Quantifying Bird and Insect Movements using Operational Weather Radars

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[6]Météo France

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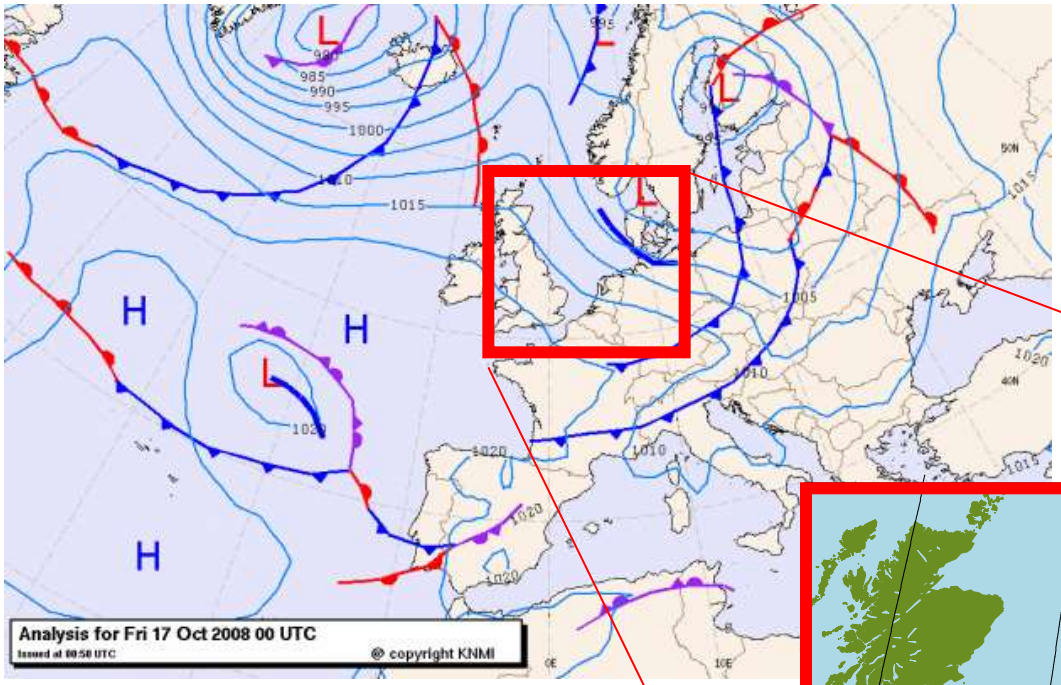
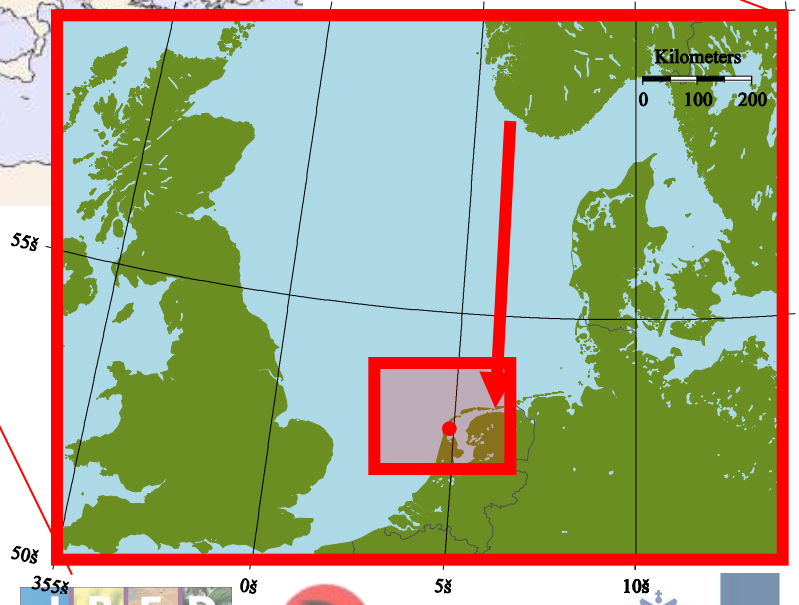
Bird migration on weather radar

Example 17 October 2008

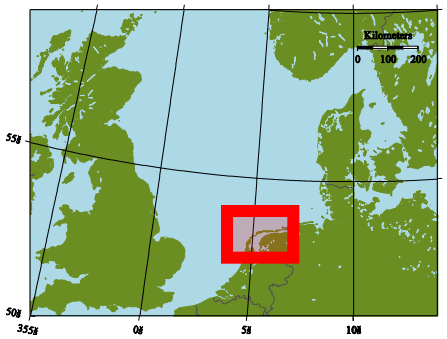


Redwing
Turdus iliacus

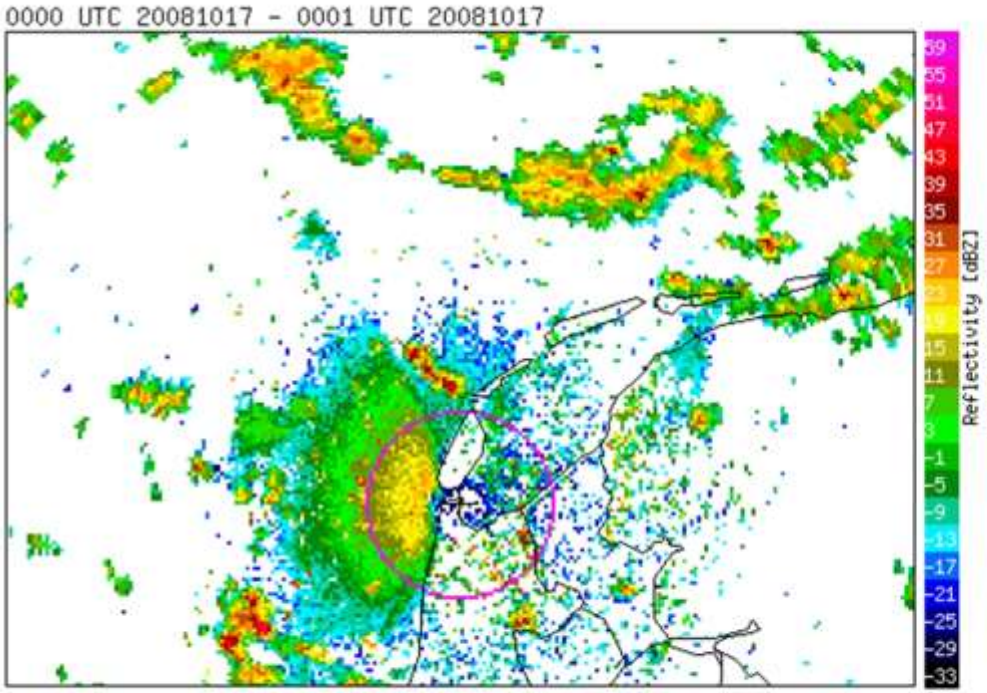


Bird migration on weather radar

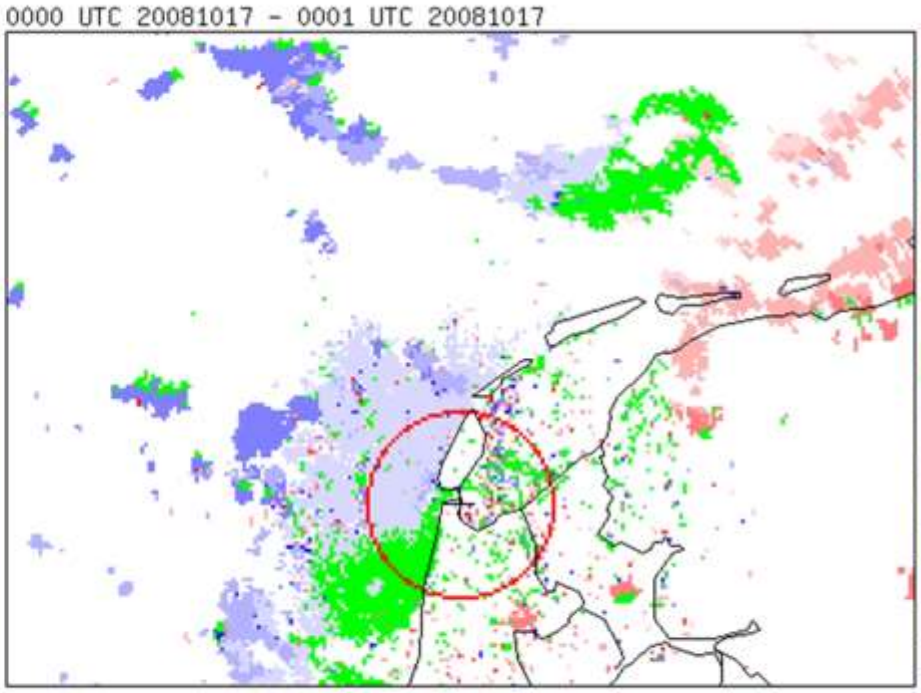
Example 17 October 2008



reflectivity factor



radial velocity



50 km

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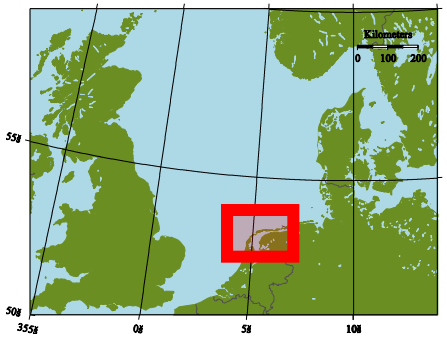
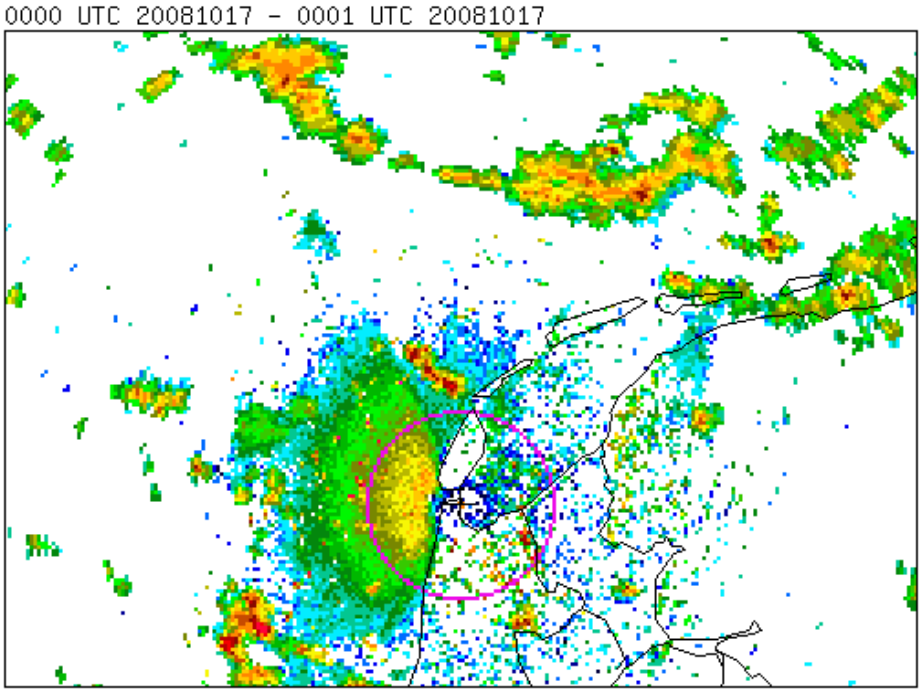
Bird migration on weather radar

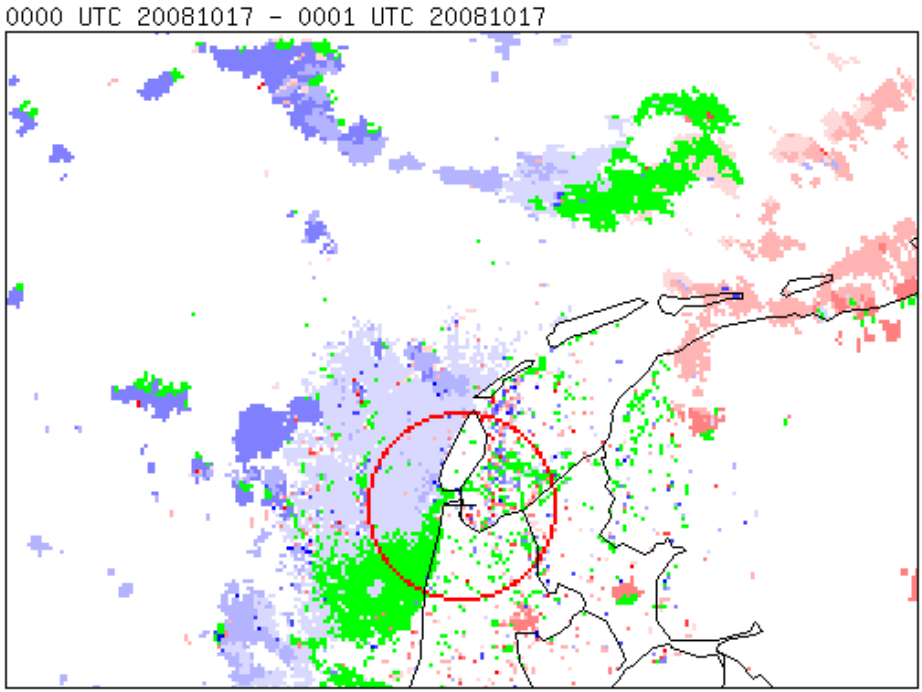
Example 17 October 2008



reflectivity factor



radial velocity



50 km

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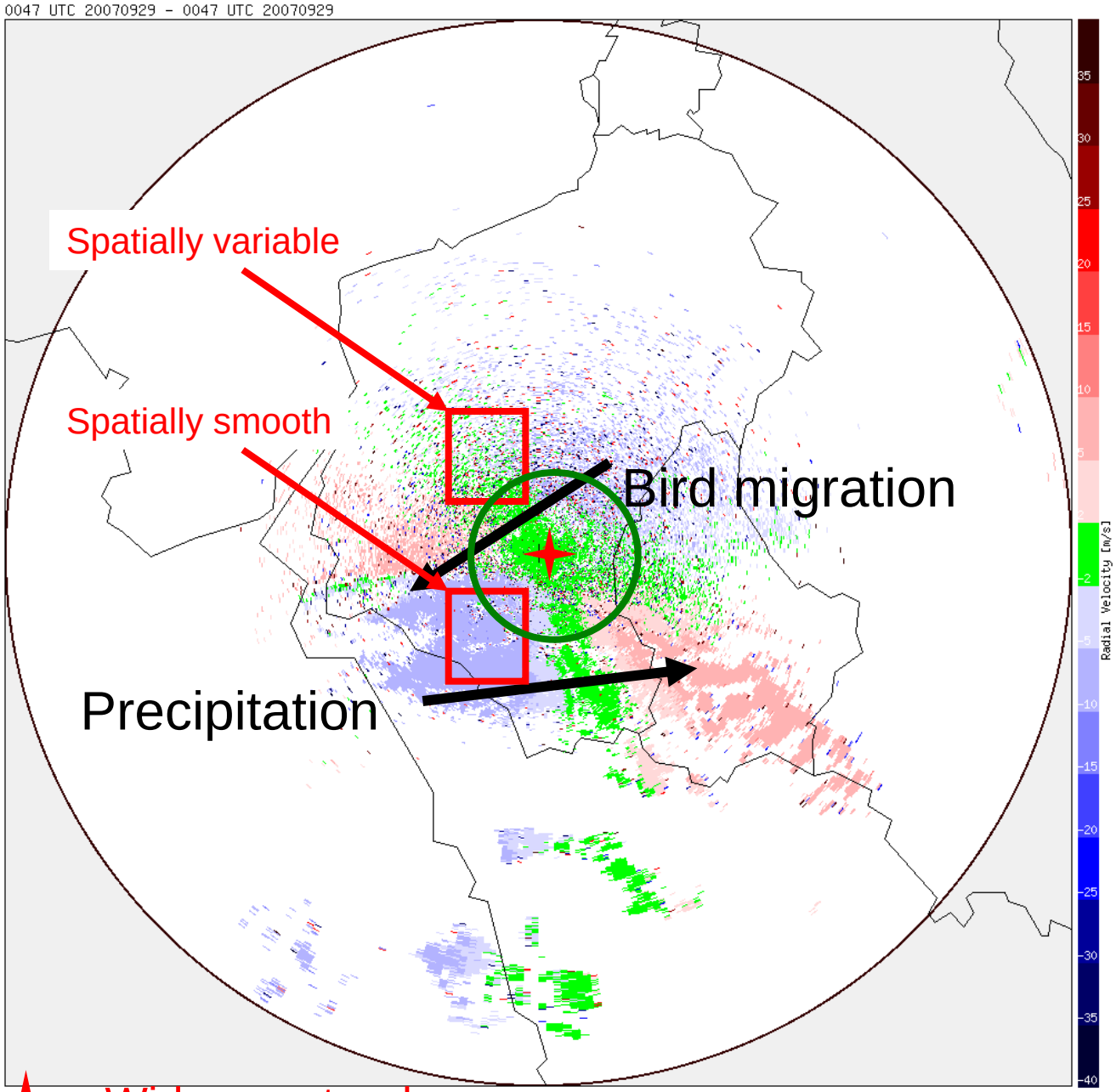
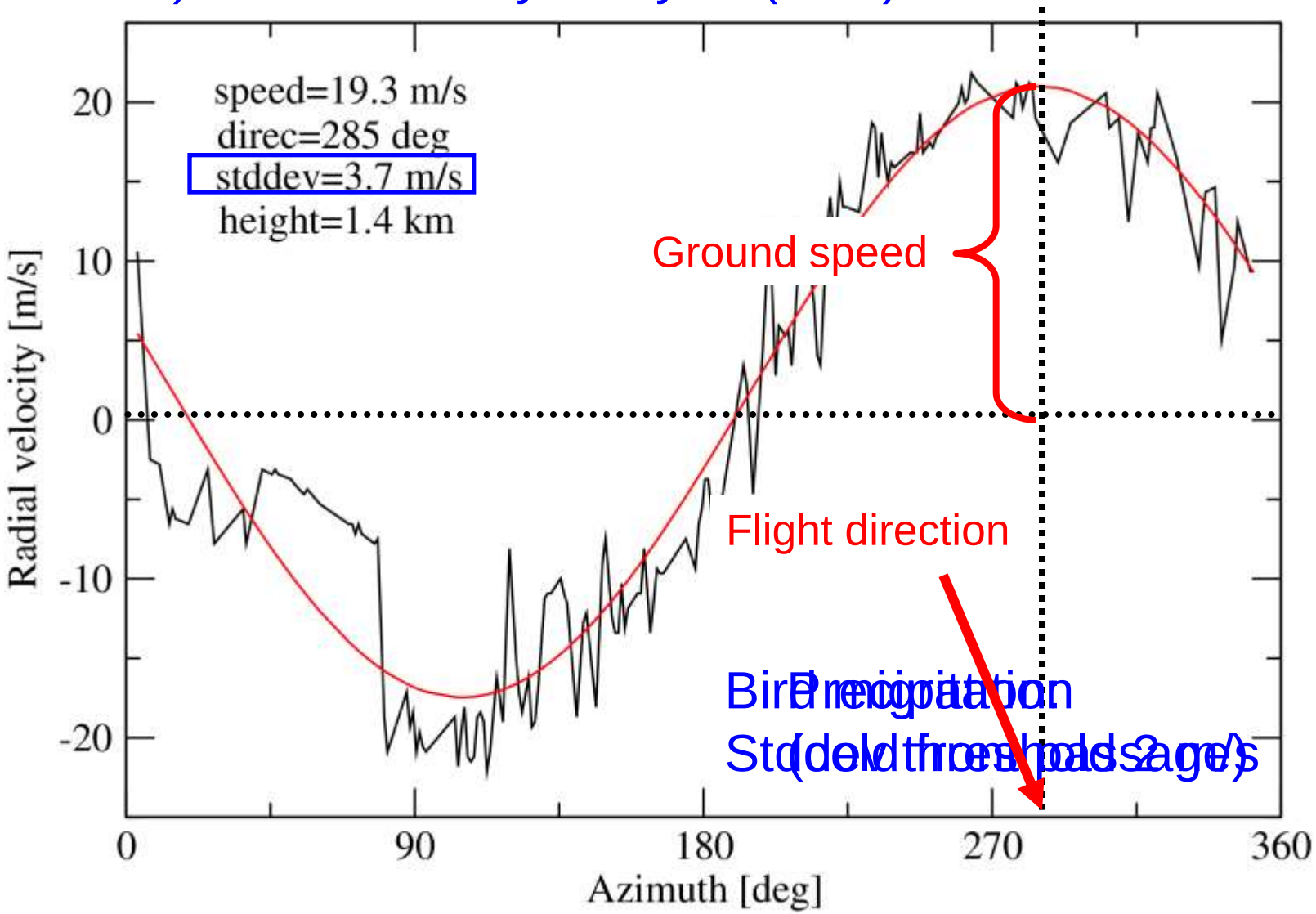
Target identification



= Wideumont radar

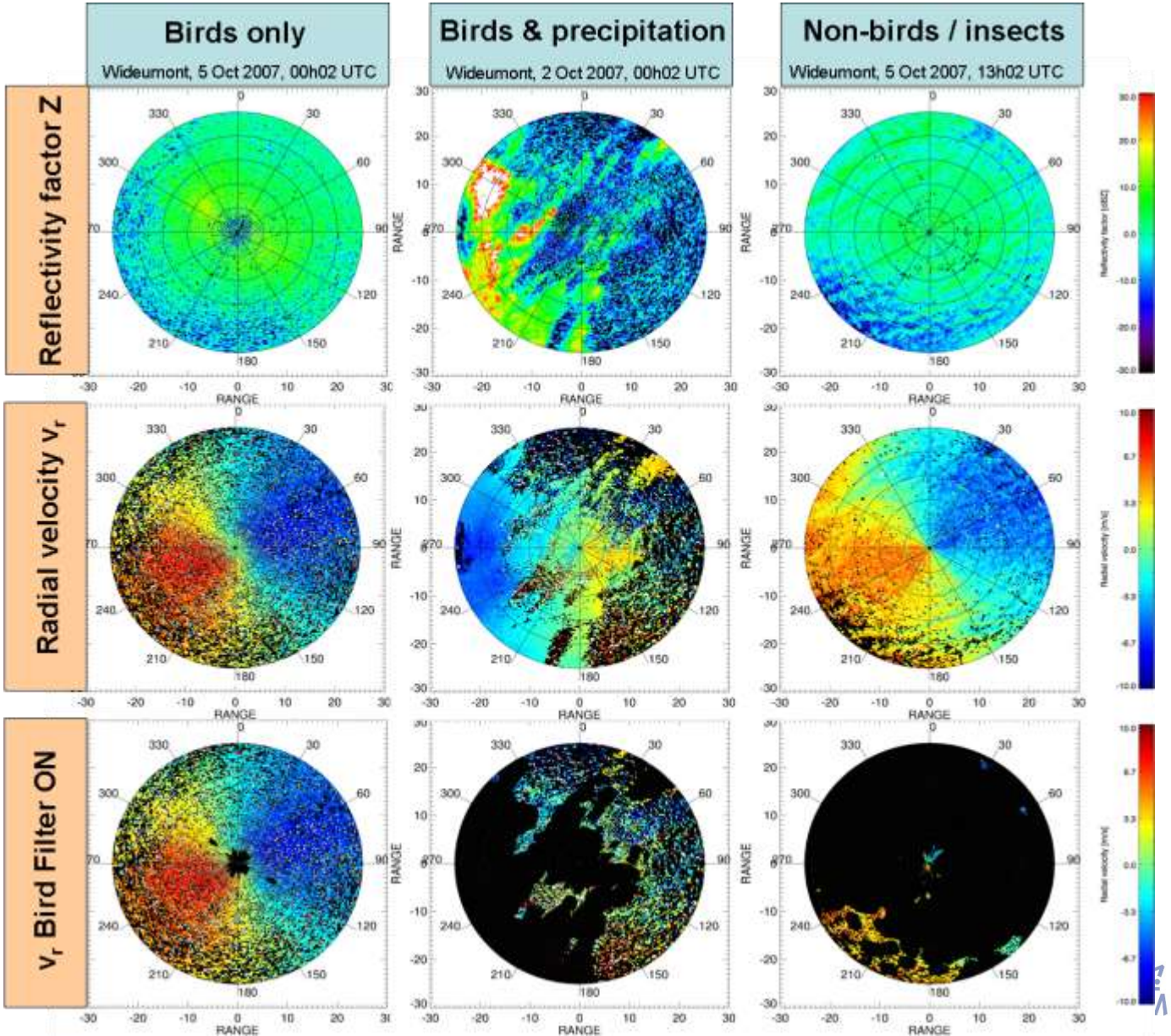
Automated processing

1) Radial velocity analysis (VVP)



Automated processing

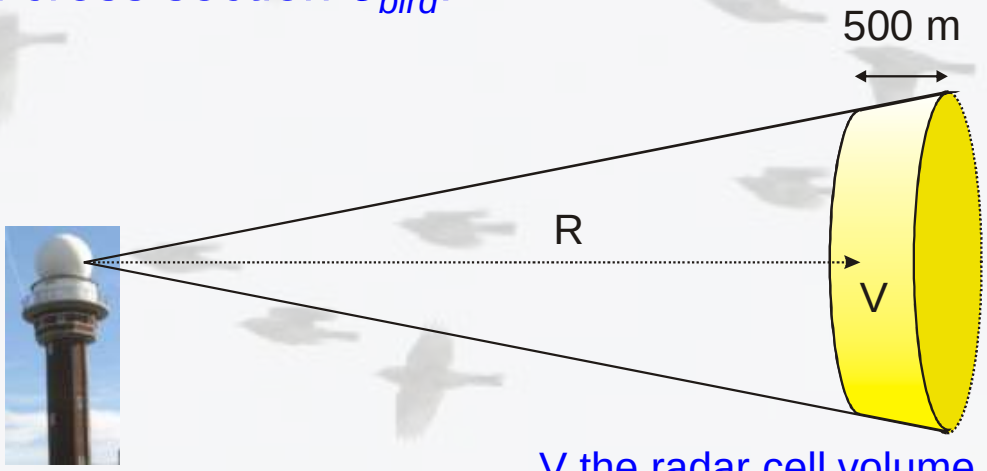
2) precipitation masking



Weather radar reflectivity

Reflectivity η (back-scatter cross-section/unit volume) related to density ρ_{bird} and cross section σ_{bird}:

$$\overline{\eta(R)} \approx \overline{\rho_{bird}\sigma_{bird}}$$



V the radar cell volume

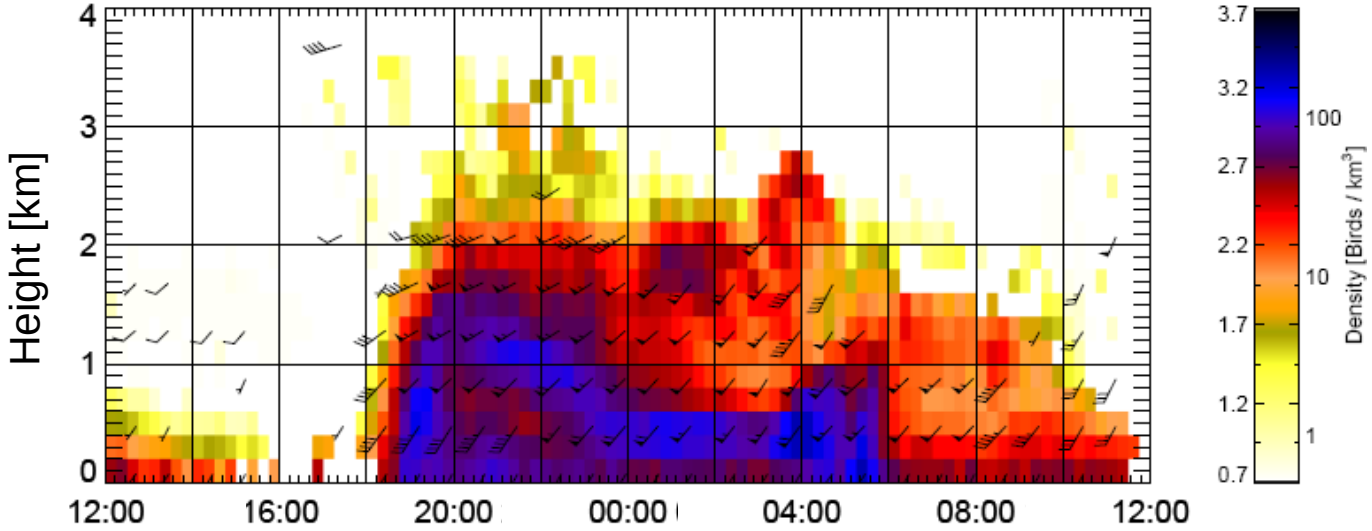
Calculate η from the reflectivity factor Z:

$$\eta(R) = \frac{\pi^5}{\lambda^4}\left|\frac{m^2-1}{m^2+2}\right| \cdot Z(R)$$

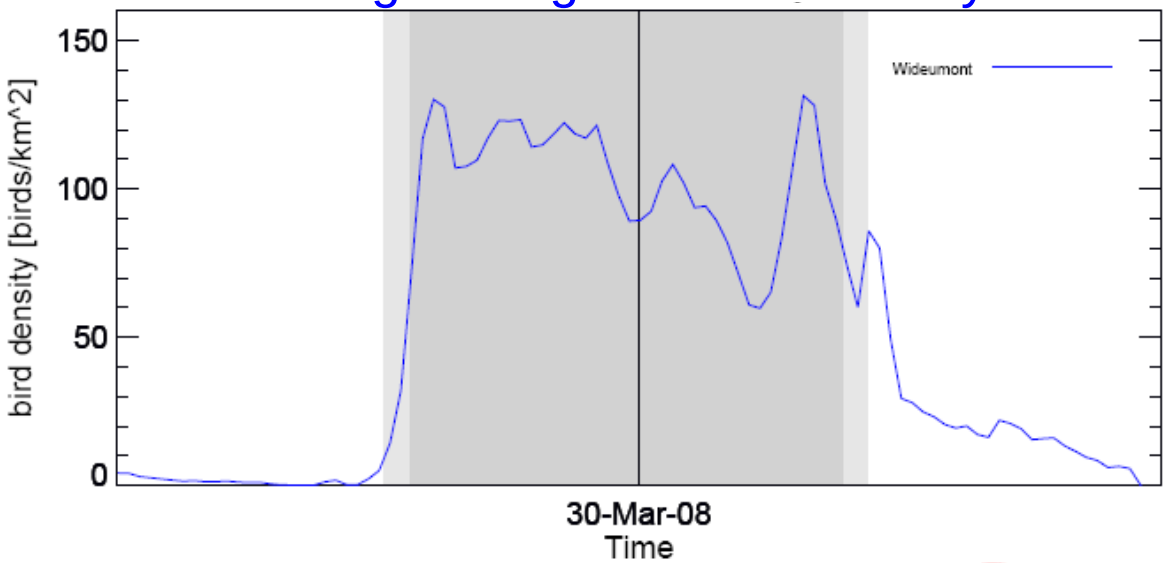
λ wavelength (5.3 cm), m index of refraction water, Z the reflectivity factor in [mm^6/m^3]

Weather radar algorithm output

Bird density altitude profile



Height-integrated bird density



night

twilight

day

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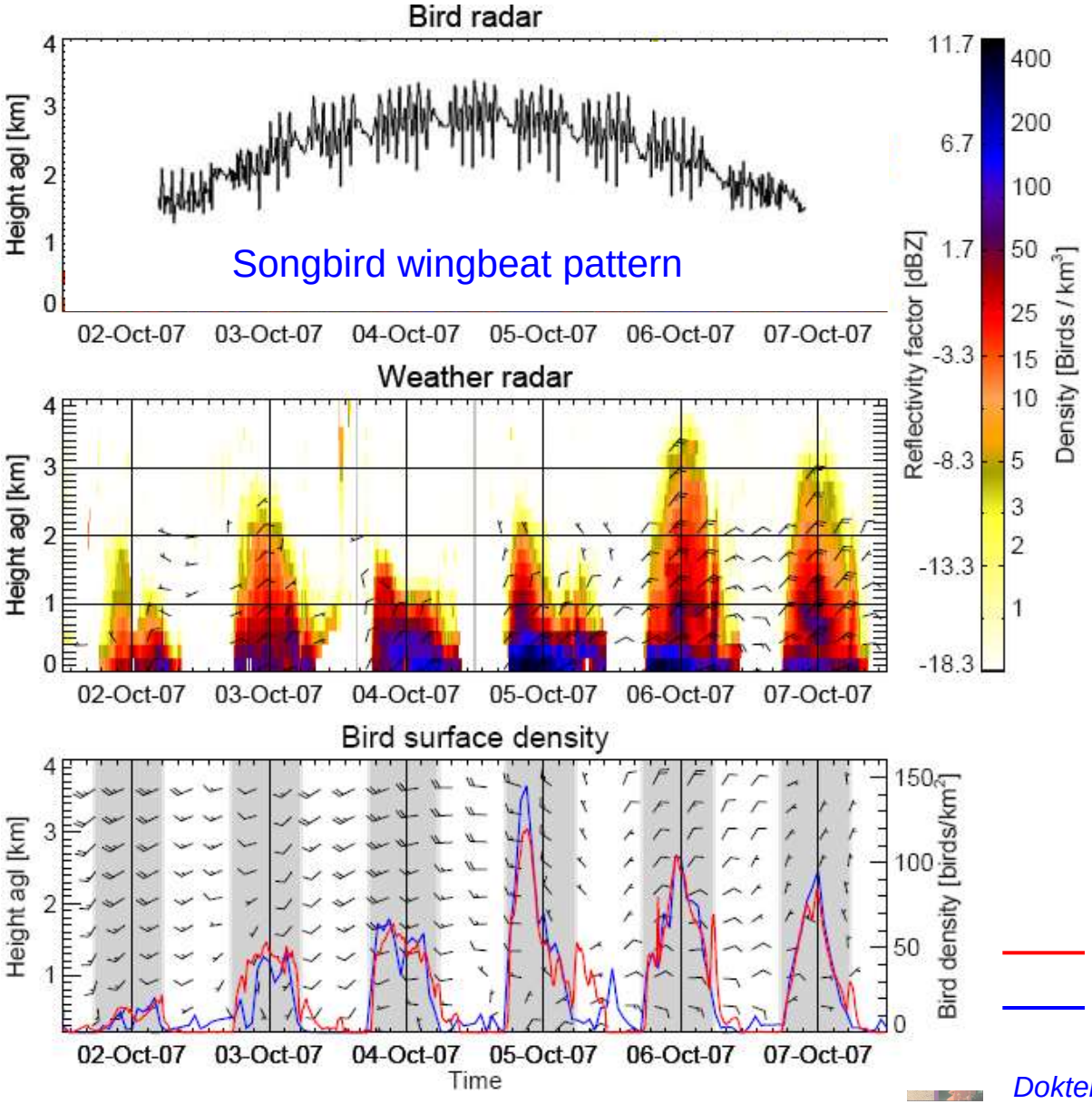
Weather radar validation

Comparison bird radar - weather radar (full migration season)



Superfledermaus

Weatherradar Wideumont

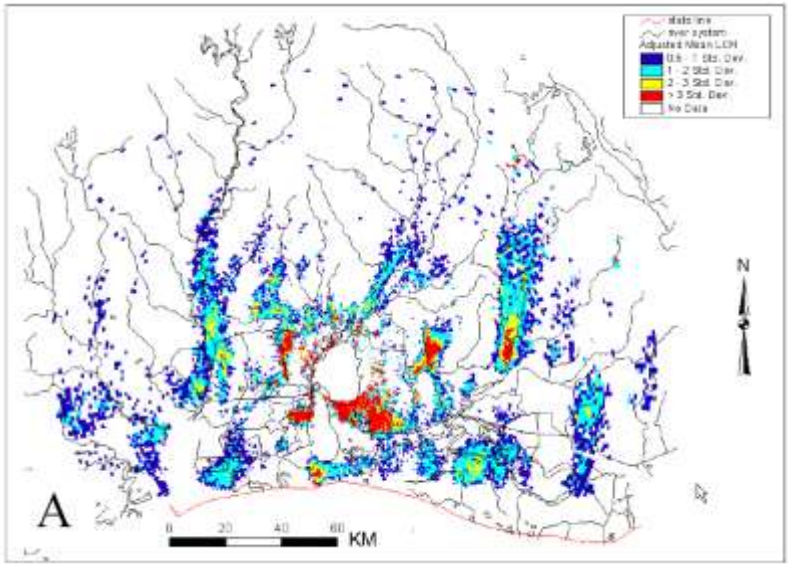
Weather radar

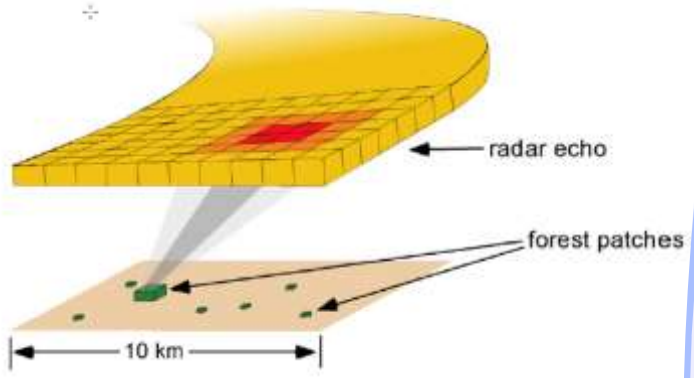
Bird radar

*Dokter et al., J. R. Soc. Interface **8 54**, 30, 2011*

Aim 1) extracting spatial information

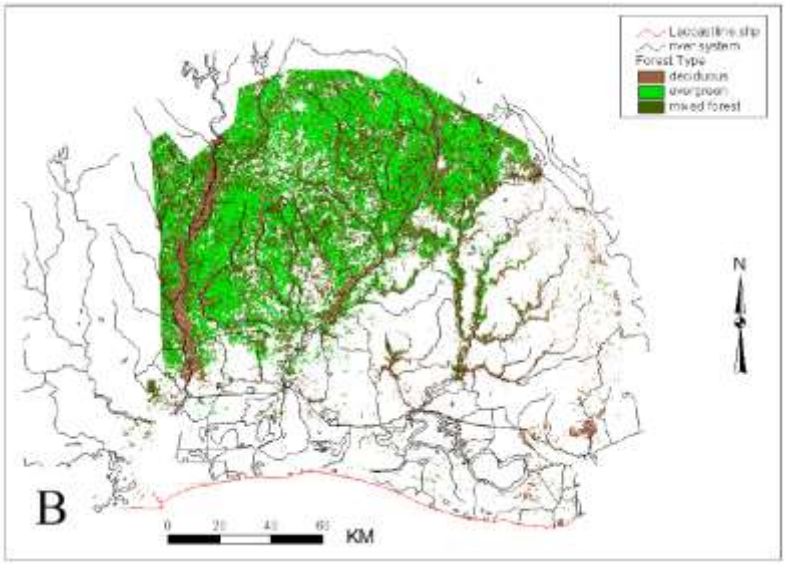
Stop-over areas (from radar reflectivity data)

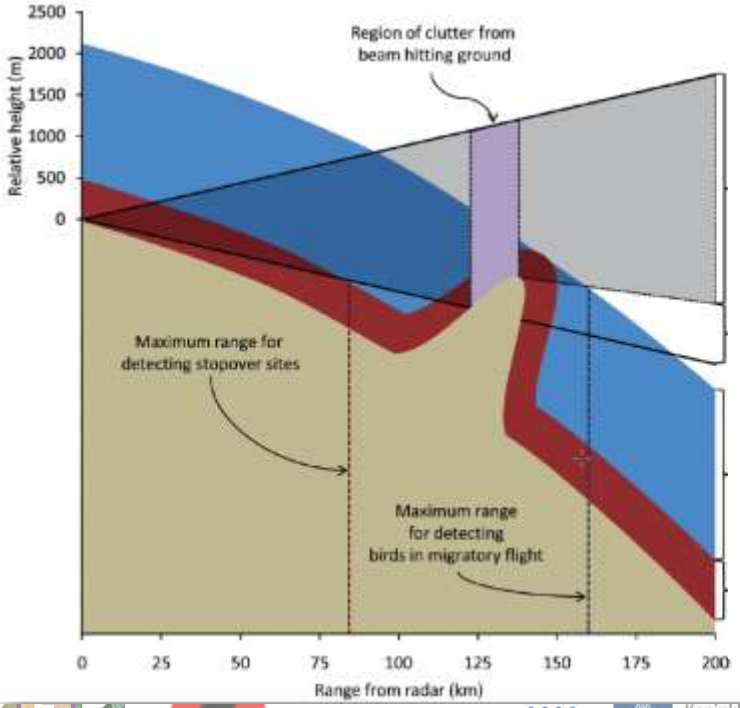




Diehl & Larkin 2005

Forest type (LANDSAT data)





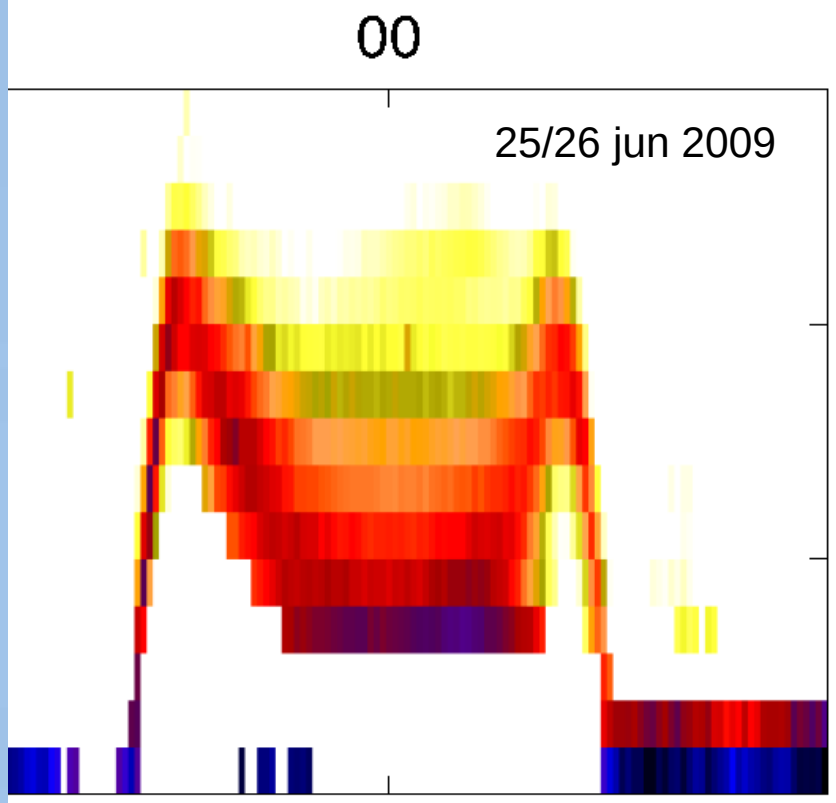
Gauthreaux & Belser 2005

Ruth et al. 2008

Aim 2) Designing a similar operational algorithm for insects

Common Swift *Apus apus*

Radar echos in summer



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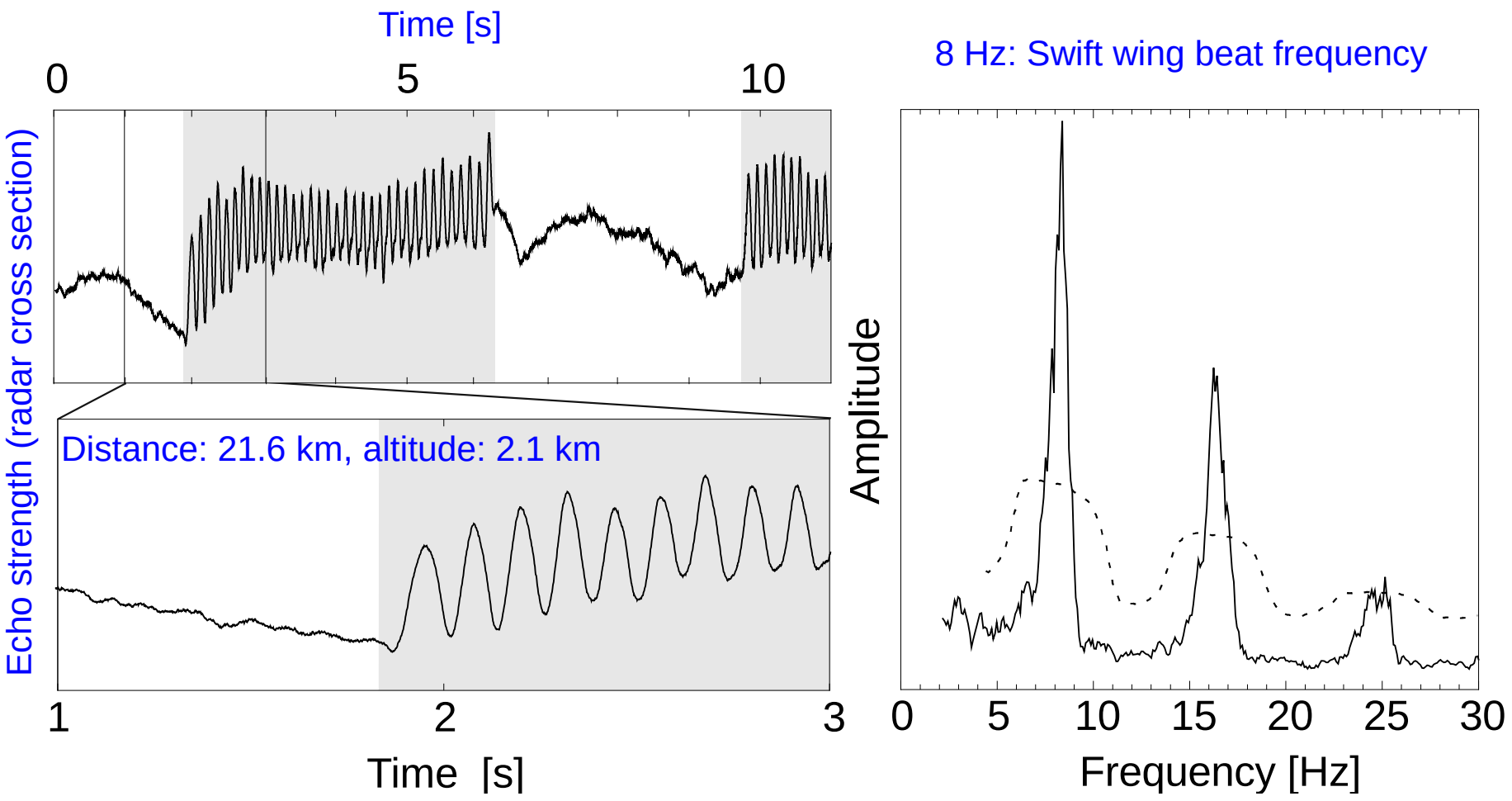
Swift wing beat pattern

Measured by KNMI weather radar



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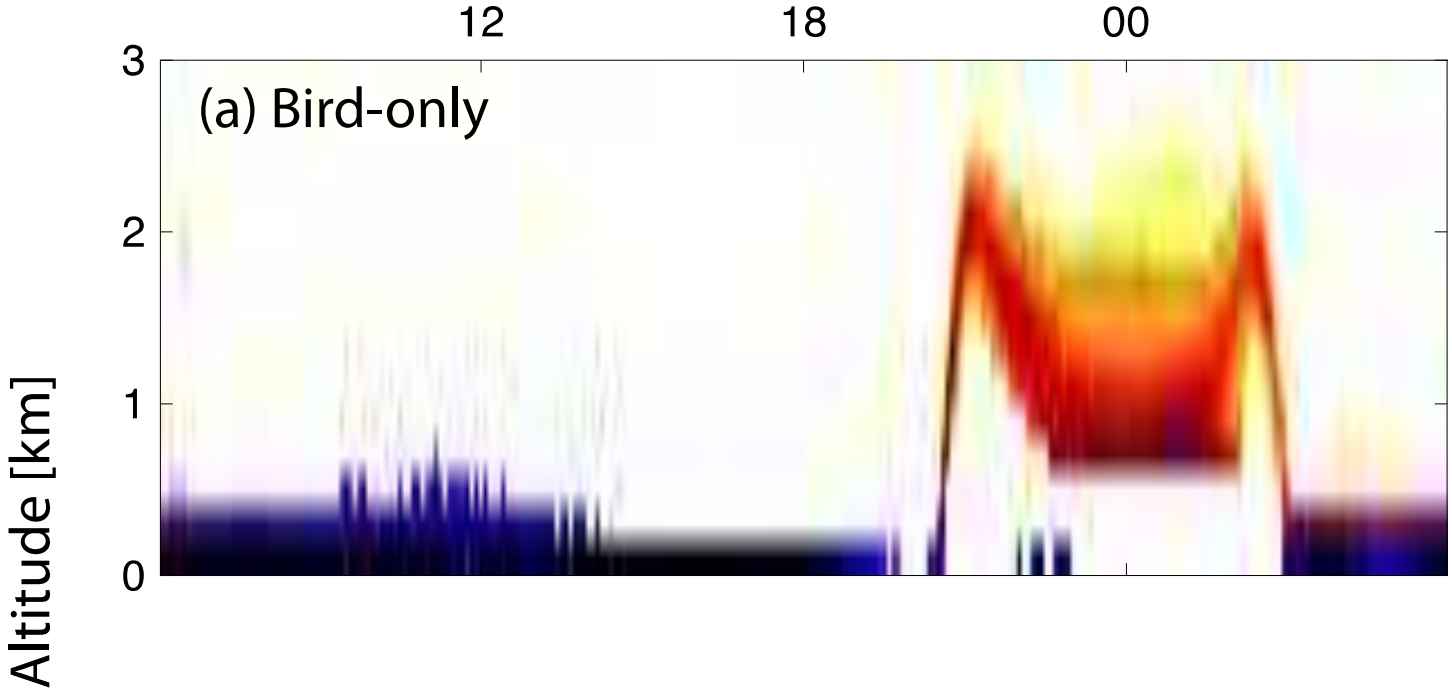
Insect & swift echoes

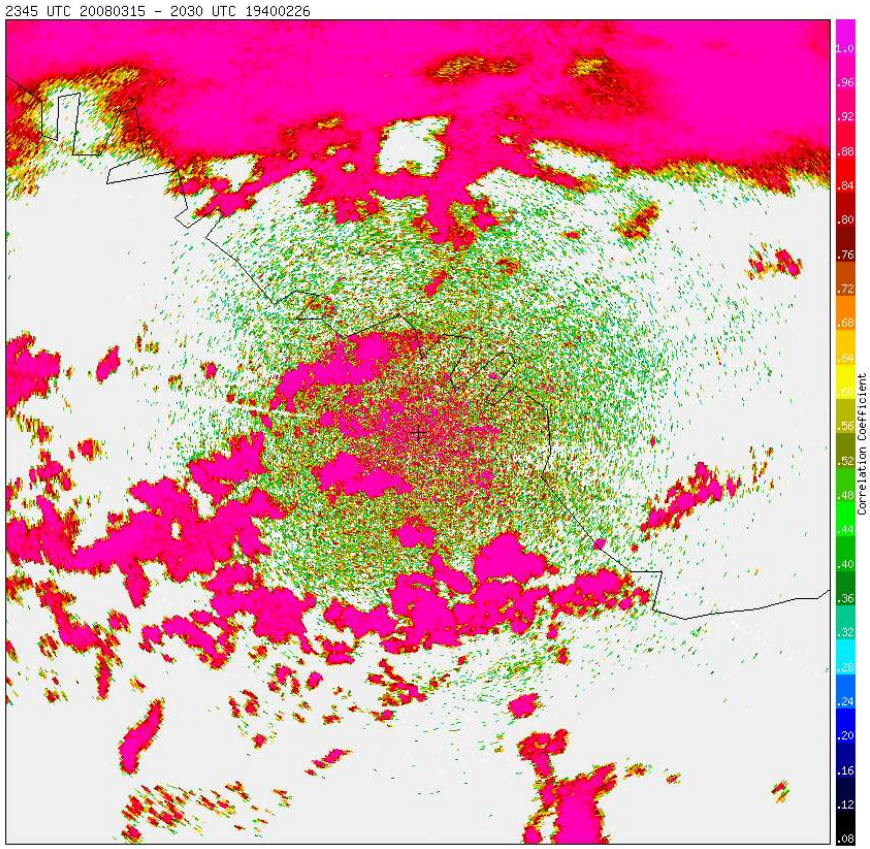


Dokter et al. 2013 Twilight ascents by common swifts, Apus apus, at dawn and dusk: acquisition of orientation cues? Anim. Beh. 85, 545

Target identification: Dual polarization radar

Detect horizontally and vertically polarized radiation independently

Bird migration & precipitation simultaneously:



Reflectivity factor Correlation coefficient ρ_{HV}

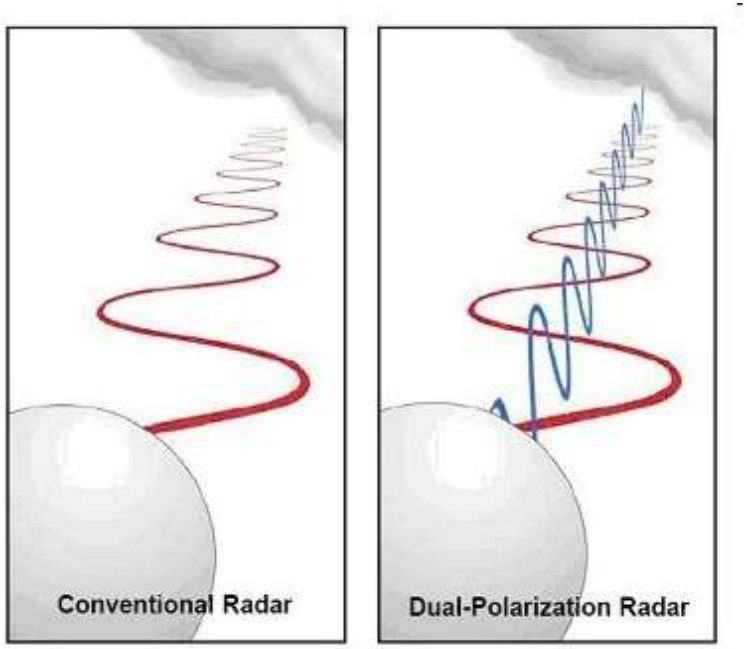
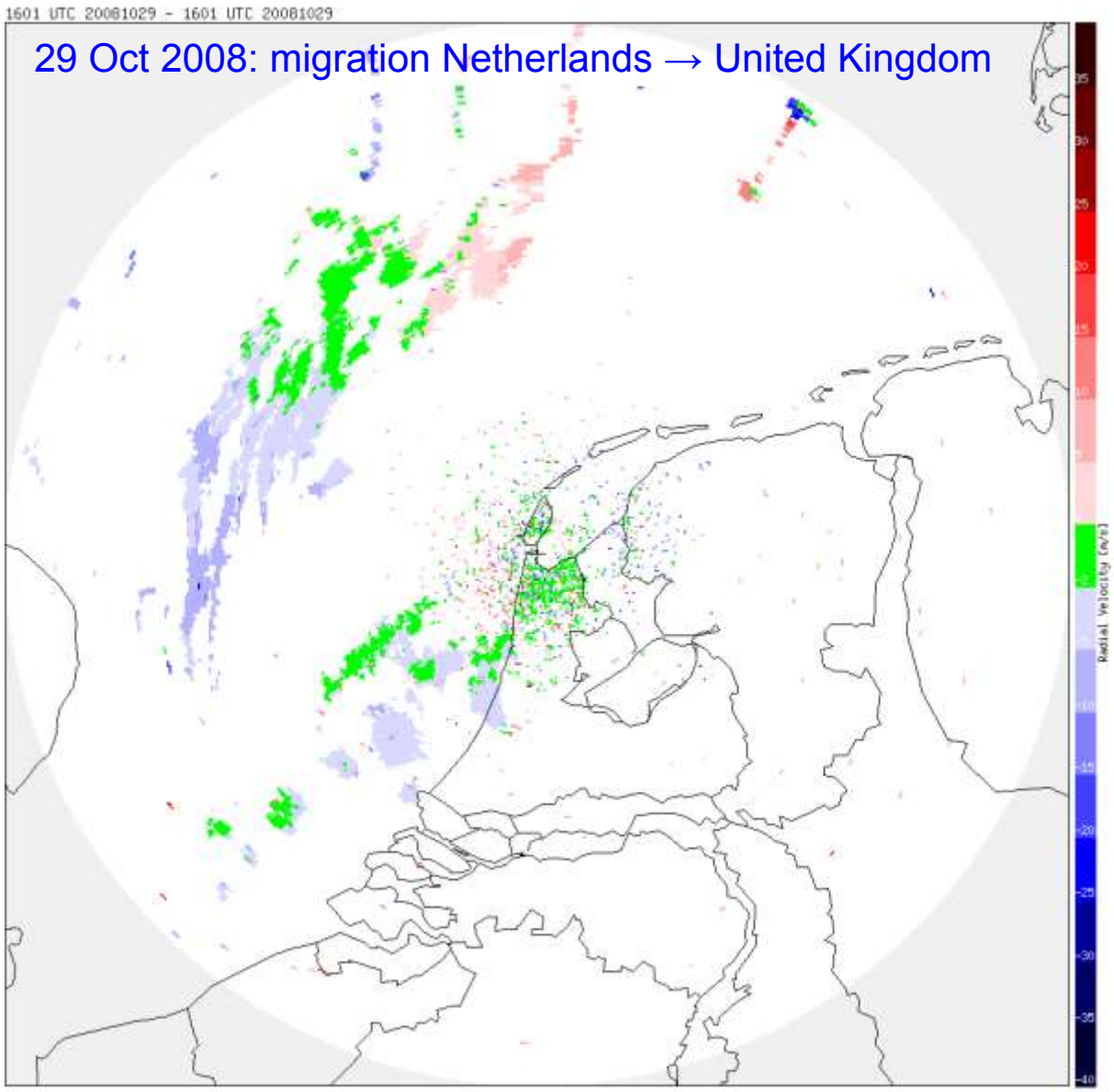


Image NOAA

Conclusions

- Weather radar can determine reliable bird density altitude profiles automatically – method is easily portable.
- A prototype insect profiling algorithm based on the bird profiling algorithm would be fairly easy to design (for situations without precipitation).
- Diurnal insect movements at mid-latitudes much more pronounced in weather radar than nocturnal movements, and more easily distinguished from birds
- Cases with spatial overlap insects/birds remain problematic (with and without dual-pol).

Thank you



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