1.2 TOWARDS AN ORGANISATIONAL AND TECHNICAL CONCEPT FOR THE ROUTINE USE OF RADAR MEASUREMENTS IN A HYDROLOGICAL SERVICE

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1. INTRODUCTION

Results from several investigations in North Rhine-Westphalia and in Germany have shown that the routine use of radar data is beneficial for hydrological model applications as well as for on-line applications such as flood warning. Last year, the German Weather Service (DWD) has installed the last radars for the nationwide radar network covering all Germany. Therefore, the State Environmental Agency of North Rhine-Westphalia (LUA) has started the construction of a concept for radar data use which should be capable of serving the needs of on-line data users as well as off-line data applications.

2. PRELIMINARY STEPS

The objectives for an integrated concept for radar data distribution and use can be summarised in three points:

- **Optimal use of existing rainfall measurement data from different sources**. Rainfall measurements from raingauge networks usually are not spatially sufficient for detailed analysis of flood events, in particular in summer with its convective rainfall events. A combination with radar data has proven to give significantly better results in model use for both, peak flow and flow volume parameters (Einfalt et al., 2000).
- **Gain of experience in radar data use in hydrological services**. The hydrological services are still lacking deep knowledge about and experience with use of radar data. Only based on daily experience, the value and the weaknesses of the information inherent in radar data can be estimated.
- **Mutual improvement steps in data quality with the German Weather Service**. The experience from daily use of the radar data will not only improve knowledge on rainfall for the hydrological services but also – through the feedback to the DWD – increase availability of radar data, its quality and may even cause the creation of other specifically application-oriented radar data products of the DWD.

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As hydrological reference applications have been selected the use of rainfall-runoff model (off-line) for design purposes through long term simulation and flood warning (on-line).

The first application serves as a design toll on a daily routine basis in North Rhine-Westphalia, the second one aims at an earlier protection of persons and valuables than it can be achieved with the current procedure, based on the use of flow level meters.

3. HYDROLOGICAL REQUIREMENTS

The hydrological requirements with respect to radar data have often been discussed, but rarely been investigated with the final user of the information. The end user in a hydrological service has different needs and pressures than a radar data user in a research institution. Since radar data use in hydrology has to be implemented on a routine service level to be successful, the hydrological services were closely linked to the design of the concept.

In order to meet requirements of the hydrological services from organisational and technical aspects, a query at the 12 state regional state agencies and most of the regional water authorities has been conducted. This query was performed partly by telephone and partly visiting the hydrological service.

3.1. Organisational Aspects

The questions and discussions on the organisational aspects touched as well the availability of data ("how long will it take until …") and the intended use of the information (integration into models or "just" visual information) in the service. Furthermore, the current practice could be investigated (some services already use – lower quality – radar data from the internet).

Answers on the intended use of radar data were not given by the query but could be formulated freely by the hydrological services. The answers showed that most services want to use radar data for rainfall runoff modelling (80% of the users; main objective was a higher spatial resolution of rainfall data), followed by flood forecast (65%), real-time control of flood detention basins and reservoirs (30%), flood warning (30%), hydraulic simulation (30%) and insurance proof matters in case of extreme rainfall (30%).

3.2. Technical Aspects

For the technical aspects, answers were to be given on required data resolution, products to be used and ways through which the data should be delivered.

Responses on data resolution were quite clear: radar rainfall data for natural catchment simulation and for flood warning should have a 1 - 5 km², 5 minute and 1 mm resolution. Most users (90%) wished to receive a forecast over two hours or two days, being function of their main concerns.

As for the rainfall data products, the expressed preferences were animated radar images (80%) and raingauge adjusted time series for user defined points (75%) or subcatchments (85%). Also warnings of extreme rainfall are of high interest.

The data delivery of the above information should be done via internet/intranet (85%) or email (50%) in case of online data, and through CD (45%) in case of offline data.

3.3. Application Matrix

Derived from the above given responses on the (radar) rainfall data requirements of different practical applications, a matrix showing these results was constructed: the application matrix (figure 1). This matrix allows to compare the characteristics of a radar product to the requirements of a certain application and, thus, to select the appropriate radar product for each application.

It should be noted that the given requirements are no reglementary values but taken from the above mentioned query. Therefore, the matrix is subject to improvements through further feedback from more experience with applications.

application matrix	spatial resolution [km]	temporal resolution [min]	volumetric resolution [mm]	forecast lead time [min]	max. time lag for daat arrival [min]	data transfer by ...
rainfall runoff models	0,1	1	0,1	-	-	CD
flood forecast	10	5	1	4320	15	Internet
flood warning	10	5	1	4320	15	SMS
hydraulic simulation	1	5	1	-	-	CD
insurance proof	1	1	1	-	-	CD
control of basins and reservoirs	5	15	1	2880	5	Internet
sewer system simulation	0,1	1	0,1	120	5	Internet

Figure 1: Extract from the application matrix

4. SOFTWARE CONCEPT

The results described above were evaluated for ways to fulfill the requirements of the hydrological services. The key items to be regarded were current deficiencies such as the current technical infrastructure of the hydrological services or unsolved questions in today's radar products and the possible ways to come up with a suitable solution for the data flow, quality control and archiving organisation.

4.1. Technical requirements

The introduction of new technologies into routine service work requires a smooth transition from the present work flow to an improved, future workflow.

In this sense, the use of existing data bases and internet technology as well as the production of user-oriented "ready-to-use" information were the keywords. The latter describes the fact that the data that are provided at the location of the users are already prepared for the intended application: no reformatting of data, no extra handling with models or tools is necessary before the data are fed into the model or used for flood warning. The extension of the existing technology towards the future introduction of radar data into daily work is also a matter of costs: investment costs for software, training costs for personnel, and learning time (= reduced efficiency in routine tasks) are main concerns.

4.2. Radar data requirements

Radar data require a thourough data quality control. A quality control scheme has been developed on the data of the German Weather Service (Maul-Kötter et al., 2000) and will further be automised to be included in the radar data processing chain.

Radar data correction can be done in some cases after the data shortcomings have been detected by the quality control component. However, effects like ground clutter, bright band and attenuation cannot be corrected for in the presence of PPI data without Doppler capacity, still present with a number of radars. Therefore, a data correction has to be specific to the radar.

Numerous radar raingauge adjustment techniques are available (Holleman, 2001), of which one appropriate for online processing has to be selected.

A definition of composit images has to be performed in order to provide a uniform data base and in order to save storage capacity.

4.3. Rainfall information flow concept

The radar rainfall data flow concept to be realised in North Rhine-Westphalia (NRW) includes the merging of five different radars of the German Weather Service (Essen, Hannover, Flechtdorf, Frankfurt and Neuheilenbach), of more than 100 online raingauges and of geographical information on the hydrological catchments.

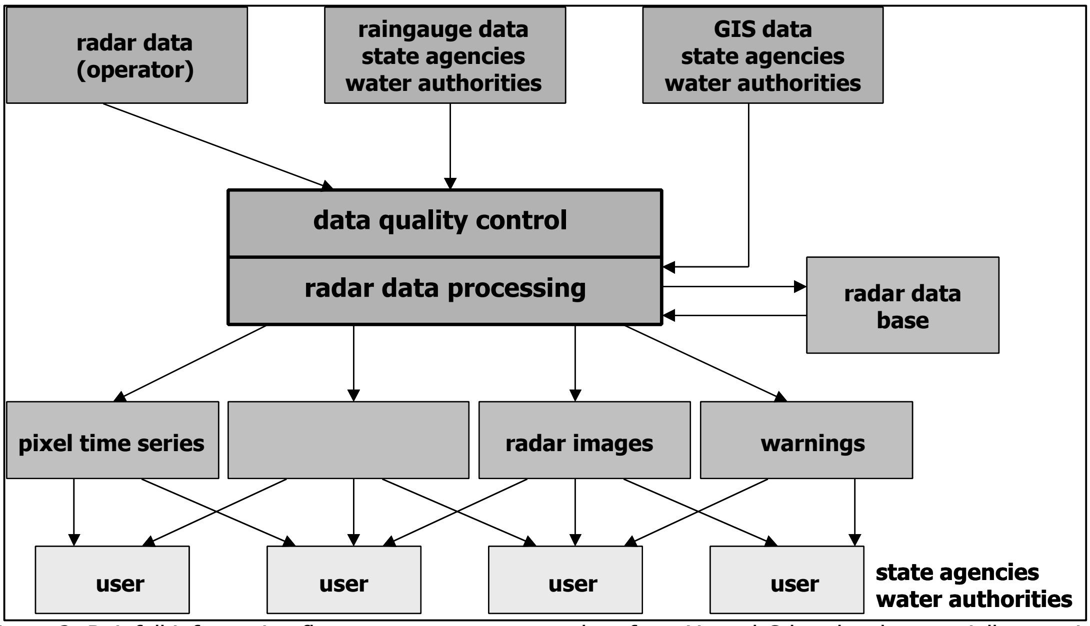

Figure 2: Rainfall information flow concept

On arrival, the radar data are quality controlled, and raw data and controlled data are stored in the radar data base (figure 2). After quality control of the raingauge data and storage of the data in the raingauge data base, the radar data are automatically adjusted to the raingauge data using one of the methods described in 4.2. The adjusted radar data are merged into a composit radar image information for the whole area of NRW and then stored in the radar data base.

For online flood warning purposes, catchment specific time series are produced automatically for a number of predefined catchments, including a rainfall forecast for a lead time of one to two hours. Online available to the user are these time series, measured and forecast composit images, and warning messages in case of a violation of predefined threshold conditions for certain areas or points.

For offline purposes, the user has to send a request to the radar data processing centre, giving the required start and end time of the radar rainfall data, accompanied by a GIS description of the catchments. The request can be formulated inside a GIS application which will be prepared for this purpose and included in the routinely used GIS tool in the hydrological services.

5. DISCUSSION

For a concept which (in principle) can be realised today, some pragmatic limitations had to be made for a first version of this software concept.

At present, the concept is only based on the radar data information from the weather service, although informations from other providers would be available and could be added. However, methods to merge data from X- and C-band radars partially covering the same area still have to be investigated.

Of the more than 180 raingauges that are run by the state services and the over 150 raingauges run by the water authorities, the minority is online at the present time. At the same time, the DWD is pushing a project to install and run an evenly distributed number of online raingauges all over Germany aiming at a good basis for real time adjustment of radar data for all radar stations of the German weather radar network.

Also, legal aspects concerning the proprietory rights on the data have to be regarded.

6. CONCLUSIONS

A first integrated concept for radar data use in German hydrological services has been developed. The concept is application driven and, therefore, pragmatic in some parts and highly automised. The objective was to provide the hydrological services with radar data information appropriate to their formulated requirements.

7. REFERENCES

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