Sampling in the Snow: High School Winter Field Experiences Provide Relevant, Real World Connections Between Scientific Practices and Disciplinary Core Ideas

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Background

Two activities are presented that engage students in the scientific process of collecting, analyzing and interpreting snow data to:

(1) learn about the insulative properties of snow, and

(2) participate in a volunteer network to learn about snow reflective properties.

These activities are aligned with multiple *Next Generation Science Standards* integrating *scientific practices*, *crosscutting concepts*, and *disciplinary core ideas.*

Data Collection And The Snow Sampling Kit

Students collect snow depth, snow density, albedo, snow surface temperature.

Figure 1. Measuring incoming and outgoing shortwave radiation using a pyranometer.

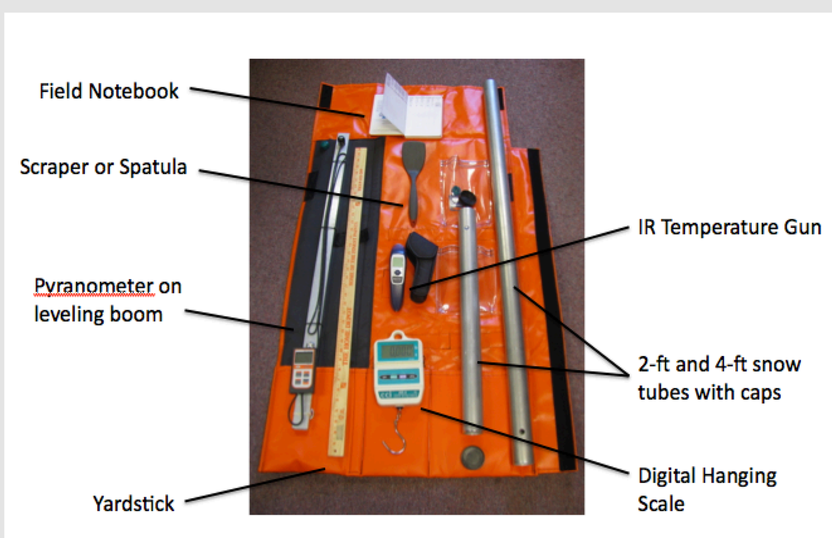

Figure 2. CoCoRAHS Snow Sampling Kit More information on the CoCoRAHS Network at:

www.cocorahs-albedo.org

Figure 3. Collecting snow depth and density data in the field.

Next Generation Science Standards and Common Core State Standards in Mathematics

Student access to the national database of snow measurements offers students "opportunities to analyze large data sets and identify correlations" and "such data sets extend the range of students' experiences and help to illustrate this important practice of analyzing and interpreting data" (NRC, 2012).

Next Generation Science Standards

- Scientific Practice
  - Analyzing *and Interpreting Data*
- Crosscutting Concepts
  - Patterns & Cause and Effect
- Disciplinary Core Ideas
  - ESS2.C -The roles of water in Earth's surface processes
  - ESS2.D-Weather and Climate

Common Core State Standards in Mathematics

- Statistics and Probability- Interpreting Categorical and Quantitative Data
  - (Math.HSS-ID.A.1)&(Math.HSS-ID.B.6)

Activity I- Determining The Thermal Index Of Snow

Introduction: Snow is an excellent thermal insulator and is ecologically significant for plants and animals that live in snow covered regions. Using the thermal index scale formula and data gathered from snow sampling activities, students can assess and interpret the insulative quality of snowpack and make predictions about temperature fluctuation at the ground/snow interface.

Thermal Index Value Data Sheet

(Adapted From Marchand, P.J. (1982). An Index For Evaluating the Temperature Stability of a Subnivean Environment, *Journal of Wildlife Management 46*: 518-520.)

Winter Ecologists:__________

$I_T = t/d$

Date: ______ Time: ______

Location: ______ I_T: ______

Condition of Snowpack: ______

t = Snow thickness (cm) ______

d= Density (g/cm³) ______

Density = Mass(g)/ Volume (cm³)

Mass (g) _____ Volume (cm³) _____

Volume of a cylinder = $\pi r^2 h$

Figure 4. Students record snow measurements on their data sheets.

Calculating The Thermal Index Of Snow:

- Thermal index (I_t) is calculated at each sample site
- **(I_t)=t/d**, where t is snow thickness (cm) and **d** is snow density (g/cm³)

Graphing, Analysis, and Interpretation:

Students should be able to:

- Model and describe temperature variation occurring at the ground/snow interface
- Analyze and predict whether the snowpack is providing adequate insulation for the plants and animals living below its surface.
- Describe variability in data and provide explanations for sampling error

Campus Site Location		*Field Hockey Field (Site 1)*			*Sloped Banking Behind Tennis Courts (Site 2)*			*Outdoor Classroom Banking (Site 3)*	
	Thermal Index Value	Snow Density (g/cm^3)	Snow Thickness (cm)	Thermal Index Value	Snow Density (g/cm^3)	Snow thickness (cm)	Thermal Index Value	Snow Density (g/cm^3)	Snow Thickness(cm)
Period 1									
Sofiya, Emily, Courtney, Alex	59	0.424	25	215	0.2	43	46	0.3	14
Emily, Dezree, Justin	111.11	0.234	26	216.49	0.194	42	33.52	0.358	12
Josh, Katelyn, Erin, Payson	206.667	0.15	31	201.5	0.189	38	29.77	0.403	12
Caroline, Sam, Sarah	220	0.15	33	211	0.19	40	50	0.32	16
Period 6									
Sawyer, Garrick	88.8	0.27	24	153.5	0.31	36	63.6	0.11	7
C.J., Christian, Morgan	178.9	0.19	34	275	0.12	33	45.2	0.31	14
Hannah, Kate, Carly	88.4	0.328	29	124	0.25	31	25.6	0.351	9
Michaela, Renee, Anne	144.5	0.2008	29	219.5	0.214	47	31.6	0.29	9
	Field Hockey Field (Site 1)			Sloped Banking Behind Tennis Courts NW Aspect (Site 2)			Outdoor Classroom Banking (Site 3)		
2014 Mean Thermal Index Values (All Classes)	**137.172125**			**201.99875**			**40.66125**		
Period 6 Mean Thermal Index Value	**125.15**			**193**			**41.5**		
Average Snow Thickness (t)	28.875			38.75			11.625		
Average Snow Density (d)	0.24335			0.208375			0.30525		

Figure 5. Student data is uploaded to the class spreadsheet and shared on Google Drive

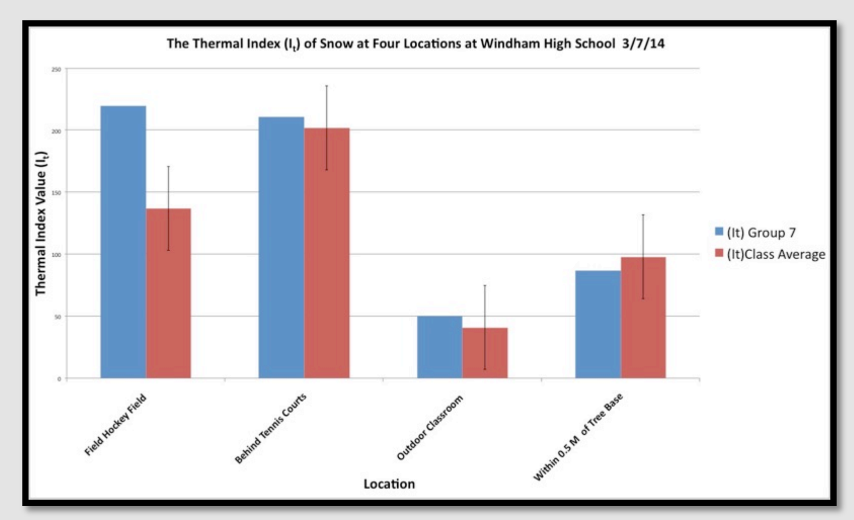

Figure 6. Students create a grouped bar chart comparing individual and mean thermal index values with respect to sampling site.

Activity II – Participating in a Citizen Science Network (CoCoRAHS) and Measuring Snow Reflectivity (Albedo)

Introduction: Classrooms participate in the CoCoRAHS Albedo Pilot Project of the National Community Collaborative Rain, Hail, and Snow (CoCoRaHS), collecting detailed snow data that's used to investigate the role snow has in local and global climate patterns.

Calculating Snow Reflectivity (Albedo):

- Snow is one of nature's best reflectors of the Sun's energy and helps to regulate surface climate above the snowpack.
- Albedo is a measure of surface reflectivity and is calculated as the ratio of incoming solar radiation to outgoing (reflected) solar radiation:

$$Albedo = \frac{Outgoing(W/m^2)}{Incoming(W/m^2)}$$

Graphing, Analysis, and Interpretation:

Students should be able to:

- Calculate snow density and snow albedo
- Identify patterns in time series analysis and investigate relationships using x-y scatterplots (Fig.7)
- Analyze snow density and albedo as a time series throughout the course of the winter snow sampling season (Fig. 8)
- Describe how surface albedo affects climate in the Arctic and in regions with seasonal snow cover

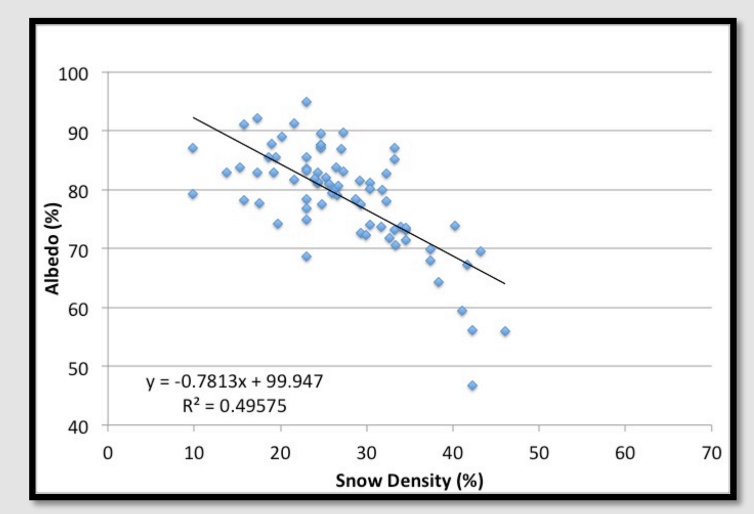

Figure 7. Students plot an xy-scatterplot to investigate the inverse relationship between snow density and albedo.

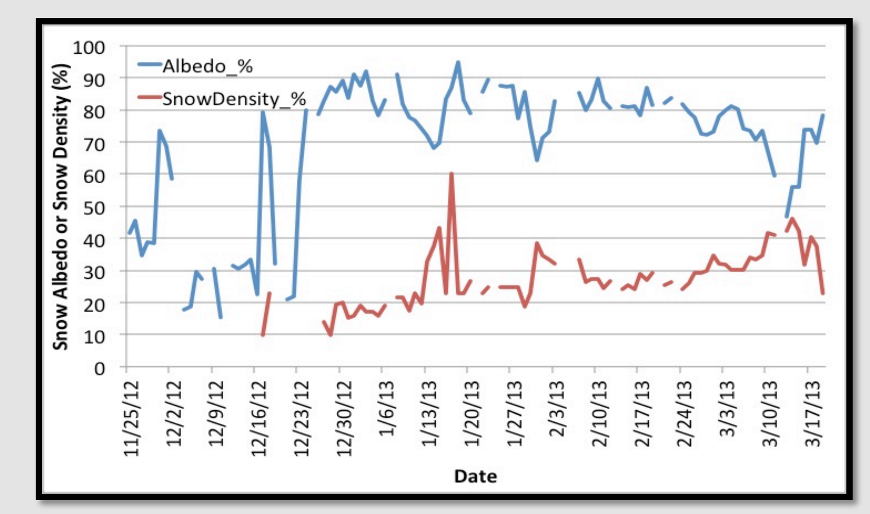

Figure 8. Students plot a double y-axis time series of snow density and albedo to investigate relationships between the two variables.

References

Barlage, M, Zeng, X, Wei, H, and Mitchell, KE. 2005. A global 0.05° maximum albedo dataset of snow-covered land based on MODIS observations. *Geophysical Research Letters 32:* L17405. doi:10.1029/2005GL022881.

Burakowski, EA, Wake, CP, Dibb, JE, and Stampone, M. 2013a. Putting the capital 'A' in CoCoRAHS: an experimental program to measure albedo using the Community Collaborative Rain, Hail, & Snow (CoCoRAHS) Network. *Hydrological Processes 27 (v. 21)*: 3024-3034.

Burakowski, EA. 2013b. Winter Climate Impacts of Historical Deforestation in New England. (Doctoral dissertation). University of New Hampshire, ProQuest, UMI Dissertations Publishing. *In press.*

Frumhoff, et al.,2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis Report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists.

Marchand, P.J. (1982). An Index For Evaluating the Temperature Stability of a Subnivean Environment, *Journal of Wildlife Management 46:* 518-520.

Marchand, P. J. (1996). *Life in the cold: An introduction to winter ecology*. (3rd ed.). Hanover and London: University Press of New England.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). Common Core State Standards for Mathematics. Washington, DC: Authors.

National Research Council (NRC). 2012. *A framework for K-12 science education: Practices, cross-cutting concepts, and core ideas.* Washington, DC: National Acadamies Press.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.