HZDR HELMHOLTZ-ZENTRUM DRESDEN-ROSSENDORF

CASUS CENTER FOR ADVANCED SYSTEMS UNDERSTANDING

AniMove 2024, June 17th to 28th

Occurrence distributions

Using the 'ctmm' R package

Inês Silva, Chris Fleming

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TECHNISCHE UNIVERSITÄT DRESDEN

CBG Max Planck Institute of Molecular Cell Biology and Genetics

UFZ HELMHOLTZ Centre for Environmental Research

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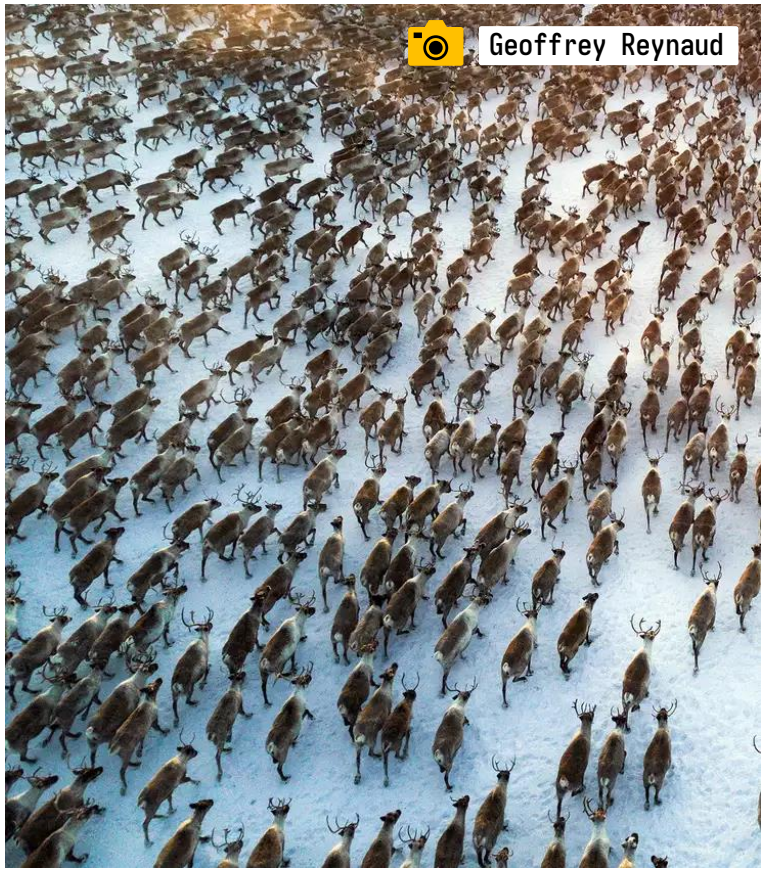

Billions of animals migrate worldwide to exploit ***seasonal resources***, ***escape severe weather***, ***breed***, or to ***avoid predation***.

Which areas of a landscape contain high-priority resources (*e.g.*, ***migratory corridors/stopovers***)?

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Billions of animals migrate worldwide to exploit ***seasonal resources***, ***escape severe weather***, ***breed***, or to ***avoid predation***.

Which areas of a landscape contain high-priority resources (*e.g.*, **migratory corridors/stopovers**)?

How likely is it to visit a location of interest (*e.g.*, **wildlife crossing sites, wind farms**)?

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Roads have significant impacts on ecological systems, increasing the ***extinction risk*** of threatened species.

Where did an animal cross a linear feature (*e.g.*, **road- or railways**)?

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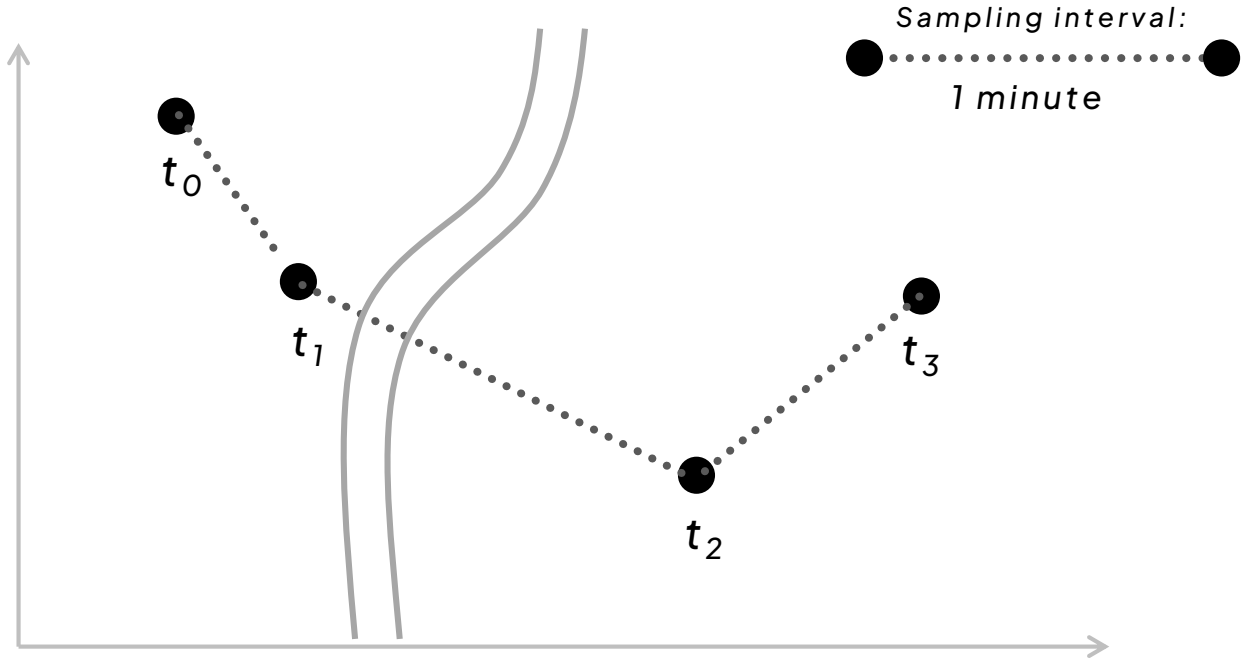

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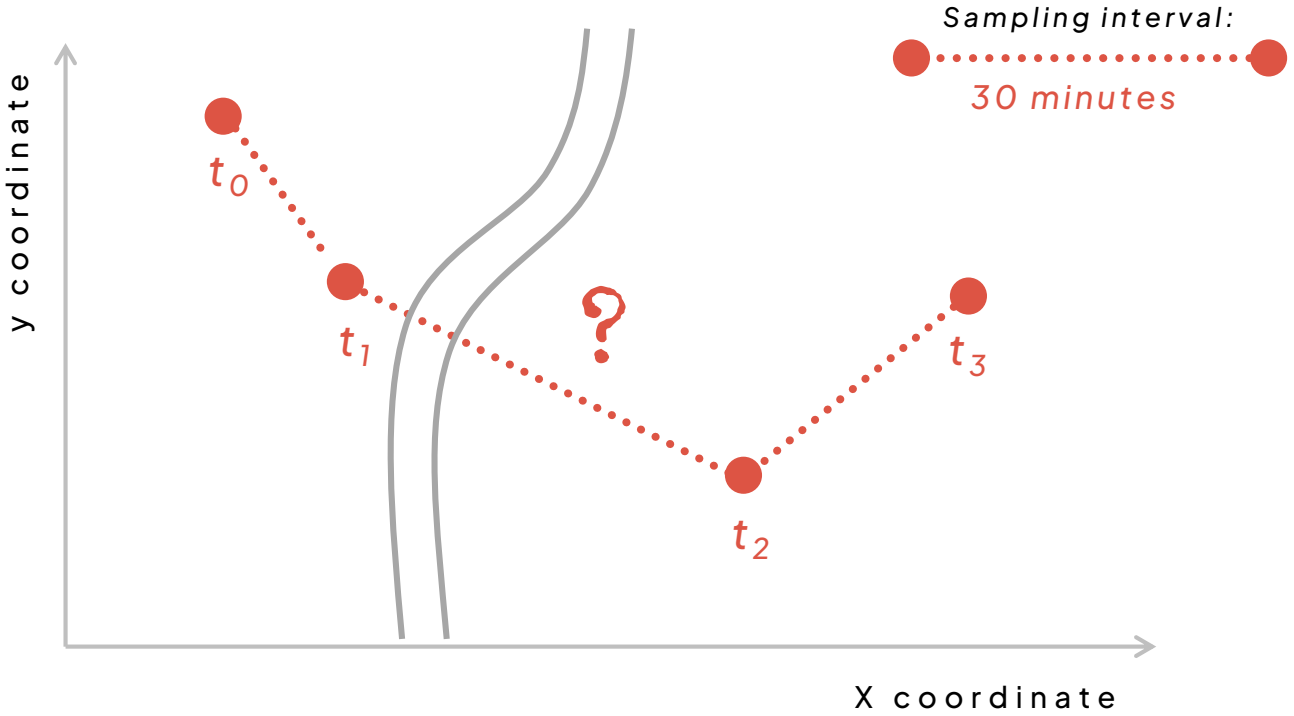

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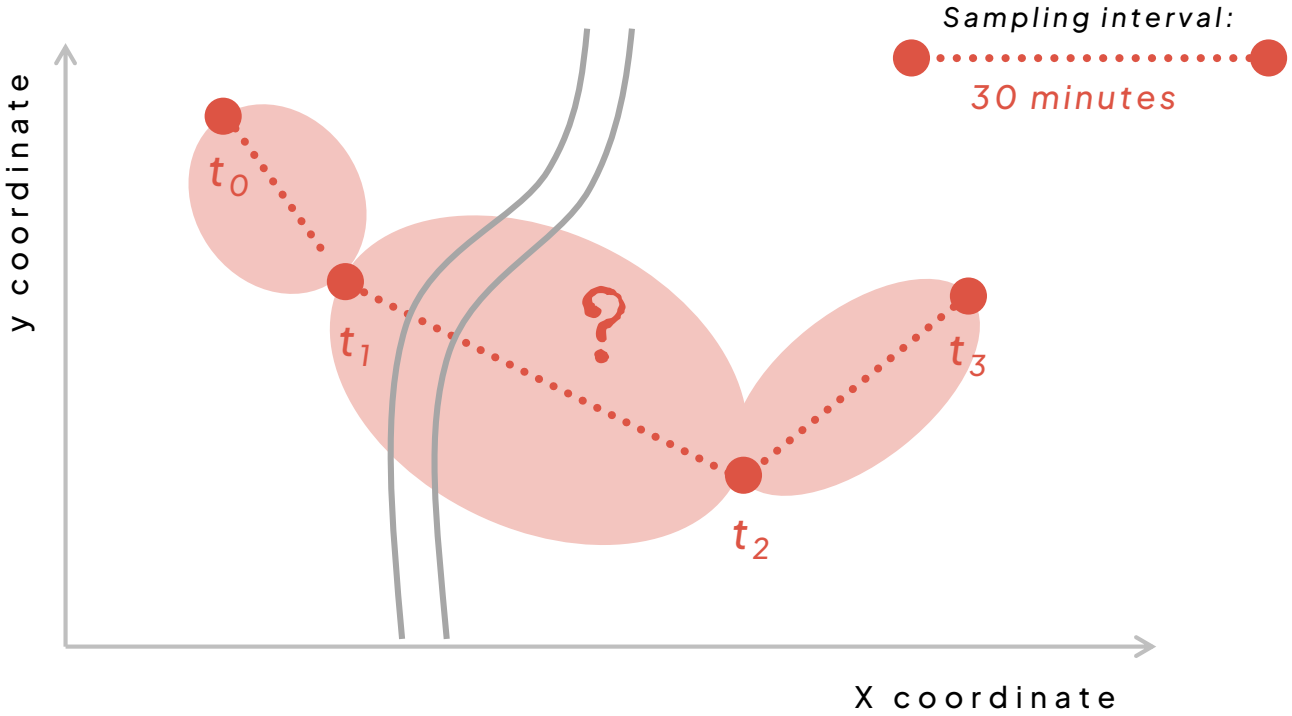

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Utilization distribution

represents an animal's distribution and the probability of use throughout an area

Range distribution

extrapolate space use into the future

"How much space does an animal need over the long term?"

What is an animal's home range area?
What is their the population range area?
Are protected areas sufficiently large?

≠

Occurrence distribution

interpolate between data points in the past

"Where did an animal go during a period of observation?"

Where did an animal cross a linear feature?
How likely is it to visit a location of interest?
How much time did it spend in a specific habitat?

Alston *et al.* (2022)

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Utilization distribution

represents an animal's distribution and the probability of use throughout an area

Range distribution

extrapolate space use into the future

≠

Occurrence distribution

interpolate between data points in the past

Estimates home ranges

Considers all realizations of the movement process that could occur.

Estimates occurrence regions

Pinpoints the one realization of the movement process that did occur.

Alston *et al.* (2022)

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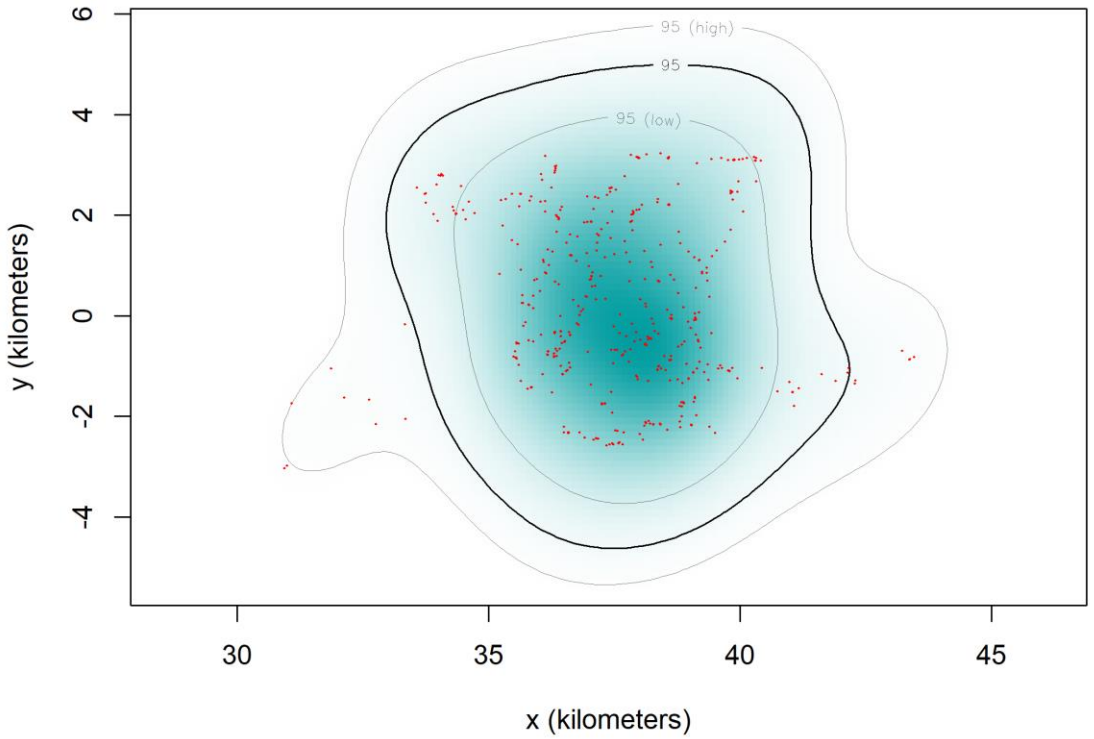
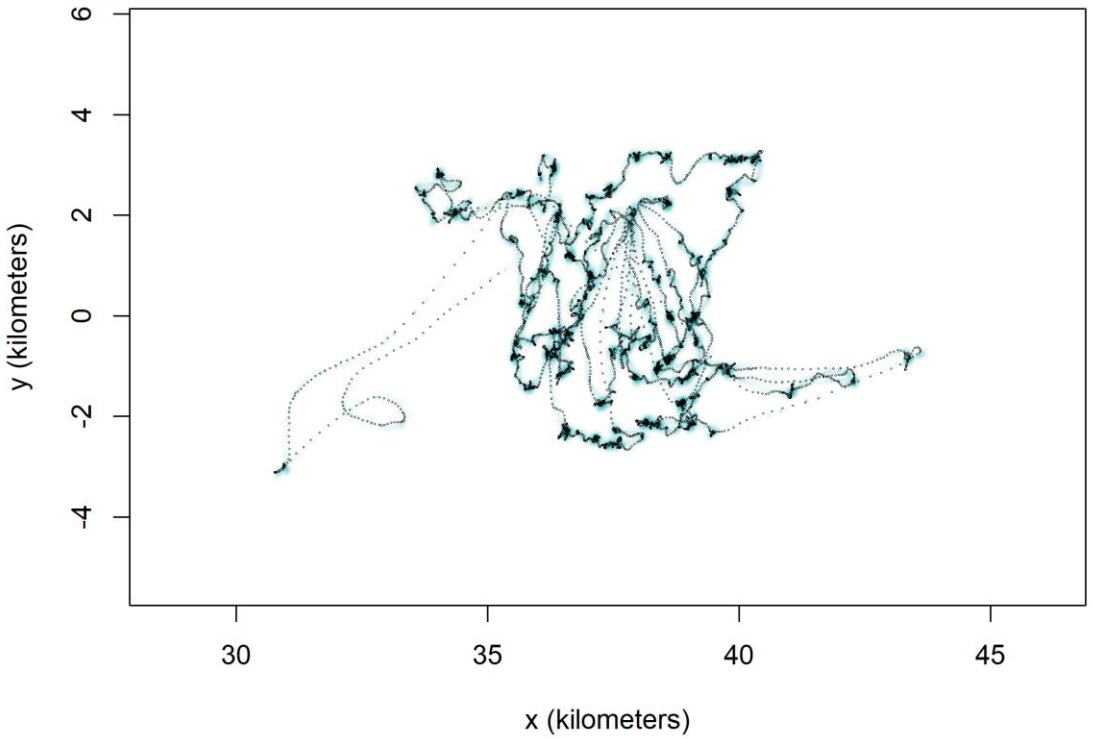
Range distribution



Occurrence distribution



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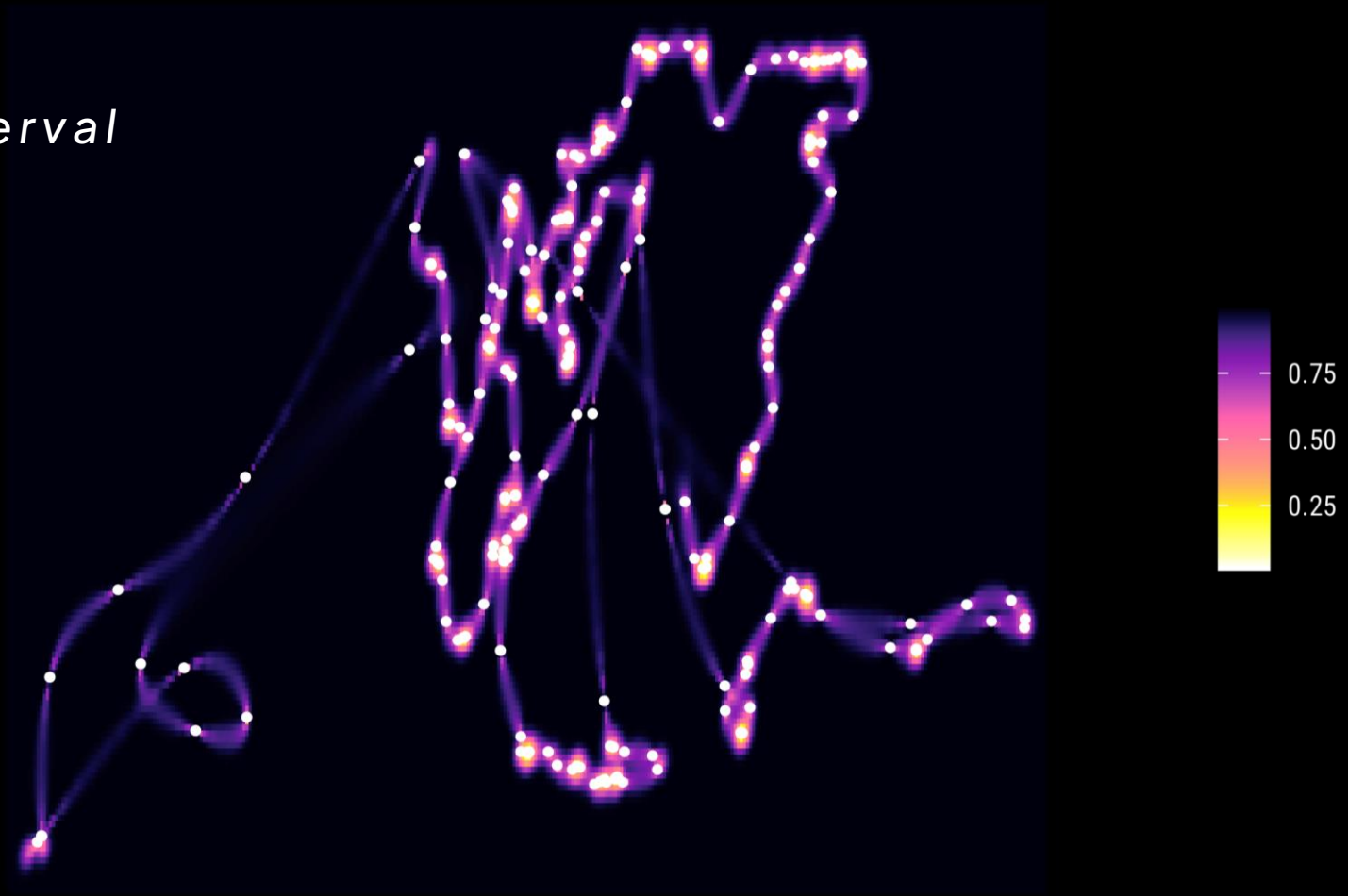
Sampling interval
Δt = 1 hour



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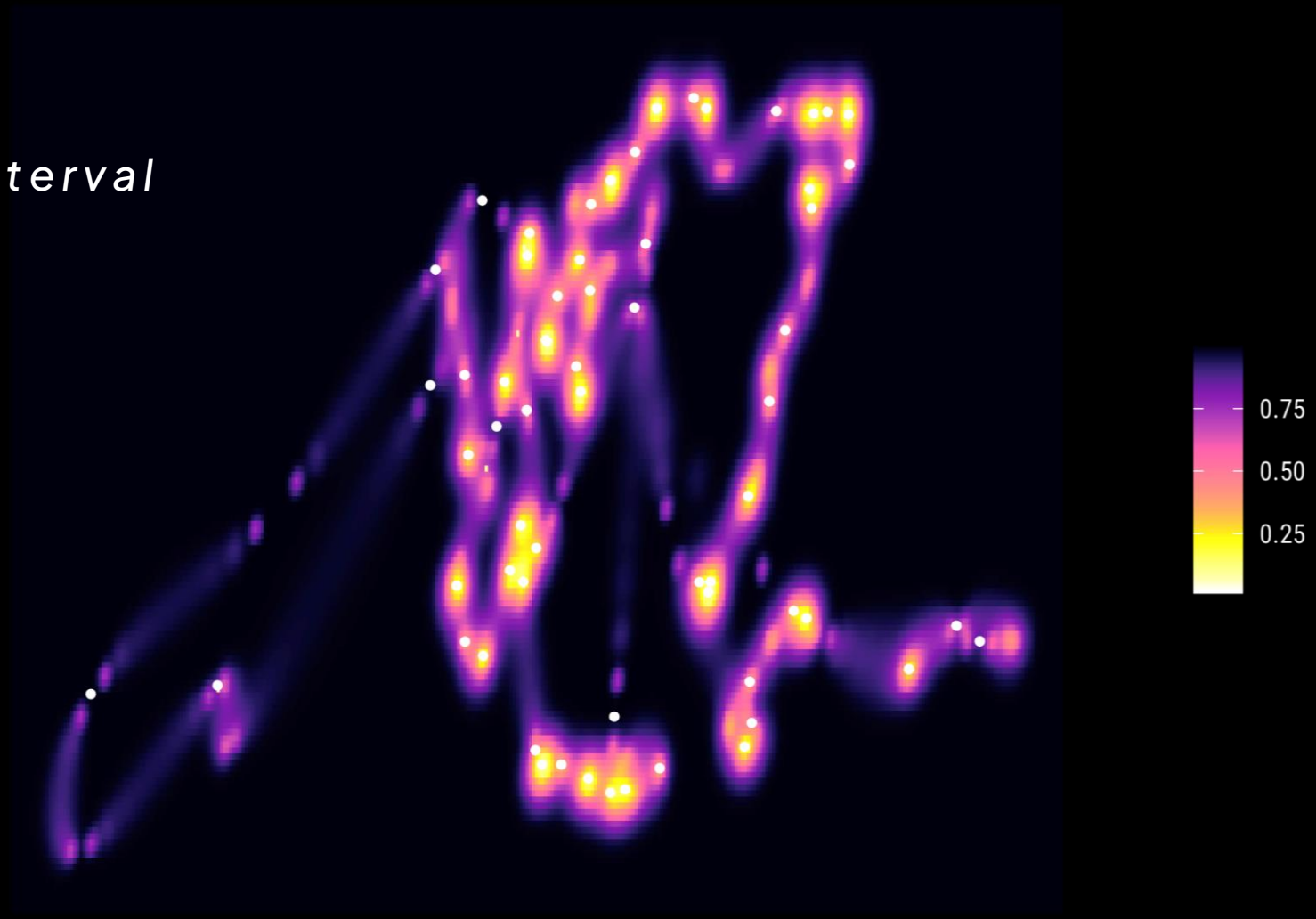
Sampling interval
Δt = 2 hours



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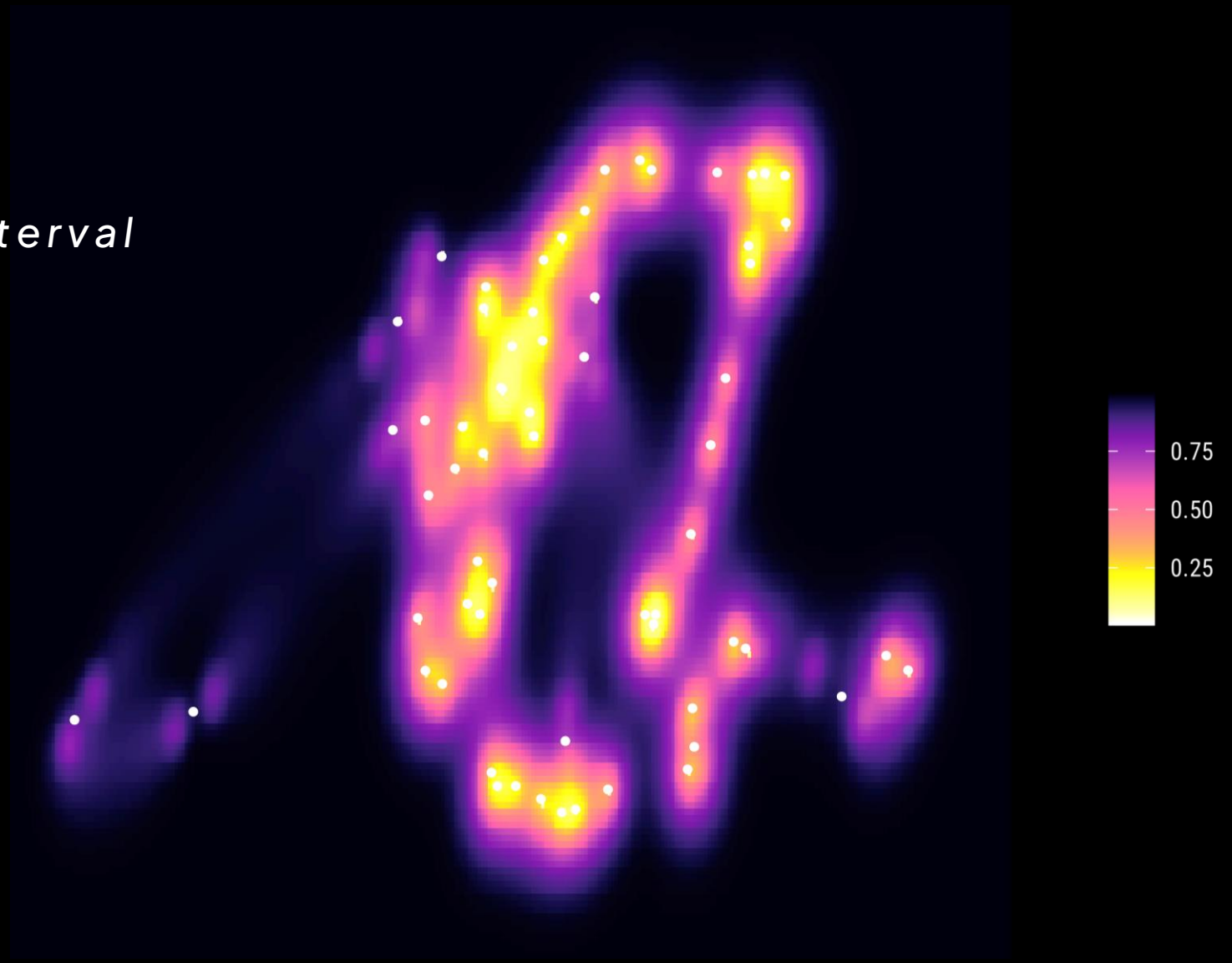
Sampling interval
Δt = 4 hours



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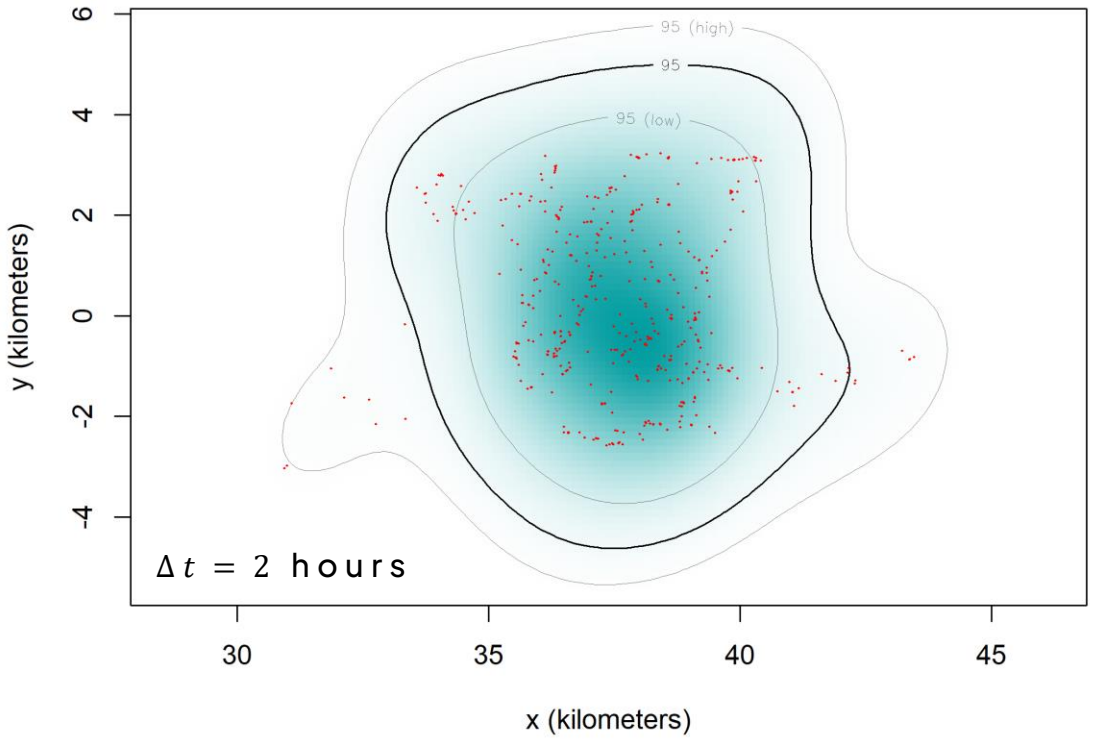
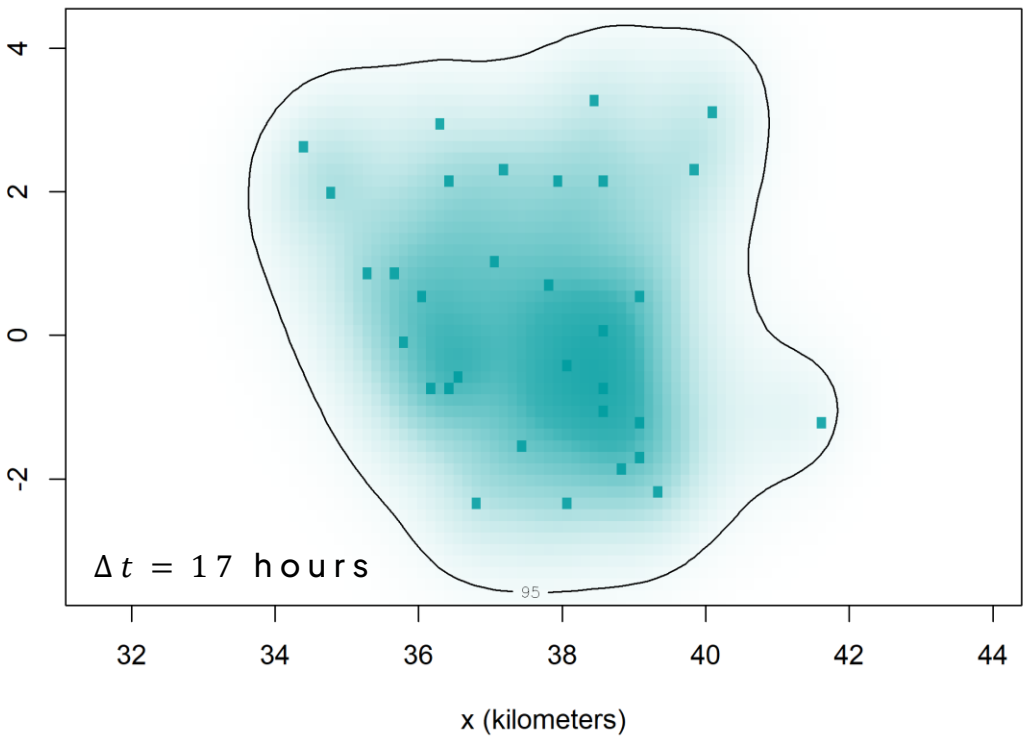
Range distribution



Occurrence distribution



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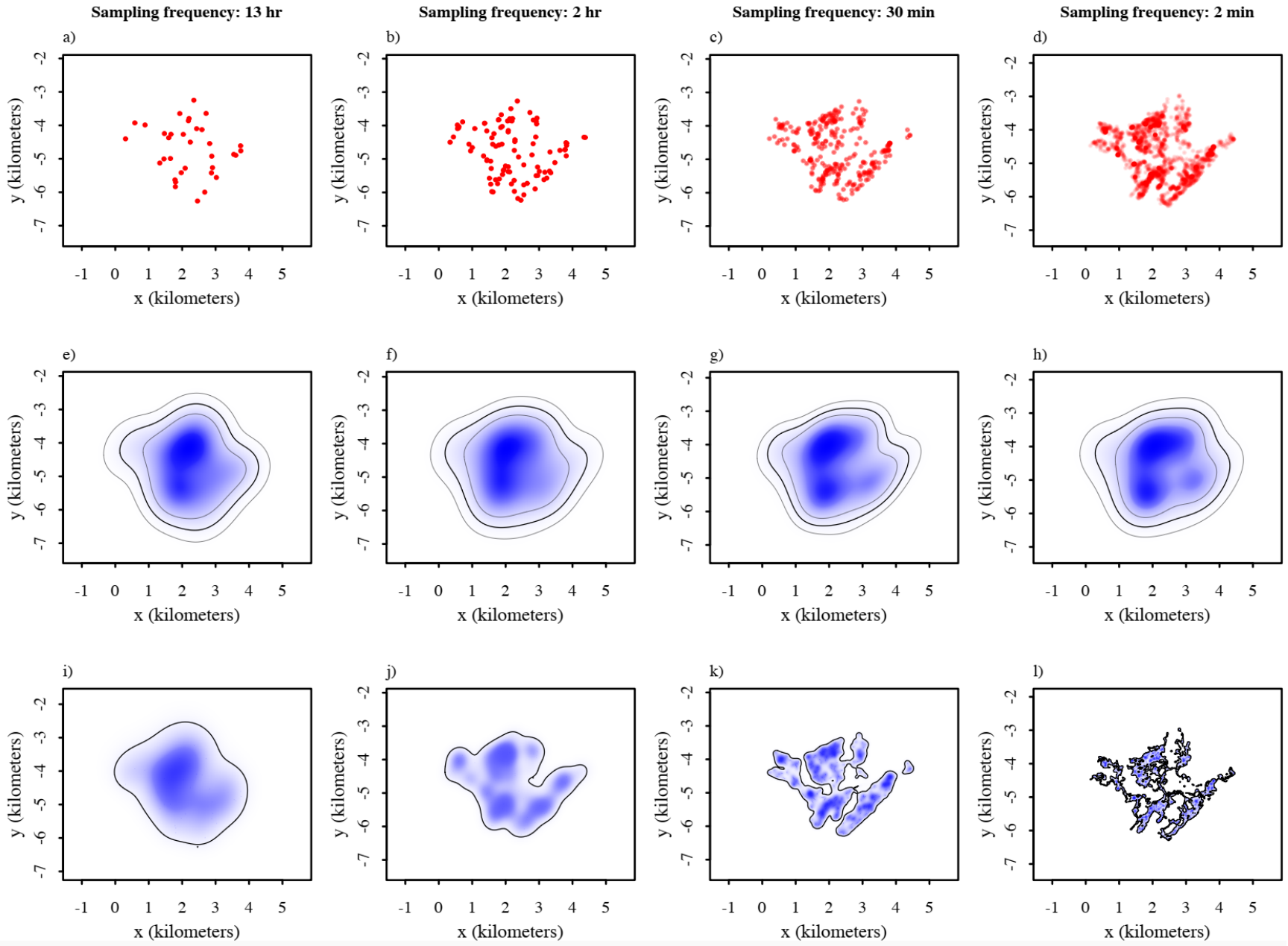

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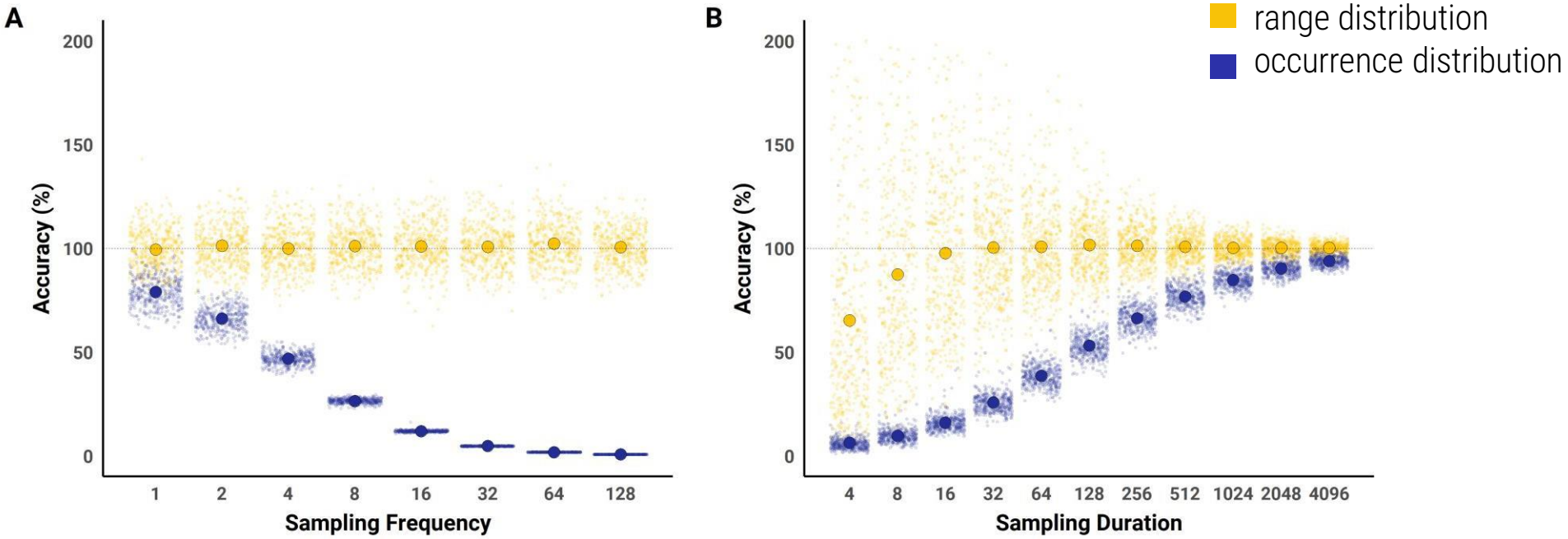
Simulated examples

Size of occurrence estimates are a function of sampling interval, while size of range estimates are not.



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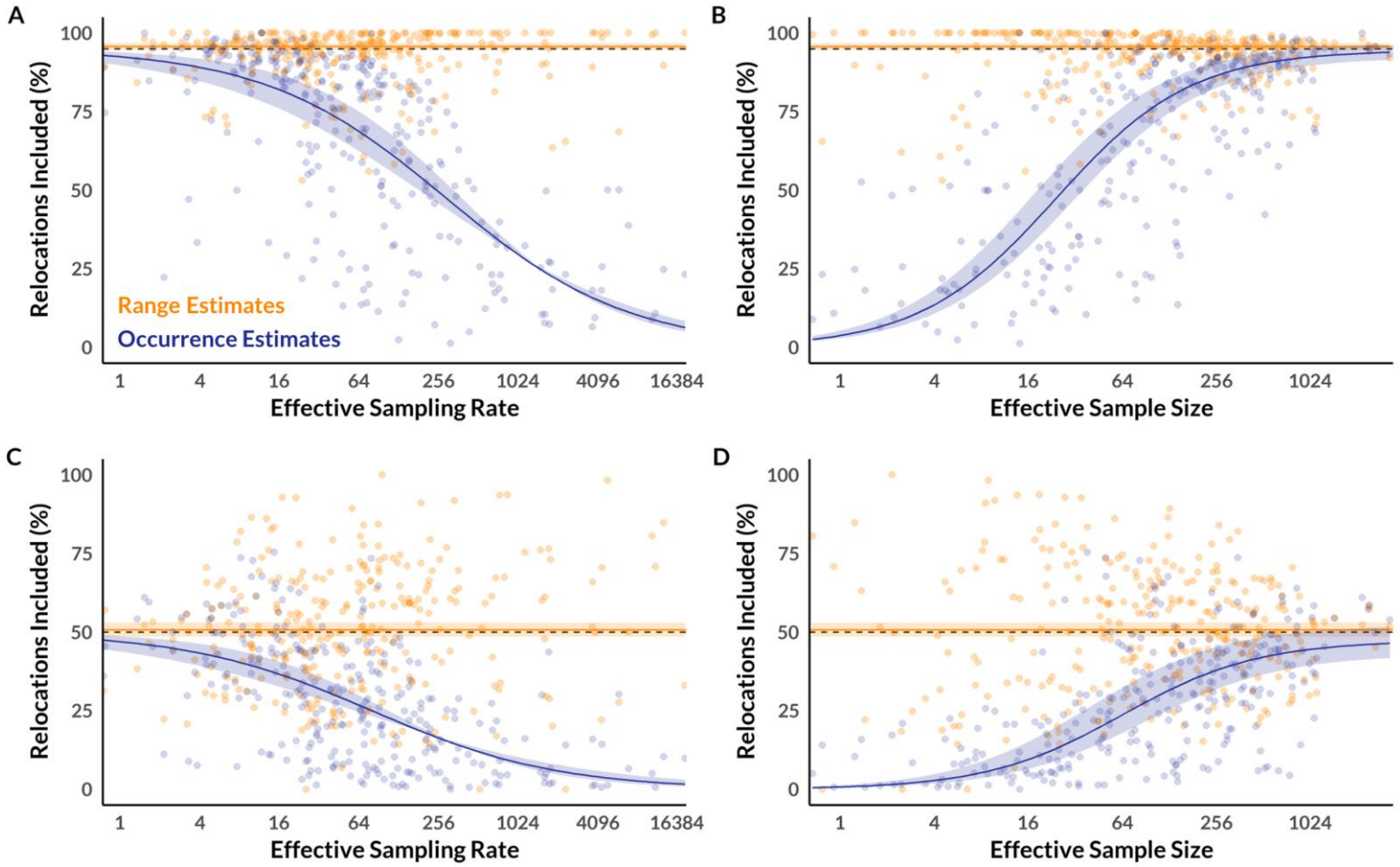
Empirical examples

Holds up in real world data!



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Generalized time-series Kriging framework:

Fleming *et al.* (2016)

Kriging is a widely used tool in geostatistics, engineering, and computer science. It is a statistically optimal framework for ***interpolating between discrete locations***, with well-known statistical properties.

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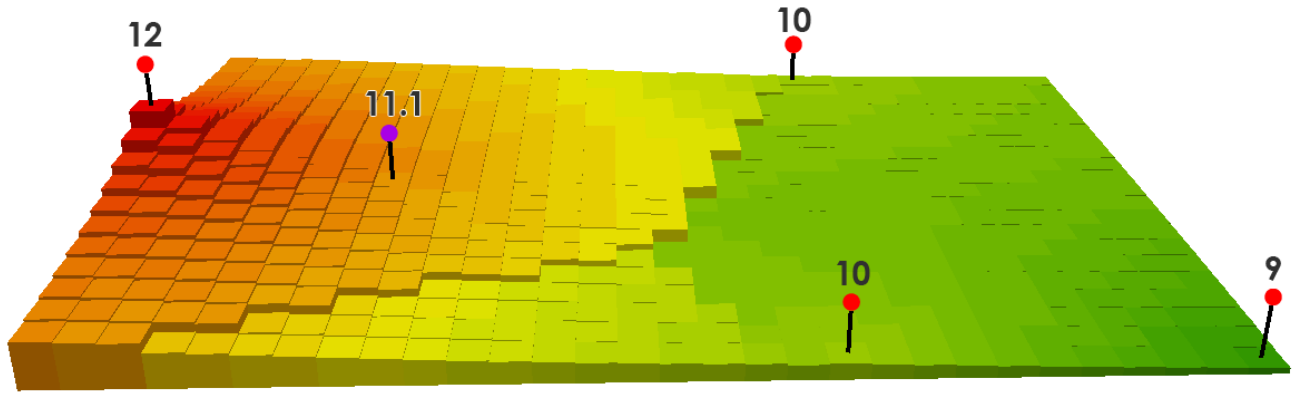
Fig. spatially interpolated temperature from weather stations.



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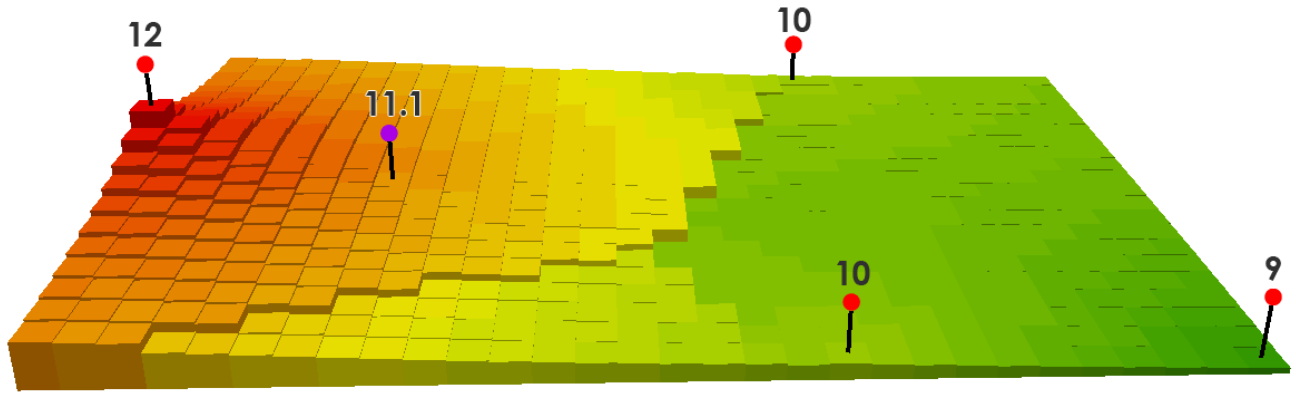

Encompasses both **Brownian Bridge Movement Model** (BBMM; Horne *et al.* 2007) and **Correlated Random Walk** library (CRAWL; Johnson *et al.* 2008).

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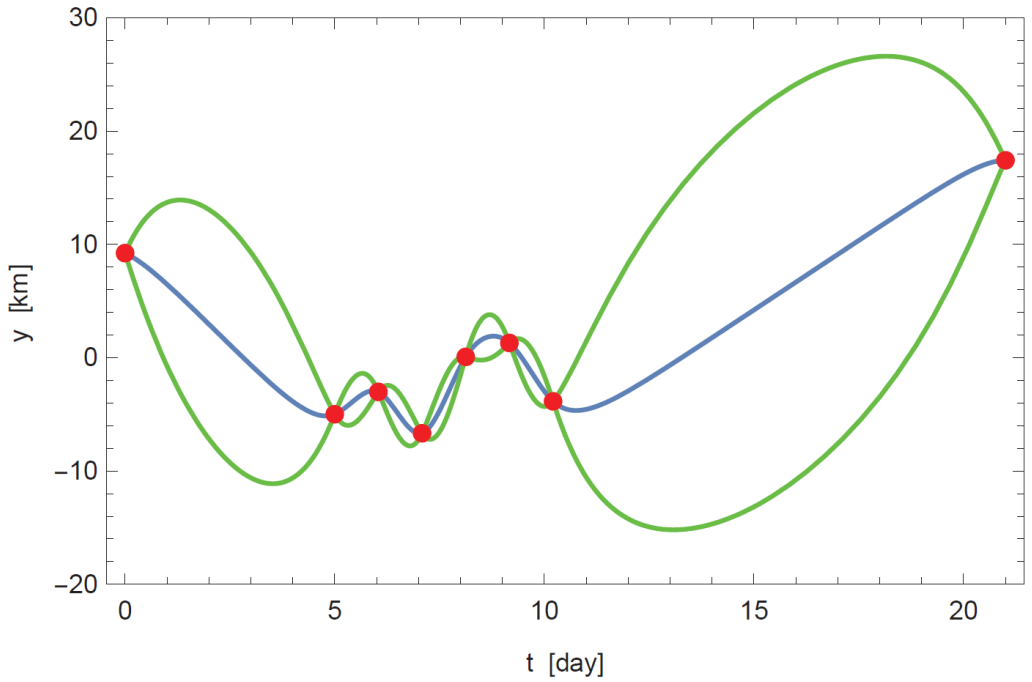

Fig. Time series of gazelle locations (red), with Krige interpolation (blue) and 95% contour intervals (green).

Not only does ***Kriging*** provide an optimal prediction surface, but it also delivers a measure of confidence of how likely that prediction will be true.

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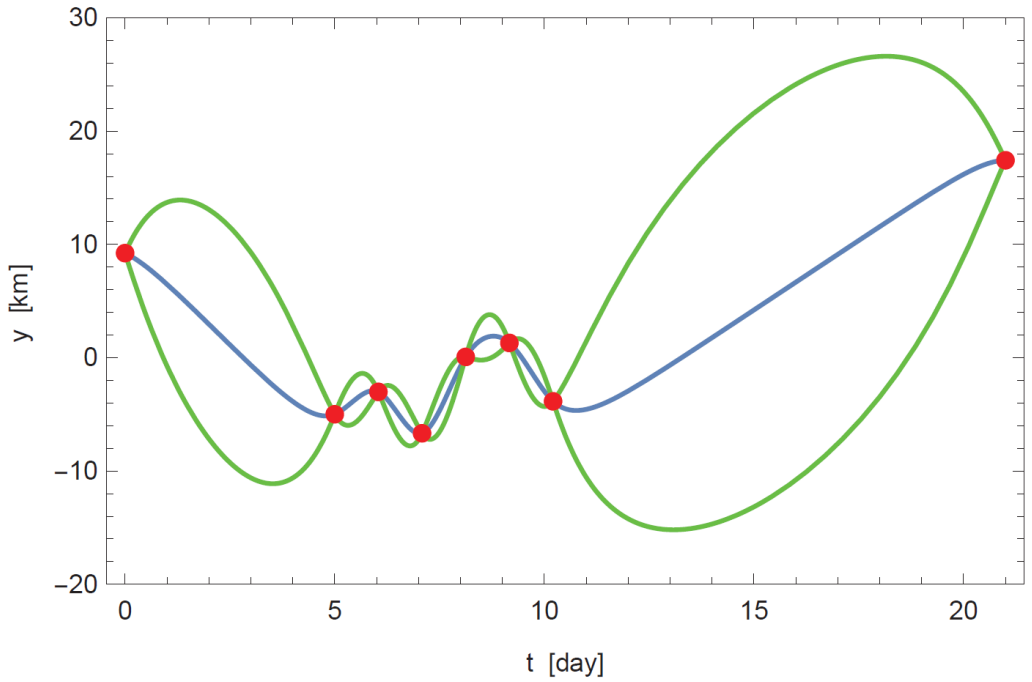

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Not only does ***Kriging*** provide an optimal prediction surface, but it also delivers a measure of confidence of how likely that prediction will be true.

Two step process:

1. ***Select a movement model,***
(describing an animal's movements)

2. ***Solve for an animal's location at time t,***
(conditional upon the data and the fitted model)

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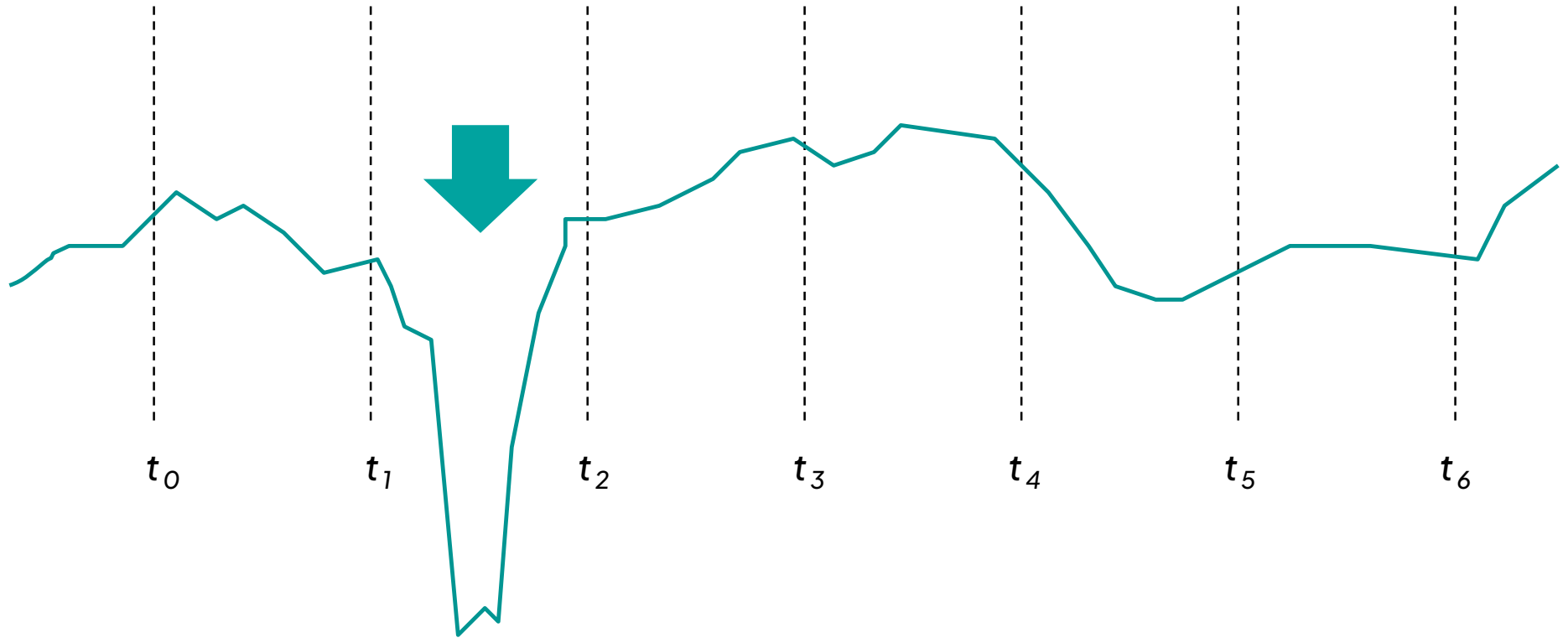
An occurrence region is sampling-dependent.

If each dashed line represented a sample point (in 1-D), this spacing would miss a major local source of variation.



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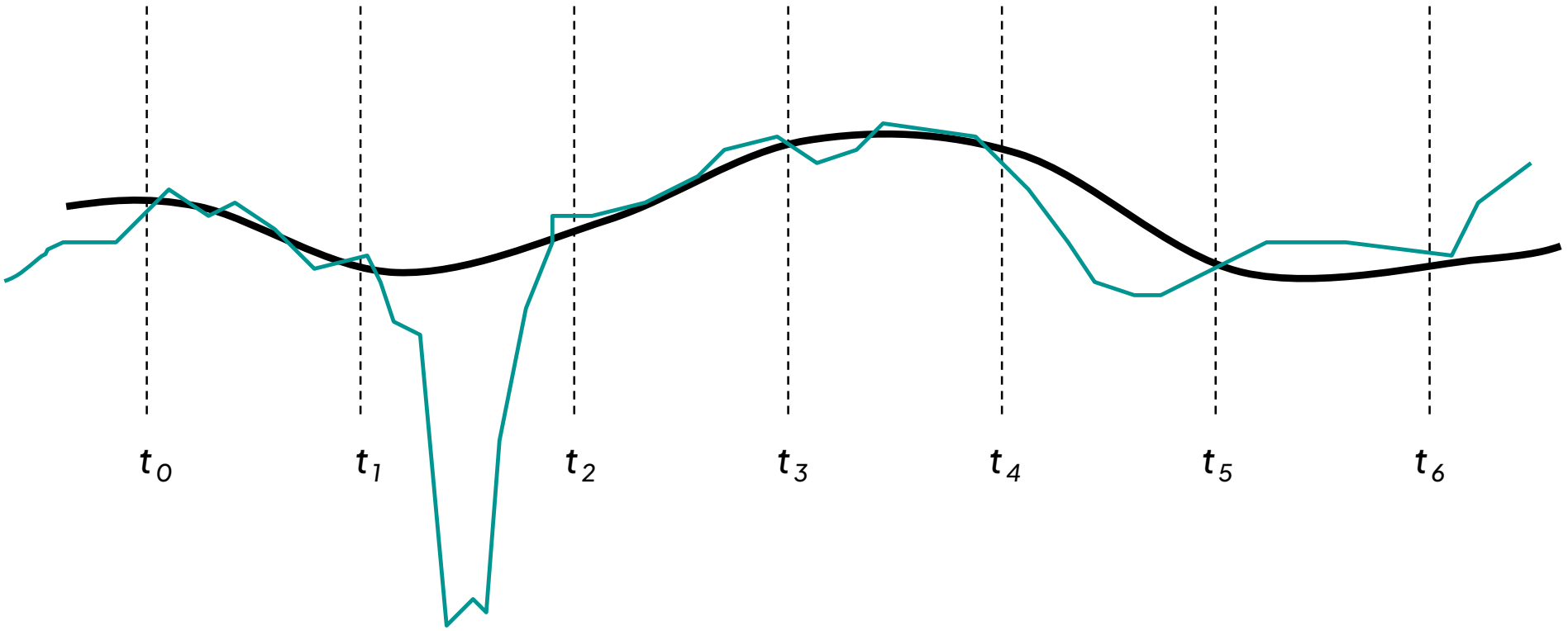
An occurrence region is sampling-dependent.

Our interpolated surface (represented in 1-D by the black line) would look like this.



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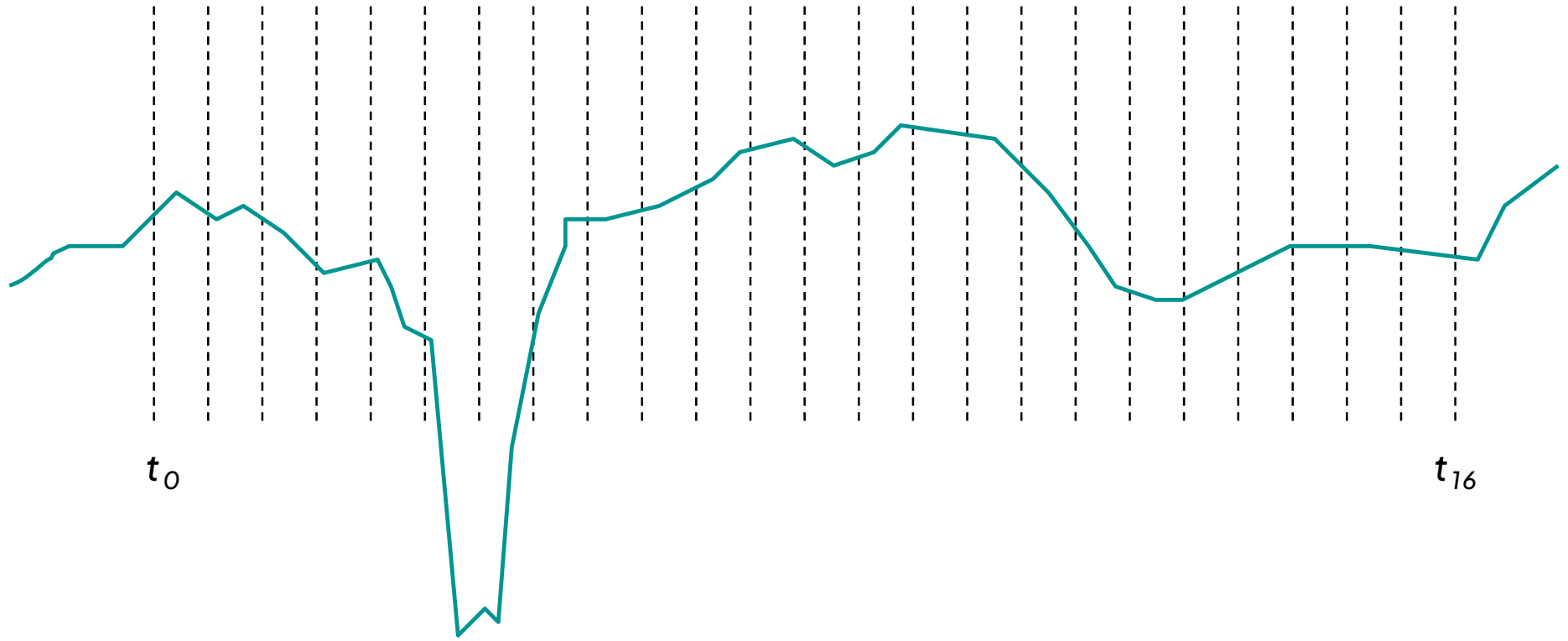
An occurrence region is sampling-dependent.

Only by increasing the sampling frequency, would we pick up that local variation.



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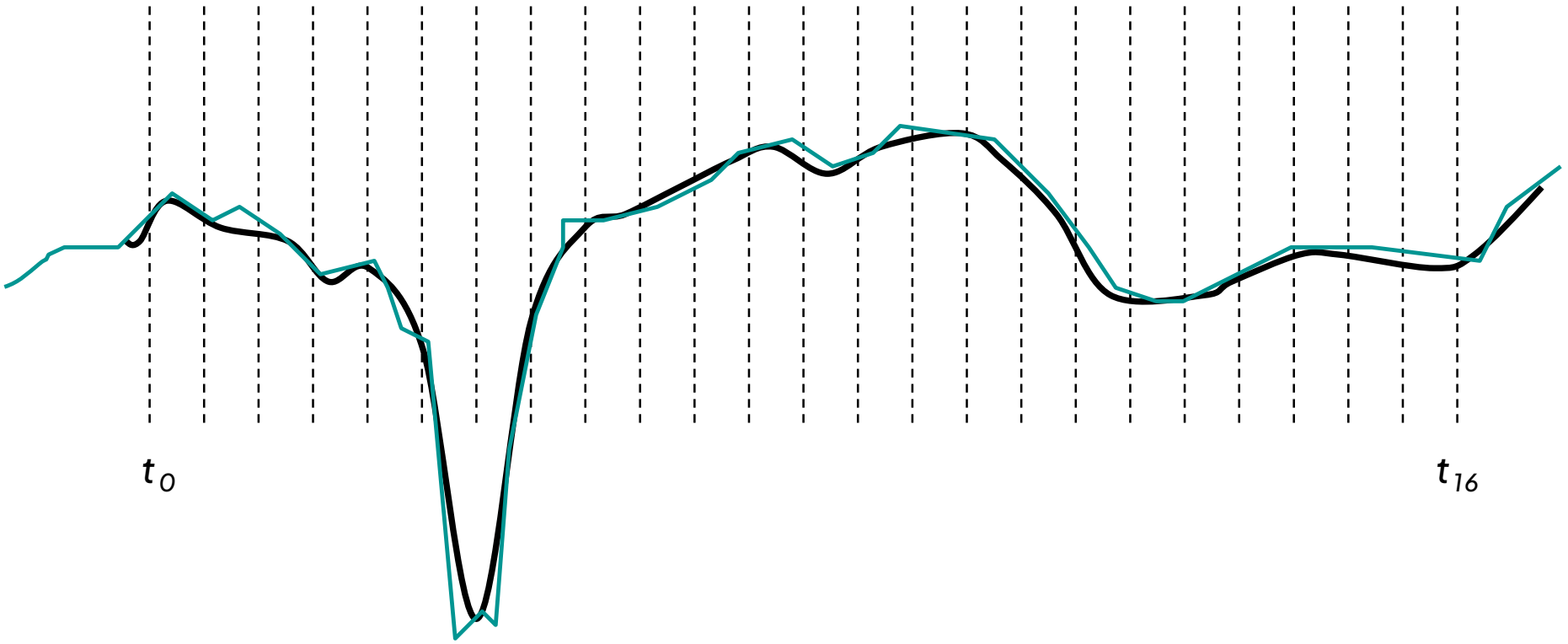
An occurrence region is sampling-dependent.

Here our interpolated surface is much closer to reality at the local level, but we pay for this in the form of higher data gathering cost.



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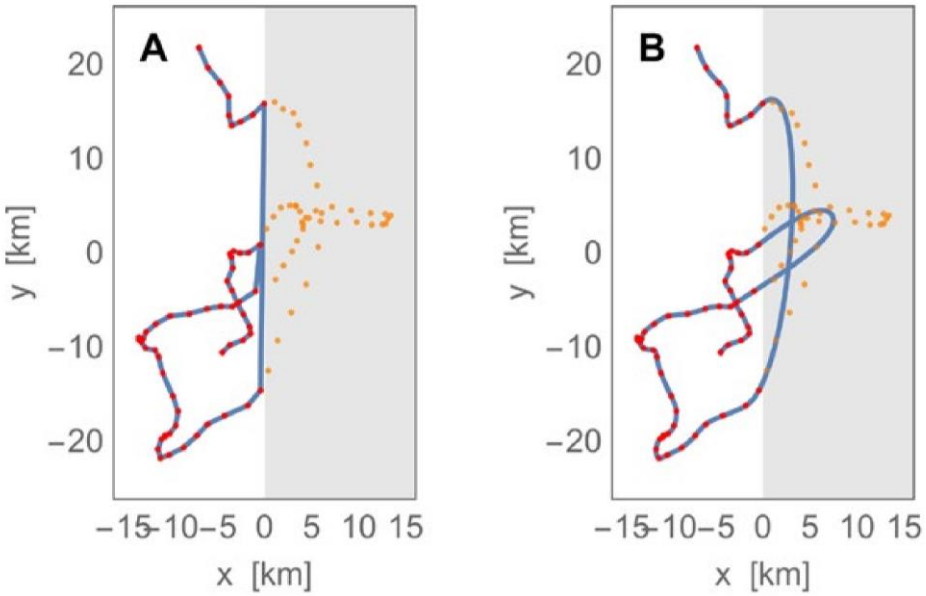
Estimating occurrence region



Now that we know how to interpolate, we can:

- Fill in missing gaps,
- Project beyond the sampling period,
- Identify areas of potential use,
  (*e.g.*, relate to human-wildlife conflict).

> Can be very ***memory-intensive***! (on large data sets, consider looping through each animal individually).

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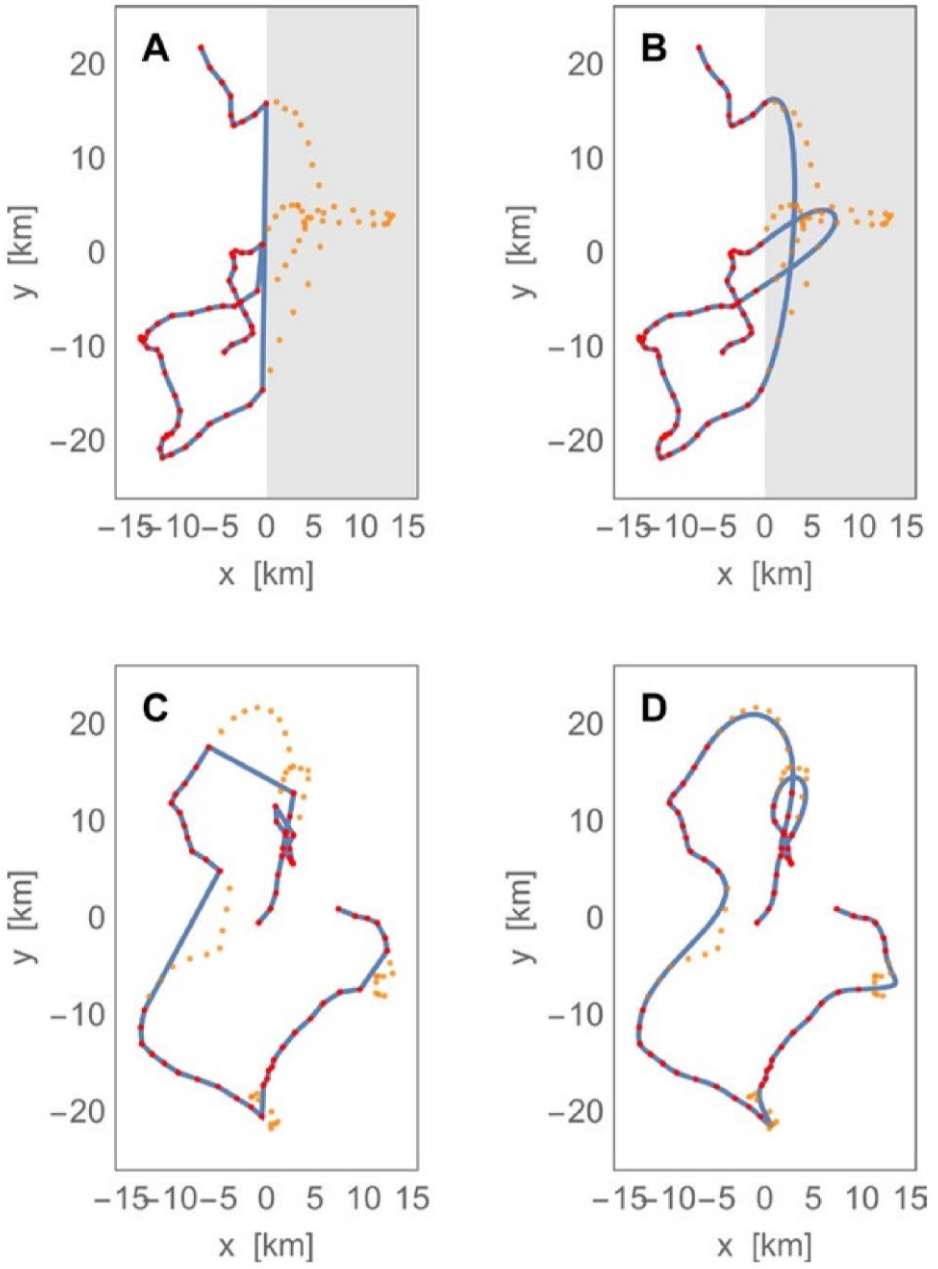

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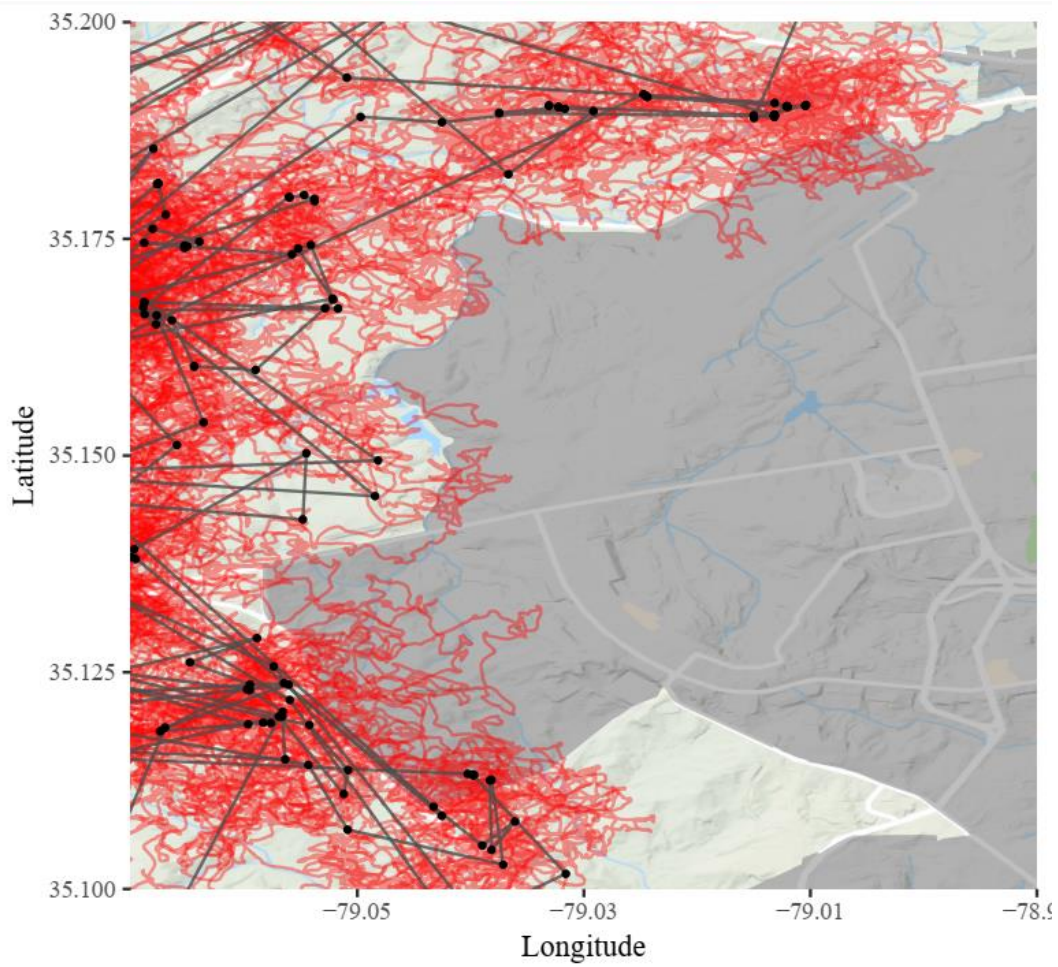

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