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UAV-based Measuring Station for Monitoring and Computational Modeling of Environmental Factors

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SECTION

Monitoring systems in aerospace

ABSTRACT & KEYWORDS

- Software application for computational modeling of environmental factors, in connection with UAV-based measuring station for environmental factors monitoring in real-time regime precise measurements, which facilitates the analysis and interpretation of the monitoring results, has been developed as an integrated mobile system for exact monitoring and computational modeling of environmental factors. This paper deals with the second stage related to the drone-dedicated system developed at the Moldova State University (MSU) in the research laboratory Environmental Physics and Modeling Complex Systems (MSU ePhysMCS Lab) for the observation and support of the air analysis for pollution, chemical and radiological contaminations. The exact data are used in modeling of the impact of biotic and abiotic factors during the real-time environmental monitoring process.

- Keywords – Environmental monitoring, computational modeling, Unmanned Aerial Vehicle (UAV), PM-pollution

INTRODUCTION

2016 European project “Educational for Drone” (eDrone, 574090-EPP-1-2016-1-IT-EPPKA2CBHE-JP)

2018 Office for Education for Drones (OED) at the MSU

2020 Advanced physical technologies with the UVS application in monitoring and modelling of environmental factors

OFFICE FOR EDUCATION FOR DRONES AT THE MSU

Co-funded by the Erasmus+ Programme of the European Union

UNIVERSITÀ DEGLI STUDI DEL SANNIO

- SmartCity SOWA environment monitoring platform
- Multispectral camera Survey 3W
- FLIR Vue Pro R infrared camera
- LiDAR 3D mobile scanner
- Drones: DongYang D800-X4, DJI Phantom 4 Pro & drone equipment

eDrone CTT & CIA courses deployment and set-up

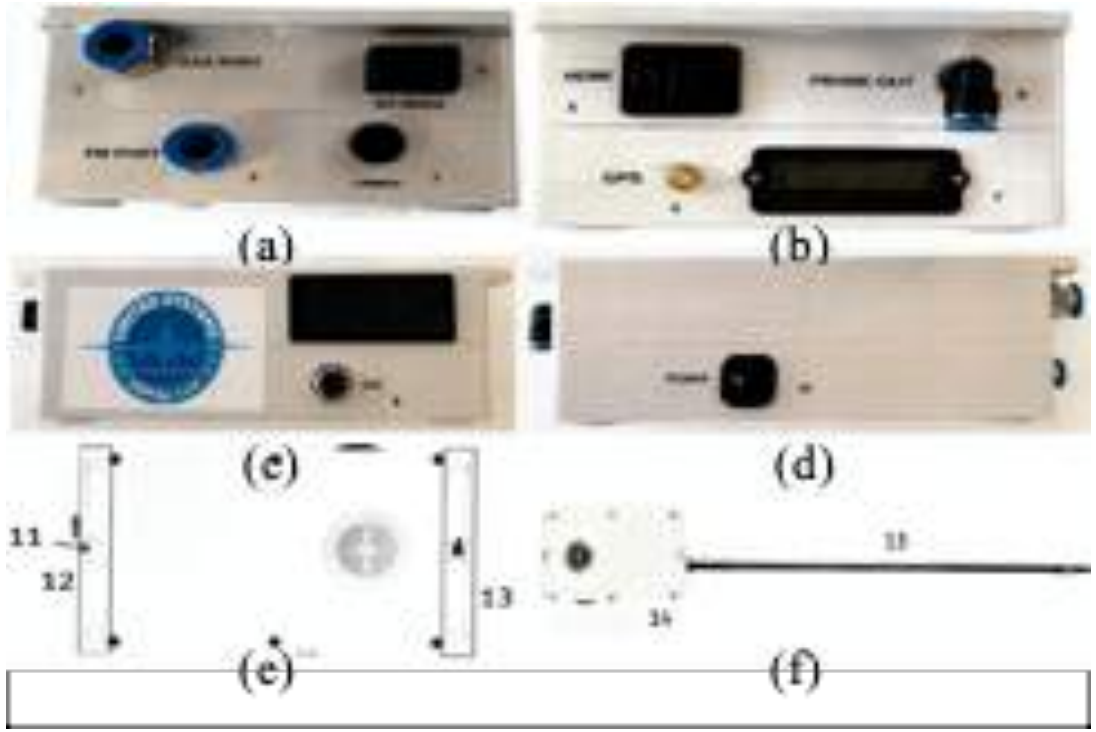
AIR CONTENT ANALYSIS SYSTEM SOWA

Functionality:
PM, Organic compounds, Formaldehyde, Hydrogen chloride,
Hydrogen cyanide detection;
Humidity range:
from 0 to 100 % RH;
Pressure range: from 300 to 1100 hPa.

Physical characteristics:
Dimensions: 220x150x80 mm;
Weight: 1100 g;
Power supply:
battery Lithium-ion
up to 3 hours;
Power supply charging: 9-29 V, drone supplied, PoE 802.3af; Connectors.

DESCRIPTION OF DEVICE ELEMENTS

Air content analysis system is a mobile air laboratory, which allows reading air content directly from the source, and it is equipped with a built-in HD camera transmitting the image with the measured parameters to the station operator.



Front (a), rear (b), left side (c),
and right side (d) of the measuring station,
and its components,
(e) and (f).

1. Gas intake;
2. Dust intake;
3. Built-in HD video camera;
4. Temperature, humidity and pressure sensors;
5. HDMI video output;
6. GPS antenna connector;
7. Battery charge indicator;
8. Air outlet from measuring chamber;
9. Power socket/LAN (PoE);
10. Power switch;
11. Place where the screw is attached to the handle;
12. Front grip fixing strip;
13. Rear grip fixing strip;
14. Measuring laboratory;
15. Measuring probes.

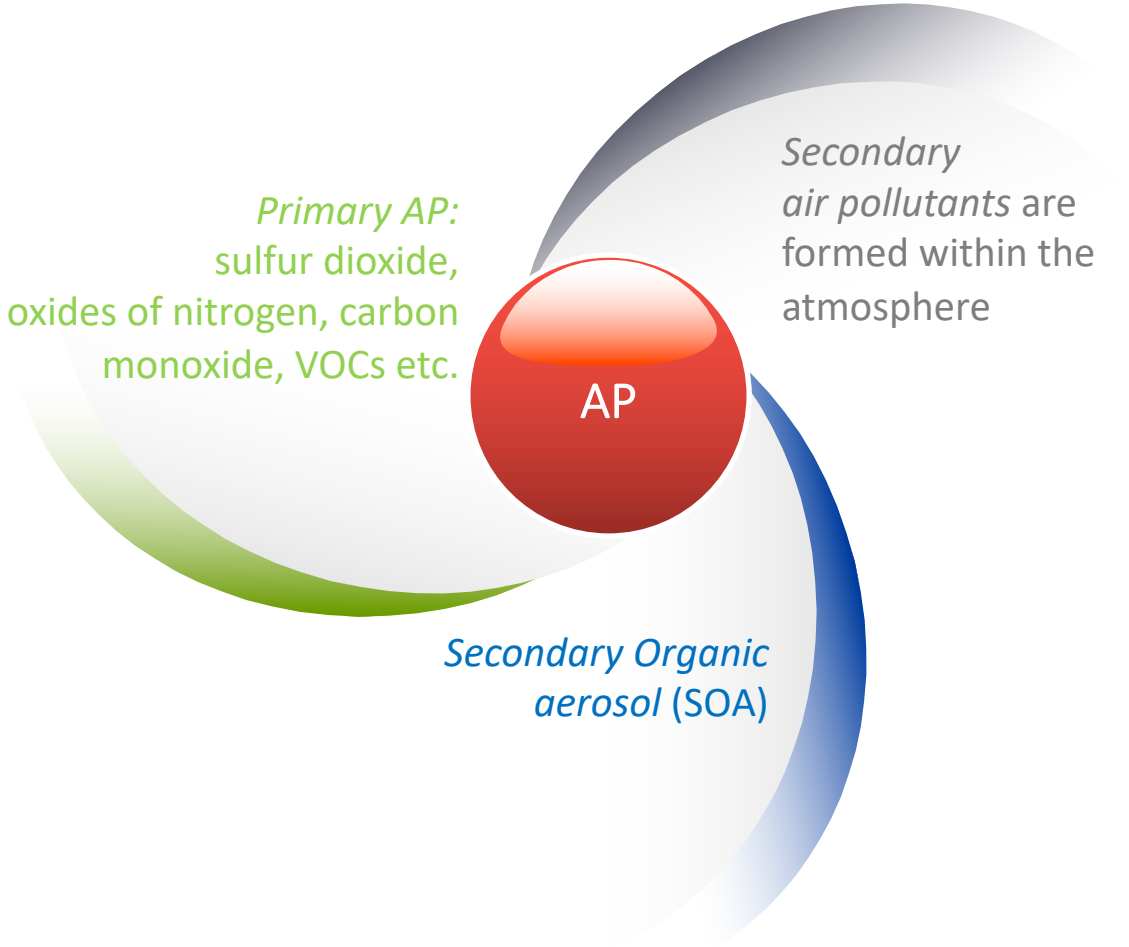
PERFORMING MEASUREMENTS

Web browser on the tablet screen.

System login screen view.

Charts with historical data view.

AIR POLLUTANTS (AP): GASEOUS & PARTICULATE

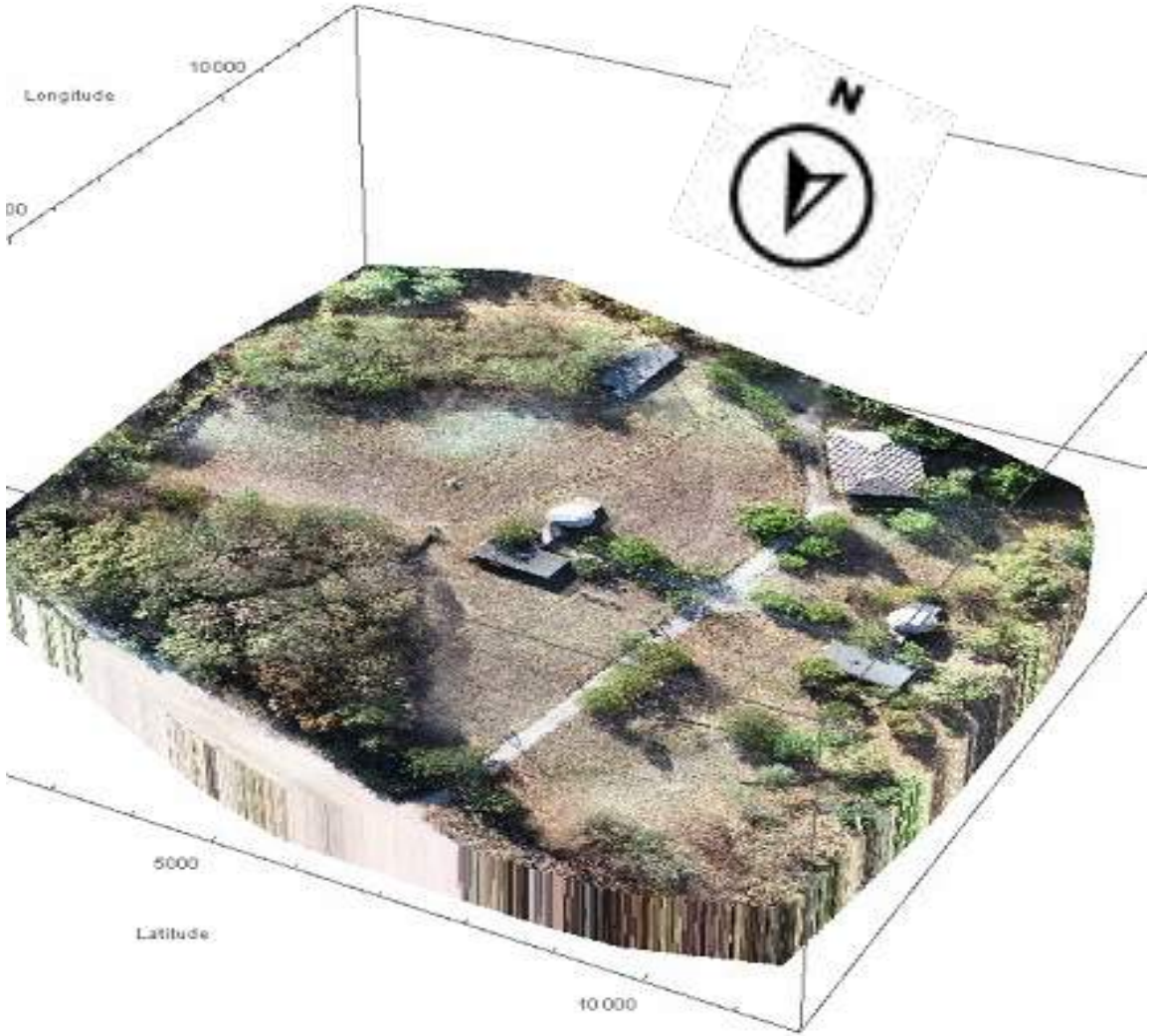


FIELD-MONITORING FLIGHT ON SEPT 17, 2020

DIGITAL 3D MAPPING OF EXPERIMENTAL TERRAIN

Measurements are performed at the MSU laboratory “Environmental Metrology and Astronomy” near Lozova village in Straseni district with geographical coordinates of (47.09, 28.39).

Figure shows 3D mapping of the corresponding terrain of 3 ha ($3 \cdot 10^4$ m^2) on September 17th, 2020 by Pix4Dmapper's photogrammetry, which algorithms transform ground and aerial drone images in a digital map and 3D model. The site is one of the highest in this region of the forestry in Codru natural reservation.



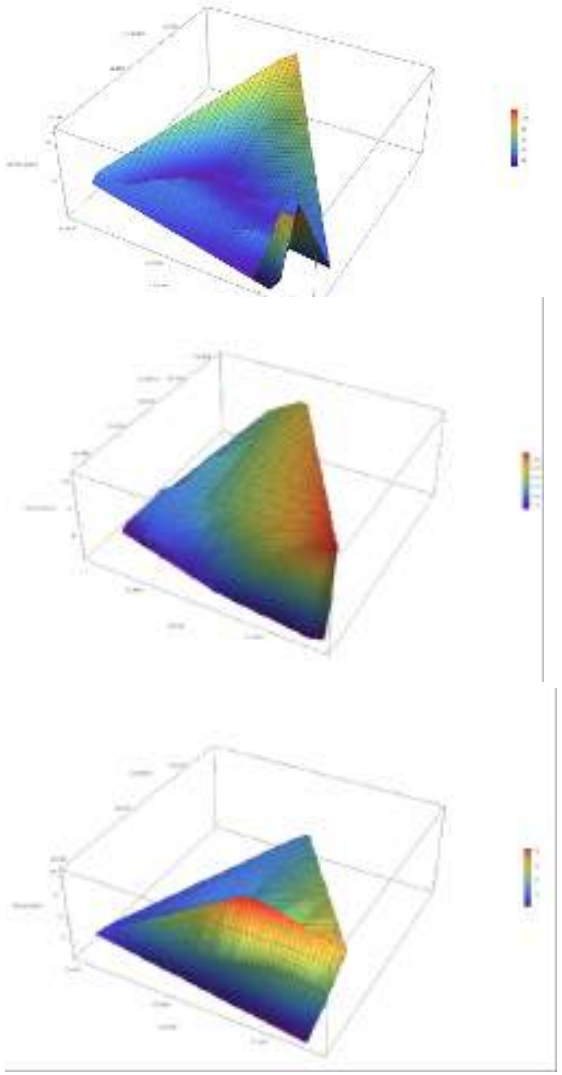
CHARTS WITH RAW DATA, ONE SITE, ALTITUDES 0, 5, 10 M

h=0 m

h=5 m

h=10 m

Concentrations of air pollution with solid microparticles PM10



- Measurements are carried out at three different altitudes of

  0 m, 5 m, 10 m

  for the given

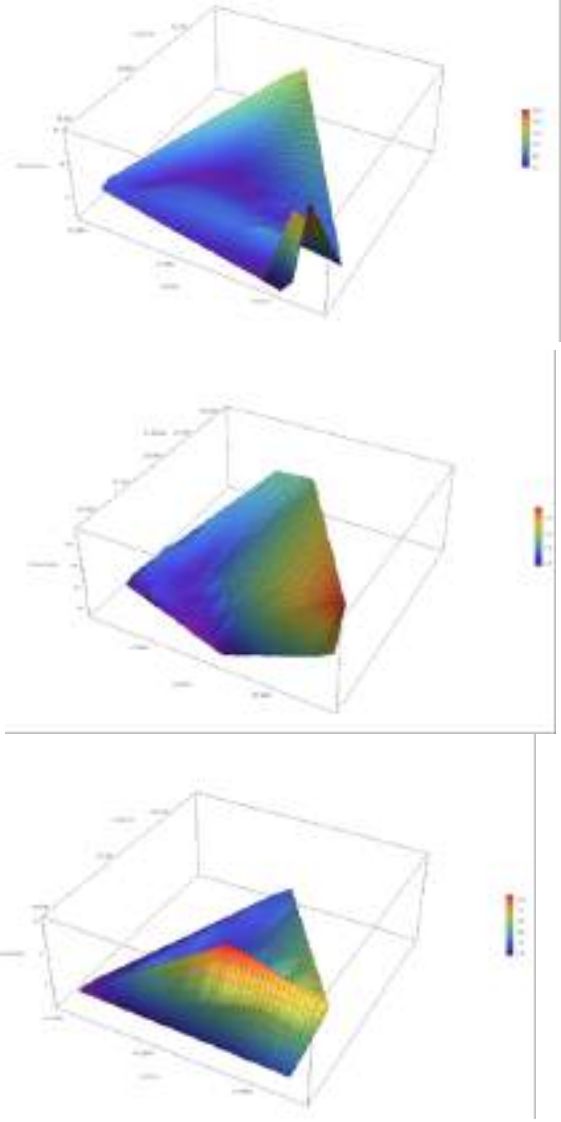
  3 altitudes x 9 sites =

  27 coordinates in space.

- Concentration:

  0 to 25 µg/m^3 at altitudes of 5 m and 10 m from the ground level, and from 0 to 120 µg/m^3 at ground level.

Concentrations of air pollution with solid microparticles PM2.5



- Measurements are carried out at three different altitudes of

  0 m, 5 m, 10 m

  for the given

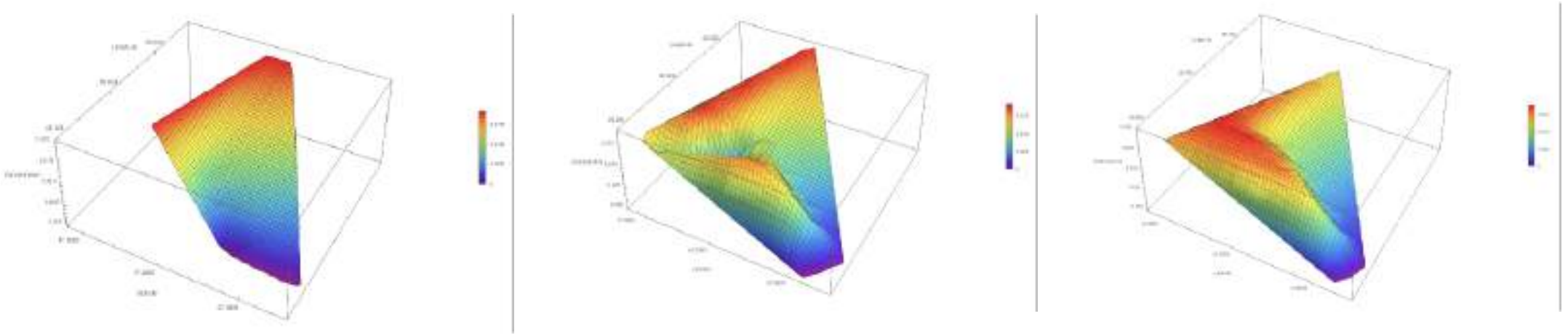
  3 altitudes x 9 sites =

  27 coordinates in space.

- Concentration:

  0 to 5 µg/m^3 at altitudes of 5 m and 10 m from the ground level, and from 0 to 15 µg/m^3 at ground level.

CONCENTRATIONS OF HCHO



- Measurements are carried out at three different altitudes of 0 m, 5 m, 10 m for the given 3 altitudes x 9 sites = 27 coordinates in space.

- Concentration: 0 to 23 $\mu g/m^3$.

The presence of air pollution sources, such as adjacent highway and road, as well as dust pollution level of ground surface at the measurement spots and trees at altitudes of over 5 m, is clearly highlighted in all figures.

OTHER EXPERIMENTAL RESULTS AND DISCUSSION

Data view during outdoor measurement & combustion experiment

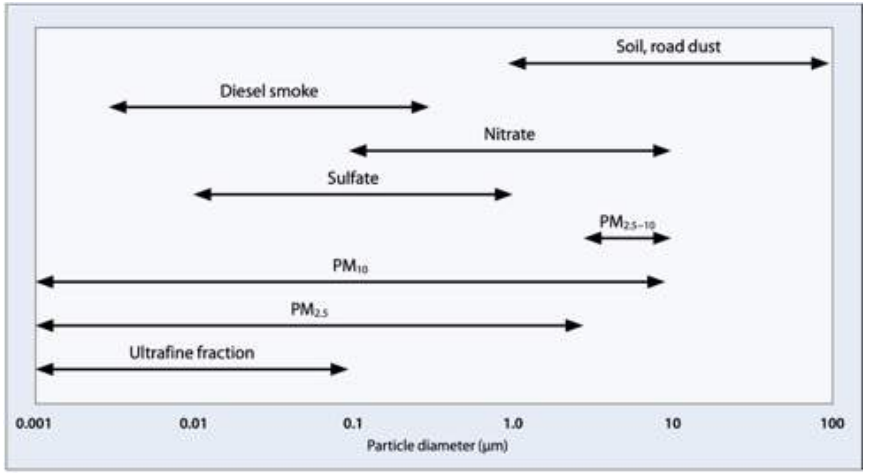
PM_{10}=36.0 µg/m^3
$PM_{2.5}$=16.6 µg/m^3
Hydrogen Cyanide=0 ppm
Hydrogen Chloride=0 ppm
VOCs=0 ppm
Formaldehyde=0.0236 ppm

PM_{10}=1307.3 µg/m^3
$PM_{2.5}$=582.1 µg/m^3
Hydrogen Cyanide=0.004 ppm
Hydrogen Chloride=0 ppm
VOCs=0 ppm
Formaldehyde=0.2140 ppm

WHO Air Quality Guidelines for 24-hour means of *Particulate Matter* (PM):
PM_{10}=50.0 µg/m^3
$PM_{2.5}$=25.0 µg/m^3

PM-POLLUTION

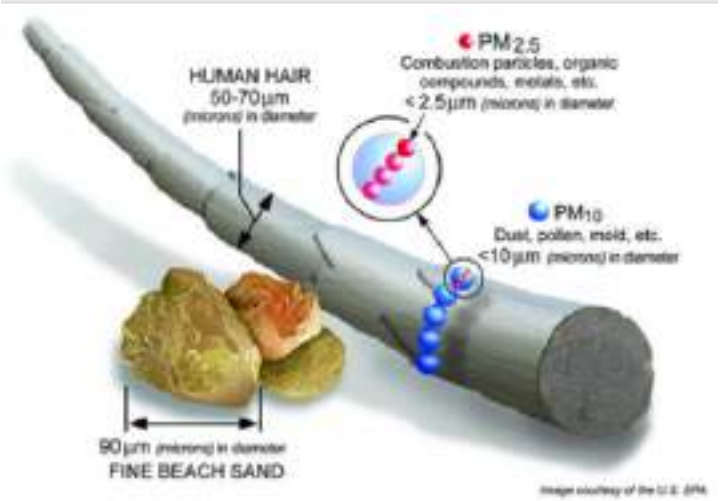
Schematic representation of airborne particles and their size range



Air quality category	PM_{10} μg/m³ averaged over 1 hour
Good	Less than 40
Moderate	40–80
Poor	80–120
Very poor	120–240
Hazardous	More than 240

Secondary air pollutants are formed from chemical reactions of primary pollutants involving the natural atmosphere components:

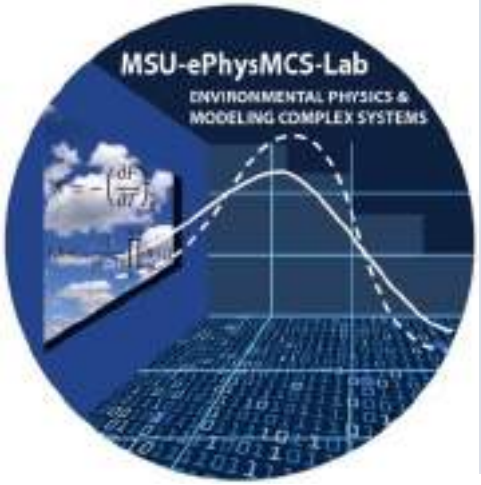
$NO + O_3 \rightarrow NO_2$ (nitrogen dioxide) + O_2;
$NO_2 + h\upsilon\ (\lambda \leq 430\ nm) \rightarrow NO + O$;
$O + O_2 \rightarrow O_3$;
$NO + RO_2$ (alkyl peroxide) $\rightarrow NO_2 + RO$;
$HNO_3 + NH_3$ (ammonia) $\leftrightarrow NH_4NO_3$



MOLDOVA STATE UNIVERSITY

Research and Innovation Institute

Environmental Physics & Modeling Complex Systems Laboratory



Thank You!

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