MINES
Saint-Étienne

Une école de l'IMT

COPIL Tableau de Bord (CHU 42)

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19/10/2023

INSPIRING
INNOVATION
SINCE 1816

Tableau de Bord (CHU 42)

Objectif: Prédiction de la charge de patients en temps réel pour permettre d'anticiper au mieux les pics d'activités au service des urgences du CHU 42

Données mise à jour toutes les 10 minutes:

- Date entrée
- Sortie rapide : distinction passage / admission
- Date de sortie (NA si le patient est toujours présent)
- Secteur : UF (Unité Fonctionnelle) ; UFR (Fonctionnelle Rapide) ; UG (Grave)

Historique de données disponibles: 3 avril 2020 – aujourd'hui

Historique de données utilisables: 1 avril 2022 – aujourd'hui

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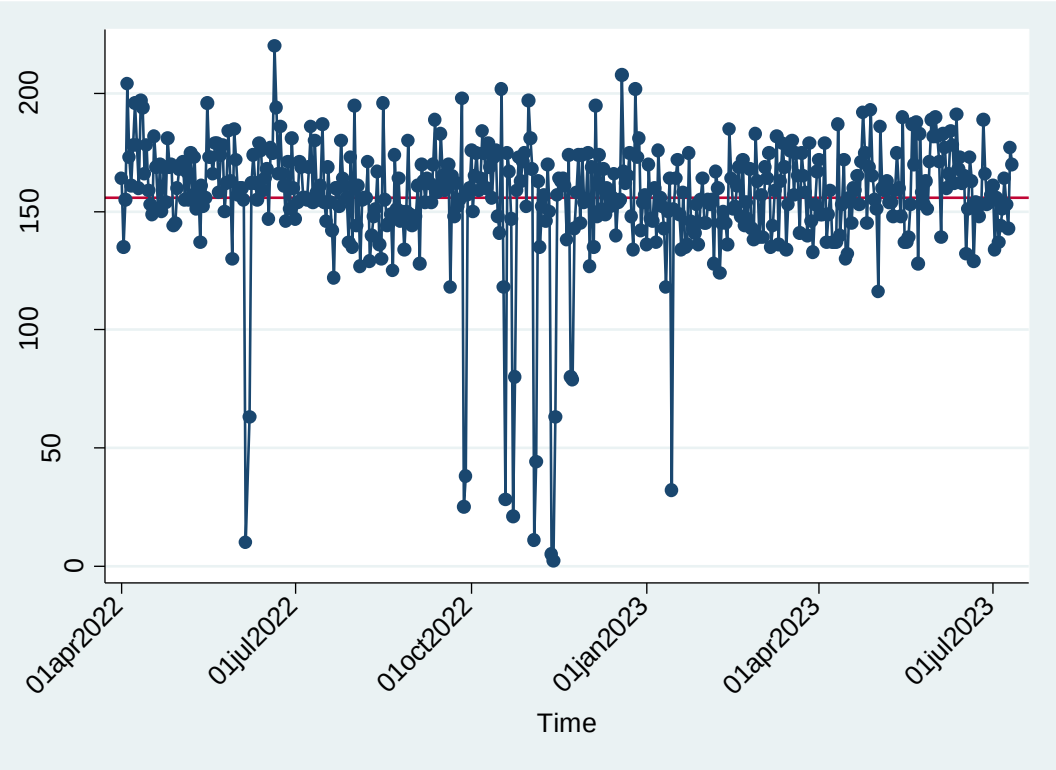
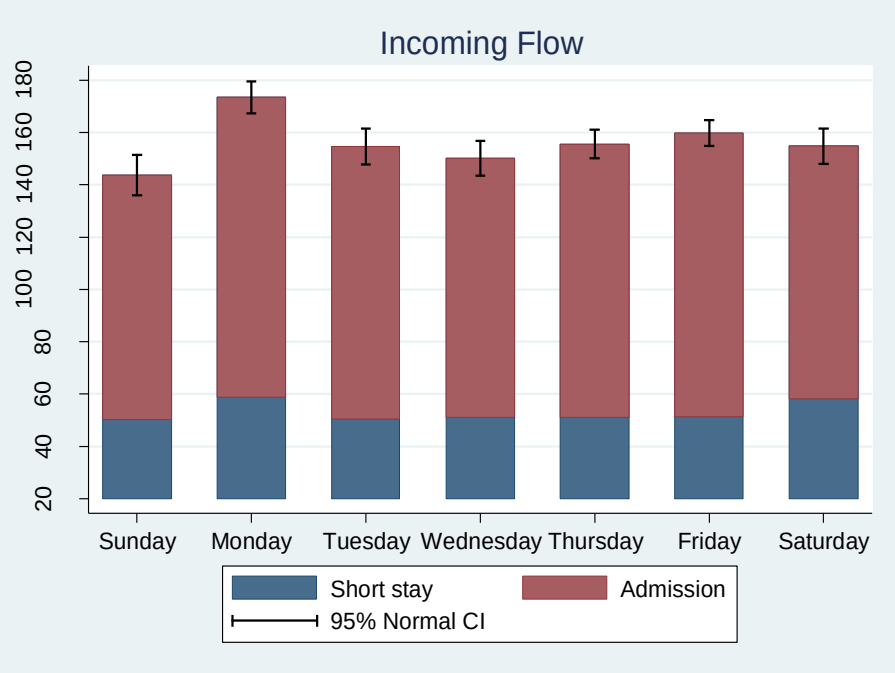
Daily incoming flow at the ED (mean=156.03)

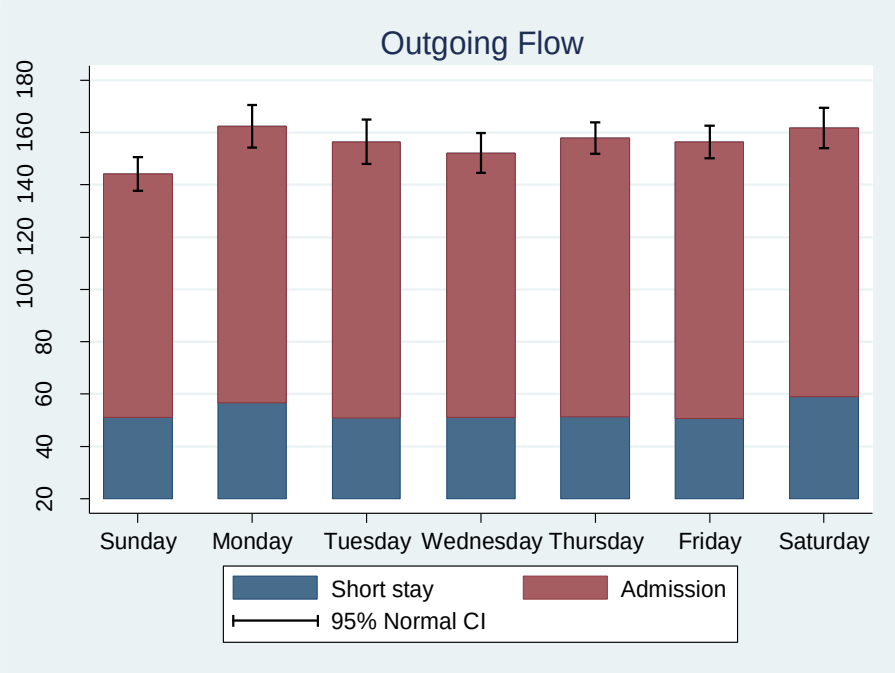


Study period: 01/04/2020 – 11/07/2023

Daily Incoming Flow



Daily Outgoing Flow



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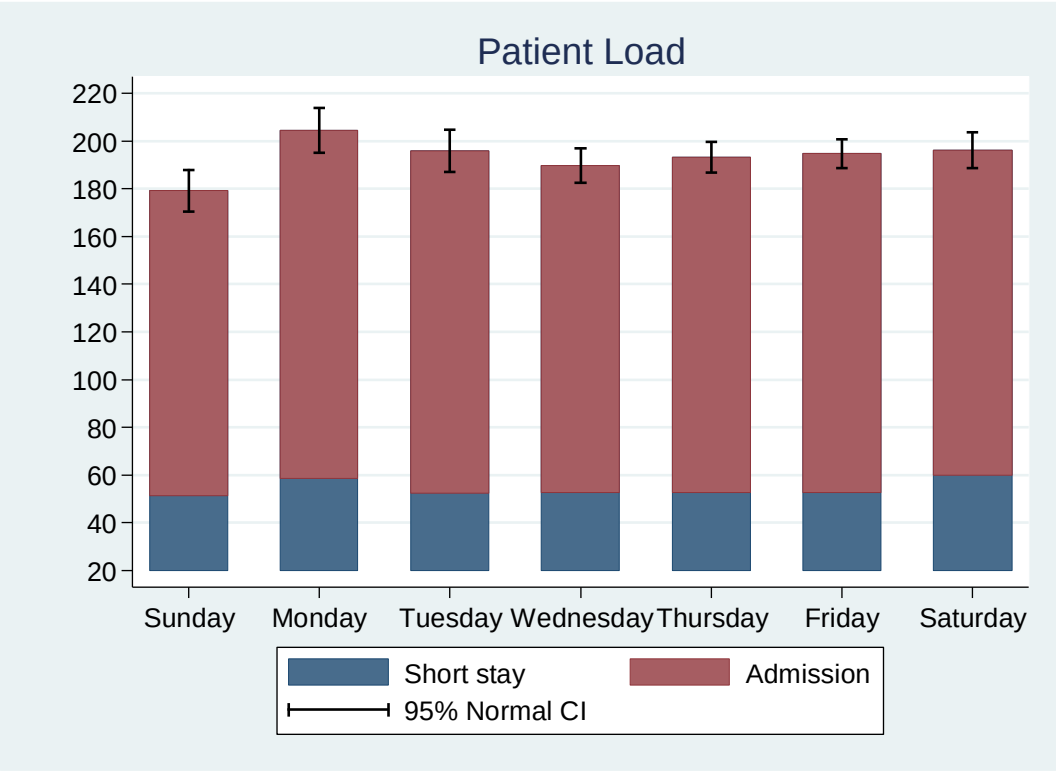
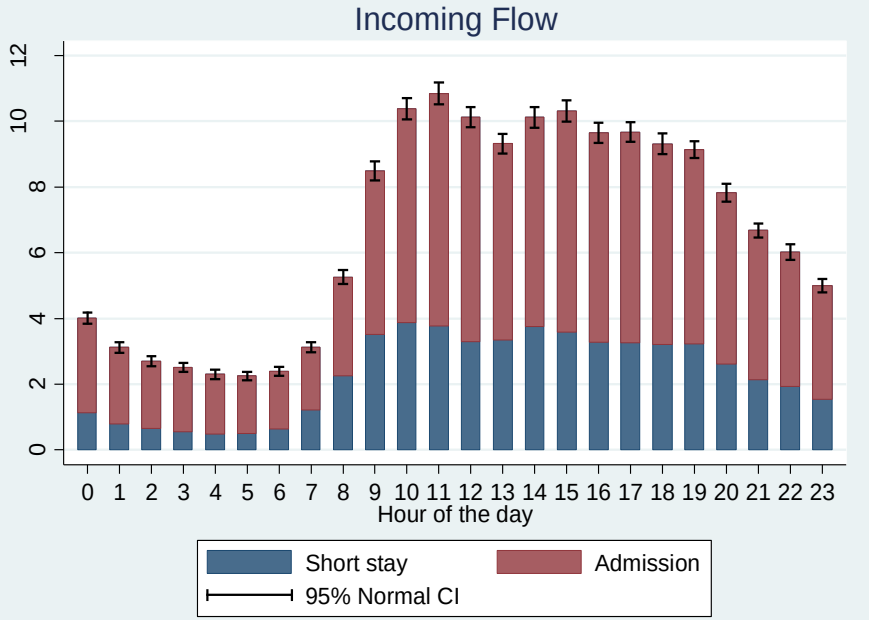
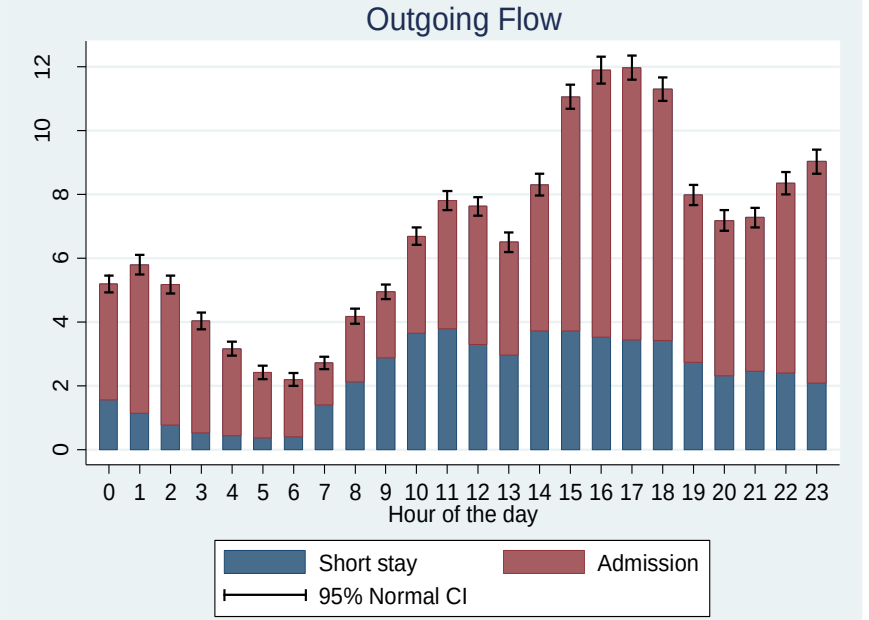
Daily Patient Loads



Hourly Incoming Flow



Hourly Outgoing Flow



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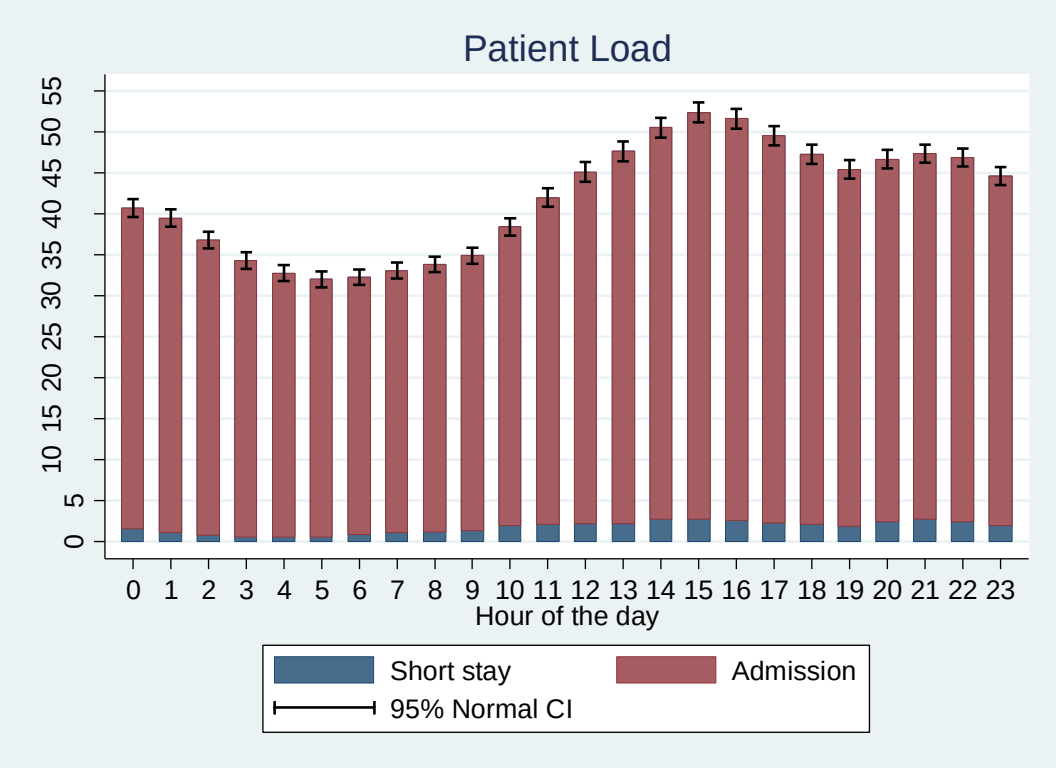
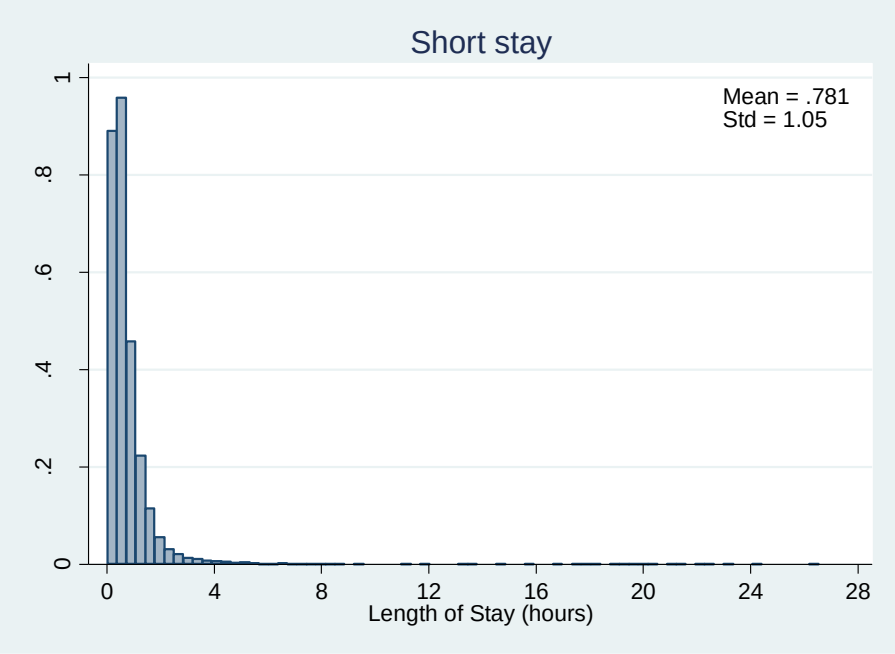
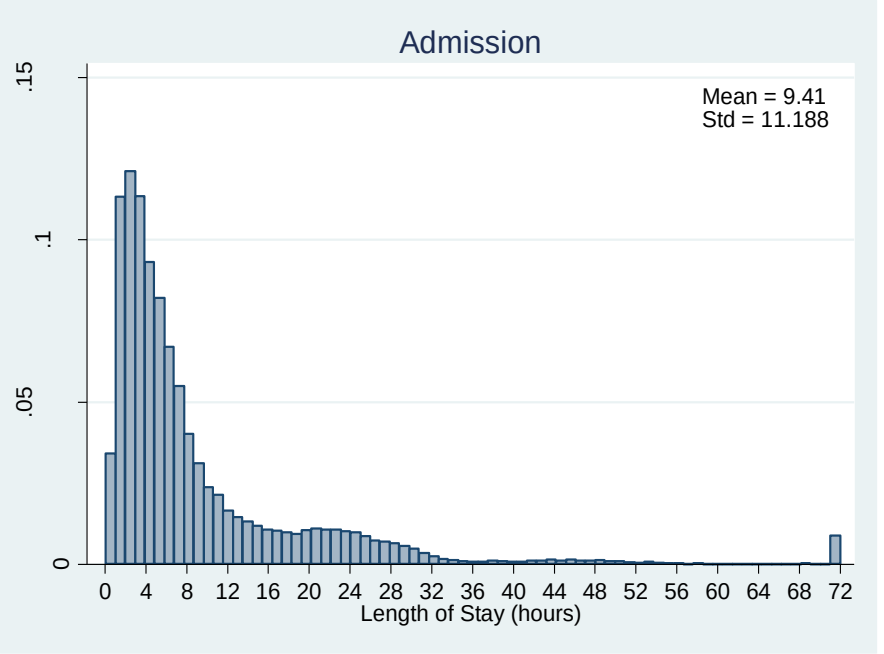
Hourly Patient Loads

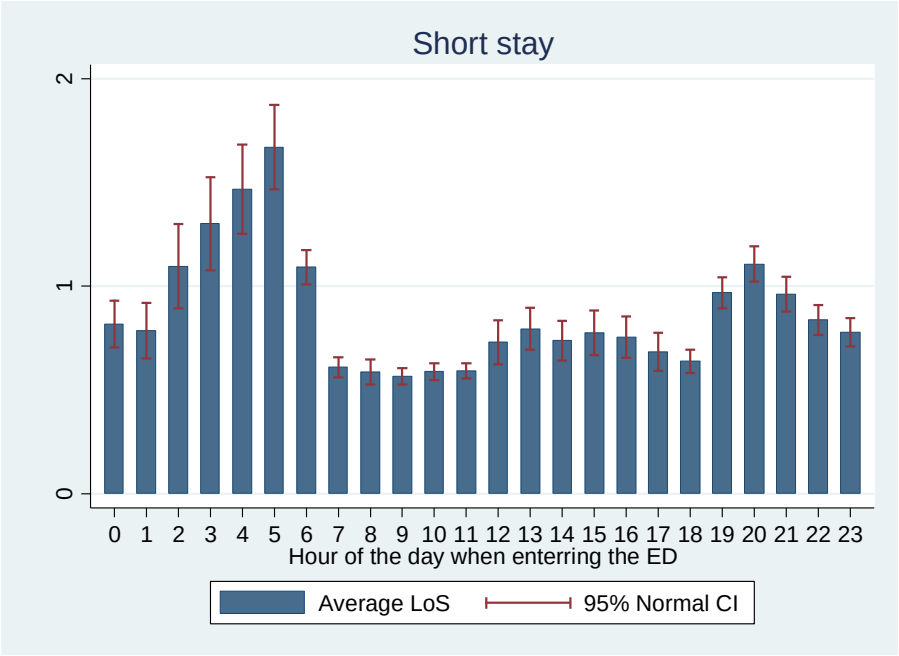


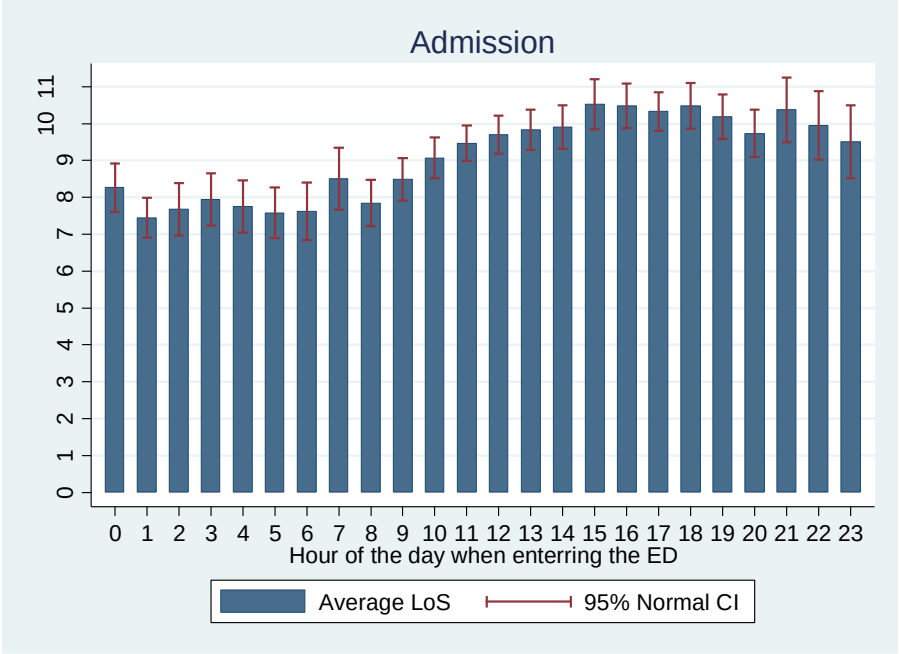
Histogram LoS





LoS vs arrival hour





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Fixed effect algorithm (linear)

Model: Dynamic Linear Regression with lags and seasonal features for hour of the day and day of the week.

$$y_t = \alpha + \beta_1 * y_{t-1} + \beta_2 * y_{t-168} + \sum_{h=0}^{h=22} \gamma_h * 1_{\{hour_t = h\}} + \sum_{d=Mon}^{d=Sat} \theta_d * 1_{\{day_t = d\}} + \epsilon_t$$

Error statistics (computed on 9h-15h only, in a real time fashion):

	Total		UF		UG		UFR	Short Stay
	MAE	MAPE	MAE	MAPE	MAE	MAPE	MAE	MAE
t + 1 hour	2.90	6.94%	1.56	8.11%	1.29	7.53%	1.08	1.40
t + 4 hours	5.78	12.27%	3.29	15.41%	2.79	14.47%	1.98	1.66
t + 24 hours	7.93	21.86%	4.21	24.63%	4.02	26.62%	1.64	1.43
t + 48 hours	8.64	24.07%	4.54	26.62%	4.35	29.60%	1.64	1.43
t + 72 hours	9.31	25.82%	4.75	27.91%	4.56	31.25%	1.67	1.47
Average hourly flow	44.94		20.84		19.11		3.33	2.19

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Automatic detection of outliers

Inter-Quartile Range (IQR) method:

- Value x is an outlier if $x < Q1 - 1.5*(Q3-Q1)$ or $x > Q3 + 1.5*(Q3-Q1)$

In our case, we can stratify the IQR method by hour of the day and day of the week, to improve the detection of outliers.

- By doing so, we identify **10 outliers** (0.22%)
- Prediction error for outliers : **MAPE = 16.32%**

Since outliers are only detected **after their occurrence,** we could add a flag indicating that the previous observation was (likely to be) an outlier.

- And in these situation **discard the accuracy rate**

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Alternative time series models

ARIMA, ARIMAX, SARIMA, SARIMAX: they all require a stationary process, or at least a transformation of the time series to make it stationary (differencing).

$$y_t = c + \sum_{n=1}^{p} \alpha_n y_{t-n} + \sum_{n=1}^{q} \theta_n \epsilon_{t-n} + \sum_{n=1}^{P} \phi_n y_{t-sn} + \sum_{n=1}^{Q} \eta_n \epsilon_{t-sn} + \epsilon_t$$

ARIMA

SARIMA

Augmented Dickey-Fuller test: The null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process.

- P-value < 0.001 for all series (Total, UF, UFR, UG, Short Stay), meaning they are all **stationary processes**.

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Alternative time series models

	Fixed effect (linear)	SARIMAX	SARIMAX	ARIMAX	ARIMAX
$(p,d,q)(P,D,Q)_s$	-	$(1,0,1)(1,0,1)_{24}$	$(1,1,1)(1,0,1)_{24}$	(1,0,1)	(1,1,1)
Differencing	No	No	Yes	No	Yes
Fixed effect	Days and hours	Days	Days	Days and hours	Days and hours
MAPE (t+1)	6.94%	7.02%	Fail to converge	6.96%	6.88%
MAPE (t+4)	12.27%	12.54%		12.27%	12.26%
MAPE (t+24)	21.86%	22.95%		22.15%	22.55%
MAPE (t+48)	24.07%	25.59%		24.47%	26.54%
MAPE (t+72)	25.82%	26.26%		24.98%	28.37%