intelligence one can measure aerosols, we propose the use of an intelligent system for the detection of atmospheric particulate matter (PM) or aerosols, which provide an economical solution for space-time measurements. The method we proposed for finer measurements was The SHARP (Synchronized Hybrid Ambient Real-time Particulate) method provides a real-time measurement of the mass concentration of particles by combining a beta (14C) radiation attenuation meter and a fast response scatterometer. The system uses digital filtering to continuously calibrate the photometer using the integrated beta attenuation data (Canadian Council of Ministers of the Environment, 2011). It minimizes moisture interference and loss of volatile components through the use of Intelligent Moisture

Reduction (IMR) combined with frequent replacement of the sampling filter. Based on the use of commercially off the shelf (COTS) sensors (Lesser et al., 2021) (Mabrouki et al, 2021) example: sensors that were used for the measurements: Sharp-GP2Y1030AU0F; GP2Y1026AU0F; and Honeywell-HPMA115S0-XXX.

Honeywell HPM Series Particle Sensor with Universal Asynchronous Receiver/Transmitter (UART) Output allows the user to more accurately and cost-effectively monitor or control environmental particulate contaminants. These HPM Series outputs at PM2.5 utilizing a laser-based light scattering particle sensing method to detect (Lesser et al., 2021) (Azrour et al, 2021).

The GP2Y1026AU0F sensor is a high-concentration sensor that comes with a built-in microcomputer and features digital signal (UART) temperature correction averaging output. The GP2Y1030AU0F sensor comes with a built-in microcomputer and features digital signal (UART) output (Molnár et al, 2019).

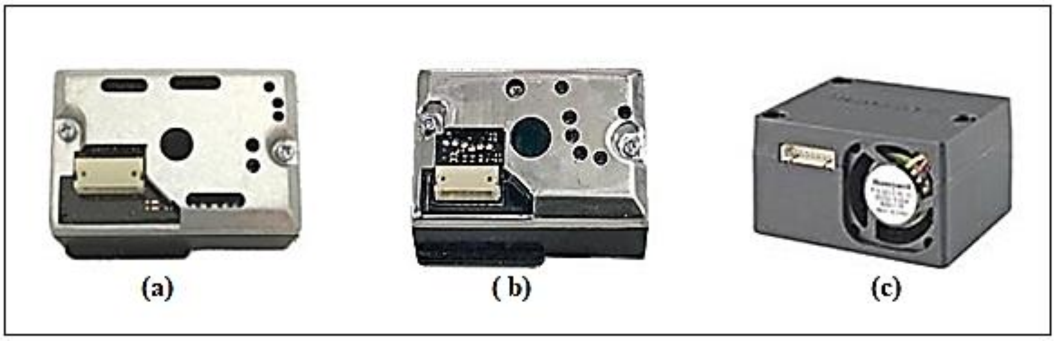


Fig 11. PM sensor, (a) Sharp-GP2Y1030AU0F, (b) GP2Y1026AU0F, (c) Honeywell-HPMA115S0-XXX (Eskandari et al, 2019]

The spatiotemporal evolution of the Dust Extinction AOT 550 nm - PM 1.0 um in the Atlantic coast is more concentrated of the order of 1,999*e-2 but generally it varies between (1.894 and 1.814)*e-2 in contrast to the evolution of PM 1.0 um in March and June and higher than figure 4, Dust Extinction AOT 550 nm - PM 1.0 um figure 6 is higher than figure 4 and figure 5 the variation of order 3.379*e-2, and for figure 7 one notices of the variation of concentration of the Dust is decreased (Mabrouki et al., 2021).

In addition, in the duration between June and September the spatial and temporal evolution of the Dust Extinction AOT 550 nm - PM2.5 is more concentrated varies between 5.829*e-2 and 5.178*e-2 figure 10 on the other hand the spatial and temporal figures of figures 8, 9 and 11 the PM2.5 concentration is less high.

The spatiotemporal evolutions of Dust Extinction AOT 550 nm - PM 1.0 um and PM 2.5 during the summer is higher compared to the whole year.

CONCLUSION

Satellite models provide a good amount of information using spectral imagery and remote sensing tools, their spatio-temporal resolution can sometimes be lacking due to their specific coverage time of flyovers. These satellite data could be improved by using corresponding ground measurements, especially in urban areas and around daily hot spots, by placing a COTS sensor network for a finer exposure profile (hourly and daily, instead of image-based prediction models). This research is focused on the detection of airborne particles, PM10 and PM2.5 which are the smaller particles with average diameter. In this first field of application that is the measurement of satellite images, the measurement sites are located north of Morocco of the most intense primary emission sources. The analysis of these images misses that there is an air pollution of this region. For the depth of the study it is mandatory to measure the alert level for a long time representing the central criterion for defining the establishment of an air quality measurement network for an agglomeration. The proposal of an Internet of Things based system with sensors, which is easy to use and collect data, is of course a good way to announce air pollution alarms and to monitor air quality at a distance.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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