What Can Be Estimated From Early Phase Fatality Data?

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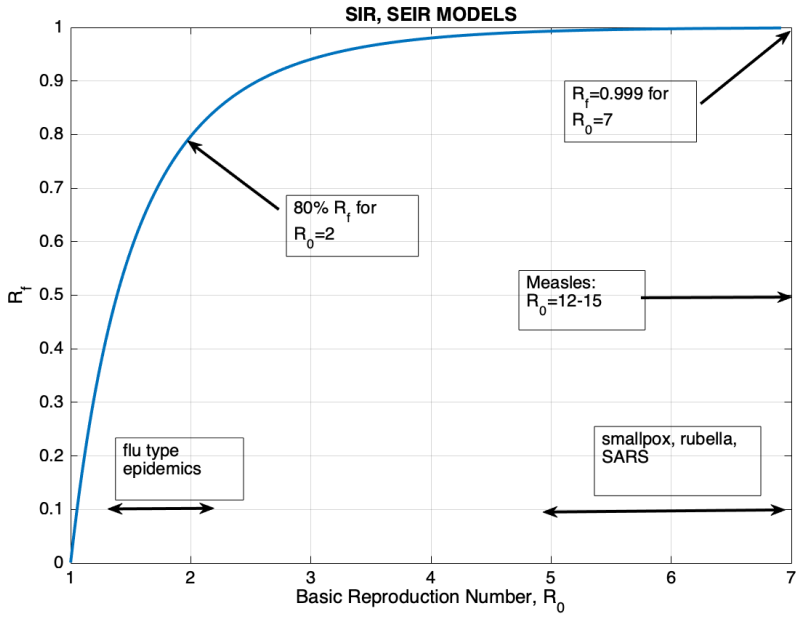
http://epikhas.khas.edu.tr

The Susceptible-Infected-Removed (SIR) model

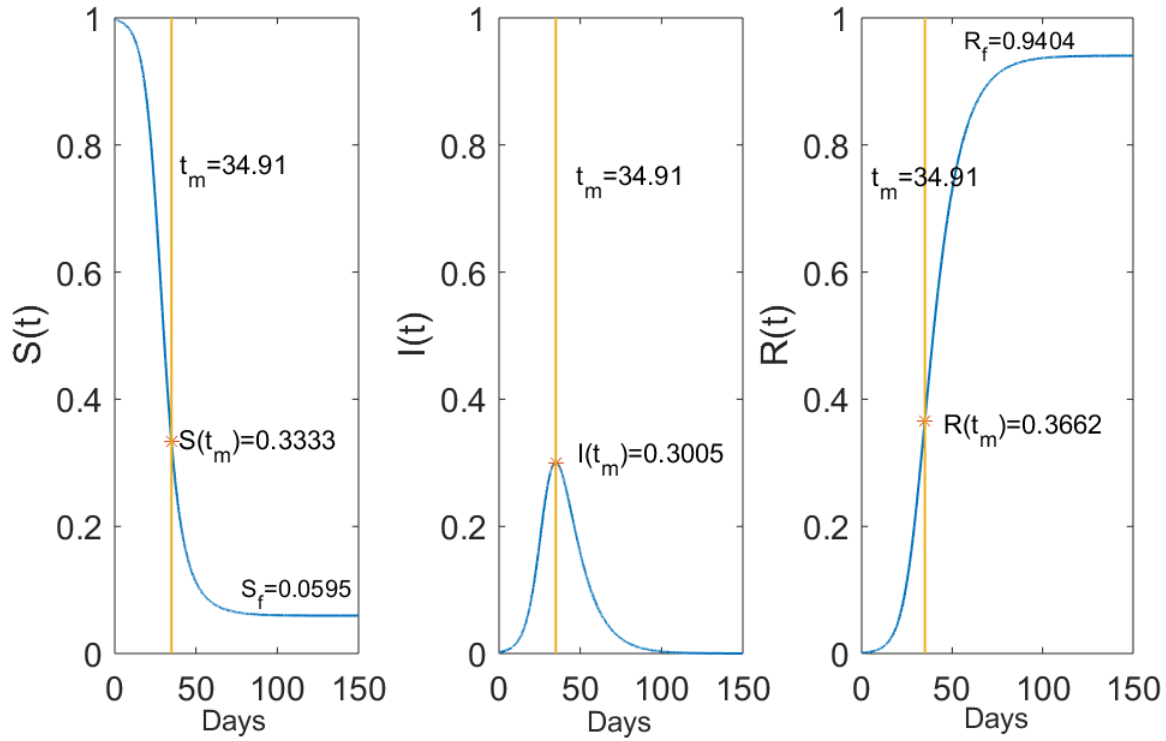
Assumptions

- Data is time homogeneous
- Susceptible individuals get infected upon contact with infected individuals.
- Infected individuals get well after a certain period and gain permanant immunity.
- $S' = -\beta SI$, $I' = \beta SI - \eta I$, $R' = \eta I$
- $R0 = \beta/\eta$, $T = 1/\eta$
- As $t \rightarrow \infty$, $I \rightarrow 0$, $R \rightarrow Rf$, $S \rightarrow Sf$

The relation between R0 and Rf: If R0>3, at the end of the epidemic, the proportion of Removed indivuduals will be 95%, those who will remain susceptible will be 5% (without vaccination)

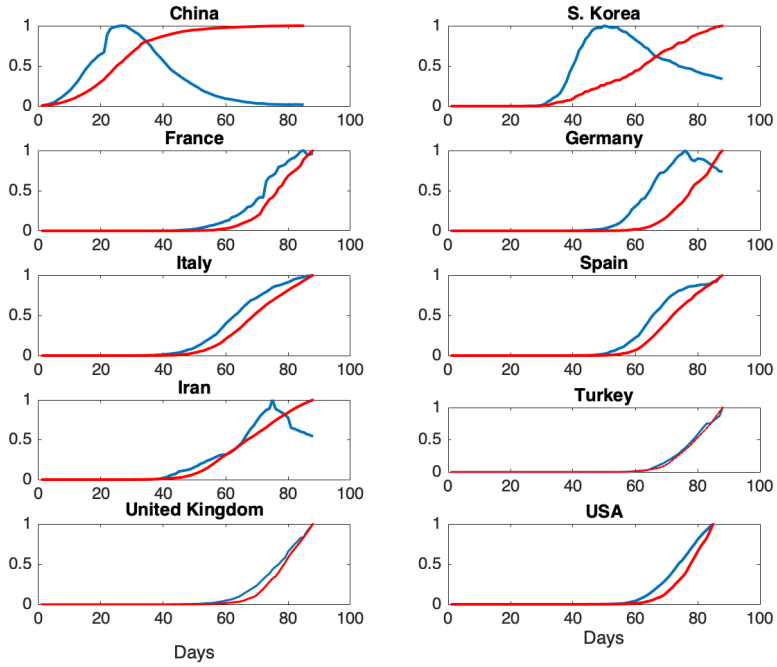


Peak of the epitemic at tm: S(tm)=1/R0. The number of infections start decreasing only after the proportion of Susceptible individuals fall below 1/R0. If R0=3, after only 1/3 remain Susceptible, that means 2/3 are affected (either still infectious or already gained immunity)



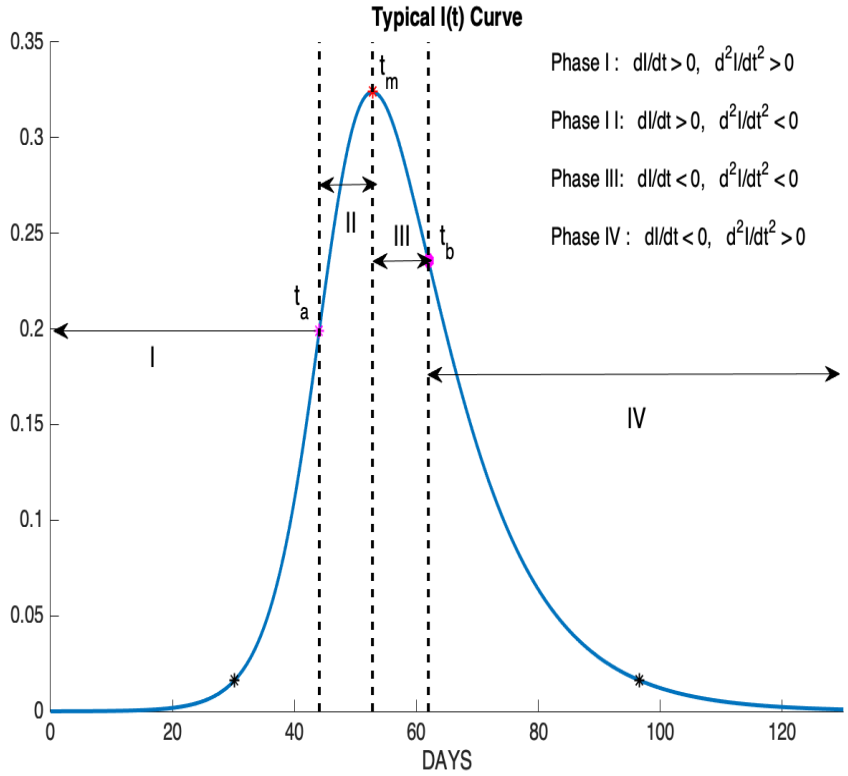
Data for daily infections and total fatalities over the period January 22-April 20, 2020

- The «first wave» of the epidemic is completed in China
- The fall off is very slow in South Korea
- Germany and Iran are beyond the peak of the epidemic
- Spain and France are near the peak
- All other countries are in the rising phase



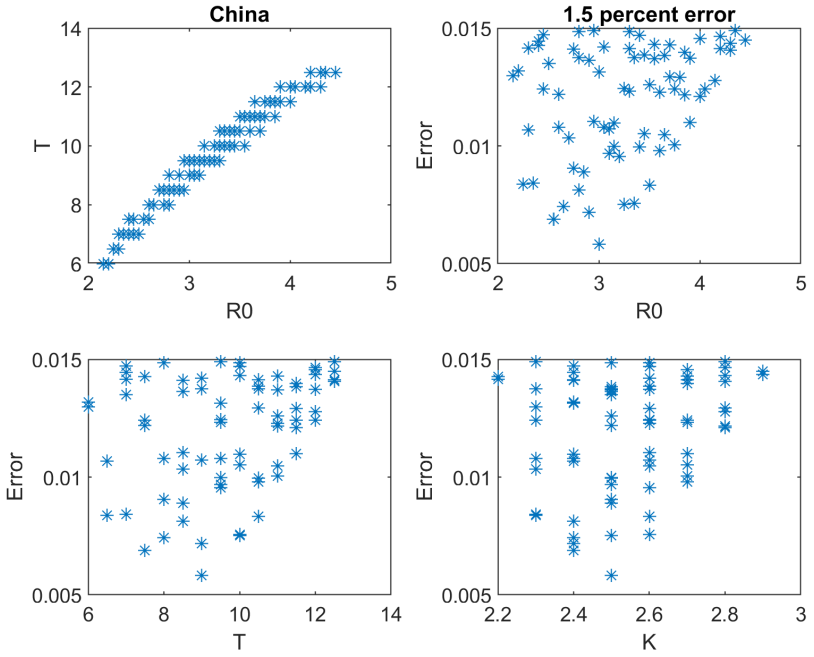
Phases of the epidemic wave I(t)

- Phase 1: I(t) is increasing and concave up
- Phase 2: I(t) is increasing but concave down
- Phase 3: I(t) is decreasing and concave down
- Phase 4: I(t) is decreasing and concave up
- The time ta is the time of fastest increase
- The time tm is the peak of the epidemic
- The time tb is the time of fastest decrease.

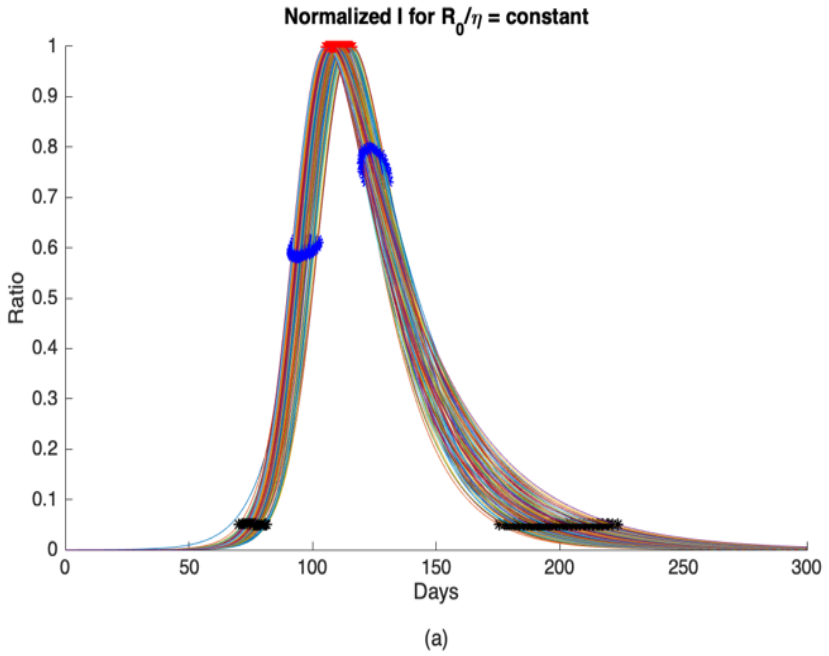


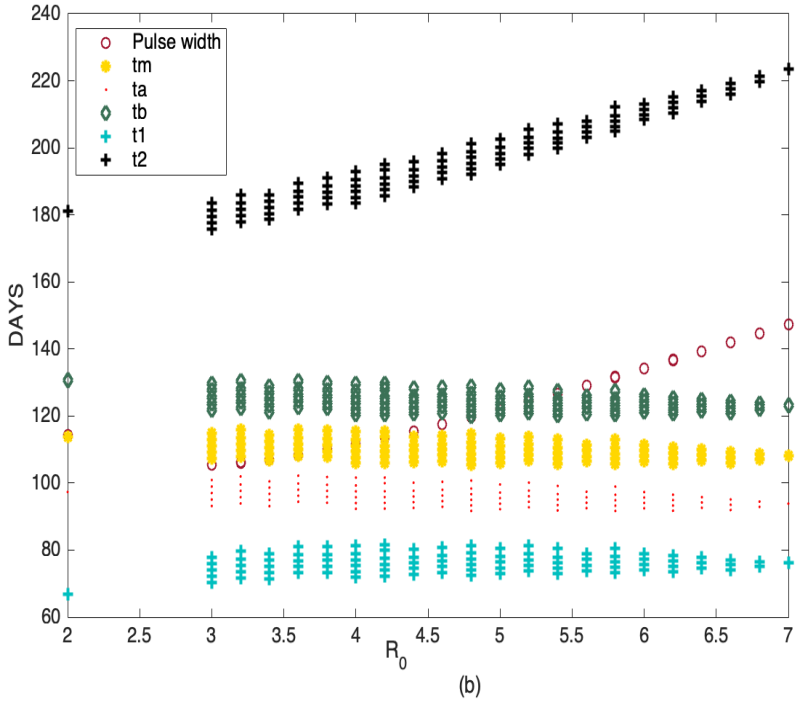
Best fitting models for China:

- Even for China, with a complete epidemic wave, R0 and T=1/eta for best fitting models lie on a curve
- R0/T is nearly constant
- R0 is likely to be 3
- T is likely to be 9 days
- Initial value of I(t) is 10^(-K), K=2.5
- PROBLEM: WHAT CAN BE DETERMINED ROBUSTLY FROM THE DATA

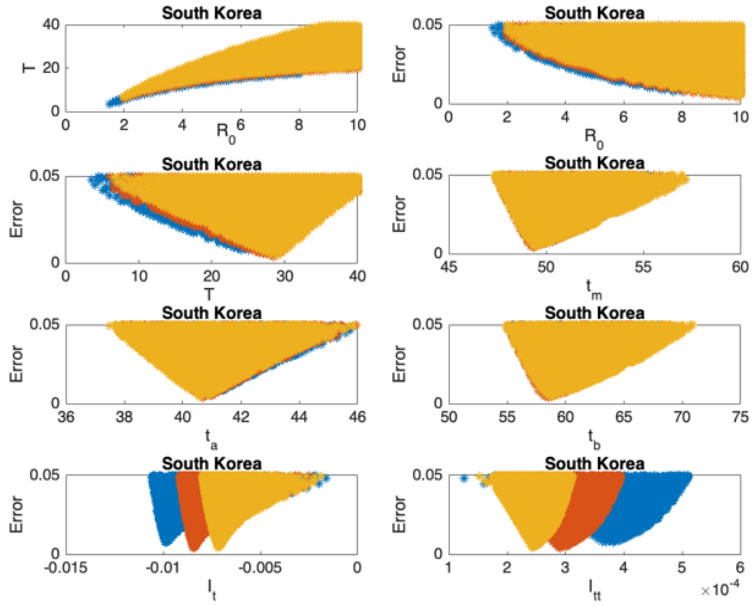


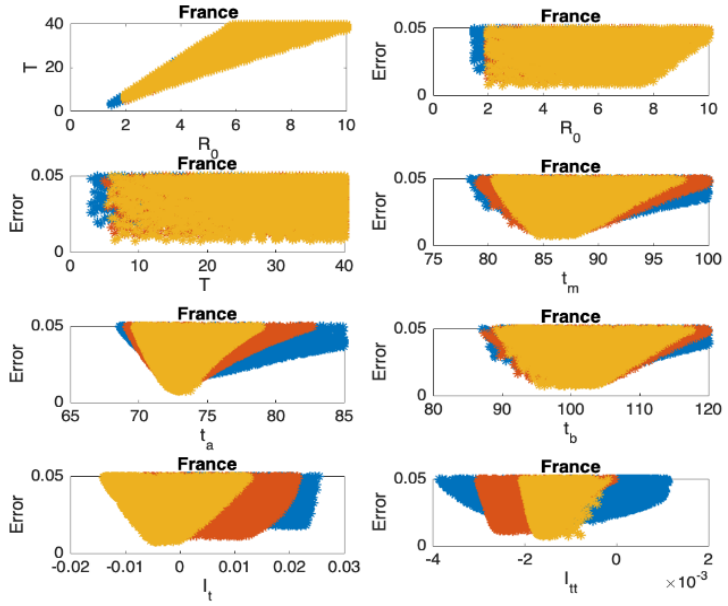
WHAT CAN BE DETERMINED ROBUSTLY FROM THE DATA? Normalized values of I(t) for 3<R0 <20, together with the inflection points (t_a, t_b), the peak point (t_m) and the timing of the$\mathbf{R_0/T = 1/5,}$ initial (t_1) and final (t_2) points when the 5% of maximum value I(t) epidemic, (b) Dependency of t_1, t_a, t_m, t_b, t_2 on R_0.



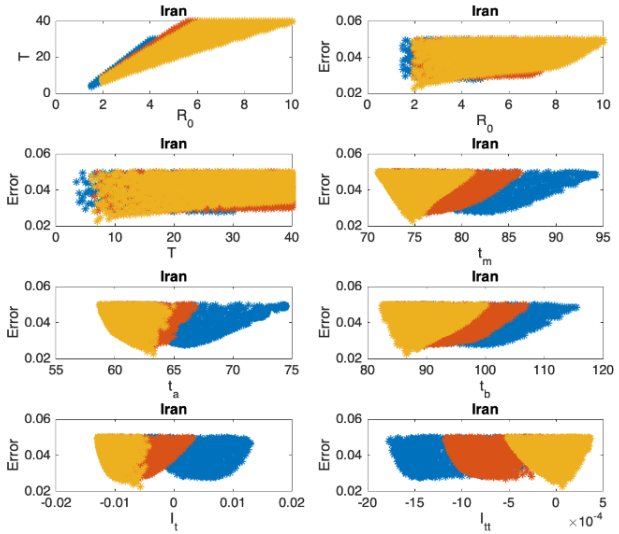


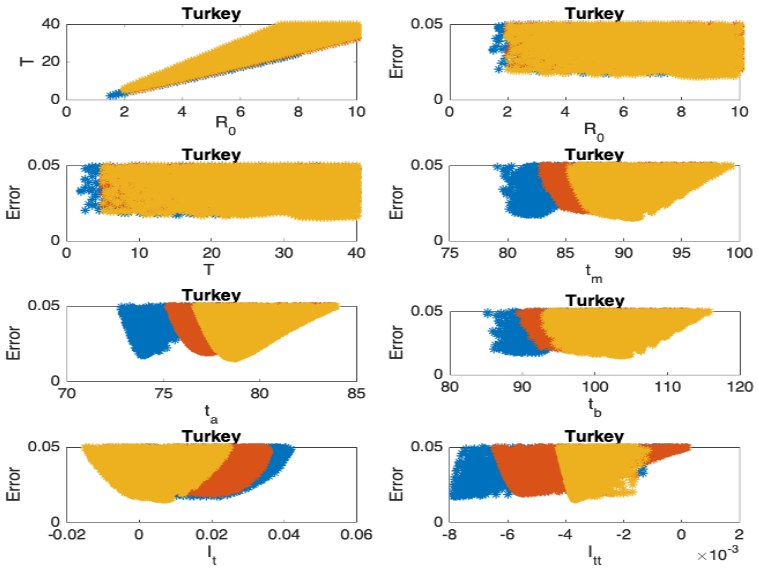
What can we estimate from EARLY PHASE data? Models based of 3 sets of data with 1 week intervals: South Korea and France





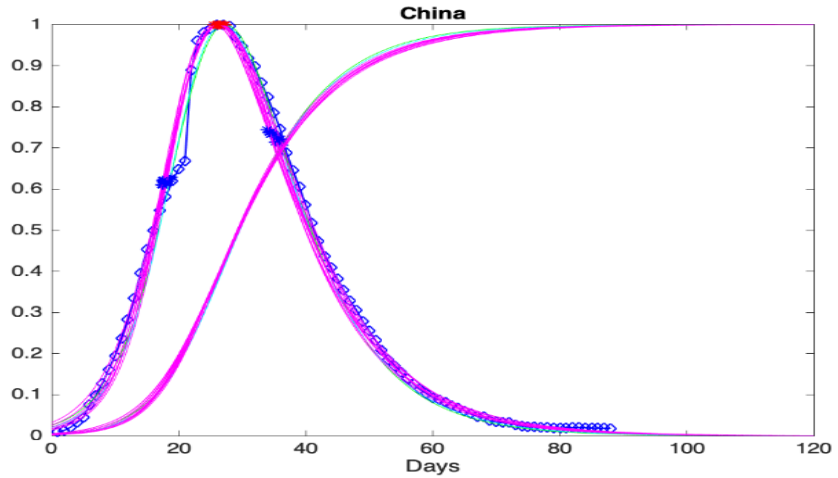
What can we estimate from EARLY PHASE data? Models based of 3 sets of data with 1 week intervals: Iran and Turkey



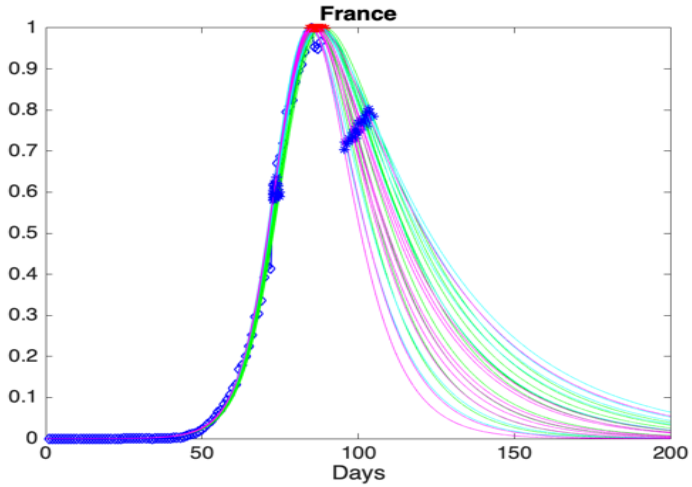


Modeling versus Forecast: Today is Day 150

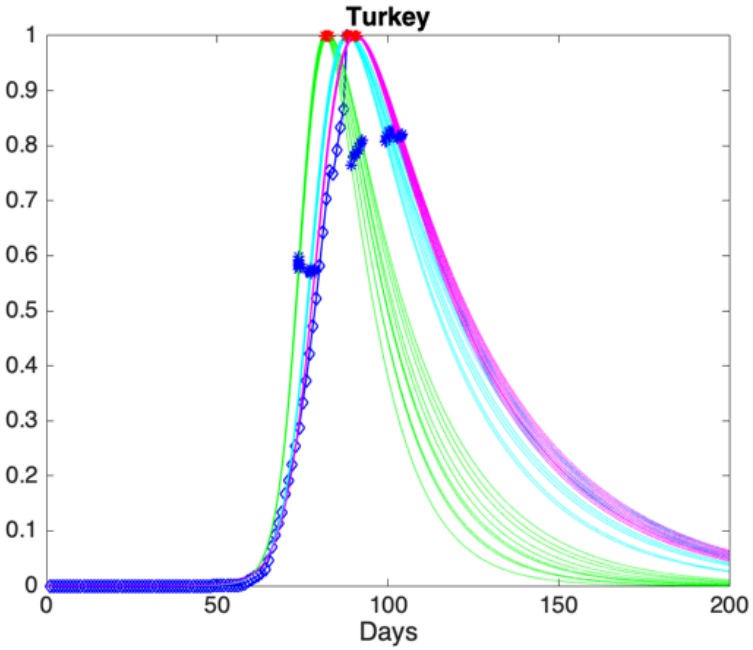
China

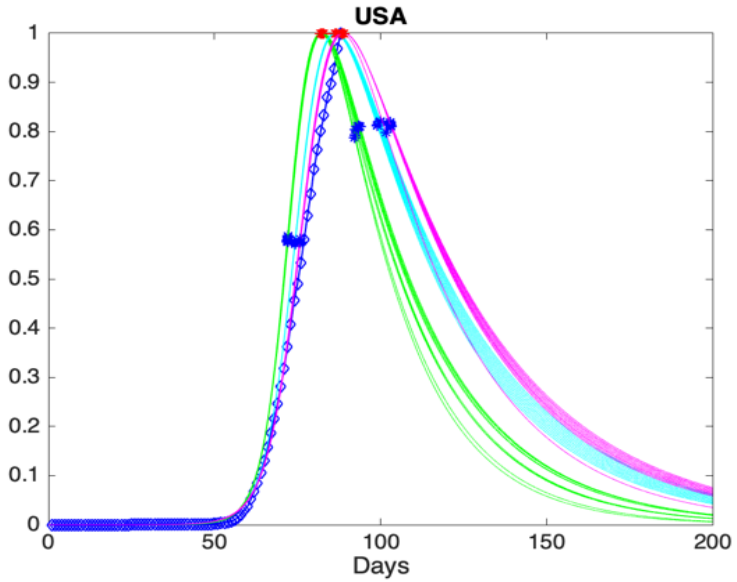


France

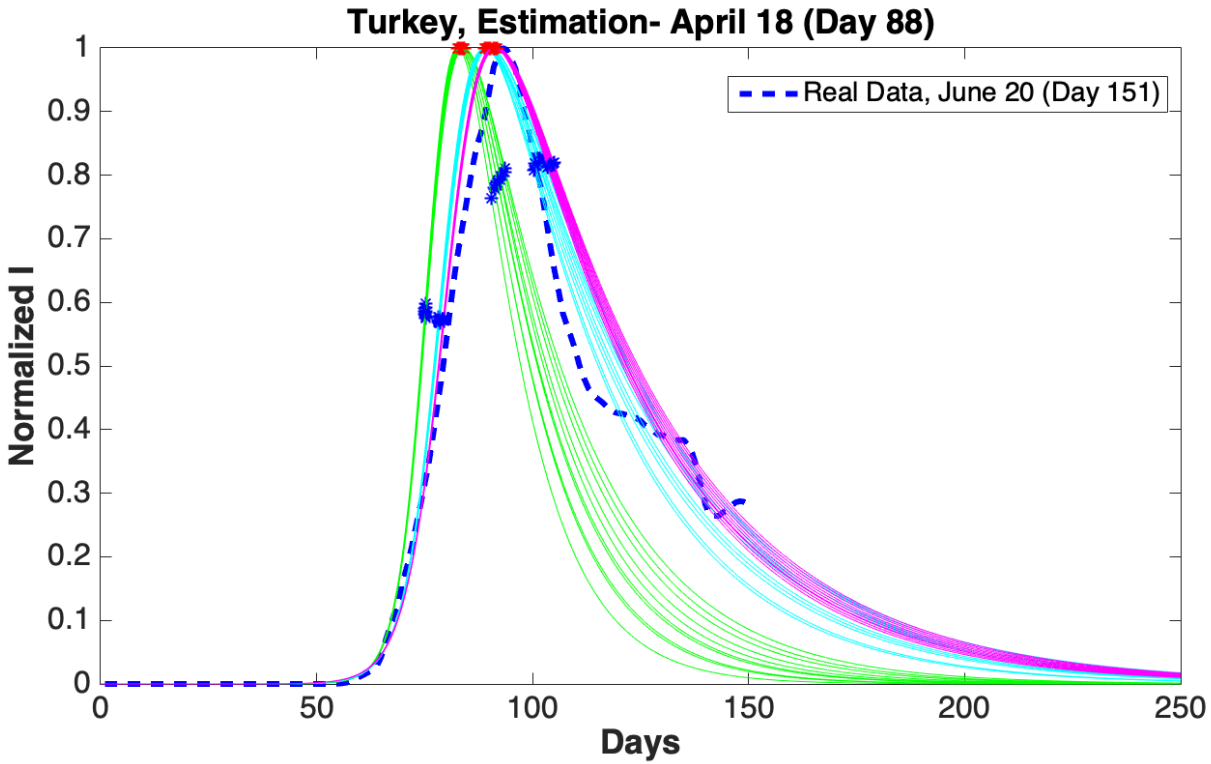


Modeling versus Forecast: Today is Day 150





Today...


Turkey, Estimation- April 18 (Day 88)
Real Data, June 20 (Day 151)
Normalized I
Days
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250