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Center for Advanced Infrastructure and Transportation

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School of Engineering

Integrated Pandemic Travel Demand and Epidemiology Modeling for COVID-19 Case Prediction and Impact on Regional Travel Behavior in 2020

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October 27th, 2021

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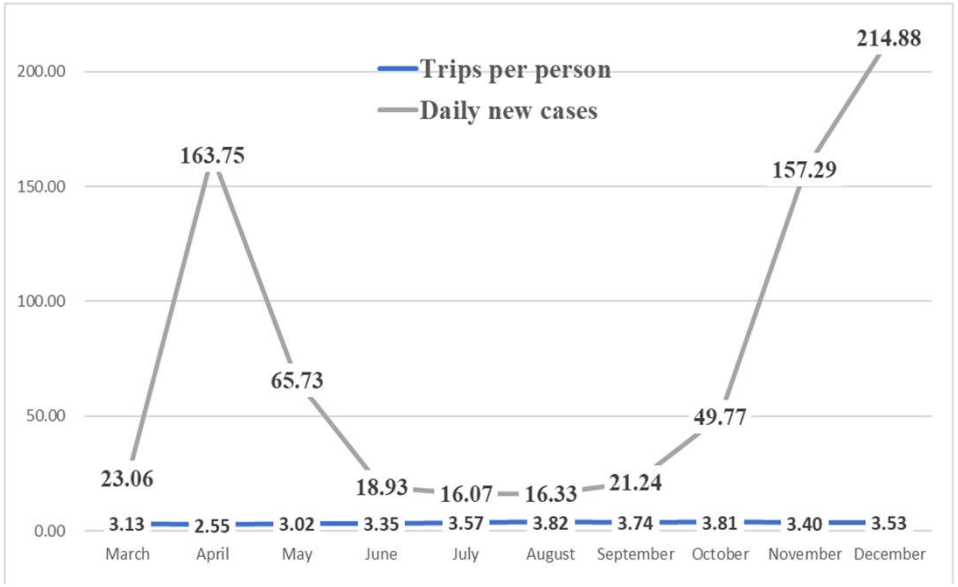
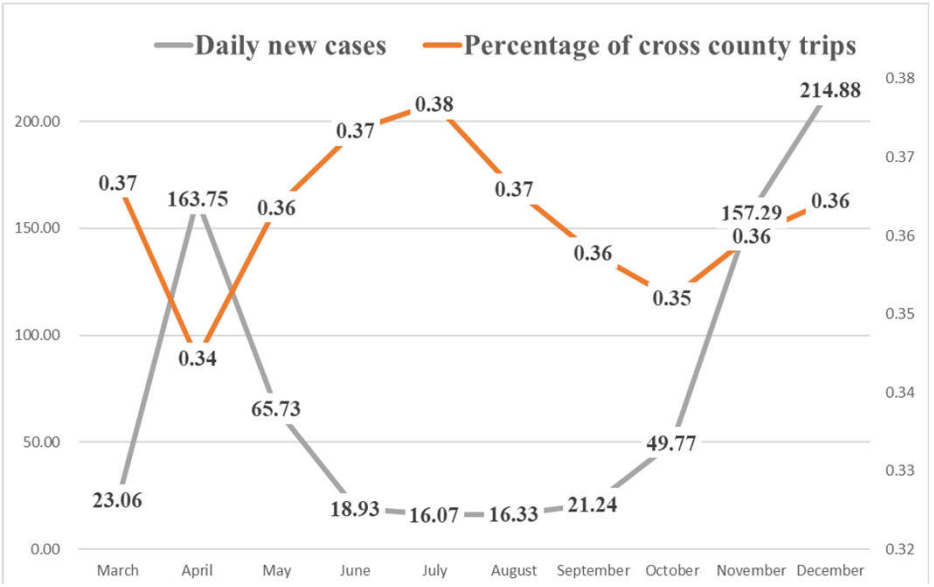
Background

	Infected people	Total population	
U.S	43.5 million	333.5 million	13.04%
New Jersey	1.15 million	8.89 million	12.93%

March 13, 2020: National Emergency Declaration
Mask wearing policy
Travel restrictions
Vaccination

Background





Data source: The University of Maryland COVID-19 Impact Analysis Platform
Region: New Jersey

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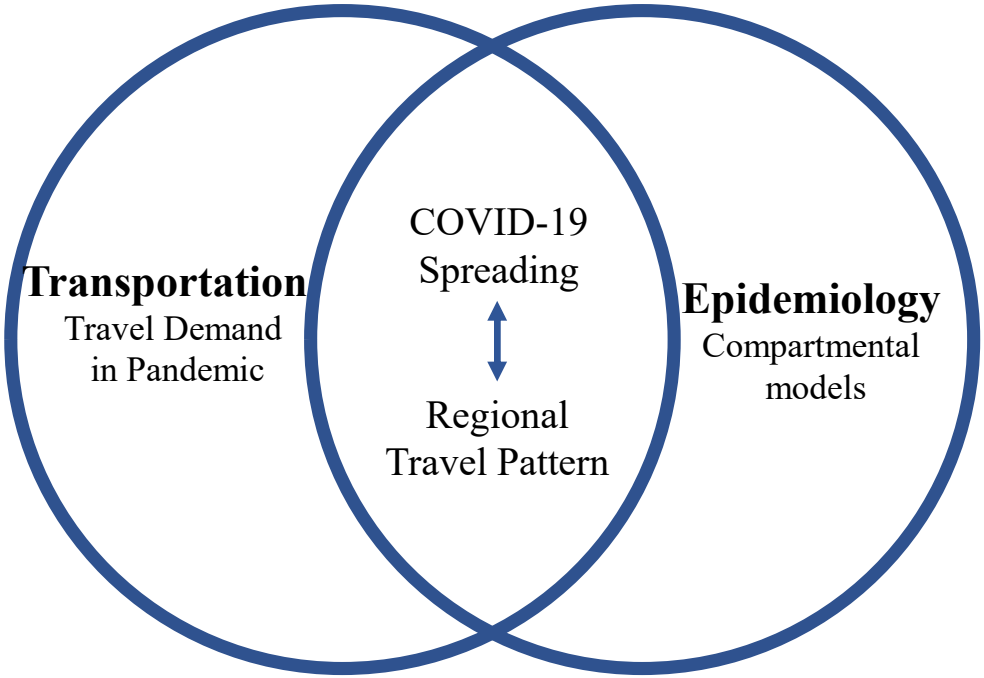
Background



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Methodology

$S(t)$: individuals not yet infected, but exposure to the virus and has the infection risk (susceptible) at day t
$I(t)$: individuals who have been infected and can spread the disease to those in the susceptible category ($S(t)$) at day t
$R(t)$: individuals who have been infected and then removed from the disease(recovered or dead) at day t

On any day t, N = $R(t) + S(t) + I(t)$, where N is the total population of a specific area (Assume a fixed population).

Spreading flow:

$$\mathcal{S} \rightarrow \mathcal{I} \rightarrow \mathcal{R}$$

$$\frac{\partial S}{\partial t} = -\frac{\beta SI}{N}$$

$$\frac{\partial I}{\partial t} = \frac{\beta SI}{N} - \gamma I$$

$$\frac{\partial R}{\partial t} = \gamma I$$

β:Transmission rate
γ:Recovered rate

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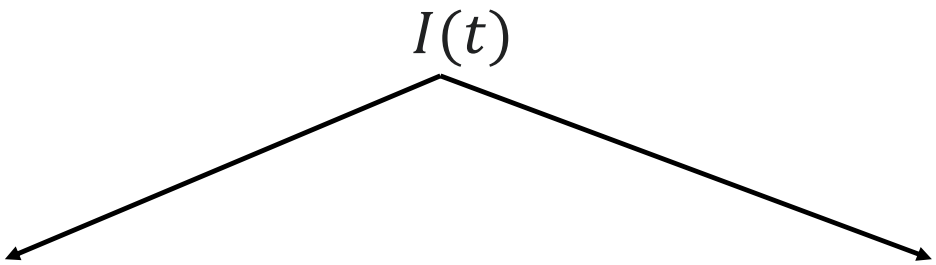
Methodology



Cases infected by interior trips
in a specific area
Local cases L$I(t)$

Cases infected by external trips (cross-boundary trips)
outside a specific area
Imported cases I$I(t)$

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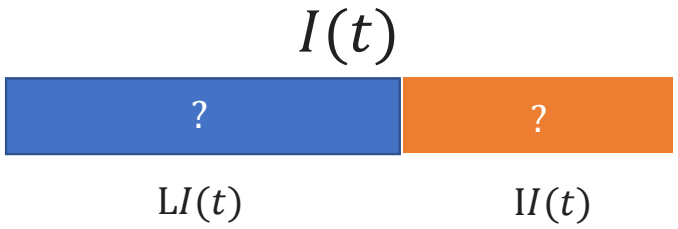
Methodology

Origin-Destination (OD) travel demand data

Number of trips between an OD-pair
- Origin is same as the Destination: internal travel
- Origin is different from Destination: external travel

Total trips from an Origin area: trip production
Total trips toward to a Destination area: trip attraction
- Percentage of internal/external trips for an O or D.



Combine parameters form OD data with the SIR model

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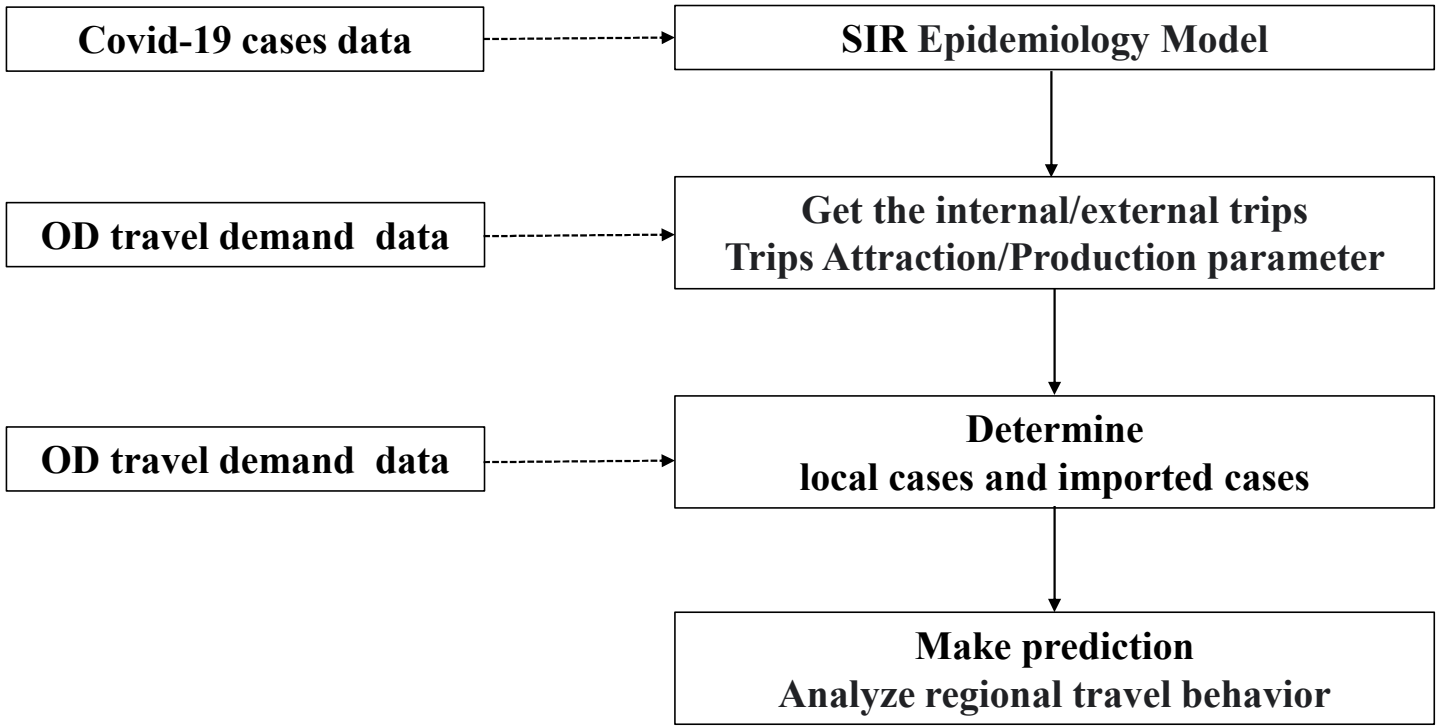
Methodology



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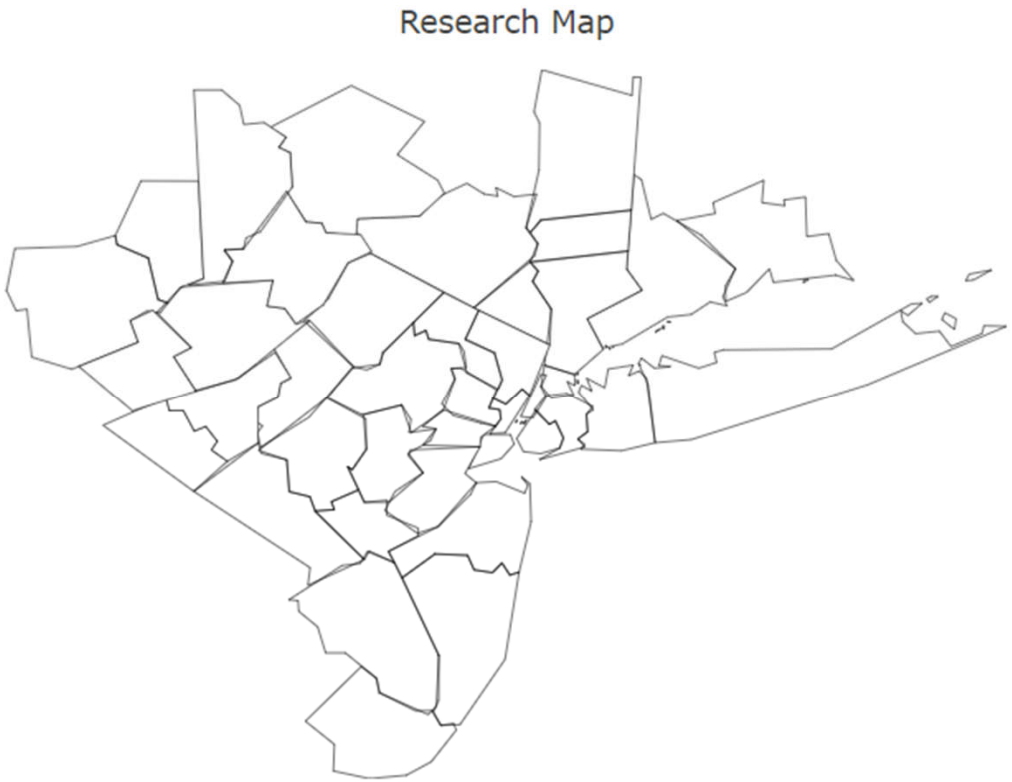
Results Analysis

New York	13 counties
New Jersey	16 counties
Pennsylvania	9 counties
Connecticut	2 counties



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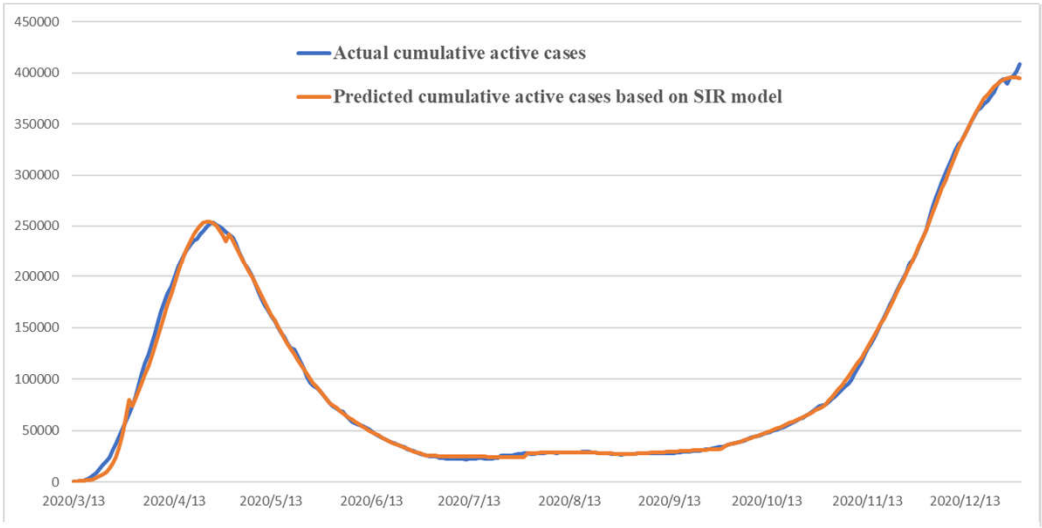
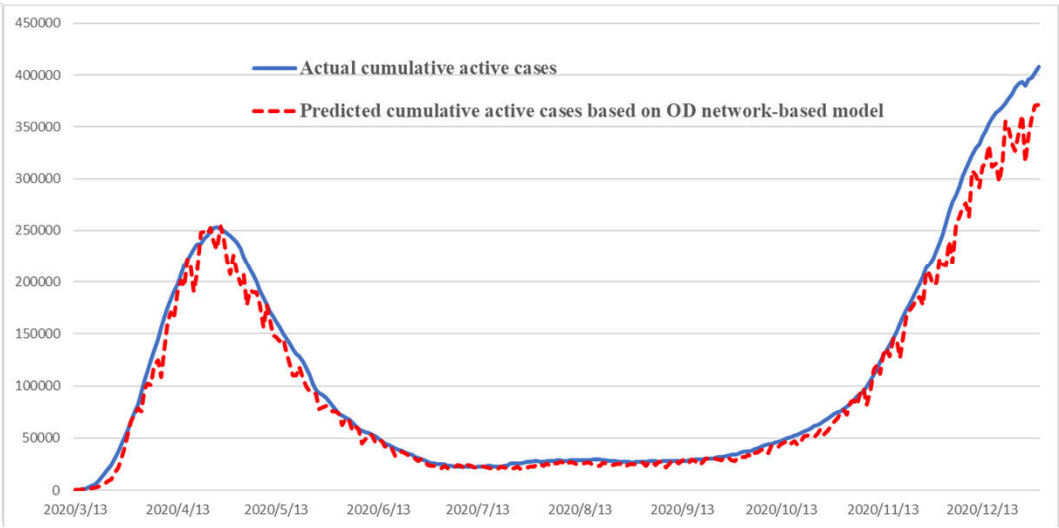
Results Analysis

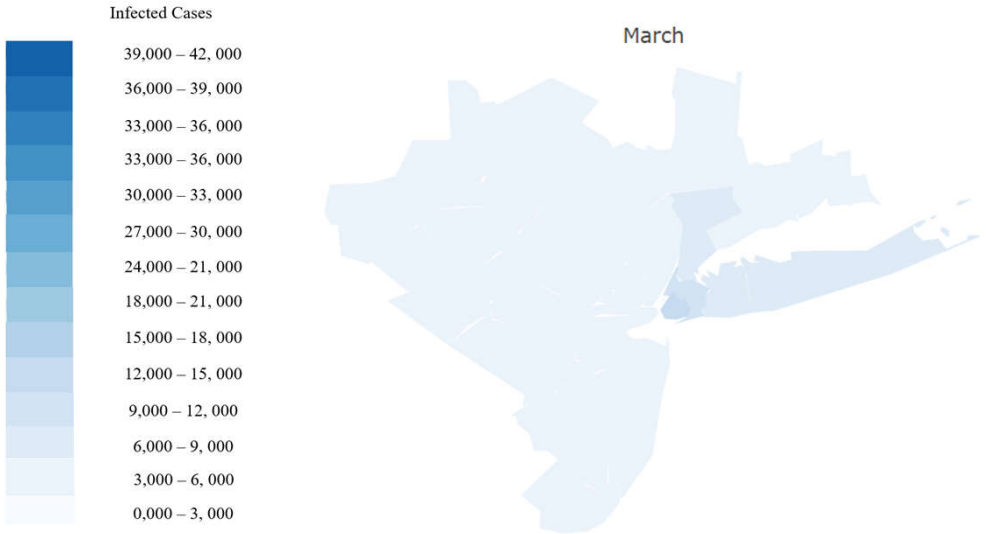




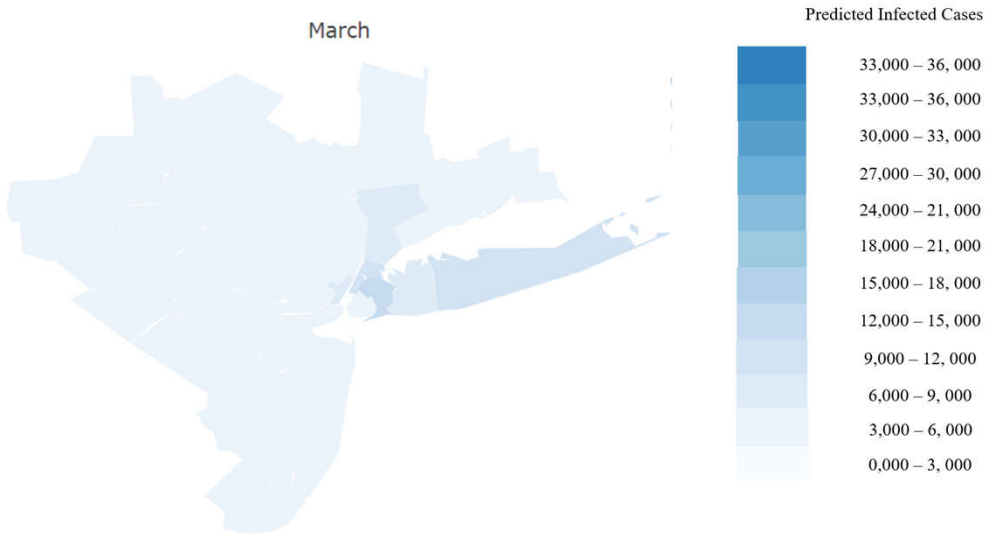
For both models, overall trend is in line with reality changes of active cases
For OD network-based model, the prediction results shows many fluctuations

Results Analysis

Actual Cases

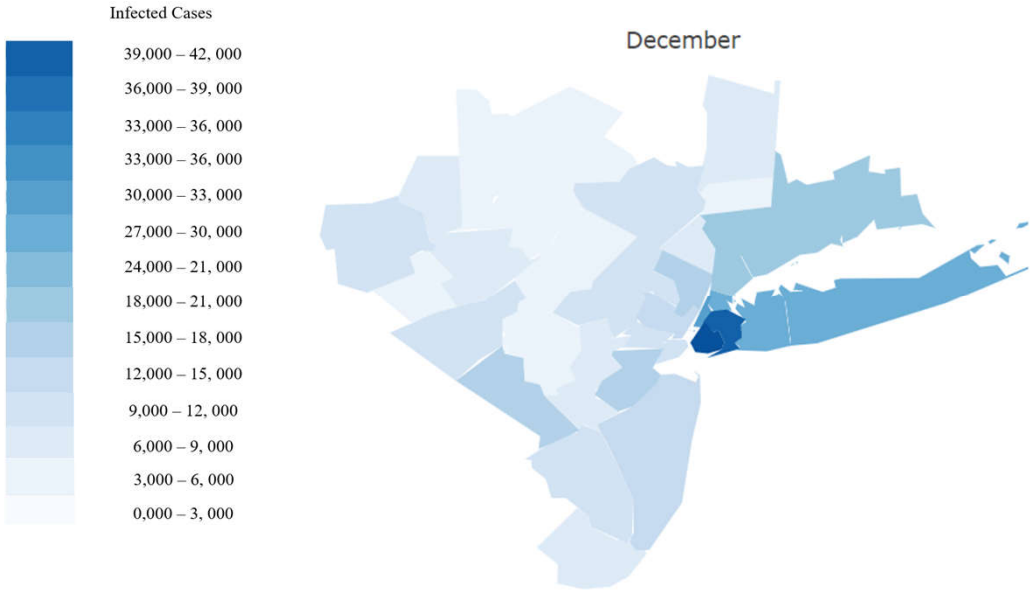


Predicted Cases



Results Analysis

Actual Cases



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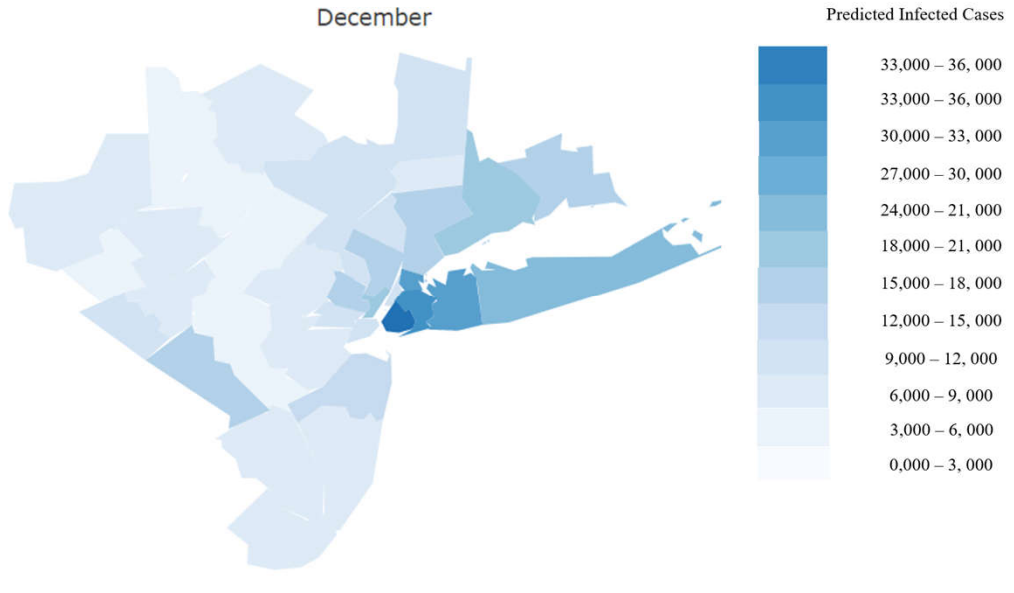
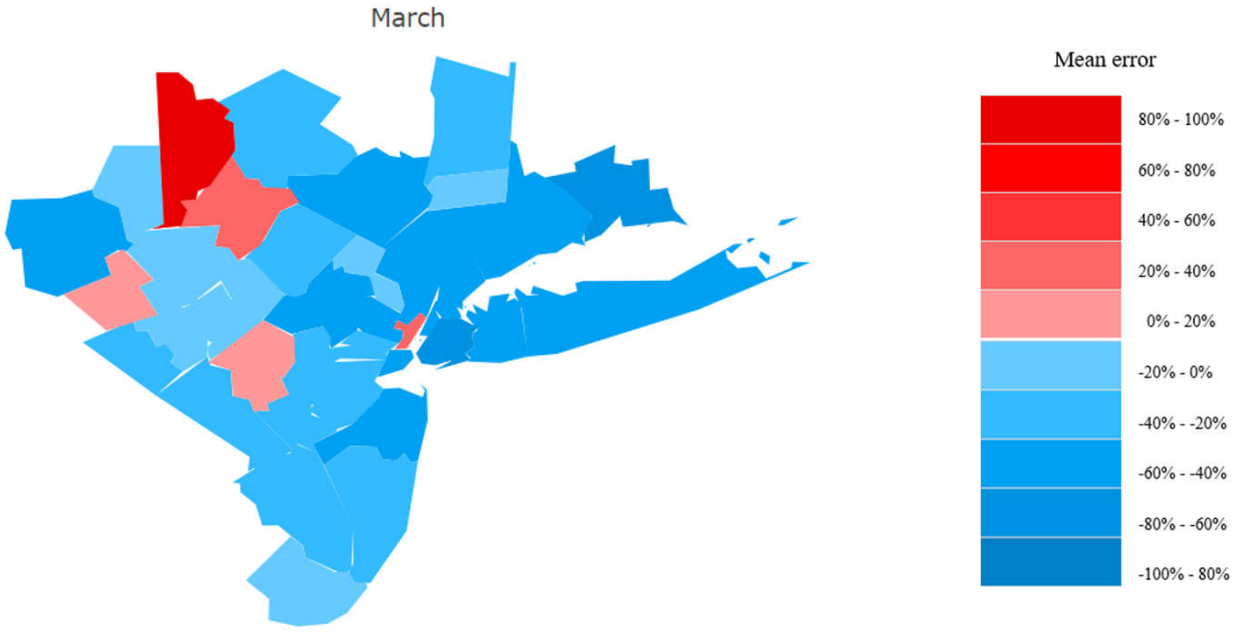


Results Analysis

Comparison of Mean Error



Results Analysis

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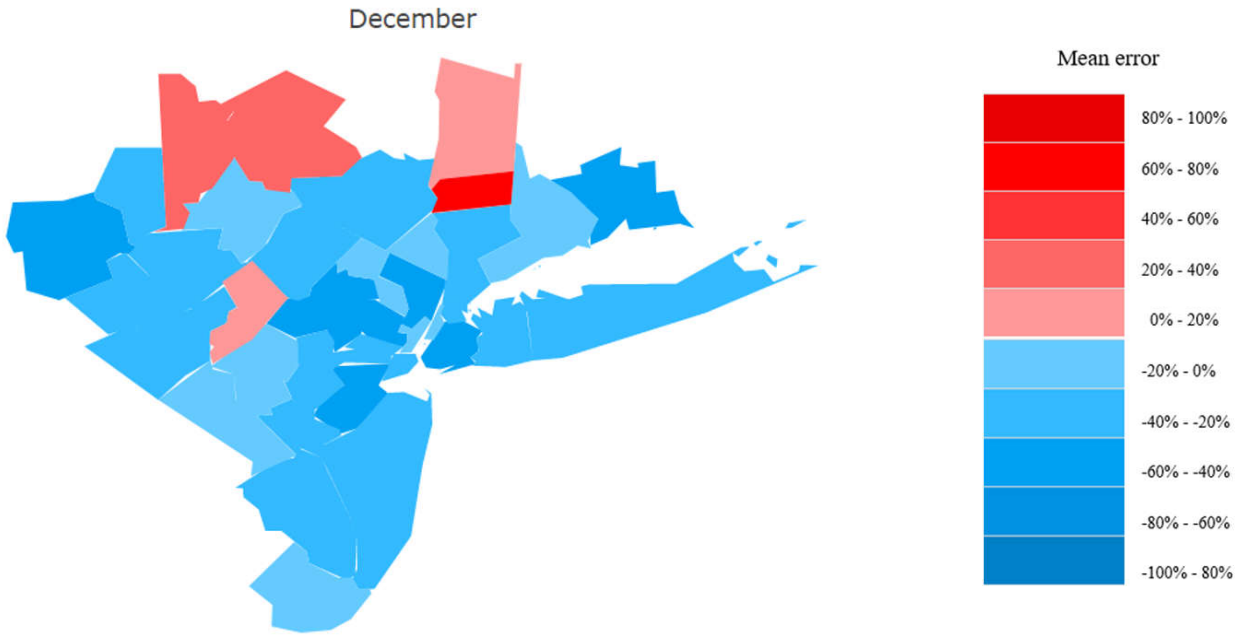

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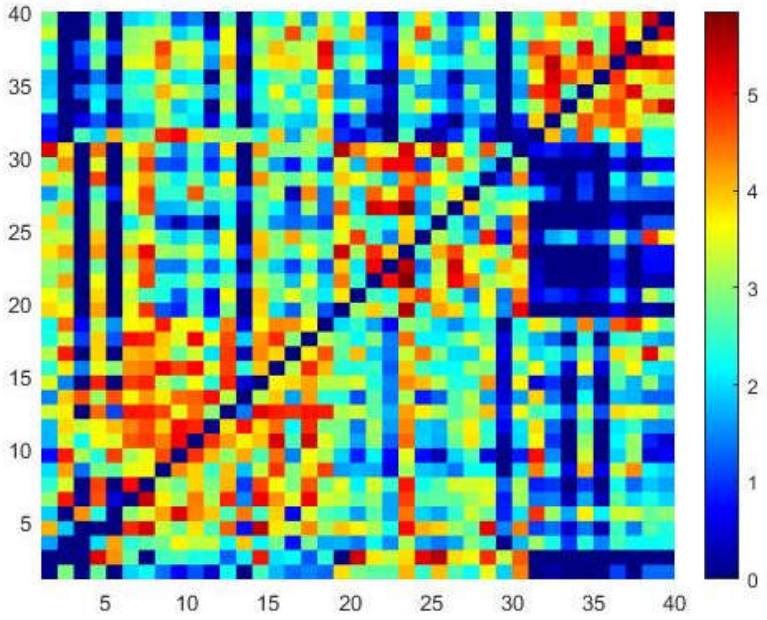
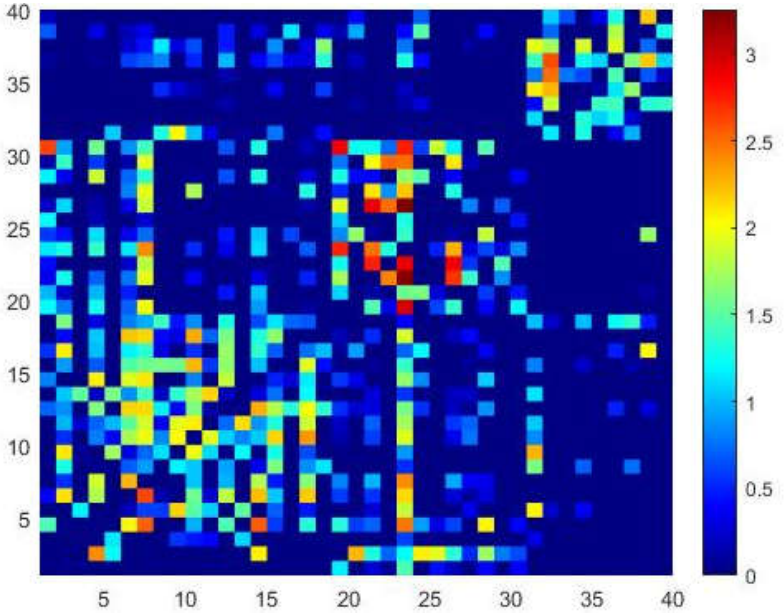
Results Analysis

Pseudo color plot Comparison between
annually average travel demand OD matrix 19 and annually average imported COVID-19 cases OD matrix





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Conclusion

Separating the confirmed cases to local cases and imported cases and tie imported cases to dynamic pandemic origin-destination demand patterns

Enable the dynamic characterization of regional travel behavior changes during the pandemic and provide the prediction of potential infectious disease breakout locations and spreading patterns.

Several empirical insights about counties with high spreading risks, such as Hudson and Essex County in New Jersey, and Manhattan area in New York.

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Conclusion

- Build time sensitive model
- Use Location-based service(LSB) data for more precise travel information
- Add such as Vaccination parameter
- Improve the accuracy

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THANK YOU!

Q&A

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