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## **COMBINING RADAR SYSTEMS TO GET A 3D – PICTURE OF THE BIRD MIGRATION**

### **ABSTRACT:**

For military training flights bird strikes en route are still a severe problem. To reduce collisions an international project has been launched by the European Space agency (ESA), aiming 1) for a compilation of information on current bird movements by various sensors, 2) to combine them in a single model, and to finally 3) predict bird strike risks for different spatial and temporal scales. A potential sensor to achieve these aims is the already existing European network of weather radars, but measurement accuracy has to be validated first. We compared data from three different weather radar systems with results from a specialized bird radar operating simultaneously within the range of these systems. The analysis clearly showed that weather radars are well suited for monitoring bird migration over time, and also for providing reliable height distributions of targets. Additionally, we compared these findings with the results from the long-range surveillance radar (ROBIN-system), being operational in the Netherlands and Belgium. Our results suggest that almost real-time information on bird movements can be provided by implementing a bird filter to the existing continent-wide network of weather radar systems. Apart from highly improved bird strike warnings, this network would yield invaluable information for scientific research on bird migration and the influence of the weather regime, climate change, and the dispersal of avian diseases.

### **Introduction**

The Integrated Applications Programme (IAP) is a new initiative within the European Space Agency (ESA). This programme aims to stimulate international projects that result in sustainable services for different communities and demonstrates the added value of integrated space systems (Meteorology, Earth observation, Telecommunication, Navigation) and non-space assets in the System of Systems approach. These integrated capabilities can offer innovative solutions in thematic areas such as Health, Safety, Energy, Development aid and Knowledge.

Following preliminary analysis ESA has found that a Bird Migration System of Systems Initiative is suitable to demonstrate the added value of integrated space and ground capabilities. The long-term objective of the AvianAlert initiative is to develop sustainable services in a system of systems that integrates space and ground systems for various user communities requiring information on bird migration and bird mobility. The user communities currently identified for the initiative are flight safety, human health, animal migration ecology, conservation and education. Sustainable services may for example integrate various existing radar systems, observation and ringing networks collecting information on bird migration, tracking of individual birds, improvement and enhancement of existing technologies, modelling tools, improved access to environmental data, Internet services and much more.

Migration ecology research is one of the key pillars in this process. Understanding the migratory behavior of birds and how this is linked to dynamic processes in the environment is essential for improving flight safety during migration, monitoring and mitigating the spread of avian borne diseases, and conservation of migratory species and their habitats.

One of the most powerful sensors to monitor bird movements over large areas is the existing network of weather radars. In Europe the OPERA-network includes 146 weather radars (Holleman & Delobbe 2007; Fig. 1). This network provides a high potential for a standardized, automated monitoring of bird migration. It has already been shown that weather radar can detect bird movements (Holleman et al. 2008). The aim of this study was to validate and to optimize existing bird migration recognition algorithms for operational weather radars (density, speed, direction) by comparing these data with measurement from a small-scale high-precision bird radar. Coordinated simultaneous radar measurements during the migratory season had been carried out at selected sites. The high resolution data collected on a small scale (several kilometres) was used to determine the accuracy of the large scale systems and to optimize the retrieval algorithms

The results presented here are from measurements performed during the autumn migration period in the Netherlands (Doppler weather radar of KNMI in De Bilt) and in Belgium (Doppler weather radar of KMI in Wideumont; Fig. 2). The small scale system is an ex-military fire-control X-band radar ("Superfledermaus") adapted specifically to collect absolute bird densities (Fig.3;(Bruderer, 2007).

### Methods and observation sites

During autumn 2007 bird migration was monitored at two different sites, first in the Netherlands near the weather radar of De Bilt operated by KNMI, and second in Belgium one near the weather radar of Wideumont operated by KMI.

The simultaneous measurements were performed with both radar systems operating in principle 24h a day. Quantitative measurements were carried out automatically. In the Netherlands the mobile "bird" radar was installed within the airforce-base of Soesterberg (N 52° 8', E 5° 17'; 10m asl), at a distance of 7.5km to the weather radar. In Belgium the "bird" radar was installed on the military airfield of St. Hubert (N 50° 2', E 5° 26'; 580m asl), at a distance of 12km to the weather radar.

Data were collected in the Netherlands from 18.8 – 16.9.2007 and in Belgium from 18.9. - 22.10.2007. Quantitative measurements by the bird radar were collected every hour based on fixed beam measurements (for details see (Schmaljohann *et al.*, 2008). Bird densities were extracted from weather radar using an improved algorithm, based on Doppler-velocity (Holleman et al. 2008) and reflectivity.

### Results

For each hour a height profile with a resolution of 200m was calculated from both data sets (Fig. 4). The temporal and spatial pattern matched well between the two radar measurements. Because the surveyed volume by the weather radar is much larger than with the bird radar, distributions from weather radar are smoother, because of larger sample sizes. However, at high intensities results from weather radar and bird radar match very well (Fig. 5). In the bird radar sample size at low densities comprises often only 1 or 2 birds targets. With respect to bird-strike warning system we investigated false alarm rates. Obviously false alarm was frequent at low densities, but less than 2% at high migration intensities (Fig. 6).

### Discussion

Our results clearly show that weather radar measurements are very well suited to provide 3D information on migratory movements. Based on the comparison we could show that reliable quantitative results are available from weather radar systems. Detailed analysis has shown that there are still some minor problems with large insect movements and perhaps patchy rain events. However, there is good evidence that an automated algorithm will be able in near future to filter bird movements from the weather radar. This will not only provide the necessary input for a automated bird warning forecast (BIRDTAM), but will allow biologist to investigate bird migration across a large range and on a long time scale. For the meteorologists the filtered data will represent real weather events more accurately than before.

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## **References**

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Fig. 1: Weather radars in OPERA and EUMETNET member countries. The map is based on entries stored at the OPERA public data base in January 2007 (from Holleman & Delobbe, 2007).



Fig. 2: Weather radar at Wideumont, Belgium.

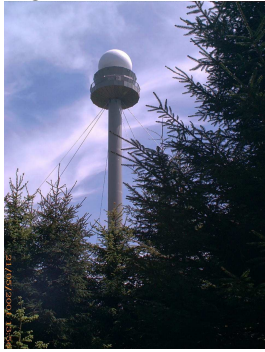


Fig 3: Tracking radar “Superfledermaus” used for validating quantitative measurements by weather radar.





Figure 5: Example of bird densities measured by the bird radar (top) and a weather radar (middle). Densities were calculated for each hour and for height intervals of 200m. Dark colours indicate high intensities. At the bottom mean values per hour (all heights summarized) are compared with results collected by the MPR-radar of the dutch air force.

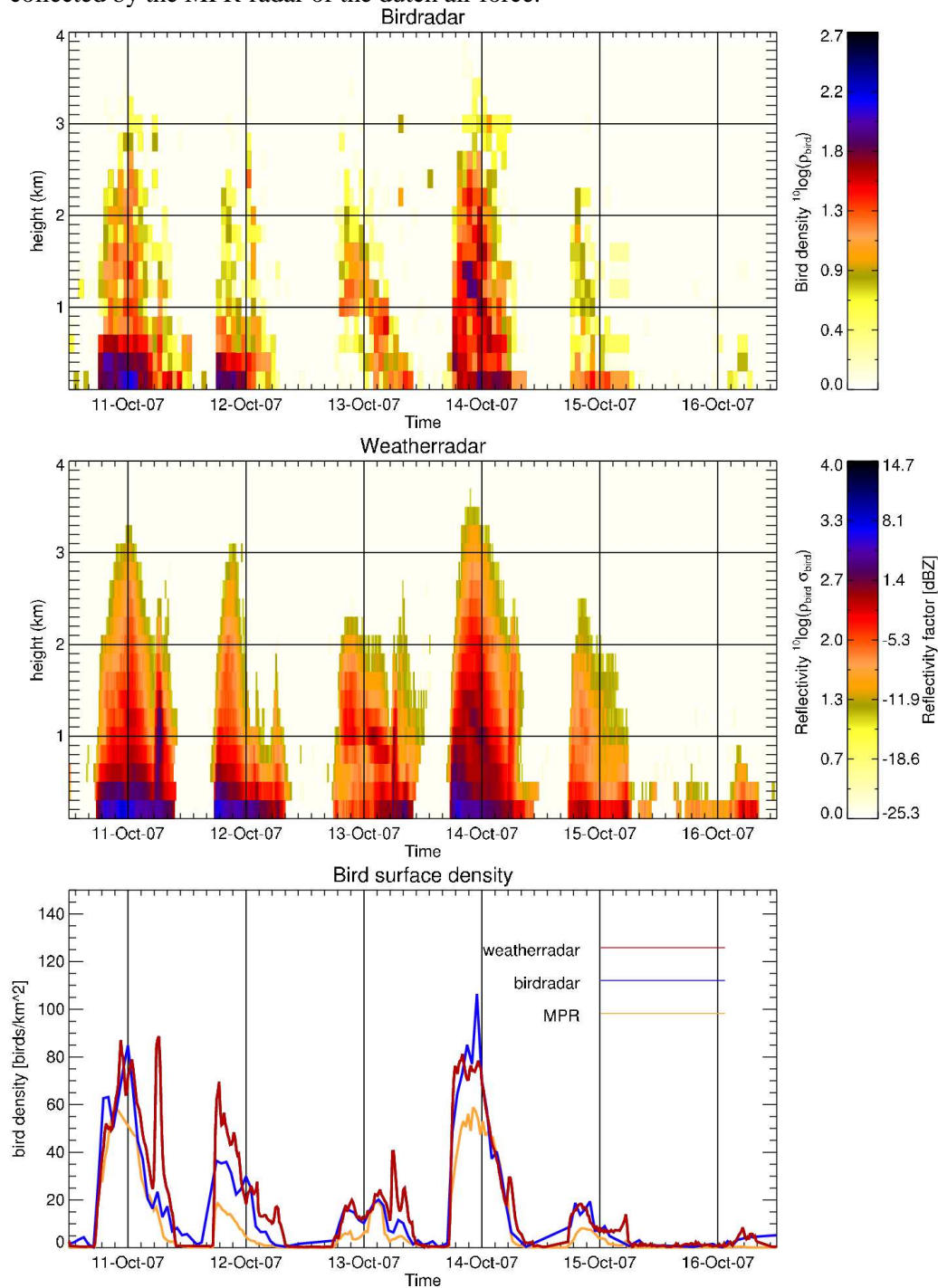


Fig. 5: Correlation between the bird densities measured by weather radar and bird radar. Good correspondence occurs at high intensities, in contrast to a large scatter at low density.

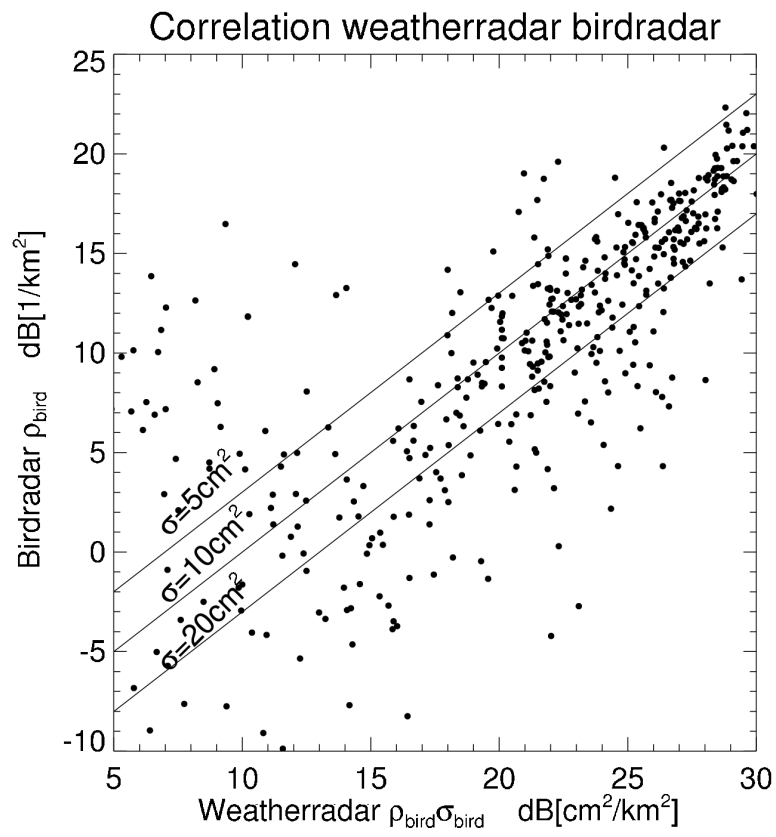


Fig. 6: Number of false alarms in relation to migration intensity. With increasing intensity false alarm rate decreases to about 0.02.

