

Establishing a Geospatial Intelligence Pipeline through Earth SySTEM Education

NOAA/NESDIS CoRP Science Symposium

University of Maryland

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Peter Dorofy
dorofyp@students.rowan.edu

Rouzbeh Nazari
nazari@rowan.edu



Talking Points

- Science versus Science Education
- National Initiatives
- 21st Century Workforce Development
- Geoscience Literacy
- Impacts on Precollege Education
- Earth SySTEM
- Pipeline in Practice
- Undergraduate Example
- Pre-College Examples

About Myself...

- Graduate Student at Rowan University
- Graduate Student at Montana University
- Director of Environmental Education Palmyra Cove Nature Center, NJ
- 15 years teaching high school physics, chemistry, geospatial technologies
- The American Council of STEM Educators
- NESTA Eastern Regional Director
- GLOBE Scientist
- American Meteorological Society (AMS) LIT Leader
- AMS Board on Outreach and Precollege Education
- AMS Distinguished Educator
- 2013 PAEMST New Jersey State Finalist



Palmyra Cove Nature Park (PCNP)

... is 250 acres of green in a highly developed area on the Delaware River just south of the Tacony Palmyra Bridge. With its woodlands, wetlands, tidal cove and wild river shore line, PCNP serves as an important feeding site for migratory birds. PCNP hosts an average of 5000 pre-K-grad and adult student-learners per year in various programs, camps, and activities.

The Institute for
Earth Observations

GLOBE TO GO!!

Burlington County College
NASA
www.bcc.edu

- Atmosphere
- Land Cover
- Hydrology
- Earth as a System
- Remote Sensing
- Climate
- Space
- Satellites
- Engineering
- And more

The GLOBE Program

NJ Partnership
Palmyra Cove Nature
Park and Environmental
Discovery Center

GLOBE TO GO!! is a collaboration between the Institute for Earth Observations at Palmyra Cove, Burlington County College, and the GLOBE Program. To find out more, please contact Peter Dorofy, Director of Environmental Education at pdorofy@bccbridges.org, or call (856) 829-1900 ext. 1264

Earth SySTEM Summer Academy

Observe the Earth. Visualize the Future.

August 26-27, 9:00 AM – 3:00 PM
1335 Route 73 S, Palmyra NJ 08065

Brought to you by the Institute for Earth Observations of Palmyra Cove Nature Park and the National Earth Science Teachers Association. This hands-on FREE workshop will introduce teachers to applications of the Earth System in Science, Technology, Engineering, and Mathematics (STEM) Education. Teachers will receive classroom resources and professional development hours.

- Ground Observations
- In-Situ Data
- High-Altitude Balloons
- Earth SySTEM Mobile Lab
- Computer Visualization
- Satellites and Remote Sensing

To register for this program, please contact John Moore, Director of Geoscience STEM education at jmoore@bccbridges.org, or call (856) 829-1900 ext. 1262

SCIENCE vs. SCIENCE EDUCATION

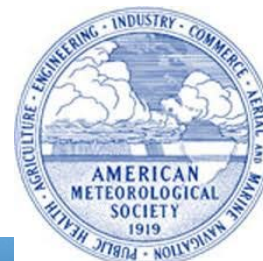
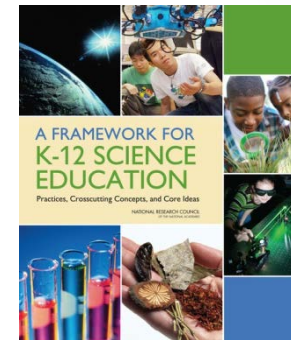
- National Economy
- National Security
- National Geoscience
Related Events



National Initiatives



- PCAST K-12 STEM Education Report
“PREPARE and INSPIRE”
- National Academy of Sciences
“Successful K-12 STEM Schools”
- National Academy of Sciences
“Framework for K-12 Science Education”
- National Science Foundation
“Preparing the Next Generation of STEM Innovators”
- Next Generation Science Standards (NGSS)
- American Meteorological Society
“Earth System STEM Education Policy Statement”

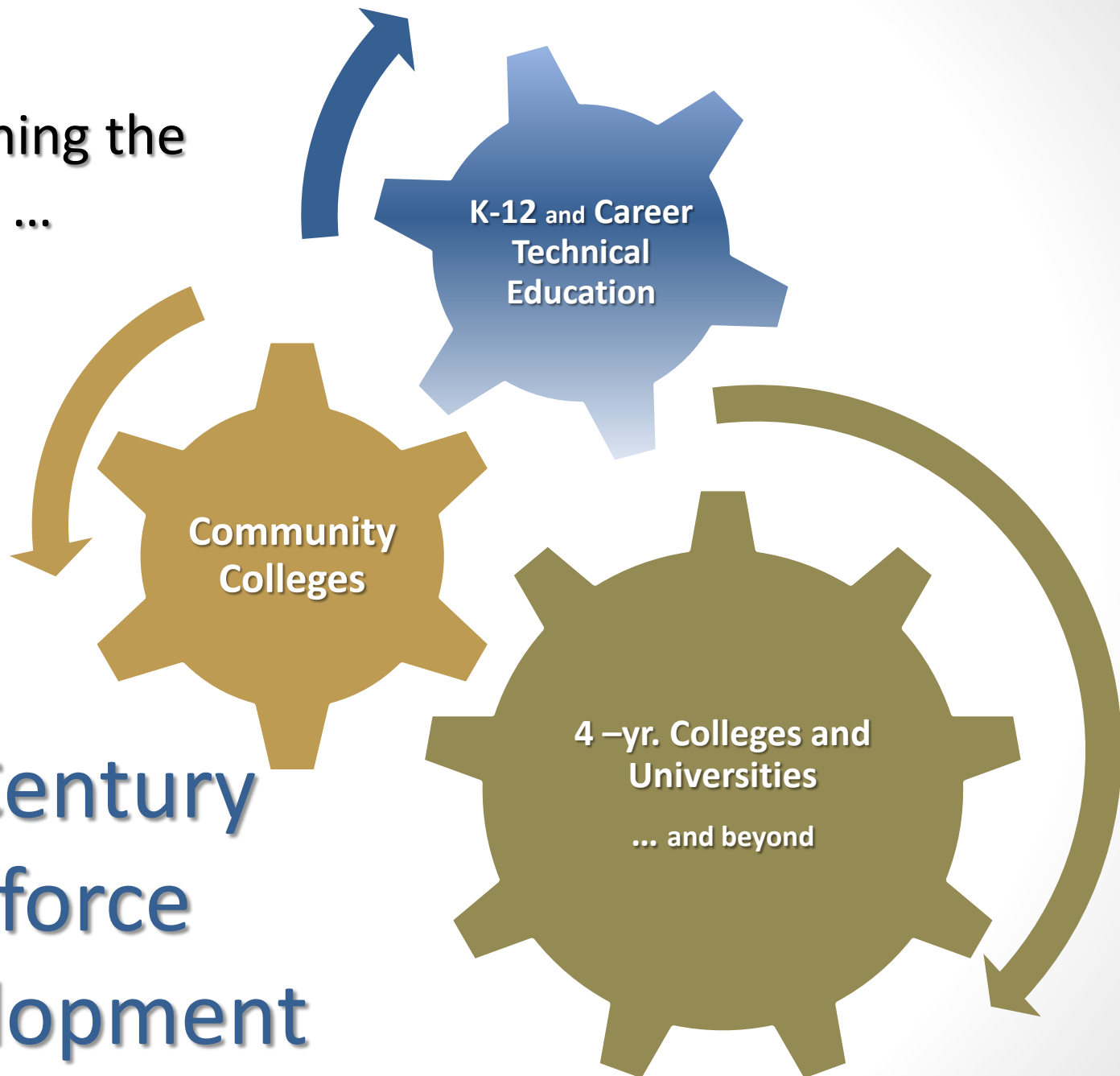


Office of Science and Technology Policy



NATIONAL ACADEMY OF SCIENCES

Establishing the
Pipeline ...

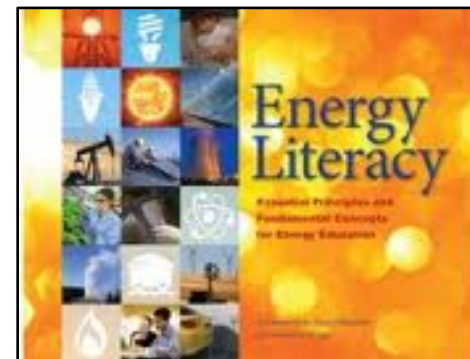
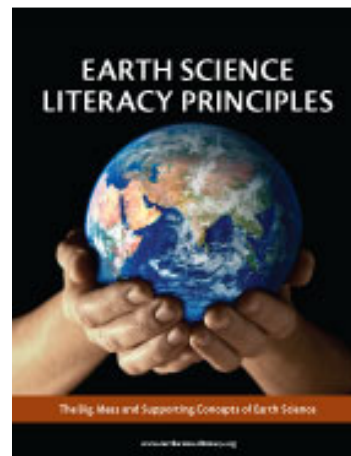
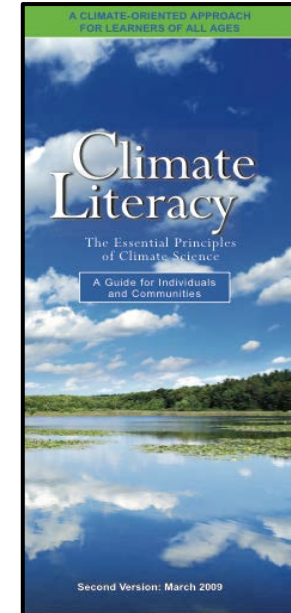
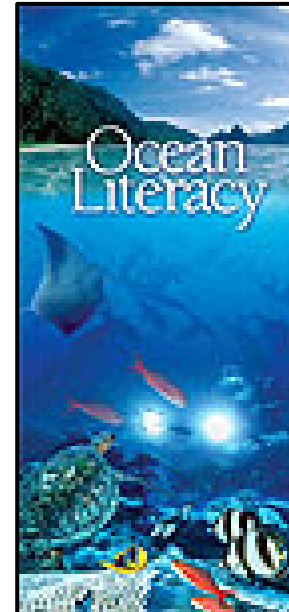
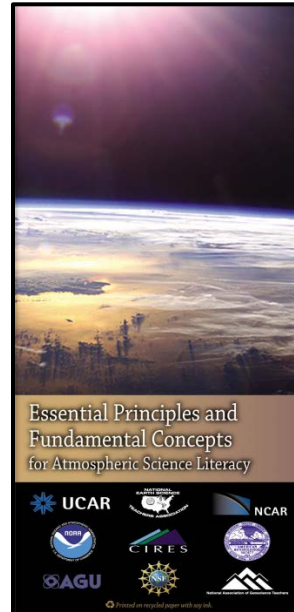


21st Century
Workforce
Development

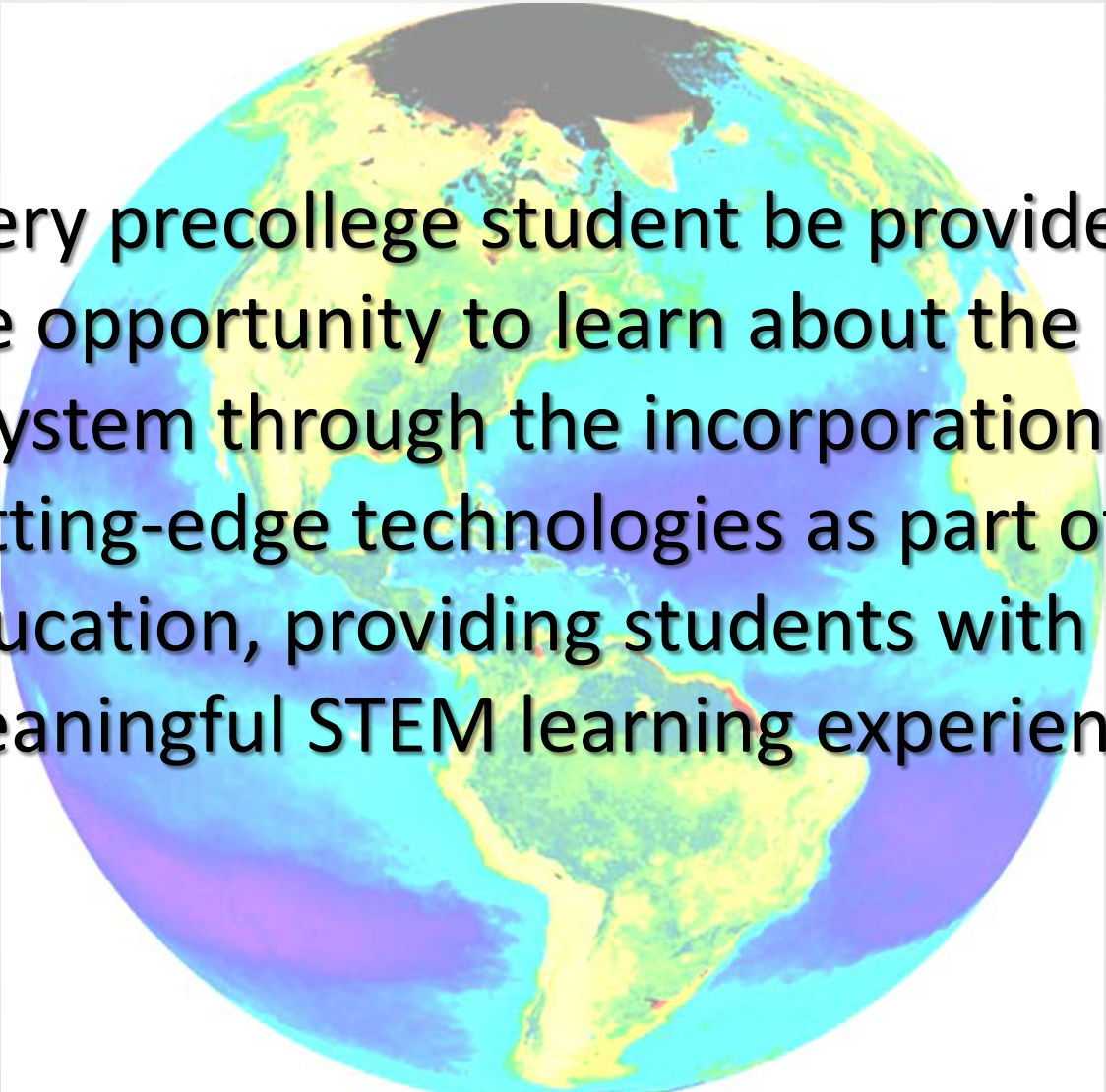
Geoscience Literacy



- Earth
- Oceans
- Atmosphere
- Climate
- Energy



American Meteorological Society Challenge



Every precollege student be provided with the opportunity to learn about the Earth as a system through the incorporation of cutting-edge technologies as part of STEM education, providing students with meaningful STEM learning experiences

Impacts on Precollege Education



- foster an interest and understanding of STEM disciplines and their relationship to Earth system science
- encourage students to pursue a career in STEM disciplines, including earth system science
- promote a lifelong understanding and appreciation of STEM and its role in advancing social and economic well-being
- increase STEM literacy to establish an informed public
- expand opportunities to broaden participation and enhance diversity
- ensure focused, rigorous, and articulated as a sequence of topics and performances
- encourages institutions of higher learning to examine their admissions requirements

Earth SySTEM Education*



Applications of the **Geosciences***
in **Science, Technology, Engineering, and
Mathematics (STEM) Education**

Earth SySTEM utilizes satellite imagery, remote sensing technology, real-time data, and computer visualizations to facilitate interactions between STEM disciplines in the study of Earth as a system.

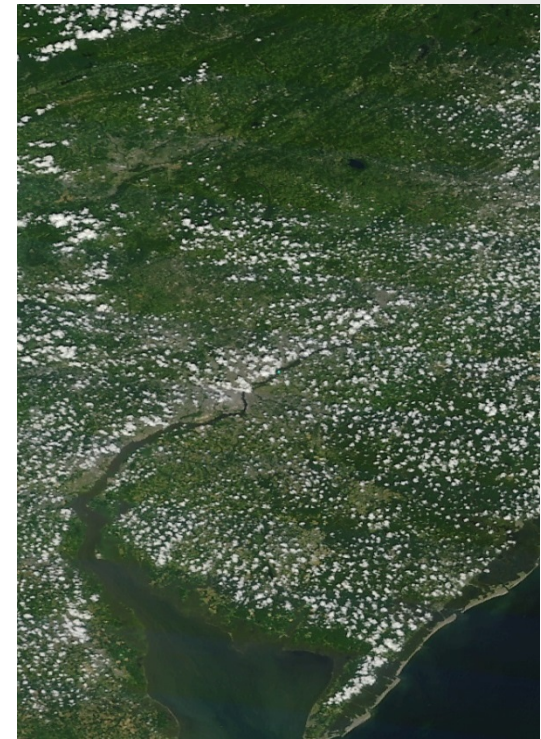
* Geoscience as defined by the NSF ...
Earth-Oceans-Atmosphere/Space

- AMS Earth System STEM Education Policy Statement
https://www.ametsoc.org/POLICY/2014Earth_STEM_Education.html

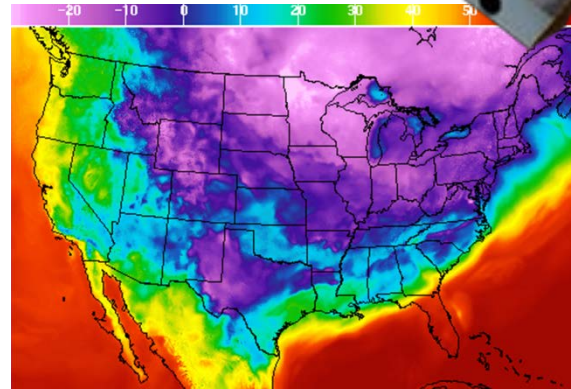
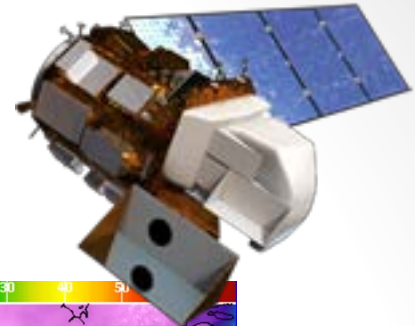
SPACE-EARTH : EARTH-SPACE

An Integrated “SEES” Earth SySTEM Educational Model

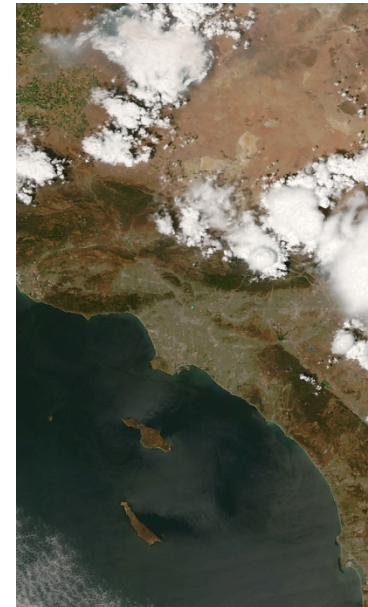
- Fosters **Geospatial Thinking**
- Identifies geo-referenced data points/sources
- Incorporates **Real-time Data**
- Develops **Geoscience and Remote Sensing** content and **applications**

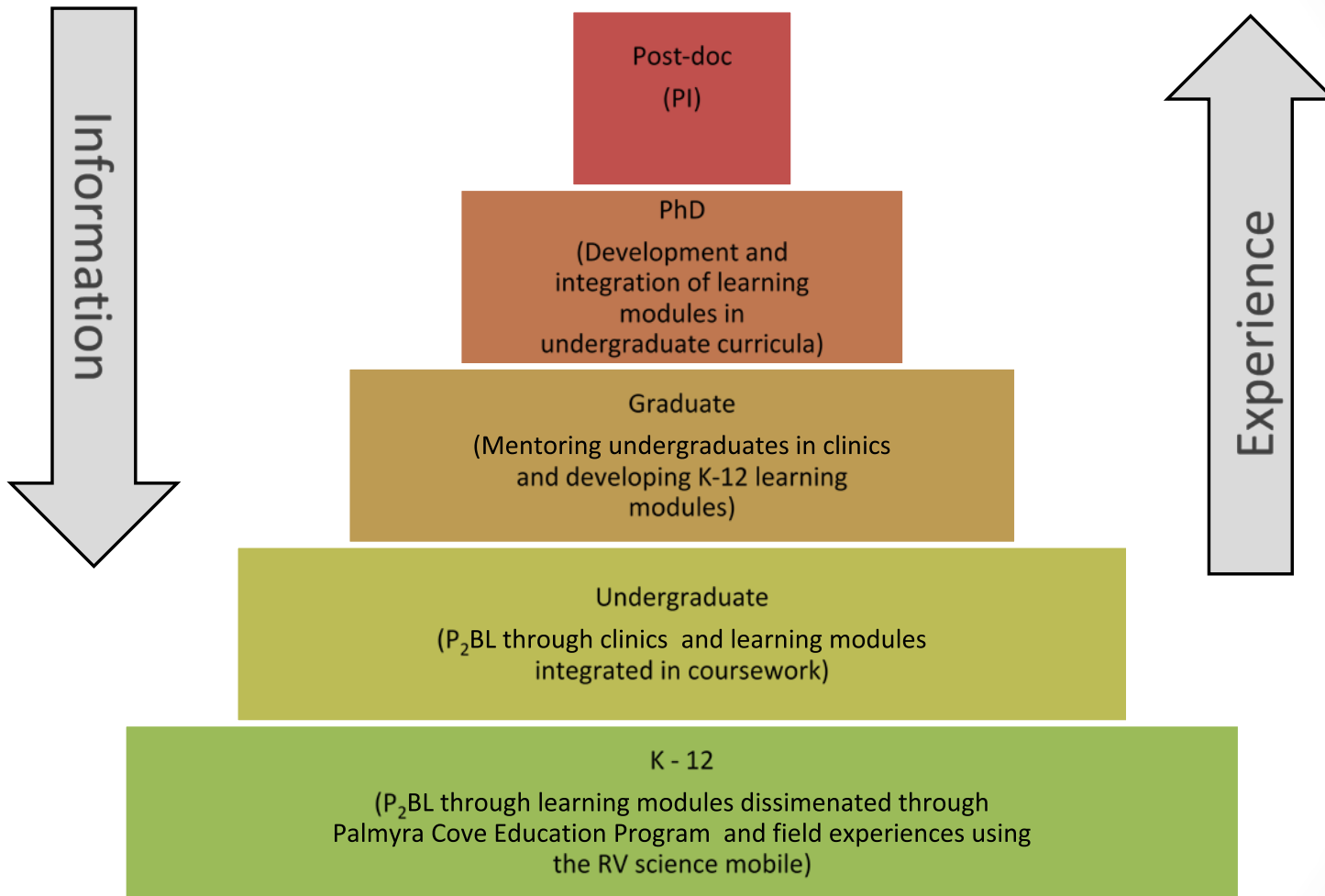


Geoscience and Remote Sensing Laboratory



- Real-Time Data
- Google Earth Display
- Geographic Information System (GIS)
- Image Analysis
- Study Earth as a System
- Monitoring
- Field Observations and Data Collection



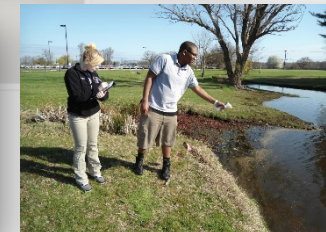
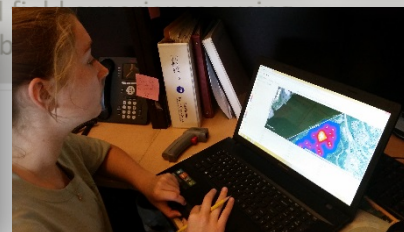
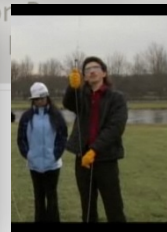
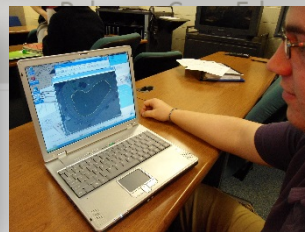
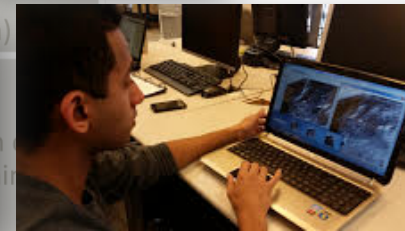




Research Experiences for Teachers

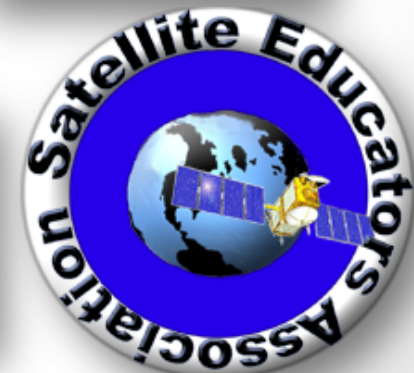
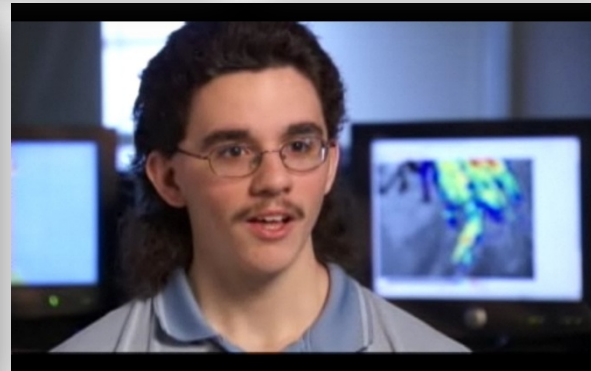
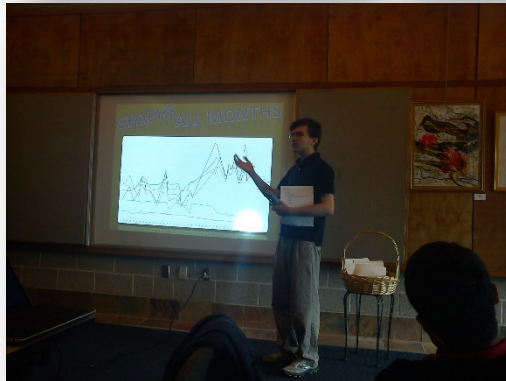
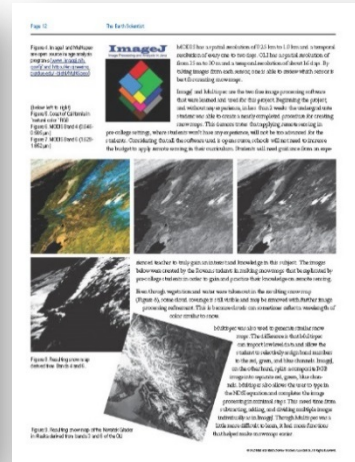
Information

Experience



(P₂BL through learning modules disseminated through

ASSESSMENTS?



Application of Earth SySTEM in Establishing a Geospatial Intelligence Pipeline

Kevin Varghese, Peter T. Dorofy, Rouzbeh Nazari

INTRODUCTION

K-12 Students are given limited opportunity in the classroom to acquire and interpret geospatial information. The next generation science standards (NGSS) include earth system and real-time data; however, this is not yet fully realized in current school curricula. A future workforce trained in geospatial intelligence will be necessary to meet 21st century challenges of a changing global environment. Applications of STEM education in Earth System - Earth SySTEM can be introduced into precollege to graduate curriculum to prepare students for these 21st century geospatial intelligence skills.

PURPOSE

The purpose of this investigation is to demonstrate an application of Earth SySTEM that can be reproduced by K-12 teachers who have limited funding and IT support. The application is the creation of snow maps using free image processing software. A procedure has been documented and slated for publication in a future issue of *The Earth Scientist*, a quarterly journal by NESTA.

FREE RESOURCES

- ImageJ and Multispec Software
- LandsatLookViewer (USGS)
- EOSDIS (NASA)

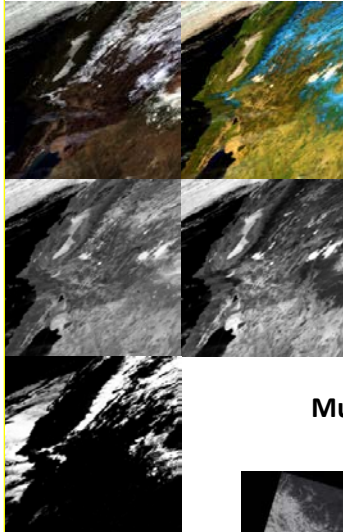
THEORY

- $$NDSI = \frac{0.56 - 1.61}{0.56 + 1.61} \geq 0.4$$
- Sensors – OLI & MODIS

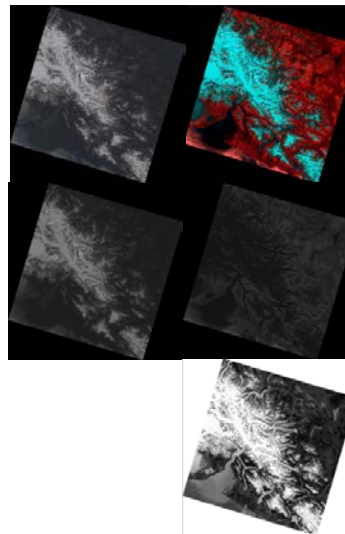
Snow is distinguished from water and clouds by thermal and reflectance properties. The Normalized Difference Snow Index (NDSI) is used to discriminate snow pixels from water, land, and cloud pixels.

PRODUCT

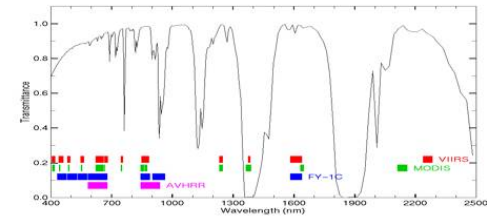
ImageJ Snow Map Trial (California Coast)



Multispec Snow Map (Novatek Glacier)



The 0.6 μm “green” and short-wave infrared near 1.6 μm bands are used in the NDSI algorithm. Index values ≥ 0.4 are classified as snow pixels.



OBSTACLES

Clouds can have similar reflectance to snow, which makes classification difficult in images that are not “cloud free”. In the current model, water at times, is mistakenly represented in the snow maps, and may be a procedural error during image processing. A procedure needs to be created for precollege students. It is important students be engaged in the activity in order to develop young interest in remote sensing.

CONCLUSIONS

Discrimination of snow from land appears to work well; however, there persists a misclassification of pixels as snow, especially off the coast of California, where “true color” images reveal water. ImageJ was able to produce black and white snow maps that easily reveal areas of snow. Multispec produced greyscale images which makes it more difficult to differentiate snow from everything else; however, Multispec is better equipped to work with low level satellite data.

FUTURE WORK

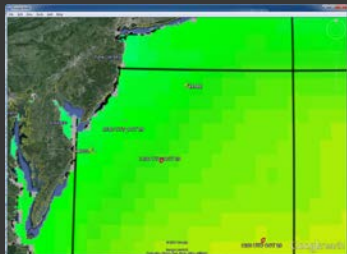
In order to remove the water from snow maps, we have to remove all NDWI values from the image. Creating a threshold limit on the Multispec images are necessary to create black and white images representing only snow. Steps taken to create these snow maps need to be recorded for students to follow.



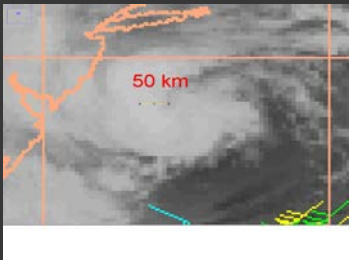
In 2012, New Jersey encountered Hurricane Sandy, a storm of historic proportions. The impacts were significant even though Sandy was classified as post-tropical cyclone as it made landfall. "Hurricane Sandy was the 18th named tropical cyclone of the 2012 Atlantic hurricane season (June 1 – November 30). Sandy formed in the central Caribbean on October 22nd and intensified into a hurricane as it tracked north across Jamaica, eastern Cuba and the Bahamas. Sandy moved northeast of the United States until turning west toward the mid-Atlantic coast on the 28th. Sandy transitioned into a post-tropical cyclone just prior to moving onshore near Atlantic City, NJ" (source: NWS).



Google Earth overlay of Buoy locations and Sandy Track



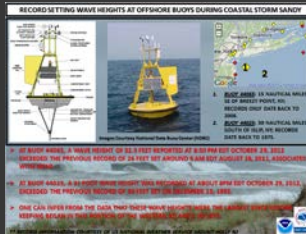
Google Earth Sea Surface temperature overlay w/Buoy and Sandy track



GOES 12 Image Analysis Using Image J software to approximate Radius of Maximum Winds (RMW) 29 Oct 2012, 1800 UT.



Suomi NPP Visible Image Overlay in Google Earth showing Buoy, Sandy track, 29 Oct 2012, 1800 UT

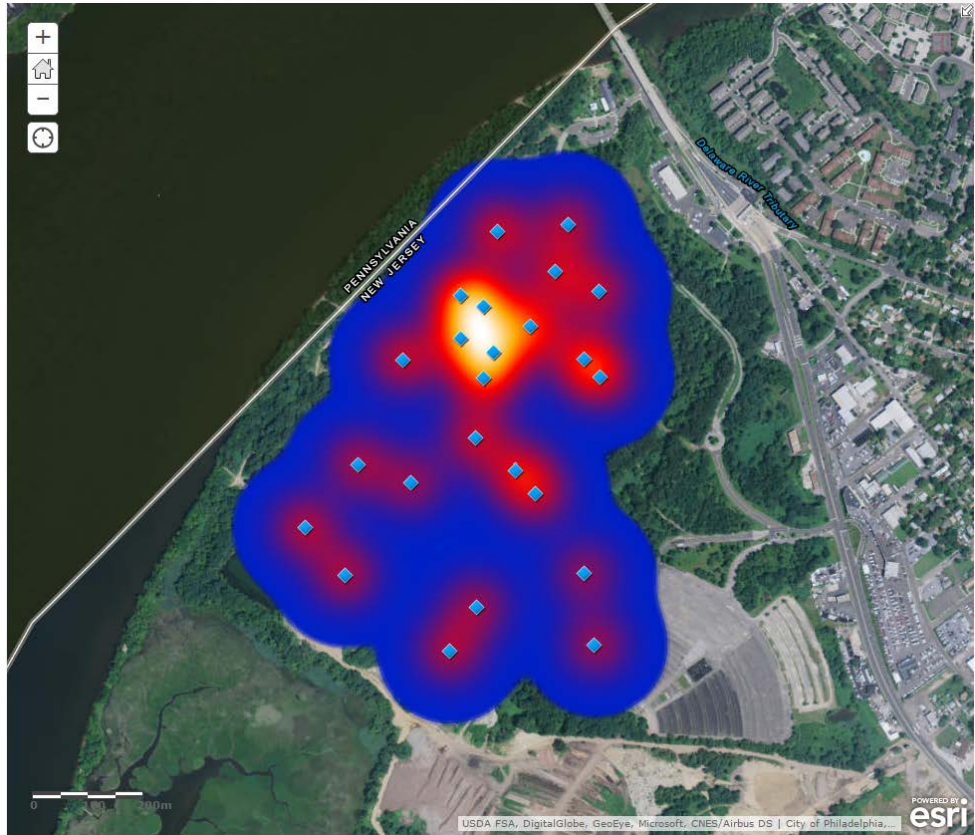
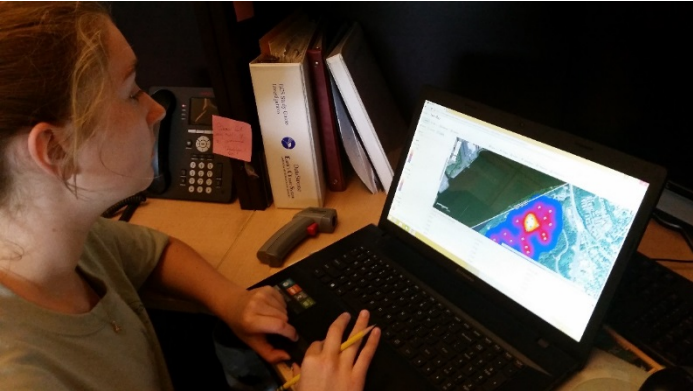


- Buoy Data
- Satellite Imagery
- Hurricane Tracking
- Sea Surface

Using Environmental Intelligence to Develop Resilience Strategies: Hurricane Sandy 2012

New Jersey M.Y.S.P.A.C.E. Team

Beaufort Wind Scale (Estimated wind speeds)									
Number	kt	km/h	mph	ft/min	mi/h	mi/min	mi/sec	Notes	Notes
0	0-1	0-1	0-1.6	0-1.0	0-0.2	0-0.03	0-0.01	Calm	Smoke rises vertically
1	1-3	1-3	1.6-4.8	1-1.0	0.2-0.3	0.03-0.05	0.01-0.02	Light air	Wind vanes begin to move
2	4-6	4-6	4.8-9.6	1.0-1.5	0.3-0.5	0.05-0.08	0.02-0.03	Light breeze	Wind felt on exposed skin; leaves rustle
3	7-10	7-10	9.6-14.4	1.5-2.0	0.5-0.7	0.08-0.11	0.03-0.04	Mod breeze	Wind felt on exposed skin; leaves rustle
4	11-15	11-15	14.4-20.8	2.0-2.5	0.7-1.0	0.11-0.15	0.04-0.05	Mod breeze	Small waves begin to form; leaves rustle
5	16-20	16-20	20.8-27.4	2.5-3.0	1.0-1.3	0.15-0.19	0.05-0.06	Mod breeze	Small waves begin to form; leaves rustle
6	21-25	21-25	27.4-34.9	3.0-3.5	1.3-1.6	0.19-0.23	0.06-0.07	Mod breeze	Small waves begin to form; leaves rustle
7	26-30	26-30	34.9-42.5	3.5-4.0	1.6-1.9	0.23-0.27	0.07-0.08	Mod breeze	Small waves begin to form; leaves rustle
8	31-35	31-35	42.5-50.0	4.0-4.5	1.9-2.2	0.27-0.31	0.08-0.09	Mod breeze	Small waves begin to form; leaves rustle
9	36-40	36-40	50.0-57.6	4.5-5.0	2.2-2.5	0.31-0.35	0.09-0.10	Mod breeze	Small waves begin to form; leaves rustle
10	41-45	41-45	57.6-65.2	5.0-5.5	2.5-2.8	0.35-0.39	0.10-0.11	Mod breeze	Small waves begin to form; leaves rustle
11	46-50	46-50	65.2-72.8	5.5-6.0	2.8-3.1	0.39-0.43	0.11-0.12	Mod breeze	Small waves begin to form; leaves rustle
12	51-55	51-55	72.8-80.4	6.0-6.5	3.1-3.4	0.43-0.47	0.12-0.13	Mod breeze	Small waves begin to form; leaves rustle
13	56-60	56-60	80.4-88.0	6.5-7.0	3.4-3.7	0.47-0.51	0.13-0.14	Mod breeze	Small waves begin to form; leaves rustle
14	61-65	61-65	88.0-95.6	7.0-7.5	3.7-4.0	0.51-0.55	0.14-0.15	Mod breeze	Small waves begin to form; leaves rustle
15	66-70	66-70	95.6-103.2	7.5-8.0	4.0-4.3	0.55-0.59	0.15-0.16	Mod breeze	Small waves begin to form; leaves rustle
16	71-75	71-75	103.2-110.8	8.0-8.5	4.3-4.6	0.59-0.63	0.16-0.17	Mod breeze	Small waves begin to form; leaves rustle
17	76-80	76-80	110.8-118.4	8.5-9.0	4.6-4.9	0.63-0.67	0.17-0.18	Mod breeze	Small waves begin to form; leaves rustle
18	81-85	81-85	118.4-126.0	9.0-9.5	4.9-5.2	0.67-0.71	0.18-0.19	Mod breeze	Small waves begin to form; leaves rustle
19	86-90	86-90	126.0-133.6	9.5-10.0	5.2-5.5	0.71-0.75	0.19-0.20	Mod breeze	Small waves begin to form; leaves rustle
20	91-95	91-95	133.6-141.2	10.0-10.5	5.5-5.8	0.75-0.79	0.20-0.21	Mod breeze	Small waves begin to form; leaves rustle
21	96-100	96-100	141.2-148.8	10.5-11.0	5.8-6.1	0.79-0.83	0.21-0.22	Mod breeze	Small waves begin to form; leaves rustle
22	101-105	101-105	148.8-156.4	11.0-11.5	6.1-6.4	0.83-0.87	0.22-0.23	Mod breeze	Small waves begin to form; leaves rustle
23	106-110	106-110	156.4-164.0	11.5-12.0	6.4-6.7	0.87-0.91	0.23-0.24	Mod breeze	Small waves begin to form; leaves rustle
24	111-115	111-115	164.0-171.6	12.0-12.5	6.7-7.0	0.91-0.95	0.24-0.25	Mod breeze	Small waves begin to form; leaves rustle
25	116-120	116-120	171.6-179.2	12.5-13.0	7.0-7.3	0.95-0.99	0.25-0.26	Mod breeze	Small waves begin to form; leaves rustle
26	121-125	121-125	179.2-186.8	13.0-13.5	7.3-7.6	0.99-1.03	0.26-0.27	Mod breeze	Small waves begin to form; leaves rustle
27	126-130	126-130	186.8-194.4	13.5-14.0	7.6-7.9	1.03-1.07	0.27-0.28	Mod breeze	Small waves begin to form; leaves rustle
28	131-135	131-135	194.4-202.0	14.0-14.5	7.9-8.2	1.07-1.11	0.28-0.29	Mod breeze	Small waves begin to form; leaves rustle
29	136-140	136-140	202.0-209.6	14.5-15.0	8.2-8.5	1.11-1.15	0.29-0.30	Mod breeze	Small waves begin to form; leaves rustle
30	141-145	141-145	209.6-217.2	15.0-15.5	8.5-8.8	1.15-1.19	0.30-0.31	Mod breeze	Small waves begin to form; leaves rustle
31	146-150	146-150	217.2-224.8	15.5-16.0	8.8-9.1	1.19-1.23	0.31-0.32	Mod breeze	Small waves begin to form; leaves rustle
32	151-155	151-155	224.8-232.4	16.0-16.5	9.1-9.4	1.23-1.27	0.32-0.33	Mod breeze	Small waves begin to form; leaves rustle
33	156-160	156-160	232.4-240.0	16.5-17.0	9.4-9.7	1.27-1.31	0.33-0.34	Mod breeze	Small waves begin to form; leaves rustle
34	161-165	161-165	240.0-247.6	17.0-17.5	9.7-10.0	1.31-1.35	0.34-0.35	Mod breeze	Small waves begin to form; leaves rustle
35	166-170	166-170	247.6-255.2	17.5-18.0	10.0-10.3	1.35-1.39	0.35-0.36	Mod breeze	Small waves begin to form; leaves rustle
36	171-175	171-175	255.2-262.8	18.0-18.5	10.3-10.6	1.39-1.43	0.36-0.37	Mod breeze	Small waves begin to form; leaves rustle
37	176-180	176-180	262.8-270.4	18.5-19.0	10.6-10.9	1.43-1.47	0.37-0.38	Mod breeze	Small waves begin to form; leaves rustle
38	181-185	181-185	270.4-278.0	19.0-19.5	10.9-11.2	1.47-1.51	0.38-0.39	Mod breeze	Small waves begin to form; leaves rustle
39	186-190	186-190	278.0-285.6	19.5-20.0	11.2-11.5	1.51-1.55	0.39-0.40	Mod breeze	Small waves begin to form; leaves rustle
40	191-195	191-195	285.6-293.2	20.0-20.5	11.5-11.8	1.55-1.59	0.40-0.41	Mod breeze	Small waves begin to form; leaves rustle
41	196-200	196-200	293.2-300.8	20.5-21.0	11.8-12.1	1.59-1.63	0.41-0.42	Mod breeze	Small waves begin to form; leaves rustle
42	201-205	201-205	300.8-308.4	21.0-21.5	12.1-12.4	1.63-1.67	0.42-0.43	Mod breeze	Small waves begin to form; leaves rustle
43	206-210	206-210	308.4-316.0	21.5-22.0	12.4-12.7	1.67-1.71	0.43-0.44	Mod breeze	Small waves begin to form; leaves rustle
44	211-215	211-215	316.0-323.6	22.0-22.5	12.7-13.0	1.71-1.75	0.44-0.45	Mod breeze	Small waves begin to form; leaves rustle
45	216-220	216-220	323.6-331.2	22.5-23.0	13.0-13.3	1.75-1.79	0.45-0.46	Mod breeze	Small waves begin to form; leaves rustle
46	221-225	221-225	331.2-338.8	23.0-23.5	13.3-13.6	1.79-1.83	0.46-0.47	Mod breeze	Small waves begin to form; leaves rustle
47	226-230	226-230	338.8-346.4	23.5-24.0	13.6-13.9	1.83-1.87	0.47-0.48	Mod breeze	Small waves begin to form; leaves rustle
48	231-235	231-235	346.4-354.0	24.0-24.5	13.9-14.2	1.87-1.91	0.48-0.49	Mod breeze	Small waves begin to form; leaves rustle
49	236-240	236-240	354.0-361.6	24.5-25.0	14.2-14.5	1.91-1.95	0.49-0.50	Mod breeze	Small waves begin to form; leaves rustle
50	241-245	241-245	361.6-369.2	25.0-25.5	14.5-14.8	1.95-1.99	0.50-0.51	Mod breeze	Small waves begin to form; leaves rustle
51	246-250	246-250	369.2-376.8	25.5-26.0	14.8-15.1	1.99-2.03	0.51-0.52	Mod breeze	Small waves begin to form; leaves rustle
52	251-255	251-255	376.8-384.4	26.0-26.5	15.1-15.4	2.03-2.07	0.52-0.53	Mod breeze	Small waves begin to form; leaves rustle
53	256-260	256-260	384.4-392.0	26.5-27.0	15.4-15.7	2.07-2.11	0.53-0.54	Mod breeze	Small waves begin to form; leaves rustle
54	261-265	261-265	392.0-399.6	27.0-27.5	15.7-16.0	2.11-2.15	0.54-0.55	Mod breeze	Small waves begin to form; leaves rustle
55	266-270	266-270	399.6-407.2	27.5-28.0	16.0-16.3	2.15-2.19	0.55-0.56	Mod breeze	Small waves begin to form; leaves rustle
56	271-275	271-275	407.2-414.8	28.0-28.5	16.3-16.6	2.19-2.23	0.56-0.57	Mod breeze	Small waves begin to form; leaves rustle
57	276-280	276-280	414.8-422.4	28.5-29.0	16.6-16.9	2.23-2.27	0.57-0.58	Mod breeze	Small waves begin to form; leaves rustle
58	281-285	281-285	422.4-430.0	29.0-29.5	16.9-17.2	2.27-2.31	0.58-0.59	Mod breeze	Small waves begin to form; leaves rustle
59	286-290	286-290	430.0-437.6	29.5-30.0	17.2-17.5	2.31-2.35	0.59-0.60	Mod breeze	Small waves begin to form; leaves rustle
60	291-295	291-295	437.6-445.2	30.0-30.5	17.5-17.8	2.35-2.39	0.60-0.61	Mod breeze	Small waves begin to form; leaves rustle
61	296-300	296-300	445.2-452.8	30.5-31.0	17.8-18.1	2.39-2.43	0.61-0.62	Mod breeze	Small waves begin to form; leaves rustle
62	301-305	301-305	452.8-460.4	31.0-31.5	18.1-18.4	2.43-2.47	0.62-0.63	Mod breeze	Small waves begin to form; leaves rustle
63	306-310	306-310	460.4-468.0	31.5-32.0	18.4-18.7	2.47-2.51	0.63-0.64	Mod breeze	Small waves begin to form; leaves rustle
64	311-315	311-315	468.0-475.6	32.0-32.5	18.7-19.0	2.51-2.55	0.64-0.65	Mod breeze	Small waves begin to form; leaves rustle
65	316-320	316-320	475.6-483.2	32.5-33.0	19.0-19.3	2.55-2.59	0.65-0.66	Mod breeze	Small waves begin to form; leaves rustle
66	321-325	321-325	483.2-490.8	33.0-33.5	19.3-19.6	2.59-2.63	0.66-0.67	Mod breeze	Small waves begin to form; leaves rustle
67	326-330	326-330	490.8-498.4	33.5-34.0	19.6-19.9	2.63-2.67	0.67-0.68	Mod breeze	Small waves begin to form; leaves rustle
68	331-335	331-335	498.4-506.0	34.0-34.5	19.9-20.2	2.67-2.71	0.68-0.69	Mod breeze	Small waves begin to form; leaves rustle
69	336-340	336-340	506.0-513.6	34.5-35.0	20.2-20.5	2.71-2.75	0.69-0.70	Mod breeze	Small waves begin to form; leaves rustle
70	341-345	341-345	513.6-521.2	35.0-35.5	20.5-20.8	2.75-2.79	0.70-0.71	Mod breeze	Small waves begin to form; leaves rustle
71	346-350	346-350	521.2-528.8	35.5-36.0	20.8-21.1	2.79-2.83	0.71-0.72	Mod breeze	Small waves begin to form; leaves rustle
72	351-355	351-355	528.8-536.4	36.0-36.5	21.1-21.4	2.83-2.87	0.72-0.73	Mod breeze	Small waves begin to form; leaves rustle
73	356-360	356-360	536.4-544.0	36.5-37.0	21.4-21.7	2.87-2.91	0.73-0.74	Mod breeze	Small waves begin to form; leaves rustle
74	361-365	361-365	544.0-551.6	37.0-37.5	21.7-22.0	2.91-2.95	0.74-0.75	Mod breeze	Small waves begin to form; leaves rustle
75	366-370	366-370	551.6-559.2	37.5-38.0	22.0-22.3	2.95-2.99	0.75-0.76	Mod breeze	Small waves begin to form; leaves rustle
76	371-375	371-375	559.2-566.8	38.0-38.5	22.3-22.6	2.99-3.03	0.76-0.77	Mod breeze	Small waves begin to form; leaves rustle
77	376-380	376-380	566.8-574.4	38.5-39.0	22.6-22.9	3.03-3.07	0.77-0.78	Mod breeze	Small waves begin to form; leaves rustle
78	381-385	381-385	574.4-582.0	39.0-39.5	22.9-23.2	3.07-3.11	0.78-0.79	Mod breeze	Small waves begin to form; leaves rustle
79	386-390	386-390	582.0-589.6	39.5-40.0	23.2-23.5	3.11-3.15	0.79-0.80	Mod breeze	Small waves begin to form; leaves rustle
80	391-395	391-395	589.6-597.2	40.0-40.5	23.5-23.8	3.15-3.19	0.80-0.81	Mod breeze	Small waves begin to form; leaves rustle
81	396-400	396-400	597.2-604.8	40.5-41.0	23.8-24.1	3.19-3.23	0.81-0.82	Mod breeze	Small waves begin to form; leaves rustle
82	401-405	401-405	604.8-612.4	41.0-41.5	24.1-24.4	3.23-3.27	0.82-0.83	Mod breeze	Small waves begin to form; leaves rustle
83	406-410	406-410	612.4-620.0	41.5-42.0	24.4-24.7	3.27-3.31	0.83-0.84	Mod breeze	Small waves begin to form; leaves rustle
84	411-415	411-415	620.0-627.6	42.0-42.5	24.7-25.0	3.31-3.35	0.84-0.85	Mod breeze	Small waves begin to form; leaves rustle
85	416-420	416-420	627.6-635.2	42.5-43.0	25.0-25.3	3.35-3.39	0.85-0.86	Mod breeze	Small waves begin to form; leaves rustle
86	421-425	421-425	635.2-642.8	43.0-43.5	25.3-25.6	3.39-3.43	0.86-0.87	Mod breeze	Small waves begin to form; leaves rustle
87	426-430	426-430	642.8-650.4	43.5-44.0	25.6-25.9	3.43-3.47	0.87-0.88	Mod breeze	Small waves begin to form; leaves rustle
88	431-435	431-435	650.4-658.0	44.0-44.5	25.9-26.2	3.47-3.51	0.88-0.89	Mod breeze	Small waves begin to form; leaves rustle
89	436-440	436-440	658.0-665.6	44.5-45.0	26.2-26.5	3.51-3.55	0.89-0.90	Mod breeze	Small waves begin to form; leaves rustle
90	441-445	441-445	665.6-673.2	45.0-45.5	26.5-26.8	3.55-3.59	0.90-0.91	Mod breeze	Small waves begin to form; leaves rustle
91	446-450	446-450	673.2-680.8	45.5-46.0	26.8-27.1	3.59-3.63	0.91-0.92	Mod breeze	Small waves begin to form; leaves rustle
92	451-455	451-455	680.8-688.4	46.0-46.5	27.1-27.4	3.63-3.67	0.92-0.93	Mod breeze	Small waves begin to form; leaves rustle
93	456-460	456-460	688.4-696.0	46.5-47.0	27.4-27.7	3.67-3.71	0.93-0.94	Mod breeze	Small waves begin to form; leaves rustle
94	461-465	461-465	696.0-703.6	47.0-47.5	27.7-28.0	3.71-3.75	0.94-0.95	Mod breeze	Small waves begin to form; leaves rustle
95	466-470	466-470	703.6-711.2	47.5-48.0	28.0-28.3	3.75-3.79	0.95-0.96	Mod breeze	Small waves begin to form; leaves rustle
96	471-475	471-475	711.2-718.8	48.0-48.5	28.3-28.6	3.79-3.83	0.96-0.97	Mod breeze	Small waves begin to form; leaves rustle
97	476-480	476-480	718.8-726.4	48.5-49.0	28.6-28.9	3.83-3.87	0.97-0.98	Mod breeze	Small waves begin to form; leaves rustle
98	481-485	481-							





The American Council of STEM Educators

John D. Moore

mr.moore.john@gmail.com

- “Making the Case for GeoSTEM Education”
- “An Opportunity for Innovation in STEM Education: GeoSTEM”
- “GeoSTEM: Establishing a Geoscience and Remote Sensing Laboratory”
- “Exploring New Frontiers in Earth System Education: GeoSTEM”

