Lab

3b

Sun Angle and Solar Energy Transfer

Real-World vs. Experimental Data Analysis

Last week each group developed a hypothesis relating sun angle to temperature and then devised an experiment to test these hypotheses. Your lab reports should contain the procedures and results of your experiment and the preliminary analysis you derived from your experimental data.

Today we will go beyond your original experimental data and use real data gathered from temperature datasets from NOAA and other sources. Additionally, new analytical techniques will be used to help better quantify the actual solar intensity at our test sites.

Upon the conclusion of these calculations student groups will revisit their preliminary analyses and:

1. Determine if their original analysis reflected similar results as those from the real-world data and,
2. Revise their analysis to include new test results and techniques learned in today's lab.

When you have completed the calculations and final analyses, please enter these into your lab report.

As with the preliminary analysis, you should have all lab group members review and amend the lab report to reflect all group members ideas and contributions. Please note that there may be different interpretations within the group when it comes to the final analysis portion. If this is the case it would be best to include all differing analyses and the reasoning behind them. Please note which members are aligned with each analysis.

You should now turn in your group lab report and be sure that all group members full names are shown on the cover. This will conclude the group portion of this lab.

A discussion question will be posted and everyone is required to write an individual and original response to this/these question(s). Once your initial response has been received, you will then be able to read and comment on the postings of your fellow students. You will be required to engage in an online discussion of these comments with at least 3 other students. The deadlines for your original post and your online discussion will be explained during lab.

Calculating Solar Intensity

Your understanding of sun angle and its impact on the earth's surface is a good first step in understanding how the sun's energy affects the planet. We will now go into more depth as we seek to understand quantifiably this impact.

The main reason why certain areas on Earth are warmer than other areas is because they receive a greater intensity of solar radiation, which is directly related to the sun angle. Sun angle (also called altitude angle) is very important because it affects the intensity of solar radiation reaching the ground. When sun angles are large (i.e. closer to 90°) solar rays are more direct and deliver more energy. As sun angle decreases, radiation is spread over a larger surface area. When more surface area "shares" the solar energy, the intensity of the energy received is less. Figure 3.5 illustrates this idea by comparing the surface area of radiation for sun angles of 70° and 36.5°. The surface area of radiation for the higher sun angle is less than for the lower sun angle, meaning that the higher the sun angle, the more intense the radiation is at the surface.

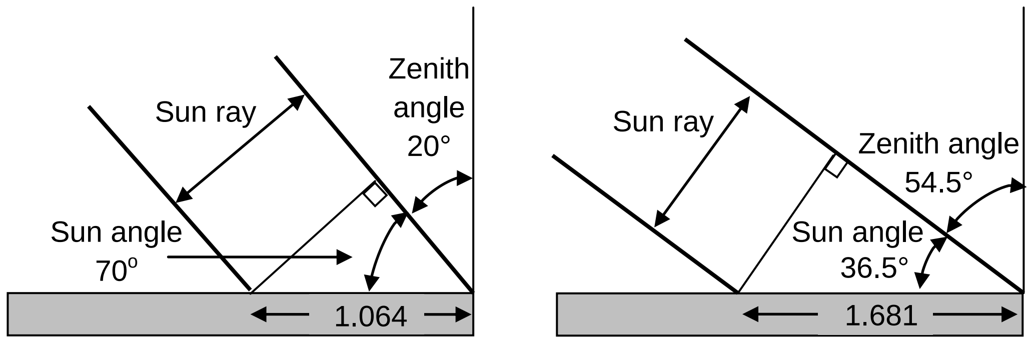


Fig. 3.5 Solar Angle and Surface Area

Surface Area of Radiation. The surface area that the sun's ray covers changes with the sun angle and can be determined through trigonometry. The following equations are used to determine the surface area:

$$\sin(\angle A) = \frac{1\text{ unit width}}{\text{surface area}} \quad \text{and} \quad \text{surface area} = \frac{1}{\sin(\angle A)}.$$

For example, if the altitude angle = 50° then

$$\text{surface area} = \frac{1}{\sin(50°)} = \frac{1}{0.766} = 1.305;$$

this means that 1 unit area of sunshine striking the earth with an altitude angle of 50° will be spread over an area of 1.305 (i.e. an area 30.5% larger).

Percentage of Beam Intensity. As solar radiation is spread over more of the Earth's surface, the intensity of the beam decreases according to the following equation:

$$\text{percent of beam intensity} = \sin(\angle A) \times 100$$

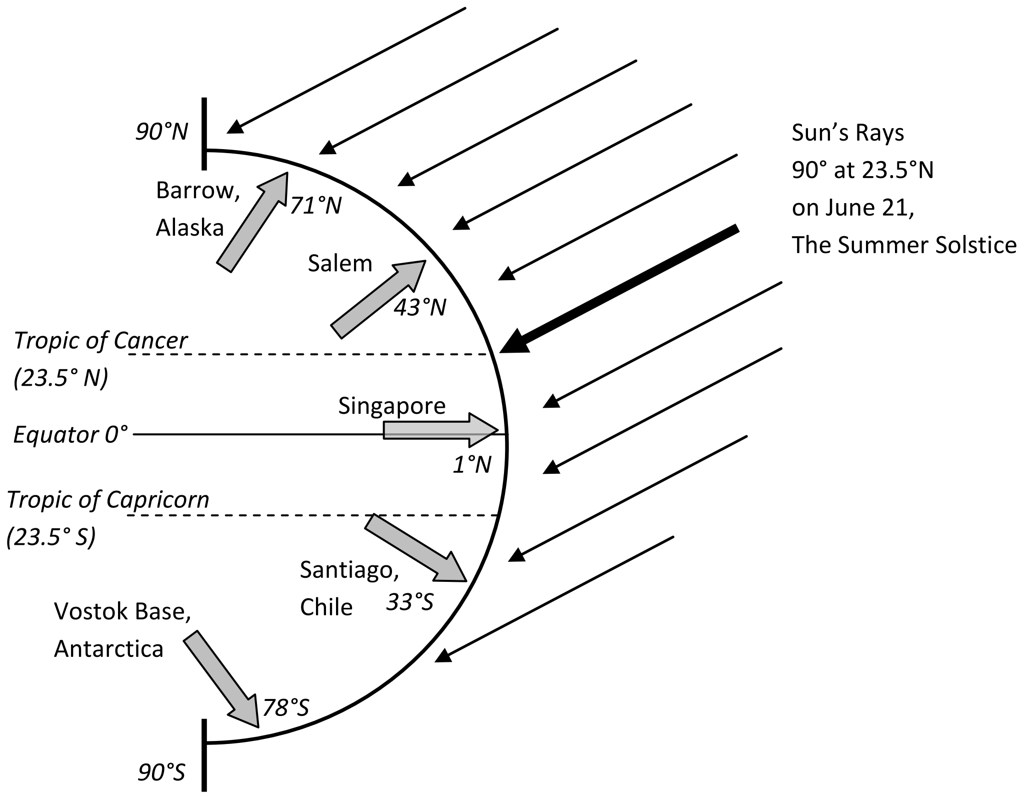
For example, if the altitude angle = 50° then:

$$\sin(50°) = 0.766 \times 100 = 76.6 \quad \text{or} \quad 76.6\%.$$

Surface Area of Radiation and Beam Intensity Exercises

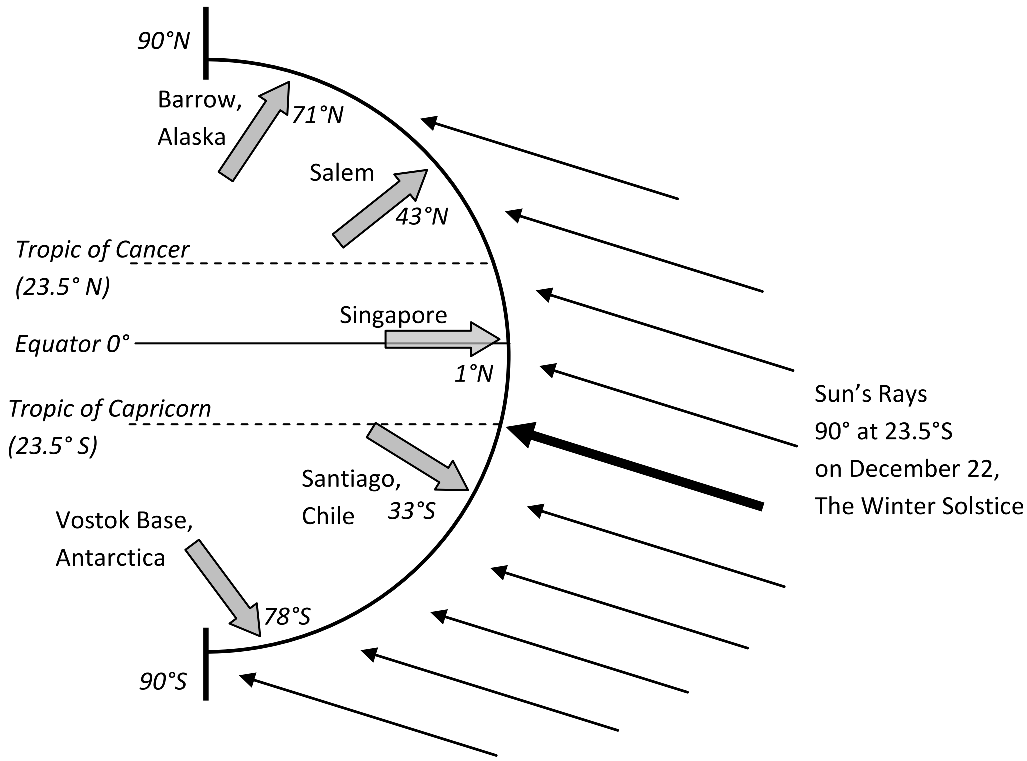
Calculate the Surface Area of Radiation (SAR) and Beam Intensity (BI%) for the following locations on the dates specified.

The Summer Solstice, June 21



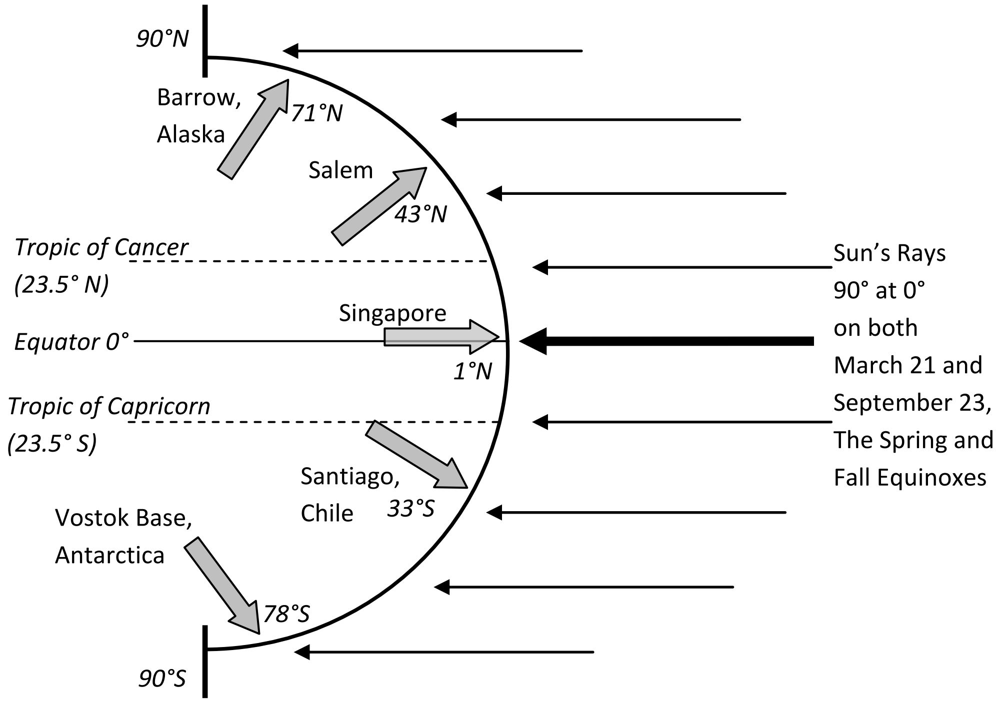
Place	Lat of Place	Lat. Of 90° Sun	Ang. Dist / Zenith Ang.	Sun Ang.	SAR	BI%
Barrow, AK	**71° N**	**23.5° N**				
Salem, MA	**43° N**	**23.5° N**				
Singapore	**1° N**	**23.5° N**				
Santiago, Chile	**33° S**	**23.5° N**				
Vostok Base, Antarctica	**78° S**	**23.5° N**				

The Winter Solstice, December 21



Place	Lat of Place	Lat. Of 90° Sun	Ang. Dist / Zenith Ang.	Sun Ang.	SAR	BI%
Barrow, AK	**71° N**	**23.5° S**				
Salem, MA	**43° N**	**23.5° S**				
Singapore	**1° N**	**23.5° S**				
Santiago, Chile	**33° S**	**23.5° S**				
Vostok Base, Antarctica	**78° S**	**23.5° S**				

The Spring Equinox (March 21) and the Fall Equinox (September 23)



Place	Lat of Place	Lat. Of 90° Sun	Ang. Dist / Zenith Ang.	Sun Ang.	SAR	BI%
Barrow, AK	**71° N**	**0°**				
Salem, MA	**43° N**	**0°**				
Singapore	**1° N**	**0°**				
Santiago, Chile	**33° S**	**0°**				
Vostok Base, Antarctica	**78° S**	**0°**				

Sine Table:

Angle	Sin Θ	Angle	Sin Θ	Angle	Sin Θ	Angle	Sin Θ
0	**0.000**	0.5	0.009	1	0.017	1.5	0.026
2	0.035	2.5	0.044	3	0.052	3.5	0.061
4	0.070	4.5	0.078	5	0.087	5.5	0.096
6	0.105	6.5	0.113	7	0.122	7.5	0.131
8	0.139	8.5	0.148	9	0.156	9.5	0.165
10	0.174	10.5	0.182	11	0.191	11.5	0.199
12	0.208	12.5	0.216	13	0.225	13.5	0.233
14	0.242	14.5	0.250	15	0.259	15.5	0.267
16	0.276	16.5	0.284	17	0.292	17.5	0.301
18	0.309	18.5	0.317	19	0.326	19.5	0.334
20	0.342	20.5	0.350	21	0.358	21.5	0.367
22	0.375	22.5	0.383	23	0.391	23.5	0.399
24	0.407	24.5	0.415	25	0.423	25.5	0.431
26	0.438	26.5	0.446	27	0.454	27.5	0.462
28	0.469	28.5	0.477	29	0.485	29.5	0.492
30	**0.500**	30.5	0.508	31	0.515	31.5	0.522
32	0.530	32.5	0.537	33	0.545	33.5	0.552
34	0.559	34.5	0.566	35	0.574	35.5	0.581
36	0.588	36.5	0.595	37	0.602	37.5	0.609
38	0.616	38.5	0.623	39	0.629	39.5	0.636
40	0.643	40.5	0.649	41	0.656	41.5	0.663
42	0.669	42.5	0.676	43	0.682	43.5	0.688
44	0.695	44.5	0.701	45	0.707	45.5	0.713
46	0.719	46.5	0.725	47	0.731	47.5	0.737
48	0.743	48.5	0.749	49	0.755	49.5	0.760
50	0.766	50.5	0.772	51	0.777	51.5	0.783
52	0.788	52.5	0.793	53	0.799	53.5	0.804
54	0.809	54.5	0.814	55	0.819	55.5	0.824
56	0.829	56.5	0.834	57	0.839	57.5	0.843
58	0.848	58.5	0.853	59	0.857	59.5	0.862
60	**0.866**	60.5	0.870	61	0.875	61.5	0.879
62	0.883	62.5	0.887	63	0.891	63.5	0.895
64	0.899	64.5	0.903	65	0.906	65.5	0.910
66	0.914	66.5	0.917	67	0.921	67.5	0.924
68	0.927	68.5	0.930	69	0.934	69.5	0.937
70	0.940	70.5	0.943	71	0.946	71.5	0.948
72	0.951	72.5	0.954	73	0.956	73.5	0.959
74	0.961	74.5	0.964	75	0.966	75.5	0.968
76	0.970	76.5	0.972	77	0.974	77.5	0.976
78	0.978	78.5	0.980	79	0.982	79.5	0.983
80	0.985	80.5	0.986	81	0.988	81.5	0.989
82	0.990	82.5	0.991	83	0.993	83.5	0.994
84	0.995	84.5	0.995	85	0.996	85.5	0.997
86	0.998	86.5	0.998	87	0.999	87.5	0.999
88	0.999	88.5	1.000	89	1.000	89.5	1.000
90	**1.000**						