Development of Daylight Availability Maps in Italy: methodology and validation.

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Introduction

The natural light plays a crucial role on the energy and environmental performances of buildings.

The energy need for electric lighting in European buildings, is currently calculated according to the procedure defined in EN15193:2007, but a critical aspect to evaluate the energy saving potential of lighting is the assessment of the daylight contribution.

Climate-based daylight modelling (CBDM) can provide better support for buildings applications, but require a large dataset of daylight data for different zone.

In this poster is described the methodology applied to build Typical Meteorological Years (TMYs) for outdoor illuminance and develop daylight availability maps for the Italian territory.

Methodology

The definition of a luminous efficacy model [η], allows to convert radiometric quantities, Global, Diffuse and Direct Irradiance [E_{gh}, E_{dh}, E_{bn} in W/m²], into photometric quantities, daylight illuminance [I_{gh}, I_{dh}, I_{bn} in lux]. The following equations describe the Italian model applied to derive daylight illuminance data, starting from solar radiation data.

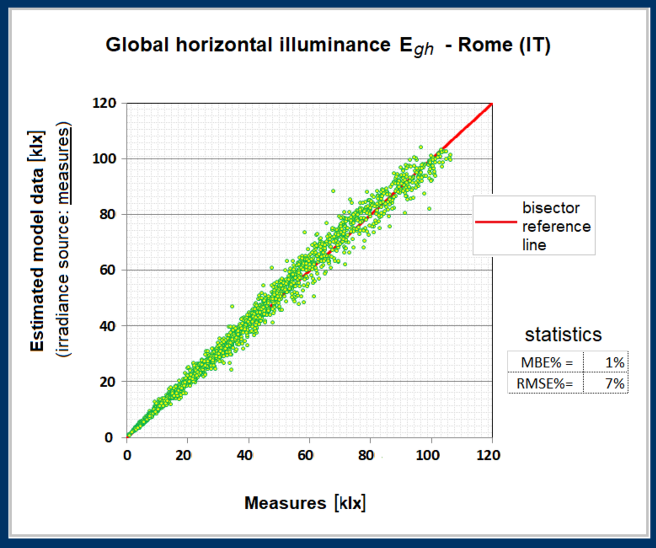
$$\begin{cases} E_{gh} = \eta_{gh} I_{gh} \quad E_{dh} = \eta_{dh} I_{dh} \quad E_{bn} = \eta_{bn} I_{bn} \\ \eta_{gh} = \lambda \cos^{a} \vartheta_z \, e^{-b(90^\circ - \vartheta_z)} (1 - \phi\Delta) \\ \eta_{dh} = \alpha \Delta^{-\beta} \\ \eta_{bn} = \dfrac{(\eta_{gh} - \eta_{dh} k)}{1-k} \\ k = I_{dh}/I_{gh} \\ \Delta = m I_{dh}/I_{0n} \end{cases}$$

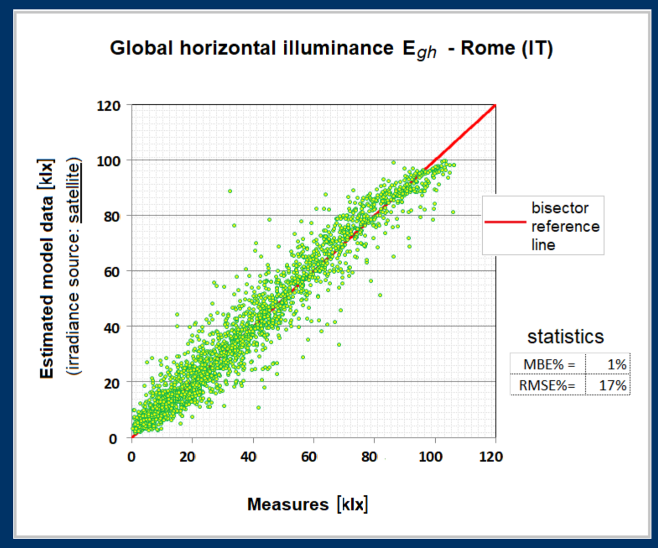
Metrics based on experimental measures carried out in Italy.

$$\begin{cases} \lambda = 129.46 \, lm \cdot W^{-1} \\ a = 0.122 \\ b = 0.029 \\ \phi = 0.07595 \\ \alpha = 85 \, lm \cdot W^{-1} \\ \beta = 0.28 \end{cases}$$

Validation of model

The results obtained, have been validated with ground measurements (monitoring period 2015-2017), carried out in three different Italian sites, to test the effectiveness of model, taking into account different latitudes of Italian territory: Milan, Rome and Lampedusa island.



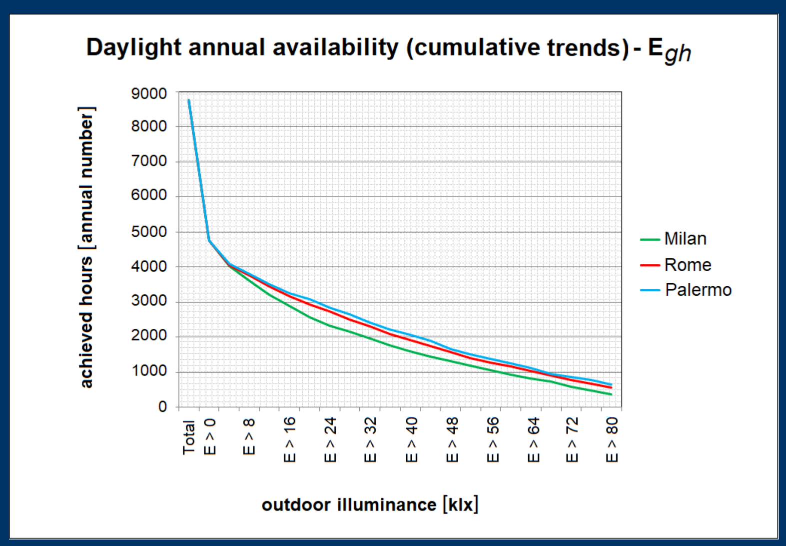


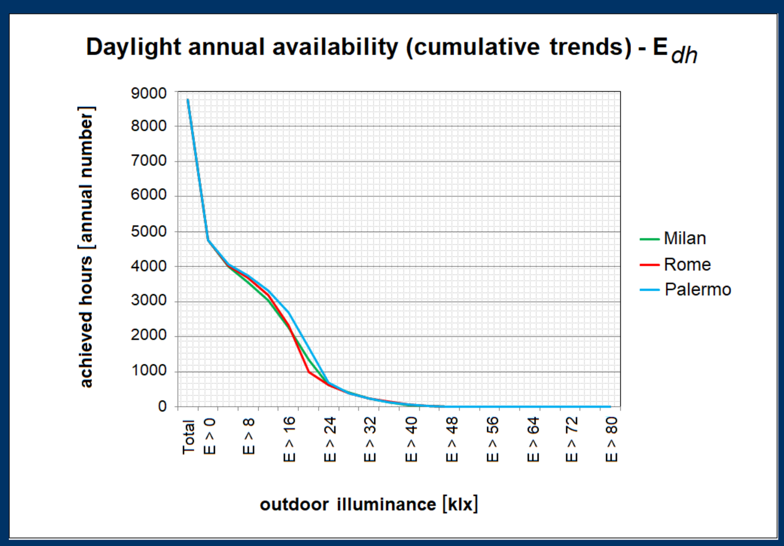
Site	Climatic conditions	Measurement [lx]
Lampedusa island	Southern Italy	Egh
Rome	Centre Italy	Egh, Edh
Milan	Northern Italy	Egh, Edh

The values of statistical indices MBE and RMSE show the effectiveness of the model and the accuracy of the parameters introduced.

Results: daylight availability diagrams

The luminous efficacy model, as defined, has allowed to calculate Typical Meteorological Years (TMYs) for all components of outdoor illuminance (global, diffuse and direct) for 243 Italian sites, considering different time profiles selected to evaluate the potential daylight autonomy.

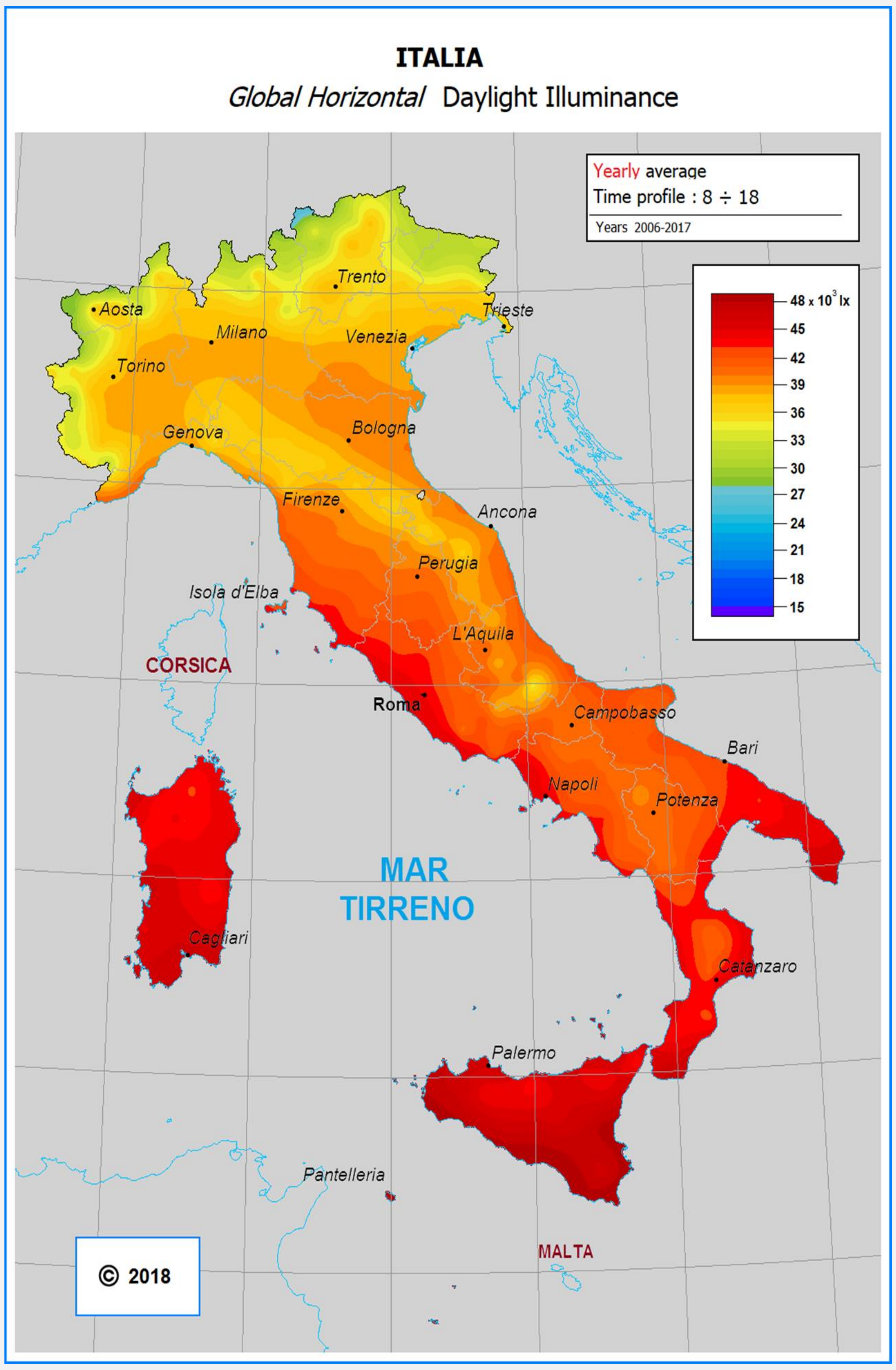




The daylight availability expressed by cumulative curves as shown in the figures above, allow to evaluate the percentage of hours in the year in which, a specific value of outdoor illuminance is achieved.
The diffuse component is usually used to evaluate the contribution of daylight in buildings, and to derive the energy need for artificial lighting, in conservative conditions.

Development of daylight maps

The application of ordinary kriging has allowed to reproduce the natural spatial pattern of daylight illuminance, and develope daylight maps for the whole Italian territory.



Conclusions

The use of daylight site data in climate based methods can play a relevant role in improving the currently used evaluation methods for the lighting energy performance in buildings and urban districts.

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