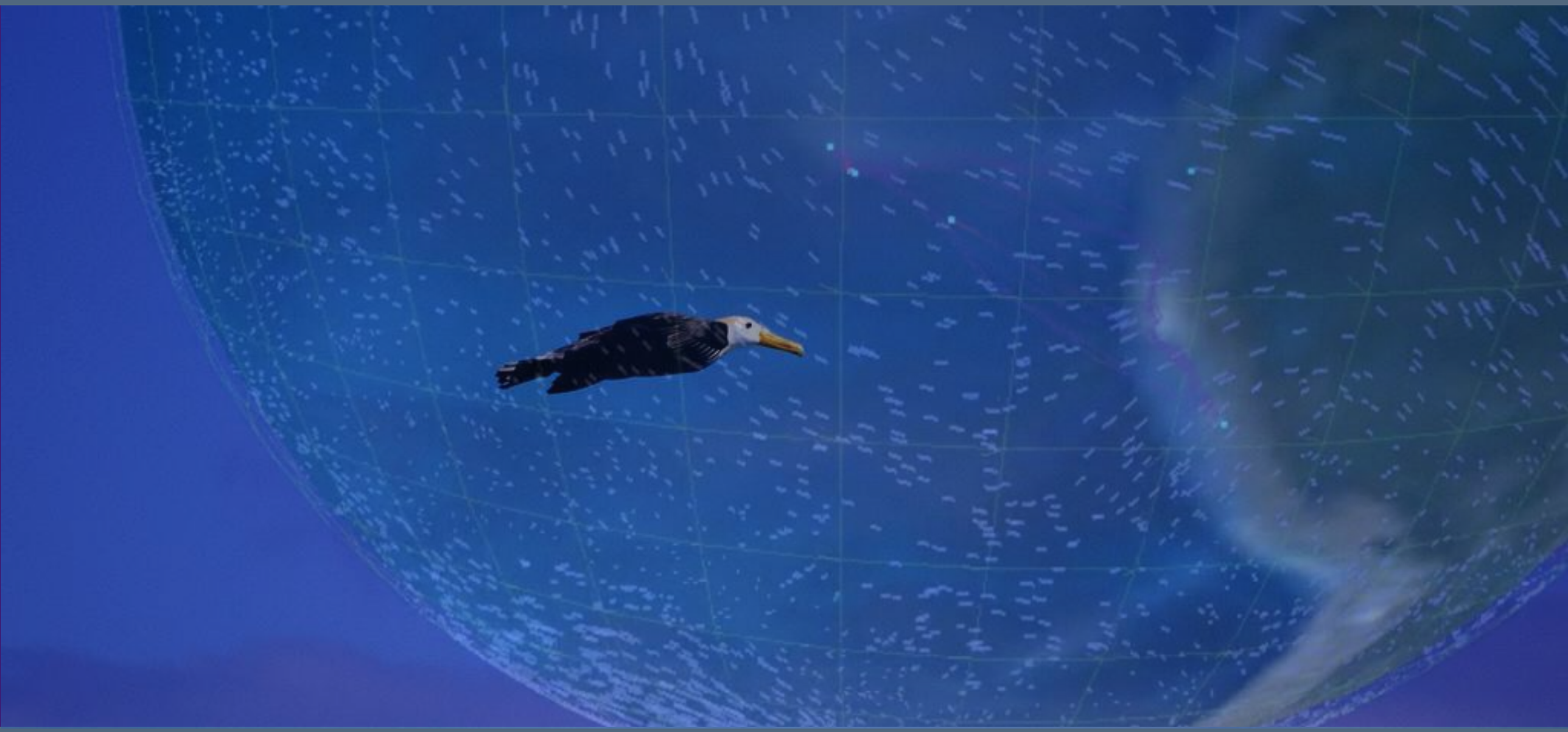
Managing animal tracking data with Movebank



Martin Storhas

Movebank Chief Developer

Max Planck Institute for Ornithology

9 July 2015

Fondazione Edmund Mach

Trento, Italy

MOVEBANK

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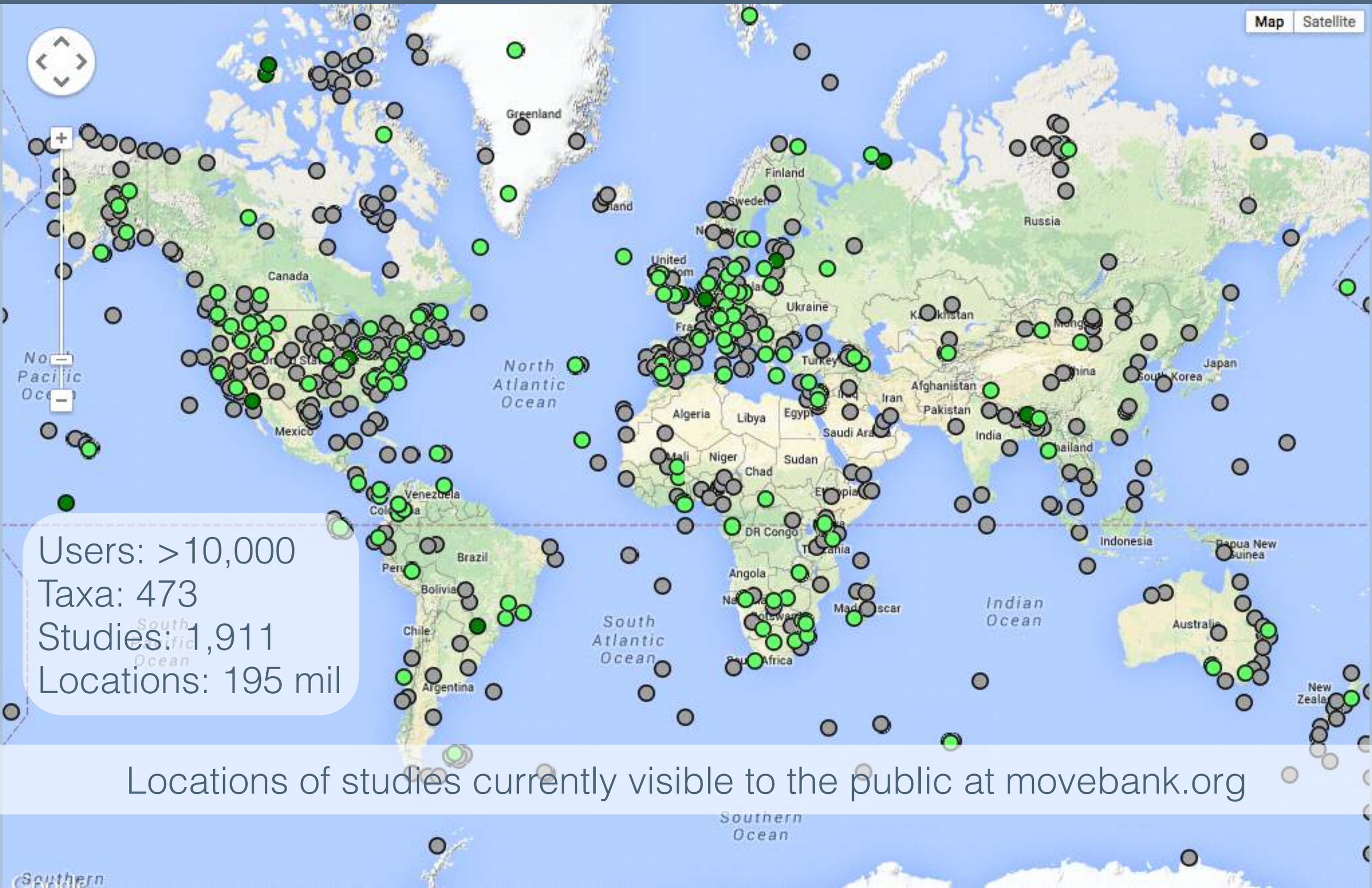

Locations of studies currently visible to the public at movebank.org

About Movebank

Movebank is a free online infrastructure created to help researchers manage, share, analyze, and archive animal movement data. The Movebank project is coordinated by the **Max Planck Institu of Natural Sciences**, and the **University of Konstanz**. Movebank collaborates with the United Nations Food and Agriculture Organization (FAO), the Ohio State University, and the U.S. Geologic National Science Foundation, the German Science Foundation, and NASA. Movebank is has long-term (>20 years) funding through the Max Planck Society and the University of Konstanz and is animal movement data.

Movebank has over 3,500 users including people from universities, government agencies, and other research and conservation groups around the world. Movebank is a resource open to all res species, study area, or source of funding. **Movebank users retain ownership of their data** and can choose whether or not to make their data available to the public. We encourage collaboration government to re-use animal tracking data and give it a second life.

The database is designed primarily for datasets that include multiple locations of individual animals, commonly referred to as tracking data. It also allows inclusion of a growing number of additio about animals and tags, manufacturer-specific measurements, and data from other bio-logging sensors attached to animals.

In addition to the main database, the **Movebank Data Repository** allows researchers to submit data sets in Movebank for publication. Submitted data sets undergo a review process and if accep licensed, and are archived and made permanently available online by the University of Konstanz.

As of August 2014, Movebank includes

- 1,306 studies
- over 1,296 contributors
- 417 taxa
- 40,615 tracks
- 100 million locations

Background

Information about animal movement is important to addressing environmental challenges such as climate and land use change, biodiversity loss, invasive species, and infectious diseases. Adva movement are allowing researchers to collect increasingly large amounts of animal movement data. However, working with these large data sets remains a challenge, and a large fraction of thes not professionally catalogued or archived.

FUNDING

Long term

Max Planck Institute for Ornithology

University of Konstanz

Previous grants

German Science Foundation

U.S. National Science Foundation

U.S. National Aeronautics and Space Administration (NASA)

GOALS

Enable collaborations

GOALS

Enable collaborations

Help scientists address new questions

GOALS

Enable collaborations

Help scientists address new questions

Promote open access to data

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Enable collaborations

Help scientists address new questions

Promote open access to data

Allow the public to explore

GOALS

Enable collaborations

Help scientists address new questions

Promote open access to data

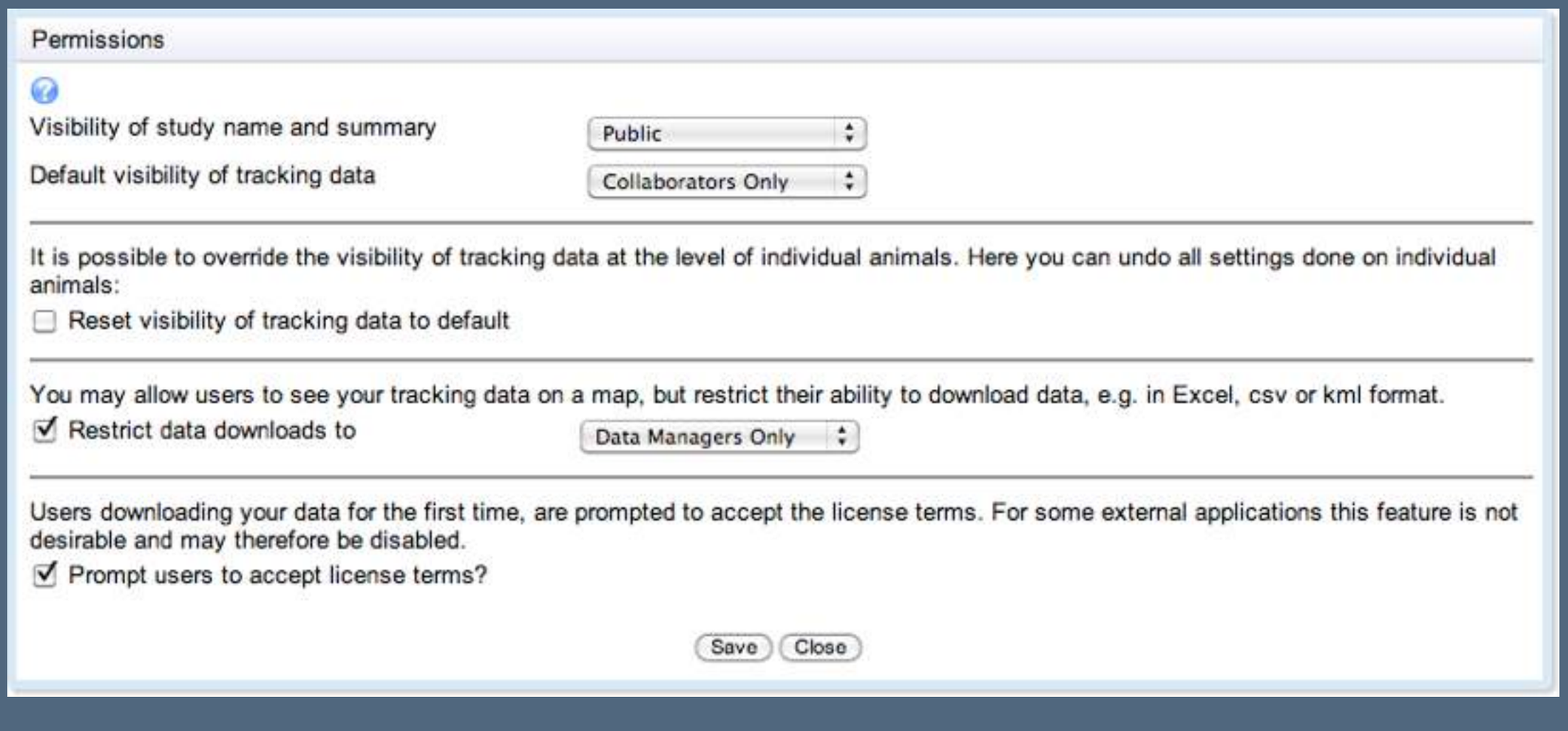
Allow the public to explore

Archive animal movement data

SHARING & PRIVACY

Data owners control access

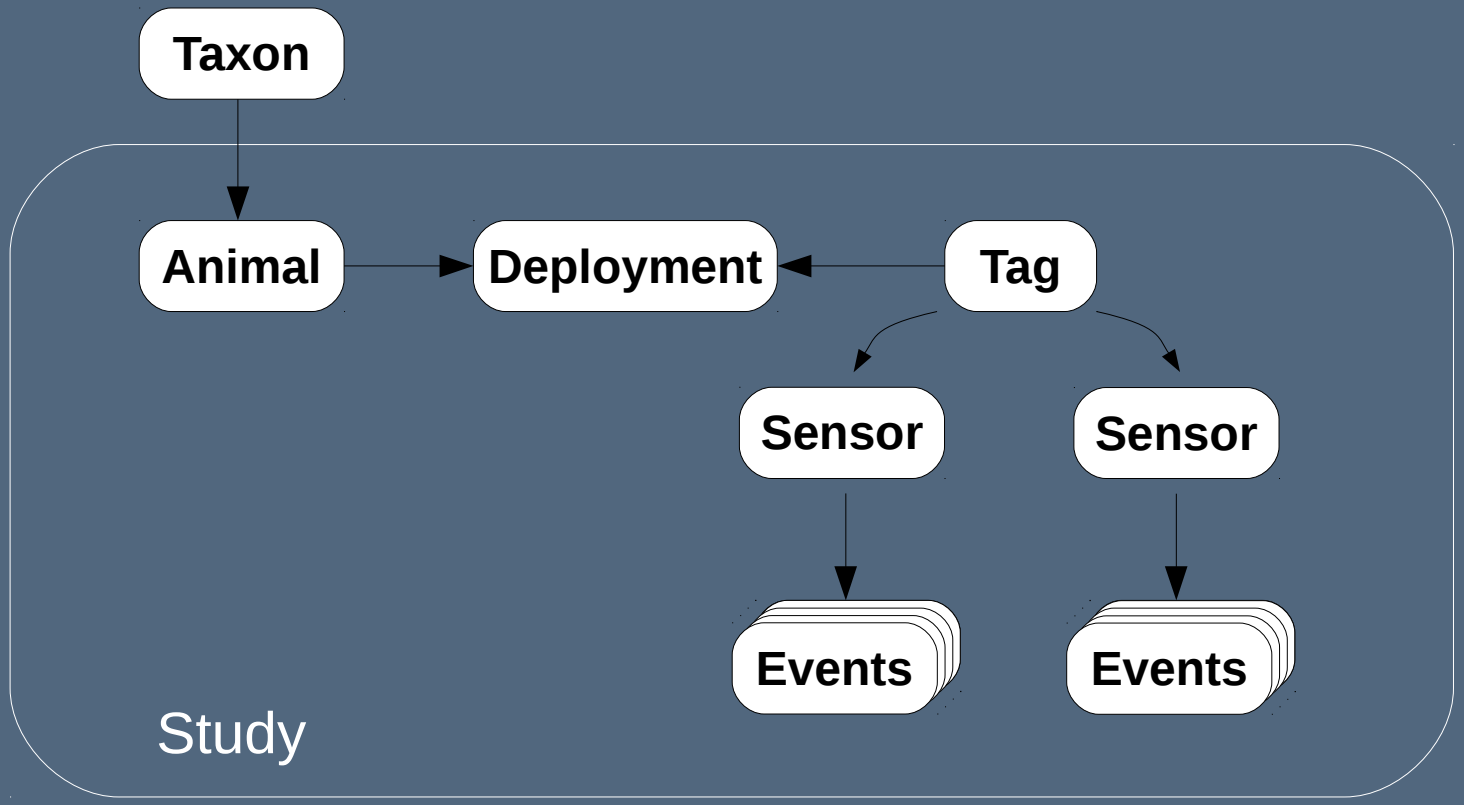
- data managers (read and write)
- collaborators (read only)
- public



DATA TYPES

Individual animal tracks and related attributes

All data are stored in user-created studies.



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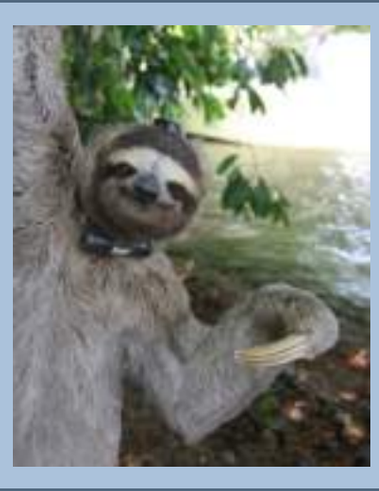
DATA TYPES

Tracking methods

- GPS
- Argos Doppler Shift
- Radio transmitter
- Bird ring
- Natural mark
- Solar geolocator: locations + light levels



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DATA TYPES

Movebank provides a common format.

What Movebank sees in your file

date	time	long	lat	species	tag	individual name	speed	heading	height	visible
2008-12-18	12:21:19.001	8.9858828	47.7382944	Aythya ferina	420	Common Pochard F	73	347.34	438.5	TRUE
2008-12-18	12:30:22.999	8.9857864	47.7382972	Aythya ferina	420	Common Pochard F	22	33.42	441	TRUE
2008-12-18	13:01:38.001	8.9859685	47.7378514	Aythya ferina	420	Common Pochard F	97	191.37	441.7	TRUE
2008-12-18	13:30:12.000	8.9855835	47.738281	Aythya ferina	420	Common Pochard F	12	351.93	442.4	TRUE
2008-12-18	14:01:25.998	8.985615	47.7382313	Aythya ferina	420	Common Pochard F	86	348	449.6	TRUE
2008-12-18	14:30:23.999	8.9857624	47.73807	Aythya ferina	420	Common Pochard F	23	336.86	453.1	TRUE

Map other Attributes

How Movebank will save the data

Sensor Type	Timestamp	Location Lat	Location Long	Animal Id	Tag Id
GPS	2008-12-18 12:21:19.001	47.7382944	8.9858828	Common Pochard F	420
GPS	2008-12-18 12:30:22.999	47.7382972	8.9857864	Common Pochard F	420
GPS	2008-12-18 13:01:38.001	47.7378514	8.9859685	Common Pochard F	420
GPS	2008-12-18 13:30:12	47.738281	8.9855835	Common Pochard F	420
GPS	2008-12-18 14:01:25.998	47.7382313	8.985615	Common Pochard F	420
GPS	2008-12-18 14:30:23.999	47.73807	8.9857624	Common Pochard F	420

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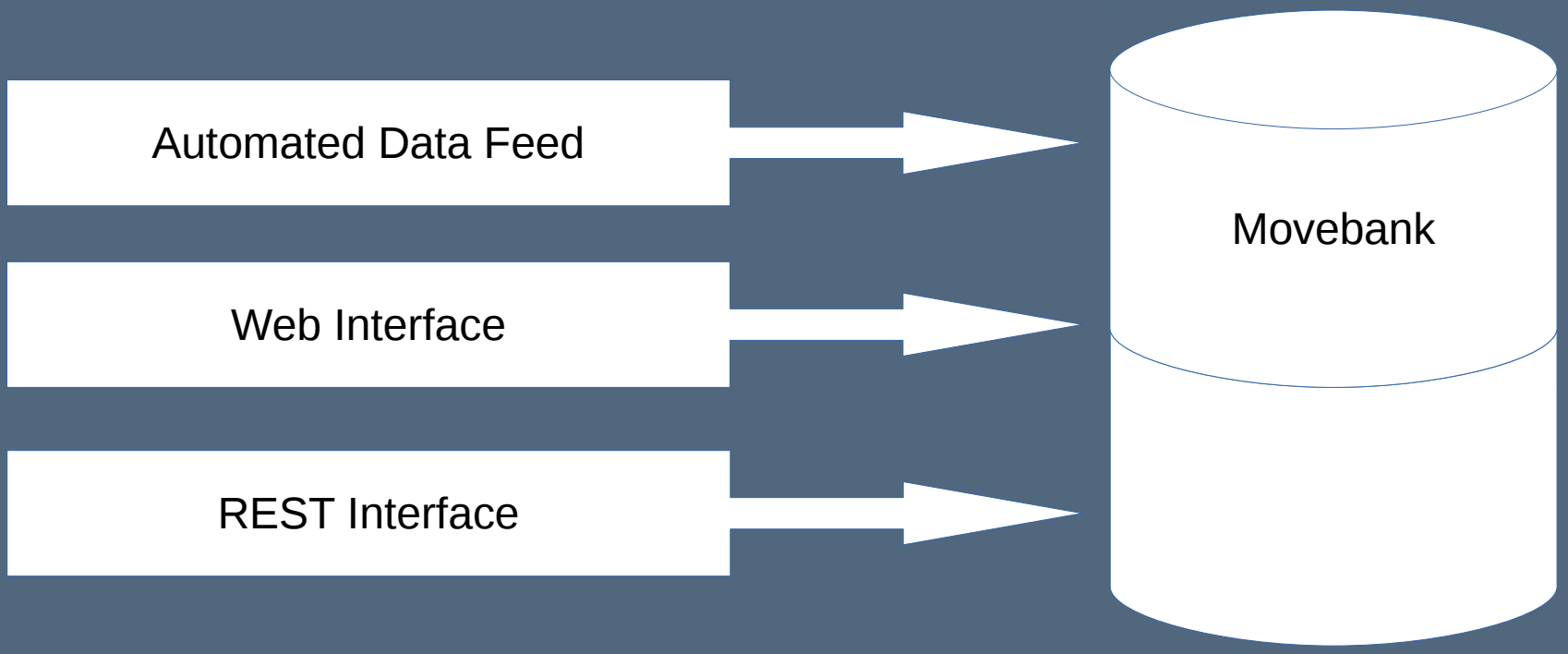
DATA IMPORT



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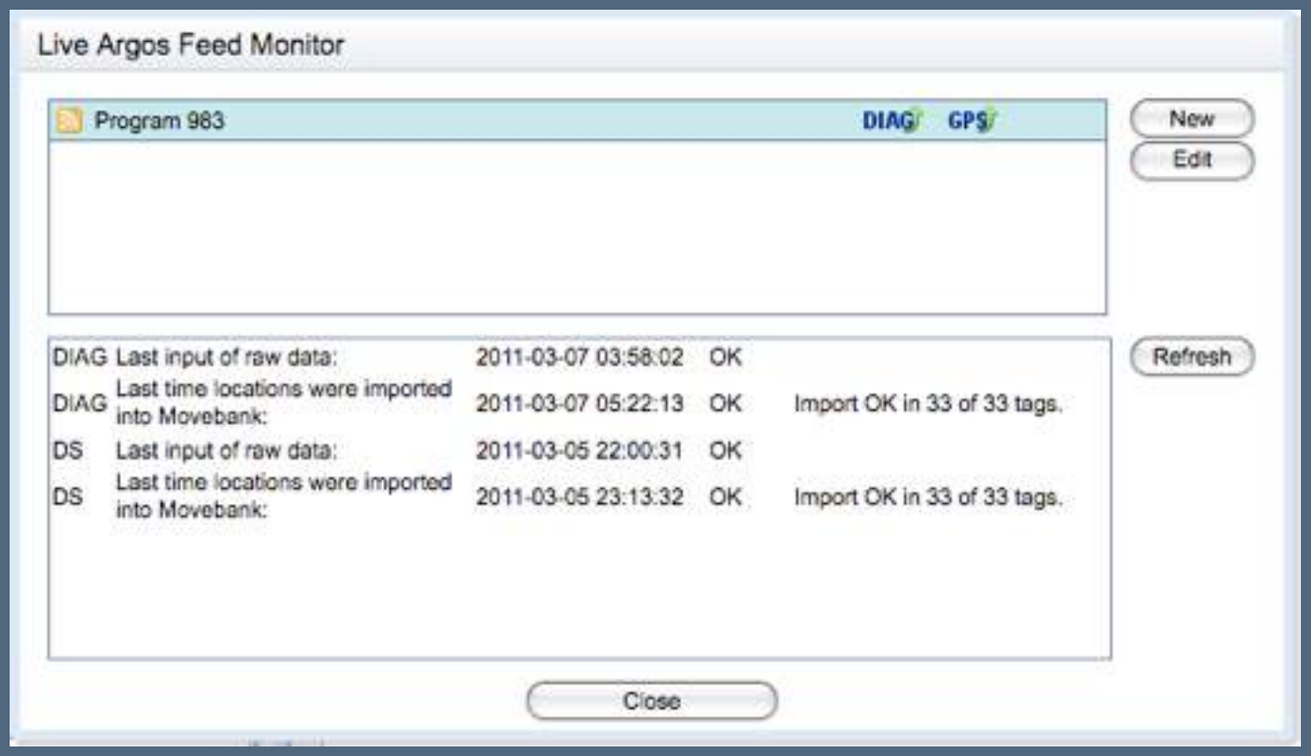
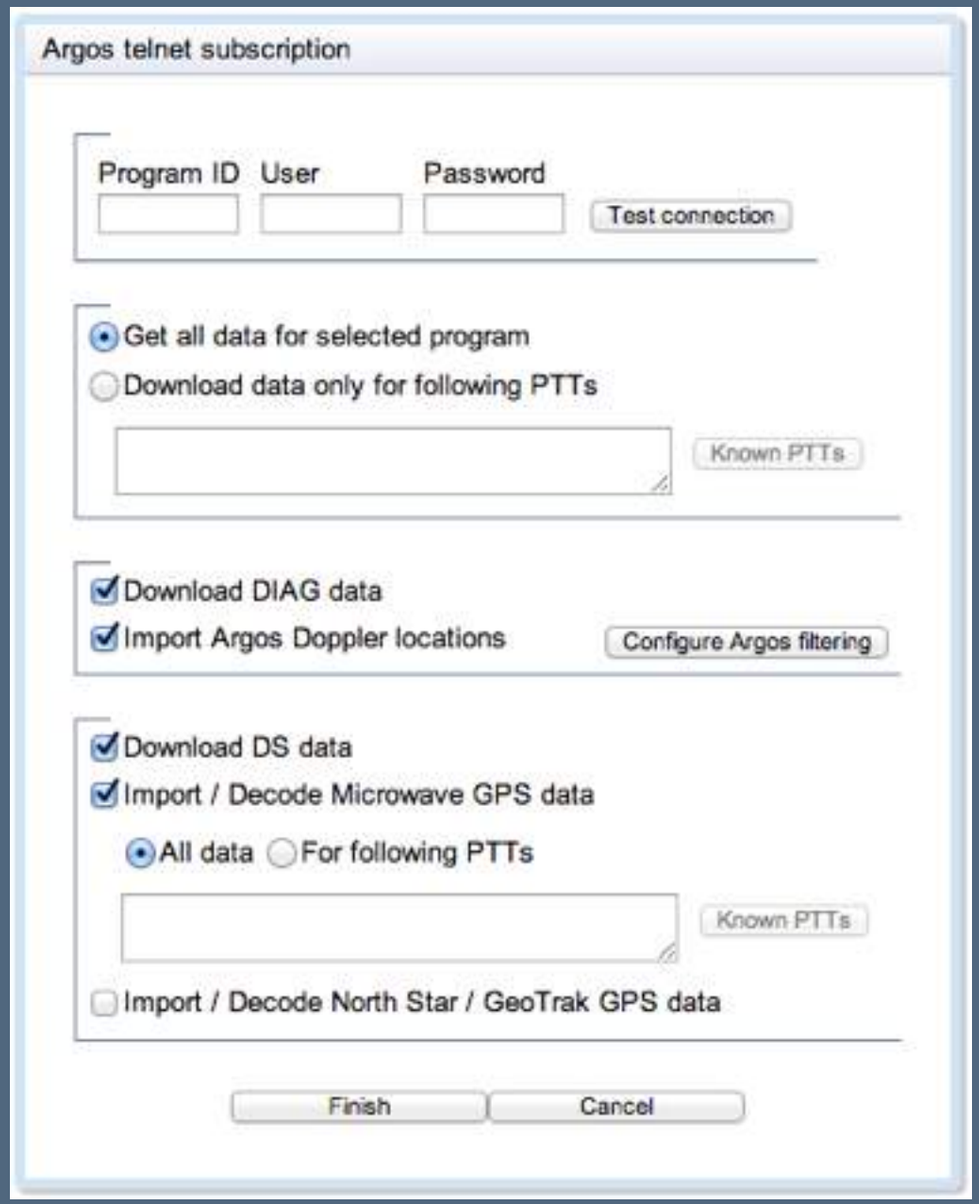
DATA IMPORT

1. Set up an automated data feed to

   Argos GPS-PTTs: Microwave and NorthStar/GeoTrak

   Argos DIAG: all PTTs





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DATA IMPORT

1. Set up an automated data feed to

   Argos DIAG

   Argos GPS-PTTs: Microwave and NorthStar/GeoTrak

   GSM-GPS tags: CTT, Ecotone, e-obs, Fleetronic, Microwave

Manage live feed: CTT GSM

Provider: CTT GSM
Feed subscriber: j.schmoe (Joseph Schmoe)
Feed activity: (•) on ( ) off

Feed elements:

Tag ID	Data points	Last import	Status
8901410325654080304 5	2184	Thu May 15 10:20:34 GMT-400 2014	OK
8901410325654080307 8	2964	Thu May 15 10:20:30 GMT-400 2014	OK
8901410325634534579 6	6484	Wed May 21 08:37:45 GMT-400 2014	OK
8901410325634534580 4	5313	Wed May 21 08:40:03 GMT-400 2014	OK

Add/Remove Tags | Refresh

Close | New | Delete

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DATA IMPORT

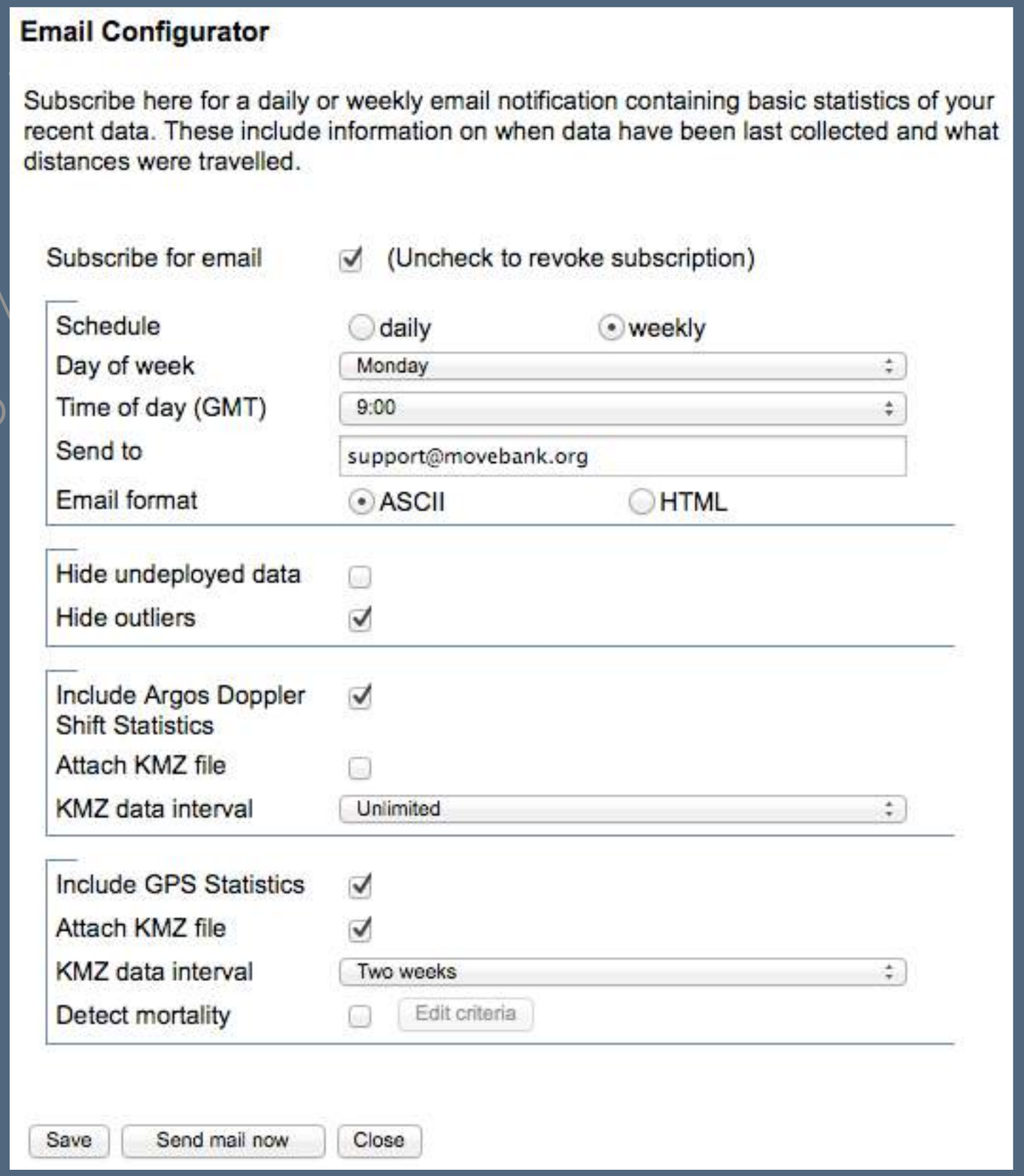
1. Set up an automated data

   Argos DIAG

   Argos GPS-PTTs: Microwav

   GSM-GPS tags: CTT, Ecoto

and receive email notifications



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DATA IMPORT

1. Set up an automated data feed.
2. Import a supported standard file.

Argos Doppler Shift raw DIAG files

GPS: e-obs, Lotek, Microwave, NorthStar/GeoTrak, Sirtrack

Solar geolocators: BAS trajectory data

Others can be added by request

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DATA IMPORT

1. Set up an automated data feed.
2. Import a supported standard file.
3. Import a custom format .csv file.

What Movebank sees in your file

date	time	long	lat	species	tag	individual name	speed	heading	height	visible
2008-12-18	12:21:19.001	8.9858828	47.7382944	Aythya ferina	420	Common Pochard F	73	347.34	438.5	TRUE
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GPS	2008-12-18 14:01:25.998	47.7382313	8.985615	Common Pochard F	420
GPS	2008-12-18 14:30:23.999	47.73807	8.9857624	Common Pochard F	420

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TOOLS

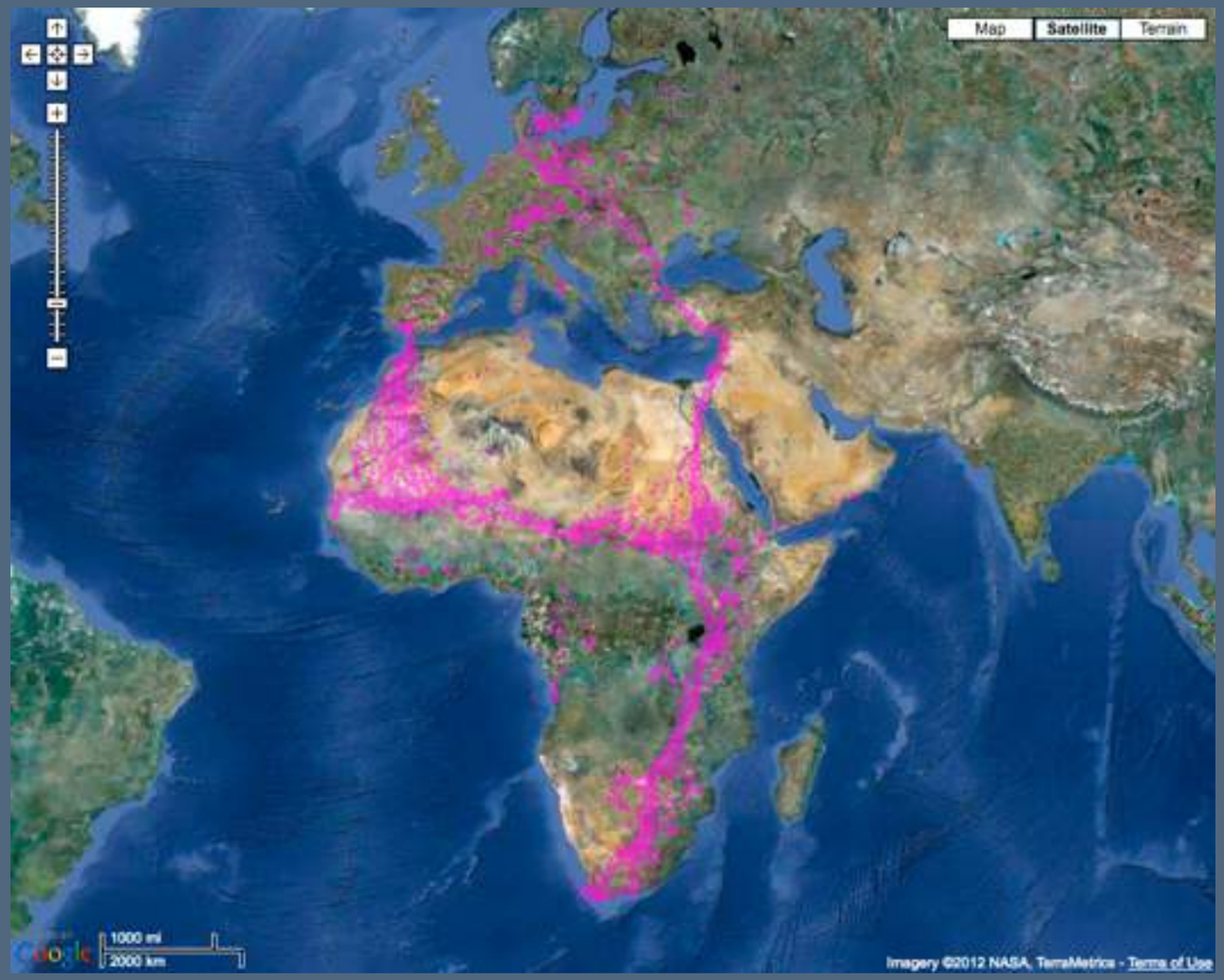
A shared database allows shared tools.

Manage | Analyze | Share | Archive

TOOLS

A shared database allows shared tools.

Mapping



data from Max Planck Institute for Ornithology and collaborators

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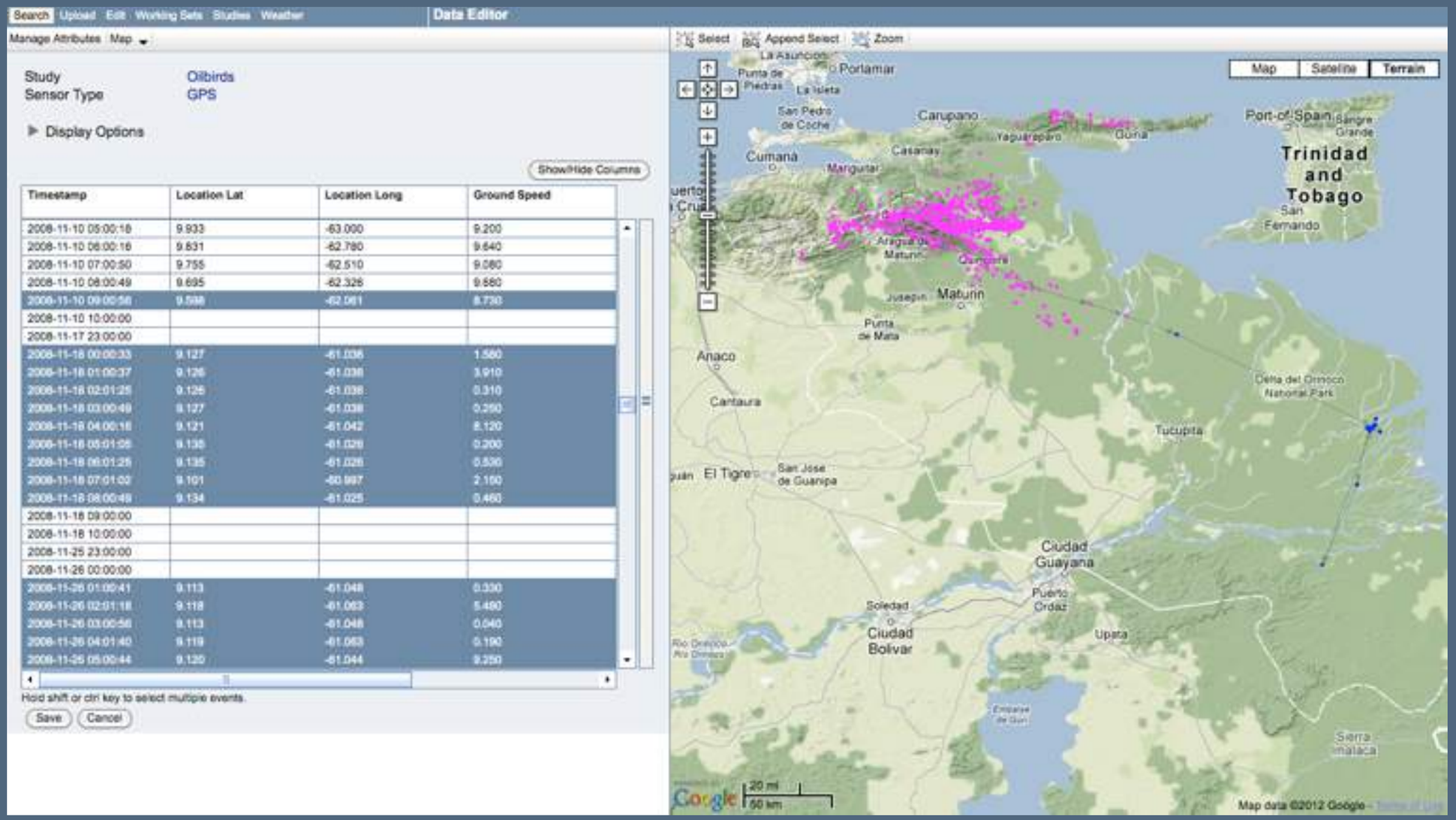
TOOLS

A shared database allows shared tools.

Mapping

Management

Event Editor



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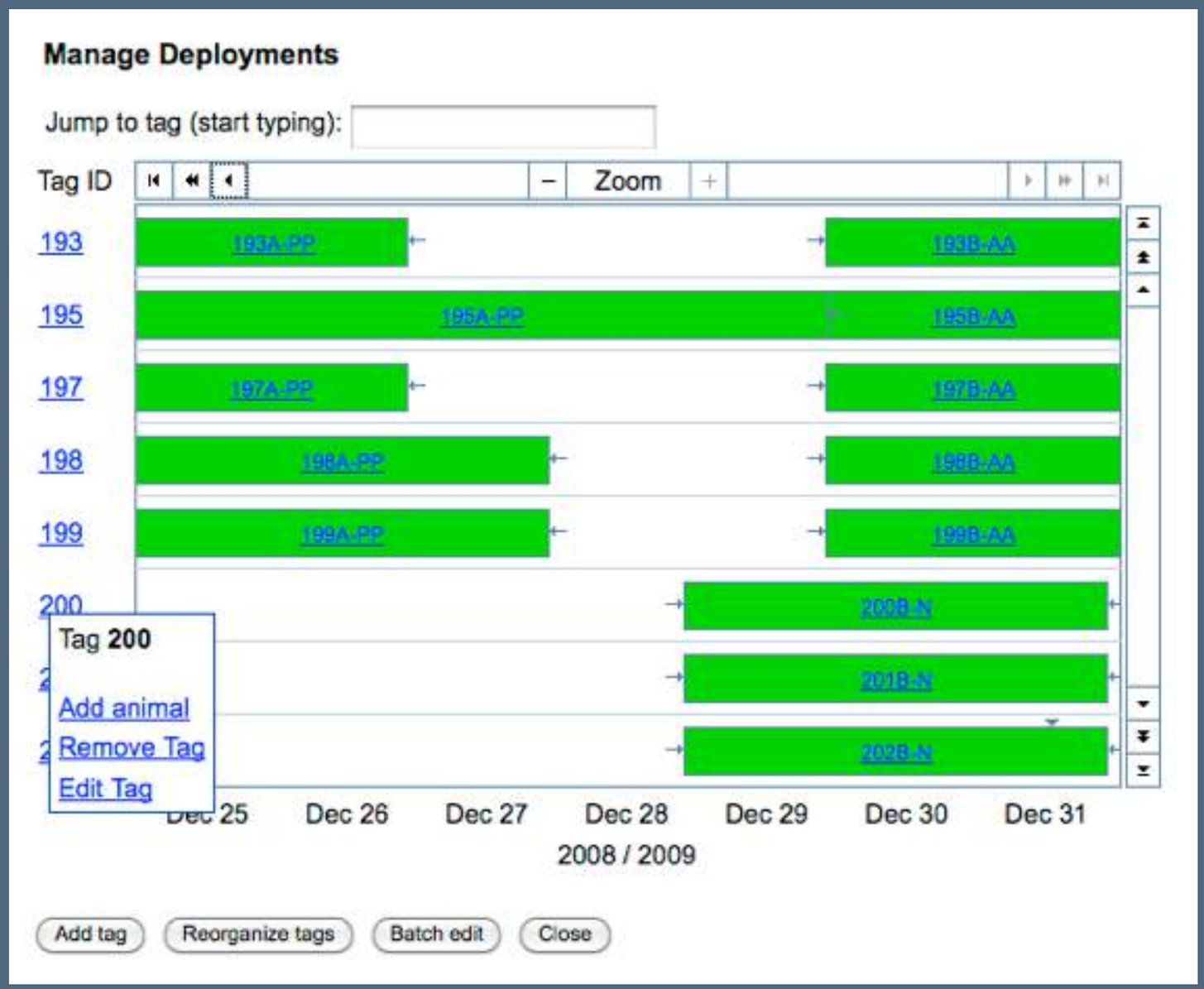
TOOLS

A shared database allows shared tools.

Mapping

Management

Deployment Manager



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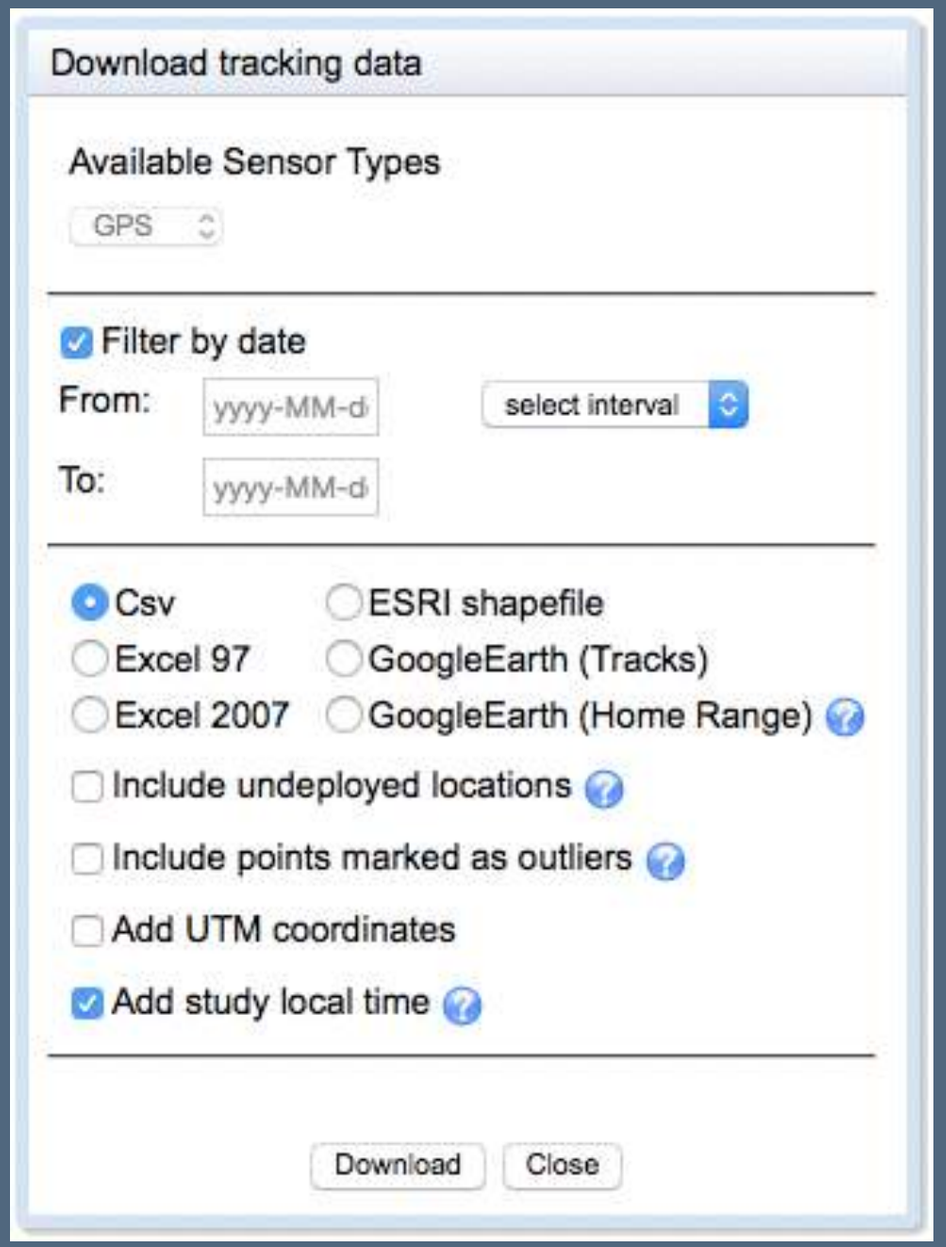
TOOLS

A shared database allows shared tools.

- Mapping
- Management
- File conversion



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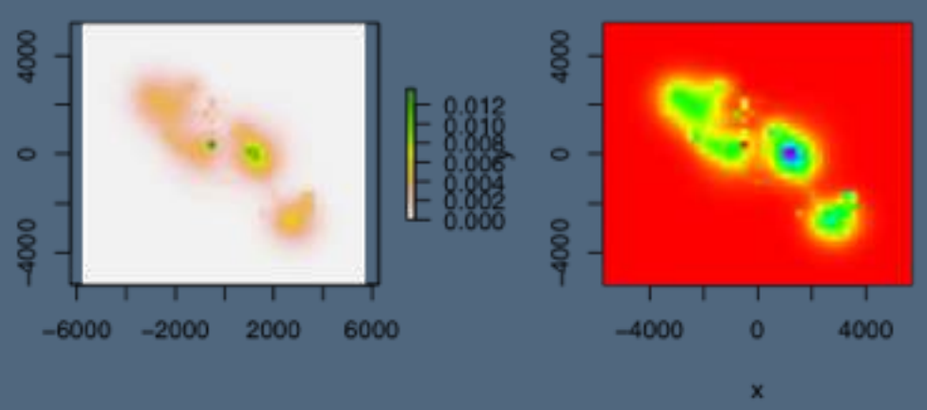
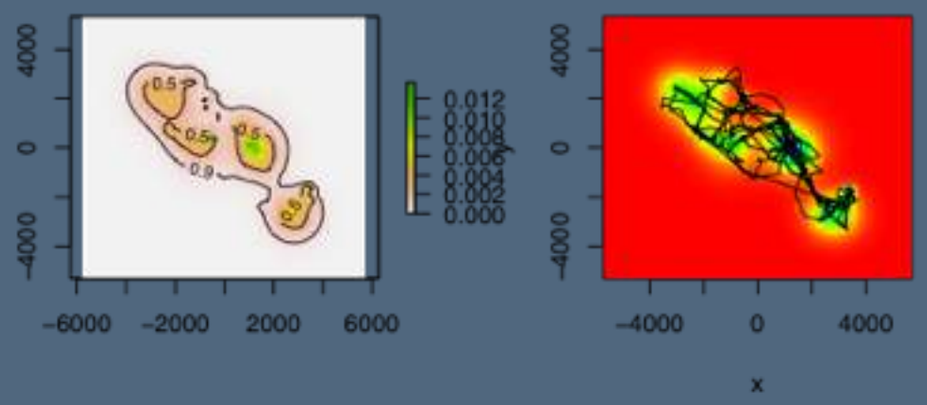
TOOLS

A shared database allows shared tools.

- Mapping
- Management
- File conversion
- Software and analysis packages



R package "move"



Kranstauber et al. 2012, Journal of Animal Ecology

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DATA FILTERS

Filters flag outliers but do not delete data.

Study: FAO-USGS goose migration (Douglas Argos Filter Tutorial)

Sensor Type: Argos Doppler Shift

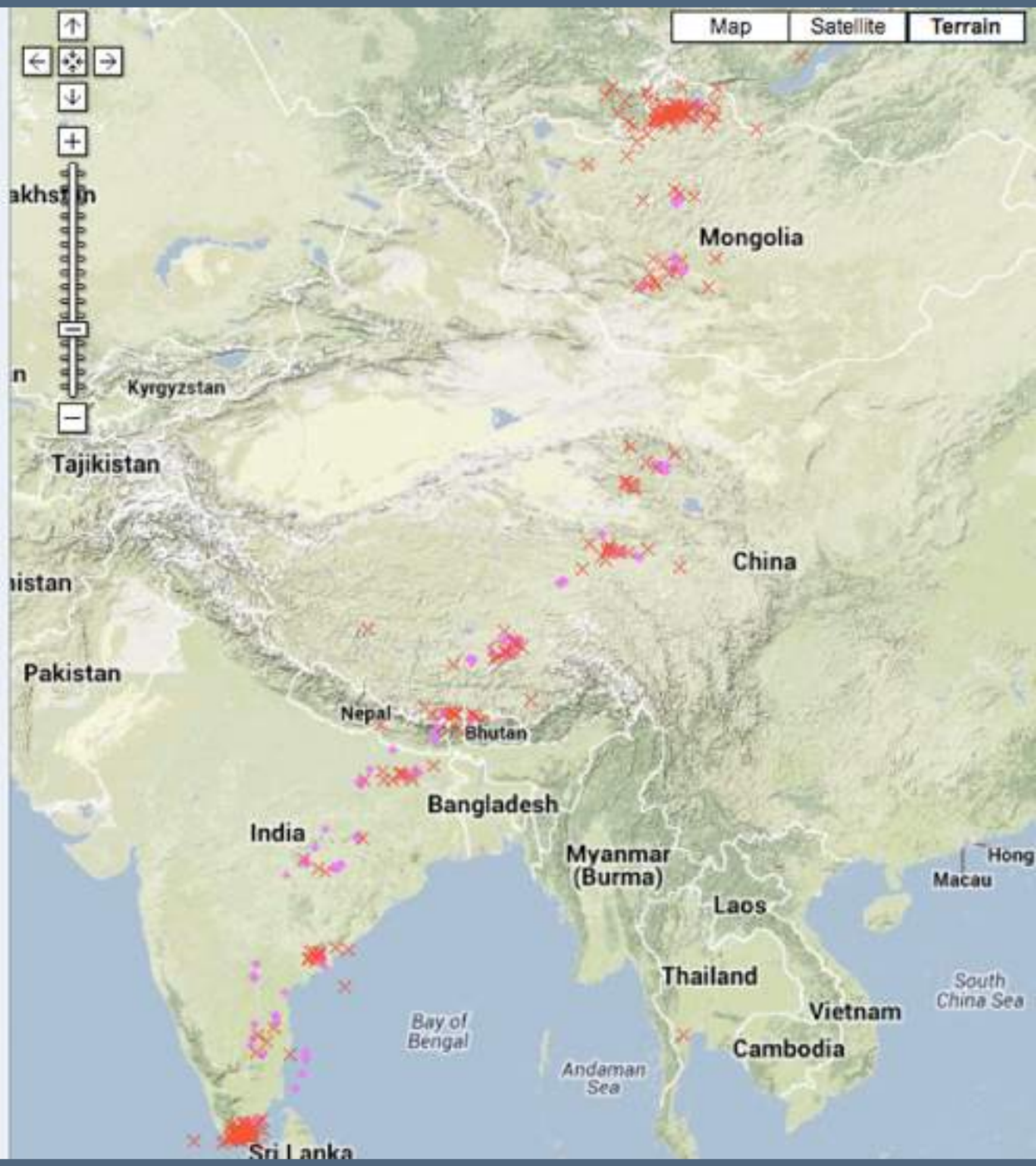
▶ Display Options

Show/Hide Columns

Timestamp	Location Lat	Location Long	Algorithm Marked Outlier
2009-01-27 11:02:10	8.488	77.760	
2009-01-27 11:22:04	8.463	77.757	
2009-01-27 12:40:40	8.505	77.797	
2009-01-27 13:04:24	8.489	77.764	
2009-01-28 09:02:37	8.493	77.771	
2009-01-28 10:35:00	8.515	77.733	
2009-01-28 11:10:50	8.493	77.767	
2009-01-28 12:16:07	8.546	77.816	true
2009-01-28 12:16:07	8.546	77.818	
2009-01-28 12:51:14	8.499	77.747	
2009-01-28 16:08:02	8.509	77.747	
2009-01-28 16:08:32	8.509	77.751	
2009-01-30 12:27:45	8.541	77.756	
2009-01-30 15:22:24	8.329	77.812	
2009-01-30 15:26:24	8.495	77.843	
2009-01-30 17:01:09	8.446	77.829	
2009-01-30 17:07:00	8.449	77.836	
2009-01-30 19:43:54	8.445	77.818	
2009-01-30 21:24:01	8.466	77.856	
2009-01-30 22:25:00	8.441	77.831	
2009-01-30 23:32:46			true
2009-02-01 00:58:42	8.501	77.897	
2009-02-01 03:34:42	8.662	78.249	true
2009-02-01 03:42:37	8.393	77.854	
2009-02-01 05:13:52	8.430	77.849	

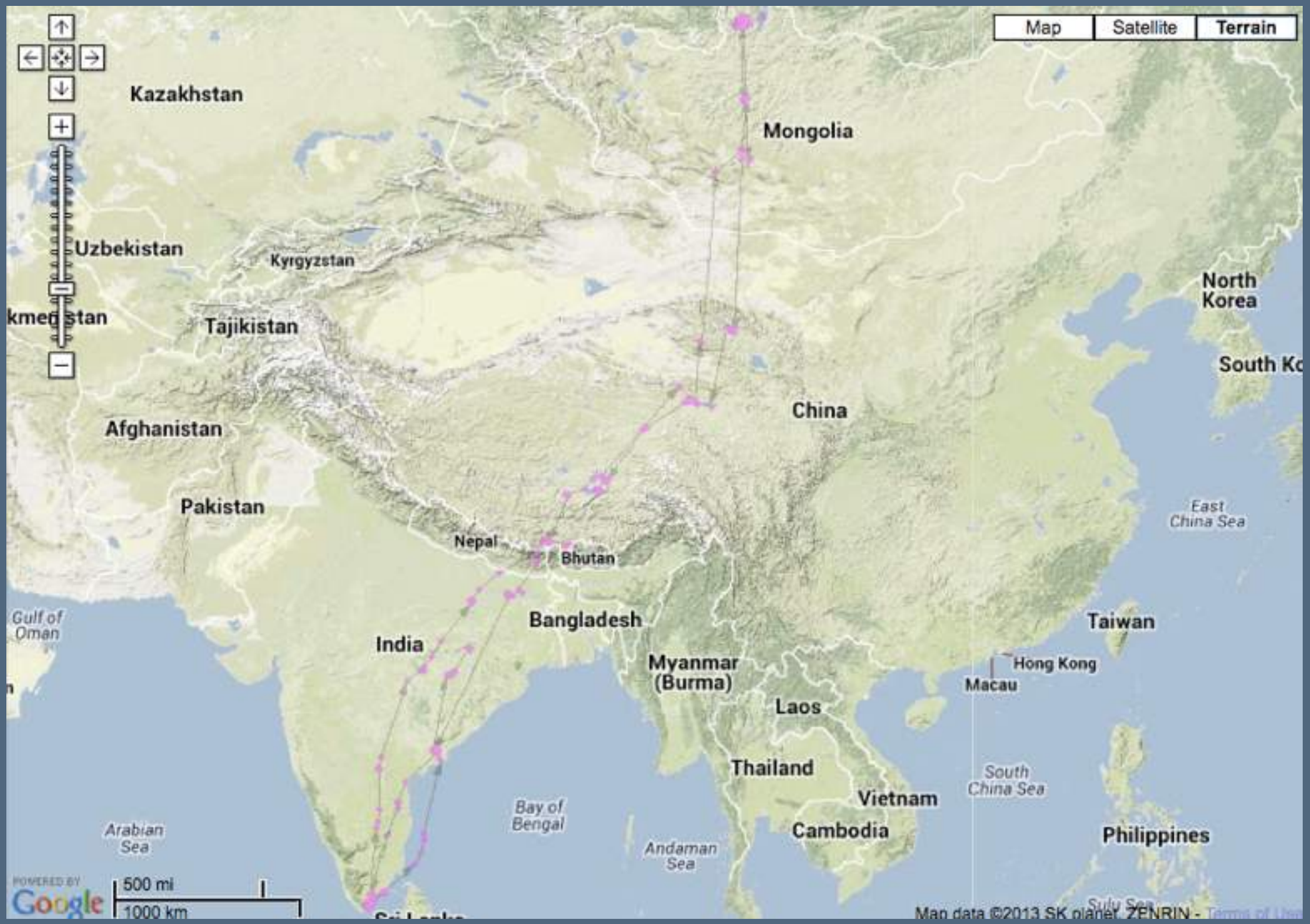
Hold shift or ctrl key to select multiple events.

Save | Cancel



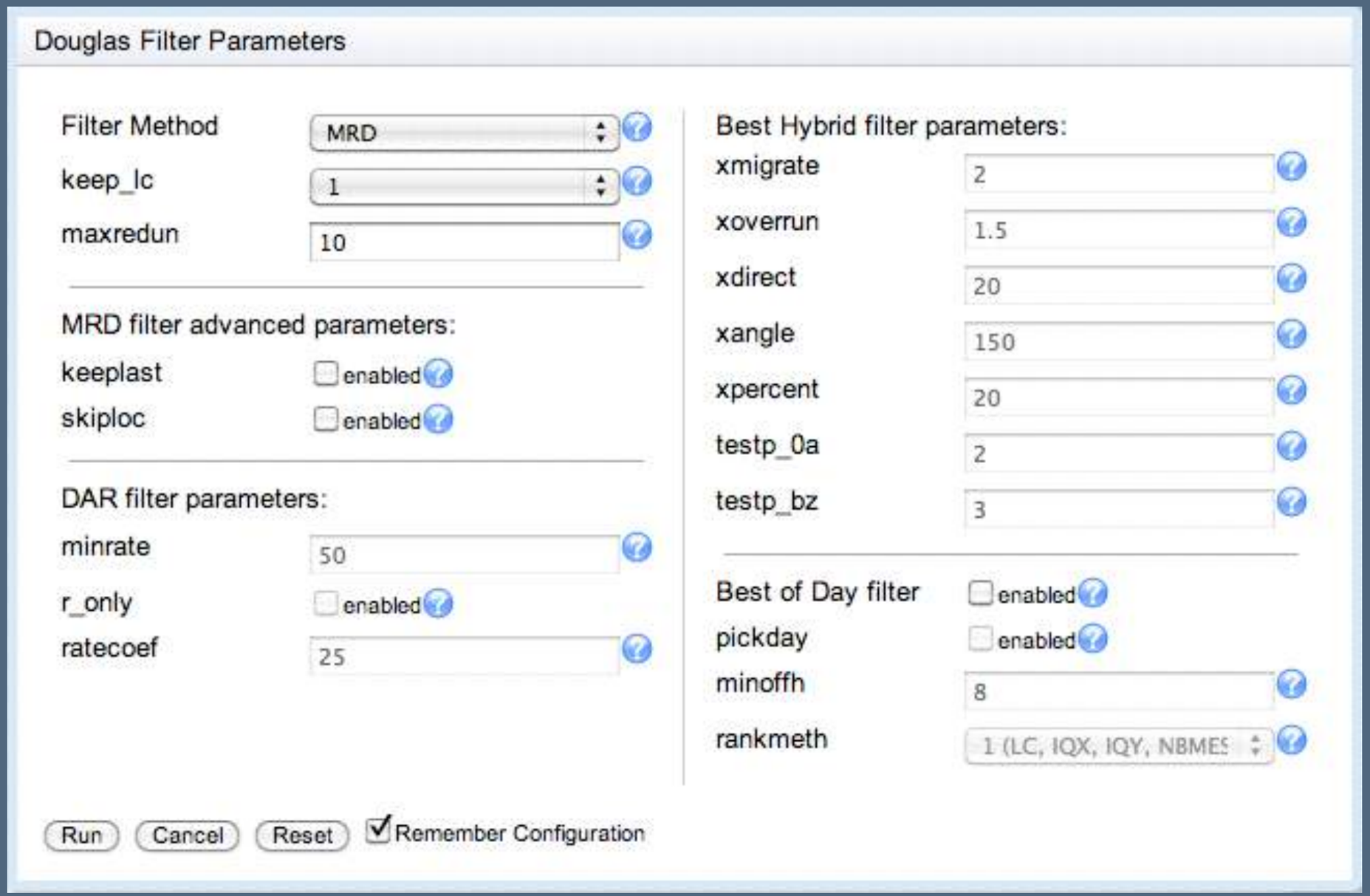
DATA FILTERS

Filters flag outliers but do not delete data.



DATA FILTERS

Douglas Argos Filter Algorithm



Douglas et al. 2012, Methods in Ecology and Evolution

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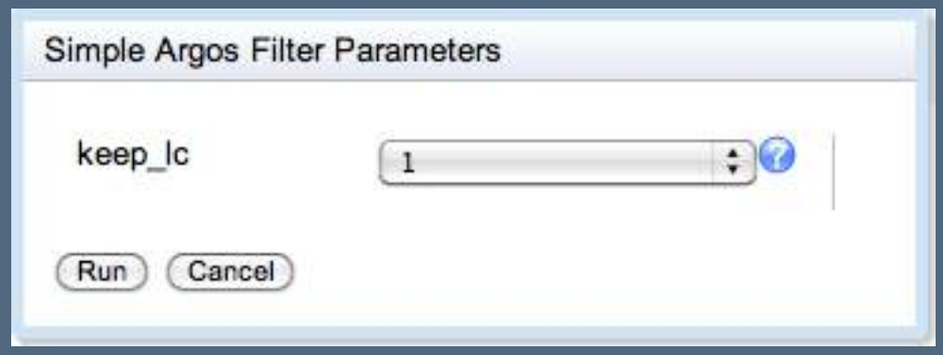
DATA FILTERS

Argos LC filter

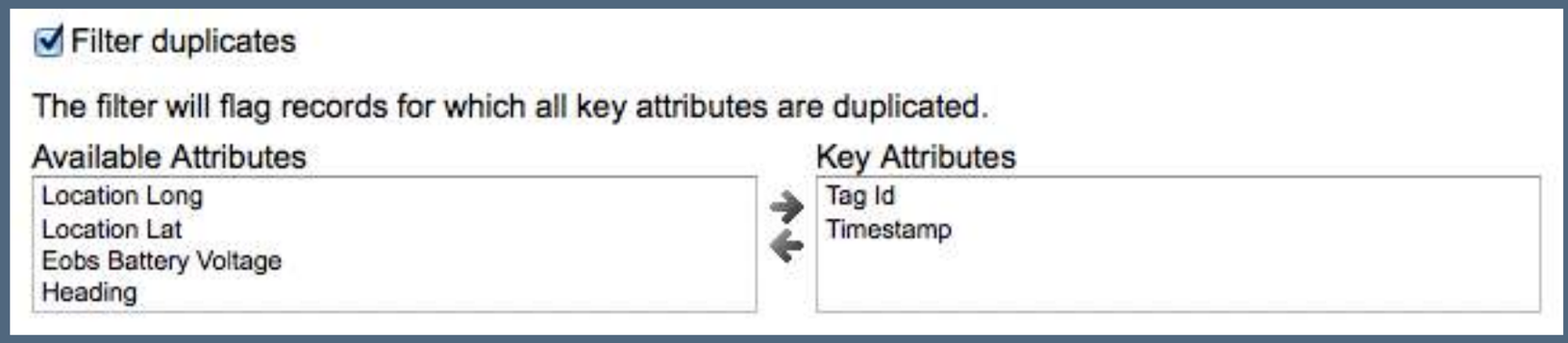


Douglas et al. 2012, Methods in Ecology and Evolution

DATA FILTERS

General purpose filters

Duplicate filter



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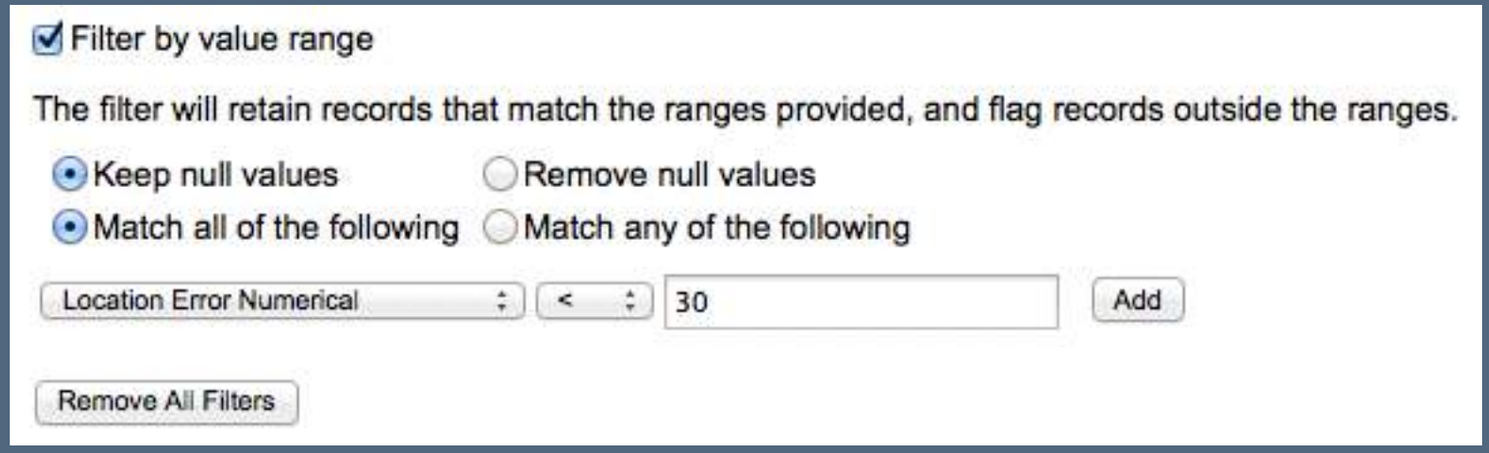
DATA FILTERS

General purpose filters

Duplicate filter

Value range filter



DATA FILTERS

General purpose filters

Duplicate filter

Value range filter

Speed filter

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ENV-DATA

Environmental Data Automated Track Annotation System

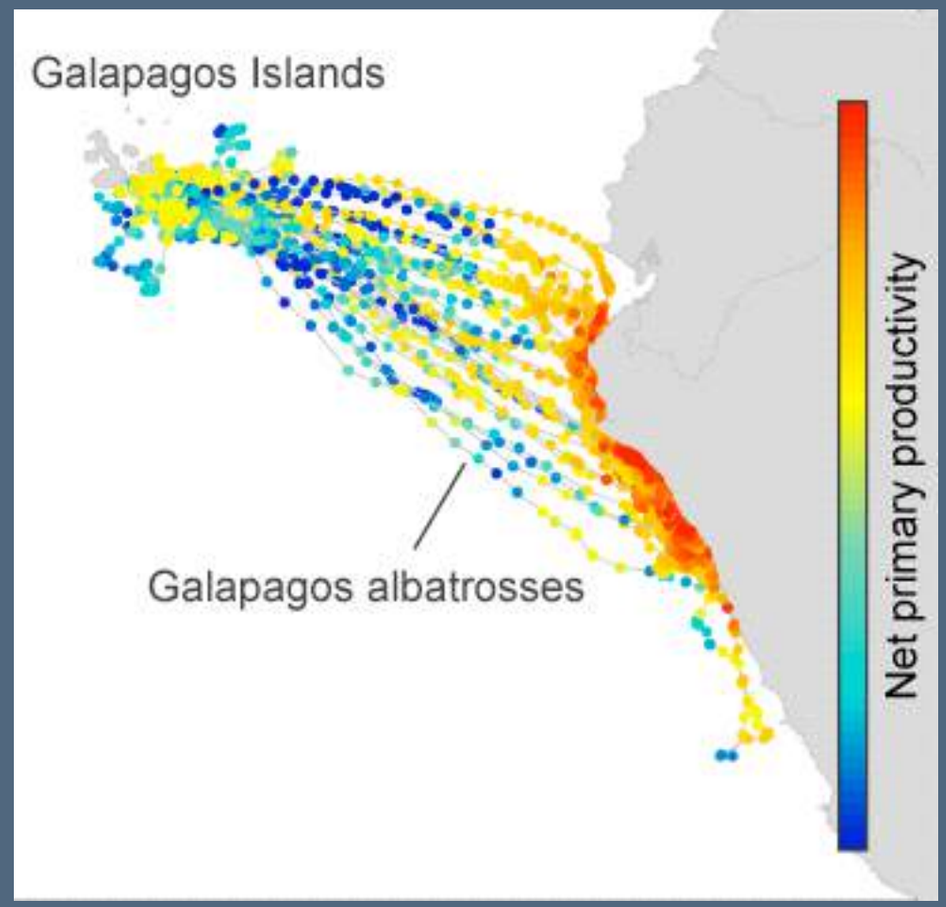
Link animal movement data to global environmental datasets:

Identify and download data files

Transform formats/projections

Interpolate values

Provide documentation



funded by the NASA Earth Science Division
Ecological Forecasting Program

Dodge et al. 2013, Movement Ecology

ENV-DATA: PRODUCTS

Topography: ASTER, ETOPO 1, and SRTM digital elevation models

ETOPO1 Global Relief Model

Dodge et al. 2013, Movement Ecology

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ENV-DATA: PRODUCTS

Topography

Weather and climate:

European Centre for Medium-range Weather Forecasts

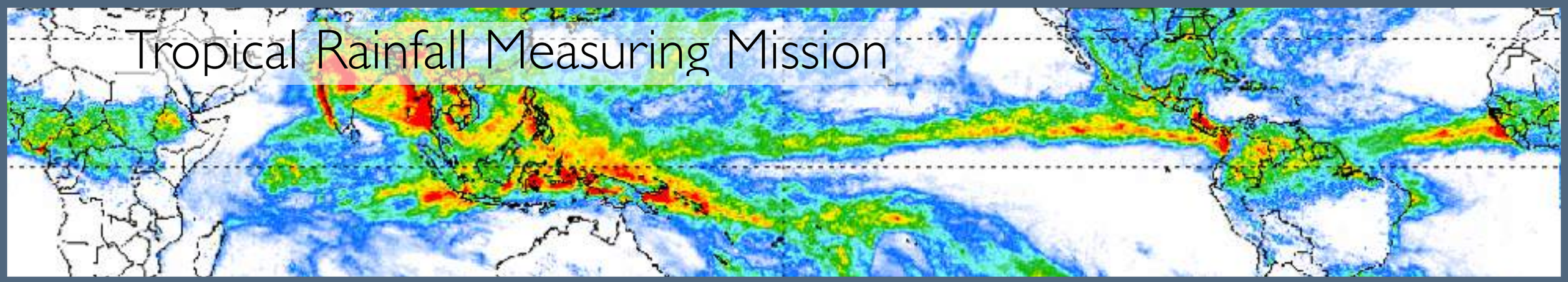
National Oceanic and Atmospheric Administration (NOAA)

NCEP-DOE Reanalysis 2

North American Regional Reanalysis (NARR)

NOAA Global Climate Indices

Tropical Rainfall Measuring Mission



TRMM average rainfall, July 2013

Manage | Analyze | Share | Archive

ENV-DATA: PRODUCTS

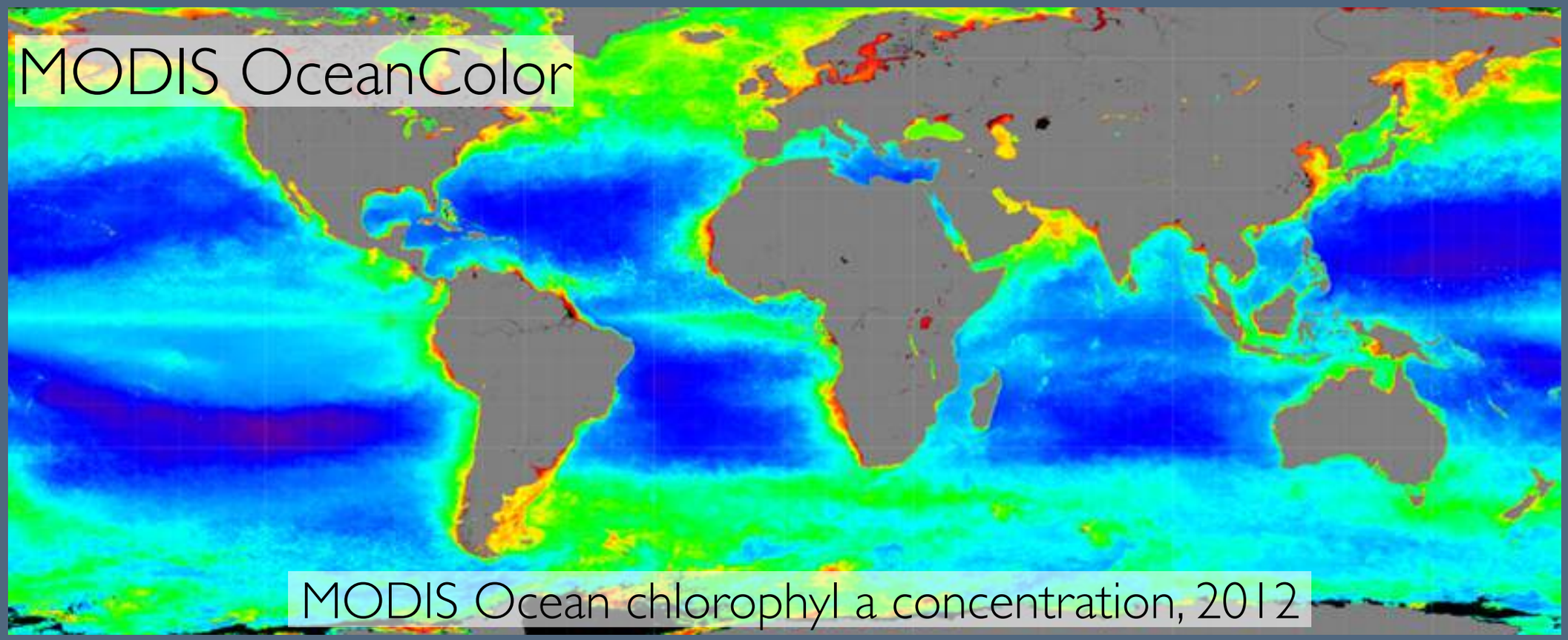
Topography

Weather and climate

Ocean conditions:

Oregon State University Ocean Productivity Reanalysis

OSCAR Ocean Surface Currents



ENV-DATA: PRODUCTS

Topography

Weather and climate

Ocean conditions

Terrestrial conditions and demographics:

MODIS Land, Snow & Ice

GlobCover Land Cover

SEDAC Human Population Density

Global Land Cover Facility AVHRR NDVI

GlobCover land cover, 2009

ENV-DATA: PRODUCTS

- Topography
- Weather and climate
- Ocean conditions
- Terrestrial conditions
- Derived variables
  - Terrain slope and rugosity
  - Orographic and thermal uplift velocity

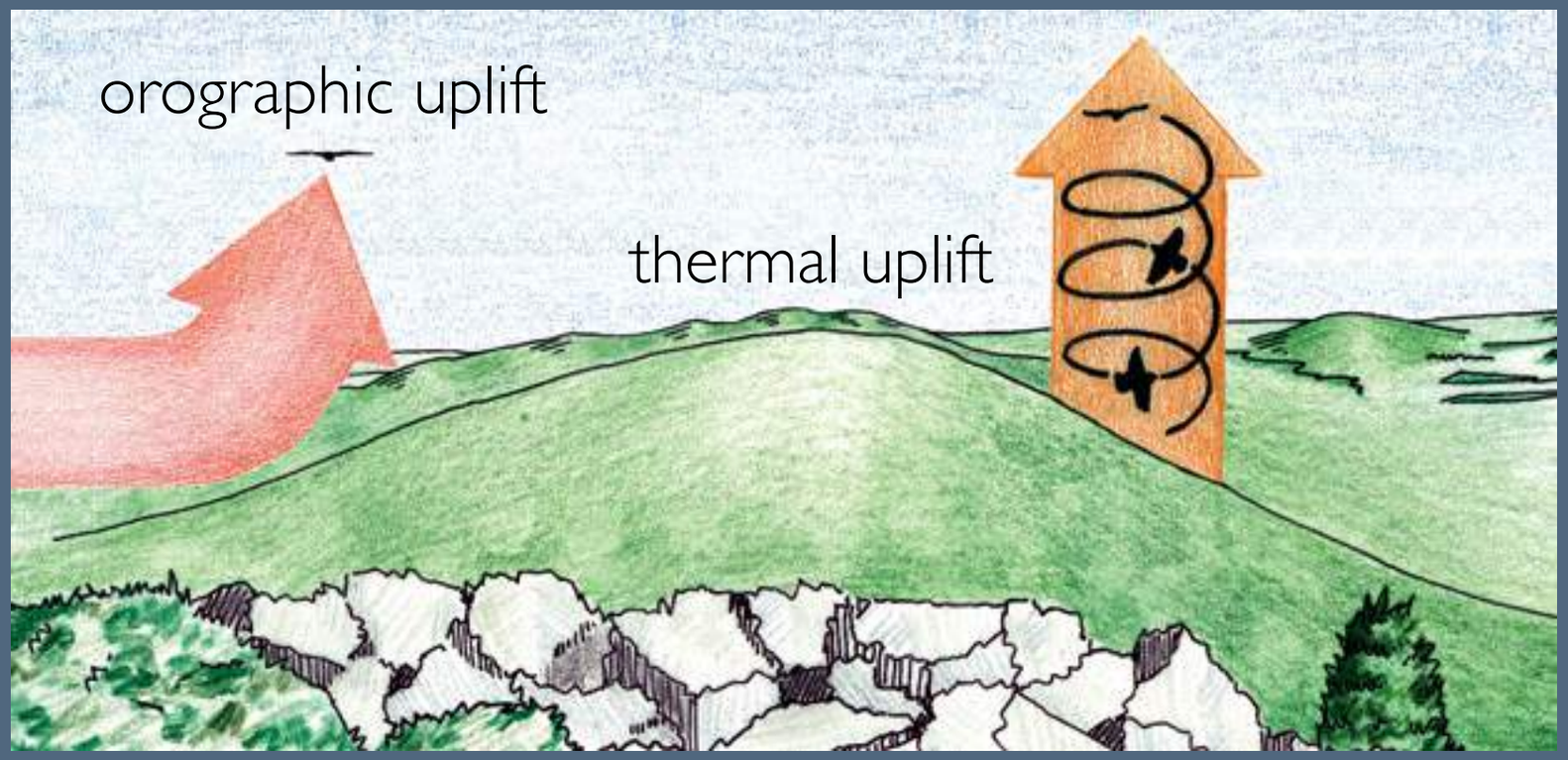


image from hawkmountain.org
Bohrer et al. 2011, Ecology Letters

INTERPOLATION

Bilinear

Inverse distance weighted

Nearest neighbor

Dodge et al. 2013, Movement Ecology

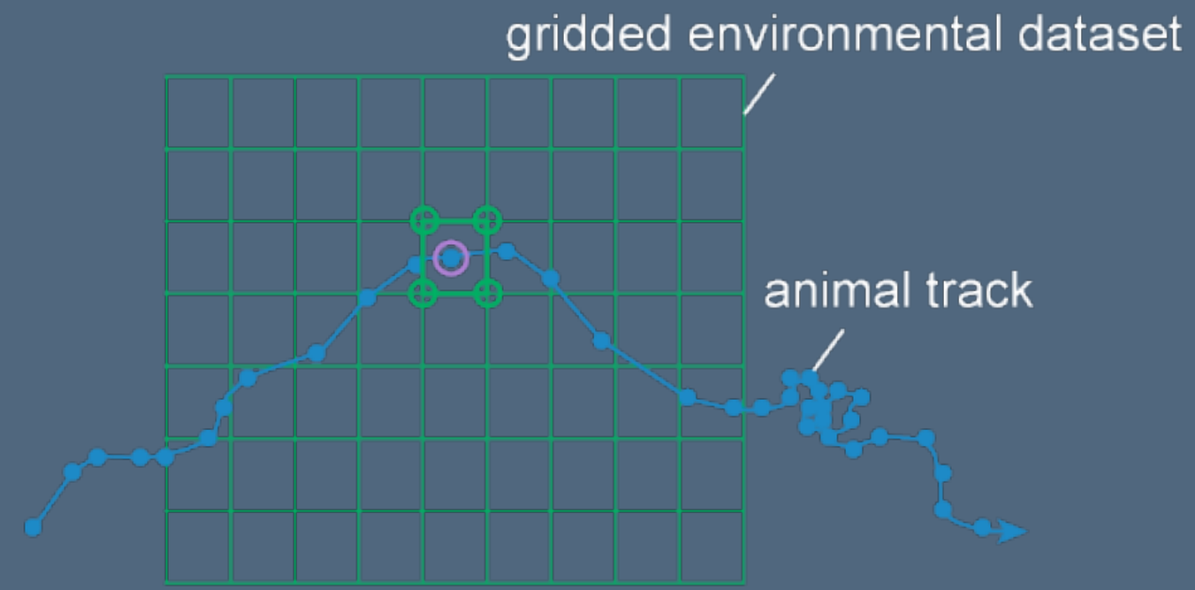
INTERPOLATION

Bilinear

Inverse distance weighted

Nearest neighbor

In space



Dodge et al. 2013, Movement Ecology

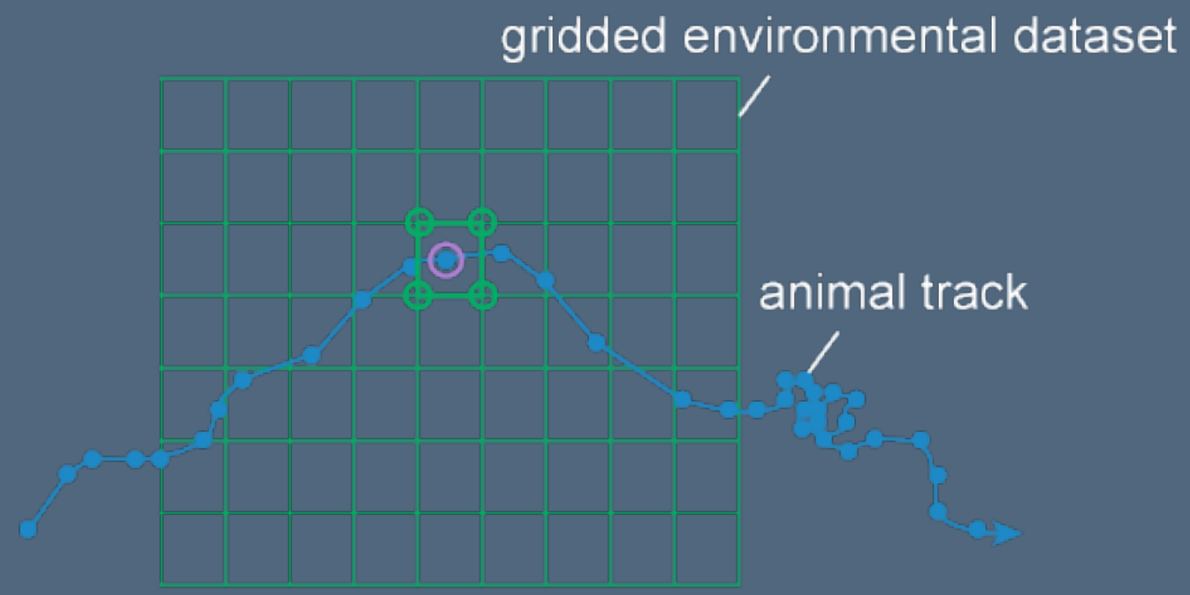
INTERPOLATION

Bilinear

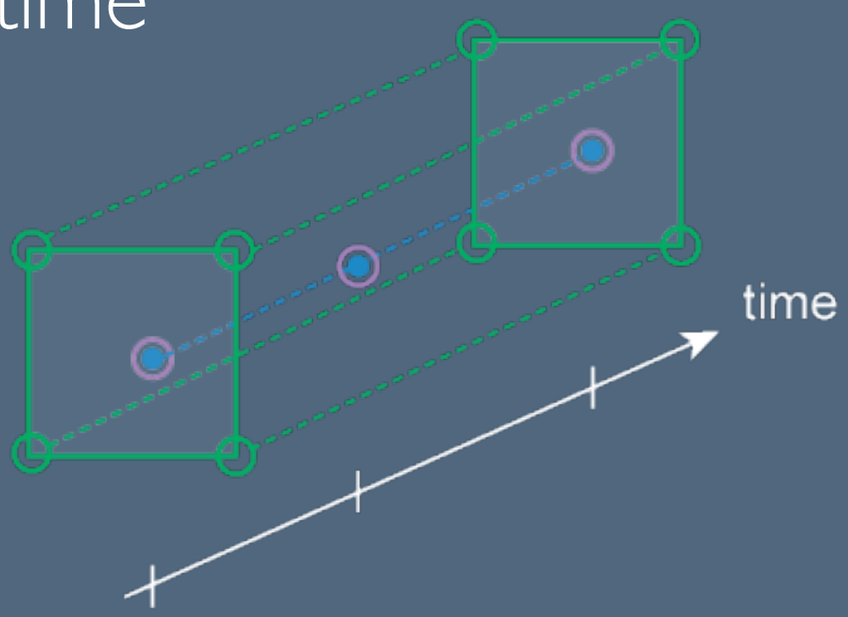
Inverse distance weighted

Nearest neighbor

In space



In time



Dodge et al. 2013, Movement Ecology

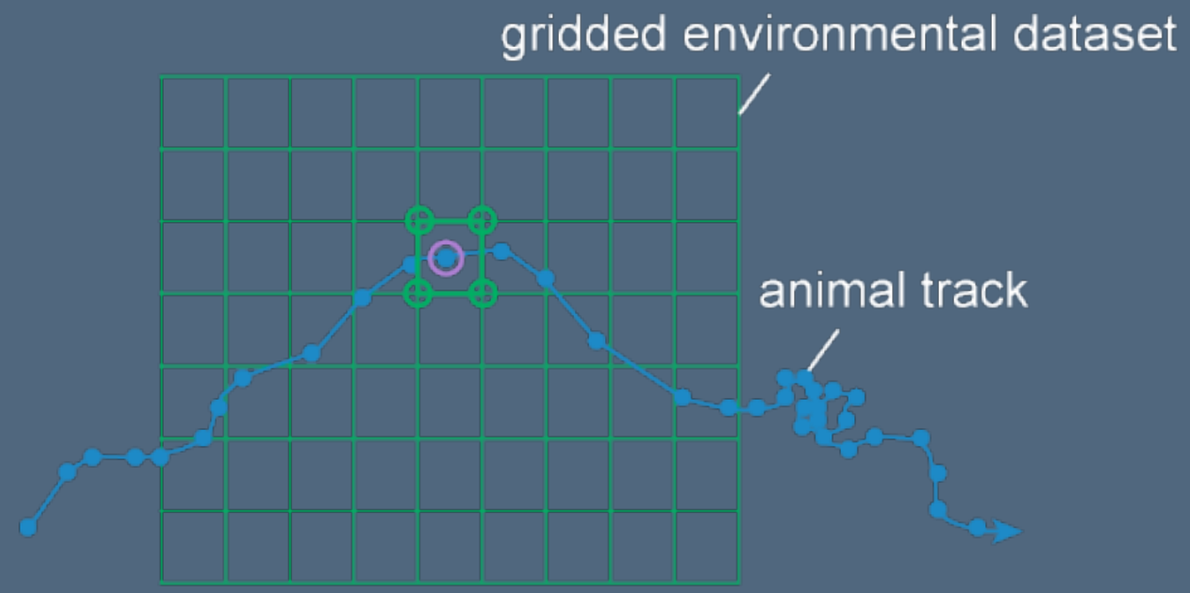
INTERPOLATION

Bilinear

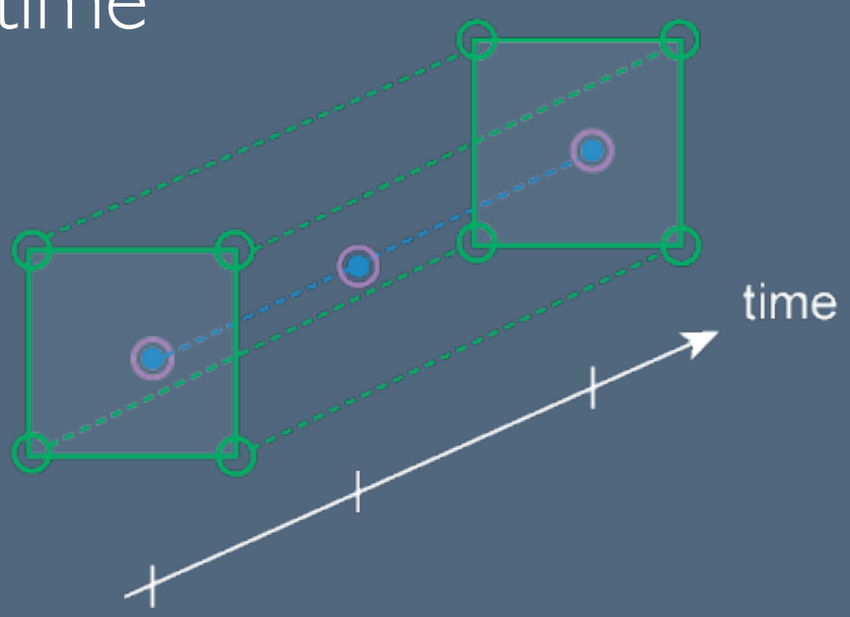
Inverse distance weighted

Nearest neighbor

In space



In time

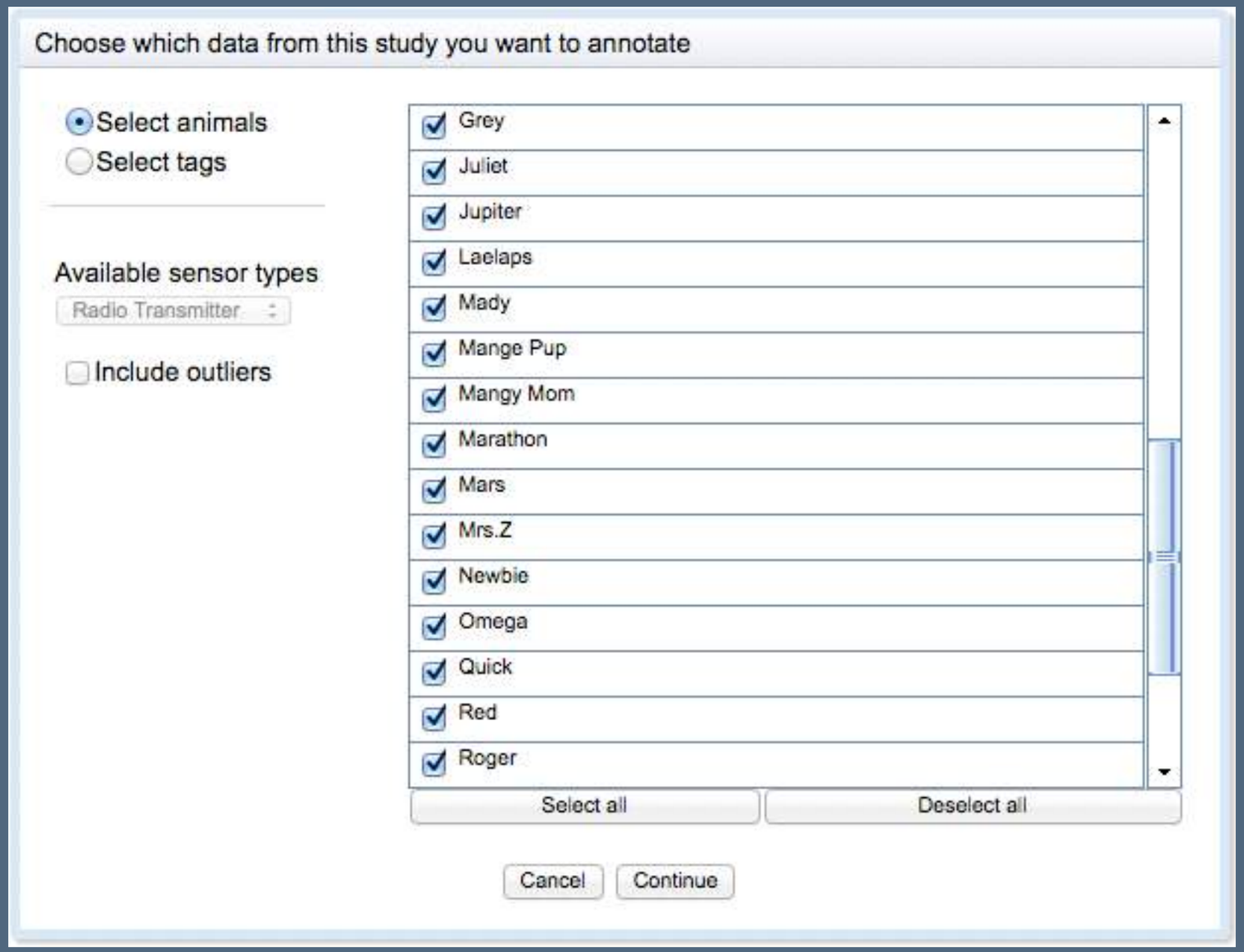


By height

Dodge et al. 2013, Movement Ecology

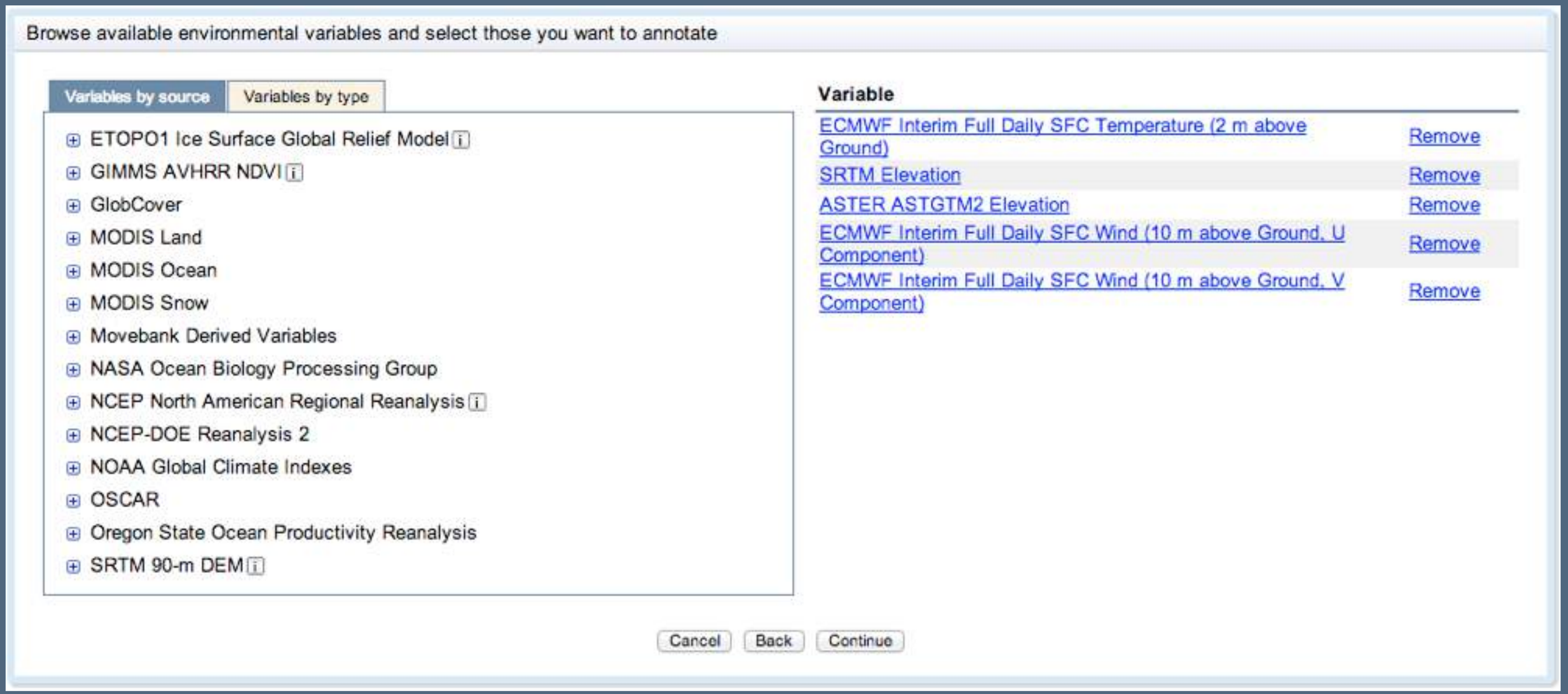
ENV-DATA: USER INTERFACE

1. Select data from Movebank.



ENV-DATA: USER INTERFACE

1. Select data from Movebank.
2. Browse and select environmental variables.



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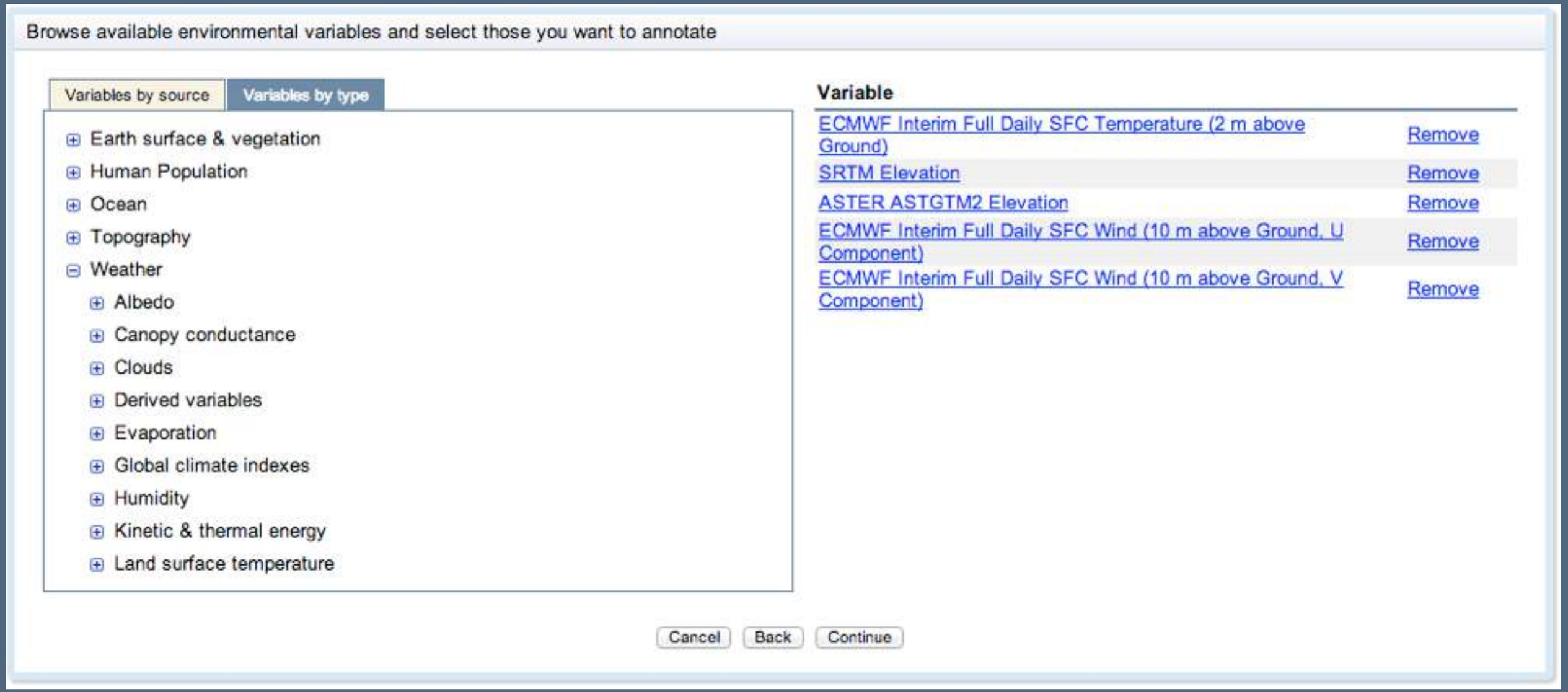

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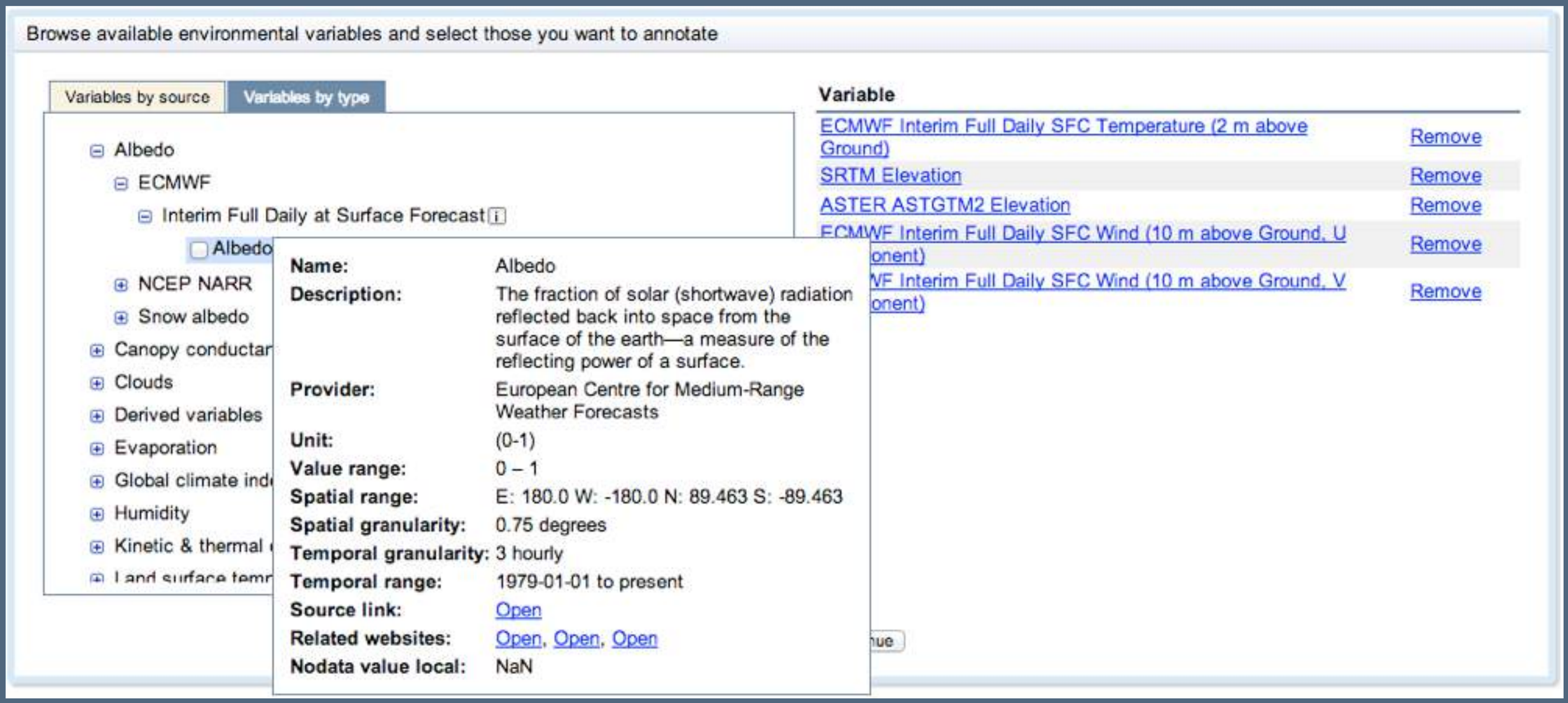
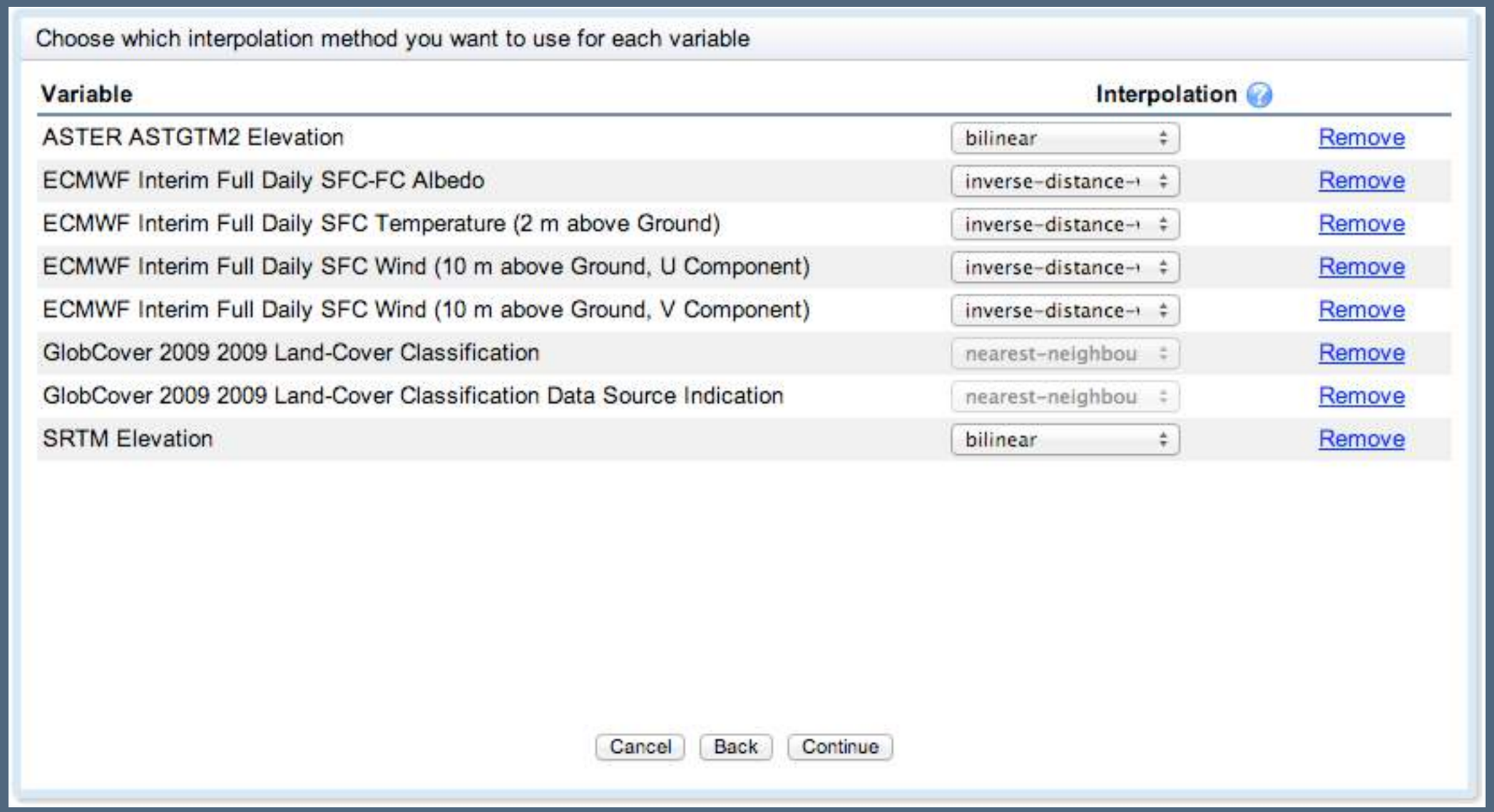


ENV-DATA: USER INTERFACE

1. Select data from Movebank.
2. Browse and select environmental variables.
3. Choose interpolation methods.



ENV-DATA: USER INTERFACE

1. Select data from Movebank.
2. Browse and select environmental variables.
3. Choose interpolation methods.
4. Submit request.

Review a summary of your order and submit your annotation request

study: Coyotes, Kays and Bogan, Albany NY

sensor type: Radio Transmitter

tracking data: Animal: Juliet, Omega, Grey, Jupiter, Laelaps, Mady, Mange Pup, Mangy Mom, Marathon, Mars, Mrs.Z, Newbie, Quick, Red, Roger

Send download notification to: username@email.com

Request name: Coyotes Env-DATA annotation

Variable	Interpolation
ASTER ASTGTM2 Elevation	bilinear
ECMWF Interim Full Daily SFC Albedo	inverse-distance-weighted
ECMWF Interim Full Daily SFC Temperature (2 m above Ground)	inverse-distance-weighted
ECMWF Interim Full Daily SFC Wind (10 m above Ground, U Component)	inverse-distance-weighted
ECMWF Interim Full Daily SFC Wind (10 m above Ground, V Component)	inverse-distance-weighted
GlobCover 2009 2009 Land-Cover Classification	nearest-neighbour
GlobCover 2009 2009 Land-Cover Classification Data Source Indication	nearest-neighbour

ENV-DATA: USER INTERFACE

1. Select data from Movebank.
2. Browse and select environmental variables.
3. Choose interpolation methods.
4. Submit request.
5. Retrieve data and documentation.

My requests

Find a list of your submitted annotation requests below. For information on submitted data sets and annotated environmental variables click on the respective links in the table.

Request	Timestamp	State	Overview	Details	
Coyotes Env-DATA annotation	2013-07-23 16:33:21.397	available	view	view	download

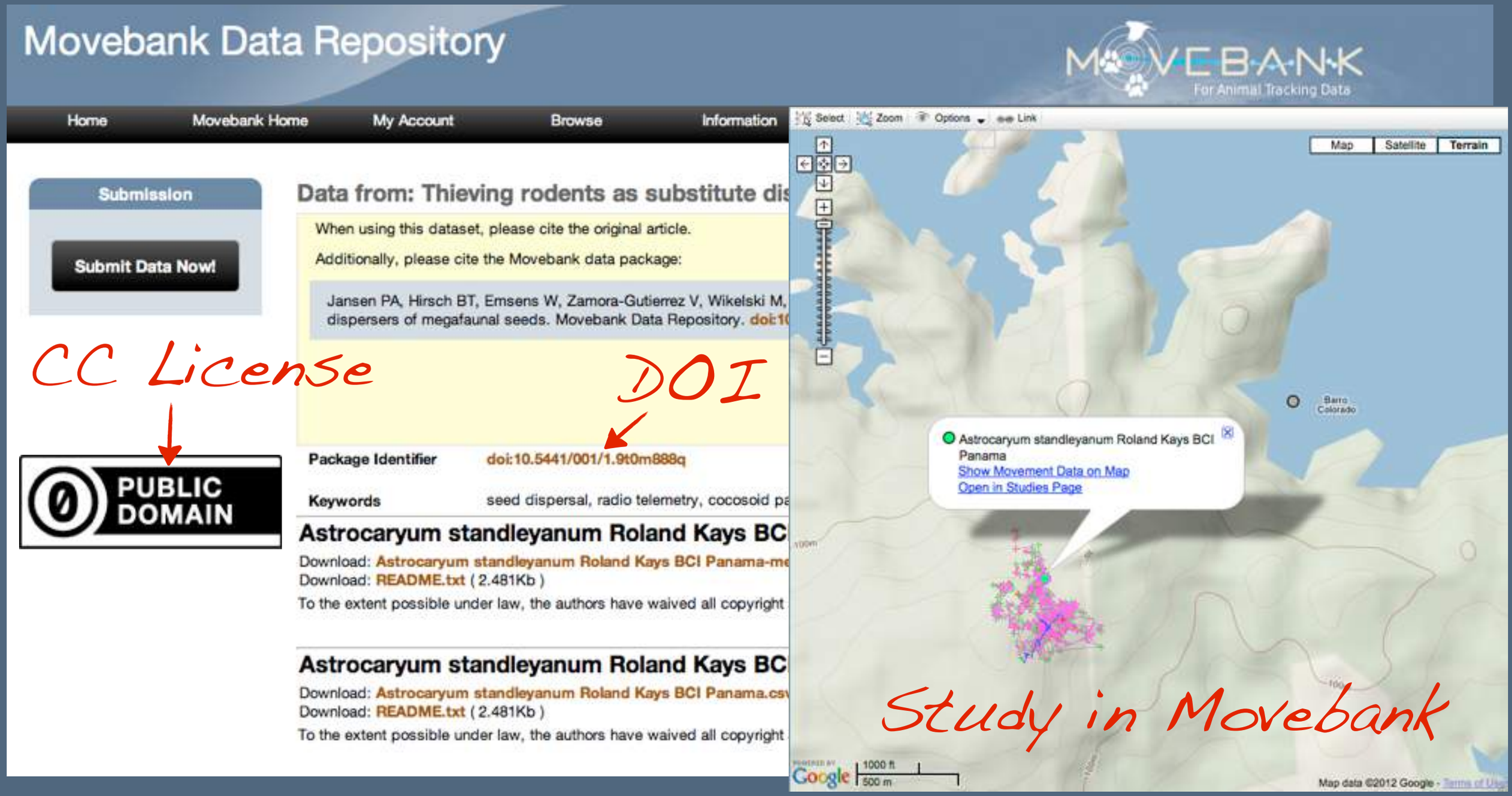
ENV-DATA: USER INTERFACE

1. Select data from Movebank.
2. Browse and select environmental variables.
3. Choose interpolation methods.
4. Submit request.
5. Retrieve data and documentation.
6. Explore your results!

Manage | Analyze | Share | Archive

DATA REPOSITORY

Have your dataset reviewed and receive a DOI.



University of Konstanz Library and Computer Center

datarepository.movebank.org

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PUBLIC OUTREACH

Show tracks on other websites.

20 September

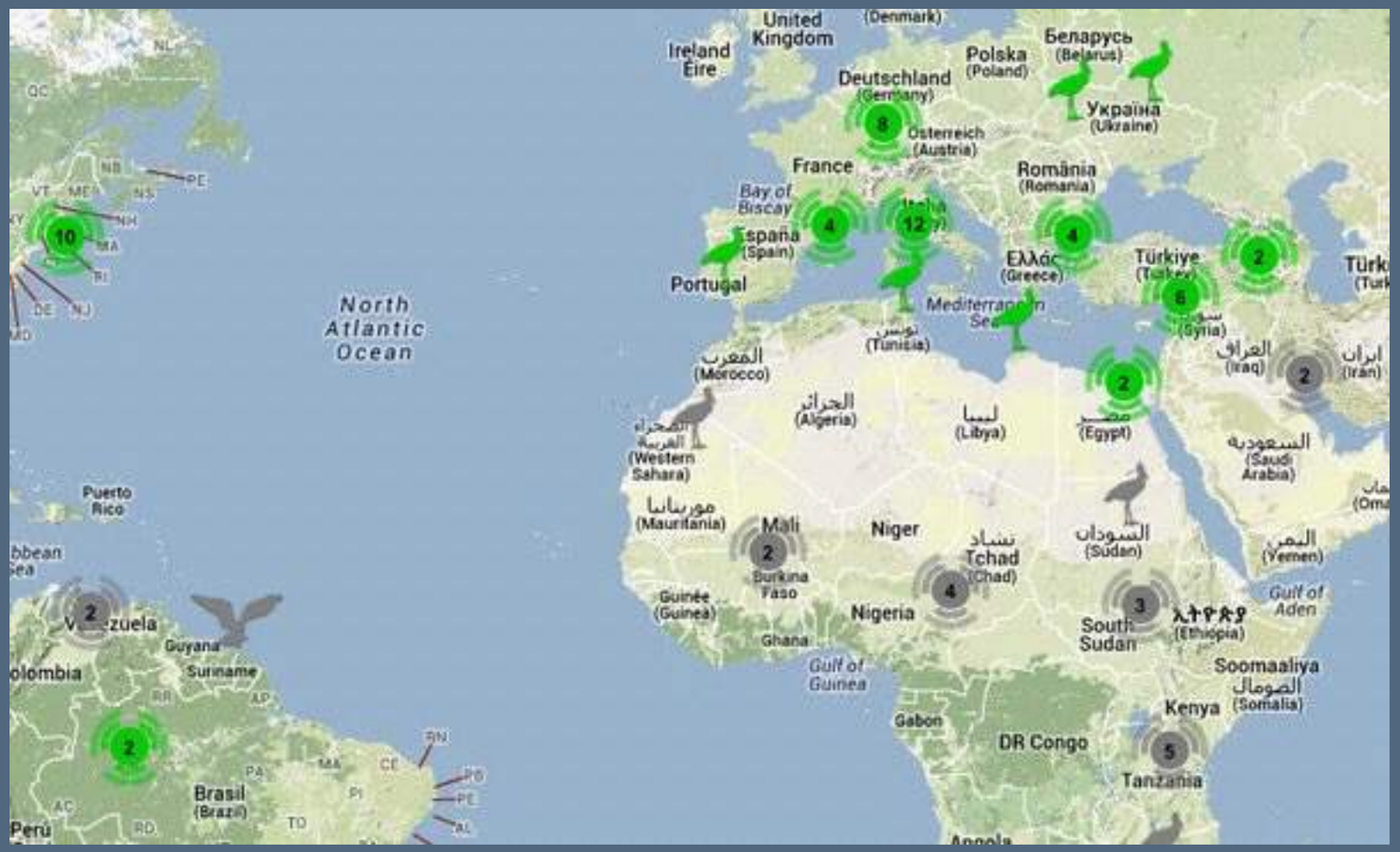
www.ospreytrax.com

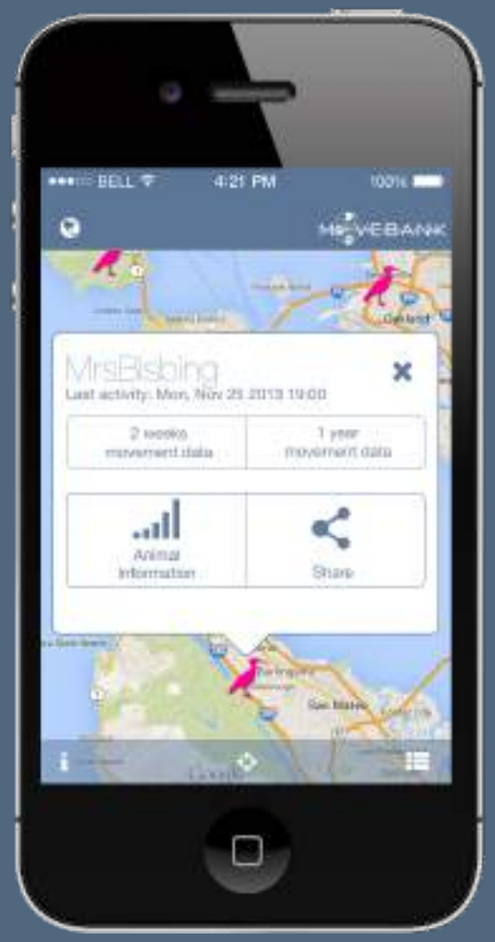
Huge news here. Belle made an amazing 56-hour non-stop flight from Cape Cod to Cuba! She was going over 40

Manage | Analyze | Share | Archive

PUBLIC OUTREACH

Animal Tracking App





available on the Apple AppStore and at Google Play

ACKNOWLEDGEMENTS

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NSF

NASA

Partners

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North Carolina Museum of Natural Sciences

ARGOS

EURODEER

Scientific Task Force on Wildlife and Ecosystem Health

The Ohio State University

FAO Fiat Panis

EMPRES

WRAM

BirdLife International

THANK YOU!

Questions, feedback, requests?

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Photo by Isidro Vila Verde, 2011

CITATION

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