Modelling *walkability* in Wellington

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What can you expect?

The slides contain

- An introduction to doing spatial data science
- An introduction to statistical models
- Insights about walkability in Wellington
- Lots of graphs and figures

Motivation

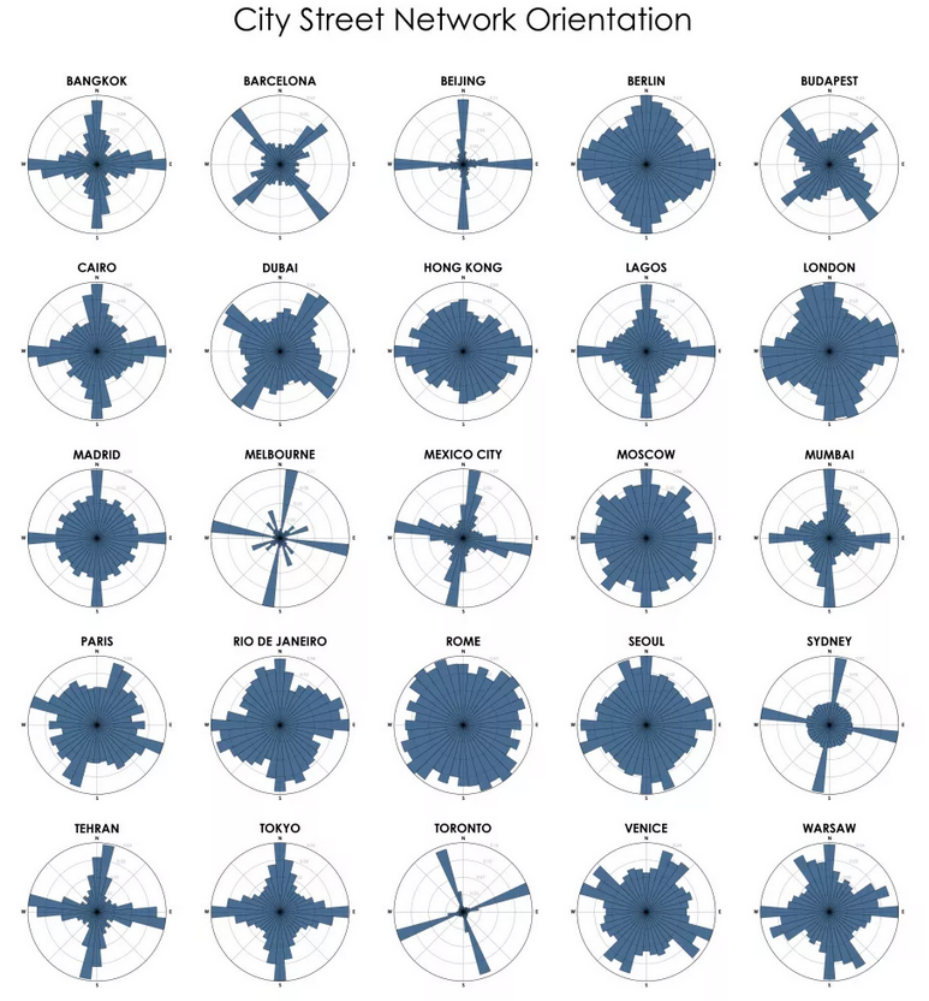
The global FOSS4G movement

- Open data sources
  - OpenStreetMap
  - Data.gov*: data.gov, data.govt.nz, data.gov.uk, data.gov.in
- Open source packages
  - osmnx, pandana, networkx, geopandas in Python
  - sf, rgdal, ggmap in R
  - QGIS

Inspiring people: Modelling critical infrastructure shutdown

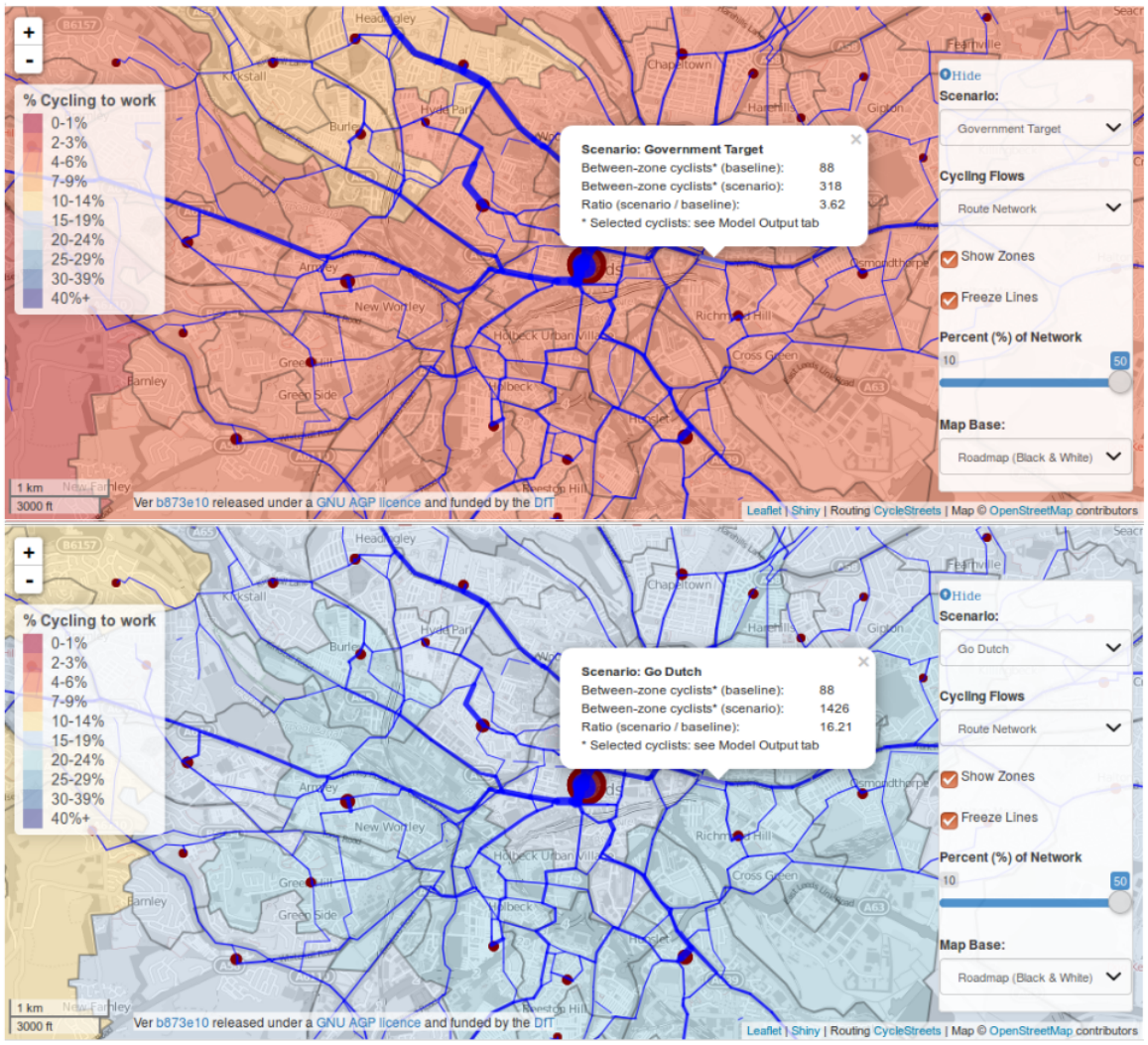
- Kuan Butts

Inspiring people: Urban form and morphology



- Geoff Boeing

Inspiring people: Propensity to cycle



- Robin Lovelace

Walkability

Importance

Reducing car reliance and encouraging more transport-related physical activity are now recognised as beneficial objectives from health, social and environmental perspectives. Evidence is accumulating that a number of built environment attributes are associated with the likelihood of residents using active transport.

– Measuring neighbourhood walkability in NZ cities

Need

Unlike cars, pedestrians are sensitive to their environment; changes to it can impact the *walking experience* or the *decision to walk*.

Task

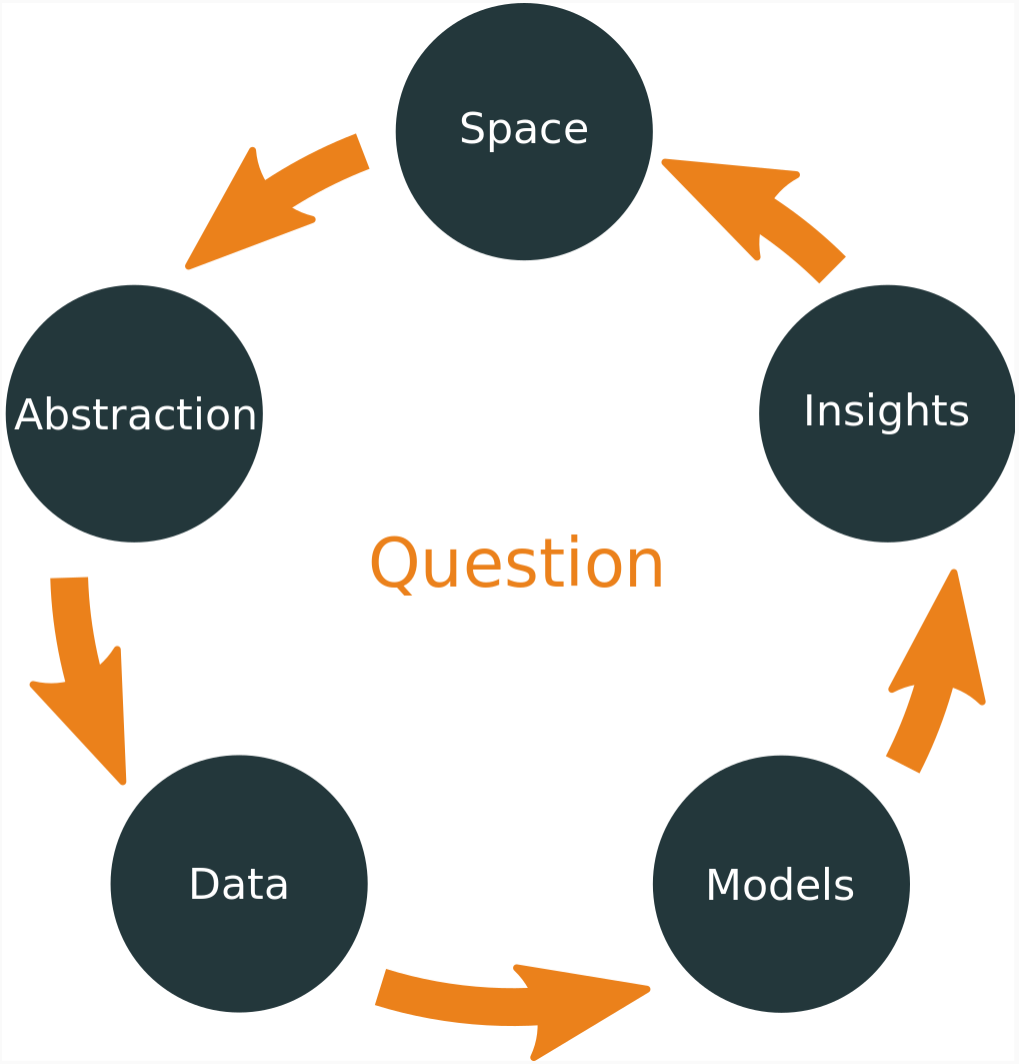
We'll explore the impact of hilly terrain on walkability Specifically, on walkability to council playgrounds - an amenity that should be locally accessible on foot.

Playground access

- Council engagement for their recent Play Policy showed:
  - 41% of playground users walked and 45% drove.
  - 58% of playground users go to their *nearest* playground.

Spatial data science

Overview



Question

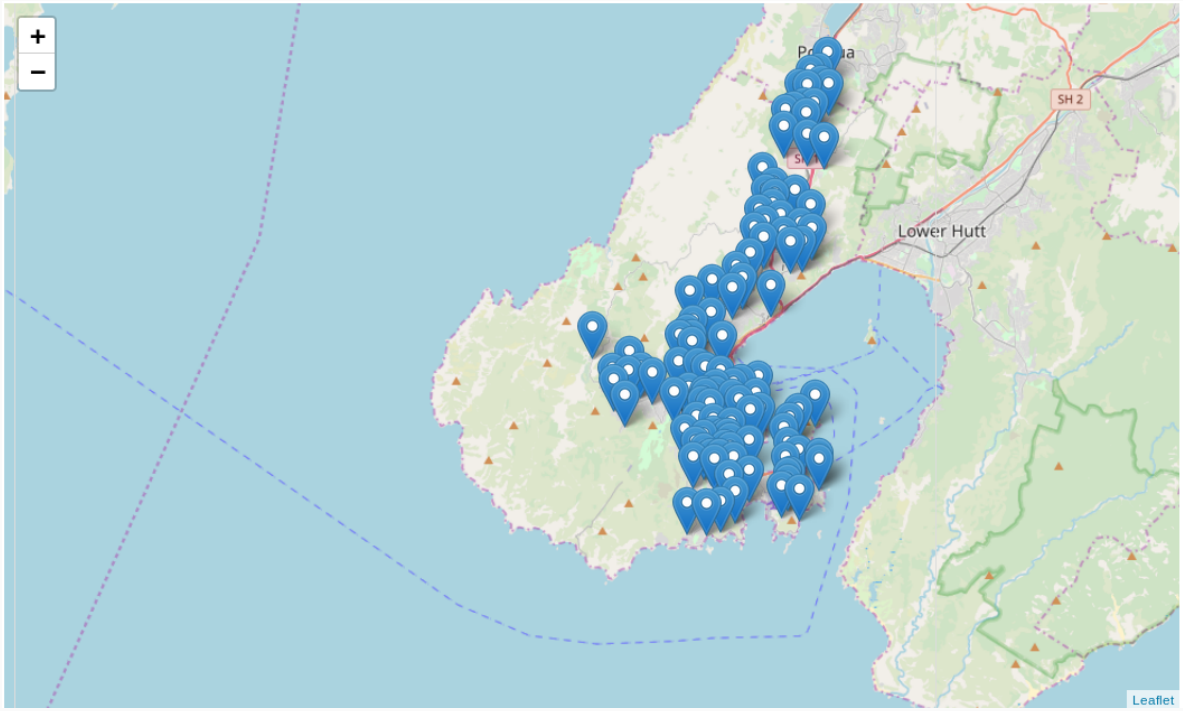
What is the impact of hills on walkability to playgrounds in Wellington?

Space

Wellington

Abstraction: spatial primitives

Points

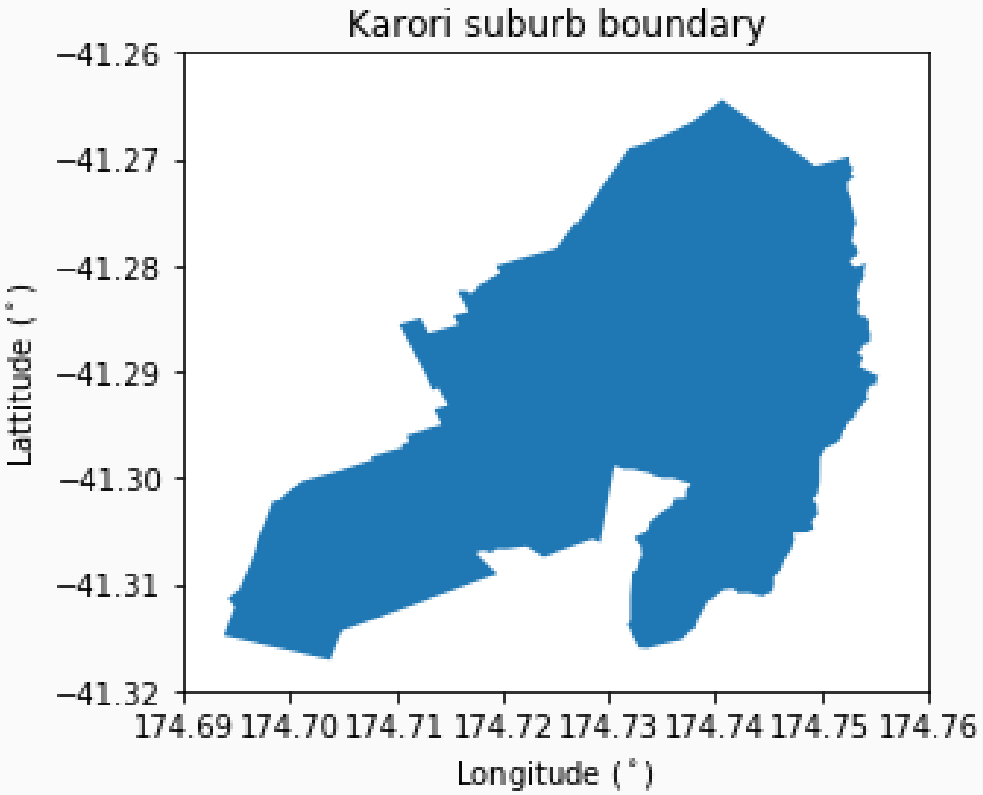


- Point coordinates of playgrounds
- *Overlaid* on map of Wellington

Lines

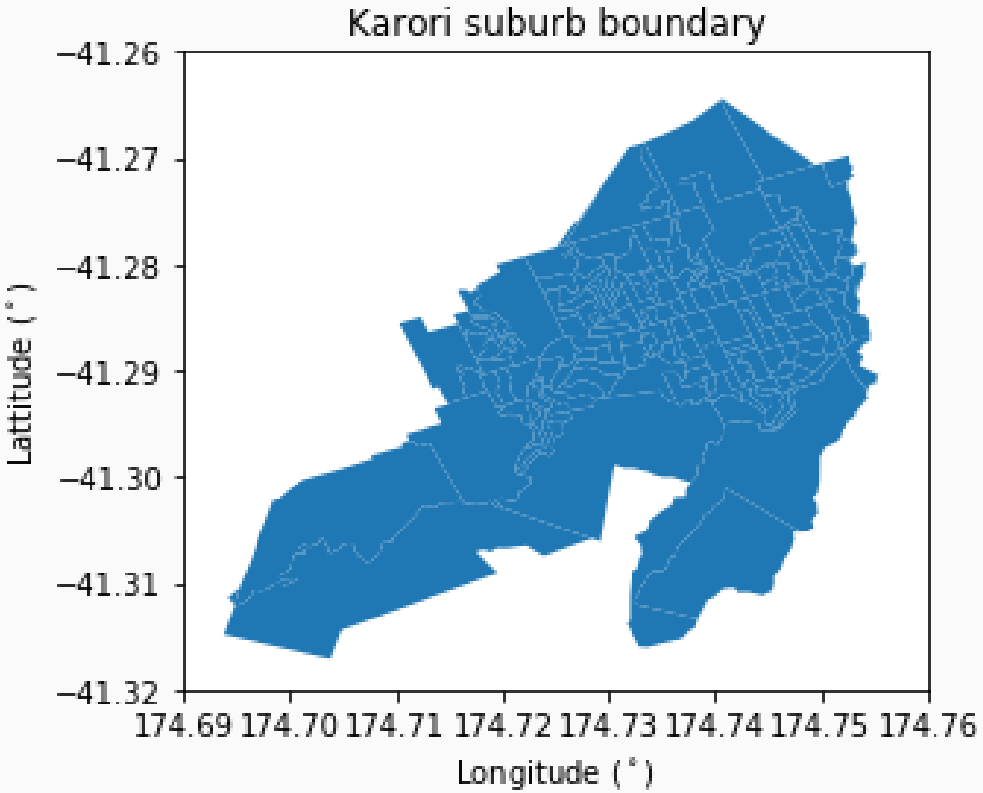
- Line segments that define a street or in this case, a route.

Polygons



- Poylgon boundary of suburb

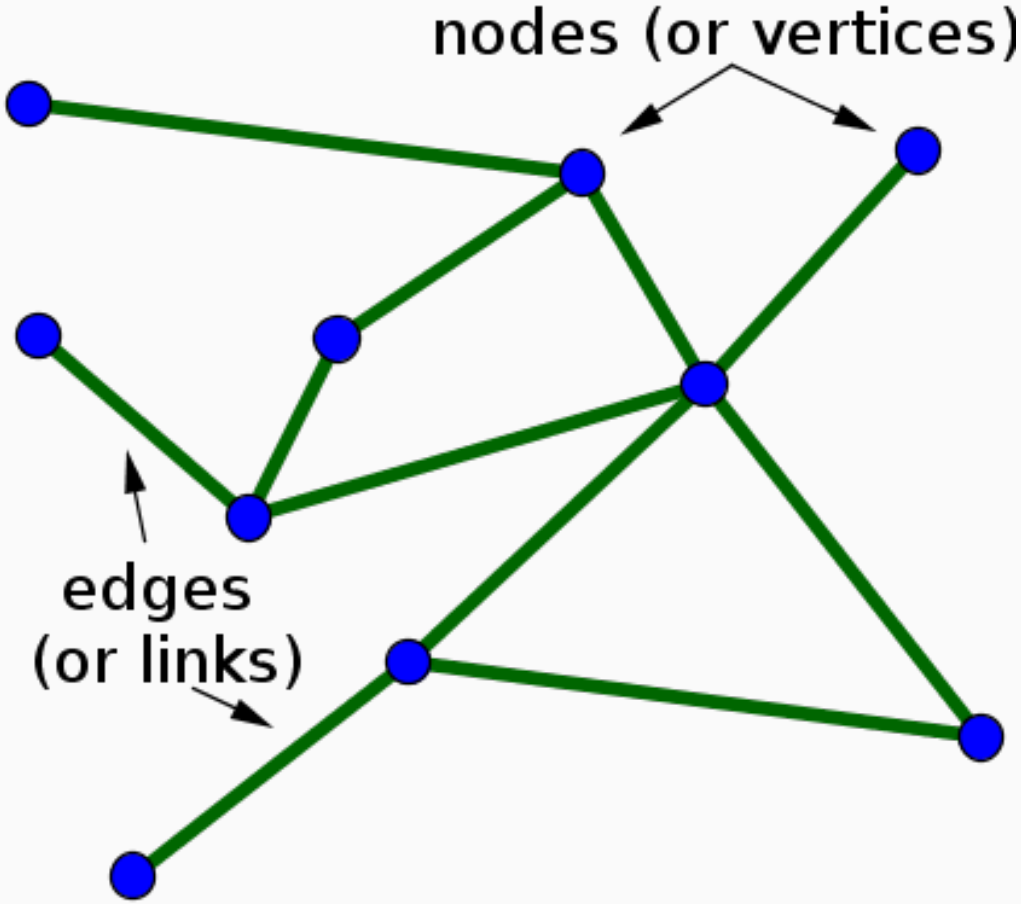
Complex abstractions



- Poylgon boundary of suburb
- Polygon boundaries of meshblocks *within* suburb

Abstraction: map to graph

What is a graph?



- Nodes / vertices
- Edges
- Edges and nodes can have associated values

Creating a street graph

Map represented as street edges with intersections as nodes

Data: spatial primitives

Spatial entities in geodataframes

	suburb	postcode	MB2019_V1_00	geometry
917	Karori	6012.0	2104100	POLYGON ((174.7527410567269 -41.27200381936174...
934	Karori	6012.0	2106100	POLYGON ((174.7533828776446 -41.28300381209932...
942	Karori	6012.0	2105503	(POLYGON ((174.7530386517898 -41.2800340600980...
944	Karori	6012.0	2149500	POLYGON ((174.7535317353109 -41.28234654562732...
947	Karori	6012.0	2149400	(POLYGON ((174.754264330901 -41.27988740170357...

Points, lines and polygons can all be compressed in a geodataframe.

Data: graphs

Graph nodes in geodataframes

	elevation	highway	osmid	x	y	geometry
1259077823	196.755	NaN	1259077823	174.792882	-41.227920	POINT (174.7928822 -41.22792)
1259077824	218.696	NaN	1259077824	174.791983	-41.229385	POINT (174.7919835 -41.2293852)
1259077827	163.804	NaN	1259077827	174.805433	-41.213698	POINT (174.8054327 -41.2136978)
3619684648	12.692	NaN	3619684648	174.780604	-41.276563	POINT (174.7806038 -41.2765628)
3619684652	12.344	NaN	3619684652	174.781234	-41.276037	POINT (174.7812341 -41.2760368)

Graph edges in geodataframes

		name	grade	length	osmid	maxspeed
1259077823	**1259072929**	Truscott Avenue	0.1319	66.800	110175609	50
	1259072943	Truscott Avenue	-0.0475	65.443	110175609	50
	6083853567	John Sims Drive	-0.1116	177.292	110176112	50
1259077824	**6083853567**	John Sims Drive	0.1650	13.022	110176112	50
1259077827	**465611807**	Cambrian Street	0.0396	71.272	107284021	50

Data used for analysis

- Street graph: with street gradient attribute for edges
- WCC playgrounds represented as points
- Suburb boundaries defined by WCC as polygons
- LINZ residential areas as polygons

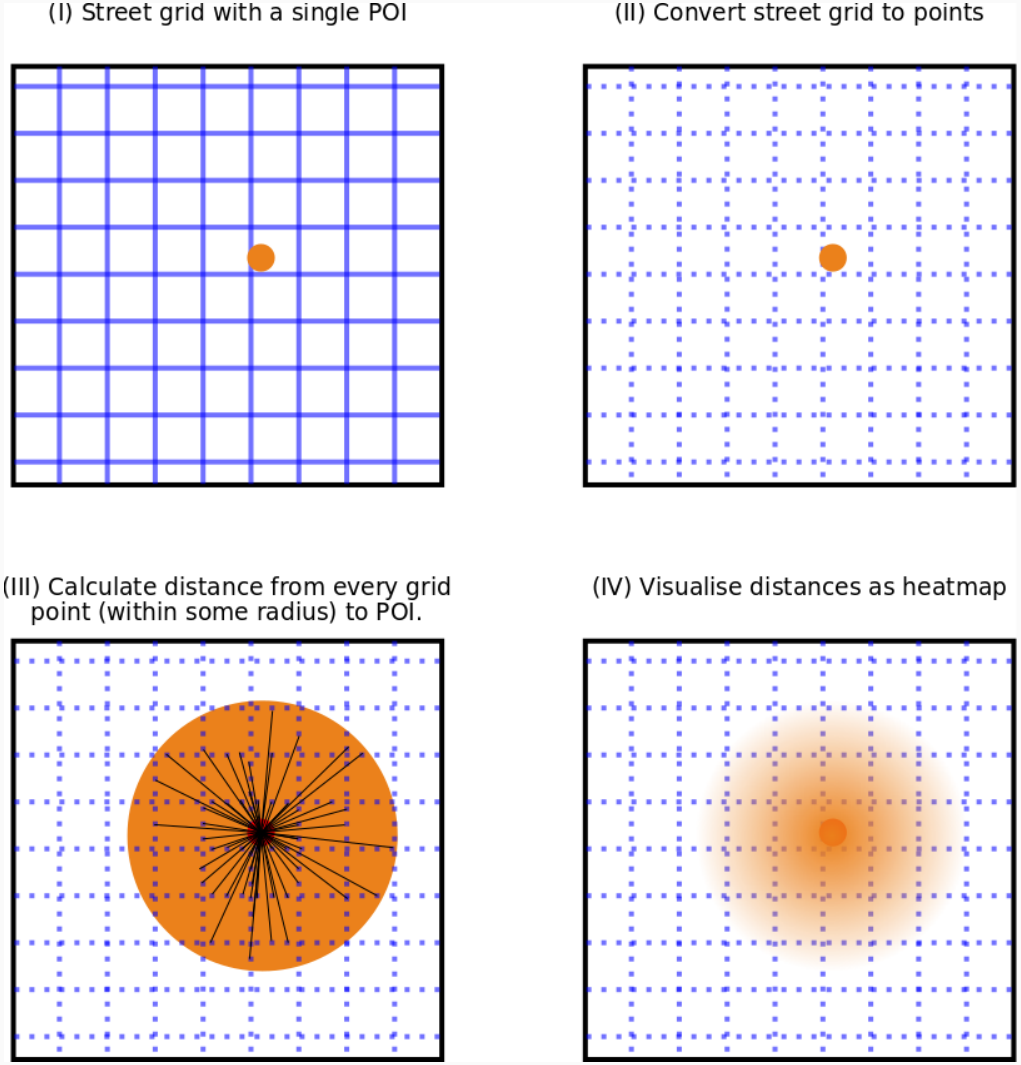
Data: enriched and aggregated for modelling

Approximating walkability as accessibility

Just to make life confusing, there are several definitions of accessibility. For the following analyses, accessibility is:

- an objective metric
- calculated with a street graph and points of interest (POIs)
  - e.g. Wellington street graph and playground locations
- calculated with a specific unit of interest
  - e.g. distance, travel time, total travel time etc.
- limited to nearest POI

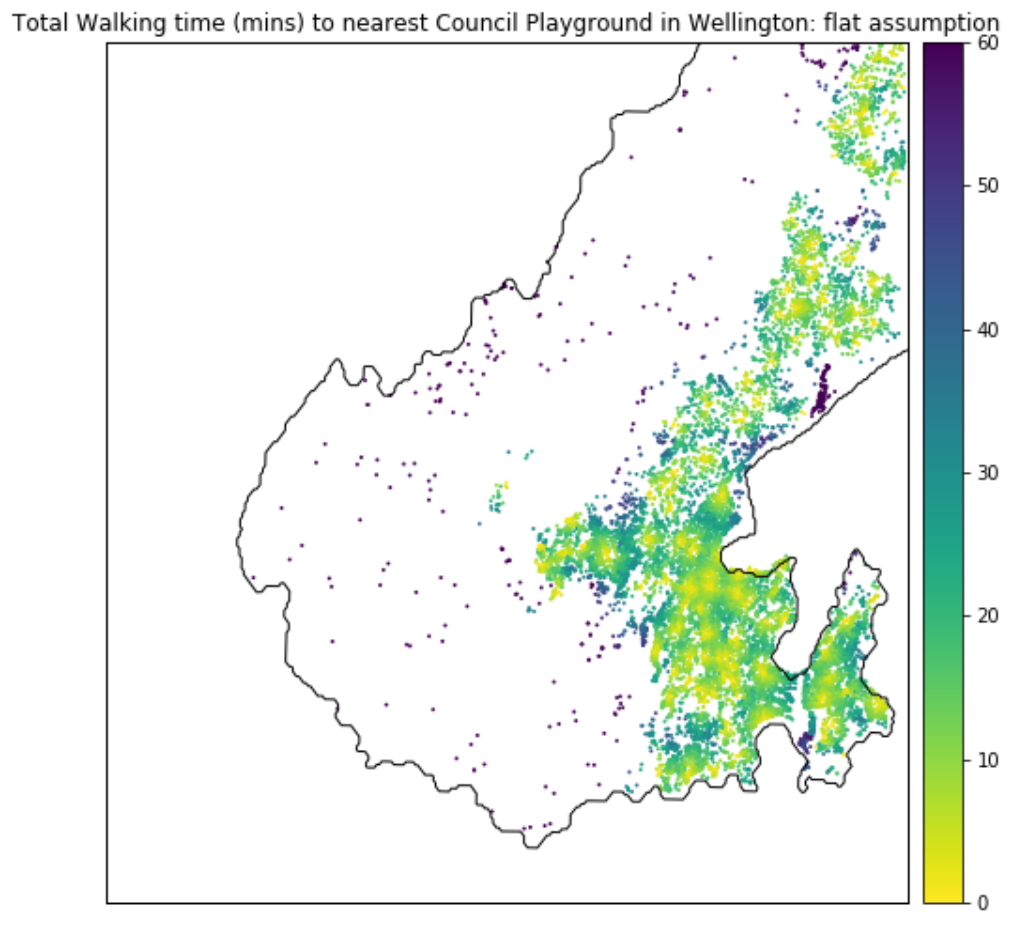
How to calculate accessibility



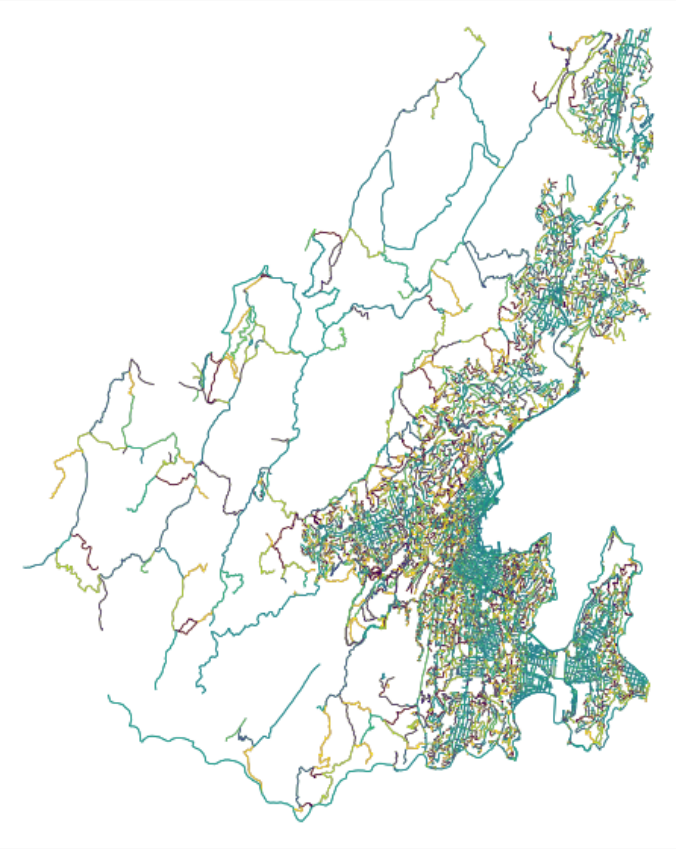
Accessibility on streets

- Find closest street graph nodes to: start and park
- Find shortest part between start and park nodes
- Sum edge weights of shortest path

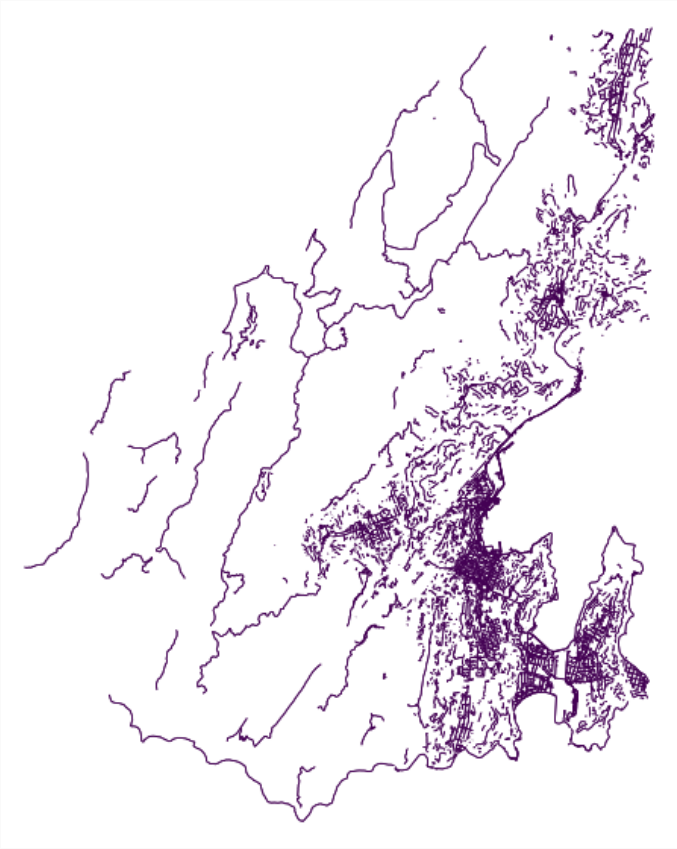
Efficient accessibility with Pandana



Street graph with gradients

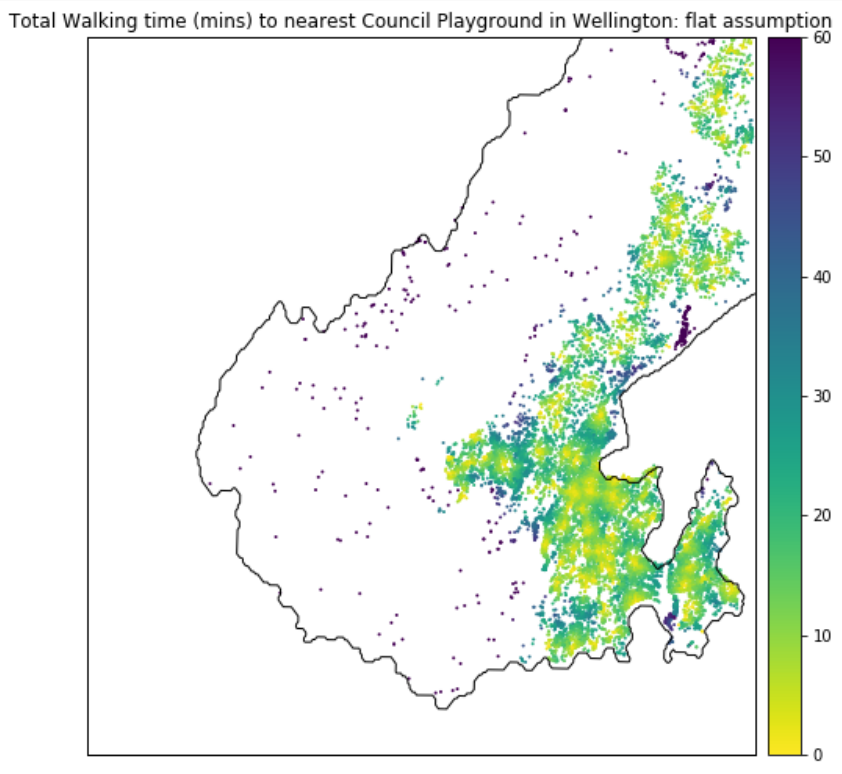


- All edges (green ~ flat gradient)

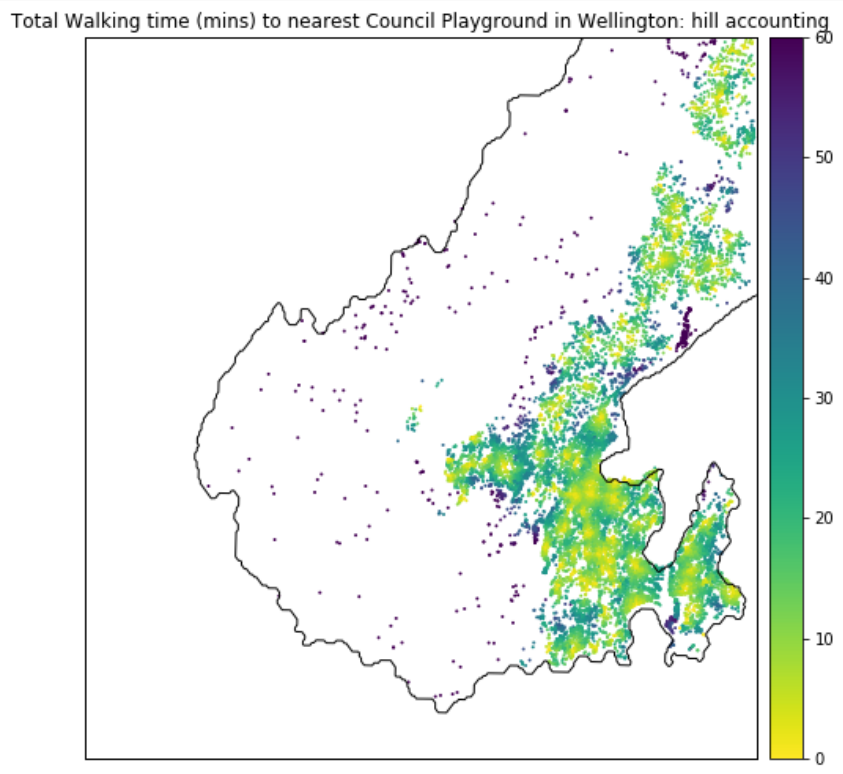


- Edges within 5% absolute gradient

Hills vs. flat land

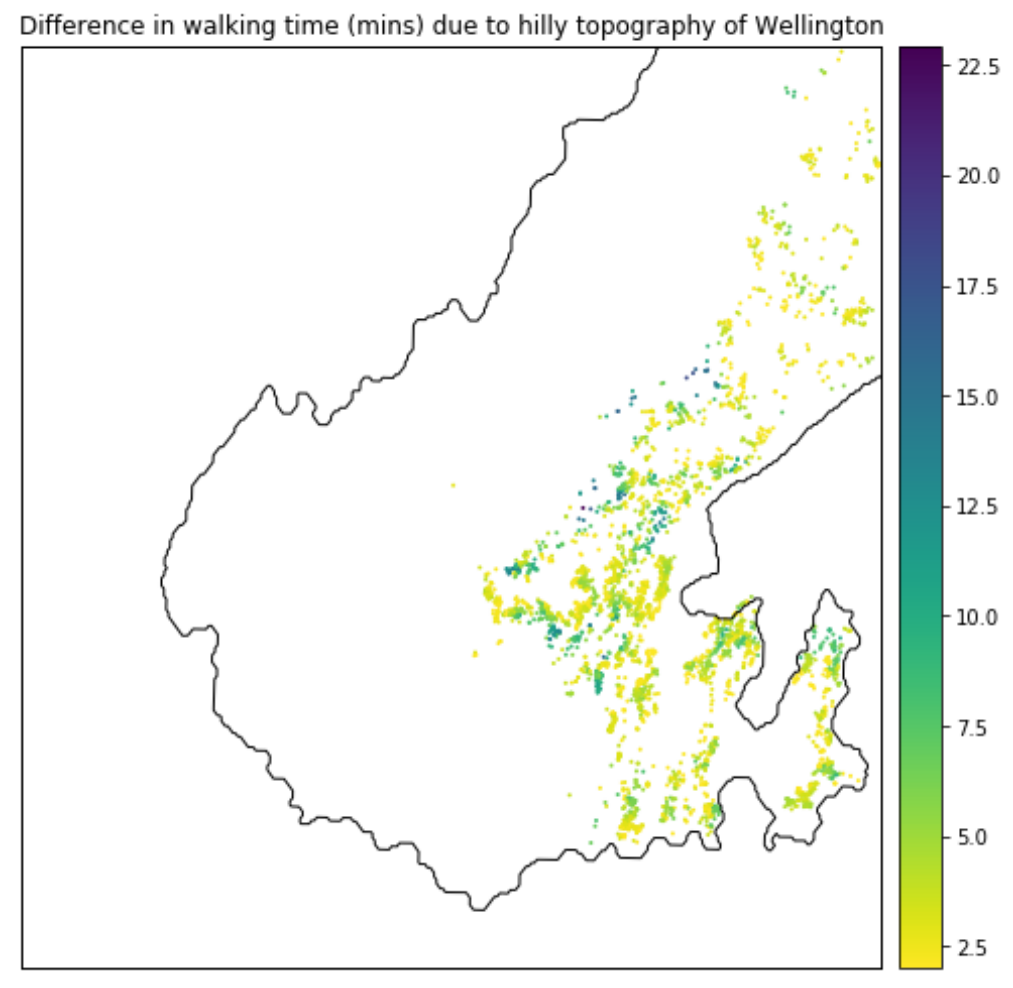


- Assuming single speed

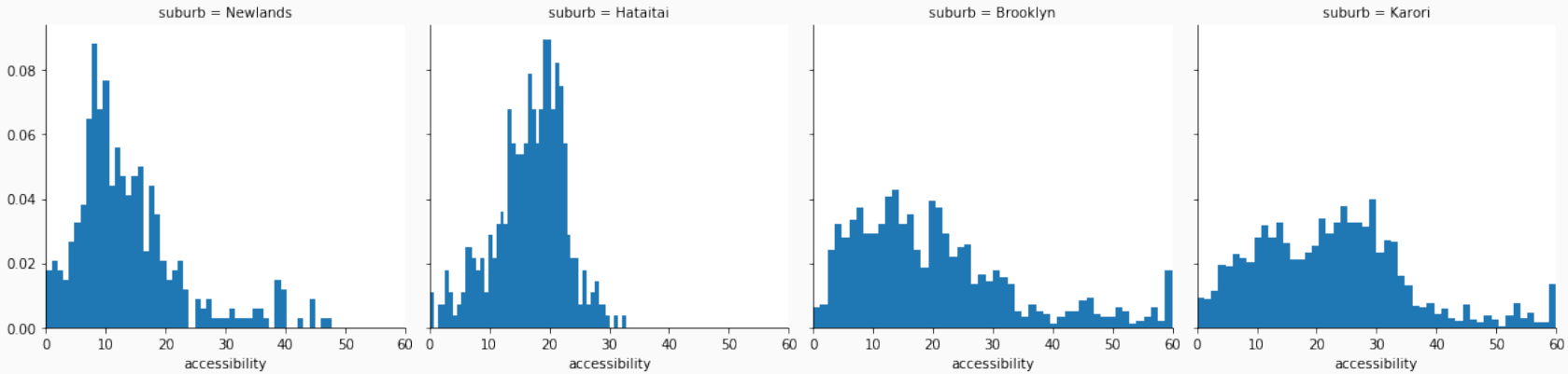


- Accounting for speed variability due to hills

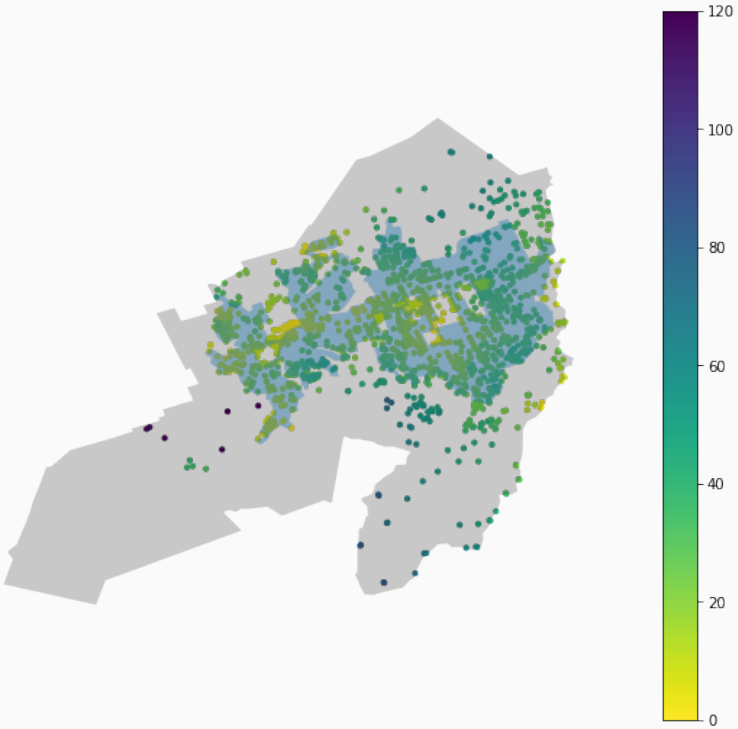
Difference due to hills



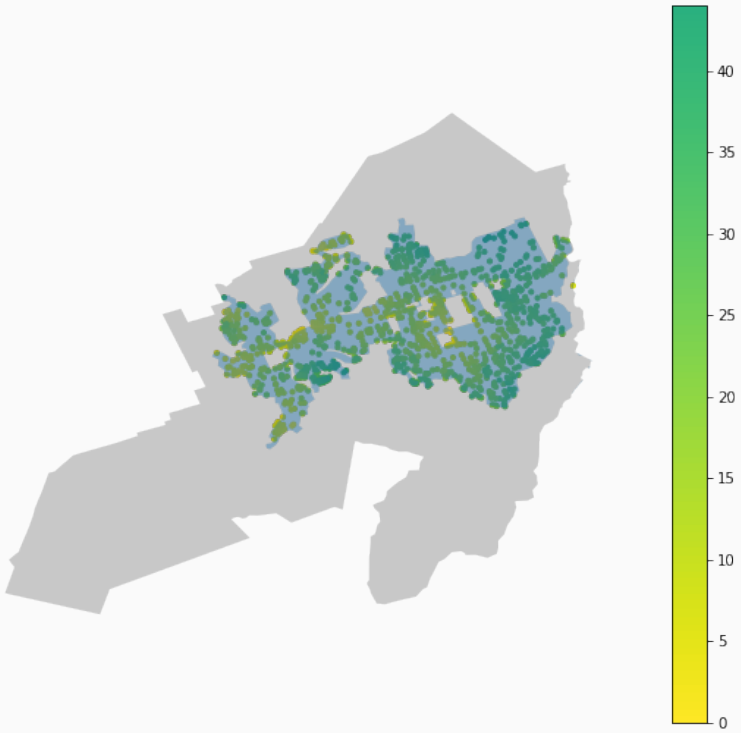
Accessibility distributions by suburb



Spatial filters

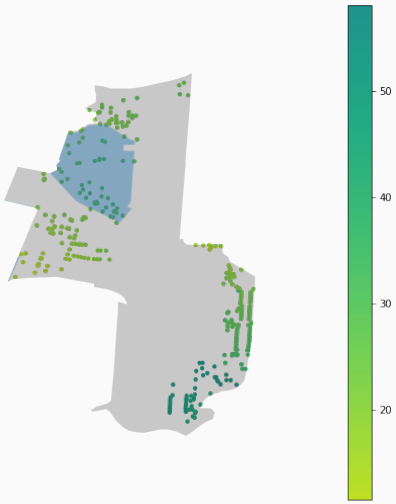


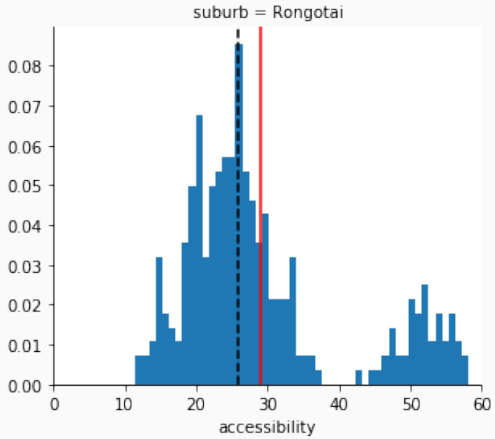
- Residential area mask



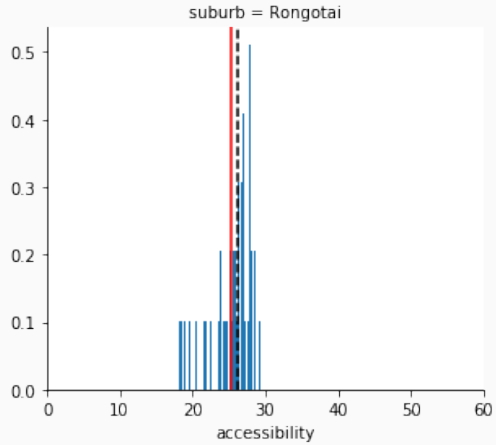
- Filtered accessibility

Why spatial filters are important: Rongotai





- All



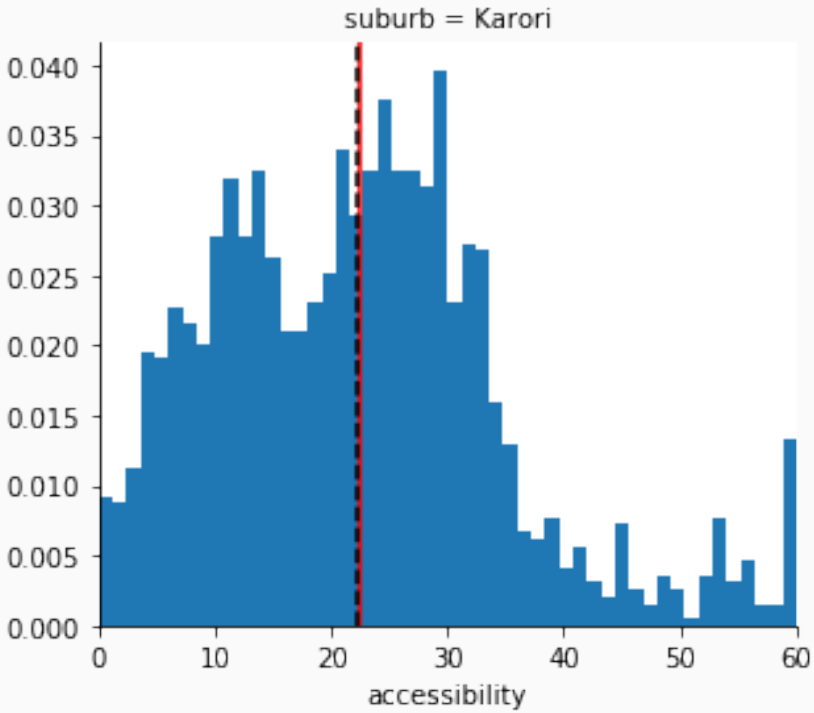
- Filtered

Model

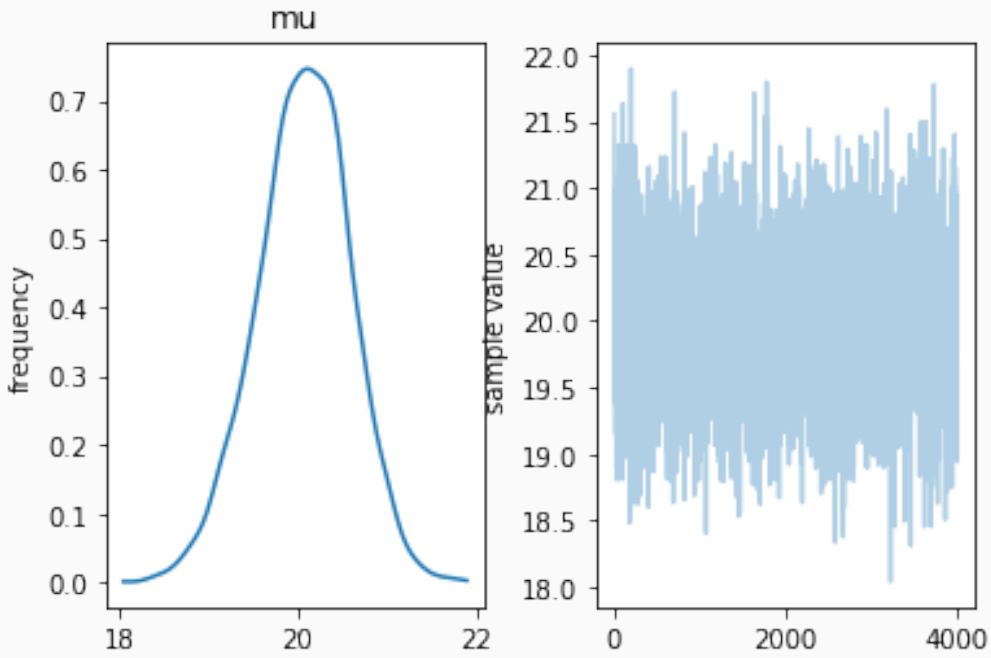
Bayesian modelling

- From the observed accessibility data, what is the average accessibility to a playground across the different Wellington suburbs?
- From the observed accessibility data, what is the variation in accessibility to a playground within a Wellington suburb?

Set up Bayesian model

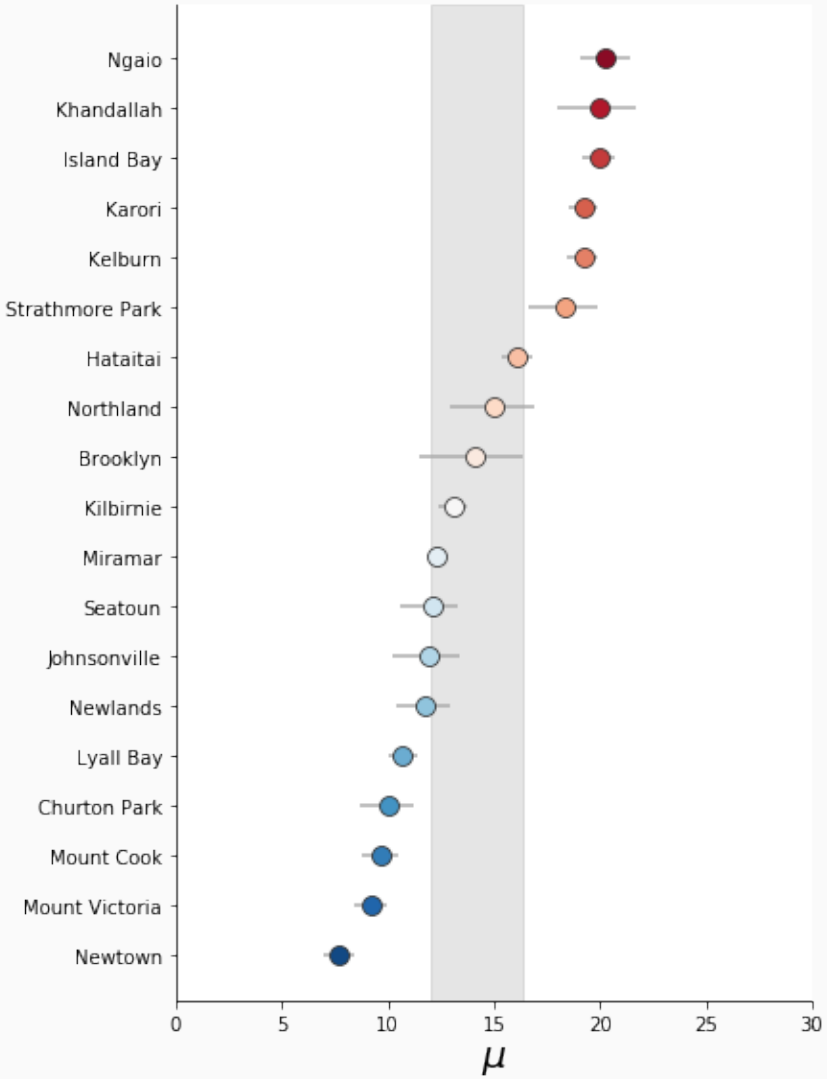


- Model individual suburb accessibility (A_s) as a lower value truncated normal distribution.
- Normal distribution: $A_s \sim N(\mu, \sigma)$
- Truncation condition: $A_s \in [0, \text{inf}]$

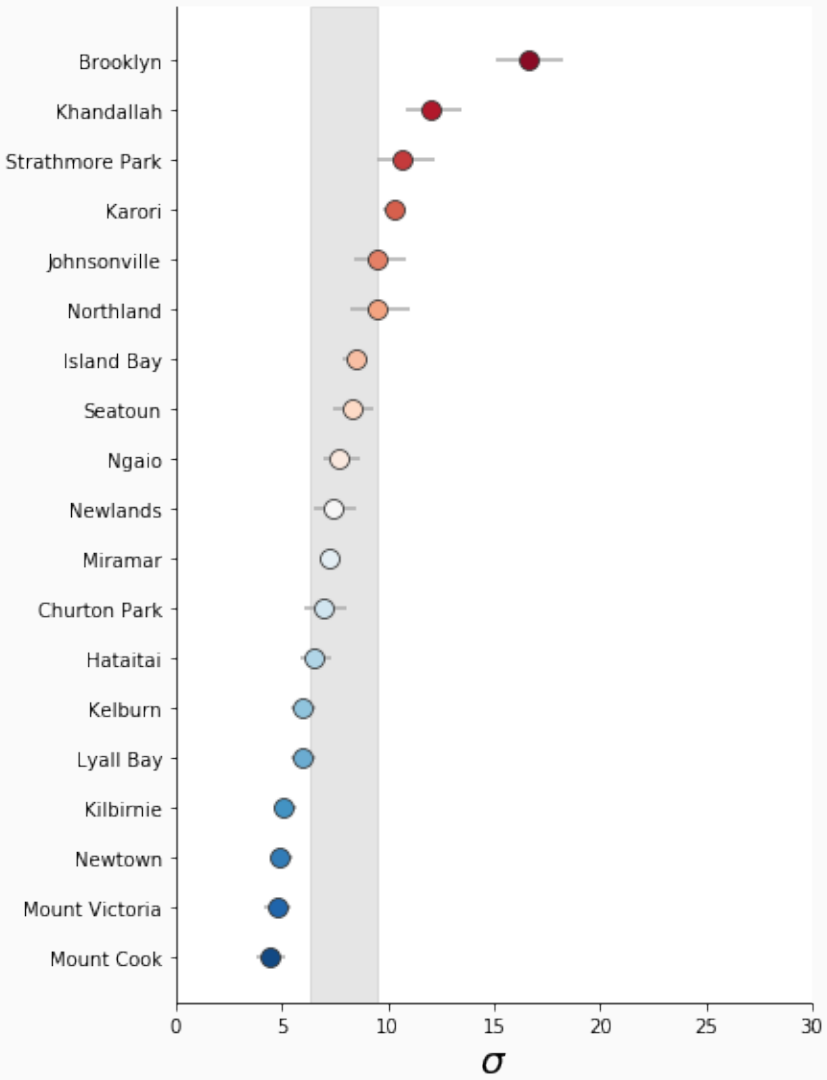


- Stan model output for μ (labelled as mu)
- Samples of μ drawn by Stan

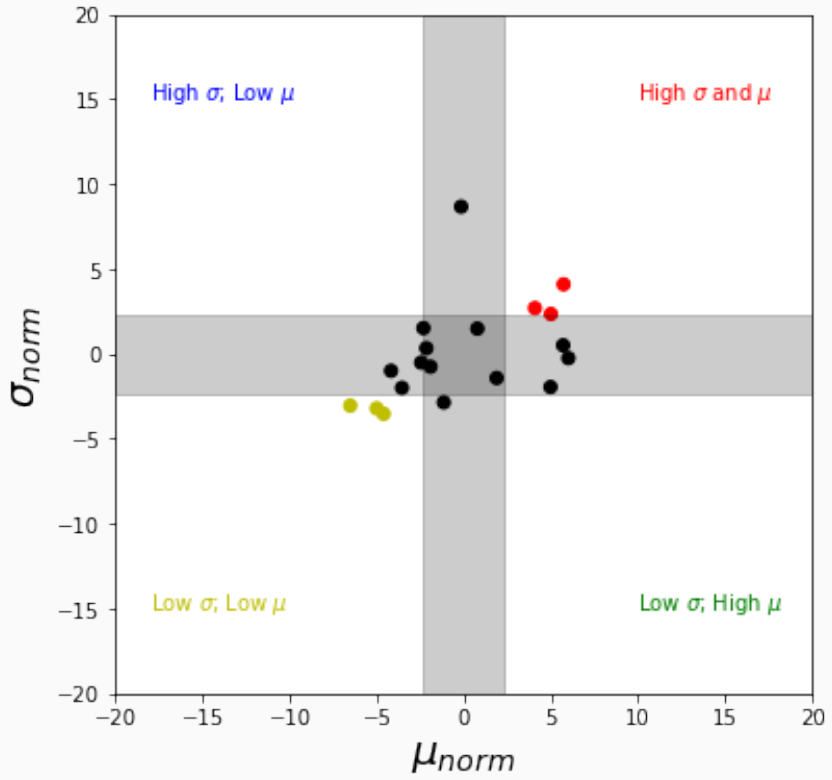
Modelling average playground accessibility by suburb



Modelling variability in playground accessibility by suburb

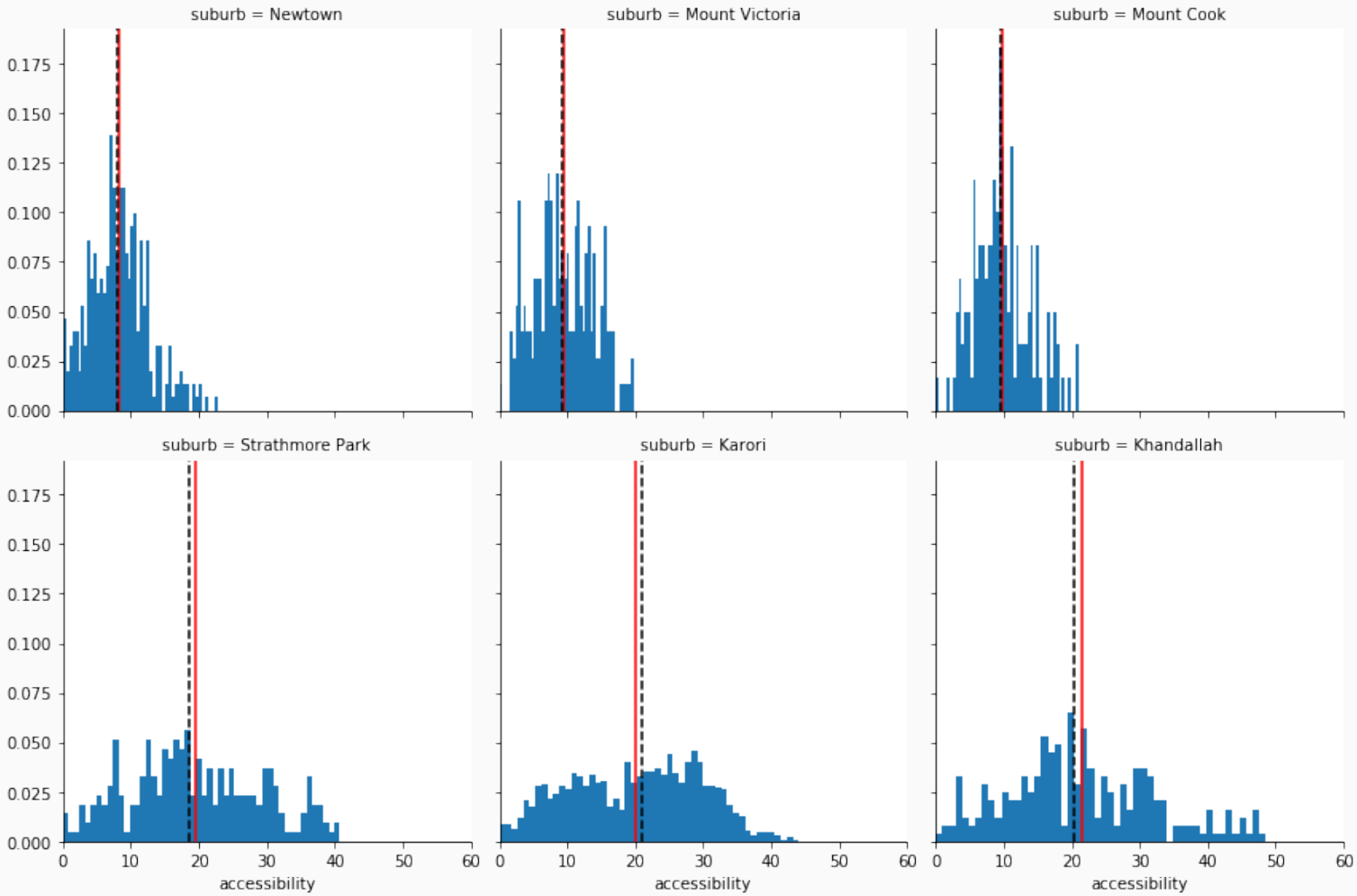


Making sense of model output



	suburb	labels	mu_norm	sigma_norm
5	Karori	High σ and μ	5.001377	2.351785
10	Strathmore Park	High σ and μ	4.082486	2.699599
17	Khandallah	High σ and μ	5.727995	4.097447
3	Mount Cook	Low σ and μ	-4.600104	-3.528490
6	Newtown	Low σ and μ	-6.516272	-3.044475
18	Mount Victoria	Low σ and μ	-4.999304	-3.206442

The best and worst of Wellington



Conclusions

What have we learned?

- Hills have a significant impact on total travel time.
- Wellington suburbs average 12-17 minutes in total travel time to nearest playground.
- But, there is a large variation *within* suburbs.

Lots more work to do!

- Impact of including school playgrounds in the analysis.
- Impact of adding a new council playground (e.g. Berhampore playground coming in ~2020).
- Areas within suburbs with poor accessibility. Are there any options nearby?
- Compare this analysis to WCC's recent Play Space Policy.

Resources

- Write up on https://shriv.github.io
- Code in https://github.com/shriv/accessibility-series/: to be updated

Image Credits

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