Example: Iterative fitting for multiple provinces in China (22-Jan-2020 -)

Table of Contents

In this example, the generalized SEIR model is automatically fitted to multiple provinces in China. As in the previous examples, I am taking some data, collected into DATA.mat from John Hopkins university [1]. To keep the computation as short as possible, the option "iter" is removed using an optional argument.

[1] https://github.com/CSSEGISandData/COVID-19

Initialisation

The parameters are here taken as constant except the death rate and the cure rate.

```
clearvars;close all;clc;
% Download the data from ref [1] and read them with the function getDataCOVID
[tableConfirmed,tableDeaths,tableRecovered,time] = getDataCOVID();
% time = time(1:end-1);
fprintf(['Most recent update: ',datestr(time(end)),'\n'])
```

```
Most recent update: 27-Jun-2020
```

```


Location = 'China';


try
    indR = find(contains(tableRecovered.CountryRegion,Location)==1);
    indC = find(contains(tableConfirmed.CountryRegion,Location)==1);
    indD = find(contains(tableDeaths.CountryRegion,Location)==1);
catch exception
    searchLoc = strfind(tableRecovered.CountryRegion,Location);
    indR = find(~cellfun(@isempty,searchLoc)) ;

    searchLoc = strfind(tableConfirmed.CountryRegion,Location);
    indC = find(~cellfun(@isempty,searchLoc)) ;

    searchLoc = strfind(tableDeaths.CountryRegion,Location);
    indD = find(~cellfun(@isempty,searchLoc));
end

% disp(tableRecovered(indR,1:2))
disp(tableConfirmed(indC,1:2))
```

ProvinceState	CountryRegion

```
    "Anhui"                "China"
    "Beijing"              "China"
    "Chongqing"            "China"
    "Fujian"               "China"
    "Gansu"                "China"
    "Guangdong"            "China"
    "Guangxi"              "China"
    "Guizhou"              "China"
    "Hainan"               "China"
    "Hebei"                "China"
    "Heilongjiang"         "China"
    "Henan"                "China"
    "Hong Kong"            "China"
    "Hubei"                "China"
    "Hunan"                "China"
    "Inner Mongolia"       "China"
    "Jiangsu"              "China"
    "Jiangxi"              "China"
    "Jilin"                "China"
    "Liaoning"             "China"
    "Macau"                "China"
    "Ningxia"              "China"
    "Qinghai"              "China"
    "Shaanxi"              "China"
    "Shandong"             "China"
    "Shanghai"             "China"
    "Shanxi"               "China"
    "Sichuan"              "China"
    "Tianjin"              "China"
    "Tibet"                "China"
    "Xinjiang"             "China"
    "Yunnan"               "China"
    "Zhejiang"             "China"
```

```
% disp(tableDeaths(indD,1:2))

% If the number of confirmed Confirmed cases is small, it is difficult to know whether
% the quarantine has been rigorously applied or not. In addition, this
% suggests that the number of infectious is much larger than the number of
% confirmed cases
```

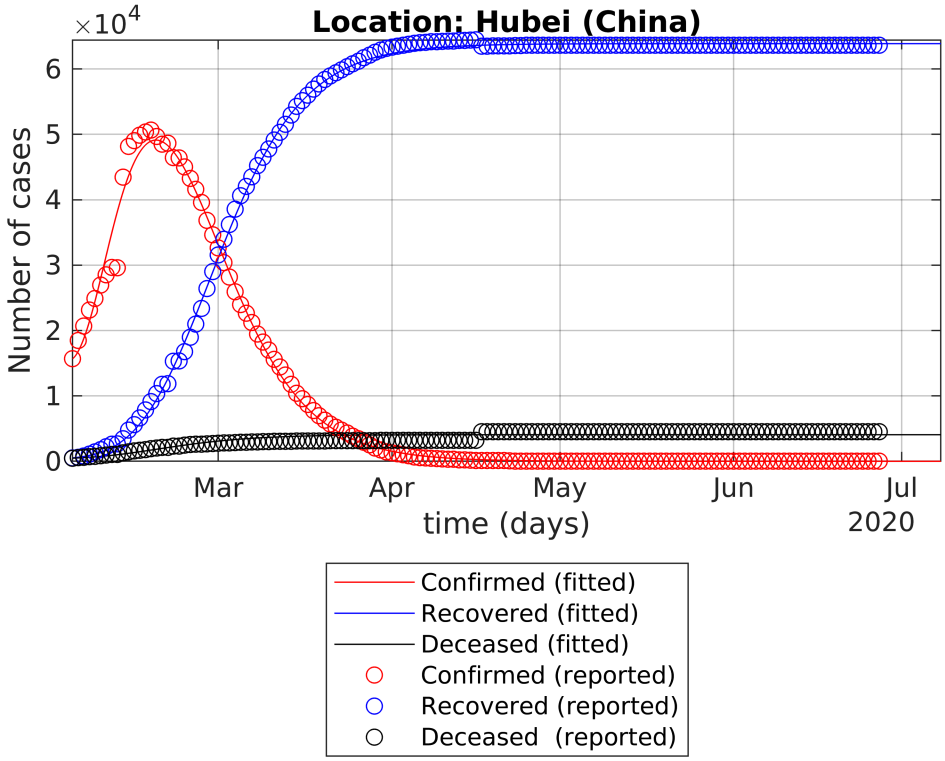
Iterative application of fit_SEIQRDP

```
timeRef = time; % Used in the loop only



for ii = 1:min([numel(indR),numel(indC),numel(indD)])
    Recovered = table2array(tableRecovered(indR(ii),5:end));
    Deaths = table2array(tableDeaths(indD(ii),5:end));
    Confirmed = table2array(tableConfirmed(indC(ii),5:end));
    minNum= max(200,round(0.2*max(Confirmed)));


    % Warning! a dummy value of Npop is used here. If you want a realistic
    % value for beta, you need to specify the correct value for Npop
     Npop= 30e6; % population (It affects the values of the parameters)
```

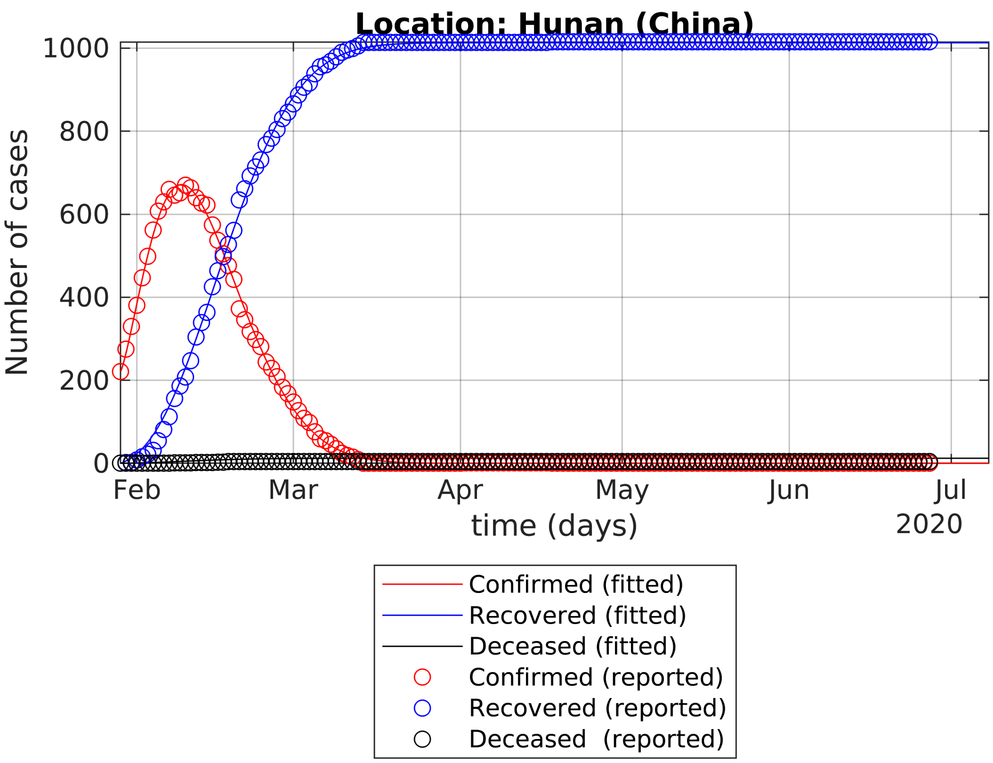
```
    % Remove case where only few infectious are recorded (to avoid bad
    % initial conditions)
    Recovered(Confirmed<=minNum)=[];
    Deaths(Confirmed<=minNum)=[];
    time = timeRef; % trick to avoid reloading the variable "time" at each new loop
    time(Confirmed<=minNum)= [];
    Confirmed(Confirmed<=minNum)=[];
    Active = Confirmed-Recovered-Deaths;
    Active(Active<0) = 0; % No negative number possible
    [~,indMin] = min(Active);
    % The fitting is only applied if enough data is collected (that is why
    % I use the case of China)
    if numel(Confirmed)>30% quick and dirty way to select high-quality dataset (more th
        tic

        % Definition of the first estimates for the parameters
        alpha_guess = 0.06; % protection rate
        beta_guess = 0.8; % Infection rate
        LT_guess = 5; % latent time in days
        Q_guess = 0.5; % rate at which infectious people enter in quarantine
        lambda_guess = [0.01,0.01,10]; % recovery rate
        kappa_guess = [0.005,0.005,10]; % death rate

        guess = [alpha_guess,beta_guess,1/LT_guess, Q_guess,lambda_guess,kappa_guess];

        % Initial conditions
        Q0 = Confirmed(1)-Recovered(1)-Deaths(1);
        I0 = 0.2*Q0; % Initial number of infectious cases. Unknown but unlikely to be z
        E0 = Q0; % Initial number of exposed cases. Unknown but unlikely to be zero.
        R0 = Recovered(1);
        D0 = Deaths(1);


        [alpha1,beta1,gamma1,delta1,Lambda1,Kappa1,lambdaFun,kappaFun] = ...
            fit_SEIQRDP(Active,Recovered,Deaths,Npop,E0,I0,time,guess,'Display','off');

%         disp(alpha1);
%         disp(beta1);
%         disp(gamma1)
%         disp(delta1)
%         disp(Lambda1);
%         disp(Kappa1)

        dt = 1/24; % time step
        time1 = datetime(time(1), 'Locale', 'en_US'):dt:datetime(datestr(floor(datenum(
        N = numel(time1);
        t = [0:N-1].*dt;


        % Call of the function SEIQRDP.m with the fitted parameters
        [S,E,I,Q,R,D,P] = SEIQRDP(alpha1,beta1,gamma1,delta1,Lambda1,Kappa1,...
            Npop,E0,I0,Q0,R0,D0,t,lambdaFun,kappaFun);
```

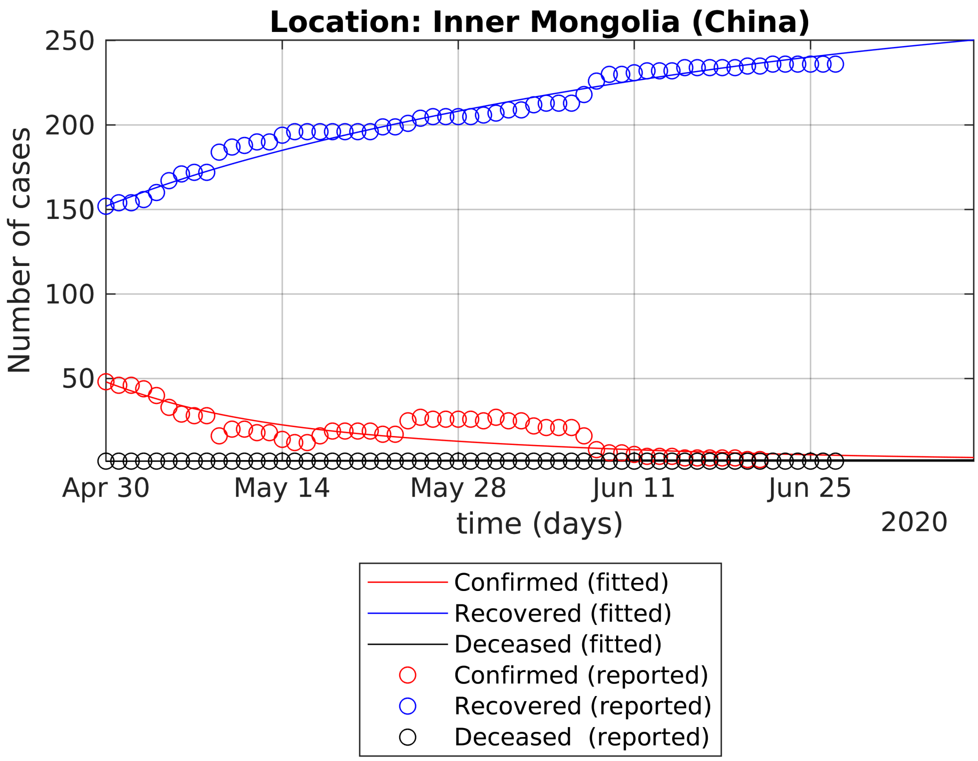
```
        figure

        semilogy(time1,Q,'r',time1,R,'b',time1,D,'k');
        hold on
        semilogy(time,Active,'ro',time,Recovered,'bo',time,Deaths,'ko');
        % ylim([0,1.1*Npop])
        ylabel('Number of cases')
        xlabel('time (days)')
        leg = {'Confirmed (fitted)',...
        'Recovered (fitted)','Deceased (fitted)',...
        'Confirmed (reported)','Recovered (reported)','Deceased  (reported)'};
        legend(leg{:},'location','southoutside');
        set(gcf,'color','w')

        %%% title %%%
        subLoc = char(table2array(tableRecovered(indR(ii),1)));
        Loc = char(table2array(tableRecovered(indR(ii),2)));
        title(['Location: ',subLoc,' (',Loc,')'])
        %%%%%%%%%%%%%

        grid on
        axis tight
        set(gca,'yscale','lin')
        toc

        pause(1)
    end
end
```

```
Elapsed time is 26.834035 seconds.
Elapsed time is 20.924616 seconds.

Elapsed time is 44.835096 seconds.


Elapsed time is 9.446558 seconds.

Elapsed time is 19.639287 seconds.
Elapsed time is 23.701926 seconds.


Elapsed time is 7.436907 seconds.

Elapsed time is 22.003936 seconds.
Elapsed time is 24.743783 seconds.


Elapsed time is 22.751113 seconds.

Elapsed time is 23.249421 seconds.
Elapsed time is 12.563553 seconds.
```

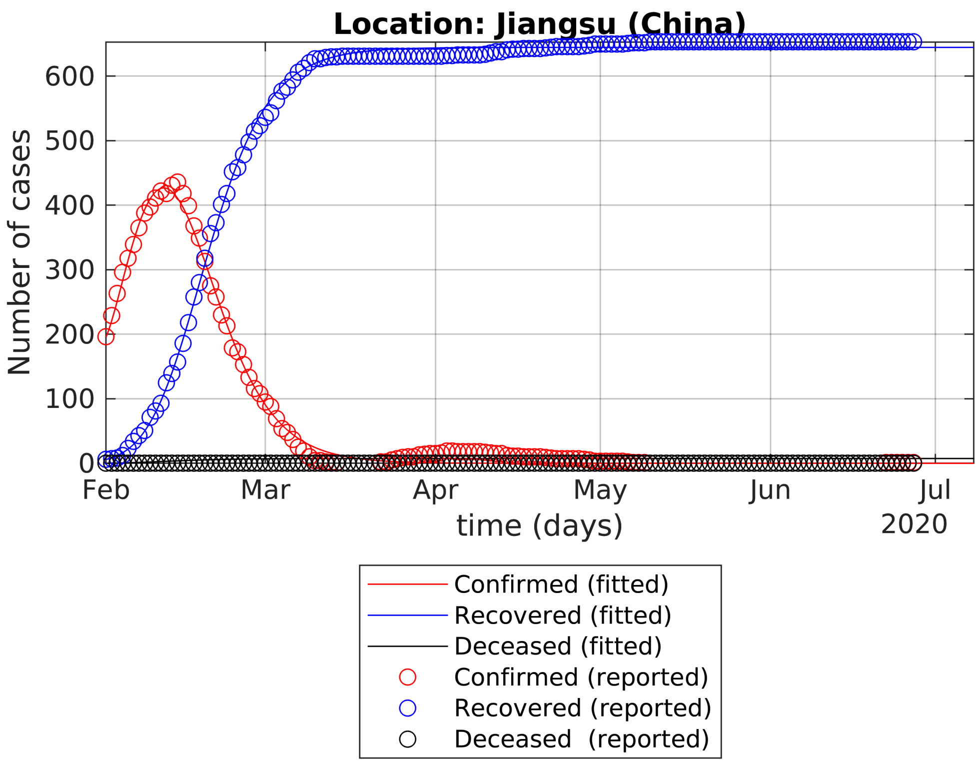



```
Elapsed time is 16.536504 seconds.
```

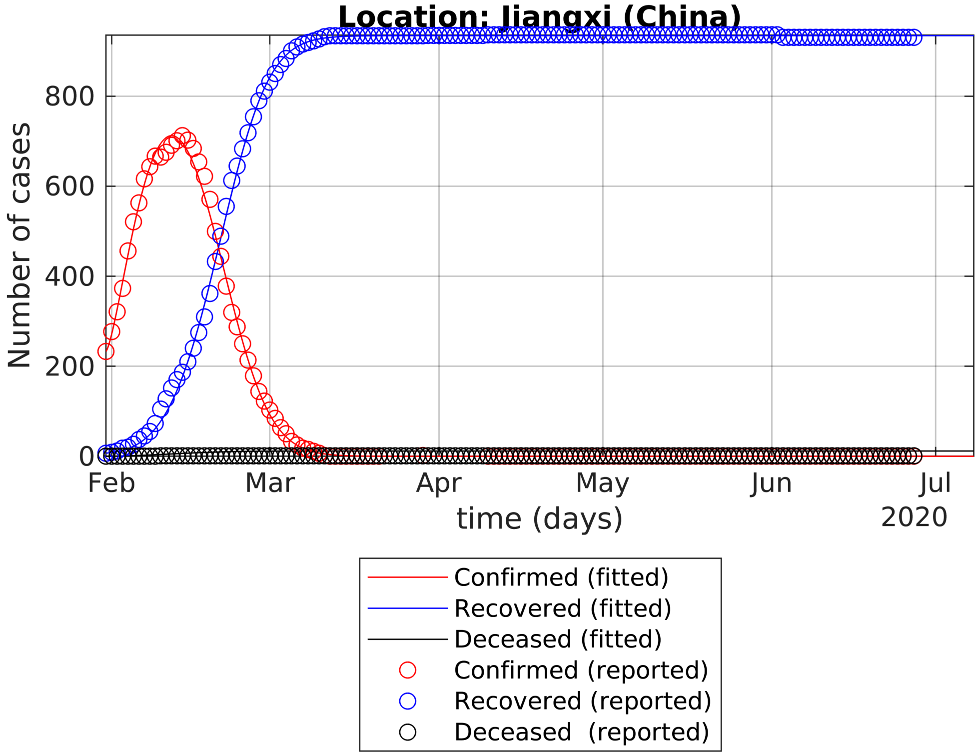




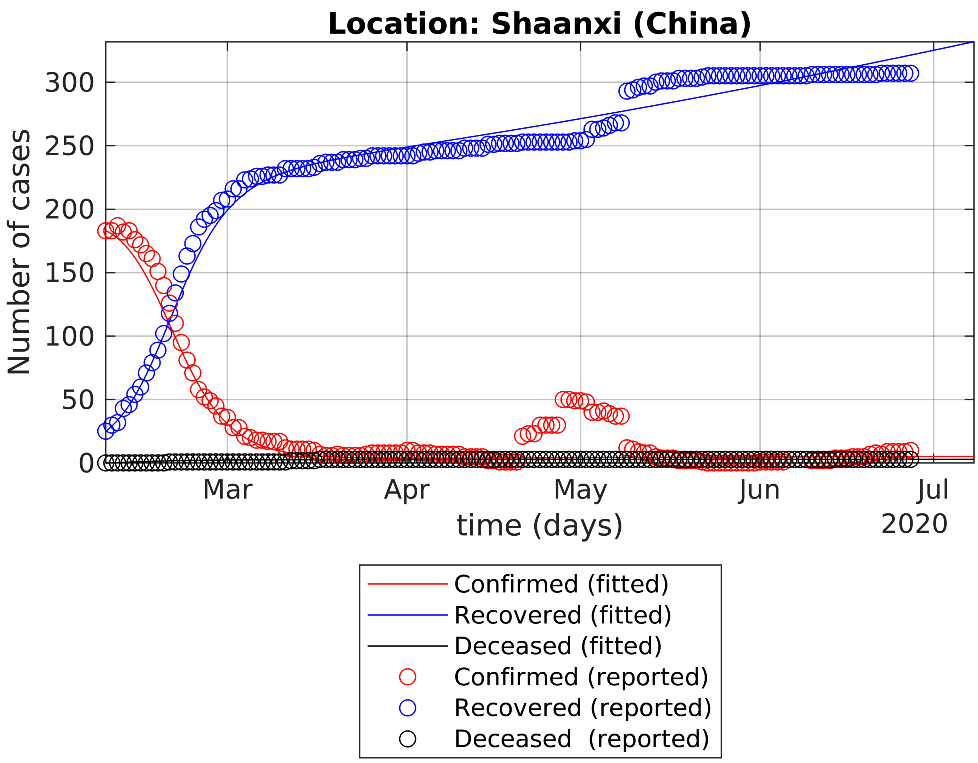

```
Elapsed time is 8.361086 seconds.
```

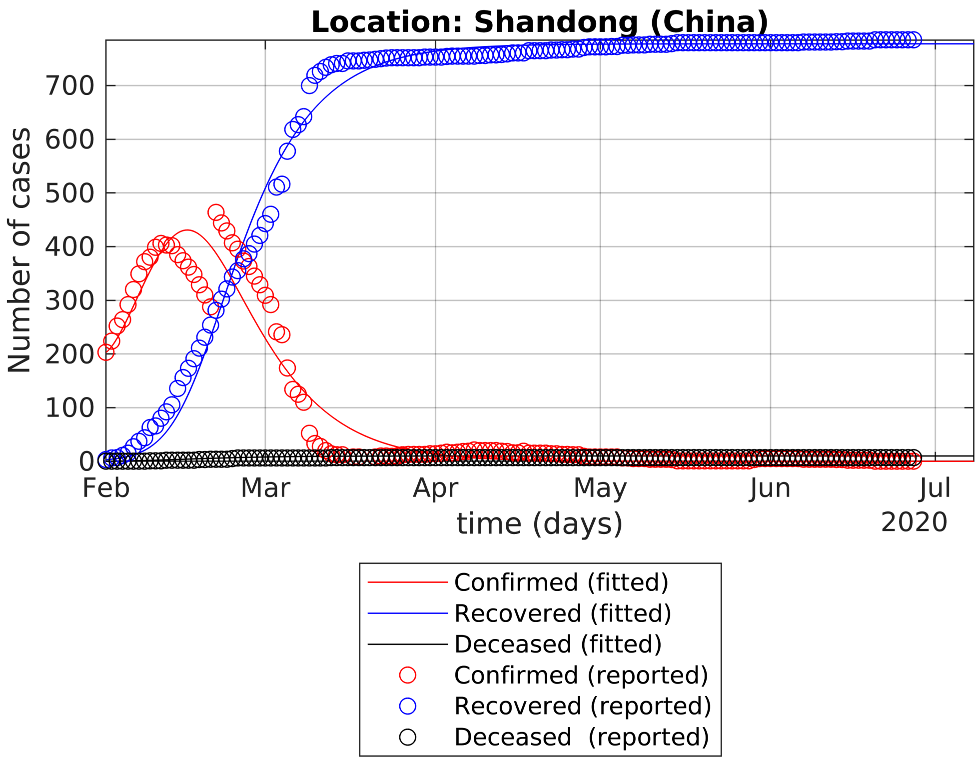



```
Elapsed time is 16.524823 seconds.
Elapsed time is 15.115279 seconds.
```

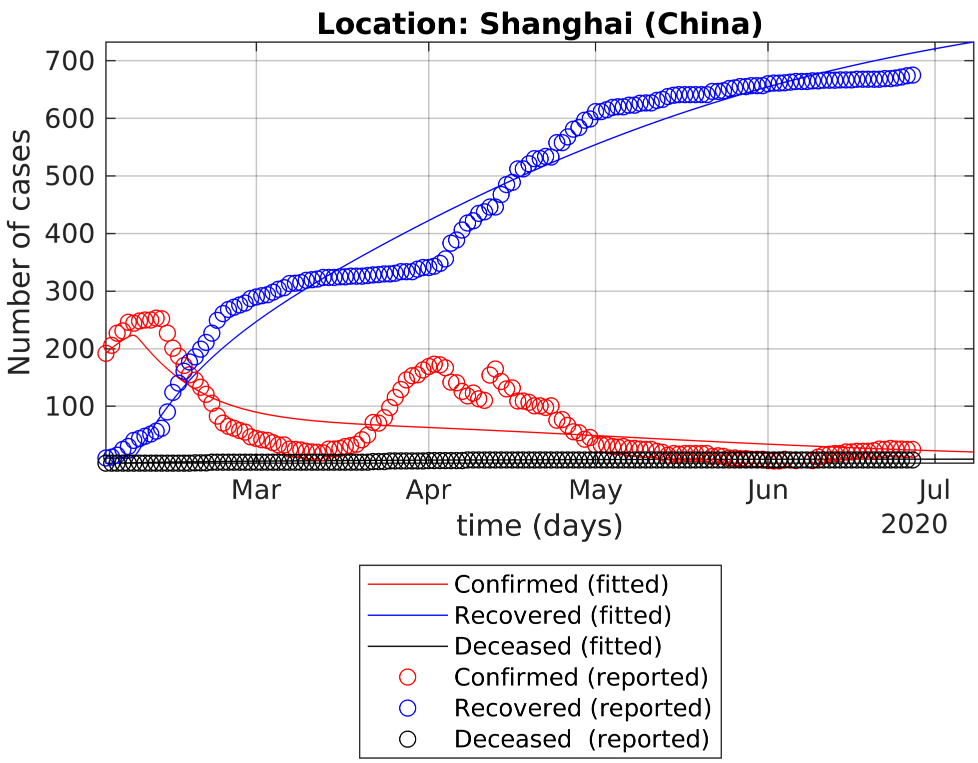


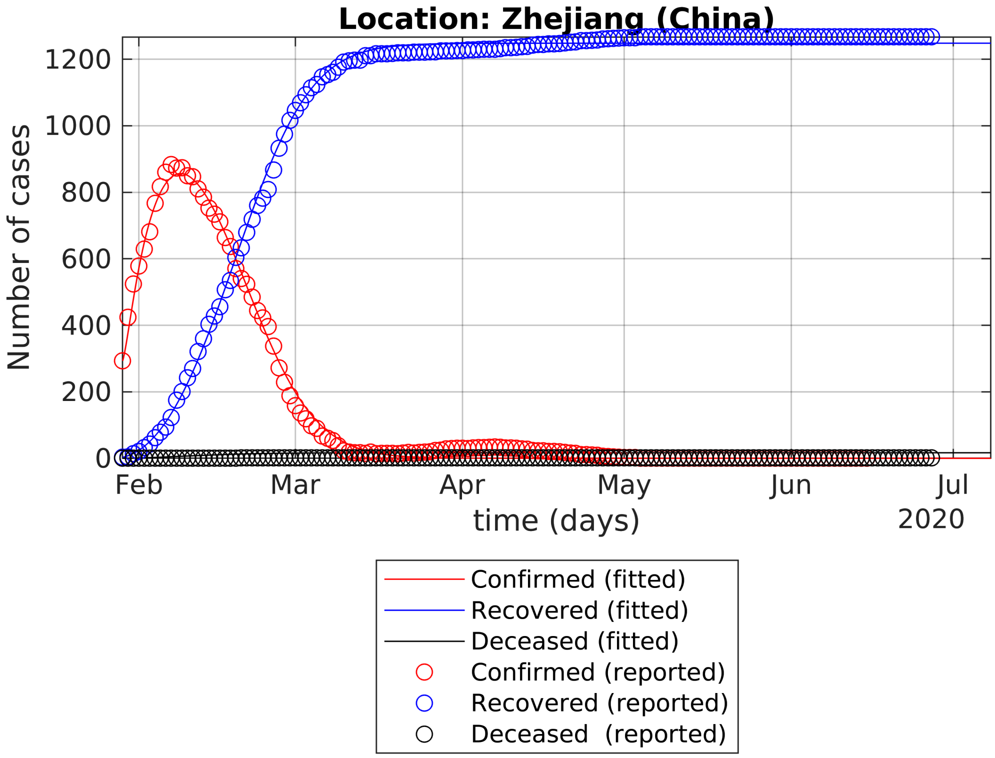

```
Elapsed time is 16.161205 seconds.
```






```
Elapsed time is 19.118127 seconds.
Elapsed time is 11.132687 seconds.
```






```
Elapsed time is 13.230047 seconds.
```