**MEER Winter Albedo Experiment**

**Today's activity brings the concept of earth's albedo down to earth and places it in your hands. You'll be working outside in the snow so dress warmly.**

**Materials:**

**Mirror assembly**

40 x 40 cm mirrors
glass mounting rod
wood mounting frame
suction cups

**Measurement Instruments**

Compass (to orient mirrors)
Level (to ensure rod is vertical)
Brunton compass (to measure mirror slope)
Vernier light sensors and Mini Environmental Quality Meters (illumnination)
Thermometer
Ruler

**Set-up Tasks:**

1. At the field site, find a sunny spot with at least 6 inches snow depth. Partner up if you don't have a mirror (there are only 12 mirrors), maximum two people per group.
2. Assemble the mirror
   a) insert the glass rod into the wooden block
   b) push the rod firmly into the snow as far as you can
   c) place the suction cups on the glass pane on the wooden block
   d) center the mirror over the suction cups and carefully push down in the center of the mirror to establish the suction
   e) adjust the support rod as needed using a level to establish a vertical alignment (in all directions!)
3. Orient the mirror to face the sun as directly as possible.

**Collect Data:** Write down the results for your mirror site in the table below.

| Variables | Measurements |
|---|---|
| orientation to sun (compass) | |
| Date and time (EST) | |
| mirror angle (Brunton) | |
| snow depth (cm) | |
| area of shadow ($cm^2$) | |
| luminosity 10 cm above snow in full sun (lux) | |
| luminosity 10 cm above mirror center (lux) | |
| luminosity 10 cm above center of mirror shadow (lux) | |
| air temperature in full sun (°C) | |
| air temperature 10 above mirror center (°C) | |
| air temperature in full shade of mirror (°C) | |
| snow temperature 10 cm below surface (°C) | |

**Follow the directions below to answer questions about the mirror's albedo:**

Use this link to NOAA's solar calculator to determine the location of the sun (azimuth, elevation and declination) at the time and date of your measurement: **https://gml.noaa.gov/grad/solcalc/.** Grab the red pin and drag it over to New Hampshire, then zoom into the PSU campus and position the dot at the correct location for your mirror. Enter in the day and exact time of your measurement. Click on the ? for more information about each variable – it will help in answering some of the questions.

1. What is the meaning of solar declination?

2. What is the value of solar declination for your location and date? Will that value be higher or lower later this month? Why?

3. When is solar noon at your location and date? Why are noon and solar noon different? Are they ever the same – if so, when?

4. How long after solar noon was your measurement?

5. Which of your variables do you think would have been different if you'd taken the measurements at solar noon on the same day?

6. What is the meaning of azimuth?

7. What is the azimuth (Az) value at your location? Click the option to show azimuth on the map while you are zoomed into the campus area. Is this about where the sun was?

8. Your compass measurement of the sun's location should be close to the Azimuth measurement. How much do they differ and why might that be (assuming you took a good measurement)?

9. What is the solar elevation at your location and time? Will that value be higher or lower later this month?

10. How big is the shadow area cast by the mirror? Will that area be smaller or larger in a month? If the mirror is located farther off the ground, what will that do to the size of the shadow?

11. Examine at the temperature data. Does the presence of the mirror change the temperature under the mirror? Above the mirror? If so, by how much? If not, why not – wouldn't you expect it to?

12. What is the definition of albedo?

13. List the following objects in order of their albedo at the time and day of your measurement:
    a) Fresh snow at the field site
    b) Snow-covered sidewalk at field site
    c) Mirror oriented towards sun at 25° elevation (mirror preset angle)
    d) Mirror oriented towards sun at 90° elevation (horizontal mirror)
    e) Mirror oriented towards sun at 0° elevation (vertical mirror)

The instruments we've used for luminosity give light intensity data as lux. The conversion from lux to watts per meter square varies with the light source but is about $1W/m^2$ = 683 lux for sunlight.

14. Given that 640 watts/$m^2$ is the average solar irradiance at the top of the atmosphere, what percentage of that is reaching your field site?

15. What percentage of the solar irradiance is being reflected by the mirror in mid-afternoon?

16. What time of day would produce more albedo off the mirror?

17. What time time year would you expect the maximum albedo off the mirror?

18. What happens to the light that is not reflected?

19. Consider the albedo of the mirrors versus the ground albedo in winter and the ground albedo in summer. In which season does the presence of the mirror have greater influence on climate?

20. How would your answer to question #19 change if the mirror were located at

a) 15° latitude?
b) 75° latitude?

Explain your reasoning for your answers.