

ANIMOVE

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

```
displayPar(mov.model=~1, err.model=list(x=~errX, y=~errY), drift.noa  
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.noa  
data=nfsNew, coord=c("longitude", "latitude"), polar.coord  
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

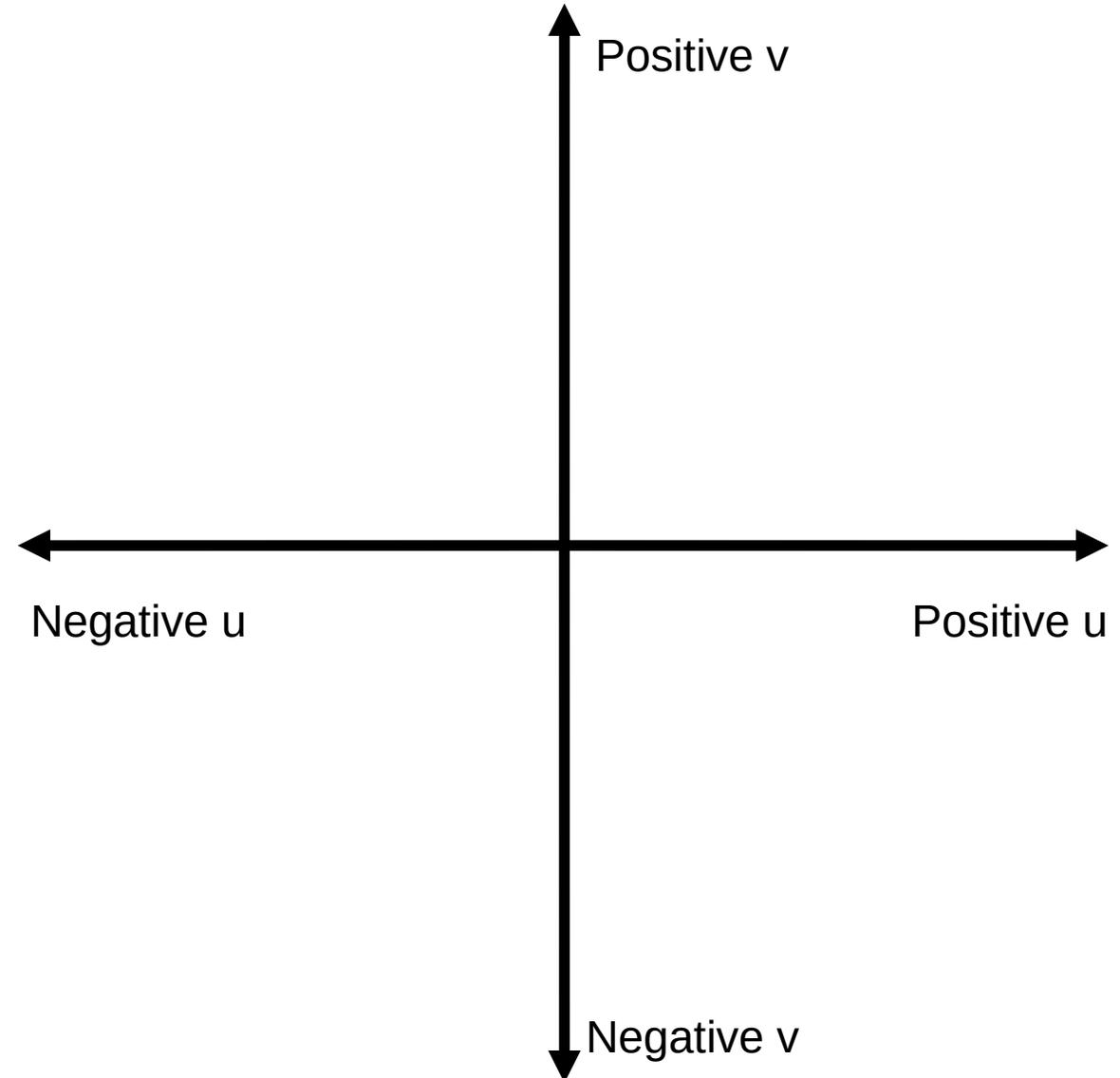
The Earth's circulation patterns are impacted by climate change

Dynamic conditions: wind and flight

Wind components

Eastward wind: u

Northward wind: v

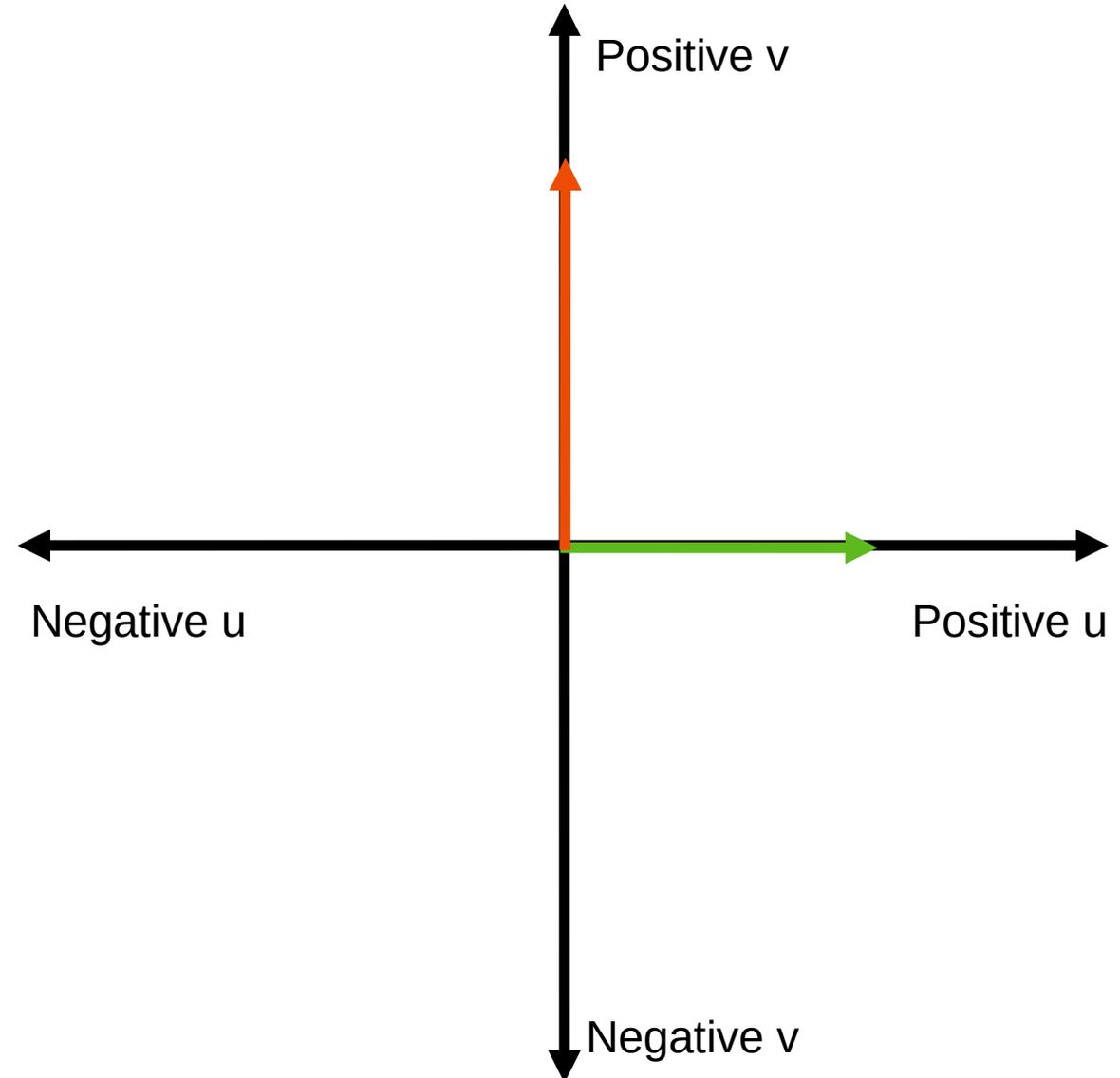


Dynamic conditions: wind and flight

Wind components

Eastward wind: u

Northward wind: v



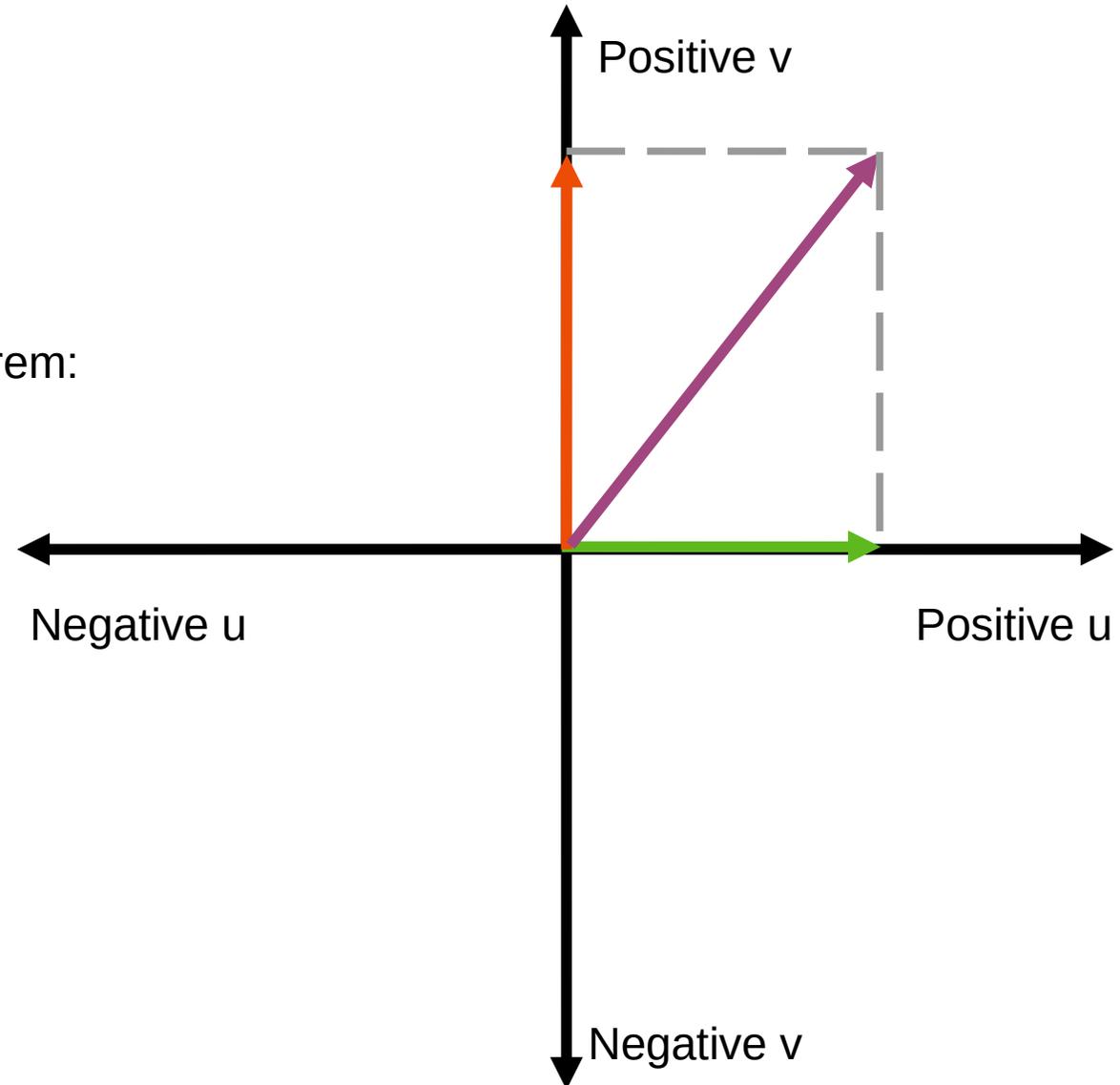
Dynamic conditions: wind and flight

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:

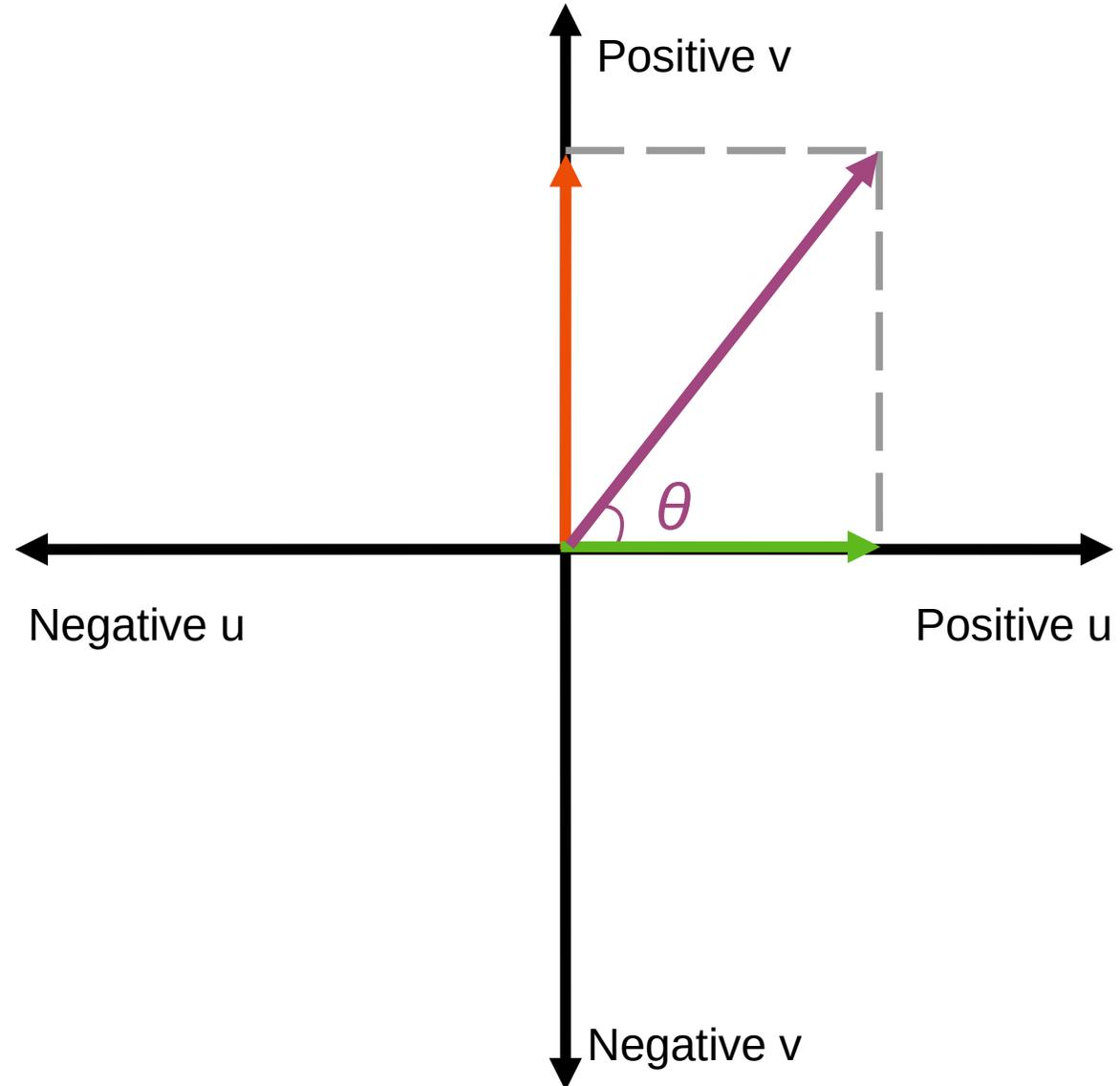
where the wind is blowing from

Ecology (sometimes):

where wind is blowing toward

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

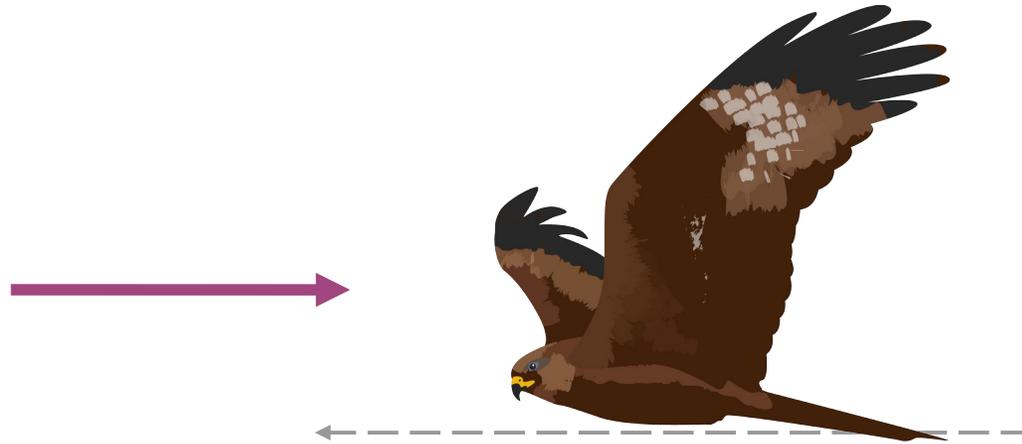
Convert from degrees to radians



Dynamic conditions: wind and flight

Headwind

wind blowing towards the animal



Dynamic conditions: wind and flight

Tailwind (wind support)

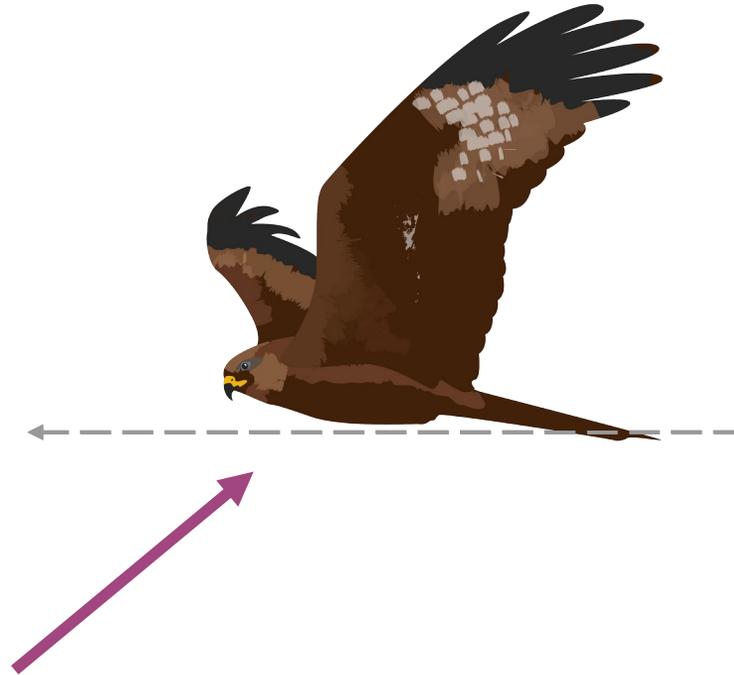
Wind blowing from behind the animal



Dynamic conditions: wind and flight

Crosswind

Wind blowing from the side of the animal

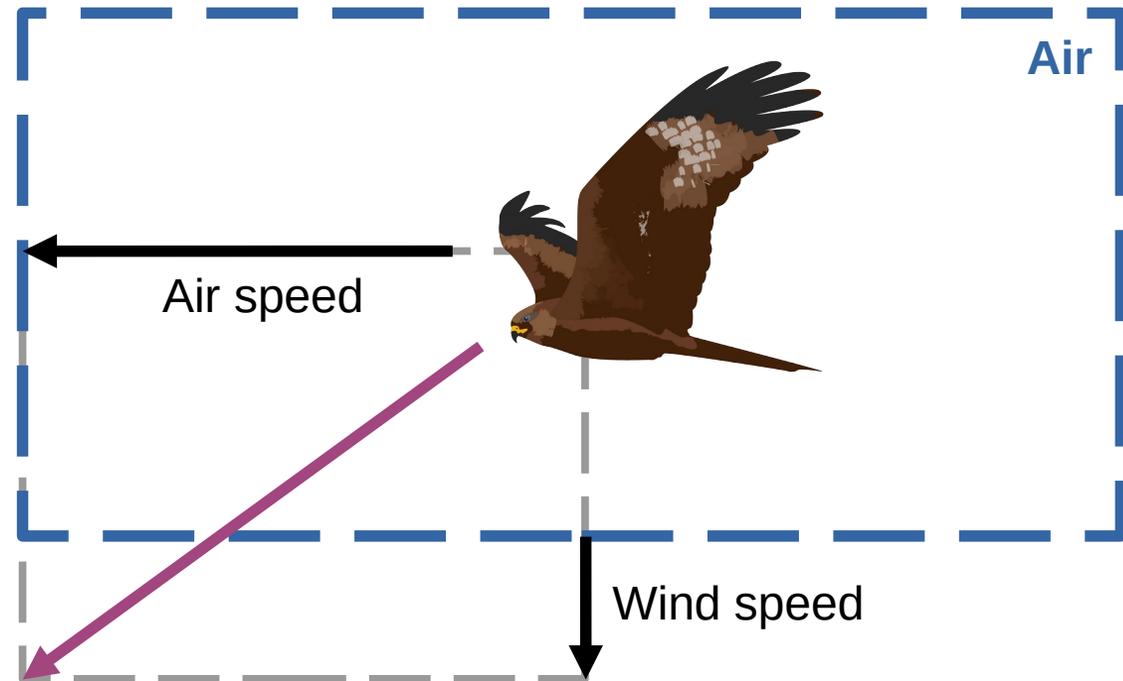


Dynamic conditions: wind and flight

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*

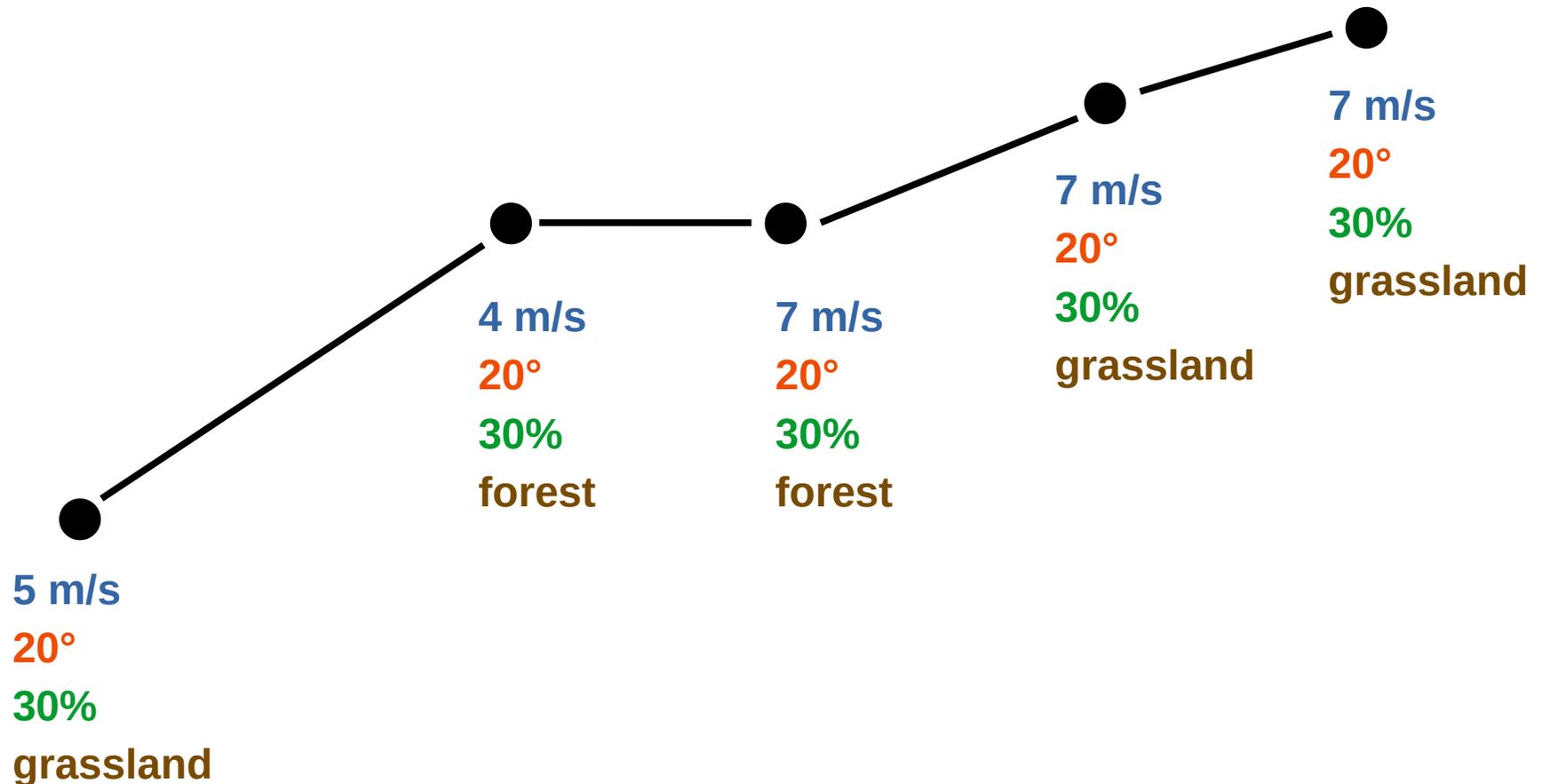
Wind speed

Temperature

Humidity

Land cover type

etc.



Spatio-temporal scales

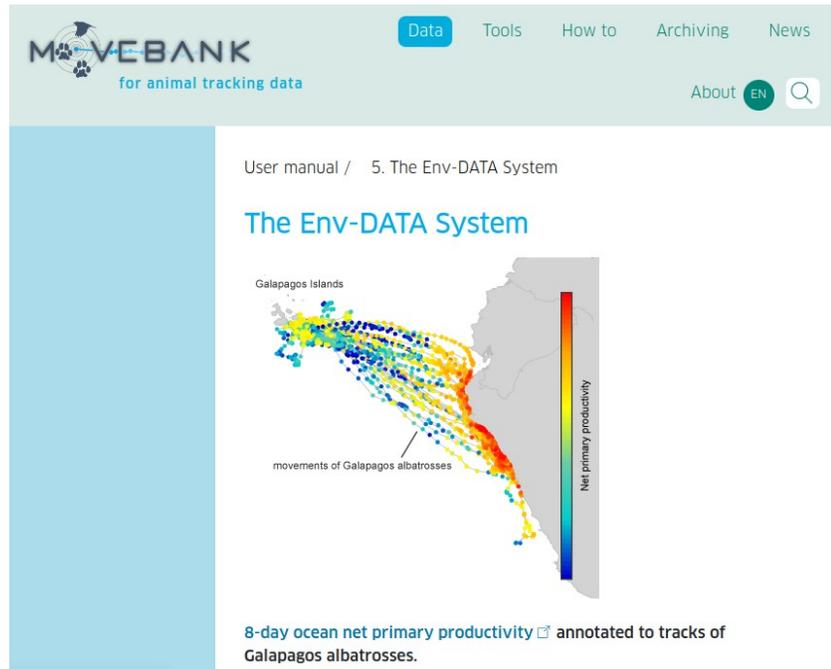
Make sure the resolution of the environmental data and the tracking data match!



Sources of environmental data

Remote sensing products

Env-DATA Service on Movebank



MOVEBANK
for animal tracking data

Data Tools How to Archiving News

About EN

User manual / 5. The Env-DATA System

The Env-DATA System

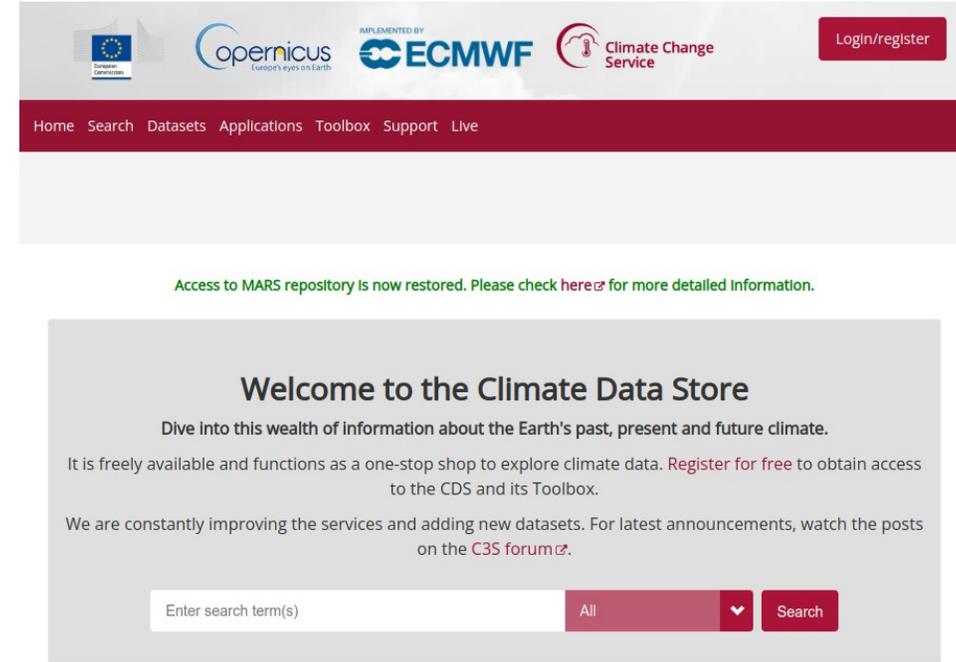
Galapagos Islands

movements of Galapagos albatrosses

Net primary productivity

8-day ocean net primary productivity  annotated to tracks of Galapagos albatrosses.

Meteorological databases, GIS databases, etc.



European Commission Copernicus IMPLEMENTED BY ECMWF Climate Change Service Login/register

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Access to MARS repository is now restored. Please check [here](#) for more detailed information.

Welcome to the Climate Data Store

Dive into this wealth of information about the Earth's past, present and future climate.

It is freely available and functions as a one-stop shop to explore climate data. Register for free to obtain access to the CDS and its Toolbox.

We are constantly improving the services and adding new datasets. For latest announcements, watch the posts on the [CDS forum](#).

Enter search term(s) All Search

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”