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REAL TIME INTEGRATION OF FOREIGN RADAR QUANTITATIVE PRECIPITATION ESTIMATIONS (QPEs) IN THE FRENCH NATIONAL QPE MOSAIC

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1. CONTEXT

The French metropolitan weather radar network (named ARAMIS) includes 28 weather radars in 2015 (31 in the near future) over a territory of 552 000 km², and the real time quantitative precipitation estimation (QPE) is one of the important public duties of Météo-France. Every 5minutes a local QPE is estimated for each radar with a spatial resolution of 1 km², and is calibrated with hourly rain gauges measurements. A map of quality codes (varying from 0 to 100) is dynamically estimated for each of these local QPEs, the quality code value for each pixel depending on the importance of several sources of errors, for example the percentage of beam blockage and the altitude of detection above the ground. Then, in accordance with the quality code values, these local QPEs are fused in a national multi-sensor QPE mosaic at the spatial and temporal resolution of 1 km² and 5 mn. This mosaic is delivered within 2 minutes of the end of the observation time.*

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Although the ARAMIS network density, the quality of this QPE mosaic is degraded in some regions, mainly due to radar beam blockages and the distance from the radars. These areas clearly appear on the annual score maps produced every year by Météo-France, by comparison of the national QPE mosaic with the ground level validated measurements of between 3500 and 4000 daily rain gauges (figure 1). Several actions have been taken in order to improve the QPE mosaic quality. One of these actions is the real time integration into this mosaic of data from radars of neighbouring countries. This has been made possible by setting up bilateral data exchanges agreements between National Meteorological Services, and has been facilitated by existing European cooperation programs like the OPERA program*. This achievement anticipates future operational use of collaborative products in Europe like the European QPE composite of the OPERA program.

(*OPERA = Operational Program for the Exchange of weather Radar information, Weather Radar program of the EUMETNET Economic Interest Group, the Network of the European Meteorological Services).

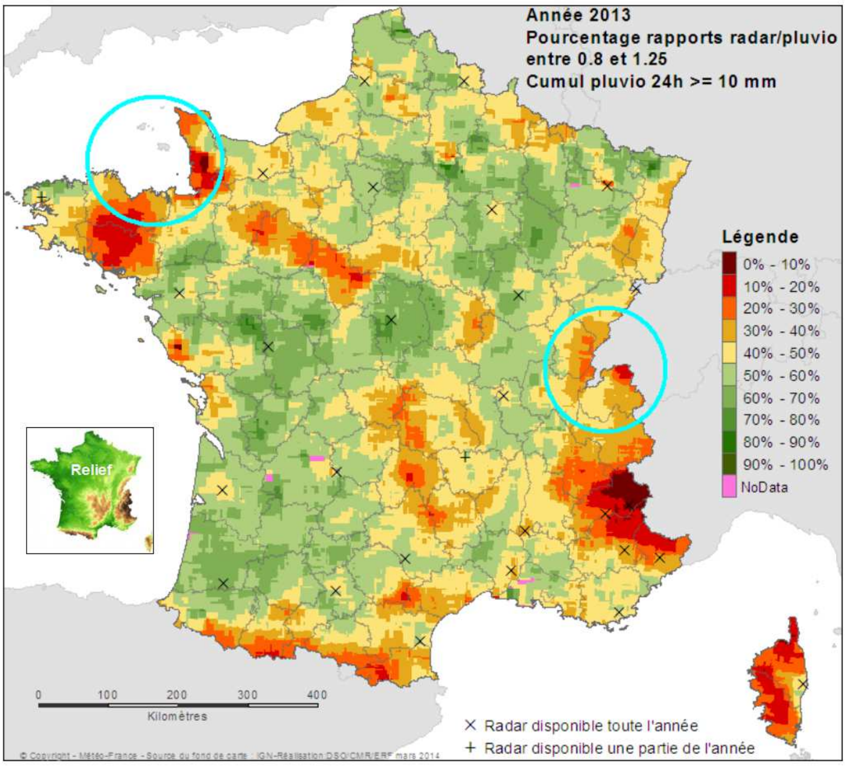

Figure 1: Example of annual score map estimated for daily precipitation estimations (percent of radar/gauges ratio included into the interval [0.8 ;1.25] for daily precipitation ≥10mm). Green to red = best to lowest quality. Year 2013 ; Small map = relief (varying from 0 to 4810m) ; Blue circles = location of the 2 cases presented.

This communication presents the general methodology used and two very different integration cases operational in 2015. The improvement of the French national multi-sensor QPE mosaic is presented for each case.

2. METHODOLOGY

The considered foreign radars are different from those used in the ARAMIS network, and also the operating procedures and the data processing. As it was not conceivable to receive in real time extensive raw data directly from each foreign radar, and to develop a full data processing chain specific for each data source, Météo-France has chosen an approach using directly common elaborate products like quantitative rainfall rate fields produced by the meteorological Offices operating these radars. These QPEs are recovered in real time (every few minutes), and post-treated in order to be as similar as possible to the French local radar products, and easily integrated in the QPE mosaic by the existing merging process. The post-treatment includes:

- Referencing the data in a local Cartesian map similar to the French Cartesian local radar products
- Eliminating residual clutter by using dynamical information and metadata
- Advecting the input rainfall rate field over 5 mn using a national advection field, in order to estimate a 5 mn precipitation field taking into account the rain motion during these 5 mn
- Eventually, using an optional specific advection scheme to use data from the preceding time step in case of late data recovery
- Realising a dynamical calibration process over the French territory by using hourly rain gauges measurements in France, the calibration of the foreign data being optimised over an other territory
- Estimating a quality codes map, close to the ones estimated for the French local radar QPEs.

The post-treated foreign QPEs are then directly fused with the French local radar QPEs in the national QPE mosaic by the existing operational process.

3. FIRST CASE: THE SINGLE JERSEY RADAR

The first case is a relatively easy case, integrating QPEs of the single Jersey radar located in the Jersey Island near the Cotentin peninsula and the North Brittany coast. Two detailed studies have shown that over the area represented by a blue circle in figure 1, the measurements of the Jersey radar are of better quality than the combined measurements of the three ARAMIS radars in the region.

The partners meteorological Offices are the UK Met Office and the Meteorological Department of the States of Jersey. Every 5 mn Météo-France recovers the Jersey instantaneous rainfall rate and the altitude of the radar measurement used. This allows to produce a post-treated QPE map and a dynamical quality codes map (figure 2).

The validation results show a general improvement of the QPE mosaic quality by the Jersey data, for all the area (figure 3), and all the validation criterions (figures 4 & 5).

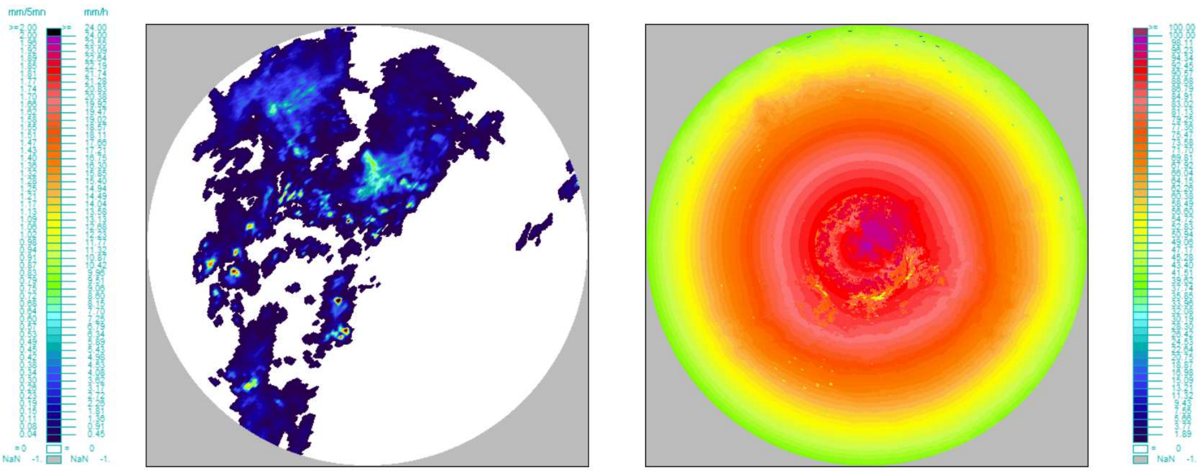

Figure 2: Example of post-treated QPE and dynamical quality codes map for the Jersey radar (07/24/2015, 09h05 UTC).

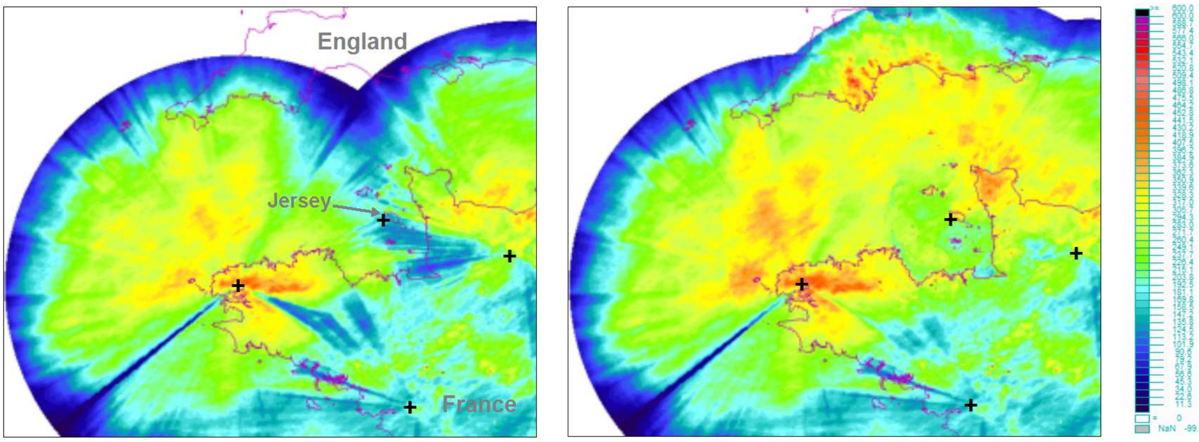

Figure 3: Cumulated precipitation field (mm) for July, August, November & December 2012. Left without Jersey data. Right with Jersey data. Black crosses: radar locations.

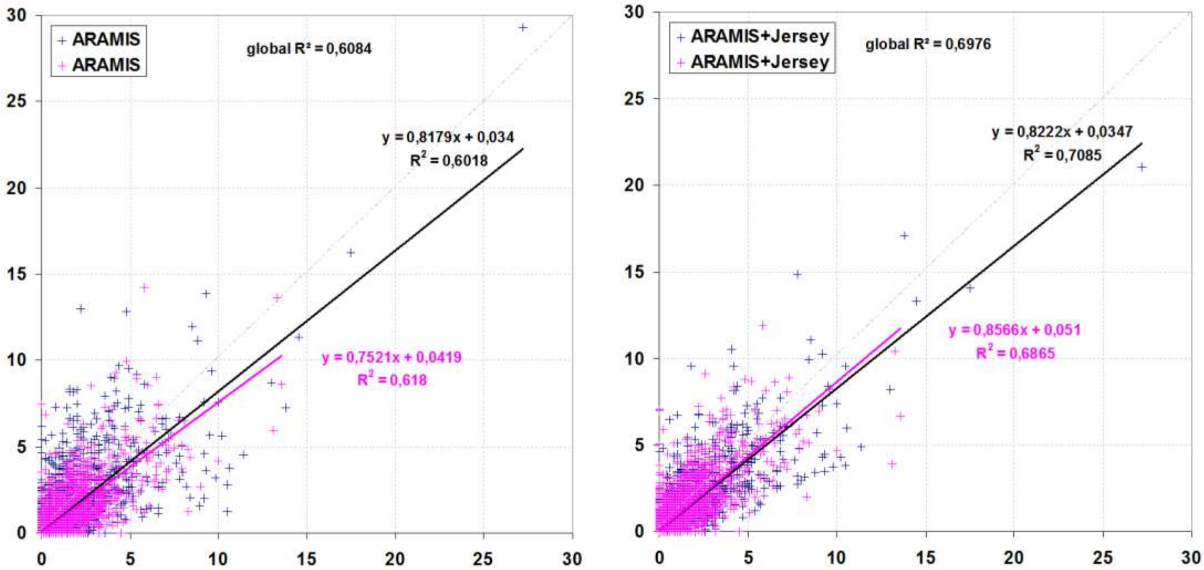

Figure 4: Example of global validation result of the QPE mosaic by comparison with 40 hourly rain gauges located from 46 to 125 km from the radar, for all hourly values (same period as fig. 3): In black: July & August ; in fuchsia: November & December ; ARAMIS = without Jersey data ; ARAMIS+Jersey = with Jersey data ; R² = square correlation coefficient.

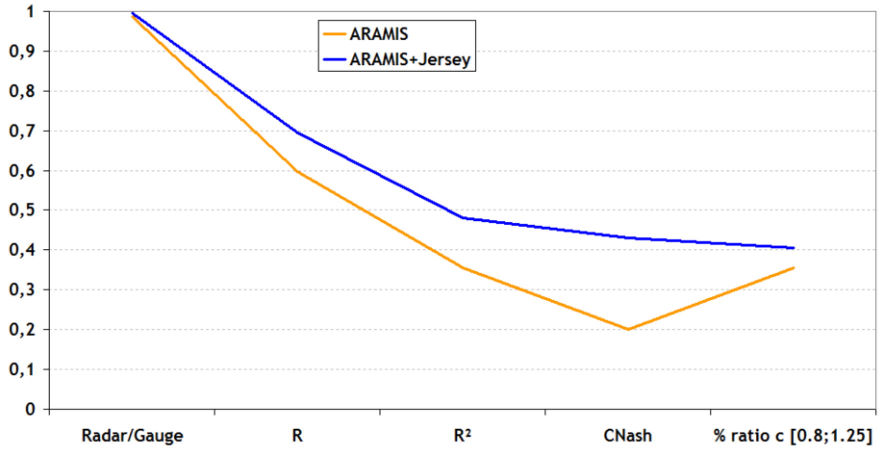

Figure 5: Example of some validation results by comparison with hourly rain gauges from 46 to 125 km from the radar, and for hourly values above 1 mm (same period as fig. 3): ARAMIS = without Jersey data ; ARAMIS+Jersey = with Jersey data. Criterions: mean radar/gauges ratio ; (R²) R = (square) correlation coefficient ; CNash = Nash criterion ; and fraction (0 to 1) of the hourly radar/gauges ratio values included into the interval [0.8 ;1.25].

4. SECOND CASE: A SWISS NATIONAL QPE MOSAIC

The second case is a less easy case. It concerns the integration of a Swiss national QPE mosaic (provided by MeteoSwiss and currently merging 3D data from four radars) on the North of the French Alps region. This area covers several mountain massifs with altitudes above 3,000 or 4,000 metres, including the Mont Blanc summit at 4810 metres. The work realised has shown that in this region, where both the French and the Swiss radar networks have degraded coverage, we can observe a patchwork of reduced areas for which alternatively each source of data is of better quality. The challenge is to optimise the final QPE quality in this difficult region by using all the contribution of existing operational radars, in addition to other actions like the deployment of local X band radars.

Every 2.5 mn Météo-France recovers the Swiss instantaneous rainfall rate mosaic, and produces a post-treated QPE and a semi-dynamical quality map tacking into account each Swiss radar on duty (figure 6).

The validation results show a significant improvement of the French QPE mosaic quality by the Swiss data limited to the North-East of the French Alps (Chablais region and the basin of the Arve river which flows from the Mont Blanc to the Rhône river in Geneva, figures 7 & 8). Some improvement can also be observed in very limited areas corresponding to great mountain massifs where the ARAMIS radar measurements are very degraded. In consequence, the validation criterions need to be analysed for each station of validation (figure 9).

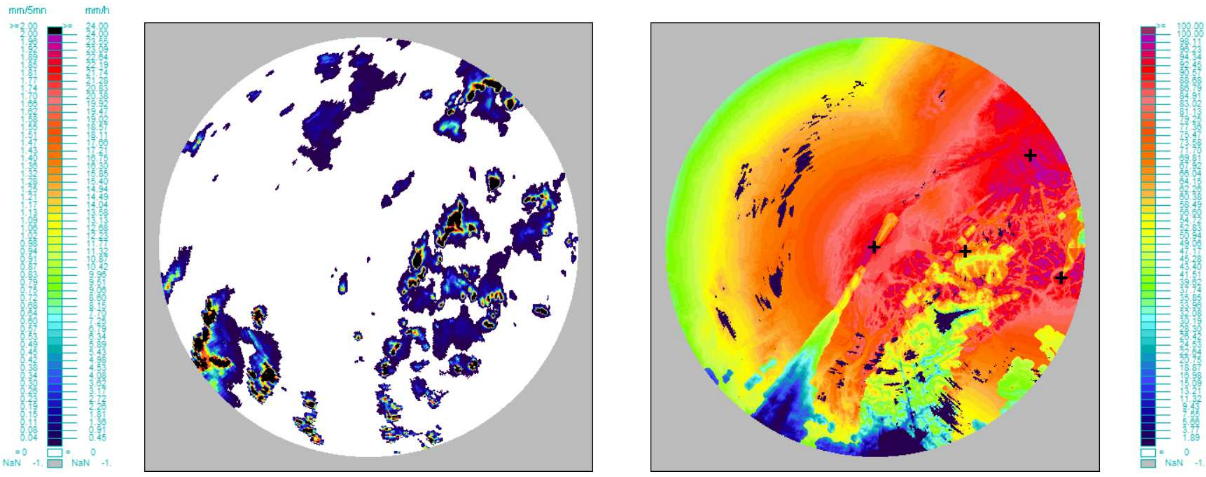

Figure 6: Example of post-treated QPE and quality codes map for the Swiss mosaic (07/22/2015, 13h25 UTC). The Swiss mosaic extent has been resized to a circle centered on the La Dole radar which is the main contributor over the French territory. (black crosses = Swiss radars location in 2015).

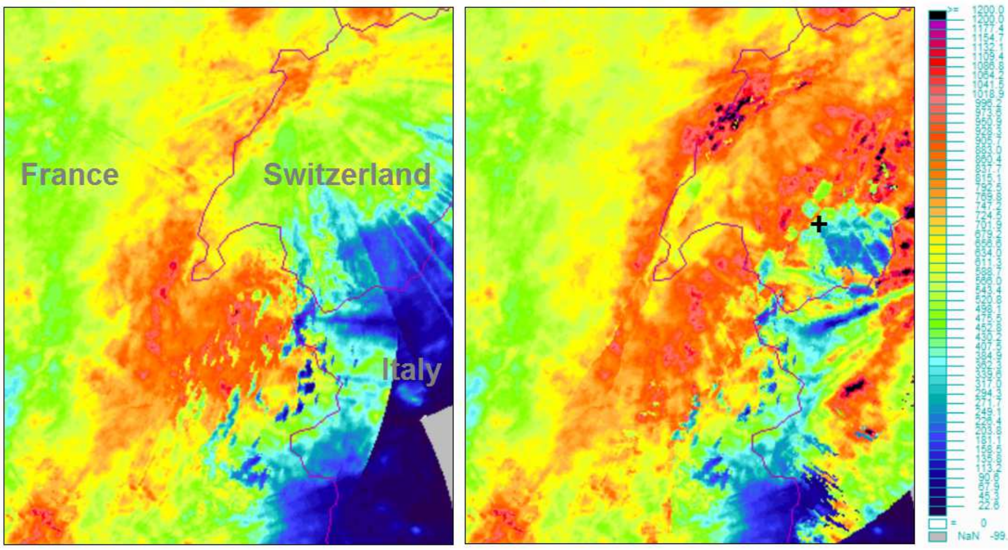

Figure 7: Cumulated precipitation field (mm) from 06/20/2013 to 11/30/2013. Left without Swiss data. Right with Swiss data. Remark: in 2013 the Swiss radar network comprised only 3 radars. From 2014 the Plaine Morte radar (black cross) improves the Swiss mosaic radar coverage.

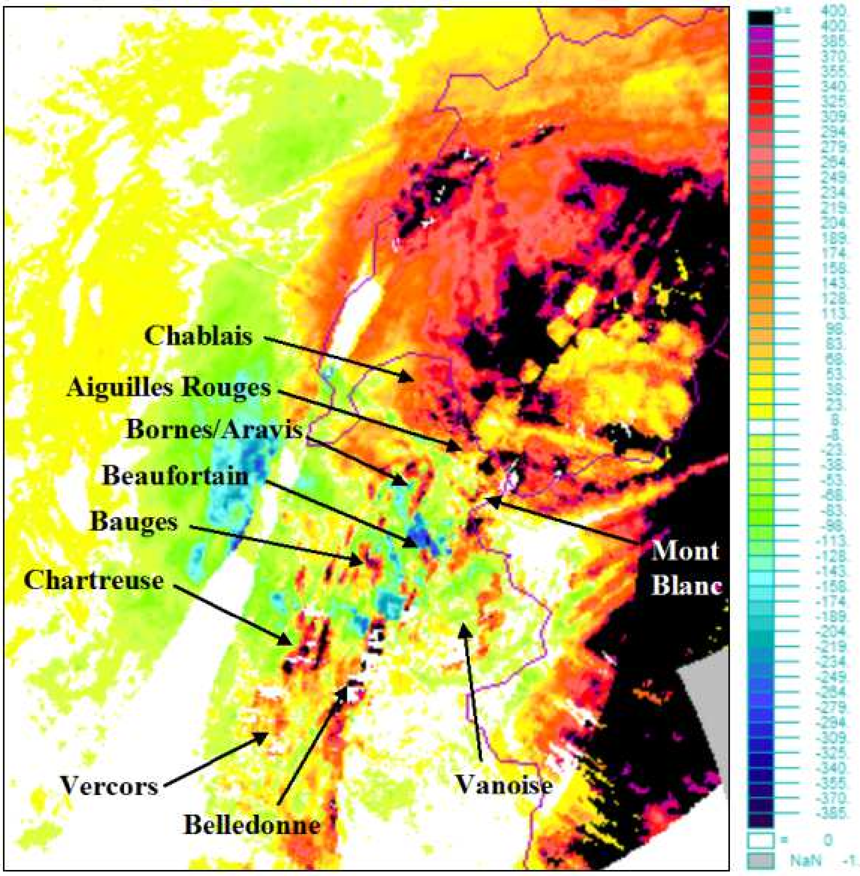

Figure 8: Difference (mm) between the cumulated precipitation fields when Swiss data are integrated or not. Yellow to red and black: increasing amount ; green to blue: decreasing amount ; white: no change. The main mountain massifs are indicated.

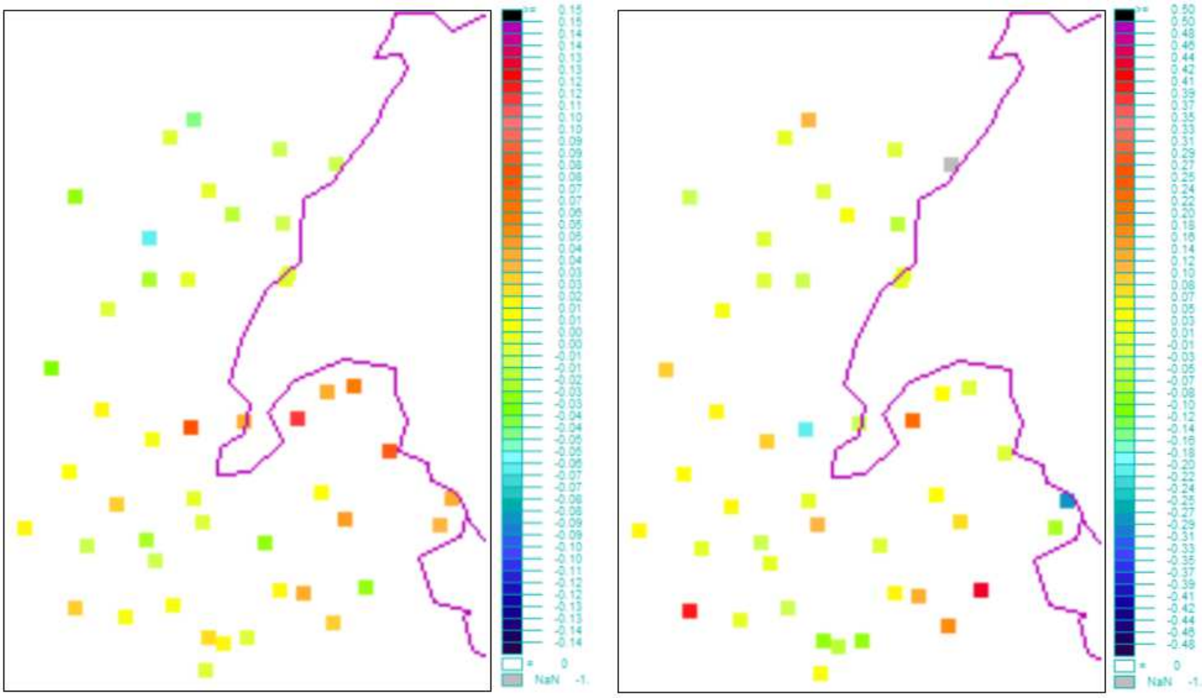

Figure 9: Example of validation criterion values for each rain gauge station. Left: improvement of the fraction (0 to 1) of hourly radar/gauges ratio values included into the interval [0.8 ;1.25] when Swiss data are integrated (color scale from -0.15 to +0.15) ; right: improvement of the Nash criterion values (color scale from -0.5 to +0.5). Yellow to red: improvement of the French QPE mosaic quality ; green to blue degradation of the French QPE mosaic quality.

5. DEVELOPMENTS AND PERSPECTIVES

For the two cases presented, the integration of data from radars of neighbouring countries has been proved to be beneficial to the French national QPE mosaic. This integration complete other actions like the deployment of local X band radars, and allows to locate these new radars in areas without any good existing radar coverage, in accordance with the needs for hydrological purposes: in the case of the two regions presented, four X band radars have been installed in the Alps region during the last years, and one X band radar will be installed in the Morbihan region in 2017 to cover the south part of Brittany (figure 10. See also 14B.3 presentation).

In the future, the integration of data from foreign radars could also be considered in the North and North East of France, for radars located in Belgium and Germany.

As indicated in section 1, such projects of bilateral data exchanges are greatly facilitated by the policy of cooperation between European National Meteorological Services, and by existing structures and programs designed for this purpose.

A great source of perspective for future improvements lies in the development (and use) of good quality collaborative products merging radar data at the European scale, like the products of the OPERA Data Centre named "Odyssey" which currently collects radar volume data from around 150 radars and produces pan-European weather radar composites (see 14B.4 presentation). The utilisation of such pan-European products of quality should facilitate the QPE estimation in cross-border areas, but also should increase the general capability of rainfall forecasting. The two cases presented in this communication thus anticipates future operational use of such products in Europe.

6. REFERENCES

14B.3: The French radar network and products: achievements and outlook, Gaussiat & all, 37th Conference on radar meteorology, AMS, 14-18 September 2015, Norman, OK.

14B.4: Odyssey 2020, a centralised processing platform to perform state of the art radar data quality control and produce QPE products for the weather services in Europe, Martet & all, 37th Conference on radar meteorology, AMS, 14-18 September 2015, Norman, OK.

7. ACKNOWLEDGMENTS

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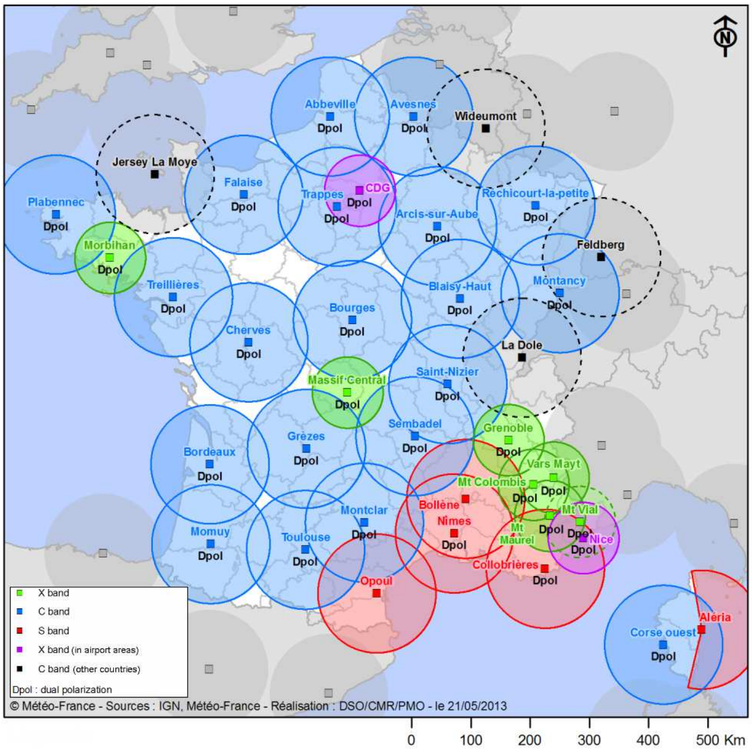

Figure 10: Expected radar coverage in France at the end of 2017 : All the ARAMIS radars are Doppler radars, and the dual polarisation radars are indicated. The CDG radar will be installed in September 2015 ; the Morbihan, Massif-Central and Corse-Ouest radars are planned for 2017 ; all the other radars are operating. The most interesting radars in other countries are highlighted. (Large circle diameters = 100km)