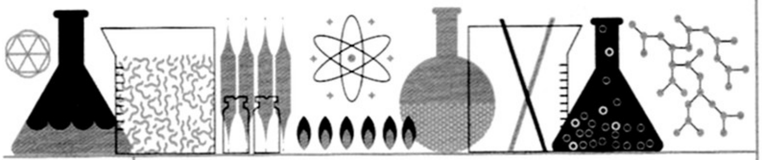

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INNOVATION

BIG DATA WILL LET US EXPLORE DISTANT PLANETS

Finding A Second Earth

Somewhere out there are worlds that can support life. Lisa Kaltenegger has a way to find them

BY JEFFREY KLUGER

THE EXISTENCE OF LIFE IS A CRAPSHOOT. YOU need a nice, solid hunk of planet you can plant your feet on. You need lots of water and other friendly chemistry, some of it forming a quilt of atmosphere to keep out the cold. And you need to be just the right distance from just the right star—not too close, not too far; not too hot, not too cold. A terrarium like that incubating for, say, a billion years, might have a fair chance of cooking up something living. Those just-right conditions don't occur often, which explains why it's been so hard to find life on the tiny handful of worlds we have even a remote chance of visiting: the moons and planets in our solar system. For a long time, scientists didn't know much about planets elsewhere, so the rest of the cosmos looked like a biological washout.

That has changed. In the past 15 years or so, astronomers have discovered more than 4,200 potential exoplanets—planets orbiting distant stars—and confirmed the existence of more than 1,050 of them. In a galaxy with 300 billion stars, there are surely untold billions of other planets out there. Is anyone home on any of them?

Few astronomers are approaching that question as creatively as Lisa Kaltenegger, 36, an exoplanet investigator who is a lecturer at Harvard University and leader of a research group at the Max Planck Institute for Astronomy, in Heidelberg, Germany. The focus of her work is not discovering exoplanets, most of which have been detected by the Kepler space telescope. Rather, she and her team are modeling them—hoovering up massive amounts of data from Kepler, the Hubble Space Telescope and various ground telescopes and processing it through computer models to determine which worlds could harbor life. These days, so-called Big Data is inescapable, from algorithms that predict what you'll buy to government surveillance. Now it seems Big Data may also be the key to finding extraterrestrial life.

Kaltenegger's model is a complex one, factoring in

Photograph by Berthold Steinhilber—laif/Redux

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a planet's size, mass, composition and orbit—whether it is in the habitable zone around its star, where temperatures would remain hospitable and water would remain liquid. Just as important are the size, nature and temperature of the star, since ones like our sun have a very different profile from, for example, a red giant's or a white dwarf's. Kaltenegger even includes a dash of the fantastical. "What if you have more than one host star? What if you see Tatooine?" she asks, referring to the childhood home of *Star Wars'* Luke Skywalker.

All that is impressive but not groundbreaking. Where Kaltenegger shakes things up is in her use of data from the only planet in the universe that, by definition, cannot wear the *exo* prefix: Earth. Her models include data about Earth's meteorology, geology and volcanology, plus one other important feature: its history.

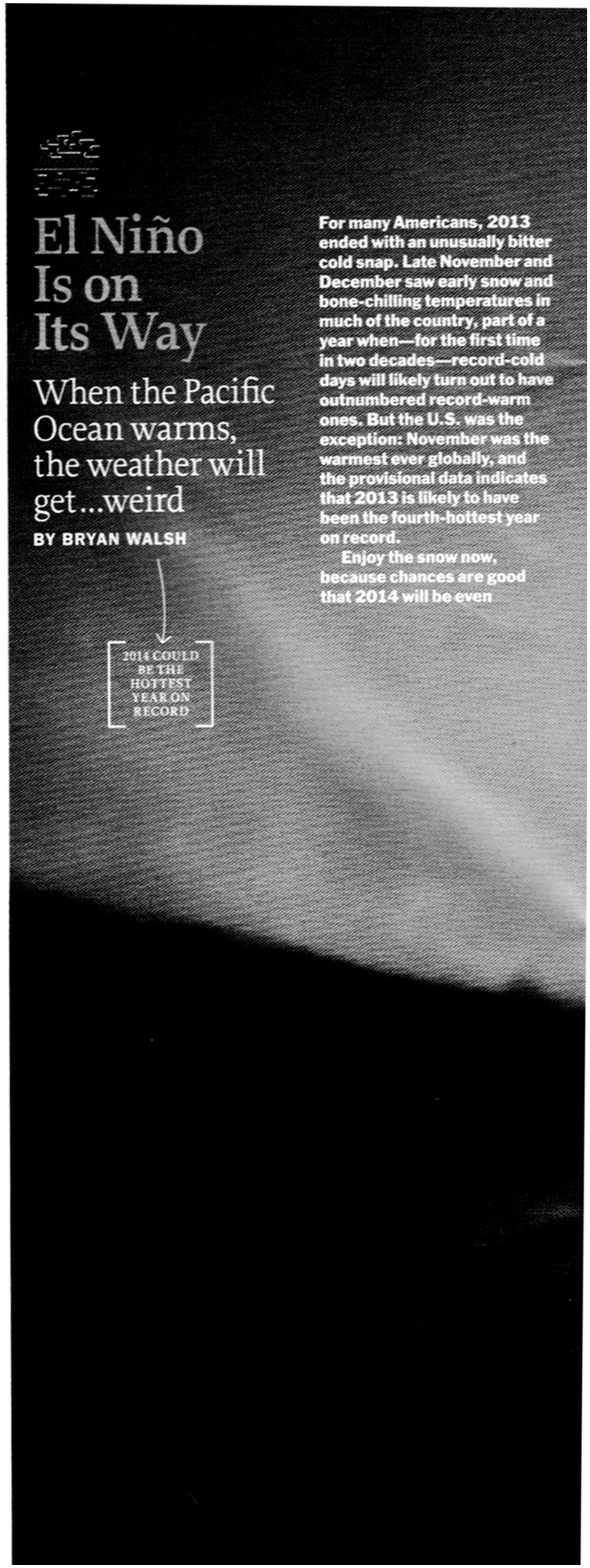
Our planet, seen by extraterrestrials, would have looked very different depending on the point at which it was being observed. Take a look at us 3.9 billion years ago, and we would have had a brown, globe-girdling ocean and an atmosphere made mostly of hydrogen sulfide, carbon dioxide and nitrogen. Not exactly the rain forest. Check in 2.4 billion years ago, and Earth's atmosphere was mostly nitrogen, carbon dioxide and methane; blue-green algae were blooming in the seas. Not long after that, photosynthesis began flooding the atmosphere with oxygen, leading to an explosion of modern forms of life.

Every bit of this could have been observed by faraway civilizations studying Earth with a technique known as spectral analysis. Since light coming from a planet breaks down in different wavelengths depending on its chemical composition, all you need to know is which elements are represented by which spectra and you can figure out what's going on in the atmosphere. We could make the same observations about other worlds. "We've determined how this spectral fingerprint looks for a young and an older Earth," Kaltenegger says. "We use that as an alien ID chart for other planets."

Kaltenegger is actually ahead of the curve this year. Telescopes can't yet resolve exoplanets visually; their existence and nature are inferred mostly by how they cause their parent stars to wobble and by the amount of starlight they block as they pass in front of them. In 2017, though, NASA will launch the Transiting Exoplanet Survey Satellite (for which Kaltenegger is a mission scientist), specifically looking for exoplanet atmospherics. Next is NASA's James Webb Space Telescope and then the European Extremely Large Telescope in the Chilean desert.

In the meantime, Kaltenegger is not waiting. In 2014 she and her team will specifically model 100 alien worlds potentially harboring different kinds of life forms to determine what they would look like from Earth. They will also model potentially habitable moons orbiting gas-giant planets. "With billions of rocky worlds," she says, "life would have to be extremely picky not to be able to evolve out there, wouldn't you say?" ■

Photograph by Todd Hido—Edge Reps



El Niño Is on Its Way

When the Pacific Ocean warms, the weather will get…weird

BY BRYAN WALSH

2014 COULD BE THE HOTTEST YEAR ON RECORD

For many Americans, 2013 ended with an unusually bitter cold snap. Late November and December saw early snow and bone-chilling temperatures in much of the country, part of a year when—for the first time in two decades—record-cold days will likely turn out to have outnumbered record-warm ones. But the U.S. was the exception: November was the warmest ever globally, and the provisional data indicates that 2013 is likely to have been the fourth-hottest year on record.

Enjoy the snow now, because chances are good that 2014 will be even