# Twilight ascents of Common Swifts: a comparative analysis

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The aim of the short term scientific mission (STSM) to Lund University, 13/7-24/7 2015, was to investigate the nocturnal flight behavior of Common swifts (*Apus apus*), specifically during twilight. The STSM was carried out in collaboration with Cecilia Nilsson and Johan Bäckman. I have previously shown that roosting swifts in the Netherlands ascend to high altitudes during dusk and dawn twilight. It is unclear why they do this, and if it is a general phenomena or not. During the STSM we analyzed data from Swedish weather radars, historical data from the Lund tracking radar and also collected new data with the Lund tracking radar.

## Background

Common swifts are specialist flyers spending most of their life aloft, including night-time periods when this species roosts on the wing. Nocturnal roosting is preceded by a vertical ascent in twilight conditions towards altitudes of up to 2.5 km, a behaviour previously explained as flight altitude selection for sleeping. It was recently shown that Common swifts perform these twilight ascents not only at dusk but also at dawn, which has cast new light on the purpose of these ascents. It has been hypothesized that the ascents may be related to orientation or navigation purposes, and that swifts profile the state of the atmospheric boundary layer during twilight ascents and/or attempt to maximize their perceptual range for visual access to distant horizontal landmarks. Studying these ascents at more northern latitudes provides an interesting way of studying the effect of different lighting conditions on the ascents, which will be possible with the weather radar network in Sweden. In addition, by using a tracking radar we will be able to shed light on the individual behaviour of swifts during the ascents, in addition to the population patterns detected with the weather radar.

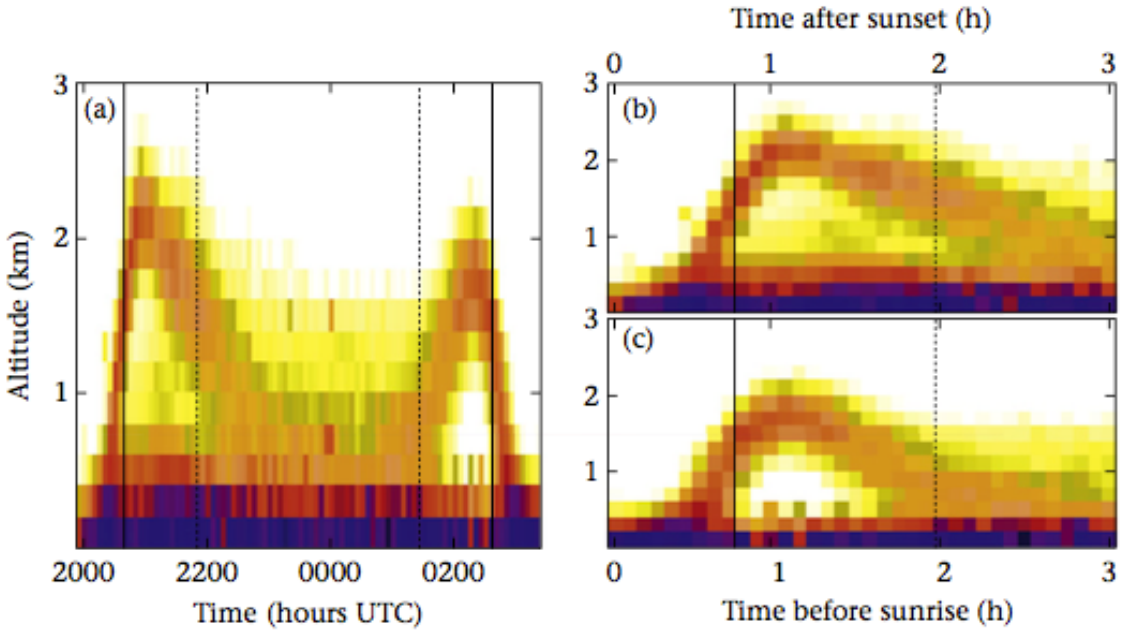


Figure 1: (a) Reflectivity altitude profile for the night of 1-2 June 2009 in the Netherlands, showing twilight ascents of swifts. In addition to the dusk ascent, swifts also participated in a dawn ascent. Both ascents were timed with respect to sunset and sunrise as each other's mirror images. (b) Dusk ascent, (c) time-inverted dawn ascent. The displayed time series started at sunset and ended at sunrise; solid vertical black grid lines indicate the transition between civil twilight and nautical twilight; dotted vertical lines indicate the transition between night and nautical twilight (from Dokter et al., 2013).

## Methods and Analysis

We analyzed data from two Swedish weather radars, Ängelholm and Stockholm. We choose the summer of 2013 to match the dates of previous tracking radar data, and data was obtained from the Swedish Meteorological and Hydrological Institute. Elevation scans were aggregated into volumes. Every 15 minutes a bird profile could be calculated based on these volumes, using the methodology by Dokter et al. (2011). Default settings were used, with the exception that no static cluttermap was used.

We also analyzed data from the small scale ornithological tracking radar in Lund. We used previously gathered, but not analyzed, data (gathered during six nights in June to August 2013) and we also gathered more data during the night of July 16th. The Lund tracking radar tracks one individual bird (or flock) at the time, giving exact positions. It is manually operated and targets are identified by the operator according to wing-beat and flight characteristics. Swifts are easily identified by their characteristic flight pattern. When in flocks the flight characteristics are much more difficult to distinguish, as the echo will reflect the wing-beats of the whole group. Only in cases where a bird during some part of the track separated enough from the others for a swift type of wing beat pattern to be visible were classified as swift flocks.

## Results

When analyzing the tracking radar data on roosting swifts, we were able to see that swifts over Lund did indeed show the same fascinating pattern of dusk and dawn ascents that have previously been described over the Netherlands (Dokter et al 2013). Flight altitudes showed the similar rapid increase and then slow decrease after sunset as well as the slow increase in altitude and then rapid decrease soon before sunrise as has previously been described. This was apparent from an analysis of how the vertical speed changed over the night (Figure 2), as well as from the weather radar retrievals as shown in Figure 4. The pattern of ascents seemed to be connected to sunset and sunrise in a similar way as the previously described pattern (Figure 1). Furthermore, we discovered that there seems to be some connection between this behavior and flocking. Flocks of swifts were seen only during the rapid ascent after sunset and during the rapid descent before sunset, and were completely absent for the other parts of the night. This suggests an exciting new social dimension to the behavior which is difficult to explain with the current hypotheses. We will now write a joint paper describing these results.

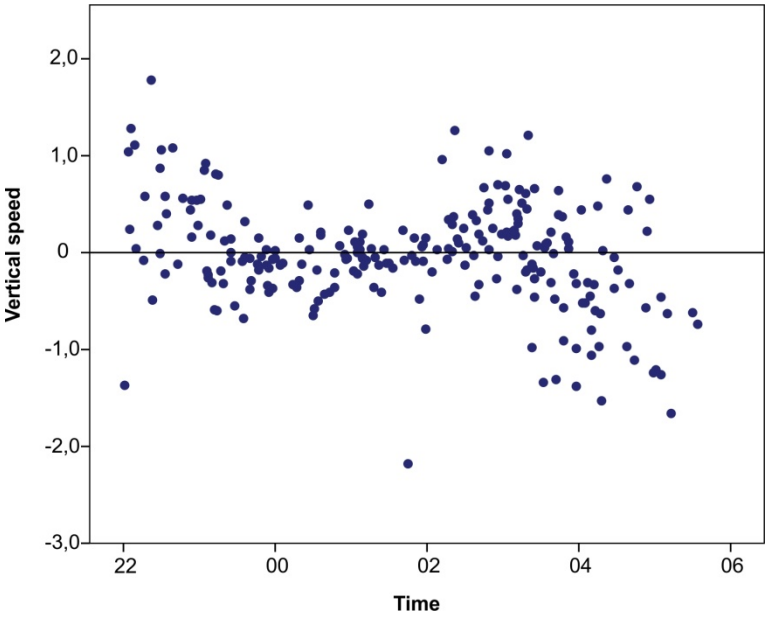


Figure 2: Vertical speed of swift and swift flocks over the duration of the night. Early in the night a high vertical speed shows that the swifts are rapidly ascending, and a while later the vertical speeds drop as swifts descend again. The reverse pattern is seen during the morning, with first a period of rather slow increases in altitude and then rapid decreases as sunrise approaches.

We further collected and analysed several long tracks of individual birds, as shown in Figure 3. We found that the birds may travel considerable distances during the ascent, and have the tendency to ascent into the direction of the wind.

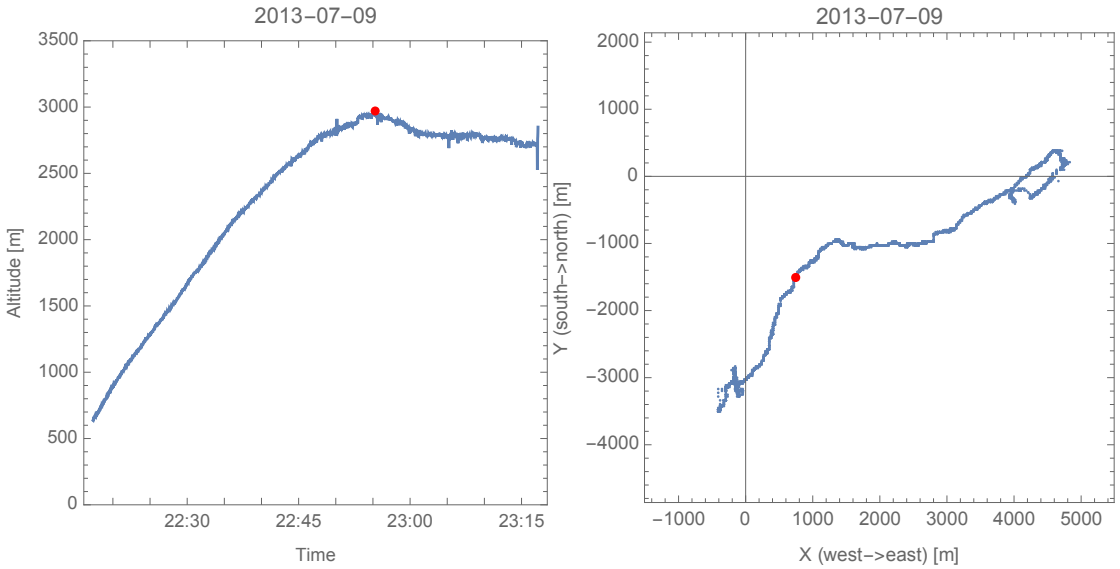


Figure 3: Individual track of an ascending swift in Lund. Tracks show that considerable distances (several kilometers) may be travelled in the ascent and descent phase. We found birds had a strong tendency to ascend into the direction of the wind.

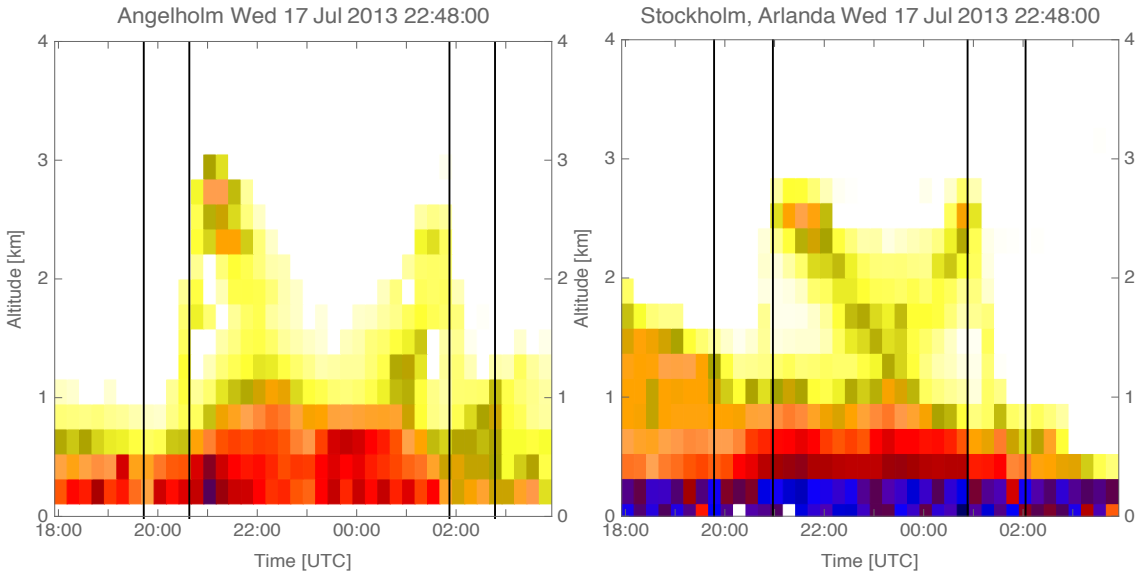


Figure 4: Twilight ascents of Swifts in Ängelholm (56.3675N, 12.8517E) and Stockholm-Arlanda (59.6544N, 17.9463E) on 17 Jul 2013. The general patterns match those observed in continental Europe (cf. Figure 1). Vertical black lines indicate the moments of sunrise, sunset and the end and start of civil twilight.

We have also made seasonal time series of radar images for the Ängelholm and Arlanda radars, to inspect the spatial distribution of the swifts across the landscape. We found that the swifts have a strong tendency to concentrate above large water bodies, both fresh water (Stockholm) and above marine inlets (Arlanda). We hope to further investigate the connection

between these spatial patterns, and the flocking behaviour found with the tracking radar in the near future.

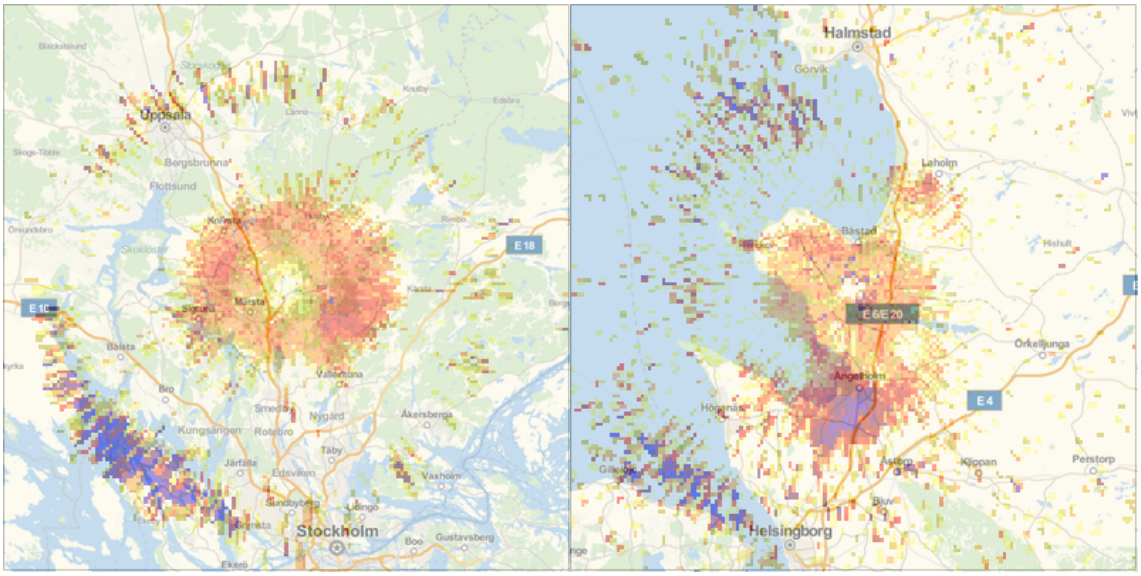


Figure 5: Radar echoes during the peak evening ascent of the swifts on 17 July 2013 21:32 near Stockholm-Arlanda (left) and on 6 July 2013 21:02 near Ängelhom (right), for an 80x80 km area around the centre the radar. It is clear that the swifts distribute non-randomly over the landscape, and have a tendency to concentrate above large water bodies.

## Outcomes of the STSM

Scientific:

- It has been shown, for the first time, that swifts at three different sites in Scandinavia perform twilight ascents during both dusk and dawn, confirming the pattern seen in continental Europe.
- Changes of the ascent pattern in varying twilight conditions have been quantified
- Heading directions of individual swifts has been quantified during the different ascent phases, both with respect to the solar position and wind direction.
- We have initiated a joint paper on the social aspects of the ascent behavior.
- We have also initiated a joint paper on how the rapidly changing light regime at high latitude sites affects twilight behavior.

Methodological:

- Conversion scripts have been built to compile the Swedish radar scan data into volume files that can be processed by the bird profiling algorithm
- To make the radar processing tools available to a wider community, integration of the bird profile algorithm into an R-package has been initiated. The package has been tested and compiled under Linux/Mac operating systems; testing under Microsoft Windows is still ongoing.
- Visualization scripts have been made that overlay radar imagery with map data for any locality.

## References


1. Twilight ascents by common swifts, Apus apus, at dawn and dusk: acquisition of orientation cues? Dokter A.M., Åkesson S., Beekhuis H., Bouten W, Buurma L., van Gasteren H., Holleman I., Animal Behaviour 85, 545–552, 2013.

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

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Dear Dr. Bauer,
Between the 13th and 24th of July 2015 Dr. Adriaan Dokter visited Lund University as a short term scientific mission (STSM) within the COST action ENRAM. The goal of the STSM was to investigate the pattern of twilight ascents by way of using both weather radar and small scale tracking radar. During the two weeks Adriaan successfully converted and processed weather radar data from the Swedish Meteorological and Hydrological Institute, confirming that swifts show the same twilight ascent behaviour also in Scandinavia. We also analysed previously gathered data from the small scale tracking radar in Lund, as well as gathered new data with the same.

The outcomes of these analysis show very promising results, and will shed further light on the interesting, and largely unknown, phenomenon of twilight ascents by swifts. During the last part of the STSM we initiated the work several joint papers that we hope to soon be able to publish.

Sincerely,

Dr. Cecilia Nilsson

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