Correlations Between COVID-19 and Dengue

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MIT PRIMES Conference

15 October 2022

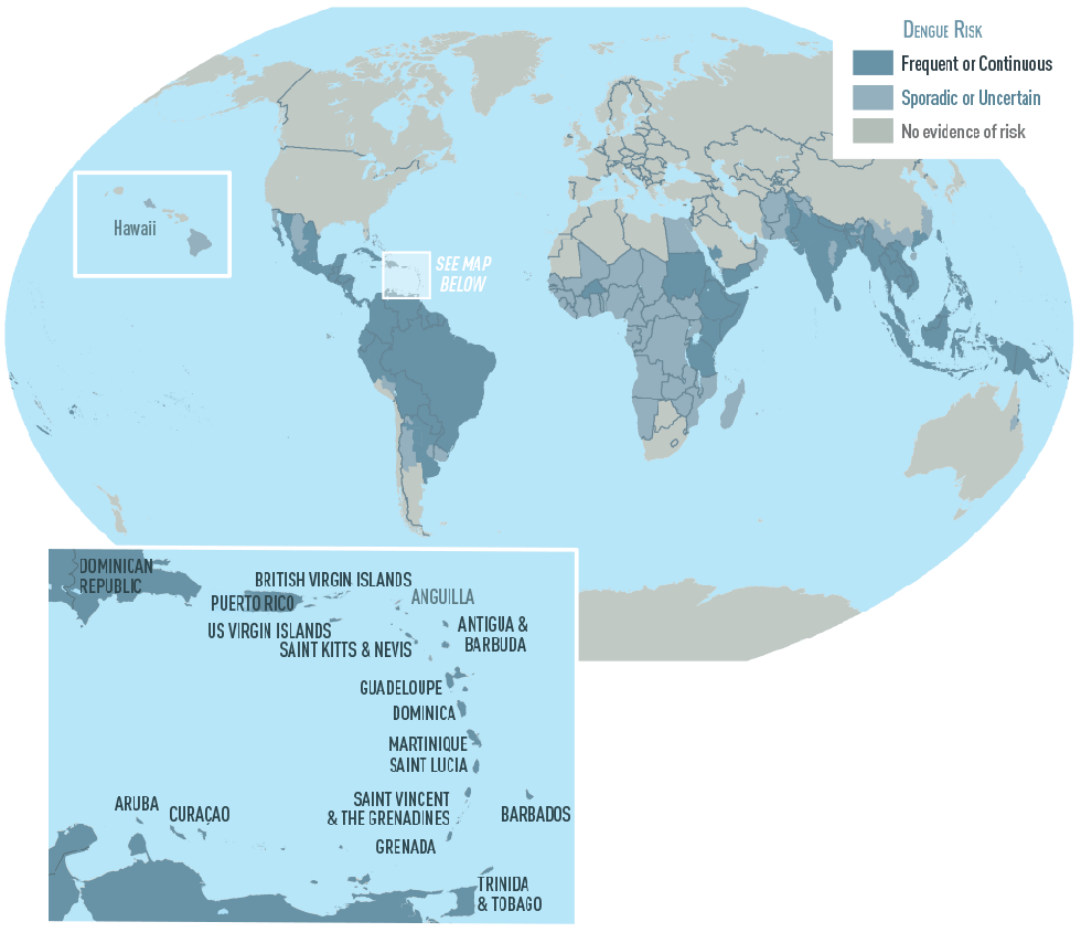
Outline

What is Dengue?

- Viral disease that is transmitted by mosquitoes
  - Aedes aegypti (Aa)
- Highly seasonal disease
  - Most prevalent before and after rainy seasons
- Four serotypes
  - Little immunity against other serotypes

How Prevalent is Dengue?

- Most prominent in Latin American and Asian countries
- Widely considered to be one of the most important mosquito-borne diseases because it is so widespread



Transmission and Epidemiology

- Mild flu-like symptoms but with the possibility of hemorrhagic fevers
- Incubation period of 5 to 7 days
- More aggressive in younger people, especially children
- Prior to World War II, infected mosquitoes were responsible for Dengue epidemics in Europe

Historical Context of COVID-19 and Dengue

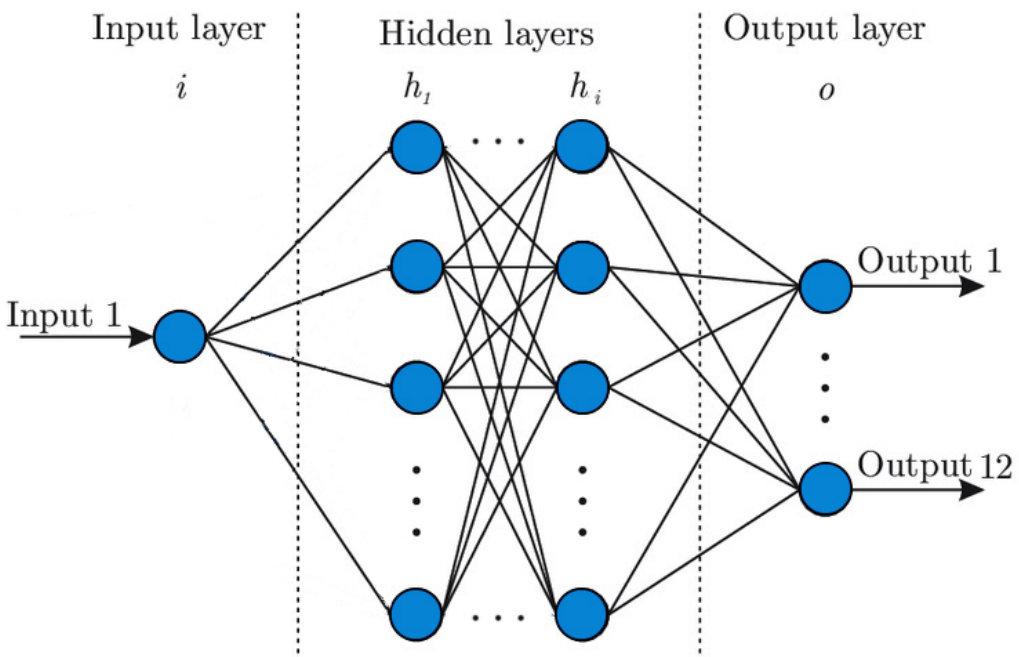
- Infections of COVID-19 and Dengue have recently been considered together, particularly in South America
- 2020 fatality rate from Dengue = 0.04%, the lowest in the past decade
  - Despite 2020 being an epidemiologically complex year
- Persistence of high Dengue cases in endemic areas
  - Occurs simultaneously with intense COVID-19 transmission

Historical Context of COVID-19 and Dengue

- Many factors need to be considered:
  - People may have been reluctant to report Dengue because of quarantine for the ongoing COVID-19 pandemic
  - Arrival of COVID-19 coincided with the mosquito season
  - Lockdown prevented the arrival of Dengue to areas where it was not endemic
- Different regions might also have different patterns
  - Countries: Brazil, Peru, and Colombia
  - External parameters: Holidays and Climate factors (temperature, humidity)

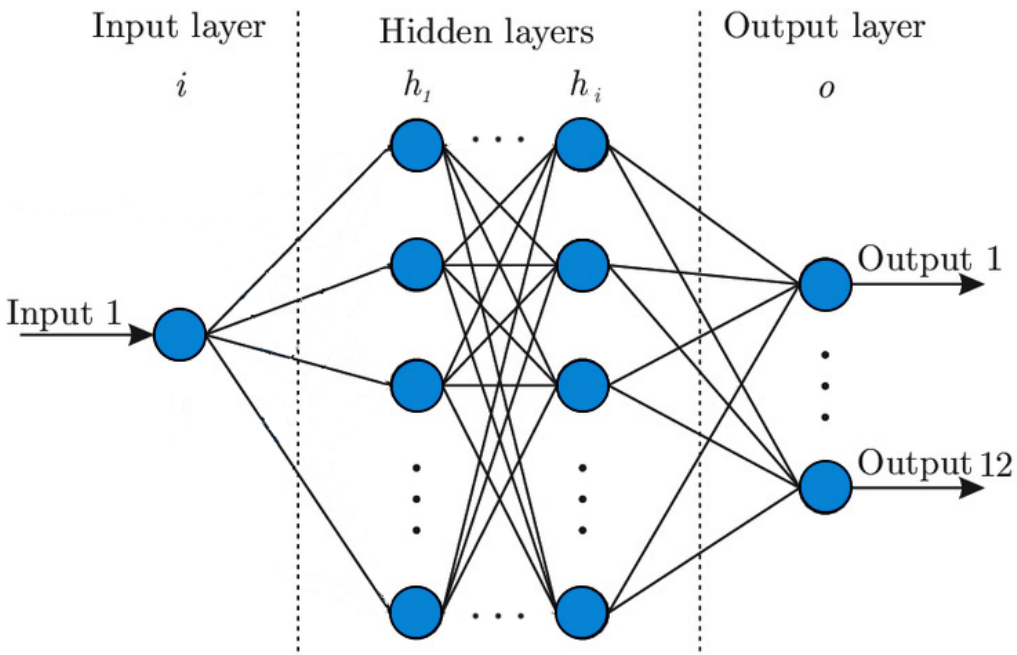
Standard Neural Network

- Has input layers, output layers, and one or more hidden layers
  - Input: initial data for the network
  - Hidden: layer where all the computation is done
  - Output: results produced



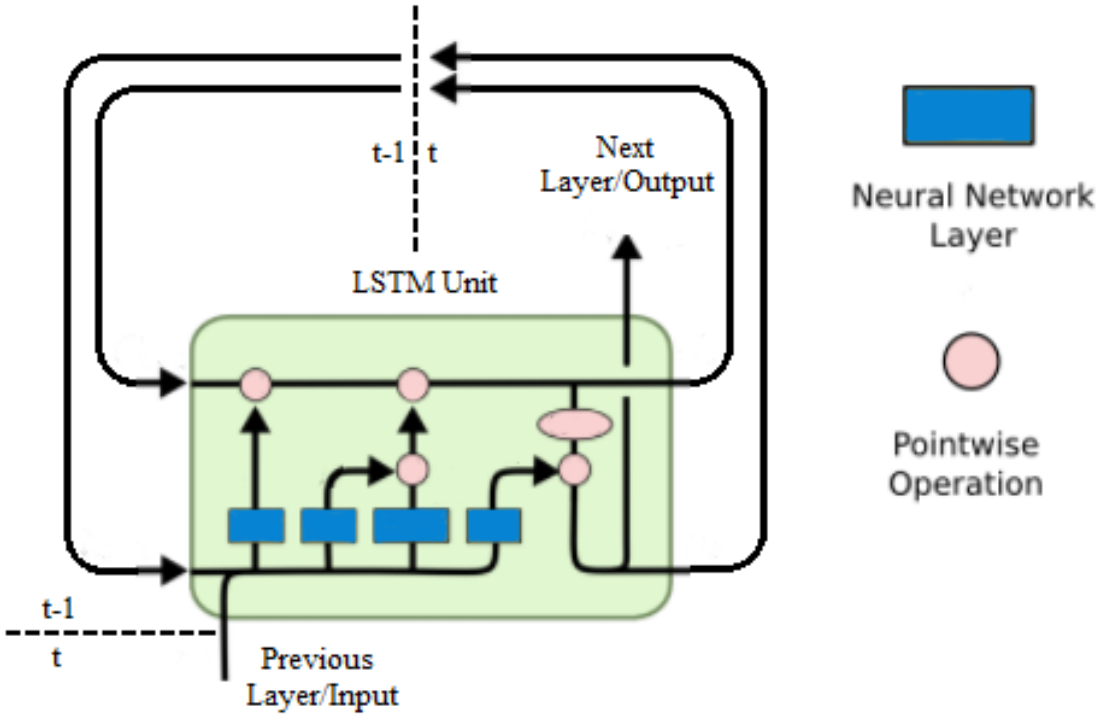
Standard Neural Network

- Split the data into a training set and a test set
- We can generate three types of graphs
  - Loss curve graph - Mean Absolute Error function
  - Actual data vs model-predicted values for both the training set and the test set



Recurrent Neural Network (LSTM Model)

- Useful in cases where there may be time lags
- Incorporates past time-series data
- Have "loops" and a forget gate - forgets useless information
- Processes sequences of data



Activation Functions

- Sigmoid function
  - $S(x) = \frac{1}{1+e^{-x}}$
- ReLU function
  - $f(x) = \max(0, x)$
- tanh function
  - $\sigma(x) = \tanh(x) = \frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$

- COVID-19 numbers are on average of a greater magnitude than Dengue numbers
- Consider the base 10 log of both
- For Brazil:

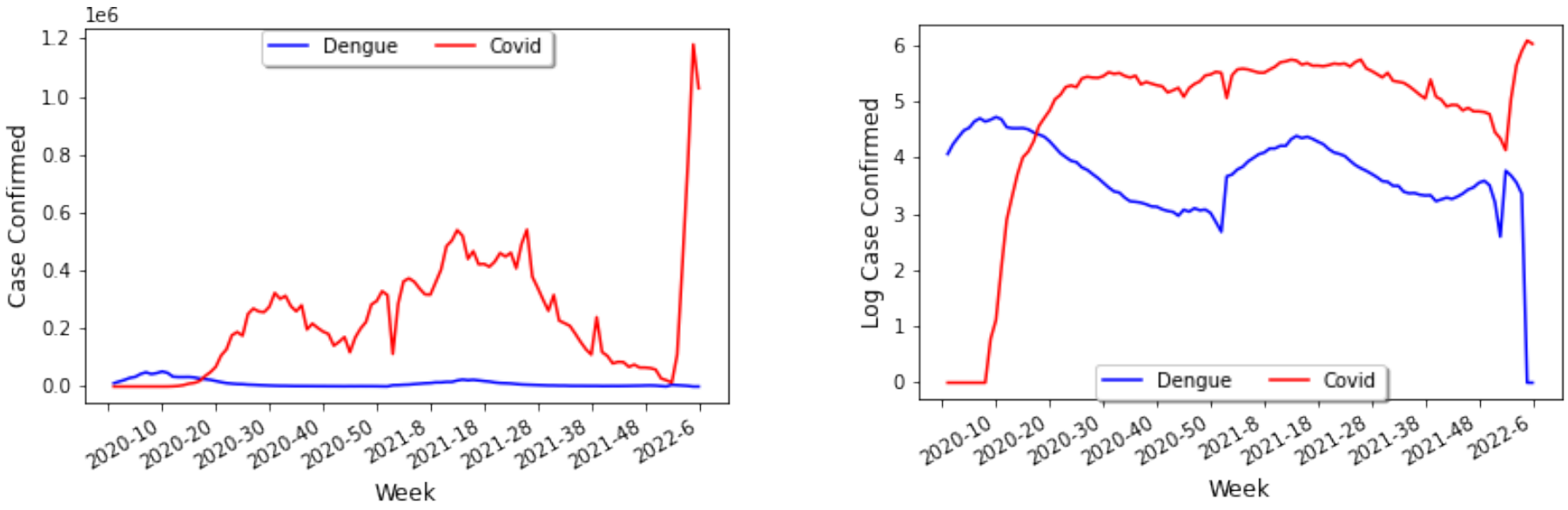


Figure: Plot of data from the Pan-American Health Organization Dataset on Dengue and the World Health Organization dashboard on COVID-19 (left) and its log plot (right).

Application of the Correlation Model

- The following graphs are for when a standard neural network is applied to Brazil.

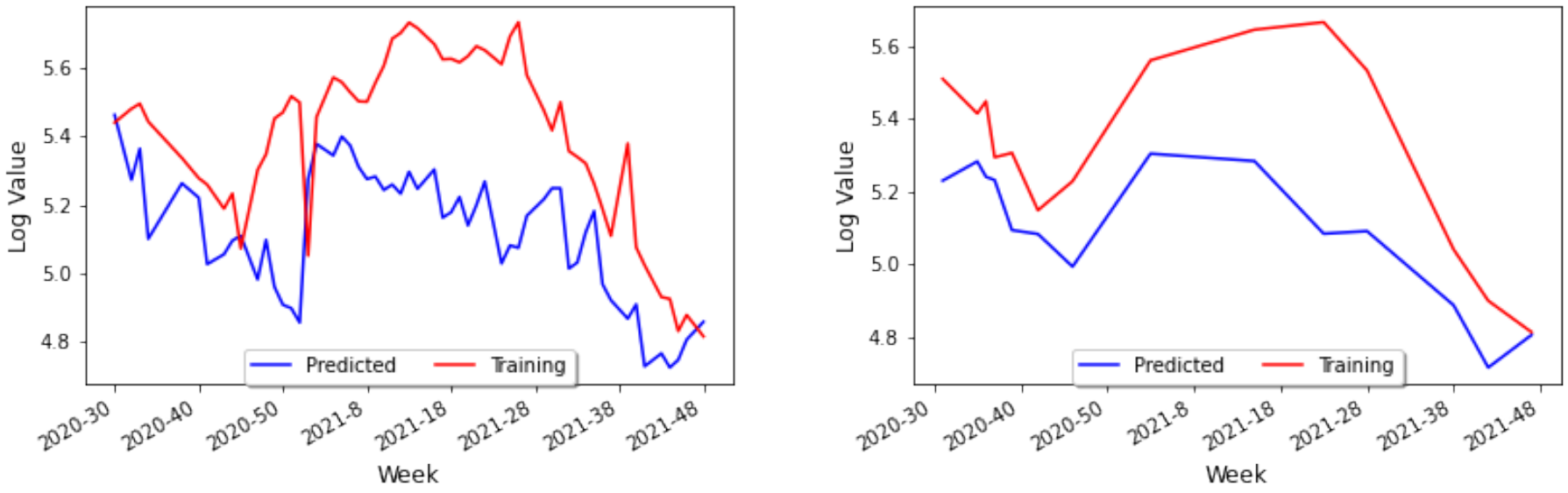


Figure: Actual data and the predicted COVID-19 data for Brazil when both holiday and climate factors are considered on the training set (Left) and the test set (Right).

Application of the Correlation Model

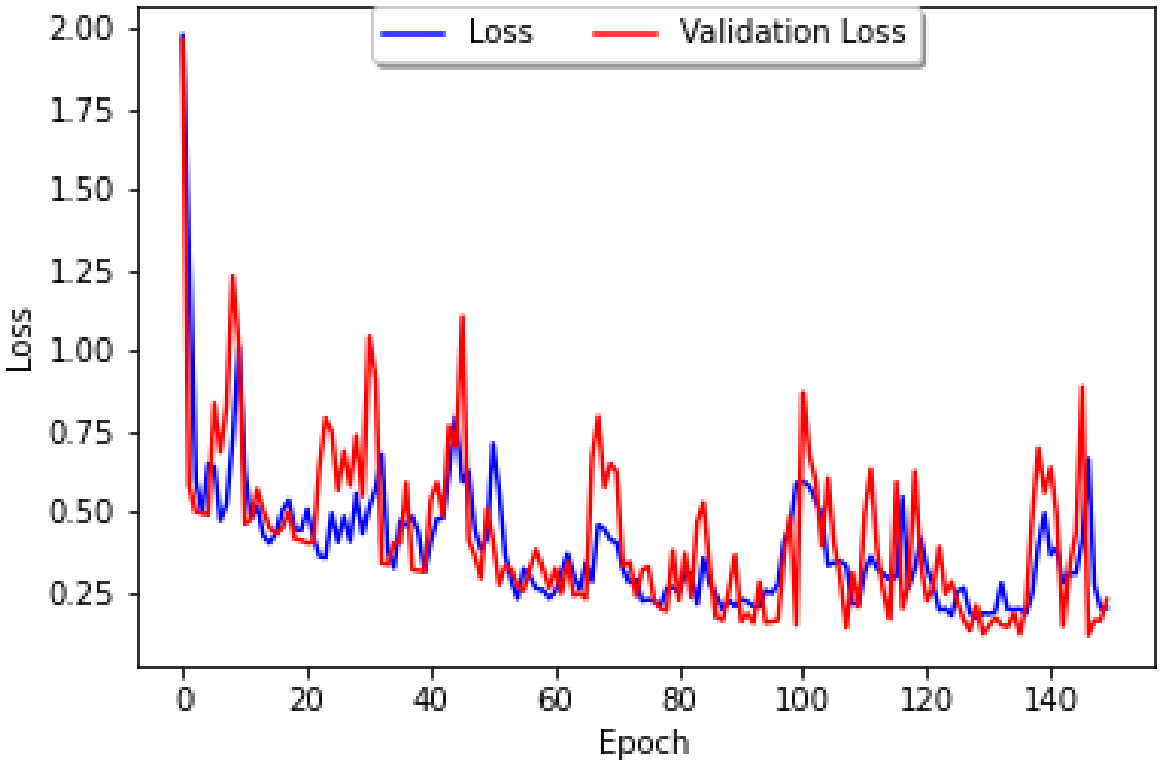


Figure: The loss curve for the model when applied to Brazil.

Application of the LSTM Model

- The following graph is generated when the LSTM model is applied to Peru.

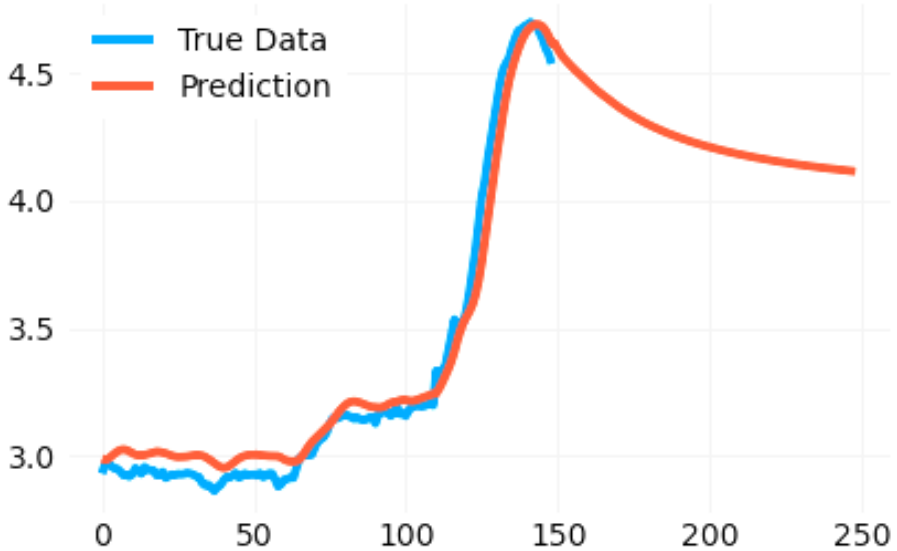
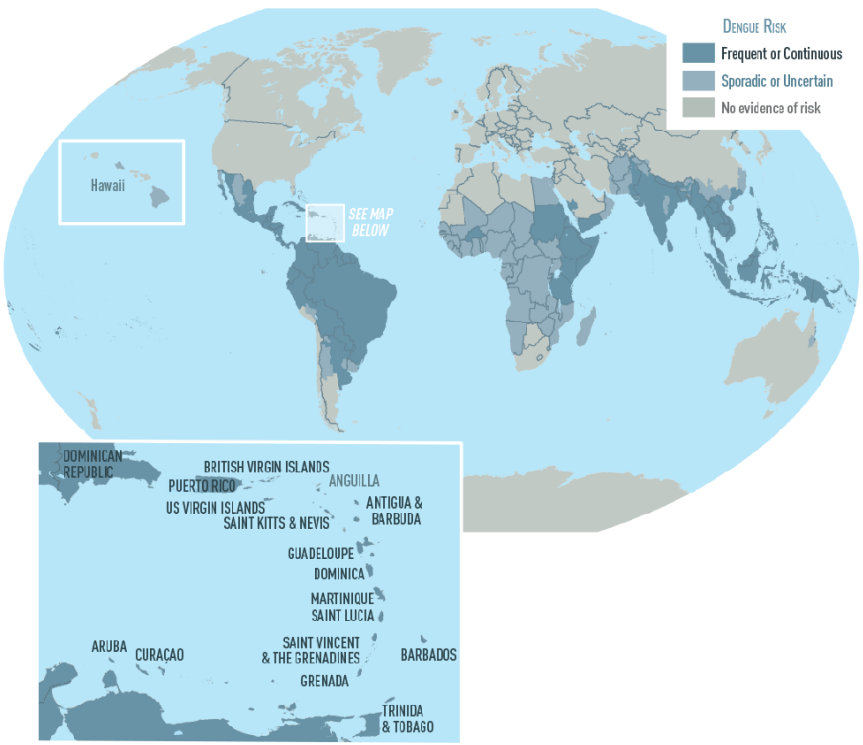


Figure: Predicting COVID-19 infections using the Long short-term memory model for Peru's dataset.

Other Countries

- South American countries
  - Brazil/Peru/Colombia
- Countries with not much data on Dengue
  - As examples, we can consider Cambodia (Southeast Asia) and Kenya (Africa)



Acknowledgements

- I would like to express my deep gratitude to my mentor Prof. Laura Schaposnik for her constant guidance, support, and encouragement throughout our project.
- Dr. Tanya Khovanova, Dr. Slava Gerovitch, Prof. Pavel Etingof, and the MIT PRIMES-USA Program for making this possible and providing us with the opportunity to work on this project
- I would like to thank Dr. Paula Bergero for her insight and for providing the inspiration for this topic
- My family

References

- P. A. H. Organization, "Epidemiological Update: Dengue in the context of COVID-19,"(12, 2020) .
- K. Eames, "The influence of school holiday timing on epidemic impact," Epidemiology & Infection 142 no. 9, (2014) 1963–1971.
- S. Chen, K. Prettner, M. Kuhn, P. Geldsetzer, C. Wang, T. Barnighausen, and D. E. Bloom, "Climate and the spread of covid-19," Scientific Reports 11 no. 1, (2021) 1–6.
- A. Notari, "Temperature dependence of covid-19 transmission," Science of The Total Environment 763 (2021) 144390.
- W. H. Organization, "Update on the Dengue situation in the Western Pacific Region,"(04, 2022) .
- https://www.cdc.gov/dengue/areaswithrisk/around-the-world.html
- https://www.cdc.gov/mosquitoes/gallery/aedes/index.html