



Ανασχεδιασμός Πλατείας Πεδίου του Άρεως με Βιοκλιματικά Κριτήρια

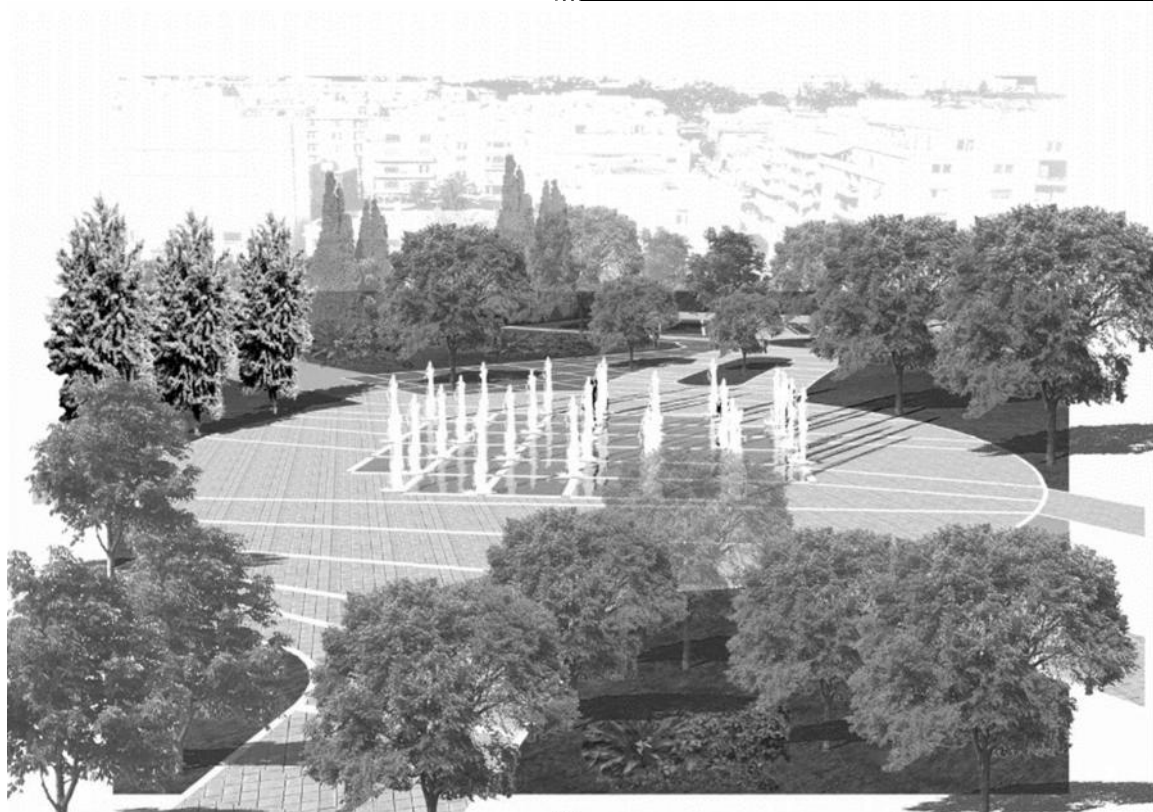


01107098

01107009



Ανασχεδιασμός Πλατείας Πεδίου του Άρεως με Βιοκλιματικά Κριτήρια



01107098

01107009

2015

Abstract

The environmental and social problems of modern big cities, which are owed mainly in the intense urbanization, make compelling the need for readjustment of outdoor urban spaces according to the bioclimatic design principles. This is achieved with various ways as, the planting of vegetation and the use of suitable materials. For that purpose, in the last years electronic computational fluid dynamics programs have been developed which are able to simulate the microclimate of an area and they constitute preciously and particularly useful tools in the effort to optimize conditions in the urban parks and more generally in the outdoor spaces.

The purpose of this thesis is the description of modern environmental problems that a person has to face in the urban web, which by extension leads to the need for redesigning the outdoor urban spaces and the presentation of the basic principles of bioclimatic design. Also, was sought the analytical presentation of computational fluid dynamics software ENVI-met and especially the version 4.0 Preview, a tool that can be proved particularly useful for the evaluation and the analysis of the microclimate of an area and was examined the reliability of the software through the comparison between results of simulation and field measurements. For this reason, a study was conducted in the park of Pedion Areos (Champ de Mars) in Athens, which includes both simulations via the program and actual measurements of temperature and relative humidity for specific days and hours. In the simulations were used real climatic elements and their results were analyzed aiming at the check of reliability, the precision of the software and the evaluation of the bioclimatic redesign of the park in 2008. Finally, through the use of software was evaluated the effect of the urban geometry, the vegetation and the water in the microclimate in order to develop guidelines for urban planning, which will lead to the improvement of microclimatic conditions after specific interventions.

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1.1.1.		18
1.1.2.		21
1.2. μ	μ	23
1.2.1. μ		24
1.2.2.		26
1.2.3. μ		27
1.2.4.		30
1.2.4.1. μ		30
1.3.		32
1.3.1.	-	36
1.3.1.1.		36
1.3.1.2.		38
1.3.2.	μ μ	40
1.3.2.1. μ	μ	41
1.3.2.2. μ		42
1.3.2.3. μ -		46
1.3.2.4. μ -	- μ	49
1.3.3.	μ μ	54
1.3.3.1.	« μ »	54
1.3.3.2. μ	μ μ	56
1.3.3.3.		61
1.3.3.4. μ		69
2 :	μ ENVI -met	74
2.1.		74
2.2.	μ Envi-met 4.0 Preview	76
2.2.1.	(Area Input File, .IN)	83
2.2.2.	μ (Database Files)	85
2.2.3.	μ (Output Files)	86
2.3. μ	ENVI-met Preview 4.0:	87
2.4.	Envi-met v3.1 Envi-met v4.0 Preview	93
3 :		96
3.1.		96
3.1.1.		96
3.1.2.		98
3.1.3.	μ	98
3.2.		99
3.2.1.		99
3.3.		100
3.4.		100
3.4.1.	:	100

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3.5.			101
3.5.1.		2004	101
3.5.2.		2008	101
3.5.2.1.			101
3.5.2.2.	μ	μ	102
4 :	μ	–	107
4.1.			107
4.1.1.			107
4.1.2.	μ		108
4.1.3	μ		109
4.2.	μ		111
4.2.1.		(Area Input File)	111
4.2.2.		– μ μ	112
4.2.3. 1	μ	: 23/04/2015	115
4.2.3.1.	μ	1 μ	115
4.2.3.2.		μ μ Envi-met	121
4.2.4. 2	μ	: 15/07/2015 –	130
4.2.4.1.	μ	2 μ	131
4.2.5. 3	μ	: 15/07/2015 –	132
4.2.5.1.	μ	3 μ	132
4.2.6.		μ 2 3 μ	133
4.2.7.	μ	4 : 15/07/2015 –	139
4.2.7.1.	μ	4 μ	141
4.2.8.		μ 3 4 μ	142
5 :	μ	μ –	147
5.1.	μ	μ	147
5.2.			149
			151
1			156
			156
			160
			160
2			161
2			161
3			166
4			171
3			174
			174

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[85].



1.1: www.enet.gr

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(μ ,) μ

μ [8]. μ μ μ μ



1.2: www.athensmagazine.gr

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1.3: www.4green.gr

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1.4: www.travelstyle.gr



1.5, 1.6:

Chengdu Tianfu District Great City
: www.inhabitat.com

1.1.2.



1.7:
: www.greenroofs.gr

40%
3%
A
8.600 μ., μ μ
μ
8 - 10 μ./
μ
2,6%, μ
μ [26].

(0,96 m²/)

9 .μ. [2].

	m ² / -
	0,96
	9,0
	8,5
μ	9,0
	50,0
	18,0

1.1 : m² μ « OECD Factbook 2014: Economic, Environmental and Social Statistics» : www.eco-news.gr

μ μ

μ 4.000 $\mu\mu$, μ μ Hyde Park
2.500 $\mu\mu$.

1.2.

μ μ , μ -

μ , μ μ μ .
 μ μ μ

1,4-5,85 μ , μ 2100.

μ μ 100 μ μ -

. μ , -

μ μ 5,5 μ , -

μ , -

μ μ -

[5]. μ , -

μ :

• μ μ .

μ μ μ μ -

(CO₂), -

. μ μ μ -

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μ μ , μ -

(, μ) . μ , μ -

(3) , μ μ -

. μ μ -

μ μ μ μ 50%

μ μ μ -

(55-65db).

60 %

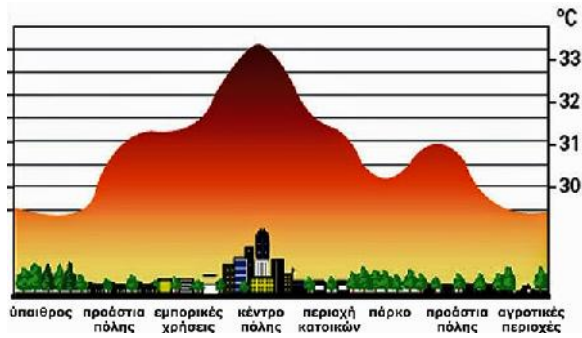
[45].

1.2.3.

(Urban Heat Island Effect)

0.7 °C

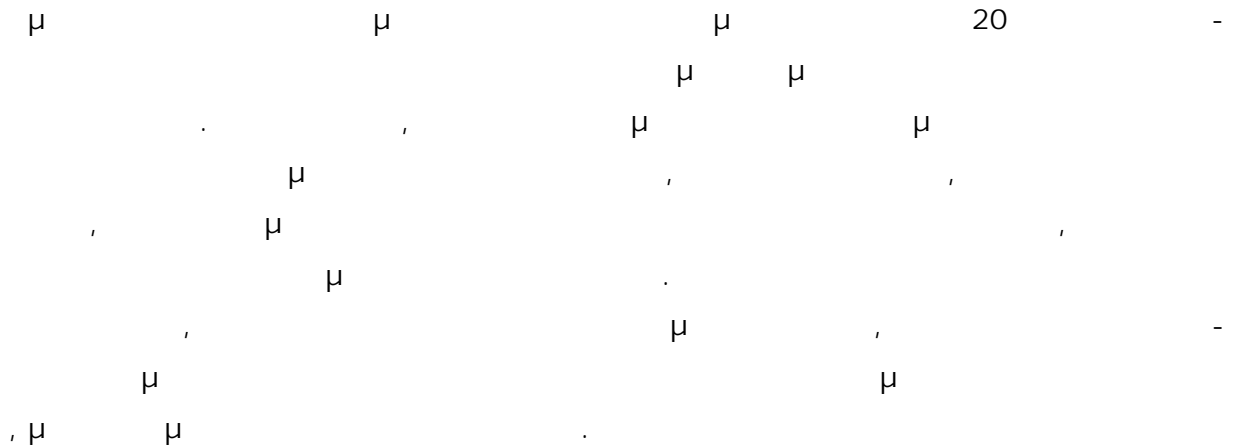
3.6 °C



1.10:

: <http://www.zeroenergybuildings.org/>

1.3.



Year	Water Usage (billion m³)	Population (billion)	Percentage (%)
2000	300.000.000	-	-
1500	500.000.000	-	-
1800	1.000.000.000	-	-
1975	4.000.000.000	1.540.000.000	38,5
1995	5.500.000.000	2.575.000.000	46,8
2000	6.000.000.000	2.860.000.000	47,7
2011	7.000.000.000	3.560.000.000	50,8
2015	7.280.000.000	3.960.000.000	54,4
2030	8.320.000.000	5.075.000.000	61,0

1.2: Water usage and population growth. Source: Worldwatch Institute. www.worldwatch.org

The growth in water usage and population is a significant concern. By 2030, the population is projected to reach 5.075 billion, and water usage is expected to increase to 8.320 billion m³. This represents a 61% increase in water usage per capita compared to 2015. The agricultural sector is the largest consumer of water, accounting for 20% of total usage in 2015. Other major sectors include industry, domestic use, and power generation. The rapid increase in water demand is driven by population growth and the expansion of irrigated agriculture. This poses a serious challenge for water security in the future, particularly in regions where water resources are already scarce or over-exploited.

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, μ ,), (, μ) -

[3].

μ μ μ μ μ μ

[44]:

- μ μ .
- μ μ .
- (, μ , -
-).
- μ .
-
- μ μ .
- μ μ μ μ μ
- .
- μ .



1.15: : blog.travelpplanet24.com



1.16: . : www.google.gr

μ μ μ

, μ , μ μ μ -

μ μ .

μ μ -

μ μ μ , -

μ μ

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1.3.1. -

1.3.1.1.

μ , -

μ , .

μ μ μ

, μ μ

, μ -

μ μ , -

60-80% .
100-150 μ. 10.000

, μ 2,5-40 μμ .

[20].



1.17: <http://wikimapia.org>

μ (μ , μ
)
μ μ μ
μ μ μ



1.18: www.healthycities2014.org

μ μ
μ μ
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- μ , μ -
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- μ .
- μ , μ .
- μ .

1.3.2.1. μ -
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 $\mu \quad \mu \quad \mu \quad \mu$.
 $\mu \quad \mu \quad \mu$

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$\mu \quad \mu$, μ -
 μ , μ , μ -

$\mu \quad \mu \quad \mu$. , $\mu \quad \mu \quad \mu \quad \mu \quad \mu$
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$\mu \quad \mu \quad \mu$,

(μ , $\mu \quad \mu$) . μ ,

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$\mu \quad \mu \quad \mu \quad \mu \quad \mu$ « -

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- μ μ .
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- μ , μ μ .

μ

μ μ μ μ μ

μ « μ » μ μ -

μ μ μ -

μ μ (Predicted Mean Vote, PMV) -

μ (Predicted Percentage of Dissatisfied, PPD).

μ μ μ μ μ μ μ μ

μ μ , μ μ μ μ μ μ ,

-3 +3. PMV μ μ ,

μ PMV μ

μ μ PMV μ .

μ -	PMV
	-3
	-2
	-1
(- -)	0
-	1
	2
	3

1.4: μ PMV. [74]

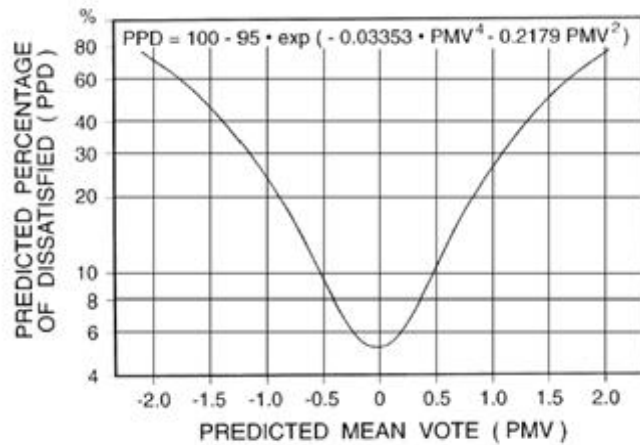
μ (PPD) μ %

μ μ μ PPD -

PMV. μ , PMV μ -1 +1 PPD

25% μ μ .

10% PPD μ -0.5 +0.5 .



1.20:

(Cooling power, CP) (PPD). [74]

μ -

(Cooling power, CP)

μ

μ

μ

μ

36,5 C,

μ

μ

μ

μ

μ

μ

μ

(Physiological Equivalent

Temperature, PET)

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

μ

Humidex

μ

μ

μ

Humidex

μ

Masterion

Richardson (1979)

$H = T + 5/9 (e - 10)$,

T

μ

(°C)

e

hPa.

μ

μ

μ

μ

μ

$e = 0.254F(0.00739T + 0.807)8$

F

(%).

Humidex

«

μ

μ

μ

μ

μ

[29].

μ μ μ

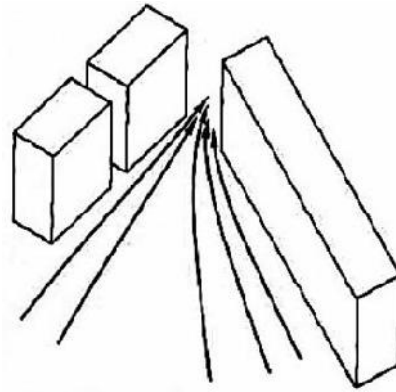
μ . μ μ

μ (μ Wise). μ μ

μ μ μ 120-125 μ , μ μ μ μ μ

μ μ μ (μ Venturi)

[29].



1.24: μ Venturi. [29]

- μ :

• μ μ μ , μ μ μ

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• μ μ μ μ .
- μ (. . .).

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• μ (μ).

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1.3.3.

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1.3.3.1.

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« μ » μ μ μ

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μ μ μ .

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μ , μ μ μ .

μ , μ μ μ - μ

μ μ μ - μ μ μ μ

μ . μ μ . μ

μ μ μ μ -

μ . μ , μ -

μ μ , μ μ

, μ μ

μ μ

μ μ μ , μ

μ μ μ .

μ μ μ « μ »:

μ μ μ μ -

μ μ μ μ 150 μ .

Т μ μ -

μ , μ μ μ μ

μ μ μ

μ [22].

μ μ μ μ -

μ , μ

μ , μ μ -

μ , μ μ

μ μ μ -

μ μ μ ,

μ . μ μ μ

[33] :

- -
 -
- » ,
- [1].

1-2 °C.

	-	-
-	0,93	0,91
μ	0,85	0,96
μ -	0,8	0,91
μ	0,73	0,95
μ	0,72	0,28
μ	0,3	0,94
-	0,3	0,9
	0,05	0,93
μ	0,03	0,87
μ -	0,4	0,63

1.6: [INT-1]

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μ μ μ

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μ μ

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[9].

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μ [9].



1.31: « », . [INT-2]

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[1].

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20-25Db,
[INT-3].

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[20]:

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4-6

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μ

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μ

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μ

μ

μ

μ

μ

μ

μ



1.35: μ
[INT-1]



1.39: www.athensinfoguide.com



1.40: [INT-1]



1.41: , Houston
www.city-data.com



1.42: Micronizers, [INT-1]

μ μ^μ

-
- μ μ :
 - μ μ
 - ()
 - μ
 - μ
 -

μ μ μ

• μ ,

μ μ , -

μ μ , -

, , μ .

μ μ μ

μ

μ

μ

μμ

μ

(Soil Model)

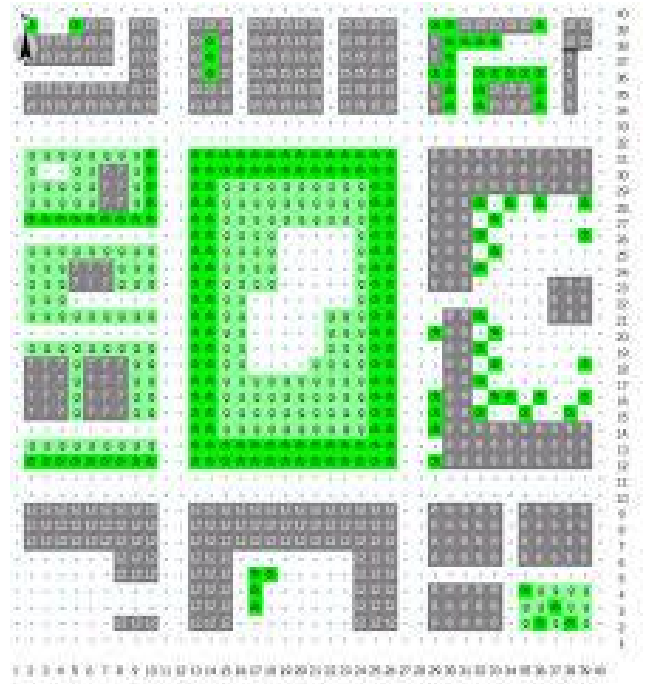
μ

μ

μ

μ

μ



μ

μ

μ

μ

μ

μ

μ

2 m ,

μ

μ

μ

μ

μ

μ

μ

(

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3

μ

2.2:

μ

μ

, μ

μ

μ

μ

μ

(Configuration File).

(Configuration File)

μ

μ

.IN (Area Input

File),

μ

μ

(Output Files)

μ

μ

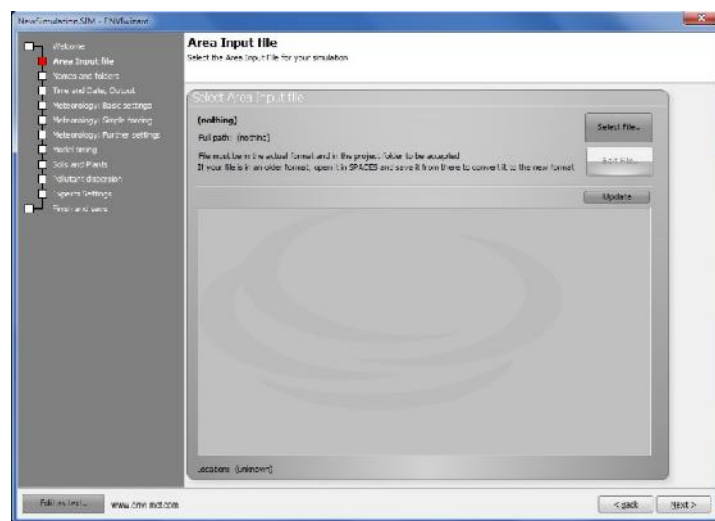
μ

.CF

μ

μ

μ



2.3: Configuration File.

: []

μ μ μ

2.3 :

• Area Input File

(Input Area).

μ .
directory, -

μ μ

μ (alias)

μ

• Names and folders

μ μ

μ -

• Time and Date, Output

μ

μ

μ ,

.

μ

μ

μ

• Meteorology: Basic settings

μ μ

μ

μ :

➤ Wind Speed measured in 10 m height (m/s)

Data)

μ

μ

(Input

μ

10 μ

μ

μ

➤ Wind Direction (deg.)

μ

μ

0

(

μ

),

90

(

)

,

μ

μ

μ

μ -

μ

➤ Roughness Length at Measurement Site

μ

μ

μ

μ .

μ

μ

10 μ

μ

μ

μ

μ .

μ

μ

μ

➤ Temperature T (Kelvin)

μ

μ

μ

μ

μ

ENVI-met

μ μ -

(

μ)

μ

μ

μ

μ

➤ Specific Humidity at model top (2500 m.)

μ μ μ

sections ENVI-met:

[POSITION]

μ , μ . μ

[SOILDATA]

μ .

[BUILDING]

μ μ 3 .

(albedo)

(μ μ μ)

[LOCALDB]

(PLANTS.DAT, SOURCES.DAT), μ

[TIMING]

μ μ

μ μ (default).

[TIMESTEPS]

μ . μ

μ μ μ 3 μ , 2 μ A (height A

height B).

- μ 1: <
- μ 2: <
- μ 3:

μ μ μ

μ 3

[NESTINGAREA]

« »

μ

ENVI-met,

(« » μ)

μ (μ)

μ . μ

Boundary Condition ~ forced or closed LBC),

(forced or closed Lateral

(outflow boundary)

(open LBC)

(inflow

boundary) μ

(cyclic LBC).

[LBC-TYPES]

section

(forced or closed

LBC)

(open LBC)

(cyclic LBC).

LBC μ

μ

μ

open LBC

μ LBC

μ

μ

[PMV]

ENVI-met μ

P.M.V. (Predicted Mean Vote)

Fanger (1972),

ENVI-met

P.P.D.

μ μ μ

(Predicted Percentage of Dissatisfied),

μ μ P.M.V.

μ μ μ μ

[PLANTMODEL]

μ μ -

ENVI-met

Deardorff (1978)

Jacobs (1994).

4.0 Preview

A-gs

A-gs.

[RECEPTORS]

receptors ()

μ μ

μ

μ

μ

.IN

μ

.CF.

μ

receptors

.IN

section [RECEPTORS]

μ

μ

μ

μ

μ

μ , μ receptors .CF

μ

μ

μμ

[SOURCES]

(sources)

μ

:

• sources.

• μ μ

• μ μ

sources

.IN

μ

μ

μ SOURCES.DAT, μ

μ

(

) .CF.

(CO2).

ENVI-met

CO2

μ

μ A-gs

CO2

μ

CO2

μ

/ ENVI-met μ

sources μ

μ

(Particulate Matter ~ P.M.)

μ

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μ

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μ

μ μ

[CLOUDS]

μ μ ENVI-met μ , μ -
 μ μ μ μ μ section. -

[SOLARADJUST]

section μ μ μ μ -
ENVI-met. , μ -
 μ μ , μ μ -
 μ . μ μ 50% 150% -
ENVI-met. μ μ μ .

[TURBULENCE]

section μ μ μ (). ENVI-met -
 μ 1.5 , E- Epsilon μ -
(default) 1 , μ μ μ μ .
sections μ μ -
(default values) μ ENVI-met. sections μ .CF -
. section μ .CF, μ -
 μ μ .

2.2.1. (Area Input File, .IN)

.IN μ μ $\mu\mu$ ENVI- met. -
(μ μ .IN) μ -
 μ μ μ , / -

- μ :
 - μ :
 - μ :
 - sources ().
 - receptors ().
 - μ μ .
 - μ μ .
- μ () $\mu\mu$
x, y z. .IN z, μ μ $\mu\mu$

.IN
 (nesting grids),
)
 , « »
 ENVI-met
 (output files)
 files. output
 (nesting area) ENVI-met
)
 μ μ μ μ
 « μ » (. . μ)
 μ ENVI-met μ μ μ
 « » μ
 section [NESTINGAREA] .CF.
 (Y)
 μ μ μ μ
 μ μ μ μ
 μ μ μ
 ENVI -met Editor.
 μ μ μ μ μ μ
 μ μ μ μ 90° μ

μ μ

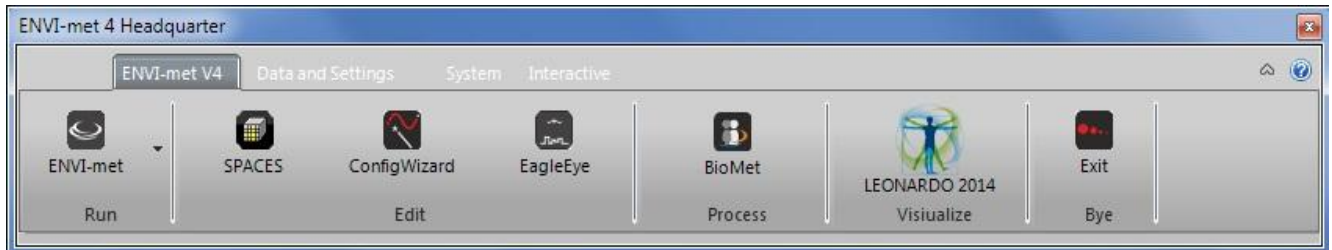
μ μ μ μ μ μ

2.2.2. μ (Database Files)

μ μ .IN μ .CF), μ (
 μ ENVI-met -
 μ , -
 μ / μ μ μ μ μ -
 μ μ , μ 2
 μ μ , / μ ,
 μ (global files)

- μ μ μ μ μ μ :
- μ SOILS.DAT
- μ PROFILES.DAT
- μ μ μ μ SOILS.DAT. μ ,
 μ
- μ PLANTS.DAT
- μ μ ENVI-met μ , μ
- μ μ μ μ μ μ -
 μ μ μ μ μ -
LAD (Leaf Area Density) RAD (Root Area Density).
- μ SOURCES.DAT
- μ μ ENVI-met μ
- (sources) μ μ , μ 3.1
 μ , μ , μ μ SO2 μ μ -
- (SO2) (NO) (NO2) .
- μ μ μ :
- μ .IN.
- μ (section) SOURCES μ
- .CF.

2.3. ENVI-met Preview 4.0:

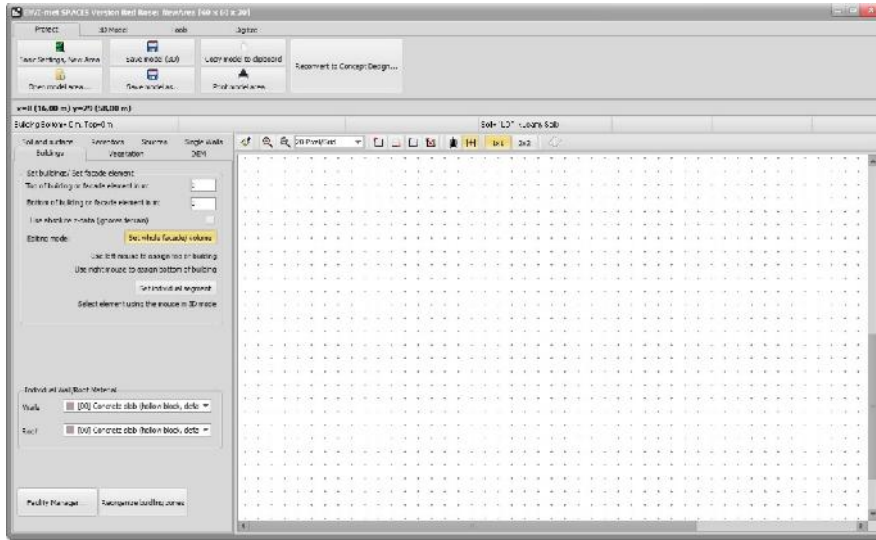


2.4: ENVI-met.

- []
- (Area Input File Editor) (.IN).
- ENVI-met, (Spaces)
- Project/Basic Settings, New Area.
- x, y z (x-Grids, y-Grids, z-Grids).
- (Nr of nesting grids).
- (Soil profile for nesting grids).
- dx, dy dz.
- (Size of grid cell in meters).
- (Method of vertical grid generation).
- (telescoping).
- (Telescoping factor %).
- (Start telescoping after height (m)).
- (Model rotation out of grid north).

μ μ μ

- (Location on earth).



2.5: [μ ()]

μ digitize/select bitmap.

- «Buildings».
 - μ «Top of building or facade element» μ μ
 - μ μ μ left mouse, «Bottom of building or facade element» μ μ
 - Pilotis) μ Right mouse, μ μ
 - μ 0 μ

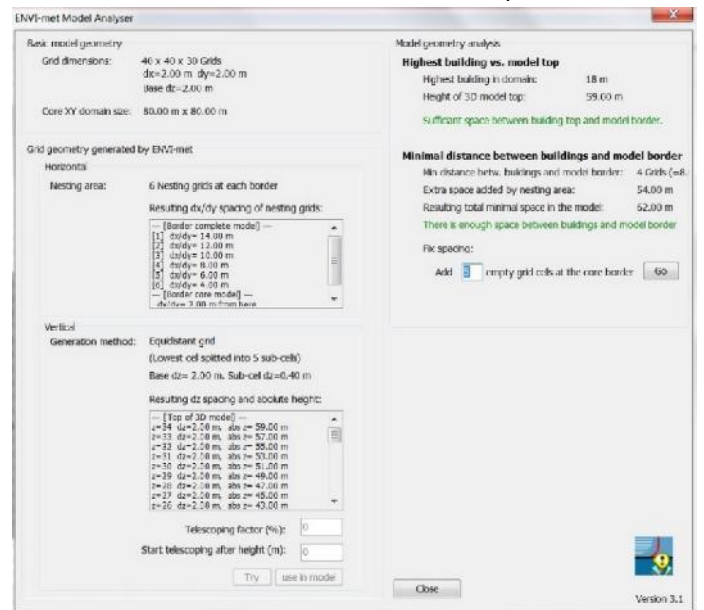
- «Vegetation».
 - μ (Vegetation) μ μ
 - μ μ μ μ μ left mouse.
 - .PLANTS. μ μ Right mouse.

- «Soil and Surface».
 - μ μ μ

(Loamy Soil),

• , «Receptors».

• / , «Sources»



2.6: ENVI-met Model Analyzer.

: []

μ 2 : μ (.CF).

ENVI-met,

(ENVI-met Configuration Editor).

μ μ .CF μ μ μ

Select your task / Create a new blank Configuration file for project.

Click on «Expert Settings»

3 :

ENVI-met, (versions). .IN.

(nesting grids),

version

()

« » .IN .CF.

2.7: Configuration () : []

• Load model configuration

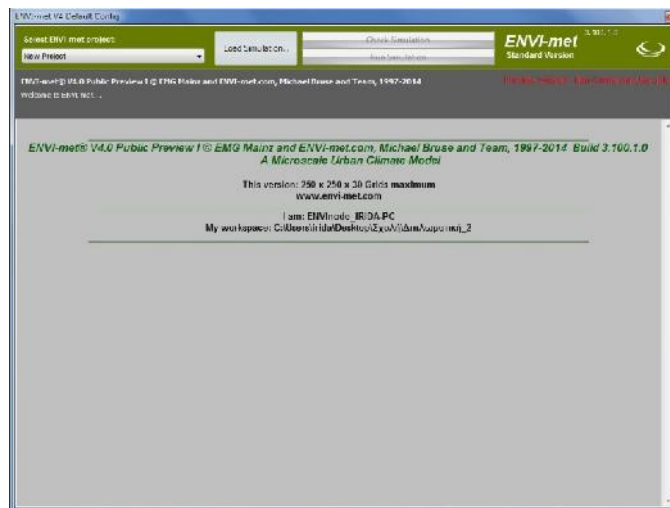
«Load model configuration». .CF

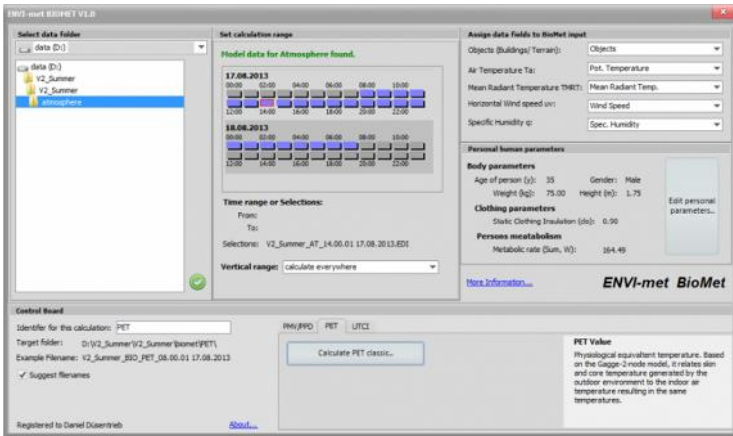
• Check Simulation

«Check Simulation», .CF

• Run Simulation

«Run Simulation», «Output».

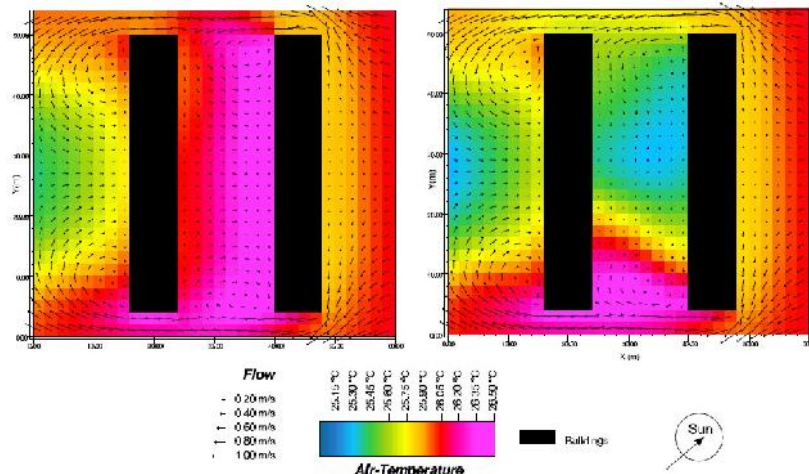




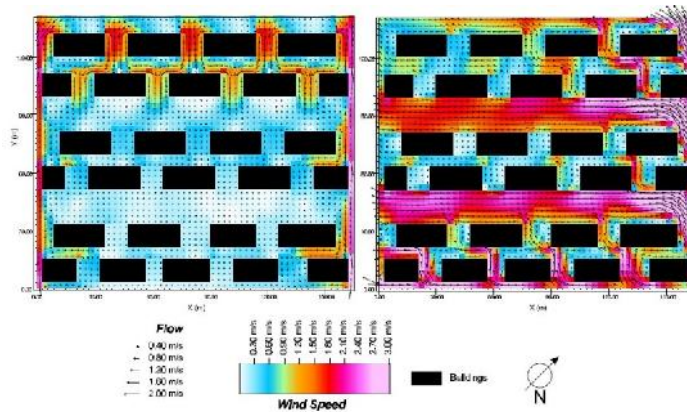
2.8: Biomet.

- **4:** Leonardo.
- **ENVI-met,** Leonardo,
- **Simulation Data/Show data Navigator.**
- **Select Main Data File A,**
- **atmosphere.**
- **2d Map data**
- **extract 2d**
- **Datalayer Legend**
- **Map/ Print map**
- **pdf**

μ μ μ



2.9: μ LEONARDO, μ μ μ () -
 () μ : [-5]



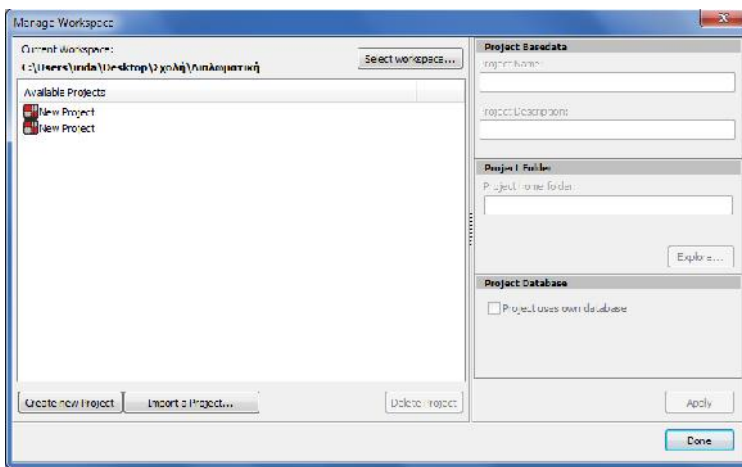
2.10: μ LEONARDO, μ μ μ () -
 (). : [-5]

- μ μ Microsoft Excel.
 Microsoft Excel μ μ μ μ μ
 .1D, 1DR, 1DT. μ μ (receptors)
 μ μ (inflow). μ , -
 , « μ » (1DR), « -
 » (1DT).

2.4. Envi-met v3.1 Envi-met v4.0 Preview

Envi-met (Envi-met v4.0 Preview), (stable)

(user interface),



2.11: projects.

(3)

Albero -Envi met

Headquarter/Data and Settings/ Albero).

μ μ μ

μ

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μ (expert & professional).

μ

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μ μ μ

3 :

3.1.

1934 μ μ 1821,
μ μ μ μ μ μ

μμ , , -



μ μ μ μ -

μ -

, -

3.1: www.local-history.gr

μ .

« » μ « »,

μ , . μ

() μ μ 25

μμ . μ -
μ (μ μ WC).

μ

μ

μ 230 μμ μ -



3.2: www.athensmagazine.gr

3.1.1.

μ , μ 70 ,
μ μ (μ μ μ)
μ 65 μ

40

99%

μ



3.3: www.tanea.gr

μ

μ

μμ

μ

μ

μ

μ

μ

μ

μ

μ

μ

60%

μ

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μ

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μ 15

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μ

μ

μ



3.4: www.local-history.gr

μ μ μ

3.2.

μ μ Campus Martius

, μ

μμ

μ

1944,
1880

μ)

μ

3.2.1.

μ 23

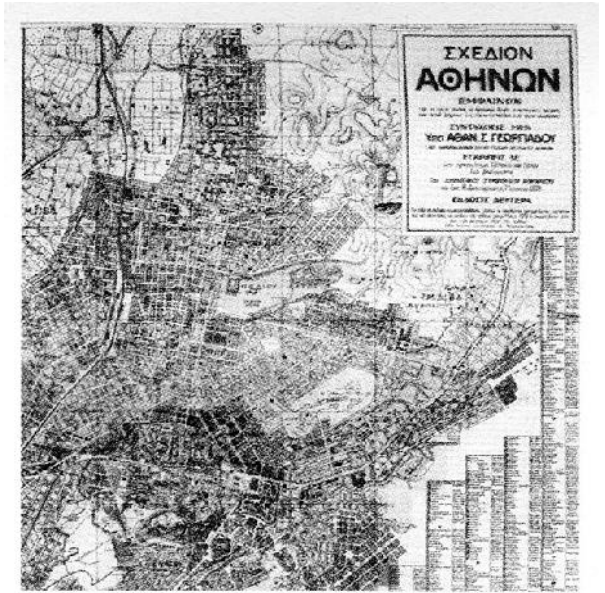
1887

μ μ

μ 1924

5,6

μ
μμ



3.6:

[INT-2]

μ

μ

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«Power»

μ

1935,

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1940

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μ

μ μ μ μ

μ μ

μ

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/

Green

Park,

1940 μ

1944,

μ

1945

μ μ μ

3.5.

3.5.1. 2004

μ - 2003 μ μ 6
μ μ ,
μ

μ 2003 μ - μ -

- μ μ μμ μ 30/5/2004:

μ , μμ , -
μ 1/3 μ

- μ μ μ μ μ μ -
μ

3.5.2. 2008

4/3/2008

μ - -
μ μ μ μ μ μ

3.5.2.1.

- μ
- μ μ μ μ μ μ μ μ -

μ μ μ

: μ

μ

μ μ



3.11: μ : www.local-history.gr

3.10:

(μ μ μ μ) μ μ

μ μ μ μ

μ

μ

3.5.2.3.

μ

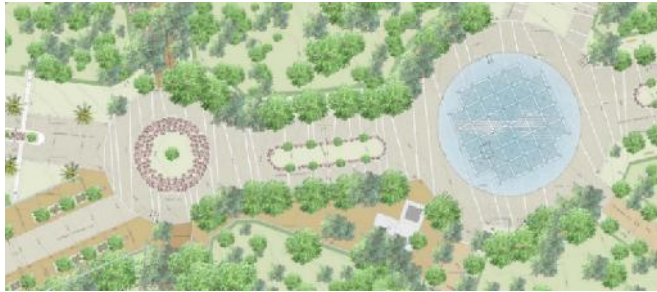
μ

μ



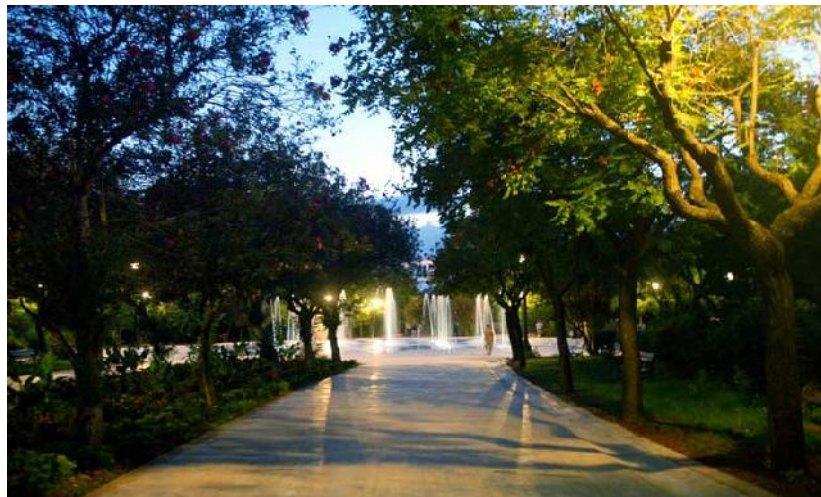
3.12:

μ « μ » μ μ



3.13, 3.14:

– 2008.



3.15:

: www.local-history.gr

μ μ μ

« »

μμ μ μ

μ μ .

μ μ , -

, μ , .



μ -

μ , -

μ , μ -

μ , μ -

μ -

μ , μ μ μ -

3.16: .
: www.athensmagazine.gr

μ

μ μ μ μ μ μ -

, μ , μ -

μ , .

μ

μ μ μ μ .

μ

μ , -

μ μ .

μ 94.000 (93.370), 1.178 (265 -

μ), 17.000 μ (), 2.000 -

μ , 50.000 (

), 24.000 (), 16.716 μ

μ μ μ

4 : μ -

4.1.

μ μ μ μ μ -

μ μ μ μ μ μ

μ μ μ μ μ

4.1.1.

μ μ μ μ μ

μ μ μ μ μ μ μ

μ μ μ μ μ μ μ

μ μ μ μ μ μ μ

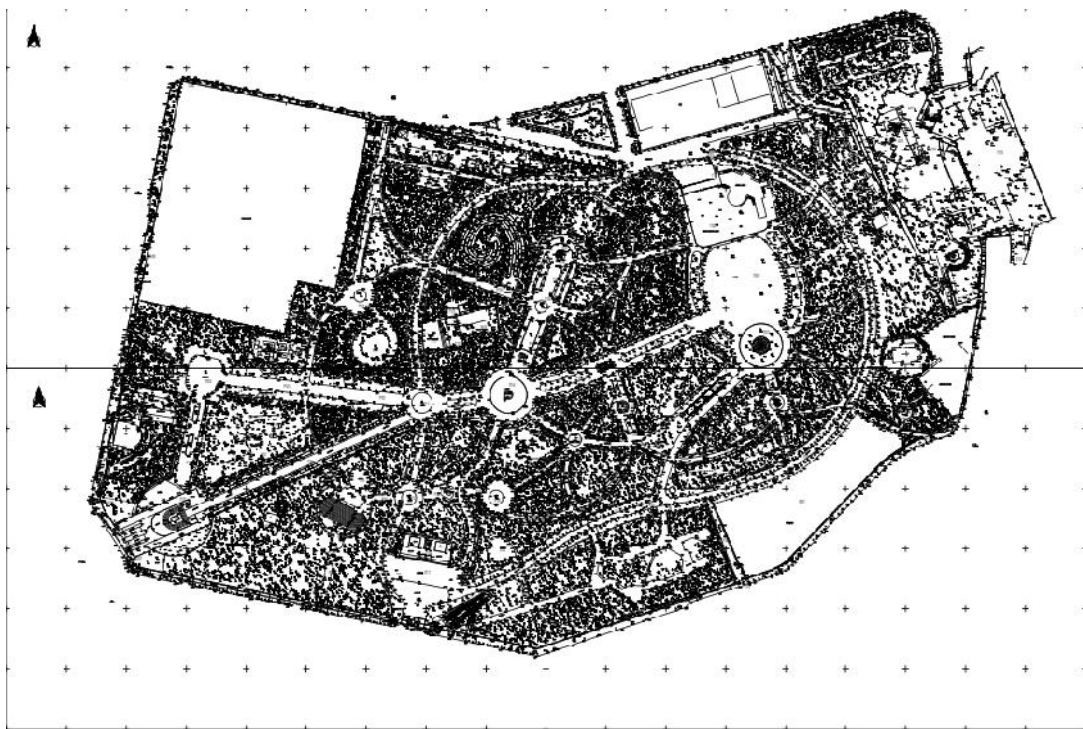
μ μ μ μ μ μ μ

μ μ μ μ μ 2008 μ

μ μ μ

μ

μ



4.1: μ μ μ μ μ μ μ

Google Street View



4.2:

μμ

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4.1.2.

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met.

μ

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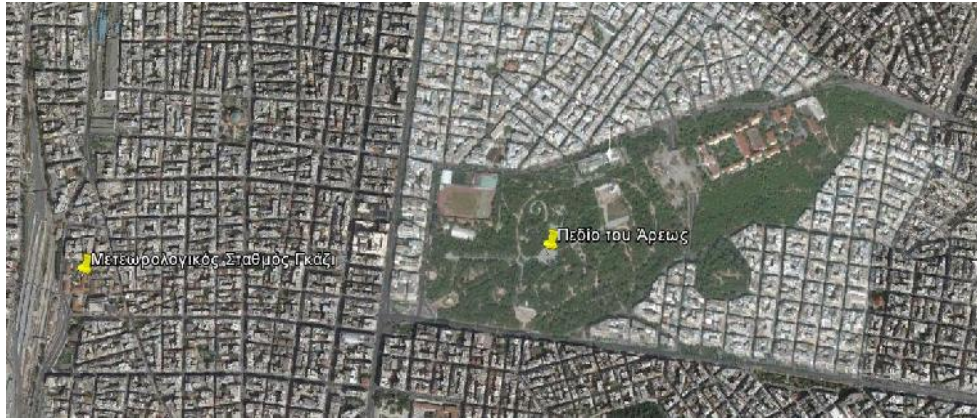
μ Envi-

μ

μ

μ

μ μ μ



4.3: - μ : Google Earth

4.1.3 μ

Envi-met. μ μ μ
 μμ μ μ μ
 μ μ μ 23/04/2015 μ μ -
 μ μ μ μ μ -



4.4: - μ :

GPS Mobile Mapper 6 Magellan



4.5: Mobile Mapper6.
: www.gpscocity.ca



4.6: RS 1365.
: uk.rs-online.com

Excel.

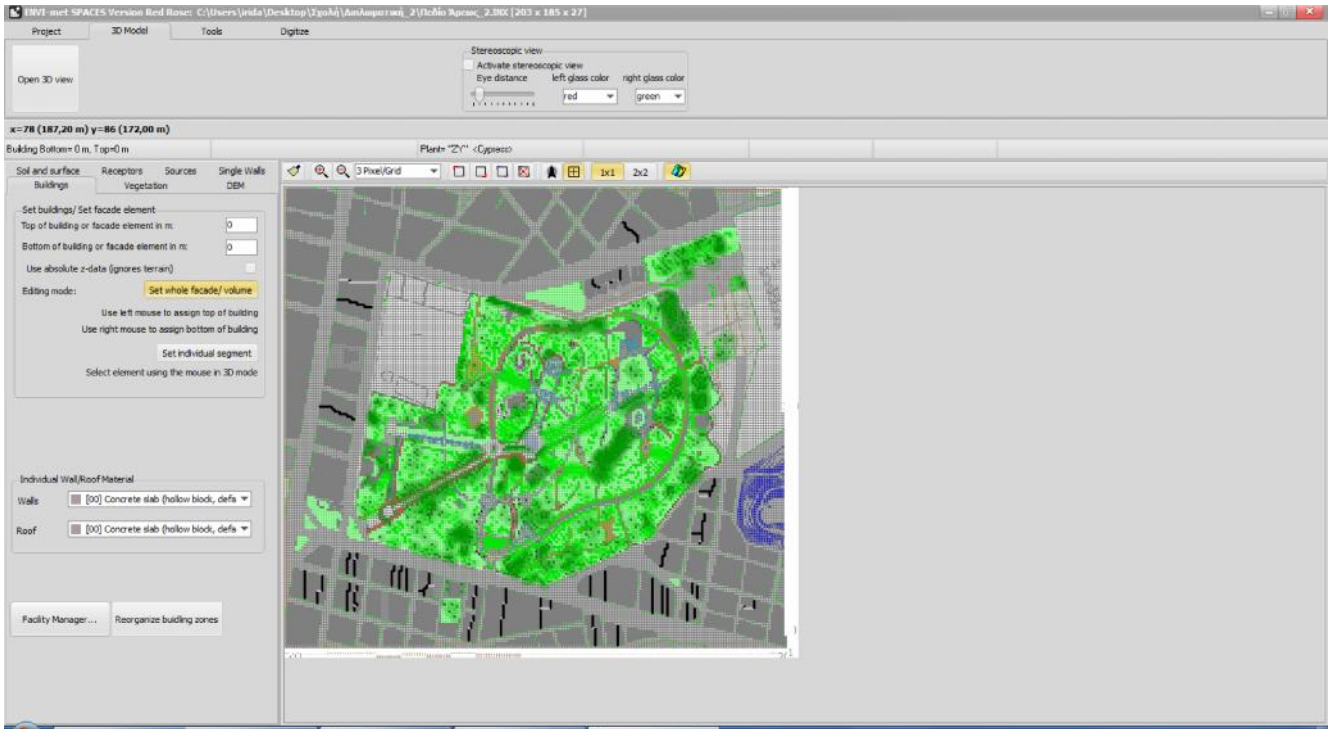


4.7: .IN (Area Input File) – Envi-met

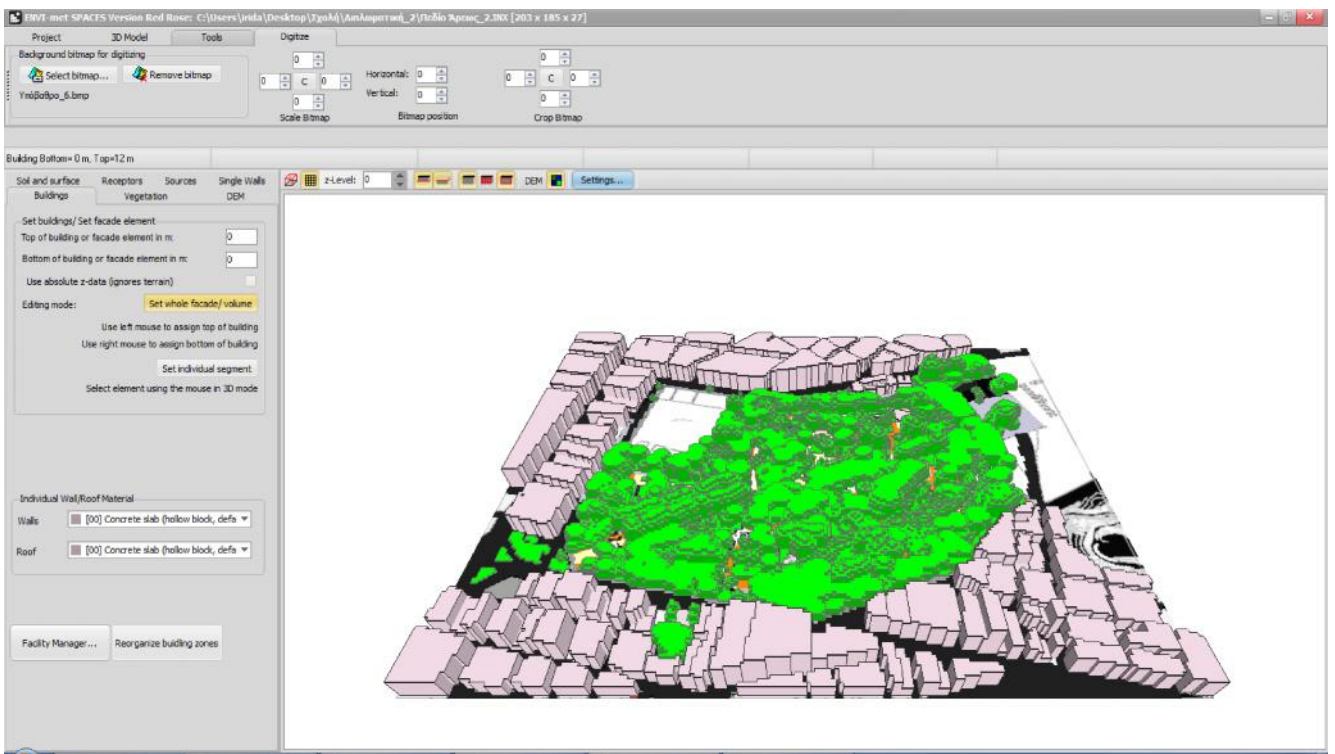
4.2.2.

Envi-met, bitmap, μμ, μμ

μ μ μ

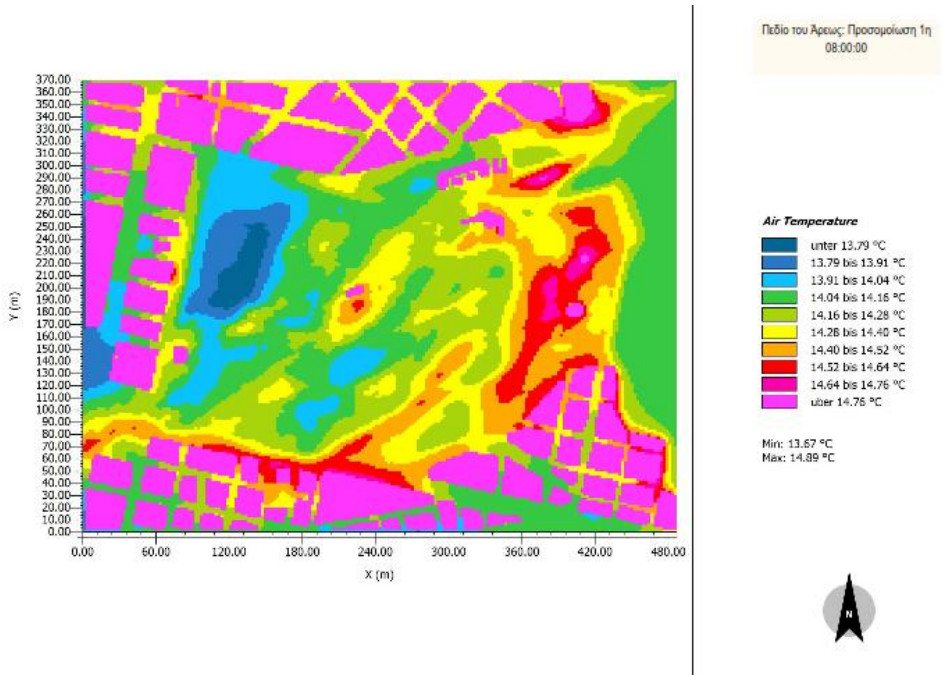


4.9: [unclear] – Envi-met

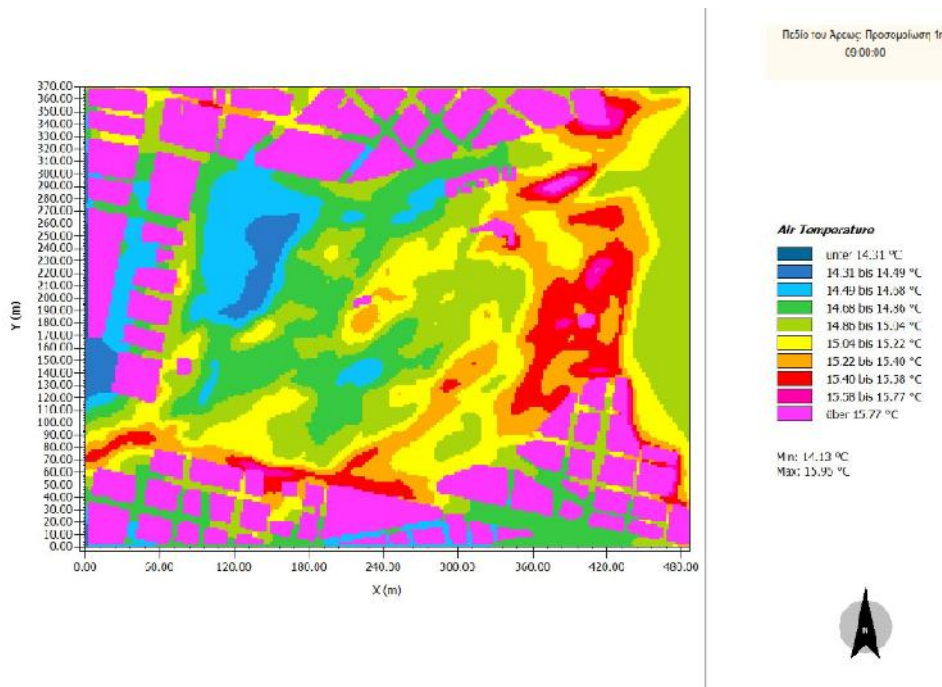


4.10: [unclear] – Envi-met

μ μ μ

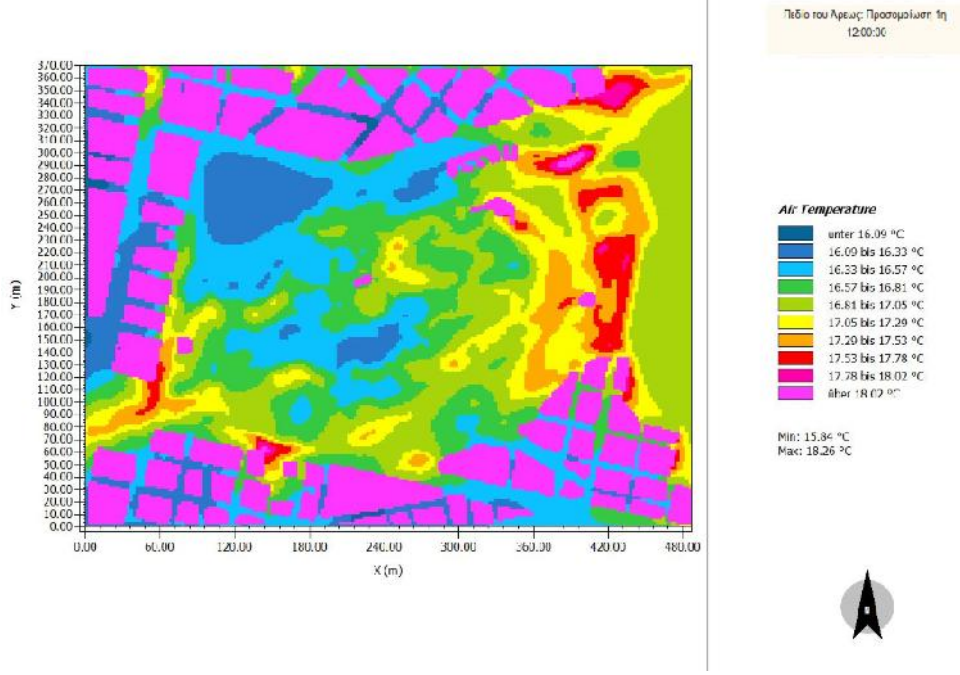


4.11: μ μ 8:00, z=1.50μ. : - Leonardo

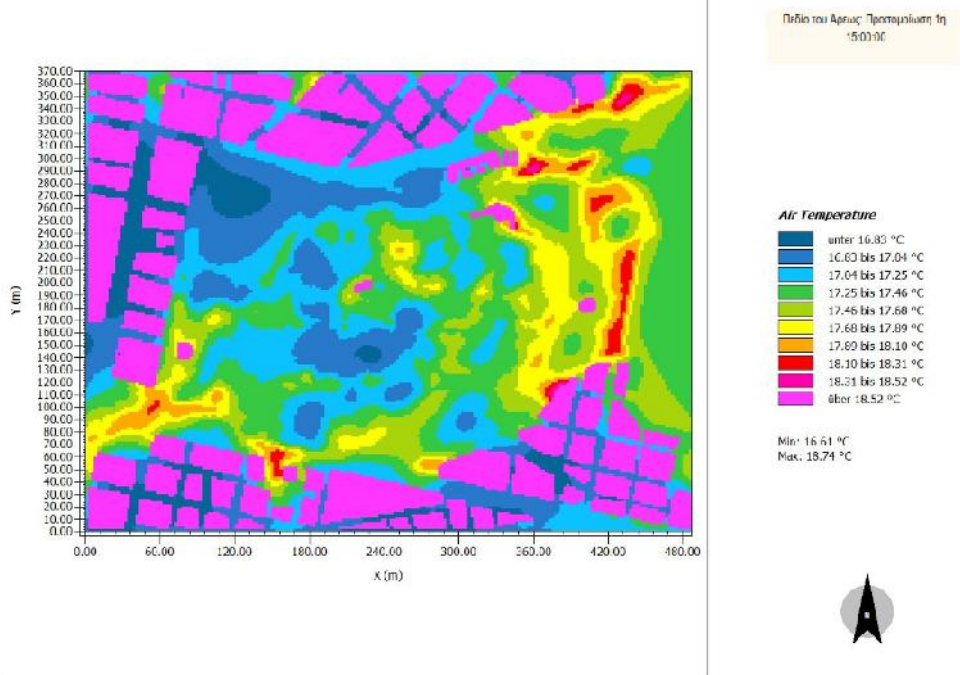


4.12: μ μ 9:00, z=1.50μ. : - Leonardo

μ μ μ

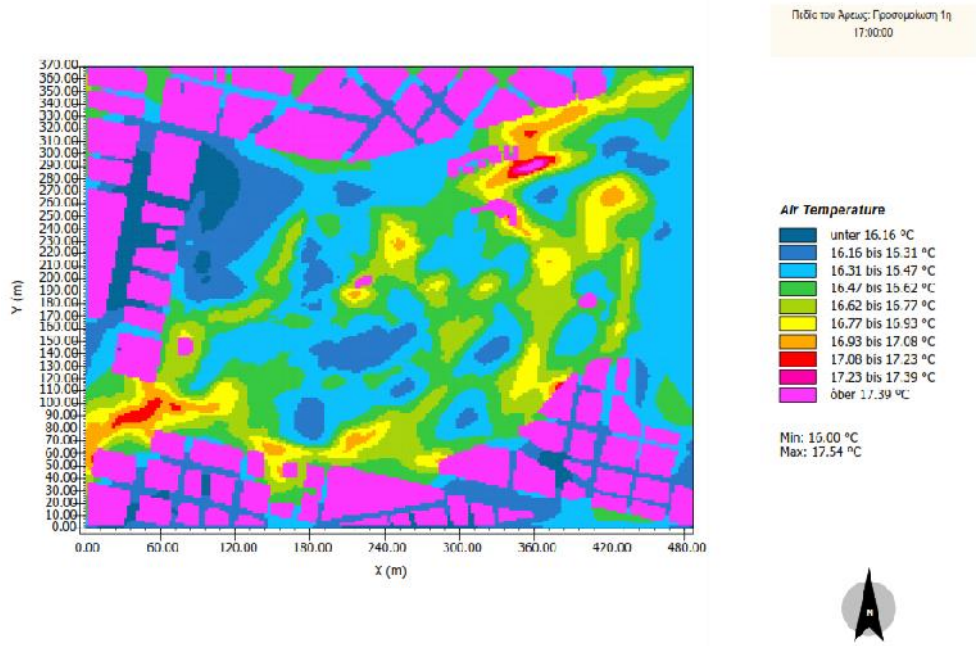


4.13: μ μ 12:00, z=1.50μ. : - Leonardo

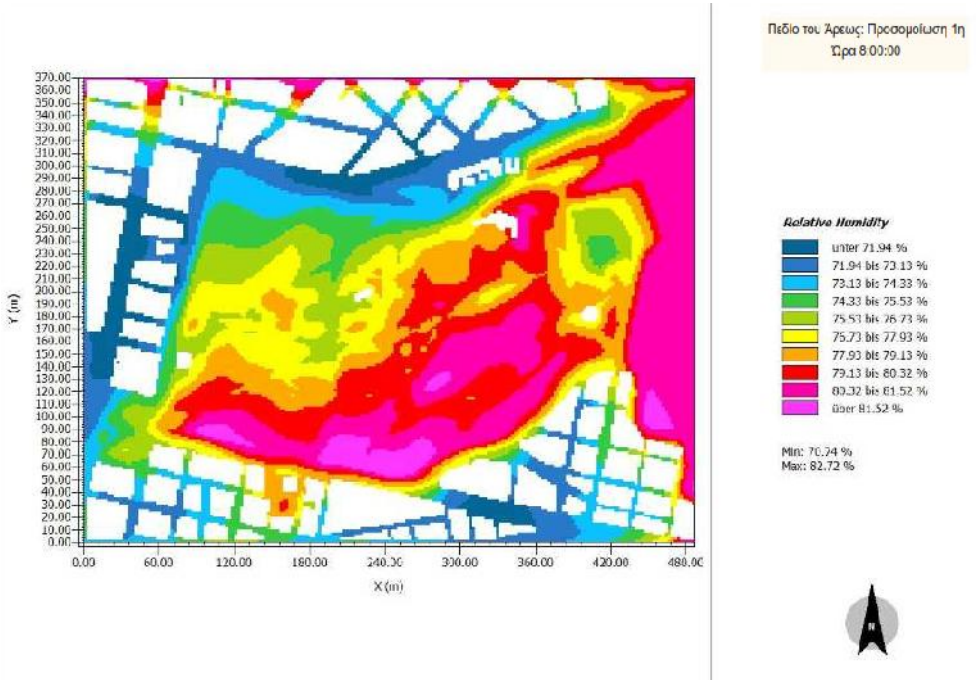


4.14: μ μ 15:00, z=1.50μ. : - Leonardo

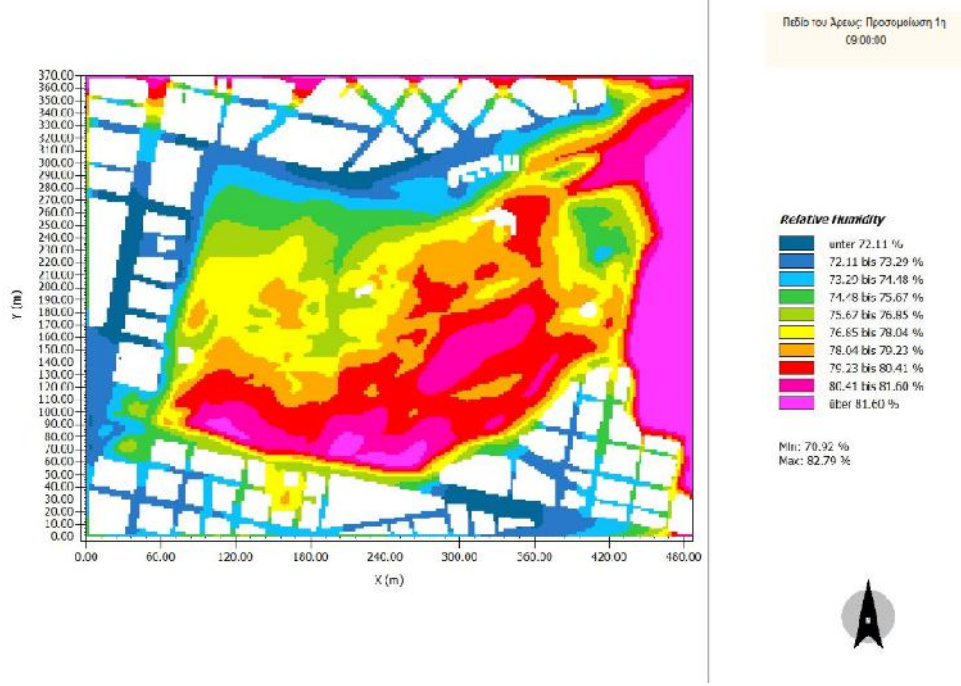
μ μ μ



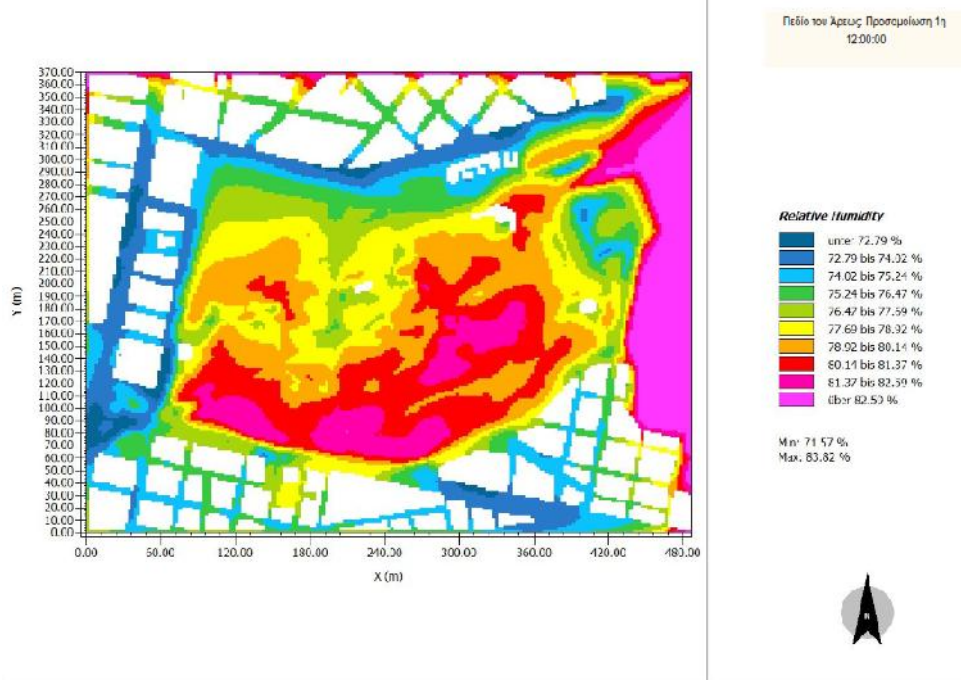
4.15: μ μ 17:00, z=1.50μ. : - Leonardo



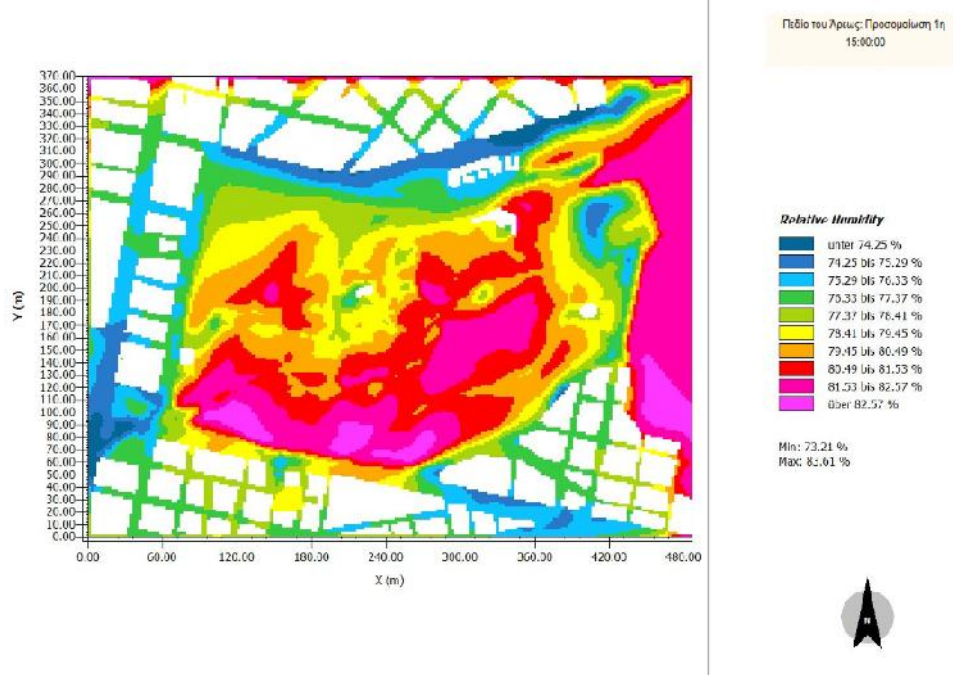
4.16: μ μ 8:00, z=1.50μ. : - Leonardo



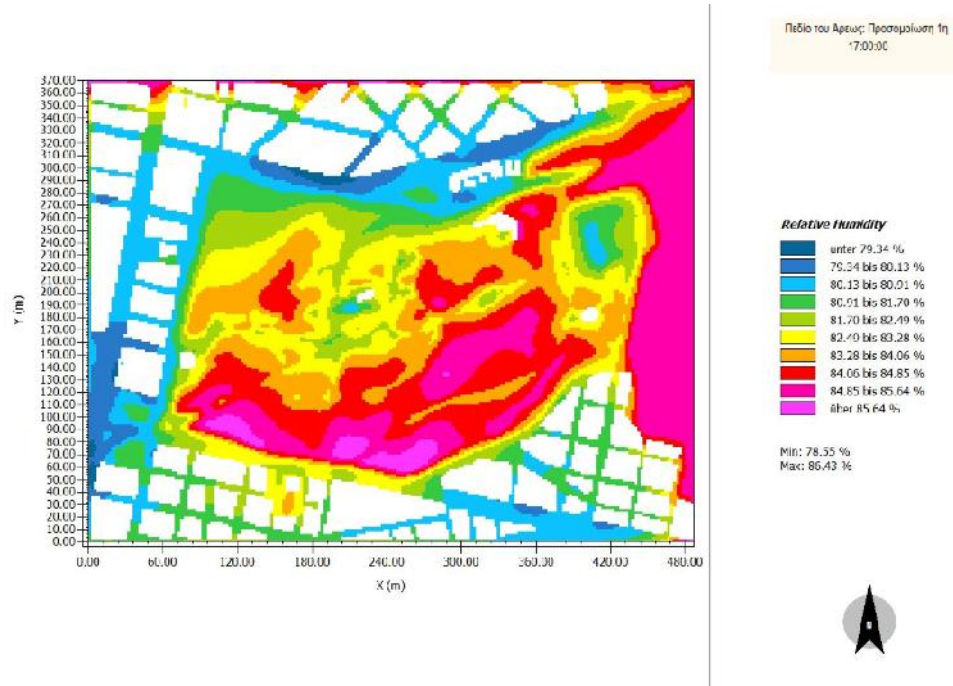
4.17: μ 9:00, z=1.50μ. : - Leonardo



4.18: μ 12:00, z=1.50μ. : - Leonardo



4.19: μ 15:00, z=1.50μ. : - Leonardo



4.20: μ 17:00, z=1.50μ. : - Leonardo

4.2.3.2.

Envi-met

1

Leonardo

μ

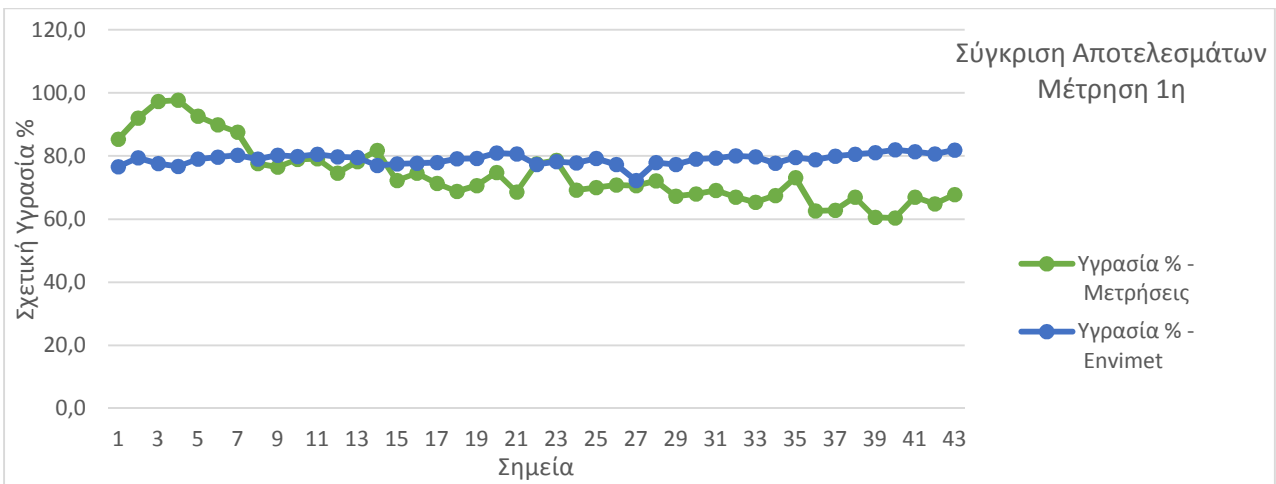
excel

Περιοχή:		Πεδίο του Άρεως, Αθήνα		
Ημερομηνία:		23/04/15		
Ώρα:		8:00:00		
Μέτρηση 1η				
A/A Σημείου	Θερμοκρασία (°C) - Μετρήσεις	Υγρασία % - Μετρήσεις	Θερμοκρασία (°C) - Envi met	Υγρασία % - Envi met
1	13,3	85,3	14,2	76,6
2	12,3	92,0	14,1	79,4
3	11,8	97,3	14,1	77,6
4	13,0	97,7	14,1	76,7
5	11,9	92,6	14,2	79,0
6	14,0	89,9	14,3	79,6
7	13,8	87,5	14,5	80,3
8	14,5	77,6	14,5	79,0
9	14,1	76,5	14,5	80,2
10	14,0	78,9	14,3	79,8
11	14,3	79,1	14,2	80,5
12	14,7	74,6	14,0	79,8
13	14,6	78,2	14,0	79,6
14	14,8	81,8	14,1	77,0
15	16,5	72,2	15,1	77,5
16	16,8	74,6	14,8	77,7
17	16,6	71,3	15,0	77,9
18	16,1	68,8	14,8	79,1
19	16,0	70,6	14,9	79,2
20	17,0	74,8	15,4	80,9
21	18,3	68,6	15,1	80,7
22	16,8	77,5	14,8	77,3
23	15,5	78,6	14,9	78,2
24	16,0	69,2	14,7	77,8
25	18,0	70,0	14,8	79,2
26	16,7	70,8	15,1	77,3
27	17,0	70,6	15,0	72,3
28	16,0	72,1	15,1	77,9
29	18,0	67,3	14,9	77,3
30	18,2	68,0	14,8	79,0
31	18,6	69,1	15,0	79,3
32	18,5	67,0	15,2	80,1
33	18,7	65,3	15,1	79,7

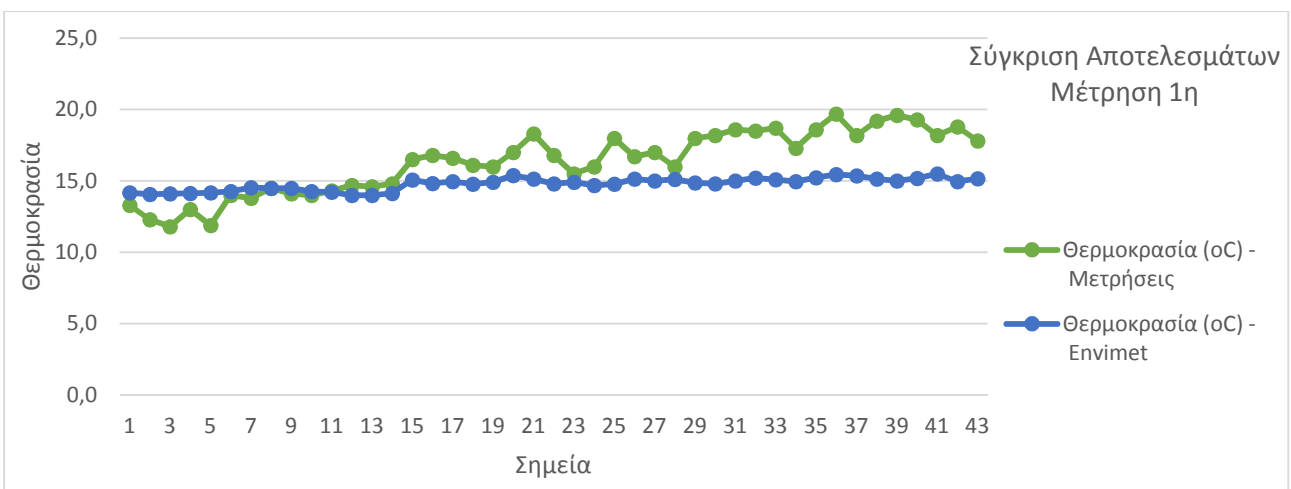
μ μ μ

34	17,3	67,5	15,0	77,7
35	18,6	73,1	15,2	79,5
36	19,7	62,6	15,4	78,8
37	18,2	62,8	15,4	79,9
38	19,2	67,0	15,1	80,6
39	19,6	60,6	15,0	81,0
40	19,3	60,4	15,2	81,9
41	18,2	67,0	15,5	81,4
42	18,8	64,8	15,0	80,7
43	17,8	67,8	15,2	81,9

4.1: μ μ & , – Envi met, 8:00. :



μμ 4.1: μ μ , – Envi met, 8:00. :



μμ 4.2: μ μ , – Envi met, 8:00. :

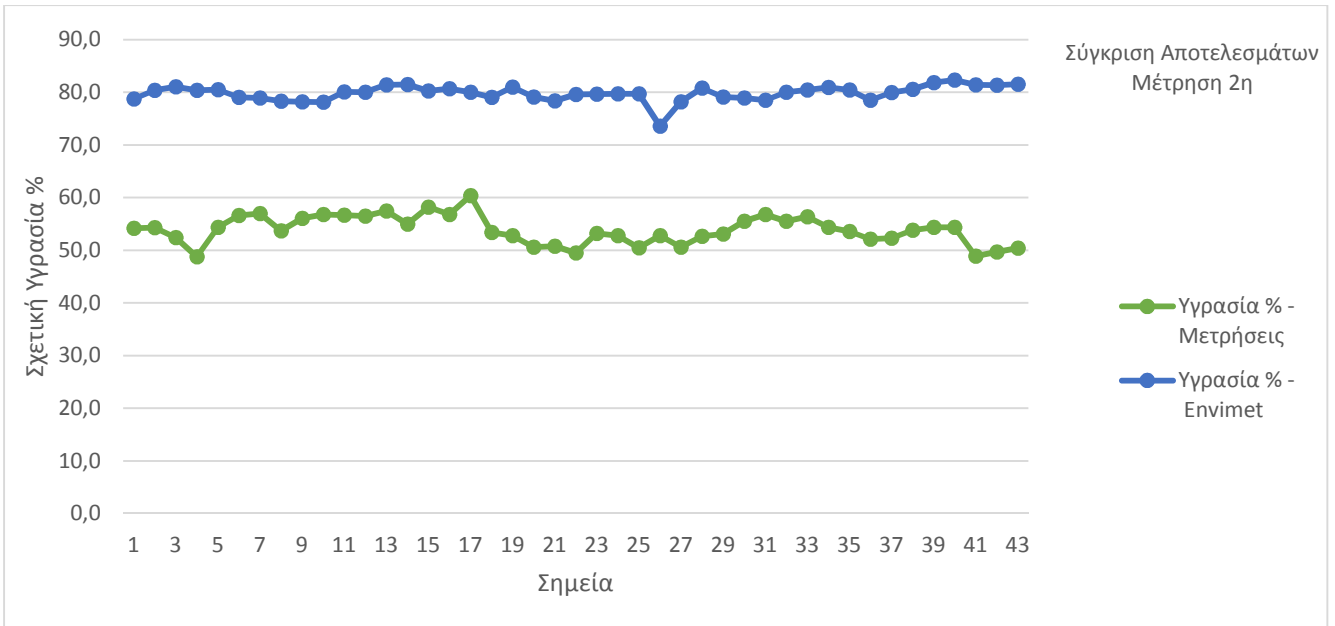
μ μ μ

Περιοχή:	Πεδίο του Άρεως, Αθήνα			
Ημερομηνία:	23/04/15			
Ώρα:	12:00:00			
Μέτρηση 2η				
A/A Σημείου	Θερμοκρασία (°C) - Μετρήσεις	Υγρασία % - Μετρήσεις	Θερμοκρασία (°C) - Envi met	Υγρασία % - Envi met
1	21,3	54,2	17,5	78,7
2	21,2	54,3	16,7	80,4
3	22,8	52,4	16,9	81,0
4	22,5	48,8	16,4	80,4
5	22,3	54,4	16,5	80,5
6	21,2	56,6	16,5	79,0
7	22,3	57,0	16,4	78,9
8	21,5	53,7	16,4	78,4
9	19,1	56,1	16,6	78,2
10	20,3	56,8	16,8	78,2
11	20,9	56,7	16,3	80,1
12	19,5	56,5	16,5	80,0
13	21,3	57,5	17,1	81,4
14	22,8	55,0	16,9	81,5
15	20,1	58,2	17,2	80,3
16	18,8	56,8	17,4	80,7
17	18,8	60,4	17,0	80,0
18	21,2	53,4	16,7	79,1
19	21,3	52,8	16,9	81,0
20	22,3	50,6	17,2	79,1
21	21,3	50,8	16,5	78,4
22	22,5	49,5	16,4	79,6
23	22,0	53,2	16,6	79,7
24	21,2	52,8	16,5	79,7
25	22,5	50,5	16,5	79,7
26	20,6	52,8	16,7	73,6
27	19,7	50,6	16,9	78,2
28	22,1	52,7	16,7	80,8
29	21,7	53,1	16,4	79,1
30	21,5	55,5	17,0	78,9
31	22,5	56,8	16,4	78,5
32	19,2	55,5	16,3	80,0
33	20,8	56,4	16,7	80,5
34	20,9	54,4	17,0	80,9
35	20,7	53,6	16,9	80,5
36	22,3	52,1	17,5	78,5
37	22,2	52,3	17,2	80,0
38	21,9	53,8	16,7	80,6
39	21,6	54,4	16,8	81,8

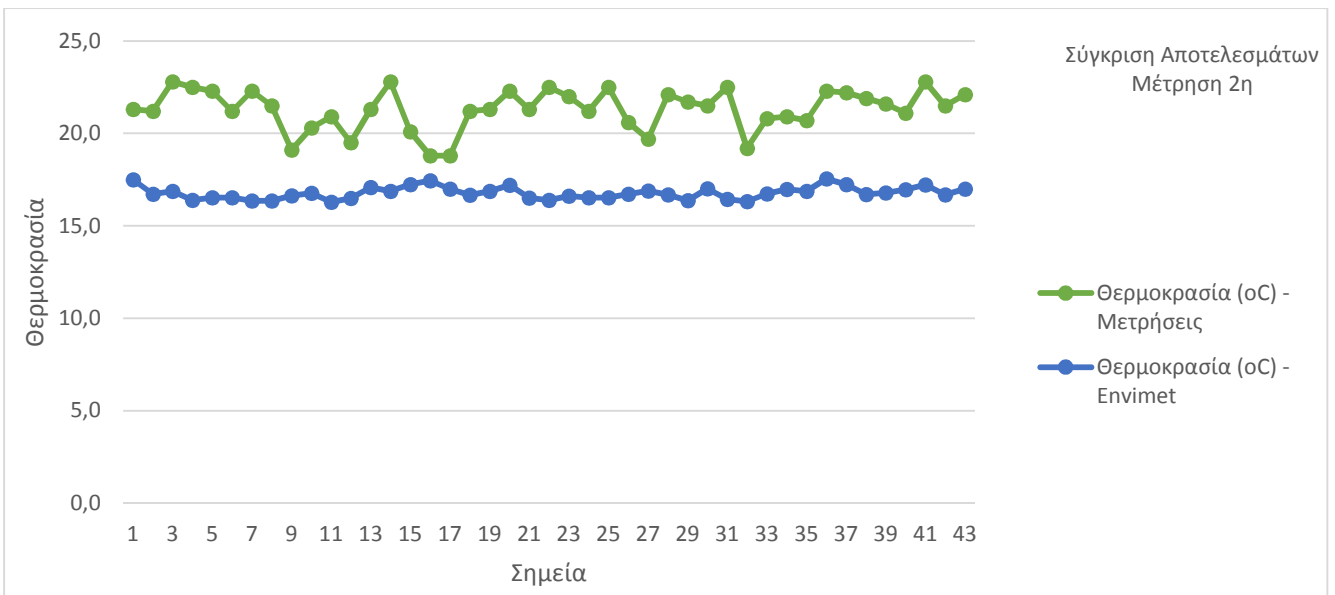
μ μ

40	21,1	54,4	17,0	82,3
41	22,8	48,9	17,2	81,4
42	21,5	49,7	16,7	81,4
43	22,1	50,4	17,0	81,6

4.2: μ μ & , – Envi met, 12:00. :



μμ 4.3: μ , – Envi met, 12:00. :



μμ 4.4: μ μ , – Envi met, 12:00. :

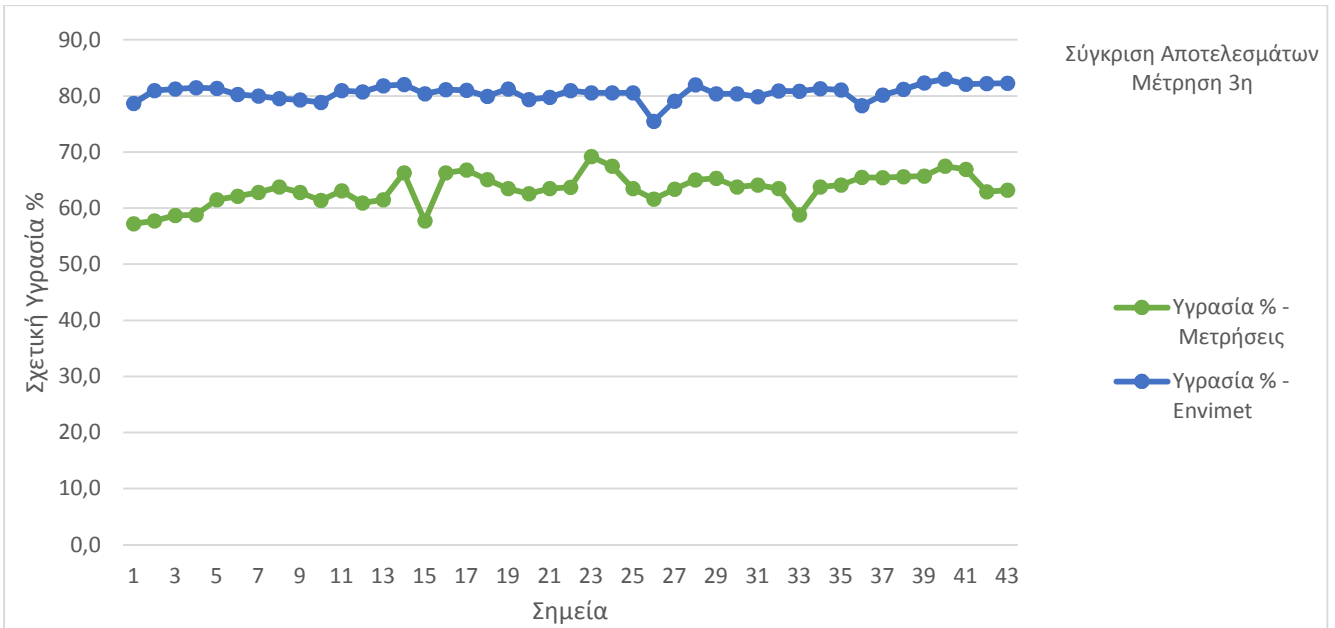
μ μ μ

Περιοχή:	Πεδίο του Άρεως, Αθήνα			
Ημερομηνία:	23/04/15			
Ώρα:	15:00:00			
Μέτρηση 3η				
A/A Σημείου	Θερμοκρασία (°C) - Μετρήσεις	Υγρασία % - Μετρήσεις	Θερμοκρασία (°C) - Envi met	Υγρασία % - Envi met
1	19,6	57,2	17,6	78,7
2	21,3	57,7	17,2	81,0
3	21,4	58,7	17,1	81,2
4	19,6	58,8	17,0	81,5
5	19,9	61,5	17,0	81,4
6	19,5	62,1	17,0	80,3
7	20,2	62,8	17,2	80,0
8	20,5	63,8	16,9	79,5
9	19,7	62,8	17,1	79,3
10	18,5	61,4	17,4	78,8
11	19,5	63,1	16,9	80,9
12	19,3	60,9	17,0	80,7
13	20,6	61,5	17,3	81,8
14	17,5	66,3	17,2	82,0
15	19,5	57,7	17,7	80,3
16	19,6	66,3	17,7	81,1
17	17,8	66,8	17,5	81,0
18	19,7	65,1	17,3	79,9
19	18,7	63,5	17,5	81,3
20	19,5	62,6	17,7	79,4
21	20,0	63,5	17,2	79,7
22	19,2	63,7	17,1	81,0
23	20,1	69,2	17,1	80,6
24	20,3	67,5	17,3	80,5
25	19,6	63,5	19,9	80,6
26	19,7	61,6	17,2	75,5
27	19,7	63,4	17,5	79,1
28	20,3	65,0	17,4	81,9
29	18,8	65,3	17,1	80,4
30	20,5	63,8	17,3	80,4
31	22,0	64,1	17,0	79,9
32	21,7	63,5	16,9	80,9
33	21,0	58,8	17,3	80,8
34	20,2	63,8	17,3	81,3
35	20,3	64,1	17,4	81,1
36	20,5	65,5	17,8	78,3
37	20,3	65,4	17,7	80,1
38	19,7	65,6	17,3	81,2
39	20,1	65,7	17,2	82,3

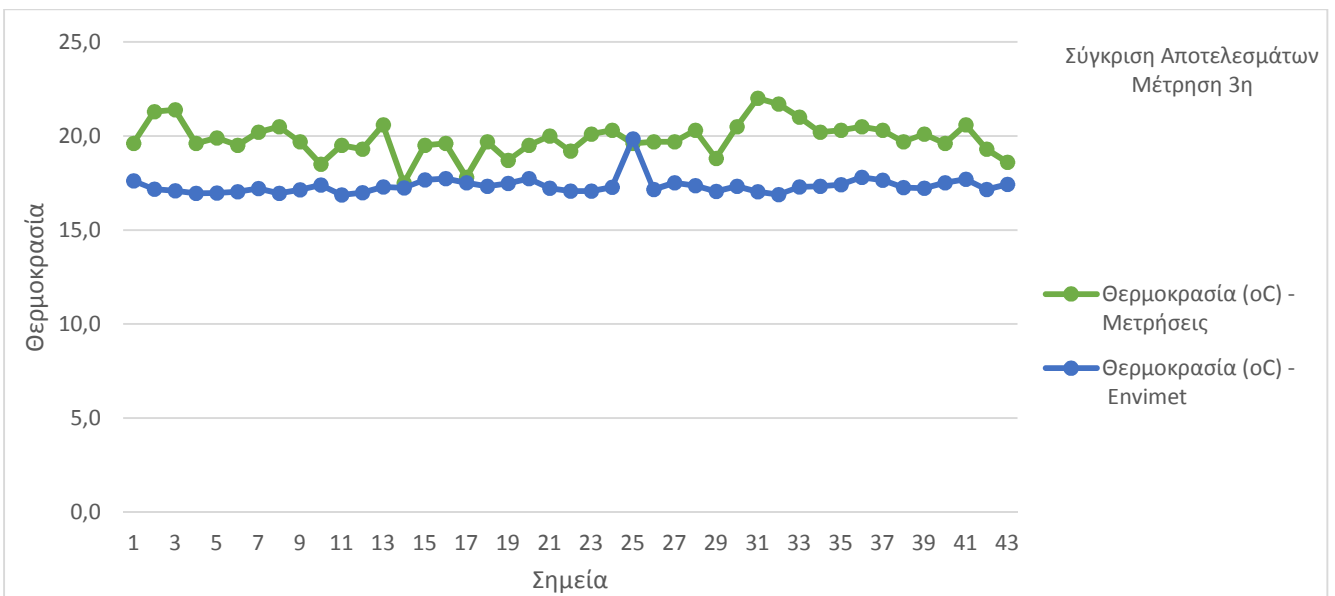
μ μ μ

40	19,6	67,5	17,5	83,0
41	20,6	66,9	17,7	82,1
42	19,3	62,9	17,1	82,2
43	18,6	63,2	17,4	82,2

4.3: μ μ & , – Envi met, 15:00. :



μμ 4.5: μ , – Envi met, 15:00. :



μμ 4.6: μ μ , – Envi met, 15:00. :

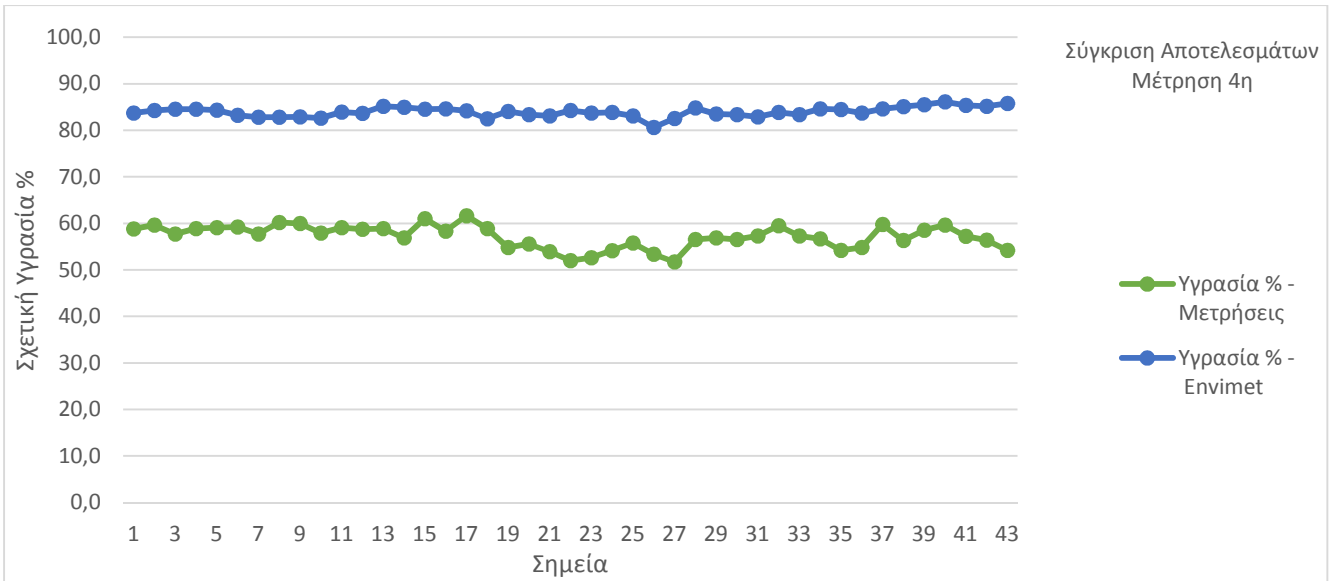
μ μ

Περιοχή:	Πεδίο του Άρεως, Αθήνα			
Ημερομηνία:	23/04/15			
Ώρα:	17:00:00			
Μέτρηση 4η				
A/A Σημείο	Θερμοκρασία (°C) - Μετρήσεις	Υγρασία % - Μετρήσεις	Θερμοκρασία (°C) - Envi met	Υγρασία % - Envi met
1	18,4	58,8	16,5	83,7
2	18,8	59,6	16,6	84,3
3	19,0	57,7	16,6	84,5
4	18,8	58,9	16,6	84,5
5	19,2	59,1	16,6	84,3
6	19,5	59,2	16,7	83,3
7	19,2	57,7	16,7	82,8
8	19,5	60,2	16,7	82,8
9	19,2	60,0	16,8	82,9
10	18,5	57,9	16,8	82,6
11	18,3	59,1	16,6	83,9
12	18,3	58,7	16,6	83,7
13	18,8	58,9	16,7	85,1
14	19,5	56,9	16,7	84,9
15	17,9	61,0	16,6	84,5
16	19,0	58,3	16,8	84,6
17	18,6	61,6	16,9	84,2
18	18,8	58,9	16,8	82,5
19	18,8	54,8	16,8	84,1
20	18,6	55,6	16,8	83,3
21	20,0	53,9	16,7	83,1
22	21,0	52,0	16,8	84,3
23	20,5	52,6	16,6	83,7
24	20,2	54,1	16,7	83,8
25	19,6	55,8	16,7	83,1
26	21,3	53,4	16,6	80,6
27	18,5	51,7	16,9	82,5
28	20,0	56,5	16,8	84,8
29	20,2	56,9	16,7	83,5
30	19,2	56,5	16,8	83,4
31	19,2	57,3	16,7	82,9
32	20,1	59,5	16,6	83,9
33	19,3	57,3	16,9	83,4
34	20,2	56,7	16,5	84,6
35	20,9	54,2	16,6	84,5
36	19,3	54,8	16,5	83,7
37	19,6	59,8	16,6	84,6
38	19,3	56,3	16,7	85,1
39	19,1	58,5	16,6	85,5

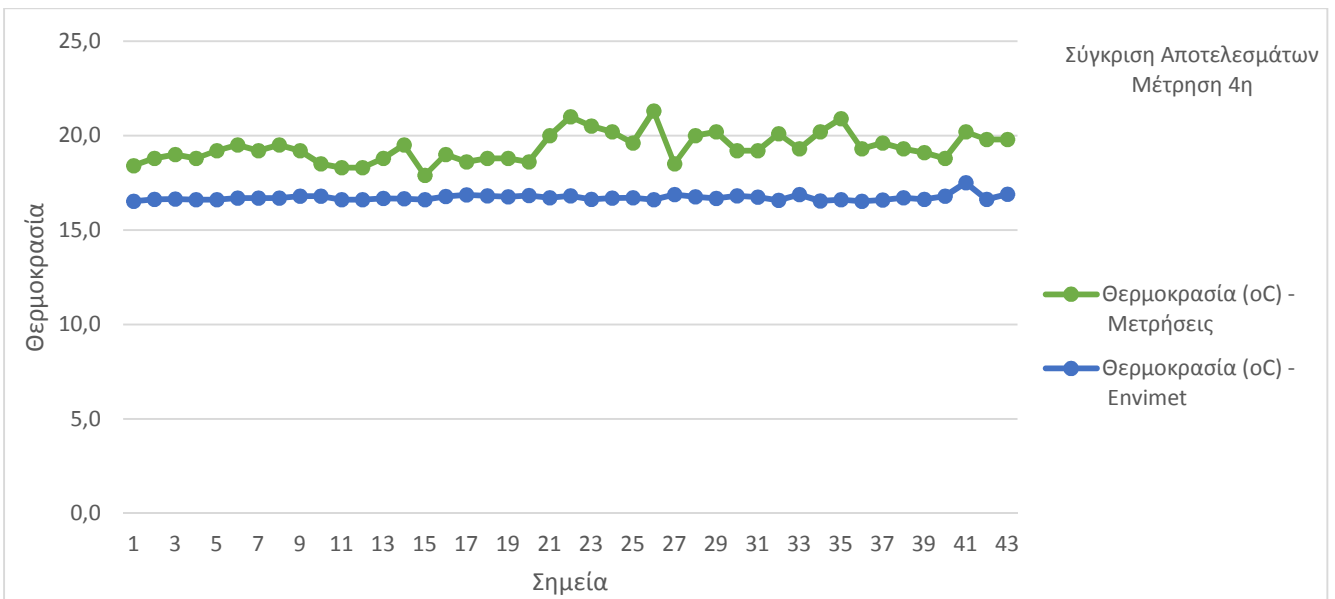
μ μ μ

40	18,8	59,6	16,8	86,1
41	20,2	57,2	17,5	85,4
42	19,8	56,4	16,6	85,2
43	19,8	54,2	16,9	85,8

4.4: μ μ & , – Envi met, 17:00. : -



μμ 4.7: μ μ , – Envi met, 17:00. : -



μμ 4.8: μ μ , – Envi met, 17:00. : -

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, $\mu \quad \mu \quad \mu$

4.2.4.1. $\mu \quad 2 \quad \mu$

$\mu \quad -$

$\mu \quad 2 \quad \mu$

$\mu \quad 2.$

μ μ μ

4.2.5.3 μ : 15/07/2015 –

μ μ μ , μ

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. μ , μ μ

. μ :

- μ μ : 15/07/2015
- : 05:00:00
- μ : 17h
- μ (10m.): 2,1 m/s
- μ : 45 ()
- μ : 295.75 Kelvin (22,6°C)
- 2500m.: 4
- 2m.: 48%

, μ μ μ

μ μ .

4.2.5.1. μ 3 μ

μ –

μ 3 μ

μ 2.

μ μ μ

4.2.6.

μ 2 3 μ

μ μ

μ , μ

μ μ

2008

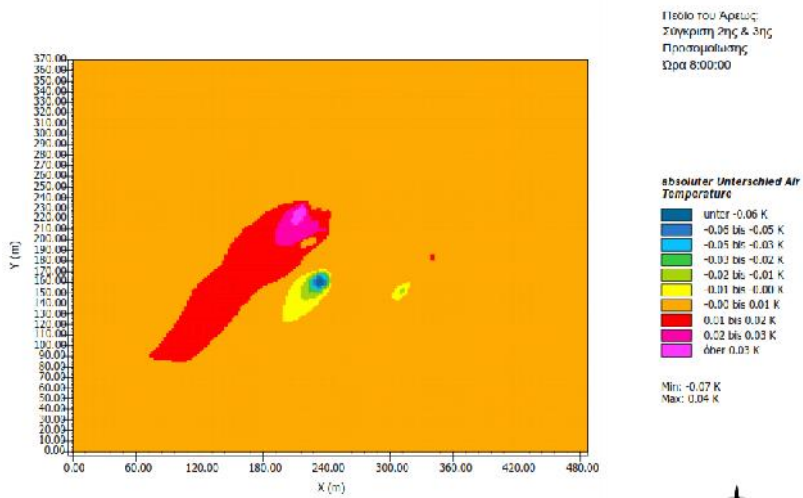
Leonardo

μ

μ

μ

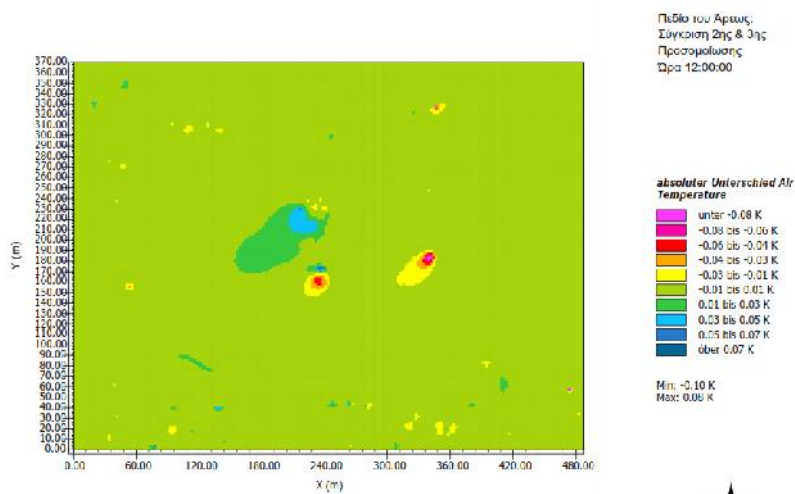
(μ



4.21:

μ 2 - 3 μ - Leonardo

8:00. :

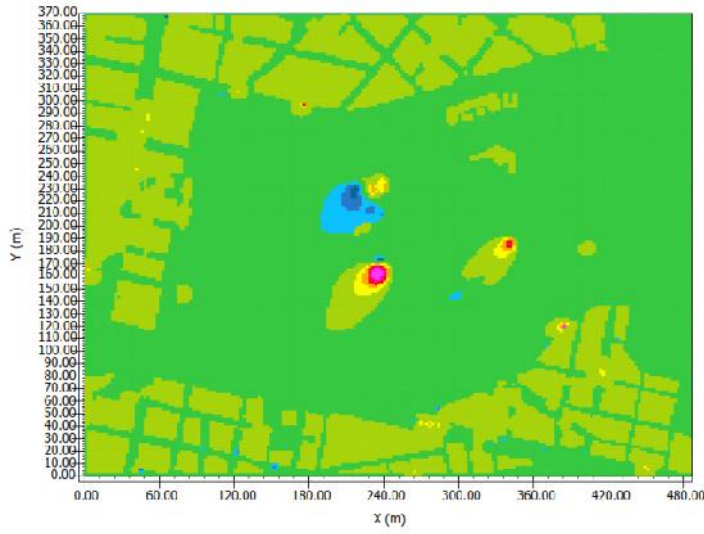


4.22:

μ 2 - 3 μ - Leonardo

12:00. :

μ μ



Πεδίο του Λεωξ:
Σύγκριση 2ης & 3ης
Προσομοίωση
Ώρα 15:00:00

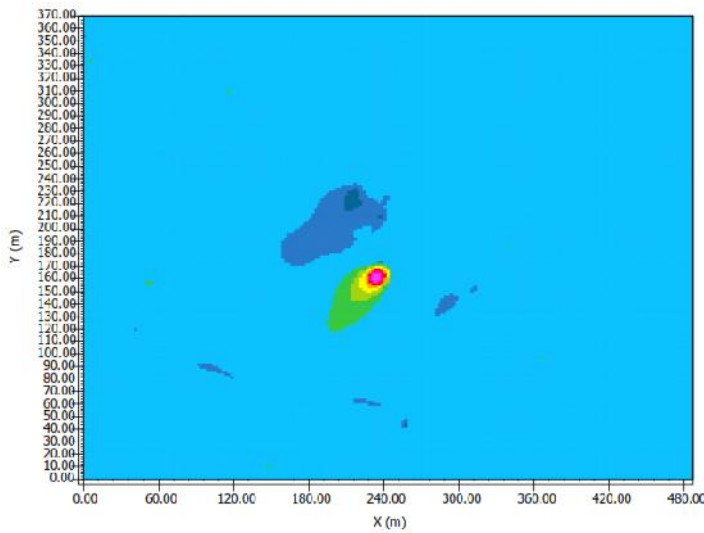
**absoluter Unterschied Air
Temperatur**



Min: 0.09 K
Max: 0.06 K

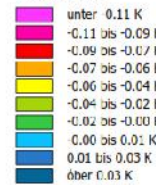


4.23: μ 2 - 3 μ nardo 15:00. : - Leo-



Πεδίο του Αρεως:
Σύγκριση 2ης & 3ης
Προσομοίωση
Ώρα 18:00:00

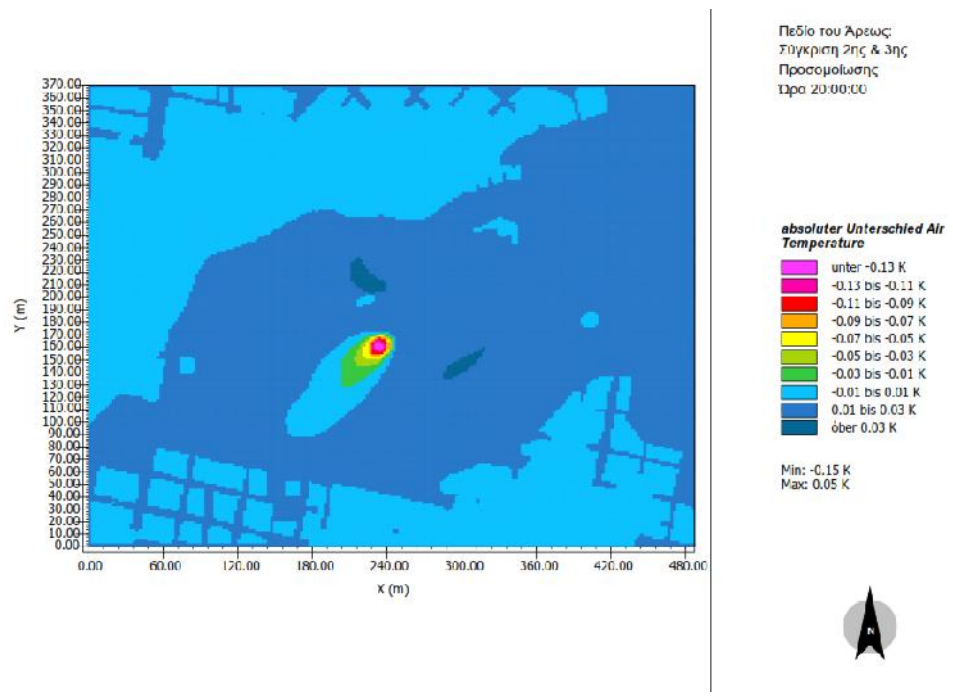
**absoluter Unterschied Air
Temperatur**



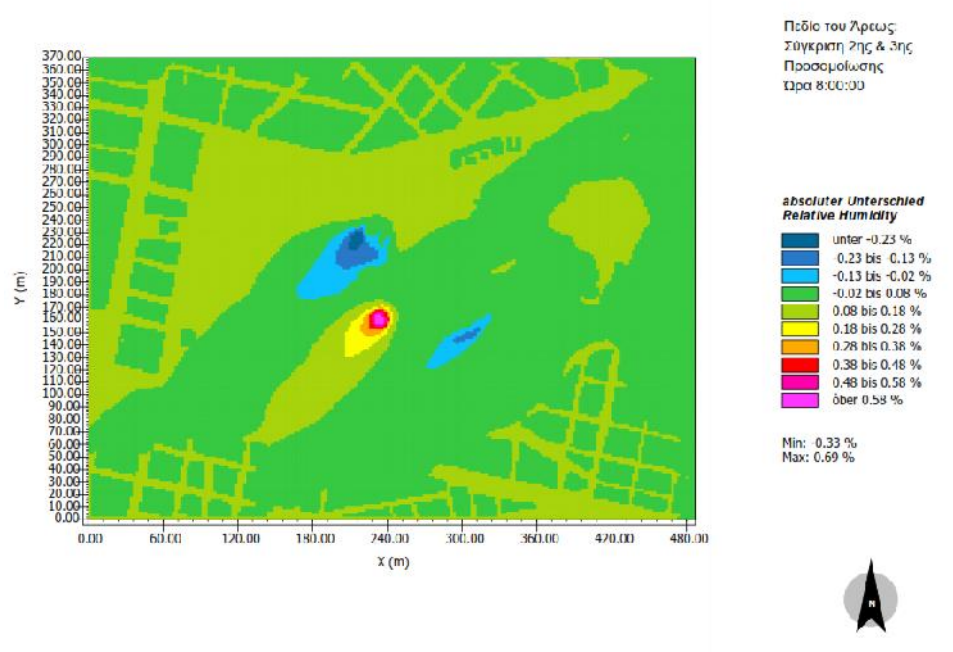
Min: 0.13 K
Max: 0.05 K



4.24: μ 2 - 3 μ nardo 18:00. : - Leo-

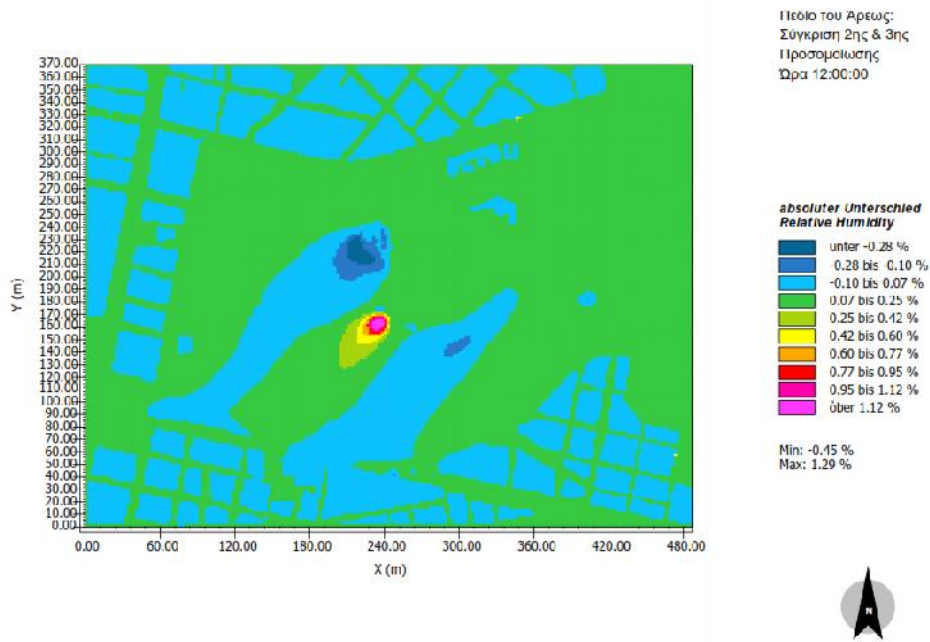


4.25: μ 2 – 3 μ 20:00. : - Leo-

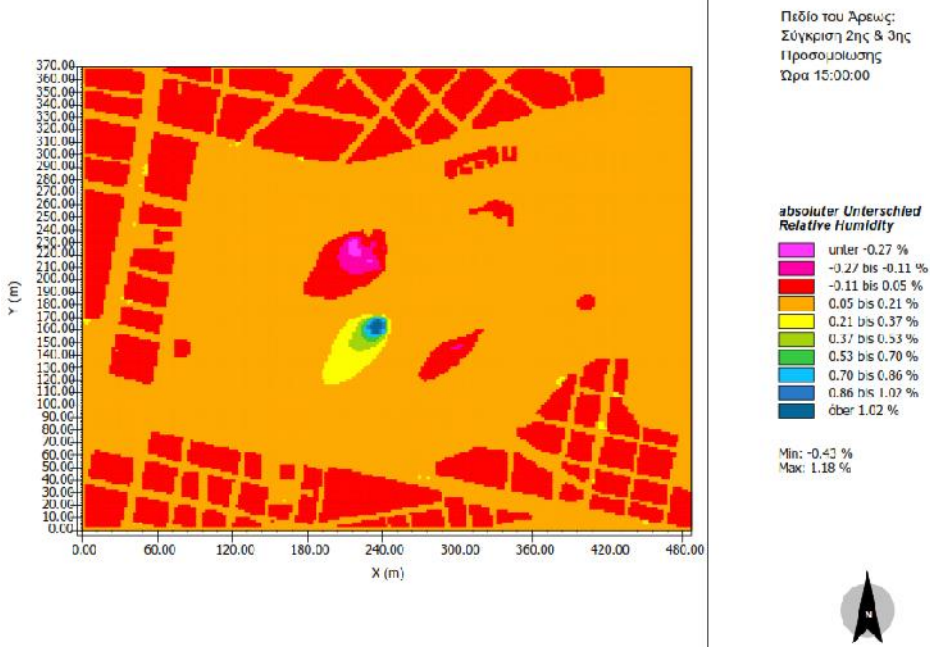


4.26: 2 – 3 μ 8:00. : - Leonardo

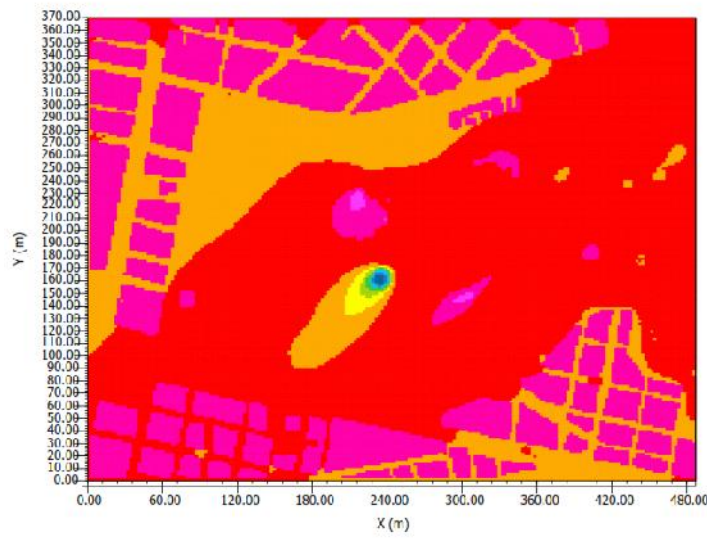
μ μ



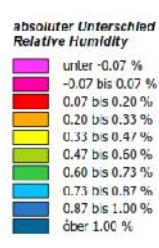
4.27: 2 – 3 μ 12:00. : -
- Leonardo



4.28: 2 – 3 μ 15:00. : -
- Leonardo



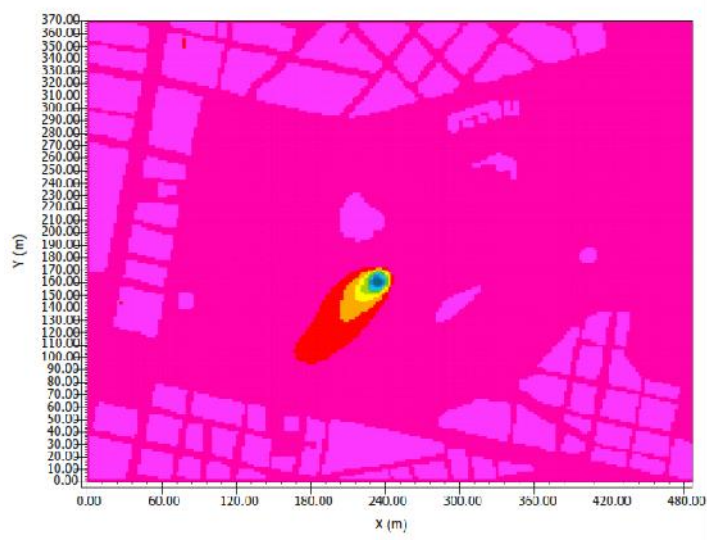
Πεδίο του Αρσούς;
Σύγκριση 2ης & 3ης
Προσομοίωσης
Ωρα 18:00:00



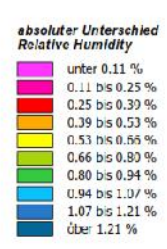
Min: -0.20 %
Max: 1.13 %



4.29: 2 – 3 μ 18:00: -
- Leonardo



Πεδίο του Αρσούς;
Σύγκριση 2ης & 3ης
Προσομοίωσης
Ωρα 20:00:00



Min: -0.02 %
Max: 1.35 %



4.30: 2 – 3 μ 20:00: -
- Leonardo

μ μ μ

μ +0,1-0,2 °C, μ
-1 2%.

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μ μ μ μ μ μ
μ μ μ μ μ μ -
μ μ μ μ μ μ -
μ μ μ μ μ μ -



4.31: μ -
- : www.newsbomb.gr



4.32: μ -
: www.kappos.eu

μ μ^μ

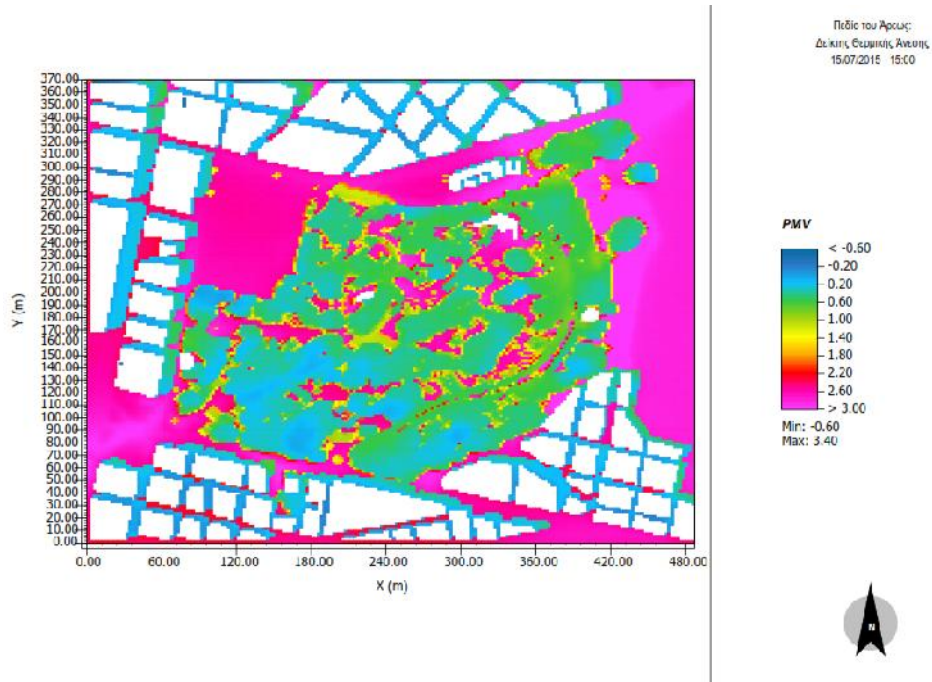
4.2.7. μ 4 : 15/07/2015 –

μ μ μ -
 μ μ μ . -
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 2008 μ μ -
 , μ μ -
 μ μ μ Envi-met, Biomet, μ μ -
 μ μ μ μ -
 μ μ μ μ -
 μ μ μ μ μ
 μ μ μ μ μ
 :

- 1
 : 15:00:00
 :
 :35
 :1,67
 :65
 μ (clo): 0.36

- 2
 : 15:00:00
 :
 :75
 :1,73
 :75
 μ (clo): 0.38

μ μ μ μ μ μ μ -
 μ μ μ μ μ μ μ (4.33).



4.33: μ μ 15.00. : - Biomet

0 (1 , 1.3.2.2) μ PMV

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(μ μ , 4.33). , μ μ

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μ μ μ μ μ

μ μ μ μ μ Acer Platanoides.

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μ (1 , 1.3.3.2) - -

μ μ μ μ μ μ μ μ

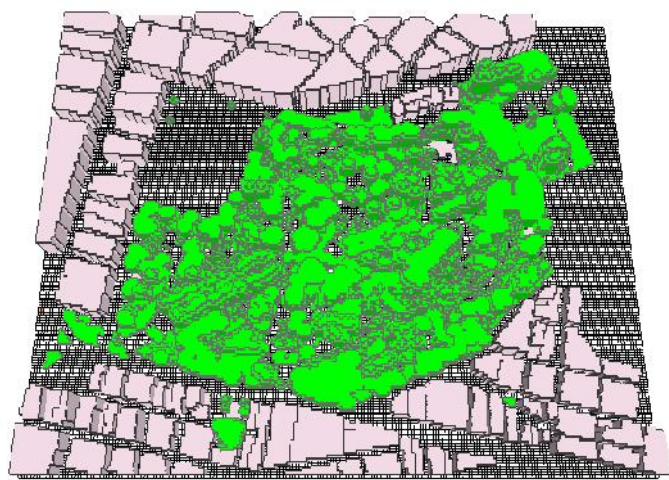
•

μ μ μ μ μ - -

μ μ μ

- $(\mu) \mu$,
 $\mu \mu \mu$
 μ , μ .
 μ 4 μ μ
 μ μ (4.34).
 μ 4 μ :

- $\mu \mu$: 15/07/2015
- : 06:00:00
- μ : 11h
- μ (10m.) : 2,1 m/s
- μ : 45 ()
- μ : 296.4 Kelvin (23,25°C)
- 2500m.: 4
- 2m.: 45%



4.34: μ 4 μ met . : – Envi-

4.2.7.1. μ 4 μ
 μ –

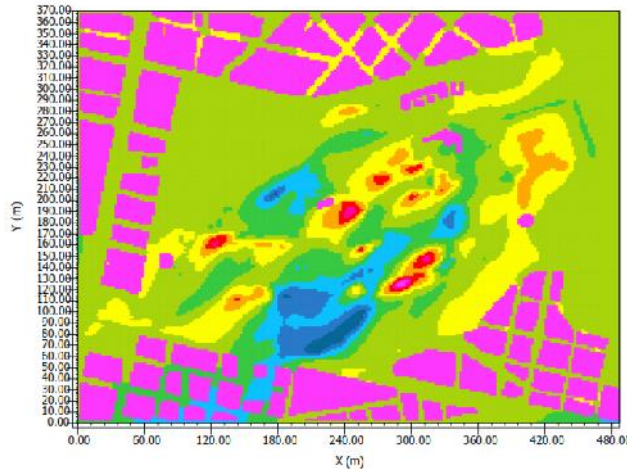
μ 4 μ μ 2.

μ μ

4.2.8. μ 3 4 μ

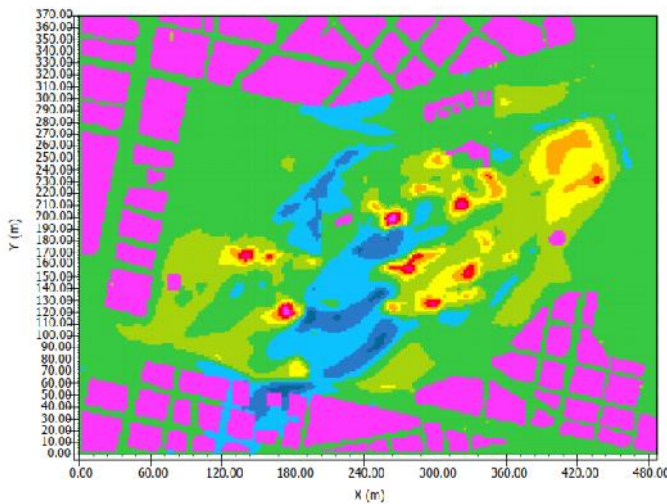
μ 3 4 μ -

) () μ



4.35: μ , 3 - 4 μ - Leonardo

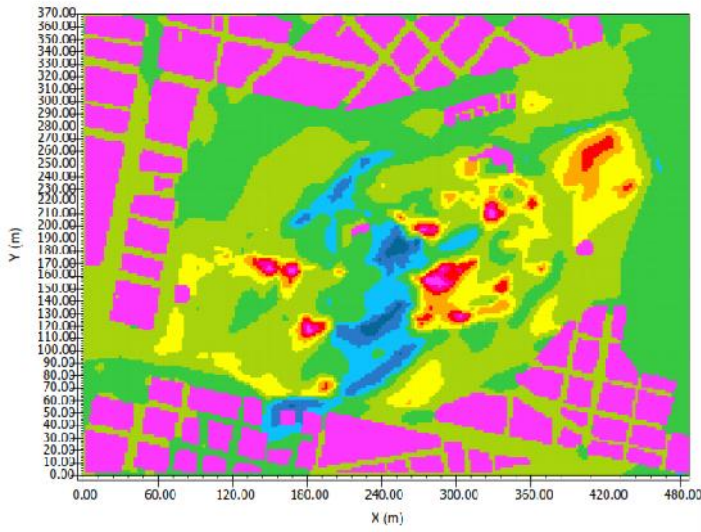
08:00. : -



4.36: μ , 3 - 4 μ - Leonardo

12:00. : -

μ μ μ



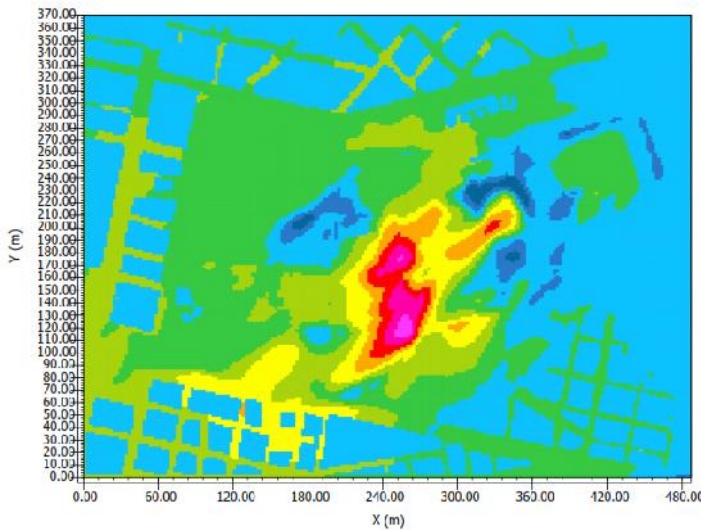
Πεδίο του Αρσένι:
Σύγκριση 3ης & 4ης
Προσομοίωσης
Ωρα 15:00:00

absoluter Unterschied Air Temperature

- unter -0.77 K
- -0.77 bis -0.71 K
- -0.71 bis -0.64 K
- -0.64 bis -0.58 K
- -0.58 bis -0.51 K
- -0.51 bis -0.45 K
- -0.45 bis -0.38 K
- -0.38 bis -0.32 K
- -0.32 bis -0.25 K
- ober -0.25 K



4.37: μ , 3 – 4 μ 15:00. :
- Leonardo



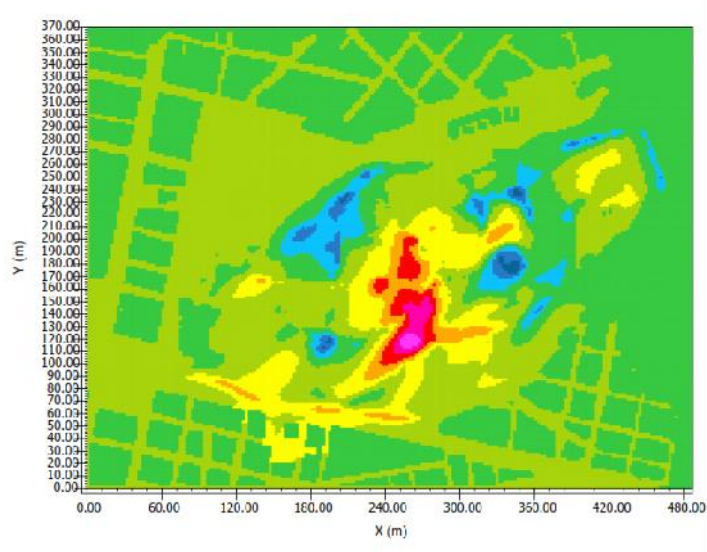
Πεδίο του Αρσένι:
Σύγκριση 3ης & 4ης
Προσομοίωσης
Ωρα 08:00:00

absoluter Unterschied Relative Humidity

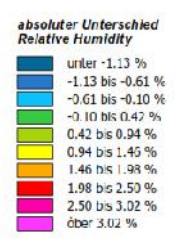
- unter -0.52 %
- -0.52 bis -0.18 %
- -0.18 bis 0.16 %
- 0.16 bis 0.50 %
- 0.50 bis 0.84 %
- 0.84 bis 1.18 %
- 1.18 bis 1.51 %
- 1.51 bis 1.85 %
- 1.85 bis 2.19 %
- ober 2.19 %



4.38: μ , 3 – 4 μ 08:00. :
- Leonardo



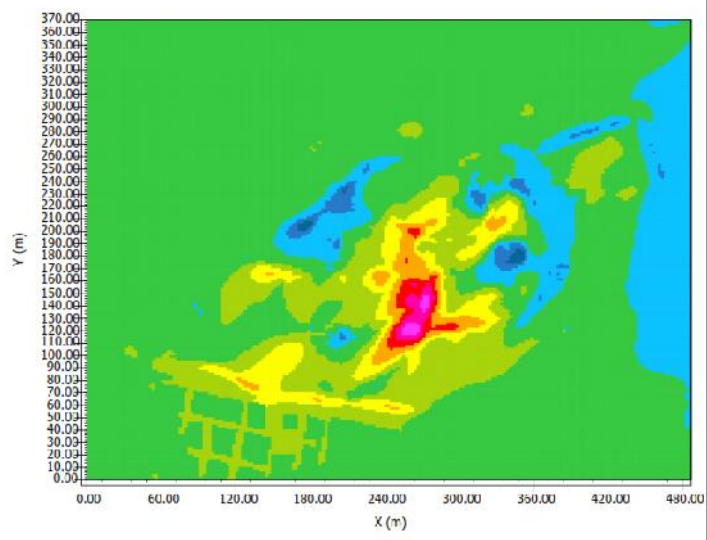
Πεδίο του Άρεως:
Σύγκριση 3ης & 4ης
Προσομοίωσης
Ωρα 12:00:00



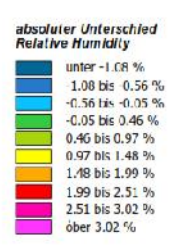
4.39:

, 3 – 4 μ
- Leonardo

12:00.



Πεδίο του Άρεως:
Σύγκριση 3ης & 4ης
Προσομοίωσης
Ωρα 15:00:00



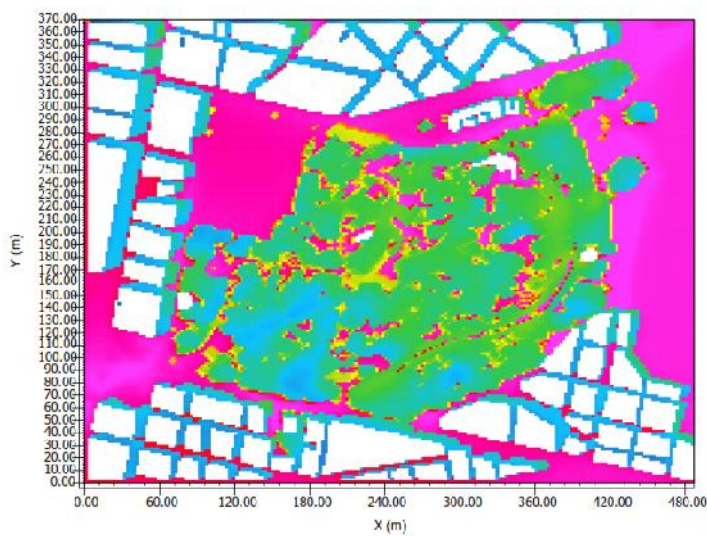
4.40:

, 3 – 4 μ
- Leonardo

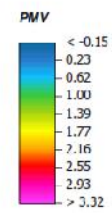
15:00.

μ μ

- $0,5\text{ }^{\circ}\text{C}$
- $0,8\text{ }^{\circ}\text{C}$.
- $0,5\text{ }^{\circ}\text{C}$.
- 3%
- $4,41, \mu$
- $0,1$



Πεδίο του Άρεως
 Δείκτης Οργανικής Άνεσης
 15/07/2015 - 15.00 | Πρωϊνάς



4.41: μ μ 15:00 – Biomet

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μ (μ -μ -)

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• μ μ μ μ μ μ

μ μ μ μ μ μ μ

μ μ μ μ

μ μ μ

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μ μ μ μ μ μ μ

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μ μ μ μ μ μ μ μ μ : 1)

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. 2) $\mu \mu$. 3) $\mu \mu$
. 4) $\mu \mu$. 5) $\mu \mu$

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• $\mu \mu \mu \mu \mu$

$\mu \mu \mu \mu \mu$

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- http://portal.tee.gr/portal/page/portal/teetkm/GRAFEIO_TYPOY/TEXNOGRAFHMA_2012/T
EXNOGRAFHMA_437/437.pdf"
40. (2011), City_SEC, -
 41. (2006). μ μ μ
 42. (2009). μ μ μ . 3
« μ » μ « μ » μ -
μ : http://library.tee.gr/digital/m2465/m2465_tzortzi.pdf
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1

1.1: : www.enet.gr 19

1.2: : www.athensmagazine.gr 19

1.3: 20

: www.4green.gr 20

1.4: μ 20

: www.travelstyle.gr 20

1.5, 1.6: μ Chengdu Tianfu District Great City 21

: www.inhabitat.com 21

1.7: 22

: www.greenroofs.gr 22

1.9: μ - : www.ecoleft.gr 25

1.8: μ - : www.protothema.gr 25

1.10: μ 27

: http://www.zeroenergybuildings.org/ 27

1.11: μ : http://www.zeroenergybuildings.org 28

1.12: [42] 31

1.13: H/W L/W (μ μ). [42] 31

1.14: μ : Google Earth 33

1.15: : blog.travelplanet24.com 35

1.16: : www.google.gr 36

μ μ μ 36

1.17: μ , : wikimapia.org 37

1.18: 37

: www.healthycities2014.org 37

1.19: « », 38

: www.naturagraeca.com 38

1.20: μ μ (PMV) μ (PPD). [74] 45

1.21: μ μ μ [-1]. 48

1.22: μ μ μ [-1]. 48

1.23: - [-1]. 48

1.24: μ Venturi. [29] 50

1.25: μ . [-1] 51

1.26: « ». [-1] 52

1.27: « μ ». [-8] 55

1.28, 1.29: μ , μ μ : www.news.gr 58

1.30: , μ μ . [INT-1] 61

1.31: « », . [INT-2] 62

1.32, 1.33: μ μ , Porto Alegre, [INT-1] 65

1.34: μ μ , [INT-1] 65

1.35:	μ	.....	66
[INT-1]		.....	66
1.35:		.....	67
:	www.socialdesignmagazine.com	.....	67
1.36:	μ μ	.....	68
1.37:		: www.kappos.eu	69
1.38:		.....	70
:	www.iefimerida.gr	.....	70
1.39:		.....	71
:	www.athensinfoguide.com	.....	71
1.40:	μ	[INT-1].....	71
1.41:		, Houston	71
:	www.city-data.com	.....	71
1.42:	Micronizers,	[INT-1].....	71
1.43:	μ , μ	[INT-1].....	72
2.1:		μ ENVI-met. : [-5]....	74
2.2:	μ μ	: [-5].....	77
2.3:	μ	Configuration File.	77
:	[	]	77
2.4:		ENVI-met.	87
:	[	]	87
2.5:	μ	().....	88
:	[	]	88
2.6:	ENVI-met Model Analyzer.	.....	89
:	[	]	89
2.7:	Configuration (	μ ) : [	90
2.8:	Biomet.	.....	91
:	[	]	91
2.9:	μ LEONARDO,	μ μ μ	92
()	()	μ μ	: [-5].....
2.10:	μ LEONARDO,	μ μ	: [-5].....
()	()	μ μ	: [-5].....
2.11:	projects.....		93
:	[	]	93
2.12:	μ Albero.	: [	94
2.13:	Albero	.....	94
:	[	]	94
3.1:		.....	96
:	www.local-history.gr	.....	96
3.2:		: www.athensmagazine.gr	96
3.3:		.....	97
:	www.tanea.gr	.....	97
3.4:	-	.....	97
:	www.local-history.gr	.....	97
3.5:		.....	98
:	-	.....	98
3.6:	μ	[INT-2].....	99
3.7:	-	.....	100
:	www.local-history.gr	.....	100

	μ	μ				
	3.9:	μ	.	:	–	102
	3.8:		.	:	–	102
	3.11:	μ				103
	: www.local-history.gr					103
	3.10:		.	:	–	103
	3.12:					103
	:	–				103
	3.13, 3.14:	μ		– 2008.	:	104
	3.15:	μ				104
	: www.local-history.gr					104
	3.16:					105
	: www.athensmagazine.gr					105
	3.17:					106
	: www.athensmagazine.gr					106
	3.18:					106
	: www.eurokinissi.gr					106
	4.1:	μμ	.	:		107
μ	4.2:	μμ	.	:		108
μ	4.3:	–	μ	.	: Google Earth	109
	4.4:	– μ	.	:		109
	4.6:	μ μ	RS 1365.			110
	: uk.rs-online.com					110
	: uk.rs-online.com					110
	4.5: Mobile Mapper6.			: www.gpscacity.ca		110
	4.7:		.IN (Area Input File).			–
Envi-met						112
	4.8:		.	:		113
	4.9:		.	:	– Envi-met	114
	4.10:		.	:	– Envi-met	114
	4.11:	μ μ		8:00, z=1.50μ.	:	–
Leonardo						116
	4.12:	μ μ		9:00, z=1.50μ.	:	–
Leonardo						116
	4.13:	μ μ		12:00, z=1.50μ.	:	–
- Leonardo						117
	4.14:	μ μ		15:00, z=1.50μ.	:	–
- Leonardo						117
	4.15:	μ μ		17:00, z=1.50μ.	:	–
- Leonardo						118
	4.16:	μ		8:00, z=1.50μ.	:	–
- Leonardo						118
	4.17:	μ		9:00, z=1.50μ.	:	–
- Leonardo						119

μ	μ	μ	μ	μ	μ	μ	μ
4.18:	μ				12:00,	$z=1.50\mu.$:
- Leonardo							119
4.19:	μ				15:00,	$z=1.50\mu.$:
- Leonardo							120
4.20:	μ				17:00,	$z=1.50\mu.$:
- Leonardo							120
4.5:			μ			μ	:
							129
4.6:			μ				:
							129
4.21:	μ	2	–	3	μ	8:00.	:
- Leonardo							133
4.22:	μ	2	–	3	μ	12:00.	:
- Leonardo							133
4.23:	μ	2	–	3	μ	15:00.	:
- Leonardo							134
4.24:	μ	2	–	3	μ	18:00.	:
- Leonardo							134
4.25:	μ	2	–	3	μ	20:00.	:
- Leonardo							135
4.26:		2	–	3	μ	8:00.	:
- Leonardo							135
4.27:		2	–	3	μ	12:00.	:
- Leonardo							136
4.28:		2	–	3	μ	15:00.	:
- Leonardo							136
4.29:		2	–	3	μ	18:00.	:
- Leonardo							137
4.30:		2	–	3	μ	20:00.	:
- Leonardo							137
4.31:	μ				–		138
: www.newsbomb.gr							138
4.32:	μ				–		: www.kappos.eu
							138
4.33:	μ		μ		15:00.		:
Biomet							140
4.34:	μ	4		μ			: – Envi-
met							141
4.35:	μ		, 3	– 4	μ	08:00.	:
- Leonardo							142
4.36:	μ		, 3	– 4	μ	12:00.	:
- Leonardo							142
4.37:	μ		, 3	– 4	μ	15:00.	:
- Leonardo							143
4.38:			, 3	– 4	μ	08:00.	:
- Leonardo							143
4.39:			, 3	– 4	μ	12:00.	:
- Leonardo							144
4.40:			, 3	– 4	μ	15:00.	:
- Leonardo							144

μ μ

4.41: μ μ 15:00 – : :
 - Biomet 145

1.1 : m² μ
 « OECD Factbook 2014: Economic, Environmental and Social Statistics » . : www.eco-
 news.gr 22

1.2: μ μ
 Worldwatch Institute. : www.worldwatch.org 32

1.3 : . [46] 39

1.4: μ PMV. [74] 44

1.5: μ Humidex. [74] 46

1.6: μ μ μ
 [INT-1] 59

8:00. 4.1: μ μ & , – Envi met,
 : 122

12:00. 4.2: μ μ & , – Envi met,
 : 124

15:00. 4.3: μ μ & , – Envi met,
 : 126

17:00. 4.4: μ μ & , – Envi met,
 : 128

μμ 4.1: μ , – Envi met, 8:00.
 : 122

μμ 4.2: μ μ , – Envi met, 8:00.
 : 122

μμ 4.3: μ , – Envi met, 12:00.
 : 124

μμ 4.4: μ μ , – Envi met, 12:00.
 : 124

μμ 4.5: μ , – Envi met, 15:00.
 : 126

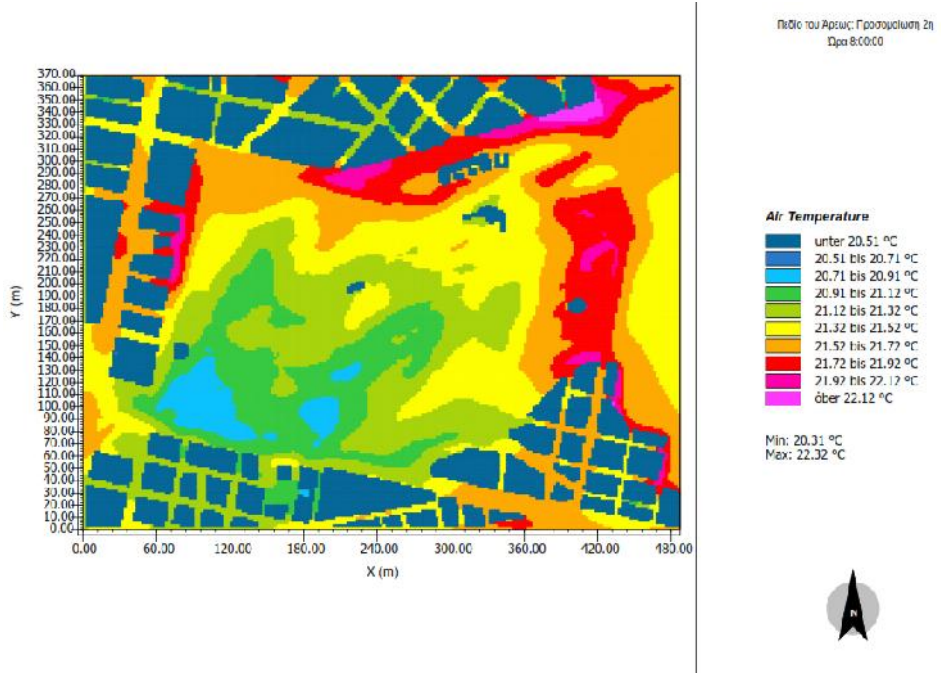
μμ 4.6: μ μ , – Envi met, 15:00.
 : 126

μμ 4.7: μ , – Envi met, 17:00.
 : 128

μμ 4.8: μ μ , – Envi met, 17:00.
 : 128

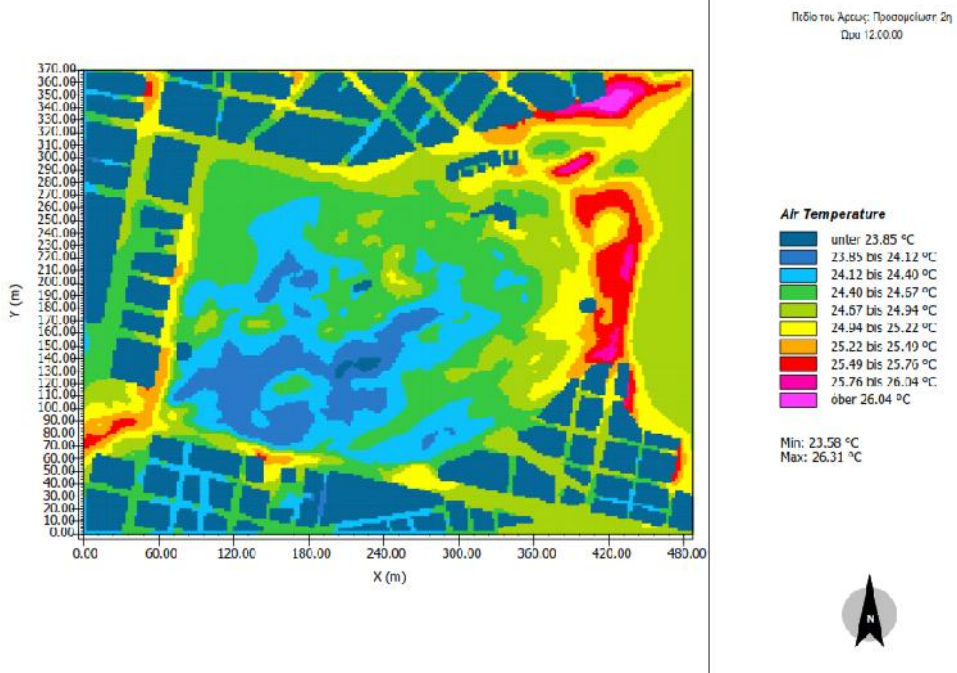
2

2



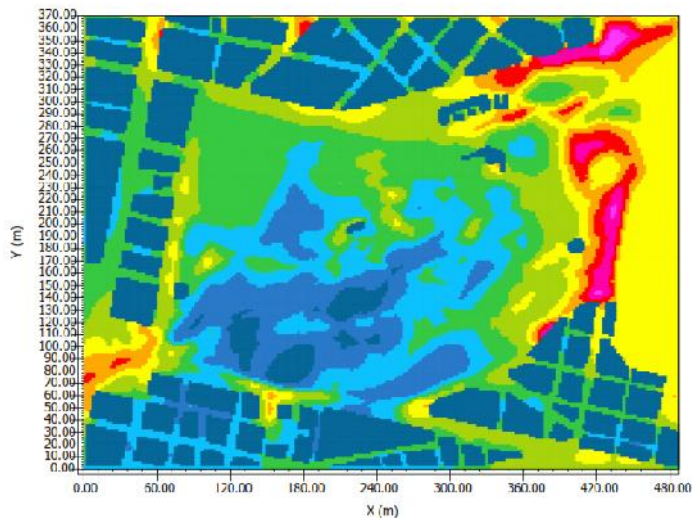
μ μ

8:00, z=1.50μ.



μ μ

12:00, z=1.50μ.



Πεδίο του Άρσεν; Προσπορευση 2η
Πρω 15:00:00

Air Temperature

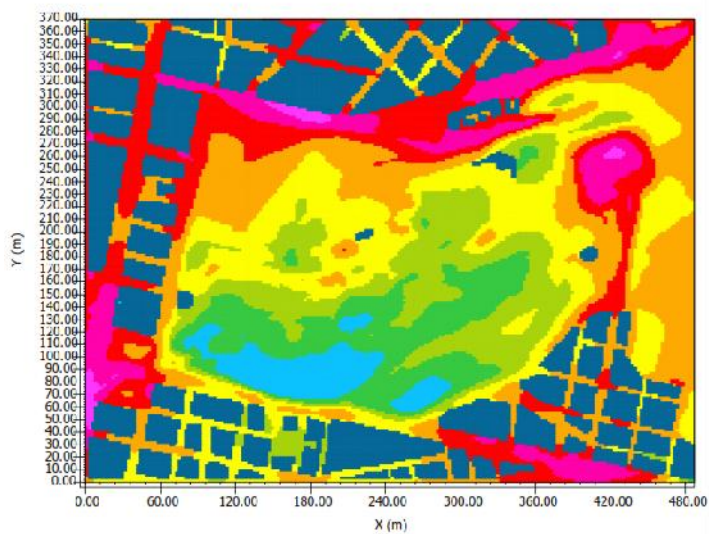
- unter 24.80 °C
- 24.80 bis 25.05 °C
- 25.05 bis 25.30 °C
- 25.30 bis 25.55 °C
- 25.55 bis 25.80 °C
- 25.80 bis 26.05 °C
- 26.05 bis 26.30 °C
- 26.30 bis 26.55 °C
- 26.55 bis 26.81 °C
- über 26.81 °C

Min: 24.54 °C
Max: 27.06 °C



μ μ

15:00, z=1.50μ.



Πεδίο του Άρσεν; Προσπορευση 2η
Πρω 18:00:00

Air Temperature

- unter 23.07 °C
- 23.07 bis 23.26 °C
- 23.26 bis 23.46 °C
- 23.46 bis 23.65 °C
- 23.65 bis 23.85 °C
- 23.85 bis 24.04 °C
- 24.04 bis 24.23 °C
- 24.23 bis 24.43 °C
- 24.43 bis 24.62 °C
- über 24.62 °C

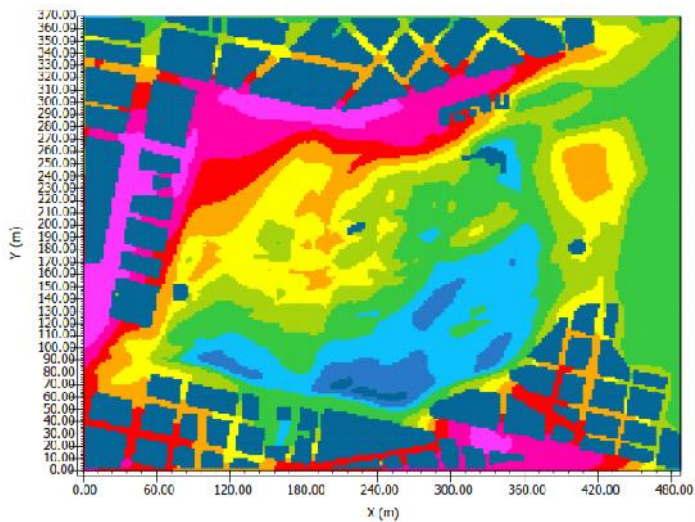
Min: 22.88 °C
Max: 24.82 °C



μ μ

18:00, z=1.50μ.

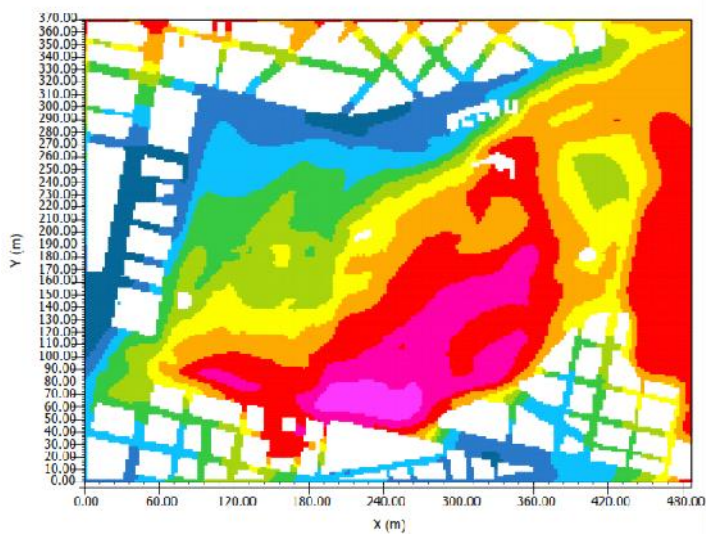
Πεδίο του Αέρα: Γροσσολιχτή 2η
Ώρα 20:30:00



μ μ

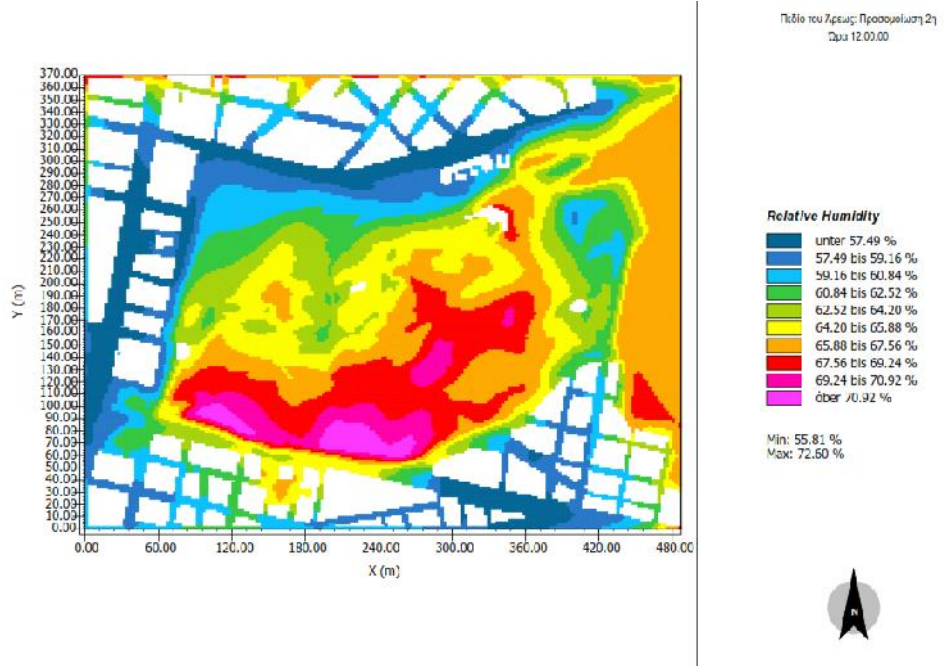
20:00, z=1.50μ.

Πεδίο του Αέρα: Γροσσολιχτή 2η
Ώρα 8:00:00



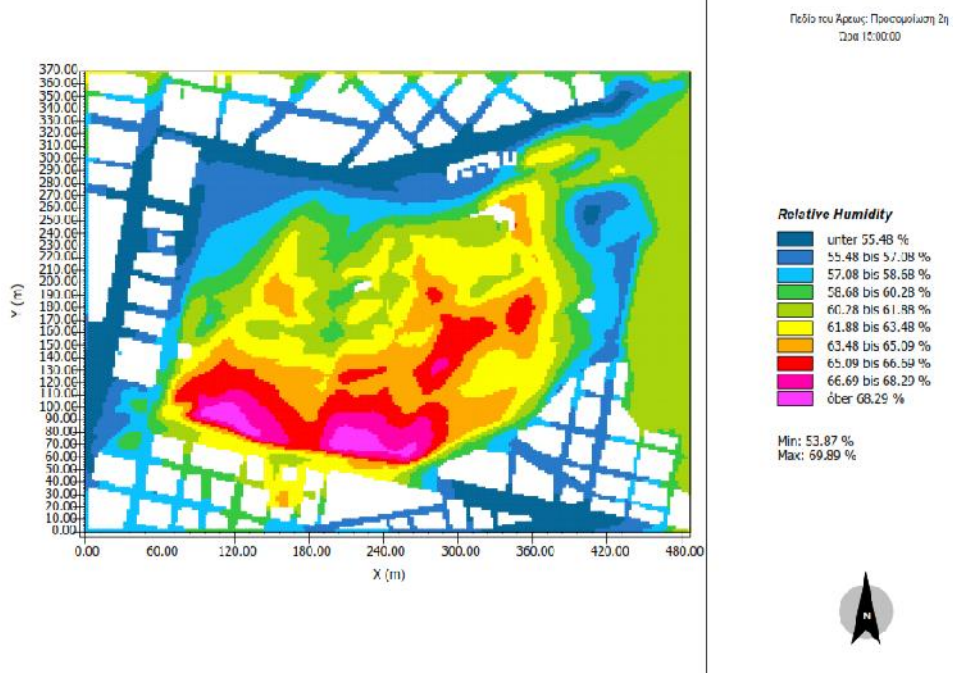
μ

8:00, z=1.50μ.



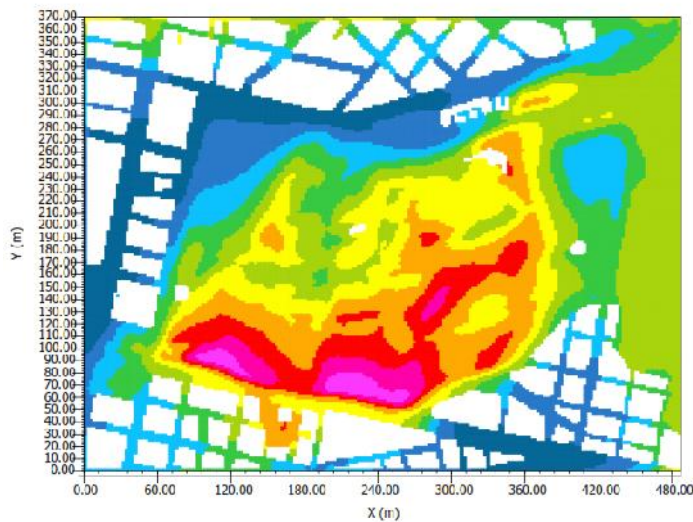
μ

12:00, z=1.50μ.



μ

15:00, z=1.50μ.



Πεδίο του Άρτους: Προσομίωση 2η
Ώρα 18.30.00

Relative Humidity

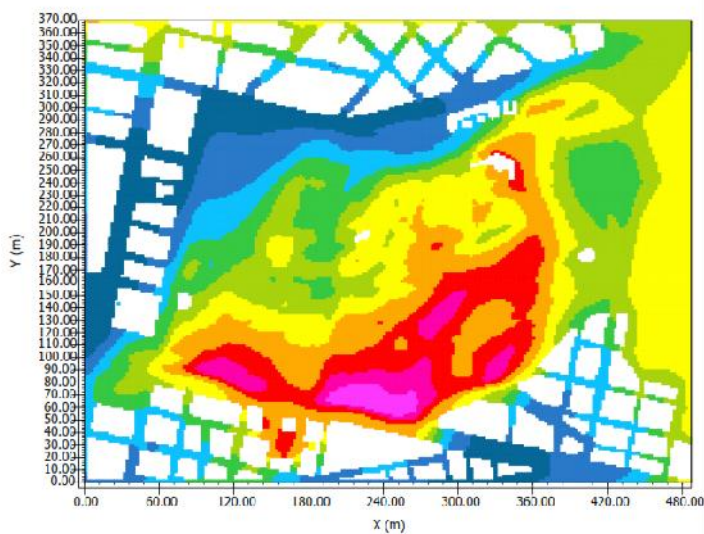
- unter 57,16 %
- 57,16 bis 58,74 %
- 58,74 bis 60,32 %
- 60,32 bis 61,89 %
- 61,89 bis 63,47 %
- 63,47 bis 65,05 %
- 65,05 bis 66,63 %
- 66,63 bis 68,21 %
- 68,21 bis 69,78 %
- über 69,78 %

Min: 55,58 %
Max: 71,35 %



μ

18:00, z=1.50μ.



Πεδίο του Άρτους: Προσομίωση 2η
Ώρα 20.00.00

Relative Humidity

- unter 61,58 %
- 61,58 bis 63,09 %
- 63,09 bis 65,19 %
- 65,19 bis 67,00 %
- 67,00 bis 68,80 %
- 68,80 bis 70,61 %
- 70,61 bis 72,41 %
- 72,41 bis 74,21 %
- 74,21 bis 76,02 %
- über 76,02 %

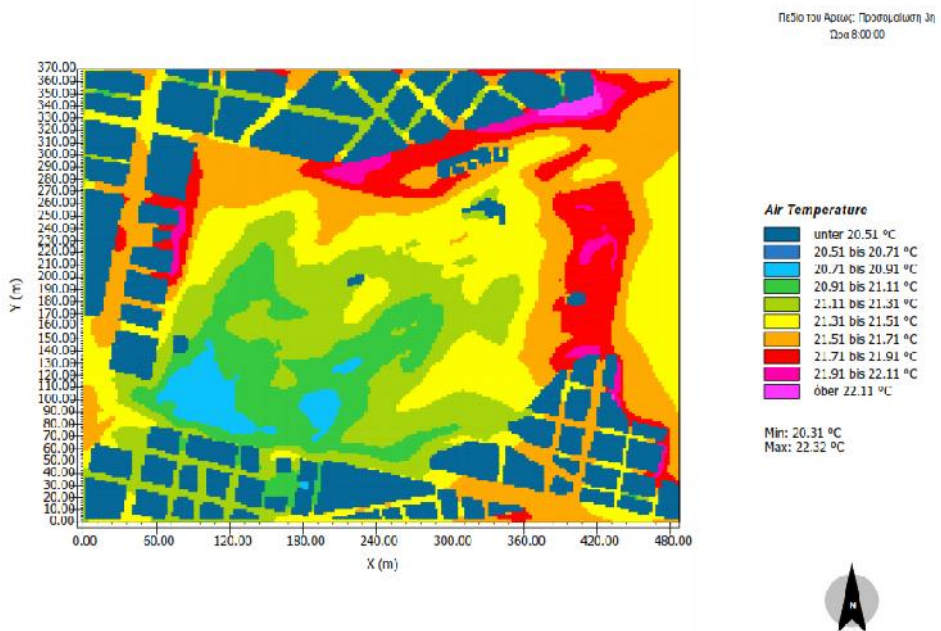
Min: 59,78 %
Max: 77,82 %



μ

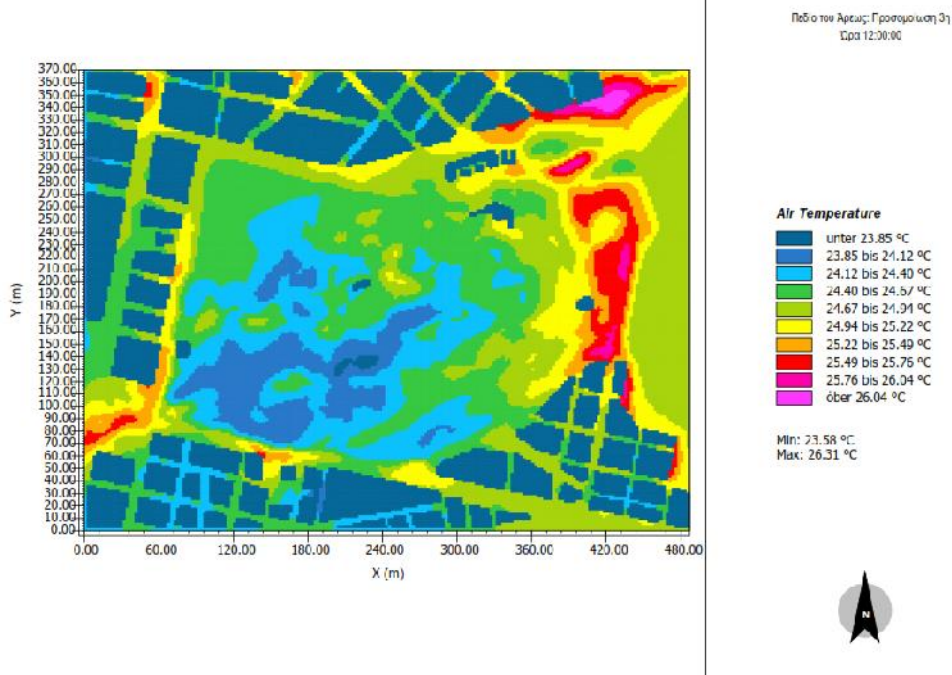
20:00, z=1.50μ.

3



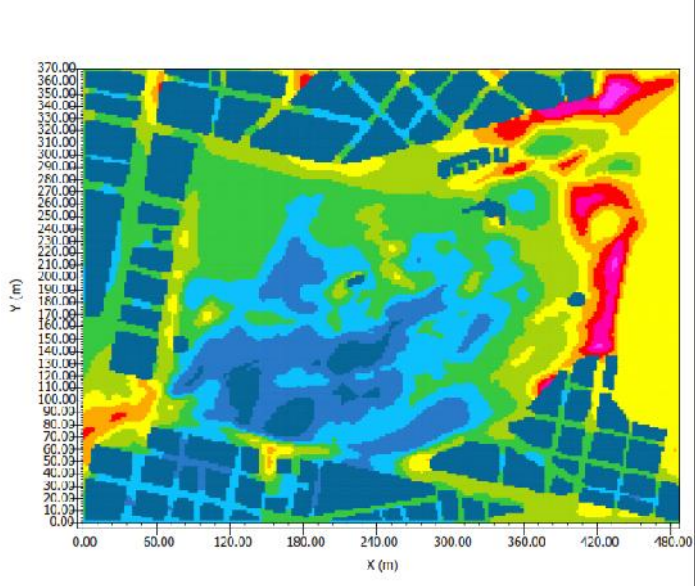
μ μ

8:00, z=1.50μ.



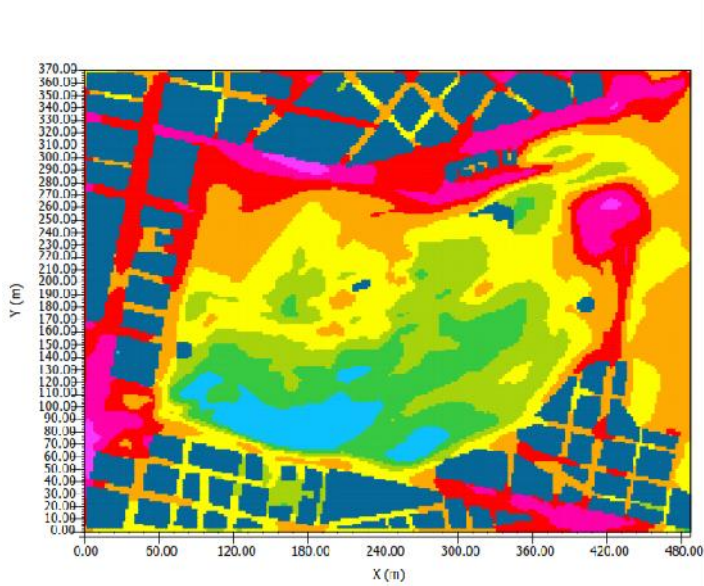
μ μ

12:00, z=1.50μ.



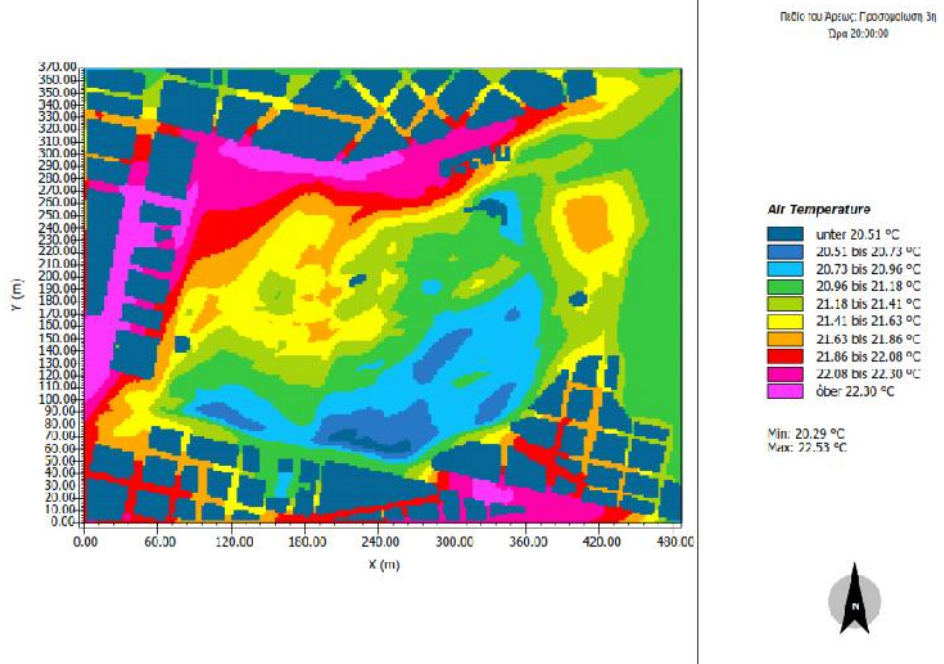
μ μ

15:00, z=1.50μ.



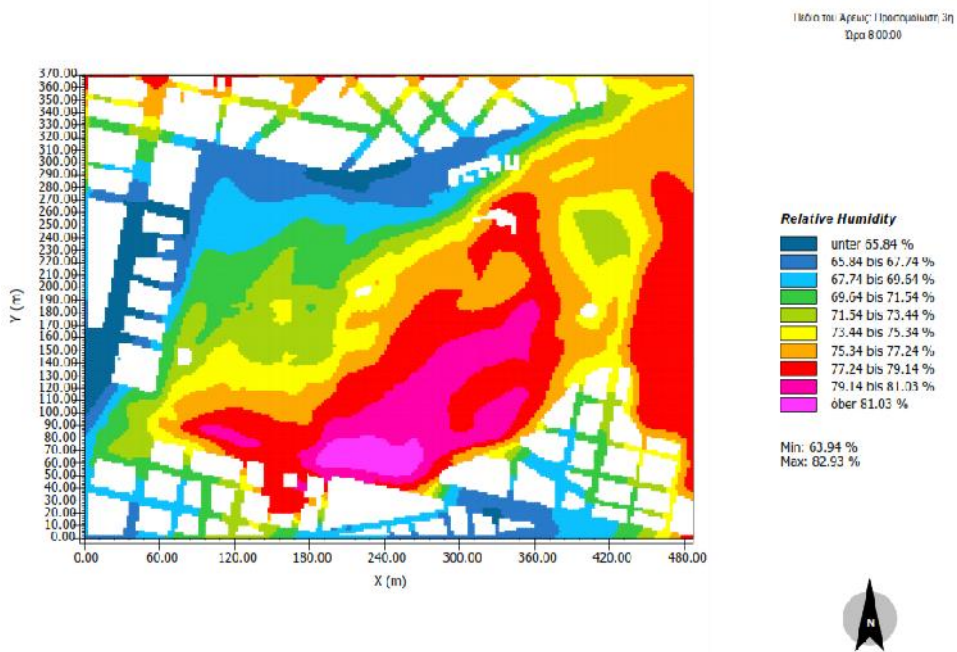
μ μ

18:00, z=1.50μ.



μ μ

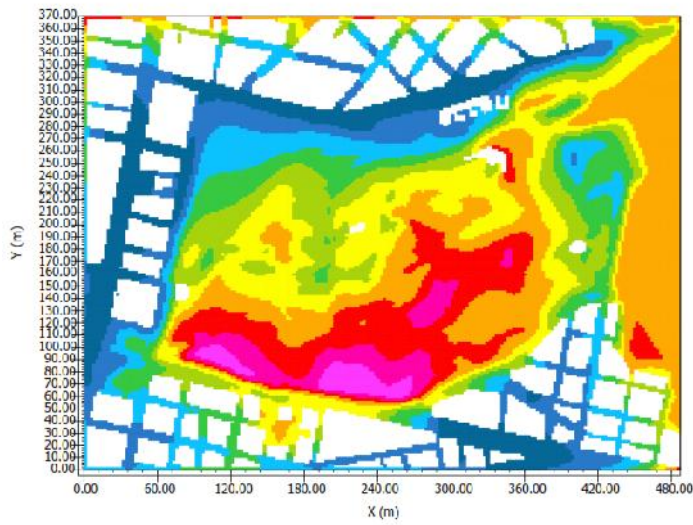
20:00, z=1.50μ.



μ

8:00, z=1.50μ.

Πεδίο του Αρσενίου: Προσομοίωση 3η
Ωρα 12.00.00



Relative Humidity

- unter 57.36 %
- 57.36 bis 59.05 %
- 59.05 bis 60.74 %
- 60.74 bis 62.43 %
- 62.43 bis 64.12 %
- 64.12 bis 65.80 %
- 65.80 bis 67.49 %
- 67.49 bis 69.18 %
- 69.18 bis 70.87 %
- über 70.87 %

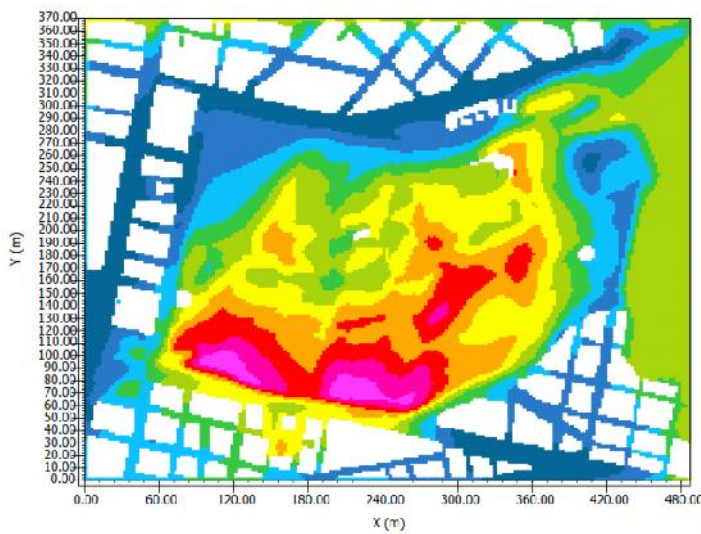
Min: 55.57 %
Max: 72.56 %



μ

12:00, z=1.50μ.

Πεδίο του Αρσενίου: Προσομοίωση 3η
Ωρα 15:00.00



Relative Humidity

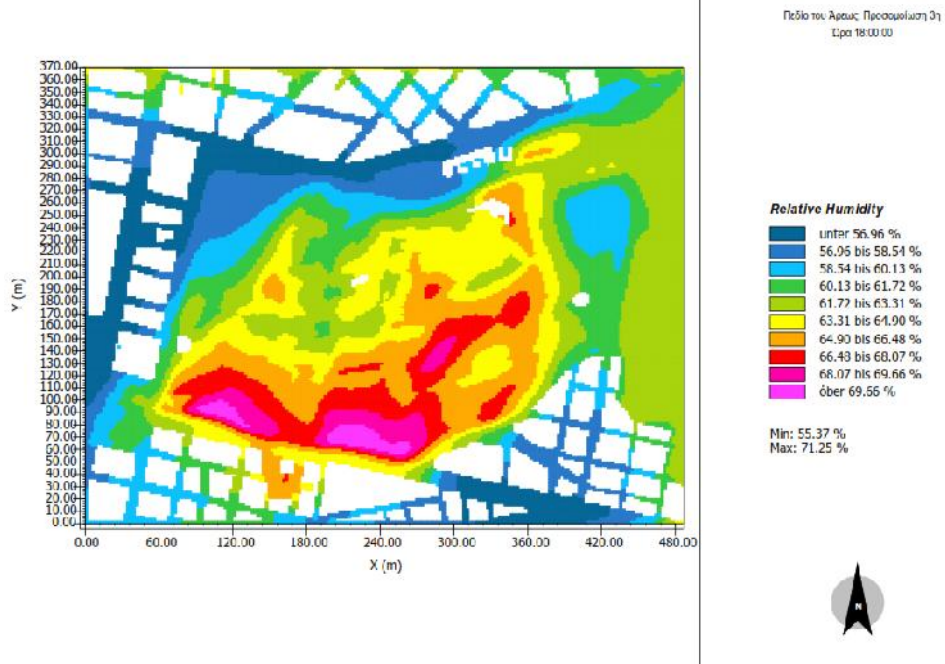
- unter 55.32 %
- 55.32 bis 56.93 %
- 56.93 bis 58.54 %
- 58.54 bis 60.15 %
- 60.15 bis 61.76 %
- 61.76 bis 63.37 %
- 63.37 bis 64.98 %
- 64.98 bis 66.59 %
- 66.59 bis 68.20 %
- über 68.20 %

Min: 53.71 %
Max: 69.81 %



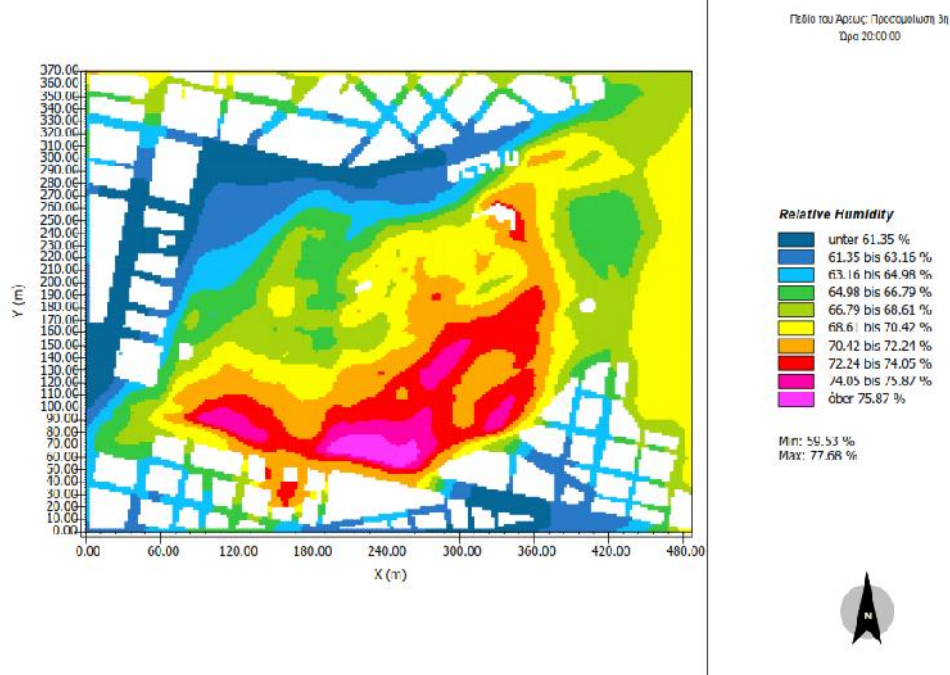
μ

15:00, z=1.50μ.



μ

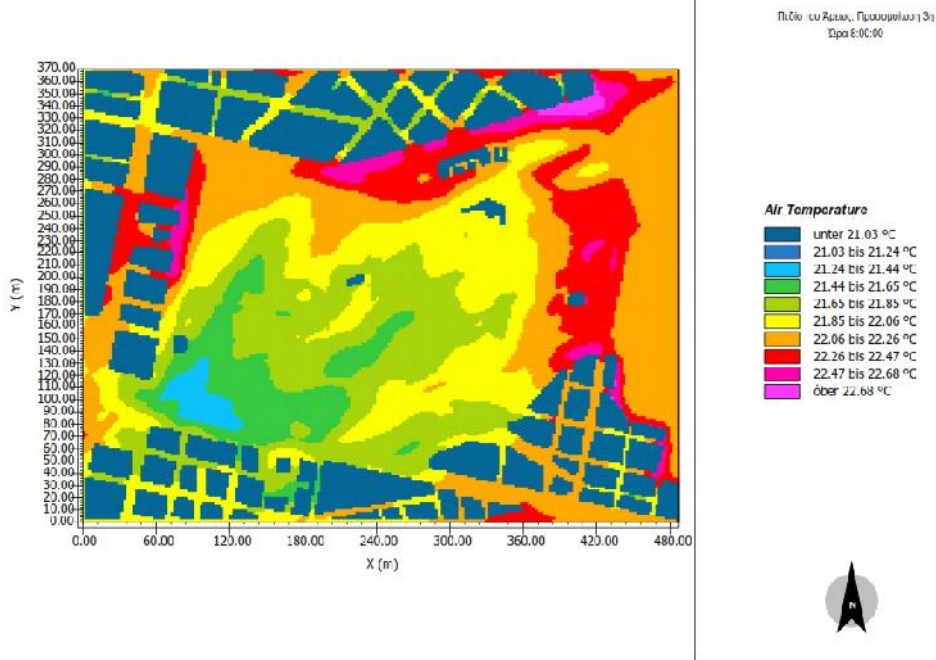
18:00, z=1.50μ.



μ

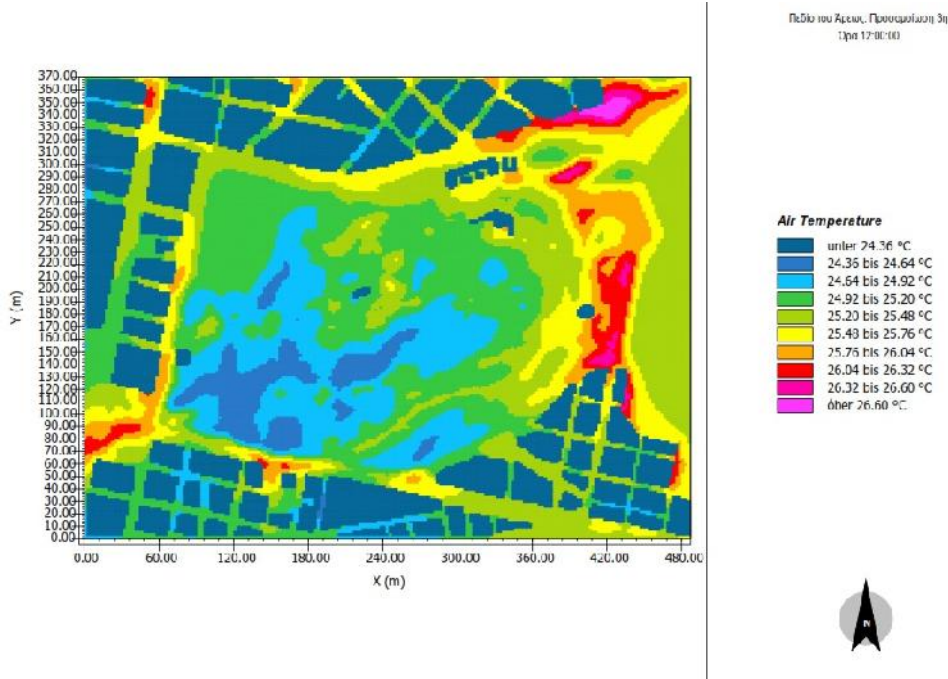
20:00, z=1.50μ.

4



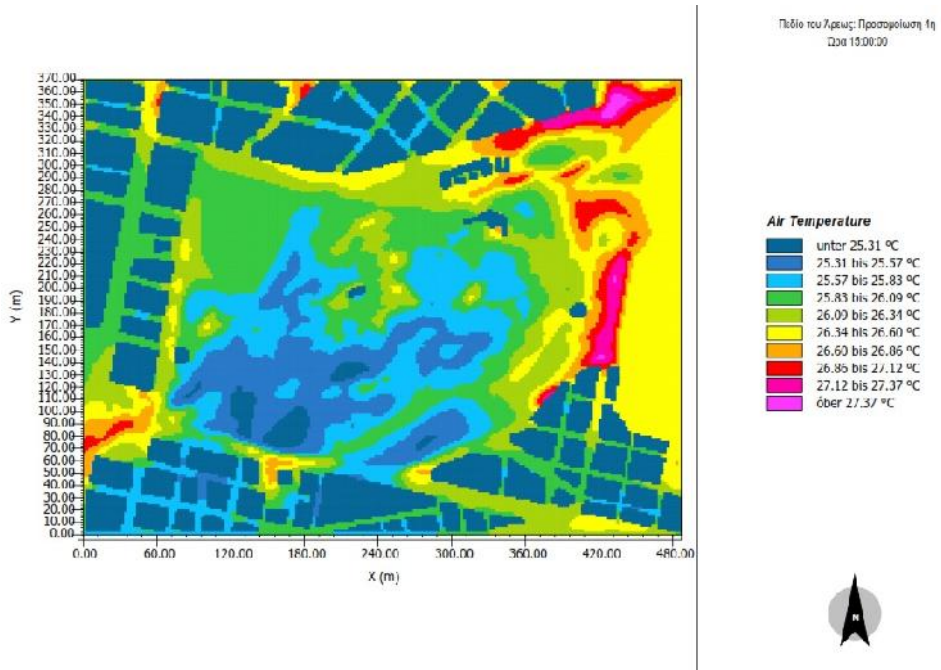
μ μ

8:00, z=1.50μ.



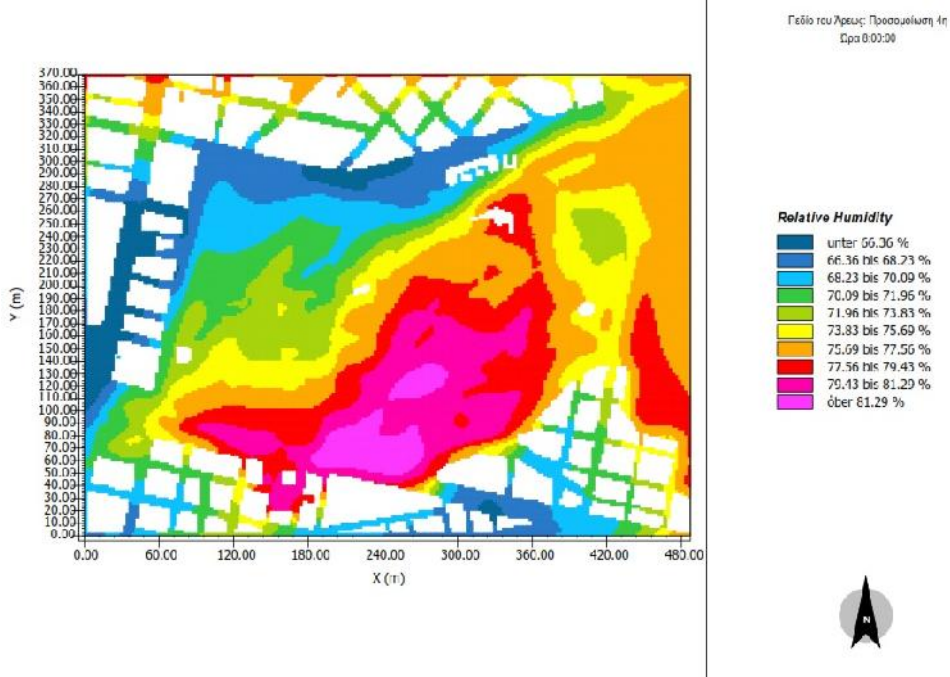
μ μ

12:00, z=1.50μ.



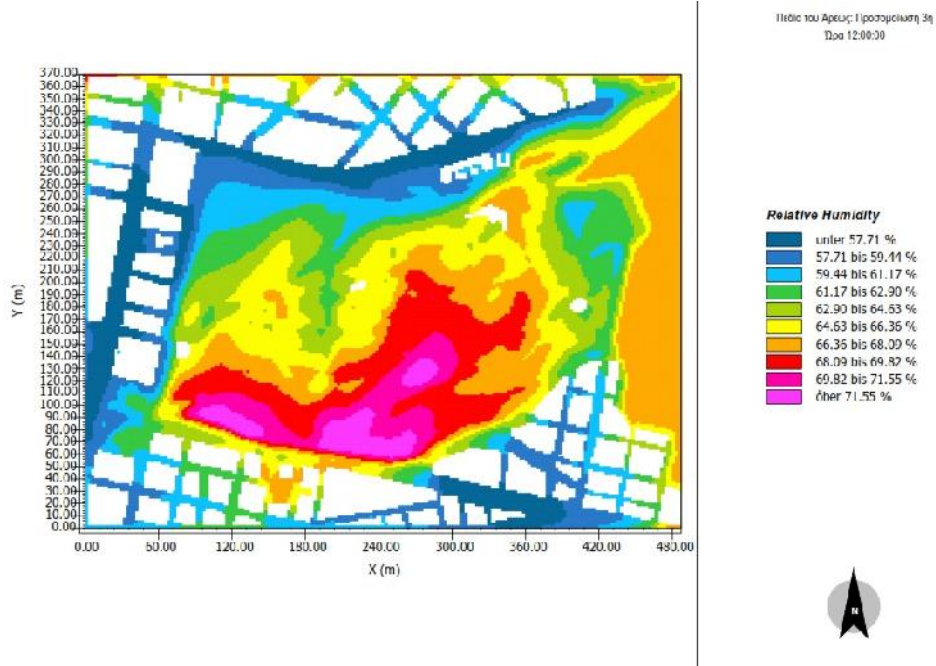
μ μ

15:00, z=1.50μ.



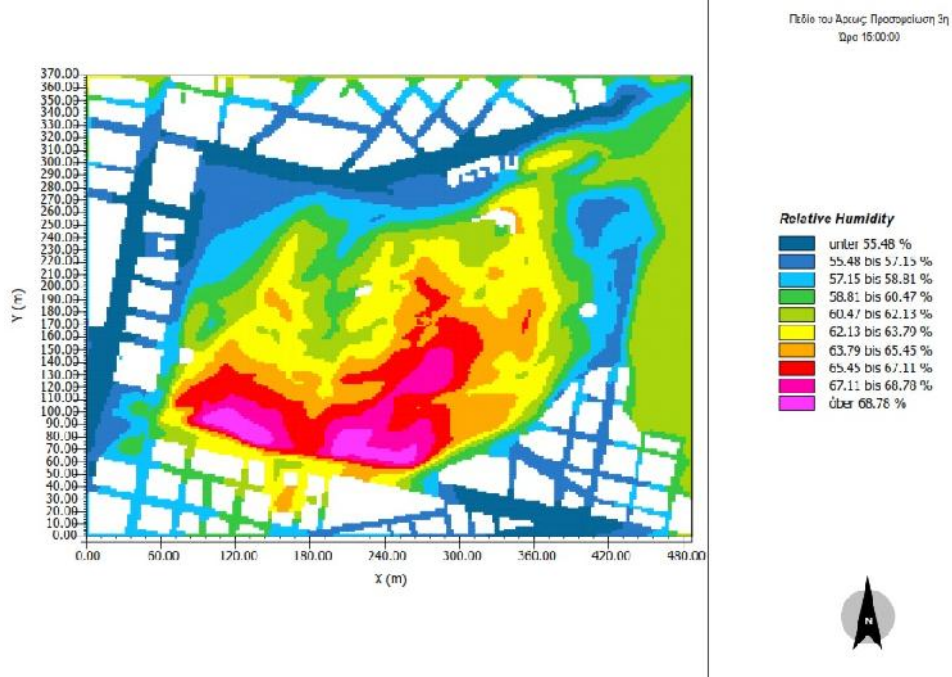
μ

8:00, z=1.50μ.



μ

12:00, z=1.50μ.



μ

15:00, z=1.50μ.

3

μ (hPa)	1004.5	1003.0	1002.5	1000.5	1001.0	1000.4
μ (°C)	9.3	9.8	11.7	15.5	20.2	24.6
μ μ (°C)	12.9	13.6	16.0	20.3	25.3	29.8
μ μ (°C)	6.5	6.9	8.4	11.6	15.4	20.1
(°C) μ μ	22.6	25.3	26.9	29.9	35.5	41.7
(°C) μ	-4.5	-4.0	-2.0	4.3	7.7	11.8
(%)	72	71	68	612	58	52
(mm)	45	48	43	28	17	10
μ μ μ μ 1 mm	5	6	6	4	2	1
μ (m/s)	2.1	2.1	2.0	1.8	1.6	1.8

					μ.		
μ (hPa)	999.7	1000.0	1002.9	1005.2	1005.2	1004.2	1002.4
μ μ (°C)	27.0	26.6	23.3	18.3	14.4	11.1	17.7
μ μ (°C)	32.6	32.3	28.9	23.1	18.6	14.7	22.3
μ μ (°C)	22.5	22.3	19.2	14.9	11.4	8.3	14.0
(°C) μ μ	42.8	40.7	38.6	33.5	27.3	22.1	
(°C) μ	16.0	16.1	11.8	5.9	0.9	-2.7	
(%)	48	49	56	66	73	73	62
(mm)	4	5	12	48	51	67	378
μ μ μ μ 1 mm	1	1	1	4	5	7	43
μ (m/s)	2.1	2.2	1.9	2.0	1.8	2.0	2.0

: