Ambient Systems for the Environmental Monitoring: Characteristic Examples at Different Spatial Scales

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Abstract. This article is a short review highlighting the important role of ambient systems for the environmental monitoring. The article focuses on modern intelligent and fully automated systems that are able to use different kinds of data coming from scientific instrumentation and sensors as informational background in order to identify, analyze, monitor and forecast a vast series of parameters and phenomena that concern the atmosphere, the weather, land and seas. Here some characteristic examples of such systems are presented along with their basic operating principles, their usefulness and their perspectives in the environmental monitoring. Ambient systems have nowadays become essential solutions for the environmental monitoring and they are going to lead to the development of fully automated systems worldwide contributing in the efforts to preserve the Earth's environment.

Keywords: Ambient systems, environmental monitoring.

1 Introduction

Nowadays, the protection of the physical environment (land, ocean and atmosphere) is a major issue worldwide regarding the sustainable future and the improvement of quality of life. The role of computing and informatics is extremely important as can provide advanced automated systems. The recent advances at these two fields have led to modern, fully automated information systems able to handle, analyze, monitor and forecast (or model) a vast series of statiotemporal characteristics, parameters and phenomena that concern the atmosphere, the weather, land and seas.

Especially during the last decade new applications and systems have appeared providing solutions for analytic measuring, recording and monitoring of parameters and phenomena from local to large scale (Triantafyllou et al. [14], Chronis et al. [3] Kazantzidis et al. [7], Garcia-Sansez et al. [4], Hwang et al. [6]). Such systems belong to the "ambient systems" considering their general operational principles. Usually, they are based on networks of instruments/sensors (Fig. 1) and are deployed to improve environmental quality control, for example to monitor humidity and

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temperatures in agricultural and other environments. Actually, the notion of ambient systems embeds the idea of large-scale heterogeneous systems being able to sense, network, inform, actuate and interact with the physical environment and the human. "These systems are at the heart of the next generation information technology, which will no longer be limited to dedicated infrastructures, such as the Internet, but will be embedded in artifacts and the environment and will consist of highly distributed, networked, heterogeneous, and largely self-organizing devices".

Ambient systems are developed and operated in different environmental applications accomplishing the special needs that are designed to serve, and providing by fully automated and intelligent way: data, products and solutions, by minimizing problems and diffusing information accurately and timely to the scientific community, governments, agencies, organizations and the citizens. Such systems provide environmental monitoring by measuring and analyzing environmental data over an unprecedented range of space and time scales using large-scale sensor networks, so that to accurately assess the impact of global warming, recognize and predict natural hazards (i.e. avalanches, floods, dangers, earthquakes, diseases), and support and manage sustainable land, water, and resource use. The general concept of ambient systems for environmental monitoring can be seen in fig. 1, differentiate according to the application but keeping the same, the general operating principles.

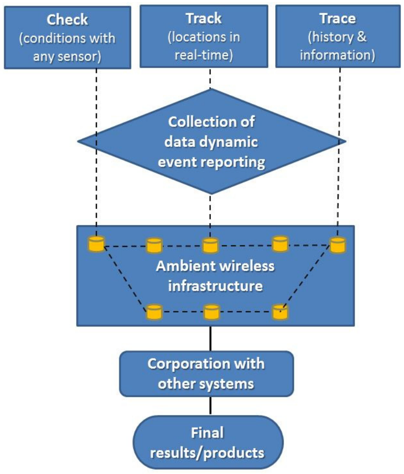


Fig. 1. General scheme of the ambient systems

2 Satellite Dissemination Systems

The most advanced, worldwide known and widely used ambient systems are the satellite data dissemination systems. Such systems have been operating for decades, they are continuously improved and expanding so that to cover the increasing needs of the scientific community. The sensors on board at the satellite platforms can collect all the appropriate information and automatically disseminate in real time basis on a network of ground stations. After all the necessary validation checking and the conversion on higher quality level data and products, all the users have access to such data and products in real time basis using their own ground station or as archived data from many dissemination facilities.

In Fig. 2 the dissemination system of Meteosat Second Generation (MSG) satellite data and products is presented as a characteristic example. The EUMETSAT (European Organization for the Exploitation of Meteorological Satellites) Application Ground Segment comprises a central processing facility and a distributed network of Satellite Application Facilities (SAF) that provide the necessary research, development, and generation of level 1 and level 2 satellite products for onward dissemination to the user community. The Central Application Facility (CAF) is responsible for the generation of level 1 processed satellite data and the generation of higher level 2 products, which primarily support the application needs for Nowcasting and Numerical Weather Prediction (NWP). The Satellite Application Facilities (SAFs) are a distributed network of thematic application facilities responsible for necessary research, development, and operational activities not carried out by the central facility.

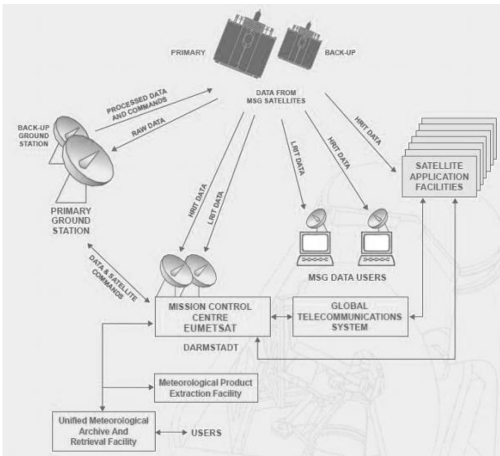


Fig. 2. A schematic data flow of Meteosat imagery from the satellite instruments to the user community network through validation, storage and product generation facilities

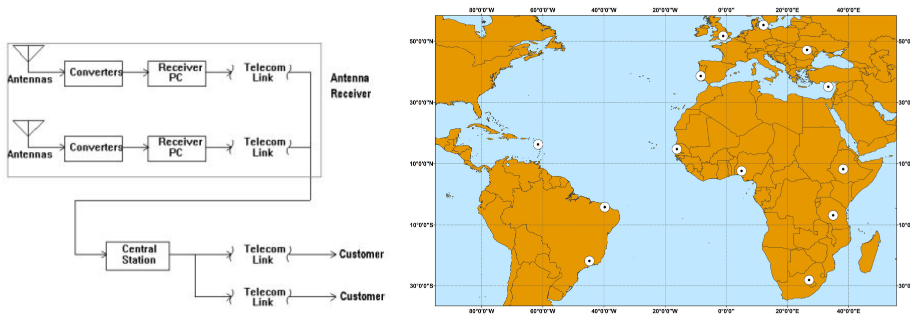
3 Large Scale Ambient Systems

There are two important sub categories of large scale environmental monitoring systems: the lightning detection systems and solar radiation systems.

3.1 Lightning Detection Systems

An interesting and important category of ambient systems is the networks of ground based sensors used to record lightning events during thunderstorms (e.g. “BrazilDAT”, “LINET”, “ZEUS”, “ATD”, “WWLLN”). The measurements of lightning events play a crucial role in the accurate detection of convection (e. g. Tadesse et al. [13], Mattos et al. [11]) and consequently they can provide valuable information to risk management and protection agencies. Such systems have increasingly developed and compared regarding their accuracy and their usefulness (e.g., Lagouvardos et al. [10], Kohn et al. [9])

A characteristic example of such systems is the Long Range Lightning Detection System with the code name "ZEUS" (Chronis et al. [3], Lagouvardos et al. [10]). The sensors of this network (Fig. 3b) can detect radio frequencies (sferics) released from lightning events at a range between 5 and 15 KHz (Chronis et al. [3]). The geographic location of every lightning event is calculated through a technique called "Arrival Time Difference Triangulation" and transmitted in real time basis to the central station of the network for further analysis, dissemination to the users and storage in the relative databases (Fig.3a).



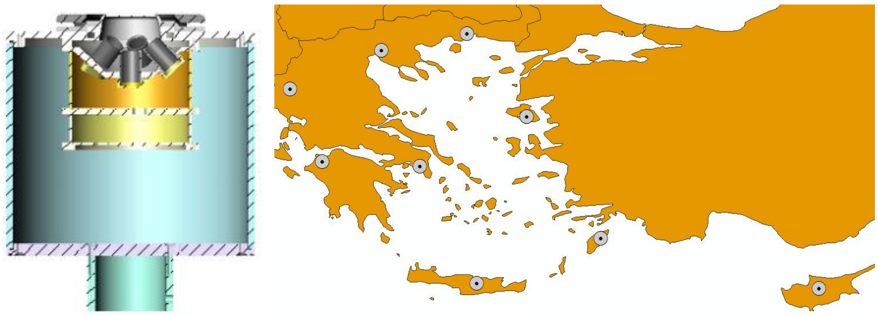
(a) **(b)**

Fig. 3. a) A schematic flow chart of the operational stages of the ZEUS system, b) Geographic locations of the ZEUS sensors network at (green dots)

3.2 Solar Radiation Systems

The downwelling solar radiation is vital for every kind of life on Earth. Traditionally it is measured through scientific instrumentation at different locations. The spatial distribution of upwelling radiation can be measured accurately using sensors on board on the satellite platforms. But the downwelling radiation it can be measured. To alternate this restriction, especially during the last decade networks of instruments that measure downwelling radiance in many spectral regions has been developed so that to provide more information about the energy balance variations in the Earth's environment.

A characteristic example of such systems is called "UVNET". More analytically, since 2003, a Greek UV (UltraViolet) Network has been established and operated a number of stations in Greece and Cyprus (Fig. 4b). The instruments of the network are multichannel filter actinometers (Fig. 4a) and provide measurements of irradiance in the UV and the visible part of the solar spectrum. Other atmospheric parameters such total ozone, erythemal UV dose, cloud transmittance and photolysis rates can also be calculated using this network of sensors (Bais et al. [2], Kazantzidis et al. [7], Kazantzidis et al. [8]). The final products of this system are presented in daily basis on the official website of the network (www.uvnet.gr).



(a) (b)

Fig. 4. a) Schematic representation of the actinometers used for measurements in the UV spectrum. b) The UV network (gray dots).

4 Micro Scale and Local Scale Ambient Systems

The most common ambient systems at micro or local scale for the environmental monitoring are those who are used in the agriculture sector. Indeed, it is well known that the monitoring of different parameters of interest for crops is a useful tool for improving agricultural production (e.g Garcia-Sanchez et al. [4], Zhu et al. [15], Alippi et al. [1]). On these issues, the Wireless Sensor Networks (WSNs) have been proven very useful with high accuracy according to the provided measurements (e.g. Hwang et al. [6], Zhu et al. [15], Garcia-Sanchez et al. [4], Quynh et al. [12]). A wireless sensor network is composed of a number of sensor nodes which usually have small volume, low cost and low power consumption (Zhu et al. [15]). The sensor nodes record data autonomously. The recorded information from the sensors is transmitted to a server and collected in a database for further analysis and/or provision to the users (Fig. 5). Some systems send commands to the nodes in order to fetch the data, while others allow the nodes to send data out autonomously (Hart et al. [5]).

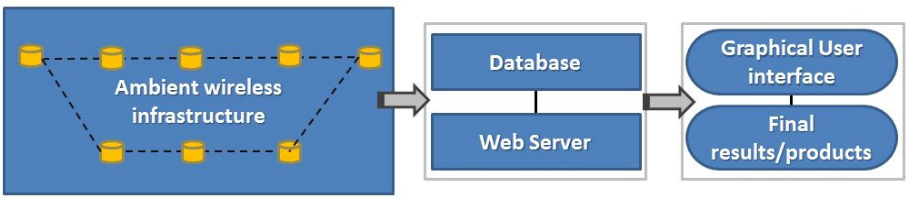


Fig. 5. Generic schematic data flow in an environmental system based on sensor network

5 Variant Scale Ambient Systems

A classical form of ambient systems for the environmental monitoring is the meteorological station networks. Such networks are installed and operate at all scales (from local to global scale) usually through the collaboration among different organizations and institutions (Fig. 6). The recorded data of each of the stations within a network are being transmitted automatically in the central station of the network in order to be validated and/or used for climatological and meteorological analyses. It is mentioned also that these networks are essential to provide with initial conditions the Numerical Weather Prediction (NWP) models that are used for weather forecasting. At this point, it is mentioned that the most commonly used meteorological networks in Greece, belong to the Hellenic National Meteorological Service (www.hnms.gr) and the National Observatory of Athens (www.meteo.gr)

Fig. 6. An example of the several meteorological station networks that operate providing to the public, in real time basis, significant meteorological parameters (http://www.meteogreece.net/)

6 Conclusions

Environmental ambient systems provide innovative ways to monitor the environment, opening new horizons and perspectives in many scientific fields that study the Earth and its characteristics in land, seas and atmosphere.

Networks of instruments and/or sensors can be operated with modern, fully automated methods are of vital importance in the environmental monitoring because can provide on a real time basis accurate information, not only in time but in space too.

As above mentioned, these systems record, collect and monitor specific environmental parameters, more generic parameters like meteorological, or other spatial and temporal parameters. Moreover, after the data storage in a server database, all the collected datasets can be analyzed and/or visualized using a Geographic

Information System (GIS), combined with a satellite image and/or map and published via the Web providing to the users easy access to the relative information.

According to different kinds of monitoring requirements, it can be realized by changing the type of sensors (or instruments) that different environmental issues such as forest fires, agriculture, floods and a vast series of parameters and phenomena can be monitored.

Therefore, such networks of sensors/instruments applied for environment monitoring, play an important role which leads to strengthening the protection of the environment in the near future.

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