Statistical Models for Road Traffic Networks

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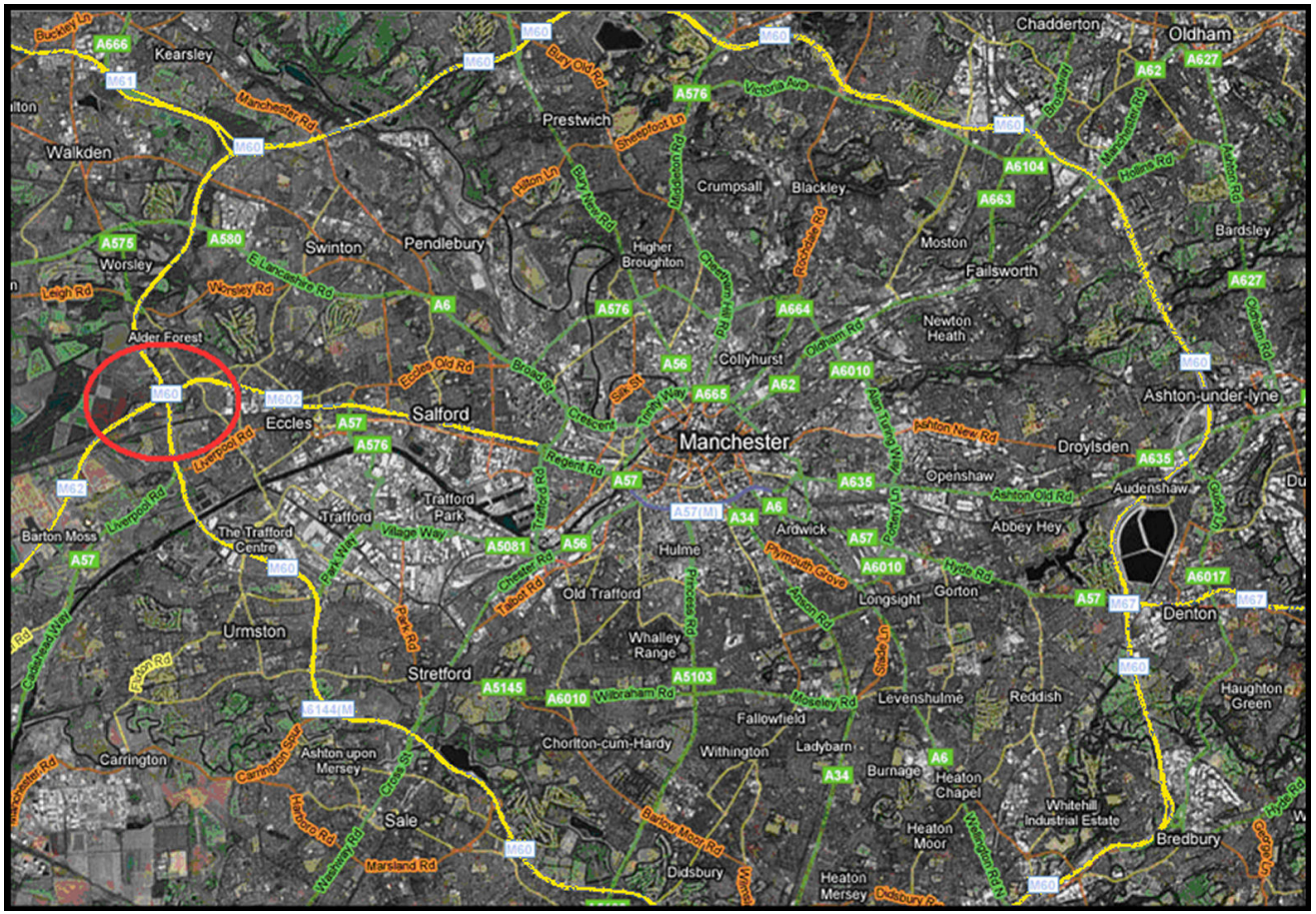
Introduction

- traffic modelling: useful to maximize network efficiency and prevent congestions
- MIDAS (**M**otorway **I**ncident **D**etection and **A**utomatic **S**ignaling) system is a data source about motorways in the UK.
- it generates a really large volume of data $\Rightarrow$ great oportunity for statistical analyses

Traffic data available: geographic locations

Manchester: M60 / M62 / M602 junction



Pictures taken from Google Maps

Traffic data available: geographic locations

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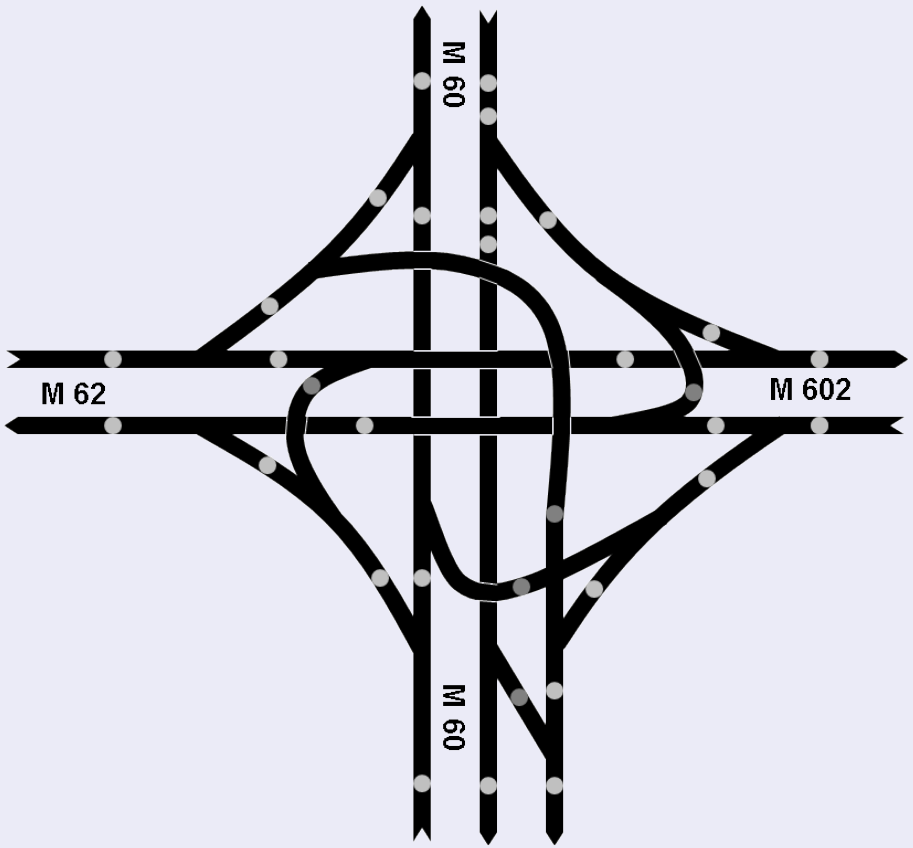
Data collecting sites: Manchester junction

Diagram

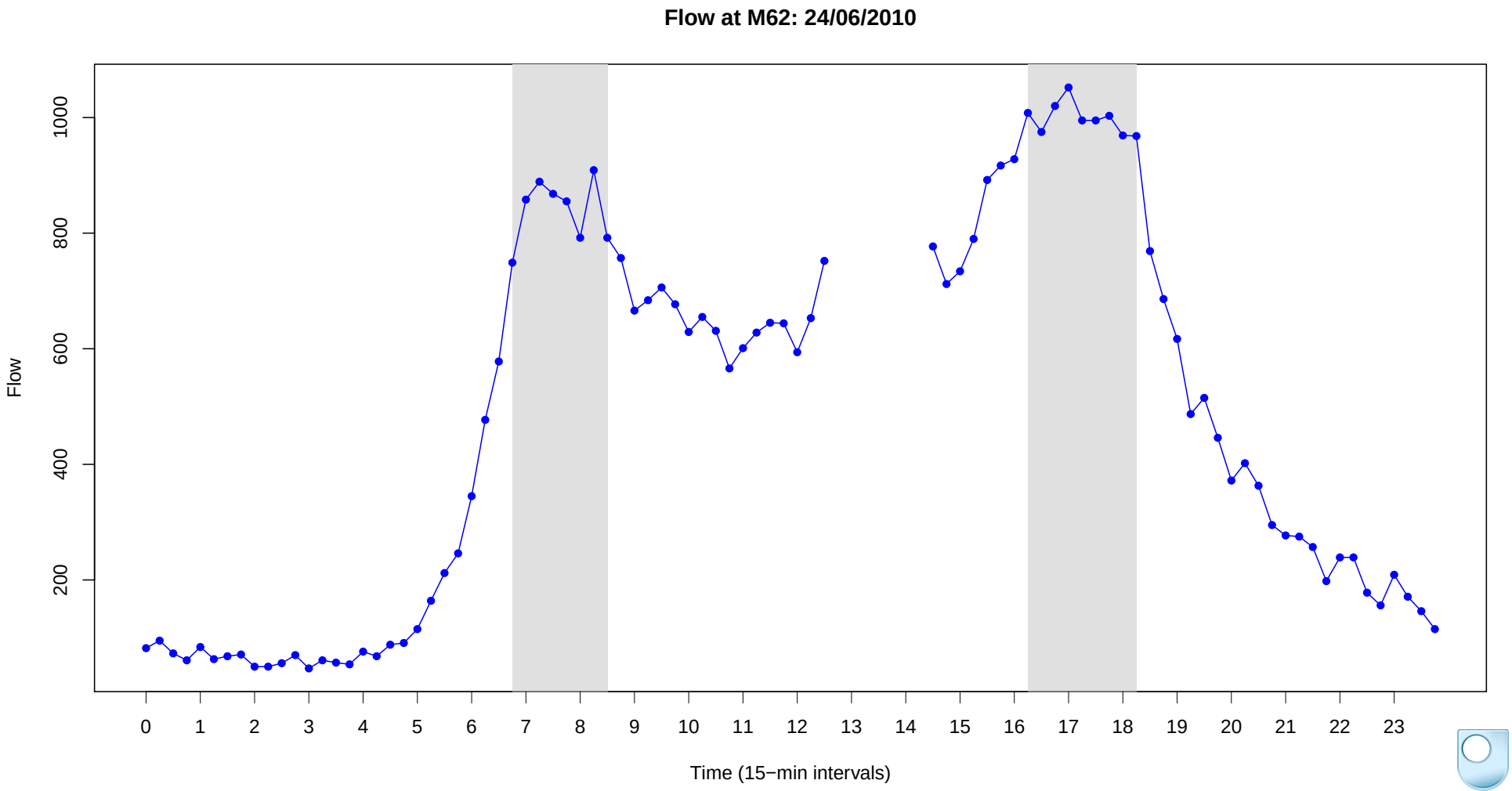


Properties

- 32 data sites
- Data are being collected since 2006

target variable: Flow

definition: flow = number of vehicles per time interval



Short-term forecasting and monitoring models can be very useful to describe future traffic conditions

restrictions:

- immediate decisions and actions are necessary based on the model - real time environment
- model has to consider future information which can affect network performance - e.g changes in the network, weather conditions, etc.

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Research Question

can a model be capable of generating accurate forecasts given complexities and requirements of the traffic field and at the same time be simple enough to be applied in real-time ?

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current model limitations

- static model estimation - not feasible on real-time
- not easily adaptable to sudden changes in traffic patterns
- difficult to accommodate network structures

Dealing with network structures

- challenge: how to describe the dependence structure between traffic flow time series ?

- approach: **graphical models**

graphical modelling idea applied to traffic flow data

- counts at upstream sites are informative about downstream sites
- a graphical representation defines set of conditional distributions: child | parents
- breaks multivariate problem into univariate conditionals:

$$Y_t(1) \qquad Y_t(2)|Y_t(1) \qquad Y_t(3)|Y_t(2).$$

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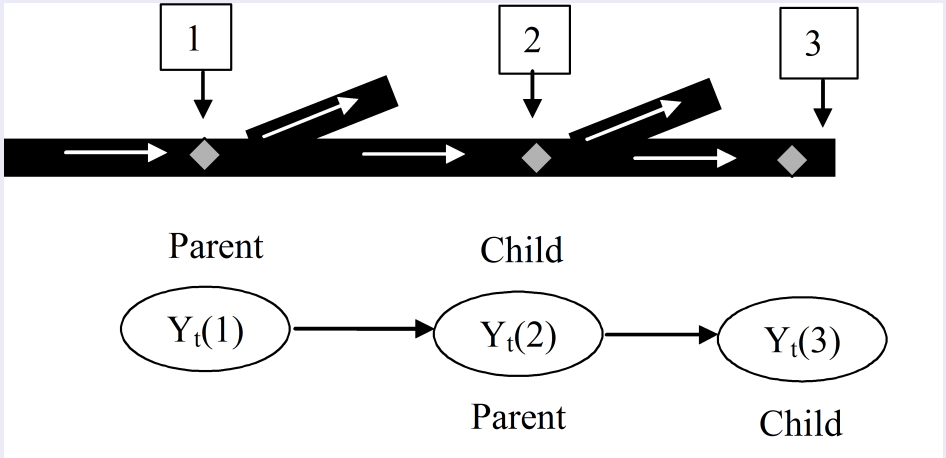

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network
graphical
structure

network graphical structure + dynamic model approach

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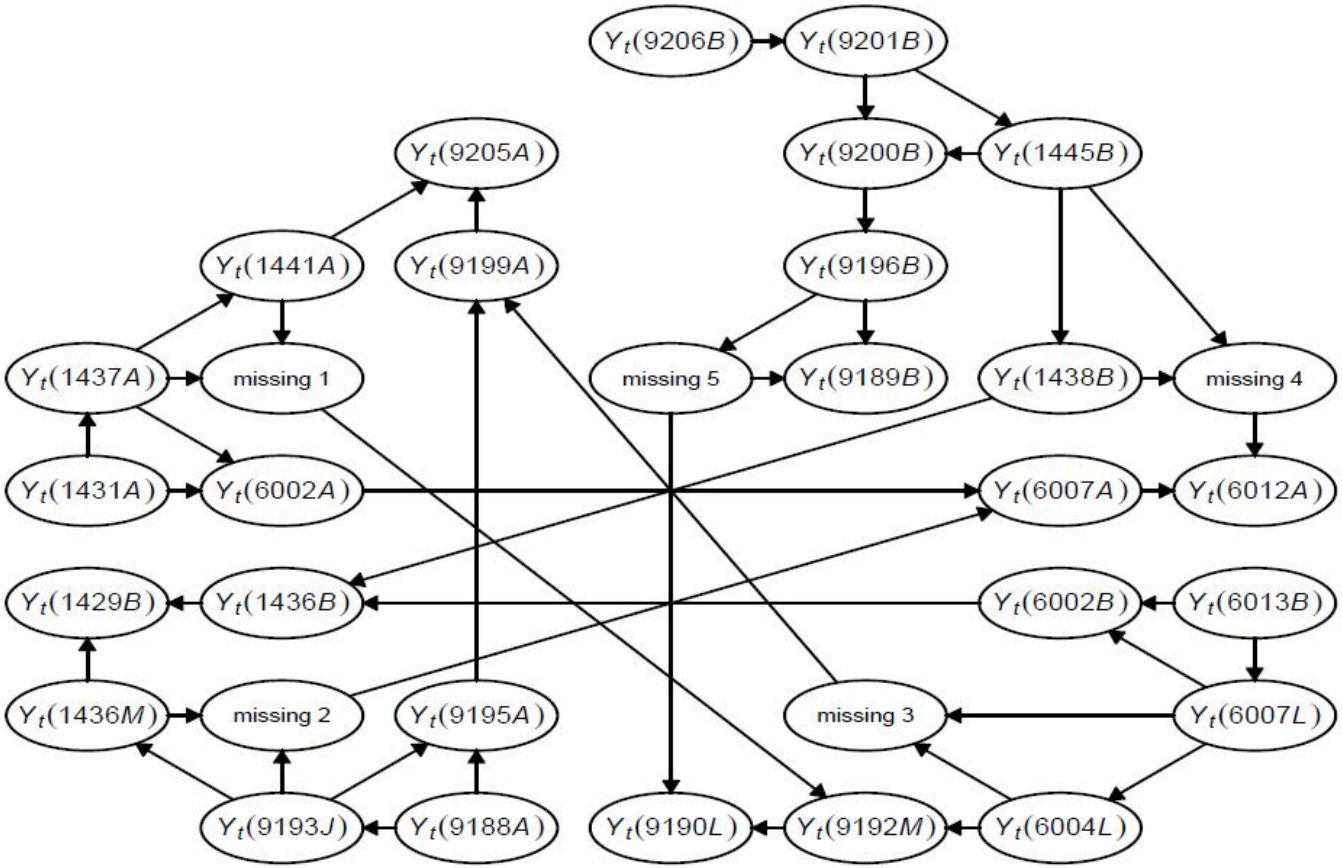
Multiregression dynamic model (MDM - Queen & Smith, 1993)

- MDM is a class of graphical dynamic models
- It represents traffic counts time series using a graphical representation of the network
- Each time series is described as a separate dynamic linear model
  - sequential estimation and intervention techniques available
- The model provides an easy way to
  - handle changes in a traffic network
  - include external information (e.g. traffic accidents or roadworks)

Example

Graphical representation for the Manchester Network (Queen *et. al.*,2007)



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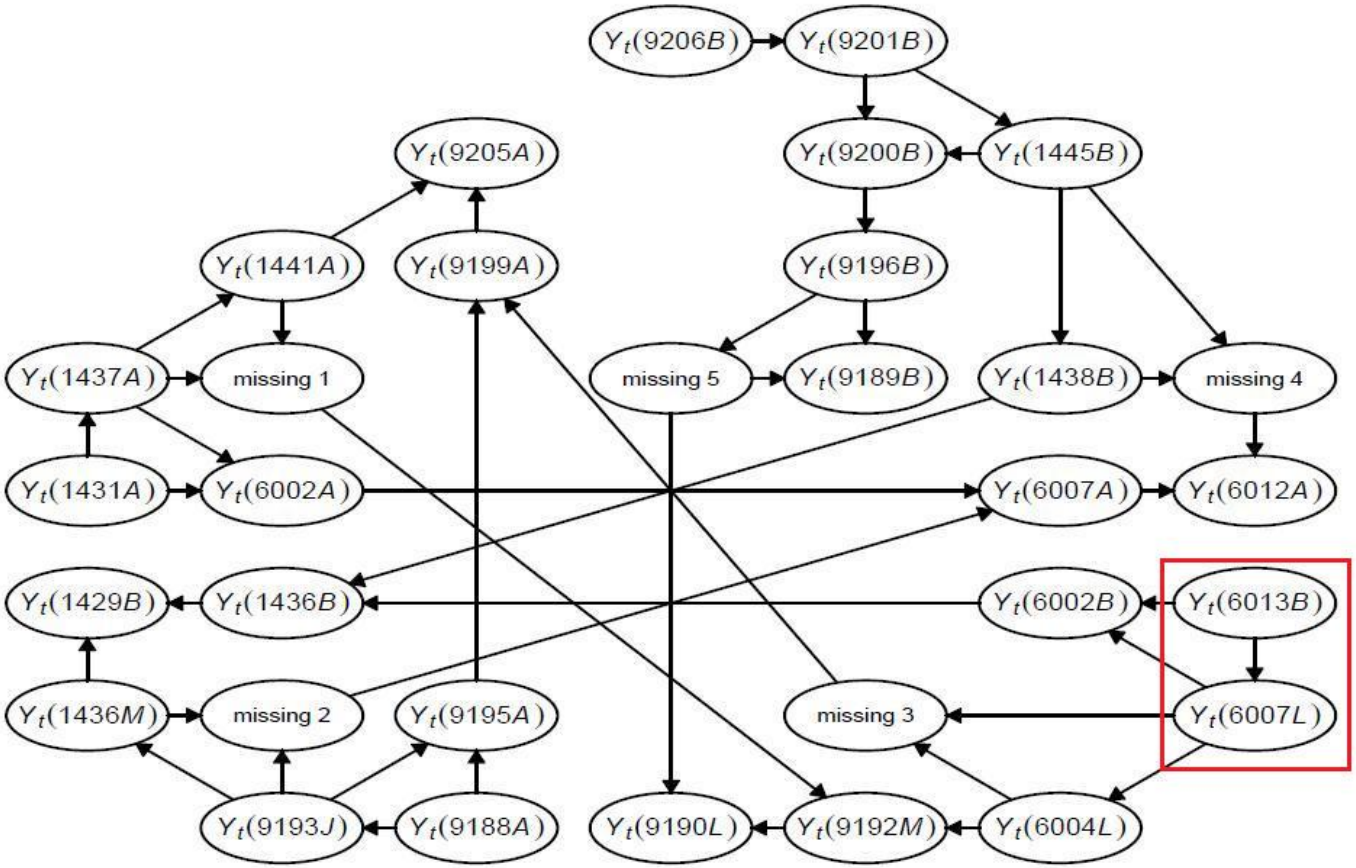

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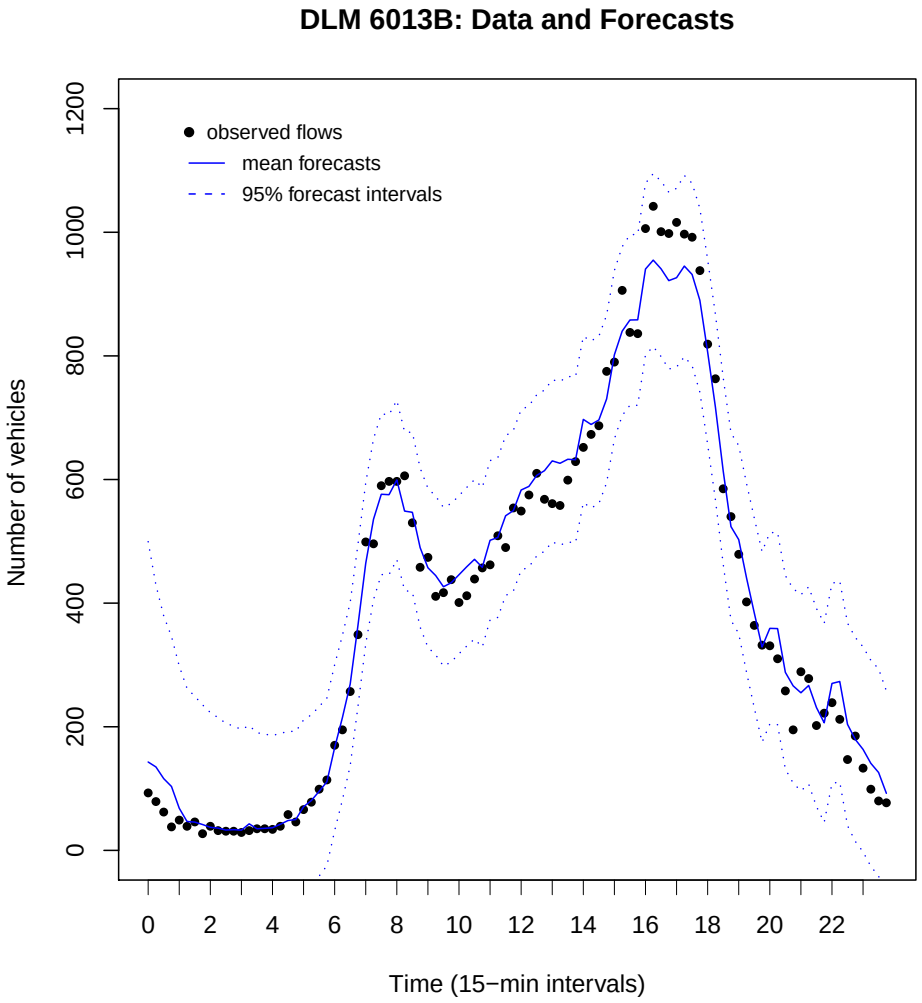
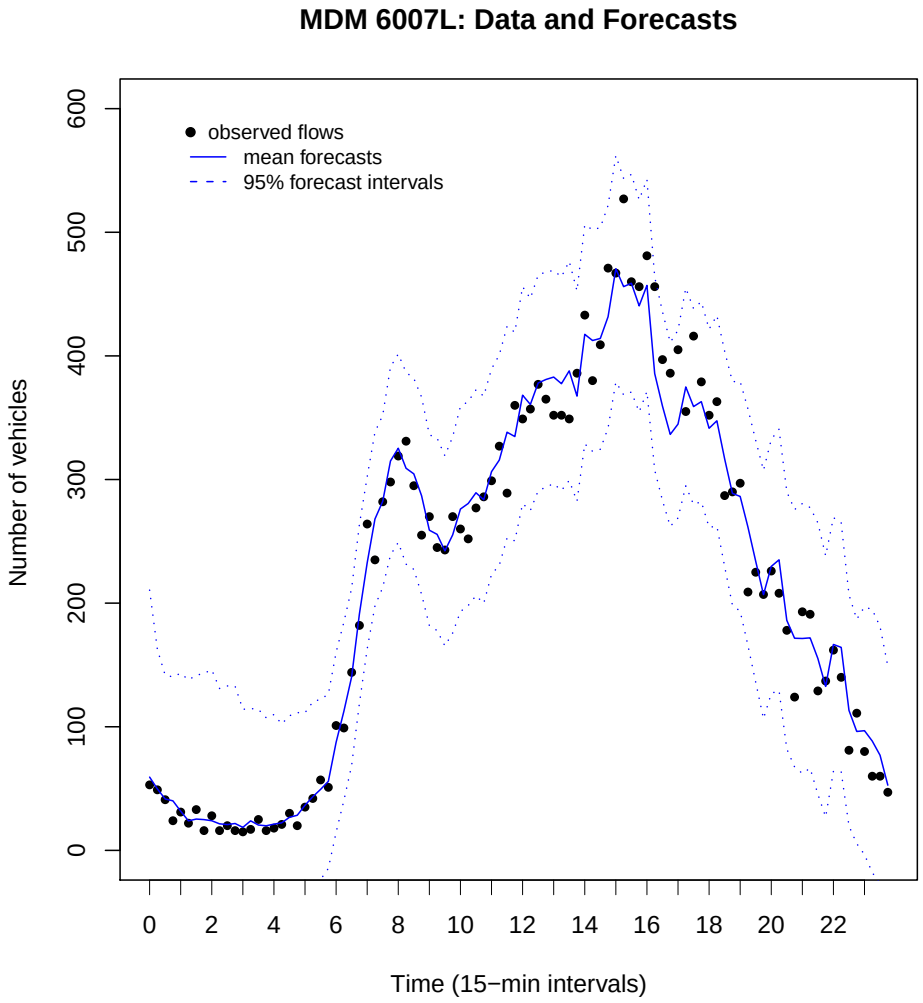

DLM 6013B: Data and Forecasts
observed flows
mean forecasts
95% forecast intervals
Number of vehicles
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12
14
16
18
20
22
Time (15−min intervals)


MDM 6007L: Data and Forecasts
observed flows
mean forecasts
95% forecast intervals
Number of vehicles
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100
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500
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Summary:

- Multiregression dynamic models can be a suitable choice to be implemented in traffic management systems
  - tackles the multivariate forecasting problem using separate simpler univariate models
  - can provide real time forecasts
  - flexible to accomodate changes in a traffic network
  - easy to intervene

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Future research topics:

- data errors and missing values **(work in progress)**
- effect of speed/ occupancy/ headway as traffic flow predictors
- model behaviour using different data resolutions
- non Gaussian assumptions