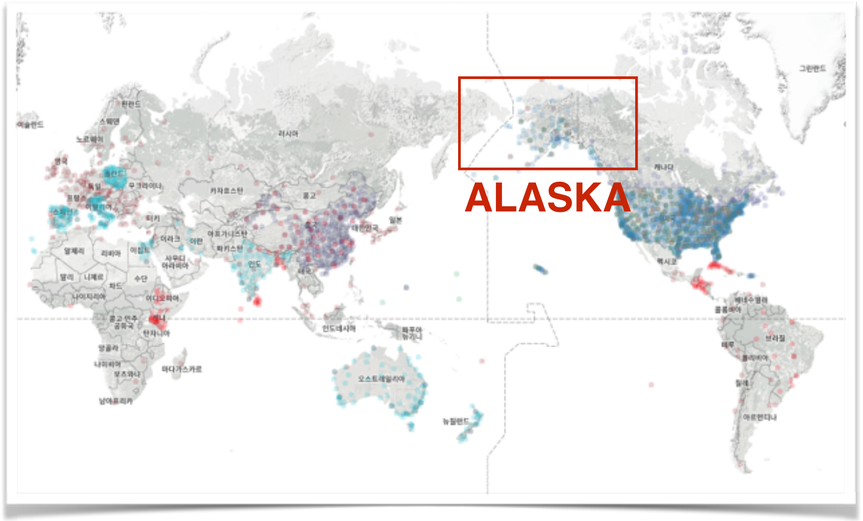
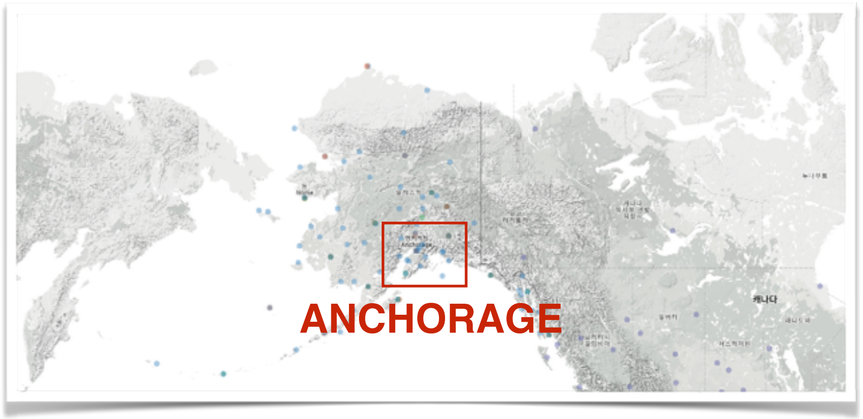
CLIMATE ANALYSIS

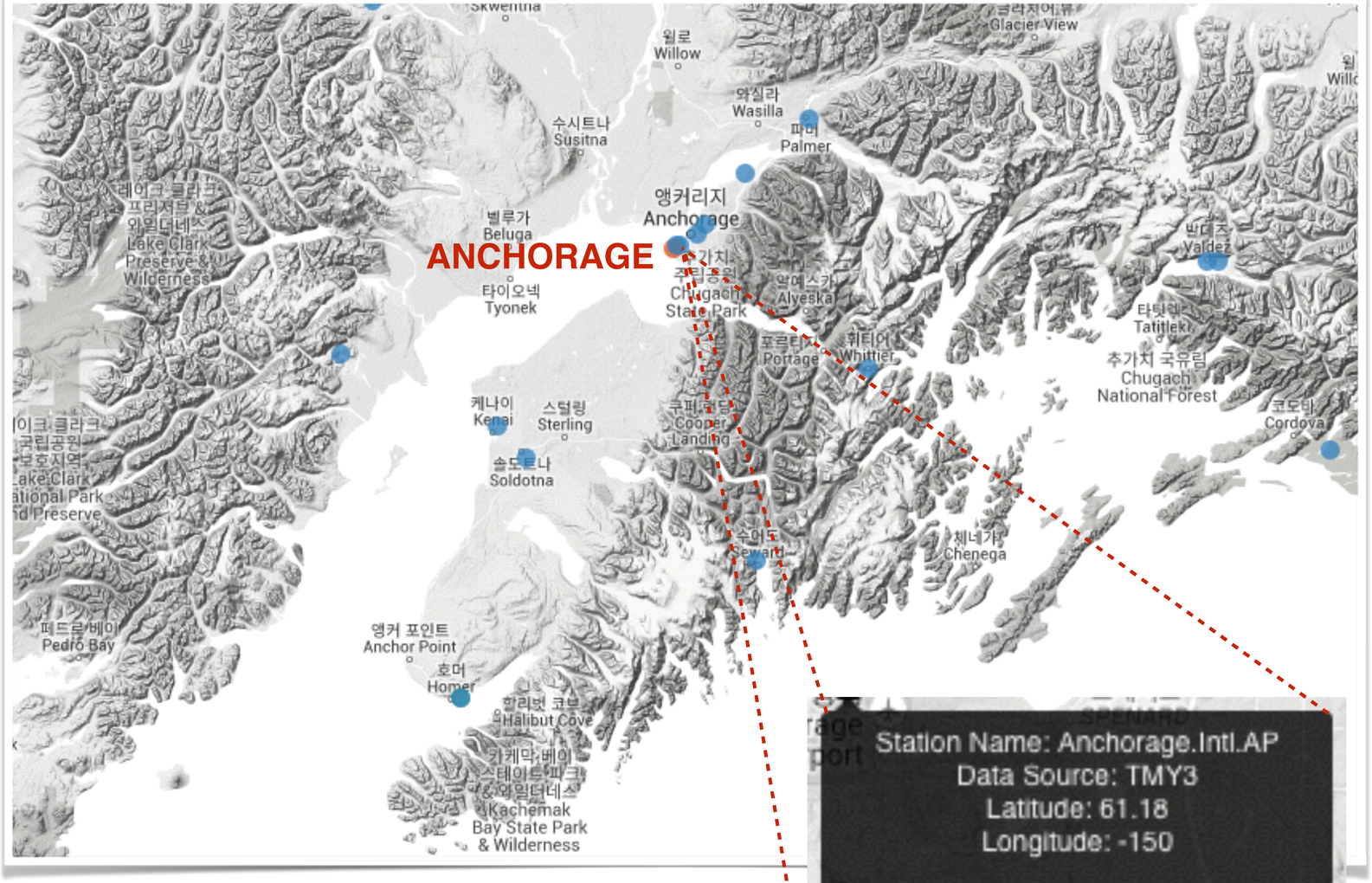
ANCHORAGE

ALASKA, US

09/28/2015 JEEEUN LEE







Station Name: Anchorage.Intl.AP
Data Source: TMY3
Latitude: 61.18
Longitude: -150

#Hours of Strong Cold Stress: 2127
#Hours of Moderate Cold Stress: 2913
#Hours of Slight Cold Stress: 2431
#Hours of Comfort: 1289
#Hours of Slight Heat Stress: 0
#Hours of Moderate Heat Stress: 0
#Hours of Strong Heat Stress: 0

ANCHORAGE

- **LOCATION** Anchorage International Airport
- **DATA SOURCE** TMY3
- **LATITUDE** 61.18°N
- **LONGITUDE** -150°
- **CLIMATE ZONE** Subarctic (50°~70°N)

CLIMATE ANALYSIS PROCESS
ANCHORAGE

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

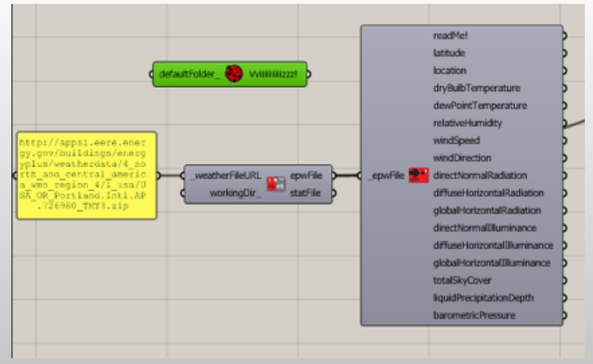
Beijing, China — Latitude: 40 — Longitude: -117 — Time Zone: -8 — 8760 Hours Weather

DOE Hourly Weather Data. Converted from NCDC Weather File

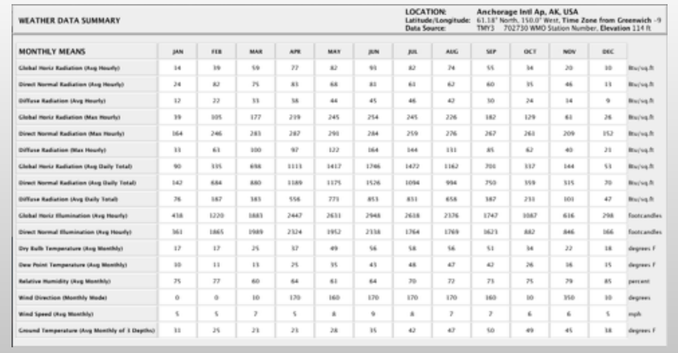
Hour of Year	Mon. No.	Day of Mon	Hour of Day	WB deg F	DB deg F	Atm Pr " Hg	Cloud Cover	Snow Flag	Rain Flag	Wind Dir.	Hum Rat lbs / lb	Density lbs/ft3	Enthalpy btu / lb	Solar Hor/it	Solar Direct	Cloud Type	Speed Knots	Calculated Dew Point	RH
		Mon	Day	t*	t	p	CC			D	W	D	H	Ish	Isd			M	%
1	1	1	1	14	17	30.3	0	0	0	0	0.0010	0.084	5.0	0	0	2	3	2	54
2	1	1	2	13	16	30.3	0	0	0	0	0.0011	0.084	5.0	0	0	2	3	0	53
3	1	1	3	15	16	30.3	0	0	0	0	0.0013	0.084	5.0	0	0	2	3	11	84
4	1	1	4	15	17	30.3	12	0	0	0	0.0013	0.084	5.5	0	2	2	3	7	69
5	1	1	5	15	16	30.3	0	0	0	0	0.0014	0.084	5.5	0	5	2	1	11	84
6	1	1	6	15	17	30.3	10	0	0	0	0.0014	0.084	5.5	0	3	2	1	7	69
7	1	1	7	15	17	30.3	0	0	0	0	0.0014	0.084	5.5	0	5	2	0	7	69
8	1	1	8	15	17	30.3	10	0	0	0	0.0013	0.084	5.5	0	3	2	2	7	69
9	1	1	9	16	18	30.3	4	0	0	0	0.0014	0.084	6.0	22	6	2	2	9	70
10	1	1	10	17	19	30.3	4	0	0	0	0.0014	0.084	6.0	51	6	2	1	10	71
11	1	1	11	18	20	30.3	4	0	0	0	0.0015	0.083	6.5	86	6	2	1	11	72
12	1	1	12	20	22	30.2	4	0	0	0	0.0016	0.083	7.0	75	6	2	1	14	74
13	1	1	13	21	23	30.2	4	0	0	0	0.0018	0.083	7.5	82	30	2	3	15	75
14	1	1	14	23	26	30.2	4	0	0	0	0.0017	0.082	8.0	90	90	2	6	15	65
15	1	1	15	22	26	30.1	10	0	0	0	0.0017	0.082	8.0	37	5	2	4	11	54
16	1	1	16	23	26	30.1	4	0	0	0	0.0018	0.082	8.0	13	6	2	4	15	66
17	1	1	17	21	26	30.1	4	0	0	0	0.0018	0.082	8.0	0	6	2	1	15	66

WEATHER DATA

epwmap



LADYBUG



WEATHER DATA SUMMARY — LOCATION: Anchorage Intl Ap, AK, USA — Latitude/Longitude: 61.18° North, 150.0° West, Time Zone from Greenwich -9 — Data Source: TMY3 702730 WMO Station Number, Elevation 114 ft

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	14	39	59	77	82	91	82	74	55	34	20	10	Btu/sq.ft
Direct Normal Radiation (Avg Hourly)	24	82	75	85	68	81	61	62	60	35	46	13	Btu/sq.ft
Diffuse Radiation (Avg Hourly)	12	22	33	58	44	45	46	42	30	24	14	9	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	39	105	177	219	245	254	245	226	182	129	83	26	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	164	246	283	287	291	284	259	276	267	261	209	152	Btu/sq.ft
Diffuse Radiation (Max Hourly)	33	63	100	97	122	164	144	131	85	62	40	21	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	90	335	698	1113	1417	1746	1472	1162	701	317	144	53	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	142	684	880	1189	1175	1526	1094	994	750	359	335	70	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	76	187	385	556	771	853	831	658	387	231	101	47	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	418	1220	1883	2447	2631	2948	2618	2376	1747	1087	616	298	footcandles
Direct Normal Illumination (Avg Hourly)	361	1865	1989	2324	1952	2138	1764	1769	1623	882	846	166	footcandles
Dry Bulb Temperature (Avg Monthly)	17	17	25	37	49	56	58	56	51	34	22	18	degrees F
Dew Point Temperature (Avg Monthly)	10	11	13	25	35	43	48	47	42	26	16	15	degrees F
Relative Humidity (Avg Monthly)	75	77	60	64	61	64	70	72	73	75	79	85	percent
Wind Direction (Monthly Mode)	0	0	10	170	160	170	170	170	160	10	350	10	degrees
Wind Speed (Avg Monthly)	5	5	7	5	8	9	8	7	7	6	6	5	mph
Ground Temperature (Avg Monthly of 1 Depths)	11	25	23	21	28	35	42	47	50	49	45	38	degrees F

CLIMATE CONSULTANT

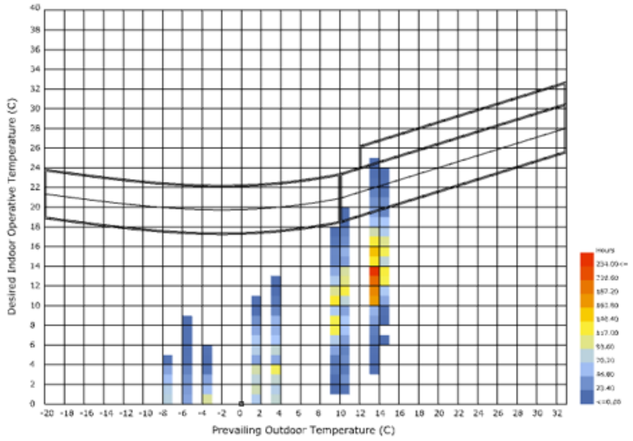
PROGRAM

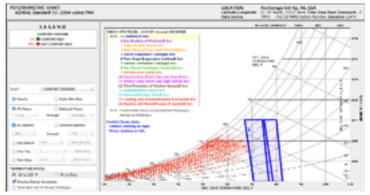
- Dry Bulb Temperature
- Dew Point Temperature
- Relative Humidity
- Wind Direction
- Wind Speed
- Ground Temperature
- Sky Cover
- Global Horizontal Radiation
- Direct Normal Radiation
- Diffuse Radiation
- …

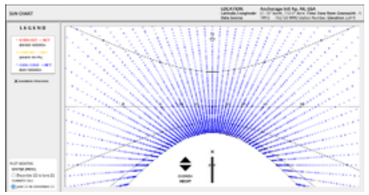
CLIMATE DATA

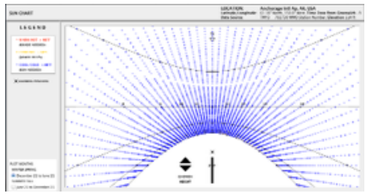
CLIMATE ANALYSIS DATA
ANCHORAGE

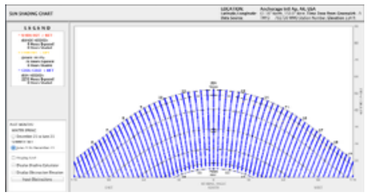
FROM LADYBUG + CLIMATE CONSULTANT

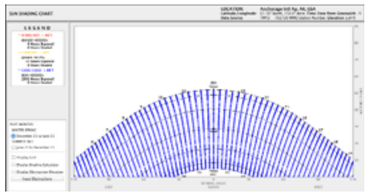


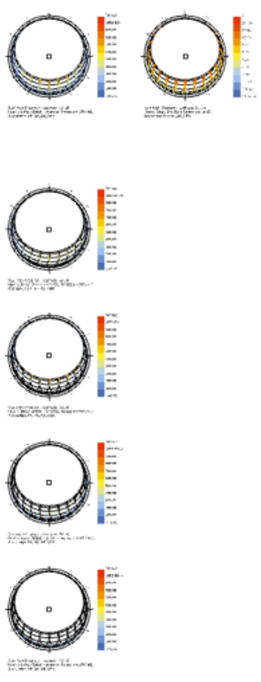


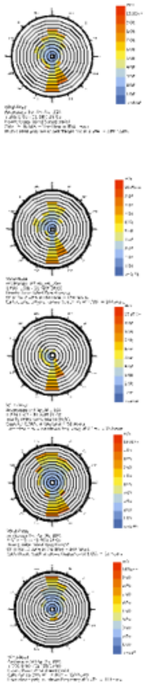


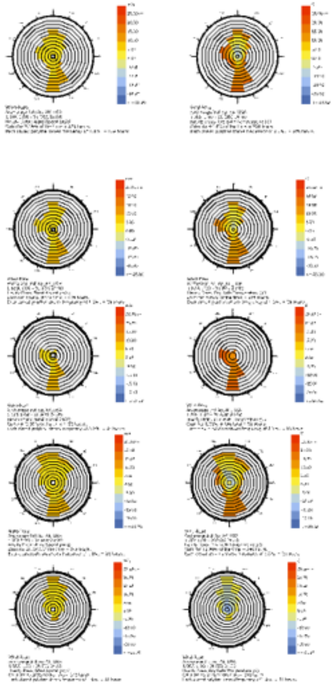


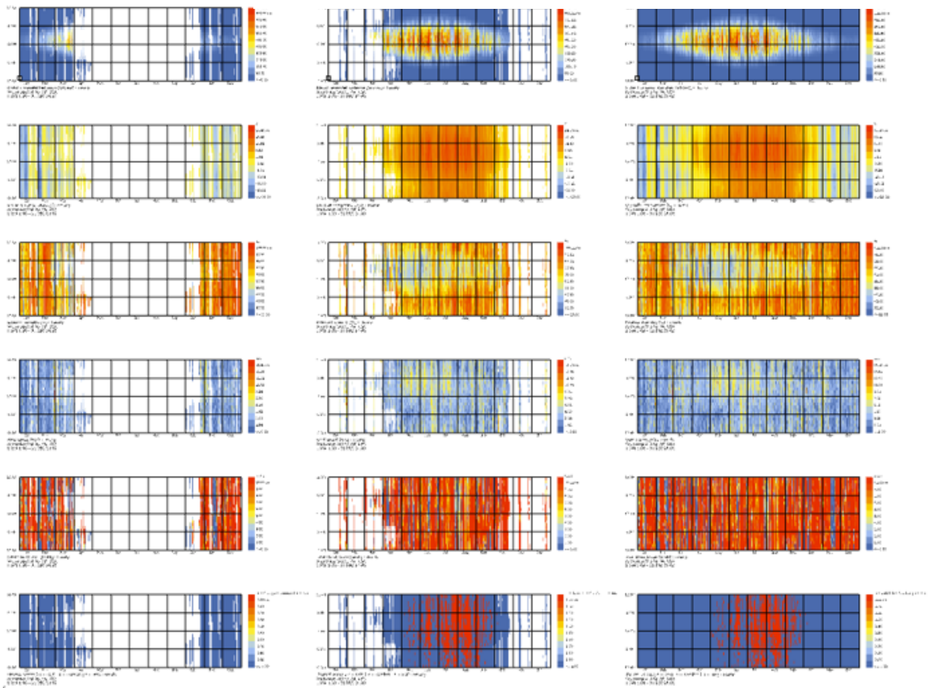










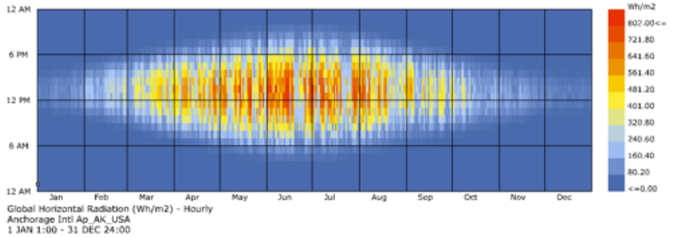


CLIMATE ANALYSIS of DATA
ANCHORAGE

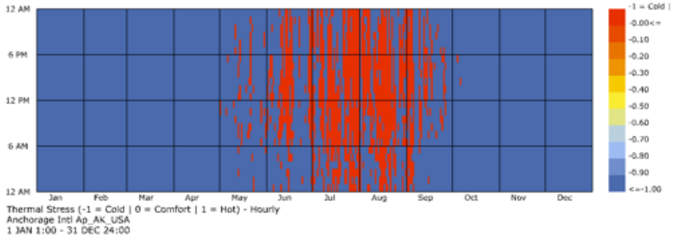
[OVERVIEW; COMFORT]

Since Anchorage is in high-latitude area, the temperature is extremely low, especially during the winter time. Except few days in summer, the temperature is mostly below the adaptive thermal comfort zone.

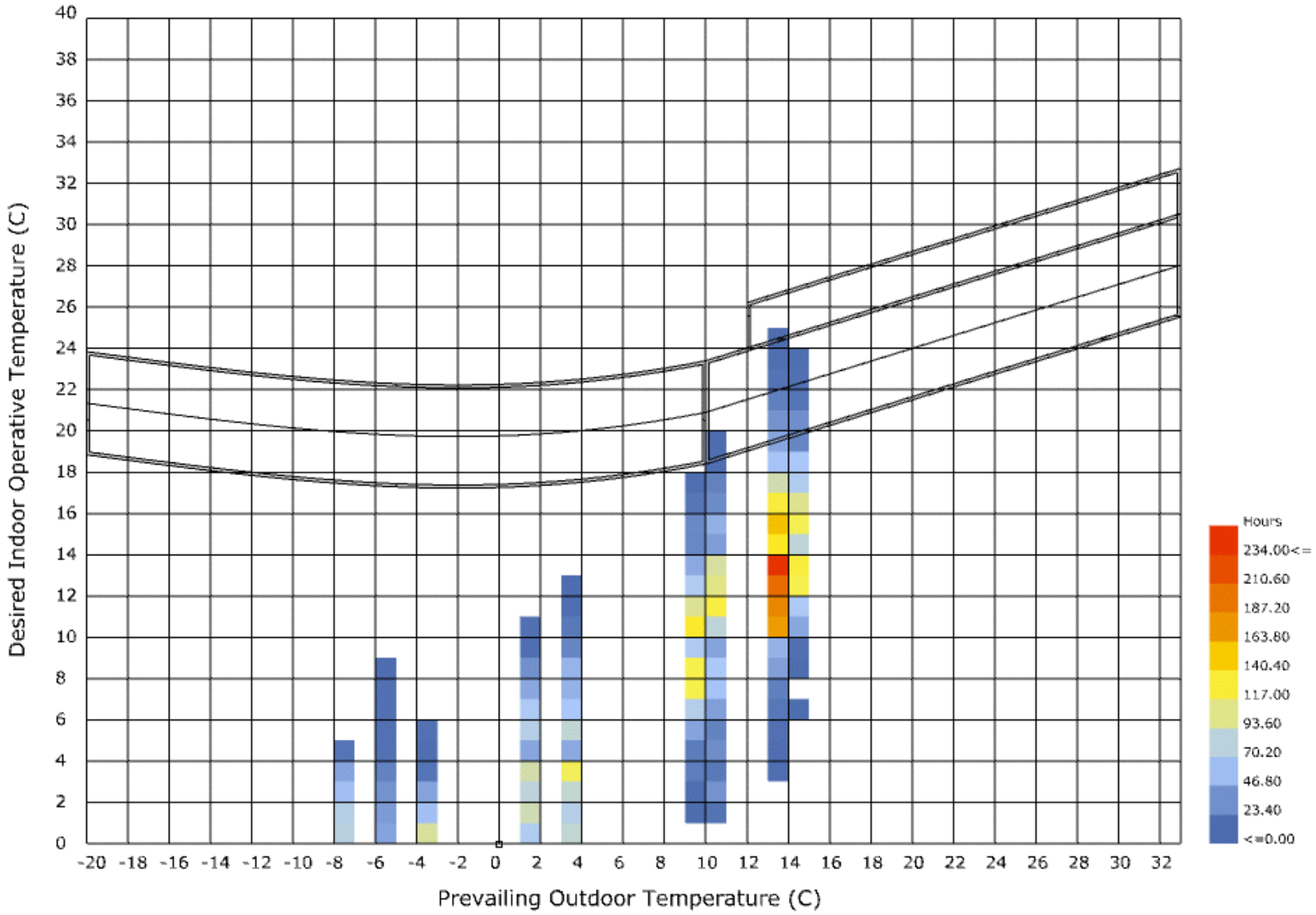
Due to the high latitude, the radiation varies a lot depending on the month of the year. Most of the time, the radiation is lacked so it gives a lot of cold stress.



Global Horizontal Radiation (Wh/m2) - Hourly
Anchorage Intl Ap_AK_USA
1 JAN 1:00 - 31 DEC 24:00



Thermal Stress (-1 = Cold | 0 = Comfort | 1 = Hot) - Hourly
Anchorage Intl Ap_AK_USA
1 JAN 1:00 - 31 DEC 24:00

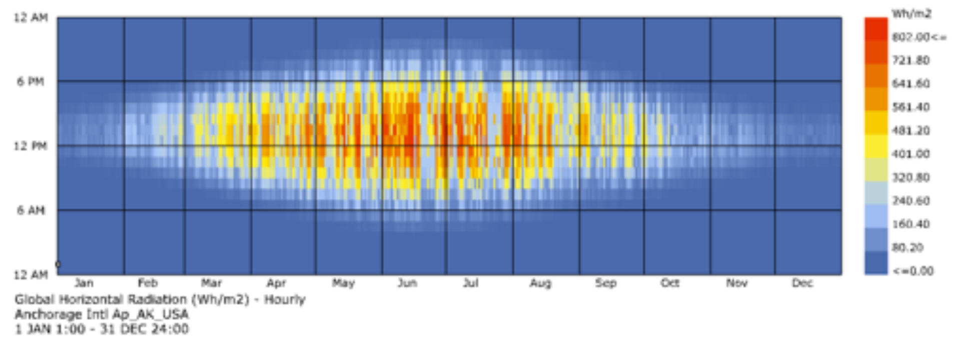
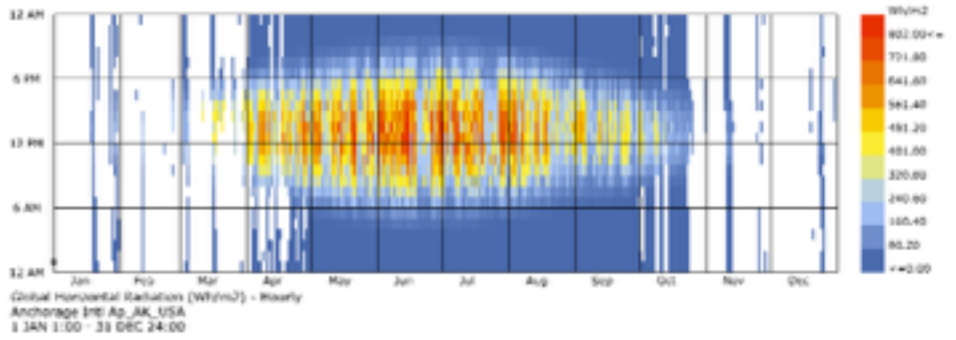


Adaptive Chart
Anchorage Intl Ap_AK_USA
1 JAN 1:00 - 31 DEC 24:00

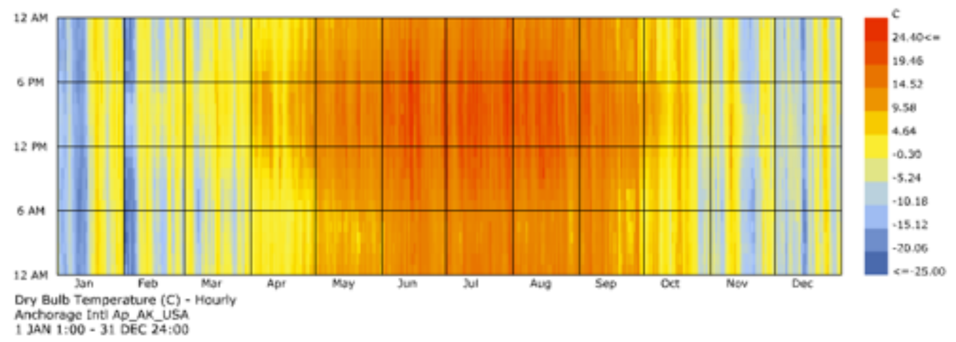
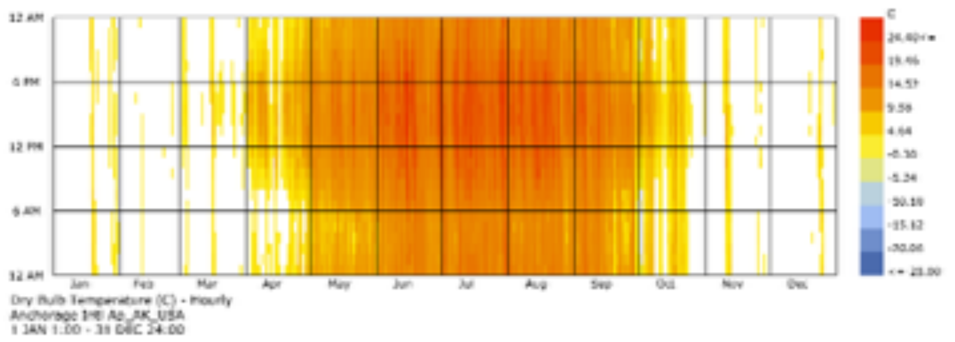
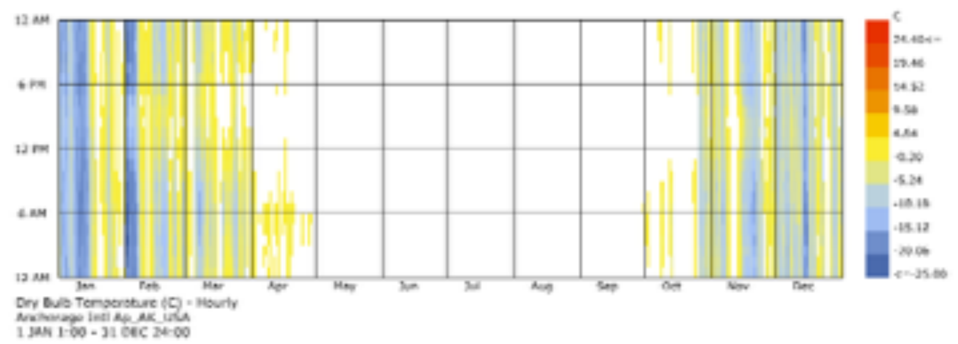
CLIMATE ANALYSIS of DATA
ANCHORAGE

[ABOVE 0°C] [BELOW 0°C]

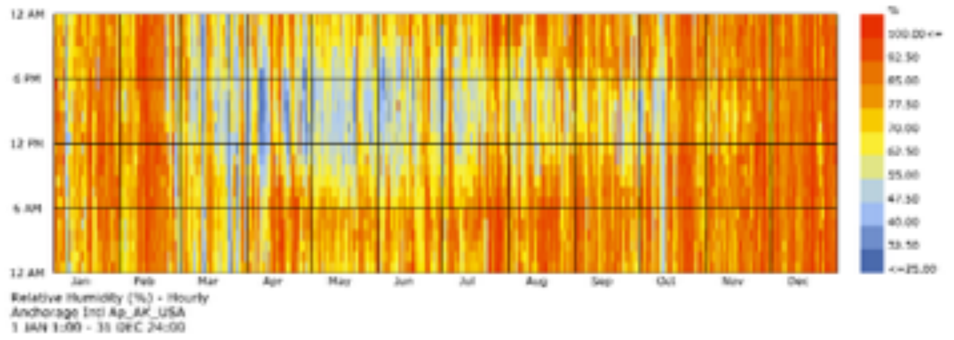
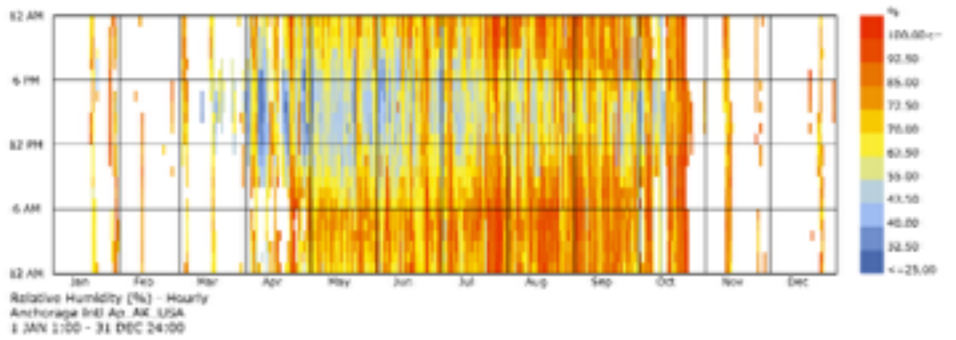
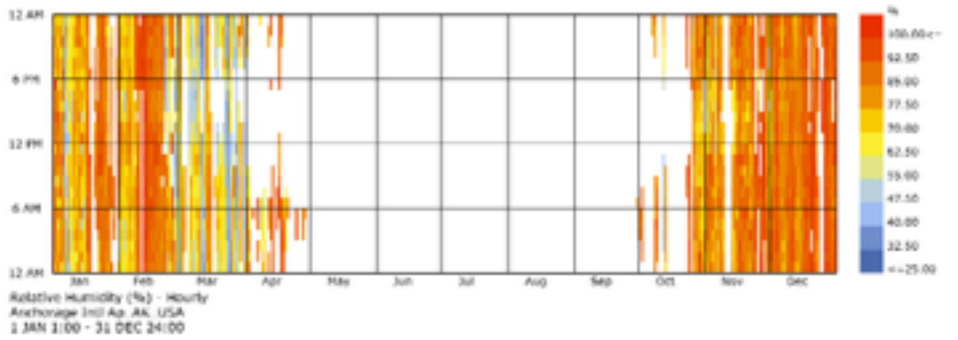
[RADIATION]

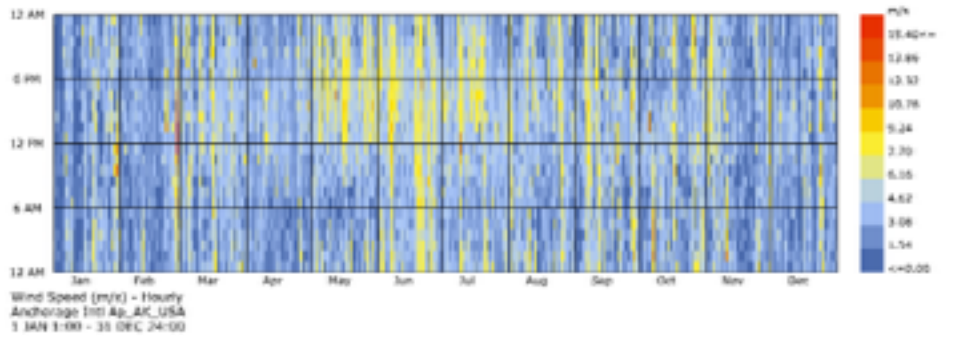
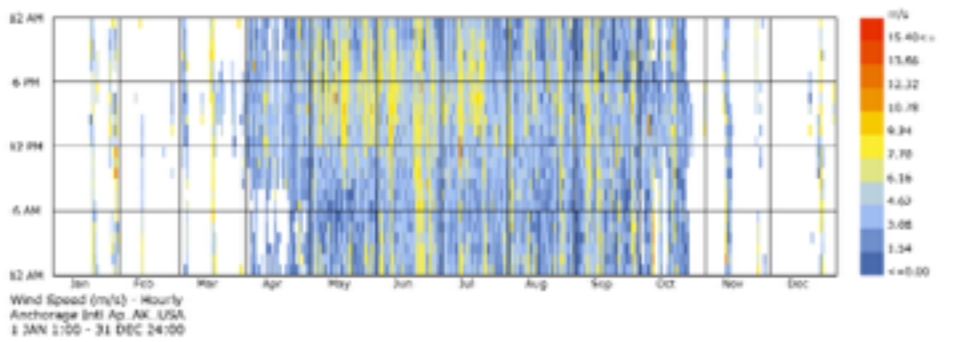

[TEMPERATURE]

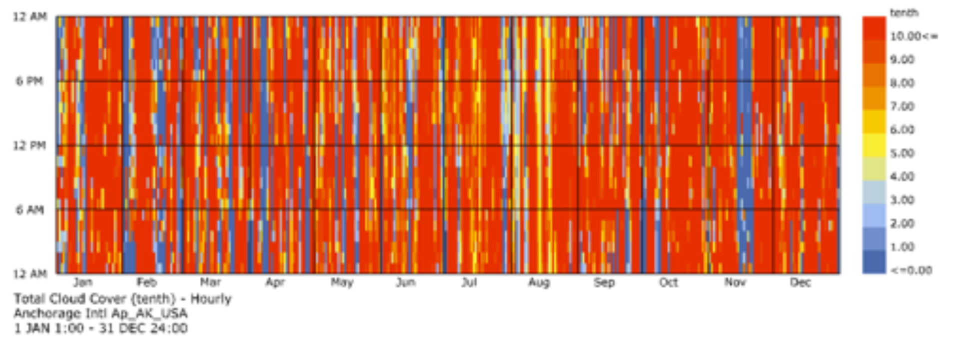
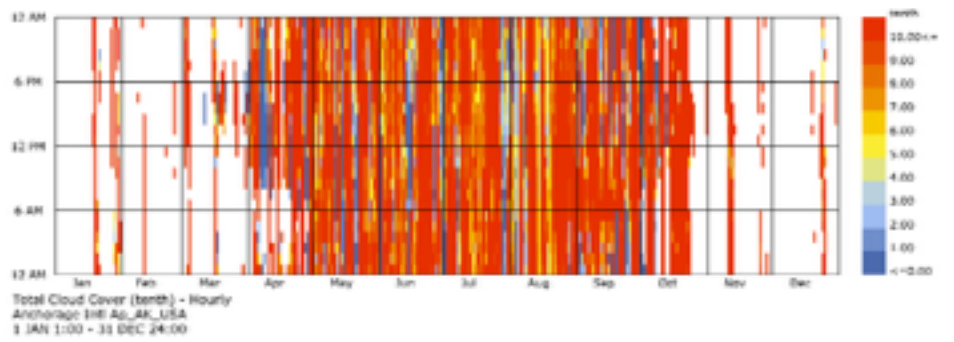
[RELATIVE HUMIDITY]

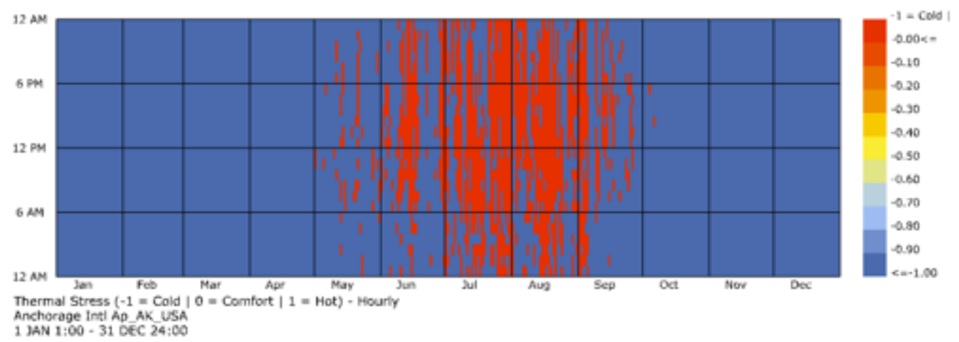
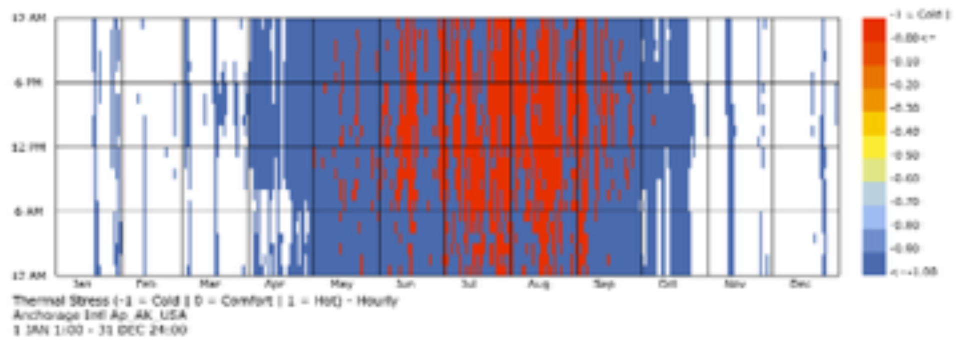
[WIND SPEED]


[CLOUD COVER]


[THERMAL STRESS]

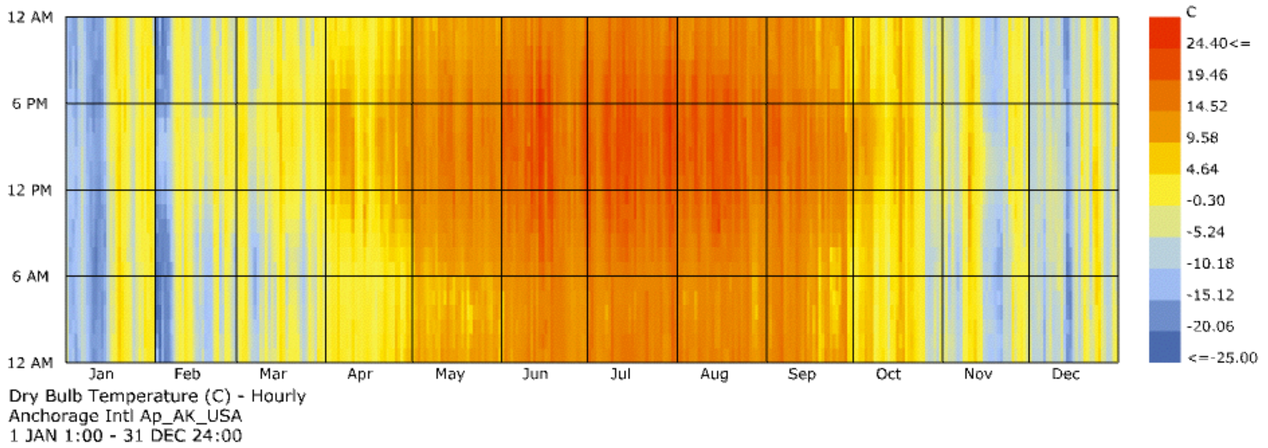




CLIMATE ANALYSIS of DATA
ANCHORAGE

[TEMPERATURE]

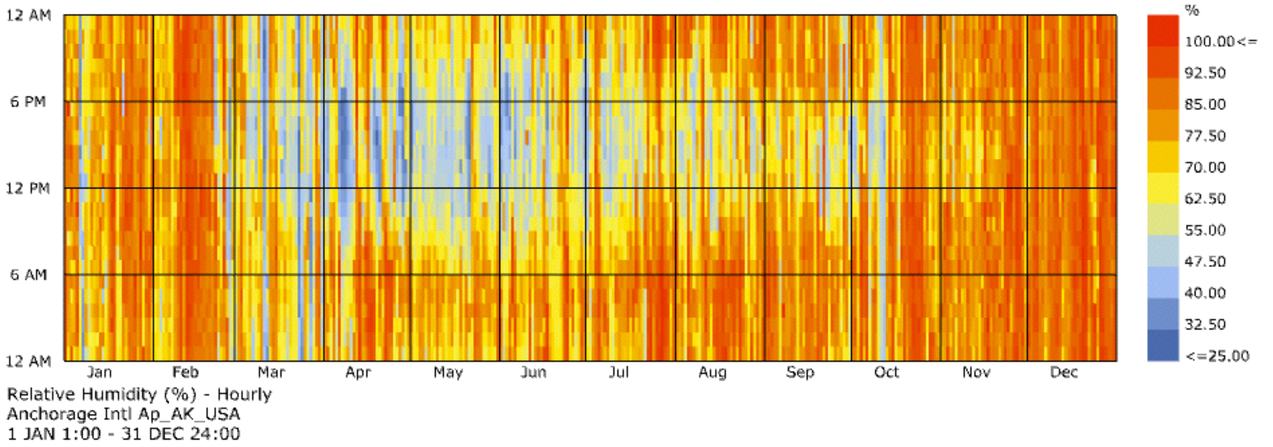
The dry bulb temperature of Anchorage has a range from -25°C to +25°C. During the summer time, from June to August, the temperature seems comfortable for people living here, but during the winter time, from December to February, it is extremely cold outside for human.

Not only for the human comfort but also for surviving there, the weather requires special design solutions over all.



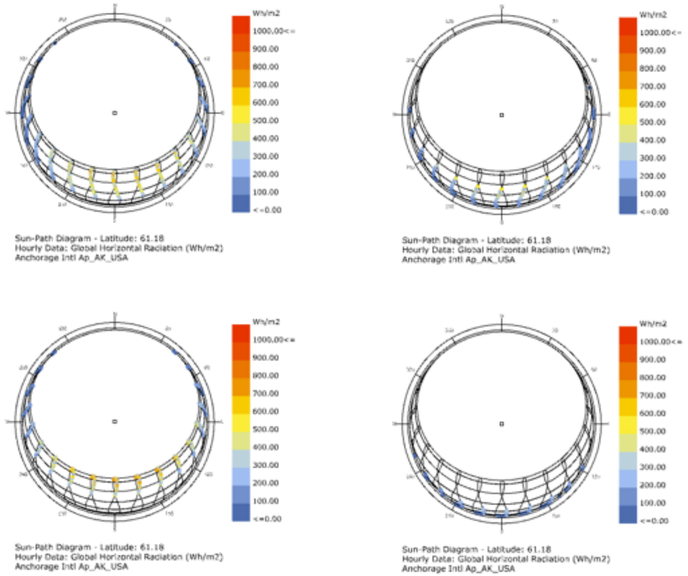
[HUMIDITY]

This graph shows that this city is pretty humid, even though it's in Subarctic area, which is usually considered dry climate. The humidity is higher during the night time than during the day time. The humidity might have caused by the geographical condition, because this city is just surrounded by the ocean and icecaps.



CLIMATE ANALYSIS of DATA
ANCHORAGE

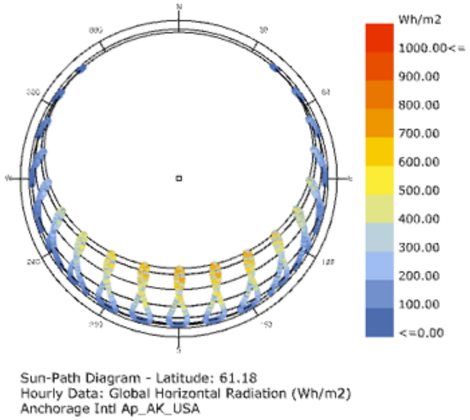
[SUN PATH]



The sun path in Anchorage is extremely low, meaning that the winter is much longer than its summer and it brings shortage of sunlight in this area.

Since the radiation from sunlight is one of the main sources that determines air temperature, it is related to the low temperature.

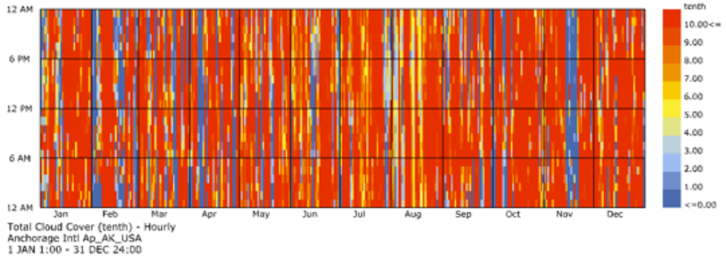
[RADIATION]



The radiation significantly fluctuates between summer and winter. Approximately the radiation in June is more than 10 times stronger than its in December.

In general, this means that different strategy will be needed for different seasons, to make balance in thermal condition. However in this area even summer doesn't have any heat stress, so maximizing daylighting in winter will be enough; minimizing it in summer is not needed.

[SKY COVER]

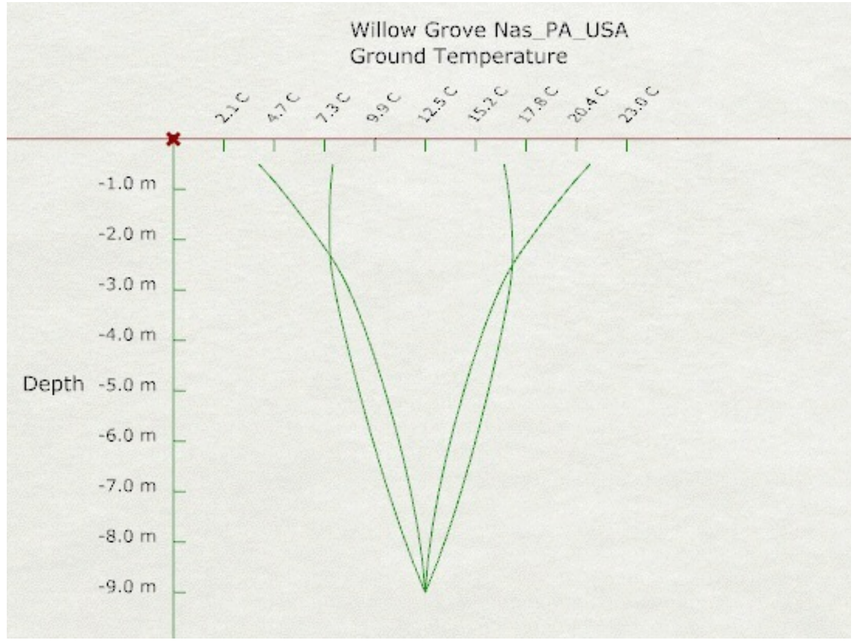


From this graph, the sky seems covered with cloud a lot. It might be relative to the high humidity.

This city doesn't have enough sunlight already, so the sunlight coming to indoor might be more limited, compare to the other region on the same latitude.

CLIMATE ANALYSIS of DATA
ANCHORAGE

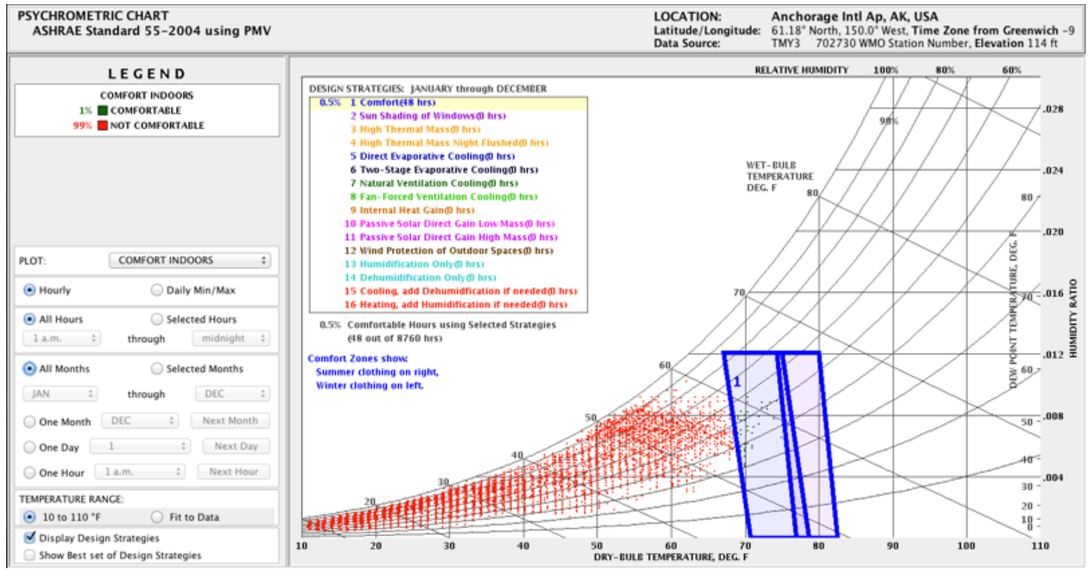
[GROUND TEMPERATURE]



This graph represents monthly data of ground temperature at three different depth; 1.64 ft, 6.56 ft and 13.12 ft. Compare to the extremely cold temperature in this city, the underground temperature is much warmer.

It shows a potential to build a strategy that using underground will allow the building to receive heat from the ground. It will be more helpful during the winter. For example, in December ground temperature has a range between 30~40°F (about 0~5°C), while the outdoor temperature is about 18°F (-7°C) in average.

[PSYCHROMETRIC CHART]

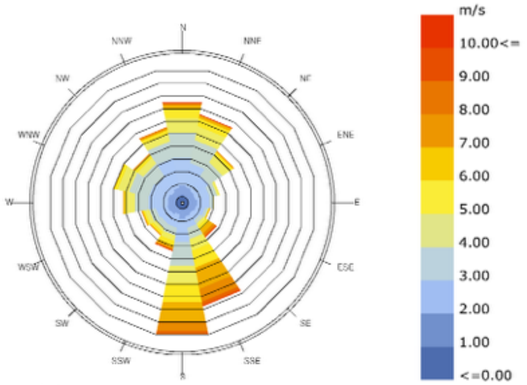


The red dots in the graph represents each hours' dry and wet bulb temperature, and humidity ratio. According to ASHRAE Standard 55's comport condition, people in Anchorage would feel comfortable only for 1% hours out of 8660 hours.

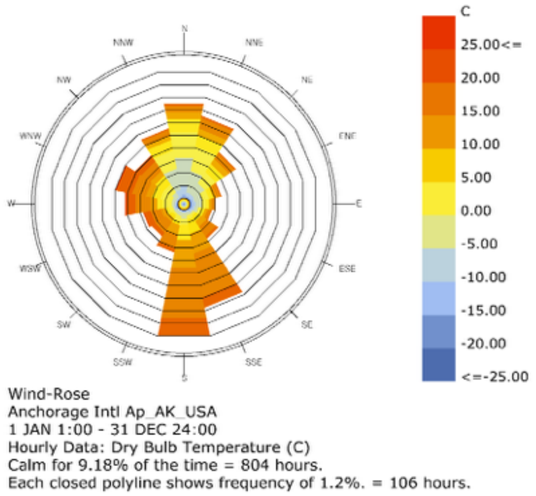
With passive and active design strategy, the area of the comfort zone can be increased.

CLIMATE ANALYSIS of DATA
ANCHORAGE

[WIND]



a. WIND SPEED



b. DRY BULB TEMPERATURE

The wind in Anchorage is mostly blown from South and North direction, other than West or East. The wind from South brings warmer air than its from North. The wind from North brings more moisture to the city than that from South does.

For further analysis, seasonal data will be helpful to understand the characteristics of wind in this area. The summer wind is mostly coming from South with warm air, which means it is welcome for this cold area. In contrast, during the winter the wind comes from North with cold air and a lot of moisture together.

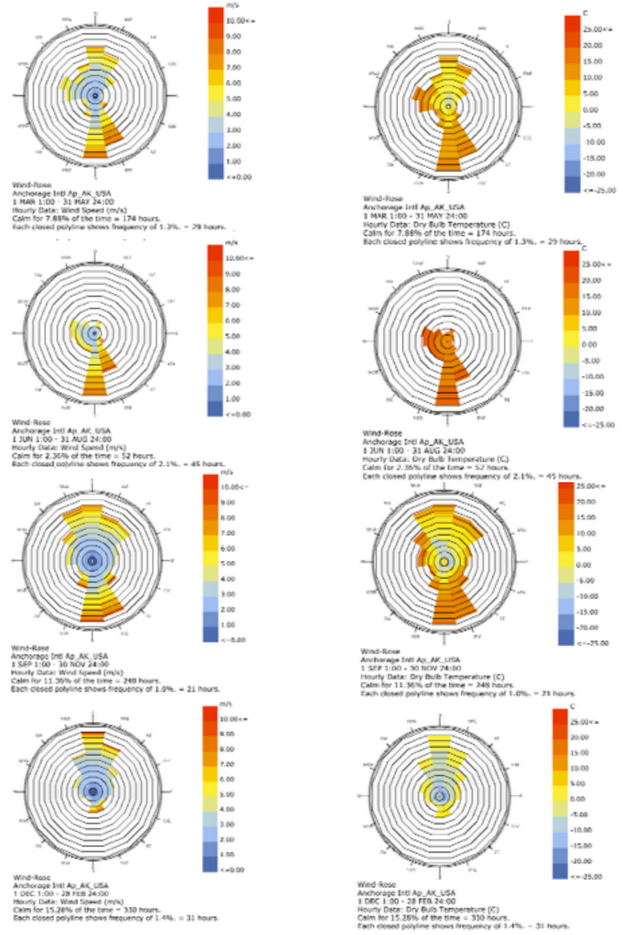
[WIND - BY SEASON]

SPRING

SUMMER

FALL

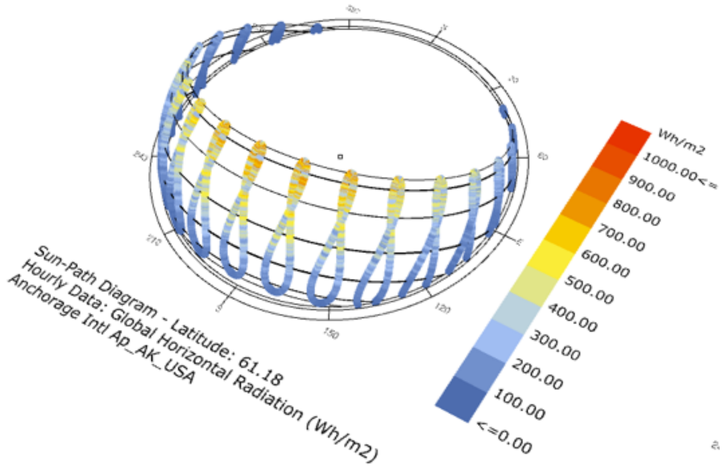
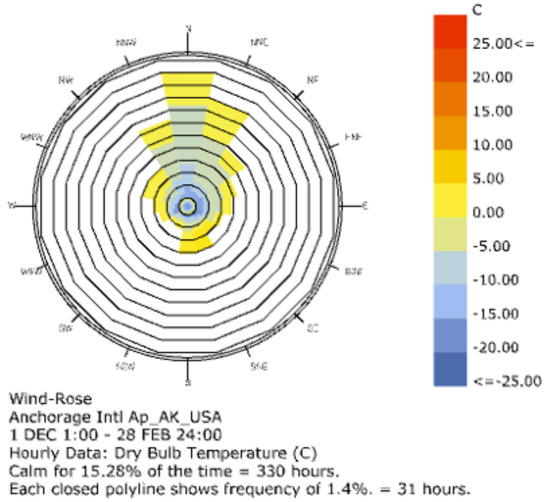
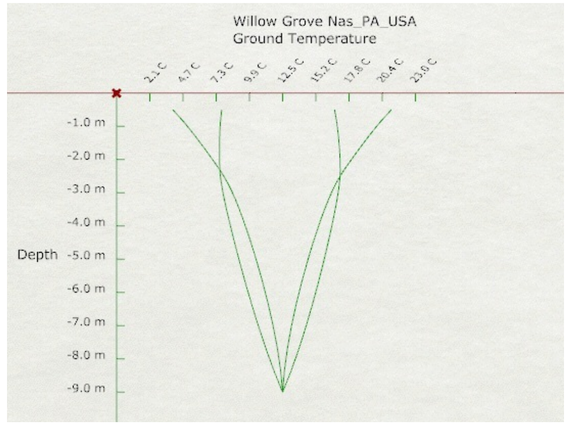
WINTER



a b

CLIMATE ANALYSIS of DATA
ANCHORAGE

[SUMMARY]

	1	2	3
			
ANALYSIS	SHORTAGE OF SUNLIGHT	COLD WIND FROM NORTH	LOW AIR TEMPERATURE + WARM GROUND TEMP.
DESIGN RECOMMENDATION	MAXIMIZE DAYLIGHTING FROM SOUTH	HEAVY INSULATION ON NORTH	USE UNDERGROUND

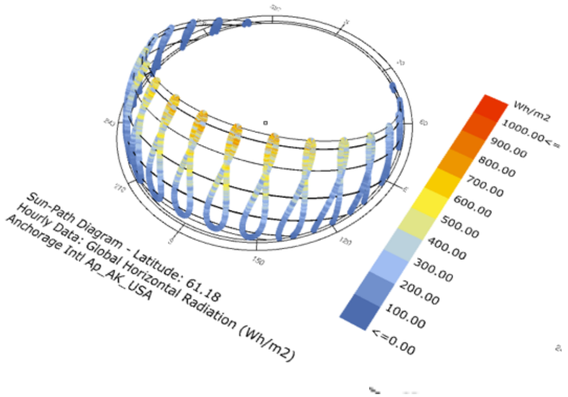
CLIMATE ANALYSIS DESIGN RECOMMENDATION
ANCHORAGE

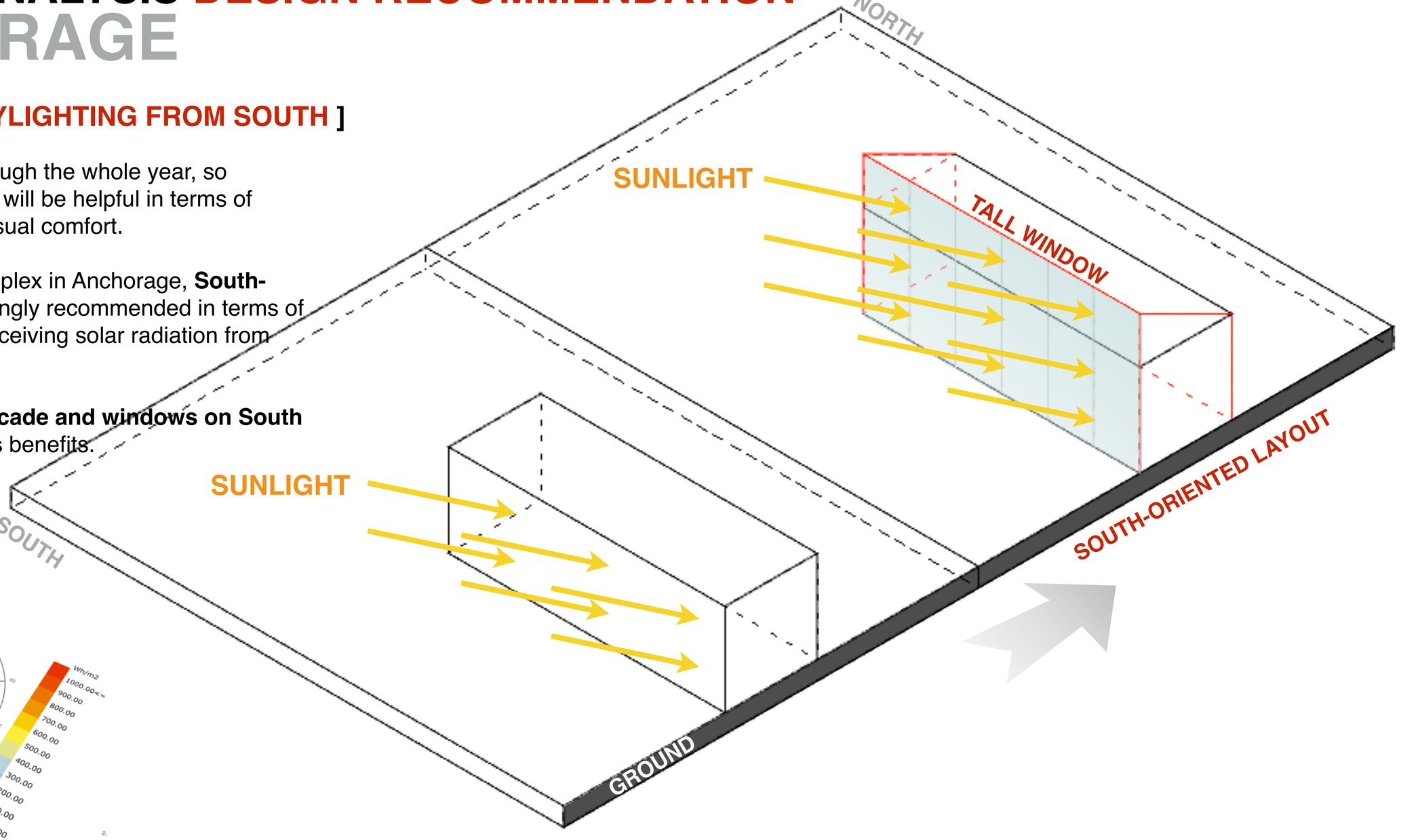
[1 MAXIMIZE DAYLIGHTING FROM SOUTH]

The sunlight is lack though the whole year, so maximizing daylighting will be helpful in terms of thermal comfort and visual comfort.

For the mixed-use complex in Anchorage, **South-oriented layout** is strongly recommended in terms of maximizing the area receiving solar radiation from South.

On top of this, **taller facade and windows on South** will amplify this layout's benefits.



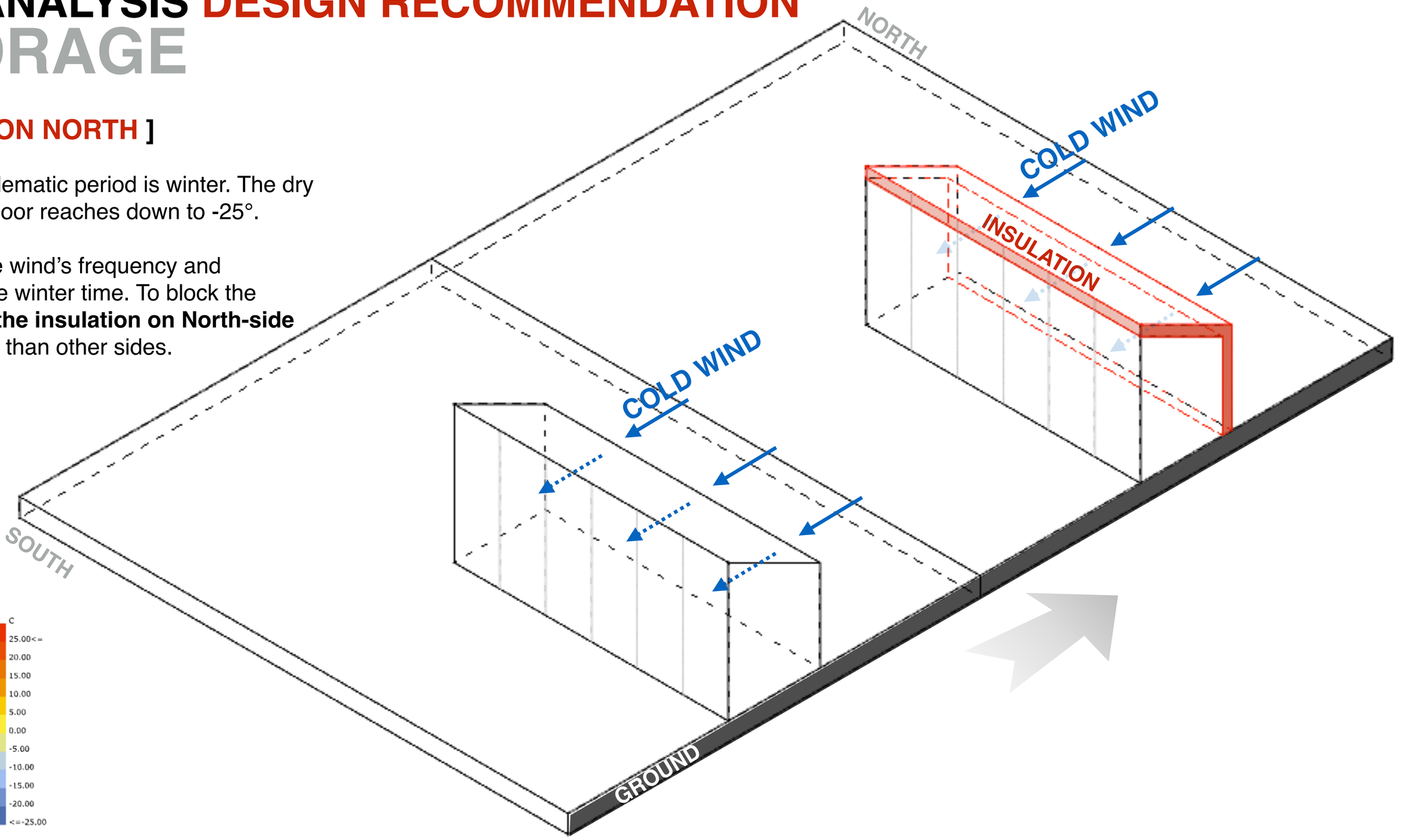


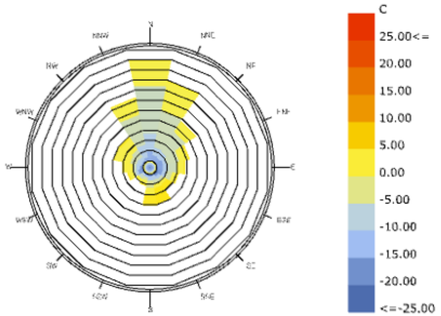
CLIMATE ANALYSIS DESIGN RECOMMENDATION
ANCHORAGE

[2 INSULATION ON NORTH]

This area's most problematic period is winter. The dry bulb temperature outdoor reaches down to -25°.

It seems related to the wind's frequency and temperature during the winter time. To block the coldness from North, **the insulation on North-side wall** should be thicker than other sides.





Wind-Rose
Anchorage Intl Ap_AK_USA
1 DEC 1:00 - 28 FEB 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 15.28% of the time = 330 hours.
Each closed polyline shows frequency of 1.4%. = 31 hours.

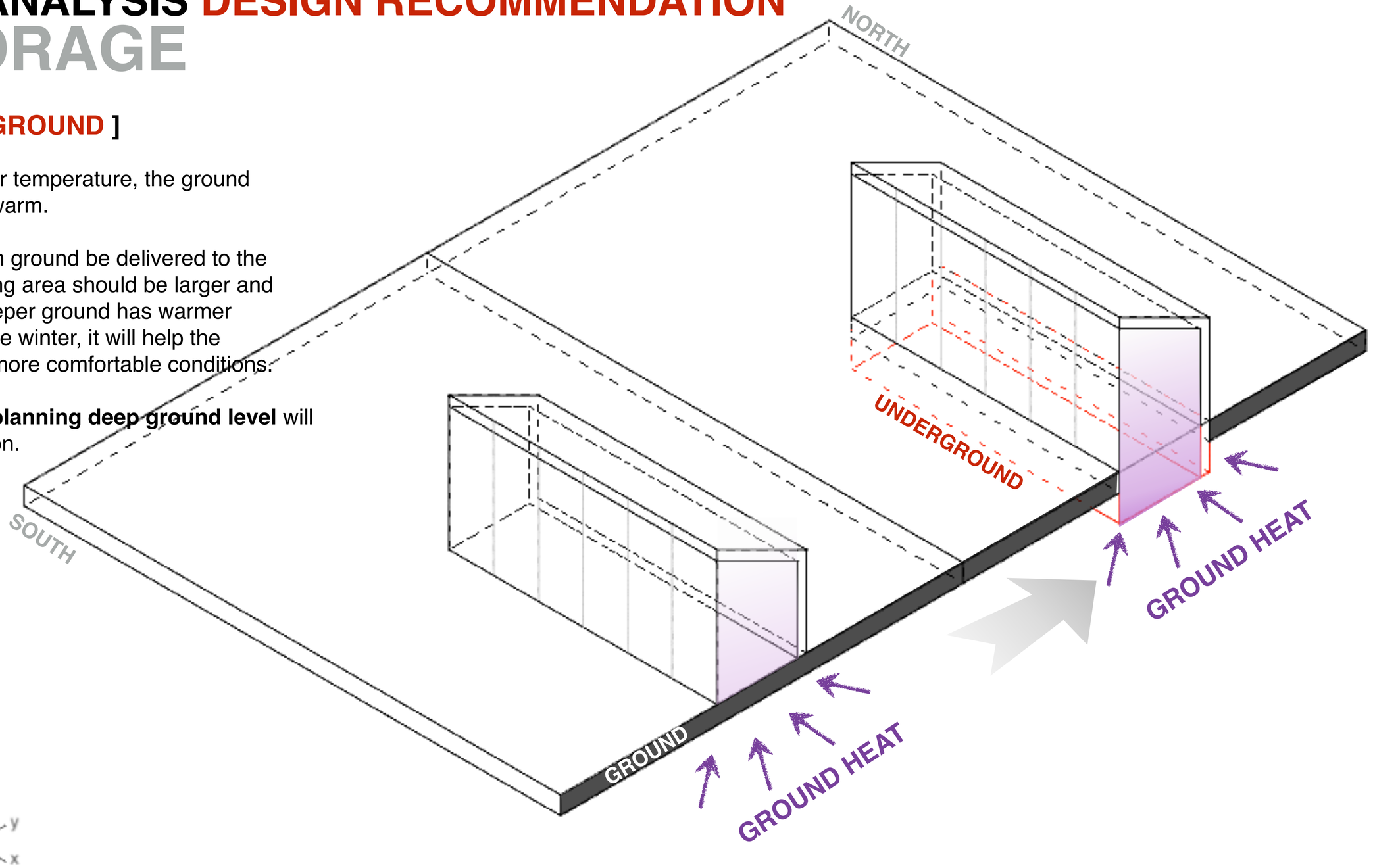
CLIMATE ANALYSIS DESIGN RECOMMENDATION
ANCHORAGE

[3 USE UNDERGROUND]

In contrast with low air temperature, the ground temperature is fairly warm.

To allow the heat from ground be delivered to the building, the interfacing area should be larger and deeper. Since the deeper ground has warmer temperature during the winter, it will help the occupants to stay in more comfortable conditions.

In order to realize it, **planning deep ground level** will be an effective solution.



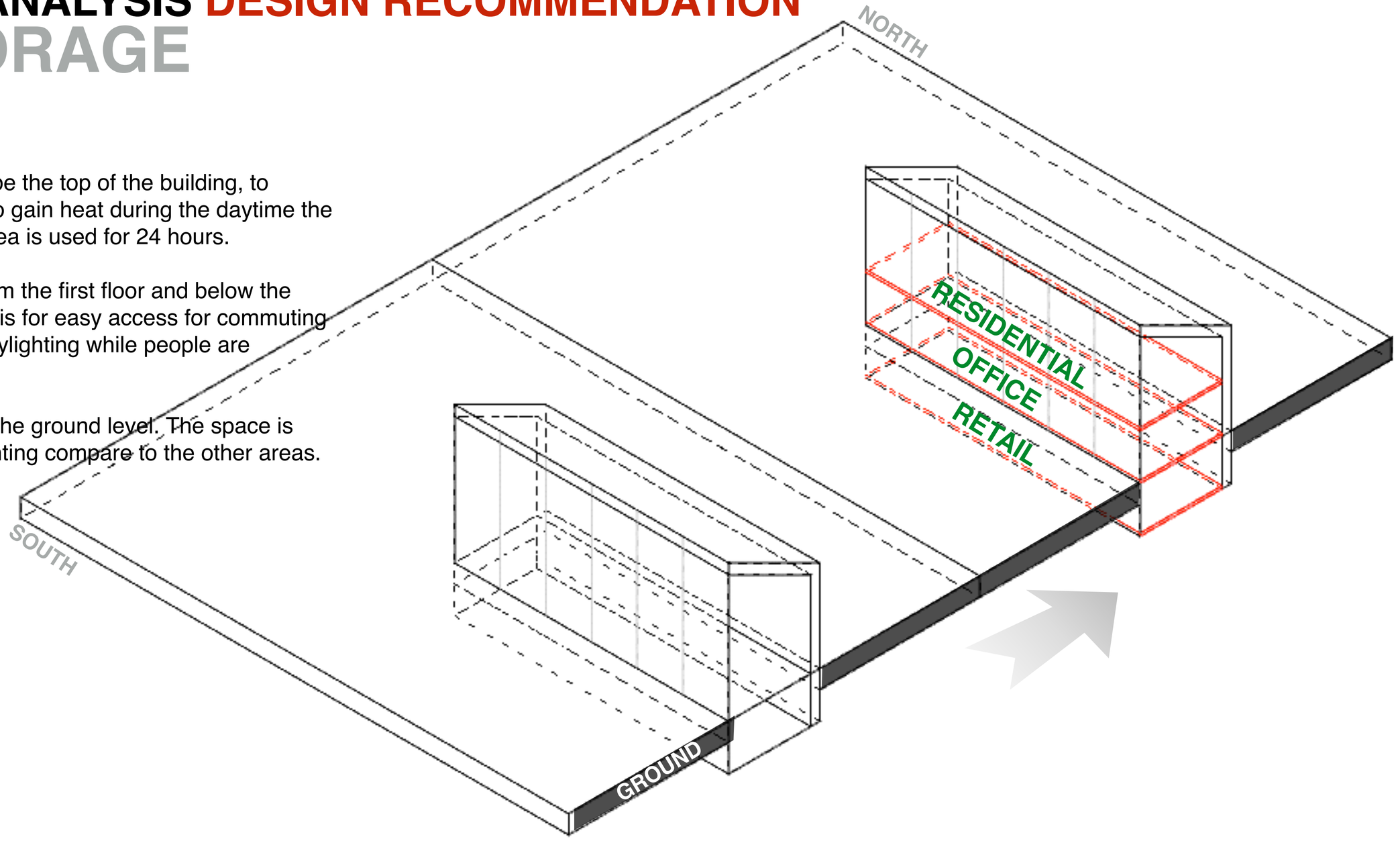
CLIMATE ANALYSIS DESIGN RECOMMENDATION
ANCHORAGE

[4 Zoning]

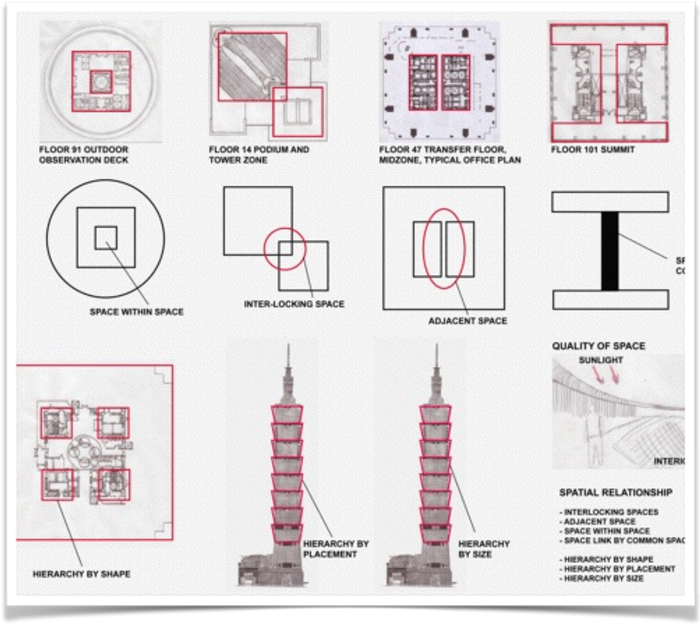
Residential area will be the top of the building, to encourage the area to gain heat during the daytime the most, because the area is used for 24 hours.

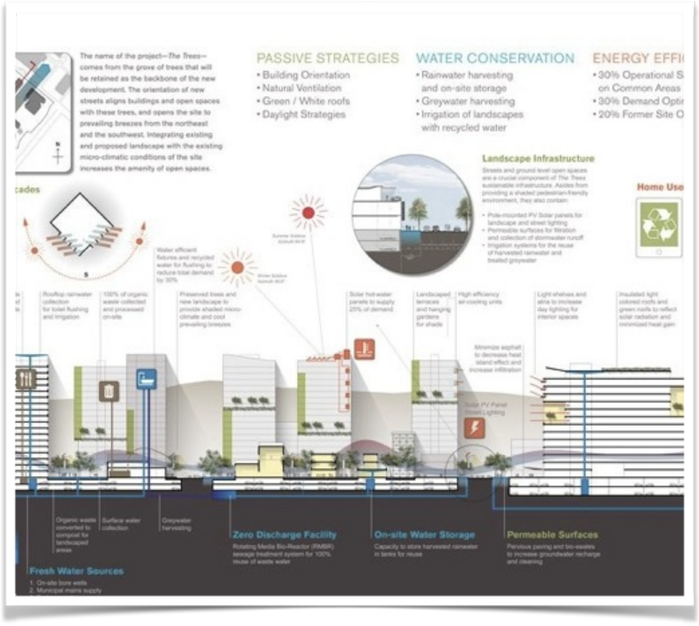
Office area will be from the first floor and below the residential area. This is for easy access for commuting and to get enough daylighting while people are working there.

Retail area will be at the ground level. The space is less related to daylighting compare to the other areas.



CLIMATE ANALYSIS NECESSARY DATA, FOR NEXT STEP
ANCHORAGE





[SITE CONDITION]

Anchorage has various geographical factors, so the wind conditions will be varied site by site. For further design step, specific conditions of the site is required.

[GROSS AREA]

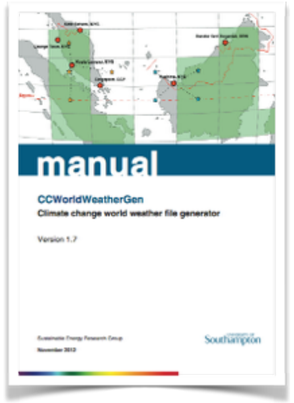
Depending on the gross area of the mixed-use complex, different design strategy should be adapted. The building's plan type, depth and section ratio will be varied depending on its gross area.

[PROGRAM]

Each programs in a building has different thermal comfort zone. For example, hotel area would require warmer comfort temperature than shopping mall area.

CLIMATE ANALYSIS CLIMATE CHANGE'S EFFECTS ON DESIGN
ANCHORAGE

[CLIMATE CHANGE - ANCHORAGE in 2050]



CCWorldWeatherGen

According to the newly-generated weather data for 2050 by CCWorldWeatherGen, the latitude of Anchorage will be changed from 61.18° to 62.50°. The biggest change is that all of the monthly average temperature in Anchorage will be above 0°C.

The winter's coldness will be milder than now, but the summer will be colder than now, which means the whether will be never in comfort zone. Since the temperature gap between summer time and winter time will be reduced, it seems to be one season throughout the year.

However it would barely affect to my design recommendation. In 2050, still every temperature is lower than comfort zone, so it is needed to apply the three design strategies for warmer indoor condition; maximizing solar radiation and daylighting, better protection from cold wind, and obtaining heat from ground.

CCWorldWeatherGen climate change weather file generator V1.8 manual

For transforming EPW weather files into climate change TMY2/EPW files. (Acknowledgements & disclaimer of warranties below)

Specify the HadCM3 data file path: C:\CCWorldWeatherGen\HadCM3data

Summary of combined HadCM3 A2 ensemble climate change predictions for the selected weather site

Selected scenario: A2 scenario ensemble for the 2050's

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Daily mean temperature	**TEMP**	(°C)	1.92	2.10	0.43	1.08	1.67	2.16	2.23	2.49	2.11	2.46	3.96	3.69	2.19
Maximum temperature	**TMAX**	(°C)	1.26	1.63	0.40	0.74	1.69	2.14	2.10	2.55	2.19	2.01	3.05	3.92	1.97
Minimum temperature	**TMIN**	(°C)	1.47	2.17	1.08	1.60	1.72	2.12	2.31	2.59	1.96	2.73	3.60	4.07	2.29
Horizontal solar irradiation	**DSWF**	W/m²	-0.12	-1.88	-1.07	-7.61	-11.97	-2.58	-1.56	-2.37	-6.27	-3.65	-1.57	-0.40	-3.42
Total cloud cover	**TCLW**	% points	-0.63	0.63	-2.50	1.00	1.88	-0.88	-0.25	-0.75	2.25	2.50	4.63	0.50	0.70
Total precipitation rate	**PREC**	%	20.22	22.38	7.51	6.31	11.46	7.40	20.83	17.61	20.39	8.47	31.14	19.17	16.07
Relative humidity	**RHUM**	% points	-0.56	-0.02	-0.62	0.09	0.21	0.11	-0.03	0.08	0.62	0.06	0.37	0.24	0.05
Mean sea level pressure	**MSLP**	hpa	6.73	0.39	3.03	0.21	-0.69	-0.36	-0.89	0.42	1.07	-0.04	0.57	0.97	0.95
Wind speed*	**WIND**	%	3.36	1.15	3.36	-0.65	-0.28	-2.55	3.91	-0.77	1.44	-1.82	-3.04	-2.36	0.15

* Please note that wind speed resides on a 96x72 grid whilst all the other data is on a 96x73 grid

EPW weather file selection

(1) Please specify the EPW file you want to transform

Select EPW File for Morphing

Current EPW baseline weather file for morphing:

Anchorage Intl Ap, USA — ***Latitude:*** 61.18 N; ***Longitude:*** -150.00 W; ***Elevation:*** 35 m

HadCM3 scenario timeframe selection

(2) Please select a HadCM3 A2 scenario ensembe timeframe

○ 2020's ◉ 2050's ○ 2080's **Load Scenario**

Closest four HadCM3 96x73 grid points to Anchorage Intl Ap, USA		***Latitude:***	***Longitude:***
	A	57.50 N	-150.00 W
	B	65.00 N	-150.00 W
	C	60.00 N	-150.00 W
A2 scenario for the 2050's	***D***	62.50 N	-150.00 W

EPW weather file morphing

(3) Click button to start morphing procedure

Start Morphing Procedure

Current morphed EPW weather file:

Morphed EPW file for: Anchorage Intl Ap, USA
HadCM3 A2 emissions senario ensemble for the 2050's

EPW/TMY2 weather file generation

(4) Click the appropriate button for EPW / TMY2 file generation

Generate Climate Change EPW Weather File

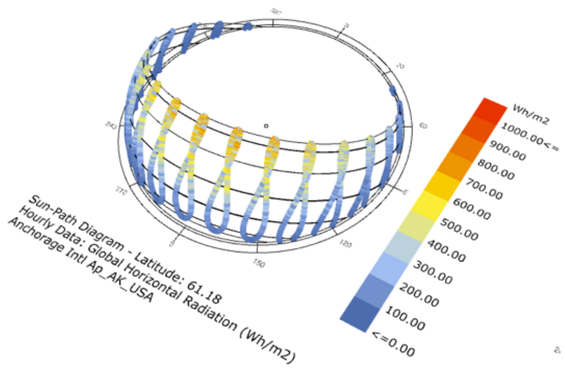
Generate Climate Change TMY2 Weather File

To create a TMY2 file of the original EPW file click the button below:

Generate Present-Day TMY2 Weather File form EPW data

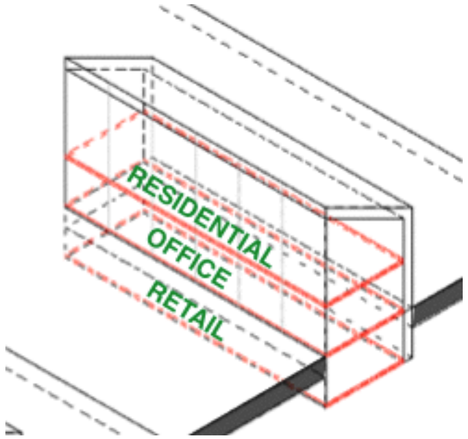
CLIMATE ANALYSIS Development Point
ANCHORAGE

[Visualizing Solar Radiation at Sun Path Graph]



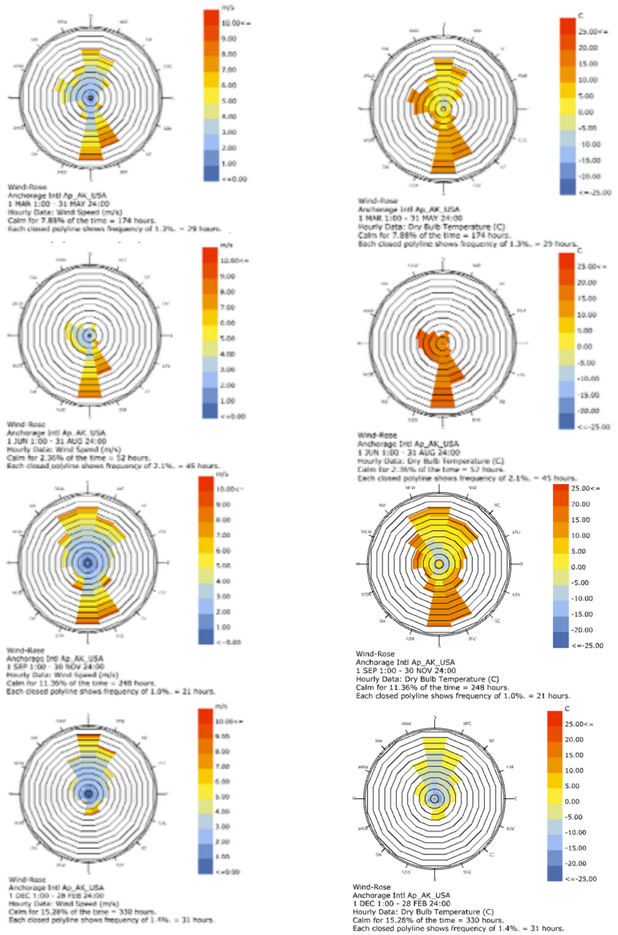
I had only solar path without combining additional data. This time, I added radiation and dry bulb temperature on the solar path graph, meaning it brings better understanding the relationship between solar radiation and temperature.

[Adding Another Design Recommendation]



I added another design recommendation. The vertical zoning of the building is depending on the needs of daylighting for each purpose.

[Defining Legend Parametric]



Last time, I compared wind speed and direction throughout seasons, but it wasn't accurate because I didn't define the same range of parameters for each seasons.

To produce more convincing data, I have defined the radiation range from 0 to 1000, and did the temperature from -25 to +25.

CLIMATE ANALYSIS

ANCHORAGE

ALASKA, US

09/28/2015 JEEEUN LEE