Geophysical Research Abstracts, Vol. 9, 10281, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10281

Improvements in the Catalan rain gauge network using a multi-criteria decision analysis

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Weather radar fields are usually merged with rain gauge data to reduce usual errors in radar data and increase the quantitative precision of its rainfall estimations. For example, geostatistical techniques can be used to merge radar and rain gauge data and thus to estimate rainfall fields with good spatial details (from radar data) and with an enhanced quantitative accuracy (from rain gauge data).

Following this idea, Catalonia (32000 km^2 region in NE Spain) has built a dense weather radar network during last ten years. Nowadays inside of this region the Catalan Meteorological Service [SMC] has three C-Band radars in operation and one more will be installed during this year. Additionally three governmental entities have real-time telemetric rain gauge networks within Catalonia. Firstly Catalan Water Agency [ACA] manages a 125 rain gauge network, secondly SMC runs a 149 rain gauge network and finally the Ebro River Hydrological Confederation [CHE] is in charge of additional 75 rain gauges. The approximated average density of rain gauges is then equals to one rain gauge each 90 km^2.

Unfortunately maintenance of this high number of rain gauges induces a huge economic cost for these entities. The ACA decided therefore make a smart redesign of its rain gauge network. New ACA rain gauge network should be designed based on next criteria: (1) radar and rain gauge data should be used for estimation of rainfall fields, (2) maximum size of new network should be less than a half of actual number of its rain gauges, (3) remaining rain gauges should be located in those regions where the others rain gauge networks have worst coverage, looking for improving the quality

of estimated rainfall fields, (4) some of new rain gauges places should have enough technical facilities to allow, in the same premises, a future installation of new equipments (e.g. disdrometers), and (5) rain gauges of actual network could be selected as part of new network if they agreed with previous criteria and if its actual sites agreed with UNE 500520:2002 standards (concern with location of sites of automatic weather stations networks).

This paper describes the used methodology to redesign the ACA rain gauges network, shows the optimization process and comments the obtained results. Ordinary kriging technique was selected to estimate rainfall field combining radar and rain gauge data. This technique allows quantify the error variance of estimations in the merging region. Therefore, if all possible combinations of rain gauge networks were evaluated, the optimal network of rain gauges would be identified selecting the network with the lowest value of error variance. However computation of all possibilities is unachievable because number of possible combinations is huge. For that reason a technique named simulated annealing was used to define iteratively the optimal number and location of the new ACA rain gauge network. A total of 200 one-hour rainfall fields composed from the SMC three-radar network were used in this study to take account spatial and temporal variability of rainfall.

Selection of final location of new ACA rain gauge network was based on a multicriteria decision analysis. Renting and maintenance costs and an inventory of available communication, energy-supply and security services were added to the above-described geostatistical criterion. Also a criterion about influence of objects located around the gauge place following UNE standards was developed and used in the analysis.

This study allowed ACA to quantify the quality of its rain gauge measurements based on analysis of influences of each gauge with complementary installations as antennas or surrounding objects as trees. Also, after the optimal redesign of its rain gauge network ACA will be able to reduce significantly its annual rain gauge maintenance budget but improving actual quality of the estimated rainfall fields in Catalonia. These budget reductions open a clear possibility of a future addition of new instrumentation (as disdrometers, vertical profilers or microradars) that will improve the rainfall field estimations in Catalonia.