Clutter detection using object identification, cloud mask and displacement vectors

Remco van de Beek, Floris Bijlsma, Hugo Hartmann and Daniel van Dijke

MeteoGroup, Agro Business Park 99-101, 6708 PV, Wageningen, The Netherlands

Remco van de Beek

1 Introduction

Clutter has been a problem in operational radar measurements since the early days of development during World War II. There are many sources of clutter in weather radar ranging from buildings and mountains to insects and airplanes. Depending on the atmospheric conditions the refractivity might change and ground clutter might be measured at locations where normally none is seen. While many scientists have tried to eliminate clutter from the data it remains a considerable problem in operational products to this day (Torres and Zrnic, 1999, Sanchez-Diezma et al., 2001, Steiner and Smith, 2001, Hubbert et. al, 2009, Rennie et al., 2010). Doppler radar data offers a way to remove much of the clutter, but has its limitations and biases precipitation data near zero velocity. Modern dual-pol radars give additional possibilities in detecting and removing these artefacts, but these data are not yet widely available in practice. In commercially available radar images there are therefore often clutter areas present. Within MeteoGroup a method for removing clutter was already used, but it was decided to improve the algorithm. This study offers a way of additional clutter detection and removal from CAPPI images. This is achieved through a combination of methods, of which the most important ones are:

1) satellite cloud mask

2) object shape identification

3) spike removal

4) use of expected radar movement vectors

The effectiveness of these methods is demonstrated below.

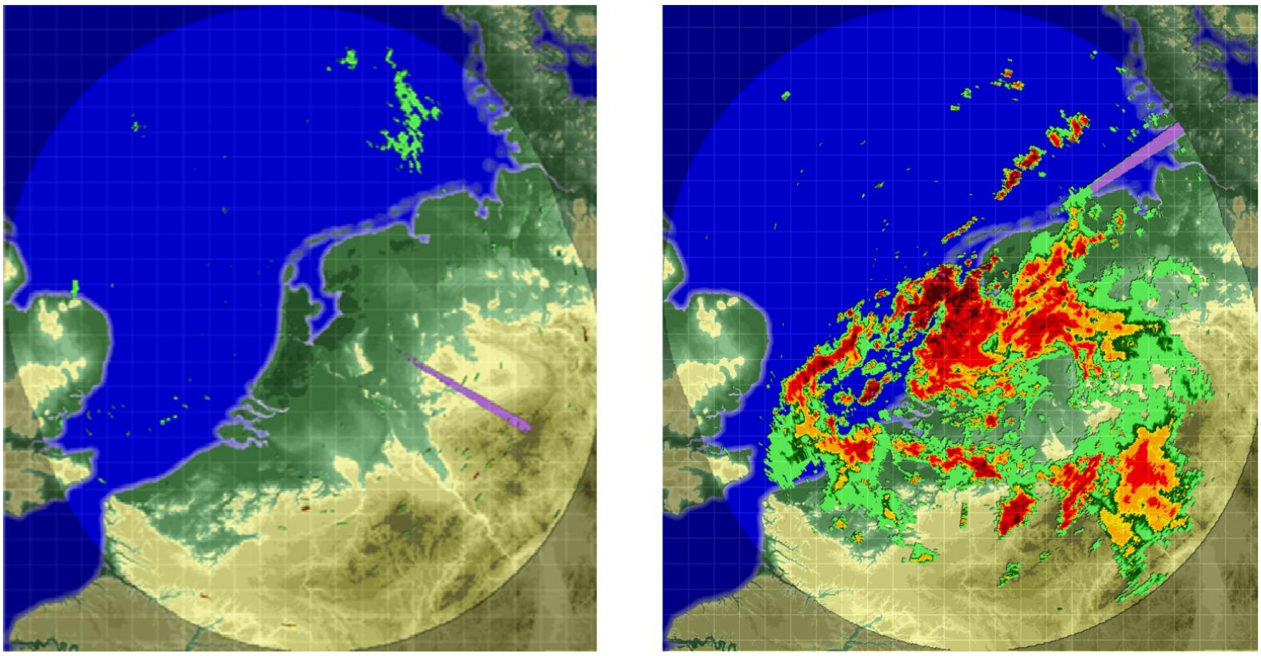

Figure 1. Example of the spike detection method. Left panel a case in a clear sky situation and right panel a case within precipitation.

2 Method

The algorithm uses CAPPI images as input. As these images usually are merged radar stations there is a loss of data compared to the raw data. Correction algorithms like those for attenuation become very difficult to apply. The proposed clutter detection and removal algorithm tries to work with the data available within the CAPPI image and consists of several steps. Each step gives a weight to each pixel and if the combined weight exceeds a set threshold the location is marked as clutter and removed. Each step has several parameters that can be set to tune the sensitivity depending on season and location. The steps are described in the following paragraphs.

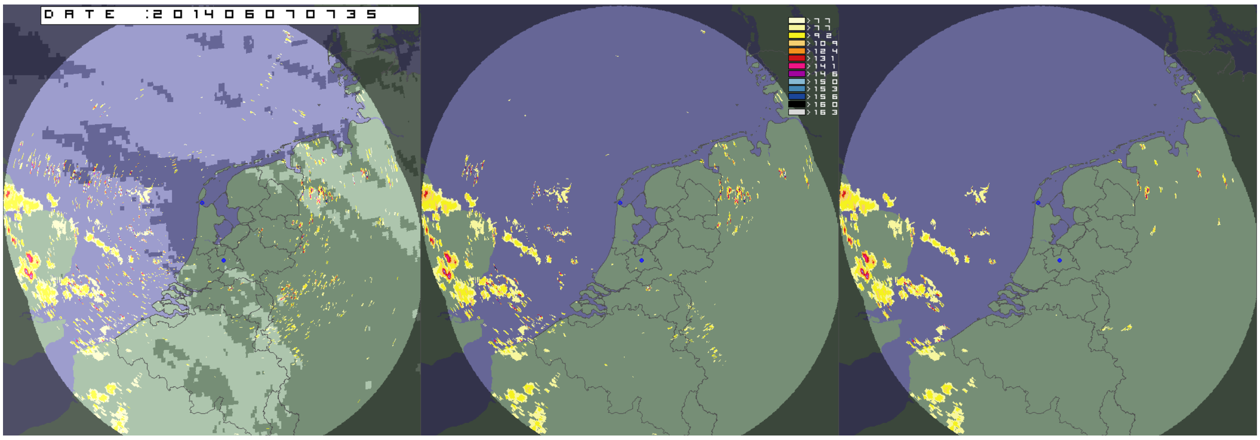

Figure 2. Example of a case with large scale clutter in the Netherlands on June 7th 2014 at 7:35 pm. The left panel shows the raw image received from KNMI with the cloudmask projected in grey. The center panel shows the old declutter algorithm and the right panel the new algorithm.

Spikes in radar data are a common problem and are visually easy to identify on a radar image. In original PPI data on a range-azimuth grid these spikes are fairly easy to identify automatically. When using CAPPI images the automatic detection becomes a larger problem. Our method looks at spike shaped objects from the location of a radar up to the maximum range of that radar. If a spike shaped object is detected it is evaluated whether the object is indeed a spike or can be precipitation.

To identify shapes and evaluate whether they are clutter reflectivity data above a certain threshold is used. This has been achieved by the development of a recursive algorithm that detects all objects in the radar image. Subsequently, the properties of the individual objects are thoroughly analyzed. An object is defined as pixels above the threshold value that connect horizontally, vertically or diagonally. For each object several characteristics, as cloudmask overlap fraction, object shape and histogram of reflectivity values, are stored for analysis. These characteristics are evaluated and compared with a history of recent true precpipitation statistics to decide whether the object might be clutter or precipitation.

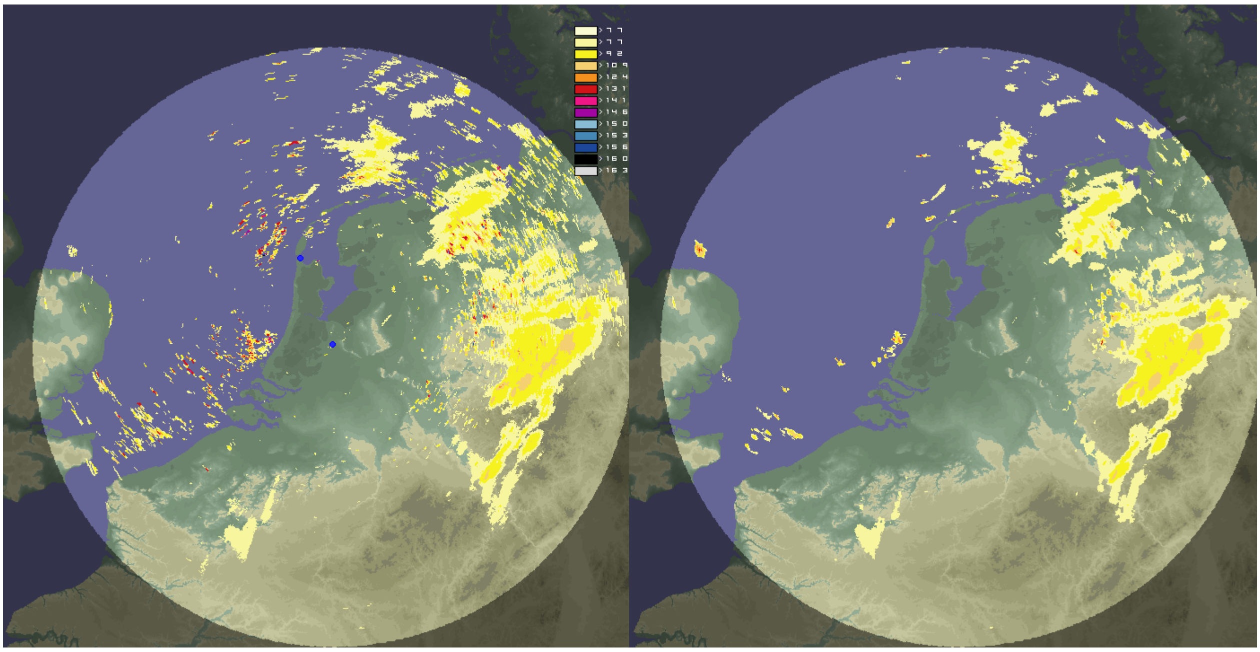

Figure 3. Example of a 24-hour accumulation case in the Netherlands on April 12th 2014. The left panel shows the accumulated image using the old declutter algorithm and the right panel the new algorithm

The cloudmask from Meteosat is used to find clear weather areas. If no clouds are detected by Meteosat reflectivity in this area is assumed to be clutter. Objects near clouds in the cloudmask are evaluated based on their shape and distance to the cloud.

Within MeteoGroup an algorithm called MTREC is used to calculate the expected radar. These movement vectors can also be used to look how the reflectivity from objects behaves through time. The movement vector is checked for cases where it is near stationary as well as stability of the object values through time. Both the near-zero velocity and the stability are compared with the surrounding area to evaluate the likelihood of clutter.

After the previous steps have been applied any pixel that has a weight beyond the set threshold is marked as clutter and removed from the image. An example of the results can be seen in Figure 2 for a single time step and in Figure 3 for the effect of a 24-hour accumulation.

3 Conclusion

This manuscript mentions six methods to identify clutter. They are given weights and if a combined weight exceeds a set threshold the pixel is marked as clutter. The results show greatly reduced clutter persistence in images, making additional bias correction easier and more accurate. Quantitative verification of the decluttered images is planned. Future challenges remain in reducing the effects of clutter within precipitation fields and making better use of model data.

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