COMPARISON OF ONSHORE AND OFFSHORE BIRD MIGRATION BY DIFFERENT RADAR SYSTEMS NEAR THE BELGIAN COAST

Maarten Reyniers(1), Robin Brabant(2), Maryna Lukach(3,4), Baptiste Schmid(5), Mathieu Boos(6)

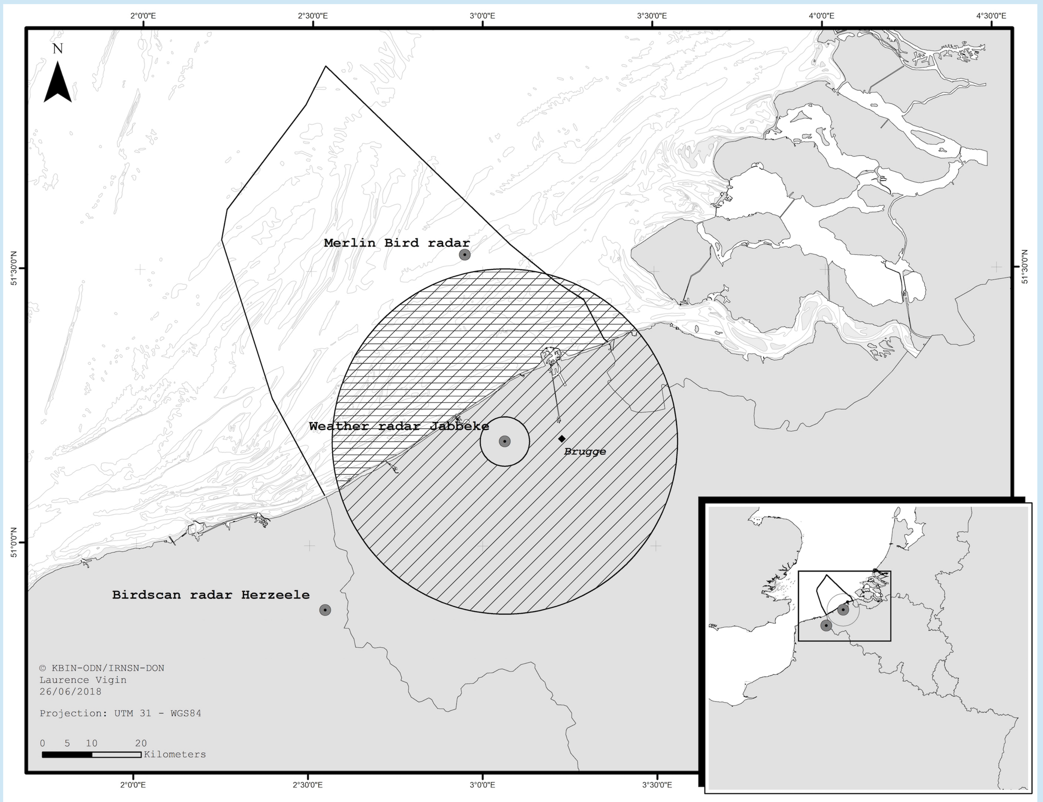
(1) Royal Meteorological Institute of Belgium (RMIB), Belgium (2) Royal Belgian Institute of Natural Sciences (RBINS), Belgium (3) School of Earth and Environment, University of Leeds, UK (4) National Centre for Atmospheric Science, University of Leeds, UK (5) Swiss Ornithological Institute, Switzerland (6) NaturaConst@, France

1. The project

The **Belgian part of the North Sea** is part of a very important **seabird migration route** within the North-East Atlantic flyway.

A unique configuration of **three different radar systems** was used to study this migration, and to cross-validate these systems for bird detection. It offers also the rare opportunity to investigate **migration over land vs migration at sea** of the same migratory events.

Study period: August-October 2016.



2. The radar systems

Merlin bird radar (BR)

- DeTect Merlin radar, operated by RBINS
- 2.92 to 3.08 GHz, power 200W
- Solid state S-band system with H and V scanning
- V-rotating radar creates a vertical 'radar screen'
- Detects individual birds or groups of birds
- 20 rpm
- range: one nautical mile (1852m)

Birdscan radar (BS)

- BirdScan-MR1, operated by Naturaconst@
- Vertically pointed radar system based on a commercial marine radar
- 25kW pulsed X-band radar (9.4 GHz)
- Combination of
  - short-pulse, PRF 1800 Hz, resolution 7.5m (below 800m)
  - long-pulse, PRF 785 Hz, resolution 110m (above 800m)

Weather radar (WR)

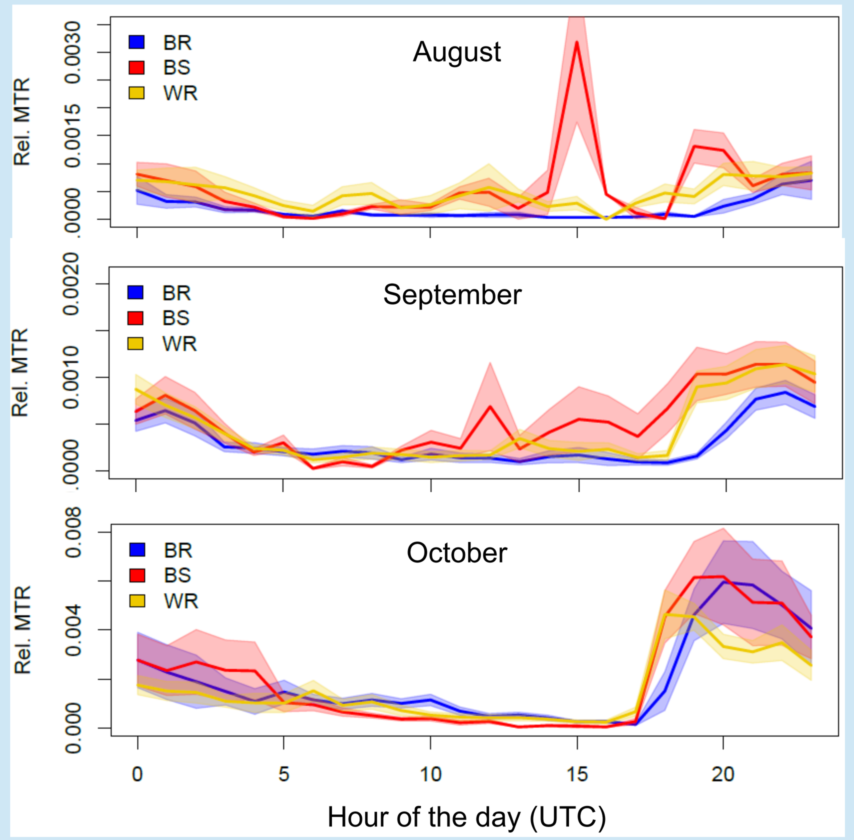
- Selex-SI radar, operated by RMIB
- Dual-pol, dual-PRF C-band radar
- 5-min duty cycle with 15 elevations between 0.3° and 25°
- Bird detection is performed on velocity subscan (8 elevations) with 150 km range
- Bird detection algorithm by Dokter et al. (2011) applied on subvolume between 5 and 35 km in range

3. Seasonal pattern

High correspondence in the **seasonal** and **diurnal** (relative) **patterns** registered by the small scale radars and the weather radar.

During the study period (autumn 2016) the bird patterns change considerably: in August and September, migration is often mixed with local movements and insects, while later in the season, the migration is "cleaner".

MTR: migration traffic rate (or bird flux) is defined as the number of targets crossing a 1 km line perpendicular to the migratory movement per hour.



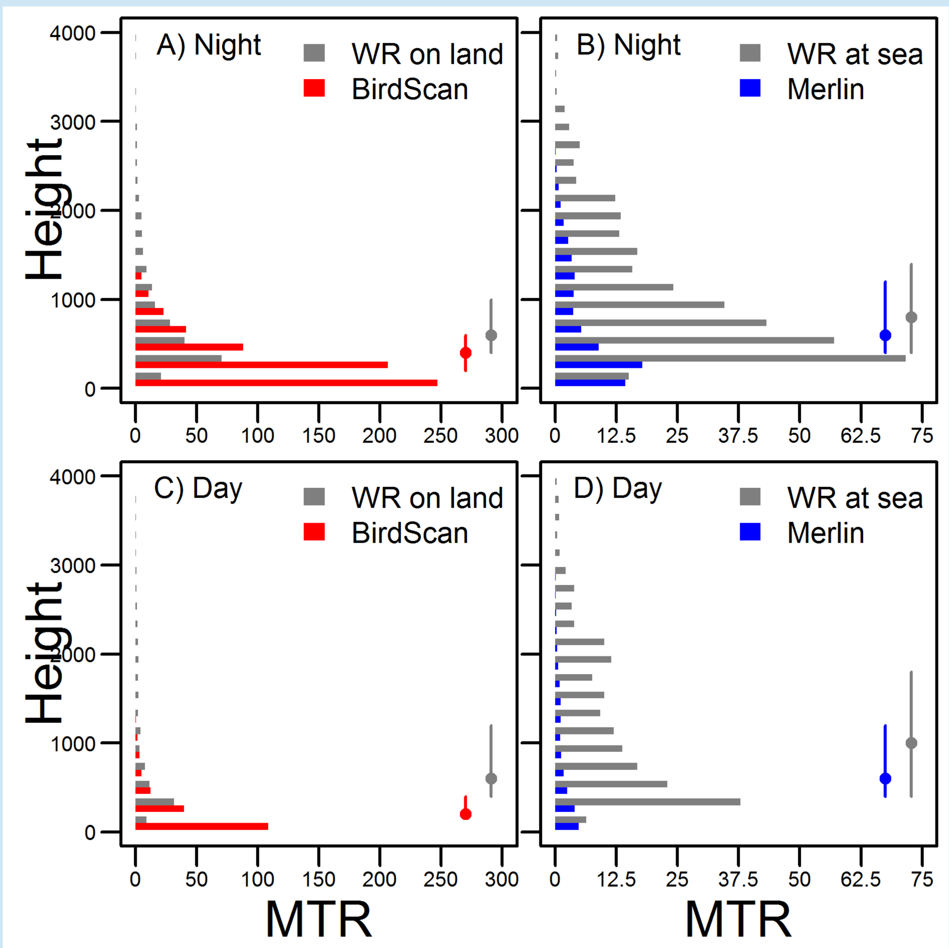
4. Onshore vs offshore

A novelty of this study is that the measurement volume of the weather radar was separated into two areas of interest: the area above land and the part at sea. This allows comparing the migration intensity along the coast and at sea.

A **preliminary** analysis of vertical bird density distributions shows that the **mean flying altitude** at **sea** is **higher** than on land.

Furthermore, **unexpectedly high MTRs** for the **weather radar** compared to the Merlin bird radar, especially at night. It is expected that the Merlin radar under-estimates the bird fluxes, since a group of birds is often seen as one bird by this radar.

However, such a **huge difference** between both radar systems is not expected and will be **further examined**.



(note the different MTR scales for left and right panels)

5. Intense migration events in dual-pol (WR)

Dual-pol studies of bird migration (e.g. Stepanian et al., 2016) often reveal a lot of additional information regarding **distinction birds/insects**, regarding **bird orientation** and even **species** (e.g. Koistinen et al., 2014).

The **qr-codes** below link to **four movies** of episodes with intense migration within the study period, providing additional insight in the migration events. The different panels in these animations show

dBZ PPI 0.9°	ZDR PPI 0.9°	V PPI 1.2°
ρ_{HV} PPI 0.9°	uPhiDP PPI 0.9°	

→ **dBZ**: (horizontal) reflectivity, elevation 0.9°
→ **ZDR**: differential reflectivity Z_H-Z_V, elevation 0.9°
→ **V**: radial velocity, elevation 1.2°
→ **ρ_{HV}**: co-polar correlation function, elevation 0.9°
→ **uPhiDP**: uncorrected differential phase, elevation 0.9°

2016-08-27

During daytime: strong signal of insects drifting from land to the seaside (and disappear there). Note the very high ZDR values (>7) and the uniform texture for both ZDR and uPhiDP. Apparently insects do not have the capability to introduce any significant differential phase shift. Some organization is seen in the insect pattern (a line in dBZ parallel to the coast between 09:30 and 11:15 UTC). During nighttime: insect signal gets mixed with birds. The radial velocity direction indicates that these birds are not migrators, but that they are merely chasing insects so these are probably swifts and/or bats.

2016-09-14

Probably there is a mixture of insects, birds chasing these insects but also migrating birds. It was a very warm night so probably mainly insects and (non-migrating) birds are seen here.

2016-10-03

Massive passerine migration. Both ZDR and uPhiDP give strong indication for a common orientation of the birds. Bird migration at sea was more intense compare to on land.

2016-10-29

Massive passerine migration, but now the ZDR and uPhiDP do not give such a clear indication of orientation. Is this due to a different species than in 2016-03-10? It seems that a large group of birds lifts off in Zeeland/South-Holland and then crosses the channel towards England in the beginning of the night.

Conclusion: the difference birds/insects is most clear in ZDR and uPhiDP.
ZDR: both insects and birds can induce very large ZDR values, but for the insect case, there is much less variability/texture in the ZDR field (it is constantly very high).
uPhiDP: insects seem to be unable to induce large differential phase shifts while birds induce differential phase shifts and sometimes the field gives an indication of their orientation (or species?).

References

Dokter A.M., F. Liechti, H. Stark, L. Delobbe, P. Tabary, and I. Holleman, 2011. Bird migration flight altitudes studied by a network of operational weather radars. J. R. Soc. Interface, 8, 30–43

Koistinen J., T. Mäkinen, and S. Pulkkinen, 2014. Classification of meteorological and non-meteorological targets with newstatistical methods applying polarimetric moments and their texture, ERAD2014, Garmisch-Partenkirchen, Germany

Stepanian P. M., K. G. Horton, V. M. Melnikov, D. S. Zrnić, and S. A. Gauthreaux Jr., 2016. Dual-polarization radar products for biological applications. Ecosphere 7(11): e01539. 10.1002/ecs2.1539

Contact information

Maarten Reyniers
Radar and Lightning Detection group
Royal Meteorological Institute of Belgium
Ringlaan 3
1180 Brussels, Belgium

Research group website: http://radar.meteo.be
Email: maarten.reyniers@meteo.be

This project was funded by the Belgian Science Policy Office (project RAVen)