'Argos-tools' manual

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Introduction

The "Argos-tools" module has been written for ArcView GIS 3.x software (ESRI, Redland, California). It has been tested on Arcview 3.1 and 3.2a, with satisfactory results.

The program is used to import data and perform basic analyses, filtering and reporting of ARGOS satellite data of animal locations.

What is Argos?

In 1978, Service Argos began providing a service to locate and receive information from transmitters (PTTs or Platform Transmitter Terminals) via satellite. The advertised standard deviations of the latitudinal and longitudinal components of the locational error for both the pre and post 1994 classification systems are as follows: LC3, sigmay = sigmax = 150 m; LC2, 350 m; and LC1, 1000 m. Assuming a bivariate normal error distribution, these errors translate into total error radii of 226, 528, and 1510 m, respectively for PTTs designed for ungulates and wolves (Keating et al. 1991). In June 1994 Argos switched to a new set of classification algorithms where the location class zero (LC0, sigma > 1000 m) was split into four classes: a new LC0 (sigma > 1000 m), 'A' and 'B' (no precision estimates), and 'Z' (rejected as implausible). There have been several studies where the errors of the locations supplied by Argos services, were measured (e.g. Hayes et al. 2001; Deutsch et al. 1997). These errors were 0.27±0.20; 0.54±0.40; 1.33±1.35; 10.10±12.31, 0.99±1.36; 7±6.92 km for LC3, LC2, LC1, LC0, LC1, LCB respectively (±SD).

Why Argos-tools?

Advanced methods for studying animal migrations and ranging behaviour using satellite telemetry have led to some a variety of sometimes spectacular discoveries. However, the processing of data from satellite-received telemetry systems like Argos has been difficult because the original data files are in a rather complicated format, which sometimes contain erroneous fixes. Despite the obvious advantages of integrating Geographic Information Systems (GIS) with animal movement studies, until now there has been no commercially available software that has built-in filters that specifically sort out the dubious fixes in the Argos data files. In response to this integration gap, we developed software that integrates one of the most commonly used GIS programs (ArcView GIS) with a collection of Argos data analysis tools. The application is an extension for ArcView GIS and requires a running version of version 3.x of the program. For the first time, trouble-free importing

and basic analyses of Argos data are incorporated in one program within a GIS environment. This software eliminates the need to edit and insert Argos data into the GIS manually, and batch processing makes it even more productive when dealing with many Argos data files.

Argos-tools at work

When plotted, unfiltered and unsorted Argos data received by users either on CD or via telnet, will look like Figure 1. These include accurate as well as a variety of false and inaccurate (plausible and implausible) location estimates. Most of the false or inaccurate location estimates comprise so-called alternative locations, or 'solution 2' in Argos terminology, and rejected 'Z-type' locations).

Figure 1. Un-filtered Argos coordinates of several falcons living in Mongolia. *(©Data of the Falcon Research Institute www.falcons.co.uk/falcon/index.htm).*
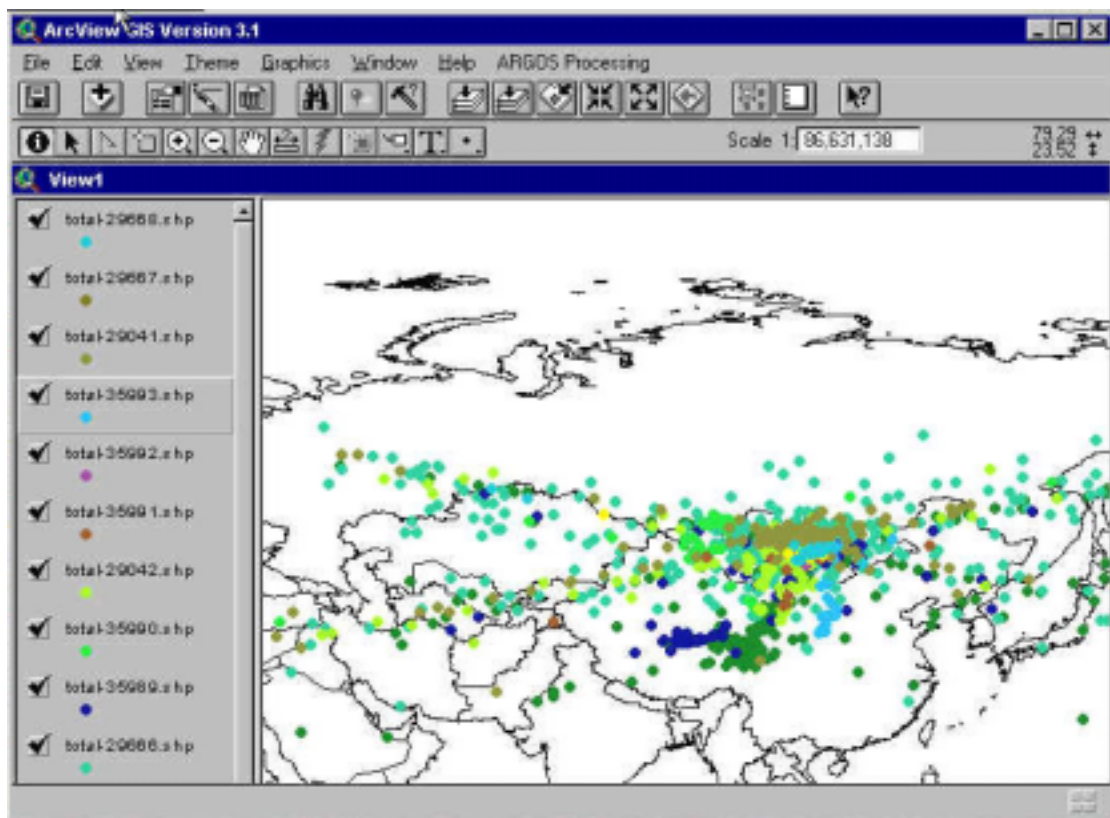
Although Service Argos does filter the data to some extent in calculating which estimates are classified as 'solution 2', this filter does not classify estimates correctly 100% of the time. Within the 'solution 1' category of locations, Service Argos does not attempt to filter estimates of

various qualities or determine whether locations are plausible. Until now users could only either sort the data manually, or use routines within statistical packages or spreadsheet macros to filter data, but these processes were sometimes complicated and laborious. The Argos Tools extension provides an easy way to sort and filter Argos data within the ArcView environment.

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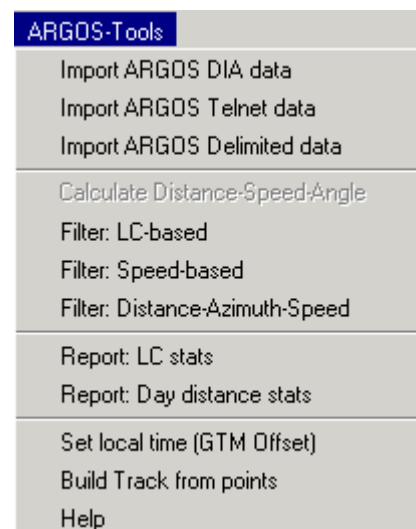- Installation and running
- Importing files
- Filtering
- Reporting

Installation and running

Loading ARGOS-GIS Extension

Place the file "Argos-tools.avx" into ArcView EXT32 folder - (Typically the folder is located at: [Drive]:\esri\AV_GIS30\ARCVIEW\EXT32)

Run ArcViewGIS and in the "File/Extensions" menu, select "Argos-tools" to activate the module. The collection of Argos-Tools functions will now be available through the menu, Argos-GIS (which appears next to the Help menu on the tool bar).

If you downloaded the programme from Spatial-online, just double click on the setup icon.

ARGOS-Tools

Import ARGOS DIA data
Import ARGOS Telnet data
Import ARGOS Delimited data

Calculate Distance-Speed-Angle
Filter: LC-based
Filter: Speed-based
Filter: Distance-Azimuth-Speed

Report: LC stats
Report: Day distance stats

Set local time (GTM Offset)
Build Track from points
Help

Importing files.

When importing Argos data, 'Argos-tools' reads the data, separates them into individual PTT shapefiles, makes a check on the first set (solution 1) and second set (alternative or Solution 2) coordinates, writes the data into a specific directory set as a 'working directory' in Arcview, and displays the data in a view panel. Figure 2 shows the display, which is obviously more plausible than the display of the same, but unfiltered data set in Figure 1.

Figure 2. Argos location estimates from 12 Falcons fitted with PTTs in Mongolia after importing into Arcview using 'Argos-tools extension'. *(©Data of the Falcon Research Institute www.falcons.co.uk/ falcon/index.htm).*
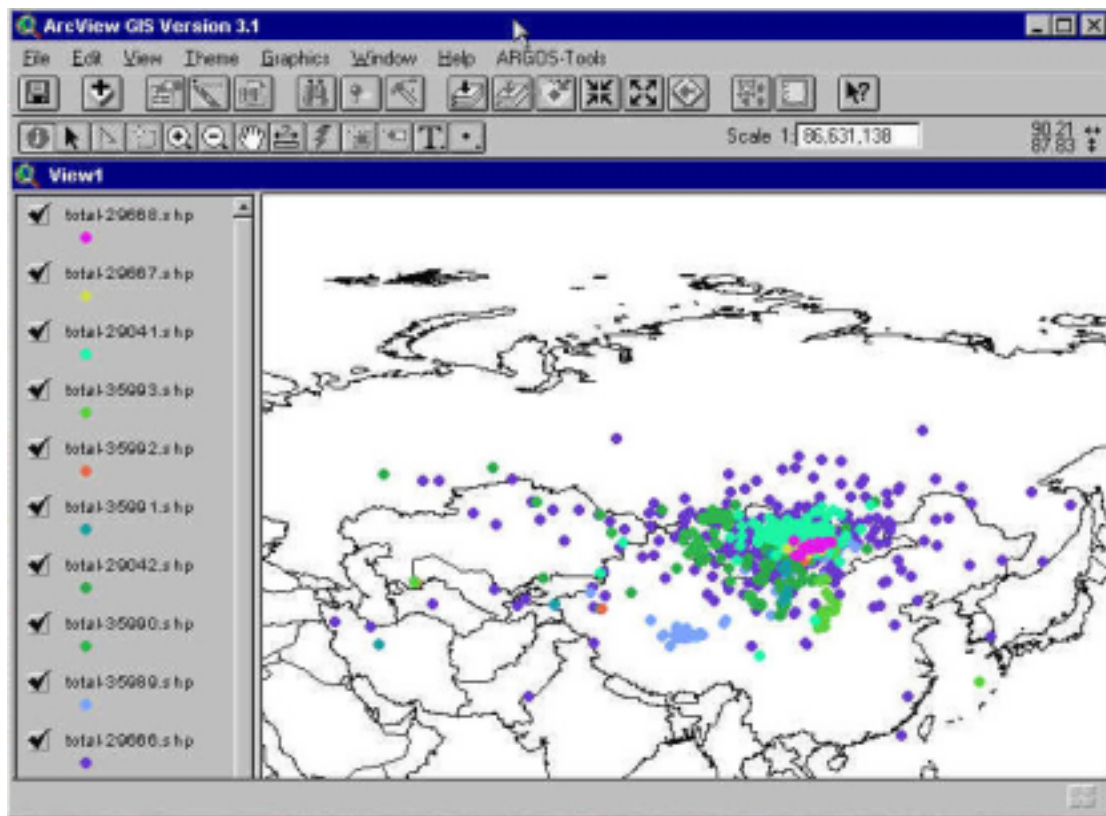

Figure 2 still shows location estimates dispersed over a wide area, and includes some implausible fixes, but at the import stage Argos tools has removed locations estimates that are wrongly assigned to solution 1 class by Argos and substitutes its alternate location estimate.

The Argos-tools module imports the following file formats:

♦ Argos *.dia (diagnostic) format
♦ Argos *.dia (diagnostic) format via e-mail, telnet, or the newly introduced Argos-web service (argosdata.cls.fr).
♦ Delimited format (e.g. exported from Excel).

These files are distributed either by Argos Standard Service (www.cls.fr), or Auxiliary Location Processing in North America ([www.argosinc.com)](www.argosinc.com), or their derivatives.

Before importing the data into Arcview it is recommended that a working directory be established (in an active "View", choose File\Set working directory), where the original Argos files, and all derivative files will be stored. Alternatively you can specify a different working directory to keep the processed files and the original files apart.

Importing from Argos diagnostic format

Select "Import Argos DIA data" from the Argos-tools processing menu then navigate to the location of the Argos *.dia files.

This procedure will import the *.dia files, and separate them into shape files with individual PTT ID numbers. It will save the shape files with the name of the original file and ID number like Total-3509.shp or PTT-322233.shp. You can select more then one *.dia file by pressing the SHIFT button and the Argos-tools will process them as a batch. Every *.dia file create its own shape files set with the name of the file in front.

Example: if you have two files: May02.dia and April02.dia, which contain PTT numbers 09 and 08, the Argos-tools will make May02-PTT09.shp, May02-PTT08.shp, April02-PTT09.shp, April02-PTTT08.shp shape-files.

You can also lump several original *.dia files into one large file in order to cover a longer time (the maximum time covered by Argos files is 1 month) using cut-and-paste functions in say WordPad or NotePad, or append the files in DOS mode. (A file merging procedure will be implemented in one of the future releases of Argos-tools.) The merged file must be saved as 'text only' format with extension *.dia. For this reason we recommend that NotePad or WordPad be used

for merging, and that the resulting file is saved as 'text-only', subsequently changing the extension of the file into *.dia.

Example: if you merge *May02.dia* and *April02.dia* into *total.dia*, Argos tools will create two shape files *total-PTT08.shp* and *total-PTT09.shp* , each containing data spanning 2 months.

Importing Argos diagnostic format via e-mail or telnet

This routine is primarily designed to import data downloaded via telnet, but parts can be used to import data received by e-mail. When you log onto the netdis.cls.fr site use the following string to download your data:

PRV/A,"Number of your programme",TX,date1/time1-date2/time2,PTTnos(coma-separated),e.g.35991,35992

PRV/A,21XX,TX,054/11-063/09,XX989,XX990,35991,XX992

Example: For a download for program number 2134 from the 54th day at 1100 to the 63rd day at 0900 for PTTs 35911, 35912, and 35913, the command would read:

PRV/A, 2134, TX, 054/11—63/09, 35911, 35912, 35913

Do not forget to activate the 'Start logging" panel in your telnet terminal window. It is recommended to save the file in the working directory with the *.txt extension.

It is absolutely imperative to use TX switch, as the alternative DS switch will return the file in the as yet unimplemented DS format.

To open the telnet file click on the "Import Argos telnet data" in the Argos-tools panel and navigate to the location of the telnet file.

As described above, Argos-tools will import the ARGOS telnet file, and separate it into shapefiles for each PTT. It will save the shape files with the original file name and ID number.

Example: if you have two files May02.txt and April02.txt, which contain PTT numbers 09 and 08, the Argos-tools will make May02-PTT09.shp, May02-PTT08.shp, April02-PTT09.shp,

April02-PTTT08.shp shape-files. Essentially this is the same as described above for importing generic *.dia files, but with telnet.e-mail distribution files you will be prompted to enter the year, as the current format of telnet/e-mail distribution files do not contain these.

You can lump several telnet *.txt files into one large file in order to cover a longer time period (by default the Argos telnet connection supplies data for the past week) by using the cut-and-paste functions in say WordPad or NotePad, or appending the files in DOS mode. (A merging procedure will be implemented in one of the future releases of Argos-tools). Do not forget to change extension of the resulting file to *.txt.

Example: if you merge *9-17May02.txt* and *17-23May.txt* (see example above) into *total.txt*, the programme will make *total-PTT08.shp* and *total-PTT09.shp* files with all which were contained in the two original files.

You can select to import more then one *.txt file at a time by pressing SHIFT button and the software will process them all.

The import procedure will ignore any command lines or the spurious text characters left in the log file (e.g. "/argos ready").

When downloading files from Argos web distribution simply save the file in TX format as a text file onto your computer. Remember that in the default settings the web downloaded files will not have alternative (solution 2) coordinates.

Files in delimited format.

Argos-tools can read comma delimited format (*.csv) files created in spreadsheet programs like Excel. Although the file extension .csv means "comma-separated values ", in reality the file can be delimited in other ways, because Argos-tools also automatically recognizes semicolon (;), comma (,) and space (" ") delimited files. This facility ensures that files are readable no matter what language-version of Excel is used. It also ensures backward compatibility, because in the past many people have processed their ARGOS data files with various Excel or Word macros, which re-wrote files in Argos original format into Excel spreadsheets. Just rename your delimited file to *.csv for Argos-tools to recognise it.

Spreadsheet created .csv files must have columns containing PTT number(s), Latitude, Longitude, Date and Time. If one of these columns is missing, the import will not work. If the columns containing alternative coordinates are present, they will be incorporated in the resulting file and used in the import filters.

To open a delimited file, click on the "Import Argos delimited data" in the Argos-tools panel and navigate to the location of the file. Several panels will appear that will ask you to indicate how columns should be arranged. At the end of this procedure Argos-Tools will import the *.cvs files, separating it into a set of shapesfiles, one for each PTT ID number. It will save the shapefiles with the original file name and ID number. It will also sort and check for alternative latitude\longitude coordinates and swap them with the primarily coordinates if they are incorrect. Click 'Cancel' in the dialogue box if your file does not have an alternative coordinates (solution 2) column.

Example. If you have a file Eagles01.csv with the data for PTT31, PTT32 on it, the programme will make two shape files Eagles01-PTT31.shp and Eagles01-PTT32.shp.

You can merge several original *.csv files into one large file in order to cover a greater timespan (the original Argos files are supplied for 1 month duration) using the cut-and-paste function in the spreadsheet program. If importing archive data that has been processed by other software (macro), care must be taken because the number of columns established by these procedures varies from macro to macro, and in some extreme cases vital information may be deleted. We therefore encourage the use of original Argos files whenever possible. If the use of Excel files is the only option, check the format of EVERY column by comparing it with the example files supplied with Argos-tools. Special attention should be given to the date and time formats.

Example. If you have several spreadsheets with the names: May01.csv, June01.csv, July01.csv with ID numbers 34, 35, 38 (ID numbers 36 and 37 sent only weak signal with no coordinates, but with some records in the files), you can merge them into one spreadsheet by cutting-and-pasting and naming the resultant file to say Data01.csv. Argos-tools will read the data and will make three shape files Data01-PTT34.shp, Data01-PTT35.shp, Data01-PTT38.shp. You will me notified that PTT36 and PTT37 'are skipped as they are empty'.

Filtering fixes

Due to the nature of the coordinate determination based on the Doppler effect, Argos supplies two sets of the possible location coordinates. One is assumed to be true location, the other is a 'dummy' point which is located at a point on the surface of the Earth that is symmetrical to the true location with respect to the path of the satellite. In some cases these locations are assigned to the wrong category by Argos, with true locations being assigned as solution 2, and their symmetrical, but false partner location being assigned to solution 1. Thus, Argos data files contain a measure of built-in uncertainty with respect to true and alternative locations. In addition, errors resulting from bounced or re-transmitted signals can distort location accuracy.

Although Argos-tools extension solves the problem of solution1 and solution2 problem at the import stage, it also has several plausibility filters, which filter out 'dubious' fixes. These filters function at different levels within the Argos dataset. They can:

♦ filter to check for validity of the alternative location

♦ filter based upon the Argos class (LC class)

♦ filter based upon the plausible ground speed of the PTT

♦ filter based upon user-set threshold values for Distance-Speed and Angle of travel the PTT

In a nut shell, Argos-tools filters out implausible locations on the basis of the likely speed of the animal, likely distance the animal can roam, and on the accuracy class into which the location estimate falls. By applying these filters to the data shown in Figure 2, a more biologically sensible display (Figure 3) results.

Alternative location filter

This filter is built into the import procedure of Argos-tools. As soon as the file is imported, the program performs an alternative location test, and swaps solution 1 with solution 2 locations where appropriate.

Figure 3. Argos location estimates for 10 falcons whose breeding grounds are in Mongolia filtered using 'Argos-tools extension' and using the built-in 'Build track from points' function. *(©Data of the Falcon Research Institute www.falcons.co.uk/falcon/index.htm).*
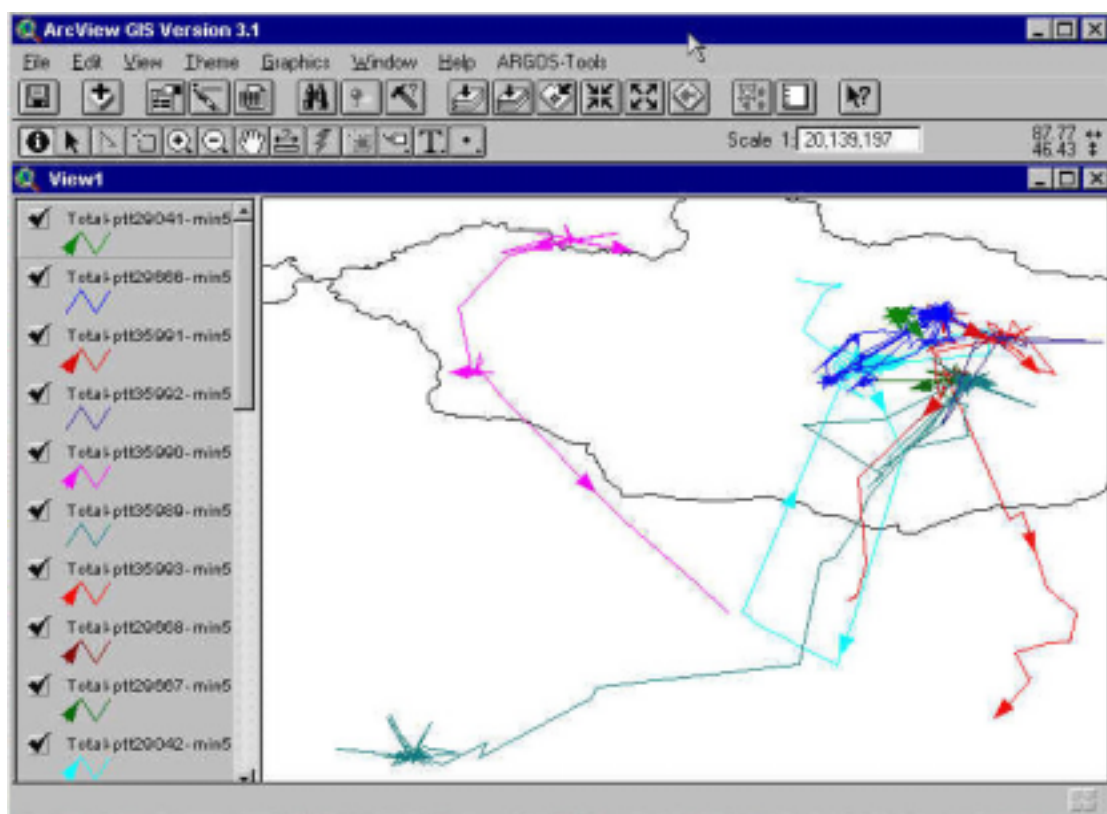
LC-class filter.

This filter simply filters out the locations **BELOW** a user specified class. For example, if the user specifies class 2, all locations with values Z, B, A, 0, 1 will be filtered out. Similarly, if the user specifies class A, all locations with values Z and B classes will be filtered out.

The procedure saves the file as ""name of the original file"-PTT-number-LC-class".shp in the directory set as the "working directory".

Example. If you apply the LC-class filter to a shape file names June-PTT322233.shp and specify the threshold LC 1 the procedure will generate a new shape file called June-PTT322233-LC1.shp.

Speed filter

This filter simply filters out fixes that suggest that the PTT has travelled at a speed above a user-specified threshold. In some instances Argos might provide fixes that are many kilometres apart, but separated by only a few minutes. Such 'movements' could be the result of a bounced signal, and if accepted as valid, sometimes has animals travelling at supersonic speeds. The procedure eliminates one of the points and recalculates the speeds. Only points with the most plausible results will remain in the resulting shape file. The procedure outputs the file: ""name of the original file"-PTT-number-Speed-value".shp in the directory set as the "working directory".

Example. If you apply the Speed filter to a shape file names June-PTT322233.shp and specify the speed threshold as 40 km/hr, the procedure will generate a new shape file called June-PTT322233-Speed40.shp.

Distance-Azimuth-Speed Filter

This filter was developed from logic suggested by Douglas (2000) in an algorithm developed for SAS-run programmes. It requires the user to set values for maximum speed (**MS**), speed coefficient (**SC**) and maximum distance (**MD**).

MD is a maximum distance (km) between consecutive locations. The programme compares a triplet of consecutive locations in chronological order. If any of the three distances between the three fixes are below the user-specified distance (The MD is set based upon knowledge of the species) the programme will keep both start and end points of the triplet. After this assessment, the middle point of the triplet becomes the start point of the next triplet. We have received good results setting MD=20 km for breeding Saker falcons in Mongolia and setting MD=40 for dispersing juveniles Steller's Sea Eagle in NE Siberia.

MS is a maximum speed, which is used to check the plausibility of Argos fixes based on a likely achievable average speed the tagged animal could sustain over a significant period of time. Again the programme compares a triplet of chronologically consecutive fixes, and calculates the speed of movement between the three fixes of the triplet, as well as the angle described by the fixes. The filter queries whether the middle fix of the triplet is plausible. Although marked for omission from display post display calculations, the middle point is used as the first point of the next triplet; the first point (of the first triplet) is assumed to be valid.

Speed coefficient, **SC,** is a tool to evaluate the angle (α) of travel as the animal passes through a triplet of locations, and has a logarithmic influence on the angle-based filtering. Again, considering a triplet of fixes, the middle fix is filtered out if:

♦ the distance between the first point and the middle point is longer than MD or

♦ the angle described by the points with its vortex at the middle point is less than: 25+SC*ln(shortest distance between the middle point and end or start point) (Angle filter *sensu* Douglas 2000).

$$\alpha < 25 + SC \ln(\min(DistA - B, DistB - C))$$

The logic of the filter is that animals that normally do not backtrack (e.g. migrants or non-territorial grazers) are allowed larger angles of travel, than animals that may backtrack ((e.g.centre place foragers or territorial animals).

D. Douglas (2000) suggests SC=15 for birds, and SC=25 for mammals and reptiles. He recommends that highly mobile animals should be assigned smaller SC values. We have had reasonable success in applying SC=10 with Saker falcons in Mongolia.

The procedure outputs the file: ""name of the original file"-PTT-number-Min(speed)XXX-Cut(SC-XXX)-redun(MDxxx)-das".shp in the directory set as the "working directory". So, when parameters of the filter are changed, the resulting shapefile name distinguishes it from other filter generated shapefiles that used different filter parameter.

Additional tools

Report LC stats

This routine calculates a frequency table of location classes for a particular shape file. One can compare the class frequency distribution before and after the application of various filters to judge the effects of the filter on the data being displayed. The procedure

Lc	Frequency	Percent
3	3	13.64
2	3	13.64
1	4	18.18
0	12	54.55
SUM	22	100.00

feb03-29666-lc-stats.dbf

will create a file: "name of imported file" – PTTnumber-LC-stat.dbf in the folder set as the working directory, and will also import this table into the ArcView project. It is possible subsequently to open this table in say, Excel, and compile LC-stat tables for comparison.

Report Day Distance stats

This procedure calculates a parameter that is known as Minimum Distance Moved, i.e. consecutive sum of distances travelled per day. In the procedure the user is asked to specify the time zone (GMT + offset) in order to have proper estimates for days. Zero offset leaves the parameter to be calculated in the default Argos days, which work in GMT time, thus making wrong assumptions about of day and night times in zones other than GMT. You can leave the GMT offset as 0 (default), in this case all calculated statistics will be assigned to GMT calendar. In any case the resulting file contain both GMT and local time columns.

The procedure creates a table file: "name of imported file" – PTTnumber-Daydist-stat.dbf in the folder set as the working directory, and will import the table into the Arcview project. It subsequently allows one to open the table in Excel, for example, and calculate sum distances for particular days, weeks, seasons etc.

Set local time (GMT offset)

This allows users to assign their local time to a particular shape file. The procedure recalculates time and date in the shape file. Do not apply this function more than once, as it may result in incorrect time and date values. Also ensure that after applying the offset you examine for accuracy the local time and date in the info function of Arcview.

Build track from points

This function allows you to create a track from points in the shape files created and processed by filters of Argos-tools. The procedure addresses the resulting track to the view with the same name as the original file with addition of 'track' at the end and writes the file into the 'working directory'. Figure 3 demonstrates tracks generated by this procedure. This function will not work on the shapefile created by other modules/extensions.

Example. If you have a shapefile *June-PTT99-LC2.shp* the 'Build track from points' command will generate file named *June-PTT99-LC2-track.shp* and will add it to the view.

Compatibility issues and known problems

It is also important to say that all resulting shape files can be used for subsequent analysis using a wide selection of ArcView GIS analysis tools, including the Animal Movement 2x (http://www.absc.usgs.gov/glba/gistools/animal_mvmt.htm) or Home Range Analysis (http://www.blueskytelemetry.com/hre.asp) extensions.

In some computers with slower processors, you may occasionally receive a 'segment violation' warning. Press 'OK' and continue to work, as this message probably results from slow over-write speed of the files generated by 'Argos-tools'.

Bugs report

Note that Argos-tools is a developing programme. We will be happy to receive feedback from you. Please report any bugs and irregularities to the authors: Maxim Dubinin and Eugene Potapov on e-mail: argos-gis@biodiversity.ru. Also check the latest news, manuals and updates of the programme at: http://gis-lab.narod.ru/programs/argos/.

IMPORTANT NOTE: We have done extensive testing of data sets available to us at the moment. However, due to the complexity of Argos files and the size of this application there will be bugs that we have missed or that only appear in some data sets. Be aware that there are substantial differences in the values filtered out by some authors and other filtering protocols. Please send detailed descriptions of any problems and, if possible the data sets with which they were associated to the authors. We will try to fix them when time permits. Satellite data processing procedure dictates that any program be thoroughly tested with non-critical data before relying on it. The user must assume the entire risk of using the program. Parts of the code were modified from work by ESRI and other Avenue programmers or translated from other programming languages. Many functions are implementations of algorithms from the published scientific literature. See bibliography and documentation in code.

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