OPERA – past, present and future

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1 Introduction

The EUMETNET Radar project OPERA (Operational Program on the Exchange of Weather Radar Information) is approaching its 20th birthday. Its most visible achievement is the Pan-European composite (fig.1), but there is much more.

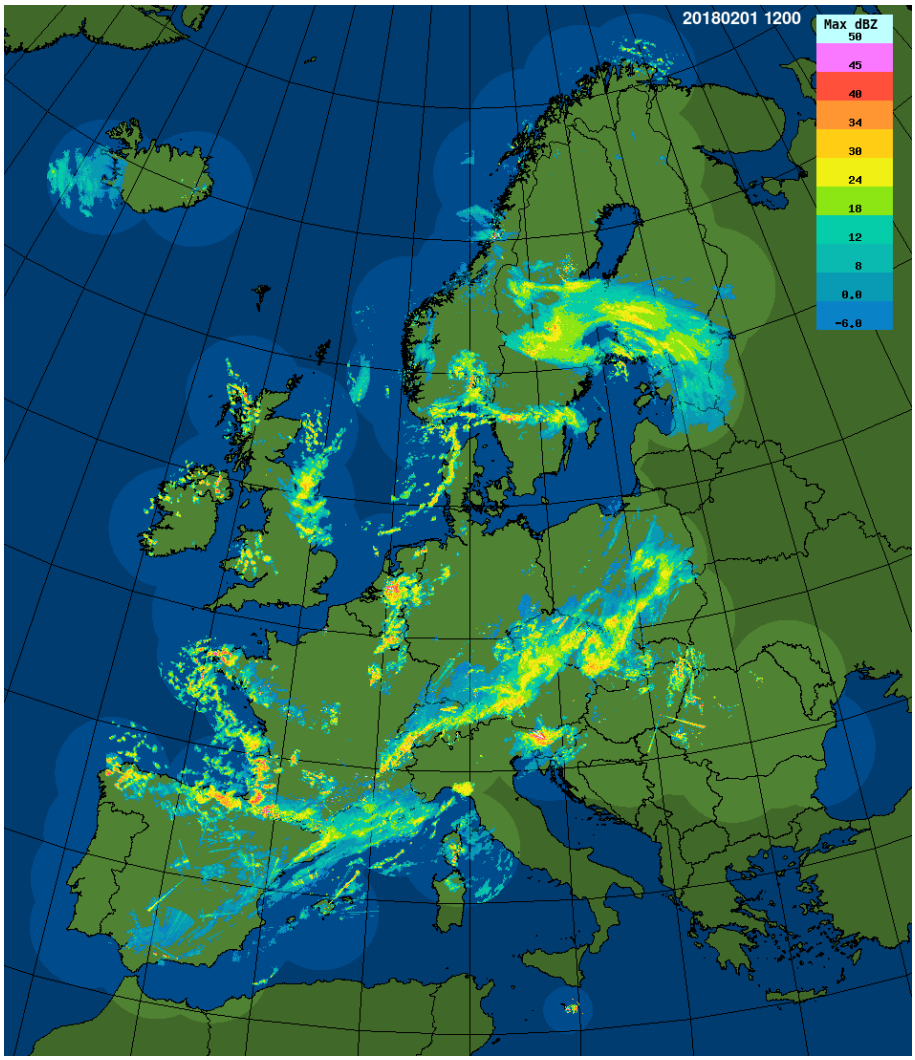

Figure 1. OPERA Maximum reflectivity composite 1 February 2018 12 UTC

2 History is history

Weather radar experts in Europe started organized co-operation in COST activities 72 (Measurement of precipitation by radar, 1979-1985) and 73 (Weather radar networking, 1985-1991). After this, operationally-oriented GORN group (Liaison Group of Radar Networking, 1992-1998) was established, which, in 1999, led to establishment of OPERA (Operational Program on the Exchange of Weather Radar Information) under the umbrella of EUMETNET (the Network of European Meteorological Services). The task given to this program was "To harmonize and improve the operational exchange of weather radar information between National Meteorological Services" (Holleman et al., 2008).

At that time, several regional exchange groups existed. Actually, bilateral exchange of data between neighbouring countries was developed in late 1980s (e.g. UK and Ireland, France and Switzerland), using "existing national codes (what we now call data formats) developed for a particular radar installation, and dedicated communication links". The COST 72 data exchange pilot project used four different formats. COST 73 proposed modifications to WMO BUFR-94 wishing that in the future the same standard format could be used everywhere (Collier, 1990).

GORN and OPERA continued the development of the data format and the software supporting it. In 2008, the OPERA Data Information Model (ODIM) was developed "…with which the encoding, decoding and management of data and products from weather radar systems may be facilitated, primarily for the purpose of international exchange in Europe" (Michelson et al., 2008, 2011 and 2014). Implementations of this information model were specified in BUFR and in HDF-5. This data model has become the standard for radar data exchange in Europe and beyond. It is vital for running the OPERA Data Center and it has also accelerated bilateral exchange of radar (volume) data between meteorological services. Most importantly, all major radar manufacturers provide conversion software between their data format and the ODIM formats.

In 2004 EUMETNET decided that OPERA should be more operational, and move from supporting bilateral exchange to running a data hub. The OPERA Pilot Data Hub received single-site Cartesian products and national composites from members and created a composite. Variability in the quality of input was surprisingly large, and the projection conversion led to loss of resolution. For creating a more homogenous product, a data centre was designed. It was called Opera Data Centre, ODC, which is pronounced same way as *Odyssée*, so it is now referred to as Odyssey. (Unlike some legends say, the name has nothing to do with a long journey.)

In order to get as homogenous products as possible, the idea from 2011 was to collect data as raw as possible, and then run all quality control centrally. Centralized clutter cancellation was running from late 2015, but the quality was still less than optimal, and more alarmingly, it was destroying some real precipitation. We've corrected this latter issue and learned from this that algorithms should be thoroughly tested before implementation. Meanwhile, several members upgraded their radars and could use locally very advanced signal processing techniques, which cannot to be repeated in ODC. Hence, in March 2017, a new agreement was made: to collect the best possible data, document how it was processed, and collect also the unfiltered data (TH) as a separate parameter. By May 2018, this decision has been implemented by 11 members.

Changes can be seen by studying the Pan-European composites, and especially by calculating long-term sums and averages. The area covered by the composite has been substantially increased by the progressive incorporation of new radars. The quality and the homogeneity of the composite have increased as well. During the first year, the homogenization was mainly due to improvements in incoming data, but from late 2015 the central processing has been removing more unwanted echoes than before through non-meteorological echo detection algorithms and the application of a satellite-based cloud mask. This increase in quality has been confirmed with quantitative studies. The negative bias in the northern areas is also obvious, and applications for VPR and different ZR for snow have been developed but not yet applied operationally.

3 Present status is an example to the rest of the world

In 2018, OPERA had 31 members. Its metadata database lists 225 radars, 152 of these (from 24 countries) are exchanging data regularly. Of the OPERA radars, 75 are from last century. The majority (178) are C-band radars, complemented by 18 S-band, 3 X-band radars. 122 radars are dual-polarization. Generally 30-40 people attend the Expert team meetings which are held two times a year. This makes OPERA by far the largest, most heterogeneous body of radar experts anywhere in the world.

To understand both the variability and common factors in this grouping, and to share experiences between members, OPERA has performed several surveys and studies. Results from a survey about maintenance show large differences in national maintenance policies, and reveals that the primary causes of missing data are not with the radar itself but are related to issues with the electricity supplies or telecommunications (Saltikoff et al., 2017). A survey about application priorities shows that the most important uses of radar data are aviation and severe weather warnings. Importance of other applications such as hydrological applications, NWP assimilation and verification, and information for general public has a large variability across Europe. These differences of priorities of national meteorological services are the main reason of the wide variability in measurement scan strategies and schedules observed over Europe.

The use of polarimetric radar variables in Europe was also subject of a survey. Currently the largest benefit of dual-polarization radars is in the quality improvement of other data (reflectivity and Doppler), especially in removal of unwanted signals such as radio interference and wind turbines. Only a limited number of OPERA members are testing dual-pol attenuation correction, and even less have started using this operationally.

For quality assessment, OPERA has benefited of co-operation with data users such as NWP, nowcasting for flood warning (Park et al.,2017) and the ENRAM community studying animal (e.g., birds, insects, etc.) movements (Bauer et al,2017), but also carried out its own studies.

Assessment of rain rate composites shows, that the homogeneity of composites increased significantly between 2012 and2015 due to national improvements both at the radars themselves and the data sent to ODC. The quality improvement tools (beam blocking and satellite-based removal of residual clutter) changed the amount of non-precipitating echoes from the end of 2015.

Assessment of accumulated precipitation (compared to a mesoscale analysis MESAN, Häggmark et al., 2000) shows that OPERA generally underestimates precipitation in winter, most prominently along the Norwegian coast. It confirms that the

monthly clutter fraction (pixels with precipitation intensities greater than 0.0 mm/h) decreased at the end of 2015, which coincides with the implementation of the new clutter filters.

Proof of a cake is in its eating, and the real value of OPERA's efforts comes from use of the exchanged radar data. The composites are visualized to operational forecasters in many participating institutes, and on some of their websites. The data is assimilated in limited-area NWP models and used for verification. Several international organizations, such as EUMETSAT and ECMWF have licenses for their duties, and a few external users have acquired a license which is available via ECOMET. These users are represented in the OPERA User Group, of which the chair attends each Expert Team meeting and provides feedback to OPERA.

4 Future is bright

In the next EUMETNET program phase, 2019-2023, OPERA is focusing even harder on the needs of users outside the radar community. We have identified several different user types, and split the production lines accordingly. There are work packages for harmonization of metadata and for quality management, assessment of new technologies, and plans for real-time exchange of data and status reports. What will certainly continue is the exchange of knowledge, information and experiences between European radar experts, which has been the heart of OPERA for 20 years.

Acknowledgement

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Secondly, there have been several enthusiastic users, whose questions and feedback have helped us to improve the products and their documentation.

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