MacPan Example

Installing MacPan

Clone/download the repository (from here) and install locally or use:

`remotes::install_github("bbolker/McMasterPandemic")` to install the package. You will need to first install the developer version of `bbmle` (`remotes::install_github("bbolker/bbmle")`) before installing `McMasterPandemic`.

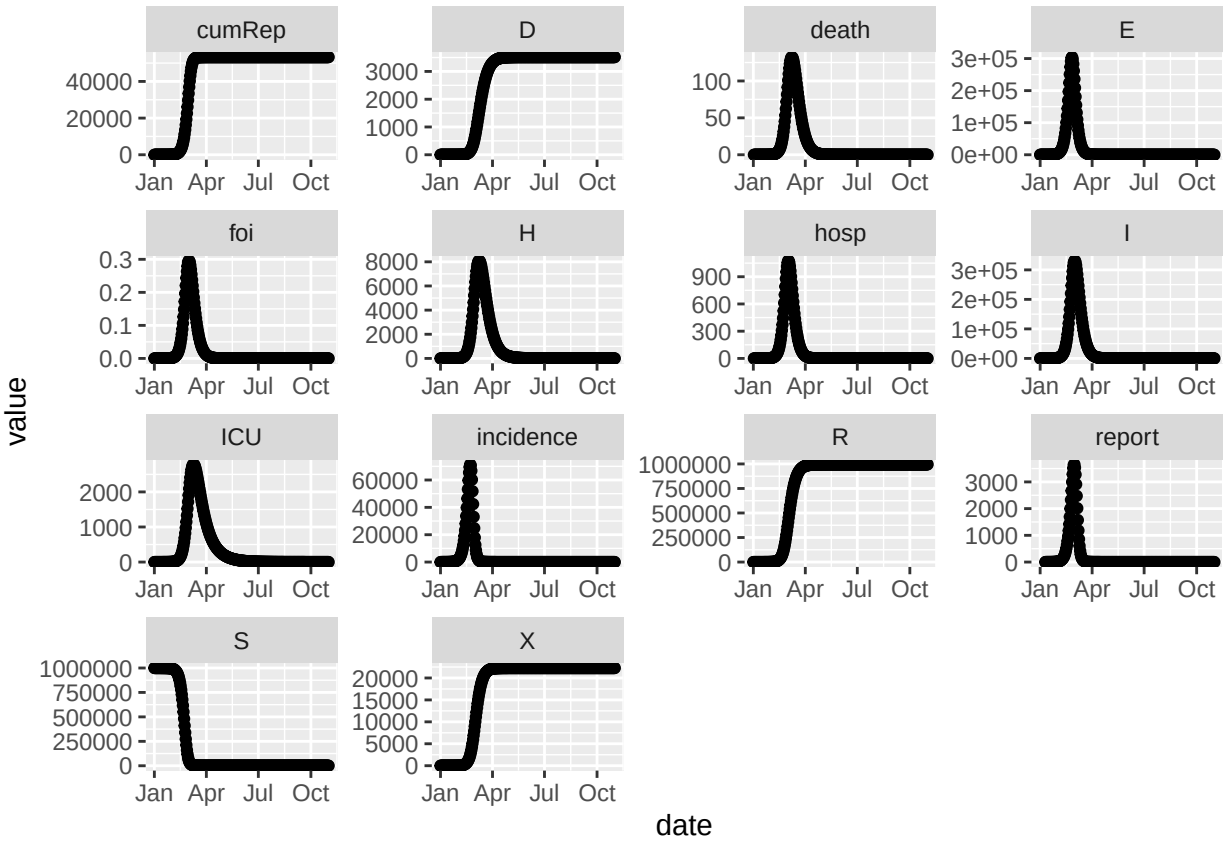
Simulating data time series

MLi: Do we have a document of the basic model (e.g. the flow diagram, and what the states/compartments mean?)

```
params <- read_params("ICU1.csv")

## Need to set up opt_pars because you need this for forecast_sim
opt_pars <- list(params=c(beta0=params[["beta0"]]))
simdat <- forecast_sim(p = unlist(opt_pars)
    , opt_pars = opt_pars
    , base_params = params
    , start_date = "2020-01-01"
    , end_date = "2020-11-01"
)
```

Plotting simulated time series

```
gg <- (ggplot(simdat, aes(x=date,y=value))
    + geom_point()
    + geom_line()
    + facet_wrap(~var,scale="free")
)

print(gg)
```



Changing parameters

MLi: Maybe use Zach's shinny app to play around with different parameters combinations. This is the way to manually change it via code.

```
print(summary(params))
```

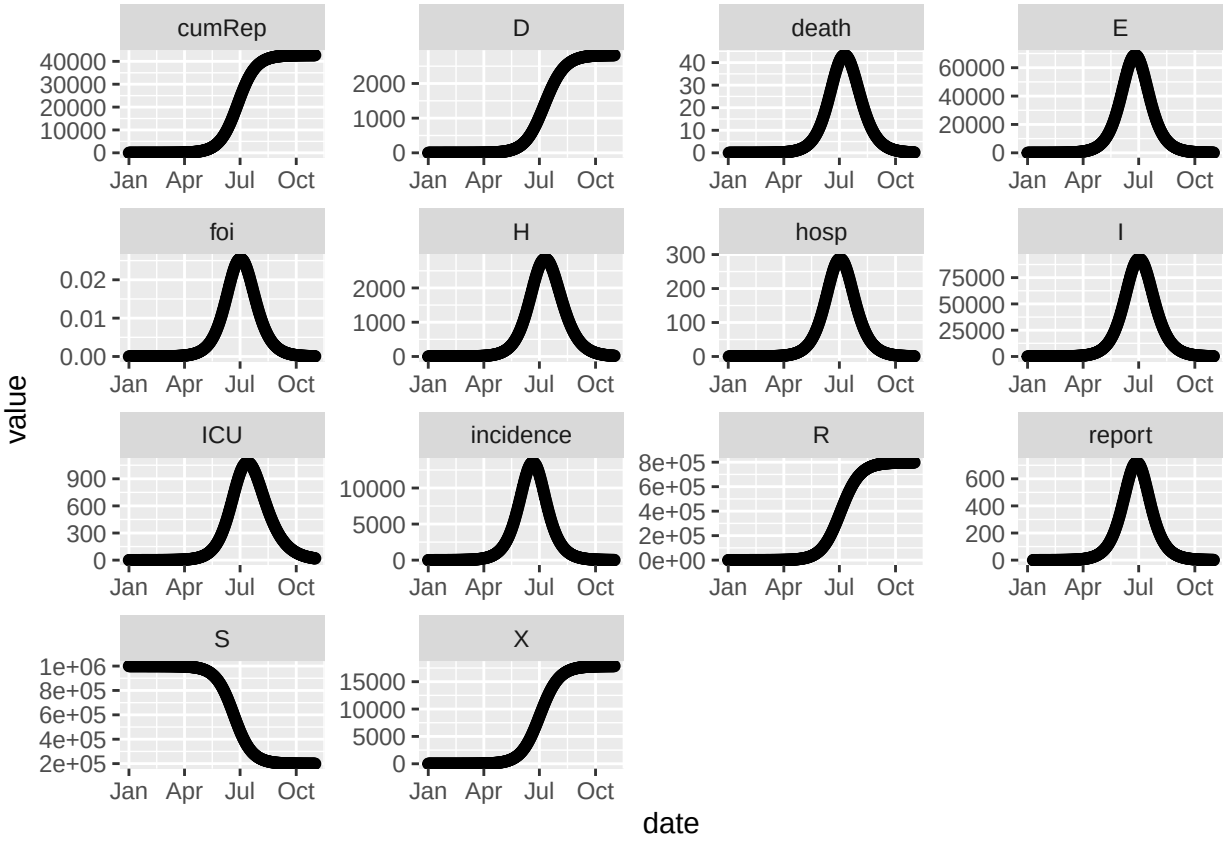
```
##         r0         R0       Gbar    CFR_gen   dbl_time
##  0.2278149  6.5180089 12.1897402  0.0352000  3.0425898
```

```
## Change R0
newparams <- fix_pars(params, target=c(R0=2))

print(summary(newparams))
```

```
##          r0          R0        Gbar     CFR_gen    dbl_time
##  0.06649208  2.00002038 12.18974018  0.03520000 10.42450796
```

```
new_opt_pars <- list(params=c(beta0=newparams[["beta0"]]))

simdat2 <- forecast_sim(p = unlist(new_opt_pars)
    , opt_pars = new_opt_pars
    , base_params = newparams    ## change parameter set here!
    , start_date = "2020-01-01"
    , end_date = "2020-11-01"
)

print(gg %+% simdat2)
```

```
## Warning: Removed 11 rows containing missing values (geom_point).
```

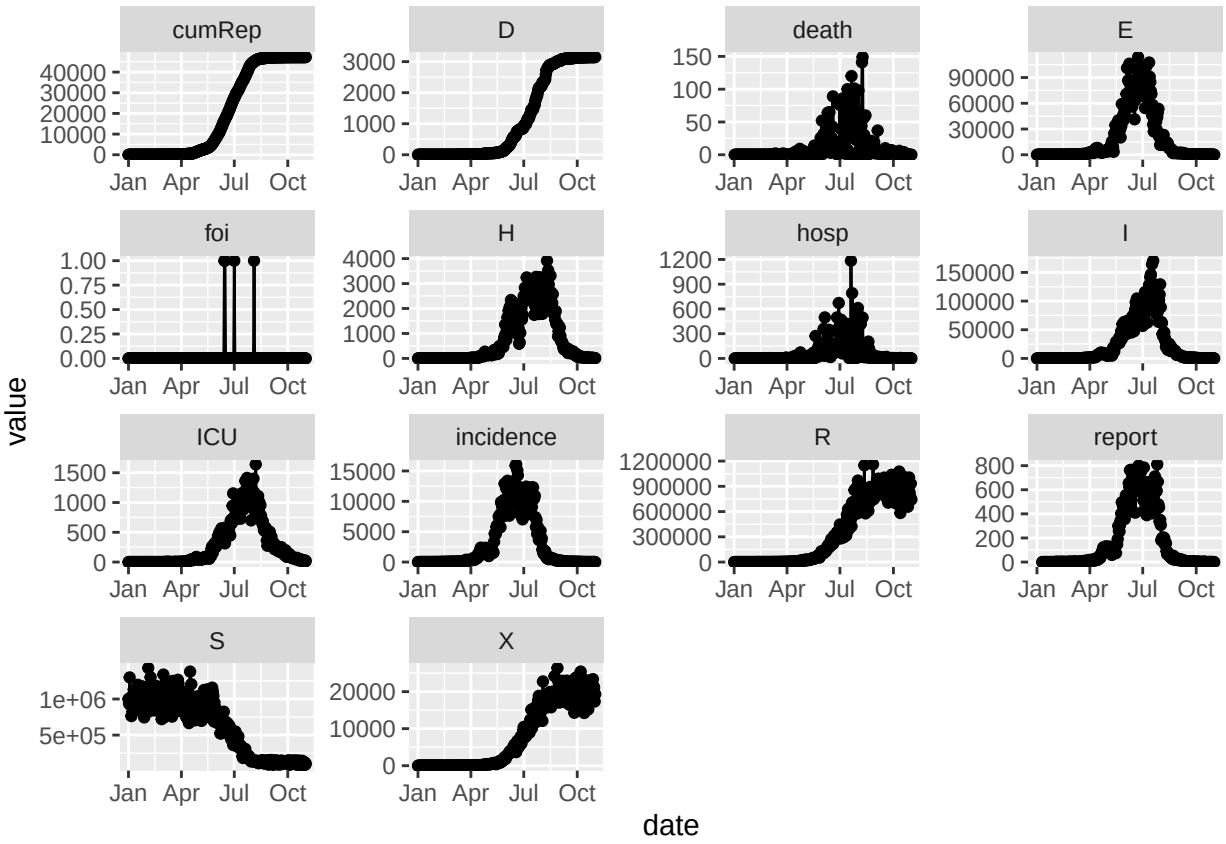


Question: Extract the reported cases time series and use epigrowthfit to estimate little r. Double check if it is the same using the summary function in macpan.

Adding Stochastic Noise

```
newparams2 <- update(newparams, obs_disp = 50, proc_disp=1)

simdat3 <- forecast_sim(p = unlist(new_opt_pars)
    , opt_pars = new_opt_pars
    , base_params = newparams2
    , stoch = c(proc=TRUE,obs=TRUE)
    , stoch_start = c(proc="2020-01-01",obs="2020-01-01")
    , start_date = "2020-01-01"
    , end_date = "2020-11-01"
)

print(gg %+% simdat3)
```

```
## Warning: Removed 11 rows containing missing values (geom_point).
```



Calibrating to simuated data

```
report_dat <- (simdat3
    %>% filter(var == "report")
)

## I am estimating beta0 only, you need to specify what parameters you want to estimate

opt_pars <- list(params = c(beta0=0.1))

fitmod <- calibrate_comb(data = report_dat
    , params = newparams2
    , opt_pars = opt_pars
    , use_DEoptim = FALSE ## We don't want to wait that long
    , debug_plot = FALSE ## TRUE to watch fitting process, don't do it in rmd
)

print(summary(fitmod))
```

```
##   start_date         r0       R0     Gbar CFR_gen dbl_time
## 1 2019-12-17 0.06275216 1.926886 12.18974  0.0352 11.04579
```

```
print(summary(newparams2))
```

```
##          r0          R0        Gbar     CFR_gen    dbl_time
##  0.06649208  2.00002038 12.18974018  0.03520000 10.42450796
```

Ontario, Canada

Reading in data from MLi's github page

```
tsdat_url <- "https://wzmli.github.io/COVID19-Canada/git_push/clean.Rout.csv"

tsdat <- read_csv(tsdat_url)
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

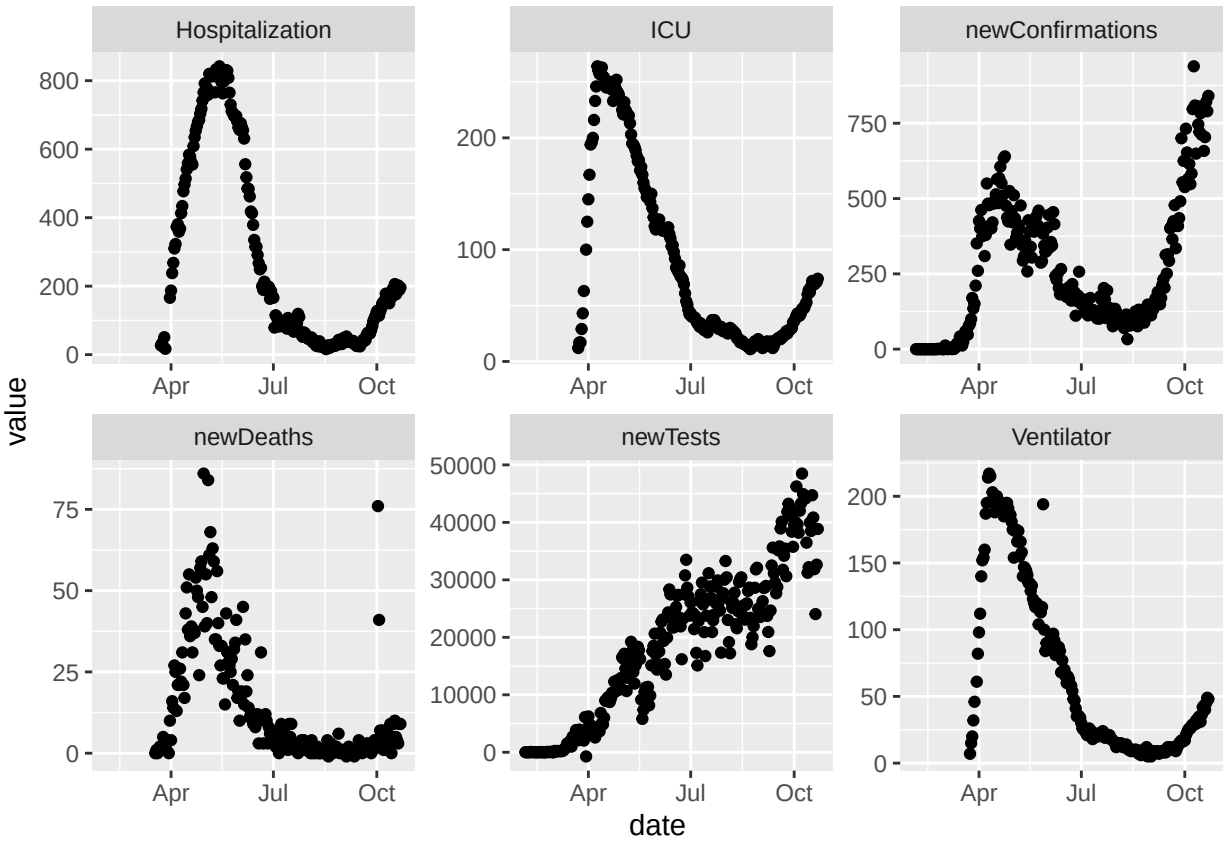
```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Date = col_date(format = ""),
##   Province = col_character(),
##   source = col_character(),
##   Note = col_character()
## )
```

```
## See spec(...) for full column specifications.
```

```
## Section 2: Clean data
### Clean ts data
Ontario_dat <- (tsdat
    %>% filter(Province=="ON")
   %>% select(Province,Date,Hospitalization,ICU,Ventilator,deceased,newConfirmations,newTests)
    %>% mutate(newDeaths=c(NA,diff(deceased))
    ## ON hosp includes ICU, our model compartment is just acute care
    , Hospitalization=Hospitalization-ICU)
   %>% select(-deceased)
   %>% pivot_longer(names_to="var",-c(Date,Province))
   %>% setNames(tolower(names(.)))
    %>% ungroup()
)
```

Question: Make some time series plots using the data and describe what is going on. Adding important dates!

```
ggont <- (ggplot(data=Ontario_dat, aes(x=date,y=value))
    + geom_point()
    + facet_wrap(~var, scale="free")
)

print(ggont)
```



Ontario MacPan setup

```
## translate variable names to internally used values
## drop unused variables
keep_vars <- c("H","ICU","death","report","newTests")

## Maybe keep reports only for simplicity

keep_vars <- c("report")

clean_tsdata <- (Ontario_dat
    %>% mutate_at("var",trans_state_vars)
    %>% filter(var %in% keep_vars)
)

date_vec <- as.Date(min(clean_tsdata$date):max(clean_tsdata$date))

date_df <- data.frame(date = rep(date_vec,1)
   , var = rep(c("report"),each=length(date_vec))
   )

calibrate_dat <- (left_join(date_df,clean_tsdata))

## Joining, by = c("date", "var")
```

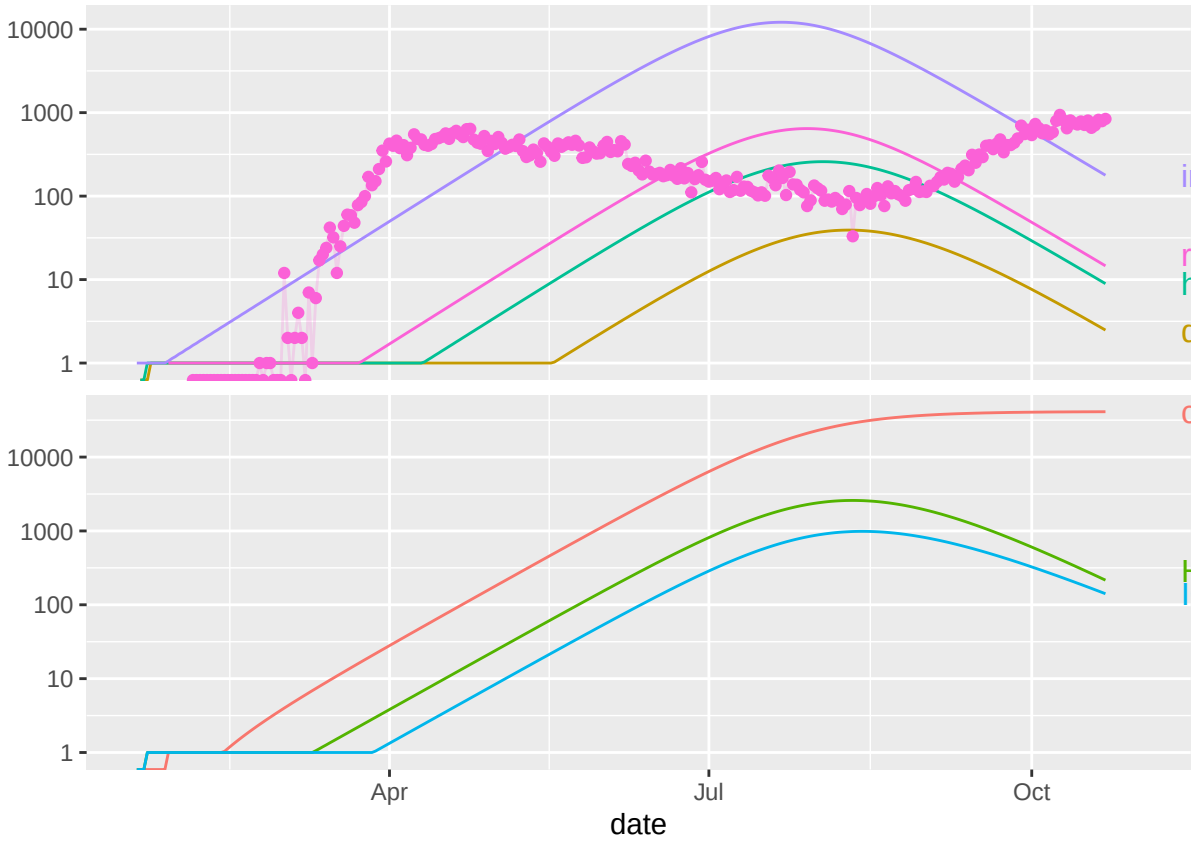
Fitting basic MacPan model

```
ontmod0 <- calibrate_comb(data = calibrate_dat
    , params = newparams2
    , opt_pars = opt_pars
    , use_DEoptim = FALSE ## We don't want to wait that long
    , debug_plot = FALSE ## TRUE to watch fitting process, don't do it in rmd
)


print(summary(ontmod0))
```

```
##   start_date        r0       R0     Gbar CFR_gen dbl_time
## 1 2020-01-20 0.0620608 1.913265 12.18974  0.0352 11.16884
```

```
print(plot(ontmod0,data=calibrate_dat))
```

```
## Loading required namespace: directlabels
```



Question: Why are the fits so bad? Ans: - Model is too simple - strong assumptions - interventions and lockdown - two distinct waves

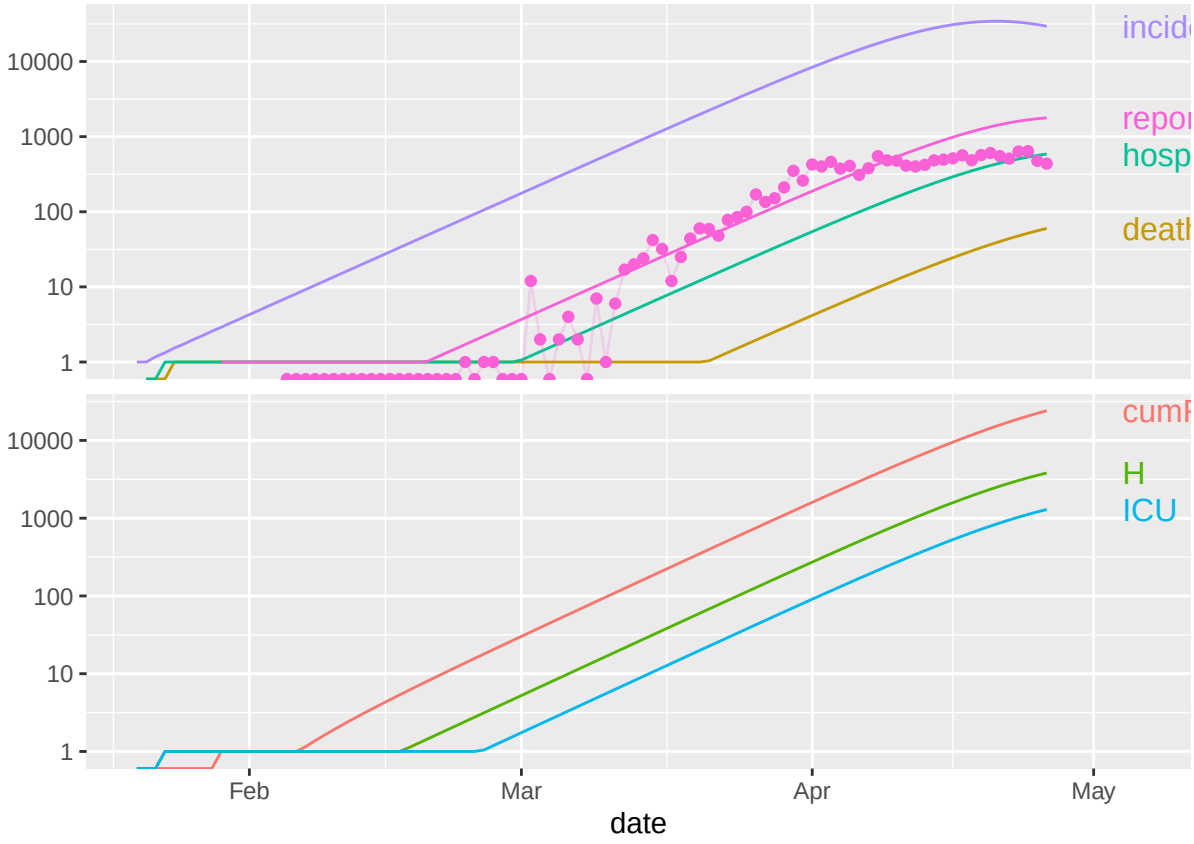
Initial wave

```
ont1stwave <- calibrate_dat %>% filter(date <= as.Date("2020-04-26"))

ontmod1 <- calibrate_comb(data = ont1stwave
    , params = newparams2
```

```
    , opt_pars = opt_pars
    , use_DEoptim = FALSE ## We don't want to wait that long
    , debug_plot = FALSE ## TRUE to watch fitting process, don't do it in rmd
)


print(summary(ontmod1))
```

```
##   start_date        r0       R0     Gbar CFR_gen dbl_time
## 1 2020-01-20 0.1283672 3.355756 12.18974  0.0352 5.399721
```

```
print(plot(ontmod1,data=ont1stwave))
```



Question: What is the growth rate (little r)? Do we get similar estimates as epigrowthfit?

MLi: Maybe do the same thing for second wave?

Mobility

We can use mobility as a proxy for change in transmission rate.

```
google_url <- "https://www.gstatic.com/covid19/mobility/Global_Mobility_Report.csv"

google <- read_csv(google_url)
```

```
## Parsed with column specification:
## cols(
##   country_region_code = col_character(),
##   country_region = col_character(),
```

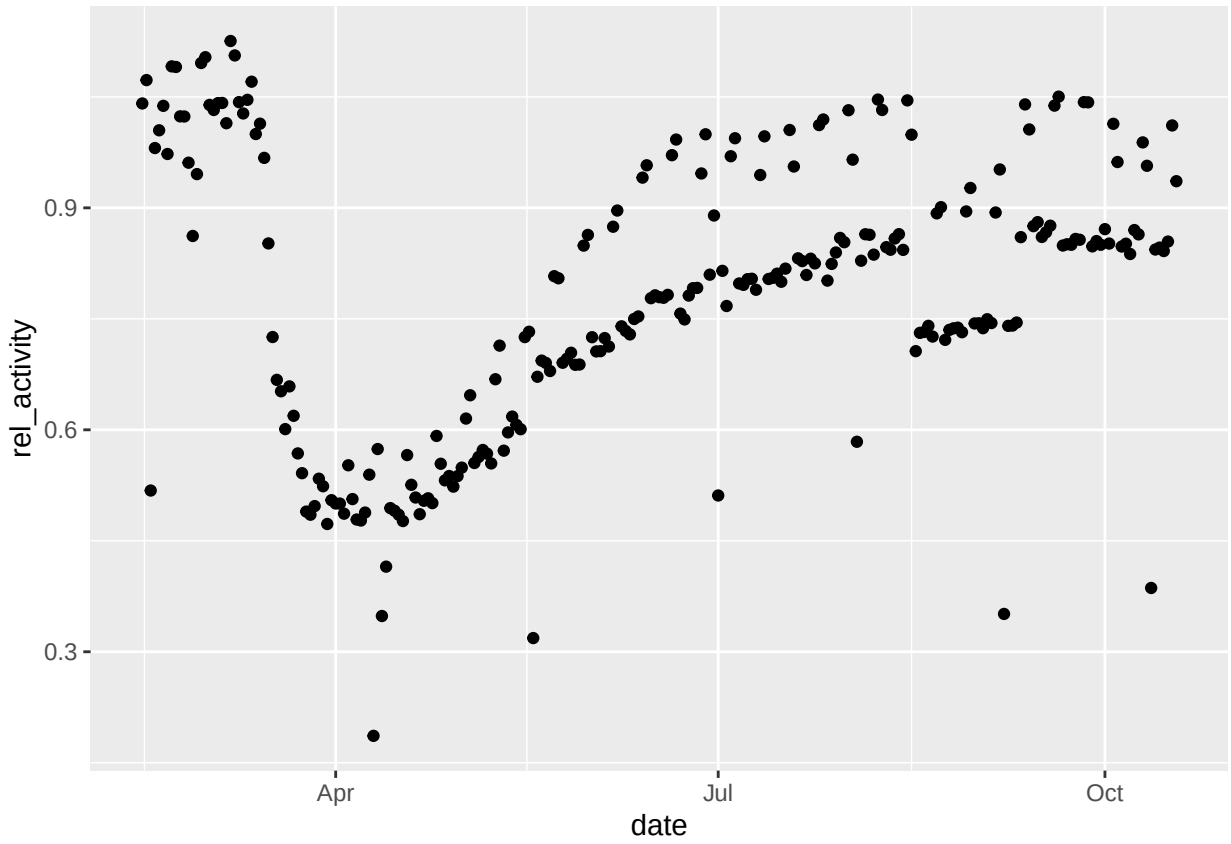
```
##   sub_region_1 = col_character(),
##   sub_region_2 = col_logical(),
##   metro_area = col_logical(),
##   iso_3166_2_code = col_character(),
##   census_fips_code = col_logical(),
##   date = col_date(format = ""),
##   retail_and_recreation_percent_change_from_baseline = col_double(),
##   grocery_and_pharmacy_percent_change_from_baseline = col_double(),
##   parks_percent_change_from_baseline = col_double(),
##   transit_stations_percent_change_from_baseline = col_double(),
##   workplaces_percent_change_from_baseline = col_double(),
##   residential_percent_change_from_baseline = col_double()
## )
```

```
## Warning: 2889631 parsing failures.
##  row        col           expected                   actual
## 2172 metro_area 1/0/T/F/TRUE/FALSE Kabul Metropolitan Area 'https://www.gstatic.com/covid19/mobility/
## 2173 metro_area 1/0/T/F/TRUE/FALSE Kabul Metropolitan Area 'https://www.gstatic.com/covid19/mobility/
## 2174 metro_area 1/0/T/F/TRUE/FALSE Kabul Metropolitan Area 'https://www.gstatic.com/covid19/mobility/
## 2175 metro_area 1/0/T/F/TRUE/FALSE Kabul Metropolitan Area 'https://www.gstatic.com/covid19/mobility/
## 2176 metro_area 1/0/T/F/TRUE/FALSE Kabul Metropolitan Area 'https://www.gstatic.com/covid19/mobility/
## .... ......... .................. ...................... ....................................
## See problems(...) for more details.
```

```
clean_google <- (google
    %>% filter(country_region == "Canada", sub_region_1 == "Ontario")
    %>% select(date, contains("baseline"))
    %>% pivot_longer(names_to="type", values_to="value", -c(date))
    %>% mutate_at("date", as.Date)
    %>% mutate_at("type", str_remove, "\\_percent.*")
    %>% mutate_at("value", ~./100+1)
)

clean_mobdat <- (clean_google
    %>% mutate(tvec=as.numeric(date-min(date,na.rm=TRUE)))
    %>% filter(type %in% c("retail_and_recreation","workplaces","driving"))
    %>% dplyr::select(date,value)
    %>% group_by(date)
    %>% summarise_at("value",mean,na.rm=TRUE)
    %>% na.omit()
    %>% rename(rel_activity = value)
#   %>% mutate_at("rel_activity", ~pmin(., 1))  ## cap at 100% (? should we ?)
     %>% ungroup()
)
```

Make a plot of relative activity and explain how this might have an effect for disease transmission/dynamics.

```
ggmob <- (ggplot(clean_mobdat,aes(date,rel_activity))
    + geom_point()
)

print(ggmob)
```



Calibrating mobility model

```
ontmod_mob <- calibrate_comb(data = calibrate_dat
    , params = newparams2
    , opt_pars = opt_pars
    , use_DEoptim = FALSE ## We don't want to wait that long
    , debug_plot = FALSE ## TRUE to watch fitting process, don't do it in rmd
    , mob_data = clean_mobdat
    , use_mobility = TRUE
)


print(summary(ontmod_mob))
```

```
##     start_date         r0         R0     Gbar CFR_gen  dbl_time
## 1   2020-01-20 0.18277545 4.91722043 12.18974  0.0352  3.792343
## 2   2020-02-04 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 3   2020-02-05 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 4   2020-02-06 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 5   2020-02-07 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 6   2020-02-08 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 7   2020-02-09 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 8   2020-02-10 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 9   2020-02-11 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 10  2020-02-12 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 11  2020-02-13 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 12  2020-02-14 0.20003919 5.49575613 12.18974  0.0352  3.465057
```

```
## 13  2020-02-15 0.20003919 5.49575613 12.18974  0.0352  3.465057
## 14  2020-02-16 0.21327573 5.96847721 12.18974  0.0352  3.250005
## 15  2020-02-17        NaN 0.79959148 12.18974  0.0352       NaN
## 16  2020-02-18 0.17471951 4.66149899 12.18974  0.0352  3.967200
## 17  2020-02-19 0.18481057 4.98323734 12.18974  0.0352  3.750582
## 18  2020-02-20 0.19868988 5.44900777 12.18974  0.0352  3.488588
## 19  2020-02-21 0.17134137 4.55689771 12.18974  0.0352  4.045416
## 20  2020-02-22 0.22102633 6.25740719 12.18974  0.0352  3.136039
## 21  2020-02-23 0.22070536 6.24526094 12.18974  0.0352  3.140600
## 22  2020-02-24 0.19272551 5.24550190 12.18974  0.0352  3.596551
## 23  2020-02-25 0.19263712 5.24252406 12.18974  0.0352  3.598202
## 24  2020-02-26 0.16639234 4.40642379 12.18974  0.0352  4.165740
## 25  2020-02-27 0.12466847 3.26311516 12.18974  0.0352  5.559924
## 26  2020-02-28 0.15989746 4.21387839 12.18974  0.0352  4.334948
## 27  2020-02-29 0.22293066 6.32979560 12.18974  0.0352  3.109250
## 28  2020-03-01 0.22621420 6.45592073 12.18974  0.0352  3.064119
## 29  2020-03-02 0.19921982 5.46733676 12.18974  0.0352  3.479308
## 30  2020-03-03 0.19634886 5.36852362 12.18974  0.0352  3.530182
## 31  2020-03-04 0.20023543 5.50257712 12.18974  0.0352  3.461661
## 32  2020-03-05 0.20032374 5.50564833 12.18974  0.0352  3.460135
## 33  2020-03-06 0.18881592 5.11485408 12.18974  0.0352  3.671021
## 34  2020-03-07 0.23534111 6.81531128 12.18974  0.0352  2.945287
## 35  2020-03-08 0.22721090 6.49453490 12.18974  0.0352  3.050678
## 36  2020-03-09 0.20080941 5.52255951 12.18974  0.0352  3.451766
## 37  2020-03-10 0.19436064 5.30078652 12.18974  0.0352  3.566294
## 38  2020-03-11 0.20208966 5.56730223 12.18974  0.0352  3.429899
## 39  2020-03-12 0.21236708 5.93519696 12.18974  0.0352  3.263911
## 40  2020-03-13 0.18268788 4.91439262 12.18974  0.0352  3.794161
## 41  2020-03-14 0.18856504 5.10654416 12.18974  0.0352  3.675905
## 42  2020-03-15 0.16913034 4.48926698 12.18974  0.0352  4.098302
## 43  2020-03-16 0.12044079 3.15921530 12.18974  0.0352  5.755087
## 44  2020-03-17 0.06787133 2.02688811 12.18974  0.0352 10.212666
## 45  2020-03-18 0.04900951 1.61081755 12.18974  0.0352 14.143115
## 46  2020-03-19 0.04780704 1.51017829 12.18974  0.0352 14.498851
## 47  2020-03-20 0.11688109 1.20522788 12.18974  0.0352  5.930362
## 48  2020-03-21 0.04791058 1.55283628 12.18974  0.0352 14.467519
## 49  2020-03-22 0.06729746 1.30776768 12.18974  0.0352 10.299752
## 50  2020-03-23        NaN 1.03199709 12.18974  0.0352       NaN
## 51  2020-03-24        NaN 0.90348096 12.18974  0.0352       NaN
## 52  2020-03-25        NaN 0.68409834 12.18974  0.0352       NaN
## 53  2020-03-26        NaN 0.66791248 12.18974  0.0352       NaN
## 54  2020-03-27        NaN 0.71312345 12.18974  0.0352       NaN
## 55  2020-03-28        NaN 0.86954441 12.18974  0.0352       NaN
## 56  2020-03-29        NaN 0.82442551 12.18974  0.0352       NaN
## 57  2020-03-30        NaN 0.62140532 12.18974  0.0352       NaN
## 58  2020-03-31        NaN 0.74522613 12.18974  0.0352       NaN
## 59  2020-04-01        NaN 0.72711535 12.18974  0.0352       NaN
## 60  2020-04-02        NaN 0.72668463 12.18974  0.0352       NaN
## 61  2020-04-03        NaN 0.67315040 12.18974  0.0352       NaN
## 62  2020-04-04        NaN 0.95362956 12.18974  0.0352       NaN
## 63  2020-04-05        NaN 0.75126381 12.18974  0.0352       NaN
## 64  2020-04-06        NaN 0.64342443 12.18974  0.0352       NaN
## 65  2020-04-07        NaN 0.63846066 12.18974  0.0352       NaN
## 66  2020-04-08        NaN 0.67893946 12.18974  0.0352       NaN
```

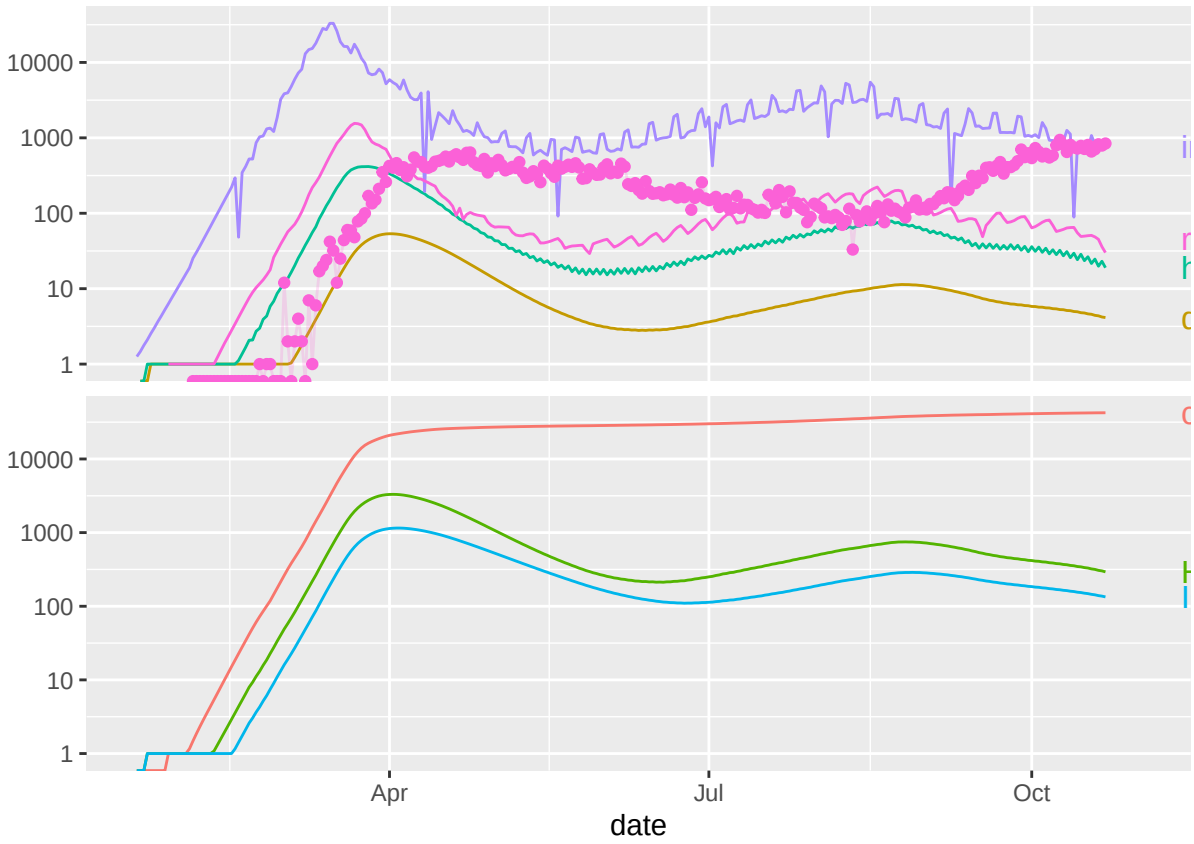
```
##  67  2020-04-09        NaN 0.89435527 12.18974  0.0352       NaN
##  68  2020-04-10        NaN 0.04756159 12.18974  0.0352       NaN
##  69  2020-04-11        NaN 1.06204711 12.18974  0.0352       NaN
##  70  2020-04-12        NaN 0.26743090 12.18974  0.0352       NaN
##  71  2020-04-13        NaN 0.43384930 12.18974  0.0352       NaN
##  72  2020-04-14        NaN 0.70231738 12.18974  0.0352       NaN
##  73  2020-04-15        NaN 0.68848302 12.18974  0.0352       NaN
##  74  2020-04-16        NaN 0.66791248 12.18974  0.0352       NaN
##  75  2020-04-17        NaN 0.63589846 12.18974  0.0352       NaN
##  76  2020-04-18        NaN 1.02092310 12.18974  0.0352       NaN
##  77  2020-04-19        NaN 0.83296700 12.18974  0.0352       NaN
##  78  2020-04-20        NaN 0.76011453 12.18974  0.0352       NaN
##  79  2020-04-21        NaN 0.67049887 12.18974  0.0352       NaN
##  80  2020-04-22        NaN 0.74183515 12.18974  0.0352       NaN
##  81  2020-04-23        NaN 0.75556870 12.18974  0.0352       NaN
##  82  2020-04-24        NaN 0.72916783 12.18974  0.0352       NaN
##  83  2020-04-25 0.18497333 1.15502958 12.18974  0.0352  3.747282
##  84  2020-04-26        NaN 0.96332162 12.18974  0.0352       NaN
##  85  2020-04-27        NaN 0.85963928 12.18974  0.0352       NaN
##  86  2020-04-28        NaN 0.88612789 12.18974  0.0352       NaN
##  87  2020-04-29        NaN 0.82234665 12.18974  0.0352       NaN
##  88  2020-04-30        NaN 0.88541691 12.18974  0.0352       NaN
##  89  2020-05-01        NaN 0.93844965 12.18974  0.0352       NaN
##  90  2020-05-02 0.07357987 1.28602006 12.18974  0.0352  9.420337
##  91  2020-05-03 0.04833166 1.47603526 12.18974  0.0352 14.341472
##  92  2020-05-04        NaN 0.96845184 12.18974  0.0352       NaN
##  93  2020-05-05        NaN 1.00816436 12.18974  0.0352       NaN
##  94  2020-05-06        NaN 1.05549654 12.18974  0.0352       NaN
##  95  2020-05-07        NaN 1.03063040 12.18974  0.0352       NaN
##  96  2020-05-08        NaN 0.96545996 12.18974  0.0352       NaN
##  97  2020-05-09 0.04916534 1.61661780 12.18974  0.0352 14.098288
##  98  2020-05-10 0.06333904 1.93841550 12.18974  0.0352 10.943443
##  99  2020-05-11        NaN 1.05077987 12.18974  0.0352       NaN
## 100 2020-05-12 0.14228965 1.18081023 12.18974  0.0352  4.871382
## 101 2020-05-13 0.06898708 1.30140074 12.18974  0.0352 10.047493
## 102 2020-05-14 0.09445927 1.23747305 12.18974  0.0352  7.338053
## 103 2020-05-15 0.11737260 1.20465711 12.18974  0.0352  5.905528
## 104 2020-05-16 0.06783482 2.02617696 12.18974  0.0352 10.218163
## 105 2020-05-17 0.07070614 2.08215690 12.18974  0.0352  9.803211
## 106 2020-05-18        NaN 0.20893394 12.18974  0.0352       NaN
## 107 2020-05-19 0.04982808 1.63897025 12.18974  0.0352 13.910774
## 108 2020-05-20 0.05600312 1.79012146 12.18974  0.0352 12.376938
## 109 2020-05-21 0.05498728 1.76822124 12.18974  0.0352 12.605592
## 110 2020-05-22 0.05172021 1.69193421 12.18974  0.0352 13.401862
## 111 2020-05-23 0.10182282 2.72619917 12.18974  0.0352  6.807385
## 112 2020-05-24 0.10064296 2.70006511 12.18974  0.0352  6.887190
## 113 2020-05-25 0.05505842 1.76977464 12.18974  0.0352 12.589304
## 114 2020-05-26 0.05686874 1.80837600 12.18974  0.0352 12.188544
## 115 2020-05-27 0.05973368 1.86696401 12.18974  0.0352 11.603959
## 116 2020-05-28 0.05417444 1.75022675 12.18974  0.0352 12.794726
## 117 2020-05-29 0.05429216 1.75286291 12.18974  0.0352 12.766986
## 118 2020-05-30 0.11920072 3.12913796 12.18974  0.0352  5.814958
## 119 2020-05-31 0.12528697 3.27849290 12.18974  0.0352  5.532476
## 120 2020-06-01 0.06776671 2.02485037 12.18974  0.0352 10.228432
```

```
## 121 2020-06-02 0.06039625 1.88023262 12.18974  0.0352 11.476659
## 122 2020-06-03 0.06051389 1.88258036 12.18974  0.0352 11.454349
## 123 2020-06-04 0.06728253 2.01541970 12.18974  0.0352 10.302038
## 124 2020-06-05 0.06288580 1.92951432 12.18974  0.0352 11.022316
## 125 2020-06-06 0.12993816 3.39559876 12.18974  0.0352  5.334439
## 126 2020-06-07 0.13916251 3.63559570 12.18974  0.0352  4.980847
## 127 2020-06-08 0.07368413 2.14048462 12.18974  0.0352  9.407008
## 128 2020-06-09 0.07115549 2.09093528 12.18974  0.0352  9.741303
## 129 2020-06-10 0.06927608 2.05425769 12.18974  0.0352 10.005577
## 130 2020-06-11 0.07772853 2.22045824 12.18974  0.0352  8.917539
## 131 2020-06-12 0.07914377 2.24870365 12.18974  0.0352  8.758076
## 132 2020-06-13 0.15789503 4.15563053 12.18974  0.0352  4.389924
## 133 2020-06-14 0.16492032 4.36229690 12.18974  0.0352  4.202922
## 134 2020-06-15 0.08938410 2.45808155 12.18974  0.0352  7.754704
## 135 2020-06-16 0.09099238 2.49185208 12.18974  0.0352  7.617639
## 136 2020-06-17 0.08994896 2.46991339 12.18974  0.0352  7.706005
## 137 2020-06-18 0.08960133 2.46262797 12.18974  0.0352  7.735903
## 138 2020-06-19 0.09126522 2.49760647 12.18974  0.0352  7.594867
## 139 2020-06-20 0.17066657 4.53618740 12.18974  0.0352  4.061412
## 140 2020-06-21 0.17955232 4.81383914 12.18974  0.0352  3.860419
## 141 2020-06-22 0.08073225 2.28058836 12.18974  0.0352  8.585754
## 142 2020-06-23 0.07747189 2.21535184 12.18974  0.0352  8.947080
## 143 2020-06-24 0.09086192 2.48910298 12.18974  0.0352  7.628578
## 144 2020-06-25 0.09504190 2.57803740 12.18974  0.0352  7.293070
## 145 2020-06-26 0.09519248 2.58127487 12.18974  0.0352  7.281533
## 146 2020-06-27 0.16025894 4.22444925 12.18974  0.0352  4.325170
## 147 2020-06-28 0.18254192 4.90968191 12.18974  0.0352  3.797194
## 148 2020-06-29 0.10268172 2.74531919 12.18974  0.0352  6.750444
## 149 2020-06-30 0.13633704 3.56097741 12.18974  0.0352  5.084071
## 150 2020-07-01        NaN 0.77135411 12.18974  0.0352       NaN
## 151 2020-07-02 0.10486792 2.79435149 12.18974  0.0352  6.609716
## 152 2020-07-03 0.08498429 2.36697076 12.18974  0.0352  8.156180
## 153 2020-07-04 0.17006644 4.51782019 12.18974  0.0352  4.075744
## 154 2020-07-05 0.18029980 4.83768691 12.18974  0.0352  3.844414
## 155 2020-07-06 0.09770246 2.63558623 12.18974  0.0352  7.094470
## 156 2020-07-07 0.09691706 2.61852029 12.18974  0.0352  7.151962
## 157 2020-07-08 0.10014740 2.68913341 12.18974  0.0352  6.921270
## 158 2020-07-09 0.10036580 2.69394784 12.18974  0.0352  6.906209
## 159 2020-07-10 0.09413595 2.55861044 12.18974  0.0352  7.363257
## 160 2020-07-11 0.15937980 4.19877032 12.18974  0.0352  4.349028
## 161 2020-07-12 0.18137421 4.87209987 12.18974  0.0352  3.821641
## 162 2020-07-13 0.10023475 2.69105852 12.18974  0.0352  6.915238
## 163 2020-07-14 0.10089001 2.70552492 12.18974  0.0352  6.870325
## 164 2020-07-15 0.10325001 2.75801435 12.18974  0.0352  6.713289
## 165 2020-07-16 0.09866271 2.65654071 12.18974  0.0352  7.025422
## 166 2020-07-17 0.10612053 2.82268340 12.18974  0.0352  6.531697
## 167 2020-07-18 0.18496828 4.98837742 12.18974  0.0352  3.747384
## 168 2020-07-19 0.16421872 4.34136611 12.18974  0.0352  4.220878
## 169 2020-07-20 0.11196611 2.95722485 12.18974  0.0352  6.190687
## 170 2020-07-21 0.11038185 2.92038031 12.18974  0.0352  6.279540
## 171 2020-07-22 0.10250688 2.74142050 12.18974  0.0352  6.761958
## 172 2020-07-23 0.11173930 2.95193255 12.18974  0.0352  6.203253
## 173 2020-07-24 0.10909102 2.89057059 12.18974  0.0352  6.353843
## 174 2020-07-25 0.18776280 5.08003060 12.18974  0.0352  3.691611
```

```
## 175 2020-07-26 0.19094516 5.18573930 12.18974  0.0352  3.630085
## 176 2020-07-27 0.09931763 2.67088860 12.18974  0.0352  6.979095
## 177 2020-07-28 0.10880583 2.88400995 12.18974  0.0352  6.370496
## 178 2020-07-29 0.11528885 3.03543153 12.18974  0.0352  6.012266
## 179 2020-07-30 0.12357488 3.23603651 12.18974  0.0352  5.609127
## 180 2020-07-31 0.12112931 3.17599277 12.18974  0.0352  5.722374
## 181 2020-08-01 0.19618925 5.36306496 12.18974  0.0352  3.533054
## 182 2020-08-02 0.16812312 4.45867543 12.18974  0.0352  4.122855
## 183 2020-08-03 0.51778832 1.11303376 12.18974  0.0352  1.338669
## 184 2020-08-04 0.11060709 2.92560132 12.18974  0.0352  6.266752
## 185 2020-08-05 0.12565815 3.28774333 12.18974  0.0352  5.516134
## 186 2020-08-06 0.12535432 3.28017017 12.18974  0.0352  5.529504
## 187 2020-08-07 0.11405943 3.00634740 12.18974  0.0352  6.077070
## 188 2020-08-08 0.20223395 5.57235998 12.18974  0.0352  3.427452
## 189 2020-08-09 0.19634546 5.36840736 12.18974  0.0352  3.530243
## 190 2020-08-10 0.11832483 3.10800197 12.18974  0.0352  5.858003
## 191 2020-08-11 0.11685008 3.07261689 12.18974  0.0352  5.931936
## 192 2020-08-12 0.12322770 3.22746948 12.18974  0.0352  5.624930
## 193 2020-08-13 0.12570156 3.28882611 12.18974  0.0352  5.514229
## 194 2020-08-14 0.11677867 3.07090991 12.18974  0.0352  5.935563
## 195 2020-08-15 0.20178303 5.55656424 12.18974  0.0352  3.435111
## 196 2020-08-16 0.18231352 4.90231620 12.18974  0.0352  3.801952
## 197 2020-08-17 0.06052835 1.88286881 12.18974  0.0352 11.451612
## 198 2020-08-18 0.07011374 2.07059348 12.18974  0.0352  9.886039
## 199 2020-08-19 0.07060649 2.08021100 12.18974  0.0352  9.817047
## 200 2020-08-20 0.07394427 2.14559935 12.18974  0.0352  9.373913
## 201 2020-08-21 0.06811267 2.03158913 12.18974  0.0352 10.176479
## 202 2020-08-22 0.13755179 3.59293738 12.18974  0.0352  5.039172
## 203 2020-08-23 0.14107581 3.68668438 12.18974  0.0352  4.913296
## 204 2020-08-24 0.06636627 1.99756880 12.18974  0.0352 10.444269
## 205 2020-08-25 0.07173672 2.10230076 12.18974  0.0352  9.662376
## 206 2020-08-26 0.07258775 2.11896586 12.18974  0.0352  9.549094
## 207 2020-08-27 0.07292915 2.12566040 12.18974  0.0352  9.504391
## 208 2020-08-28 0.07045223 2.07719951 12.18974  0.0352  9.838541
## 209 2020-08-29 0.13863493 3.62158797 12.18974  0.0352  4.999802
## 210 2020-08-30 0.15200127 3.98720223 12.18974  0.0352  4.560141
## 211 2020-08-31 0.07525414 2.17140988 12.18974  0.0352  9.210752
## 212 2020-09-01 0.07537055 2.17370863 12.18974  0.0352  9.196525
## 213 2020-09-02 0.07265878 2.12035841 12.18974  0.0352  9.539757
## 214 2020-09-03 0.07759408 2.21778252 12.18974  0.0352  8.932991
## 215 2020-09-04 0.07548299 2.17592958 12.18974  0.0352  9.182827
## 216 2020-09-05 0.13803318 3.60565306 12.18974  0.0352  5.021598
## 217 2020-09-06 0.16252893 4.29122097 12.18974  0.0352  4.264762
## 218 2020-09-07        NaN 0.27343861 12.18974  0.0352       NaN
## 219 2020-09-08 0.07394045 2.14552417 12.18974  0.0352  9.374397
## 220 2020-09-09 0.07408319 2.14833207 12.18974  0.0352  9.356336
## 221 2020-09-10 0.07576484 2.18150052 12.18974  0.0352  9.148666
## 222 2020-09-11 0.12400536 3.24667888 12.18974  0.0352  5.589655
## 223 2020-09-12 0.19948287 5.47645014 12.18974  0.0352  3.474720
## 224 2020-09-13 0.18528803 4.99880901 12.18974  0.0352  3.740917
## 225 2020-09-14 0.13028000 3.40430805 12.18974  0.0352  5.320442
## 226 2020-09-15 0.13255763 3.46269691 12.18974  0.0352  5.229025
## 227 2020-09-16 0.12413597 3.24991207 12.18974  0.0352  5.583774
## 228 2020-09-17 0.12679955 3.31629194 12.18974  0.0352  5.466480
```

```
## 229 2020-09-18 0.13051266 3.41024366 12.18974  0.0352  5.310957
## 230 2020-09-19 0.19880622 5.45302824 12.18974  0.0352  3.486547
## 231 2020-09-20 0.20390212 5.63105317 12.18974  0.0352  3.399411
## 232 2020-09-21 0.11923980 3.13008308 12.18974  0.0352  5.813052
## 233 2020-09-22 0.11996980 3.14777038 12.18974  0.0352  5.777681
## 234 2020-09-23 0.11966920 3.14047968 12.18974  0.0352  5.792194
## 235 2020-09-24 0.12297618 3.22127181 12.18974  0.0352  5.636435
## 236 2020-09-25 0.12251714 3.20998034 12.18974  0.0352  5.657553
## 237 2020-09-26 0.20079090 5.52191419 12.18974  0.0352  3.452085
## 238 2020-09-27 0.20066736 5.51760973 12.18974  0.0352  3.454210
## 239 2020-09-28 0.11875862 3.11845857 12.18974  0.0352  5.836605
## 240 2020-09-29 0.12177353 3.19174136 12.18974  0.0352  5.692100
## 241 2020-09-30 0.11966965 3.14049041 12.18974  0.0352  5.792172
## 242 2020-10-01 0.12856650 3.36079397 12.18974  0.0352  5.391351
## 243 2020-10-02 0.12034891 3.15698068 12.18974  0.0352  5.759480
## 244 2020-10-03 0.18848488 5.10389083 12.18974  0.0352  3.677468
## 245 2020-10-04 0.16677280 4.41787538 12.18974  0.0352  4.156236
## 246 2020-10-05 0.11867186 3.11636546 12.18974  0.0352  5.840872
## 247 2020-10-06 0.12027040 3.15507187 12.18974  0.0352  5.763240
## 248 2020-10-07 0.11442162 3.01489763 12.18974  0.0352  6.057834
## 249 2020-10-08 0.12804557 3.34763495 12.18974  0.0352  5.413285
## 250 2020-10-09 0.12557880 3.28576427 12.18974  0.0352  5.519620
## 251 2020-10-10 0.17793125 4.76238369 12.18974  0.0352  3.895590
## 252 2020-10-11 0.16462240 4.35340106 12.18974  0.0352  4.210528
## 253 2020-10-12        NaN 0.35571561 12.18974  0.0352       NaN
## 254 2020-10-13 0.11696426 3.07534756 12.18974  0.0352  5.926145
## 255 2020-10-14 0.11808049 3.10212199 12.18974  0.0352  5.870124
## 256 2020-10-15 0.11610571 3.05485247 12.18974  0.0352  5.969966
## 257 2020-10-16 0.12149675 3.18496922 12.18974  0.0352  5.705068
## 258 2020-10-17 0.18757161 5.07372512 12.18974  0.0352  3.695374
## 259 2020-10-18 0.15586288 4.09705071 12.18974  0.0352  4.447160
## 260 2020-10-19 0.15586288 4.09705071 12.18974  0.0352  4.447160
## 261 2020-10-20 0.15586288 4.09705071 12.18974  0.0352  4.447160
## 262 2020-10-21 0.15586288 4.09705071 12.18974  0.0352  4.447160
## 263 2020-10-22 0.15586288 4.09705071 12.18974  0.0352  4.447160
```

```
print(plot(ontmod_mob,data=calibrate_dat))
```



MLi: It is trying to fit a bit better.

Question: What assumptions are we making? Do we think mobility have the same effect throughout the pandemic?

Adding more mobility flexibilities

- mob break
- new mob intercept and slope
- smoother on the breakpoint

```
ontmod_mob2 <- calibrate_comb(data = calibrate_dat
    , params = newparams2
    , opt_pars = opt_pars
    , use_DEoptim = FALSE ## We don't want to wait that long
    , debug_plot = FALSE ## TRUE to watch fitting process, don't do it in rmd
    , mob_data = clean_mobdat
    , use_mobility = TRUE
    , mob_breaks = c("2020-04-15", "2020-08-8")
    , mob_breaks_int = TRUE
    , mob_logist_scale = 3
)


print(summary(ontmod_mob2))
```

```
##     start_date         r0        R0     Gbar CFR_gen  dbl_time
## 1   2020-01-20 0.13167067 3.4398844 12.18974  0.0352  5.264249
## 2   2020-02-04 0.13298168 3.4736374 12.18974  0.0352  5.212351
```

```
## 3   2020-02-05 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 4   2020-02-06 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 5   2020-02-07 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 6   2020-02-08 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 7   2020-02-09 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 8   2020-02-10 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 9   2020-02-11 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 10  2020-02-12 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 11  2020-02-13 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 12  2020-02-14 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 13  2020-02-15 0.13298168 3.4736374 12.18974  0.0352  5.212351
## 14  2020-02-16 0.13395727 3.4988901 12.18974  0.0352  5.174390
## 15  2020-02-17 0.11092108 2.9328890 12.18974  0.0352  6.249012
## 16  2020-02-18 0.13104289 3.4237953 12.18974  0.0352  5.289468
## 17  2020-02-19 0.13182761 3.4439139 12.18974  0.0352  5.257982
## 18  2020-02-20 0.13288083 3.4710335 12.18974  0.0352  5.216307
## 19  2020-02-21 0.13077643 3.4169810 12.18974  0.0352  5.300245
## 20  2020-02-22 0.13451735 3.5134403 12.18974  0.0352  5.152846
## 21  2020-02-23 0.13449432 3.5128410 12.18974  0.0352  5.153728
## 22  2020-02-24 0.13243181 3.4594551 12.18974  0.0352  5.233993
## 23  2020-02-25 0.13242512 3.4592827 12.18974  0.0352  5.234258
## 24  2020-02-26 0.13038256 3.4069237 12.18974  0.0352  5.316257
## 25  2020-02-27 0.12687809 3.3182621 12.18974  0.0352  5.463096
## 26  2020-02-28 0.12985912 3.3935872 12.18974  0.0352  5.337686
## 27  2020-02-29 0.13465375 3.5169893 12.18974  0.0352  5.147626
## 28  2020-03-01 0.13488783 3.5230857 12.18974  0.0352  5.138693
## 29  2020-03-02 0.13292045 3.4720563 12.18974  0.0352  5.214752
## 30  2020-03-03 0.13270519 3.4665015 12.18974  0.0352  5.223211
## 31  2020-03-04 0.13299629 3.4740146 12.18974  0.0352  5.211778
## 32  2020-03-05 0.13300286 3.4741843 12.18974  0.0352  5.211521
## 33  2020-03-06 0.13213449 3.4518018 12.18974  0.0352  5.245770
## 34  2020-03-07 0.13553129 3.5398781 12.18974  0.0352  5.114296
## 35  2020-03-08 0.13495850 3.5249275 12.18974  0.0352  5.136002
## 36  2020-03-09 0.13303891 3.4751155 12.18974  0.0352  5.210109
## 37  2020-03-10 0.13255512 3.4626322 12.18974  0.0352  5.229124
## 38  2020-03-11 0.13313401 3.4775726 12.18974  0.0352  5.206387
## 39  2020-03-12 0.13389052 3.4971587 12.18974  0.0352  5.176970
## 40  2020-03-13 0.13166295 3.4396863 12.18974  0.0352  5.264557
## 41  2020-03-14 0.13211414 3.4512786 12.18974  0.0352  5.246578
## 42  2020-03-15 0.13059897 3.4124473 12.18974  0.0352  5.307448
## 43  2020-03-16 0.12649892 3.3087574 12.18974  0.0352  5.479471
## 44  2020-03-17 0.12138560 3.1822522 12.18974  0.0352  5.710292
## 45  2020-03-18 0.11876536 3.1186213 12.18974  0.0352  5.836274
## 46  2020-03-19 0.11802970 3.1009005 12.18974  0.0352  5.872650
## 47  2020-03-20 0.11547774 3.0399156 12.18974  0.0352  6.002431
## 48  2020-03-21 0.11833144 3.1081613 12.18974  0.0352  5.857675
## 49  2020-03-22 0.11637634 3.0613037 12.18974  0.0352  5.956083
## 50  2020-03-23 0.11369578 2.9977778 12.18974  0.0352  6.096507
## 51  2020-03-24 0.11218204 2.9622687 12.18974  0.0352  6.178772
## 52  2020-03-25 0.10905034 2.8896343 12.18974  0.0352  6.356213
## 53  2020-03-26 0.10872723 2.8822032 12.18974  0.0352  6.375102
## 54  2020-03-27 0.10937422 2.8970946 12.18974  0.0352  6.337391
## 55  2020-03-28 0.11148469 2.9459984 12.18974  0.0352  6.217420
## 56  2020-03-29 0.11073916 2.9286652 12.18974  0.0352  6.259278
```

```
## 57  2020-03-30 0.10734595 2.8505691 12.18974  0.0352  6.457134
## 58  2020-03-31 0.10909735 2.8907163 12.18974  0.0352  6.353474
## 59  2020-04-01 0.10840588 2.8748245 12.18974  0.0352  6.394000
## 60  2020-04-02 0.10782917 2.8616116 12.18974  0.0352  6.428197
## 61  2020-04-03 0.10613138 2.8229294 12.18974  0.0352  6.531030
## 62  2020-04-04 0.10930907 2.8955929 12.18974  0.0352  6.341168
## 63  2020-04-05 0.10490582 2.7952063 12.18974  0.0352  6.607328
## 64  2020-04-06 0.10086251 2.7049168 12.18974  0.0352  6.872198
## 65  2020-04-07 0.09796799 2.6413709 12.18974  0.0352  7.075241
## 66  2020-04-08 0.09520782 2.5816047 12.18974  0.0352  7.280360
## 67  2020-04-09 0.09507969 2.5788497 12.18974  0.0352  7.290171
## 68  2020-04-10 0.04794866 1.5562794 12.18974  0.0352 14.456029
## 69  2020-04-11 0.08642552 2.3966147 12.18974  0.0352  8.020168
## 70  2020-04-12 0.05180435 1.6940724 12.18974  0.0352 13.380097
## 71  2020-04-13 0.05147836 1.6857112 12.18974  0.0352 13.464827
## 72  2020-04-14 0.05241783 1.7092977 12.18974  0.0352 13.223499
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## 74  2020-04-16 0.05659142 1.3633459 12.18974  0.0352 12.248274
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## 87  2020-04-29        NaN 0.8973190 12.18974  0.0352       NaN
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## 109 2020-05-21 0.06410705 1.3211244 12.18974  0.0352 10.812340
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## 263 2020-10-22 0.15895701 4.1864570 12.18974  0.0352  4.360595
```
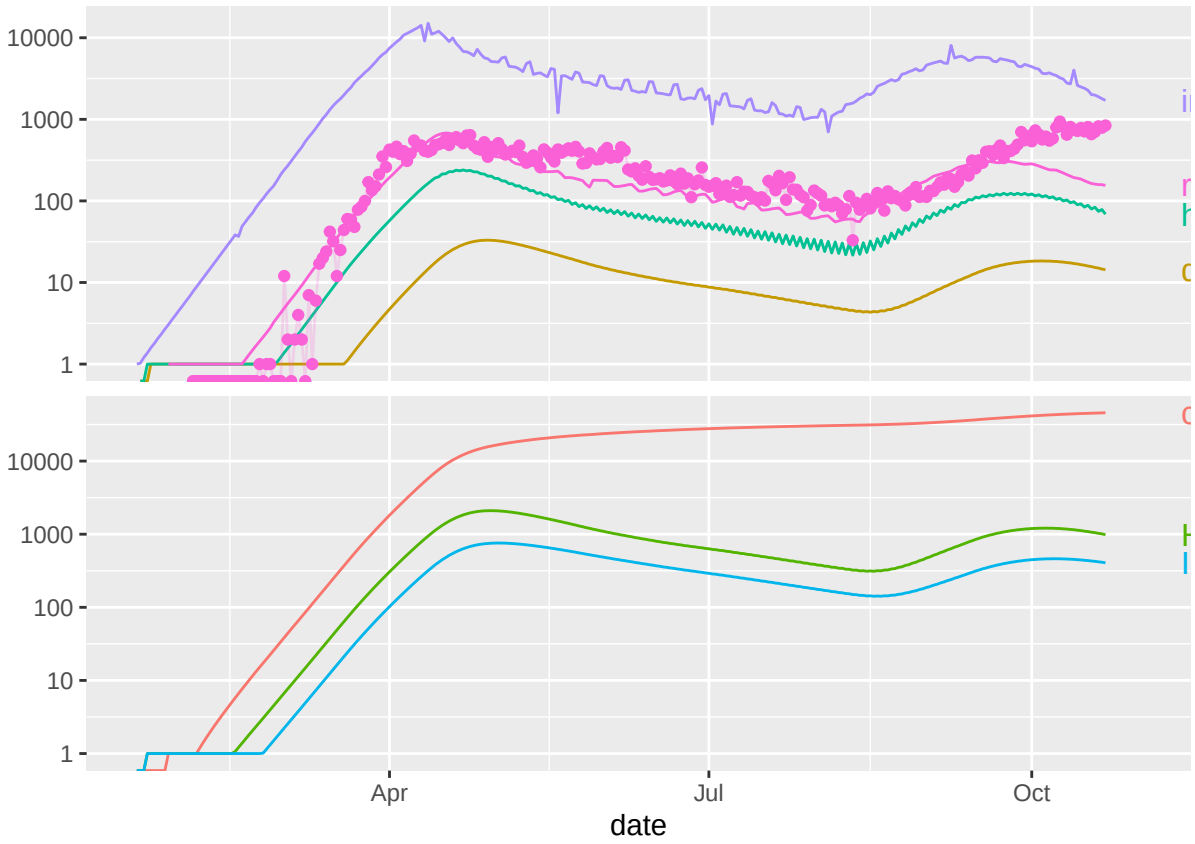

```
print(plot(ontmod_mob2,data=calibrate_dat))
```



MLi: The last curve down is probably due to new lockdown/stage restrictions. Maybe add another breakpoint, idk.