Explaining Bike Share use worldwide by Environmental and Sociodemographic Factors

Richard Bean

University of Queensland/Catalyst Calculations

21 September 2023

Amsterdam, the 1960s

The Provo movement

Jasper Grootveld (1932-2009) interviewed by Michael Apted of 7-Up fame in 1966.
In the winter of 1944-45, all bikes were stolen by Germans. Cars - terrible traffic jams, noise, poisonous pollution, injuries and nervousness/stress from crashes. Solution: electric taxis and white bicycles. One of the benefits: silence.

First generation bike sharing

- Wittefietsenplan, Amsterdam, 1965

Second generation bike sharing

- Coin based manual systems, Denmark, 1990s

Third generation bike sharing

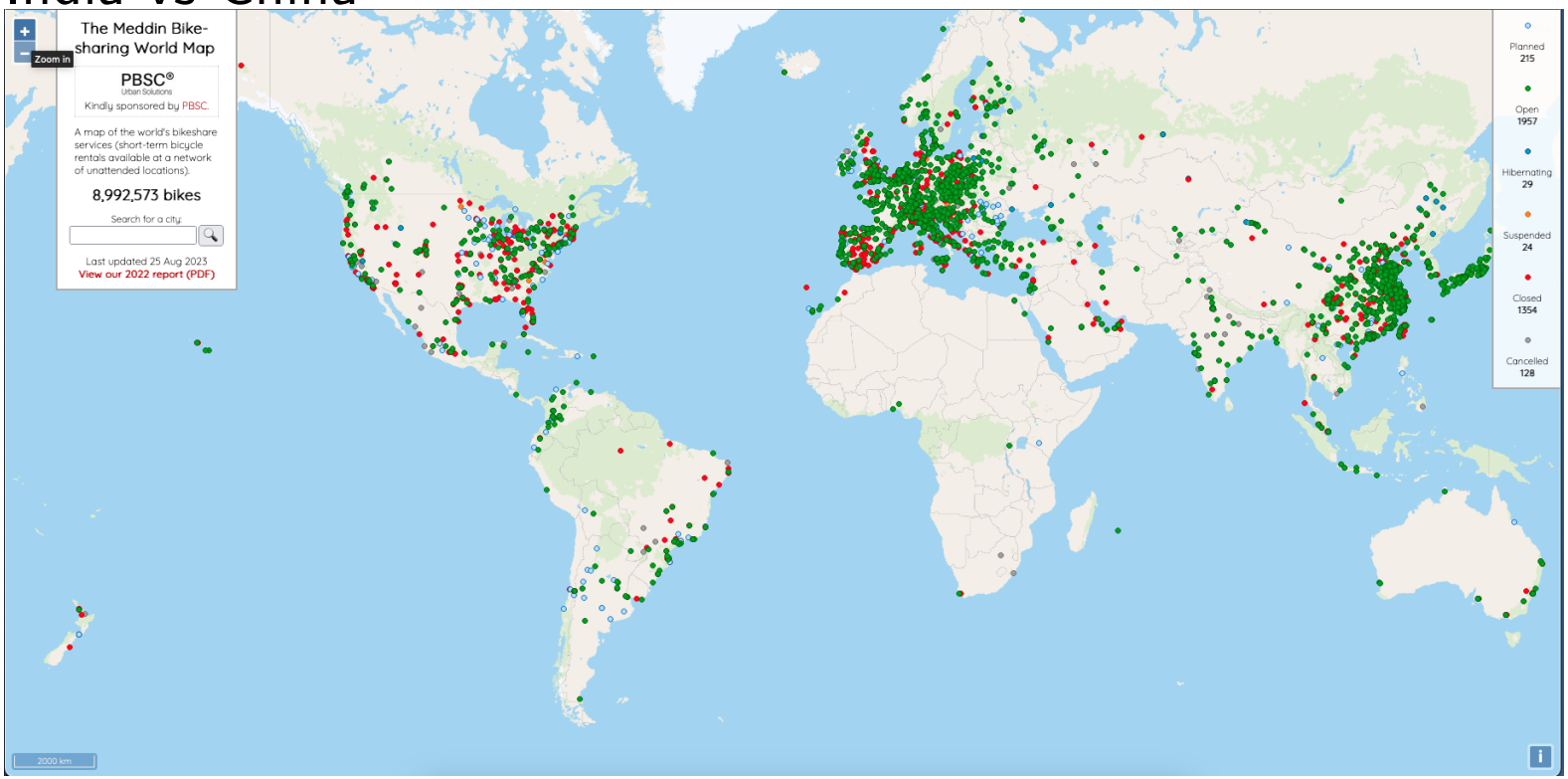
- Dock based systems, 2000s
- Portsmouth *Bikeabout* (1995), Rennes *Vélo à la carte* (1998), Lyon *Vélo'v* (2005)
- Alpha+ cities - Paris *Vélib'* (July 2007)
- Alpha++ cities - London (July 2010), NYC (May 2013)
- Potential for data collection

Fourth generation bike sharing

- Dockless
- Hybrid - electric and classic
- GPS tracking
- Micromobility

Bike sharing goes global

- 9,000,000 bikes worldwide in 1,950 active schemes
- North: Fairbanks, Alaska (64.84 N), Murmansk (68.97 N), Skrova (68.17 N), Oulu (65.01 N), Trondheim (63.43 N)
- South: Rio Gallegos, Argentina (51.62 S), Christchurch (43.53 S)
- India vs China



Australian Schemes

- Large scale systems in Brisbane (150 stations), Melbourne CBD (50 stations)
- Brisbane Oct 2010 to Aug 2021 - replaced by dockless e-bikes (Neuron, Beam, Lime to 2021)
- Melbourne May 2010 to Nov 2019 (Ofo, O Bike, Reddy Go to 2018, now Uber, Lime, Beam)

My First CityCycle Subscription 2011

CityCycle Tax Invoice

Brisbane, December 5th, 2011

Your CityCycle subscription details :

Subscription:	Annual Subscription
Subscription fee :	AUD $ 60.50
Total:	AUD $ 60.50 (Including GST 10 %: AUD $ 5.50)
Subscriber number:	10648
Pin code:	
Full Name:	Mr. Richard Bean
Date of birth:	
Address :	Toowong 4066
Email :	
Phone number one :	
Phone number two :	
Card number :	XXXXXXXX-98376
Expiry date :	04-2014

JCDecaux CityCycle Australia Pty Ltd, 95 Robertson street, Fortitude Valley QLD 4006. ABN: 38 134 928 500

Data Collection

- Began collecting data in April 2012 after CityCycle scheme completion
- Inspired by blog posts of
  - Oliver Nash (mathematician/quant, Ireland)
  - Oliver O'Brien (developer, UK)

Oliver Nash - October 2009

INTERNET ARCHIVE WayBackMachine https://ocfnash.wordpress.com/2009/11/08/dublin-bikes-alternate-data/

20 captures
5 Dec 2009 – 7 Jan 2015

Oliver Nash's Blog

Math, IT, non-sense.

Dublin Bikes Alternate Data

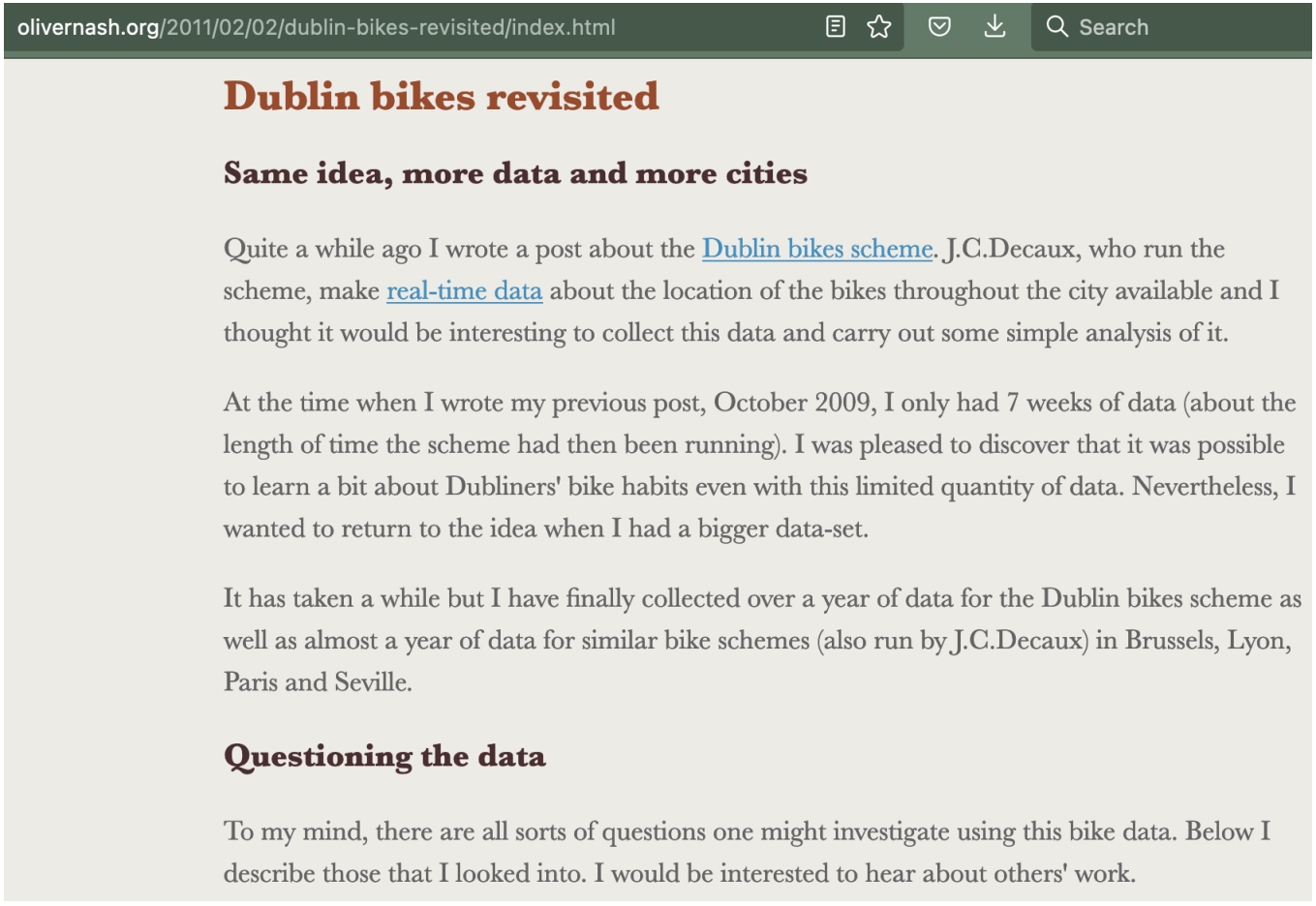
A fairly esoteric post

As I consider this post, it seems to me that the set of people who might be interested in it is even smaller than usual for my posts. Nevertheless I hope that the information I give below might be useful to some people and I have reason to believe that at least one person will be interested so I thought I'd share the results of some of my recent investigations.

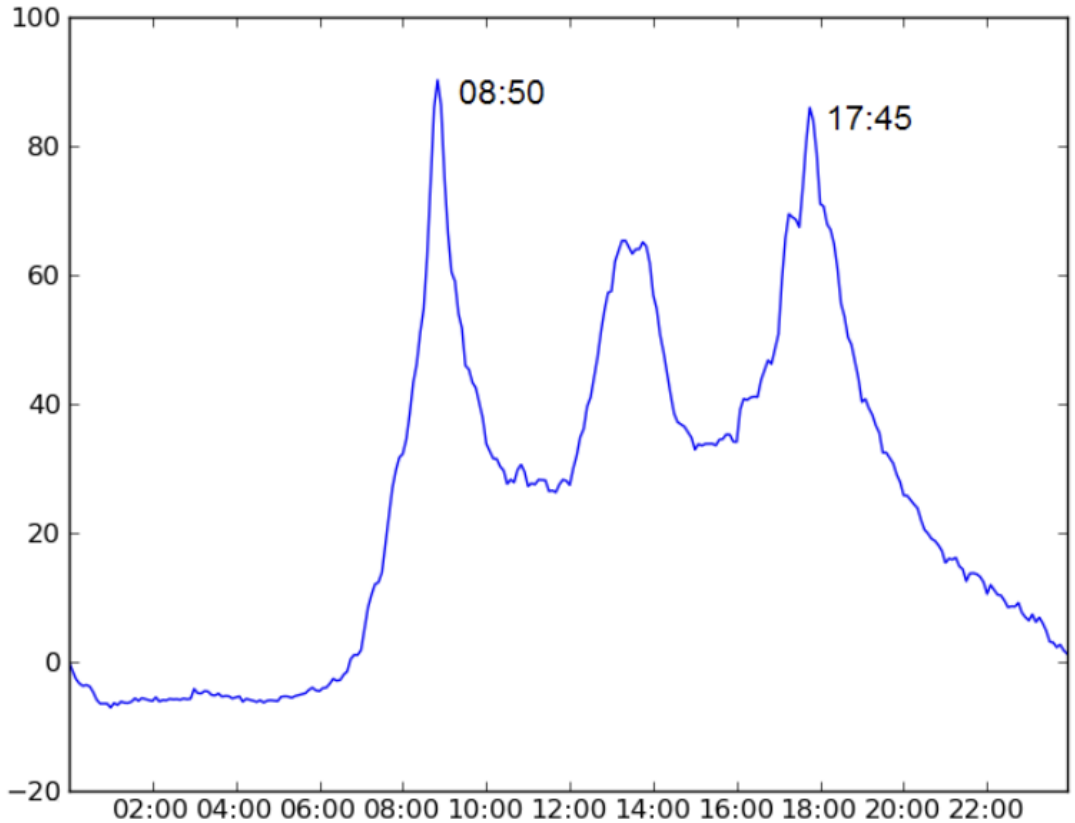
Various sources of Dublin Bike data

I have already written a **post** on the Dublin Bikes scheme. As I explained there, the data I am currently gathering is obtained by querying URLs of the form **http://www.dublinbikes.ie/service/stationdetails/1**. These are the same URLs which are used to update the **map** on the **Dublin Bikes website** as well as the map in **Fusio**'s iPhone app. I established the first of these facts by using **Wireshark** to sniff all the packets travelling through my PC's wifi connection while browsing the Dublin Bikes website. To find out what Fusio's app. is doing, I sniffed the packets of my iPhone's wifi connection while running the app. Unfortunately I could not use Wireshark to do this because the router which I had my iPhone and PC connected to acts as an ethernet switch (as

Oliver Nash - February 2011

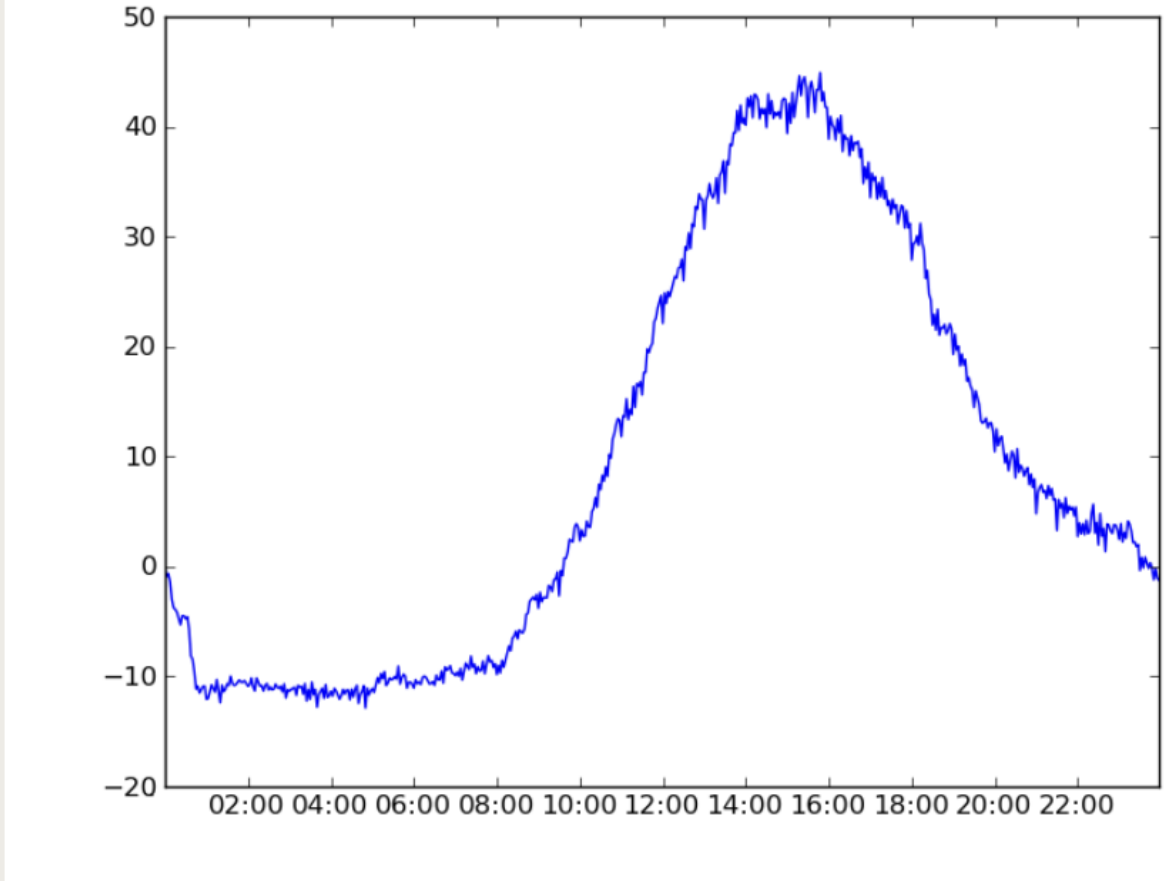


Oliver Nash - trimodal weekdays



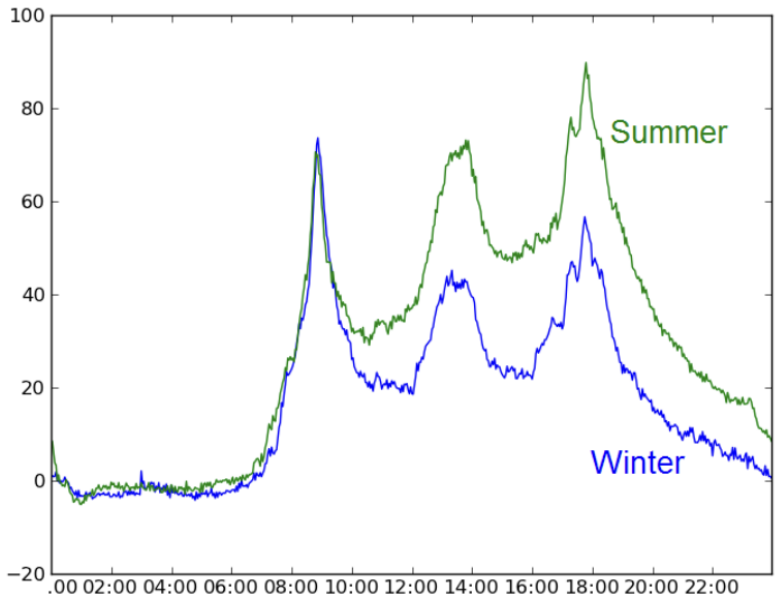
Dublin bike usage by time of day (weekdays)

Oliver Nash - unimodal weekends



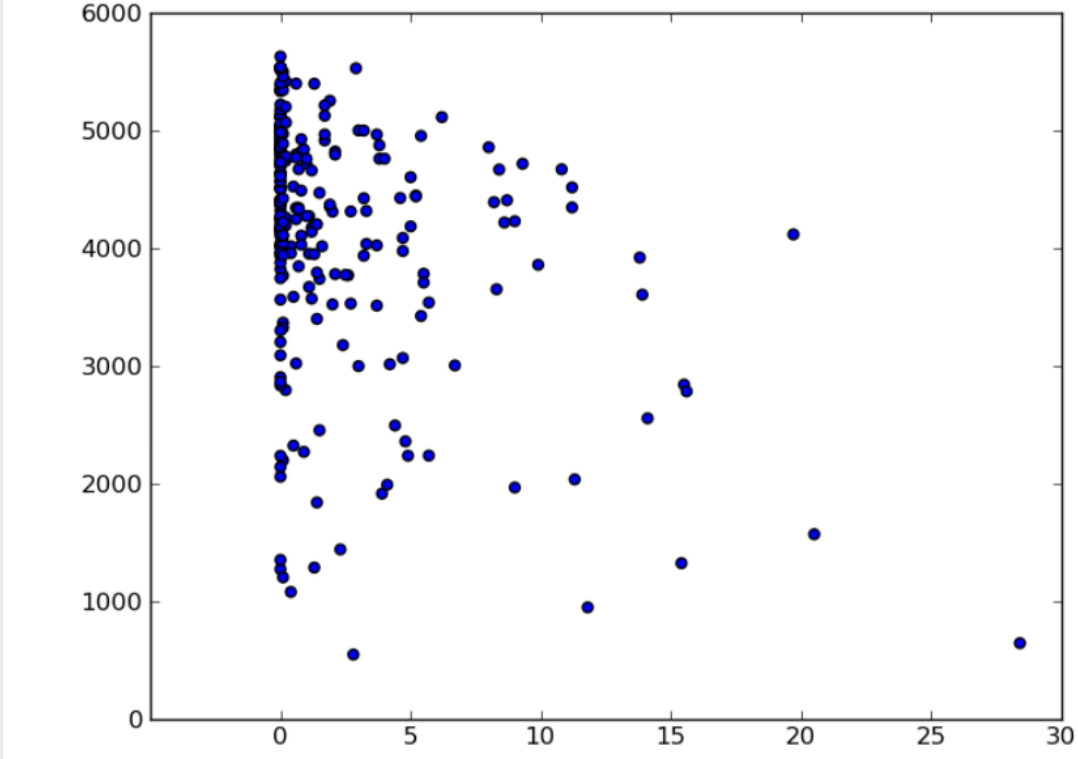
Dublin bike usage by time of day (weekends)

Oliver Nash - Summer/winter



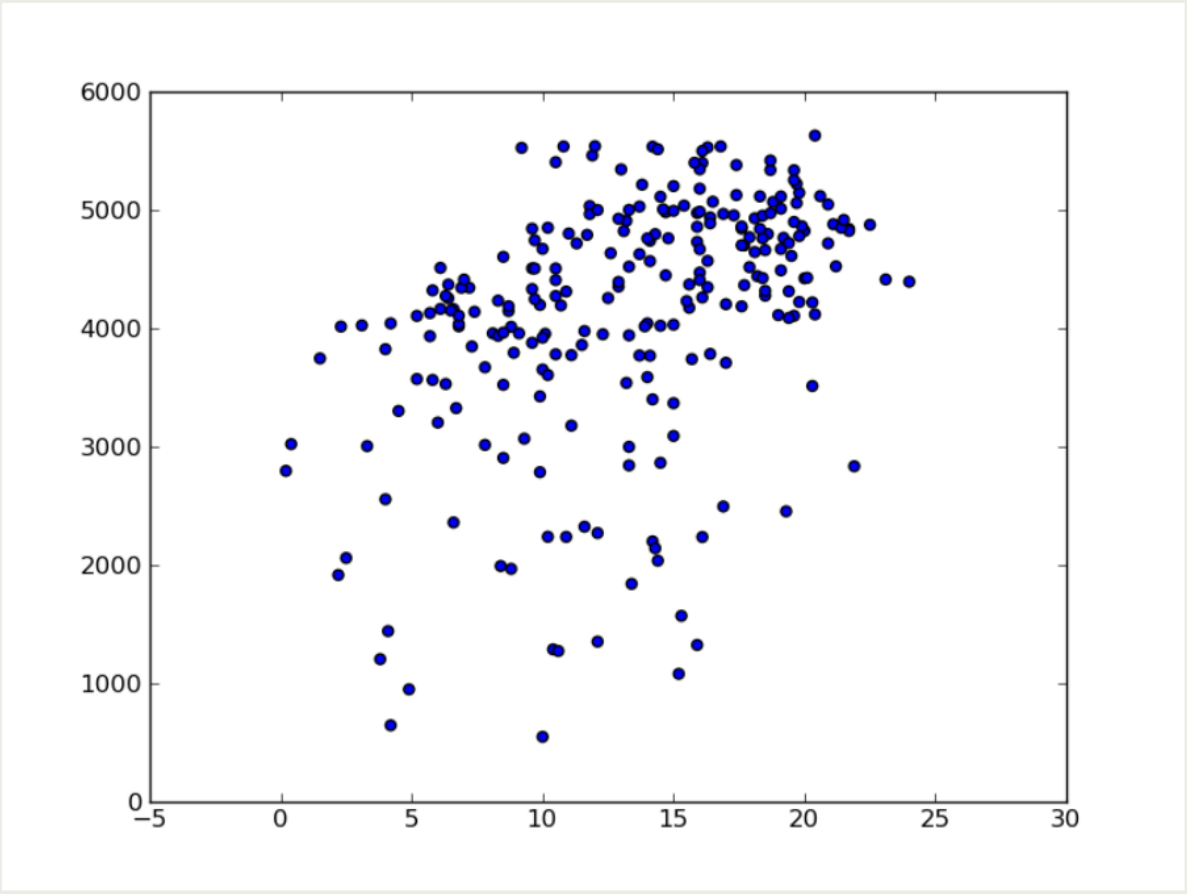
Dublin bike usage by time of day (weekdays): Winter vs. Summer

Oliver Nash - Daily rainfall



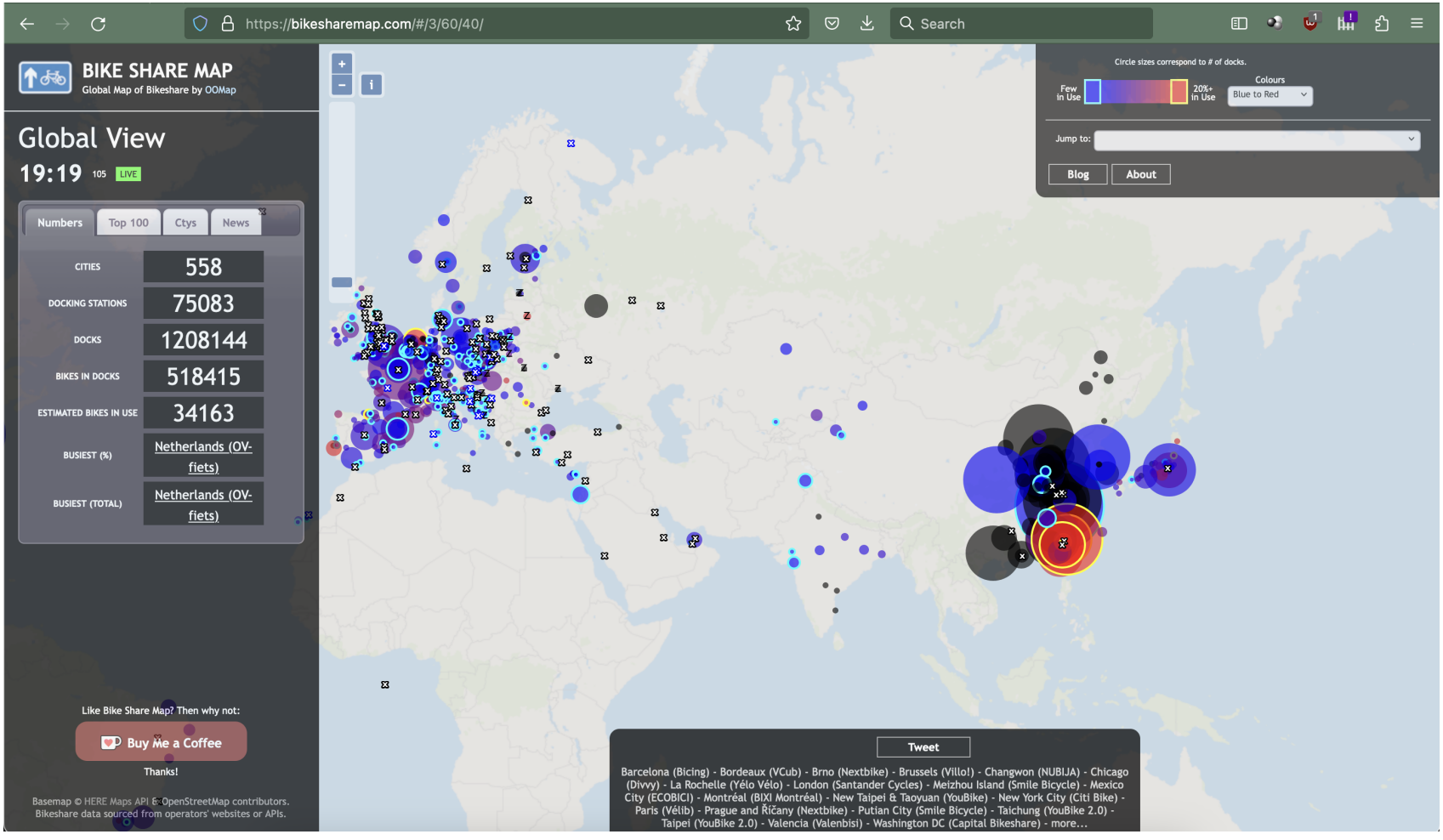
Busyness vs. rainfall (mm) (no apparent relationship)

Oliver Nash - Summer/winter



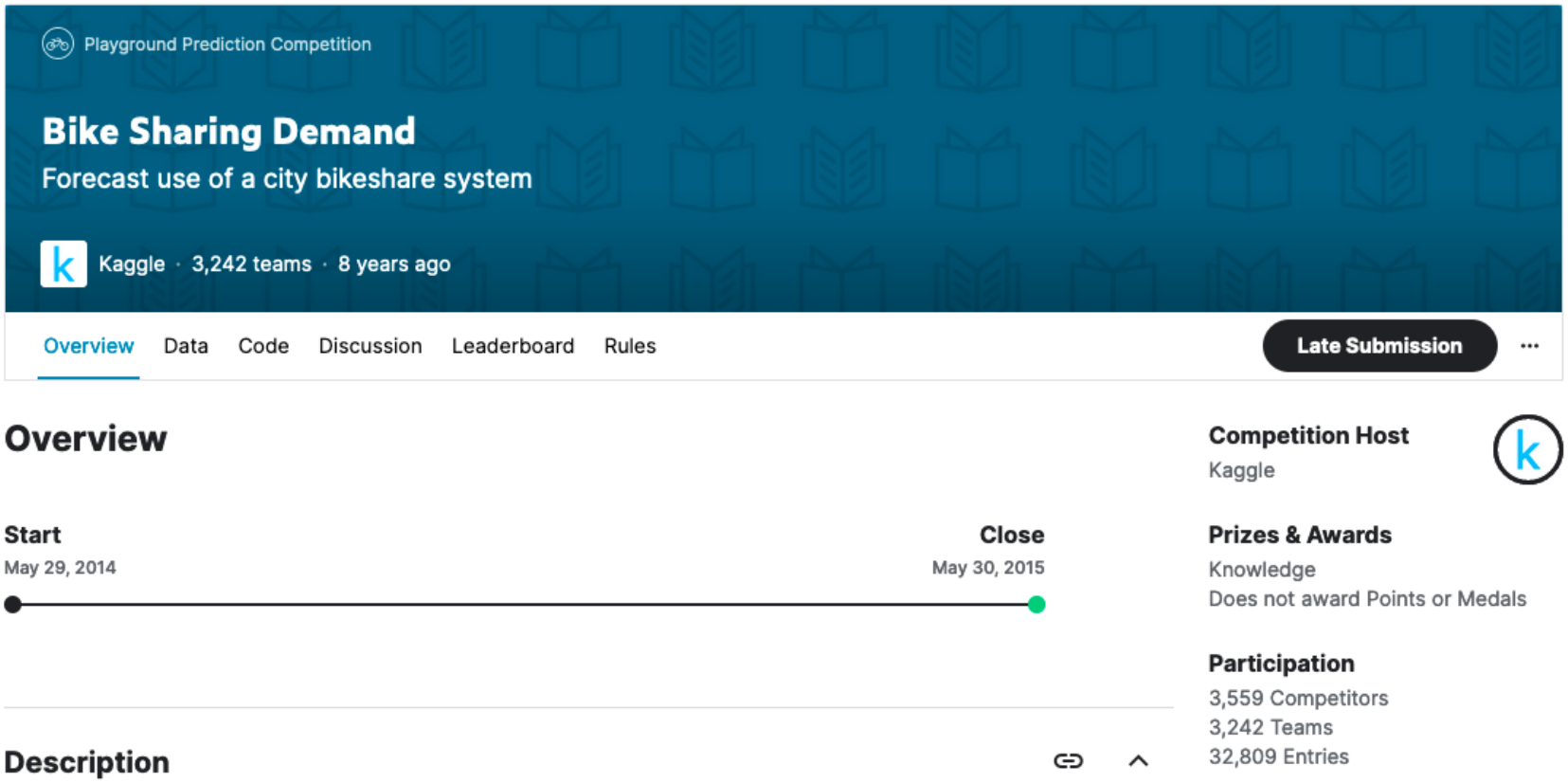
Busyness vs. max temp. (plausible positive relationship)

Oliver O'Brien



Kaggle Competition

Algorithms for rebalancing or forecasting demand



Data Collection

- Expansion to dozens of other schemes - JCDecaux
- Publishing of high-resolution datasets - weather, topography (DEM), bike paths, land use over the period 2012-2023

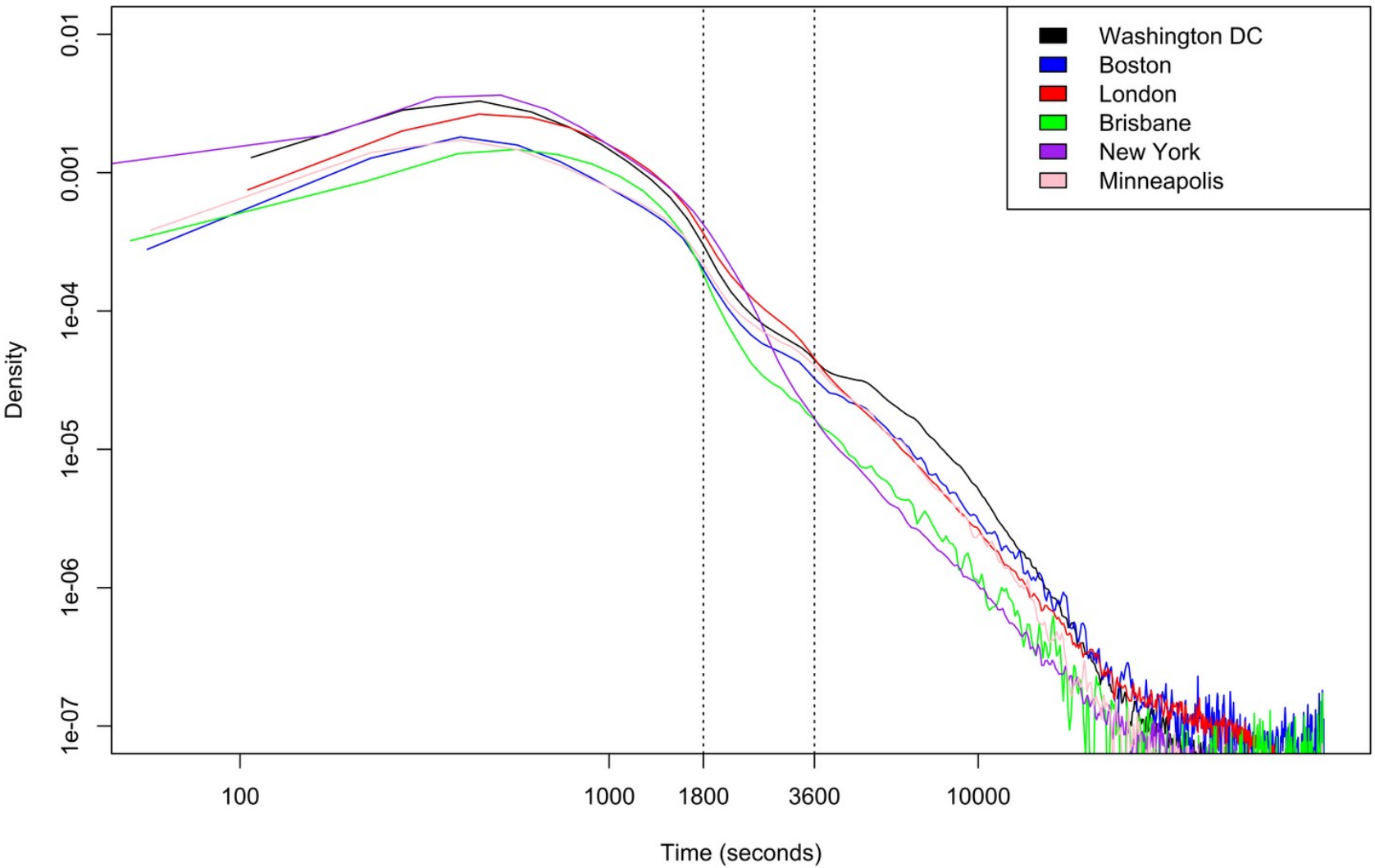
Three papers - factors Affecting Bike Share Use

- Temporal variables - time of day, day of week, day of year
- Natural and built environment - bikeways, land usage data
- Weather, gender, and age of users
- Gradient and type of bikes (electric vs. classic)
- Weight of bikes
- Commercial / non-profit system
- Helmet laws

Initial CityCycle analysis

- Obtain “trip” data rather than “flow” data where possible
- Fixes “rebalancing” issues which aren’t actually trips, maintenance

Compare trip times to other schemes



What happens without progressive pricing? 2013

What happens without progressive pricing? 2016

Brisbane Bikeway Types


(a) Bicycle Awareness Zone


(b) Bicycle Path


(c) Bicycle Route


(d) Bicycle Lane


(e) Connect


(f) Informal Off Road


(g) Informal On Road


(h) Separated Pathway


(i) Shared Pathway

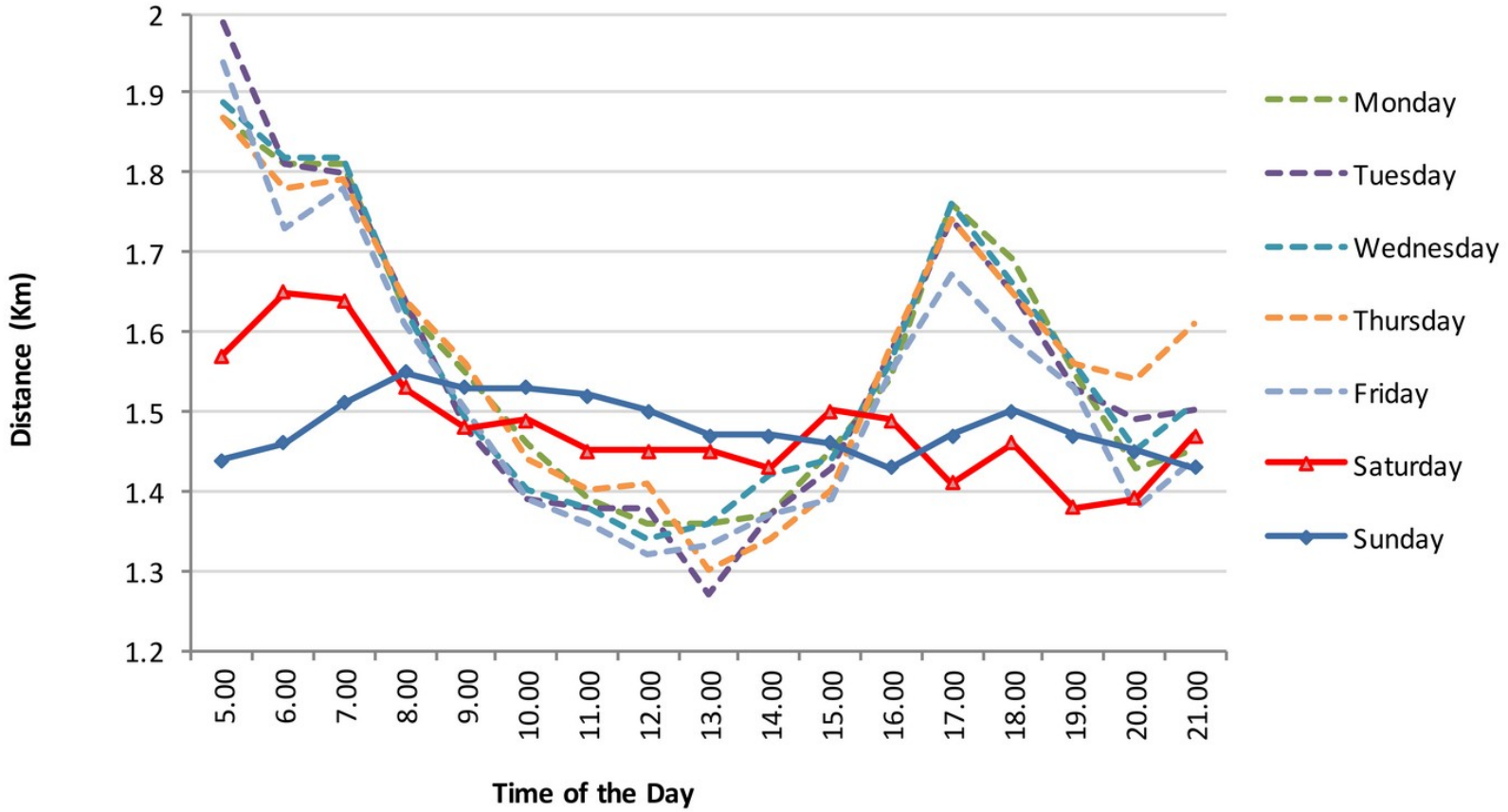
Brisbane Bikeway Types

Table 1
Length of bikeway by bikeway type in Brisbane and CityCycle areas. Spearman correlation of station usage and infrastructure type.

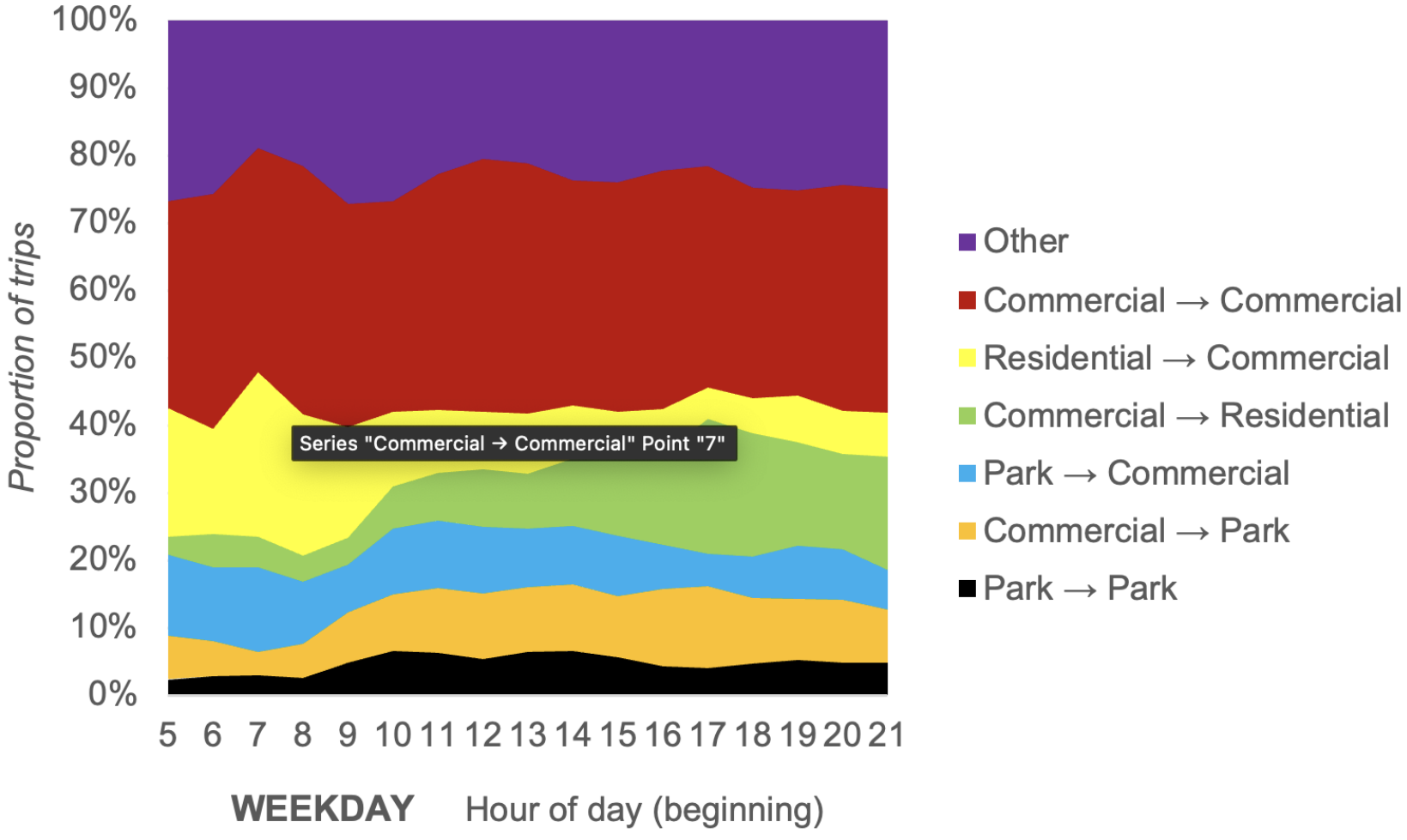
Infrastructure type	*Length Brisbane area (km)*	*Length in CityCycle area (km)*	*Correlation Coefficient*[1]	*P-value for correlation coefficient*
Shared Pathway	327.9	18.0	0.42	<0.01*
Bicycle Lane	186.7	21.3	0.03	0.69
Bicycle Awareness Zone (BAZ)	303.7	40.3	-0.07	0.39
Bicycle Path	23.9	2.6	0.27	<0.01*
Bicycle Route	76.9	8.2	0.13	0.11
Connect	19.5	5.0	0.16	0.049*
Informal Off Road	65.8	4.6	0.00	0.98
Informal On Road	18.2	4.1	-0.13	0.12
Separated Pathway	1.8	1.3	0.29	<0.01*

[a] Correlation coefficient with usage considering infrastructure of this kind within 400 m of each station.
∗ Statistically significant value ($p < 0.05$).

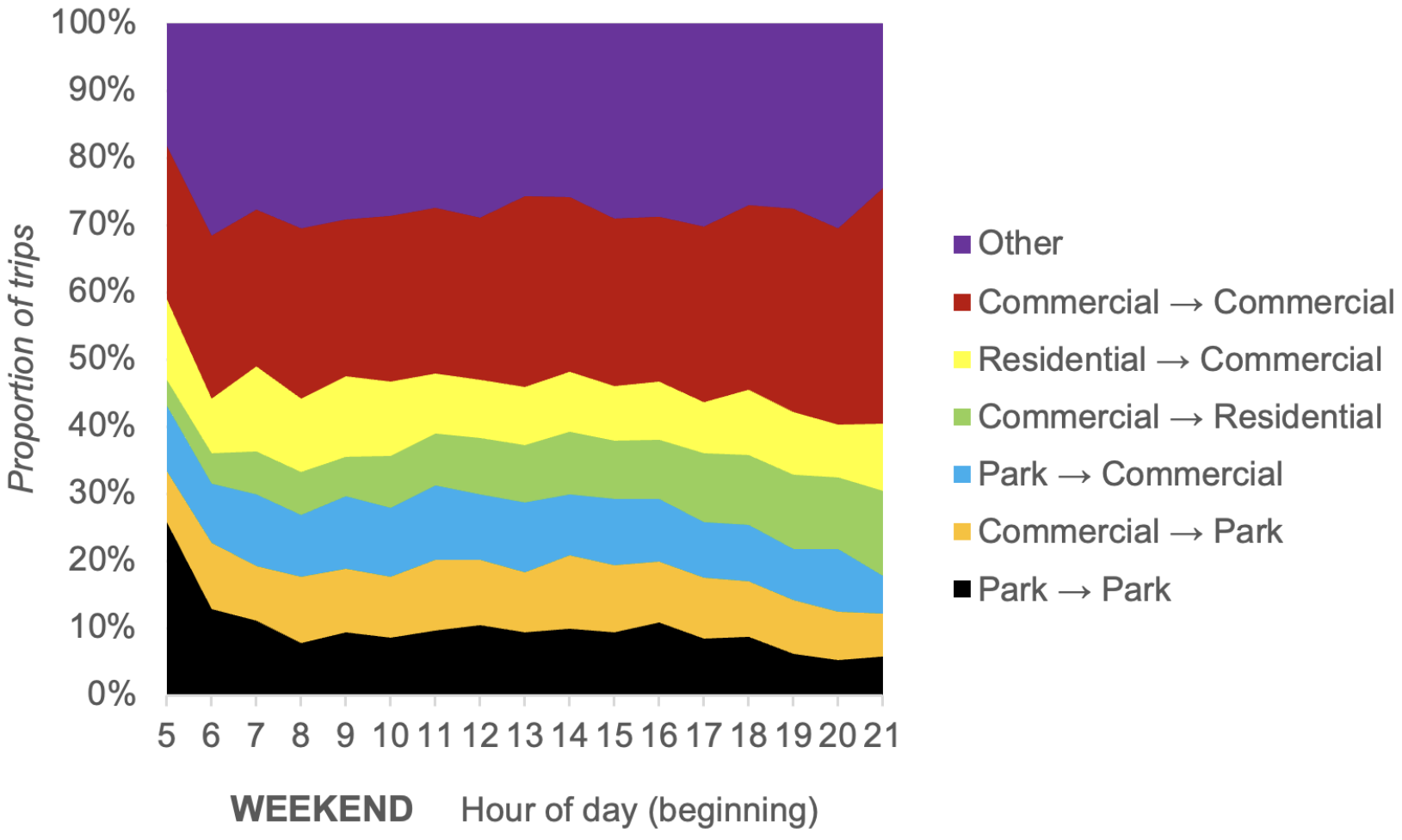
Trip data - speed by time of day by day of week



Weekday land use



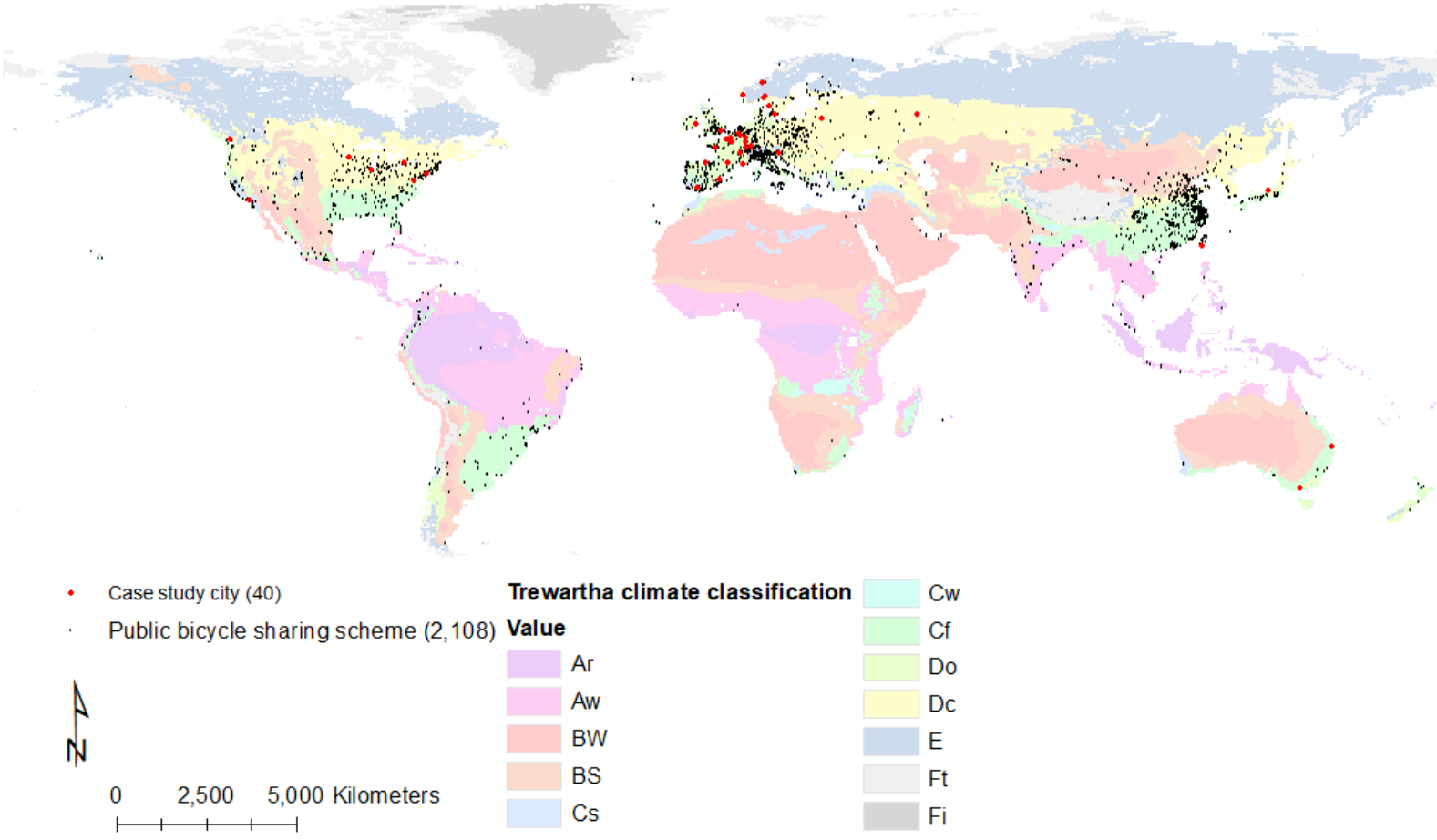
Weekend land use



Second paper - impact of weather on Bikeshare Use

- Weather's effect across different climate zones.
- Interpretable models and visualizable models - Generalized Additive Model vs Random Forest
- GAM - *the linear response variable depends linearly on unknown smooth functions of some predictor variables*
- Differences in male and female ridership

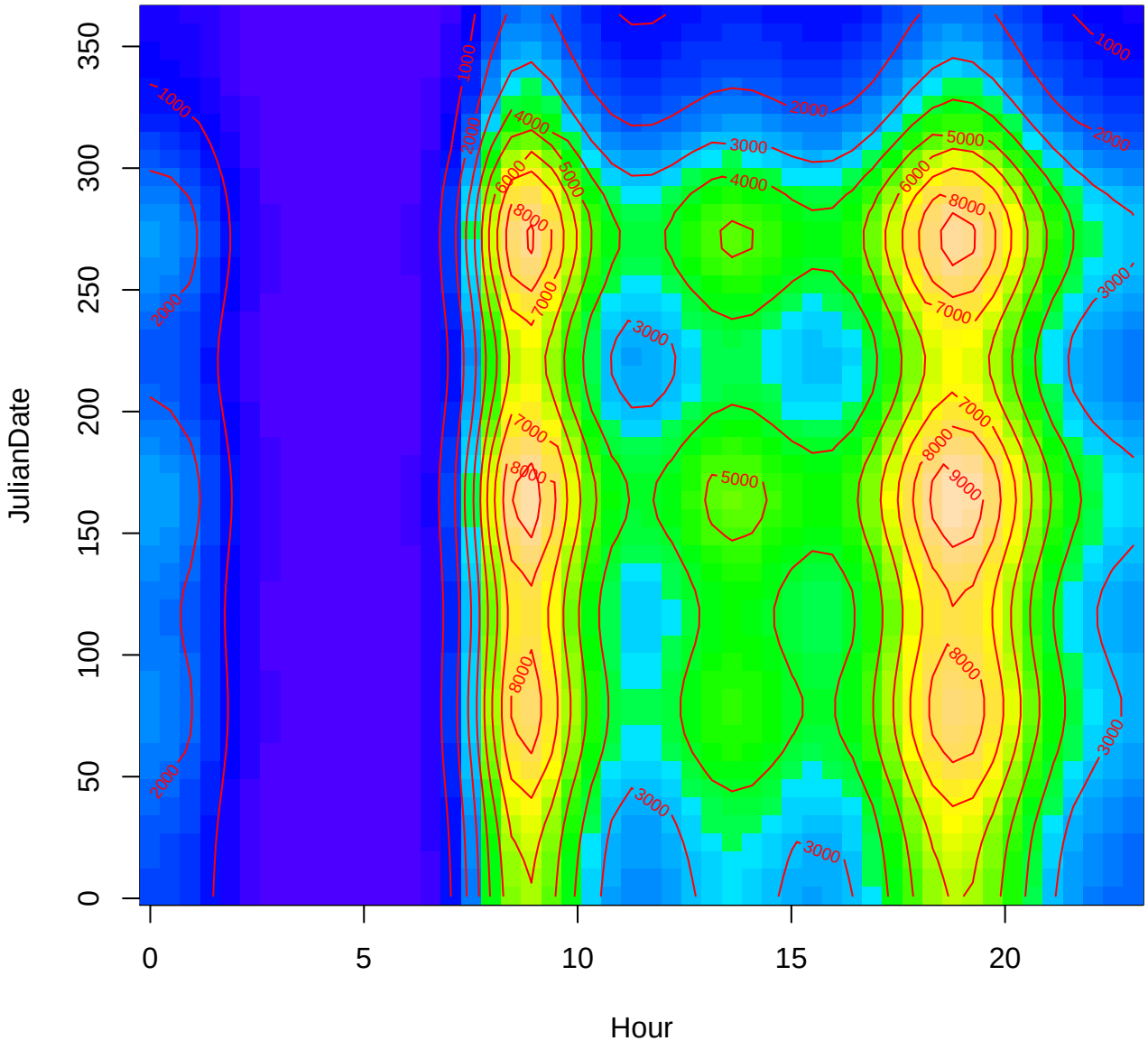
Map of schemes examined



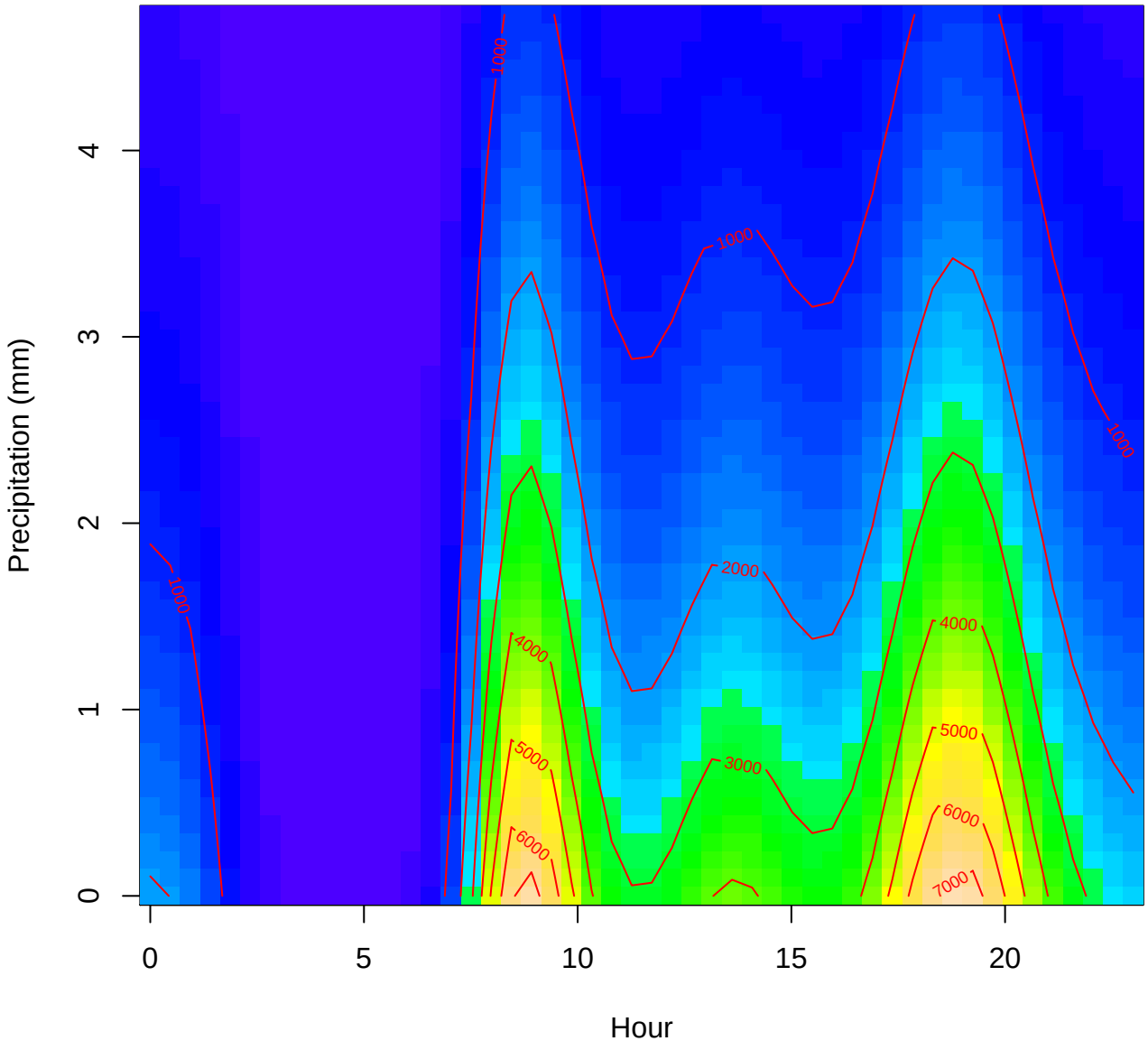
Weather data

- Copernicus Climate Data Store (CDS)
- European Centre for Medium-range Weather Forecasting (ECMWF)
- ERA5-HEAT (UTCI) and ERA5 data
- UTCI Universal Thermal Comfort Index
- Hourly resolution from 1940 to date, 0.25 degrees resolution worldwide
- Cities chosen by climate zone - 40 cities, 100,000,000 trips, five “climate zones”

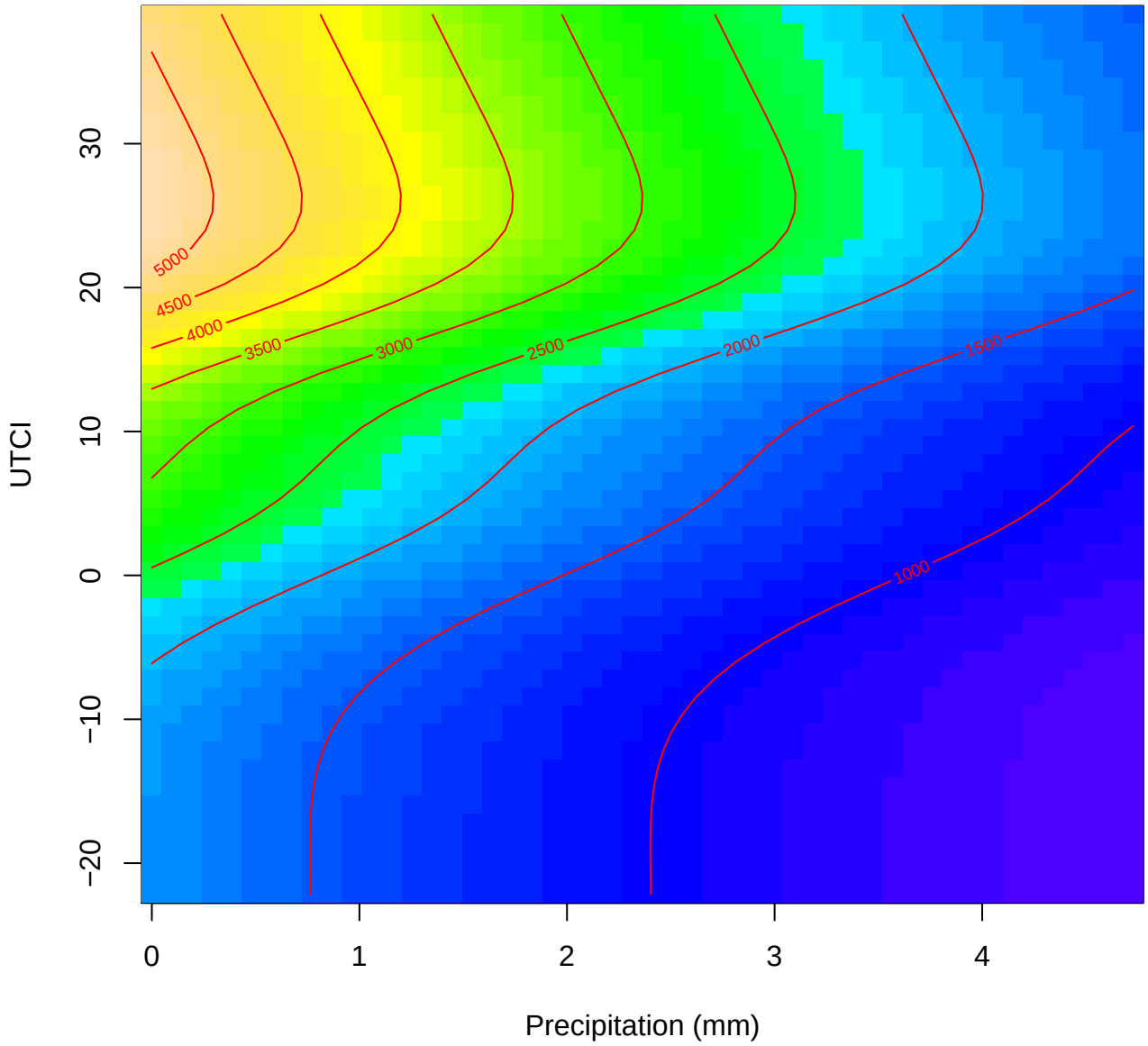
Paris usage vs hour and date - weekday GAM



Paris usage vs hour and rain - weekday GAM



Paris usage vs rain and temperature - weekday GAM



Some findings

- The most significant variable is time of day, followed by precipitation
- A UTCI value of around 27-28 degrees is optimal for cycling
- Hourly usage follows a bimodal or trimodal pattern on weekdays
- Weekend usage peaks at around 2-3pm except in hotter cities (around 5pm)
- Precipitation decreases female usage more than male usage

Climate change

A step-change in the temperature of 1 or 2 degrees (all else equal) would tend to increase usage; exceptions in some hot cities such as Seville

Third paper - gender Gap in Urban Cycling

- Barriers faced by women in cycling
  - Safety concerns - darkness/daylight hours
  - Precipitation
  - Steeper gradients
- Recommendations to overcome these barriers

Third paper - data

- JAXA - Japan Aerospace Exploration Agency - 30m LiDAR data worldwide
- NYC 30 cm DEM data; Brisbane 1 m DEM data
- Data from 10 cities over 14 years (Feb 2010 - Jan 2023) with 229,000,000 bicycle trips
- USA: Columbus, SF, Chicago, Boston, NYC, Minneapolis
- Non-US: Guadalajara, Mexico City, Brisbane, Helsinki
- Gender and age data
- GAM to separate out partial effects of gender

Third paper - cities

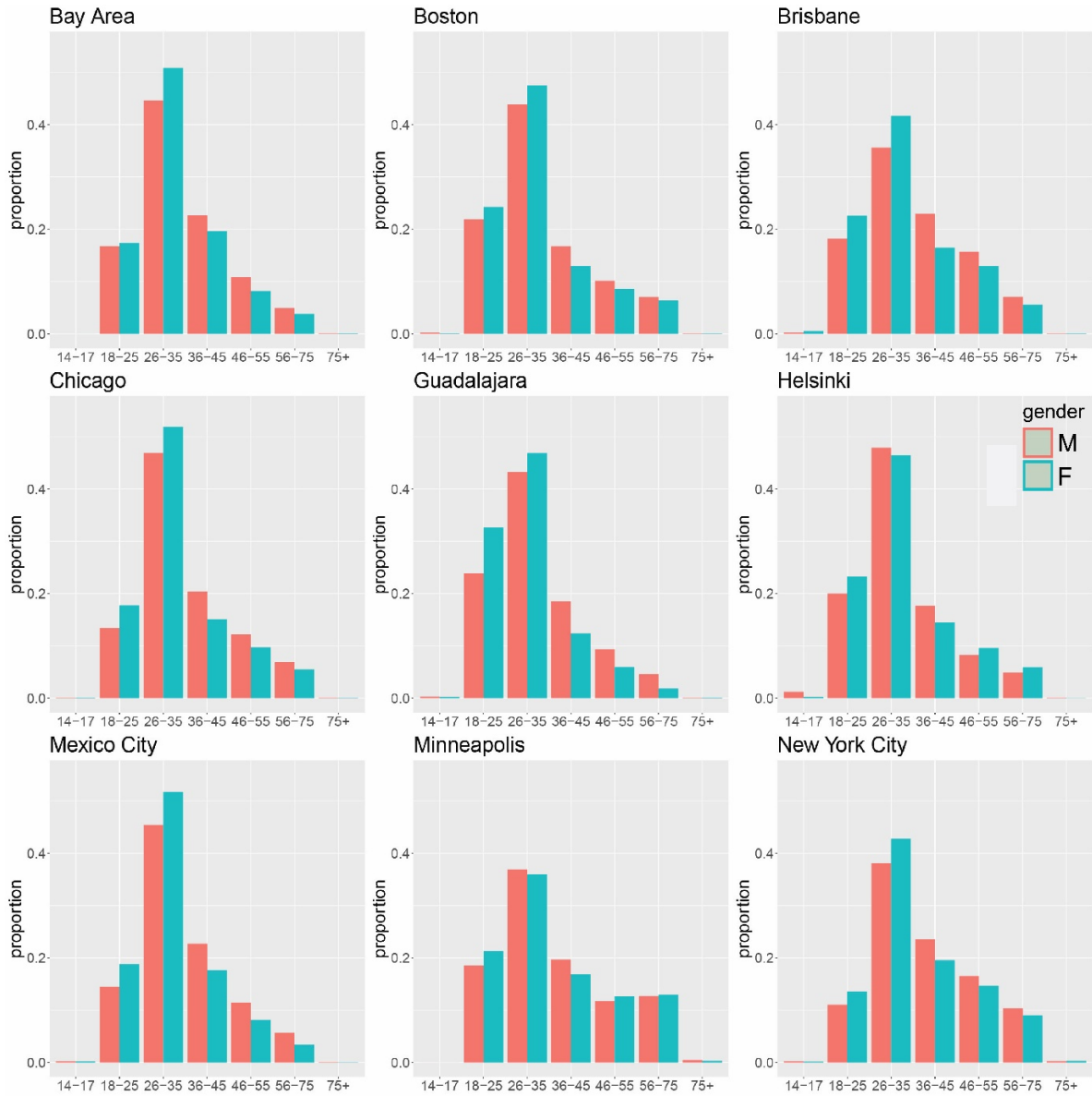
Table 2. List of cities studied, sorted by share of female users.

City Name	*Start Month*	*End Month*	*Total male trips*	*Total female trips*	*Female trips %*	*Link to data***
Columbus	Mar 2018	Mar 2020	30,131	5,524	15.5	CoGo
San Francisco Bay Area*	Jun 2017	Apr 2019	1,902,810	637,069	25.1	Bay Wheels
Chicago	Jun 2013	Dec 2019	12,235,830	4,112,553	25.2	Divvy
Boston	Jul 2011	Apr 2020	6,843,613	2,334,078	25.4	Bluebikes
Guadalajara	Dec 2014	Jan 2023	16,232,629	5,658,999	25.9	Mibici
New York City	Jun 2013	Jan 2021	74,574,098	26,339,265	26.1	Citi Bike
Mexico City	Feb 2010	Jul 2022	56,371,073	20,002,605	26.2	Ecobici
Brisbane*	Oct 2010	Mar 2015	423,938	185,073	30.4	CityCycle
Minneapolis*	Apr 2011/18	Nov 2012/19	380,283	196,815	34.1	Nice Ride
Helsinki*	May 2017	Oct 2017	568,686	378,586	40.0	City Bikes
Total			169,563,091	59,850,567	26.1	

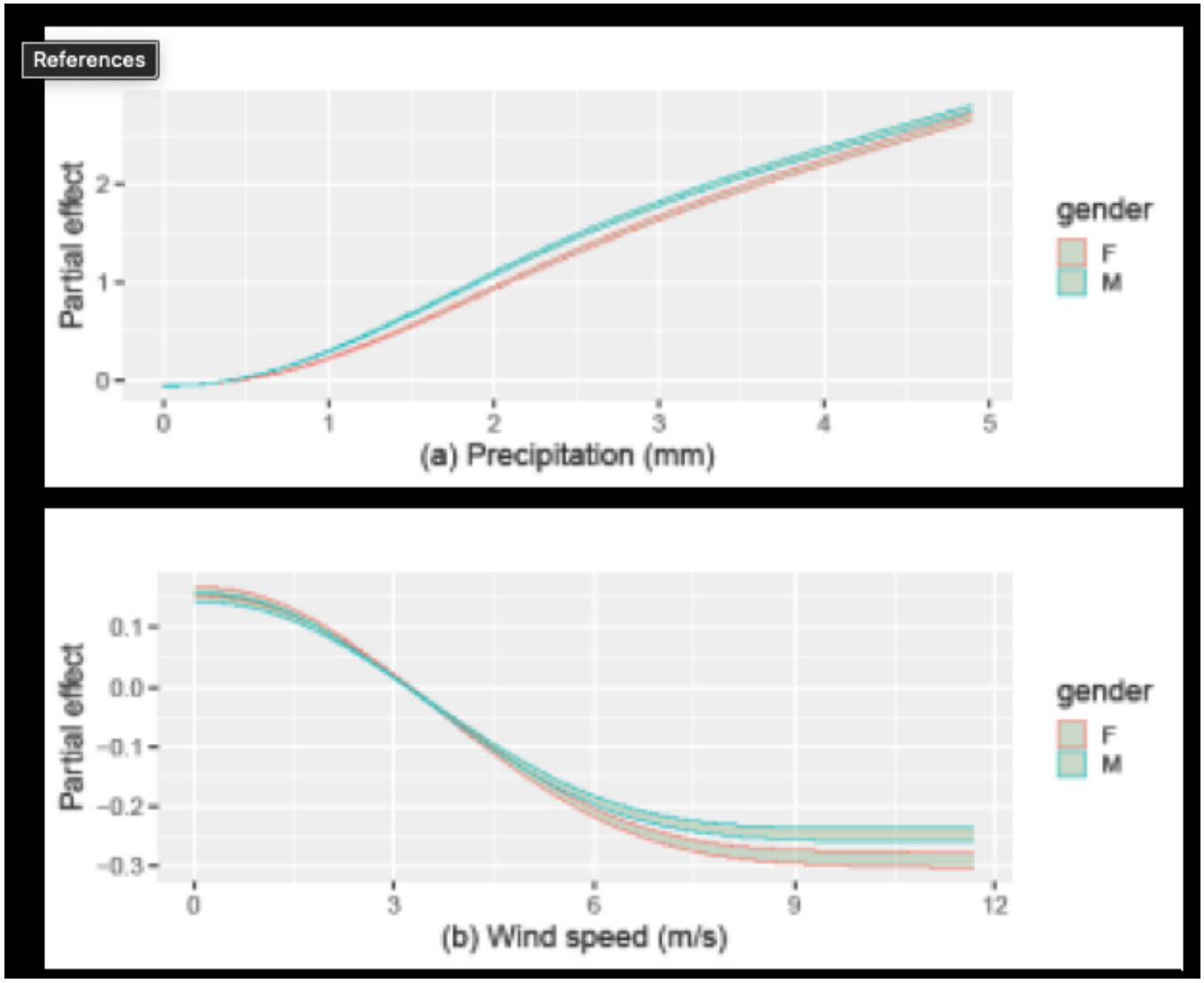
*The Minneapolis system is open only April-November. The Helsinki system is only open May-October. For Brisbane, until 1 December 2013, bike hire was only available between the hours of 5am and 10pm. The San Francisco Bay Area includes San Francisco, East Bay (Oakland and Berkeley), and San Jose.

**We only provide a link where the data are publicly available.

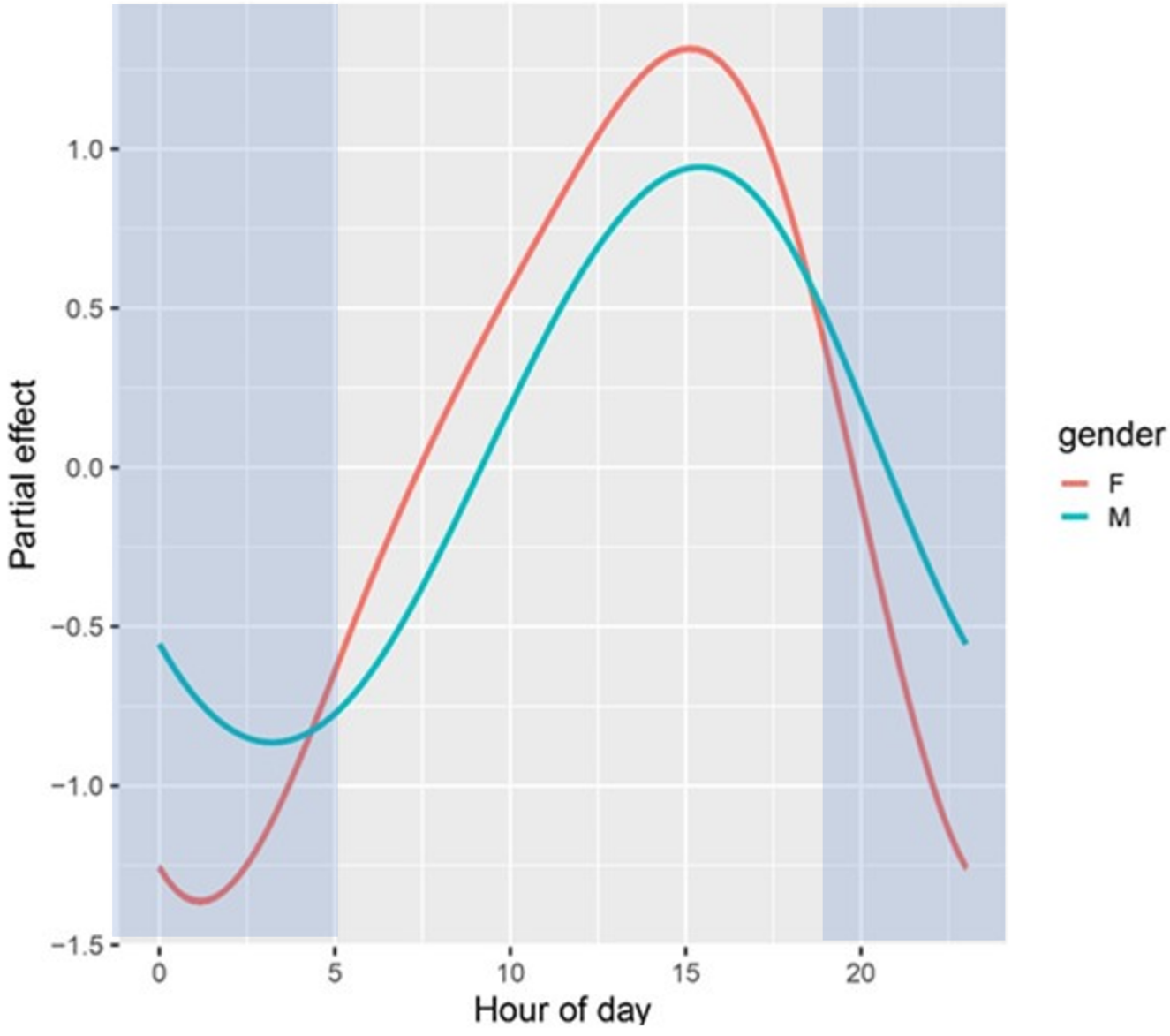
Third paper - by gender and age



Third paper - NYC 2019 partial effects, wind/rain



Third paper - NYC partial effects, time of day



Third paper - NYC partial effects, gradient

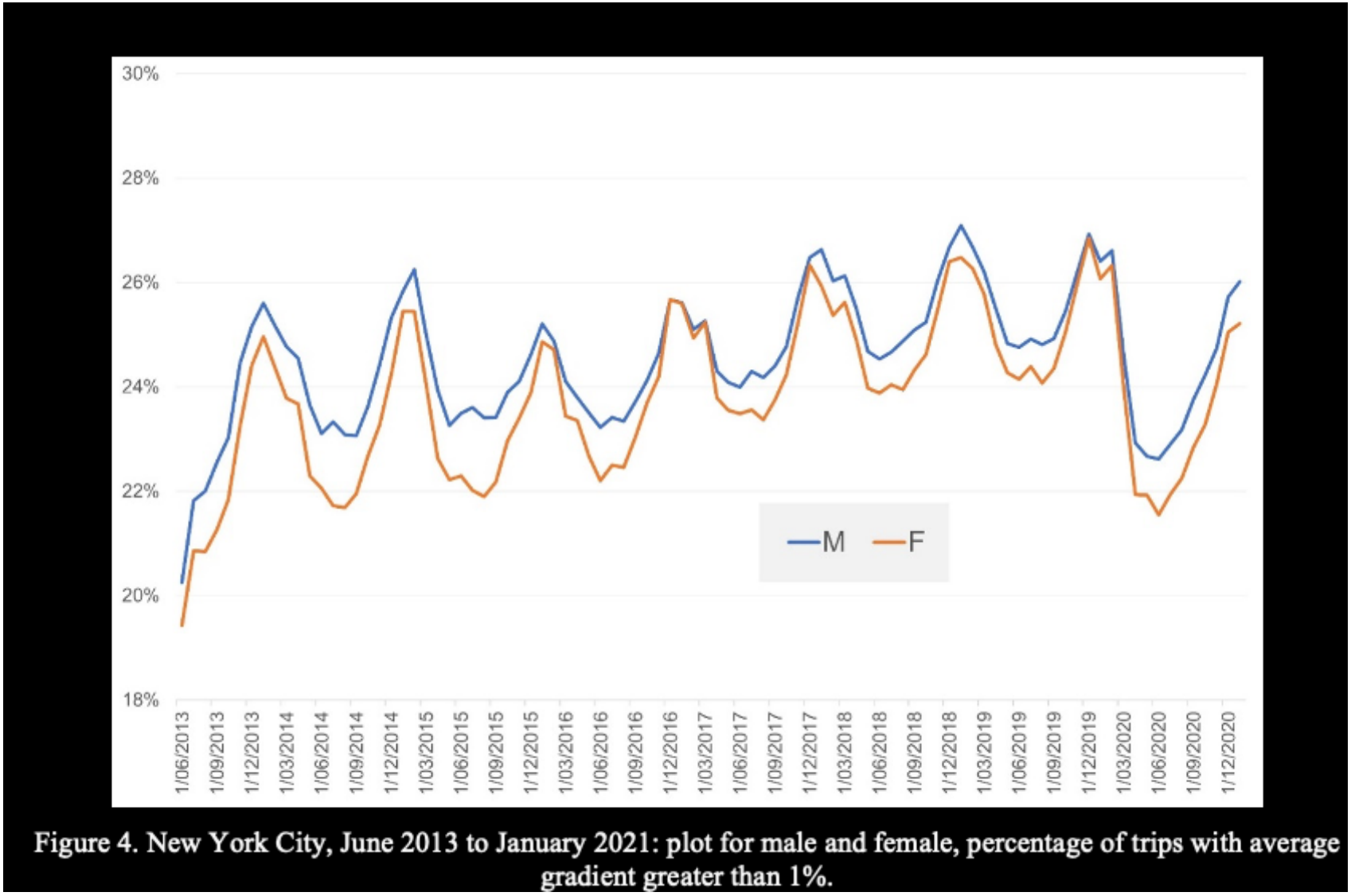


Figure 4. New York City, June 2013 to January 2021: plot for male and female, percentage of trips with average gradient greater than 1%.

Implications and Policy Changes

- Barriers facing cyclists.
- Potential policy changes to boost cycling uptake.
  - Partial electrification of fleet
  - Separated bikeways and lower speed limits
  - Minimize exposure of bike paths (Garrard, 2021)

Conclusion

- Co-authors Jonathan Corcoran and Dorina Pojani
- Recap of key findings.
- Future prospects and areas of further research.
- “Just a hobby” - how else did I use this?
  - Energy forecasting
  - “The Conversation” articles
  - Grants - difficult e.g. ARC

Questions

Thank you for your attention! I'm open to questions.