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Definition of allowable targets from indoor climate observations in exhibition rooms: the case study of the Rosenborg Castle (Denmark)

F. Frasca, E. Verticchio, A. Bile, E. Fazio, G. Favero, C. Chimenti, A. Vulpiani, M. Moscarini, S. Lupi, A. Grinde, A.M. Siani

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Figure 1- The Rosenborg Castle (Lat. 55.7° and Long. 12.6°).

Introduction

The study of microclimate through multi-year high-quality observations are necessary to assess the climate-induced degradation in artworks and to plan Preventive Conservation actions.

The Rosenborg Castle

The Rosenborg Castle (Fig. 1) is a museum partner of the European project CollectionCare[1]. A microclimate system for hygrothermal observations has been operating in most rooms since 2001.

Aim

Definition of a methodology to study multi-year indoor climate observations in exhibition rooms:

(a) the evolution of hygrothermal variables throughout years and

(b) the definition of the historical indoor climate targets for hygroscopic artworks conservation.

Data source

Indoor temperature (T) and relative humidity (RH) observations were collected in thirteen rooms of the Rosenborg Castle. Outdoor T and dew point (DP) data, were extracted from Copernicus CDS[2] , as monthly averaged reanalysis by hour of day. Both indoor and outdoor air mixing ratio (MR) were calculated[3].

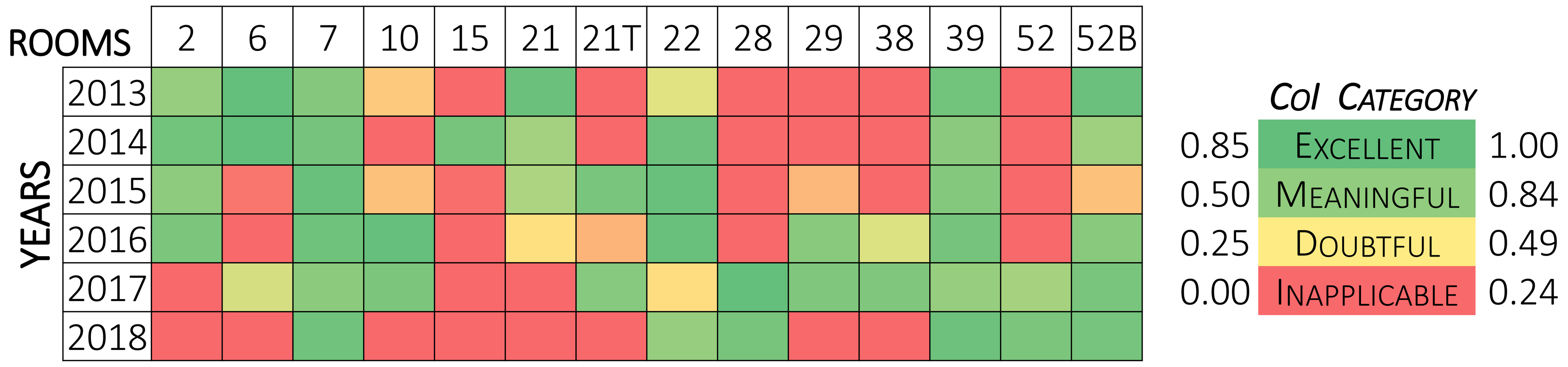
Method & Results:

Data were analysed through a three-step procedure.

1. Completeness index (CoI[4]) of indoor climate observations

Observations collected in Room 7 and Room 39 are the most representative (CoI threshold ≥ 0.85, i.e. about 7500 valid records) of the hourly evolution of indoor climate in the Castle throughout the selected period (**Table 1**).

Table 1- Completeness index (CoI) matrix for the time series collected in each room over the years.



2. Inter-year variability of indoor observations:

T distributions are similar throughout the years except for 2016, whose median has the lowest value (**Fig. 2a**). RH distributions of 2016-17 are higher than other years (**Fig. 2b**). In this case, Wilcoxon test (α = 0.05) has shown that these two years are significant similar (p-value > 0.8). Indoor T values are always higher than outdoor T ones, especially in winter (**Fig. 3a**, blue points). MR values lie close to the bisector except for summer 2015 (**Fig. 3b**, red diamonds).

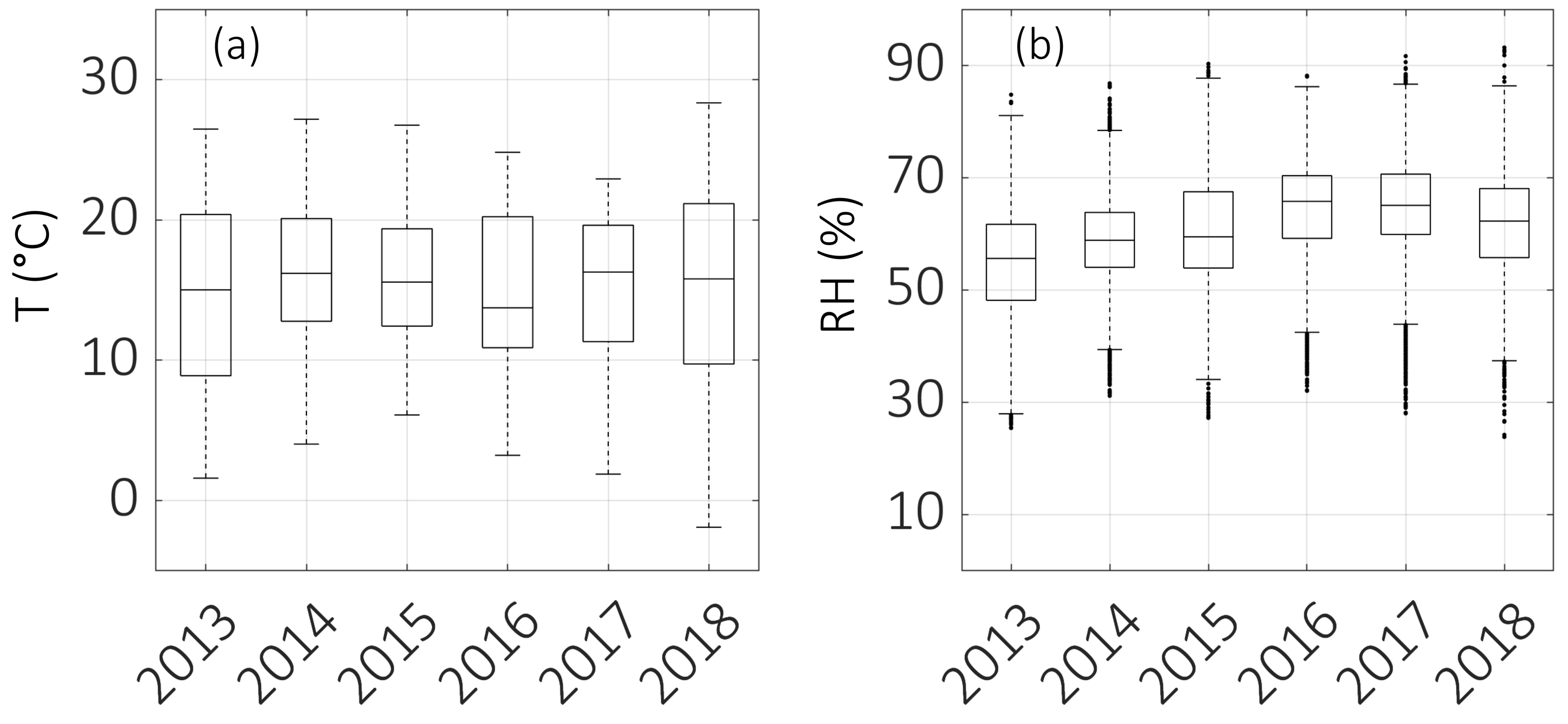


Figure 2- Box-and-whiskers plots of indoor T and RH observations.

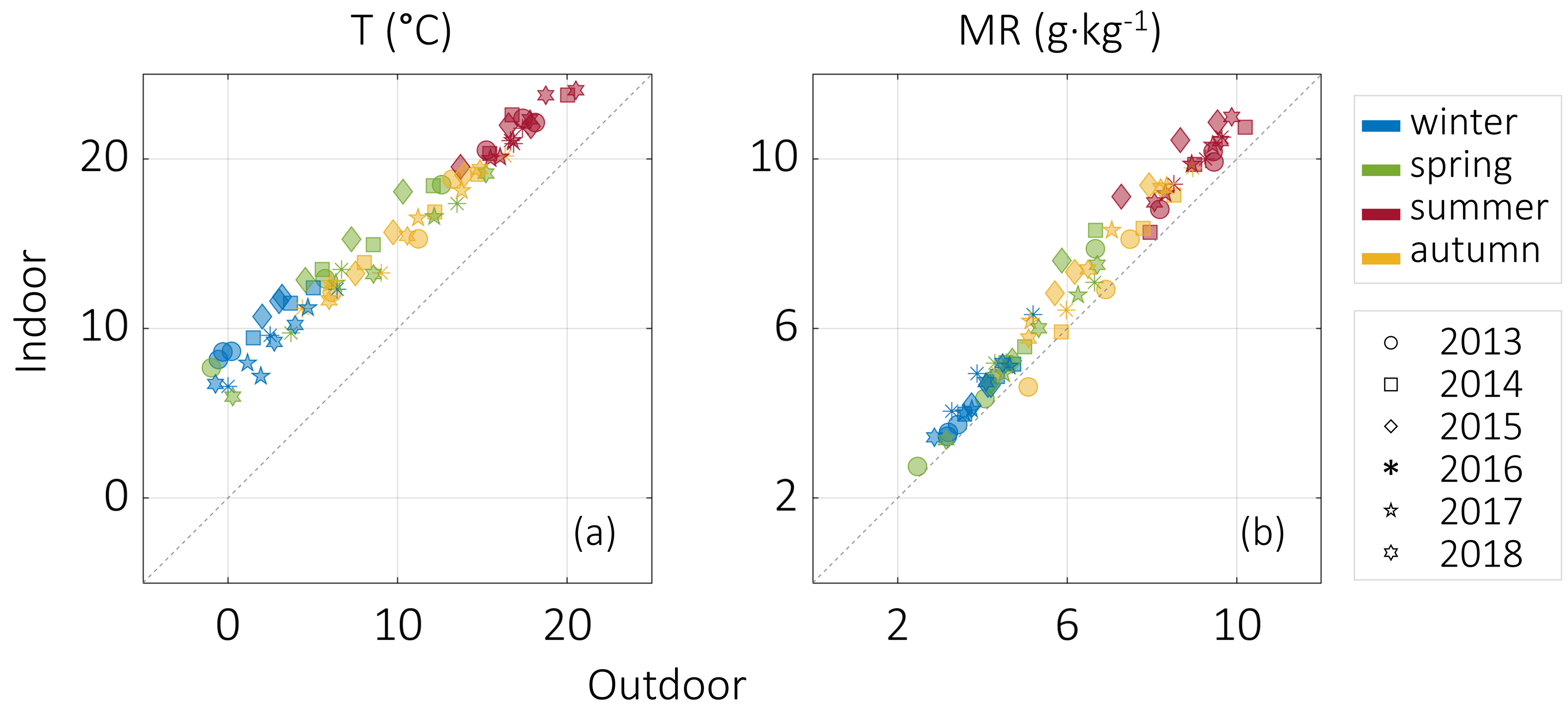


Figure 3- Indoor *vs* outdoor T and MR.

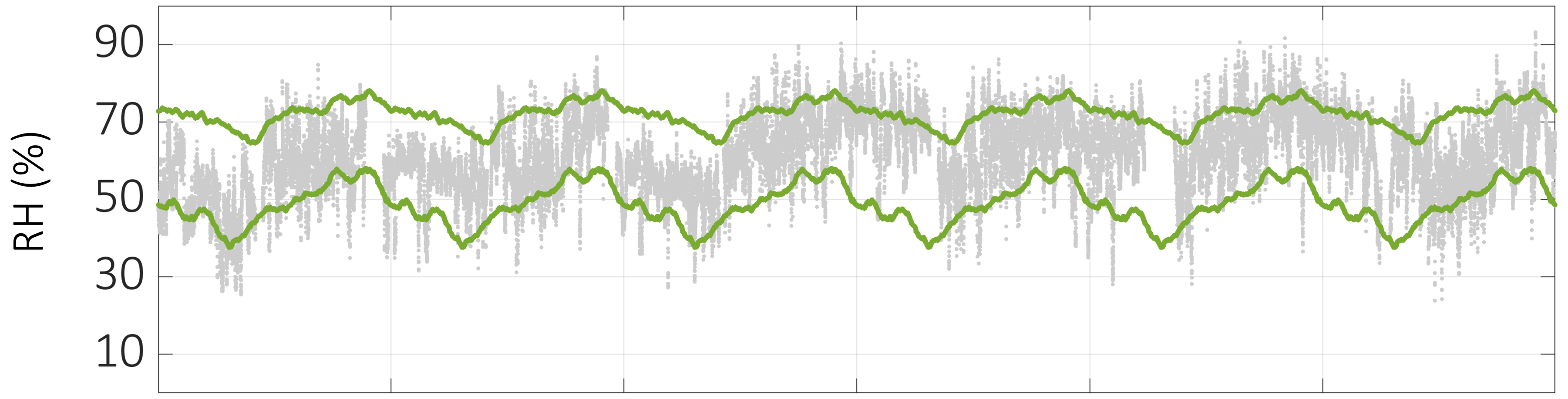
3. Historical indoor climate target[5]:

Fig. 4 summarises the definition of a procedure to identify the allowable indoor climate target when multi-year observations are available.

I. Dataset	II. Actual RH short-term bands	III. Historical indoor climate targets
Collection of multi-year hourly RH observations	Computation of daily 7th and 93rd percentile on multi-year observations	RH short-term climate-targets with 30-days seasonal adjustment

Figure 4- Procedure to define allowable indoor climate target.

Fig. 5 shows the allowable RH band useful to identify potentially moisture-induced risks to hygroscopic/organic artworks: here, 2013 was drier while 2016-17 were more humid than the actual year.



% time	year	2013	2014	2015	2016	2017	2018
	higher	1	3	6	13	12	8
	within	84	90	88	81	85	83
	lower	15	7	6	5	3	8

Figure 5- *Historical indoor climate targets* (green lines) throughout six years of RH observations (gray dots) and percentage of time in which individual yearly RH observations are within the *actual RH short-term bands*.

Conclusion

Due to the year by year variability, a specific calendar year[5] cannot be identified as representative of the historical climate of the room. A target indoor RH is retrieved from six-year observations, showing that hygrothermal conditions are more than 80% of time within the allowable band, i.e. in safe conditions.

References

[1] Perles, A., et al., 2020. *IOP Conference Series: Materials Science and Engineering*, 949 -1, 012026. DOI: 10.1088/1757-899X/949/1/012026; **[2]** Hersbach, H., et al., 2019. *ERA5 monthly averaged data on pressure levels from 1979 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS).* (Accessed on 28-12-2020), DOI : 10.24381/cds.6860a573; **[3]** EN 16242 (2012), European Committee for Standardization: Brussels, Belgium; **[4]** Frasca, F., et al., 2017. *Environmental Science and Pollution Research*, 24(16), 13895-13907. DOI: 10.1007/s11356-016-6504-9; **[5]** EN 15757 (2010), European Committee for Standardization: Brussels, Belgium

For more info on CollectionCare: https://www.collectioncare.eu/

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