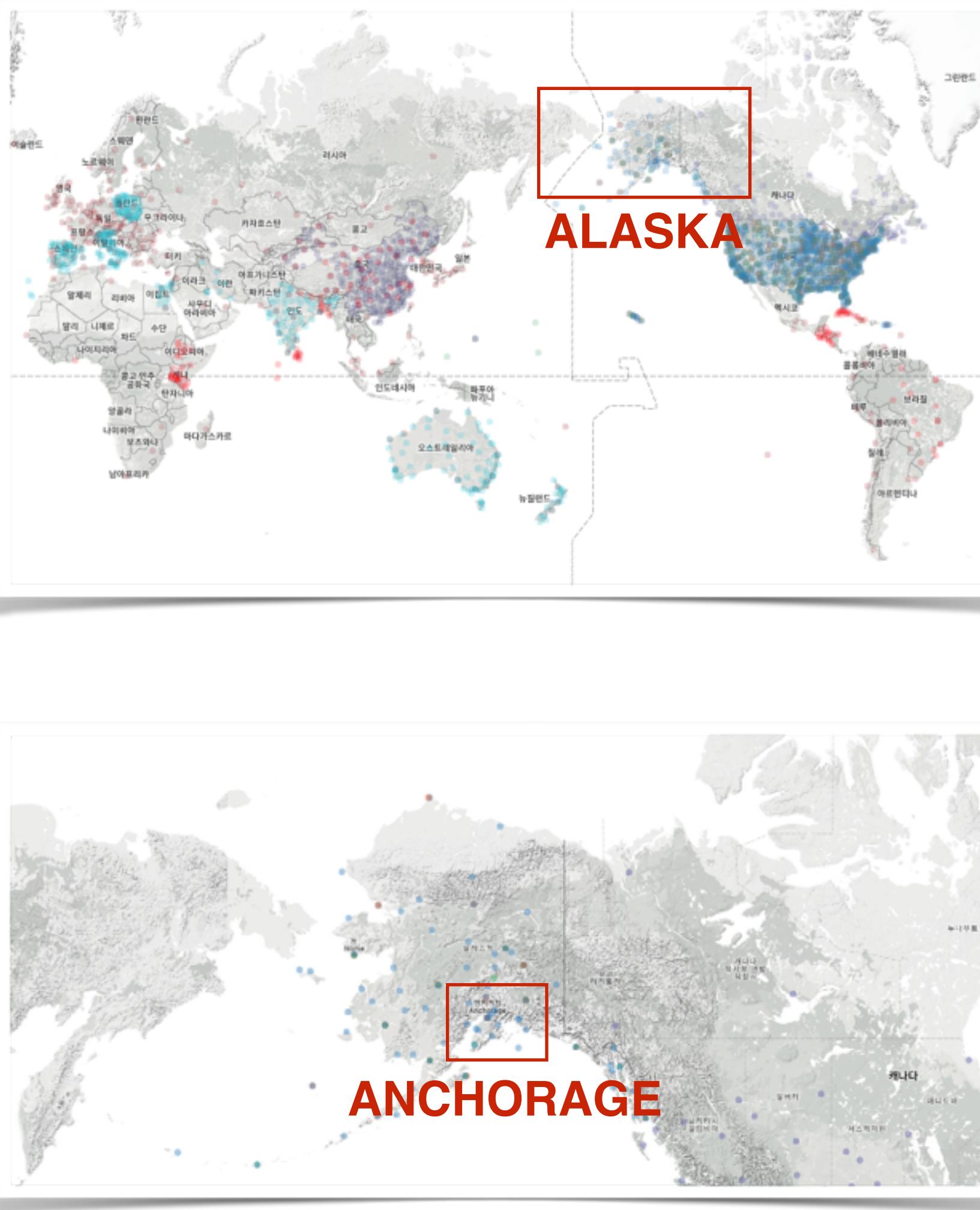




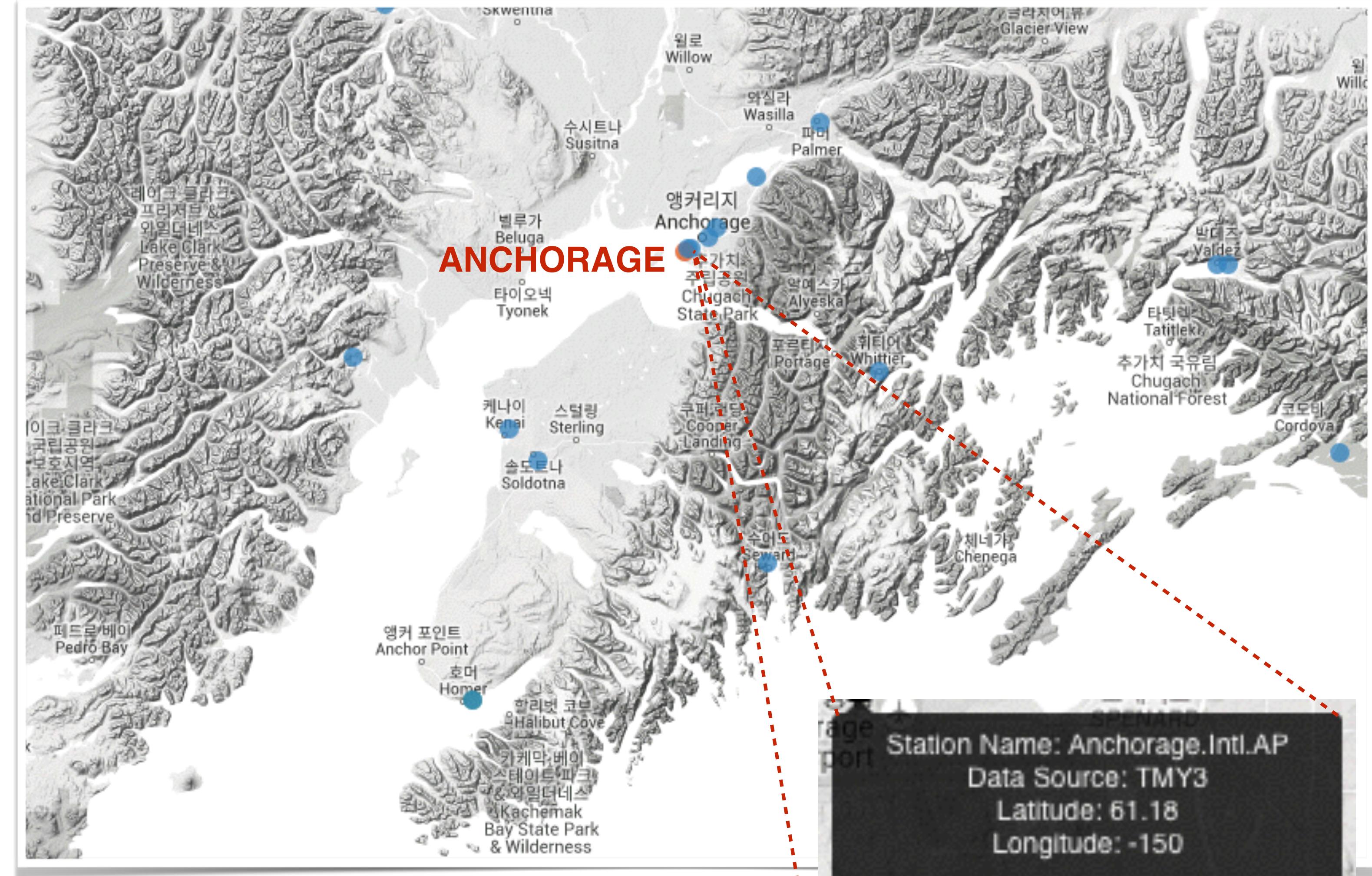
CLIMATE ANALYSIS
ANCHORAGE
ALASKA, US

09/21/2015 JEEEUN LEE

© Alaska Stock



ANCHORAGE



- LOCATION Anchorage International Airport
- DATA SOURCE TMY3
- LATITUDE 61.18°N
- LONGITUDE -150°
- CLIMATE ZONE Subarctic ($50^{\circ}\text{~}70^{\circ}\text{N}$)

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

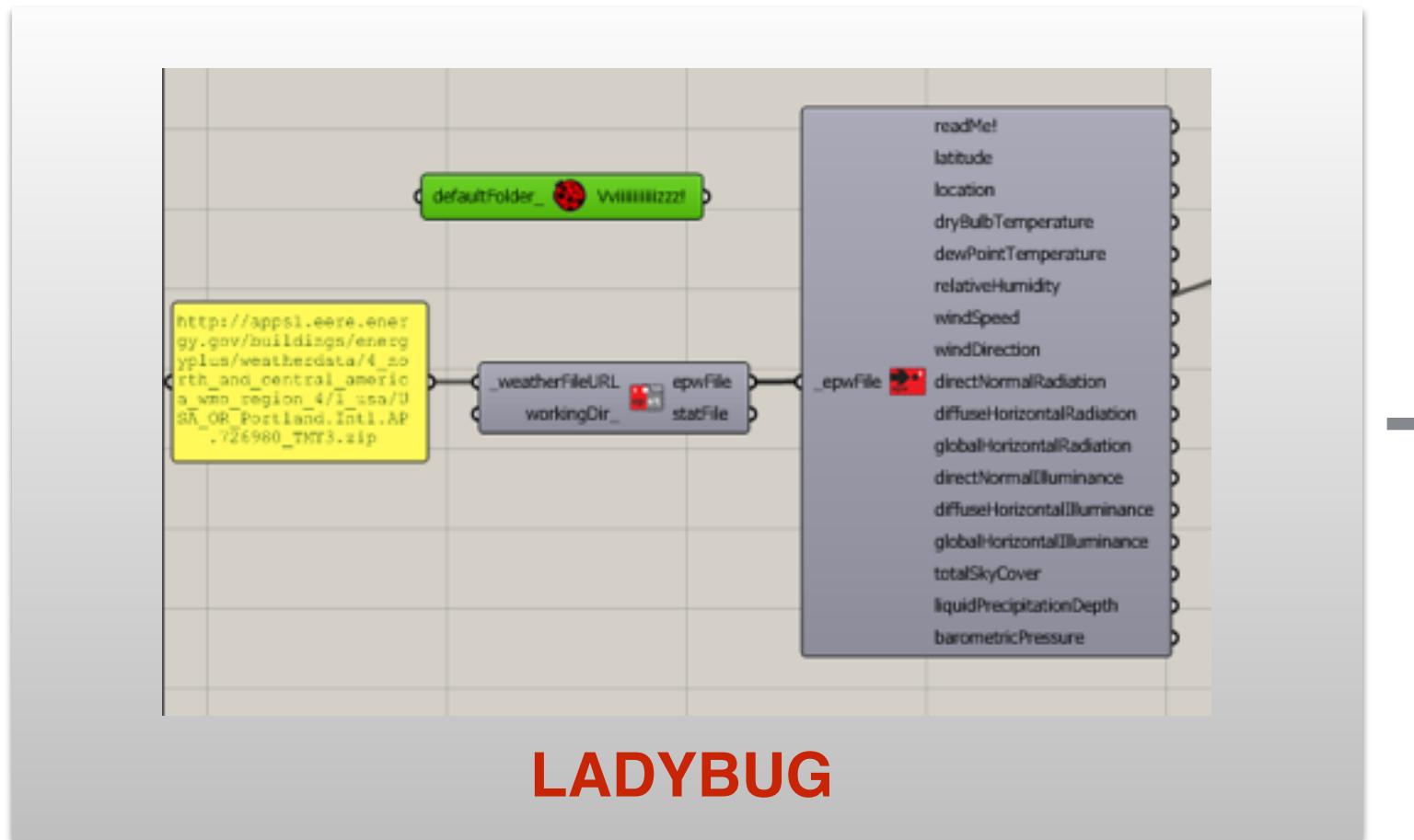
#Hours of Strong Cold Stress:	2127
#Hours of Moderate Cold Stress:	2913
#Hours of Slight Cold Stress:	2431
#Hours of Comfort:	1289
#Hours of Slight Heat Stress:	0
#Hours of Moderate Heat Stress:	0
#Hours of Strong Heat Stress:	0

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

Hour	DOE Hourly Weather Data, Converted from NEDC Weather File												Calculated
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Hum	Radi	Density	Enthalpy	Solar	
Year	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Hum	Radi	Density	Enthalpy	Solar	
1	1	1	1	17	50.3	0	0	0	0.0010	0.001	0.0	0	
2	1	1	2	17	50.3	0	0	0	0.0011	0.001	0.0	0	
3	1	1	3	17	50.3	0	0	0	0.0011	0.001	0.0	0	
4	1	1	4	17	50.3	12	0	0	0	0.0012	0.001	3.3	
5	1	1	5	17	50.3	0	0	0	0.0014	0.001	0.0	0	
6	1	1	6	17	50.3	10	0	0	0	0.0014	0.001	3.5	
7	1	1	7	17	50.3	0	0	0	0.0014	0.001	0.0	0	
8	1	1	8	17	50.3	10	0	0	0	0.0012	0.001	3.5	
9	1	1	9	17	50.3	4	0	0	0	0.0014	0.001	6.0	
10	1	1	10	17	50.3	4	0	0	0	0.0014	0.001	6.0	
11	1	1	11	18	50.3	4	0	0	0	0.0015	0.001	6.5	
12	1	1	12	19	50.2	4	0	0	0	0.0016	0.001	7.0	
13	1	1	13	21	50.2	4	0	0	0	0.0019	0.001	7.5	
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15	1	1	15	22	50.1	10	0	0	0	0.0017	0.001	8.0	
16	1	1	16	23	50.1	4	0	0	0	0.0018	0.001	8.0	
17	1	1	17	23	50.1	4	0	0	0	0.0012	0.001	8.0	



WEATHER DATA PROGRAM

CLIMATE CONSULTANT

WEATHER DATA SUMMARY												CLIMATE DATA											
LOCATION: Anchorage Int'l 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																							
Global Horiz Radiation (Avg Hourly)												14 19 59 22 82 91 82 24 55 34 20 10 Btu/sq-ft											
Direct Normal Radiation (Avg Hourly)												24 82 75 83 68 82 63 62 60 51 46 13 Btu/sq-ft											
Diffuse Radiation (Avg Hourly)												32 22 33 38 44 45 46 42 30 24 14 9 Btu/sq-ft											
Global Horiz Radiation (Max Hourly)												39 305 277 219 245 254 245 226 182 129 81 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)												11 61 100 97 122 164 144 131 85 62 40 21 Btu/sq-ft											
Global Horiz Radiation (Avg Daily Total)												90 131 688 1113 1417 1766 1472 1162 701 312 144 53 Btu/sq-ft											
Direct Normal Radiation (Avg Daily Total)												142 684 840 1189 1179 1526 1094 994 759 515 70 Btu/sq-ft											
Diffuse Radiation (Avg Daily Total)												76 187 183 556 771 853 831 658 387 231 101 47 Btu/sq-ft											
Global Horiz Illumination (Avg Hourly)												418 1220 1683 2447 2831 2948 2658 2376 1747 1087 616 298 Footcandles											
Direct Normal Illumination (Avg Monthly)												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 45 48 47 42 26 18 15 degrees F											
Relative Humidity (Avg Monthly)												75 77 60 64 61 64 70 72 73 75 79 85 percent											
Wind Direction (Avg Monthly)												0 0 10 170 160 170 170 160 10 350 10 degrees											
Wind Speed (Avg Monthly)												5 5 7 5 6 9 8 7 2 6 6 5 mph											
Ground Temperature (Avg Monthly of 2 Depths)												33 25 28 23 28 35 42 47 50 49 45 38 degrees F											

WEATHER DATA

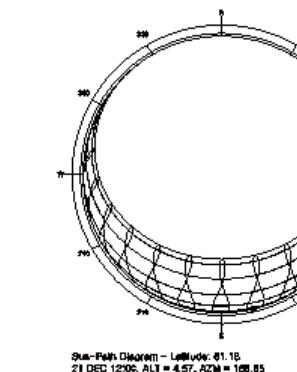
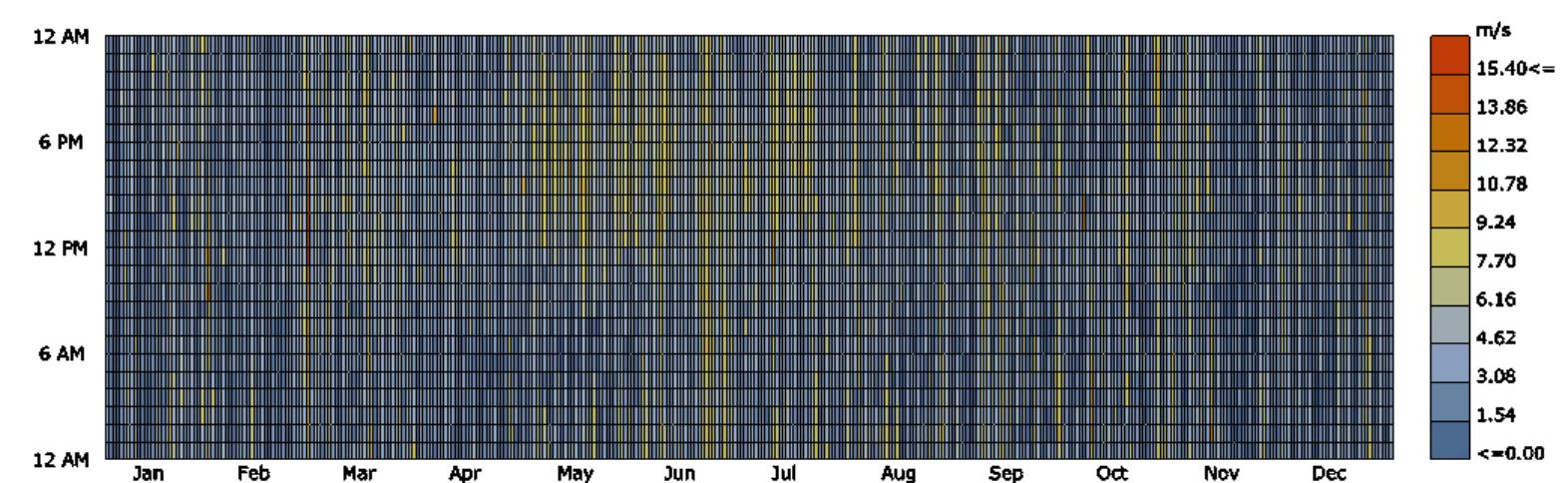
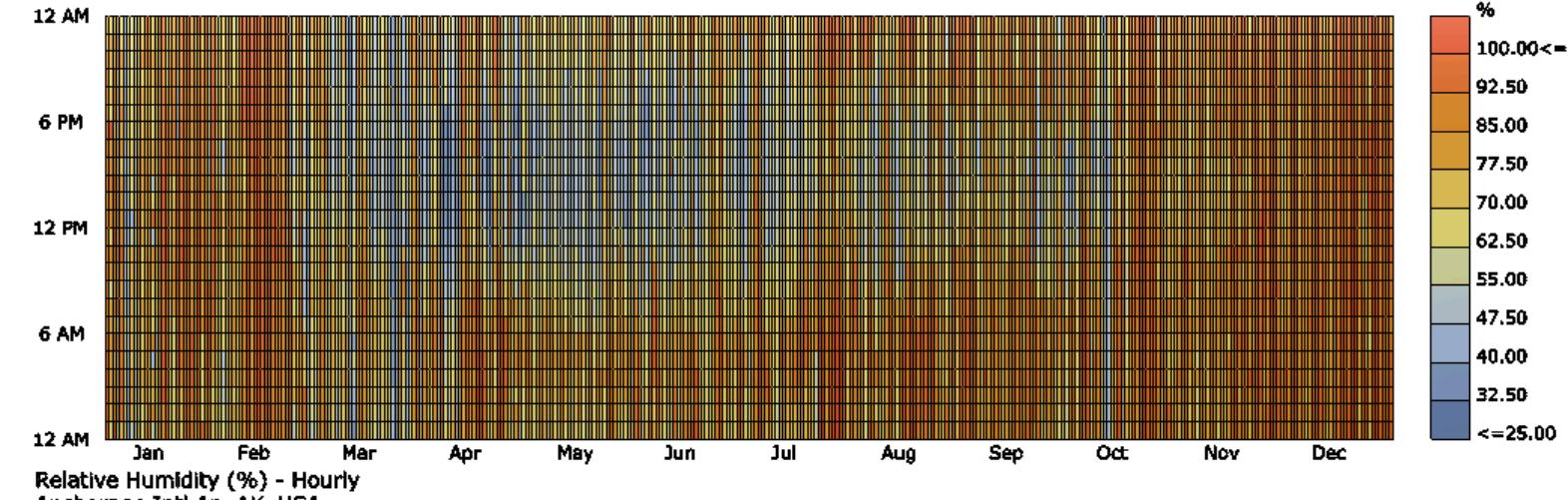
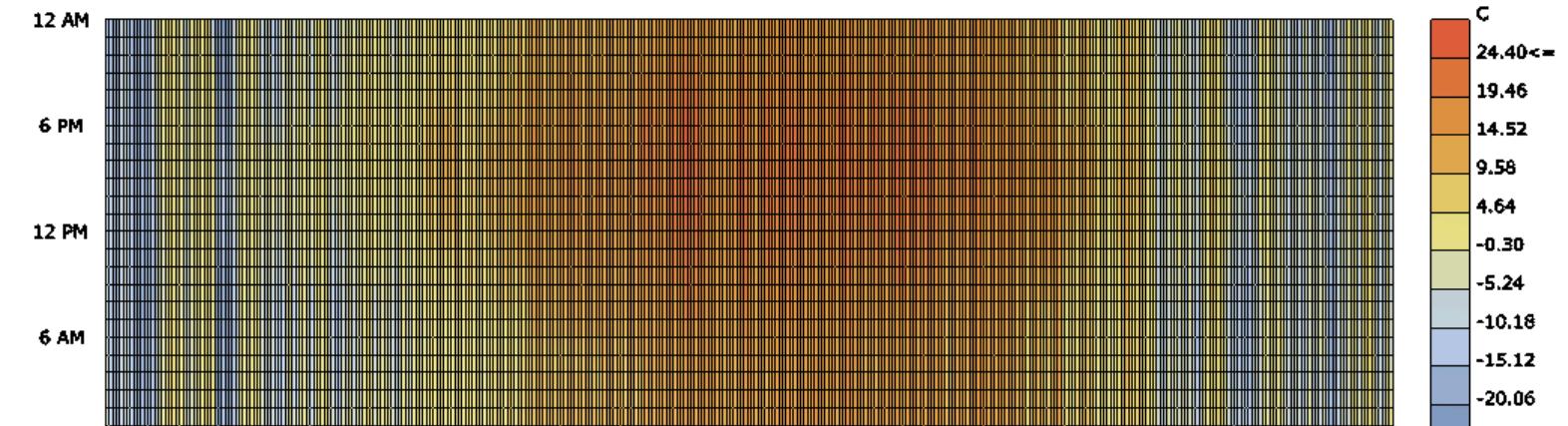
PROGRAM

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

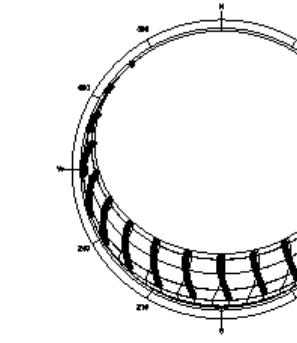
CLIMATE DATA

CLIMATE ANALYSIS DATA ANCHORAGE

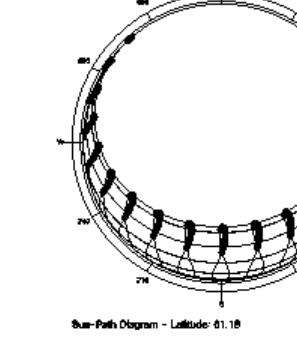
FROM LADYBUG



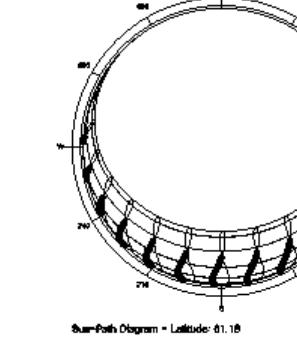
Wind-Rose
Anchorage Intl Ap_AK_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 9.18% of the time = 804 hours.
Each closed polyline shows frequency of 1.2% = 106 hours.



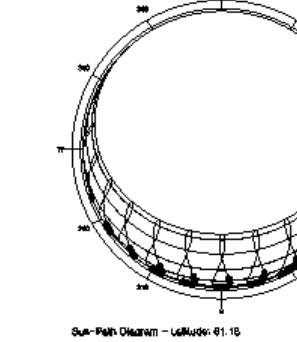
Wind-Rose
Anchorage Intl Ap_AK_USA
1 MAR 1:00 - 31 MAY 24:00
Hourly Data: Wind Speed (m/s)
Calm for 7.85% of the time = 174 hours.
Each closed polyline shows frequency of 1.3% = 29 hours.



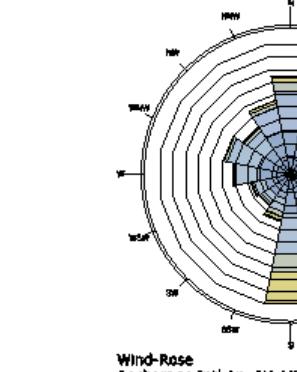
Wind-Rose
Anchorage Intl Ap_AK_USA
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Hourly Data: Wind Speed (m/s)
Calm for 2.36% of the time = 52 hours.
Each closed polyline shows frequency of 2.1% = 45 hours.



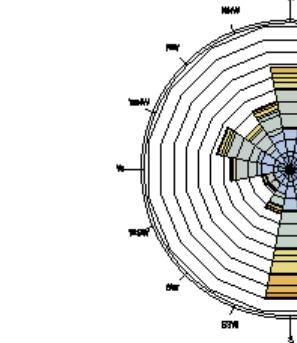
Wind-Rose
Anchorage Intl Ap_AK_USA
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Hourly Data: Wind Speed (m/s)
Calm for 11.36% of the time = 246 hours.
Each closed polyline shows frequency of 1.0% = 21 hours.



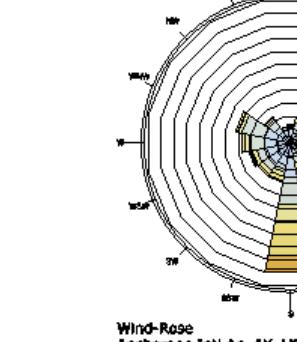
Wind-Rose
Anchorage Intl Ap_AK_USA
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Hourly Data: Wind Speed (m/s)
Calm for 15.26% of the time = 330 hours.
Each closed polyline shows frequency of 1.4% = 31 hours.



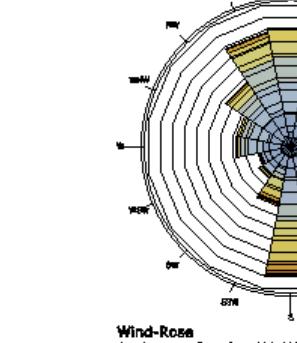
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Hourly Data: Relative Humidity (%)
Calm for 9.18% of the time = 804 hours.
Each closed polyline shows frequency of 1.2% = 106 hours.



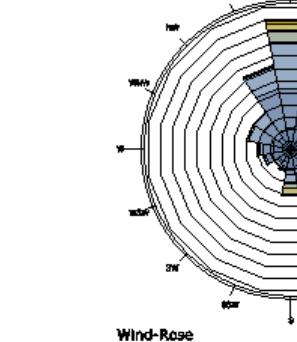
Wind-Rose
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Hourly Data: Dry Bulb Temperature (C)
Calm for 7.85% of the time = 174 hours.
Each closed polyline shows frequency of 1.3% = 29 hours.



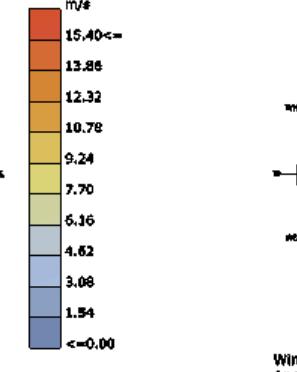
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Hourly Data: Relative Humidity (%)
Calm for 2.36% of the time = 52 hours.
Each closed polyline shows frequency of 2.1% = 45 hours.



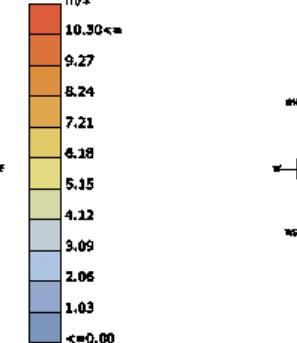
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Anchorage Intl Ap_AK_USA
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Hourly Data: Dry Bulb Temperature (C)
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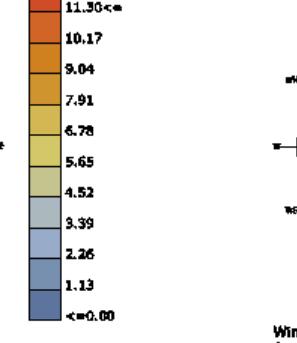
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Hourly Data: Relative Humidity (%)
Calm for 15.26% of the time = 330 hours.
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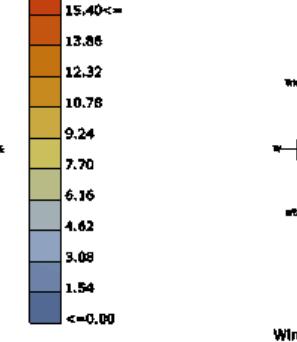
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Calm for 9.18% of the time = 804 hours.
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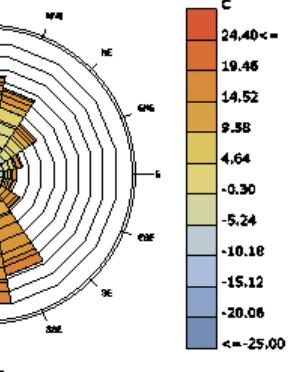
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Calm for 7.85% of the time = 174 hours.
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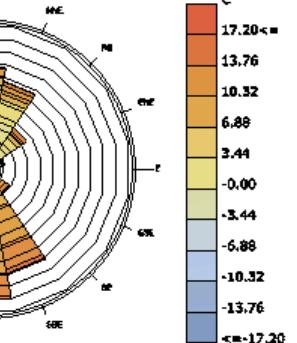
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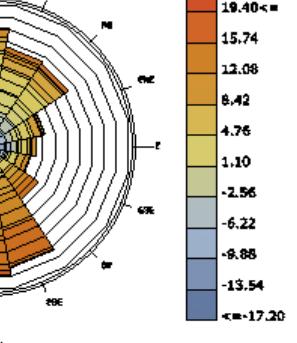
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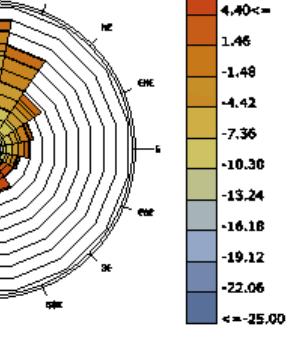
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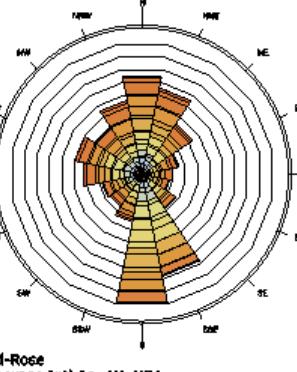
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Each closed polyline shows frequency of 1.3% = 29 hours.



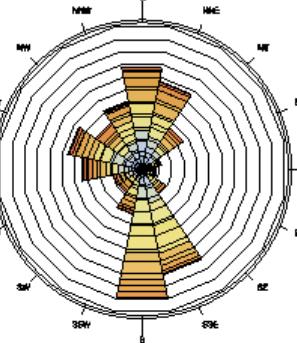
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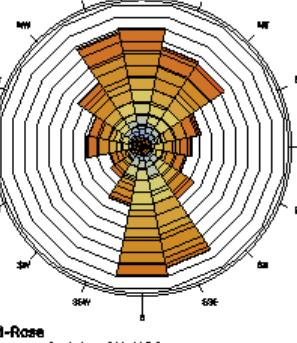
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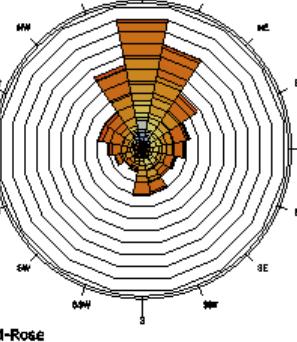
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Anchorage Intl Ap_AK_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 9.18% of the time = 804 hours.
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Wind-Rose
Anchorage Intl Ap_AK_USA
1 MAR 1:00 - 31 MAY 24:00
Hourly Data: Relative Humidity (%)
Calm for 7.85% of the time = 174 hours.
Each closed polyline shows frequency of 1.3% = 29 hours.



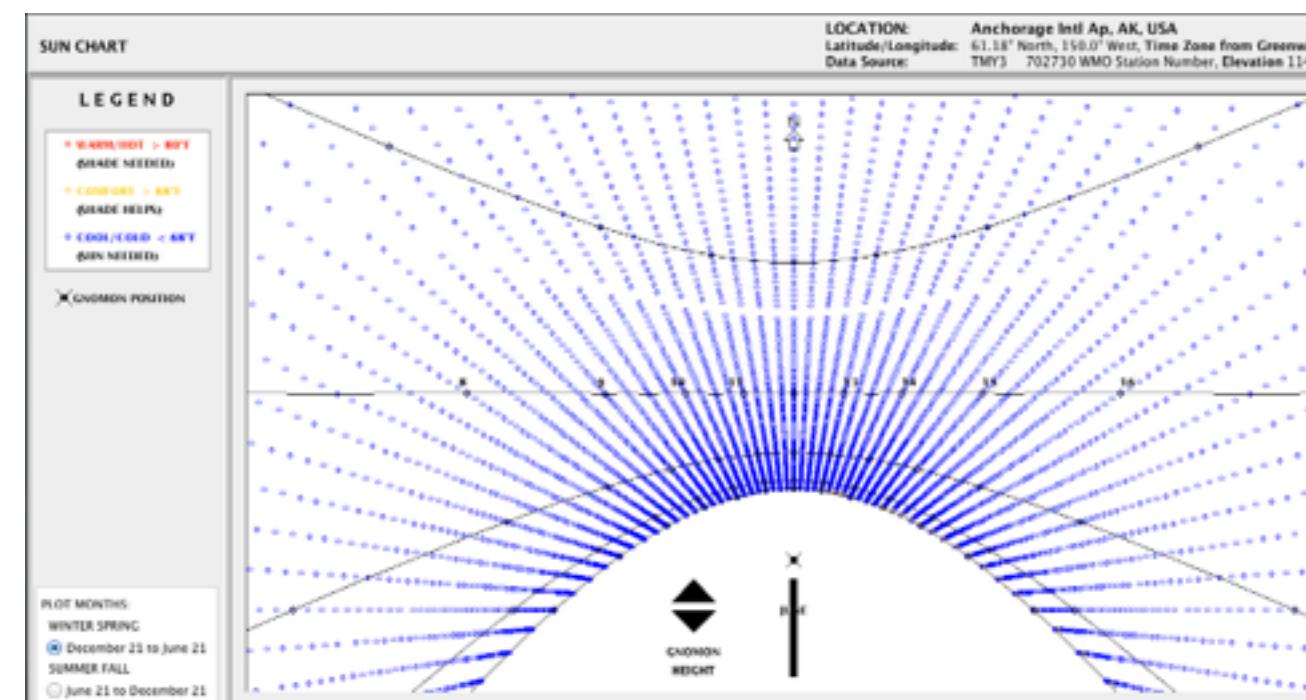
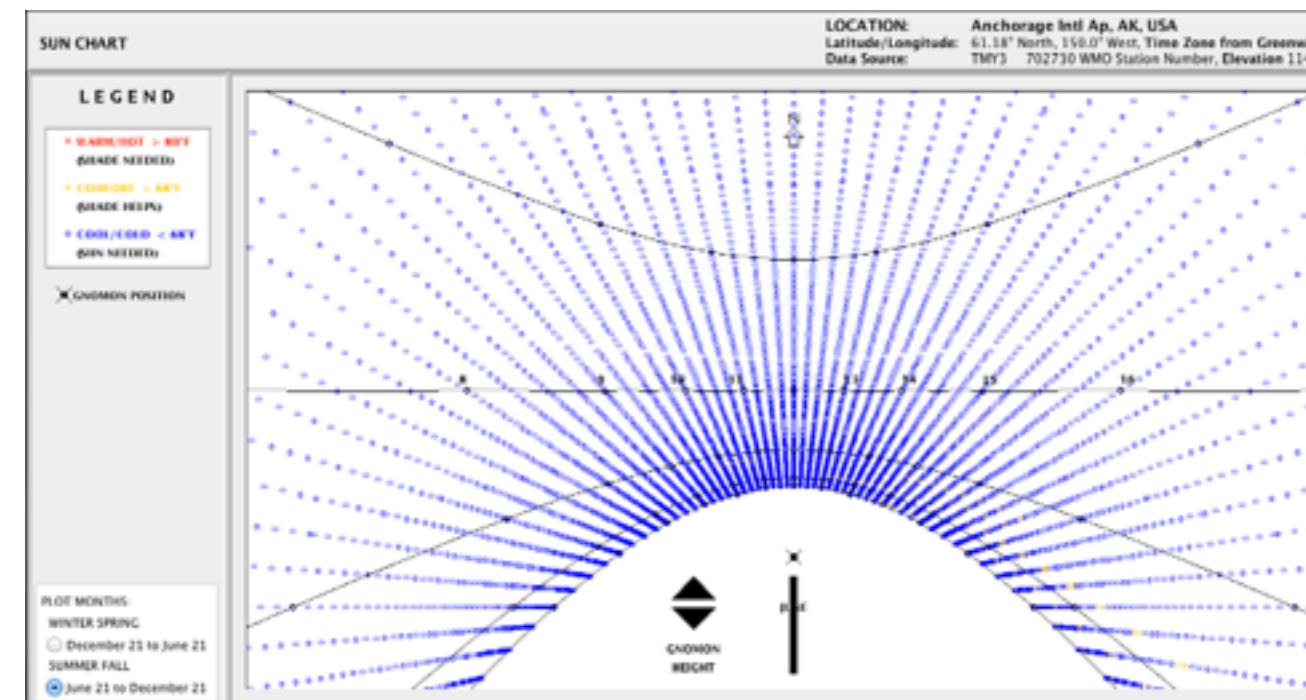
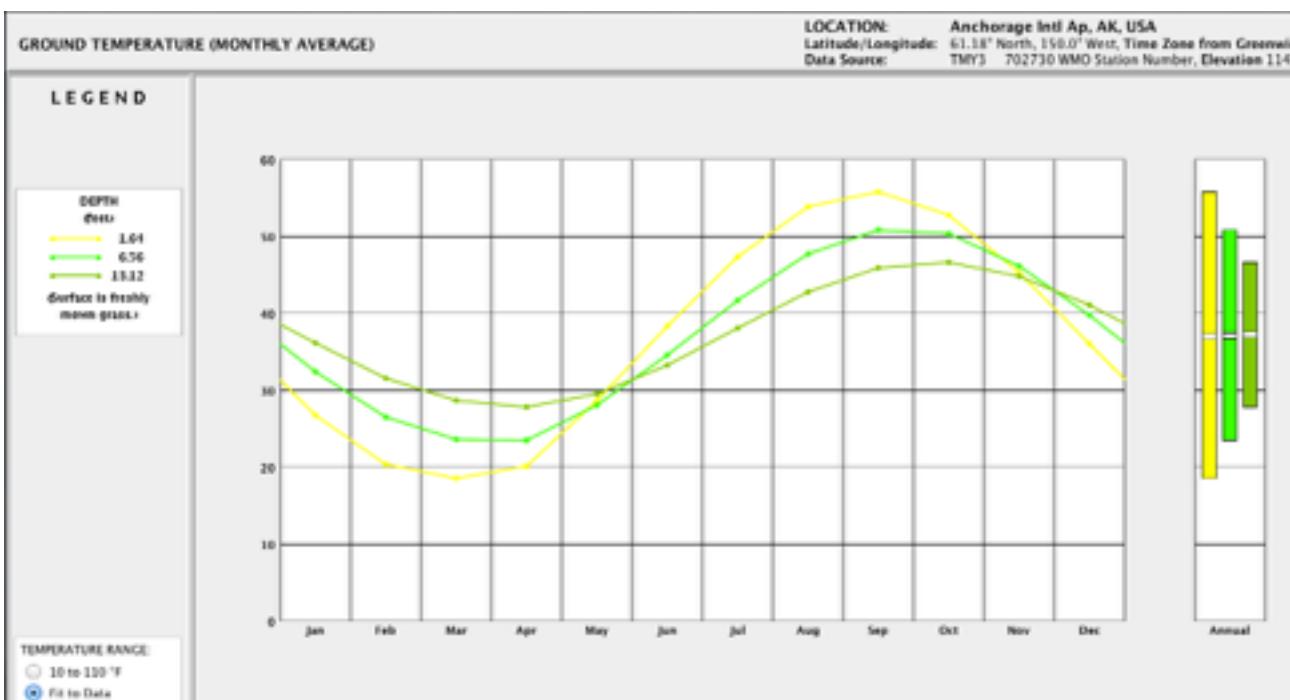
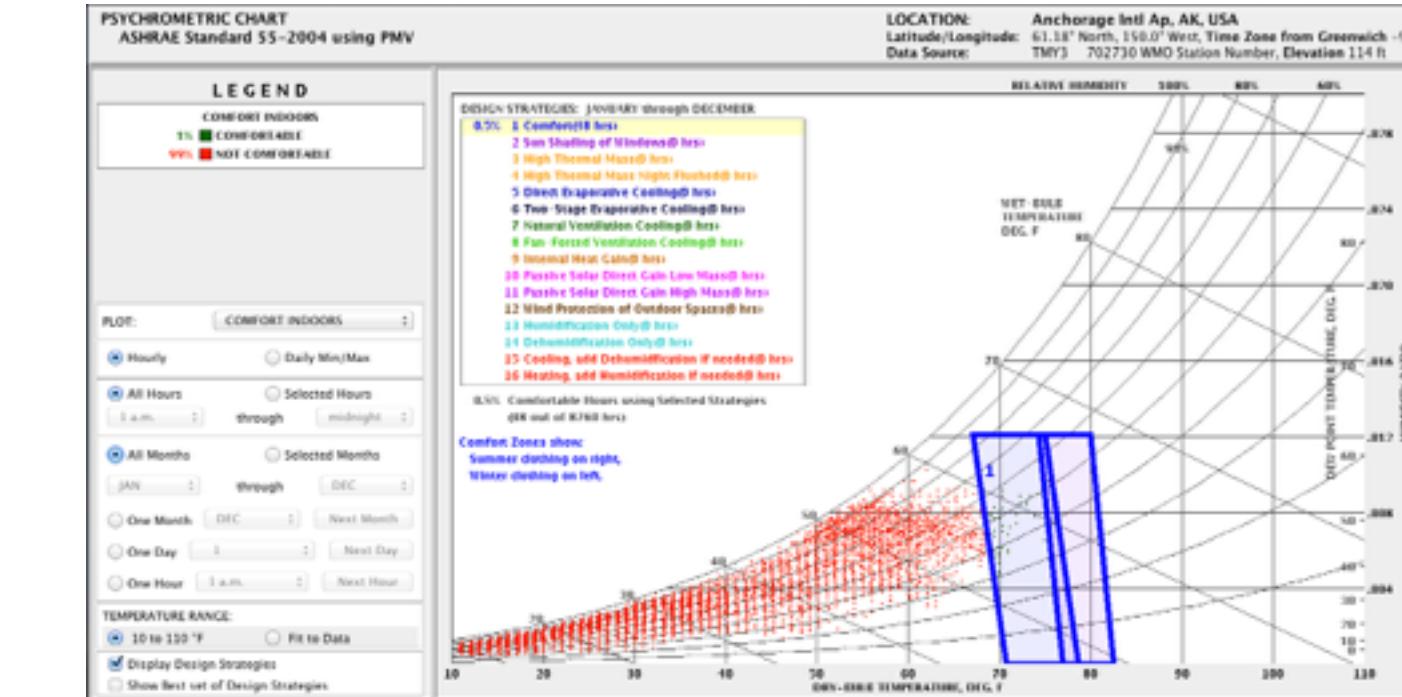
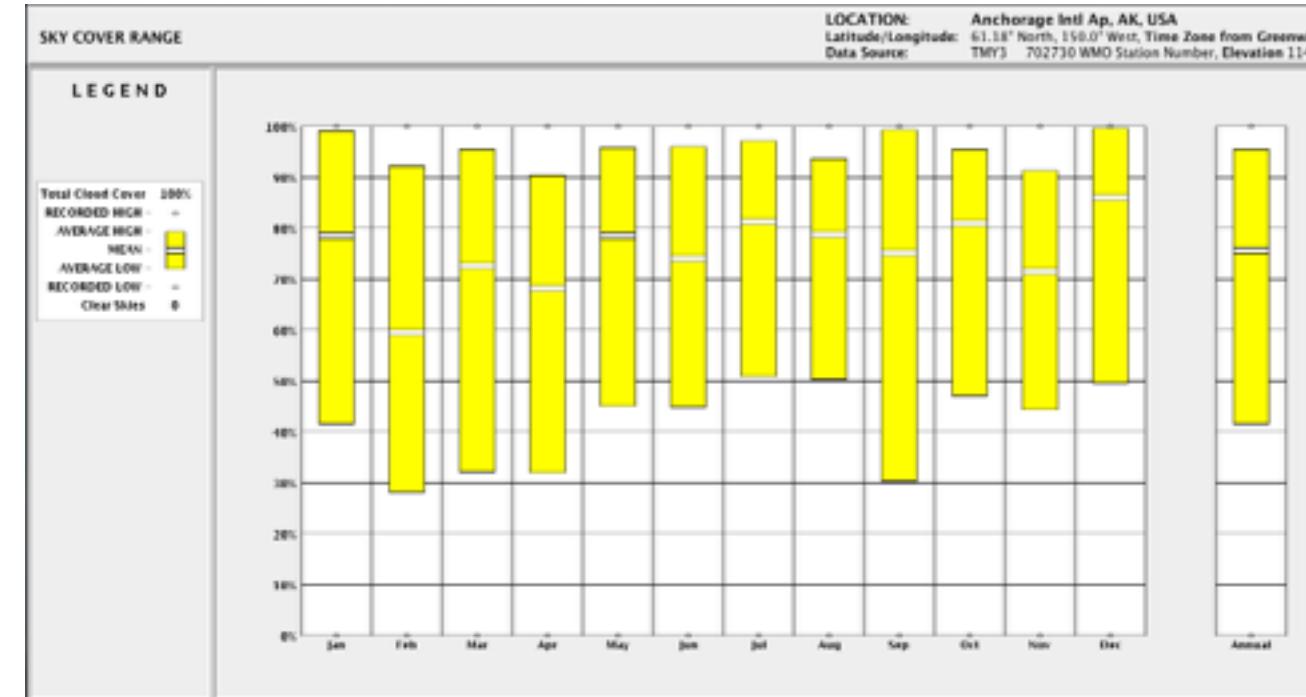
Wind-Rose
Anchorage Intl Ap_AK_USA
1 SEP 1:00 - 30 NOV 24:00
Hourly Data: Dry Bulb Temperature (C)
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Wind-Rose
Anchorage Intl Ap_AK_USA
1 DEC 1:00 - 28 FEB 24:00
Hourly Data: Relative Humidity (%)
Calm for 15.26% of the time = 330 hours.
Each closed polyline shows frequency of 1.4% = 31 hours.

CLIMATE ANALYSIS DATA ANCHORAGE

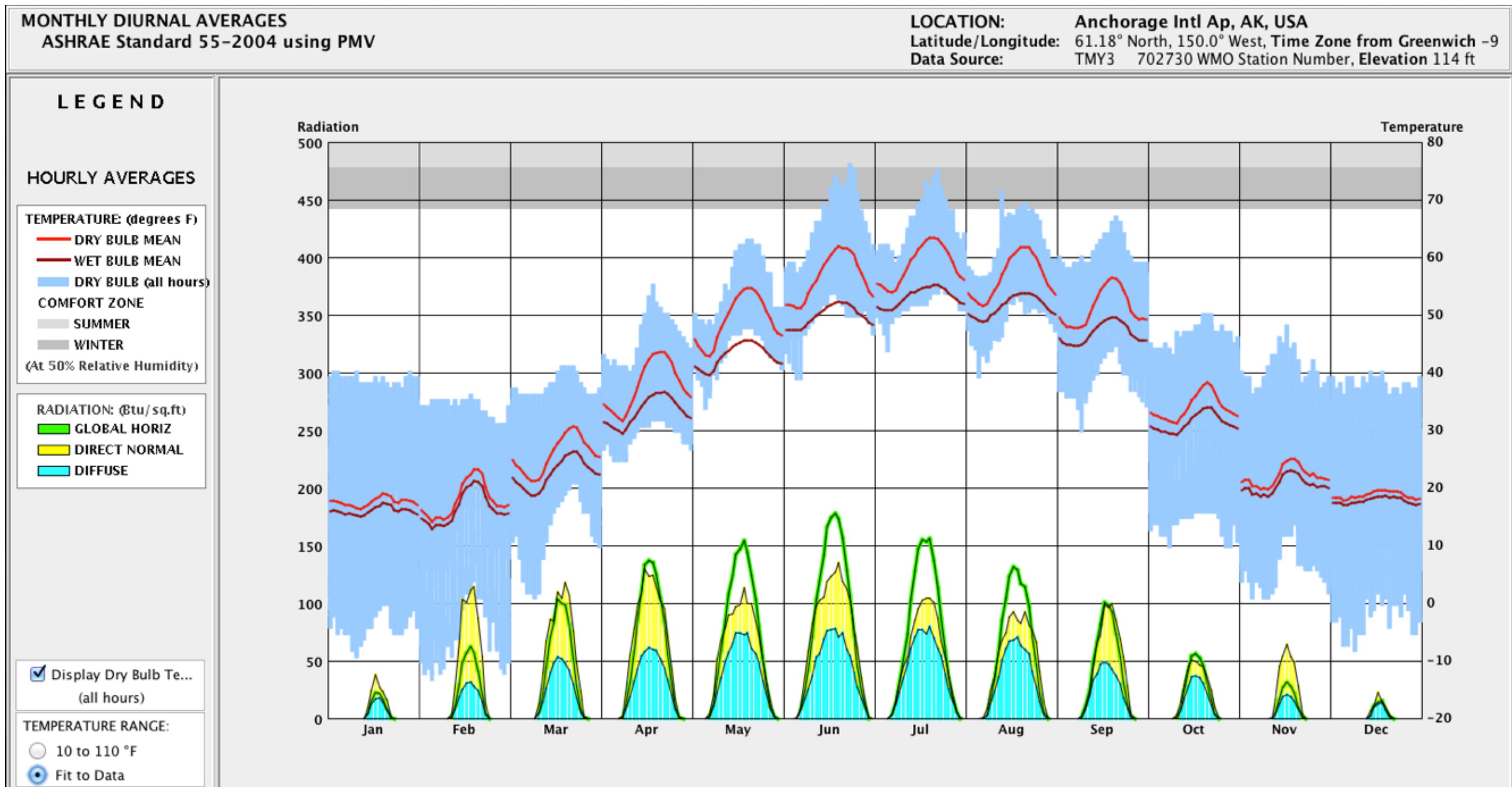
FROM CLIMATE CONSULTANT



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 thermal comfort zone determined by ASHRAE Standard 55. Due to the high latitude, the radiation varies a lot depending on the month of the year.

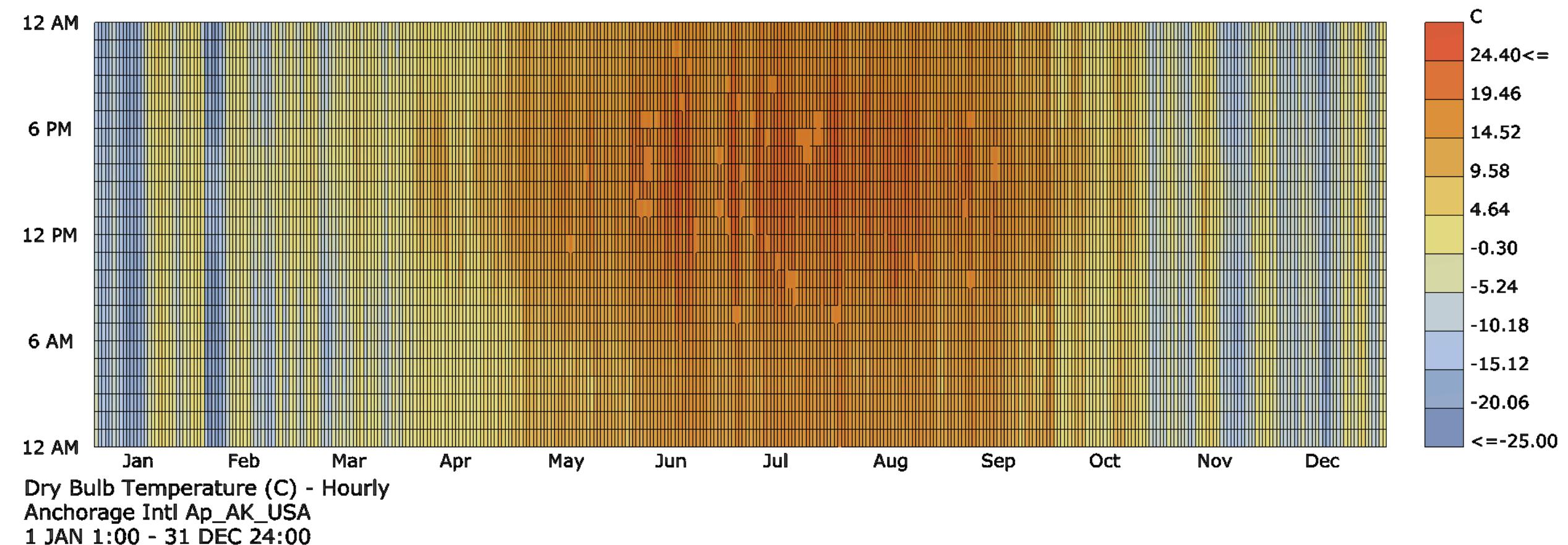


CLIMATE ANALYSIS of DATA ANCHORAGE

[TEMPERATURE]

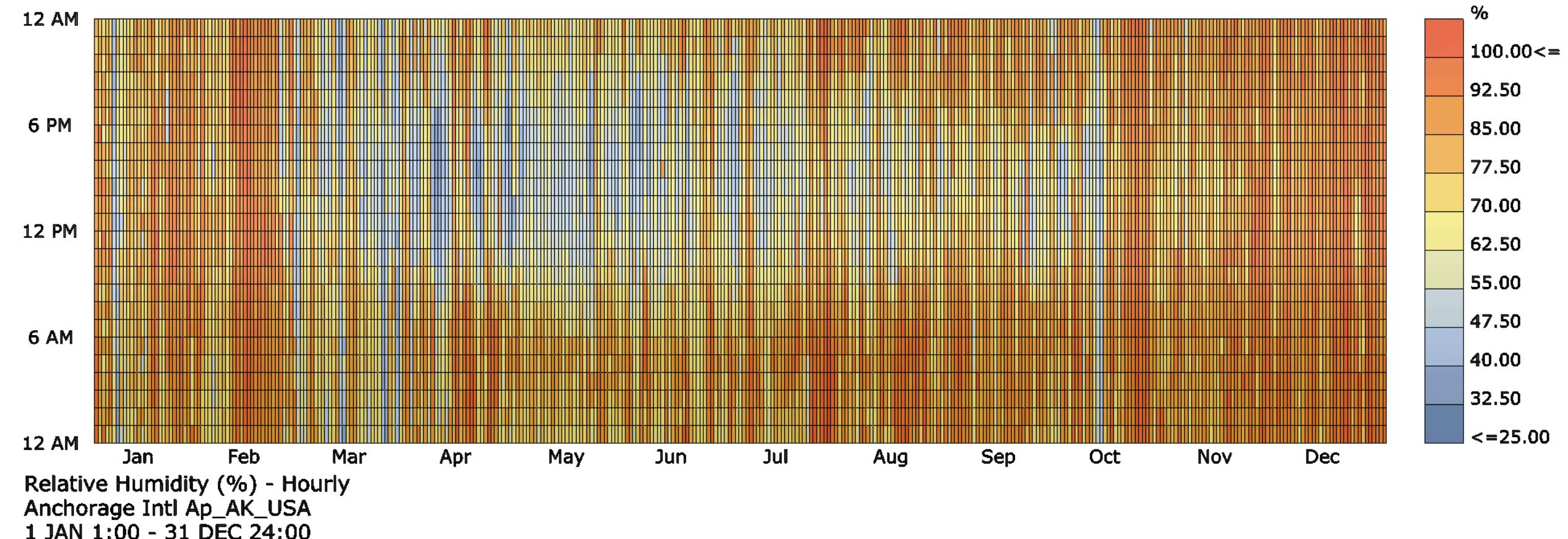
The dry bulb temperature of Anchorage has a range from -25°C to +25°C. During the summer time, from June to August, the temperature seems comfortable for people living here, but during the winter time, from December to February, it is extremely cold outside for human.

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



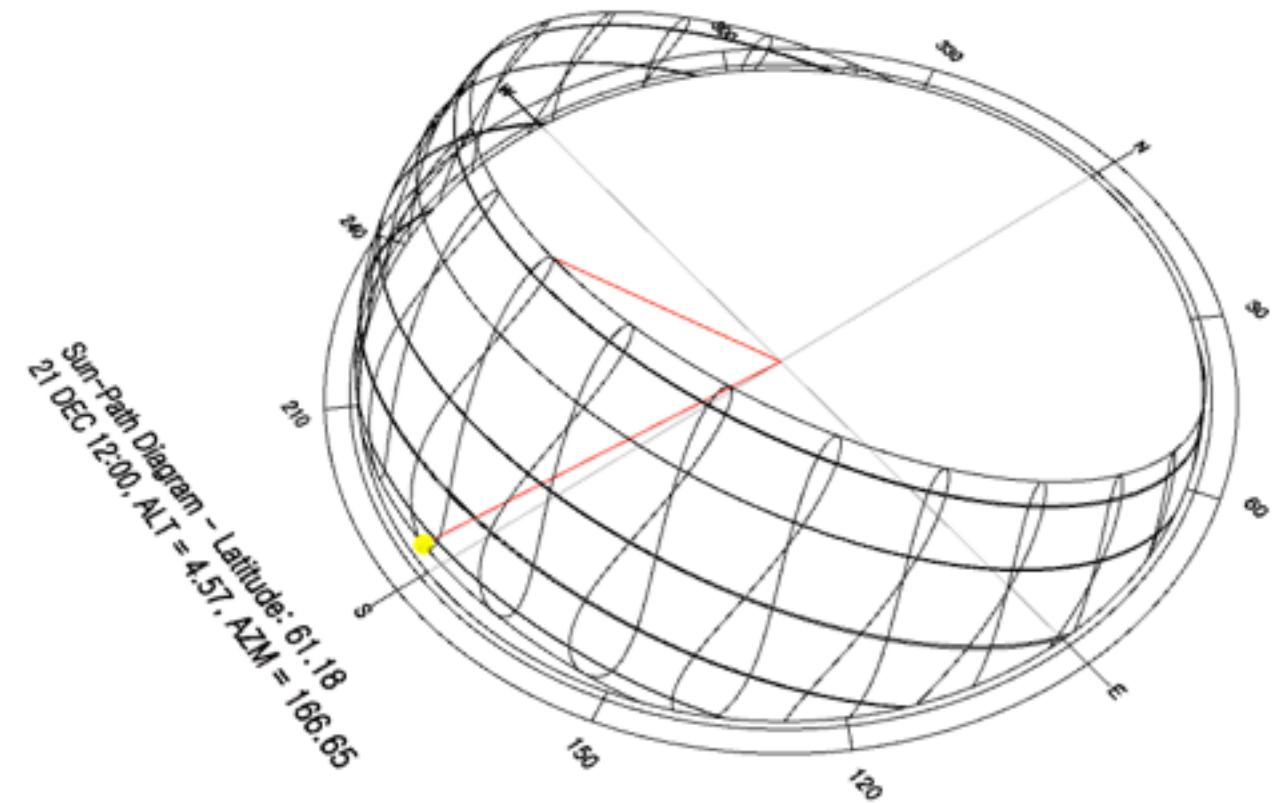
[HUMIDITY]

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

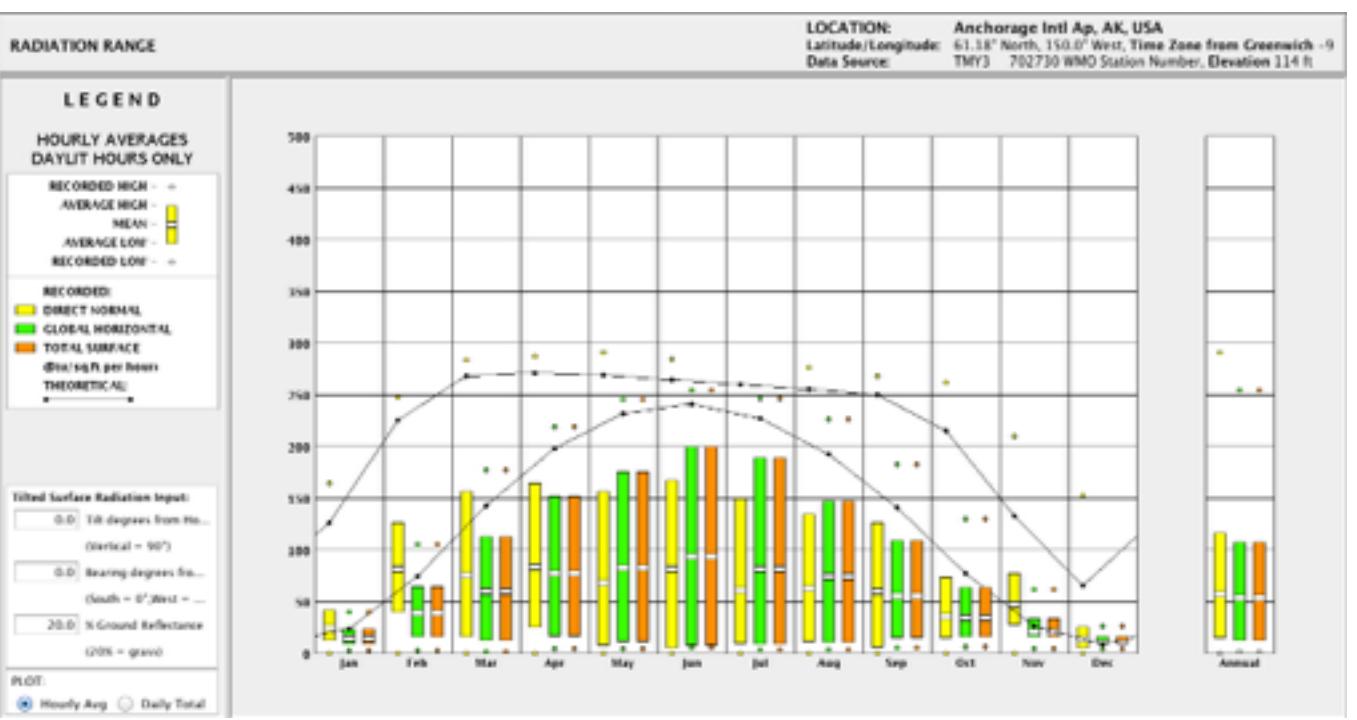
[SUN PATH]



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.

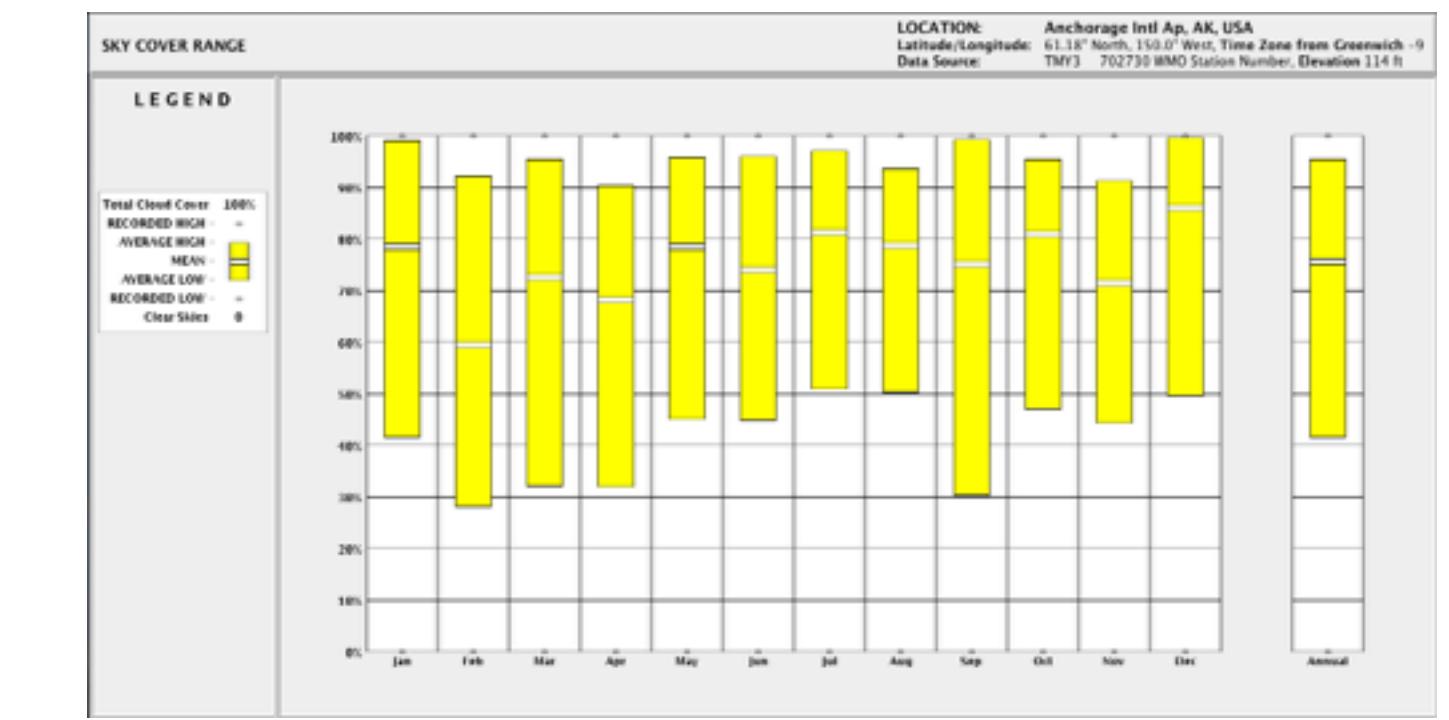
[RADIATION]



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]

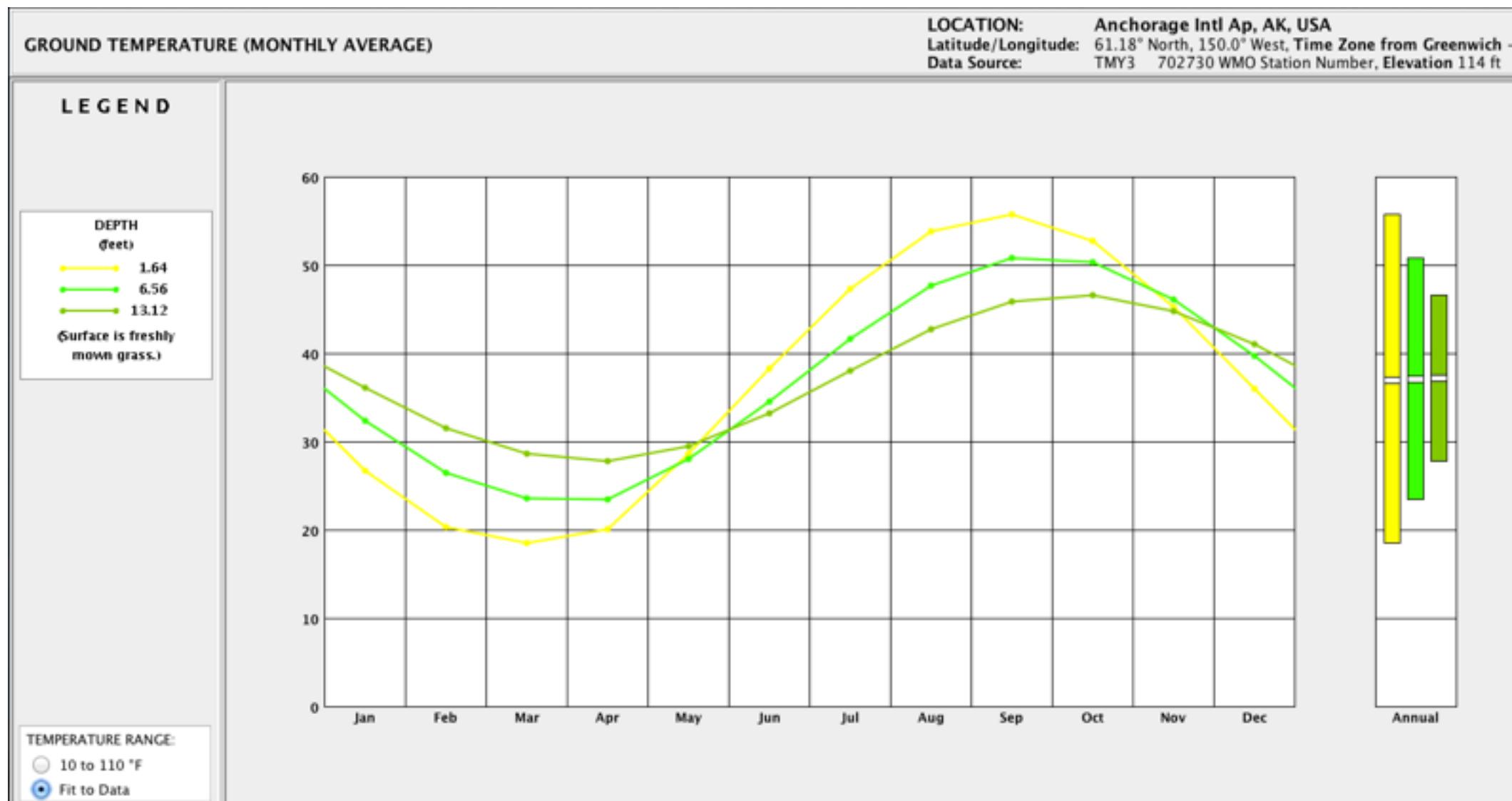


From this graph, the sky seems covered with cloud a lot. It might be relative to the high humidity.

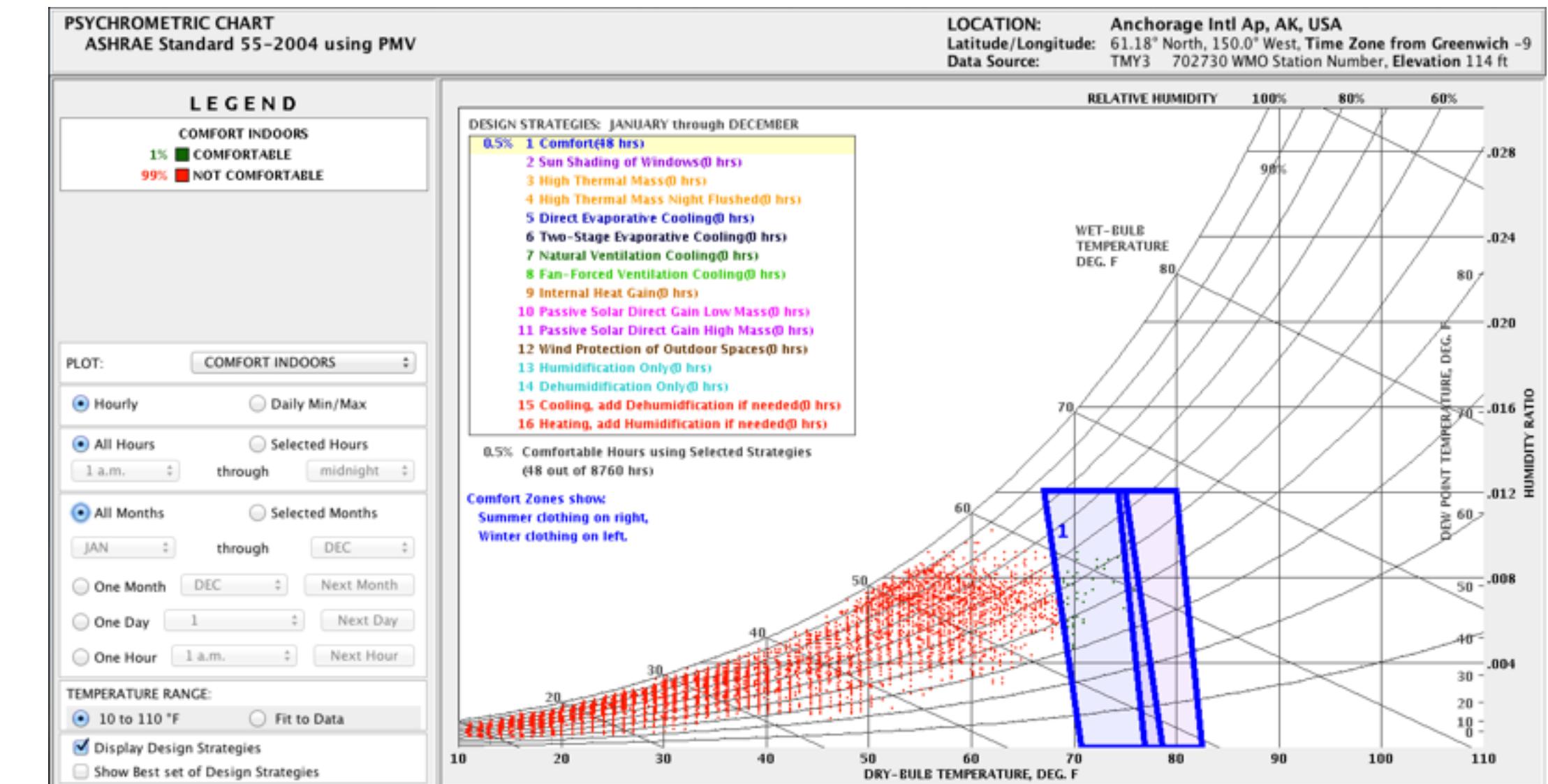
This city doesn't have enough sunlight already, so the sunlight coming to indoor might be more limited, compare to the other region on the same latitude.

CLIMATE ANALYSIS of DATA ANCHORAGE

[GROUND TEMPERATURE]



[PSYCHROMETRIC CHART]



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.

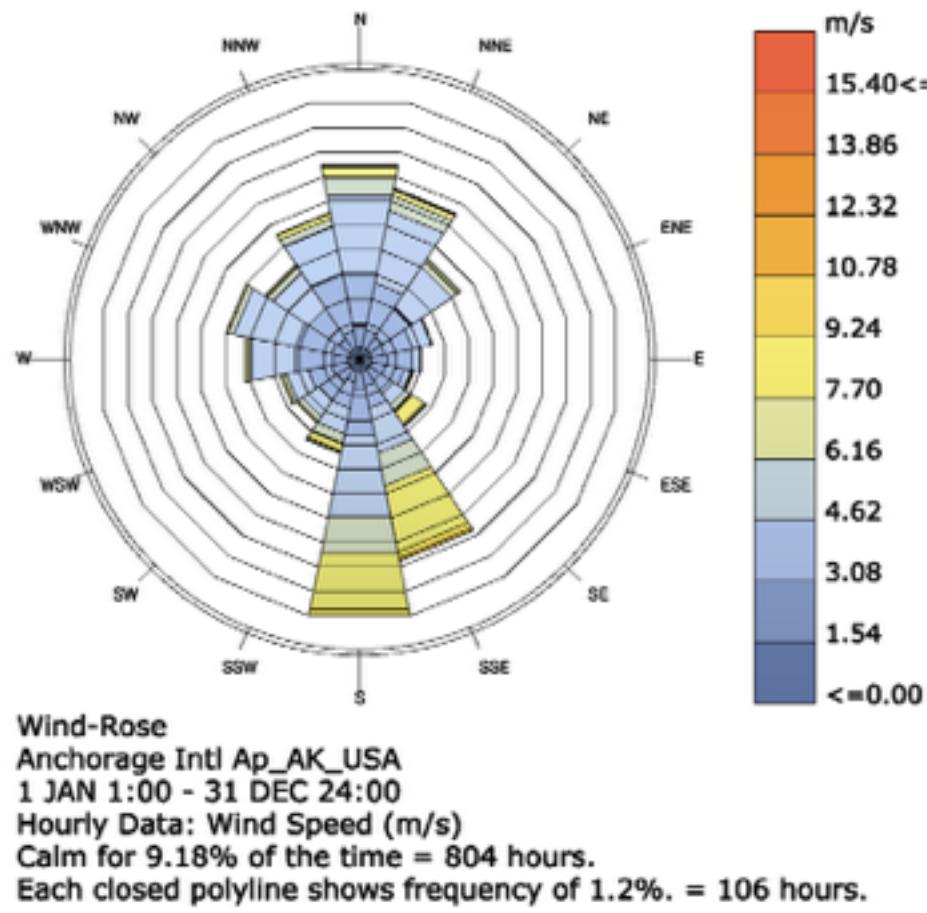
It shows a potential to build a strategy that using underground will allow the building to receive heat from the ground. It will be more helpful during the winter. For example, in December ground temperature has a range between 30~40°F (about 0~5°C), while the outdoor temperature is about 18°F (-7°C)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

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

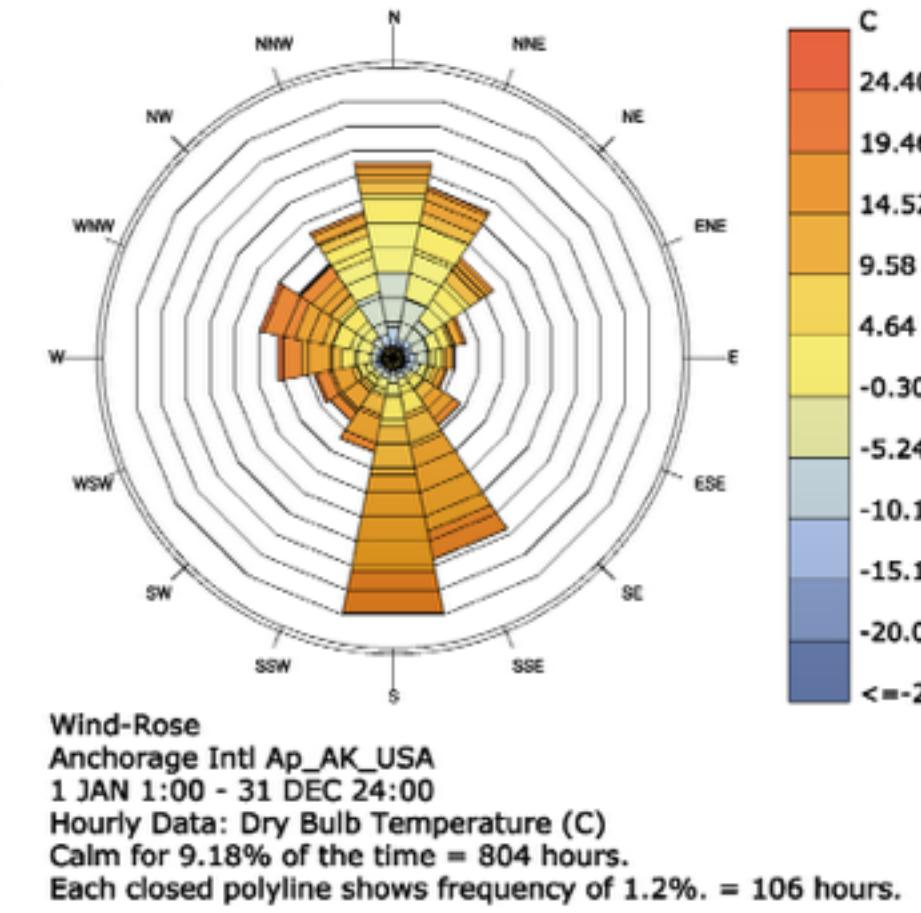
With passive and active design strategy, the area of the comfort zone can be increased.

CLIMATE ANALYSIS of DATA ANCHORAGE

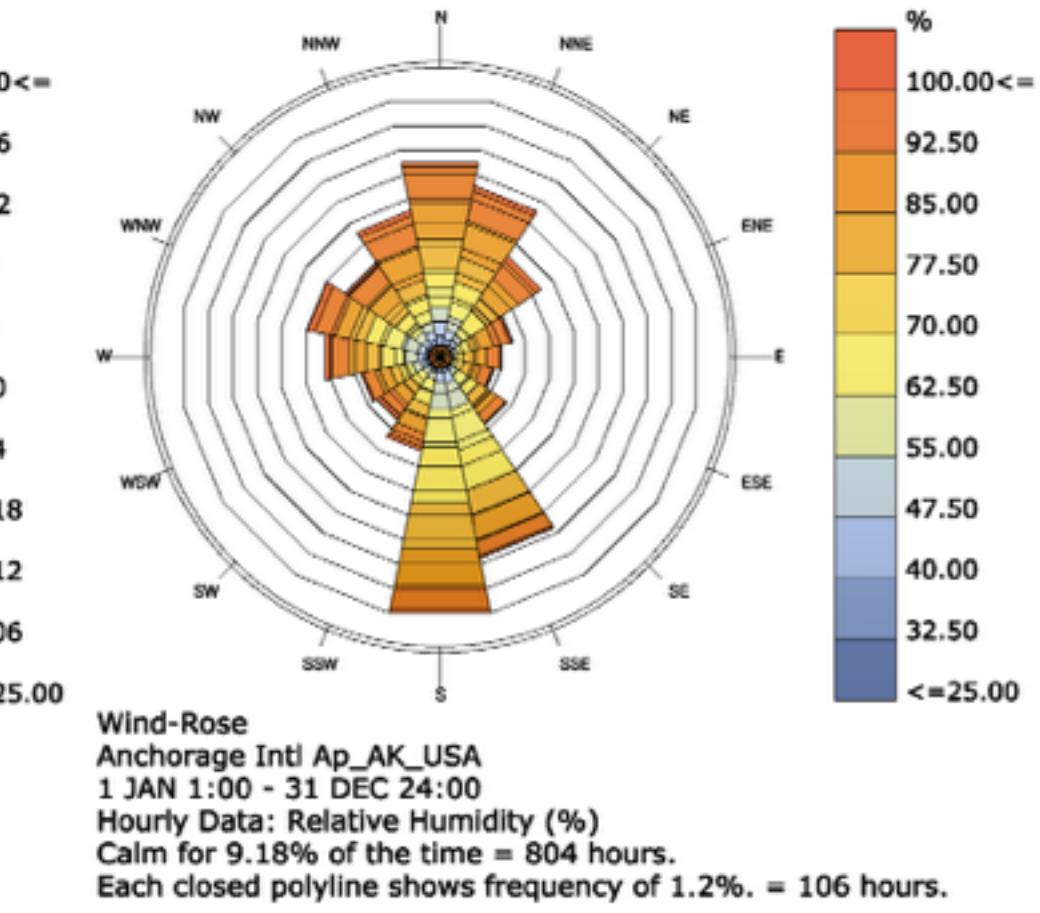
[WIND]



a. WIND SPEED



**b. DRY BULB
TEMPERATURE**

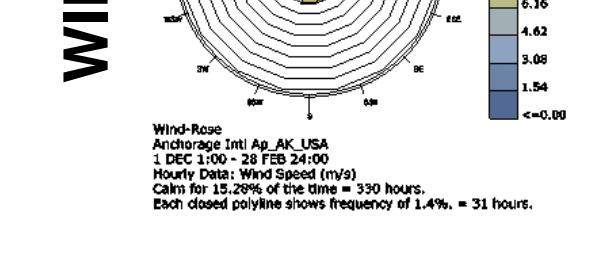
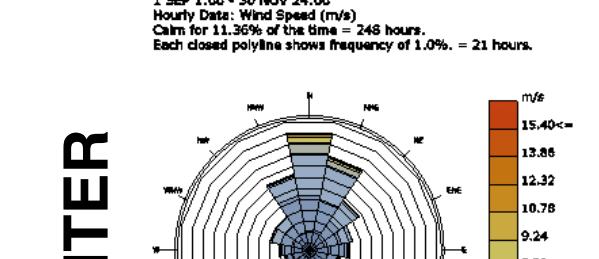
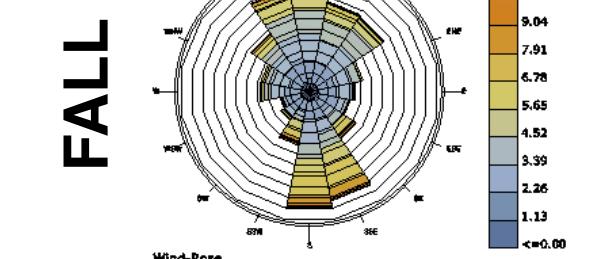
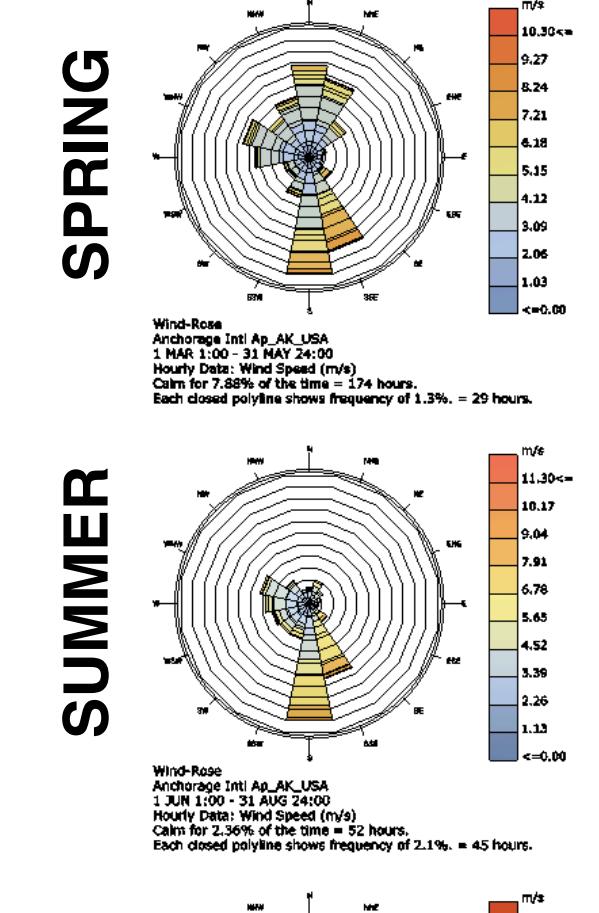


c. RELATIVE HUMIDITY

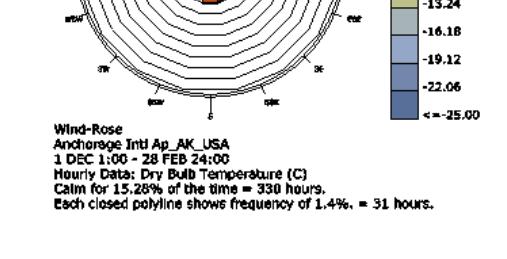
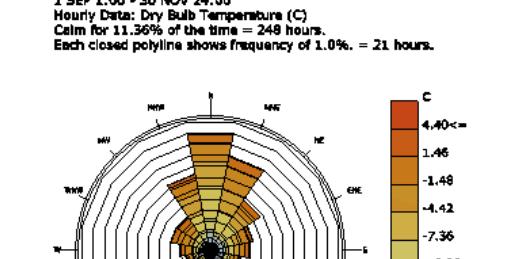
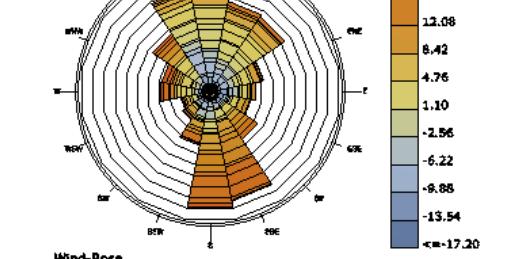
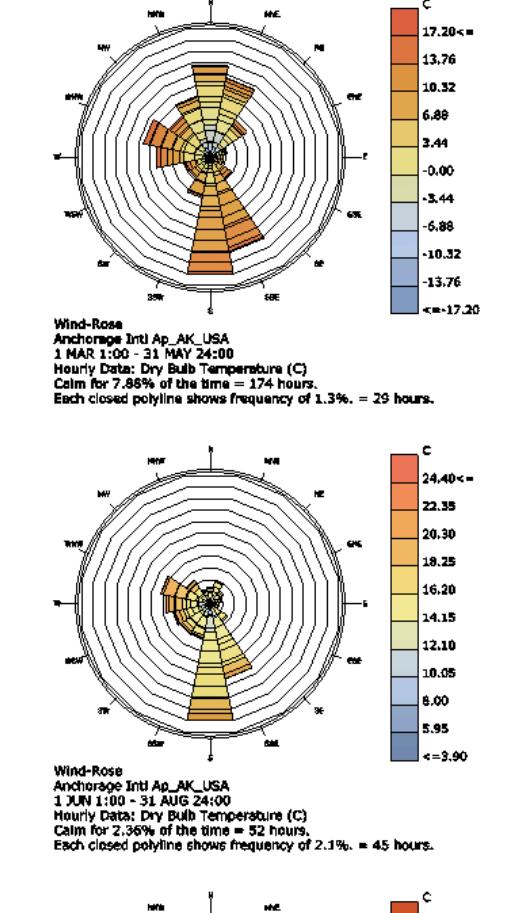
The wind in Anchorage is mostly blown from South and North direction, other than West or East. The wind from South brings warmer air than its from North. The wind from North brings more moisture to the city than that from South does.

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.

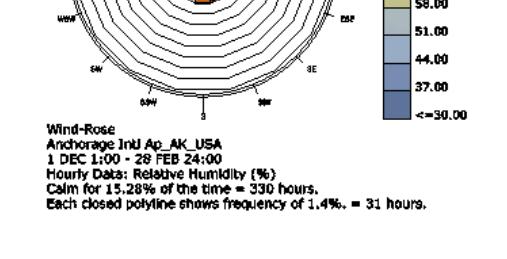
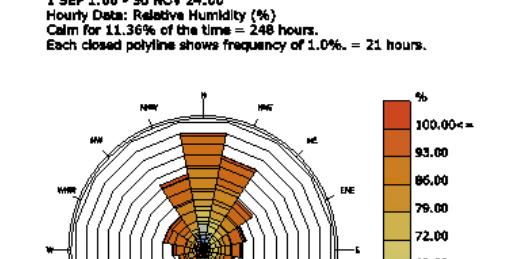
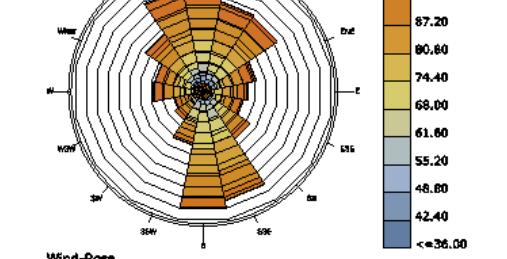
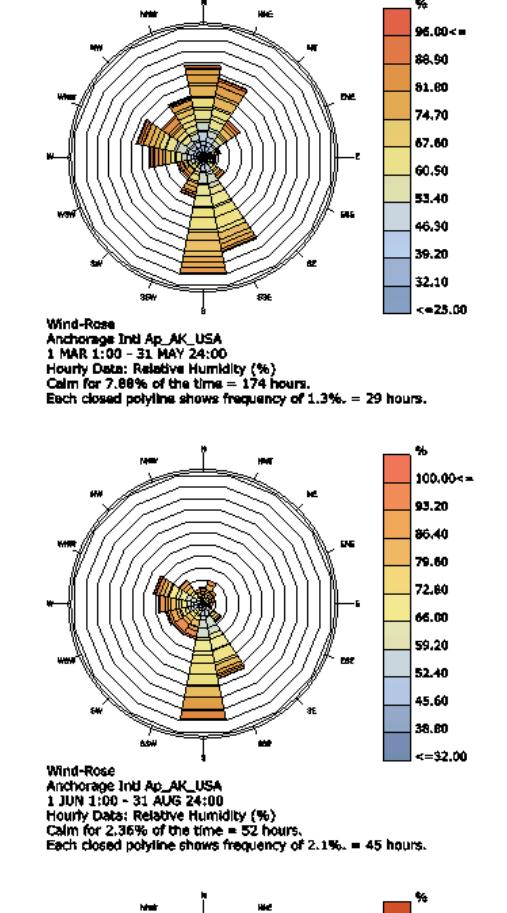
[WIND - BY SEASON]



a



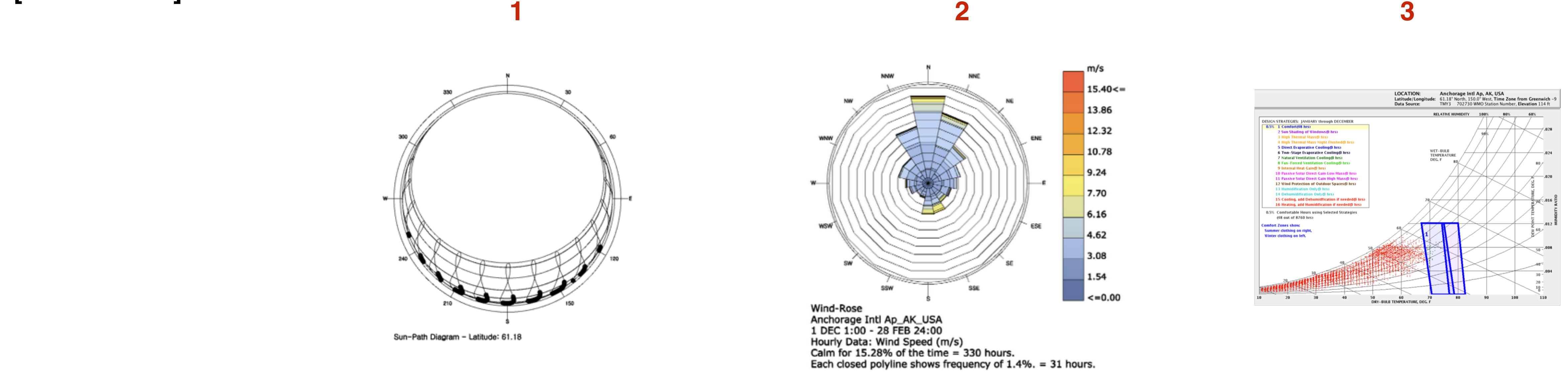
b



c

CLIMATE ANALYSIS of DATA ANCHORAGE

[SUMMARY]



ANALYSIS

SHORTAGE OF SUNLIGHT

DESIGN
RECOMMENDATION

MAXIMIZE DAYLIGHTING
FROM SOUTH

COLD WIND FROM NORTH

HEAVY INSULATION
ON NORTH

LOW AIR TEMPERATURE
+
WARM GROUND TEMP.

USE UNDERGROUND

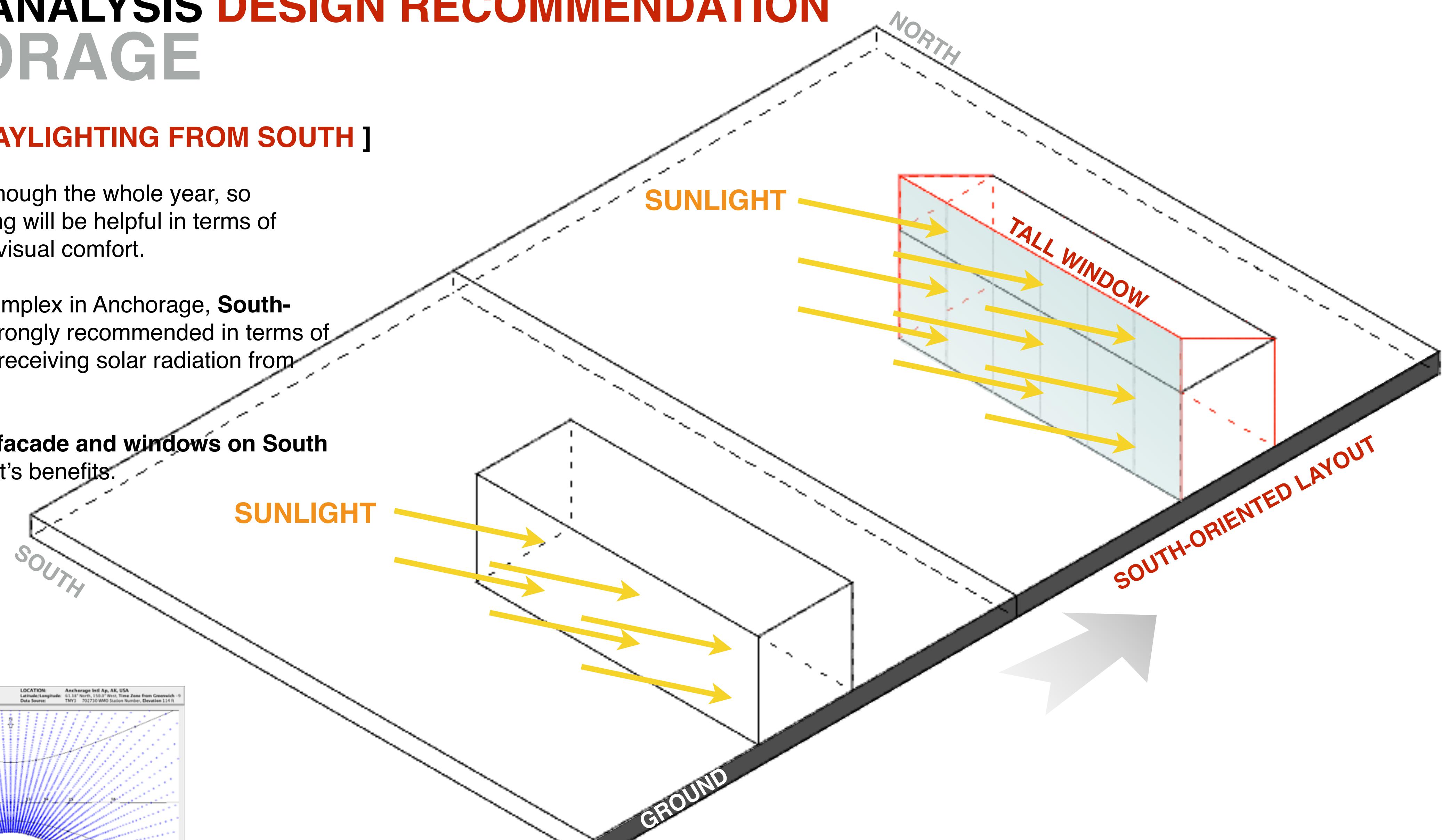
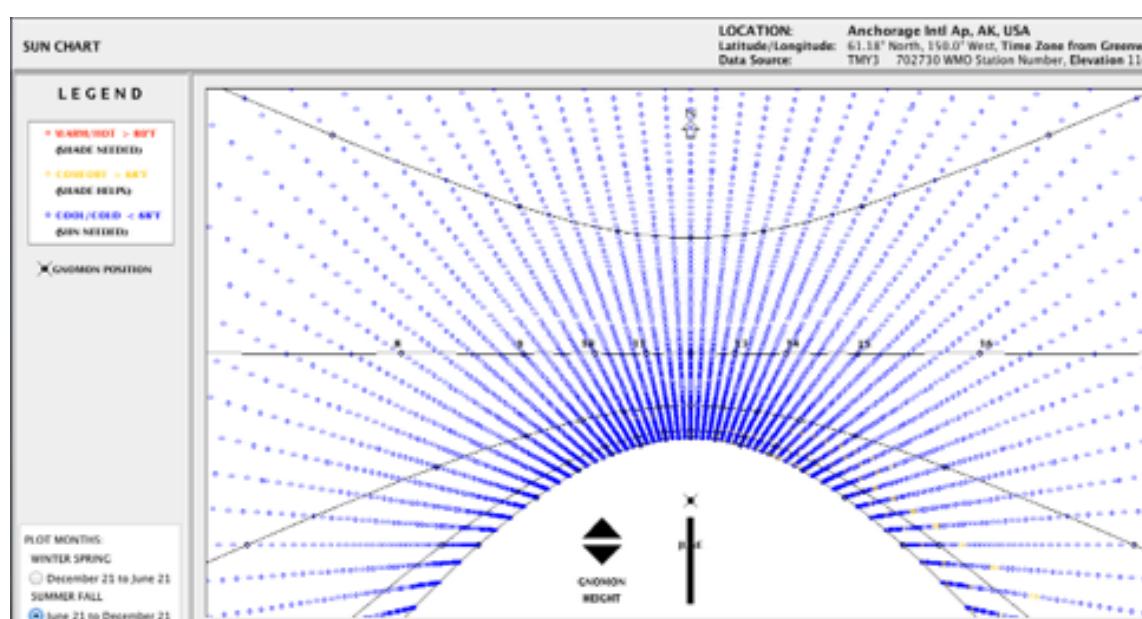
CLIMATE ANALYSIS DESIGN RECOMMENDATION ANCHORAGE

[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.

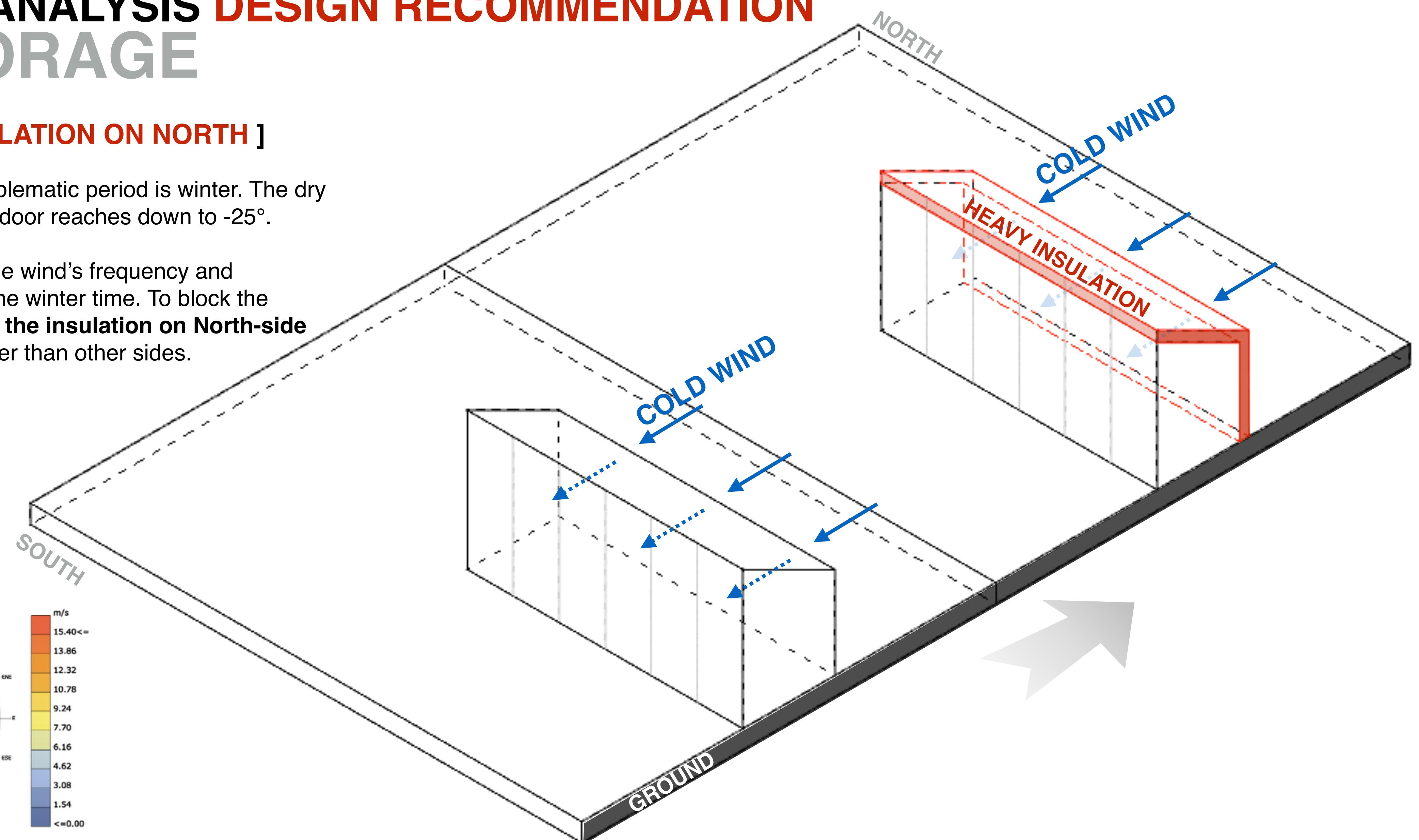
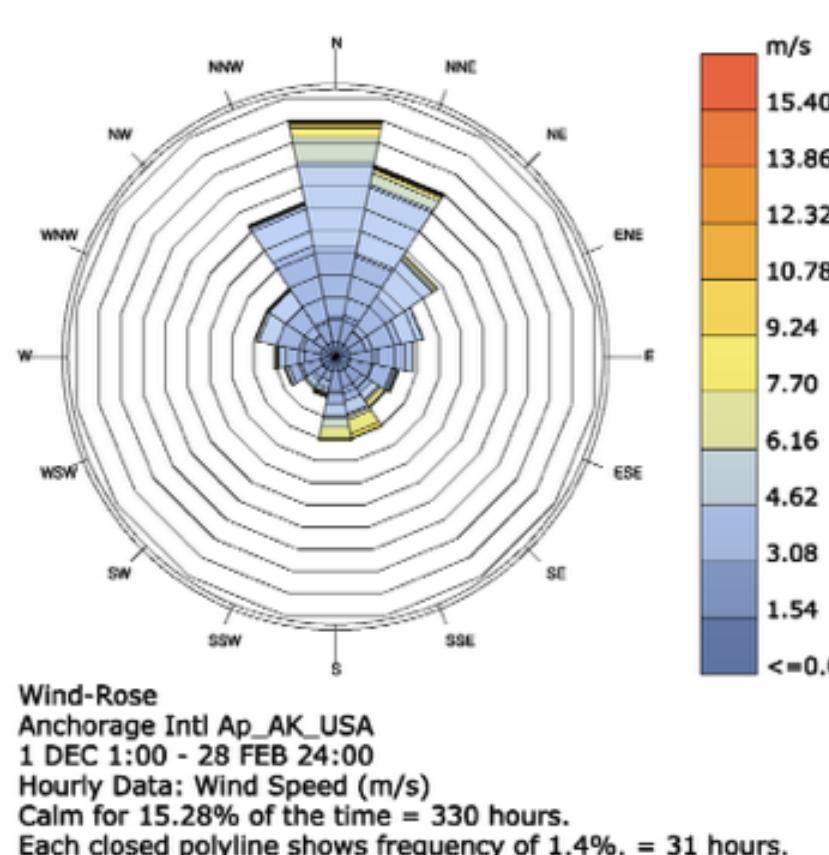


CLIMATE ANALYSIS DESIGN RECOMMENDATION ANCHORAGE

[2 HEAVY 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 heavier than other sides.



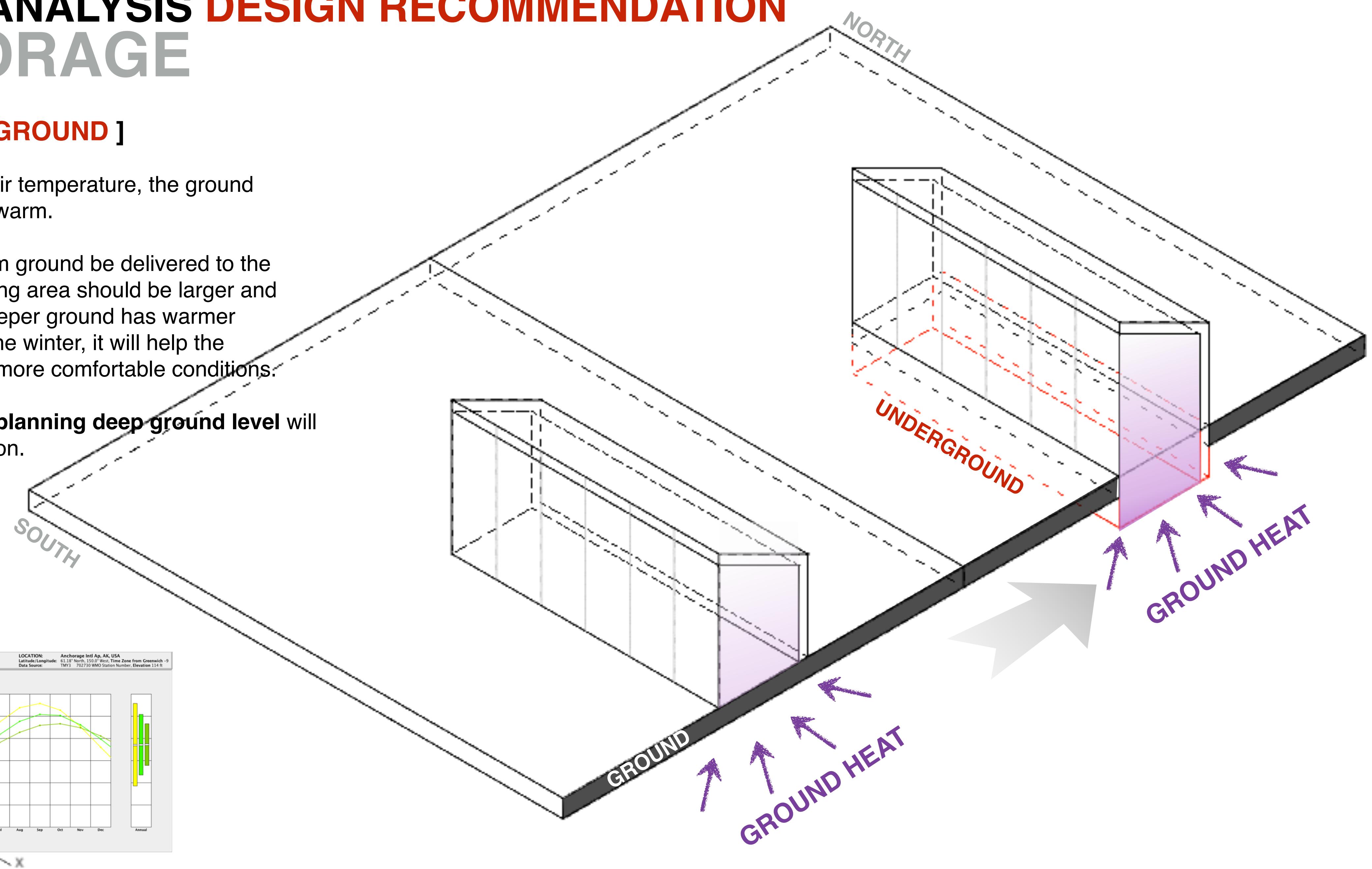
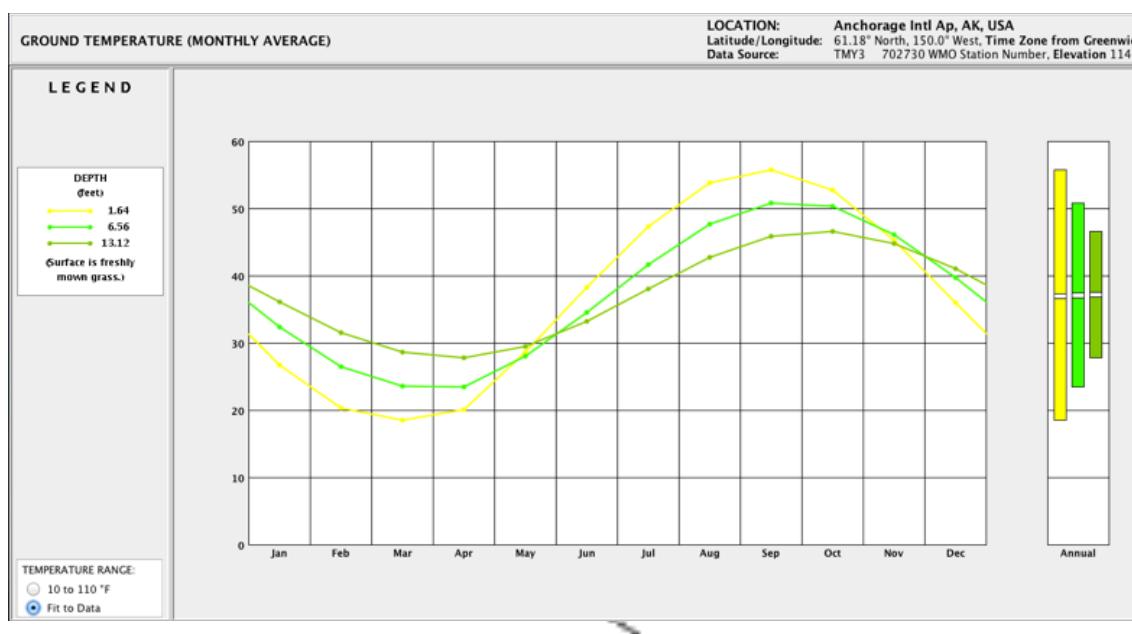
CLIMATE ANALYSIS DESIGN RECOMMENDATION ANCHORAGE

[3 USE UNDERGROUND]

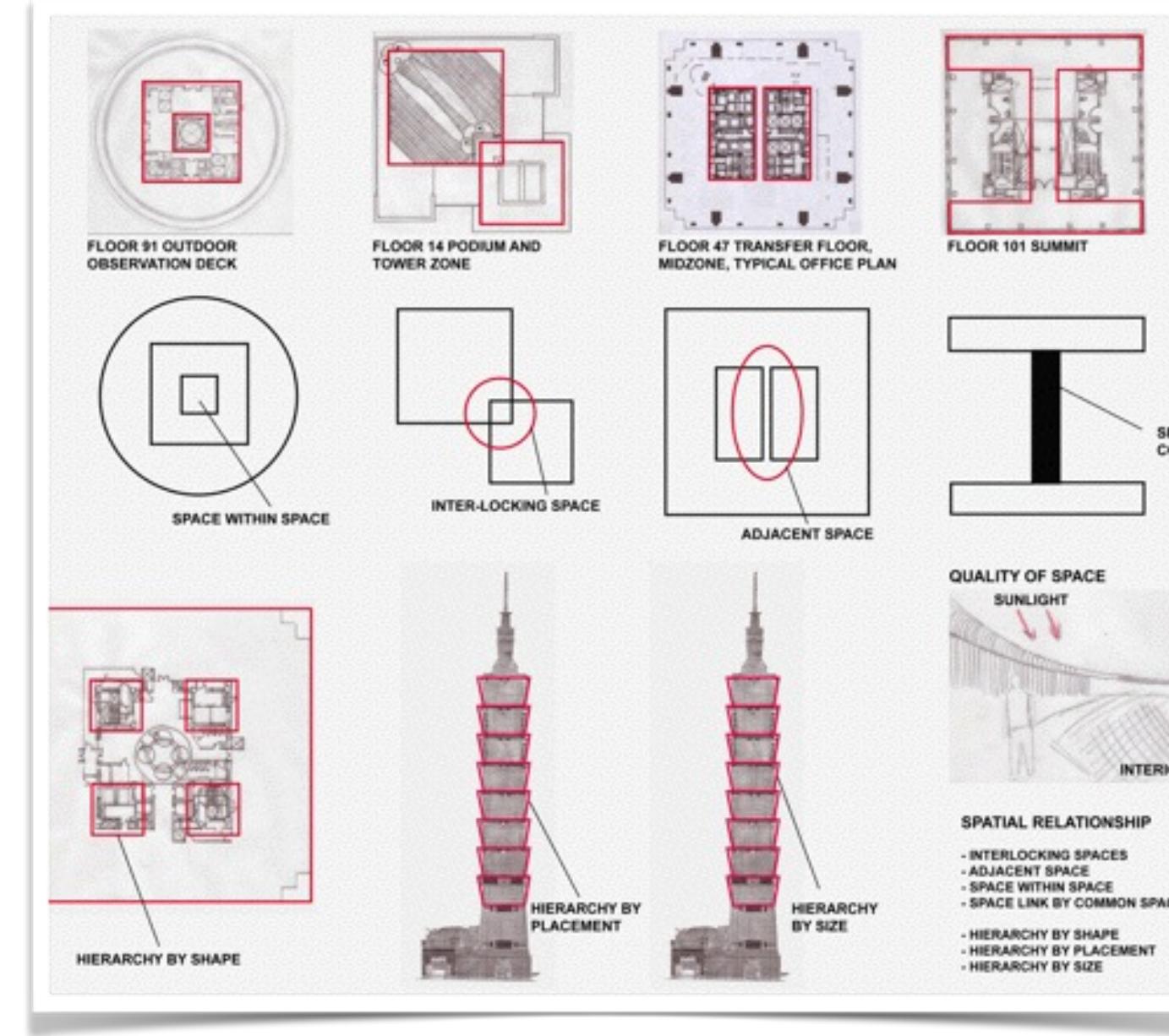
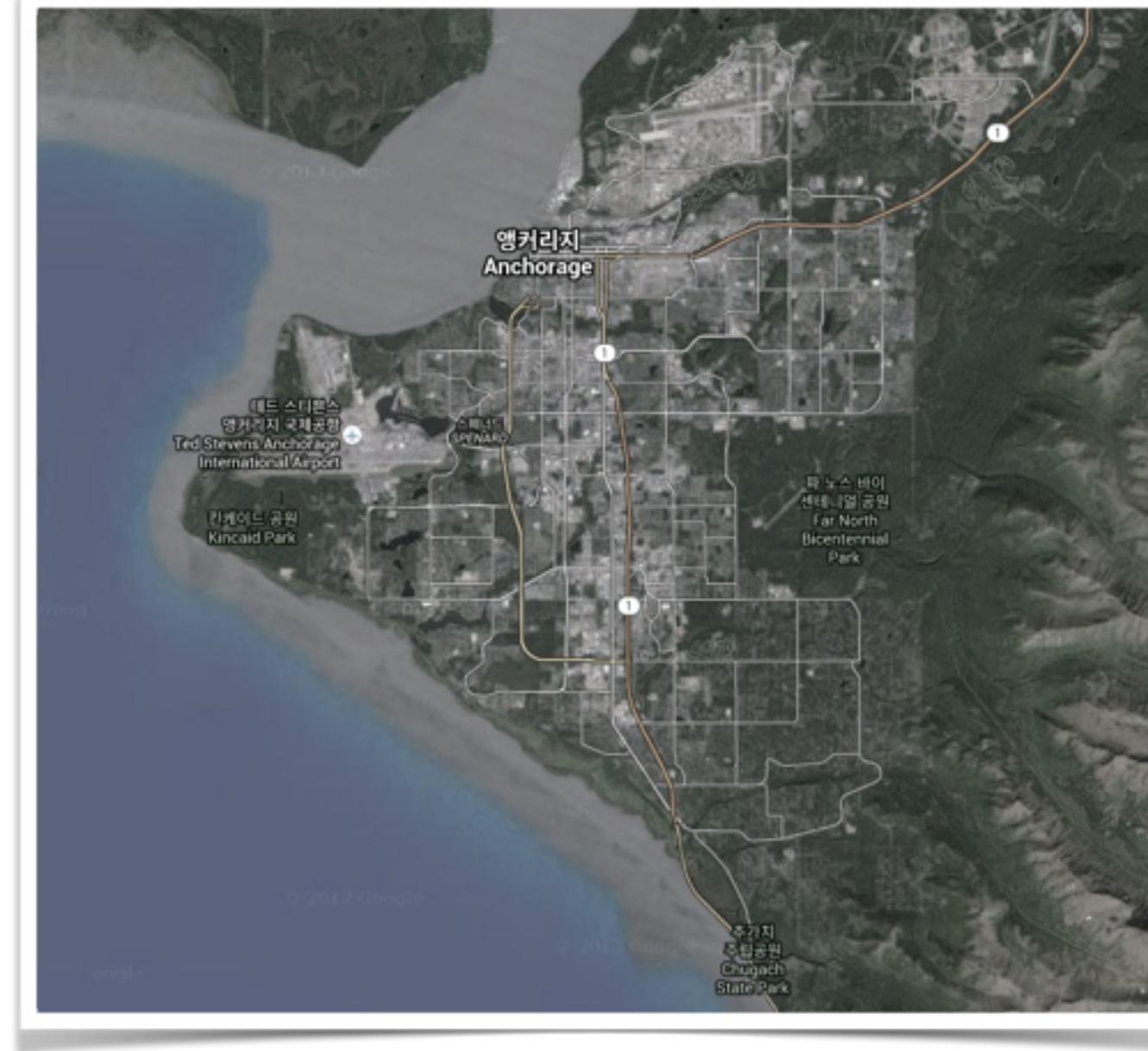
In contrast with low air temperature, the ground temperature is fairly warm.

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 NECESSARY DATA, FOR NEXT STEP ANCHORAGE

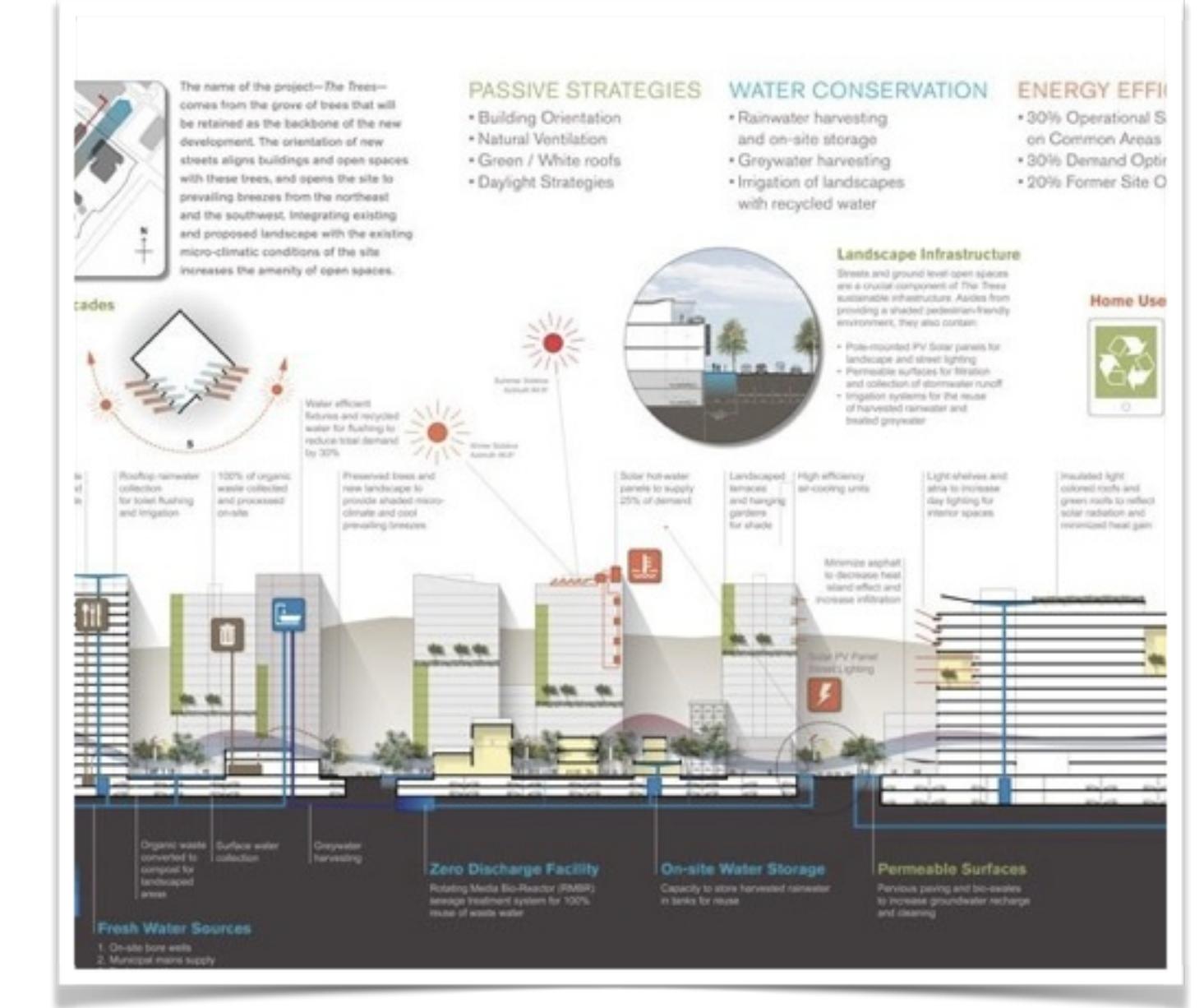


[SITE CONDITION]

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.

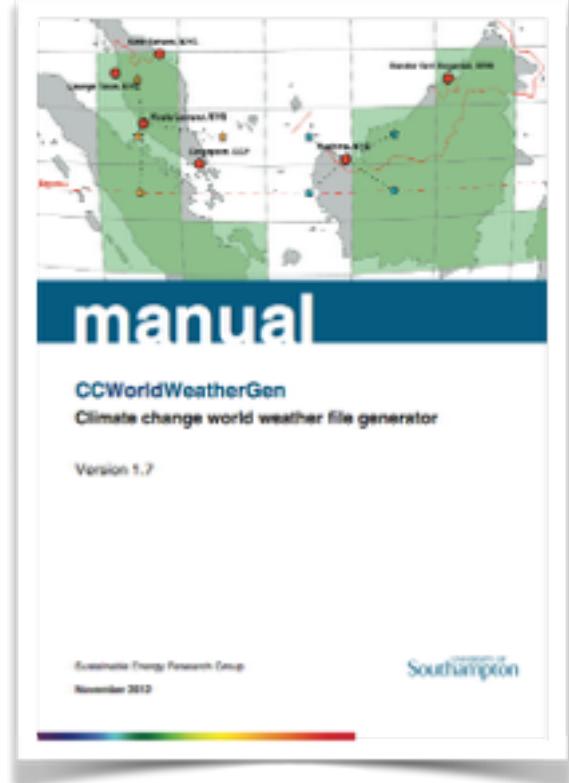


[PROGRAM]

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 weather 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/m ²	-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 ensemble timeframe

2020's 2050's 2080's Load Scenario

Closest four HadCM3 96x73 grid points to Anchorage Intl Ap, USA Latitude: 57.50 N Longitude: -150.00 W
A Latitude: 65.00 N Longitude: -150.00 W
B Latitude: 60.00 N Longitude: -150.00 W
C Latitude: 62.50 N Longitude: -150.00 W
D Latitude: 62.50 N Longitude: -150.00 W

EPW weather file morphing

(3) Click button to start morphing procedure

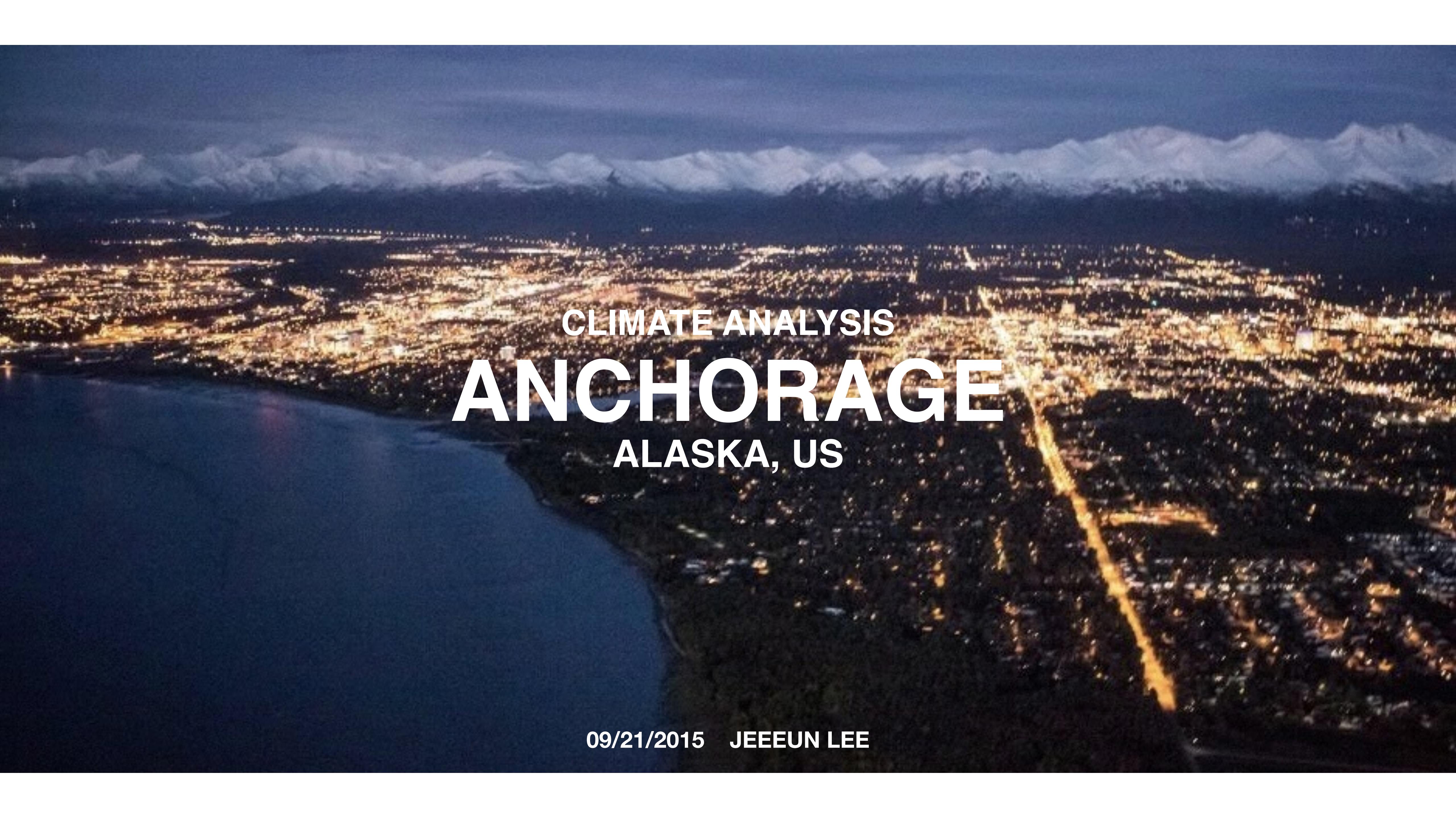
Start Morphing Procedure

Current morphed EPW weather file:
Morphed EPW file for: Anchorage Intl Ap, USA
HadCM3 A2 emissions scenario 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 from EPW data

An aerial photograph of Anchorage, Alaska at night. The city is densely packed with lights, and a river or bay is visible in the foreground. In the background, a range of mountains is covered in snow under a dark sky.

CLIMATE ANALYSIS
ANCHORAGE
ALASKA, US

09/21/2015 JEEEUN LEE