STSM Report

Comparison of the regional, seasonal and annual variation of the bird passage using data from five weather radars in Netherlands and Belgium

Martina Scacco

Ornis italica (Rome, Italy), martina.scacco@gmail.com

1. INTRODUCTION

This is the report due at the completion of the Short Term Scientific Mission (STSM) which I carried out within the COST Action ES1305 (*European Network for the Radar surveillance of Animal Movement*, ENRAM), under Working Group 2: Improvement of weather radar data quality and validation of biological classification algorithms.

Host institution:

Computational Ecology Group, Institute of Biodiversity and ecosystem Dynamics, University of Amsterdam.
Supervised by Dr. Adriaan M. Dokter and Dr. Judy Shamoun-Baranes.

Date:

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Purpose:

This STSM aims at quantifying the number of birds travelling across different regions, and comparing the bird counts within and between seasons in different years (from 2012 to 2015), using data from five weather radars included in the FlySafe-BAM (FlySafe Bird Avoidance Model): two located in Netherlands (Den Helder, De Bilt) and three in Belgium (Wideumont, Jabbeke and Zaventem).

2. MATERIALS AND METHODS

The five weather radars used for this data comparison are included in the FlySafe-BAM (FlySafe Bird Avoidance Model) and are part of the OPERA network [1].
They have been collecting data simultaneously during the last four years; in particular for this analysis data from April 2012 until December 2015 were available for the two radars in The Netherlands (De Bilt and Den Helder) and for one out of three radars in Belgium (Wideumont), whereas data from April 2013 to December 2015 were available for the other two radars in Belgium (Jabbeke and Zaventem).

The aim of this STSM is to use the available data for a regional comparison of the bird density, confronting data from the five weather radars mentioned above.
An easy way to visualize this data comparison is represented by plotting a cumulative bird density curve for each radar in different months and years, in order to additionally find out possible seasonal and yearly variations in the bird density values (see *Section 3*, *Fig.3.2.1*).

To reach this goal, as a first step, the application of a post-processing rain filter was needed.

The analyses were performed using *R 3.2.1* [2] and *OriginPro 8.5*.

3. RESULTS AND DISCUSSION

3.1 Selection of the rain filter parameters

As mentioned above, the first step of the analysis included the application of a post-processing rain filter.
The basic idea of this filter involves:

- The identification of the rain according to the combination of three parameters (altitude, reflectivity and standard deviation of the radial velocity) [3];
- Exclusion of all data collected at the time in which the identified rain occurred.

In order to define the threshold values of the parameters mentioned in the first point, I started with plotting a weekly bird density height profile and a height-integrated bird density [4] for each radar, to visualize the bird density distribution of all weather radars with no weather filters applied (*Fig.3.1.1*).
Both plots in *Figure 3.1.1* show clear marks of rain contamination, in form of black stripes (above) and steep peaks (below).
I tried different threshold values of standard deviation and reflectivity at different altitudes in order to exclude more accurately as possible times in which the rain occurs.
The intermediate and the final result of this rain filter are shown respectively in *Figure 3.1.2.a* and *Figure 3.1.2.b* and were obtained with the following threshold values:

- In the <u>first rain filter</u> (*Fig.3.1.2.a*) rain was identified as such when:
  - radial velocity standard deviation < 2;
  - reflectivity > 5.158 (if altitude > 2 Km).

- In the <u>second rain filter</u> (*Fig.3.1.2.b*) rain was identified as such when:
  - radial velocity standard deviation < 1.7;
  - reflectivity > 5.158 (if altitude > 1 Km) and reflectivity > 2.939 (if altitude > 2 Km).

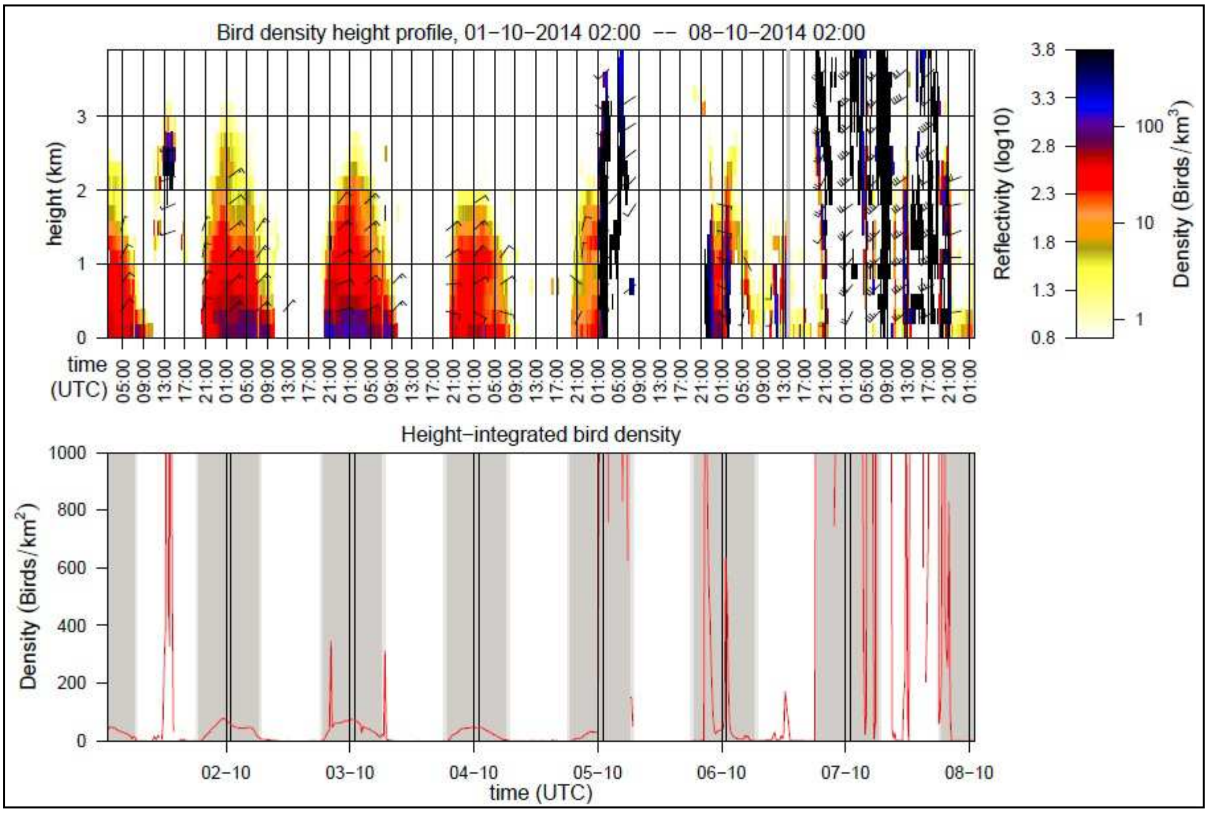

Fig. 3.1.1: Example of a plot with the weekly bird density height profile (above) and the height-integrated bird density (below) using data from the radar Wideumont (Belgium) in the week October 1-8, 2014. No weather filter applied.

Comparing the two plots in *Figure 3.1.2*, resulting from the two different filters explained above, it emerges that the second filter is more efficient in excluding the rain clutter.

The selection of 1.7 (instead of 2) as threshold value for the standard deviation also appears a good choice, since it reduces (but unfortunately not avoids) the loss of information at high bird density values (e.g. compare the data at 1 Km of altitude around 5:00 in the morning on the first day of the week in *Figure 3.1.2.a* and *Figure 3.1.2.b*: in the second plot the white hole on the left hand is completely filled but not the one on the right hand, at the same time but on the 6th day of the week).

This filter seems to work quite well for those radars in which the rain contamination is well delimited in time and the precipitation occurred at high intensity (showing high reflectivity values) (e.g. in the weather radars Wideumont and Jabbeke).
Unfortunately these conditions are not often observed and the applied filter didn't work as expected on data from three radars out of five (De Bilt, Den Helder and Zaventem) (*Fig.3.1.3* and *Fig.3.2.1*).
A possible improvement includes the reduction of the information loss at higher bird density values, probably selecting a lower threshold value for the standard deviation of the radial velocity (even lower than 1.7).

Additionally, before using the filtered data for the following analysis, a ground clutter filter was also applied, excluding all data below 500 m of altitude a.s.l. (above sea level) (*Fig.3.1.3*).

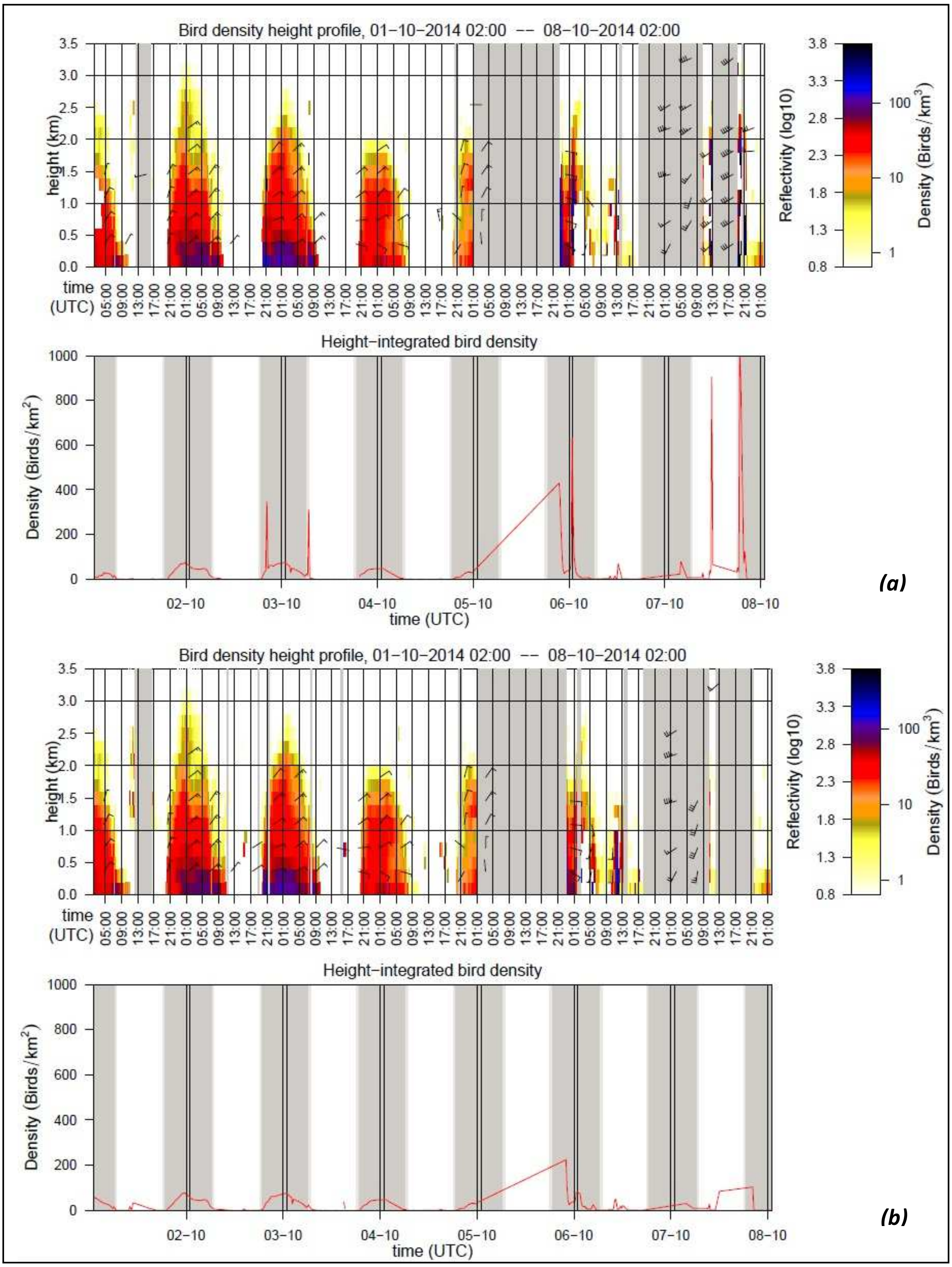

Fig. 3.1.2: Comparison of the effects produced by the two rain filters using data from the radar Wideumont (Belgium) in the week October 1-8, 2014. *(a)* First rain filter. *(b)* Second rain filter.

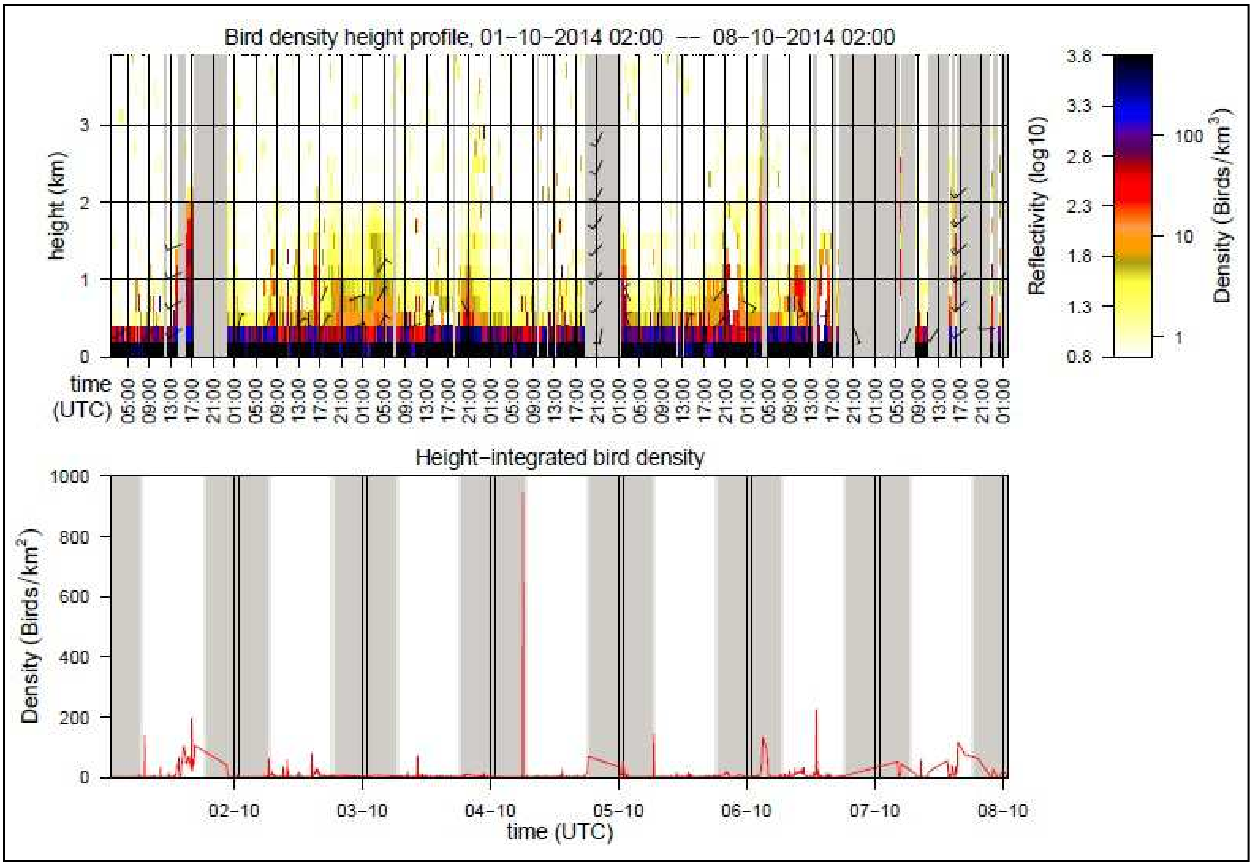

Fig. 3.1.3: Second rain filter applied on data from the radar Den Helder (The Netherlands) in the same week October 1-8, 2014. In this case the application of the rain filter was not completely successful probably due to the more scattered occurrence of rain precipitations and the lower values of bird density.
A strong ground clutter is also evident between 0 and 500 m of altitude.

3.2 Regional, seasonal and annual variation of the bird density

After having applied the second rain filter (the one considered more efficient in filtering out the rain clutter, see *Section 3.1*) I plotted a cumulative curve of bird density for each weather radar, to visualize the regional, seasonal (*Fig.3.2.1* and *Fig.3.2.2*) and annual variation of this parameter (*Fig.3.2.2*).

In *Figure 3.2.1* a monthly cumulative curve is plotted for each of the five radars (sum of the number of birds recorded in one month per Km2 from each radar), outlining the seasonal and regional difference of bird density. In particular, we can notice a clear difference in the density values shown by the five radars, with De Bilt recording the highest values (up to 650000 birds recorded in one month) while the other four radars showing lower values (all between 0 and 250000 birds recorded).

Looking at the same figure we can also identify a seasonal pattern which is more evident for the radars Jabbeke and Wideumont and masked in the other three radars.

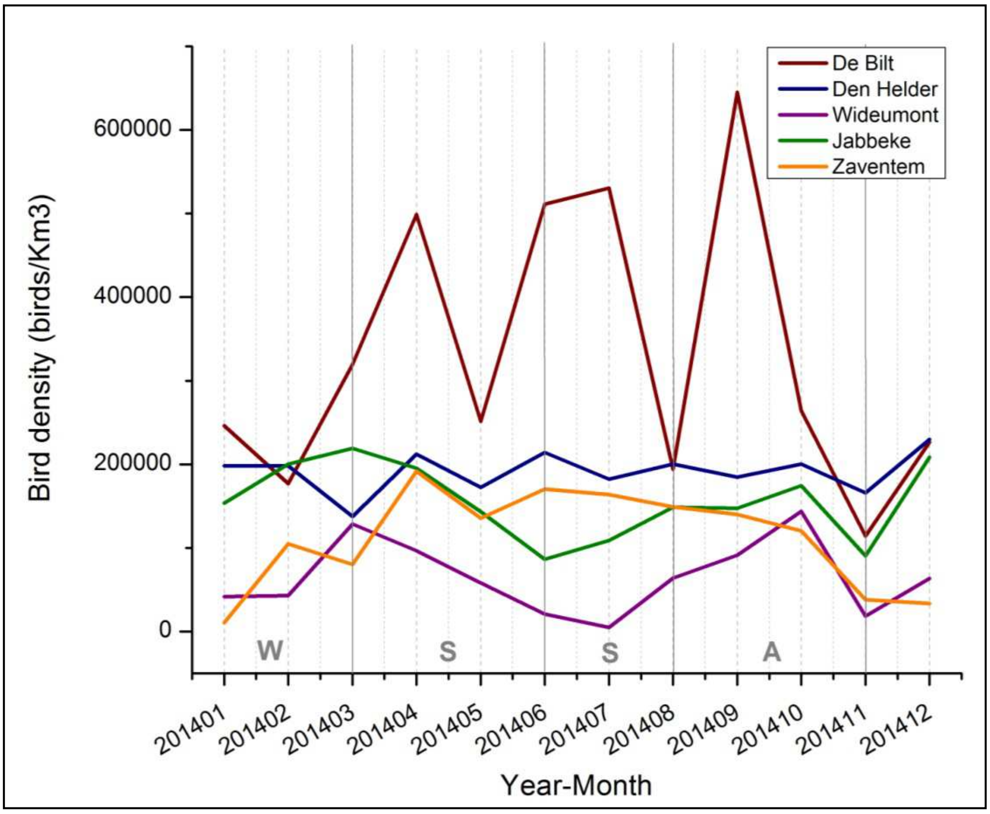

Fig. 3.2.1: Comparison of the cumulative curve of bird density among the five radars using data from 2014 with the second rain filter applied.

In *Figure 3.2.2* I plotted the same cumulative curve showed in *Figure 3.2.1* using data from 2013 to 2015 and grouping the radars in the plot *a* and *b* according to the similarities of their seasonal patterns.

The first plot (*Fig.3.2.2.a*), showing data from the radars Jabbeke and Wideumont, well illustrates a similar seasonal pattern of the bird density over these two regions (both radars are in Belgium with Jabbeke located closer to the coast) with a higher number of birds recorded by Jabbeke.

The peak passage of birds is clearly in March and August in both the years 2013 and 2014; in 2015 two additional peaks appeared in December/January (respectively for Jabbeke and Wideumont) and July (for both of them) while the previous ones are displaced (from March to February in Jabbeke and from March to April in Wideumont) or maintained (October) (*Fig.3.2.2.a*).
Looking at the corresponding weekly bird density height profiles, this variations seem to reflect a real change in the bird passage (instead of a bias due to a variation in the rain clutter).

The plot in *Figure 3.2.2.b* shows the seasonal pattern of bird density as recorded by the radars Zaventem (Belgium), De Bilt and Den Helder (both located in The Netherlands) from 2013 to 2015.
The recorded pattern shows some similarities among these three radars, but generally it seems to be less clear, with additional or displaced peaks of bird passage and a high variation during the three subsequent years of recording (*Fig.3.2.2.b*). Since the rain filter didn't work properly on the data from these three radars (as supported also by the corresponding bird density height profiles), this more complex visualization is probably due to a higher rain contamination in the dataset (see *Section 3.1*).

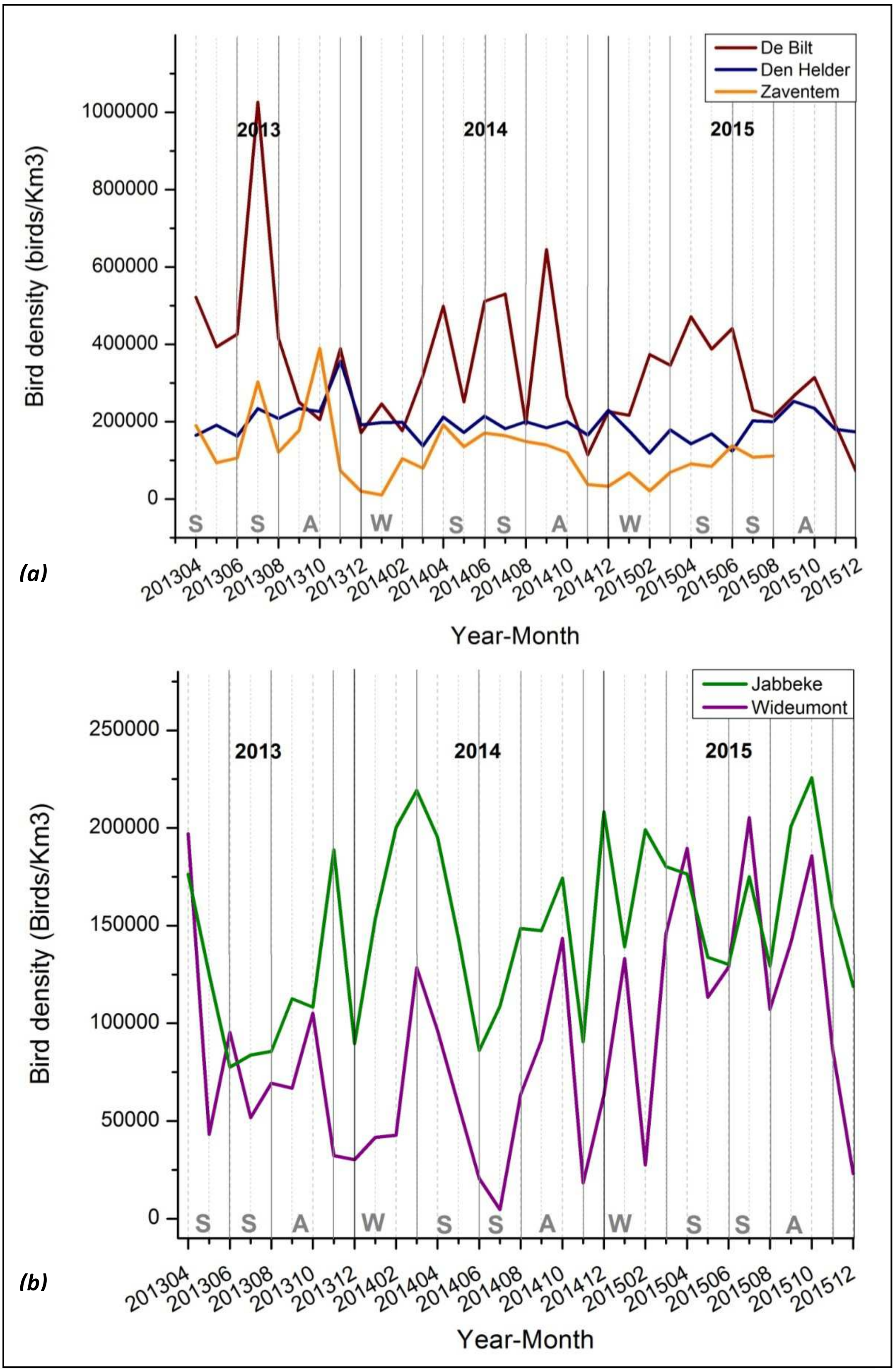

Fig.3.2.2: Comparison of the cumulative curve of bird density using data from 2013 to 2015.
(a) Comparison among the radars Zaventem (Belgium), De Bilt and Den Helder (The Netherland).
(b) Comparison between the radars Jabbeke and Wideumont (both of them located in Belgium).

4. CONCLUSIONS

The post-processing rain filter applied to the dataset worked properly on two out of five radars, giving reliable results about the regional, seasonal and annual variation of bird density.
In fact this filter seems to work quite well for those radars in which the rain contamination is well delimited in time and the precipitation occurred at high intensity (showing high reflectivity values).
Possible improvements include additional tests to reduce the information loss at higher bird density values (probably selecting a lower threshold value for the standard deviation of the radial velocity) and to better exclude the rain clutter, selecting more accurately the times in which the rain occur (e.g. changing the filter parameters according to multiple altitude sections).

The analyses performed during this STSM represent an important step to understand how the available radar systems work and how to get reliable results from a comparison of data collected from these different devices, outlining the possible problems arose during the data collection and trying to avoid them in the future.

5. AKNOWLEDGMENTS

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6. REFERENCES

[1] Holleman I., Delobbe, L. and Zgonc, A. (2008). *Update on the European weather radar network (OPERA).* Proc. Fifth European Conf. on Radar in Meteorology and Hydrology, June-July 2008, Helsinki, Finland, 5pp

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