ANIMOVE

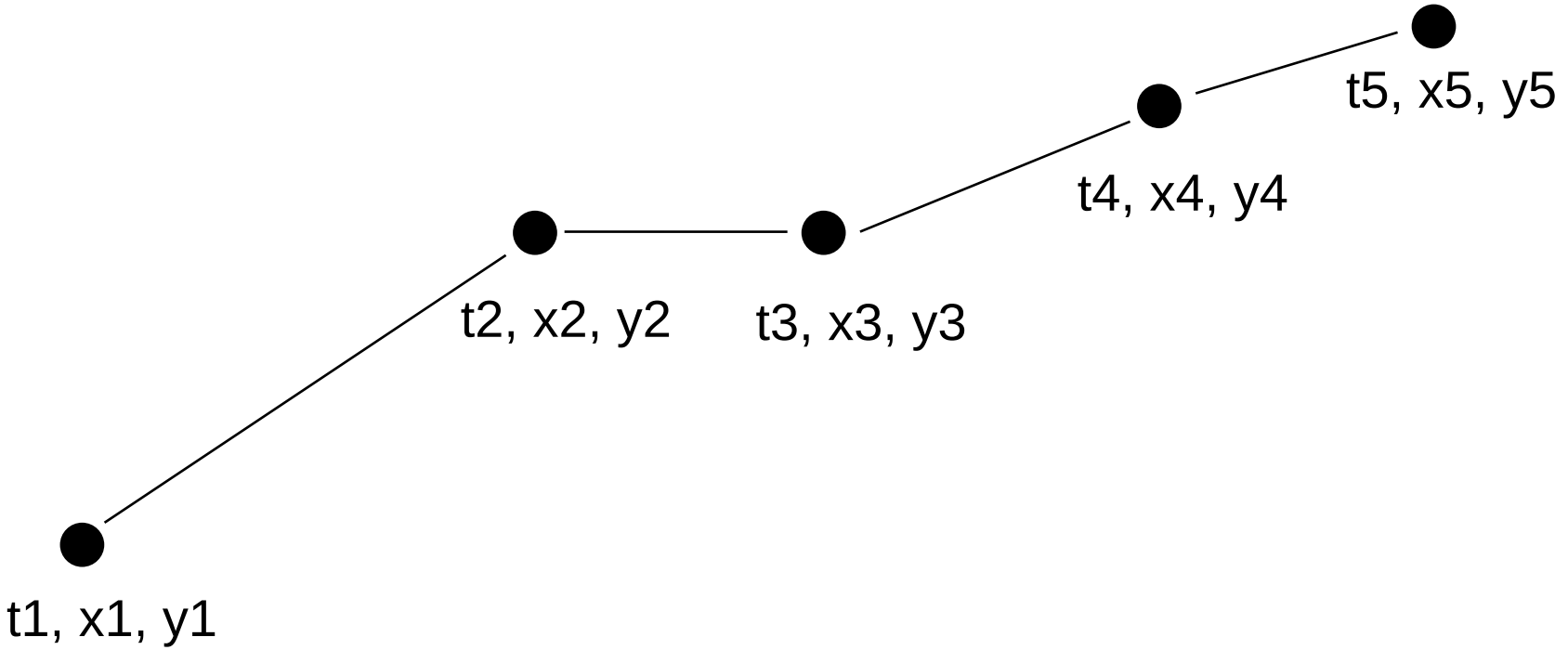
```
P1.y=diag(c(0, 0.001, 0.001))

splayPar(mov.model=~1, err.model=list(x=~errX, y=~errY), drift=TRUE,
         data=nfsNew, fixPar=c(NA, 1, NA, 1, NA, NA, NA, NA))

t <- crwMLE(mov.model=~1, err.model=list(x=~errX, y=~errY), drift=TRUE,
            data=nfsNew, coord=c("longitude", "latitude"), polar.coord=FALSE,
            Time.name="Time", initial.state=initial.drift,
            fixPar=c(NA, 1, NA, 1, NA, NA, NA, NA),
            control=list(maxit=2000,trace=1, REPORT=10),
```

June 2024

Properties of Movement

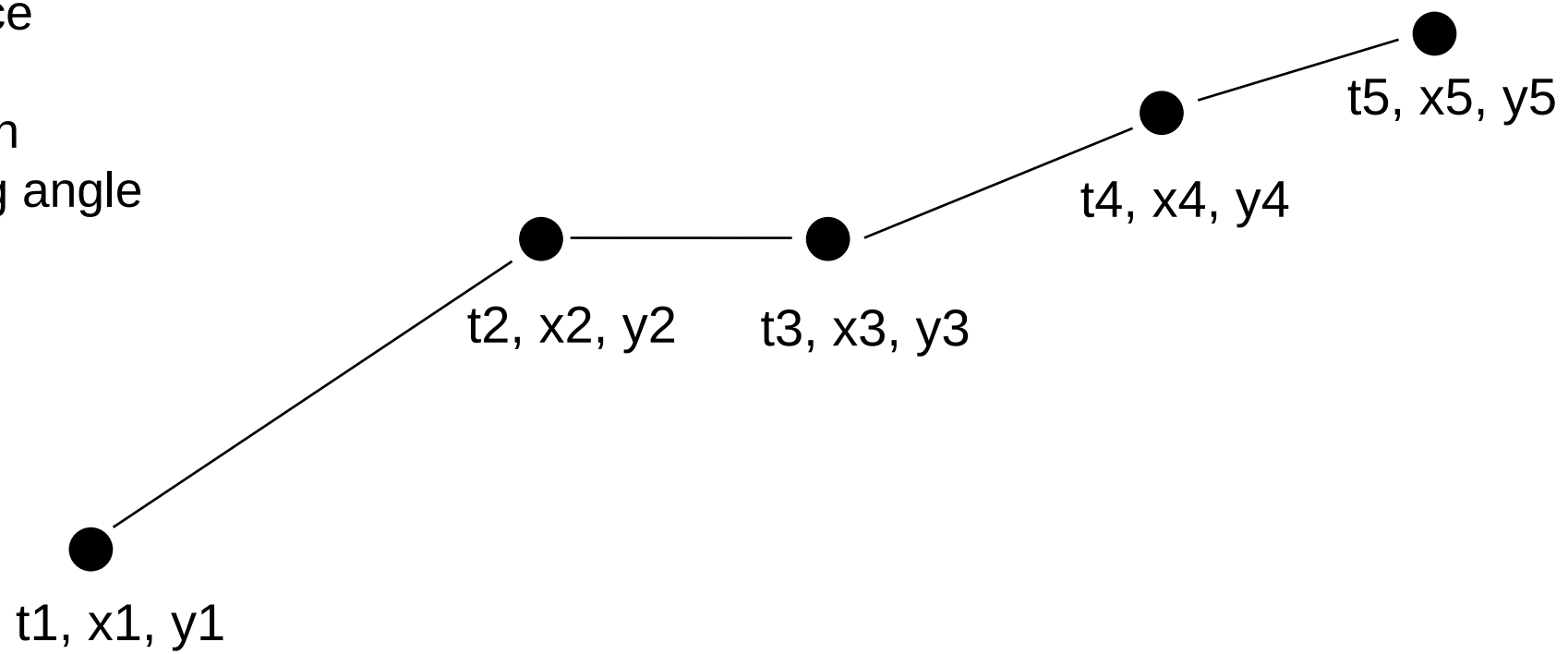
Spatial and temporal organization of movement trajectories

Properties of Movement data



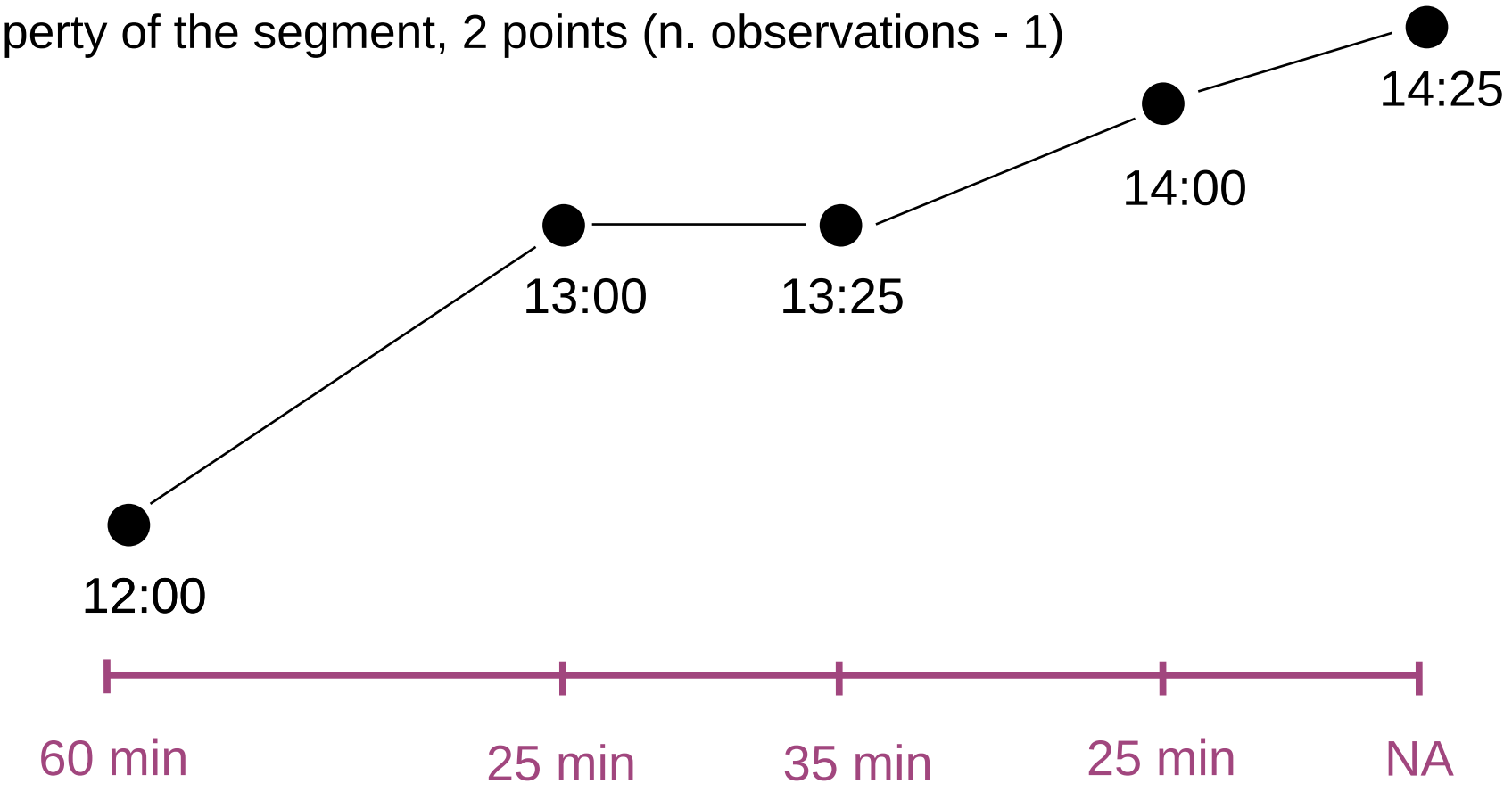
Properties of Movement data

- Time lag
- Distance
- Speed
- Azimuth
- Turning angle



Time lag

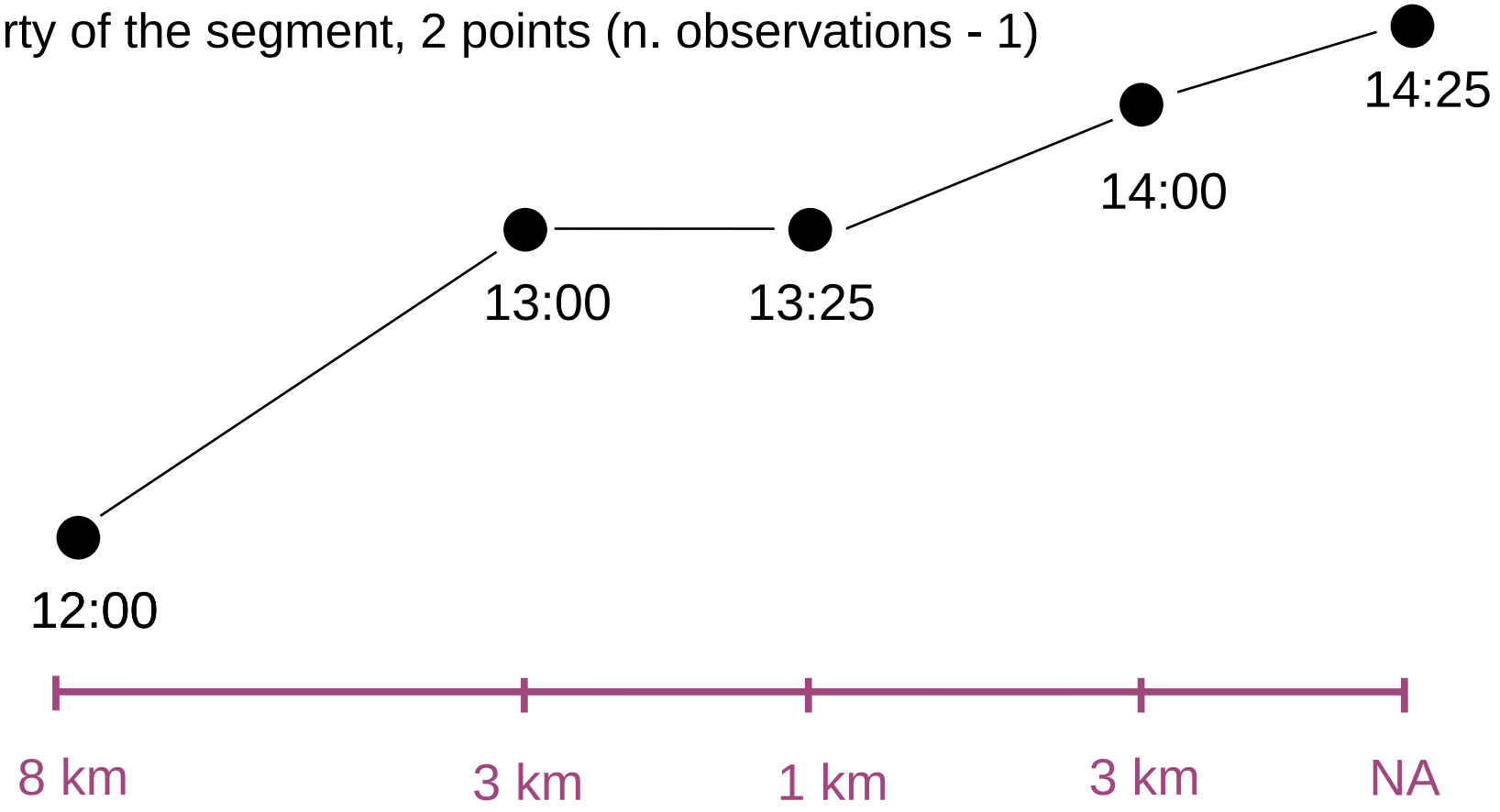
Property of the segment, 2 points (n. observations - 1)



Step length / Distance

Distance

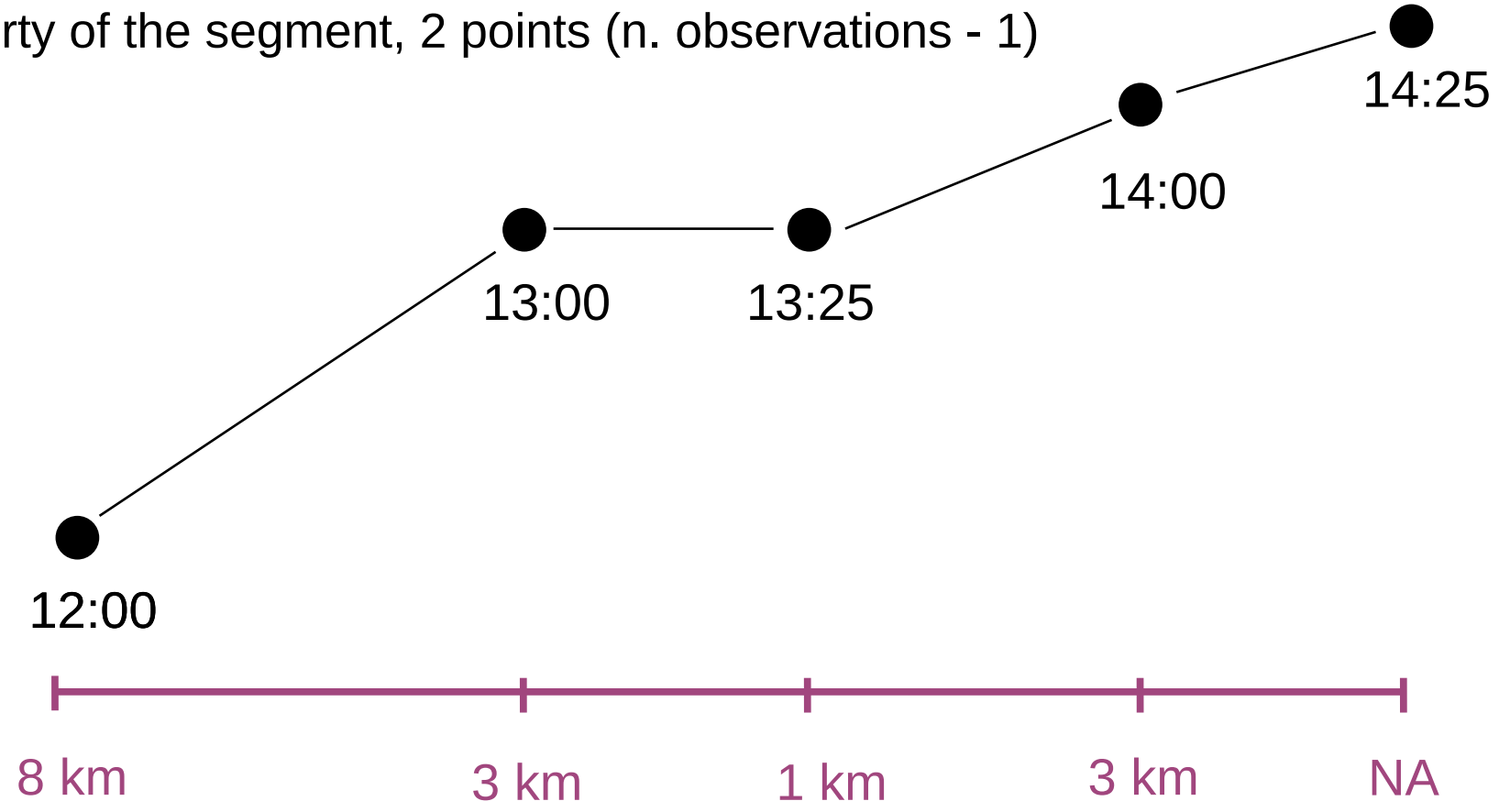
Property of the segment, 2 points (n. observations - 1)



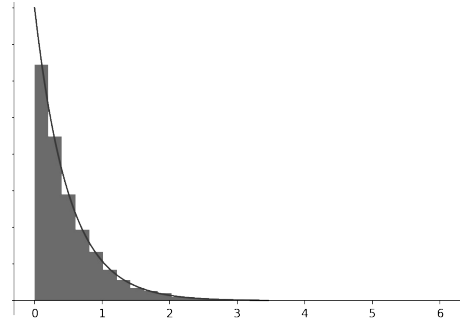
Step length / Distance

Distance

Property of the segment, 2 points (n. observations - 1)



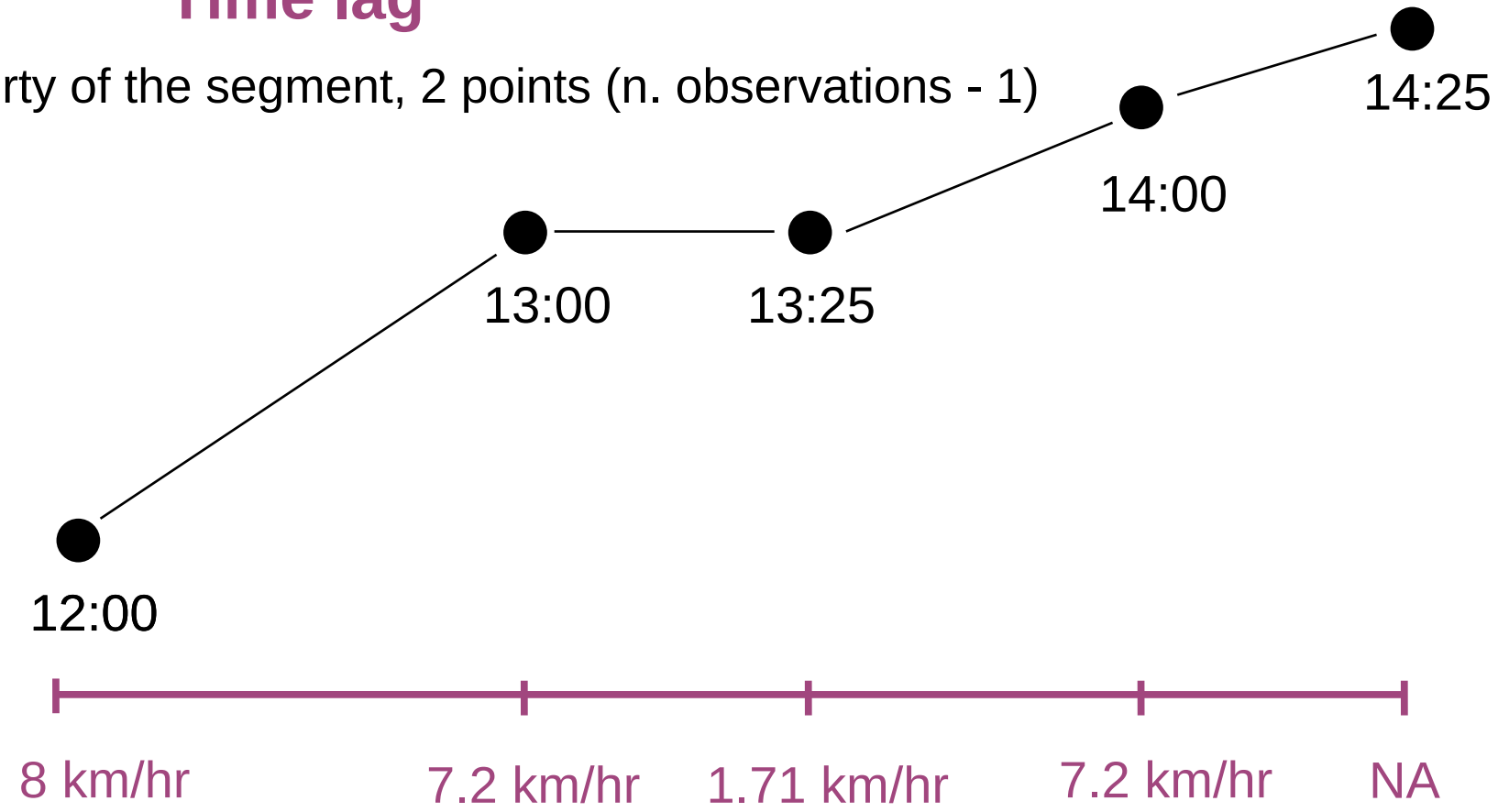
Typical distribution



Ground speed

$$\text{Speed} = \frac{\text{Step length}}{\text{Time lag}}$$

Property of the segment, 2 points (n. observations - 1)



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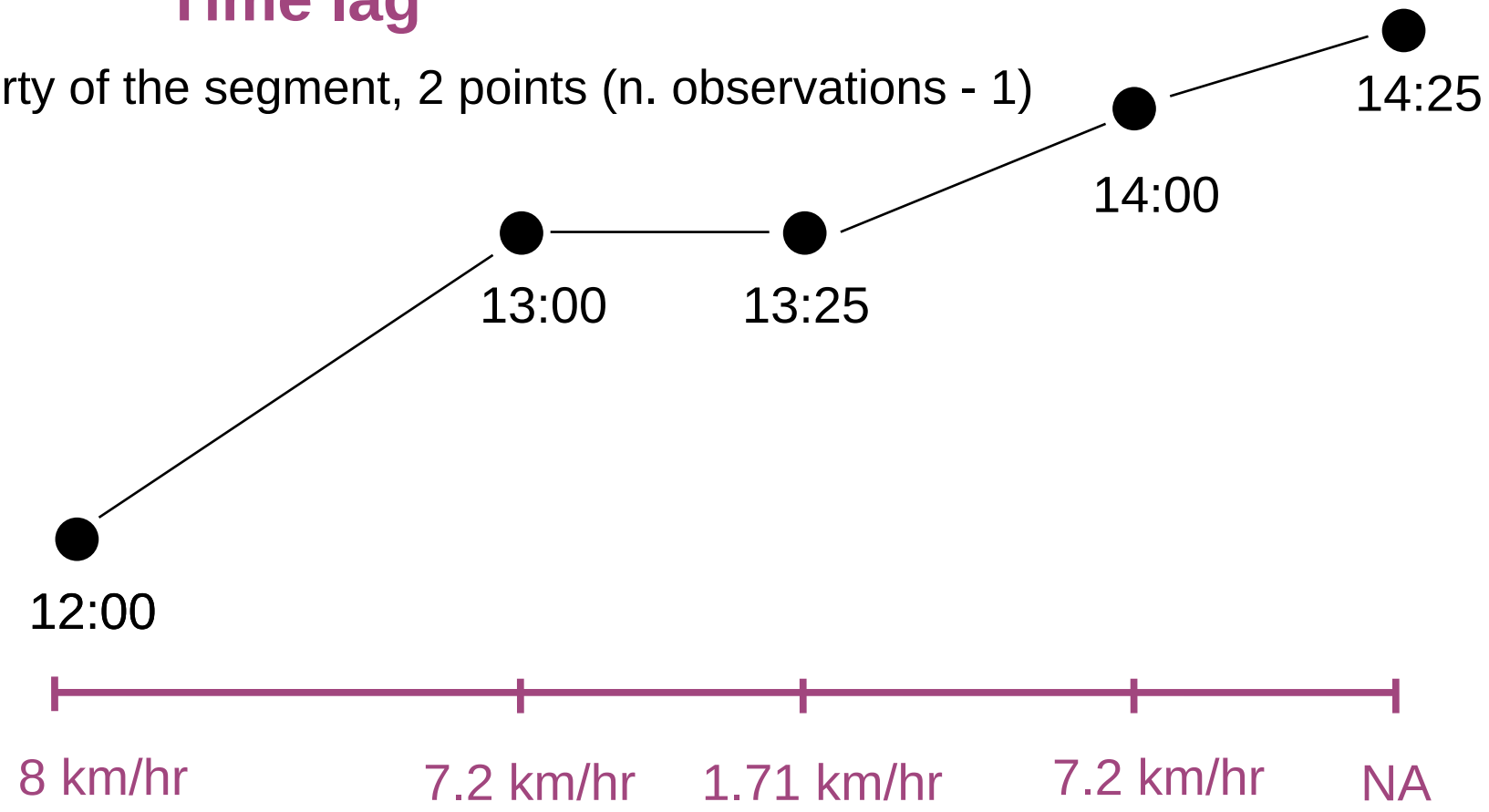
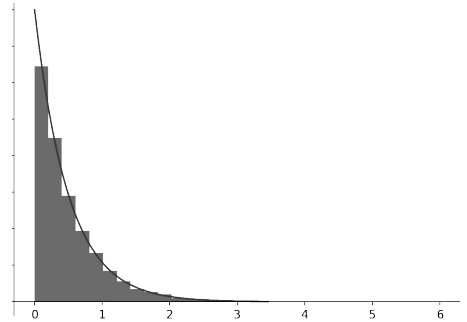
Property of the segment, 2 points (n. observations - 1)



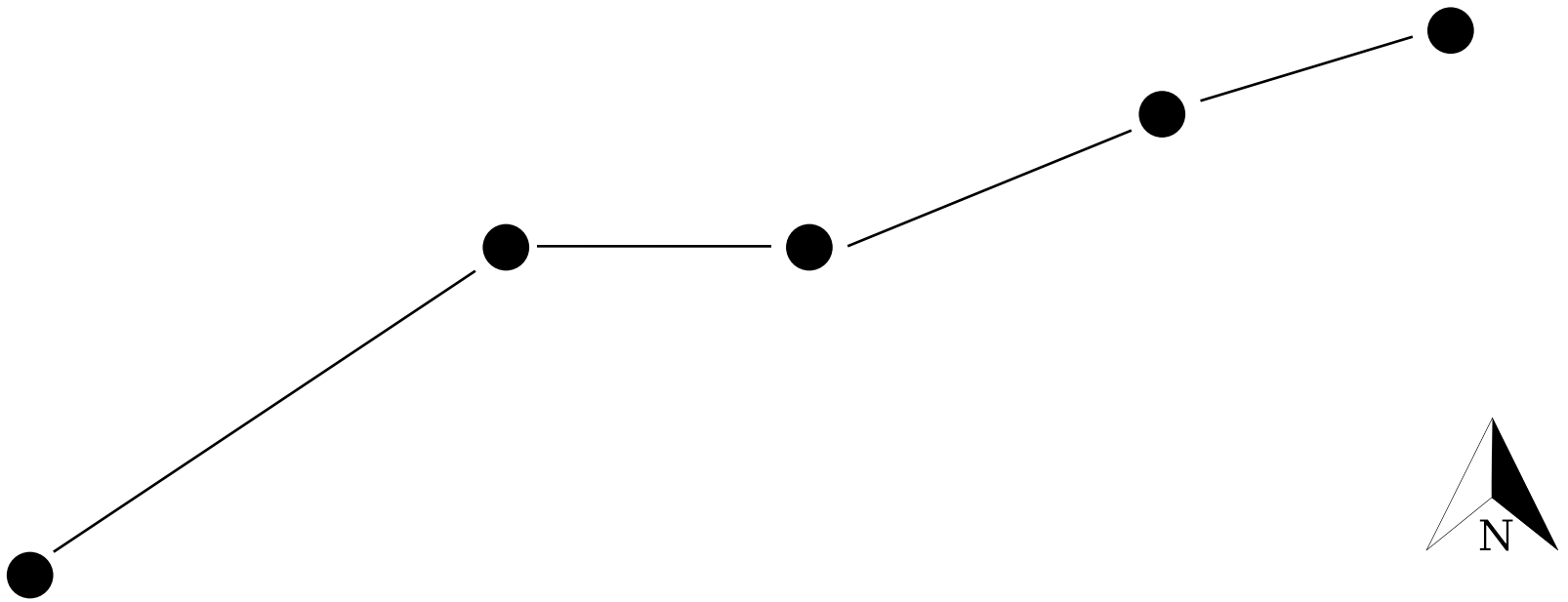
Typical distribution



Direction / Azimuth

Direction of Movement, or Azimuth

- The angle formed between a reference direction (North) and a line from the observer to a point of interest (the following step)
- Property of the segment (2 points): N. observations - 1



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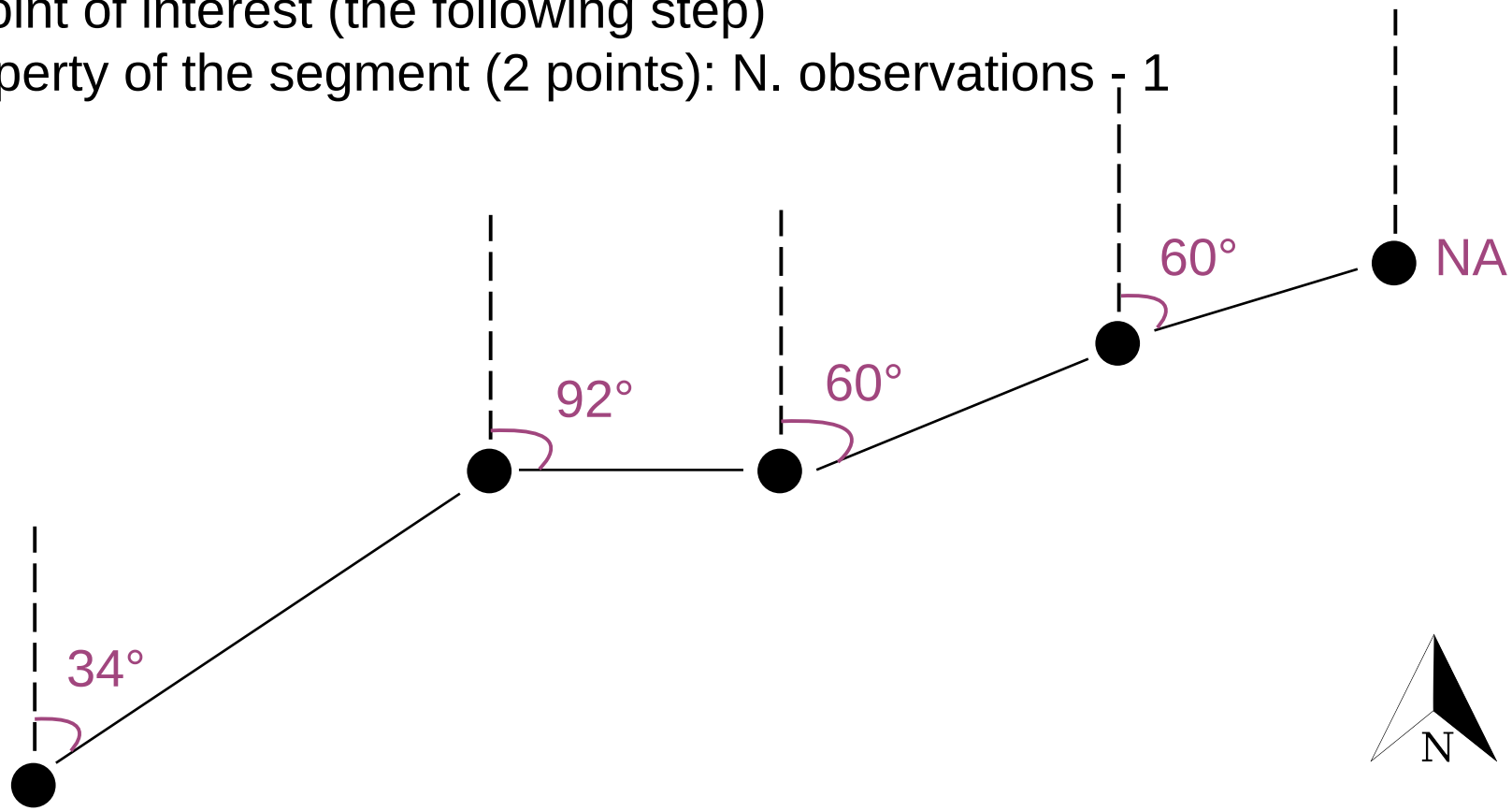

Direction / Azimuth

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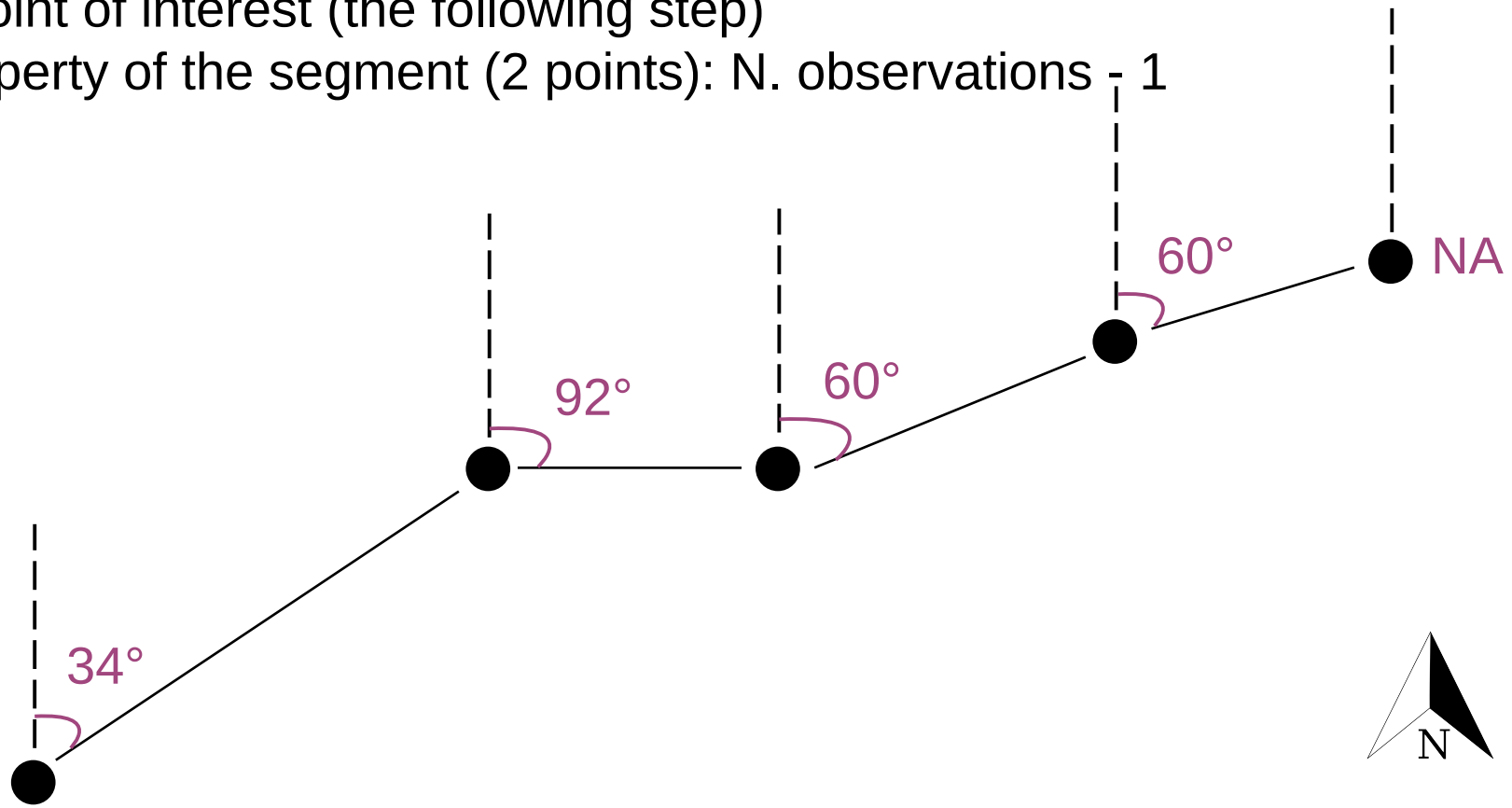
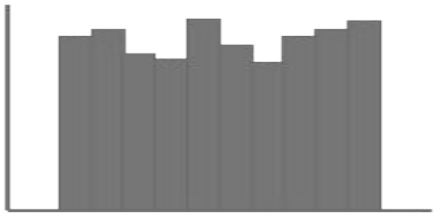
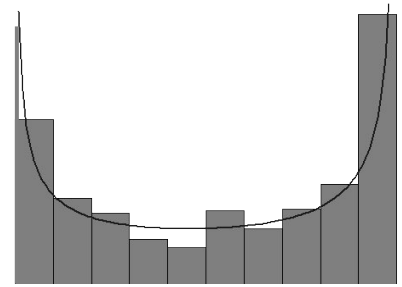


Typical distribution



Local movement

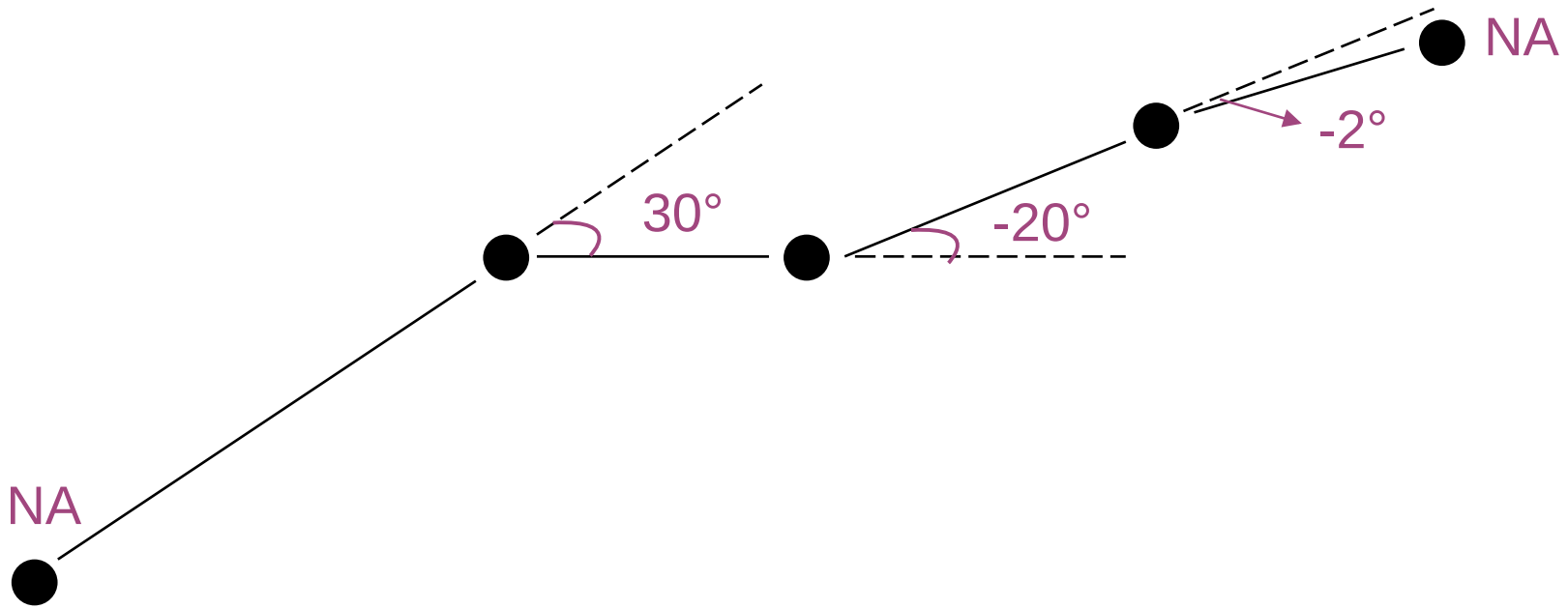


North migration

Turning angle

Turning angle

- **Relative** angle between consecutive segments
- Left turn: negative; right turn: positive
- Between -180 and +180 OR – *π* to *π* (or *π to 2π*)
- Property of **two segments (3 points): N. observations - 2**



Turning angle

Turning angle

- **Relative** angle between consecutive segments
- Left turn: negative; right turn: positive
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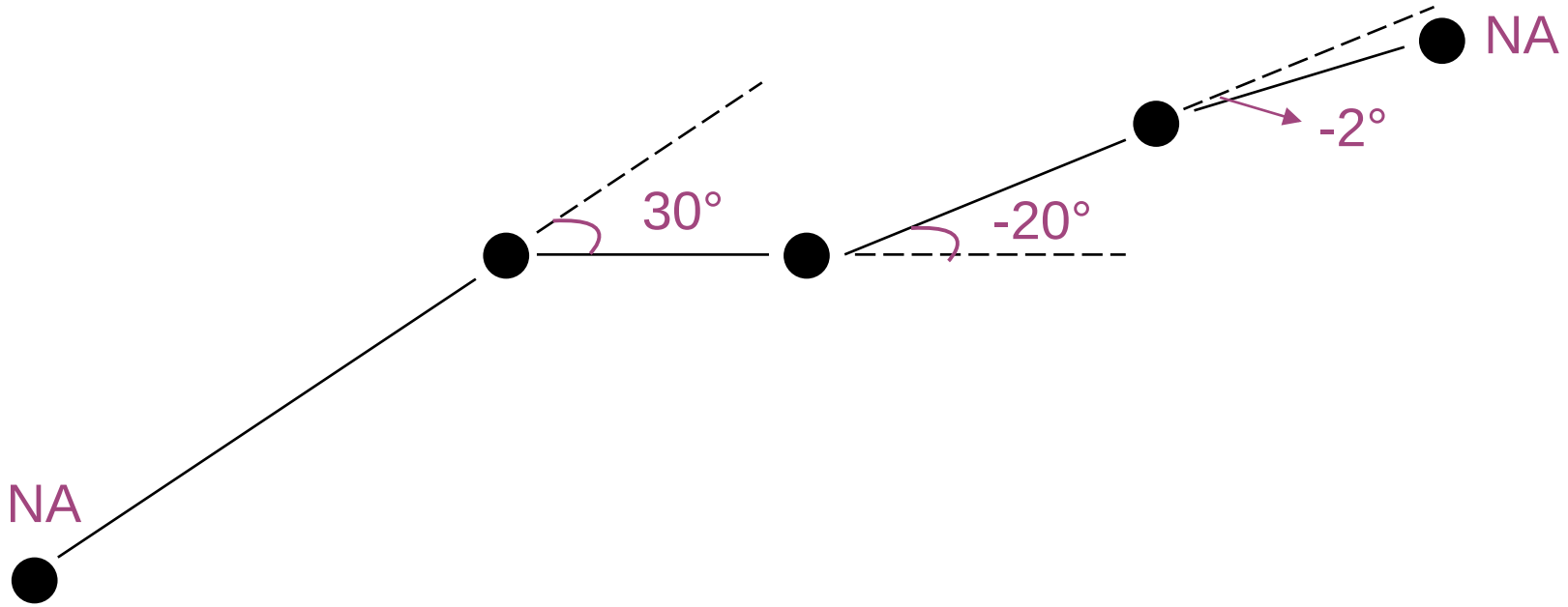
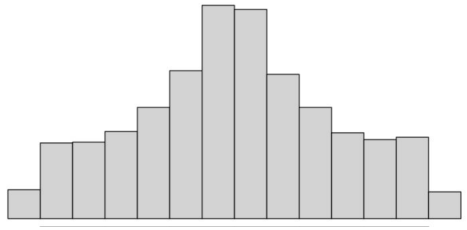
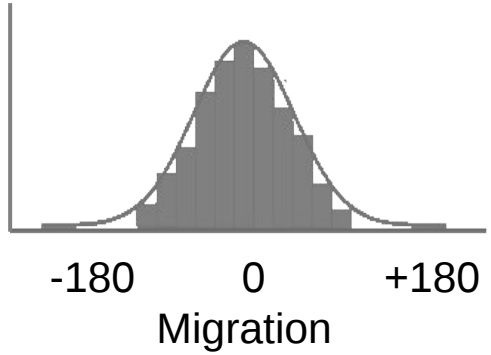


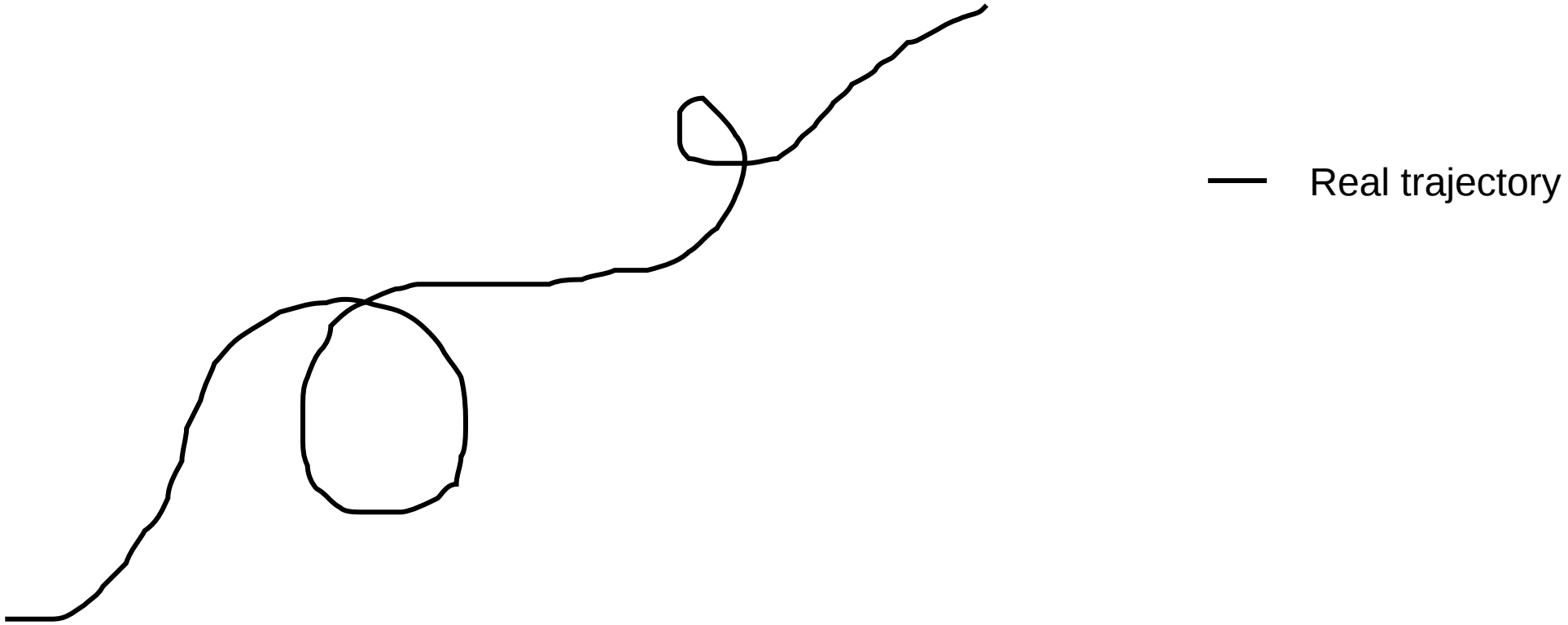
Typical distribution





Effect of sampling frequency

Most trajectories have **gaps and shifts**.
This affects the **calculation and comparability of movement metrics.**



Effect of sampling frequency

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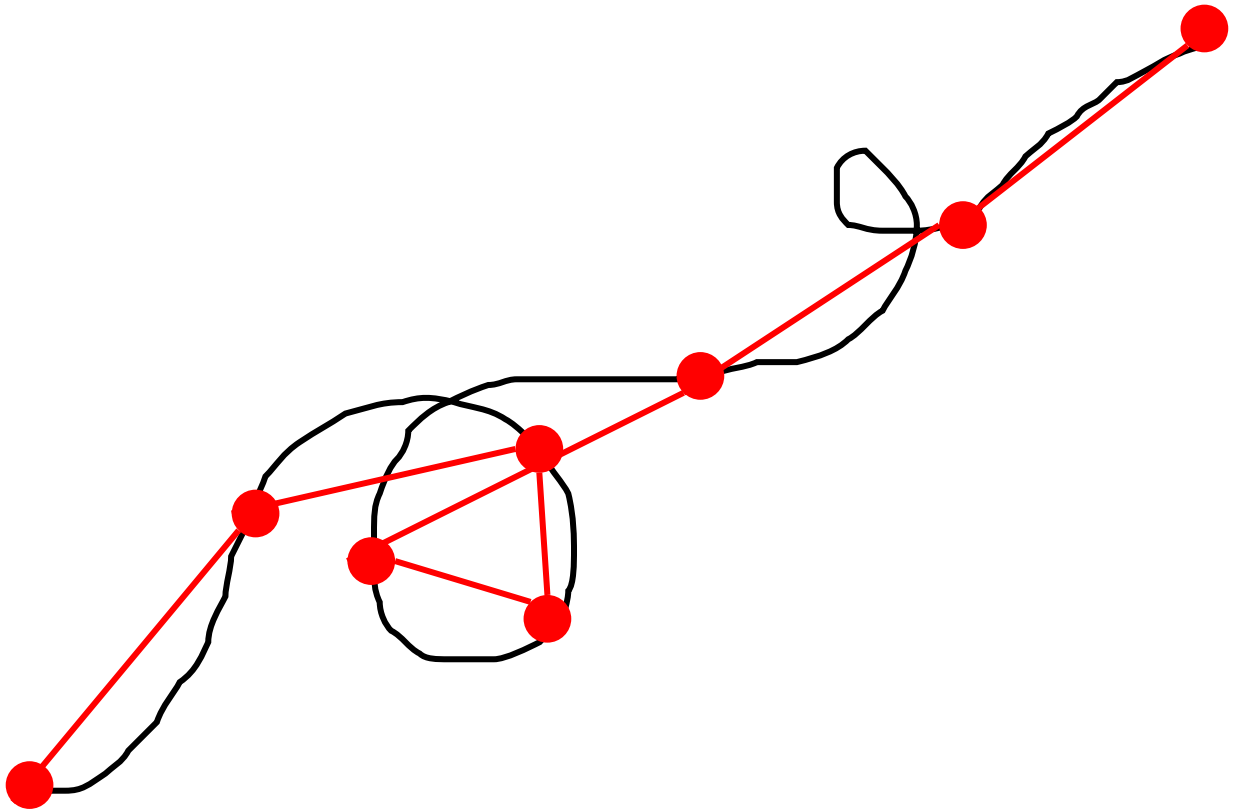
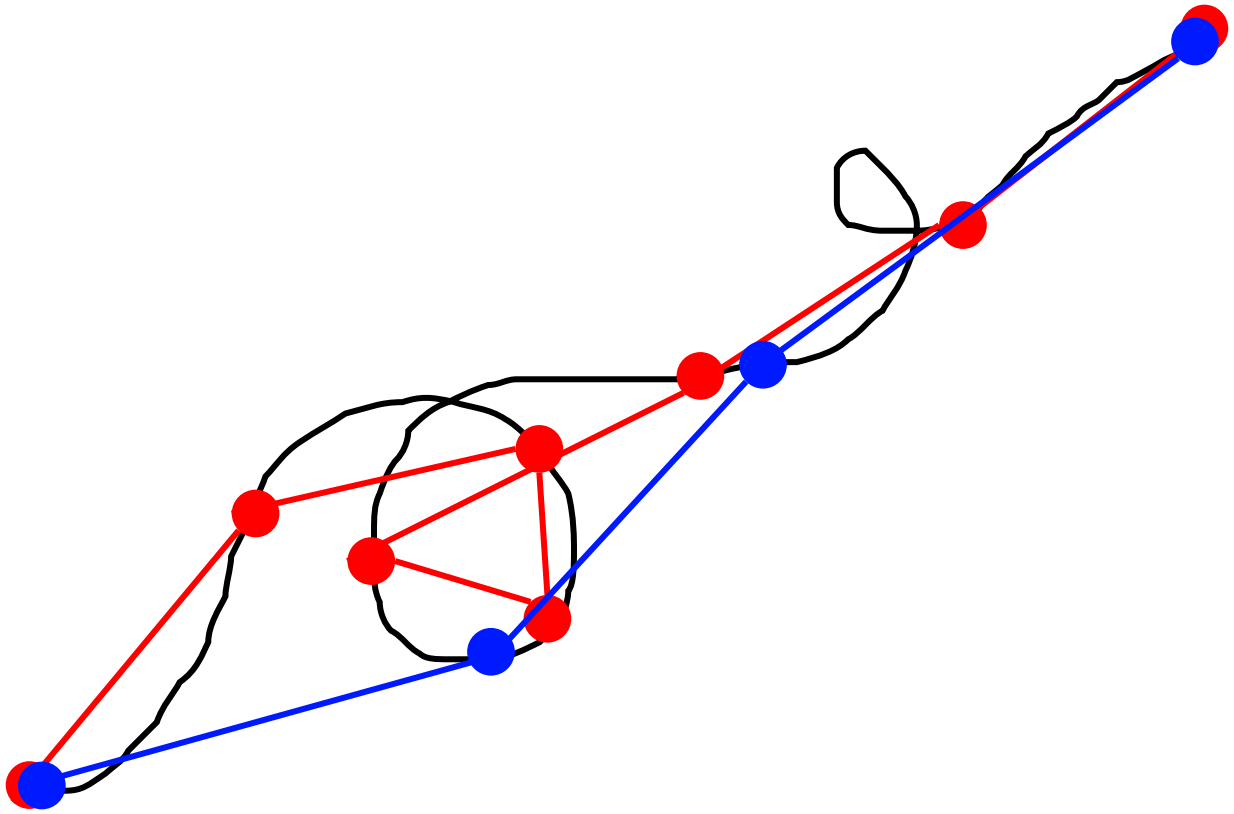


Real trajectory
Data sampled every 15 min

Effect of sampling frequency

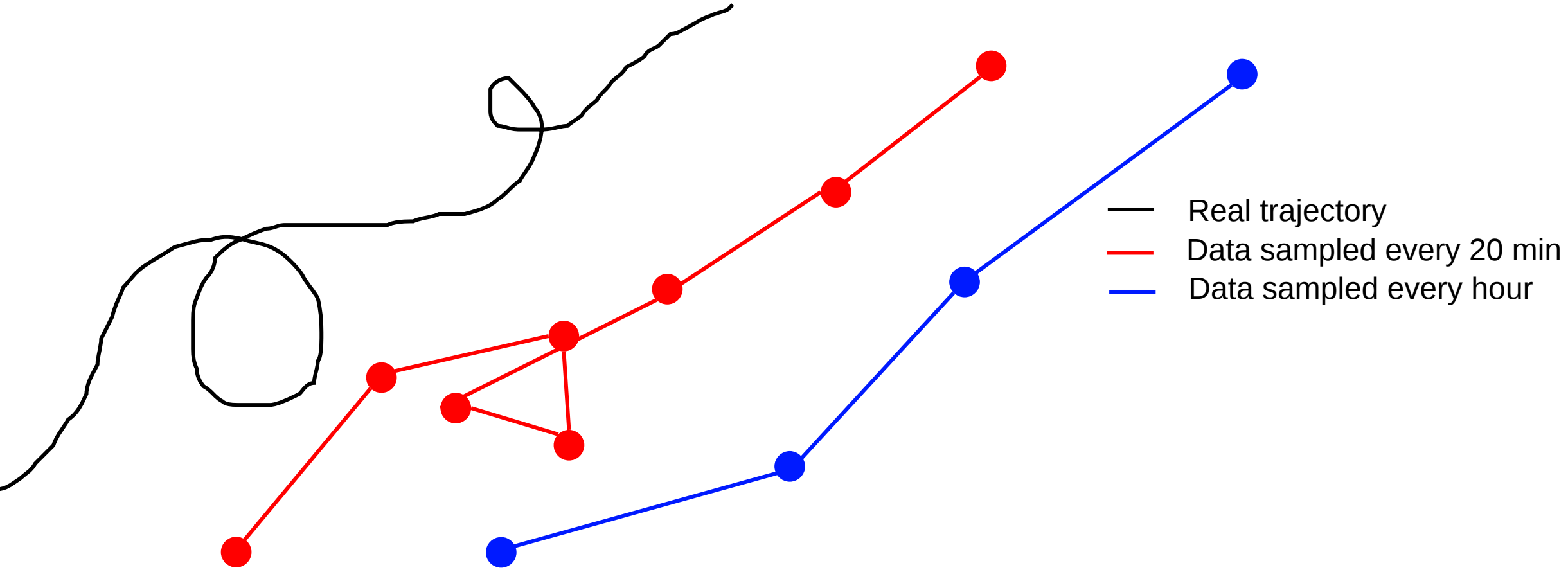
Most trajectories have **gaps and shifts**.
This affects the **calculation and comparability of movement metrics.**



Real trajectory
Data sampled every 20 min
Data sampled every hour

Effect of sampling frequency

Most trajectories have **gaps and shifts**.
This affects the **calculation and comparability of movement metrics.**



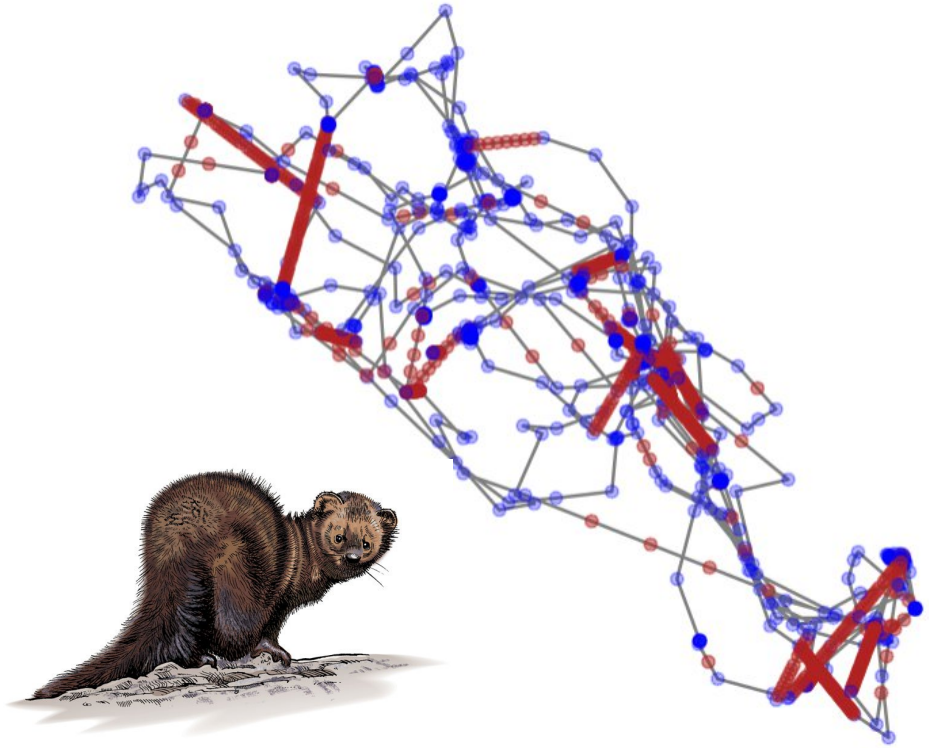
Interpolation and Thinning

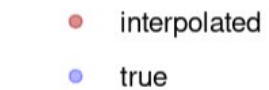
Most trajectories have **gaps and shifts**. **How can we deal with irregular data?**

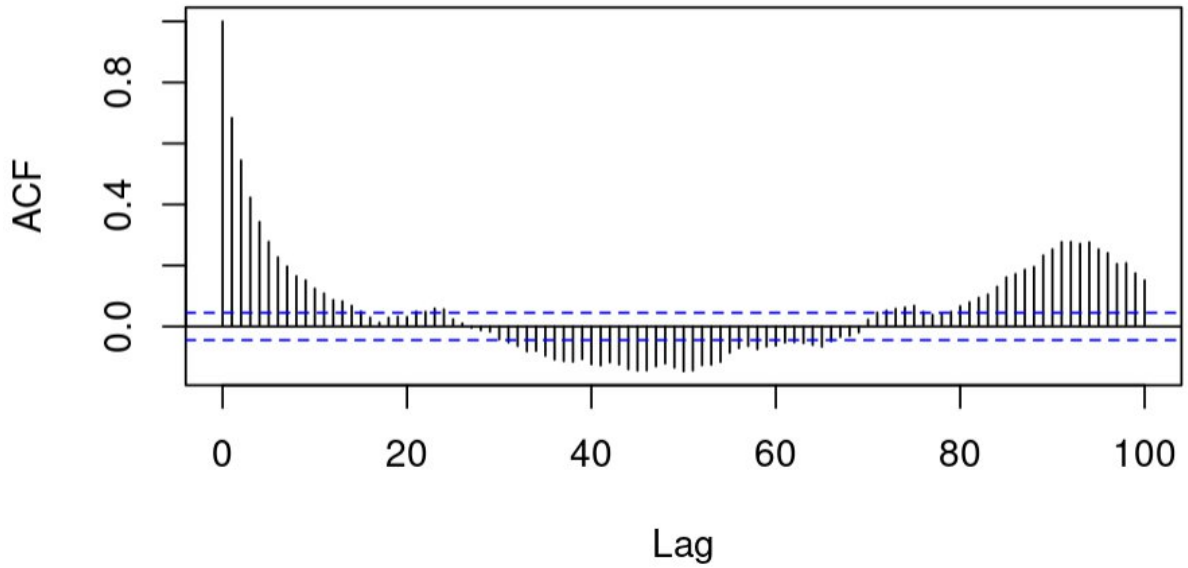
Three (four) solutions:

- **Interpolation** (fill locations in gapy sections). Problem: underestimating speed, variance in azimuth and turning angle. Introduces artificial autocorrelation in the data. Interpolation has to be used with care!
- **Subsampling/thinning** (drop locations to reduce data to largest gap in time). Problem: dropping data removes auto-correlation and affects (underestimates) speed and turning angle.
- **Segment** and work with different parts of your data depending on the purpose.
- (Work with methods that can deal with irregular data (e.g. dBB))

Interpolation



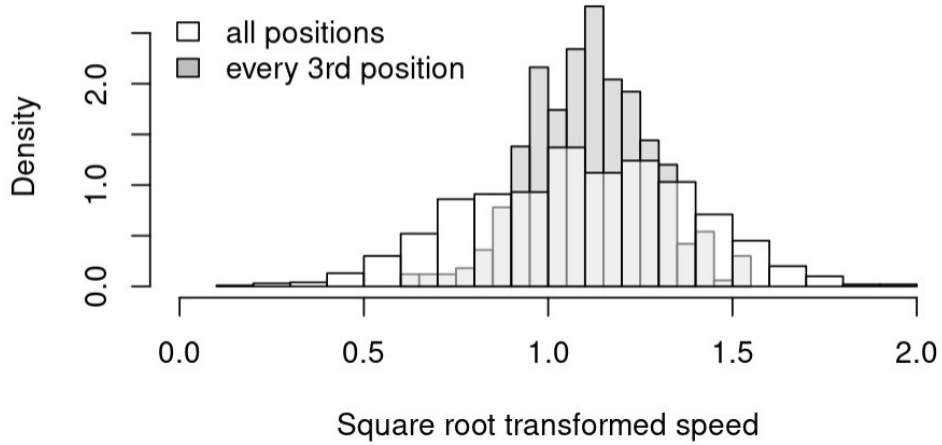




- Sometimes gaps are biologically meaningful (in this case, the fisher was denning)
- By adding linearly interpolated values we are creating artificial autocorrelation in the data.
- Rather work with gaps and errors then introducing points (unless we are sure they were in a static location and/or we need regular sampling for smooth visualizations)

Thinning

Thinning can sometimes be the quickest solution if we want to **compare movement data collected at different sampling frequency**. However, we need to be aware of the effect of thinning on the metrics we calculate.



In the thinned track we underestimate distance covered in the same time lag (unless the track is very directed). **The more tortuous the track, the stronger the effect of sampling frequency on the calculation of speed and distances**). In the case of speed, **high values are only possible with high sampling frequency.**

- **Always report ground speed together with its rate of sampling!**
- **Always compare the "operational sampling rate"** that we observe in the data (how many fixes I get per unit time), irrespective of the sampling schedule I chose.

Hands on

How to do this in R in the script:
*“**5B_TrackMetrics_Outliers_InterpolationThinning.R**”*