A COMPARISON OF THE WIND PROFILES IN THE BASQUE COUNTRY.

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ABSTRACT

There are two wind profiles recorded in the Basque Country. One is from a boundary layer wind profiler sited at the coast and the other is from a Doppler Weather Radar, on top of Kapildui mountain (1177 m). The study incorporates as a reference wind profiler, data from the World Meteorological Organization (WMO) radiosonde which is close to them at the Santander station. A comparison between the wind profiles of the three systems was studied in order to improve the performance and therefore the quality of the profiles registered by the wind profiler and the weather radar. The methodology applied in the comparison of the wind profiles took into account: the different technologies, the different sites of the systems and the differences caused by the meteorology due to the distance between the systems. The goal of the study has been the design of a tool which integrates all the information available and at the same time reveals abnormal behaviours of the data. Suspicious data will be checked by quality procedures of each system later.

1. INTRODUCTION AND OBJETIVES

In meteorology and in applied meteorology sciences the role of wind profiles is becoming increasingly important (Kadygrov,2005, OFCM 1998). A good temporal and spatial resolution is required for this. To achieve this objective, remote sensing technology offers new systems a higher temporal resolution than radiosonde. At this moment in time the Basque Meteorology Agency (Euskalmet) has three different systems [4] (Web page). A boundary layer wind profiler radar, an automatic radiosonde, both of which are sited on the coast and a Doppler Weather Radar, in the south of the region.

The automatic radiosonde began working, in April 2012, an there isn’t an historical database available as yet. This is the reason why this data was replaced with data from Santander radiosonde.

The main goal of the work is to integrate the three systems. This integration has two benefits:

1.-Comparison with the measurements of the three systems. Evaluation of the wind profiles in order to know how complementary the three systems are (Weber and Wuertz, 1990).

2.-Systems monitoring. Quantify non meteorological situations. In these cases, an inspection of the data and the systems is required to identify the causes.

![Figure 1. Observation Systems of the Basque Country.](image-url)
first layers. The wind profiler boundary layer LAP-3000® (1290MHz) with RASS option was placed on a cliff, close to one of the urban areas with the highest population density in the Basque Country (Strauch et al 1984). The wind profiler gives information of wind and virtual temperature profiles every 30 minutes. The wind profiler being approximately 79 km away from the weather radar site. The system operates with 5 beams, one pointing to the zenith and the other four towards 4 cardinal points, north, south, east and west. It operates with two resolution modes, the high resolution mode (60m) which includes observations of low levels in the atmosphere, up to altitudes of 2 km and the low resolution mode (200m) covering higher levels of up to altitudes of 7 km. Depending on the meteorological conditions and situations of rainfall, it is possible to obtain information up to 7 km, but the normal range is about 3km as indicated by the manufacturer of this type of systems. It is important to emphasize that the system presents a very rigorous maintenance plan and it is included in the e-winprof, European network [5] (Web page). Finally, Kapildui's meteorological radar, a METEOR 1500C model from Selex Gematronik (Holleman, 2003), is a polarimetric doppler radar, working on C band. The altitude of the installation, 1km above sea level approximately avoiding the topographic barriers of the Basque Country, is an inconvenience for this study. This system operates with a scheduler of 10 minutes. Four scans are performed, two of which are volumetric scans, with ranges of 300km and 100 km respectively and the other two are elevation scans. The 100 km ranged scan and the two elevation scans operate in Doppler mode.

It is important to emphasize that the comparison between the observations for these systems is very complicated because of the distance between the systems, the complex localization and the different altitudes. These features reduce the comparable database. Figure 2.

The aim of this study is to compare/integrate wind profiles in the region, comparing the results of the three systems. The radiosonde of Santander, not located in the Basque country but closed to both systems, is used as a reference system for the reliability of the measurements or, failing that, the wind profiler. The result of the comparison allows for observation the behavior and differences for these three systems, depending on the meteorological conditions, and to use it as a support for later improvements of wind products for the meteorological radar.

3. DATABASE DESCRIPTION

The database of the year 2011 was studied.

The next table shows the more relevant characteristics which should be considered in the comparison of three systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Time Resolution</th>
<th>Space Res. (m)</th>
<th>First level (m)</th>
<th>Last level (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiosonde</td>
<td>12 h Variable</td>
<td>59</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Wind P. WPR</td>
<td>30 min 60-200</td>
<td>195</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Weather Radar</td>
<td>10 min 100</td>
<td>700</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Main features of the three systems

Since the systems present differences in the database obtained, a module of transformation of the information is to be proposed in the methodology in order to obtain comparable time series.

A remark about quality to be noted; The quality information related to each system is used to gain a better interpretation of the results.

The algorithm used to obtain the wind profiles from the weather radar is Volume Velocity Processing (VVP) (Waldteufel et Corbin, 1979). This algorithm is implemented by the manufacturer in its rainbow software (Rainbow software- Selex-Gematronik 2005). It determines the vertical profile centered above the radar site. It uses as basic input parameters; a Doppler volumetric scan, range (minimum and maximum), height (top, bottom and step). The outputs are several parameters derived of the mean radial velocity. The parameterization of the VVP is then studied taking into account the recommendations of Holleman (2005), errors due to non-linearities of the wind field are controlled by application of the use of a maximum range of 25 km, a minimum range of 5 km and the rejection of low elevations <1º are recommended to reduce error due to poor quality data (sidelobe clutter and ground clutter). In the first step, the recommendation of Holleman was used but low
availability of data were obtained, this was the main reason to test these parameters taking into account the scan coverage of the operational scan. Finally a compromise between Holleman recommendations and the geometry of the volumetric scan was applied (the minimum range was set to 0 km and the maximum to 25 km to and elevation below 1° were used (0.5°, 0°, -0.5°).

4. METHODOLOGY
The methodology is divided in two parts
a.-Studying the availability of the three systems independently. Special attention needed with the weather radar due to the poor quality of the data in clear air conditions. The configuration of operating parameters of the weather radar is the setting for precipitation measurements during operation.
b.-Comparative. In order to obtain a good comparison, an initial database as complete as possible is required. The methodology of comparison considers; a cleansing process for each system and a calculation process. Data and quality information about the data, is transformed very carefully to be used in comparison. In case of the radiosonde and wind profiler system, the wind profiles are the operational. With the weather radar the study attempts as it’s secondary aim to improve the existing operative data, achieved by making two adjustments (system operating parameters and products parameters).

5. RESULTS
After study of the VVP algorithm, the optimization of the parameters were made to achieve the best and most complete wind profile database from the weather radar. The scan strategy and the site of the weather radar had to be evaluated to improve the VVP at the product level. The databases from the other two systems are not susceptible to the study due to the fact that both are operational databases under control of e-winprof and WMO.

The differences applied in the recommendation of Holleman point to a need to increase the coverage in the layer below the altitude of the radar (1 km). These modifications were made checking and increasing the data availability without losing quality. Special attention with the clutter contamination in the wind profiles and homogeneity of the wind field were evaluated during this step. The increase of the wind profiles is showed in Figure 3.A

The percentage of valid wind profile data registered by the weather radar using the operating parameters fixed is less than 20%, according to the modifications of the Holleman (2005) recommendation. Figure 3.B

The study of availability by heights (test height) shows a maximum around 1.5 km. In gates below this altitude, the weather radar for the availability is lower. Figure 3.C

Although the months with a higher availability of valid data are correlated with wet months (rainy seasons), a diurnal behaviour is showed during the spring and autumn seasons. In addition, the diurnal behaviour decreases during the summer season (drier season) due to weak echoes. More time and samples will increase the signal to noise ratio.

Figure 3 Sensitive study of availability of wind profiles of Kapildui Weather radar A) Comparative between Holleman and New settings. B) Percentage of valid against non valid (X-Axis months) C) X-Axis Count valid cases, Y-Axis Height, stacked by months. Height test. D) X-Axis Count valid cases, Y-Axis Hours, stacked by months. Diurnal evolution test.

The bibliography shows an increase in the signal from biological targets, insects or birds have a diurnal behaviour which could explain this behaviour. Figure 3.D

The comparative analysis looks for relationships between the three systems. To this purpose the correlation coefficient is applied to the wind speed variable and the u, v components. The results obtained for the wind speed variable are included in the table 2.

-At the lower layers, the distance, location and the meteorological affinity are the requirements for a good correlation coefficient. Systems which meet these conditions are Punta Galea WPR and Santander radiosonde.

- The best agreement between the three systems is given in the layer between 2 and 3 km.

-However, this correlation is not the highest value, the highest value is in the upper layers between the Kapildui weather radar and Santander radiosonde, in this case synoptic scale is comparable to the distance scale in meteorological situations with valid data in those heights. In a statistical point of view the interpretation of the results are very depend to the number of cases and the therefore to the meteorological type of situations which are comparable. The sample of the population is not representative of the meteorology of the region. Only few meteorological situations are comparable and the results are biased.
Table 2. Values of the Pearson Coefficients for the three systems

<table>
<thead>
<tr>
<th>Height &lt;1km</th>
<th>Weather radar VS WPR</th>
<th>Weather radar VS Radiosonde</th>
<th>WPR VS Radiosonde</th>
<th>Nº of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.551</td>
<td>0.510</td>
<td>0.702</td>
<td>287</td>
<td></td>
</tr>
<tr>
<td>1km&lt; Ht&lt;2km</td>
<td>0.411</td>
<td>0.538</td>
<td>0.516</td>
<td>1039</td>
</tr>
<tr>
<td>2km&lt; Ht&lt;3km</td>
<td>0.485</td>
<td>0.718</td>
<td>0.698</td>
<td>292</td>
</tr>
<tr>
<td>3km&lt; Ht&lt;4km</td>
<td>0.670</td>
<td>0.815</td>
<td>0.706</td>
<td>89</td>
</tr>
<tr>
<td>4km&lt; Ht&lt;5km</td>
<td>0.650</td>
<td>0.900</td>
<td>0.669</td>
<td>50</td>
</tr>
<tr>
<td>5km&lt; Ht&lt;6km</td>
<td>0.597</td>
<td>0.914</td>
<td>0.511</td>
<td>48</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS

Due to the low percent of valid data, the quality of the Doppler measurements of Kapildui weather radar can be improved in two ways:
- Product level. The study of the inputs settings of the wind products according to the coverage set in operation is required.
- Operation level. The operating parameters established through the Doppler scan must be evaluated.

In meteorological situations of clear air, the radar return signals are weaker than those with precipitation. This situation happens frequently, in the summer months. During these months the availability of data decreases and it is recommended, if the goal is wind measurements, to define an optimum Doppler scanning (reducing the velocity of the antenna, low elevations and increasing the time of the Doppler scan).

Diurnal variations are identified in some months of the year. These are transitions months from cold to warm seasons. One of the causes of this diurnal pattern could be associated with biological targets. These targets also follow a diurnal pattern.

Another scattering mechanism such as Bragg scattering emerge due to an increase in irregularities in the index of refraction. This will increase the availability of data in non-precipitation situations.

The study of wind profiles recorded in the Basque Country reveals that the measurements complement each other. This means that the measurements are not redundant. Only during some synoptic situations and in the upper layers are the distance between the systems and the meteorological scale comparable. In these cases it is possible to find linear behaviours. This is a major tool for system monitoring, which needs other source of verification (numerical models).

Moreover the distance in the lower layers is crucial, finding the best relations between Santander and Punta Galea, the closest systems in location. These results should be improved by using instead of the Santander Station, the automatic radiosonde Station of Artega (the newest upper observation system of the Basque Country. Artega station is four times closer to Punta Galea than Santander. The short distance between them and being both locations with a similar micrometeorology will improve the comparison.

7. REFERENCES