

# Investigating the Empirical Existence of Static User Equilibrium

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# Traffic Modeling : User Equilibrium Frameworks

*Equilibrium frameworks central in Transportation Research since Wardrop [Wardrop, 1952]*

## Various Developments :

- Dynamic Stochastic User Equilibrium [Han, 2003]
- Restricted Stochastic User Equilibrium [Rasmussen et al., 2015] more realistic in alternatives
- Boundedly User Equilibrium [Mahmassani and Chang, 1987]
- Assignment techniques inspired from other fields such as Network Science [Puzis et al., 2013]

# Validation and Practical Use

*Static User Equilibrium lacks empirical validation in the literature*

→ Some examples such as the behavioral study of user route choices (“Wardrop’s first principle”) in [Zhu and Levinson, 2010]

**However still largely used**

→ in theoretical literature, as for example [Leurent and Boujnah, 2014]

→ in real-world application, such as the MODUS model for Parisian region

# Empirical Investigation of SUE Existence

**Research Objective :** *Investigate empirically the spatio-temporal stationarity of flows, combining different complementary quantitative approaches on a concrete dataset*

→ Construction of a real-time dataset for Paris region on 6 month by data crawling

→ Complementarity of approaches (Complex Systems general paradigm) :  
Spatio-temporal data visualization, Network analysis, Spatial analysis

# Dataset Construction

*Difficulty to find Open Data on Transportation Systems*  
*[Bouteiller and Berjoan, 2013]*

→ Construction of an open historical travel time dataset for major links in the region of Paris, collecting in real time public traffic data from `www.sytadin.fr`

**Data collection :** Each two minutes, automated python script

- fetch raw webpage giving traffic information
- parse html code
- insert all links in a sqlite database with the current timestamp.

*Openly available (CC Licence) at*

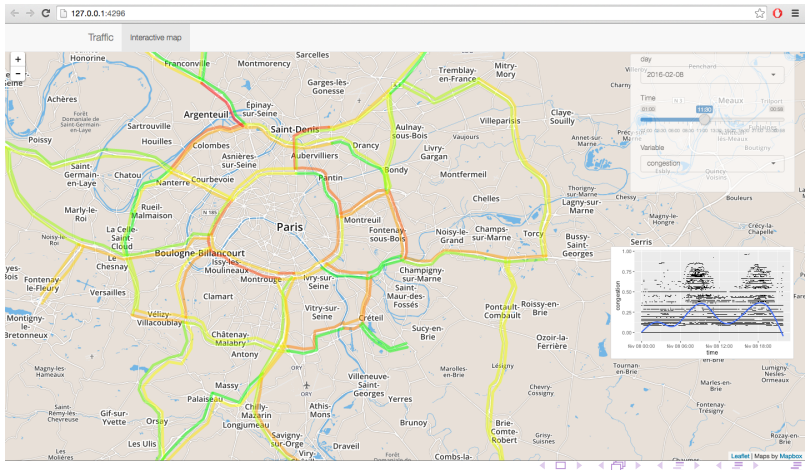
`http://37.187.242.99/files/public/sytadin_latest.sqlite3`

**Data summary :** 10 month (since Feb. 2016), 2min time granularity, effective travel time for 101 links ( $\simeq$  10km spatial granularity)

# Interactive Data Visualization

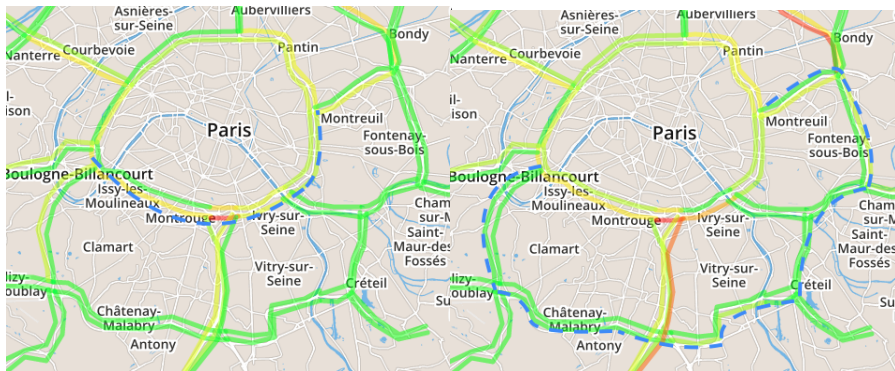
*Interactive web-application for spatio-temporal exploration*

<http://shiny.parisgeo.cnrs.fr/transportation>



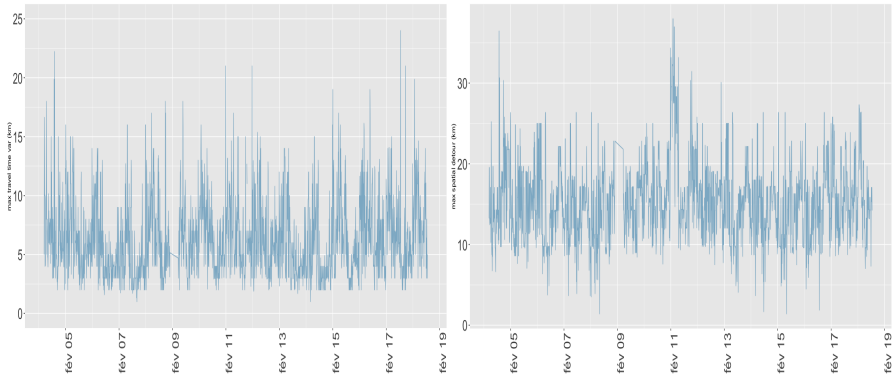
# Spatio-temporal Variability : Example

*Very high spatial variability on 10min time interval, here on 11/02/2016  
00:06*



# Spatio-temporal Variability

*Maximal travel time and spatial variabilities on a two week sample*





# Stability of Network Measures

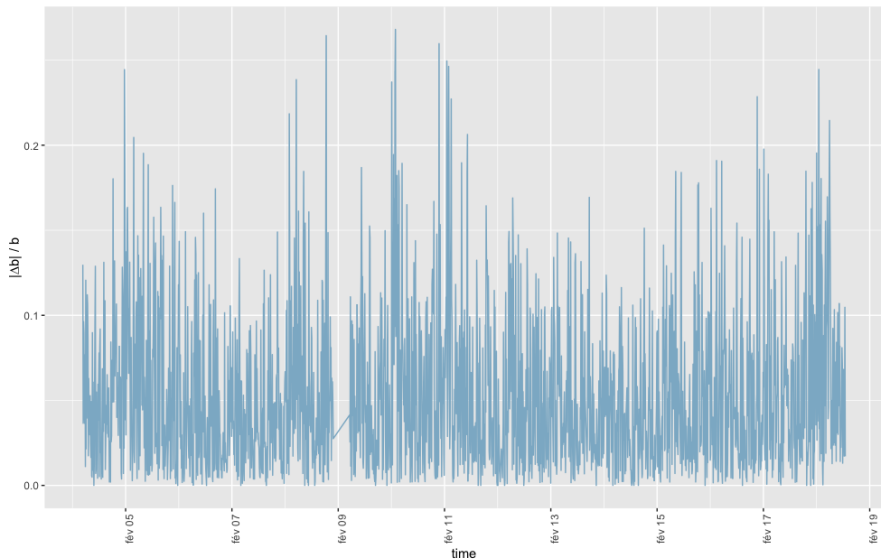
## Network Betweenness Centrality

$$b_i = \frac{1}{N(N-1)} \cdot \sum_{o \neq d \in V} \mathbb{1}_{i \in p(o \rightarrow d)} \quad (1)$$

## Variability

$$\Delta b(t) = \frac{|\max_i(b_i(t + \Delta t)) - \max_i(b_i(t))|}{\max_i(b_i(t))} \quad (2)$$

# Stability of Network Measures



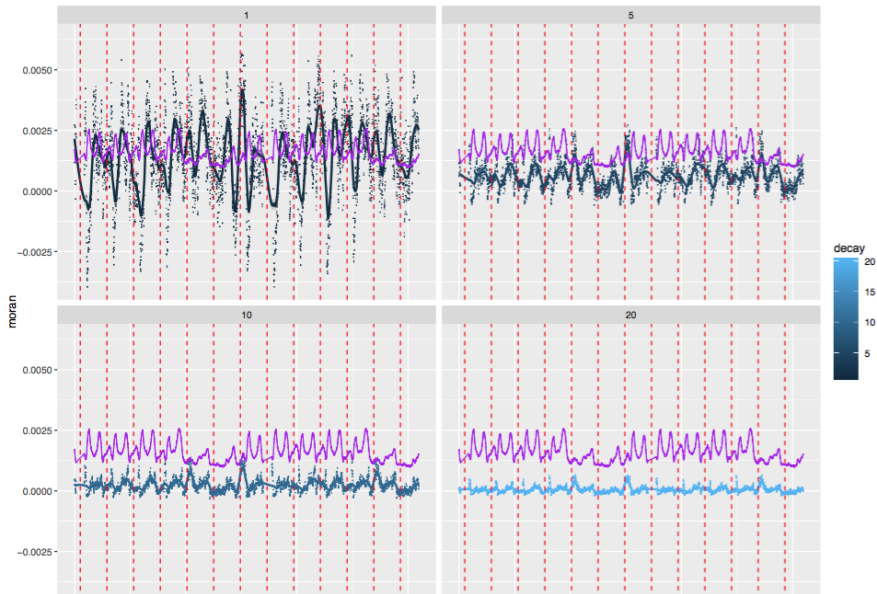
# Spatial Heterogeneity

Spatial Autocorrelation as an index of spatial variability

$$\rho_i = \frac{1}{K} \cdot \sum_{i \neq j} w_{ij} \cdot (c_i - \bar{c})(c_j - \bar{c}) \quad (3)$$

with weights  $w_{ij} = \exp\left(\frac{-d_{ij}}{d_0}\right)$

# Spatial Heterogeneity



# Theoretical and Practical Implications

## Theoretical Implications

- Need for more systematic comparison of framework validity : multi-modeling. [Kryvobokov et al., 2013] compares two LUTI models
- Can still be used e.g. for integration within more complex models

## Practical Implications

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# Explanative Interpretations

# Possible Developments

# Conclusion



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