Method for the Solar potential evaluation of the unoccupied urban volume

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ABSTRCT: Using the commercially available Solar Analyst software tool, a simple method is introduced which permits the calculation of the solar energy exposure of a flat surface at any height above the street level within the complex unoccupied volume of an urban environment. The digital surface map (DSM) of an urban area is modified by incrementing only the height of the street (and not surrounding buildings) and running the Solar Analyst tool on the modified DSM to obtain the solar irradiation of the new surfaces that are now above the street level. The methodology is applied to two distinct areas of Lisbon and highlights how the solar potential map for each of the areas evolves comparatively as a function of height above the street level.

1. Methodology

1.1 Building identification from Digital Surface Map (DSM)

The DSM is modified by only increasing the height of the ground and not the building's height. This requires the careful identification of the buildings in the DSM.

Figure 1: DSM of two locations in Lisbon, *Parque das Nações* and Downtown, *Baixa Chiado).* Building outline is identified in red and centre street line in yellow.

1.2 Digital Surface Map (DSM) modification

With the building outline identified, the DSM is modified by only increasing the areas which are not occupied by the buildings.

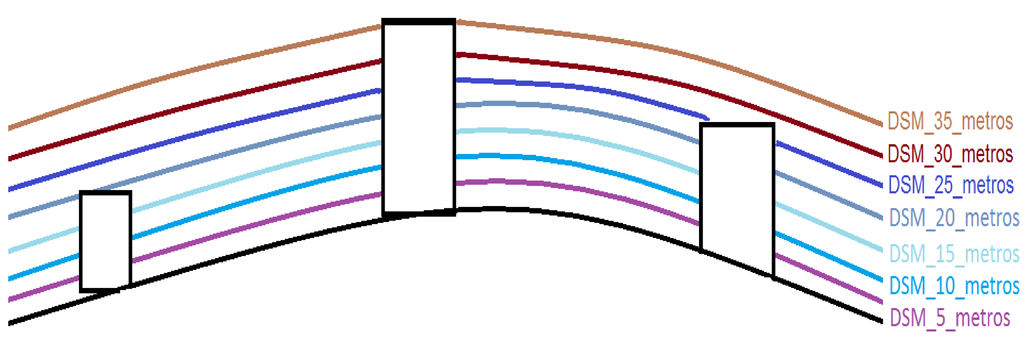

Figure 2: Schematic representation of the modified DSM where 5 meters is added incrementally to the street but not to the buildings.

1.3 Simulation of solar irradiation

The Solar Analyst tool was employed to simulate the solar irradiation for winter solstice, which is the day of the year where the shadows will be longest.

The Solar Analyst tool atmospheric parameters were calibrated so that the hourly **diffuse + direct = global** irradiance matched the PV-GIS clear-sky data.

The irradiance data was integrated and then normalized and classified into three categories with respective to unobstructed areas (which have the maximum possible daily irradiation). The areas with highest irradiation were classified as those that had at least 95% of daily irradiation. Intermediate areas were classified having between 50% and 95% of daily irradiation, and lowest areas with less than 50% daily irradiation.

This translates into shading fractions of 0 to 5%, 5 to 50% and 50 to 100%, respectively.

2. Results

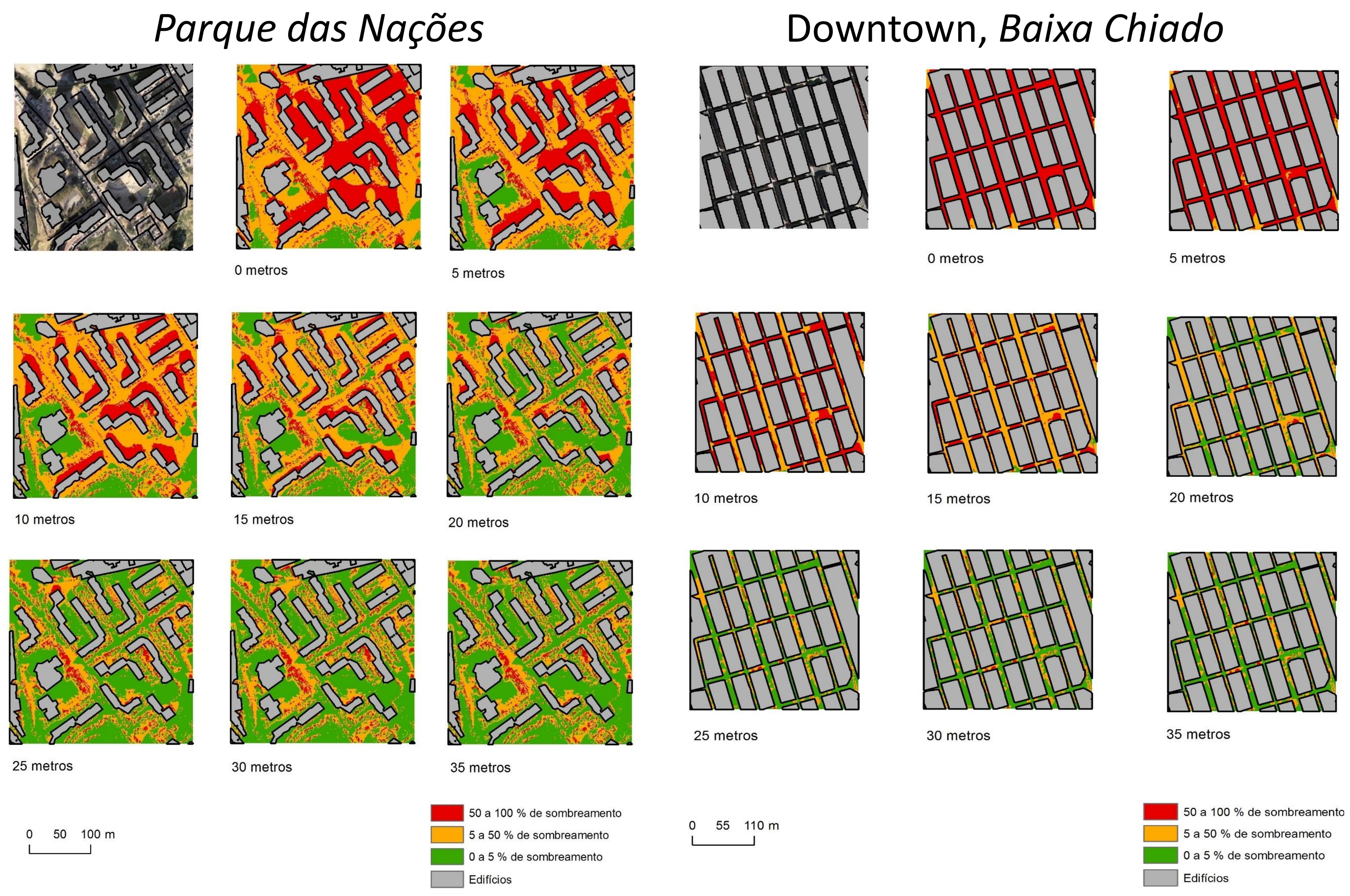

Figure 3: Shading fraction maps calculated from daily solar irradiation as a function of height above street level. Left: *Parque das Nações.* Right: Downtown, *Baixa Chiado*). Also shown at top right is a satellite image of the respective two areas where the buildings have been greyed out.

The maps allow the identification of areas with high and low irradiation.

For PV applications, areas with a low shading fraction (0 to 5%) are areas where an autonomous off-grid PV system could be sized without considering losses due to shading.

Areas with an intermediate shading fraction (5% to 50%), the irradiation short-fall would require an increase in solar panel areas. Because systems tend to be modular, the easiest way to increase production could be to add a second solar panel, thus increasing solar panel area by two. In these areas, sufficient energy production would be ensured by doubling the PV panel areas of each autonomous off-grid system.

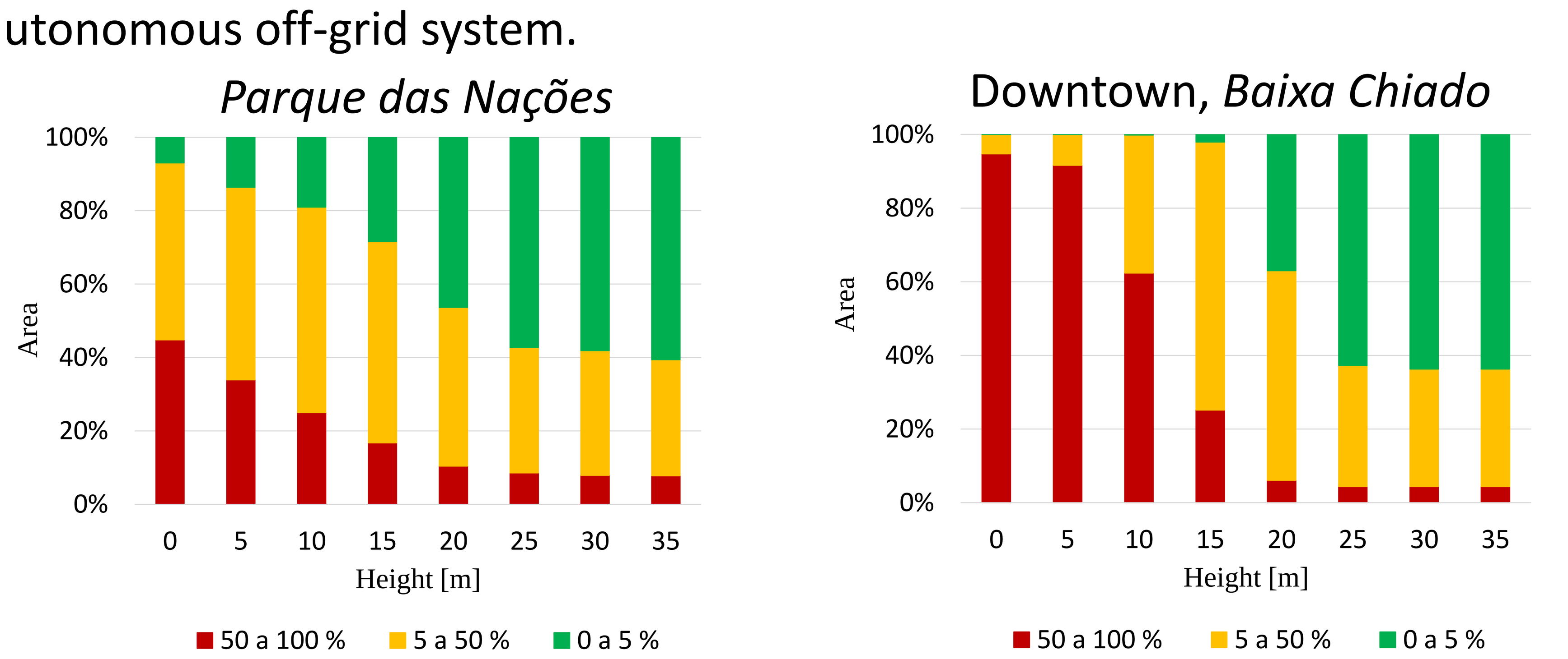

Figure 4: Percentage of area affected classified shading fractions as a function of height above street level. Left: *Parque das Nações.* Right: Downtown, *Baixa Chiado*).

The above graphs quantify percentage of areas that suffer from different shading fractions. For the more open urban area of *Parque das Nações,* the decrease in shading is more gradual as height increases. For the downtown *Baixa Chiado* area, the high shading fractions area starts of greater but then decreases more rapidly after 5 m above street level.

For the *Parque das Nações*, ca 60% of the area is adequate for installing a PV systems only requiring double the standard panel area. However, for *Baixa Chiado* this occurs between 10 to 15 m.

Above 25 m, the shading fraction areas are similar.

3. Conclusions

A simple method for determining the solar irradiation in the unoccupied volume of the public space has been demonstrated using accessible commercial software tools. This methodology can be easily implemented for urban planners to determine e.g. which volumes of the urban area can be viably powered by PV. Application can be street lighting, bus shelters, information points, mobile bicycle charging stations etc.

A clear shading fraction evolution signature is evident for differing urban morphologies.

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