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The unfortunate information loss due to irreversible filtering in weather radar data processing

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Weather radars were originally developed for monitoring and nowcasting of convective storms and for quantitative precipitation estimation (QPE). In order to improve the data quality for these purposes, filtering and thresholding is generally applied at several levels in the radar data processing chain. A few filters can only be applied directly at the radar signal processor (e.g. Doppler filters) as they require I and Q data, but most other filtering and thresholding can be done at a later stage (i.e., post processing). If the data are archived or made available only after such post-processing filters have been applied, they will be of much less use for most applications besides making pretty rainfall pictures. Such a reduction in value can be even more significant if large parts of the original radar data are rejected by “quality” masking, e.g. utilizing rain gauges or satellite imagery. If we want to maintain the full potential of weather radars, it is essential to distribute and archive radar data from the early phases of processing before applying irreversible filters and “quality” thresholds.

The reason for not applying any post-processing filters in the archived and internationally exchanged data is that there are many applications that all require different settings of such filters in order to optimally use radar data (or for radar data to be useful at all in some cases). Some of these applications (both meteorological and non-meteorological) are:

- Monitoring and analysis of mesoscale weather. This application requires information about the mesoscale reflectivity and wind patterns. For example, birds, insects and debris are often the primary scatterers in the detection of downbursts, tornadoes, gust fronts, sea breeze fronts and dry synoptic scale fronts as well as in the detection of the height of the boundary layer. Removing weak or all non-meteorological echoes will hence remove very valuable meteorological information.

- Nowcasting. Depending on how this is done, data requirements may vary greatly. Well-trained human forecasters (i.e., those trained in interpreting meteorological signatures in non-meteorological echoes) are likely best off with data on which only Doppler clutter filters have been applied. Numerical nowcasting systems are still in their early phase of development. Nowcasting of precipitation requires data with most non-meteorological echoes removed whereas for nowcasting of winds insect echoes are the primary tracers of wind, having a much higher availability than meteorological echoes.

- Data assimilation in NWP models. Wind assimilation requires information about the nature of the scatterers in the measurement volume – passively floating insects and precipitation are “good”, birds are “bad”. For reflectivity assimilation it is extremely important to know that zero reflectivity means dry weather (as opposed to something that was removed because it was judged to be non-meteorological). Post-processing algorithms will generally remove this information.

- QPE, hydrological monitoring and modelling. For this application it is extremely important to remove all clutter because residual clutter can generate large accumulations, especially over longer time periods. Recognition of hail is very important for avoiding false alarms in cases of unusually high reflectivities.

- Bird/bat/insect migration monitoring for pest control, aviation flight safety, conservation ecology, etc. This application requires data with static and anthropogenic clutter removed, but obviously other non-meteorological echoes should be retained. In the future we can envisage the existence of nowcasting of insect, bat and bird movements to prevent collisions of birds and airplanes or wind farms, as well applications in monitoring long-term changes in habitat use and animal population numbers.

- Other applications (e.g. forest fire monitoring, monitoring of ducting conditions, etc.). The requirements of these applications will vary depending on the case.

For meteorological services it is presently not feasible to distribute and archive raw I and Q (i.e. level 1) data because of the large amount of data. Signal processors generally greatly reduce the volume of data, but important information may be lost (e.g. full Doppler spectra or refractivity). For operational applications, it is (at this time) recommended to apply signal processing before distribution and archiving with a primary aim of separating non-aerial ground clutter contaminations from other scatterers. The precise settings of the signal processor should then of course be included with the data, but all other processing steps such as thresholding and range averaging (which is generally done by signal processors at weather services in Europe) should be done after distribution. If such unfiltered radar data are available, post-processing can be carried out specifically for each application, either centrally or locally (e.g. using one of the available open-source packages).

It is important to realize that even though operational weather radars are generally intended for weather monitoring, there are many more applications that can benefit from radar data, and that the meteorological community can provide important services. Furthermore, we can certainly learn a lot about radar data quality from user feedback, which will help us to improve meteorological data as well. The data have no absolute quality but they are dependent on the application and user requirements. Given the cost of acquiring, operating, and maintaining weather radars, our community has a task of utilizing them optimally for a broad range of applications and stakeholders. Because the cost of bandwidth and storage capacity is only a very small fraction of the cost of a weather radar, not distributing and archiving the rawest form of data possible will be a waste of public resources.