MicroRadarNet: an innovative high-resolution low-cost x-band weather radar network

MICRORADARNET: AN INNOVATIVE HIGH-RESOLUTION LOW-COST X-BAND WEATHER RADAR NETWORK

Stefano Turso, Marco Zambotto, Marco Gabella, Fiammetta Orione, Riccardo Notarpietro, Giovanni Perona

Remote Sensing Group – Electronics Department – Politecnico di Torino
C.so Duca degli Abruzzi, 24 – Turin – Italy
Presenting author e-mail: stefano.turso@polito.it

1. ABSTRACT

In this paper, an innovative micro radar network for meteorological purposes has been presented. The key aspects of this network, named MicroRadarNet (MRN), are a short range strategy (about thirty kilometers) and the implementation of effective enhancing techniques. High resolution spatial and temporal data is processed in real-time, yielding a synthetic and consistent evaluation of the information coming from the sensor network. This approach implies in turn a sensible reduction of the overall operational costs, including management and maintenance aspects, if compared to the traditional long range C-band approach.

2. INTRODUCTION

In the framework of the European INTERREG IIIB Alpine Space Programme, the FORALPS project ("Meteo-hydrological Forecast and Observations for improved water Resource management in the ALPS") promoted in 2004 the design and development of an innovative weather micro radar network. The Remote Sensing Group at the Politecnico di Torino has being developing this new network from its early ideation stages. The initial design scenario was specifically tailored to enable along-valley and vertical radar coverage for region exhibiting a complex orography (e.g. narrow valleys in the Alps). This suggested the adoption of a non-conventional vertical plane sounding to collect just 2 low elevation opposite rays and a vertical ray yielding the vertical reflectivity profile. To cover a broader range of operational needs, this initial design concept was then extended to collect the entire vertical plane and finally to include the more traditional horizontal scanning plane as well. Since from the early stages, the emerging sensor network concept suggested to design the apparatus as tightly related to a network of similar small unattended units. The result of the above approaches and suggestions is MicroRadarNet (MRN): a low-cost X-band micro radar network. MRN is already an operational entity, since a small number of MRN micro radars have been distributed on the territory. Operational units have been installed on the Politecnico di Torino roof (October 2006), on the roof of the Aosta Valley Civil Protection (March 2007), on an open field in Klagenfurt Airport (September 2007). An ever-growing database of meteorological case studies is being collecting data sets, thus providing a real-data test bench to refine assessment and data enhancements algorithms.

3. KEY ASPECTS AND MOTIVATION

C-band radar constellations are typically used for long range meteorological target detection. On the contrary, an X-band radar network works at short ranges. This prevents the shortcomings which typically occur when adopting C-band radar constellations within regions exhibiting a complex orography. Moreover, the availability on-the-shelves of low-cost portable X-band RF unit facilitated the development and deployment of a prototypal sensor network.
Both the traditional horizontal scanning and the non-conventional vertical scanning approaches are implemented. The vertical scanning mode has proven to be particularly effective when applied to the monitoring of orographically challenging regions, like Alpine Valleys. This scanning mode highly mitigates the effects of orography, thus enabling effective along-valley

sounding and vertical profile retrieval. On the other hand, the horizontally scanning mode covers the more traditional weather monitoring needs.

4. NETWORK ARCHITECTURE

A number of MRN nodes (the micro radars) are distributed on the territory, collecting weather information. High-performance embedded processing units execute in real-time the on-board evaluations on the incoming instrumental data. The resulting data sets are uploaded to the MRN server cluster. This validates and stores into a SQL database the received weather data. A subset of the MRN servers interfaces to the final users, to provide any requested data sets through regular Web pages. Typically, MRN units connect to the MRN servers via commercial GSM providers. The newest technologies enabling wireless data transmission have been investigated. However, well-assessed second generation services (GPRS and EDGE) have been chosen as the preferred radio-link for both MRN node control and data exchange. These radio data services are commonly supplied by most GSM service providers worldwide and they were found to provide a robust communication channel for the low bit rate needs of the network. All other MRN connections are Web based. The overall low power consumption may permit the feeding through rechargeable power cells. Authorized MRN users can remotely control their apparatus through the GSM network (by sending SMS commands). This mechanism assures both a high availability of the apparatus and a smart card level security environment. MRN exposes a password-protected Web site as its basic way of interaction with its final users. MRN users can select a certain MRN session, observe its content via a specialized Web viewer and eventually store it locally.

5. CONCLUSIONS

A consistent amount of case studies clearly shows that MicroRadarNet has enough potentialities to provide meteorological information. The proposed strategy, based on a short range sensor network, shall effectively lower the overall operational costs and integrate with long range C-band radars, thus preventing the shielding shortcomings which typically occur when adopting conventional weather radars for the monitoring of orographically complex areas.

6. REFERENCES

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