MCMC Predictions of

...

COVID19 Infections

Understanding the problem

Problem

COVID19 outbreak in a small Indian town

Predict # of cases for the next 2 months

SIRD Model

The (SIRD)

- **S**usceptible
- **I**nfected
- **R**ecovered
- **D**eaths

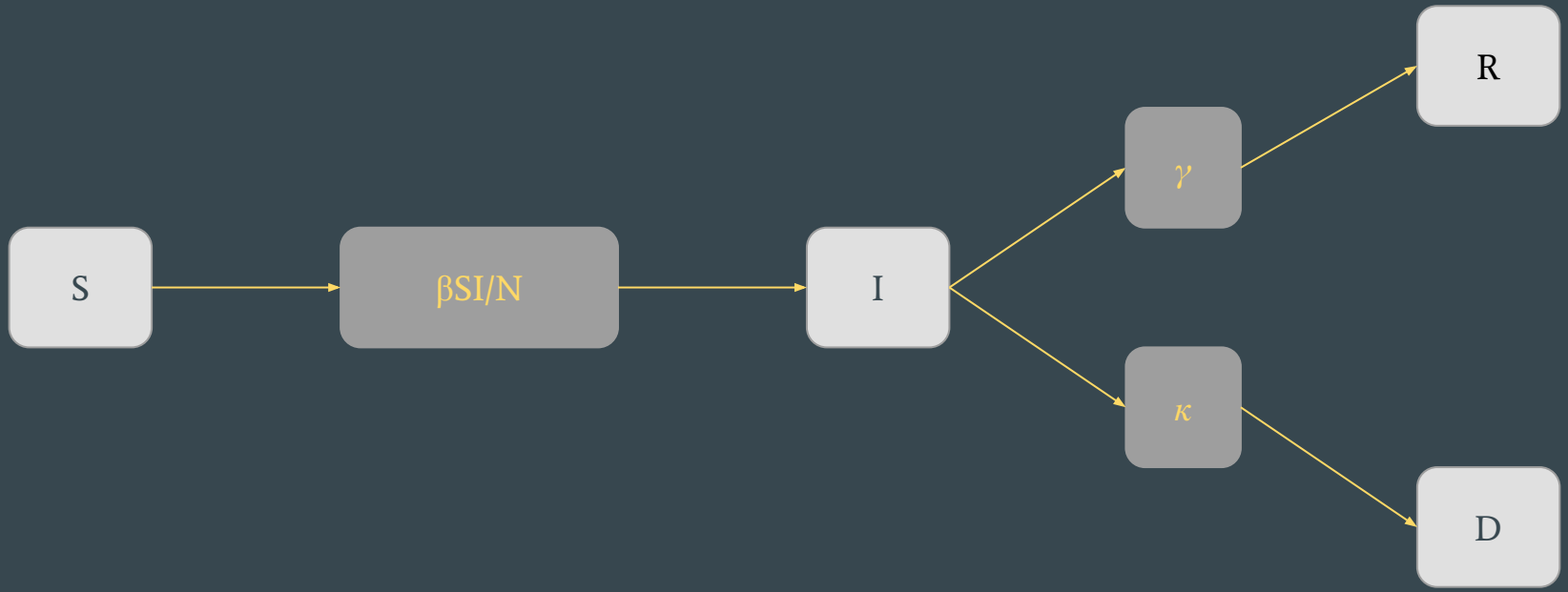
model is a set of ODEs that mimic viral dynamics.

Objective

- Use Markov Chain Monte Carlo Methods to predict cases
- Make conclusions for policymakers
- Compare with observed data

SIRD MODEL

(Compartmental Model)



SIRD Model

Differential Form

- $\beta \rightarrow$ rate of infection
- $\gamma \rightarrow$ rate of recovery
- $\kappa \rightarrow$ rate of mortality

Constraints:

- N = S + I + R + D
- $0 = \frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} + \frac{dD}{dt}$

$$\frac{dS}{dt} = -\frac{\beta SI}{N}$$

$$\frac{dI}{dt} = \frac{\beta SI}{N} - \gamma I - \kappa I$$

$$\frac{dR}{dt} = \gamma I$$

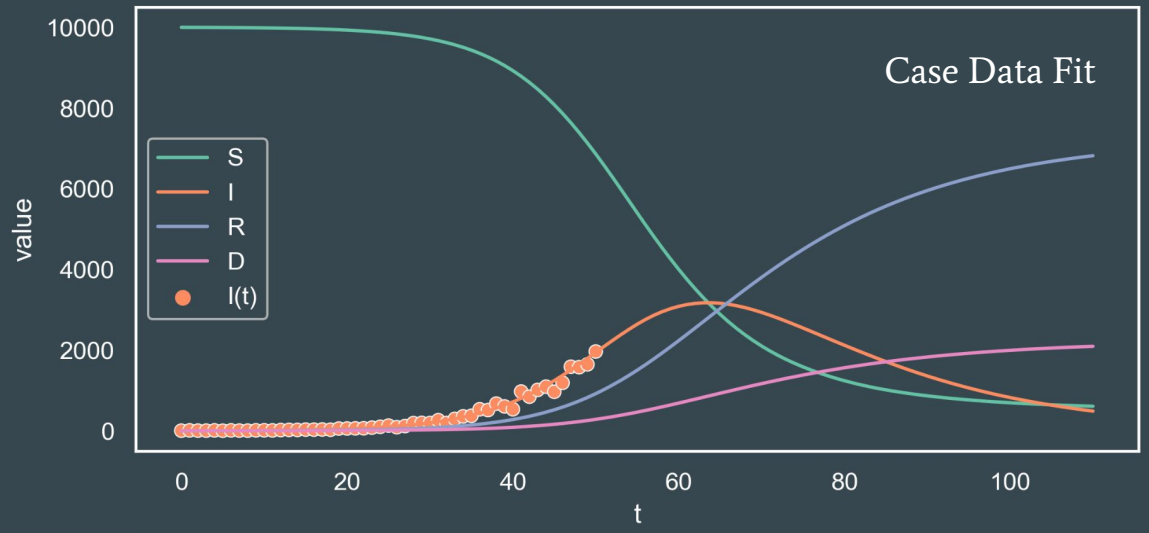
$$\frac{dD}{dt} = \kappa I$$

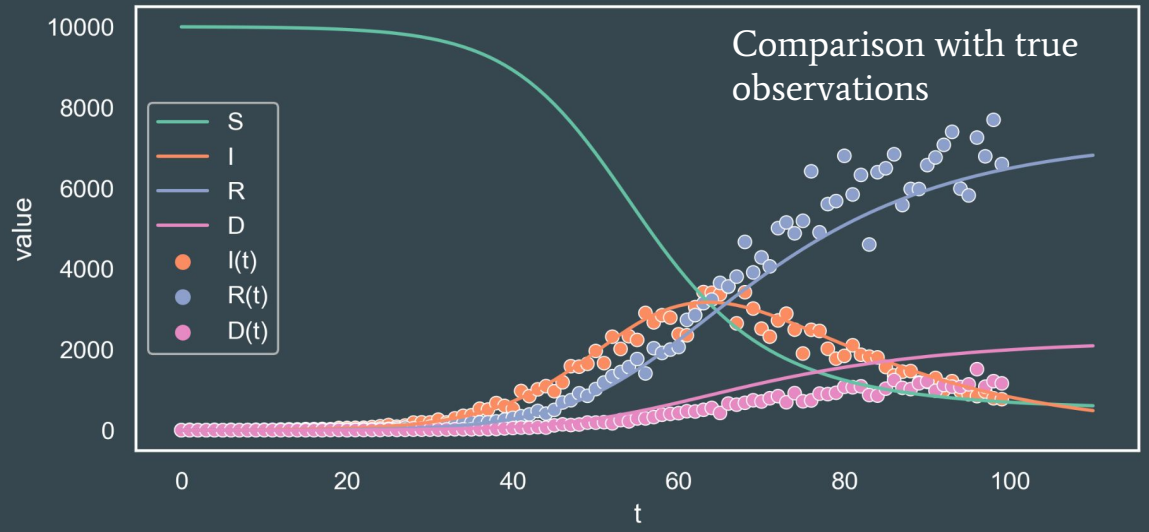
Solution to SIRD Model

- 51 days worth of infection data provided
- Runge Kutta Method of 5(4) was used to generate a solution using Delhi parameters
  - $\beta \rightarrow 0.2070$
  - $\gamma \rightarrow 0.0505$
  - $\kappa \rightarrow 0.0155$

Conclusion:

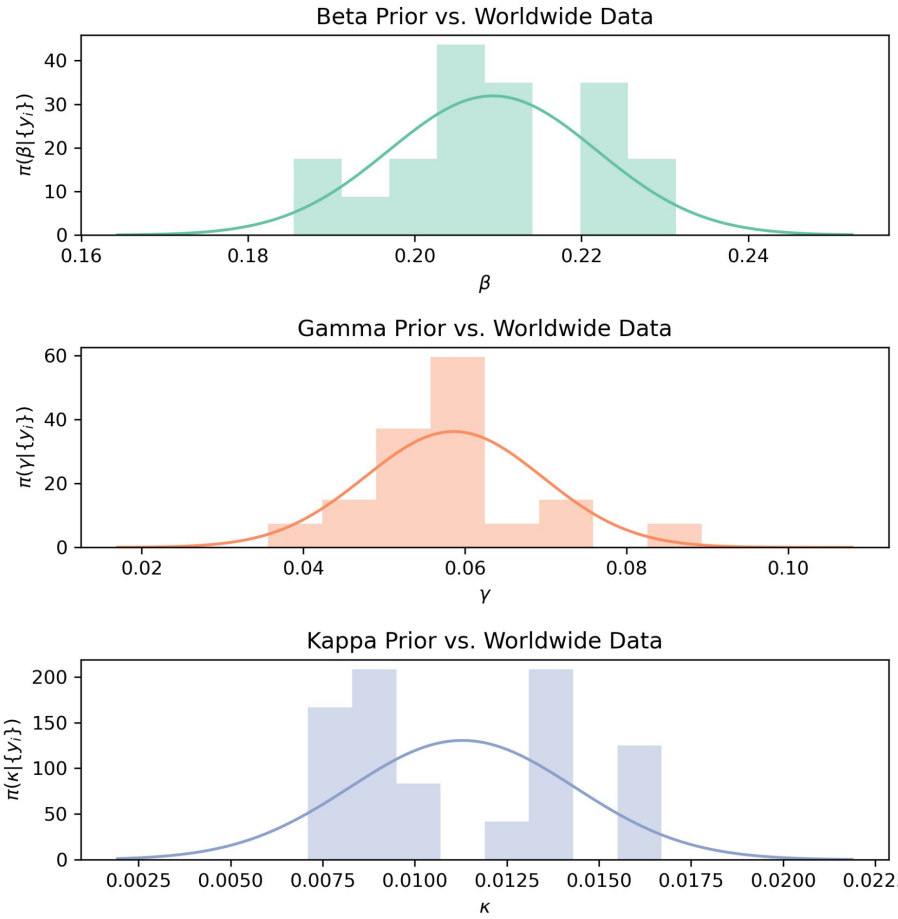
- True parameters ~ Delhi parameters





Prior Dist v. Data

The Histogram and Normal Distribution of the Prior Data



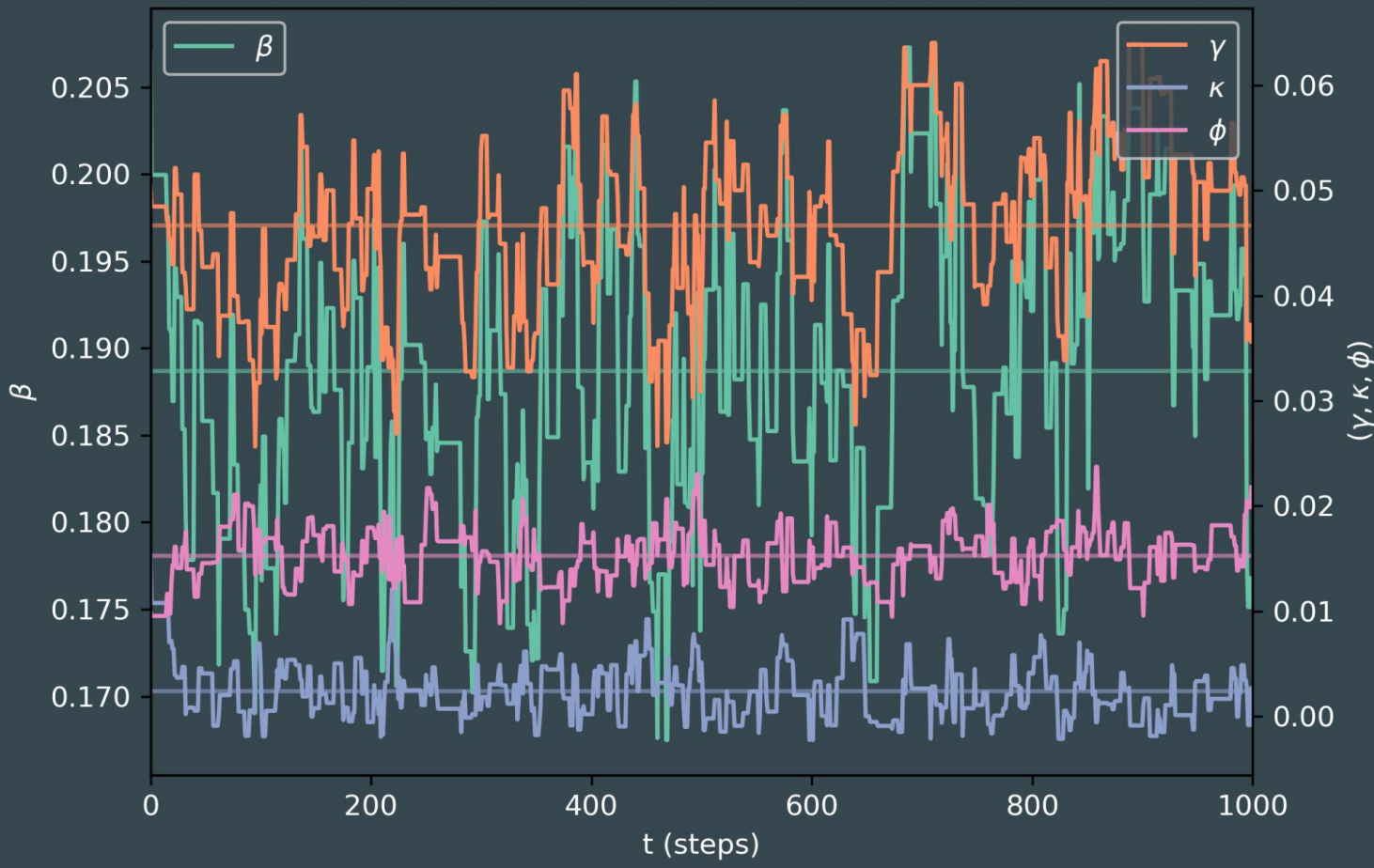
Markov Chain Monte Carlo Method

Initial Setup	• Define Prior • Define Likelihood
Compute current (cur) probability	• Get the posterior probability of the current parameters
Compute updated (new) probability	• Perform random walk • Get posterior probability
Conditional Accept	• If new/cur > 1 : accept • Elif (0 < random < new/cur < 1) : accept

Long Term MC Simulation

As $t \to \infty$

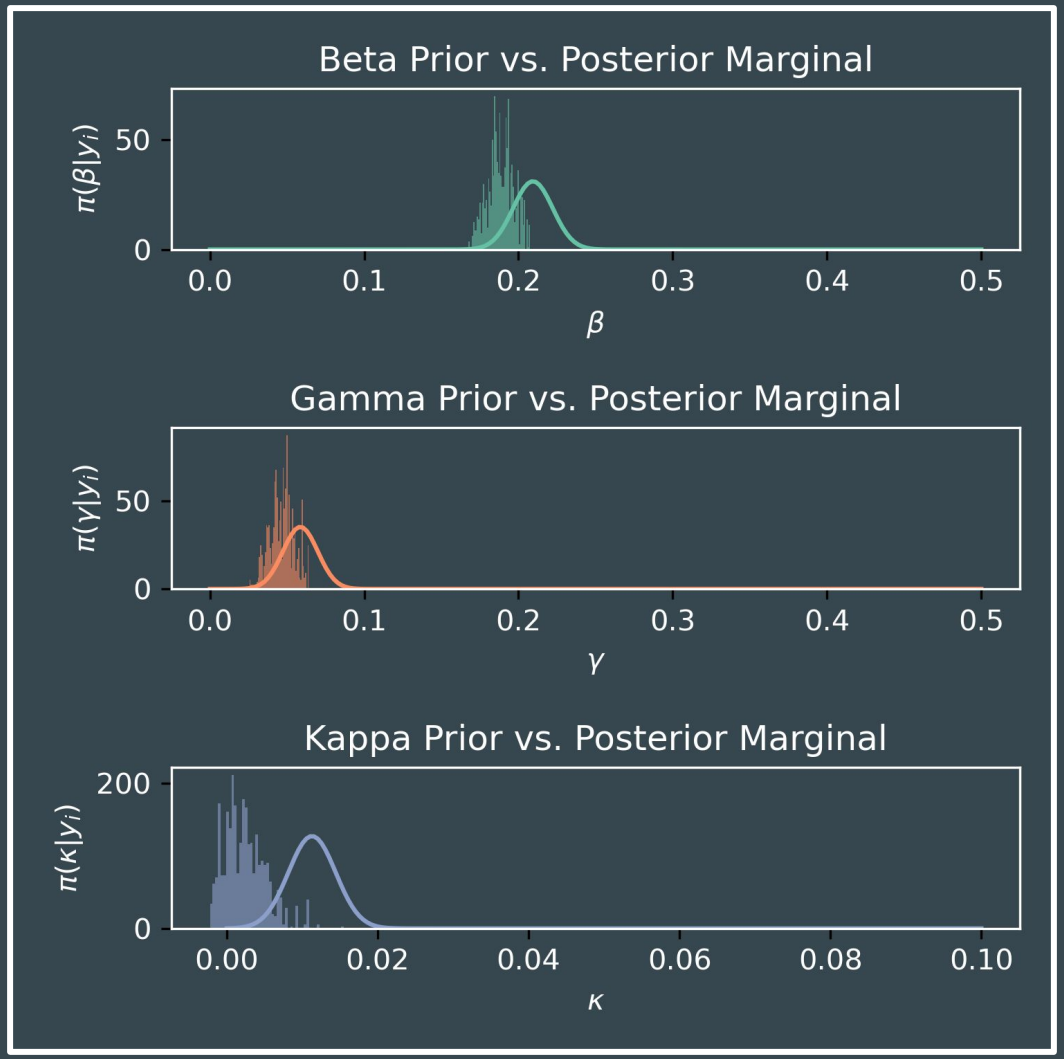
- $\beta \to 0.1898$
- $\gamma \to 0.0477$
- $\kappa \to 0.0150$



90% Credibility Intervals

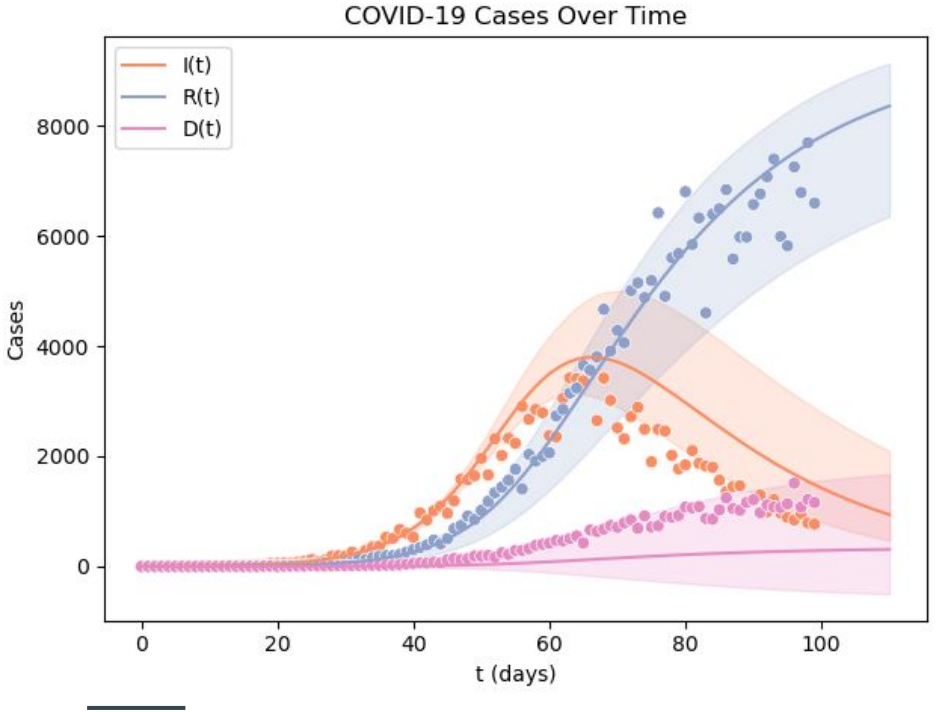
Parameter	Beta	Gamma	Kappa	Phi
Lower Bound	0.1760	0.0353	0*	0.0112
Upper Bound	0.2025	0.0613	0.0075	0.0202

* negative value


Beta Prior vs. Posterior Marginal
$\pi(\beta|y_i)$
50
0
0.0
0.1
0.2
0.3
0.4
0.5
β
Gamma Prior vs. Posterior Marginal
$\pi(\gamma|y_i)$
50
0
0.0
0.1
0.2
0.3
0.4
0.5
γ
Kappa Prior vs. Posterior Marginal
$\pi(\kappa|y_i)$
200
0
0.00
0.02
0.04
0.06
0.08
0.10
κ

Future Predictions & Envelope

- Predictions fitted against observations
  - Infections → overestimate
  - Recovery → accurate
  - Deaths → underestimate
- Envelope
  - Infection data not contained
  - Recovery and Deaths contained



Recommendations to Policymakers

- According to prediction → almost at peak even without interference
- Light restrictions
  - masking
  - social distancing

Sources of Error

- Due to overflow/underflow errors → inconvenient values dumped
- Extra parameter phi → extra uncertainty
- Overall model is very simple