Greek report on activities with respect to the GCOS Implementation Plan

Submission to the United Nations Framework Convention on Climate Change (UNFCCC)

Hellenic Ministry of Environment, Energy and Climate Change

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Contents

Introduction

This report constitutes the submission of Greece on progress with the GCOS implementation plan, as described in decision 11/CP.13. It provides additional information on national GCOS activities using the revised "UNFCCC reporting guidelines on Global Climate Change Observing Systems" (FCCC/SBSTA/2007/L.14/Add.1).

The structure of this report and the caption numbering of the tables included follow the structure described in the above mentioned guidelines.

1. Common issues

Systematic observations of the Greek environment started immediately after the Revolution of 1821 and the foundation of the Modern Greek state in 1829. In 1846, the National Observatory of Athens (NOA) was established, aiming at promoting the observations of astronomical and other parameters of natural science. In its 170 years history, the observatory on top of the Hill of the Nymphs (landmark in Athens, facing the Parthenon) has long been used by Greek and foreign Astronomers as the basis for astronomical, meteorological, geoastrophysical measurements and observations. Nowadays, NOA hosts the UNESCO Chair for Natural Disasters and operates the National Seismological Network and it is participating in the OPTICON and other international research networks, hosting the Greek Focal Point on the Global Earth Observing System of Systems (GEOSS).

In 1896 NOA was expanded with the addition to the Astronomical Department of two new, the Meteorological and the Seismological. In 1942 the Departments were named Institutes and in 1955 the Ionosphere Institute, was added. In 1999 the names of the institutes of NOA were updated and five Research Institutes was operating: Institute of Astronomy and Astrophysics (IAA), Institute for Space Applications and Remote Sensing (ISARS), Institute of Geodynamics (GI), Institute of Environmental Research and Sustainable Development (IERSD) and finally in 2003 the Institute of Astroparticle Physics "NESTOR" became the fifth institute of NOA. After a major reform in the structure of all research institutes in Greece in 2012, two of the institutes of NOA were merged (Institute of Astronomy and Astrophysics (IAA) and the Institute for Space Applications and Remote Sensing (ISARS) merged to form the Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing) and one (NESTOR) moved under another administrative unit (Institute of Nuclear and Particle Physics, National Center for Scientific Research, DEMOKRITOS). Currently NOA has the following three institutes:

- Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing (IAASARS)
- Institute for Environmental Research and Sustainable Development (IERSD)
- Institute of Geodynamics (GI)

IAASARS, besides the research and educational activities, is evolved in carrying out other activities and providing services to the scientific community and for public outreach. The activities of the Institute encompass a wide area in Space Research and Applications. Its main objective is to carry out R&D projects in these fields, which include Space and Ionospheric Physics, Remote Sensing, and Wireless Communications. Additional activities include: systematic collection and processing of data derived from observations made in space or from the surface of the earth, performance of autonomous studies in other specific subjects of space research and applications, etc.

The Institute of Environmental Research and Sustainable Development (IERSD) has been performing continuous meteorological observations for over 150 years at Thissio site. As a result, it has the largest, most complete and reliable climatological records in the country. These observations include measurements of air & ground temperature, relative humidity, wind speed, wind direction, barometric pressure, evaporation, rainfall, cloudiness, visibility, sunshine duration and miscellaneous

phenomena. Solar radiation and more recently daylight measurements are also recorded at the meteorological station at Thissio.

Since 2000, meteorological data are available on a routine base from the IERSD meteorological station at Penteli site. These data include measurements of air temperature, relative humidity, wind speed, wind direction, barometric pressure, rainfall, as well as solar radiation & daylight. The data are available in a database and they are published every year in the Climatological Bulletin, which is edited by the Institute. There are also a number of research teams in IERSD active in the following thematic areas: Air Pollution/Quality, Energy Conservation, Atmospheric Research, Energy Planning & Sustainable Development, Environmental Impact and Health Assessment, Climate, Weather, Water & Sustainability, Radar Meteorology / Remote Sensing and Instrumentation Servicing.

Since 1858, the IERSD has been operating a complete first-class meteorological station. Up until 1931, the IERSD was the main meteorological establishment in the country, operating almost all the existing network of meteorological stations. In 1932, the operation of all stations was undertaken by the newly founded Hellenic National Meteorological Service (HNMS). The operation of HNMS comprised part of the Meteorological Institute in NOA until 1934, when it is transferred to the Ministry of Aviation and its mission was to cover all the meteorological and climatological needs of the country. It is based at the former Athens International Airport at Elliniko, and operates under the auspices of the Hellenic Air Force, staffed by both military and civilian personnel.

In 1954, NOA starts the first program to measure solar radiation parameters, and in 1965 establishes an air pollution monitoring network for Athens, which continued operation till 1975 when it was transferred to the newly founded air pollution directorate of the Ministry for the Environment, Physical Planning and Public Works (now the Ministry of Environment Energy & Climate Change (MEECC)).

Greece is among the countries with very high earthquake activity because of its location at the confluence of 3 tectonic major plates. GI is one of the oldest Institutes in Greece operating continuously since 1893. In 1897 the first seismograph was installed in Athens and in 1899 the first seismic network started to operate. Since then, systematic and detailed seismic observations started for the region extending from 34° to 42° N and 19° to 30° E. The location of the Head Office of GI is on the hill of Nymphs, opposite to Acropolis, at the center of Athens. It is the main center in Greece, for the continuous monitor of the seismicity of the country and reporting to national and international authorities.

In view of the geography of Greece (18400 km of coastline, 9835 islands), and the historical preoccupation with the sea (fishing, trading and shipping), the Institute of Hydrographic Office is founded in 1905, under the Hellenic Navy General Staff, which begins systematic observations of currents, salinity, sea surface temperature and other sea state marine parameters. In 1906 the first hydrographic survey was performed while in 1908 the first nautical chart was published by the Hellenic Navy. In 1919 was funded the International Hydrographic Organization (IHO) and Greece participate as founding member. In 1921 the Hydrographic Office is upgraded to forms to an independent service of the Hellenic Navy (Hellenic Navy Hydrographic Service (HNHS) under the Hellenic Navy General Staff, which is responsible, among others, for the establishment and operation of a network of permanent stations for measuring and collecting hydrographic, oceanographic cartographic and navigation

information, with the aim to: support the operational requirements of the Hellenic Navy and the Hellenic Forces in general, Contribute to the safety of Navigation, Promote the Hydrography, Oceanography, Cartography and other Marine sciences, support, in case of request, of public services and private sector, etc..

In 1945, the Hellenic Hydrobiological Institute of the Academy of Athens was founded in Piraeus, incorporating the Hydrobiological Station in Rhodes (Reale Istituto di Ricerche Biologiche) which had been set up by the Italians during their occupation of the Dodecanese. In 1965 the Hydrobiological Institute of the Academy of Athens was amalgamated with the Laboratory of Fisheries Studies, forming a new body, the Institute of Oceanographic and Fisheries Research (IOFR), which became fully functional in 1970. Fifteen years later, in 1985, as a result of new research legislation (law 1514), the National Centre for Marine Research (NCMR) was established. The latter organisation had evolved from the previous one (IOFR) although it was now a public sector organisation under the jurisdiction of the General Secretariat of Research and Technology, part of the Ministry of Industry, Energy and Technology (now the Ministry of Development). The NCMR thus became the main vehicle of marine research in Greece. In 1987, further progress was made with the establishment of the Institute of Marine Biology of Crete (IMBC) in Heraklion, Crete. IMBC rapidly developed and played an important role in the areas of marine biology, fishing and aquaculture. The integration of NCMR and IMBC took place on June 3, 2003, consequent upon enactment of Presidential decree (law 2919/25.6.2001). The new organisation, a public sector body operating under public sector regulations, is called the Hellenic Centre for Marine Research (HCMR).

In 2001, Greece became associated and then, in 2005, full member of the European Space Agency (ESA), participating in all the core activities of the Agency, including those of Global Monitoring of Environment and Security (GMES). The ESA activities are at present coordinated by the General Secretariat for Research and Technology (GSRT) of the Ministry of Education and Religious Affairs, Culture and Sports.

The network of systematic observation of climatic parameters in Greece includes the Hellenic National Meteorological Service (HNMS), services of the Greek Armed Forces, the Ministry of Rural Development and Food, the Ministry for the Environment, Physical Planning and Public Works, as well as a number of national research centers. Furthermore, the Public Power Corporation of Greece (PPC) operates a network of meteorological stations in the vicinity of its thermal and hydro power plants and dams for electricity production.

2. Atmospheric essential climate variables

Overview

The main institutions that contribute to the national oceanic observations are the Hellenic National Meteorological Service (HNMS, http://www.hnms.gr/hnms/greek/index_html), the National Observatory of Athens (NOA, http://www.noa.gr), the National Agricultural Research Foundation (NAGREF, http://www.nagref.gr/), the Atmospheric Physics Laboratory of the Aristotle University of Thessaloniki (AUTH, http://lap.physics.auth.gr/), the Centre of Renewable Energy Sources (CRES, http://www.cres.gr/kape/index.htm), the Atmospheric Modeling and Weather Forecasting group (AM&WFG, http://forecast.uoa.gr/about.php) of the National and Kapodistrian University of Athens (School of Physics, Division of physics of Environment-Meteorology) and the Laboratory of Hydrology and Water Resources of National Technical University of Athens (School of Civil Engineering/ NTUA, http://hoa.ntua.gr/).

Measurements of meteorological parameters

The Hellenic National Meteorological Service (HNMS) operates a network of 79 land surface and 3 upper air measurement stations. In addition, all of them are registered to World Meteorological Organization (WMO). The available data time series cover a period of 35-40 years. The majority of the stations have been in operation since 1955.

The Ministry of Rural Development and Food (MRDF) has been operating a large network of agrometeorological stations, some of which have been operating for more than 50 years. In the last years, after a complete refurbishment, 40 of these stations are operating under the supervision of the Directorate of Agricultural Research and Applications of the Ministry, and provide a full and continuous set of data, which are collected and stored centrally. Another 120 agrometeorological stations are operated by two different Departments of the Ministry of Rural Development and Food and the Ministry of Environment Energy & Climate Change (80 of them by the General Directorate of Plant Production (of MRDF) with the rest divided between the Special Secretariat for Forests (of MEECC) (former Department of Forests of MRDF) and the Department of Land Reclamation (of MRDF). Measurements are taken automatically every minute and averages are recorded every hour (except for precipitation which is recorded every 10 minutes in order to capture intensity).

The Institute of Mediterranean Forest Ecosystems and Forest Products Technology is part of the National Agricultural Research Foundation (NAGREF), which in 2011 merged with three other organizations of the Ministry of Rural Development and Food forming the Hellenic Agricultural Organization “DEMETER” to which the Institute now belongs. The Institute operates a network of 21 additional meteorological stations in forest area since 1960, which was refurbished in 1994 so as to become fully automated. The stations cover mostly forest areas, while the data are fed into a database of meteorological information that covers a period of 40 years.

The National Observatory of Athens (NOA) also operates two 1st class meteorological stations in Athens (in Thissio since 1842 and Penteli since 1998). These stations measure, on a continuous basis, air temperature, barometric pressure, rainfall, relative humidity, wind direction and velocity, along with a full set of solar radiation parameters. The availability of data time series varies from 10 to 50 years in relation to the respective station and measured parameter. Since early 2006, NOA has started the installation of automated meteorological stations along the country. Till

July 2012, have been installed more than 240 stations (Figure 1). These stations measure and record every 10 minutes temperature, relative humidity, pressure, rainfall, wind direction and velocity, while 4 of them measure and record every 1 minute. The historical data and real-time provided by the websites: http://penteli.meteo.gr/meteosearch/, http://www.meteo.gr/observations.asp & http://www.meteo.noa.gr/WeatherOnLine respectively.

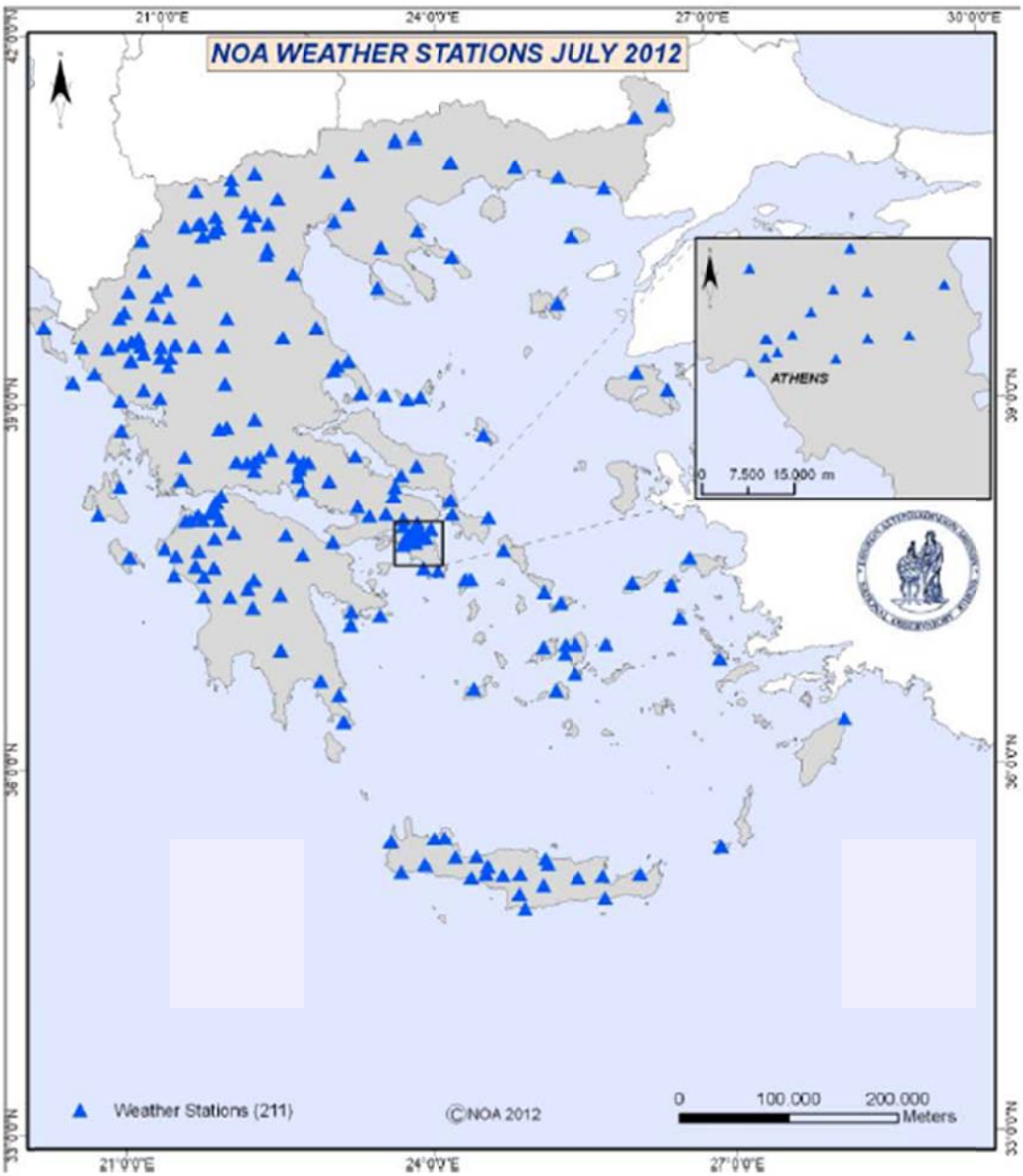

Figure 1. NOA Meteorological stations network.

A number of national research centres, namely the National Center for Scientific Research 'Demokritos', the Centre of Renewable Energy Sources (CRES) and universities (National Technical University of Athens, Aristotle University of Thessaloniki, University of Patras, University of Ioannina, University of Athens, University of Crete), also operate meteorological stations. The time series of these stations vary in length from a few years to a few decades, and their data are widely available:

- National Centre of Scientific Research "**DEMOKRITOS**" operates two meteorological stations, one of which measures aerosol parameters.
- In the wider area of Athens (687 km^2), 15 fully automatic telemetric hydrometeorological stations are installed and already operating in the framework of the METEONET network. This network was developed by members of the **Laboratory of Hydrology and Water Resources** and is supported by the Computer Center of the **National Technical University of Athens** (School of Civil Engineering). The measurements performed by the METEONET network concern air temperature and precipitation, wind speed gust and direction, relative humidity, solar radiation, net radiation and sunshine duration, whereas the Zografou station performs also measurements of air pressure and water vapour. All data measurements are publicly available at the webpage of the METEONET project (http://hoa.ntua.gr/). The data are collected every ten minutes and updated (in the webpage) every 8 hours on a daily basis. Historical data, concerning the period of operation of each station (2005-now) are available on demand. These data are not provided to any international data centre and are used for national purposes only at the moment.
- The University of Patras-Laboratory of Atmospheric Physics (LAPUP) operates an automatic weather station located at 38° 17’ 31’’ N longitude and 21° 47’ 18’’ E latitude. It consists of an 11-m high weather mast. The instrumentation is positioned at the appropriate height (10 m) via a motorized system, in order to facilitate its regular calibration. The meteorological parameters measured are: wind velocity and direction, air temperature and relative humidity, pressure, global and diffuse solar radiation, rainfall amount and rate. The instruments are calibrated according to current international standards. Data acquisition is performed using a Campbell Scientific data logger. Data are acquired every 30 s and 10 min average values are stored. The averaging period can be modified according to the requirements of specific field experiments. Raw data is stored and checked for inconsistencies, prior to its use, via quality control software developed by the LAPUP. Detailed metadata records are maintained.
- The **Laboratory of Meteorology** of the **University of Ioannina** (Department of Physics) operating ten meteorological stations and one environmental in several locations: University of Ioannina, Island in the lake of Ioannina, Metsovo in Ioannina, Koronisia in Arta, Vourgareli in Arta, Ammoudia in Preveza, Trapeza in Konitsa, Kalpaki in Ioannina, Lorida Sagiadas in Thesprotia, Paramythia in Thesprotia. The stations measure temperature, humidity, wind, pressure, radiation, rain and temperature/humidity of fuels. The station in the University of Ioannina also measures evaporation, UVA, UVB, infrared, lighting, etc.. The environmental station located in the suburbs of Ioannina and measures PM10, PM2.5, NO_x, O_3, BTX, etc..
- The **Department of Meteorology and Climatology** (DMC) of the **Aristotle University of Thessaloniki** (School of Geology) established the Olympus Meteorological Center which operates a station monitoring atmospheric essential climate variables (Precipitation, Temperature, Atmospheric Pressure, Wind Speed, Wind Direction, Relative Humidity, Radiation, Net Radiation).
- The **Laser Remote Sensing Unit** is located in the Laboratory of Laser Development and their Applications of **National Technical University of Athens**-(Physics Department). The infrastructure currently available at LRSU

includes: 1) a 6-wavelength (elastic and Raman) aerosol/water vapor lidar system operating at 355-387-407-532-607-1064 nm (0.5-14 km), 2) a mobile single-wavelength elastic backscatter lidar system, equipped with a 532 nm polarization detection channel, 3) a 4-wavelength (266-289-299-316 nm) DIAL system for ozone monitoring in the lower troposphere (0.5-6 km), 4) a fully equipped meteorological station for in situ P,T,U, rainfall and wind measurements, 5) total ozone and aerosol optical depth (IR) measurements capabilities using the Micro-TOPS II technology.

- The **group of Meteorology and Klimatology** of the **Department of Environmental Physics-Meteorology** in **University of Athens** (School of Physics) monitoring a Data Base of daily Temperature and Rainfall at 20 surface stations covering Greece.
- The **Environmental Chemical Processes Laboratory** (ECPL) of University of Crete (Department of Chemistry) operates a meteorological station at Finokalia (35^o 20'N, 25^o 40'E) on the north coast of Crete. The meteorological parameters monitoring are: Temperature, Relative Humidity, Solar Radiation, wind speed and direction height of Rain. Data acquisition is performed using a Campbell Scientific data logger. Data are acquired every 5 min.

The Ministry of Rural Development and Food and the Ministry of Environment, Energy & Climate Change operate a large network of rain gages and snow gages. The network consists of more than 250 rain gages and 1000 snow tables.

Measurements of atmospheric electricity discharges

The National Observatory of Athens (NOA) has been operating a network of stations aimed at detecting lightning strikes. The network consists of 6 recording stations, located in the UK, Denmark, Romania, Italy, Cyprus, Portugal and Greece. It has been in operation (detection and recording) since 2005, covering a major part of Europe, whole Mediterranean Sea area and part of northern Africa. The lightning-strike data provide real-time information regarding the location of thunder cells and severe rainstorm activity. This is crucial information for predicting floods and providing more accurate local forecasts. This information is provided to the meteorological community via Internet (http://www.noa.gr/forecast/lightning.gif).

Meteorological RADAR

HNMS has a network of meteorological radars

- 4 C-band Doppler
- 2 C-band Doppler/dual polarization
- 2 S-band Doppler

The above-mentioned network is fully automated, covers the major part of the territory of Greece (limited coverage of south west area), carries out two kinds of scanning (short range: 150Km and long range: 250Km/ 400Km for C-bands/ S-bands respectively), with a frequency of 15 min. The network is to operate in full scale as from October 2008. Moreover, NOA operates a mobile X-band/dual polarization meteorological radar. This radar is used for research purposes (http://www.meteo.noa.gr/ENG/iersd_radar.htm).

Wind Measurements

The Centre of Renewable Energy Sources (CRES) and several companies have established and operate wind measurement masts, usually of 30m height, for the

collection of data to estimate wind energy potential and identify possible locations for the establishment of wind parks. The number of masts varies with the needs of possible wind park developers. CRES has performed wind measurements in more than 30 places, in various regions of Greece (Cyclades, Crete, Ionian Islands, Peloponnese, Attica, Evia, central Greece). Also maintains permanent stations recording wind data in Andros and Agia Marina in Lavrion. Data collected, apart from the ones collected by CRES, are not available free of charge.

Ozone and UV-radiation measurements

Aristotle University of Thessaloniki (AUTH) and National Technical University of Athens (NTUA) have been monitoring the total (column) ozone amount at two locations on a continuous basis for more than 30 years. Since 2005 total ozone is derived also at the 9 stations of UVNET (described in this section) from multifilter radiometer data.

The Laboratory of Atmospheric Physics (LAP) in Aristotle University of Thessaloniki hosts the World Ozone Mapping Center, which utilizes measurements from the 100 stations of WMO Global Ozone System (part of GAW) and of TOMS (Total Ozone Mapping Spectrometer) to generate and archive global maps of total ozone column (http://lap.physics.auth.gr/ozonemaps/). Furthermore, the Institute of Mediterranean Forest Ecosystems and Forest Products Technology of NAGREF, also measures (since 2003) average monthly ozone concentration in 3 forest areas (in Vatada near the town of Amfilohia at 350 m height, St Nicolas in the Evrytania province at 1120 m height and on Ossa mountain at 740 m height) and in Athens (Ano Ilisia).

At the station of Thessaloniki (AUTH-LAP) solar UV radiation is monitored since the beginning of the 1990s with 2 spectroradiometers providing spectral irradiance measurements several times during the day. The UV-A, erythemal irradiance (UV-B) and total solar radiation are measured continuously since 1981, 1991 and 1993 respectively.

However, since 2004 a team effort coordinated by the Laboratory of Atmospheric Physics (LAP) of the Aristotle University of Thessaloniki (AUTH) resulted in the establishment of the National Network for Monitoring of Solar UV Solar Radiation, UVNET (www.uvnet.gr), that aims at the long-term monitoring of solar ultraviolet radiation over Greece and Cyprus, with the following goals:

- Studying of the effects of UV exposure on human beings and the ecosystem, as well as the short-term forecast of UV radiation levels.
- The awareness of the public concerning their protection from the biological effects from their exposure to ultraviolet radiation.
- Providing of continuous and reliable information to all relevant public organizations, national or international organizations, health services and also to any citizen for the actual level and the possible effects from the exposure to the biologically effective UV rays of the sun.

In the framework of this network, 9 stations have been installed at Thessaloniki, Mytilene, Ioannina, Athens, Patras, Heraklion, Nicosia, Rhodes and Xanthi using state of the art instrumentation and technology for obtaining the measurements and the dissemination and exploitation of the results.

The instruments that are used are the NILU-UV multi-filter radiometers, which measure solar irradiance at 5 narrow bands in the UVB (280-315 nm) and UVA (315-400 nm), and the Photosynthetically Active Radiation (PAR, 400-700 nm). The instruments are connected on-line with a central data base maintained at AUTH, enabling immediate recording and display of the measurements. Based on appropriate methodologies and software the following products are derived form the network measurements:

- The solar spectral irradiance at specific wavelengths (305, 312, 320, 340 and 380 nm)
- The total column of ozone.
- The transmittance of the atmosphere in the UV and visible part of the spectrum
- The cloud optical depth
- The photolysis rates of ozone, nitrogen dioxide and formaldehyde
- The UV-B and UV-A irradiance and the PAR
- Biologically relevant doses related to the influence of UV radiation to humans and plants.

The Laboratory of Atmospheric Physics (LAP) of the Aristotle University of Thessaloniki (AUTH) and The **Laboratory of Atmospheric Physics** of the **University of Patras** (LAPUP) in the framework of the Cooperation program which has been supported from European Regional Development Fund and National Resources, have been established the "Greek Network for Solar Energy" (GNSE) (http://www.helionet.gr/) operating a network of 14 stations monitoring solar ultraviolet radiation over Greece (Argos, Athens, Volos, Finokalia, Thessaloniki, Ioannina, Kozani, Mytilini, Xanthi, Orestiada, Patra, Preveza, Pylos, Rhodes).

Concerning radiation parameters LAPUP measures, the UV radiation at several spectral bands (NILU-UV 04108 radiation sensor), Global horizontal solar irradiance, diffuse horizontal solar irradiance, sunshine duration and direct normal irradiance sensor, also operates a sky camera. Finally LAPUP monitoring 12 pyranometers for measuring global horizontal solar irradiance in the frame of the Hellenic Network of Solar Energy (www.helionet.gr). The instruments are calibrated according to current international standards. Data acquisition is performed using Campbell Scientific data logger. Data are acquired every 1 s and 1 min average values are stored. The averaging period can be modified according to the requirements of specific field experiments. Raw data is stored and checked for inconsistencies, prior to its use, via quality control software developed by the LAPUP. Detailed metadata records are maintained.

In collaboration with the Atmospheric Modeling and Weather Forecasting group (AM&WFG) of the National and Kapodistrian University of Athens (School of Physics, Division of physics of Environment-Meteorology) and the National Centers for Environment Prediction in U.S.A. (NCEP), forecasts of the UV index are provided for Greece and Cyprus.

AM&WFG is part of School of Physics and the Institute of Accelerating Systems and Applications (IASA) of National and Kapodistrian University of Athens (NKUA). The research activities of the group are related to atmospheric, air pollution, soil dust cycle, climatic variability and wave modeling and applications related to data assimilation, weather, wave and air quality forecasting, agricultural and wind energy

applications. The AM&WFG participated in a number of projects in USA such as the NARSTO project (Ozone study over NE USA) and the Mercury budget over NE USA. National projects like SKIRON, NHREAS, POSEIDON, PYTHAGORAS, etc. These activities brought significant research experience to the members of the groups. The AM&WFG participates in the CESTM/ASRC project on weather and air quality forecasting over NE USA. The SKIRON modeling system is an integrated limited area modeling system developed from the AM&WFG. It is in use in approximately 20 research institutes and weather services worldwide. It is based on the Eta/NCEP model. It is in operational use at NKUA (http://forecast.uoa.gr) with more than 7000 visitors per day. Recently the AM&WFG delivered an upgraded version of SKIRON system at HCMR called POSEIDON II.

Since 2006, aerosol optical properties are monitored with a Cimel sunphotometer which is part of the AERONET. Finally, LAP operates broadband radiometers for the measurement of UV-B, UV-A and total solar radiation since the beginning of 1990s.

The National Observatory of Athens' station in Thissio (Athens) measure total UV since 1989, UV-B since 1995 and total solar radiation components since 1989, 1995 and 1953, respectively.

The **Laboratory of Process Analysis and Design** (LPAD) of **National Technical University of Athens** (School of Chemical Engineering) operating a station in Attica (Pireaus Region) which measures Ozone, air pollutants (SO_2, NO_x, CO) and Aerosols. Finally, The station monitoring by ECPL at Finokalia running measurements concerning Aerosols (EC-OC (EUSAAR 2), ions, metals, PON, P, ions (Cl, NO_3, SO_4, Oxalate, MSA) in PM_1/ OM, SO_4, NO_3, NH_4 dans PM_1/, PM_{10} concentration, Rd-Th concentration), Gases (O_3, CO, NO, NO_2) and Greenhouse gases (CO_2, CH_4, N_2O, CO), along with Optical Measurements (ABS 7- PM_{10}, Light Extinction at 530 nm in PM_{10}) and Deposition (ions+metals+PON+ P) and Size Distribution (N dist. (10-880 nm)).

Ground level air pollutants

The Ministry of Environment, Energy and Climate Change operates local networks for monitoring air pollution in the major urban areas of Greece. In the greater Athens area, the network consists of 18 stations that measure air pollutants of which 16 measure ground level ozone. In Voiotia two stations consists in Oinofita and Aliartos under the framework of the Program of Trans boundary Transport of Pollution. The greater Thessalonica area network consists of 8 stations. Thirteen additional stations, all of which measure ozone, are located in other cities. The data are available to the public through the National Environmental Data Center of Ministry of Environment, Energy and Climate Change (http://www.e-per.gr, http://env.ypeka.gr/deltia/e1220400.html) and through the European Environmental Agency (http://cdr.eionet.europa.eu/gr).

In addition, the Public Power Corporation of Greece operates 34 air quality stations near its power plants that monitor air pollutants (SO_2, NO_x, PM10, PM2,5 and O_3) and meteorological parameters (wind direction and velocity, temperature and relative humidity). All stations are automated, operating continuously. Data are gathered and kept in a centralised database.

Details about on the contribution of Greece in international systems and networks are presented in tables 1.a, 1.b and 1.c. The abbreviations in brackets next to the number of stations correspond to the organization that operates the respective station(s).

Satellite observations

Greece is a member of the European organization for the exploitation of Meteorological Satellites (EUMETSAT), the consortium that operates the meteorological observation satellite METEOSAT, and is represented in EUMETSAT by HNMS. For more details it is recommended to visit the EUMETSAT home page (http://www.eumetsat.int). It should be noted that EUMETSAT has a decentralised network of Satellite Application Facilities (SAFs) for the generation of products from EUMETSAT satellite data.

In addition, Greece is a member of ESA and participates in basic, as well as in optional, research projects. Greece also participates in several actions of Copernicus (the new name for the Global Monitoring for Environment and Security programme, previously known as GMES) program of ESA (http://www.copernicus.eu/).

Table 1.a. National contribution to the surface-based atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the internatio nal data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	4 (HNMS)	4 (HNMS)	4 (HNMS)	4 (HNMS)	4 (HNMS)
	Precipitation	4 (HNMS)	4 (HNMS)	4 (HNMS)	4 (HNMS)	4 (HNMS)
Full World Weather Watch/Global Observating System (WWW/GCOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour	79 (HNMS) 13 (NTUA) 2 (NCSR) 6 (NAGREF) 1 (NOA)	79 (HNMS) 13 (NTUA)	79 (HNMS) 13 (NTUA) 2(NCSR) 1 (NOA)	79 (HNMS)	79 (HNMS) 1 (NOA)
	Precipitation	79 (HNMS) 16 (NTUA) 5 (NAGREF) 1 (NOA)	79 (HNMS) 16 (NTUA)	79 (HNMS) 16 (NTUA) 1 (NOA)	79 (HNMS)	79 (HNMS) 1 (NOA)
Baseline Surface Radiation Network (BSRN)	Surface radiation	14 (GNSE)	14 (GNSE)	14 (GNSE)		
Solar radiation and radiation balance data	Surface radiation	12 (NTUA) 1 (AUTH) 1 (NOA) 5 (NAGREF)	12 (NTUA) 1 (AUTH)	12 (NTUA) 1 (AUTH) 1 (NOA)	1 (AUTH)	1 (AUTH) 1 (NOA)
Ocean drifting buoys	Air temperature, air pressure					
Moored buoys	Air temperature, air pressure	11 (HCMR)	11 (HCMR)	11 (HCMR)	11 (HCMR)	11 (HCMR)
Voluntary observing ship climate project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour					
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure					
	Precipitation					

Table 1.b. National contribution to the upper-air atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Upper Air Network (GUAN)	Upper-air-temperature, upper-air wind speed and direction, upper-air water vapour					
Full WWW/GOS Upper Air Network	Upper-air-temperature, upper-air wind speed and direction, upper-air water vapour	3 (HNMS)	3 (HNMS)	3 (HNMS)	3 (HNMS)	3 (HNMS)

Table 1.c. National contributions to the atmospheric composition

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
World Meteorological organization/Global Atmosphere Watch (WMO/GAW) Global Atmospheric CO_2 and CH_4 Monitoring Network	Carbon dioxide					
	Methane	1 (NOA)		1 (NOA)		
	Other greenhouse gases	1 (NOA)		1 (NOA)		
WMO/GAW ozone sonde network	Ozone	1 (AUTH)		1 (AUTH)	1 (AUTH)	1 (AUTH)
WMO/GAW column ozone network	Ozone	2 (AUTH) 2 (NTUA)	2 (NTUA)	2 (AUTH) 2 (NTUA)	2 (AUTH) 2 (NTUA)	2 (AUTH) 2 (NTUA)
WMO/GAW Aerosol Network	Aerosol optical depth	3 (AUTH)		3 (AUTH)	3 (AUTH)	3 (AUTH)
	Other aerosol properties	1(NCSR) 3 (AUTH)		1 (NCSR) 3 (AUTH)	1 (NCSR) 3 (AUTH)	3 (AUTH)

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
EARLINET-ASOS Aerosol Network	Aerosol optical depth	2 (NTUA)		3 (NTUA)	2 (NTUA)	
	Other aerosol properties	2 (NTUA)		3 (NTUA)	2 (NTUA)	

3. Oceanic essential climate variables

Overview

The main institutions that contribute to the national oceanic observations are the Hellenic Centre for Marine Research (HCMR, http://www.hcmr.gr/) and the Hellenic Navy Hydrographic Service (HNHS, http://www.hnhs.gr/portal/page/portal/HNHS).

Hellenic Centre for Marine Research (HCMR)

The Hellenic Centre for Marine Research (HCMR) was set up as a single institution in order to integrate government-funded marine science research in Greece. The institutes of National Centre for Marine Research (NCMR) with the Institute of Marine Biology of Crete (IMBC), were merged together with their respective field stations and become the Hellenic Centre for Marine Research (Law: (2919/25.6.2001)).

Its present structure consists of five institutes, which carry out research into specific thematic areas.

- Institute of Oceanography
- Institute of Aquaculture
- Institute of Marine Biological Resources
- Institute of Inland Waters
- Institute of Marine Biology and Genetics

It enjoys top-level scientific support from its two research vessels, the RV AEGAEO and RV PHILIA, its state-of-the-art 2-man submersible THETIS as well as three deepwater ROVs, named the MAX ROVER, SUPER ACHILLES and SEABOTIX.

The global scientific community can also access the Mediterranean Marine Science Journal, (http://www.medit-mar-sc.net/index.php/marine), HCMR publications, Collected Reprints abstracts, and data-rich projects such as HNODC, IASON and ELNAIS.

The HCMR is member of the European Global Ocean Observating System (EuroGOOS). In the previous years the HCMR has participated in several operational oceanography R&D projects, such as:

- **MFSPP** (1998-2001): Development of multiparametric M3A station, VOS Measurements, High resolution regional and coastal models
- **MFSTEP** (2002-2004): Consolidation of MFS observing system
- **MARSAIS** (2001-2003): Synergy between SAR and buoy data, Validation of Algorithms, Detection and forecasting of oil-spills
- **FerryBox** (2002-2005): Implementation of a European network for FerryBox measurements, Operational phase: 2002-2003
- **MAMA** (2002-2004): Coordination on Mediterranean Scale, Capacity building
- **MERSEA_S1** (2003-2004): GMES Initial phase
- **ROSES** (2003-2004): ESA GSE
- **EPAN/ESPEN** (2003-2005): Improved wave monitoring and forecasting products – oil spill risk assessment
- **MERSEA-IP** (2004-2008): Global monitoring and forecasting. HCMR: Coordination of Mediterranean Observations, M3A system

- **EUROCEANS (2005-2008):** ESA, developing models for assessing and forecasting the impacts of climate and anthropogenic forcing on foodweb dynamics
- **MARCOAST** (2006-2009): ESA GMES service network
- **ESONET-NoE** (2007-2011): ESA GMES
- **SPICOSA** (2007-2011): developing a selfevolving, holistic research approach for integrated assessment of Coastal Systems
- **MYOCEAN** (2009-2012): GMES, setting up infrastructures and services in preparation for the GMES Marine Services
- **OPEC** (2012-2015): research and development to develop Operational Ecology to augment the capabilities of the GMES Marine Service
- **MYOCEAN2** (2012-2014): delivering and operating a rigorous, robust and sustainable Ocean Monitoring and Forecasting system of the GMES Marine Service (OMF/GMS) to users for all marine applications

Detailed information concerning all the programs that HCMR participated is available (pdfs in Greek Language): http://www.hcmr.gr/gr/listview2_el.php?id=844

The following paragraphs include the main activities currently run by the HCMR, concerning the observation of ECVs.

- **The POSEIDON System (Long term *(climatic)* variability monitoring):** HCMR established the system and keeps it running. The main monitoring, forecasting and information system (**Moored buoys)** in Greece
- **HCMR participates in EURO-ARGO** network (network of autonomous instruments-drifting buoys). ARGO floats can continuously measure important variables that characterize the ocean (column distribution of temperature, salinity, oxygen etc.) and report it, using satellite connections, to processing centres.
- **HCMR participates in EMSO**, a large-scale European Research Infrastructure in the field of environmental sciences. EMSO is based on a European-scale network of seafloor observatories
- **SESAME project** (FP6 project on Climate Change effects in the Mediterranean and Black Sea: **HCMR coordinator**)

The POSEIDON System

The main monitoring, forecasting and information system is the **POSEIDON System**, developed by HCMR through EEA infrastructure funding:

- POSEIDON-I: 14.1 M€ (1997-2000),
- POSEIDON-II: 9.8 M€ (2005-2009)
- POSEIDON-III: 1.1 M€ (2010-2011),

which continuously upgraded through collaborative research projects. The system operated by HCMR and supported by the Hellenic National Meteorological Service & the Hellenic Hydrographic Service. By establishing a network of observation buoys and the creation of a specialized operational centre for the processing of the data collected and the production of forecasts, POSEIDON system is an operational monitoring, forecasting and information system for marine environmental conditions in the Eastern Mediterranean. The system targeted to end-user needs such as maritime transport, fisheries, tourism, as well as environment & climate monitoring.

The network of observation 16 buoys records continuously the physical, biological and chemical parameters of the Greek seas. These data are then transmitted to the operational center where they are sorted and fed into forecasting models. POSEIDON

system is a unique planning tool in the endeavor for the protection of the marine environment. It also provides a competitive advantage for the development of business activity, the prevention of disaster, and the safeguarding of human life. In the frame of the world-wide trend for the development of operational oceanography, POSEIDON network places Greece among the leading countries in this field. The ten stations (SE of mount Athos, Lesvos, Skyros, Saronikos, Mykonos, Santorini, Kalamata, Cretan sea (E1M3A), Pylos, Zakynthos) providing atmospheric and sea data are presented in table 3.1. Two of them, in Cretan sea (E1M3A), and Pylos, are the reference **deep sites** which operate since 2000 and 2008 respectively. The observation buoys are equipped with sensors that monitor:

- Air-pressure
- Air-temperature
- Wind speed and direction
- Wave height, period and direction
- Sea surface salinity and temperature
- Surface current speed and direction

In two sites additional deep physical and biochemical observations are made:

- Salinity and temperature in depths 20-1000 m
- Chlorophyll-A and light attenuation at 20-100 m
- Dissolved oxygen at 20-100 m
- Current speed and direction at 20-50 m
- Radioactivity
- Radiance - Irradiance

All the stations report data on air temperature and pressure, wind speed (mean and gust) and direction, as well as sea surface temperature, waves (significant and maximum height, direction) and current (speed and direction) data. These data are online available in the POSEIDON webpage (http://www.poseidon.hcmr.gr/) either as time series graphs or as text based format for the latest transmission.

Seven "Seawatch" instrumentation platforms are deployed in areas where the water depth does not exceed 300m and are equipped with sensors for the basic met-ocean parameters recording. Every station can potentially monitor temperature, salinity, pressure and bio-chemical parameters in several depths by adjusting instruments on the mooring line. By now several sensors are attached on the buoy shell measuring sea surface parameters such as salinity, temperature, current speed and direction and a variety of wave parameters. On the top of the platform meteorological parameters are measured such as air pressure, air temperature as well as wind speed and direction. The 3 "Seawatch- Wavescan" buoys are multi-parametric instrumentation platforms and are deployed in deep offshore locations. Due to a inductive mooring cable, ctd instruments are adjusted on the mooring line providing salinity, temperature and pressure data down to 1000m depth. Biochemical parameters such as oxygen and chlorophyll are also measured from the sea surface down to 100m depth. ADCP profilers collect current data every 5m from the sea surface to the depth of 50m. On the upper part of the buoy a variety of sensors record the atmospheric variability. Except the basic meteorological parameters, additional parameters are measured such as rainfall, radioactivity, radiance and irradiance. One of the "Wavescan" multi-parametric instrumentation platforms, deployed at southern Ionian Sea, communicates through an acoustic modem with a Deep Sea Module platform which is deployed at 1763 m depth. The main purpose of deploying this instrumentation platform is to

record sea pressure and detect anomalies on the sea surface altimetry which could indicate a tsunami incident over the specific sea area. The platform has also adjusted sensors measuring temperature and salinity down to the sea basin.

A new platform with additional sensors (CO2, CH4, pH, Passive Acoustics) is now constructed: POSEIDON-3.

The POSEIDON operational center receives, processes and analyzes all the data on an operational basis. Poseidon system uses data from other platforms also integrated (e.g. ARGO floats). These data, which are archived and utilized for forecast and research purposes need management, which means efficient storage, cleaning (pre data mining process), and availability in-source for the production of forecasts and other scientific issues and outsource (other institutes, web generally). The operational center receives the above data on a 3-hourly basis. They are stored in text files and then are transferred to a normalized sql database. The data base has been designed to support fast access to all available parameter values and their metadata. Appropriate links have been established to associate the transmitted data with their metadata and the relevant quality control flags which assigned to the data providing a reliability score of the recorded values. This quality control process is an integral and important part of the operational process. Its significance derives from the fact that ocean data measurements are sparse and often present a variety of dubious and false values. Bio-fouling, sensor failures, anchoring and transmission problems are among the common causes of corrupted data. In terms of operational activities, this analysis must be held in real-time conditions and has to be as reliable as possible.

Concerning the future of the Poseidon system, the main goals are the following:

- The complete upgrade of the existing buoys with next generation atmospheric and oceanographic sensors and state of the art communication devices
- The extension of the network coverage to the Ionian Sea.

Participation in the Euro-Argo Network

Greek Argo is a component of the Euro Argo research infrastructure. Argo Observe ocean processes and circulation on scales from a few weeks to seasons and inter-annual, integrated observing system: complementarity with satellite observations (altimetry) and ocean models and is an essential component of GMES MCS.

Greece is an active member of the Euro-Argo network. HCMR Contributes to the network with 3 floats per year approved from the Greek Secretary General for R&D. Additionally, HCMR is considering the possibility of developing a DMQC facility for Argo profiles collected within the Eastern Mediterranean region.

The EURO-ARGO network constitutes an important asset of the ARGO network. The ARGO network is a global network of autonomous instruments-drifting buoys- which can continuously measure, throughout their lifetime, important variables that characterize the ocean (column distribution of temperature, salinity, oxygen etc.) and report it, using satellite connections, to data gathering and processing centres. EURO-ARGO is the single most important in-situ observing infrastructure for the GMES (Global Monitoring for Environment and Security) Marine Core Service. It delivers the above mention critical data (especially over the vertical dimension of the oceans) that are strongly complementary to satellite observations for assimilation in ocean analysis and forecasting models.

Euro-Argo aims to establish a long-term global array of in situ measurements integrated with other elements of the climate observing system (in particular satellite observations) to:

- Detect climate variability from seasonal to decadal scales and provide long-term observations of climate change in the oceans. This includes regional and global changes in temperature and ocean heat content, salinity and freshwater content, sea level and large scale ocean circulation.
- Provide data to constrain global and regional ocean analysis and forecasting models, to initialize seasonal and decadal forecasting coupled ocean-atmosphere models and to validate climate models.
- Provide information necessary for the calibration and validation of satellite data

The main goals of the Greek team for next years can be summarized to the following:

- Launch of the Greek Argo infrastructure funded by the National Strategic Reference Framework (NSRF) which will contribute to an enhanced monitoring over Aegean and Ionian seas as well as Eastern Mediterranean region in general. 25 Iridium floats will be deployed during the next 4 years
- By the end of 2013 to deploy 6 floats in total in the Ionian (2 floats), in the Aegean Sea (3 floats) and South of Crete (1 float). One of these floats has been already purchased with PERSEUS funds, two will be purchased with IONIO (Interreg-III) allocated funds, while National Greek Argo programme will contribute with three additional floats

The expected benefits from the implementation of these goals are to:

- Expand the observing capacity of the POSEIDON system
- Increase the forecasting skill of the POSEIDON hydrodynamic models through data assimilation of ARGO T/S profiles
- Contribution to UNFCCC (monitoring of climate variables)

Emso

The Basic scientific objective of Greek EMSO is the Long-term monitoring, of environmental processes and the interaction between geosphere, biosphere, and hydrosphere, including natural hazards and climate change impacts (dense water convection Adriatic vs Aegean). For the implementation of this program in Pylos Deep reference site is used.

Sesame

The scientific objectives of SESAME program are:

- Assess the changes or regime shifts in the SES ecosystems over the last 50 years and assess the potential mechanisms that relate these changes to changes in natural and anthropogenic forcings.
- Assess the current status of the SES ecosystems through analysis of existing and newly collected data and model simulations.
- Predict changes in the SES ecosystem responses to likely changes in climate and anthropogenic forcings during the next five decades.
- To assess and predict changes in the ability of the ecosystems to provide goods and services. Goods: tourism and fisheries/Services: ecosystem stability through conservation of biodiversity, and mitigation of climate change through carbon sequestration

Through the implementation of the project new data have been and will be collected and WOCE-type stations have been already established with various positive

consequences as described above. In specific, the gathering of high quality field data, the analysis of samples and the preparation of datasets to feed the SESAME databases are being used to tune and validate the ecological models. Seven WOCE-type stations in the Mediterranean and Black Sea have been established (2 in the Black Sea and 4 in the Mediterranean – 1 in the Greek waters North Aegean). In addition, Long time-series from selected stations in the Mediterranean and the Black Sea will be also collected. SESAME consortium is determined to maintain the operation of these WOCE-type stations beyond the duration of the project. Acquired data will be incorporated into the SESAME databases thus establishing a long-term information in Mediterranean and Black Seas.

Voluntary Observing Ships

As regards to voluntary observing ships, in general there are 18 ships cooperating with the HCMR, although their use is not organized on a regular basis. These ships cooperate with HCMR under the context of various programs. However, in the present there is no such program running.

Hellenic Navy Hydrographic Service (HNHS)

The Hellenic Navy Hydrographic Service consists of 7 divisions: Digital Cartography Division, Hydrography Operations Division, Cartography Division, Safety of Navigation Division, Oceanography Division, Administrative and Logistics Division and Computing Center Division.

The mission of the of the Hellenic Navy Hydrographic Service is the collection, analysis and use of data and information of the Hellenic sea waters in the fields of Hydrography, Oceanography, Cartography and Navigation in order to:

- Support the relevant operational requirements of the Hellenic Navy and the Hellenic Armed Forces, generally.
- Contribute to the safety of navigation and to promote the subjects of Hydrography, Oceanography and Cartography.
- Support, in case of request, of public services and the private sector

The Hellenic Navy Hydrographic Service is responsible for:

- Storing data and information of the marine environment in order to cover the operational requirements of the Hellenic Navy and the Hellenic Forces in general.
- Carried out Hydrographic and Oceanographic surveying, maritime works and studies using the best available tools and technics.
- Publication and distribution of nautical charts, special naval charts and nautical publications.
- National co-ordinator in the international NAVTEX service for promulgation of Maritime Safety Information. Issue of Notices to Mariners
- Definition of channels, safety anchorages, restricted areas, dangers to navigation as well as the way of their marking.
- Maritime study on the installation of lighted or not lighted buoys, landmarks, mooring buoys and navigational radio-aids.
- Definition of shore boundaries, terrestrial port zones, port works and installations of aquacultures (sea farms).

- Installation of networks of permanent measuring stations for the collection of hydrographic, oceanographic and navigational information.

During the various oceanographic cruises, many types of data are collected, according to the operational and scientific needs.

- Conductivity, Temperature, Depth profilers (CTD) are used for recording the **temperature, salinity, density and sound velocity fields** of the Hellenic Seas.
- Side Scan Sonars and Sea-bottom profilers are used for examining the **geological and geoacoustic properties of the sea bed and the sea-bottom stratification**.
- Bottom corers and samplers are used for collecting **sediment cores and samples of the sea-floor**.
- Current Meter Profilers are used for recording the **sea currents** in areas of specific interest.

All collected data are analyzed, stored in data bases and used in order to understand the physical phenomena and to produce environmental studies.

The Hellenic Navy Hydrographic Service maintains a quite dense network of permanent tide gauge stations equipped with instruments for Sea - level Monitoring (Figure 2):

- A network of **Twenty one (21)** permanent Sea Level (SL) Stations is located in Aegean and Ionian seas Harbours.
- At each station site a combination of sensors, type of recording and transmission of data exists.
- All stations are using analog recording, nine (9) of them also have digital outputs with GSM transmission of data.
- From those nine (9) stations, four (4) transmit data in real time mode, using GPRS.
- Nine (9) stations also have a temperature sensor.
- One (1) station has a CGPS system.

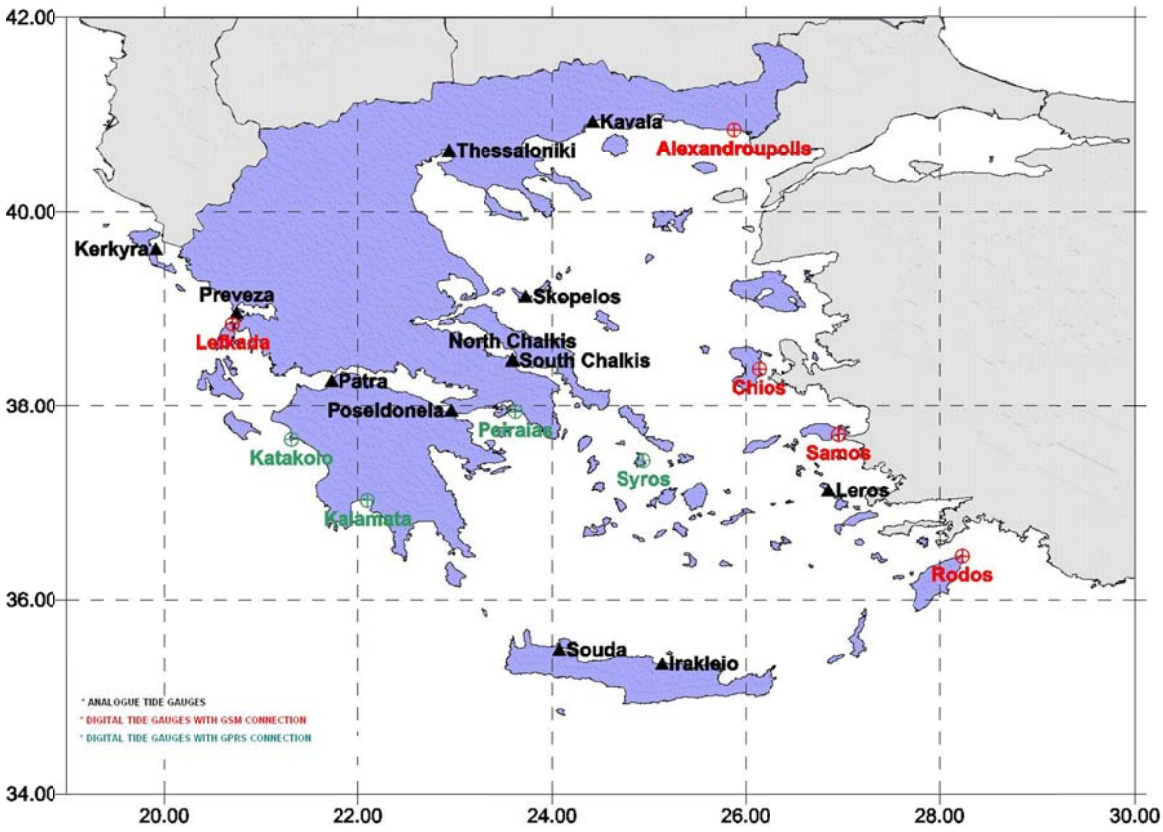

Figure 2. Map of Permanent Network of Sea - level and Temperature Monitoring

The Hellenic Navy Hydrographic Service has a continuously cooperation with the following Organizations: **ESEAS** (European Sea level Service), **PSMSL** (Permanent Service for Mean Sea Level), **IOC** (Intergovernmental Oceanographic Commission). In addition it is also partner in the **National Tsunami Warning System** as active member of the Intergovernmental Coordination Group-North Atlantic Mediterranean and connected Seas Tsounami Warning System (ICS-NERAMTWS).

National Contribution

In tables 3.a and 3.b the total national contribution to oceanic essential climate variables are reported. The climate of Greece does not justify the participation in some networks (ie global tropical moored buoy network). In this case the relevant cells are shaded grey.

Table 3.a. National Contributions to oceanic essential climate variables - surface

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
Global surface drifting buoy array on 5x5 degree resolution	Sea surface temperature, sea level pressure, position-change-based current	0	N.A.	5	0	0
GLOSS Core sea-level framework	Sea level	21	N.A.	22	3	21
Voluntary observing ships (VOS)	All feasible surface ECVs	25	N.A.	25	0	0
Ship of opportunity programme	All feasible surface ECVs	0	N.A.	1	0	0

N.A. not available.

Table 3.b. National contributions to the oceanic essential climate variables – water column

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
Global reference mooring network	All feasible surface and subsurface ECVs	10	10	11	10	10
Global tropical moored buoy network	All feasible surface and subsurface ECVs					
Argo network	Temperature, salinity, current					
Carbon inventory survey lines	Temperature, salinity, ocean tracers, biochemistry variables					

Satellite observations

Using information gathered by the HCMR, and the HNMS, the global products that require satellite observations and are being currently developed are presented in Table 4.

The launching of a satellite in 2010 has improved the data collection and creates a new climatological database.

Table 4. Global products requiring satellite observations-oceans

ECVs/ Global products requiring satellite observations	Fundamental climate data records required for Product generation (from pas, current and future missions)
Sea Level Sea level and variability of its global mean	Altimetry
Sea Surface Temperature Sea surface temperature: assessment of spatial and temporal variability. Use of SST products (Sea Surface Temperature) in the EUMETCAST context of the EUMETSAT organization. For wave height and other sea level measurements, products of satellites JASON 1 & 2 are being used in the context EUMETCAST context of the EUMETSAT organization.	Single and multi-view IR and microwave imagery
Ocean color Examination of the patterns of ocean color (i.e. light intensity) and oceanic chlorophyll-a concentration derived from several sensors (Sea WiFS, MODIS)	Multi-spectral VIS imagery
Ocean salinity Research towards the measurement of changes in sea surface salinity	Microwave radiance

Actions taken in response of the recommended actions in the GCOS implementation plan

1. Including sea level objectives in the capacity-building programmes of GOOS, JCOMM, WMO, other related bodies and the system-improvement programme of GCOS: The possibility of including sea level objectives on the gathering of satellite data is under consideration by the HCMR.
2. Implementing a wave measurement component as part of the Surface Reference Mooring Network: The observation buoys of the POSEIDON System are equipped with sensors that monitor wave height period and direction. The offshore wave forecasting model of POSEIDON system uses the outputs of the weather and circulation models to produce 72 hours prediction of wave conditions in the Aegean Sea. The wave forecast consist from the following parameters:

- Significant wave height
- Mean wave direction
- Mean wave period

3. Developing capability for systematic measurement of biochemical and ecological ECVs

4. Supporting data rescue projects and implementing regional, specialized and global data and analysis centres: The Hellenic National Oceanographic Data Centre (HNODC) is part of the institute of Oceanography, one of the five institutes of the Hellenic Centre for Marine Research (HCMR). It operates as a National Agency and is responsible for processing, archiving and distributing marine data. HNODC is also developing techniques for oceanographic data processing and data base maintenance. Furthermore it promotes the International Exchange of Data in the frame of its cooperation with the Intergovernmental Oceanographic Commission (IOC) of UNESCO as it is responsible for the coordination of International Data Exchange (IODE) in Greece. HNODC runs many projects and European activities. Further information on these projects can be found in the webpage http://hnodc.hcmr.gr/.

4. Terrestrial Observations

Overview

The main institutions that contribute to the national terrestrial observations are the Ministry of Environment Energy & Climate Change (MEECC, http://www.ypeka.gr/), the National Technical University of Athens (NTUA, http://www.ntua.gr/), the Public Power Corporation (PPC, http://www.dei.gr/?lang=2), the Institute of Geology and Mineral Exploration (IGME, http://www.igme.gr/portal/page?_pageid=33,56803&_dad=portal&_schema=PORTAL) and the National Agricultural Research Foundation (NAGREF, http://www.nagref.gr/index_uk.htm).

Observation System on quantity/quality of surface and ground water

The purpose of the EU Water Framework Directive is to establish a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater. In line with the provisions of the Water Framework Directive, Greece has established and recently revised a national monitoring program for the assessment of the status of surface water and ground water, in order to obtain a coherent and comprehensive overview of water status within each river basin district.

The implementation of the Water Framework as well of the related daughter Directives fall within the scope of the activities of the Secretariat. The Secretariat, in collaboration with the Regional Water Authorities, formulates and, upon approval by the National Council for Water, implements the national monitoring program. The Secretariat is composed of four Directorates and is headed by a Special Secretary, appointed by the Ministry of Environment, Energy and Climate Change and the Government.

The revised monitoring program takes, among others, into consideration the analysis of pressures and impacts associated with each water body, and is fully operational from 2011. More than 600 surveillance and operational monitoring stations refer to surface waters (inland, transitional and coastal) and 1400 stations refer to groundwater (Figures 3 & 4). The program monitors biological, general physicochemical, and specific chemical parameters, as well as priority pollutants and morphological and quantitative data (http://www.ypeka.gr/Default.aspx?tabid=249&locale=el-GR&language=en-US). The data and information obtained are stored in electronic data bases, including the National Data Bank of Hydrological and Meteorological Information and the National Environmental Information Network and processed for reporting, and dissemination purposes.

For the implementation of the national monitoring program, the Special Secretariat for Water coordinates the following participating organisations:

- General Chemical State Laboratory of Greece (GCSL, Ministry of Economy and Finance)
- Hellenic Centre for Marine Research (HCMR)
- Institute of Geology & Mineral Exploitation (IGME)
- Greek Biotope/Wetland Centre (EKBY)
- The Municipal Water and Sewerage Company of Larissa (DEYAL)
- Land Reclamation Institute (LRI), (Hellenic Agricultural Organization, Department of NAGREF)

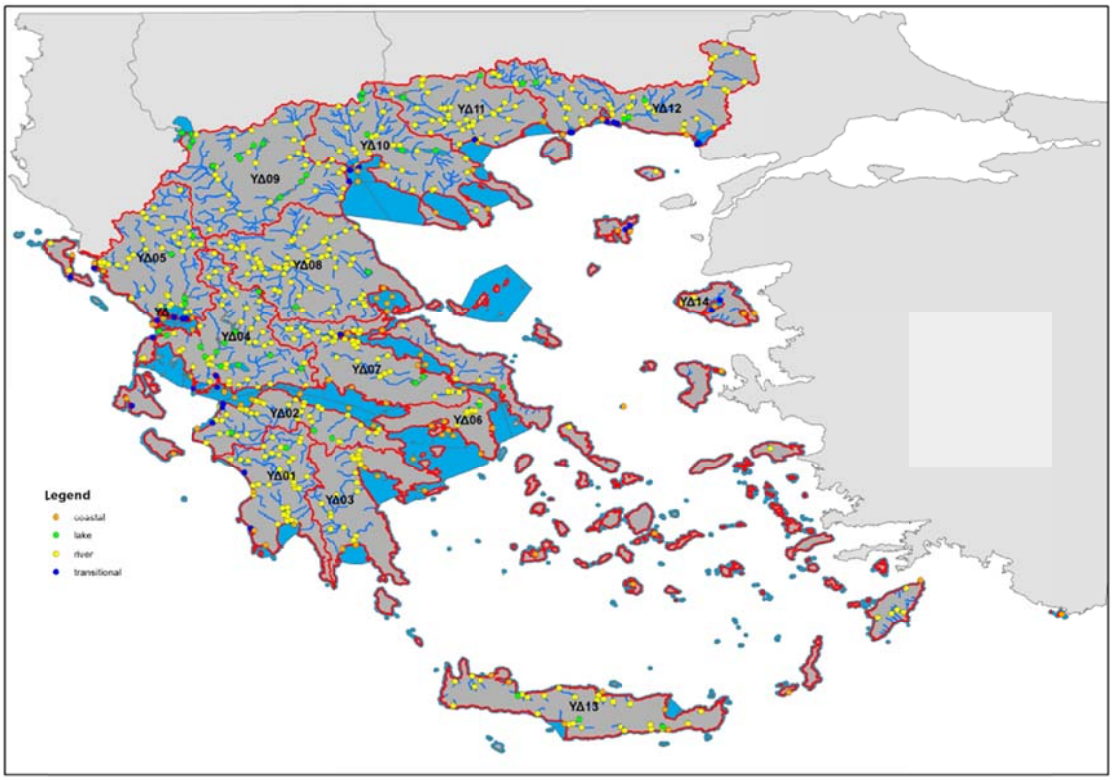

Figure 3. Network of surface waters

(http://www.ypeka.gr/LinkClick.aspx?fileticket=hgp1EfmS32k%3d&tabid=249&language=el-GR)

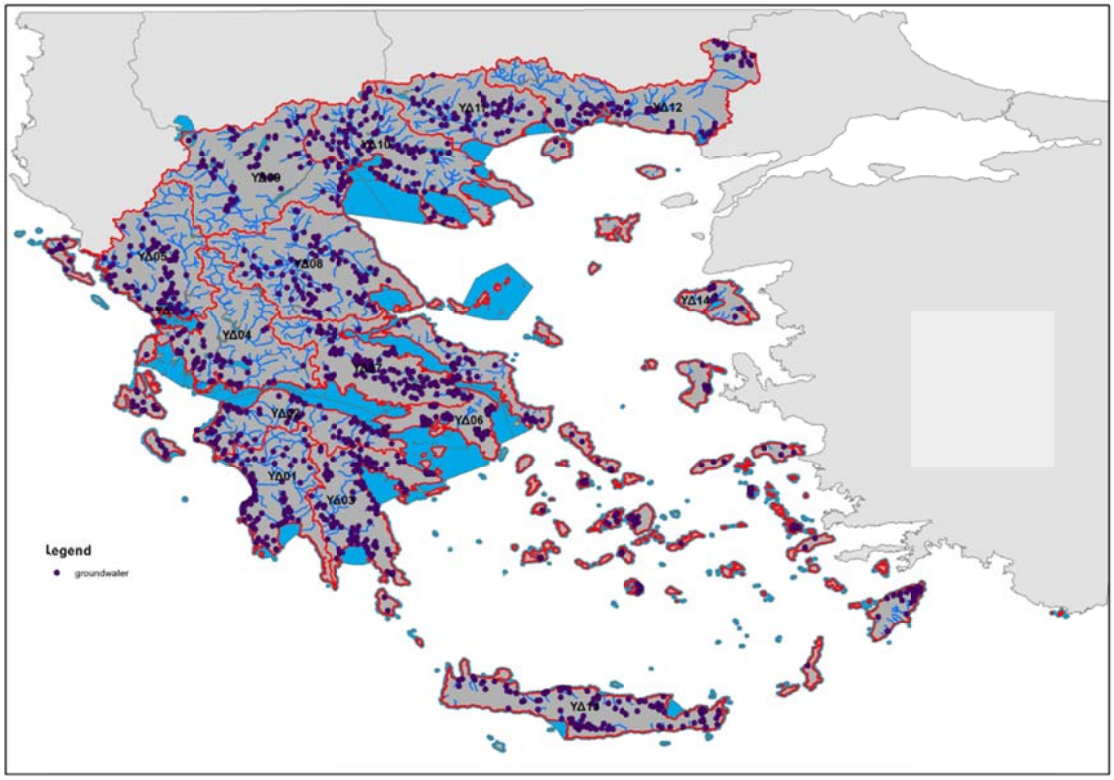

Figure 4. Network of ground waters

(http://www.ypeka.gr/LinkClick.aspx?fileticket=67Patn%2fdMdk%3d&tabid=249&language=el-GR)

An effort for gathering all available meteorological and hydrological data in one database is the project of the National Data Bank of Hydrological & Meteorological (NDBHMI) which was assigned to the National Technical University of Athens (Laboratory of Hydrology and Water Resources) by the Ministry of Environment Energy & Climate Change. This project provides the required infrastructure for the implementation of the E.U. Water Framework Directive for the protection, rational management and exploitation of the water resources in the national level.

The core of the project was the development of a Data Bank (http://www.hydroscope.gr/) which will contain the total amount of hydrometeorological and hydrogeological data covering the whole country. The data are acquired from 2500 stations which are distributed in Greece and are placed by the participating organisations:

- The Ministry of Environment Energy & Climate Change
- The Hellenic National Meteorological Service
- The Public Power Corporation
- The Ministry of Rural Development and Food
- The Ministry of Development & Competitiveness
- The National Observatory of Athens

Various software applications are linked to the central Database of the project supporting the analysis and synthesis of the data and the elaboration of secondary information. The distributed form of the database allows a continuous online operation and exchange of data between the participating organisations.

Furthermore, the Ministry of Rural Development and Food and some of its supervised entities (National Agricultural Research Foundation (NAGREF), Forest Research Institute (FRI) and Greek Agricultural Insurance Organization), the Ministry of Environment Energy & Climate Change and the Public Power Corporation operate an extended network of rainfall and snowfall gages. The network consists of more than 250 rain gages and more than 1000 tables to measure the height of snow. Furthermore, the Institute of Geology and Mineral Exploration (IGME) operates a large network of surface and ground water measurements.

Among these stations, only 46 hydrometric stations, supervised by PPC, meet international specifications so as to be able to contribute quality controlled data to the corresponding databases. The Ministry of Rural Development and Food also operates 277 (Ministry of Rural Development and Food: 240, Greek Agricultural Insurance Organization: 2, National Agricultural Research Foundation: 26, Forest Research Institute: 9) stations for the measurement of surface water quantities.

Observation System on quantity/quality of ground

IGME in corporation with the other Geological Institutes of Europe (www.eurogeosurveys.org) have prepared the «Geochemical Atlas of Europe» (http://weppi.gtk.fi/publ/foregsatlas/) using the Global Geochemical Baselines (a program of International Union of Geological Sciences, IUGS, and International Association of GeoChemistry, IAGC). In the framework of this global reference network, the following stations operate in Greece:

- 41 stations for the observation of residual soil
- 41 stations for the observation of floodplain sediments or alluvial soil of large catchment areas.

- 41 stations for the observation of overbank sediments or alluvial soil of small catchment areas.

Moreover, NAGREF operates four stations for the observation of ground temperature in two depths. The data from these stations are provided to the respective European Union services.

Forest ecosystem health observation

The "Institute of Mediterranean Forest Ecosystems and Forest Products Technology" is one of the oldest research institutes in Greece. It was established in Athens, Greece, in 1929 as the research arm of the Greek Forest Service. Its title soon changed to "Forest Research Institute of Athens" (FRIA) In its more than 80 years of operation, the Institute has produced excellent research always focusing on the research needs of the practicing foresters of the Forest Service. In 1989 the Institute was integrated into the National Agricultural Research Foundation (NAGREF) and got its current official title. Both the historic name and the official title are currently in use. In 2011 NAGREF was merged with three other organizations of the Ministry of Rural Development and Food forming the Hellenic Agricultural Organization "DEMETER" to which the Institute now belongs. http://www.ypeka.gr/Default.aspx?tabid=543&language=el-GR

Greece, and in particular the Forest Research Institute (FRIA), is a member of the ICP-Forests Network (International Cooperative Programme on Forests) of the UNECE and of the "FUTMON", a Life+ and European Union co-financed project for the "Further Development and Implementation of an EU-level Forest Monitoring System". A network of plots (Level I and Level II) has been established in Greece and a number of parameters concerning the growth conditions are monitored on a regular basis. In particular, Greece has ninety one (147) Level I and eight (8) Level II plots, representing important forest ecosystems (Maquis, Oaks, Beech, Fir) and geological types of the country. The following parameters are monitored: crown condition, soil, foliage, increment, deposition, soil solution, meteorology, ground vegetation, phenology, air quality (ozone), and litter fall (http://www.ypeka.gr/Default.aspx?tabid=232).

CO_2 flux measurements

A station for CO_2 vertical flux measurements has been established and operated for a number of years in Kalamata by NAGREF, in the frame of the research project MEDFLUX of the European Commission.

National Contribution

In Table 5 the national contribution to the terrestrial domain essential climate variables is reported.

Satellite observations

Greece is a member of ESA and participates in basic, as well as in optional, research projects. Greece also participates in three actions of the Global Monitoring for Environment and Stability (GMES) program of ESA. In the framework of this program estimation of forest land change and of forest carbon reserves (GMS-Forest Monitoring) is performed.

Table 5. National contributions to the terrestrial domain essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVs	Number of stations or platforms currently operating	Number of stations or platforms operating in accordance with the GCMPs	Number of stations or platforms expected to be operating in 2010	Number of stations or platforms providing data to the international data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS baseline river discharge network (GTN-R)	River discharge					
GCOS Baseline Lake Level/ Area/Temperature Network (GTN-L)	Lake level/area/ temperature					
WWW/GOS synoptic network	Snow cover					
GCOS glacier monitoring network (GTN-G)	Glaciers mass balance and length, also ice sheet mass					
GCOS permafrost monitoring network (GTN-P)	Permafrost borehole temperatures and active layer thickness					
Global Terrestrial Network – Hydrology (GTN-H)	Available data from existing global hydrological observation networks	3	3	3	3	3

ANNEX I

Acronyms

AM&WFG	Atmospheric Modeling and Weather Forecasting group
AUTH	Aristotle University of Thessaloniki
BSRN	Baseline Surface Radiation Network
CRES	Centre of Renewable Energy Sources
DEMETER	Hellenic Agricultural Organization
DEYAL	Municipal Water and Sewerage Company of Larissa
ECVs	Essential Climate Variables
EKBY	Greek Biotope/Wetland Centre
ESA	European Space Agency
ESEAS	European Sea level Service
EUMETSAT	European organization for the exploitation of Meteorological Satellites
FRI	Forest Research Institute
FRIA	Forest Research Institute of Athens
GAW	Global Atmosphere Watch of WMO
GCOS	Global Climate Observing System
GCSL	General Chemical State Laboratory of Greece
GEOSS	Global Earth Observing System of Systems
GI	Institute of Geodynamics
GMES	Global Monitoring of Environment and Security
GMS	Geostationary Meteorological Satellite
GOOS	Global Ocean Observing System
GSN	GCOS Surface Network
GSRT	General Secretariat for Research and Technology
GTN-G	Global Terrestrial Network – Glaciers
GTN-L	Global Terrestrial Network – Lakes
GTN-P	Global Terrestrial Network – Permafrost
GTN-R	Global Terrestrial Network – Rivers
GTOS	Global Terrestrial Observation System
GUAN	GCOS Upper Air Network
HCMR	Hellenic Centre for Marine Research
HNGS	Hellenic Navy General Staff
HNHS	Hellenic Navy Hydrographic Service
HNMS	Hellenic National Meteorological Service
HNODC	Hellenic National Oceanographic Data Centre

IAA	Institute of Astronomy and Astrophysics
IAASARS	Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing
IAGC	International Association of GeoChemistry
IASA	Institute of Accelerating Systems and Applications
ICP-Forests Network	International Cooperative Programme on Forests
ICS-NERAMTWS	Intergovernmental Coordination Group-North Atlantic Mediterranean and connected Seas Tsounami Warning System
IERSD	Institute of Environmental Research and Sustainable Development
IGME	Institute of Geology and Mineral Exploration
IHO	International Hydrographic Organization
IMBC	Institute of Marine Biology of Crete
IOC	Intergovernmental Oceanographic Commission of UNESCO
IODE	International Data Exchange
IOFR	Institute of Oceanographic and Fisheries Research
ISARS	Institute for Space Applications and Remote Sensing
IUGS	International Union of Geological Sciences
LAP	Laboratory of Atmospheric Physics of AUTH
LRI	Land Reclamation Institute
MEECC	Ministry of Environment Energy & Climate Change
MRDF	Ministry of Rural Development and Food
NAGREF	National Agricultural Research Foundation
NCEP	National Centers for Environment Prediction in U.S.A.
NCSR	National Center for Scientific Reasearch, DEMOKRITOS
NDBHMI	National Data Bank of Hydrological & Meteorological
NKUA	National and Kapodistrian University of Athens
NOA	National Observatory of Athens
NSRF	National Strategic Reference Framework
NTUA	National Technical University of Athens
OPTICON	
PPC	Public Power Corporation
PSMSL	Permanent Service for Mean Sea Level
SAFs	Satellite Application Facilities
SST	Sea Surface Temperature
TOMS	Total Ozone Mapping Spectrometer
UNESCO	United Nations Educational, Scientific and Cultural Organization
VOS	Volunteer Observing Ship
VOSClim	Voluntary observing ship climate project

WMO	World Meteorological Organization
WWW	World Weather Watch of WMO