

A photograph of a bison standing in a grassy field. The bison is facing right, showing its dark, shaggy coat and large, curved horns. The field is covered in tall, golden-brown grass and small white flowers. In the background, there is a dense forest of green coniferous trees under a clear blue sky.

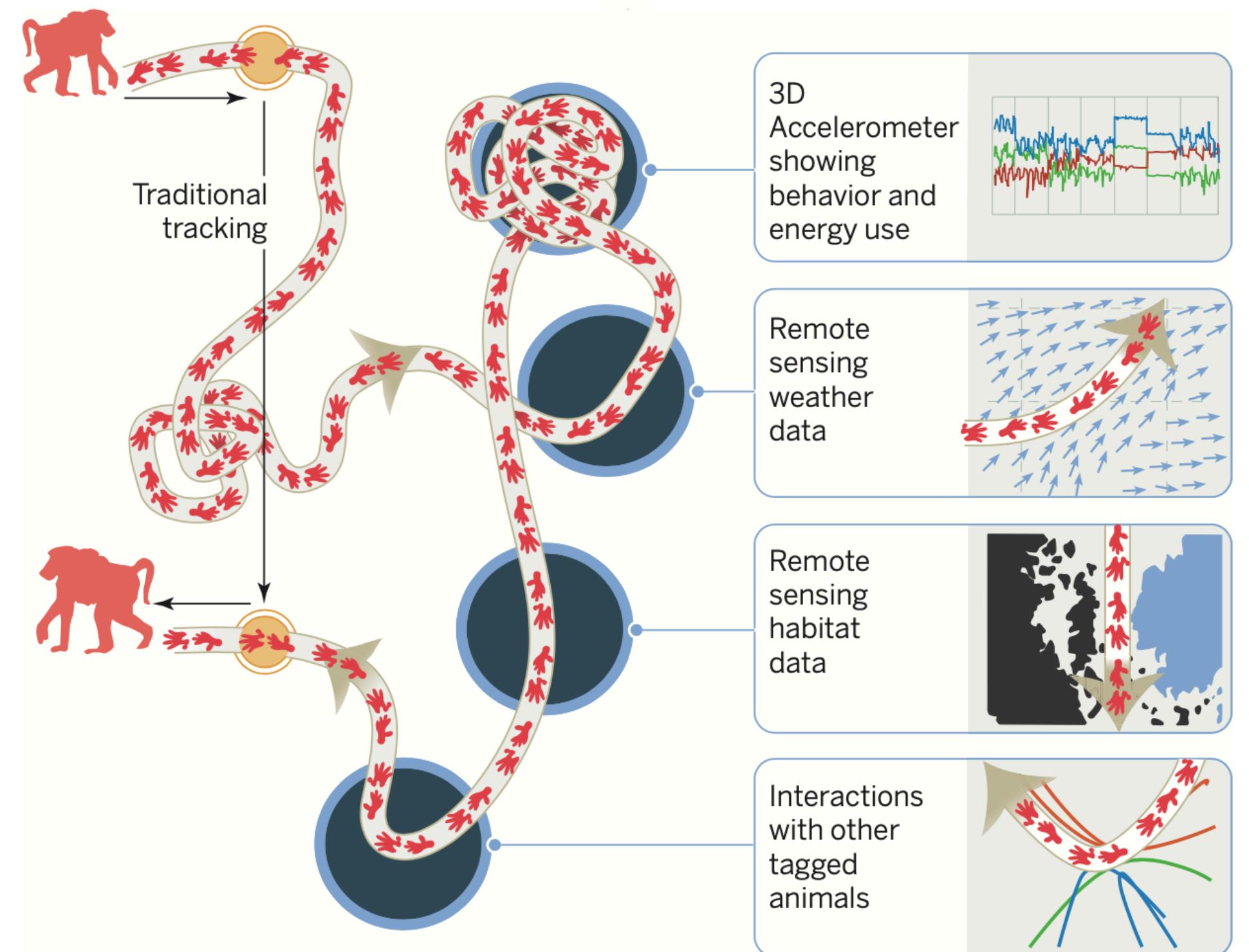
GUIDELINES FOR ESTIMATING BEHAVIORAL STATES

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September 8, 2022

Guiding questions

1. What are your research objectives?
2. Do your tags report sizable location errors?
3. How frequently are your tags transmitting?
4. Are you trying to estimate > 2 states?
5. Are you interested in fine- or coarse-scale behavioral patterns?

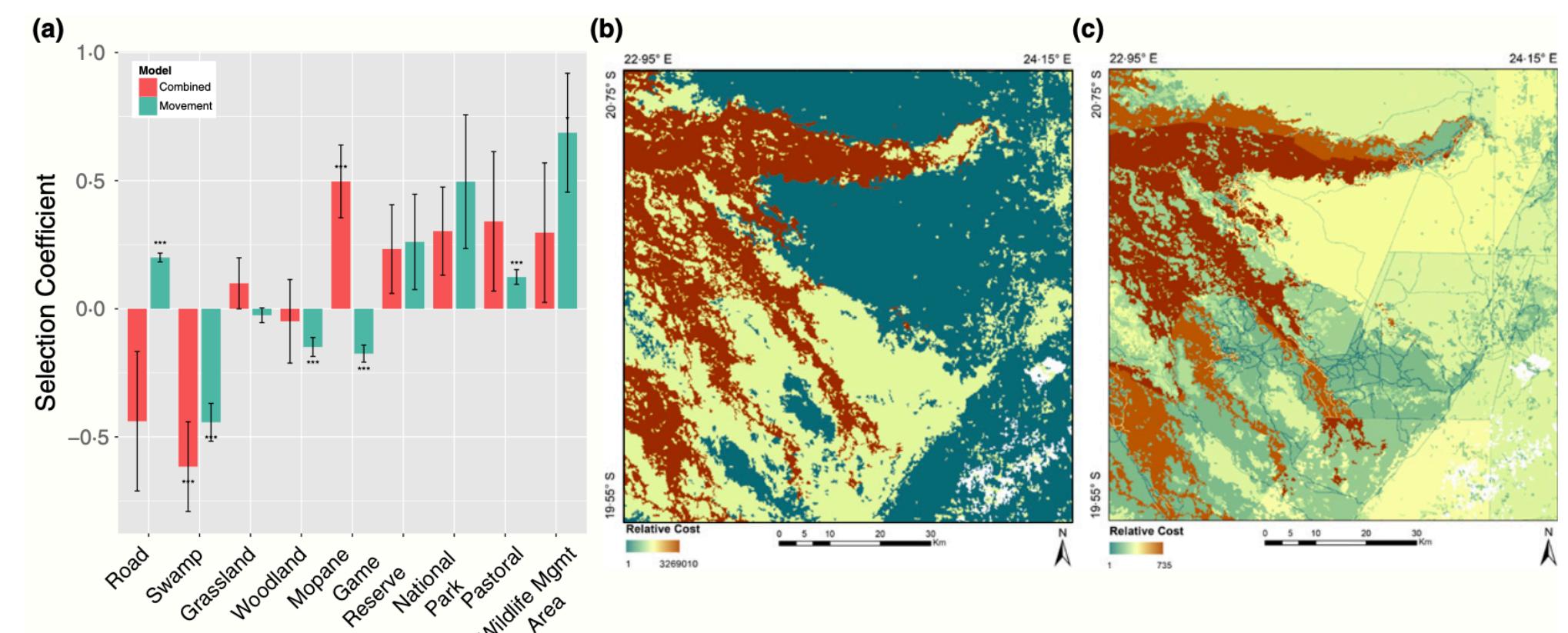
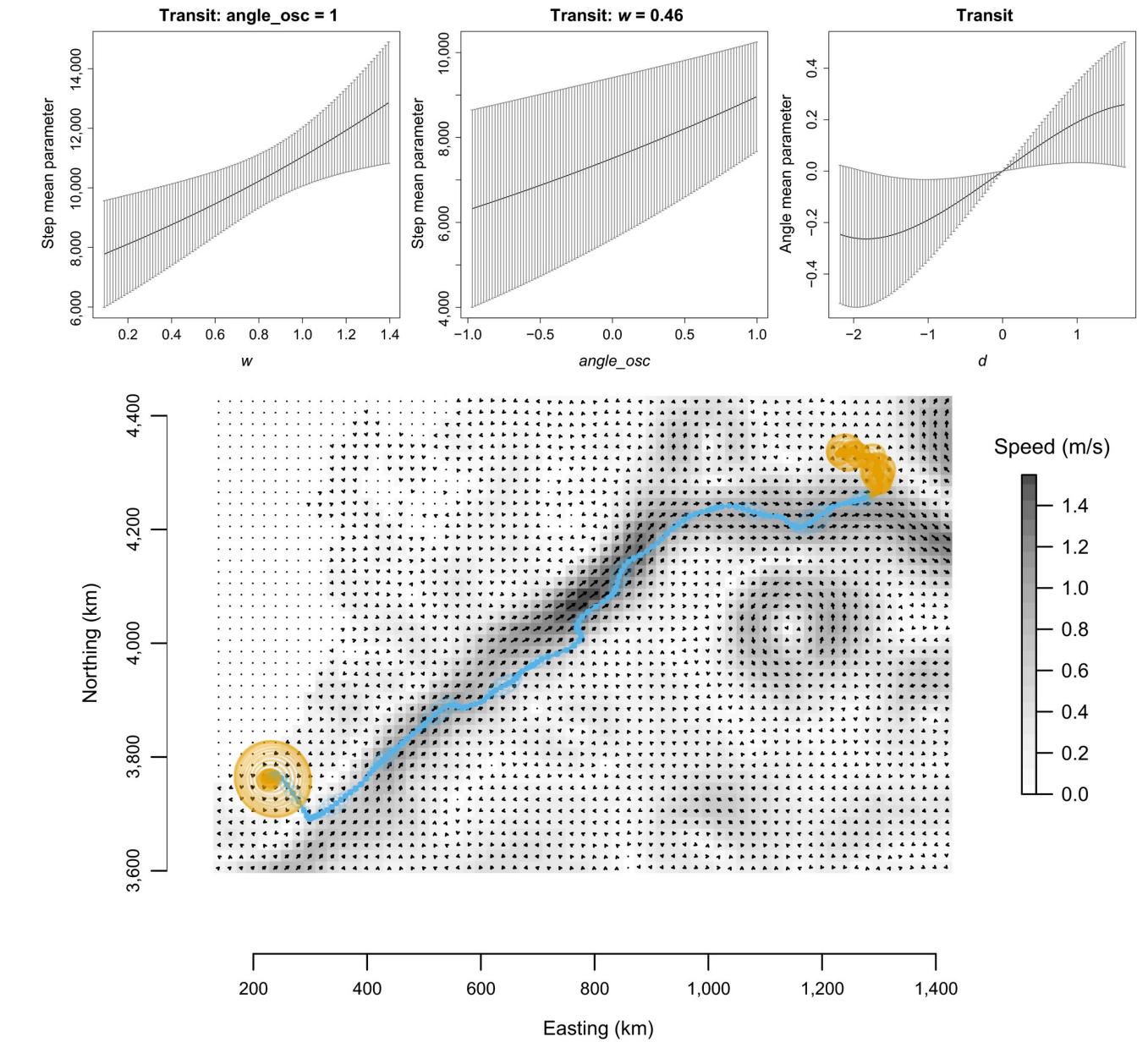


Kays et al. 2015

1. What are your research objectives?

- Often, the estimation of behavioral states serves as an intermediate step for subsequent analyses
- Estimating states to identify foraging grounds or movement corridors
 - SSM, HMM, M3/M4
- Investigating the effect of environmental covariates on state transition rates
 - SSM or HMM
- Estimating and characterizing states from numerous data streams
 - HMM or M3/M4
- Estimating behavioral state-habitat associations
 - HMM or M3/M4

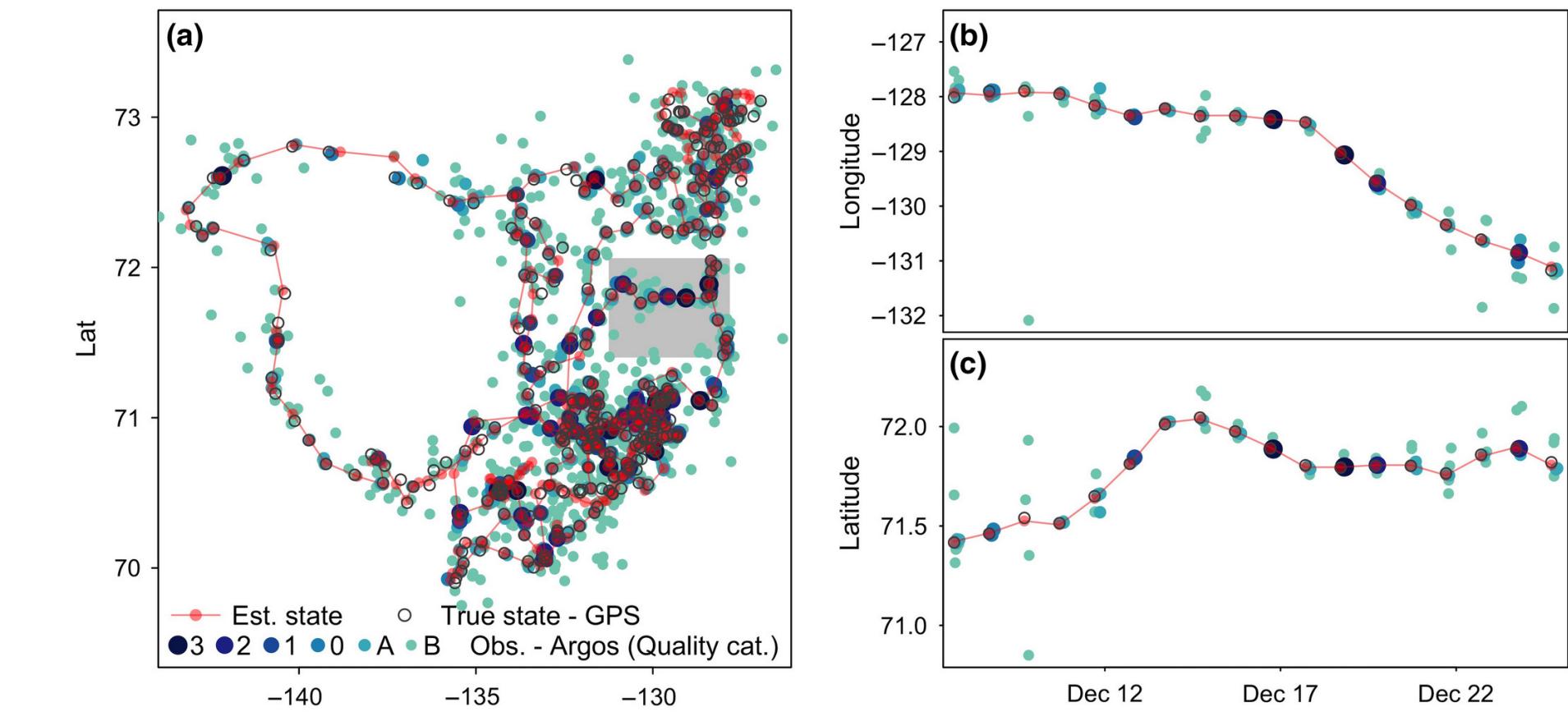
McClintock and Michelot 2018



Abrahms et al. 2017

2. Do tags report sizable location error?

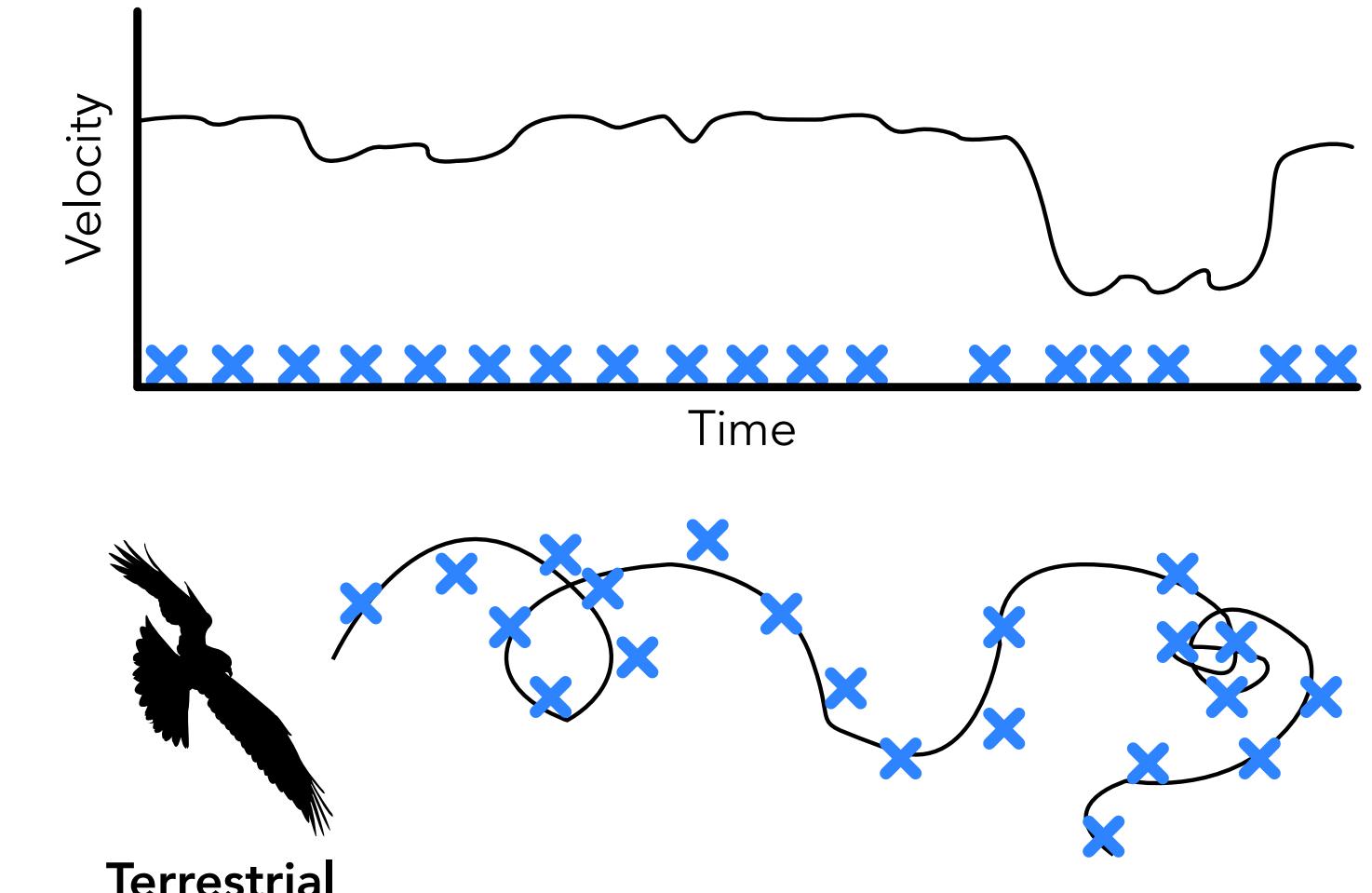
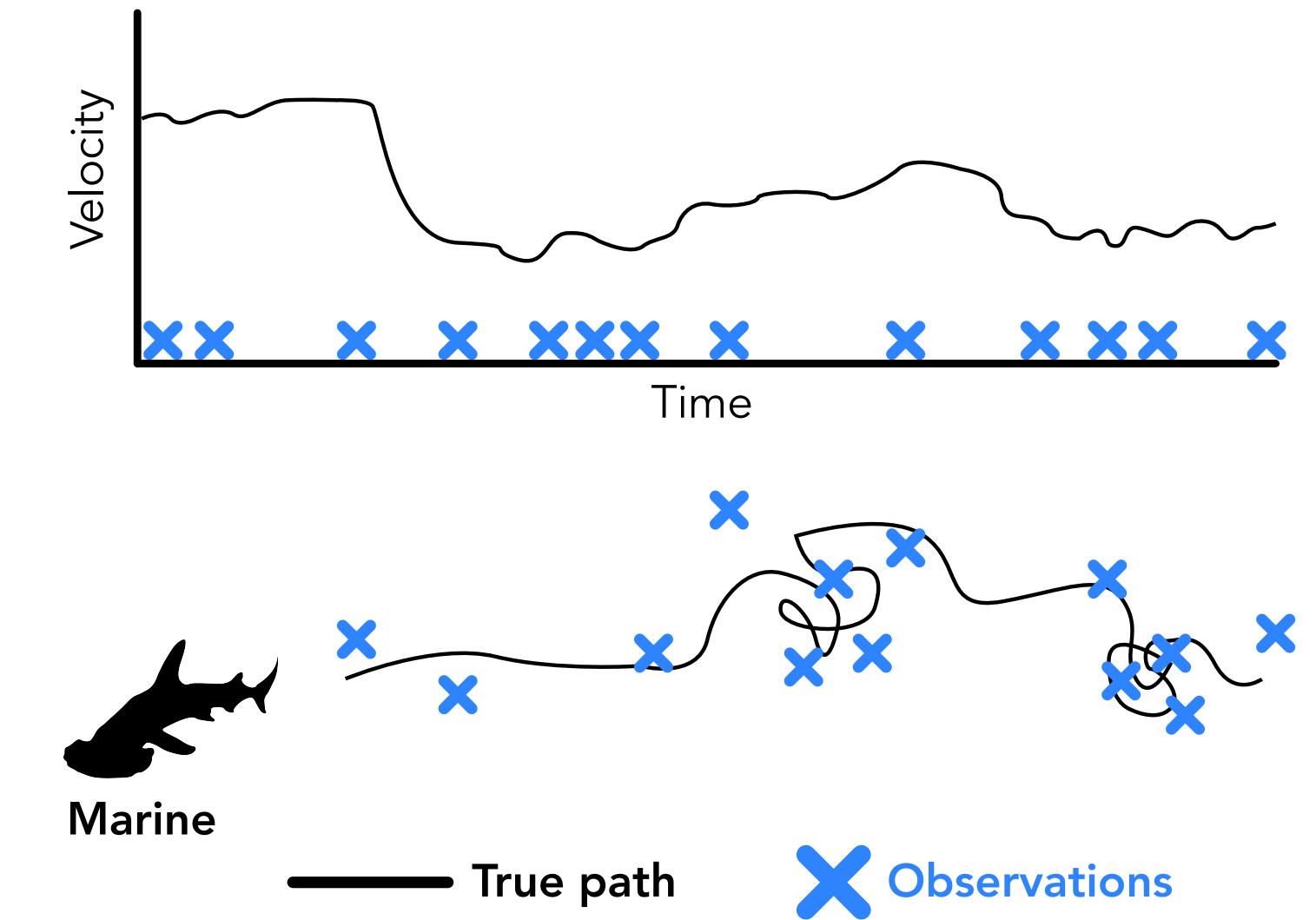
- For marine animals tracked w/ Argos satellites, majority of positions often have errors > 1.5 km
- For terrestrial animals tracked w/ GPS (or marine animals tracked w/ FastlocGPS), errors are often around 30 m
- Animals tracked with Argos (via doppler shift)
 - SSM
 - Alternatively, HMM or M3/M4 may be used if locations have first been processed via SSM
- Animals tracked with some form of GPS transmission
 - SSM, HMM, M3/M4



Auger-Methe et al. 2021

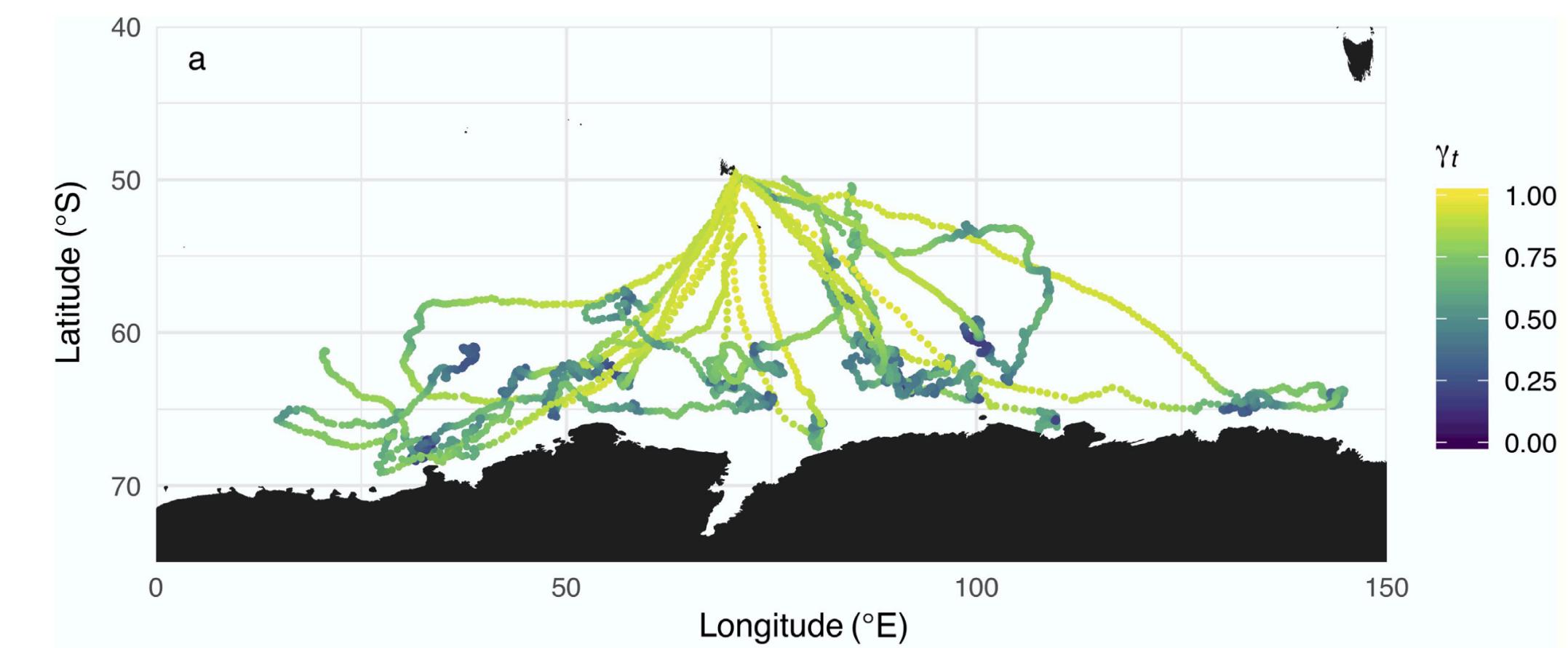
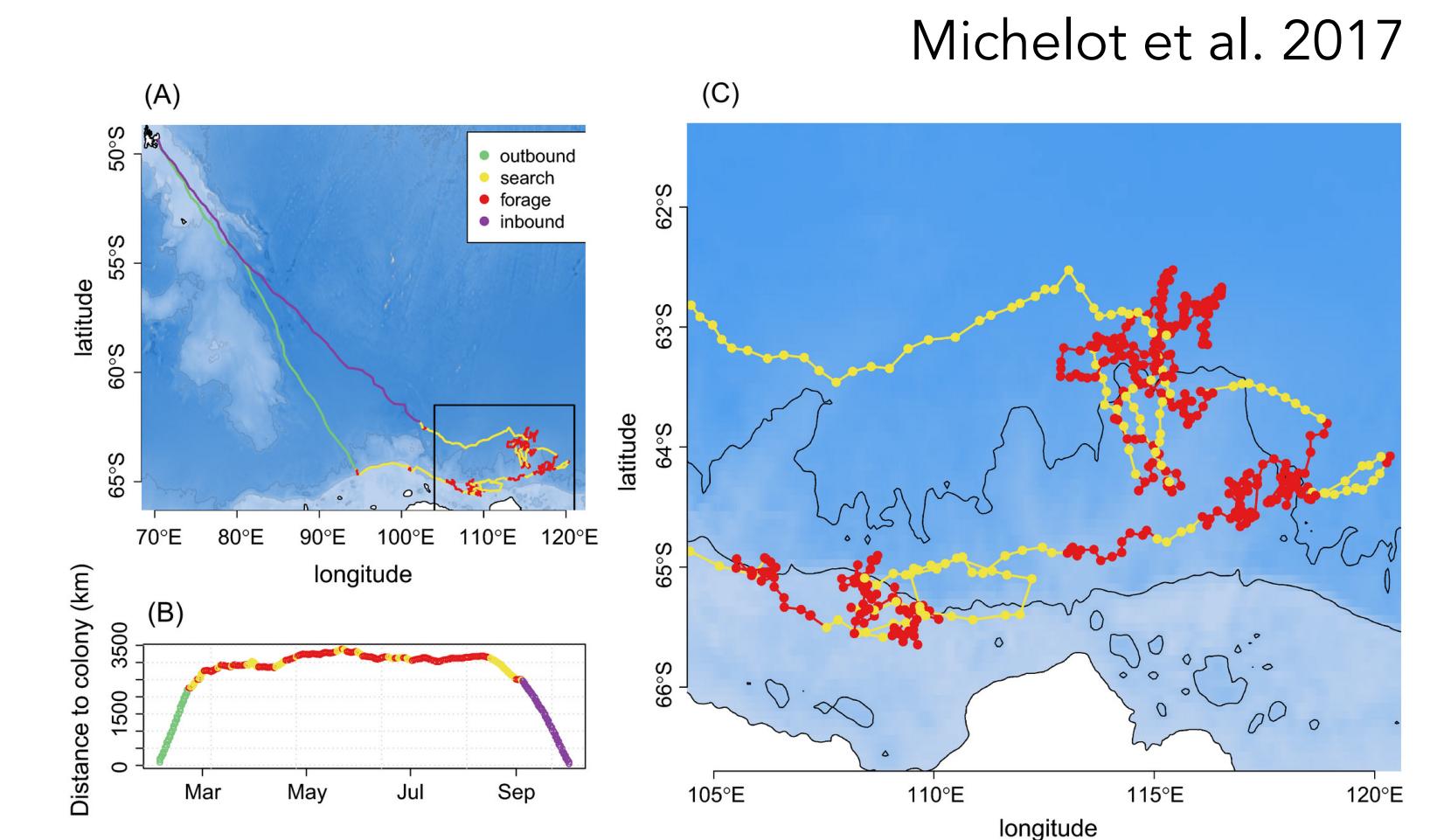
3. How frequently are tags transmitting?

- A question of dataset size, as well as (ir)regular time intervals
- Time intervals are highly irregular
 - M3/M4 or continuous-time SSM/HMM
- Time intervals are regular
 - SSM, HMM, M3/M4
- Observations are transmitted very frequently (e.g., <5 min time intervals)
 - SSM or M3/M4
 - Hidden semi-Markov models (HSMMs)



4. Trying to estimate >2 states?

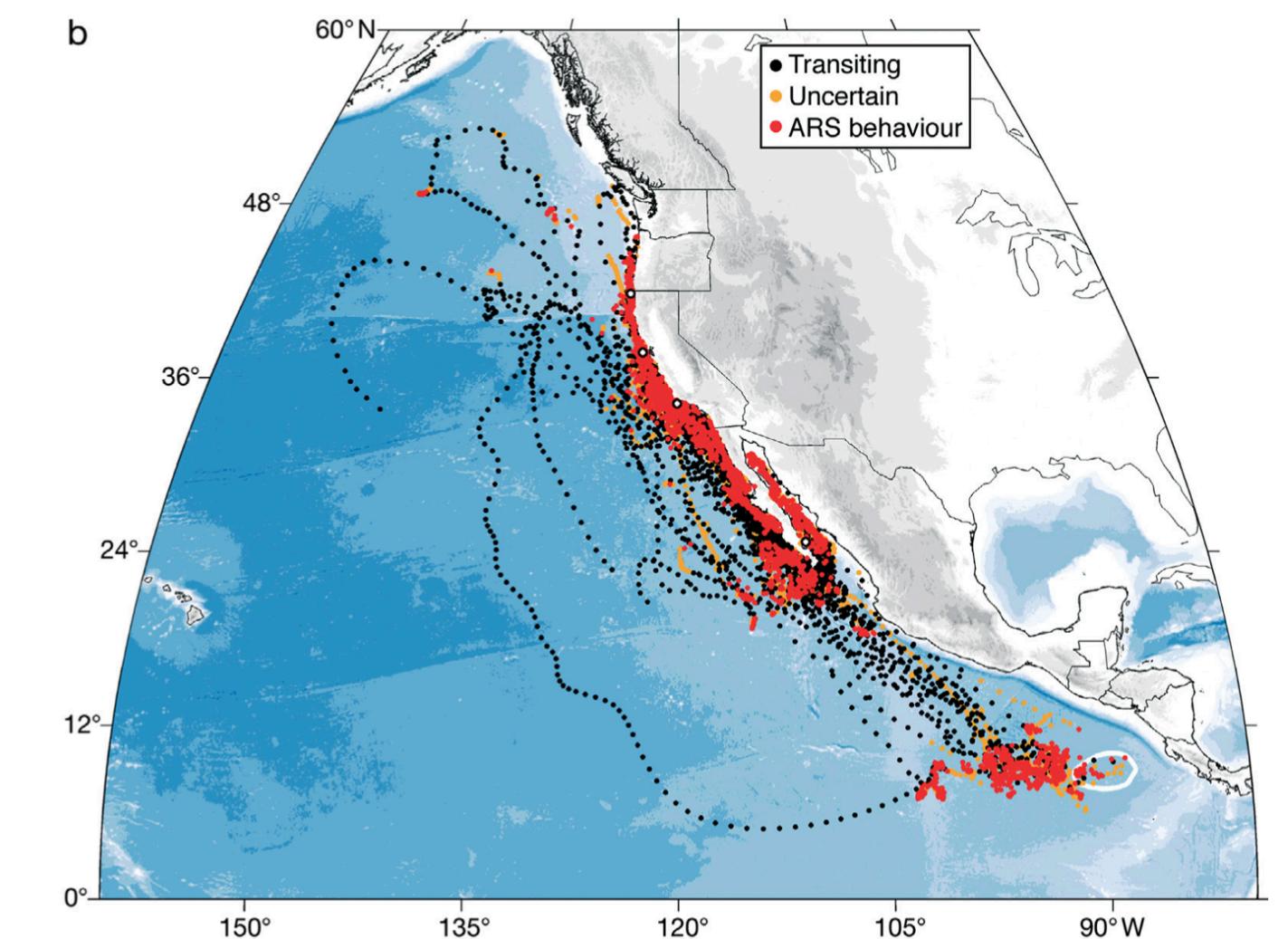
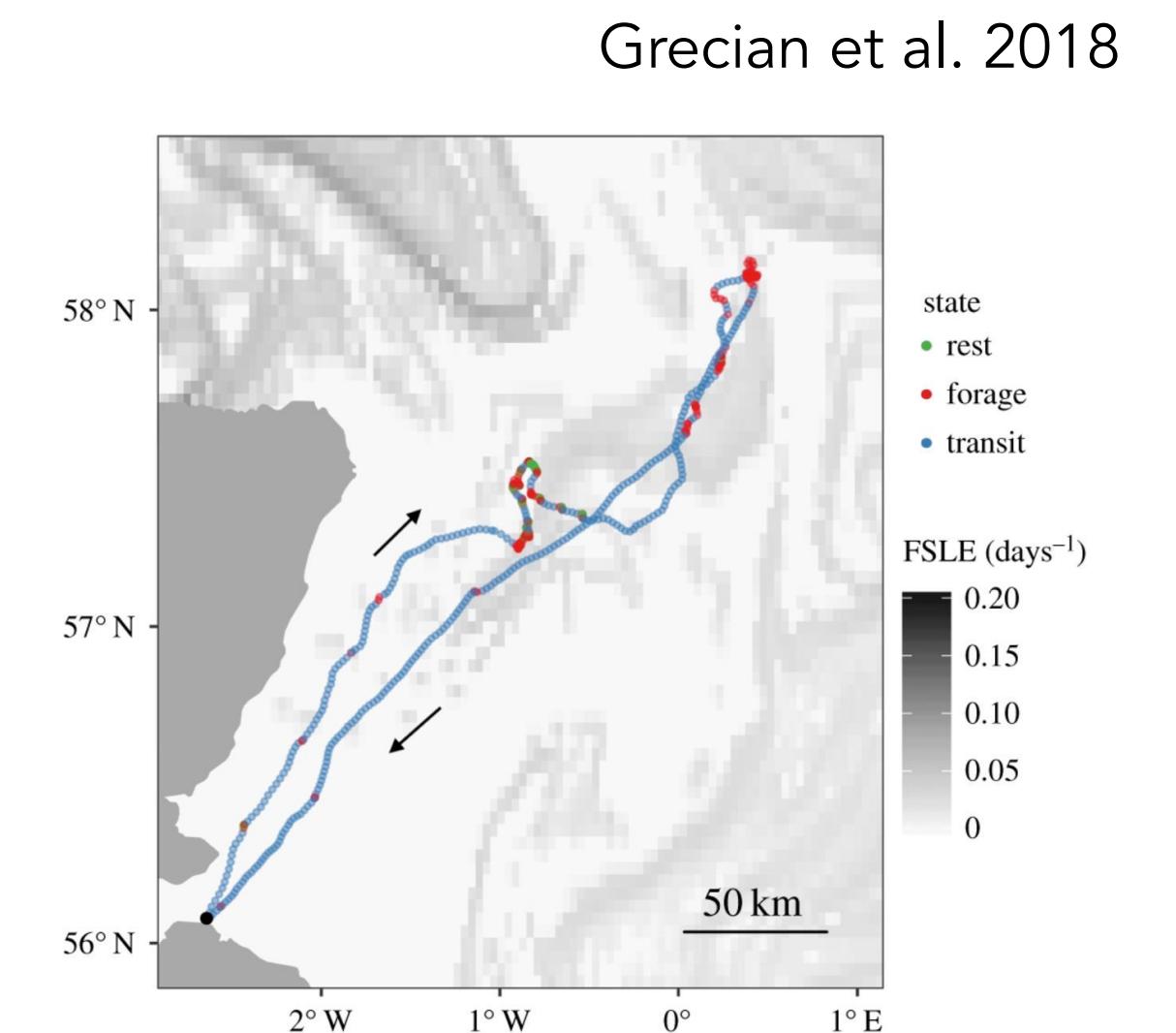
- Also impacted by number of data streams and differences between possible states
- HMM or M3/M4
- Is it a move persistence model for SSM?
 - Behavioral changes along a continuum of multiple states; no discrete switches



Jonsen et al. 2019

5. Interested in fine- or coarse-scale patterns?

- Also depends on time intervals and underlying movement patterns of animal
- Fine-scale
 - SSM, HMM, M3
- Coarse-scale
 - M4
 - Will need to coarsen time step if using SSM, HMM, or M3



Bailey et al. 2009

Other methods not covered

Accounting for Argos location error ONLY

- CTCRW SSM in `crawl` R package

Estimating latent behavioral states

- Bayesian SSM in `bsam` R package
- HMM performed using TMB in `hmmTMB` R package
- Segmentation and clustering of tracks in `segclust2d` R package

See 'Useful Resources' page on workshop website for associated info

References

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