Introduction to the Integration of Animal Tracking and Remote Sensing

Part 2: Integration of Animal Tracking and Remote Sensing Data

Juan Torres-Pérez (NASA), Justin Fain (BAERI), Sativa Cruz (BAERI)
Invited Speakers: Morgan Gilmour (NASA), Claire Teitelbaum (USGS/Univ. of Georgia)

Training Learning Objectives

By the end of this training attendees will be able to:

1. Identify the types of animal tracking tags and sensors that are commonly used in animal tracking.
2. Identify the types of remote sensing data and products that can be used for species distribution models and step-selection functions.
3. Recognize the process for integrating remote sensing and animal tracking data in species distribution models and step selection functions to facilitate an understanding of animal movements in relation to their environment.
4. Recognize key takeaways from examples of terrestrial and marine applications that inform and characterize animals' habitats.

Prerequisites

- Fundamentals of Remote Sensing

Training Outline

Part 1

Introduction to Animal Tracking and Remote Sensing at NASA

May 20, 2025

12:00 - 13:30 EDT (UTC-4)

Part 2

Integration of Animal Tracking and Remote Sensing Data

May 22, 2025

12:00 - 13:30 EDT (UTC-4)

Homework

Opens May 22, 2025 – Due June 5, 2025 – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.

Part 2 – Trainers

Juan Torres-Pérez
Research Scientist
NASA Ames

Sativa Cruz
Research Scientist
BAERI/NASA Ames

Justin Fain
Research Scientist
BAERI/NASA Ames

Integration of Animal Tracking and Remote Sensing Data – Guest Instructors

Dr. Morgan Gilmour

Research Scientist

NASA Ames Research Center

Dr. Claire Teitelbaum

Assistant Unit Leader

USGS

University of Georgia

Part 2 - Learning Objectives

By the end of this session, attendees will be able to:

1. Identify steps in the process for accessing animal tracking data in **species distribution models** to facilitate an understanding of animal movements in relation to their environment.
2. Identify steps in the process for accessing animal tracking data in **step selection functions** to facilitate an understanding of animal movements in relation to their environment.
3. Recognize key takeaways from examples of **terrestrial applications that inform and characterize animals' habitats**.
4. Recognize key takeaways from examples of **marine applications that inform and characterize animals' habitats**.

How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all of the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

Section 1: Integration of Animal Tracking & Remote Sensing: A Marine Case Study on Tracking Frigatebirds at Palmyra Atoll

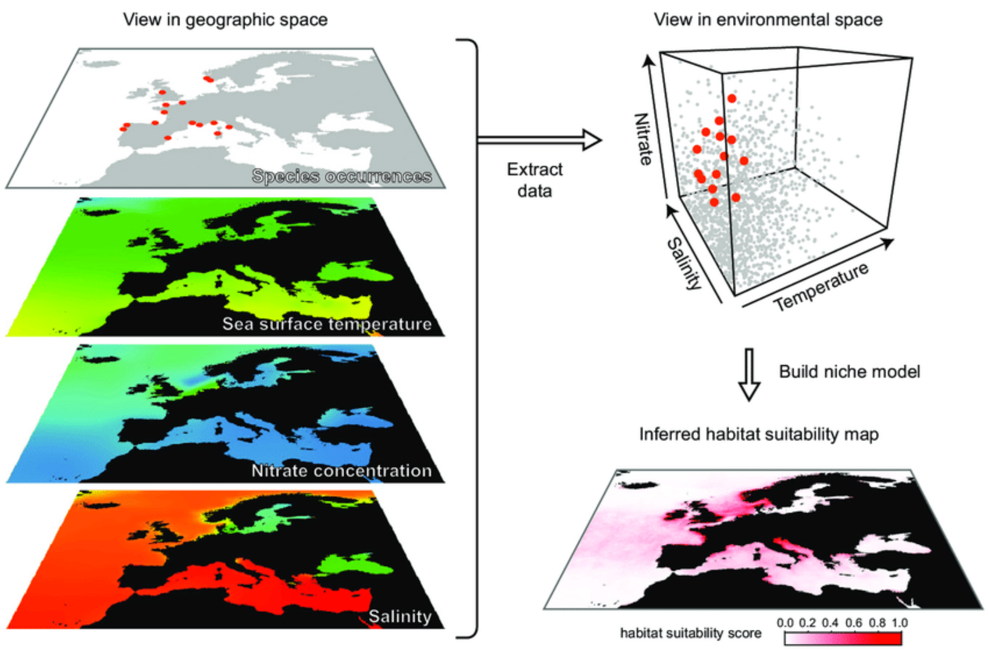
Remote Sensing Data Considerations

- Determine which **environmental covariates** you're interested in
  - A literature search can help understand what variables were important and/or of interest in other study regions, or for similar or related species
- Determine the **temporal resolution** best suited for your species, habitat, and research question
  - Finescale data (e.g., hourly, daily) may not be available in all regions
  - Regions/seasons with high cloud cover can generate a lot of NA's in the data, so using coarser resolutions may help
  - Consider the scale of each variable; some may not change much on an hourly basis (e.g., temperature) and may also not change much across a small horizontal scale
- Record the **spatiotemporal resolution** of the environmental data so that you can report it later.


Image credit: NASA GSFC

Recap: Characterizing Animals' Habitats via Species Distribution Models

- Species Distribution Models (SDM)
  - Help us understand the likelihood of animals' presence in different habitat types
  - Asks the question: **How did the environment differ between where the animal did and did NOT go?**
  - Result: Habitat suitability map
- Steps
  - Prepare animal tracks
  - Define presence/absence points
  - Download environmental covariates
  - Model
    - Binary response variable (present/absent) predicted by environmental covariates



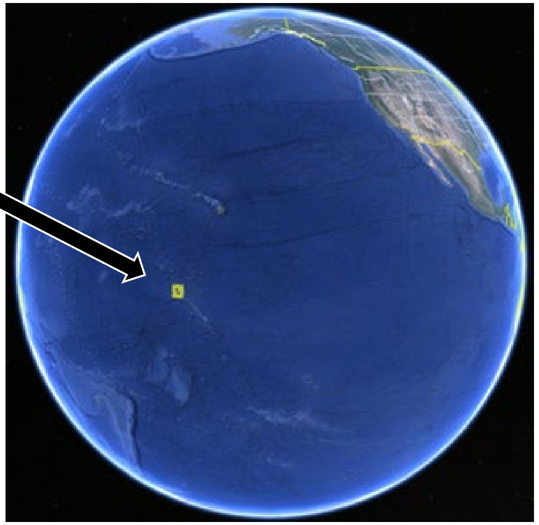
Marcelino & Verbruggen 2015 *J. Phycol*

Tracking Dataset: Great Frigatebirds at Palmyra Atoll

Dataset details

- Species: Great frigatebird (*Fregata minor*)
- Tag type: GPS
- Sample size: 7 birds
- Dates: June 2022 - March 2023
- Original tracking project objective: Quantify movement within & outside marine protected area
  - Project results published here: https://doi.org/10.1111/gcb.70138
  - Dataset available here: https://doi.org/10.24431/rw1k8ez

Palmyra Atoll

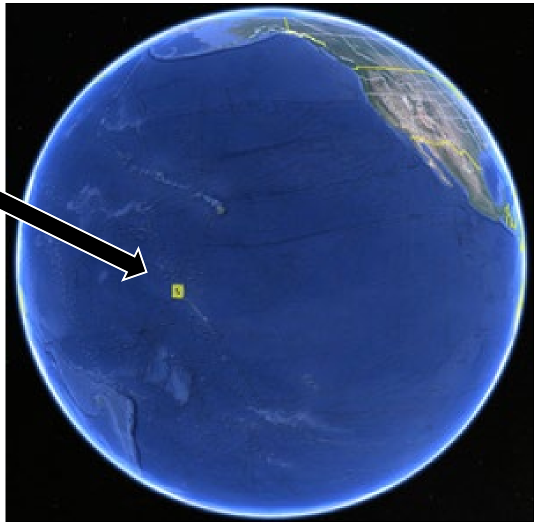


Tracking Dataset: Great Frigatebirds at Palmyra Atoll

- **Ecological context**
  - Frigatebirds are seabirds: They nest on islands and search the ocean for food like fish & squid.
  - Frigatebirds are central-place foragers: They need to forage in the ocean and return to their nest regularly to feed their growing chick.

- SDM can help answer the question: What is the ocean like where frigatebirds travel and forage?

Palmyra Atoll



Tracking Data: Great Frigatebirds at Palmyra Atoll

- Data prep
  - Basic cleaning steps
    - Remove NA's in locations (GPS data, so not many NA's)
    - Apply speed filter (25 m/s [90 km/hr])
    - Calculate distance to nest & filter for points >5 km away

```
> # Show dataframe
> glimpse(frigatebird.tracks)
Rows: 135,316
Columns: 5
$ Timestamp          <dttm> 2022-06-04 19:40:08, 2022-06-04 19:45:07, 2022-06-04 19:50:11, 2022-06-04 1…
$ LocationLong       <dbl> -162.0737, -162.0736, -162.0736, -162.0737, -162.0736, -162.0736, -162.0736,…
$ LocationLat        <dbl> 5.879910, 5.879928, 5.879931, 5.879917, 5.879932, 5.879929, 5.879933, 5.8799…
$ TagLocalIdentifier <chr> "eobs_9829", "eobs_9829", "eobs_9829", "eobs_9829", "eobs_9829", "eobs_9829"…
$ Island             <chr> "Palmyra", "Palmyra", "Palmyra", "Palmyra", "Palmyra", "Palmyra", "Palmyra",…
> 
```

Tracking Data: Great Frigatebirds at Palmyra Atoll

- Data prep: Apply speed filter

```
# Apply speed filter ----

# First, calculate Inter-point distances (unit=seconds)
frigatebird.tracks$InterPtDist<-trakR::InterpointDist(tracks = frigatebird.tracks,
                                                      ID = "TagLocalIdentifier",
                                                      lat = "LocationLat",
                                                      lon = "LocationLong")

# Second, calculate Inter-point time (unit=meters)
frigatebird.tracks$InterPtTime<-trakR::InterpointTime(tracks = frigatebird.tracks,
                                                      ID = "TagLocalIdentifier",
                                                      DateTime = "Timestamp")

# Third, calculate Inter-point speed (unit=km/hr)
frigatebird.tracks$Speed<-trakR::Speed(Dist = frigatebird.tracks$InterPtDist,
                                       Time = frigatebird.tracks$InterPtTime)

# Fourth, filter out points based on speed threshold
# 25 m/s (90 kmphr; speed filter from: Weimerskirch & Prudor 2019
# https://doi.org/10.1038/s41598-019-41481-x)
frigatebird.tracks<-frigatebird.tracks %>%
  filter(Speed<90)
#
```

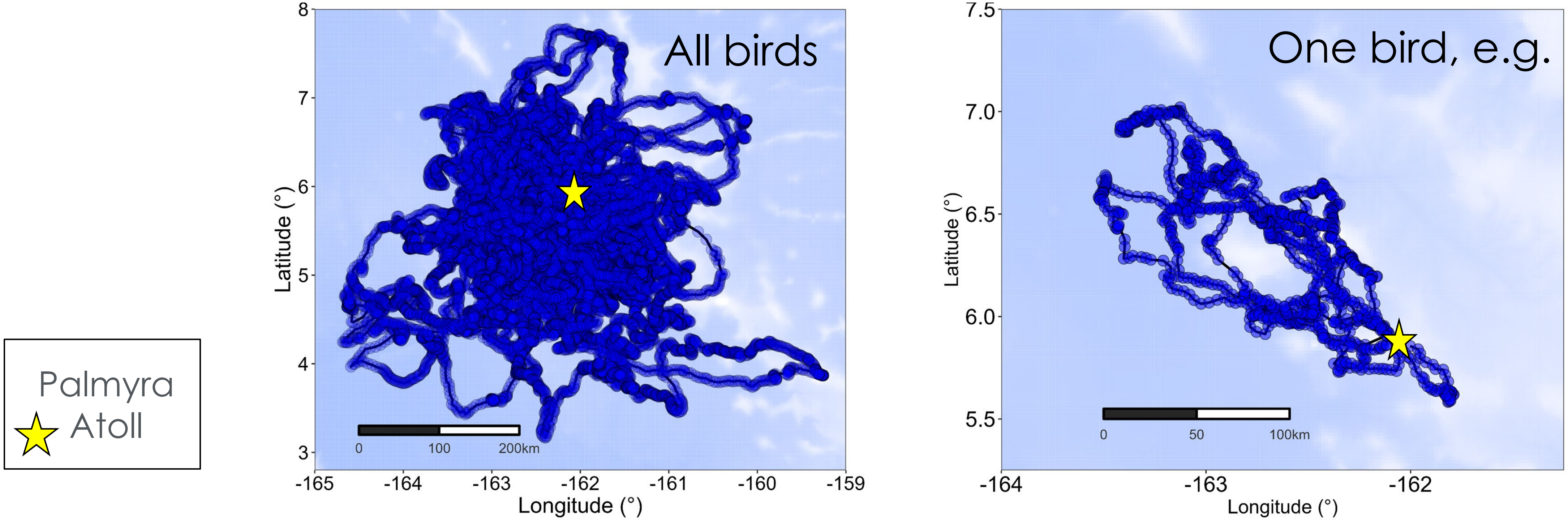
Tracking Data: Great Frigatebirds at Palmyra Atoll

- Data prep: Keep points > 5 km from nesting island
  - This is because seabirds spend many hours sitting on their nests, and this doesn't tell us anything about oceanographic habitat

```
# Calculate distance to nest island ----

# Define nest island location
palmyra<-data.frame(LocationLong=-162.072567,
                    LocationLat=5.879722,
                    Island="Palmyra")

frigatebird.tracks$Dist2Island<-trakR::AddDist2Colony(tracks = frigatebird.tracks,
                                                      dataLat = "LocationLat",
                                                      dataLon = "LocationLong",
                                                      CaptureSitesData = palmyra,
                                                      SiteName = "Island",
                                                      capLat = "LocationLat",
                                                      capLon = "LocationLong")

# Filter locations >5 km from Palmyra for analyses
frigatebird.tracks<-frigatebird.tracks %>%
  filter(Dist2Island > 5)
#
```

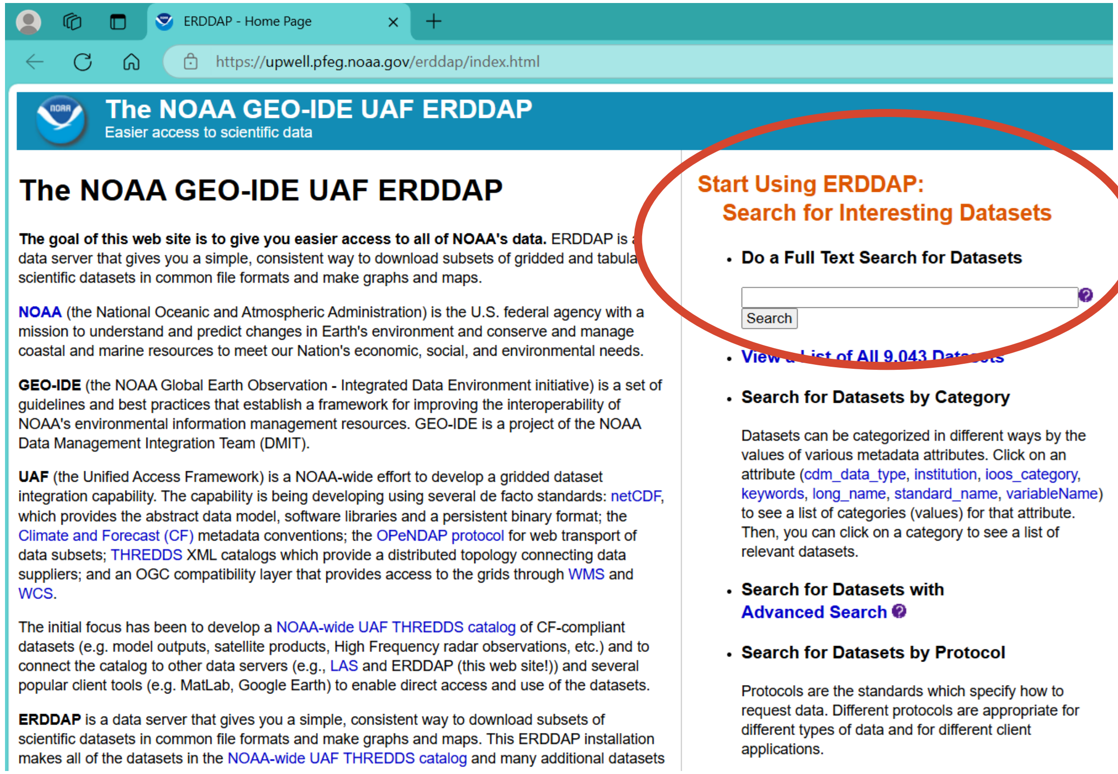
Tracking Data: Great Frigatebirds at Palmyra Atoll

- Data prep
  - Visualize tracking data: Does it look as you expected?



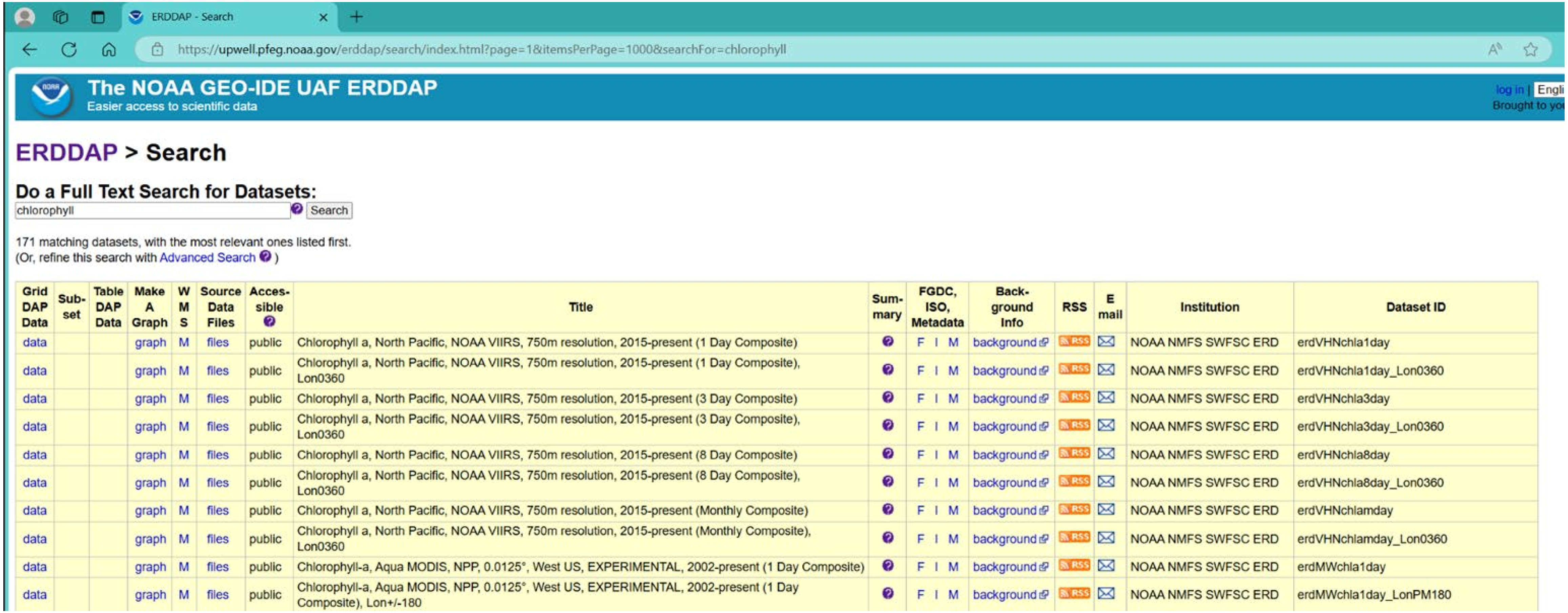
Download Remote Sensing Data via R: ERDDAP

- R-pkg: rerddapXtracto
  - Can extract data for single points along the track (function: rxtracto) or over a whole grid (function rxtracto_3D)
- How it works:
  - ERDDAP: Environmental Research Division Data Access Program
  - Provides standardized way to access and download data from many sources
  - We use NOAA’s ERDDAP here, but you can substitute other ERDDAP platforms



Download Remote Sensing Data via R: ERDDAP

- Example: “chlorophyll” search


ERDDAP - Search

https://upwell.pfeg.noaa.gov/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=chlorophyll

The NOAA GEO-IDE UAF ERDDAP
Easier access to scientific data

log in | Engli
Brought to yo

ERDDAP > Search

Do a Full Text Search for Datasets:

chlorophyll [Search]

171 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Acces-sible	Title	Sum-mary	FGDC, ISO, Metadata	Back-ground Info	RSS	E mail	Institution	Dataset ID
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (1 Day Composite)		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchla1day
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (1 Day Composite), Lon0360		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchla1day_Lon0360
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (3 Day Composite)		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchla3day
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (3 Day Composite), Lon0360		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchla3day_Lon0360
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (8 Day Composite)		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchla8day
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (8 Day Composite), Lon0360		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchla8day_Lon0360
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (Monthly Composite)		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchlamday
data			graph	M	files	public	Chlorophyll a, North Pacific, NOAA VIIRS, 750m resolution, 2015-present (Monthly Composite), Lon0360		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdVHNchlamday_Lon0360
data			graph	M	files	public	Chlorophyll-a, Aqua MODIS, NPP, 0.0125°, West US, EXPERIMENTAL, 2002-present (1 Day Composite)		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdMWchla1day
data			graph	M	files	public	Chlorophyll-a, Aqua MODIS, NPP, 0.0125°, West US, EXPERIMENTAL, 2002-present (1 Day Composite), Lon+/-180		F I M	background	RSS		NOAA NMFS SWFSC ERD	erdMWchla1day_LonPM180

Download Remote Sensing Data via R: ERDDAP

- View the metadata for your chosen dataset via rerddap function “info”
  - Does this match the spatiotemporal extent of your tracking data?

```
> ## Chlorophyll ----
> CHL<-rerddap::info("erdMBchlamday_LonPM180")
> CHL
<ERDDAP info> erdMBchlamday_LonPM180
 Base URL: https://upwell.pfeg.noaa.gov/erddap
 Dataset Type: griddap
 Dimensions (range):
     time: (2008-01-16T12:00:00Z, 2025-03-16T12:00:00Z)
     altitude: (0.0, 0.0)
     latitude: (-45.0, 65.0)
     longitude: (-180.0, 179.975)
 Variables:
     chlorophyll:
         Units: mg m-3
>
```

Download Remote Sensing Data via R: ERDDAP

Download steps

1. Determine spatiotemporal extent of data to download
2. Download grid of environmental data
3. Append environmental data to each frigatebird location (next section)

```r
# Download environmental variables via ERDDAP
## Data prep ----

# Step 1: Determine spatial extent of frigatebird tracks
extent_to_download<-data.frame(Longitude=c(min(frigatebird.tracks$LocationLong),
                                           max(frigatebird.tracks$LocationLong)),
                               Latitude=c(min(frigatebird.tracks$LocationLat),
                                          max(frigatebird.tracks$LocationLat)))

# Step 2: Determine temporal extent of frigatebird tracks
dates_to_download<-data.frame(min_date=min(frigatebird.tracks$Timestamp),
                              max_date=max(frigatebird.tracks$Timestamp))

# Step 3: Set location to hold downloaded data
out_folder<-"C:/Users/Desktop/Frigatebird_evars/"

# Set cache to out_folder
rerddap::cache_setup(full_path = out_folder,temp_dir = FALSE)
```

Download Remote Sensing Data via R: ERDDAP

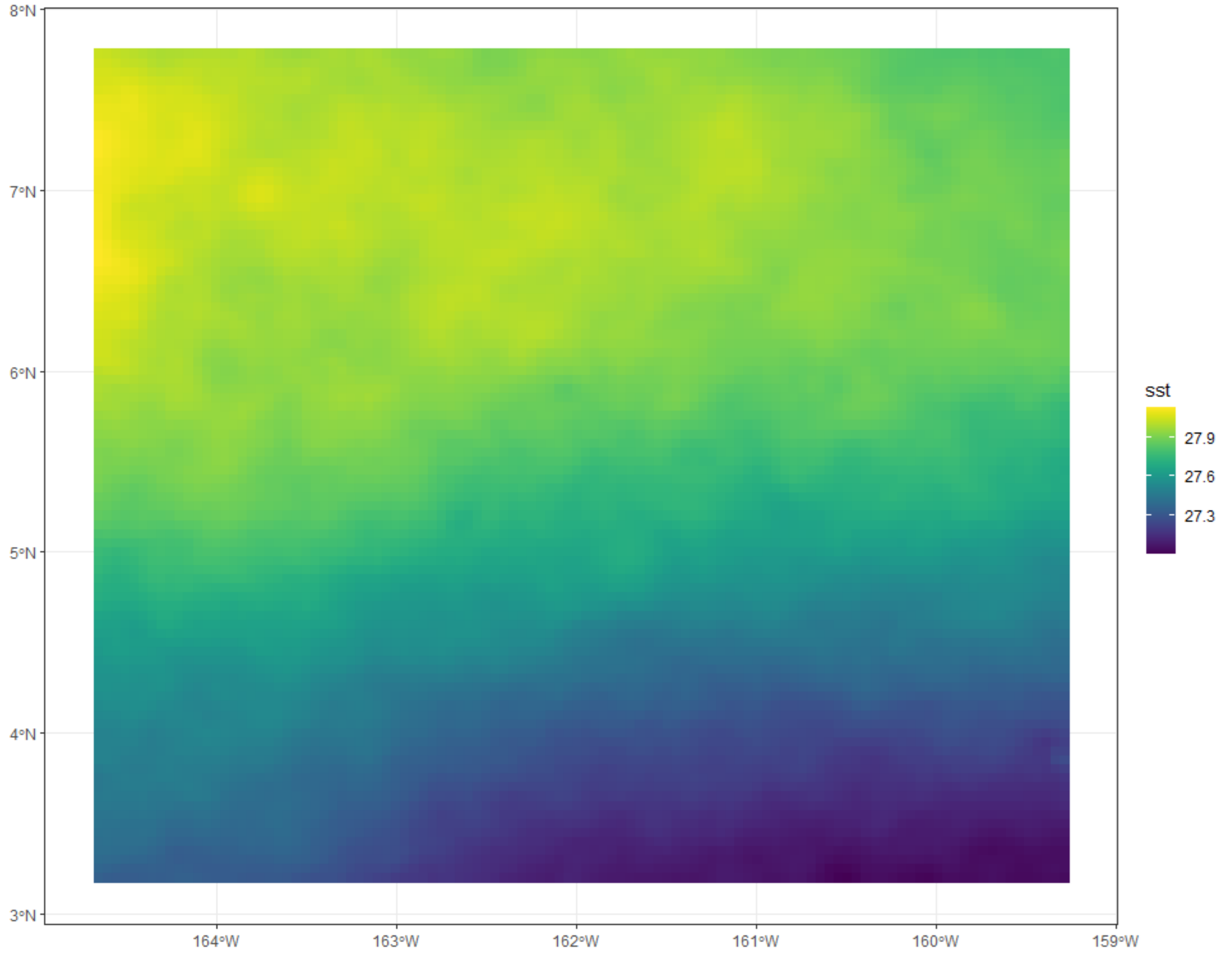
- Download reminders
  - Set cache_remove=FALSE to save file for later, if desired (will save as .nc file)
  - Resulting dataframe can be converted to tidy-data (helpful for ggplot, e.g.)

```
# Sea surface temperature ----
SST<-rerddap::info("jplMURSST41mday")
SST

# Download data
sst<-rerddapXtracto::rxtracto_3D(dataInfo = SST,
                                 parameter = "sst",
                                 xcoord = c(min(extent_to_download$Longitude),
                                            max(extent_to_download$Longitude)),
                                 ycoord = c(min(extent_to_download$Latitude),
                                            max(extent_to_download$Latitude)),
                                 tcoord = c(dates_to_download$min_date,
                                            dates_to_download$max_date),
                                 # zcoord = c(0,0),
                                 verbose = TRUE,
                                 cache_remove = FALSE)

# Plot to verify download was successful
rerddapXtracto::plotBBox(sst)

# Convert to tidy format (dataframe)
sst_tidy<-rerddapXtracto::tidy_grid(sst)
```

Download Remote Sensing Data via R: ERDDAP

- Download reminders
  - Several rerddapXtracto functions also enable plotting (e.g., plotBBox)

```
# Plot to verify download was successful
rerddapXtracto::plotBBox(sst)
```



Download Remote Sensing Data via R: R-pkg marmap

- Download bathymetry directly from the NOAA ETOPO 2022 database (via National Centers for Environmental Information)
  - Citation for bathymetry dataset: https://www.doi.org/10.25921/fd45-gt74
- Reminders
  - Downloads as a grid
  - Use keep = TRUE to save file for later (if desired)
  - Resulting dataframe can be converted to tidy-data (helpful for ggplot, e.g.)
  - If downloading data in the Pacific (across the dateline) use antimeridian = TRUE

```r
## Download bathymetry via marmap package ----

bathymetry<-marmap::getNOAA.bathy(lon1 = max(extent_to_download$Longitude),
                                  lon2 = min(extent_to_download$Longitude),
                                  lat1 = min(extent_to_download$Latitude),
                                  lat2 = max(extent_to_download$Latitude),
                                  antimeridian = TRUE,
                                  resolution = 4, #units=arc-minutes
                                  keep = TRUE,
                                  path = out_folder)

#
```

Append Remote Sensing Data to Animal Tracks

- Read in .nc files

```
# Append environmental covariates to tracking data ----
## Read in .nc files ----

library(ncdf4)

# List all the chlorophyll files in your out_folder, e.g.
files<-list.files(path=out_folder,
                  pattern="chla",
                  full.names=TRUE)

# Open the chlorophyll files
chla.nc<-nc_open(files)
# Confirm that there's data
ncdf4::ncvar_get(chla.nc,varid = "chlorophyll")

# Create a raster "stack" of the chlorophyll data. Each layer is a date.
dat_chla<-lapply(files,function(x)raster::stack(x,varname="chlorophyll"))
dat_chla<-raster::stack(dat_chla)
#
```

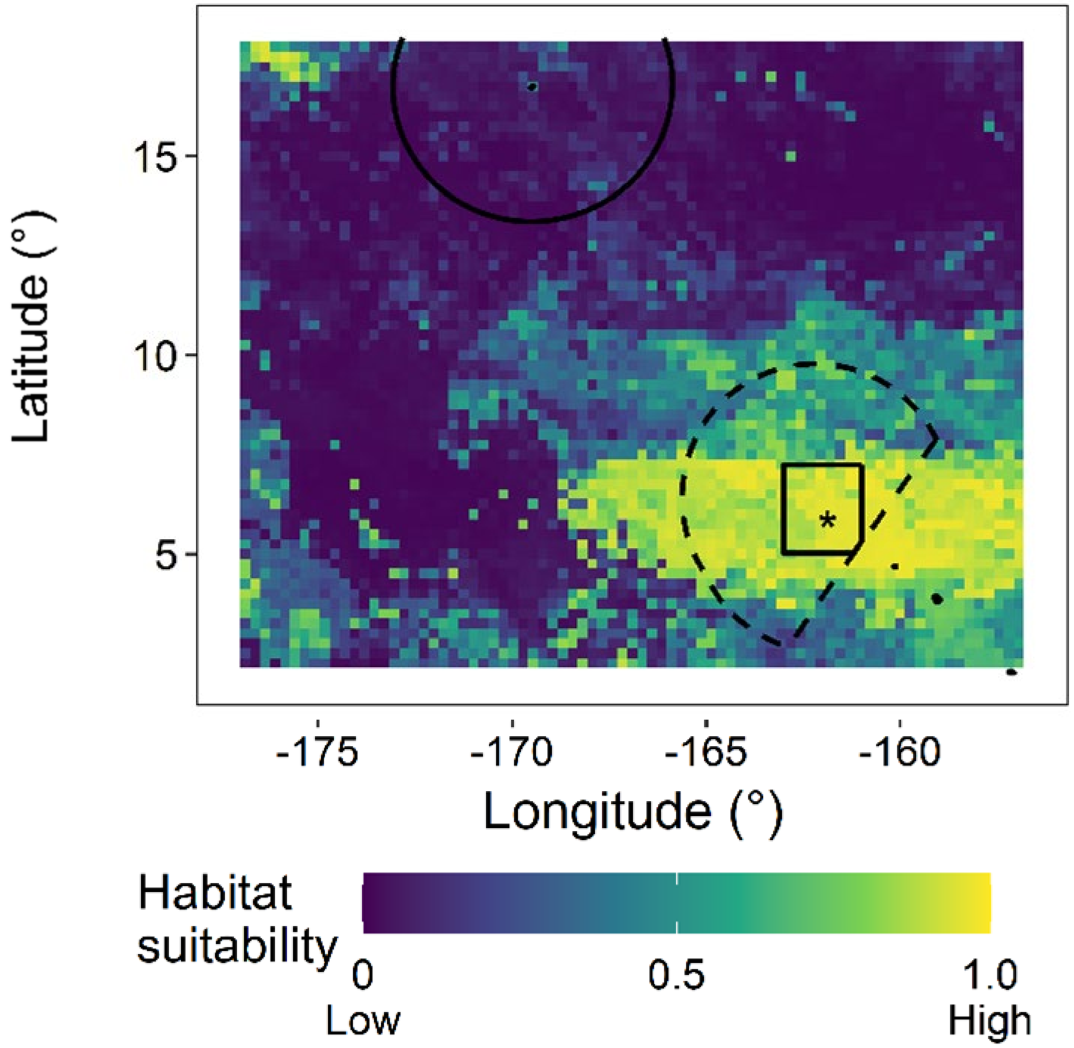
Append Remote Sensing Data to Animal Tracks

- See code demo

Species Distribution Model

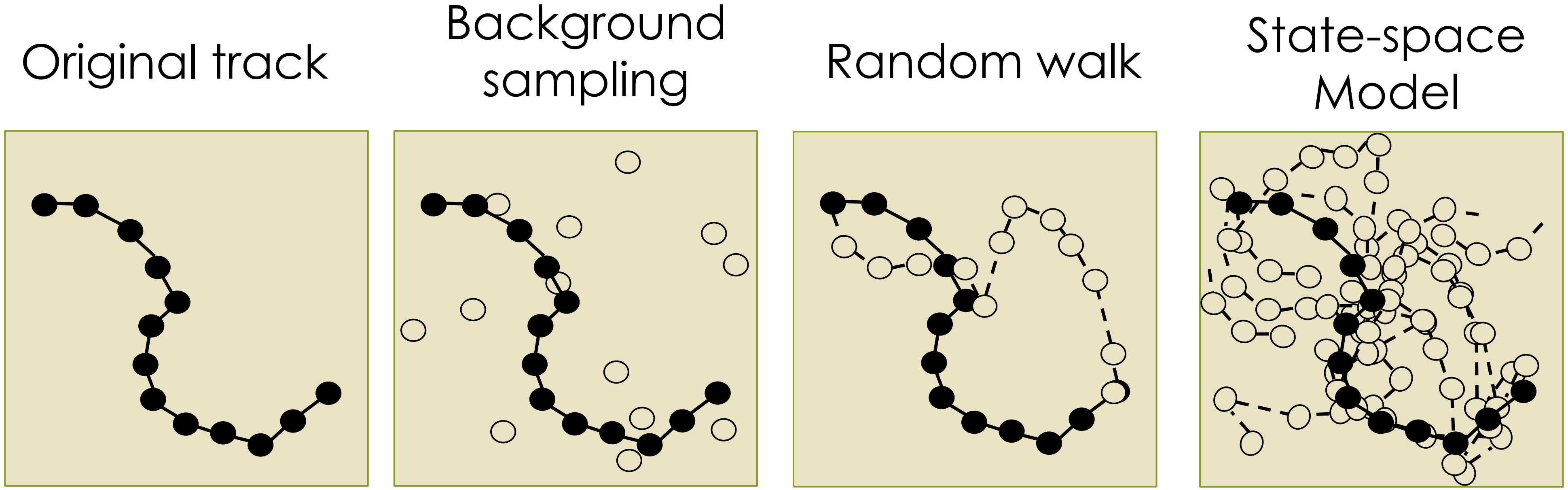
Basic Steps

1. Simulate pseudo-absences: Select points where animals did NOT go
2. Predict species occurrence with statistical model
    a. Species presence (or absence) = environmental covariate + environmental covariate etc.
3. Assess resulting model
    a. Evaluate results statistically
    b. Plot
    c. Evaluate results within context of species' behaviors, known habitats



Species Distribution Model: Simulate Pseudo-Absences

- Pseudo-absence: A location where an animal did NOT go
- Needed to form binary response variable in SDM (presence, absence)
- Can be simulated a few ways:
  - Randomly-sampled points (background sampling)
  - Chosen from distribution of turn angles and transit speeds from tracking dataset (random walk)
  - Chosen from state-space model parameters



Species Distribution Model: Predict Habitat

- A few options to model species-environment relationships
  - **Generalized linear model (GLMM)**
    - Parametric
    - Estimates linear relationships
  - **Generalized additive mixed model (GAMM)**
    - Semi-parametric
    - Smoothers used to represent non-linear relationships
  - **Boosted regression tree**
    - Non-parametric
    - Boosting optimizes the partition of variance

Species Distribution Model: Predict Habitat

- Code demo

Species Distribution Model: Evaluation

Approaches to assess model fit (there are many!)

1. Evaluate model explanatory power
   a. R^2
2. Evaluate model predictive skill
   a. Area Under the receiver characteristic Curve (AUC)
   b. True Test Statistic
   c. Cross-validation
3. Understand similarity of presence/absence points
   a. Bhattacharyya's coefficient
4. Examine relative importance of variables (environmental predictors)

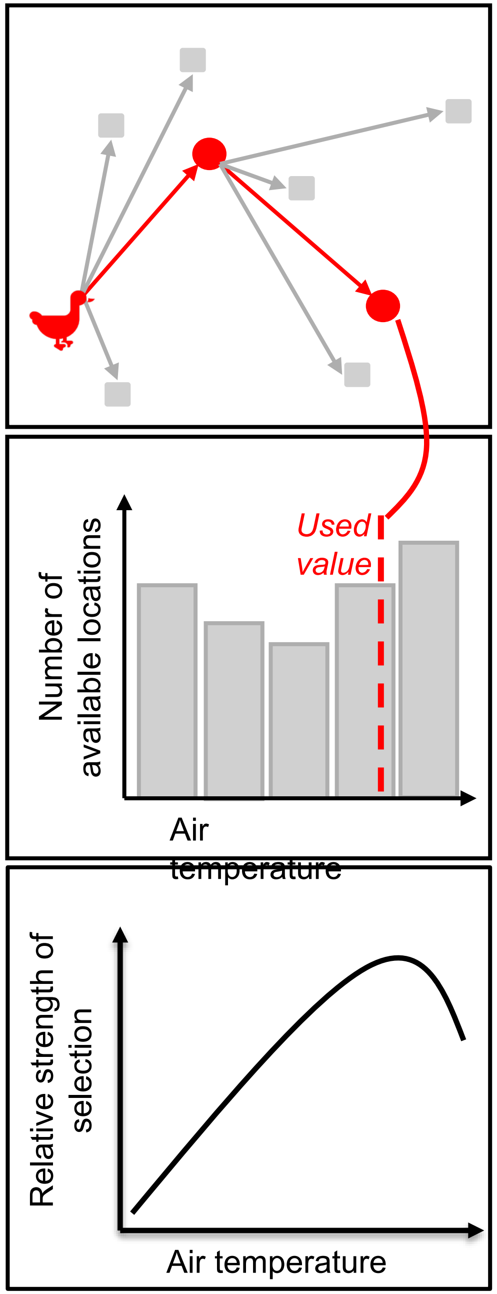
Section 2: Integration of Animal Tracking & Remote Sensing: A Terrestrial Case Study on Tracking Deer

Tracking Dataset: Red Deer

- Source: amt R-package
- Verein für Wildtierforschung Dresden und Göttingen e.V.
- 826 relocations of one red deer from northern Germany
  - 6-hour data
- March 2008 - April 2009
  - No winter data

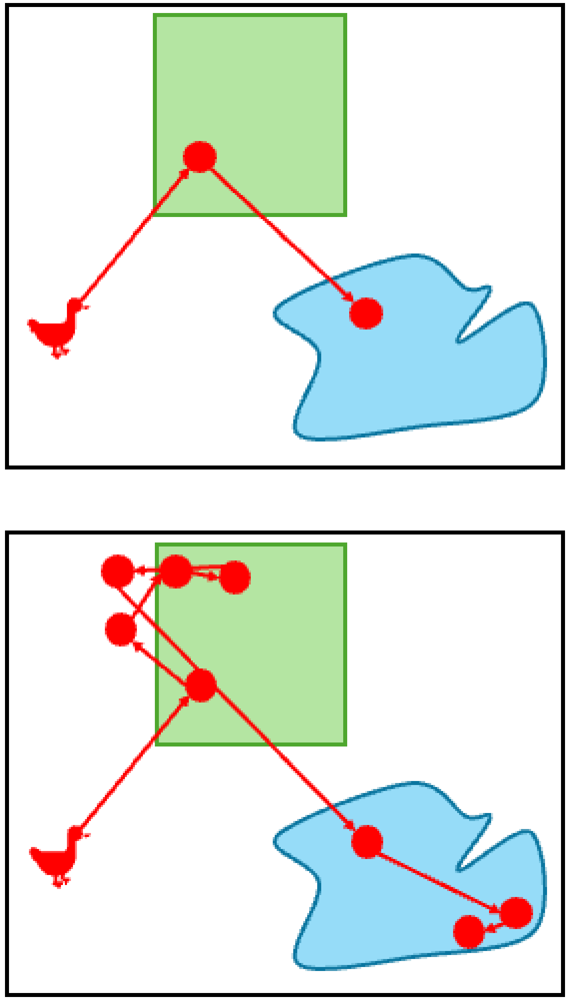
Step-Selection Functions

- Similar conceptually and statistically to SDMs
- Key differences
  - Specific way of defining “used” and “available” locations
  - Require regularly sampled locations
  - Analysis is at the level of an individual movement “step”
  - Remote sensing data can easily be time-matched
- Steps
  - Regularly sampled animal tracks
  - Define presence/absence points **by simulating alternative “steps” based on step lengths and turn angles**
  - Model
    - Binary response variable (case/control) predicted by environmental covariates using **conditional logistic regression**



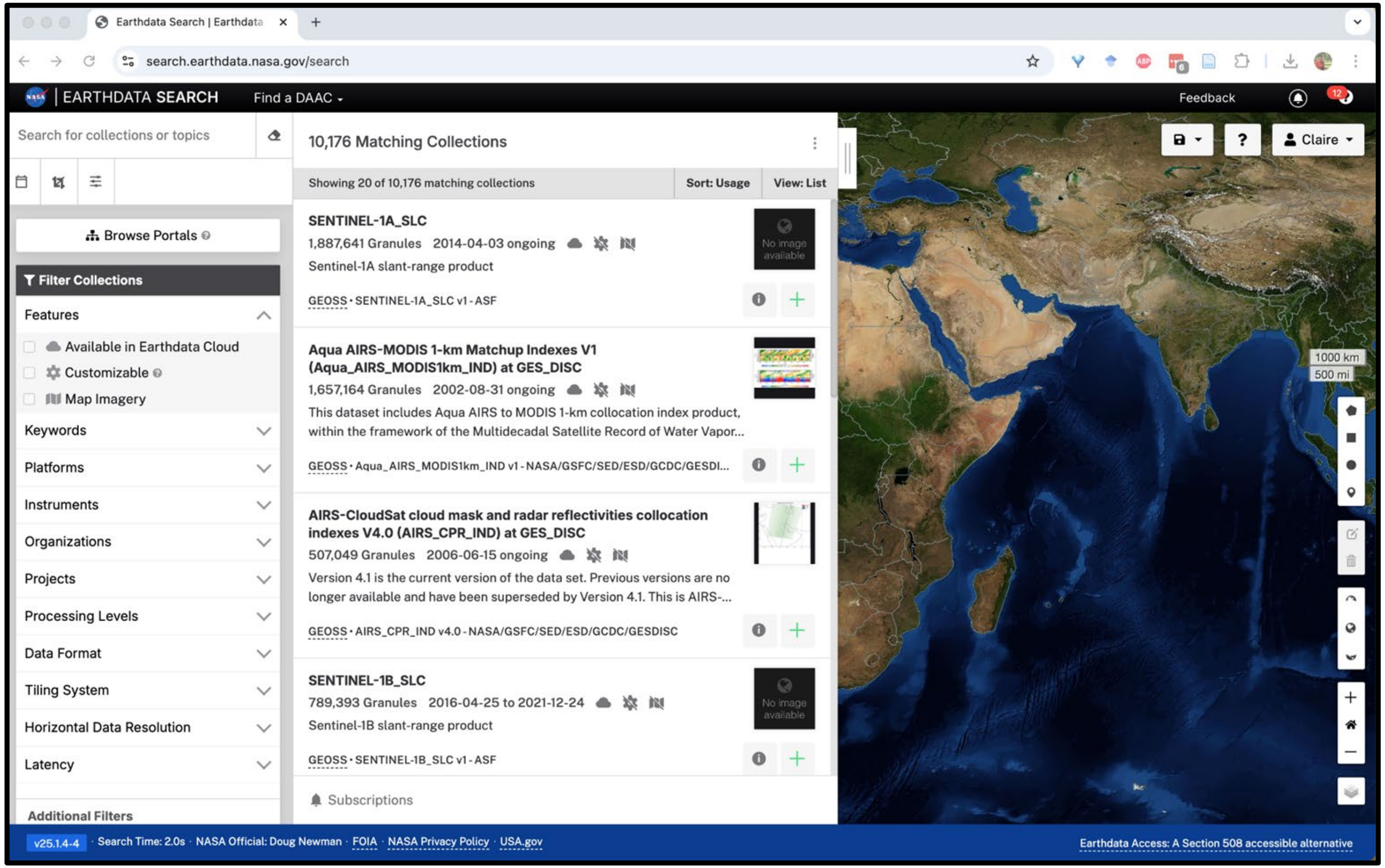
Tracking Data

- Data must be regularly sampled
  - Within some ***tolerance***
  - Gaps are okay: analyze ***bursts***
  - Generally compatible: GPS, Argos, etc. (active)
  - Generally not compatible: MOTUS, RFID (passive)
- **Temporal resolution:** what questions can you answer?
  - Daily step: local dispersal/relocation
  - Hourly step: functional movements (foraging, etc.)
  - Minute step: fine-scale habitat use
- Temporal and **spatial scale** are often related
  - What environmental conditions represent a *daily* location?
- **Multiple individuals** can be analyzed separately or together
  - Together: population-level inference
  - Separately: individual differences in habitat use



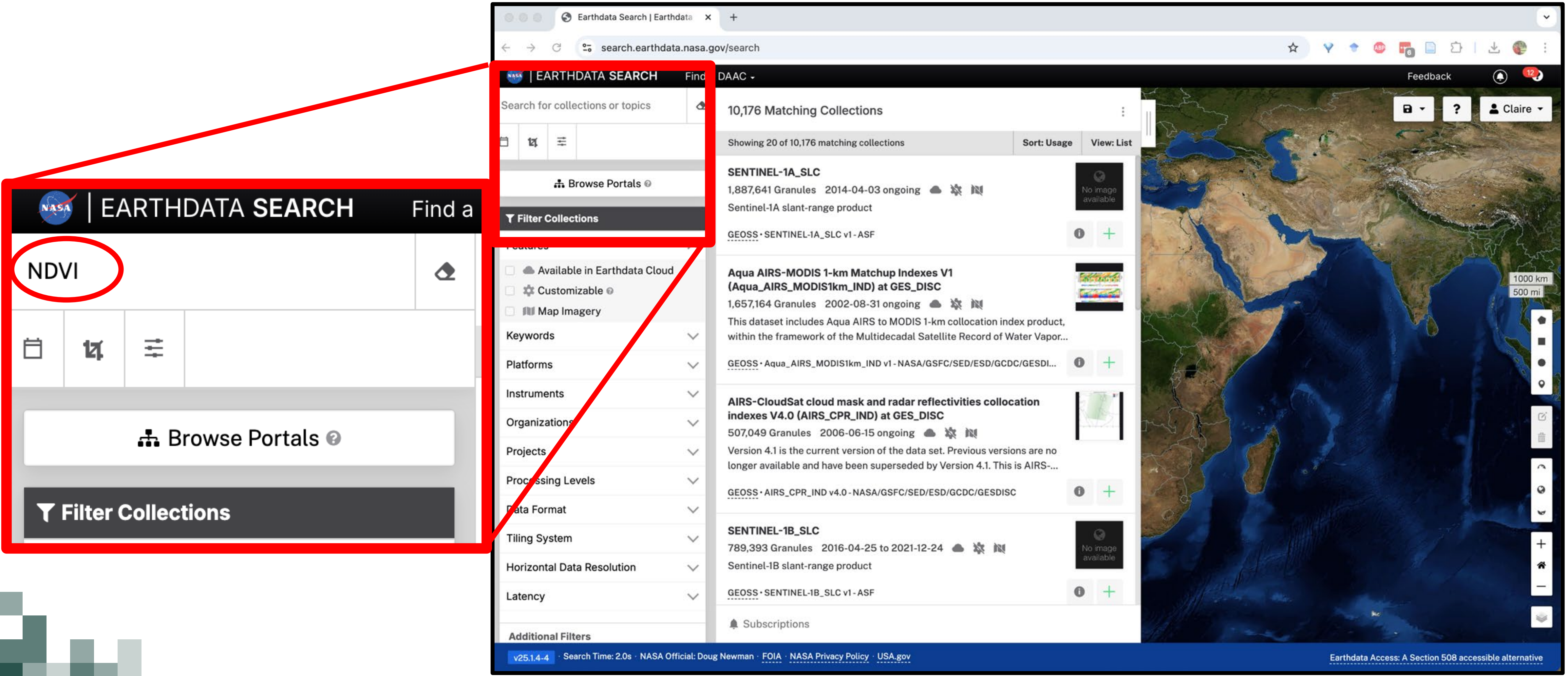
Download Remote Sensing Data via NASA Earthdata

1. Navigate to https://search.earthdata.nasa.gov/search



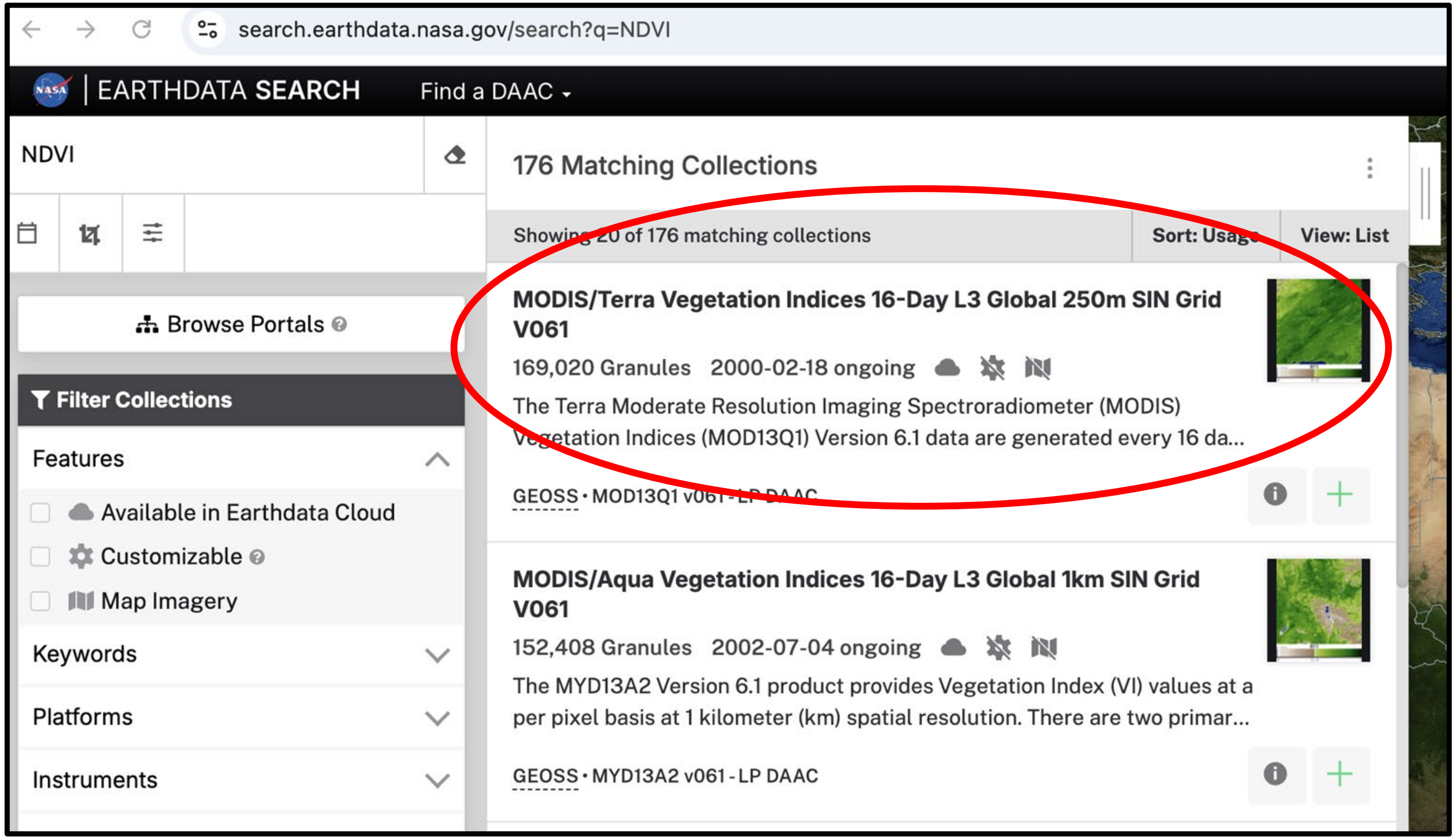
Download Remote Sensing Data via NASA Earthdata

2. Enter search terms (vegetation, sea surface temperature, land cover, etc.)



Download Remote Sensing Data via NASA Earthdata

3. Select desired product



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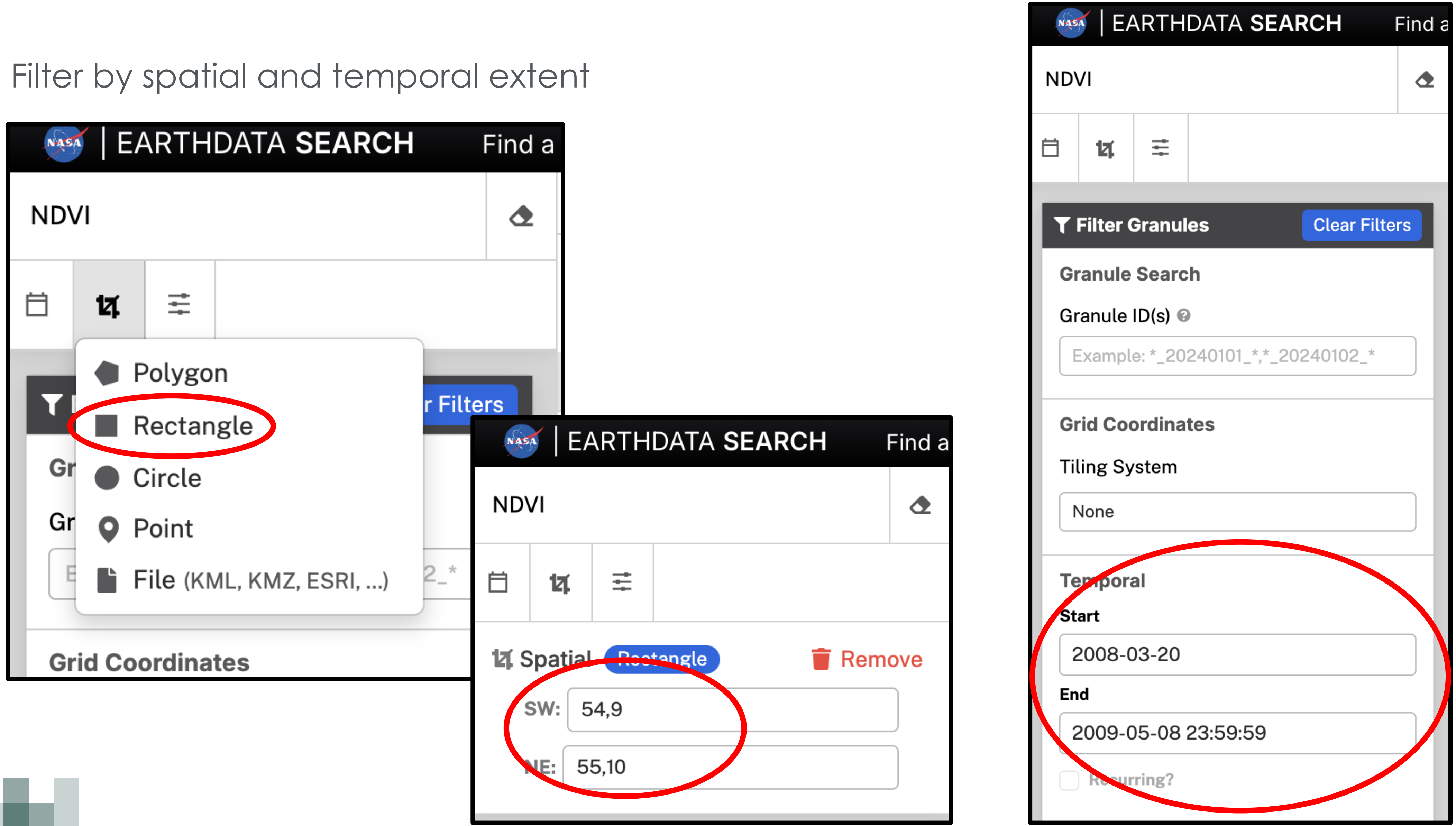
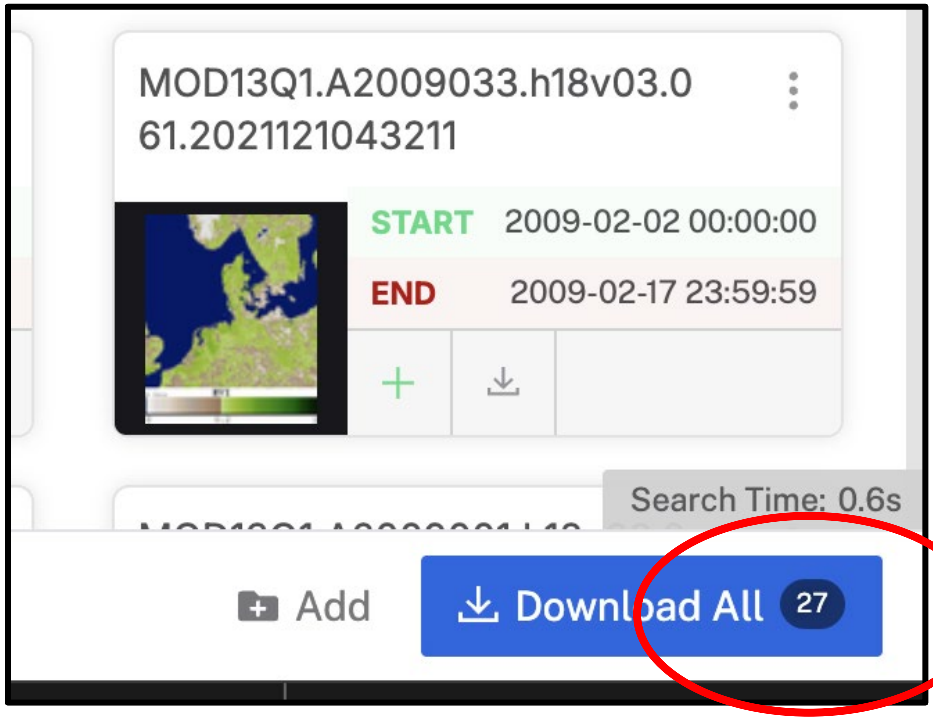
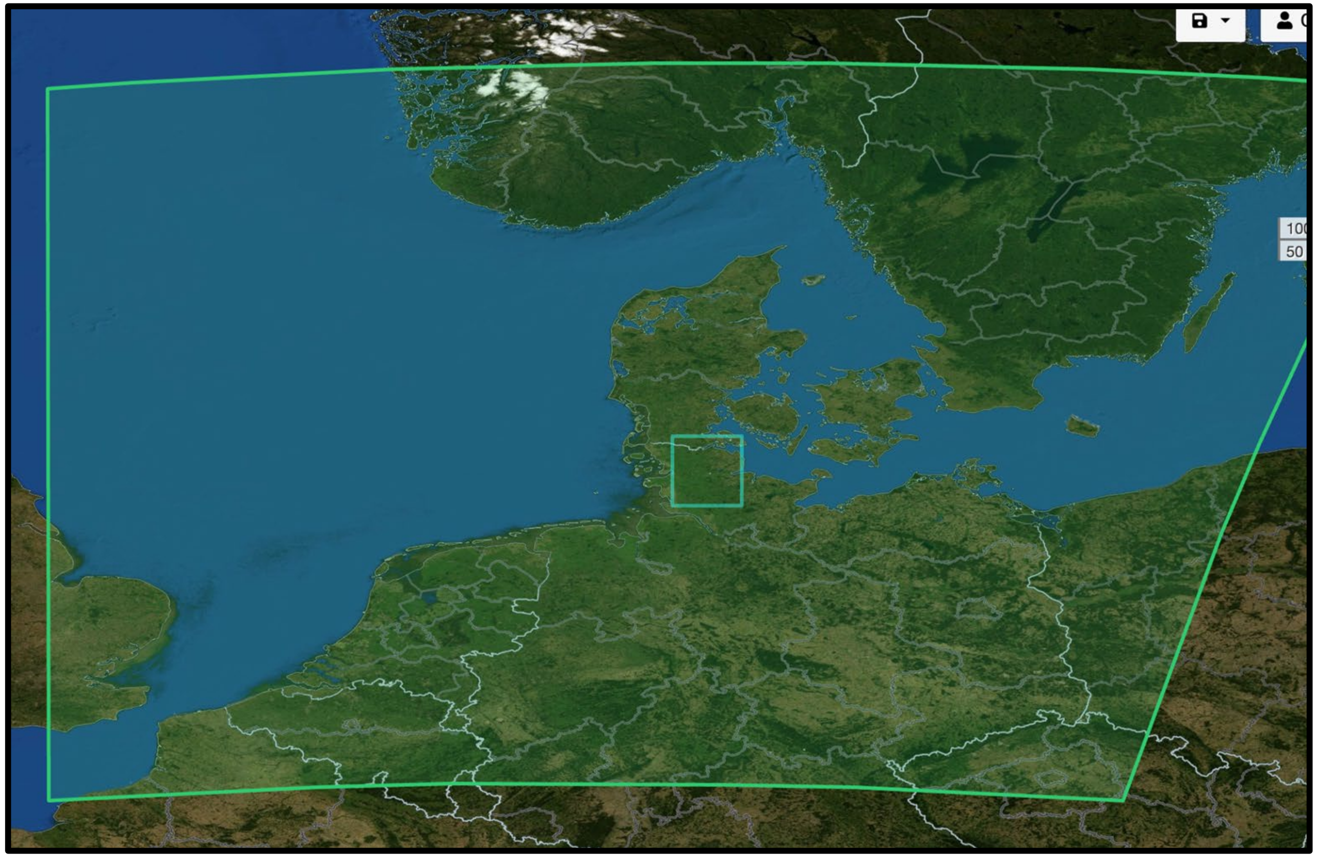
4. Filter by spatial and temporal extent



Download Remote Sensing Data via NASA Earthdata

5. Check map and number of granules



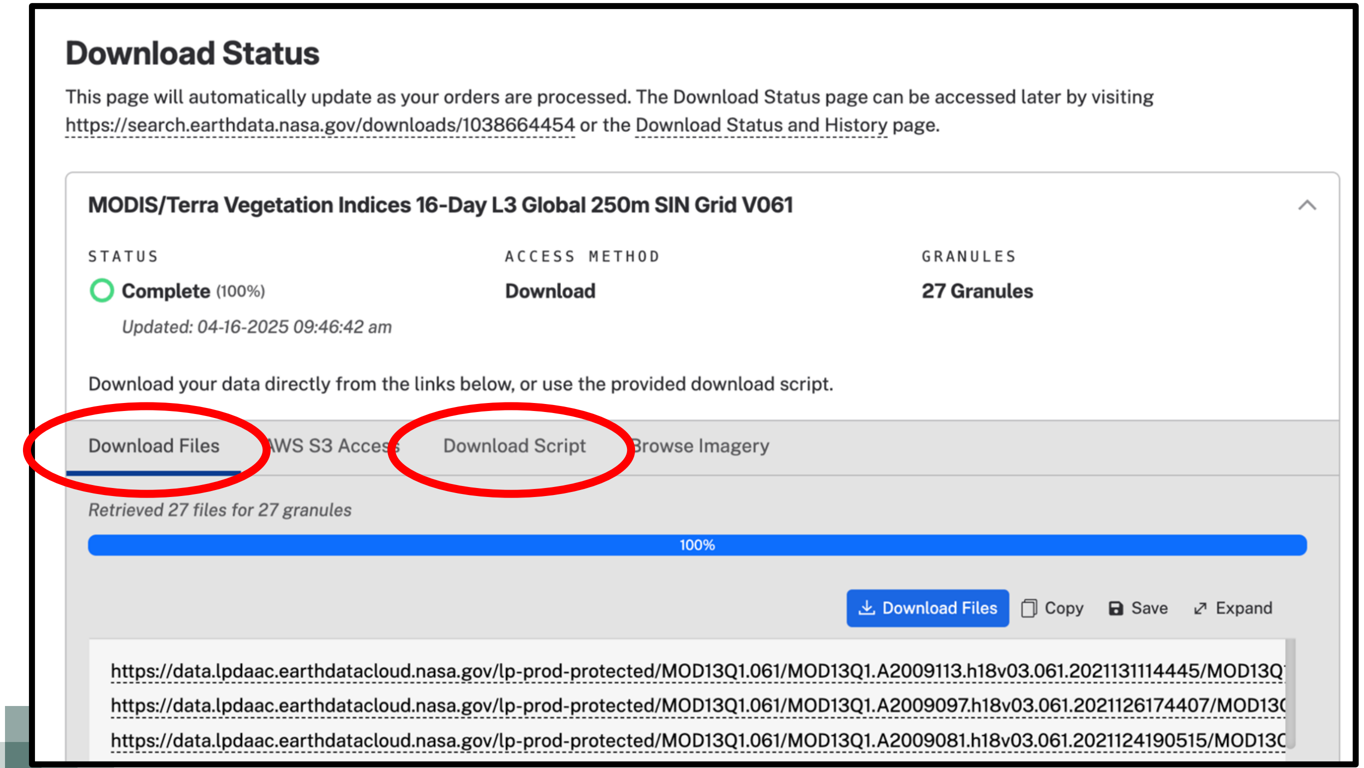


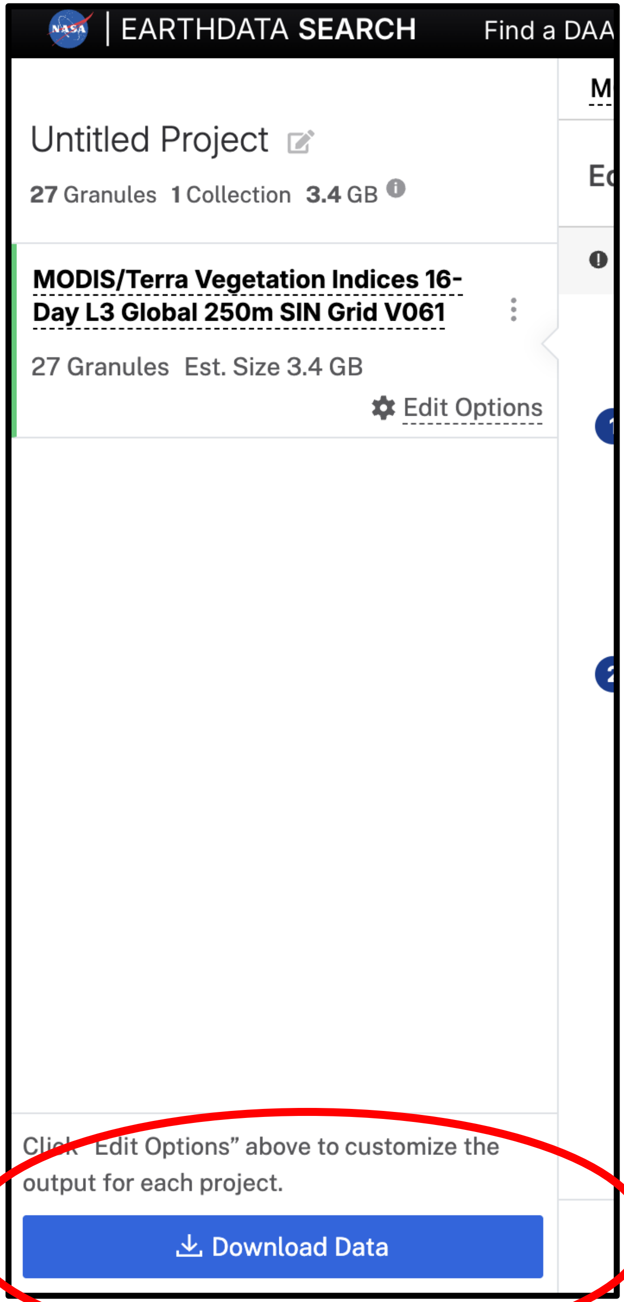
Download Remote Sensing Data via NASA Earthdata

6. Follow download instructions

    Option 1: use the Earthdata Download tool (https://nasa.github.io/earthdata-download/)

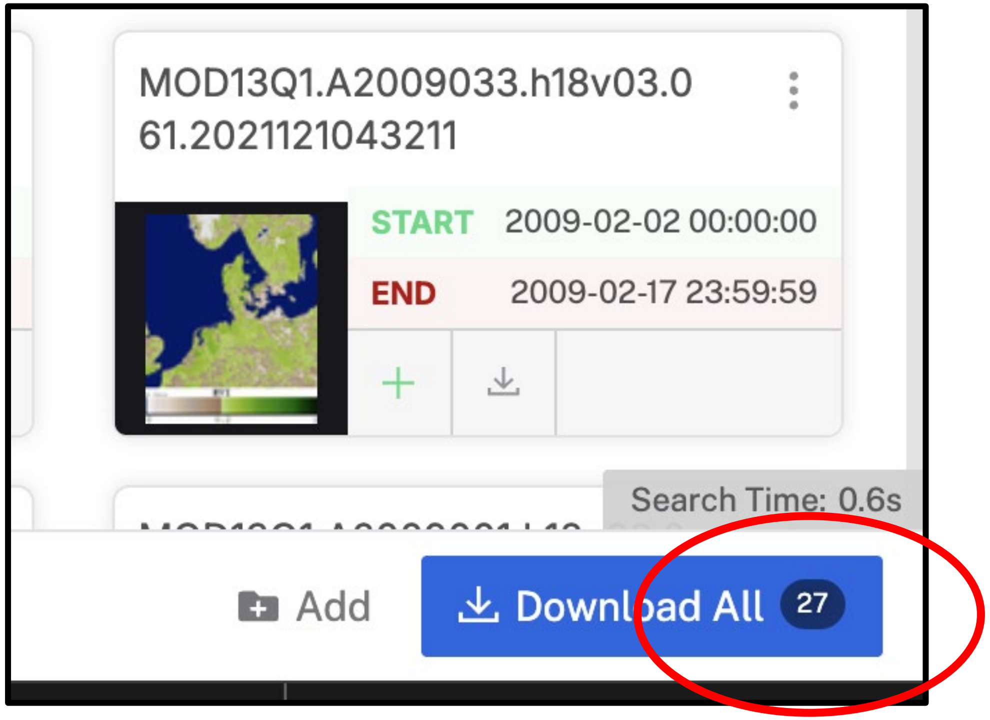
    Option 2: use command-line tools ("Download Script" tab)





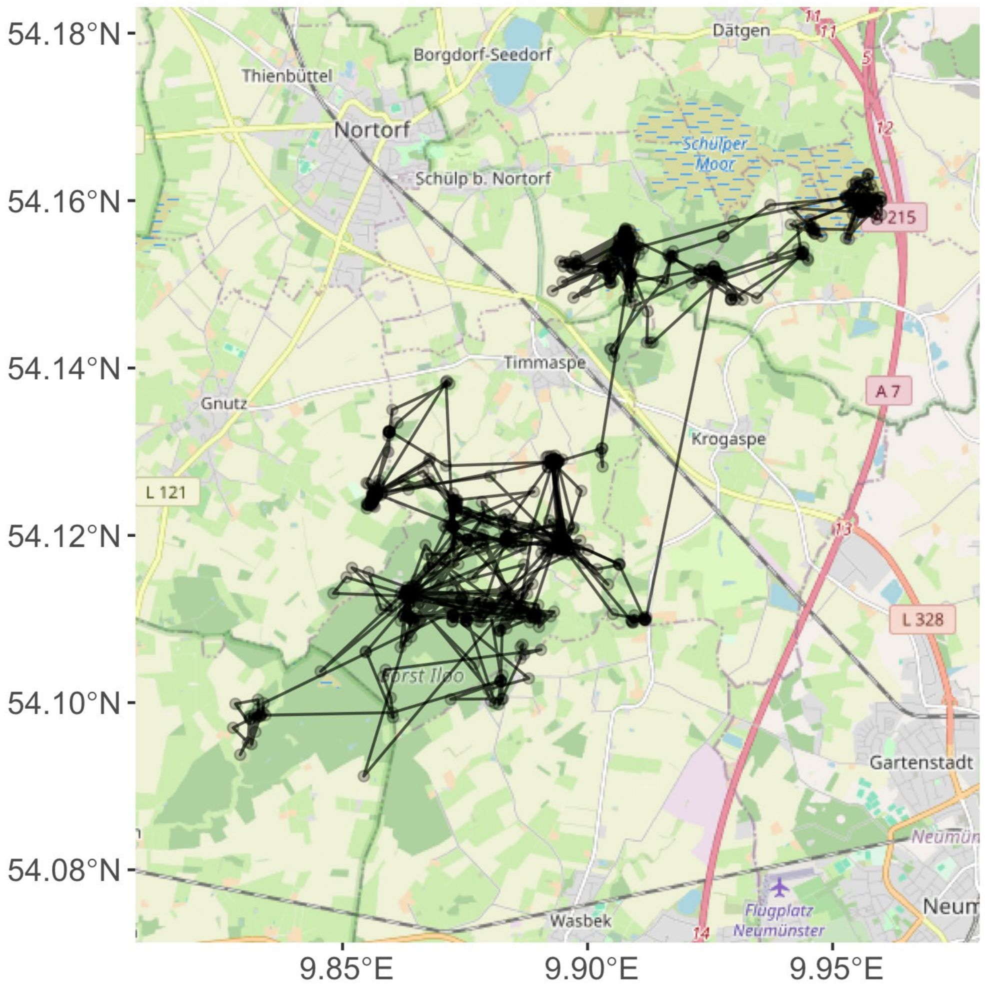
A Note on Post-Processing Spatial Data

- Many products will include multiple granules
  - Locations
  - Dates/times
- Many granules will include multiple layers
  - Variables
  - QA/QC
- Put your GIS skills to use!
  - Mosaicking to combine spatial tiles
  - Stacking to combine temporal tiles
  - Cropping to include only needed area
- **Always check original documentation!**
  - What does each layer mean?
  - Rescaling values



Conduct Step Selection Analysis

1. Clean telemetry data
2. Process telemetry data to ***regular steps*** and identify ***bursts***
3. Simulate alternative ***(control) steps***
    a. model distributions of step lengths and turning angles
4. Identify spatial and temporal extent of data
5. Download and process desired environmental (remote sensing) data
6. Extract environmental data
    a. At step end points
    b. At step starting points
    c. Along trajectories
7. Perform ***conditional logistic regression***
8. Inference and mapping
    a. Relative strength of selection: primary metric

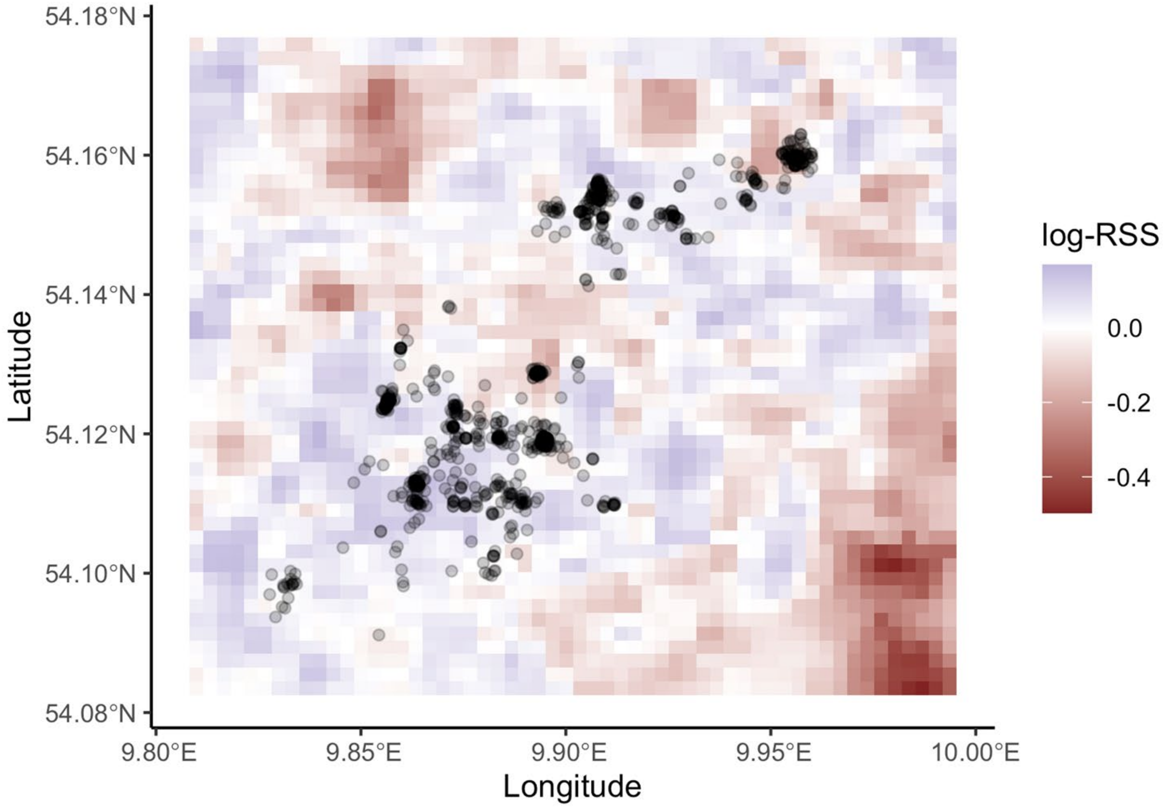


Conduct Step Selection Analysis

- See code demo

Model Interpretation

- **Relative strength of selection (RSS)**: what does this mean?
  - NOT probability of use
  - Requires defining reference conditions: average, home range, etc.
  - For a single variable: average change in the space use probability…as we change the covariate of interest…while averaging over possible values of other covariates
- SSFs: available environment changes across space and time
  - Simulation methods can help



Resources

Resources

- Animal telemetry concepts
  - Animals as sensors: Ellis-Soto, D., Wikelski, M., & Jetz, W. (2023). Animal-borne sensors as a biologically informed lens on a changing climate. *Nature Climate Change*, *13*(10), 1042-1054. https://doi.org/10.1038/s41558-023-01781-7
- Remote sensing resources:
  - Earthdata Search: https://search.earthdata.nasa.gov/search
  - rerddapXtracto R package: https://cran.r-project.org/web/packages/rerddapXtracto/index.html
- Additional analysis platforms
  - Movebank Env-DATA system: https://www.movebank.org/cms/movebank-content/env-data
  - MoveApps: https://www.moveapps.org/

Resources

SSFs

- The “original” step-selection paper: Fortin, D., Beyer, H. L., Boyce, M. S., Smith, D. W., Duchesne, T., & Mao, J. S. (2005). Wolves influence elk movements: behavior shapes a trophic cascade in Yellowstone National Park. *Ecology*, *86*(5), 1320-1330. https://doi.org/10.1890/04-0953
- amt R package: https://cran.r-project.org/web/packages/amt/
  - Step-selection vignette: https://cran.r-project.org/web/packages/amt/vignettes/p4_SSF.html

Resources

Species Distribution Models

- SDM code in this training based on: Hazen et *al*. (2021). Where did they not go? Considerations for generating pseudo-absences for telemetry-based habitat models. *Movement Ecology* 9:5. https://www.doi.org/10.1186/s40462-021-00240-2
  - SDM & pseudo-absence code here: https://github.com/elhazen/PA-paper
- Additional suggestions
  - R-pkg. aniMotum: Jonsen et *al*. (2023). aniMotum, an R package for animal movement data: Rapid quality control, behavioural estimation and simulation. *Methods in Ecology and Evolution* 14: 806-816. https://doi.org/10.1111/2041-210X.14060 and code here: https://ianjonsen.github.io/aniMotum/index.html
  - Great discussion of SDMs: Braun et *al*. (2023). Building use-inspired species distribution models: Using multiple data types to examine and improve model performance. *Ecological Applications* e2893. https://www.doi.org/10.1002/eap.2893

Summary of Part 2

- When integrating animal tracking and remote sensing data, it is very important to consider:
  - The environmental variables that affect the presence/absence of the animal species of interest.
  - The spatiotemporal resolution of the remote sensing data.
- Species Distribution Models help us understand the likelihood of the presence of a particular animal species depending on the habitat type.
- The selection of a particular Species Distribution Model will depend on the research question and available datasets.

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 5/22/2025
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 5/6/2025**

- **Certificate of Completion:**
  - Attend this live webinar (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

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Thank You!