OCPM

(Office de Consultation Publique de Montréal)

Proposal for PDM

(Plan de développement de Montréal)

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THE SUN AND THE CITY OF MONTRÉAL

One of the main goals of planning cities and building is to provide health, comfort and safety for people; and right here the role of climatic response of a city as well as its buildings are essential. Considering the remarkable effects of the Sun in Montréal and its complex climate, basic and applied researches are needed to help the architects, the urban planners and the clients for more accurate decision making and decision taking.

Regarding the vision and the mission of the OCPM and PDM, this proposal aims pointing to one of the greatest challenges of architects and urban planners. This challenge is how to develop and improve the quality of both internal and external living spaces by means of integrated solar-climatic design which could be illustrated using the computer program developed by me which is called SOLARCHVISION.

After a prelude on the subject of static and dynamic Sun Path Diagrams for Montréal as a result of Global Warming, different optimizations regarding passive and active strategies are presented here; afterwards, the positive and negative effects of the Sun are analyzed for both outdoor and indoor spaces to demonstrate the solar-climatic performance of the urban fabric as well as the building form.

Such process would result in developing healthier, more comfortable and more energy saving living spaces of tomorrow. On the other side, in many cases it result in finding certain solutions which costs no more than to know where and/or how to design and invest.

In order to have better view on this matter at the end of this proposal three different case studies are analyzed as follow:

1- Montréal Downtown (from Bell Center to Place-des-Arts)
2- Mount Royal Chalet (Kondiaronk Belvedere)
3- Fontaine School at Nuns' Island (OCPM open project)

Firstly, the analysis of Montréal Downtown discovers the comfortable and uncomfortable parts of the urban fabric in different seasons. Different models are useful as a base for locating and design of pedestrian, places for stay, shading/reflecting devices, trees and solar collectors.
Secondly, the analysis of the open public space in front of Mount Royal Chalet also points to its situations within a year-cycle which is followed by presenting some practical alternatives to improve the qualities of this fantastic place at any time of the year.
Finally, the analysis of primary school in Nuns' Island (Île-des-Sœurs) demonstrates the essential effects of building form, building orientation and building skin as well as building interior layout.

Introduction, Problem Definition & Research Objectives

"*one of the greatest challenges of architects is to design buildings not only receive more from the kind face of the sun; but also protect themselves from the unkind face of the sun*."[1]

But, "*Considering buildings as standing objects, the urban design should be intelligent enough to provide comfort both inside and outside through the whole cycle of the year. The significance and complexity of optimizing the orientation and proportion of building masses at the scale of neighbourhood and city greatly increases when we take into consideration the comfort factor outdoors beside indoors. The comfort and discomfort inside a building have a direct effect on the building energy consumption and the energy costs paid by the occupants,* ***while in outdoor spaces the problem is more related to the health and safety rather than energy and money!*** *Thus, even though orientating long rows of building masses toward the South direction is a common idea to achieve maximum solar radiation in winters and to minimize summer gains, in most cases it results in developing uncomfortable areas between building blocks (i.e. paths and yards) where these parts will be in long-time shade in winters as well as long-time radiation in summers. Although these negative effects could be corrected by proper shades, reflectors, planting, etc., different and more enhanced optimizations would be gained from sound integration and distribution of indoor and outdoor spaces within the design.*" [2]

Therefore "*The state of art in architecture is to adjust both internal space and external living spaces together and beside each other.*"[3]

The main goals of SOLARCHVISION studies are:

1. Producing basic design guidelines using the available data of different climates for both active and passive strategies;
2. Evaluation of alternatives for urban fabric, building skin and in/outdoor spaces through design process from point of view of the Sun and climate.

[1] "A New Approach for Solar Analysis of Buildings", SAMIMI M., PARVIZSEDGHY L. & ADIB A., WORLDCOMP'08 – Proceedings of The 2008 International Conference on Software Engineering Research & Practice, editors: ARABNIA H.R. & REZA H., CSREA PRESS

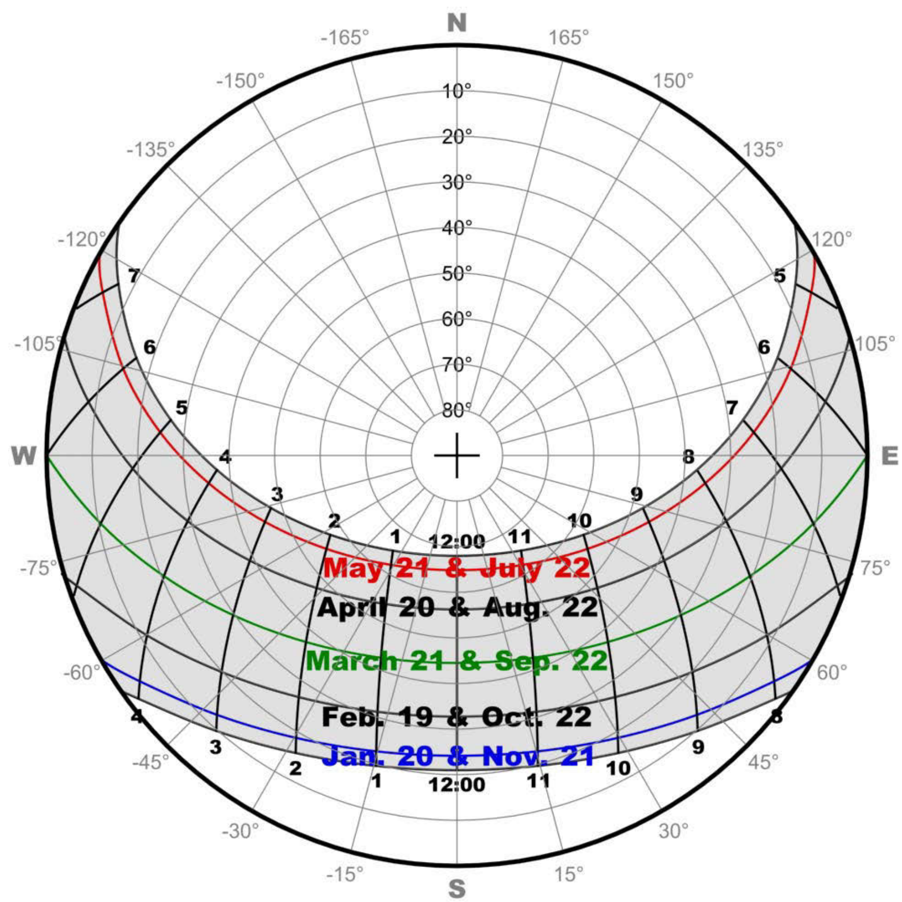
[2] "SOLARCHVISION Studies on Young Cities Project" Book, SAMIMI M., NASROLLAHI F., TU-Berlin, 2013 and also "External and Internal Solar-Climatic Performance Analysis of Building Geometries using SOLARCHVISION", CISBAT 2011, EPFL University, Lausanne, Switzerland

[3] "The Variety of Problems and Problems of the Variety" in the Book "Sustainable Environmental Design in Architecture - Impacts on Heath", SAMIMI M., NILI M.Y., SEIFI S., editors: STAMATINA RASSIA & PANOS M. PARDALOS to be published by Springer

SOLARCHVISION analysis can be applied through the whole design process in a variety of design fields ranging from basic design and urban design to architectural design and landscape architecture. Moreover The intelligent design of shading or reflecting devices in different facades, form finding process of membrane structures and optimization of single and group of solar collectors can be done by this program.

Sun Path

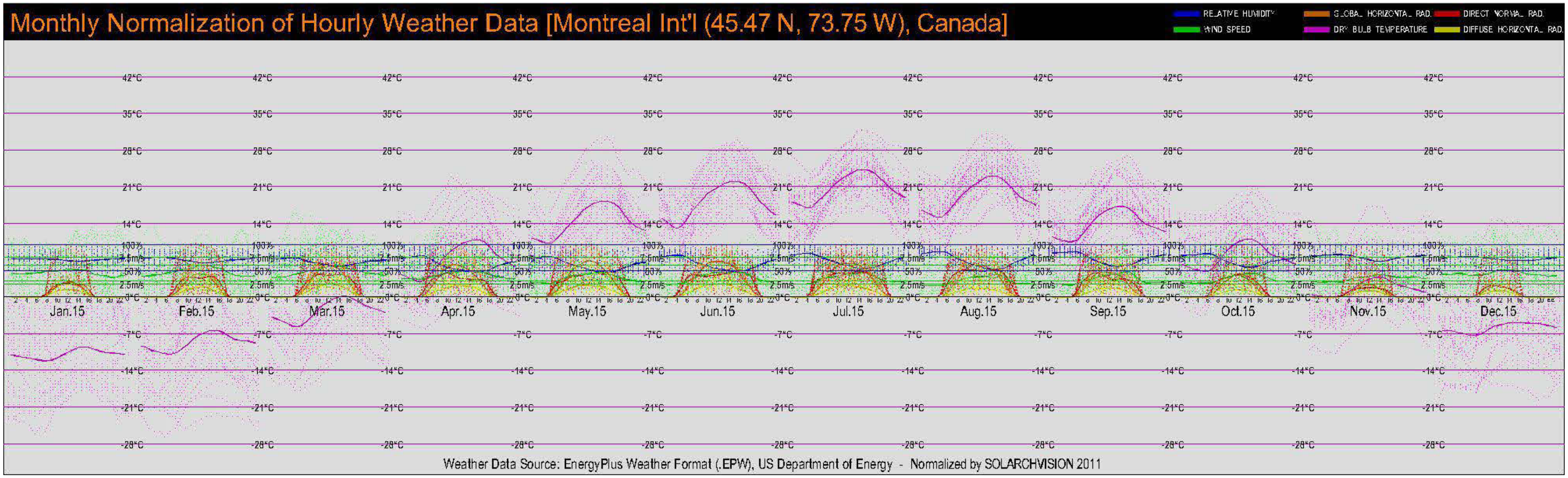
The position of the Sun in the sky is described by two factors of the Azimuth angle and the Altitude angle. Different points on the earth in regard to their latitude have different Sun paths. Below the Sun path for the latitude of 45° is plotted which shows the position of the Sun in the sky of Montréal in different months of the year and in different hours of the day.



Montréal Sun Path

Climatic Factors and TMY (Typical Meteorological Year)

There are a number of different parameters which introduce the characteristics of a climate such as temperature, humidity, wind speed, wind direction, solar direct radiation, solar diffused radiation, etc. At the moment, most of the building simulation computer programs use a TMY file as their input data for their further calculations. A TMY file presents hourly data of Typical Meteorological Year in a location. Below you find an hourly plot by SOLARCHVISION in different months of the year of Montréal TMY file which is provided by U.S. Department of Energy website as a ".EPW" - EnergyPlus format.

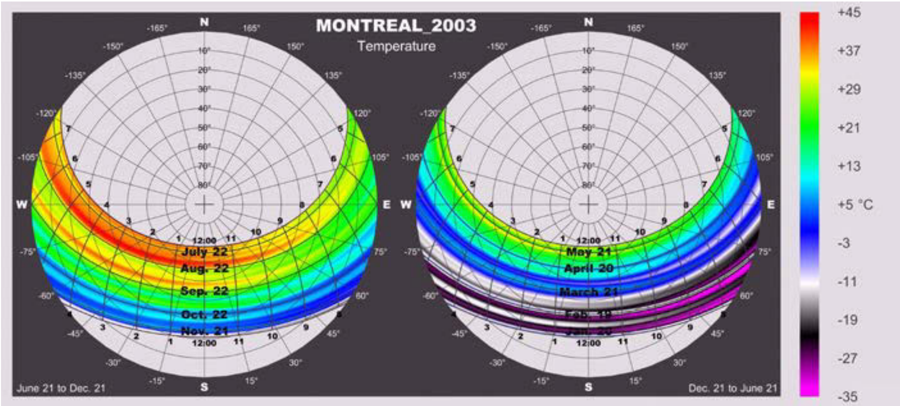


Humidity: ■ - Wind Speed: ■ - Temperature: ■ - Solar Radiation (Global Horizontal: ■ - Diffused Horizontal: ■ - Direct Normal: ■)
Plot of Different Climatic Factors in a Typical Meteorological Year of Montréal

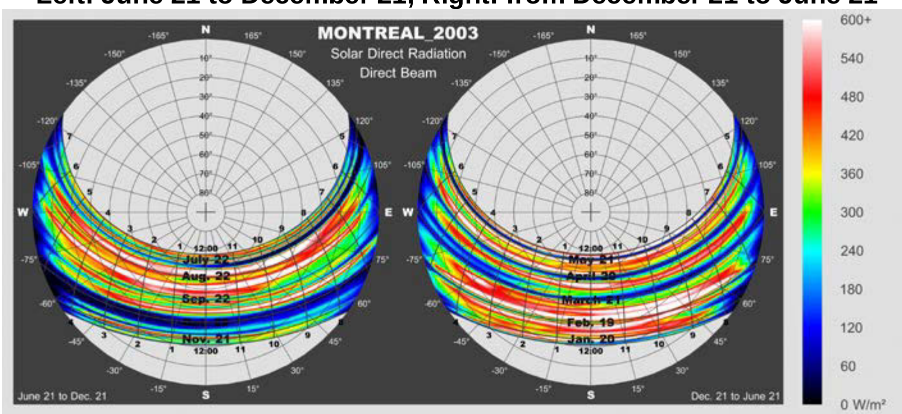
These files include certain characteristics of a site; however they do not include the changes of the climate in different years. Moreover the extreme-year conditions are not presented in a TMY file. Although there might be a number of places on the Earth which the extreme-year conditions do not play an important role, for an advance design in the city of Montréal these extremes are so impostant.

The following studies on the next pages show the changes in the amount of direct solar radiation and temperature trough different years based on CWEEDS files (Canadian Weather Energy and Engineering Datasets) for the station MONTRÉAL-JEAN-BREBEUF between 1953 and 2005.
"*CWEEDS files include the long term weather records necessary for urban planning and the design of energy efficient buildings.*"[4]

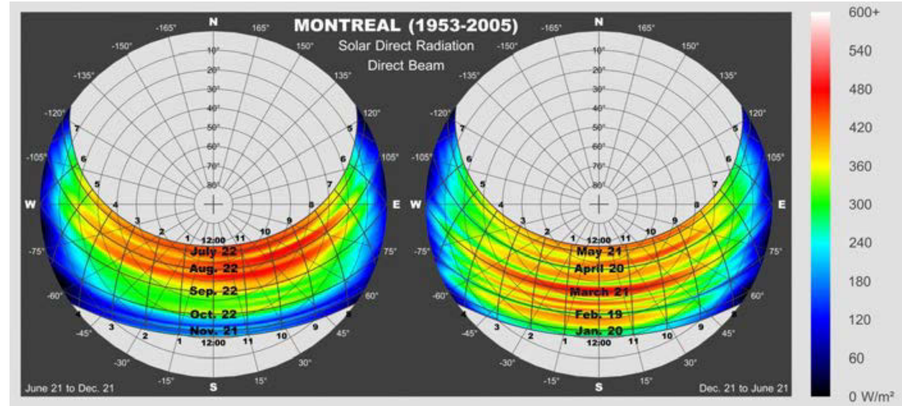
[4] National Climate Data and Information Archive of Environment Canada Website



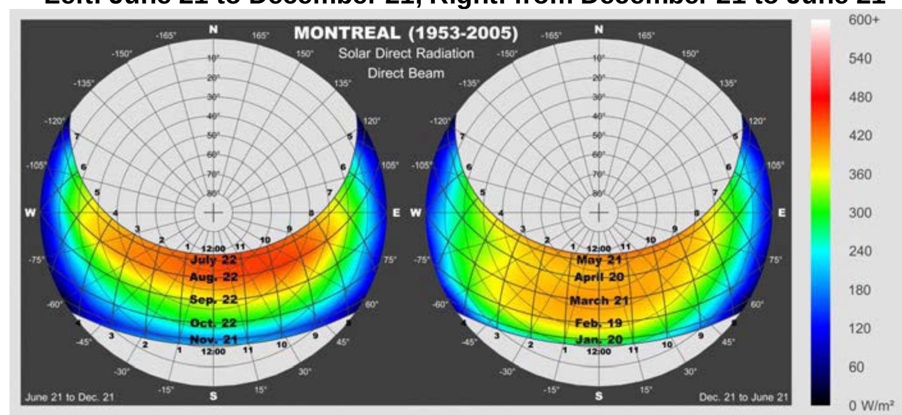
Montréal (2003) – Above: Temperature, Below: Amount of Direct Radiation
Left: June 21 to December 21, Right: from December 21 to June 21

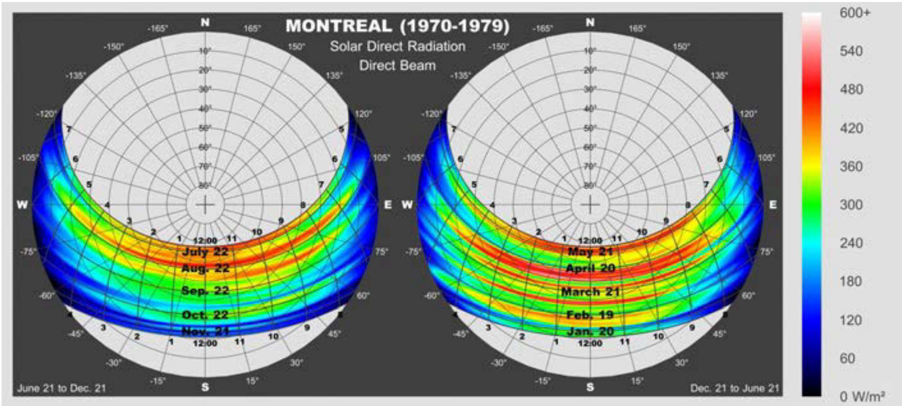


Above diagram shows an extreme-year where the temperature reached its highest (above +35°C) in July and August (Red Color) and also it reached the lowest (below -35°C) in January and February (Magenta Color). In below diagram it can be seen that in the sunny situation, where the amount of direct radiation is high, the probabilities of having an extreme high temperature or even extreme low temperature are remarkable. Therefore the sunny days in winter are the coldest ones!

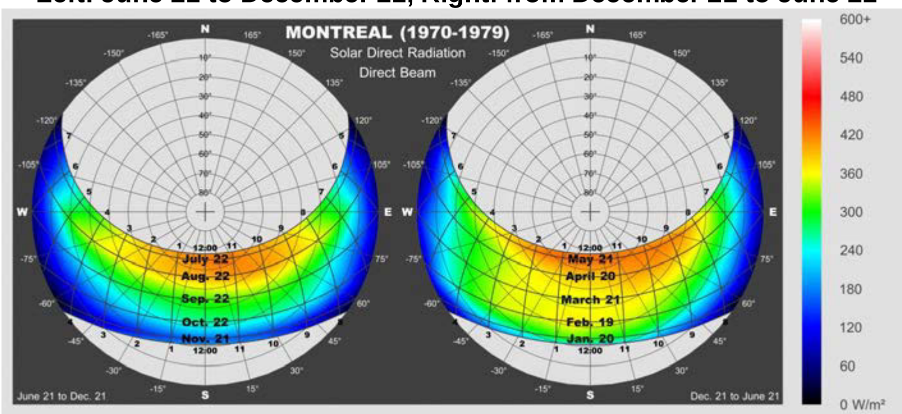


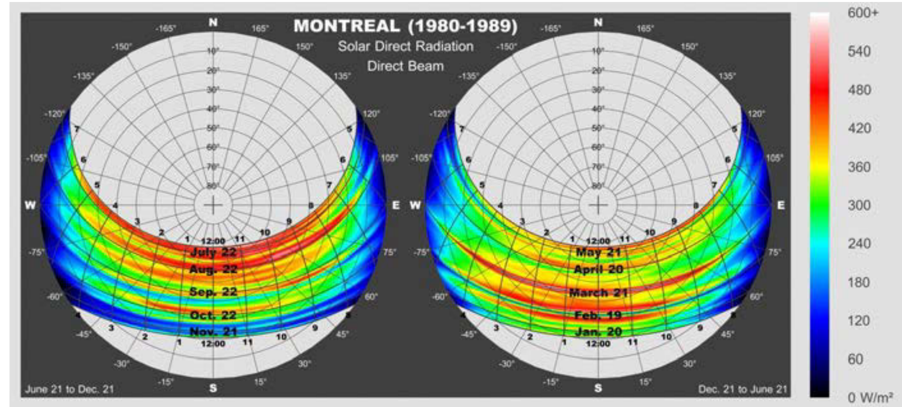
Amount of Direct Radiation in Montréal (1953-2005) – Above: 5-day Normalization, Below: 30-day Normalization
Left: June 21 to December 21, Right: from December 21 to June 21



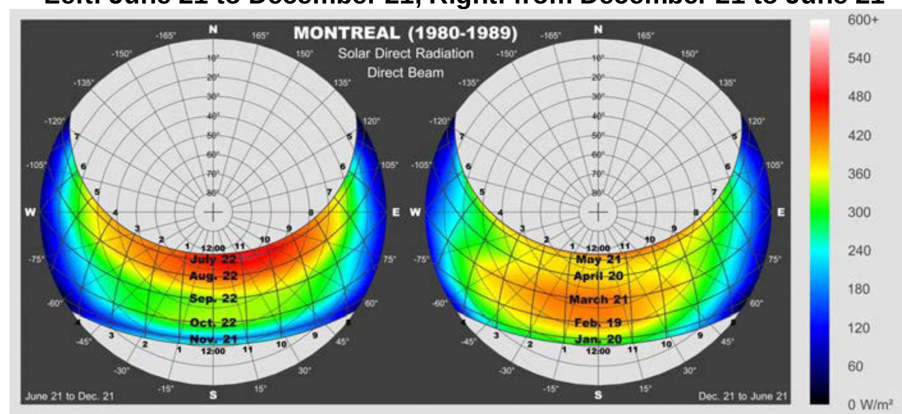


Amount of Direct Radiation in Montréal (1970-1979) – Above: 5-day Normalization, Below: 30-day Normalization
Left: June 21 to December 21, Right: from December 21 to June 21

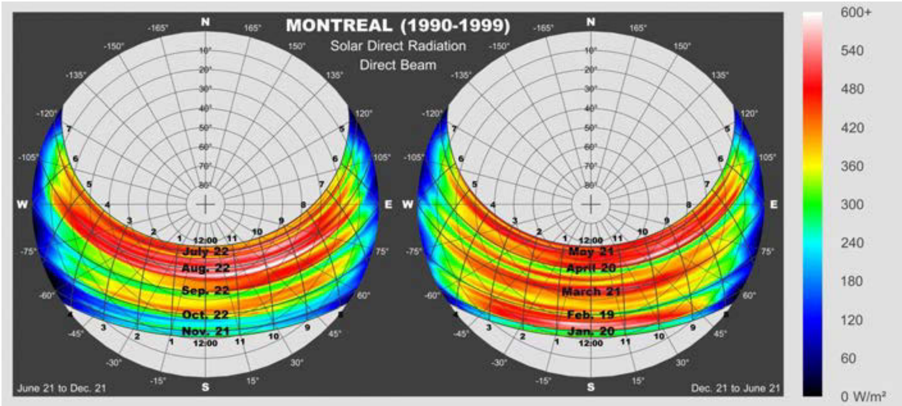




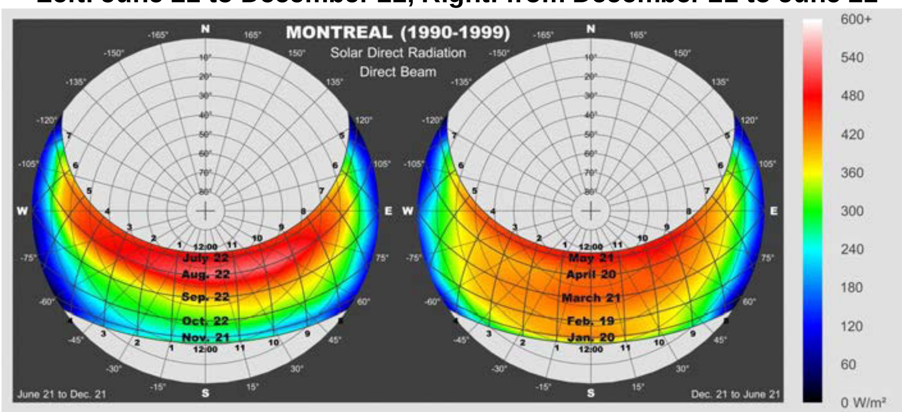
Amount of Direct Radiation in Montréal (1980-1989) – Above: 5-day Normalization, Below: 30-day Normalization
Left: June 21 to December 21, Right: from December 21 to June 21



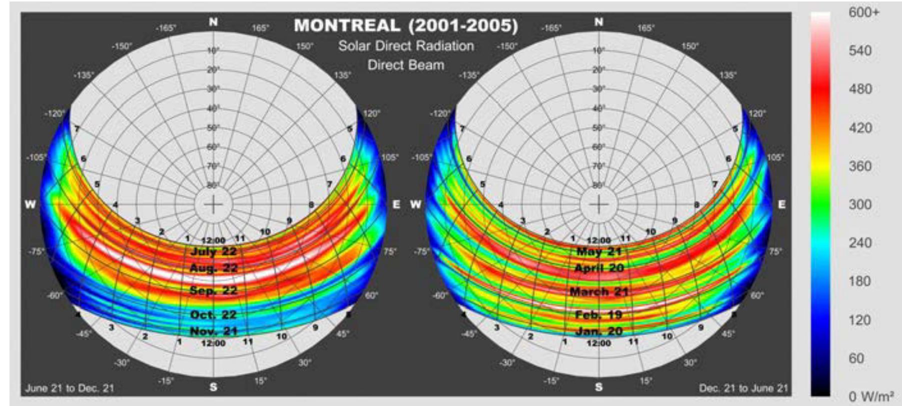
By comparing the above diagrams with the diagrams at Left and on the previous page, we can see an increase in the amount of solar direct radiation of 80's in comparison with 70's.



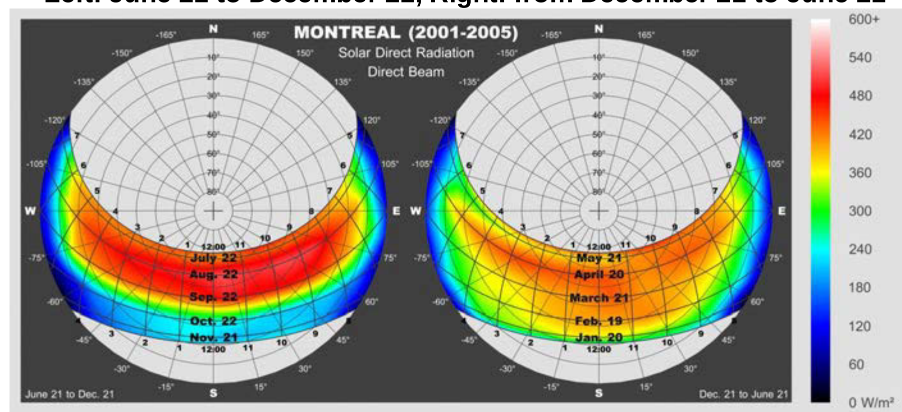
Amount of Direct Radiation in Montréal (1990-1999) – Above: 5-day Normalization, Below: 30-day Normalization
Left: June 21 to December 21, Right: from December 21 to June 21



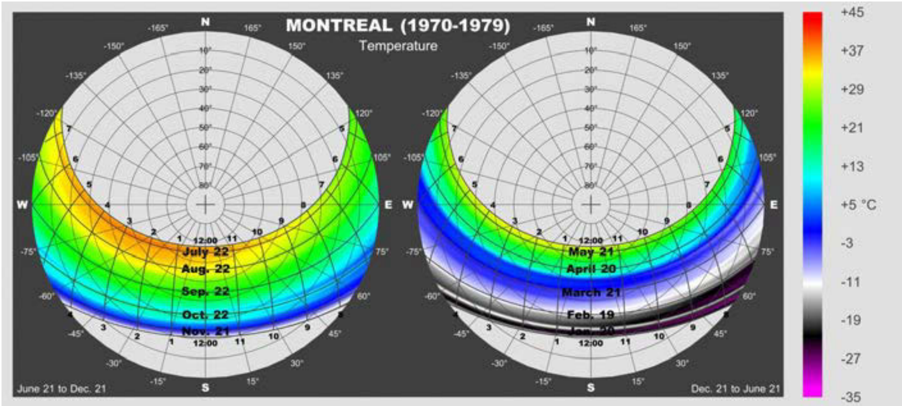
By comparing the above diagrams with the diagrams of the previous page, we can see an increase in the amount of solar direct radiation of 90's in comparison with 80's.



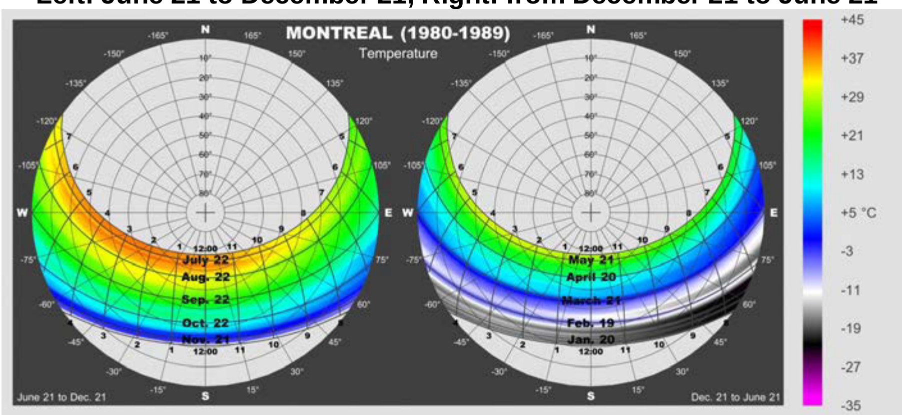
Amount of Direct Radiation in Montréal (2001-2005) – Above: 5-day Normalization, Below: 30-day Normalization
Left: June 21 to December 21, Right: from December 21 to June 21



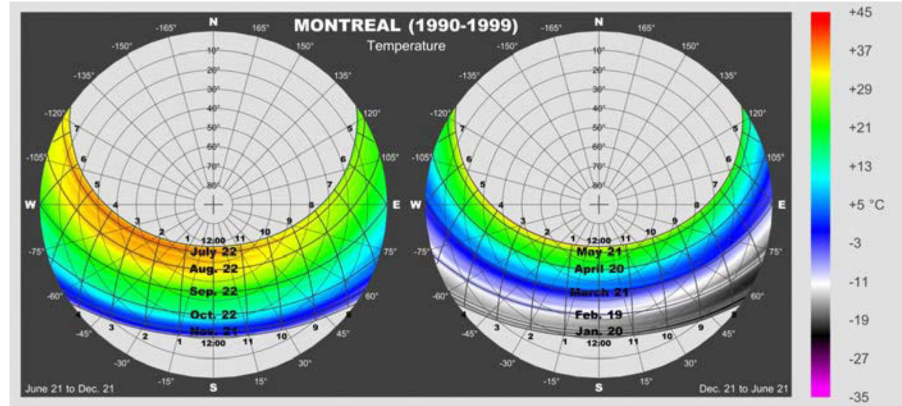
By comparing the above diagrams with the diagrams of at left, we can see an increase in the amount of solar direct radiation of 2000's in comparison with 90's. Therefore the diagrams of 70's, 80's, 90's and 2000's illustrate remarkable increase in the amount of solar radiation in Montréal during the time which could be resulted by Global Warming phenomenon.



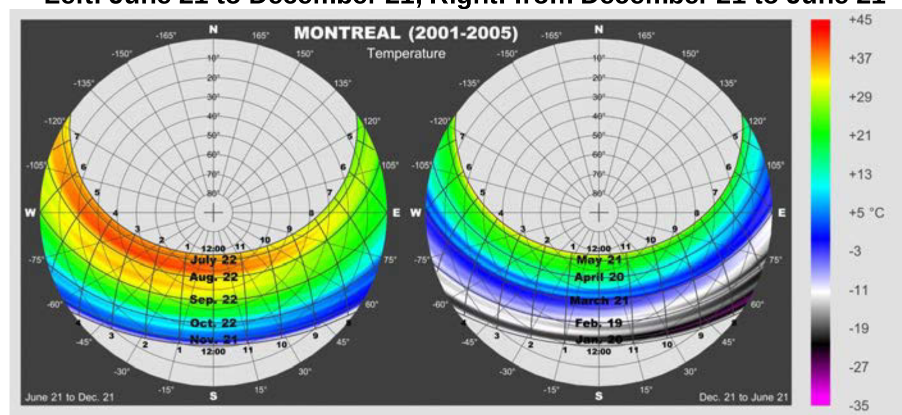
5-day Normalization of Daily Temperature in Montréal – Above: (1970-1979), Below: (1980-1989)
Left: June 21 to December 21, Right: from December 21 to June 21



By comparing the above diagrams of 70's and 80's, we can see an increase in the temperature model of 80's in comparison with 70's especially in winter.



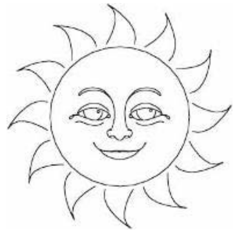
5-day Normalization of Daily Temperature in Montréal – Above: (1990-1999), Below: (2001-2005)
Left: June 21 to December 21, Right: from December 21 to June 21



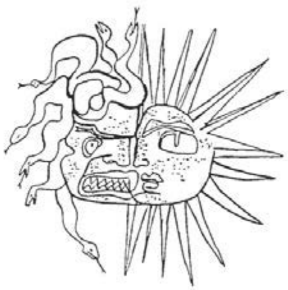
By comparing the above diagrams of 90's and 2000's, we can see a remarkable increase in the temperature model of 2000's in comparison with 90's especially in summer. On the other side, however in winter the extreme temperature decreased in 2000's in comparison with 90's, the period of cold days (which is plotted as blue, white and black) decreased about 15 days as a result of Global Warming!

Active/Passive Strategies and Kind/Unkind Faces of the Sun

“In architecture and in relationship with the sun there have been always questions about the form and orientation of buildings, the amount of openings in each direction, and the layout of building masses beside each other. From one side the answer to these questions relates to the passive or active strategy that architect approaches. In an active strategy, form and orientation are designed so that the building facades receive more energy from the sun; while this energy is useful directly in cold times, also it can be used in cooling systems in hot times. Therefore, in an active strategy the sun would better be considered as a friend.”[5]

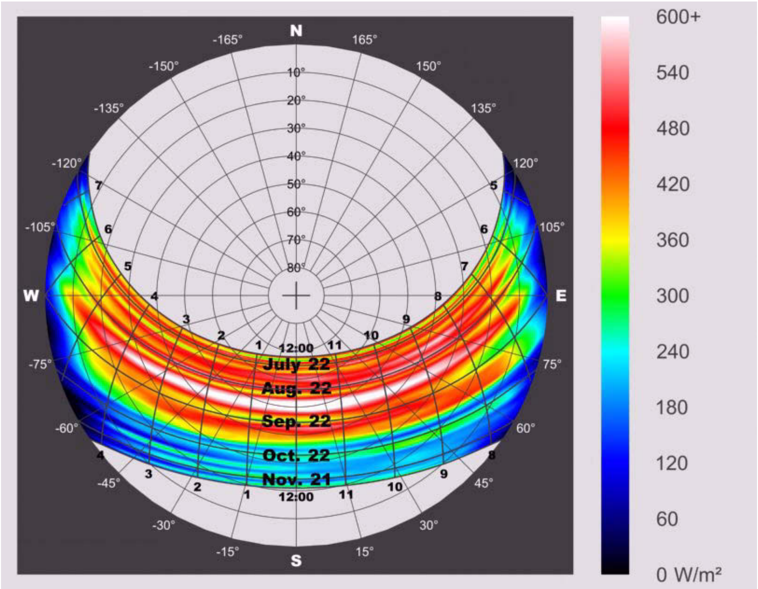


The kind face of the sun in active strategy.

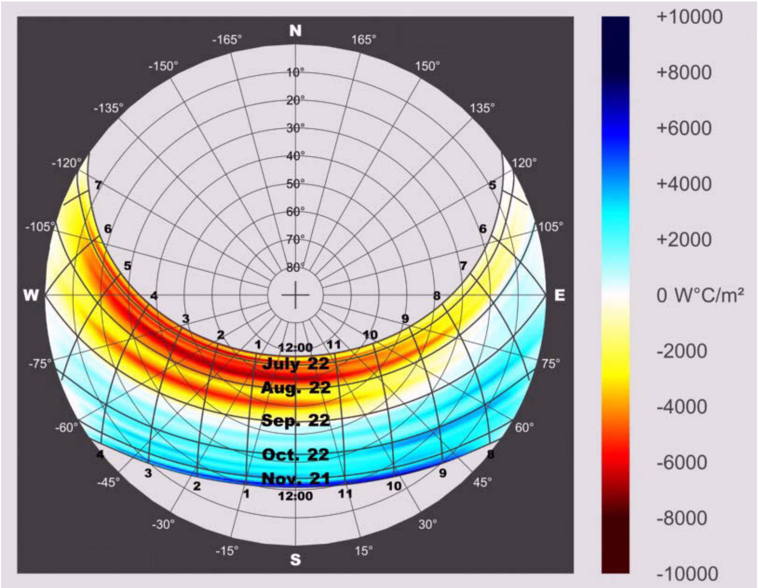


Kind and unkind faces of the sun in passive strategy – 1948 Le Corbusier Sketch

But in a passive approach *“The sun has two different faces: The kind face of the sun which appears in cold times; and its unkind face which appears in hot times. In according to the properties of each location, kind and unkind faces of the sun differ from place to place, these local faces of the sun more than whatever depend on two parameters: 1st, the intensity of direct and diffused solar radiation in each moment; 2nd, the amount of Need to Shade/Shine in according to the difference between comfortable temperature and outdoor temperature in each moment.”* [6]



(2001- 2005) Hourly Direct Solar Radiation for Montréal from June to December



(2001- 2005) Hourly +/- Effects of the Direct Solar Radiation for Montréal from June to December (18°C is considered as the base for calculating Need to Shade/Shine)

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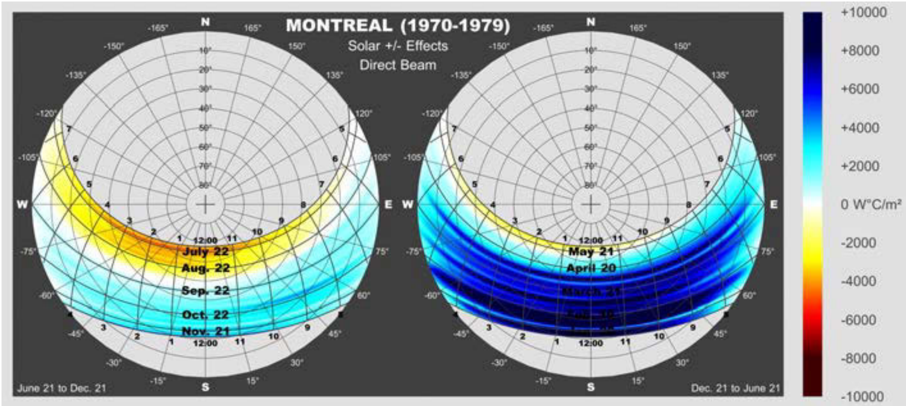
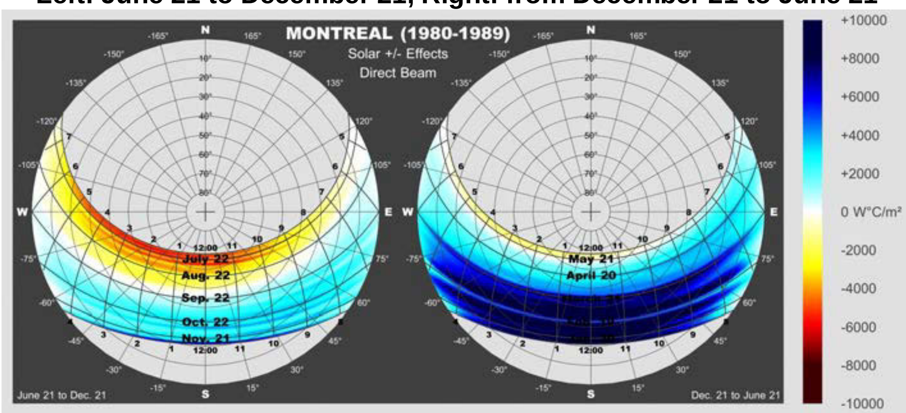
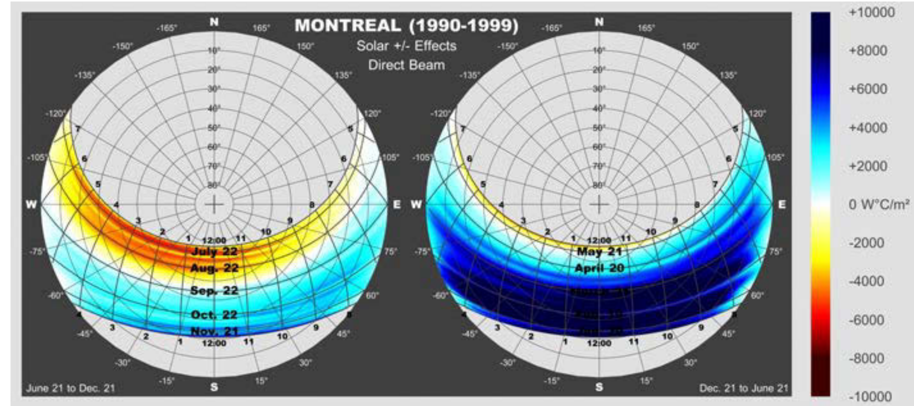
[5] "SOLARCHVISION Studies on Young Cities Project” Book, SAMIMI M., NASROLLAHI F., TU-Berlin, 2013 and also “External and Internal Solar-Climatic Performance Analysis of Building Geometries using SOLARCHVISION”, CISBAT 2011, EPFL University, Lausanne, Switzerland

[6] "A New Approach for Solar Analysis of Buildings”, SAMIMI M., PARVIZSEDGHY L., ADIB M., WORLDCOMP'08 – Proceedings of The 2008 International Conference on Software Engineering Research & Practice, editors: ARABNIAH. R., REZA H., CSREA PRESS

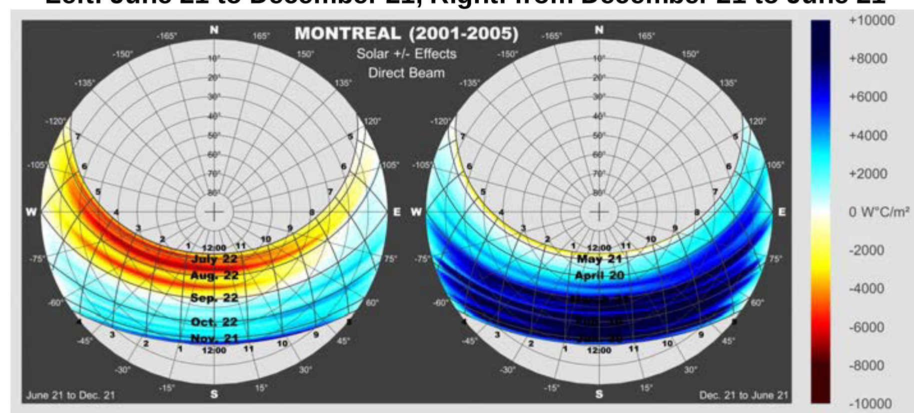


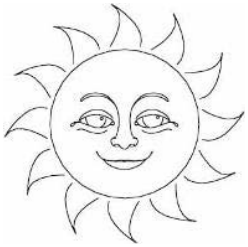
5-day Normalization of Positive/Negative Effect of Direct Radiation in Montréal – Above: (1970-1979), Below: (1980-1989)
Left: June 21 to December 21, Right: from December 21 to June 21

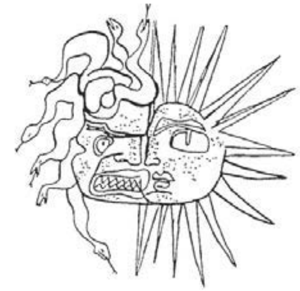


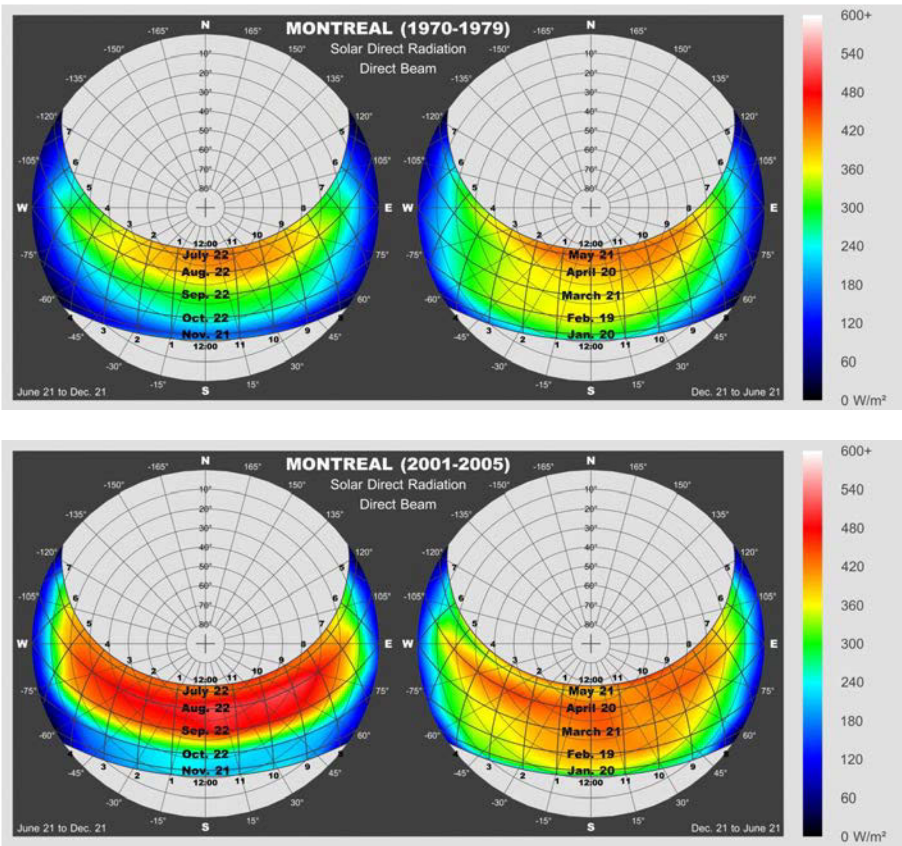


5-day Normalization of Positive/Negative Effect of Direct Radiation in Montréal – Above: (1990-1999), Below: (2001-2005)
Left: June 21 to December 21, Right: from December 21 to June 21



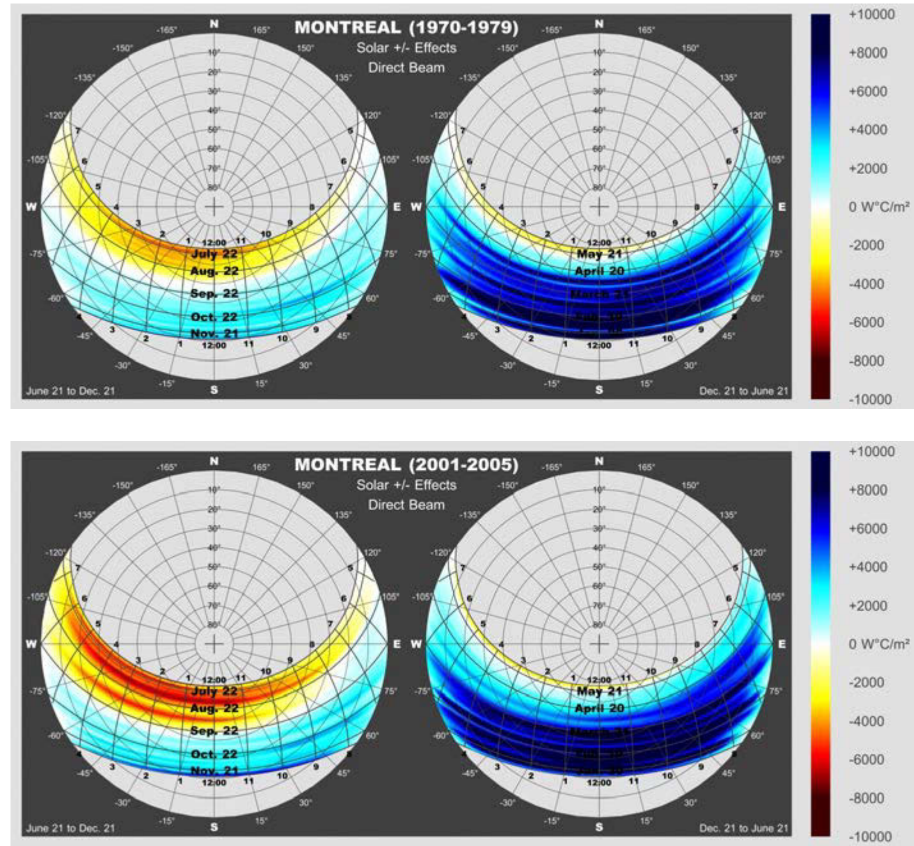






Comparison of Direct Radiation in Montréal through past years – Above: 70's, Below: 2000's

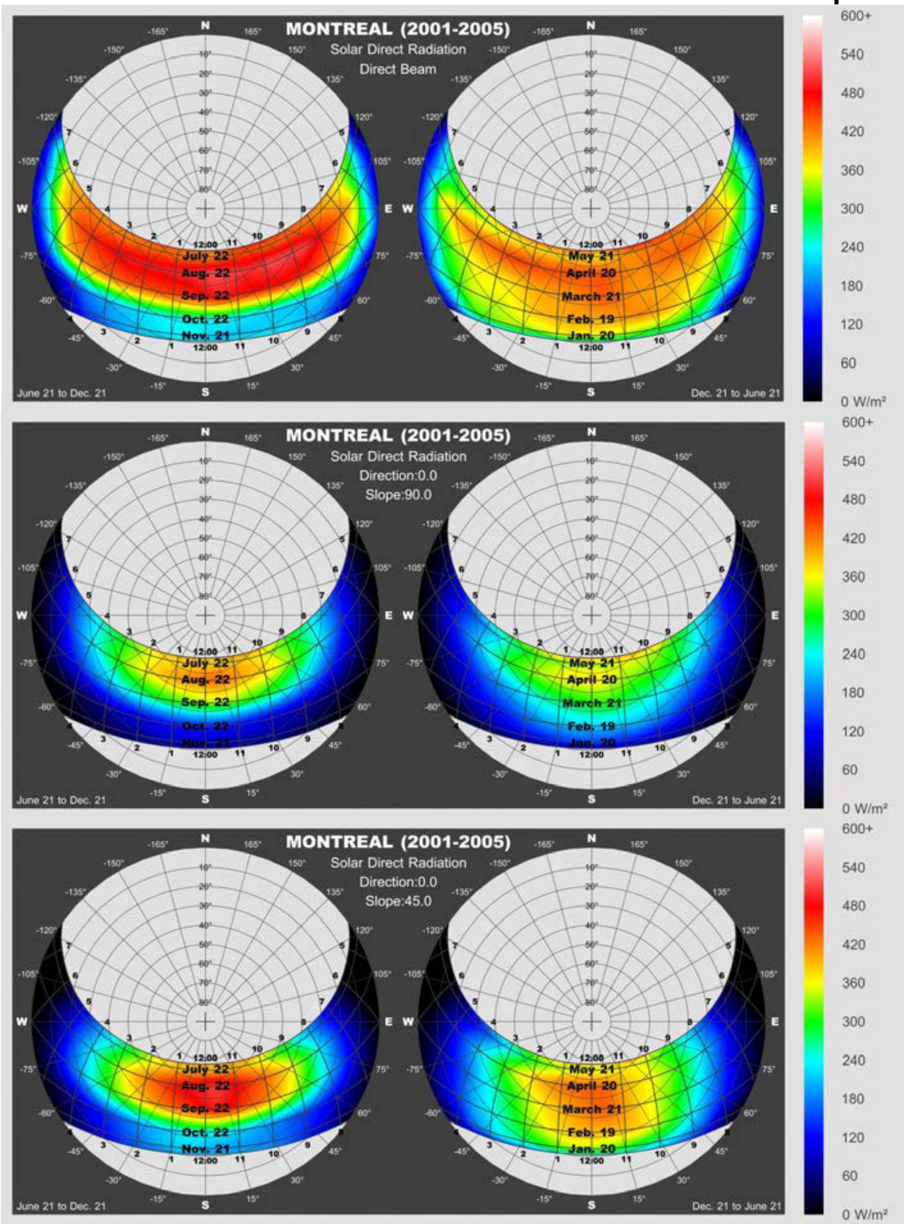
Above diagrams illustrate the increase in solar radiation both in summer and winter which could be resulted in more active utilization of solar energy in Montréal.



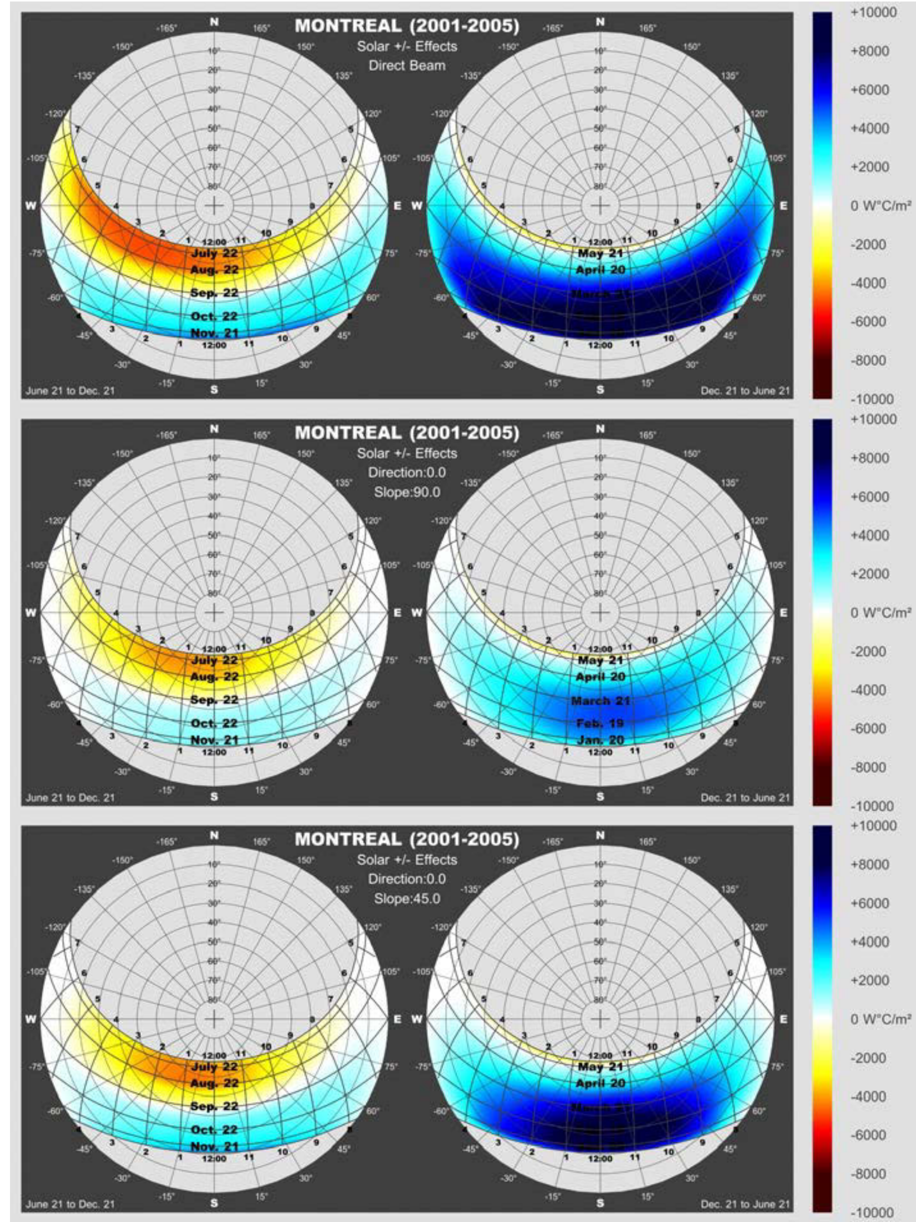
Comparison of Positive/Negative Effect of Direct Radiation in Montréal through past years – Above: 70's, Below: 2000's

Above diagrams illustrate the increase extremes Positive/Negative Effect of Direct Radiation both in summer and winter which point to the necessity of passive design now and in future.

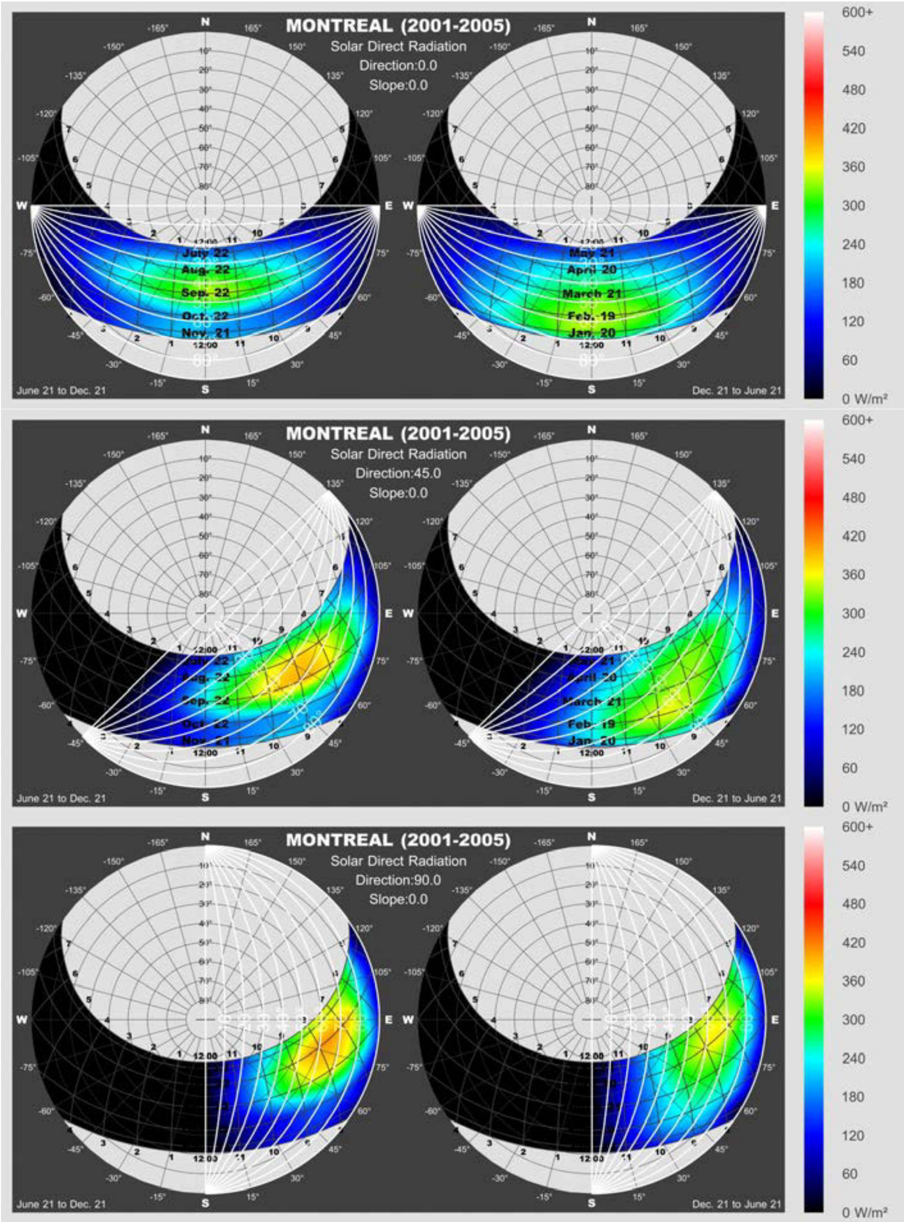
Solar Radiation and its Effects on Different Directions & Slopes



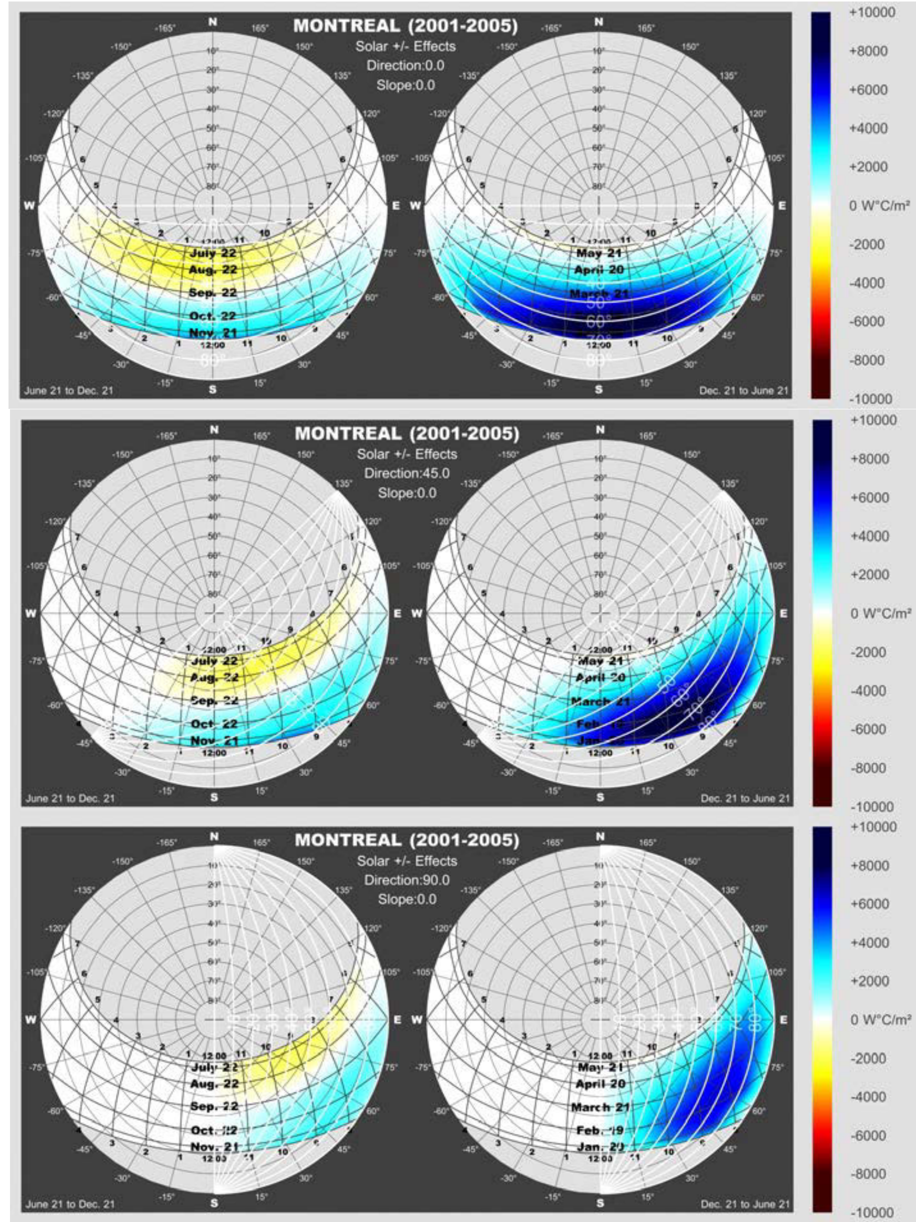
Amount of Direct Radiation in Montréal
Left: from June 21 to December 21, Right: from December 21 to June 21
Above: Beam, Middle: Horizontal Surface, Below: 45° Slope toward South Direction



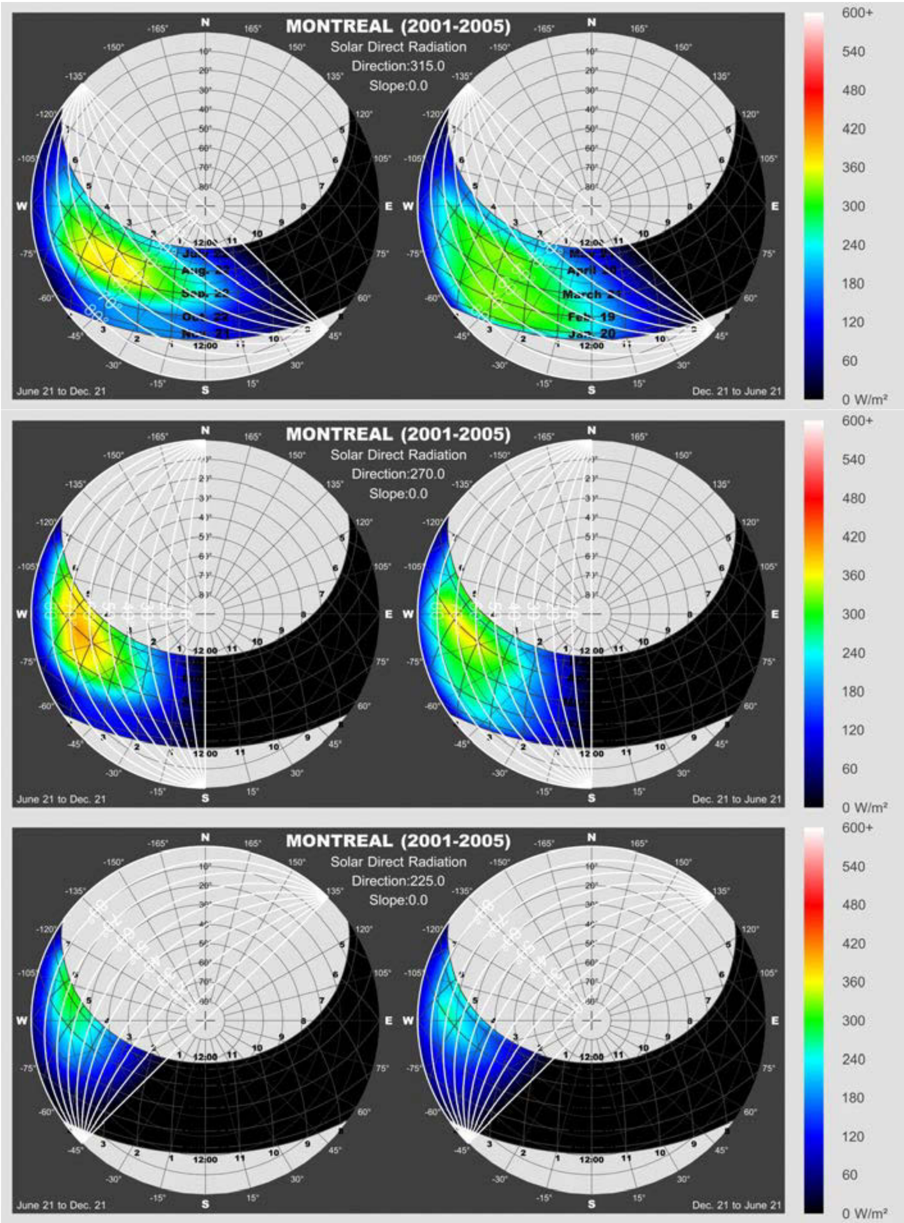
Positive/Negative Effect of Direct Radiation in Montréal
Left: from June 21 to December 21, Right: from December 21 to June 21
Above: Beam, Middle: Horizontal Surface, Below: 45° Slope toward South Direction



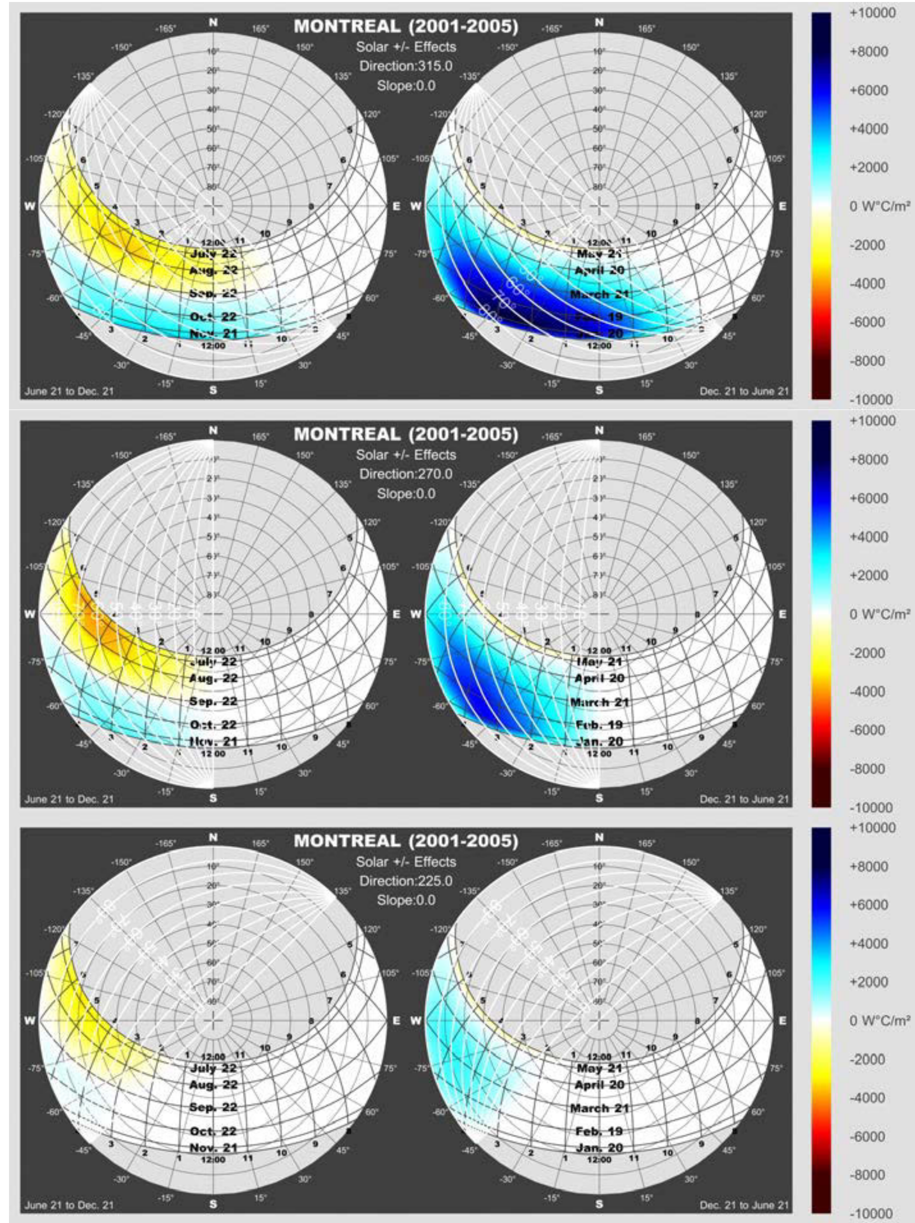
Amount of Direct Radiation in Montréal
Left: from June 21 to December 21, Right: from December 21 to June 21
Above: South Direction, Middle: S.E. Direction, Below: East Direction



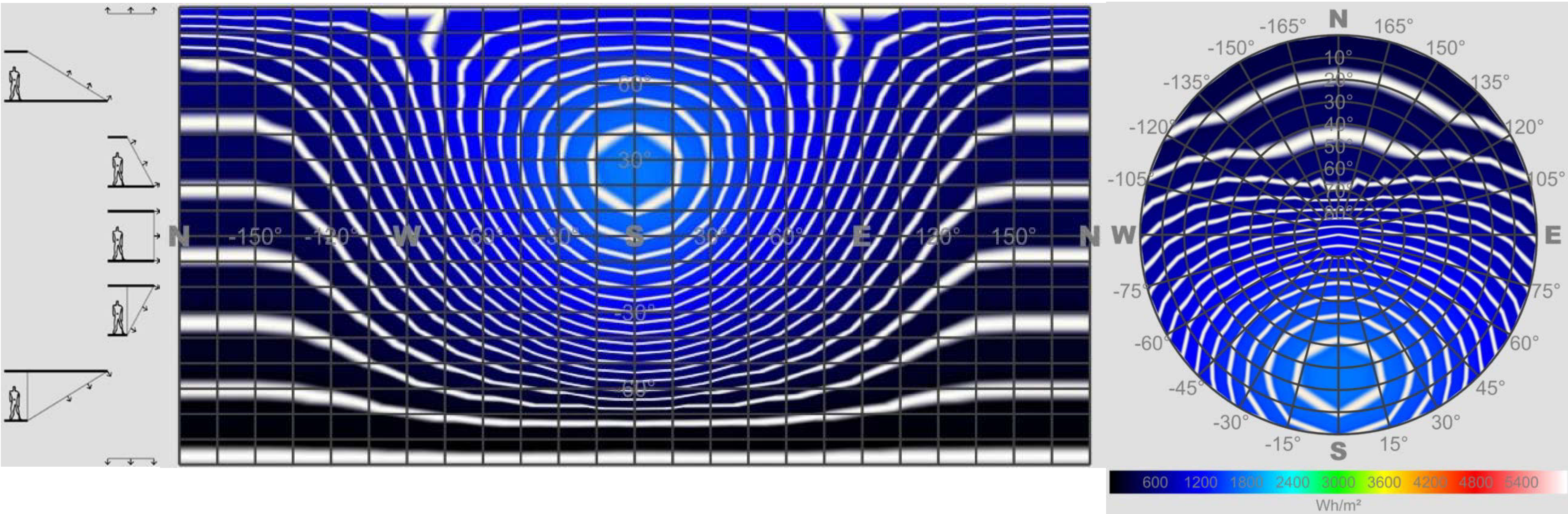
Positive/Negative Effect of Direct Radiation in Montréal
Left: June 21 to December 21, Right: from December 21 to June 21
Above: South Direction, Middle: S.E. Direction, Below: East Direction



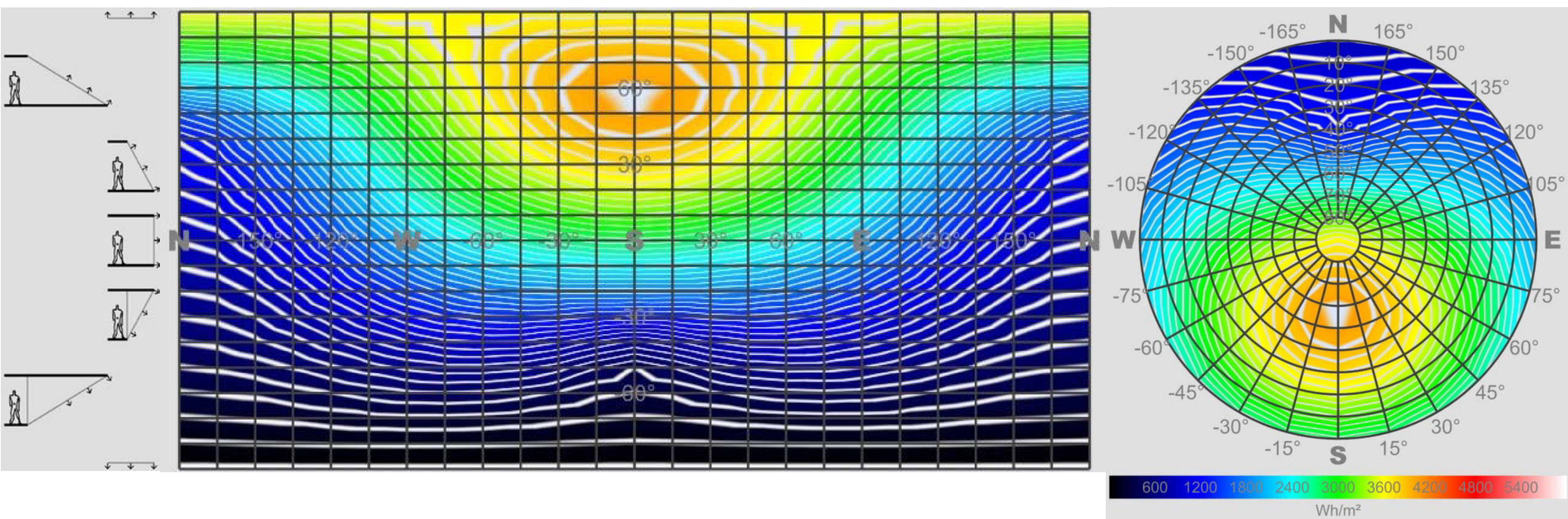
Amount of Direct Radiation in Montréal
Left: from June 21 to December 21, Right: from December 21 to June 21
Above: S.W Direction, Middle: West Direction, Below: N.W. Direction



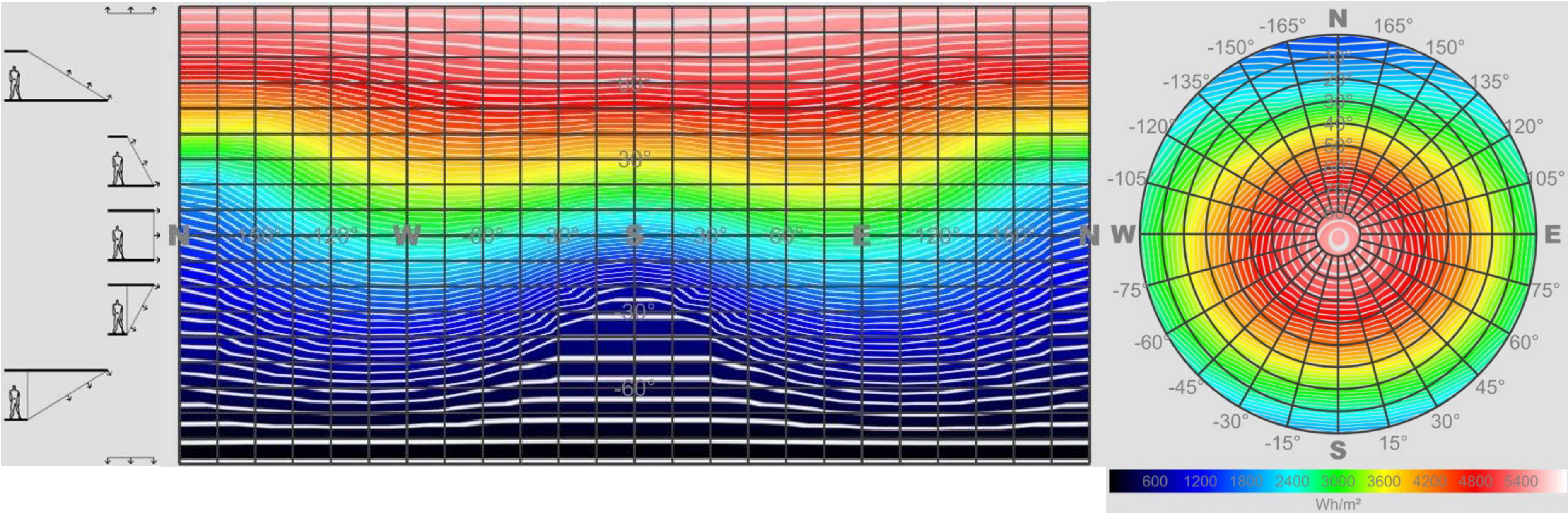
Positive/Negative Effect of Direct Radiation in Montréal
Left: June 21 to December 21, Right: from December 21 to June 21
Above: S.W Direction, Middle: West Direction, Below: N.W. Direction



December 21 Global Radiation on different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)



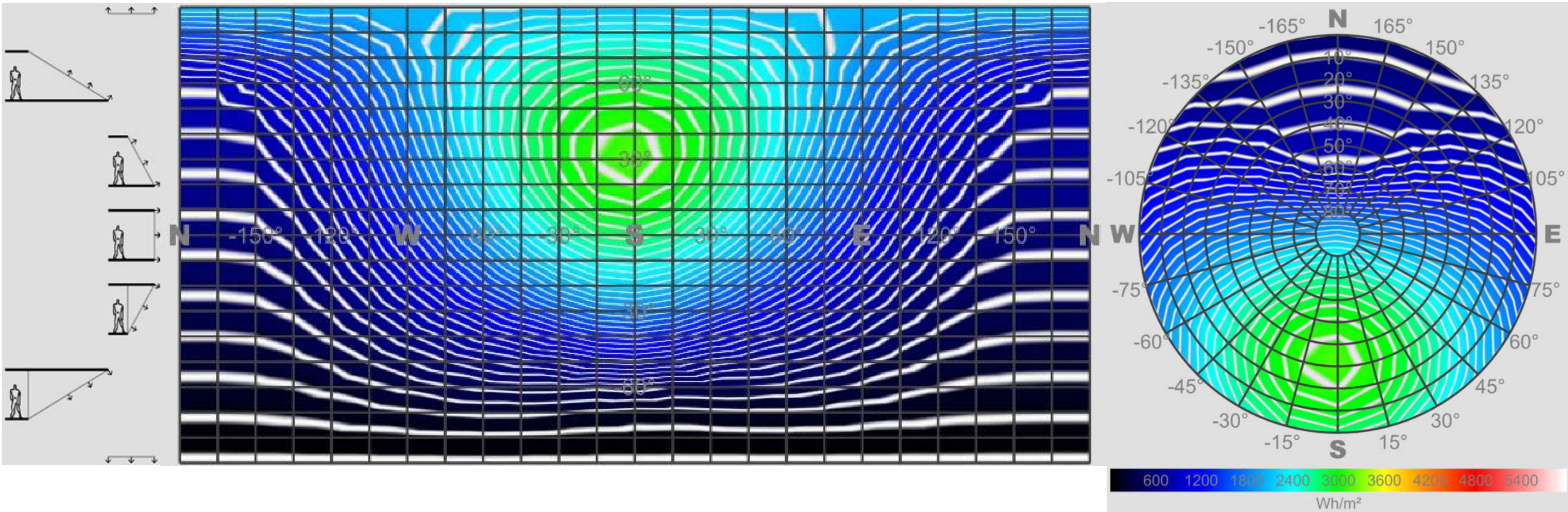
March 21 Global Radiation on different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)



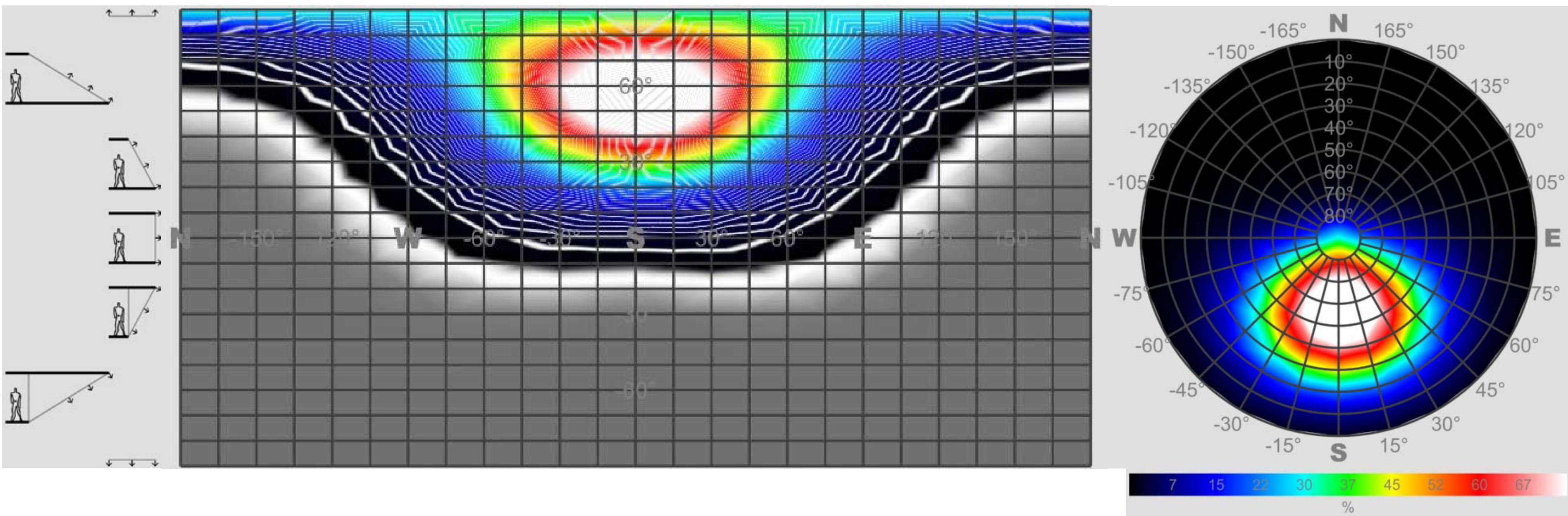
June 21 Global Radiation on different directions and slopes in Montréal– Left: positive and negative slopes, Right: positive slopes (hemisphere)

Above diagram and previous diagrams on the previous page show the amount of total direct and diffuse solar radiation collected by different directions and slopes through different days of the year in Montréal. For instance on December 21, the maximum total radiation is collected by a surface toward the South with 25° slope. On March 21, the maximum total radiation is collected by a surface toward the South with 60° slope; and finally on June 21 this is a horizontal surface which collects maximum solar radiation. It is also worth noting that, as it can be seen in the diagram of June, in summer the amount of solar radiation received with South facade is remarkably lower in comparison with East and West facades.

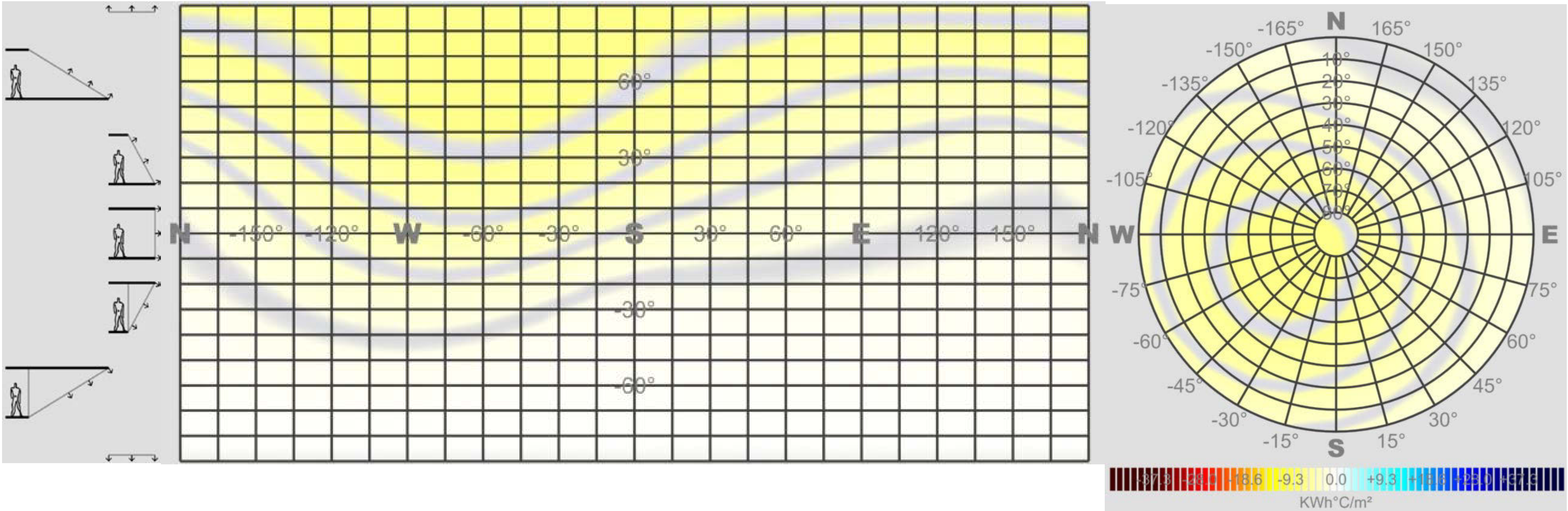
The following diagram of Year-cycle Global Radiation on the next page also shows the amount of total direct and diffuse solar radiation collected by different directions and slopes through all days of the year in Montréal. The maximum total radiation is collected by a surface toward the South with 30° slope; however it is not advisable to use this slope as optimized slope for collectors while the further active performance analysis is required to find out the direction in which the best performance could be achieved throughout all months of the year. As the diagram of “Year-cycle Active Analysis of different directions and slopes in Montréal” which is calculated by SOLARCHVISION illustrates the optimized orientation for collectors and PVs in Montréal is South with slope of 55° with ±15° tolerance in slope and ±20° tolerance in direction: this area is plotted in within a red boundary.



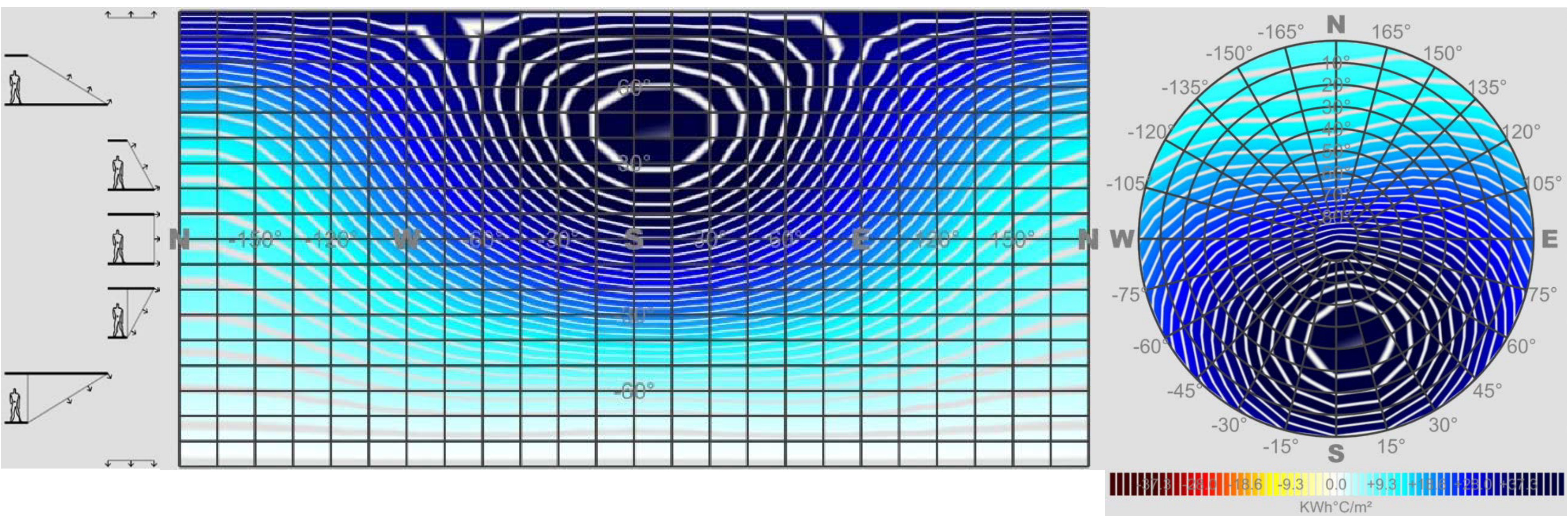
Year-cycle Global Radiation on different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)



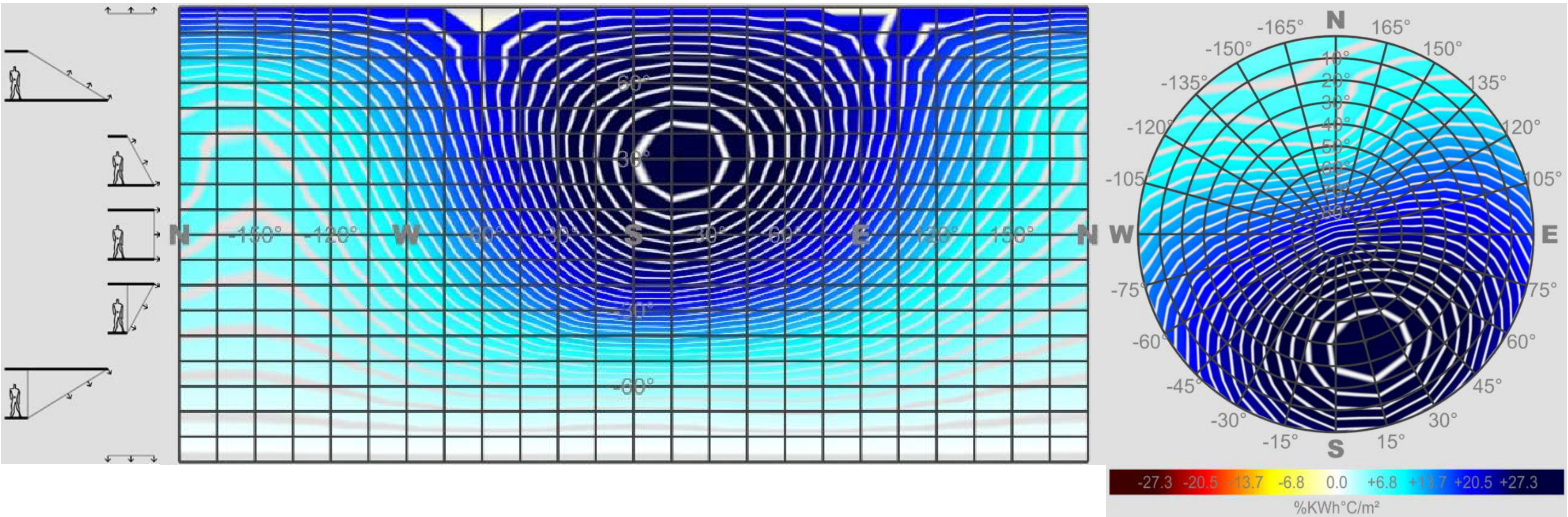
Year-cycle Active Analysis of different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)



Year-cycle Negative Solar Effects of different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)



Year-cycle Positive Solar Effects of different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)

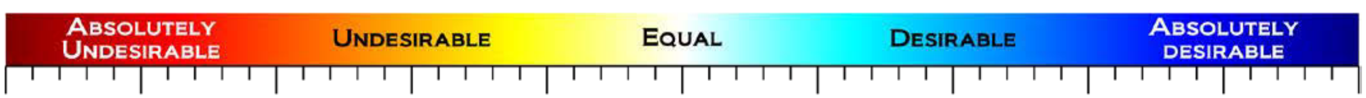


Year-cycle Passive Analysis of different directions and slopes in Montréal – Left: positive and negative slopes, Right: positive slopes (hemisphere)

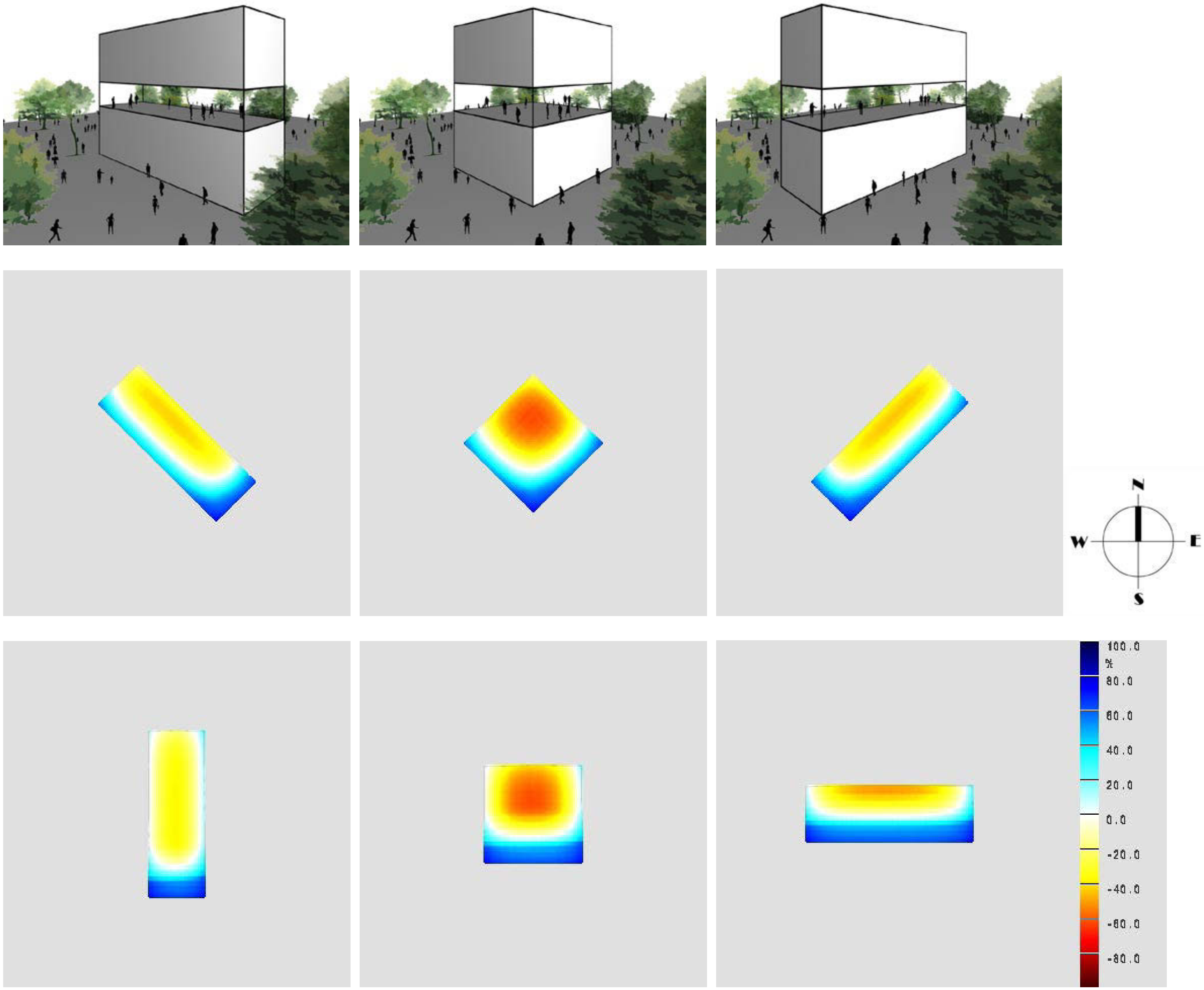
Above diagram and the diagrams on the previous page illustrate the negative, positive and total/percentage effects of the Sun collected by different directions and slopes through all days of the year in Montréal. As the final Year-cycle Passive Analysis shows the most desirable direction to be opened to the Sun is South direction with 15° rotation to East and with 30° slope; however as it can be seen in above diagram, in Montréal, a large variety of directions from East to South and West with different slopes are proper to be opened in regard with an energy-efficient approach in design.

Indoor and Outdoor Solar-Climatic Performance Analysis

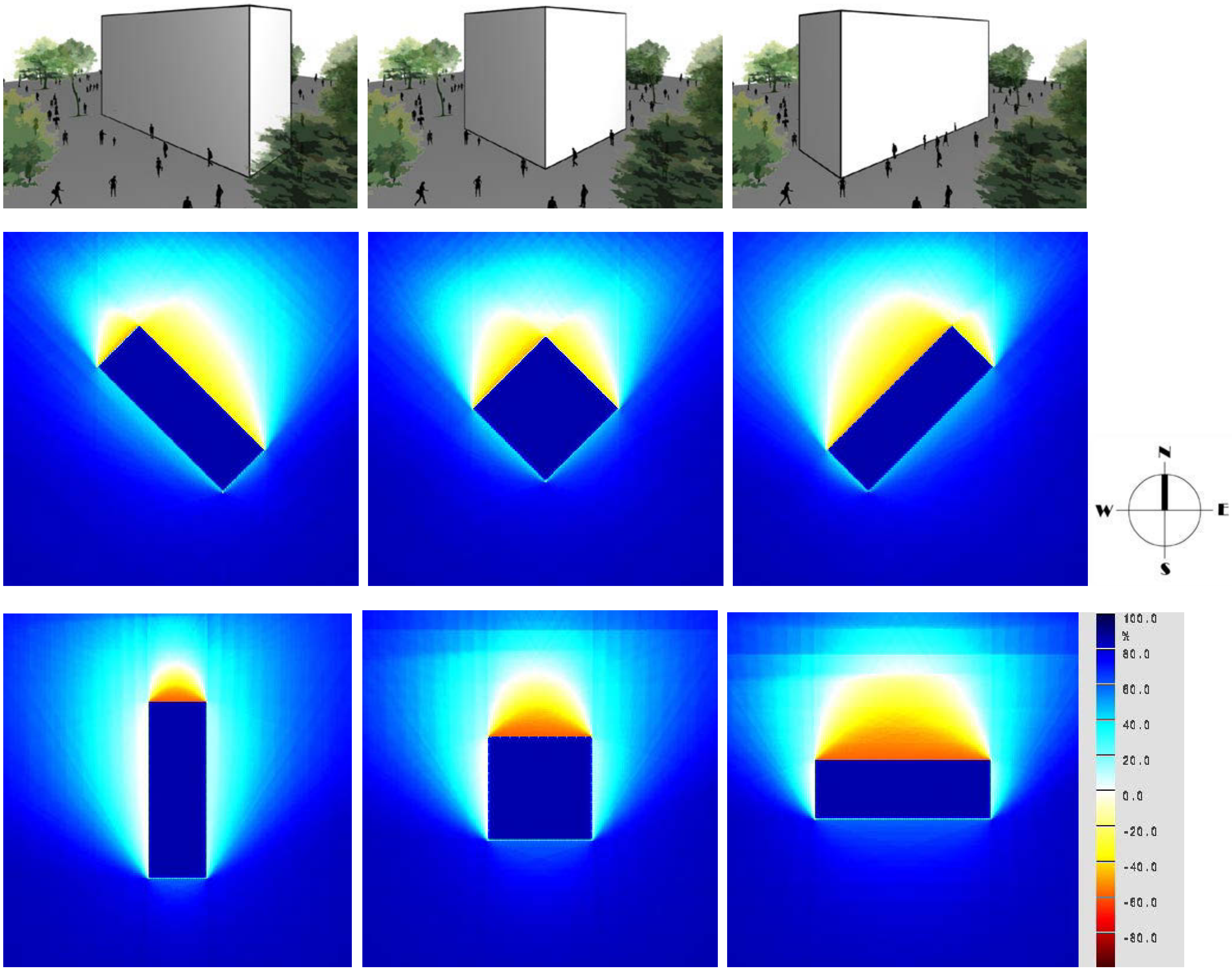
SOLARCHVISION is a computer program which defines a new method in architectural solar analysis. In addition to calculating and mapping solar radiation models, this program brings a brand new vision for discovering the advantages and the disadvantages of design decisions about the kind and unkind faces of the Sun in each location and through any period of time. In this vision, different points of building skin and outdoor areas are analyzed simultaneously to find out the proper or improper solar response of architectural design inside the climate condition.
There are several local parameters which affect the result of this analysis such as Sun path, direct/diffused radiation according to atmospheric factors, changes in outdoor temperature and humidity, building program, the geometry of the building and its surroundings, etc. The factor of wind is not considered in this analysis; however, the overly of CFD analysis with SOLARCHVISION analysis is possible.



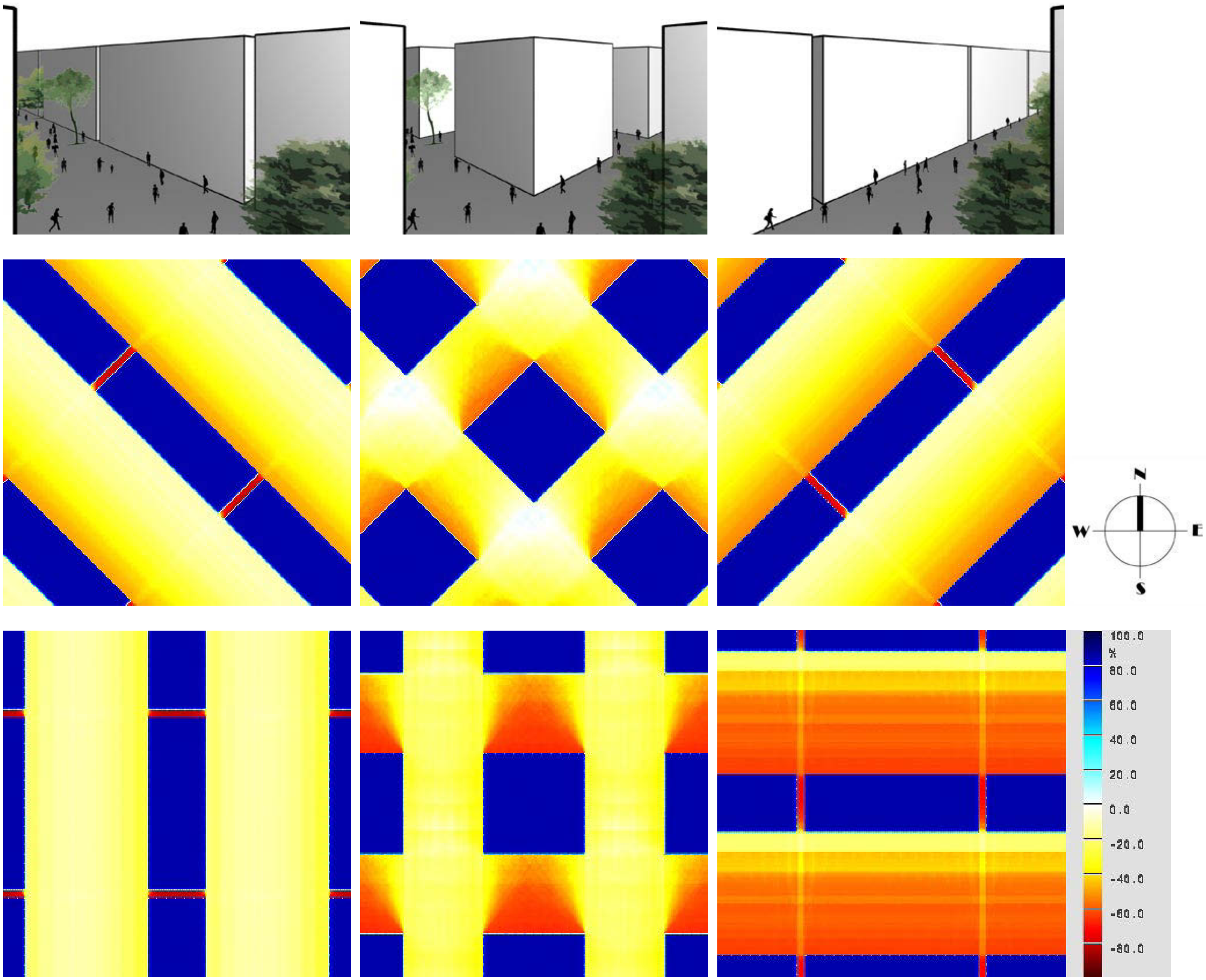
In SOLARCHVISION solar-climatic performance analysis the points are rated from red in the most undesirable situation to blue in the most desirable situation, while the middle values are displayed in colours such as yellow and cyan. It is worth noting that red does not mean as hot and blue does not mean as cold! Red, in winter and summer, presents a poor solar-climatic design performance while blue, in winter and summer, presents a proper solar-climatic design performance.



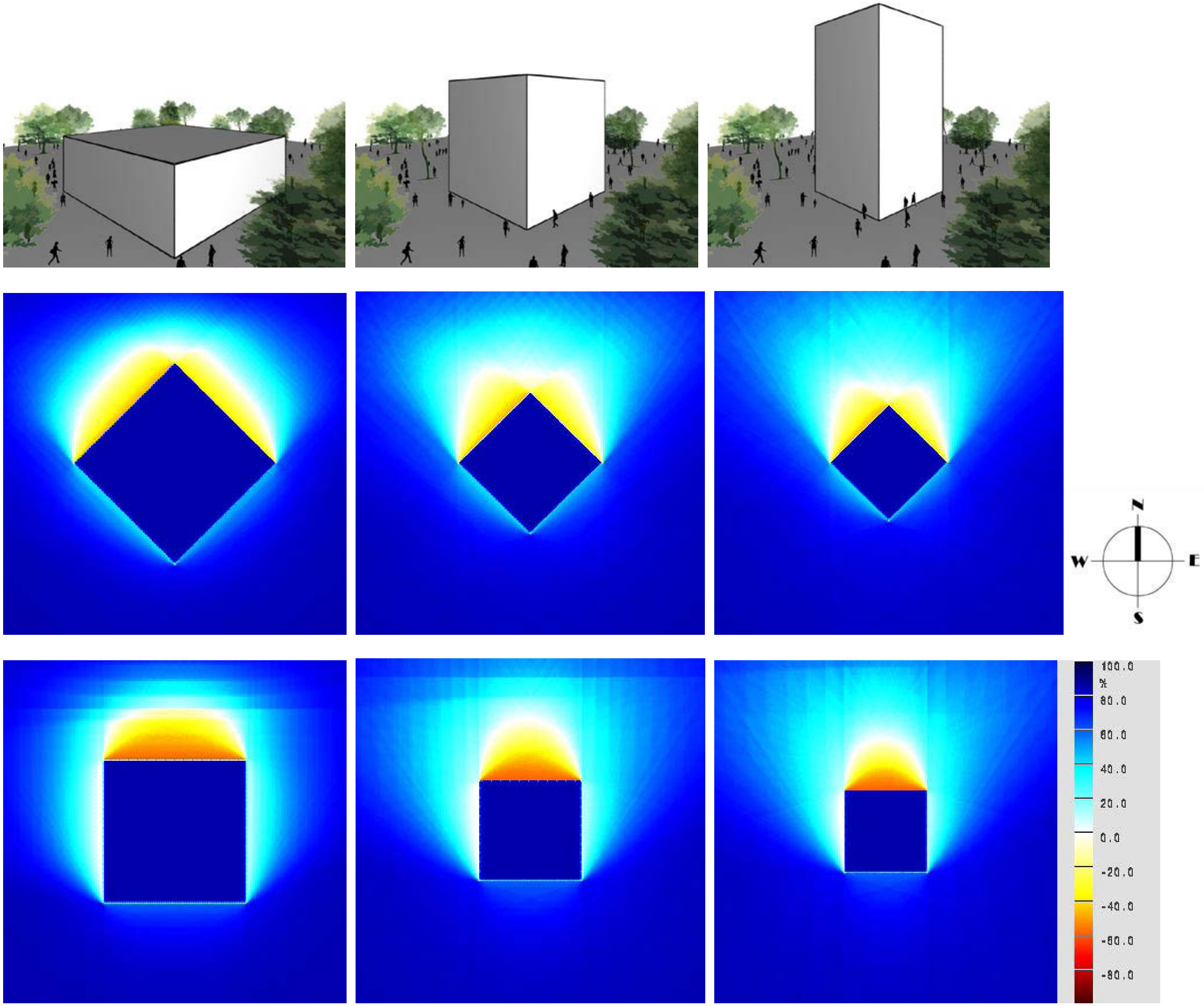
Indoor solar-climatic performance for different orientations and proportions in Montréal



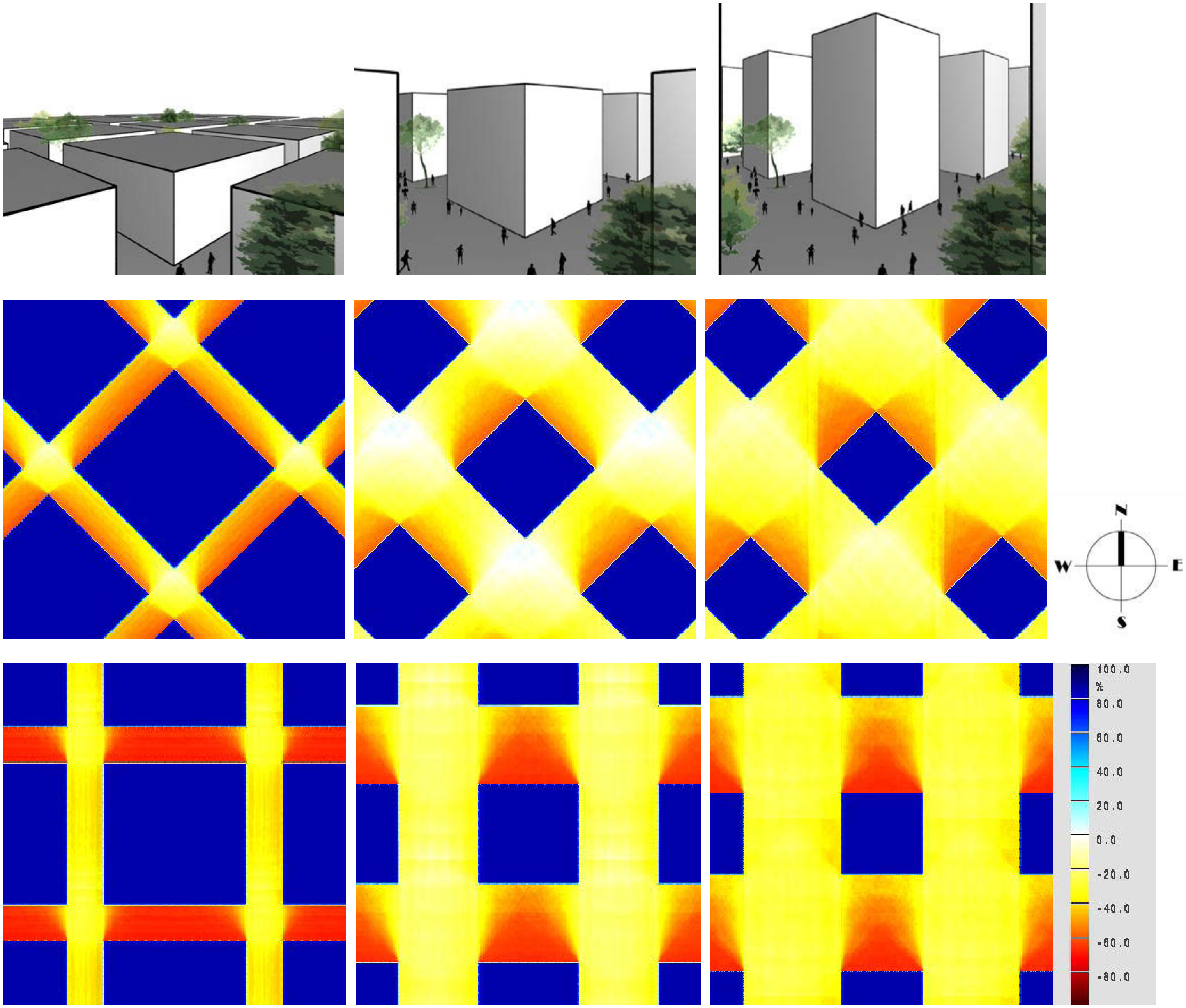
Outdoor solar-climatic performance for different orientations and proportions for a single building in Montréal – the negative effect of a narrow building oriented to the South on the urban fabric s remarkable as it blocks almost all direct solar radiation in winter.



Outdoor solar-climatic performance for different orientations and proportions for multiple buildings in Montréal

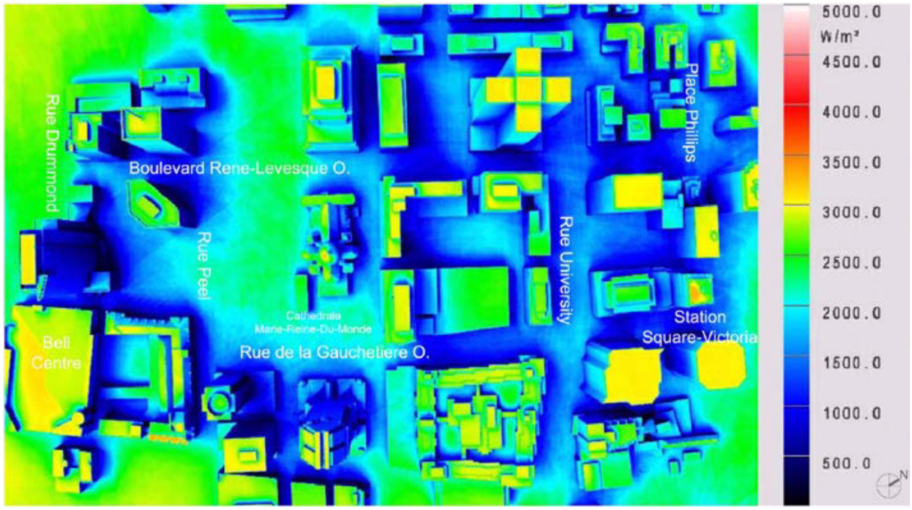


Outdoor solar-climatic performance for different orientations and proportions for a single building in Montréal – with changes in height



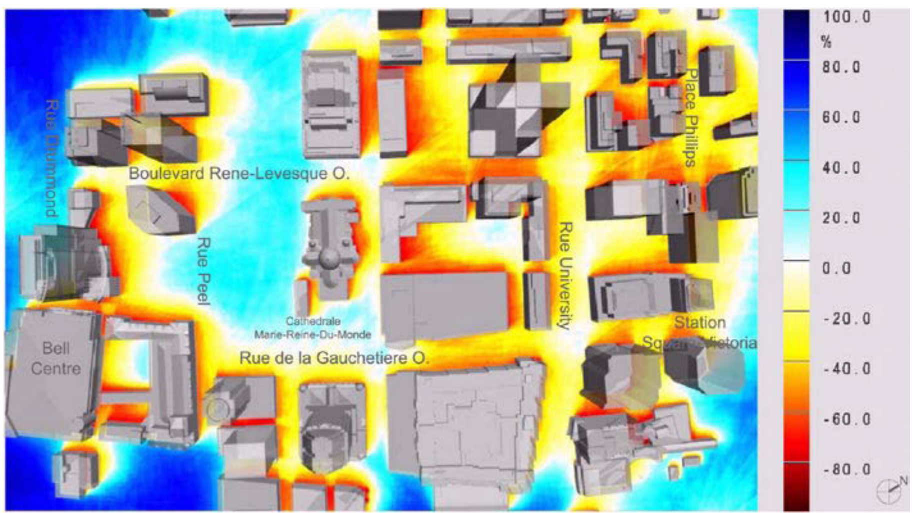
Outdoor solar-climatic performance for different orientations and proportions for multiple buildings in Montréal – with changes in height

From Bell Centre to Square Victoria



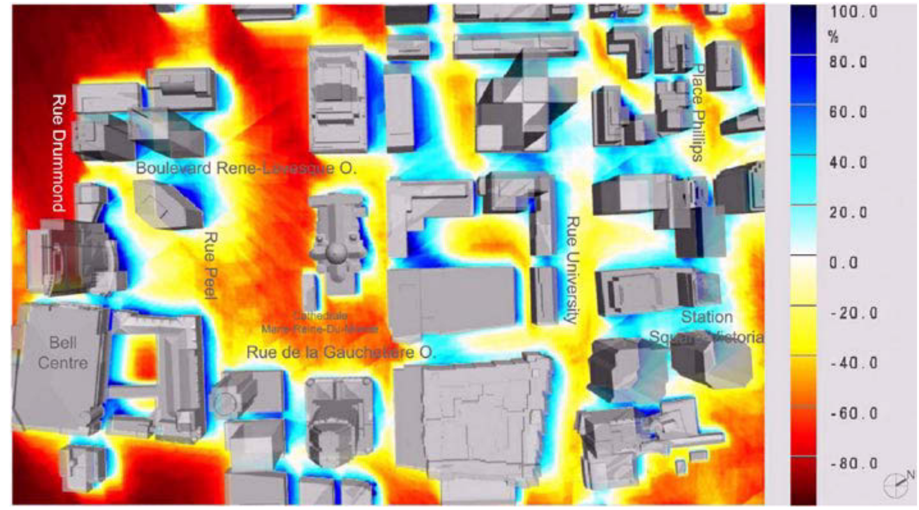
Year-cycle Radiation Model of Montréal Downtown

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during a year-cycle.



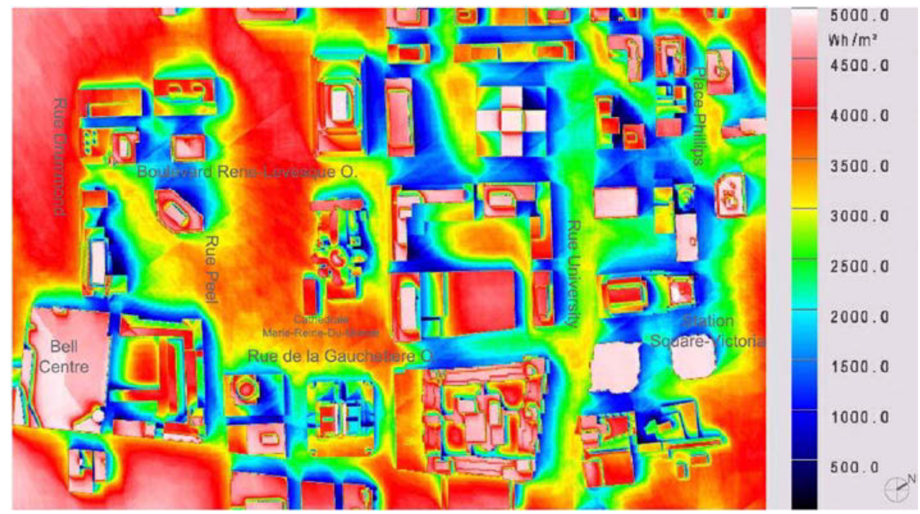
Year-cycle SOLARCHVISION Comfort Model of Montréal Downtown

This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during a year-cycle.



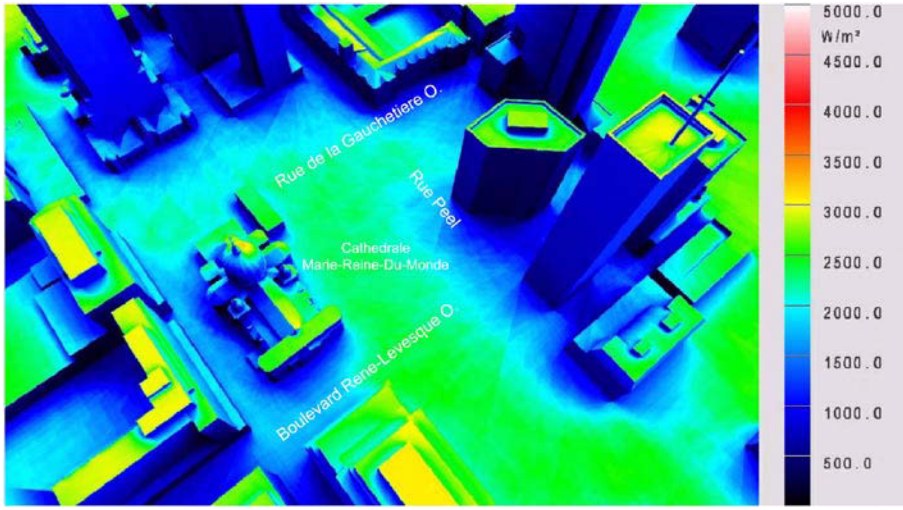
Summer SOLARCHVISION Comfort Model of Montréal Downtown

This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during summer (Cooling period).



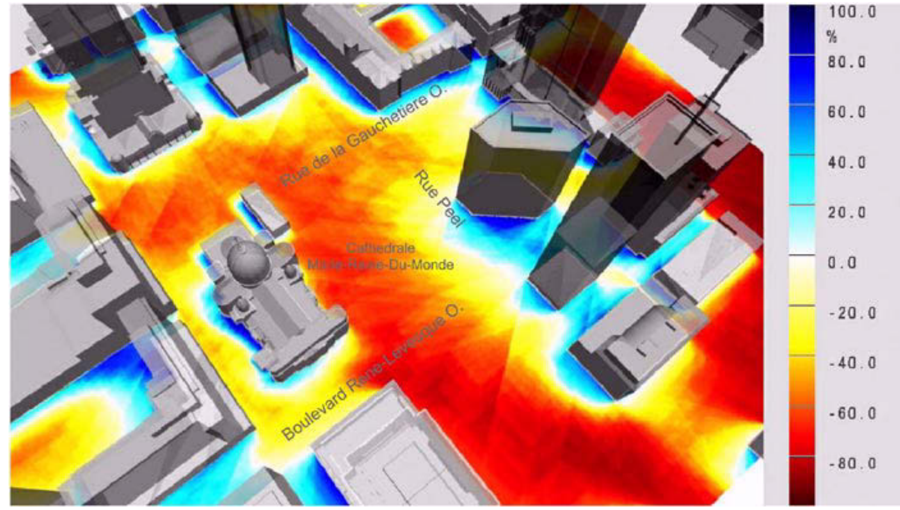
Summer Radiation Model of Montréal Downtown

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during summer (Cooling period).



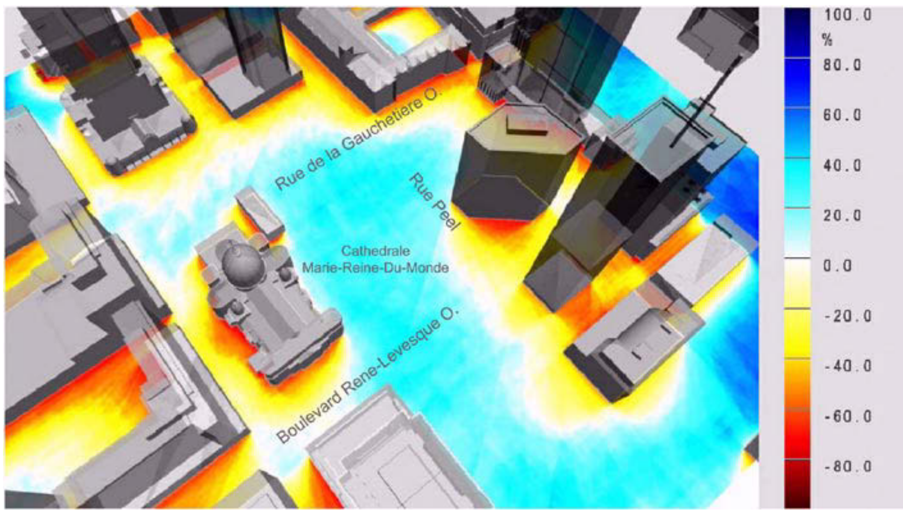
Year-cycle Radiation Model of Montréal Downtown – Square Dorchester & Parc de la place du Canada

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during a year-cycle.



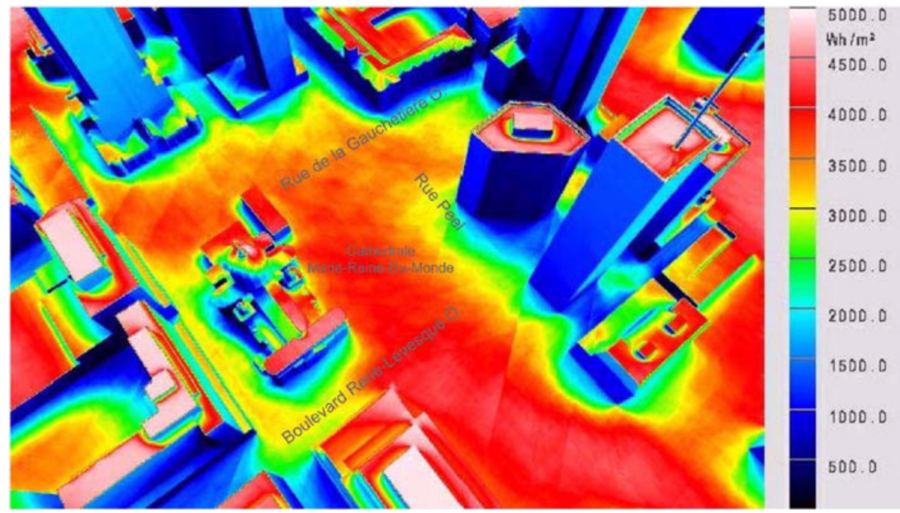
Summer SOLARCHVISION Comfort Model of Montréal Downtown – Square Dorchester & Parc de la place du Canada

This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during summer (Cooling period).



Year-cycle SOLARCHVISION Comfort Model of Montréal Downtown – Square Dorchester & Parc de la place du Canada

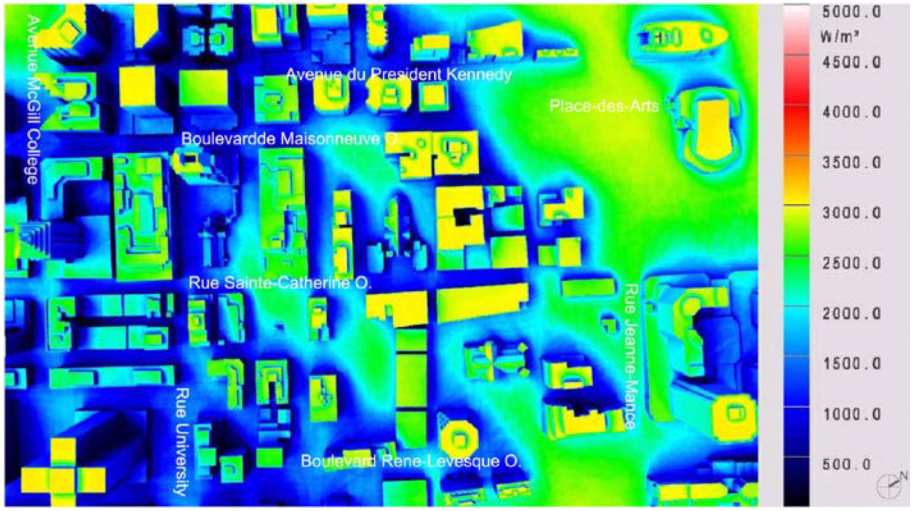
This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during a year-cycle.



Summer Radiation Model of Montréal Downtown – Square Dorchester & Parc de la place du Canada

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during summer (Cooling period).

From McGill Street to Place-des-Arts

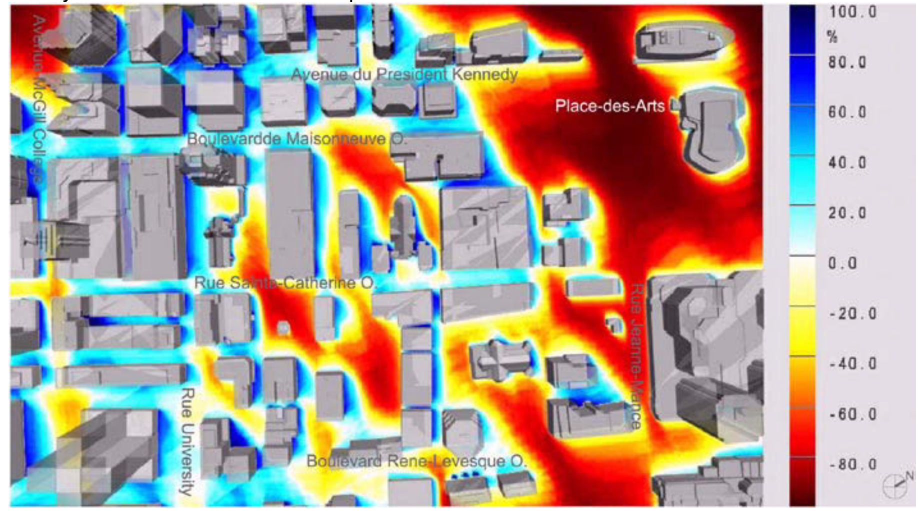


Year-cycle Radiation Model of Montréal Downtown

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during a year-cycle.

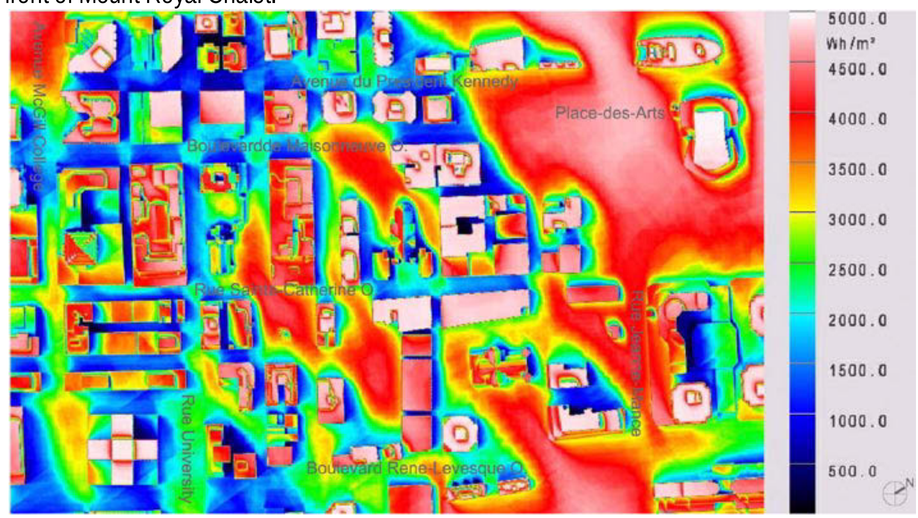
Year-cycle SOLARCHVISION Comfort Model of Montréal Downtown

This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during a year-cycle. It is worth noting that if the building blocks in the urban fabric of Montréal were oriented toward true South like what we see at Toronto, there would be more undesirable spaces created notably between paths in East-West directions. Therefore the general orientation of Montréal urban fabric grid is remarkably intelligent in regard to the sun and climate. On the other side as we see the narrow buildings create more undesirable effects on urban fabric in comparison with tall buildings; thus, it is advisable to install optimized reflectors at top end of these buildings to reflect solar radiation from the sky and their roof to the urban space.

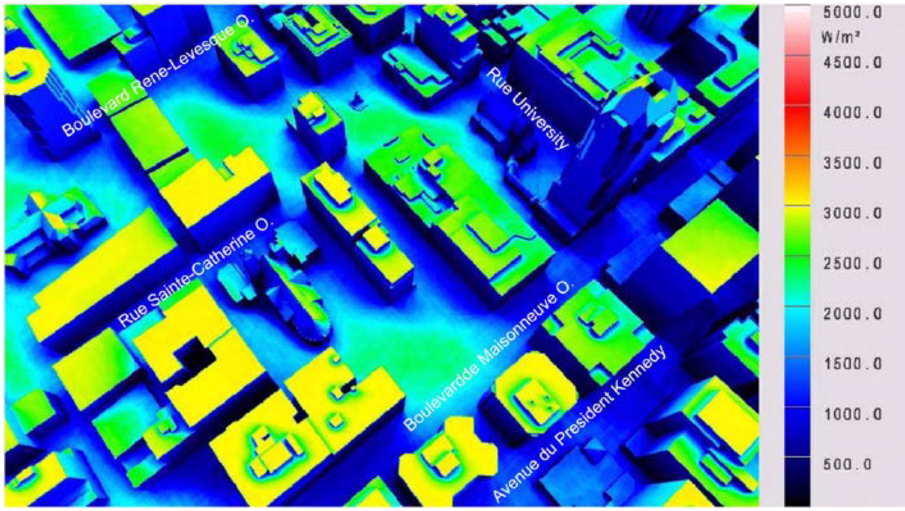


Summer SOLARCHVISION Comfort Model of Montréal Downtown

This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during summer (Cooling period). As that the solar-climatic performance of Place-des-Arts is not impressive, it is advisable to use tensile membrane structures there which can both produce shade in summer and protect against rain and snow in the other seasons as we discuss later about the public space in front of Mount Royal Chalet.

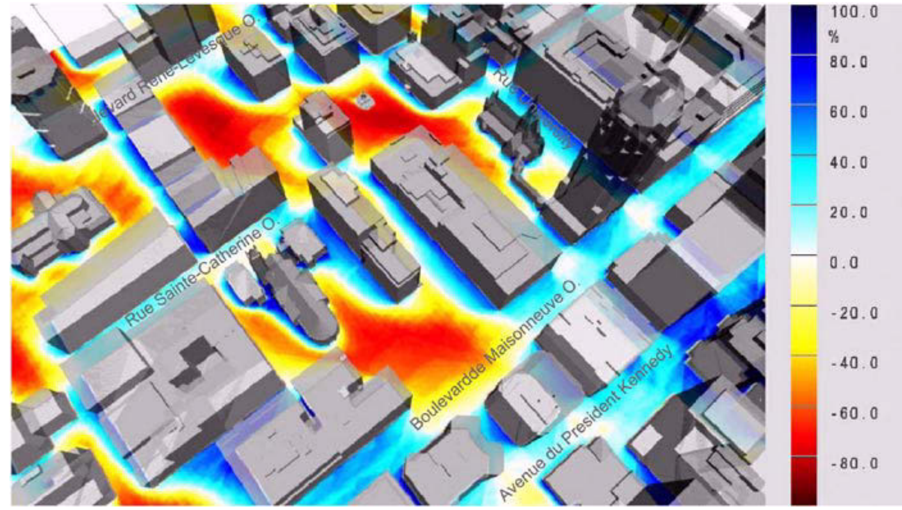


Summer Radiation Model of Montréal Downtown – from McGill Street to Place-des-Arts



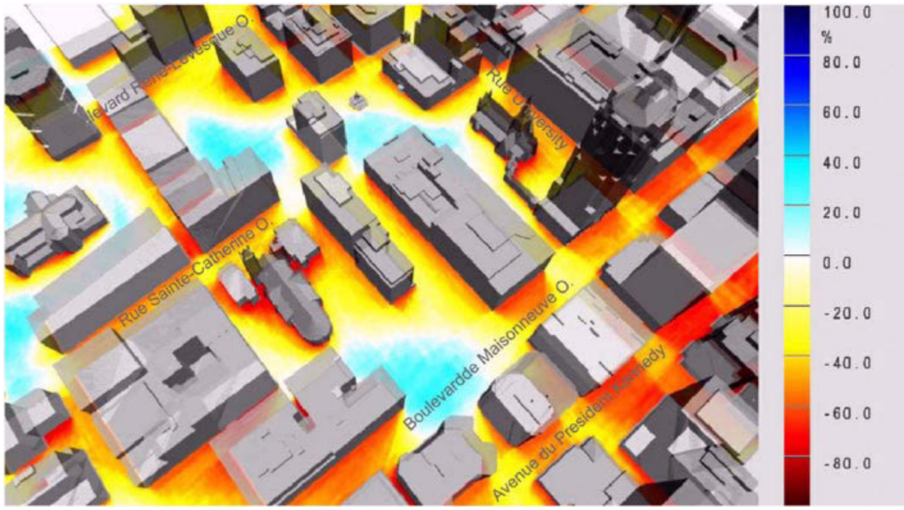
Year-cycle SOLARCHVISION Comfort Model of Montréal Downtown – between Blvd. Rene-Levesque & Blvd. Maisonneuve

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during a year-cycle.



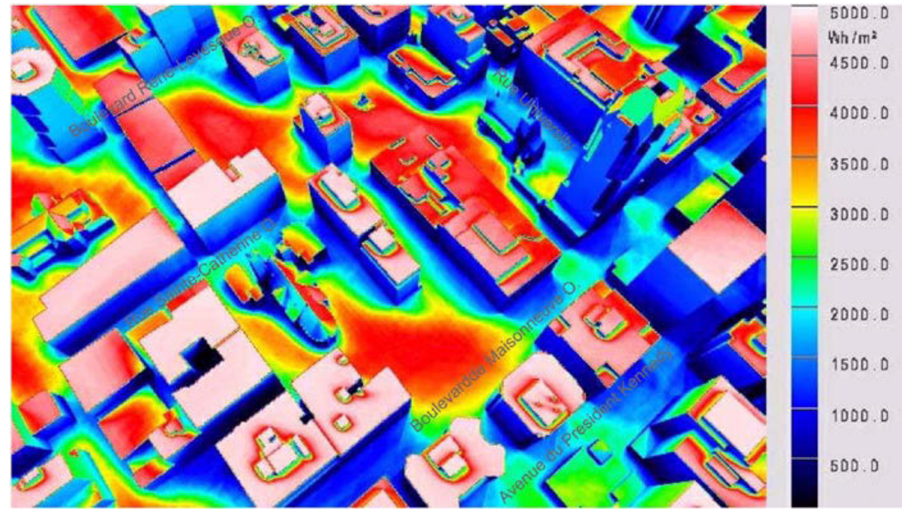
Summer SOLARCHVISION Comfort Model of Montréal Downtown – between Blvd. Rene-Levesque & Blvd. Maisonneuve

This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during summer (Cooling period).



Year-cycle SOLARCHVISION Comfort Model of Montréal Downtown – between Blvd. Rene-Levesque & Blvd. Maisonneuve

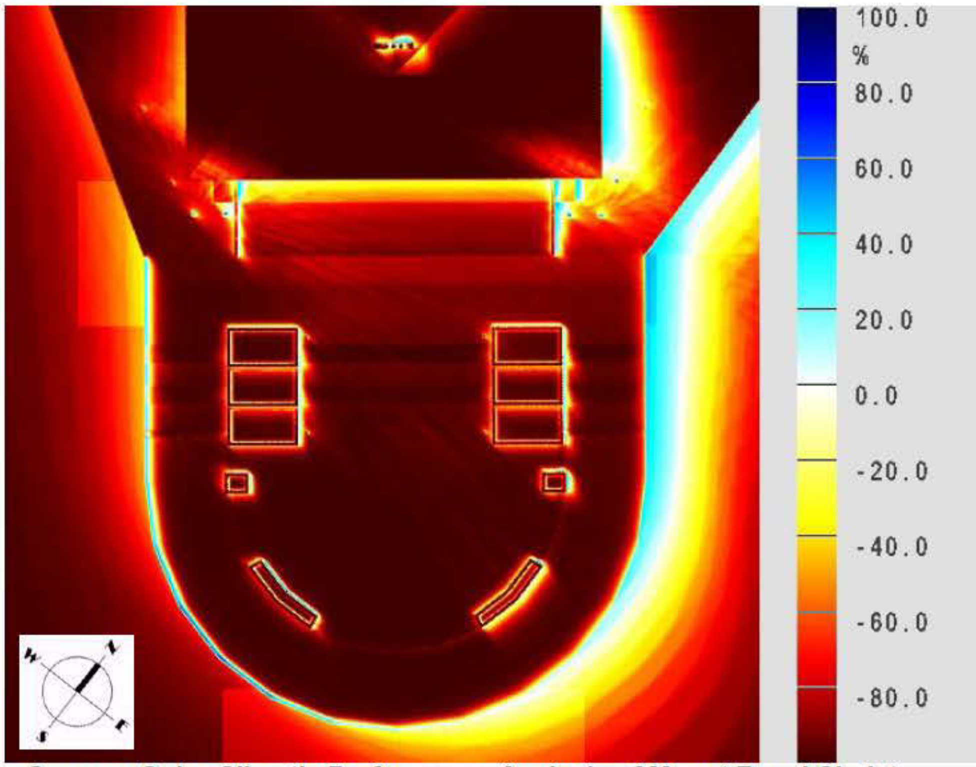
This analysis discovers the points with high and low solar-climatic performance analysis of Montréal downtown during a year-cycle.



Summer Radiation Model of Montréal Downtown – between Blvd. Rene-Levesque & Blvd. Maisonneuve

This analysis discovers the maximum and minimum values of solar radiation in Montréal downtown during summer (Cooling period).

Mount Royal Chalet (Kondiaronk Belvedere)



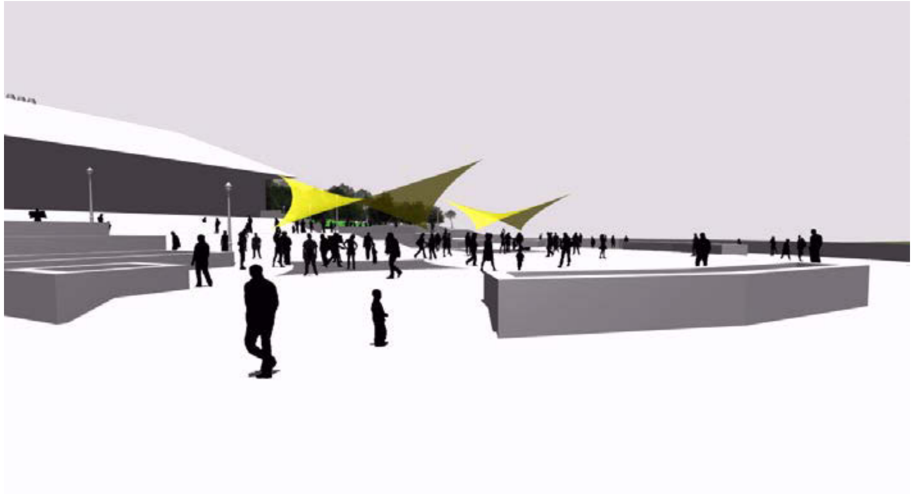
Summer Solar-Climatic Performance Analysis of Mount Royal Chalet

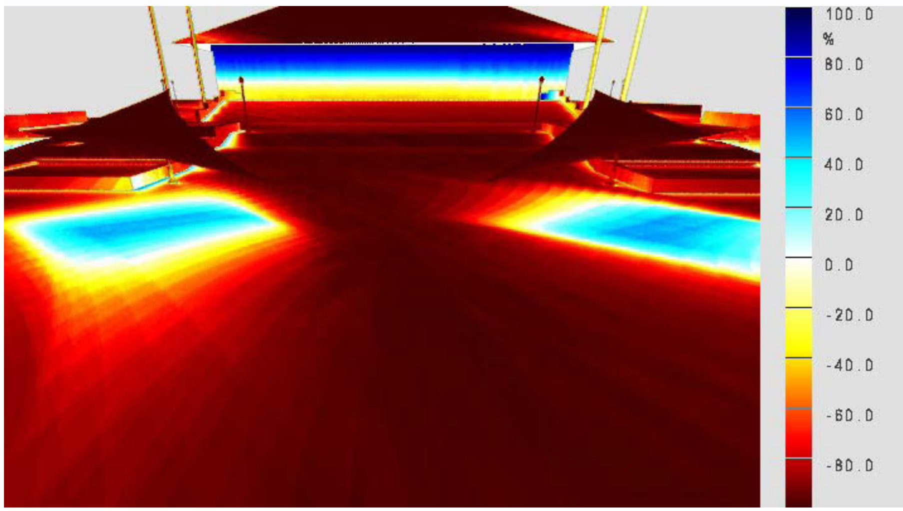
Above diagram illustrate low solar-climatic performance of this important part of the city of Montréal during summer (cooling period). As the visitors walk and climb to reach this fantastic view to the city, in summer there is almost no place to rest and enjoy more in shade. Even in a rainy or snowy day there is no in-between space in this plaza.

General view to the city of Montréal from Mount Royal Chalet

Two slightly different alternatives have been developed for improvement of the solar-climatic performance of this place with minimum effect on the perspectives toward the city as well as the Mount Royal Chalet. These alternatives are presented in the following pages as some samples of what kind of integrated design which can happen here in the future.

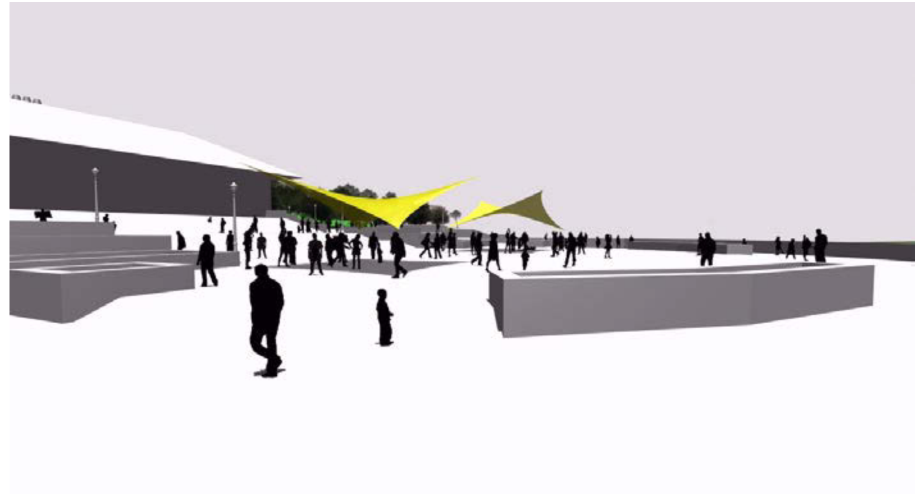
1st Alternative – Tensile membrane structures with high points toward the city and the building

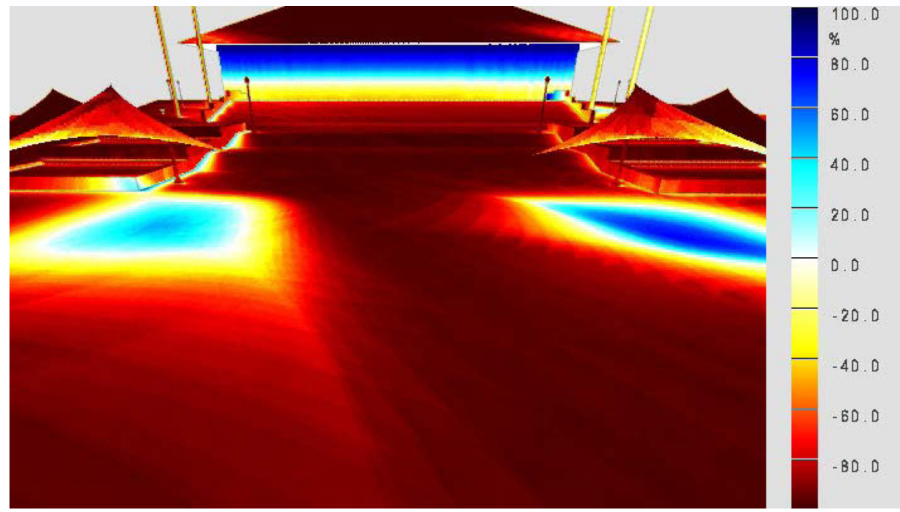




Summer Solar-Climatic Performance Analysis

2nd Alternative–rotated CW and CCW from 1st Alternative





Summer Solar-Climatic Performance Analysis

1st Alternative – General view to the Mount Royal Chalet

1st Alternative – General view to the city of Montréal from Mount Royal Chalet

2nd Alternative – General view to the Mount Royal Chalet

2nd Alternative – General view to the city of Montréal from Mount Royal Chalet

Fontaine School at Nuns' Island (OCPM open project)

Last case study of this report is about the solar-climatic analysis of one of the open project of OCPM: Fontaine primary school which is designed to be built in Nuns' Island.
The comparison of the analysis of this building in current orientation as well as other possible orientation in the triangular site show how much quality we can add to the building envelope, building skin, classes as well as playgrounds by just rotating the building!
Whether at this stage of the project a simple conceptual change like this would not be simple or because of some other technical reasons (e.g. being close to a canal at one corner of the site); it could be a good sample of what OCPM may consider in its further projects as one of the main goals of planning cities and building is to provide health, comfort and safety for people.

Orientation #1 – site plan

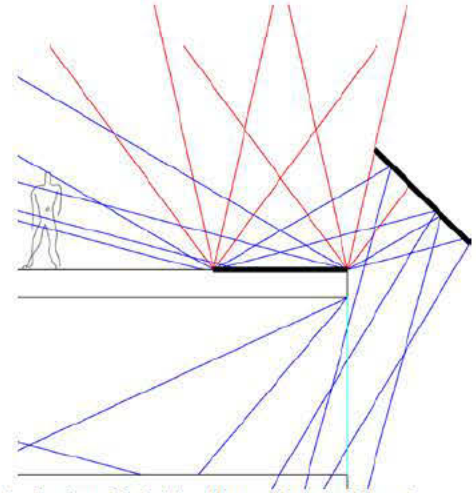
Above diagram shows the current orientation of the Fontaine School.
The following analysis on the next pages shows solar-climatic performance of the building in this orientation. Locating the playground in the East side of the site is a good idea to receive the rays of the Sun in cold mornings of Montréal; however the building would create some undesirable shades after 12:00 during the year. On the other side both East and West directions of the building receives notable solar radiation but during the coldest months of the year they do not collect the most part of direct radiation. According to the diagrams which are presented at the end of this report controlling the daylight for the directions of East and West is more complex in comparison with controlling the daylight for the directions of South and North. Considering these facts and in order to create slightly comfortable interiors and exteriors in this project, another alternative is presented on the next page which is the rotated mirror of this nice design.

Current First Floor Plan

Orientation #2 – site plan

Above diagram shows the second choice for orientation of the Fontaine School.

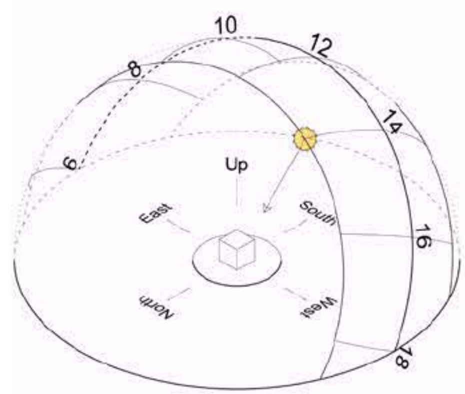
The following analysis on the next pages shows a certain increase in energy-efficiency performance of this building in comparison with the current layout. On the other side the play ground of the school would have a better condition as it creates no shades during cold winters of Montréal. Position and orientation of external vertical shading devices which are designed for the gym would be also perfect for this orientation as they block the North-West rays of the Sun in summer. They also allow the South-West rays of the Sun in winter to reach the building skin. To improve the solar-climatic performance of this building in this case it is advisable to design and install a tilted reflector at the Northern edge of this building to reflect valuable rays of the Sun into the North rooms and produce more daylight.



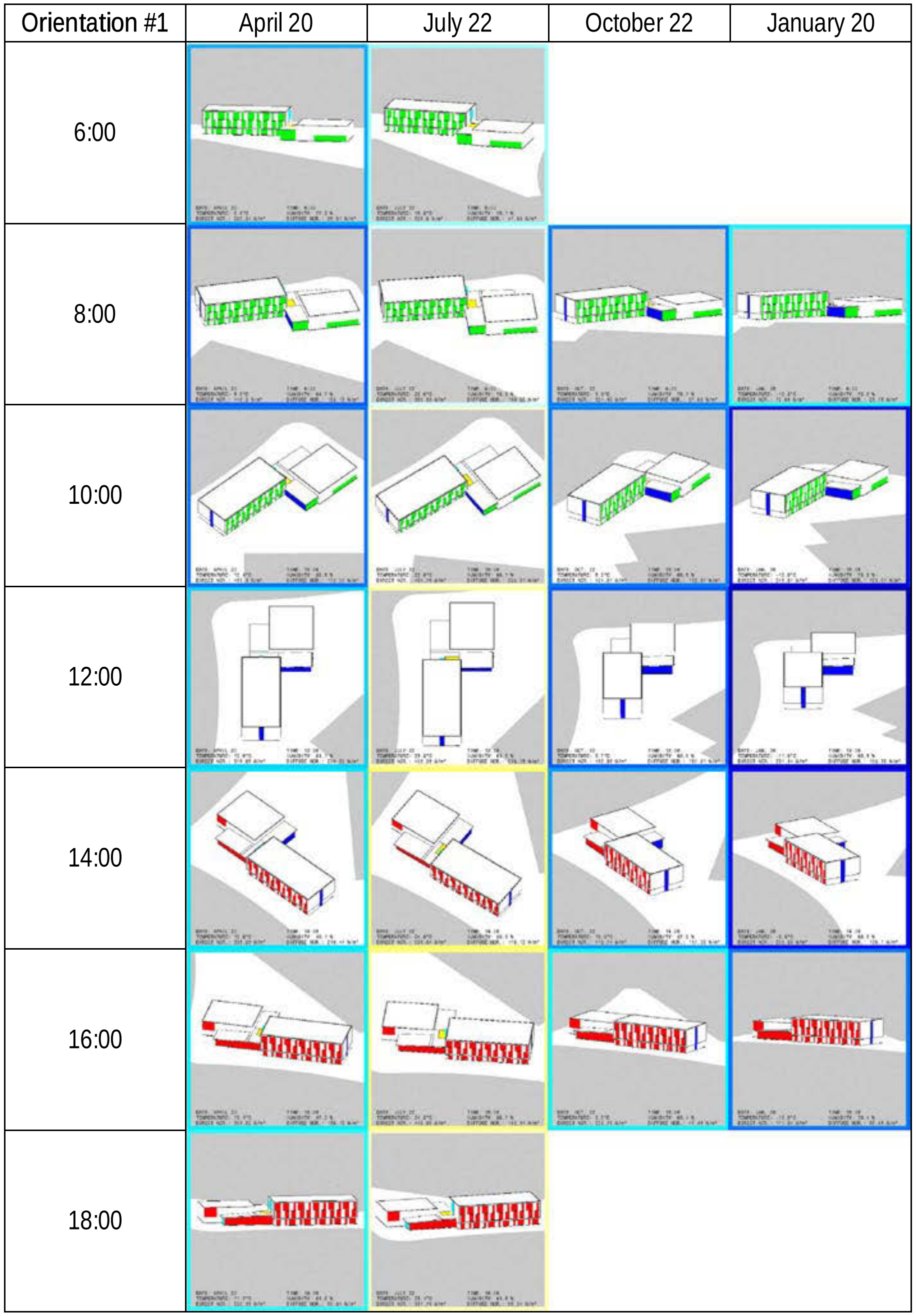
Optimized Reflectors can help to bring light to the other side of buildings (useful for North-side, East-side and West-side directions)

The following tables present different perspectives at which the sun observe these two alternatives in different hours of the day through each month. The color of rectangular boundary of each perspective illustrates the solar positive and negative effects at each hour. On the other side the glazing surfaces at each direction are painted as follow: North: Cyan, South; Blue, East: Green, West: Red. Such studies are extremely usefull to determine whether the form of building, reflectors and shading devices work correctly or not.

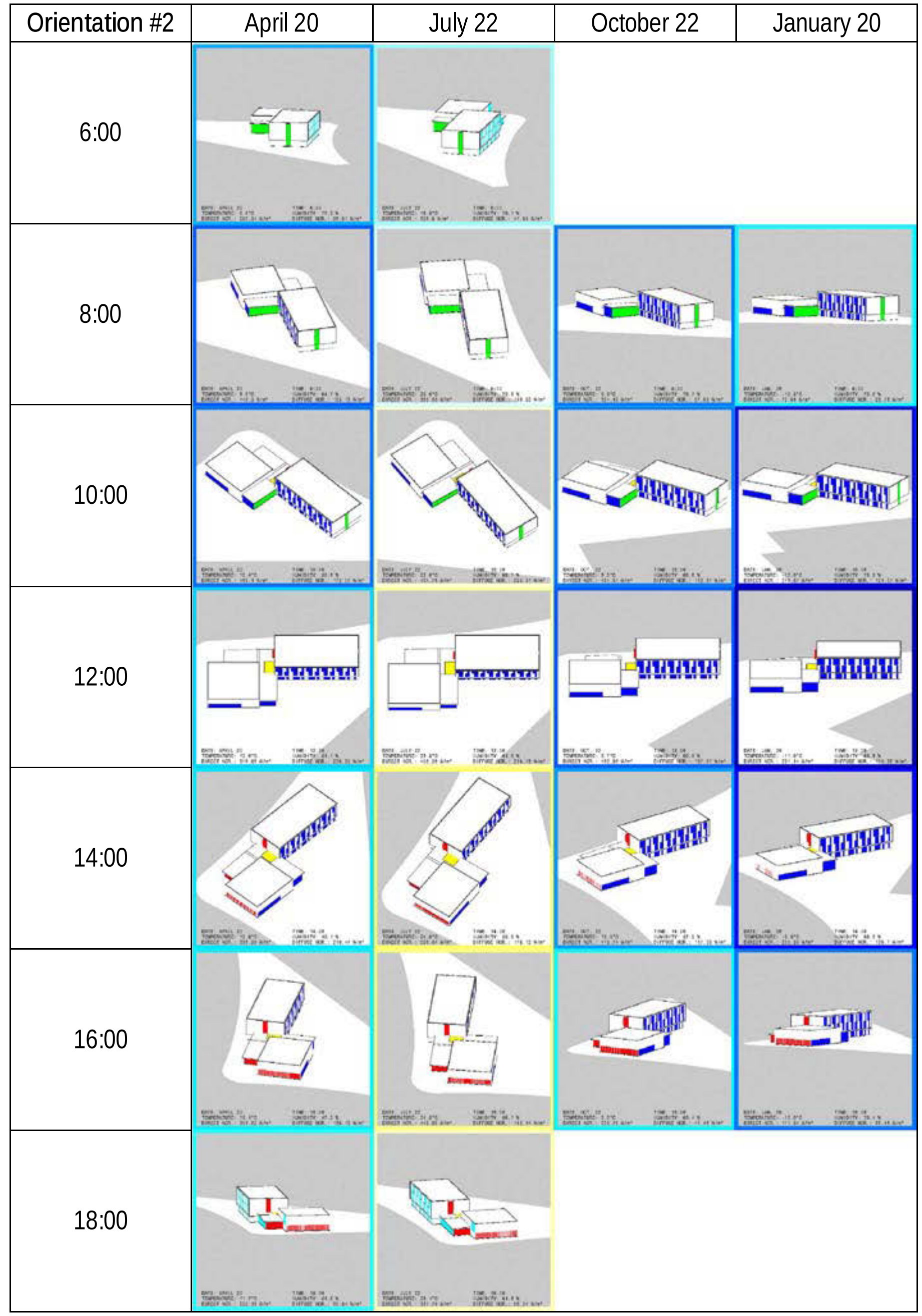
"I suppose if we ever knew exactly where the light was coming from, getting there would be easy" [7]



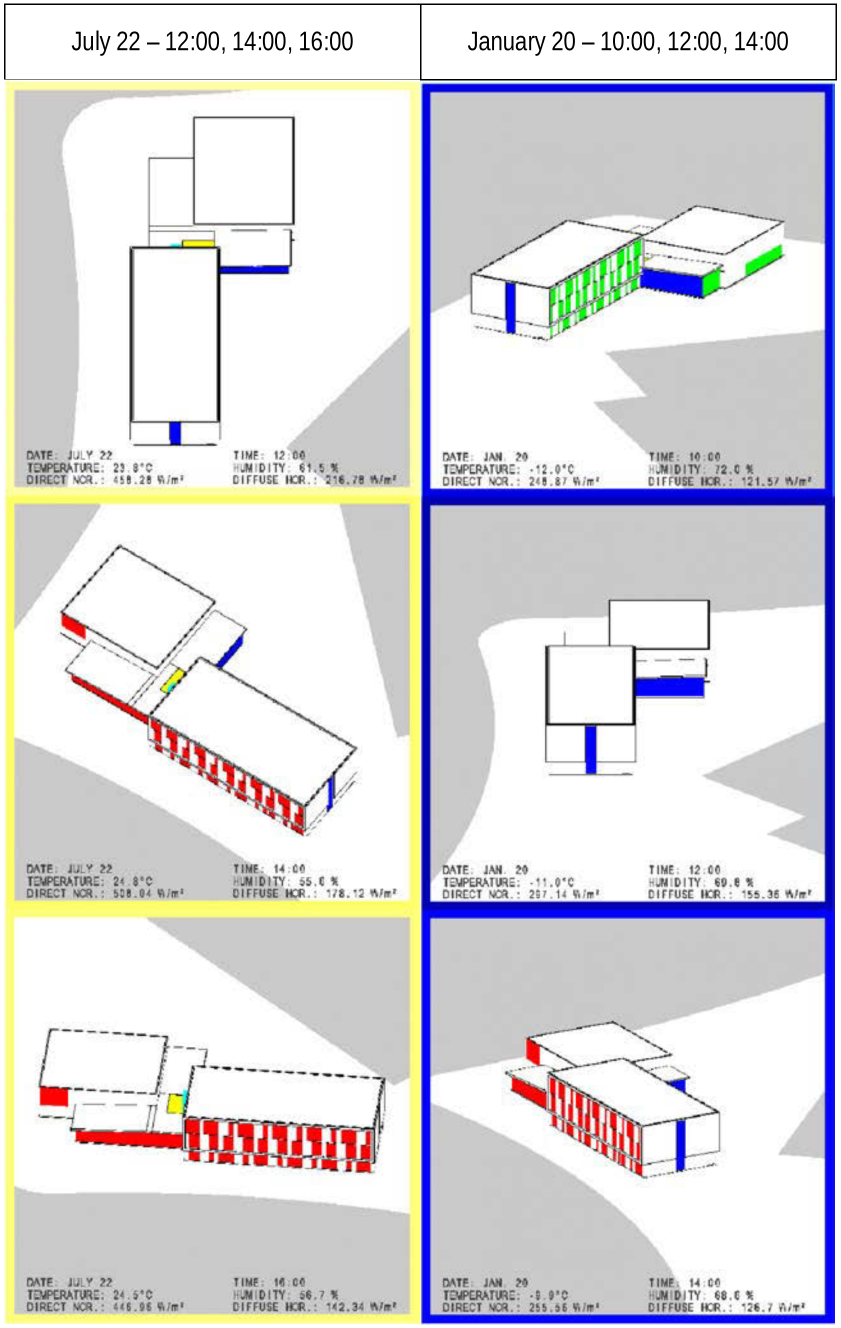
[7] Brian May, Back to the Light, 1993



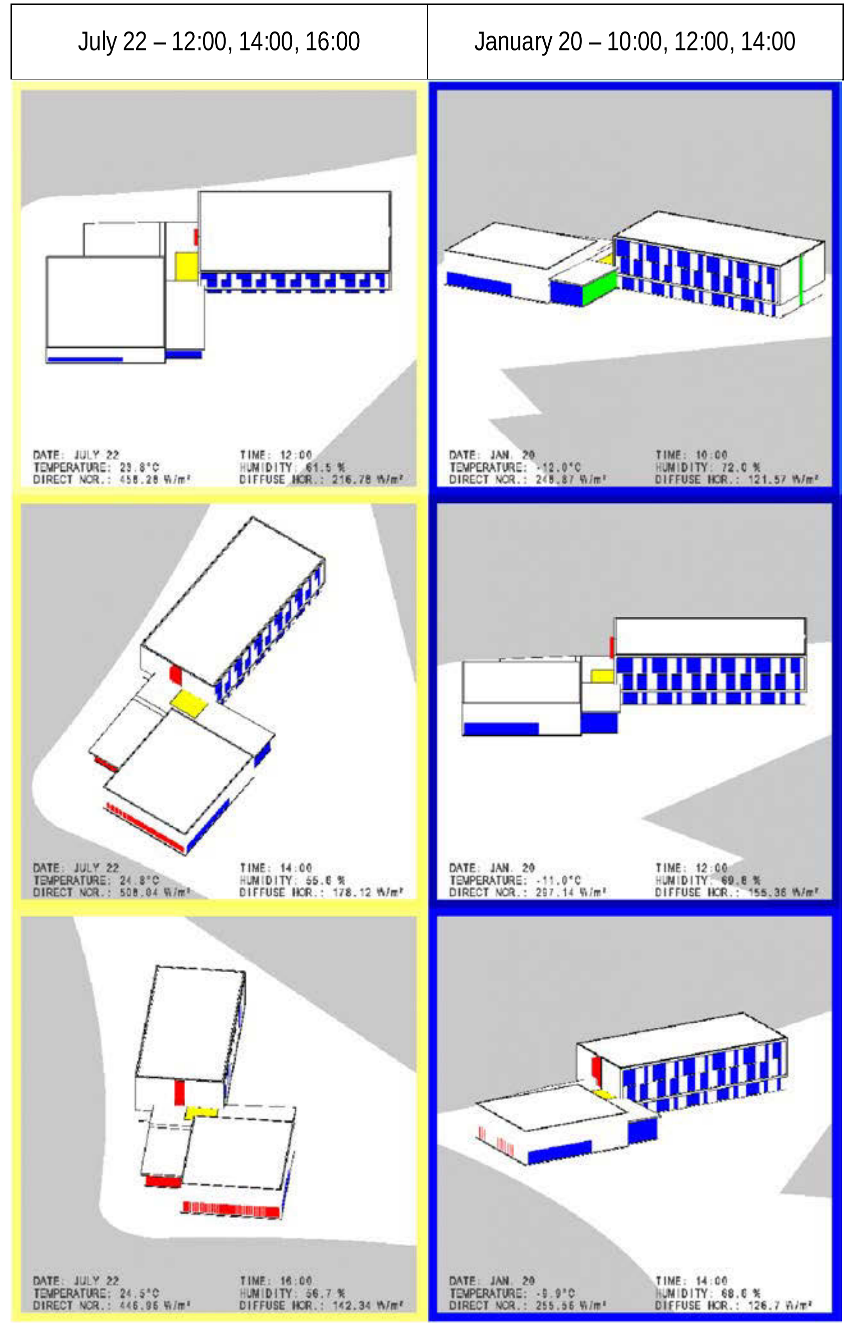
Orientation #1 - Perspectives from the Sun in different times of the year



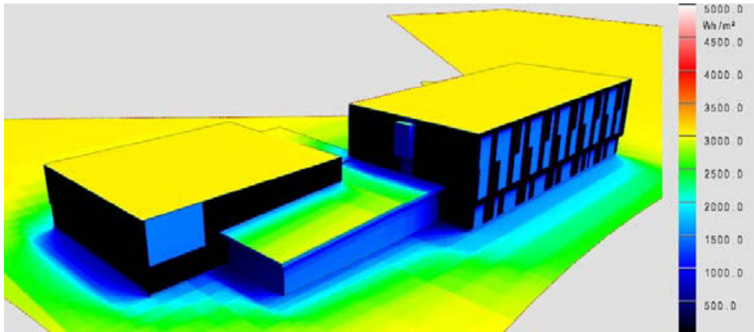
Orientation #2 - Perspectives from the Sun in different times of the year

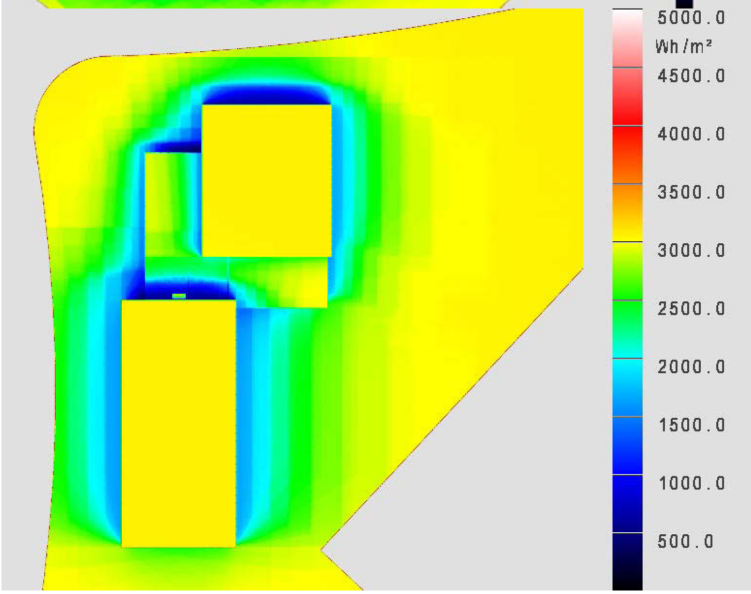


Orientation #1 –Perspectives from the Sun in critical times of the year

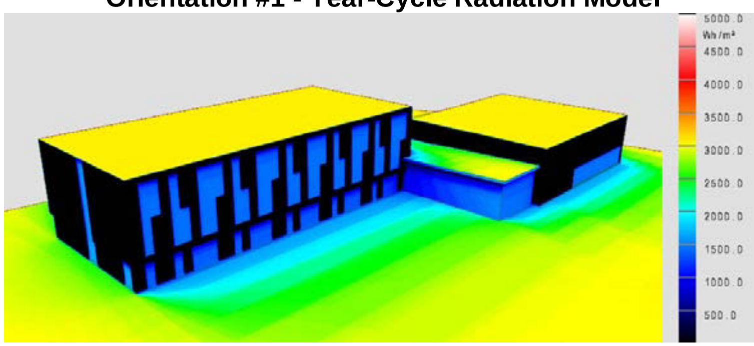


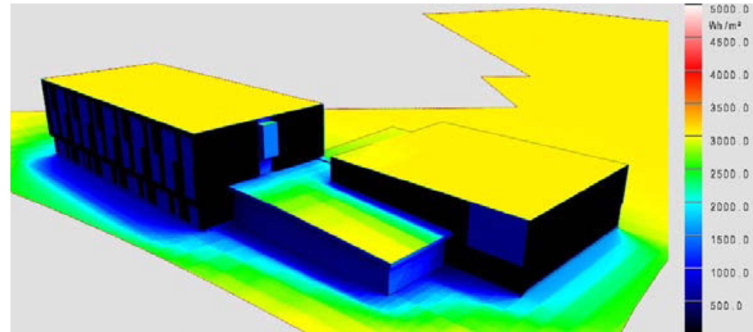
Orientation #2 –Perspectives from the Sun in critical times of the year

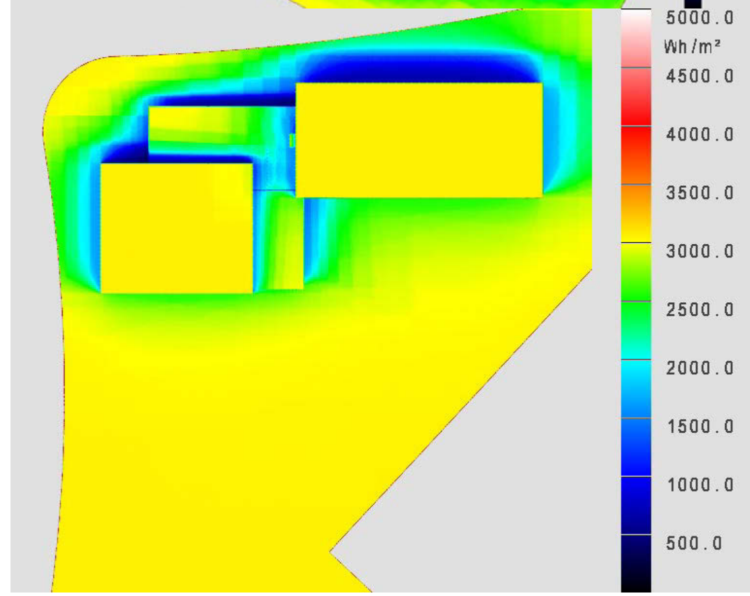




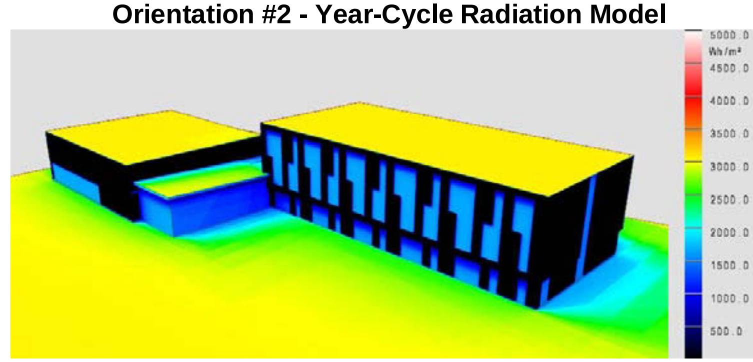
Orientation #1 - Year-Cycle Radiation Model

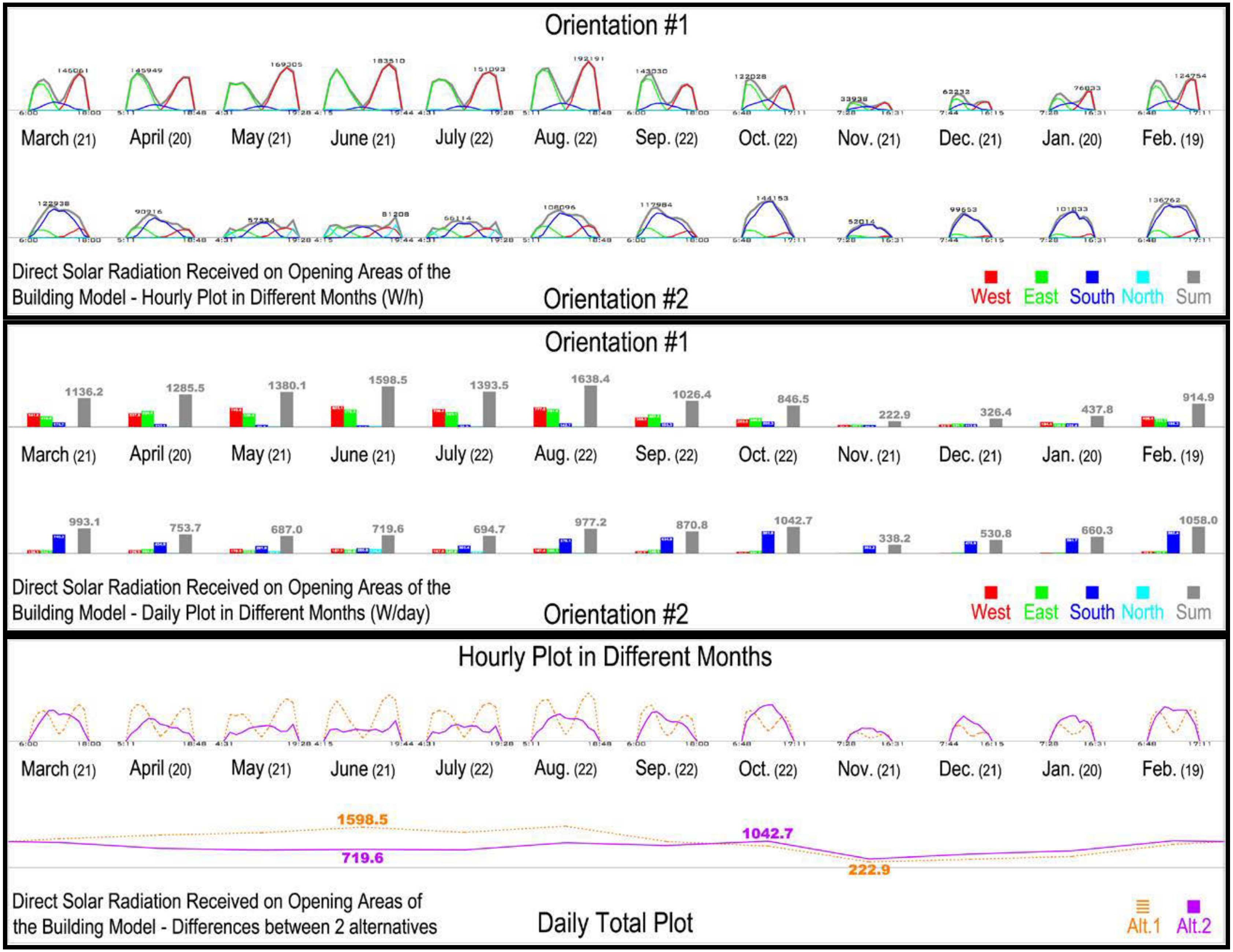


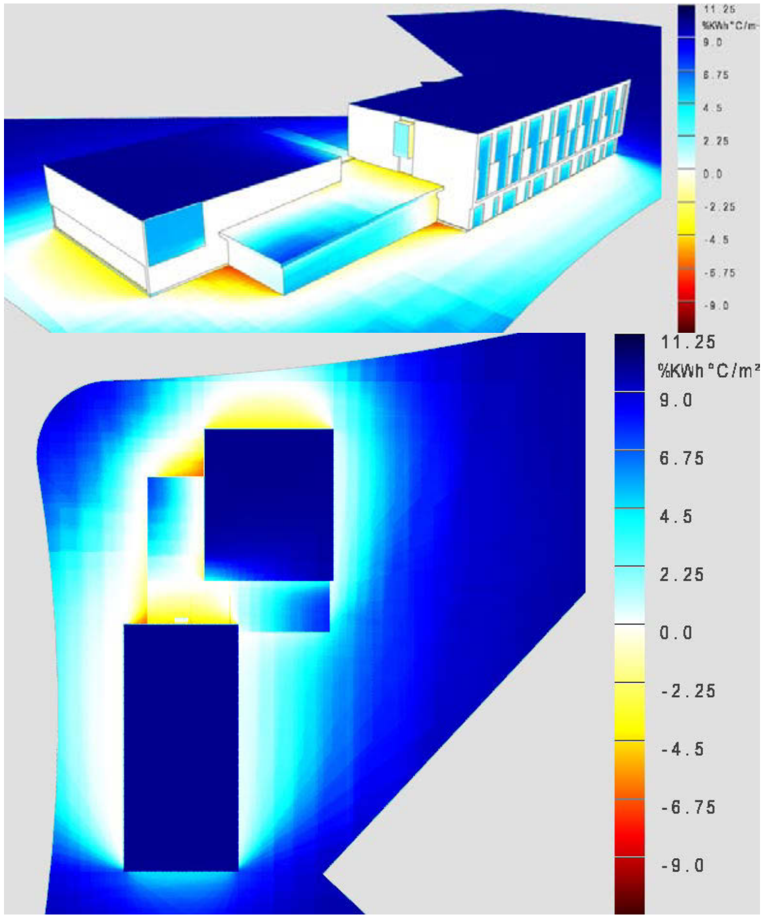




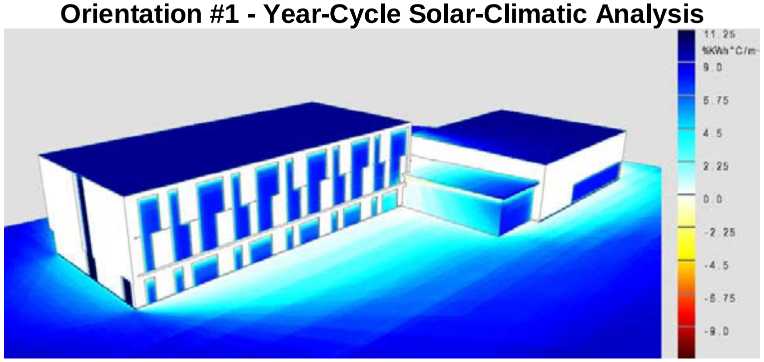
Orientation #2 - Year-Cycle Radiation Model

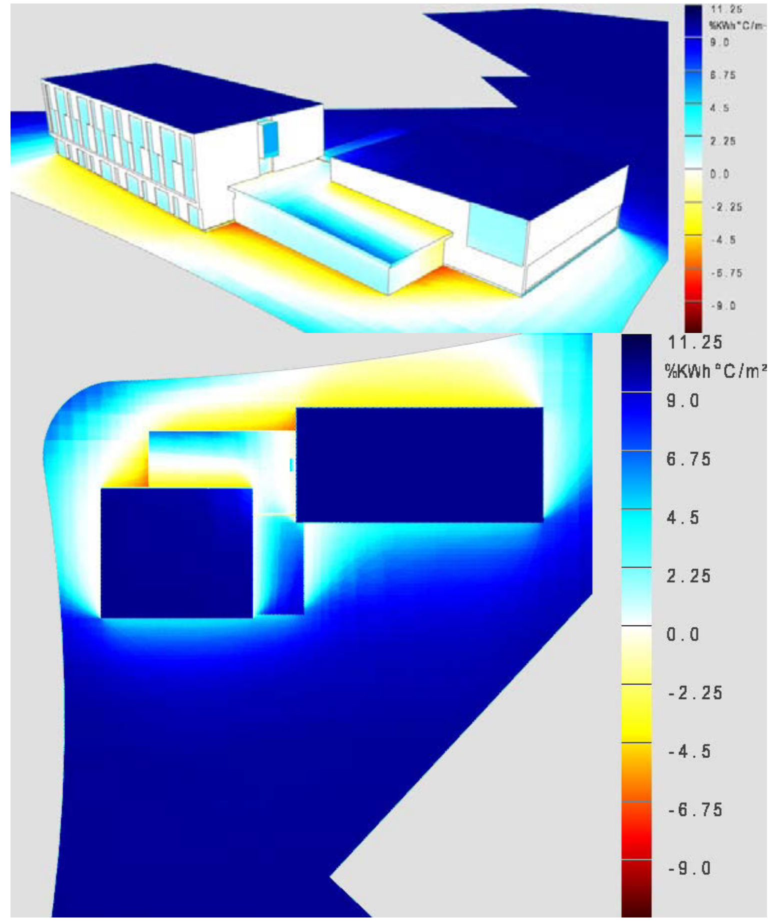



Orientation #1
145061
145949
169305
183510
151093
192191
143030
122028
33938
62232
76833
124754
March (21)
April (20)
May (21)
June (21)
July (22)
Aug. (22)
Sep. (22)
Oct. (22)
Nov. (21)
Dec. (21)
Jan. (20)
Feb. (19)
122938
90916
57534
81208
66114
108096
117984
144153
52014
99653
101833
136762
Direct Solar Radiation Received on Opening Areas of the Building Model - Hourly Plot in Different Months (W/h)
Orientation #2
West East South North Sum
Orientation #1
1136.2
1285.5
1380.1
1598.5
1393.5
1638.4
1026.4
846.5
222.9
326.4
437.8
914.9
March (21)
April (20)
May (21)
June (21)
July (22)
Aug. (22)
Sep. (22)
Oct. (22)
Nov. (21)
Dec. (21)
Jan. (20)
Feb. (19)
993.1
753.7
687.0
719.6
694.7
977.2
870.8
1042.7
338.2
530.8
660.3
1058.0
Direct Solar Radiation Received on Opening Areas of the Building Model - Daily Plot in Different Months (W/day)
Orientation #2
West East South North Sum
Hourly Plot in Different Months
March (21)
April (20)
May (21)
June (21)
July (22)
Aug. (22)
Sep. (22)
Oct. (22)
Nov. (21)
Dec. (21)
Jan. (20)
Feb. (19)
1598.5
1042.7
719.6
222.9
Direct Solar Radiation Received on Opening Areas of the Building Model - Differences between 2 alternatives
Daily Total Plot
Alt.1 Alt.2

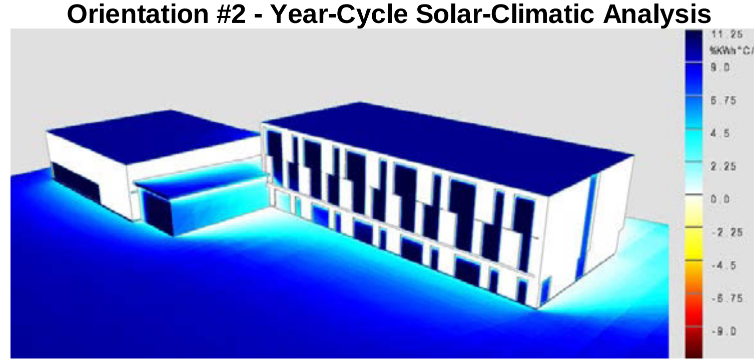


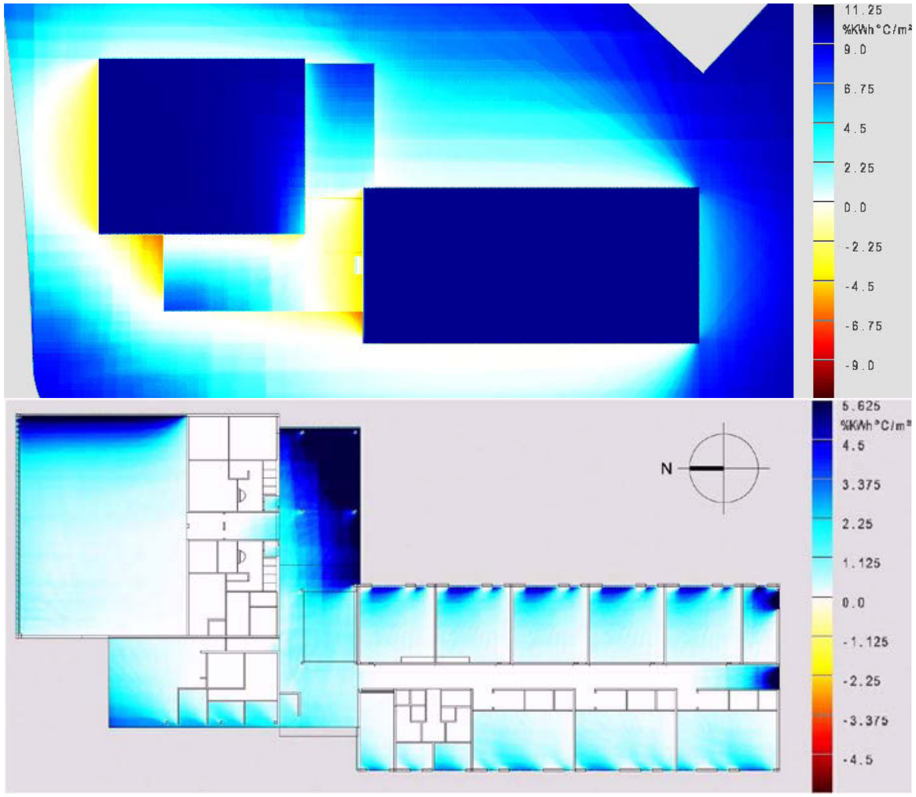
Orientation #1 - Year-Cycle Solar-Climatic Analysis



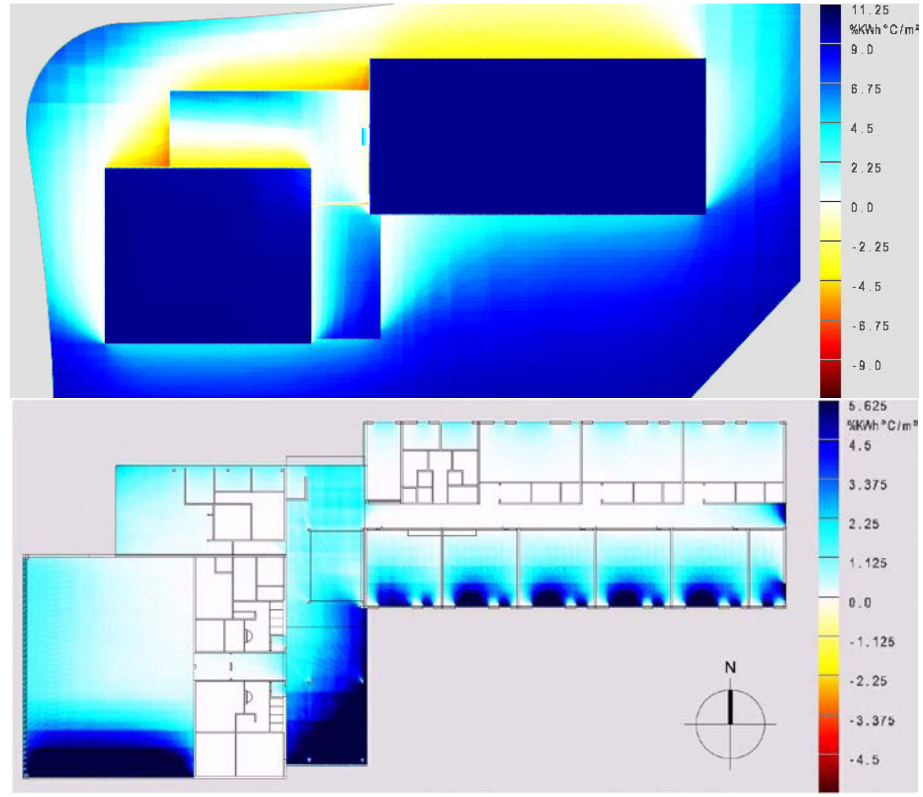


Orientation #2 - Year-Cycle Solar-Climatic Analysis

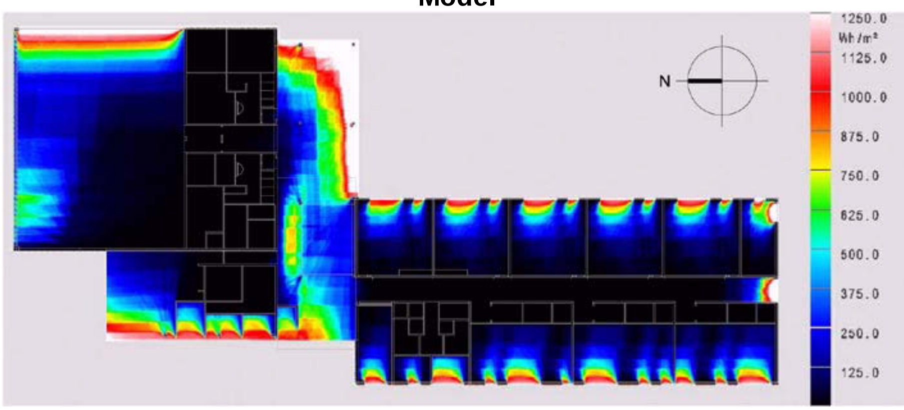


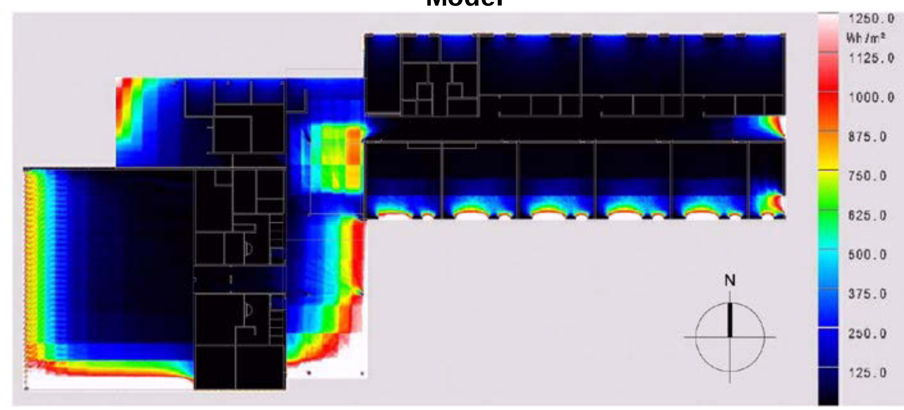


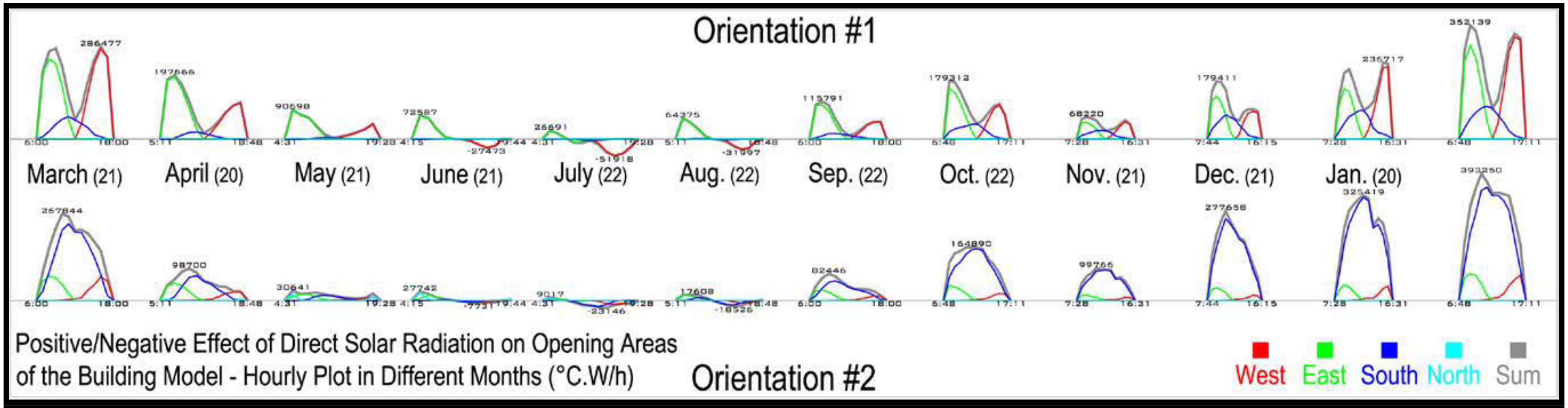
Orientation #1 - Year-Cycle Solar-Climatic Analysis and Radiation Model

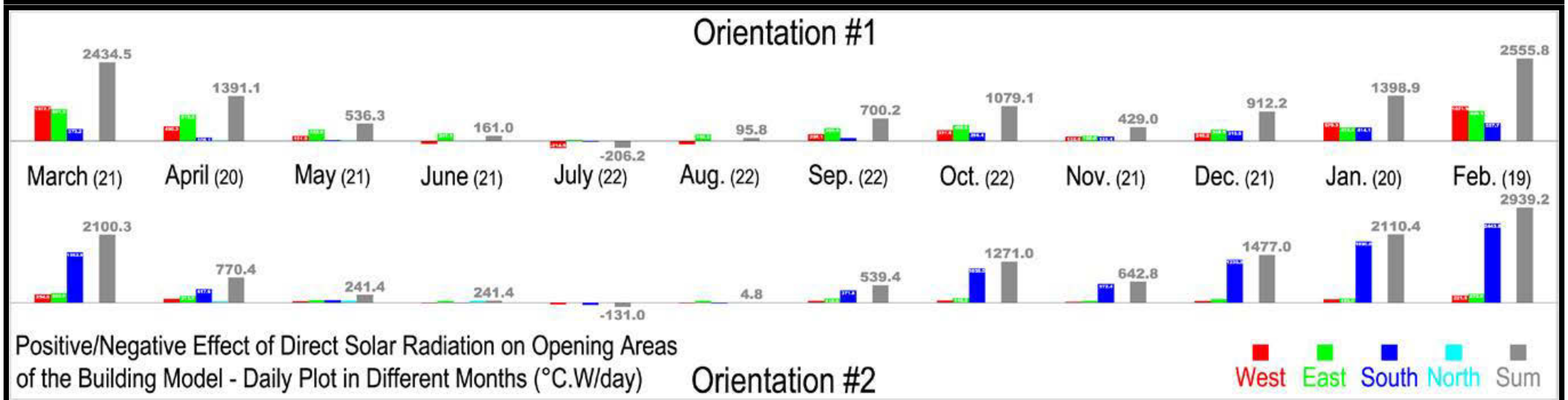


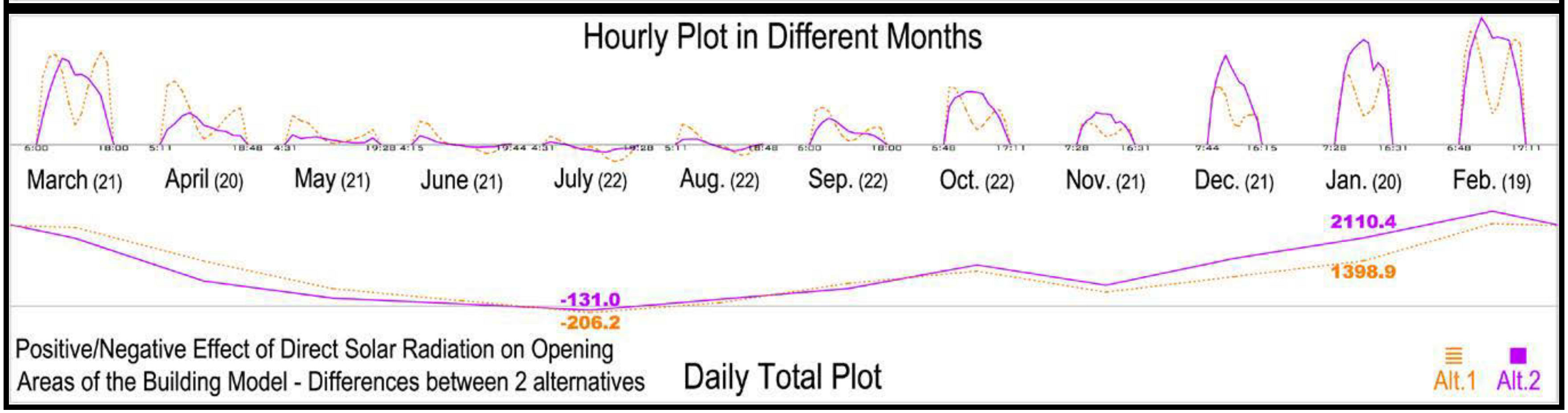
Orientation #2 - Year-Cycle Solar-Climatic Analysis and Radiation Model






Orientation #1
Orientation #2
March (21)
April (20)
May (21)
June (21)
July (22)
Aug. (22)
Sep. (22)
Oct. (22)
Nov. (21)
Dec. (21)
Jan. (20)
Positive/Negative Effect of Direct Solar Radiation on Opening Areas of the Building Model - Hourly Plot in Different Months (°C.W/h)
West
East
South
North
Sum


Orientation #1
2434.5
1391.1
536.3
161.0
-206.2
95.8
700.2
1079.1
429.0
912.2
1398.9
2555.8
March (21)
April (20)
May (21)
June (21)
July (22)
Aug. (22)
Sep. (22)
Oct. (22)
Nov. (21)
Dec. (21)
Jan. (20)
Feb. (19)
2100.3
770.4
241.4
241.4
-131.0
4.8
539.4
1271.0
642.8
1477.0
2110.4
2939.2
Positive/Negative Effect of Direct Solar Radiation on Opening Areas of the Building Model - Daily Plot in Different Months (°C.W/day)
Orientation #2
West
East
South
North
Sum


Hourly Plot in Different Months
March (21)
April (20)
May (21)
June (21)
July (22)
Aug. (22)
Sep. (22)
Oct. (22)
Nov. (21)
Dec. (21)
Jan. (20)
Feb. (19)
2110.4
1398.9
-131.0
-206.2
Positive/Negative Effect of Direct Solar Radiation on Opening Areas of the Building Model - Differences between 2 alternatives
Daily Total Plot
Alt.1
Alt.2