Predicting the Impact of COVID-19 on the Emergency Departments in Lombardy, Italy

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Introduction - TSUNAMI project

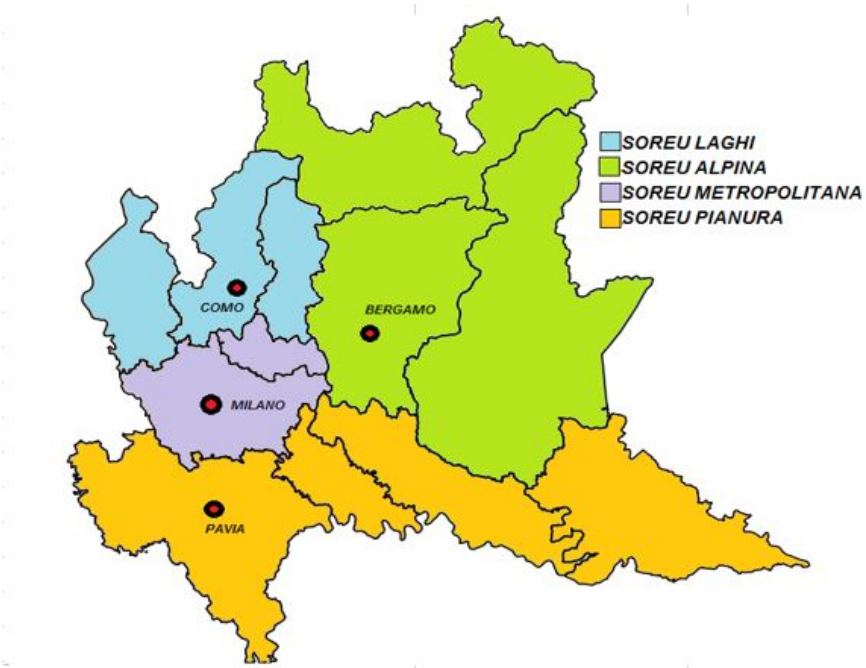
The Lombardy region in Italy relies on the emergency medical service called **AREU**.

PROBLEM: The number and type of **calls** to the emergency call center changed dramatically due to **COVID-19** pandemic.

AIM: Predictive model is crucial to **organize** solutions of an emergency event.

TSUNAMI PROJECT

AREU is organized by peripheral structures called **SOREU**: supra-provincial area.



AREU can use: daily-seasonal variations, social and demographic factors, weather circumstances, and epidemiological factors.

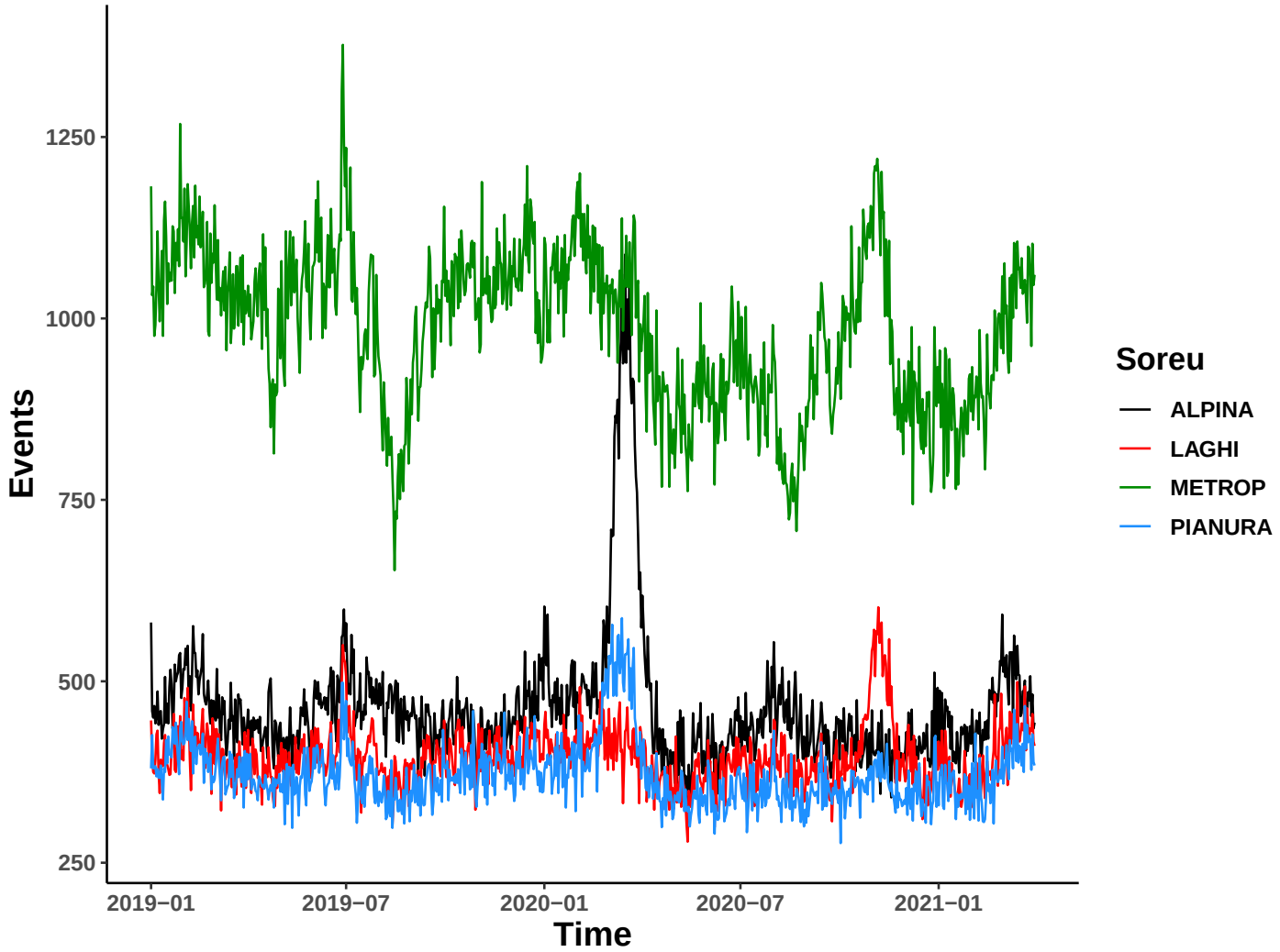
- **AREU data**: information about all the calls received → SOREU, Time, if the calls activated an aid, i.e., it becomes an event, etc;
- **ARPA data**: weather data collected from sensors located across the Lombardy → Temperature, rainfall, snowfall;

- **ISTAT and ISS data**: demographic and epidemiological data
  → Flu incidence, number of car accidents, etc.

BUT also COVID-19 related factors.

- **Department of Civil Protection**: number of hospitalized patients with symptoms, swabs, etc;
- **ISS**: reproduction number R_t.

Events: Received a call, this becomes an event if there is a dispatch of transport and/or equipment.



Goal: Predict

- **events**,
- for the SOREU **Metropolitana** (Milano and Monza provinces).

Method:

- **Generalized Additive Model** with **negative-binomial** family;
- The data were aggregated at **hour** and **SOREU** levels;
- Final predictions were aggregated at the **day** level.

- **Prediction error**:

$$\boxed{\frac{\hat{y}_i - y_i}{y_i}},$$

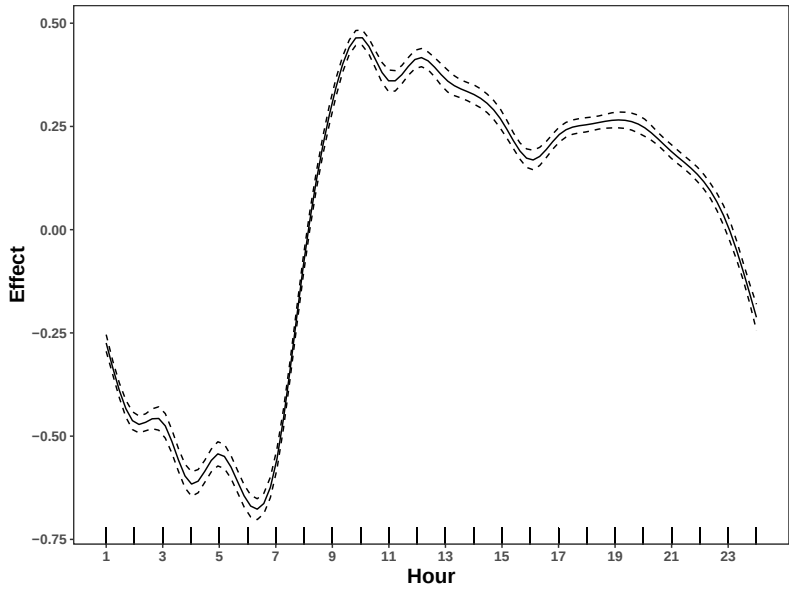
  where y_i is the observed value and $\hat{y}_i$ the predicted one at day i level.

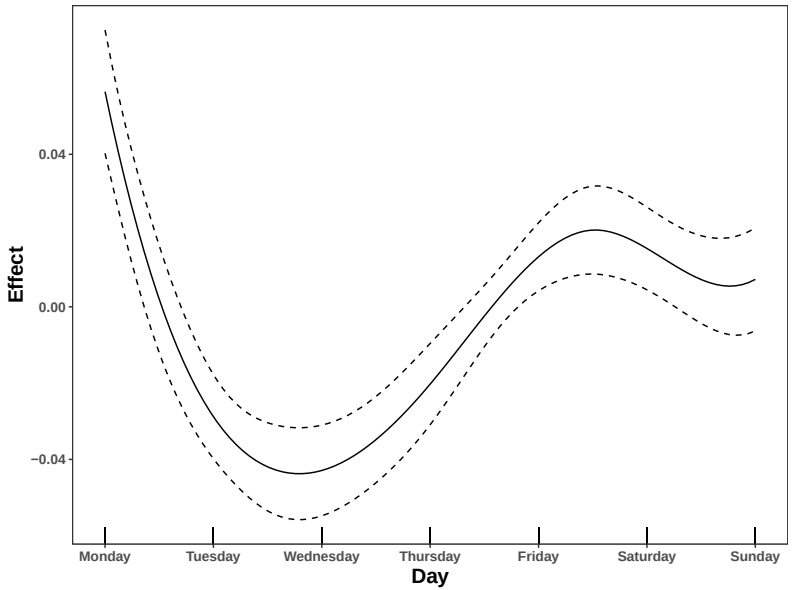
- **Performance metric**: mean absolute error.
- **Cross-validating** across 4 periods of time in 2020 and 2021.

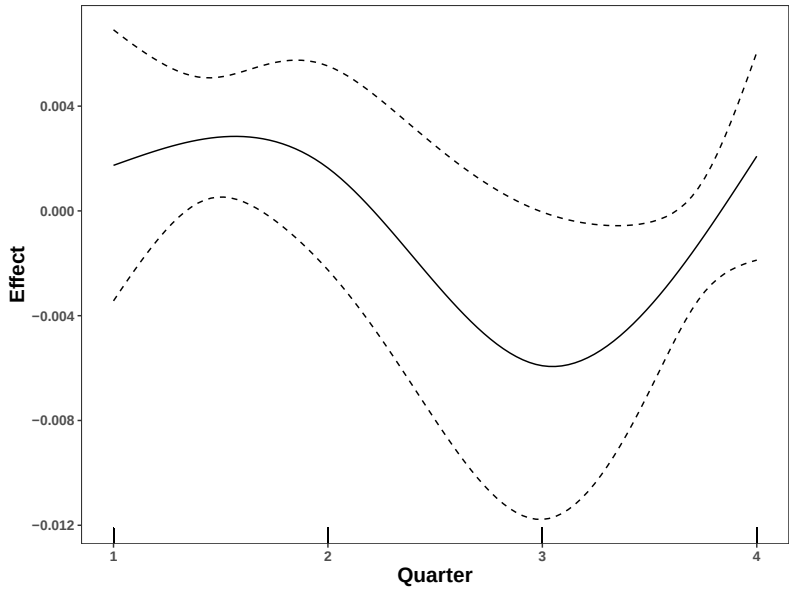
The following covariates were then selected:

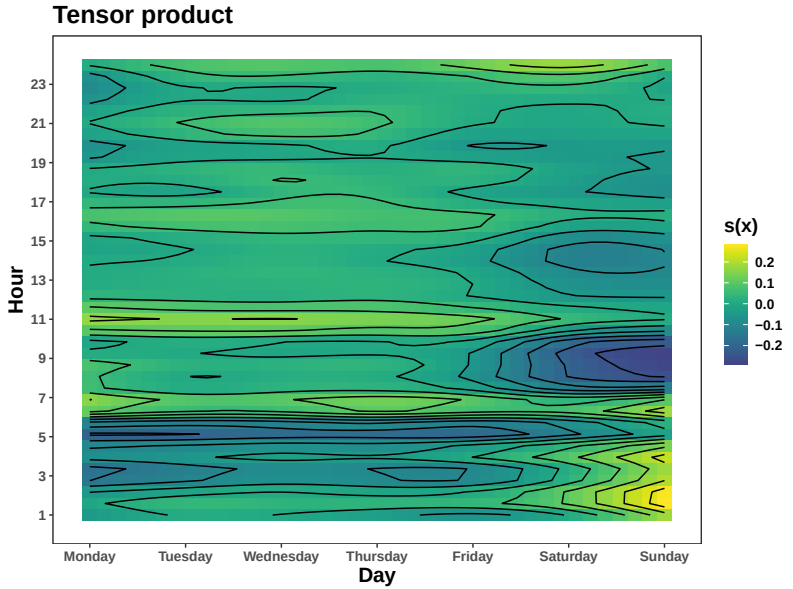
- cubic regression spline for **Hours** with 24 basis;
- cubic regression spline for **Quarter** with 4 basis;
- P-spline for **Day** with 7 basis;
- Tensor product smooths between **Day** and **Hour**;
- **Temperature** lagged one day;
- **Events** of the day before lagged 1-2-3 by hour;
- **Events** aggregated by day and lagged 1, 2 and 7 days;
- R_t lagged one day;
- **Flu** incidence lagged one day.

Results

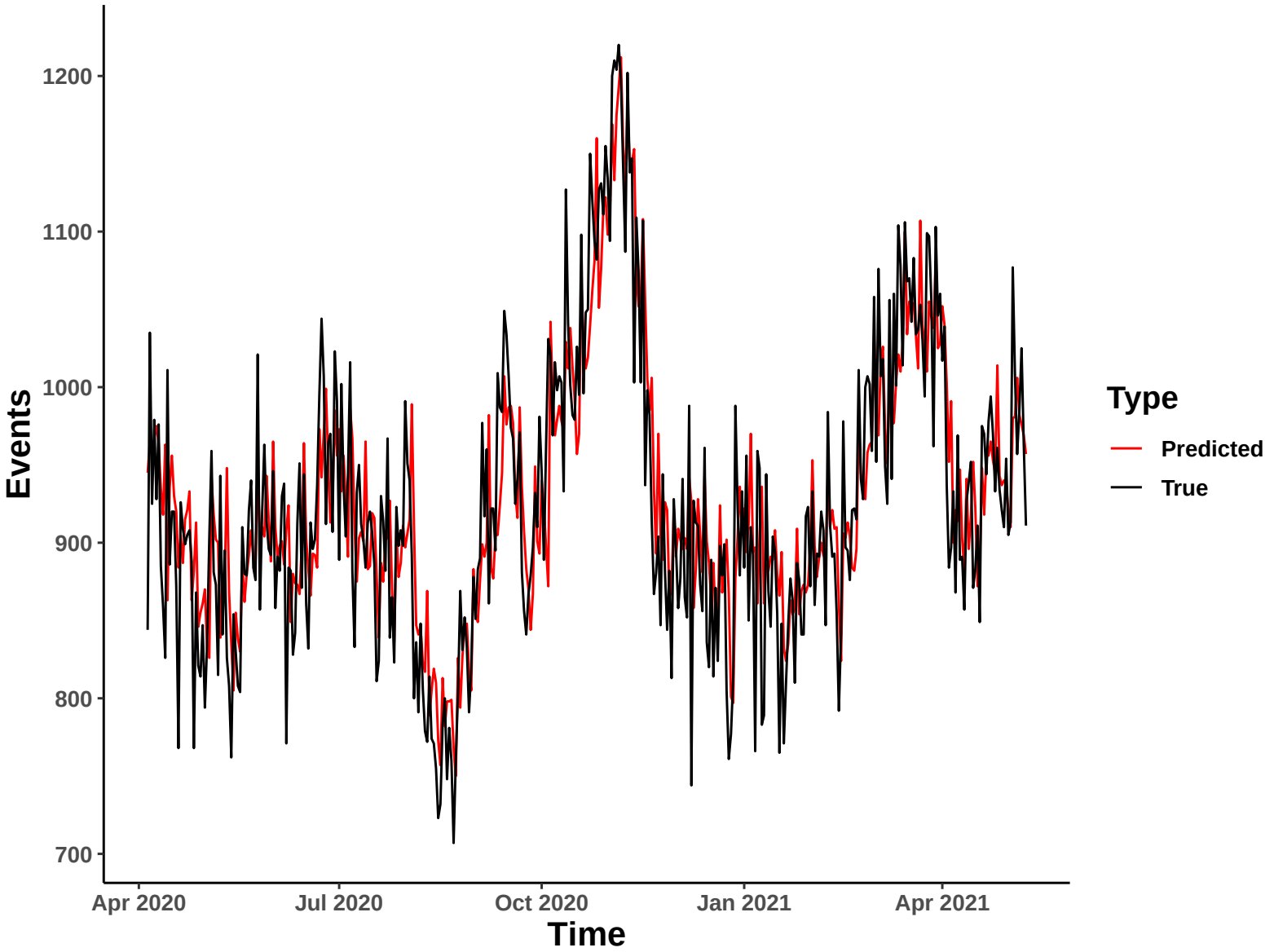

Effect
0.50
0.25
0.00
−0.25
−0.50
−0.75
1
3
5
7
9
11
13
15
17
19
21
23
Hour


Effect
0.04
0.00
−0.04
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Day

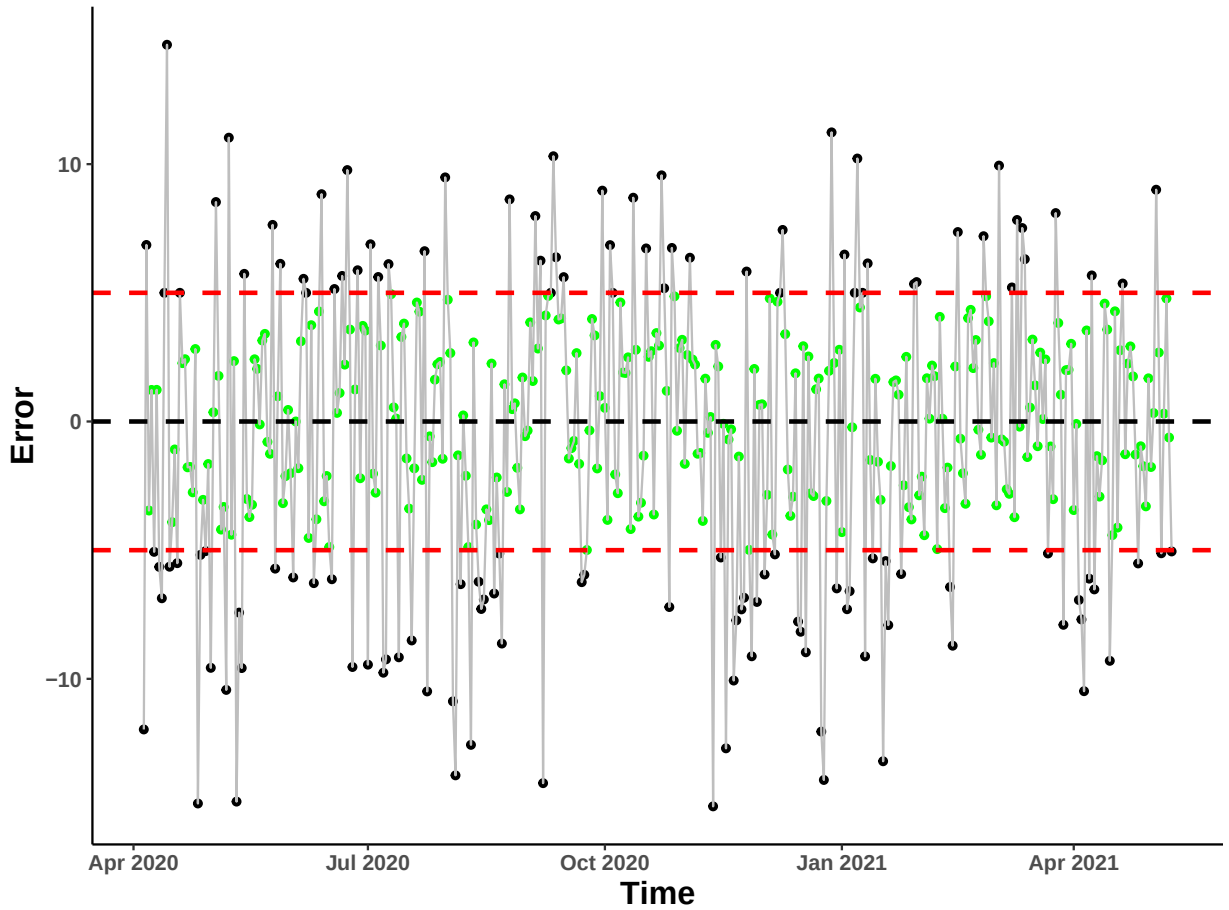

Effect
0.004
0.000
−0.004
−0.008
−0.012
1
2
3
4
Quarter


Tensor product
Hour
23
21
19
17
15
13
11
9
7
5
3
1
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Day
s(x)
0.2
0.1
0.0
−0.1
−0.2

Results - One Day Ahead

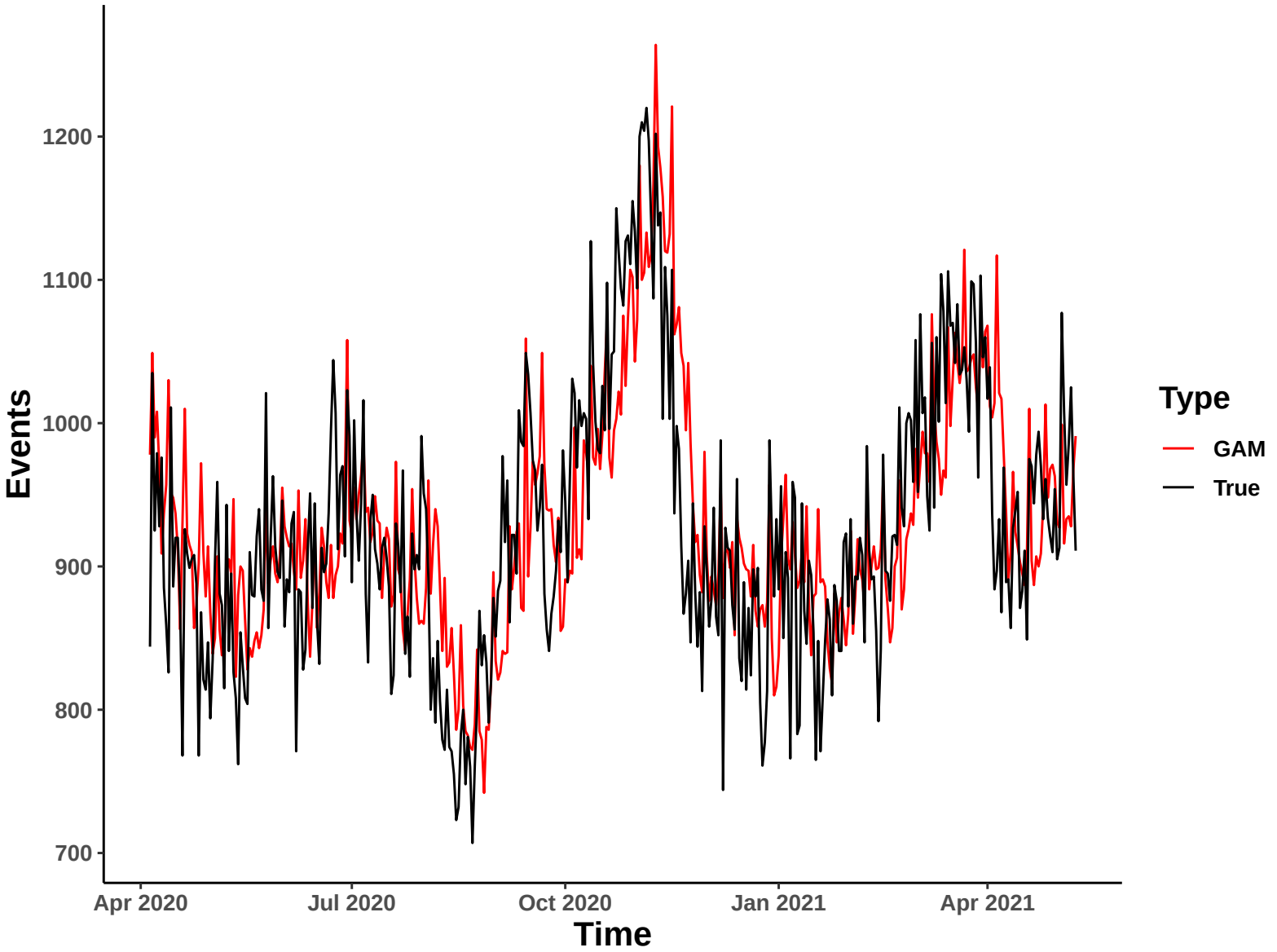


Results - One Day Ahead

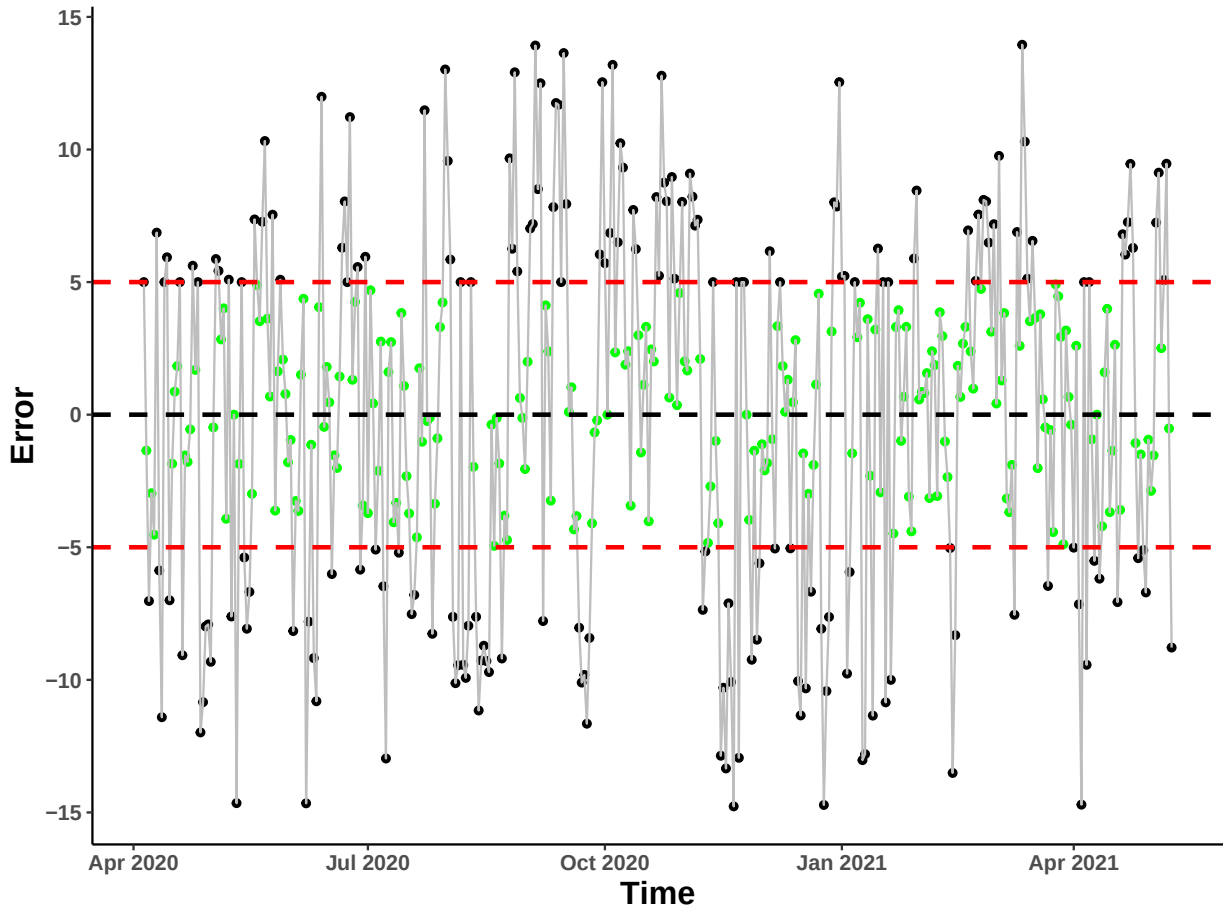


- 87% of predictions has absolute error below 5%;
- *MAE* = 4.41, *MeAE* = 3.4.

Results - Five Days Ahead



Results - Five Days Ahead



- 55% of predictions has absolute error below 5%;
- *MAE* = 5.24, *MeAE* = 4.97.

- We proposed a valuable model to predict the number of events occured on the SOREU **Metropolitana**;
- capturing the **daily** and **seasonal** variation and incorporating **epidemiological** aspects as well as **weather** information.

Further direction would be applying

- the **Generalized Additive Mixed Models** to better deal with the data autocorrelation structure;
- a **Bayesian extension** assigning appropriate Markov random field priors with different forms and degrees of smoothness to deal with the trend and seasonal components.