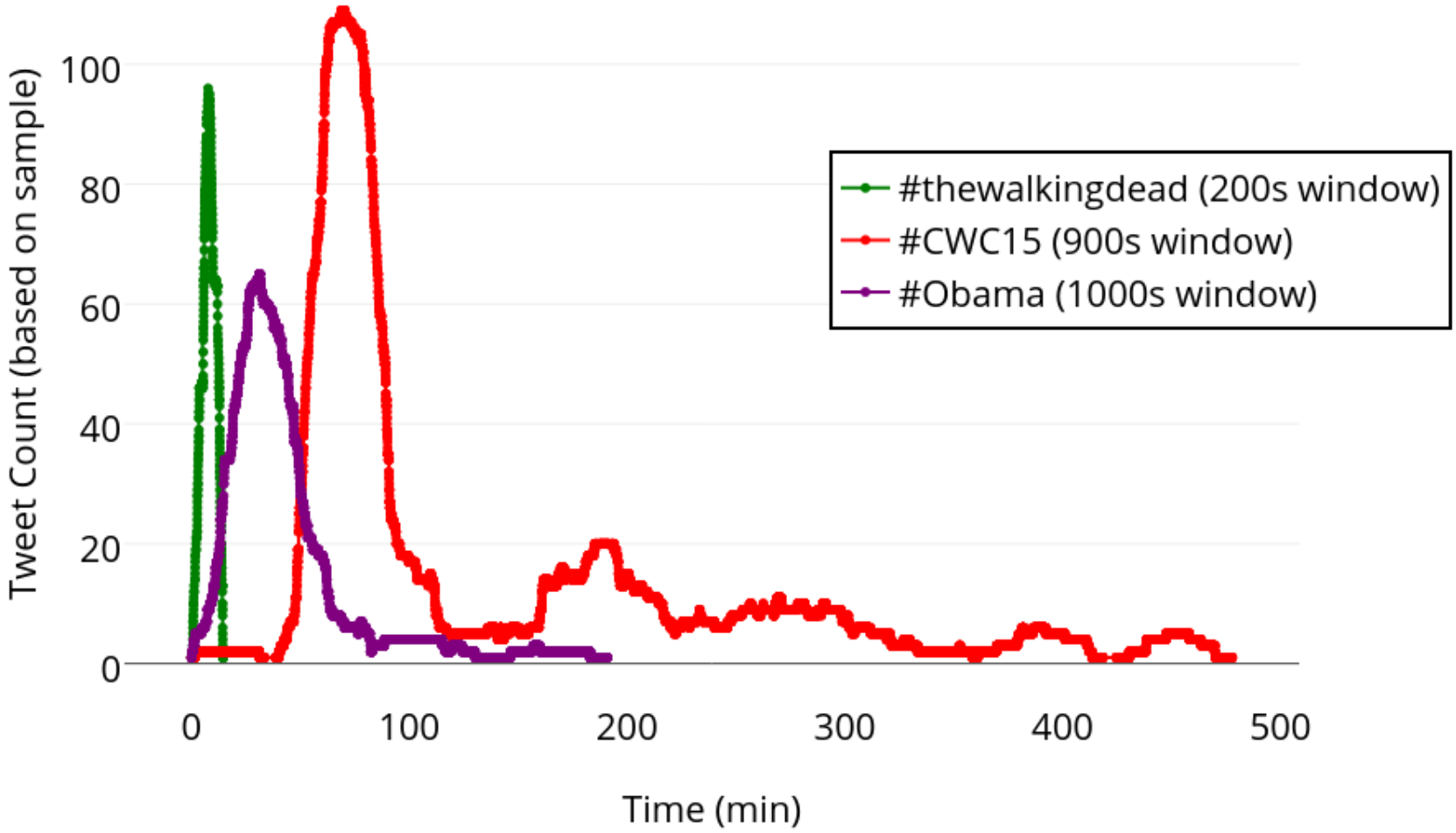
Mathematical Modeling of Trending Topics on Twitter

Jonathan Skaza

April 14, 2015

Comparison of Trending Topics



"Window" refers to the moving sum period (e.g., each point represents count in past 200s)

Project Objectives

- Quantify the diffusion of information on Twitter

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- Compare and contrast different trending topics

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- Compare spread of information to spread of infectious disease
- Create a reproducible output product

Agenda

1. Twitter overview, facts, and figures

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2. Methodological strategy

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3. Previous studies

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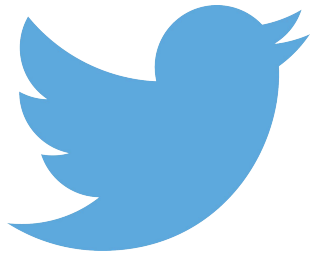
2. Methodological strategy
3. Previous studies
4. Results and discussion

About Twitter

- Created in 2006



About Twitter

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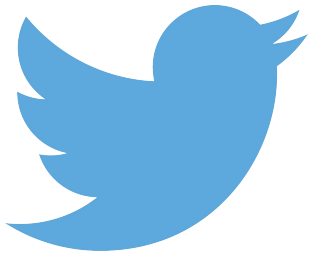
- Incorporated in 2007



About Twitter

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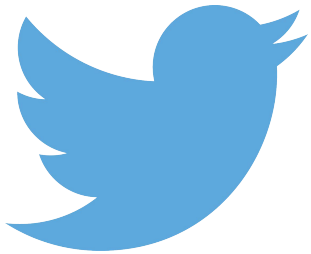
- 288 million monthly active users – 500 million Tweets per day



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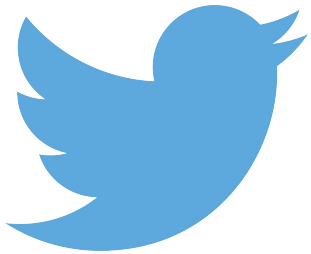
- Source: `about.twitter.com`



Anatomy of a Tweet

Jonathan Skaza
@SkazaSays

Follow

Fun fact: Since field was expanded to 64 teams, average sum of seeds in Final Four has been 11 (this year, it's 10) #MarchMadness

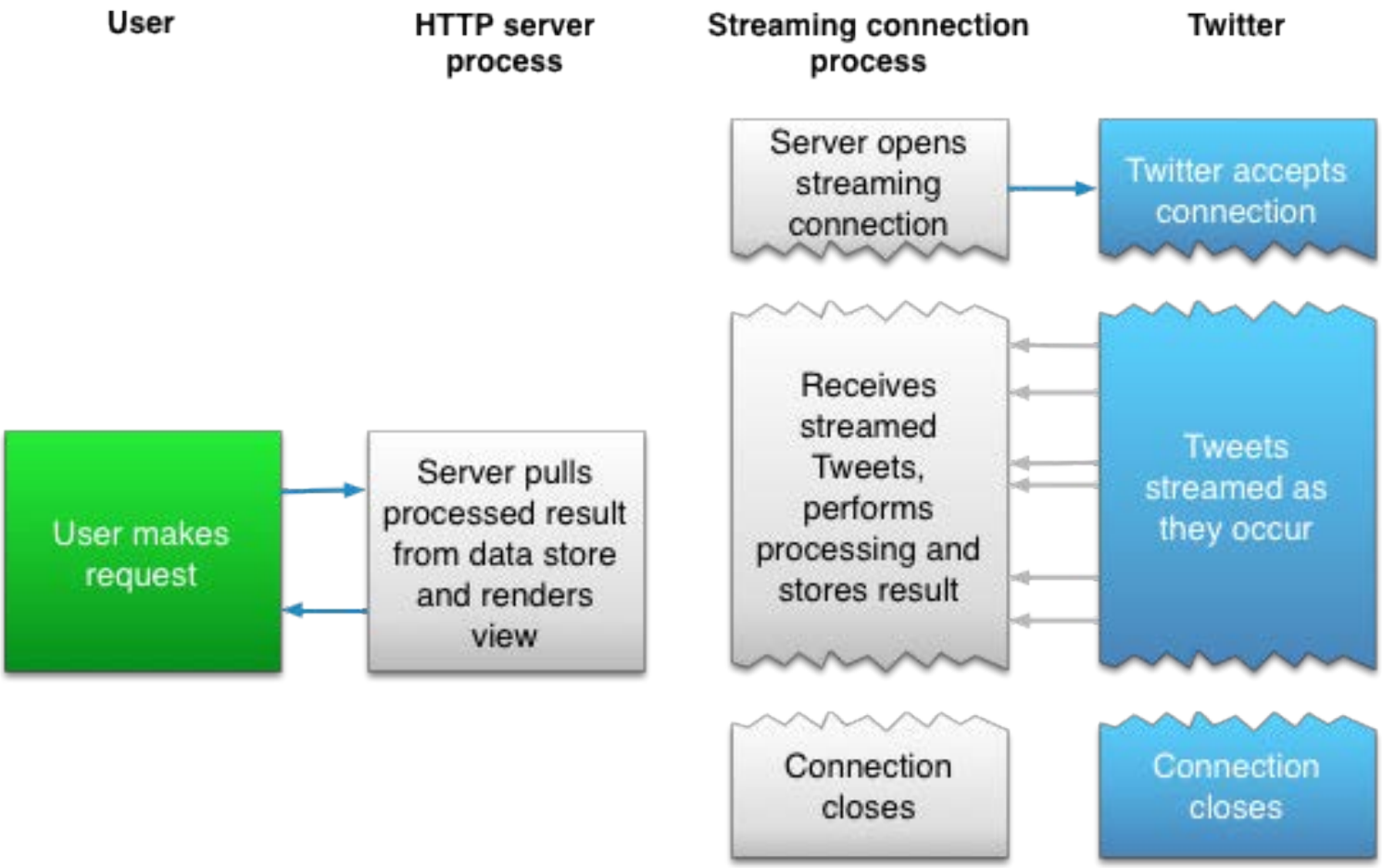
12:24 PM - 31 Mar 2015

1 RETWEET

Twitter Application Programming Interface (API)

- Two different flavors: REST and Streaming

Streaming API



Source: `dev.twitter.com`

Streaming API Request Parameters

delimited	locations
stall_warnings	count
filter_level	with
language	replies
follow	stringify_friend_id
track	

Source: Twitter Developers Documentation

stream.filter(track=['#'])

Data Collection

Raw Tweet


```
{"created_at":"Fri Mar 27 18:16:52 +0000 2015","id":581520276292280320,"id_str":"581520276292280320","text":
"Loving the #NCAA #MarchMadness? Find out fun facts like which states listened most, overall listening hours
and more! http:\/\/t.co\/DWfDTDnDg8","source":"\u003cahref=\"http:\/\/twitter.com\" rel=\"nofollow\"\u003e
Twitter Web Client\u003c\/a\u003e","truncated":false,"in_reply_to_status_id":null,"in_reply_to_status_id_str"
:null,"in_reply_to_user_id":null,"in_reply_to_user_id_str":null,"in_reply_to_screen_name":null,"user":{"id":
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speakers","url":"http:\/\/www.westwoodone.com","description":"Westwood One offers audio products and content
to reach listeners whenever, wherever they are. #powerofsound","protected":false,"verified":true,"followers_
count":1123,"friends_count":337,"listed_count":24,"favourites_count":1923,"statuses_count":2113,"created_at"
:"Fri Aug 23 19:28:54 +0000 2013","utc_offset":-10800,"time_zone":"Atlantic Time (Canada)","geo_enabled":
false,"lang":"en","contributors_enabled":false,"is_translator":false,"profile_background_color":"FAFAFA",
"profile_background_image_url":"http:\/\/pbs.twimg.com\/profile_background_images\/378800000066715369\/34
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/pbs.twimg.com\/profile_banners\/1694596596\/1422292326","default_profile":false,"default_profile_image":
false,"following":null,"follow_request_sent":null,"notifications":null},"geo":null,"coordinates":null,"plac
e":null,"contributors":null,"retweet_count":0,"favorite_count":0,"entities":{"hashtags":[{"text":"NCAA","i
ndices":[11,16]},{"text":"MarchMadness","indices":[17,30]}],"trends":[],"urls[{"url":"http:\/\/t.co\/DWfDTD
nDg8","expanded_url":"http:\/\/bit.ly\/1CiR90h","display_url":"bit.ly\/1CiR90h","indices":[118,140]}],"user
_mentions":[],"symbols":[]},"favorited":false,"retweeted":false,"possibly_sensitive":false,"filter_level":
"low","lang":"en","timestamp_ms":"1427480212649"}
```
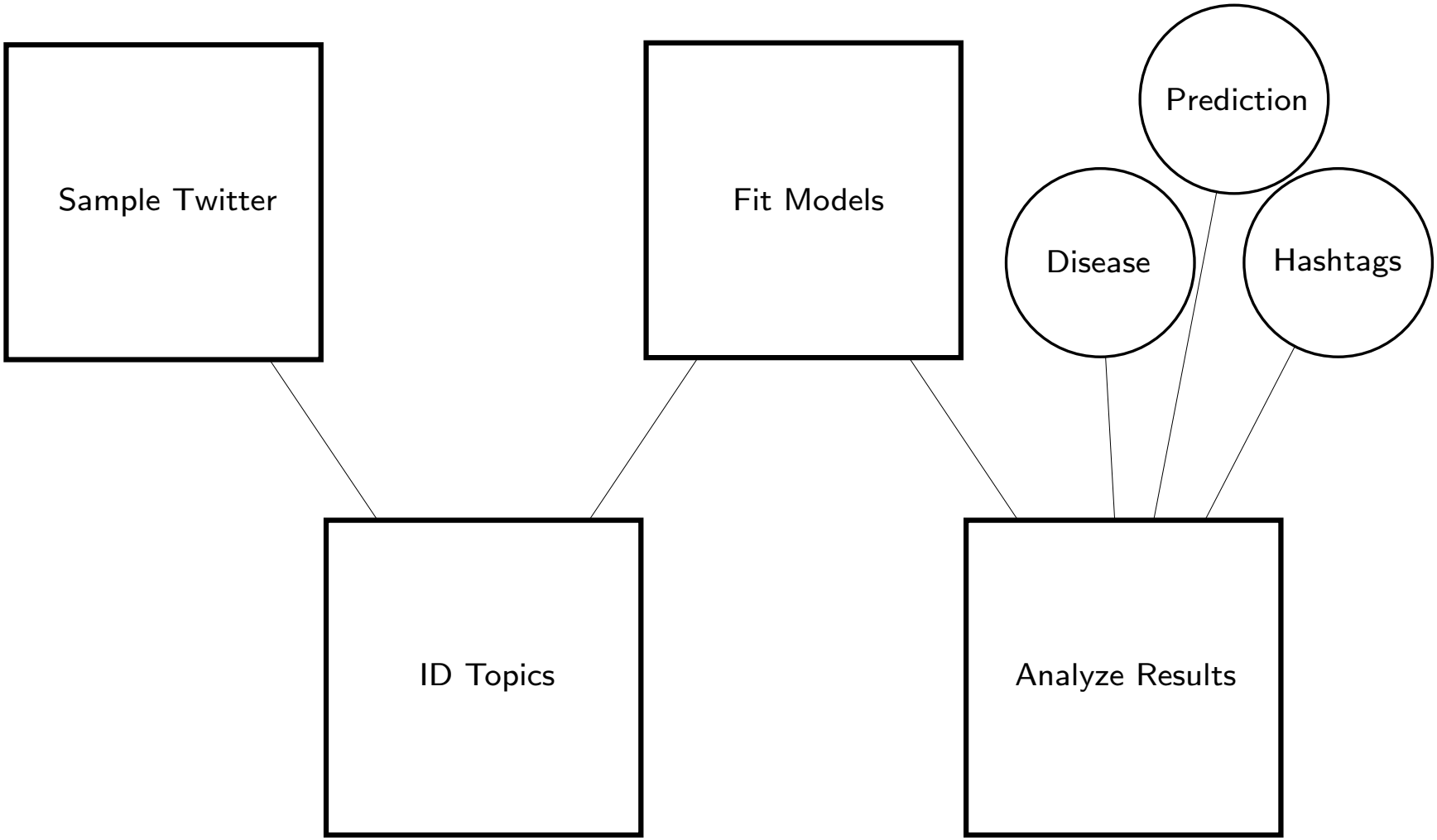

Data Collection

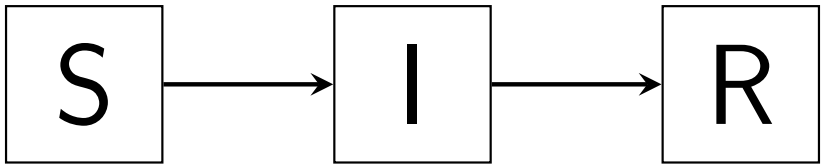
Processed Tweet

```
Fri Mar 27 18:16:52 +0000 2015,['NCAA', 'MarchMadness']
```

Methodology



SIR Model

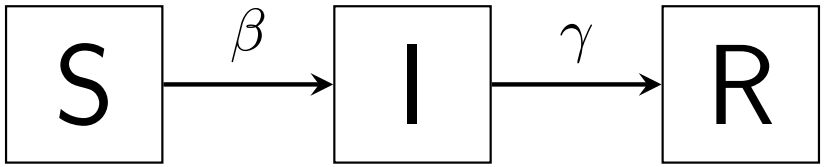


Developed by Kermack and McKendrick (1927)

Disease: Proximal to infected individual $\rightarrow$ Catch disease $\rightarrow$ Recover from disease

Meme: Twitter user $\rightarrow$ Tweet about topic $\rightarrow$ Move on in life

SIR Model



$$\frac{dS}{dt} = -\beta SI$$
$$\frac{dI}{dt} = +\beta SI - \gamma I$$
$$\frac{dR}{dt} = +\gamma I$$

Use Markov Chain Monte Carlo (MCMC) simulation techniques to estimate β, γ, initial S, and initial I (Coelho, Codeco, and Gomes, 2011)

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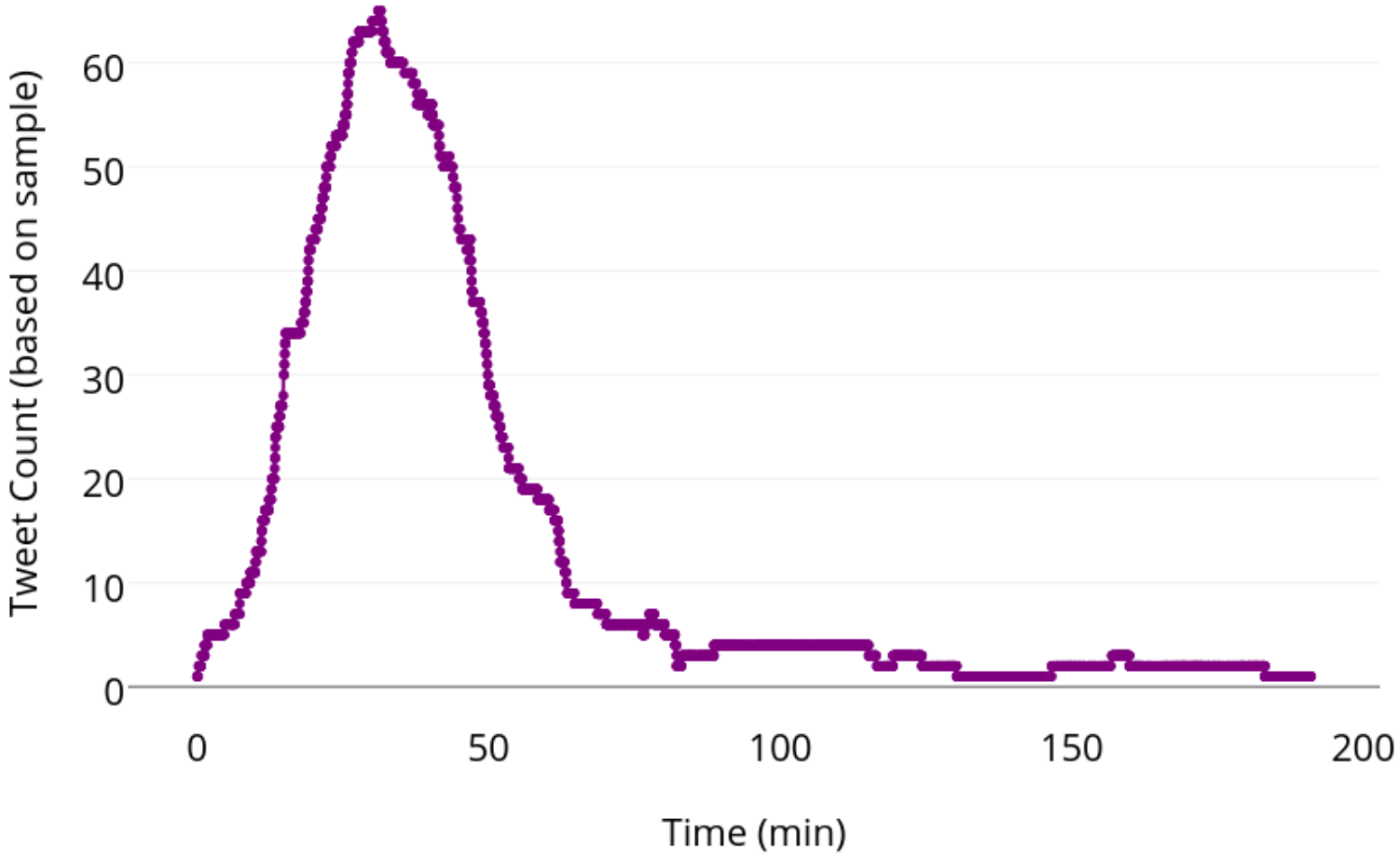
  - Zombie apocalypse (Witkowski and Blais, 2013)

Application of Methodology to #Obama



Specify Prior Probability Distributions

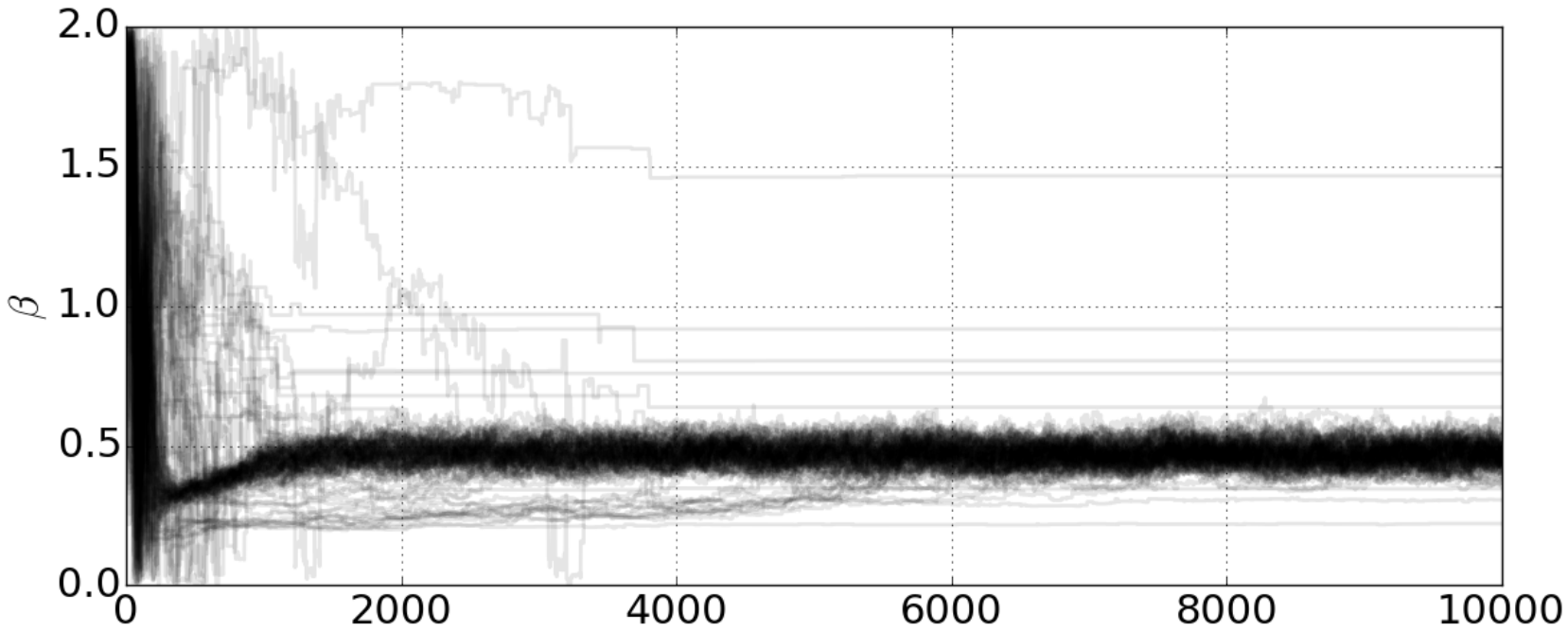
Prior Probability Distributions

- $\beta \sim U(0, 2)$
- $\gamma \sim U(0, 2)$
- $S_0 \sim U(30, 5000)$
- $I_0 \sim U(0, 10)$

Example of MCMC Parameter Estimation

Code Snippet

```
model = MCMCModel(sim, beta = Uniform(0,2))
model.run_mcmc(10000)
```



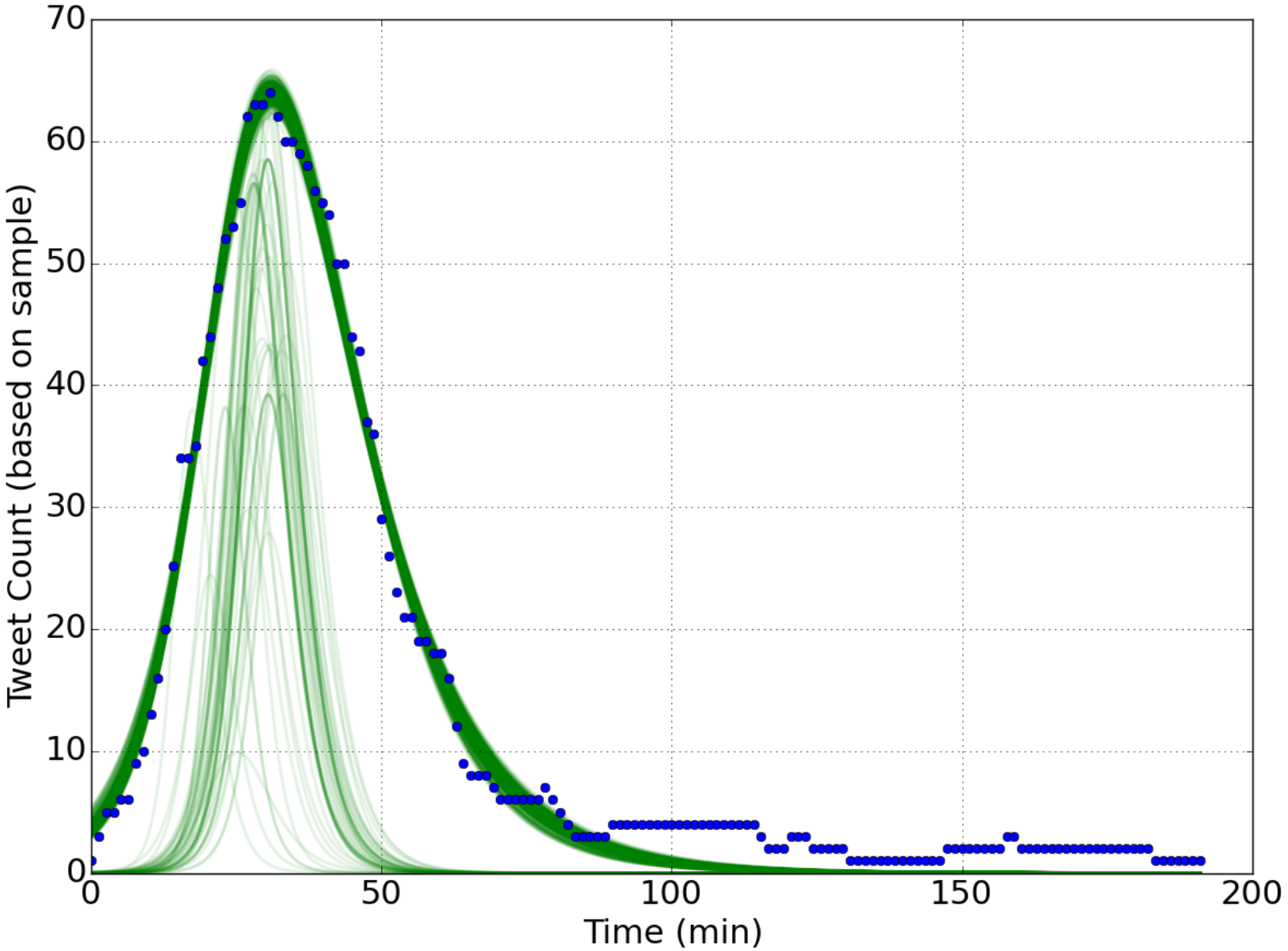
Run #Obama Simulation

Simulate 500 times, drawing from posterior probability distributions

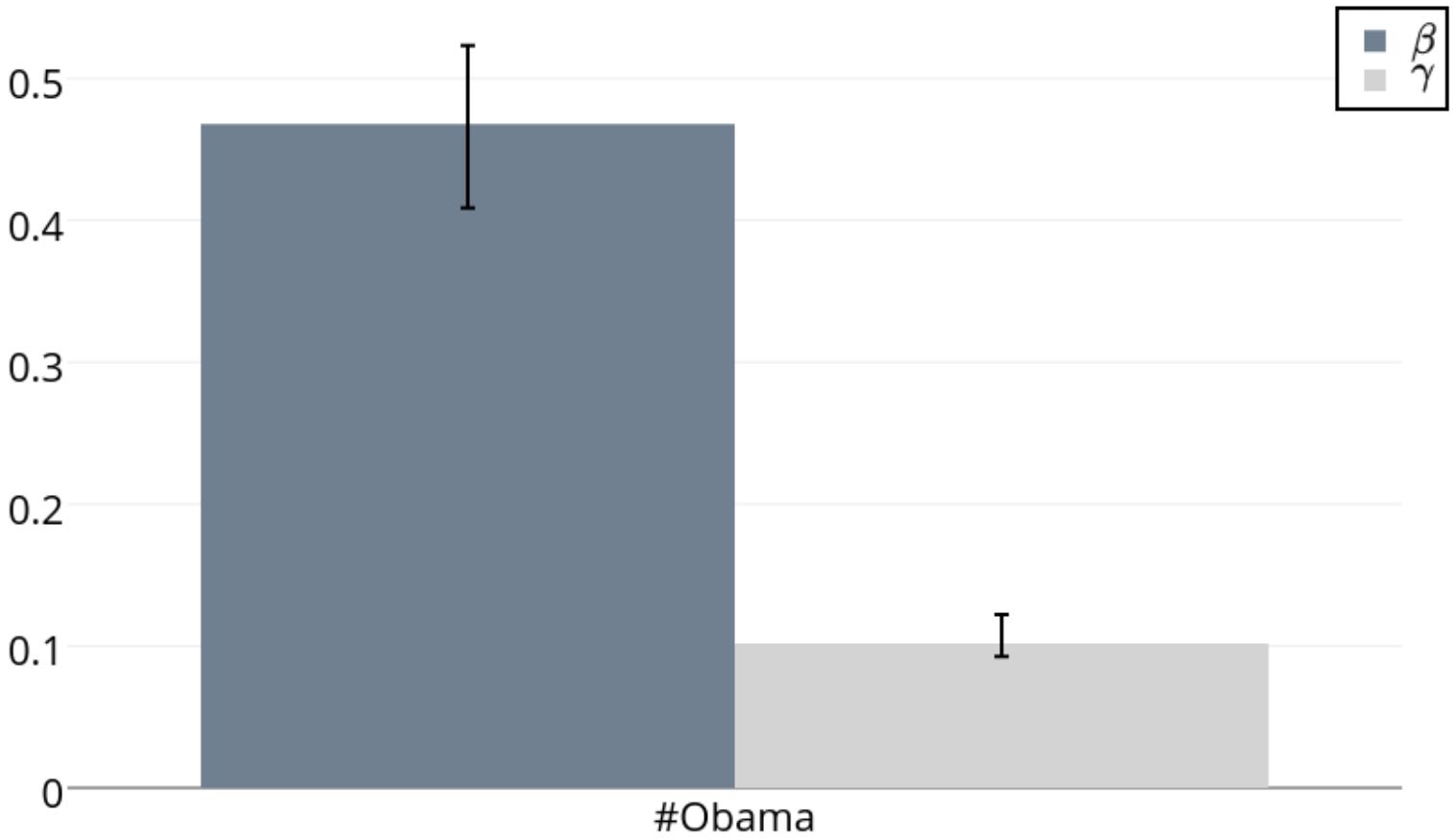
Code Snippet

```
for i in range(500):
    model.draw()
    sim.run(0,191)
    plot(sim.t,sim.I,'g-',alpha = .1)
```

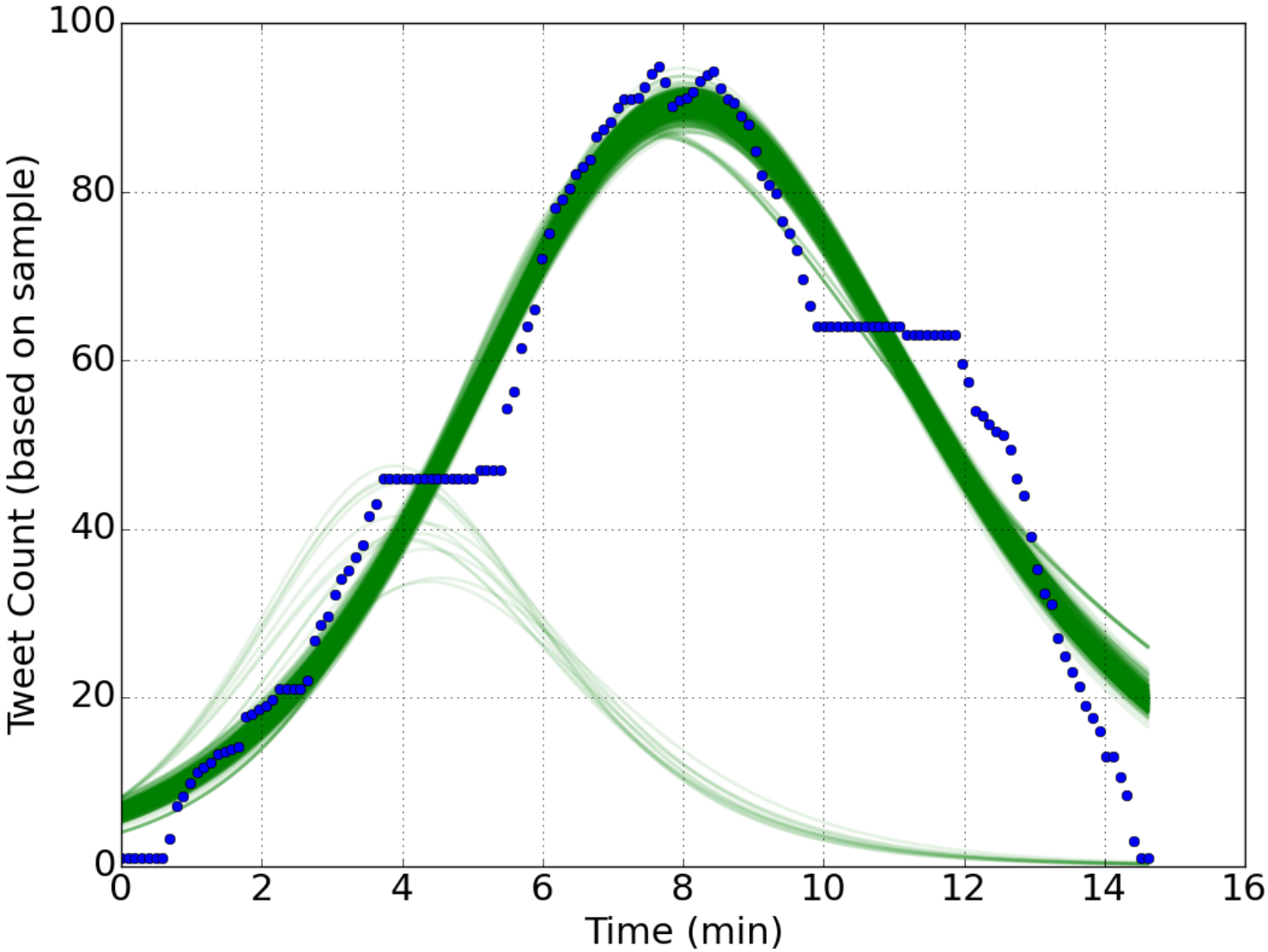
Simulation Results for #Obama



Best Parameter Estimates & Credible Intervals

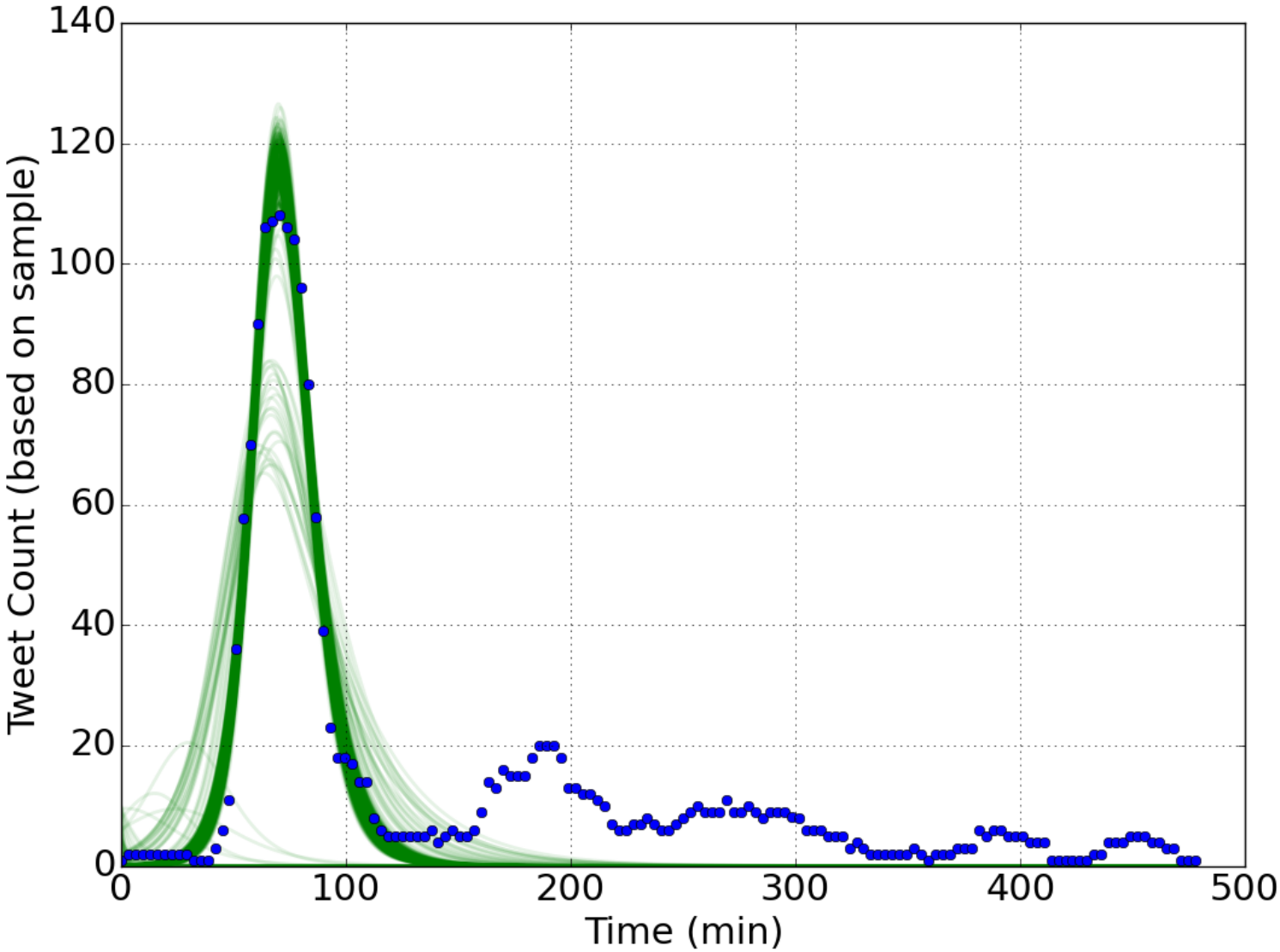


#thewalkingdead Simulation



#thewalkingdead Parameter Estimation

#CWC15 Simulation



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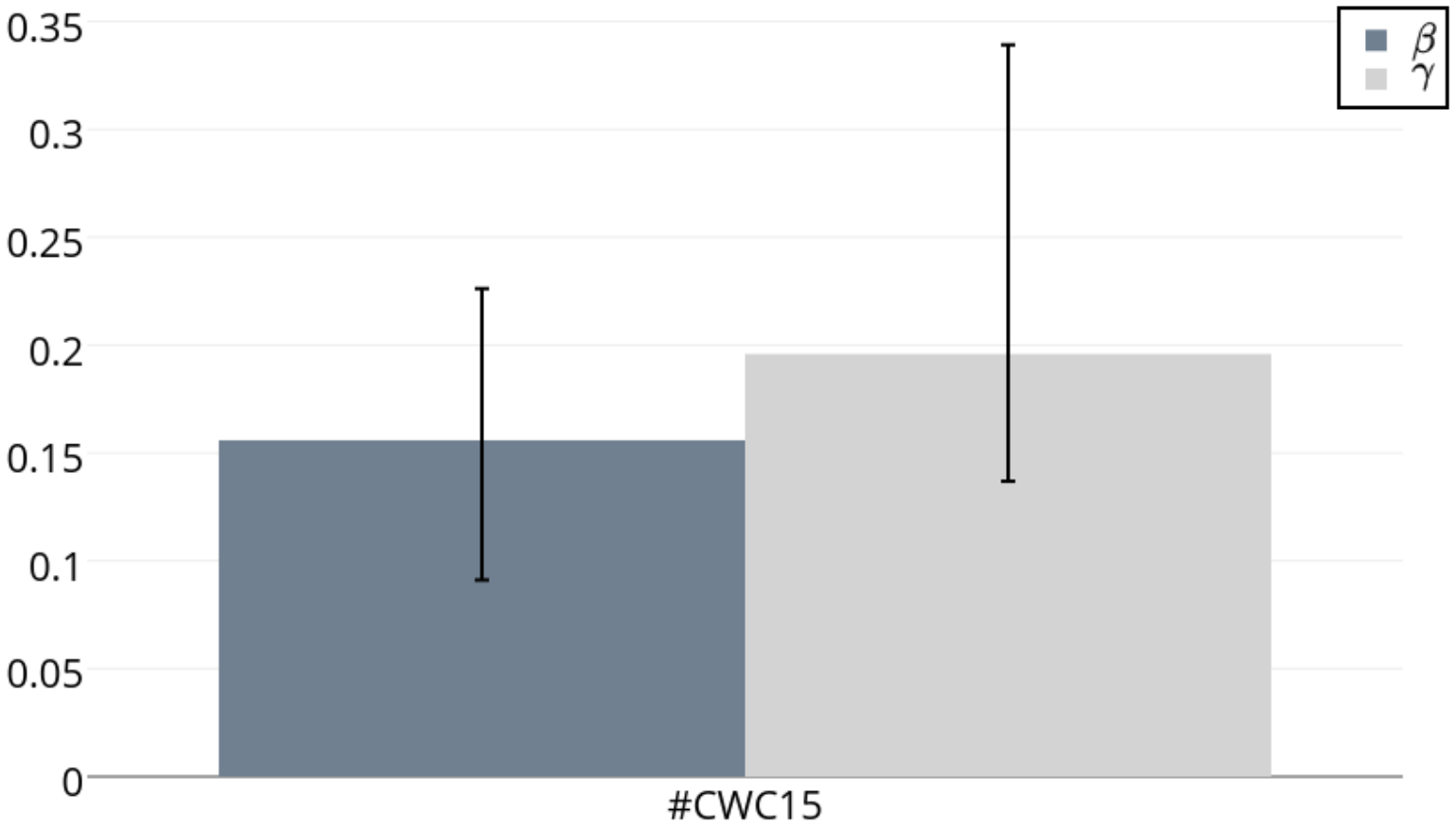
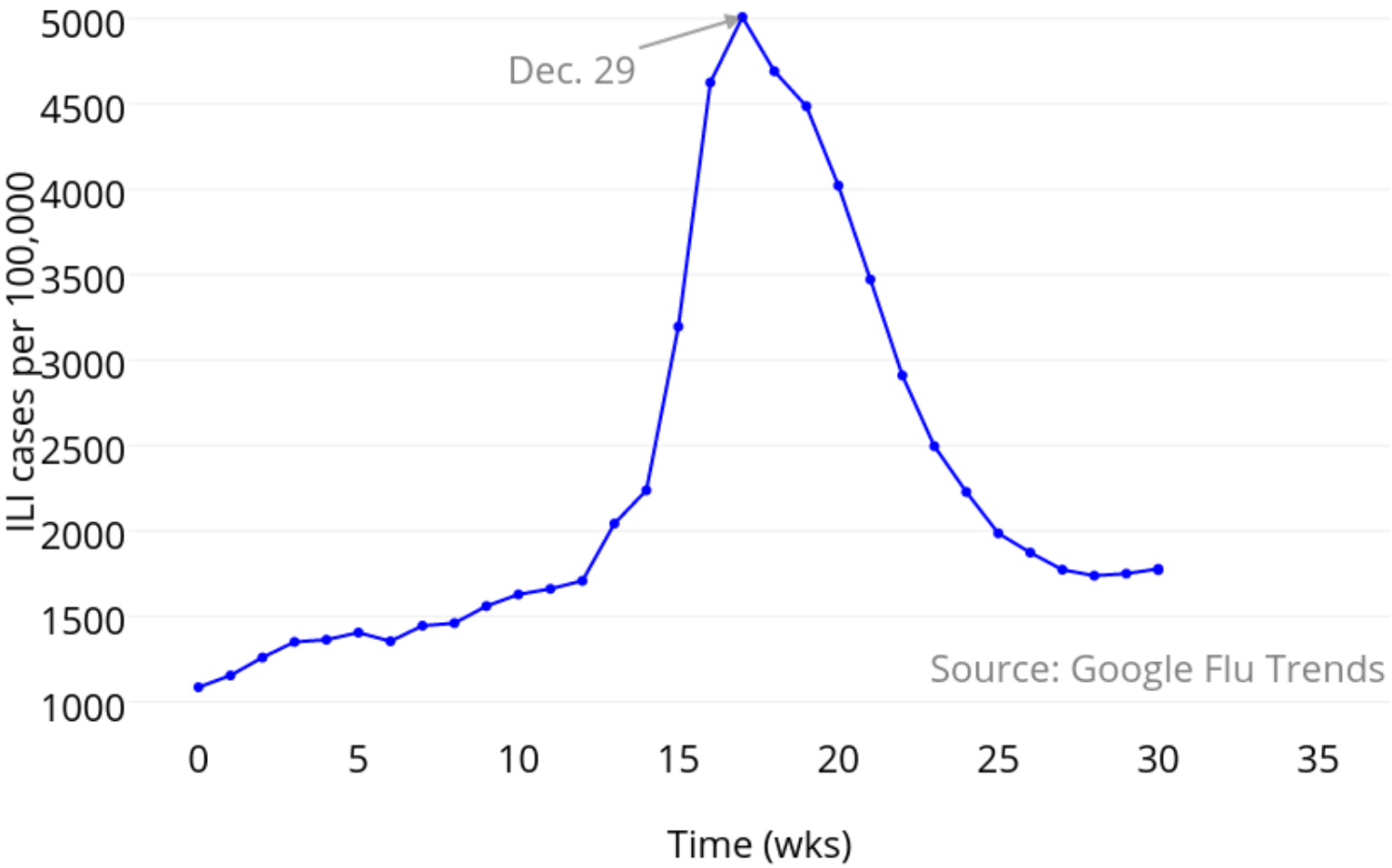
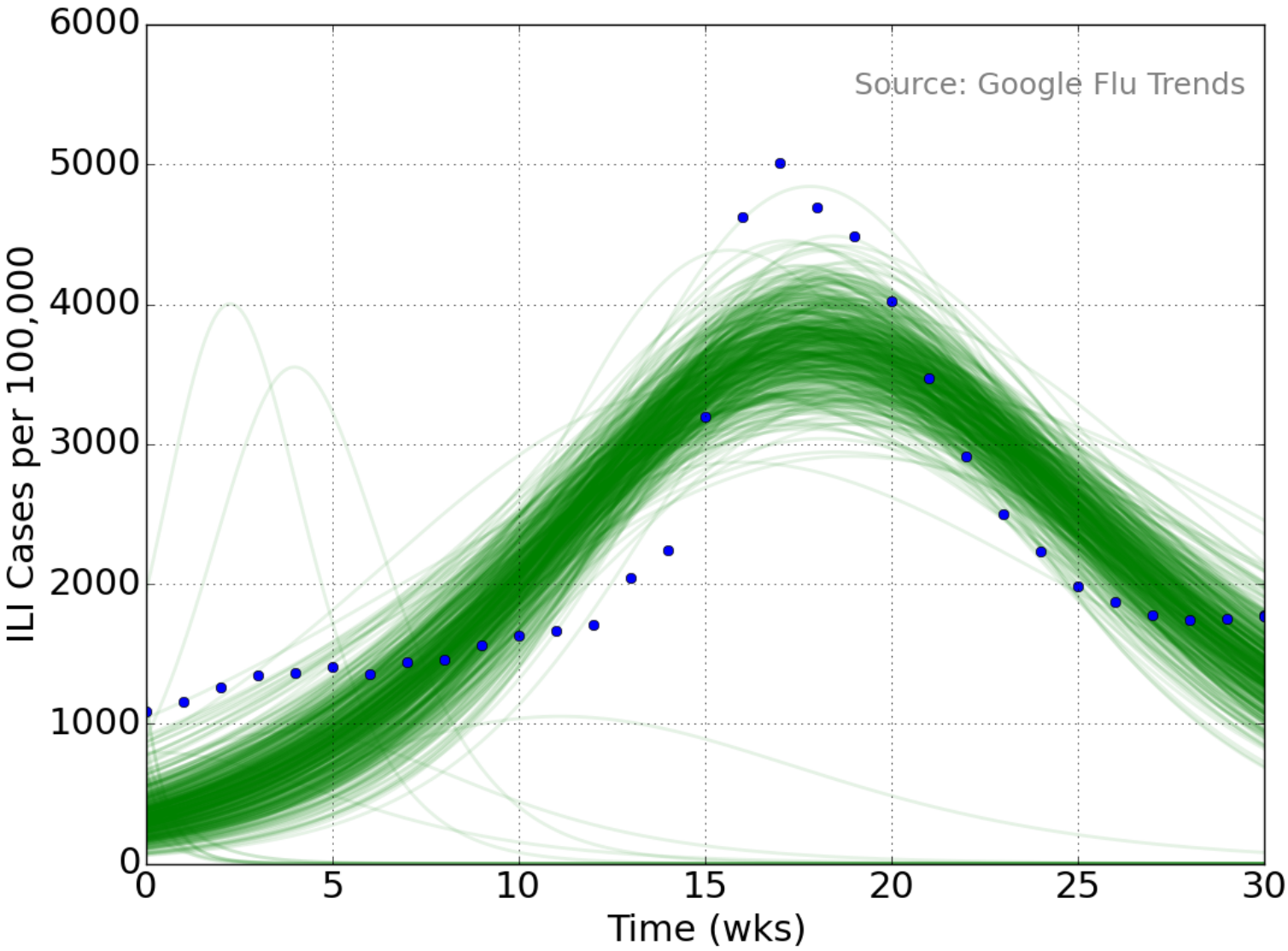


2013-14 U.S. Flu Season (September 1st - April 6th)



Flu Simulation



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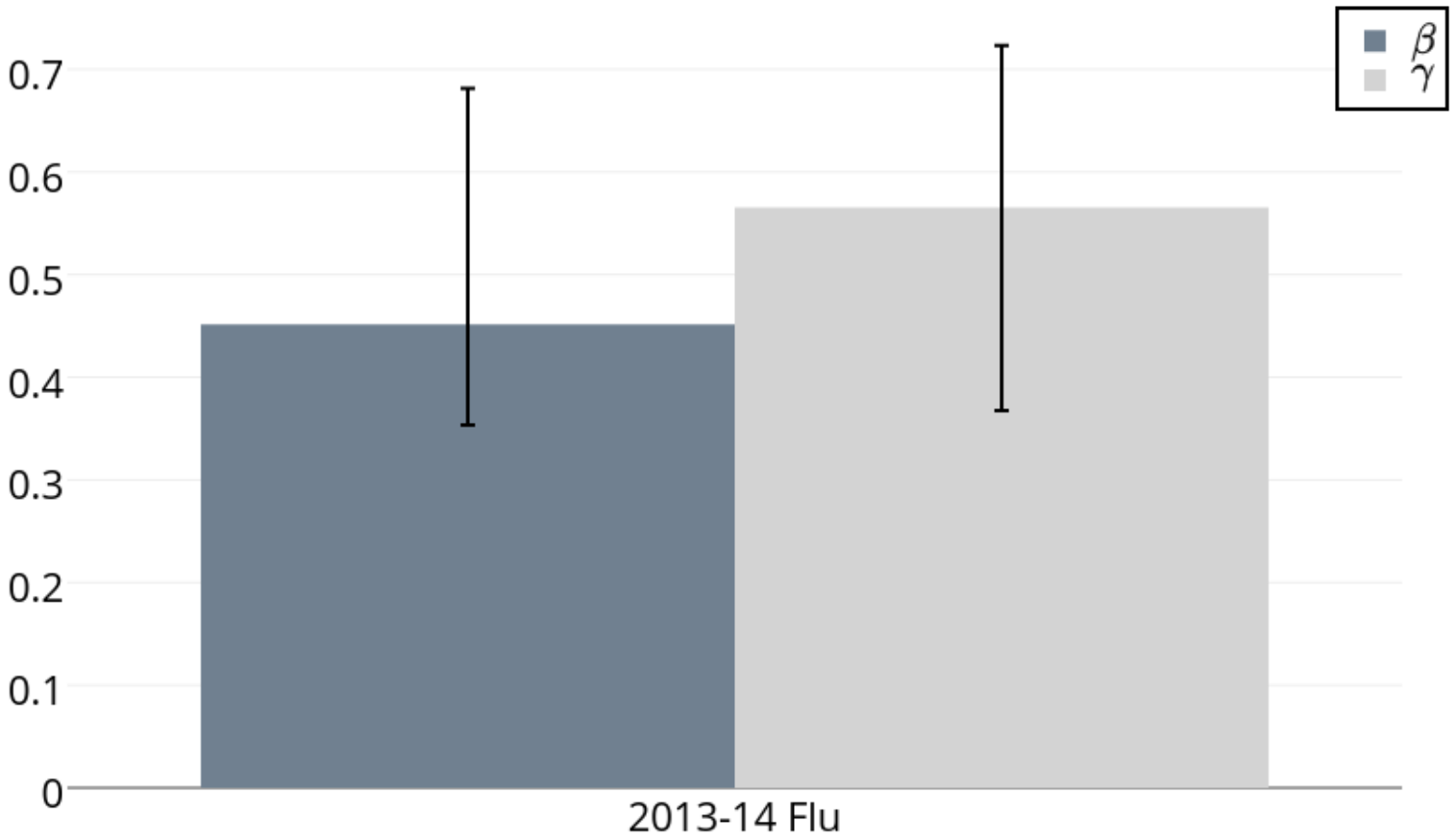
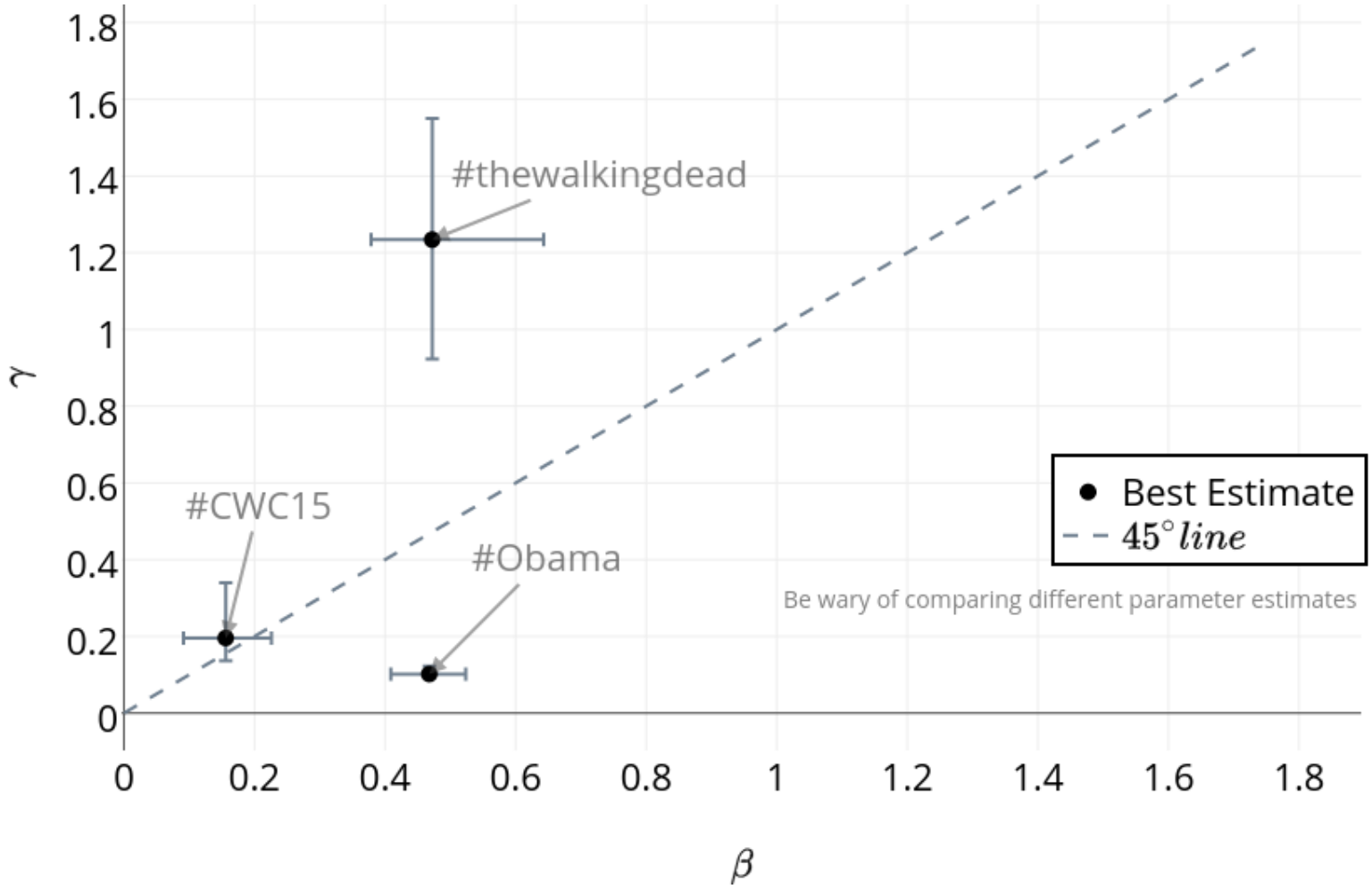
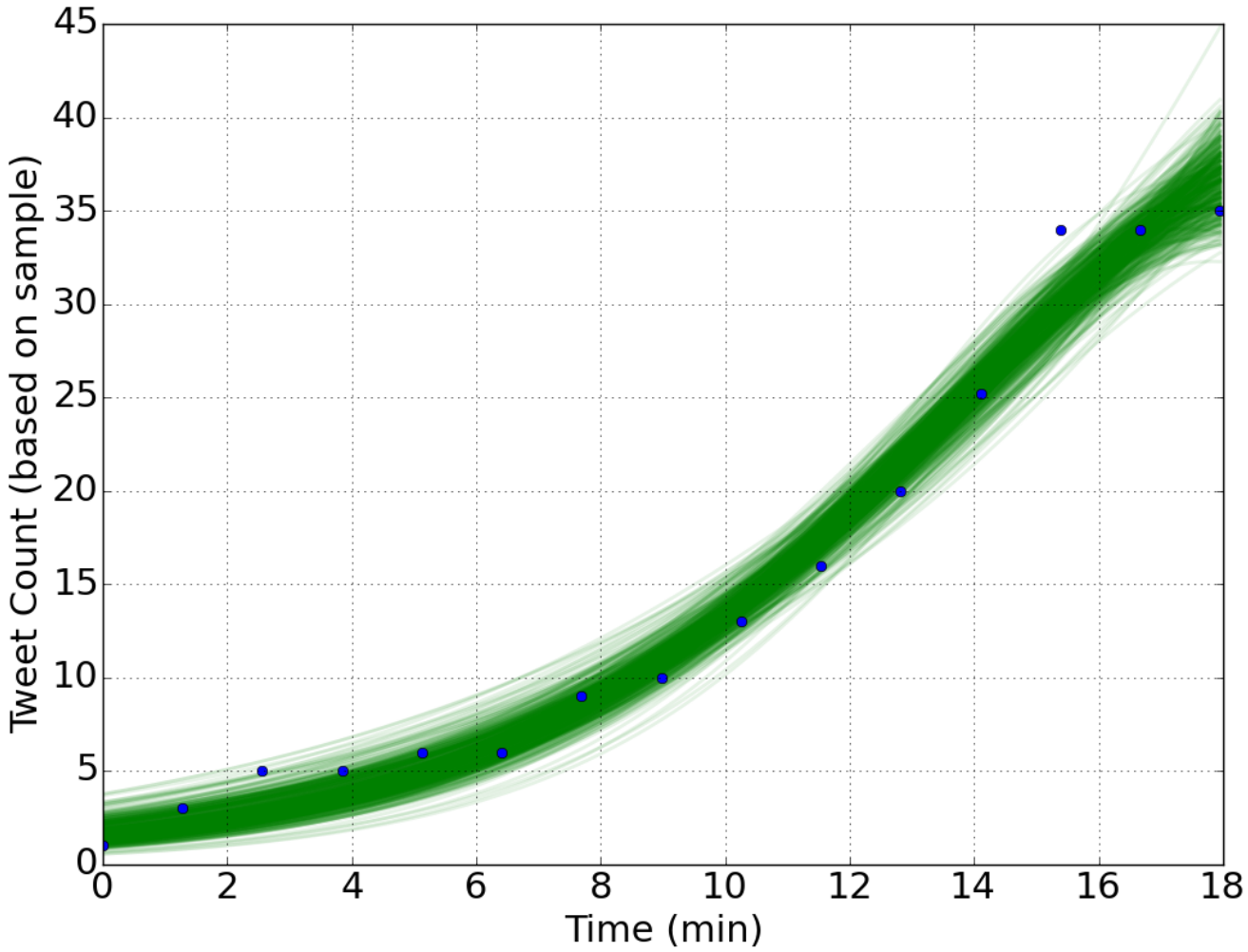


Comparison of Model Parameters



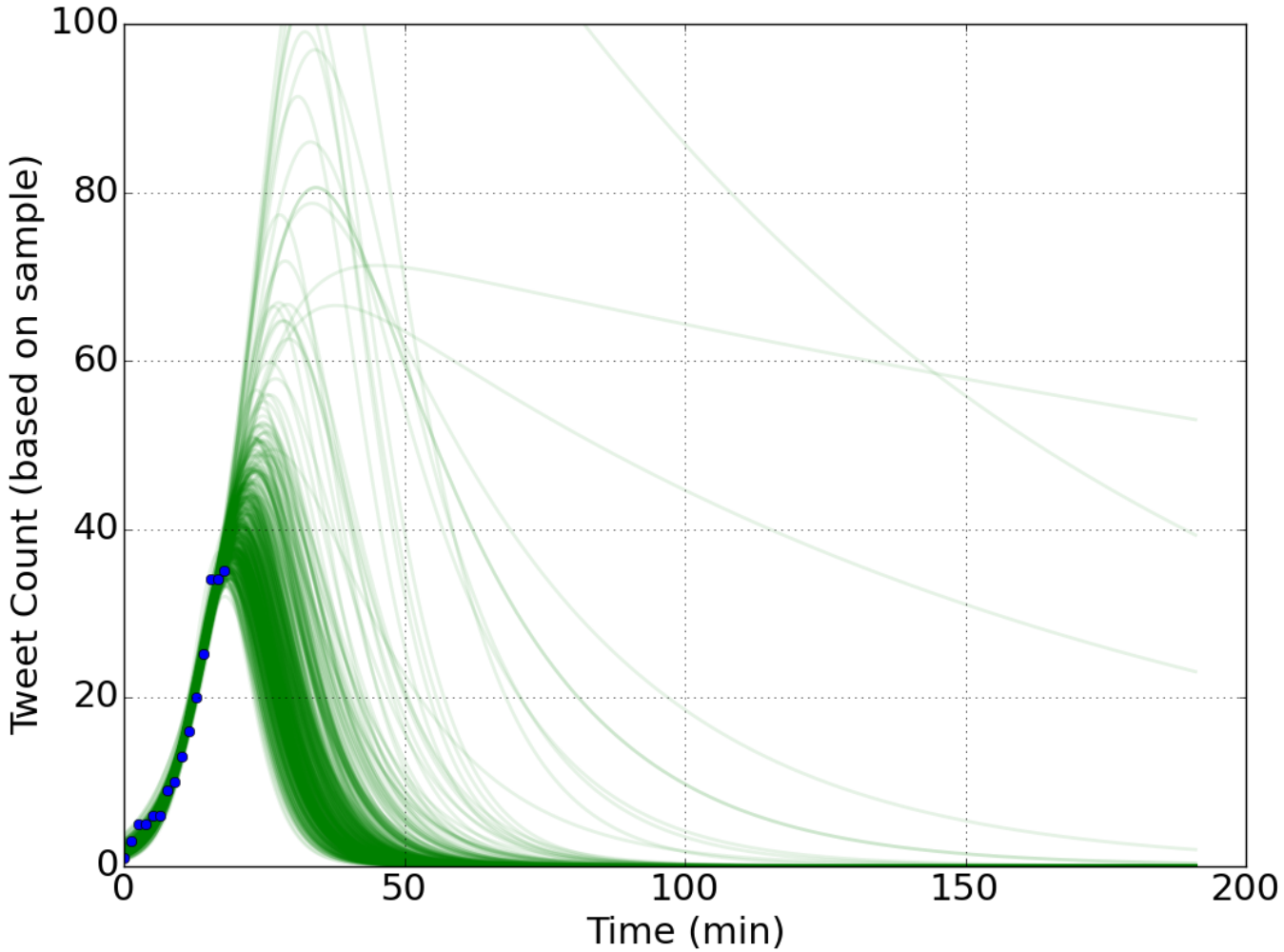
Prediction Using #Obama

Fit model to training set



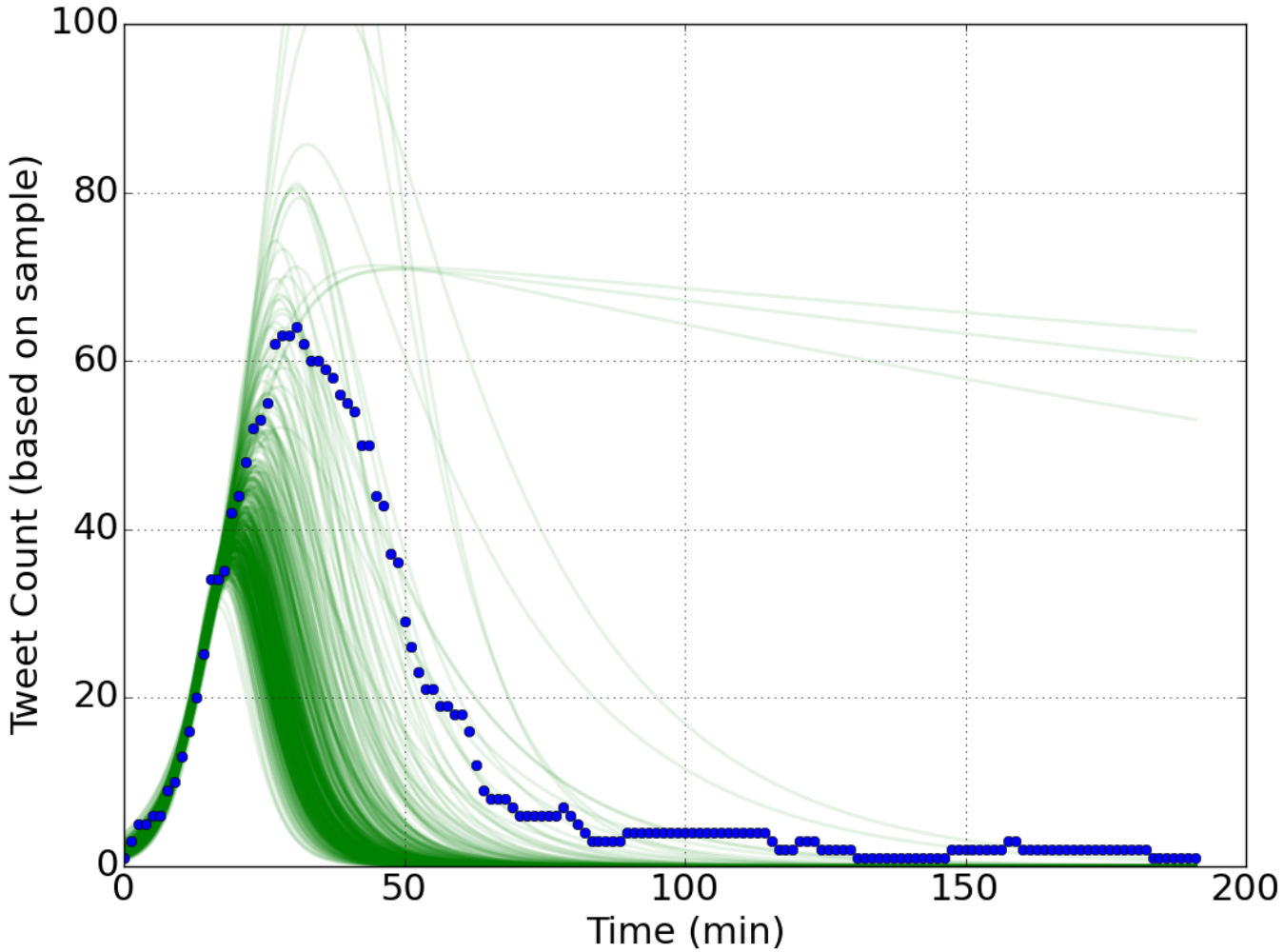
Prediction Results for #Obama

Run simulation over longer timescale



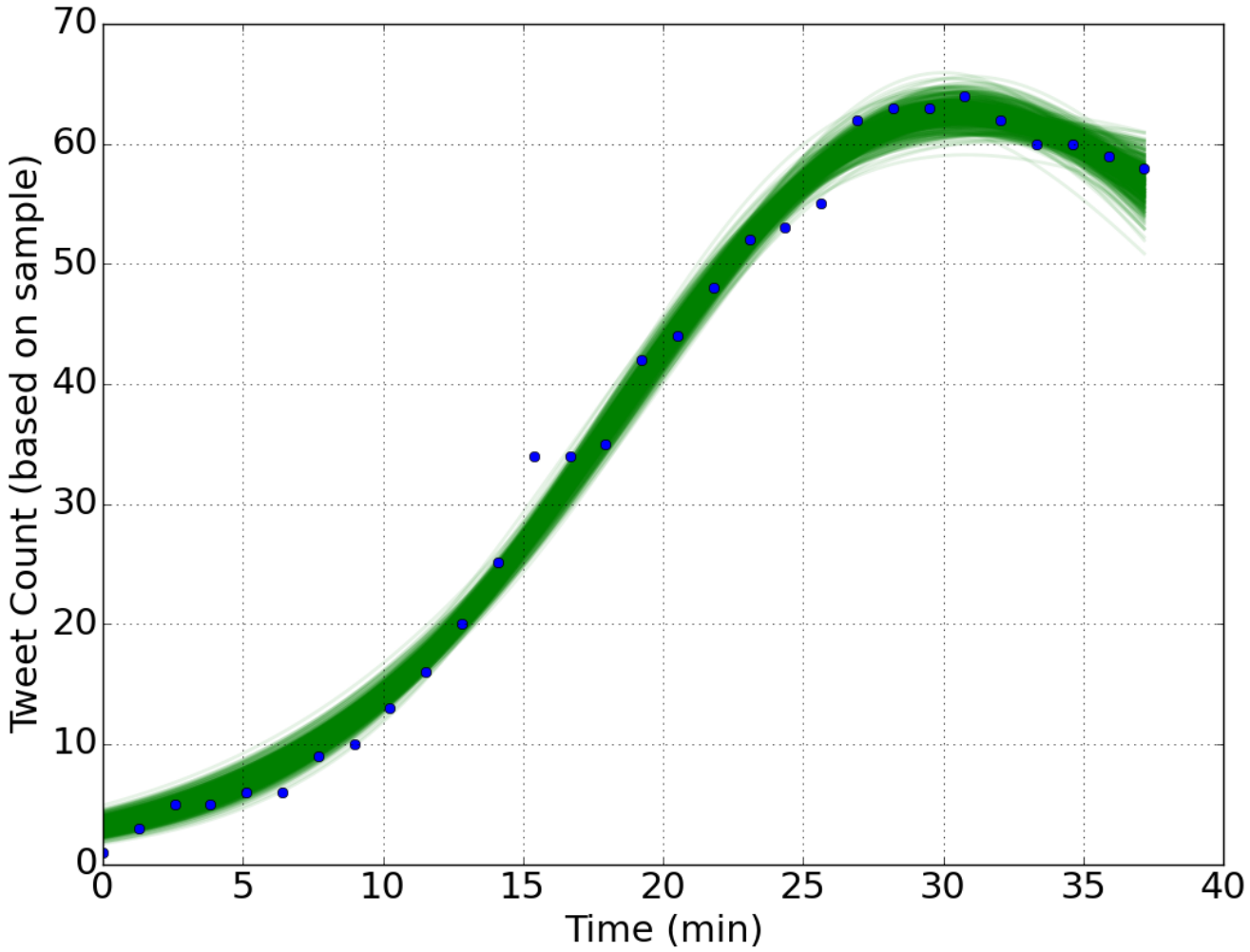
Prediction Results for #Obama

Comparison to actual (i.e., validation) data



Prediction with a Larger Training Set

Notice that the training set now captures the peak



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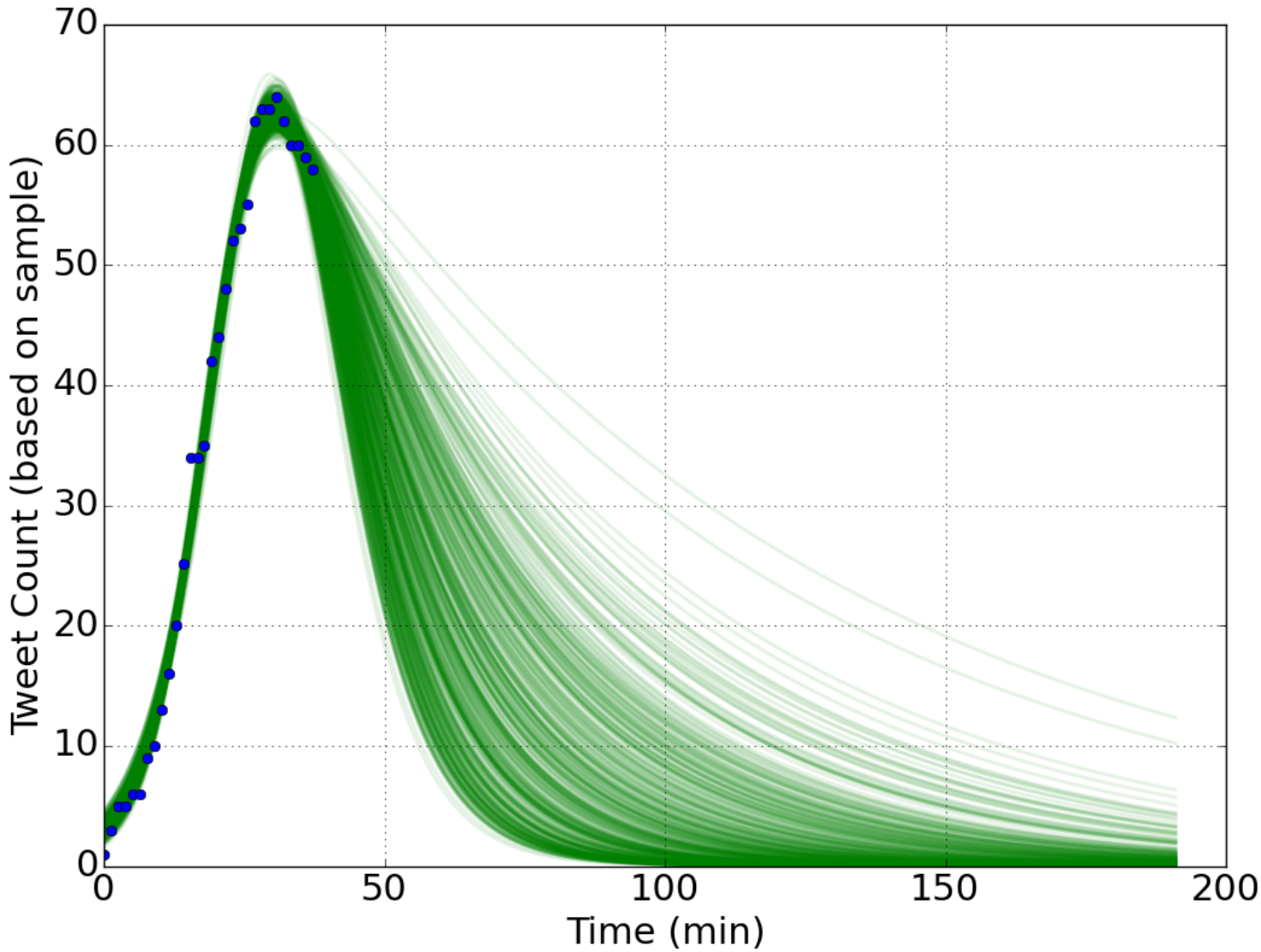

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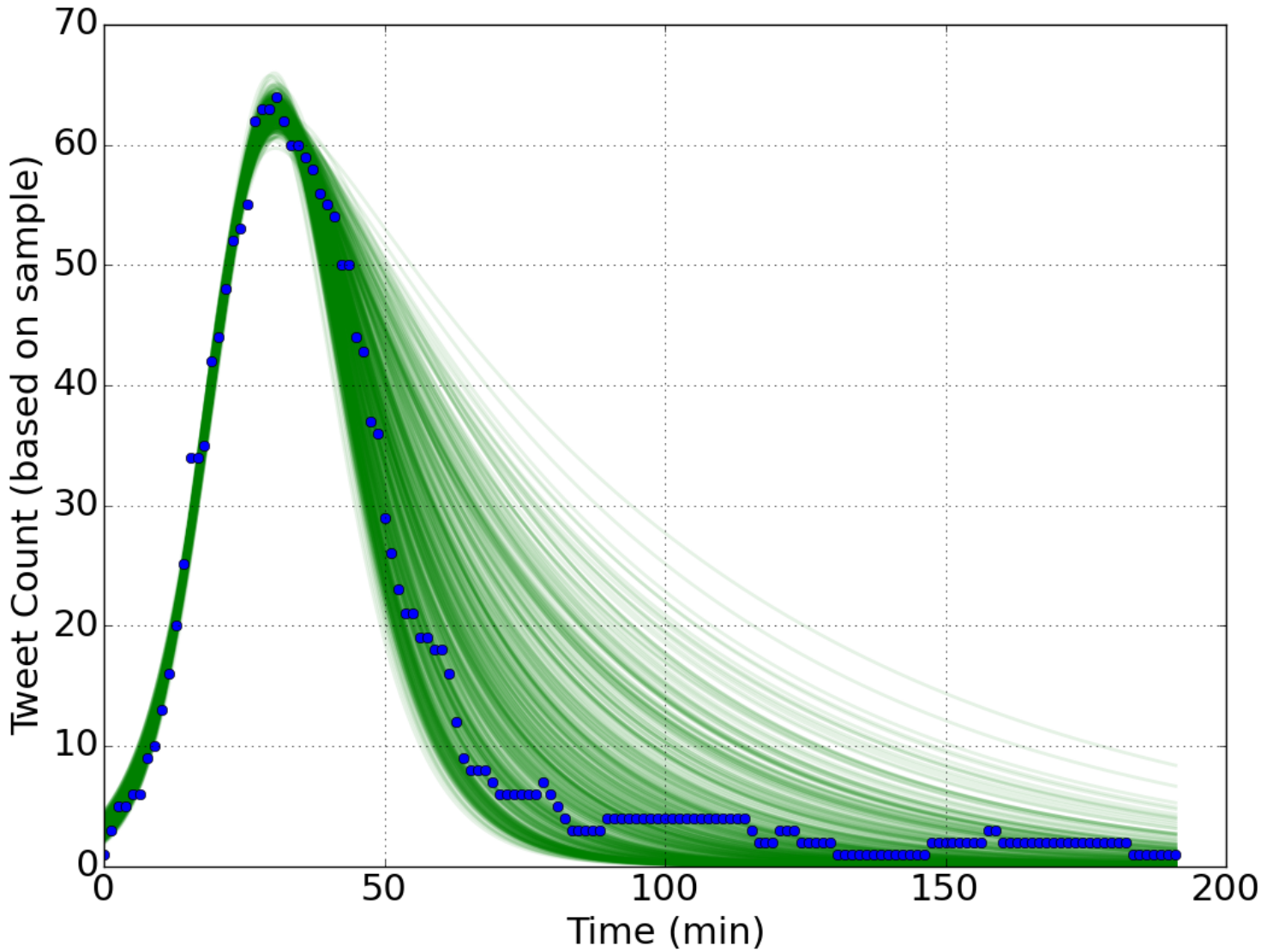

Potential Future Work

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- Develop interactive display
- Compare to stochastic modeling strategy

Acknowledgments

Advisor: Brian Blais, PhD

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Honors Program Coordinator: James Segovis, PhD

Questions?

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Twitter: @SkazaSays