Measuring Albedo

Materials

- Light meters
- Student worksheets

Background:

Albedo is a measure of reflectivity. It is the ratio of the solar radiation (short wave radiation) reflected by a surface to the total incoming solar radiation. Albedo can either be expressed in a ratio (dimensionless number) or as a percentage. The higher the value, the more energy is reflected back to the source. Complete reflection is 1 or 100%, and complete absorption is 0. Surfaces that have a low albedo such as rocks or water are dark colored and will absorb more incoming solar radiation. High albedo surfaces are light, such as snow, ice, or sand, and reflect most of the incoming solar radiation back into the atmosphere.

Incoming solar radiation is measured in Watt/m^2, and the instrument that is used for the measurement is called a **pyranometer**. Since pyranometers are very expensive, the following experiment will be done with lightmeters. Lightmeters provide a measure of the light intensity (measured in the unit, **lux**), a good approximation of solar radiation.

Procedure:

At this station you will measure the albedo of different surfaces such as grass, sand, dirt, asphalt, snow, or concrete. At each site, you will measure light intensity of your light source and different surfaces with a lightmeter and calculate the albedo for each material.

1. Point the lightmeter directly to the incoming light source (sun or lamp). Avoid measurements if a shadow covers the lightmeter.
2. Record the incoming illuminance on your data sheet.
3. Point the lightmeter directly at the surface that you want to measure.
4. Record the reflected illuminance on your data sheet.
5. Calculate the albedo for the surface by determining the ratio of the outgoing illuminance to the incoming illuminance.
6. Conduct measurements for other surface types. Ensure that you measure the incoming versus reflected illuminance in a short time period.

Measuring Albedo

Date and Time: ___________________________ **Data Collectors:**____

Description of conditions (e.g. temperature, cloud cover, time of day, other observations relevant to measurement):

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Sketch experimental setup:

Type of surface cover	Outgoing illuminance	Incoming illuminance	Albedo

Measuring Albedo

Debrief in large group that includes at least one member of each data collection team

Compare the data from the different groups by looking at variation of data, identifying possible outliers and discussing reasons, emerging patterns or relationships. Please discuss the following guiding questions:

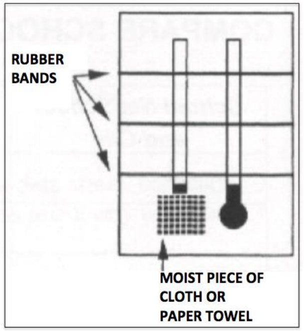
1) Which surface had the highest albedo? Which surface had the lowest albedo?

2) Which surfaces in the Arctic would have the highest albedo, assuming the sun hits the surface at the same angle: open ocean or sea ice? Explain why.

<u>Thinking globally:</u>
3) What is the effect of a large volcanic eruption that reaches the stratosphere (like Mount Pinatubo on the Philippines in 1991) on the albedo in the Arctic?

4) What is the effect of a dust storm on the albedo of ice sheets? Explain why.

Measuring Relative Humidity



Materials

- 2-4 red bulb glass thermometers
- Wet cloth
- Cardboard squares, rubber bands
- Student worksheets

Background

Relative humidity measures the amount of water vapor that is currently in the air *compared to* how much water vapor the air can hold at that temperature. Relative humidity can be defined as:
Relative humidity % = (Moisture in the air now / Maximum possible moisture air can hold at the current temperature) x 100. The amount of water vapor air can hold is dependent on the air temperature. Warm air can hold more moisture than cold air, so the relative humidity of air is higher on a warm, cloudy day than on a clear, cold day. Relative humidity is stated as a percent. If the relative humidity is 50%, this means that the air contains half of the water vapor that it can hold at that temperature.

Procedure

At this station you will create a sling hygrometer to measure relative humidity.
1) Lay two thermometers side by side on a piece of cardboard. Use rubber bands to hold them in place (see image).
2) Wrap the bulb of one thermometer with a moistened piece of cloth or paper towel (=wet bulb thermometer) and keep it moist.
3) Read and record the temperature of the dry bulb and the wet bulb. The dry bulb thermometer simply measures the air temperature.
4) Carefully fan the cardboard with the two thermometers in the air for about 30 seconds or until the wet bulb temperature stops falling and remains constant.
5) Record the temperatures for both thermometers on the worksheet and calculate the difference between the temperatures [dry bulb temperature – wet bulb temperature].
6) On the Relative Humidity chart find the dry bulb temperature that you measured on the y-axis and the difference between the two measured temperatures on the x-axis. The relative humidity is given as a percentage where the corresponding rows

Relative Humidity Chart

Difference between Dry Bulb and Wet Bulb Temperature

Dry Bulb Temperature	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
5	72	58	45	33											
6	73	60	48	35											
7	74	62	50	38	26										
8	75	63	51	40	29	19									
9	76	64	53	42	32	22	12								
10	77	66	55	44	34	24	15	6							
11	78	67	56	46	36	27	18	9							
12	78	68	58	48	39	29	21	12	7						
13	79	69	59	50	41	32	23	15	10						
14	79	70	60	51	42	34	26	18	13						
15	80	71	61	53	44	36	27	20	13	6					
16	81	71	63	54	46	38	30	23	15	8					
17	81	72	64	55	47	40	32	25	18	11					
18	82	73	65	57	49	41	34	27	20	14	7				
19	82	74	65	58	50	43	36	29	22	16	10				
20	83	74	66	59	51	44	37	31	24	18	12	6			
21	83	75	67	60	53	46	39	32	26	20	14	9	6		
22	83	76	68	61	54	47	40	34	28	22	17	11	8		
23	84	76	69	62	55	48	42	36	30	24	19	13	10		
24	84	77	69	62	56	49	43	37	31	26	20	15	12	5	
25	84	77	70	63	57	50	44	39	33	28	22	17	14	8	
26	85	78	71	64	58	51	46	40	34	29	24	19	16	10	5
27	85	78	71	65	58	52	47	41	36	31	26	21	18	12	7
28	85	78	72	65	59	53	48	42	37	32	27	22	19	13	9
29	86	79	72	66	60	54	49	43	38	33	28	24	21	15	11
30	86	79	73	67	61	55	50	46	39	35	30	25	22	17	13

All temperatures are shown in degrees Celsius.

Instructions:

To determine relative humidity, find the dry bulb temperature on the left (y-axis) and the difference between that and the wet bulb temperature on the top (x-axis). Where the row and column meet, read the relative humidity as a percentage.

Measuring Relative Humidity

Date and Time: ___________________________ **Data Collectors:**____

Description of conditions (e.g. temperature, cloud cover, time of day, other observations relevant to measurement):

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Sketch experimental setup:

	Measurement 1	Measurement 2
Temp dry bulb [deg. C]		
Temp wet bulb [deg. C]		
Difference		
Relative humidity (read off chart) [%}		

Relative Humidity

Debrief in large group that includes at least one member of each data collection team

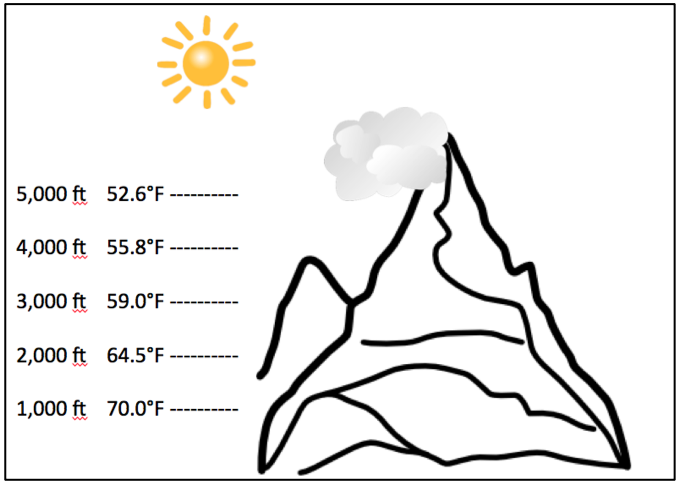
Compare the data from the different groups by looking at variation of data, identifying possible outliers and discussing reasons, emerging patterns or relationships. Please discuss the following guiding questions:

1) What were the average and the range of relative humidity determined by the groups? What were the average and the range of air temperature measured by all groups?

<u>Thinking globally:</u>

2) Think about the effect that changing air pressure has on relative humidity. Does the relative humidity of an air parcel change if it moves upslope?

3) Which side of a mountain chain receives higher precipitation–the windward facing or the leeward facing side? Why?



Measuring Soil Temperature

Materials

- 2-4 soil thermometers
- nail or spike, hammer for pilot hole
- Student worksheets

Background

Soils are a mixture of weathered bedrock or other local rock material (“parent material”) and organic matter. The temperature of soil fluctuates over the day and over the year and is affected mainly by variations in air temperature and solar radiation. The water content of the soil plays an important role in the temperature exchange between air and soil temperature since higher water content in the soil increases the thermal conductivity of the soil. A temperature gradient exists if the air and soil temperature are different, and heat will be transferred to reduce the temperature gradient. Soil surface temperatures are usually closer to the air temperature, while deeper soil layers are usually delayed in displaying any changes in air temperature. Thus, soil temperature varies with depth below ground. The degree of shading by plants and trees, as well as a snow cover, affects the temperature profile in the ground due to insolation properties (insolation = **in**coming **sol**ar radi**ation**).

Measuring Soil Temperature

Procedure

At this station you measure soil temperature by placing the thermometer in the ground at different depths and carefully measuring the temperature. Air temperature measurements will also be conducted at this station.

1. Choose two different sampling sites that appear to have different soil properties (sandy versus clay or different vegetation cover) for each student group conducting a measurement. Note the density of soil and the vegetation cover
2. Measure the air temperature about 30 cm (one foot) above the ground using a thermometer or temperature probe. Make sure not to measure in direct sunlight since that will cause an erroneously high measurement. Record the temperature.
3. Make two pilot holes at each site that have the approximate diameter of your thermometers (by using for example a thick nail and a hammer or a hand-drill). The pilot holes should be about 5 cm (2 inches) deep. Try to disturb the soil as little as possible when pulling out the nail or drill. Twisting as you pull out may help. If the soil cracks or bulges, choose another site and drill new holes.
4. Measure 5 cm (2 inches) from the temperature sensor (not the tip–the sensor is often located about 2 cm above the tip) and mark the two thermometers (this will be the depth to which the thermometers are being inserted in the ground).
5. Gently push the thermometers into the soil down to the mark that you made on the thermometer shaft. Put on safety equipment such as gloves and goggles if working with glass thermometers. Be careful to not break the glass of the thermometer when pushing it in the soil to avoid injuries to your hands. You are measuring the soil temperature at 5 cm depth. Wait 2 minutes. Record the temperature for each thermometer on the worksheet as the 5 cm reading. Remove the thermometers from the holes.
6. Now deepen both holes to 10 cm (4 inches) using the thick nail or spike. Measure 10 cm (4 inches) from the temperature sensor and mark the thermometer shaft.
7. Insert the thermometer in the same hole and gently push it down until the mark on the thermometer shaft is level with the surface, indicating that the temperature sensor is 10 cm below the surface. Wait 2 minutes and record the temperature.
8. Calculate the average of the two measurements for 5 cm depth and 10 cm depth below ground.
9. Compare the measurements from different sites.

Measuring Soil Temperature

Date and Time: ___________________________ **Data Collectors:**____

Description of conditions (e.g. temperature, cloud cover, time of day, other observations relevant to measurement):

____

____

Sketch experimental setup:

	Site 1	Site 2	Site 3
Vegetation cover			
Air temp at 30 cm [deg. C]			
Soil temp at 5 cm (hole 1) [deg C]			
Soil temp at 5 cm (hole 2) [deg C]			
Average temp 5 cm depth			
Soil temp at 10 cm (hole 1) [deg C]			
Soil temp at 10 cm (hole 2) [deg C]			
Average temp 10 cm depth			

Measuring Soil Temperature

Debrief in large group that includes at least one member of each data collection team

Compare the data from the different groups by looking at variation of data, identifying possible outliers and discussing reasons, emerging patterns or relationships. Please discuss the following guiding questions:

1) At which sampling location did you find the largest difference between air and soil temperatures?

2) Which soils would you expect to warm faster with warming air temperatures? Why?

Wet soils or dry soils?
Snow covered soils or barren soils?
Light soils or dark soils?

<u>Thinking globally:</u>
3) Increasing soil temperature in the Arctic raises important concerns with climate scientists as well as the local population in the Arctic. Can you brainstorm why?