Council of Europe

Under the aegis of the General Secretariat for Civil Protection, Greece

October 2007, Vol 5

www.civilprotection.gr

Forest Fire Net

Forest Fire Net is published by European Center for Forest Fires (ECFF) Athens 2007

Forest Fire Net is a publication of the **European Center for Forest Fires.**

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Prologue

Data first. This volume of Forest Fire Net (FFNet) hosts a data file of forest fires in Greece during summer 2007; devastating fires with high death toll and environmental, health, social and economic impacts.

A case study data file. Quality, accuracy and broad types of data are the cornerstones for prevention, for developing guidelines, as well as for improving tactics and enhancing strategies. In this data file, an effort is made to answer the question: "what type of data need to be recorded in big forest fire events". Geographical, vegetation, meteorological data, as well as data on health, environmental and infrastructure impacts, together with the resources and means used for suppressing the fire are presented. Definitely, more details on each type of data need to be included, e.g. the terrain of burned areas, on-site environmental measurements, as well as long-term health impacts assessment.

This data file is actually the work of a number of specialists, experts and service people, engaged in the real events; their contribution is highly appreciated.

Milt Statheropoulos
ECFF director

Section 1

"Forest fires in Greece during summer 2007: The data file of a case study"

by P. Balatsos, Hellenic Ministry of Agriculture, M. Chalaris, Hellenic Fire Brigade, S. Karma, National Technical University of Athens, A. Pappa, National Technical University of Athens, C. Spiliopoulou, National and Kapodistrian University of Athens, M. Statheropoulos, European Center for Forest Fires, P. Theodorou, General Secretariat for Civil Protection, GR

1.1 Introduction

Summer 2007 was one of the worst for South Europe in regard to forest fires. In Fig. 1, the hectares burned per year in five Mediterranean countries for the last five years are presented; for year 2007, the area burned is referred up to the 31st of August *(Source: European Forest Fire Information System - EFFIS)*.

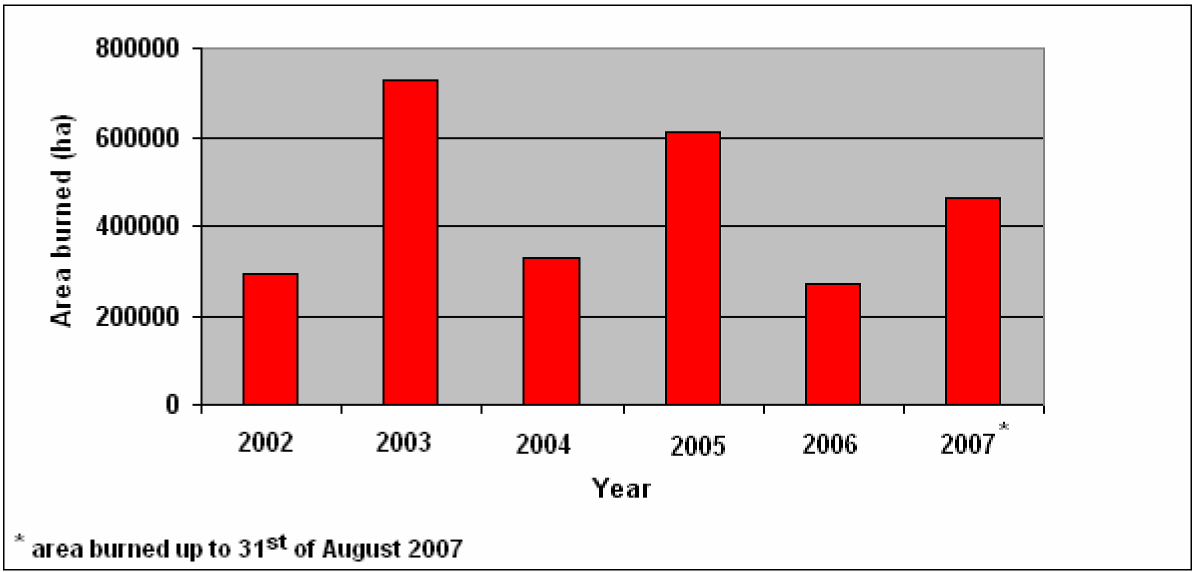

***Fig. 1. Forest fires in five Mediterranean countries (Portugal, Spain, France, Italy, Greece): Total area burned per year** (Source: EFFIS).*

Especially for Greece, the total area burned until the 31st of August 2007 was 269.114 ha; 11.2% of it was on NATURA 2000 sites *(Source: EFFIS)*. Some of the largest forest fires in Greece occurred in Peloponnese, between the 24th and 31st of August 2007. In this critical period a number of 137 forest fires initiated in Peloponnese, according to the Hellenic Fire Service.

The present data file focuses on the forest fires that took place in Peloponnese (Greece) and for the time frame in between the 24th and 31st of August. This allows better collecting and presenting all necessary data and also serves in better presenting a case study. It should be noted that the areas burned in Peloponnese consist almost 65% of the total areas burned in Greece until the end of August 2007 *(Sources: Hellenic Ministry of Agriculture; EFFIS)*.

In Fig. 2, the fire weather indicator (FWI) values in Greece that are referred to the time period May-August are presented, for the years 2002 until 2007.

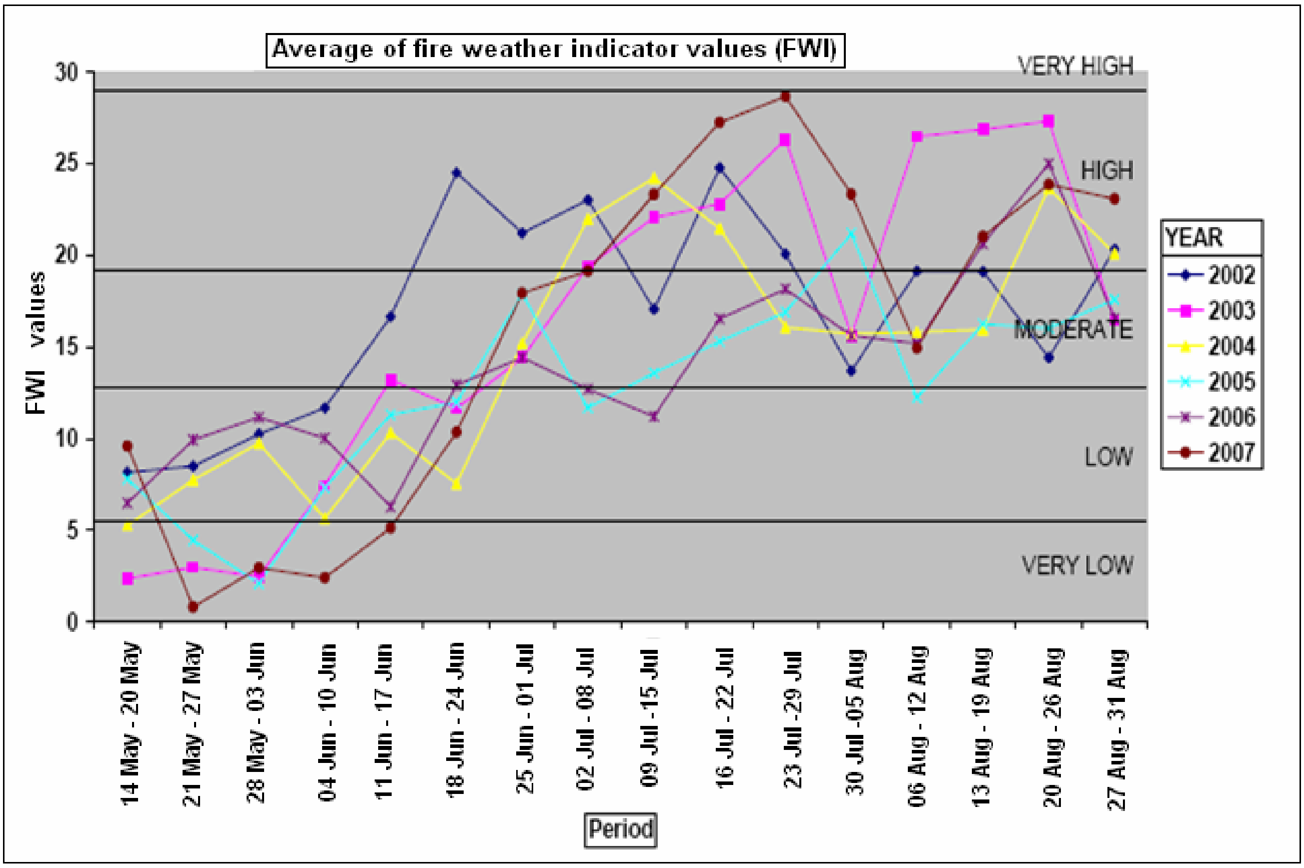

***Fig. 2. Fire weather indicator values (FWI) in Greece for the time period May-August, since 2002** (Source: EFFIS).*

In Figs. 3 and 4, the fire danger map of Greece on the 23th and 24th of August, which are the days that the big forest fires in Peloponnese began, are presented *(Source: Ministry of the Interior Public Administration and Decentralization, General Secretariat for Civil Protection, Greece –GSCP, GR)*.

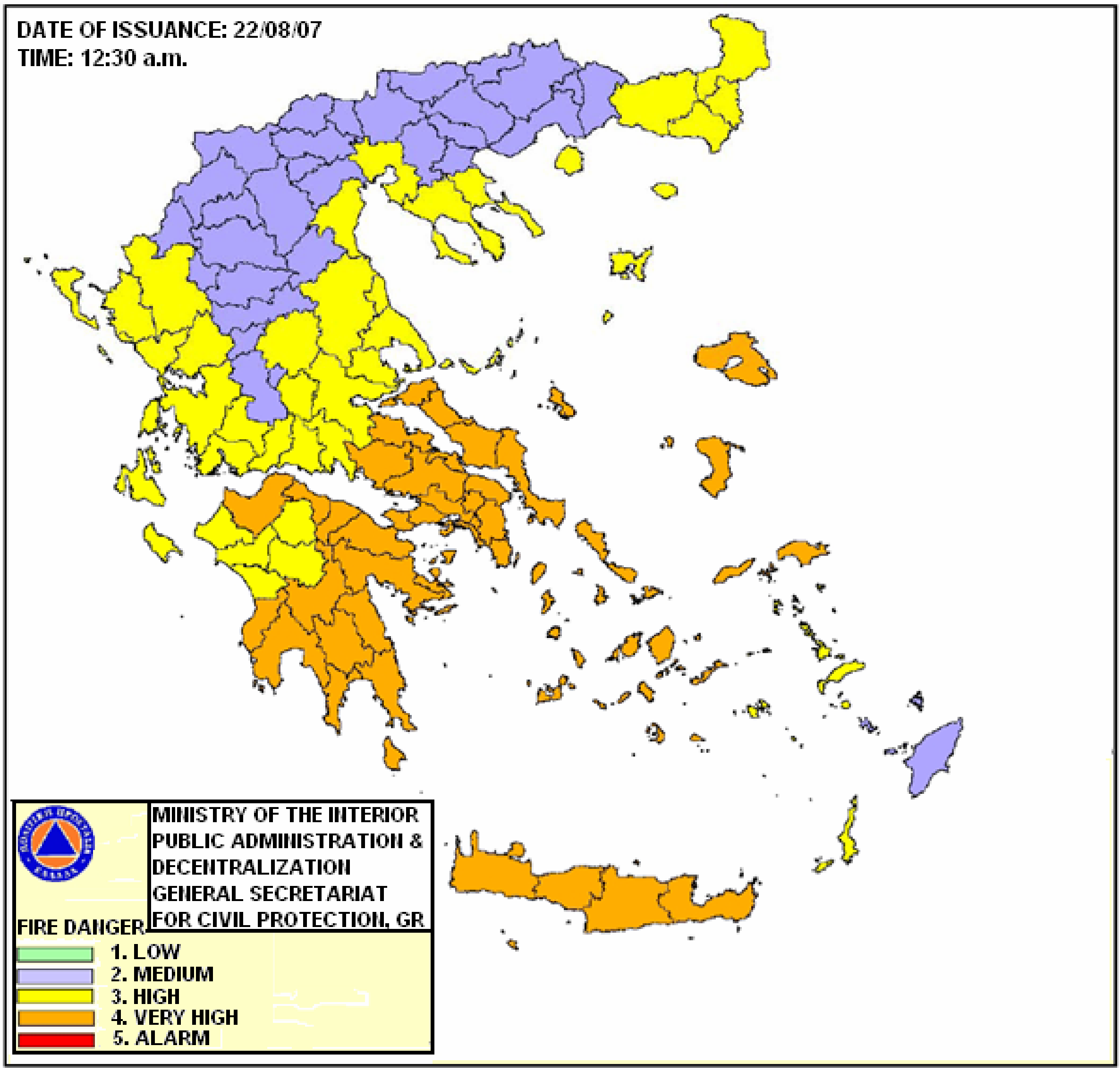

Fig. 3. Fire danger map of Greece on the 23th of August 2007** **(Source: GSCP, GR).

As it is shown in Fig. 4, the fire danger in Peloponnese area, which is marked with a slashed line, was at number 4 meaning that it was very high. According to the same source, the fire danger in all prefectures of Peloponnese on the 25th and 26th of August remained also at number 4.

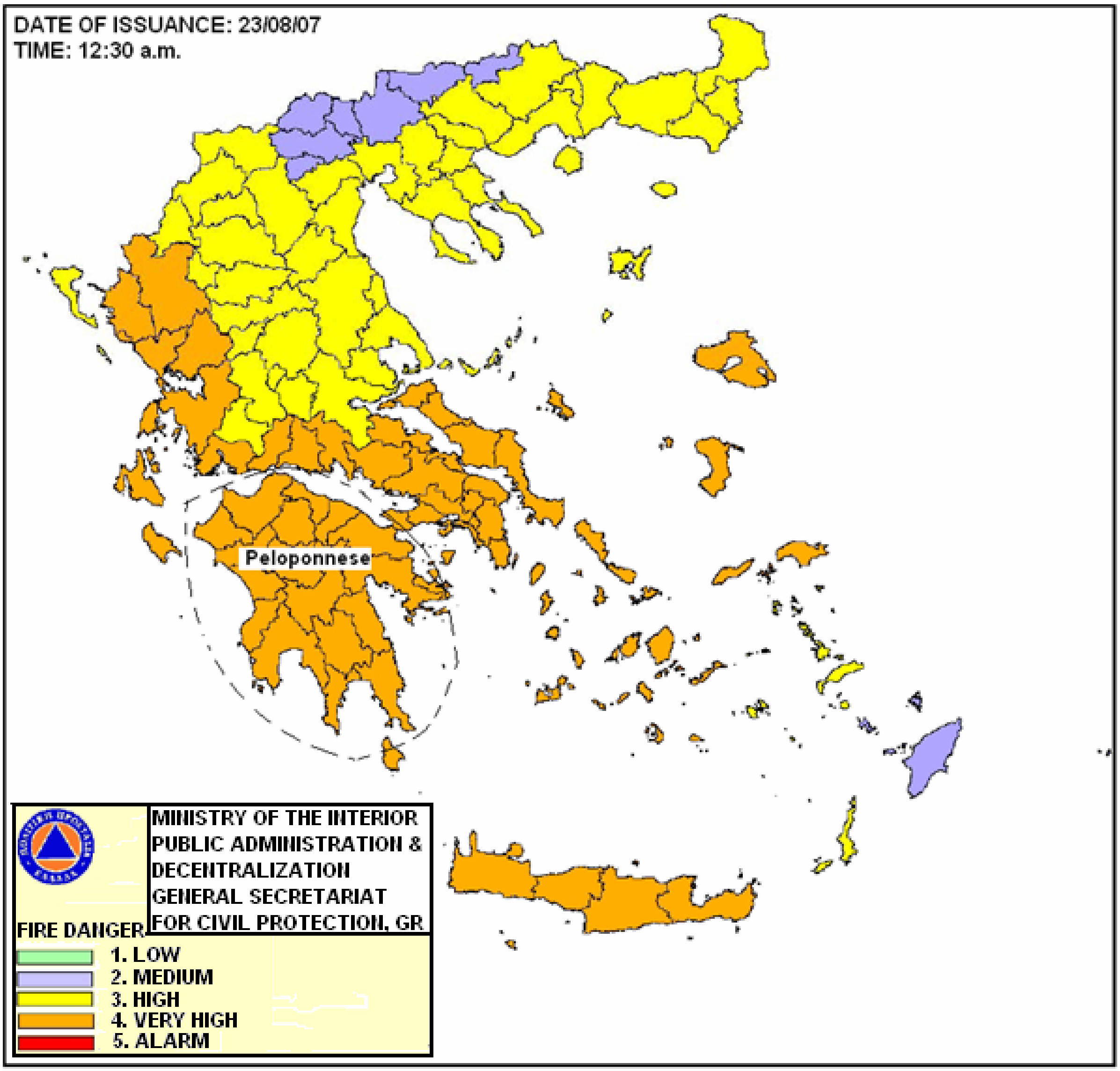

Fig. 4. Fire danger map of Greece on the 24th of August 2007, where the Peloponnese area is marked with a slashed line (Source: GSCP, GR).

In order to record the big forest fires in Peloponnese during August 2007, geographical, vegetation and meteorological data, as well as data on health, infrastructure and environmental impacts were collected and presented, together with fire suppressing resources and means.

1.2 Geographical data

Generally, the Peloponnese (Fig. 5) covers an estimated area of 21,549 km² (8,320 square miles). The geographical coordinates given by the World Geodetic System are 37° 20′ 59″ N, 22° 21′ 8″E.

Fig. 5. Satellite image of Peloponnese, Greece.

In Peloponnese, two high mountains are situated, which are included in NATURA 2000 network of the European Commission; Taygetus mountain range, with height reaching the 2,407 m that is extended to the prefectures of Arkadia, Laconia and Messinia and Parnonas mountain range with height that reaches the 1935 m and is extended to the prefectures of Arkadia and Laconia.

In Fig. 6, the total areas burned (ha) in Peloponnese (Greece) in summer 2007 are shown.

Fig.6. Areas burned (ha) per prefecture of Peloponnese in summer 2007

(Source: Hellenic Ministry of Agriculture)

NASA images of Peloponnese recorded on the 24th and 25th of August 2007 are presented in Fig. 7. The extension of the forest fires and the smoke haze produced are clearly shown.

Fig.7. NASA images of Peloponnese on the 24th and 25th of August 2007.

The European Space Agency (ESA) has also mapped the areas burned (*Source: GSCP, GR)*. The ESA's Earth Remote Sensing Satellite-2 (ERS-2) and the Envisat satellites, continuously survey fires burning across the Earth's surface with onboard sensors, such as the Along Track Scanning Radiometer (ATSR) and the Advanced Along Track Scanning Radiometer (AATSR), known as the ATSR Word Fire Atlas. An image of the area burned in Laconia prefecture is shown in Fig. 8.

Fig. 8. Image of the area burned during August 2007 in Laconia prefecture by the European Space Agency (Peloponnese, Greece) (purple color)

1.3 Vegetation Data

The land cover types that were burned in Greece for the time period until the 31st of August 2007, are presented in Table 1 *(Source: EFFIS).*

Table 1. Distribution of burned area (ha) in Greece by land cover types until the 31st of August 2007

Land cover	Area burned (ha)	% of total burned
Forest land	151.355	56,2
Agriculture	114.649	42,6
Artificial surfaces	3.110	1,2
Total	**269.114**	**100.0**

Focusing on Peloponnese, the relevant available data regarding the burned areas in summer 2007 are presented in Table 2. Almost 55% of the total area burned in Peloponnese is attributed to forest land *(Source: Hellenic Ministry of Agriculture).* Specifically for Arkadia, Ilia, Laconia and Messinia prefectures, the most of the areas were burned during the time frame 24-31 of August *(Source: Hellenic Ministry of Agriculture).* According to table 2, almost the 43% of the total area burned in Peloponnese is attributed to Ilia prefecture.

Table 2. Total area burned (ha) in Peloponnese fires during August 2007 per prefecture *

Prefecture of Peloponnese	Total area burned / prefecture (ha)
ARGOLIDA	993,0
ARKADIA	43.117,3
ACHAIA	14.306,0
ILIA	77.756,0
KORINTHIA	4.037,5
LACONIA	21.496,0
MESSINIA	18.604,5
TOTAL AREA BURNED	180.310,3

**Source: Hellenic Ministry of Agriculture*

1.4 Meteorological Data

The meteorological data presented in this work have been recorded during August 2007 by five different meteorological stations of Hellenic National Meteorological Service (HNMS) that are situated in Peloponnese. Names and locations of the stations are shown in Fig. 9.

Fig.9. Location of meteorological stations in Peloponnese (HNMS)

In Figs. 10 to 14, the daily minimum and maximum temperature recorded for the time period 1st to 31st of August 2007 by the five meteorological stations are presented.

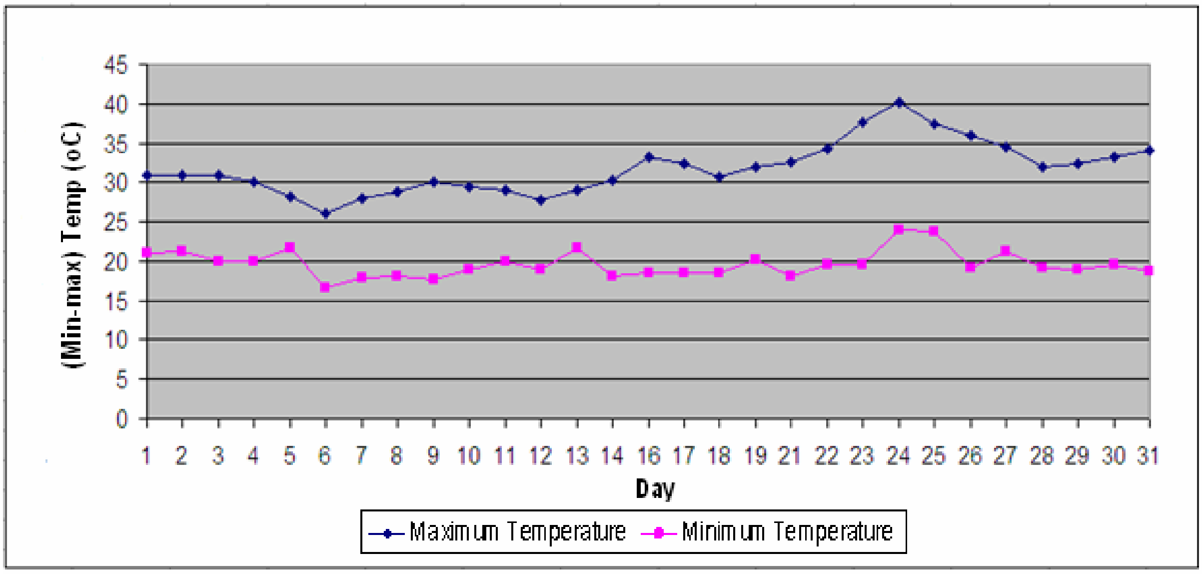

Fig. 10. Daily minimum and maximum temperature in August 2007 (Andrabida)

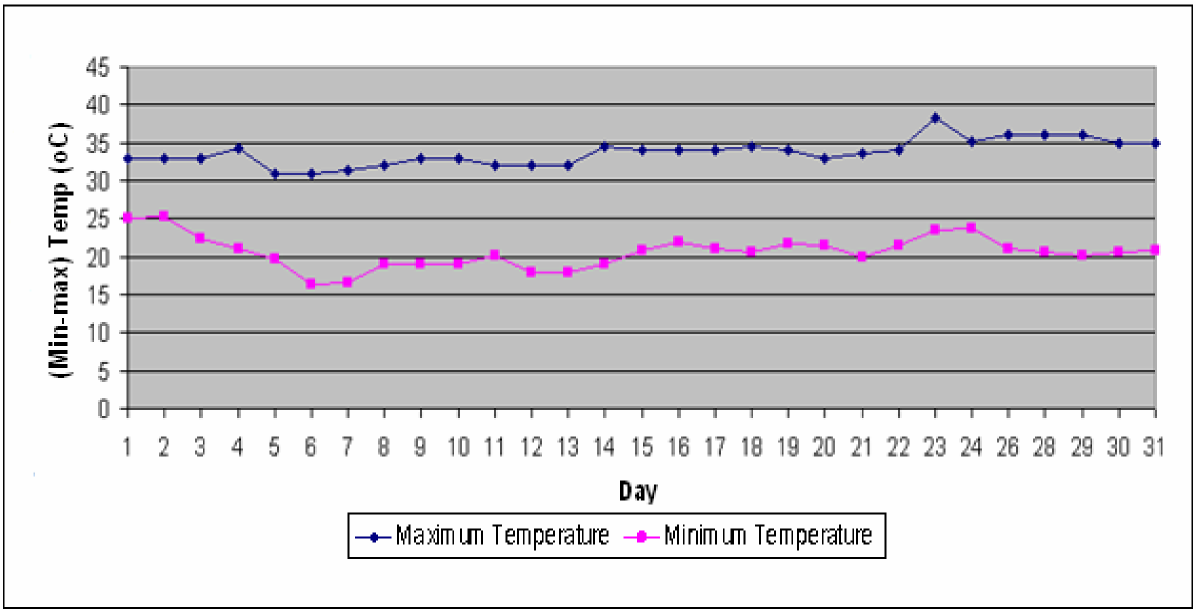

Fig. 11. Daily minimum and maximum temperature in August 2007 (Korinthos)

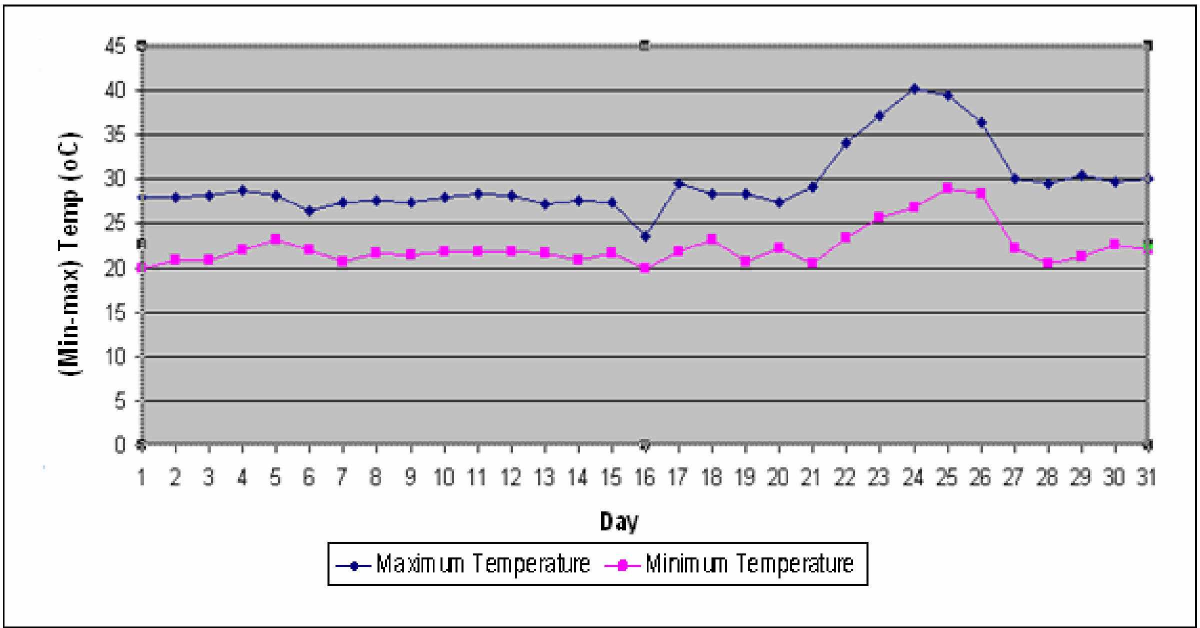

Fig. 12. Daily minimum and maximum temperature in August 2007 (Methoni)

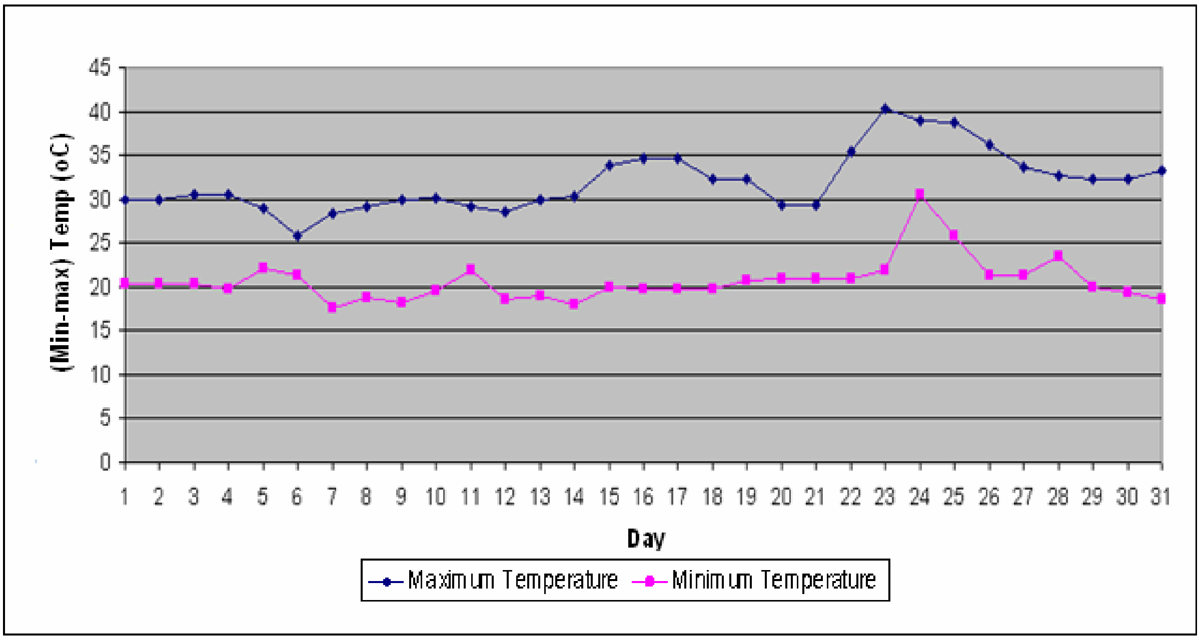

Fig. 13. Daily minimum and maximum temperature in August 2007 (Araxos)

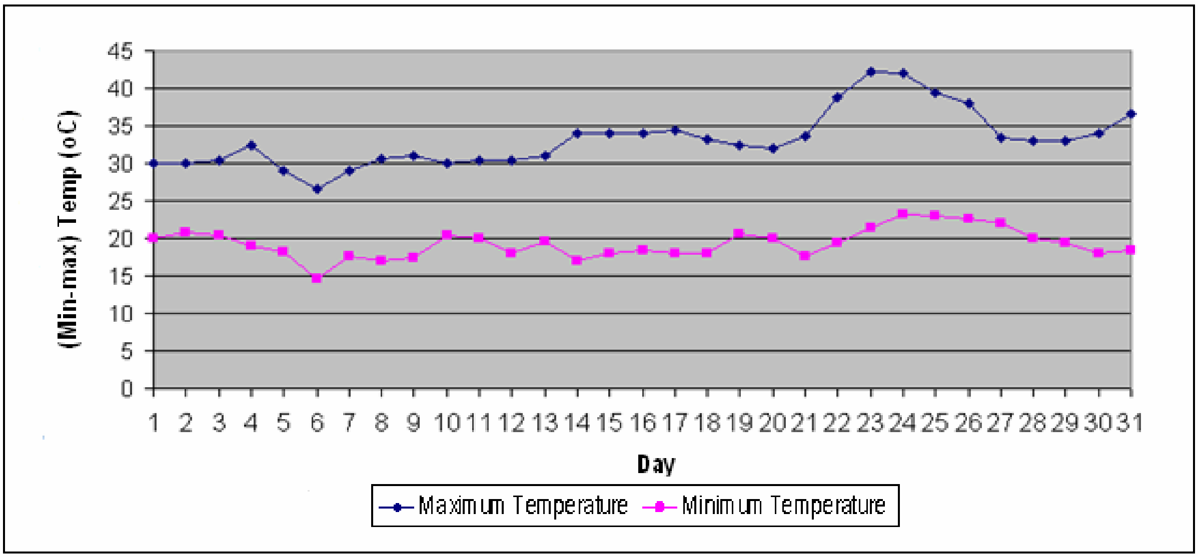

Fig. 14. Daily minimum and maximum temperature in August 2007 (Pyrgos)

In Figs. 15 to 19, the profiles of the average relative humidity (RH%) recorded by the five meteorological stations during August 2007 are shown.

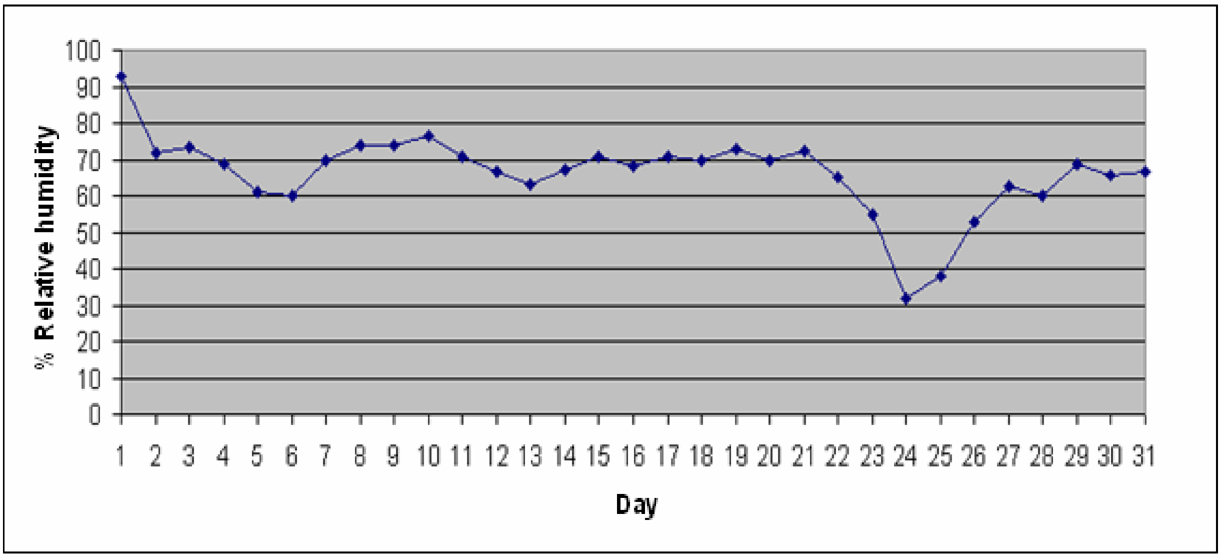

Fig. *15. Daily average of relative humidity in August 2007 (Andrabida)*

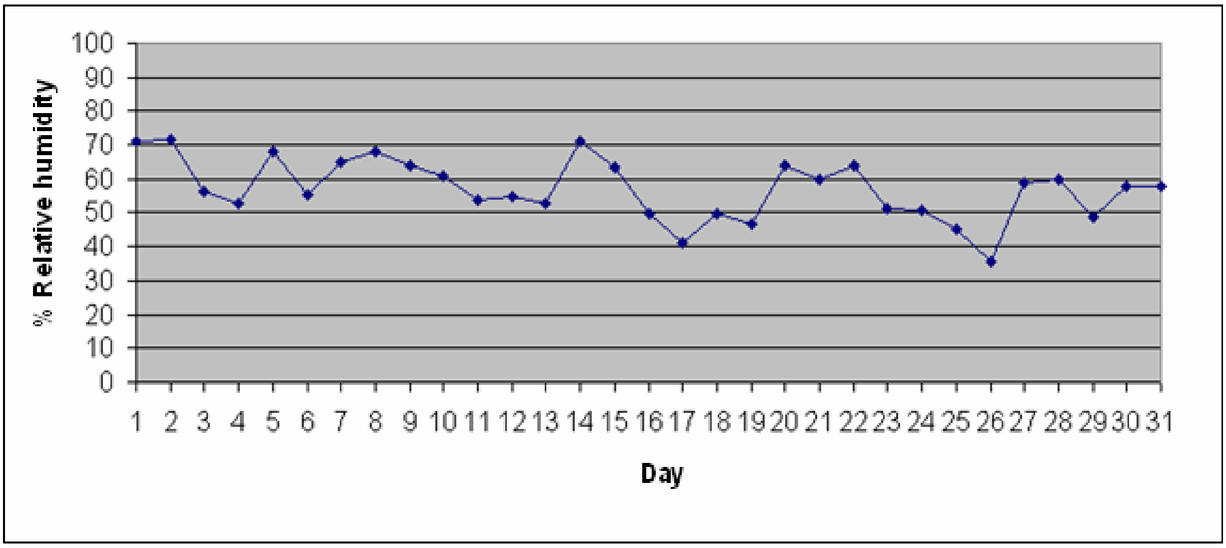

Fig. 16. Daily average of relative humidity in August 2007 (Korinthos)

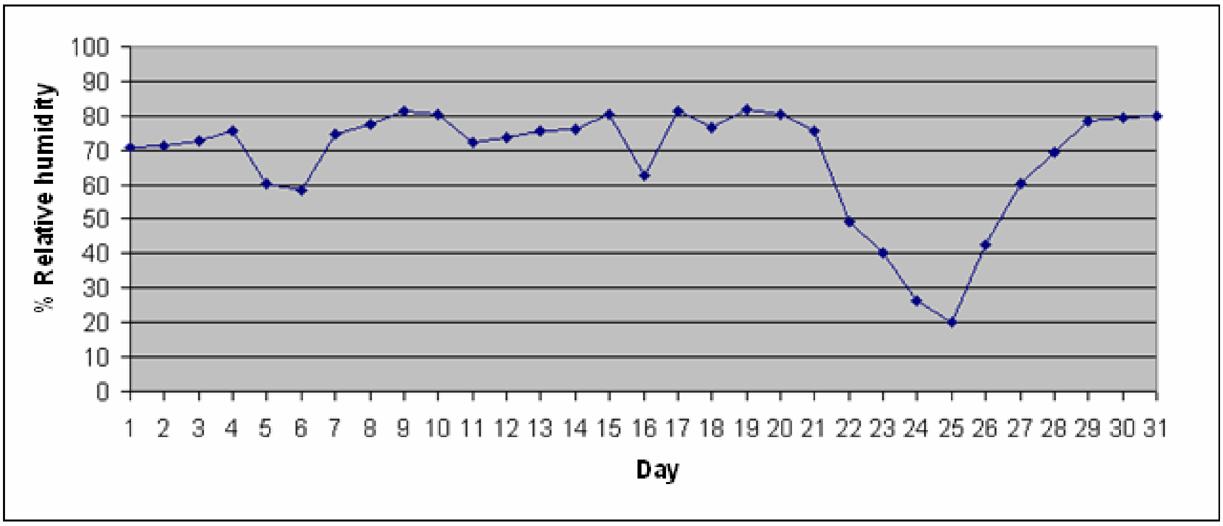

Fig. 17. Daily average of relative humidity in August 2007 (Methoni)

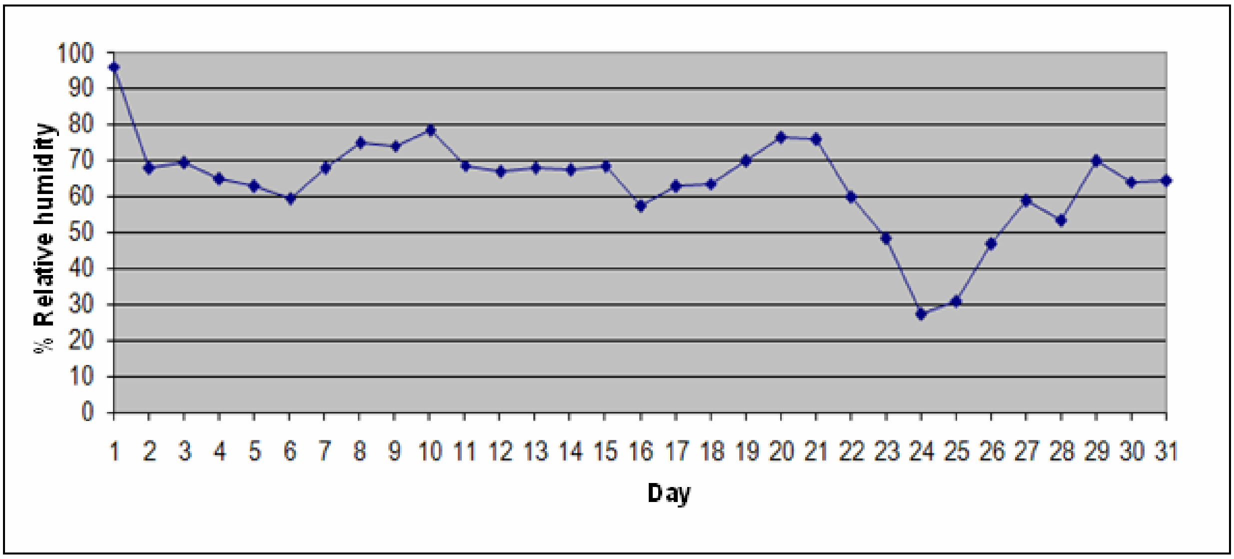

Fig. 18. Daily average of relative humidity in August 2007 (Araxos)

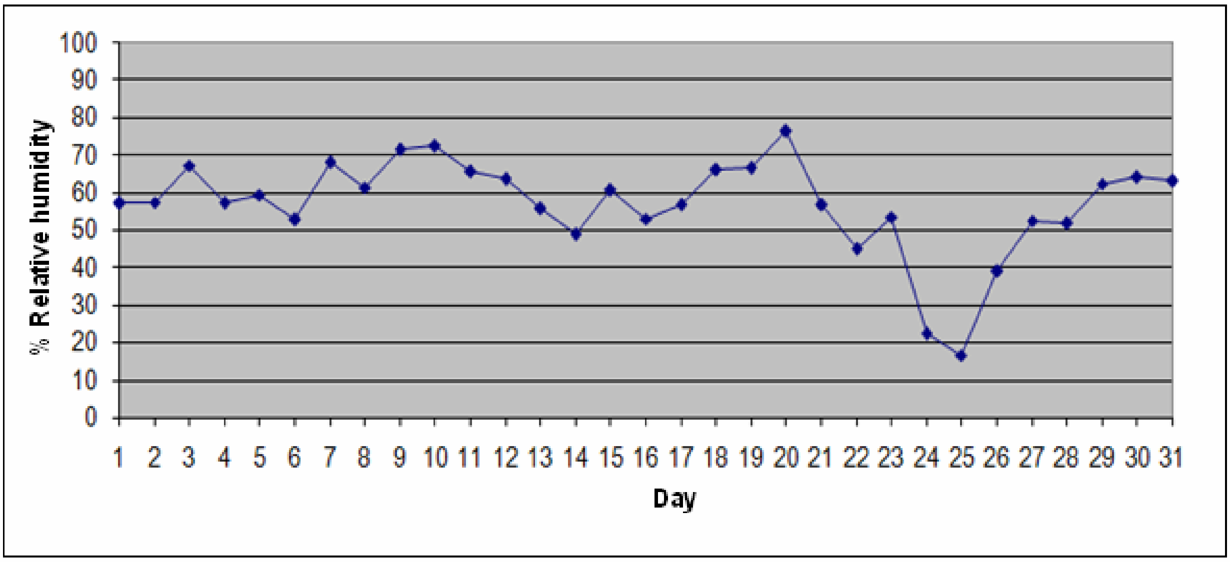

Fig. 19. Daily average of relative humidity in August 2007 (Pyrgos)

All stations recorded maximum temperatures and lowest relative humidity in the same time frame; 21st to 31st of August 2007.

In Figs. 20 to 24, the profiles of average and maximum wind speed recorded by the five meteorological stations in Peloponnese during August 2007 are presented.

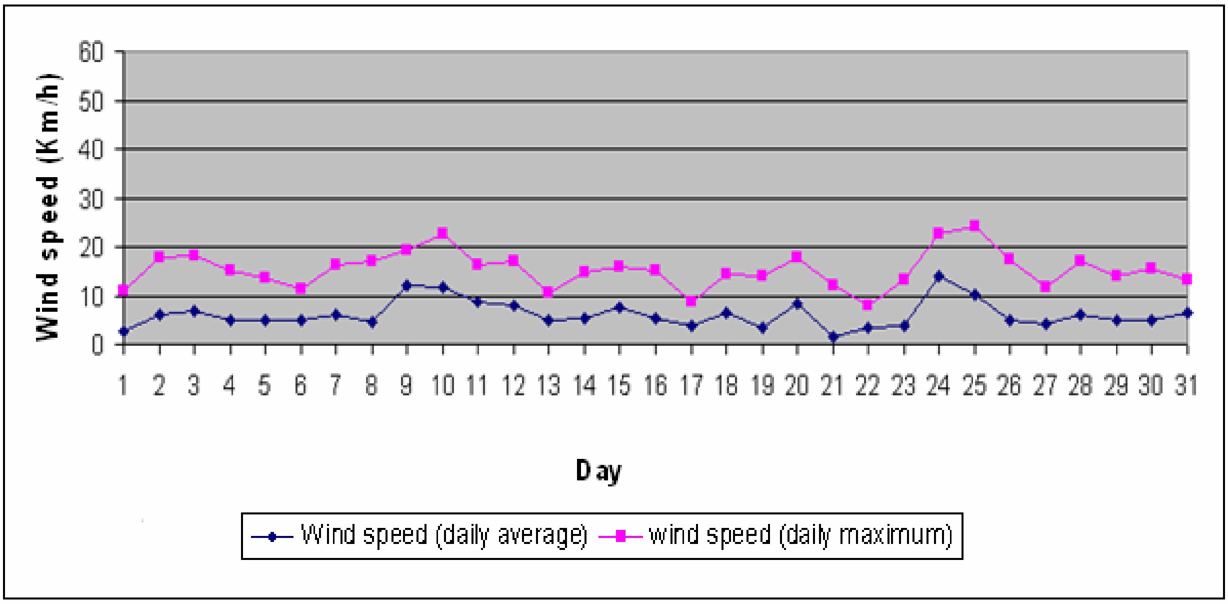

Fig. 20. Daily average and maximum wind speed values in August 2007 (Andrabida)

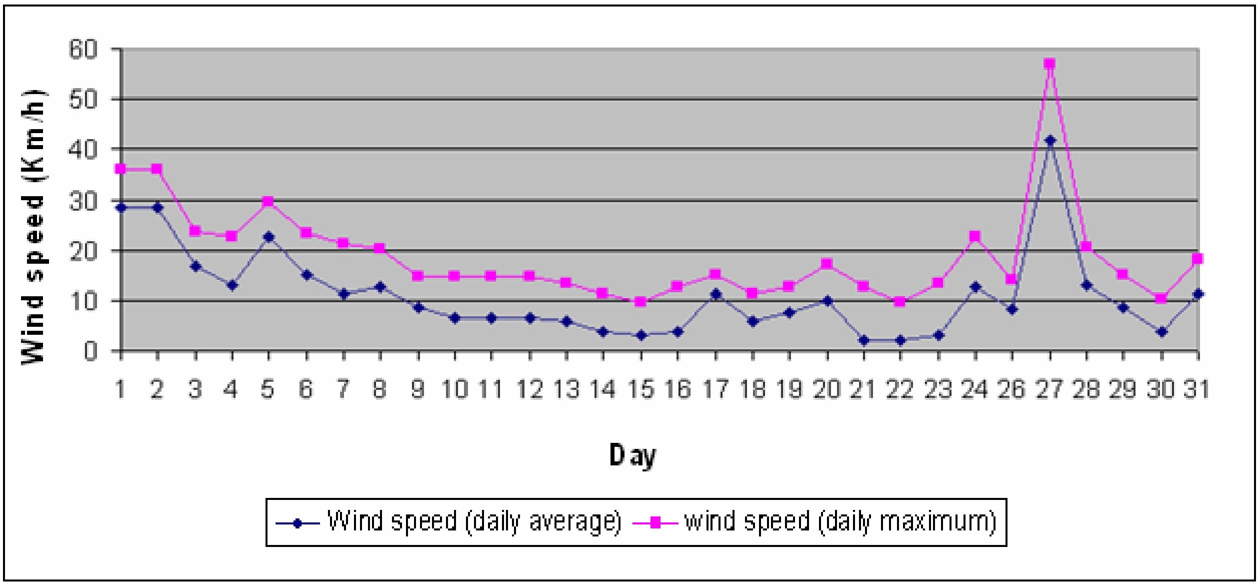

Fig. 21. Daily average and maximum wind speed values in August 2007 (Korinthos)

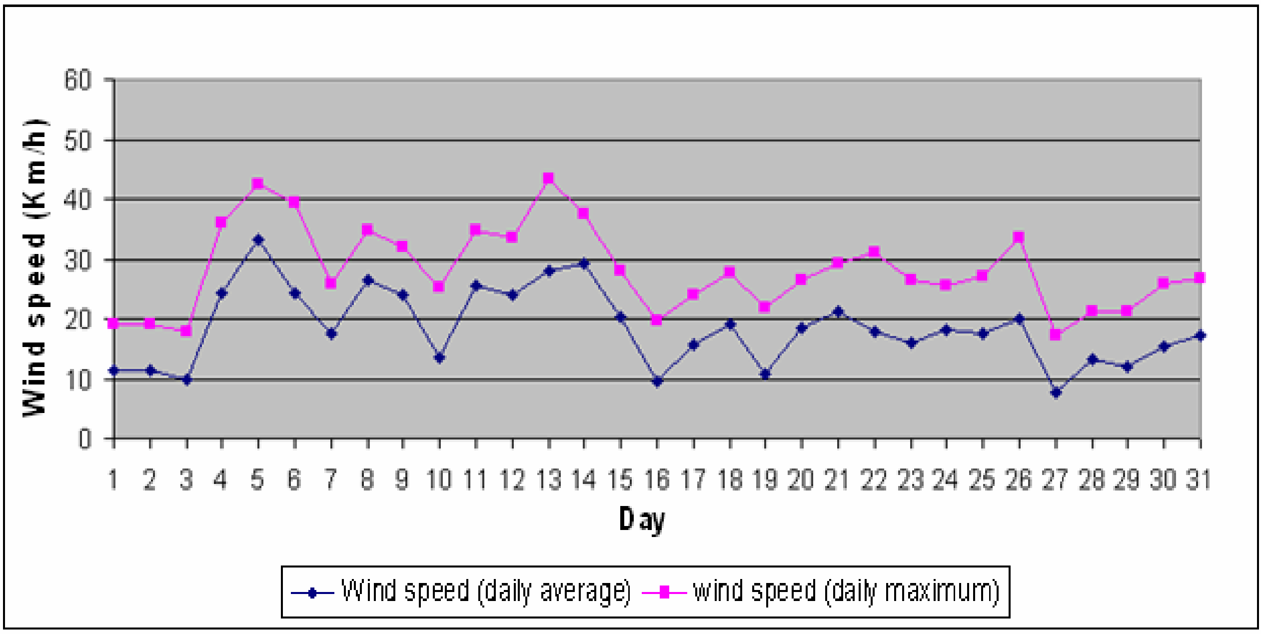

Fig. 22. Daily average and maximum wind speed values in August 2007 (Methoni)

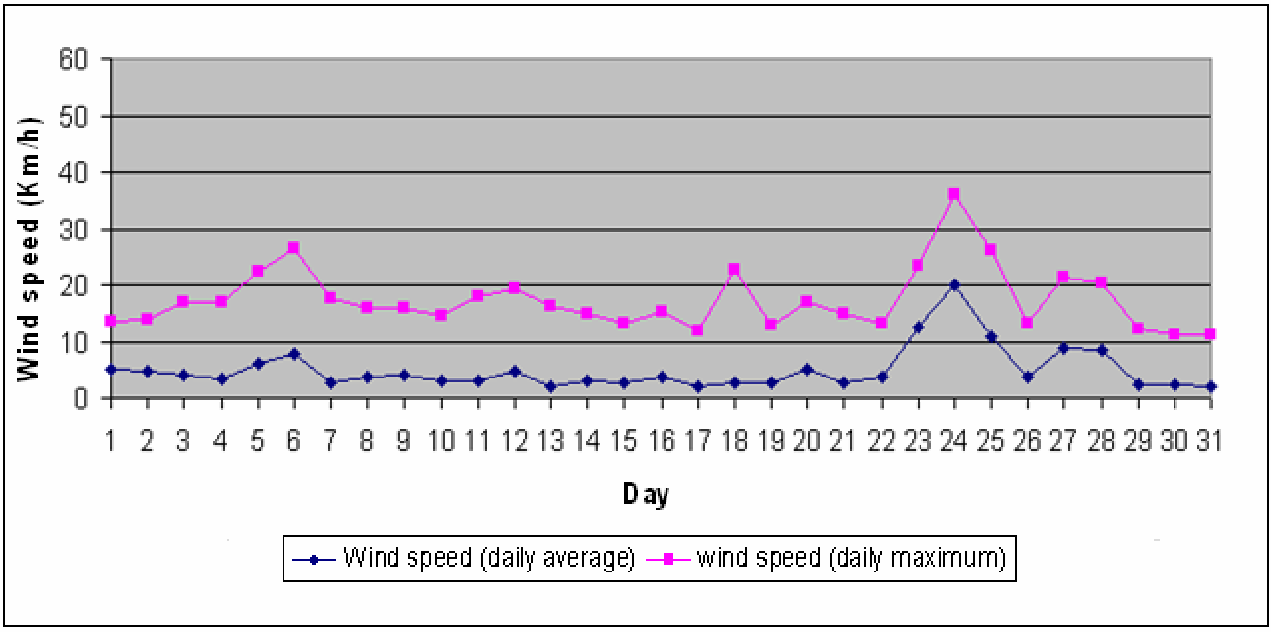

Fig.23. Daily average and maximum wind speed values in August 2007 (Araxos)

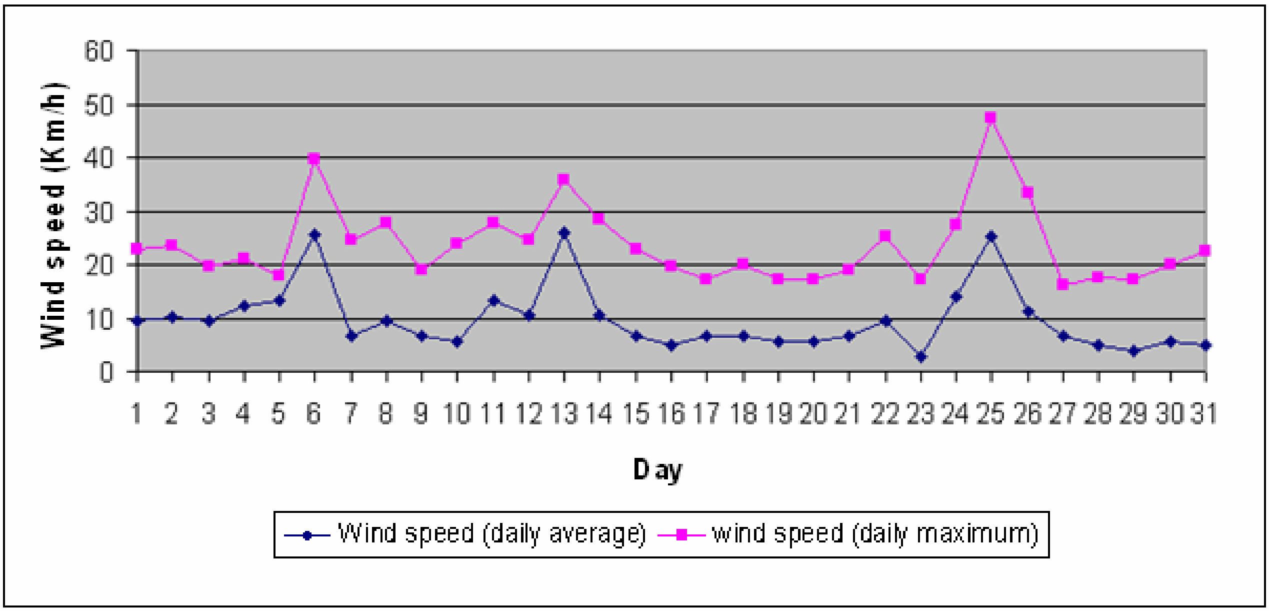

Fig.24. Daily average and maximum wind speed values in August 2007 (Pyrgos)

For evaluating Figs. 20-24, Table 3 can also be used.

Table 3. Wind scales

Beaufort No	Wind Intensity (Description)		Wind speed (km/h)	
0	Calm		< 1	
1	Light Air		1-5	
2	Light Breeze		6-11	
3	Gentle Breeze		12-19	
4	Moderate Breeze		20-28	
5	Fresh Breeze		29-38	
6	Strong Breeze		39-49	
7	Moderate or Near Gale		50-61	
8	Gale or Fresh Gale		62-74	
9	Strong Gale		75-88	
10	Whole Gale or Storm		89-102	
11	Violent Storm		103-117	
12	Hurricane		>= 118	

1.5 Resources used for suppressing the fires

In general, national and international resources were used for suppressing the mega fires in Greece during summer 2007. These data are presented in Tables 4 and 5.

Table 4. National resources used during forest fires in Greece 2007 *

Resources	Number of Means
Aerial means	***a.Aircrafts***
	21 Canadair 21 PZL & GRUMMAN 1 Be-200
	b.Helicopters
	2 SUPER PUMA 3 BK-117 19 Helicopters
Ground means	930 Fire vehicles
Personnel	7.310 Fire-fighters 3.000 Soldiers 200 Volunteers fire-fighters of the Hellenic Fire Service Hundreds of volunteers and citizens

**Source: Hellenic Fire Service*

The international resources that contributed to the fire suppression in Greece consisted of a total number of 23 aircrafts and 18 helicopters, supported by 319 people. In addition, 32 fire-brigade vehicles have been provided supported by 402 people. Most of the international resources were provided to Greece through the Community Civil Protection Mechanism (MIC).

Table 5. International resources used during forest fires in Greece 2007*

Resources by Country	Number of means
Aerial Means	
France	4 Aircrafts
Spain	4 Aircrafts
Italy	1 Aircraft
Croatia	1 Aircraft
Turkey	1 Aircraft
Portugal	1 Aircraft
Russia	1 Aircraft
Romania	1 Helicopter
Serbia	7 Aircrafts
Germany	5 Helicopters
Switzerland	3 Helicopter
Holland	3 Helicopters
Austria	3 Aircrafts & 2 Helicopters
Norway	1 Helicopter
Sweden	1 Helicopter
Slovenia	1 Helicopter
Ground means	
Cyprus	14 vehicles, 139 fire-fighters
France	72 fire-fighters
Israel	60 fire-fighters
Hungary	5 vehicles, 19 fire-fighters
Albania	1 vehicle, 4 fire-fighters
Serbia	7 vehicles, 55 fire-fighters
Bulgaria	5 vehicles, 46 fire-fighters
National Volunteers Group	7 people

**Source: Hellenic Fire Service*

1.6 Health Impacts

Forest fires and the resultant smoke can cause a number of health impacts on the exposed population and the fire-fighters. Those impacts are related with factors, such as the toxicity of forest fire smoke components, the characteristics of the smoke exposure, as well as the vulnerability of the exposed population. In general, the forest fire smoke is consisted of substances that can be respiratory irritants, such as aldehydes (e.g. acroleine), asphyxiants (e.g. carbon monoxide) and carcinogens (e.g. benzene, benzo[a]pyrene). Particles are also considered hazardous components of the forest fire smoke.

Generally, the fine particles, such as nanoparticles (with diameter less than 100nm) and respirable particle (with diameter between 0,1 and 10 μm) are considered more aggressive compared to the inhalable particles (with diameter between 10 to 20 μm). This is due to their small size that allows them to penetrate deeply the lungs. Health impacts due to smoke exposure are classified as acute, short-term and long-term, depending on the time duration that is needed for symptoms to appear.

1.6.1 Short-term health impacts

Irritation of eyes and nose, cough or the acute respiratory infection are indicative short-term health impacts due to smoke exposure.

In Table 6, the number of admissions to medical centers and hospitals of Peloponnese for the time period between the 17th of August 2007 and the 10th of September 2007 are presented. Diagnosis was classified accordingly. Two sensitive groups of population (children, pregnant women) have been summed up and are presented in one column. The column referred as “other” includes the cases diagnosed with fractures, fever e.t.c. The number of deaths is also given.

The data presented have been recorded by 19 medical centers and hospitals of Peloponnese in Tripoli, Krestena, Megalopoli Tropaia, Pyrgos, Gastouni, Ancient Olympia, Blaxioti, Areopoli, Kastori, Gutheio, Amaliada, Kalamata, Meligala, Kuparissia, Patra, Varda, Andritsaina, Dimitsana for the period 17th of August until 10th of September 2007*(Source: Ministry of Health).*

Table 6. Number and causes of admissions to 19 hospitals and medical centers of Peloponnese recorded in between the 17th of August to the 10th of September 2007.

Month	Date	Respiratory problems-asthma	Ocular problems	Burnings	Cardiopulmonary problems	Pregnant women-children	Other	Total No of patients	Deaths
August 2007	17	20	2	3	6	18	1	50	0
	18	19	4	1	13	8	0	45	0
	19	17	4	2	16	17	5	59	2
	20	26	5	1	19	20	3	74	0
	21	29	3	2	18	15	3	70	0
	22	18	2	3	25	23	1	72	0
	23	28	3	3	15	43	0	92	0
	24	52	9	14	14	21	5	115	0
	25	149	68	28	8	24	8	285	45
	26	79	64	15	14	26	1	199	1
	27	76	21	14	18	25	5	159	7
	28	50	15	8	18	19	5	115	0
	29	21	4	6	18	15	6	70	1
	30	34	4	6	18	14	5	81	0
	31	30	5	5	11	21	8	80	1
September 2007	1	17	6	9	14	15	6	67	0
	2	14	4	0	14	6	0	38	0
	3	21	1	4	12	21	4	63	0
	4	18	5	4	11	21	1	60	1
	5	26	2	5	20	17	2	72	1
	6	16	3	1	13	15	2	50	0
	7	10	0	2	13	10	0	35	0
	8	10	1	2	9	13	3	38	1
	9	17	0	1	16	11	0	45	1
	10	18	5	0	14	13	0	50	0

It can be observed that the number of admissions registered for the time period 24-31 of August 2007 was significantly increased in comparison with the relevant numbers before the 24th and after the 31st of August, a fact that can be related to the forest fires that occurred during that period.

In Fig. 24, the profile of the number of admissions to hospitals and medical centers of Peloponnese per category of symptoms, as presented in Table 6, is shown, emphasizing on the period 24-31 of August 2007.

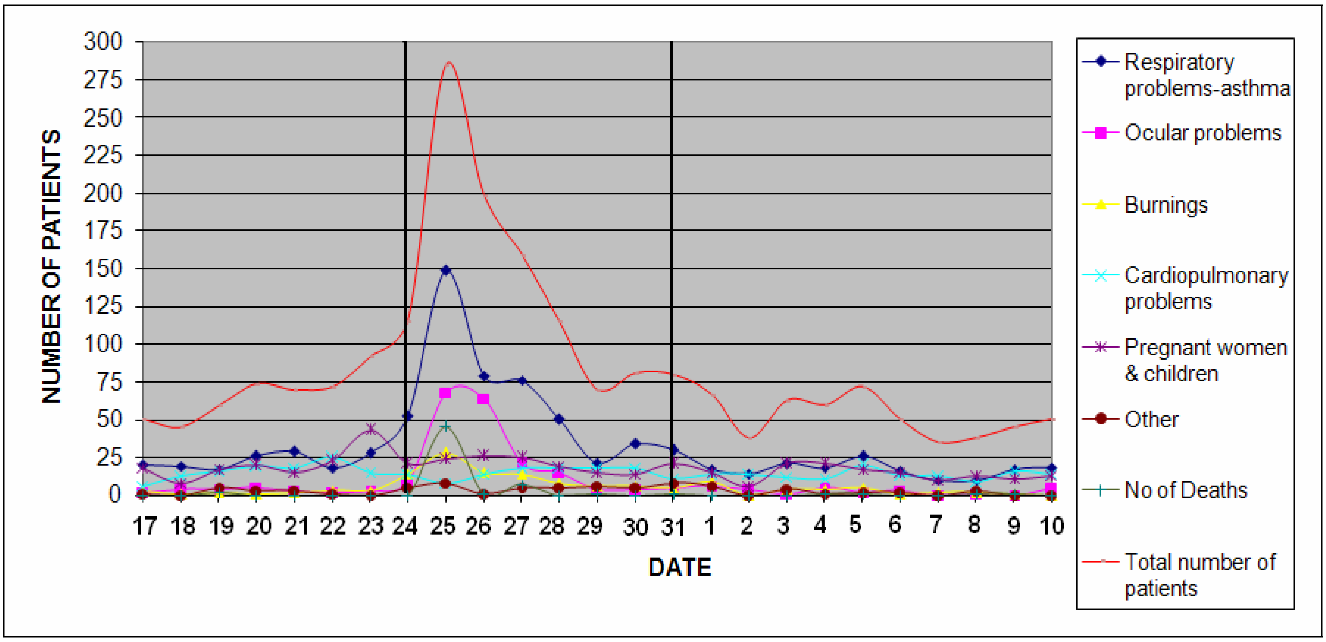

Fig. 24. Profile of the number of admissions and number of deaths according to 19 medical centers and hospitals of Peloponnese in between the 17th of August to the 10th of September 2007

1.6.2 Long-term health impacts

Pulmonary or chest diseases, asthma, cardiac problems or carcinogenicity, can be a number of long-term health implications that may appear after a significant time than the exposure happened. Generally, the time duration of the exposure to hazardous substances can have various health impacts. Acute exposure is usually less than 24-h, short-term exposure lasts usually one week, sub-chronic lasts about the 10% of someone's life, whereas chronic exposure consists a significant time duration, over 10% of human life.

Forest fire-fighters are a group that is more at risk to have long-term health impacts, due to the frequency and duration of their exposure to forest fire smoke. In contrast, long-term health implications on populations that are not exposed frequently to forest fire smoke are usually limited. However, long-term health impacts can be significant for the sensitive groups of population, such as people with pre-existing respiratory problems, asthma, cardiac problems, as well as the elderly, children, infants, pregnant women and smokers. The use of effective personal protective equipment and possible evacuation of population are some of the measures that can be applied for copying with forest fire smoke impacts.

1.6.3 Deaths and toxicological data

The death toll in summer 2007 due to the devastating forest fires in Greece was 68. Generally, severe burns, as well as inhalation of significant quantities of toxic compounds are potential causes of death.

According to the results of the toxicological analysis for a total number of 43 cases that were examined by the Forensic Medical Service of Patra, it was found that 22 were caused due to total fire burns, 17 due to various degrees of burns, 3 due to asphyxia by smoke inhalation and one due to coronary disease. In addition, 14 more cases have been examined by the Forensic Medical Service of Nafplion and 4 by the Department of Forensic Medicine and Toxicology, School of Medicine of the University of Athens, for which the main cause of death was also total burns

1.7 Impacts on houses and infrastructures

A significant number of houses and public infrastructures (working facilities, churches, storages, stables) were totally or partially destroyed during the big forest fires in Peloponnese, as shown in Table 9.

Over 1.000 houses in Peloponnese were totally damaged and over 450 were partially damaged. Regarding the public infrastructures almost 70 were destroyed, the 30 of them were situated in Ilia prefecture.

Table 9. Structural damages in Peloponnese during summer 2007*

Prefecture of Peloponnese	Houses		Public Infrastructures		Other		% Damages per prefecture
	Total damage	Partial damage	Total damage	Partial damage	Total damage	Partial damage	
Arcadia	185	110	6	3	157	171	**20**
Ilia	524	238	30	12	498	233	**49**
Korinthia	3	0	1	0	14	5	**1**
Laconia	12	36	1	2	108	38	**6**
Messinia	95	40	7	3	67	9	**7**
Achaia	193	62	4	0	132	145	**17**
Total	**1012**	**486**	**49**	**20**	**976**	**601**	**100**

* *Source: Hellenic Ministry for the Environment, Physical Planning & Public Works, 10-10-07*

The total number of structural damages in Peloponnese, including houses, public infrastructures or other, reached the number of 3.144. The 49% of the total damages took place in Ilia and the 20% in Arkadia. In Fig. 25, the number of structural damages per prefecture is presented on a map of Peloponnese.

Fig.25. Number of structural damages in Peloponnese per prefecture

1.8 Environmental Impacts

1.8.1 Forest fire smoke and air pollution

Generally, big vegetation fires can contribute a significant percentage to the environmental pollution due the smoke emissions evolved during the phenomenon. The produced smoke is a complicated chemical mixture of components, such as gases, liquids and solids. Smoke from vegetation fires can be considered an aerosol consisting of water vapour, permanent gases, e.g. carbon dioxide (CO_2), carbon monoxide (CO), Nitrogen Oxides (NOx), as well as Sulfur Oxides (SO_x) and ammonia (NH_3) but usually in small quantities, Volatile Organic Compounds (VOCs), such as methane (CH_4) and other hydrocarbons that can be aliphatic, aromatic, oxygenated (alcohols, aldehydes, ketones, furans, carboxylic acids, esters) or halogenated (chloro-hydrocarbons), Semivolatile organic compounds (SVOCs), such as polyaromatic hydrocarbons (PAHs) and particles that can be coarse (PM_{10}, with diameter<10 μm) or fine ($PM_{2.5}$, PM_1, with diameters<2.5 μm, 1μm) depending on their size; the major amount of particles produced in a forest fire (over 90%) is 10 μm or less in diameter. Indicative field measurements of $PM_{2.5}$ and PM_{10} (30-min mean values), carried out in an area situated downwind of a forest fire that took place at Mountain Parnitha (Athens, Greece) in summer 2007, shown that values were respectively 3 and 1.5 times multiple than the threashold limit values (TLVs-24h) of 65 μg/m^3 and 150 μg/m^3 given by the American Conference of Governmental Industrial Hygienists (ACGIH), in respect *(Field Chemical Analysis and Technology Unit/National Technical University of Athens, FIACTU/NTUA unpublished data).*

It has to be noted that when the forest fire is in the close proximity of an urban or rural area, the phenomenon of expansion to rural fields, rural/urban constructions or landfills is very often. In such cases co-burning of wood, plastics, fertilizers, pesticides, fungicides or wastes together with the forest fuel takes place; the chemical composition of the produced smoke is more complicated and usually more aggressive for the receptors, such as the environment and the exposed populations.

Contribution of forest fires to air pollution includes elevated trace gases, particles and CO_2, which is a greenhouse gas; during the smoke haze of 1997 in Indonesia, atmospheric concentrations of particulate matter, SO_2, CO, CH_4 and CO_2, as well as relative humidity were elevated. In addition, photochemical reactions can take place under sun radiation, and therefore secondary products can be produced in the smoke plume. VOCs and CO have been described as precursors to ground level ozone, especially when NO_2 is present.

1.8.2 Forest fire smoke and soil/water pollution

Forest fire smoke particles can pollute surface water directly by deposition or can be part of the soil. In this case or after a rainfall, suspended soil particles, as well as dissolved inorganic nutrients and other materials, can be transferred into adjacent streams and lakes reducing water quality and hence, disturbing aquatic ecosystems balance. In sandy soils, leaching may also move mineral through the soil layer into the ground water.

Forest fires can also have effects on properties of forest soils. Generally, soil pH can usually be increased by the soil heating, as a result of organic acids denaturation. In addition, increased levels of nutrients, such us phosphorus (P), potassium (K) and calcium (Ca) can be found in the soil after a fire. Although large amounts of total nitrogen (N) and phosphorus (P) are lost during burning, extractable ammonium-N ($N\text{-}NH_4^+$) and phosphorus (P) are increased in the upper soil layers. Generally, changes in soil properties can affect concentrations of nutrients that are contained in the tree needles.

1.8.3 Assessment of atmospheric emissions

According to the EFFIS, indicative assessment of atmospheric emissions up to the 31st of August 2007 shown that more than 12.3 million tons of CO_2 were emitted in Europe, which were attributed to an estimated total burned biomass in Europe of 7.3 million tons.

In Table 10, the estimated atmospheric emissions per European country up to the 31st of August 2007, such as CO_2, CO, CH_4, $PM_{2.5}$, PM10, total particulate matter (PM), non-methane hydrocarbons (NMHC), VOCs, NO_X, organic carbon (OC), and elemental carbon (EC), are presented.

Table 10. Burned biomass and estimated emissions estimates from forest fires up to 31st of August 2007 by country

Emission type	Country emissions (x 10^3 ton)										
	Albania	Bosnia	Bulgaria	Croatia	Cyprus	France	Fyrom	Greece	Italy	Portugal	Spain
CO2	2052.6	1278.7	558.9	248.4	43.1	52.8	474.7	4500.5	1825.8	194.1	1045.1
CO	82.6	50.3	27.6	10.6	1.9	2.2	22.2	188.1	72.3	7.6	43.0
CH4	4.3	2.6	1.4	0.5	0.1	0.1	1.1	9.7	3.8	0.4	2.2
PM2.5	8.2	5.0	2.6	1.0	0.2	0.2	2.1	18.6	7.2	0.8	4.3
PM10	9.7	6.0	3.1	1.2	0.2	0.3	2.5	21.9	8.6	0.9	5.0
PM	13.6	8.4	4.2	1.7	0.3	0.4	3.5	30.6	12.0	1.3	7.0
NMHC	3.5	2.2	1.1	0.4	0.1	0.1	0.9	7.9	3.1	0.3	1.8
VOC	4.3	2.6	1.3	0.5	0.1	0.1	1.1	9.6	3.8	0.4	2.2
NOX	5.8	3.5	1.9	0.7	0.1	0.2	1.5	13.1	5.0	0.5	3.0
OC	4.9	3.0	1.5	0.6	0.1	0.1	1.2	11.0	4.3	0.5	2.6
EC	0.6	0.4	0.2	0.1	0.0	0.0	0.1	1.3	0.5	0.1	0.3
Burned Biomass (x10^3 ton)	1161.3	752.5	328.1	140.8	26.0	31.8	288.3	2703.1	1095.3	116.4	628.6

Abbreviations:
CO2 - Carbon Dioxide, CO - Carbon Monoxide, CH4 – Methane, PM2.5 - 2.5 micron particulate matter, PM10 - 10 micron particulate matter, PM - total particulate matter NMHC - non-methane hydrocarbon, VOC - volatile organic compounds, NOX - nitric oxide, OC - organic carbon, EC - elemental carbon

1.9. Comments and proposals

Collection of geographical, meteorological and vegetation data, as well as of data regarding the resources used for suppressing the fires, and of data relatively to the impacts on health, the environment and infrastructures can be used as a platform for documenting future big forest fires.

Generally, documentation of different types of data can be used for optimizing prevention and copying with forest fires and their impacts. Data files can contribute to better organizing and managing the information regarding big forest fire events.

1.10 Summarizing

The following types of data are proposed to be included in a forest fire disaster file:

1. Geographical data

- map of the area
- coordinates of the area
- elevation

2. Vegetation data

- area burned by land cover type (forest, agriculture, artificial surfaces)
- areas burned per prefecture

3. Meteorological data

- temperature (daily average, minimum and maximum values)
- relative humidity (daily average values)
- wind speed (daily average and maximum values)

4. Resources used for suppressing the fires

- Aerial means (national and international)
- Ground means (national and international)
- Personnel (national and international)

5. Health Impacts

- Short-term health impacts due to smoke exposure and fire burnings (number of admissions to hospitals and medical centers)
- Long-term health impacts due to smoke exposure (epidemiological studies), especially for sensitive groups of population and the fire-fighters
- Number of deaths and toxicological data (cause of deaths)

6. Impacts on houses and infrastructures

- Total number of structural damages per prefecture
- Type of structural damage (total or partial) of the affected houses and public infrastructures

7. Environmental impacts

- Field chemical analysis data by on-line monitoring of air quality during a forest fire
- Field chemical analysis data by monitoring quality of soil and water

1.11 Acknowledgements

We would like to thank for their contribution to this data file:

- *Mr D. Katsantonis, Hellenic Ministry for the Environment, Physical Planning & Public Works*
- *Mr T. Kolydas, Hellenic National Meteorological Service*
- *Dr N. Kotakidis, Forensic Medical Service of Nafplion, Hellenic Ministry of Justice*
- *Dr P. Koutsaftis, Forensic Medical Service of Athens, Hellenic Ministry of Justice*
- *Mr S. Penteas, Regional Health Care System of Western Greece, Hellenic Ministry of Health*
- *Dr A.Tsiola, Forensic Medical Service of Patra, Hellenic Ministry of Justice*

Section 2

"Early Warning Systems (EWSs)"

by A. Pappa and S.Karma, National Technical University of Athens, GR

2.1 Introduction

Natural hazards, such as forest fires, floods, volcanic eruptions, or earthquakes, may cause a significant number of casualties, having also the respective economic or social impacts. Generally, early warning systems (EWSs) can be used as a shield of protection from the risks posed by natural disasters. There are a number of parameters that can contribute to the effectiveness of a EWS, such as the preparedness of the relevant organisations, the public awareness and education of the communities at risk, and also the on-time dissemination of warnings or alarms.

KEY ELEMENT 1	KEY ELEMENT 2	KEY ELEMENT 3	KEY ELEMENT 4
Risk knowledge	**Monitoring and warning service**	**Dissemination and communication**	**Response capability**
Systematically collect data and undertake risk assessments Are the hazards and the vulnerabilities well known? What are the patterns and trends in these factors? Are risk maps and data widely available?	*Develop hazard monitoring and early warning services* Are the right parameters being monitored? Is there a sound scientific basis for making forecasts? Can accurate and timely warnings be generated?	*Communicate risk information and early warnings* Do warnings reach all of those at risk? Are the risks and the warnings understood? Is the warning information clear and useable	*Build national and community response capabilities* Are response plans up to date and tested? Are local capacities and knowledge made use of? Are people prepared and ready to react to warnings?

Fig. 1. The Four Key Elements of Effective Early Warning Systems

(Source: UNISDR)

In Fig. 1, the key elements of a EWS are shown *(Source: United Nations International Strategy for Disaster Reduction-UNISDR*, *Developing Early Warning Systems "A Checklist". EWC III Third*

International Conference on Early Warning from concept to action, 27 – 29 March 2006, Bonn, Germany). Risk knowledge by collecting data for risk assessment, development of monitoring and warning services, dissemination and communication of risk information for early warning of population and building response capabilities consist the four key elements of an effective EWS. In this work, two representative EWS which are proposed for copying with forest fires and their impacts are described.

2.2 Forest fires and Early Warning Systems

Generally, forest fires destroy several hundred million hectares of forest land every year in a global basis. Most of the fires occur as consequence of extreme weather situations, for example during extended droughts or after precipitation-rich periods that result in rich growth of vegetation and an increased availability of fuels (combustible material). Specifically, large scale forest fires can cause emergency situations due to the huge quantities of smoke produced, posing a significant threat for the communities affected. Smoke episodes that took place in South East Asia during 1997-98, in Western Europe during summer 2003 (France, Portugal, Spain), in USA during summer 2000 (Montana) and 2007 (California), as well as in Australia in 2003 and 2006 are indicative examples. Forest fires and the resulted smoke haze can have serious health effects on the exposed population, are responsible for visibility reduction in critical infrastructures (e.g. airports, highways), they contribute to atmospheric pollution and also have impacts on the economy of the areas.

Secondary effects of devastating forest fires include soil degradation; the affected areas are more vulnerable to disastrous floods in case of heavy rainfall, as well as to landslides. Impacts on water quality are also significant. Early warning (EW) of forest fires is crucial for copying with their impacts. In the following, representative proposals, aiming at the development of EWS for forest fires and forest fire smoke, are described.

2.3 Early Warning Systems for forest fires

2.3.1 Global Early Warning System for Wildland Fire *(Contact details: johann.goldammer@fire.uni-freiburg.de, GFMC)*

2.3.1.1 Introduction

United Nations International Strategy for Disaster Reduction (UNISDR) endorses a joint effort for developing a Global EWS for copying with wildland fires, a project that was presented during the Third International Conference on Early Warning, which took place on March 2006 in Bonn, Germany *(From Sudden Local Wildland Fire Disasters to Transboundary Impacts of Creeping Wildland Fire Mega Events: Needs for Global Early Warning of Wildland Fire within a UN Multi-Hazard Global Early Warning System)*. This project is supported by a global partnership; the Global Fire Monitoring Center (GFMC) / Fire Ecology Research Group Max Planck Institute for Chemistry, the Canadian Forest Service (CFS), the Bushfire Cooperative Research Center in Australia (CRC), the Global Observation of Forest and Land Cover Dynamics in Canada (GOFC-GOLD), the University of Maryland in USA (UMD), the World Meteorological Organization (WMO), the Bureau of Meteorology Research Centre in Australia (BMRC), the European Centre for Medium Range Weather Forecasting (ECMWF), the German Aerospace Center (DLR) and also the National Institute of Meteorology in Spain, the Finnish Meteorological Institute and the Met Office in UK.

More specifically, this global early warning system will be based on existing science and technologies. It will include an information network for effective dissemination of early warning messages of fire danger to global or local communities. In addition, historical records of global fire danger information will take place, in order to assist strategic planning efforts and enhance early warning products. It is also in the scope of this project to support technology transfer and also through this EWS to provide training for global, regional, national, and local community applications in: a) early warning system operation, b) methods for local to global calibration of the system, and c) using the system for prevention, preparedness, detection, and fire response decision-making.

2.3.1.2 Methodologies and Systems for Early Warning of Wildland Fires

Generally, early warning (EW) of wildland fires and the related hazards include a variety of methodological approaches, as they are presented in the following (J.G. Goldammer, Early Warning of Wildland Fires – A Global Synthesis, GFMC):

(a) Assessment of fuel loads. Ground measurements and also satellite data allow for the determination of the amount of fuels available for wildland fire (combustible materials). This is important because dryness and fire risk alone do not determine the extent and severity of fire impacts.

(b) Prediction of lightning danger. Methods exist for observing / tracking lightning activities as source of natural ignition, such as ground-based lightning detection systems, or space-borne monitoring of lightning activities.

(c) Prediction of human-caused fire factors. Modeling/predicting human caused fire starts is crucial, since in most countries fires are caused directly or indirectly by human activity. This field of research requires adequate consideration to socio-economic factors (e.g. ownerships, land uses, etc.).

(d) Prediction of fuel moisture content. This term is closely related to the readiness and ease of vegetation to burn. EW systems include meteorological danger indices and space-borne information on vegetation dryness (intensity and duration of vegetation stress) and soil dryness. Prediction of inter-annual climate variability / drought is important for preparedness planning in many countries.

The above four referred factors are related to the ignition danger, which is associated to the starting of the fire. Once the fire stars, it is critical also to consider the propagation patterns, which are basically related to fuel loads, terrain characteristics and wind flows.

(f) Prediction of wildfire spread and behavior: Airborne and space-borne monitoring of active fires allows for the prediction of fire fronts movements to areas with values at risk. The technologies used include airborne instruments to monitor fire spread in situations of reduced visibility (smoke obscured) or to cover large areas. A large number of orbiting and geostationary satellites are available to identify active fires. Numerous wildland fire behaviour models are in place that allows the prediction of spread and intensity of wildland fires.

(g) Assessment of smoke pollution. In situ air quality monitoring systems allow for tracking fire smoke pollution and issue alerts (warnings to populations). Specifically, surface wind prediction allows for prediction of smoke transport from fire-affected regions to populated areas. Satellite images can depict smoke transport. To predict future of fire occurrence, weather conditions, which have great impact on the beginning and spreading of the fire, should be considered in a medium- to long term perspective.

(h) Prediction of climate variability and fire danger: Climate variability is considered critical for initiation and spreading of forest fires. During El Niño events, for example, sea temperature at the surface in the central and eastern tropical Pacific Ocean becomes substantially higher than normal. During La Niña events, the sea surface temperatures in these regions become lower than normal. It should be mentioned that these temperature changes can drive major climate fluctuations around the globe and they can last for 12 months or more; droughts associated with recent El Niño events have resulted to widespread controlled burning and uncontrolled wildfires, causing extreme fire and smoke episodes, particularly in the South East Asia and in the U.S.A.

(i) Prediction of climate change and fire danger: Recent Intergovernmental Panel on Climate Change (IPCC) reports have emphasized on climate change and its significant impacts, particularly in northern latitudes, for many decades ahead. Model projections of future climate, in both broad and regional scales, are consistent in this regard. An increase in boreal forest fire numbers and severity, as a result of a warming climate with increased convective activity, is expected to be an early and significant consequence of climate change. Increased lightning fire occurrence is expected under a warming climate. Fire seasons are expected to be longer and also with increased severity. Extended extreme fire danger conditions are also expected, which can lead to major forest fire events.

According to the above, the greatest challenge ahead for an effective early warning system is the transfer of knowledge and adapting technologies to various groups of populations that are vulnerable to the destructive effects of uncontrolled wildfires.

2.3.1.3 Development of the Global Wildland Fire EWS

For the development of the proposed global EWS for wildland fires, a number of activities will take place that are referred to the structure of the System, the operational implementation and also the technology transfer that will be achieved through this project.

A number of steps will be followed for structuring the system:

- Reviewing and summarizing literature and data on global fire activity to assess risk to global communities and areas of priority
- Adapting a current risk monitoring system for global application, using the Canadian Forest Fire Weather Index System in a prototype
- Developing protocols in order to utilize current weather forecasting models for fire danger modelling
- Adapting Fire Weather Index (FWI) System to operate in a forecasting mode providing probability of event characteristics
- Integrating global hotspot databases with FWI data, presenting a current global fire status product (showing where current fire problems are, and providing basis for assessing severity of forecasted fire danger conditions)
- Utilizing historical satellite detected hotspot and archived numerical analysis of FWI to further calibrating the System
- Run studies to assess form and utility of products with end users and their social and economic impact.

Operational implementation will include:

- The development of procedures within robust framework of the World Watch (global network of operational meteorological services) in order to run early warning system on a daily operational basis
- The analysis and production of current fire danger assessment
- The analysis and production of forecasted fire danger
- The dissemination of early warning information through multiple channels

- The establishment of procedures, as new tools and products developed, with a number of operating services in order to maintain and update the System.

The activities related to technology transfer will include:

- Training and workshops through the World Meteorological Organization framework and the United Nations University. The relevant topics will be:

  -Early Warning Systems operations

  -Basic understanding of fire danger and early warning

  -Calculating FWI components

  -Provision of FWI algorithms

  -Developing and implementing decision-aids, based on early warning to mitigate the impacts of fire through prevention, preparedness, detection, and fire response

  -Involvement of local communities in the application of early warning information in wildland fire management (Community-Based Fire Management-CBFiM), especially in wildfire prevention, and preparedness for copying with wildland fire disasters (including smoke pollution and health)
- Promotion of the early warning system project through presentations to land and forest fire managers at conferences, professional meetings, etc.
- Publication of documents regarding the early warning system.

One of the expected impacts of the System is to become a significant training tool for the local communities, in order to mitigate fire damage and to achieve fire prevention, detection, preparedness, and fire response plans before wild fire problems begin. It is also expected to provide the foundation for building resource-sharing agreements between nations in times of extreme fire danger. Another expected impact is the training and development of local expertise and capacity building in wildland fire management for System sustainability.

2.3.2 Star & Caring Wings” - An Early Warning System for Forest Fire Smoke Impacts *(Contact details: stathero@chemeng.ntua.gr, NTUA)*

2.3.2.1 Introduction

The project “Star & Caring Wings: An Early Warning System for forest fire smoke impacts” is endorsed by the UNISDR and it is an initiative of the National Technical University of Athens; it will be run by coordinated activities of organizations, operational bodies, universities and research institutes from China, France, Greece, Morocco, Portugal and United Kingdom. It primarily aims at the development of an early warning system for forest fire smoke impacts.

The huge quantities of smoke produced during big forest fires are among others responsible for serious health impacts on the exposed population, short and long-term health impacts on firemen and front line personnel, as well as for the reduced visibility in critical infrastructures, such as airports and highways, and also for environmental impacts, such as on air, soil and water quality. Forest fire smoke (FFS) is generally considered a complex mixture of compounds, such as gases, liquids and solids, as the result of forest fuel combustion. This complex mixture consists of more than 150 different chemical compounds, most of them hazardous for human health. In cases that a forest fire is near the interface of urban or rural areas the forest fire front usually expands to constructions, agricultural areas, landfills or waste disposals; fertilizers, pesticides and wastes can co-burned with the forest fuel, and hence more hazardous compounds (e.g. dioxins) may be contained in the produced FFS.

It should be noted that forest fire smoke components can spread over borders and travel thousands of kilometres, reaching heavily populated urban areas and having the respective health implications. The trans-border (and sometimes transcontinental) impacts of forest fire smoke makes it a global issue. All the big forest events have confirmed the necessity to adopt enhanced methods in order to cope effectively with forest fires smoke and their severe resultant haze that threats the fire crews on the front line, the populations in the vicinity of the fires and the population in a global basis.

According to the above, it seems that there is a need for a project that will focus on effective Early Warning of FFS impacts. More specifically, further research on FFS health impacts is needed, considering FFS as a complex mixture with chemical composition that is depended on the fire front path. It should be also emphasized that according to current studies, detailed work needs to be done for FFS health impacts assessment; medical protocols for monitoring fire-fighters exposure to smoke, establishment of exposure limits to smoke for sensitive groups of population and the fire-fighters.

In addition to health impacts, forest fire smoke haze has serious impacts on the public services operation. It is known that especially in big forest fire incidents, airports and highways are closing and public services, such as public schools and hospitals are put under strong stress.

"Star & Caring Wings" is an Early Warning System for coping with forest fire smoke impacts, allowing early and fast response. The System includes a combination of strategies, technologies and procedures that will address existing voids in coping with serious big forest fire incidents and their impacts. It will have star architecture (Fig. 2); using field measurements and connecting the decision making with fire personnel and relevant operational bodies.

More specifically, the project will:

- Improve awareness of forest fire smoke complexity in various organisations and communities. As assessment indicator will be used the number of organizations that will be informed on risk assessment regarding forest fire smoke components
- Review/ enhance already existing indexes for air quality monitoring. As assessment indicator will be used the number of indexes used for air quality monitoring
- Benchmark existing technologies (e.g. field sensors, portable chemical instruments) for measuring forest fire smoke components in the field. As assessment indicator will be used the implementation of such benchmarking of technologies that it does not currently exist.
- Enhance evacuation criteria. As assessment indicator will be used the number of levels of critical situation based on air quality indexes, health impacts and visibility.
- Prepare guidelines and possible administrative and legal activities for implementing the system. As assessment indicator will be used the preparation of such guidelines.

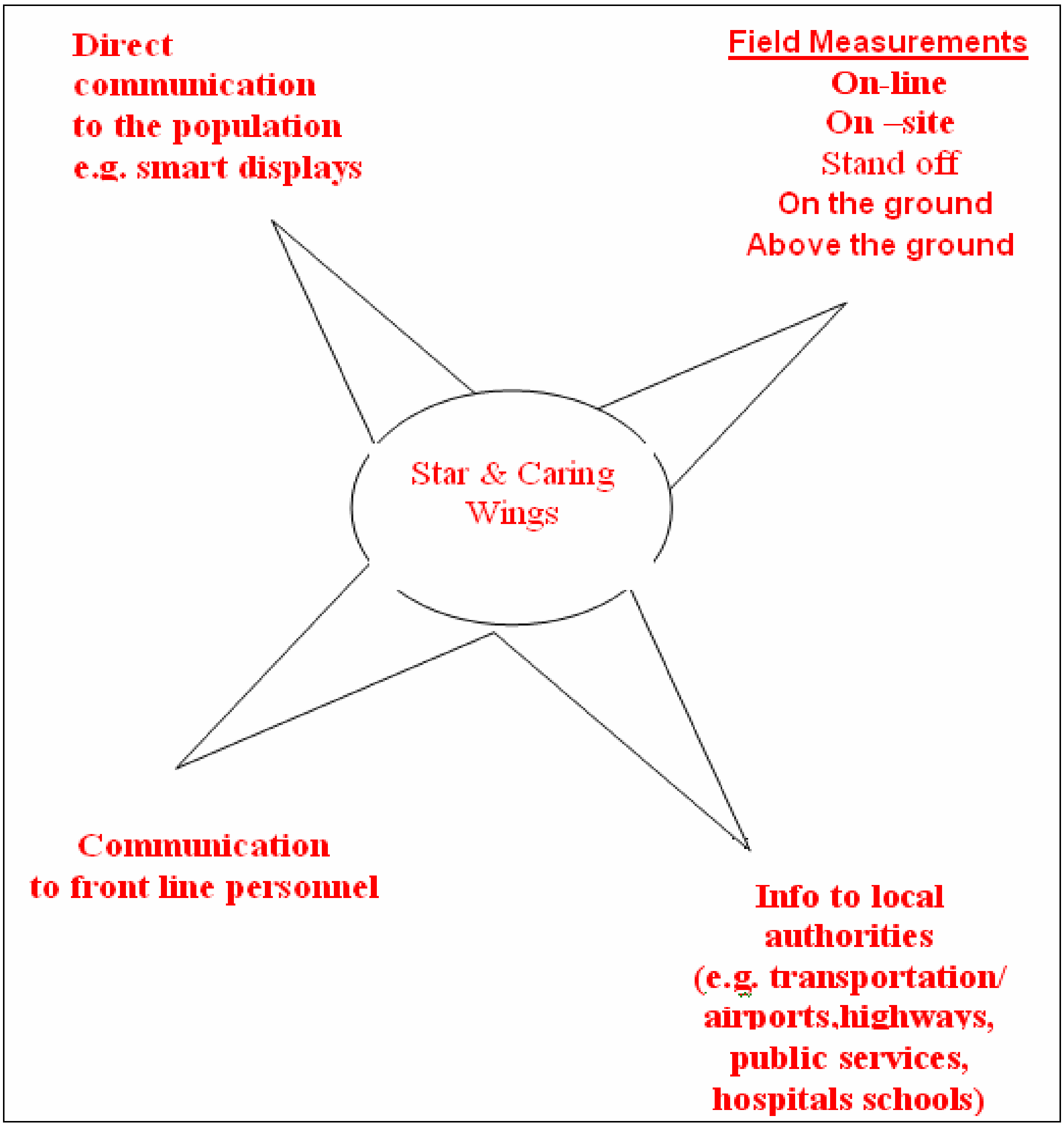

Figure 2. Star architecture of the Early Warning System "Star and Caring Wings" for coping with forest fire smoke impacts

• Develop types of smart displays for direct early warning of population. As assessment indicator will be used the development of such displays.

2.3.2.2 Description of the Star & Caring Wings EWS

The "Star & Caring Wings: An Early warning system for forest fire smoke impacts" is a system that aims at on-line, field measuring of critical components of forest fire smoke, evaluating the danger from forest fire smoke, monitoring population exposure and deciding on various levels of fast response with deployment of specific emergency plans. The exact Strategies, Steps, Procedures and Technology of the "Star & Caring Wings" will be presented in the following:

(i) Strategies

The “Star & Caring Wings” will be based on the following:

- Increase of awareness among population and firemen personnel
- Educating firemen and authorities on forest fire smoke issues
- Evaluate and use state-of-the-art smoke measurement technologies capable of on-line, field and fast-to-response operations
- Decision making based on established and pre-decided criteria
- Two-channel communication: to authorities and population
- Adapting the system effectively to local administrative and legal systems.
- Making the system part of already existing emergency plans.
- Promote the needs for further research on the issues of the project among various organizations and more specifically on development of low cost, effective personal protective means for population.

(ii) Steps

The steps that will be folowed for the implementation of the Early Warning System will include:

- Identification of the fire incident.
- Preliminary evaluation of the danger using a forest fire smoke Road Map.
- Continuous field measurements of specific indexes, regarding forest fire smoke components.
- Decision making on various levels of fast response.
- Communication to authorities and to population.

(iii) Procedures

Procedures have to be determined that will allow for defined sequence of activities. These procedures will include:

- Methods for sampling and measuring on-line and in the field
- Conditions evaluation in specific time frames
- Communication procedures
- Emergency plans

(iv) Technology

The project will employ technologies that will allow various levels of measurements, decision making and information communication. The following are some of the technologies that will be evaluated among others during the project implementation:

- Field chemical analysis based on sensors (e.g. Carbon Monoxide measurements).
- Field measurements of particles
- Field measurements by using portable Gas Chromatographer
- Field measurements by using portable Gas Chromatographer-Mass Spectrometer (GC-MS) and Gas Chromatographer-Ion Mobility Spectrometer (GC-IMS)
- LIDAR (Light Detection And Ranging) measurements
- TOF MS (Time Of Flight Mass Spectrometer) measurements
- ACITOF MS (Ambient Chemical Ionization Time of Flight Mass Spectrometer) measurements
- Chemical analysis of expired air (breath analysis) for smoke exposure assessment
- Decision support and communication
- Wearable and palm-top computers
- Smart displays

(v) Key Actors

Organizations, operational bodies, universities and research institutes from China, France, Greece, Morocco, Portugal and United Kingdom will be part of the partnership.

One of the expected impacts of the project “Star & Caring Wings: An Early Warning System for forest fire smoke impacts” is the reduction of human exposure to smoke during big forest fire incidents in various regions (S. E. Asia, Australia, Europe, USA). In addition, enhancement of awareness regarding forest fire smoke impacts among relevant organizations and reduction of secondary consequences, such as vulnerability of airports and highways, due to reduced visibility are other expected impacts of the project. Supporting of firemen in coping with forest fire smoke health and safety issues is also expected. Furthermore, promotion of research on air quality monitoring technologies related to disasters, as well as improvement of direct warning of population by using smart displays are also in the scope of the project. Enhancement of research on developing cost efficient protection equipment for population against forest fire smoke is a core expected impact.

Section 3

"Organization of a master in disaster management in the framework of EUR-OPA"

3.1 Master in disasters in the framework of EUR-OPA

by E. Fernandez-Galiano, Executive Secretary of the European and Mediterranean Major Hazards Agreement (EUR-OPA), Council of Europe

Recent disasters have clearly shown that success in limiting the effects of major hazards on people and property necessarily relies on preparation and the ability to react rapidly and efficiently to unexpected events. For instance, the heavy toll on human lives and the high ecological and economic loss caused by forest fires in southern Europe over the past years have been linked to lack of preparedness by affected populations and fire fighters or to poor disaster management capacities. It is thus of paramount importance to promote more instruction at all levels to train capable professionals in advance planning and the development of operational skills and competence in the field. In addition, it is equally important that the human relation aspect be given priority in the design of operational procedures and in the education of crisis managers.

Managing disasters does not rely exclusively on technical instruments. The human factor has a fundamental role to play and it is for this reason that the Council of Europe supports and welcomes the enclosed programme on a Master in Disaster Management.

3.2 Master in disaster Management*:* A proposal for a graduate programme prepared and supported by the European and Mediterranean Major Hazards Agreement (EUR-OPA)- Open Partial Agreement of the Council of Europe

by M. Statheropoulos, European Center for Forest Fires

3.2.1 Aim of the programme

The Master in Disaster Management is a graduate programme that delivers specialized knowledge and skills to those who are already working in coping with all phases of disasters, as well as, to newcomers in the profession of disaster management. The programme is drawing on the experience and networking of the specialized Centers of the agreement, on the knowledge and skills of the faculty and the collaborated organizations.

The programme is strongly focusing on developing operational-oriented knowledge and skills and is using multidisciplinary and integrated approaches. Studies are full or part time and are organized around the following areas:

- Humanitarian Crises and Diplomacy in Disasters
- Public Safety/ Social and Business Continuity in Disasters
- Social and Business Continuity in Disasters
- State of the art Technology in Disaster Management
- Environmental Crises and Health Impacts in Disasters

Students will develop the knowledge and skills to cope effectively with all phases of disaster management and will be able to adapt to the legal system of countries or to the procedures of international organizations.

3.2.2 General principles and courses of the programme

Students must complete totally 21 credits (3 credits per course) for 6 courses and a master thesis. In addition, students should take all 5 basic courses in the hosting organization and then they can take one course from a list of courses carried out in the hosting University or any other collaborative organization. The students are encouraged to prepare a master thesis working on a study on collaborative organizations or at relevant national organizations.

The programme can be completed in 18 months. One year is spend in the hosting University and 6 months can be spend in local, regional, national or international organizations. The hosting University can be in Brussels or Paris in cooperation with the Council of Europe. Students are strongly encouraged to spend the 6 months working on local or national issues so that to make the best use of their knowledge and experience in the country and organization of origin.

Furthermore, students eligible for the programme must have a higher education background. Priority will be given on those already working for local or national public relevant organizations

3.2.3 Structure model

There will be five fixed professors specialized on scientific fields relevant to disasters and disasters management. The main goal is also to have adjunct professors from all the Countries of the European Community that will teach in rotate during the courses. Administration office will be served by 3-4 people. Supervisor for the master thesis will also be assigned.

3.2.4 Scientific areas of the programme

- Humanitarian Crises and Diplomacy in Disasters

It examines the role and intervention of organizations in humanitarian crises and focuses on those that arising from natural disasters. It presents case studies from UN, WHO and the Council of Europe. It emphasizes on cases characterized as national security cases. It demonstrates the role to diplomacy for co-ordinate support. It focuses on legal, cultural and gentre issues regarding disasters.

- Public Safety/ Social and Business Continuity in Disasters

It analyses all elements of public safety and security. It presents successful cases of public safety and early warning systems. It also examines public health in emergencies. It emphasizes on communication issues. It also examines social attitudes regarding disasters. It analyses the status of businesses in disasters. It examines all necessary steps and procedures for securing business continuity.

- State of the art Technology in Disaster Management

It examines all phases of disaster management. It presents and analyses prevention planning, mitigation, preparation, response and recovery. It examines decision support systems, information communication technology (ICT) in disasters, satellite imaging, and geographic information systems (GIS).

- Environmental Crises and Health Impacts in Disasters

It focuses on monitoring the quality of air, water and soil in disasters. It examines technological accidents. It presents field methods and procedures for on-line, on-site monitoring. It examines short and long term health impacts. It presents relevant regulations and policies.

3.2.5 Strengths and weaknesses of the programme

- **Strengths**

1) Council of Europe is an authority in Human rights and ethics
2) Network of more than 40 countries
3) Members' experience in coping with natural disasters
4) Foreign offices and diplomats are central in decision making of the Council of Europe

- **Weaknesses**

1) Not enough experience in management of master courses
2) Complicated and slow decision making procedures through the National Representatives
3) The cost of the courses (10-15.000 euros)

3.2.6 Opportunities and Challenges

- **Opportunities**

1) So far, there is no real master programme in Europe in Disaster Management that has pan-European approval (geographically)
2) Issues relevant to big disasters and threats are becoming quite important for Europe

- **Challenges**

1) This master has to be competitive towards similar masters that are very specific
2) To persuade member states in scientific and operational level
3) To surpass the difficulties that new initiatives encounter (e.g. where to allocate the head offices)