European Operational Program for Exchange of Weather Radar Information (OPERA)

Product Datasheet on

Instantaneous surface rain rate (in mm/h) and 1h rainfall accumulation (in mm) composites (2 km; 15 min)

Prepared by:	Haase, G., Koutek, M., Lankamp, B., Leijnse, H., von Lerber, A., Meyer, V., and Stephan, K.
Project:	OPERA NIMBUS
Production Centre:	GeoSphere Austria
Development by:	KNMI, SMHI and GeoSphere Austria
Application Domain:	A high-resolution European weather radar composite
Processing Software:	BALTRAD v.3.1.0-73, NIMBUS v.2024.04

1. Overview

The OPERA NIMBUS production generates and disseminates pan-European instantaneous surface rain rate (in mm/h) and 1-hour rainfall accumulation (in mm) composites, both at 15-minute intervals, with a spatial resolution of 2 km (Figure 1). This production system is implemented on the operational platform at GeoSphere Austria.

The OPERA-developed NIMBUS software is utilized to generate the rain rate composite (RR) and 1-hour rainfall accumulation (ACC) composites from the incoming OPERA network radar reflectivity volume data. The NIMBUS software is built upon the open-source BALTRAD software (Michelson et al., 2018). It utilizes a NIMBUS-specific data ingestor tailored to the OPERA network, followed by the BALTRAD toolbox for pre-processing the incoming data. This pre-processing currently involves applying four filters to reduce unwanted radar echoes in the data. Subsequently, the BALTRAD software is utilized to create the Pan-European radar reflectivity composite.

For the RR composite, the value of each composite rain rate pixel is calculated by selecting the lowest radar pixels relative to sea level and applying the Marshall Palmer Z–R relationship ($Z=aR^b$, with coefficients a=200 and b=1.6) to convert the reflectivity factor value (dBZ in linear units) into rainfall intensity (mm/h). The ACC composite is the sum of the previous four 15-minute RR composites.

A common definition for dry pixels is following the ODIM documentation (ODIM 2.4):

- "nodata" refers to pixels that are out of range or in a blanked sector.
- "undetect" indicates that the received radar signal is at or below the noise level (this is generally associated with dry weather).

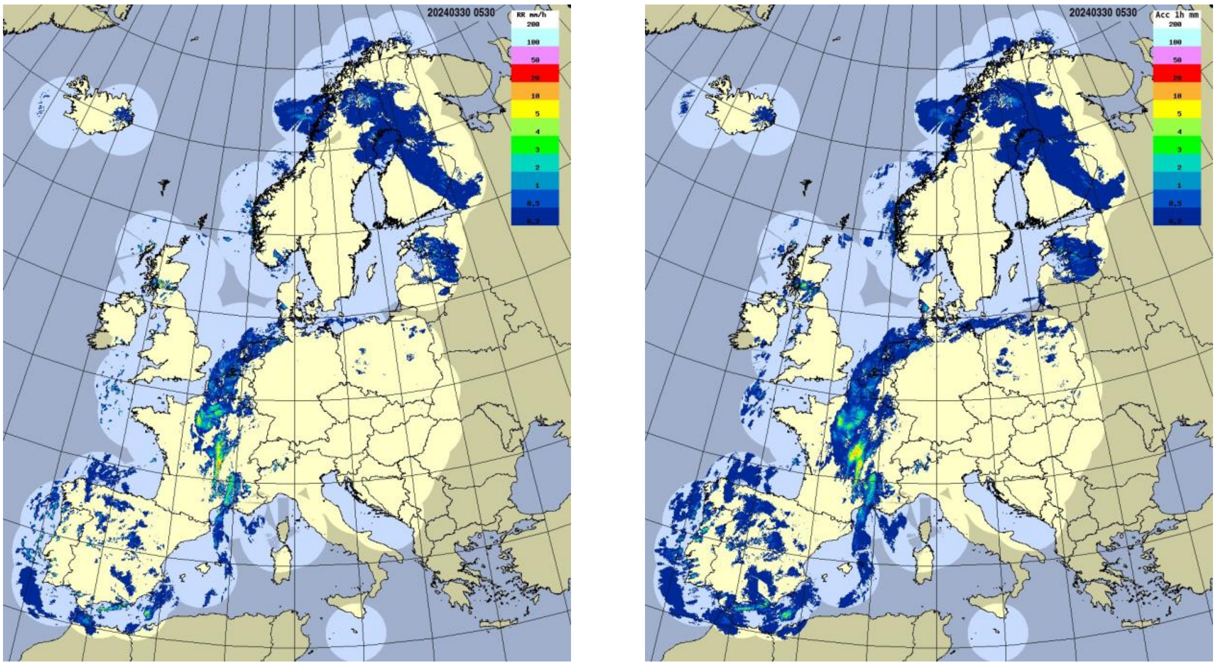

Figure 1. Example images of the NIMBUS composites of instantaneous surface rain rate (in mm/h) (left) and 1-hour rainfall accumulation (in mm) (right) on March 30 2024 at 05:30 UTC.

2. Product Audience

This meteorological information is intended to meet the diverse needs of end-users, including National Meteorological and Hydrological Services (NMHSs, members of OPERA), as well as a broad spectrum of weather information consumers.

3. Input Data

The horizontal reflectivity factor observations are collected by ground-based C- and S-band weather radars located across Europe (Figure 2) and are accessible through the OPERA network as volumes and scan datasets in real time via OPERA's CUMULUS/STRATUS service. While the majority of these observations have a high frequency with a 5-minute interval, some incoming data still maintain sampling frequencies of 6, 7, or 10 minutes. It's important to note that the radar scanning strategy may vary among data producers and even within a NMHSs' radar network.

Additionally, to enhance the overall quality of collected incoming reflectivity factor datasets, a set of filtering and correction techniques are selectively applied using BALTRAD toolbox. These techniques include anomaly removal, filtering based on occurrence frequency, beam blockage correction, and satellite filtering (for more details, refer to Saltikoff et al., 2019). The data provider can select which filter is applied to their data.

4. Product Coverage

Spatial coverage over a pan-European region is defined with the corner coordinates approximately: (70 N 30 W), (70N 50E), (32N 15W), (32 N 30E) with the horizontal resolution grid size of 2 km by 2 km. The image size is therefore 2200 by 1900 pixels. The composites cover almost the whole of Europe in a Lambert Equal Area projection.

Temporal coverage is the 15-minute interval inside which are start and end date-time of each scan, and it is updated every 15 minutes or 96 times per day. For the NIMBUS 15-minute composites, the data time widow is - 12 minutes before and + 7 minutes after the nominal times of HH:00, HH:15, HH:30, and HH:45. Note that Nimbus takes the input data that is closest to the nominal time for production of the composites.

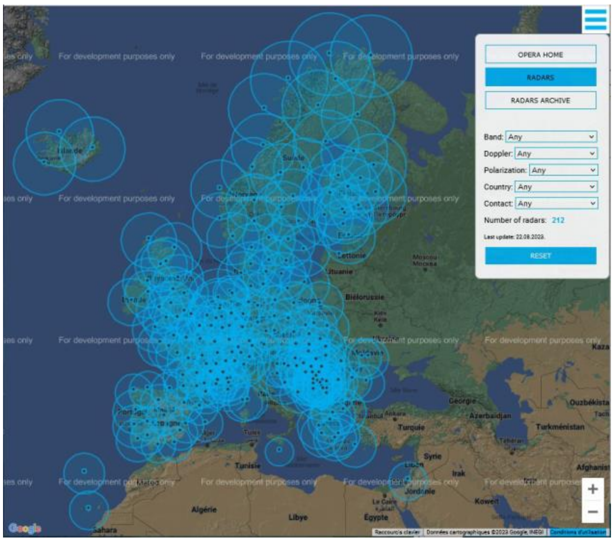

Figure 2. Google map with all radars (X-, C- and S-band) listed in the OPERA informative database. Source of the map: https://www.eumetnet.eu/activities/observations-programme/current-activities/opera. Please note that currently only reflectivity factor of C- and S-band radars are considered for the composite product.

5. References

Michelson D., Henja A., Ernes S., Haase G., Koistinen J., Ośródka K., Peltonen T., Szewczykowski M. and J. Szturc, 2018. BALTRAD Advanced Weather Radar Networking. Journal of Open Research Software, 6(1), p.12.DOI: https://doi.org/10.5334/jors.193.

Michelson D. B., Lewandowski R., Szewczykowski M., Beekhuis H., Haase H., Mammen T., and D. Johnson, 2021: EUMETNET OPERA weather radar information model for implementation with the HDF5 file format Version 2.4, Document on behalf of EUMETNET OPERA, 55p. (www.eumetnet.eu/wp-content/uploads/2021/07/ODIM_H5_v2.4.pdf).

Saltikoff, E., Haase G., Delobbe L., Gaussiat N., Martet M., Idziorek D., Leijnse H., Novák P., Lukach M.; Stephan K., 2019: OPERA the Radar Project. Atmosphere 10, 320. DOI: https://doi.org/10.3390/atmos10060320.

Szturc, J., Ośródka, K. and Jurczyk, A. (2011), Quality index scheme for quantitative uncertainty characterization of radar-based precipitation. Met. Apps, 18: 407-420. https://doi.org/10.1002/met.230.

6. Contact

OPERA support can be reached through email to support.opera@eumetnet.eu. Responses from the service desk are provided on a best-effort basis.

Instantaneous surface rain rate (in mm/h)

File naming: T_PAAH22_C_EUOC_YYYYMMDDhhmm.hdf

Summary

The product is a 2D gridded Cartesian dataset of instantaneous surface rain rate composite (in mm/h) over Europe stored in HDF5 format and structured according to the OPERA metadata standard ODIM version 2.4 (Michelson et al., 2021). The spatial resolution is 2 km x 2 km with a temporal resolution of 15 minutes.

Currently, the compositing of incoming volume radar data is performed by using the lowest elevation angle scan for each radar. The reflectivity factor (Z) of a given composite pixel is then set to that measured by the radar that provides data closest to sea level for that pixel. Hence, no averaging of reflectivities is done in computing the composite. The conversation to rain rate (R) is performed by applying the Marshall-Palmer Z–R relationship ($Z = aR^b$, with coefficients a=200 and b=1.6).

The NIMBUS quality index follows the total QI function of BALTRAD (Szturc et. al., 2011), which sets the QI to the minimum of the three quality indicators of the BALTRAD toolbox (bropo, beamb, and satfilter). If none of these filters have been applied, the quality index is set to 1. The quality index value range is between 0 (poorest quality) and 1 (best quality). Note that the quality index calculation may be renewed in the near future, so the current value should be used with caution.

Production method

Generation of the product involves four processing main steps:

1) Ingestion of the incoming data and combining them to the specified 5-minute volumes if needed.
2) Quality control of input reflectivity data for the lowest scan of each radar.
3) The mapping technique is used to create the composite, and the selected reflectivity factor value at a given pixel is obtained by selecting the reflectivity from the radar that provides data closest to sea level for that pixel.
4) The conversation to rain rate is performed by applying the Marshall Palmer Z–R relationship ($Z = aR^b$, with coefficients a=200 and b=1.6).

Data availability

For EUMETNET OPERA members:

Data are available directly from GeoSphere Austria with login credentials requested from support.opera@eumetnet.eu.

For external users:

The composite products are available via National Meteorological Services following the EUMETNET licensing (https://www.ecomet.eu/), please contact your national service provider (https://www.ecomet.eu/contact/members)
or via API-interface offered by Météo-France (https://portail-api.meteofrance.fr/devportal/apis).
The required license and access to the API, please communicate through the email address vd@meteo.fr.

General remarks

- The NIMBUS composite is based on polar scans and volumes.
- The data is provided in ODIM-HDF5 format only.
- It should be noted that NIMBUS production relies on the quality, availability, and timeliness of the incoming data from members via the CUMULUS/STRATUS production line. Hence, delays at the reception of input data files may occur and cannot be compensated for.
- All expected radars, if available, are taken into account during the data processing, unless they are located outside the composite domain or data quality is insufficient.
- For some radars, long-range scans that are generally optimized for reflectivity are preferred, even if (velocity optimized) scans closer to the nominal time are available.
- The incoming radar data may include low reflectivity factor values, typically representing noise, which are not removed by the NIMBUS central processing. Therefore, for visualizing the composite products, users can apply an appropriate threshold to achieve a “cleaner” radar image. A typical value could be 0.01 mm/h for the surface rain rate product.

1-hour rainfall accumulation (in mm)

File naming: T_PASH22_C_EUOC_YYYYMMDDhhmm.hdf

Summary

The product is a 2D gridded Cartesian dataset of 1-hour rainfall accumulation (in mm) over Europe stored in HDF5 format and structured according to the OPERA metadata standard ODIM version 2.4 (Michelson et al., 2021). The spatial resolution is 2 km x 2 km with a temporal resolution of 15 minutes.

Currently, the compositing of incoming volume radar data is performed by using the lowest elevation angle scan for each radar. The reflectivity factor (Z) of a given composite pixel is then set to that measured by the radar that provides data closest to sea level for that pixel. Hence, no averaging of reflectivities is done in computing the composite. The conversation to rain rate (R) is performed by applying the Marshall-Palmer Z–R relationship ($Z=aR^b$, with coefficients a=200 and b=1.6). The 1h-rainfall accumulation product is calculated as the sum of the previous four 15-minute rain rate composites.

The NIMBUS quality index follows the total QI function of BALTRAD (Szturc et. al., 2011), which sets the QI to the minimum of the three quality indicators of the BALTRAD toolbox (bropo, beamb, and satfilter). If none of these filters have been applied, the quality index is set to 1. The quality index value range is between 0 (poorest quality) and 1 (best quality). The quality of the rainfall accumulation product is determined by taking the minimum value of the quality indices of the four contributing rain rate composites. Note that the quality index calculation may be renewed in the near future, so the current value should be used with caution.

Production method

Generation of the product involves five processing main steps:

1) Ingestion of the incoming data and combining them to the specified 5-minute volumes if needed.
2) Quality control of input reflectivity data for the lowest scan of each radar.
3) The mapping technique is used to create the composite, and the selected reflectivity factor value at a given pixel is obtained by selecting the reflectivity from the radar that provides data closest to sea level for that pixel.
4) The conversation to rain rate is performed by applying the Marshall Palmer Z–R relationship ($Z=aR^b$, with coefficients a=200 and b=1.6).
5) The 1h-rainfall accumulation product is calculated as the sum of the previous four 15-minute rain rate composites.

Data availability

For EUMETNET OPERA members:

Data are available directly from GeoSphere Austria with login credentials requested from support.opera@eumetnet.eu.

For external users:
The composite products are available via National Meteorological Services following the EUMETNET licensing (https://www.ecomet.eu/), please contact your national service provider (https://www.ecomet.eu/contact/members)

or via API-interface offered by Météo-France (https://portail-api.meteofrance.fr/devportal/apis). The required license and access to the API, please communicate through the email address vd@meteo.fr.

General remarks

- The NIMBUS composite is based on polar scans and volumes.
- The data is provided in ODIM-HDF5 format only.
- It should be noted that NIMBUS production relies on the quality, availability, and timeliness of the incoming data from members via the CUMULUS/STRATUS production line. Hence, delays at the reception of input data files may occur and cannot be compensated for.
- All expected radars, if available, are taken into account during the data processing, unless they are located outside the composite domain or data quality is insufficient.
- For some radars, long-range scans that are generally optimized for reflectivity are preferred, even if (velocity optimized) scans closer to the nominal time are available.
- The incoming radar data may include low reflectivity factor values, typically representing noise, which are not removed by the NIMBUS central processing. Therefore, for visualizing the composite products, users can apply an appropriate threshold to achieve a “cleaner” radar image.