Harnessing the Power of Earth System Science for Developing Science Practices and Crosscutting Concepts

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Wendy Van Norden, Michael Passow,

National Earth Science Teachers Association, Boulder, CO

Fall 2014

Today (All events in this room)

- 8:00 am – 9:00 am - How Weird Can It Get? Developing Weather and Climate Literacy
- 9:30 – 10:30 - Earth Science Rocks! Using Earth Science Activities to Engage Students as Scientists
- 12:30 pm – 1:30 pm - Harnessing the Power of Earth System Science for Developing Science Practices and Crosscutting Concepts
- 2:00 – 3:00 – Using Data in the Earth and Space Science Classroom to Engage Students as Real Scientists
- 3:30 – 4:30 - NESTA Rock and Mineral Raffle

Session evaluations are available at
http://www.nsta.org/conferences/evaluations

Overview

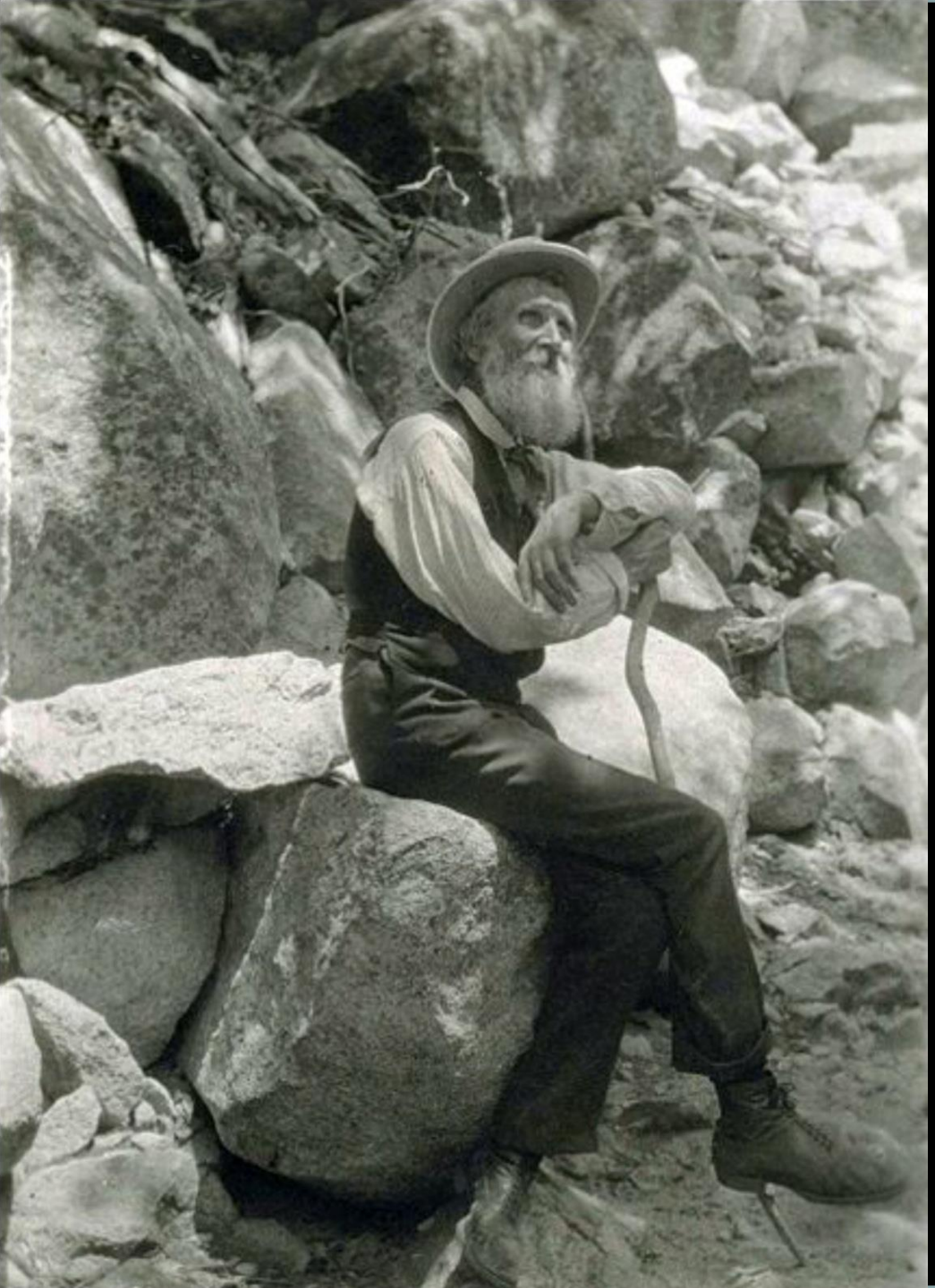
- NGSS Relevance
- Brief introduction to Earth System Science (ESS)
- “Black Carbon”
- “Rising Seas”
- Wrap-up

NGSS and Earth and Space Science

- The NGSS places significant emphasis on Earth and space science from a systems perspective
  - ESS is particularly well-suited for demonstrating **cross-cutting concepts**, in addition to **science and engineering practices**
- Some associated **disciplinary core ideas**
  - MS/HS-LS2 – Ecosystems: Interactions, Energy and Dynamics
  - MS/HS-ESS2 – Earth's Systems
  - MS/HS-ESS3 – Earth and Human Activity

Examples of NGSS Relevance

- *NGSS PE MS-ESS3.5*: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- *NGSS PE HS-ESS3.1*: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- *NGSS PE HS-ESS2-2*: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
- Science and Engineering Practices: Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations
- Crosscutting Concepts: Cause and Effect; Systems and System Models; Stability and Change



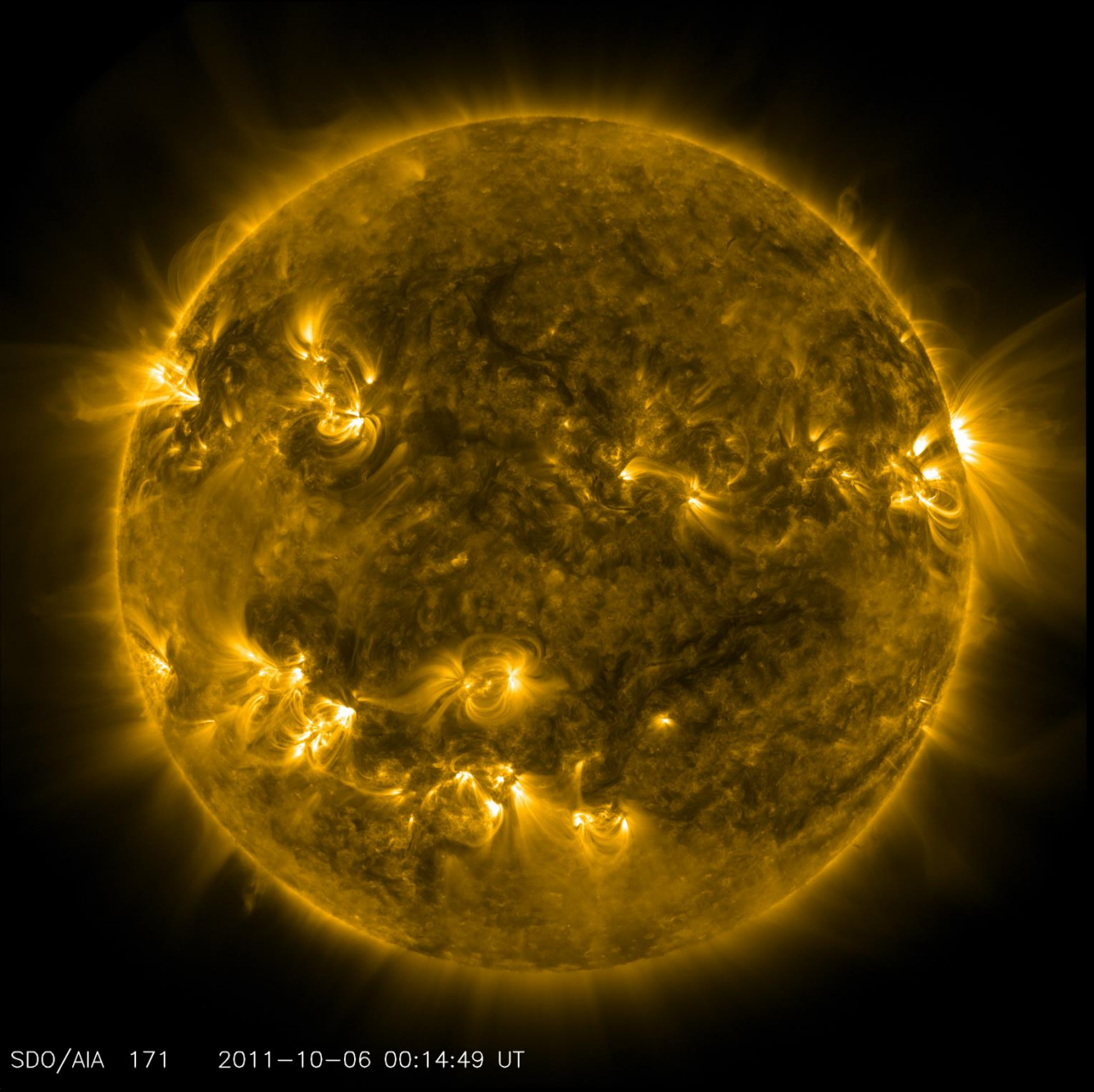
"When we try to pick out anything by itself, we find it hitched to everything else in the universe."
John Muir
"My First Summer in the Sierra"
1911

What is Earth System Science?

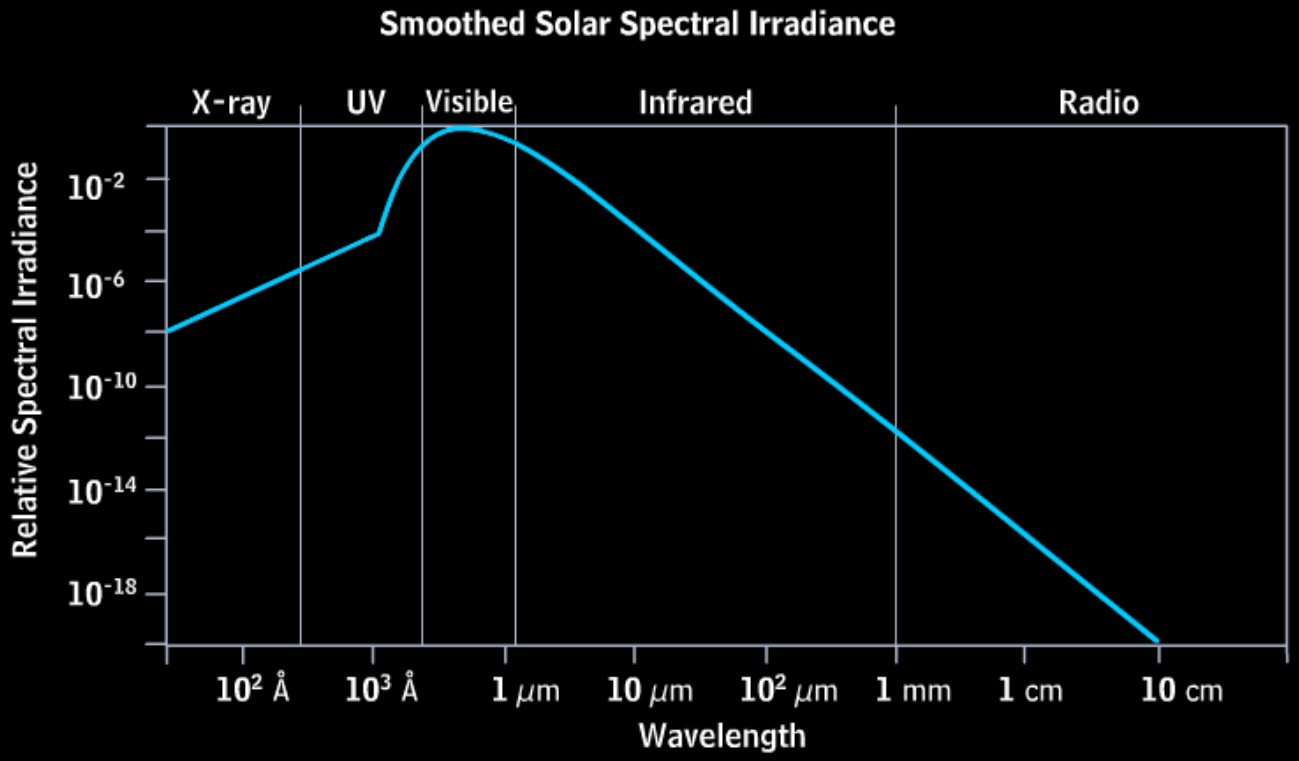
- John Muir was right!
  - In the 1980s and 90s, geoscientists realized that studying the different parts of the Earth separately didn't work
  - you can't really understand what is going on without **looking at the whole system**
- Earth System Science focuses on interactions among the different parts of the Earth system
  - Processes and cycles
  - Events

What is the Earth System?

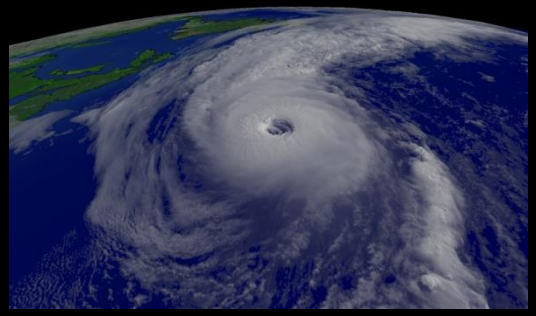
- **The atmosphere (Air)** extends up from the Earth surface for several hundred kilometers.
- **The biosphere (Life)** is all living things, from single-celled bacteria to plants and animals.
- **The geosphere (Land)** includes all minerals, rocks, molten rock, sediments, and soils
- **The hydrosphere (Water)** includes the ocean, rivers, lakes, streams, groundwater, water vapor, ice, snow, glaciers, and sea ice. (**“cryopsphere”**)



It all starts at the Sun!

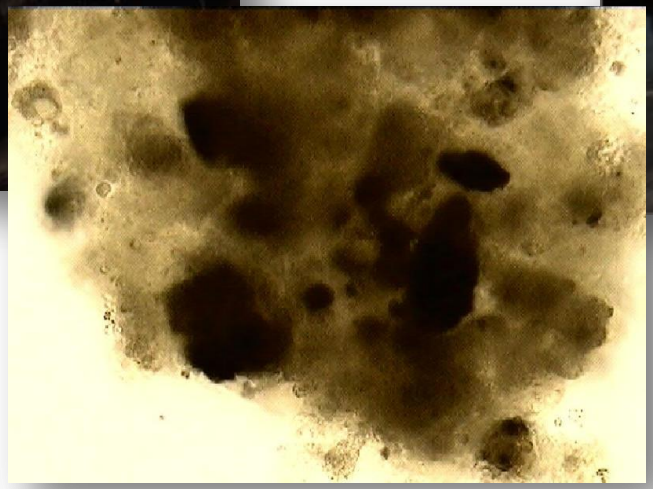


Energy from the Sun is the ultimate source of almost all energy in the Earth system!



“Black Carbon: A Dusty Situation”

Lesson Summary: Students investigate the climate effects of increasing amounts of black carbon on the absorption of solar radiation on the Earth's surface.



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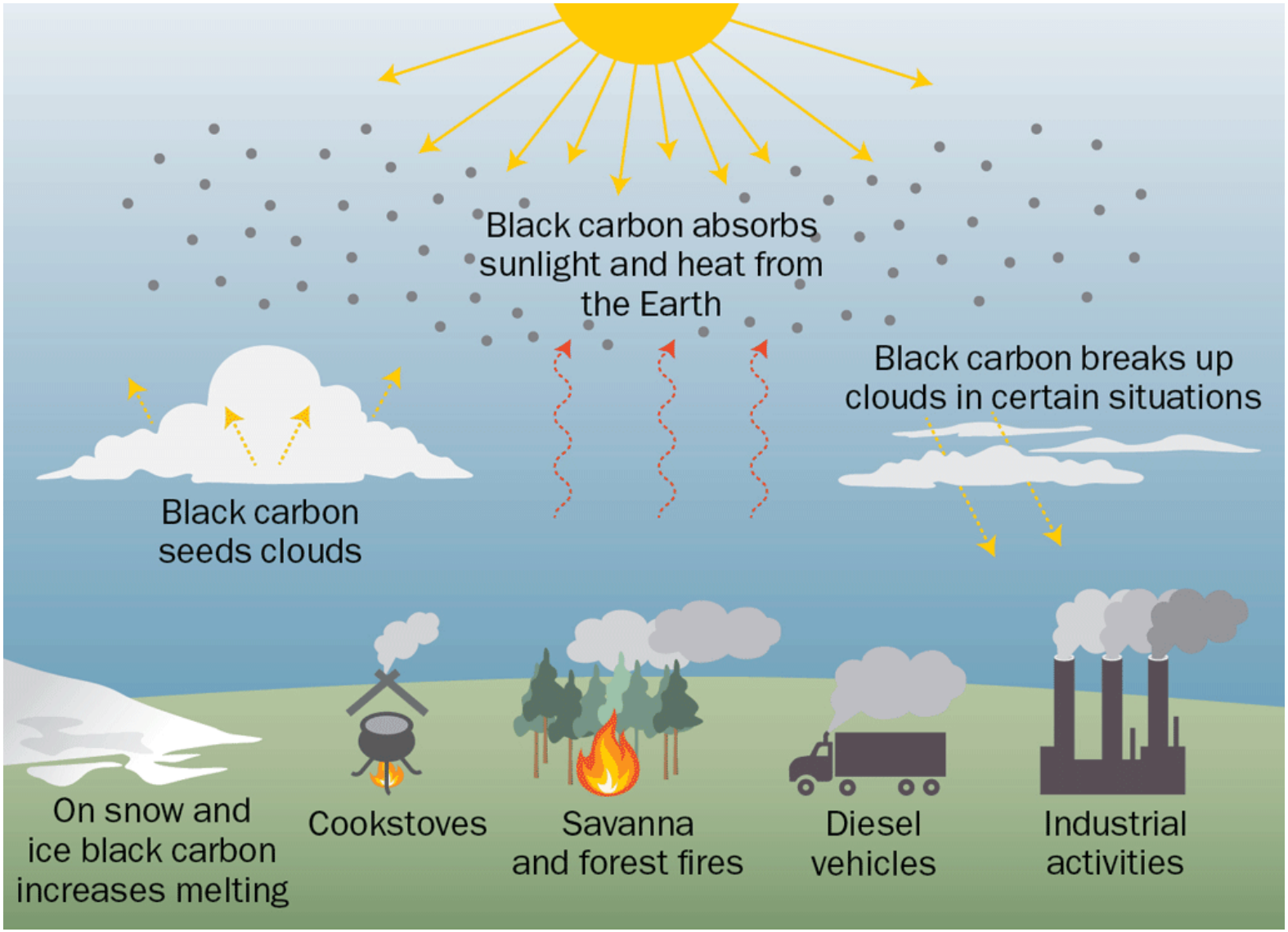
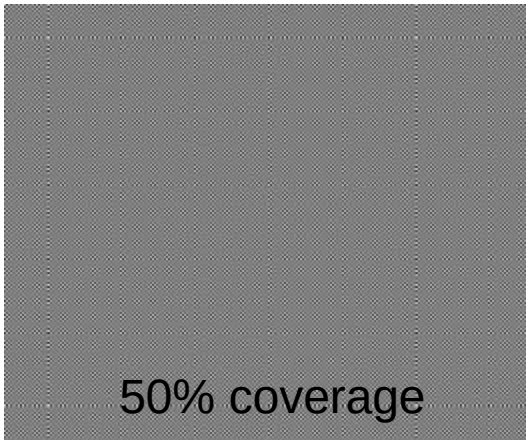


Black Carbon: A Dusty Situation

Lab Question: How does an increase in black carbon impact surface warming?



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Black Carbon: A Dusty Situation

Data Table

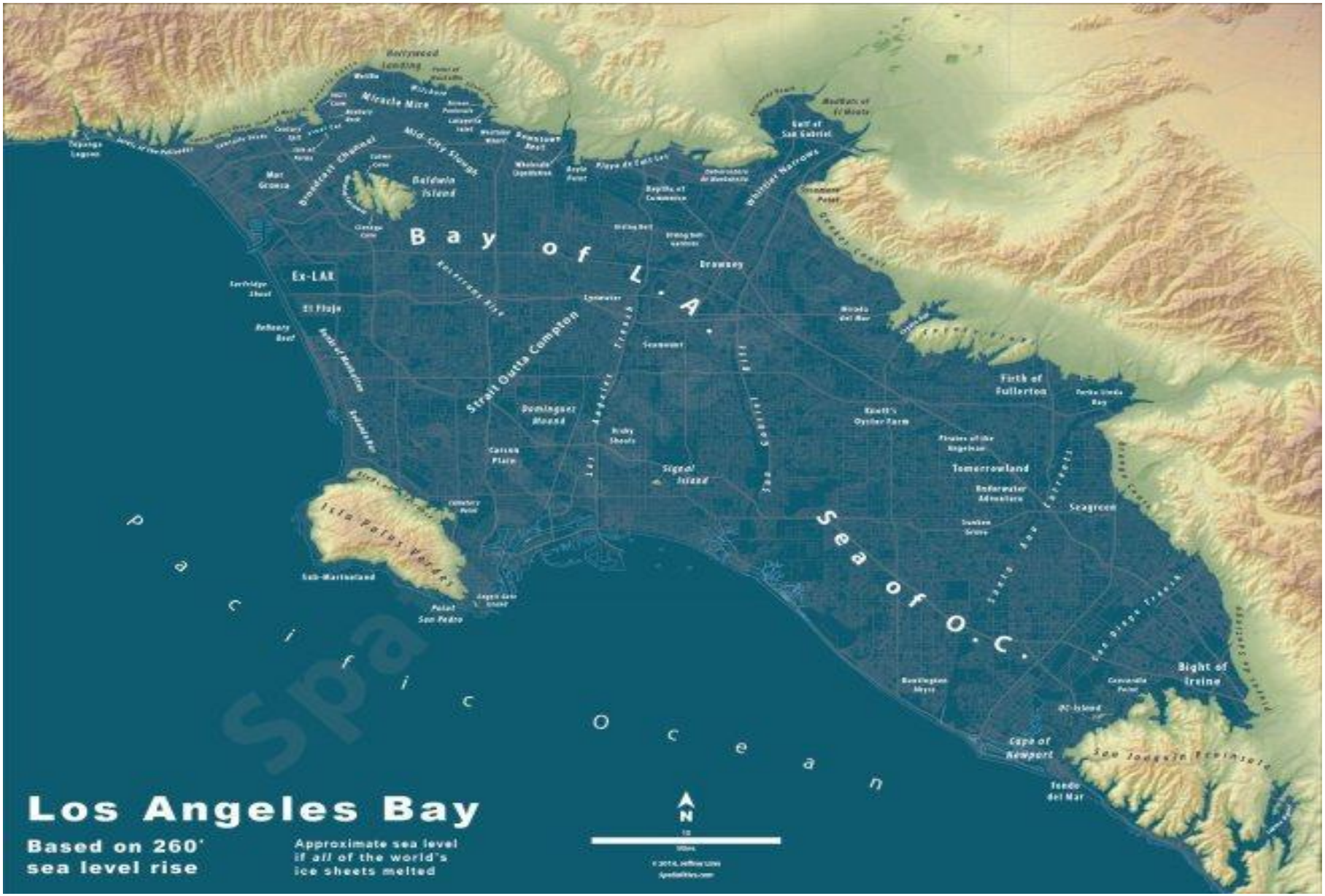
	Time (min)	White Paper Temp (°C)	10% Dots Paper Temp (°C)	50% Dots Paper Temp (°C)	80% Dots Paper Temp (°C)
Starting Temp	0				
Heat-Up Time	2				
	4				
	6				
	8				
	10				
	12				
	14				
	16				
	18				
	20				
Cool-Down Time	22				
	24				
	26				
	28				
	30				
	32				
	34				
	36				
	38				
	40				

WINDOWS TO THE UNIVERSE

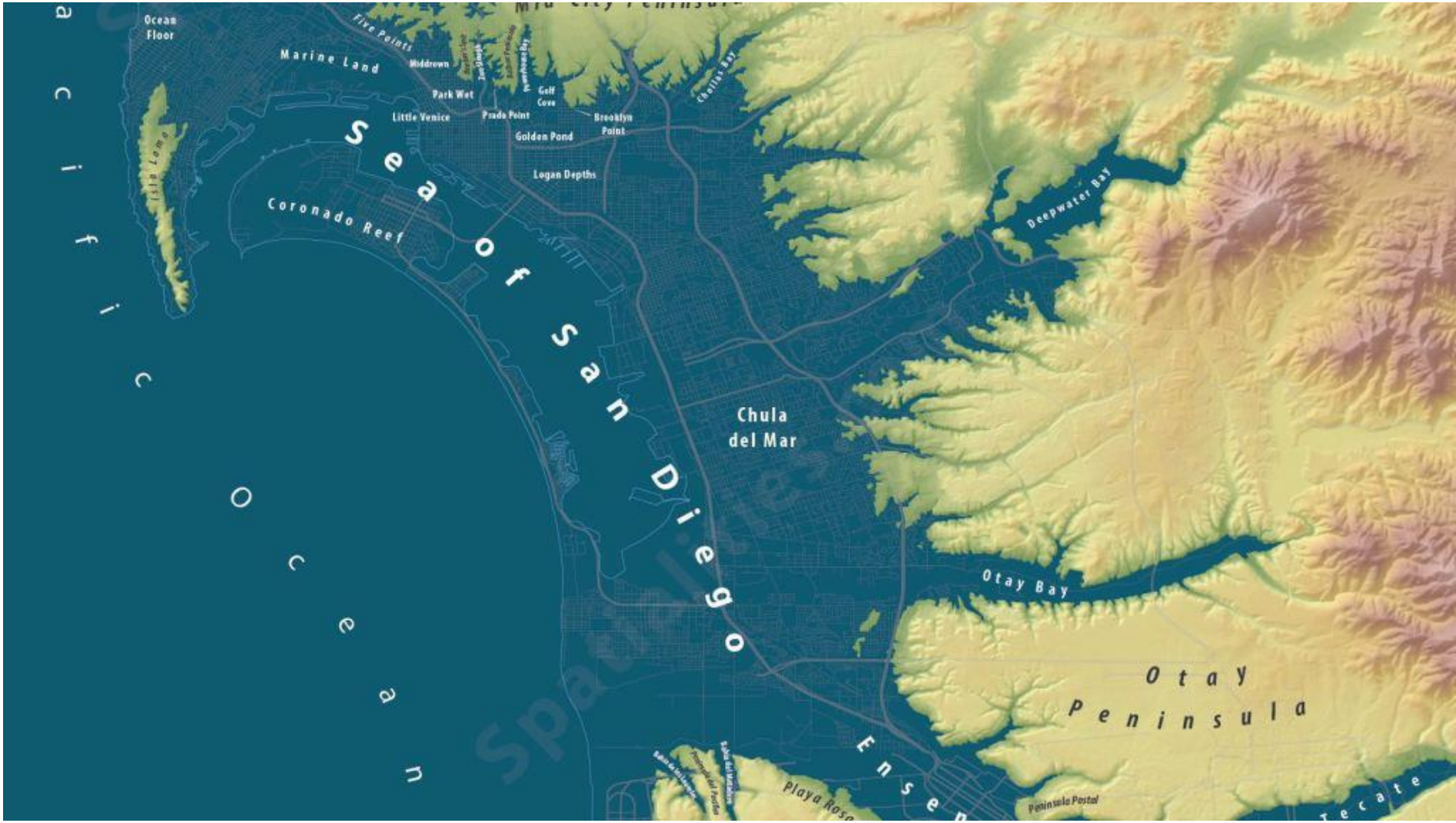
“Rising Seas” Activity

In this activity, students will:

- analyze sea level data to identify the rate of sea level rise,
- make projections of sea level rise into the future, and
- interpret the impact of projected sea level rise on communities
- *NGSS Performance Expectation HS ESS3-1 (see below) in the context of changes in sea level and impacts on populations*



http://grist.org/cities/heres-what-your-city-will-look-like-when-the-ice-sheets-melt



http://grist.org/cities/heres-what-your-city-will-look-like-when-the-ice-sheets-melt/

Key points

- Global mean sea level (GMSL) – average global sea level corrected for vertical land motions and short and long term variability
- Tidal gauge measurements from global network
- Satellite altimetry
- Sea level is affected by several factors, including vertical land motion (subsidence, glacial rebound, tectonic motions) and change of the ocean level itself

Short to long term variability in local sea level

- Waves, tides
- Floods
- Seasonal weather patterns
- Atmosphere-ocean oscillations (like ENSO, PDO, etc.)

GMSL

Affected by:

- Thermal expansion of the ocean water
- Addition of water from land based sources (glaciers, ice sheets)
  - Melting sea ice does not increase sea level

GMSL **anomaly** – the difference between the GMSL at a given time and a reference GMSL (ie, the amount of change from a reference global mean sea level)

Figure 1 - Global mean sea level anomalies (in mm) determined from tidal gauge measurements by several authors, relative to the five-year average from 1900 - 1905.

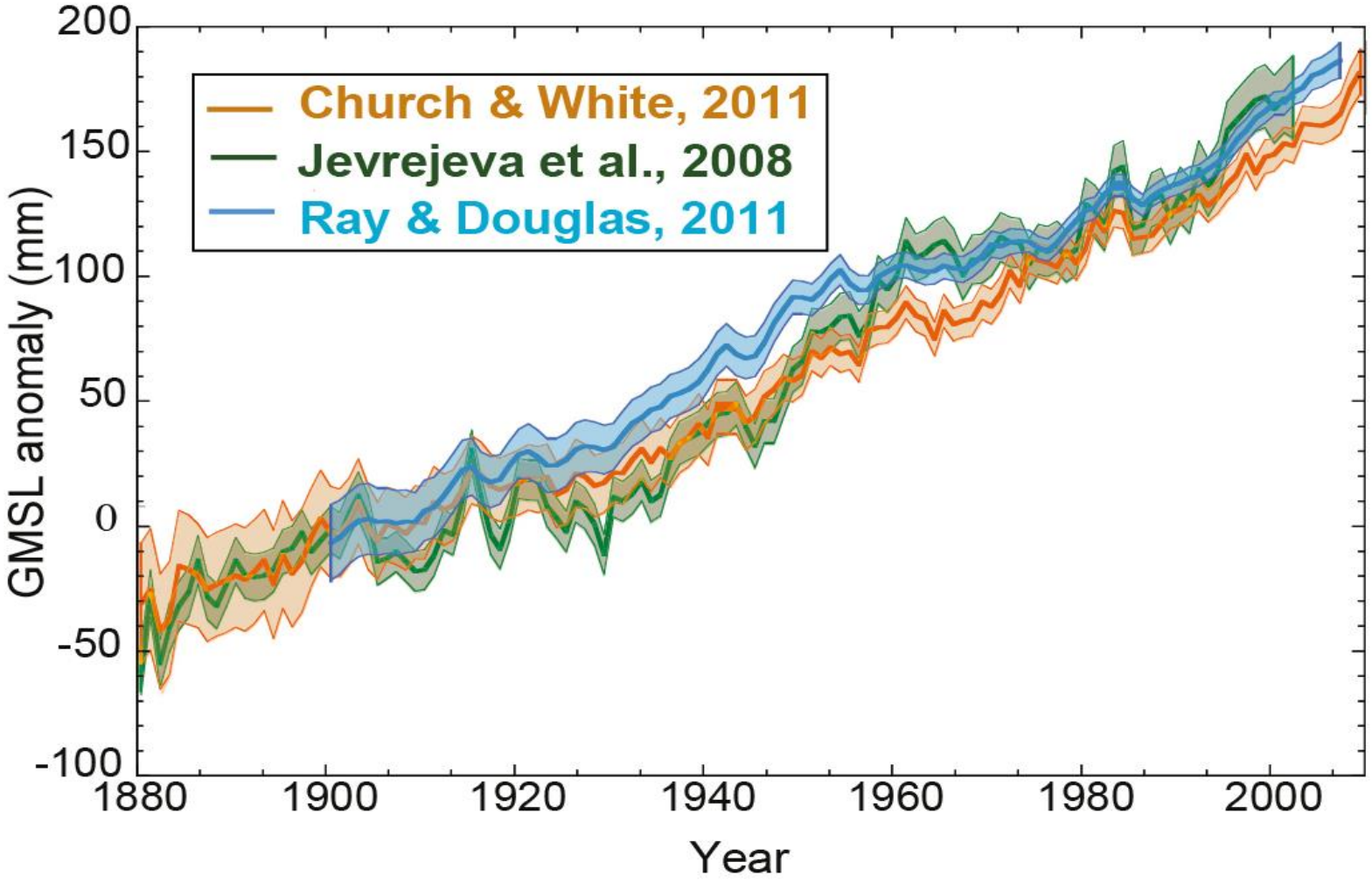
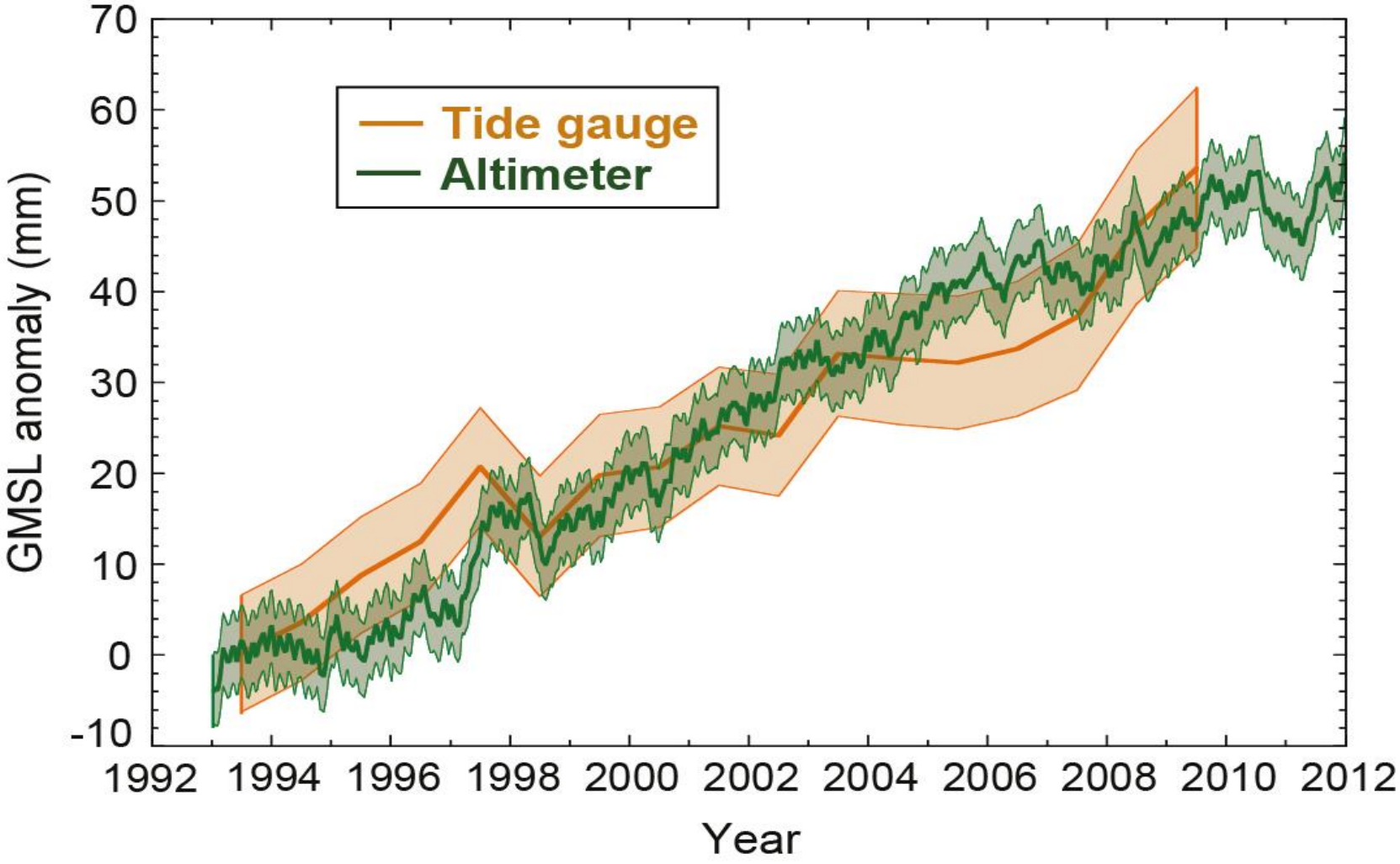


Figure 2 - Global mean sea level anomaly (in mm) from 1993 - 2010 based on tidal gauge and satellite altimetry data, with seasonal variations removed and smoothed with a 60-day running mean.



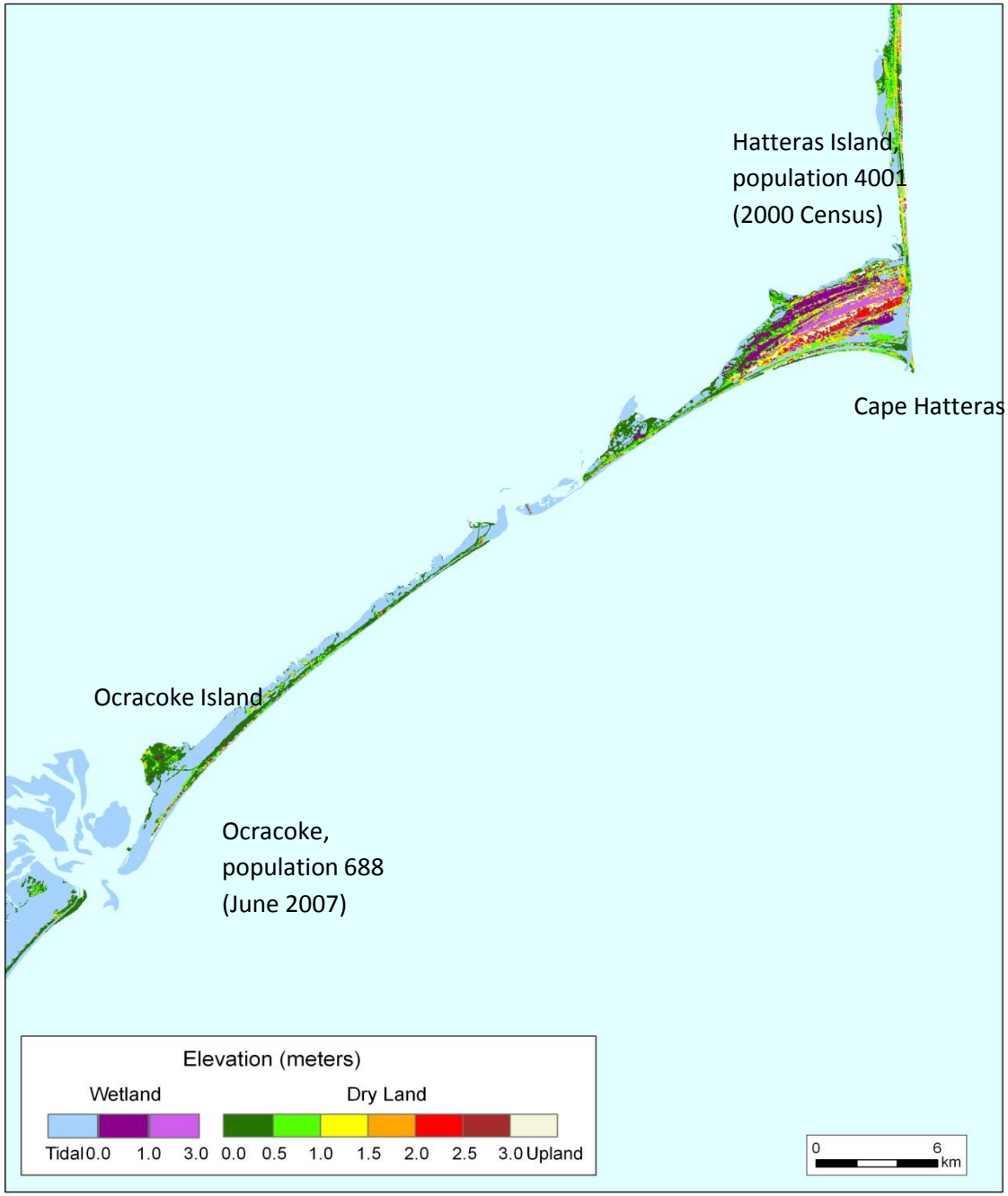


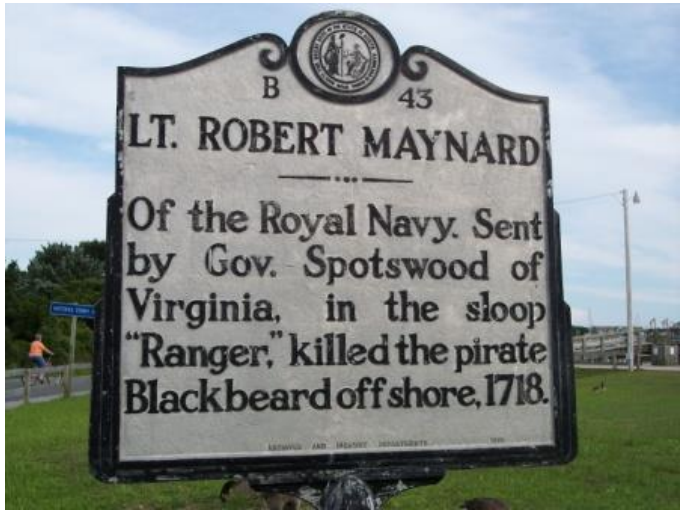
Figure 3 - Elevations in meters of islands in the Outer Banks of North Carolina from James G. Titus and Jue Wang, 2008.

Results

4. ~1.7 + .1 mm/yr from 1900 to 2000
7. ~2.9 + .1 mm/yr from 1993 to 2012
8. $2.9\frac{\text{mm}}{\text{yr}} \times 38\ \text{yrs} = 110.2\ \text{mm by } 2050$

   255.2 mm by 2100
10. 165 mm by 2050, 310 mm by 2100

Edward Teach, aka Blackbeard!



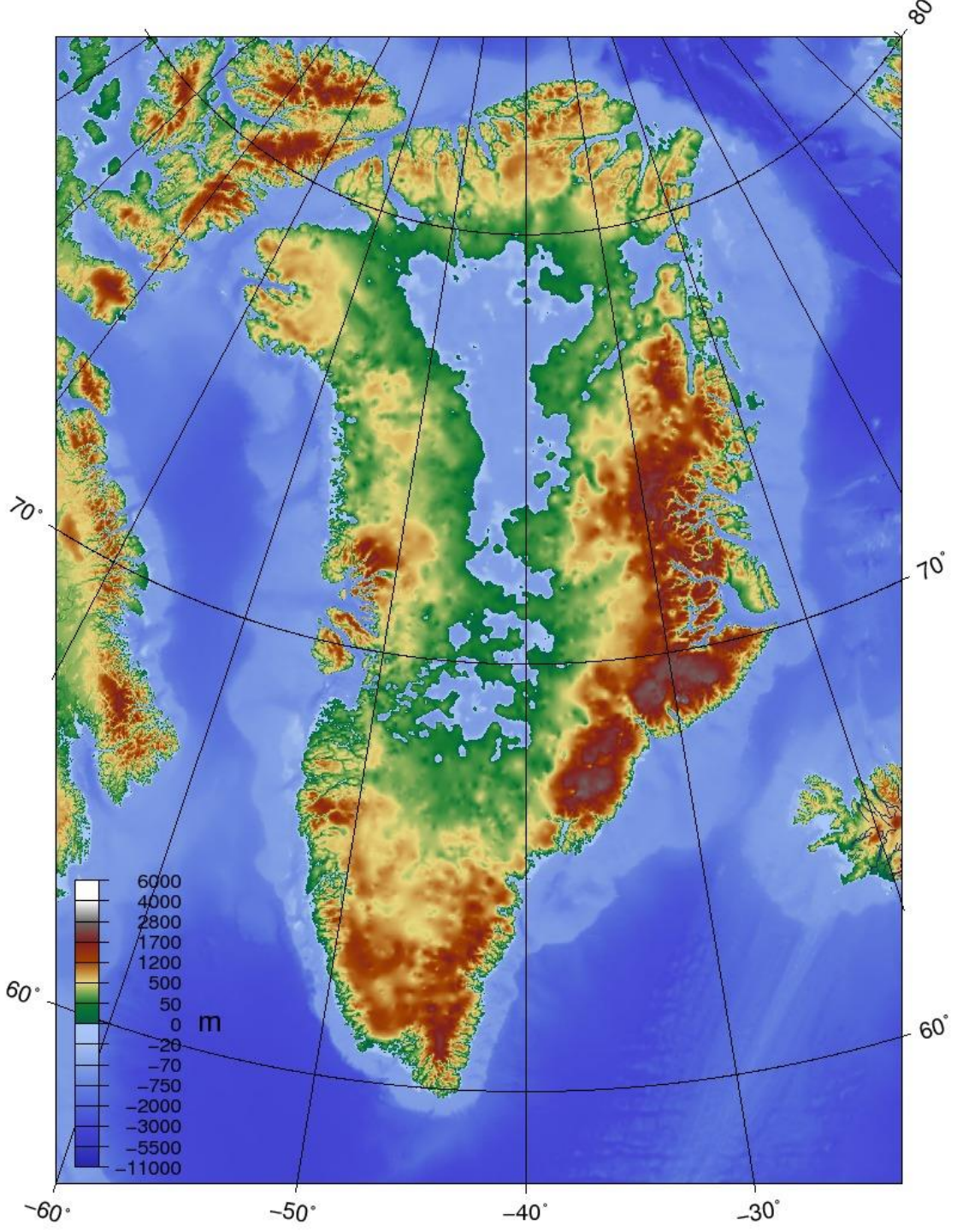
Capture of the Pirate, Blackbeard, 1718, Jean Leon Gerome Ferris, painted in 1920

Melting Ice Sheets

- These results do not account for the possible melting of large ice sheets (Greenland, West Antarctic)
- West Antarctic – “Past the point of no return” – 1.2 – 3.6 m
- Greenland Ice Sheet – would produce ~7.2 m sea level rise

Terrain under West Antarctic Ice Sheet – slopes downward inland

Topographic map of Greenland bedrock, in effect showing the topography without the extant ice sheet.



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Climate and Global Change

Warm near the equator and cold at the poles, our planet is able to support a variety of living things because of its diverse regional climates. The average of all these regions makes up Earth's global climate. Climate has cooled and warmed throughout Earth history for various reasons. Rapid warming like we see today is unusual in the history of our planet. The scientific consensus is that climate is warming as a result of the addition of heat-trapping greenhouse gases which are increasing dramatically in the atmosphere as a result of human activities.

Permafrost is ground that is below the freezing point of water (0°C or 32°F) for two or more years. Permafrost is found at high latitudes like the Arctic and Antarctic. It is also common at high altitudes - like mountainous areas wherever the climate is cold. Permafrost has been thawing relatively quickly in recent years. Scientists have found that the rate of permafrost thaw has increased because of global warming.

Image courtesy of the USGS

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Teachers - Become an Educator Member of Windows to the Universe for special benefits and opportunities, including information about valuable special offers for classroom grants, professional development with travel and/or stipends, research grants, and more!

Windows to the Universe is now offering on-site professional development workshops for teachers. Find out more about this opportunity here. Information about our upcoming workshops and events at the NSTA conference in Indianapolis is available under 2012 on our Teacher Resources/Workshops page.

Scientists are concerned that melting Arctic sea ice will increase the amount of fresh water in the Beaufort Gyre, which could spill out into the Atlantic and cause major climate shifts in North America and Western Europe. Our new lesson plan, The Case of the Leaky Gyre, explores the circulation in ocean gyres and the potential climate impacts. Watch the Changing Planet: Fresh Water in the Arctic video.

Courtesy of Jack Cook, WHOI (Woods Hole Oceanographic Institute)

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Teachers participate in hands-on activities at a workshop at the NSTA National Conference on Science Education.
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Image Courtesy of UCAR's Office of Education and Outreach

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Welcome!

You are at the hub for the Earth and Space Science Educator E-Newsletter from Windows to the Universe. Here, you can access the current newsletter and the archive of past newsletters.

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October 2014 Newsletter

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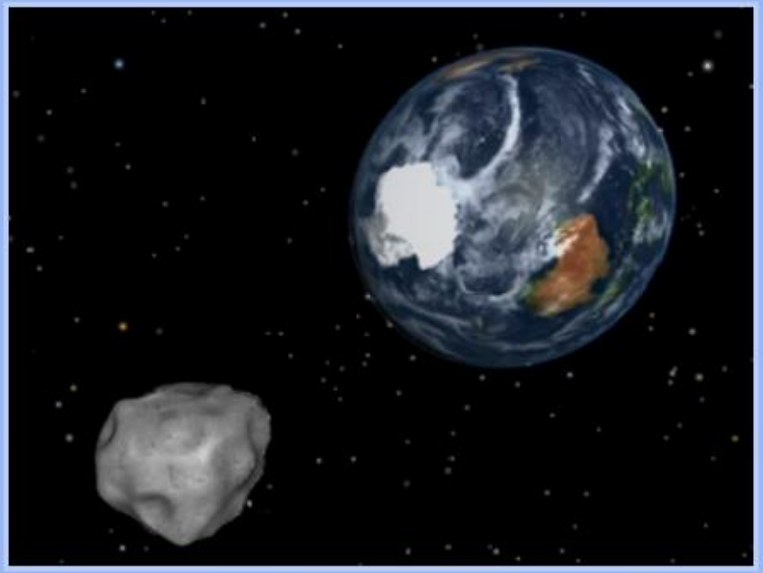

A near-Earth asteroid - named 2012 DA14 by astronomers – passed within 17,200 miles from Earth on February 15, 2013. On closest approach at about 1:25 p.m. CST on February 15, although it was within the orbit of the Moon and even geosynchronous satellites, it didn't strike Earth! Find out more from NASA! Fragments of a meteorite hit Chelyabinsk, Russia on 2/15/2013 injuring over 500. Learn about meteors and meteorites.

NASA/JPL-CalTech

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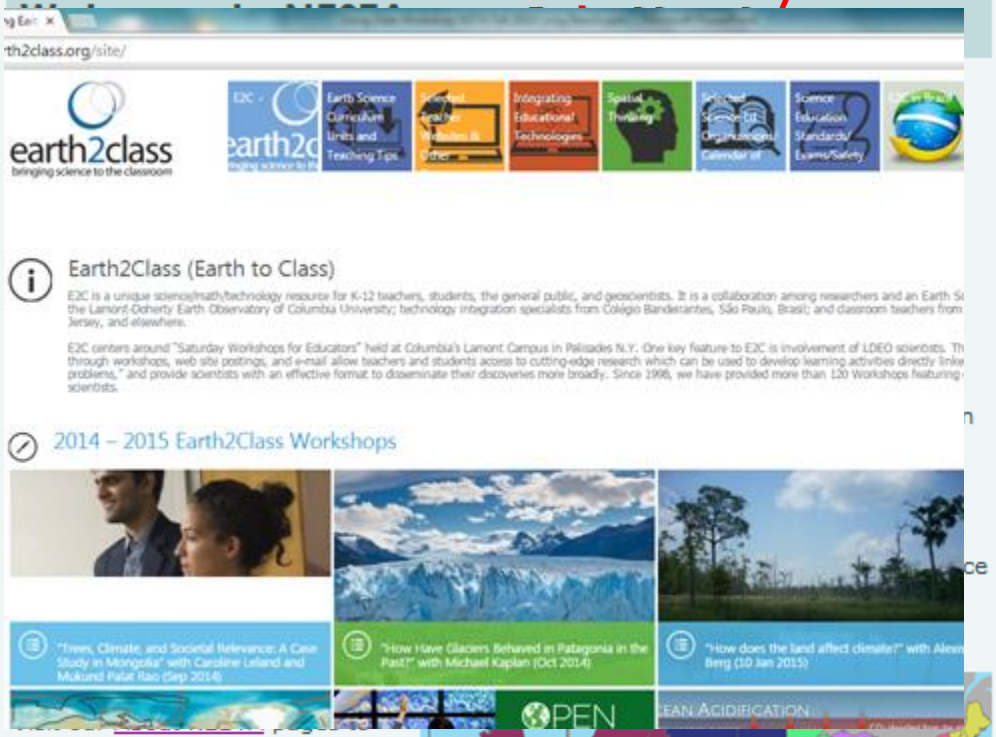

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Upcoming Events

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Earth Science Week 2014: 'Earth's Connected Systems'
10/12/2014 - 8:00am

STANYS Earth Science Breakfast
11/04/2014 - 7:00am

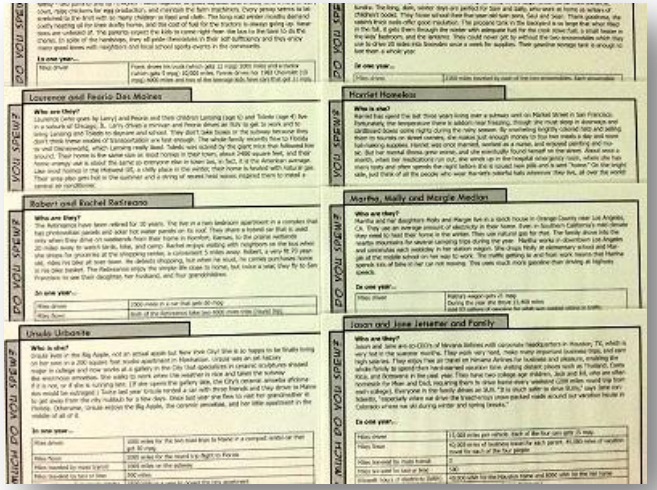
Harnessing the Power of Earth System Science for Developing Science Practices and Crosscutting Concepts
10/17/2014 - 9:30am

Harnessing the Power of Earth System Science for Developing Science Practices and Crosscutting Concepts
11/07/2014 - 8:00am

Questions?

Classroom Activity Kits
Available at the NESTA Trading Post

Glaciers: Then and Now



CO2: How Much Do You Spew?

Traveling Nitrogen

And online in the Windows to the Universe Online Store!

Bumper Stickers, too!

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Please join us at the

Rock and Mineral Raffle, 3:30 – 4:30 pm

This room

Rocks & Mineral Fossils & Sand Kits, and many other goodies!