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The new radar of Basque Meteorology Agency: Configuration and some considerations for its operative use

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1 Introduction

At the end of 2005 begins running Basque Meteorology Agency Dual Doppler Radar with full coverage of the Basque Country area (North of Iberian Peninsula). Property of Meteorology and Climatology Direction of the Transportation and Civil Works Department of Basque Country Government, it is operated under Basque Meteorology Agency (Euskalmet) responsibility, mainly for surveillance and monitoring severe weather events. For this reason, we must explore and exploit all the capabilities of this new instrumentation.

In this paper we present actual configuration and some considerations for the generation and use of different Radar information. We also present actions that we plan to perform for full operative use of the Kapildui Radar system.

We consider different topics as product generation, data storage, qualitative and quantitative applications and its use in numerical modeling assimilation and validation.

2 System description

Euskalmet Radar is sited in Kapildui mountain (1174 m), a location near the political capital of Basque Country (Vitoria-Gasteiz). Some details about Radar installation, construction and site selection are shown in Aranda and Morais (2006).

Kapildui Radar is a METEOR 1500 Doppler Weather Radar with Dual polarization capabilities from Gematronik. This Radar is based in a Klystron transmitter system, operates in C-band frequency, uses the advanced signal processing environment Aspen DRX as digital receiver and signal processor. The ASPEN DRX performs the initial preprocessing of the reflectivity and Doppler data. The radar control processor RCP interfaces to the signal processor and buffers the preprocessed raw data, establishing an efficient control structure for all components in the system and interfaces the radar with the two software packages used, Ravis and Rainbow.

Data transfer to remote workstations is performed by means of Ethernet interface running the TCP/IP protocol. The connection from the radar site to the Kapildui Rainbow operator workstations and the workstation located in Lakua is established via microwave link and optical fiber.

Ravis is used for Radar control and maintenance, and allows local and remote real time control providing data display, online calibration, diagnosis and maintenance functions. Rainbow is the Meteorological application software used for radar control, supervision, management, data analysis, data display and some products generation.

The METEOR 1500C Kapildui Radar System comprises an Antenna system CDP07 which features a 0.7 degree C-band reflector, dual linear horizontal and vertical polarization with an electrical reflector diameter of 6.68 m. A pedestal with high positioning accuracy and a low loss sandwich panel radome. A Transmitter/Digital Receiver featuring 250 kW peak power Klystron transmitter driven by a dual pulse solid state modulator (TXC 1500) and a dual conversion low-noise receiver (RXC 1500) is also present.

The radar site operates a Linux workstations based system. At Kapildui site a Linux PC is used as Rainbow server workstation controlled from Lakua site where a Linux PC is used as Rainbow client workstation. The radar data acquisition is completely managed by the Rainbow server workstation; raw data is acquired and stored, and the product generation is automatically scheduled according to the installed scheduler job on the server, as well. A notebook with Ravis is also available for maintenance operation in Kapildui site. We are using as local and remote workstations two HP ProLiant ML350 G4, dual proccesor Xeon 3.0 GHz-1MB cache, 4 Gb DDR SDRAM, 72 GB hard disk SCSI hot-plug, with double network slots Gigabit Ethernet.

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3 Actual configuration

Kapildui´s radar is an operational radar mainly dedicated to continuous surveillance, we have established different modes of operation for this purpose.

At present time, operative configuration consists of two volumetric scans and two elevation scans that are done each ten minutes period in polarization mode. First scan defined is a volumetric scan in reflectivity mode that covers a range of 300km, giving us data far away from the Basque Country area. Second scan is a volumetric scan in Doppler /Reflectivity mode that covers the Basque Country Area with a range of 100km. Third and fourth scans are two elevations scans fixed on two directions of special meteorological interest, corresponding to a vertical scan in 241º direction and 339º direction respectively. The main mode features are summarized in Table 1.

Table 1. Most relevant scans characteristics.

Mode features	first scan	second scan	third scan	fourth scan
Scan Type	vol	vol	ele	ele
Data types	Z,ZDR	Z,V,W, ZDR.	Z,V,W, ZDR.	Z,V,W, ZDR.
Execution time (s)	130	383	16	16
Angle Step (º) - AS	0.8	1	0.3	0.3
Range Step (km)	1	0.25	0.25	0.25
PRF (Hz)	495	900/675	600	600
Maximum range (km)	300	100	100	100
Pulse length (L : 2μs ; S : 0.8μs)	L	S	S	S
Scan Strategy	Optimised	Optimised	AS.	AS.
Number of Elevations	5	14		
Lowest elevation (º)	0	-1.5	-1.2	-1.2
Highest elevation (º)	2.5	35	50.4	50.4
FilterMode(IIRDoppler) First gate value, decrease with height	12	9	10	10

The filter mode is settled according to the recommendations of the manufacturer. At this moment, no pre-processing algorithms are established (no clutter correction maps used). In the future other configurations are going to be tested for precipitation specific situations and for improving radar use in non-precipitation situations.

4 System management

4.1 System control.

A remote radar control from the client workstation in Lakua Offices is done, using Rainbow Control Center (RCC). Under the RCC windows environment operating in Linux we have different applications, the system logger (RainLOG), the radar manager (RainRM), the radar view (RainVIEW), a volume explorer application (3DRAVE) and a display tool (RainDART). RainLOG is used for the examination of logging messages from the system. RainVIEW is used to monitor the key radar information. 3DRave is used for the visualization and analysis of polar radar raw data files and for creation of polar based data correction maps. RainDART is used for the display and analysis of Radar data, and for some products generation. RainRM is the application used for all configuration tasks for the overall radar operation.

Through the radar manager RainRM we can check the radar status and take control on radar operation based on the scheduler configuration. We can establish the scan definition and pre-processing, configure schedules, tasks and products and consider conversion aspects.

In the product Selector window all necessary configuration files can be accessed, edited, created, stored or deleted. System control is based in pre-processing definition files, product definition files, conversion definition files, scan definition files, task files and scheduler job files.

With the scheduler definition we configure the automatic operation of the radar, in the scheduler control window we start predefined scheduler and predefined start time with the desired time repetition.

4.2 Backup and archiving data.

Different backup an archiving data strategies are adopted depending on the data affected (rawdata or products files) and the system component involved (2 different location). For the main computer in Kapildui site we are doing full system weekly incremental backup. Computer in Lakua site (Basque Government offices) is generating all products through Rainbow DART application, so in this computer we have rawdata, binary products and generated images that are fully accessible in Miñano site (Euskalmet offices). Those data are transferred to EJIE (Basque Government computer services providers), rawdata are put in a specific radar directory under daily backup action from EJIE personnel, images and other products generated with rainbow applications or with other tools are archived in a specific directory structure (no backup affected) with direct access from Lakua and Miñano offfices. When no-rawdata products accumulated have a specified volume, them are transferred to a external hard disk for archiving purposes. With actual configuration we are generating daily 0.5 Gb of rawdata and 1.8 Gb of others products (2/3 corresponding to images data). Products in image format are generated and stored for their operative use using the intranet.

To manage the disk space and the housekeeping off all the Rainbow files we use RainADMIN administration Service, in both computers configured in such a way that continuous operation is guaranteed. This system is combined with cron shell scripts executed automatically to distribute all the products to different visualization systems.

4.3 Data quality control.

For the moment we are dealing with systematic check-up of data availability based in control scripts designed for this particular purpose. We are controlling rawdata availability as well as the rest of the products generated for intranet, internet and surveillance panel users. On the other hand, quality for different products generated are evaluated through visual inspection and documented. All information generated is archived in a specific directory for quality control. Information available includes Gematronik and internal mails related with Radar maintenance or other interventions, log files, availability documents and quality control documents referring specific problematic events detected including different graphical information.

Some products are available through internet in real time each ten minutes. We have chose two products for public dissemination, one ppi product for 1º elevation from the 300 km range volume scan and one two kilometres pseudocappi focused on 150 km range from the same volume scan. In near future we are going to include more products in our web (www.euskalmet.euskadi.net). We are also offering Radar maps to Basque public television (ETB1 ETB2) under demand. In near future some radar data and selected products will be opened for external users.

5 Developments and actual/future applications

We have accomplished some actions for immediate use of radar data according to a previous specific plan (Euskalmet 2005). This plan considers different items as formation aspects, internal and external for surveillance, forecasters personnel and for operators level, the definition of operation parameters and products for different purposes, backup and archiving strategies, the implementation of development and operative procedures and others aspects.

Goals for these first months of radar activity are achieved. We have settle the operative configuration, selected most relevant products, and established system for automatic generation of graphical information. We have implemented especial web pages for dissemination of products through the intranet, and also selected some products for the Euskalmet web page. We have introduced this new information in the surveillance panel and in the procedures for severe weather reports and other meteorological reports.

We have established internal developments related with some aspects considered critical for the correct operation control of the system and future exploitation of all system capabilities.

5.1 Errors characterization

The main objective of this internal development is the characterization, control and resolution (if possible) of different error sources, considering non-meteorological and meteorological aspects. Main non-meteorological errors expected are motivated from radar calibration, anomalous beam propagation, obstacles, clutter, antenna rotation velocity, spatial resolution and volume integration, among others. Even in the hypothetical case of no instrumental errors present, other errors related with meteorological factors are usually present. Errors related with Z-R relation, dielectric non-constant, rain attenuation, differences in rain drops shapes and sizes, high vertical wind, water presence in the radome, etc. Most of the products especially suffer errors motivated for the absence of a unique relation Z-R for all the data volume.

In the future we are going to establish some kind of quality index affecting radar data, in order to present each different map product accompanied with its related quality map. We also need to control data availability, without an acceptable data availability, addressing systematic error characterization and control is non-sense.

5.2 Analysis and visualization tools implementation and products selection

The main objective of this internal development is to guarantee the best products selection for each particular application (Internet, Intranet, Surveillance Panel, operative applications, etc ..) and to assure the availability of adequate tools for visualization and generation of the different products.

More details about real-time visualization of different radar data in the Euskalmet surveillance panel must be seen in Gaztelumendi et al (2006). All radar products prepared must be set considering the potential use of radar data in different ways; for weather surveillance, for severe weather and for hydrological applications, etc.

5.3 Analysis of meteorological phenomena.

Radar is an irreplaceable tool for studies of different meteorological phenomena, specially those related with the physics of precipitation. Dual polarization capabilities are going to be used for studies about formation of clouds and types of precipitation. In particular we are going to use ZDR capabilities for the identification of hail presence. The most efficient technique for discriminating hail from water is to use differential reflectivity. Reflectivity in the horizontal (ZH) and vertical polarizations (ZV) are similar for spherical hailstones, which is not the case for non-spherical raindrops.

Analysis of high resolution reflectivity fields are used in studies about precipitation distribution in our territory and rain fall characterization. In stratiform precipitation there is a clear separation of ice and water: Above the bright band ice particles dominate, below water phase is found and in the bright band a mixture of both constituents are present.

We must focus on the problem of conversion to precipitation rates using the conventional Z-R relationship, because generally give rise to a significant overestimation of the on-ground precipitation accumulation. On the other hand, radar estimation of precipitation behind hail cells can be significantly underestimated due to attenuation.

Doppler wind data should be used in evaluation of organized convective systems and in studies about dynamics of these systems.

5.4 Quantitative precipitation estimation

Under this topic, we study different existent rain adjustment schemes and algorithms for high resolution rain fields estimation derived from weather radar measurements in combination with rain data available in our territory (rain gauges and disdrometers).

Previous to a Quantitative precipitation estimation (QPE) we need good quality data coming from the AWS network and from the Radar. Reflectivity fields need some corrections to ensure good quality for this particular purpose. Especial focus must be put in beam propagation changes and blockage and variations of reflectivity in the vertical (VPR). The VPR are considered one of the main causes of difference between surface gauge observations and radar observations aloft.

QPE for different temporal periods is going to be used for detection of severe weather and warnings related with precipitation accumulation in real time, for NWP verification, in hydrological applications and for high resolution precipitation fields analysis.

5.5 Quantitative precipitation forecast

We need to identify methods for Quantitative Precipitation Forecasting (QPF) and to incorporate such techniques in future operational routines for short term prediction of precipitation (0-3 hours). Extrapolation Tracking and Lagrangian advection techniques seem to be most usually adopted in mesoescale resolution. Those nowcast methods usually require calculating velocity and direction of rain structures from successive radar images. For longer forecast lead times, numerical weather prediction models perform better than nowcast methods, as they resolve dynamically the large scale flow and allow processes to evolve in time in accordance with imposed boundary conditions.

5.6 NWP data assimilation

The main objective in this topic is to investigate the most effective techniques available for radar data assimilation, to incorporate such techniques in numerical weather prediction (NWP) running operationally in Euskalmet. Numerical prediction is highly dependent upon the correct representation on initial atmospheric state. A good data assimilation technique and good data incorporated in initial state improve short range weather forecast and allow the use of first hours forecast as “spin up” time decrease.

The mesoscale models used in EUSKALMET are mesoscale models for short-range NWP based on the non-hydrostatic equations. For operational purposes, gets boundary values provided by the Global Forecast System (GFS), and in this moment takes interpolated GFS fields as initial fields. In near future models must starts with a special analysis. This initial state is generated by an assimilation scheme of conventional data, like surface and radiosonde measurements, Pta Galea Profiler data and high-resolution observations derived from Kapildui radar. In first instance we incorporate different wind data profiles derived from Kapildui radar wind data (some preliminary results in Gelpi et al 2006), incorporating in near future 2D wind fields and 3D reflectivity data. We are going to check different precipitation-humidity assimilation techniques available (Physical initialisation, Latent heat nudging, variational assimilation, …) and wind assimilation techniques (Optimal interpolation, variational assimilation, successive correction method, nudging, ….) to incorporate the best approximation for operational application, considering mesoscale models in use and system configuration possibilities.

5.7 NWP verification.

Under this subject we are going to define operative procedures for NWP verification and validation based in radar information. Before starting verification of a precipitation forecasts, radar-based precipitation analyses have to be made available (see section 6.4 - QPE), robust scores must be used for the different verification and validation procedures established.

Once good QPE spatial distribution maps are available we perform an areal verification through visual inspection of precipitation fields comparing predicted versus observed pattern. Differences between forecasted and observed precipitation patterns concerning spatial distribution and intensity can be identified in a qualitative way. We are going to establish subjective scores considering the pattern present and the differences observed concerning spatial distribution and intensity.

On the other hand a point verification system is going to be implemented based on QPE interpolation to selected locations. In this case we use scores for predicted-registered punctual data comparison based in the same system we use for actual validation of numerical results versus registered AWS data (Gelpi et al 2006).

Both approximations gives us an important indicator of the quality of the numerical forecast and a deeper understanding of the behaviour of our models.

6 Conclusions

We have presented actual configuration of the new radar of Basque Meteorology Agency, and some considerations for its operative use, and for future applications.

Qualitative applications are, in this moment, the way weather radar information is mostly used in Euskalmet during the first months of use.

Some quantitative applications have just started, and much more are planned for near future.

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