Light-level geolocation analyses

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Contents

Preface

Note: The Manual is currently under development and content may not show up (ask Simeon if you need immediate access)!

This manual is part of the following publication and has been written by the same group of authors:

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Geolocation by light is a method of animal tracking that uses small, light-detecting data loggers (referred to as geolocators) to determine the locations of animals based on the light environment they move through.

Technological and fieldwork issues aside, effective use of light level geolocation requires translation of a time series of light levels into geographical locations. Geographical locations that are derived from light-level data are subject to error which directly arises from noise in the light-level data, i.e. unpredictable shading of the light sensor due to weather or the habitat (Lisovski et al., 2012). Although light-level geolocation has provided a wealth of new insights into the annual movements of hundreds of bird species and other taxa, researchers struggle with the analytical steps that are needed to obtain location estimates, interpret them, present their results, and document what they have done.

This manual has been written by some of the leading experts in geolocator analysis and is based on material created for several international training workshops. It offers code and experience that we have accumulated over the last decade, and we hope that this collection of analysis using different open source software tools (R packages) helps both newcomers and experienced users of light-level geolocation.

Acknowledgements

We want to acknowledge all people that have been involved in the development of geolocator tools as well as all participants of the many international geolocator workshops. Furthermore, we like to acknowledge Steffen Hahn and Felix Liechti organisewho organised a first workshop of the analysis of geolocator data from songbirds back in 2011. This workshop has been financially supported by the Swiss Ornithological Institute and the Swiss National Science Foundation. The National Centre for Ecological Analysis and Synthesis (NCEAS) has supported two meetings with experts in geolocator analysis in 2012 ans 2013 and many of the tools that are discussed in this manual were kick started at these meetings. We want to thank James Fox from Migrate Technology Ltd. as well as the US National Science Foundation for contiouing financial support to develop tools and organise workshops.

License

Chapter 1

Structure of the manual

This manual should allow users with limited knowledge in R coding to perform a state-of-the-art analysis of geolocator data. Thus, we start with the very basics of loading packages and data 3 Starting with the initial data editing steps, which we call twilight annotation 9, we provide instructions on how to use several prominent analysis packages, illustrate the general analysis workflow using example data, and provide some recommendations for how to visualize and present results. We do not cover every available analysis package but focus on what we percieve to be the most frequently used tools, which are GeoLight 4, probGLS 5, SGAT 6 and FLightR 7. The manual … for geolocator tracks.

The datasets

To illustrate the capabilities of the different packages, discuss the potential pitfalls, and provide some recommendations, we will use raw geolocator data from four individuals of different species.

TagID	Species	Folder	Tag type	Movebank information
M034	Red-backed Shrike	LanCol	Integio (Migrate Technology Ltd.)	TBA
14SA	European bee-eater	MerApi	PAM (Swiss Ornithological Institute)	TAB
PasCir01	Purple martin	PasCir	Custom	TBA
xxx	xxxx	XX	Lotek	

Although all of these tag types record light values over time, they differ in some key details. First, tags often differ in the frequency at which they write/log data. Many tags collect a reading every minute and store the maximal light value every 5 or 10 minutes. Other may store a maximum every 2 minutes. The tag that yielded the Purple martin data set, averaged 1min readings every 10min instead of taking a maximum. These four tags also differ in their sensitivity and how they record light levels. Some tags are sensitive only at low light levels and quickly "max out" when they experience a lot of light. As such, their light-levels do not have units and are simply an index of light intensity. The Integio tags can record unique light values for all natural light levels on earth, and they store lux values that range from 0 to ~70,000. Depending on the tag type, you may have to perform some preliminary steps such as log-transforming your data or time shifting light values for sunsets (we will provide details while working on the specific datasets).

Reproducing the analyses

This manual contains code that can be copy pasted into an R script and executed to reproduce the results. In order to do so, you need to download the raw data as well as annotated twilight files used in this manual.

The data need to be in a specific structure of folders and we do recommend you have a similar structure for your own analysis. During the processing of the data we save intermediate steps that allow us to step into the next analysis step without going through all initial and often time consuming parts. Having your raw data and your results in a well structured fomr, becomes especially important if you run analyses for many tags of the same or different species. It is also recommended that you create a single R script for each analysis (e.g. for each individual and each analysis using different tools). For example, you can name the R scripts using the tag id and the tool e.g. `14SA_SGAT.R`. Since this manual is dealing with tags from different species, the following structure with sub-folders per speces (first three letters of the genus name and the species name) is setup within the main folder (called *data*):

- RawData
  - LanCol
  - MerApi
  - PasCir
- Results
  - LanCol
  - MerApi
  - PasCir
- RCode
  - LanCol
  - MerApi
  - PasCir

You can download the folders with the raw data as well as the annotaded twilight files directly via R and extract into a *data* folder.

```
url <- "https://github.com/slisovski/TheGeolocationManual/raw/master/download/data.zip"

temp <- tempfile()
download.file(url, temp)
unzip(temp, exdir = "data")
```

We also recommend using R Studio and creating a project (File -> NewProject). Alternatively, you can set the working directory using the `setwd` function. With the *data* folder in your project folder (or more in general in your working directory) you should be able to run the code provided in this manual.

We also recommend to use *R Studio* and to create a project (File -> NewProject). Save the project file into the existing *Data* folder. This makes sure that *Data* is your working directory and it will remain the working directory even if the folder moves around on your drive. Alternatively, you can set the working directory using the `setwd` function. With the suggested folder structure and the raw data and the annotaded twiligth files you should be able to run the code provided in this manual.

Chapter 2

Getting started

To analyse light-level geolocator data in R we need a couple of R packages as well as functions that allow to run our code. We created a package called *GeoLocTools* that contains functions that are not nessesarily associated to a certain package but are used in this manual. Importantly the package can also run a check on you system (function: *setupGeolocation()*), detecting packages that are already on your computer and installs the missing tools directly from CRAN or GitHub.

The package requires *devtools* (install if nessesary using the *install.packages()* function). With *devtools* on your system, you are able to download and built as well as install R packages directly from GitHub (e.g. *GeoLocTools*).

```
library(devtools)
install_github("SLisovski/GeoLocTools")
```

You should now be able to load the package and run the `setupGeolocation()` function. We recommend to include this line at the beginning of each script you create for a geolocator analysis. Also check (every now and then), if there is a new version of *GeoLocTools* available. And if that is the case, re-install the package using the same code you used for initial installation.

Chapter 3

Loading data

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Chapter 4

GeoLight

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Chapter 5

probGLS

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Chapter 6

SGAT

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Chapter 7

FLightR

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Chapter 8

Data repositories

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Chapter 9

Twilight Annotation

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