Romania's Advanced Nowcasting Environment: Observations, Systems and Guidance

1. Introduction

Romania has implemented an advanced environment in support of nowcasting activities. This paper describes the implementation of observational networks, including AWOSs, lightning detection, an integrated radar network with advanced decision support systems, NWP models ad satellite derived support products.

The Romanian National Meteorological Administration (RNMA) is the national authority in the meteorology field, except aeronautical meteorology (another organization, ROMATSA, being responsible for this activity). Under these circumstances, RNMA plays an important role in almost all activities carried out over Romanian territory, its primary mission being protection of life and goods. RNMA serves all Romanian citizens through Government authorities, but also performs specialized meteorological services for any kind of end-user (like public organizations, private companies etc.). In order to be successful in its missions, RNMA has to develop, up-grade and maintain the national meteorological system (observational infrastructure, communication, processing, displaying and dissemination systems, qualification of the personnel etc.) at high standards. It is important to note that Romania is an Eastern European country and the whole process of transition to European Union over the last 15 years has highly impacted the meteorological activity.

Romania, despite its relatively small area, has 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 thunderstorms 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 Water and Environmental Protection.

2. National Integrated Meteorological System - SIMIN project

In November 2000, the Romanian National Meteorological Administration – RNMA (Romanian National Institute of Meteorology and Hydrology – ANM at that time) 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 nation's various resources and real-time detection capabilities, and also facilitates the exchange of data at the local, regional, and global levels.

The Project Team led by 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 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 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.

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 1 illustrates the top level SIMIN architecture, showing the primary forecasting sites and sensor locations.

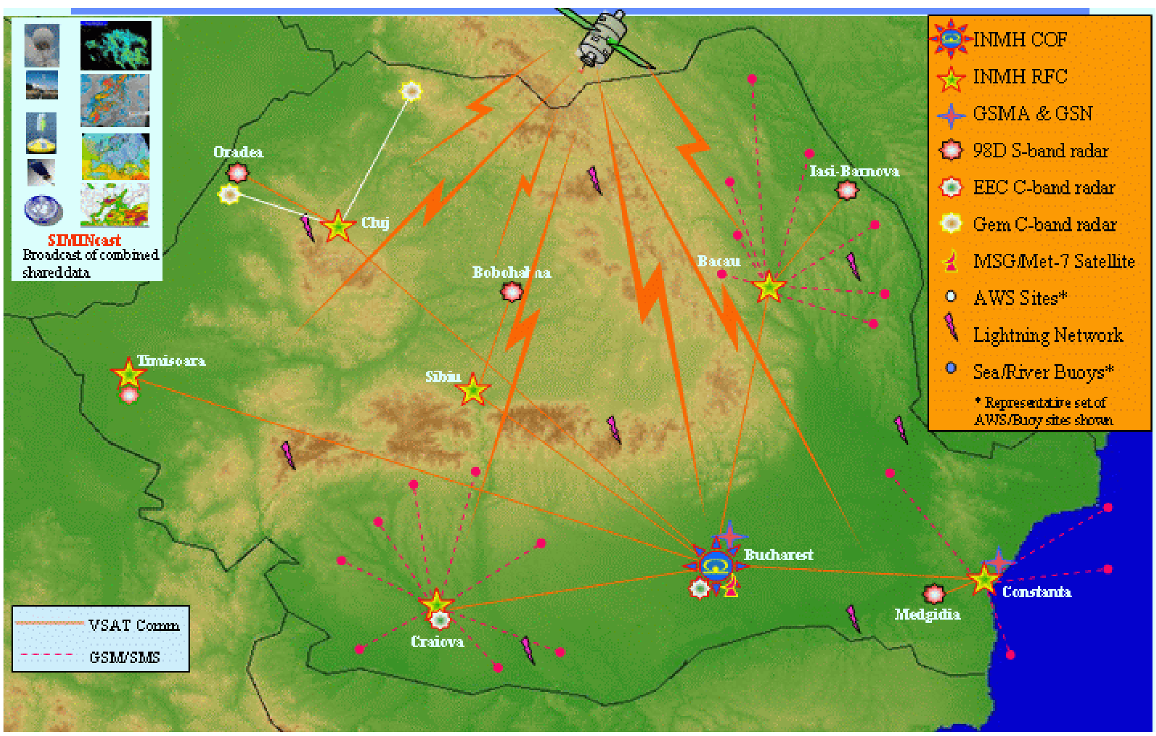

Fig. 1 - SIMIN National Architecture.

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). ANM maintains the responsibility for Fundamental Forecasting supporting the nation. The SIMIN COF is located at the ANM national headquarters in Bucharest. The COF has responsibility for national forecasts, system wide coordination, international cooperation and agency policy control for ANM. 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 ANM in conducting their daily operations, through the use of Briefing Terminals, receiving products 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

SIMIN has upgraded the ANM 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 phenomena 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. (Isn't this already done?) 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 1 Km 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. 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.

SIMIN uses a three-level data collection and distribution architecture, interconnecting all ANM 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 SIMIN cast. Various communications technologies are used for the collection and distribution of data, dependent on the bandwidth needs, cost of operation, and end user requirements. The primary high bandwidth site-to-site WAN communication used between ANM 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. The existing ANM 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. 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 ANM COF and RFC sites and the FPCs. The COF CG controls the SIMINcast distribution of data throughout SIMIN. 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. 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. The distribution of end user products from the ANM 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.

3. Surface Observation Processing

The surface observation network (the meteorological stations) is a very important component of the RNMA observational system. The data provided by this network is used directly by the forecasters (they receive hourly reports from all meteorological stations), is used in climatological studies, serves as input for NWP and part of this data is introduced in the international meteorological data flow (GTS). The network consists of approximately 135 meteorological stations that perform various types of observations (synoptic, climatologic, agro meteorological etc.). Data coming from 23 out of these 135 stations is representing the RNMA contribution to the international data flow. Figure 2 illustrates the geographical distribution of the RNMA surface observation network. It is important to note the fact that the number and the locations for the meteorological stations are slightly varying from one year to another depending on various conditions (new needs for meteorological information in a specific area, degradation, from meteorological standpoints, of some locations, administrative problems -like RNMA is not the owner of the station land / building, budget cuttings, etc.

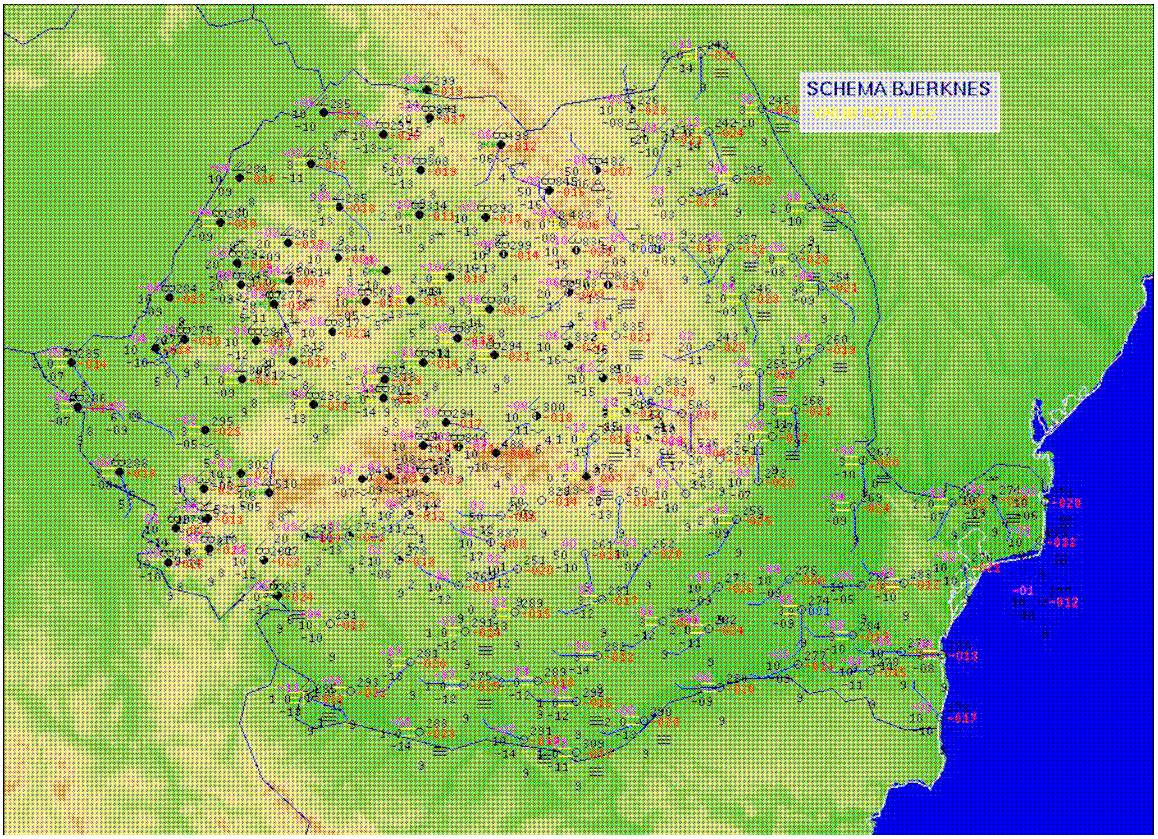

Fig. 2 - RNMA surface observation network.

At the beginning of 90s, all the meteorological stations were using classic instruments for measuring the various parameters. In 1995, RNMA acquired the first automatic surface observation stations (ASOS), but, due to the fact that these ASOS were very few, it can not be considered the start for the modernization of the network. This modernization happened only in 2000 when 10 ASOS were installed in 10 important locations (mostly county capitals locations). The modernization continued with the SIMIN project – 60 new ASOS were installed all over Romania. In the present, the national network contains 73 fixed location ASOS and another 2 mobile ASOS. In the first half of 2005 another 15 ASOS were installed, and other infrastructure modernization projects are in progress (like agro meteorological projects, INTEROPERATE project etc.).

Another aspect of the network modernization is the data collection method. Before 1998 the collection and validation of the data was done manually, using phones and radio communication devices. In 1998 another communication concept was introduced: GSM SMS (short message system). All the stations were provided with cell phones and all the observers were reporting to the collecting centre using SMS service. Later on, in the frame of SIMIN project, a complex application for data collection, transmission and validation was implemented. This application has three components, one for each level of collection and validation: local (station site), regional and national.

4. Upper-air observations

Romanian upper-air network consists of three operational upper-air sounding stations located in Bucharest, Cluj and Constanta. All three stations are equipped with Vaisala DigiCORA systems upgraded to Loran C in 2004 in order to use RS-92 KL sondes and, alternatively, Vaisala GPS sondes RS-92 SGP. The upper-air measurements program consists of two soundings per day at the synoptic hours of 00 and 12 GMT in Bucharest and Cluj stations. The Loran C wind finding system and RS-92 KL radiosondes are used. Currently the measurements program in Constanta is temporary interrupted for the hydrogen building reconstruction and it is estimated that during 2005 the activity will be resumed. Meteorological variables measured in upper-air programs include pressure, temperature, humidity, and wind direction and wind speed. The obtained data are examined using quality control procedures, coded in TEMP bulletins and disseminated in national and international data flow at the a.m. synoptic hours.

Upper-air meteorological measurements used daily as input for numerical weather forecast models are therewith the main support for nowcasting activity, especially to analyse and predict severe weather and the evolution of the local meteorological phenomena. For this purpose the upper-air data are daily processed to derive the thermodynamic parameters and other atmospheric variables such as: potential and equipotential temperatures, main isotherm levels, height and strength of inversions, onset and dissipation of fog, convective condensation level, precipitable water content, vertical stability (convective instability indices, thunderstorms, hail, turbulence), mixing level, etc. Two types of aerological diagrams are automatically performed for visualization and graphical analyze of physical processes: thermodynamic diagram and daily variations of the main upper-air parameters for the last seven days. The upper-air data are recorded on temporary files in order to perform CLIMAT-TEMP bulletins and update database at every end of month. At the same time the main upper-air climatological parameters are computed assuring hereby the input data for climatological studies of the atmosphere.

5. Satellite data acquisition and processing

Since 1970, in the frame of Satellite Meteorology Department there are sustained preoccupation concerning the use of digital information provided by the geostationary and polar-orbital meteorological satellites for specific activities. The main purpose of the RNMA Satellite Department is to provide satellite images, derived products for operational meteorology purposes, and integration of the satellite derived parameters in NWP models. Meteorological products and geophysical parameters are derived and made available to the operational services like the National and Regional Forecasting Centres. Taking into account all these aspects, a NOAA AVHRR / HRPT system was installed in 1998 – 1999 by SMARTECH company. The software for the acquisition and pre-processing (SMARTrack and SMARTVue) was also delivered by SMARTECH. The development of new algorithms is done using ERDAS IMAGINE and ENVI software. Also the RNMA - Satellite Department benefits by the direct reception of digital High Resolution Imagery Transmissions data from METEOSAT and High Rate Information Transmission and Low Rate Information Transmission data from MSG (Meteosat Second Generation). These two receiving stations have been manufactured by VCS-Engineering and were provided in the frame of SIMIN project. The systems actually receive, store and process all the HRI data dissemination formats (A-format, B-format and X-formats for foreign satellites) and HRIT and LRIT data from MSG. The products derived from MSG data are listed below and are used to support the nowcasting and very short range forecast:

Cloud Mask (CMa)

This product shall provide information on the possible occurrence of clouds within each pixel. The central aim is to delineate all absolutely cloud-free pixels in a satellite scene with a high degree of confidence.

Cloud Type (CT)

The main objective of this product is to support detailed cloud analysis. It may be used as input to an objective meso-scale analysis or as an image product for display at the forecaster's bench.

Cloud Top Temperature and Height (CTTH)

The CTTH product shall contain information on the cloud top temperature and height for all pixels identified as cloudy in the satellite scene with the highest possible spatial and temporal resolution. The main use of this product is in the analysis and early warning of thunderstorm development.

Precipitating Clouds (PC)

The Precipitating Clouds product provides information on the probability of weak, moderate and strong precipitation.

Convective Rainfall Rate (CRR)

The CRR product provides the maximum level of information on convective rainfall from the SEVIRI channels. The main use of this product is the monitoring of convective systems and their rain intensity.

Total Precipitable Water (TPW)

The TPW gives information on the total atmospheric water vapour contained in a vertical column of unit cross-sectional area extending from the Earth's surface to the "top" of the atmosphere. This product can be used for objective quantitative studies giving a diagnosis of the total water vapour content in pre-convective areas and therefore helps to classify the air mass in terms of severe weather air masses. Also it gives some information on the intensity of the phenomena to be expected and localisation where severe convection is likely to occur.

Layer Precipitable Water (LPW)

The LPW product provides, in absence of clouds, information on the atmospheric water vapour contained in a vertical column of unit cross-sectional area in three layers in the troposphere. The special interest of this product is the detection of dry-over-moist configurations and of horizontal moisture gradients, as these factors contribute to severe storm formation.

Stability Analysis Imagery (SAI)

The SAI product gives an index summarising the information content in the SEVIRI channels on the vertical thermodynamic structure of the cloud-free atmosphere. In particular, information on the stability of the troposphere is given by SAI with the scope of delineating unstable and stable areas.

High Resolution Wind Vectors on HRV (HRW)

The HRW provides information on mesoscale wind vectors at two different horizontal resolutions: a basic wind product at a scale of approximately 20-25 km, a fine-scale product with a resolution of 10 km. Both products use data from the HRVIS channel and are thus solely extracted during daytime.

Automated Satellite Interpretation Imagery (ASII)

This product provides an automatic interpretation of features seen on satellite images. Hence, the product identifies fronts, wave structures, areas of intensification at fronts by jet streak crossing, position of the jet axis, comma clouds, enhanced convection areas, etc. The result of the automatic interpretation will be given in the form of text and object attributes, which can be overlaid on the satellite IR image.

Rapid Development Thunderstorms (RDT)

The RDT provides information about significant convective systems from meso-alpha scale down to smaller scales, and possible isolated storms (meso-gamma scale). The objectives are twofold: identification, monitoring and tracking of intense convective systems and detection of rapidly developing convective cells.

Air Mass Analysis (AMA)

The goal of the AMA product is to evaluate basic quantities that describe air masses (upper and middle level humidity, mean temperature, atmospheric stability, cloud pattern, etc) and to combine them into one integrated classification of the air mass. The main use is to monitor air masses and air mass boundaries for an early recognition of unstable weather situations.

6. Lightning detection network (LDN)

This type of network represents something new for Romania, therefore we can not speak about modernization but about a new type of information. The network was installed in 2002 in the frame of SIMIN project. The purpose was gathering precise information on the electric activity of the atmosphere. The manufacturer of the network is Vaisala company. The system provides information on its own display, but the data is also integrated into RNMA data flow and can be displayed on other integrated platforms / applications. Below is a brief description of the system, with main specifications and few considerations on localization accuracy.

The LDN consists of:

1. Detection Network of 8 SAFIR 3000 Total Lightning Automatic Detection Stations, located on RNMA sites (Fig. 3);

2. Spare parts set;

3. Transmissions from the detection stations to the Network Centre, using the RNMA communication means (leased lines, wireless 64 kbp

4. A network centre situated at RNMA HQ comprising:

- Central Processing System (CPS) performing the acquisition and processing of detection network data (SCM), the technical control of the detection network (DCM) and data storage into Oracle database.
- Main User Terminal performing the real-time mapping of Total Lightning localizations and thunderstorm nowcasting processing & display (PDM or BPDM), and post processing on archived data (DAM & EPM).

The Detection Stations are made of a VHF Interferometric sensor designed to perform the accurate angular localization of total thunderstorm electrical activity (intra-cloud and cloud to ground lightning), complemented by a wide band LF electric field sensor for the characterization of lightning strikes to ground. Detection stations are connected via telecommunication means to the central processing system.

The Central Processing System (CPS) acquires the data transmitted by the detection stations and computes the locations of lightning discharges by triangulation technique. The CPS processes and displays the technical status of the detection stations and communication links, and can be remotely accessed from VAISALA technical centre for diagnostics and maintenance. The CPS stores the processed data to the Oracle data base.

The Main User Terminal receives the data from the CPS and depending on the selected processing modules perform the advanced real-time processing and display of lightning and storm nowcasting information, as well as post processing of archived data, such as:

- Localization of Total lightning activity;
- Discrimination of lightning type;
- Total lightning activity density mapping;

• Automatic thunderstorm cells identification and tracking (direction and velocity);

• Automatic thunderstorm cells nowcasting;

• Automatic storm warning functions.

Detection performance

• Type of lightning discharges: Total lightning activity, (intra-cloud + cloud to ground lightning);

• Detection efficiency: 90 % (see simulation map hereafter);

• Localization accuracy: minimum < 1 km (mean error, see simulation map hereafter);

• Coverage: (see simulation maps)

Processed data provided by the CPS

• Localization of total lightning activity (date, time, lat., long, intensity);

• Discrimination of lightning type, and characterisation of CG return stroke parameters:

  o Polarity

  o Peak current

  o Rise time

  o Decay time

Processing on display terminal

• Total lightning activity density mapping;

• Automatic thunderstorm cells identification and tracking;

• Automatic thunderstorm cells nowcasting;

• Automatic warning functions for user defined sites and areas.

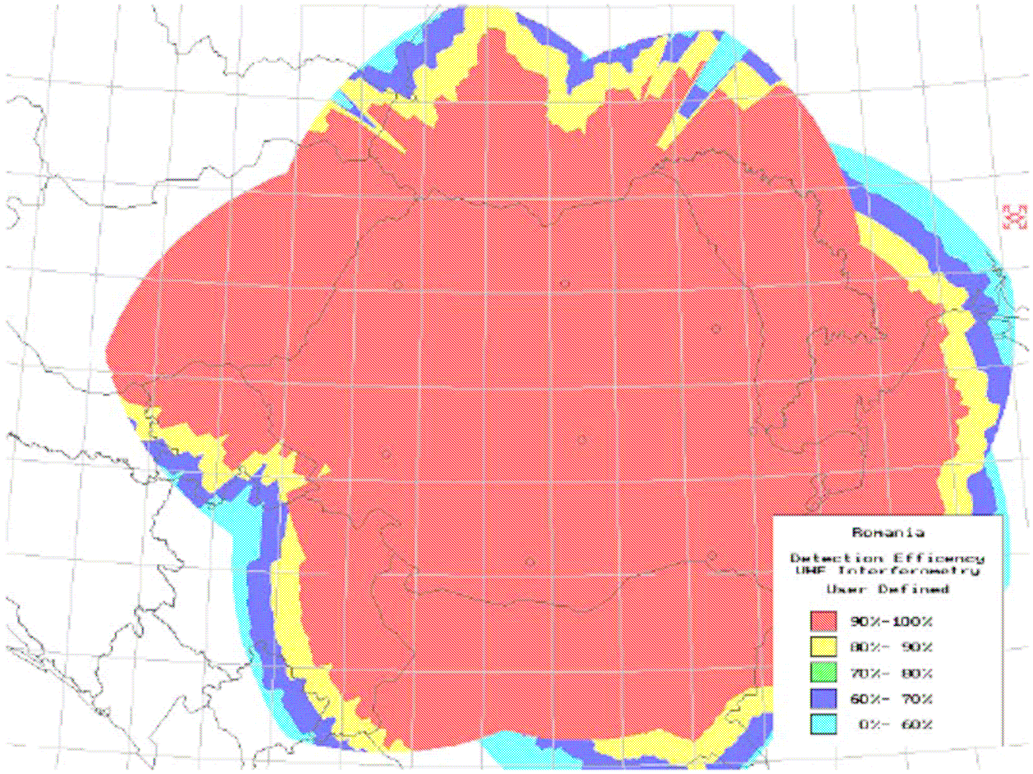

Fig. 3 - Simulation of Total Lightning Detection Efficiency (Cloud to Ground and Intra Cloud lightning) with 8 SAFIR detection stations over Romania.

7. 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 ANM headquarters created a national radar mosaic, also in analog paper map format. Figure 4 represents an example of the three types of National Radar Mosaic with 8 coontributing radars.

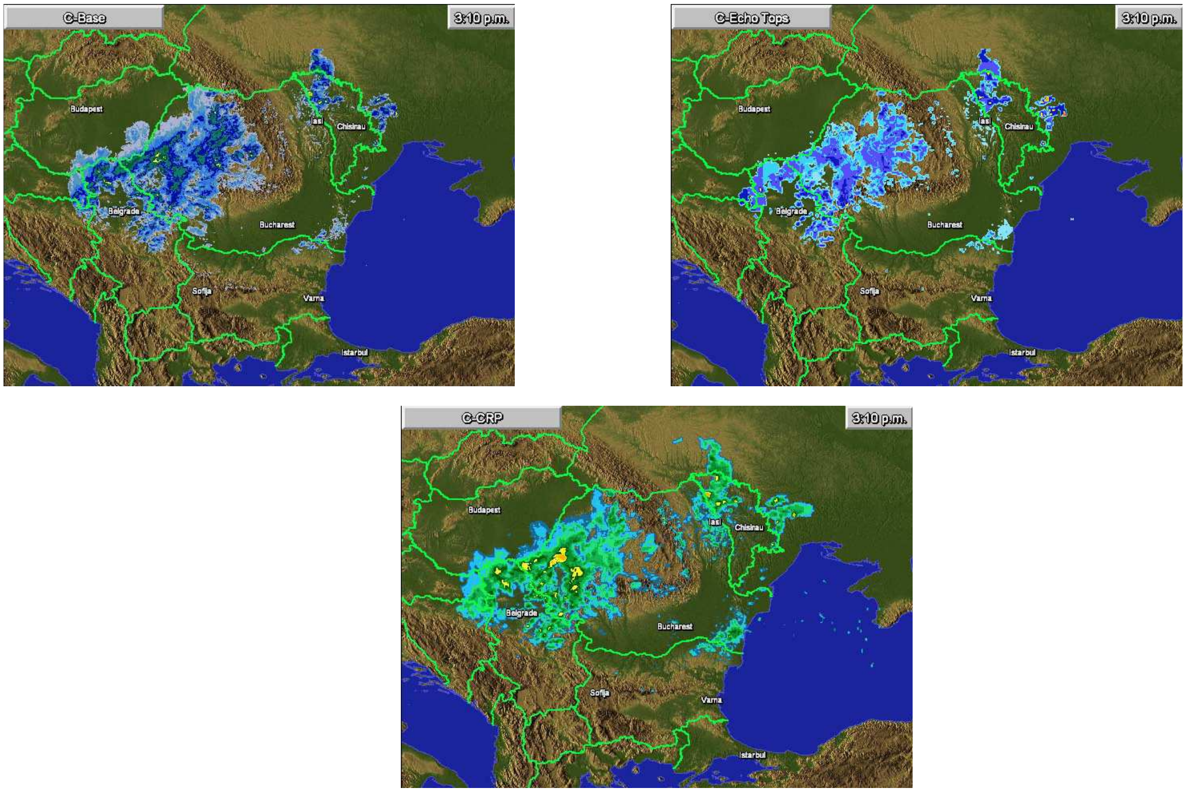

Fig. 4 - The three types of National Radar Mosaic with 8 contributing radars.

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 ANM. 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. 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.

8. Forecasting/Nowcasting Operations

SIMIN provides a variety of tools to support improvements to the existing ANM 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 Voiceover- IP technologies on the VSAT WAN, which allows the ANM COF to hold daily teleconferences will all RFC forecast operations. This capability is essential to harmonizing the forecasts throughout the nation.

8.1 Numerical Weather Prediction

The basis of the national Numerical Weather Prediction (NWP) System of ANM 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.

8.2 Forecasting Environment

The integrated forecasting environment of SIMIN centers on the Forecaster Workstation using the neXREAP application, from Harris Corp., and is used in the forecast operations of the ANM COF, ANM 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.

8.3 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 ANM 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.

8.4 Transition Issues

As might be expected, the largest issues faced by the ANM 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. The RPI consists of various products from BSI, integrated specifically for the SIMIN environment. The MetModel is provided by BSI and Harris Corp. 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, it is only through the extensive dedicated support and commitment exhibited by the ANM team that the transition has been possible. 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 5. The main benefit brought by SIMIN is materialized through increasing the capacity of response, the credibility and visibility of ANM – Romania, as the National Meteorological Service, acknowledged by the World Meteorological Organization (WMO) and the Romanian Law of Meteorology.

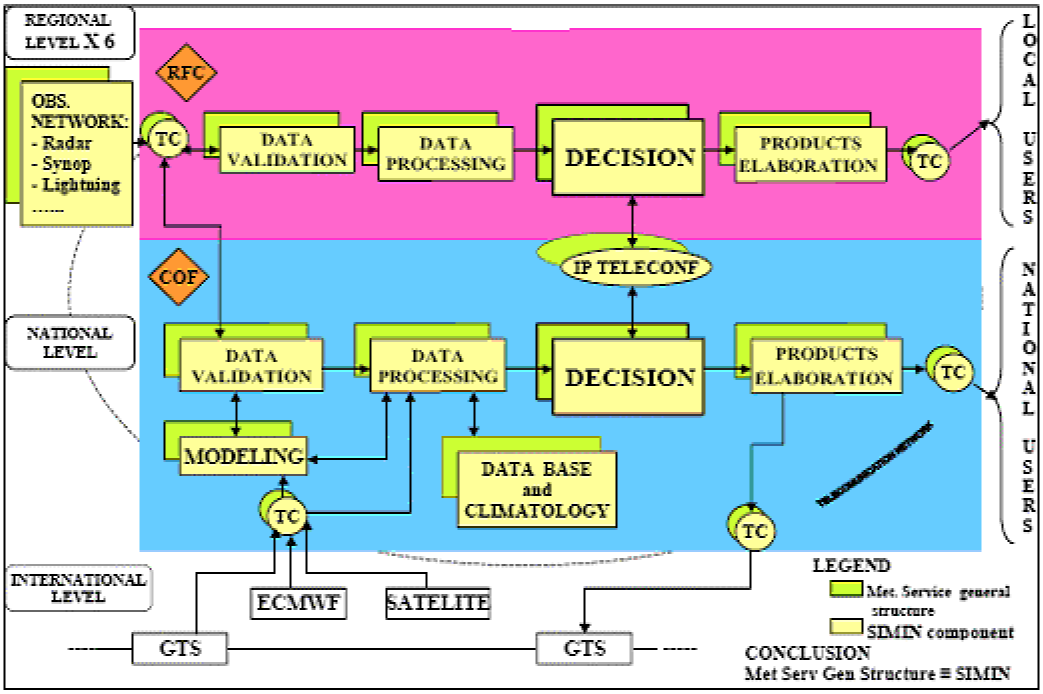

Fig. 5 - National Meteorological Service Components

Any National Meteorological Service has two compulsory tasks:

1 - Ensuring the protection of life and goods in case of severe meteorological events;

2 - 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. 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 humanm casualties. (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. 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 ANM. While many components have been available for some time, the operational transition of the fully functioning system has resulted in noticeable improvements in ANM 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, ANM – 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. 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.

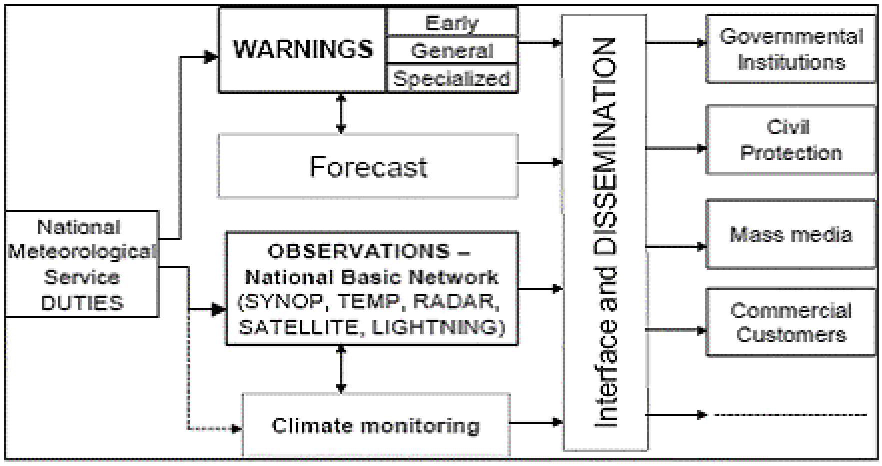

Fig.6 - The Building Blocks to Effective Meteorological Service

9. Summary

Consequently, SIMIN means:

- Modernizing the technical infrastructure of ANM –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”.

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.