

PHILADELPHIA, PENNSYLVANIA CLIMATE ANALYSIS



ESTHER HAH

ARCH 753 BUILDING PERFORMANCE SIMULATION
PENNDESIGN

OBJECTIVE

THE PROJECT INVESTIGATES THE CURRENT PERFORMANCE AND COMFORT OF A STUDIO UNIT. IT AIMS TO IMPROVE UPON THE SPACE THROUGH PASSIVE RE-DESIGN WITH THE TOOLS OF GRASSHOPPER, LADYBUG, HONEYBEE, IN CONJUNCTION TO CLIMATE CONSULTANT AS WELL AS THE MENTIONED SUPPORTING MATERIALS AND DOCUMENTS IN THIS BOOKLET.

TABLE OF CONTENTS

CLIMATE ANALYSIS

LOCATION

TEMPERATURE

WIND ROSE // SUN PATH // SKY COVER

IDEAL LEVELS OF COMFORT

UTCI (UNIVERSAL THERMAL CLIMATE INDEX)

BASE CASE ANALYSIS

DAYLIGHTING

GLARE ANALYSIS

INDOOR COMFORT

RE-DESIGN PROPOSAL

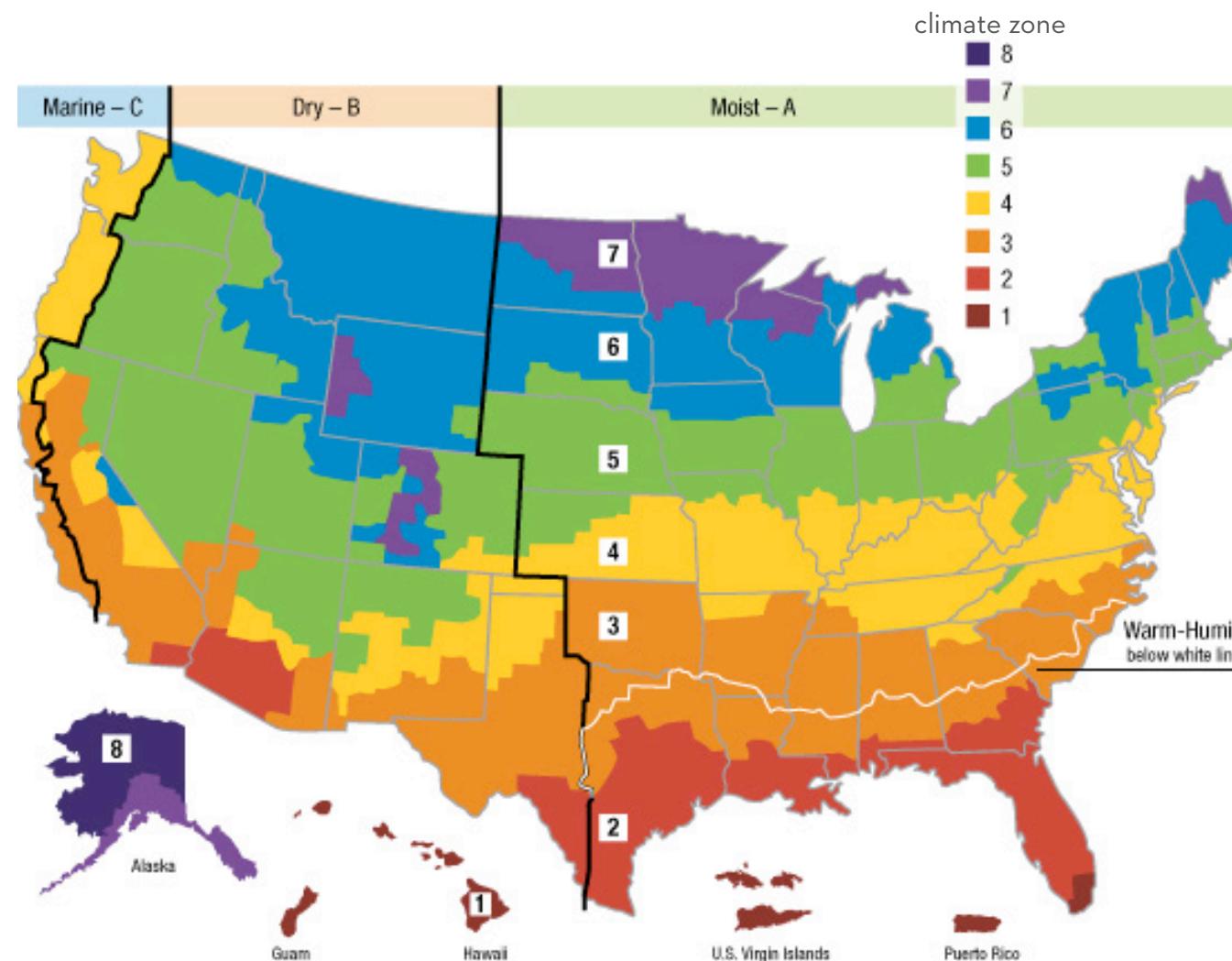
DAYLIGHTING

GLARE ANALYSIS

INDOOR COMFORT

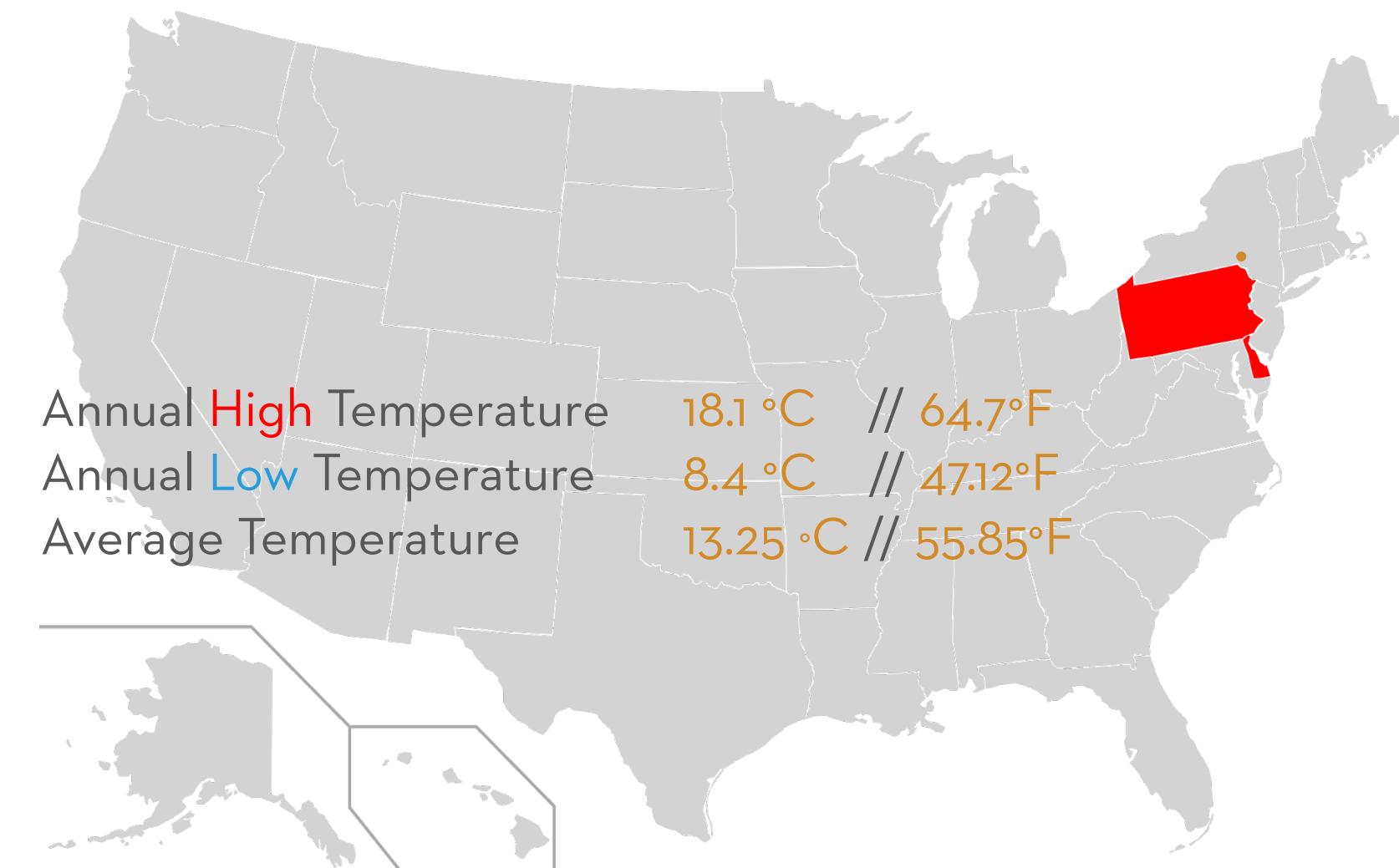
CONCLUSION

U.S Climate Zone Map



Because the United States has such differing climates from coast to coast, understanding climate classification, temperature, and relative humidity are vital throughout the design process.

LOCATION Philadelphia, PA
CLIMATE ZONE 4A
CHARACTERISTIC Mixed-Humid

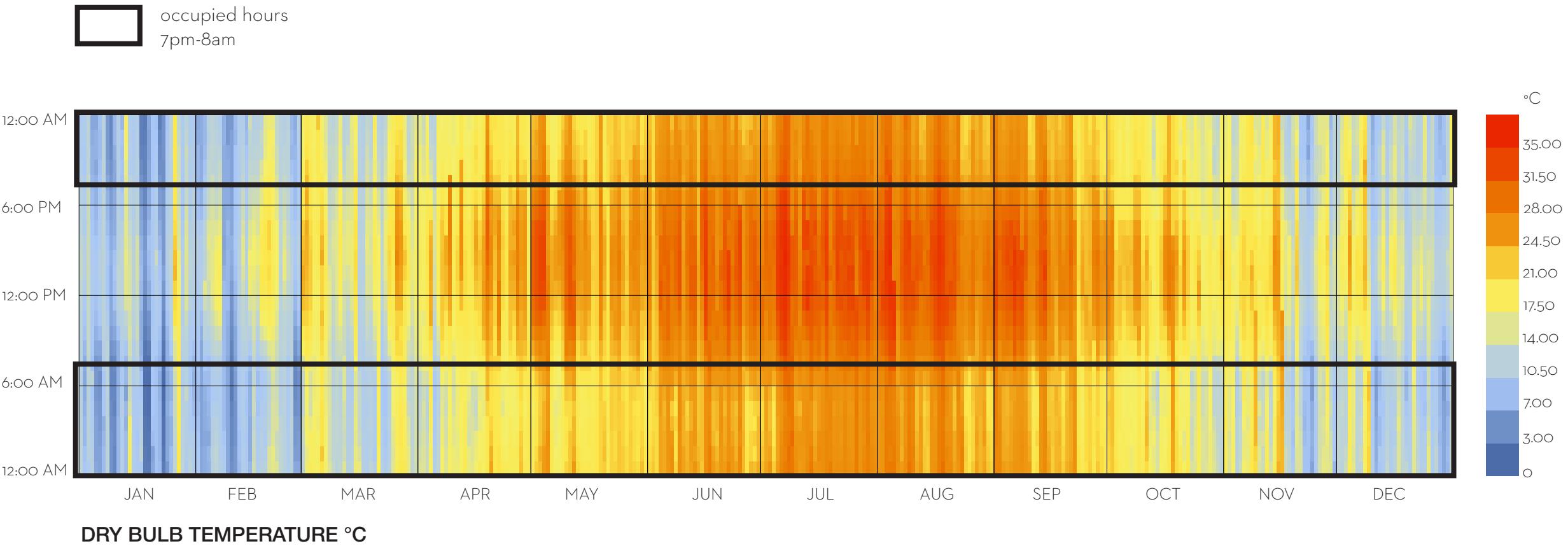


The climate in Pennsylvania varies quite a bit across the state. In Philadelphia, the climate zone is 4A, which is defined as mixed-humid. The annual temperature averages 55.85 °F, with its high being 64.7°F and low at 47°F. It is considered mixed-humid because of its average annual precipitation at 41.45 inches.

TEMPERATURE

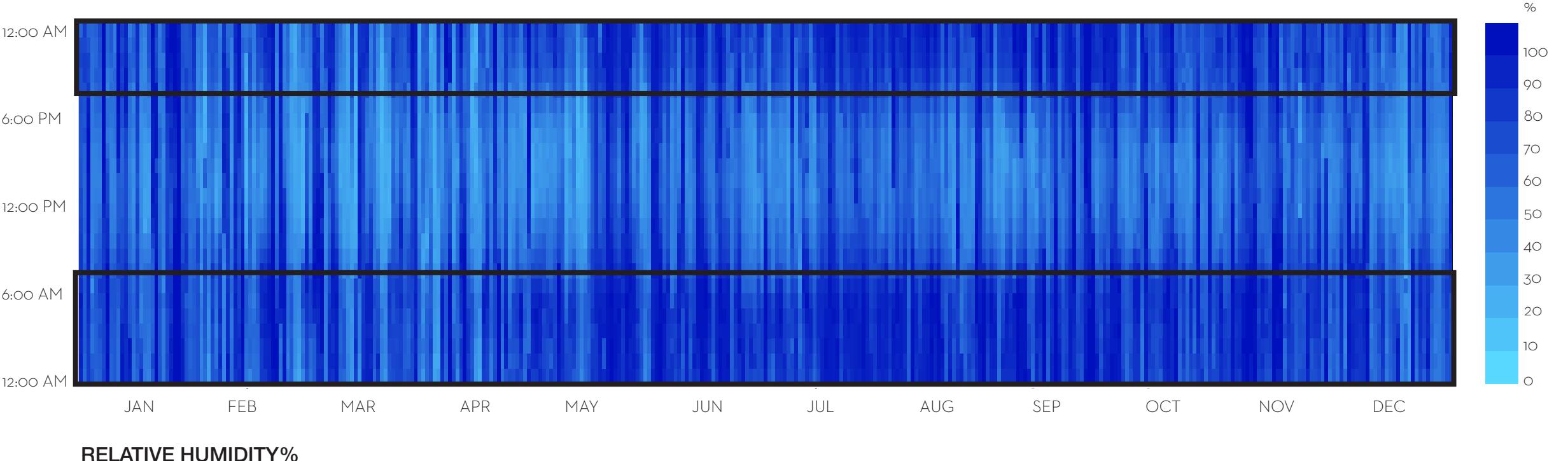
PHILADELPHIA // PA
CLIMATE ANALYSIS

According to the TMY3 data, the temperature in Philadelphia is mostly high in the months of June through September in between the times of 9am-5pm.



Because this building type is residential, and is not occupied to the typical times of 9am-5pm as a commercial building, it is important to note the occupied hours.

In this case, the space is mainly occupied from 7pm-8am. In turn, outside temperature (24 °C) is not as high as during the day (35 °C). However, relative humidity high all year round, but specifically higher in the evening than during the day at 80% or more, which increases the occupant of feeling temperature and can lead to discomfort.



WIND ROSE

SUN PATH

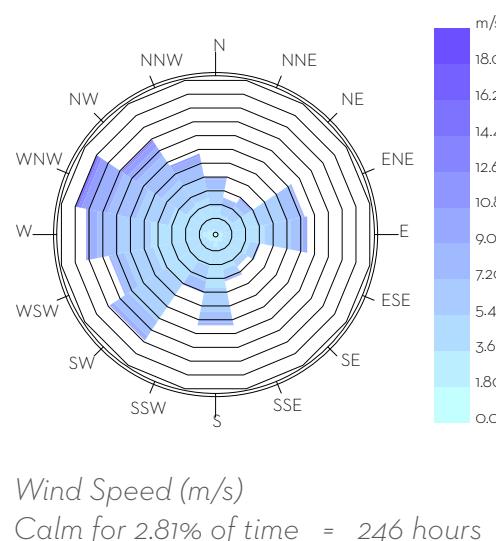
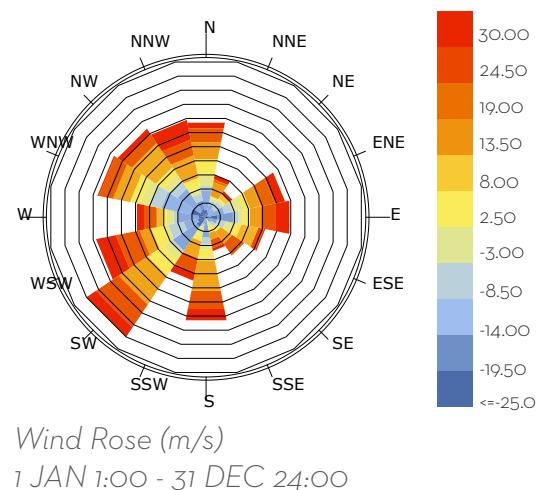
SKY COVER

PHILADELPHIA // PA
CLIMATE ANALYSIS

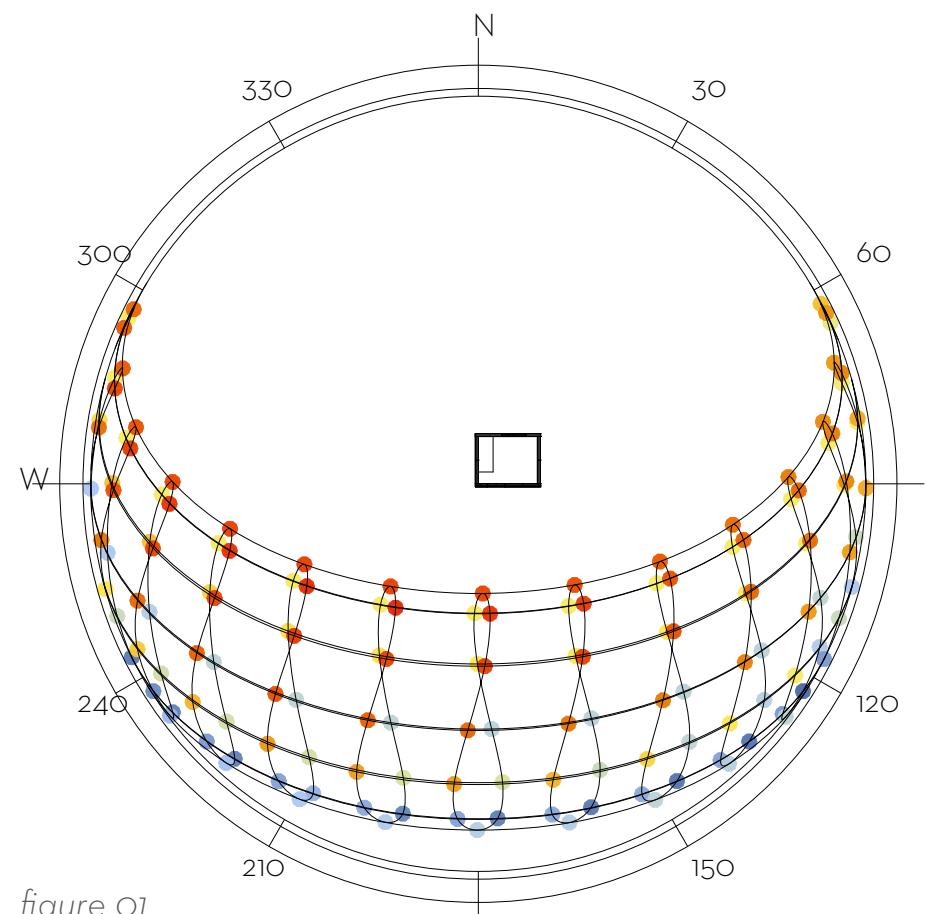
IDEAL LEVEL OF COMFORT:

Sky Cover
< 50% (6 out of 10)

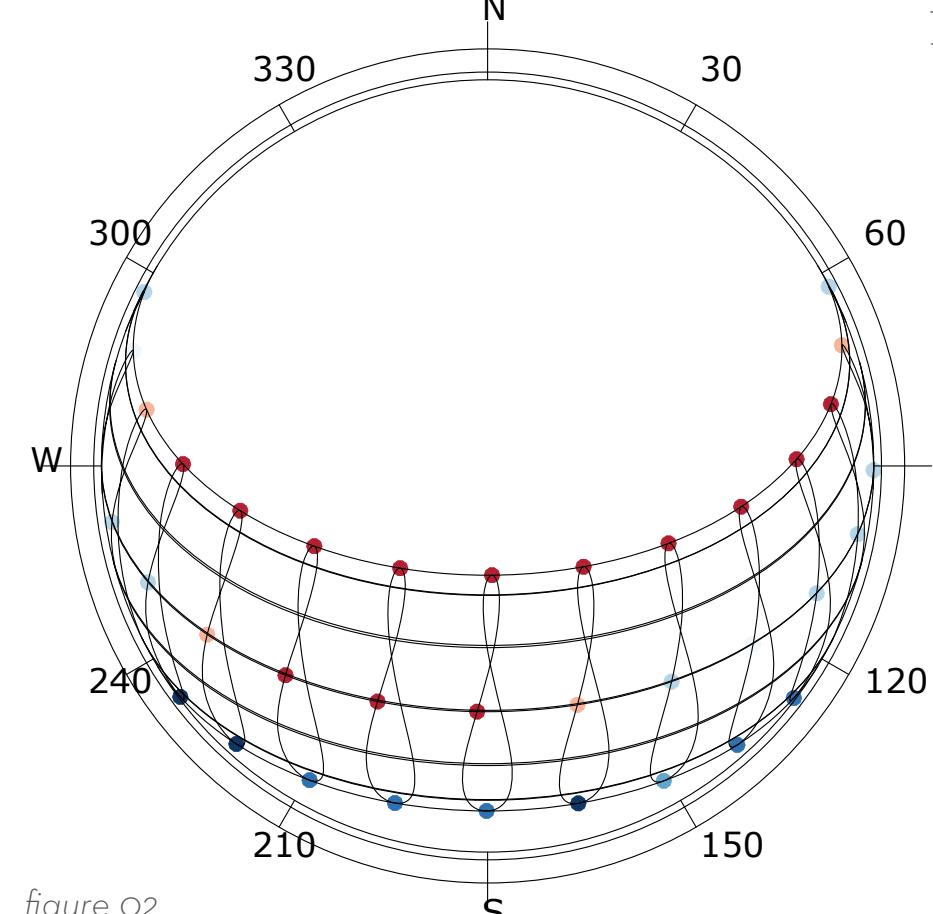
The wind in Philadelphia is mostly westerly wind. Throughout the year, there is constant strong and warm winds from the West, which reinforces its mixed-humid climate.



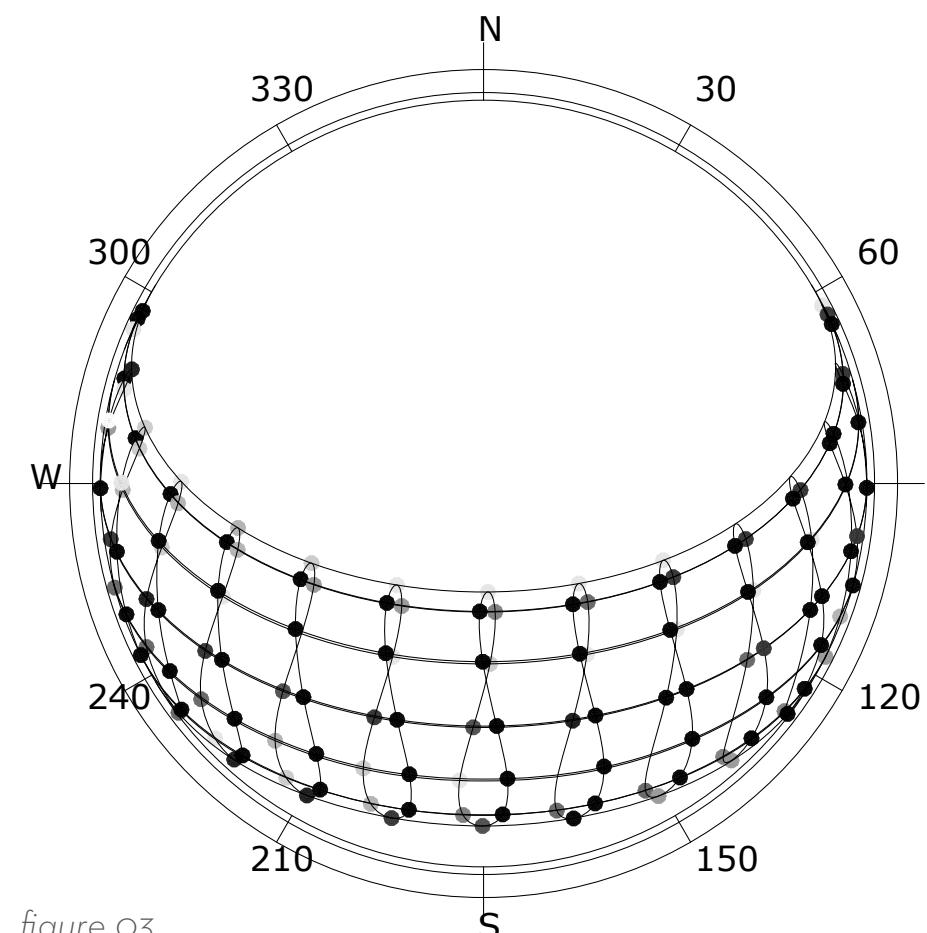
DRY BULB TEMPERATURE



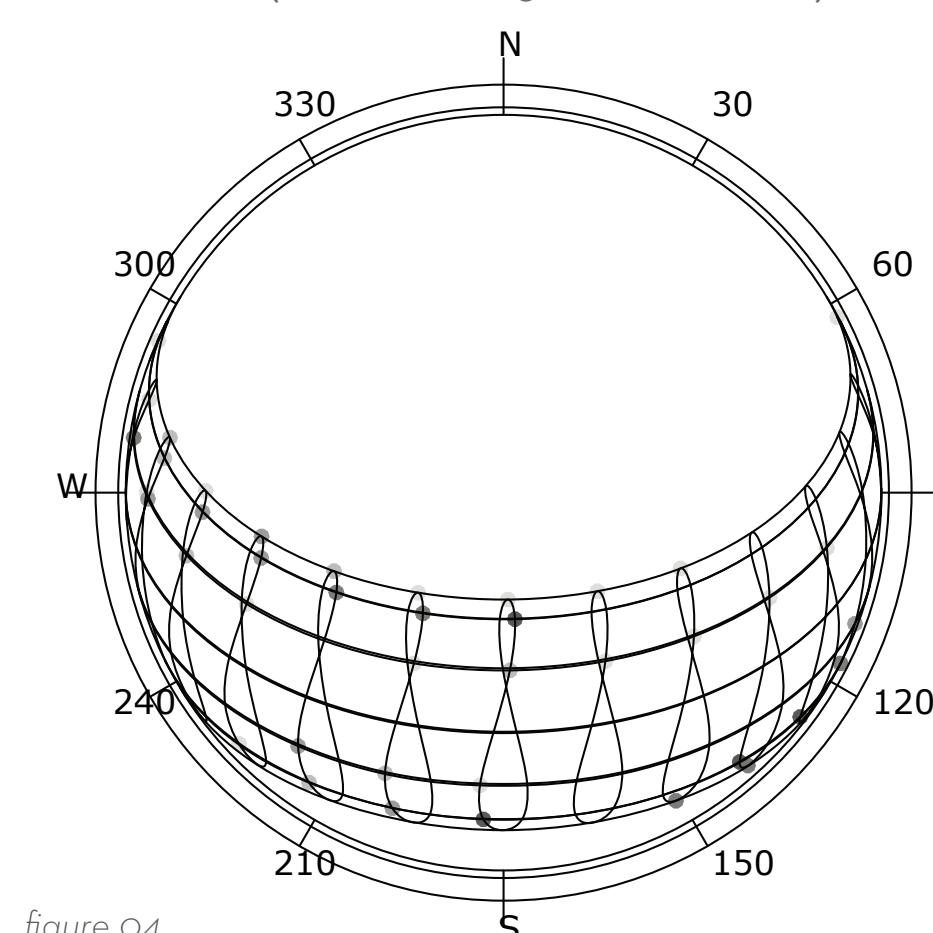
OUTDOOR COMFORT



SKY COVER



SKY COVER (LESS THAN 50% COVERED)



Legend for Outdoor Comfort:
 -3 Extreme Cold
 -2 Cold
 -1 Cool
 0 Comfort
 1 Warm
 2 Hot
 3 Extreme Heat

Legend for Sky Cover:
 0.00 to 6.00

IDEAL LEVELS OF COMFORT

PHILADELPHIA // PA
CLIMATE ANALYSIS

Temp

Less than 24C,
Above 18C

Humidity

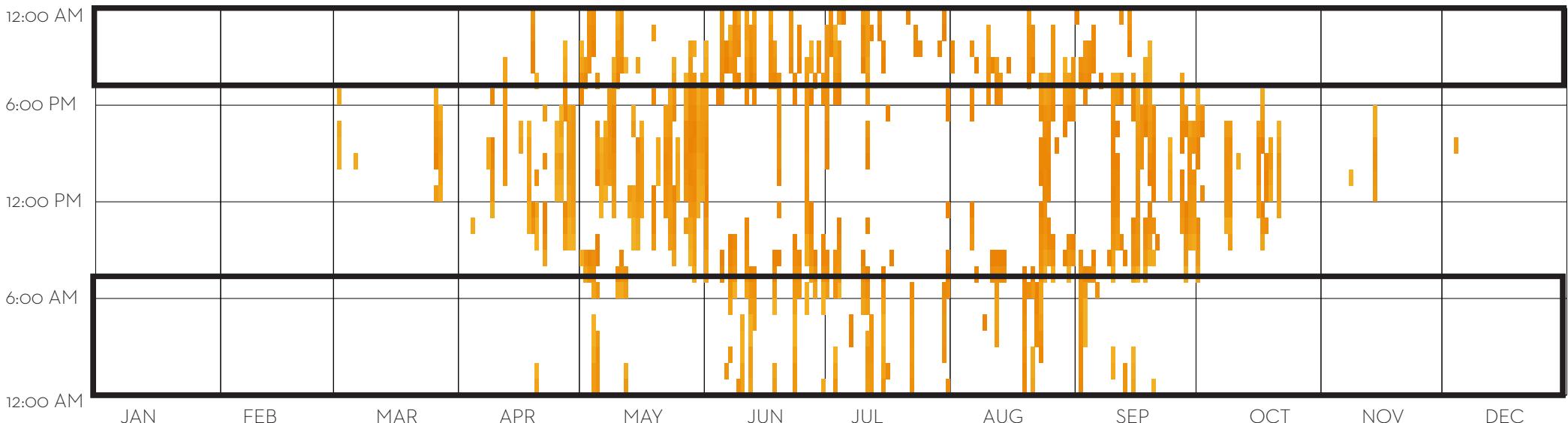
Less than 80C,
Above 2C

Wind Speed

Less than 10m/s,
Above 2m/s

occupied hours
7pm-8am

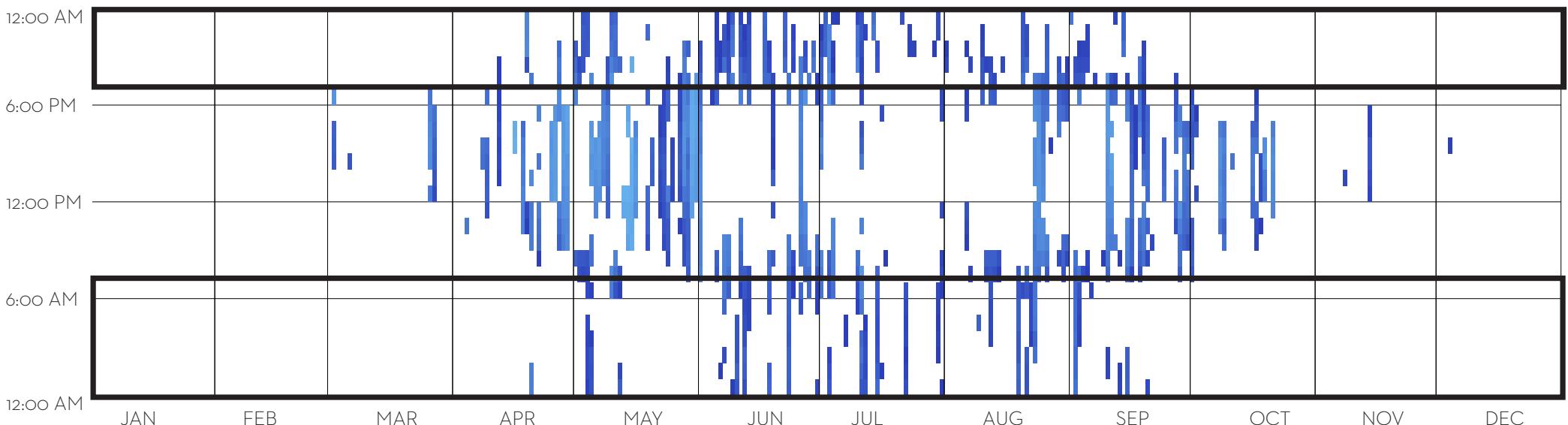
DRY BULB TEMPERATURE °C



°C

35.00
31.50
28.00
24.50
21.00
17.50
14.00
10.50
7.00
3.00
0

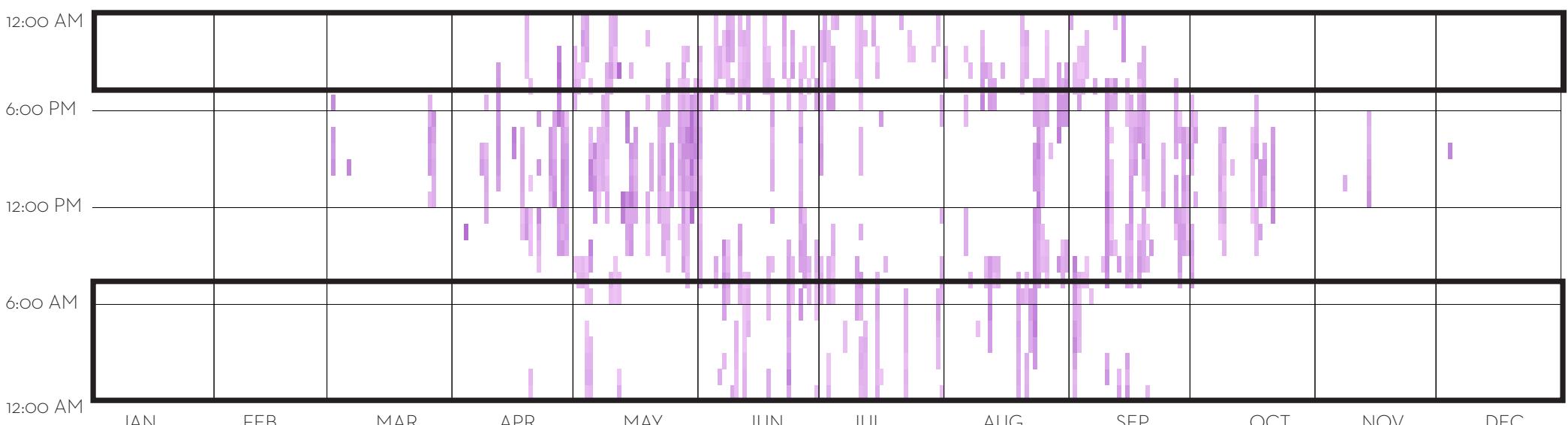
RELATIVE HUMIDITY %



%

100
90
80
70
60
50
40
30
20
10
0

WIND SPEED m/s



m/s

18.00
16.20
14.40
12.60
10.80
9.00
7.20
5.40
3.60
1.80
0

Percent of Time Comfortable:

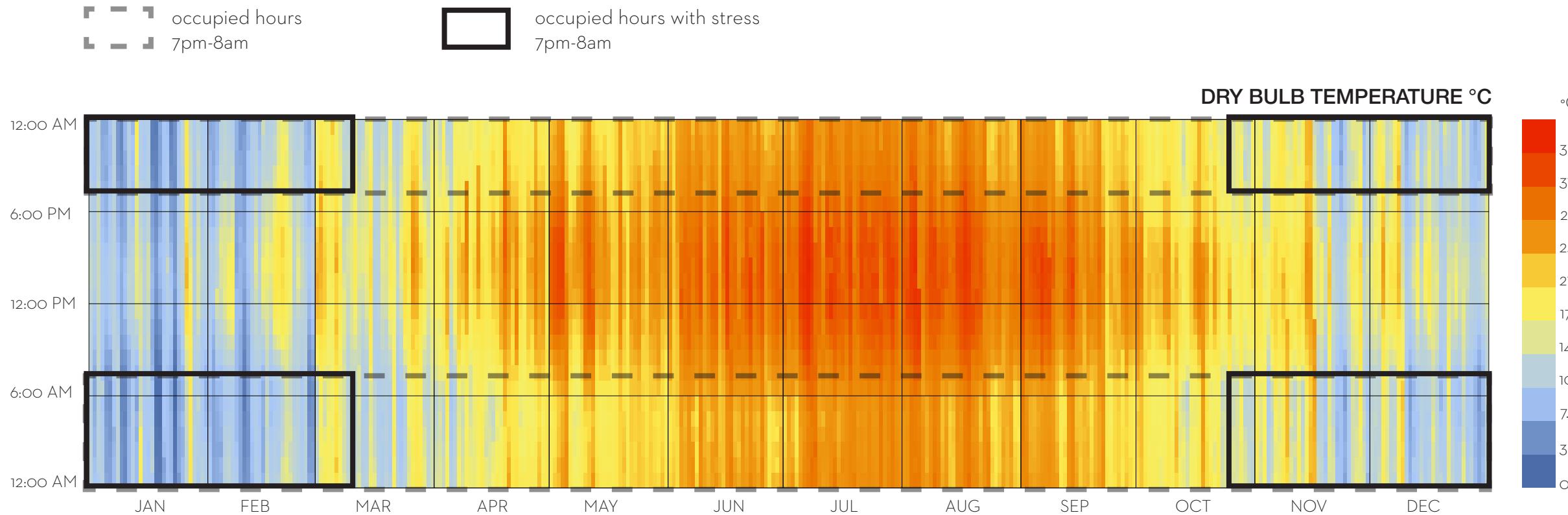
45.10%

Heat Stress

3.43 %

Cold Stress

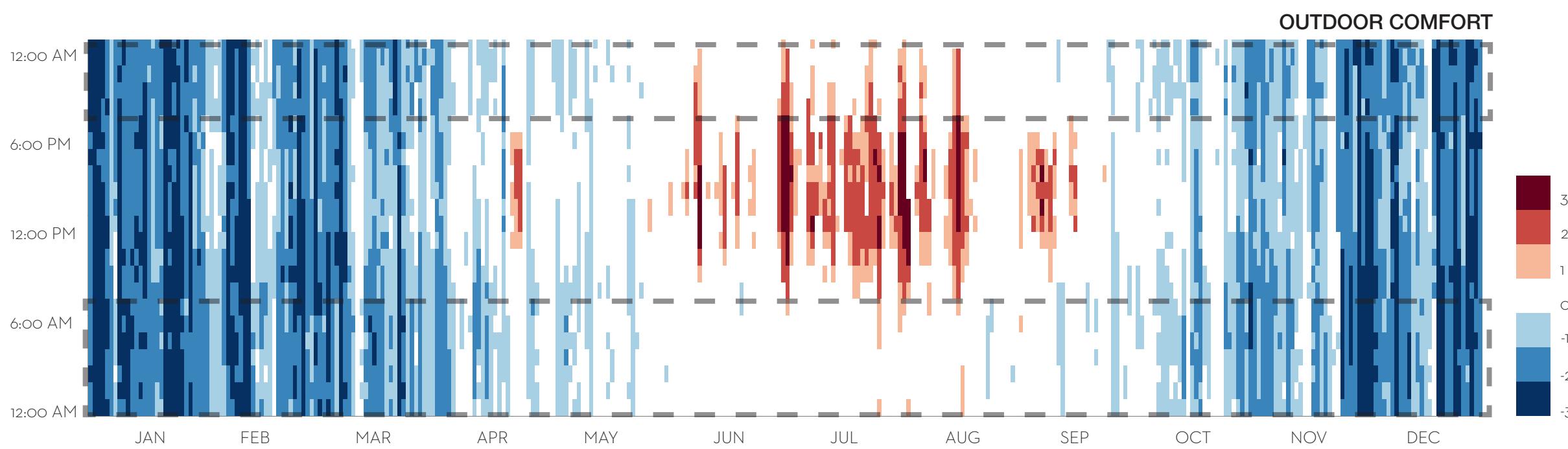
28.79%



The Universal Thermal Climate Index takes into consideration of the microclimatic effects in an environment such as **radiant temperature, relative humidity, wind speed, etc.**, and indicates a thermal value felt by occupants.

As shown in the diagrams, the most intense **heat stress** happens during the day from **10am-6pm**.

A main concern would be in the evening when the occupant would be present, in which the cold stress occurs in the months of **Nov-Mar** throughout the day and into the night.



PROJECT DESCRIPTION

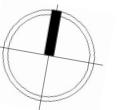
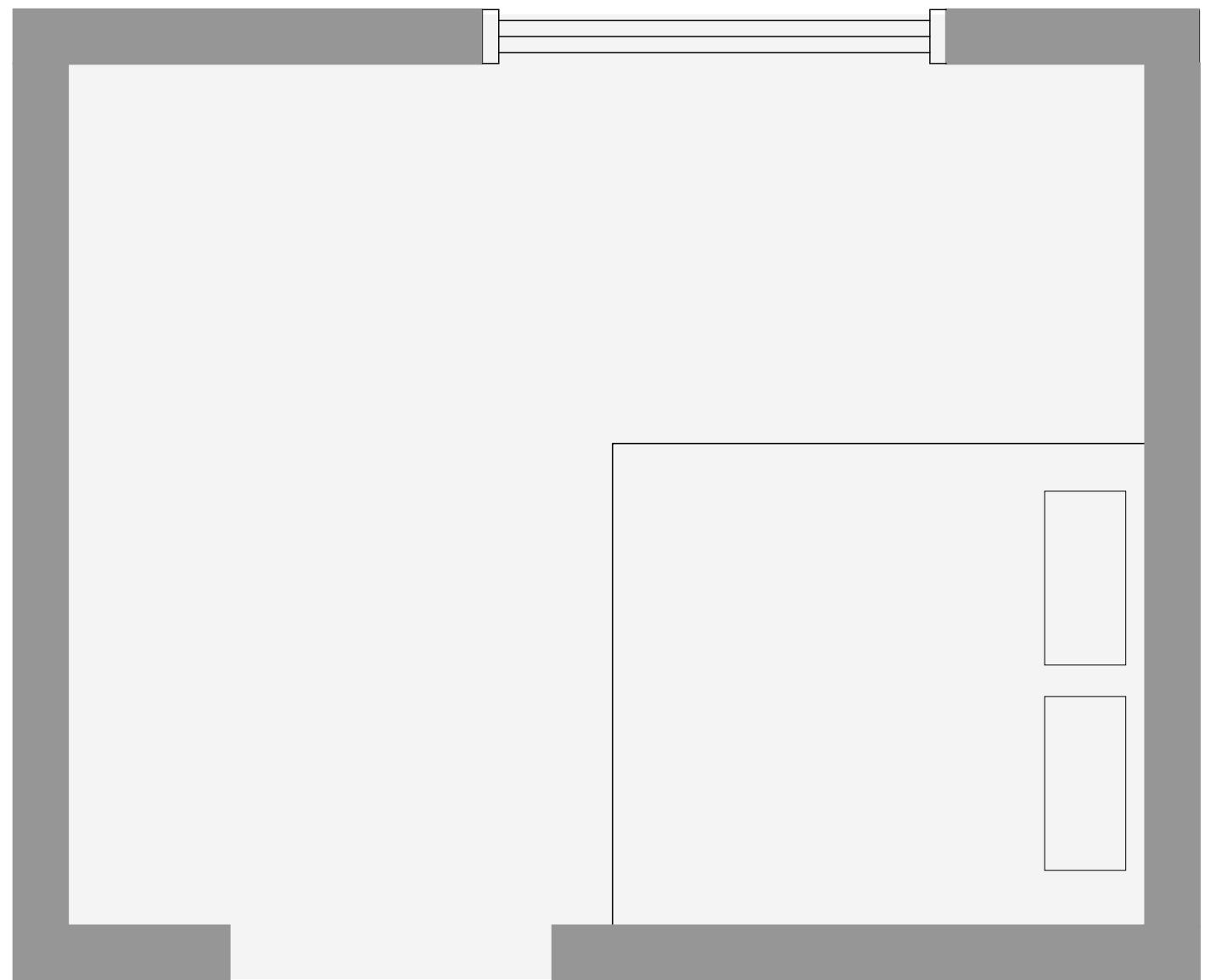
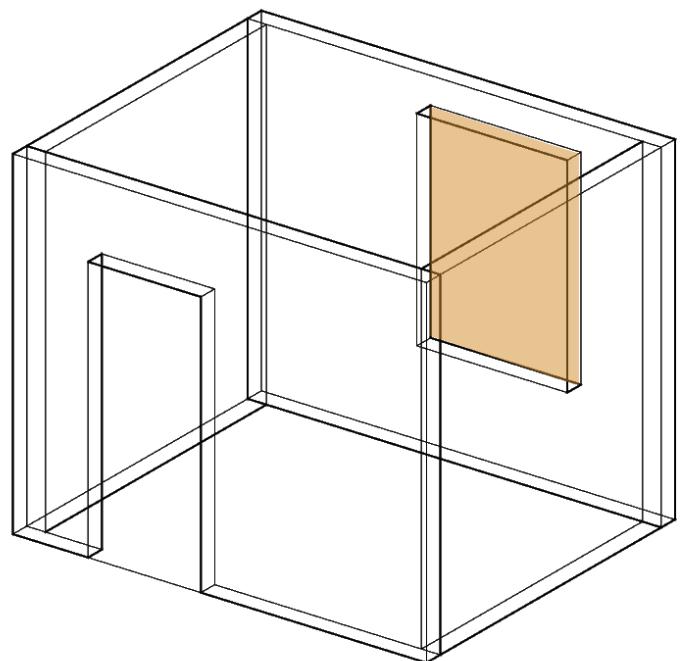
LOCATION PHILADELPHIA, PA

GLAZING
(window - wall ratio) 0.3

ORIENTATION 7PM-8AM

PROGRAM STUDIO APARTMENT

OCCUPIED HOURS 7PM-8AM



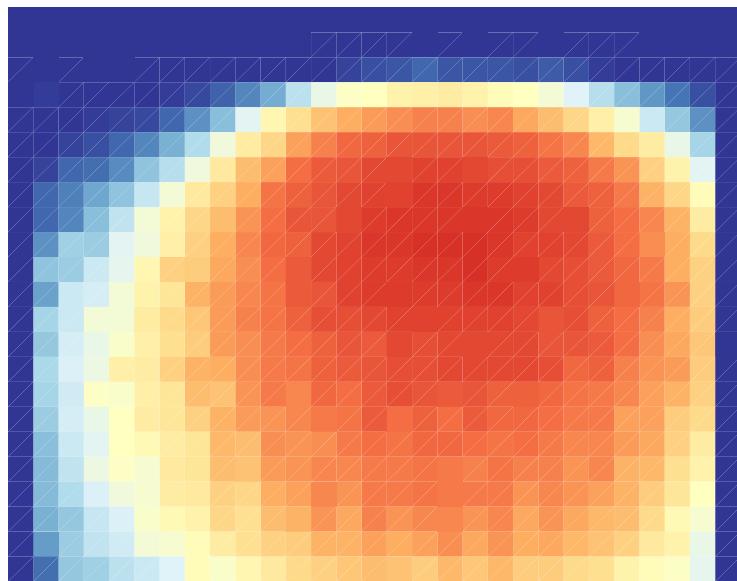
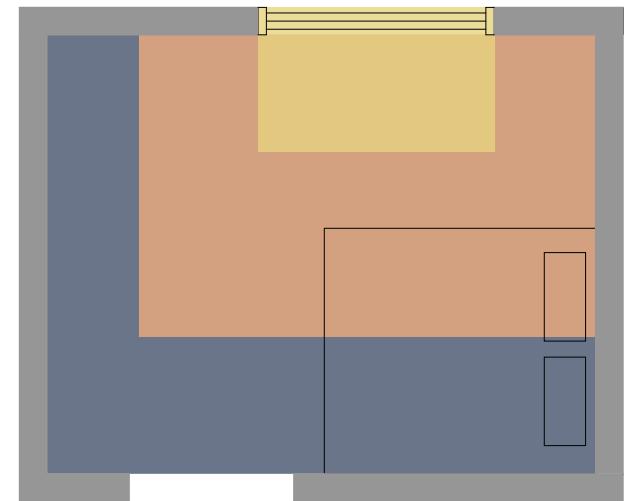
BASELINE DAYLIGHT

PHILADELPHIA, PA

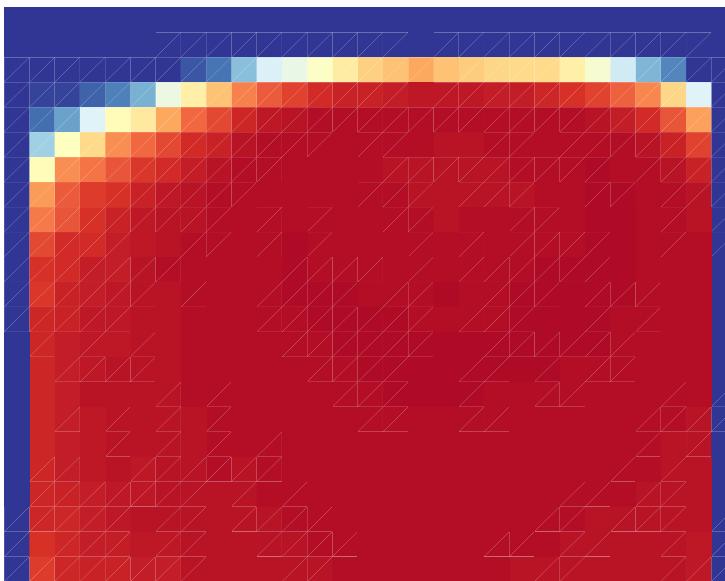
ILLUMINANCE ASSUMPTION

The diagram to the right is a quick sketch of the illuminance assumption for the space. There is abundance of light coming in during the day, but it does not evenly distribute throughout the room. It would be interesting to see what the results are in order to improve upon the current situation.

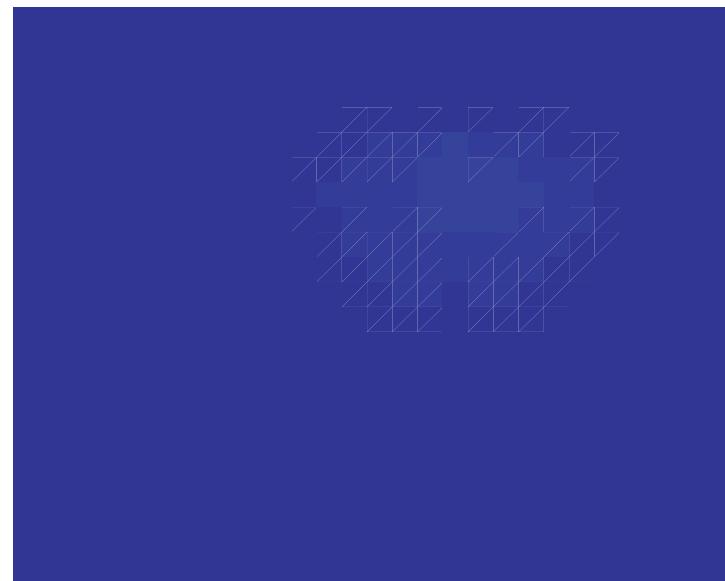
BEST ILLUMINANCE	
GOOD ILLUMINANCE	
POOR ILLUMINANCE	



DAYLIGHT AUTONOMY (DLA)
300 LUX

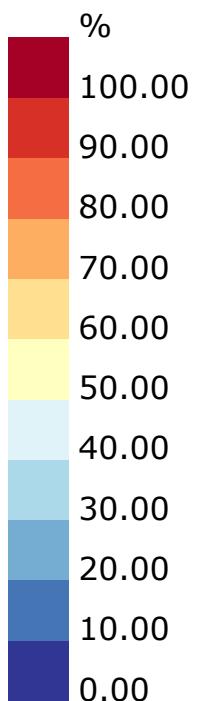


USEFUL DAYLIGHT (UDLI)
100-2000 LUX

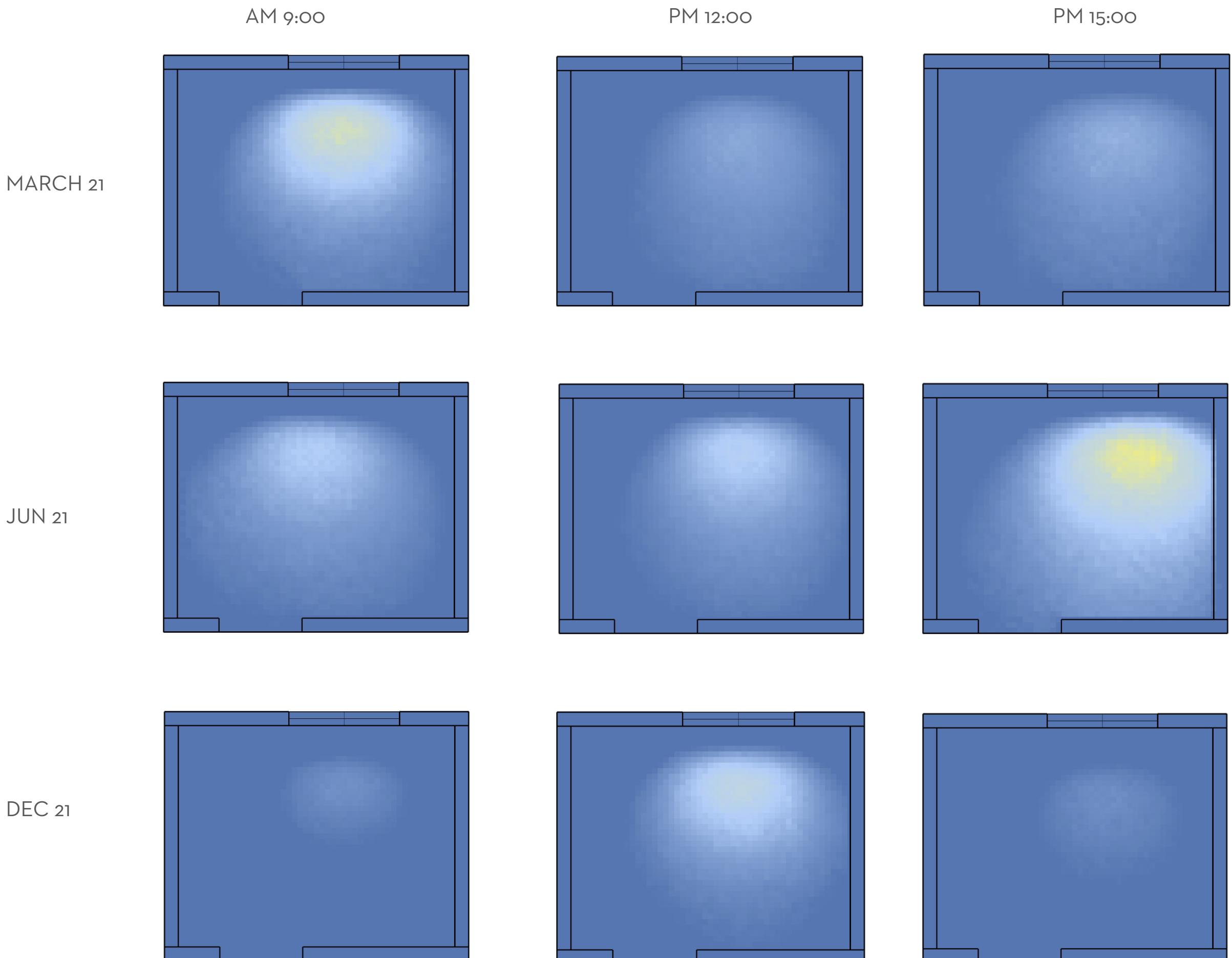
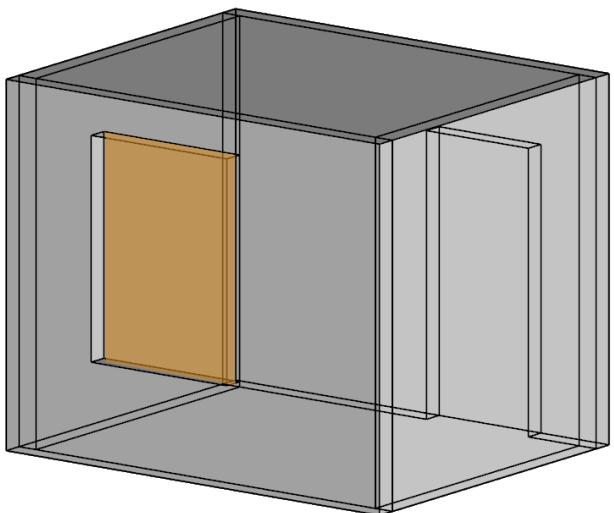


USEFUL DAYLIGHT (UDLI)
>2000 LUX

SDA (SPATIAL DAYLIGHT AUTONOMY):
68.97%



**BASELINE
DAYLIGHT**
PHILADELPHIA, PA



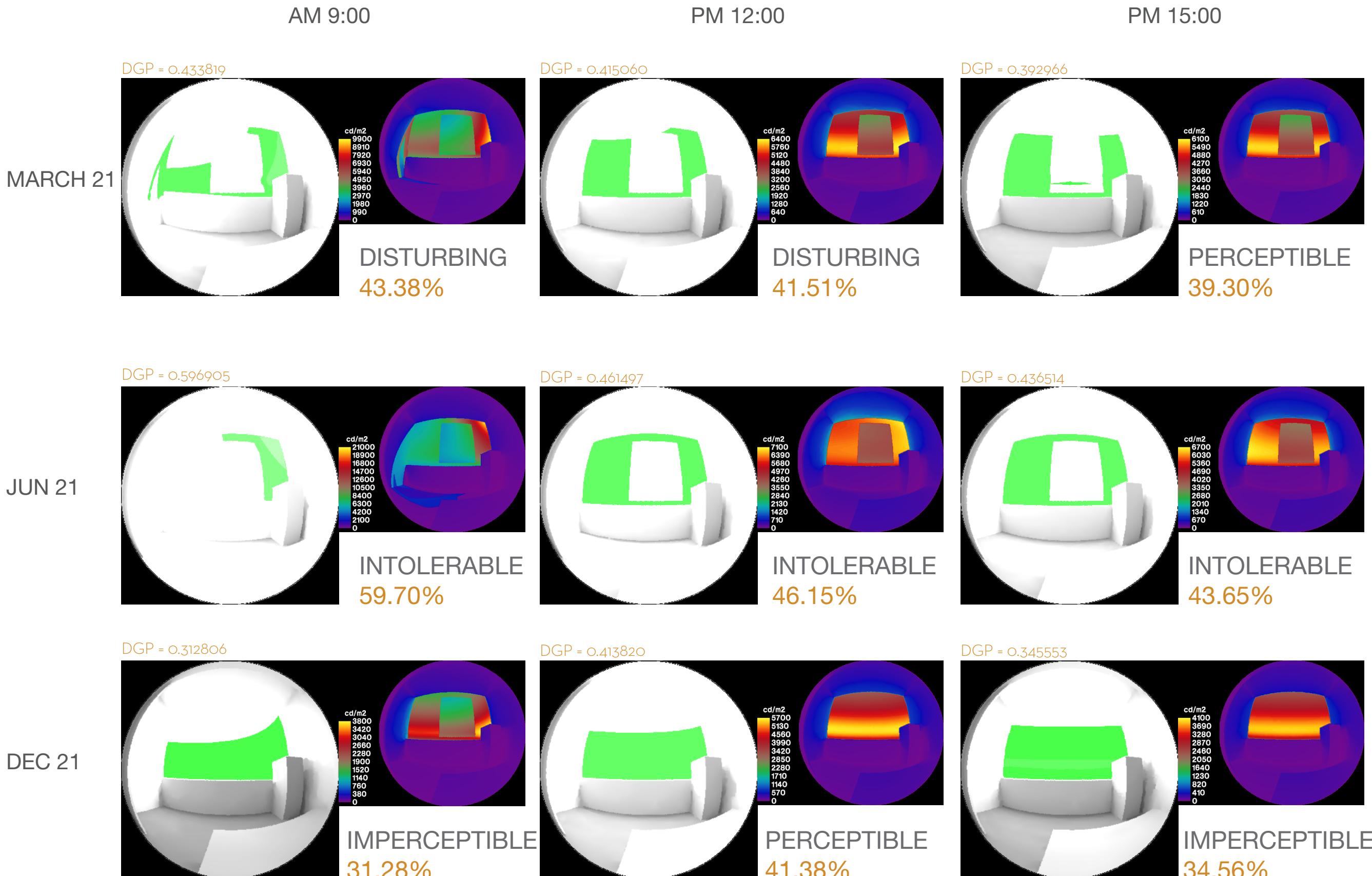
ANALYSIS CONCLUSION

From the study, it is evident not enough daylight reaches the depth of the space.

BASELINE GLARE ANALYSIS

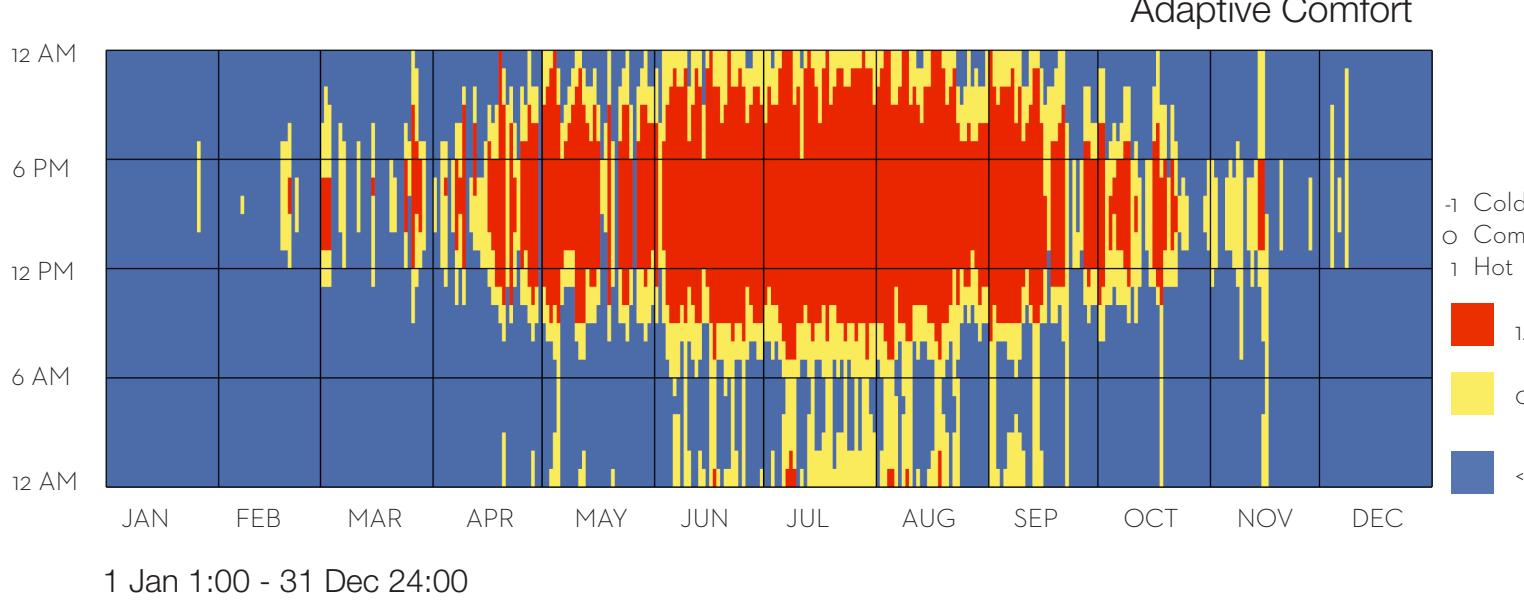
PHILADELPHIA, PA

The frames are representative of glares in March, June, and December. Since the summer months have more potential for glare, the analysis was tested for two summer months and one month in the winter.



ENERGY SIMULATION

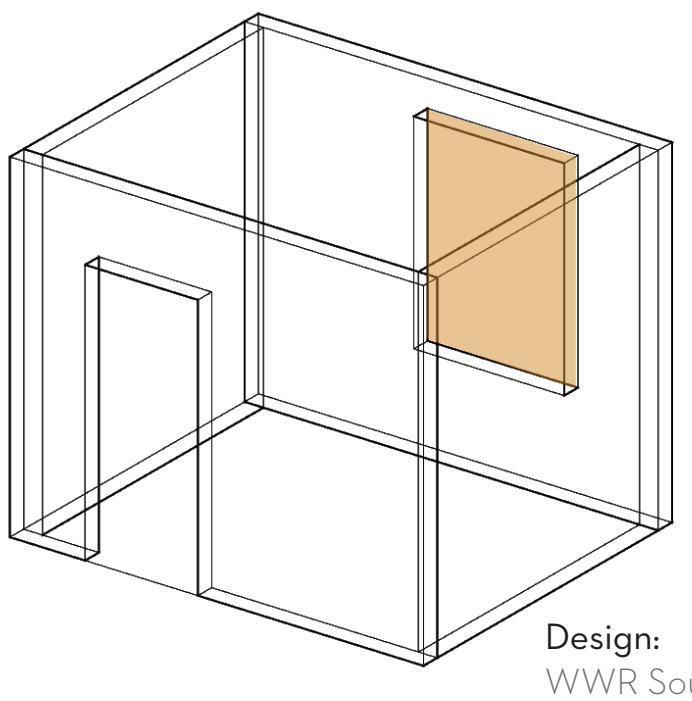
ORIGINAL ROOM
PHILADELPHIA, PA



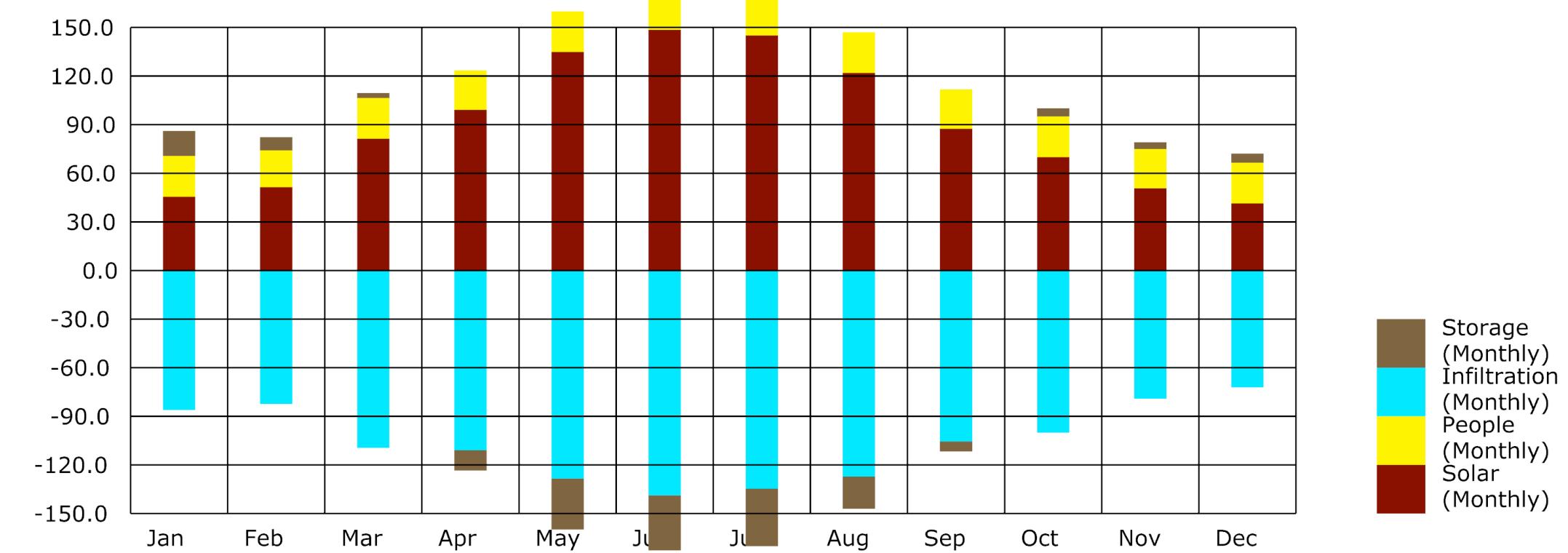
COMFORTABLE : 20.43%

HOT : 40.38%

COLD : 39.19%

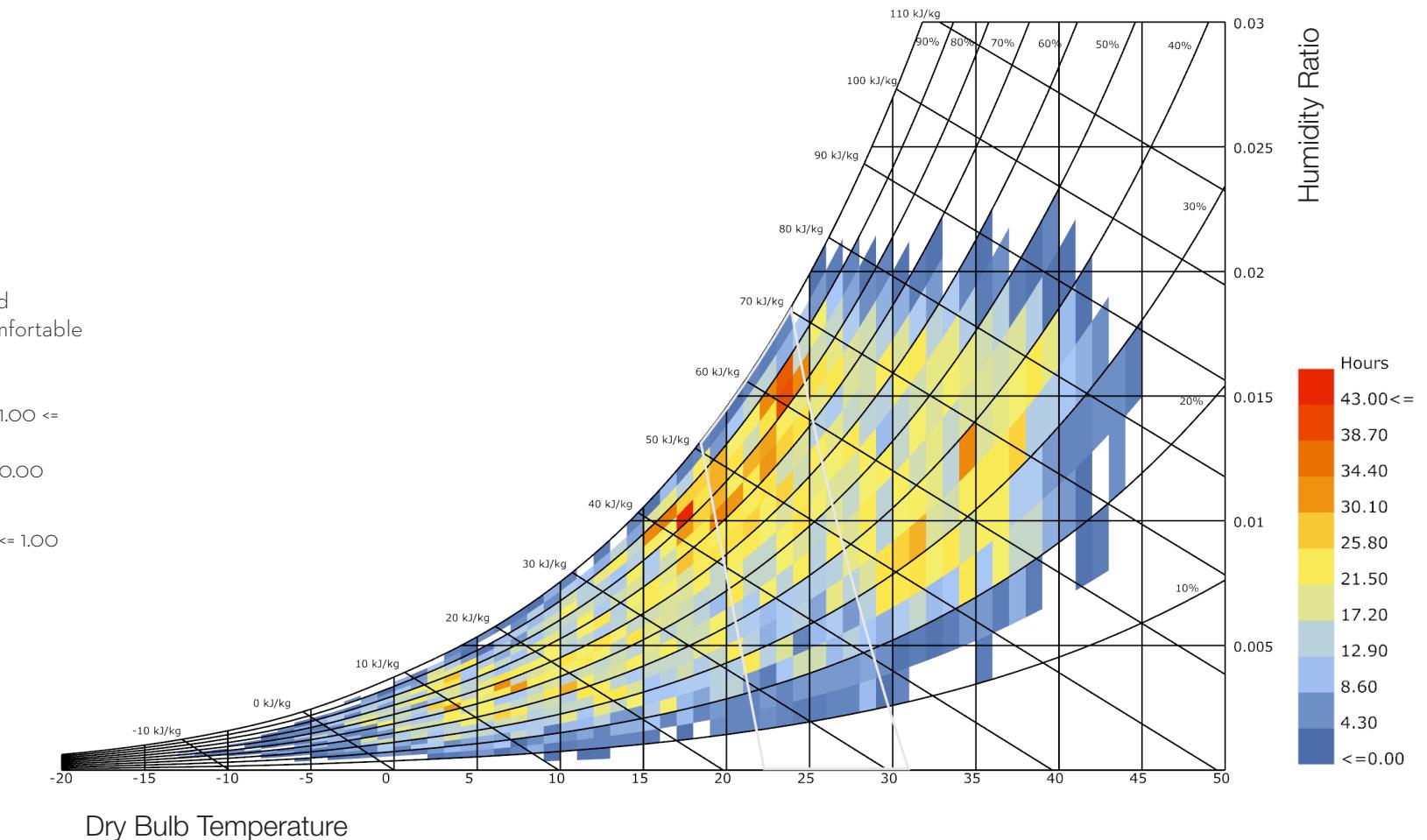


Energy (kWh)



Psychrometric Chart

Philadelphia International Ap PA USA TMY3
1 Jan 1:00 - 31 Dec 24:00



Storage (Monthly)
Infiltration (Monthly)
People (Monthly)
Solar (Monthly)

BASELINE CONCLUSION

LOCATION	PHILADELPHIA, PA
GLAZING (window - wall ratio)	0.3
PROGRAM	STUDIO APARTMENT
OCCUPIED HOURS	7PM-8AM

PROBLEMS: DISTURBING + INTOLERABLE GLARE
POORLY DISTRIBUTED DAYLIGHT

LOCATION	PHILADELPHIA, PA
GLAZING (window - wall ratio)	0.6
PROGRAM	STUDIO APARTMENT
OCCUPIED HOURS	7PM-8AM

GOALS: REDUCE GLARE
BETTER DISTRIBUTE DAYLIGHT
MAINTAIN OR BETTER INDOOR
COMOFRT LEVEL

BASE CASE DESIGN:

Design Challenge:
The space is fairly comfortable during the occupied hours of 7pm-8am. The only concerning time of discomfort is during the day in the peak summer months, specifically 9am-5pm. and December through January for the most of winter. However, it is evident there is a lack of daylight entering the space, but “disturbing” and “intolerable” amount of glare.

CHALLENGE:

THE CHALLENGE IS TO REDUCE GLARE TO A “PERCEPTEBLE LEVEL,” AND TO BETTER DISTRIBUTE DAYLIGHT ENTERING THE SPACE WITHOUT WORSENING THE LEVEL OF COMFORT IN THE ROOM.

RE-DESIGN PROPOSAL:

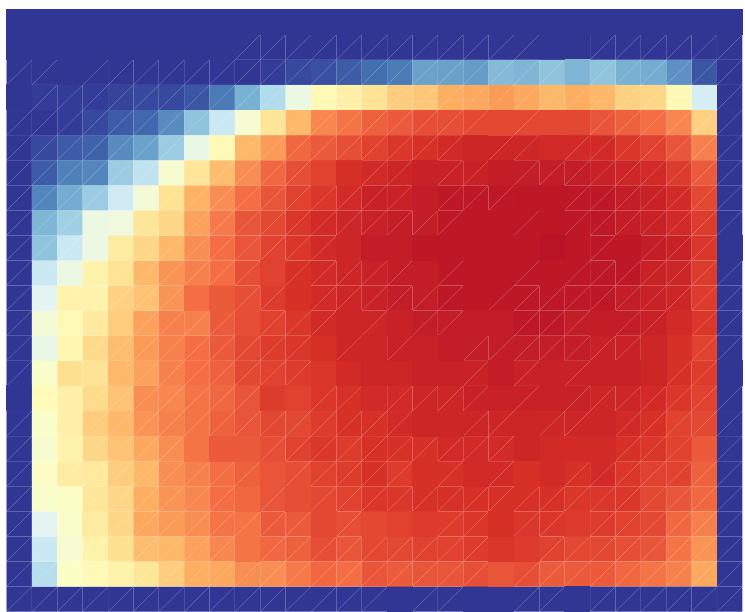
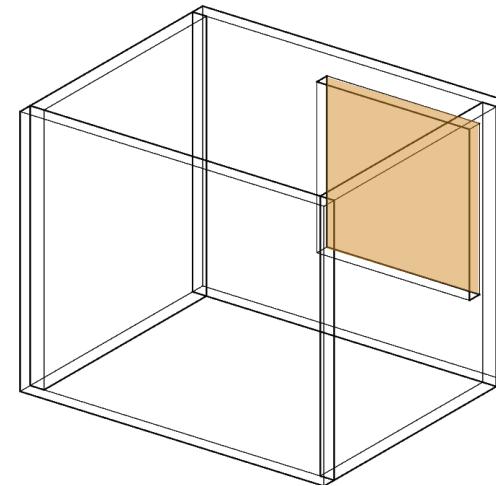
Design Approach:
The method of practice is figuring out what window to wall ratio works better to bring adequate daylight and what loads may be most affected as a result through the continuation of honeybee and ladybug analyses.

Design Result:
The result shows high levels of solar energy and infiltration. The next design schemes will be addressing how to balance the two with a new room layout that allows for better areas of daylight.

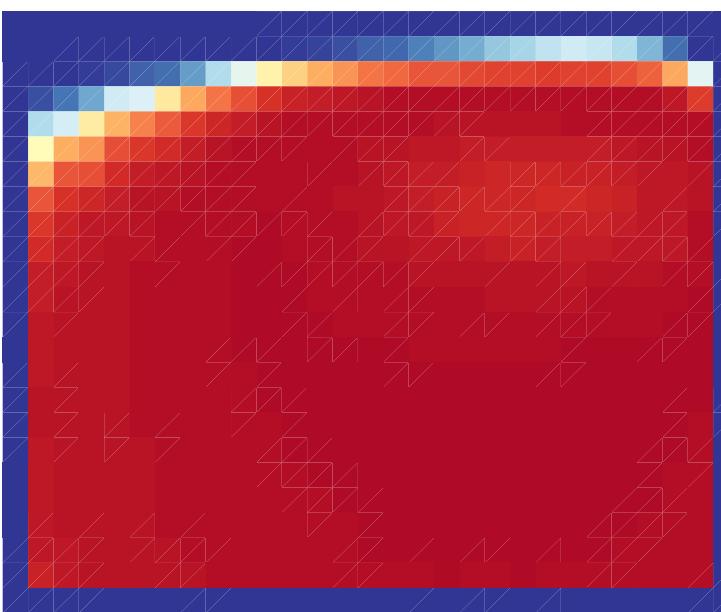
**PROPOSED
DESIGN
DAYLIGHT**
PHILADELPHIA, PA

ILLUMINANCE ASSUMPTION

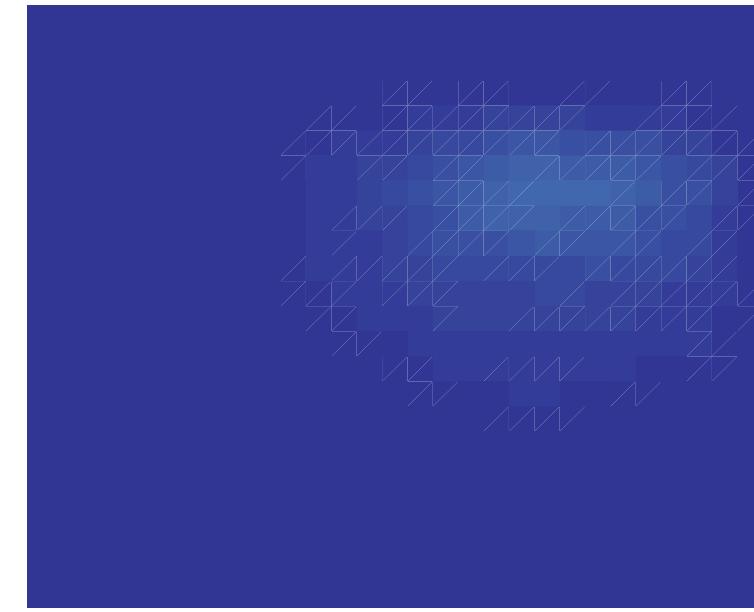
The diagram to the right is a quick sketch of the illuminance assumption for the space. There is abundance of light coming in during the day, but it does not evenly distribute throughout the room. It would be interesting to see what the results are in order to improve upon the current situation.



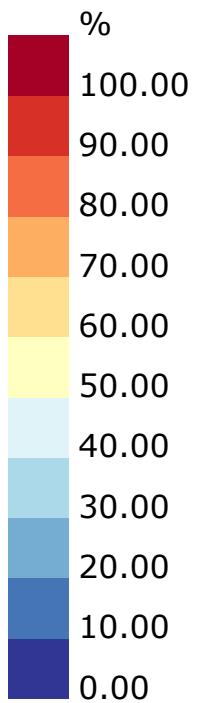
DAYLIGHT AUTONOMY (DLA)
300 LUX



USEFUL DAYLIGHT (UDLI)
100-2000 LUX



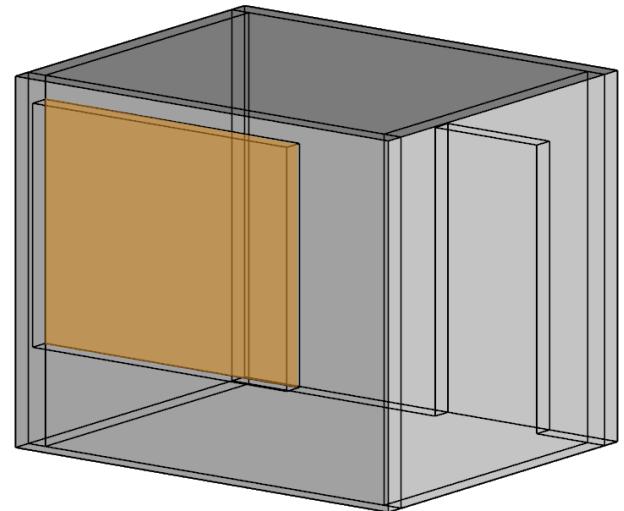
USEFUL DAYLIGHT (UDLI)
>2000 LUX



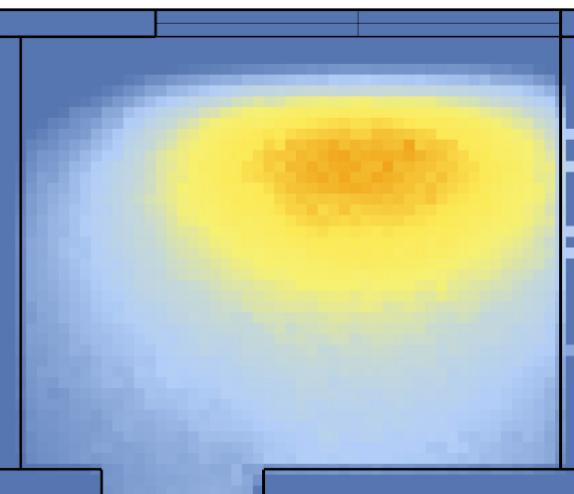
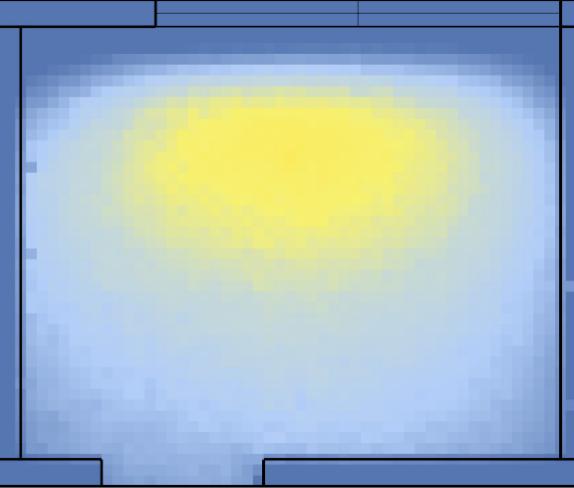
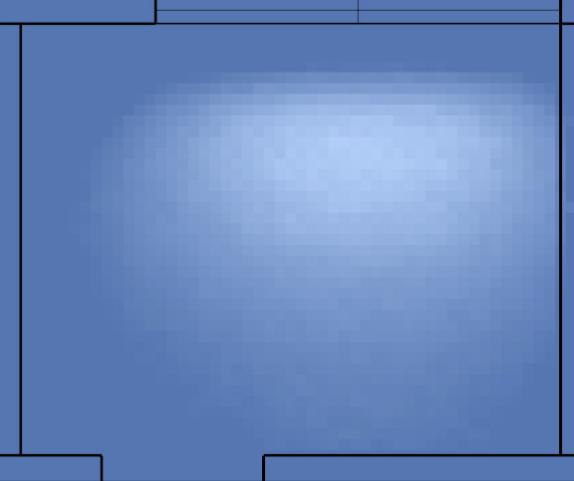
SDA (SPATIAL DAYLIGHT AUTONOMY):
76.79%

DAYLIGHT II

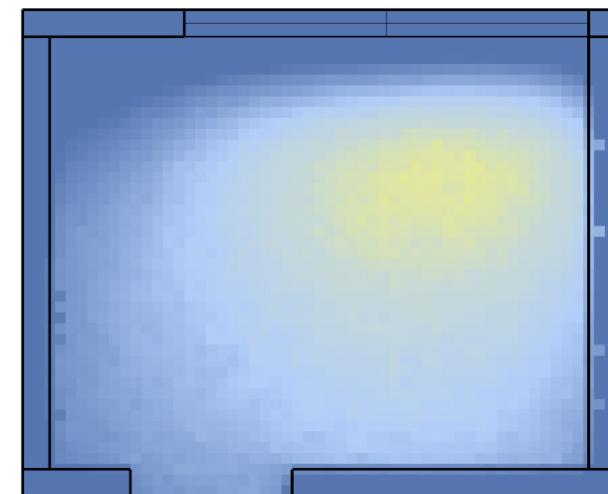
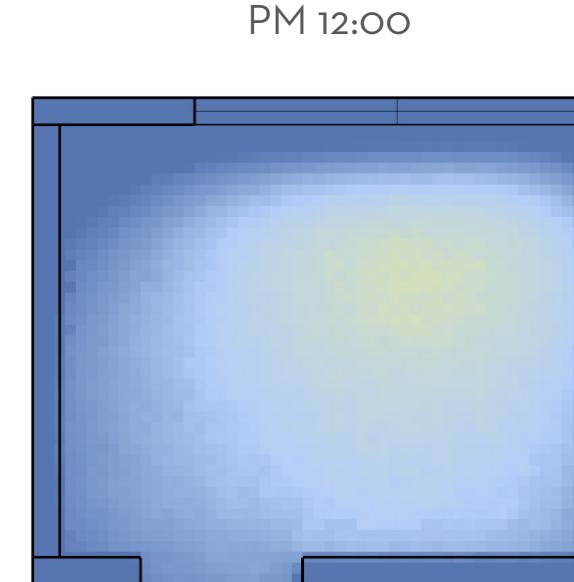
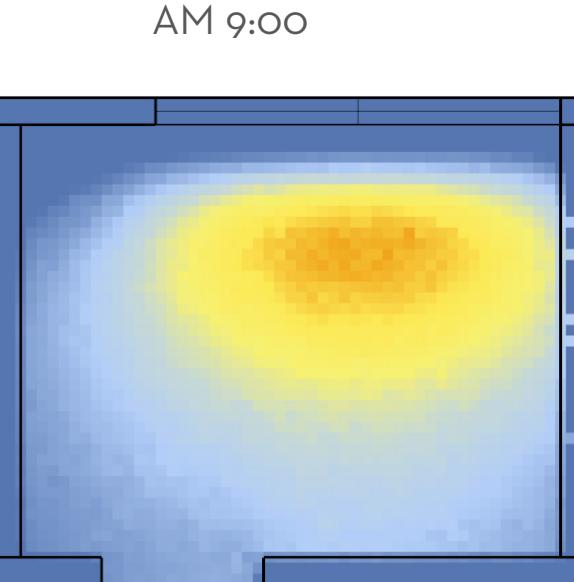
PHILADELPHIA, PA



JUN 21



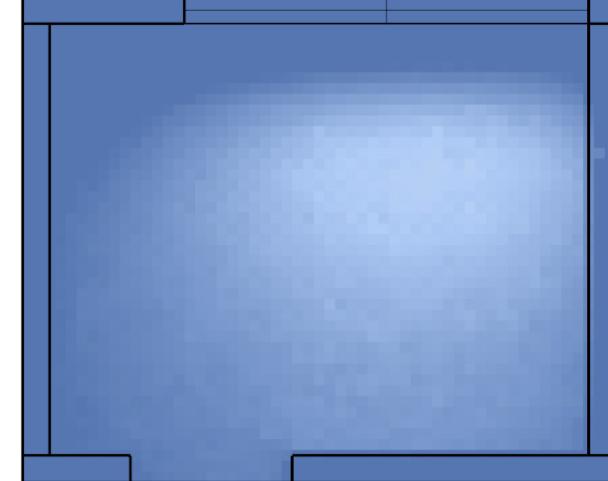
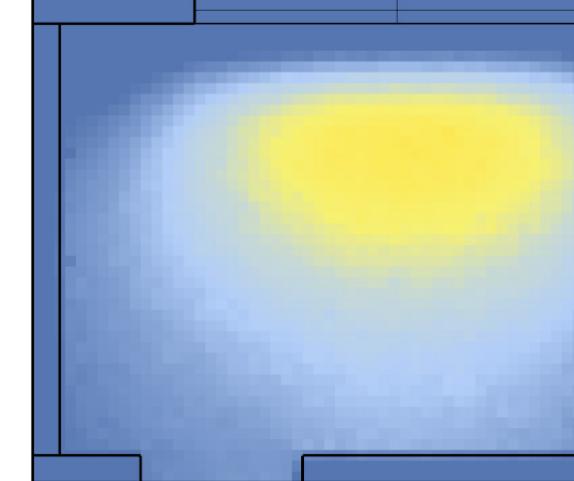
MARCH 21



ANALYSIS CONCLUSION

By enlarging the window in height and width, daylight has exponentially increased into the depths of the space.

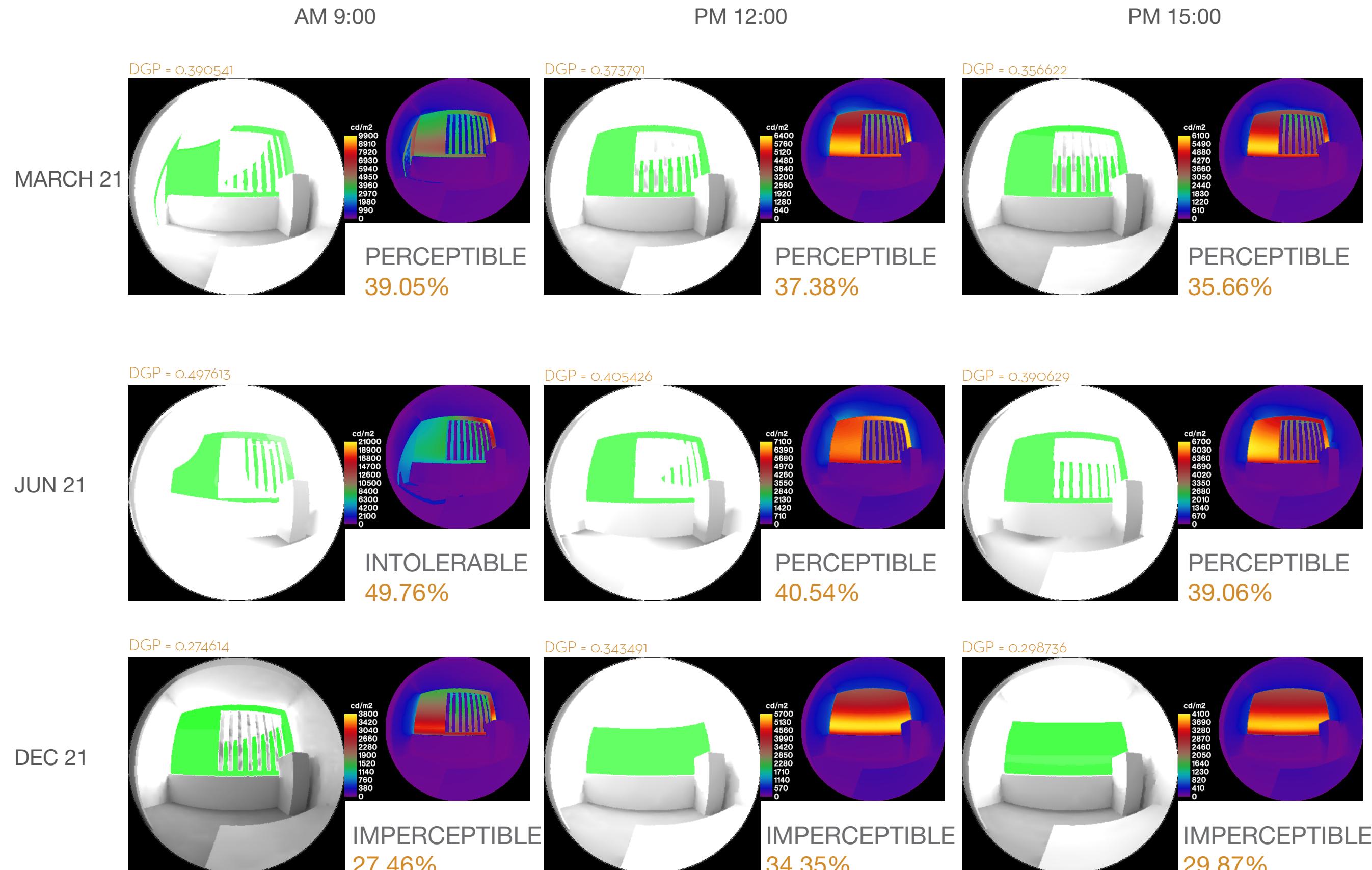
DEC 21



RE-DESIGNED GLARE ANALYSIS

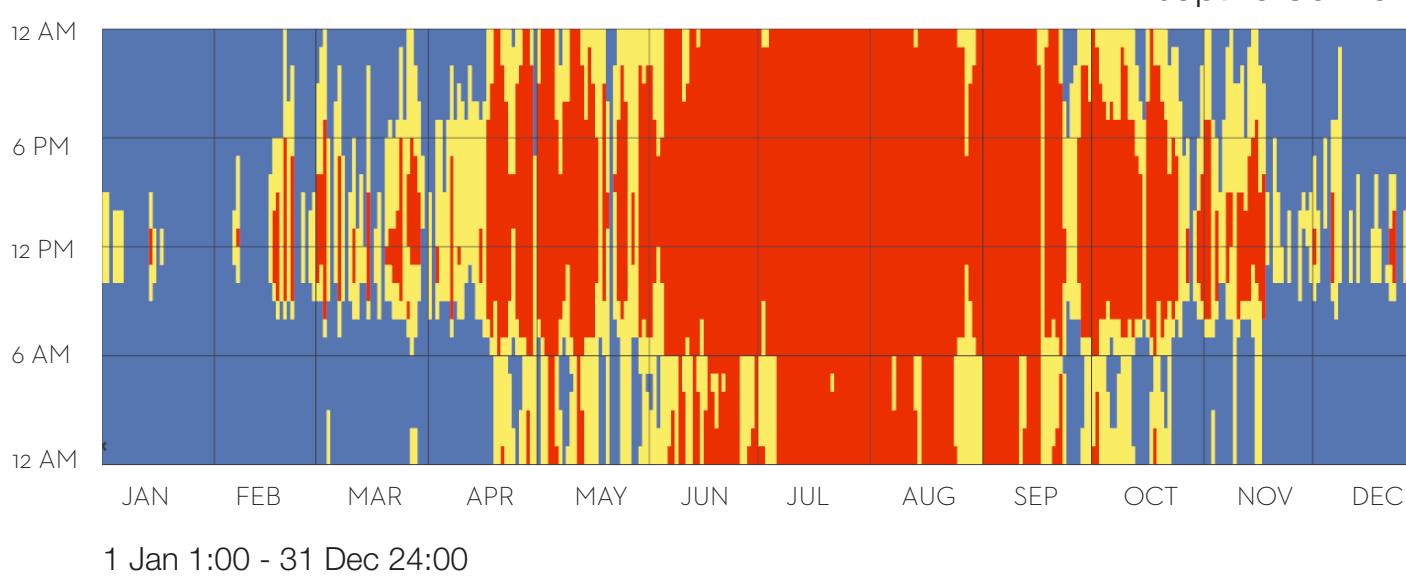
PHILADELPHIA, PA

The frames are representative of glares in March, June, and December. Since the summer months have more potential for glare, the analysis was tested for two summer months and one month in the winter.



ENERGY SIMULATION

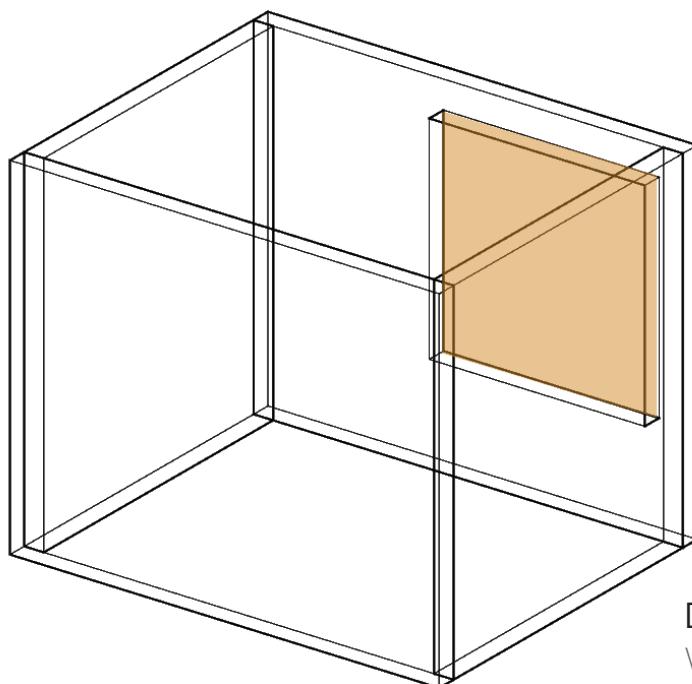
ORIGINAL ROOM
PHILADELPHIA, PA



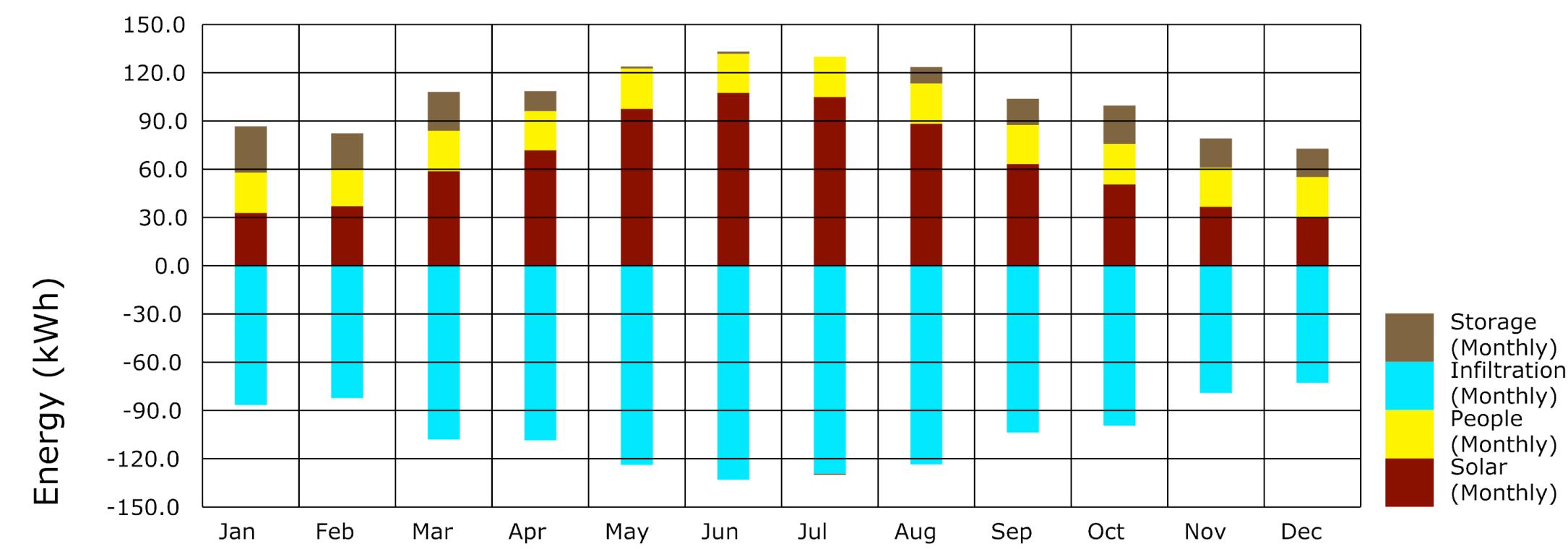
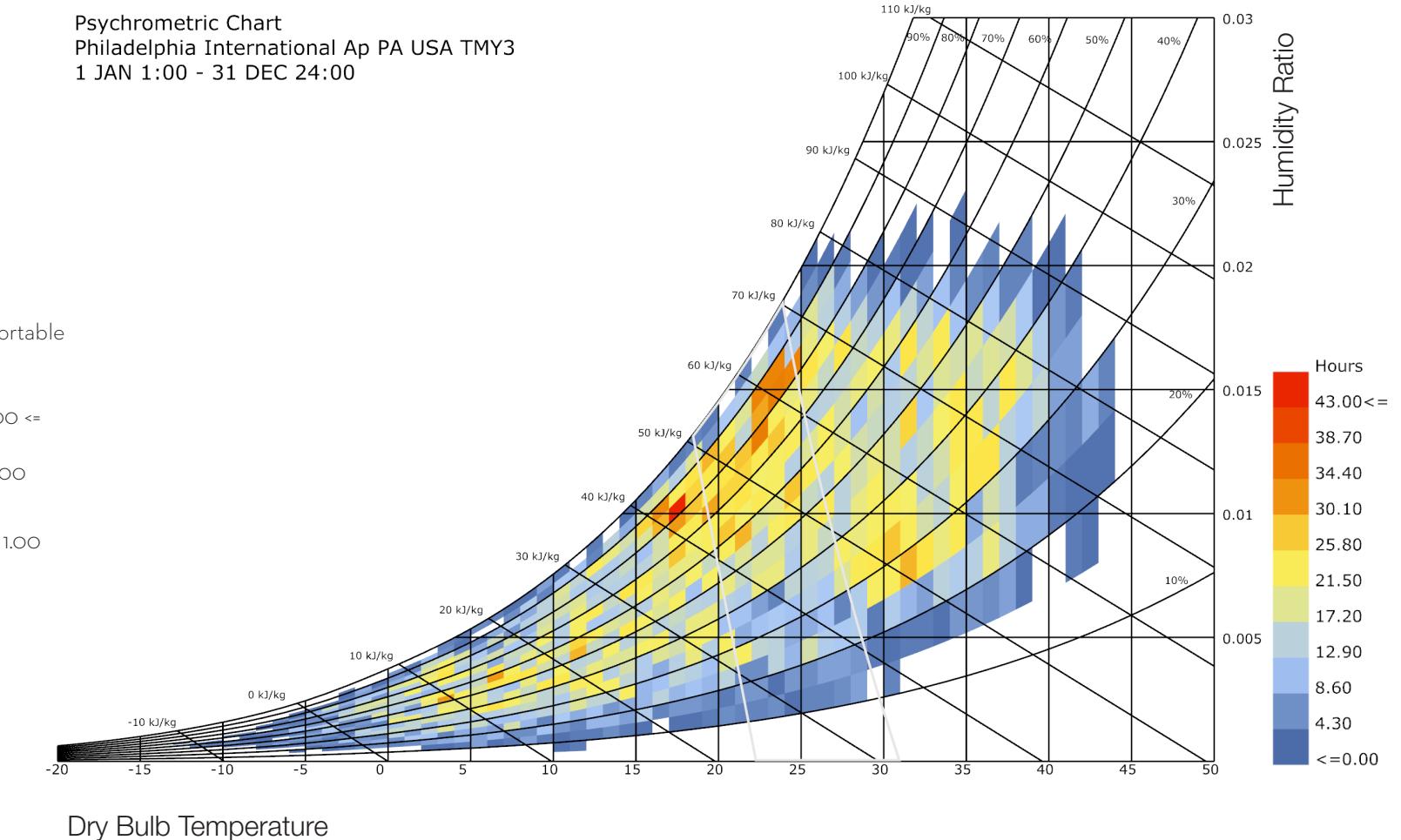
COMFORTABLE : 23.70%

HOT : 14.92%

COLD : 61.46%



Psychrometric Chart
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



BASE CASE DESIGN:

Design Challenge:

Though the space is fairly comfortable during occupied hours, there is tremendous amount of concentrated light that results to poorly distributed daylighting and glare beside the bed.

CHALLENGE:

**REDUCE GLARE
(40% OR MORE
“DISTURBING +
INTOLERABLE”)**

**BETTER DISTRIBUTE
DAYLIGHTING**

RE-DESIGN RESULT:

Design Result:

The larger window to wall ratio provided a more evenly distributed daylighting entering the space. With the re-design of a louver shading device, glare has been drastically reduced. However, additional passive methods could include tree coverage to further minimize glare. Since the north wall is the only wall that faces the outdoors, the proposed window to wall ratio (0.6) is the most advantageous without imposing on the closet space adjacent to the opening.

Though the window to wall ratio is larger in the new design, the amount of energy in the solar load is less than the base case design. The shading device has helped control the solar load while still allowing for better daylight.

ACHEIVEMENT:

**REDUCED GLARE
(<40% “PERCEPTIBLE
+ IMPERCEPTIBLE”)**

IMPROVED DAYLIGHTING