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Review of the current and likely future global NWP requirements for Weather Radar data

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SUMMARY AND PURPOSE OF DOCUMENT

This document provides the current status and future global NWP requirements from ECMWF and Météo-France. These requirements, sufficiently general, are assumed to be representative of the needs of weather national services in global and regional data assimilation.

ACTION PROPOSED

Review document in preparation for workshop on weather radar data exchange to be discussed

WORKSHOP ON RADAR DATA EXCHANGE – REQUIREMENTS FOR WEATHER RADAR DATA (EXETER, UK, 24-26 APRIL 2013)

1. Introduction

This document summarizes requirements from ECMWF and Météo-France centers. Even though these requirements are specific to two NWP centers we believe that they are representative of needs from the global (ECMWF) and regional (Météo-France + ALADIN/HIRLAM consortia) communities, using different radar products (ECMWF: rainfall composites, MF: raw data).

2. Current status and use of the data

ECMWF is operationally assimilating NCEP Stage IV surface rain composites (2D) over the USA in the 4D-Var system. These hourly composites are based on the American NEXRAD radar network and they are exchanged in GRIB format.

MF is operationally assimilating volumes of French radar reflectivity data and Doppler radial wind in the 3D-Var AROME system. These data are received in BUFR format. They contain a flag providing information on the type of echo associated with the measured signal.

3. Future requirements for use of the data

Coverage

From ECMWF point of view, there is a strong interest in extending the coverage to Europe (OPERA, part of EUMETNET), China, Japan and Australia

From MF point of view, there is a strong interest in extending the coverage to neighbouring countries (bordering France) to cover the domain of the AROME mesoscale model. In priority, Belgium (2), Germany (14), Spain (14), England (17), Sardinia, Italy (21)) and Austria (5), Netherlands (2) and Denmark (5) in particular as well (Potentially 80 radars).

Products

For ECMWF, there is a strong preference on composite products for the following reasons:

- very difficult to process single radar data on a global scale. The process of creation of composites should be delegated to Regional Centres.
- data policy can be weaker on processed composites than on the original volume data.
- Regional Centres with a direct access to the data would be in better position to provide appropriate quality control information complementing the composite data

For ECMWF, in the short term (3-4 years), the focus is expected to remain on surface rain composites.
In the longer term volume radar data could be of interest, in terms of precipitation rates and reflectivity. For the assimilation of reflectivity data attenuation corrections and frequency or wavelength are required.

MF has developed a specific assimilation for its regional model (AROME), by using single-site volume data of raw reflectivity and unfolded radial wind. ALADIN/HIRLAM consortia begin to assimilate in their regional assimilation system (HARMONIE) the raw radar data in a similar manner as adopted at Météo-France. MF and ALADIN/HIRLAM consortia are strongly implicated

in OPERA4 which offers (for the short term) to specify homogeneous radar data for assimilation purposes (common data format template and common data information).
Recent experience of radar assimilation at MF shows that it is fundamental to access unprocessed volumes, but with crucial information about the identification of different kind of echoes (see figure 1 an example of such distinction at MF). A unique value of Quality Indicator (QI) may be not enough for an efficient assimilation of reflectivity. Indeed, the quality flag must allow to distinguish between the pixels to the noise level (no rain detected by the radar) and other clutter (ground clutter, sea clutter or also absence of measurement because of beam blockage). When possible, the attenuation correction is given by the radar producers (reliable algorithms become available but only from polarimetric radars). It is mostly fundamental for some of the radar wavelengths such as X-band radars.
Additional metadata allow to provide information about radar sensitivity (minimum detectable reflectivity) and level of signal-noise-ratio. It is usefully exploited to not necessarily assimilate no-precipitating signal when signal-to-noise ratio is very low. All necessary metadata are summarized at the end of this paragraph.

Experience within OPERA shows that it seems possible to provide additional layers of information to allow to distinguish between such pixel for the assimilation of reflectivity data. But for radial wind, in short term, it could be more difficult for some countries to modify their radar operating mode in order to provide unfolded velocities.

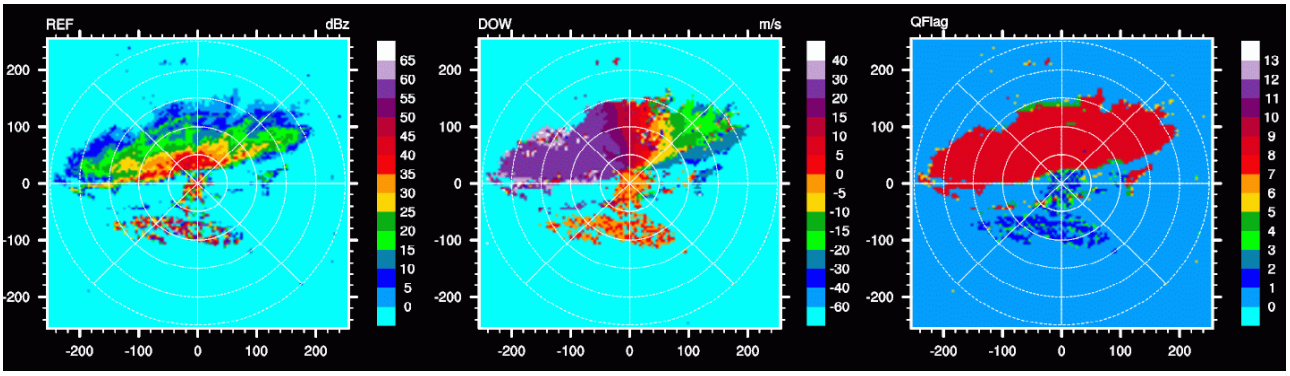

Figure 1: For the 0.8° Plan Position Indicator (PPI) from the Toulouse radar on the 05/02/2013 at 18 UTC, reflectivity field (left), Doppler radial wind (middle) and corresponding quality flag (right) within following scale meaning: 0= noise, 1=static clutter, dynamic clutter, 3=very close to clutter, 4=clear sky echo, 5=sun, 6=sea clutter, 7=drizzle, 8=precipitation, from 9 to 15= different hydrometeors.

Several reasons to justify the strongest preference of Météo-France for original volume data of raw reflectivity and radial wind, instead of composite products:

- The measurement of rainfall rate on the ground is not a direct measure of the radar instrument: it therefore combines errors from different inversion algorithms of the raw reflectivity data (in the upper atmosphere). We consider that it is important to use raw data as close as possible to the measured signal of the instrument for better quality controls and error specifications.
- Moreover, the different sources of errors are still currently mixed in the composite products. The composite products do not allow the necessary distinction of the observation errors. The assimilation of composite products also needs improved specifications of quality control information required for the assimilation of raw data to be produced by Regional Centres.

Necessary Metadata:

- Type of radar (Doppler and dual-polarization capabilities)
- 3 db beamwidth

- radar power (or to access the minimum detectable signal, the radar constant and the power sensitivity)
- Radar location : latitude, longitude, altitude and height above the ground.
- Radar wavelength or frequency
- Type of geometry (polar, cartesian) and to know if single-site Plan Position Indicator (PPI) or Constant Altitude Plan Position Indicator (CAPPI).
- Pulse duration

Resolution and frequency

The minimum required horizontal resolution is 2 km.

For MF, in the longer term the horizontal might be increased to 1 km.
As concerning the frequency, for MF, the AROME NWP system is based on a Rapid Update Cycling where assimilation is done every 3 hours, nearly down to every hour. A minimum update frequency of 1 hour is required. In the longer term, a 15 minute update frequency will be desirable.
For ECMWF, 15 minutes frequency is desirable.

Timeliness
For ECMWF, for operational applications, quasi-real-time data availability are needed (ideally within 15 minutes).

For MF, the requirement for the timeliness is between 15 and 30 minutes after the measurement. Therefore the 20 minute delay is acceptable even though 15 minutes would be optimal.
A timeliness down to 5 minutes could be interesting but seems to be currently impossible in order to keep the same quality of single-site data.

Format

For ECMWF, GRIB for composites on regular grids and BUFR for raw volume data are the only required formats. In both formats quality control information has to be included in the appropriate form.

Météo-France prefers BUFR format but other are possible (HDF format will do). The content of the file is more important than the actual format. The chosen format should handle all quality flags needed for each pixel.