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In situ monitoring of the weathering agents of Saint-Remi Basilica (Reims, France)



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Introduction

Variations of **temperature** and **humidity** can create weak stress compared to the resistance of the materials, but can irreversibly damage the stone through time.



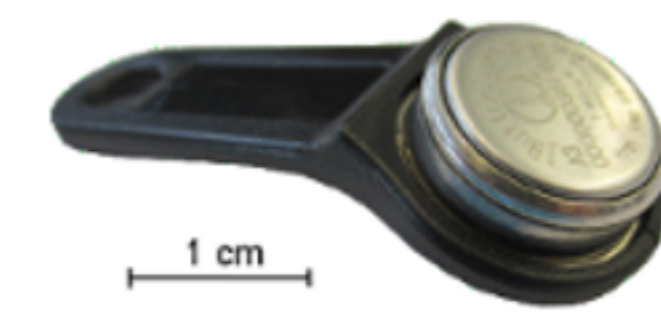
View of the Saint-Remi Basilica.

The **Saint-Remi Basilica** (Reims, France) is an architecturally complex building, composed of various stones at different orientations and heights. The **variability** of the **micro-environmental parameters** are studied through a sensor network

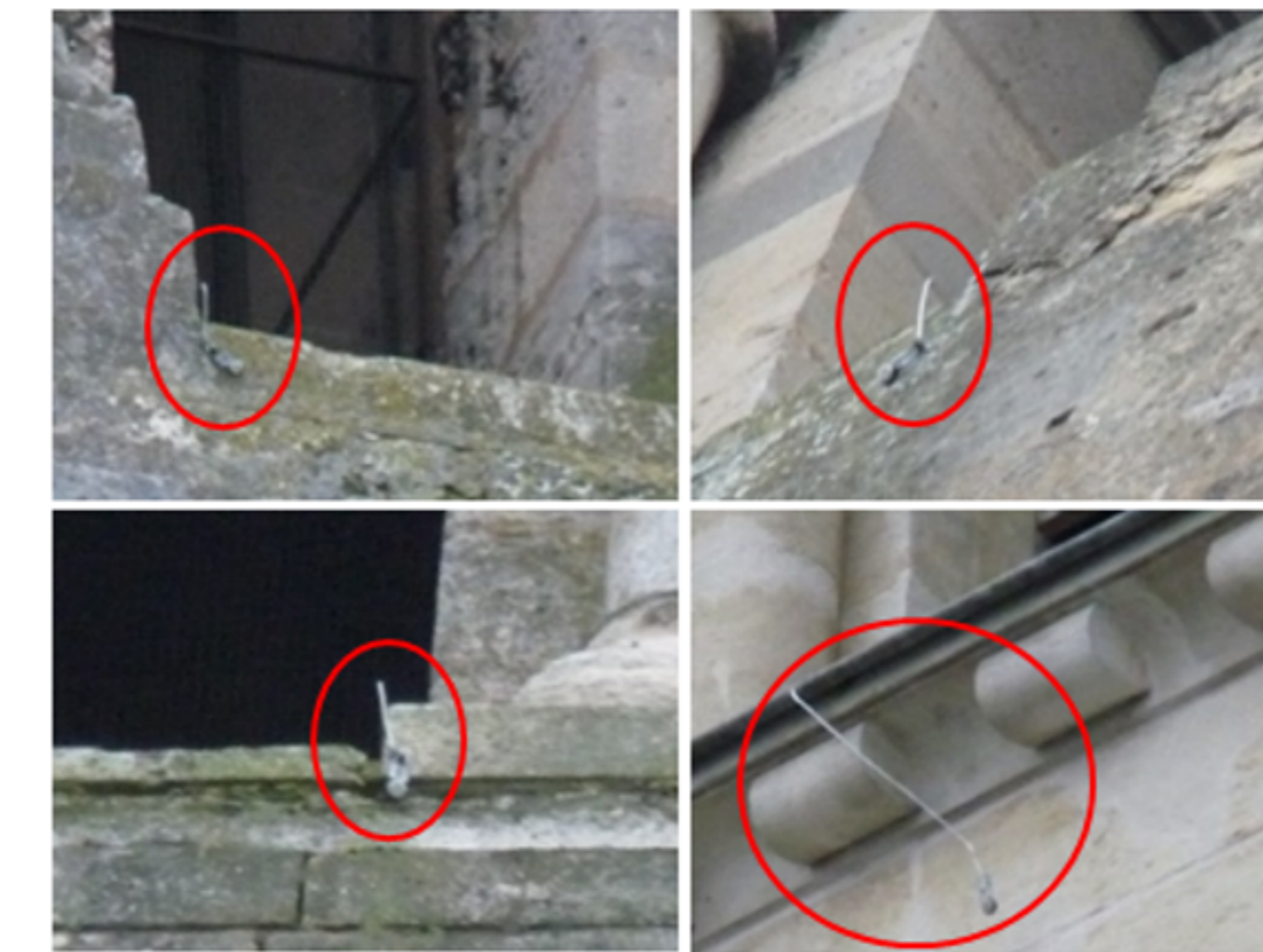
Climatic Monitoring

14 sensors (i-Buttons) recording **temperature** and **relative humidity** were placed on the 2 towers of the Saint-Remi Basilica.

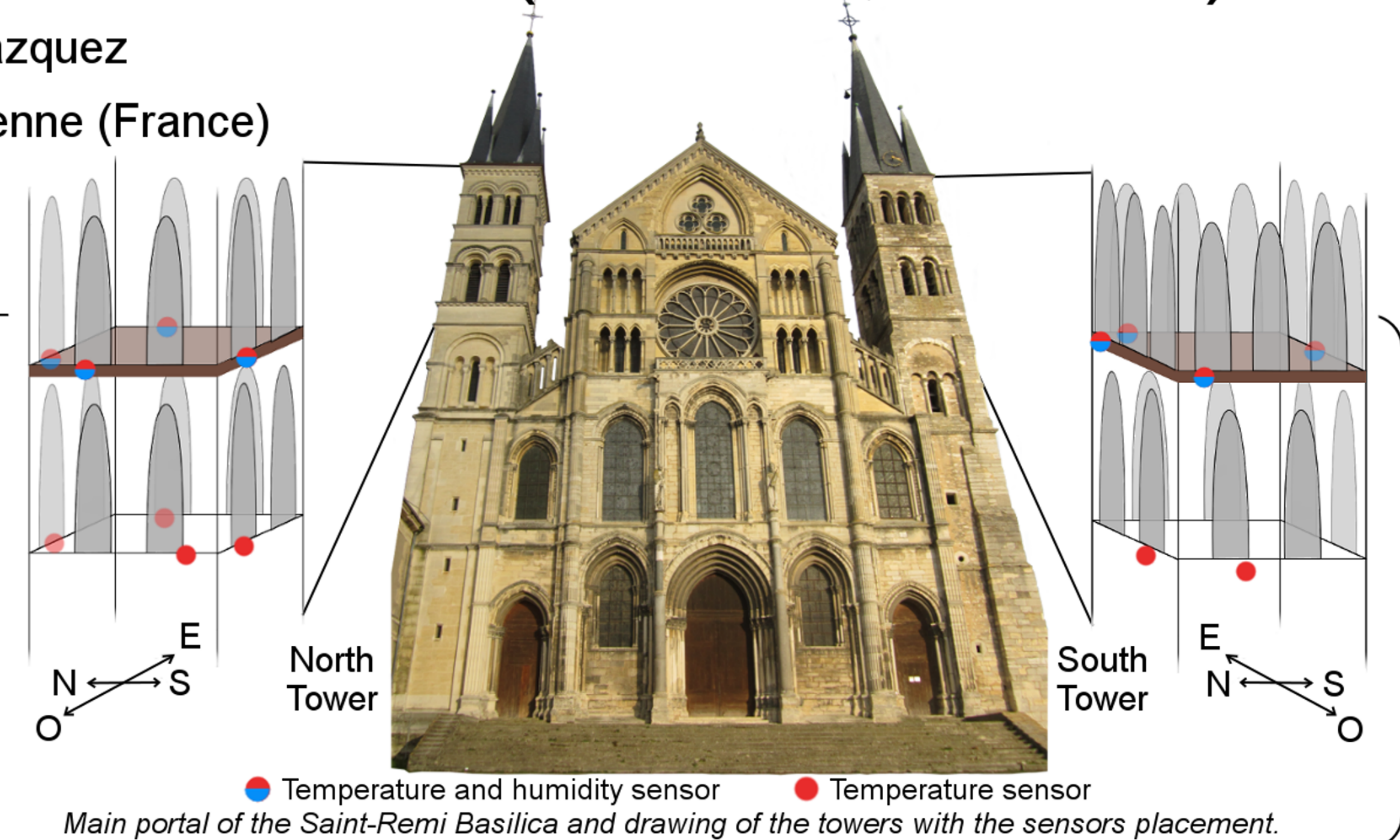
Different heights: 19 and 23m.
Different orientations:
North, South, East and West.



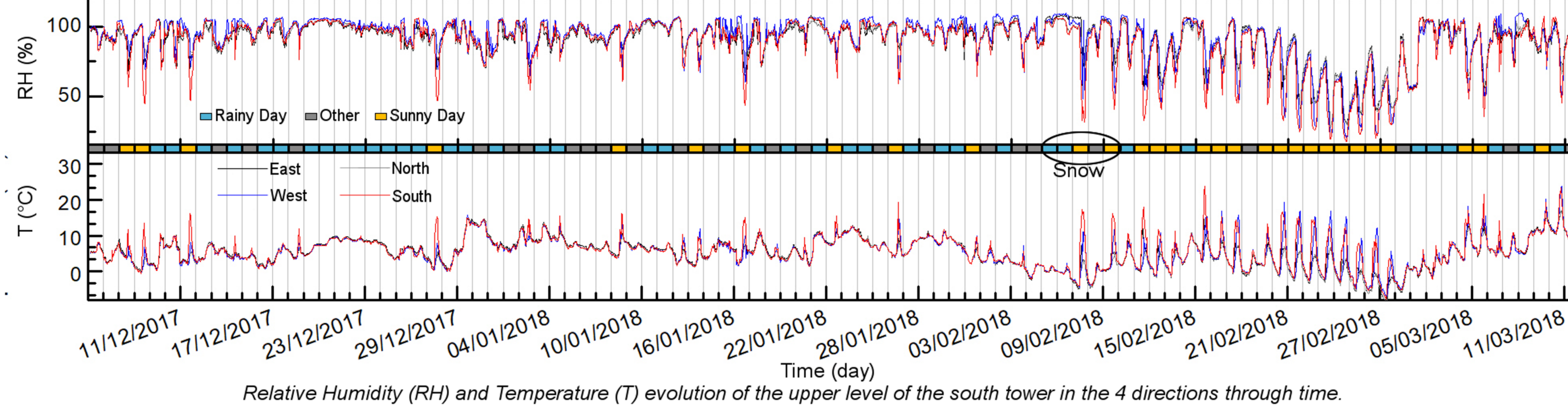
i-Button sensor.



Pictures of sensors in place on the towers.



Long term observation



Recording: 1 measurement per hour since December 2017.

2 types of variation of temperature and humidity:

- with the **daily cycle**: up to 20,5°C and 67% humidity on the **South** façade. Recording throughout the year will allow to identify **seasonal cycles** as well.
- with the **orientation**: up to 14°C and 39% humidity between **South** and **North**.

Façades facing **South** and **West** present the largest temperature increase and humidity decrease.

These results are also valid for the lower level of the South tower and for the North tower.

Modelling of the Basilica's environment during winter:

- categorization of days : **30 sunny**, **41 rainy**, **26 other**.
- possible freeze-thaw cycles (from the 21th to the 28th February).

One day observation

Recording: every 2 minutes during one day.

Temperature variations are linked to the **façade sun exposure** throughout the day.

Low rate of temperature variation: **below 1°C/min**. No thermal shock.

Observation of **short cycles of temperature**: short variations of a few degrees, duration of **5 to 40 minutes**.

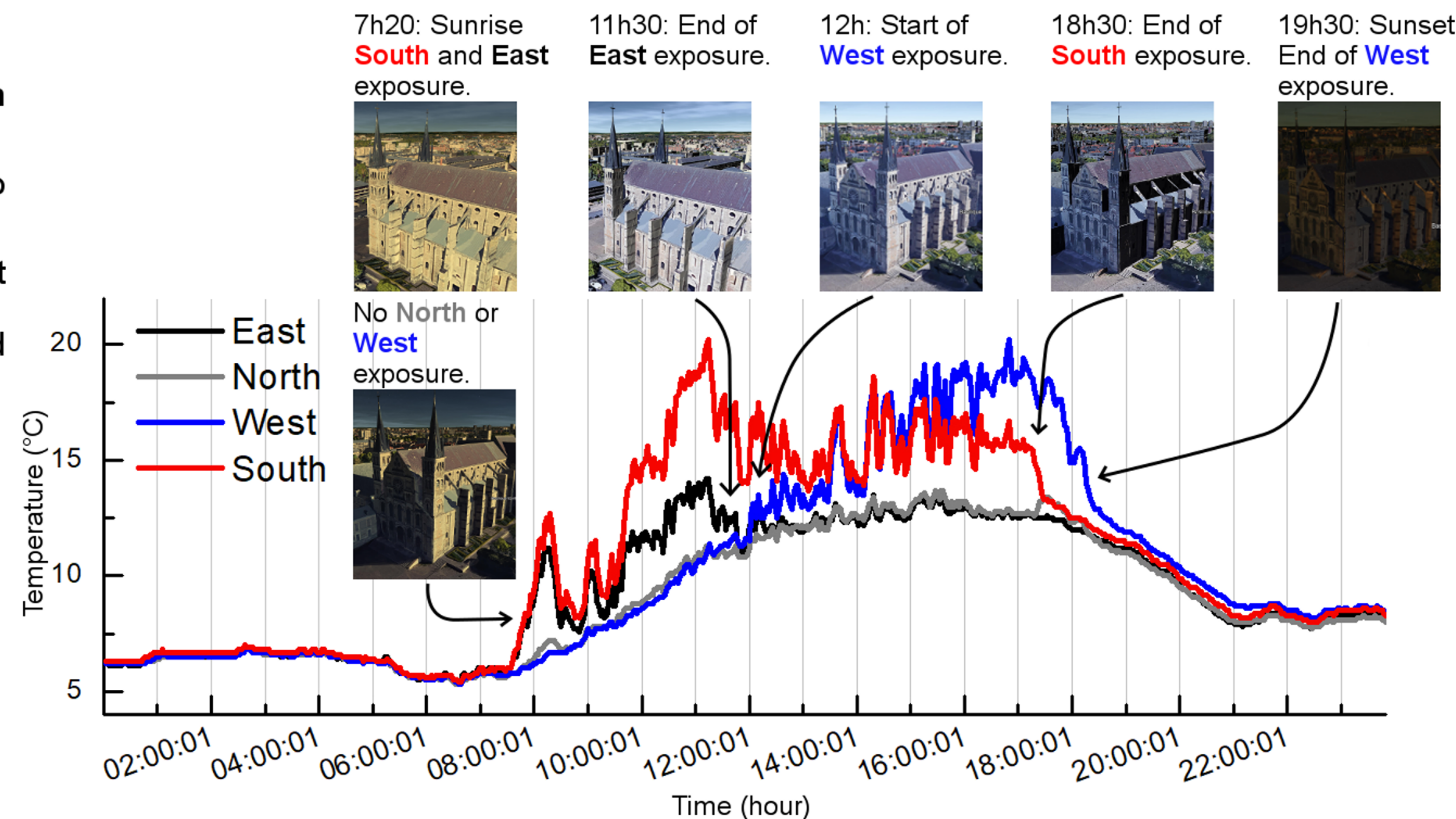
They are due to quick changes in the environment like cloud cover or windspeed.

These variations also impact humidity to a lesser extent.

These observations are valid for the other sensors.



Façades orientation of the Basilica (Google Earth view).

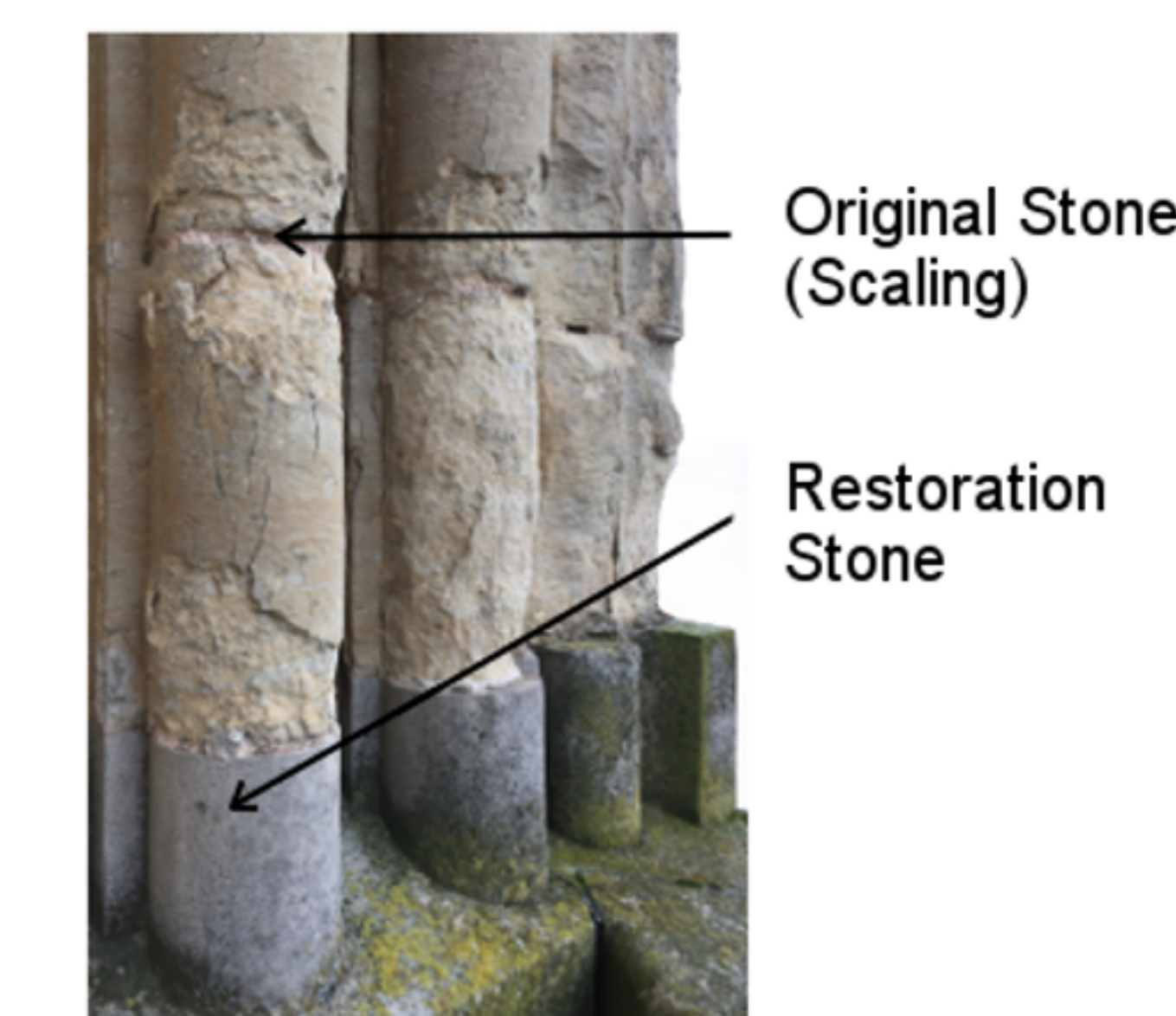


Conclusion

Micro-climates were identified on the Basilica:

- Façades exposed to the sun: **South**, East-morning and **West**-afternoon.
 - ↳ Higher temperatures, short and daily cycles of variations of temperature and humidity.
 - ⇒ More thermal fatigue and wetting/drying cycles.

- **North** and other shadowed façades during the day.
 - ↳ Higher relative humidity, daily cycles and less intense short cycles.
 - ⇒ More sensible to frost weathering.



Picture of weathered and restoration stones on the Basilica.

The monitoring will last **3 years**. The climatic data will be used in **laboratory ageing test** in order to **predict stone behaviour through time** depending on the micro-climate.

These informations will ultimately be used to construct a **risk map** for the Basilica's stones and help future restorations.