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GENERATION OF DAILY LOAD TYPOLOGY FOR DISTRICT HEATING SIMULATION AND OPTIMISATION

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IMT-Atlantique - DSEE / GEPEA - OSE

Copenhague, September 9th 2019

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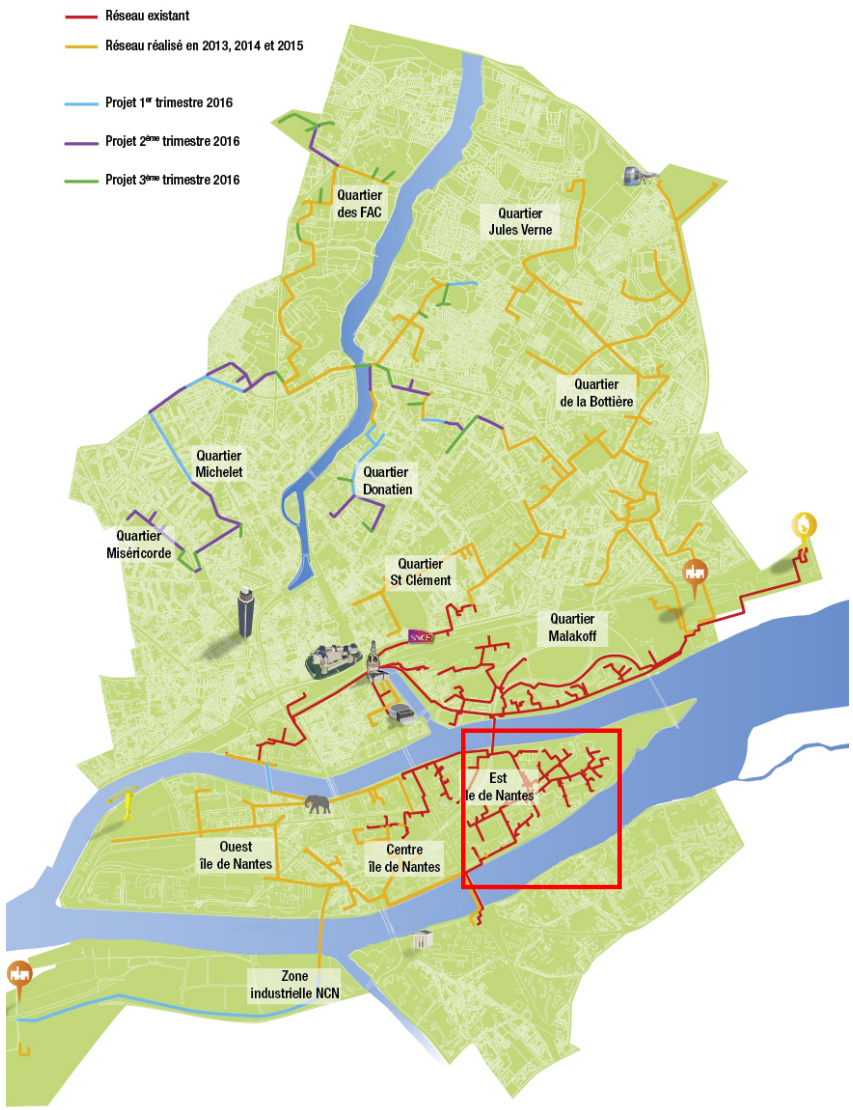
- 85 km of pipes
- Multi-sources (2 sites, 8 production units)
- 360 substations (16000 dwellings - sport, health & public facilities ...)
- 84 % from RES & R

→ Focus on a specific part :

- Connected through a heat exchanger
- 37 Substations



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Combining data from monitoring and DH modelling :

1. Characterisation of the DH (inverse methods)
   - Heat loss coefficient
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2. Optimisations :
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   - Control laws of the secondary side
   - Supply temperature in the network

Iterative methods : gradient methods or metaheuristics

0.5 [s/simu] $\times$ 10 [it] $\times$ 24 [hours] $\times$ 365 [days] $=$ **12 h** [of simulation]

Need of reducing computational costs

➙ Simulations from Typical Days (TD) instead of a whole Time Series (TS) ?
For what impact on results ?

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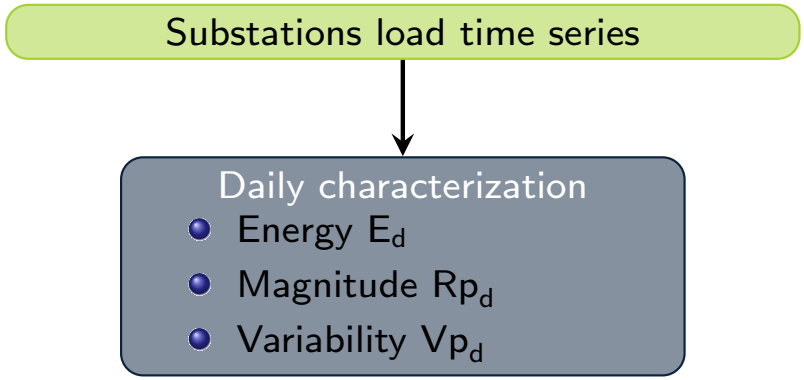
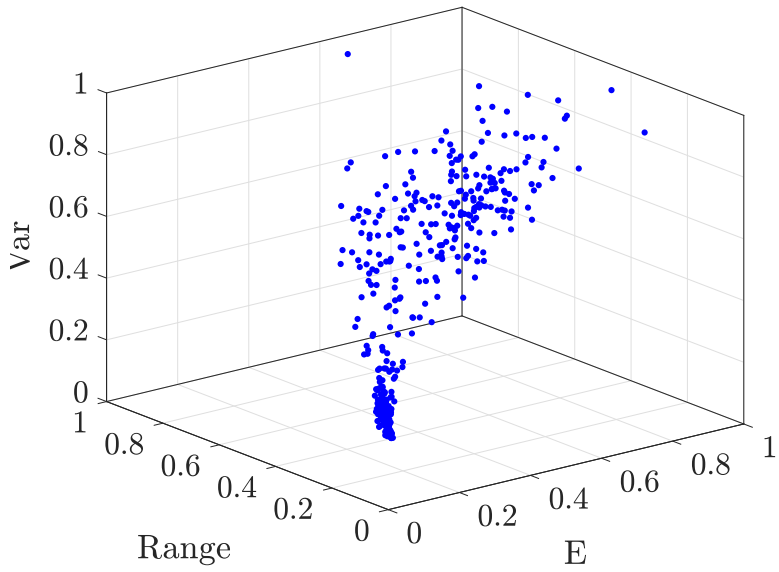


$$E_d = \sum_{ss=1}^{N_{ss}} \sum_{h=1}^{24} P_d(ss,h)$$

$$Rp_d = \max_h \left(\sum_{ss=1}^{N_{ss}} P_d(ss,h) \right) - \min_h \left(\sum_{ss=1}^{N_{ss}} P_d(ss,h) \right)$$

$$Vp_d = \sum_{ss=1}^{N_{ss}} \sum_{h=1}^{24} \left| \frac{dP_d(ss,h)}{dt} \right|$$



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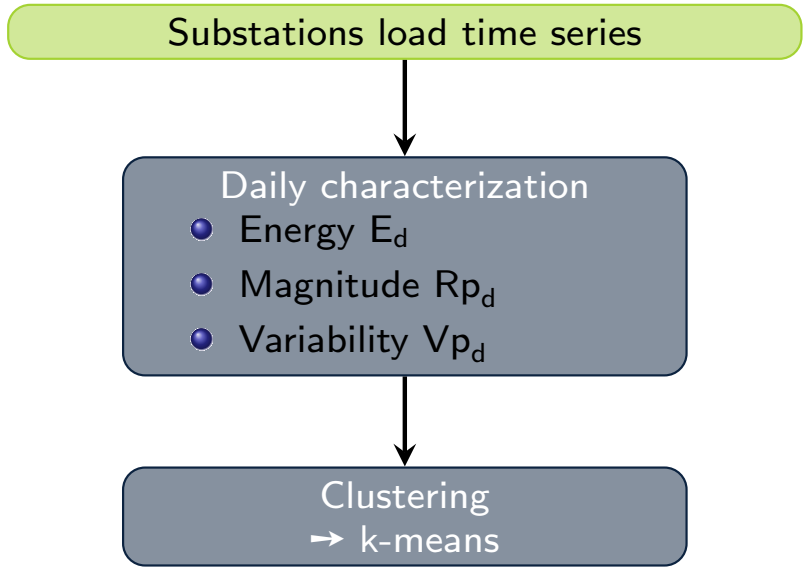

K ?

- Dense and distant clusters
- Similarity between days

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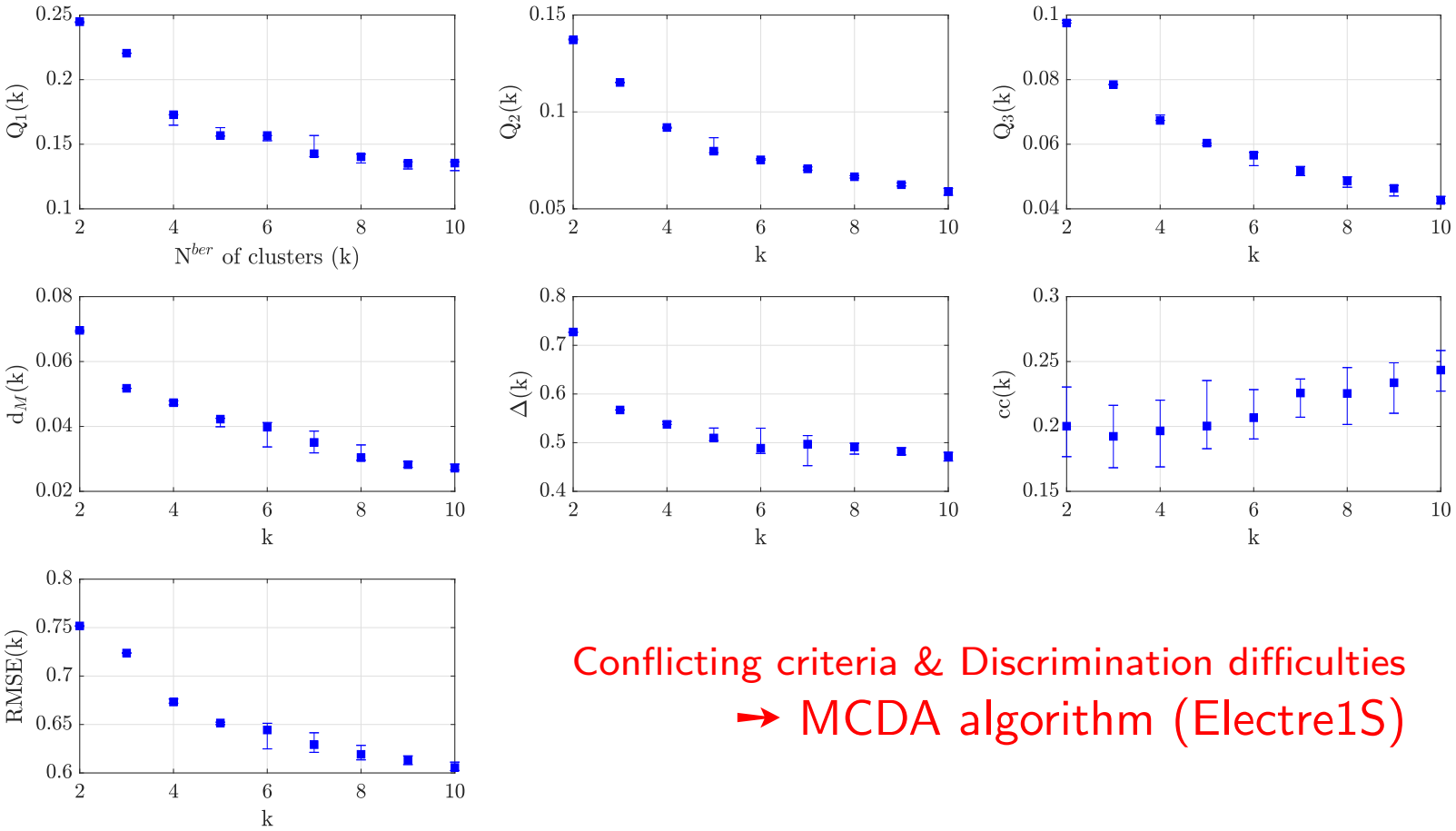
Clustering Evaluations

- $(Q_i(d))_{i\in[1,3]}$ & $d_M = \max(d)$: intra-clusters distances (to be minimized)
- $\Delta_m = \min(\Delta)$: inter-cluster distances (to be maximized)
- $cc = \min_j (R^2)$ and RMSE : days cross-correlation & differences (resp. maximized and minimized)



Conflicting criteria & Discrimination difficulties
➔ MCDA algorithm (Electre1S)

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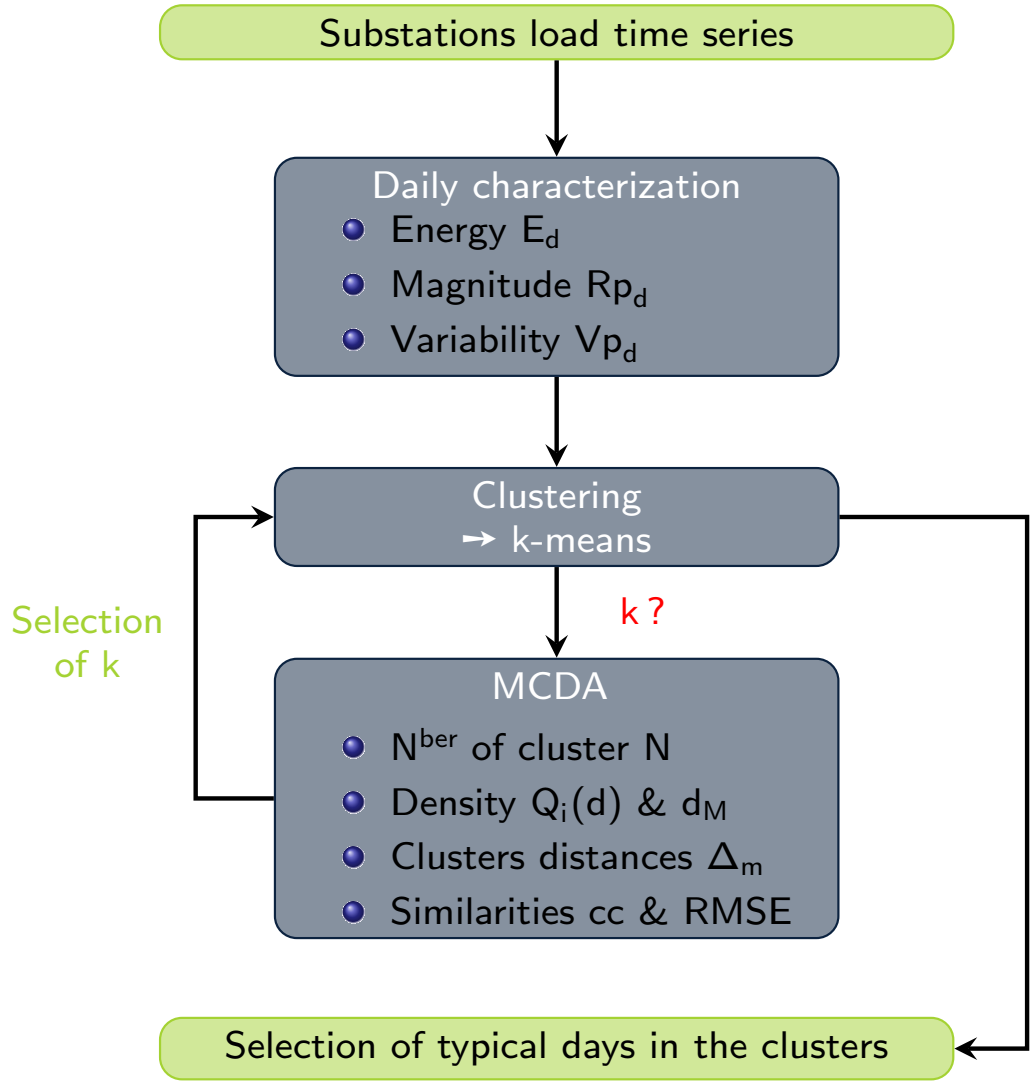
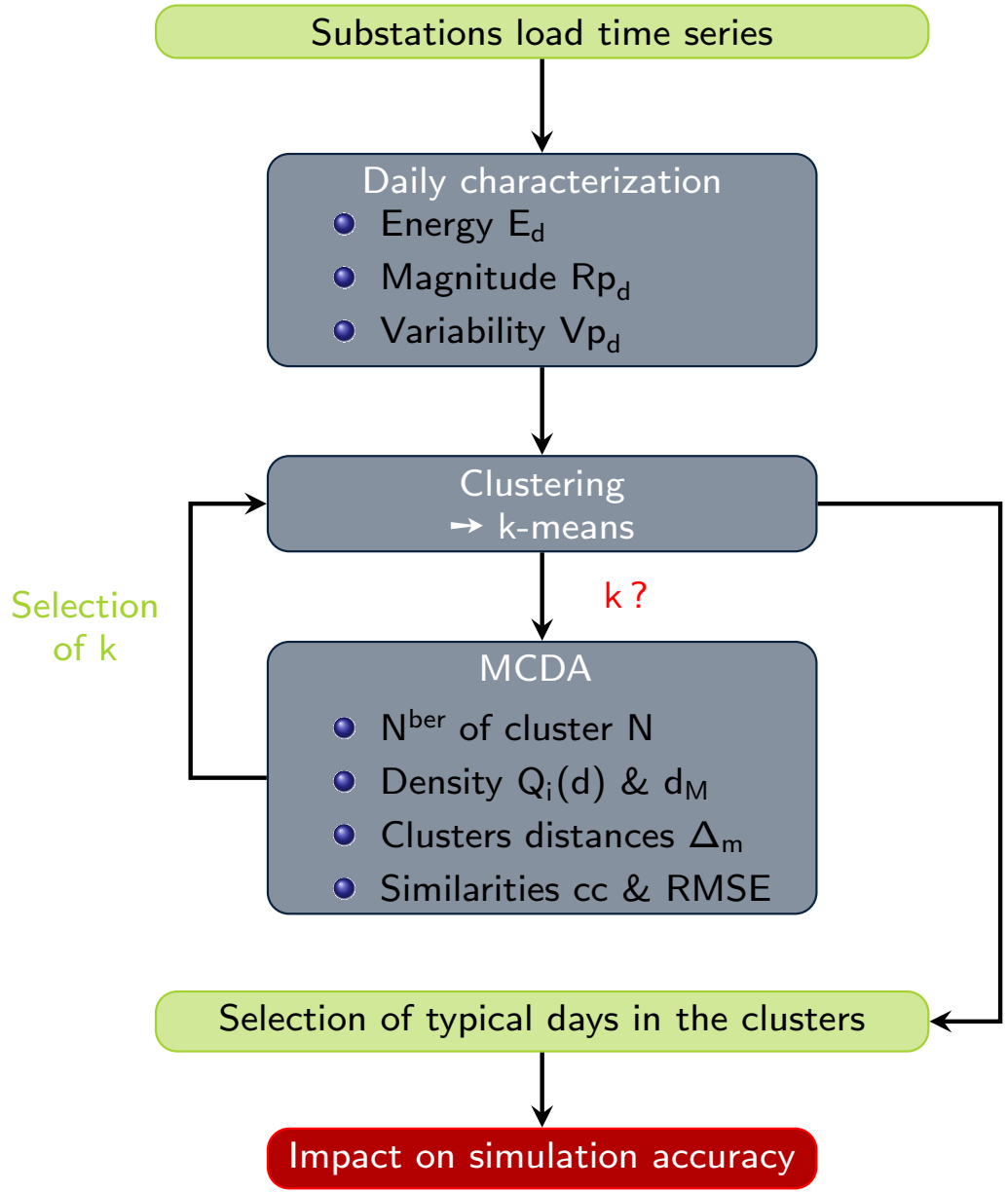


⚠ Selection among the days in the cluster
➙ Possibility characterize the typical day with other variables (T_{out} etc.)

Typology methodology
MCDA



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Results
Typical days characterisation

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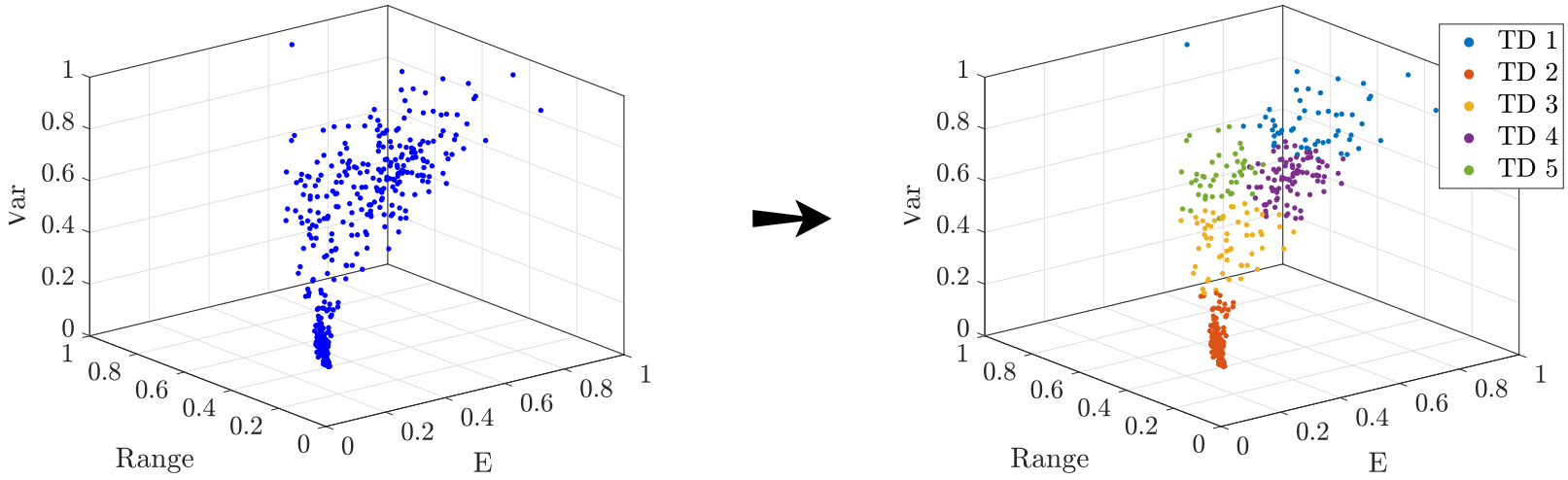

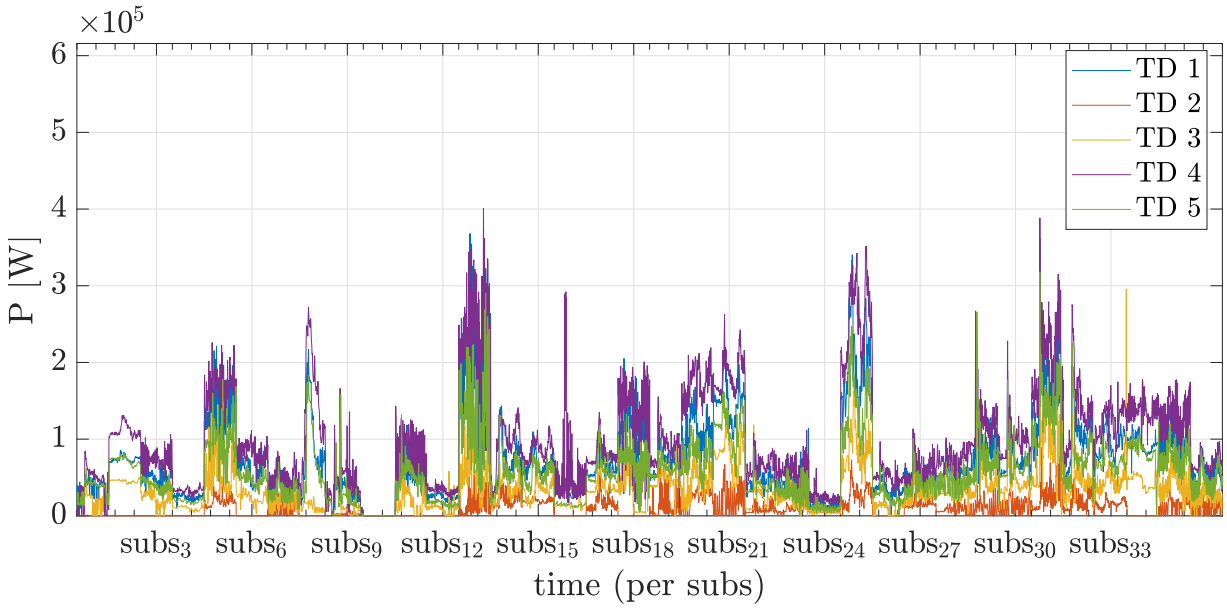

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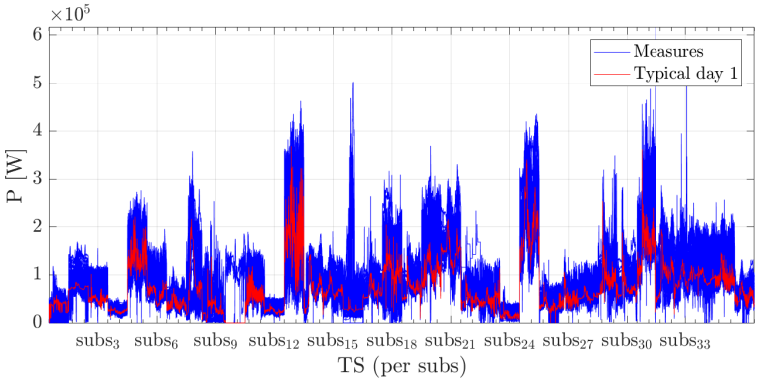

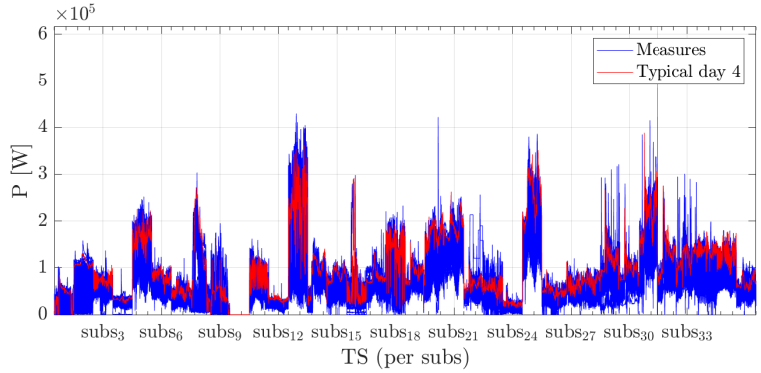

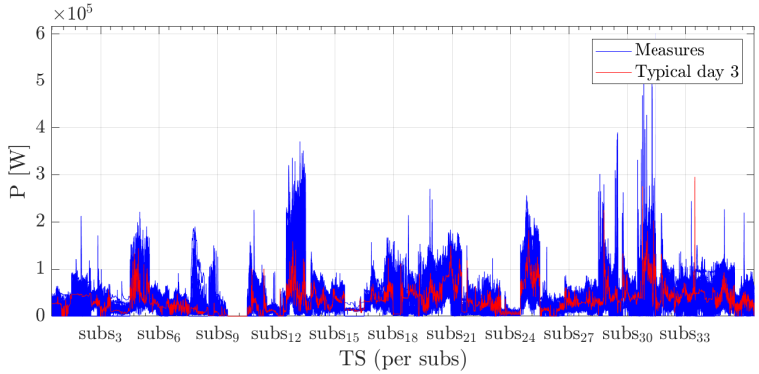

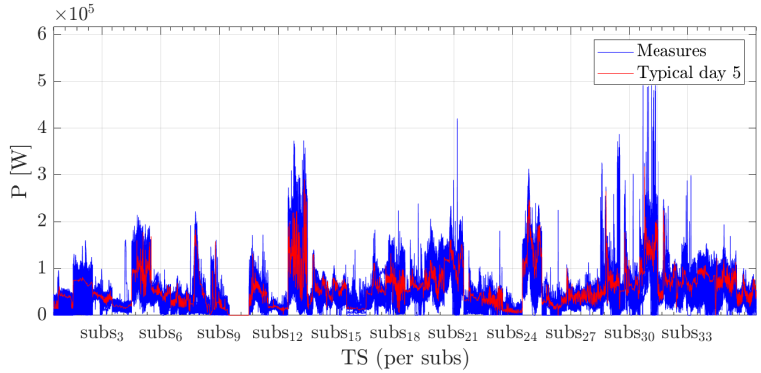

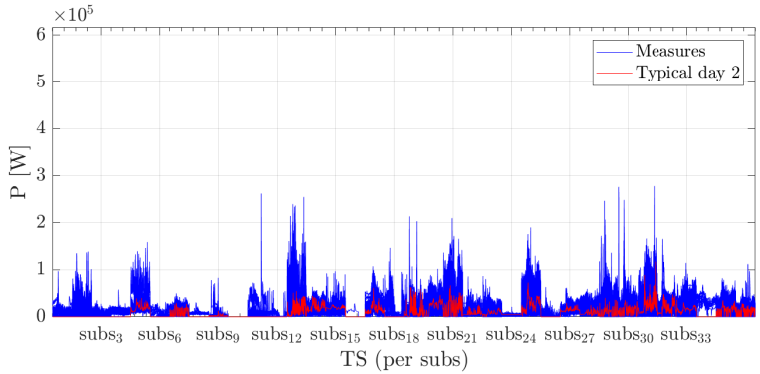

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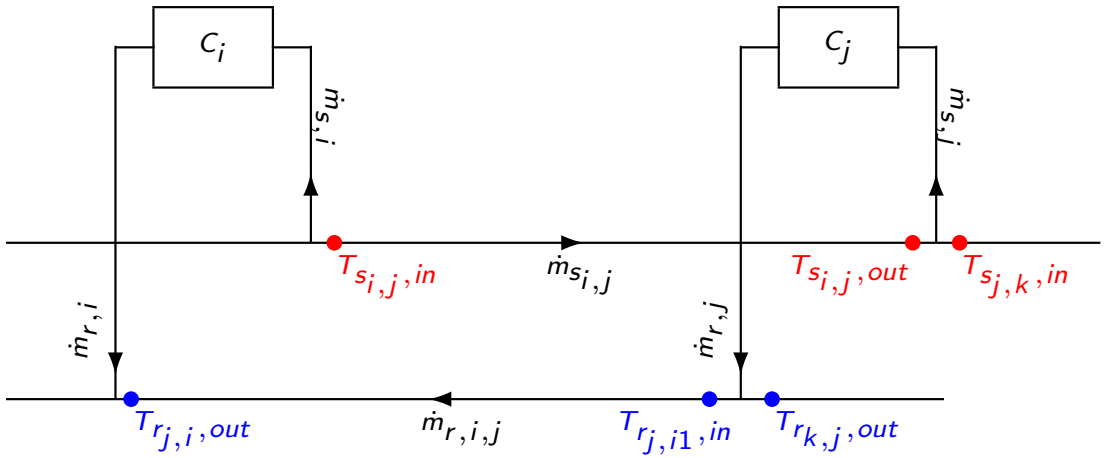
Simulations with a pseudo-dynamic model



- Masse balance :

$$\sum_{j \in \{Pr(i)\}} \dot{m}_{\bullet,i,j} = \sum_{k \in \{Su(i)\}} (\dot{m}_{\bullet,k,i} + \dot{m}_{\bullet,i})$$

- Thermal losses :

$$T_{\bullet,i,j,out} = T_{ext} + (T_{\bullet,i,j,in} - T_{ext}) \exp\left(-\frac{SU}{C_p \dot{m}_{\bullet,i,j}}\right)$$

- Pressure drops :

$$\Delta H = k_{i,j} . \dot{m}_{i,j} \left|\dot{m}_{i,j}\right|$$

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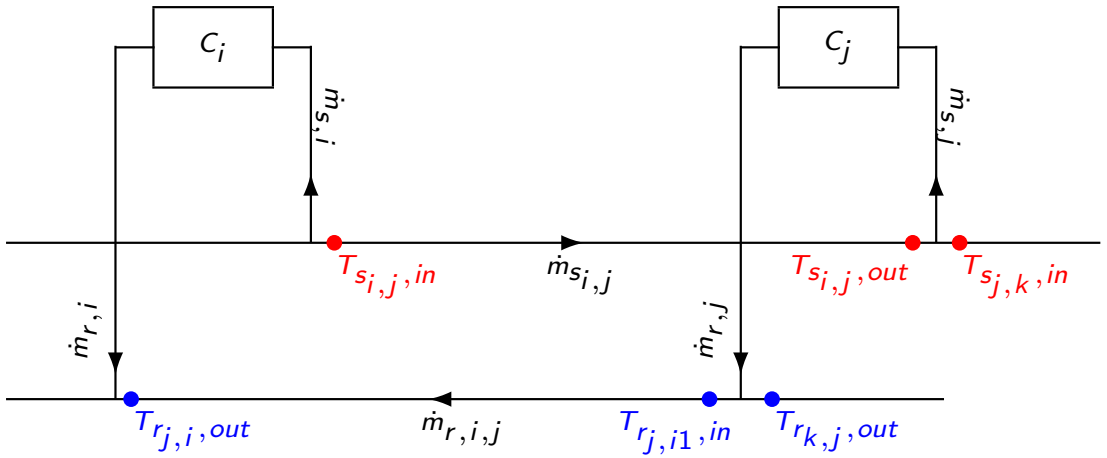

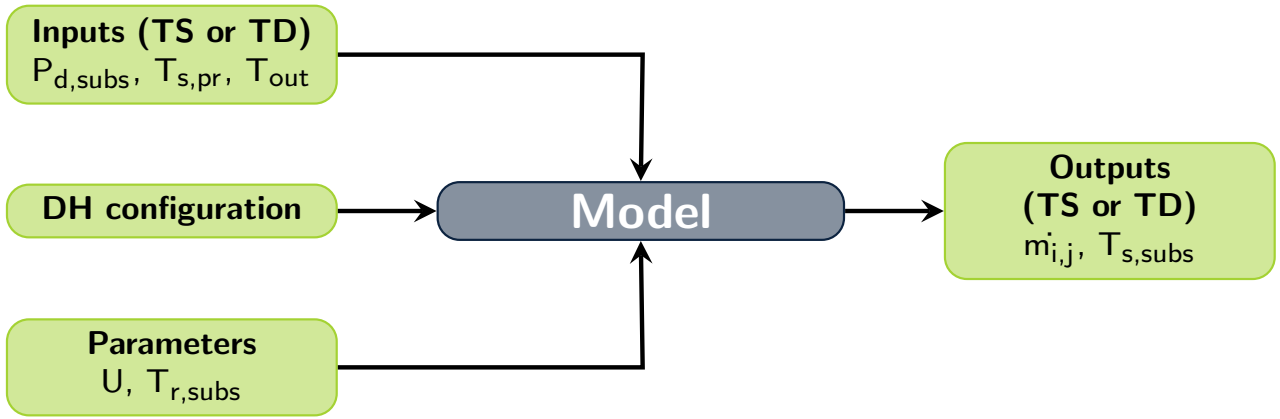

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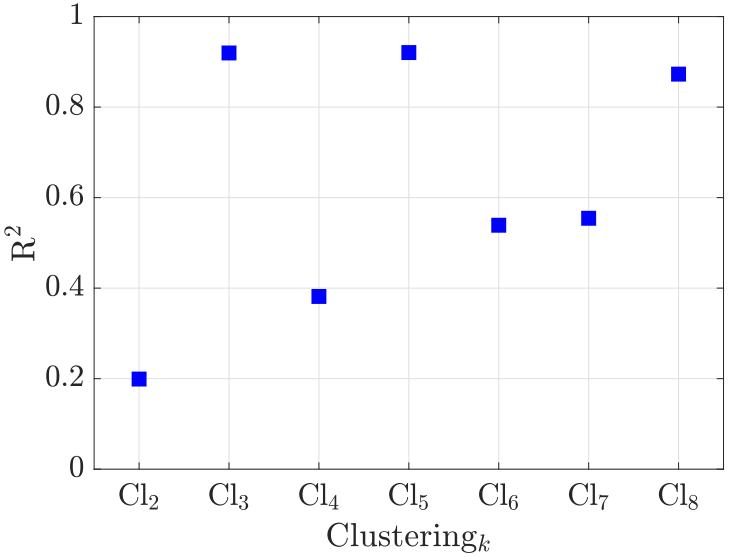
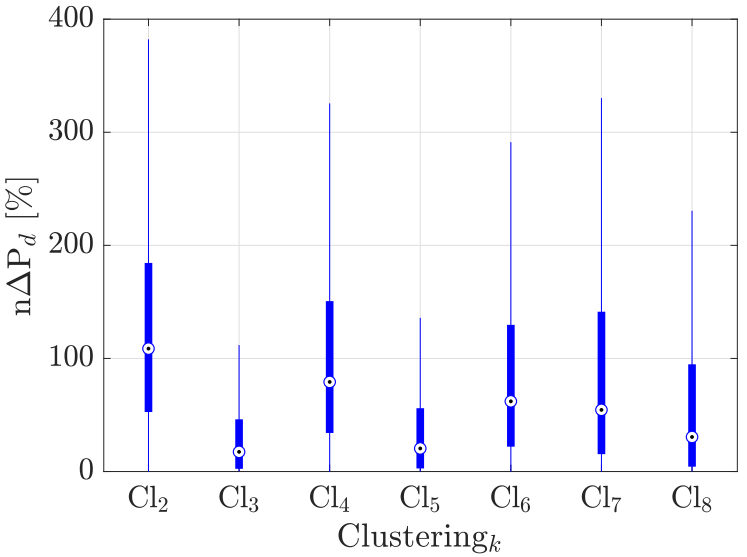
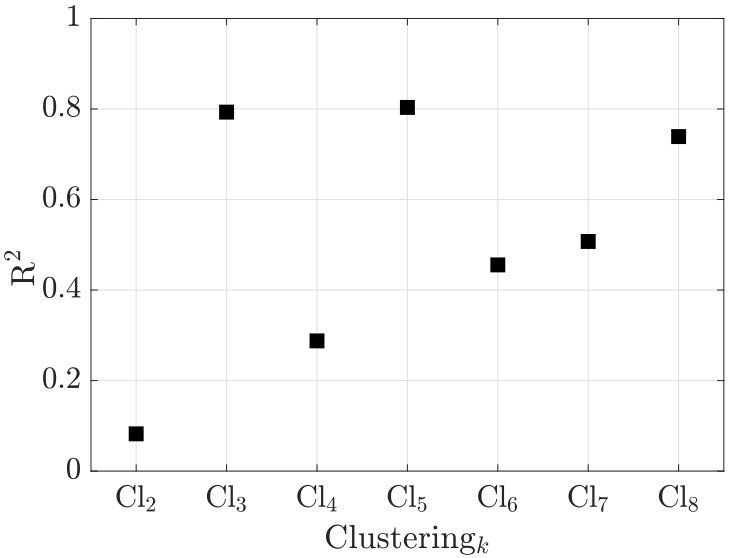
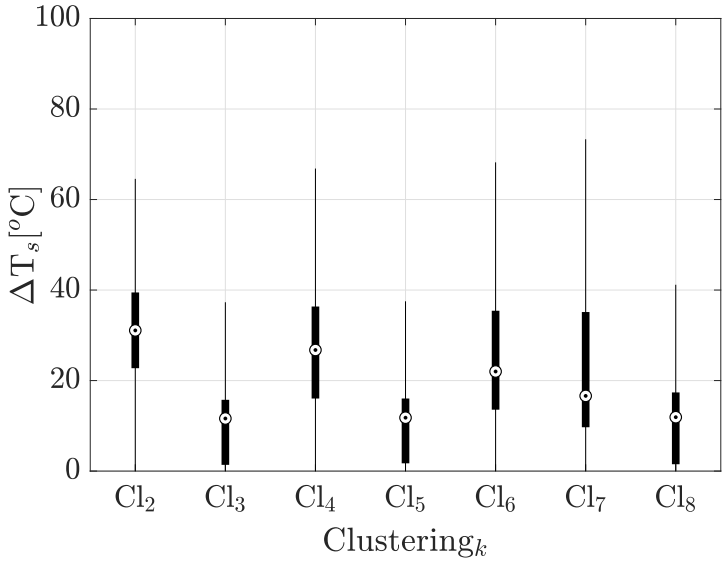
Typology impact on inputs





Typology impact on outputs





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A robust load typology method

- Based on k-means clustering method
- k is choosen through MCDA
- Typical days extract from the database
- Validation by evaluating the impact on simulations

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Iterative methods with typical days

0.5 [s/simu] $\times$ 10 [it] $\times$ 24 [hours] $\times$ 5 [typic days] = **10 min** [of simulation]

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Other applications

- Complete/Replace TS of some substations

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Thanks for your attention

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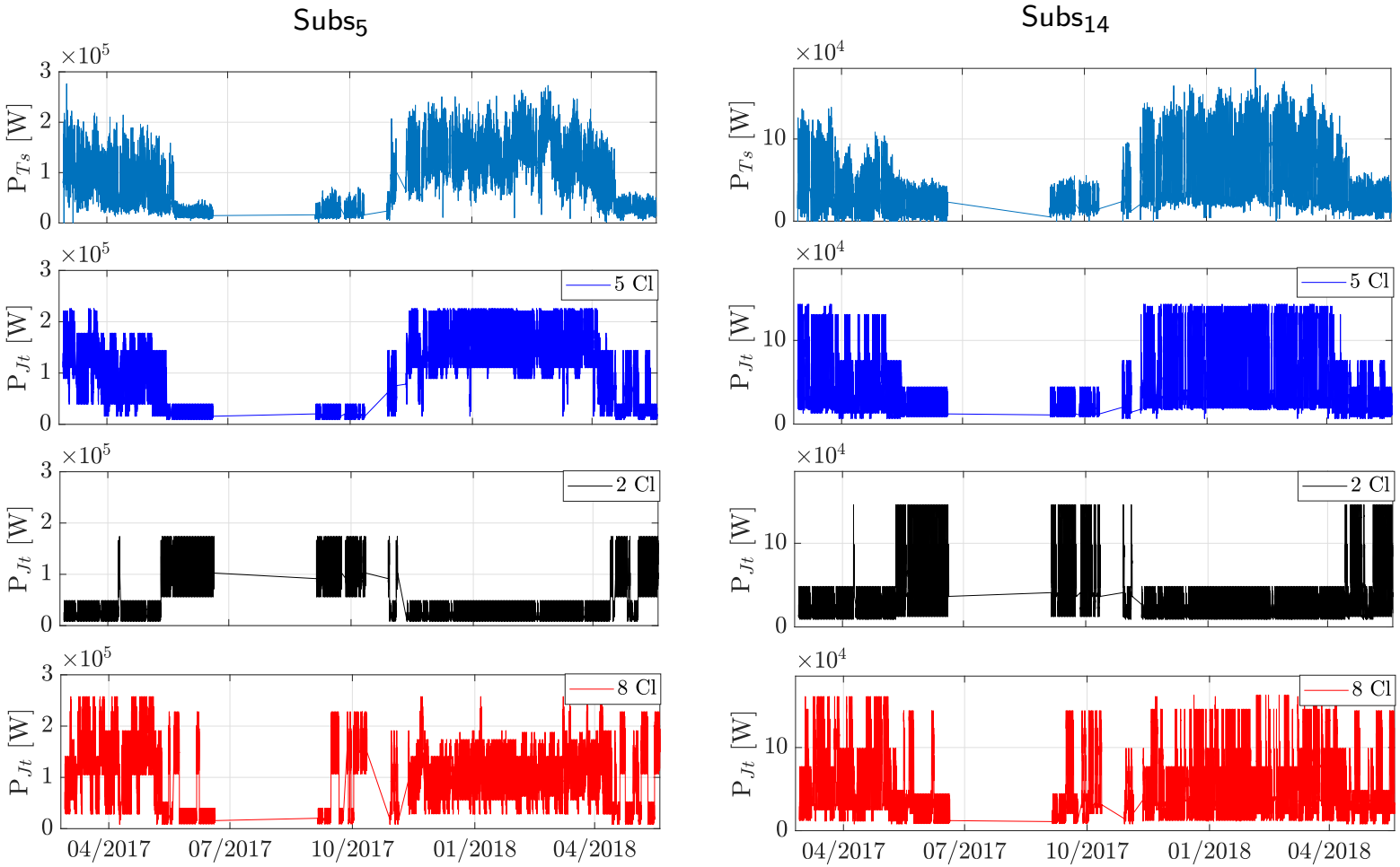
Times series generation from typical days



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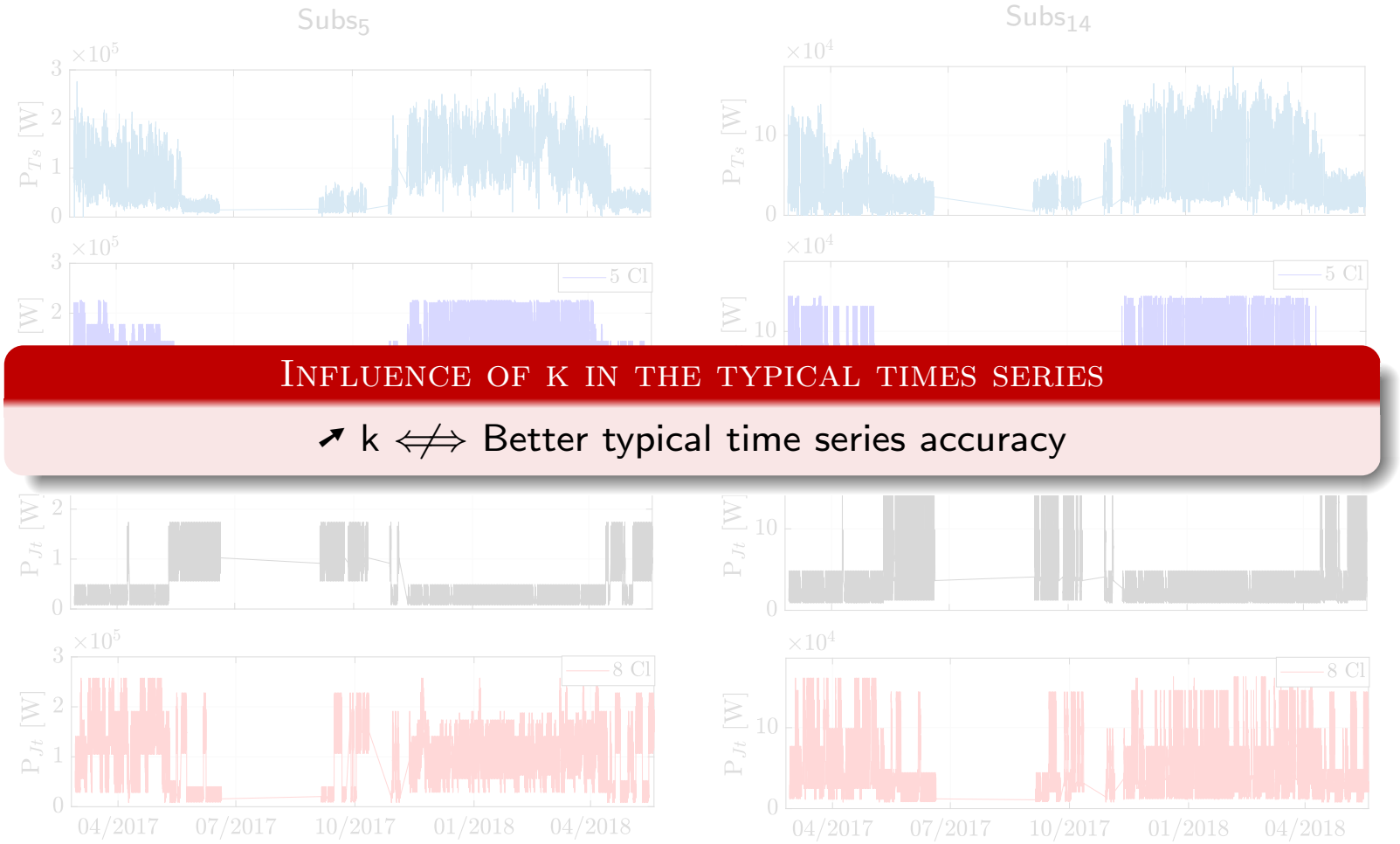
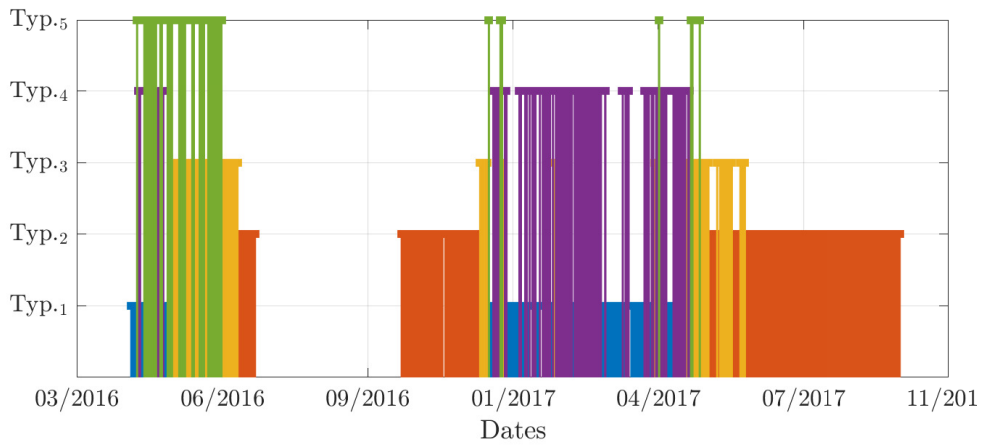


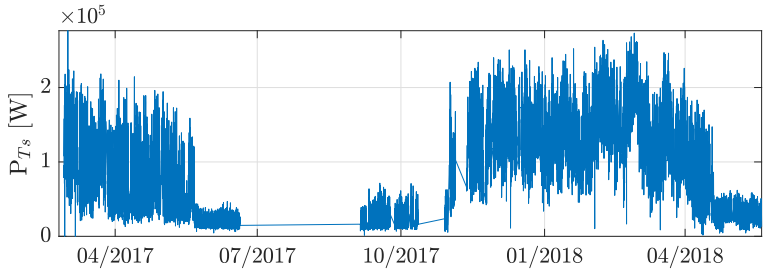
Influence of k in the typical times series

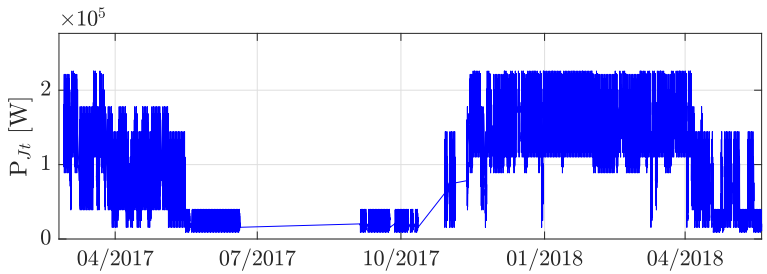
↗ k ⟺ Better typical time series accuracy

Typical days characterisation

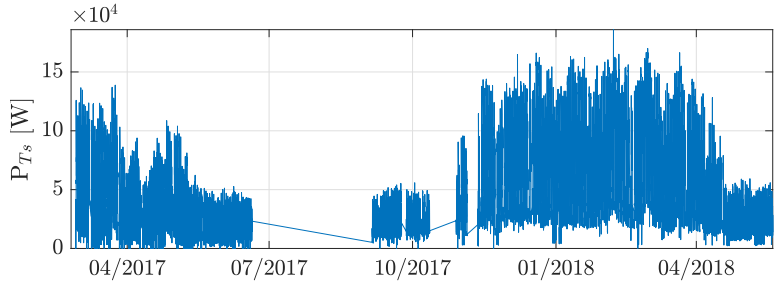


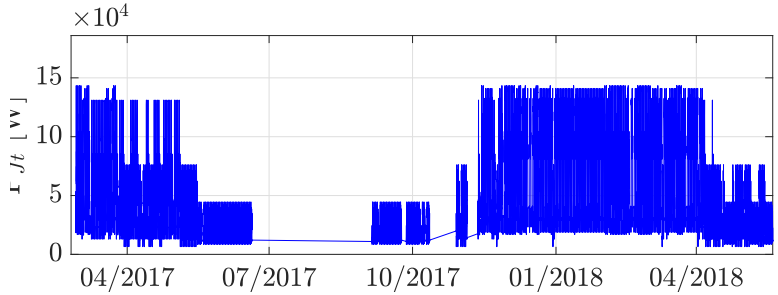
$subst_5$





$subst_{14}$





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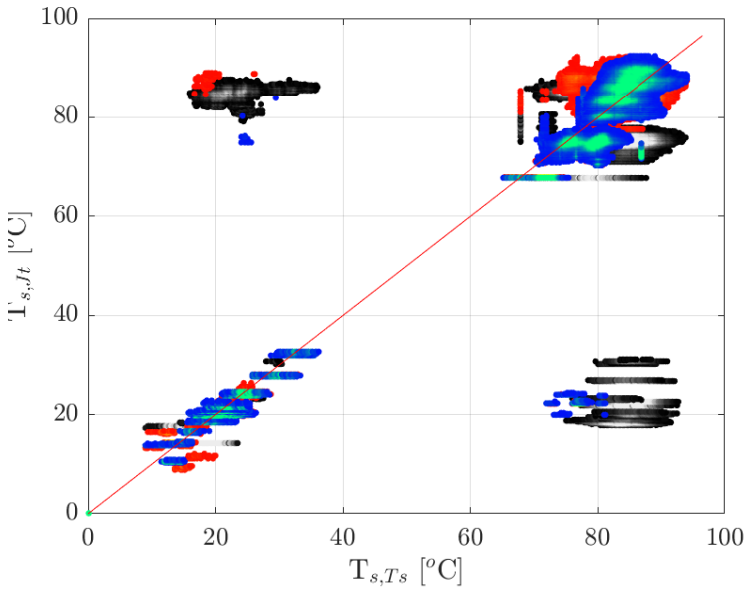
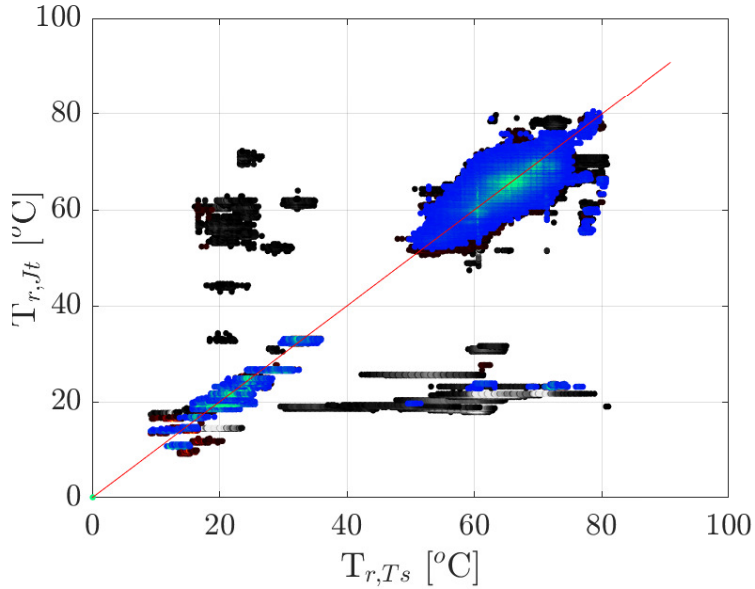
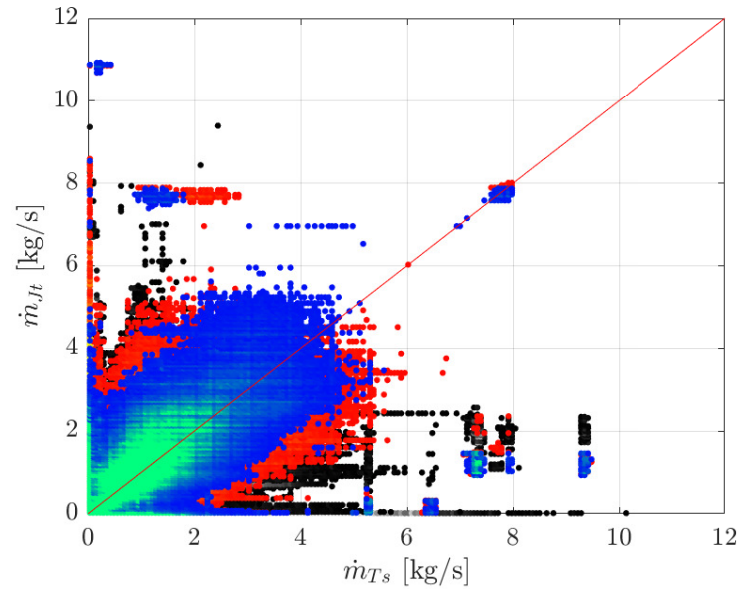
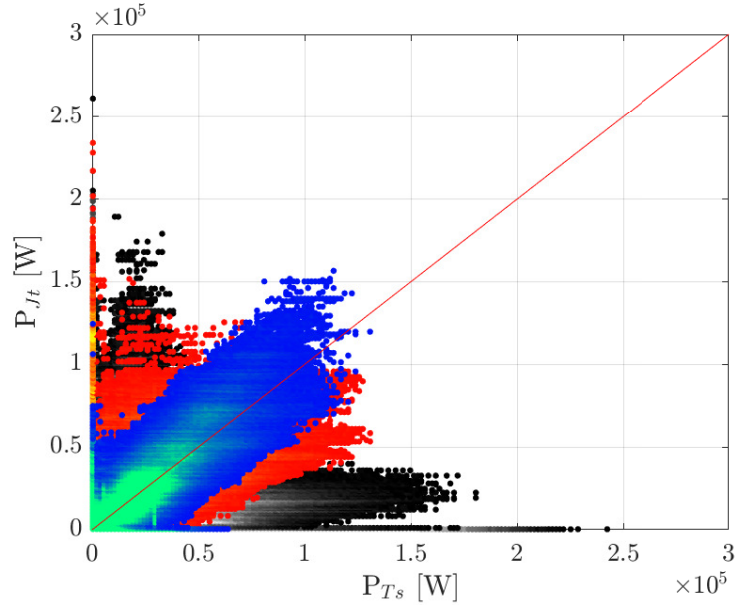
Times series and clustering comparisons









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