Data, data everywhere

Earth 530: Earth surface processes in the Critical Zone

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Critical Zone:

- Term published by the U.S. National Research Council in 2001 BROES report

= Thin veneer at Earth's surface spanning from the top of vegetation canopy through soil to deep in the subsurface where fresh groundwater circulates.

Tropical rainforest:

- Extensive forest canopy with complex understory
- Thick mature soils and deep weathered regolith
- Potentially deep aquifers

Polar realm:

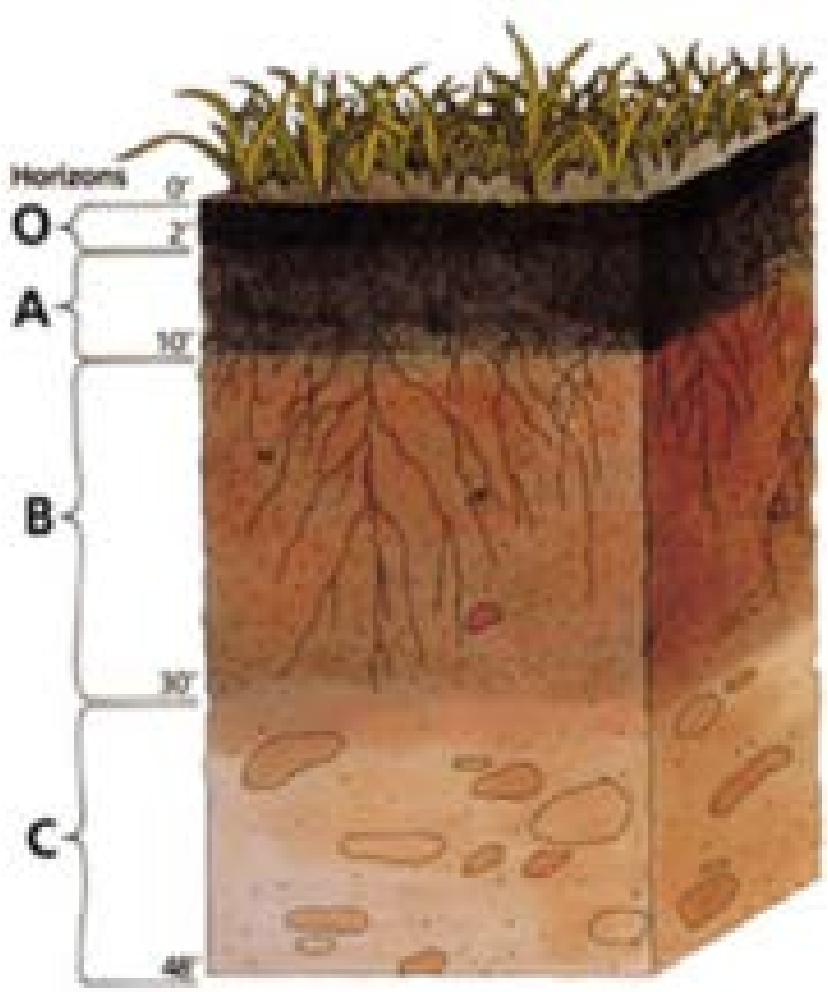
- Stunted vegetation
- Thin discontinuous soils
- Permafrost

Longyearbyen Valley, Spitsbergen

Soil is a central component of the Critical Zone

Important for:

- agriculture
- water filtration
- C sequestration
- biodiversity



But the CZ is much more…..

Soil exists at the "…e Critical Zone

- biodiver…

But the CZ is much more…..

Societal relevance:

The zone within which most terrestrial life exists and depends on.

Ongoing climate and land use changes to the zone may stress terrestrial life including humanity – thus a better understanding of CZ processes and function may aid adaptation to change.

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Changes in the global value of ecosystem services

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ABSTRACT

In 1997, the global value of ecosystem services was estimated to average $33 trillion/yr in 1995 $US ($46 trillion/yr in 2007 $US). In this paper, we provide an updated estimate based on updated unit ecosystem service values and land use change estimates between 1997 and 2011. We also address some of the critiques of the 1997 paper. Using the same methods as in the 1997 paper but with updated data, the estimate for the total global ecosystem services in 2011 is $125 trillion/yr (assuming updated unit values and changes to biome areas) and $145 trillion/yr (assuming only unit values changed), both in 2007 $US. From this we estimated the loss of eco-services from 1997 to 2011 due to land use change at $4.3–20.2 trillion/yr, depending on which unit values are used. Global estimates expressed in monetary

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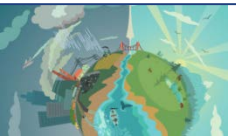
Total global gross domestic product (2013): US$74.3-87.3 trillion (source: Wikipedia)

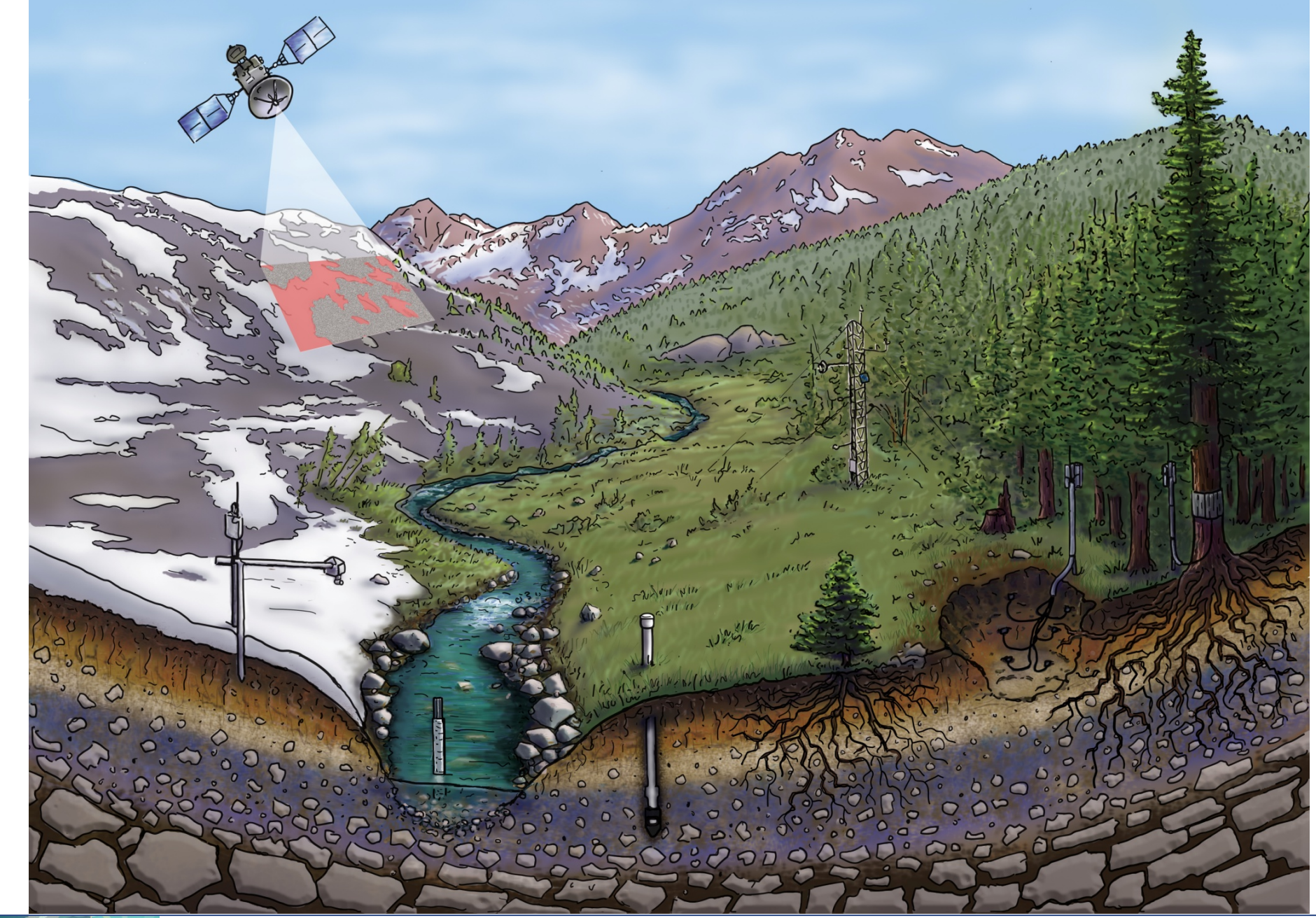


Critical Zone Services

* Pollination
* Fulfillment of cultural, spiritual/intellectual needs
* Regulation of climate
* Insect pest control
* Maintenance and provision of genetic resources
* Maintenance and regeneration of habitat
* Provision of shade and shelter
* Prevention of soil erosion
* Maintenance of soil fertility
* Maintenance of soil health
* Maintenance of healthy waterways
* Water filtration
* Regulation of river flows and groundwater levels
* Waste absorption and breakdown

If we allow natural assets to decline, so do the benefits. But if we care for and maintain natural assets, we will reap greater returns.


Reynolds Creek
Eel River
Boulder Creek
Southern Sierra
Intensively Managed Landscape
Shale Hills
Jemez River Basin
Santa Catalina Mountain
Calhoun Forest
Luquillo

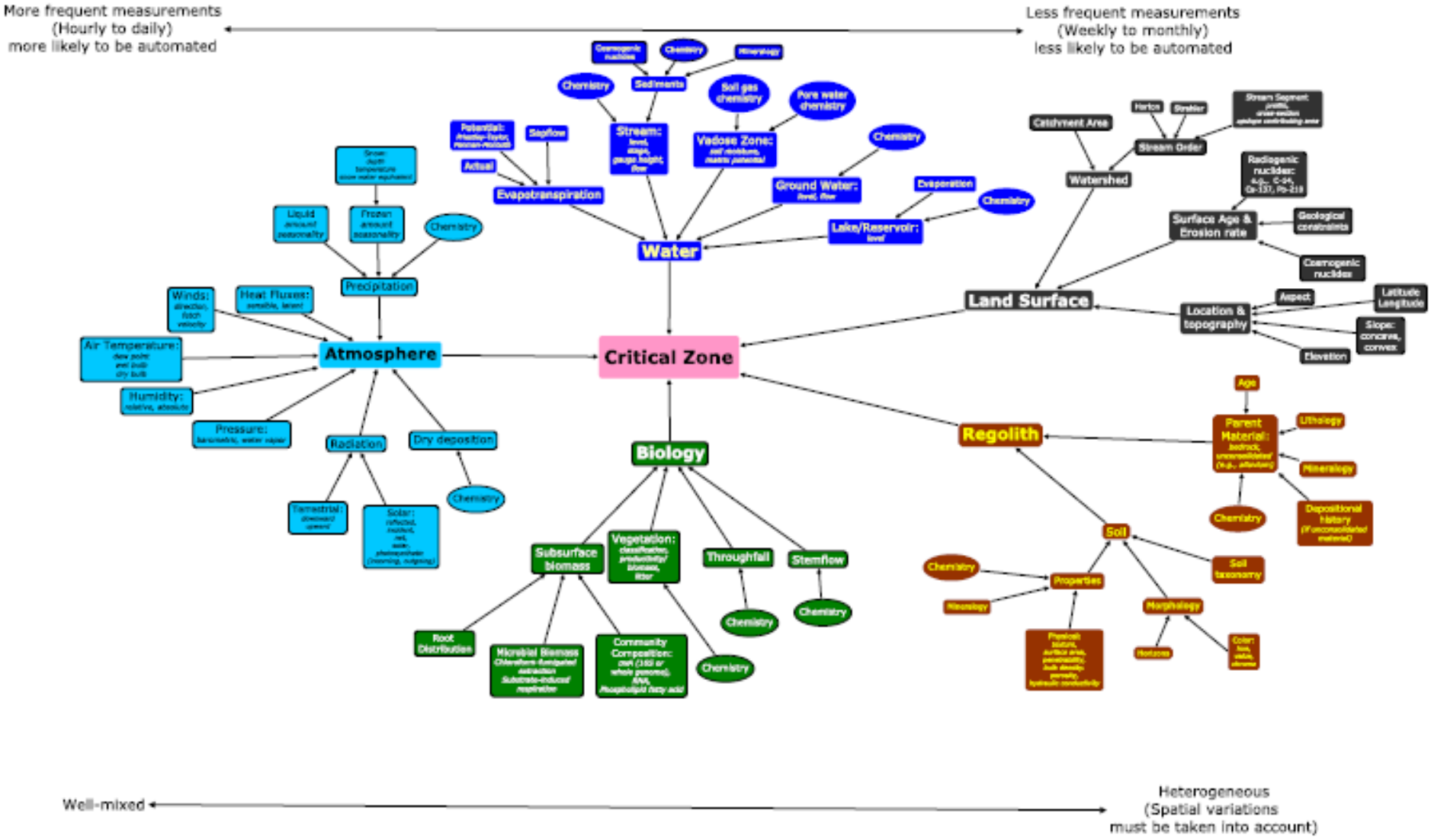


PennState
College of Earth
and Mineral Sciences

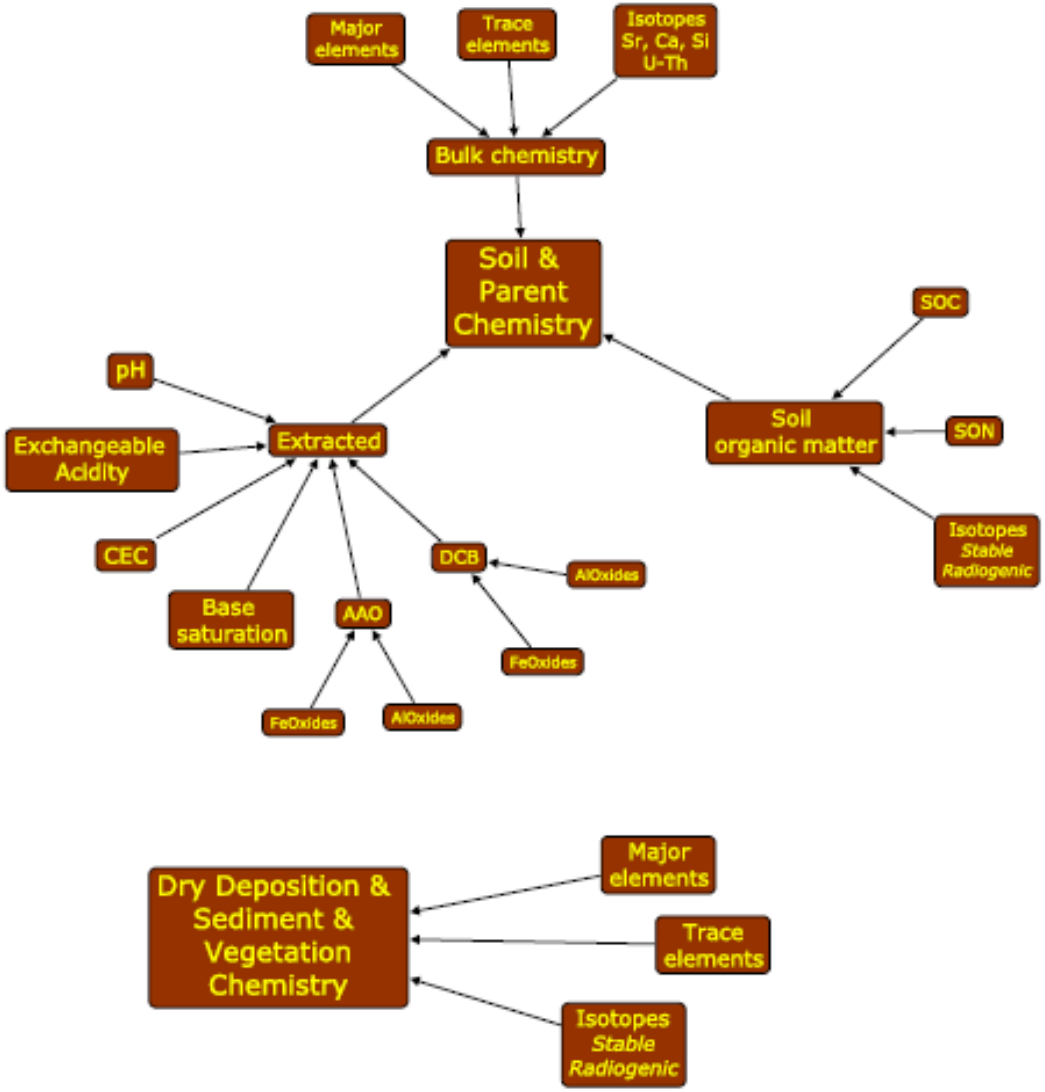
MASTER OF EDUCATION IN

Earth Sciences

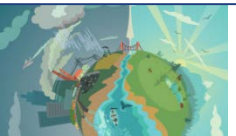
CZOs have drafted an ontology that describes the structure of the data



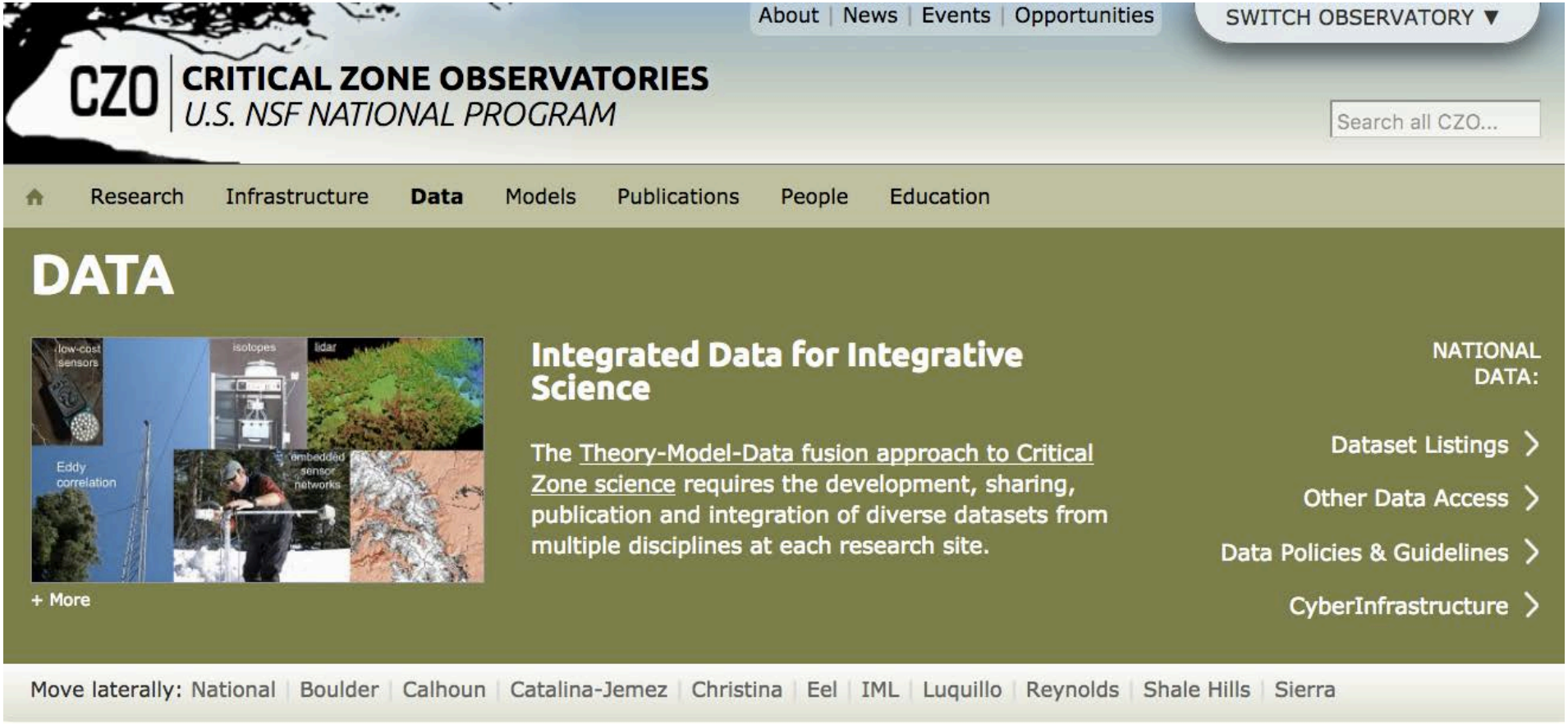
Solid chemistry



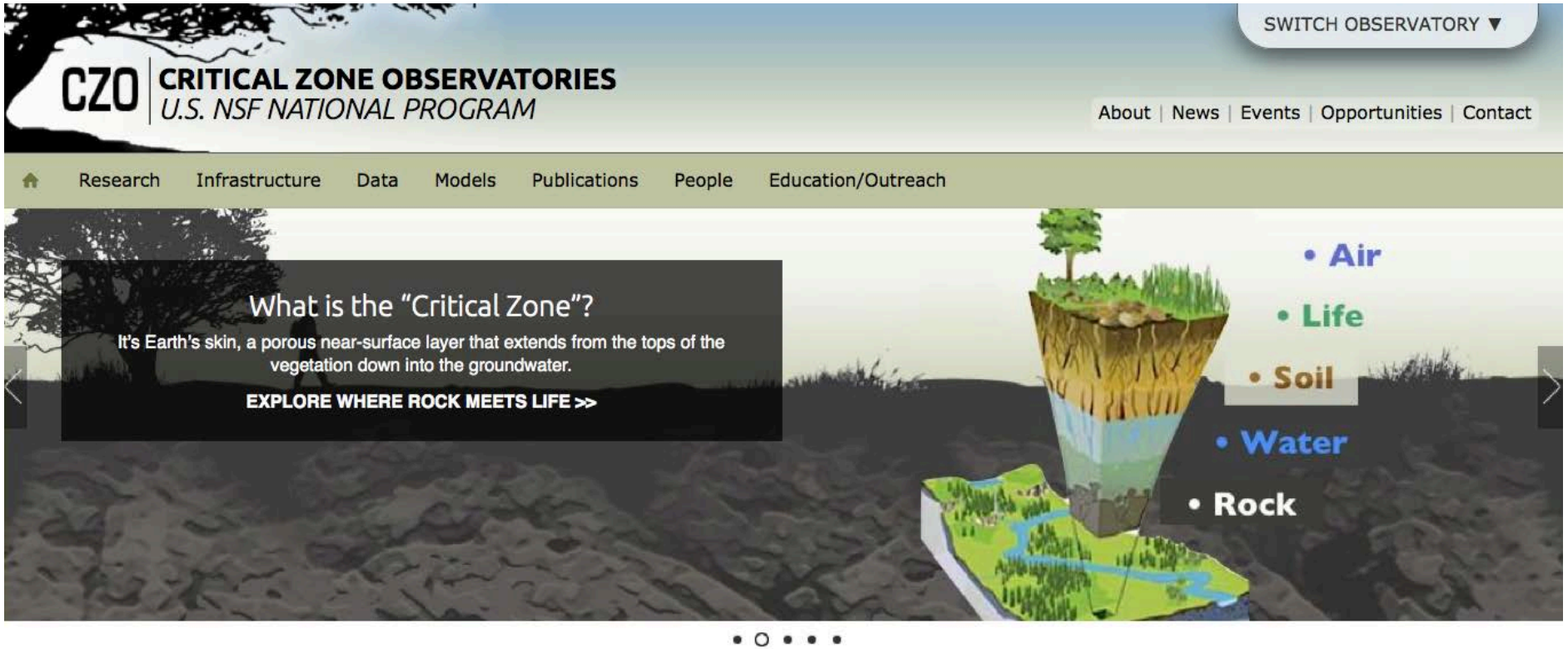
CZO →	Boulder Creek	Calhoun	Catalina-Jemez	Christina River	Eel River	IML	Luquillo	Reynolds Creek	Shale Hills	Southern Sierra
Land-Atmosphere										
LiDAR	X	Z	X	X	X	X	X	Y, Z	X	X
Eddy flux	Y	Z	X			X, Y, Z		Y	X	X, Z
Wind speed and direction	X	Z	X	X	X	X, Y	Y	Y	X	X
Precipitation and throughfall	X	X, Z	X	X	X	X, Y	Y	Y	X	X, Y, Z
Wet and dry deposition	Y	X, Z	X	X		Y	Y	Y	X	X
Snowpack distribution and duration	X		X					Y	X	X
Vegetation and Microbiota										
Structure and function above and below biomass	X	X	X	X	X, Z	X	Y	Y, Z	X	X, Y, Z
Microbial composition above and below ground	X	X, Z	X	X	X	X	Y	Z		X, Z
ET - species composition and structure relationships	Y	Z	X		X	y		Y, Z	X	X
Soil (Vadose Zone)										
Solid - elemental composition and mineralogy	X	X, Z	X	X	X	X	X	Y, Z	X	X, Y
Solid - texture and physical characterization	X	X, Z	X	X	X	X	X	Y, Z	X	X, Y, Z
Solid - organic matter content	X	X, Z	X	X	X	X	X	Y, Z	X	X, Z
Solid - radiogenic isotope composition	X		X	X		X	X		X	X, Z
Fluid - soil moisture (sensors)	X	X, Z	X	X	X	X	X	Y, Z	X	X, Z
Fluid - soil temperature (sensors)	X	Z	X	X	X	X	X	Y, Z	X	X, Z
Fluid - soil solution chemistry (samplers)	X	X, Z	X	X	X	X	X		X	X, Y, Z
Fluid - soil gas chemistry (samplers/sensors)		X, Z	X	X	X		X, Y	Z	X	Z
Saprolite and Bedrock (Saturated Zone)										
Solid - petrology and mineralogy	X	X, Z	X	X	X	Y	X	Z	X	X, Z
Solid - elemental composition and OM content	X	X, Z	X	X	X	X	X	Z	X	X, Z
Solid - texture, physcial/architectural constraints	X	X, Z	X	X	X	X	X	Z	X	X, Z
Fluid - potentiometric head, temperature (sensors)	X	Z	X	X	X	X	X	Y	X	X
Fluid - groundwater chemistry (samplers/sensors)	X	X, Z	X	X	X	X	X	Z	X	X, Z
Fluid - saprolite/weathered bedrock gas chemistry		X, Z			X					X
Geophysical surveys - depth to bedrock	X		X	X	X		X	Y	X	X
Surface Water										
Instantaneous discharge	X	X, Z	X	X	X	X, Y	X, Y	Y	X	X, Y, Z
Stable isotopes of water	X	Z	X		X		X		X	X
Stream water chemistry (samplers/sensors)	X	X, Z	X	X	X	X	X, Y, Z	Z	X	X, Y
Sediments (samplers/sensors)	X	Z	X	X	X	X	X	Y, Z	X	Y, X
Extent of wetted channel		Z			X					Y, X
Aquatic biota (invertebrates, fish, etc.)					X		Y			Y



All that CZO data is publicly available…….



Outreach: criticalzone.org



Outreach to secondary education community:

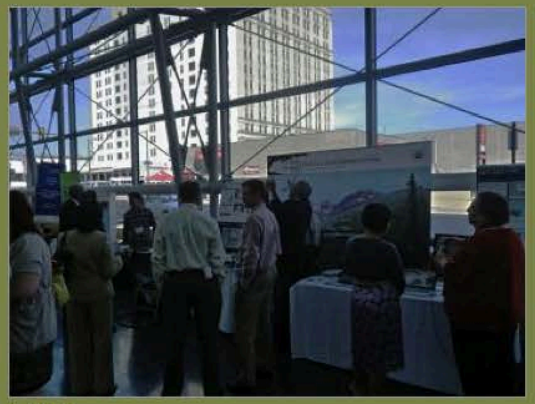
SWITCH OBSERVATORY ▼

CZO | CRITICAL ZONE OBSERVATORIES
U.S. NSF NATIONAL PROGRAM

About | News | Events | Opportunities | Contact

Research | Infrastructure | Data | Models | Publications | People | **Education/Outreach**

K-12 Education



+ More

A national-scale CZO education and outreach effort has begun.

The CZOs participate in a variety of organizational forums to develop a focused and effective education and outreach presence.

NATIONAL EDUCATION-OUTREACH:

- General Public
- K-12 Education
- Higher Education
- Research Community

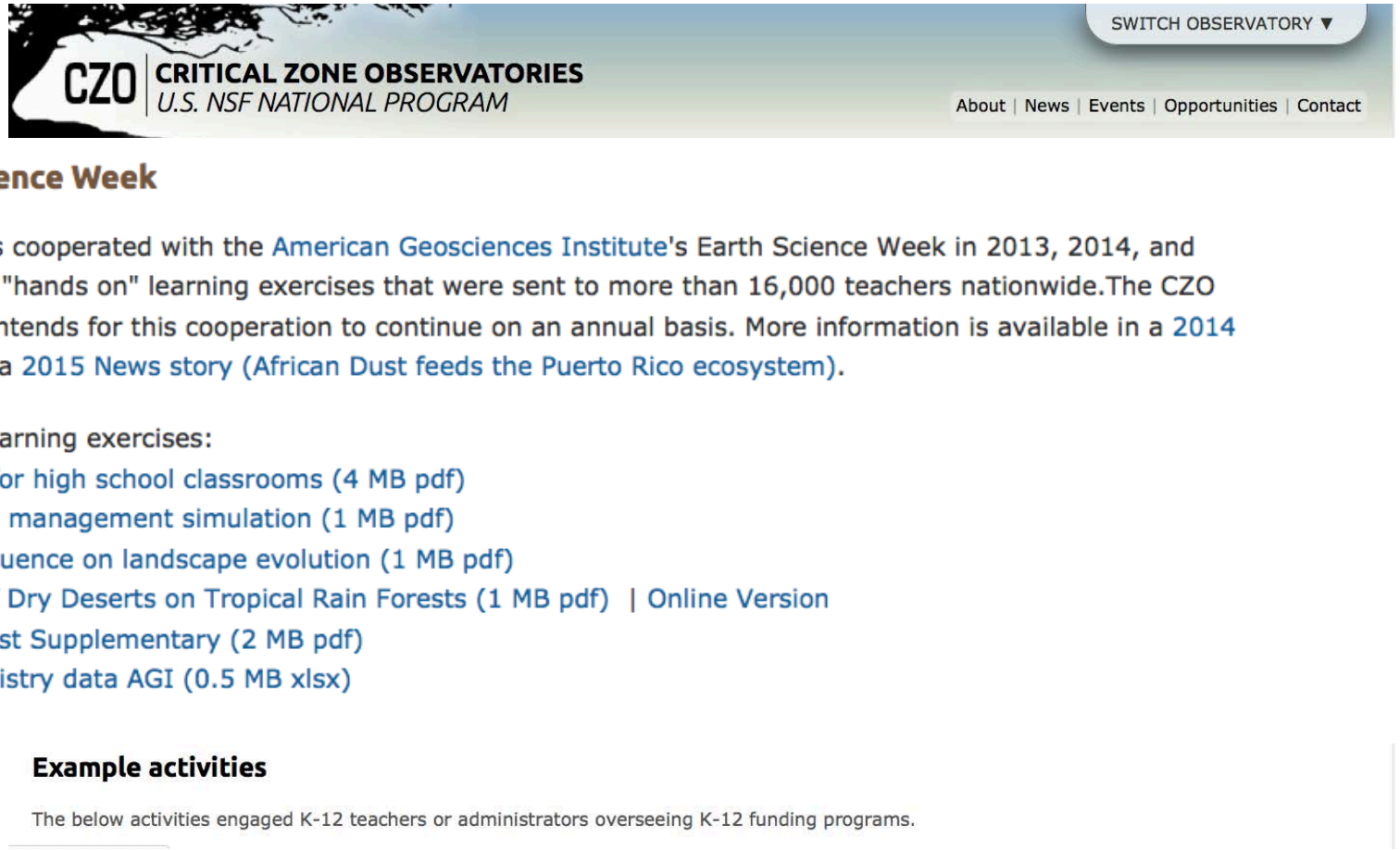
Move laterally: National | Boulder | Catalina-Jemez | Christina | IML | Luquillo | Reynolds | Shale Hills | Sierra

Example activities

The below activities engaged K-12 teachers or administrators overseeing K-12 funding programs.

http://criticalzone.org/national/education-outreach/k-12-education-1national/

Outreach to secondary education community:



http://criticalzone.org/national/education-outreach/k-12-education-1national/

Outreach to secondary education community:

Earth 530 integrates various scientific disciplines that include the study of:

- weathering and soils
- landforms and landscapes
- erosion and sedimentation
- hydrogeology
- low-temperature geochemistry
- biology and ecology
- Earth systems

Upon completion students can apply knowledge of fundamental concepts to understanding how they affect our daily lives in the Critical Zone.

The concepts covered in the course are based on ongoing research funded by the U.S. National Science Foundation and the European Commission.

Critical zone science is transdisciplinary

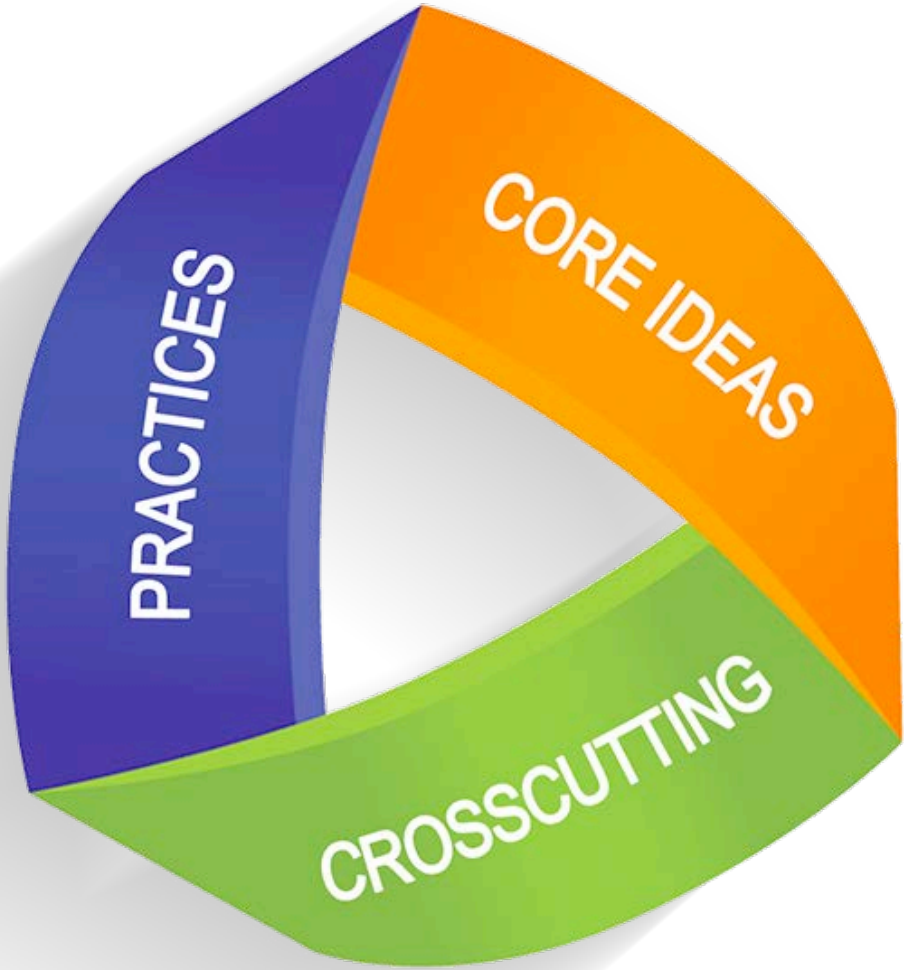
- **different disciplines working jointly**

Thus Earth 530 aligns well with the three dimensions of science learning of the Next Generation Science Standards:

- Crosscutting concepts
- Science and Engineering practices
- Disciplinary core ideas

Science is both a body of knowledge and an evidence-based model and theory building enterprise that continually extends, refines, and revises knowledge.

The three dimensions are combined to form Standards.



High School

Life Science	Earth & Space Science	Physical Science
High School Life Science Introduction	High School Earth & Space Science Introduction	High School Physical Science Introduction
HS. Structure and Function	HS. Space Systems	HS. Structure and Properties of Matter
HS. Inheritance and Variation of Traits	HS. History of Earth	HS. Chemical Reactions
HS. Matter and Energy in Organisms and Ecosystems	HS. Earth's Systems	HS. Forces and Interactions
HS. Interdependent Relationships in Ecosystems	HS. Weather and Climate	HS. Energy
HS. Natural Selection and Evolution	HS. Human Sustainability	HS. Waves and Electromagnetic Radiation
High School Engineering Design Introduction		
HS. Engineering Design		

Back

High School

Earth's Systems

Download

Show Tips

Students who demonstrate understanding can:

Performance Expectations

Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. HS-ESS2-2

▸ Clarification Statement and Assessment Boundary

Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS2-3

▸ Clarification Statement and Assessment Boundary

Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. HS-ESS2-5

▸ Clarification Statement and Assessment Boundary

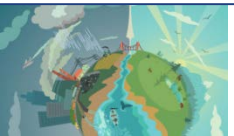
Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. HS-ESS2-6

▸ Clarification Statement and Assessment Boundary

Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. HS-ESS2-7

▸ Clarification Statement and Assessment Boundary

A unique facet of critical zone science is that it considers depth in time and space, that is a geological perspective, that might otherwise be disregarded in the classical Earth surface and environmental sciences.



Introduction to Lidar

Lidar = Light Detection and Ranging

Range. The measurement of the speed which a pulse of light returns to a sensor is converted to elevation above sea level.

$R = \frac{1}{2}(tc)$

- R = range
- *t* = time
- *c* = speed of light

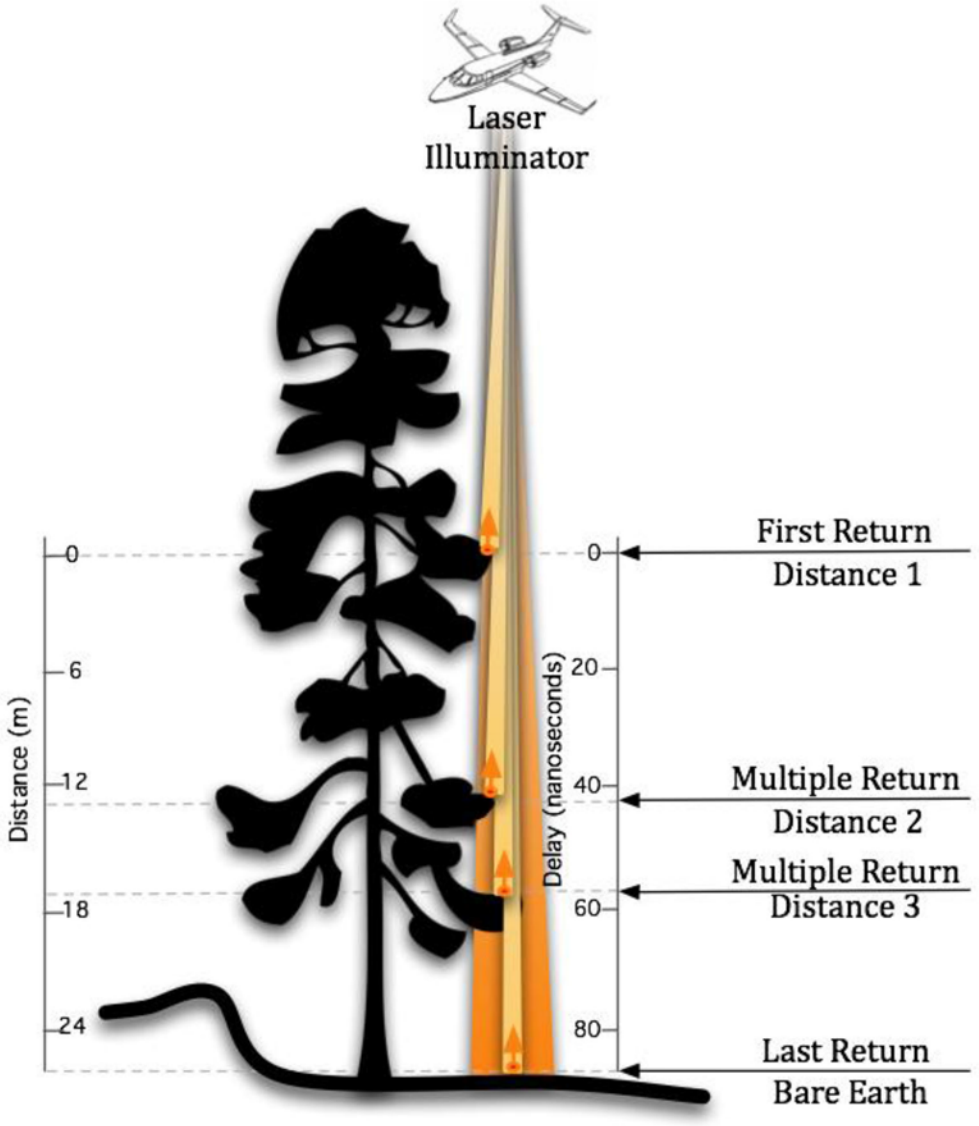
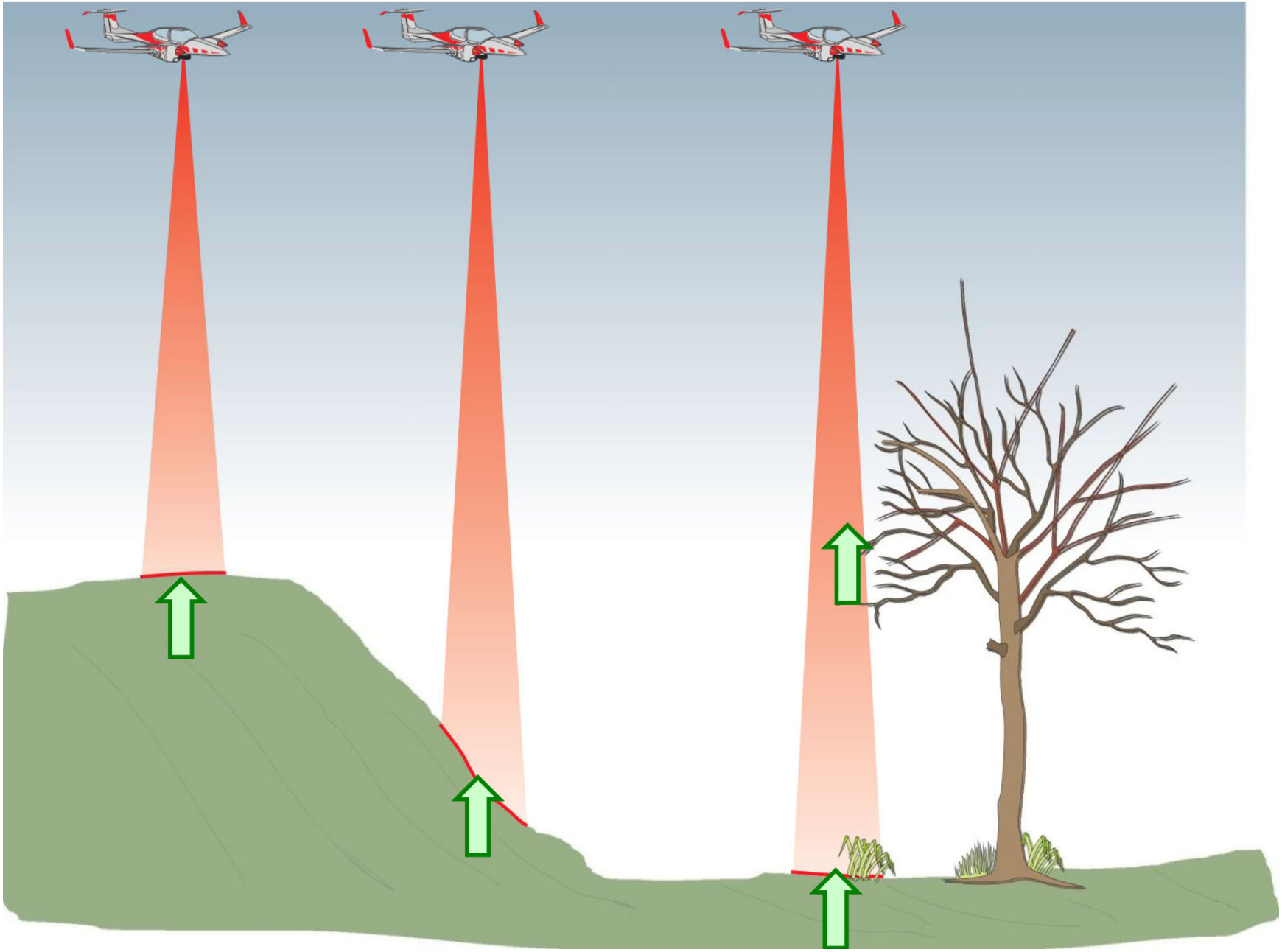
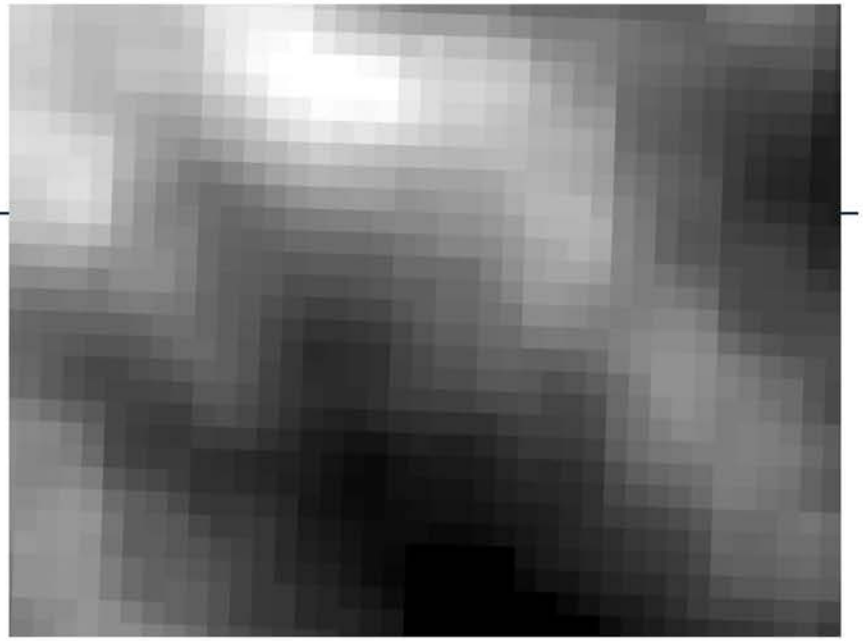


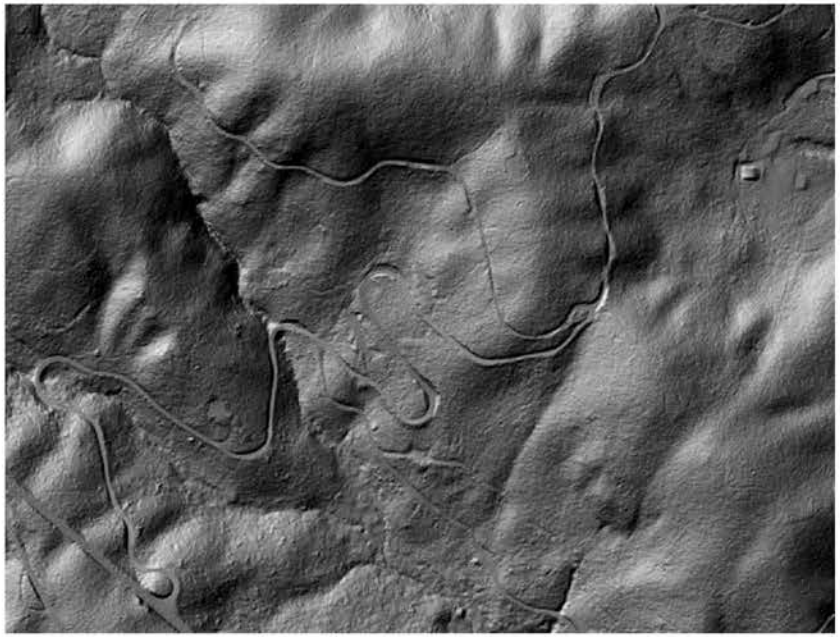
Image modified from Lefsky et al. 2004 with tree graphic from globalforestscience.org.



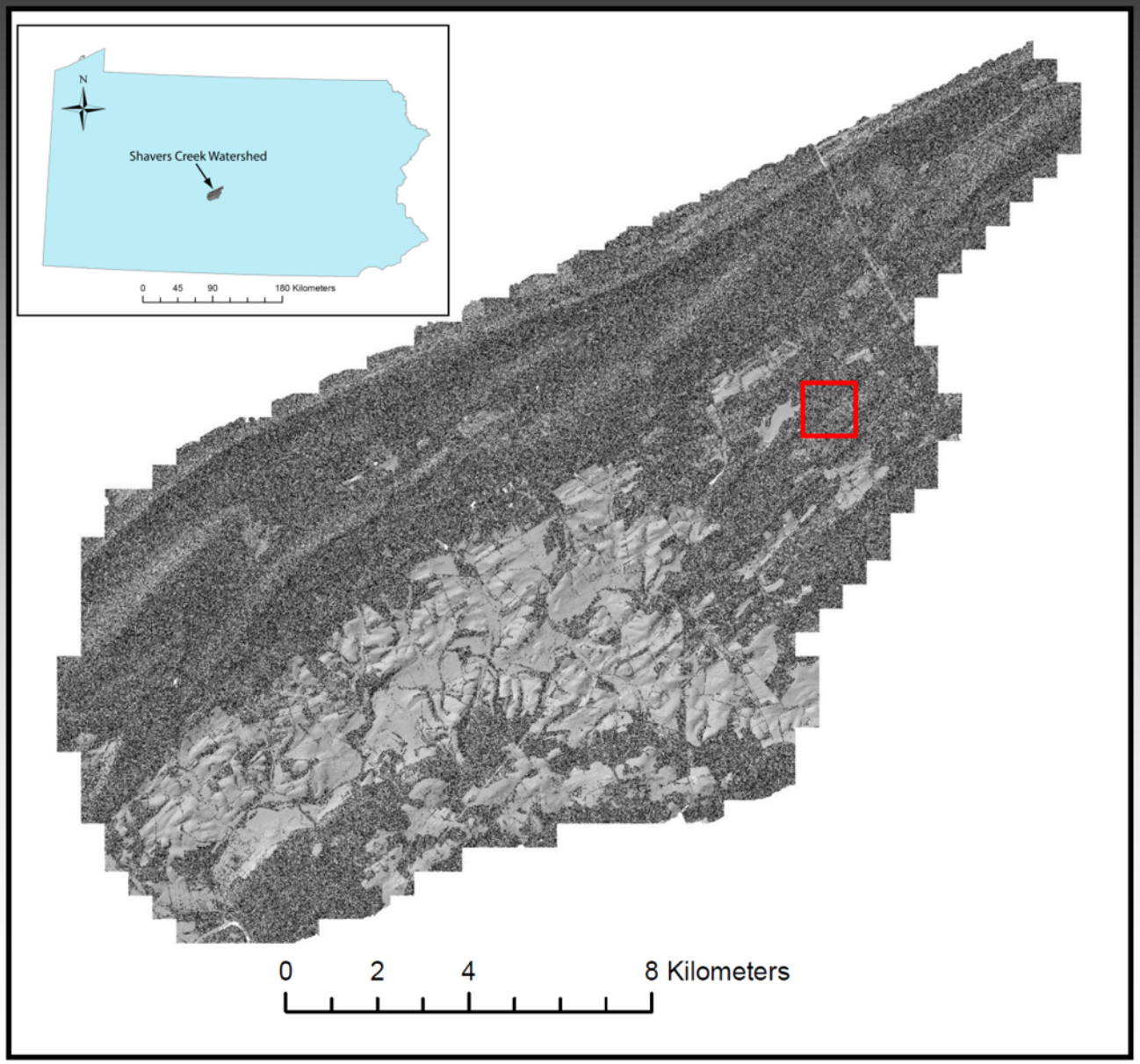


Lidar technology can penetrate the vegetation, and extract the bare earth for ecosystem and earth science studies.

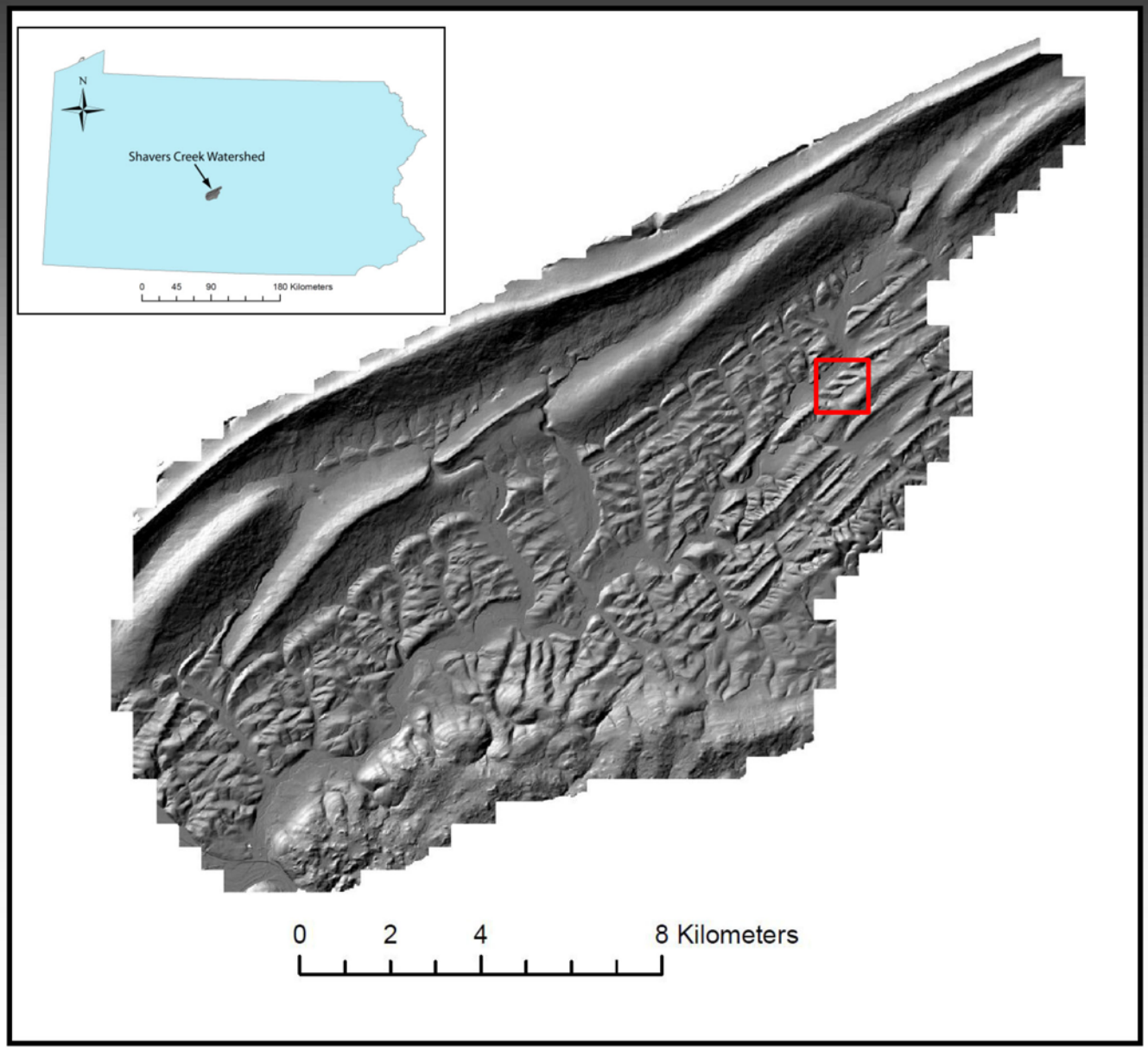
•Upper Left: 1 m resolution aerial photography
•Upper Right: 30 m resolution DEM from USGS
•Lower Right: 1 m resolution DEM from Lidar



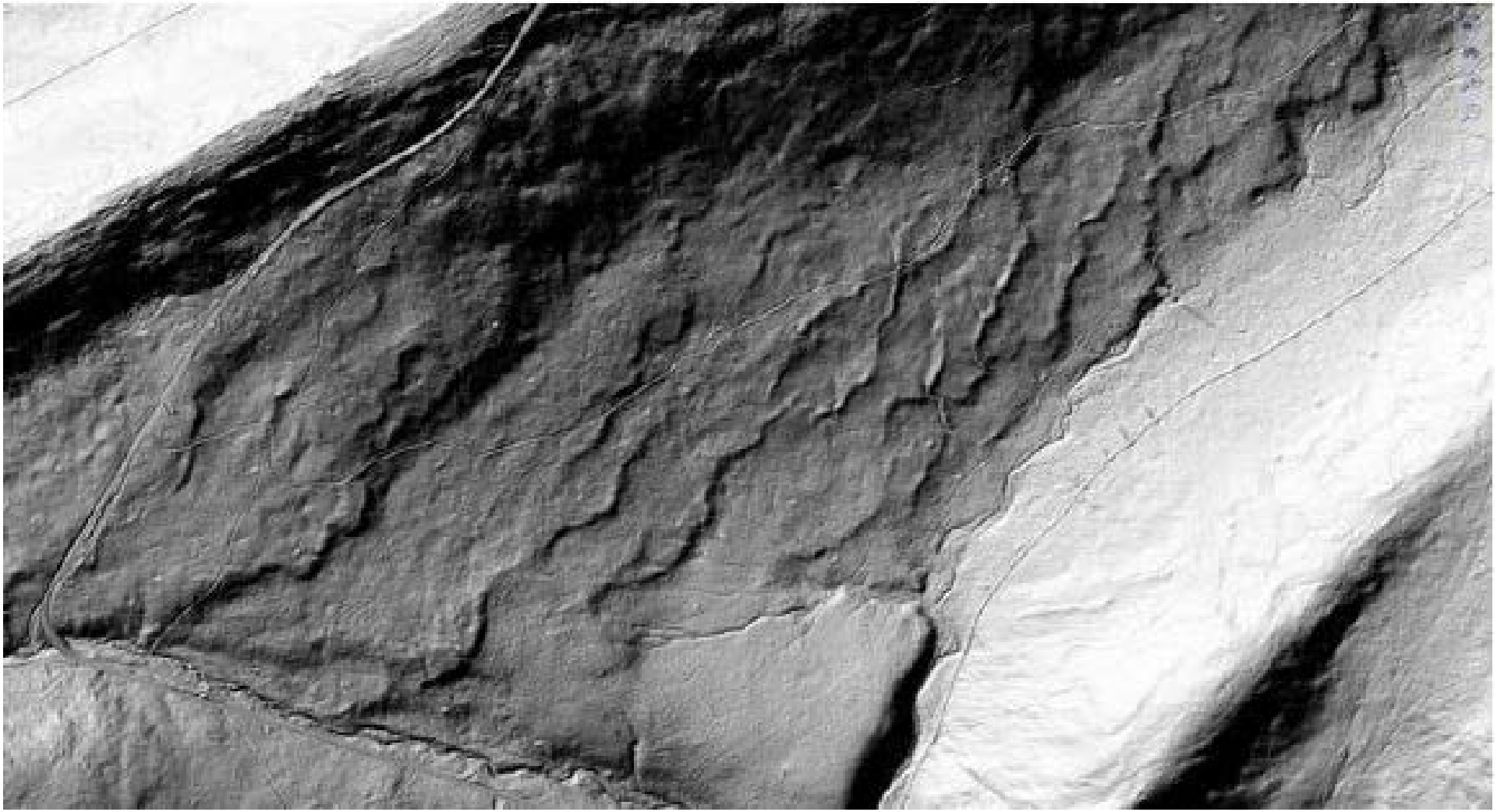
LiDAR acquisition at Shavers Creek was completed in two phases:
Leaf-on survey completed 7/14/2010 – 7/16/2010



LiDAR acquisition at Shavers Creek was completed in two phases:
Leaf-off (snow clear) survey completed 12/3/2010 – 12/9/2010



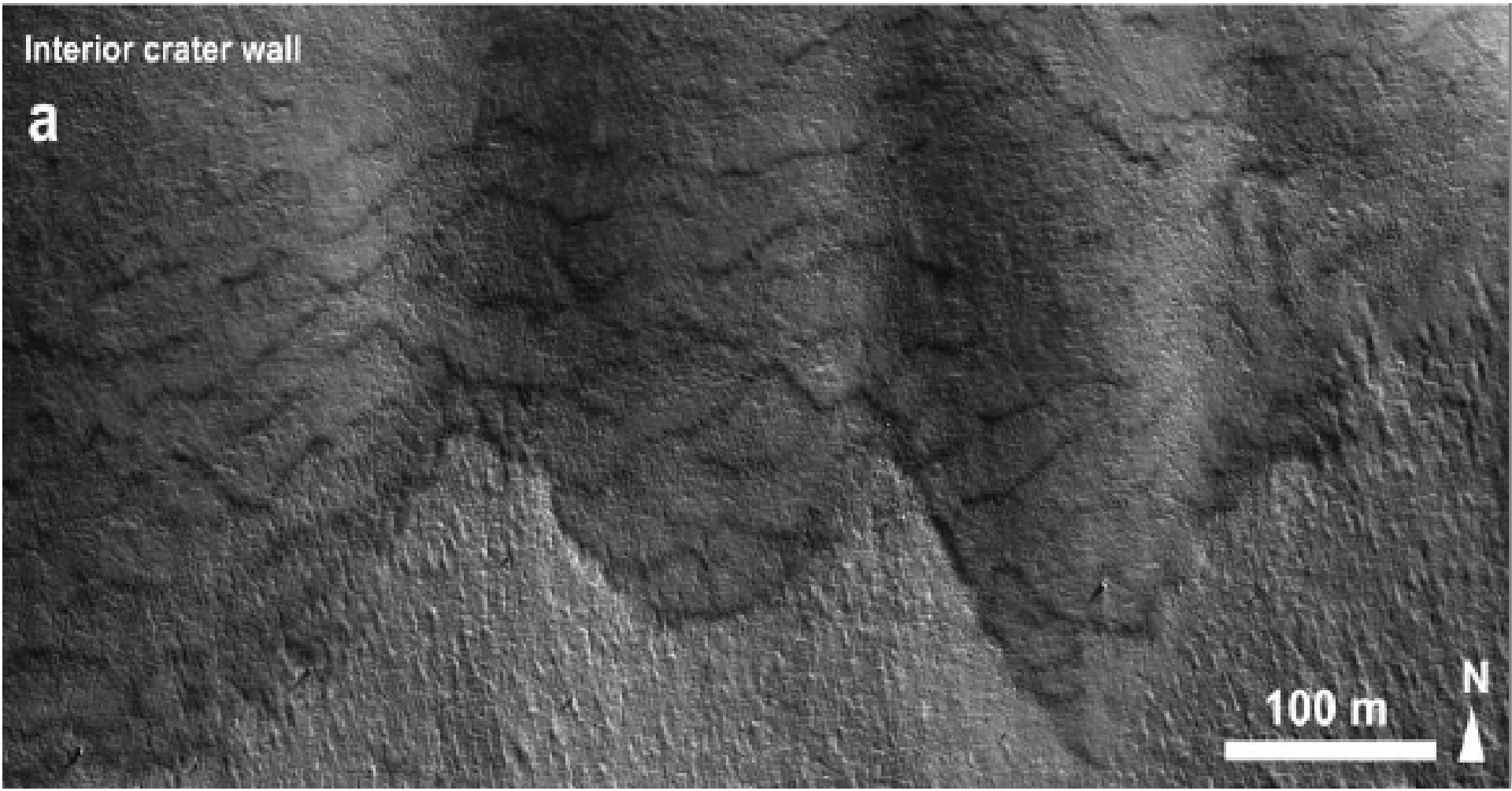
South facing slope, Tussey Mountain, near Pine Grove Mills, Centre/Huntingdon Cty, PA



Chugach Mountains, Alaska

Talkeetna Mountains, Alaska

Mars



Water is life. CZ processes are mediated by freshwater. How many of you or your students can answer a simple question like:

"Where does a raindrop go when it hits Earth's surface?"

or

"Where does the stream behind our school ?"

or

"Where does the water in our well at home come from?"

or

"is the stream behind our school flowing less (or more) than it was last year, or ten years ago, or……?