Automated Fire and Flood Hazard Protection System

Auto-Hazard Pro

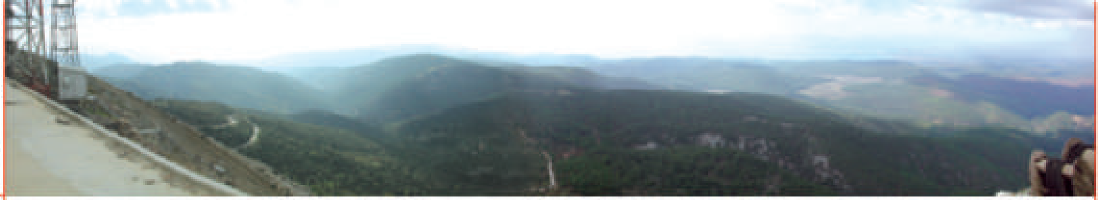
final brochure

Jan 2002 - Dec 2004

en

Web site: www.autohazard.org

The European Commission
Community Research
Energy, Environment and Sustainable Development



AUTO-HAZARD PRO, a European Union-funded research project, has been designed to improve the level of technological development on wildfire and flood risk management in Europe, and therefore, to help authorities on taking the appropriate actions to protect the environment and humans. The Automated Fire Hazard Protection System integrates real-time and on-line fire and flood hazard management schemes into a GIS-type platform. Specific results include:

(i) a geographical data base, with electronic information (i.e., fire occurrence, topography, soils, weather, vegetation, land use, administrative and technical resources) and digital mapping capabilities for natural hazards, fire protection and effects mitigation;

(ii) a Decision Support System dealing with proactive planning and emergency management of real-time fire episodes, including weather data management, geographical data viewer, a priori risk forecasting, automatic fire detection, optimal resource dispatching, and post-fire effects in the format of a flood warning module.

Satellite and GIS Cartography

Multi-spectral QuickBird satellite images (2.5-m resolution) for the whole island of Lesvos, Greece, and for the forest area within the Province of Madrid, Spain, and IKONOS 1-m panchromatic and 4-m multi-spectral data for Samos Island, Greece, were used to extract useful geographical information to study and monitor the wildfires and floods (e.g., fuel models, road networks, land-use boundaries, watersheds and stream networks, etc.).

The appropriate database was developed and integrated into the DSS; the database was also used as input to various simulation models and for mapping purposes.

Figure 2: Fuel model, road network, and land-uses retrieved from QuickBird image mosaic.

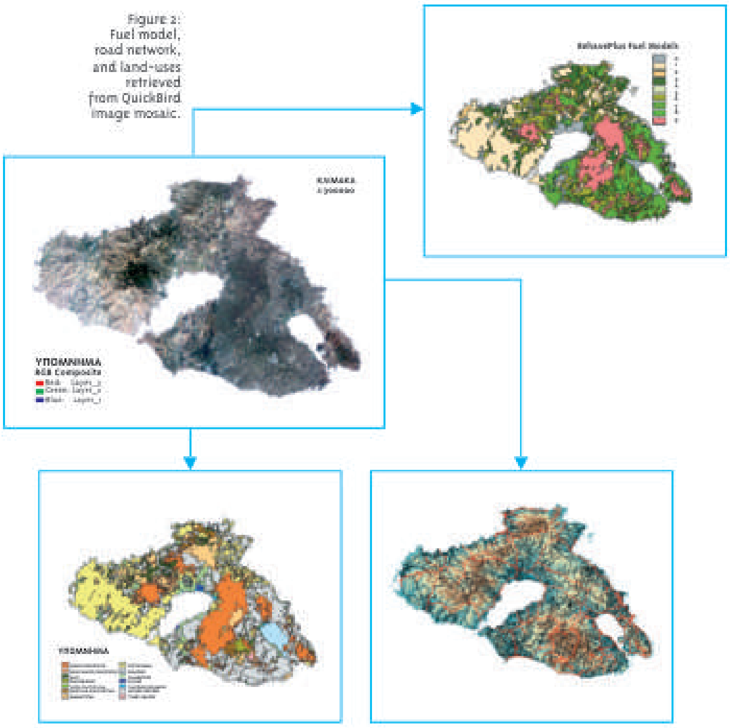
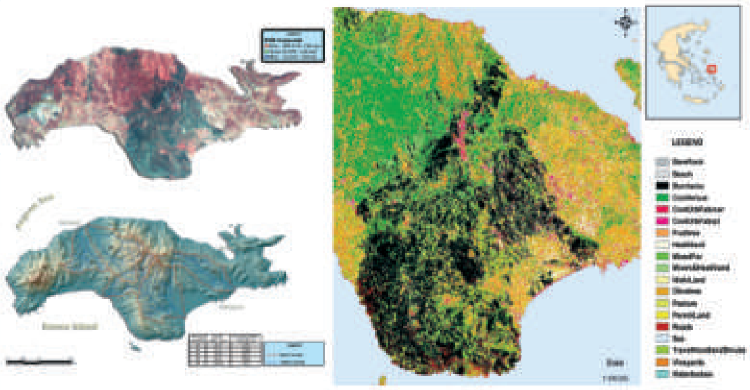


Figure 3: IKONOS mosaiced images, hydrological study and land use map of burned area of Samos Island, Greece, (fire 2000).



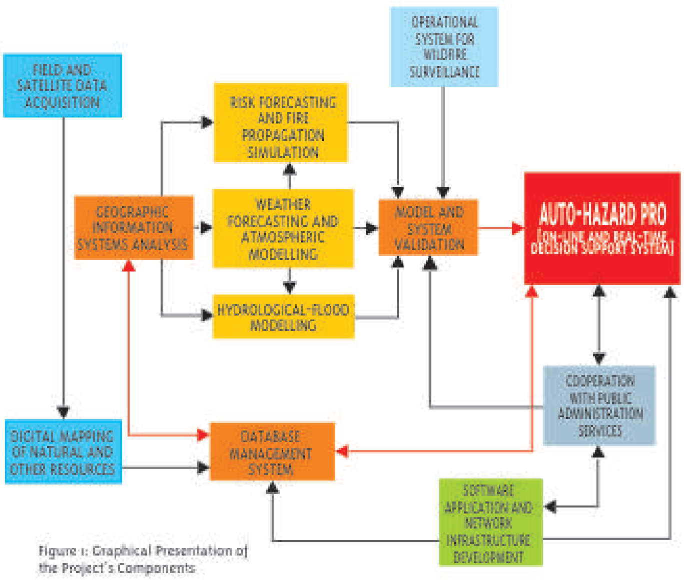
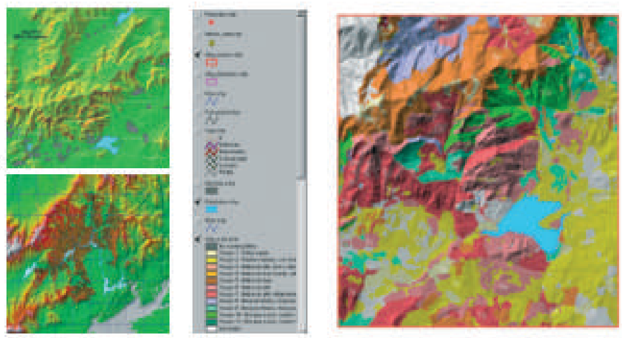


Figure 1: Graphical Presentation of the Project's Components

Figure 4: Topography and forest fuels retrieved from the QuickBird image, in Madrid, Spain.



Collection, input, storage, management and analysis of the information were based on advanced and automated methodologies using remote sensing, GPS, digital mapping and Geographic Information Systems (GIS).

Development of the prototype system was accomplished on 3 study areas in Greece and Spain, with the potential to later encompass whole regions of EU countries on operational basis.

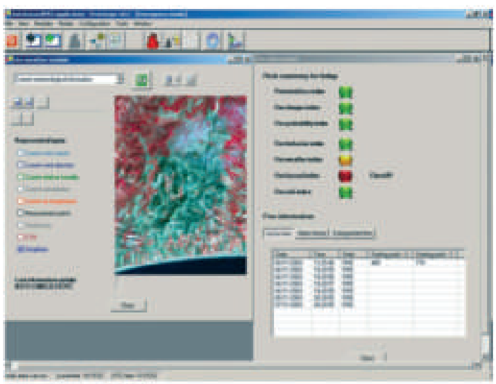


Figure 5: A snapshot of the AUTO-HAZARD PRO DSS.

Software Application and Network Infrastructure

The AUTO-HAZARD PRO Decision Support System (DSS) is the outcome of the program that integrates and automates the methodologies and the scientific results of the work done along the project, by using a user-friendly graphical interface (Figure 5).

It is an integrated system, that when installed in a operational management center can provide to decision makers important information in regard to proactive planning and the level of readiness with the help of danger forecast, the fire detection by using a multi-spectral camera, and the fire simulation. It can also propose to the manager the load of air and ground forces that should be dispatched. Furthermore, it includes functions regarding flood forecast and estimation of soil erosion as a post fire effect.

The DSS philosophy was to create a system that supports effectively its end-users along the whole fire risk management process (and externally flood hazard) by means of a fast and easy to use interface, which allows taking advantage of the capabilities of the diverse technologies, models and systems it integrates (i.e., GIS, communication software, automatic fire detection, fire risk index generation and flood risk generation models). Thus, the user-friendly and efficiently designed application allows the user viewing the meteorological conditions, checking the fire risk in different time horizons, simulating the propagation of a fire or sending messages to fire-fighting resources (Figure 6) through different communication technologies (SMS, e-mail and Net sending).

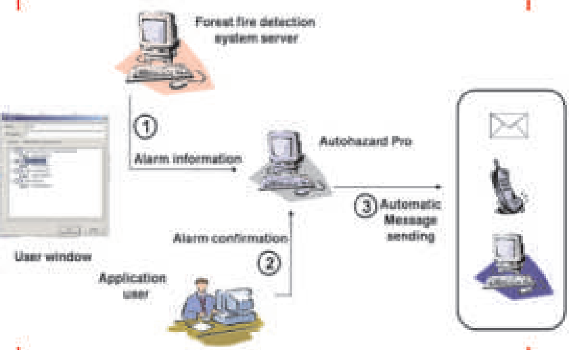


Figure 6: Event message sending.

The AUTO-HAZARD PRO DSS is divided on six main modules that allow the user visualizing different kinds of information and performing different tasks that will support him/her during the whole fire management process.

These modules are: Fire weather module, Fire detection module, Fire danger rating module, Fire propagation simulation module, Resource dispatching module and Flood danger module. The final application provides capabilities of simultaneous visualization of different information (fire danger indices, available resources and active fires), fire alarm information management and resource information management.

Innovative Wildfire Risk Forecasting

An innovative large scale Wildfire Danger Rating System (WDRS) was developed. The main output of WDRS is the Fire Danger Index that is based on Fire Weather Index, Fire Hazard Index, Fire Risk Index and Fire Behavior Index (Figure 7). These indices are not just a relative probability for fire occurrence but a quantitative rate for fire danger appraisal in a systematic manner. Six indices maps are generated for both the current day and the next four ones. The function mapping of the indices is accomplished with Artificial Neural Networks (NN), and the training of NN is based on historical fire data.

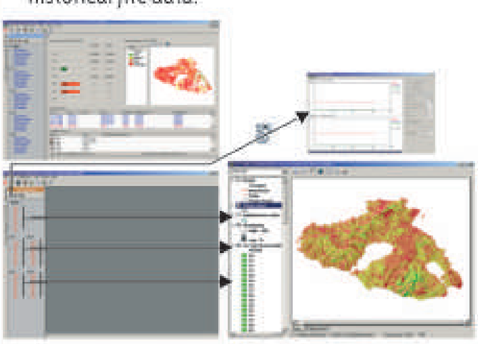
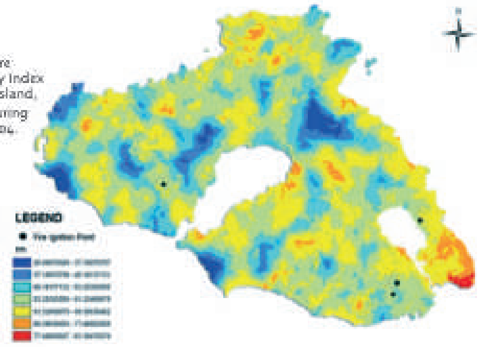


Figure 7: The AUTO-HAZARD PRO fire danger rating module.

The validation of Fire Probability Index was performed during summer of 2004 in the study area of Lesvos Island (Figure 8) and concluded to:

- The fire ignition in Lesvos is depended mainly on human factors, regardless the size of burned area. This is also confirmed by the interrogation files of the Fire Department.
- The operational use had satisfying results. 12 out of 28 fires, from June till September 2004, ignited in areas classified as "Medium Danger" and 16 ignited in "High Danger". No areas classified as "Extreme Danger" while, rarely, very small areas classified as "Very High Danger."
- The Fire Probability Index (FPI) is suitable for mid-term forecast of wildfire danger.

Figure 8: Relative Fire Probability Index of Lesvos Island, Greece, during August 2004.



In addition, the fire propagation simulation estimates the severity of an incipient fire by predicting fire size (area and perimeter), fire spread speed and direction, energy release, flame length and intensity (Figure 9); predicts possible threats and damages (Figure 10); assists to plan tactical operations, and select and dispatch resources (Figure 11).

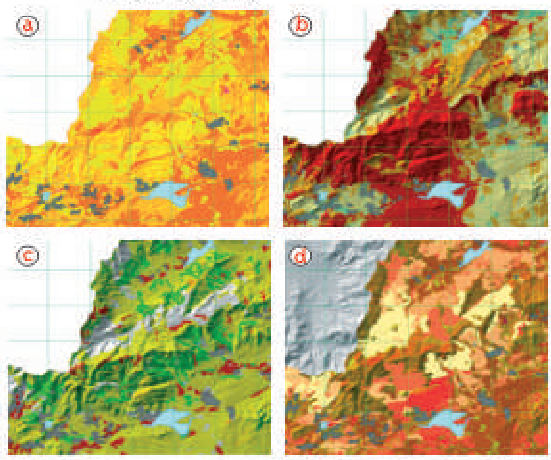


Figure 9: Maps of Linear Intensity (a), Potential Crown Fire (b), Rate of Spread (c) and Potential Loss Index (d) in resolution of 20 m., Madrid Province, Spain.

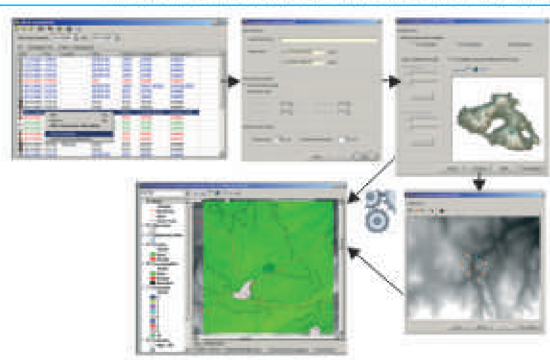


Figure 10: The AUTO-HAZARD fire propagation simulation module.

A wizard guides the user through the steps of the dispatching advice generation. The results can be either saved, printed or sent to external devices.

Figure 11: The AUTO-HAZARD resource dispatching module.

Post-Fire Flood Forecasting and Erosion Hazard

The AUTO-HAZARD PRO has assessed the flood phenomena as post-fire incidents on the island of Samos, after the devastating fires and floods of the year 2000. The selected watershed (i.e., Imbressos River) was studied and the pertinent flood control responses were examined, analyzed and evaluated, particularly considering their range of applicability (Figure 12). The estimation of flood risk in real-time and the long term estimation of soil erosion risk independent of real-time were the two basic aspects of the Flood Module of the AUTO-HAZARD DSS (Figure 13). The Flood Module is based on two separate procedures, namely the preprocessing and the on-site analysis procedure. Two modeling methodologies proposed and developed to evaluate the flood risk of a catchment and estimate the soil erosion in burned catchments using GIS platform for Samos Island (Figure 14).

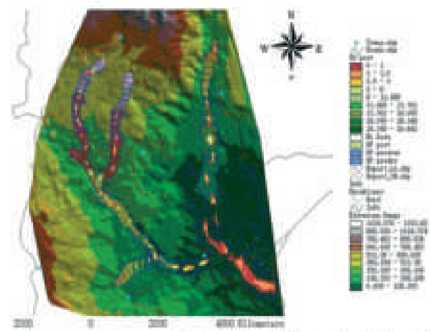


Figure 12: Floodplain analysis (after fire)

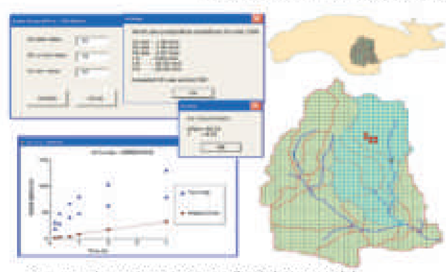


Figure 13: The AUTO-HAZARD PRO flood danger module.

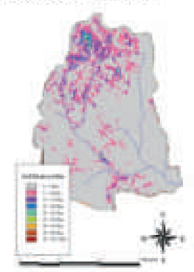
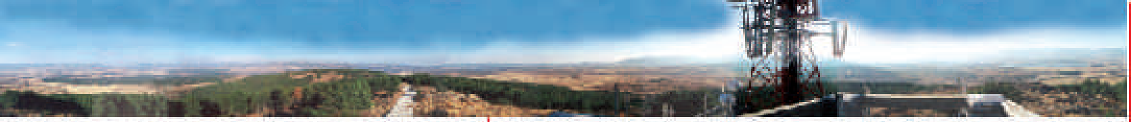


Figure 14: Grid of soil erosion in t/ha.

Automated Forest Fire Detection

A new ground-based forest fire detection system was developed and demonstrated on Lesvos Island, Greece, and near Madrid, Spain (Figure 15). The detection system consists of a multi-spectral camera that detects the smoke via its near-infrared channel and provides

Figure 15: Forest Fire Detection System.



on-line and real-time an NDVI image. Within AUTO-HAZARD PRO, field sensors of fire detection system are linked to selected operational centers, where the manager evaluates the alarm signal and the image to stimulate proper responses (Figure 16). In Figure 17 the alarm is shown as a result of the smoke generated, and the red line combines the detections that are part of the alarm.

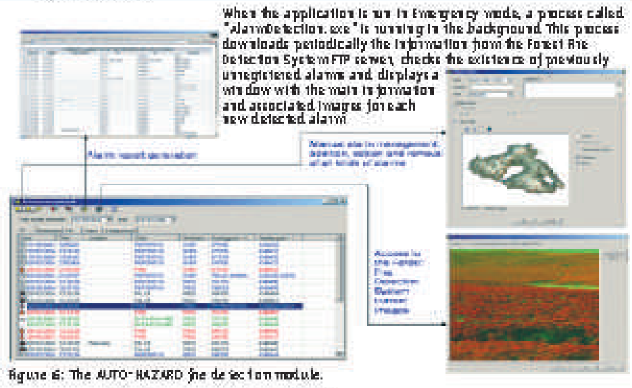


Figure 16: The AUTO-HAZARD fire detection module.

Figure 17: False color image with detections (crosses) and raised alarm (red border around detections).

Operational Weather Forecasting

Within the project, 5-day high resolution weather forecasts are provided by the SKIRON/Eta weather modeling system at approximately 10-km horizontal grid increments for AUTO-HAZARD PRO's study areas.

Figures below show two characteristic meteorological conditions that are directly associated with forest-fire spreading and floods, respectively. In particular, Figure 18 shows an example of the 72nd-hour SKIRON/Eta forecasted wind field over Greece, together with the meteograms for location in Lesvos (Molyvos); the model has predicted high wind speed over the Aegean reaching 12 m/s and 16 m/s in Lesvos Island (Molyvos). Such wind conditions are often related to forest-fire spreading.

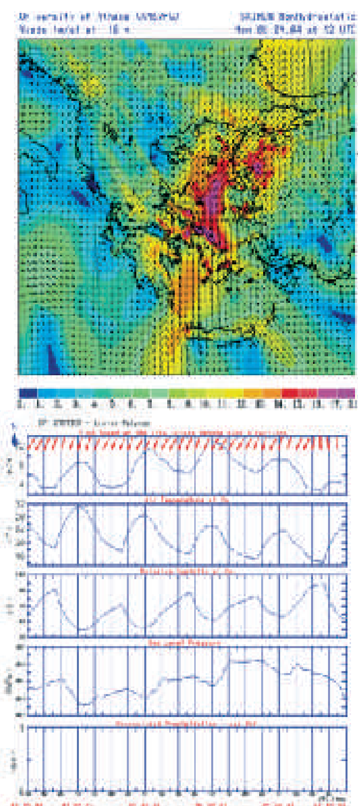


Figure 18: 72nd-hr SKIRON/Eta forecast of the wind field over Greece on 6/9/2004 at 12UTC (left upper pict.) and meteograms for the whole 120-hr forecasting period for Lesvos (left down pict.).

Figure 19 shows the 60th-hour forecast of the accumulative precipitation over Greece together with the meteograms for location in Samos Island (Pythagorio). The model predicted heavy precipitation over the Aegean Sea that may be associated with local flooding. These forecasts were verified by the collected meteorological observations.

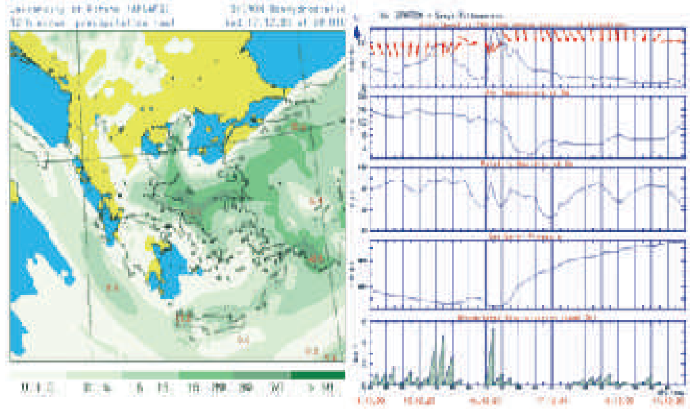


Figure 19: 60th-hr SKIRON/Eta forecast of the accumulative precipitation field over Greece on 17/12/2003 21:00 UTC (left), and meteograms for the 120-hr forecasting period for Samos, Greece (right).

An example of the forecast sequence of the wind field zoomed over Spain with the forecast started at 12 UTC on 14/12/03 is shown in Figure 20, as well as the meteograms for one of the five stations for the same forecasting period.

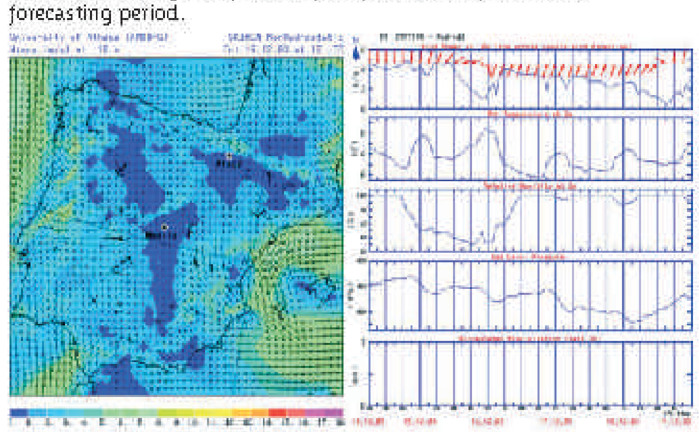


Figure 20: Wind field over the Iberian Peninsula (left), and meteograms for the 120-hr forecasting period for one of the five weather stations in the Madrid Province, Spain. (right)

The best treatment of forest-fire spreading and the accurate prediction of floods are closely connected with the spatiotemporal accuracy of wind and precipitation forecasts, respectively, provided by Numerical Weather Prediction (NWP) models. The statistical analysis performed showed that SKIRON/Eta forecasting skill remains high even for the 5th day forecast (example in Figure 21).

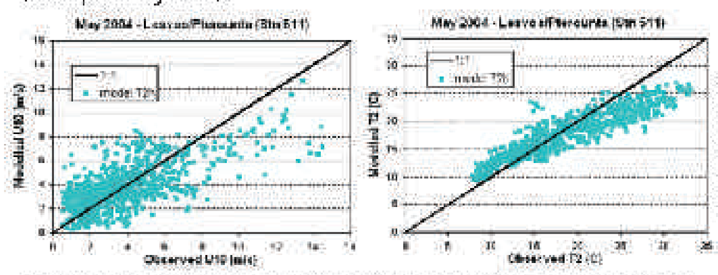


Figure 21: Comparison between observations and SKIRON/Eta forecasts for Pterounta, Greece, in May 2004.

Discrepancies, systematic or not, from the observations always exist. The forecasts were validated with Remote Automatic Weather Stations (Figure 22) observations, and further improvement of the forecasts was carried out by developing and using a Kalman filtering technique to SKIRON/Eta outputs.

Figure 22: Remote Automatic Weather station in Lesvos Island, Greece (e.g., Agia Paraskevi).

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1 1-2 February 2002
Kick-off meeting
General Secretariat for Civil Protection, Athens, Greece

2 15-16 November 2002
1st General Project Meeting
Madrid, Spain

3 2-3 November 2004
Short Project Workshop
Municipality of Buitrago, Madrid Province, Spain

4 10 December 2004
Final AUTO-HAZARD Workshop
Institute of Mediterranean Forest Ecosystems and Forest Products Technology, National Agricultural Research Foundation, Athens, Greece

5 26-29 June 2003
Mid-term review and
2nd General Project Meeting
Lesvos Island, Greece

6 2-3 November 2004
Field demonstration
Municipality of Buitrago, Madrid Province, Spain

7 26-29 June 2003
Field demonstration
Lesvos Island, Greece

The dissemination of the weather forecasts by SKIRON/Eta was achieved via ftp, for the partners and on line meteograms in graphical form from the web page of the group (http://forecast.uoa.gr/forecastnew.html).
The high visibility of the webpage (more that 5,000 visitors per day) ensures the publicity of the project results to a large number of potential users. The project has also been promoted through the Athens 2004 Olympic Games for which weather forecasts were provided together with investigation of smoke dispersion problems for test events.

WEB SITE

The WWW presence of the project (www.autohazard.org) has contributed to its dissemination procedures and as a means of internal project communications.
The Arc Internet Map Server (IMS) cartographic modelling capabilities, the on-line and real-time weather information and the Fire Danger Indices were also uploaded on the project's web site in order to inform the end-users for operational, training and scientific purposes (Figure 23).

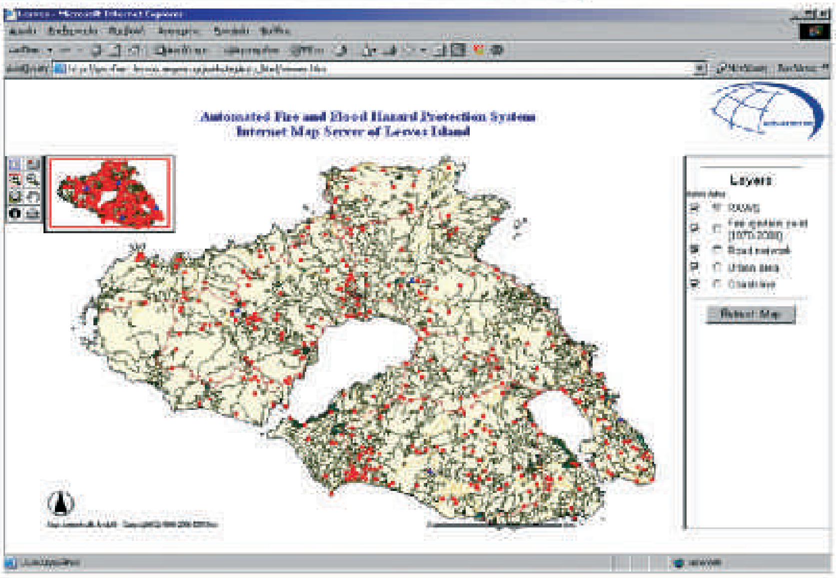

Figure 23:
Main page of Lesvos Internet Map Server