Project 4

Contents

What is dengue?

- Dengue fever a disease caused by the dengue virus which is transmitted to humans via the bite of an infective mosquito.
- There is no specific treatment for dengue fever. Hence, the most effective way is to prevent infection.
- According to WHO, dengue is now endemic in more than 100 countries.

Home » Asia » Hanoi still reports more than 1,000 dengue cases last week despite cold season

Hanoi still reports more than 1,000 dengue cases last week despite cold season

by NEWS DESK

December 20, 2022 Asia 1 Comment

India World Sports Business & Economy Entertainment States Parliame

World

Posted at: Jan 4 2023 11:23AM

Cambodia sees sharp rise in dengue fever cases in 2022

Phnom Penh, Jan 4 (UNI) Cambodia reported 12,500 dengue fever cases in 2022, a significant increase from 1,811 cases in 2021, a health official said on Wednesday.

Home » Asia » Philippines dengue cases top 200,000 for 2022

Philippines dengue cases top 200,000 for 2022

by NEWS DESK

December 9, 2022 Asia, Headlines 2 Comments

Dengue in Singapore

Singapore is on track to face its worst dengue outbreak in history

By Nectar Gan, CNN
Published 4:55 AM EDT, Fri July 3, 2020

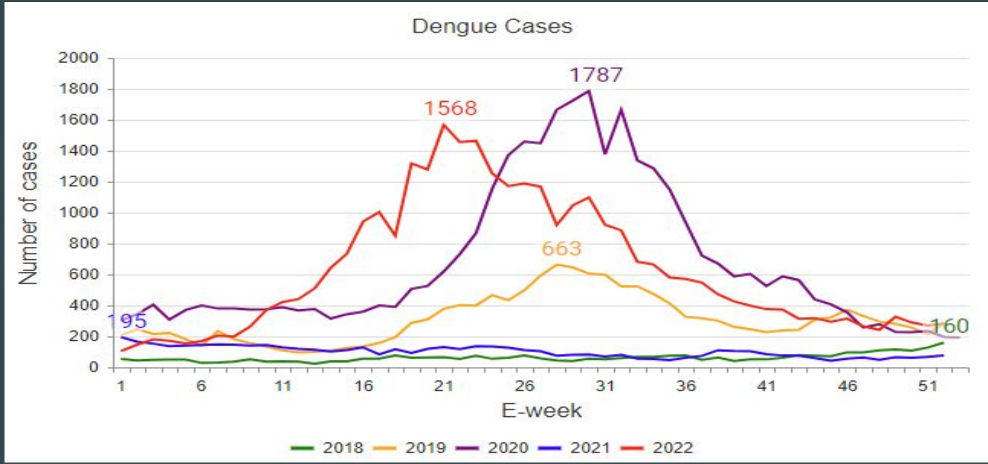
Singapore's dengue 'emergency' is a climate change omen for the world

By Heather Chen, CNN
Published 10:13 PM EDT, Mon June 6, 2022

More than 30,000 dengue cases reported in 2022, six times that of 2021: NEA

Dengue in Singapore

- Singapore - high income nation where dengue is hyper-endemic.
- All four dengue serotypes are in active circulation and weekly reported case counts above zero for the past 20 years.
- Estimated average economic impact of dengue in Singapore from 2010 to 2020 is $1.014 to $2.265 Billion USD.



Cost of Dengue

Cost	Estimated $ values
Loss of Productivity ● Long MC - Fever for 2 to 7 days; plus long term illness	● Using 5 days x median salary of $5000, loss of $5000/22*5 = $1,136
Ilness (Medical Cost) ● Consultation ● Medicine cost ● Hospitalization ● Blood Tests etc	● $20 to 55; polyclinic $13.20 ● $100 ● Using Ward B, average of $800 per night. For 5 nights, average of $4,000. ● $70 to $80

Estimated Cost of Dengue: $5350

Wolbachia Intervention

- The release of Wolbachia-infected mosquitoes is a promising disease intervention strategy that aims to control dengue and other arboviral infections.
- Mosquitoes infected with Wolbachia are
  - Less likely to disseminate a large number of vector-borne diseases, such as dengue
  - Can suppress/replace the wild type mosquito population due to cytoplasmic incompatibility
- Effectiveness
  - 98% suppression of Aedes aegypti mosquito population and up to 88% reduction in dengue incidence at Tampines and Yishun study sites with at least one year of releases in 2019.
  - Similar observations have been made in the 2022 dengue outbreak where areas have 70% less dengue compared to similar areas without Wolbachia.
  - Two forms of reduction
    1. Specifically at the hot spots and overall across the country

Wolbachia Intervention

- Limitations
  - Wolbachia technology is nascent, and off-the-shelf commercial solutions for increasing scale are not available.
  - NEA and their collaborators are, therefore, custom-developing innovative engineering solutions to automate production and release, so that the Wolbachia technology can be implemented sustainably and cost-effectively.
  - This process involves the integration of multiple technical disciplines, including biotechnology, engineering, and data analytics, and hence requires considerable time and development of expertise.
- Estimated Cost
  - $5 million facility at Techplace II in Ang Mo Kio Avenue 5 was opened in 2019 to provide scalability in the production

Is Wolbachia Intervention a good solution?

- Yes - it is more cost efficient.
- Splitting the cost of the facility to be 10 years, it would cost $500, 000 yearly.
- Although the specific cost for Wolbachia is not publicly available, even if we estimate the cost to be $1 mil (to try to include manpower costs etc), it would still be worth it.
- Just being able to prevent 187 would be cost efficient.

$$\frac{\$1,000,000}{\$5,350} = 187$$

Problem Statement

We are required to predict peak periods and locations to start the Wolbachia intervention.

Why the need to predict?

To prevent future outbreaks of the dengue fever, we need to know when it is the best time to release the Wolbachia-infected mosquito and where as the number of mosquitos are limited.

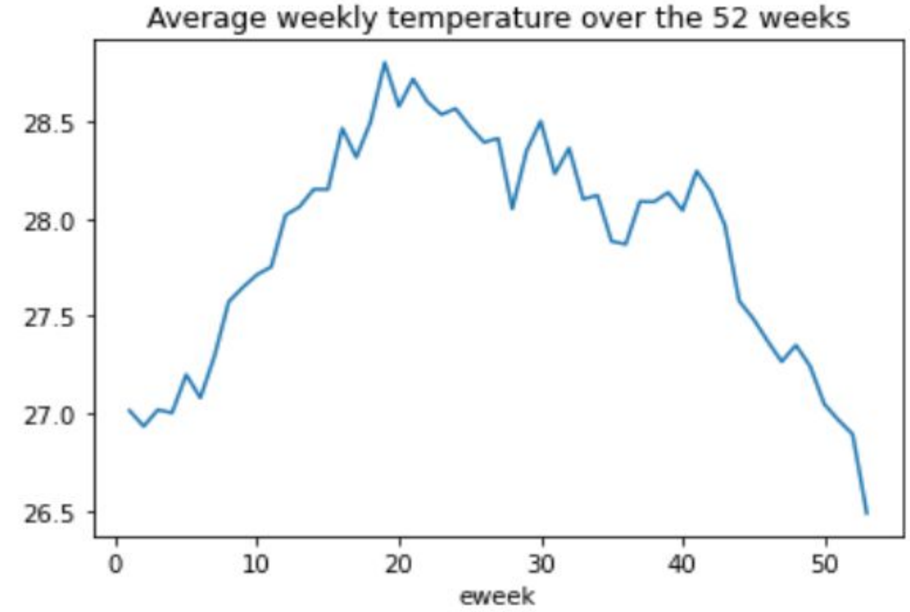
What data we need?

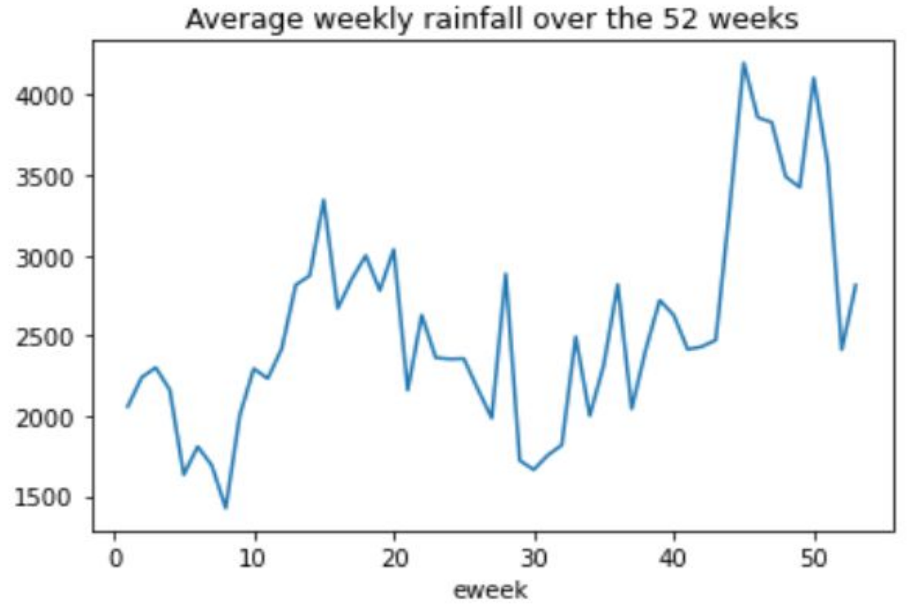
Rainfall and temperature data to identify the peaks.

Historical data of dengue cases and where the locations are.

EDA (Temporal)

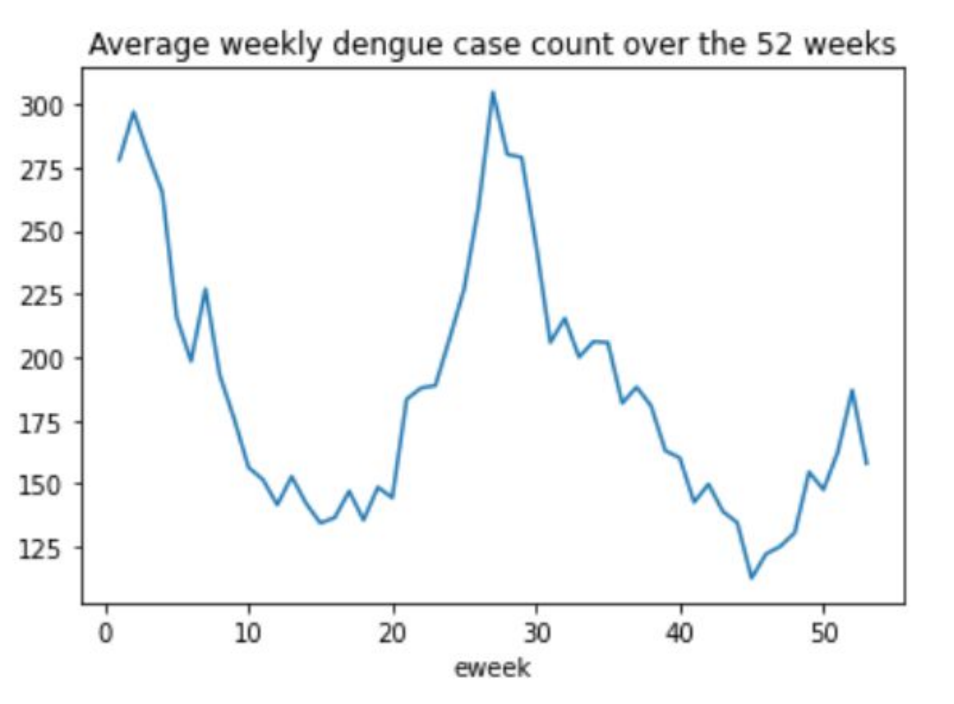
Temperature peaks in mid-year, rainfall peaks at end-year.





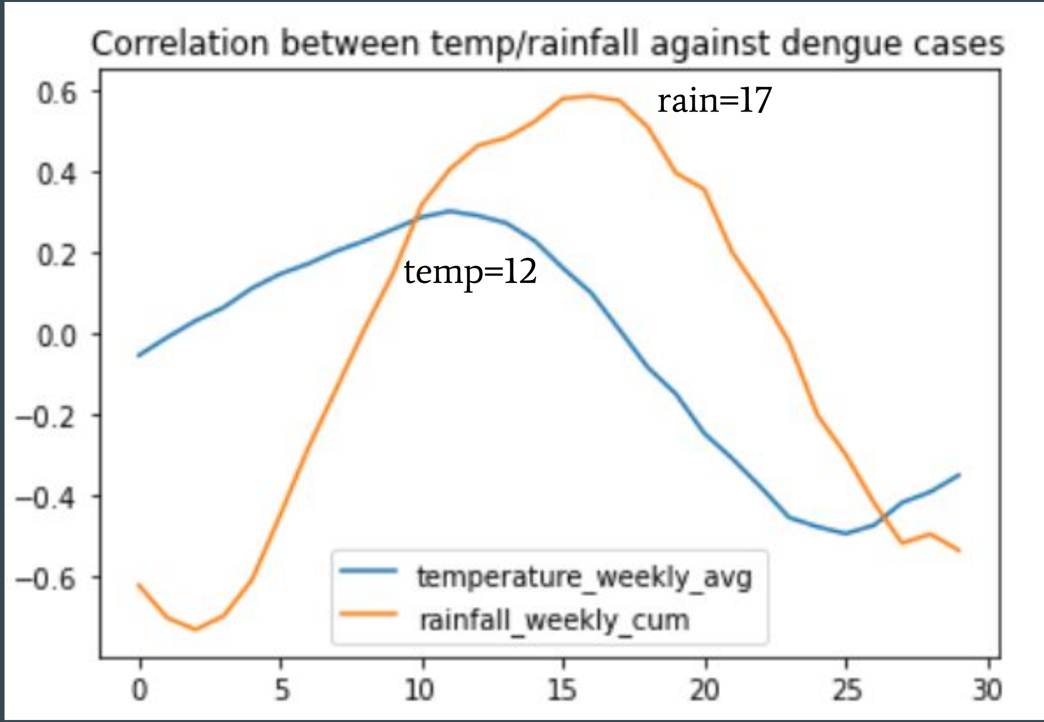
EDA (Temporal)

Two peaks in dengue cases - start of year and mid year.



EDA (Temporal)

Finding which lag period correlates best between dengue cases and temperature / rainfall



Model (Temporal)

We formulate a linear combination of lagged temperature and lagged rainfall.

$$V = \alpha Temp_k + (1 - \alpha) Rainfall_j$$

Where V is the prediction variable

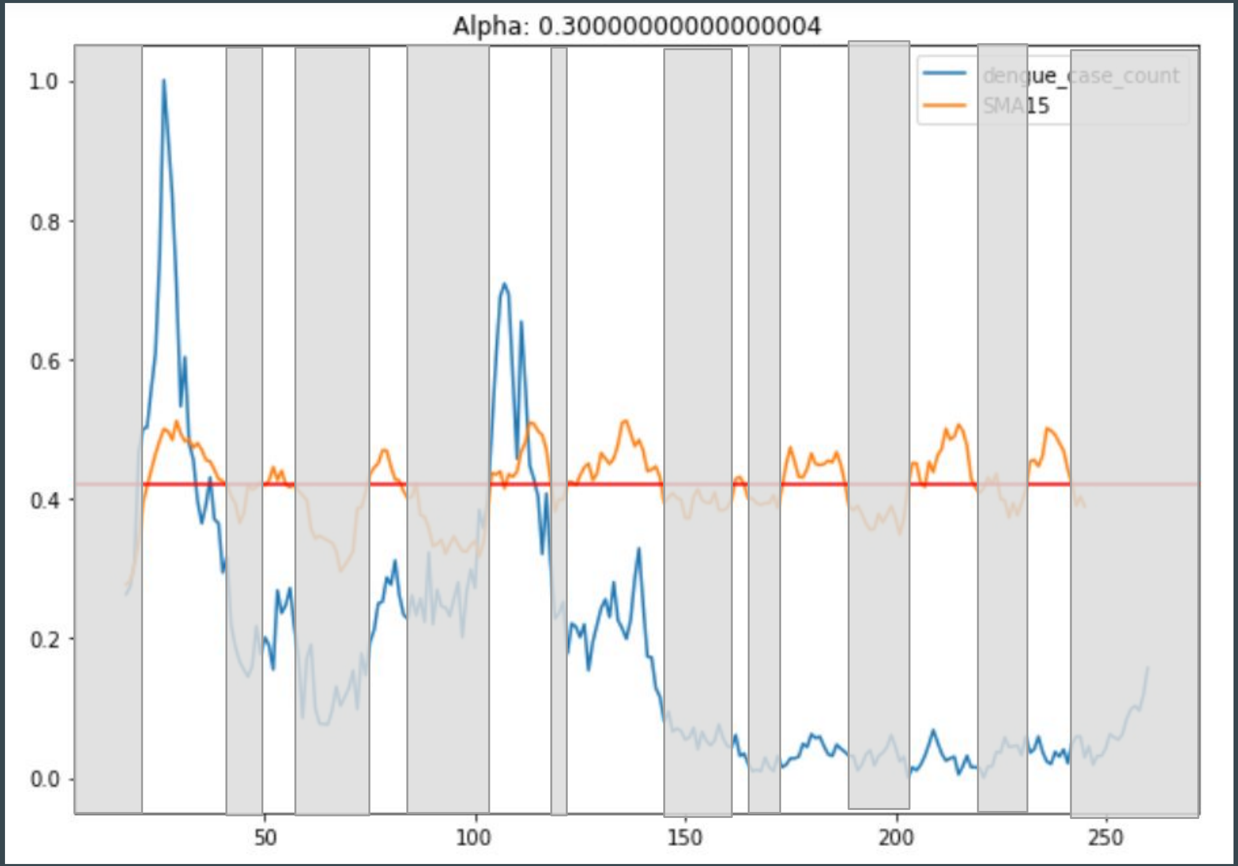
α is the weightage ratio ($0<\alpha<1$)

The lag parameters k = 12, j = 17 as defined earlier

Signal (Temporal)

Using a single SMA of 15 period, at $\alpha = 0.3$, we obtain the most optimal signal.

When signal (orange line) crosses above 0.42, it correlates with a peak that happens.



Model (Temporal) - refined

We then subject V to 2 simple moving averages (fast and slow)

$$SMA_{fast}$$
$$SMA_{slow}$$

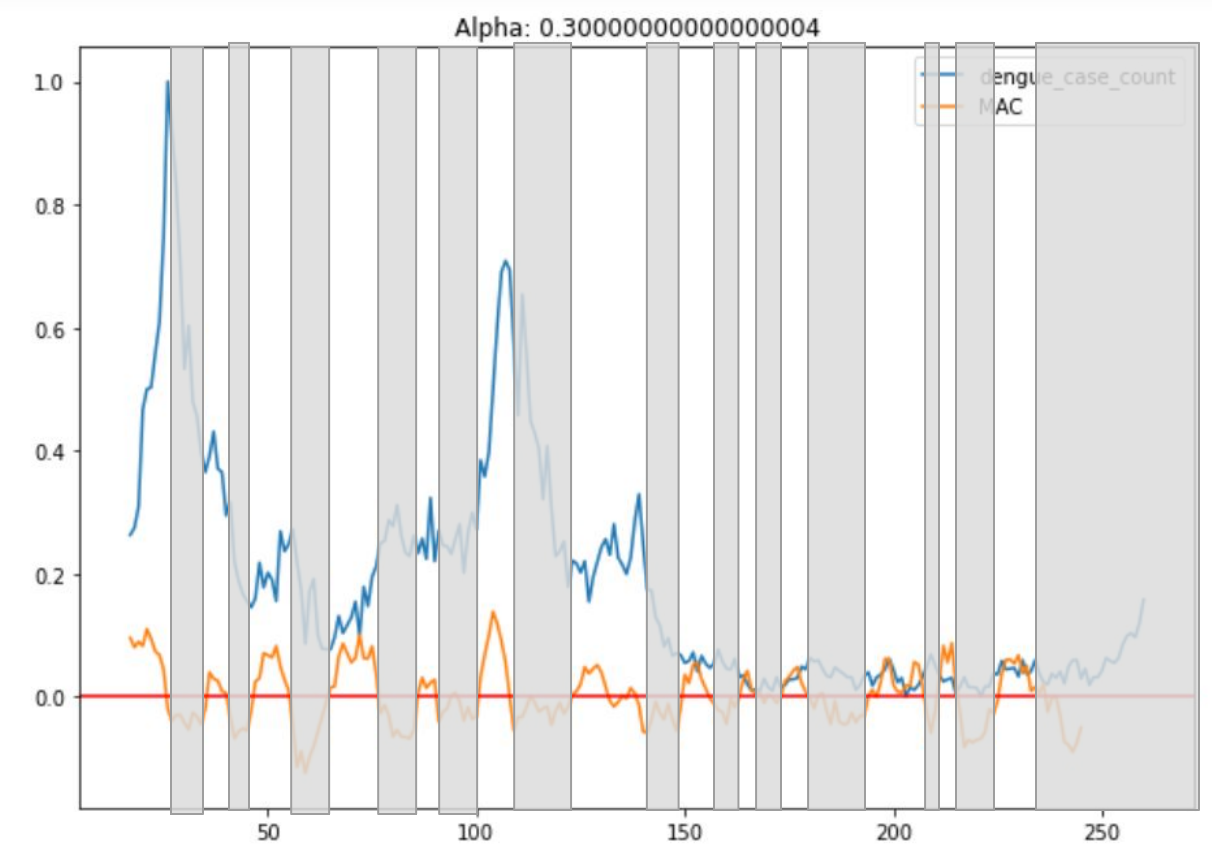
And we calculate the difference between these 2 SMA (**Moving-Average Crossover** technique)

$$MAC = SMA_{slow} - SMA_{fast}$$

Signal (Temporal) - refined

Using a MAC signal, easier to tell when signal crosses above 0.

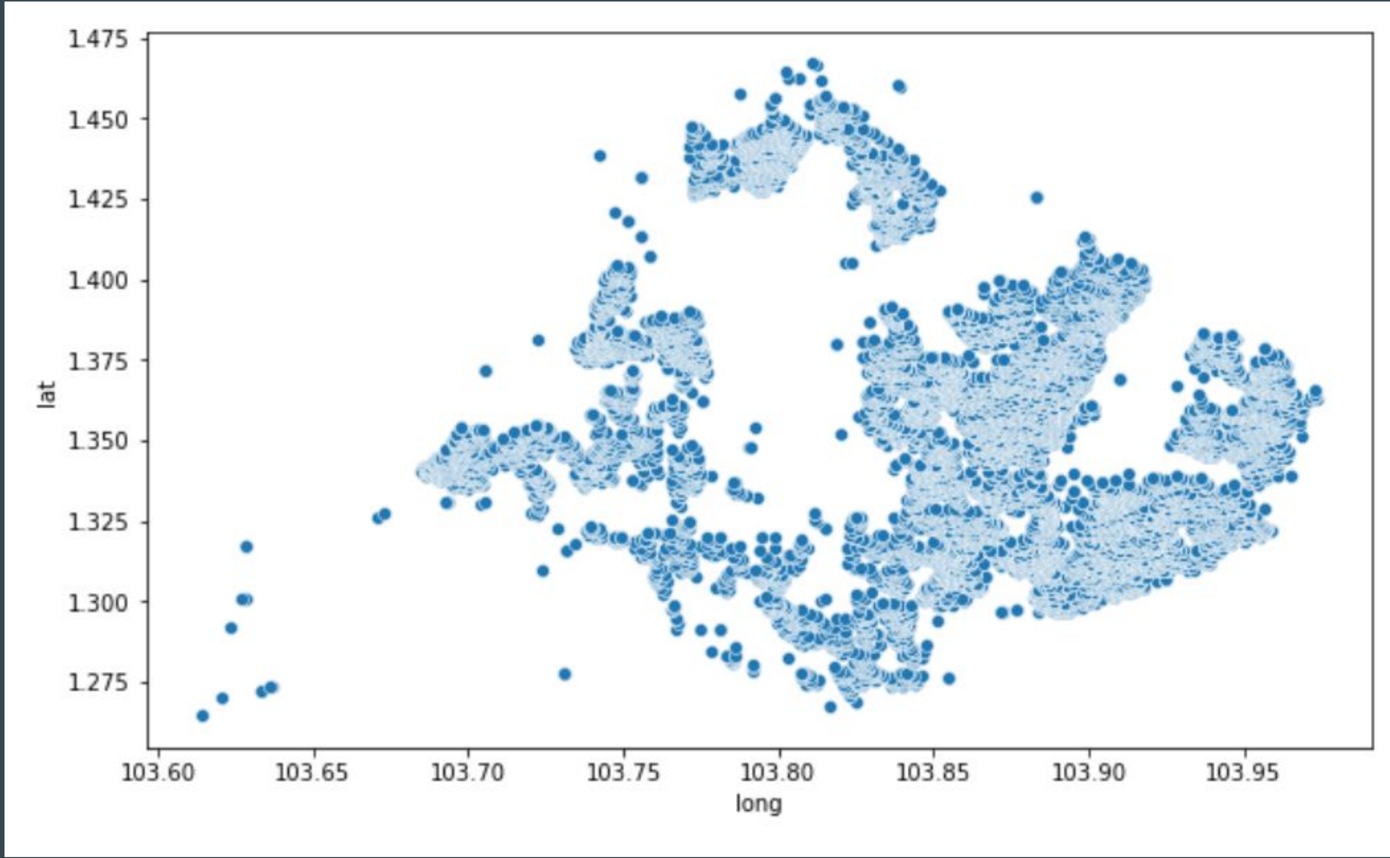
It also correlates well with when peaks happen



EDA (Spatial)

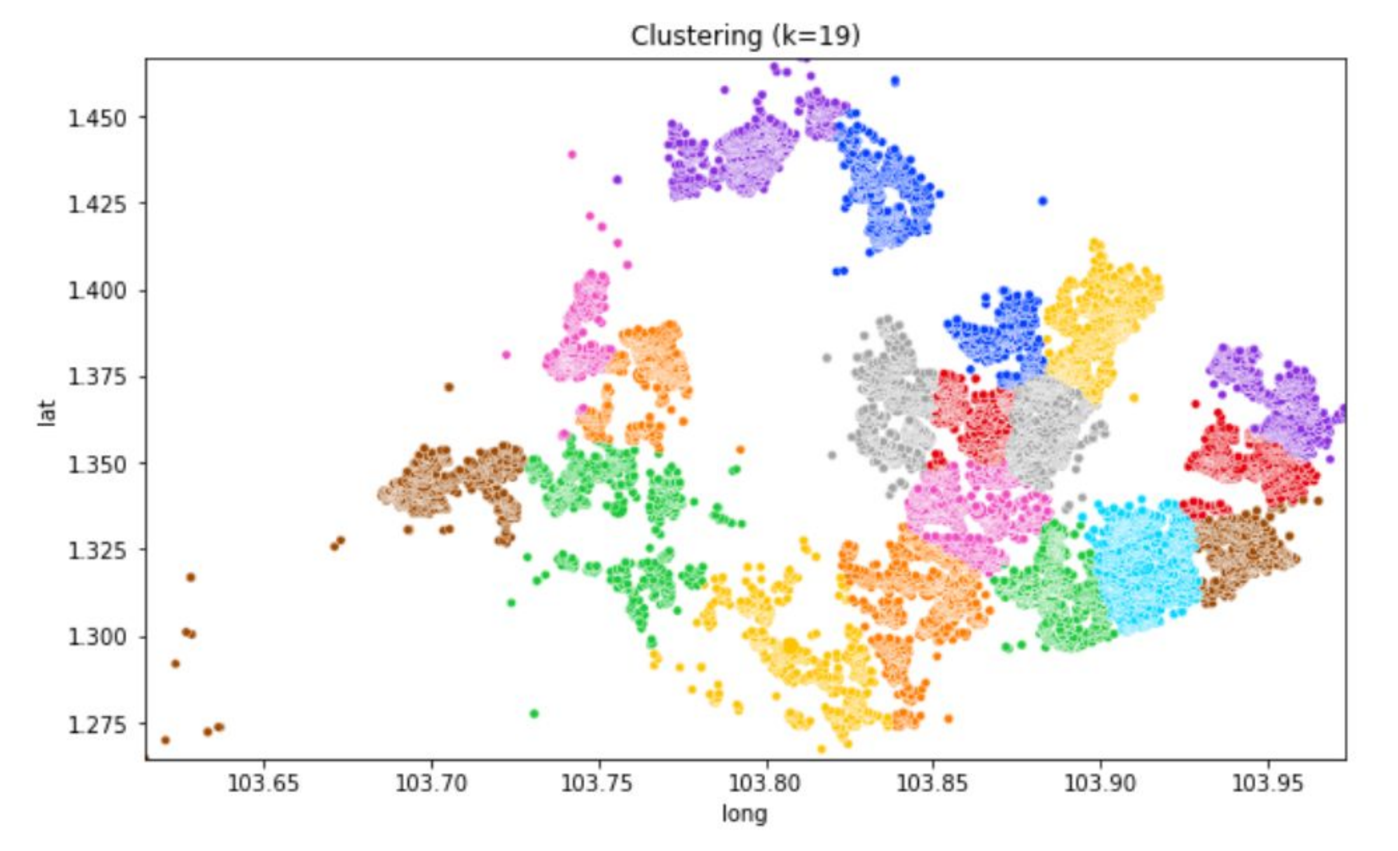
Dengue cases scattered all over Singapore,

Seems pretty even.



EDA (Spatial)

Cluster them
(using kmeans)

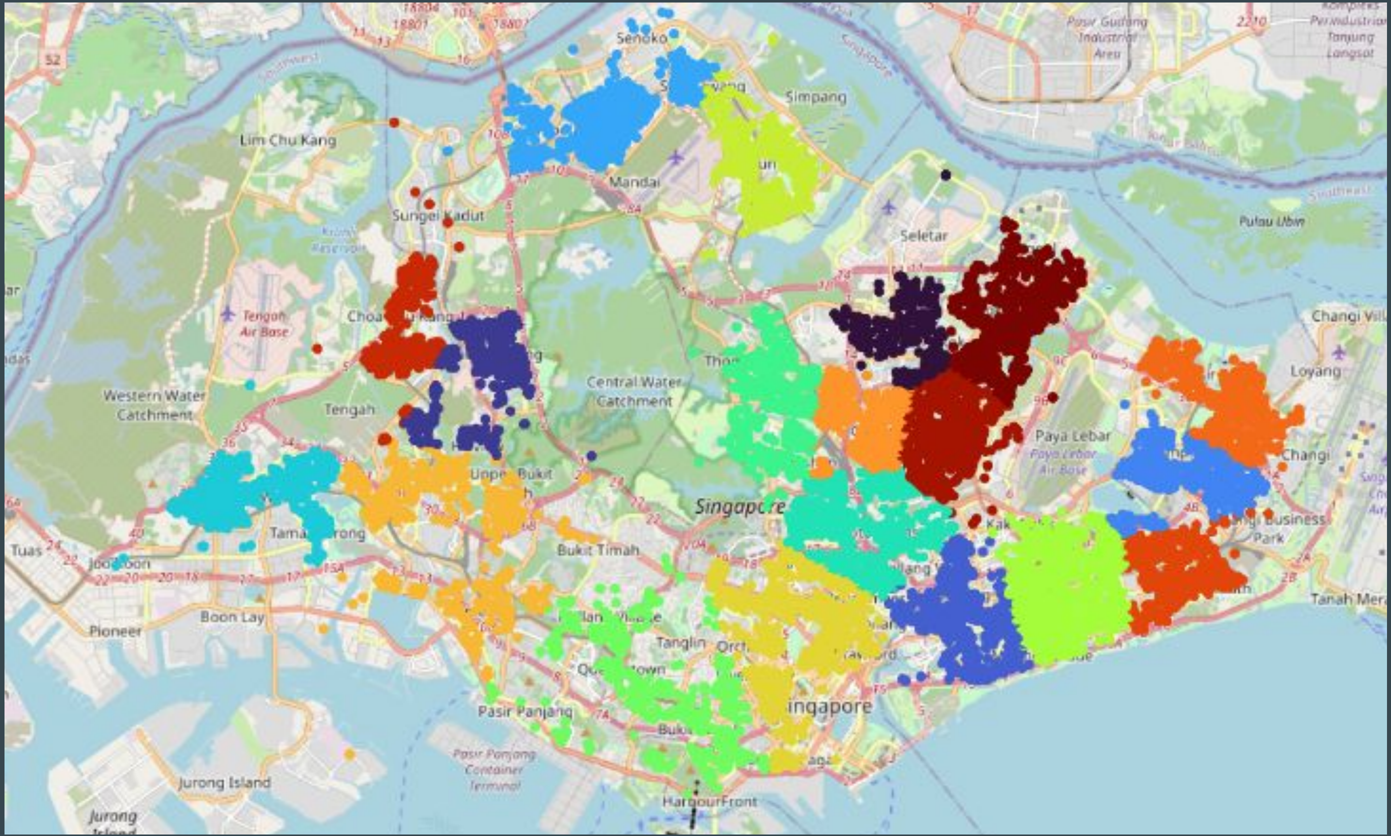


EDA (Spatial)

Overlay on a Map.

Very clear clusters belong to several towns.

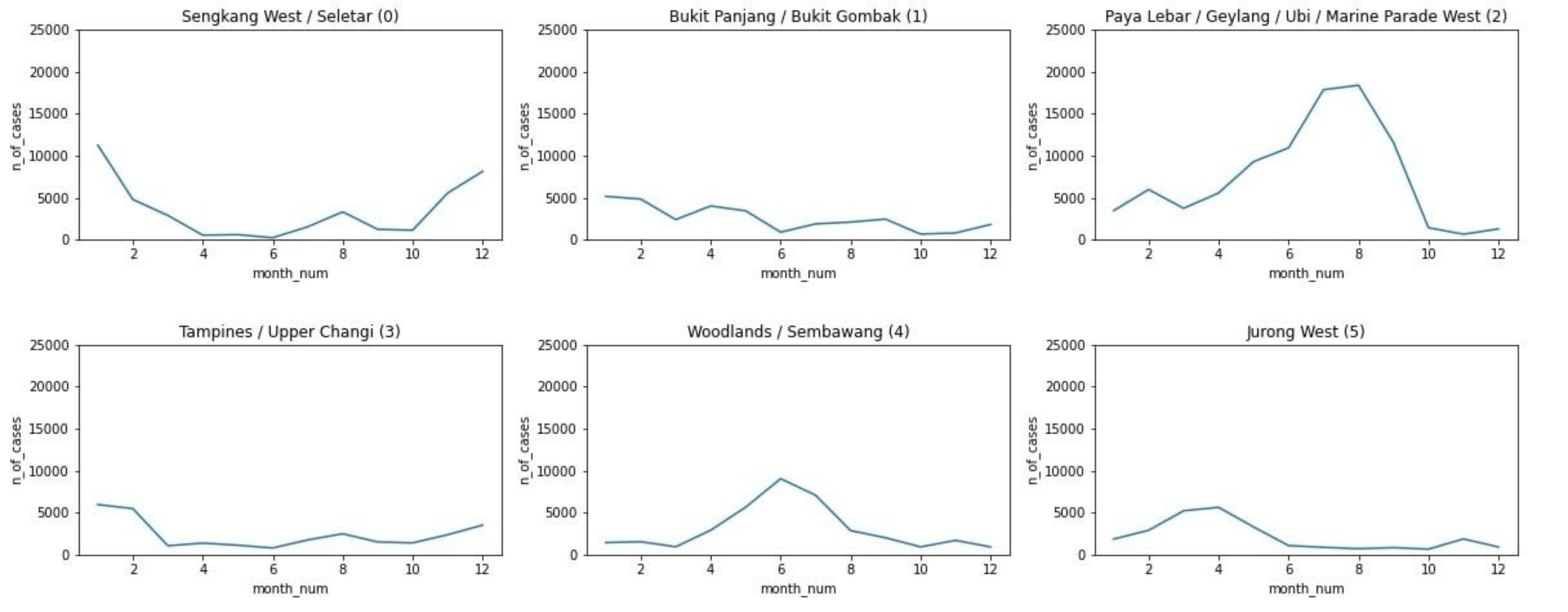
Housing estates have denser occurrence.

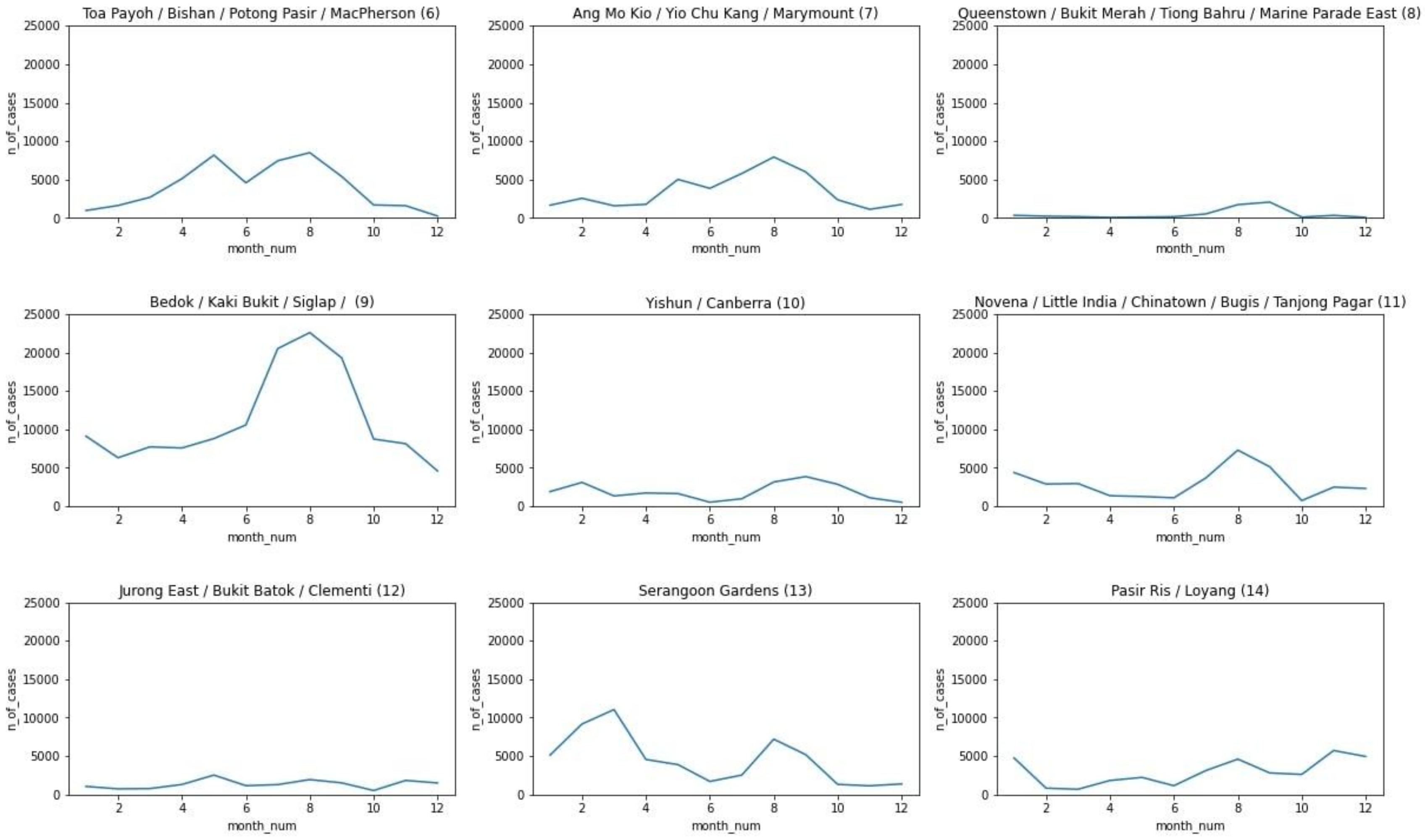


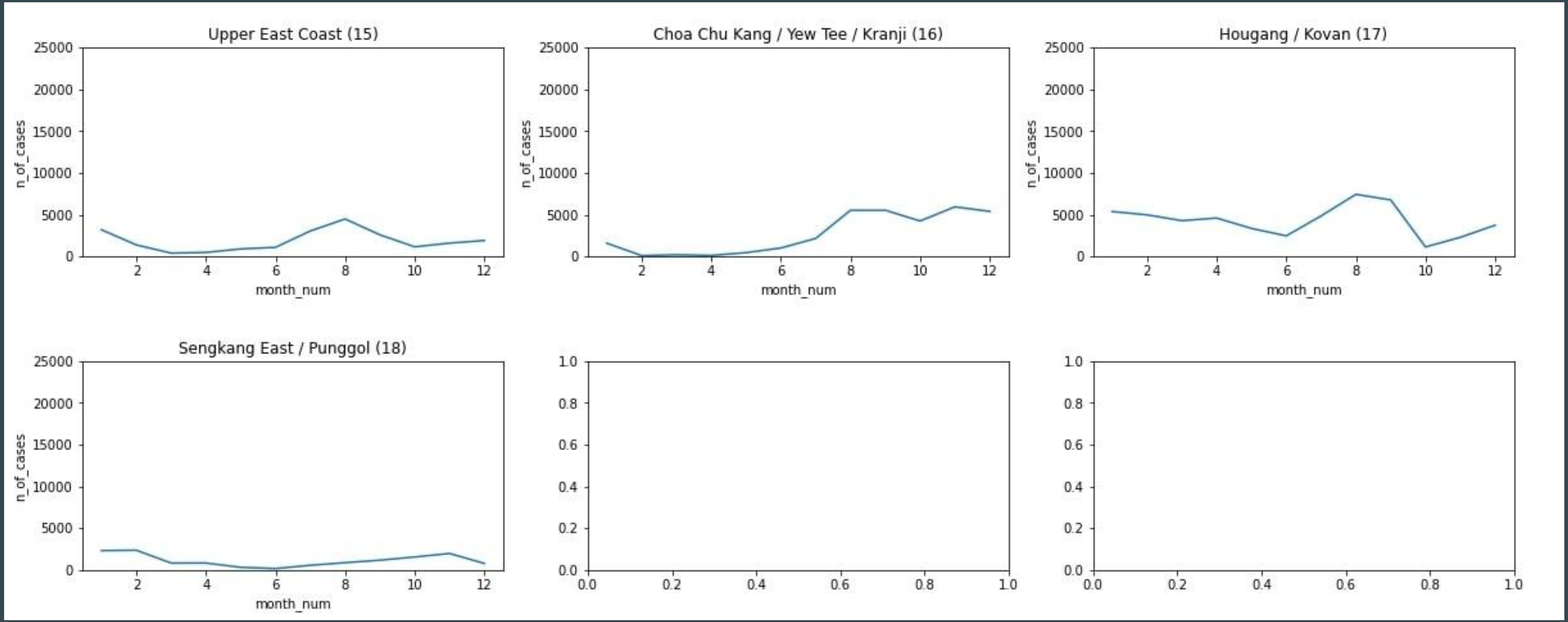

Woodlands / Sembawang
Yishun / Canberra
CCK / Yew Tee / Kranji
Bukit Panjang / Bukit Gombak
Sengkang West / Seletar
Sengkang East / Punggol
AMK / YCK / Marymount
Serangoon Gardens
Hougang / Kovan
Pasir Ris / Loyang
Tampines / Upper Changi
Jurong West
Jurong East / Bukit Batok / Clementi
Toa Payoh / Bishan / Potong Pasir / MacPherson
Bedok / Kaki Bukit / Siglap / Marine Parade East
Upper East Coast
Paya Lebar / Geylang / Ubi / Marine Parade West
Queenstown / Bukit Merah / Tiong Bahru
Novena / Little India / Chinatown / Bugis / Tanjong Pagar

EDA (Spatial - Temporal)

We look at monthly dengue cases by individual clusters




Toa Payoh / Bishan / Potong Pasir / MacPherson (6)
Ang Mo Kio / Yio Chu Kang / Marymount (7)
Queenstown / Bukit Merah / Tiong Bahru / Marine Parade East (8)
Bedok / Kaki Bukit / Siglap / (9)
Yishun / Canberra (10)
Novena / Little India / Chinatown / Bugis / Tanjong Pagar (11)
Jurong East / Bukit Batok / Clementi (12)
Serangoon Gardens (13)
Pasir Ris / Loyang (14)
n_of_cases
month_num
0
5000
10000
15000
20000
25000
2
4
6
8
10
12

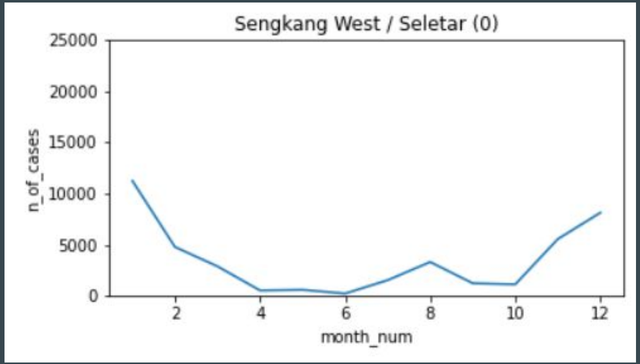

Upper East Coast (15)
Choa Chu Kang / Yew Tee / Kranji (16)
Hougang / Kovan (17)
Sengkang East / Punggol (18)
n_of_cases
month_num
0
5000
10000
15000
20000
25000
2
4
6
8
10
12
0.0
0.2
0.4
0.6
0.8
1.0

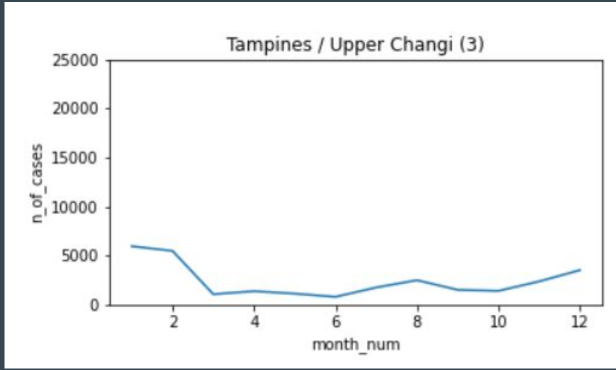
EDA (Spatial - Temporal Grouping)

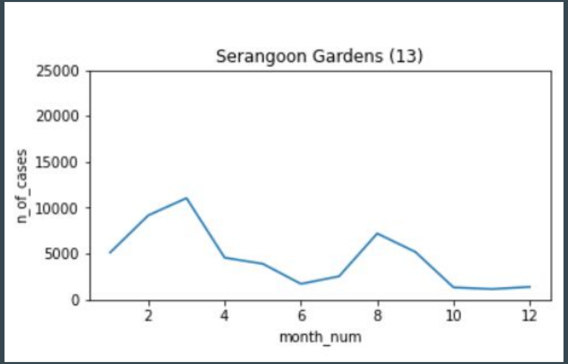
Start-of-year peak

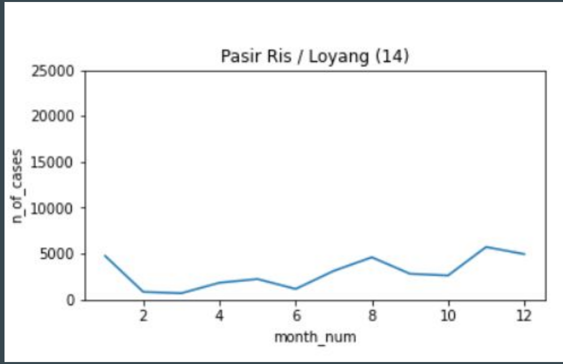
Observation:

North east cluster



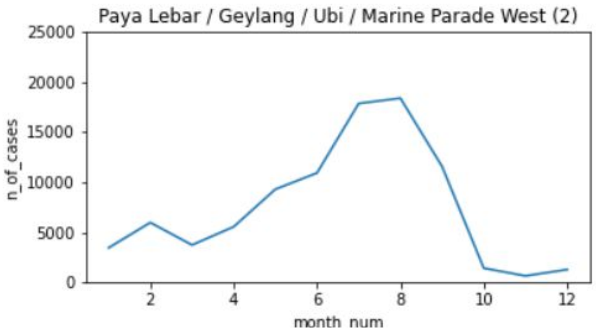


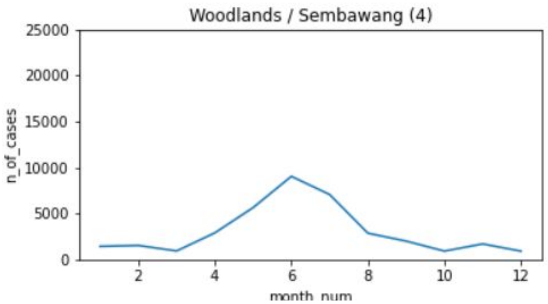


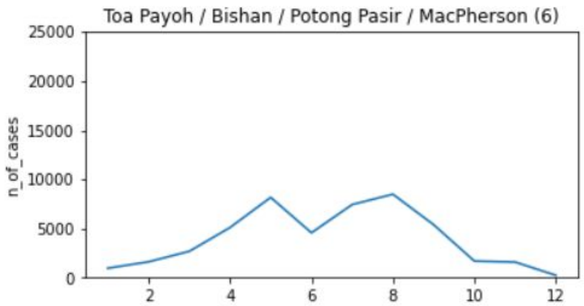


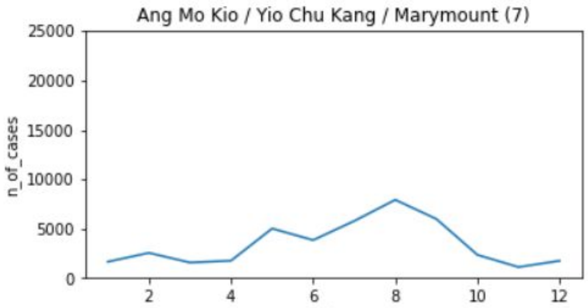
EDA (Spatial - Temporal)

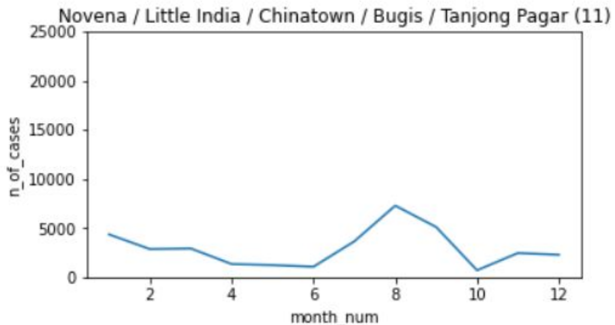
Mid-year peak

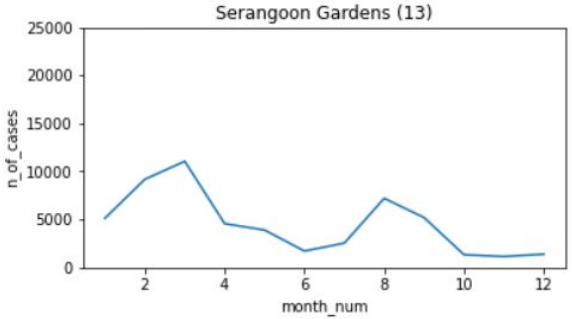


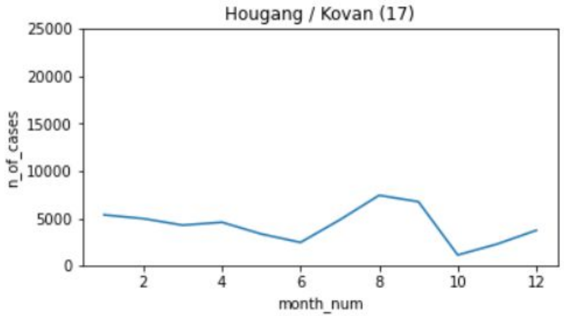












Recommendation

- Assume we have a positive MAC signal now (January 2023)
- We will be expecting a peak to happen soon.

Will need to release Wolabchia to counter the peaks

- Locations to focus on will therefore be (North-east of Singapore):
  - Sengkang West
  - Seletar
  - Tampines
  - Upper Changi
  - Bedok
  - Kaki Bukit
  - Siglap
  - Serangoon Gardens
  - Pasir Ris
  - Loyang

Conclusion

We have developed a model using lagging rainfall and temperature to predict the peak of dengue high-season. We separately split the nation into several clusters using historical spatial trends. Collectively, the spatial clustering and temporal prediction work together for NEA officials to identify when and where to target release of Wolbachia mosquitoes to combat the outbreak.