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Effect of facade reflectance on outdoor microclimate: An Italian case study

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1 *Effect of facade reflectance on outdoor microclimate: an Italian case study*

2 **Abstract:**

3 Global warming affects the built environment with relation to its own characteristics, form, density. Heat
4 waves effects would have limited effects if most of the cities would not be affected by Urban Heat Island
5 that strongly increase their impacts (particularly on urban population). Does the choice of façade colours
6 and materials contribute to this issue?

7 The paper reports a research on a case study in Italy that tries to answer to this question comparing the
8 trend in outdoor temperature increase closed to the building façade with relation to its colour and
9 reflectance variations modelled by using Envi-met software. The outcomes point out that there is a
10 correlation between the building façade reflectance and the temperature trend but this has a very limited
11 influence on outdoor microclimate in open spaces as it varies in a range of less than 1°C.

12 **Keywords**

13 Outdoor thermal comfort; reflectance; facade colour; Envi-met; building facade
14

15 **1 Introduction and literature**

16 Global warming is nowadays a consolidated issue in the scientific literature and research: a number of
17 initiatives and policies have been launched, both at international and local level, to reduce the current level
18 of CO₂ emissions involving very different sectors from industry to agriculture, from circular economy to
19 material recycling and of course to a massive adoption of renewable energy sources, as outlined in the last
20 IPCC Report (IPCC, 2018) and policy decision as Clean Energy Act (European Commission, 2017). In this
21 general framework, the built environment and contemporary cities play a central role considering at least
22 two main relevant perspectives.

23 On the one hand, most of the population is living and will live in the future in the cities, spending a relevant
24 part of their time inside buildings or in the space in-between them (the so called public open space).
25 Therefore ensuring adequate level of indoor and outdoor comfort is becoming a more and more relevant
26 priority strictly related to the potential effects of climate change and global warming as many studies have
27 already evidenced (Kristian Fabbri, Di Nunzio, Gaspari, Antonini, & Boeri, 2017) (Jacopo Gaspari, Fabbri, &
28 Lucchi, 2018) (J. Gaspari & Fabbri, 2017) (K. Fabbri, Di Nunzio, Gaspari, Antonini, & Boeri, 2017) and as
29 specific research papers on outdoor microclimate report in the dedicated scientific literature (Almhafdy,
30 Ibrahim, Ahmad, & Yahya, 2013),(Santamouris & Kolokotsa, 2015) (Sözen & Koçlar Oral, 2019), (Fong,
31 Aghamohammadi, Ramakreshnan, Sulaiman, & Mohammadi, 2019), (Battista, Carnielo, & De Lieto Vollaro,
32 2016), (Sharmin, Steemers, & Matzarakis, 2017).

33 On the other one, the peculiar characteristics of building materials, paving solutions and vegetation can
34 strongly influence the microclimate of the urban fabric and may contribute to phenomena such as Urban
35 Heat Island (UHI). Kruger et al. explain the impact of sky-view-factor (SVF) and urban geometry on urban
36 climate simulation (Krüger, Minella, & Rasia, 2011), Tseliou & Tsiros (2016) contributed with a research on
37 urban microclimate and thermal sensation in outdoor area in Athens with some improvements scenarios ,
38 Santamouris and Kolokotsa analysed the correlation between overheating and fuel poverty (Santamouris &
39 Kolokotsa, 2015). Heat Waves (HW) are well described in the literature review by Ward et al (Ward, Lauf,
40 Kleinschmit, & Endlicher, 2016) and Moriti et al (Morini, Castellani, De Ciantis, Anderini, & Rossi, 2018).
41 UHI/HW mitigation measure in central European cities (Vuckovic, Maleki, Kiesel, & Mahdavi, 2015) have
42 been investigated with relation to façade reflectance especially by Mauri et al. (Mauri, Battista, de Lieto
43 Vollaro, & de Lieto Vollaro, 2018) as well as by Alchapar and Correa who report a useful classification of
44 building materials to mitigate UHI effect (Alchapar & Correa, 2016).

45 Thus a targeted field of research has been developed dealing with the role of building materials (Castaldo
46 et al., 2017), (Kyriakodis & Santamouris, 2018), (Santamouris & Kolokotsa, 2015),(Lai, Liu, Gan, Liu, & Chen,
47 2019), of green spaces, of urban forms (Sharmin et al., 2017) and more generally dealing with the role of
48 the built environment on the outdoor comfort (Yang, Zhao, Bruse, & Meng, 2013) (Sun et al., 2017).

In a built environment, solar radiation mainly impacts on horizontal surfaces and on those belonging to the building envelopes, whose characteristics influence the reflectance. Since architects and urban planners usually perceive the material's functional and aesthetic features as more relevant, they primarily focus the design choices accordingly, paying less attention to thermo-physical performances despite their crucial role in influencing the outdoor comfort. Several research found in the literature confirm this relevance, although focusing more on the effects on horizontal surfaces, like roofs (Schabbach, Marinoski, Güths, Bernardin, & Fredel, 2018) (Li, Zhao, Zeng, Peng, & Wu, 2017), green roofs (Berardi, 2016), (Doulos, Santamouris, & Livada, 2004), (Salata, Golasi, Vollaro, & Vollaro, 2015) and urban canyons (Castaldo et al., 2017). Less attention is given on building envelopes (Alchapar, Correa, & Cantón, 2014) which are more investigated with relation to construction systems and material features for cladding purposes (Mauri et al., 2018) (Azarnejad & Mahdavi, 2015), (Alonso et al., 2017). This topic is investigated by several authors (Coakley, 2002) (Du & Sharples, 2010) (Takebayashi et al., 2016) (Azarnejad & Mahdavi, 2015), providing direct references about the relationships between colour, reflectance and outdoor microclimate, on which this paper focuses. The definition of reflectance is provided by some studies on the outdoor thermal comfort as "The ratio of the radiant flux reflected by a surface or a medium to the incident flux. Measured values of reflectance depend upon the angles of incidence and view and the spectral character of the incident flux: these factors should be specified." (Steinmant, 1987). Within this framework, the potential influence of material's texture and colour on the surrounding microclimate appears a relevant correlation to be further evaluated, particularly with reference to the outdoor air temperature.

2 Aim

This research aims at assessing the effect of the building outer finishing reflectance on the outdoor surrounding microclimate. In particular, air temperature variations have been estimated for different reflectance values, corresponding to different façade cladding materials. The simulations have been performed for a case study located in the Northern Italy in the city of Parma.

3 Case of study

The territory of Parma municipality is entirely flat, with an average height of 57m above sea level and bordered by the Taro streams on the west side and Enza on the east one. According to the Italian regulations (DPR 26/08/1993 n.412), the city is classified within the climatic zone E, with 2.502 Winter Degrees Day. The climate is typically continental, with hot and muggy summers and harsh winters. Kopper Classification of Parma (Italy) is Marine West Coast Climate, the subtype for this climate is "Cfb (Köppen & Geiger, 1936) (M. Kotttek, J. Grieser, C. Beck, B. Rudolf, 2006). The annual rainfall is around 780 mm, with peaks in autumn, while an average 35-40 cm of snow fall every winter. The predominant summer winds come from the North-East and have an average speed of 2 m/s (by ARPAER (ARPAER www.arpae.it, n.d.)). The fog is frequent, especially during autumn, more intense in the north of the Via Emilia and towards the Po river.



Figure 1. Location of Parma in the Italian territory.



Figure 2. Case-study building. Right: view of PEEP Sidoli area. Left: case study building south facade

The case-study is a multi-storey-building (Figure 1) dating back to 1983 included in the South-East expansion of the city and belonging to the “PEEP Sidoli” housing project (Figure 2). It covers a surface of 660 m² and is 31 meters tall, reaching a total volume of over 20.450 m³.

Developed towards the east-west axis, the plan has a very regular shape with three stair bodies partially emerging from the north façade. This side faces a public square, while the south one faces a public park. East and West façades look on circulation spaces and parking lots. Social housing apartments are hosted in nine of the ten floors above ground, while the ground floor and the basement host garages, common areas and technical rooms. Prefabricated reinforced concrete pillars and beams provide the structural frame. The main envelope layer is made with brick block walls.

North and south main façades, including balcony and loggias parapets, are brick cladded till the fifth floor, while reinforced concrete prefab panels cover the upper floors. East and west facades are instead brick cladded for the ground floor only, while the concrete panels cover entirely the other nine floors.

4 Research methodology

The research carried out on the case study is divided into four steps:

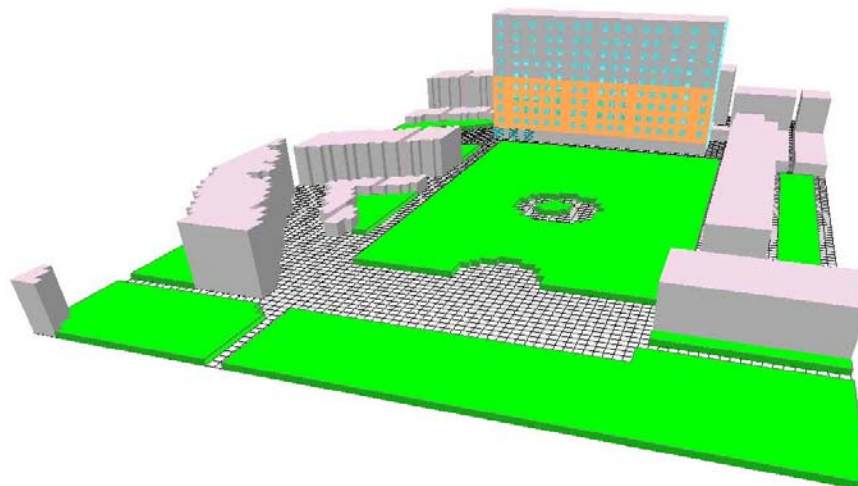
1. collection of climate data and modelling of the physical-environmental conditions in the area surrounding the investigated building;
2. definition of a set of façade configurations ("scenarios") with different reflectance values of the external finishing;
3. modelling of the conditions that occur in each scenario;
4. comparison and interpretation of the outputs.

118 4.1 Envi-met outdoor microclimate modelling

119 The outdoor microclimate was modelled with Envi-met V.4.4 (*Envi-met* www.envi-met.com, n.d.) a
120 modelling software, largely used in the scientific field (Battista et al., 2016) (Sharmin et al., 2017)
121 (Mehaoued & Lartigue, 2019) (Noro & Lazzarin, 2015), which allows to create a three-dimensional model to
122 simulate the interactions between the building and the surrounding external environment and therefore to
123 evaluate the effects of architectural choices in the specific context.

124 The study considered an area of 180m x 120m (figure 3), including the investigated building and its
125 immediate surroundings, with existing buildings and horizontal surfaces (both green and paved).

126 The model has been defined dividing the area into square cells of $x=1.5$ m, $y=1.5$ m, $z=1.5$ m, grid $120 \times 80 \times$
127 30 in a regular grid, without nesting area. The three-dimensional model of the building was subsequently
128 generated, thus determining the orientations and dimensions of all its contact surfaces with the outside air.



129 **Figure 3.** Envi-met 3D model
130
131

132 Since ENVI-met returns the individual variable calculated values for specific points, some "receptors" have
133 been positioned within the building adjacent park, in order to obtain suitable information on the
134 environment conditions. The initial positioning of the receptor set – as figure 4 shows – included four
135 receptors AA, BB, CC, DD at different distances from the building in the green area. After setting the
136 measurement protocol and testing the receptors, the gained data revealed that results from receptors BB,
137 CC, DD didn't show significant variations and it was definitely decided to consider only the numerical
138 outputs provided by the AA receptor (at a distance of 10.2 m from the façade) for the purposes of this
139 study.
140

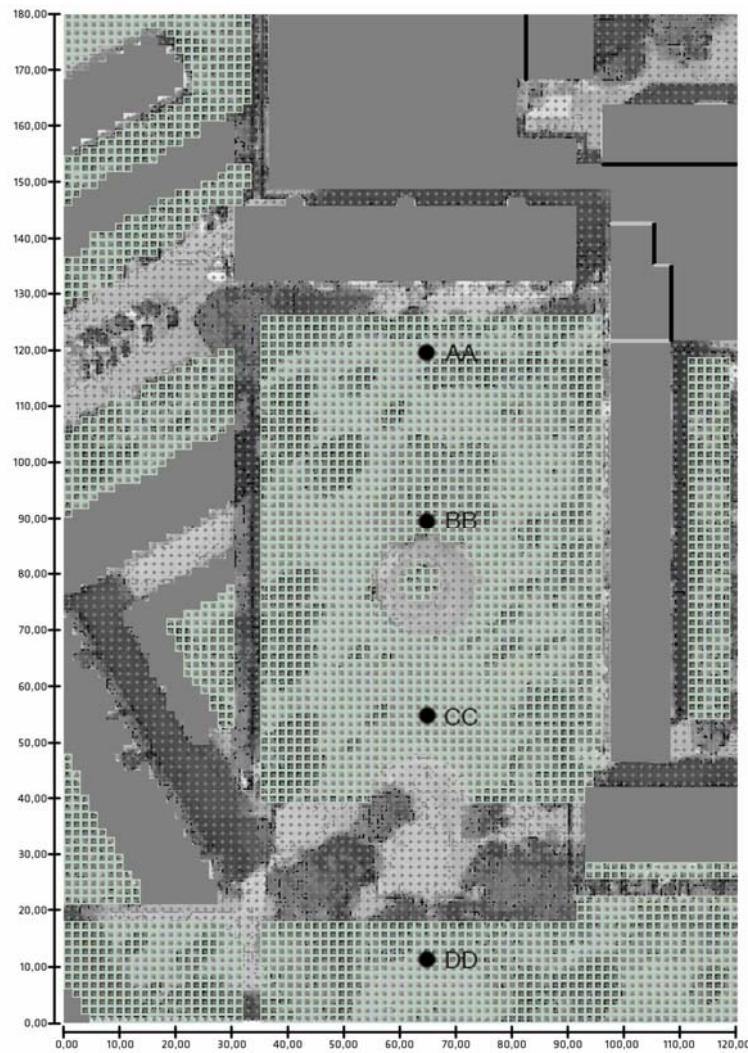


Figure 4. Positioning of the receptors.

Weather Data

The climatic data, such as temperature and relative humidity, were obtained from the ARPAE-ER 'Servizio IdroMeteoClima-Simc', through the Dext3er application and refer to the station located in the city of Parma ("Parma urbano") (ARPAER www.arpae.it, n.d.). 6th August 2017 was chosen for simulations as it is the overheating peak day registered during the last heat wave in Parma.

The initial boundary conditions are:

- start date: 06.08.2017
- start time: 8:00
- total simulation time: 14 (h)
- wind speed measure in 10 m height (m/s): 2 m/s
- wind direction (deg): 90

Table 2 reports the outdoor air values. The first two columns report air temperature and relative humidity as initial meteorological condition (simple forcing).

4.2 Scenarios definition assuming different material options and related reflectance for cladding the façade.

The scope is to investigate how different reflectance values may impact on the outdoor temperature in the spaces narrowing the building. Two materials were chosen for this investigation: stoneware panels and High-Pressure Laminate [HPL] panels (Trespa) ([Trespa www.trespa.com](http://www.trespa.com), n.d.) in several colours. The first is frequently used in façade cladding and the second one is a cheaper and quite recent material that is often used in retrofitting and renovation actions. It is a robust, homogeneous panel of raw wooden elements (till

165 70% natural fibres are used) aggregated using thermosetting resins and coated with a High-Pressure
 166 Laminate (HPL) on both sides.

167 Both the panels reflectance (Touchaei, Akbari, & Tessum, 2016) (Coakley, 2002) was obtained by using App
 168 Albedo (Reflectance APP (<http://misclab.umeoce.maine.edu/research/HydroColor.php>), n.d.) (Nechad,
 169 Ruddick, & Park, 2010).

170 The app allows to get the albedo or reflectance value from most of material surfaces and to transfer it to
 171 Envi-met software improving the reliability of calculation outputs. The reflectance capture process requires
 172 to compare the material under investigation with a grey card to be used as baseline reference. A number of
 173 different materials have been explored and definitely the following options were assumed:

- 174 - Scenario 0: starting condition of the building façade
- 175 - Scenario 1: the building façade (starting condition) is covered using HPL panels light grey colour;
- 176 - Scenario 2: the building façade (starting condition) is covered using HPL panels intense red colour;
- 177 - Scenario 3: the building façade (starting condition) is covered panels light grey colour;
- 178 - Scenario 4: the building façade (starting condition) is covered using stoneware panels red colour.

179

180 4.3 Scenarios modelling






181 Each scenario was modelled changing only the outer finishing of the façade. The existing wall section
 182 includes a brick block layer (12 cm), a thermal-acoustic insulation layer (6 cm) and an inner lightweight brick
 183 block layer (8cm). These materials were modelled assuming an emissivity of 0.89 (having an opaque
 184 finishing), equal reflectance and albedo as set by the app “Reflectance App”

185 (Reflectance APP (<http://misclab.umeoce.maine.edu/research/HydroColor.php>), n.d.).

186 Table 1 provides the reflectance for the wall section of each scenario.

187

188 **Table 1** Building Facade Reflectance values for each scenario

Scenario	Sample	Facade finishing		Reflectance	
0		Exposed brick finishing	Exposed concrete panels	0.29	0.43
1		HPL panels light grey colour		0.60	
2		HPL panels intense red colour		0.11	
3		stoneware panels light grey colour		0.57	
4		stoneware panels red colour		0.13	

189

190 4.4 Model calibration

191 Within the scope of the study, a calibrated model such as Oblivious would strengthen the results but it
 192 must be stressed that scientific literature does not provide a validated procedure to calibrate Envi-met
 193 results, as instead happens with software dealing with Building Energy Performance simulation following
 194 ASHRAE Guideline 14 (ANSI/ASHRAE, 2002). The calibration of Envi-met model can refer to:

195 a) weather simulation data from on-site point, as described in Fabbri et al. (K. Fabbri, Canuti, & Ugolini,
 196 2017) Fabbri & Costanzo (K Fabbri & Costanzo, 2019) and Tsitoura et al, (Tsitoura, Michailidou, & Tsoutsos,
 197 2016), where air temperature in a point is not influenced by local radiation (this ensure more reliable
 198 results than using data source in a distance larger than 10 km
 199 <https://content.meteoblue.com/en/specifications/data-sources/weather-simulation-data>);

200 b) on site measurement by probes as described in some research (Eckmann et al., 2018) (Forouzandeh,
 201 2018) (Nasrollahi, Hatami, Khastar, & Taleghani, 2017) (Piselli, Pigliautile, Castaldo, Cotana, & Pisello, 2017)
 202 (Salata, Golasi, de Lieto Vollaro, & de Lieto Vollaro, 2016) (Sharmin et al., 2017) (Tseliou & Tsiros, 2016).

203 The first option is adopted in the present study and the calibration has been performed using weather data
 204 simulation by Meteoblue (*Meteoblue* (www.meteoblue.com), n.d.) for comparing scenario 0 (starting
 205 conditions). Table 2 reports all air temperature data. Envi-met results for scenario 0 concern hours in a

range 10:00, 13:00 and 16:00 at 1.35 m. As Table 2 shows data gained by the weather-service Meteoblue (column D) are compared with those gained from receptor AA (column E) revealing that, in the most representative time interval during the day, the gap between the two is less than $\pm 5\%$. Figure 5 provides a graph considering air temperature trends by weather data, Meteoblue, Envi-met and linear regression R^2 equal to 0.909. Accordingly, the model can be assumed as calibrated.

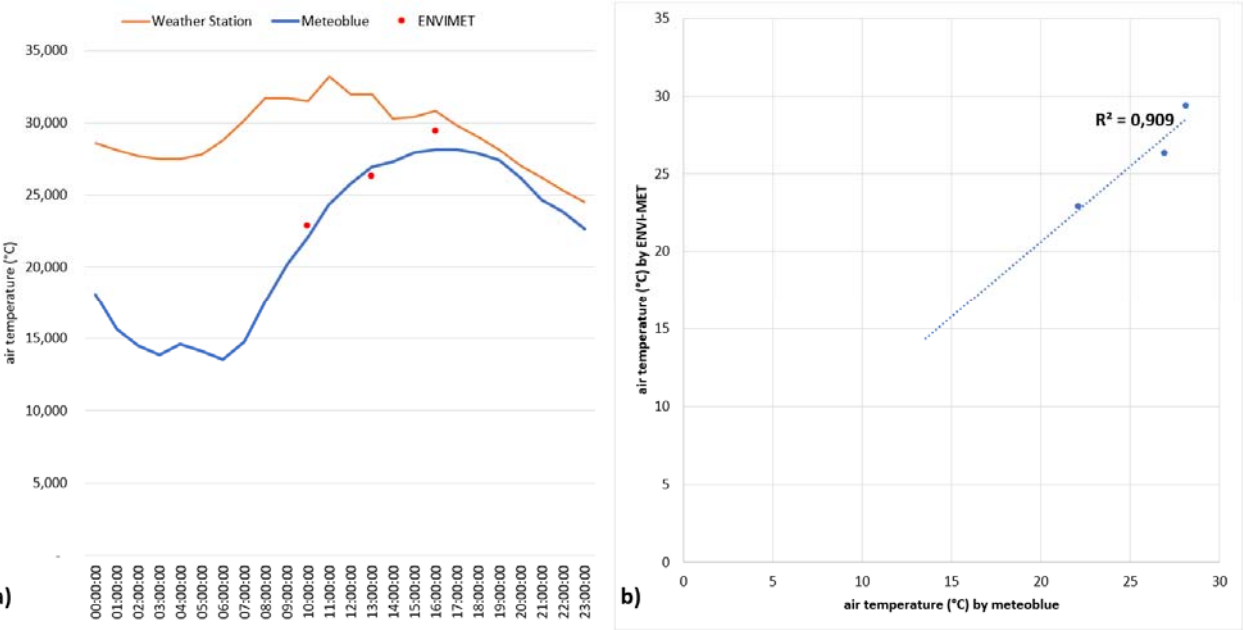
211

Table 2. Air temperature (°C) outdoor average at 2 above sea level from ARPAER, Meteoblue and Envi-met

213

A	B	C	D	E
hours	ARPAER Dexter (ARPAER www.arpae.it , n.d.)	ARPAER Dexter (relative humidity, %)	Weather simulation data (meteoblue)	Envi-met results Scenario 0 receptor AA as starting conditions
08:00	31.70	46	17.60	
09:00	31.70	42	20.13	
10:00	31.50	42	22.10	22.86 [-3.44%]
11:00	33.20	44	24.36	
12:00	32.00	37	25.77	
13:00	32.00	43	26.94	26.27 [+2.49%]
14:00	30.30	44	27.29	
15:00	30.40	46	27.94	
16:00	30.80	45	28.16	29.39 [-4.37%]
17:00	29.80	44	28.14	
18:00	29.00	45	27.87	

214



215

216

217

Figure 5. Outdoor air temperature measurement scale adopted in OMM.

218 5 Results

Simulation outcomes (Atmosphere files from Envi-met) were extracted and elaborated using Envi-met Leonardo. Outdoor air distribution map was set as closest as possible to ground level (1 m). Simulation outcomes deal with: a) Outdoor Microclimate Map (OMM) representing the air temperature isolines distribution from Leonardo; b) specific temperature values with relation to receptor AA.

223

224 a) Outdoor Microclimate Map

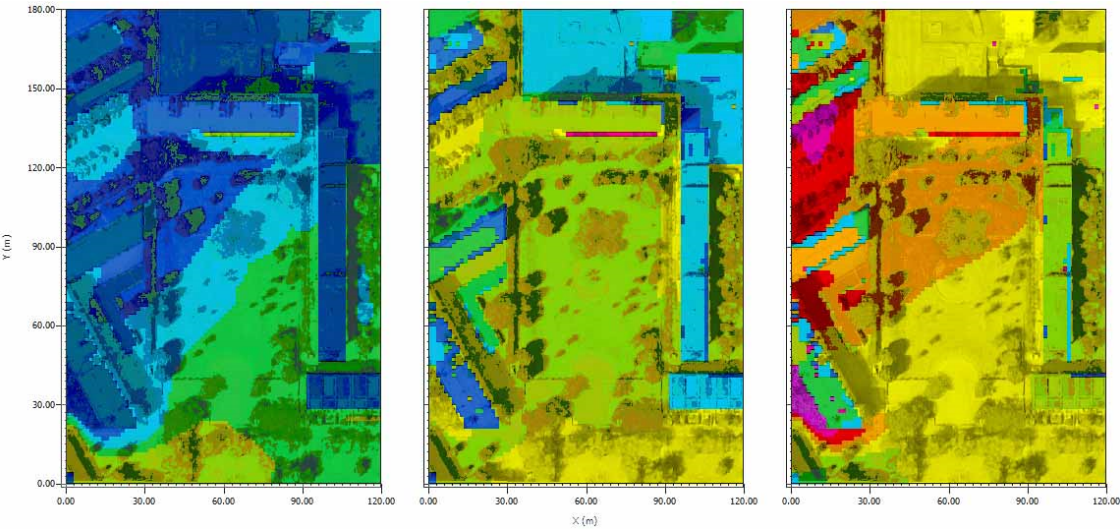
225 Simulations provided Outdoor Microclimate Maps concerning air temperature variations of the five
226 investigated scenarios. The considered time range is between 8:00 and 20:00 and results are reported at
227 10:00, 13:00, 16:00. For each scenario the following outcomes are included in this study:

- 228 1) Outdoor air temperature Maps at 10:00, 13:00, 16:00 for all the analysed scenarios (figures 7 to 11);
229 2) Outdoor air temperature Maps at 10:00, 13:00, 16:00 comparing the starting condition with the
230 scenarios in which reflectance value is minimum and maximum.

231 There were not observed relevant differences occurring in terms of relative humidity, mean radiant
232 temperature, wind speed, surface temperature in the investigated scenarios. All the reported maps adopt
233 the same scale as figure 6 shows.



234
235 **Figure 6.** Outdoor air temperature measurement scale adopted in OMM.
236



237
238 **Figure 7.** OMM outdoor air temperature. Scenario 0: building façade - starting condition. (right: results at 10:00, center results at
239 13:00, left: results at 16:00)
240

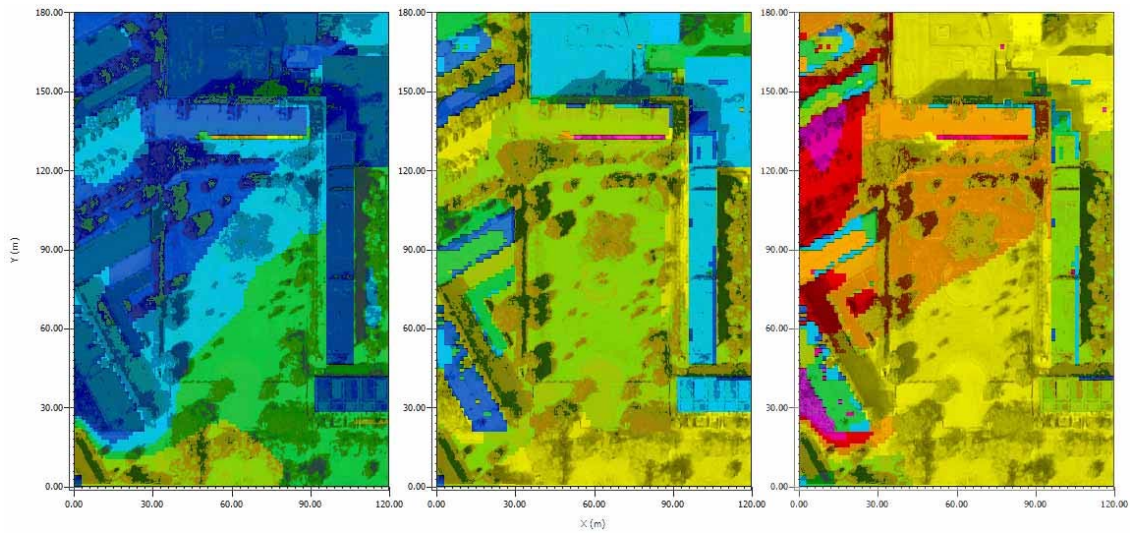


Figure 8. OMM outdoor air temperature. Scenario 1: building façade - HPL panels light grey colour. (right: results at 10:00, center results at 13:00, left: results at 16:00)

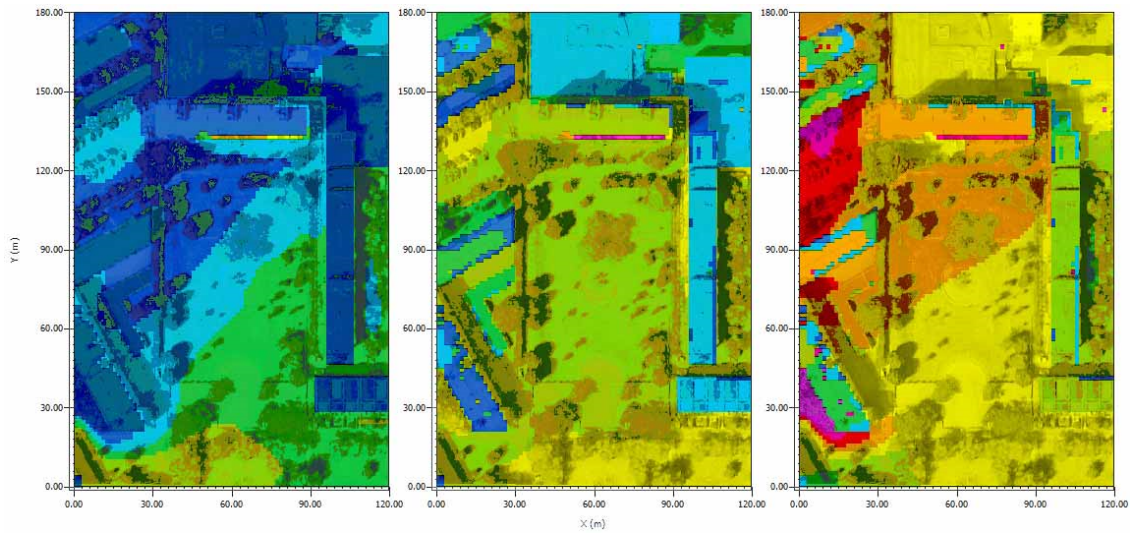


Figure 9. OMM outdoor air temperature. Scenario 2: building façade - HPL panels intense red colour. (right: results at 10:00, center results at 13:00, left: results at 16:00)

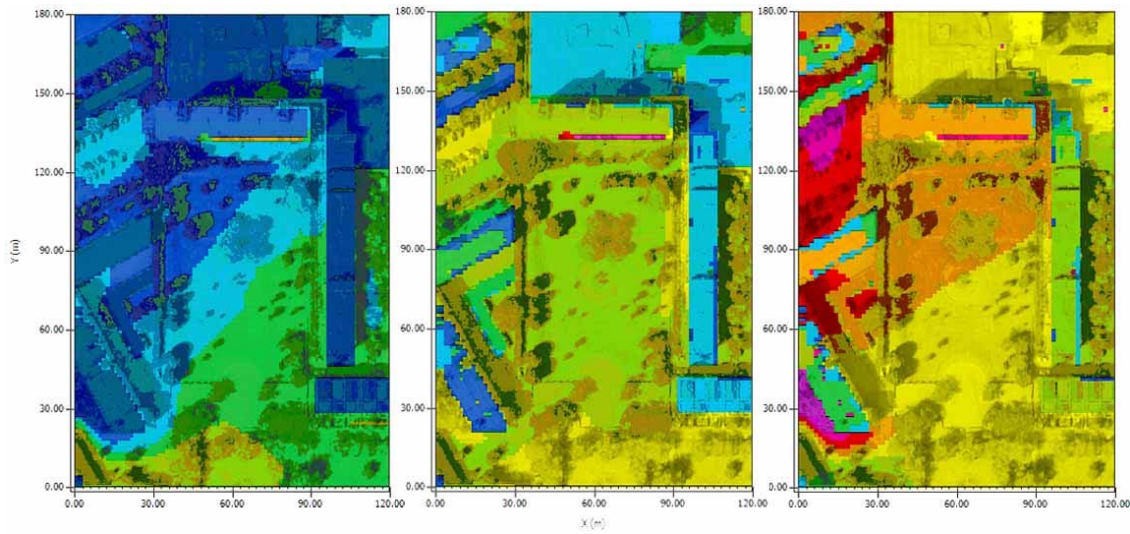


Figure 10. OMM outdoor air temperature. Scenario 3: building façade - stoneware panels light grey colour. (right: results at 10:00, center results at 13:00, left: results at 16:00)

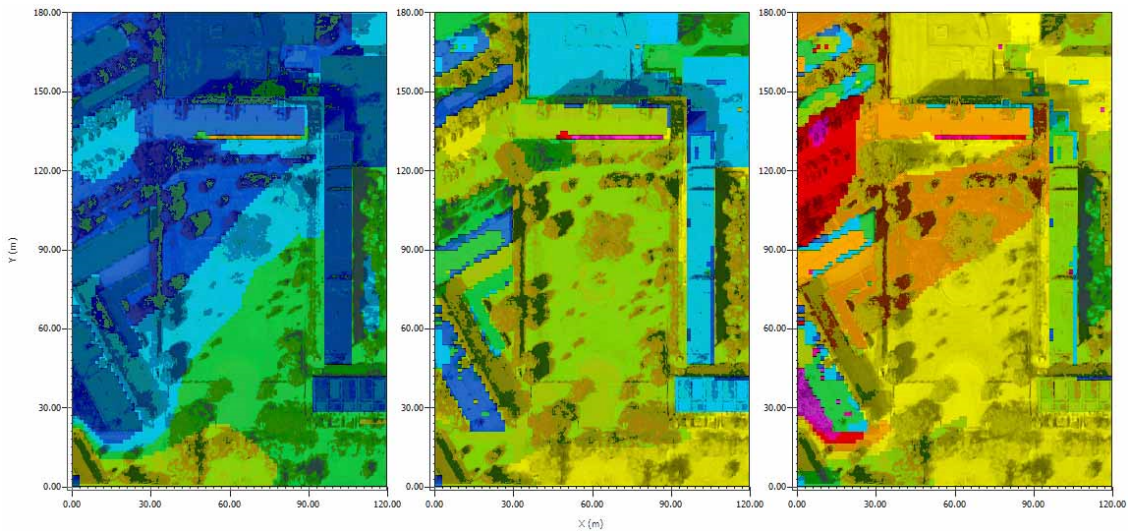
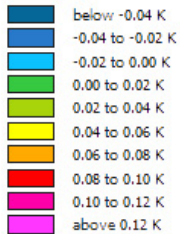


Figure 11. OMM outdoor air temperature. Scenario 4: building façade - stoneware panels red colour. (right: results at 10:00, center results at 13:00, left: results at 16:00)

Reading each figure (7 to 11) from left (h 10.00) to right (h 16.00) side it can be noted that, in all the simulations for the outdoor space of the investigated building, an increase of temperature can be registered following its own shade and the ones of the neighbouring buildings. However, no relevant variations can be detected. Reading the figures from top to bottom, that means scenarios are compared in the three specific time hours, it can be noted that OMM are really very similar and there are significant impacts in terms of temperature variations with relation to material and colour options for the façade cladding.

In order to discuss this observation, comparative OMM between the starting condition (scenario 0) and the other scenarios (1,2,3,4) have been produced with reference to outdoor air temperature ($^{\circ}\text{C}$). All the reported OMMs adopt the same measurement scale [K] (figure 12).

absolute difference Air Temperature



Min: -0.04 K
Max: 0.17 K

Figure 12. outdoor air temperature measurement scale.

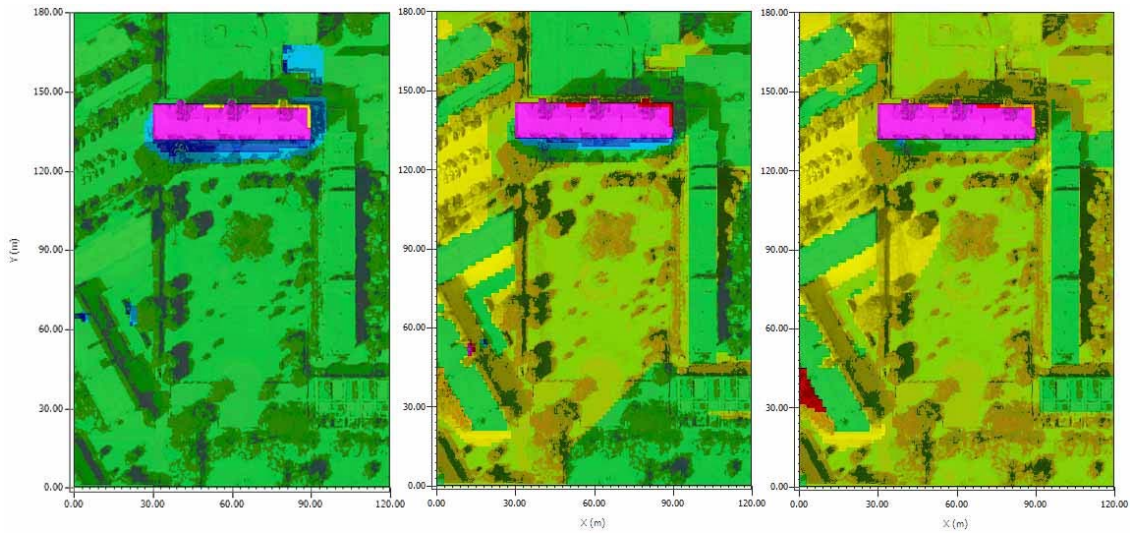


Figure 13. OMM comparing outdoor air temperature between Scenario 01 and Scenario 1. (right: results at 10:00, center results at 13:00, left: results at 16:00)

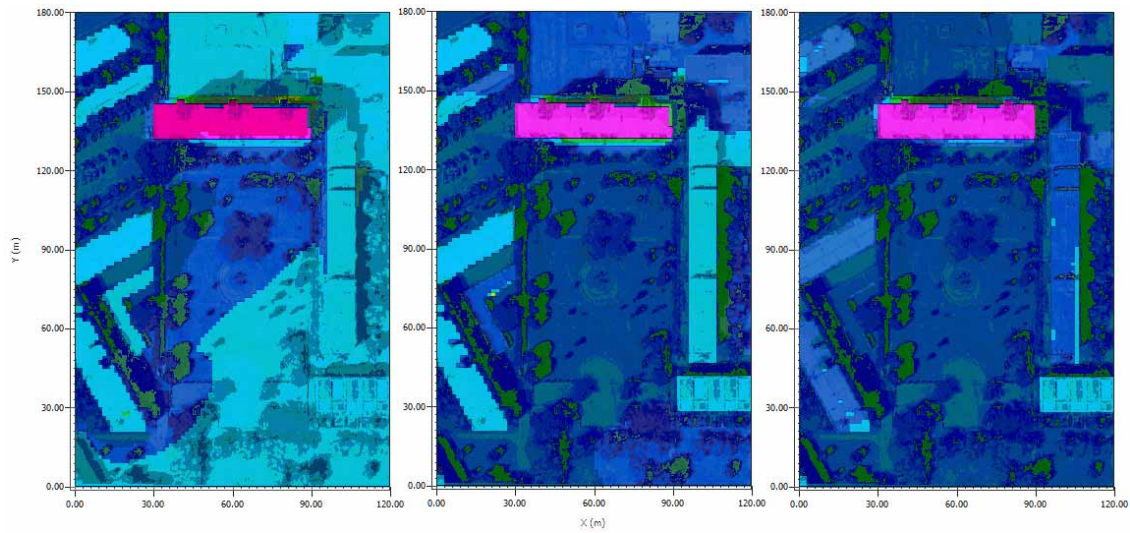
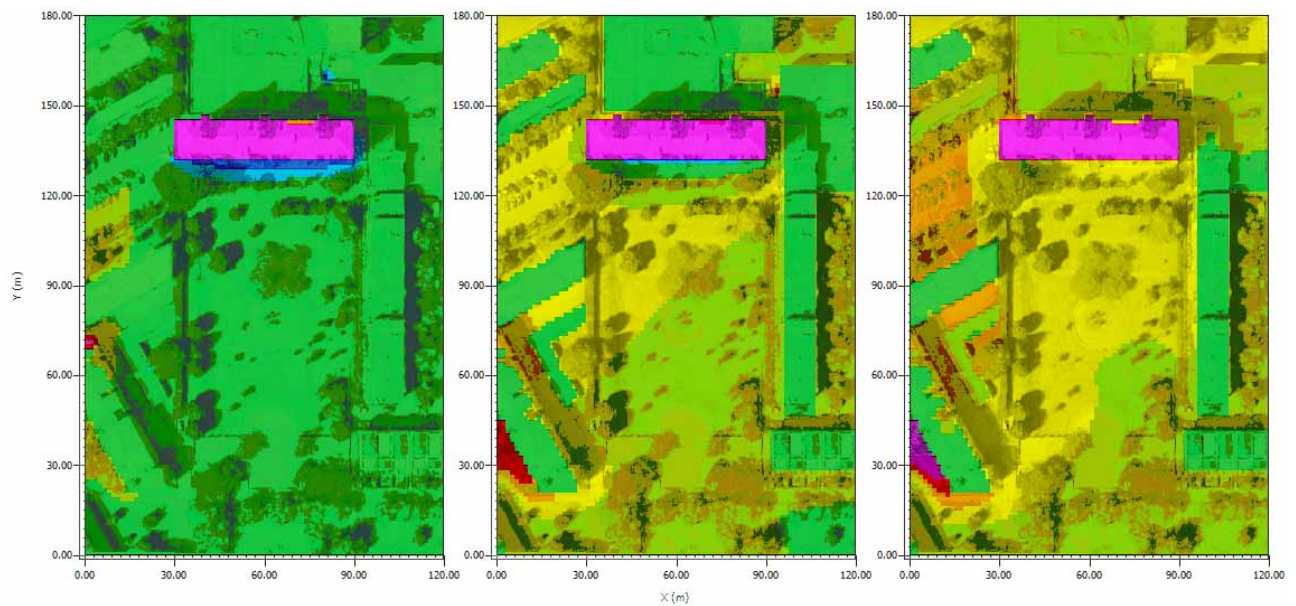
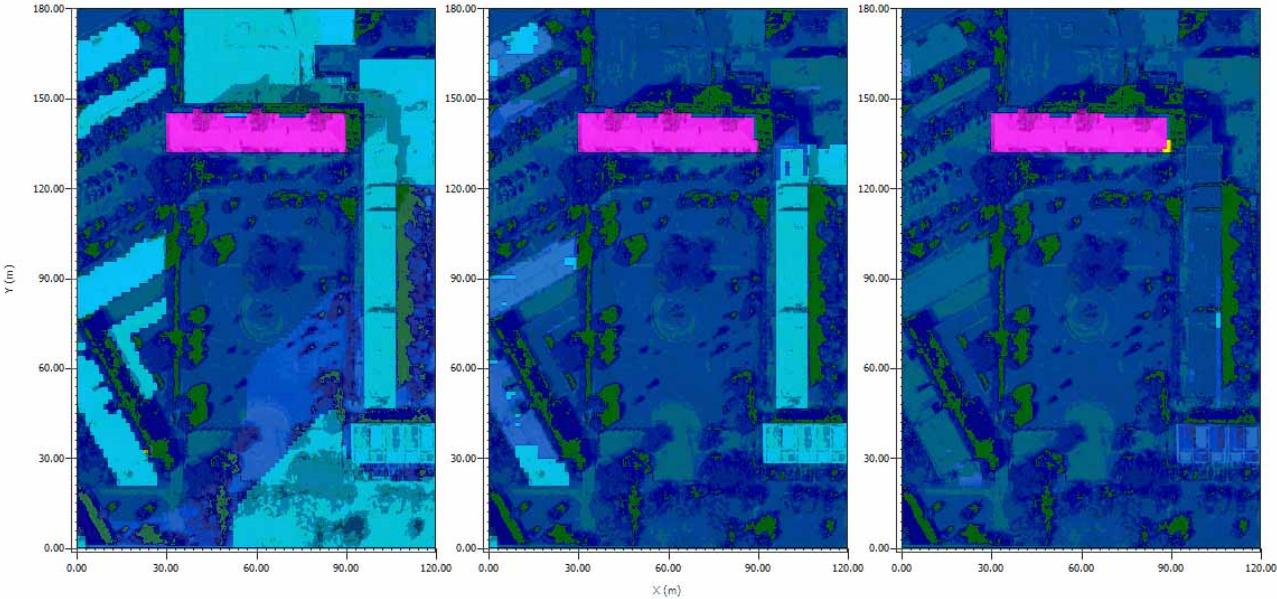


Figure 14. OMM comparing outdoor air temperature between Scenario 0 and Scenario 2. (right: results at 10:00, center results at 13:00, left: results at 16:00)



281 **Figure 15.** OMM comparing outdoor air temperature between Scenario 0 and Scenario 3. (right: results at 10:00, center results at
 282 13:00, left: results at 16:00)
 283



284 **Figure 16.** OMM comparing outdoor air temperature between Scenario 0 and Scenario 4. (right: results at 10:00, center results at
 285 13:00, left: results at 16:00)
 286
 287

288 Looking at each figure (13 to 16) from left (h 10.00) to right (h 16.00) side it can be noted that very similar
 289 effects derive from the use of different materials having very similar colours for the façade cladding.
 290 Particularly the red ones produce a slight decrease of air temperature. This results more evident during the
 291 afternoon. Using a light grey colour there is instead a slight increase of temperature during the afternoon.
 292

293 *b) temperature values in the receptor AA in the green area facing the investigated building*

294 OMMs do not allow to detect significant variations of outdoor air temperature. Therefore, data referred to
 295 air temperature of each scenarios were extracted in receptor AA (figure 4) that is 10.2 far from the building
 296 envelope. Comparing reflectance and air temperature value referred to receptors placed in the green area
 297 facing the building, a small variation within a range of 0.19 °C can be detected.

298 Table 3 reports reflectance values referred to each scenario, the related outdoor temperature of receptor
 299 AA, the temperature difference with relation to scenario 0 at 10.00 and 16.00.

300 With the increase of reflectance, a very small outdoor temperature variation can be registered.

301

302 **Table 3.** Temperature variations elaboration.

<i>Material</i>	Exposed brick and concrete	HPL panels light grey colour	Gap respect sc.0	HPL panels intense red colour	Gap respect sc.0	stoneware panels light grey colour	Gap respect sc.0	stoneware panels red colour	Gap respect sc.0
Reflectance	0.36	0.60		0.11		0.57		0.13	
h. 10:00 (°C)	22.19	22.19	0	22.16	-0.03	22.19	0	22.13	-0.06
h. 13:00 (°C)	24.80	24.82	+0.02	24.75	-0.05	24.83	+0.03	24.66	-0.14
h. 16:00 (°C)	27.10	27.13	+0.03	27.04	-0.06	27.14	+0.04	26.91	-0.19

303

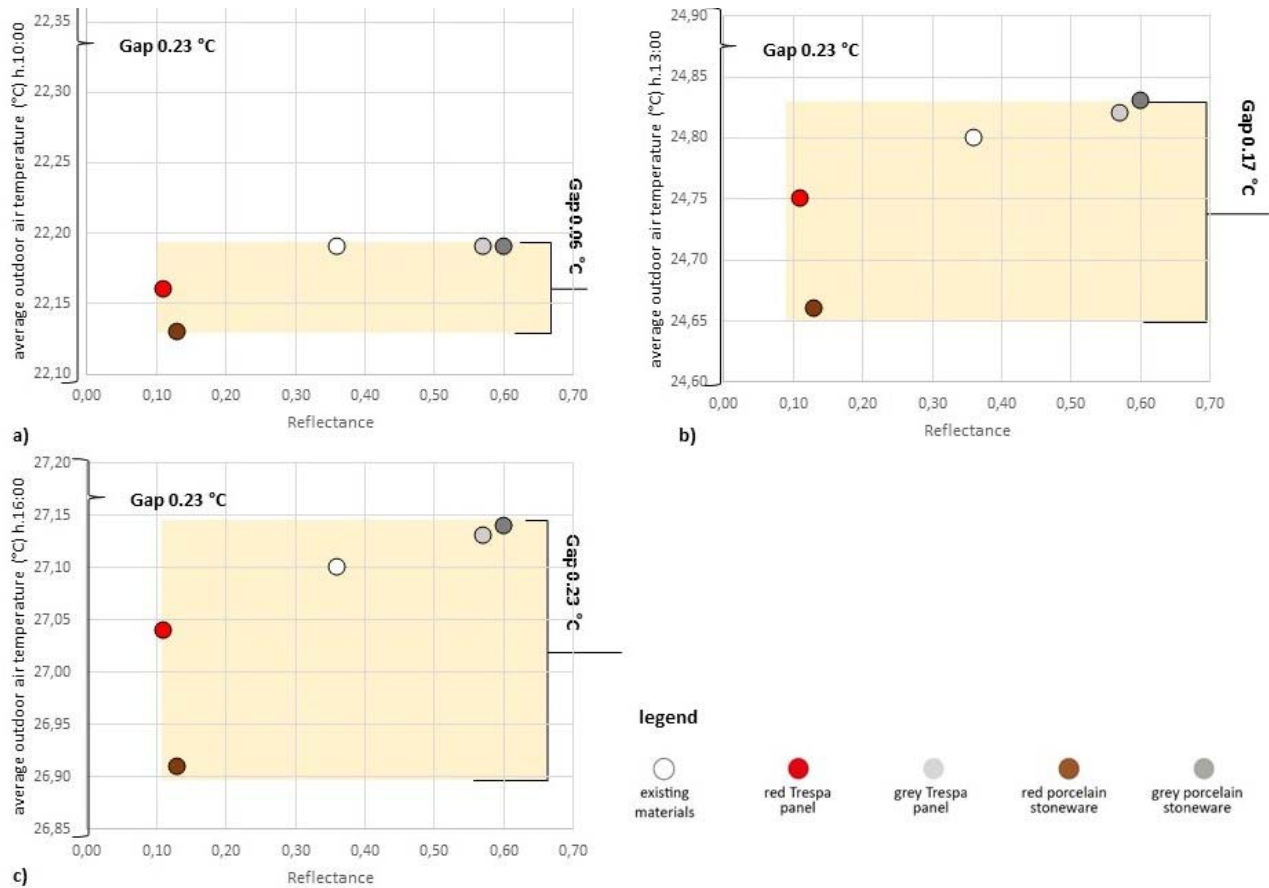


Figure 17. Comparison between reflectance and average outdoor air temperature with reference to receptor AA. Graphs show on the y axe the ΔT gap of 0.23°C while on the right side ΔT gaps for each time hour are reported: ΔT at 10.00 is 0.06°C; ΔT at 13.00 is 0.17°C; ΔT at 16.00 is 0.23°C. Despite the very limited variations it can be noted that with the increase of radiation and air temperature the gap between colours having a reflectance less than 0.3 or more than 0.6 increases.

Figure 17, obtained by table 3, displays the correlation between reflectance and air temperature with relation to each time.

Graph a) reports the temperature variation with relation to receptor AA of each scenario compared to the state of art scenario (scenario 0). It can be noted that the variation between scenarios 1 (HPL panels light grey colour) and 2 (stoneware panels light grey colour) is limited to 0.06 °C compared to scenarios 3 (HPL panels intense red colour) and 4 (stoneware panels red colour). Thus it can be argued that reflectance has no influence. Graph b) reports a similar observation at 13.00 with a registered gap of 0.17 °C while in Graph c) at 16.00 is 0.23. Comparing the graphs, the gap depends on the simulation hour. The variation is still very limited and included in a range $\pm 0.3^\circ\text{C}$ that produces no significant impact on outdoor comfort and microclimate. A further interesting observation is that there is no linear correlation between reflectance and air temperature.

6 Discussion

The outcomes of OMM, tables and graphs show a relation between the façade reflectance and outdoor temperature, but this is so limited ($\pm 0.02^\circ\text{C}$ and $\pm 0.19^\circ\text{C}$) that it is not able to influence the outdoor microclimate. Accordingly, it can be said that the façade choices do not affect the outdoor space. Despite this, the correlation between reflectance and outdoor air temperature is less or more evident with relation to the investigated time range of the day.

7 Conclusions

The research investigated the relation between the colour of some building façade options and the potential effect on the outdoor microclimate using Envi-met simulations. The adopted methodology allows to evaluate the variations for each scenario. Results are discussed using OMM and data extracted from the receptor to analyse the reflectance influence. The methodology can be easily replicated elsewhere both in case of real case studies and simulations.

The scientific literature provides some studies about the impacts of material and colour choices for cladding building façades on outdoor microclimate with relation to urban canyon, while this study is aimed at investigating the potential effects on open spaces. The proposed study considers one input variable (façade reflectance) and one output variable (air temperature) without exploring the effects that may derive from modifying paved or green surfaces or coming from other potential elements of interaction (i.e. wind). This is due to the major impacts that these could produce on air temperature, consequently reducing the chance to observe the investigated phenomenon.

The results confirm that the façade reflectance is not able to significantly influence open spaces microclimate, despite the correlation between the two variables was demonstrated.

Thus, it can be concluded that in case of open outdoor spaces, the role of paved or green horizontal surfaces has a much more relevant influence on comfort compared to the very minor contribution offered by the properties of façade materials of the facing buildings. This evidences a great difference with relation to other urban forms such as courtyards or street canyon.

In outdoor spaces solar radiation plays a main role in influencing the microclimate and so happens with simulation software where solar radiation reflection depends on reflectance surface and Sky View Factor (SVF) by buildings and trees. When SVF is near to 1 – like in the case study – reflectance does not influence the microclimate of the open space. On the contrary, being SVF value less than 1 and sometimes of 0.5, reflectance can contribute to solar trapping as happens with urban canyons and especially dense urban fabric.

Further studies in this sector may investigate other urban forms (adopting the same methodological approach), compare simulation outcomes with in-situ captured data and analyse indoor microclimate with relation to the variation of the building façade reflectance.

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