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## **Arrival Dates of Migrating Birds in Central Europe and Climate Variability**

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This study is based on time series of 3 bird phenological data sets ('first barn swallow', 'first cuckoo call' and 'all swallows have left') from the archive of the Central Institute for Meteorology and Geodynamics in Vienna, which have been collected at 65 Austrian stations from 1951 – 1999. Only a rather small fraction of the spatial variability of the long term mean entry dates (minimum time series length 30 years) can be explained by station coordinates and station elevation. In case of both swallow phases the explained spatial variability is about 10% and in case of the 'first cuckoo call' about 33%. The entry dates of the 'first cuckoo call' move from east to west with about 100 to 200 km/day, however, the swallow arrival dates are not unequivocally related with the station longitude The swallows appear to leave first in the eastern part of Austria (70 to 140 km/day from east to west). The relation of the entry dates with station latitude is more clear-cut. The entry dates of the bird phases occur first in the south and move in case of the 'first barn swallow' with 40 to 200 km /day north and in case of 'first cuckoo call' with 20 to 56 km/day north. 'All swallows have left' occurs first in the north and moves with about 70 km/day south. As to be expected, birds arrive first at the low elevation stations. The phase 'first barn swallow' moves with 110 to 230 m/day from low to high elevation stations and the phase 'first cuckoo call' with 100 to 120 m/day. Swallows leave at about the same time at all altitudes in autumn.

Because most of the bird phenological time series are incomplete and because of the lack of information on the temporal development of the population density, which influences first sighting dates, the following conclusions about temporal trends have to be taken as tentative. A very first subjective spatial attribution of temporal trends of 'first barn swallow' from 1980 to 1999 shows 3 subregions in Austria, where the

swallows in the Alpine area appear to arrive earlier and in the surrounding lowlands trends towards later arrival dates predominate. The 'first cuckoo call' shows nearly everywhere trends towards later occurrence dates. With few exceptions the swallows seem to leave earlier in autumn.

The correlation analysis between the bird phenological observations and atmospheric variables are based on the NCAR reanalysis data set with a monthly resolution and Austrian homogenised temperature time series. Linear trends have been subtracted from all time series before regression. Among the atmospheric variables temperature and wind show the highest correlations with the bird phenological observations. The mean monthly temperature of April can explain about 25% of the year to year variability of the swallow arrival dates. The year to year variability of the 'first cuckoo call' can be explained by about 35% with the April temperature and by 25% by the mean monthly distribution of the meridional geopotential component at 850 hPa along 20°E over a distance from 23.5° to 47°N during April. A multiple regression model combining both atmospheric variables can explain 39% of the year to year variability of the 'first cuckoo call'. Air flow and temperature are strongly related, where southerly air flows are connected with higher temperatures and earlier arrival times of the cuckoo.

In order to make it easier to find candidates, which might explain the predominant trend of both bird phases towards later arrival times, all time series involved have been smoothed with a Gaussian filter. Time series of decreasing precipitation sums from an area  $0^{\circ} - 20^{\circ}E$  and  $5^{\circ} - 30^{\circ}N$  show the best match from all atmospheric variables with the long term trend of the spring bird phases towards later arrival times. The only restriction are the last 15 years of the precipitation time series (1984-1999), where precipitation sums are still low but increasing, whereas the birds continue their trend towards later arrival times. Precipitation in the African overwintering areas governs the food supply of the birds, where dry years with low food availability are connected with late arrival times in Europe. Another atmospheric factor with a good potential to influence the bird arrival time is the air flow situation. The northerly flow component for instance in March between  $0^{\circ} - 23.5^{\circ}$  N over the Sahara has been increasing since the sixties of the last century at the surface and at 850 hPa. At the surface the northerly wind speeds have also increased during April between  $23.5^{\circ} - 47^{\circ}$ N during the last decades. This could mean that headwind situations have become more frequent.

Summarisingly one can conclude that even with a monthly resolution a number of potential relationships between bird phenological entry dates and atmospheric variables can be identified. Future research will have to quantify and strengthen these relationships between the atmosphere and bird arrival dates with time series of atmospheric variables at a higher temporal resolution.