VOL. 99 • NO. 12 • DEC 2018

EOS

Earth & Space Science News

Special Issue

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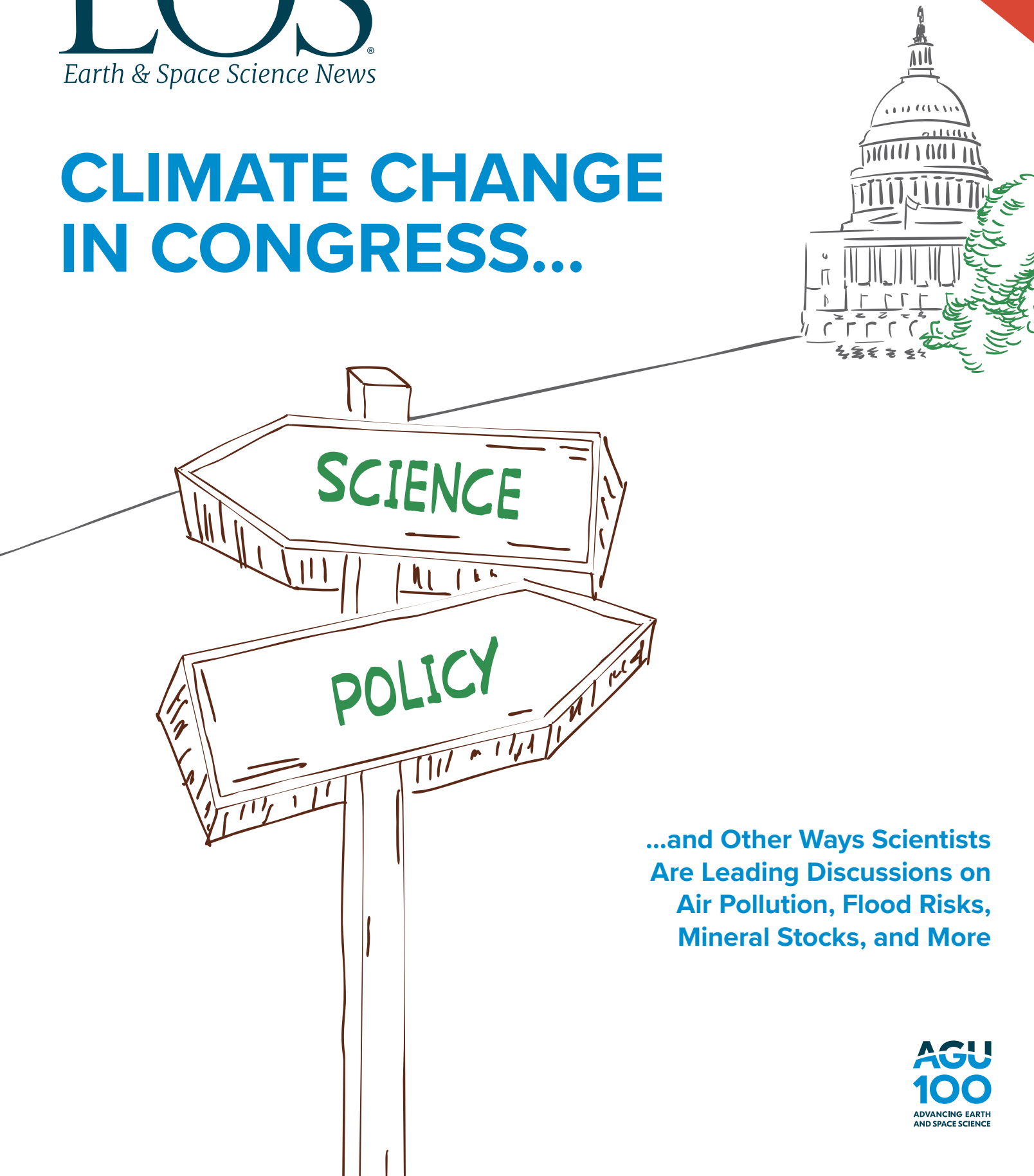


...and Other Ways Scientists Are Leading Discussions on Air Pollution, Flood Risks, Mineral Stocks, and More

AGU 100
ADVANCING EARTH AND SPACE SCIENCE

Huge Blades of Ice May Partially Cover Jupiter's Moon Europa

Europa, a moon of Jupiter, has long been heralded as one of the most promising places to look for life in the solar system. That's because it contains an ocean of liquid water beneath its surface that might, much like Earth's ocean, be a habitable place.

But now scientists have proposed a potential hitch to safely placing a lander on Europa: Blades of ice up to 15 meters tall might be clustered around the moon's equatorial region.

These features, which exist in cold, dry areas on Earth and have been spotted on Pluto, are formed when the Sun's rays shine on ice, causing it to completely skip melting into a liquid and instead turn directly into a gas. Known as penitentes—the Spanish term for religious figures kneeling in penance—because of their appearance, these blades could prevent a lander from exploring parts of Europa.

Remarkable Sculpting

Penitentes are found on Earth in cold and dry conditions at tropical latitudes, for example, in the Andes mountains of northern Chile. They begin to form when a field of ice naturally develops small pits on its surface.

When the Sun is nearly overhead, its rays preferentially strike the bottoms of these pits, warming the ice. This warming ice doesn't melt in a traditional sense: The air is so dry that the heated ice immediately gets transformed into gas in a process called sublimation.

As sublimation continues, the pits deepen. Over time, the cumulative sublimation eats away at the ice, creating penitentes with typical heights of 1–5 meters.

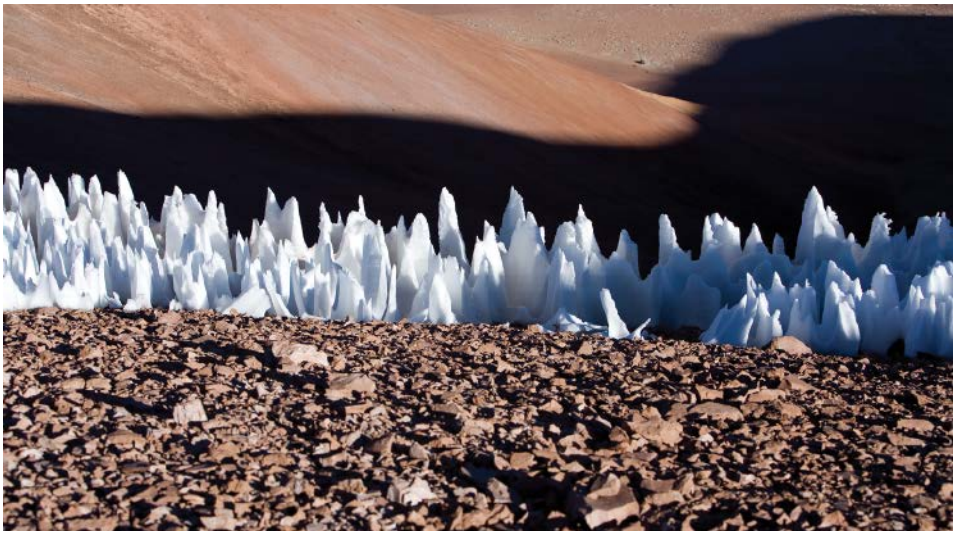
Penitentes can last a year or two on Earth, and they've even been re-created in laboratory experiments. The New Horizons spacecraft has also spotted these features on Pluto, where the towering columns are believed to be made of frozen methane.

> These blades could prevent a lander from exploring parts of Europa.

Now Jeff Moore, a planetary geologist at NASA Ames Research Center in Moffett Field, Calif., and his colleagues have proposed another location where penitentes might form: on Europa.

"The raw ingredients seem to be there," Moore said. These ingredients include the moon's icy surface, its cold temperature (between −203°C and −141°C), and the relatively constant angle at which sunlight strikes it.

"We hypothesize that penitentes can grow, and indeed have grown [on Europa]," the researchers write in their study, which was published in *Nature Geoscience* in October (http://bit.ly/europa-penitentes).



Penitentes in the Andes mountains in Chile. Credit: ESO

Towering Tall

Using estimates of noontime temperatures on Europa and the reflectivity of its surface, among other parameters, the researchers estimate that ice on the moon sublimates at a rate of roughly 30 centimeters per million years. That's millions of times slower than the rate on Earth, mostly because Europa is much farther from the Sun. At the distance of Europa, "the Sun is 25 times less bright," Moore said.

But even the creeping pace at which ice turns into water vapor on Europa is faster than the rate at which Europa's surface is eroded by charged particles from Jupiter. And because penitentes form more rapidly than they're eroded, they should exist on the Jovian moon, the researchers reason.

Given that Europa's surface is about 50 million years old—on the basis of its relative lack of craters—Moore and his colleagues estimate that penitentes as tall as 15 meters might tower over Europa's equatorial region.

"The Sun sculpts these special features in a way that is remarkable," said Douglas MacAyeal, a geophysicist at the University of Chicago who was not involved in the research. But remarkable or not, the spires themselves might not be good news. Penitentes would "imply a hazard of attempting to land on an equatorial surface of Europa," MacAyeal said.

Awaiting a Flyby

Unfortunately, images of Europa taken by spacecraft aren't detailed enough to reveal or refute the presence of penitentes. However, radar data of the Jovian moon are consistent with the existence of penitentes near Europa's equator, Moore and his colleagues note. Microwave wavelength radar observations of Europa have revealed that its equatorial region tends to reflect less radiation than its higher latitudes. If the moon's surface is rough near the equator—due to penitentes, for example—that could explain these measurements: The deep pits of these ice blades tend to scatter and absorb radiation.

In the coming decade, NASA's Europa Clipper mission is expected to put a spacecraft in orbit around Jupiter that will complete flybys of Europa's surface, and scientists hope that a lander might follow. Moore and his colleagues are looking forward to mining the first data from the Europa Clipper mission, which will skim as close as 25 kilometers above Europa, to look for penitentes.

"If they're there, we'll see them," he said.

By **Katherine Kornei** (email: hobbies4kk@gmail.com; @katherinekornei), Freelance Science Journalist