Wavelet Augmented Regression Profiling (WARP): improved long-term estimation of travel time series with recurrent congestion

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Long term forecast and Profile Estimation

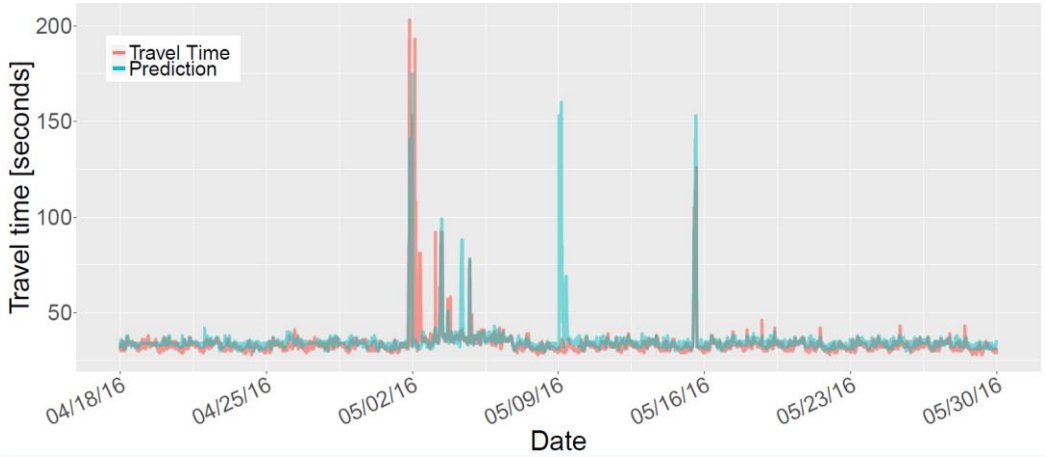
- Aims:
  - Long term estimation of Highway Travel Time from Historical Data
  - Reach best estimate of the underlying true temporal distribution of travel times
  - Use these estimates to forecast a week ahead
- Challenges:
  - Need to classify non-recurrent congestion as noise
  - Need to extract all seasonality
  - Automatically ignore rare events

Site Selection and Rationale

Current Profile Estimates

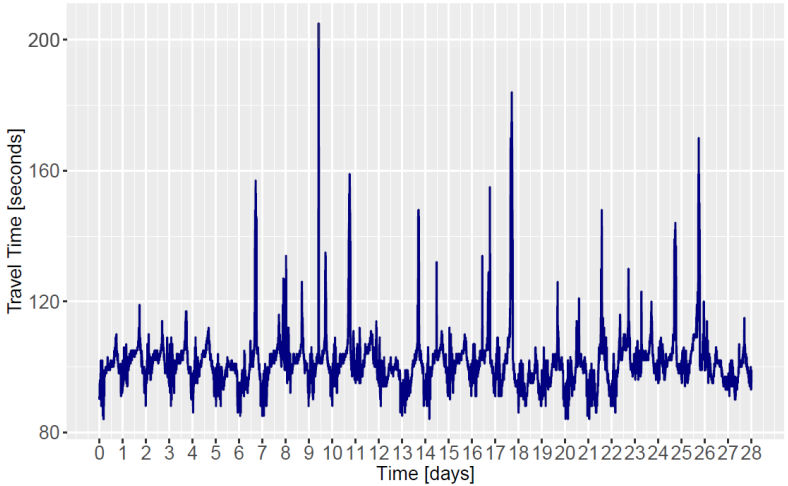
- Uses EWMA + Segmentation
- Can lead to overestimation or repetition of events

$$\hat{x}_i^{d+1} = \alpha * x_i^d + (1 - \alpha) * \hat{x}_i^d$$



Examples of Travel Times

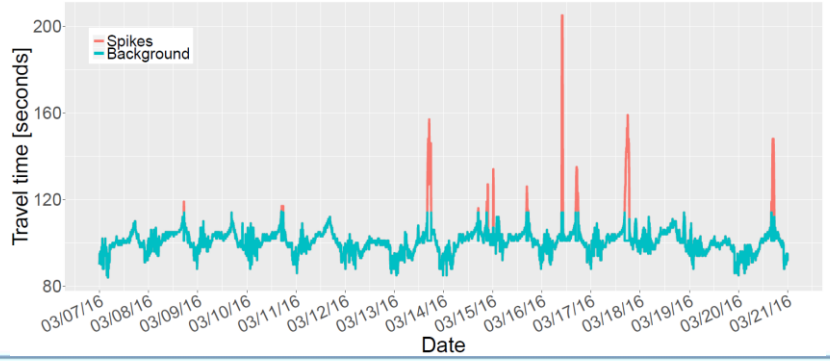
- Each link is the network has assigned a “Traffic Profile” $= \mathbb{E}[\, travel\ time \,] \ \forall\ t$
- Different regimes: Background and Spikes
- Not all spikes contain information about recurring congestion



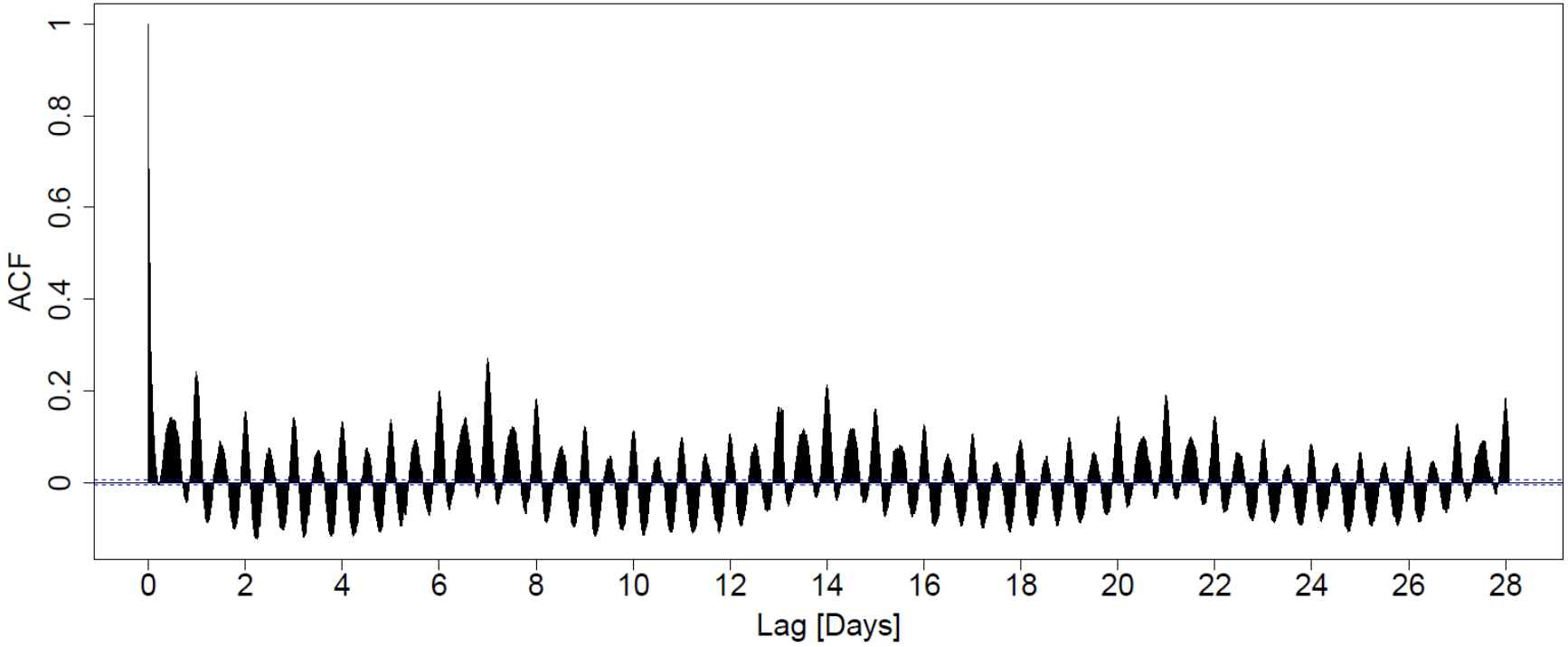
$$Travel\ Time = \ \ Background + Spikes + Noise$$

Travel Time: Components

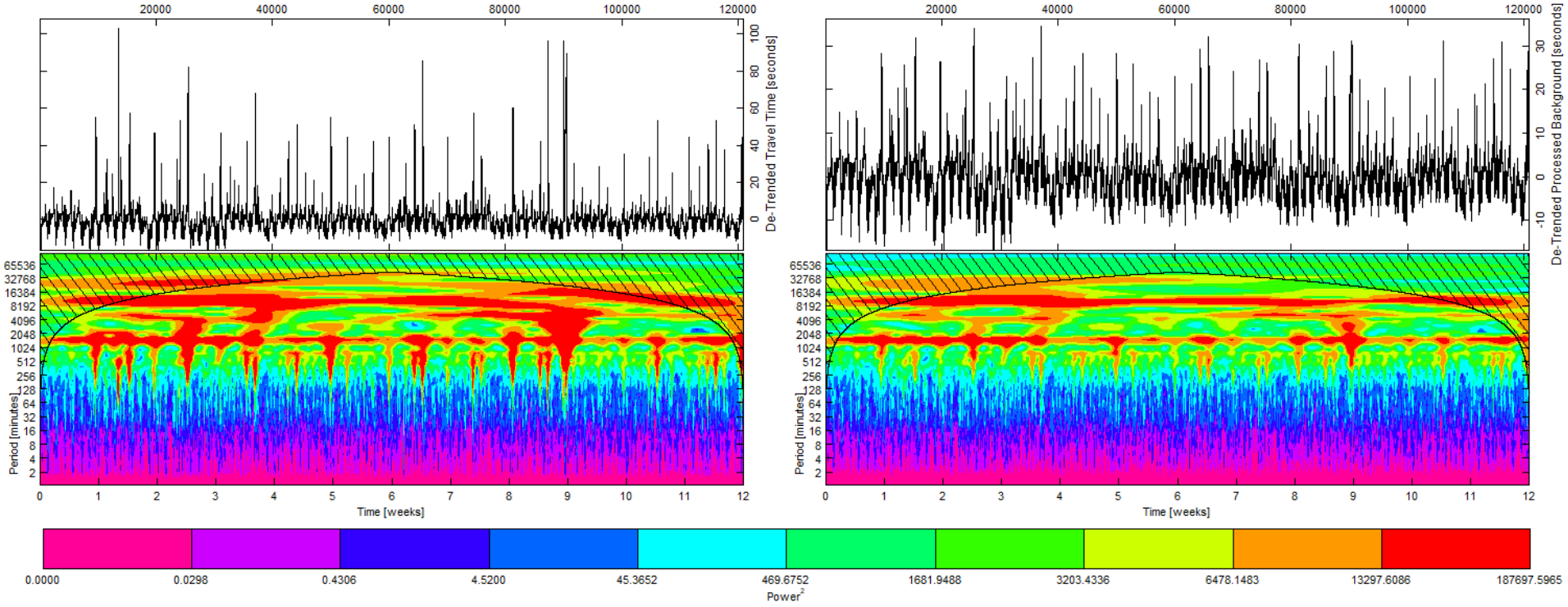
- Background
  - Stable Around Mean
  - High Frequency – Low Amplitude
  - Suitable for Spectral Filtering
- Spikes
  - Zero most of the time
  - Low Frequency – High Amplitude
  - Suitable for Seasonal Analysis



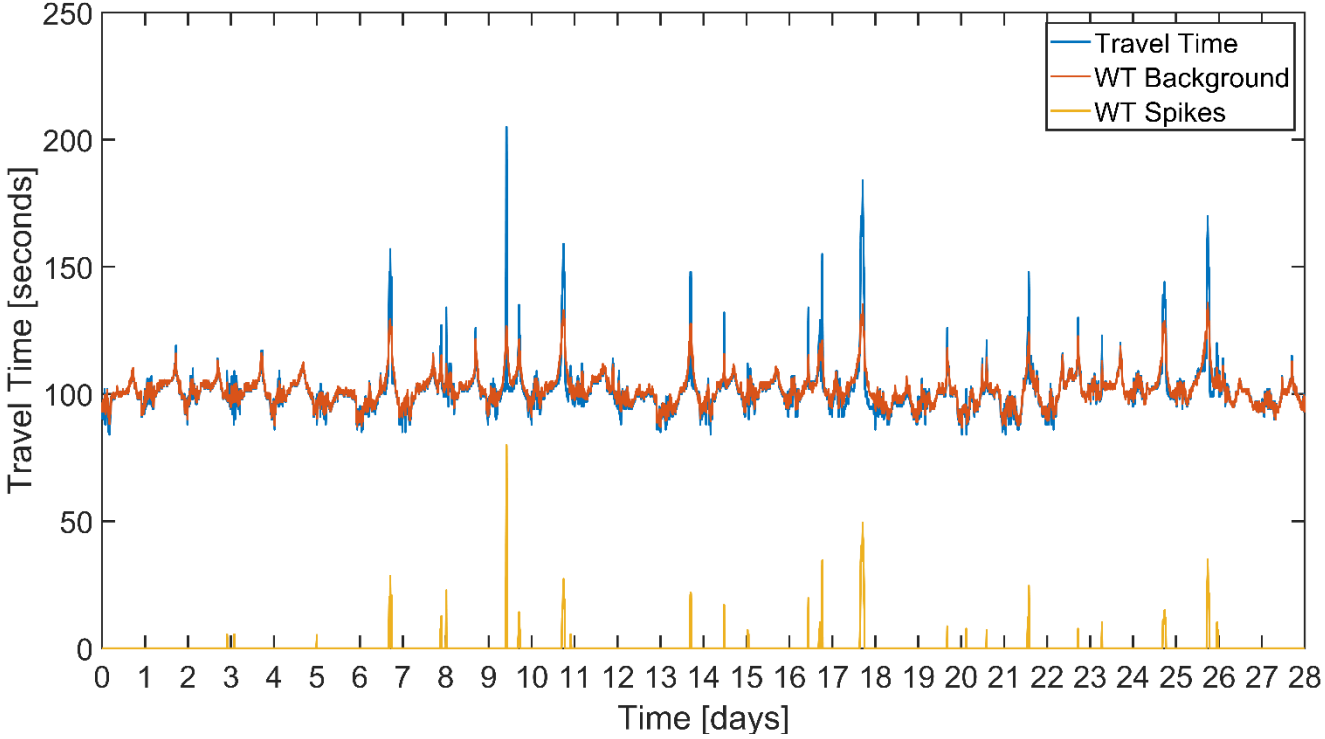
Autocorrelation of travel time series



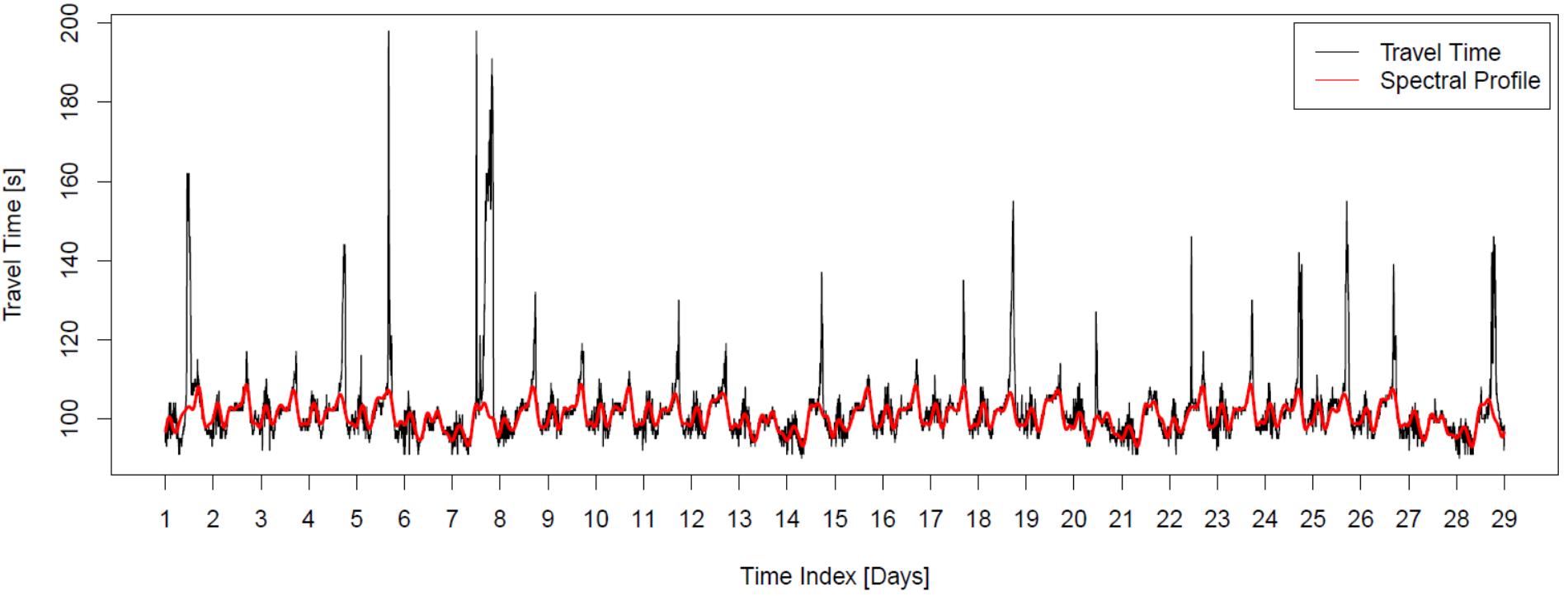
Algorithm: Wavelet based decomposition



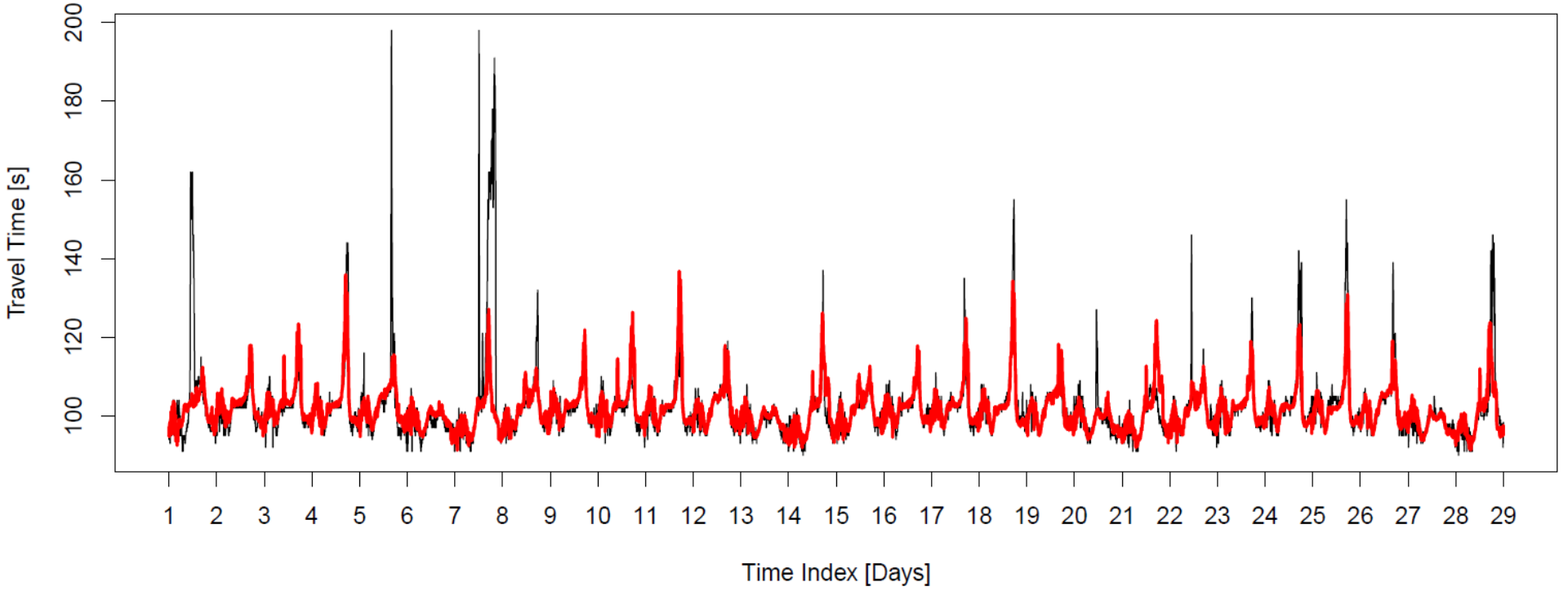
Algorithm: Decomposition



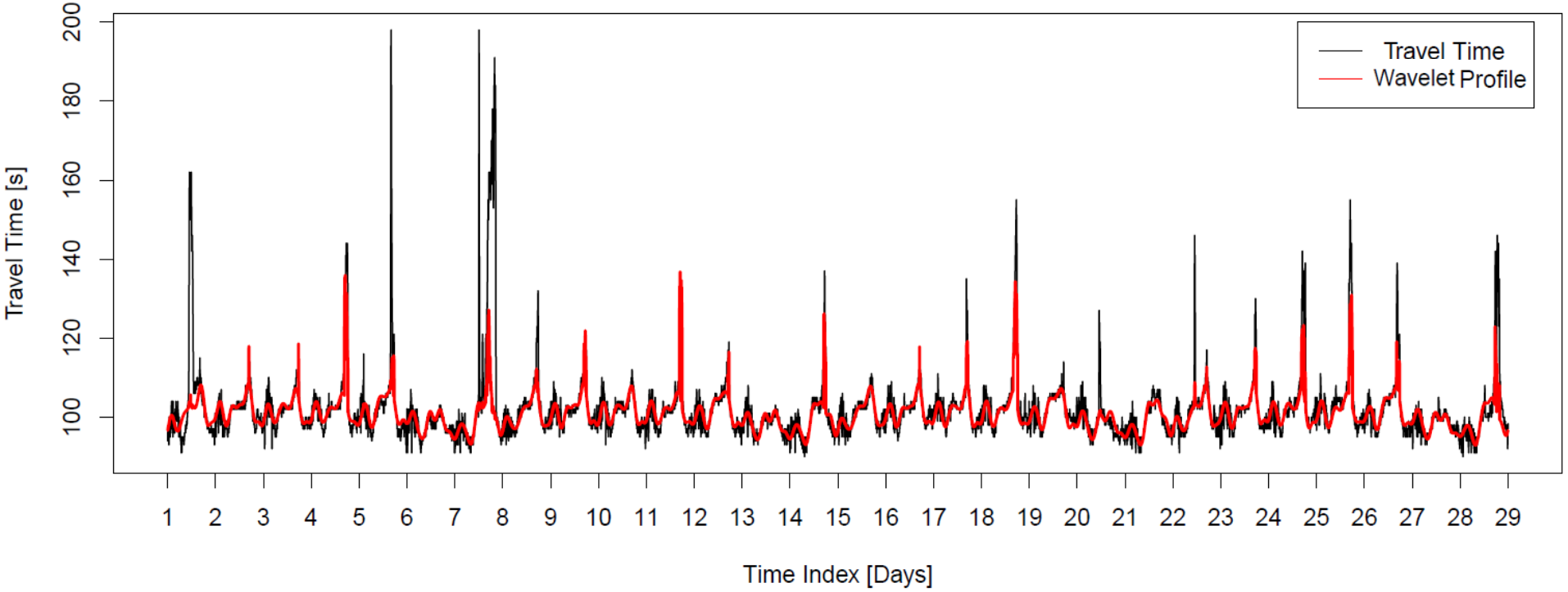
Algorithm: Background Analysis



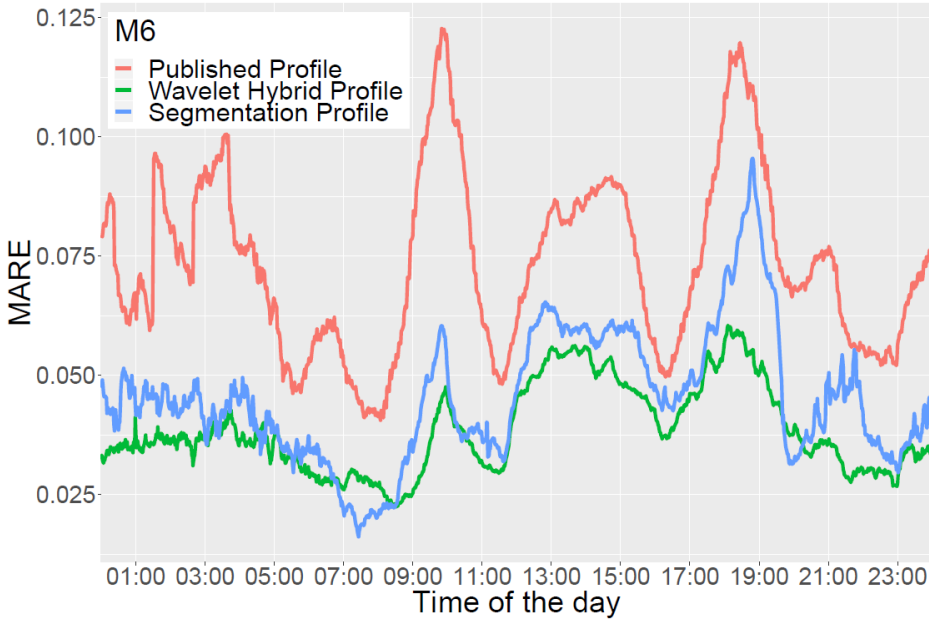
Algorithm: Seasonal Analysis

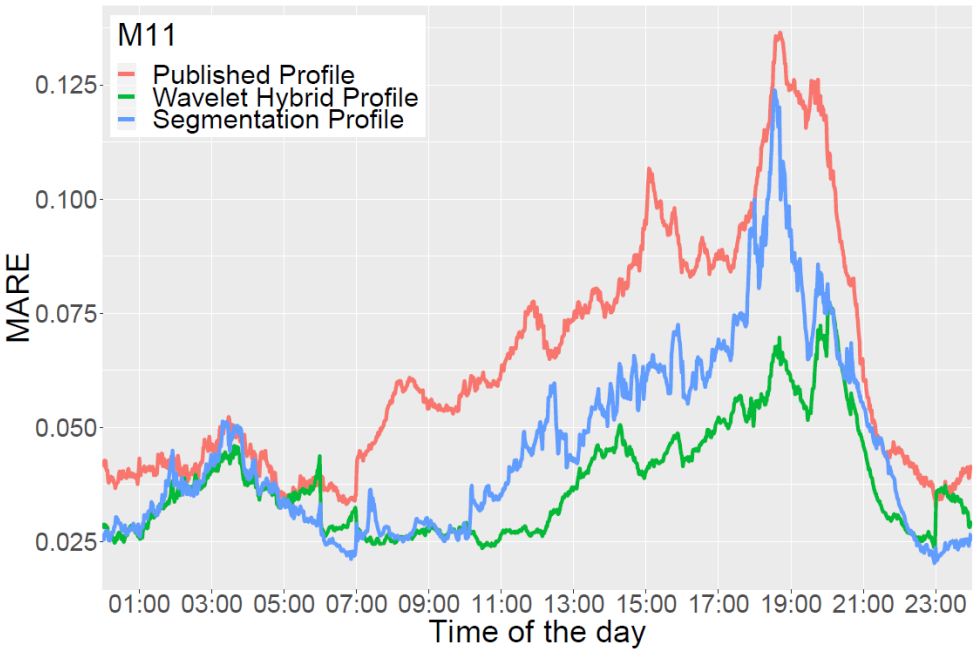


Algorithm: Recombination

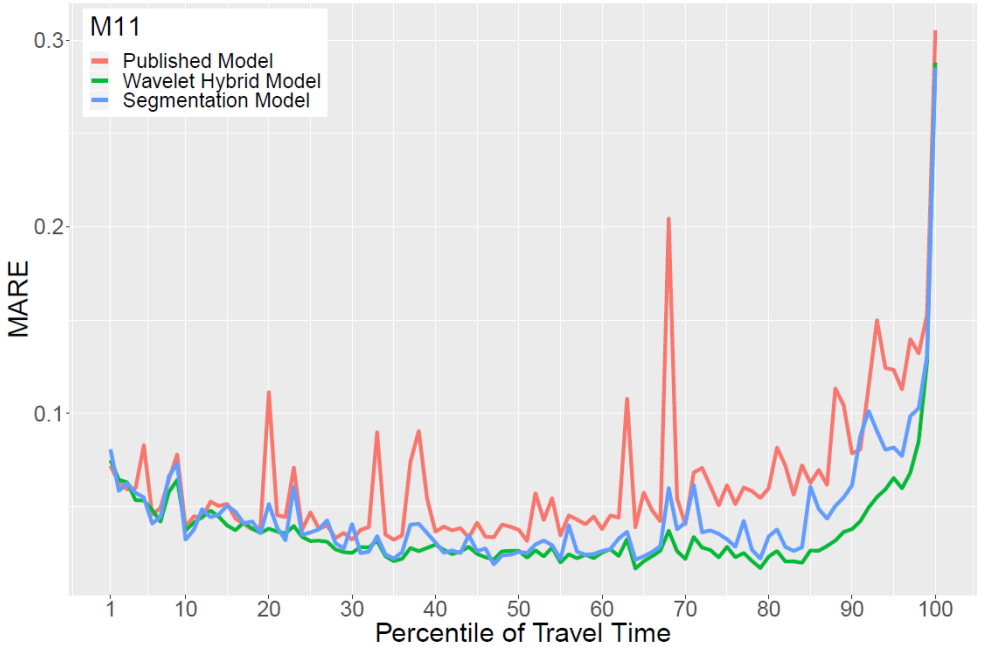


Results – Time of the Day (M6 & M11)





Results – Percentile of Travel Times (M6 & M11)



Results – Mean Absolute Relative Error Distribution

TABLE I: MARE Distribution in M6 prediction

Profile / MARE	$(> -25\%]$	$(-25\%, -15\%]$	$(-15\%, -5\%]$	$(-5\%, 5\%)$	$[5\%, 15\%)$	$[15\%, 25\%)$	$[> 25\%)$
Published M6	1.58	0.54	5.69	56.21	30.79	3.17	2.02
Wavelet M6	1.57	0.51	3.22	81.73	12.14	0.70	0.13

TABLE II: MARE Distribution in M11 prediction

Profile / MARE	$(> -25\%]$	$(-25\%, -15\%]$	$(-15\%, -5\%]$	$(-5\%, 5\%)$	$[5\%, 15\%)$	$[15\%, 25\%)$	$[> 25\%)$
Published M11	0.85	1.15	19.21	62.83	13.21	1.65	1.10
Wavelet M11	0.78	0.32	3.29	81.33	12.47	1.09	0.73

Conclusion and Way Forward

- Achieved:
  - Presented an Algorithm for Profile Generation and Forecasting
  - Based on seasonal variation, frequency smoother and filtering of rare events
  - Much better accuracy than existing estimation methods
  - Ability to distinguish between recurrent and outstanding congestion

- Way Forward:
  - More sophisticated analysis in the Frequency Space
  - Extensions for incident detection
  - Data-guided automatization of the filtering parameter

Thank you!

If you have any questions, please do not hesitate to email:

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