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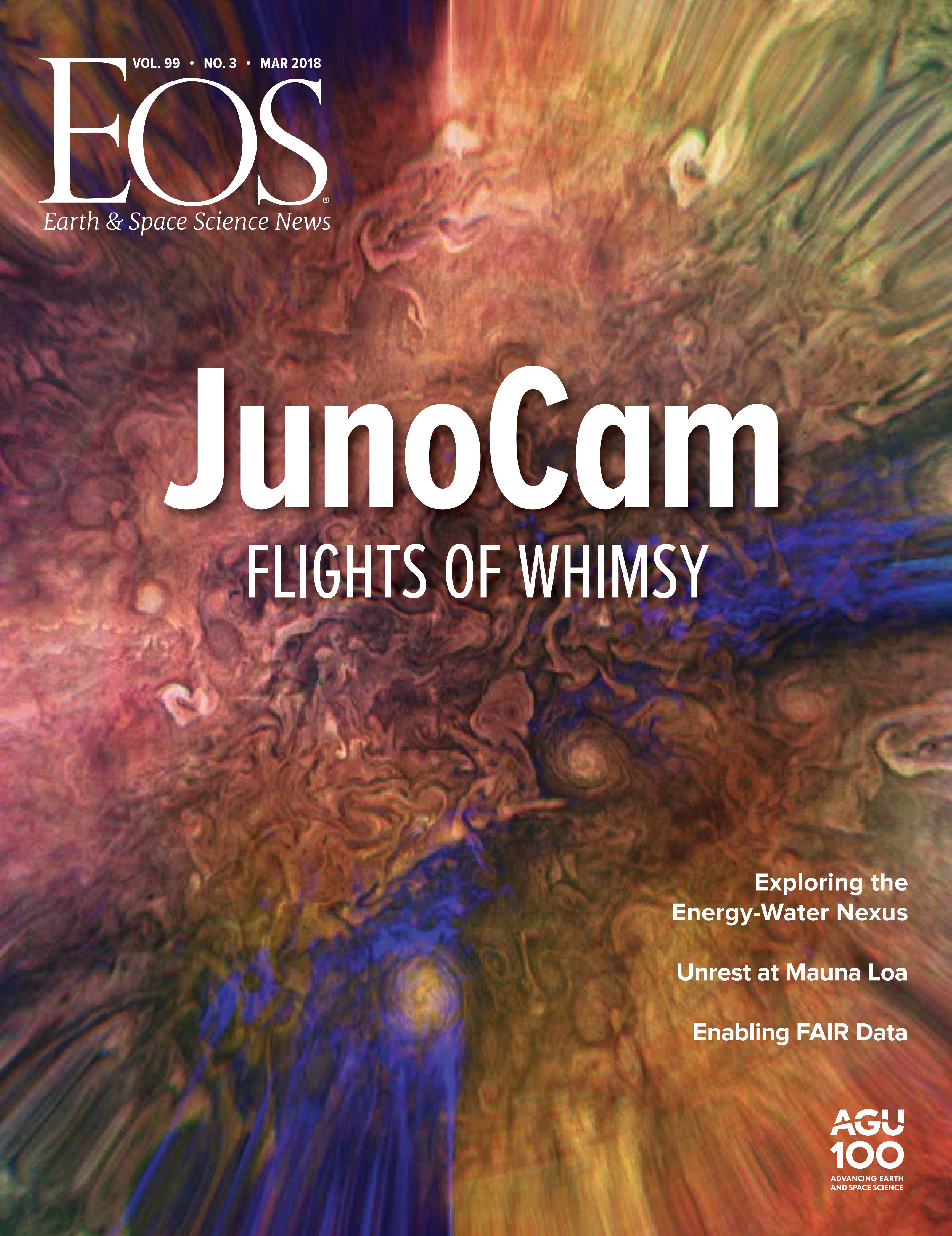

JunoCam
FLIGHTS OF WHIMSY

Exploring the Energy-Water Nexus

Unrest at Mauna Loa

Enabling FAIR Data

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A comparison of teosinte and modern corn. Credit: NSF

found at the roots of modern corn. Unexpectedly, the bacterial communities for teosinte and corn were similar.

"It's important to note that this study was conducted with soils that have been farmed for 25 years," said Timothy Bowles, an agroecologist at the University of California, Berkeley, who was not involved in the research. "These soils may have lost some of the wild microbes" that help teosinte thrive, he explained.

Bowles suggested that future studies using wild soils from teosinte's natural habitat might reveal bigger differences between the bacteria around the roots of teosinte and modern corn.

Helping Corn Fend for Itself

Identifying the traits that allow teosinte to thrive in organic soils could allow us to create crops better suited to the techniques of sustainable agriculture. The goal is to find the genes behind teosinte's success and breed them into new varieties of corn created specifically for more eco-friendly farming.

This study looked at only a few varieties of teosinte, but its findings encourage assessing even more. "One of the promising things coming out of this work is that it shows variation in the communities colonizing the roots of these plants—that variation has a genetic component that we can screen plants for," said Bowles.

So could we breed more eco-friendly corn? Perhaps. But "plant breeding is a long process; it could take 10–20 years to create something commercially available," said Schmidt. It also depends on the interest on the part of companies developing new crops.

"It's promising that there is so much interest in developing microbial products to replace fertilizers," said Schmidt. "This goes one level below that, so you're changing the seed instead of the soil."

By **Alex Fox** (email: almfox@ucsc.edu; @Alex_M_Fox), Science Communication Program Graduate Student, University of California, Santa Cruz

A Decade of Atmospheric Data Aids Black Hole Observers

The Atacama Pathfinder Experiment (APEX) 12-meter telescope in Chile's Atacama Desert, shown here, will join others to image the immediate surroundings of a black hole in April. Credit: European Southern Observatory/H. H. Heyer, CC BY 4.0 (http://bit.ly/ccby4-0)

A worldwide collaboration of radio astronomers called the Event Horizon Telescope (EHT) is taking a close look at the atmosphere here on Earth to get a better view of an elusive area of deep space. Thanks to the astronomers' recent modeling of the past 10 years of global atmospheric and weather data, they can now predict when nine radio telescopes and arrays scattered around the world are most likely to have the clear view they need to make their extraordinary simultaneous observations.

Their quarry is the perilous boundary of a black hole, called the event horizon, and the surrounding region of space. Their target is not just any black hole: It's the hulking, supermassive black hole that lurks at the heart of the Milky Way.

"You have to get all the participating observatories to collectively agree to give the EHT folks time on the sky when they ask for it…and that's a big deal," said Scott Paine, an astrophysicist at the Smithsonian Astrophysical Observatory (SAO) in Cambridge, Mass., who also happens to be an atmospheric scientist.

Trying to ensure that EHT scientists would make the most of valuable worldwide observing time, Paine advised that they approach the problem scientifically using global atmospheric records. Along with EHT director and SAO astrophysicist Sheperd Doeleman, he spearheaded the creation of a model that predicts the probability of good simultaneous observations at all sites using data gathered by the National Oceanic and Atmospheric Administration (NOAA). Using this new model, the EHT collaboration is coordinating a weeklong observing campaign that will take place in April (see http://eventhorizontelescope.org).

It's not the first time the collaboration will peer at our galaxy's central black hole, which is known as Sgr A*(pronounced "Sagittarius A-star") and is about 4 million times the mass of our Sun. The inaugural attempt took place in April 2017, and they geared up to try again this year, with the expectation of better results. This April and into the future, they hope to achieve the best "seeing" possible for the collection of EHT telescopes and arrays, thanks to newly developed tools for selecting dates and times of optimal meteorological conditions for the overall observing network.

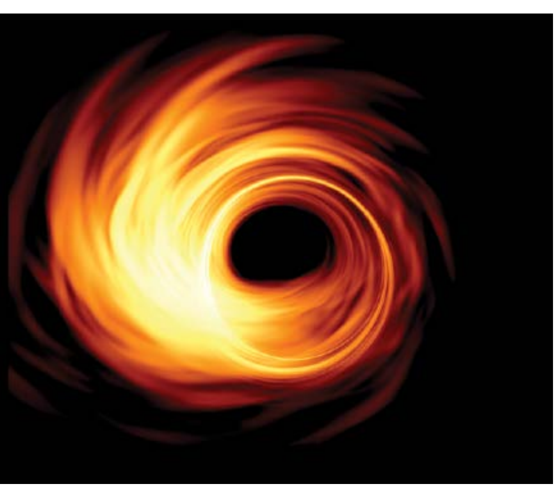
"These tools allow us to determine the ideal observing windows for EHT observations and to assess the suitability and impact of new EHT sites," said Harvard University undergraduate student Rodrigo Córdova Rosado in a recent presentation of this work. Córdova Rosado, a junior who worked on the project with Paine and Doeleman, presented a poster about this research on 9 January at the 231st meeting of the American Astronomical Society at National Harbor in Maryland (see http://bit.ly/Cordova-Rosado-poster).

A Worldwide Telescope Array

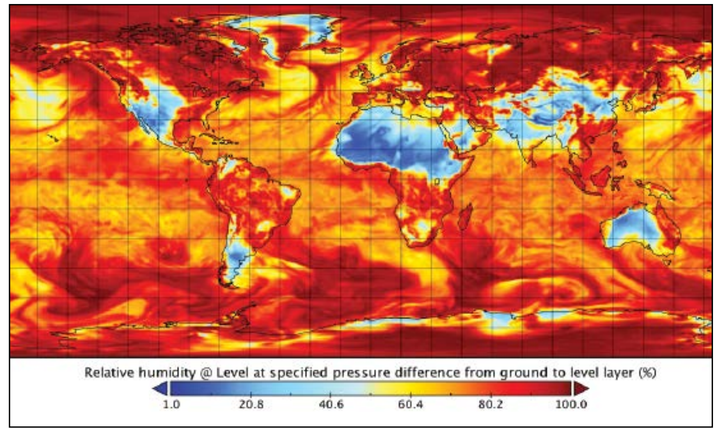
Although a black hole, by definition, does not emit light, gas and dust surrounding the black hole emit copious light as the incredible gravity of the black hole pulls the material into itself. The brilliant glow, in turn, silhouettes the black hole.

Because of the black hole's ultracompact size, imaging its immediate environment requires an observing technique called very long baseline interferometry (VLBI). VLBI coordinates observations from multiple radio telescopes around the globe to amplify the light from a target and increase the signal-to-noise ratio of an observation. The wider the physical footprint of the array used in VLBI is, the stronger and clearer the radio signal is. Astronomers have used VLBI to view stars coalescing from giant gas clouds, and they plan to use it to glimpse protoplanets forming in circumstellar disks.

EHT's nine radio telescopes and arrays at seven observing sites compose the largest VLBI array in the world. Getting onto the observing schedule at any one of the telescopes is competitive, and negotiating for simultaneous observing time on all nine is even more difficult.



A simulation of light emitted by hot gas as it orbits a black hole, viewed from 45° above the orbital plane, similar to what EHT hopes to see. Brightness indicates the intensity of the emitted radio frequency light. The black hole's intense gravity bends light emitted from inner parts of the accretion disk around its event horizon, creating the black hole silhouette seen in the center. Credit: Hotaka Shiokawa



A map of worldwide relative humidity data on 2 February 2012 from NOAA's Global Forecast System. The color gradient shows areas of low (blue) and high (red) relative humidity between 0 and 30 millibars above ground-level pressure—essentially the relative humidity at the surface for GFS data. Researchers with the Event Horizon Telescope collaboration extracted data from maps such as this, generated for many atmospheric layers, to determine the humidity along an observing direction. Credit: Córdova Rosado et al., 2018, http://adsabs.harvard.edu/abs/2018AAS...23115714L; data from NOAA/National Centers for Environmental Information

A Two-Pronged Predictive Approach

Deciding when to observe requires solving two problems at once, according to Paine. "There's the strategic problem," he said, "that is, which week or two weeks are you going to ask for from the observatories."

The second is a tactical problem. "Once you've got your block of time, and you're allowed to use a certain number of days within an allocated period, which ones are you going to trigger observations on?" He added, "We've been looking at both problems."

That's where NOAA comes in. Córdova Rosado tackled the first problem by gathering global weather data from NOAA's Global Forecast System (GFS) recorded from 2007 to 2017 at approximately 6-hour intervals. Because EHT observes using radio waves, the researchers were primarily interested in records of relative humidity, ozone mixing ratio, cloud water vapor ratios, and temperature at each of the sites because each of those atmospheric conditions affects the quality of observations. Córdova Rosado ran those data through an atmospheric model that Paine had created to calculate how opaque the atmosphere appears at EHT's observing frequency of 221 gigahertz, or a wavelength of 1.4 millimeters.

According to Vincent Fish, a research scientist at the Massachusetts Institute of Technology (MIT) Haystack Observatory in Westford, coordinated, ground-based radio observations of the galactic center thrive at 221 gigahertz. "At longer observing wavelengths," he explained in an MIT press release, "the source would be blurred by free electrons...and we wouldn't have enough resolution to see the predicted black hole shadow. At shorter wavelengths, the Earth's atmosphere absorbs most of the signal." Fish was not involved in this research.

EHT Sites Prefer It Dry

Córdova Rosado statistically combined each of the yearly opacity trends to calculate for each day of the year the probability that Sgr A* would have favorable observing conditions simultaneously at all seven sites. The team found that the second and third weeks of April were the best times of year for EHT to observe Sgr A*. The middle of February was a good backup observing window for both the Milky Way's center and another black hole target.

Some sites, like the South Pole Telescope and the Atacama Large Millimeter/Submillimeter Array (ALMA) in Chile, offer remarkably stable opacities throughout the year because the areas enjoy consistently low humidity. For more variable Northern Hemisphere sites, the winter months provide the most favorable observing conditions.

According to Paine, each of the EHT sites may serve a different purpose for each target, either to act as a mission-critical observing location or to enhance the image quality. The team may not need perfect conditions at all sites for every observation.

More Telescopes, More Targets

Although climate change has undoubtedly affected the 2007–2017 NOAA meteorological data, it hasn't significantly influenced the humidity levels that are the most important factor for getting clear radio observations, Paine explained.

Paine described the EHT atmospheric model as the first step in creating what he called a "merit function" that he and his colleagues will use to assess the value of conducting observations on a particular day. Continued access to NOAA's GFS data, he said, will be critical to making the best use of limited observing time.

"[NOAA's] resources are not only used for weather and climate tasks, but they're also getting leveraged for things like astronomy," he said. "We're fortunate to have this resource for optimizing very expensive astronomical observations."

By **Kimberly M. S. Cartier** (@AstroKimCartier), News Writing and Production Intern