SEEING OUR EARTH

2020

NSF NASA GAGE SAGE UNAVCO IRIS


GALLEY
patagonia

The National Science Foundation Geophysical Facilities

The broad range of geophysical sciences enables us to see parts and processes of our planet otherwise obscured from the human eye. The National Science Foundation funds two geophysical facilities to support Earth science around the globe: the Geodetic Facility for the Advancement of Geoscience (GAGE) and the Seismological Facility for the Advancement of Geoscience (SAGE). Each facility is comprised of geophysical instrumentation pools and networks, extensive open-access data archives, expert staff, and data-rich educational resources and student opportunities. Together, these facilities promote advances in our understanding of Earth structure and dynamics; continental deformation; tectonic plate boundary processes; the processes that drive earthquakes, volcanic eruptions and landslide hazards; continental water storage, atmospheric, ice sheet and glacier dynamics; and interactions between the solid Earth, hydrosphere, and atmosphere. The capabilities enabled by the SAGE and GAGE Facilities contribute to issues of national/global strategic importance, including geohazard assessment and disaster resilience; environmental management and economic development; national security; and STEM (science, technology, engineering, and mathematics) education and workforce development.

UNAVCO

Founded in 1984, **UNAVCO** has over 35 years of experience providing high-precision measurements of Earth's surface and how it changes over time. With funding from the NSF and National Aeronautics and Space Administration (NASA), UNAVCO manages and operates the GAGE Facility in support of science worldwide. Under three programs, UNAVCO provides expertise in geodetic data collection, including management of global and regional instrument networks; data distribution; and education, outreach, and development of a diverse and adept next-generation workforce. Geodetic tools supported by UNAVCO include GPS/GNSS; borehole strainmeters, tiltmeters, and seismometers; and imaging techniques such as terrestrial laser scanning, photogrammetry, and satellite radar differencing (InSAR). These tools provide sub-centimeter insights into processes large and small on our dynamic planet.

IRIS

The Incorporated Research Institutions for Seismology (IRIS), operator of the SAGE Facility, is a world leader in advancing discovery, research, and education in seismology to understand our planet and to benefit society. IRIS, in collaboration with the U.S. Geological Survey, manages and operates the Global Seismographic Network and maintains a large and diverse pool of portable seismic instrumentation for use in research experiments. IRIS Data Services handles the collection, quality assurance, curation, management, and public distribution of seismic data and data products. IRIS also has an Education and Public Outreach program that provides workforce development and educational resources for students, educators, and the general public; these are designed to be inclusive and enhance participation of traditionally underrepresented groups in the geosciences.






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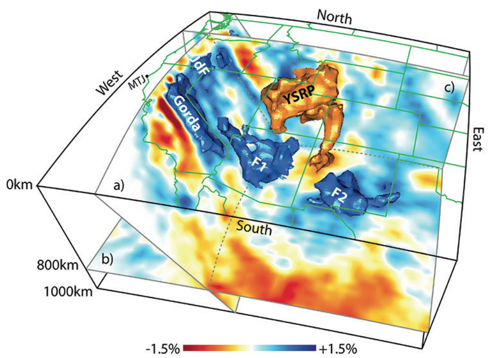
SEEING OUR EARTH



Tomography of the western U.S. showing zones of fast seismic wave velocities (blue) and slower ones (orange and red).
Image/Obrebski et al, 2010; see https://bit.ly/2ZinFiB

Imaging and Imagining

There is much to see on our amazing planet, inside and out, and our eyes can only take in so much. To really understand Earth, we rely on technologies to extend our vision. Geophysical tools enable us to image the subsurface, detect particles in the air, and map out changes beneath our feet that are too subtle or too large to notice in a single lifetime.

For example, researchers use seismic recordings to map out areas down deep where seismic waves move faster or slower depending on the characteristics of the rock, such as composition or temperature. This technique, called tomography, allows us to image the hot, buoyant roots of the Yellowstone hot spot (YSRP, in orange, above) and the cool, dense downgoing slab of the Juan de Fuca tectonic plate (JdF, in blue).

DECEMBER 2019

S	M	T	W	T	F	S
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JANUARY 2020

FEBRUARY

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1 New Year's Day	2	3	4
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12	13	14	15	16	17	18
19	20 Martin Luther King, Jr. Day	21	22	23	24	25
26	27	28	29	30	31	

Main Photo: Sunrise at Mammoth Hot Springs, Yellowstone National Park. *Photo/Neal Herbert, National Park Service, January 2016*

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Preparing an unoccupied aerial system (UAS) equipped with a high-resolution digital camera to take flight over flightless birds.
Photo/Annie Zaino, UNAVCO, January 2019

Home on the Rocks

While seeing penguins close-up on the ground is exciting, seeing them from the air, via photos taken from an unoccupied aerial system (UAS), offers a much better and much less invasive view of their colony structures and a faster way to complete population counts. UAS survey photos were stitched together in a process called structure-from-motion to create a 3D model of this rookery on Ross Island, Antarctica. Surveys enable researchers to understand population dynamics and the effects of factors such as climate change on polar ecology. Look for the gray fuzzy dots among the black dots to identify the fluffy chicks with their parents.

JANUARY

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FEBRUARY 2020

MARCH

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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9	10	11	12	13	14 Valentine's Day	15
16	17 Presidents' Day	18	19	20	21	22
23	24	25	26	27	28	29

Main Photo: Aerial view of an Adélie penguin rookery on Ross Island, Antarctica. *Photo/UAS flight by Keith Williams, UNAVCO, January 2019; see https://bit.ly/2SVqtQB*

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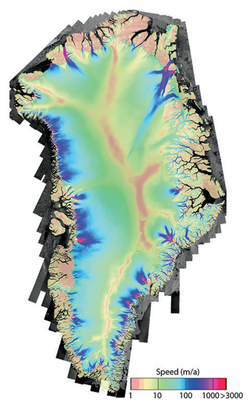

Ice velocities of Greenland, calculated from 1995-2015 SAR and Landsat 8 satellite data.
Image/Joughin et al., 2018; see https://bit.ly/2Zgt3md

Accelerating Ice

Greenland is home to Earth's second-largest ice sheet, with glaciers covering approximately 80% of its surface. Motion of this ice is slowest at the ice sheet's center and accelerates in channels along the edges. The fastest glacier in Greenland is Jakobshavn Isbræ, in the west. Researchers have clocked Jakobshavn Isbræ at more than 17 kilometres per year, or over 46 meters per day (or 10.5 miles and 150 feet, respectively). Tracking Greenland's speeding glaciers is critical for understanding current and future sea level rise.

FEBRUARY

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MARCH 2020

APRIL

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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8 Daylight Savings Time Begins @ 2am	9	10	11	12	13	14
15	16	17	18	19 Spring Equinox	20	21
22	23	24	25	26	27	28
29	30	31				

Main Photo: Land, ice, sea, and sky south of Daneborg, east Greenland. Geophysical tools are used to better 'see' each of these elements of our planet. *Photo/Thomas Nylen, UNAVCO, August, 2015*

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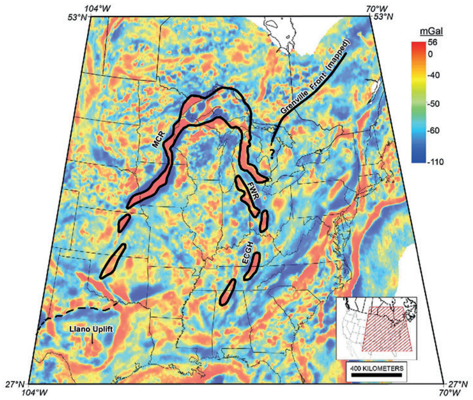

Map of gravity anomalies in the north-central U.S., showing the Midcontinent Rift outlined in black.
Image/Stein et al., 2018; see https://bit.ly/2YDrKwF

Torn Not Broken

In the middle of the North American continent, far from any active volcanoes or plate boundaries, massive lava flows indicate the geologic past was not like the present. What happened? Geophysics provides us some good clues. Gravity measurements and seismic surveys used to image the subsurface in the mid-continent show a double-armed structure reaching from Lake Superior southwestward and southeastward through the mid-western U.S. This structure is a failed rift—a place where the continent started to pull apart to form a new ocean, but then stopped. The evidence that remains offers a snapshot of one of plate tectonics' most important processes—how continents form and break up.

MARCH

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APRIL 2020

MAY

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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Main Photo: Cliffs of 1.1-billion-year-old volcanic rocks from the Midcontinent Rift in Tettegouche State Park, Minnesota. *Photo/John Brueske, iStock photo*

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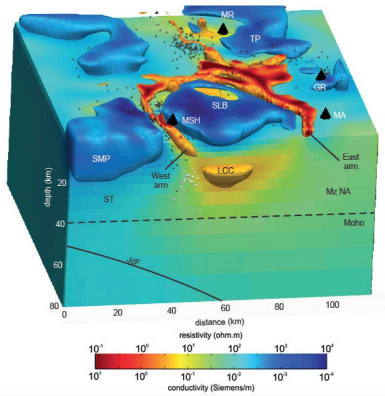

A 3D resistivity model under Mount St. Helens (MSH), Mount Rainier (MR), Mount Adams (MA), and Goat Rocks (GR).
Image/Bedrosian et al., 2018; see https://go.nature.com/2MgD3bC.

Ring Around the Hard Rocks

While most of the volcanoes along the Cascades Arc align neatly over the subducting Juan de Fuca plate, Mount St. Helens sits farther west. Why is that? A recent geophysical survey using a technique called magnetotellurics measured the electric resistivity of the subsurface and shows that Mount St. Helens sits directly atop a ring of highly conductive rocks. This ring represents rocks of different composition and different strength than the surrounding crust, with the westernmost arm dividing the zone of older, more rigid rocks into two. Rising magma may bypass the rigid rocks on the west, exploiting the weaker rocks to reach the surface where it can erupt, thus offsetting Mount St. Helens from its siblings.

APRIL

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MAY 2020

JUNE

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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24	25 Memorial Day	26	27	28	29	30
31						

Main Photo: Mount Rainier as seen from Coldwater Peak, just north of Mount St. Helens. *Photo/Michael Gottlieb, UNAVCO, September 2014*

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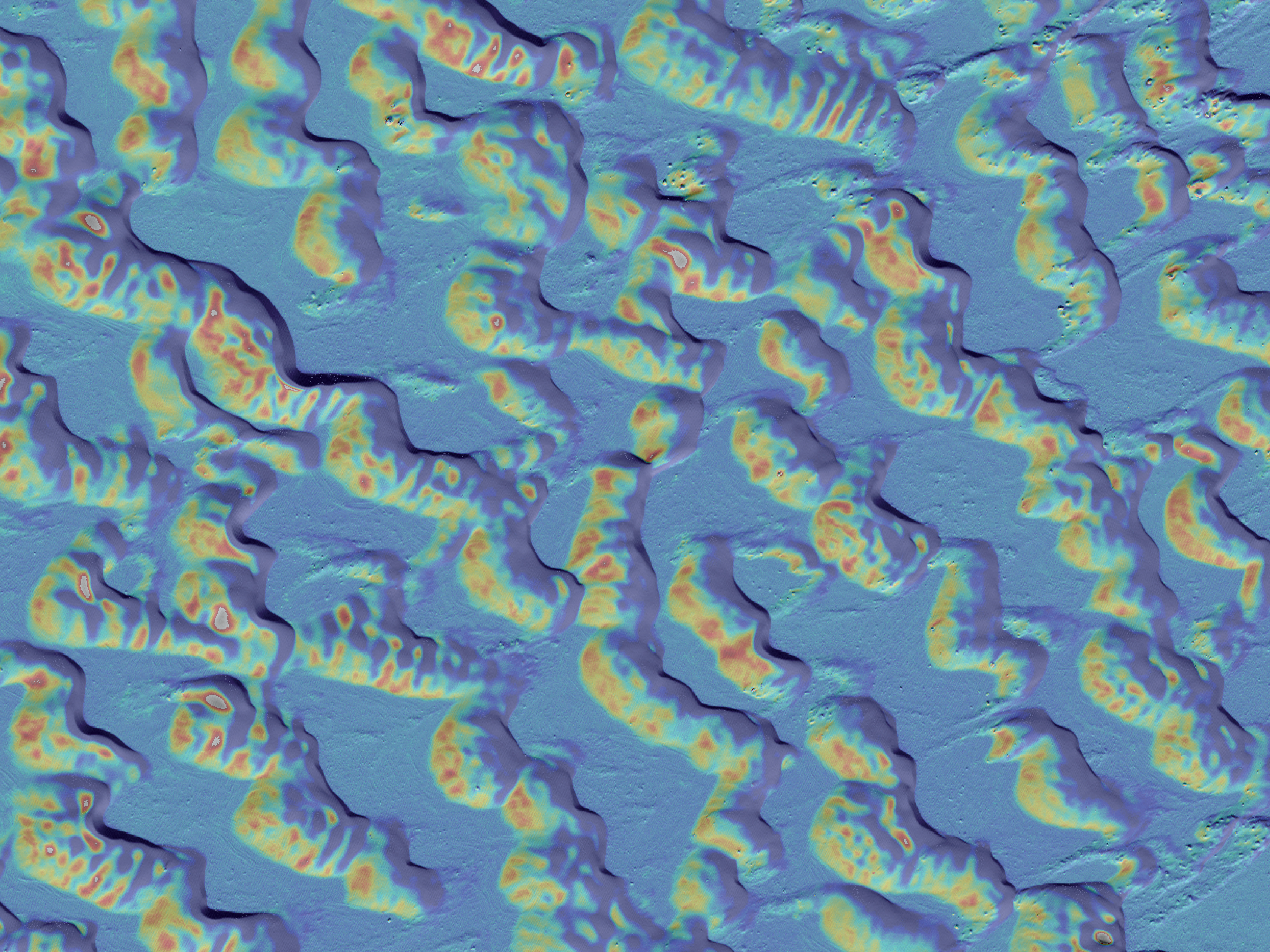

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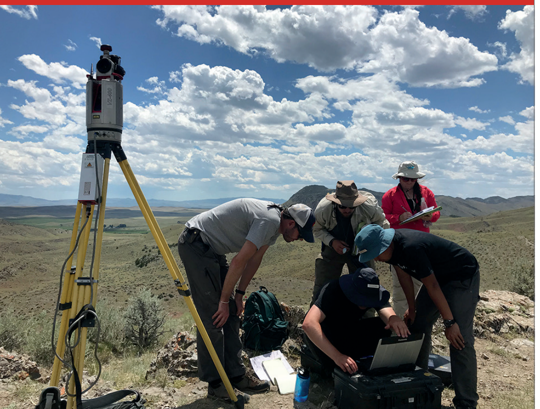

Students from the Indiana University Geologic Field Station use a ground-based lidar system to scan geological structures in southwest Montana.
Photo/Sarah W.M. George, University of Arizona, July 2019

Shifting Sands

Sand dunes as you've never seen them before? This aerial view of White Sands National Monument was created by calculating the difference in height of the dunes between two overflight lidar surveys, showing the direction and magnitude of erosion and deposition. Lidar, or Light Detection and Ranging, determines distance by calculating the travel time of reflected laser signals from either an airborne platform or a tripod, resulting in high-resolution elevation maps. Multiple surveys reveal changes in the land surface, like the migration of sand dunes.

Imagery collected in September 2009 and June 2010. Deposition or upward movement is colored in blue. Erosion or downward motion is colored in red and yellow. The dunes are migrating towards the north-east, driven by a dominant wind direction from the southwest.

MAY

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31						

JUNE 2020

JULY

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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14	15	16	17	18	19	20 Summer Solstice
21	22	23	24	25	26	27
28	29	30				

Main Photo: Lidar image of migrating dunes at White Sands National Monument, New Mexico. *Image/Chelsea Scott, ASU. Differencing performed with OpenTopography's vertical differencing tool. 2009 Data: Kocurek- https://doi.org/10.5069/G9ZK5DMD. 2010 Data: Ewing- https://doi.org/10.5069/G97D2S2D. Matlab code: Perron et al., (2008).*

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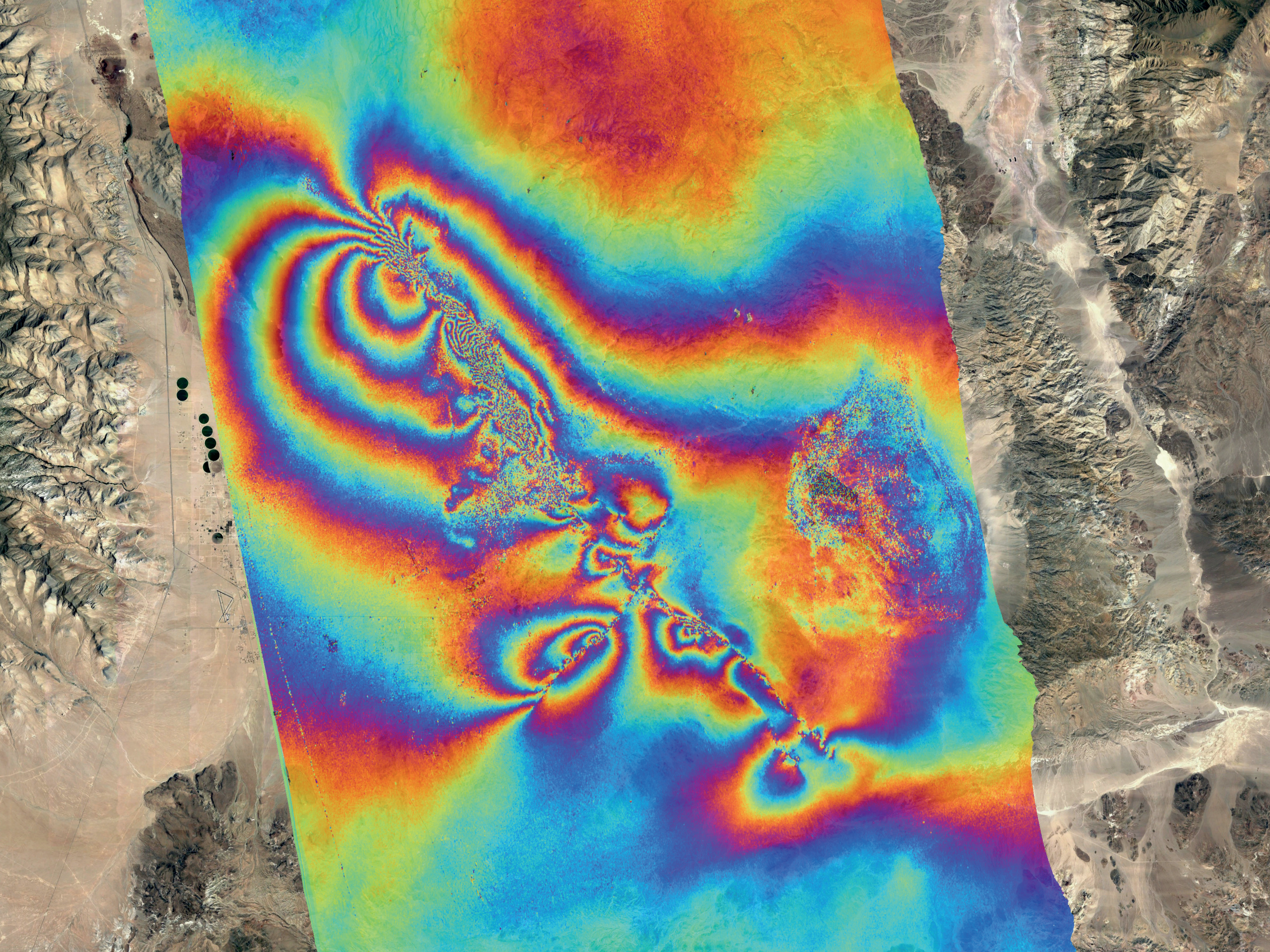

SEEING OUR EARTH

Fault offsets from the July 2019 Ridgecrest earthquakes.
Photo/Ken Hudnut, USGS, July 2019

The Breaking Earth

A ground-based rainbow? No, these bands of color show how much the ground moved in the Ridgecrest, California region as a result of two earthquakes in July 2019. Scientists use data from radar-equipped satellites to map changes in broad swaths of Earth's surface. This image compares the path length (or slant range) of radar pulses traveling to the ground and back from one satellite pass (before the earthquake) to the next (after the earthquake). This method, InSAR, is used to measure changes in Earth's shape down to the centimeter.

Each repetition of the light spectrum (from purple through yellow to green) represents 12 cm of motion along a direct path toward the satellite. The closer the bands, the more the motion—here, the bands cluster around the multiple faults that ruptured. Maximum offsets measured on the ground were up to 1.5 m, or 5 ft.

JUNE

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JULY 2020

AUGUST

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1	2	3	4 Independence Day
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Main Photo: Motion resulting from the July 2019 magnitude 6.4 and 7.1 earthquakes near Ridgecrest, California. *Image and interferogram/Sang-Ho Yun, Jet Propulsion Laboratory, California Institute of Technology. Original data: ALOS-2 PALSAR-2 Product – JAXA (2019). Background Image: Google Earth.*

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SWL 30K

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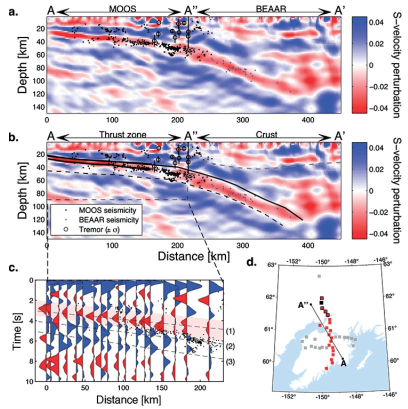

Imaging of the earth beneath the Kenai Peninsula, Alaska, reveals the subducting Pacific plate, shown in red in the top image.
Image/Kim et al., 2014; see https://bit.ly/2MgHUcN

Under Land and Sea

Understanding subduction zones, where one tectonic plate dives under another, is particularly challenging because the contact between the two plates is often located beneath the ocean. Recent technological advances have enabled more deployments of seafloor instruments to extend our view outward from shore. One such array is the Alaska Amphibious Community Seismic Experiment, consisting of 105 seismometers underwater and on land along the Alaska Peninsula to image the forces beneath one of the most seismically and volcanically active regions on the planet.

JULY

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AUGUST 2020

SEPTEMBER

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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Main Photo: Broadband ocean bottom seismometers ready for deployment aboard the R/V Sikuliaq.
Photo/Anne Sheehan, University of Colorado, July 2018

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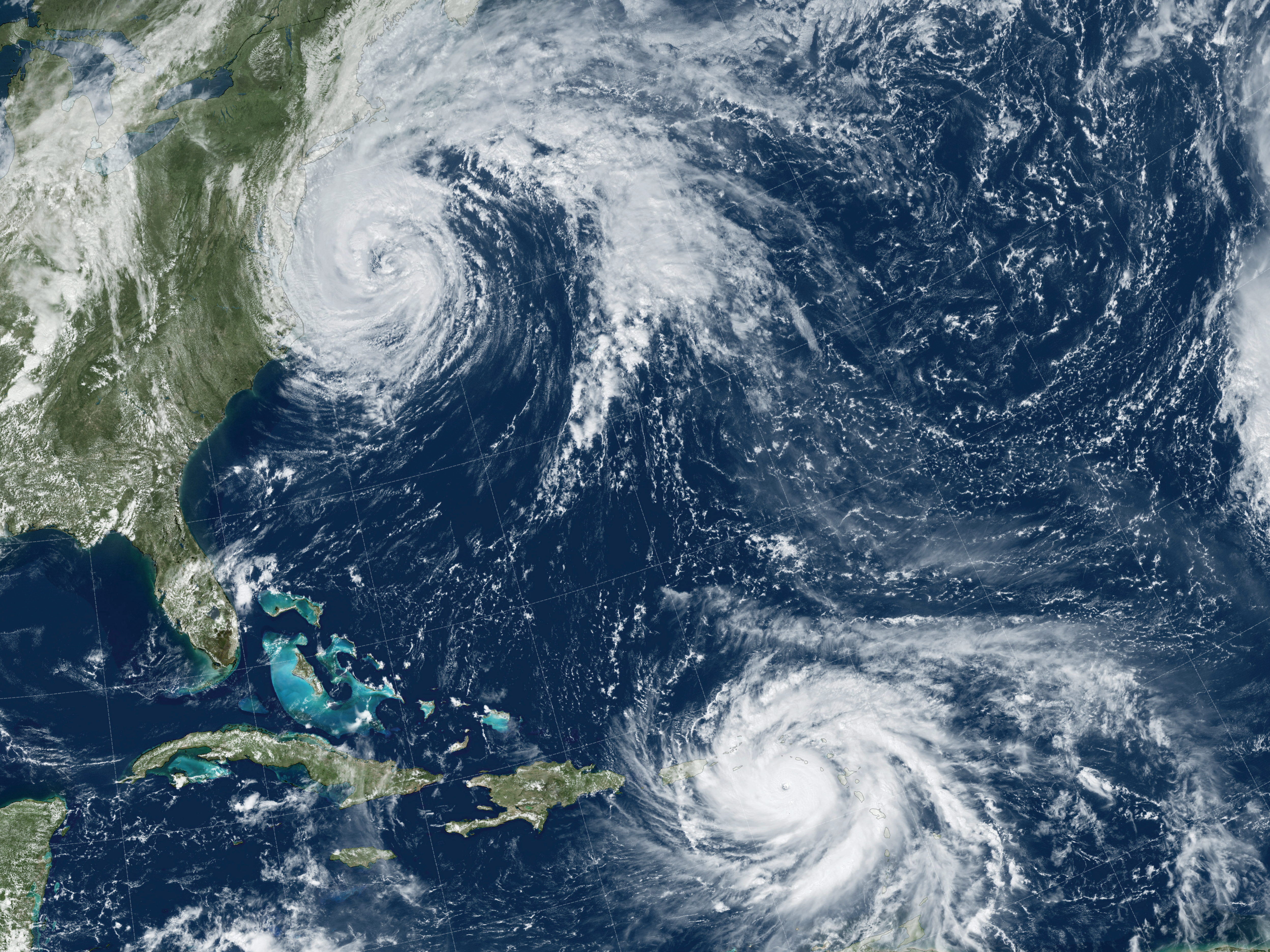

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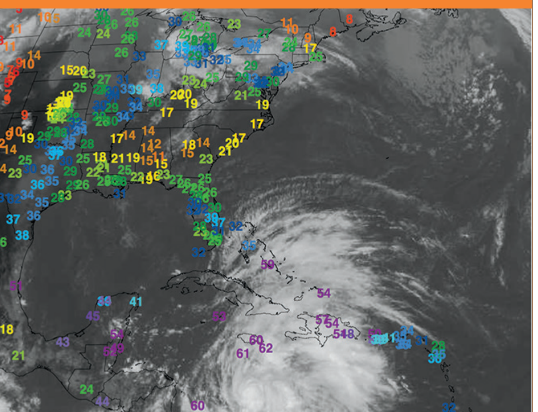
EARTH



A snapshot of Hurricane Sandy on October 23, 2012. Colored numbers show precipitable water vapor, or moisture that can turn into rain, as measured by GPS on the ground.
Image/John Braun, UCAR

Looking Up and Ahead

Hurricanes are powerful but picky—they can only travel to and maintain their power in areas with warm water, low winds aloft, and high humidity into the mid-levels of the atmosphere. Measuring these and other factors enables hurricane track forecasts. With more data, scientists are able to better calculate possible trajectories. GPS allows us to 'see' the humidity in the atmosphere in real-time by measuring the delay moisture causes on the satellite signals received by GPS stations on the ground. These delays offer a map of high- and low-humidity areas, and how they change as the hurricanes pass through. Additionally, seismometers can be used to measure the strength of hurricanes by recording vibrations from waves that are impacting the ocean floor and the coast.

AUGUST

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SEPTEMBER 2020

OCTOBER

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7 Labor Day	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22 Fall Equinox	23	24	25	26
27	28	29	30			

Main Photo: Hurricanes Jose (upper left) and Maria (lower center) in September 2017. Hurricane Maria resulted in significant and sustained damage to property and critical infrastructure, widely impacting the population of Puerto Rico. *Image/NASA Earth Observatory*

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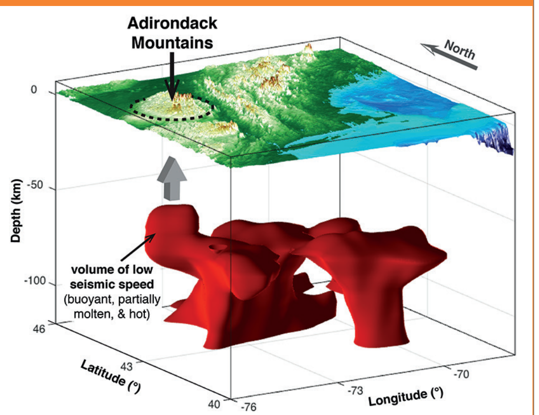

A 3D view of the area of low seismic speeds imaged beneath the Adirondack Mountains.
Image/Xiaotao Yang and Haiying Gao, 2018; see https://bit.ly/2OnrbHt

Mystery Mountains

Not all mountains form the same way, and getting at the root cause of mountains may mean getting to the roots of the mountains themselves. Using seismometers to image the structures beneath Earth's surface can help us see what lies below. Here, scientists use seismometers to map out zones where seismic waves travel faster and slower beneath the Adirondacks, allowing us to 'see' underneath them. The work revealed a 'slow' zone, which may mean hotter materials are located there. One possibility? The blob is an upwelling from below that, together with thermal expansion, pushed up and formed the Adirondack Mountains.

SEPTEMBER

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OCTOBER 2020

NOVEMBER

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
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25	26	27	28	29	30	31 Halloween

Main Photo: Peak autumn foliage in the Adirondack Mountains of New York near Lake Placid. *Photo/DenisTangneyJr, iStock photo*

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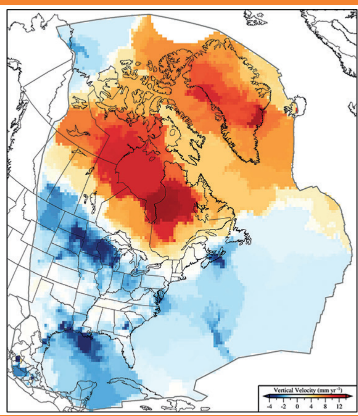

Vertical motions of North America showing up (red) or down (blue) motions, as measured by GPS.
Image/Corné Kreemer, University of Nevada Reno; see https://bit.ly/2ZfDVB7

Ancient Ice, Current Seas

Predicting future coastlines requires much more than knowing how fast current glaciers will melt; we also need to factor in thermal expansion of the oceans and the vertical motions of our coasts. GPS is one tool for measuring the ups and downs of our land—much of which has to do with past glaciers. North America is still recovering from the last major glaciation by rebounding (going up relative to the Earth's center) where it was previously being depressed by ice (in red, above) and relaxing and sinking where it bulged up around the ice's edge (in the surrounding blue). The sinking of the Atlantic coast means preparing for faster and greater sea level rise than in neighboring areas.

OCTOBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	**31**

NOVEMBER 2020

DECEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	**21**	22	23	24	**25**	26
27	28	29	30	31		

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1 Daylight Savings Time Ends @ 2am	2	3 Election Day	4	5	6	7
8	9	10	11 Veterans Day	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26 Thanksgiving Day	27	28
29	30					

Main Photo: The Chesapeake Bay coastline is affected by both rising seas and sinking land. *Photo/Wendy Bohon, IRIS, July 2017*

NSF NASA
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SAGE National Science Foundation's Seismological Facility for the Advancement of Geoscience
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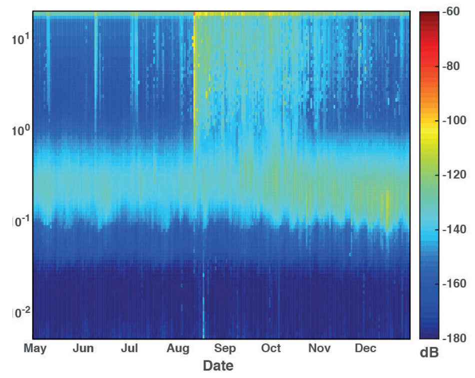
SEEING OUR EARTH



A sequence of earthquakes in northern Alaska shows up as high-frequency energy (neon green) on this spectrogram from a Transportable Array seismic station.

Image/Kasey Aderhold, IRIS

High-Resolution Vision

One outcome of improved technology and more sensors is a more detailed picture of the inner workings of Earth. Alaska is by far the most seismically active state in the U.S., but because of Alaska's vast size and remoteness, many regions did not have sensors until recently. The deployment of EarthScope's Alaska Transportable Array, a network of 280 new and contributing seismic stations blanketing the region, came at just the right time to capture two large earthquakes and their aftershocks in the Brooks Range. The nearby earthquakes are visible in the upper part of the plot above, while the bright band across the middle shows the continuous energy primarily from distant ocean waves. Earthquakes as small as magnitude 1 yield important information about regional faults, tectonic stresses, and future earthquake hazard.

NOVEMBER

S	M	T	W	T	F	S
1	2	**3**	4	5	6	7
8	9	10	**11**	12	13	14
15	16	17	18	19	20	21
22	23	24	25	**26**	27	28
29	30					

DECEMBER 2020

JANUARY 2021

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	**18**	19	20	21	22	23
24	25	26	27	28	29	30
31						

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21 Winter Solstice	22	23	24	25 Christmas Day	26
27	28	29	30	31		

Main Photo: The Brooks Range, Alaska, as seen from EarthScope Transportable Array seismic station D25K, about 50 km from the magnitude 6.4 Kaktovik mainshock on August 12, 2018.

Photo/Jason Theis, IRIS, June 2016

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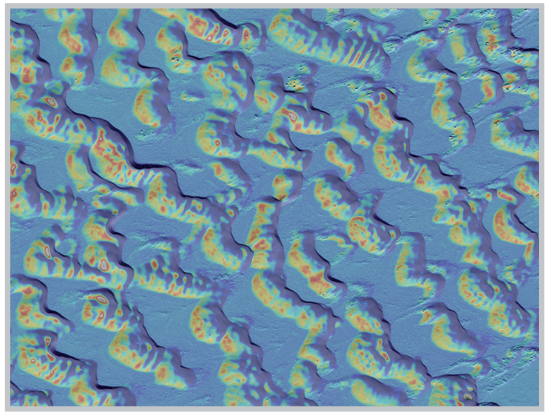
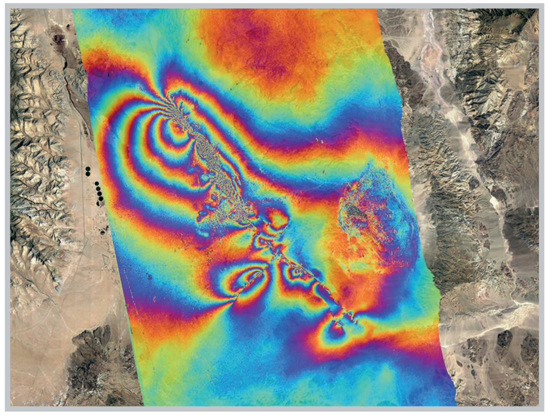
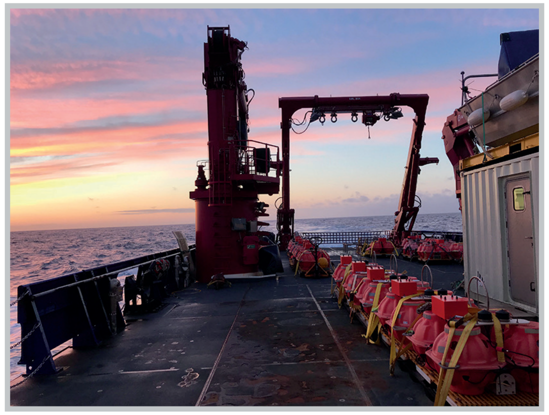
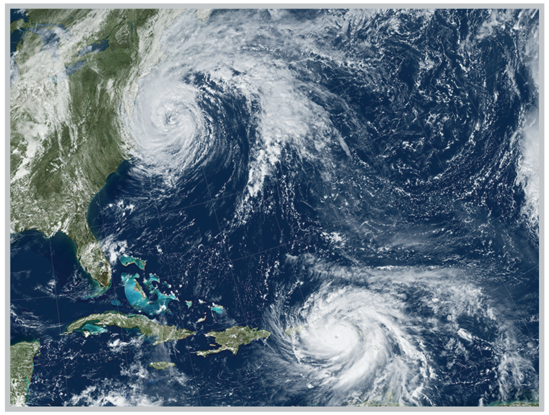


COVER PHOTO: Grand Prismatic Hot Spring in the Yellowstone Caldera. *Photo/Dave Mencin, UNAVCO, July 2008*

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