

# Data visualization for functional time series

Rob J Hyndman  
December 2018



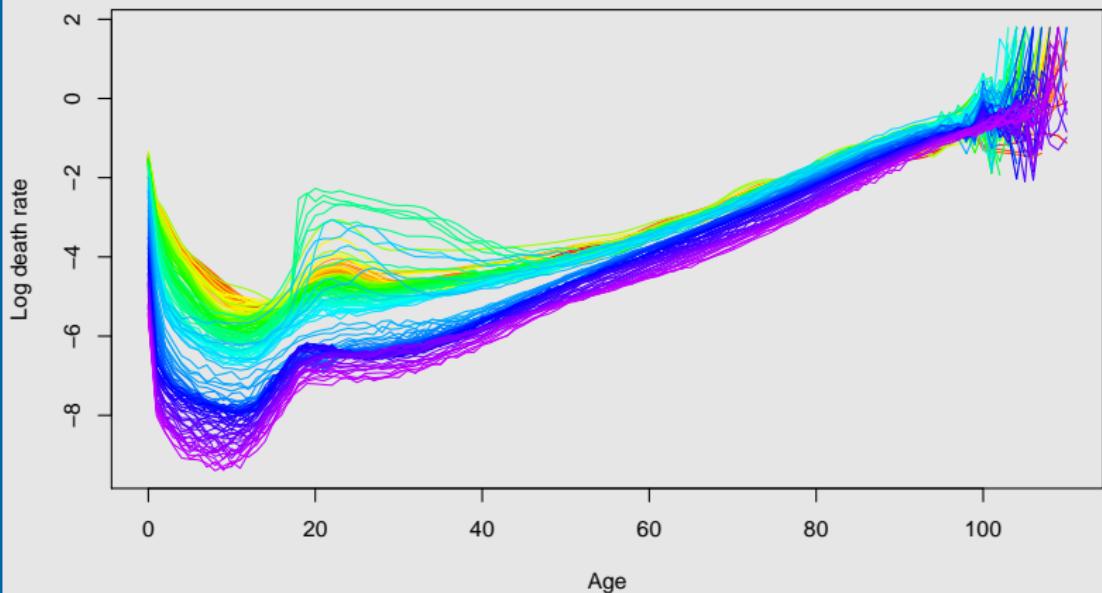
# Outline

1 Intro

2 Smart metre data analytics

# Rainbow plots

FRATNP: male death rates (1816–2006)



# Functional box plots

# Functional ACF plots

# Functional season plots

# Calendar plots

# Embedded pairwise distance plots

# Outline

1 Intro

2 Smart metre data analytics

# Disaggregated electricity demand data



# Disaggregated electricity demand data



# Smart metre data

vec.ausnetservices.com.au

## Request your Smart Meter Data

**NOTE:** You will need your electricity bill handy to complete this form

Once you submit this form you will be sent an email with instructions on how to have your smart meter data redirected to the Victorian Energy Compare website where you can compare energy retail offers and claim your \$50 Power Saving Bonus

**First Name**

Enter the First Name provided to your energy retailer 

**Last Name**

Enter the Last Name provided to your energy retailer 

**NMI (National Meter Identifier)**



630XXXXXXXX

**Meter Number**



**Phone Number**

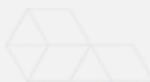


**Postcode**

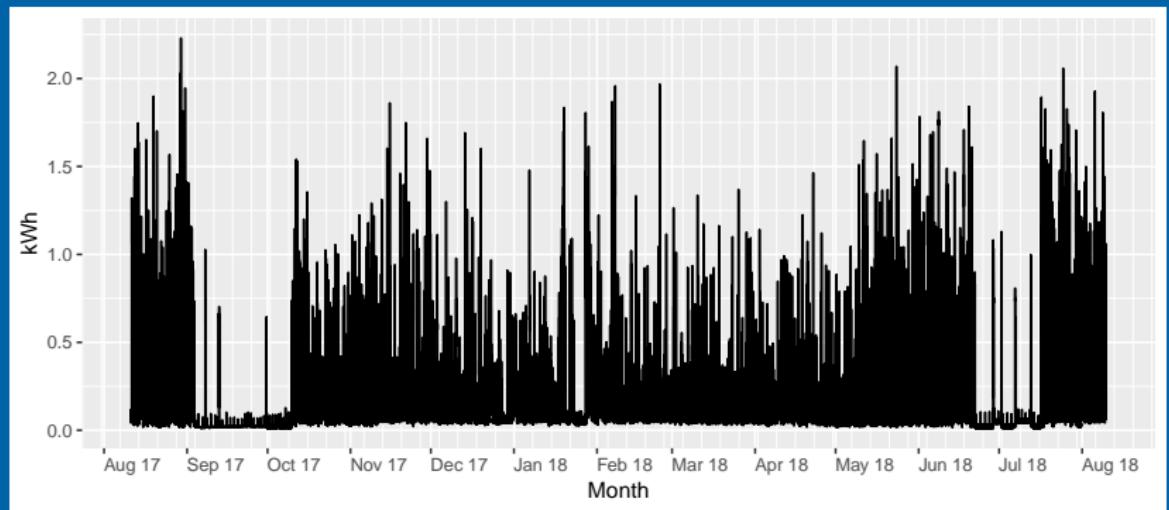
**Email Address**



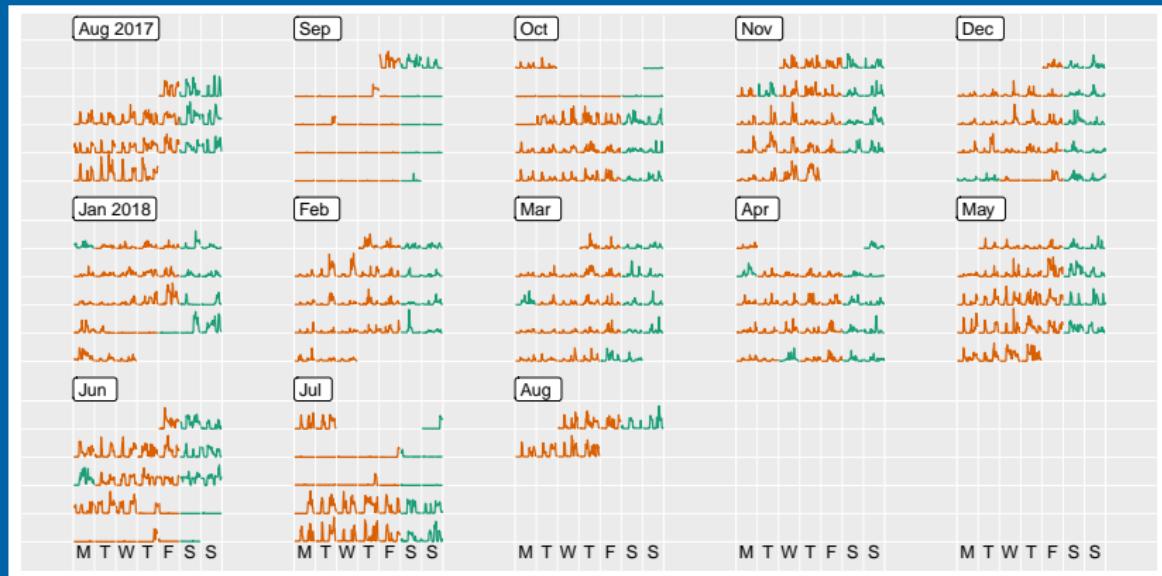
**Confirm Email**



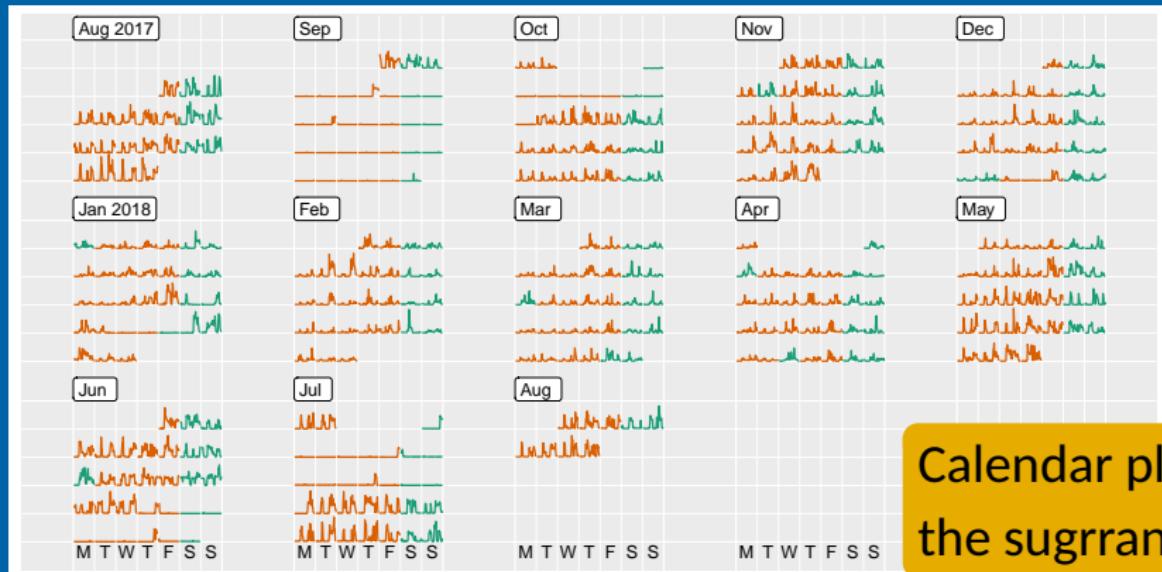
# George's data



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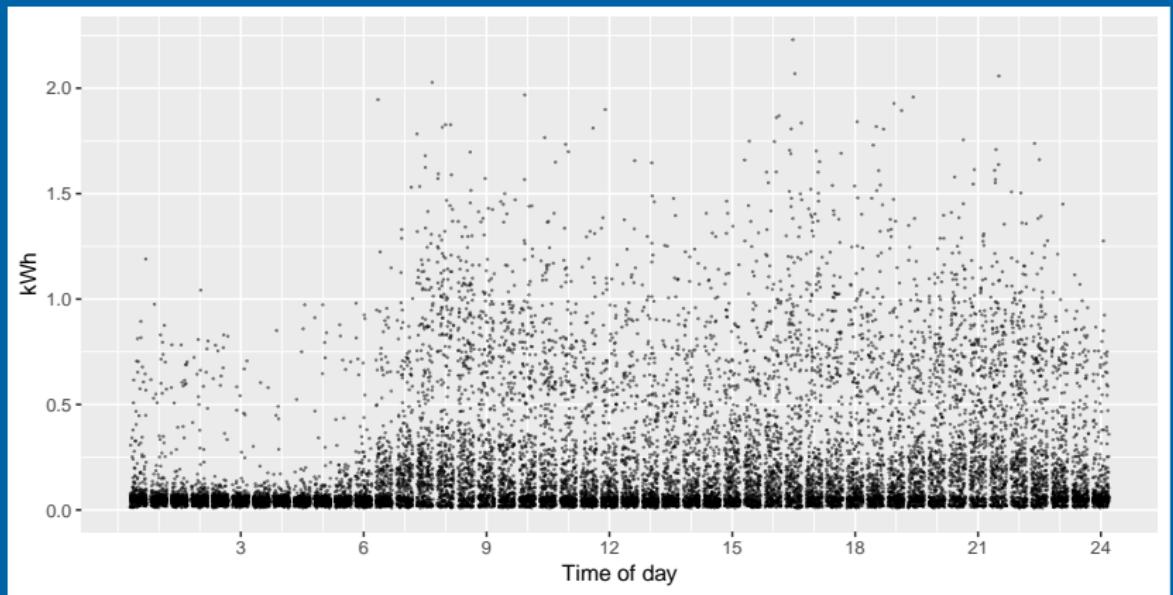


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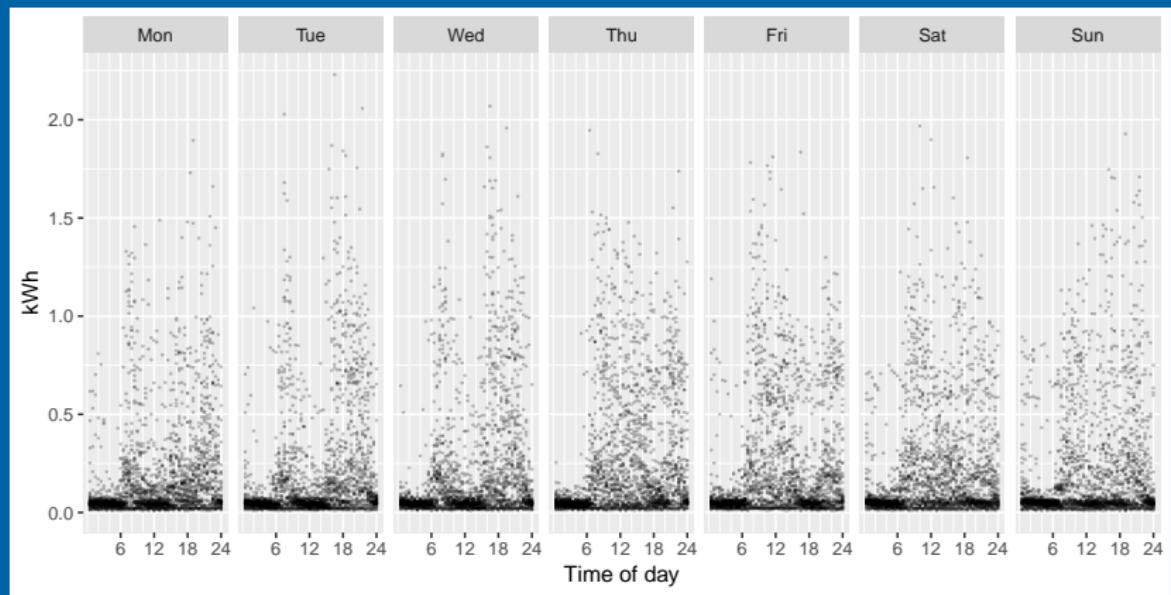


Calendar plot av  
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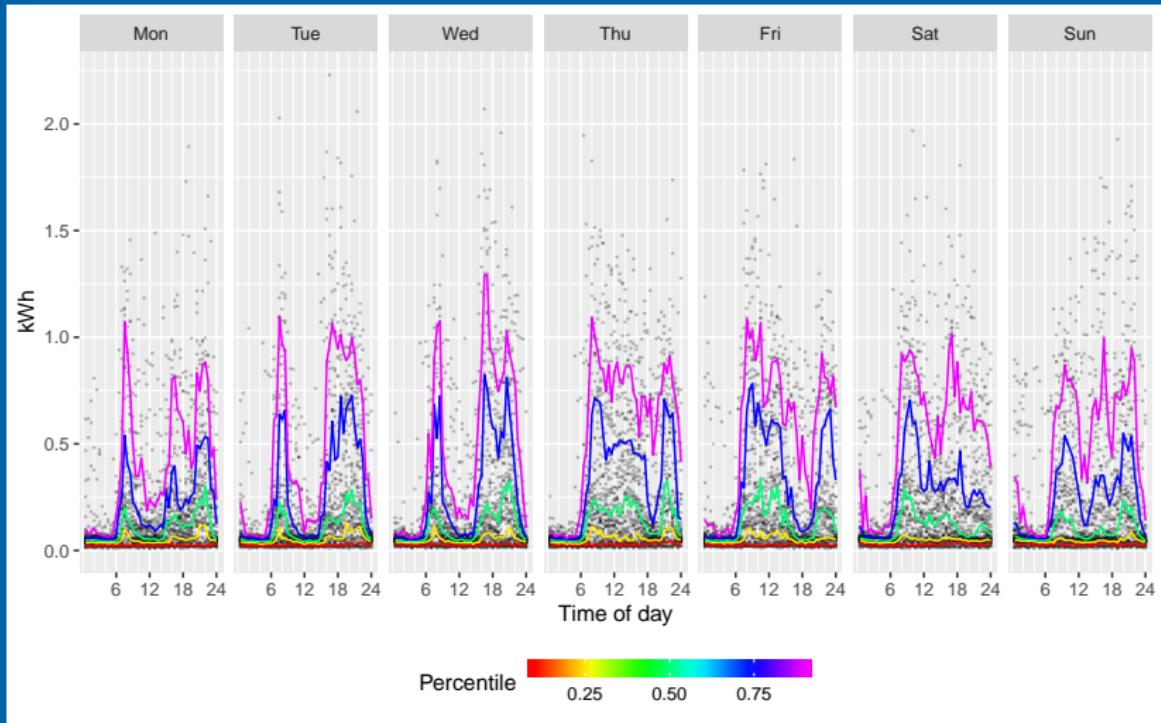
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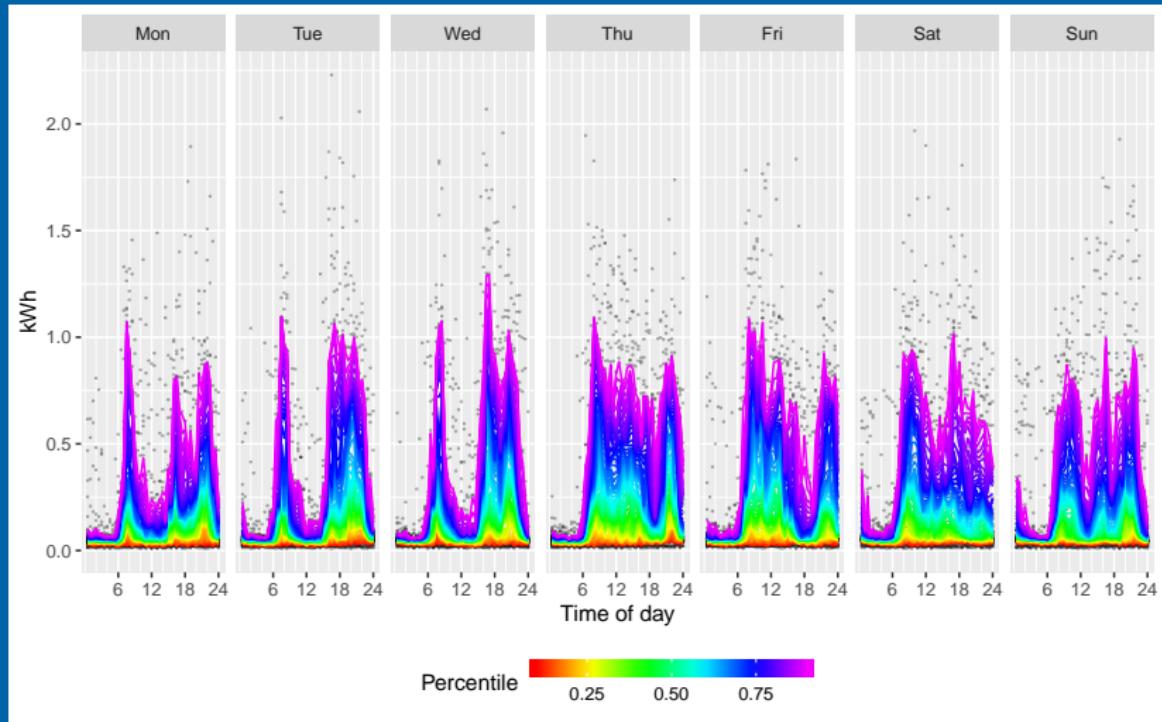
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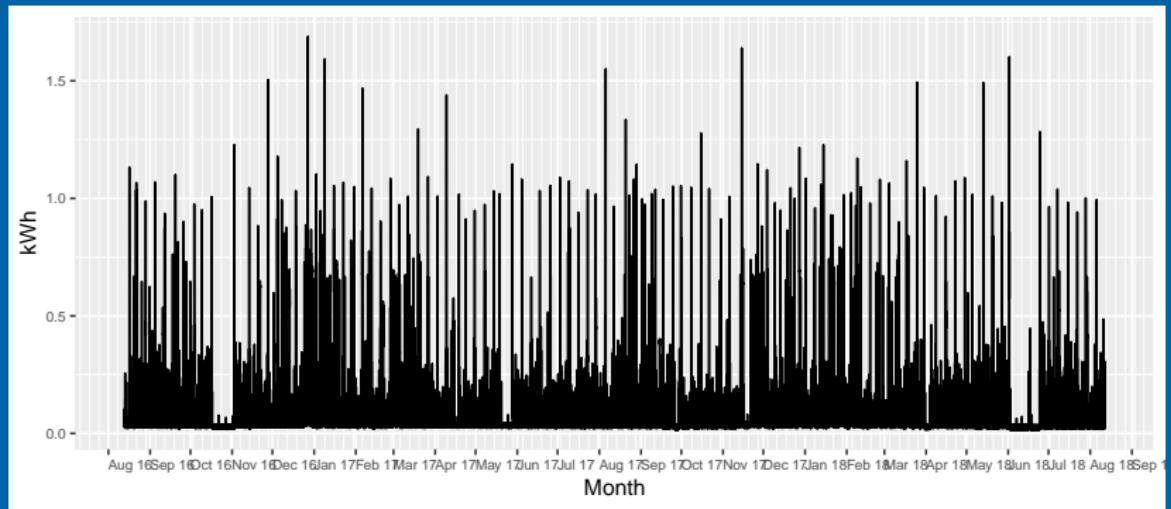
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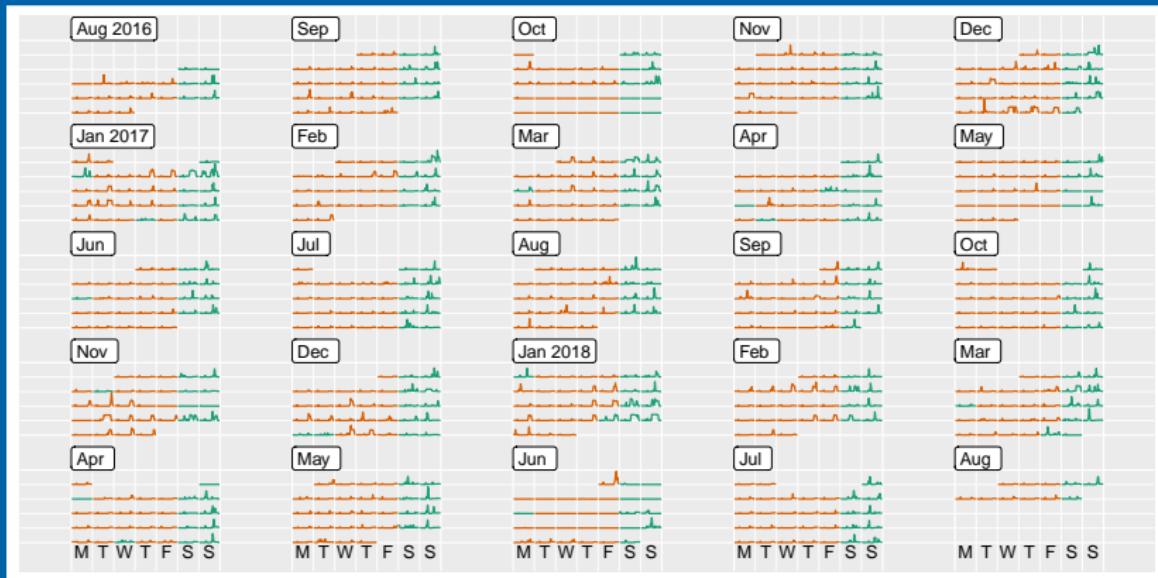
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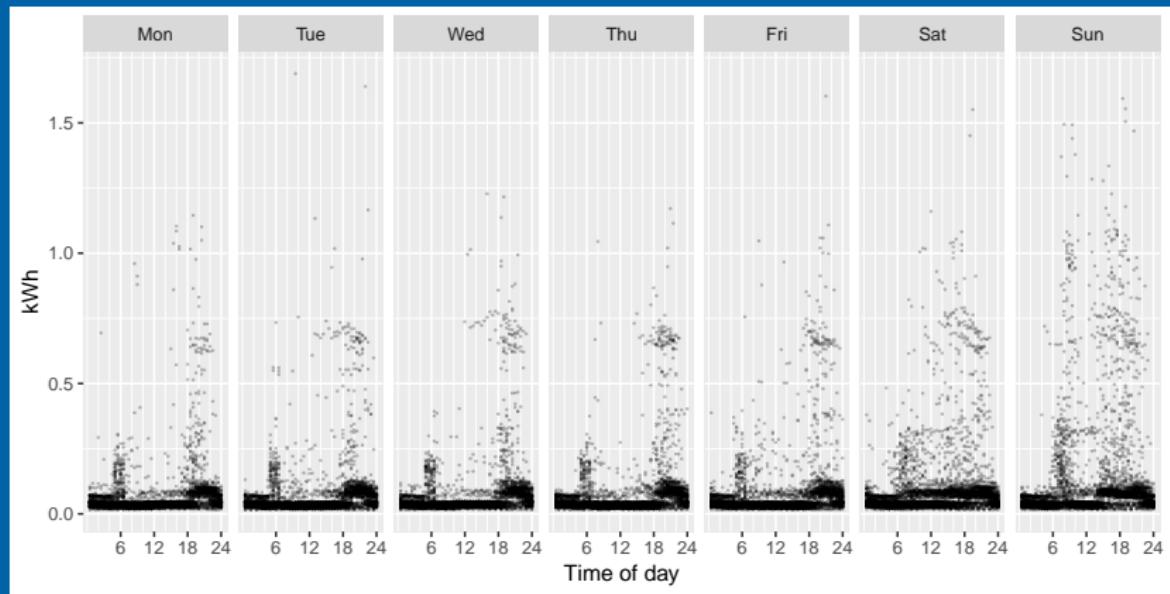
# Clare's data



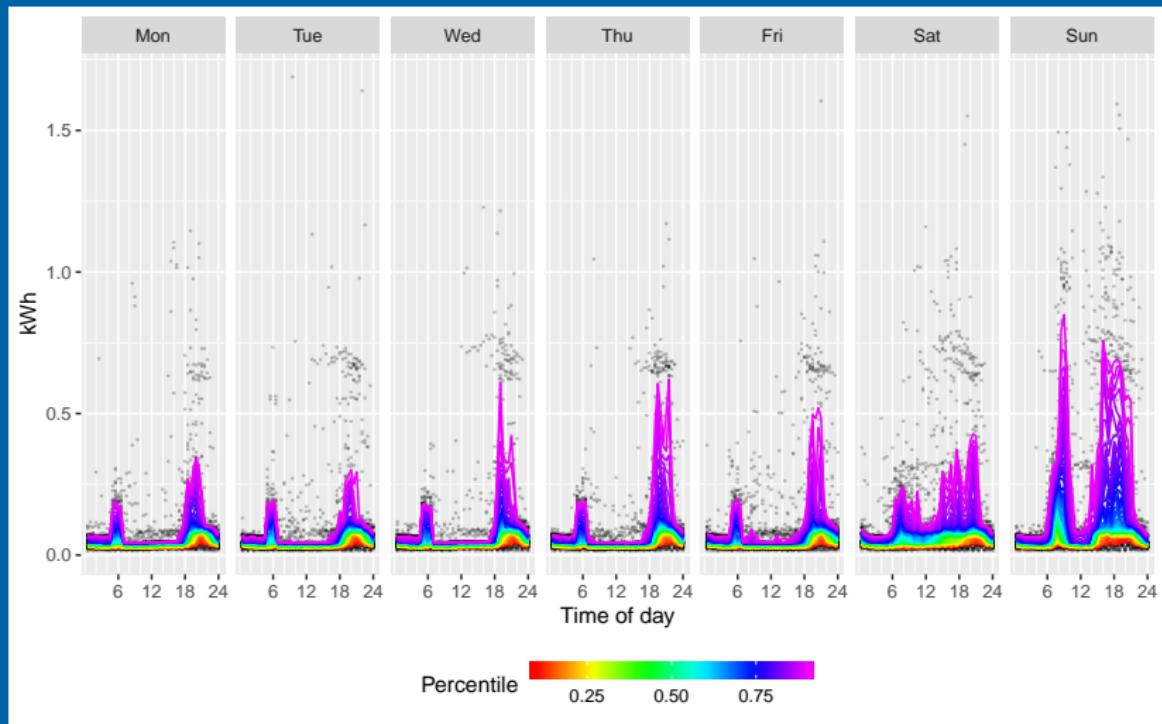
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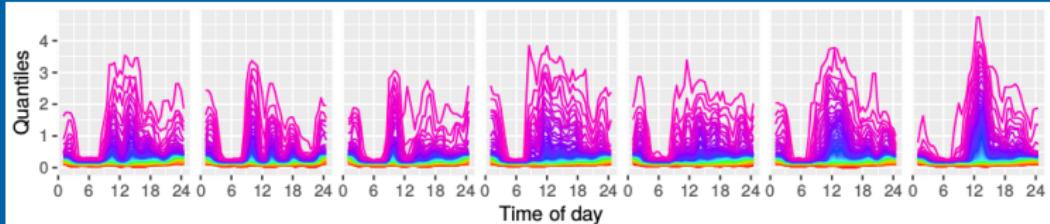
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# Percentiles conditional on time of week

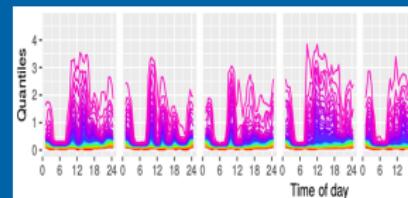
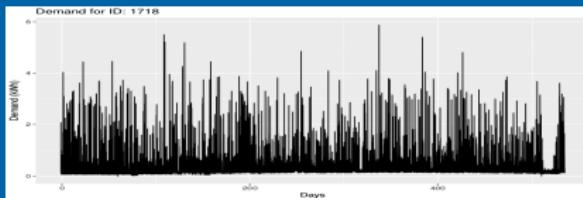


- Percentiles for each household and each half-hour of the week.
- Provides a unique fingerprint of typical usage for a given household.
- 336 probability distributions per household.
- Avoids missing data issues and variation in series length
- Avoids timing of household events, holidays, etc.
- Allows clustering of households based on probabilistic behaviour rather than coincident behaviour.
- A more complicated version also allows it to change across

# Finding anomalous smart metres

## Irish smart metre data

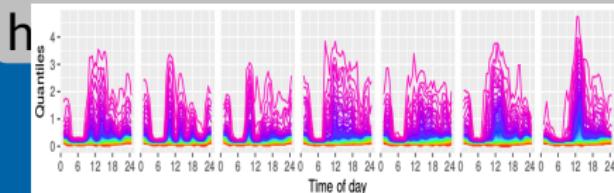
- 500 households from smart metering trial:  
14 July 2009 – 31 December 2010.
- Electricity consumption at 30-minute intervals.
- Heating/cooling energy usage excluded.



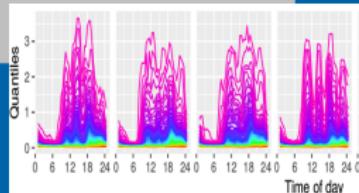
The time series of  $535 \times 48$  observations per household is mapped to a set of  $7 \times 48 \times 99$  percentiles giving a bivariate surface for each household.

# Finding anomalous smart metres

Can we compute pairwise distances between all

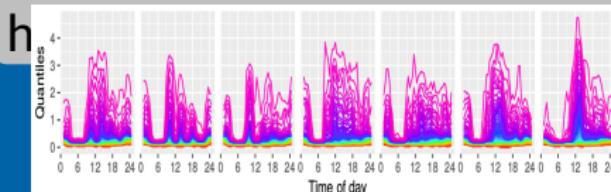


← ? →  
Distance

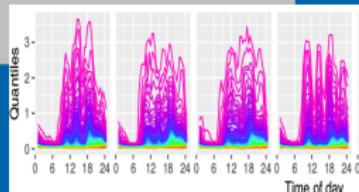


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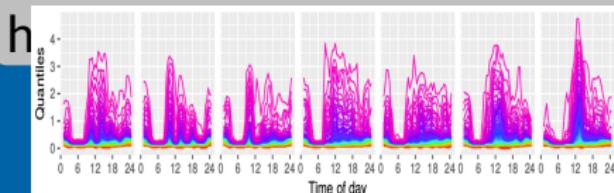
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Distance



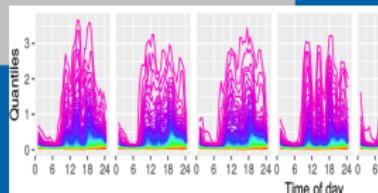
- Jensen-Shannon measure gives distance between two densities

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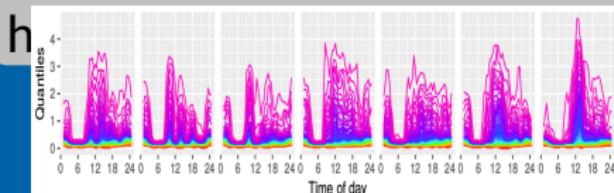
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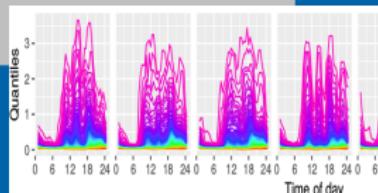
- Jensen-Shannon measure gives distance between two densities
- Distance between household  $i$  and household  $j$ :  
 $\Delta_{ij} = \text{sum of } 7 \times 48 \text{ JS distances.}$

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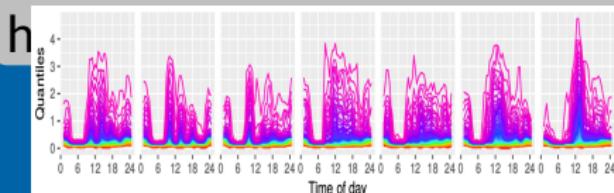
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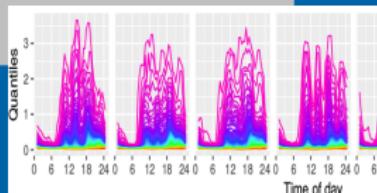
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 $w_{ii} = \exp(-\Delta_{ii}^2/h^2)$

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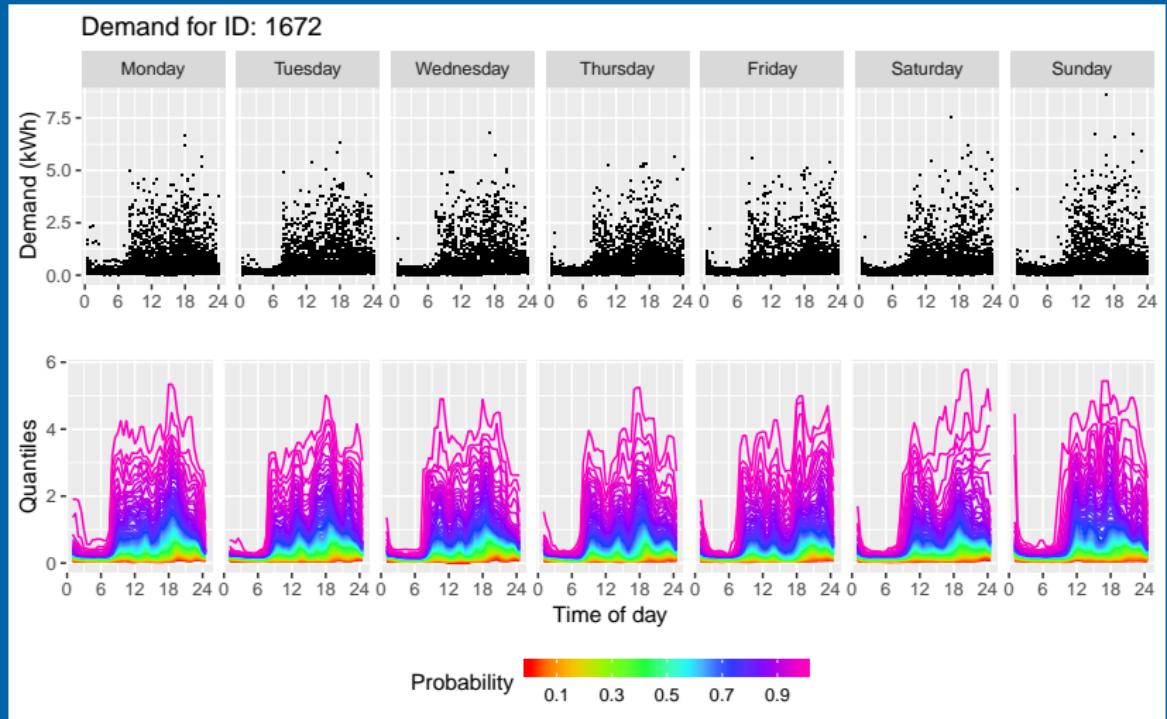


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Distance

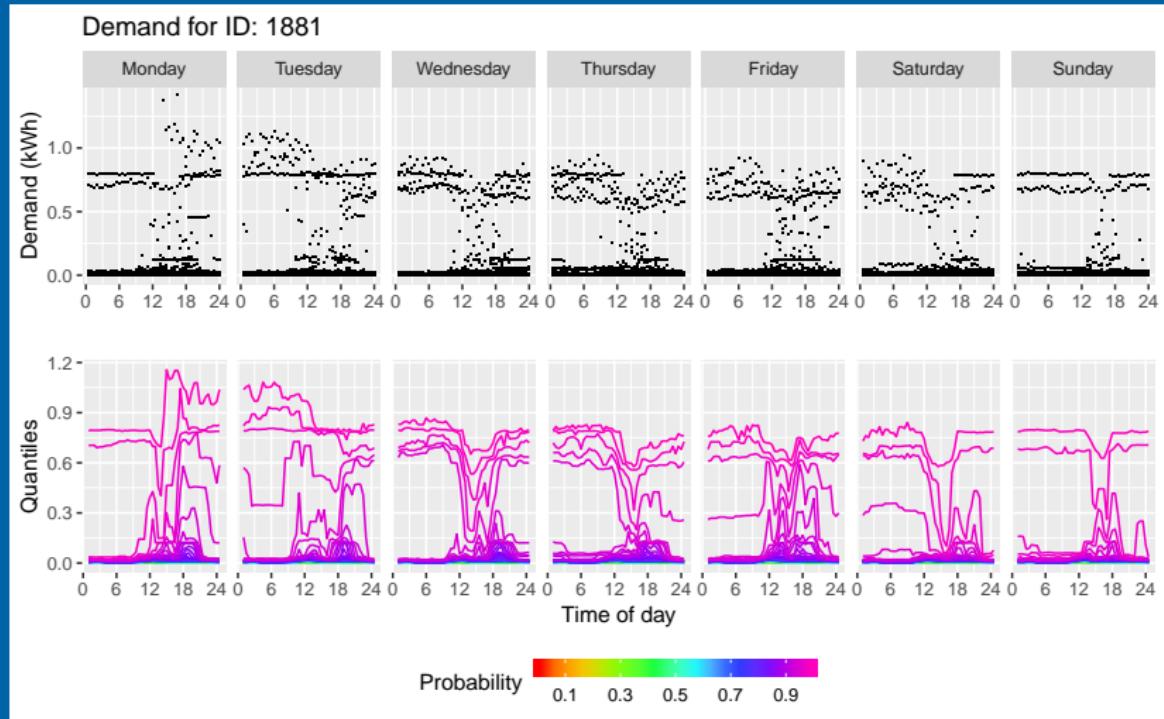


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# Most typical household



# Most anomalous household

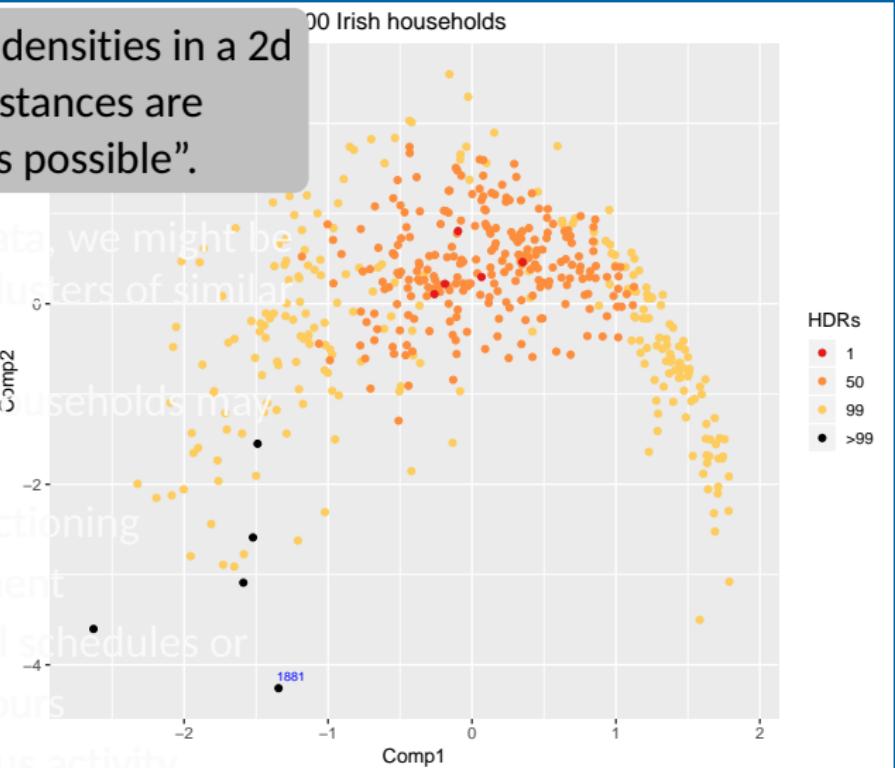


# Visualization via embedding

Embed conditional densities in a 2d space where the distances are preserved “as far as possible”.

- With more data, we might be able to find clusters of similar households.

- Anomalous households may be due to:
  - malfuctioning equipment
  - unusual schedules or behaviours
  - nefarious activity



# Thanks



Di Cook



Kate Smith-Miles



Anastasios Panagiotelis



Souhaib Ben Taieb



Nick Tierney



Earo Wang



Dilini Talagala



Mitchell O'Hara-Wild



Cameron Roach



Puwasala Gamakumara



Thiyanga Talagala



Sayani Gupta

Fur  
rob