Optic flow and energy invariants combined may explain gulls' altitude profiles during offshore takeoff

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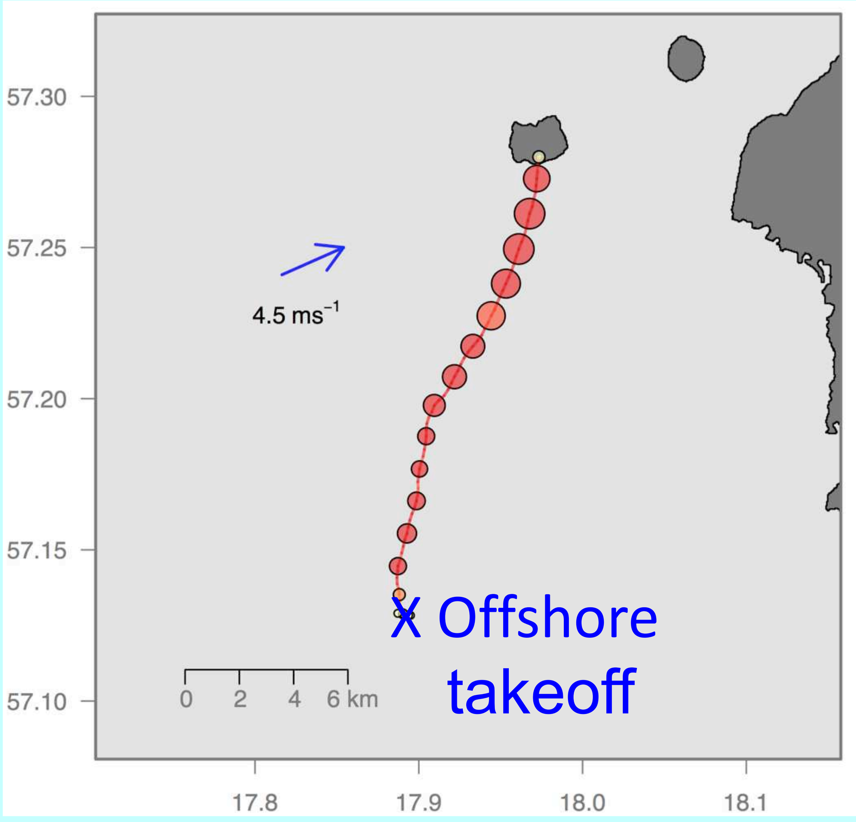
Aim: To investigate which cues are used by Gulls to control their altitude during takeoff by testing the constant optic flow hypothesis

GPS tracking of Gulls



Lesser black-backed gull *Larus fuscus* equipped with Bio-logger UvA-BiTS (Sampling interval of the GPS: 15 sec)

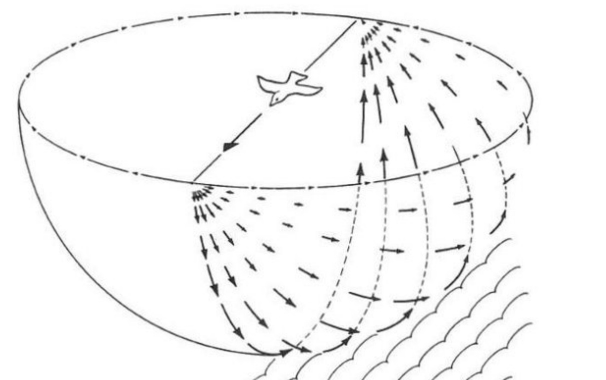
Gull take-off trajectory in Baltic Sea (Stora Karlsö Island, Sweden)

"Preferred ventral optic flow" Hypothesis

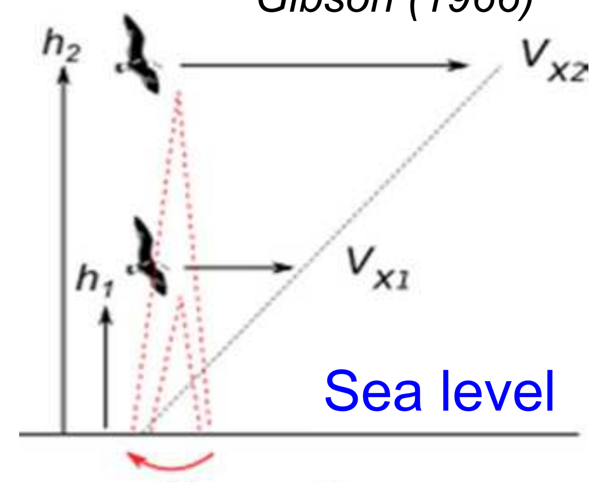
- When gulls are flying forward, the image of the sea sweeps backward across their ventral viewfield and forms an "optic flow", which depends on both the groundspeed and the groundheight.
- The "ventral optic flow" perceived by the gull, i.e., the apparent angular velocity ω created by a point directly below on the flight track, is simply equal to the ratio *Vx/h*, between groundspeed, *Vx* and the groundheight, *h*.

Are gulls controlling their altitude by keeping this ratio constant ?

(as flying insects are doing, Franceschini, Serres, Ruffier, 2007)



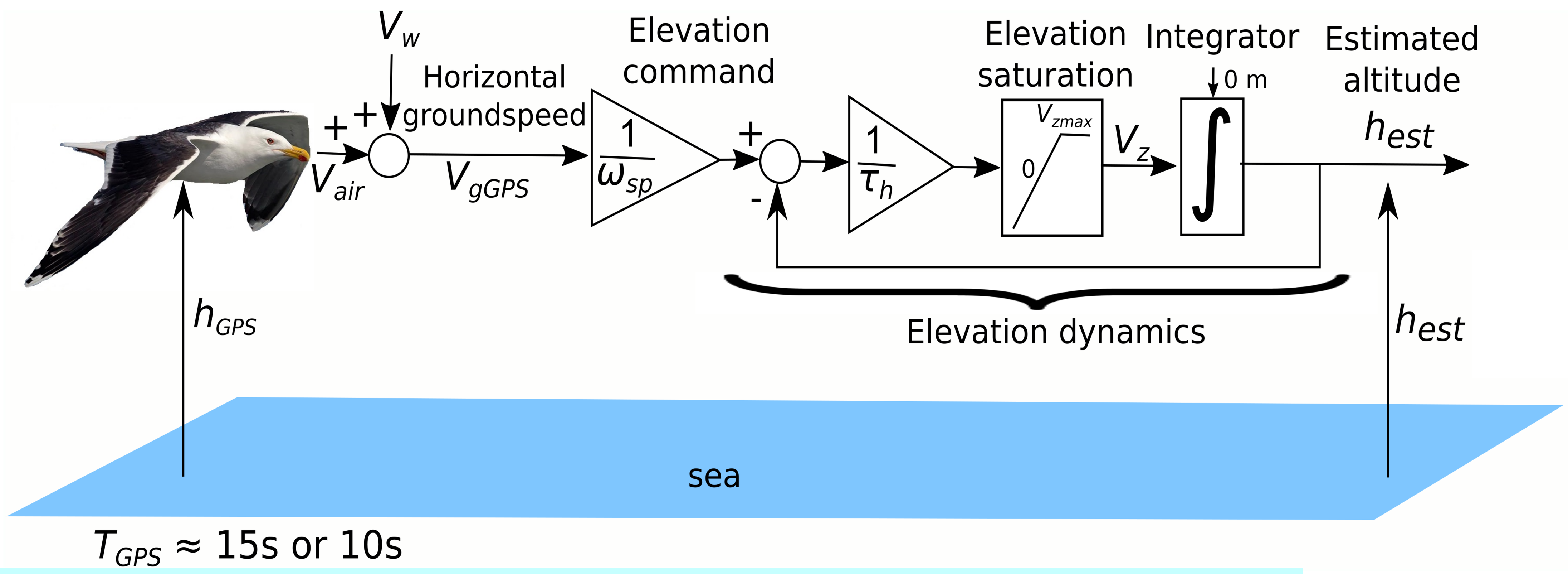
Gibson (1966)

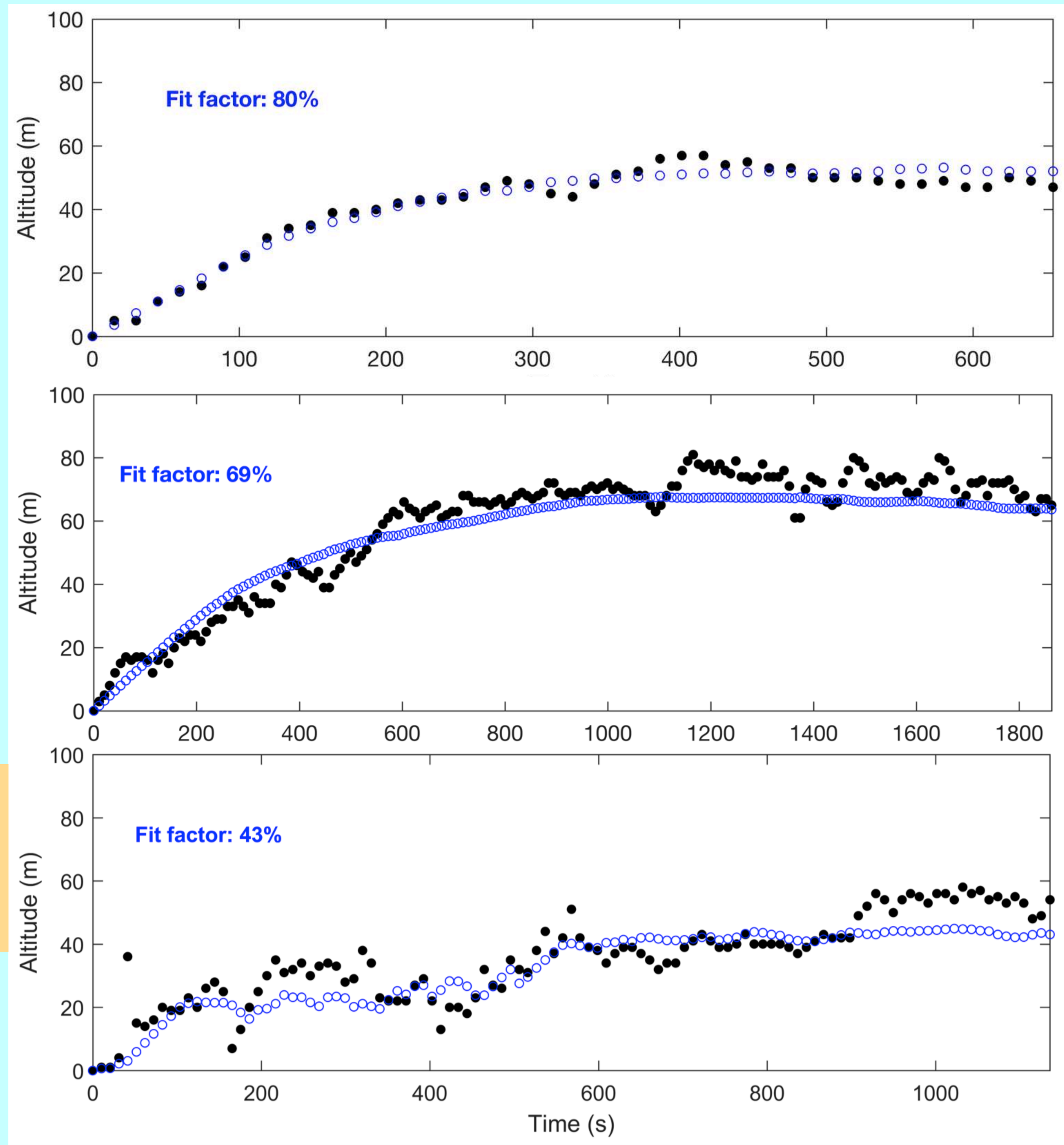


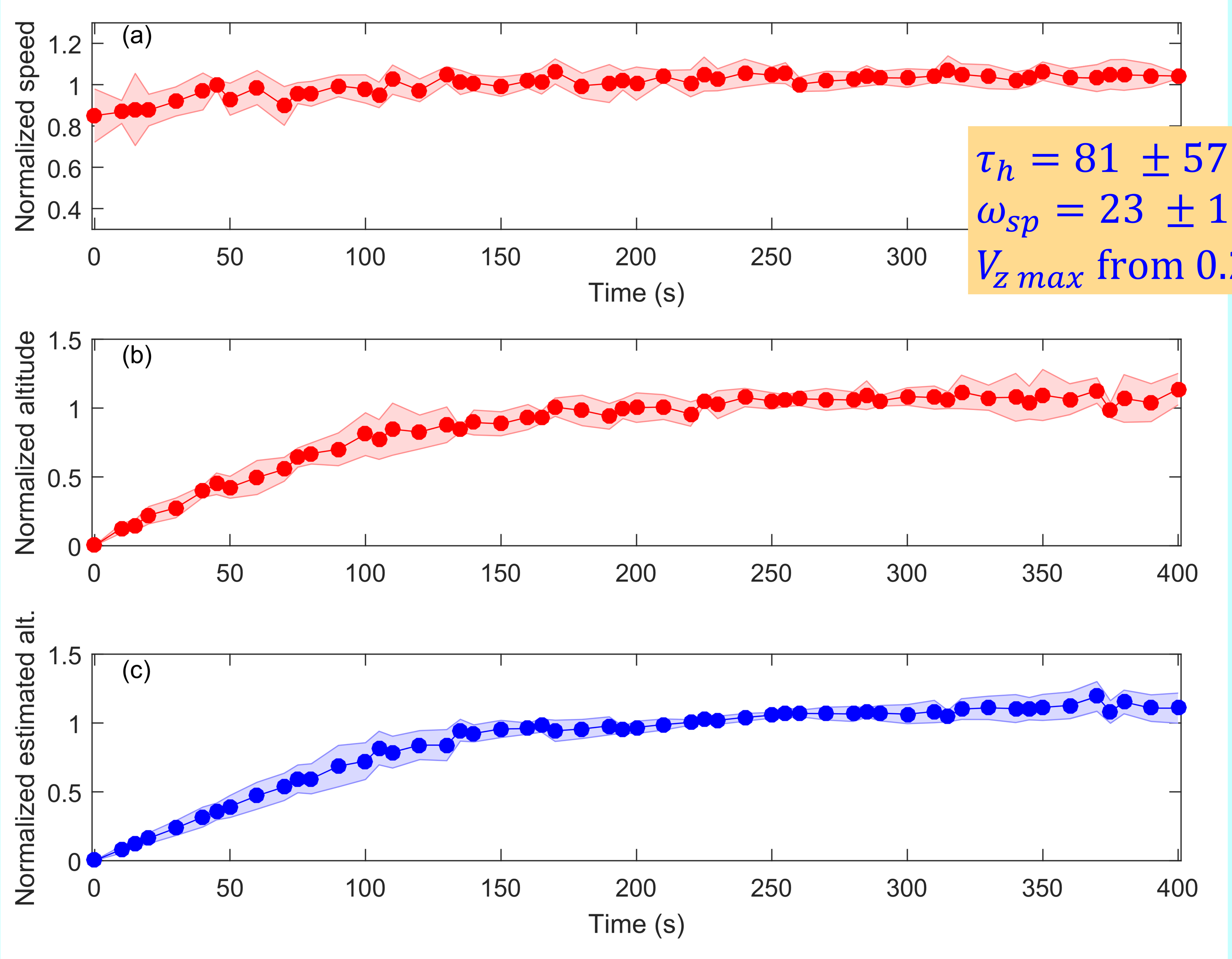
$$\omega = \frac{V_{x2}}{h_2} = \frac{V_{x1}}{h_1}$$

Results: Altitude Control Model parameterized using individual bird metrics (mass, wingspan, …)

- We used high time resolution (10-15sec) GPS tracking of lesser black backed gull from off-shore takeoff towards their breeding colony.
- The altitude control model is based on (i) the bird elevation dynamics and (ii) the "constant optic flow" hypothesis using individual bird metrics.







$\tau_h = 81 \pm 57\ sec$
$\omega_{sp} = 23 \pm 10°/sec$
$V_{z\,max}$ from 0.2 to 0.45 m/sec

(a) Normalized horizontal groundspeed coming from GPS data
*(b) Normalized altitude **measured** by GPS (by removing the first 100 seconds).*
*(c) Normalized altitude **estimated** by the optic-flow based altitude model.*
Red dots represent GPS recorded at a sampling time 10 s (12 trajectories) or 15 s (6 trajectories), blue dots represent the altitude computed by the model.
Dots represent the median value and shaded areas represent the median absolute deviation (MAD).

The figure is based on 18 trajectories extracted from 9 tracked gulls.

Conclusion

- A linear 1st order parametric model on gulls' data (18 trajectories) gives a fit factor value of 37.6% on average (range: 10 – 80%).
- By introducing a ceiling in the climbing rate according to Hedenström et al., 2003, In: *Avian Migration* (prediction 10), the non-linear parametric model on 18 trajectories gives a fit factor value of 57.1% on average (range 15 – 80%).
- For GPS-tracked offshore takeoffs by gulls, the normalized altitude computed with the mathematical model using GPS derived horizontal groundspeed data predicts altitudes close to actual GPS recorded altitude, thus suggesting **gulls use an optic flow-based system for control of takeoff flight.**