

ANIMOVE

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

splayPar(mov.model=~1, err.model=list(x=~errX, y=~errY), drift.no=1,
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.no=1,
data=nfsNew, coord=c("longitude", "latitude"), polar.coord=0,
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

Environmental annotations

Movement in context

Environmental Factors Influence Movement

- The physical environment determines the costs of movement
- Distribution of resources and predators impact decision-making

Adaptations to the Environment

- Explain behavioral and morphological adaptations and evolution in animals as a response to their environment.

Environment-Movement Feedback

- Not only does the environment influence animal movement, but animal movement can also influence the environment.

Dynamic conditions: wind and flight

Energy Conservation

Tailwinds help them move faster and save energy, headwinds can slow them down.

Habitat Selection

Wind conditions can influence where birds choose to live, breed, and forage.

Behavioral Changes

Birds alter their flight behavior or activity levels in response to changes in wind speed and direction.

Climate Change Impact

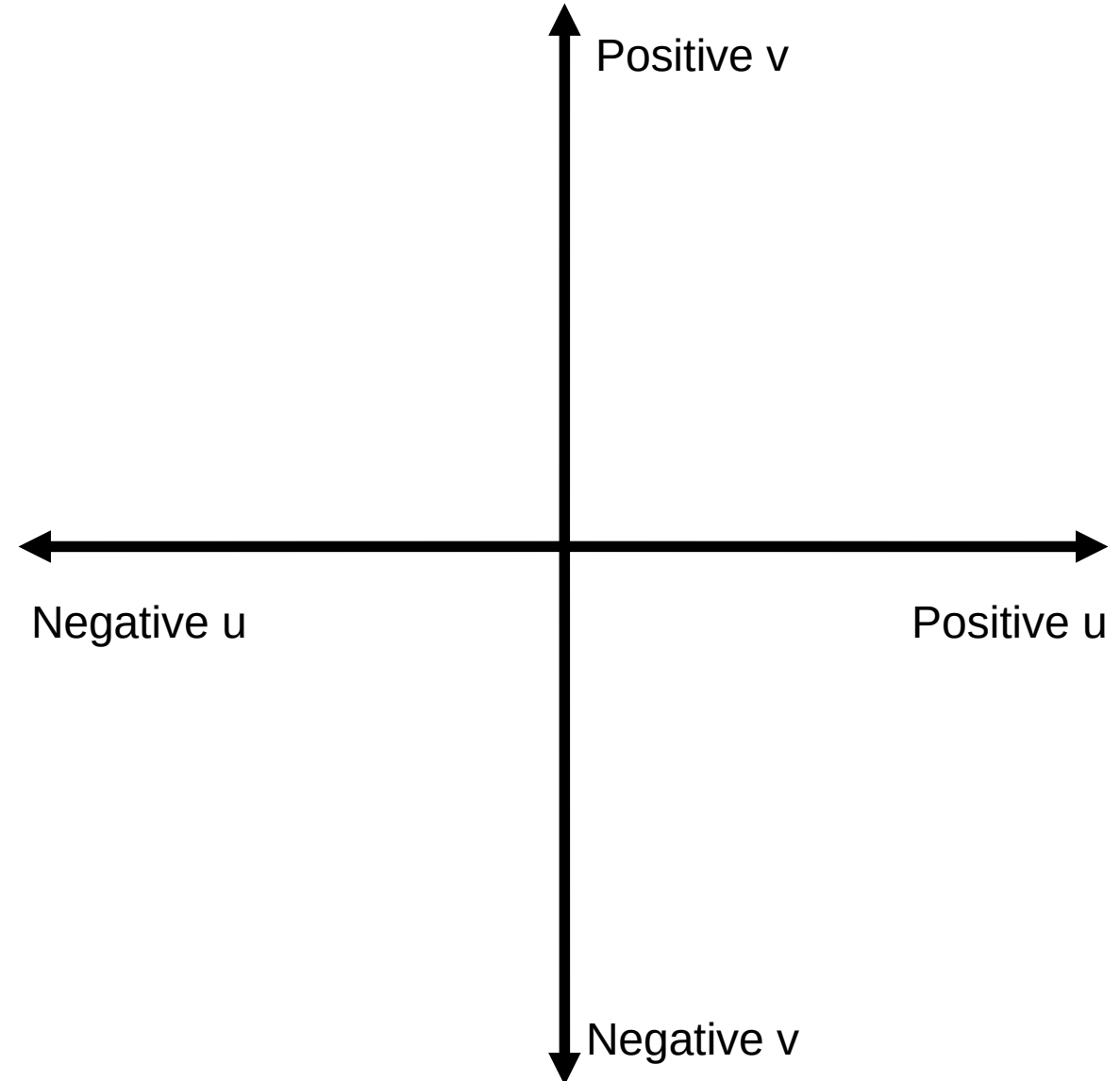
The Earth's circulation patterns are impacted by climate change

Dynamic conditions: wind and flight

Wind components

Eastward wind: u

Northward wind: v

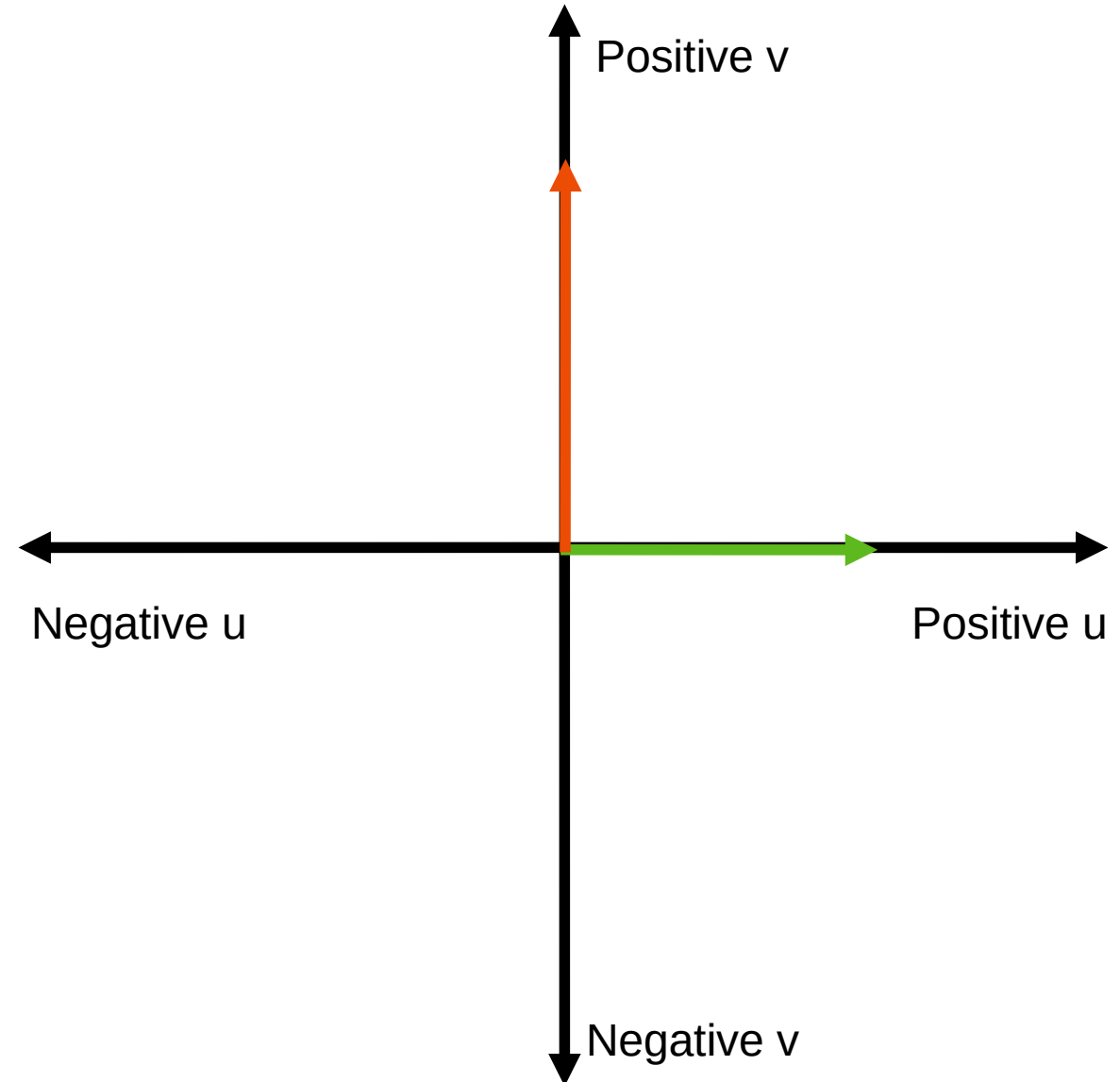


Dynamic conditions: wind and flight

Wind components

Eastward wind: u

Northward wind: v



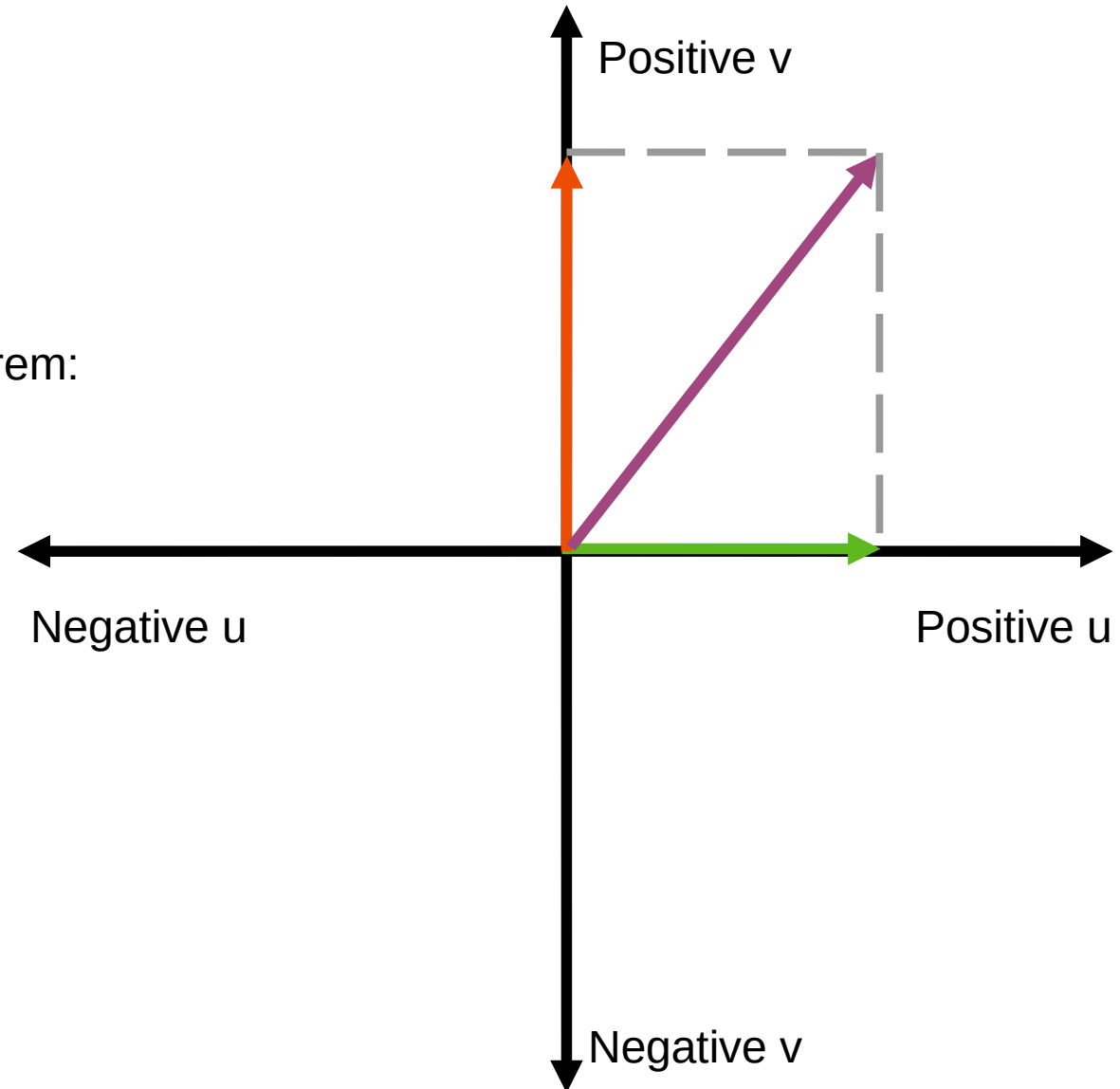
Dynamic conditions: wind and flight

Wind speed

Magnitude of the wind vector.

Calculated using the Pythagorean Theorem:

$$ws = \sqrt{u^2 + v^2}$$



Dynamic conditions: wind and flight

Wind direction

Meteorology:

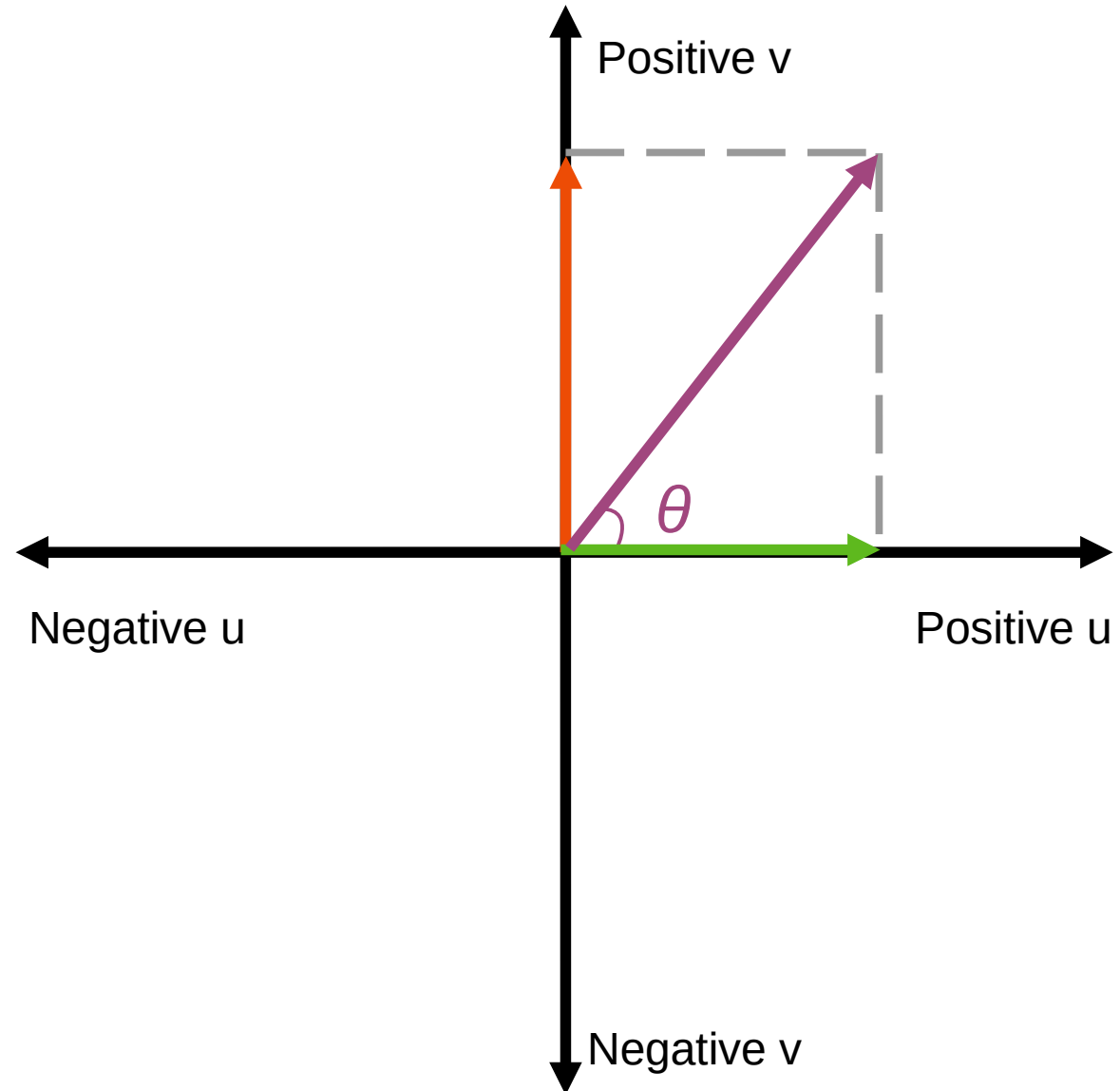
where the wind is blowing from

Ecology (sometimes):

where wind is blowing toward

$$\text{atan2}(y, x) = \begin{cases} \arctan \frac{y}{x} & x > 0 \\ \arctan \frac{y}{x} + \pi & y \geq 0, x < 0 \\ \arctan \frac{y}{x} - \pi & y < 0, x < 0 \\ +\frac{\pi}{2} & y > 0, x = 0 \\ -\frac{\pi}{2} & y < 0, x = 0 \\ \text{undefined} & y = 0, x = 0 \end{cases}$$

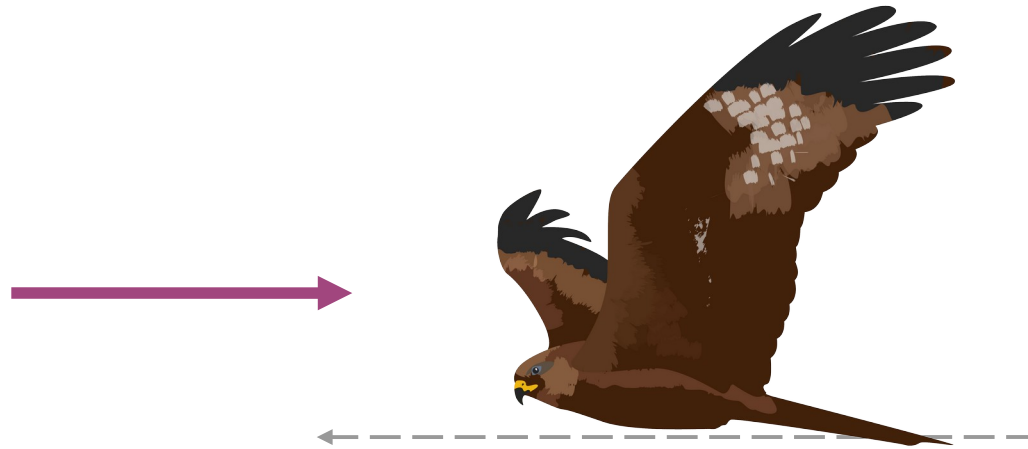
Convert from degrees to radians



Dynamic conditions: wind and flight

Headwind

wind blowing towards the animal



Dynamic conditions: wind and flight

Tailwind (wind support)

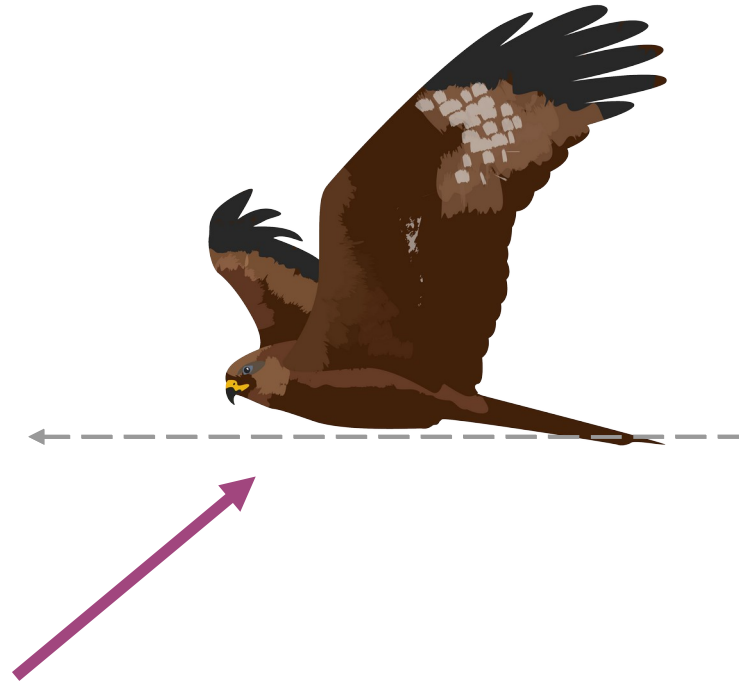
Wind blowing from behind the animal



Dynamic conditions: wind and flight

Crosswind

Wind blowing from the side of the animal

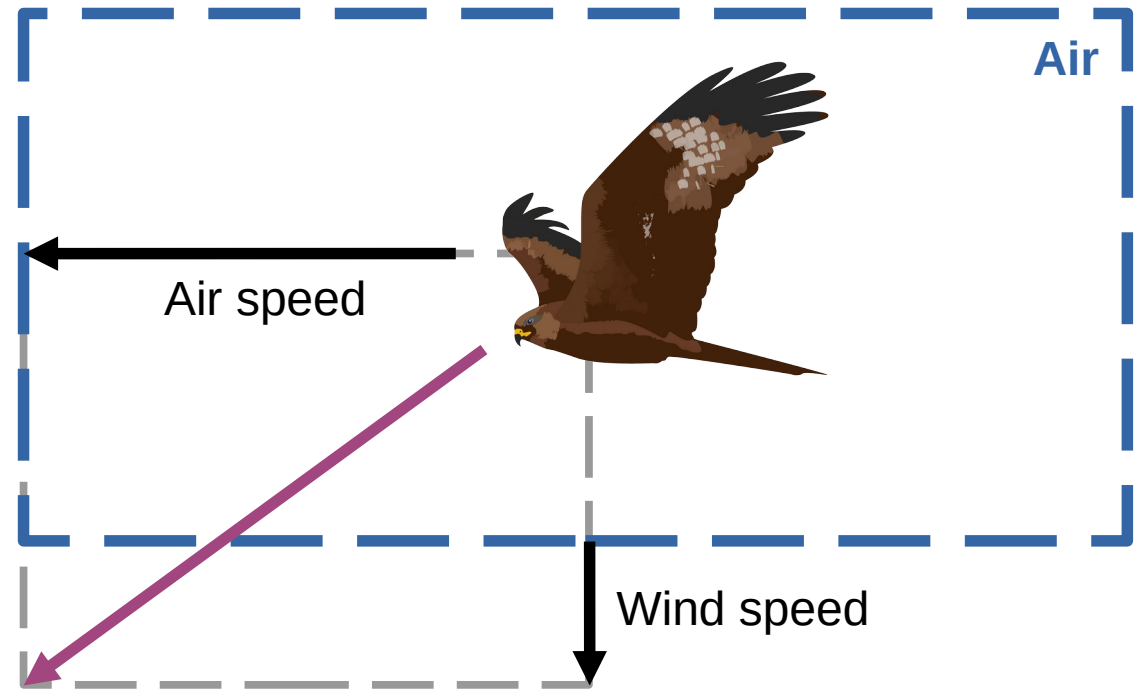


Dynamic conditions: wind and flight

Let's re-visit speed...

Ground speed

- Vector sum of air speed and wind speed
- Wind can shift the animal's trajectory



Track annotations

Relating each tracking point to environmental conditions and variables at that point in **time** and **2D or 3D space**

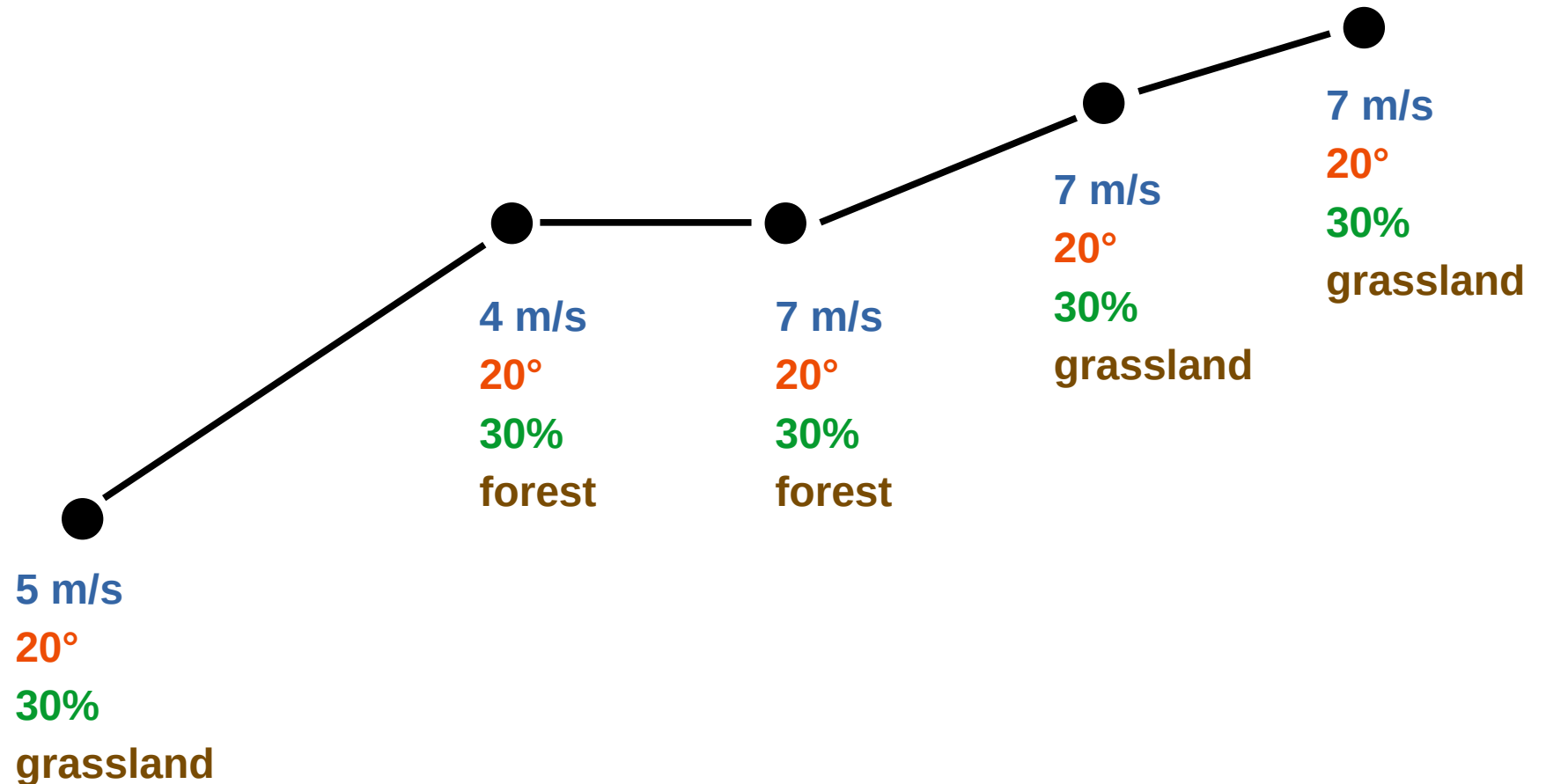
Wind speed

Temperature

Humidity

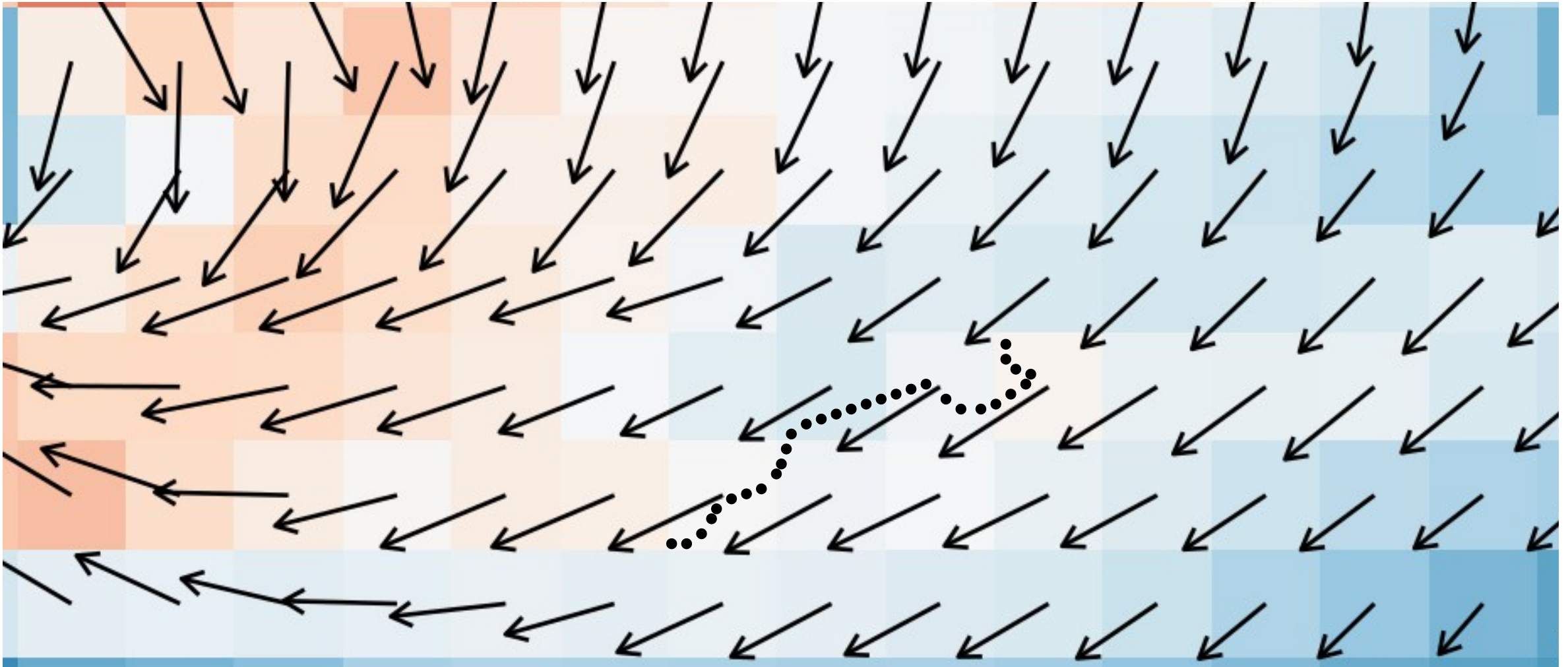
Land cover type

etc.



Spatio-temporal scales

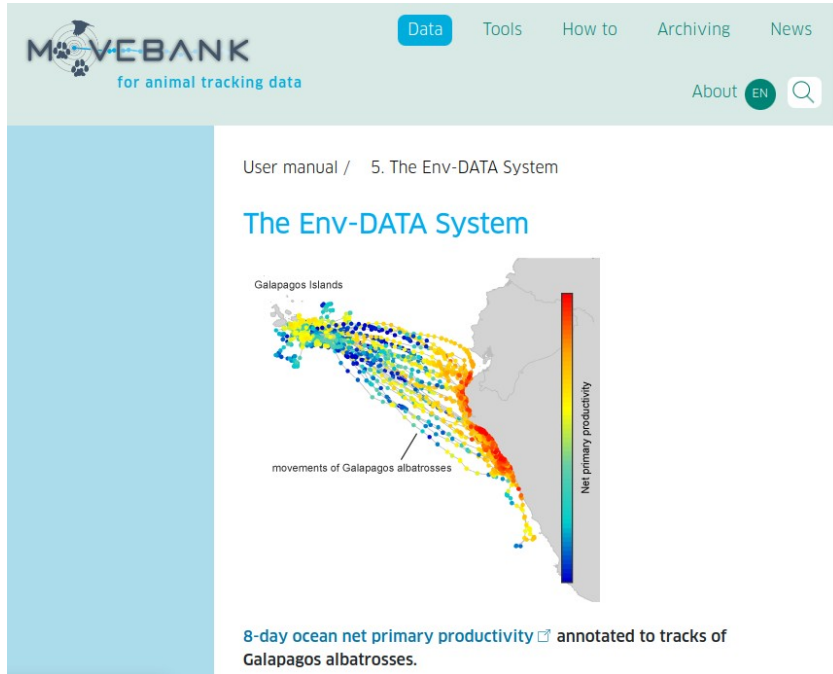
Make sure the resolution of the environmental data and the tracking data match!



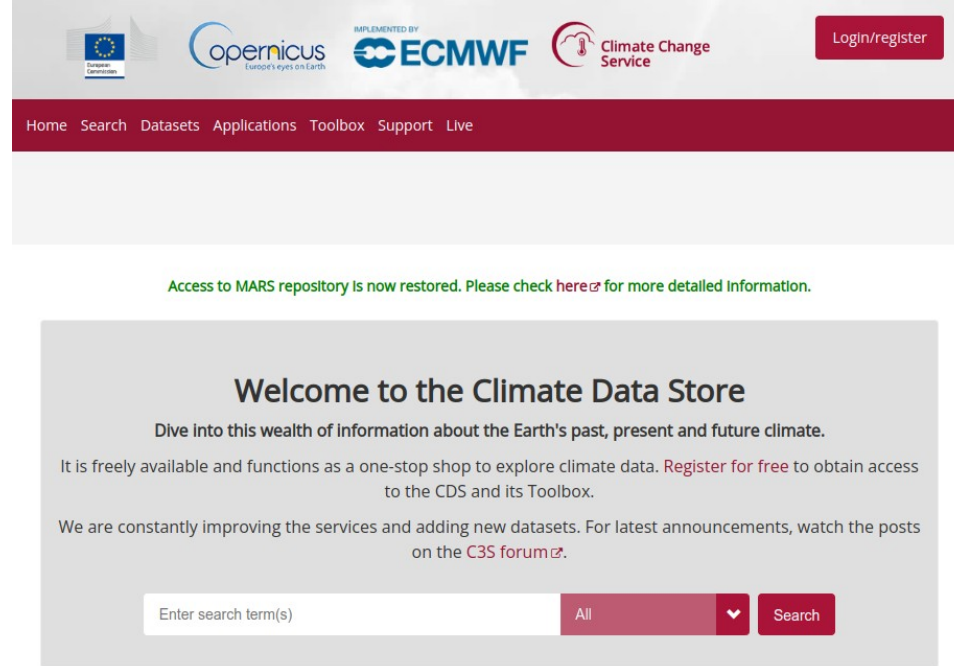
Sources of environmental data

Remote sensing products

Env-DATA Service on Movebank



Meteorological databases, GIS databases, etc.



Env-DATA: <https://www.movebank.org/cms/movebank-content/env-data>

ERA5 weather data: <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=form>

Download ECMWF data directly in R: <https://github.com/bluegreen-labs/ecmwfr>

Env-DATA Service on Movebank

Tips and tricks!

For generic CSVs:

- The timestamps need milliseconds.
- Column names should exactly match the instructions.
- There should be no NA values in the x, y and time columns
- To be safe, make sure there are no NA values in any other column as well!
- Only upload files with a max. 1 million rows

Overall

- Don't request many variables at once
- Don't request data from different products at once
- Get in touch with the support team if you don't get back your data in over a week

Hands on

How to do this in R in the script:
“EnvironmentalAnnotations.R”