Considerations for compositing radar data from three countries

G. Lempio¹, T. Einfalt¹, A. Lobbrecht²

¹hydro & meteo GmbH & Co.KG, Breite Str. 6-8, D-23552 Luebeck, Germany, g.lempio@hydrometeo.de

²HydroLogic BV, Stadsring 57, 3811 HN Amersfoort, Netherlands, arnold.lobbrecht@hydrologic.nl

(Dated: 03 June 2012)

Guido Lempio

1. Introduction

The radar coverage of the Netherlands is unequal: the Dutch radars of De Bilt and Den Helder have only limited coverage, while the German Emden radar is just opposite the border and the Essen, Wideumont and Zaventem radars are completing the required information for a good Dutch composite.

The motivation for a better Dutch composite is that in the north eastern, south eastern and south western border areas of the Netherlands the radar coverage is not sufficient. Frequently precipitation has been largely underestimated or has not even been detected in these areas, due to a large distance from the two Dutch radars. Therefore a pilot project has been started to produce an international composite including data from radars in the Netherlands, Belgium and Germany. This composite is now one important element of the HydroCity project (Lobbrecht et al. 2012).

One of the challenges in compositing is the number of different available data products from the different radars. Requirements for compositing are radar data quality control of the single radars, using various filtering and correction algorithms and the mapping of the corrected radar data onto a uniform rectangular grid with a homogeneous data presentation with availability in near real time.

The paper is based on experience of a three months time interval from summer 2011 which was analyzed for the HydroCity research project. In this study the composite has been adjusted to numerous rain gauges from the Netherlands and Germany. The results are presented in detail in this paper.

2. Sensors and Contributed Data, real time acquisition and quality control

2.1 Single radar data

2.1.1 KNMI radars Den Helder and De Bilt

The KNMI radar data from Den Helder (DEH) and De Bilt (DBI) are available as a volume scan with 14 elevations performed every 5 minutes. In this study the corrected reflectivity of scan 3 with an elevation of 0.8° was selected from the volumes of both radars. The data resolution is 1° × 1 km for a range of 240 km. These data are pre-processed for clutter and other corrections with simple methods but still heavily affected by such errors. Applied thresholds at the radar site are clutter-to-signal ratio (CSR) and signal-to-noise ratio (LOG).

2.1.2 German radars Emden and Essen

The German Weather Service (DWD) provides the DX-product radar data from Emden (EMD) and Essen (ESS). The DX-product consists of only one sweep with an orographic dependent elevation for each octant of a PPI. In the case of EMD and ESS the elevation of each ray is 0.8°. The spatial resolution is 1° × 1 km with a range of 128 km and the measurement takes place every 5 minutes.

2.1.3 Belgium radars Wideumont and Zaventem

The KMI provides radar data from Wideumont (WID) and Zaventem (ZAV). The data from WID are available as RAINBOW-3 volume files with 5 elevations performed every 5 minutes. The sweep with elevation angle of 0.9° was selected. The data resolution is 1° × 250 m for a range of 240 km. The data from ZAV are now (since April 2012) available as IRIS-RAW volume files with 10 elevations of a range of 125 km performed every 5 minutes. The sweep with the elevation angle of 1.0° was selected. The data resolution for a range of 125 km is 1° × 125 m.

In this study only the KMI radar from WID was available. The online composite of HydroNet now is running including the data from radar ZAV.
2.1.4 Radar data delivery

What caused considerable work was the delivery of the data: For radar data from three countries four different radar data formats were employed, and it was not possible to obtain all data in a uniform, well documented form like the OPERA standard HDF5. For radar data users who are working in transboundary areas, this inhomogeneity in the data delivery can turn out to be a major cost factor.

2.1.5 Data Pre-Processing Chain

Before using the radar data for compositing each PPI has to run through a specific processing chain performed by the SCOUT software (hydro&meteo, 2009) to eliminate measurement errors.

- Clutter map:
  For each radar a specific clutter map was created based on the data of the last month and applied to the radar data to interpolate the radar data for clutter affected range bins. At the moment clutter maps are produced manually, but future plans include the production of automatic clutter maps.

- Speckle filter:
  This filter removes very small echoes defined by a configured number of adjacent pixels, in this case 16 pixels.

- Gabella filter:
  A texture based filter (Gabella & Notarpietro, 2002) is used to smooth extreme peaks in the image, e.g. due to ground clutter within a rain field.

- Beam blockage filter:
  A data-driven method to correct for beam blockage in polar radar PPI data has been applied which does not require the existence of a DEM (digital elevation model) or precise knowledge about the radar parameters as other methods do (e.g. Bech et al., 2003). Although being based on the disregard of physical properties of the radar beam, a careful visual and statistical analysis of the radar data leads to the determination of beam specific correction factors and results in satisfactory correction results. The filter parameters were determined individually for each radar.

The radar data from KMI and KMNI have been transformed to a range resolution of 1 km by averaging the reflectivity values.

2.2 Rain gauge data

2.2.1 Origin: The Netherlands

The KNMI supplies continuous rain gauge data in hourly values from 32 automatic weather stations at the following locations:

2.2.2 Origin: Germany

The German Weather Service (DWD) supplies rain gauge data in minute-by-minute values at the following locations:
3. Applied algorithms to produce the composite

3.1 Compositing

There are several ways to generate a composite of radar data. The most obvious method is to take the maximum value of all radars for a pixel. But this method applied to the international Dutch composite creates sharp edges at the boundaries of the radar range.

The algorithm to generate the composite in this study is called the weight-based method where each radar is associated with a weight matrix. This matrix determines the influence of the values from each radar in the composite. Hence the composite was created based on the weight and reflectivity of each radar $i$:

$$ C = \sum_{i=1}^{k} w_i R_i $$

(1)

$C$ is the composite image, $w_i$ is relative weight matrix for radar $i$, $R_i$ is measurement of radar $i$, $k$ is the number of radars contributed to the composite. The relative weights of each radar were calculated by:

$$ w_i = \frac{Q_i}{Q_0} $$

(2)

$Q_i$ is absolute weight matrix for each radar $i$, $Q_0$ is cumulated weight matrix where $Q_0$ is defined as:

$$ Q_0 = \sum_{i=1}^{k} Q_i $$

(3)

The individual weight factors in the $Q_i$ are simply the inverse distances from the radar. Due to a large amount of false echoes close to the radars DBI and DEH the weight factors near the radar location were also decreased.

Additionally, each radar has been pre-analyzed for systematic differences over the radar range for a longer period. For example, the Den Helder radar is known to have detected too low reflectivity values for a part of summer 2011, due to a hardware problem. For such cases, it is important to apply a kind of bias correction to the data of the concerned radar before using it for compositing.
3.2 Adjustment

The adjustment is based on 49 rain gauges from the KNMI and the DWD. The adjustment method used is a Brandes type method (Goudenhooft & Delobbe, 2009) employing an IDW interpolation for the calculated factors at the rain gauge locations. Here an example is shown for a daily adjustment of the data for the meteorological day from June 18th 2011 at 06:30 a.m. to June 19th 2011 at 06:30 a.m. For most of the area covered by the WID radar there is no rain gauge information, hence the correction factor field has the value 1.0.

For the area of the Dutch water boards the correction factor field (Fig. 3) for this example shows large gradients caused by very inhomogeneous precipitation during this day.

Applying this correction factor filed to the composite radar data leads to the result of increased amount of precipitation over the area of the Dutch water boards (Fig. 4).
4. Summary and outlook

The quality of the international radar composite for The Netherlands is better than the current quality of the national composite of the KNMI because the areas far from the two Dutch radars are covered by radars from the neighbouring countries. This reduces errors due to underestimation of precipitation and the different viewing angle of the foreign radars permits to better correct for radar errors of the Dutch radars (e.g. for anomalous propagation).

The international radar composite for The Netherlands has been made available online since April 2012 on the HydroNET website of the HydroCity project. The data updating interval is five minutes.

New algorithms for adjusting the radar composite in real-time are tested to be available in June 2012. For real time adjustment, the rain gauge data are available as hourly values, for which a correction factor field is derived for the last hour and applied to the radar data. Some of the encountered uncertainties are described in Einfalt & Frerk (2012).

Already running in real-time is the SCOUT nowcasting module which permits to take into account growth and decay of rainfall fields (Tessendorf & Einfalt 2011).

For the HydroCity project, the OPERA data exchange standard HDF5 unfortunately was not available as a standard from two of the three radar data providers. In the future, data access would be much easier if this format would be also used in practice by all weather services being part of OPERA.

Acknowledgment

Thanks to Joël Hemperius (HydroLogic) for setting up the server, putting everything on the web and providing illustrations.

References


