Meteorological forecasting of arctic bird migration to warn air traffic in Finland

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Abstract

Radar observation on the arctic spring migration over Southern Finland was carried out scientifically for the first time during the years 1960-1962. Two decades later the method was used together with visual observation for real time warning air traffic during the top period of this migration. Since then the visual observation has become very popular in many coastal areas in Estonia and in Finland both in spring and in autumn. On account of these observations it is now known that about 20 species totalling several million birds participate the arctic migration that continues from the beginning of May until the middle of June. More birds will then return and can pass Southern Finland chiefly between 25th of September and 20th of October.

The forecast length of air traffic warnings has been extended from hours to two days by applying meteorological weather forecasts as input to migration prediction. Finnish Meteorological Institute has provided daily predictions of migration intensity for aviation since the year 2001. The forecast length is 18-54 hours and the intensity is calculated for several groups of birds, one of which is arctic migration. The seasonal timing and population of migrants is obtained from ornithological statistics. Migration intensity is modulated according to the forecasted weather in the departure areas of the migrants. The model includes accumulation of resting birds during periods of adverse weather. The modulating weather parameters of arctic migration are wind speed and direction, occurrence of thick fog and low cloud as well as intense precipitating areas.

Introduction

The mass migration of arctic birds (Fig. 1) was well known in Finland but only by means of visual observation until the start of radar observation in early 1960’s (Bergman & Donner 1964). In three different radar station the passing flocks of the common scoter (*Melanitta nigra*) and the long-tailed duck (*Clangula hyemalis*) were recorded on 16 mm negative film in southern Finland during the second-third weeks of May. In clear weather the flocks were flying to ENE in visual altitude along the Gulf of Finland. In the night or in bad visibility they headed more to NE and at the same time over the mainland. Now their flyway was of importance for air traffic because echoes of the flocks were measured even from the altitude of four kilometres.

Also the migration of these species to N-NE was observed with the same method in the Gulf of Bothnia in the springs of 1969-1970 (Bergman 1974).

On the Soviet Union side of the Baltic, in Estonia, the spring migration of these species was also observed with radar (Jacoby 1983). Furthermore, a study of the late summer migration of the common scoter by radar observation was taken into program in Estonia and in Lithuania (Jacoby & Zhalakyavichyus 1980). It was considered that using of a network of visual and radar observation it could be possible to forecast the mass migration and warn airports if meteorological variables were taken into account (Jacoby 1976).

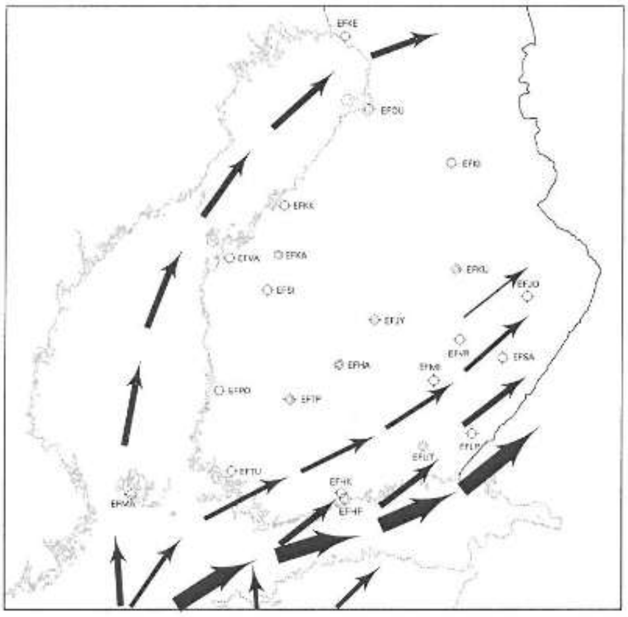

Fig. 1. *About 20 species totalling several millions of birds participate the arctic migration event. Arrows illustrate the main flyways of arctic migration in spring in the Gulf of Finland (south-eastern way) and in the Gulf of Bothnia (western way).*

Also in southern Sweden methods were developed by radar observation to reduce bird hazards to aircrafts (Larsson 1976). In the same way was done in Germany (Becker 1979). In North America, possibility to forecast the mass migration of the snow goose (*Anser c. caerulescens*) with help of meteorological variables was analysed critically (Blokpoel & Richardson 1979).

Effort for developing a real time warning system

On basis of the former background an idea was suggested in the Bird Strike Working Group of the Helsinki-Vantaa Airport to develop, with aid of simultaneous visual and radar observation, a real time warning system for arctic migration. The aim was to observe the migration of the common scoter, the long-tailed duck, the brent goose (*Branta bernicla*) and the barnacle goose (*Branta leucopsis*) with the surveillance radar of the airport and by visual means on the game research station Söderskär situated on a lighthouse island off the nearby coast in the Gulf of Finland.

On practical level the work was carried out in the years 1982-1984. As a result, Heavy Bird Activity (HBA) –warnings were given for few hours when the bird mass over the mainland was passing the airport (Stenman 1984).

Unfortunately the work had to be interrupted in the airport because of installation of the new radar equipment that could not distinguish birds any more. The interruption was tragic so far as the scientific development was concerned because the radar ornithology elsewhere was during that period of time in the phase of strong development (e.g. Becker 1986, DeFusco et al. 1986, Larkin & Quine 1988, Alfiya 1990, Leshem 1990 and Buurma & Bruderer 1990). Moreover, in some BSCE-meetings a recommendation was repeated to improve a co-operation in radar observation between the Soviet Union and Finland.

After the collapse of the Soviet Union in the autumn 1991 the visual observation of the arctic migration began to be intensified strongly because the Finnish field ornithologists could set up several observation bases on the coast of Estonia. On the same time information between different bases in Estonia and in Finland about the migration events developed technically with high rate, so that in the Helsinki-Vantaa Airport almost real time information about the migration events could be received and, if necessary, HBA-warnings be given. In the 1990's migration reports were continually published in Finnish. Therefore the knowledge particularly on the amount of migrating birds was improved whole the time.

Meteorological forecasts improved the warning system

The Bird Strike Working Group of the Helsinki-Vantaa Airport asked the Meteorological institute to assist in developing the warning system. A positive answer was received, probably influenced by the long working experience with weather radar by the author Koistinen. Doppler weather radars, which typically scan the atmosphere continuously every 5 minutes and store all measured data in digital form, provide an excellent tool for measuring and nowcasting intensity and patterns of precipitation as well as bird and insect migration (Dokter et al. 2010, Chilson et al. 2012). However, automatic and reliable separation of birds from all other scattering media present in weather radar data is not yet well established. Research and development to create such tools is ongoing e.g. in the Finnish Meteorological Institute. The new tools exploit dual polarization capability, which is included in the most recent generation of weather radars. Automatic bird diagnostics which are capable of recognizing even different types of migration (e.g. concentrated streams of migrating arctic waders and waterfowl from widespread nocturnal small passerines) will be very useful for real time warning services and for validation of migration forecasts.

In the previous Section an effort of real time detection and warning of heavy bird activity was described. Such a warning can be considered also a nowcast i.e. a forecast valid for a couple of hours assuming persistence in the migration intensity. In a recent Finnish activity the forecast length of air traffic warnings has been extended from hours to two days by applying meteorological weather forecasts as input to migration prediction. Finnish Meteorological Institute has provided daily predictions of migration intensity for aviation since the year 2001. The forecast length is 18-54 hours and the intensity is calculated for several groups of birds, one of which is arctic migration. The daily forecast model is shortly described in the following. The average seasonal timing and population of migrants, which is called climatological migration (N), is obtained from ornithological statistics. For example, during the two weeks long peak period of migration in spring the climatological number of arctic migrants leaving the Baltic Sea region is 300 000 individuals each day. The forecasted daily migration estimate (E) is modulated according to the forecasted weather in the departure areas of the migrants:

$$E = [(P + N) S]d , \qquad (1)$$

where P is accumulated number of resting migrants which did not migrate during the previous days due to adverse weather conditions. Factor S denotes the effect of weather on migration ($0 \leq S \leq 1$) and d denotes drifting factor ($0 \leq d \leq 1$). Magnitude of the drifting factor depends on forecast wind speed and direction over the Gulf of Finland. It simulates the fact that large number of birds may leave the more southern parts of the Baltic Sea but due to western winds their migration route will pass Finland south of the country. As an example of a forecast we can take a case in which there has been no migration (according to the model) due to bad weather during the two previous days (P = 600 000), weather becomes moderately good for takeoff (S = 0.5) and wind drift will have small deviating effect (d = 0.9). Then the daily forecast will be (600 000 + 300 000)·0,5·0,9 = 400 000 individuals of arctic migrants passing Finland. The weather factor S is a multiplicative combination of several weather components averaged over the Baltic Sea region:

$$S = U \cdot D \cdot V \cdot H \cdot R \cdot L, \qquad (2)$$

where U denotes wind speed effects, D wind direction, V visibility, H lowest cloud layer height, R intensity and type of precipitation (rain, snow) and L the effects of snow and ice cover. For each weather component specific categorical lookup tables exist for spring and autumn seasons which define the magnitude of the component depending on the forecasted weather over the Baltic Sea region (spring) and over the White Sea region (autumn). Although the weather forecast is taken from a numerical weather prediction model, input to Eq. (2) is not substituted automatically but is performed by aviation meteorologists. The model does not include explicit altitude distribution of migration but rough estimates are given by the meteorologists e.g. in cases when thick capping cloud layers exist.

Finnish Air Force has used the forecasts more than 10 years and they have been quite satisfied with them. In spite of the service a jet engine was lost in autumn 2006 when it collided with nocturnal flock of Wigeons (*Anas penelope*). It is interesting to note that at the time of the accident arctic bird migration forecast (mainly ducks) in the region was ‘heavy’. The accident could have been avoided if the forecast had been taken into account in the flight excercise. The most significant limitation of the model is that we are not able to verify it until reliable diagnostic tools for measuring the real number of migrants are available. Field observations can be used but they can’t estimate migrating population during nights and in cases when birds fly far off the coast, at high altitude or above layers of low clouds or fog.

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