SIMIN - THE INTEGRATED SYSTEM FOR METEOROLOGICAL SURVEILLANCE, FORECAST AND ALERT IN ROMANIA

Dr. Vladimir Ivanovici, Scientific Director, Scientific Director, National Administration for Meteorology, Bucharest, Romania; Phone: +4 021 230 31 46; Fax: + 4 021 230 31 43;e-mail: ivanovici@meteo.inmh.ro

Dr. Elena Cordoneanu, Head of Weather Forecasting National Center, National Administration for Meteorology, Bucharest, Romania; Phone: +4 021 230 31 46; Fax: + 4 021 230 31 43;e-mail: cordoneanu@meteo.inmh.ro

Dr. Doina Banciu' Head of Data Processing Dept., National Administration for Meteorology, Bucharest, Romania; Phone: +4 021 230 31 46; Fax: + 4 021 230 31 43; e-mail: doina.banciu@meteo.inmh.ro

Mr. Aurel Apostu, Head of National Telecommunication and Technical Support Center, National Administration for Meteorology, Bucharest, Romania; Phone: +4 021 230 31 46; Fax: + 4 021 230 31 43; e-mail: aurel.apostu@meteo.inmh.ro

Mr. Gerard Allen; Manager Business Development, Lockheed Martin Corporation - MS2, Syracuse, NY
Phone: +1-315-456-1880; Fax: +1-315-456-0439; email: gerry.allen@lmco.com

Abstract

The Project Team led by The National Administration of Meteorology (ANM) and Lockheed Martin, has integrated current technologies in weather radars, automated weather observation stations, lightning detection networks, weather satellite reception, numerical weather prediction models, hydrological buoys, forecaster decision/display systems, and various forms of telecommunication. The Project Team has successfully integrated state-of-the-art, commercial-off-the-shelf (COTS) technologies and products with the resources of Romania's existing legacy meteorological infrastructure.

SIMIN provides a turn-key integrated national system that modernizes ANM's capability to detect, monitor and forecast meteorological phenomena and the resulting hydrological impacts, and elevates Romania to a regional leadership position in weather prediction for the 21st Century. SIMIN has upgraded the ANM sensor network and fully integrated with the existing sensors to provide comprehensive national coverage of all observation types. SIMIN has upgraded the ANM meteorological processing capabilities including fully integrated and highly automated Forecasting and Nowcasting workstations for national, regional, and defense forecasting operations. Enhanced NWP platforms support ALADIN and MM5 mesoscale modeling. Observational processing supports real-time surface observation validation and climatology database archiving for the nation.

SIMIN has upgraded the ANM communication infrastructure to support real-time collection and distribution of meteorological data and products throughout Romania. This includes LAN/WAN upgrades for ANM sites, as well as message processing upgrades for internal and external data exchange. SIMIN has supplied over 75 local and remote Briefing Terminals to End-Users throughout the Romanian Government, to ensure all information promptly reaches critical decision makers.

1 Introduction*

Romania, despite its relatively small area, has a substantial variation in its terrain and other factors influencing the airflow dynamics. The hilly and mountainous areas are strongly affected by flash flooding, and all areas are subject to diverse conditions ranging from severe thunderstorm with hail in summer, to heavy snowstorms in winter. Upgrading and integrating the various environmental and meteorological sensor data to provide a comprehensive understanding of the rapidly evolving environment and its impacts on human activities, is a necessity for achieving the modernization plan of the Romanian Authorities for Waters and Environmental Protection.

In November 2000, the Romanian National Institute of Meteorology and Hydrology (INMH) began the first stage of the plan to modernize Romania's capabilities for detecting, monitoring and predicting meteorological and hydrological phenomena affecting Romania, by implementing the *National Integrated Meteorological System - SIMIN* project. SIMIN addresses Romania's primary objective of modernizing and integrating the nations various resources and real-time detection capabilities, and also facilitates the exchange of data at the Local, Regional, and Global levels.

2 Program Overview

The Project Team led by INMH and Lockheed Martin, has integrated current technologies in weather radars, automated weather observation stations, lightning detection networks, weather satellite reception, numerical weather prediction models, hydrological buoys, forecaster decision/display systems, and various forms of telecommunication. The Project Team has successfully integrated state-of-the-art, commercial-off-the-shelf (COTS) technologies and products with the resources of Romania's existing legacy meteorological infrastructure. SIMIN provides a turn-key integrated national system that modernizes INMH's capability to detect, monitor and forecast meteorological phenomena and the resulting hydrological impacts, and elevates Romania to a regional leadership position in weather prediction for the 21st Century.

SIMIN has upgraded the INMH sensor network and fully integrated with the existing sensors to provide comprehensive national coverage of all observation types. SIMIN adds 5 WSR-98D S-band radars, 60 AWOS stations, Meteosat 7 and MSG satellite receiving stations, an 8 sensor Lightning Detection Network, 4 Aviation Weather observation stations, and 11 meteo/hydro observations buoys.

SIMIN has upgraded the INMH meteorological processing capabilities including fully integrated and highly automated Forecasting and Nowcasting workstations for national, regional, and defense forecasting operations. Enhanced NWP platforms support ALADIN and MM5 mesoscale modeling. Observational processing supports real-time surface observation validation and climatology database archiving for the nation.

SIMIN has upgraded the INMH communication infrastructure to support real-time collection and distribution of meteorological data and products throughout Romania. This includes LAN/WAN upgrades for INMH sites, as well as message processing upgrades for internal and external data exchange.

---

* Corresponding Author: Dr. Vladimir Ivanovici, INMH, Bucharest, Romania; e-mail: ivanovici@meteo.inmh.ro

SIMIN has supplied over 75 local and remote Briefing Terminals to End-Users throughout the Romanian Government, to ensure all information promptly reaches critical decision makers.

3 SIMIN System Architecture

The SIMIN system is a distributed architecture with one national center, connected to multiple regional sites. It supports all types of users, with a suite of tools dependent on the operational need of each user. Figure 3-1 illustrates the top level SIMIN architecture, showing the primary forecasting sites and sensor locations.

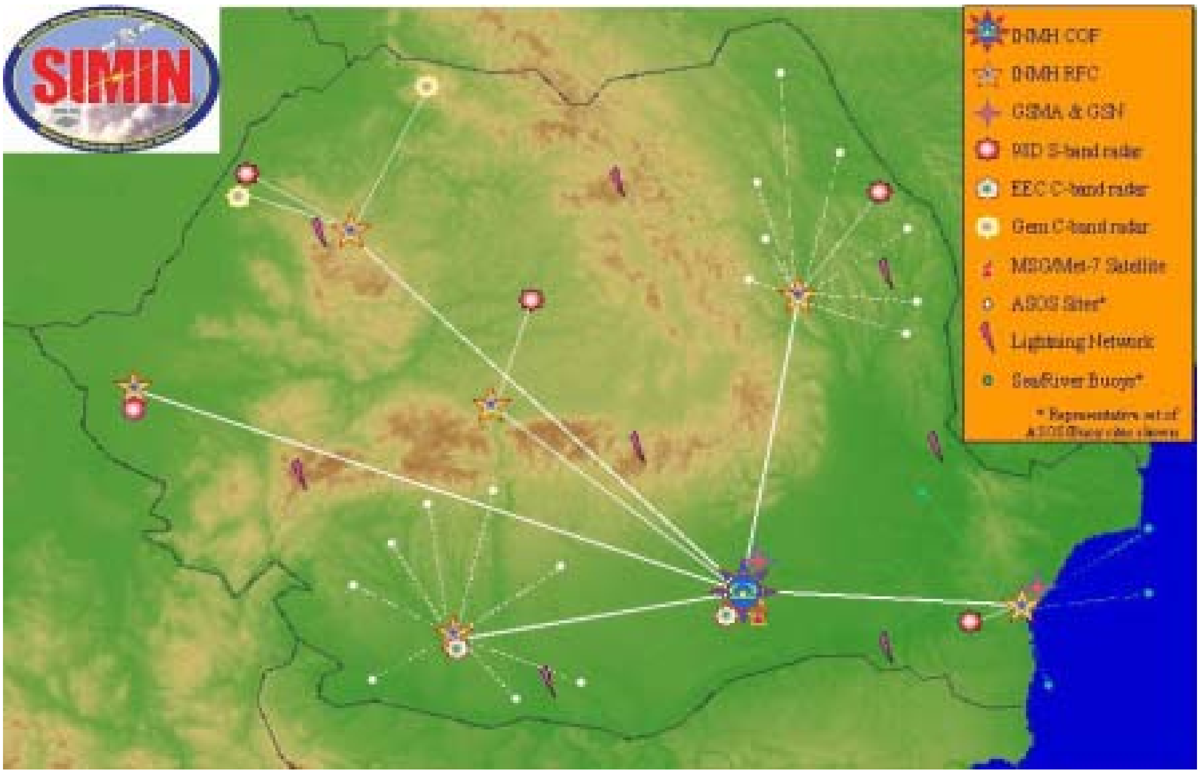

Figure 3-1 SIMIN National Architecture

3.1 Sites and Users

SIMIN sites are categorized as one of five types. The types are the Central Operations Facilities (COF), Regional Forecast Centers (RFC), Forecast Product Centers (FPC), Sensor Sites, and Associated Subscribers (AS). INMH maintains the responsibility for Fundamental Forecasting supporting the nation. The SIMIN COF is located at the INMH national headquarters in Bucharest. The COF has responsibility for national forecasts, system wide coordination, international cooperation and agency policy control for INMH. There are six (6) RFCs located throughout the country, with regional data collection and forecast responsibility.

Other forecasting users of SIMIN include Forecast Product Centers (FPC) that support specific Tailored forecast operations. This includes forecast operations at the General Staff of Military Aviation (GSMA) and General Staff of Navy (GSN). These agencies coordinate the specific needs of their organization, utilizing the national resources available from the SIMIN sensor network and integrated applications.

Non-forecaster end users of SIMIN include many users throughout the country providing various Operations Support functions. This includes users at the Ministry of Agriculture (MOA), Ministry of Transportation (MOT), Ministry of Interior (MOI), Civil Protection, Ministry of Defense (MOD) and various other agencies reporting to these organizations. These users utilize the products and information provided by INMH in conducting their daily operations, through the use of Briefing Terminals, receiving product from the appropriate forecasting site.

Operations and Maintenance users at all locations support the continued administration of all system equipment including sensors, computers, networks, and software applications. This allows SIMIN to remain in continuous operation, supporting all national needs.

3.2 SIMIN Sensor Network

SIMIN has upgraded the INMH sensor network and integrated with the existing legacy components to provide comprehensive sensor coverage.

The classical Surface Observation network has been upgraded to integrate sixty (60) Automated Weather Observation Stations (AWOS) from Vaisala, in addition to twelve (12) existing automated stations, at strategic locations throughout the country. Another 88 surface observation stations remain in operation as manual stations. All automated and manual stations are integrated to comprise the Romanian Surface Observation Network.

The previously existing 1960s era weather radars used throughout the country, have been replaced with WSR Doppler radars. SIMIN integrates five (5) WSR-98D S-band radars with four (4) existing C-band[*] radars, to form a 9 radar network. The WSR-98D is an upgraded version of the WSR-88D systems used in the US NWS network. The existing C-band radars (2 from EEC and 2 from Gematronik[*]) have been integrated into the SIMIN national radar network. Data from the C-band radars is converted to 88D/98D formats, to facilitate integration with all applications in the system. National radar mosaic products are also produced to provide a national scale view of phenomenon detected by radar. This allows full national coverage to be provided by the radar network, plus nearly 150Km across the boarders of all neighboring countries, with accessibility to all products by all appropriate users.

SIMIN provides new satellite receiving systems to support real-time collection of METEOSAT 7 satellite imagery, as well as a receiving system for the new MSG satellite. These receiving systems are provided by VCS Engineering, Germany. This dual system supports continued operation during the transition from METEOSAT 7 to MSG. Imagery from both satellites is collected, formatted, and distributed to all forecasting sites as appropriate. Products from an existing NOAA receiving system are also collected and distributed throughout the system for use in forecast operations.

SIMIN provides an eight (8) sensor Lightning Detection Network (LDN), using the SAFIR sensor technologies supplied by Vaisala. The network provides national coverage at approximately 1Km accuracy, for both cloud-to-cloud and cloud-to-ground lightning. The information received from the LDN is distributed throughout the system in near real-time to support integrated forecast operations.

---

[*] From two commercial suppliers of C-band radars.

[*] At the time of this writing, only one Gematronik radar has been installed by the previously existing contract.

SIMIN provides eleven meteorological/hydrological buoys in two configurations, provided by AANDERAA. Three (3) are in a sea configuration for use on the Black Sea. Eight (8) are in a river configuration for use along the Danube River. The river sites also include a water level sensor nearby the buoy location.

3.3 Communications

SIMIN uses a three-level data collection and distribution architecture, interconnecting all INMH sites and end user locations. Sensor data is collected from the sensor sites to an RFC. The COF then collects all relevant data from each RFC in the nation. Data collected from regional sites, is combined with data collected or generated at the COF, for distribution to all forecasting operations sites. This combined data stream of common shared data is called SIMINcast[*].

Various communications technologies are used for the collection and distribution of data, dependent on the bandwidth needs, cost of operation, and end user requirements.

3.3.1 VSAT WAN Communications

The primary high bandwidth site-to-site WAN communication used between INMH sites in SIMIN is a Very Small Aperture Terminal (VSAT) satellite system, interconnecting the COF to all RFCs and 98D radar sites. The VSAT supports multiple channels or Permanent Virtual Circuits (PVC). This configuration allows the establishment of a private network with channels independently configured for the needs of each data link. Each link supports TCP/IP protocols, to allow standard applications to communicate over the distributed system WAN.

The SIMINcast PVC uses the Multicast Dissemination Protocol (MDP) for the distribution of high bandwidth data to the remote RFCs. MDP provides guaranteed delivery of all data to all sites, while minimizing overhead. The SIMINcast MDP is set to distribute data at rates up to 312Kbps. This architecture provides excellent distribution performance for the SIMIN network. For example, measurements of the distribution times for radar data distributed from the COF indicate all radar products reach the remote RFCs in an average of 37 seconds.

3.3.2 International Data Communications

The existing INMH interface to GTS and other international data circuits was provided by a Messir-Comm from COROBOR, France. SIMIN provided hardware and software upgrades, in order to improve overall performance and throughput. SIMIN uses Messir-Comm as the external data source, and integrates this data into the data communications environment.

3.3.3 Internal Data Communications

Data communications internal to SIMIN is controlled by the Communications Gateway (CG), provided by Harris Corp. The CG controls all internal data collection from SIMIN sources and external data from Messir-Comm. It then controls routing of all data to all applications internal to the INMH COF and RFC sites, and the FPCs. The COF CG controls the SIMINcast distribution of data throughout SIMIN.

---

[*] For illustration purposes, users in the US may think of SIMINcast as being similar to NWS NOAAPORT.

3.3.4 Surface Observation Communications

The collection of surface observations from the new AWOS as well as manual stations, to the RFC is performed using GSM mobile phone SMS text messaging technologies. This provides a convenient and cost effective means to collect the very low bandwidth surface observations, without the need for developing an independent network. The GSM mobile phone market in Romania currently provides adequate coverage of all sites in the observation network, with excellent reliability.

3.3.5 Lightning Network Communications

The collection network for unprocessed lightning data in the LDN uses a low bandwidth VPN, over the GSM mobile phone network. The LDN requires continuous TCP/IP connectivity from each sensor to the central server in Bucharest, at data rates of 32Kbps to 64Kbps for each sensor. The GSM network selected for this application has proven to be reliable and cost effective.

3.3.6 End User Product Communications

The distribution of end user products from the INMH forecast product site to remote AS end user Briefing Terminals is conducted via various VPN and dial-up connections, depending on the end user needs. This connection is a low bandwidth connection, requiring approximately 28.8Kbps for the average site. Special point-to-point applications ensure products are delivered to all online users as quickly as the available bandwidth will allow.

4 Surface Observation Processing

Within the SIMIN project a Surface Observation Processing (SOP) application has been developed to support the collection, validation, and distribution of all surface observations in the country. The SOP was developed by a local Romanian company, in cooperation with INMH, ensuring the data processing for all Romanian surface observation stations, either automated or manual.

Generally the SOP is quite similar with the old procedure available in INMH, involving three levels of processing sites: local, regional and central.

4.1 SOP Local site

When there is an automated station the Local Site SOP application (SOP-LS) retrieves raw measured data and derived data calculated in the station, for further processing, decoding, local display, and archiving. Messages are generated from the measured parameters and supplemented with human observations, then automatically sent to the Regional Collecting Center using GSM/SMS text messaging technology. The SOP-LS supports all automated stations within SIMIN, including the new Vaisala MAWS 301 and 201 stations, and previously existing automated stations from various suppliers including Vaisala MILOS 500, Vitel 1040, Thies AWS 7800, and Thies DL 15. From the manual stations, messages are entered by the observer into a mobile phone, and sent as GMS/SMS text messages to the Regional Center.

4.2 SOP Regional Collection

The Regional Collection SOP application (SOP-RC) collects hydro-meteorological messages sent from all automated and manual observation stations assigned to the Regional Center. It supports manual data editing and validation of the received data and generates collective messages of multiple stations in standard formats, according to WMO regulations and national practices. All data are decoded and stored in the local database, allowing the display in alphanumeric and graphic format. Messages are automatically sent to the National Center via the SIMIN Communications WAN.

4.3 SOP National Collection

The National Collection center SOP application (SOP-NC) supports all required capabilities of the SOP-LS and SOP-RC applications, with additional features to support national operational responsibilities.

4.4 SOP features

While the SOP application set follows the same logic as the old INMH procedures, they involve a higher level of sophistication and capabilities characterized by the following features:

- High flexibility in defining new message types (alert, rain, agricultural, climatological, free text, etc.) and templates, new variables, etc.

- Calculation of a large amount of derived parameters from the measured data;

- Pre-configured time schedule for collection, generation, sending, and receiving of messages;

- Parallel use of raw data formats for data exchange between SOP applications, ensuring higher level of data precision and compression, and standard formats for data exchange with other applications;

- The possibility of local configuration and control of all applicable parameters and features of the sensor stations associated with command, control, status, and calibration;

- A real-time display to allow the operator at local sites to continuously monitor the measured meteorological parameters, including alphanumeric and graphic display capabilities;

- The collection center SOP-RC/NC can automatically interrogate certain automated stations that do not have a local PC and SOP-LS application;

- The collection center SOP-RC/NC can interrogate a missing station to request data, and accept the raw data returned, in case messages are not reported by user pre-configured time schedule;

- The collection center SOP-RC/NC can activate a higher frequency of data collection and message transmission for any selected site, in special situations;

- All SOP levels provide a more elaborate data validation process, depending on the application level including features such as;

    - Verification of message formats from manual stations;

    - Multiple correlations between measured and observed parameters

    - Temporal validation by graphical visualization of the parameter evolution for each station, for a user specified time interval and time step, with the possibility to correct any value;

- Spatial validation by visualization in one or more geographically plotted forms: i) one or more parameters via the Bjerknes scheme, ii) time differences for a given parameter at two selected times, iii) variance from climatological values, for a given parameter; iv) the sum of a selected parameter for a given interval;

- The SOP-NC also provides comparison with INMH forecast model outputs.

5 Radar Operations Transition

Before October 2000, the Romanian weather radar network consisted of ageing manually operated radar systems. Specifically the Russian MRL-2 and MRL-5 equipment was used. The disadvantages of such equipment were the obsolete technologies, the manual exploitation of the system, and the large amount of time necessary for processing and distribution. The MRL-2 was designed in 1967 and the MRL-5 in 1972, thus repair and maintenance was always an issue. Manual operation forced the radar operator to sit in front of the radar display and draw the radar echoes on paper by hand. The manual collection also required a large amount of time necessary for acquiring the radar information, putting it on a paper map and disseminating to the end-users. Therefore, radar data was not available in real-time. Every three hours, on the basis of the local information received from the component systems of the network, the National Radar Center at the INMH headquarters created a national radar mosaic, also in analog paper map format. Figure 5-1 represents an example of national radar mosaic product used till recently by INMH.

The first step of the national network modernization was achieved in October 2000 when two modern systems manufactured by Enterprise Electronics Corporation (EEC) were commissioned in the Southern part of Romania. These two systems met the criteria imposed by the EUMETNET GORN and OPERA programs for harmonizing and improving the exchange of the data from operational weather radars in Europe. For the first time, in 2000 Romania had its first regional radar mosaic, with only two systems, and updated every 20 minutes. Figure 5-2 represents an example of the first stage radar mosaic covering the southern portion of the country.

The second step was early 2001 when Romanian Water Authority (RWA) installed and commissioned another radar system. This equipment is manufactured by Gematronik (METEOR 500C type) and currently is operated also by INMH. It is anticipated that in late 2003 or early 2004, RWA will install a second Gematronik METEOR 500C in the Northwestern part of Romania. Before the SIMIN integration, these radars were not included in the national network.

SIMIN has concluded the transition of the Romanian weather radar network from exclusively manually operated and obsolete systems, to one of the most modern and unique radar networks in the world. SIMIN has installed five (5) new and modern WSR-98D S-band radar systems, to complete the national network. The WSR-98D system, from the Beijing Metstar Radar Co., is based on the technology and meteorological algorithms developed over more than 30 years in the US NEXRAD network. It generates an impressive suite of more than 70 products, including both base and derived products.

The SIMIN added value consists not only in installing the new WSR-98D radar systems, but also in bringing the power of a reliable radar network and integration of the existing digital systems (EEC and Gematronik) into this network. In this respect, Romania is one of very few countries that has fully integrated three types of radar equipment into one integrated network.

Currently, SIMIN produces individual site radar products every 6 minutes, depending on the radar and mode of operation. Three types of national radar mosaics are produced every 10 minutes. The available national radar mosaic products include first tilt base reflectivity, echo top and composite reflectivity. The fact that Romania has three radar products at a nationwide scale is another unique feature of the SIMIN radar network. Figure 5-3 illustrates an example of a current Romanian National Radar Base Reflectivity Mosaic product.

Using the communications infrastructure, all radar products may be made available anywhere in the system in near real-time. This includes the COF, RFC, FPC, and AS sites, culminating with a variety of special integrated displays developed for real-time interpretation of radar data in Nowcasting and Forecasting environments. These applications range from the versatile 98D Principal User Processor (PUP), the OmniWeatherTrac and VIPIR advanced radar visualization, the Integrated neX-REAP workstations, and End User Briefing Terminals. As users of the system become more familiar with the available radar products, this real-time access to national radar information by all users will dramatically increase the early warning benefits to the nation.

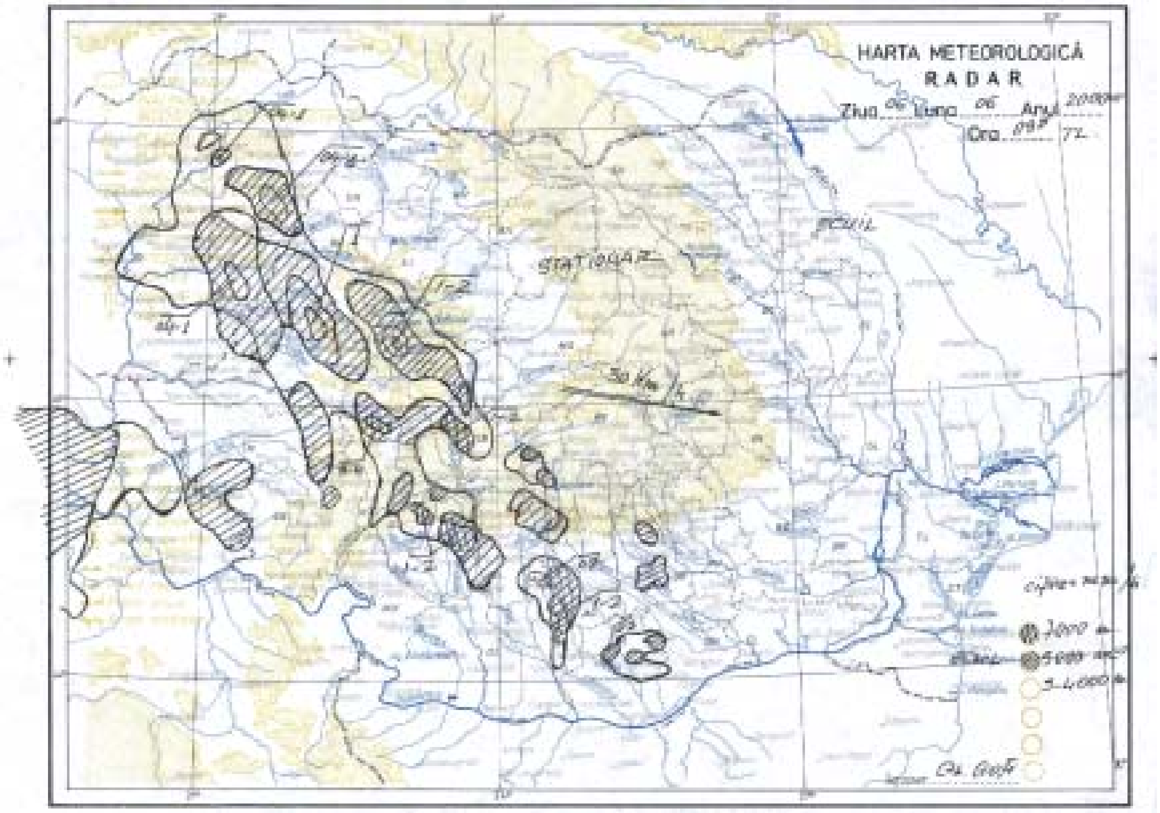

Figure 5-1 Manual National Radar Mosaic

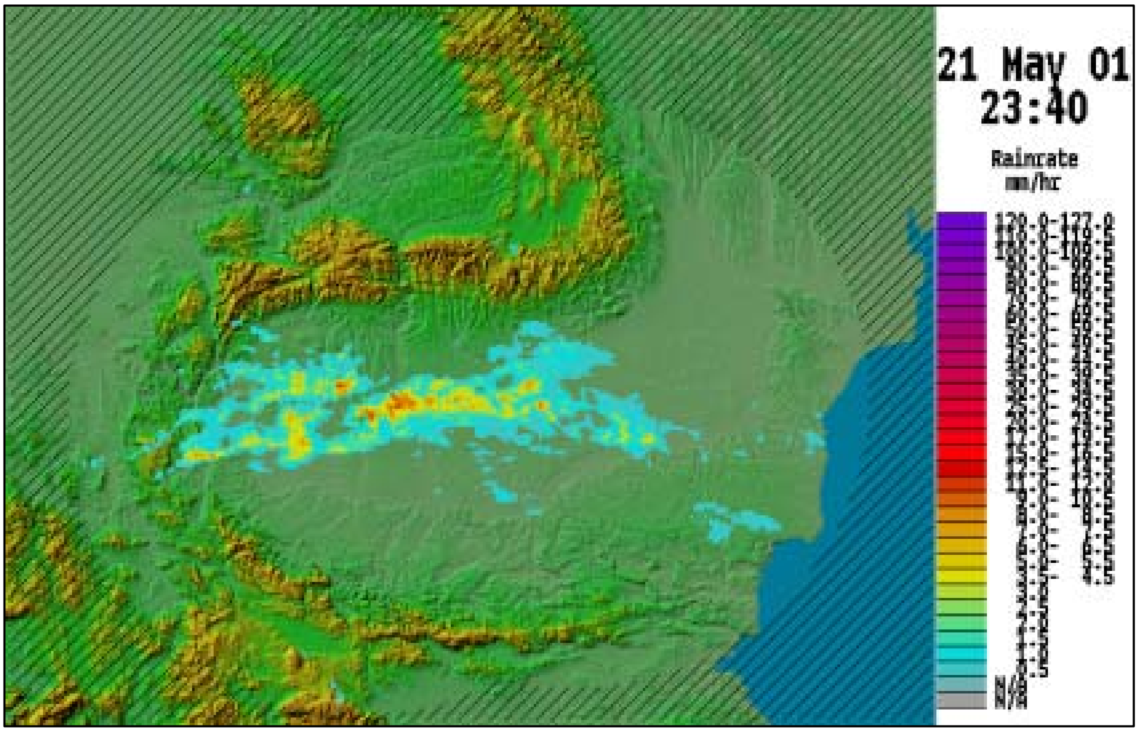

Figure 5-2 Initial Regional Mosaic with 2 Radars

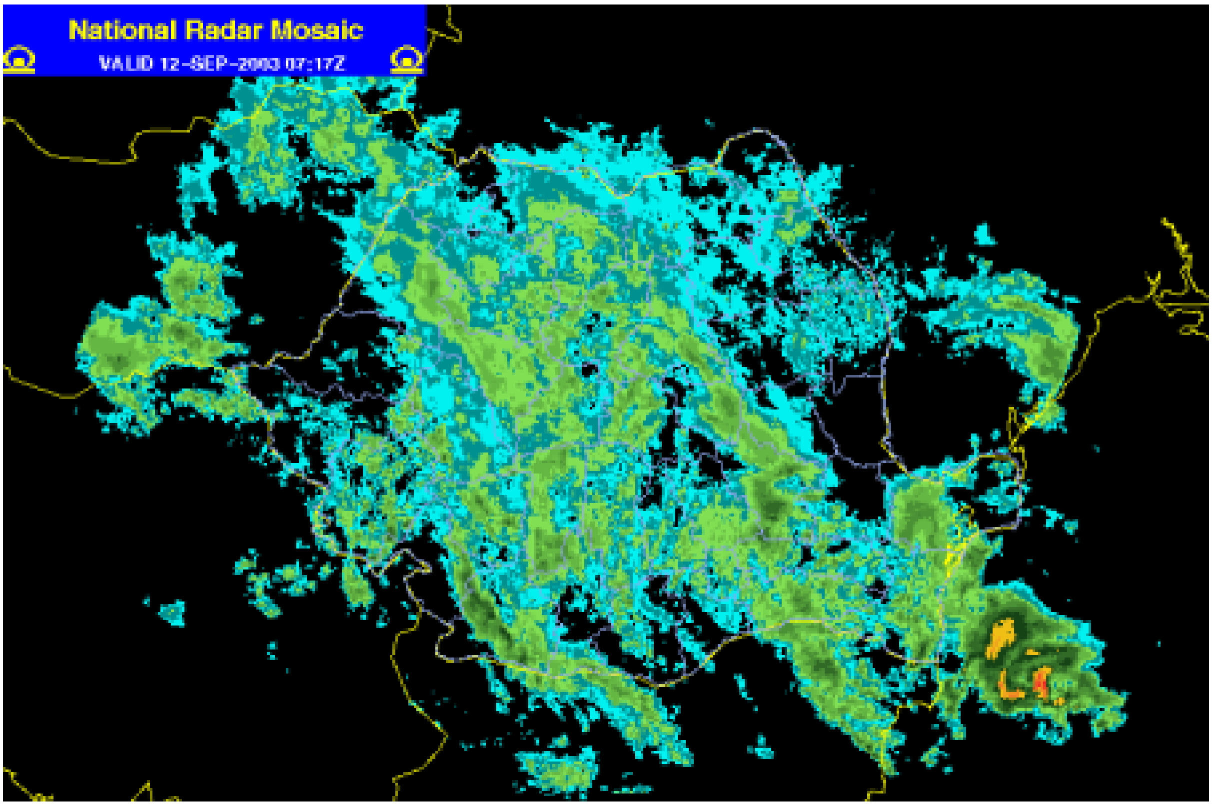

Figure 5-3 – One form of the National Radar Base Reflectivity Mosaic, from 07:17 UTC Sept 12th, 2003

6 Forecasting/Nowcasting Operations

SIMIN provides a variety of tools to support improvements to the existing INMH Forecasting and Nowcasting environments. This includes applications for numerical weather prediction, applications for advanced radar processing, and applications for integrated product generation, display and distribution of all meteorological data types. A key requirement for the Forecasting and Nowcasting upgrades was the need to support various types of forecasting operations, define products to user specifications, and distribute them to a wide variety of end users in different operating environments throughout the country. SIMIN also provides site-to-site voice communications via Voice-over-IP technologies on the VSAT WAN, which allows the INMH COF to hold daily teleconferences will all RFC forecast operations. This capability is essential to harmonizing the forecasts throughout the nation.

6.1 Numerical Weather Prediction

The basis of the national Numerical Weather Prediction (NWP) System of INMH is the ALADIN model, which has been developed within an international cooperation. The initial and boundary conditions are supplied by the ARPEGE global model from MeteoFrance. SIMIN provides an enhanced computing platform for the development and run time environment of ALADIN. While the new 8-CPU server environment is a modest platform by NWP standards, the enhancement allows significant improvements over the existing ALADIN environment. Thus the decrease of integration time has led to the transition from the model integration in lagged mode to a synchronous one. The improvements allow further upgrades to ALADIN to support a wider area of coverage, a greater resolution, and an increase in the number of vertical levels. In addition to ALADIN, SIMIN provides an implementation of the MM5 model for a domain large enough to fit the area covered by the radar network, with a lower resolution. The SIMIN MM5 implementation is coupled with the AVN model from the US NWS.

6.2 Forecasting Environment

The integrated forecasting environment of SIMIN centers on the Forecaster Workstation using the neX-REAP application, from Harris Corp., and is used in the forecast operations of the INMH COF, INMH RFCs and the FPCs at GSMA and GSN. NeX-REAP provides a wide variety of interactive tools to support forecast operations. This includes integrated processing of data from various sensor platforms and processing equipment including:

- Surface and Upper Air station data
- Alphanumeric products from WMO sources
- Various NWP Forecast models
- METEOSAT, MSG and NOAA satellite imagery
- Individual and Mosaic Radar products
- Lightning Strike information
- Manual vector graphic products
- Thermodynamic analysis products

Key features of the neX-REAP system are the ability to define the content of all products used in operations, and fully automate the product generation. This includes products used for forecast operations, as well as those for distribution to Associated Subscribers using Briefing Terminals.

These features provide the ability to highly automate the generation of a large majority of the routine products, leaving more time for detailed analysis and monitoring of developing conditions. The automated distribution of products allows a diverse set of end users to continuously receive real-time information in support of their specific operations. This includes users such as Civil Defense, Water Management, Transportation authorities, and many other governmental agencies.

6.3 Nowcasting Environment

The nowcasting environment of SIMIN centers on the display and advanced processing of radar information available in the Romanian National Radar Network. The WSR-98D PUP provides the initial display of radar information. C-band radar products are converted to 88D/98D formats allow the PUP to display of products from all radars in the network. The Radar Product Integrator* application set from Baron Services Inc., BSI, provides the foundation of the nowcasting environment at the INMH COF and RFCs. The RPI provides a unique combination of real-time radar processing, enhanced 2D and 3D visualization, and automated product distribution and alert messaging.

The RPI provides real-time processing and display of radar information with capabilities designed to enhance early warning to the public. This includes display of street level mapping for all cities in Romania, allowing warnings to occur at the local level.

The RPI includes an integrated implementation of a hydro-static NWP model*, to provide current and forecasted value-added radar products, such as precipitation types and accumulation amounts. These advanced products provide situational awareness to Nowcasting operations, greater than what is possible with radar information alone.

The Nowcasting environment also includes a Forecaster Workstation with the neX-REAP application to provide a full set of integrated information to this environment. Generation of a standard product set is also possible using the Forecaster Workstation.

The RPI integrates the Open RPG environment for the C-band radars, to allow production of standard 88D/98D product set.

6.4 Transition Issues

As might be expected, the largest issues faced by the INMH team during the transition to the new SIMIN environment, was the large influx of new technologies that must be learned concurrently with continued support of routine operations. To help alleviate these difficulties, the transition was planned to take place in three phases; Initial Products, Enhanced Products, and Final Products. The entire transition spanned a 12 to 15 month period, depending on the order of site installation. During this transition, on-site support from Lockheed Martin and appropriate subcontractors was provided to ease the transition into operations. This support included standard workshop activities, hands-on application guidance, and real-time trouble shooting assistance. Additional remote support was provided from all SIMIN team members. These actions helped to ease the difficulties that are always expected from the operational transition of a new system. Even with this assistance,

---

* The RPI consists of various products from BSI, integrated specifically for the SIMIN environment.

* The MetModel is provided by BSI and Harris Corp.

it is only through the extensive dedicated support and commitment exhibited by the INMH team that the transition has been possible.

7 Benefits to Romania Resulting from SIMIN

The benefits brought by SIMIN to the Romanian meteorology are unquestionable.

Under the aspect of the meteorological infrastructure modernization, SIMIN complies with the intended purpose of achieving a National Integrated Meteorological System, comprising all the functional components of a National Meteorological Service, as illustrated in Figure 7-1.

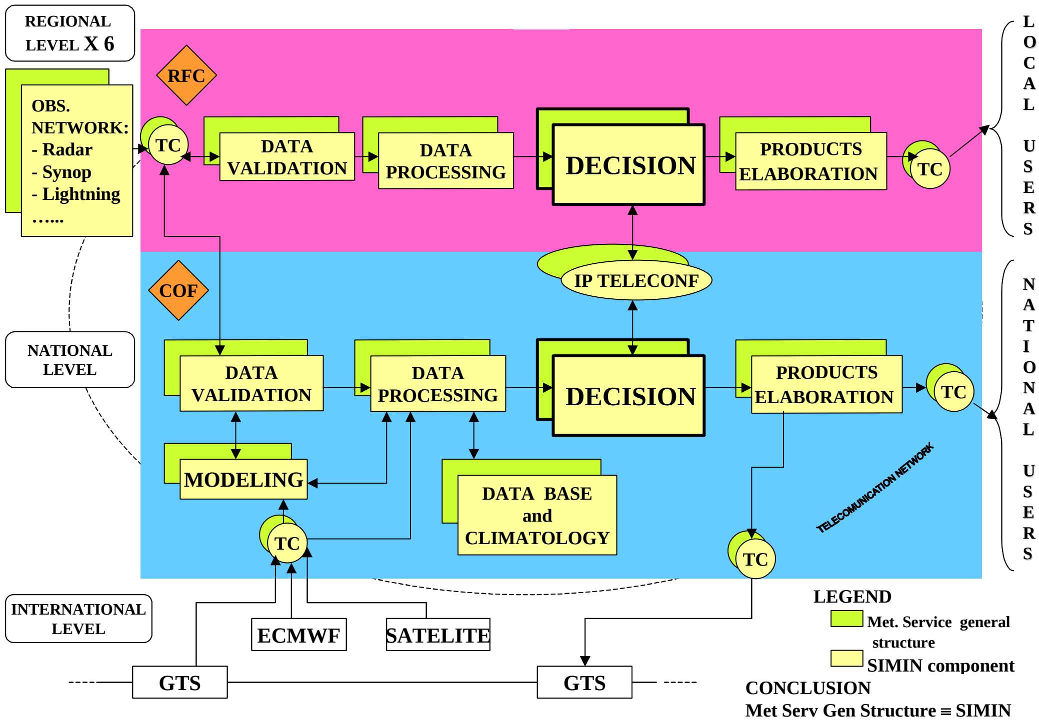

Figure 7-1 National Meteorological Service Components

The main benefit brought by SIMIN is materialized through increasing the capacity of response, the credibility and visibility of INMH – Romania, as the National Meteorological Service, acknowledged by the World Meteorological Organization (WMO) and the Romanian Law of Meteorology.

Any National Meteorological Service has two compulsory tasks:

- Ensuring the protection of life and goods in case of severe meteorological events; and
- Providing reliable, comparable long-term meteorological data series for substantiation and climatological studies for the present, and for the future generations.

In order to accomplish these compulsory tasks, the elaboration of meteorological warnings cannot be separated from the elaboration of weather forecasts, the product dissemination, and the interface with the users. Each of these activities is absolutely necessary within any functioning meteorological system. Figure 7-2 illustrates this principle.

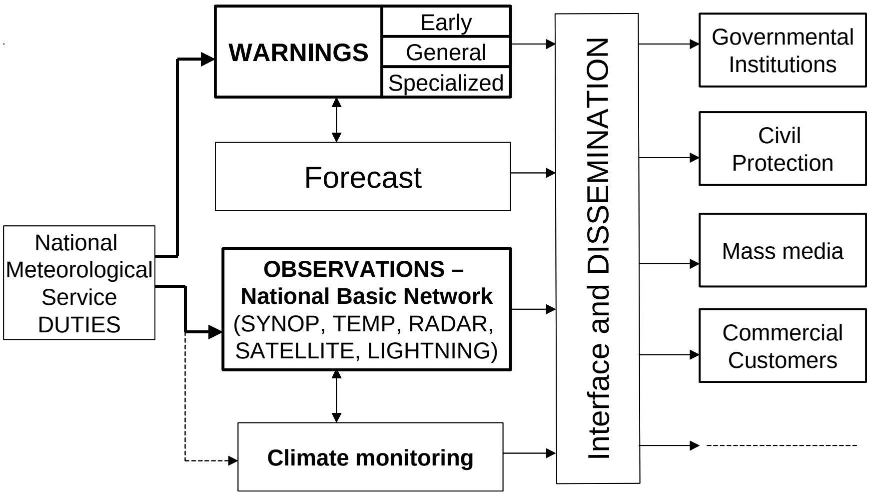

Figure 7-2 Mission Tasks of National Meteorological Services

These general requirements are entirely available for Romania that, on the one hand, always faces a large range of severe meteorological events, and on the other hand, has had a long-standing meteorological network, providing a very long series of observational data. But the historical database is an old-fashioned one, technologically speaking, and does not easily support significant advances in early warning.

Romania faces a wide variation in extremes of severe weather conditions. It receives heavy rains which generate floods over large surfaces, and also extremely dangerous flash floods, which are hard to predict / localize. There are also strong wind events, sometimes with a tornado-like aspect, generating damages in the forest-related sector and destroying / deteriorating buildings. The electric discharges also cause loss of life every summer. During the winter the snowfalls and associated strong winds generate transportation damages and other severe impacts.

The WMO statistics for 2002, World Meteorological Organization, Bulletin Vol. 52, No. 3, July 2003, situate Romania on a mean position both regarding the human life losses of 0.68 / mil. This positions Romania immediately after France and just ahead of Turkey, Belgium, Poland, and others, in terms of human casualties. (Reference Table 7-1) The same WMO report provides national economic losses due to abnormal weather, with Romania recording 0.16% of GNI. This positions Romania after Austria, Germany, but ahead of Hungary, Italy, UK, etc., in terms of economic impacts. (Reference Table 7-2.)

The new S-band DOPPLER weather radars, the lightning detection network, the modern procedures of data processing and numerical modeling, and the telecommunication network of SIMIN provide a significant improvement in weather surveillance and meteorological forecasts to INMH. While many components have been available for some time, the operational transition of the fully functioning system has resulted in noticeable improvements in INMH ability to issue early warnings over the interval June 1st to September 30th 2003. Continued improvement is expected as the transition continues.

With respect to the national surface observation network, INMH – Romania has a network of 160 surface weather stations using a synoptic program. Most of these stations are able to provide observation series older than 25 years, and 44 weather stations recording observations older than 100 years (Table 7-3). In this domain, the 60 automatic weather stations included in SIMIN, the new data collection and validation system and the database server constitute components generating benefits.

Table 7-1 Weather Fatalities by Country

WMO Member	2002 Fatalities*	Population* (Millions)	Fatalities/ Million
Mongolia*	43	2	21.50
Costa Rica	30	4	7.50
Jamaica*	13	3	4.33
Peru*	76	26	2.92
Morocco*	79	29	2.72
Ecuador*	34	13	2.62
Cyprus	2	0.766	2.61
South Africa*	94	43	2.19
Hong Kong*	14	7	2.00
Chile	28	15	1.87
Russia	264	146	1.81
Czech Republic	18	10	1.80
Indonesia*	275	210	1.31
Brazil*	193	170	1.13
Uruguay	3	3	1.00
Saudi Arabia	19	21	0.90
Canada*	25	31	0.81
Papua New Guinea	4	5	0.80
France*	42	59	0.71
ROMANIA	**15**	**22**	**0.68**
Egypt*	33	64	0.52
Colombia	21	42	0.50
Turkey	28	65	0.43
Switzerland	3	7	0.43
Belgium	4	10	0.40
Madagascar*	5	16	0.31
Poland	11	39	0.28
Australia*	5	19	0.26
Lithuania	1	4	0.25
Denmark	1	5	0.20

---

* Fatalities include those reported killed and missing.

* Populations from World Development Report 2002.

* Members marked with an asterisk gave numbers of fatalities associated with all reported events.

WMO Member	**2002 Fatalities***	**Population* (Millions)**	**Fatalities/ Million**
Italy*	5	58	0.09
Bahamas*	0	0.302	0.00
Dominican Rep*	0	9	0.00
Kazakhstan*	0	15	0.00
Macao, China*	0	0.422	0.00
Norway*	0	4	0.00
Trinidad & Tobago	0	1.301	0.00
Venezuela	0	24	0.00
TOTALS:	**1238**	**1033**	**1.2**

Table 7-2 Economic Losses from Weather

Member	**Loss (Mil US$)**	**GNI[1]**	**Loss (% of GNI)**
Mongolia	137.8	0.9	15.31
Lithuania*	261.886	10.7	2.45
Jamaica	67.415	6.4	1.05
Australia	4078.225	394.1	1.03
Mauritius*	45.12	4.512	1.00
Chile	650	69.9	0.93
Guyana	5.3	0.667	0.79
Georgia*	20	3.2	0.63
Nicaragua	11.95411	2.1	0.57
Austria	1095	204.2	0.54
Germany	10 000	2 057.6	0.49
Canada	2 000.5	647.1	0.31
Trinidad & Tobago	10.62	6.477	0.16
ROMANIA	**61.268**	**37.4**	**0.16**
Uruguay	25	20.3	0.12
Hungary	37	47.5	0.08
Costa Rica	8.024	14.4	0.06
New Zealand	12.610837	50.1	0.03
Latvia	1.6	6.9	0.02
Italy	200.35	1 154.3	0.02
South Africa	15.055	129.2	0.01
Turkey	17	201.5	0.01
Congo	0.15	1.8	0.01
UK	78.125	1 463.5	0.01
USA	300.00000	9645.6	0.00
Sweeden	4.372	237.5	0.00
Marocco*	0.286	33.8	0.00
Bahamas*	0	4.533	0.00

---

[1] Gross National Income, GNI, in thousands of millions of US dollars. Formerly Gross National Product, GNP, GNI is the broadest measure of national income.

* Members marked with an asterisk evaluated losses in money terms for all reported events.

Member	**Loss (Mil US$)**	**GNI**[1]	**Loss (% of GNI)**	
Dominican Rep*	0	18.0	0.00	
Kazakhstan*	0	17.6	0.00	
Norway*	0	151.2	0.00	
Venezuela*	0	104.1	0.00	
2002 Totals	19 145	16 747	Mean	0.11%
2001 Totals	13 230	19 770	Mean	0.067%

Table 7-3 Observation Station History

Data series duration (years)	**Number of stations**	**Of which:**	
		Existing automatic stations	**SIMIN automatic stations**
≤ 25	19	-	6
26 – 50	32	-	6
51 – 75	49	5	14
76 – 100	16	2	8
101 – 124	40	2	25
≥ 125	4	1	1
TOTAL	**160**	**10**	**60**

8 A Black Sea Storm as seen by the SIMIN System

Since its installation, many meteorological events have been observed in the integrated SIMIN environment. A storm occurring 12th September 2003 has been chosen as an example of SIMIN capabilities. This storm was selected not only for its unusual characteristics, but also for its grave consequences. The remote monitoring of the meteorological phenomena over the Black Sea, a region with very poor classical observation data, was possible using the facilities offered by the SIMIN system. This Case Study provides a brief reconstruction of the events, and several sample products from SIMIN.

8.1 The Forecasts

On September 10th, after a long period of dryness, the forecast models and other information available within the SIMIN environment indicated that atmospheric instability and a probability of high precipitation would occur over the next three days. The Weather Forecasting National Center therefore released a Warning (nr. 67/2003) concerning the anticipated phenomena.

On September 11th, a large low-pressure area formed covering Central Europe, as well as the Central and Eastern basin of the Mediterranean Sea. All of the global atmospheric model results available at INMH (ARPEGE, GSM, ECMWF, UK-MET) showed the tendency of the extension of the cyclonic area over the Black Sea. The ALADIN model, which is a meso-scale model running at 10Km horizontal resolution, showed the same tendency but with more details.

The 30-hour ALADIN meso-scale forecast of the surface pressure and wind fields, valid September 12th at 06 UTC, agreed quite well with the large-scale models, Ref Figure 8-1. However the ALADIN model forecasted the Low in the Western Black Sea to be deeper and positioned not so far out into the sea. The strong wind and high ageostrophic flow over South-Eastern Romania and the

North-Western Black Sea, forecasted precipitation (Ref. Figure 8-2) and high positive vorticity nuclei (Ref. Figure 8-3) allowed the INMH forecasters to predict the deterioration of weather condition over the western Black Sea basin during the day of September 12th. Additionally the INMH wave forecast model indicated wave heights to be heights around 3-4 meters (Ref. Figure 8-4). This information provided INMH justification to continue the Warning condition.

Another Warning (nr. 68/2003) was issued on the morning of Sept 12th, 2003, specifying the intensification of the phenomena over the South-East Romania and Western Black Sea

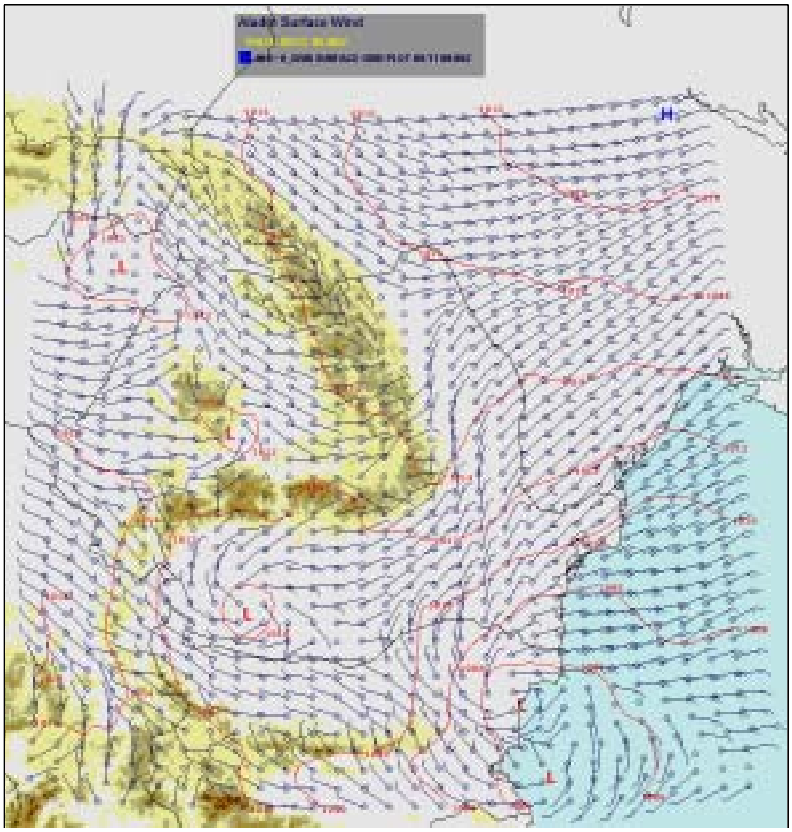

Figure 8-1 ALADIN 30-Hr Forecast of Sfc Pressure and Winds, Valid Sept 12th, 06 UTC

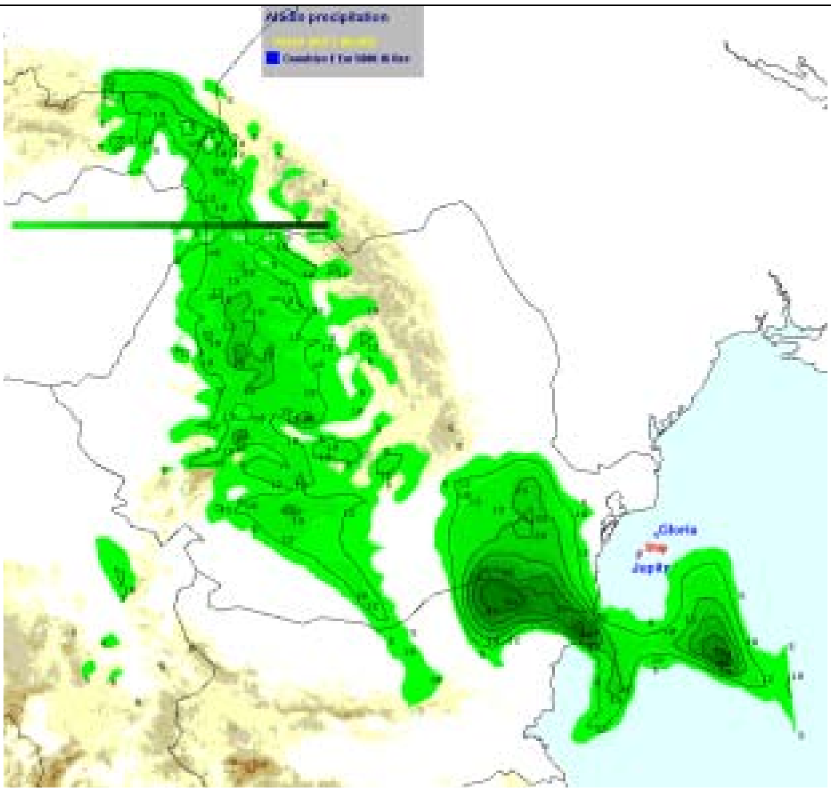

Figure 8-2 ALADIN 30-Hr Forecast of Precipitation, Valid Sept 12th, 06 UTC

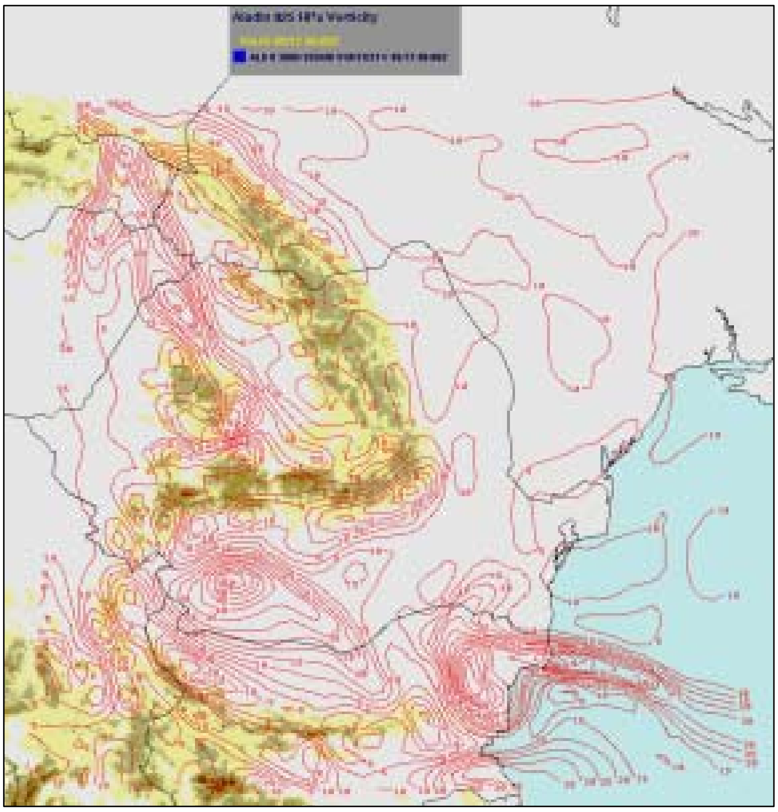

Figure 8-3 ALADIN 30-Hr Forecast of Vorticity, Valid Sept 12th, 06 UTC

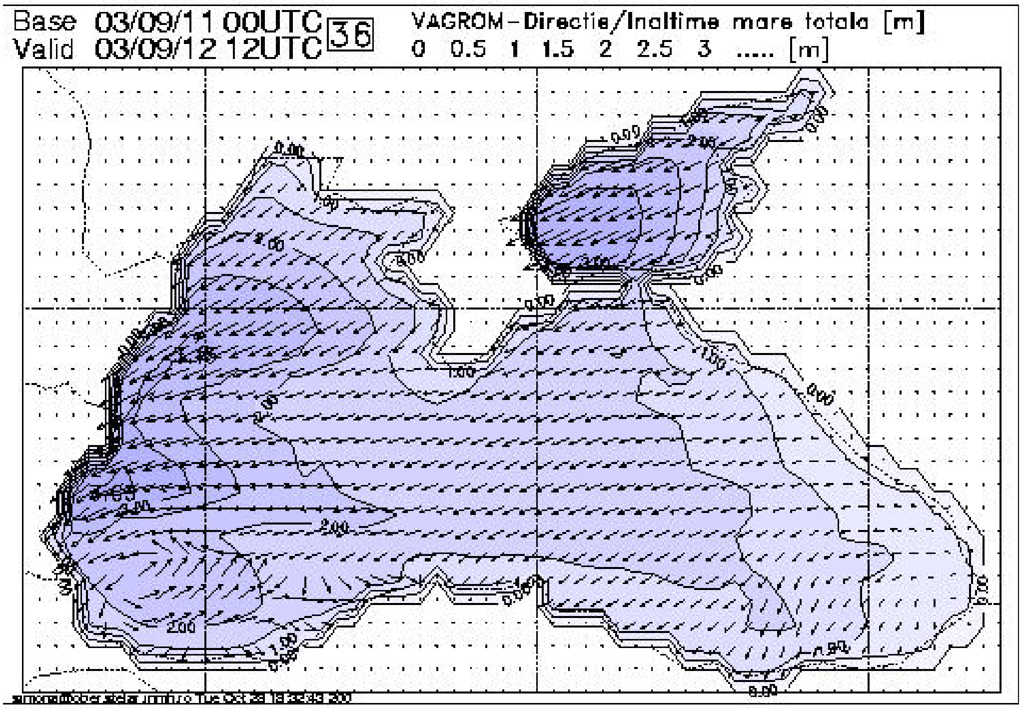

Figure 8-4 VAGROM Wave Model, Valid Sept 12th, 12 UTC

8.2 Forecast Verification and Nowcasting Response

Indeed, the GSM analysis of the surface pressure field and 500-hPa Geopotential field on September 12th, 06 UTC confirmed the foreseen evolution, Ref. Figure 8-5 and Figure 8-6. These analysis fields agree quite well with the large-scale features forecasted by INMH.

Moreover, the remote sensing capabilities provided by SIMIN provide a real-time integrated view of the phenomenon to National and Regional forecasters. In the absence of remote sensing, observation of the phenomena over the sea would not have been possible. Under the situation, the progress of the storm could not have been monitored by the INMH forecasting team. The NOAA Polar Orbiter image, Ref Figure 8-7, shows the event from the satellite perspective. The WSR-98D Radar in Medgidia, Ref Figure 8-8, provides the most detailed observation of the development of the storm over the western basin of the Black Sea, during the morning of Sept 12th, 2003.

After seven hours, the storm moved slowly to the North, affecting Romanian territorial Black Sea waters, as seen in the METEOSAT image of Figure 8-9 and the National Radar Mosaic in Figure 8-10.

Additionally, at 12 UTC, the surface observation station on the oil platform Gloria (~50km offshore, as marked in Figures 8-2 and 8-11) reported 16-17 m/s wind speeds, with 22-23 m/s wind gust, and 6-7 m wave heights. The Gloria station did not record significant amounts of precipitation until Sept 12th, 06 UTC. At that time it reported 13.5 l/m2, accumulated during the previous 24 hours. Conversely, other land stations on and close to the Romanian boarders recorded precipitation up to 130.5 l/m2 accumulated during the previous 24 hours, Ref. Figure 8-11, from the SOP application. This corresponds well with the forecasted amount by the ALADIN model.

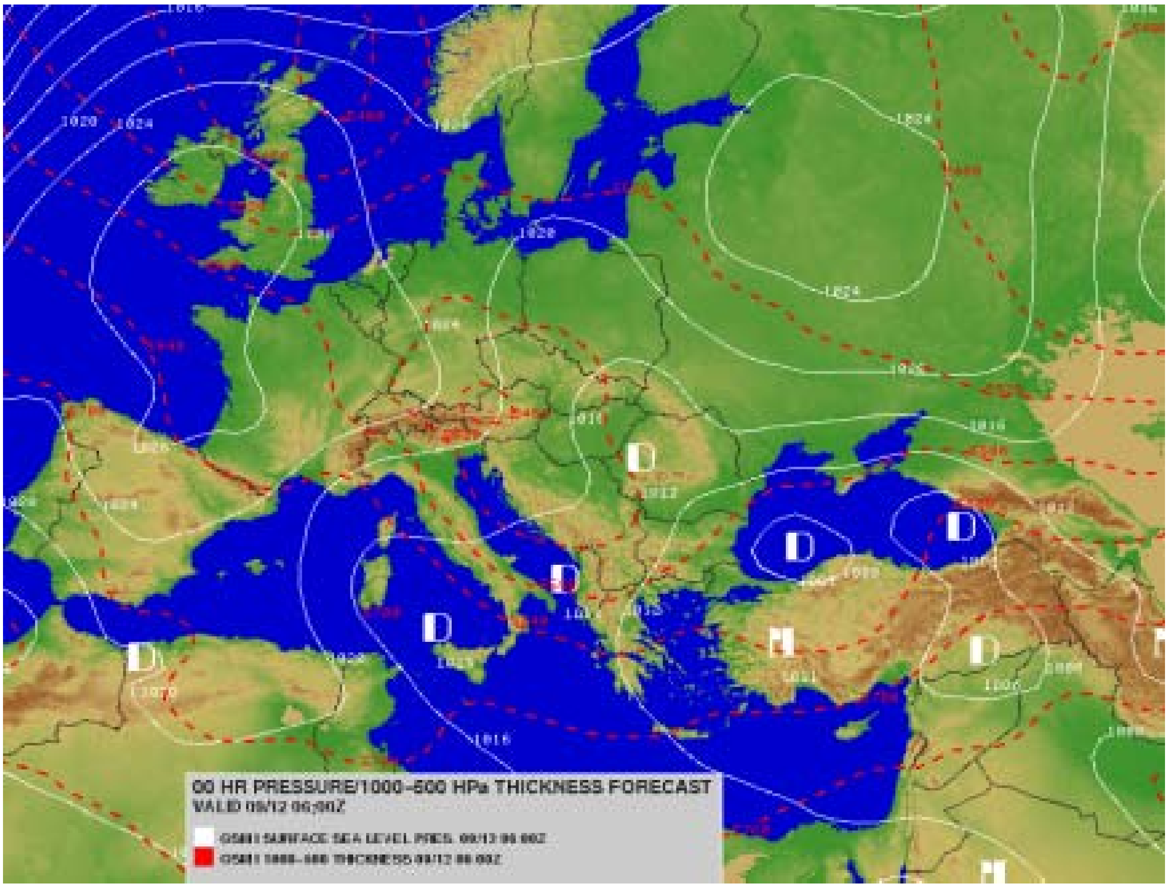

Figure 8-5 GSM Analysis of Surface Pressure and 1000-500 hPa Thickness, valid at Sept 12, 06 UTC

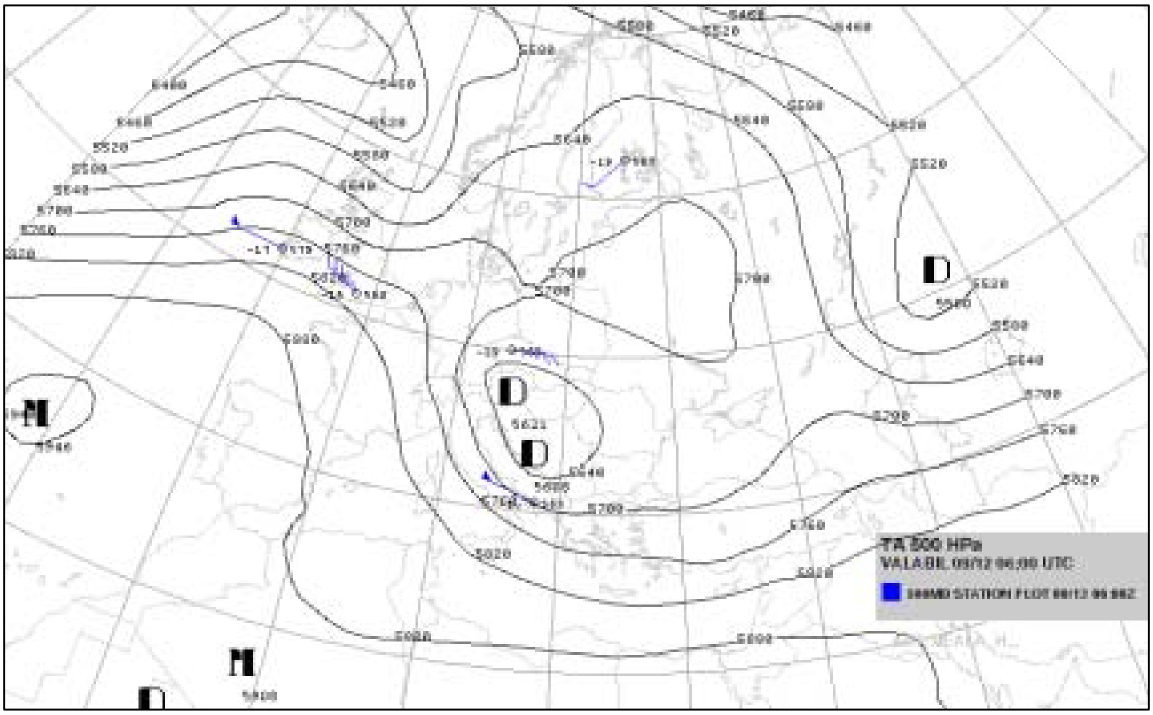

Figure 8-6 GSM Analysis of 500 hPa Geopotential, valid at 06 UTC Sept 12th, 2003

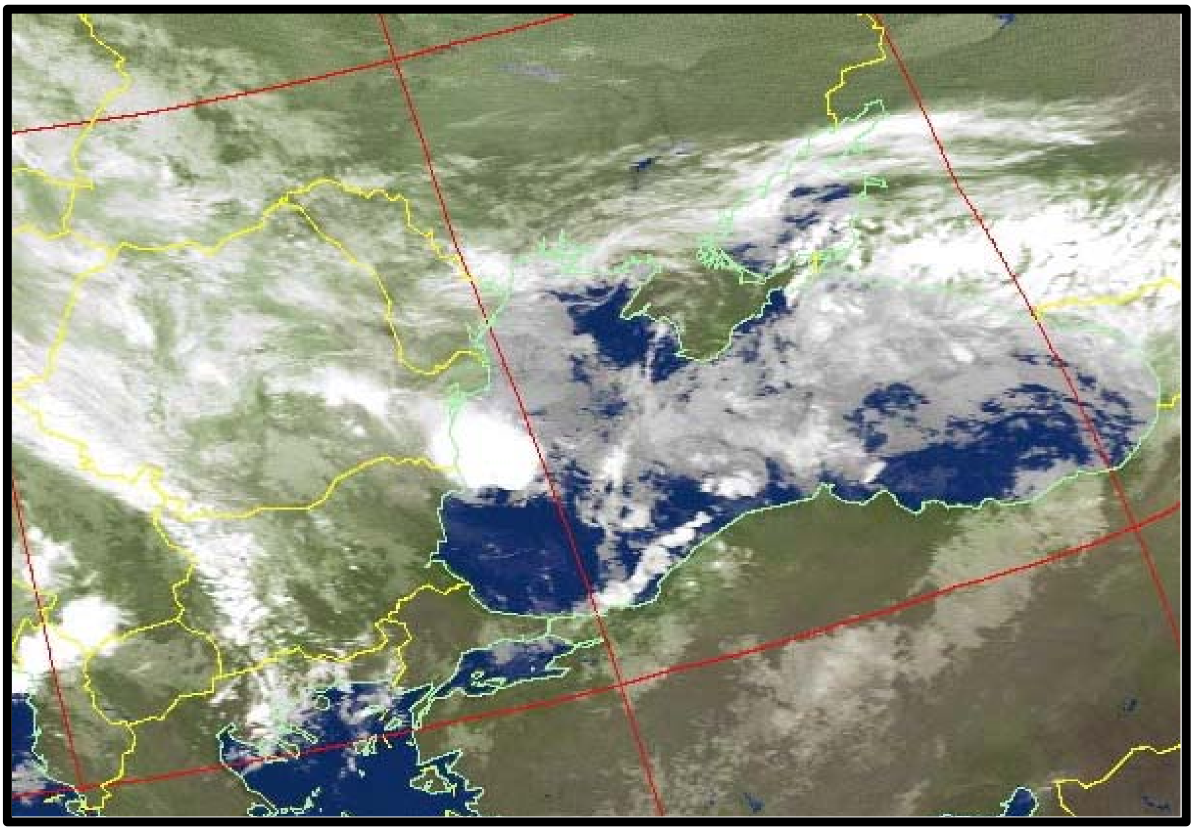

Figure 8-7 NOAA Polar Orbiter Satellite Image Sept 12th , 2003

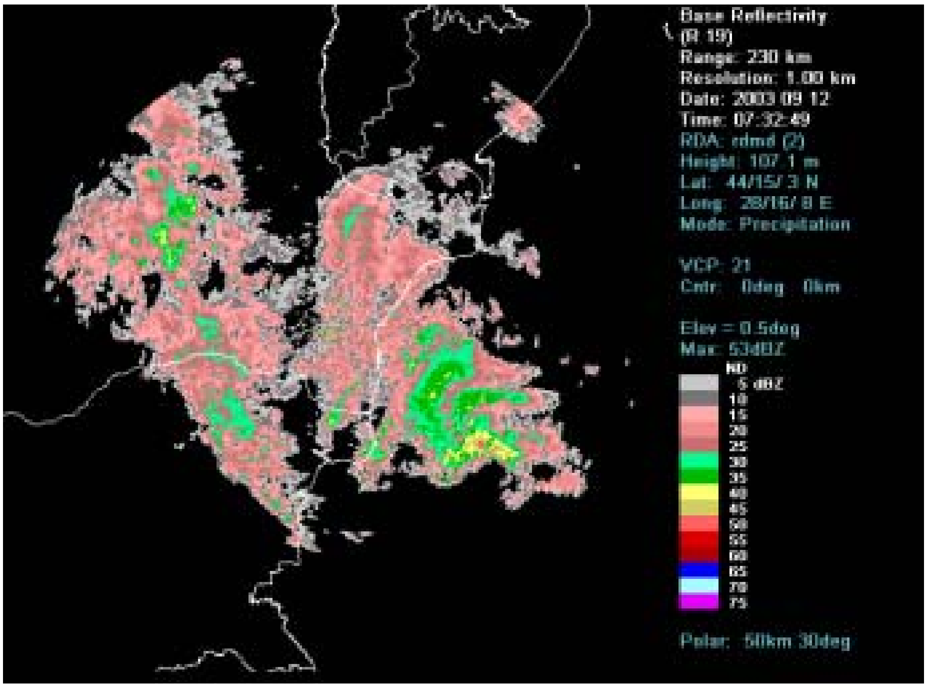

Figure 8-8 Reflectivity Product from the WSR-98D Radar at 07:32 UTC Sept 12th, 2003

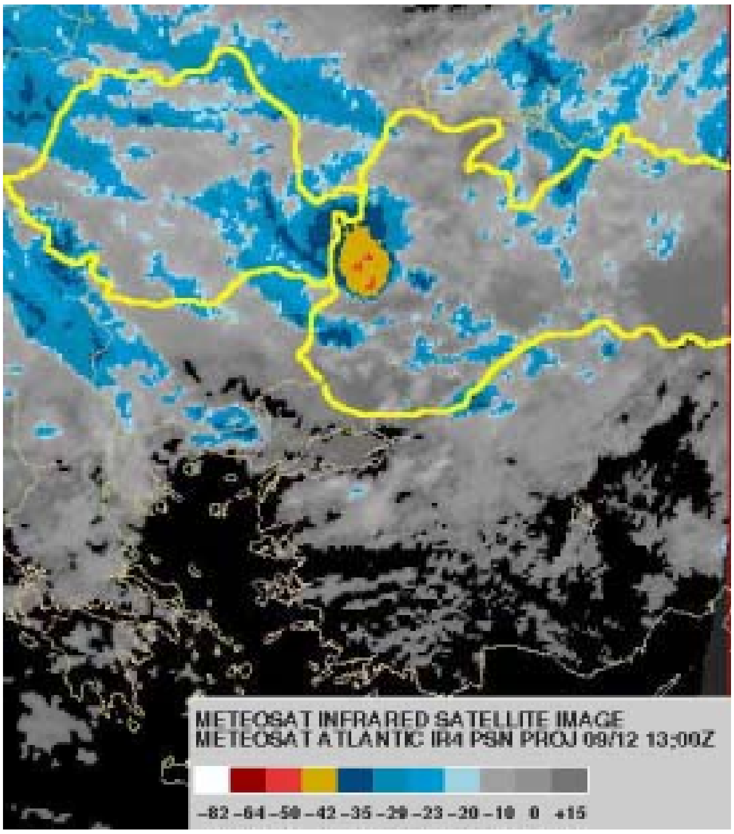

Figure 8-9 METEOSAT 7 InfraRed Satellite Image at 13:00 UTC Sept 12th, 2003

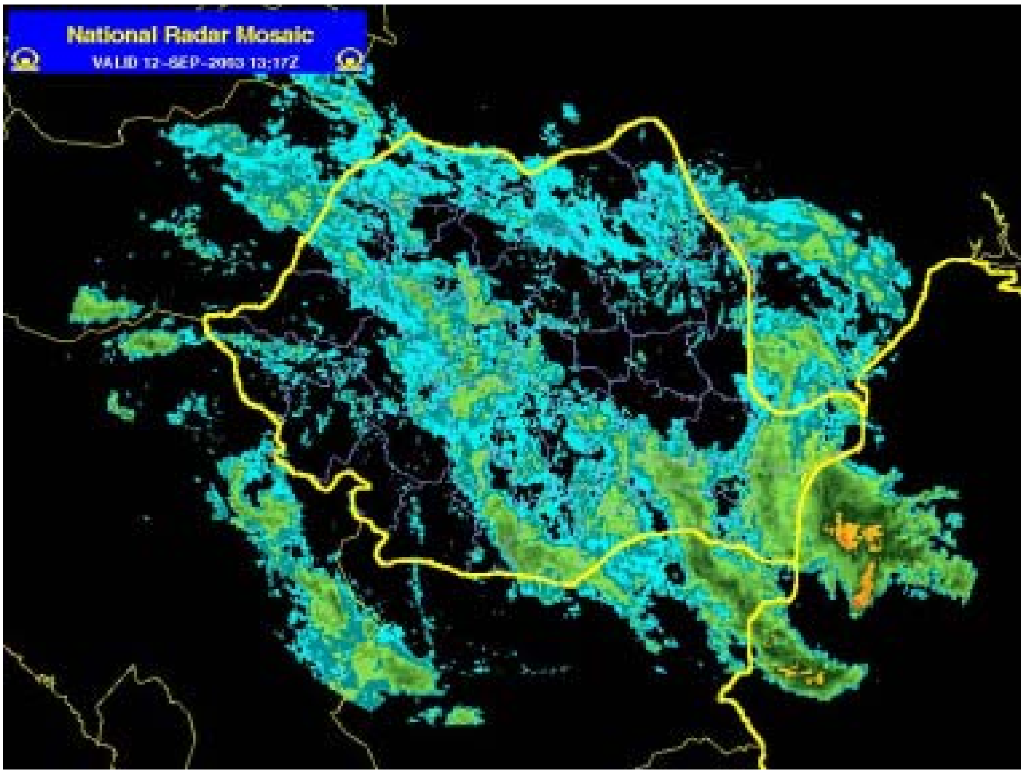

Figure 8-10 The National Radar Mosaic at 13:17 UTC, Sept 12th 2003

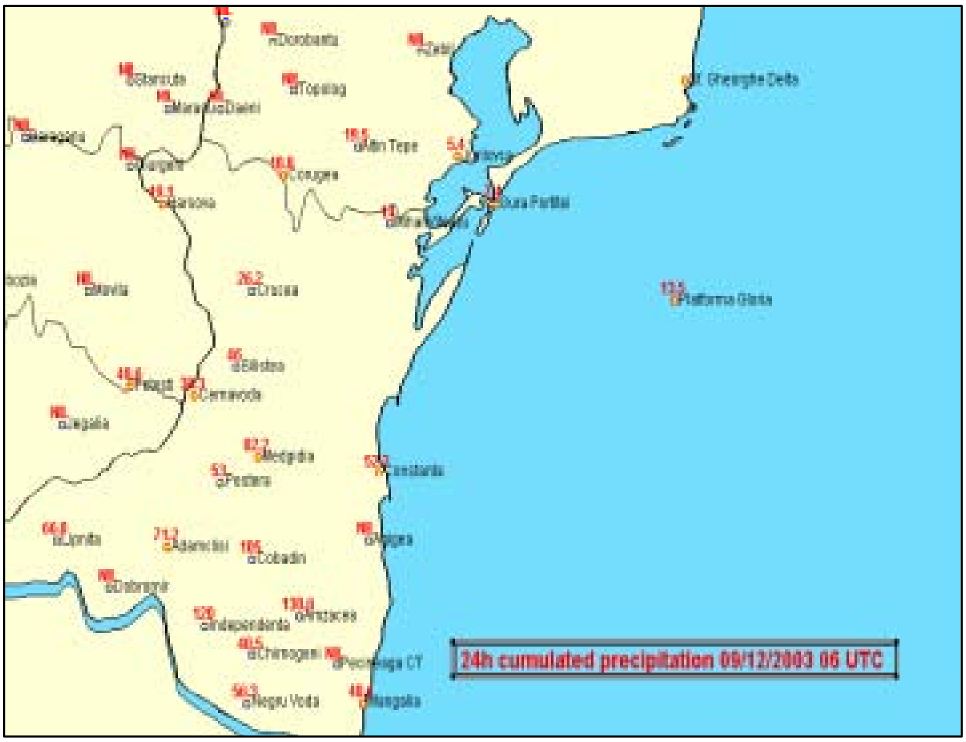

Figure 8-11 24-hour Precipitation Accumulation, Sept 12th ,06 UTC

8.3 The Unfortunate Results

Another signature of the storm intensity concerns the tragic accident of the Ukrainian ship “Slavutich 7“ belonging to the “Ukrichflot” company. On Sept 12th, the ship suffered engine damage and drifted near the Jupiter Oil Platform, Lat 44°31’96” N, Lon: 29°28’03” E, Ref Figure 8-2. Unfortunately, the damaged engines did not allow the vessel to heed the warnings from INMH in time to avoid the storm. An SOS was sent at 12:07 UTC, near the time of the severe conditions observed by the Gloria platform, to the NE of Jupiter, as described in 8.2. Being battered by the storm the ship broke apart, as seen in Figure 8-12, and subsequently sank. The photo is taken from a movie captured from the Jupiter Platform. (Used with permission of videographer N. Barliva, engineer, Petromar Company.) This accident clearly shows the severity of this Black Sea storm, and demonstrates the need for early warning in Romania.

Figure 8-12
The Breakup of a Vessel Caught in the Black Sea Storm of Sept 12th, 2003

9 Summary

Consequently, SIMIN means:

- Modernizing the technical infrastructure of INMH – Romania in all its components (Radar data, synoptic data, satellite data, lightning detection, national and international communication, data validation, data processing and visualization, modeling, elaboration of warning and forecast products, climatological database, dissemination of products to the users, etc.);

- Improving the capacity building of the human resources, both by performing trainings for each component and directly through using the new equipment. It is very important to take into account the ever-growing motivation level of the young specialists using a high technology.

As a result of these points, there is an improved capacity of response in the Romanian meteorology community for the surveillance of atmospheric-related phenomena, elaboration of forecasts and warnings, climatological support, as well as increased visibility through public awareness and capacity building at national and European level.

The main benefits of SIMIN consist in fulfilling the essential goals and tasks of the National Meteorological Services, by providing the technical infrastructure and Human Resources for effective response to dangerous phenomenon, to ensure protection of life and goods and provide direct economic benefits which is ready to be realized in the rapidly developing Romanian "meteorological market", (Ref Figure 9-1).

SIMIN provides the meteorological infrastructure upgrade, which forms the first stage of the Romanian Governments' multi-stage plan for modernization of various environmental monitoring and control systems throughout the country.

Further details of the SIMIN system may be found at the website
http://www.lmco.com/syracuse/IWS.

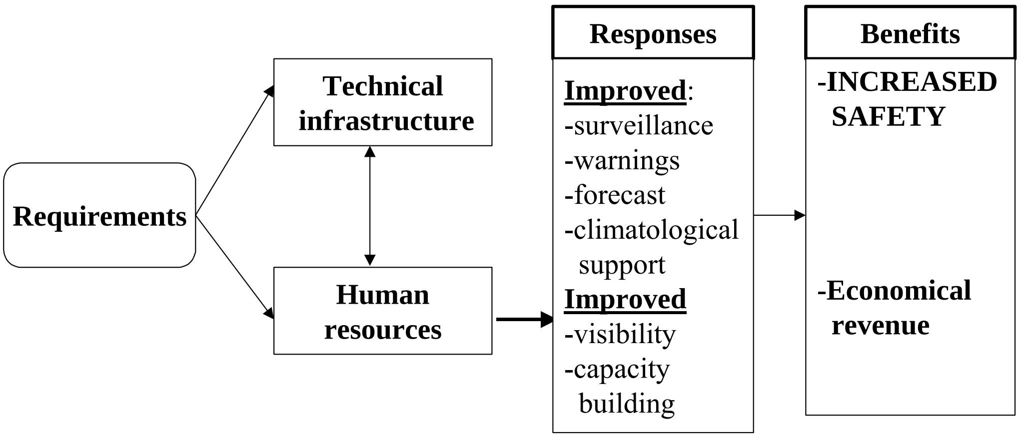

Figure 9-1 The Building Blocks to Effective Meteorological Service