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► **To cite this version:**

Julien Serres, Thomas J Evans, Susanne Åkesson, Olivier Duriez, Judy Shamoun-Baranes, et al..
Optic flow and energy invariants combined may explain gulls' altitude profiles during offshore takeoff.
The 6th International Bio-logging Science Symposium (BLS6), Sep 2017, Lake Constance, Germany.
hal-02078084

HAL Id: hal-02078084

<https://amu.hal.science/hal-02078084v1>

Submitted on 25 Mar 2019

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

J. Serres⁽¹⁾, T. Evans⁽²⁾, S. Åkesson⁽²⁾, O. Duriez⁽³⁾, J. Shamoun-Baranes⁽⁴⁾, F. Ruffier⁽¹⁾, A. Hedenström⁽²⁾

(1) Aix Marseille Univ, CNRS, ISM, Marseille, France, julien.serres@univ-amu.fr

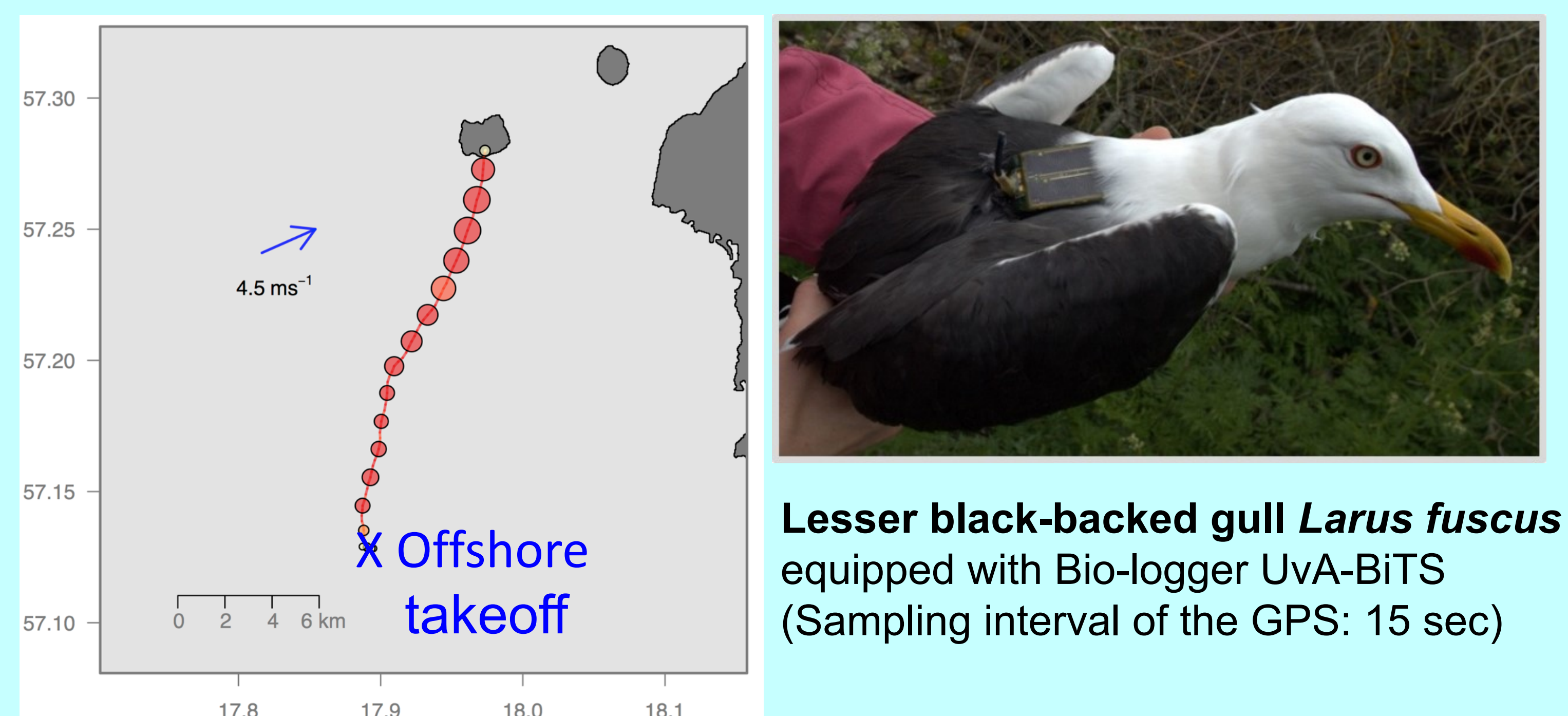
(2) CANMove centre, Department of Biology, Lund University, Box 117, SE-221 00 Lund, Sweden

(3) CEFE UMR 5175, CNRS - Université de Montpellier, 34293 Montpellier cedex 5, France

(4) Theoretical & Computational Ecology, Inst. of Biodiversity and Ecosystem Dynamics, Univ. of Amsterdam, 1090GE Amsterdam, The Netherlands

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

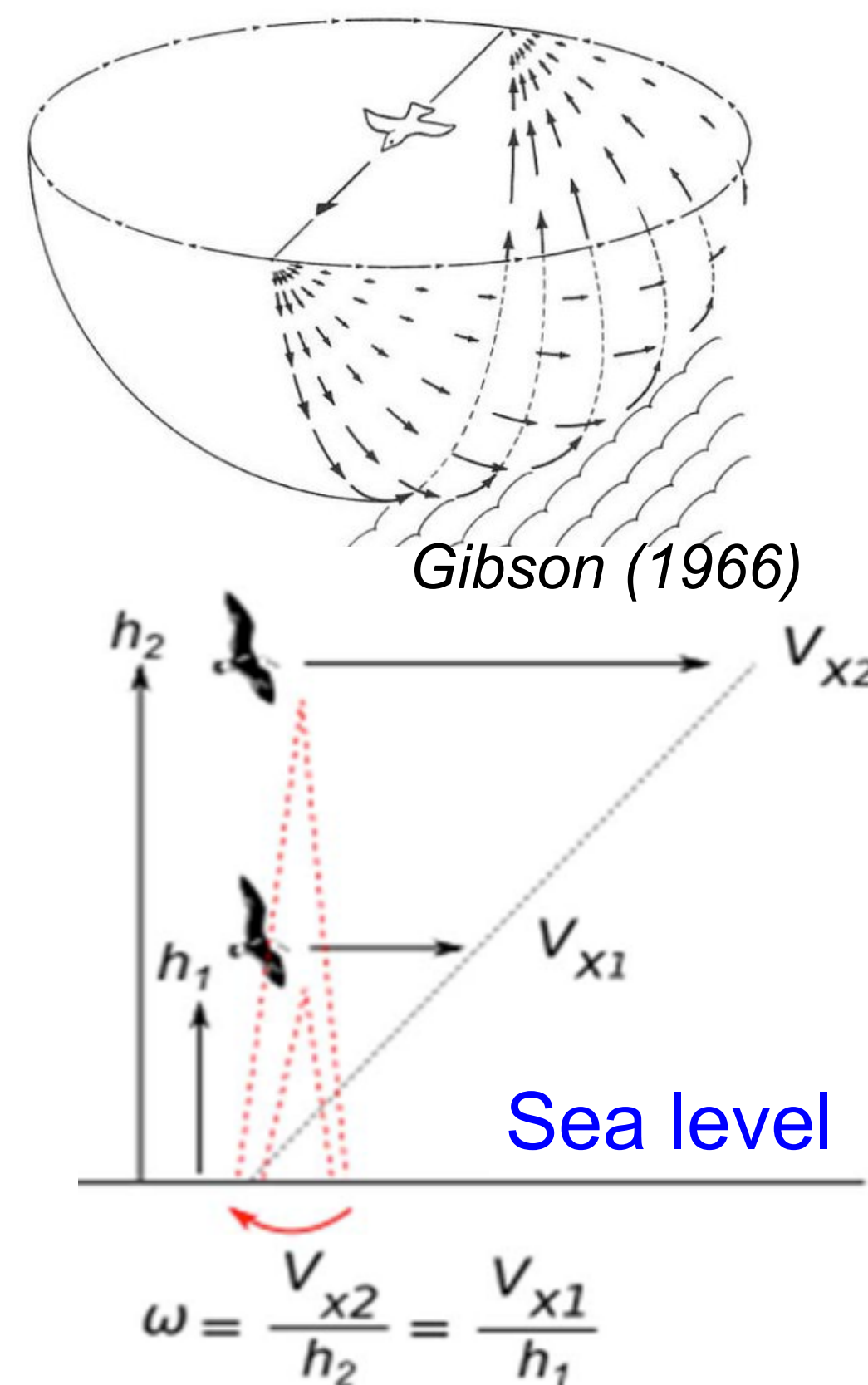
GPS tracking of Gulls



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 V_x/h , between groundspeed, V_x and the groundheight, h .

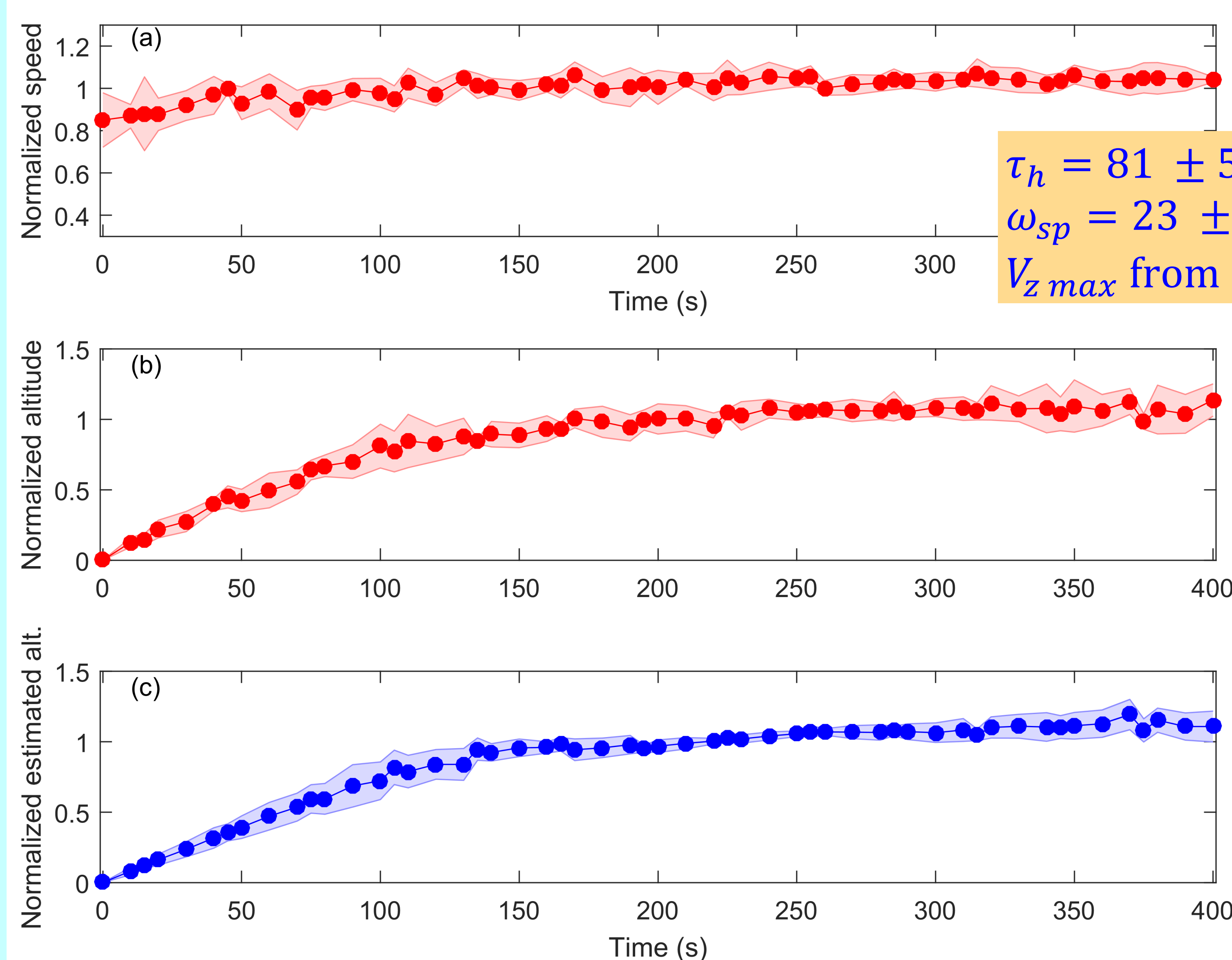
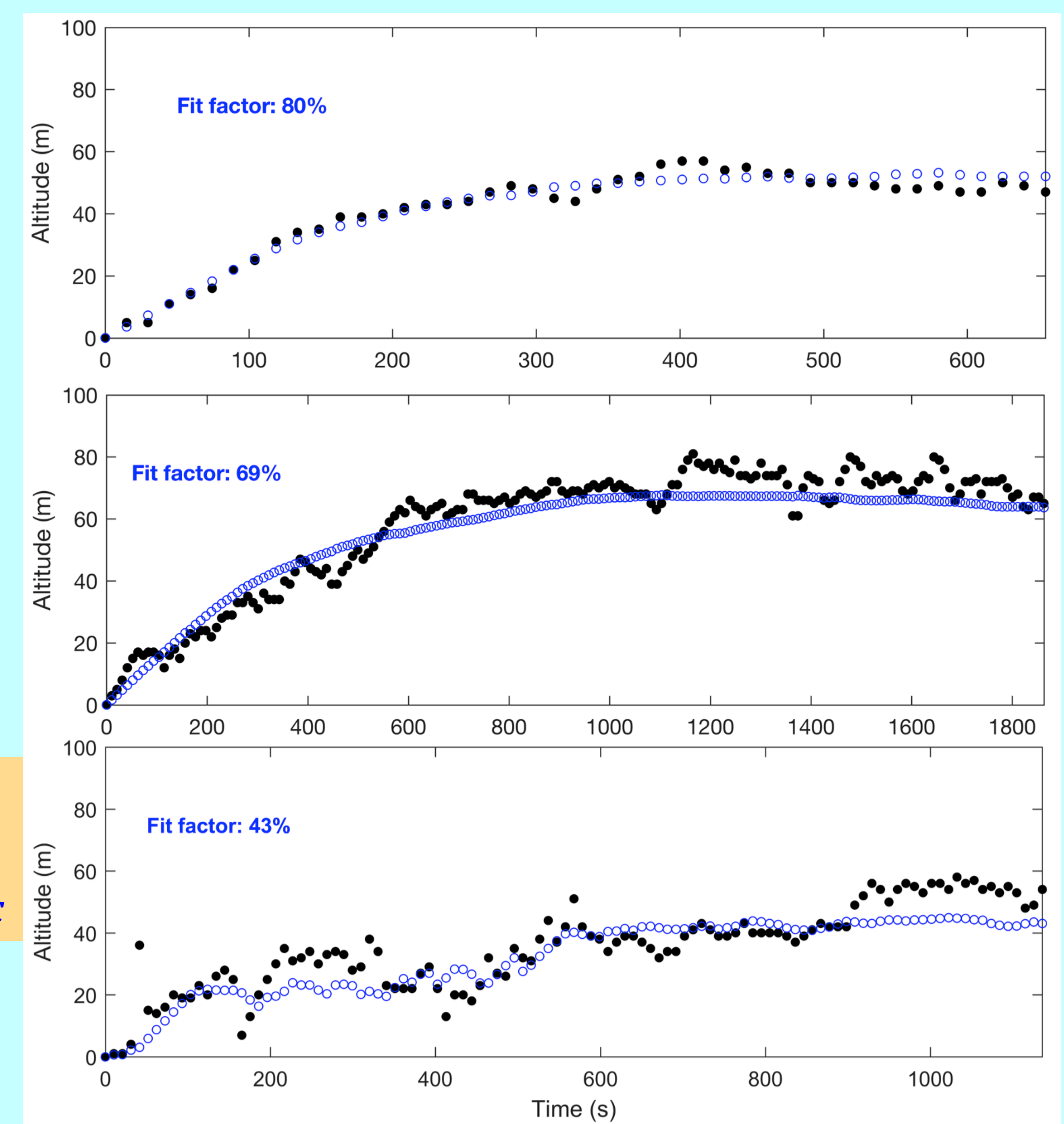
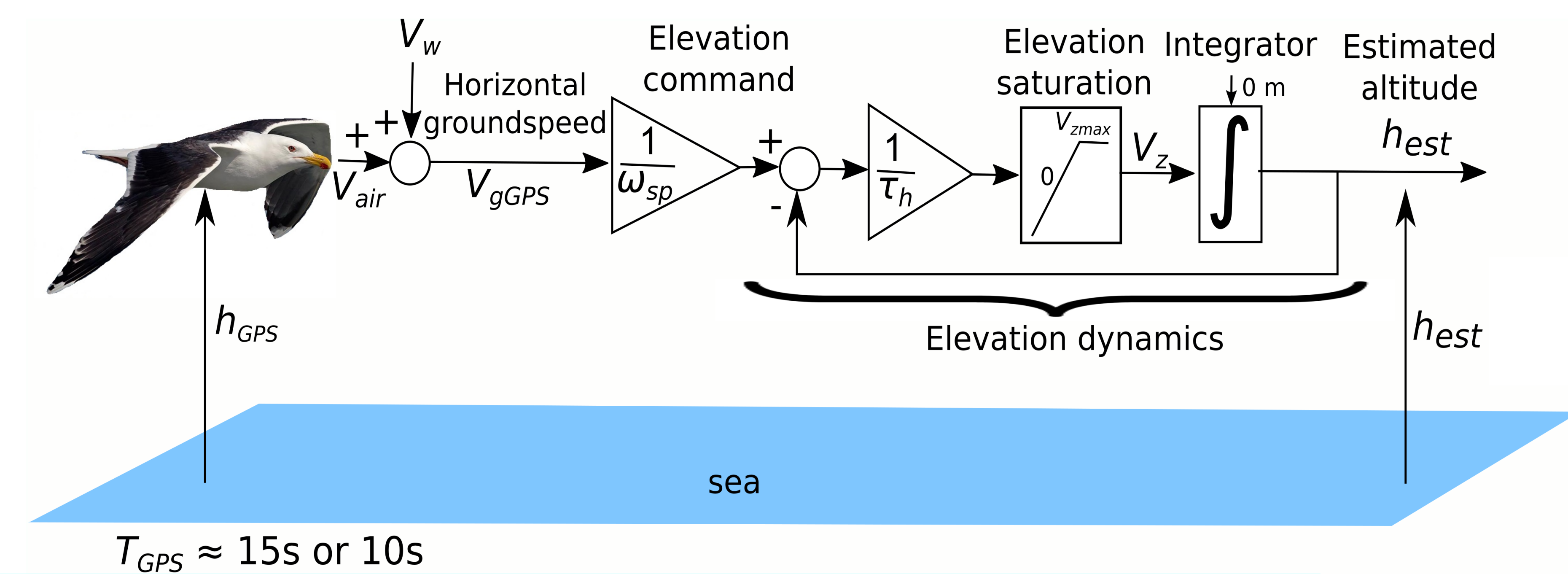


Are gulls controlling their altitude by keeping this ratio constant?

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

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.



$\tau_h = 81 \pm 57 \text{ sec}$
 $\omega_{sp} = 23 \pm 10^\circ/\text{sec}$
 V_{zmax} 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**.