LEMMA_Mvmt_Force

Chris Hoover

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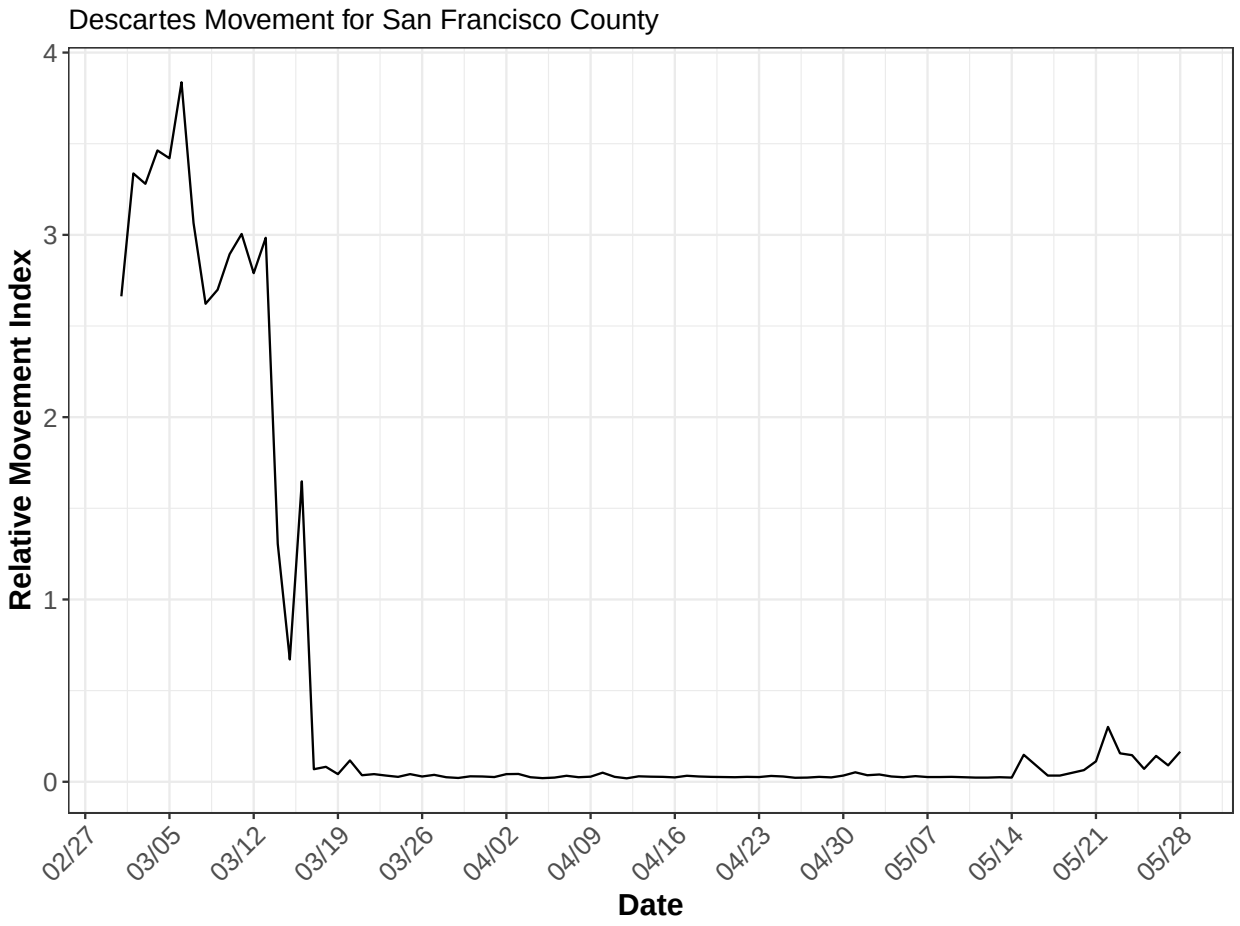
Purpose

Use movement data incorporated into a dynamic model of COVID transmission via a forcing function to fit early-stage outbreak dynamics and forecast transmission into the future using movement projections.

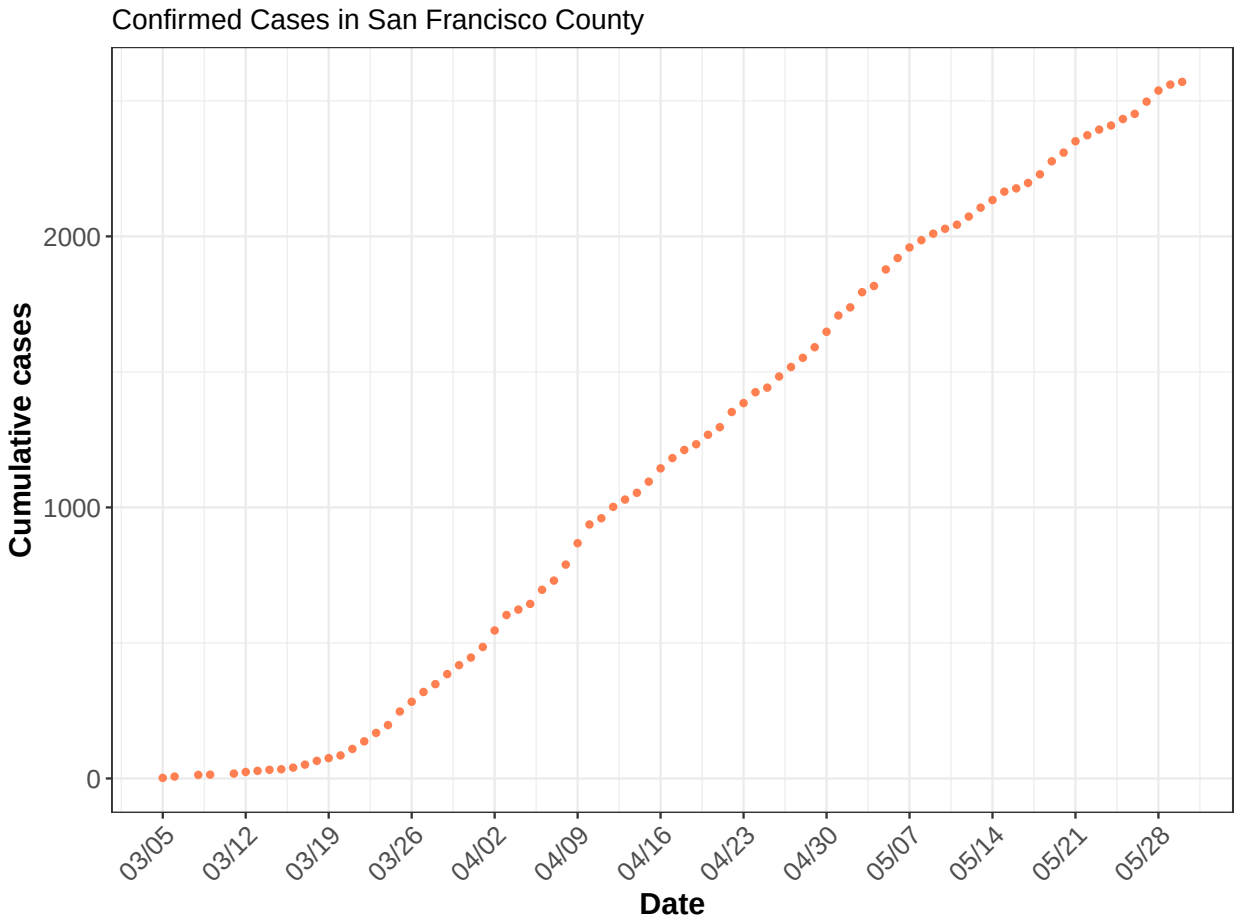
Movement Data

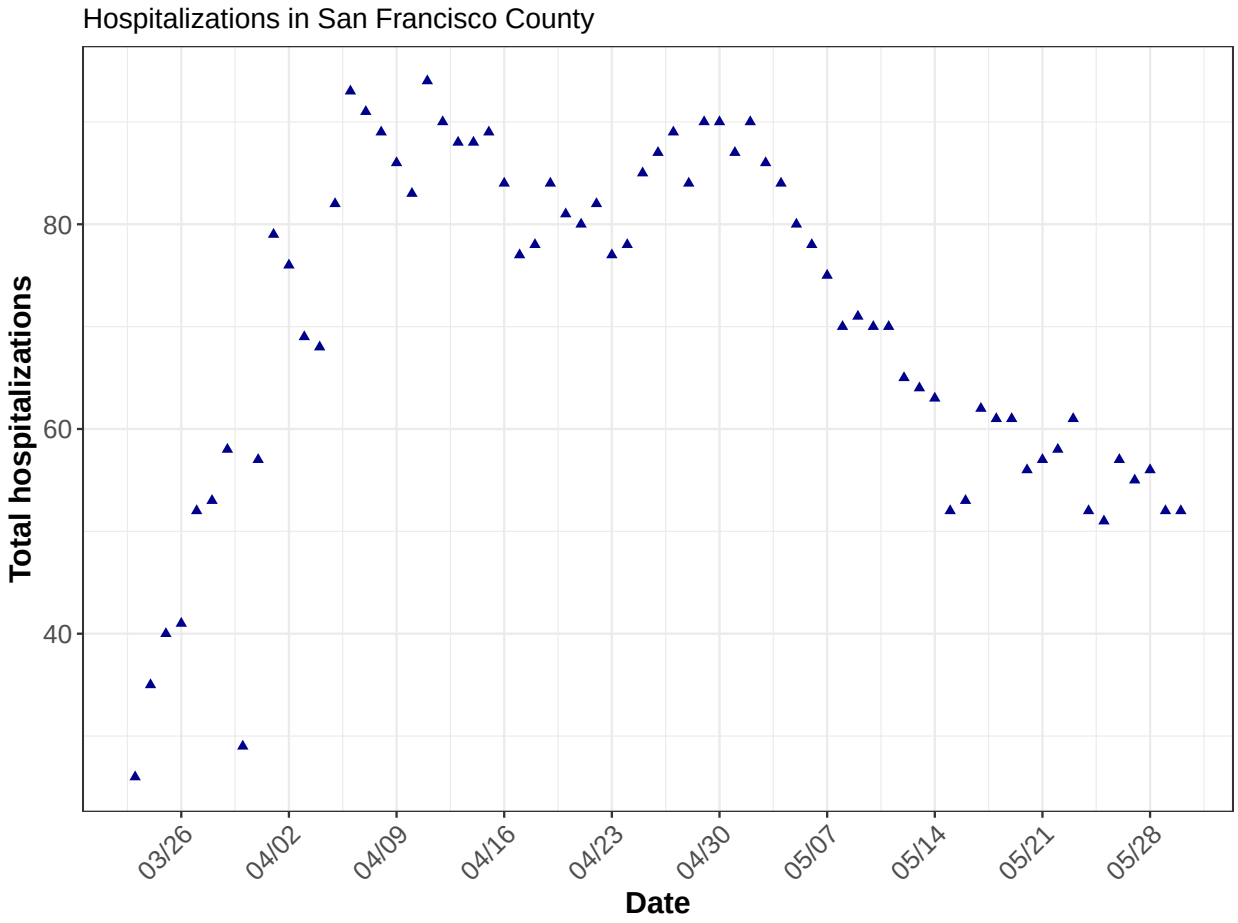
Descartes Labs

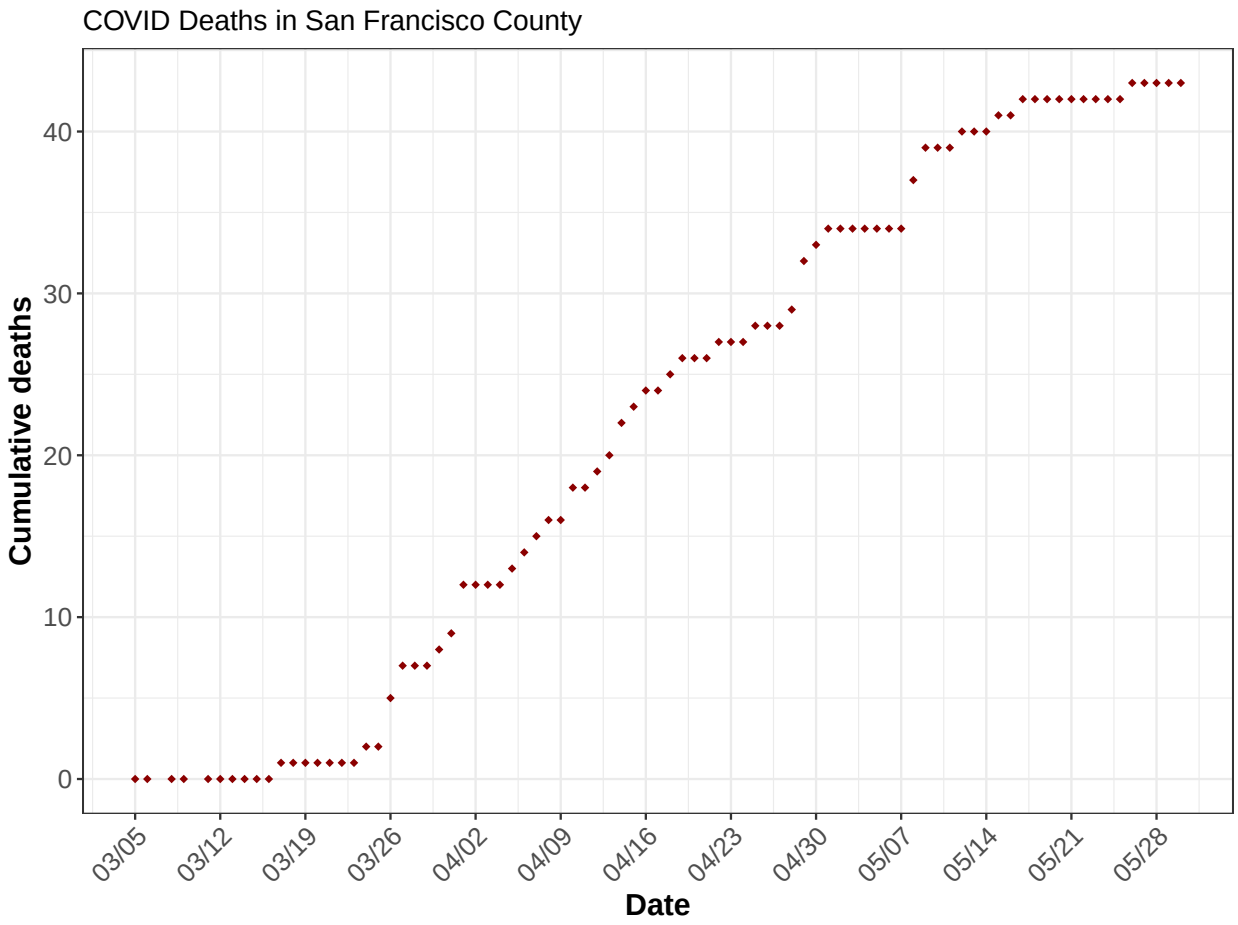
Technical report here. Data represents "the median of the max-distance mobility for all samples in the specified region" derived from anonymized mobile phone data.



Epi Data


Confirmed Cases in San Francisco County
Cumulative cases
2000
1000
0
03/05
03/12
03/19
03/26
04/02
04/09
04/16
04/23
04/30
05/07
05/14
05/21
05/28
Date


Hospitalizations in San Francisco County
Total hospitalizations
80
60
40
03/26
04/02
04/09
04/16
04/23
04/30
05/07
05/14
05/21
05/28
Date



Model

We use a slight tweak to LEMMA to add an explicit deaths compartment in order to fit to deaths data in addition to hospitalizations

$$
\begin{aligned}
\dot{S} &= -\beta S(I_R + I_H)/N \\
\dot{E} &= \beta S(I_R + I_H)/N - \sigma E \\
\dot{I_R} &= \sigma(1-\alpha)E - \gamma_R I_R \\
\dot{I_H} &= \sigma\alpha E - \rho I_H \\
\dot{H} &= \rho I_H - \gamma_H H \\
\dot{D} &= \gamma_H \mu H \\
\dot{R} &= \gamma_R I_R \gamma_H (1-\mu) H
\end{aligned}
$$

```
## Loading required package: parallel
```

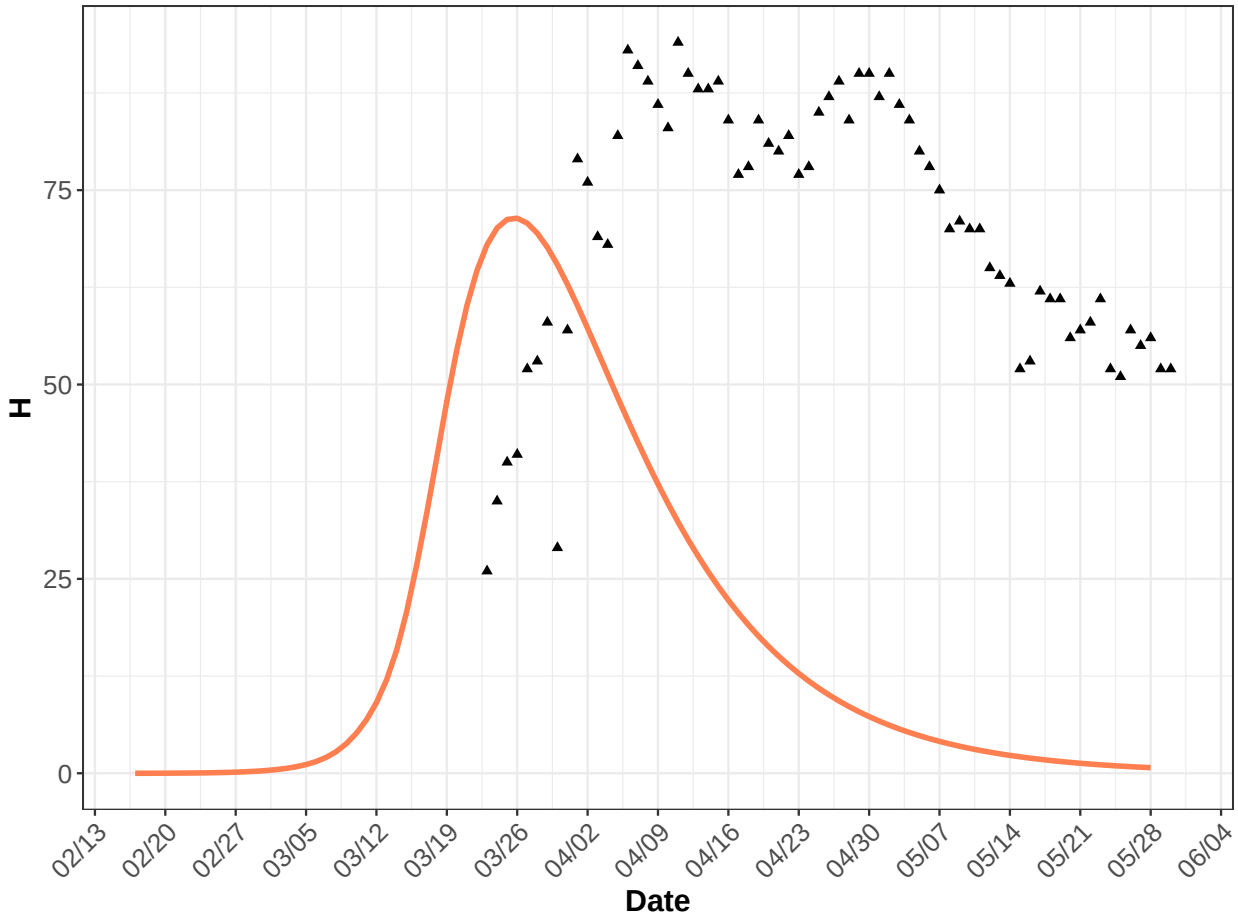
```
## [[1]]
```

Table 1: Parameter values and descriptions used in the model

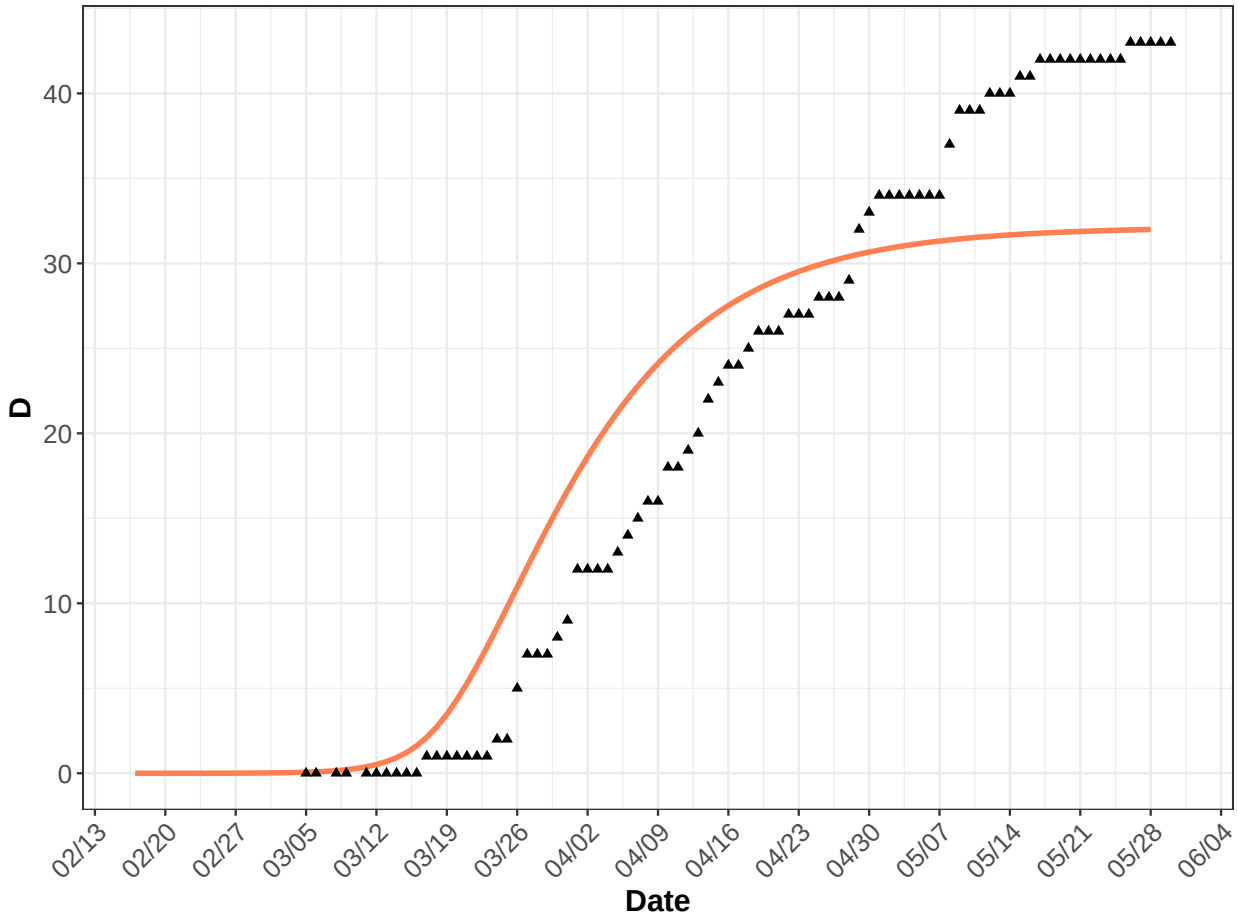
	Value	Definition
N	883305	population size
t.sim	102	time to run simulation
E_0	2	starting number of exposed
β	0.1	transmission rate
c_r	1	Relative contact rate between S and Ir
c_h	1	Relative contact rate between S and Ih
σ	0.25	1/serial interval
α	0.05	proportion severely symptomatic (will be hospitalized)
ρ	0.25	time between symptom onset and hospitalization
γ_r	0.2	1/time to recovery (non-infectiousness) for mildly symptomatic
γ_h	0.083	1/time hospitalized
μ	0.2	proportion of hospitalized cases who die

```
##  [1] "forcats"       "stringr"       "dplyr"         "purrr"
##  [5] "readr"         "tidyr"         "tibble"        "ggplot2"
##  [9] "tidyverse"     "deSolve"       "RevoUtils"     "stats"
## [13] "graphics"      "grDevices"     "utils"         "datasets"
## [17] "RevoUtilsMath" "methods"       "base"
##
## [[2]]
##  [1] "forcats"       "stringr"       "dplyr"         "purrr"
##  [5] "readr"         "tidyr"         "tibble"        "ggplot2"
##  [9] "tidyverse"     "deSolve"       "RevoUtils"     "stats"
## [13] "graphics"      "grDevices"     "utils"         "datasets"
## [17] "RevoUtilsMath" "methods"       "base"
##
## [[3]]
##  [1] "forcats"       "stringr"       "dplyr"         "purrr"
##  [5] "readr"         "tidyr"         "tibble"        "ggplot2"
##  [9] "tidyverse"     "deSolve"       "RevoUtils"     "stats"
## [13] "graphics"      "grDevices"     "utils"         "datasets"
## [17] "RevoUtilsMath" "methods"       "base"

## Warning: Removed 22 rows containing missing values (geom_point).
```



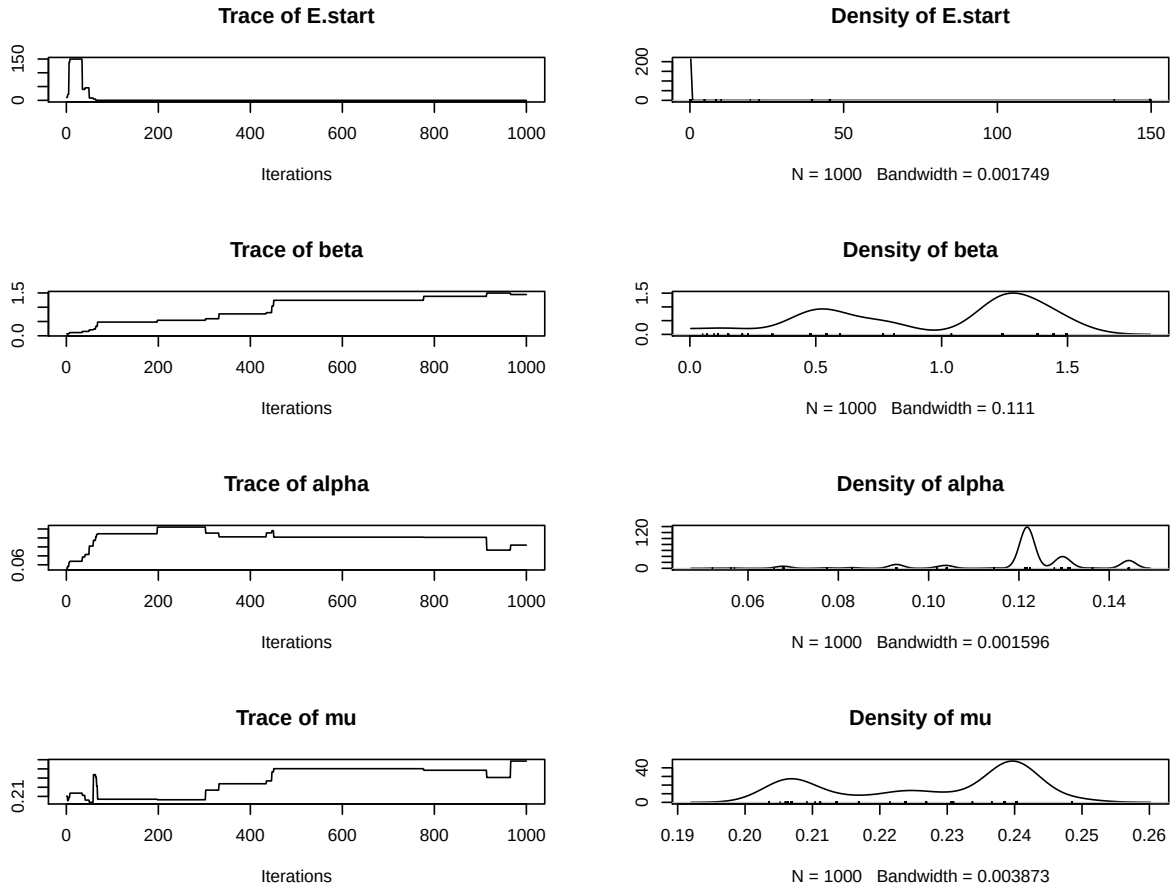

```
## Warning: Removed 6 rows containing missing values (geom_point).
```



TODO: Two populations

- How to divide movement/contact between the two populations?

```
## iteration: 100 out of 1000  acceptance rate: 0.12
## iteration: 200 out of 1000  acceptance rate: 0.065
## iteration: 300 out of 1000  acceptance rate: 0.04333333
## iteration: 400 out of 1000  acceptance rate: 0.0375
## iteration: 500 out of 1000  acceptance rate: 0.036
## iteration: 600 out of 1000  acceptance rate: 0.03
## iteration: 700 out of 1000  acceptance rate: 0.02571429
## iteration: 800 out of 1000  acceptance rate: 0.02375
## iteration: 900 out of 1000  acceptance rate: 0.02111111
## iteration: 1000 out of 1000  acceptance rate: 0.021
```




```
##
## Iterations = 1:1000
## Thinning interval = 1
## Number of chains = 1
## Sample size per chain = 1000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##           Mean       SD  Naive SE Time-series SE
## E.start 5.1582 25.45565 0.8049782       6.267791
## beta    0.9621  0.41705 0.0131883       0.312439
## alpha   0.1207  0.01598 0.0005055       0.005852
## mu      0.2275  0.01455 0.0004600       0.010076
##
## 2. Quantiles for each variable:
##
##              2.5%       25%       50%      75%    97.5%
## E.start 1.818e-08 7.026e-07 7.026e-07 0.008801 149.7447
## beta    1.121e-01 5.424e-01 1.242e+00 1.242112   1.4960
## alpha   6.785e-02 1.213e-01 1.218e-01 0.129379   0.1443
## mu      2.064e-01 2.070e-01 2.366e-01 0.240244   0.2485
```