Extended Abstract ERAD 2014

Bird migration across the Bay of Biscay observed by meteorological radar

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Introduction

In the past 60 years radar technology has been increasingly applied in ornithological research in various geographical areas worldwide (e.g. Sutter 1957a, Drury et al. 1962, Casement 1966, Richardson 1980, Hilgerloh 1989, Gudmundsson 1993, Bruderer 1999, Gauthreaux et al. 1999, Biebach et al. 2000, Matsyura 2011). It contributed greatly to increase our understanding of avian migration. Radar technology is in many ways superior to other methods used in bird migration studies such as visual counts or bird banding due to less expenditure of time and effort, better applicability for large-scale monitoring (Sutter 1957b, Lowery et al. 1966, Eastwood 1967, Burger 1997, Desholm et al. 2006, Larkin et al. 2012, Beason et al. 2013), e.g. in areas with difficult access or adverse conditions i.e. geographical barriers. Geographical barriers such as mountain ranges, deserts or large water bodies have a strong impact on migratory flyways of birds. It is well known that many migratory bird species have developed strategies to avoid or reduce the crossing of barriers. Due to the vast dimensions of both bird movements and barriers and often adverse conditions prevailing in such areas, radar technology has proved to be a useful research tool.

The Bay of Biscay stretching from the northern coast of Spain to the eastern coast of France is considered a potential geographical barrier. It is situated in the occidental end point of one of the migratory pathways of birds in Europe which runs along the Atlantic facade from southern Scandinavia to the southeastern Iberian Peninsula. For reasons of population dynamics and conservation of both birds and coastal ecosystems it is important to understand and investigate the significance of the Bay of Biscay during bird migration.

Along the Bay of Biscay a network of radars has been established for meteorological purposes monitoring the respective area continuously. It has been known from other sites that these radars do not only register meteorological phenomena, but also biological targets. Since the installation of the wind profiler at Punta Galea (Bilbao, Spain) in 1996 certain patterns indicating presence of biological targets were identified. These patterns occurring during avian migration season coincide with findings previously described by other authors.

The aim of this paper is to present a first approach to assess the suitability of wind profiler data as a bird observation tool and to point out to possible advantages and drawbacks using

this data to investigate avian migration. It is the first time wind profiler data is used for biological purposes.

Material & methods

Data was obtained from Euskalmet, the Basque Service of Meteorology, and analysed in collaboration with the Society of Sciences Aranzadi. It consisted in historical data from the Euskalmet wind profiler at Punta Galea in the Basque Country (Spain). It is an L-band boundary layer wind profiler with radio acoustic sounding system (RASS) option. The operating frequency is 1290 MHz and it has a low mode (high resolution), which reaches about 2 km, and a higher mode (lower resolution) reaching about 8 km in optimal conditions. The system is described in Alonso et al. (1998). Wind and temperature measurements are performed every 30 minutes by means of five beams, one vertical and four directed to the four cardinal points.

Consensus, moments and spectral data of three consecutive years (2010-2012) were assessed as to presence / absence of a particular pattern of biological origin. The pattern consisted in biological signals occurring at night from about 30-60 minutes after sunset until about 1 hour prior to sunrise. “One day” started at sunset of the respective day and lasted until sunrise of the following day. Primarily graphics of moment data, i.e. spectral width, radial velocity and SNR ratio, and wind barbs from consensus data were evaluated. If the moment data did not show clearly enough, if the signals could be of biological origin, e.g. if signals were too weak or partially masked by precipitation, the spectral data for the vertical beam was consulted in the mode “contour” and “stacked”. Unclear cases and nights masked by precipitation were counted as absence. Finally independent of the strength of the signals, the mean number of days with biological presence per month was calculated.

Results

The moment and spectral data showed increased nocturnal activity from February to October (Fig. 1). In all three years the signals began in the last ten days of February, while in autumn signals occurred until the end of October. The analysis showed two annual peaks of activity, the first one in April/May and the second in August/September. No signals were detected from November to January. Overall the signals were observed between 500-4000m above ground level.

Generally the patterns observed in spring differed from those in summer and autumn. In spring, from about February to April, the moment data exhibited extensive patterns occurring practically throughout the night from shortly after sunset to shortly before sunrise. The patterns were particularly conspicuous in spectral width data where high activity corresponded to filled areas in the graph while lower activity resulted in more patchy or “porous” patterns (Fig. 2). Overall the strongest signals occurred from end of February to beginning of April. In cases of high activity, the spectral data (Fig. 3) showed big patches similar to ink blots which suddenly appear and increase in size shortly after sunset. For lower activity, the “ink blots” became smaller. They clearly differed from the clear-air or precipitation patterns which showed typically a cone-like shape. In summer and autumn, the moment patterns consisted mainly in a “hook” shortly after or at sunset, or as a very weak pattern similar to spring, from sunset to sunrise and the spectral data showed less extensive “ink

blots". Further details on differences between precipitation and migration patterns see Table 1.

Wind profiles did not depict these nocturnal signals with such clarity and regularity (Fig. 4). They were only visible in nights with very high activity in spring. In such cases, aberrant wind directions and velocities were observed, i.e. barbs with a considerably higher SNR (10-30 dB higher) in the same or different direction compared to surrounding areas where no biological targets were registered.

Discussion

The seasonal and temporal distribution and peaks of the days with targeted nocturnal signals coincide largely with seasonal avian migration patterns, i.e. generally the periods March to May and August to October are known as main migration seasons in the area. This supports the hypothesis that these signals are of biological origin, more precisely of ornithological origin. Overall in spring the number of days with migration is somewhat higher than in autumn and signals in spring are stronger than in autumn. This is actually contradictory to current knowledge on bird migration where observations have shown that autumn migration is more concentrated and numerous than spring migration. This would actually imply stronger signals in autumn. A possible explanation for this aberrant pattern might be diverging migratory routes in spring and autumn as observed for certain species in other studies, e.g. by Fransson et al. (2005), Tøttrup et al. (2012). However, this is still to be investigated for the respective region.

An interesting aspect was that wind profiles did not illustrate the biological signals as clearly and regularly as the moment and spectral data. A possible explanation could lie in the signal processing applied to the data which possibly filtered the signals caused by migratory birds. In case of high bird densities, some signals would still remain despite the filtering. However, in case of lower densities, signal processing might erase all ornithological signals.

A main challenge for data analysis was the high precipitation rate along the Basque coast. Along the Basque coast, precipitation plays a considerable role. Precipitation rates are among the highest of Europe. Depending on the meteorological conditions, strong and/or extended precipitation events might occur which mask biological signals completely and impede the use of wind profiler data for ornithological purposes in certain periods. It is especially critical as these precipitation events might coincide with the main migration seasons. For example April and also October exhibit one of the highest precipitation rates of the region (Euskalmet). In April there was great variation in number of precipitation days between the years 2010-2012. Generally birds tend to avoid heavy precipitation e.g. by adapting their route or waiting for more favourable conditions. In any case, based on own observations, lighter precipitation does not stop migratory movements completely, but radar data can already be obscured to a considerable degree so that it is not possible to clearly discern presence and absence of biological signals. More research is required to determine to what extent data collection for biological purposes is actually affected by precipitation.

Low bird densities represent another challenge in the analysis of wind profiler data from late spring until autumn. If densities are low, only weak signals are registered and it is not always possible to assign them to biological targets. In combination with light precipitation or other meteorological interferences, low densities might already be masked and not discernible anymore.

Another issue is the lack of detailed information on biological targets. Despite the long wavelength of L-band radars, biological signals are detected, however, as in other radar types, it is not possible to identify the actual targets simply by radar data. It is known from previous radar studies, that there are many bird species migrating at night and forming a massive movement of individuals (e.g. Sutter 1957b, Parslow 1962, Steidinger 1968, Bruderer 2001). Such movements involving such a high number of individuals are not known from bats or insects in Europe. Therefore it was concluded that these nocturnal patterns in wind profilers are due to birds (Wilczak 1995). However, it remains unclear if and in what proportion bats or insects are involved, if at all. To clarify and verify the actual kind of biological targets it would be necessary to apply a second verification system such as a thermal-imaging camera, moon-watching or also a more sensitive X-band radar (Schmaljohann et al. 2008).

Further research needs to be done to investigate which densities are still visible in the radar data. In addition, as data also indicated a rough altitudinal range where migration takes place it would be valuable to extract more exact information as to migration altitude and possible correlations with meteorology and season.

Conclusion

The analysis of wind profiler data showed that it is possible to extract seasonal, temporal and to certain extent altitudinal data on biological targets. Considerable variability was observed, however, the annual patterns were repeated in all three years. In any case it is clear, that wind profiler data alone is not enough to study biological phenomena. To obtain more detailed information further research needs to be done, for example by calibrating the wind profiler by a second verification system such as a thermal-imaging camera or moon-watching to be able to better interpret and correlate bird densities with wind profiler data.

Literature

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Tab. 1: Comparison of meteorological vs. nocturnal biological patterns observed in wind profiler data from sunset to sunrise.

	Biological patterns	Meteorological patterns	Disadvantages	Advantages
Moment	• Start around sunset • Stop around sunrise • Seasonal variation • High SNR ratio • High variability in spectral width and radial velocity	• No specific temporal/seasonal pattern • Low SNR ratio • Low variability of spectral width	Rain obscures biological signals	Weaker migration also depicted
Consensus	• Wind profiles: locally deviating values (wind errors)	• Wind profiles: uniform	Rain obscures biological signals; weaker migration not depicted	
Spectral	• Mode “contour”: centred “ink blots” • Mode “stacked”: various pointed peaks; positive and negative velocities	• Mode “contour”: 1-2 conical shapes • Mode “stacked”: few, rather rounded peaks; positive velocities	Rain obscures biological signals	Weaker migration also depicted; more detailed information than in consensus data

Figures

Fig. 1: Frequency of days with bird migration per month in the years 2010-2012.

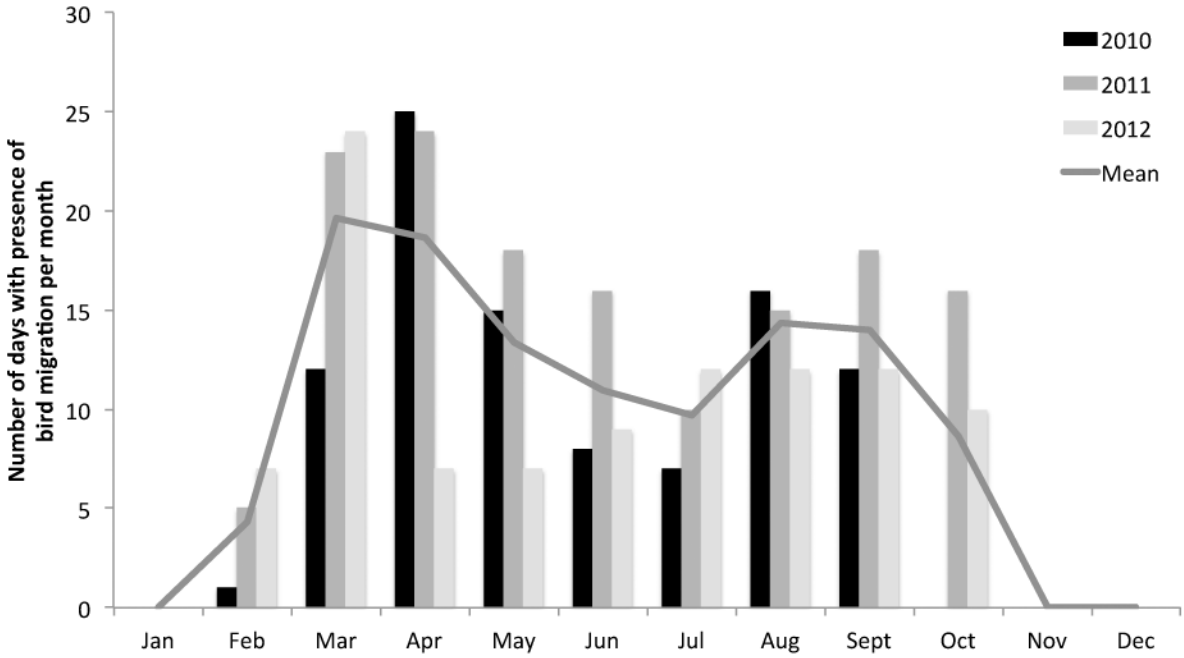
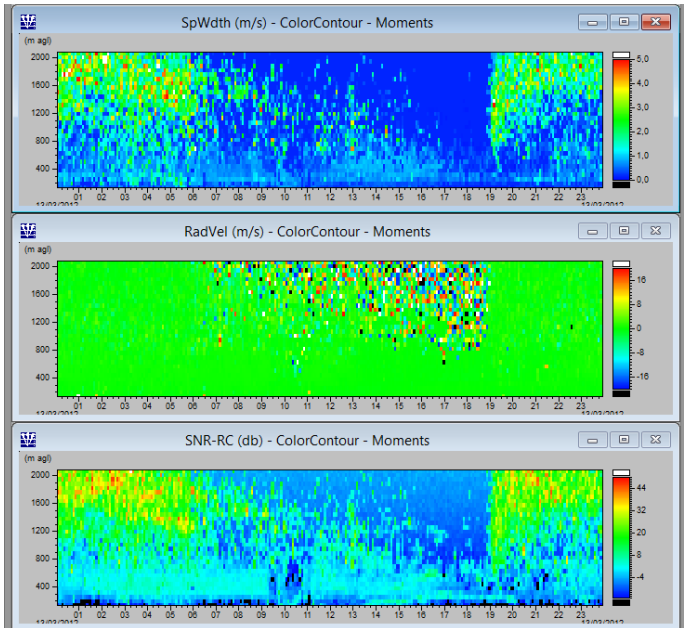


Fig. 2: Examples of strong (A: 13 March 2012) vs. light (B: 29 March 2012) migration events observed in moment data.

A:



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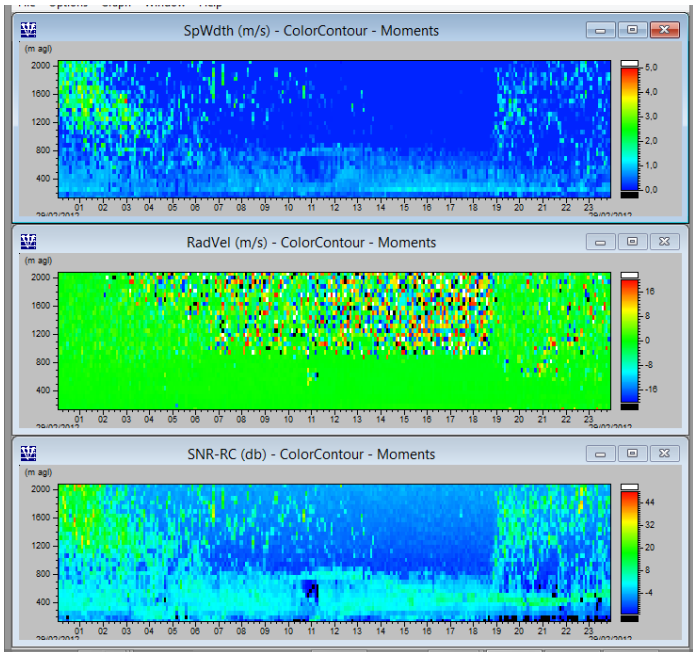
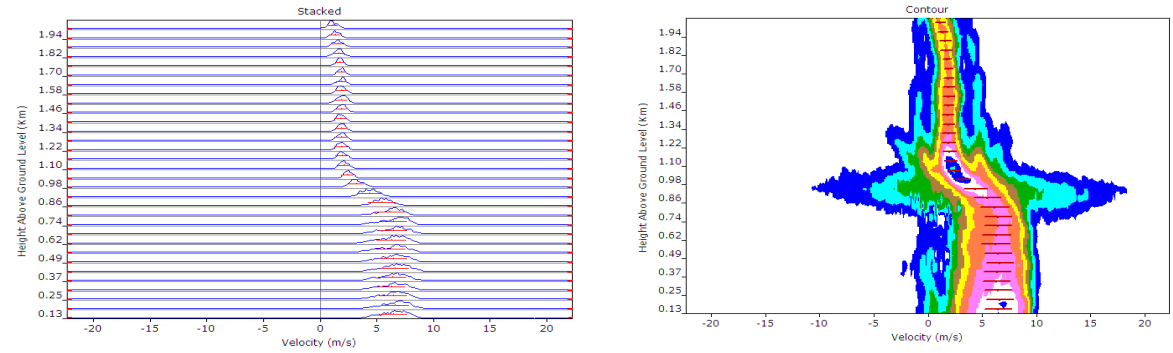


Fig. 3: Examples of spectral data for precipitation (a) and migration (b) as depicted in stacked and contour mode.

a)



b)

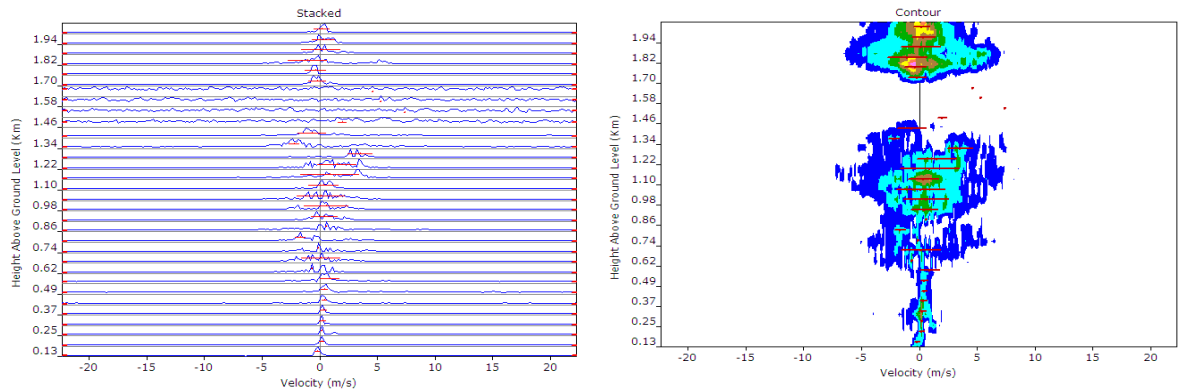
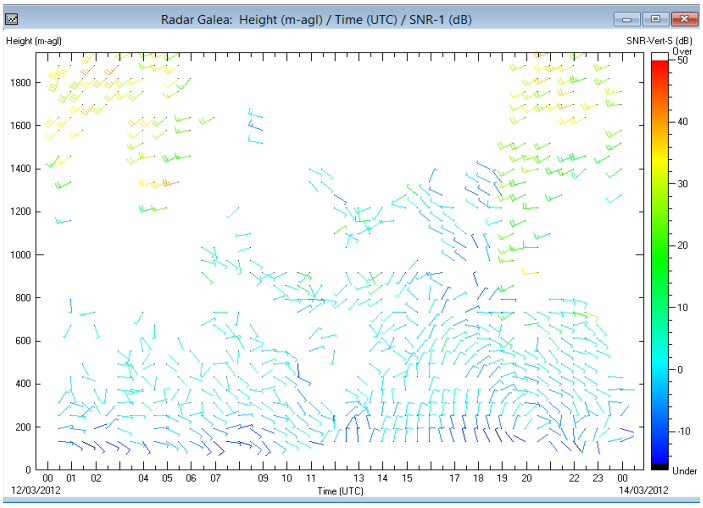
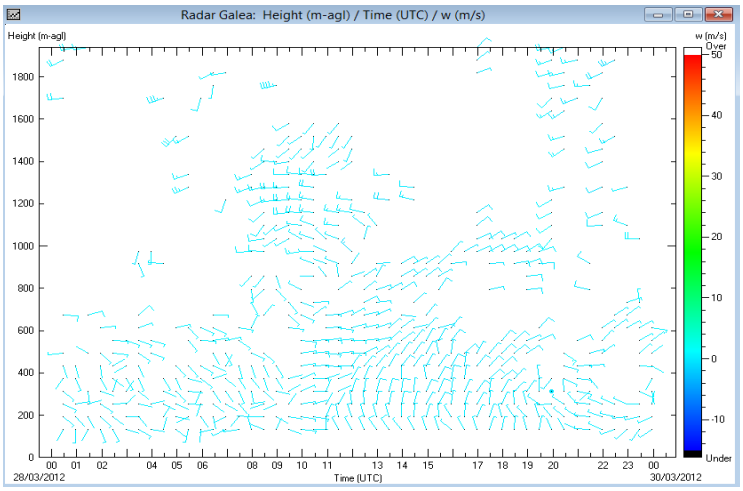


Fig. 4: Examples of consensus data for wind measurements in a strong (A: 13 March 2012) and light (B: 29 March 2012) migration event.

A:



B: