Last edited by **Edouard Goudenhoofdt** 5 minutes ago

RADQPE User Guide

Motivation

RADQPE provides high resolution radar-based quantitative precipitation estimation in realtime for Belgium and its surroundings.

The product is used at the Royal Meteorological Institute of Belgium for several services:

- Rainfall monitoring by forecasters
- Very short term rainfall forecasting (nowcasting)
- Extreme rainfall warnings
- Web and smartphone applications
- Official report for extreme precipitation (calamity fund)
- Monitoring and verification of numerical weather prediction models
- Hydrological modeling

The product is sent to external users for various applications:

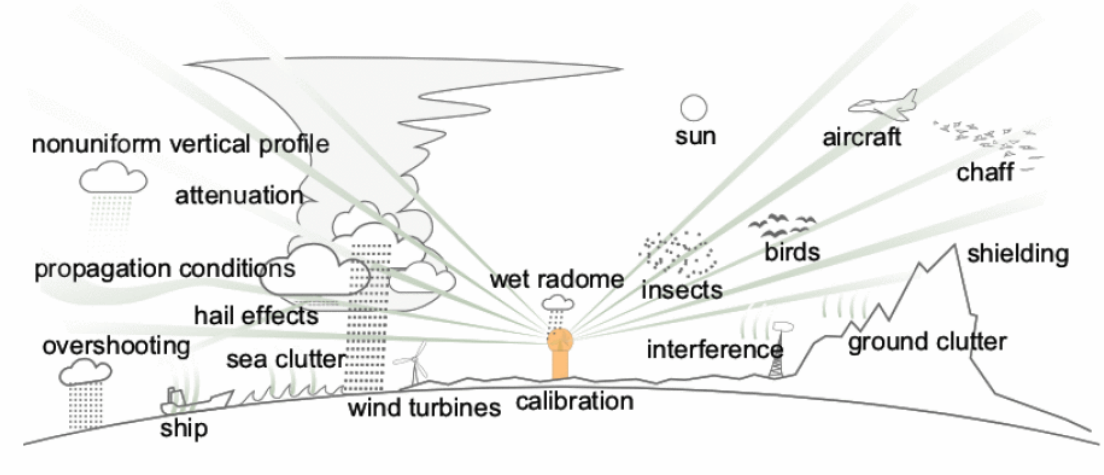
- Flood warnings (IBGE, WL, SPWMI)
- Sewer system management (SBGE)
- Free water quality monitoring (SPWARNE)
- Optimization in agriculture (CRA-W)

Methods

The RADQPE product is obtained after a careful processing of the weather radar measurements and a merging with rain gauge measurements. The scientific basis can be found in Goudenhoofdt and Delobbe (2016). There is a continuous improvement process based on research and quality control. The methods are summarized below. More details can be found in this presentation (pw=ksSxDyrBWA).

Weather radar measurements

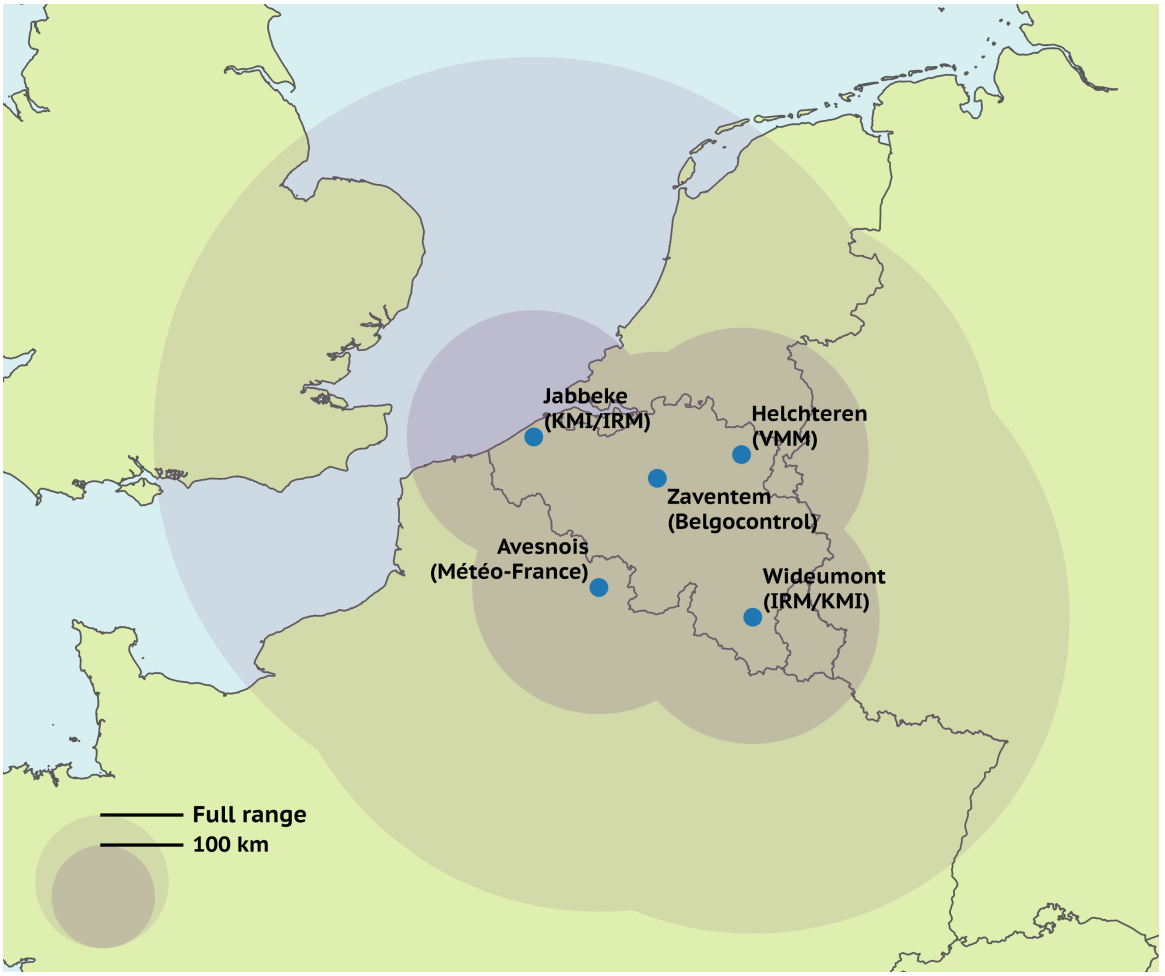
Radars emit electromagnetic pulses, typically with a length of 500m and a width of 1 degree. Part of the energy of this pulse is reflected back to the radar by precipitation. Radars performs scans at different elevations in about 5 minutes. Estimating rainfall from radar measurements is a challenge because of the many sources of error and uncertainty.



Phenomena affecting the radar data quality. From Ivan Holleman, KNMI, 2006.

RADQPE is based on the 3D reflectivity measurements of the following radars:

- Avesnois, France, French National Meteorological Service
- Helchteren, Belgium, Flanders Environment Agency
- Jabbeke, Belgium, The Royal Meteorological Institute of Belgium
- Neuheilenbach, Germany, German National Meteorological Service
- Wideumont, Belgium, The Royal Meteorological Institute of Belgium



These radars exhibit various technology, scanning strategy and data processing. They use Doppler capabilities to remove non-meteorological echoes with zero velocity (e.g. hills). Some processing can lead to loss of information and make further processing difficult.

Rain gauge measurements

The following automatic rain gauge networks are used by RADQPE:

- 91 weighted gauge OTT2, SPWMI, Belgium
- 42 weighted gauge OTT2, VMM, Belgium
- 19 weighted gauge OTT2, WL, Belgium

The quality control by data providers is void (WL), limited (SPW) or unknown (VMM). No extra quality control is performed before writing the data in the RMIB database.

Quality control of the radar measurements

- Identification of permanently contaminated measurements (hills, wind farms, interference).
- Correction for radar beam blockage by terrain
- Identification of clutter (i.e. non-meteorological echoes or signals) based on satellite cloudiness products
- Identification of clutter based on vertical profiles of radar reflectivity
- Identification of clutter based on image texture
- Identification of clutter based on dual-polarisation technology (only Helchteren and Jabekke)

From radar measurements to ground rainfall rate estimation

1. Identification of convective precipitation
2. Extrapolation to ground of non convective precipitation using an averaged vertical profile of reflectivity
3. Interpolation of missing data (vertically then horizontally)
4. Conversion of reflectivity into rain rates based on precipitation type (hail, convective, stratiform)

Single radar accumulation and bias correction

1. The movement of precipitation between 5-min snapshots is obtained using optical flow methods. It is used to accumulate rain rates over the past 1 hour and 24 hours.
2. The accumulations are adjusted by a mean field bias (MFB), which is computed based on the rain gauges measurements corresponding to the same duration
3. To remove radar calibration difference before compositing, the single radar rain rates are adjusted by the median of the 24h biases (computed at the previous step) for the past month.

Compositing, accumulation and radar-gauge merging

1. For the months with dominant convective precipitation (May, June, July, August), the single radar rain rates are combined into a composite by

taking the maximum value of the 3 closest radars.
2. For other months, the composite is based on all values weighted based on the distance to the radar.
3. Rainfall accumulation of the composite rain rates are made for the past 5 minutes, 10 minutes, 1 hour and 24 hours.
4. The 1h and 24h composite accumulations are adjusted by the MFB correction
5. The 1h bias correction of the previous step is applied to the composite rain rate. The correction is also applied to the 5 and 10-min composite accumulations

Product

Spatial resolution

The Belgian Lambert 2008 is used as projection. The composite has a spatial resolution of 1km with each estimate representing the averaged precipitation on a square of size 1km. Note that the contributing single radar products have a typical range of 250km but their resolution decreases with the distance to the radar. The composite covers an area from 0.3W to 9.7E in longitude and from 47.4N to 53.7N in latitude.

Temporal resolution

The Coordinated Universal Time (UTC) is used as reference.

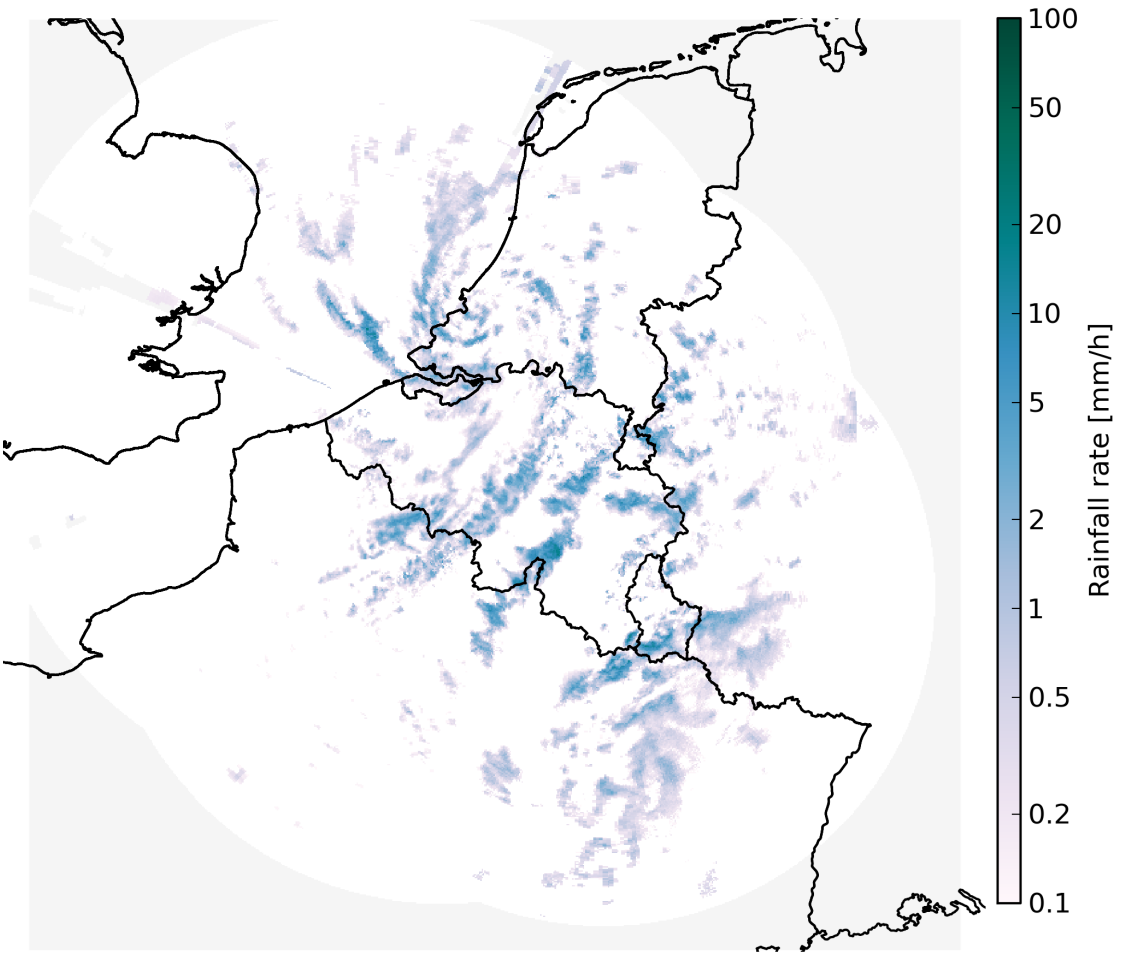
The rain rate composite is generated every 5 minutes with a maximum delay of 5 minutes.

The following rainfall accumulations are available:

- 5-min accumulation every 5 minutes
- 10-min accumulation every 5 minutes
- 1-hour accumulation every 5 minutes
- 24-hours accumulation every hour

Visualisation

A standard visualisation product for Belgium and the full domain are available in the PNG format



Visualisation of the RADQPE product

Data format

The products are available in the standard georeferenced raster format GeoTIFF. The values are coded as integers (int16) after a scaling of 100 (e.g. 1 = 0.01mm). This should be compatible with most software's.

The products are also available in the HDF5 format following the European weather radar information model (ODIM). This model is supported by the open source GDAL raster library, which is available in C++, java and python, and used by many software's.

Example files and their visualisation(pw:radqpe2020) are provided to check the proper handling of the data.

For pytnon users you can follow this tutorial. We can also mention this function of the open source radar processing library *wradlib*.

For advanced processing like metadata handling or high performance computing the HDF5 interfaces can be used (e.g. h5py for python). A quick guide to ODIM is available below. Details can be found in the ODIM reference.

Quick guide to ODIM

The data in an HDF5 file is made of groups and several attributes associated to a given group. An ODIM file contains several datasets (e.g. in /dataset1) which are defined by :

- geolocalisation : several attributes in the ”where” group (e.g. /dataset1/where)
- time information : "startdate", "starttime", "enddate" and "endtime" attributes in the ”what” group (e.g. in /dataset1/what)
- product type : "product" attribute in group ”what”

Additional information regarding the processing might be provided in the "how" group. Each dataset contains one or several physical quantities (e.g. in /dataset1/data1) which are identified by the "quantity" attribute in the "what" group (e.g. in /dataset1/data1/what). The data values (e.g. in /dataset1/data1/data) are stored as one long unpadded binary string starting in the upper-left corner and proceeding row by row (north to south), from left (west) to right (east).

The geolocalisation of a dataset is defined by the following attributes:

- xscale and yscale : the grid resolutions
- xsize and ysize : the grid sizes (number of pixels)
- UL_x and UL_y : the native coordinates of the upper left corner of the upper left pixel (this is specific to RMIB)

The projection of the datasets is stored as a PROJ4 string in the attribute ”projdef” of the group "/where". Based on the geolocalisation information one can construct the native coordinates of the grid. The native projection definition can then be used to reproject the data in any projection.

Filenaming convention

The timestamp corresponds to the rain rates estimation time or the end of the rainfall accumulation period. Here is the list of products for a given timestamp:

- 20210319110000.rad.best.comp.rate.qpe.*extension*
- 20210319110000.rad.best.comp.acrr.qpe.5m.*extension*
- 20210319110000.rad.best.comp.acrr.qpe.10m.*extension*
- 20210319110000.rad.best.comp.acrr.qpe.1h.*extension*
- 20210319110000.rad.best.comp.acrr.qpe.1d.*extension*

The extension is one of the following:

- tif
- hdf
- belgium.png
- full.png

Archive

The following products are archived since 2017 and available on request:

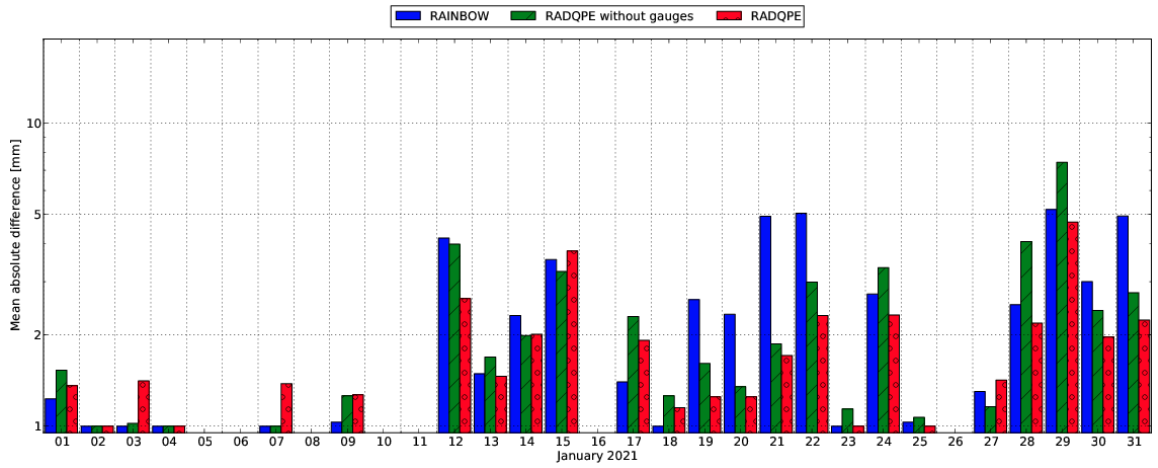
- *.rad.best.comp.rate.qpe.hdf
- *.rad.best.comp.acrr.qpe.1h.hdf
- *.rad.best.comp.acrr.qpe.1d.hdf

Quality control

An automatic quality control of the product is performed daily against the rain gauges of the RMI climatological network. This network is not used in the processing and is therefore an independent reference. The verification is performed for different applications:

- Estimation of events exceeding 1mm (e.g. meteorological applications)
- Estimation of events exceeding 5mm (e.g. hydrological applications)
- Detection of precipitation (e.g. crop science applications)

Various scores including an headline score are computed for each day and averaged over a month. The scores are also computed at each gauge location for 1 month or 1 year. The RADQPE product is compared to a RADQPE version without gauge information and to a basic product provided by the radar manufacturer (RAINBOW).



Example of quality control

Service level

The service is provided on a best effort basis.

In case of system failure, the operator will ask a system administrator to reboot the machine. This triggers an automatic restart and cleaning of the system, which should solve most issues. In a last resort, the operator will contact the RADQPE system maintainer but there is no official guard.

This is the availability of the rain rate composite for the last years:

year	percentage
2020	99.32
2019	99.55
2018	97.28
2017	98.33

The unavailability is partially explained by failures of the ICT infrastructure. Another part is caused by scheduled maintenance of the system during dry periods. The failures of RADQPE system itself have been very limited despite the numerous updates.

Contacts

1. RMI operators +32 (0)2 373 06 83 operators@meteo.be

- Service interruptions
- Severe quality issues

2. User interface +32 (0)2 373 06 12 infometeo@meteo.be

- General information
- Technical issues

3. Product maintainer +32 (0)2 373 05 63 edouard.goudenhoofdt@meteo.be

- User experience
- Quality issues
- Feature request