Section: Statistics at link level

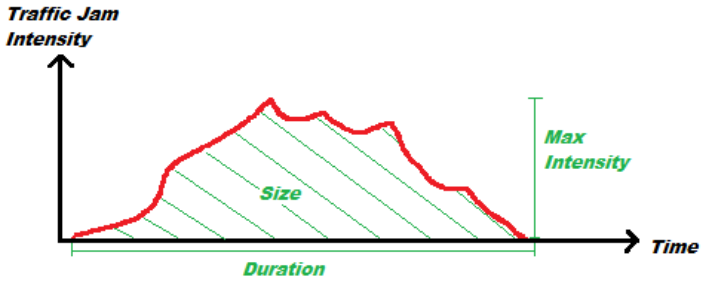
We calculated seven distinct statistics at link level to get an overall understanding of traffic jams. The statistics were calculated separately for each of the selected links, and also for all of them as a whole. Four out of the seven statistics are un-normalized, which means that, for their calculation, there was no re-scaling in any sense. The other three statistics are normalized (re-scaling time and traffic intensity scales). In the following, we present descriptions of the un-normalized and normalized statistics, and then the results of their calculations.

Un-normalized statistics description

The following four un-normalized statistics of traffic jams were calculated: duration, maximum intensity, size and auto-correlation.

Duration, maximum intensity and size

The following image shows in a graphical way the definitions of duration, maximum intensity and size of a single traffic jam:



These three statistics give us an insight of the magnitude of the traffic jam events regarding time and intensity.

Autocorrelation

By considering traffic jams as stochastic processes, average autocorrelation functions were computed. The purpose of this was to know the dependency of intensity present values with respect to past values.

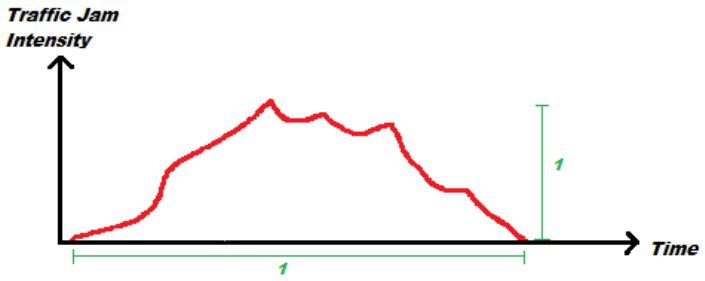
The true autocorrelation function of a traffic jam is unknown, but it can be estimated from one sample traffic jam as follows:

$$\widehat{\Re}_{XX}(\tau) = \frac{1}{(K-\tau)\sigma^2} \sum_{k=1}^{K-\tau} (x_k - \mu)(x_{k+\tau} - \mu)$$

where K is the duration of the traffic jam (number of samples), τ is the time delay variable, $\tau < K$, μ is the sample mean of traffic intensity, σ^2 is the sample variance of traffic intensity, and x_k is the value of the traffic intensity at the time k, $k \in \{1,2, \dots, k, \dots, K\}$. We estimate the true autocorrelation function of a link as the average autocorrelation functions of all the traffic jams in the link during the period of analysis.

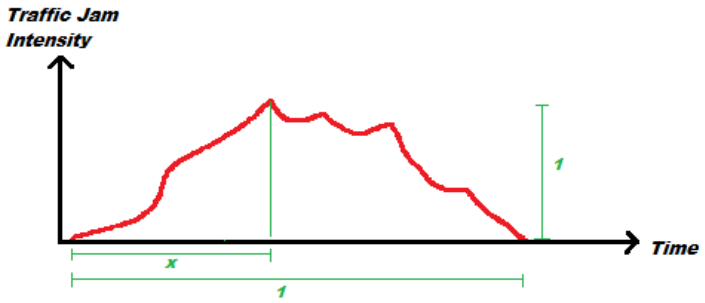
Normalized statistics

The normalized statistics calculated were: location of the maximum, skewness, and the three parameters (a, b, c) of a trapezoid model of traffic jams: congestion-building (a), congestion-plateau (b) and congestion-clearing (c). For their calculation, each traffic jam was re-scaled in the time and intensity axes as follows:



Location of the maximum

The location of the maximum is the normalized time in which the global maximum occurred (a number between 0 and 1 or a percentage).



Skewness

If we imagine the shape of the traffic jam through time as a probability distribution, then we can calculate the skewness as a measure of asymmetry, which we expect to be correlated with the location of the maximum statistic.

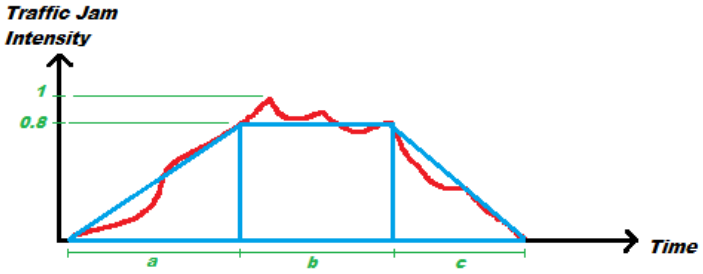
The sample skewness of one traffic jam is calculated as:

$$s = \frac{1}{size} \sum_{k=1}^{K} (x_k) \left(\frac{k - \mu}{\sigma} \right)^3$$

where μ is the sample mean, σ is the sample standard deviation and $size$ is the area under the traffic jam curve. It should be noted that the normalization in time is made by σ and the normalization in intensity is made by $size$.

Trapezoid model parameters

We created a trapezoid model of a traffic jam composed of three variable parameters: congestion-building (a), congestion-plateau (b) and congestion-clearing (c), plus a fixed heuristic threshold of 0.8 that determines where the congestion-plateau starts and ends. The following Figure depicts the model graphically:

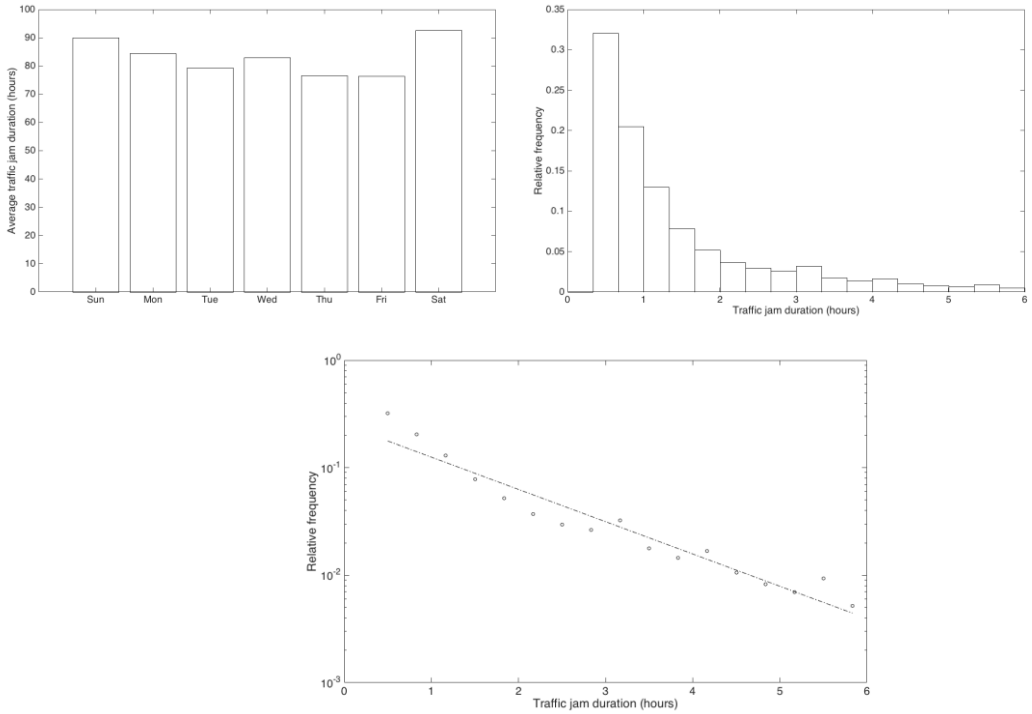


The main purpose of this model is to determine how similar is the time of congestion-building with the time of congestion-clearing.

Results: statistics for all links of M6

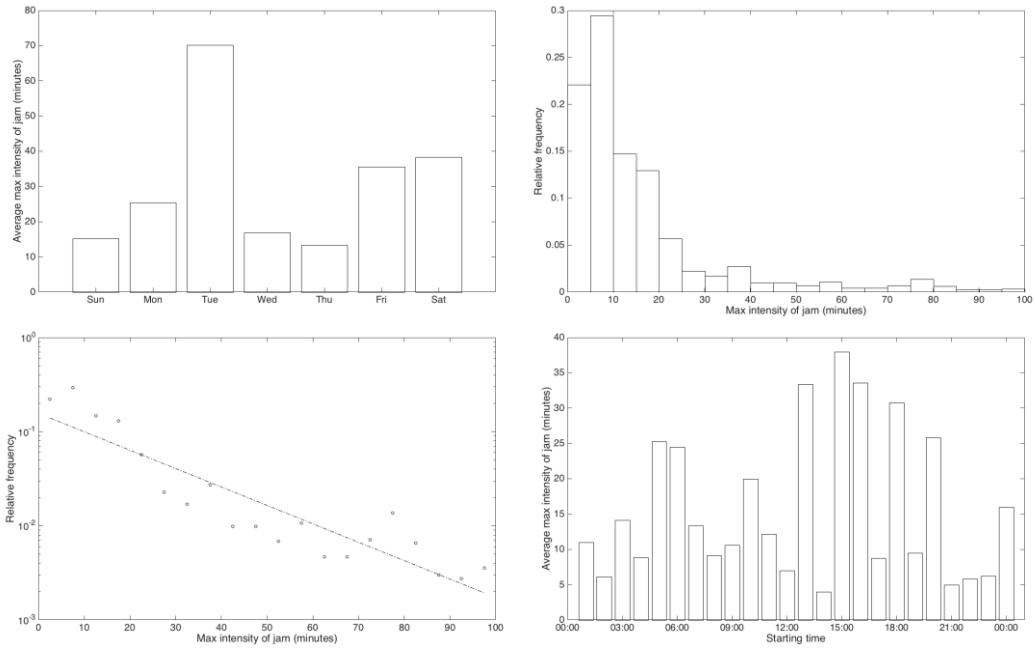
The statistics were calculated for all the weekdays (Monday to Friday) from March 1st to May 20th, and just for spontaneous traffic jams (not considering traffic jams caused by special or accidental events).

Duration



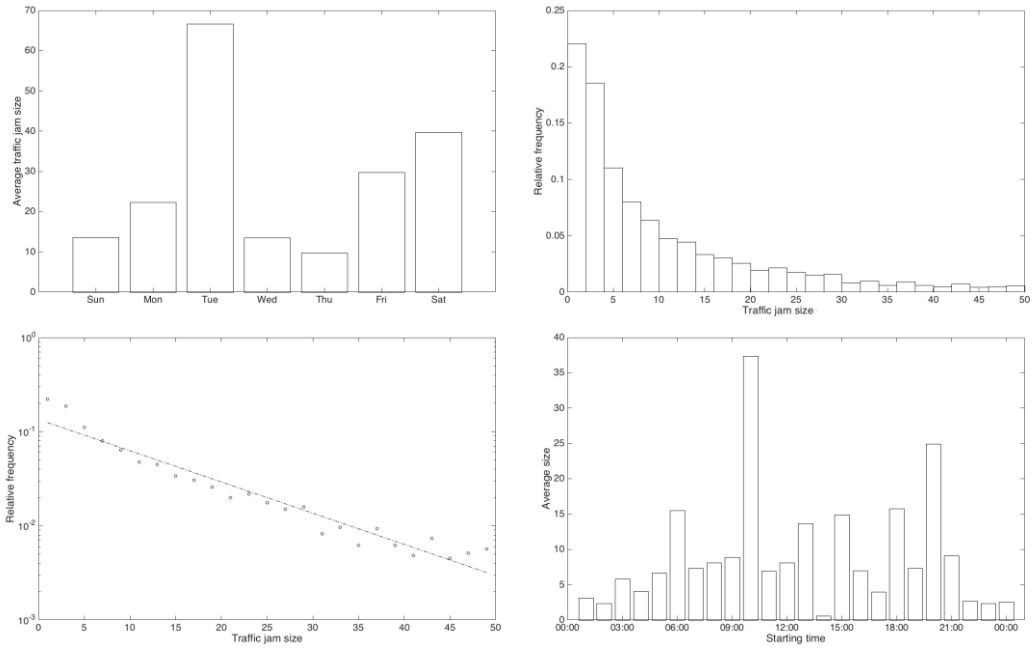
Mean duration is 65.9. We can say that the typical traffic jams have durations of one hour.

Maximum traffic jam intensity

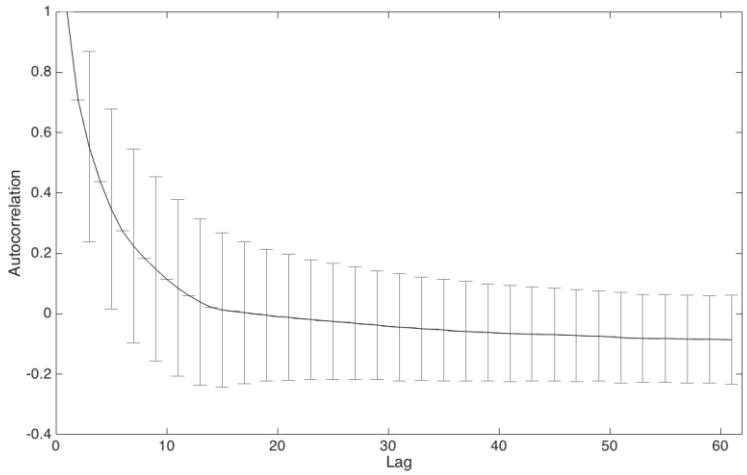


The mean maximum intensity is 28.78.

Size

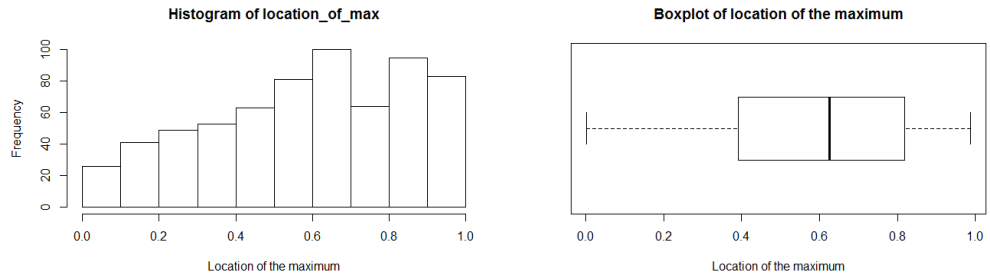


Autocorrelation



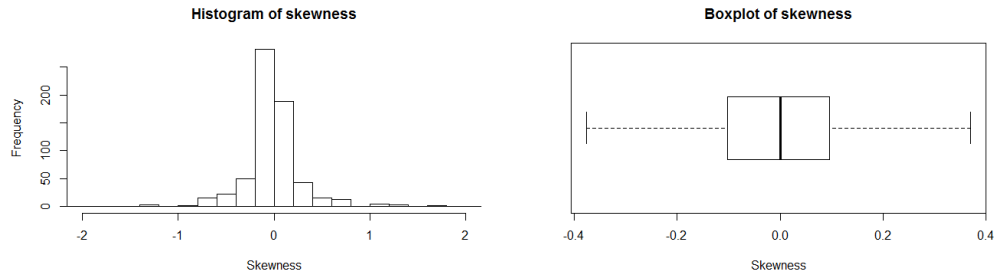
Based on this, we consider that the present and future values of traffic jam intensity depend mostly on the last ten minutes.

Location of the maximum



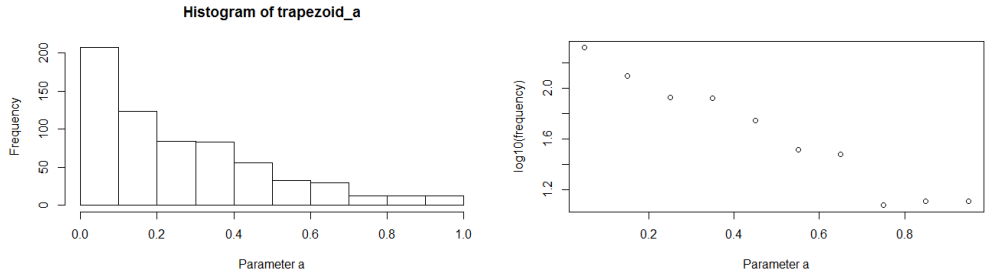
The mean location of the maximum is 0.58 and the median is 0.63.

Skewness



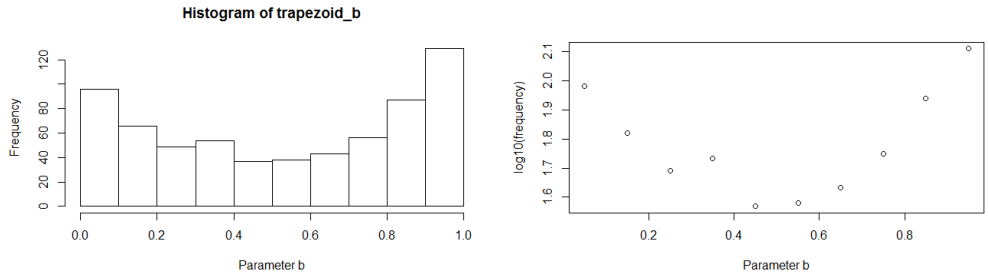
The median and mean of the skewness are very close to zero. This means that the traffic jams tend to be very symmetric.

Trapezoid parameter *a*



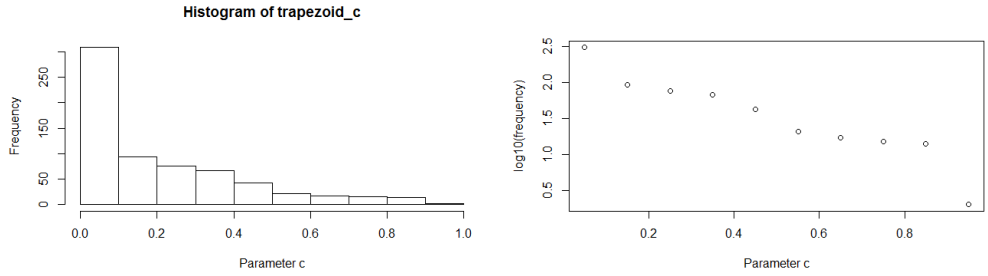
The mean is 0.26 and the median is 0.2.

Trapezoid parameter *b*



It should be noticed that *b* tends to have extreme values (close to zero or to one). This suggests that there might be two types of traffic jams: the ones that have a plateau, and the ones that does not.

Trapezoid parameter *c*



The mean is 0.19 and the median is 0.13. Parameter *c* tends to be smaller than parameter *a*. This suggests that traffic jams tend to take more time to build than to clear up.

Results: statistics per link of the M6

The following are the summary statistics for the M6 links (except link 117011001 that has no traffic jams).

Link ID	Mean Location of Maximum	Mean Skewness	Mean a	Mean b	Mean c
117007703	0.59	-0.022	0.22	0.60	0.17
117008401	0.49	0.270	0.32	0.31	0.37
117012301	0.60	-0.040	0.26	0.52	0.21
117016001	0.59	-0.020	0.32	0.43	0.24
123025901	0.64	-0.830	0.32	0.52	0.16
117007501	0.51	0.068	0.35	0.31	0.33
117012303	0.53	-0.039	0.20	0.58	0.21