

Package Usage

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Introduction

This document demonstrate the usage of package functions in analysis. Since most of the functions are parts of a workflow, it's better to explain them together than giving separate code examples in function help.

First we load the libraries and prepare the data. Note a sample was generated so that the model fitting process can finish in seconds instead of minutes.

```
library(ctmm)
library(ctmmweb)
data(buffalo)
# take a 100 point sample from each animal to speed up model fitting etc
data_sample <- sample_tele_list (../reference/sample_tele_list.html) (buffalo, 100)
```

Basic data structure

To plot multiple animals location with ggplot2, we need to merge all location data into a single data.frame. merge_tele will merge ctmm telemetry object into a list of location data.table and information data.table. data.table is compatible with data.frame but has much better performance.

```
# basic data structure
merged_data <- merge_tele (../reference/merge_tele.html) (buffalo)
# a list of locations data.table/data.frame and information table
dt <- merged_data$data
info <- merged_data$info
```

In dt :

- identity are animal names
- id are animal names as a factor. We will need this when we want to maintain the level information.

```
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (head(dt))
```

timestamp	longitude	latitude	t	x	y	identity	row_name	id	row_no
2005-07-14 05:35:00	31.88776	-24.96738	1121319300	35215.76	836.7338	Cilla	4109	Cilla	1
2005-07-14 07:35:00	31.85942	-24.94288	1121326500	32127.59	-1629.8224	Cilla	4110	Cilla	2
2005-07-14 08:34:00	31.85512	-24.94914	1121330040	32759.68	-2153.6281	Cilla	4111	Cilla	3
2005-07-14 09:35:00	31.85694	-24.95424	1121333700	33347.02	-2048.1883	Cilla	4112	Cilla	4
2005-07-14 10:35:00	31.85977	-24.94735	1121337300	32625.39	-1661.8450	Cilla	4113	Cilla	5
2005-07-14 11:34:00	31.84466	-24.93435	1121340840	30986.23	-2978.3344	Cilla	4114	Cilla	6

You can calculate distance and speed outliers on dt :

```
# distance_center column is added
dt_distance <- calculate_distance (../reference/calculate_distance.html) (dt)
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (head(dt_distance))
```

timestamp	longitude	latitude	t	x	y	identity	row_name	id	row_no	inc_x	inc_y	inc_t	gr
2005-07-14 05:35:00	31.88776	-24.96738	1121319300	35215.76	836.7338	Cilla	4109	Cilla	1	-3088.16863	-2466.55624	7200	Ci

timestamp	longitude	latitude	t	x	y	identity	row_name	id	row_no	inc_x	inc_y	inc_t	gr
2005-07-14 07:35:00	31.85942	-24.94288	1121326500	32127.59	-1629.8224	Cilla	4110	Cilla	2	632.09224	-523.80571	3540	Ci
2005-07-14 08:34:00	31.85512	-24.94914	1121330040	32759.68	-2153.6281	Cilla	4111	Cilla	3	587.33596	105.43981	3660	Ci
2005-07-14 09:35:00	31.85694	-24.95424	1121333700	33347.02	-2048.1883	Cilla	4112	Cilla	4	-721.62814	386.34329	3600	Ci
2005-07-14 10:35:00	31.85977	-24.94735	1121337300	32625.39	-1661.8450	Cilla	4113	Cilla	5	-1639.16106	-1316.48941	3540	Ci
2005-07-14 11:34:00	31.84466	-24.93435	1121340840	30986.23	-2978.3344	Cilla	4114	Cilla	6	-46.20168	-50.72027	3660	Ci

```
# always calculate distance first then calculate speed outlier with distance columns added
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (head(calculate_speed
(../reference/calculate_speed.html) (dt_distance)))
```

timestamp	longitude	latitude	t	x	y	identity	row_name	id	row_no	inc_x	inc_y	inc_t	gr
2005-07-14 05:35:00	31.88776	-24.96738	1121319300	35215.76	836.7338	Cilla	4109	Cilla	1	-3088.16863	-2466.55624	7200	Ci
2005-07-14 07:35:00	31.85942	-24.94288	1121326500	32127.59	-1629.8224	Cilla	4110	Cilla	2	632.09224	-523.80571	3540	Ci
2005-07-14 08:34:00	31.85512	-24.94914	1121330040	32759.68	-2153.6281	Cilla	4111	Cilla	3	587.33596	105.43981	3660	Ci
2005-07-14 09:35:00	31.85694	-24.95424	1121333700	33347.02	-2048.1883	Cilla	4112	Cilla	4	-721.62814	386.34329	3600	Ci
2005-07-14 10:35:00	31.85977	-24.94735	1121337300	32625.39	-1661.8450	Cilla	4113	Cilla	5	-1639.16106	-1316.48941	3540	Ci
2005-07-14 11:34:00	31.84466	-24.93435	1121340840	30986.23	-2978.3344	Cilla	4114	Cilla	6	-46.20168	-50.72027	3660	Ci

```
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (info)
```

identity	interval_s	interval	duration_s	duration	sampling_start	sampling_end	start	end	points
Cilla	3600	60 minutes	12674460	5 months	2005-07-14 05:35:00	2005-12-07 22:16:00	2005-07-14 05:35	2005-12-07 22:16	3527
Gabs	3600	60 minutes	7163340	2.8 months	2005-04-05 05:56:00	2005-06-27 03:45:00	2005-04-05 05:56	2005-06-27 03:45	1996
Mvubu	3600	60 minutes	9208020	3.6 months	2005-07-15 05:02:00	2005-10-29 18:49:00	2005-07-15 05:02	2005-10-29 18:49	2572
Pepper	7200	2 hours	21633900	8.5 months	2006-04-25 05:09:00	2006-12-31 14:34:00	2006-04-25 05:09	2006-12-31 14:34	1725
Queen	3600	60 minutes	9067080	3.6 months	2005-02-17 05:05:00	2005-06-02 03:43:00	2005-02-17 05:05	2005-06-02 03:43	1756
Toni	3600	60 minutes	20968440	8.2 months	2005-08-23 06:35:00	2006-04-22 23:09:00	2005-08-23 06:35	2006-04-22 23:09	5766



In app we can select a subset of full data by selecting rows in the data summary table 4.

1. Individuals

Time in Seconds ? Help

Show entries Search:

	identity	start	end	interval	duration	points
1	Cilla	2005-07-14 05:35	2005-12-07 22:16	60 minutes	5 months	3527
2	Gabs	2005-04-05 05:56	2005-06-27 03:45	60 minutes	2.8 months	1996
3	Mvubu	2005-07-15 05:02	2005-10-29 18:49	60 minutes	3.6 months	2572
4	Pepper	2006-04-25 05:09	2006-12-31 14:34	2 hours	8.5 months	1725
5	Queen	2005-02-17 05:05	2005-06-02 03:43	60 minutes	3.6 months	1756
6	Toni	2005-08-23 06:35	2006-04-22 23:09	60 minutes	8.2 months	5766

Showing 1 to 6 of 6 entries Previous Next

To select a subset in script, we can select animal names for `identity` column or numbers for `id` factor column in `dt` with `data.table` syntax. `data.table` is also `data.frame` so you can use `data.frame` syntax too.

It's suggested to always select a subset from full data like this, because the subset will carry the `id` column which still hold all animal names in levels, then a consistent color mapping can be maintained (otherwise `ggplot` will always draw first animal in same color).



```

# select by identity column
dt_sub1 <- dt[identity %in% c("Gabs", "Queen")]
# select by id factor column value
dt[as.numeric(id) %in% c(1, 3)]
#>
  timestamp longitude latitude t x
#> 1: 2005-07-14 05:35:00 31.88776 -24.96738 1121319300 35215.76
#> 2: 2005-07-14 07:35:00 31.85942 -24.94288 1121326500 32127.59
#> 3: 2005-07-14 08:34:00 31.85512 -24.94914 1121330040 32759.68
#> 4: 2005-07-14 09:35:00 31.85694 -24.95424 1121333700 33347.02
#> 5: 2005-07-14 10:35:00 31.85977 -24.94735 1121337300 32625.39
#> ---
#> 6095: 2005-10-29 14:49:00 31.91272 -24.95795 1130597340 34515.66
#> 6096: 2005-10-29 15:49:00 31.91805 -24.95593 1130600940 34365.50
#> 6097: 2005-10-29 16:49:00 31.92247 -24.95555 1130604540 34383.81
#> 6098: 2005-10-29 17:49:00 31.92560 -24.95899 1130608140 34805.98
#> 6099: 2005-10-29 18:49:00 31.92659 -24.96000 1130611740 34930.80
#>
  y identity row_name id row_no inc_x inc_y
#> 1: 836.7338 Cilla 4109 Cilla 1 -3088.16863 -2466.55624
#> 2: -1629.8224 Cilla 4110 Cilla 2 632.09224 -523.80571
#> 3: -2153.6281 Cilla 4111 Cilla 3 587.33596 105.43981
#> 4: -2048.1883 Cilla 4112 Cilla 4 -721.62814 386.34329
#> 5: -1661.8450 Cilla 4113 Cilla 5 -1639.16106 -1316.48941
#> ---
#> 6095: 3474.2789 Mvubu 11148 Mvubu 8091 -150.15422 563.42090
#> 6096: 4037.6998 Mvubu 11150 Mvubu 8092 18.30518 447.61830
#> 6097: 4485.3181 Mvubu 11151 Mvubu 8093 422.17554 261.34066
#> 6098: 4746.6588 Mvubu 11152 Mvubu 8094 124.81949 83.89143
#> 6099: 4830.5502 Mvubu 11154 Mvubu 8095 NA NA
#>
  inc_t group_index median_x median_y distance_center speed
#> 1: 7200 Cilla_0 41637.19 171.4182 6455.809 0.54893708
#> 2: 3540 Cilla_0 41637.19 171.4182 9678.689 0.23190999
#> 3: 3660 Cilla_0 41637.19 171.4182 9176.930 0.16304700
#> 4: 3600 Cilla_0 41637.19 171.4182 8582.171 0.16304700
#> 5: 3540 Cilla_0 41637.19 171.4182 9196.382 0.59392053
#> ---
#> 6095: 3600 Mvubu_0 40443.01 377.6464 6687.504 0.21987205
#> 6096: 3600 Mvubu_0 40443.01 377.6464 7094.516 0.12444811
#> 6097: 3600 Mvubu_0 40443.01 377.6464 7320.312 0.13792833
#> 6098: 3600 Mvubu_0 40443.01 377.6464 7131.928 0.04177742
#> 6099: NA Mvubu_0 40443.01 377.6464 7086.102 0.04177742

```

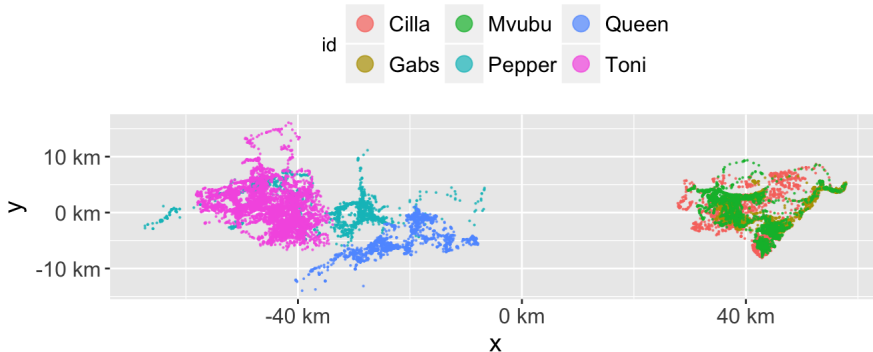
Visualization

You can reproduce most of the plots in [Visualization](#) page with [functions](#).

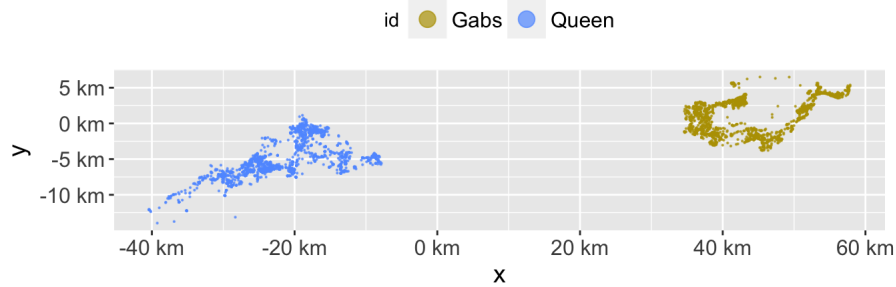
```

# plot animal locations
plot_loc (../reference/plot_loc.html) (dt)

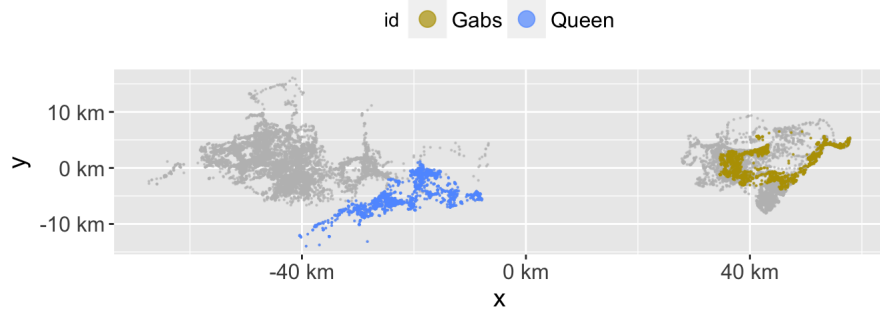
```



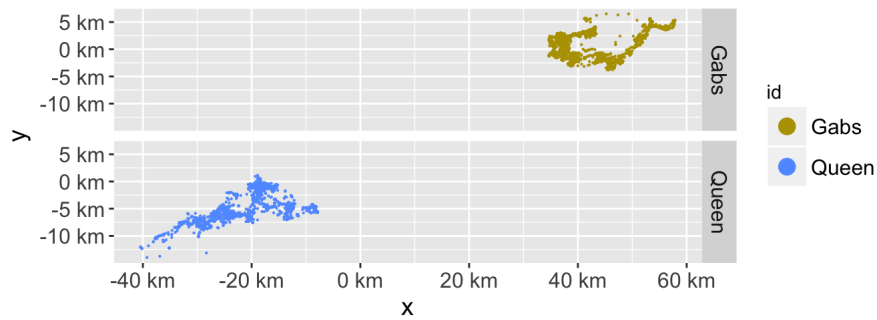
```
# plot a subset only. Note the color mapping is consistent because dt_sub1 id column hold all animal names in levels.
plot_loc (../reference/plot_loc.html) (dt_sub1)
```



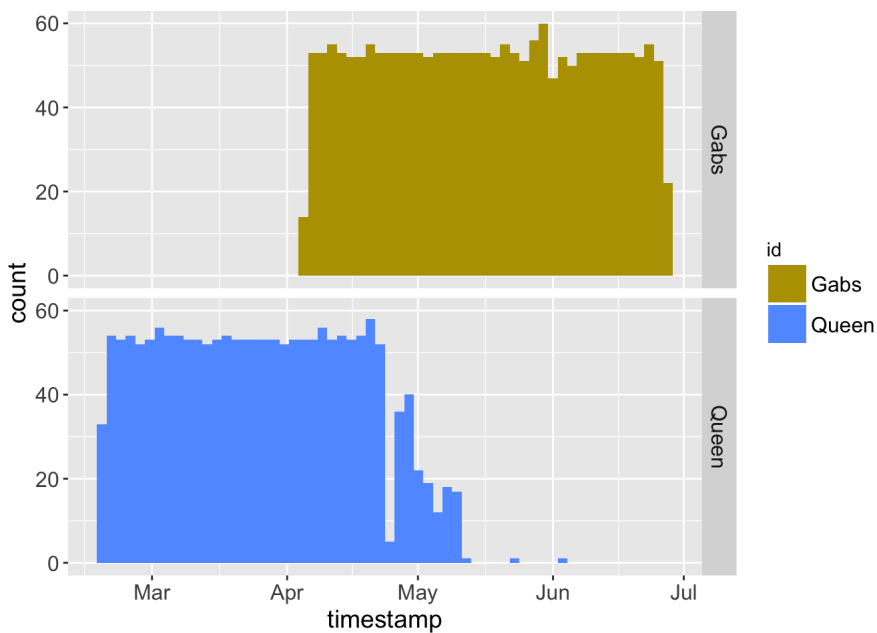
```
# with subset and full data set both provided, subset will be drawn with full data as background.
plot_loc (../reference/plot_loc.html) (dt_sub1, dt)
```



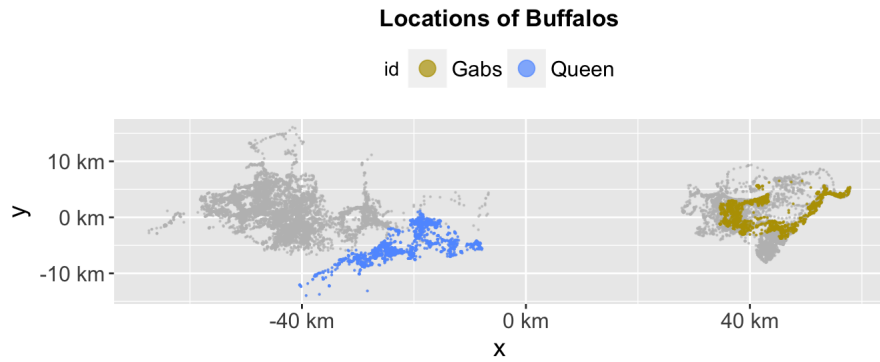
```
# location in facet
plot_loc_facet (../reference/plot_loc_facet.html) (dt_sub1)
```



```
# sampling time
plot_time (../reference/plot_time.html) (dt_sub1)
```



```
# take the ggplot2 object to further customize it
plot_loc (../reference/plot_loc.html) (dt_sub1, dt) +
  ggplot2::ggtitle (http://www.rdocumentation.org/packages/ggplot2/topics/labs) ("Locations of Buffalos") +
  # override the default left alignment of title and make it bigger
  ctmweb:::CENTER_TITLE
```



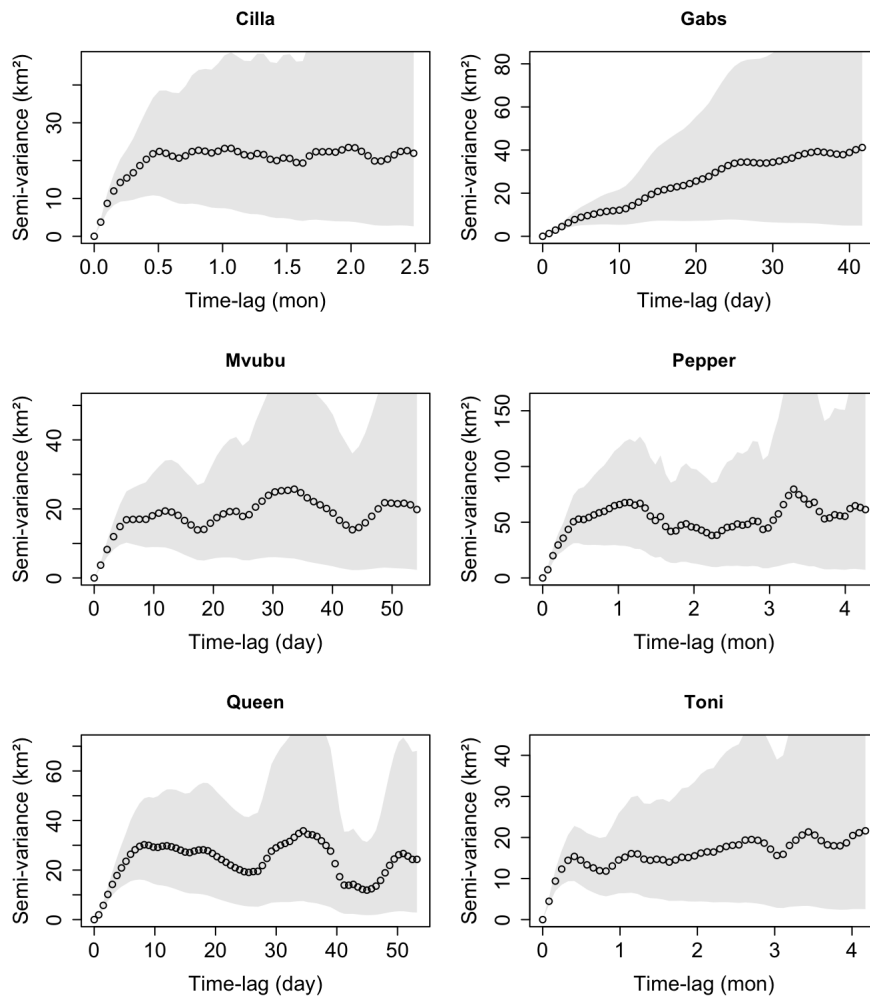
```
# export plot
g <- plot_loc (../reference/plot_loc.html) (dt_sub1, dt)
ggplot2::ggsave (http://www.rdocumentation.org/packages/ggplot2/topics/ggsave) ("pic/test.png", g)
#> Saving 7 x 5 in image
```

Variogram

We can plot [variograms in various modes](#).

[Empirical variograms based on telemetry data](#)

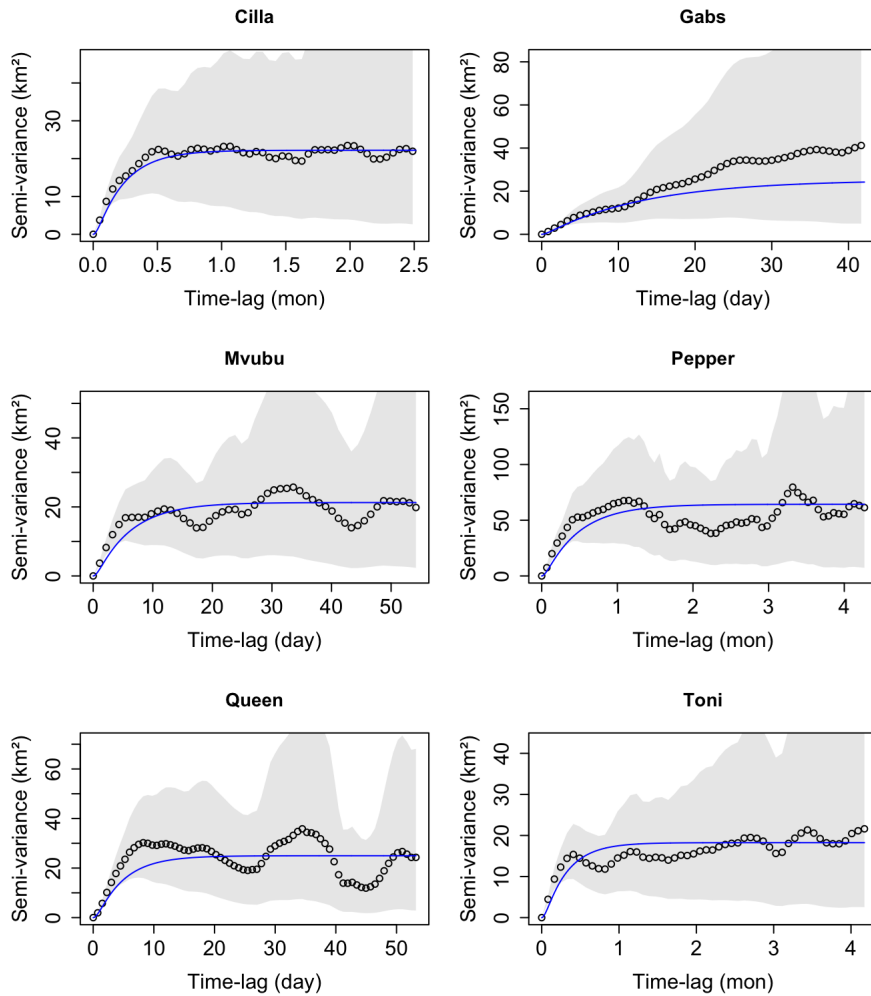
```
vario_list <- lapply(data_sample, ctmweb::variogram)
# names of vario_list are needed for figure titles
names(vario_list) <- names(data_sample)
plot_vario (../reference/plot_vario.html) (vario_list)
```




```
# sometimes the default figure settings doesn't work in some systems, you can clear the plot device then use a smaller title
size
# dev.off()
# plot_vario(vario_list, cex = 0.55)
```

Variogram of guesstimated models from `ctmm::ctmm.guess` (<http://www.rdocumentation.org/packages/ctmm/topics/variogram.fit>) on telemetry data.

```
guess_list <- lapply(data_sample,
  function(tele)
    ctmm::ctmm.guess (http://www.rdocumentation.org/packages/ctmm/topics/variogram.fit) (tele, interactive
= FALSE))
plot_vario (../reference/plot_vario.html) (vario_list, guess_list)
```

Model summary table

Fit models on data in para 

```
# fit models in parallel.
model_fit_res <- par_fit_tele (../reference/par_fit_tele.html) (data_sample)
#> running parallel with mclapply in cluster of 6
#> user system elapsed
#> 17.230 0.577 5.192
# a data.table of models information summary
model_summary_dt <- summary_model_fit (../reference/summary_model_fit.html) (model_fit_res)
# you can also open it with RStudio's data.frame viewer
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (model_summary_dt)
```

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	NA	NA	CI low	259 km²	2.8 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	16.348	31.361	ML	380 km²	4.7 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	NA	NA	CI high	524 km²	8.0 days		
2	Cilla	OUF anisotropic	Cilla - OUF anisotropic	2.241	NA	NA	CI low	260 km²	2.1 days	0.000 hours	0.0 km/day
2	Cilla	OUF anisotropic	Cilla - OUF anisotropic	2.241	16.641	31.737	ML	380 km²	4.6 days	0.945 hours	16.0 km/day

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
2	Cilla	OUF anisotropic	Cilla - OUF anisotropic	2.241	NA	NA	CI high	523 km ²	10.2 days	13.658 hours	60.2 km/day
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	NA	NA	CI low	163 km ²	3.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	5.532	9.749	ML	344 km ²	9.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	NA	NA	CI high	591 km ²	27.0 days		
4	Gabs	OUF anisotropic	Gabs - OUF anisotropic	2.262	NA	NA	CI low	163 km ²	3.1 days	0.000 hours	0.0 km/day
4	Gabs	OUF anisotropic	Gabs - OUF anisotropic	2.262	5.533	9.755	ML	344 km ²	9.1 days	0.000 hours	6,527.0 km/day
4	Gabs	OUF anisotropic	Gabs - OUF anisotropic	2.262	NA	NA	CI high	591 km ²	26.9 days	0.044 hours	870,828.0 km/day
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	NA	NA	CI low	238 km ²	2.3 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	13.642	24.798	ML	369 km ²	4.2 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	NA	NA	CI high	528 km ²	7.6 days		
6	Mvubu	OUF anisotropic	Mvubu - OUF anisotropic	0.605	NA	NA	CI low	245 km ²	1.5 days	0.000 hours	4.3 km/day
6	Mvubu	OUF anisotropic	Mvubu - OUF anisotropic	0.605	15.802	27.536	ML	370 km ²	3.4 days	4.930 hours	8.2 km/day
6	Mvubu	OUF anisotropic	Mvubu - OUF anisotropic	0.605	NA	NA	CI high	520 km ²	7.4 days	11.274 hours	12.0 km/day
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0.000	NA	NA	CI low	433 km ²	3.1 days	6.274 hours	4.4 km/day
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0.000	18.953	29.749	ML	643 km ²	6.1 days	12.350 hours	5.3 km/day
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0.000	NA	NA	CI high	894 km ²	12.1 days	24.309 hours	6.2 km/day
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	NA	NA	CI low	163 km ²	2.3 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	10.982	19.733	ML	268 km ²	4.5 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	NA	NA	CI high	399 km ²	8.7 days		
9	Queen	OUF anisotropic	Queen - OUF anisotropic	0.324	NA	NA	CI low	170 km ²	1.9 days	0.000 hours	4.4 km/day
9	Queen	OUF anisotropic	Queen - OUF anisotropic	0.324	12.104	20.852	ML	276 km ²	3.9 days	2.973 hours	8.7 km/day
9	Queen	OUF anisotropic	Queen - OUF anisotropic	0.324	NA	NA	CI high	406 km ²	8.0 days	6.612 hours	13.1 km/day
10	Toni	OU isotropic	Toni - OU isotropic	0.000	NA	NA	CI low	246 km ²	3.5 days		
10	Toni	OU isotropic	Toni - OU isotropic	0.000	21.862	40.212	ML	344 km ²	5.7 days		

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
10	Toni	OU isotropic	Toni - OU isotropic	0.000	NA	NA	CI high	458 km ²	9.3 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	NA	NA	CI low	233 km ²	3.3 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	23.030	40.472	ML	326 km ²	5.4 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	NA	NA	CI high	433 km ²	8.9 days		
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	NA	NA	CI low	237 km ²	1.4 days	0.000 hours	2.3 km/day
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	27.429	44.527	ML	325 km ²	3.9 days	15.154 hours	3.8 km/day
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	NA	NA	CI high	427 km ²	10.9 days	34.337 hours	5.2 km/day
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	NA	NA	CI low	250 km ²	1.8 days	0.000 hours	2.0 km/day
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	25.205	43.701	ML	344 km ²	4.5 days	12.441 hours	4.0 km/day
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	NA	NA	CI high	453 km ²	10.8 days	30.751 hours	6.0 km/day

There could be multiple models fitted for each animal if they are **update candidates**. In the app you can select a subset of models then check their variograms, home ranges and occurrences. **You will also need to select a subset of models in R script.**

model_fit_res hold every model for same animal under a list item of animal name.

- model_fit_res list [6] List of length 6
- Cilla list [2] List of length 2
 - OU anisotropic list [18] (ctmm::ctmm) List of length 18
 - OUF anisotropic list [18] (ctmm::ctmm) List of length 18
 - Gabs list [2] List of length 2
 - OU anisotropic list [18] (ctmm::ctmm) List of length 18
 - OUF anisotropic list [18] (ctmm::ctmm) List of length 18
 - Mvubu list [2] List of length 2
 - OU anisotropic list [18] (ctmm::ctmm) List of length 18
 - OUF anisotropic list [18] (ctmm::ctmm) List of length 18
 - Pepper list [1] List of length 1
 - OUF anisotropic list [18] (ctmm::ctmm) List of length 18
 - Queen list [2] List of length 2
 - OU anisotropic list [18] (ctmm::ctmm) List of length 18
 - OUF anisotropic list [18] (ctmm::ctmm) List of length 18
 - Toni list [4] List of length 4
 - OU isotropic list [18] (ctmm::ctmm) List of length 18
 - OU anisotropic list [18] (ctmm::ctmm) List of length 18
 - OUF anisotropic list [18] (ctmm::ctmm) List of length 18
 - OUF isotropic list [18] (ctmm::ctmm) List of length 18

We need to convert it into a flat list to make the selection easier.

```
# the nested structure of model fit result
names(model_fit_res)
#> [1] "Cilla" "Gabs" "Mvubu" "Pepper" "Queen" "Toni"
names(model_fit_res[[1]])
#> [1] "OU anisotropic" "OUF anisotropic"
# convert to a flat list
model_list <- list_model_fit (../reference/list_model_fit.html)(model_fit_res)
names(model_list)
#> [1] "Cilla - OU anisotropic" "Cilla - OUF anisotropic"
#> [3] "Gabs - OU anisotropic" "Gabs - OUF anisotropic"
#> [5] "Mvubu - OU anisotropic" "Mvubu - OUF anisotropic"
#> [7] "Pepper - OUF anisotropic" "Queen - OU anisotropic"
#> [9] "Queen - OUF anisotropic" "Toni - OU isotropic"
#> [11] "Toni - OU anisotropic" "Toni - OUF anisotropic"
#> [13] "Toni - OUF isotropic"
```

Then we can find the model names in model summary table by `model_no` or `model_type`. The code here is in `data.table` syntax, but you can use the table as `data.frame` if you want.

```
# select subset in model summary table by model_no
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable)(model_summary_dt[model_no %in% c(1, 3, 10, 11, 12, 13)])
```

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	NA	NA	CI low	259 km ²	2.8 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	16.348	31.361	ML	380 km ²	4.7 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	NA	NA	CI high	524 km ²	8.0 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	NA	NA	CI low	163 km ²	3.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	5.532	9.749	ML	344 km ²	9.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	NA	NA	CI high	591 km ²	27.0 days		
10	Toni	OU isotropic	Toni - OU isotropic	0.000	NA	NA	CI low	246 km ²	3.5 days		
10	Toni	OU isotropic	Toni - OU isotropic	0.000	21.862	40.212	ML	344 km ²	5.7 days		
10	Toni	OU isotropic	Toni - OU isotropic	0.000	NA	NA	CI high	458 km ²	9.3 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	NA	NA	CI low	233 km ²	3.3 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	23.030	40.472	ML	326 km ²	5.4 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	NA	NA	CI high	433 km ²	8.9 days		
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	NA	NA	CI low	237 km ²	1.4 days	0.000 hours	2.3 km/day
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	27.429	44.527	ML	325 km ²	3.9 days	15.154 hours	3.8 km/day
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	NA	NA	CI high	427 km ²	10.9 days	34.337 hours	5.2 km/day
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	NA	NA	CI low	250 km ²	1.8 days	0.000 hours	2.0 km/day

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	25.205	43.701	ML	344 km ²	4.5 days	12.441 hours	4.0 km/day
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	NA	NA	CI high	453 km ²	10.8 days	30.751 hours	6.0 km/day

```
# select by model type
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (model_summary_dt[model_type == "OU anisotropic"])
```

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	NA	NA	CI low	259 km ²	2.8 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	16.348	31.361	ML	380 km ²	4.7 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	NA	NA	CI high	524 km ²	8.0 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	NA	NA	CI low	163 km ²	3.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	5.532	9.749	ML	344 km ²	9.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	NA	NA	CI high	591 km ²	27.0 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	NA	NA	CI low	238 km ²	2.3 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	13.642	24.798	ML	369 km ²	4.2 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	NA	NA	CI high	528 km ²	7.6 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	NA	NA	CI low	163 km ²	2.3 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	10.982	19.733	ML	268 km ²	4.5 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	NA	NA	CI high	399 km ²	8.7 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	NA	NA	CI low	233 km ²	3.3 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	23.030	40.472	ML	326 km ²	5.4 days		
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	NA	NA	CI high	433 km ²	8.9 days		

```
# select first(best) model for each animal using the smallest AICc value
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (model_summary_dt[dAICc == 0])
```

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0	NA	NA	CI low	259 km ²	2.8 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0	16.348	31.361	ML	380 km ²	4.7 days		
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0	NA	NA	CI high	524 km ²	8.0 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0	NA	NA	CI low	163 km ²	3.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0	5.532	9.749	ML	344 km ²	9.1 days		
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0	NA	NA	CI high	591 km ²	27.0 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0	NA	NA	CI low	238 km ²	2.3 days		

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0	13.642	24.798	ML	369 km ²	4.2 days		
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0	NA	NA	CI high	528 km ²	7.6 days		
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0	NA	NA	CI low	433 km ²	3.1 days	6.274 hours	4.4 km/day
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0	18.953	29.749	ML	643 km ²	6.1 days	12.350 hours	5.3 km/day
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0	NA	NA	CI high	894 km ²	12.1 days	24.309 hours	6.2 km/day
8	Queen	OU anisotropic	Queen - OU anisotropic	0	NA	NA	CI low	163 km ²	2.3 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0	10.982	19.733	ML	268 km ²	4.5 days		
8	Queen	OU anisotropic	Queen - OU anisotropic	0	NA	NA	CI high	399 km ²	8.7 days		
10	Toni	OU isotropic	Toni - OU isotropic	0	NA	NA	CI low	246 km ²	3.5 days		
10	Toni	OU isotropic	Toni - OU isotropic	0	21.862	40.212	ML	344 km ²	5.7 days		
10	Toni	OU isotropic	Toni - OU isotropic	0	NA	NA	CI high	458 km ²	9.3 days		

```
# Because each model have 3 rows, the `estimate == "ML"` filter can make sure each model only be selected once.
knitr::kable (http://www.rdocumentation.org/packages/knitr/topics/kable) (model_summary_dt[estimate == "ML"])
```

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
1	Cilla	OU anisotropic	Cilla - OU anisotropic	0.000	16.348	31.361	ML	380 km ²	4.7 days		
2	Cilla	OUF anisotropic	Cilla - OUF anisotropic	2.241	16.641	31.737	ML	380 km ²	4.6 days	0.945 hours	16.0 km/day
3	Gabs	OU anisotropic	Gabs - OU anisotropic	0.000	5.532	9.749	ML	344 km ²	9.1 days		
4	Gabs	OUF anisotropic	Gabs - OUF anisotropic	2.262	5.533	9.755	ML	344 km ²	9.1 days	0.000 hours	6,527.0 km/day
5	Mvubu	OU anisotropic	Mvubu - OU anisotropic	0.000	13.642	24.798	ML	369 km ²	4.2 days		
6	Mvubu	OUF anisotropic	Mvubu - OUF anisotropic	0.605	15.802	27.536	ML	370 km ²	3.4 days	4.930 hours	8.2 km/day
7	Pepper	OUF anisotropic	Pepper - OUF anisotropic	0.000	18.953	29.749	ML	643 km ²	6.1 days	12.350 hours	5.3 km/day
8	Queen	OU anisotropic	Queen - OU anisotropic	0.000	10.982	19.733	ML	268 km ²	4.5 days		
9	Queen	OUF anisotropic	Queen - OUF anisotropic	0.324	12.104	20.852	ML	276 km ²	3.9 days	2.973 hours	8.7 km/day
10	Toni	OU isotropic	Toni - OU isotropic	0.000	21.862	40.212	ML	344 km ²	5.7 days		

model_no	identity	model_type	model_name	dAICc	DOF mean	DOF area	estimate	area	tau position	tau velocity	speed
11	Toni	OU anisotropic	Toni - OU anisotropic	0.528	23.030	40.472	ML	326 km ²	5.4 days		
12	Toni	OUF anisotropic	Toni - OUF anisotropic	0.878	27.429	44.527	ML	325 km ²	3.9 days	15.154 hours	3.8 km/day
13	Toni	OUF isotropic	Toni - OUF isotropic	0.904	25.205	43.701	ML	344 km ²	4.5 days	12.441 hours	4.0 km/day

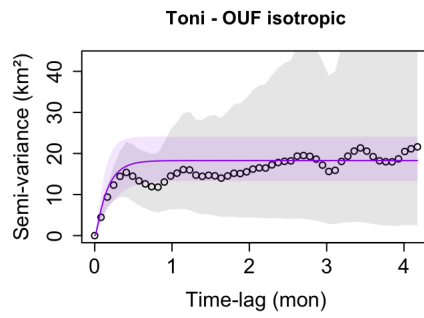
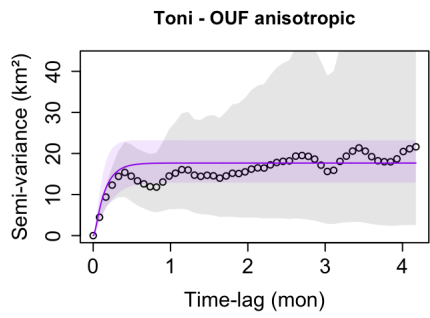
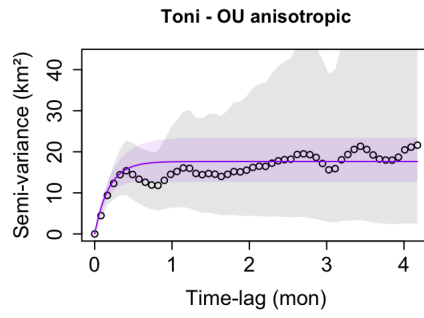
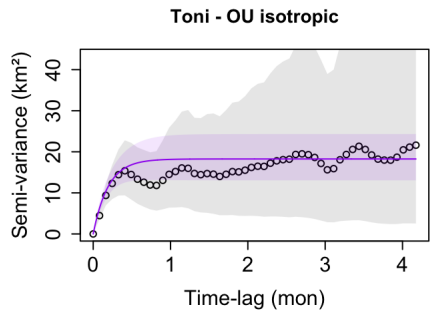
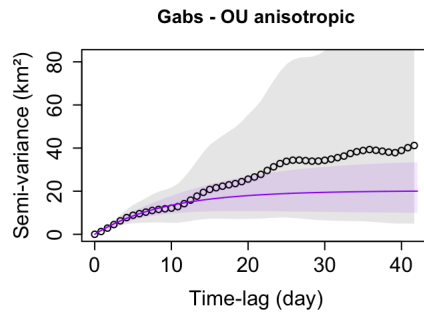
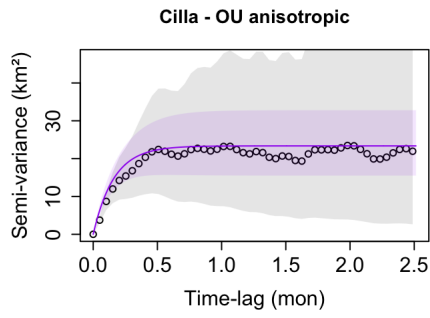
```
# Combine this condition with filter above to select models
# The expression is enclosed with () to enable automatical printing of result. Both model_name and identity are selected in
# same filter. We need the model_name to filter the model list, and the animal name to filter the variograms
(names_sub2 <- model_summary_dt[(estimate == "ML") &
  (model_no %in% c(1, 3, 10, 11, 12, 13)), .(model_name, identity)])
#>
#>   model_name identity
#> 1: Cilla - OU anisotropic   Cilla
#> 2: Gabs - OU anisotropic   Gabs
#> 3: Toni - OU isotropic     Toni
#> 4: Toni - OU anisotropic   Toni
#> 5: Toni - OUF anisotropic   Toni
#> 6: Toni - OUF isotropic     Toni
```

Once you have selected the models in summary table, you can filter the actual models list with model names. Note this is a different subset from `dt_sub1` above.

```
# filter model list by model names to get subset of model list.
model_list_sub2 <- model_list[names_sub2$model_name]
```

Now we can plot variograms with selected models. Note the `vario_list_sub2` need to match with `model_list_sub2` in length and animal, so they are based on same data.

```
# get corresponding variograms by animal names.
vario_list_sub2 <- vario_list[names_sub2$identity]
# specify a different color for model
plot_vario (../reference/plot_vario.html) (vario_list_sub2, model_list_sub2, model_color = "purple")
```



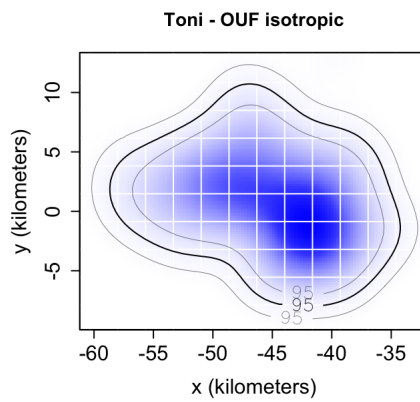
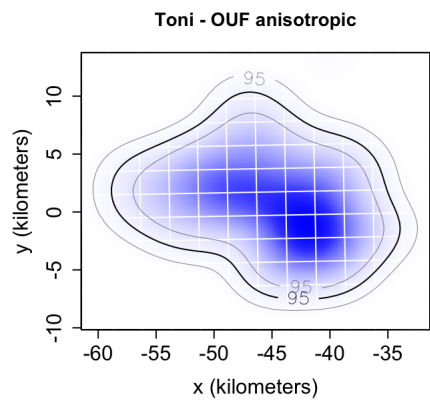
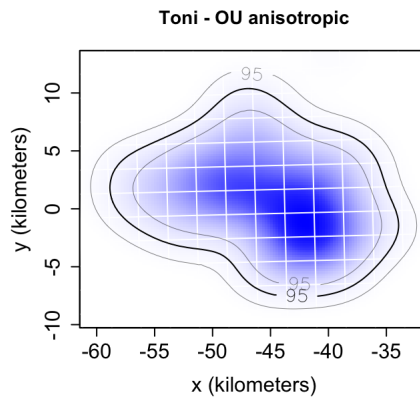
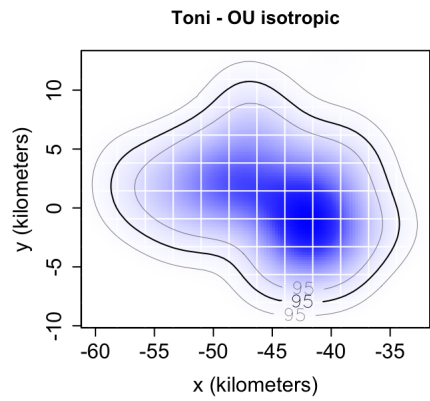
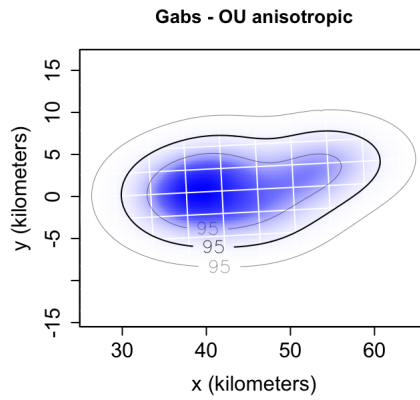
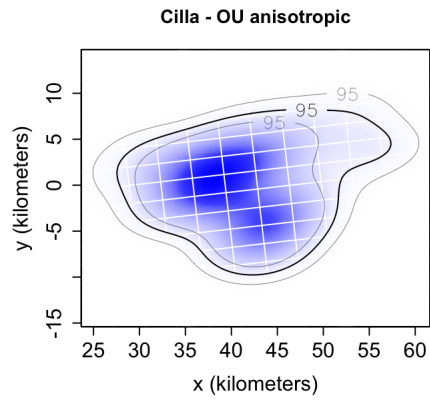
Home range



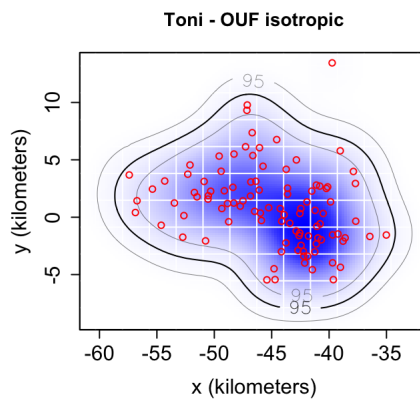
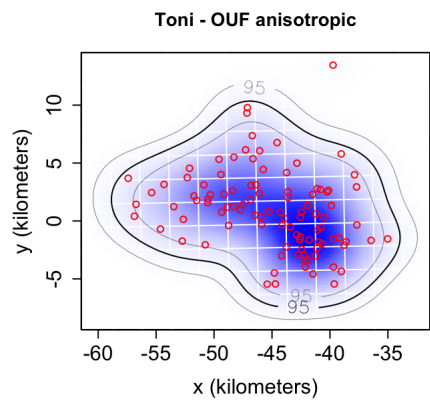
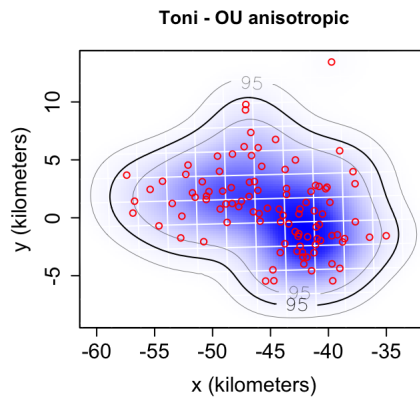
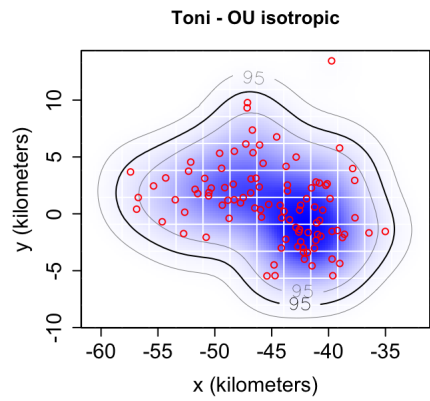
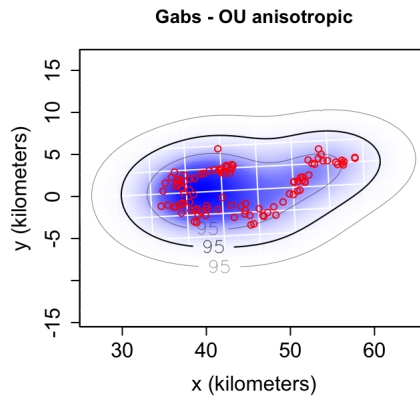
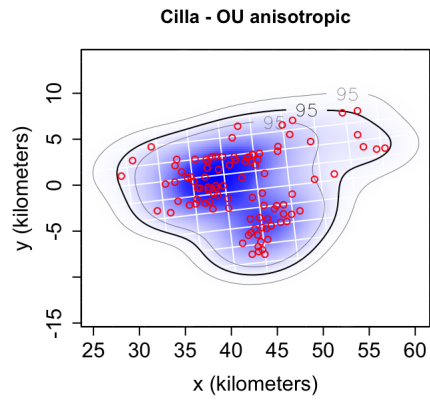

```

# calculate home range with ctm::akde. Note we didn't use parallel here because we want to calculate all animals together to
put them in same grid.
tele_list_sub2 <- data_sample[names_sub2$identity]
hrange_list_sub2 <- akde (http://www.rdocumentation.org/packages/ctmm/topics/akde) (tele_list_sub2, CTMM = model_list_sub2)
# name by model name
names(hrange_list_sub2) <- names(model_list_sub2)
# summary of each home range. There is no summary table function here because we borrowed the model table in app to make the
home range summary table. To reproduce that in functions need model table/model_fit_res and the selection as parameters, which
will be quite awkward. If there is a strong request from users, a summary table function can be added.
lapply(hrange_list_sub2, summary)
#> $`Cilla - OU anisotropic`
#> $`Cilla - OU anisotropic`$DOF
#>   area bandwidth
#> 31.36118 45.88222
#>
#> $`Cilla - OU anisotropic`$CI
#>           low           ML           high
#> area (square kilometers) 240.4693 353.0512 486.909
#>
#>
#> $`Gabs - OU anisotropic`
#> $`Gabs - OU anisotropic`$DOF
#>   area bandwidth
#> 9.749387 10.900132
#>
#> $`Gabs - OU anisotropic`$CI
#>           low           ML           high
#> area (square kilometers) 152.3578 321.278 552.1451
#>
#>
#> $`Toni - OU isotropic`
#> $`Toni - OU isotropic`$DOF
#>   area bandwidth
#> 40.21237 60.08822
#>
#> $`Toni - OU isotropic`$CI
#>           low           ML           high
#> area (square kilometers) 215.8846 301.8926 402.0963
#>
#>
#> $`Toni - OU anisotropic`
#> $`Toni - OU anisotropic`$DOF
#>   area bandwidth
#> 40.47168 62.55900
#>
#> $`Toni - OU anisotropic`$CI
#>           low           ML           high
#> area (square kilometers) 208.9942 291.9162 388.477
#>
#>
#> $`Toni - OUF anisotropic`
#> $`Toni - OUF anisotropic`$DOF
#>   area bandwidth
#> 44.52701 67.35656
#>
#> $`Toni - OUF anisotropic`$CI
#>           low           ML           high
#> area (square kilometers) 210.3728 288.9375 379.7743
#>
#>
#> $`Toni - OUF isotropic`
#> $`Toni - OUF isotropic`$DOF
#>   area bandwidth
#> 43.70137 64.09546
#>
#> $`Toni - OUF isotropic`$CI
#>           low           ML           high
#> area (square kilometers) 217.416 299.5758 394.6996
# plot home range
plot_ud (../reference/plot_ud.html) (hrange_list_sub2)

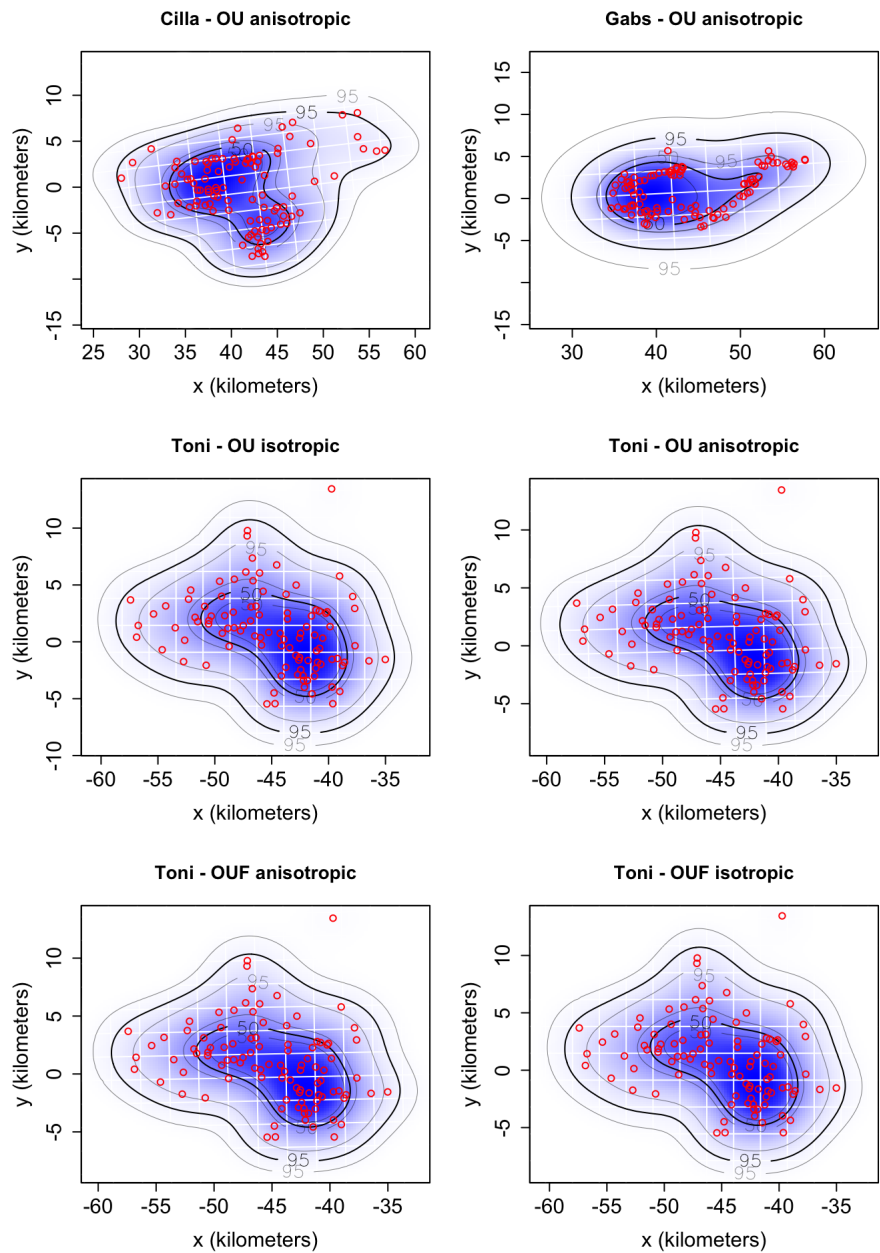
```



```
# plot home range with location overlay
plot_ud (../reference/plot_ud.html) (hrange_list_sub2, tele_list = tele_list_sub2)
```



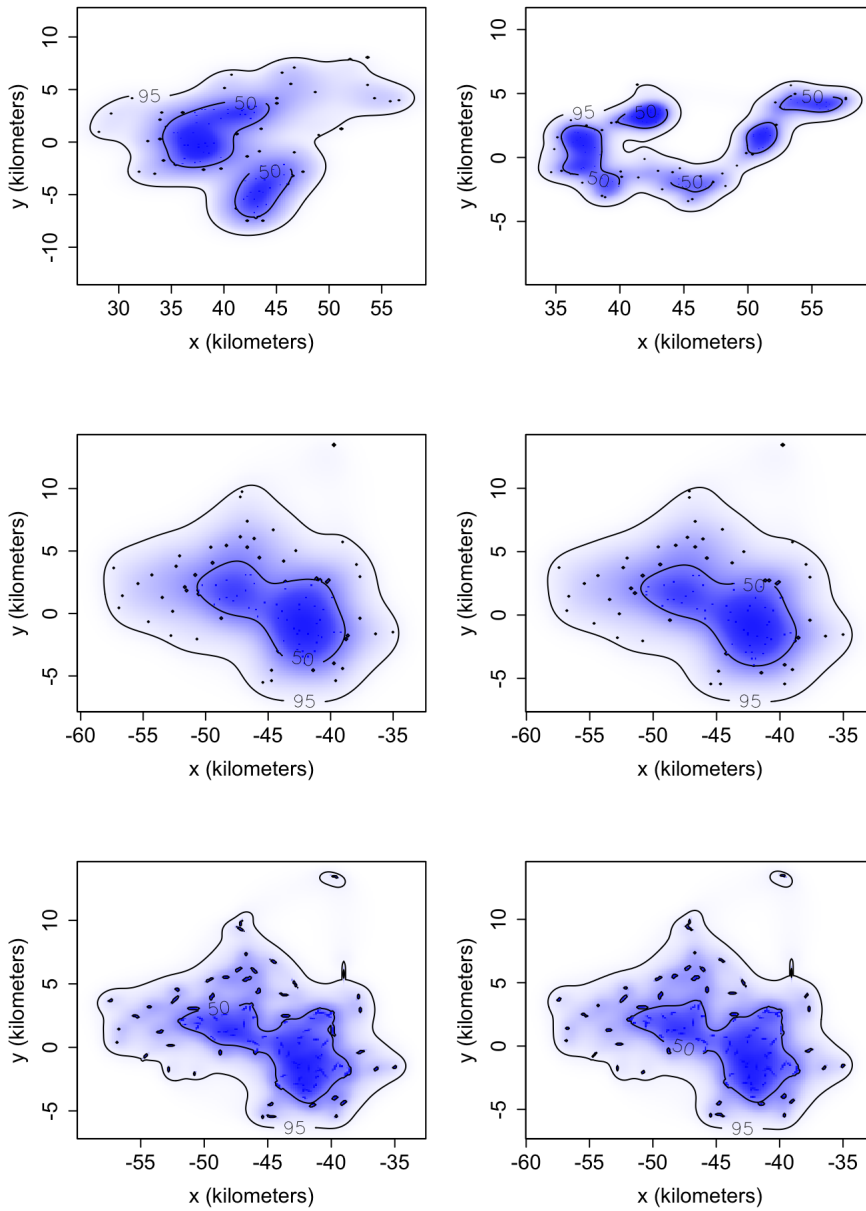
```
# plot with different level.UD values
plot_ud (../reference/plot_ud.html) (hrange_list_sub2, level_vec = c(0.50, 0.95), tele_list = tele_list_sub2)
```



Occurrence



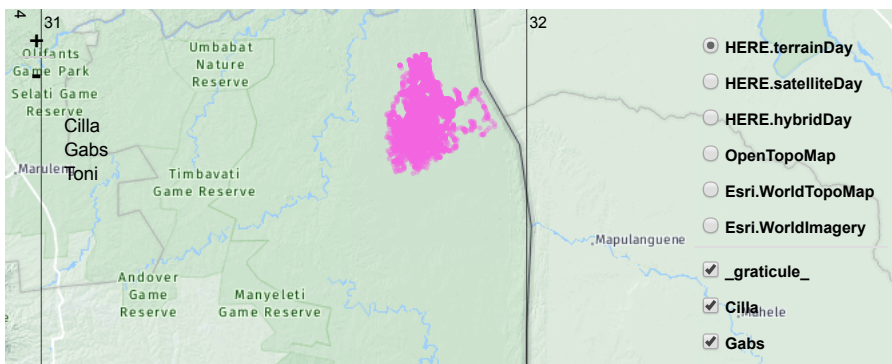
```
# calculate occurrence in parallel
occur_list_sub2 <- par_occur (../reference/par_occur.html)(tele_list_sub2, model_list_sub2)
#> running parallel with mclapply in cluster of 6
# plot occurrence. Note tele_list is not needed here because the location overlay usually interfere with occurrence plot.
plot_ud (../reference/plot_ud.html)(occur_list_sub2, level_vec = c(0.50, 0.95))
```

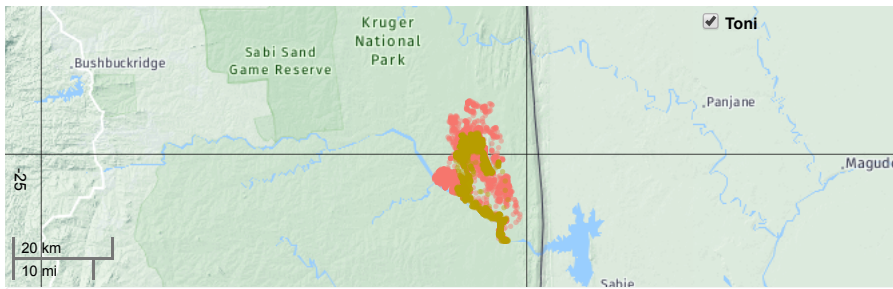


Map

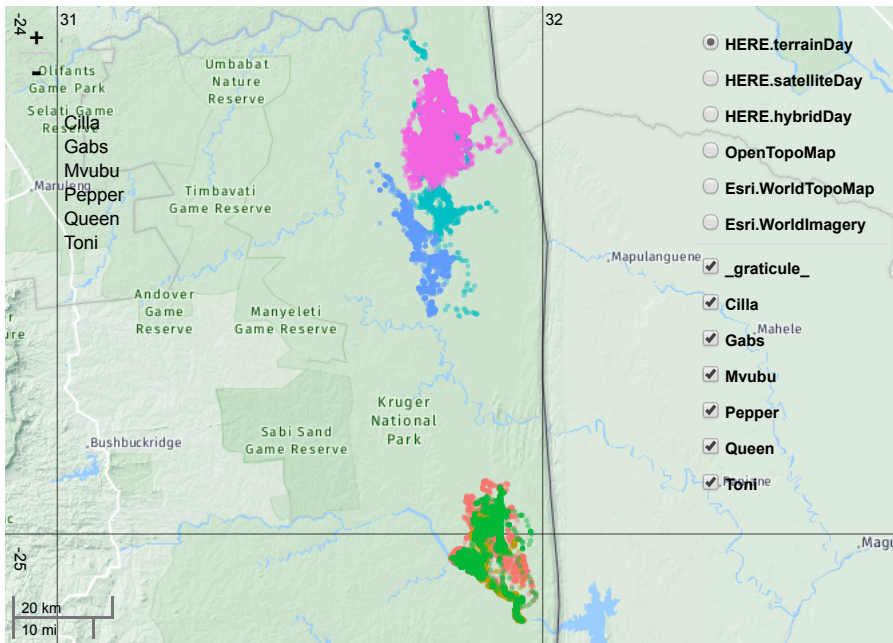
We can [build an interactive online map](#).

```
# this is needed for using pipe operator
library(leaflet)
# selecte_dtl is used for visualization plot. all the model selections above are based on a different subset. We need to get
corresponding dt subset for model selections
dt_sub2 <- dt[identity %in% names(tele_list_sub2)]
point_map ( ../reference/point_map.html) (dt_sub2)
```






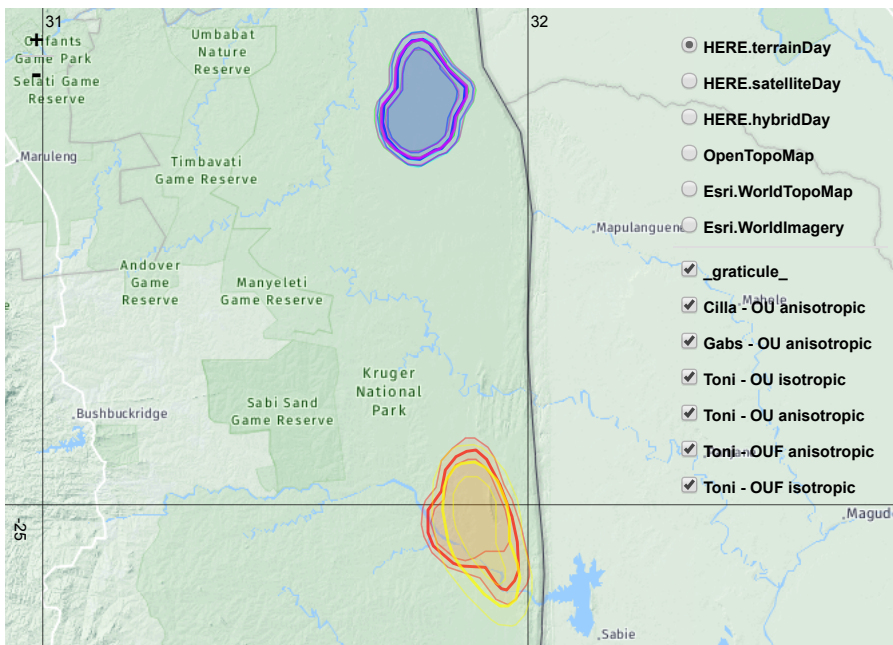
```
point_map ( ../reference/point_map.html) (dt)
```



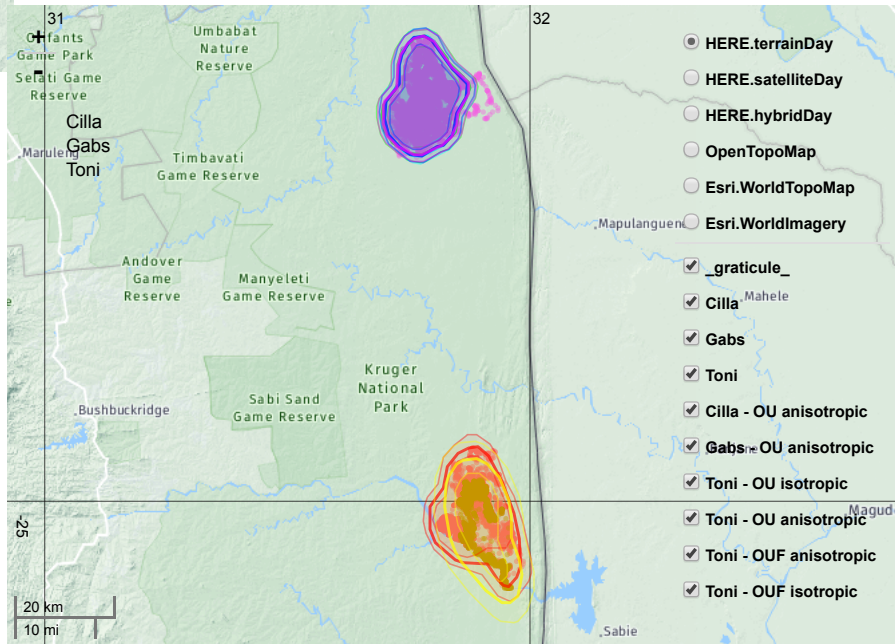
```
# save map to html. It will be self contained single html and can be shared.
htmlwidgets::saveWidget (http://www.rdocumentation.org/packages/htmlwidgets/topics/saveWidget) (point_map
( ../reference/point_map.html) (dt_sub2), file = "point_map.html")
```

Home range map need more parameters. See the  help documents for detailed explanations.

```
range_map ( ../reference/range_map.html) (hrange_list_sub2, 0.95, rainbow(length(hrange_list_sub2)))
```




```
# note dt_sub2 is corresponding to hrange_list_sub2  
point_range_map (./reference/point_range_map.html) (dt_sub2, hrange_list_sub2, 0.95,  
rainbow(length(hrange_list_sub2)))
```



Developed by Xianghui Dong.

Site built with pkgdown (<http://hadley.github.io/pkgdown/>).

