# Learning about *walkability* in Wellington with Python and open data

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# What can you expect?

# The slides contain

- An introduction to doing spatial data science
- A smattering of Python code
- Lots of graphs and figures
- Some insights about walkability in Wellington

# Motivation

# The global open data movement

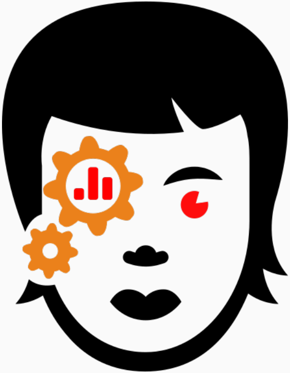
- Data sources
  - OpenStreetMap
  - Data.gov*: data.gov, data.govt.nz, data.gov.uk, data.gov.in
- Inspiring people generating tools / insights with open data
  - Kuan Butts
  - Geoff Boeing

# Limited analysis of NZ

I want to learn about the coolest little capital in the world

- How are we being served?
    - housing
    - public transport
    - amenities
    - infrastructure
- Can things be better?

# .. but I'm still just a Data Scientist



Audiens Cave

# 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.*

# Python package set up

# Main packages

```
# Geoprocessing
import osmnx as ox                       # Processing OSM as graphs
import networkx as nx                    # Graph structure processing
import pandana as pa                     # Efficient accessibility computing
import geopandas                         # Processing geodataframes
from shapely.geometry import \
Point, Polygon, LineString               # Core geometric objects
```

# Supporting packages

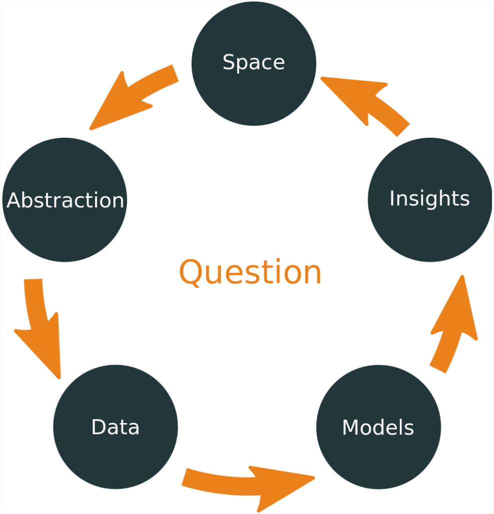
```
# Plotting
import matplotlib.pyplot as plt        # Classic Python plotting package
import seaborn as sns                  # Ggplot2-like plotting in Python
import folium                          # Interactive, web-ready maps
from descartes import PolygonPatch     # Geometric patches for matplotlib

# General utilities
import yaml                            # Reading stored API keys
import numpy as np                     # Processing arrays and matrices
import pandas as import pd             # Processing dataframes

# Bayesian analysis
import pystan                          # Running Bayesian models
```

# Spatial data science

# Overview



# Question

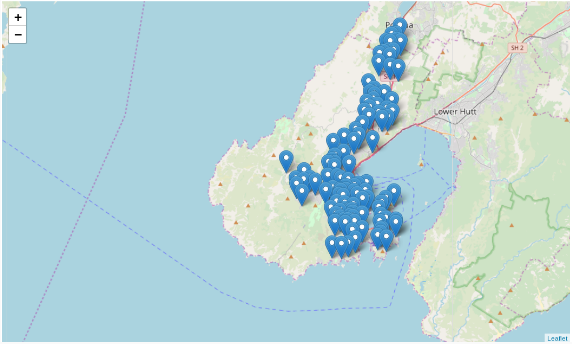
What is the impact of hills on walkability to playgrounds in Wellington?

# Space

# Wellington

# Abstraction: spatial primitives

# Points

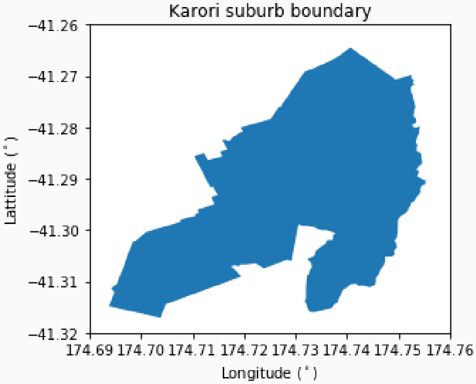



- Point coordinates of playgrounds
- *Overlaid* on map of Wellington

# Lines

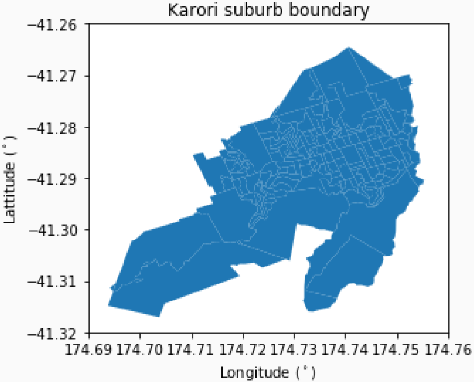
- Line segments that define a street or in this case, a route.

# Polygons




- Poylgon boundary of suburb

# Complex abstractions




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

# Abstraction: map to graph

# Creating a street graph

```
G_sub = ox.graph_from_point((wcc_playgrounds.ix[32]['lat'],
                             wcc_playgrounds.ix[32]['lon']),
                             distance=1500,
                             network_type='walk')
ox.plot_graph(G_sub, fig_height=8)
```

Map represented as street edges with intersections as nodes

# Data: spatial primitives

# Spatial entities in geodataframes

```
(wlg_meshblock_suburbs_ov
.query('suburb == "Karori"')[['suburb', 'postcode', 'MB2019_V1_00', 'geometry']]
.head())
```

| | 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

```
nodes_gdfs, edges_gdfs = ox.graph_to_gdfs(G_sub)
nodes_gdfs.head()
```

| | 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

```
edges_gdfs[['name', 'grade', 'osmid', 'maxspeed']].head()
```

| | | 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

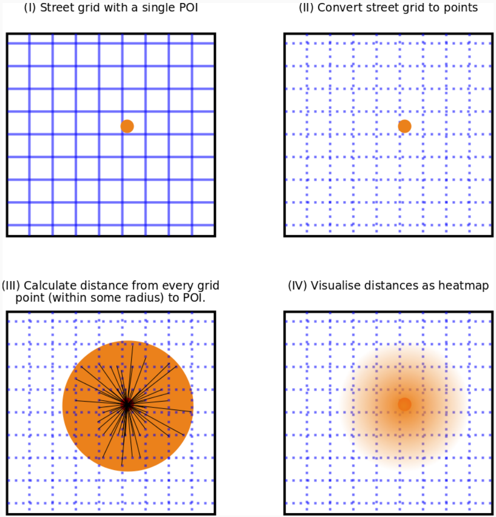
# Model 1

# 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

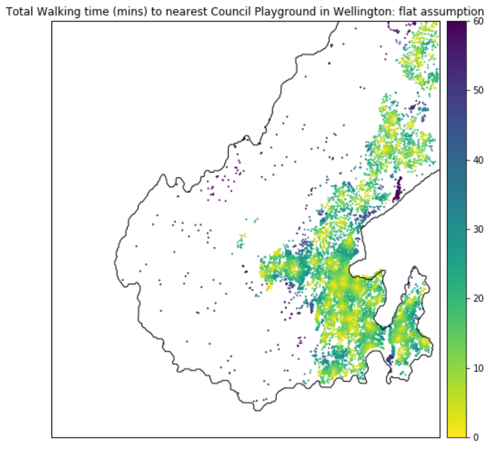
# How to calculate accessibility



# 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

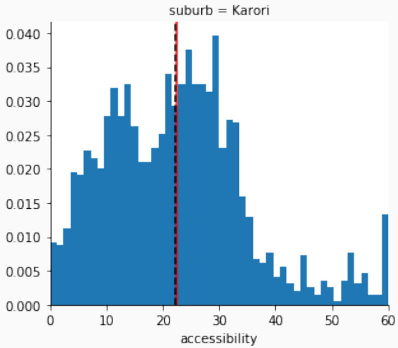


# Model 2

## Bayesian modelling

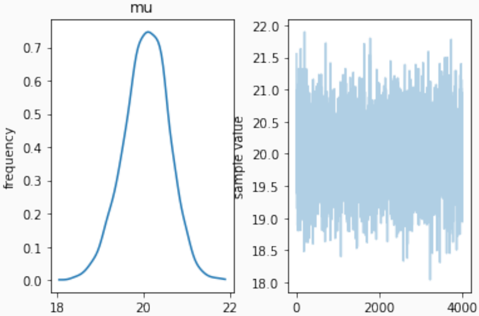
*From the observed accessibility data, what is the average accessibility to a playground across the different Wellington suburbs?*

# 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: $A_s \in [0, \inf]$

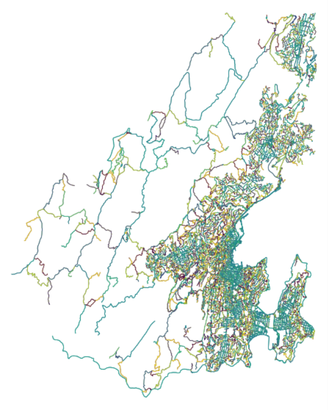
# Efficient Bayesian modelling with Stan



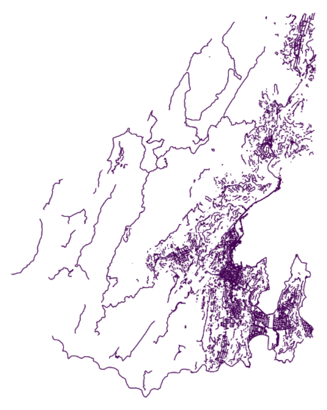

- Stan model output for $\mu$ (labelled as mu)
- Samples of $\mu$ drawn by Stan

# Insights (mostly visual)

# Street graph with gradients

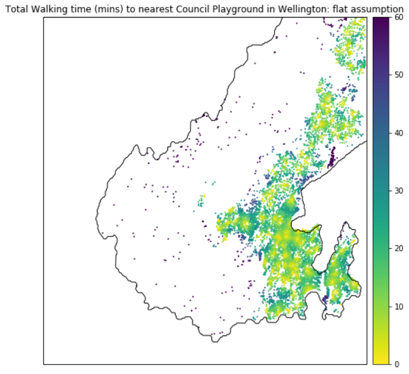


- All edges (green ~ flat gradient)

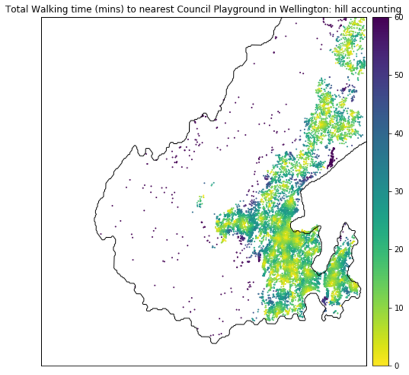


- Edges within 5% absolute gradient

# Hills vs. flat land

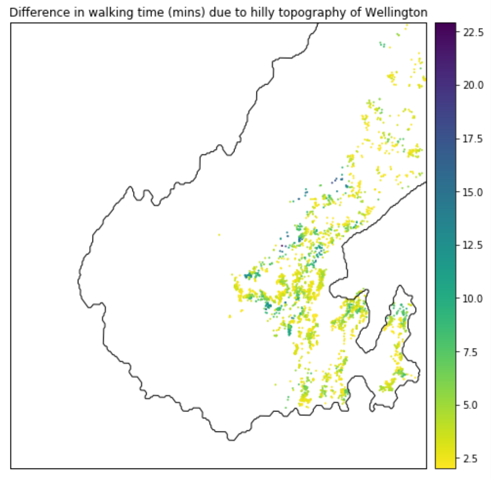



- Assuming single speed

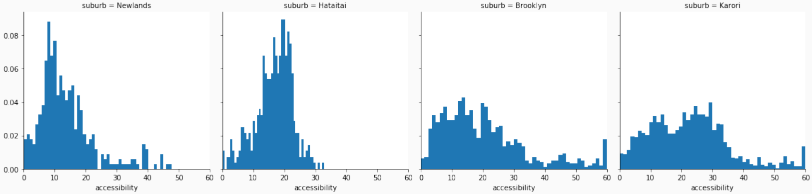



- Accounting for speed variability due to hills

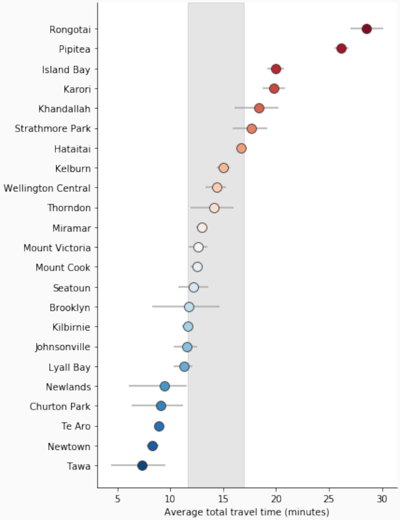
# Impact of hills on playground accessibility



# Accessibility by suburb



# Modelling playground accessibility by suburb



## What have we learned?

- Hills have an impact on total travel time. Differences in total travel time can be up to 20 minutes.
- 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!

- Making graphs better
- Removing the 60 minute spikes from the Bayesian modelling
- Exploring the heterogeneity in accessibility *within* suburbs
- Impact of including school playgrounds in the analysis
- Impact of adding a new council playground (e.g. Berhampore playground coming in ~2020)

## Resources

- Write up on https://shriv.github.io
- Code in https://github.com/shriv

# Image Credits

- Created by Thibault Geffroy for NounProject
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