DAYLIGHTING INFORMATION THROUGHOUT EUROPE USING THE SATEL-LIGHT AND SODA INTERNET SERVERS

Dominique Dumortier, Frans Van Roy

Département Génie Civil et Bâtiment–URA CNRS 1652
ENTPE, Rue Maurice Audin, 69518 Vaulx-en-Velin, Cedex - Tel: +33 4 72 04 70 87, Fax: +33 4 72 04 70 41
E-mail: dominique.dumortier@entpe.fr

ABSTRACT

The Satel-Light Internet server (www.satel-light.com) provides to designers and engineers daylight information which was previously unavailable. It is based on a database of daylight and solar radiation, covering Western and Central Europe, which was produced as part of a European project called SATELLIGHT. This database has been computed from the images produced by the Meteosat satellite. Thus it has an excellent spatial resolution (every 5 km on average) and an excellent temporal resolution (every 30 mn). Through a user-friendly interface, the server provides maps, data files and statistics, which can be used to evaluate the daylight potential of any site in Europe. It produces half hourly values of illuminances (horizontal or sloped) but also sky luminances in 13 zones of the sky vault. For a set of case studies, Satel-Light combines these luminances with "directional daylight factors" to produce indoor illuminance information. Thanks to a European project called SODA (http://soda.jrc.it), the Satel-Light database will be extended to a total of 5 years (1996 to 2000). The aim of SODA is to expand and federate various solar radiation databases available on the Internet, through a centralized access and application services. One of these services is dedicated to daylighting. It allows to describe interactively a room and its fenestration system, and for any site in Europe, to evaluate the potential of daylight inside that room.

KEYWORDS

Daylighting, Internet, Database, Illuminances, Solar Radiation

I. INTRODUCTION

I.1 What daylight data for daylighting ?

The performance of a daylighting system strongly depends on the luminances of the section of the sky seen from the interior of the building. These luminances may change quickly depending on the sky conditions and on the solar elevations specific to the site. Thus, the optimization of the energetic performances of windows and daylighting systems requires time series and/or statistics of sky luminances, if not available, at least time series and statistics of horizontal and vertical illuminances (most apertures of buildings tend to be vertical in residential and office buildings), Is this information readily available throughout Europe ?

In Europe, only 17 measuring stations have recorded horizontal and vertical illuminances. Only 6 of them have also recorded sky luminances. All these stations belong to the International Daylight Measurement Programme launched by the CIE in 1991. The IDMP data is of good quality: measurements are made at least every 5 minutes, their quality is controlled with a CIE standard procedure and most of the stations have taken part to cross calibration procedures [IDMP, 1999]. The IDMP data is extremely useful for model development and validation. But, there are too few stations, particularly in the South and the Center of Europe, to provide a good database for daylighting design.
Climatic atlases such as the new European Solar Radiation Atlas [ESRA, 1994] or Meteonorm [Meteonorm, 2000] provide information for more than a hundred sites in Europe. In those

commercial products, illuminances are computed from other meteorological data such as monthly means of daily irradiation or daily sunshine duration. These means are based on 10 years of data or more. Except for a few sites, these products do not provide hourly time series for a whole year: hourly values are only generated for one day in the month, using a "typical" profile. There are also no time series or statistics related to the luminance of the sky. But in fact, the major drawbacks of these products are the lack of coherence between their various origins and their lack of geographic continuity.

I.2. The SATELLIGHT and SODA European projects

A database providing sloped illuminances, as well as sky luminances, using satellite images seemed a logical approach to answer the shortcomings of the existing products. Every 30 minutes, a geostationary satellite such as Meteosat, produces an image of the earth covering Western and Central Europe with a resolution of about 5km by 7km. It provides the coherence and the geographic continuity which is missing from the ground measurements.

This is why, in January 1996, we started a 3 year-European research program called "SATELLIGHT". Its objective was to build from two years of Meteosat images, a database of solar radiation and daylight for Western and Central Europe (roughly from Lisbon to Moscow). The first part of the project was dedicated to the development and the validation of the algorithms used to produce irradiances and illuminances from the satellite images [Satel-Light, 1999]. The second part was dedicated to the production of the database and the development of an Internet access to it. The project ended in 1999. Since then, the web server (http://www.satel-light.com) has been used by more than 1600 individuals and companies. It provides for free, half-hourly time series and statistics, on irradiances, illuminances and sky luminances. A section specifically dedicated to daylighting produces work plane illuminances inside simple case studies for any given site in Europe. We will show examples of the information available from the server, in the following sections.

Initially restricted to two years (1996 to 1997), the Satel-Light database will soon cover three more years (1998 to 2000), thanks to a European project called SODA (http://soda.jrc.it). SODA stands for SOlar radiation DAtabases. This European project has been initiated in 2000 and will end December 2002. Its aim is to expand and federate various solar radiation databases available on the Internet, through a centralized access and application services. Some of these services are dedicated to solar heating, photovoltaic, health hazards related to UV. One called SODALIGHT is dedicated to daylighting. This application available on the Internet (an "applet") allows to define a simple room and its windows. Through a transparent link to the SATELLIGHT database, it produces the frequencies at which a given level of diffuse illuminance is reached, anywhere in Europe.

II. OUTDOOR DAYLIGHT INFORMATION

From the user's point of view, the Satel-Light server (http://ww.satel-light.com) is divided into two main sections: "Site" and "Maps". The "Site" section is dedicated to the production of site specific information. The "Maps" section is dedicated to the production of maps.
In the "Site" section, the user first selects a site: from a list of the most populated centers, from a database of city names (more than 750,000), from latitude and longitude coordinates, or from a click on a map. Once he has validated his site, he has access to two subsections:

"Outdoor" and "Daylighting". "Outdoor" is the default subsection. It allows him to select a period of time (months, years) and a daily schedule expressed either in clock time or in solar time. Then, he selects the parameter he needs: global, diffuse, direct illuminances, on a horizontal or on a tilted surface, sky luminances. Finally, he selects the information he needs for these parameters: hourly time series, monthly means, monthly cumulative frequencies. The server generates the information and sends an e-mail to the user when it is ready.

The information requested by the user is presented in a web page. The data is made available in html tables or in text files. Graphs use the GIF format standard on the web. Figures 1 to 2 present some of the information that can be produced by Satel-Light. We have selected the city of Lyon, a period of time covering the two years of the database: 1996 and 1997 and a schedule corresponding to office hours: 8:00 to 18:00.

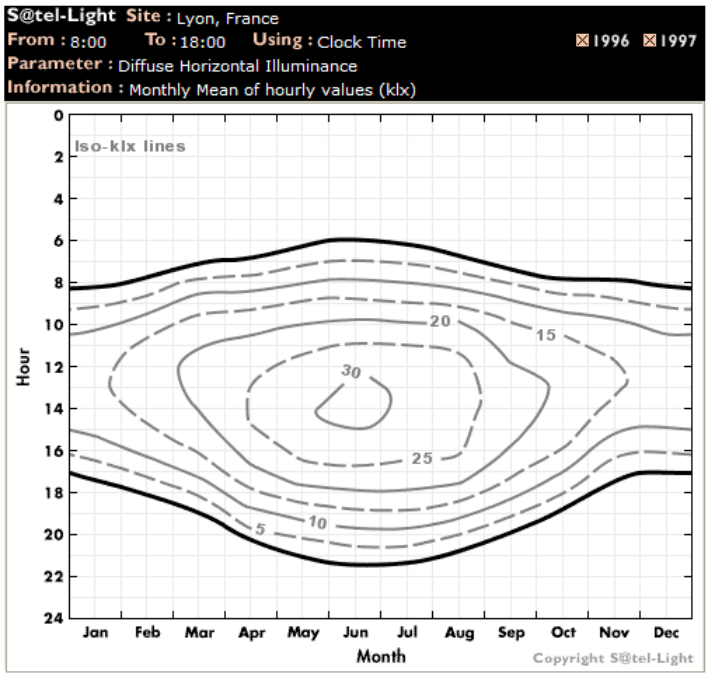

Figure 1: Month-Hour mean diffuse horizontal illuminance, Lyon, all year, plotted with iso klux curves. Hours in clock time are presented on the y axis. Months are presented on the x axis.

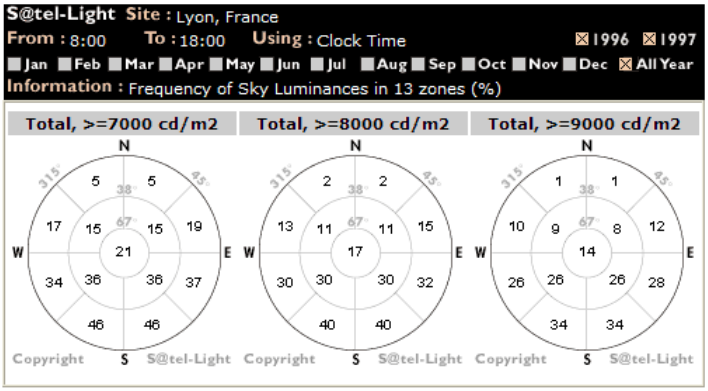

Figure 2: Frequency at which the mean luminance of 13 zones in the sky, exceed a given level: Lyon, all year, from 8:00 to 18:00, clock time. The 13 mean luminances are computed every half hour from the luminances of a larger number of zones in the sky vault (a total of 835). Exceeded luminance levels range from 1000 cd/m^2 to 9000 cd/m^2.

The procedure is the same to produce maps from the “maps” section. The user fills a form to select the information he needs. The server generates the information and sends an e-mail to the user when it is ready. Maps can be produced for 13 zones in Europe, or over all Europe, and for a great number of parameters: mean values of illuminances and irradiances, frequencies that given levels are exceeded, sunshine duration, clear, intermediate and cloudy sky frequencies...They are available as GIF images and as “active maps”: numbers are displayed as the user moves the mouse over the map.

III. INDOOR DAYLIGHT INFORMATION

As mentioned above, when the user has selected his site, he has access to two subsections: “Outdoor” and “Daylighting”. The “Daylighting” subsection, provides information specific to daylighting design.

III.1 Daylight autonomy diagrams

Figure 3 shows the daylight autonomy diagram produced by Satel-Light for the city of Lyon, all year, from 8:00 to 18:00, clock time. This diagram shows as straight lines corresponding to various daylight autonomy levels (0%, 10 %, 20%…on the right), the link which exists between the diffuse indoor illuminance (x axis) and the daylight factor (y axis). It is based on the availability of the diffuse outdoor horizontal illuminance, in Lyon, during the period of time selected by the user. In Lyon, a daylight factor of 6% is needed to maintain 500 lux, 80% of the time. With a daylight factor of 2%, 500 lux can be maintained only 20% of the time.

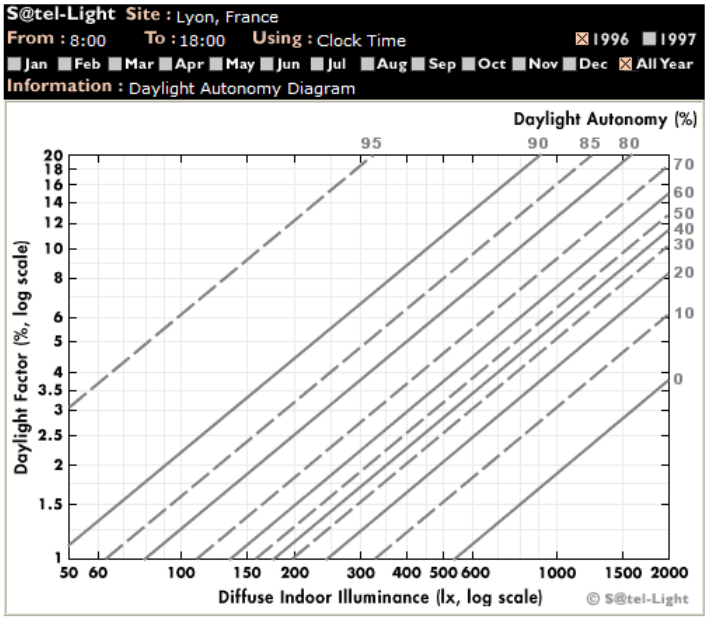

Figure 3: Daylight autonomy diagram for the city of Lyon, all year, from 8:00 to 18:00.

III.2 Indoor daylight availability

Satel-Light produces hourly time series and statistics showing the availability of daylight inside a few case studies. The user first selects one of the case studies (see Figure 4) and an orientation (North, East, South or West). Then, he selects the information he needs: daylight autonomy, hourly time series, monthly means of hourly values, monthly cumulative frequencies of diffuse illuminances, frequency of sunshine, at any point on the work plane.

The diffuse horizontal illuminance at any point on the work plane is computed every half-hour, by combining the average luminance of 13 zones of the sky with their Directional Daylight Factors (DDFs). A DDF describes the contribution of a zone of the sky to the diffuse horizontal illuminance at a given point on the work plane. For each case study, the directional daylight factors on the work plane have been pre-computed using the Genelux light simulation program. Figure 5 presents the results obtained for case study #1, in Lyon, all year, from 8:00 to 18:00. We have selected the frequency that a diffuse indoor illuminance exceeds 500 lux and 3 different orientations.

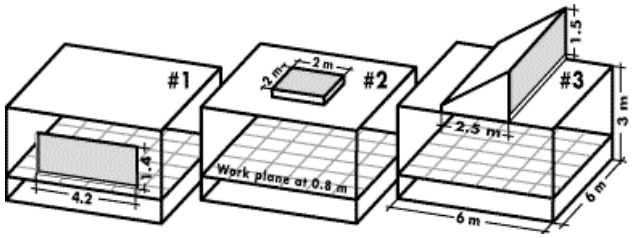

Figure 4: The 3 case studies available in Satel-Light. 4 orientations are available for the façade and the shed configurations: North, East, South or West.

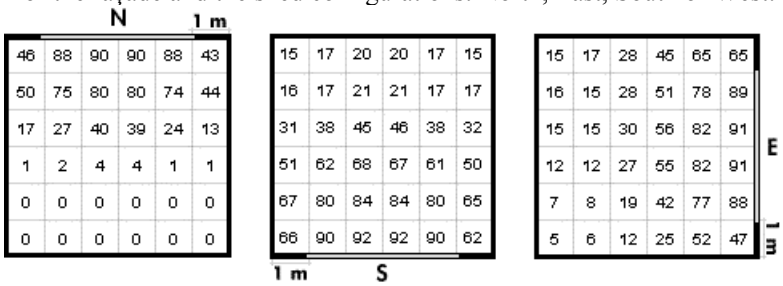

Figure 5: Frequencies (%) that an indoor illuminance of 500 lux is exceeded on the work plane, window facing north (left), south (center) and east (right), Lyon, all year, from 8:00 to 18:00.

For all 3 orientations, the frequencies at which 500 lux is exceeded on the work plane are similar in the first 2 meters away from the window. Going farther away from the window, the differences start increasing. The frequencies go down to 0% in the north facing room, 5% in the east facing room and to 15% in the south facing room. This is the effect of the bright circumsolar zone of the clear and quasi clear skies, which are taken into account by the method. It is also shown by the dissymmetry observed in the east facing room.

The daylighting section of the Satel-Light server produces information that is quite unique. However, it is restricted to a set of predefined case studies because of the complexity of the computation of directional daylight factors.

To provide more flexibility, we have developed within the European project SODA, a daylighting service called SODALIGHT. It allows the user to define a room (in terms of size, surface reflection factors) and a fenestration system (horizontal and/or vertical windows, glazing transmission factor). Figure 6 illustrates the use of its interface. Once the room has been defined, the user can click on the "Daylight Factors" tab to obtain the daylight factors at various points of the work plane (see Figure 7, left). He can also click on the "Autonomy" tab to obtain the frequencies at which a given level of illuminance is exceeded on the work plane, at a given location (see Figure 7, right). The daylight factors are computed for overcast conditions using the standard formulae for horizontal and vertical windows [Tregenza, 1993]. Then they are combined with outdoor diffuse illuminance frequencies, for the site selected by the user. This is done via a transparent link to Satel-Light, using the XML language.

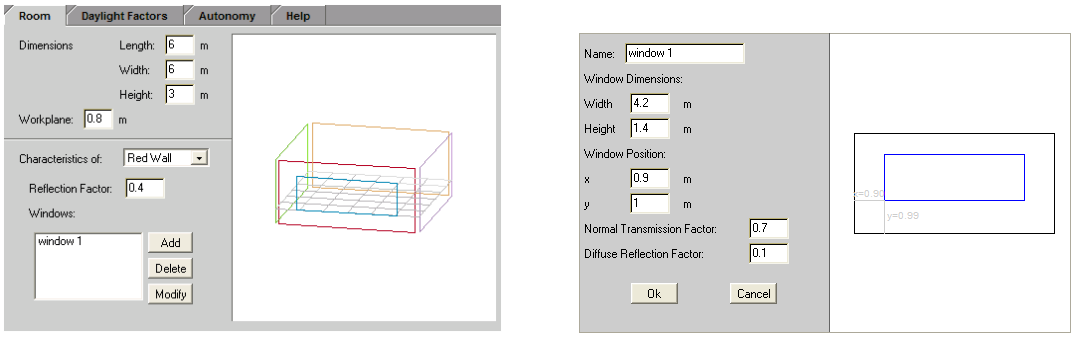

Figure 6: The SODALIGHT applet: definition of the room (left) and the window (right).

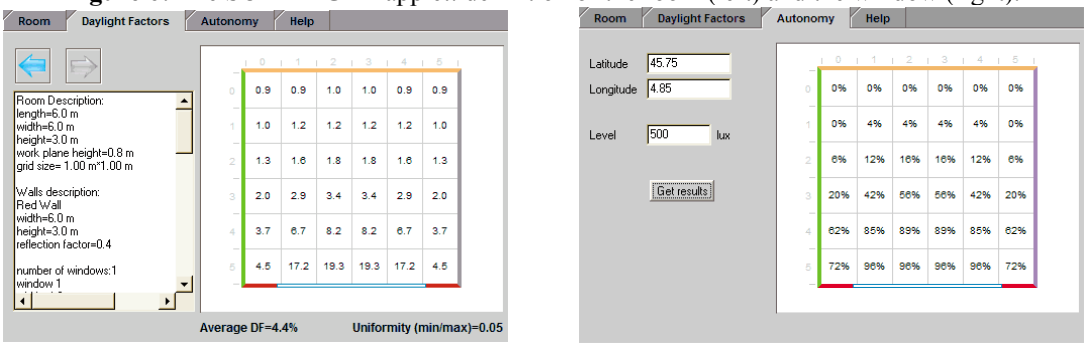

Figure 7: The SODALIGHT applet computes instantaneously daylight factors (left) and produces the frequencies at which indoor illuminances are exceeded for any site in Europe (right, Lyon).

IV. CONCLUSION

The Satel-Light server provides daylight information, which was previously difficult to access or simply unavailable. The access to the database is fast and easy. It is flexible, the user can create the information he needs for any site in Europe, any period of time. With either the "daylighting" section of Satel-Light, or SODALIGHT, the daylighting service of SODA, it is possible to produce detailed information on the variations of indoor illuminances on a yearly basis. The accuracy of the method used to produce indoor illuminances by Satel-Light could be improved by increasing the number of zones in the sky (for now, this is a question of computation time). The refinement of this method and its validation should be based on simultaneous measurements of sky luminance distribution and indoor illuminances. SODALIGHT could also be improved by using orientation factors, since it is based on overcast daylight factors. The second generation of the Meteosat satellite (MSG) planned to be launched in the fall of 2002 will provide new spectral channels, which will further improve the accuracy of the irradiances and the illuminances produced from the satellite images. A new European project called HELIOSAT-3 (www.heliosat3.de) has been started to work with this new data.

V. REFERENCES

[ESRA, 1994], Scharmer K., Greif J., Page J., Dogniaux R., Czeplak G., Wald L., Lund H., Joukoff A., Borisenko E.P., Aguiar R., Collares Pereira M., Littlefair P., Albuisson M., Bourges B. (1994) The European Solar Radiation Atlas. JOU2-CT-94-00305; http://www-helioserve.cma.fr/esra.

[IDMP, 1999], Dumortier D., Koga Y. (1999). Status of the International Daylight Measurement Programme (IDMP) and its server: http://idmp.entpe.fr, *CIE 24th Session, Warsaw*, pp. 282-286

[Meteonorm, 2000], Meteotest, FabrikStrasse 14, CH-3012, Bern, Meteonorm 2000, Global Meteorological Database for Solar Energy and Applied Meteorology, http://www.meteotest.ch

[Satel-Light, 1999], Dumortier D., Fontoynont M., Heinemann D., Hammer A., Olseth J.A, Skartveit A., Ineichen P., Reise C., (1999) Satel-light, a www server which provides high quality daylight and solar radiation data for Western and Central Europe, *CIE 24th Session, Warsaw*, pp. 277-281.

[Tregenza, 1993], Tregenza P., (1993). Daylighting Algorithms, *ETSU 1350, Crown Copyright*.