Estimation and control of epidemics via Safe Blues

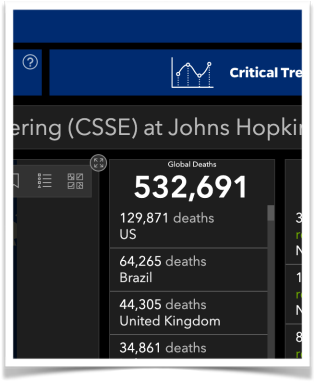
Yoni Nazarathy

Based on joint work with Raj Dandekar (MIT),
Shane Henderson (Cornell), Marijn Jansen (UQ),
Sarat Moka (UQ), Chris Rackauckas (MIT),
Peter Taylor (Melbourne), and Aapeli Vuorinen (UQ, Melbourne).

safeblues.org

@ynazarathy

Presented as a Zoom Public Lecture at BrisScience, July 6, 2020



$$\text{Deaths} : p = \frac{532{,}691}{11{,}367{,}743} \approx 4.5\,\%$$

WARNING: COVID can break 30% of hearts

Number of people you love : $n \approx 10$

Assumed proportion infected : $F = 0.75$

Chance to lose a loved one : $1 - (1 - F \times p)^n \approx 30\,\%$

If $p = 1\,\% : 1 - (1 - F \times p)^n \approx 7.3\,\%$

If $n = 20 : 1 - (1 - F \times p)^n \approx 50\,\%$

We are fighting back...

But social distancing hurts…

So governments are doing their best*
to find the sweet spot…

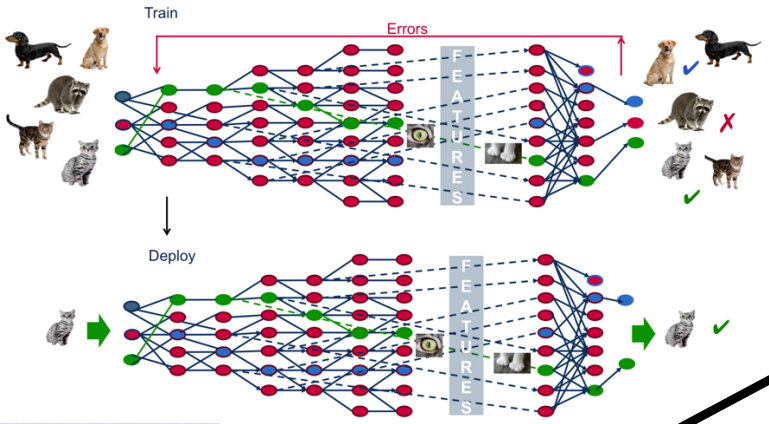
* With the exception of some governments across the Americas

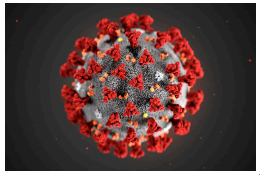
How?

Clinical aspects…

Economic aid…

Modelling to inform policy…



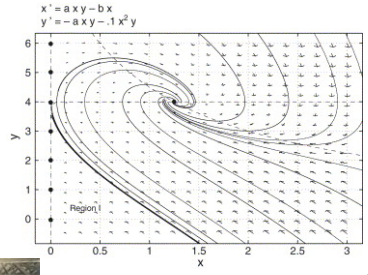


2019-2020+

COVID-19 Pandemic

2000+

Smart Mobile Devices



1955 - 2015+

Computational Statistics
(ML/DS/AI)

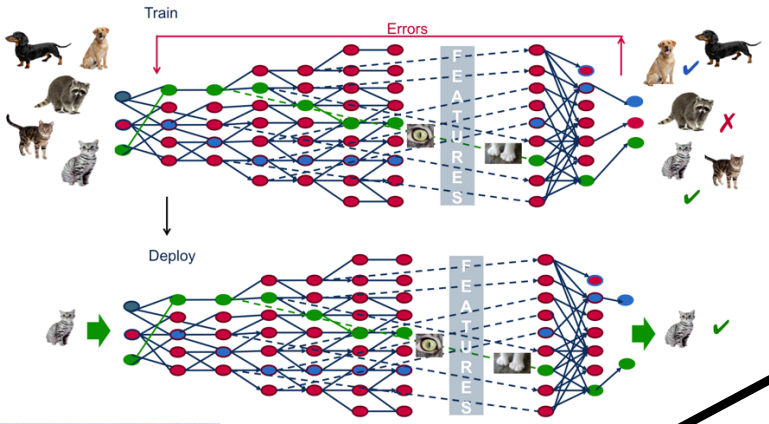
1928-1933

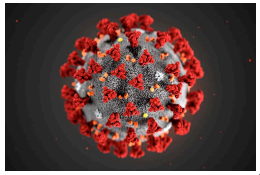
SIR Model
(Kermack–McKendrick theory)

1918-1920

Spanish Flu

Modelling to inform policy…





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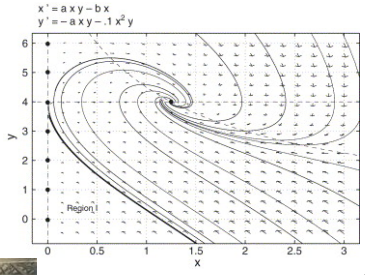

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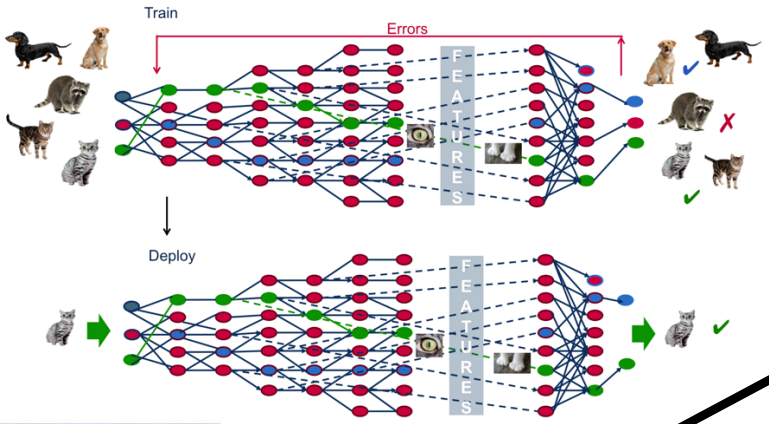

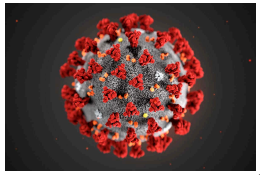

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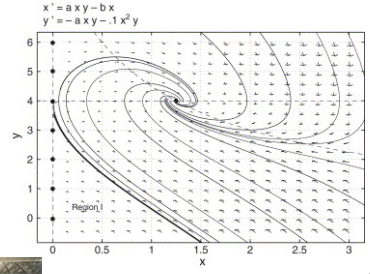

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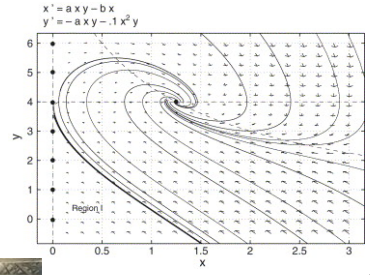

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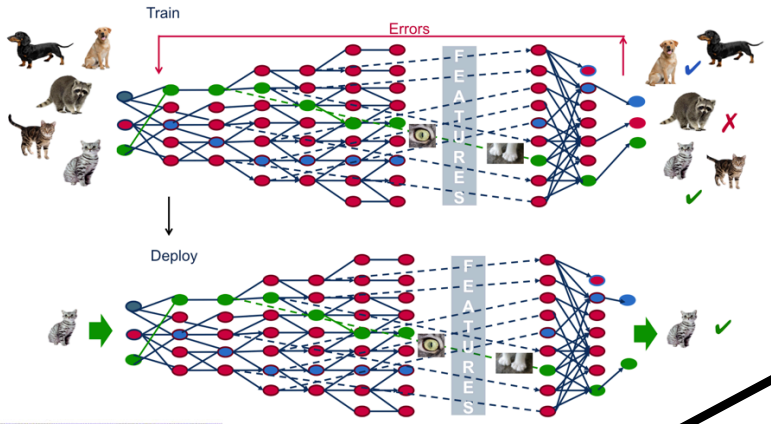
(Kermack–McKendrick theory)



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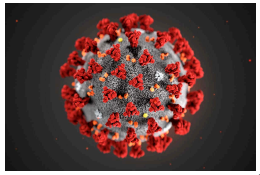
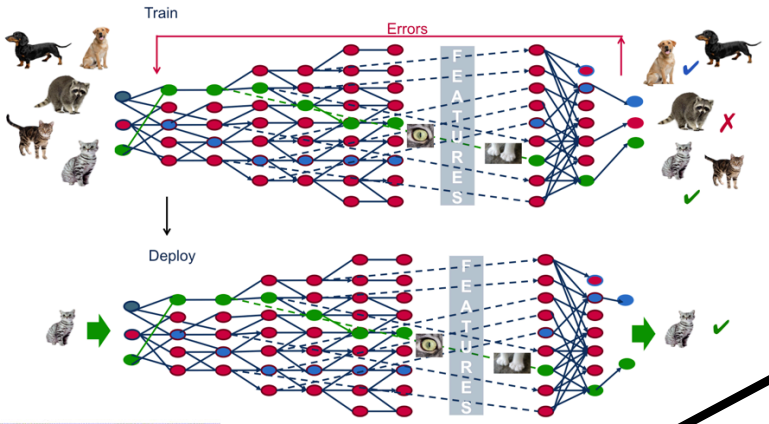
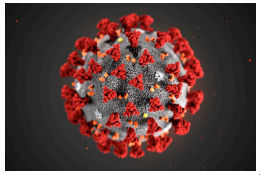


2019-2020+

COVID-19 Pandemic

?





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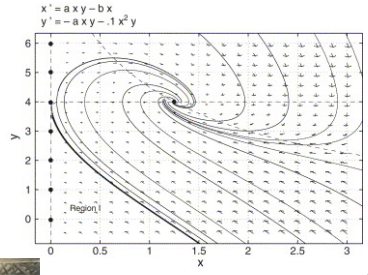

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Safe Blues

Quantifying an epidemic with a single number,

the reproductive number: **R**

R = The number of secondary infections induced by an infected individual

R < 1 : Exponential Decay

```
julia> 1000*0.7*0.7*0.7*0.7*0.7
168.06999999999994
```

R > 1 : Exponential Growth

```
julia> 1000*1.4*1.4*1.4*1.4*1.4
5378.239999999998
```

What is **R** for COVID?

What affects **R**?

biology

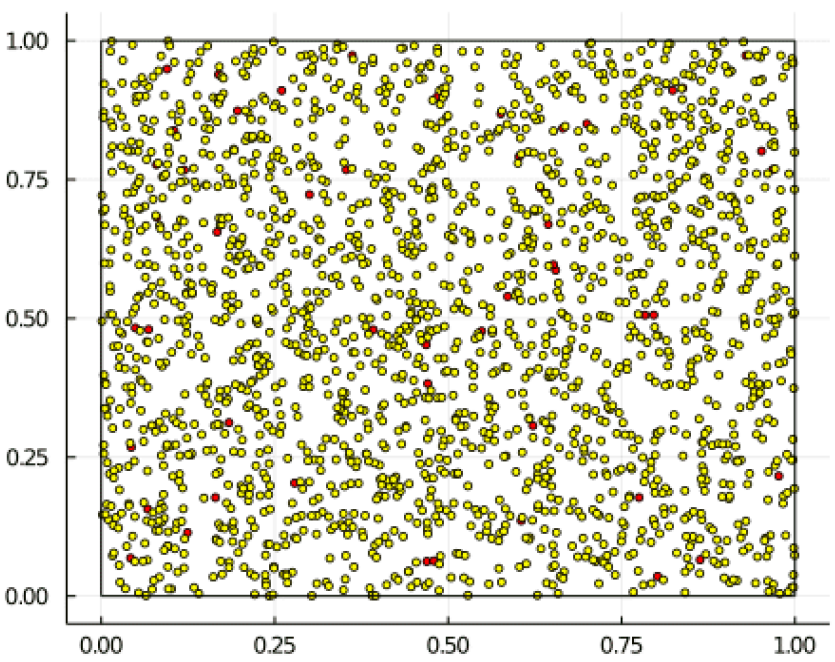
environment

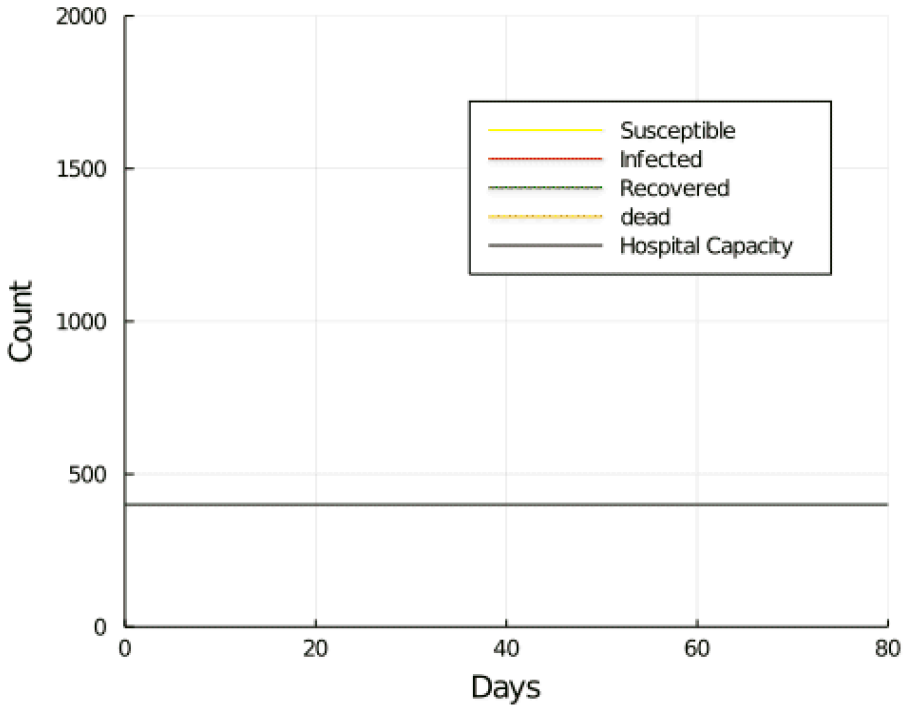
conduct

contact

Social distancing level

Illustration: SIR Toy Model





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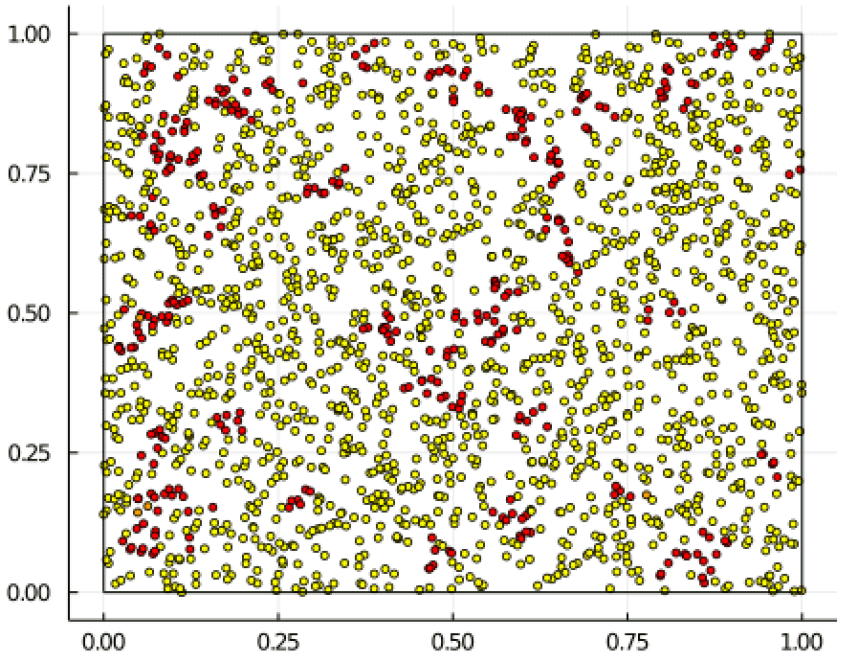

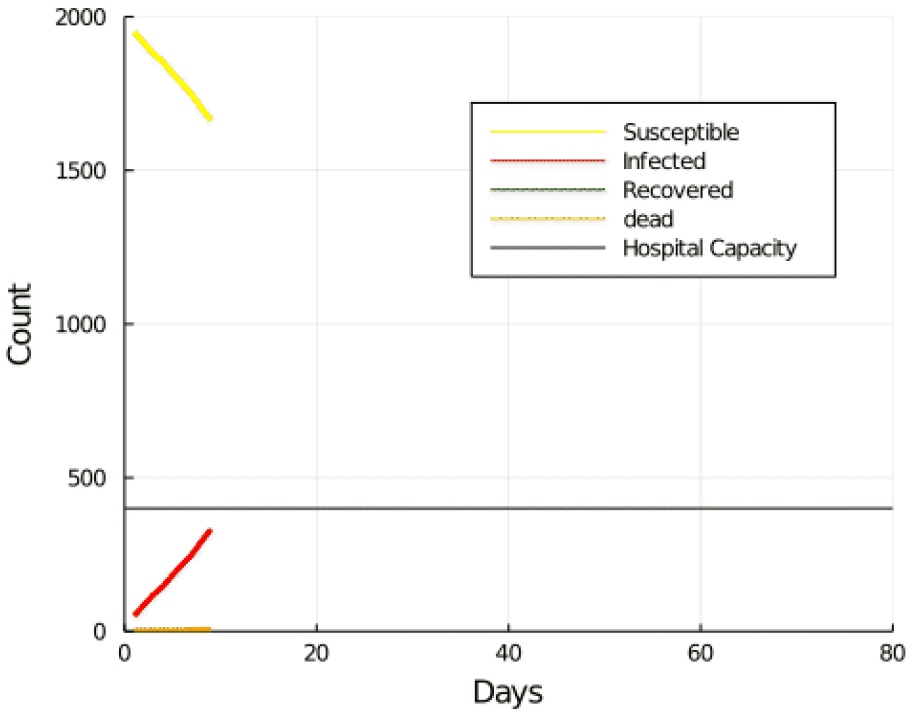

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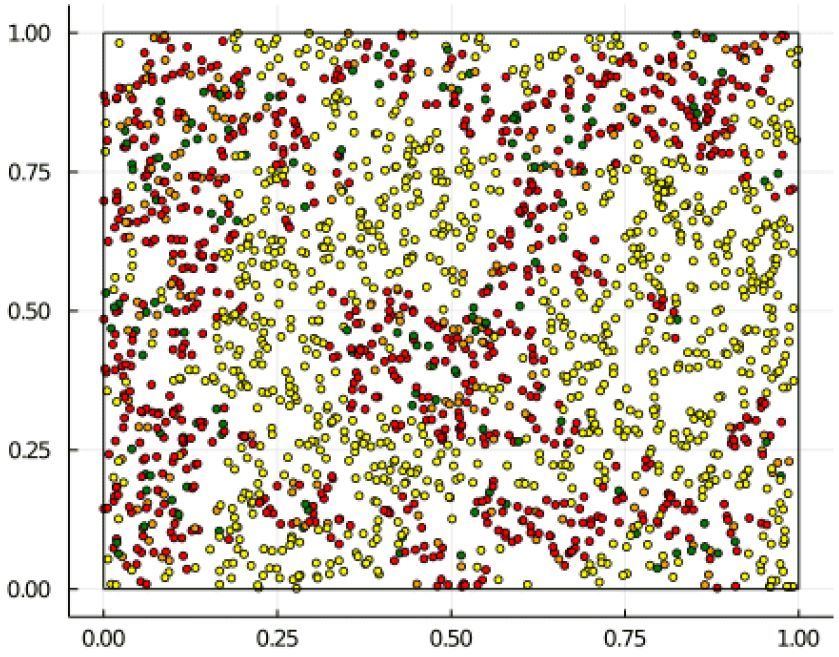

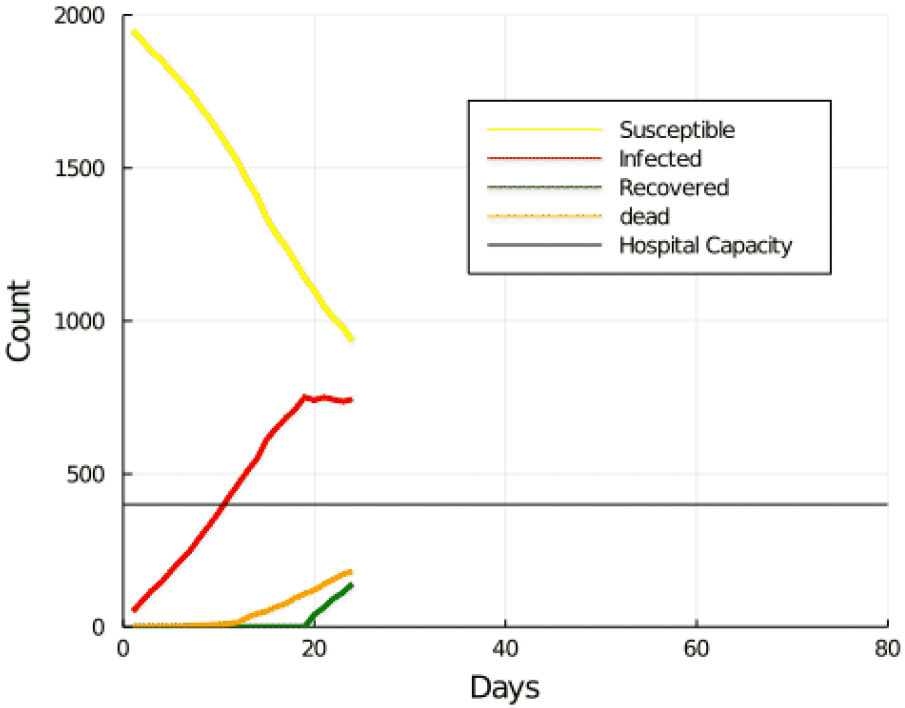

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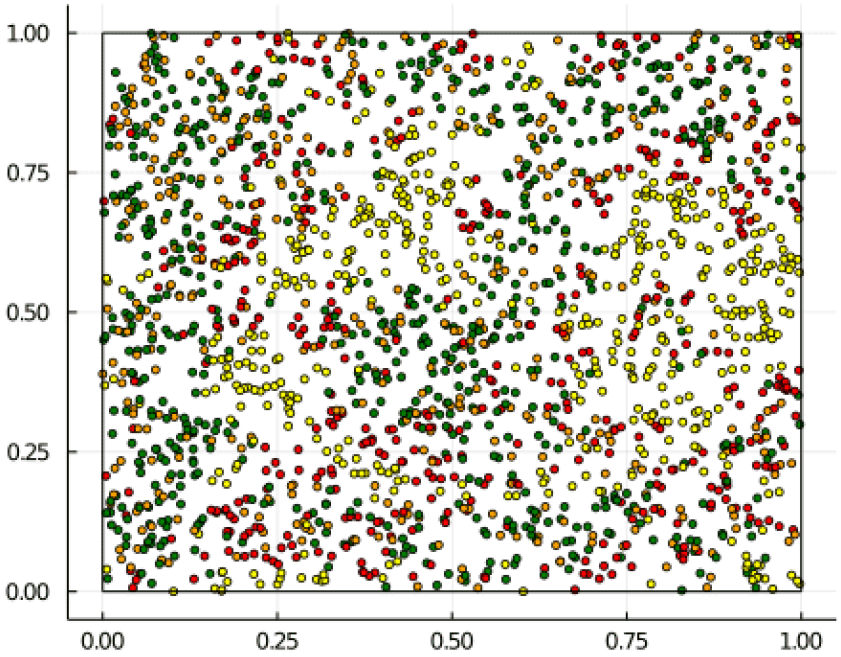

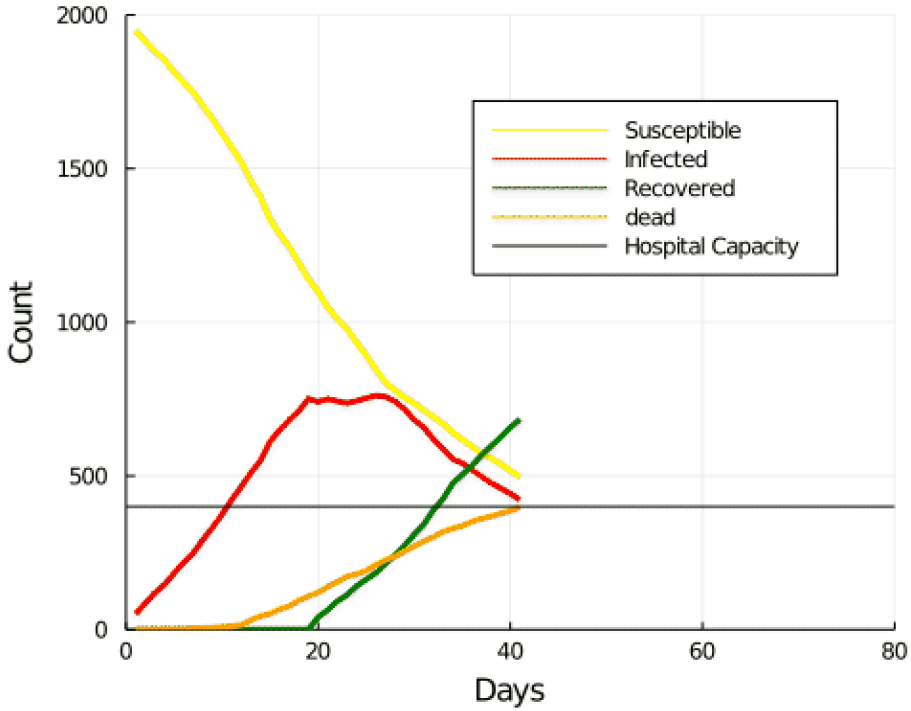

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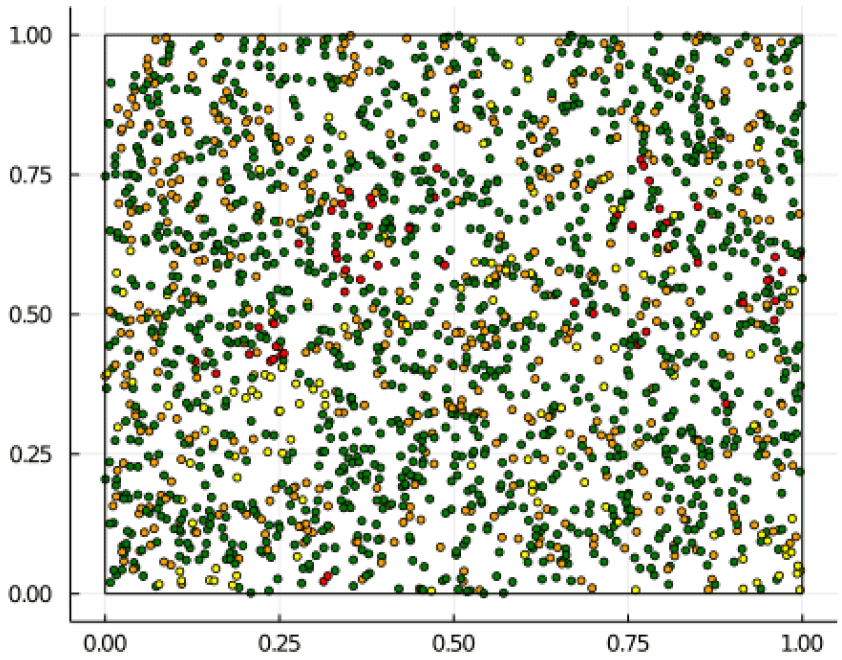


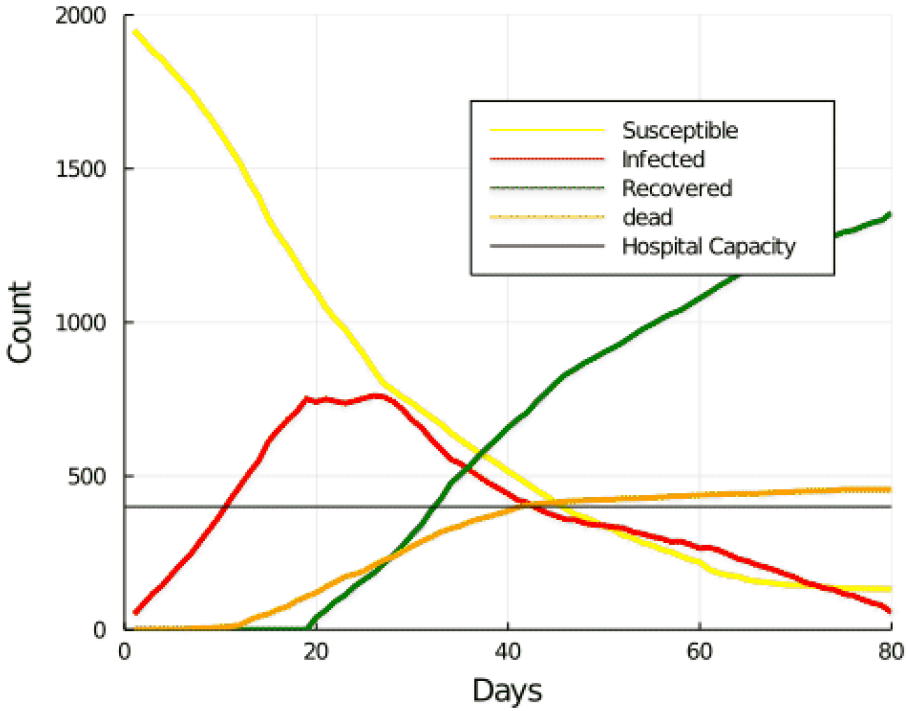
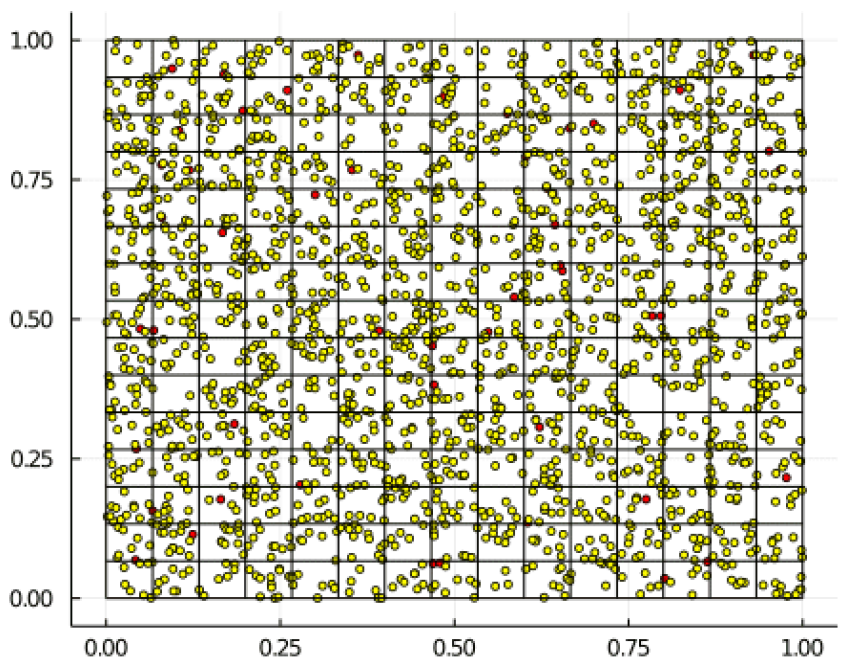
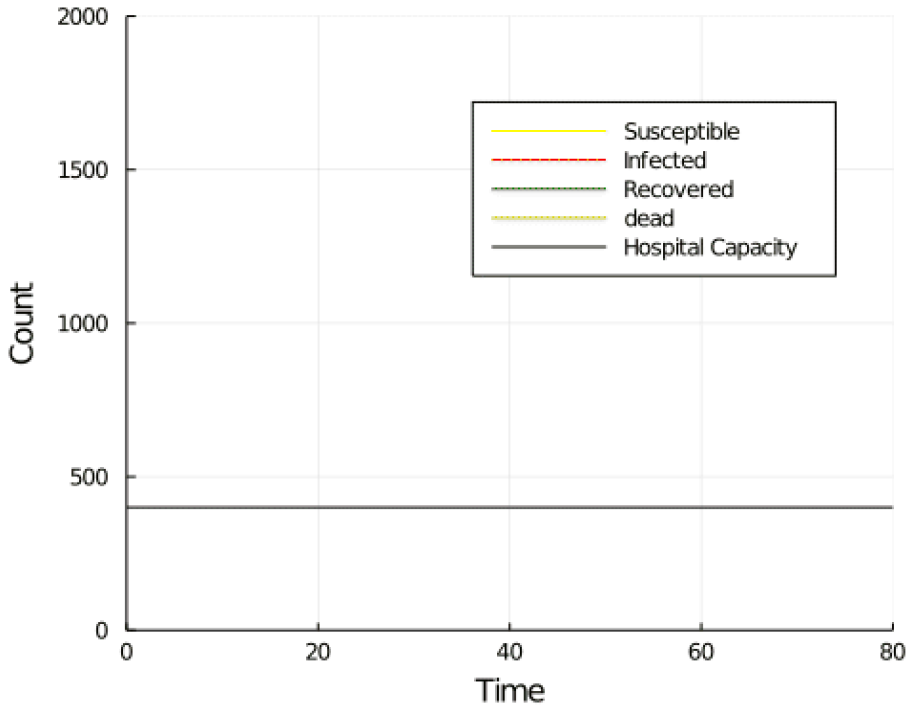


Illustration: SIR Toy Model with Social Distancing





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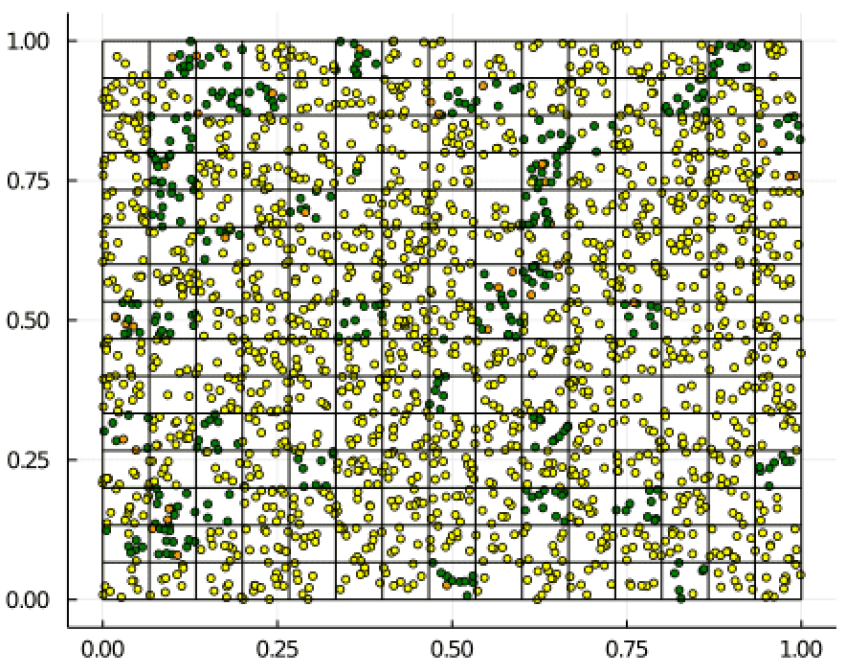
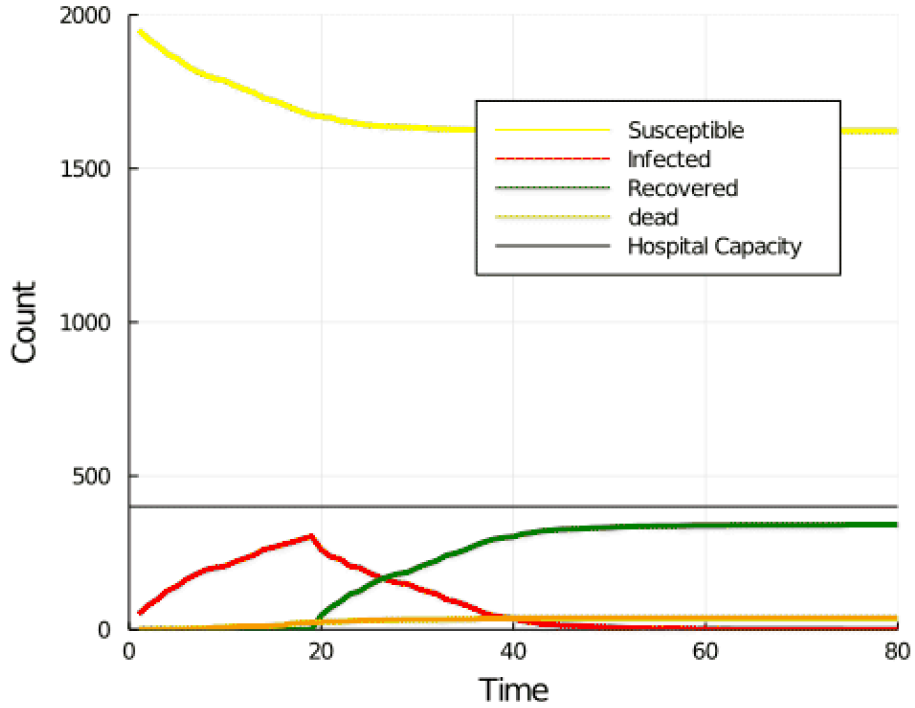
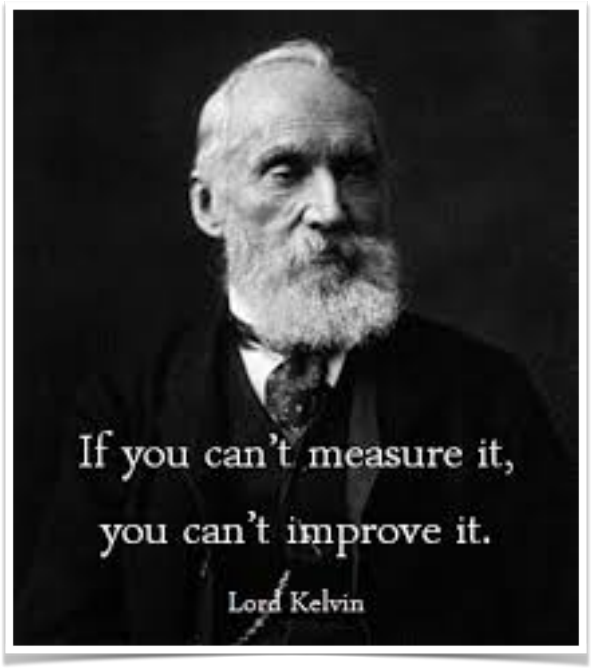




But how does social distancing work for non-toy models?

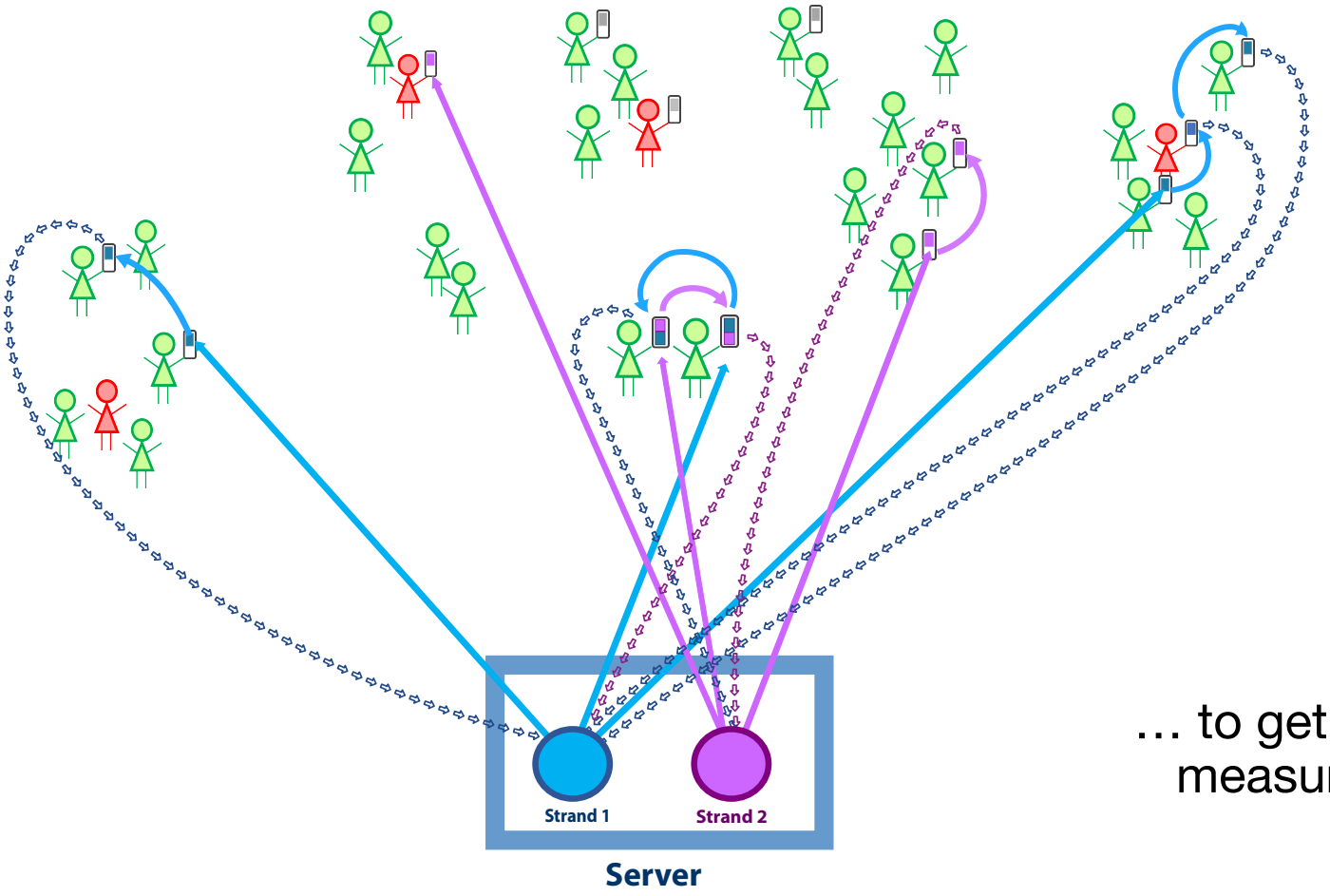


Big Problem: COVID measurements are noisy, partial, and **delayed**!

Safe Blues: A Method for Estimation and Control in the Fight Against COVID-19

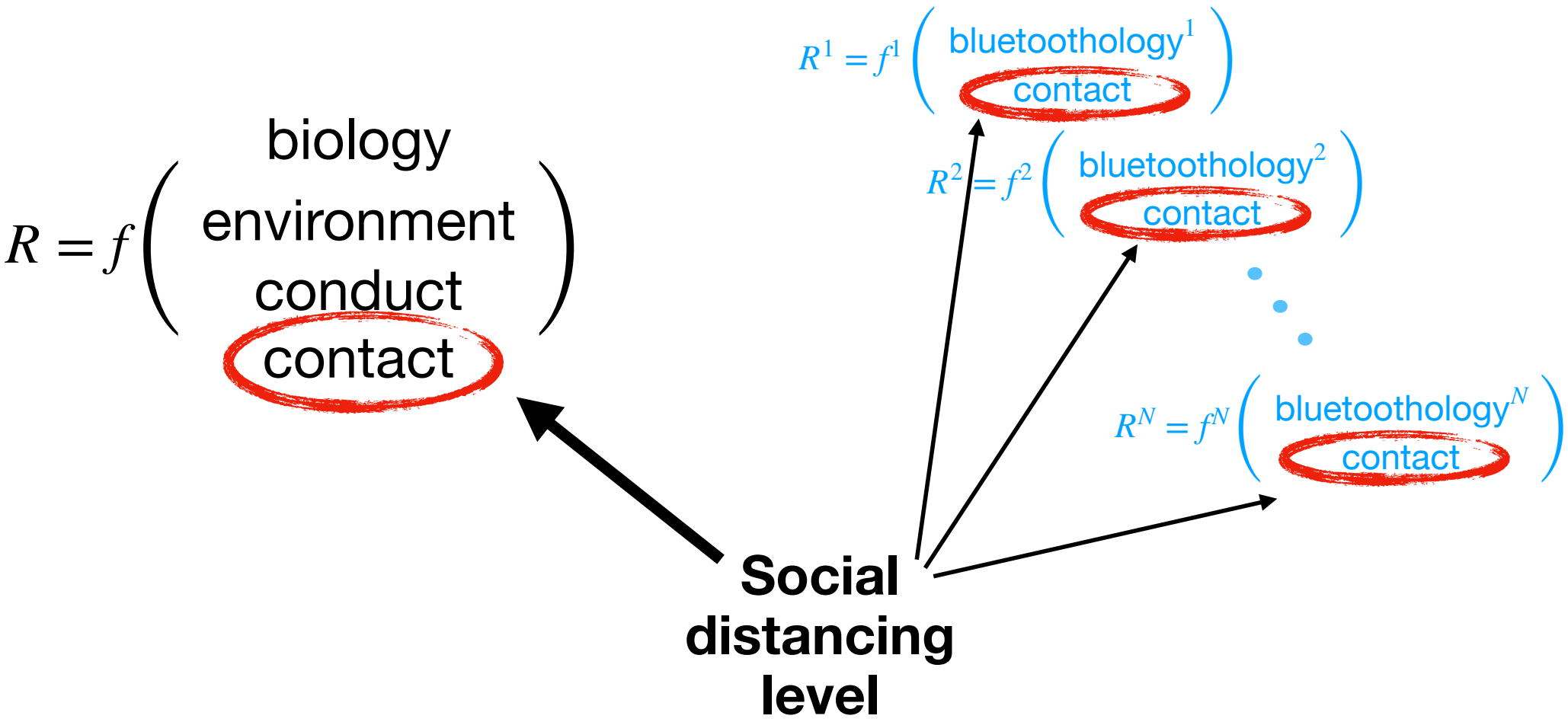
safeblues.org

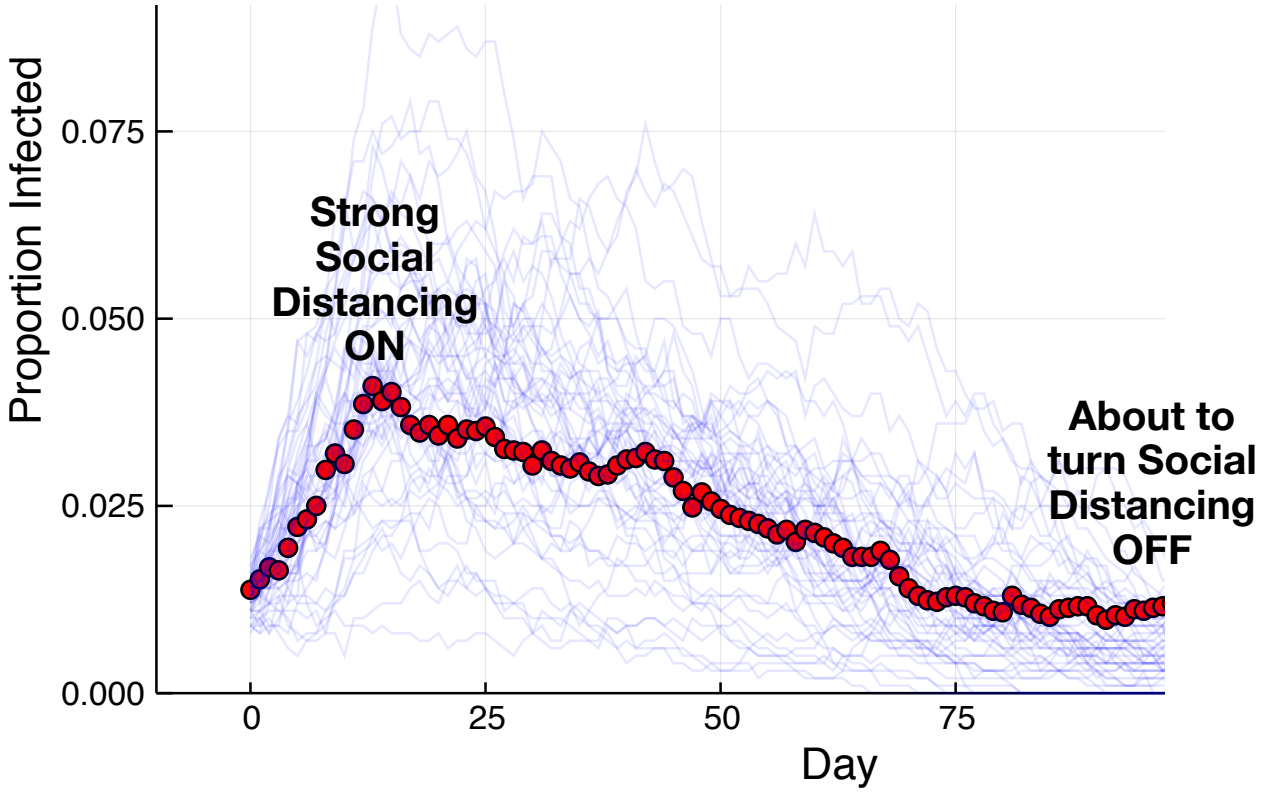
Safe Blues is about injecting many virtual safe viruses…

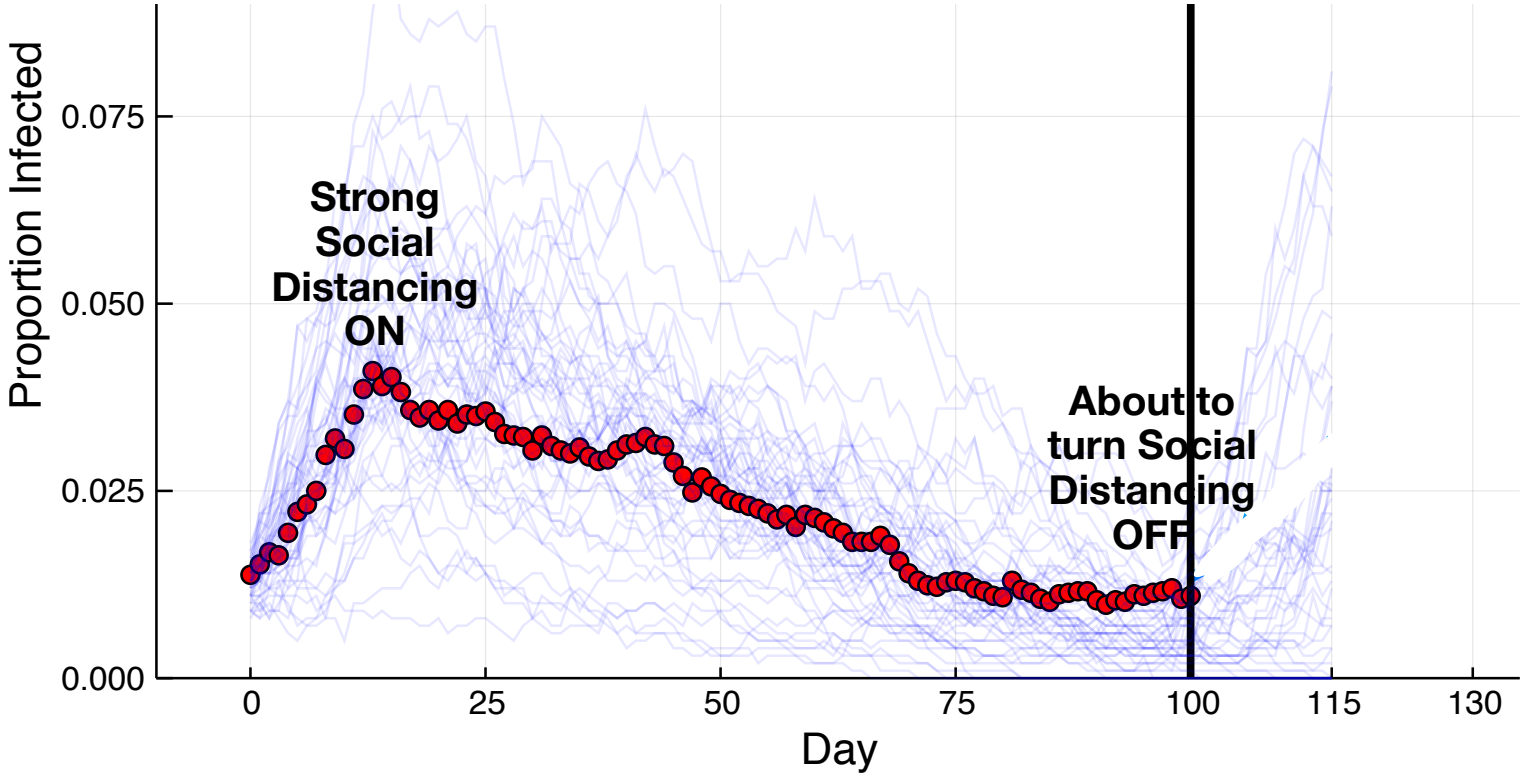


… to get **real time** measurements

Safe Blues = virtual safe viruses




Proportion Infected
0.075
0.050
0.025
0.000
Strong
Social
Distancing
ON
About to
turn Social
Distancing
OFF
0
25
50
75
Day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0.075
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Strong
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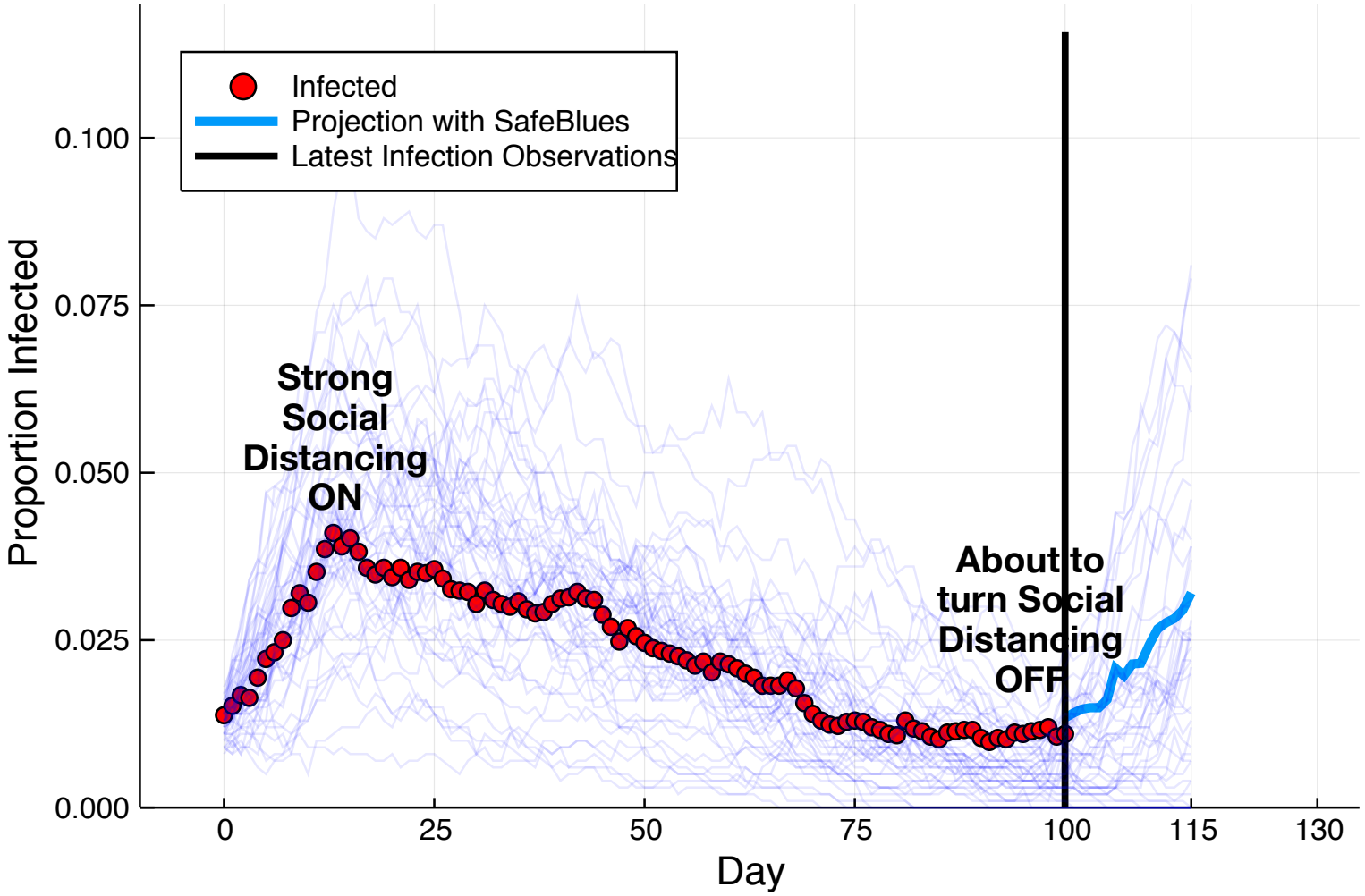
OFF
0
25
50
75
100
115
130
Day


Infected
Projection with SafeBlues
Latest Infection Observations
Proportion Infected
0.100
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About to turn Social Distancing OFF
0
25
50
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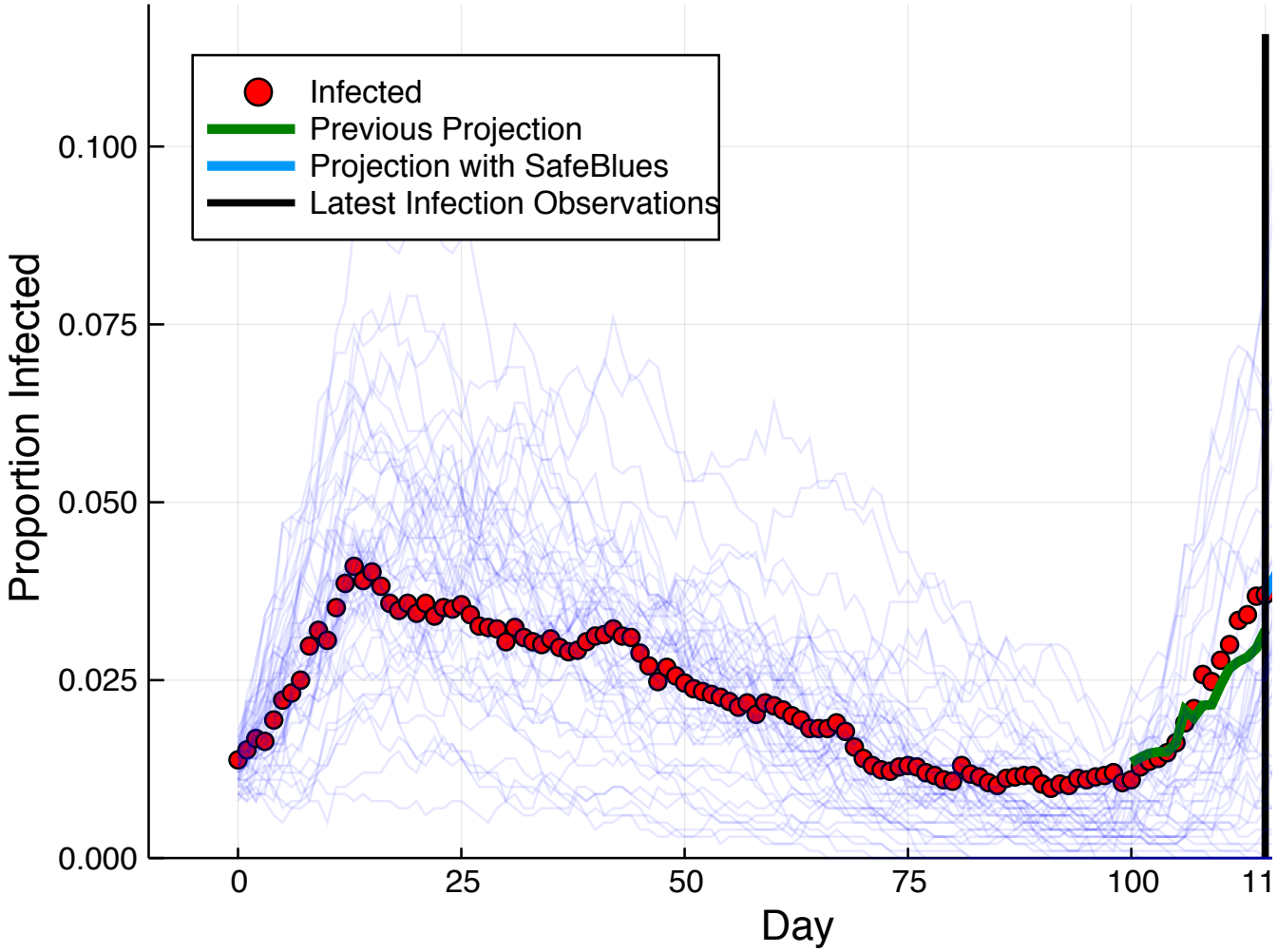
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Proportion Infected
0.100
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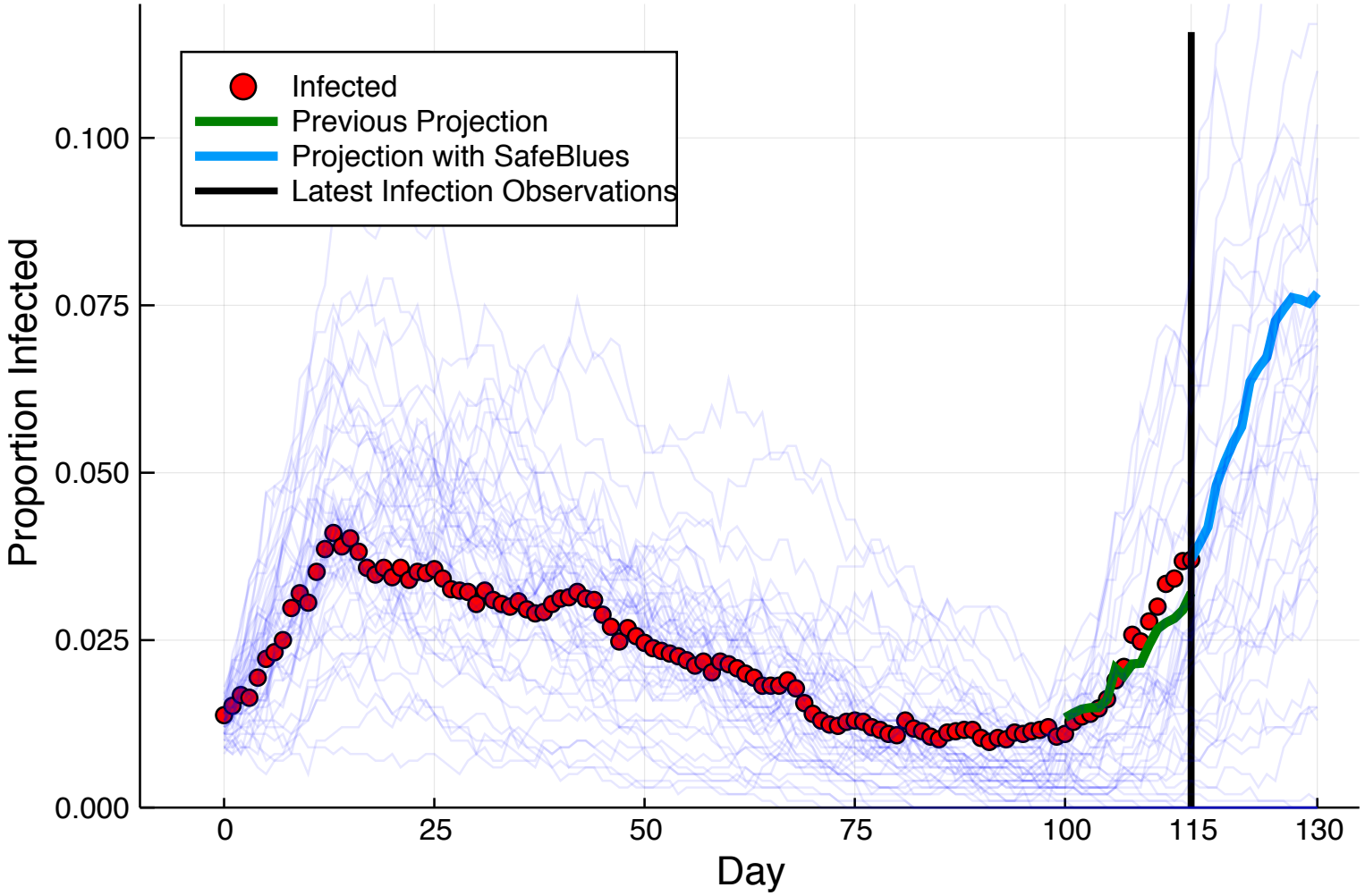
0.050
0.025
0.000
0
25
50
75
100
11
Day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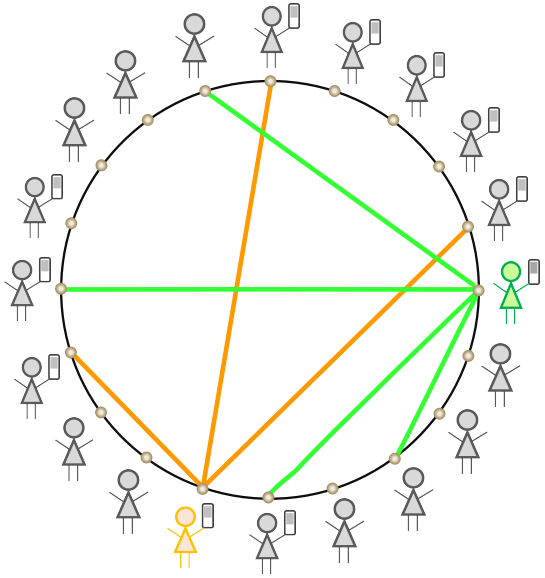
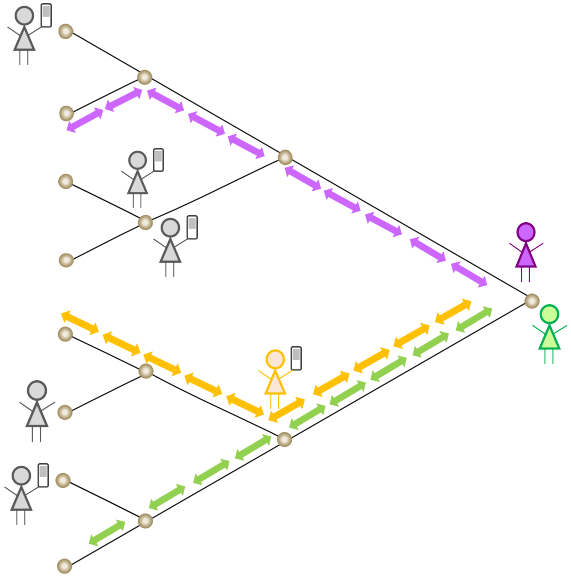
Day

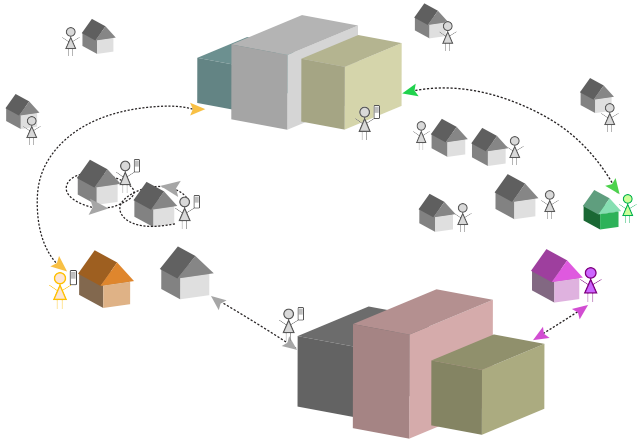
How we tested Safe Blues…



Model I

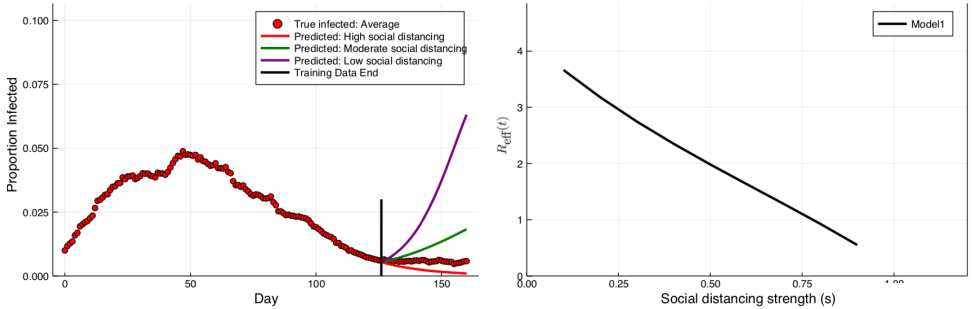


Model II



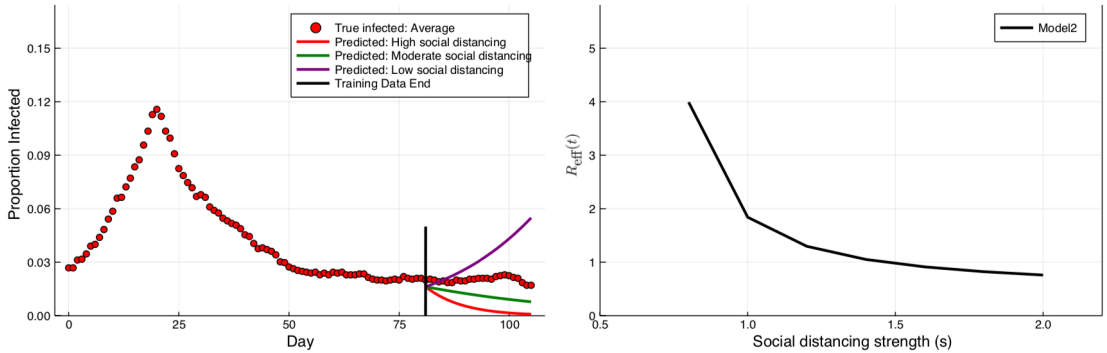
Model III

Understanding the effect of various social distancing regimes

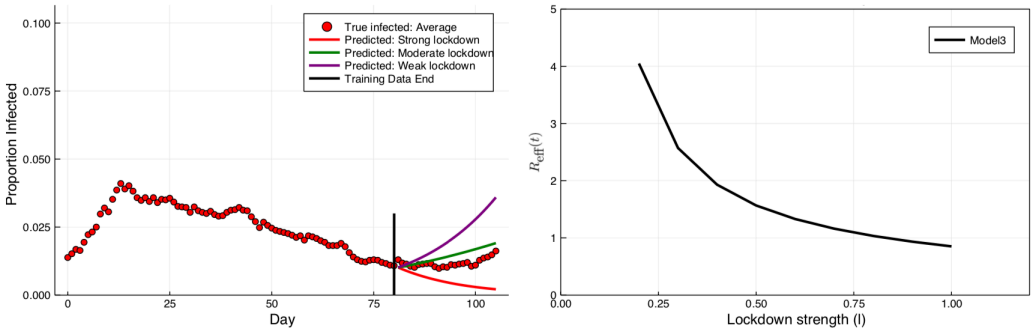


(a) Model I.

$$
\begin{aligned}
S' &= -C\beta(p)\delta SI, & \tilde{S}' &= -C\beta(p)\tilde{S}\tilde{I},\\
I' &= C\beta(p)\delta SI - \gamma(p)\delta_\gamma I, & \tilde{I}' &= C\beta(p)\tilde{S}\tilde{I} - \gamma(p)\tilde{I},\\
R' &= \gamma(p)\delta_\gamma I, & \tilde{R}' &= \gamma(p)\tilde{I}.
\end{aligned}
$$



(b) Model II.



(c) Model III.

Safe Blues is not a contact tracing app

… but can be added to such an app

Currently working towards an Android App
and an experiment based on “Trace Together”…

BlueTrace Protocol

Privacy-Preserving
Cross-Border
Contact Tracing

Read Policy Brief | Read White Paper

Thank you

If you think Safe Blues is a good idea,
then please let your government know about it.

safeblues.org

@ynazarathy