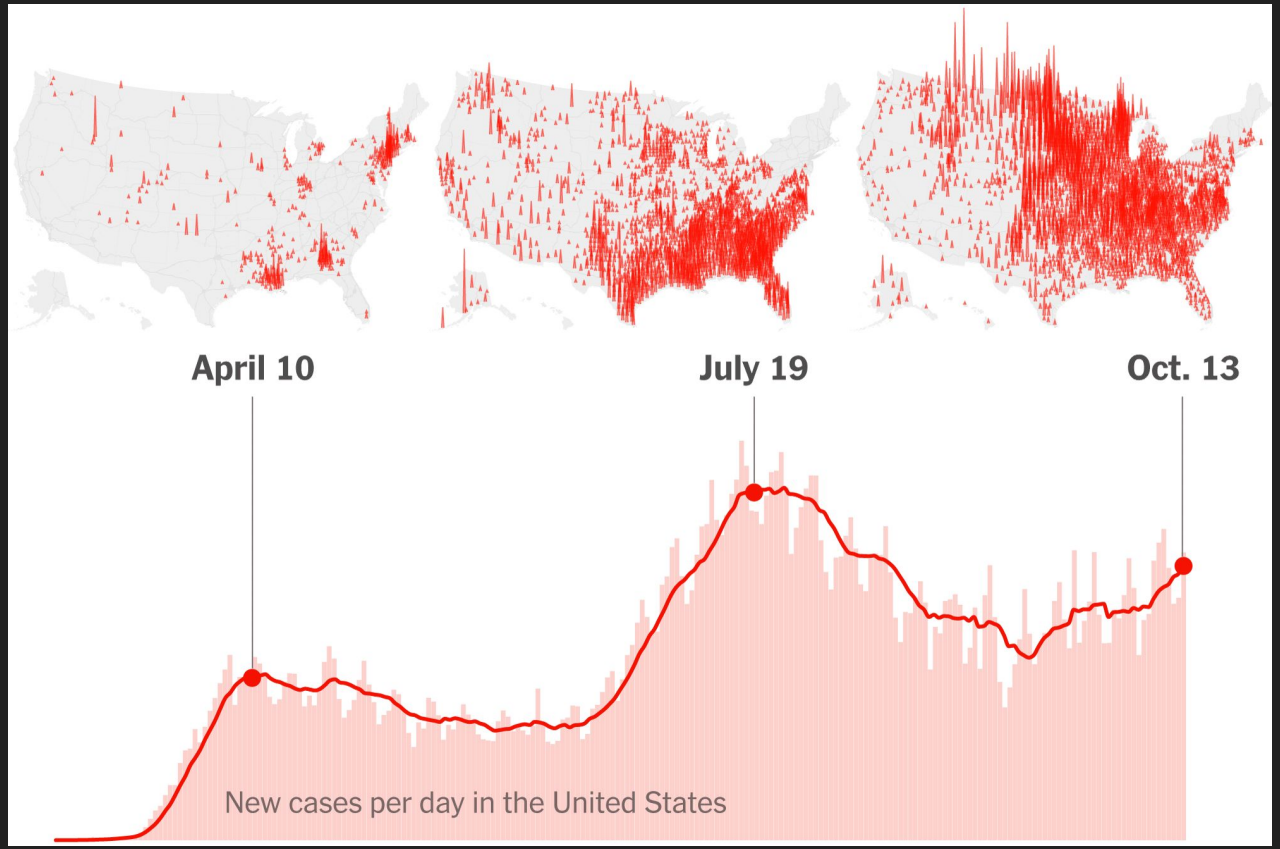
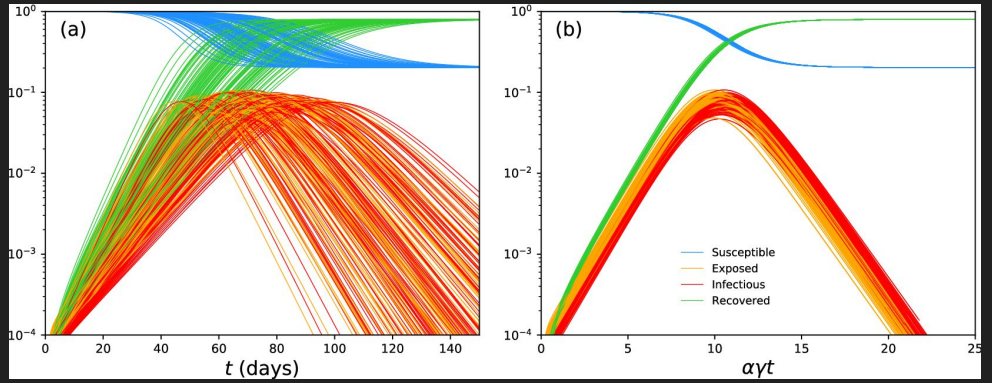
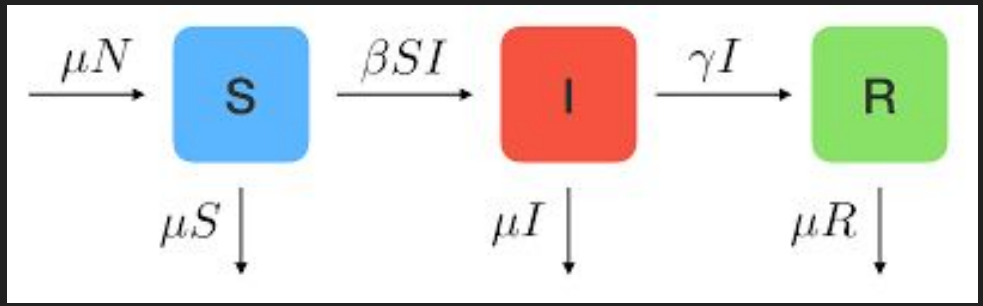
Lab 5: Modeling Epidemics Part I



Today's Lab

1. Learn/Review Conceptual Basics of Compartmental Modeling
2. Learn how to fit compartmental models to data and assess their fit (R)
3. Break into groups and start brainstorming for disease modeling project





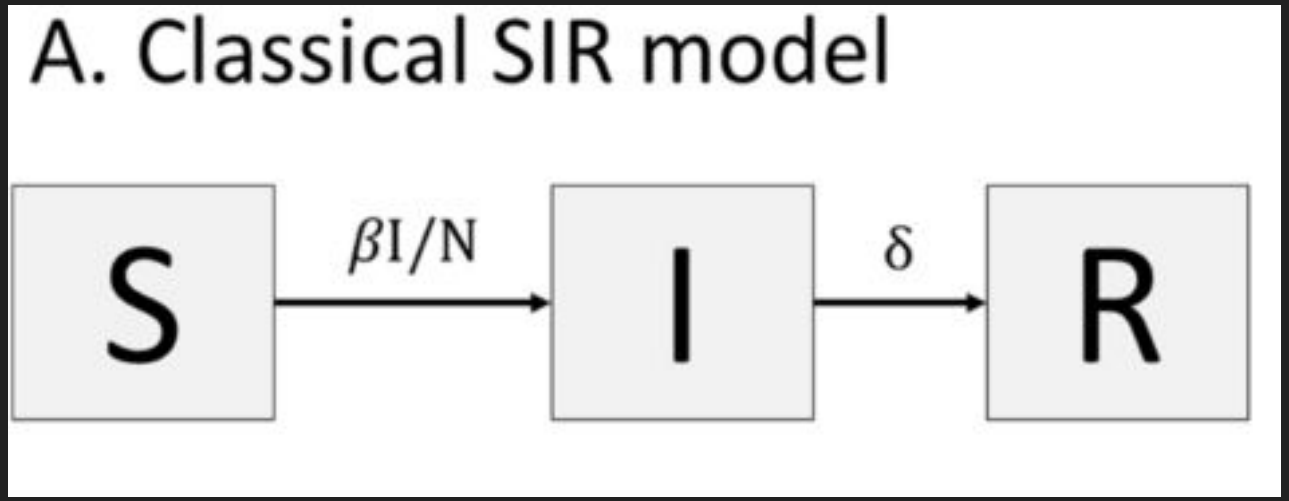
What is a model, and when is it useful?

“All models are wrong but some are useful” - Statistician George Box

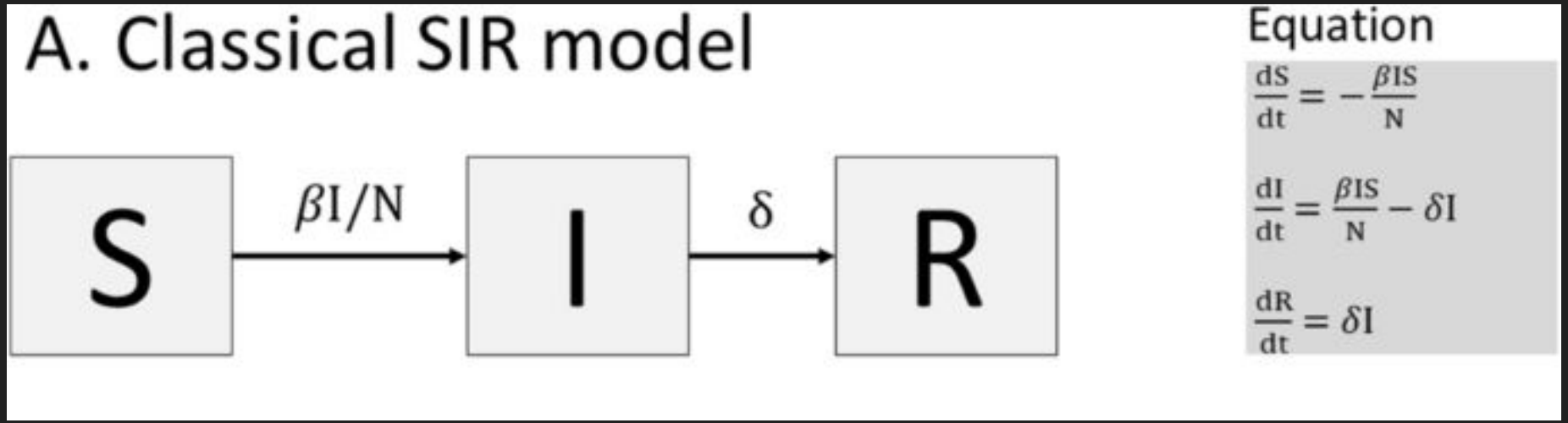
Model: A simplified description, especially a mathematical one, of a system or process, to assist calculations and predictions

Mathematical Model: Takes one or more input parameters and produces outputs

Compartmental Models



Compartmental Models



Talking about models

State Variable: Describe the instantaneous state of the system; may change through the course of a simulation

Parameter: Fixed quantity describing some aspect of the systems; doesn't change during simulation.

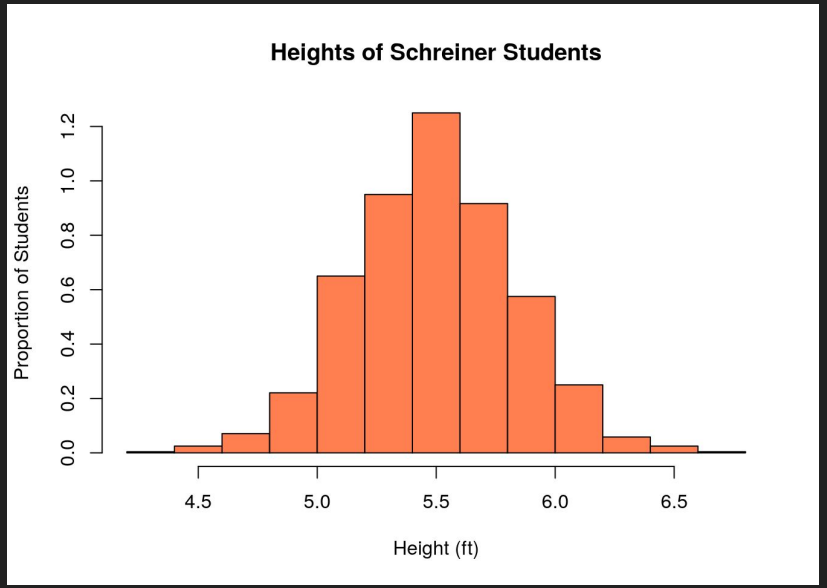
What are the state variables and parameters of the SIR model we just looked at?

How do we confront a model with data?

One option: Maximum likelihood

Maximizing P(Data|Hypothesis)

Given the sample we found to the right, what's the probability that the true height 5.5ft? What about 5.75 ft? What about 8ft?

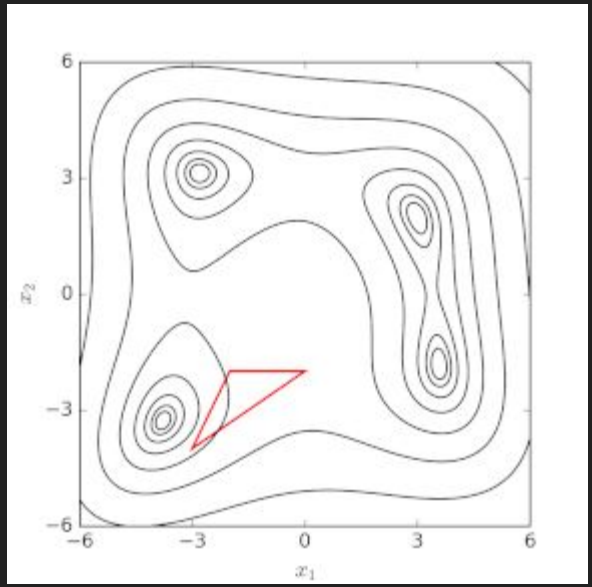


How to optimize maximum likelihood in practice?

It's relatively easily to search through parameter space if you only have one parameter.

What if you have 2? 3? 10?

You need a smarter optimization approach! Many of these exist; the one we're using today is the "Nelder-Mead" algorithm



Your Task

1. Take a real dataset and create an epidemic model to represent it
    a. Describe what changes you need to make compared to the SIR model
    b. Be able to describe the aspects of the system that inspired you to make that change
2. Fit the model to data and present your param estimates
    a. Compare your results to primary lit and see if they're supported. Discuss why there might be differences between your result and others
3. Describe what aspects of the system change when you incorporate this additional wrinkle
    a. What sorts of dynamics/patterns might you be missing if you treat it like an SIR system?
4. Present your findings in a clear and effective scientific presentation (12min, 3min for questions)
    a. Presentation date: March 13th

Possible Diseases + Datasets

1. The 1918 Influenza Epidemic in the US (city-level case data)
2. The 2020 Covid-19 epidemic in the US (county-level case data)
3. 2018 Measles outbreak in Chad (data from: https://reliefweb.int/disaster/ep-2018-000075-tcd, summarized in this master's thesis)
4. HIV in humans (Cape Verde or Morocco) https://link.springer.com/chapter/10.1007/978-3-030-49896-2_6
5. Rabies: https://zenodo.org/records/5015975
6. Ebola:https://data.humdata.org/dataset/guinea-ebola-evd-2021-subnational-cases-deaths-hospitalisations-and-contact-tracing
7. Malaria
8. Tick-borne disease
9. Avian Conjunctivitis (Mycoplasma gallisepticum)
10. Daphnia disease
11. White Nose in Bats