



A PORTABLE
LOW-COST
SHORT-RANGE
X-BAND RADAR
for rain estimation
within valleys



Région Autonome
Vallée d'Aoste



Regione Autonoma
Valle d'Aosta



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Problems when applying
quantitative information
from weather radar:
poor resolution
at long-ranges,
orography.

Precipitation is much more variable in time and space than other meteorological variables.

This is true not only for short time scale, but even from a climatological point of view.

In mountainous terrain, precipitation is even more variable both in space and time because of orographic effects and the interaction of the wind with the mountains.

This variability within the radar scattering volume is in contrast with the usual assumption of homogeneous beam filling.

Unfortunately, this assumption is the basis of the meteorological radar equation.

In turn, the radar equation is the basis for estimating reflectivity, attenuation and phase shift along the beam.

Radar is giving an excellent overview of the weather in time and space.

But we should neither expect miracles nor oversell radar as a

quantitative tool.

Perhaps much, of what we would like to do, can only be achieved at short ranges from the radar.

This is not because we miss careful investigations, but simply, because radar is seeing the rain aloft, while we need to know what is arriving at ground level.

Echoes from the ground have to be eliminated.

Obstacles as well as earth curvature lead to a variable horizon, allowing us to see precipitation at variable height, often too far from the ground.

All these difficulties increase rapidly with range between the observed volume and the radar location.

Furthermore, precipitation is too variable for the coarse resolution of our instruments.

The variability of natural precipitation is so large that the radar beam often does not resolve it.

As a result we find different types of particles and non-homogeneous

reflectivity in the pulse volume, aloft and compared to the ground level.

And in mountainous terrain, precipitation is even more variable both in space and time.

The full range of actually operating long-range, high-cost, C-band, meteorological radars is useful for weather forecasting and surveillance.

Unfortunately, the same quality of results, which are obtainable with large efforts at close ranges, cannot be reproduced for quantitative applications at far ranges.

This is particularly true in mountainous terrain.

One could think of placing a long-range, high-cost, C-band, radar on the top of the mountains.

However, this choice implies high installation costs, severe ground clutter contamination and, nevertheless, difficulty, if not impossibility, of "looking" inside the valleys.

An alternative idea is to develop a portable, low-cost, short-range,

X-band radar (Gabella et al. 2006), which can be placed inside the valleys (Joss et al., 2005).

The consequence is obviously to adopt a vertical scanning strategy, which should be "tailored to the valley", instead of a standard horizontal one.

These novel and innovative ideas are the results of a successful research and technological development project (within the EU 5th Framework Programme), which has tried to tackle the complexity of the precipitation fields.

The title of the project is Validation of multisensor precipitation fields and numerical modeling in Mediterranean test sites (VOLTAIRE).

Detailed information concerning the project results as well as the Final Report and the "Dissemination Deliverables 9.1 9.6" can be found on the

VOLTAIRE website:

<http://www.voltaireproject.org/>

INNOVATION

The **RSG "Remote Sensing Group"** has realized a customized version of the micro-radar starting from standard hardware:

standard antennas, amplifiers, receivers and modulators, interfaced through a Personal Computer (PC) port.

This solution permits us to control via PC the pulse repetition frequency, the pulse length, the antenna rotation and position, the transmitter switching, etc.

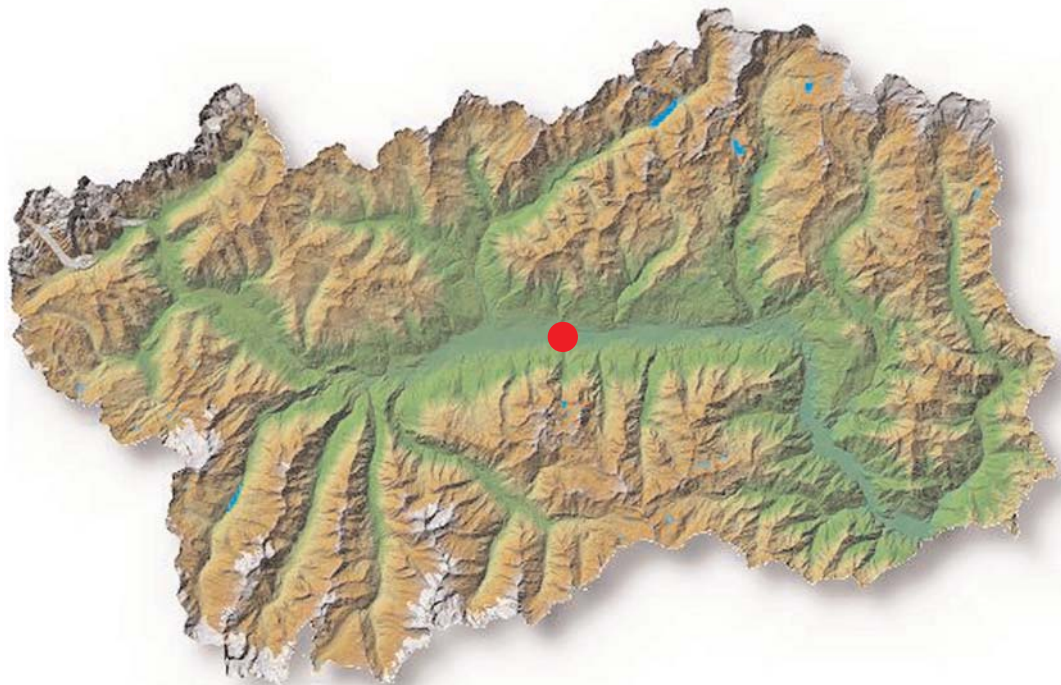
The data flow from the hardware can be directly processed by the PC, which acts as **Radar Signal Processor**.



the micro-radar can be easily transported

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The Remote Sensing Group (Politecnico di Torino) had faith in these innovative concepts and ideas. Together with the Regione Autonoma Valle d'Aosta (within the present Interreg FORALPS project), the Remote Sensing Group (RSG) planned, designed, developed and manufactured a portable, low-cost, short-range, X-band radar, called the "micro-radar". This micro-radar has been installed on 2007 March, 16th at the Airport of Aosta (St-Christophe), and some preliminary - and encouraging - results are available, resulting from the comparison with rain gauges surrounding the radar site.



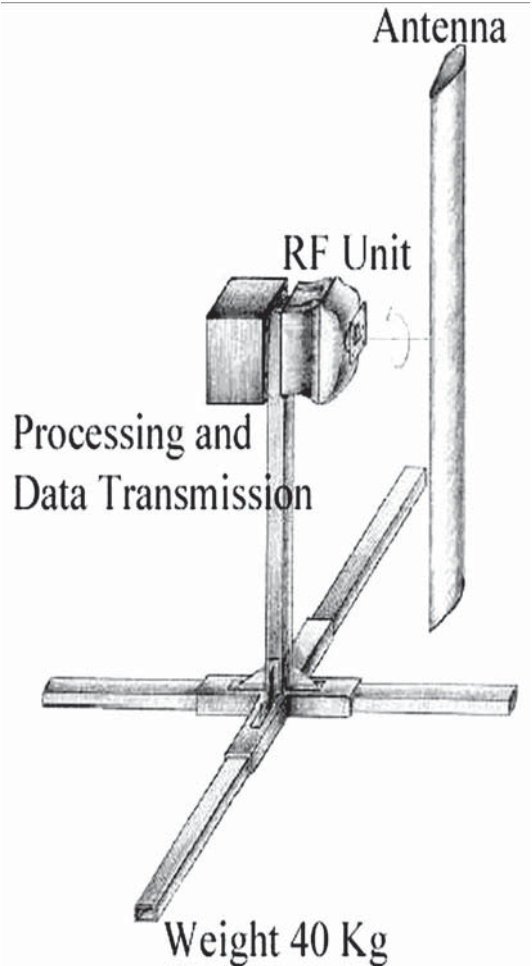
MICRO-RADAR

The micro-radar is currently based on a fan-beam antenna rotating in the vertical plane: the main lobe, in fact, can be broad across the valley, but has to be quite narrow along it.

This sort of Range-Height-Indicator along the valley with good resolution in the vertical plane is another innovative concept: a scanning program implemented as a vertical rotation.

Since the micro radar unit acts in an unmanned / unwired scenario, specific design strategies have been adopted for what concerns the data transmission.

The huge amount of data gathered per each round is averaged in range and elevation around three specific directions (here called 'rays'): two opposite low elevation rays and a vertically pointing one.



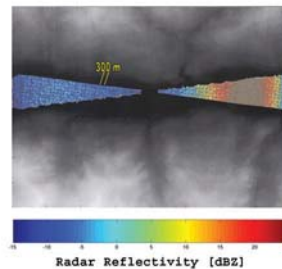
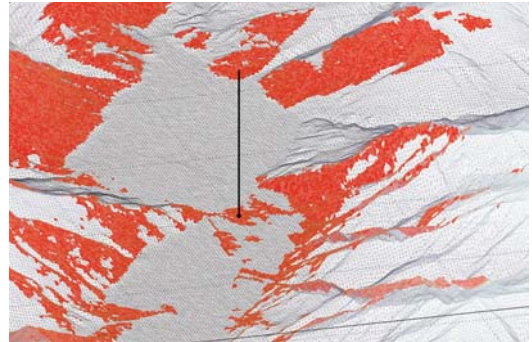
REAL-TIME

This real-time on-board preprocessing acts also among adjacent round as a space / time average engine.

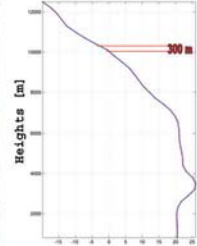
The resulting net raw data decimation factor is around 1 e 6.

This heavy duty performed by the Radar Signal Processor makes it possible to send a meaningful averaged data stream even though a low bit rate radio link, as the General Package Radio Service (GPRS).

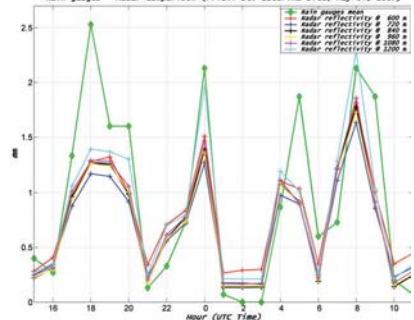
The data stream ends up in a SQL database and is accessible for download and visualization via a standard web site (more evolved radio link services such as the HSDPA are supported as well and adopted where available).



Radar Reflectivity
Vertical Profile

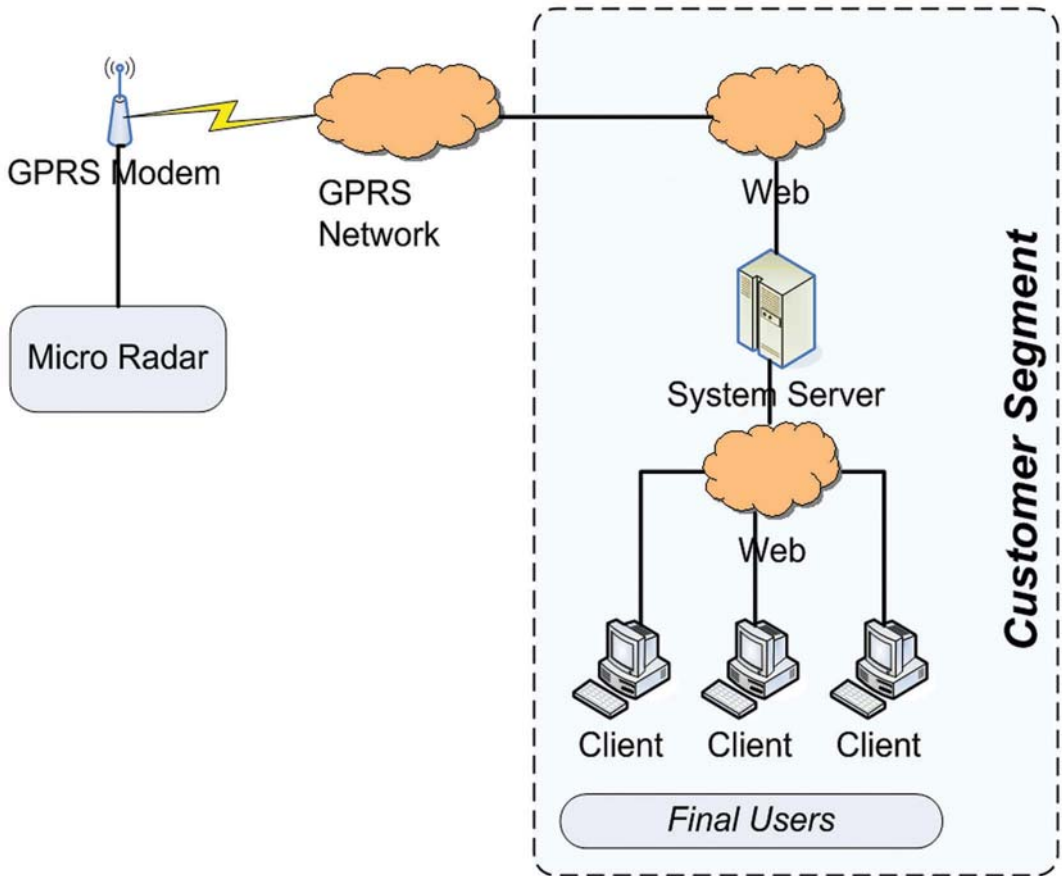


Radar Reflectivity [dBZ]
rain gauges - Radar comparison (Griff St. Caterina Site, May 04, 2007)



the three rays of the micro-radar
in the basic operational mode

RADIO CONFIGURATION



the micro-radar unit will upload meteorological data to the System Server through the GPRS radio interface.

Micro-radar users will gain access to the system outputs through the usual web interface (via any web browser)

VISUALIZATION

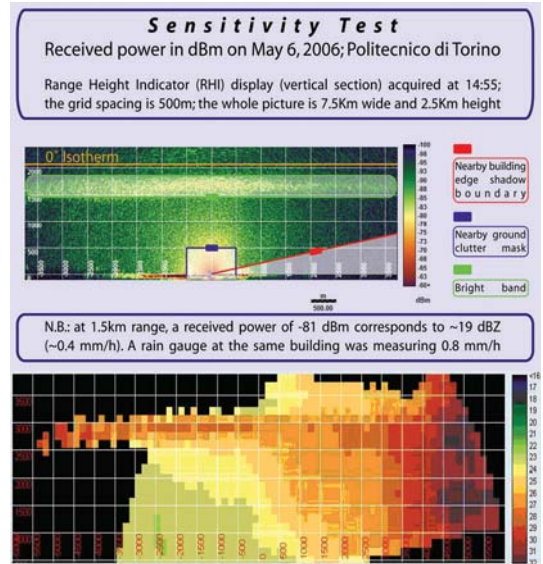
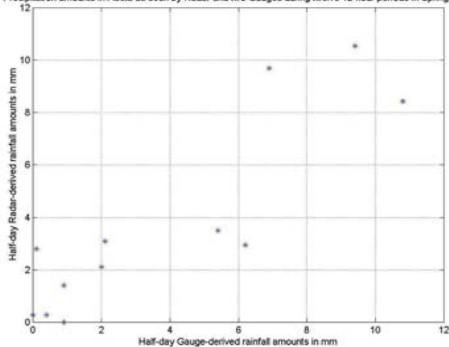
RHI display of the average of 30 acquisitions (1 per minute) between 16 and 16.30 CET on July 6, 2006, in Turin.

The whole picture is large 12 km by 3.5 km (from 450 to 3950 m altitude).

Resolution is 150x150 m.

Radar reflectivity values are in dBZ. The bright band is around 3000 m, clearly visible in the left side of the image, while some convection (32 dBZ and stronger) is developing on the right above the hills to the East of Turin.

Precipitation amounts in Aosta as seen by Radar and two Gauges during twelve 12-hour periods in Spring 2007



Fit between 12-hour accumulated rain depth derived from bulk-adjusted radar echoes (700 m above the radar site inside Aosta airport) and from in situ measurements performed by two nearby gauges during spring 2007. The average value of the two gauges is used as reference on the abscissa axis.

Solutions when applying quantitative information
from weather radar:
the use of many
Low-cost, short-range,
X-band radars
to complement
long-range weather radars

Many vertically-scanning low-cost short-range X-band radars for rain estimates can be a valid alternative to our long-range C-band radars. Long-range radars have proved to be useful for weather forecasting and qualitative surveillance.

However, the results, verified with large effort at close ranges, CANNOT be generalized.

It seems impossible to reproduce the results easily obtained close to the radar for QUANTITATIVE APPLICATIONS at far ranges.

This is ESPECIALLY TRUE IN MOUNTAINOUS TERRAIN.

Therefore, an interesting solution could be to combine the data of many, small, low-cost and short-range X-band radar for rain estimates within valleys.

ACKNOWLEDGMENTS

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