A draft solar-climatic and impacts analysis of proposed towers added to Montréal’s downtown

OCPM

(Office de Consultation Publique de Montréal)

Mémoire: projet immobilier sur la rue St-Antoine Ouest

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1: RMM Solarch Studio,
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February 2014

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A draft solar-climatic and impacts analysis of proposed towers added to Montréal's downtown

Contrary to popular belief, cold and at times cloudy conditions, like those of a Montréal winter, should not be considered a convincing reason to avoid applying and optimizing solar designs in buildings and urban quarters. In contrast, solar studies as well as consideration of the sun in architectural and urban design are essential in cities with extreme temperature conditions, whether cold or hot, simply because in many cases, extreme temperature conditions are also sunny.

Even in Montréal with winter temperatures between -10°C and -30°C, the availability of direct normal radiation can exceed 750W/m² and sometimes even reach 1000W/m². In other words, in such locations the coldest and warmest temperatures most often likely occur on sunny days. This simple fact increases the importance and great benefit of considering the sun, both in planning of buildings as well as the interaction of those buildings with outdoor areas in Montréal (for more information see Fig. D3-D4 and Fig. E3-E4 in the appendix).

On the coldest days of winter, the effect of having often abundant direct solar radiation on the building skin (e. g. windows) and in urban areas happens to coincide with the increase need for energy for heating. On other winter days, when it is completely cloudy, or when it snows, direct radiation decreases; however, in most of these cases, the need for benefiting from direct radiation is lower as the air temperature is less cold, often close to 0°C (for more information see Fig. B3-B4 and Fig. C3-C4 in the appendix).

A change in the hourly daily temperature associated with solar gains can have a significant effect on the heating and cooling loads of buildings, as well as on the levels of comfort or discomfort in useable spaces inside and outside of buildings (see Fig. 21 as well as Fig. A3-A4 in the appendix). The urban fabric: building skin and the HVAC system, can be designed to respond effectively to the general solar-climatic patterns at each location. The issues concerned with the outdoor space, on the other hand, are more related to health and safety, rather than energy loads and operating costs. For instance long episodes of overshadowing in winter conditions can increase the ice build-up in some areas and as a result, increase the danger of damage and injuries caused by falling ice.

In this regard the solar-climatic analysis presented here highlights the overshadowing impacts of proposed high-rise buildings south-east of the Bell Center. It is important to mention here that the attention of the OCPM should be drawn to what appears to be the negative effects that could likely result from the proposed layout of the tower in Site #2 on the long pedestrian path to the north-east of the Bell Center between Saint-Antoine and Des-Canadiens-De-Montréal streets. The proposed arrangement of buildings in this area could most likely lead to the creation of an undesirable and unsafe pedestrian path in the future when considered in terms of solar-climatic aspects. In addition, the current layout of tower in Site #2 also interferes with the important view axis line and blocks the perspectives in the spaces between Saint-Jacques and Des-Canadiens-De-Montréal streets (see Fig. 1).

Though the information in this document presents SOLARCHVISION best practices by February 2014, the information contained in this document could be improved further still. The quality of the analysis in this document was currently limited because of a lack of access to precise 3-dimensional models of the proposed project as well as other building blocks of this neighbourhood in Montréal. A best effort was applied by the author to assemble a basic model using the 2-dimensional drawing provided in OCPM documents namely Plans Annexés (document 1.5.3.1: http://ocpm.qc.ca/sites/ocpm.qc.ca/files/pdf/P72/1e3a.pdf) well as GoogleEarth to illustrate general impacts. Higher quality input information cold likely change and improve the results. The author welcomes further exchanges with the OCPM consultation committee so that additional updates to this type of information and analysis can be shared regarding this project. In addition, similar solar-climatic studies during the processes of building skin and urban design can improve many aspects including the potentials and performances in terms of energy production, energy demand, daylight, health, comfort and safety for long periods of time; with the added benefit that most of these architectural rearrangements and improvements do not necessarily increase the construction costs.

In addition to mapping direct and diffuse solar radiation on buildings, and urban surfaces which can be performed by available tools, architects as well as urban planners always need an analysis to find out the effect of each architectural element on building skin and urban areas in regard to the varied effects of the sun in different cycles (hourly, daily, annual and in decades). An integration of ingenious passive design as well as application of intelligent active solutions and systems during the architectural design process can simply improve building skin performance and improve significantly the operation of interior building spaces in terms of energy efficiency, daylighting, comfort, health and safety factors. On the other hand, achieving similar results by using advance materials and technologies not only requires an increase in enormous construction costs but also is not possible in theory/practice.

Also, as is discussed, the issues concerned with the outdoor spaces can also lead to immediate impacts. Long lasting building volumes need long time horizons. Bearing in mind the fact that there are just a few solutions available to improve the quality and performance of outdoor spaces, the responsibility of the city and decision makers as well as the time allocated to planning, etc. should be increased so that the designers can comfortably investigate different parameters and impacts from early stages of design and come up with a responsive solution and integrated form.

Consequently one of the recommendations from this modest study undertaken is to move the tower in Site #2 to west.

In the studies presented the effects of wind are not applied which can increase the impacts especially in urban areas. In the case of accepting the location of the tower in Site #2 and in regard with the minimum and inappropriate distance between this tower and Windsor tower, performing comprehensive wind studies should be seriously considered which is more complex, time-consuming, etc.

It is hoped that along with the request to take into account the solar climatic analysis and impacts considerations, that the OCPM will also ensure the following considerations have also been addressed as part of the overall project plan. These additional considerations could include: how will the buildings and surrounding areas will be able to manage frequent and intense rainfalls, an analysis of how the building and area will contribute to the urban heat island effect, how will snow load and snow clearing be handled, how all accessible spaces near these buildings will be made to be safe to the public no matter what the weather conditions or the season, how the buildings and spaces in that area will be built in order to be able to, as a whole unit, provide maximum benefit and minimum impacts under the exposure to daily and weekly weather condition scenarios and finally, how will the buildings and area handle what are likely changing climate conditions over the next 50-100 years.

There are a growing number of initiatives to integrate best practices of sustainable development as early as possible in the urban planning and development. These best practices are increasingly considering the full range of benefits and impacts from renewable energy considerations and these can be extended to projects of all scales, including buildings such as the ones proposed in this project.

It would be reasonable to think that a comprehensive and robust solar climatic analysis with the best quality input data for the 3D landscape could be considered as part of the borough and city sustainable development plans. It would also make sense that borough and City urban planning and zoning bylaws take solar climatic analysis impacts and benefits into account especially for example if seasonal risks like falling ice can be minimized and the safety and comfort of public spaces can be enhanced as a result.

The city and province's public health groups are also increasingly advocating urban design approaches that will if possible reverse or mitigate the negative impacts from the Urban Heat Island effects and from Heat waves. Proper solar climatic analysis as part of the design stage could ensure the buildings and surrounding spaces are designed to be as comfortable and safe as possible year-round.

Finally urban planners and architects are also updating their professional codes to strive for improved, efficient and sustainable urban designs. Solar climate analysis could be easily considered to be part of this new and sustainable approach in these areas.

The author thanks the OCPM consultation committee for accepting this document and the invitation is open to the committee to contact the author for any further required information or questions they may have regarding this document.

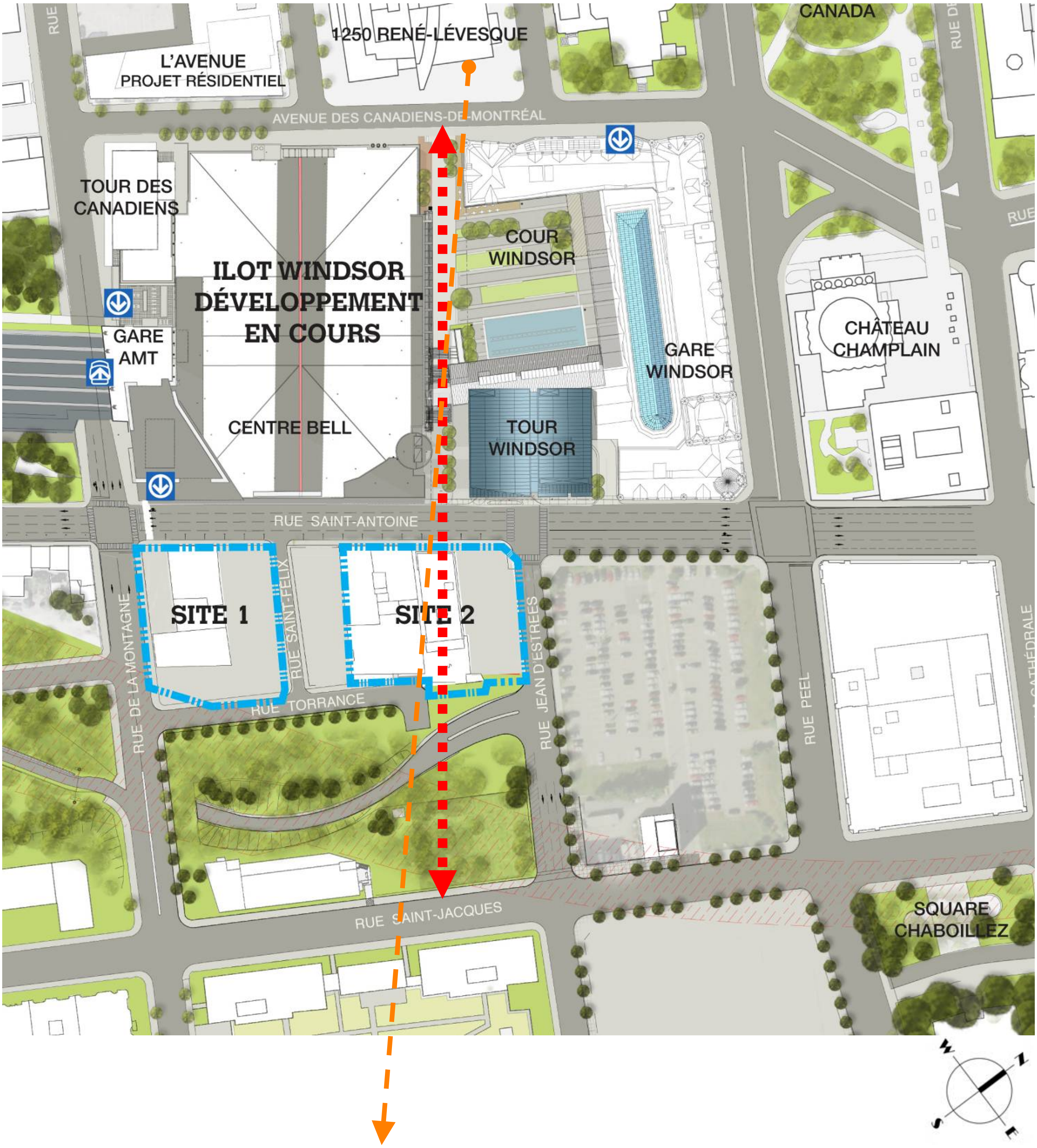


Fig. 1: Highlighted axis (orange: view to St Lawrence River [see Fig. 2], red: long pedestrian path on north-east of Bell Center and its continued axis towards Saint-Jacques street) on the site plan (Redéveloppement urbain, document 3a, page 15)

Fig. 2-5: Photos from the pedestrian path on the northern side of Bell Center (9:00 a.m., 16 Feb. 2014, Air temperature: -15°C)

The photos presented here Fig.2-13 are taken at 9 a.m. on 16 February 2014. Air temperature was around - 15°C and as it can be seen in the photos it was sunny. If these photos were taken one hour earlier the whole pedestrian path was completely exposed to sun. Nevertheless, at this time still large portion of this area is not shaded and this situation can basically continue until 10 a.m. This period (between 8 a.m. to 10 a.m.) includes the position of the sun in which the positive impact of the sun is greatest.

"*When the altitude of the sun is 15° or lower, the amount of direct radiation decreases significantly as the rays have to go through more layers of the atmosphere. Therefore, despite the low temperatures, which generally occur at the time of sunrise, the positive effect of the sun reaches its maximum a few hours after sunrise, when the sun is at a higher altitude, but the temperature is still low*" (Samimi et al. 2014).

Fig. 6-9: Photos from the pedestrian path on the north-east side of Bell Center (9:00 a.m., 16 Feb. 2014, Air temperature below -15°C)

Fig. 10-13: Photos from the pedestrian path on the eastern side of Bell Center (9:00 a.m., 16 Feb. 2014, Air temperature below -15°C)

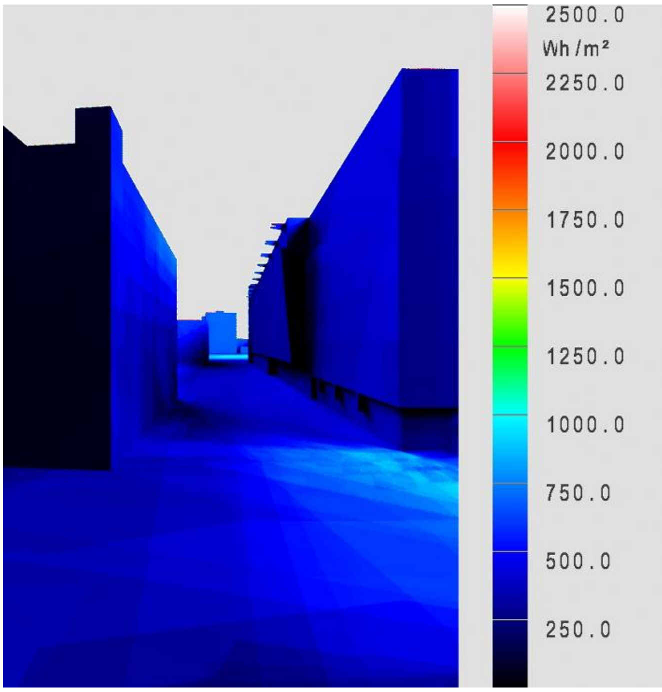


Fig. 14: Annual solar radiation model of current situation

Fig. 15: Photo showing current situation (Bell Center is located on the right)

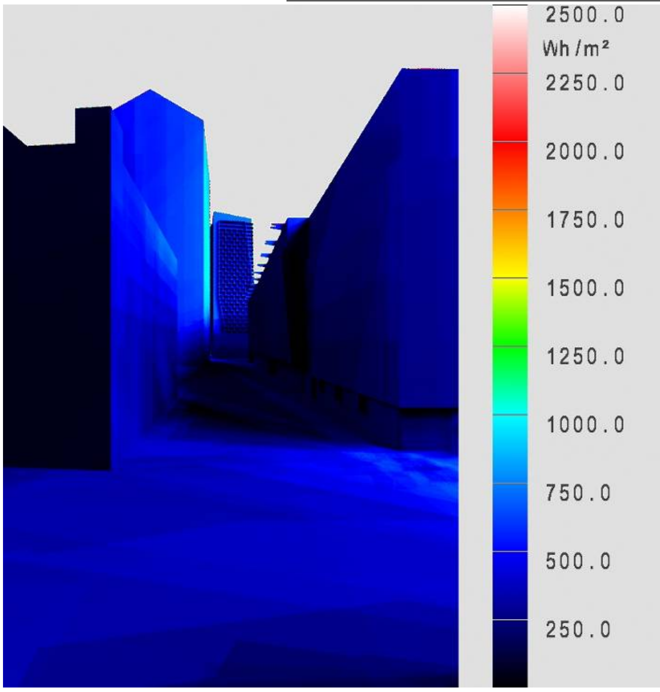
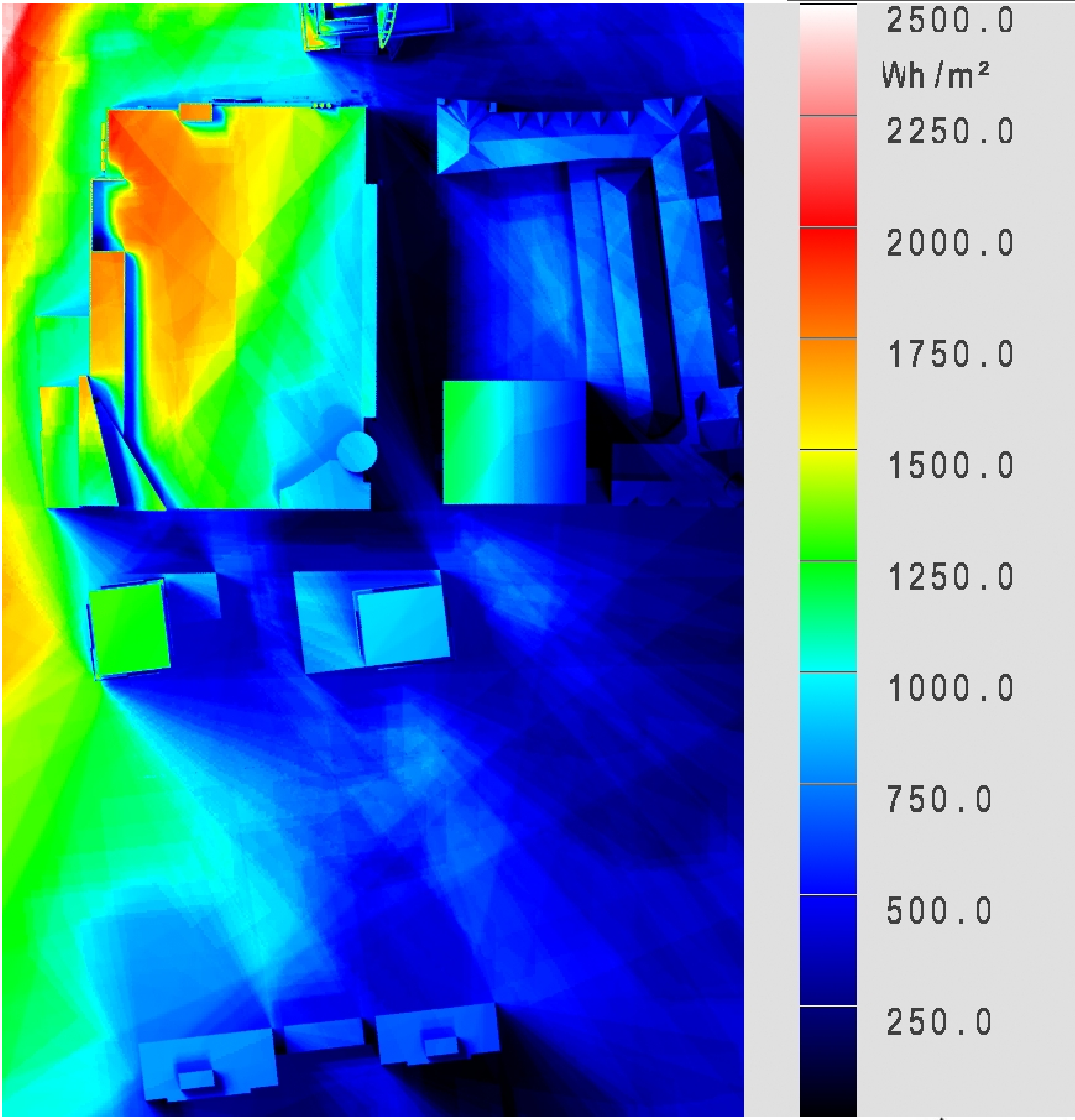


Fig. 16: Annual solar radiation model of future situation considering the effect of Windsor under-construction tower and accepting the proposed arrangement of tower in Site #2

The figures 14-15 present annual solar radiation models of current and future situation in Montréal's Typical Meteorological Year in case of Windsor tower being constructed and the position of tower in Site #2 being finalized right in front of the pedestrian path. A comparison between two demonstrates that future situation can result in an increase in snow accumulation as well as less benefit from the sun, sky and vista towards St Lawrence River for people, whether inside or outside of buildings.



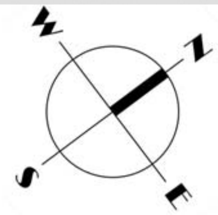
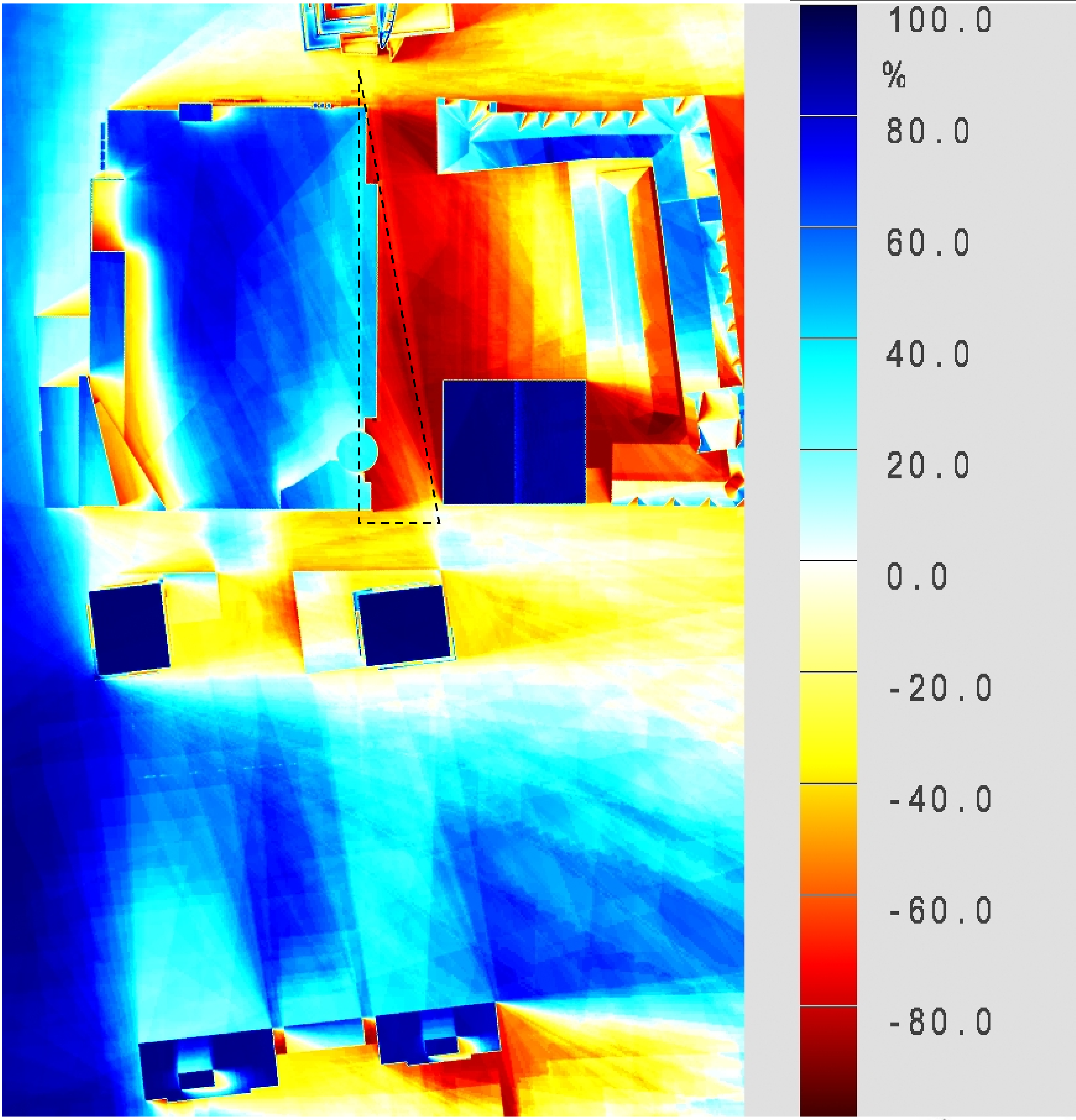


Fig. 17: Annual solar radiation model

Figure 17 presents the plan with the annual solar radiation model of future situation in Montréal's Typical Meteorological Year in case of Windsor tower being constructed and the position of tower in Site #2 being finalized right in front of the pedestrian path.



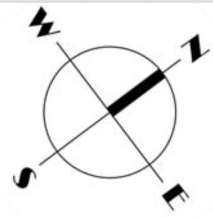


Fig. 18: Annual solar-climatic performance analysis

Figure 18 presents the plan with the analysis of positive and negative effects of solar radiation as well as the positive and negative impacts of building blocks in Montréal's typical meteorological year cycle in case of Windsor tower being constructed and the position of tower in Site #2 being finalized right in front of the pedestrian path.

As is illustrated in this analysis, it is necessary that the negative effect of the tower in Site #2 is highlighted on the pedestrian path to the north-east of the Bell Center. That's is simply because not only this tower but also Windsor tower as well Bell Center produce shades in cold times (heating period).

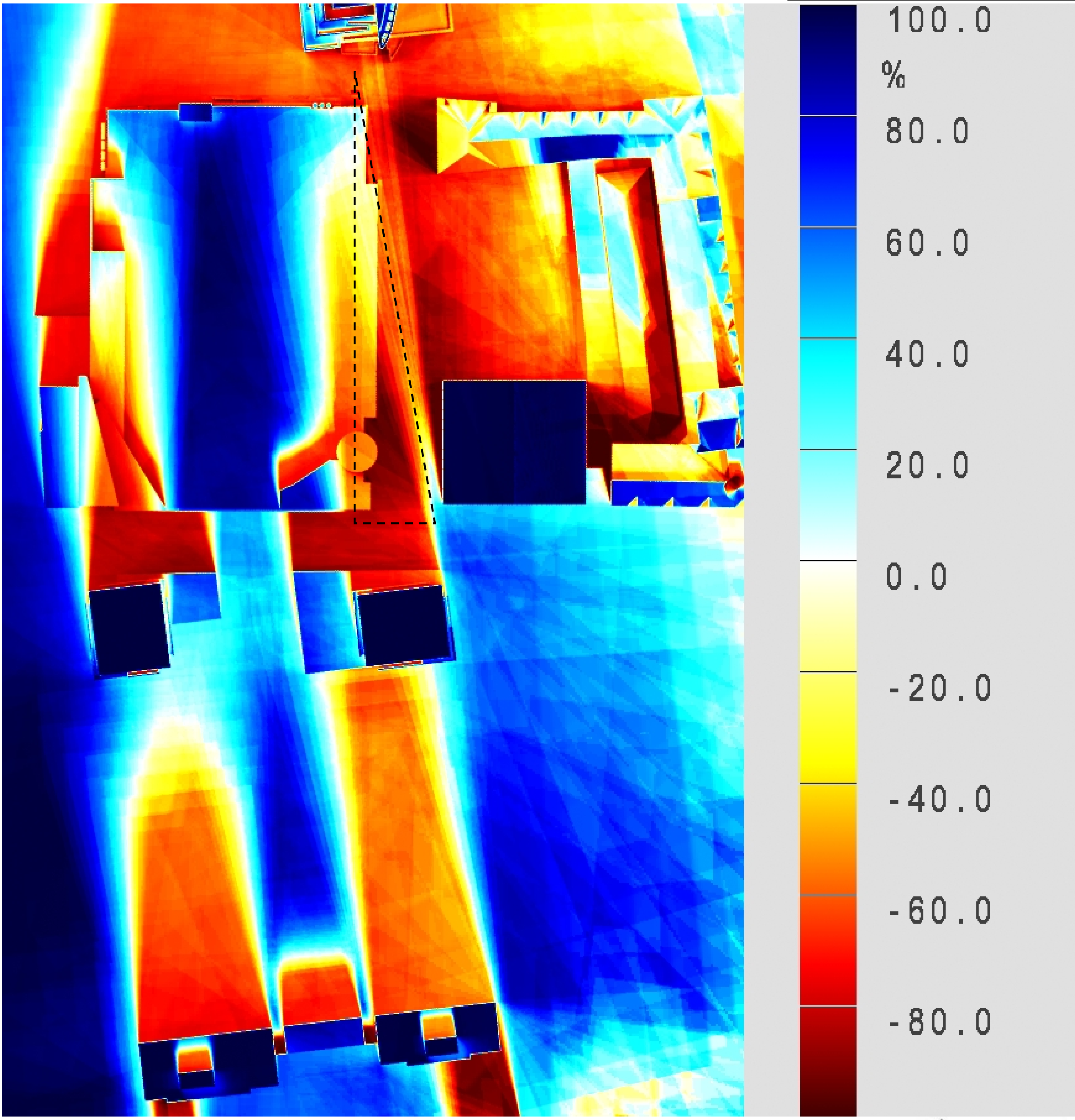
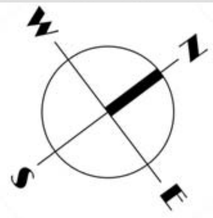


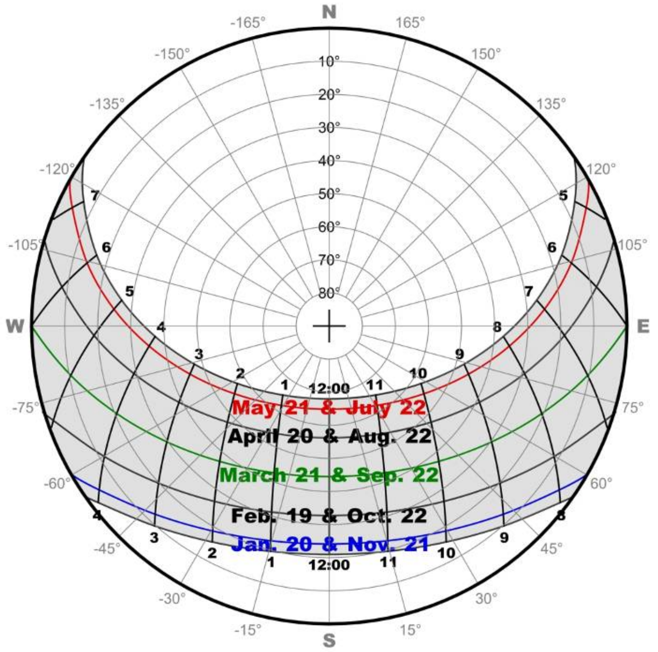
Fig. 19: Solar-climatic performance analysis from 8 a.m. to 10 a.m. between December 21 and September 22



As is discussed the negative over shadowing effects in cold times resulted from the location of proposed tower in Site #2 occur in the mornings between 8 a.m. and 10 a.m. when it's sunny and cold. The analysis presented in figure 19 which is done for all sky conditions (sunny/cloudy) in Montréal's typical meteorological year between December 21 and September 22 demonstrates the impact of tower in Site #2 on the pedestrian path to the north-east of the Bell Center.

A comparison between Figure 19 and the analysis provided in Figure 18 highlights the undesirable and unsafe situation that can be produced as is remarked with the triangle.

Figure 21 illustrates the positive and negative effects of direct radiation in Montréal's typical meteorological year. The blue areas present the times in which not only the amount of direct radiation is high but also the need for solar gains is high as the temperature is very low (sunny winter days). In this period it is essential to receive solar radiation on the building skin as well in urban areas to improve the comfort as well as other factors.



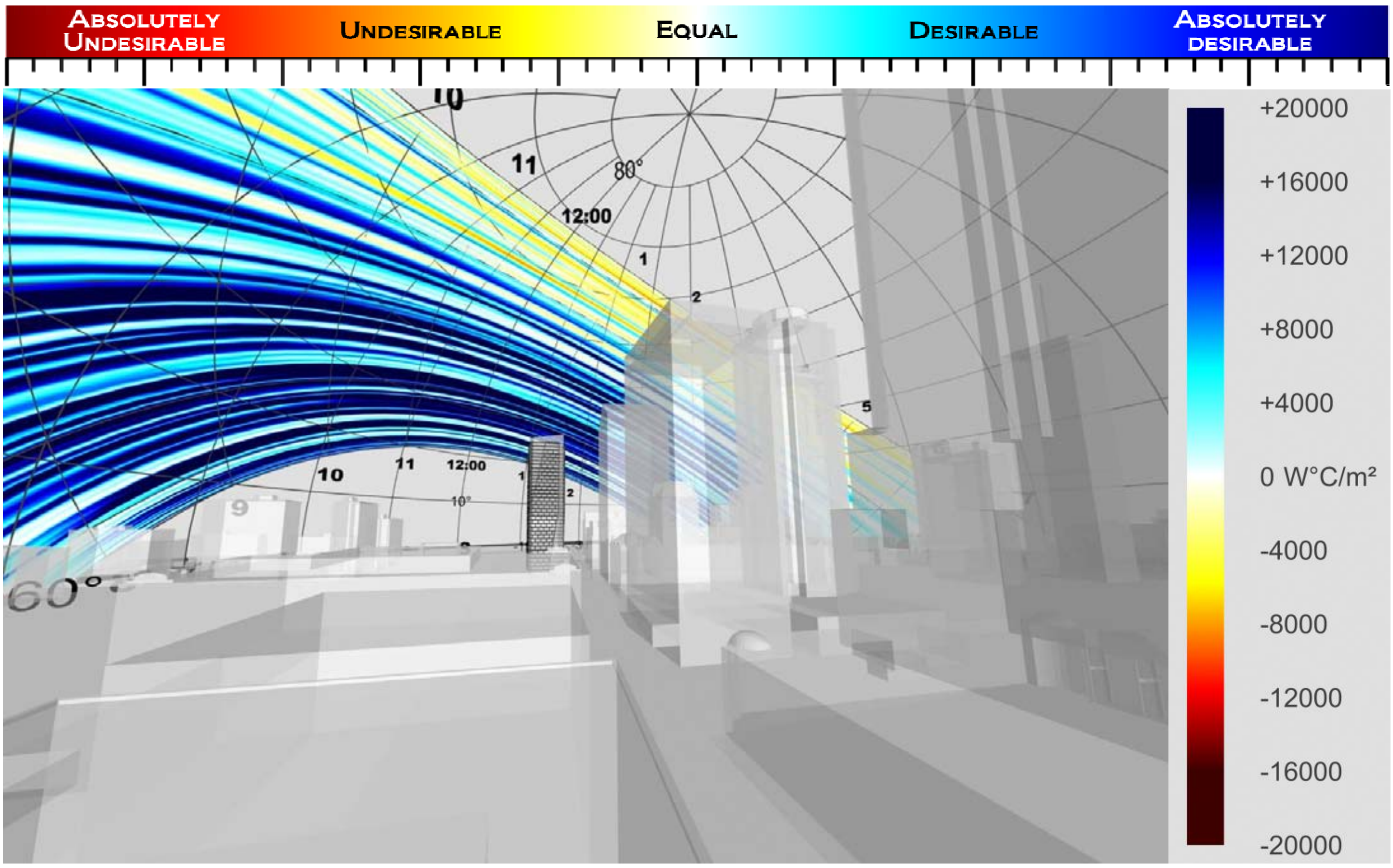


Fig. 20-21: Montréal sun path and Typical Meteorological Year pattern of positive and negative effects of direct beam radiation in Montréal calculated by SOLARCHVISION (based on TMY hourly data from U.S. Department of Energy)

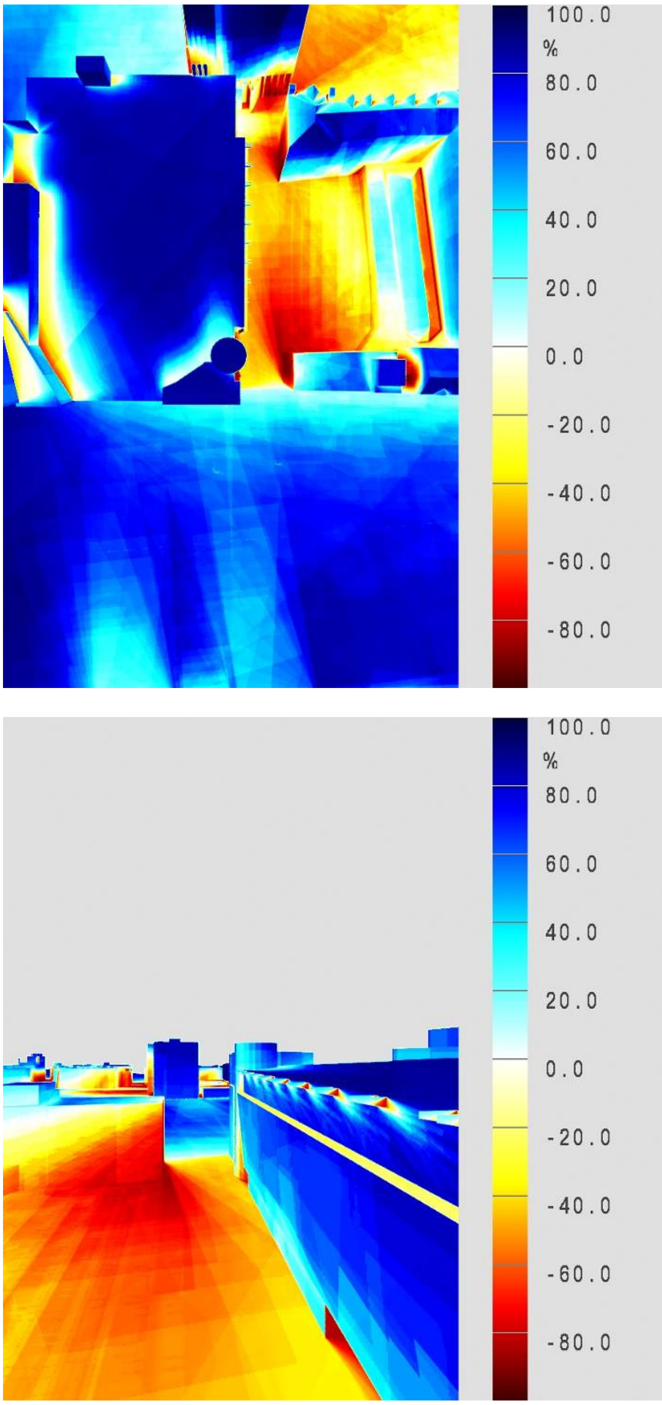


Fig. 22-23: SOLARCHVISION spatial analysis of current situation regarding solar-climatic performances (comfort and energy levels) in urban areas as well as building skin

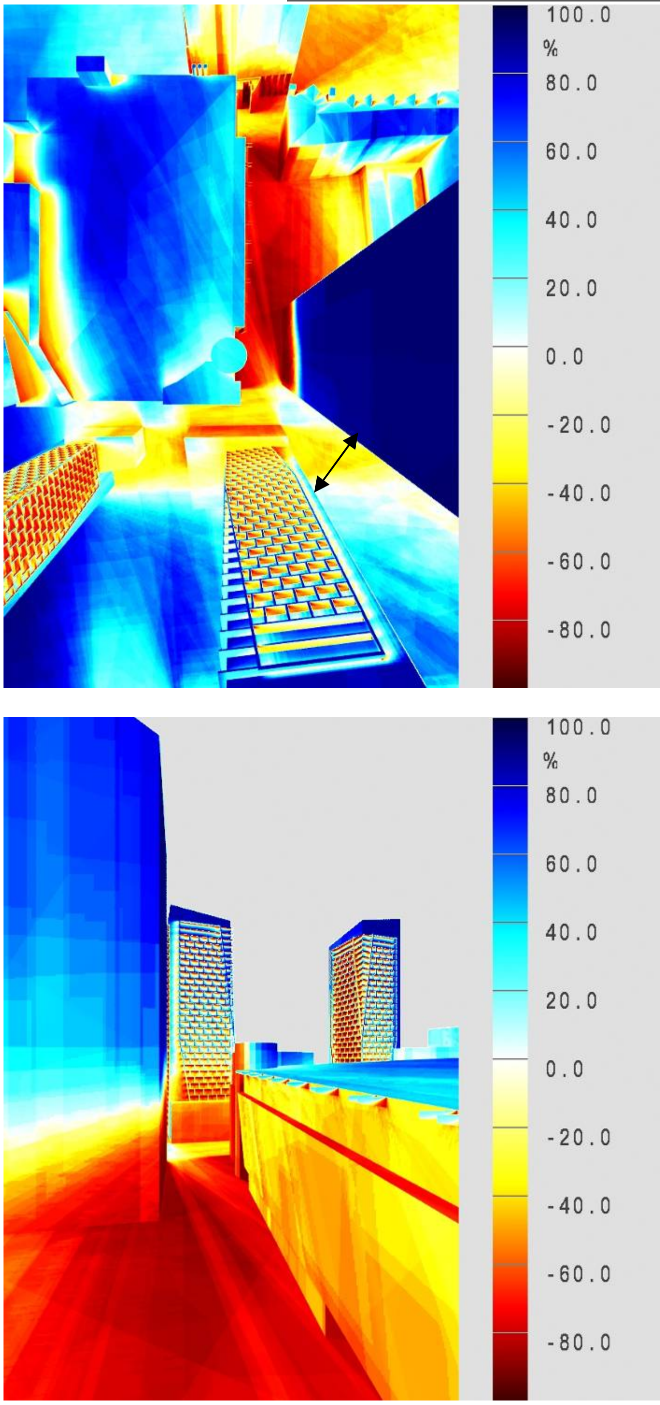
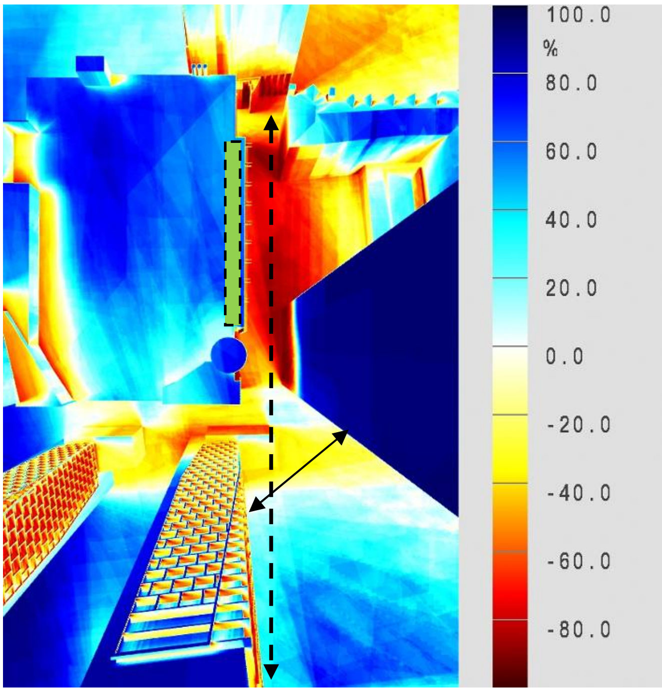


Fig. 24-25: SOLARCHVISION spatial analysis of future situation regarding solar-climatic performances (comfort and energy levels) in urban areas as well as building skin

Figures 22-25 present annual solar-climatic impacts (SOLARCHVISION models) of current and future situation in Montréal's Typical Meteorological Year before and after construction of Windsor tower and in case the position of tower in Site #2 is finalized right in front of the pedestrian path. A comparison between these diagrams highlights significant changes on reducing the performance of urban area as well as Bell Center façade.

As illustrated in Figure 24, and in regard to minimum space between tower in Site #2 and Windsor tower the wind can produce serious problems in this area not only for the urban area but also for the occupant. It is therefore suggested that more space provided between two to reduce the effects remarkably at the corners.



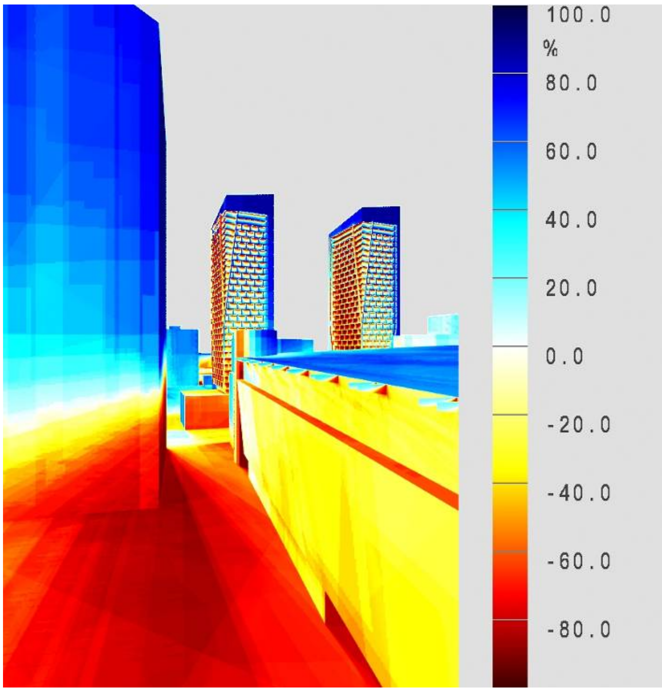


Fig. 26-27: SOLARCHVISION spatial analysis of an improved version for future situation regarding solar-climatic performances (comfort and energy levels) in urban areas as well as building skin

Figures 26-27 present similar analysis in case of moving the tower in Site #2 to the west so that more space provided between critical corner points of this tower and Windsor tower. In this case not only the undesirable situation on the pedestrian path would be improved but also the tower dose not interfere the perspectives to the sun, sky and vista towards St Lawrence River.

It is also necessary to mention that in terms of solar-climatic aspects, this alternative is not the best solution that can be achieved; although the situation is improved. To achieve better condition it can be suggested to design and install a number of optimized solar reflectors at the north-east edge of Bell Center (as is painted in green in Fig. 26) to reflect in the afternoon direct radiation as well as reflections from Bell Center's east roof to the pedestrian path.

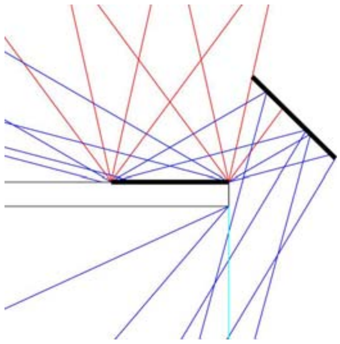


Fig. 28: An idea for using reflectors to filter winter rays

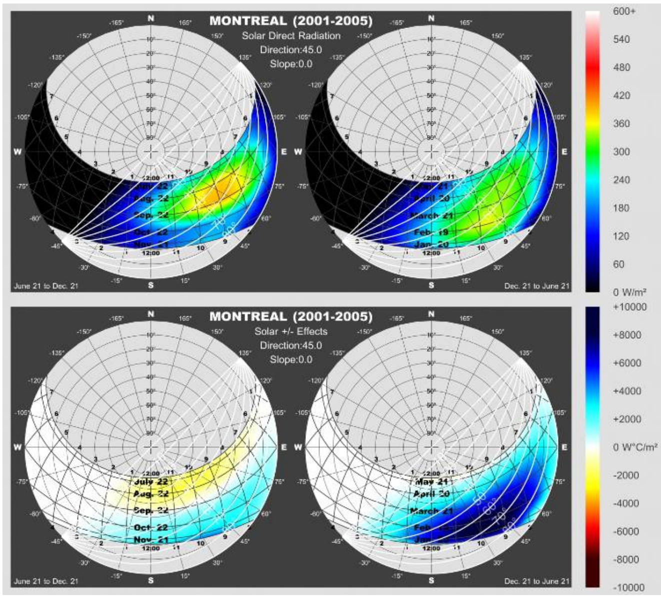
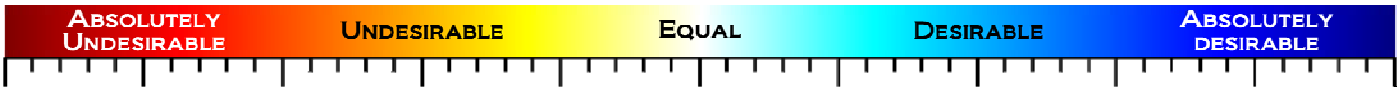


Fig. 28-29: The amount of direct radiation (above) and its positive/negative effects (below) on S.E. direction in two cycles of the year (left: from June to December, right: from December to June), based on Montréal CWEED information between 2001 and 2005 (The sun and the city of Montréal, proposal for PDM, OCPM, 2013)

Alongside improving the optimization of building volumes, it is also essential that proper architectural solutions have been identified and developed to improve energy efficiency aspects of whole building system as well as all individual units in all directions. A number of reasons that highlight the importance of this task have been noted in the introduction to this document.



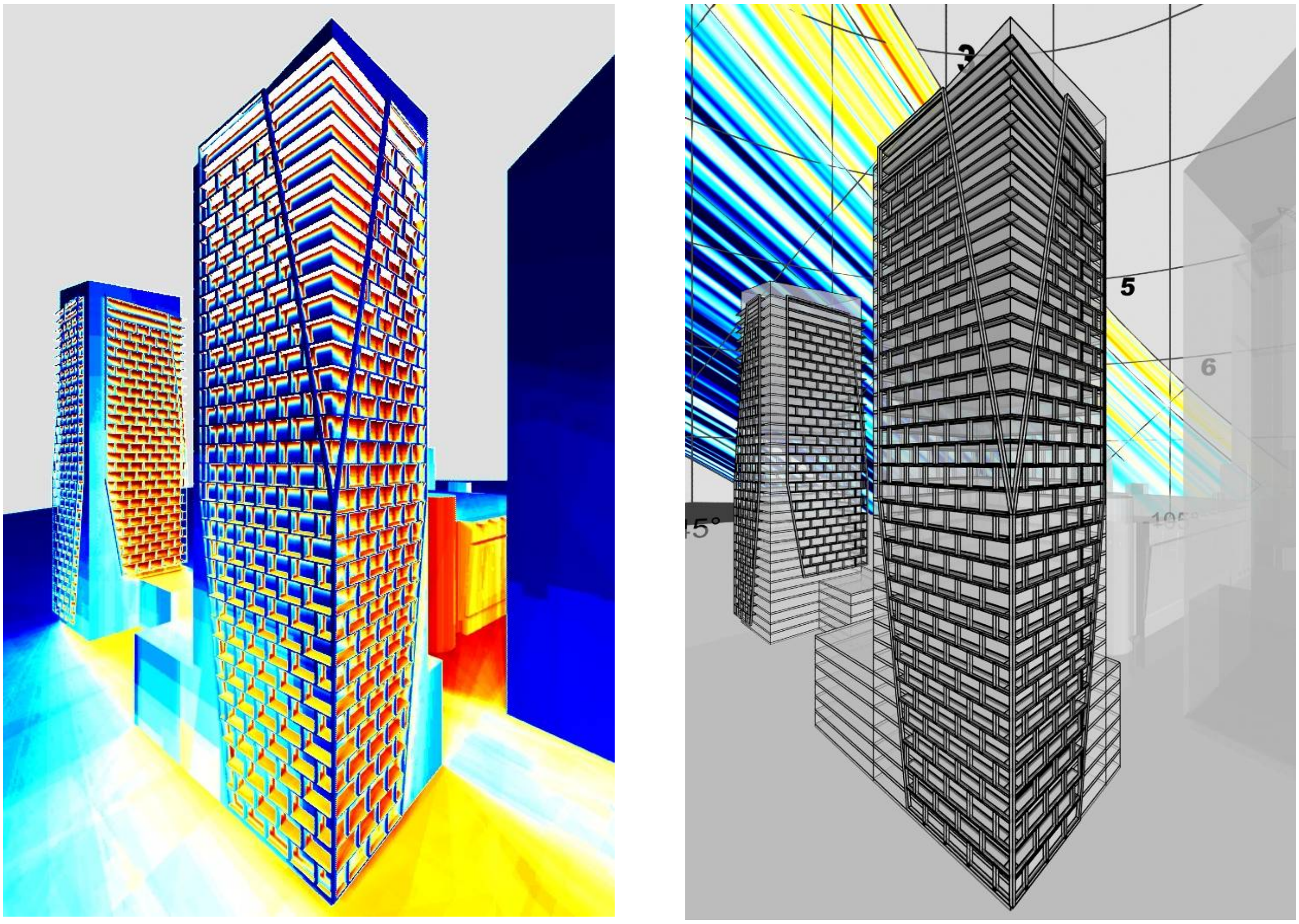


Fig. 29-30: solar-climatic performance analysis of proposed building skin
(based on energy efficiency as well as comfort temperature levels in the interiors)

Figure 29 present SOLARCHVISION design performance analysis of the north-east and south-east façade of the proposed towers. In regard to this analysis the vertical and horizontal elements can produce undesirable shade on glass façade. The negative effects presented as red on the north-east façades also highlights the necessity of reduction of glass areas in this façade. A similar analysis should be performed for other orientations.

Besides average environmental conditions, a study of the frequency and the impact of extreme environmental conditions at different intervals (e. g. day, year, decade, etc.) are also essential. In addition to meteorological and climate information, there are also a number of available weather forecasts and climate scenarios. These provide essential information which should be integrated in the design process, the operation and system control management systems of buildings, neighbourhoods and cities which have expected lifetimes of several decades or longer (see “Weather Forecast Data an Important Input into Building Management Systems”, http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/docs/REFcsts/).

Appendix

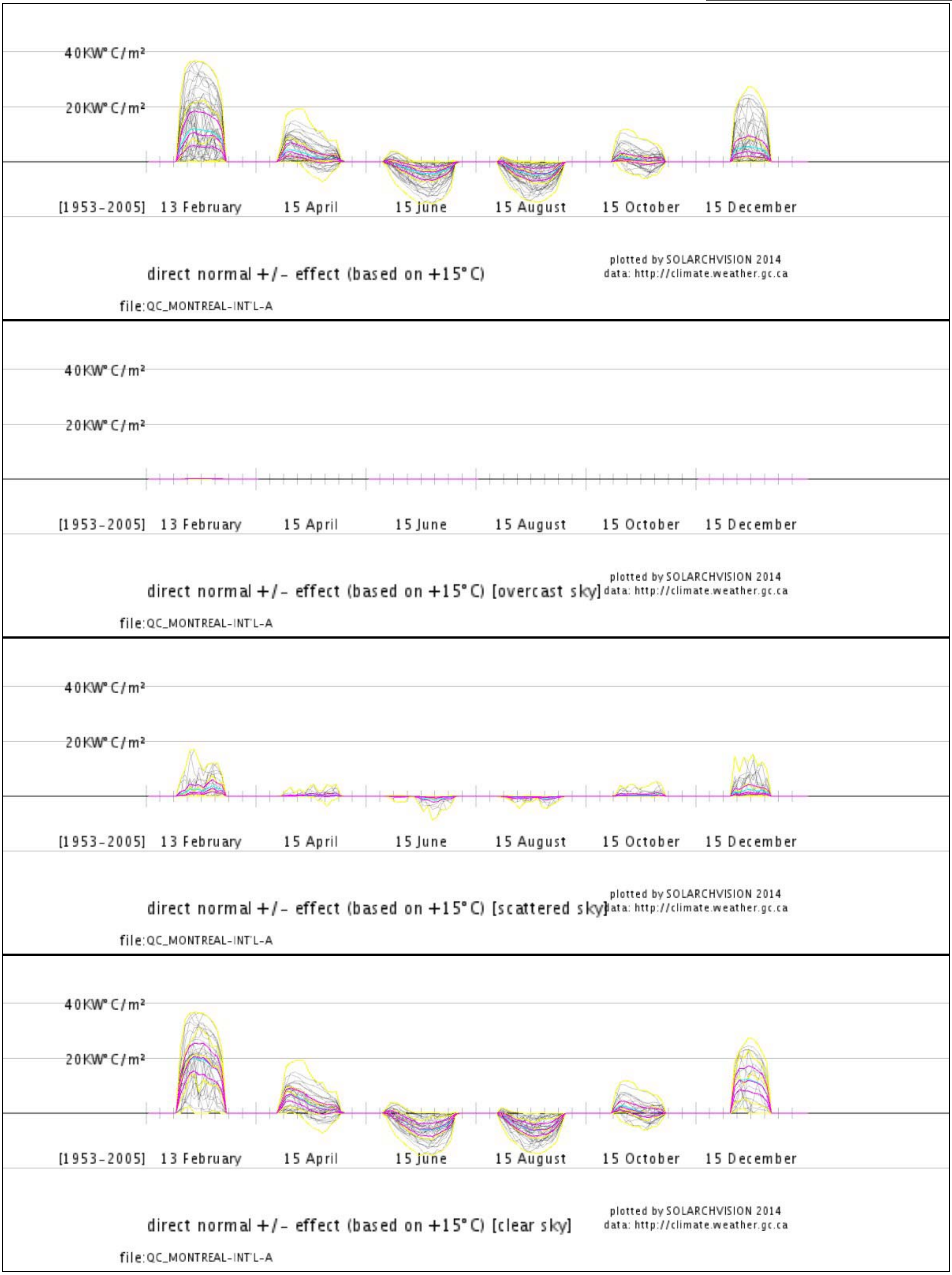


Fig. A1-A4: 1953-2005 hourly positive and negative effects of direct beam models in different months with the mean, average high, average low, max. and min. values in general and different sky conditions (clear, scattered, overcast) based on CWEED files

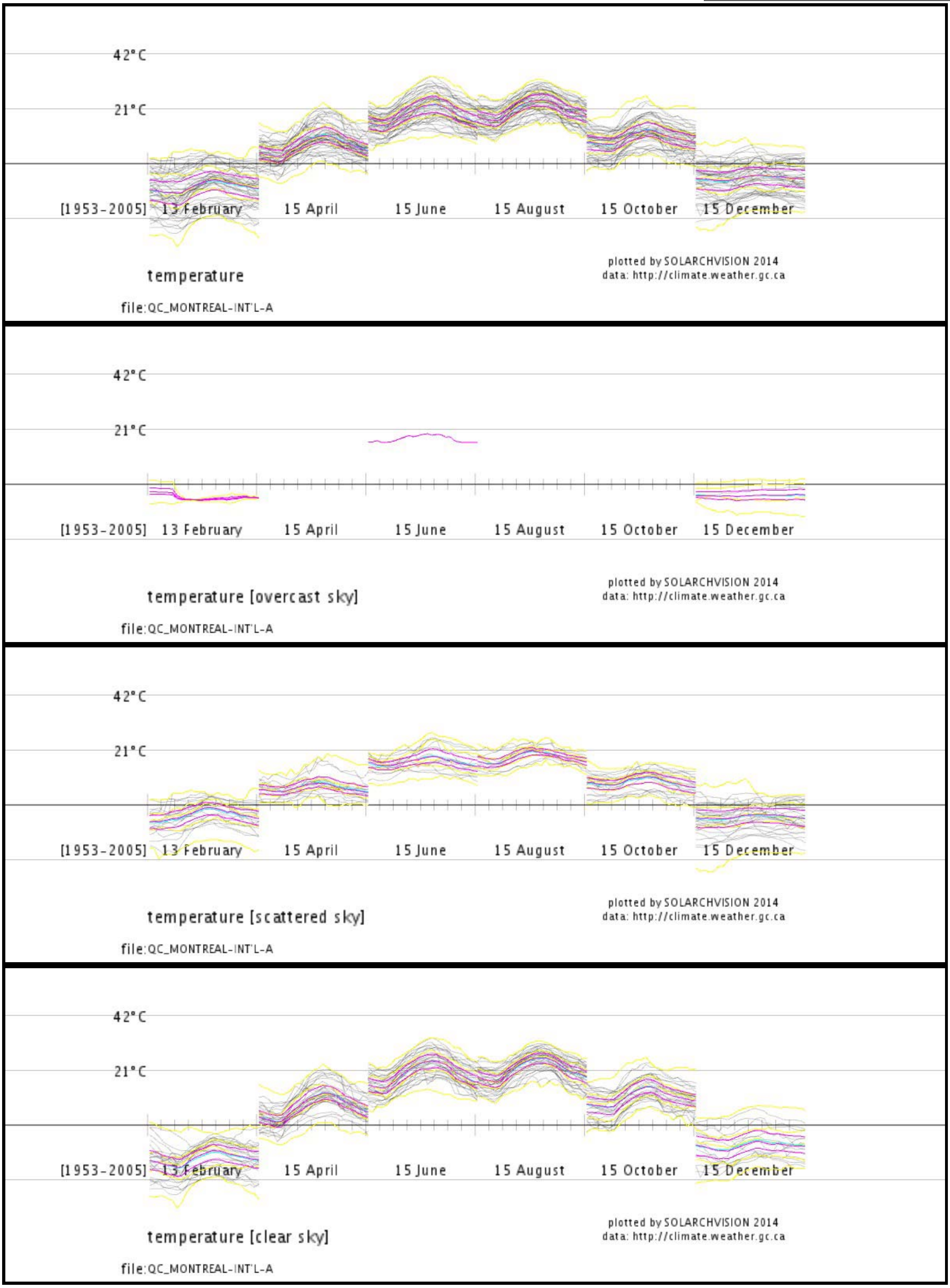


Fig. B1-B4: 1953-2005 hourly temperature models in different months with the mean, average high, average low, max. and min. values in general and different sky conditions (clear, scattered, overcast) based on CWEED files

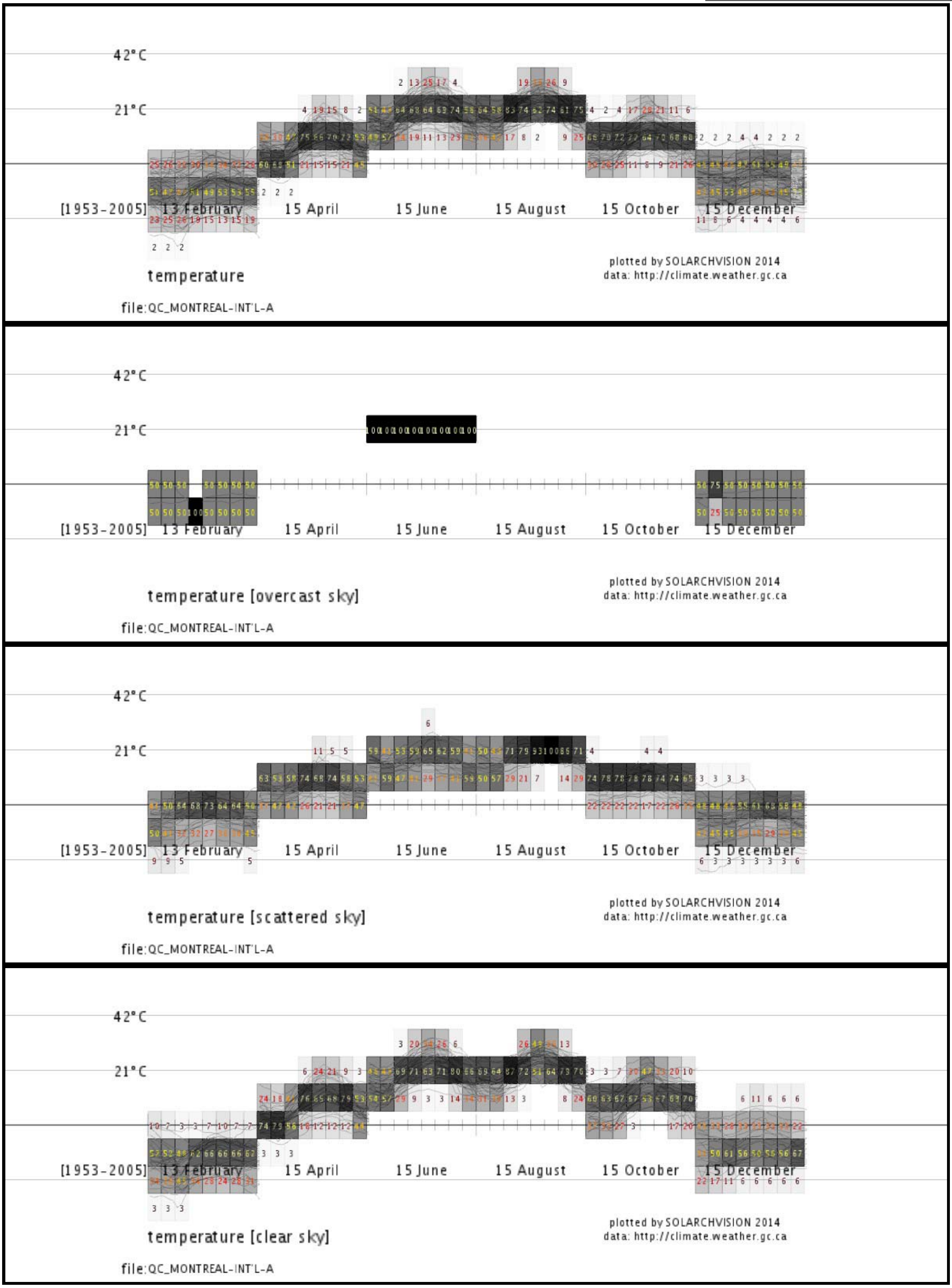


Fig. C1-C4: 1953-2005 hourly temperature models in different months with probabilities in general and different sky conditions (clear, scattered, overcast) based on CWEED files

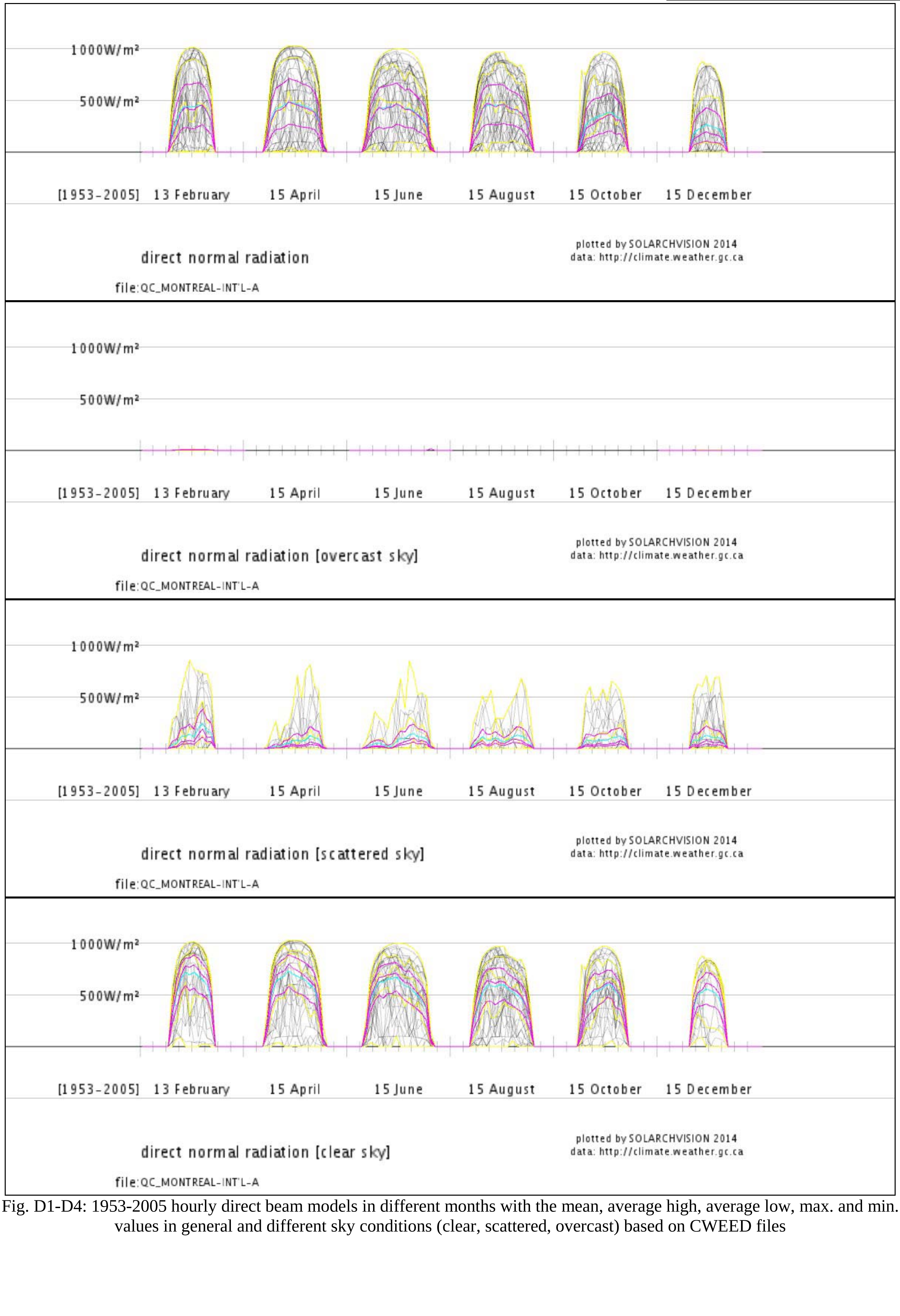


Fig. D1-D4: 1953-2005 hourly direct beam models in different months with the mean, average high, average low, max. and min. values in general and different sky conditions (clear, scattered, overcast) based on CWEED files

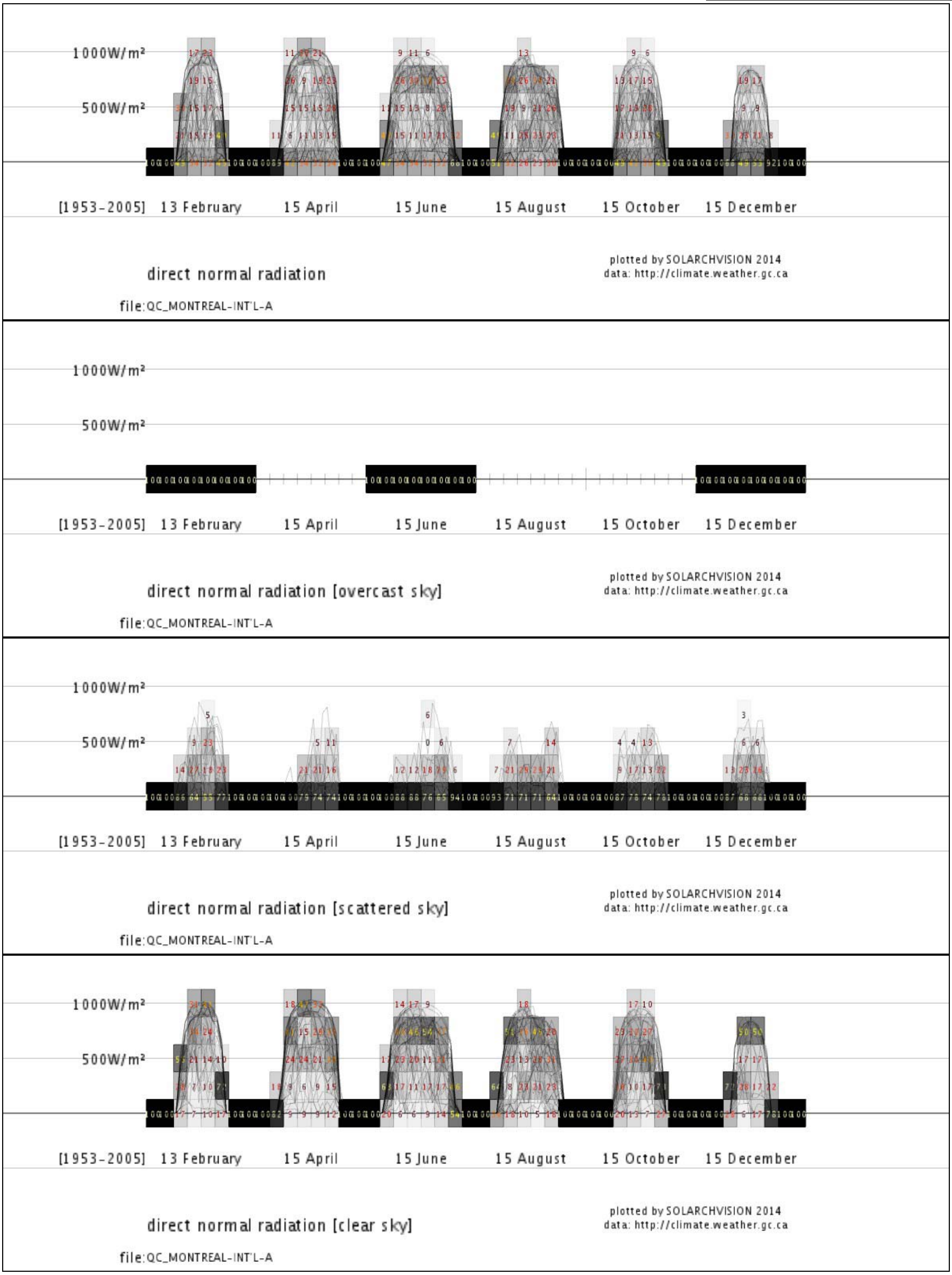


Fig. E1-E4: 1953-2005 hourly direct beam models in different months with probabilities in general and different sky conditions (clear, scattered, overcast) based on CWEED files