14.4 THE HELLENIC WEATHER RADAR NETWORK – UPGRADES, DESCRIPTION AND FUTURE PLANS

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1. INTRODUCTION

Greece recently completed the upgrade and expansion of its weather radar network. The Hellenic weather radar network includes four recently upgraded weather radars and four new weather radar systems. The upgraded weather radars were analog manually operated systems: two S-band radars in Larissa and Thessaloniki, and two C-band radars in Andravida and Athens, all with magnetron transmitters. The upgrade of the four radars includes their Dopplerization, a new digital receiver (SIGMET's RVP8) and fully automated remote operation capability. Four new C-band Doppler weather radars with klystron transmitters were installed in new locations (Preveza, Kavala, Aegina (island) and Astypalaia (island)) to complete the coverage of the Greek territory. Data archiving, quality control, generation of weather products and data dissemination to various agencies and users will be conducted at two central locations in Athens and Larissa. Currently, the network and its radar nodes are in the testing phase and soon it will be fully operational. A detail description of the upgraded weather radar network, its radar and network specifications and area of coverage are presented here. Scanning strategies and future weather products are also discussed along with challenging issues and problems that arise from the complex topography of continental Greece and the need to provide quality measurements over the numerous and highly populated Greek islands that are vacation destination for millions of tourists every year.

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2. BACKGROUND

The acquisition of reliable meteorological data provides the basis for the operational work of all Meteorological Services worldwide. Prior to the 2004 Olympic Games in Athens, the Hellenic National Meteorological Service (HNMS) had four old Weather Surveillance Radars (WSR-74). Two C-band systems located in Athens (Ymittos mountain) and Andravida (western Greece) and two S-band systems located in Thessaloniki (Northern Greece) and Larissa (central continental Greece), manufactured by Enterprise Electronics Corporation (EEC). The magnetron-based systems had no Doppler or remote control capability and their manual operation was intermittent due to frequent malfunctions in the transmitter, the lack of replacement parts and natural tear in the radome. Calibration and data quality control procedures were not available, making the quality of the reflectivity measurements questionable. Furthermore, there was no network capability and thus no central data storage and processing center was available to HNMS for the development of a national scale radar reflectivity mosaic.

The 2004 Olympic games in Athens commencement the first effort to improve the Hellenic weather radar network, when HNMS decided to proceed with the modernization of its services in order to offer adequate weather information during the Athens Olympic Games. Athens is located at the eastern part of continental Greece where the average annual rainfall accumulation is as low as 400 mm (Baltas and Mimikou, 2002). The greater metropolitan area of Athens has a population of more than four millions that is approximately 40% of the entire population of Greece. The heavy urbanization and population growth the last 50 years and the presence of mountains in the periphery of Athens (Fig. 1) helps the collection of rainwater in small highly populated low elevation areas in Athens. Furthermore, until recently flood protection works in Athens were not given any priority and the primitive storm drainage network was insufficient (Baltas and Mimikou, 2002). The lack of anti-flooding protection measures such as channel improvements and storm drainage works created conditions favorable for flash floods events that are frequently observed in Athens. 179 lives were lost during the last 100 years, out of which 96 during the period 1960-1995 (Nicolaidou and Hadjichristou, 1995).

Given the aforementioned reasons, Doppler weather radar coverage of the greater metropolitan area of Athens was critical for near real-time weather information not only during the Olympic Games period but for continuous monitoring. As a result, HNMS decided the installation of a modern Doppler weather radar on the isle of Aegina to cover the Athens area (Fig. 1).

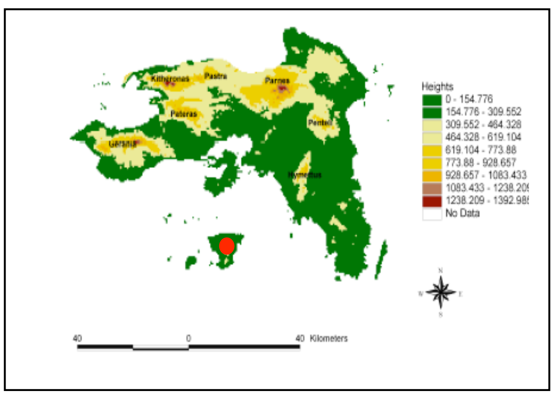

Fig. 1 Topographic map of Athens and the location (red dot) of the new radar in Aegina (from Baltas and Mimikou, 2002).

The installed system was the DWSR-2501C C-band radar from EEC, with a 250 kW klystron transmitter, solid-state modulator, digital receiver and signal processor, a 14' parabolic antenna (1° beamwidth), and EEC's EDGE™ (Enterprise Doppler Graphics Environment) software control and display system. The system was installed in the top of a hill (466 m altitude) and preliminary data collected from the radar indicate the presence of strong sea-clutter that affect the observation of precipitation at low levels in the greater metropolitan area of Athens. Baltas and Mimikou (2002) discuss the factors considered for the selection of the Aegina's island for the installation of the Athens weather radar.

3. RECENT UPGRADES

In 2004, HNMS outline a project entitled "Development of a Network of Weather Radars" tendered by Information Society SA. The project aimed to supplement and modernize the existing network to the extent that it covers the largest portion of the Greek sovereignty possible. The modernization project called for the upgrade of the four old WSR-74 radar systems and the purchasing of 3 new radar systems. The upgrading of the old weather radar included the replacement of the old magnetron transmitter, new solid-state modulator, installation of the digital signal processor (RVP8, SIGMET), new Radar Control Processor (RCP), use of new control and data processing and visualization software (IRIS), new RF and IF receiver components and radome repairs at all four sites. The upgraded WSR-74C/S radars are fully integrated in the new weather radar network, since 3 of the afore-mentioned components (RVP8, RCP, IRIS) are identical to the respective components of the new radars installed. This arrangement enables the best possible interconnection and homogeneity of the newly-developed network, by reducing the basic requirements that arise from the operational usage of modern weather radar network.

Fig. 2 The Hellenic weather radar network

In addition, three new weather radars were installed in Preveza, Kavala and Astypalaia (Fig. 2) The new C-band radar systems (TDR 43-250) from RadTec Enginnering Inc. offer a 250 kW klystron transmitter, solid-state modulator, an offset feed 14' parabolic reflector (1° beamwidth), Sigmet's RVP8 digital receiver, and IRIS display (Hellenic Network Characteristics, Tables 1 and 2).

Radar site	Lat. (°N)	Long. (°E)	Antenna Height (meters)
Athens	37° 56.767	23° 48.829	1023
Thessaloniki	40° 31.689	22° 56.542	33
Larissa	39° 38.678	22° 27.621	104
Andravida	37° 55.349	21° 17.221	30
Aigina	37° 43.290	23° 29.460	466
Preveza	38° 54.993	20° 45.168	34
Kavala	40° 55.532	24° 37.678	38
Astypalaia	36° 35.954	26° 26.429	367

Table 1: Radar Location

Radar site	Band / Doppler	MODEL	Start of operation (Operate/ Planned)
Athens	C-D	WSR 74 (Magnetron)	1978 (O)
Thessaloniki	S-D	WSR 74 (Magnetron)	1983 (O)
Larissa	S-D	WSR 74 (Magnetron)	1980 (O)
Andravida	C-D	WSR 74 (Magnetron)	1979 (O)
Aegina	C-D (DPOL)	DWSR 2501 (Klystron)	2004 (O)
Preveza	C-D	TDR 43-250 (Klystron)	2007 (O)
Kavala	C-D (DPOL)	TDR 43-250 (Klystron)	2007 (O)
Astypalaia	CD	TDR 43-250 (Klystron)	2007 (P)

Table 2: Radar Characteristics

Furthermore, the project included the infrastructure works, e.g., construction of access roads; connection with the power grid, water supply and sewerage networks; construction of facilities (e.g., parking lots, etc.); installation, connection and setting to operation of support equipment including hardware/software for information exchange and relating to safety and protection of personnel and equipment (antennae, radome, power cables) and data, etc. against lightning or power surcharge; functional interconnection of all subsystems and connection of the same with the existing installations of the Hellenic National Meteorological Service (HNMS). All radars will be remotely operated from HNMS HQ in Athens, the Regional Weather Center in Larissa, and the local weather bureau, while their status of operation will be the responsibility of HNMS HQ. When the project is completed and the HNMS radars are set to operation, the images will be transmitted to all above locations for data processing and quality control.

4. FUTURE PLANS

The development of a national-scale weather radar network and products is a monumental task.

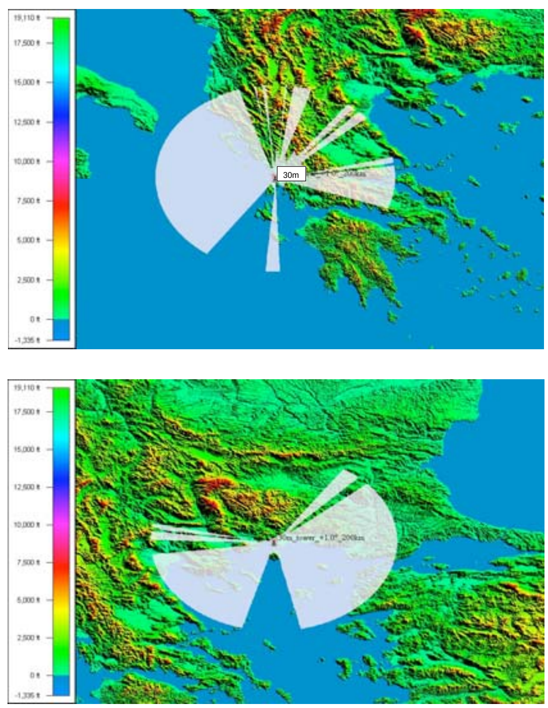

Fig. 3 Examples of beam blockage at 1° degree elevation scan from Preveza (upper panel) and Thessaloniki (lower panel).

The heterogeneous nature of the Hellenic weather radar network (C/S-band, magnetron/klystron systems, polarimetric and Doppler) and the limited human resources and radar meteorology expertise at the HNMS makes the task more difficult.

Currently the network is under evaluation (testing acceptance period). Once past the evaluation period, the identification of uncertainties related to radar beam propagation and the adjustment of vertical profiles of reflectivity have been assigned the highest priority from HNMS. This task will help to determine the volume scan strategy for the radars.

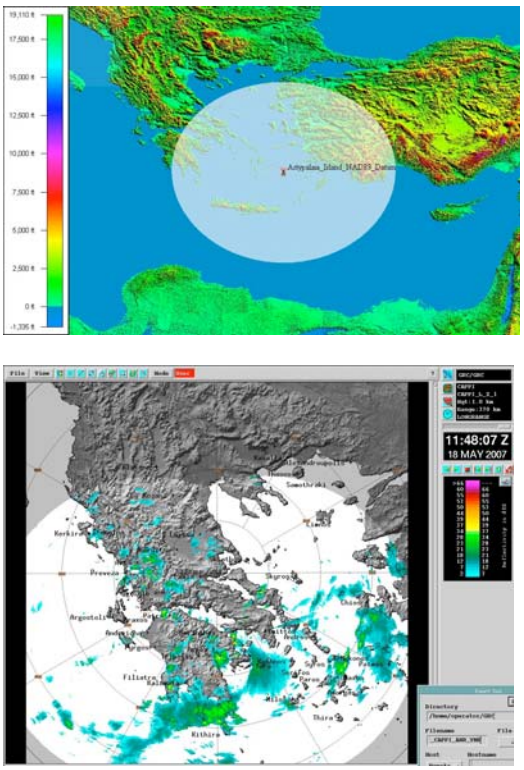

Fig. 4 Coverage (400 km range) of the S-band Doppler weather radar in Astypalaia (top), example of composite CAPPI from Andravida and Athens weather radars.

The mountainous topography of continental Greece presents operational difficulties with total and partial beam blockage (Fig. 3). Inhomogeneous beam filling due to beam blockage is a serious problem when deriving precipitation rates from radar measurements. The Aegean see contains hundreds of small and large island that attract millions of tourist every year. The S-band radar in Astypalaia will be responsible for providing coverage over the central Aegean Sea (Fig. 4). The land/sea contrast provided by the Greek islands, local sea breeze circulations and humidity gradients will favor the development of anomalous propagation (AP) conditions. Furthermore, the removal of sea clutter will be challenging for most of the radars that are located in coastal areas since Doppler filtering, which assumes that non-precipitation echoes are static in space, is not an effective method for identifying and treating sea clutter.

5. REFERENCES

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